KERALA UNIVERSITY OF FISHERIES AND OCEAN STUDIES (KUFOS)

Panangad, Kochi- 682506, Kerala

Integrated Bachelors-Masters in Marine Biology

OBE Syllabus

2026

Programme Overview

The M.Sc. Marine Biology programme offered by the Department of Marine Biosciences, Faculty of Ocean Science and Technology (FOST), Kerala University of Fisheries and Ocean Studies (KUFOS) is a premier postgraduate programme established in 2012 to train highly skilled marine scientists capable of addressing challenges in marine biodiversity, ecosystem conservation, climate change, blue biotechnology and the Blue Economy. In 2024, the programme adopted a revised Outcome-Based Education (OBE) curriculum aligned with the National Education Policy (NEP 2020), integrating marine biology with oceanography, biotechnology, fisheries sciences, environmental management, research methodology, and emerging technologies through competency-based and experiential learning.

From 2026, the programme is offered under the Advanced Marine Station for Ocean Biology (AMSOB) initiative of the Ministry of Earth Sciences (MoES), Government of India, as part of the Deep Ocean Mission (DOM). Students benefit from academic collaborations with the National Institute of Ocean Technology (NIOT), Chennai, and other premier MoES and national research institutions through expert lectures, internships, collaborative research, advanced laboratory training, and exposure to state-of-the-art ocean science facilities. A distinctive feature of the programme is its Integrated Coastal and Island Field-Based Curriculum, which provides extensive hands-on training across estuarine, mangrove, coral reef, seagrass, offshore, and island ecosystems. Students gain practical experience in biodiversity assessment, ecological monitoring, oceanographic sampling, habitat mapping, taxonomy, environmental assessment, and modern analytical techniques. The programme also includes compulsory SCUBA diving training (subject to medical fitness and certification requirements), enabling students to develop underwater research skills for marine biodiversity surveys, coral reef assessment, ecological monitoring, and scientific diving.

The two-year, four-semester programme combines classroom teaching, laboratory practicals, seminars, workshops, field expeditions, internships, and an independent fourth-semester research dissertation under the guidance of KUFOS faculty and collaborating scientists.

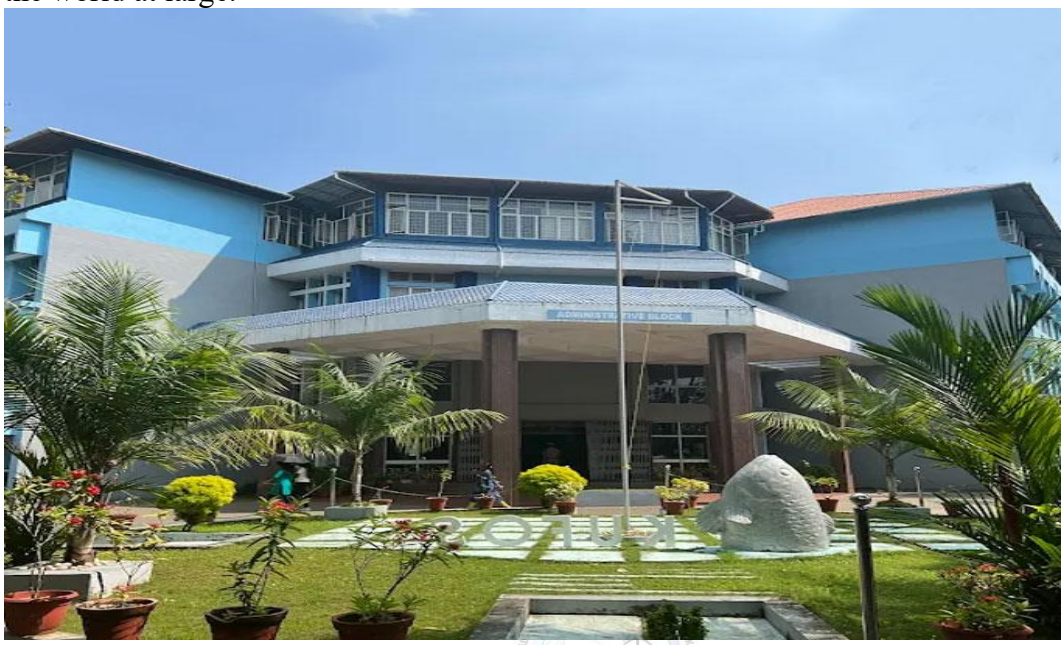
Graduates are well prepared for careers in universities, MoES institutions, national research laboratories, environmental consultancy, marine biotechnology, fisheries and aquaculture, conservation agencies, offshore and ocean technology sectors, and international organizations. The programme also provides an excellent foundation for doctoral studies, competitive fellowships, and entrepreneurship in marine bioresources, mariculture, ornamental fisheries, and other Blue Economy sectors.

With its OBE curriculum, AMSOB–MoES support, NIOT and national institutional collaborations, Integrated Coastal and Island Field-Based Curriculum, and mandatory SCUBA training, the M.Sc. Marine Biology programme at KUFOS offers one of India's most comprehensive and field-oriented postgraduate programmes in marine sciences.

University Mission and Vision

Mission

The mission of the university is to serve as a flagship of higher learning through demonstrated and growing excellence in teaching, research, extension, scholarship and creative work in fisheries and ocean studies, comparable with global standards that will benefit the country and the world at large.



The KUFOS Vision

- To produce professionally and technically competent manpower in Fisheries and Ocean studies to cater the needs of the fast-developing sector.
- Develop entrepreneurship among the fisheries graduates by imparting hands-on training and give opportunities to develop management skills through Fisheries Work Experience Programme.
- Undertake research and extension activities in the field of Fisheries and Ocean studies by undertaking research in frontier areas and by promoting interdisciplinary/ inter-departmental/ inter-institutional co-operation.
- Provide employment opportunities for the people especially fisher folk by imparting trainings on modern techniques of fishing, primary handing, preservation, production of value-added fishery products, ornamental fish culture, hatchery production of seeds of various cultivable fin and shell fishes and their farming.
- Provide consultancy services so as to put into practice the technologies developed among the entrepreneurs and generate income for the institution.
- Achieve the mission and goals laid down by the University.
- Develop infrastructure facilities and inter-institutional co-operative programmes in order to make the campus the nucleus of the Fisheries and Ocean studies in the world.

Goals

- To further the advancement in learning and conduct research in fisheries, ocean studies and allied subjects.
- Impart education in fisheries and ocean studies and allied subjects.
- Formulate new courses and curriculum in fisheries and ocean studies sector in accordance with the technical advances in the respective fields

- Act as a nodal agency to establish relationship with institutions and universities functioning at national and international levels
- Act as a centre of excellence having leading role for HRD in Fisheries and Ocean studies
- Foster and encourage entrepreneurship in Fisheries and Ocean studies.

Programme Vision

To emerge as a centre of excellence in Integrated Marine Biology education, research and innovation by developing globally competent professionals capable of advancing marine biodiversity conservation, sustainable ocean resource management, blue economy initiatives and interdisciplinary marine sciences for the benefit of society and the marine environment.

Programme Mission

1. To impart comprehensive and interdisciplinary education in marine biology, ocean sciences and allied disciplines through outcome-based teaching, practical training and field-oriented learning.
2. To promote research, innovation and scientific inquiry in marine biodiversity, marine biotechnology, ecosystem dynamics, fisheries biology, climate change and blue economy sectors.
3. To develop technical, analytical and entrepreneurial skills among students through experiential learning, industry exposure, laboratory training, marine expeditions and community engagement programmes.
4. To foster sustainable utilization, conservation and management of marine and coastal ecosystems through scientific approaches, environmental ethics and policy awareness.
5. To prepare professionally competent graduates with leadership qualities, communication skills, ethical values and lifelong learning abilities capable of addressing regional, national and global challenges in marine sciences and ocean sustainability.

Table of Contents

ABOUT THE UNIVERSITY

KERALA UNIVERSITY OF FISHERIES AND OCEAN STUDIES (KUFOS)

The Kerala University of Fisheries and Ocean Studies (KUFOS) is a State University established by the Government of Kerala for higher education, research, extension and innovation in fisheries, ocean science and allied disciplines. It is the first public university in India exclusively dedicated to fisheries and ocean studies. The University was established to promote excellence in education, research and technology development in fisheries, marine sciences, aquatic resources and related interdisciplinary fields, while supporting the sustainable development of the fisheries and ocean sectors.

KUFOS offers undergraduate, postgraduate, doctoral and post-doctoral programmes across fisheries, ocean sciences, engineering, management, food technology, maritime law and other emerging disciplines. The University integrates academic learning with research, innovation, industry interaction and extension activities to address regional, national and global challenges in fisheries, food security, climate resilience and the Blue Economy**.**

History

The Kerala University of Fisheries and Ocean Studies was established on 20 November 2010 through legislation enacted by the Government of Kerala. The University commenced its academic activities on 1 April 2011 following the reorganization of the erstwhile College of Fisheries. Since its establishment, KUFOS has evolved into a multidisciplinary institution dedicated to fisheries, ocean sciences and allied disciplines, contributing to education, research, innovation and extension for the sustainable development of aquatic resources.

Act of Establishment

KUFOS was established under the Kerala University of Fisheries and Ocean Studies Act, 2010 (Act 5 of 2011) enacted by the Kerala Legislative Assembly. The Act provides for the establishment of a university dedicated to teaching, research, extension and human resource development in fisheries, ocean studies and allied sciences. The Act also provides for the constitution of academic bodies, faculties, boards of studies and research activities necessary for the functioning of the University.

Campuses

KUFOS functions through multiple campuses strategically located to support education, research and field-based learning**.**

Panangad Campus, Kochi

The 62-acre Panangad Campus serves as the administrative headquarters of the University. It houses the administrative offices, central library, advanced laboratories, classrooms, research facilities and several academic departments.

Puthuvype Campus

Located on approximately 50 acres, the Puthuvype Campus supports marine and brackish-water aquaculture, coastal and ocean engineering research, field training and extension activities. It includes hatcheries, aquaculture farms, experimental facilities and marine engineering infrastructure.

College of Fisheries, Payyanur

The Payyanur Campus in Kannur district extends the University's academic and research activities to northern Kerala and provides undergraduate and postgraduate education along with regional research and extension programmes**.**

Faculties

According to the University's official academic structure, KUFOS offers programmes under the following faculties:

- Faculty of Fisheries Science
- Faculty of Ocean Science and Technology
- Faculty of Fisheries Management
- Faculty of Fisheries Engineering

These faculties collectively offer undergraduate, postgraduate, doctoral and post-doctoral programmes in fisheries, ocean sciences and allied disciplines.

Research Centres

KUFOS has established Centres of Excellence to promote advanced research in priority areas of fisheries and ocean sciences. The officially established Centres of Excellence include:

- Centre of Excellence for Indigenous Fish Production and Aquatic Animal Health Management (CIFPAAH)
- Centre of Excellence in Aquatic Resource Management and Conservation (CARMC)
- Centre of Excellence for Food Processing and Packaging Technology (CEFPT)
- Centre for Climate Resilience and Environment Management (CCREM)

These centres facilitate basic and applied research, interdisciplinary collaboration and technology development aligned with the University's mandate.

National Collaborations

KUFOS actively collaborates with leading national universities, research institutions, government organizations and industries to promote excellence in education, research, innovation and extension. Through Memoranda of Understanding (MoUs) and academic partnerships, the University facilitates collaborative research, student internships, faculty exchange, skill development, consultancy and technology transfer in fisheries, aquaculture, marine biology and ocean sciences.

Major national collaborators include ICAR–Central Marine Fisheries Research Institute (CMFRI), ICAR–Central Institute of Fisheries Technology (CIFT), CSIR–National Institute of Oceanography (NIO), Indian National Centre for Ocean Information Services (INCOIS), National Centre for Earth Science Studies (NCESS), Export Inspection Agency (EIA), Seafood Exporters Association of India (SEAI), Agricultural Skill Council of India (ASCI) and other academic, research and industrial organizations. These collaborations provide opportunities for advanced research, hands-on training, technology development and knowledge sharing.

International Collaborations

KUFOS has established international collaborations with reputed universities and research organizations to strengthen global academic engagement, collaborative research and capacity building. These partnerships promote faculty and student exchange, joint research projects, international training programmes, academic mobility and scientific cooperation in fisheries, marine sciences and allied disciplines.

The University has signed Memoranda of Understanding (MoUs) with institutions including National Taiwan Ocean University (Taiwan), National Chung Cheng University (Taiwan), Asia University (Taiwan), Shu-Te University (Taiwan), Bournemouth University (United Kingdom), Hawassa University (Ethiopia) and Texas State University (USA). KUFOS also participates in the Indo–Norwegian Academic Exchange Programme in collaboration with NOFIMA – Norwegian Institute of Food, Fisheries and Aquaculture Research, Norway, promoting international research and academic exchange.

This version is appropriate for a university handbook because it is concise, avoids exaggerated claims, and mentions only collaborations documented in official KUFOS publications.

Recognition and Accreditation

The Kerala University of Fisheries and Ocean Studies (KUFOS) is a State University established by the Government of Kerala under the Kerala University of Fisheries and Ocean

Studies Act, 2010 (Act 5 of 2011). The University is recognized by the University Grants Commission (UGC) under Section 2(f) of the UGC Act, 1956, and has also been accorded recognition under Section 12(B), making it eligible for central assistance from the UGC.

KUFOS has been accredited with an 'A' Grade by the National Assessment and Accreditation Council (NAAC) in its first cycle of accreditation, reflecting its commitment to quality in higher education, research, governance, and extension activities.

Academic programmes offered by the University are recognized by the relevant statutory and professional bodies wherever applicable. Fisheries and agricultural programmes are accredited by the Indian Council of Agricultural Research (ICAR), while engineering programmes are approved by the All-India Council for Technical Education (AICTE), in accordance with the respective regulatory requirements.

The University maintains an Internal Quality Assurance Cell (IQAC) to promote quality enhancement through continuous monitoring, academic audits, curriculum development, outcome-based education, research excellence, and institutional best practices.

FACULTY OF OCEAN SCIENCE AND TECHNOLOGY

The Faculty of Ocean Science and Technology, established under the KUFOS Act 2010 by the Government of Kerala and formalized through the KUFOS First Statute 2013, is a centre of excellence for education, research, and extension in diverse fields. The faculty plays a pivotal role in addressing the scientific and technical challenges of ocean sciences, environmental studies, and food technology, fostering innovation and sustainability.

With a total of 11 postgraduate (M.Sc.) programs and a Postgraduate Diploma in Food Business Management, the Faculty provides comprehensive education across a broad spectrum of disciplines. These include areas such as applied geology, atmospheric science, biotechnology, disaster management, environmental science, food science and technology, marine biology, marine chemistry, microbiology, physical oceanography, and advanced technologies like remote sensing and GIS. This interdisciplinary approach equips students with the necessary expertise to tackle global challenges in ocean and environmental systems, as well as the food industry.

The faculty emphasizes practical learning and hands-on experience, offering extensive training opportunities in collaboration with renowned institutions like CMFRI, NIO, CIFT, INCOIS, and CIFNET. Students are exposed to real-world applications, including sampling and data analysis, climate change predictions, and advanced research methodologies. This practical exposure enhances their understanding of both theoretical concepts and their practical implications.

The modern infrastructure, including advanced laboratories and research facilities, provides students with a conducive environment for innovation and skill development. Workshops, seminars, and guest lectures by leading scientists and industry experts further enrich the academic experience, inspiring students to explore emerging trends and technologies. Graduates of the FOST are well-equipped to excel in various national and international organizations, research institutions, universities, and industries. The multidisciplinary training and exposure they receive prepare them for impactful careers, addressing critical issues in ocean sciences, environmental sustainability, and food technology.

With its vibrant academic community, state-of-the-art facilities, and commitment to excellence, the Faculty of Ocean Science and Technology remains a preferred destination for aspiring scientists and professionals seeking to make meaningful contributions to the world.

DEPARTMENT OF MARINE BIOSCIENCES

The Department of Marine Biosciences, under the Faculty of Ocean Science and Technology (FOST), Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi, is dedicated to excellence in teaching, research, and innovation in marine biological sciences. The department promotes interdisciplinary education by integrating marine biology with oceanography, biotechnology, microbiology, ecology, environmental sciences, fisheries, and conservation biology to address contemporary challenges related to marine biodiversity, ecosystem health, climate change, and the sustainable development of marine resources.

The department currently offers Integrated B.Sc.–M.Sc. Marine Biology**,** M.Sc. Marine Biology**,** M.Sc. Biotechnology**,** and M.Sc. Microbiology programmes. These programmes provide a strong foundation in biological sciences through outcome-based education, laboratory practicals, field studies, seminars, internships, and research, equipping students with the knowledge and technical skills required for careers in research, academia, biotechnology, environmental management, and higher studies.

Research in the department encompasses a broad range of disciplines, including marine biodiversity and taxonomy, marine ecology, coastal and estuarine ecosystem dynamics, marine biotechnology, microbial ecology, environmental pollution, climate change, marine bioresources, ecosystem restoration, and marine conservation. Faculty members and research scholars actively participate in multidisciplinary research projects and collaborate with leading national research organizations and government agencies engaged in marine and ocean sciences.

The department is equipped with well-established teaching and research laboratories supporting molecular biology, microbiology, marine ecology, environmental analysis, and biodiversity studies. Students receive extensive field-based training in estuarine, mangrove, coastal, offshore, and island ecosystems, gaining practical experience in biodiversity assessment, ecological monitoring, oceanographic sampling, water quality analysis, habitat mapping, taxonomy, and environmental assessment. Through collaborations with premier national institutions, the department provides opportunities for expert lectures, internships, collaborative research, and exposure to advanced scientific facilities, fostering academic excellence and professional competence in marine biosciences.

REGULATIONS GOVERNING THE FIVE-YEAR INTEGRATED POSTGRADUATE PROGRAMME

(FYIPGP)

[Applicable from the 2026 Admission onwards]

PREAMBLE

These Regulations shall be called the **"Regulations for the Five-Year Integrated Postgraduate Programme (FYIPGP)"** of the Kerala University of Fisheries and Ocean Studies (KUFOS).

These Regulations are formulated in alignment with the principles and recommendations of the **National Education Policy (NEP) 2020**, and shall form an integral part of the Five-Year Integrated Bachelor's–Master's Programmes offered by the University. The Regulations provide a comprehensive framework for the design, implementation, academic progression, evaluation and award of qualifications under the Five-Year Integrated Postgraduate Programme.

The FYIPGP framework is designed to provide a structured, multidisciplinary and outcome-oriented educational experience while providing students with flexibility in academic pathways, multiple exit options, academic mobility, interdisciplinary learning, skill development and research orientation. The framework shall facilitate progression from undergraduate-level learning to advanced postgraduate-level learning within an integrated academic structure, while enabling students to obtain an appropriate undergraduate qualification at designated stages of the programme. The Regulations shall be implemented in accordance with the approved academic pathways, credit requirements, course structures and academic provisions prescribed by the University from time to time.

1. SCOPE

- These Regulations shall apply to the **Five-Year Integrated Postgraduate Programmes (FYIPGP)** offered by the Kerala University of Fisheries and Ocean Studies with effect from the **2026 admissions onwards**.
- The provisions contained herein shall govern the academic structure, curricular framework, academic pathways, credit requirements, progression, exit options, evaluation, grading, credit transfer and award of degrees under the FYIPGP.
- The FYIPGP shall be implemented in accordance with the principles of NEP 2020 and the applicable University regulations, ordinances, statutes and decisions of the competent academic authorities.
- The programmes shall follow a student-centric and flexible academic framework incorporating multidisciplinary learning, discipline-specific specialization, skill development, research orientation and real-world application.

- The programmes shall be designed to address the evolving academic, research, technological, professional and industry requirements, particularly in the areas relevant to fisheries, ocean sciences, marine sciences, food sciences, climate sciences and allied disciplines offered by the University.

---

2. OBJECTIVES

The objectives of the Five-Year Integrated Postgraduate Programme shall be:

- To provide an integrated academic pathway leading from undergraduate education to postgraduate education within a five-year programme.
- To provide students with structured academic pathways enabling specialization in a Major discipline along with opportunities for Minor, multidisciplinary and other approved academic components.
- To provide flexibility through multiple academic pathways and designated exit options, enabling students to obtain appropriate undergraduate qualifications upon fulfillment of the prescribed academic and credit requirements.
- To promote multidisciplinary and interdisciplinary learning by enabling students to undertake courses beyond their principal discipline.
- To develop disciplinary knowledge, technical competencies, research capabilities, communication skills, critical thinking, innovation, ethical values and professional competence.
- To integrate skill development, laboratory learning, field-based learning, internship, project work and research into the academic programme.
- To provide opportunities for academic mobility through credit accumulation, credit recognition, credit transfer and credit redemption in accordance with applicable University and regulatory provisions.
- To facilitate progression from undergraduate-level learning to advanced postgraduate-level learning while maintaining continuity and coherence between the undergraduate and postgraduate components.
- To promote research orientation and prepare students for higher studies, research, professional employment, entrepreneurship and other emerging career opportunities.
- To provide a flexible, choice-based and outcome-based curriculum responsive to changing academic, societal, technological and professional requirements.

3. DEFINITIONS

For the purpose of these Regulations, unless the context otherwise requires:

- **Academic Bank of Credits (ABC)** is a digital academic repository established by the Ministry of Education/UGC for accumulation, transfer and academic mobility of credits earned by students from recognized Higher Education Institutions.

- **Academic Flexibility** means the provision for multidisciplinary learning through flexible curricular structures, including multiple academic pathways, entry and exit options and choice of courses.
- **Academic Year** means a twelve-month academic cycle comprising two semesters.
- **Ability Enhancement Course (AEC)** means a course designed to develop proficiency in languages and communication skills.
- **Audit Course** means a course which a student may undertake without earning academic credits.
- **Capstone Course** means an advanced-level course through which students demonstrate the cumulative knowledge and competencies acquired during the programme through project work, research, practical application or other approved activities.
- **Course** means a well-defined unit of study within the programme designed to achieve specified learning outcomes.
- **Course Teacher** means the faculty member responsible for the teaching, assessment, academic records and other academic activities associated with a course.
- **Credit** means a unit used to measure the academic workload associated with a course or other approved academic activity over a semester.
- **Credit Accumulation** means the process of earning and storing academic credits in the Academic Bank of Credits.
- **Credit Recognition** means the formal acceptance of credits earned from eligible institutions and recorded in the Academic Bank of Credits.
- **Credit Redemption** means the utilization of accumulated academic credits towards fulfillment of the credit requirements prescribed for the award of a qualification.
- **Credit Transfer** means the mechanism through which credits earned by a student from a recognized institution may be transferred and recognized towards fulfillment of the requirements of a programme, subject to applicable regulations.
- **Department/Faculty** means a Department or Faculty established in accordance with the KUFOS Act, Statutes and other applicable University provisions.
- **Discipline-Specific Core (DSC)** means mandatory courses forming an essential part of the discipline-specific curriculum of the programme.
- **Discipline-Specific Course** means a course providing in-depth knowledge and understanding of a particular discipline.
- **Discipline-Specific Elective (DSE)** means an elective course selected by a student from a prescribed pool of courses within the discipline.
- **End-Semester Examination (ESE)** means the examination or evaluation conducted at the end of a semester as prescribed for the respective course.
- **In-Semester Assessment** means the continuous assessment conducted during the semester.
- **Major** means the primary area of academic specialization pursued by a student under the programme.

- **Minor** means a structured set of courses providing complementary academic knowledge and competencies in a discipline other than the Major.
- **MOOC** means a Massive Open Online Course offered through SWAYAM, KUFOS or another recognized agency, subject to approval under the applicable University provisions.
- **Multidisciplinary Course (MDC)** means a course designed to broaden the student's knowledge and understanding across disciplines.
- **Programme** means the structured combination of courses and other approved academic components leading to the award of a qualification.
- **Semester** means a half-year academic term comprising instruction, continuous assessment, examinations and other prescribed academic activities.
- **Skill Enhancement Course (SEC)** means a course intended to develop practical, cognitive, communication, creativity, critical-thinking, collaboration, digital and other transferable skills.
- **Value-Added Course (VAC)** means a course intended to promote personality development, ethical values, social responsibility and holistic development.

The above definitions shall be read in conjunction with the definitions and terminology prescribed in the prevailing University Regulations.

4. STRUCTURE OF THE FYIPG PROGRAMME

- The FYIPGP shall comprise an integrated undergraduate and postgraduate academic structure extending over **five academic years and ten semesters**.
- The programme shall be structured to provide progressive development from foundational and discipline-specific undergraduate learning to advanced postgraduate learning.
- The programme shall incorporate:
  - Foundation components;
  - Major discipline components;
  - Minor and/or multidisciplinary components, wherever applicable;
  - Discipline-specific courses;
  - Skill Enhancement Courses;
  - Ability Enhancement Courses;
  - Value-Added Courses;
  - Multidisciplinary Courses;
  - Internship/apprenticeship and field-based learning, wherever prescribed;
  - Capstone-level learning;
  - Project and research components; and
  - Advanced postgraduate-level courses in the fifth year.
- The first three years of the programme shall constitute the undergraduate stage leading to a **three-year UG Degree** upon fulfilment of the prescribed requirements.

- ❖ The fourth year shall provide the option of pursuing a **Four-Year UG Degree (Honours)** or **Four-Year UG Degree (Honours with Research)**, subject to the eligibility and academic requirements prescribed by the University.
- ❖ Students fulfilling the prescribed requirements may continue to the fifth year and complete the postgraduate component of the FYIPGP.
- ❖ The FYIPG Degree shall be awarded upon successful completion of the prescribed programme requirements and a minimum of **221 credits**.

5. ACADEMIC PATHWAYS

5.1 Single Major Pathway

The Single Major pathway shall provide students with in-depth academic specialization in a single discipline without pursuing a structured Minor.

For the three-year UG stage, students shall earn a minimum of **68 credits in the Major discipline**, representing at least 50% of the 133 credits required for the three-year degree.

Students shall also complete the prescribed additional Discipline-Specific Courses and three Multidisciplinary Courses from disciplines other than the Major.

5.2 Major with Minor Pathway

The Major with Minor pathway shall enable students to pursue in-depth study in the Major discipline together with structured learning in a secondary discipline.

A student shall be eligible for a Minor upon earning a minimum of **27 credits** in the selected Minor discipline, comprising:

- 24 credits from Discipline-Specific courses; and
- 3 credits from a Skill Enhancement Course offered in the Minor discipline.

Students shall complete the prescribed Multidisciplinary Courses from disciplines other than the Major and Minor.

5.3 Major with Multiple Disciplines Pathway

The Major with Multiple Disciplines pathway shall provide students with a Major discipline together with structured academic exposure to additional disciplines.

A student may earn **12 credits in each selected additional discipline**, subject to the prescribed curriculum and academic pathway.

The additional disciplines shall be different from the Major, and the prescribed Multidisciplinary Courses shall be completed from disciplines other than the Major and selected additional disciplines.

6. OVERALL QUALIFICATION STRUCTURE

The FYIPGP shall provide the following academic outcomes:

Stage	Duration	Minimum Credits	Qualification/Outcome
Stage I	3 years / 6 semesters	**133**	Three-Year UG Degree
Stage II	4 years / 8 semesters	**177**	Four-Year UG Degree (Honours)
Stage II – Research	4 years / 8 semesters	**177**	Four-Year UG Degree (Honours with Research)
Stage III	5 years / 10 semesters	**221**	Five-Year Integrated Postgraduate Degree

The detailed conditions governing **exit, continuation, progression, eligibility, research pathway and award of the respective degrees** shall be prescribed in the subsequent provisions of these Regulations.

PART II

ACADEMIC PROGRESSION, EXIT OPTIONS AND CONTINUATION TO FYIPGP

This part should follow **Section 6: Structure of the FYIPG Programme** in the draft. I have kept the provisions close to the KUFOS regulation and have not added new eligibility conditions of my own.

7. ACADEMIC PROGRESSION, EXIT OPTIONS AND CONTINUATION

7.1 General Provision

The FYIPGP shall provide students with flexible academic progression and multiple exit options at designated stages of the programme.

A student may either:

a) Exit the programme after successful completion of the prescribed requirements at the end of the third year and receive the corresponding Three-Year Undergraduate Degree;
b) Continue to the fourth year and obtain a Four-Year Undergraduate Degree (Honours);
c) Subject to eligibility, continue through the research pathway and obtain a Four-Year Undergraduate Degree (Honours with Research); or
d) After satisfying the prescribed requirements for progression to the fifth year, continue into the FYIPGP and obtain the Five-Year Integrated Postgraduate Degree.

The three-year and four-year exit options and progression to the FYIPGP shall be governed by the credit requirements and other academic conditions prescribed in these Regulations.

8. THREE-YEAR EXIT OPTION

8.1 Eligibility for Three-Year UG Degree

A student shall be eligible to exit the programme at the end of the **sixth semester** upon:

a. successful completion of all courses prescribed for the first three years; and

b. acquisition of a minimum of **133 credits**.

The student shall satisfy the prescribed Discipline-Specific, Foundation, Major/Minor, Multidisciplinary and other curricular requirements applicable to the selected academic pathway.

8.2 Discipline-Specific Requirement for Three-Year Exit

A student intending to exit with the Three-Year Undergraduate Degree shall acquire a minimum of **94 credits**, approximately 70% of the total 133 credits, from the prescribed Discipline-Specific pathway and capstone-level courses identified for the three-year programme.

Each Discipline-Specific Core course shall normally carry **4 credits**.

The detailed distribution of credits among Major, Minor, Multidisciplinary and other components shall be as prescribed in the approved curriculum of the respective programme.

8.3 Three-Year Exit in the Major with Minor Pathway

Students pursuing the Major with Minor pathway shall earn a minimum of **27 credits** in the Minor discipline, comprising:

a. **24 credits** from six Discipline-Specific courses of 4 credits each; and

b. **3 credits** from a Skill Enhancement Course offered within the Minor discipline.

8.4 Three-Year Exit in the Major with Multiple Disciplines Pathway

Students pursuing the Major with Multiple Disciplines pathway shall earn the prescribed credits in the selected additional disciplines.

The regulation provides for **24 credits**, comprising **12 + 12 credits** from the selected multidisciplinary disciplines through three courses of 4 credits each in each discipline.

8.5 Award on Three-Year Exit

A student successfully completing the requirements for the three-year exit shall be awarded the appropriate **Three-Year Undergraduate Degree in the Major discipline**, with recognition of the Minor or additional disciplinary pathway, wherever applicable.

The degree nomenclature shall be as prescribed by the University for the corresponding academic pathway.

9. PROGRESSION TO THE FOURTH YEAR

- A student who has successfully completed the first three years and earned the minimum **133 credits** may continue to the fourth year.
- The student shall earn an additional **44 credits during the fourth year**, resulting in a minimum cumulative requirement of **177 credits** for the Four-Year Undergraduate Degree.
- Of the additional 44 credits required in the fourth year:
    a) **36 credits** shall be obtained from advanced-level courses in the Major discipline; and
    b) **8 credits** may be earned through the Minor pathway.

For students following pathways that do not involve a Minor, the additional 8 credits may be earned within the Major discipline or from another discipline, as prescribed in the curriculum.

10. FOUR-YEAR UNDERGRADUATE DEGREE (HONOURS)

10.1 Eligibility

A student shall be eligible for the Four-Year Undergraduate Degree (Honours) upon:

a. successful completion of the first three years with a minimum of 133 credits;

b. successful completion of the prescribed fourth-year curriculum;

c. acquisition of a minimum of **177 credits** across the eight semesters; and

d. fulfillment of all other prescribed academic requirements.

10.2 Fourth-Year Mini Project

Students opting for the Four-Year Undergraduate Honours Degree shall undertake a **4-credit mini project** in the fourth year as a mandatory component.

The mini project shall be carried out under approved academic supervision in accordance with the programme curriculum.

10.3 Exit with Four-Year Honours Degree

The exit option with a Four-Year Undergraduate Degree (Honours) shall be available at the end of the **eighth semester**.

A student opting to exit shall have:

a. successfully completed all prescribed courses; and

b. earned a minimum of **177 credits**.

The student shall follow the prescribed University procedure for exercising the exit option and issuance of the corresponding degree documentation.

11. FOUR-YEAR UNDERGRADUATE DEGREE (HONOURS WITH RESEARCH)

11.1 Research Pathway

Students may opt for the Four-Year Undergraduate Degree (Honours with Research) pathway subject to the eligibility, selection and seat availability prescribed by the University and the respective Department Council.

The Honours with Research pathway shall provide advanced disciplinary learning and an intensive research experience through an approved research project.

11.2 Eligibility

Eligibility for admission to the Four-Year Undergraduate Degree (Honours with Research) pathway shall require a minimum **CGPA of 7.5 at the end of the sixth semester**, as specified in Clause 6.3.6 of the KUFOS Regulations.

The number of seats and detailed selection criteria shall be determined by the respective Department Council.

11.3 Research Project

Students admitted to the Honours with Research pathway shall undertake an **original research project carrying 12 credits** during the fourth year.

The research project shall be undertaken under the supervision of an approved research guide.

The research project may be undertaken:

a. within the concerned Department;

b. in another Department, where permitted;

c. in a national laboratory;

d. in an institute of national importance; or

e. in an industrial R&D laboratory for interdisciplinary research.

The project shall involve appropriate research activities including problem identification, investigation, data collection, analysis and reporting.

11.4 Credit Requirement

A student seeking the Four-Year Undergraduate Degree (Honours with Research) shall earn a minimum of **177 credits across the eight semesters**, including the prescribed **12-credit research component**.

11.5 Exit with Honours with Research Degree

The exit option with a Four-Year Undergraduate Degree (Honours with Research) shall be available at the end of the **eighth semester**, subject to fulfillment of the eligibility and academic requirements.

Students opting to exit shall complete the prescribed University procedure for issuance of the Four-Year Undergraduate Degree (Honours with Research).

12. PROGRESSION TO THE FIFTH YEAR – FYIPGP

- A student seeking progression to the fifth year of the FYIPGP shall have successfully completed the Four-Year Undergraduate Honours pathway and acquired a minimum of **177 credits**.
- Students who have completed the fourth year may either exercise the applicable undergraduate exit option or, where eligible, continue to the fifth year of the FYIPGP.
- Students continuing into the FYIPGP shall be eligible for the corresponding Four-Year Undergraduate Honours Degree or Four-Year Undergraduate Honours with Research Degree.
  However, the corresponding UG certificate shall be **conferred only upon completion of the FYIPGP**, in accordance with the University Regulations.
- A student continuing into the FYIPGP shall have completed the mandatory **4-credit mini project in the fourth year**.

13. FIFTH-YEAR POSTGRADUATE COMPONENT

- The fifth year shall constitute the postgraduate component of the integrated programme.
- The postgraduate curriculum shall be aligned with the corresponding FYUGP Major/academic stream to ensure continuity, coherence and smooth academic progression.
- The fifth-year curriculum shall comprise **7 to 12 courses carrying a total of 44 credits**.
- The fifth-year courses shall be offered at appropriate **postgraduate academic levels**, with Level **500–599** representing first-year postgraduate-level courses and Level **600–699** representing second-year postgraduate-level courses under the postgraduate framework.

14. AWARD OF THE FIVE-YEAR INTEGRATED POSTGRADUATE DEGREE

- A student successfully completing the prescribed undergraduate and postgraduate components of the FYIPGP shall acquire a minimum of **221 credits**.
- The Five-Year Integrated Postgraduate Degree in the Major discipline shall be awarded upon:
    a) Successful completion of the prescribed courses;
    b) Acquisition of the minimum **221 credits**;
    c) Fulfillment of all prescribed academic, attendance and evaluation requirements; and
    d) Successful completion of the fifth-year postgraduate curriculum.
- The degree awarded shall be:
  Master of Science in [Major Discipline]
  The degree nomenclature shall be determined in accordance with the approved nomenclature of the respective FYIPGP.

15. INTEGRATED EXIT AND PROGRESSION FRAMEWORK

The complete academic progression under the FYIPGP shall be:

Semester 1–6
133 credits
↓
Three-Year UG Degree – Exit Option

OR

↓ Continue

Semester 7–8
177 credits
↓
Four-Year UG Degree (Honours) – Exit Option

OR

Four-Year UG Degree (Honours with Research) – Exit Option
subject to research eligibility and selection

OR

↓ Continue

Semester 9–10
Additional 44 credits
↓
221 credits
↓
Five-Year Integrated Postgraduate Degree – M.Sc.

The University regulations expressly provide that students who do not exit after the three-year stage may pursue the Four-Year Honours/Honours with Research pathway or continue into the FYIPGP.

16. MAXIMUM PERIOD FOR COMPLETION

- Students may avail themselves of academic breaks during the programme and resume their studies thereafter, subject to the maximum permissible period for completion.
- The maximum period for completion without readmission shall be:

Programme	Maximum Period
Three-Year UG Programme	**5 years**
Four-Year UG Programme	**6 years**

FYIPGP	7 years

- Students shall complete the programme within the applicable maximum period, irrespective of academic breaks availed during the programme.

17. RE-ADMISSION AND RE-ENTRY

- Students exiting before completion of the third year shall be issued a **Course-cum-Credits Certificate** to facilitate re-entry into another institution and preservation of earned credits through the Academic Bank of Credits (ABC).
- Students who are not eligible for promotion to the next higher semester may clear their backlogs through supplementary examinations in accordance with the University regulations.
- Upon satisfying the conditions for promotion, such students may be re-admitted to the appropriate higher semester along with the junior regular batch and continue their studies as regular students.
- Such re-admission shall remain subject to the maximum permissible period prescribed for completion of the programme. Re-admission under this provision shall be permitted **only once**.
- Students who have successfully completed a programme pathway may be readmitted for pursuing an additional Minor or second Major, subject to the applicable University norms.

18. ACADEMIC MOBILITY AND CREDIT TRANSFER

- The FYIPGP shall facilitate academic mobility through recognition, accumulation and transfer of credits in accordance with the Academic Bank of Credits and applicable University regulations.
- Students may earn credits from other recognized Higher Education Institutions or approved online learning platforms, subject to the conditions prescribed by the University.
- Approved online courses may include courses offered through **SWAYAM, NPTEL and other recognized agencies**, subject to recommendation by the Board of Studies/Department Council and approval under the applicable University provisions.
- Credits earned through approved external learning shall be appropriately recorded in the student's Grade Card.

19. Grade Card

- The University shall issue a Grade Card under its seal to each student upon completion of every semester.
- The Grade Card shall include the following details:
  - Title of each course undertaken, indicating Core, Elective, and Audit categories (audit courses shall be recorded only if successfully completed).
  - Credits assigned to each course and the corresponding grades obtained.

- Total credits earned during the semester, with a distinction between Core and Elective credits, along with the Semester Grade Point Average (SGPA).
- Cumulative credits earned up to the end of the semester.
- The grading system adopted for FYUGP/FYIPGP, based on a 10-point scale with the following letter grades: S, A, B, C, D, and F, and corresponding grade points 10, 9, 8, 7, 6, and 0 respectively.

❖ The computation of Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) shall be based on the grades awarded for each course, reflecting the overall academic performance of the student.

Range of Marks*	Grades	Grade Points (G_i)
90–100	O – Outstanding	10
80–90*	A – Excellent	9
70–80*	B – Very Good	8
60–70*	C – Good	7
50–60*	D – Satisfactory	6
Below 50	F – Fail	0
—	Ab – Absent	0

❖ *Where X–Y range denotes X inclusive and Y exclusive.

A. Computation of SGPA and CGPA

(i) SGPA

The SGPA is the ratio of the sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student, i.e.,

$$\mathbf{SGPA(S_i) = \Sigma(C_i \times G_i) / \Sigma C_i}$$

where:

- $\mathbf{C_i}$ is the number of credits of the *i*th course; and
- $\mathbf{G_i}$ is the grade point scored by the student in the *i*th course.

(ii) CGPA

The CGPA is also calculated in the same manner, taking into account all the courses done by a student over all the semesters of a programme, i.e.,

$$\mathbf{CGPA(S_i) = \Sigma(C_i \times S_i) / \Sigma C_i}$$

where:

- $\mathbf{S_i}$ is the SGPA of the *i*th semester; and
- $\mathbf{C_i}$ is the total number of credits in each semester.

Classification for the Degree

Classification for the Degree	CGPA
First Class with Distinction	8.0 and above
First Class	6.5–8.0*
Second Class	6.0–6.5*

*Where X–Y range denotes X inclusive and Y exclusive.

B. Final Grade Card

The Grade Card issued at the end of the final semester shall contain the details of all the courses taken, including:

- titles of the courses;
- credits associated with each course;
- grades obtained in each course;
- CGPA; and
- class.

The rank shall be awarded based on CGPA corrected to the **2nd decimal**.

Degrees Awarded under FYUGP and FYIPGP

Upon successful completion of the FYUGP or FYIPGP, degrees in the respective discipline(s) shall be awarded to students in accordance with the approved academic pathways.

Nomenclature of the 3-Year Undergraduate Degree

The nomenclature of the 3-Year Undergraduate Degree shall be as follows:

(i) Bachelor of Science Major in [Subject] — for the Single Major pathway;

(ii) Bachelor of Science Major in [Subject] with Minor in [Subject] — for the Major with Minor pathway;

(iii) Bachelor of Science Major in [Subject] with [Subject], [Subject] — for the Major with Multidisciplinary pathway.

Nomenclature of the 4-Year Undergraduate Degree

(i) FYUG (Honours) Degree

The format of the FYUG (Honours) Degree shall be:

- **Bachelor of Science (Honours) Major in [subject]** for Single Major pathway;

- **Bachelor of Science (Honours) Major in [subject] with Minor [subject]** for Major with Minor Academic Pathway; and
- **Bachelor of Science (Honours) Major in [subject] with [subject], [subject]** for Major with Multiple Discipline(s) Academic Pathway.

(ii) FYUG (Honours with Research) Degree

The format of the FYUG (Honours with Research) Degree shall be:

- **Bachelor of Science (Honours with Research) Major in [subject]** for Single Major pathway;
- **Bachelor of Science (Honours with Research) Major in [subject] with Minor [subject]** for Major with Minor Academic Pathway; and
- **Bachelor of Science (Honours with Research) Major in [subject] with [subject], [subject]** for Major with Multiple Discipline(s) Academic Pathway.

Nomenclature of the 5-Year Integrated Postgraduate Degree

(i) The format of the FYIPG Degree shall be:

Master of Science in [subject]

This nomenclature shall apply **irrespective of the Academic Pathway chosen by the student**.

(ii)

Upon successful completion of FYIPGP, students shall be awarded FYIPGP Degree certificates as mentioned in Clause 16.4.3(i).

Students shall submit **two separate application forms** for obtaining their Four-Year Undergraduate Degree certificates:

- Four-Year Undergraduate (Honours) Degree certificate; or
- Four-Year Undergraduate (Honours with Research) Degree certificate,

as applicable under Clauses 16.4.2(i) and 16.4.2(ii), respectively.

TRANSITORY PROVISIONS

Notwithstanding anything contained in these Regulations, the **Vice Chancellor** shall, for a period of **one year from the date of coming into force of these Regulations**, have the power to provide by order that these Regulations shall be applicable to any programme with such modifications as may be necessary.

KERALA UNIVERSITY OF FISHERIES AND OCEAN STUDIES
FACULTY OF OCEAN SCIENCE AND TECHNOLOGY
DEPARTMENT OF MARINE BIOSCIENCES
Five-Year Integrated Bachelors Masters Marine Biology Programme
Consolidated Course Framework- Credit wise

Course Components	**Sem I**	**Sem II**	**Sem III**	**Sem IV**	**Sem V**	**Sem VI**	**Sem VII**	**Sem VIII (H/R)**	**Sem VIII (H)**	**Sem IX**	**Sem X**
Core / Major	4	4	12	16	20	20	20	8	16	20	-
Minor	8	8	-	-	-	-	-	-	-	-	-
AEC	6	6	-	-	-	-	-	-	-	-	-
MDC	3	3	3	-	-	-	-	-	-	-	-
VAC	-	-	6	3	-	-	-	-	-	-	-
SEC	-	-	-	3	3	3	-	-	-	-	-
Internship	-	-	-	2	-	2	-	-	-	-	-
Project	-	-	-	-	-		-	12	4	-	20
Seminar	-	-	-	-	-	-	-	2	2	-	-
MOOC	-	-	-	-	-	-	2	-	-	2	2
Total Credits	**21**	**21**	**21**	**24**	**23**	**25**	**22**	**22**		**22**	**22**
B.Sc. degree	**135 (120)**										
B. Sc. Honours/ Hounours with Research	**179 (160)**										
Integrated 5 year	**223 (200)**										

H/R- Honours with Research | H- Honours

Syllabus Framework

SEMESTER I				
Course Category	Course Title	T	P	Credits
Major I	Fundamentals of Marine Environment	3	1	4
Minor I	Introduction to Oceanography and Ocean Expeditions	4	0	4
Minor II	Cell Biology	3	1	4
AEC	Functional English I	3	0	3
AEC	Hindi/Malayalam I	3	0	3
MDC	Ocean Literacy	3	0	3
Total Credits				21
Additional Components	• Orientation to Marine Research Institutes and Industry Exposure • Expert Lecture Series			
SEMESTER II				
Major I	Fundamentals of Ecology and Biodiversity	3	1	4
Minor I	Marine Chemistry: Organic and Biogeochemical Perspectives	3	1	4
Minor II	Analytical Biology and Scientific Methods	3	1	4
AEC	Communicative English	3	0	3
AEC	Hindi/Malayalam II	3	0	3
MDC	Marine Heritage (Offered by Marine Biology)	3	0	3
Total Credits				21
Additional Components	• Introductory Workshops on Research Ethics and Scientific Writing • Exposure Sessions on Deep Ocean Mission			
SEMESTER III				
Major I	Marine Biodiversity I: Invertebrates and Reef Ecology	3	1	4

Major II	Molecular and Biochemical Processes	3	1	4
Major III	Marine Geomorphology, Habitat Dynamics and Marine Fossils	3	1	4
VAC	Marine Field Methodology and Instrumentation	2	1	3
VAC	Understanding India: Coastal Cultural Heritage	3	0	3
MDC	Marine Bioprospecting	3	0	3
Total Credits				21
Additional Components	• Onboard Exposure Training • Swimming and Basic Water Safety Training • *Invited lectures on* Critical Thinking, Logic and Scientific Communication			
SEMESTER IV				
Major I	Marine Biodiversity II: Vertebrates and Marine Mammals	3	1	4
Major II	Marine Botany and Algal Diversity	3	1	4
Major III	Marine Microbiology	3	1	4
Major IV	Animal Physiology and Plant Physiology	3	1	4
SEC	Molecular Taxonomy and DNA Barcoding	2	1	3
VAC	Seaweed Culture Techniques	3	0	3
Internship	Field Internship / Research Exposure Training	-	-	2
Total Credits				24
Additional Components	• Research Methodology and Research Ethics Module • SCUBA Orientation Programme • Institutional Interaction Programmes with NIOT, CMLRE, NCSCM and INCOIS			
SEMESTER V				
Major I	Marine Ecological Dynamics and Marine Environment Assessment	3	1	4
Major II	Marine Pollution and Ecotoxicology	3	1	4
Major III	Integrative Fish Taxonomy	3	1	4
Major IV	Biostatistics, Data Analysis and Artificial Intelligence & Machine Learning	3	1	4

Major V	Genomics, Proteomics and Metabolomics	3	1	4
SEC	Advanced Microscopic and Laboratory Techniques	2	1	3
Total Credits				**23**
Additional Components	• Scientific Writing and Paper Writing Workshops • Industry Exposure Certification			
SEMESTER VI				
Major I	Deep Sea -Ecology and Biodiversity	3	1	4
Major II (Elective I)	ICZM and Marine Protected Areas	4	-	4
	Climate Change and Ocean Acidification			
	Telecommunication Systems in Ocean Sciences			
	Spectroscopic Techniques for natural product analysis			
Major III	Blue Economy, Carbon Sequestration and Carbon Credit Systems	3	1	4
Major IV (Elective II)	Marine Mammals and Megafauna	4	-	4
	Marine Data Analysis			
	Bioinformatics for Marine Natural Products			
	Ocean Policy, Governance and Areas Beyond National Jurisdiction (ABNJ)			
Major V	Marine Capture and Culture Fisheries	3	1	4
SEC	Spatial Tools, GIS and Remote Sensing for Marine Ecosystem Assessment	2	1	3
Project	Minor Project (Exit Students)	-	-	2
	Summer Internship (Others)			
Total Credits				25
Additional Components	• SCUBA Diving Certification Training • Ocean Expedition and Onboard Research Exposure			
SEMESTER VII				
Major I	Island Ecology and Artificial reefs	3	1	4

Major II	Polar Marine Biology	3	1	4
Major III	Marine Litter & Debris-Mitigation and management,	3	1	4
Major IV	Marine Enzymes, Drug Development and Industrial Applications	3	1	4
Major V	Bioinformatics and Computational Marine Biology	3	1	4
MOOC	MOOC / Online Collaborative Course	2	-	2
Total Credits				22
Additional Components	• NET/GATE Foundation Training • Science Communication and Outreach Activities			
SEMESTER VIII (B.Sc. Honours with Research)				
Major I	Marine Spatial Planning and Ecosystem Services	3	1	4
Major II	Advanced Blue Biotechnology and Genetic Engineering	3	1	4
Project	Research Project			12
	Scientific Review Writing, Professional Skills and Seminar			2
Total Credits				22
SEMESTER VIII (B.Sc. Honours)				
Major I	Marine Spatial Planning and Ecosystem Services	3	1	4
Major II	Advanced Blue Biotechnology and Genetic Engineering	3	1	4
Major III (Elective III)	Blue Carbon and Nature-based Solutions	4	-	4
	Marine Spatial Planning			
	Artificial Intelligence Applications in Marine Sciences			
	Marine Environmental Impact Assessment			
	Advanced Blue Biotechnology			
Major IV (Elective IV)	Ecosystem Services Valuation	4	-	4
	Advanced Statistical Modelling			
	Conservation Genetics and Genomics			
	Genetic Engineering			

	Marine Biotechnology Ethics, Regulations and Intellectual Property			
Project	Project			4
	Scientific Review Writing, Professional Skills and Seminar			2
Total Credits				22
SEMESTER IX				
Major I	Design and Management of Marine Protected Areas	3	1	4
Major II	Blue Economy Pathways and Sustainable Development	3	1	4
Major III	Nanobiotechnology and Marine Functional Products	3	1	4
Major IV (Elective V)	Ocean Governance and Maritime Law	4	-	4
	Water Quality Management			
	Community-based Coastal Management			
	Conservation Genetics and Genomics			
Major V (Elective VI)	Threatened Marine Species Management	4	-	4
	Marine Biofuels and Functional Foods			
	Marine Bioremediation and Environmental Biotechnology			
	Intellectual Property and Commercialization			
MOOC	MOOC / Collaborative International Course	-	-	2
Total Credits				22
SEMESTER X				
Dissertation	Major Dissertation / Industry-Research Linked Project	-	20	20
MOOC	MOOC / Advanced Specialized Online Course	2	-	2
Total Credits				**22**
Total Credit after 10 Semesters		**223**		

Semester I

Major I: Marine Environment and Environmental Science
Credits: 3+1 = 4
Course Objectives

- To introduce the structure and functioning of marine and general environmental systems.
- To understand interactions between organisms and the marine environment.
- To familiarize students with environmental issues, conservation, and sustainability.

Unit I: Fundamentals of Environment and Marine Ecosystems
Definition, scope and components of environment; Atmosphere, hydrosphere, lithosphere and biosphere; Ecology and ecosystem concepts; Structure and functions of ecosystems; Marine ecosystems: estuaries, mangroves, coral reefs, lagoons and open ocean; Ecological concepts: Food chains, Food webs, Ecological pyramids, Energy flow; Biogeochemical cycles: Carbon cycle, Nitrogen cycle, Phosphorus cycle.
Unit II: Physical and Chemical Characteristics of Marine Environment
Physical properties of seawater: Temperature, Salinity, Density, Pressure; Light penetration and photic zones; Dissolved gases in seawater; Nutrients and marine productivity; pH and buffering system; Ocean currents, tides and waves; Water quality assessment and monitoring.
Unit III: Marine Biodiversity and Ecological Interactions
Marine flora and fauna; Plankton, nekton and benthos; Marine biodiversity and its significance; Species interactions: Predation, Competition, Symbiosis, Commensalism, Parasitism; Adaptations of marine organisms; Ecosystem services of marine environments.
Unit IV: Environmental Pollution and Climate Change
Environmental pollution: Air pollution, Water pollution, Soil pollution; Marine pollution: Plastic pollution, Oil spills, Heavy metals, Agricultural runoff; Eutrophication Bioaccumulation and biomagnification; Climate change and global warming; Ocean acidification; Coral bleaching; Sea level rise. Marine debris and classification
Unit V: Environmental Conservation and Sustainable Development
Principles of environmental conservation; Biodiversity conservation strategies; Marine protected areas; Coastal zone management; Sustainable fisheries; Blue economy concepts; Environmental laws and policies in India; Environmental impact assessment; Sustainable development goals (SDGs); Major threats to marine diversity; IUCN.
Practicals
Measurement of temperature, salinity and pH; Water quality analysis; Identification of plankton and benthic organisms; Observation of marine biodiversity samples; Preparation of food web and ecological pyramid charts; Field visit to coastal or estuarine ecosystem; Preparation of environmental reports.
References

1. Castro, P. & Huber, M. E. *Marine Biology*. McGraw-Hill Education.
2. Kaiser, M. J. et al. *Marine Ecology: Processes, Systems, and Impacts*. Oxford University Press.
3. Lalli, C. M. & Parsons, T. R. *Biological Oceanography: An Introduction*. Butterworth-Heinemann.
4. Bharucha, E. Textbook of *Environmental Studies for Undergraduate Courses*. Universities Press.
5. Ministry of Environment, Forest and Climate Change publications and manuals.

Minor I: Introduction to Oceanography and Ocean Expeditions
Credits: 3+1 = 4
Course Objectives

- To provide foundational understanding of ocean sciences.
- To introduce ocean exploration techniques and expeditions.
- To develop awareness about ocean resources and marine research.

Unit I: Introduction to Oceanography
Definition, scope and branches of oceanography; History and development of ocean sciences; Importance of oceans in Earth systems; Distribution of oceans and seas; Ocean basin features: Continental shelf, Continental slope, Abyssal plains, Mid-ocean ridges, Trenches; Marine resources
Unit II: Physical Oceanography
Physical properties of seawater; Temperature and salinity distribution; Density and stratification; Ocean circulation; Surface and deep-water currents; Waves: Formation, Characteristics, Types; Tides and tidal cycles; El Niño and La Niña; Monsoon and ocean interactions
Unit III: Chemical and Biological Oceanography
Chemical composition of seawater; Nutrients and dissolved gases; Marine productivity; Marine plankton: Phytoplankton, Zooplankton; Marine food chains and food webs; Marine microorganisms; Carbon cycle in oceans
Unit IV: Ocean Expeditions and Marine Technology
History of ocean expeditions; Major oceanographic expeditions; Research vessels and submersibles; Ocean sampling techniques; Navigation and marine mapping; Sonar and echo sounding; Remote sensing and GIS in oceanography; Introduction to marine instrumentation
Unit V: Oceans and Human Society
Fisheries and aquaculture; Shipping and maritime trade; Marine mineral and energy resources; Marine pollution; Ocean conservation; Maritime laws and international conventions; Ocean literacy; Career opportunities in ocean sciences
Practicals
Handling of oceanographic instruments; Ocean floor feature identification; Seawater parameter analysis; Plankton observation and identification; Marine sampling techniques; GPS and navigation exercises; Interpretation of oceanographic charts and satellite images; GIS basics; Coastal observation and reporting.
References

1. Castro, P. & Huber, M. E. *Marine Science*. McGraw-Hill Education.
2. Garrison, T. *Oceanography: An Invitation to Marine Science*. Cengage Learning.
3. Trujillo, A. P. & Thurman, H. V. *Essentials of Oceanography*. Pearson.
4. National Institute of Oceanography manuals and educational publications.
5. Ministry of Earth Sciences educational resources and reports.

Minor II: Cell Biology
Credits: 3+1 = 4
Course Objectives

- To introduce cellular structure and function.
- To understand cellular processes and molecular mechanisms.
- To familiarize students with basic laboratory techniques in cell biology.

Unit I: Introduction to Cell Biology
History and scope of cell biology; Cell theory; Prokaryotic and eukaryotic cells; Cell size and shape; Cell organization; Microscopy: Light microscope, Electron microscope, Phase contrast microscope
Unit II: Cell Structure and Organelles
Plasma membrane and membrane models; Membrane transport mechanisms; Cell wall and extracellular matrix; Nucleus and chromosomes; Endoplasmic reticulum; Golgi apparatus; Lysosomes and peroxisomes; Mitochondria and chloroplasts; Cytoskeleton and cell movement
Unit III: Biomolecules and Cellular Metabolism
Carbohydrates; Proteins; Lipids; Nucleic acids; Enzymes and enzyme action; Cellular respiration; ATP and bioenergetics; Introduction to photosynthesis
Unit IV: Cell Division and Molecular Genetics
Cell cycle; Mitosis; Meiosis; DNA replication; Transcription; Translation; Gene expression; Mutations
Unit V: Applied Cell Biology
Stem cells; Cancer biology basics; Cell culture techniques; Biotechnology applications; Marine biotechnology overview; Ethical aspects of biotechnology
Practicals
Handling and use of microscopes; Observation of plant and animal cells; Observation of mitosis and meiosis; Temporary slide preparation; Biomolecule tests; Identification of cell organelles
References

1. Alberts, B. et al. *Molecular Biology of the Cell*. Garland Science.
2. Karp, G. *Cell and Molecular Biology*. Wiley.
3. Alberts, B. et al. *Essential Cell Biology*. Garland Science.
4. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology Verma, P. S. & Agarwal, V. K. S. Chand Publications.
5. Powar, C. B. *Cell Biology*. Himalaya Publishing House.

MDC: Ocean Literacy
Credits: 3+0 = 3
Course Objectives

- To develop awareness about oceans and their importance.
- To understand human dependence on oceans.
- To promote ocean conservation and sustainability.

Unit I: Understanding the Ocean
Definition and importance of ocean literacy; Essential principles of ocean literacy'; Origin and evolution of oceans; Oceans and climate regulation; Ocean circulation and weather systems; Human dependence on oceans
Unit II: Marine Biodiversity and Ecosystems
Marine biodiversity overview; Coral reefs; Mangrove ecosystem; Seagrass ecosystem; Marine food chains and food webs; Ecosystem services; Endangered marine species
Unit III: Oceans and Human Activities
Fisheries and coastal livelihoods; Shipping and maritime trade; Tourism and recreation; Marine resources; Blue economy; Traditional knowledge of coastal communities
Unit IV: Threats to Oceans
Marine pollution; Plastic pollution; Climate change; Ocean acidification; Overfishing; Habitat destruction; Marine invasive species; Coastal disasters: Tsunami, Cyclones; Impacts of climate change on ocean and ocean dynamics
Unit V: Ocean Conservation and Sustainable Future
Topics
Marine conservation initiatives; Marine protected areas; Ocean governance; Sustainable development goals; Citizen science; Ocean awareness programmes; Careers in marine sciences and conservation
References

1. Castro, P. & Huber, M. E. *Marine Science*. McGraw-Hill Education.
2. UNESCO Intergovernmental Oceanographic Commission Ocean Literacy publications.
3. Sverdrup, K. & Kudela, R. *Introduction to the World's Oceans*. McGraw-Hill.
4. Ministry of Earth Sciences educational materials and reports.
5. Centre for Marine Living Resources and Ecology publications and awareness materials.

Semester II

Major I: Ecology, Biodiversity and Productivity
Credits: 3+1 = 4
Course Objectives

- To provide fundamental understanding of ecological principles, biodiversity patterns and biological productivity in marine and coastal ecosystems
- To introduce ecological interactions and ecosystem functioning
- To familiarize students with methods of biodiversity assessment and productivity estimation.

Unit I: Fundamentals of Ecology
Definition, scope and branches of ecology; levels of ecological organization; habitat and niche; abiotic and biotic factors; ecological tolerance; population ecology; community ecology; ecological succession; energy flow in ecosystems; food chains, food webs and ecological pyramids; ecological efficiency and ecosystem stability.
Unit II: Marine and Coastal Biodiversity
Concept and significance of biodiversity; genetic, species and ecosystem diversity; marine biodiversity patterns; biodiversity in estuaries, mangroves, coral reefs, seagrass beds and open oceans; plankton, nekton and benthos; marine floral diversity; marine faunal diversity; endemic and endangered marine species; ecosystem services provided by marine biodiversity.
Unit III: Ecological Interactions and Adaptations
Species interactions including predation, competition, mutualism, commensalism and parasitism; adaptations to marine environments; behavioural and physiological adaptations; reproductive strategies in marine organisms; migration and dispersal; ecological indicators; keystone species and ecological resilience.
Unit IV: Biological Productivity in Marine Ecosystems
Primary productivity and secondary productivity; photosynthesis in marine systems; factors influencing productivity; phytoplankton productivity; nutrient dynamics and productivity; trophic levels and energy transfer; productivity in estuaries and coastal waters; methods for estimation of productivity; relationship between productivity and fisheries.
Unit V: Biodiversity Conservation and Ecosystem Management
Threats to biodiversity; habitat degradation and invasive species; introduction to marine pollution impacts on biodiversity; climate variability and ecosystem responses; conservation biology principles; marine protected areas; ecosystem restoration; sustainable utilization of marine resources; biodiversity laws and international conventions; ecosystem-based management approaches; Invasive species and Inversional biology.
Practicals
Identification of plankton and benthic organisms; estimation of biodiversity indices; preparation of food webs and ecological pyramids; estimation of primary productivity using light and dark bottle method; observation of ecological adaptations in marine organisms; field visit to estuarine or coastal ecosystem; preparation of biodiversity records and ecological reports.
References

1. Castro, P. & Huber, M. E. *Marine Biology*. McGraw-Hill Education.
2. Kaiser, M. J. et al. *Marine Ecology: Processes, Systems, and Impacts*. Oxford University Press.
3. Lalli, C. M. & Parsons, T. R. *Biological Oceanography: An Introduction*. Butterworth-Heinemann.
4. Sharma, P. D. *Ecology and Environment*. Rastogi Publications.
5. Zoological Survey of India publications and faunal records.

Minor I: Marine Chemistry: Organic and Biogeochemical Perspectives
Credits: 3+1 = 4
Course Objectives

- To introduce the chemical nature of seawater and marine biogeochemical processes;
- To familiarize students with organic chemistry relevant to marine sciences;
- To understand nutrient cycling and chemical interactions in marine ecosystems.

Unit I: Fundamentals of Marine Chemistry
Structure and properties of atoms and molecules; chemical bonding; states of matter; solutions and concentrations; acids, bases and buffers; chemical composition of seawater; major and minor constituents of seawater; salinity and chlorinity; dissolved gases in seawater; pH and buffering mechanisms in marine systems.
Unit II: Organic Chemistry for Marine Sciences
Introduction to organic chemistry; hydrocarbons; functional groups; alcohols, aldehydes, ketones and carboxylic acids; amino acids and proteins; carbohydrates and lipids; marine organic matter; dissolved and particulate organic matter; marine biomolecules and their ecological significance.
Unit III: Marine Biogeochemical Cycles
Carbon cycle; nitrogen cycle; phosphorus cycle; sulfur cycle; silica cycle; nutrient regeneration in marine systems; sediment-water interactions; microbial role in nutrient cycling; biogeochemical processes in estuaries and coastal ecosystems.
Unit IV: Marine Chemical Processes and Productivity
Chemical properties influencing marine productivity; nutrient limitation; dissolved oxygen dynamics; redox reactions in marine systems; organic matter decomposition; trace metals in marine ecosystems; chemical indicators of water quality; ocean-atmosphere chemical interactions.
Unit V: Applied Marine Chemistry and Environmental Perspectives
Chemical pollution in marine systems; eutrophication; heavy metals and toxic substances; hydrocarbons and oil pollution; ocean acidification; basic analytical methods in marine chemistry; water quality monitoring; marine chemistry in aquaculture and fisheries; sustainable management of marine environments.

Practicals
Preparation of standard solutions; estimation of salinity and chlorinity; determination of dissolved oxygen; estimation of pH and alkalinity; qualitative analysis of organic compounds; estimation of nutrients; analysis of water quality parameters; laboratory safety and chemical handling.
References

1. Emerson, S. & Hedges, J. *Chemical Oceanography and the Marine Carbon Cycle*. Cambridge University Press.
2. Chester, R. & Jickells, T. *Marine Geochemistry*. Wiley-Blackwell.
3. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*. Pearson.
4. A Textbook of Organic Chemistry Bahl, A. & Bahl, B. S. S. Chand Publications.
5. National Institute of Oceanography manuals and marine chemistry publications.

Minor II: Analytical Biology and Scientific Methods
Credits: 3+1 = 4
Course Objectives

- To introduce analytical and scientific approaches in biological sciences;
- To familiarize students with scientific methodology, biological measurements and laboratory techniques;
- To develop scientific reasoning and analytical skills.

Unit I: Scientific Methods and Biological Inquiry
Nature and scope of science; scientific method; hypothesis formulation; experimental design; variables and controls; observation and inference; data collection methods; ethics in biological research; laboratory safety; scientific reasoning and critical thinking.
Unit II: Basic Analytical Techniques in Biology
Units and measurements; accuracy and precision; errors in biological analysis; preparation of solutions and reagents; concentration calculations; pH measurement; centrifugation; chromatography; electrophoresis; spectrophotometry; microscopy and imaging techniques.
Unit III: Biological Data and Statistical Approaches
Types of biological data; tabulation and graphical representation; mean, median and mode; standard deviation and variance; sampling methods; probability concepts; introduction to biostatistics; interpretation of scientific data; use of computers in biological analysis.
Unit IV: Molecular and Biochemical Analytical Methods
DNA and RNA extraction principles; protein estimation methods; enzyme assays; molecular markers; immunological techniques; introduction to bioinformatics; analytical applications in marine biology and environmental studies.
Unit V: Scientific Communication and Research Applications
Scientific writing; preparation of laboratory records; preparation of research reports; literature survey methods; referencing and citation styles; plagiarism and ethics; seminar presentation techniques; analytical approaches in biodiversity and environmental studies.

Practicals
Preparation of laboratory reagents and buffers; calibration of laboratory instruments; use of pH meter and spectrophotometer; separation techniques using chromatography; graphical representation of biological data; basic statistical analysis; preparation of scientific reports and presentations.
References

1. Zar, J. H. *Biostatistical Analysis*. Pearson.
2. Dawson, C. *Practical Research Methods*. How To Books.
3. Wilson, K. & Walker, J. *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press.
4. Arora, P. N. & Malhan, P. K. *Biostatistics*. Himalaya Publishing House.
5. Kothari, C. R. *Research Methodology: Methods and Techniques*. New Age International.

MDC: Marine Heritage
Credits: 3+0 = 3
Course Objectives

- To introduce the cultural, historical and ecological heritage associated with oceans and coastal regions
- To develop awareness regarding traditional marine knowledge systems, maritime history and conservation of marine heritage resources.

Unit I: Introduction to Marine Heritage
Concept and scope of marine heritage; oceans in human civilization; relationship between coastal societies and oceans; marine heritage of India; maritime traditions and cultural diversity of coastal communities.
Unit II: Maritime History and Exploration
History of navigation and seafaring; ancient maritime trade routes; maritime history of India; spice trade and Indian Ocean trade networks; famous explorers and ocean expeditions; ports and harbour development.
Unit III: Coastal Cultures and Traditional Knowledge
Traditional fishing practices; indigenous coastal knowledge systems; coastal architecture and lifestyles; folklore, festivals and cultural practices associated with the sea; traditional boat building; sustainable practices in coastal communities. Traditional knowledge about marine ecosystem and fisheries.
Unit IV: Marine Archaeology and Heritage Resources
Marine archaeological sites; shipwrecks and submerged structures; underwater archaeology methods; preservation of marine artefacts; museums and marine heritage interpretation; legal frameworks for marine heritage protection.
Unit V: Marine Heritage Conservation and Sustainable Future
Threats to marine heritage; tourism and heritage management; conservation of coastal cultural landscapes; public awareness and education; role of marine heritage in sustainable development; blue culture and ocean stewardship.
References

1. Russett, N. L. *Maritime Heritage and Modern Ports*. Routledge.
2. Gillis, J. R. *The Human Shore: Seacoasts in History*. University of Chicago Press.
3. UNESCO publications on underwater cultural heritage.
4. National Institute of Oceanography marine archaeology publications.
5. *Maritime Heritage of India*. India, Notion Press.

Semester III

Major I: Marine Biodiversity I: Invertebrates and Reef Ecology
Credits: 3+1 = 4
Course Objectives

- To introduce the diversity and classification of marine invertebrates
- To understand the ecological significance of marine invertebrates in marine ecosystems
- To develop knowledge on coral reef ecosystems, reef ecology and conservation

---

Unit I: Introduction to Marine Biodiversity and Invertebrates
Concept and scope of marine biodiversity; classification and diversity of marine organisms; importance of marine invertebrates in ecosystem functioning; evolutionary trends in marine invertebrates; principles of taxonomy and systematics; marine biogeographic regions; ecological roles of invertebrates in marine ecosystems; Marine zoogeography
Unit II: Lower Marine Invertebrates
General characteristics and classification of Protozoa; Porifera; Cnidaria and Ctenophora; organization and functional adaptations; feeding and reproduction; ecological importance of sponges and cnidarians; coral-forming organisms; jellyfish blooms and ecological impacts; symbiotic associations in lower invertebrates.
Unit III: Higher Marine Invertebrates
General characteristics and classification of Platyhelminthes; Annelida; Arthropoda; Mollusca and Echinodermata; adaptive radiation in marine invertebrates; larval forms and dispersal; ecological and economic importance of crustaceans and molluscs; benthic ecology; commercially important marine invertebrates.
Unit IV: Reef Ecology and Coral Reef Ecosystems
Coral reef formation and distribution; types of coral reefs; reef-building corals and symbiosis with zooxanthellae; reef biodiversity and trophic interactions; reef productivity and nutrient cycling; reef-associated fauna and flora; reef fish interactions; threats to coral reefs; coral bleaching; reef restoration and conservation strategies.
Unit V: Conservation and Applied Aspects of Marine Biodiversity
Marine biodiversity assessment methods; biodiversity indices; marine protected areas; endangered marine invertebrates; invasive marine species; conservation of coral reef ecosystems; sustainable utilization of marine biodiversity; role of marine biodiversity in fisheries and biotechnology; ecosystem-based conservation approaches.
Practicals
Identification and classification of marine invertebrates; study of larval forms; preparation of taxonomic keys; observation of coral reef organisms; biodiversity estimation methods; preparation of reef ecosystem charts; field visit to rocky shore, estuary or reef-associated ecosystem; maintenance of biodiversity records.
References

1. Castro, P. & Huber, M. E. *Marine Biology*. McGraw-Hill Education.
2. Brusca, R. C., Moore, W. & Shuster, S. M. *Invertebrates*. Sinauer Associates.
3. Loya, Y. et al. *Coral Reef Ecology*. Springer.
4. Russell, F. E., Nagabhushanam, R. *The Venomous and Poisonous Marine Invertebrates of the Indian Ocean.* United States: Science Publishers.
5. Walls J. G. *Encyclopaedia of Marine Invertebrates*, TFH Publications
6. Richard C. Brusca, *Invertebrates*, Sinauer Associates
7. Krishnamoorthy Venkataraman, Chandrakasan Sivaperuman, *Marine Faunal Diversity in India- Taxonomy, Ecology and Conservation*, Academic Press
8. Zoological Survey of India faunal series and marine biodiversity publications.

Major II: Molecular and Biochemical Processes
Credits: 3+1 = 4
Course Objectives
To understand molecular and biochemical processes occurring in living systems; to introduce biomolecules, enzymes and metabolic pathways; to familiarize students with molecular biology techniques and their applications in marine sciences.

Unit I: Biomolecules and Cellular Chemistry
Structure and properties of carbohydrates; proteins; lipids and nucleic acids; amino acids and peptide bonds; enzymes and enzyme kinetics; vitamins and coenzymes; water and biological buffers; biochemical organization of cells.
Unit II: Molecular Basis of Life
DNA structure and replication; RNA types and transcription; genetic code and translation; regulation of gene expression; mutations and DNA repair mechanisms; recombinant DNA technology basics; molecular evolution concepts.
Unit III: Bioenergetics and Metabolism
ATP and biological energy transfer; glycolysis; Krebs cycle; electron transport chain; oxidative phosphorylation; photosynthesis overview; lipid metabolism; protein metabolism; metabolic regulation; integration of metabolic pathways.
Unit IV: Molecular and Biochemical Techniques
DNA and RNA isolation methods; PCR principles; electrophoresis; spectrophotometry; chromatography; protein estimation methods; enzyme assays; immunological techniques; molecular markers; introduction to omics approaches.
Unit V: Applications in Marine and Environmental Sciences
Marine molecular biology applications; molecular taxonomy and DNA barcoding; biochemical adaptations in marine organisms; marine biotechnology overview; molecular responses to environmental stress; applications in aquaculture and fisheries; ethical issues in molecular biology and biotechnology.
Practicals
Qualitative tests for carbohydrates, proteins and lipids; preparation of buffers; enzyme activity assays; DNA extraction; agarose gel electrophoresis; chromatography techniques; spectrophotometric analysis; preparation of biochemical reports.

References

1. Nelson, D. L. & Cox, M. M. *Lehninger Principles of Biochemistry*. W.H. Freeman.
2. Alberts, B. et al. *Molecular Biology of the Cell*. Garland Science.
3. Lehninger, A. L. *Principles of Biochemistry*. Worth Publishers.
4. Satyanarayana, U. & Chakrapani, U. *Biochemistry*. Elsevier India.
5. Walker, J. M. & Rapley, R. *Molecular Biology and Biotechnology*. Royal Society of Chemistry, Indian Edition.

Major III: Marine Geomorphology, Habitat Dynamics and Marine Fossils
Credits: 3+1 = 4
Course Objectives

- To introduce marine geological and geomorphological processes;
- To understand habitat dynamics and sedimentary environments;
- To familiarize students with marine fossils and historical marine ecology.

Unit I: Introduction to Marine Geomorphology
Origin and evolution of ocean basins; structure of the Earth; plate tectonics and continental drift; ocean floor topography; continental shelf, slope and rise; abyssal plains; trenches and mid-ocean ridges; marine geological processes.

Unit II: Coastal and Marine Habitat Dynamics
Coastal geomorphology; beaches, dunes, mudflats and lagoons; estuarine dynamics; sediment transport and deposition; waves, tides and currents influencing habitats; shoreline changes; coastal erosion and accretion; habitat formation processes.

Unit III: Marine Sediments and Depositional Environments
Types and sources of marine sediments; biogenic, terrigenous and chemical sediments; sediment grain size analysis; sedimentary structures; carbonate sediments; deep sea sediments; marine sedimentation processes; sediment-water interactions.

Unit IV: Marine Fossils and Historical Marine Ecology
Introduction to palaeontology; fossilization processes; marine fossil groups; microfossils and macrofossils; geological time scale; evolution of marine life through geological ages; palaeoecology; fossils as indicators of past marine environments; applications of marine fossils in climate and environmental reconstruction.

Unit V: Applied Marine Geology and Habitat Conservation
Marine mineral resources; coastal zone management; habitat degradation and restoration; impacts of human activities on marine habitats; introduction to marine geohazards; tsunamis and coastal vulnerability; habitat conservation and sustainable coastal management.

Practicals
Identification of marine sediments; grain size analysis; preparation of sediment profiles; identification of marine fossils; geological map interpretation; observation of coastal geomorphological features; field visit to coastal habitats; preparation of habitat assessment records.

References
International References

1. Trujillo, A. P. & Thurman, H. V. *Essentials of Oceanography*. Pearson.
2. Kennett, J. P. *Marine Geology*. Prentice Hall.
3. McGowran, B. *Introduction to Marine Paleontology*. Elsevier.
4. Geological Survey of India publications on marine geology and coastal geomorphology.
5. National Institute of Oceanography technical manuals and coastal geology publications

MDC: Marine Bioprospecting
Credits: 3+0 = 3
Course Objectives

- To introduce marine bioresources and their potential applications;
- To provide understanding of marine natural products and bioactive compounds;
- To familiarize students with marine bioprospecting approaches and sustainable utilization of marine resources.

Unit I: Introduction to Marine Bioprospecting
Definition and scope of marine bioprospecting; importance of marine bioresources; marine biodiversity as a source of novel compounds; marine ecosystems with bioprospecting potential; historical development of marine natural product research; interdisciplinary nature of marine bioprospecting.
Unit II: Marine Organisms and Bioactive Compounds
Marine microorganisms including bacteria, fungi and microalgae; sponges, corals, molluscs and echinoderms as sources of bioactive compounds; marine algae and seaweeds; secondary metabolites in marine organisms; marine toxins and pigments; ecological roles of marine natural products.
Unit III: Extraction and Screening Methods
Collection and preservation of marine samples; extraction techniques for marine compounds; chromatography and spectroscopic methods; bioassay-guided screening; antimicrobial and antioxidant assays; molecular approaches in marine bioprospecting; metabolomics and omics approaches.
Unit IV: Applications of Marine Bioprospecting
Marine pharmaceuticals and drug discovery; nutraceuticals and cosmeceuticals; marine enzymes and industrial products; marine biotechnology applications; antifouling compounds; aquaculture and fisheries applications; marine biomaterials and biopolymers.
Unit V: Sustainability, Ethics and Future Perspectives
Sustainable harvesting of marine resources; marine conservation and biodiversity protection; intellectual property rights and patenting; biopiracy and ethical concerns; national and international regulations; blue biotechnology; future prospects of marine bioprospecting in India and globally.
References

1. Kim, S.-K. *Marine Biotechnology: Trends and Applications*. Wiley-Blackwell.
2. McClintock, J. B. & Baker, B. J. *Marine Chemical Ecology*. CRC Press.
3. Handbook of Marine Natural Products Kobayashi, J. & Kubota, T. *Handbook of Marine Natural Products*. Springer.
4. Central Marine Fisheries Research Institute marine biotechnology and marine bioresource publications.
5. Central Salt and Marine Chemicals Research Institute marine bioproduct and marine biotechnology publications.

Semester IV

Major I: Marine Biodiversity II: Vertebrates and Marine Mammals
Credits: 3+1 = 4
Course Objectives

- To introduce the diversity, classification and ecological significance of marine vertebrates;
- To understand adaptations and ecological roles of marine mammals;
- To familiarize students with conservation and management of marine vertebrate resources.

Unit I: Introduction to Marine Vertebrates
Classification and diversity of marine vertebrates; evolutionary origin of vertebrates; adaptations to marine environments; zoogeographical distribution of marine vertebrates; ecological importance of marine vertebrates in marine ecosystems.
Unit II: Marine Fishes
General characteristics and classification of cartilaginous and bony fishes; morphology and functional adaptations; feeding and reproductive biology; migration in fishes; coral reef fishes and pelagic fishes; economically important marine fishes; fish behaviour and ecological interactions; Adaptations in fishes of different habitats: pelagic, coastal, coral, deep sea and polar regions.
Unit III: Marine Reptiles and Seabirds
Marine reptiles including sea turtles and sea snakes; adaptations of marine reptiles; nesting biology and migration; seabirds and their ecological significance; feeding ecology and breeding behaviour; threatened marine reptiles and seabirds; conservation strategies.
Unit IV: Marine Mammals
Classification and diversity of marine mammals; cetaceans, pinnipeds, sirenians and marine carnivores; anatomical and physiological adaptations to aquatic life; feeding ecology and migration; communication and social behaviour; marine mammal habitats and distribution; marine mammal strandings and rescue approaches; Biodiversity assessment methods of marine mammals

---

Unit V: Conservation and Management of Marine Vertebrates
Threats to marine vertebrates including overfishing, bycatch, habitat destruction and pollution; climate change impacts; endangered marine vertebrates; marine protected areas; conservation laws and international conventions; marine mammal conservation in India; sustainable fisheries and ecosystem-based management.

Practicals
Identification of marine vertebrates; study of fish morphology; skeletal studies of fishes; identification of marine reptiles and seabirds; observation of vertebrate adaptations; preparation of taxonomic records; biodiversity assessment methods; field visit to fish landing centres, aquaria or coastal ecosystems.
References

1. Castro, P. & Huber, M. E. *Marine Biology*. McGraw-Hill Education.
2. Reeves, R. R. et al. *Guide to Marine Mammals of the World*. National Audubon Society.
3. Hoelzel, A. R. *Marine Mammal Biology: An Evolutionary Approach*. Blackwell Publishing.
4. Zoological Survey of India marine vertebrate faunal publications.
5. Central Marine Fisheries Research Institute marine fisheries and marine mammal publications.


KERALA UNIVERSITY OF FISHERIES & OCEAN STUDIES - KUFOS
Est 2010

Major II: Marine Botany and Algal Diversity
Credits: 3+1 = 4
Course Objectives

- To provide comprehensive understanding of marine flora with special emphasis on seaweeds, seagrasses, mangroves and phytoplankton;
- To introduce taxonomy, ecology and economic importance of marine plants;
- To familiarize students with applications of marine botany in ecosystem management, biotechnology and conservation.

Unit I: Introduction to Marine Botany and Marine Floral Diversity
Scope and importance of marine botany; marine primary producers and their ecological significance; classification of marine plants; marine habitats supporting floral diversity; introduction to phytoplankton, seaweeds, seagrasses and mangroves; role of marine vegetation in coastal productivity and ecosystem stability; distribution patterns of marine flora.
Unit II: Phytoplankton Diversity and Productivity
General characteristics and classification of phytoplankton; cyanobacteria; diatoms; dinoflagellates and coccolithophores; morphology and reproduction of phytoplankton; phytoplankton pigments; phytoplankton ecology and seasonal succession; primary productivity and carbon fixation; harmful algal blooms and red tides; ecological role of phytoplankton in marine food webs and biogeochemical cycles.
Unit III: Seaweeds and Marine Macroalgae
General characteristics and classification of green algae, brown algae and red algae; morphology and life cycle patterns; intertidal and subtidal seaweed communities; ecological importance of seaweeds; seaweed cultivation and mariculture; economically important seaweeds; agar, alginate and carrageenan industries; medicinal and nutraceutical importance of marine algae; seaweeds in bioremediation and blue biotechnology.
Unit IV: Seagrass and Mangrove Ecosystems
General characteristics and adaptations of seagrasses; distribution and ecological significance of seagrass meadows; productivity and ecosystem services of seagrasses; mangrove classification and zonation; physiological adaptations in mangroves; mangrove productivity and nutrient cycling; role of mangroves and seagrasses in shoreline stabilization, carbon sequestration and nursery ground formation; associated biodiversity.

Unit V: Conservation, Environmental Interactions and Applied Marine Botany
Threats to marine vegetation including habitat destruction, eutrophication, invasive species and climate variability; conservation and restoration of mangroves, seagrasses and seaweeds; marine floral diversity assessment methods; remote sensing applications in marine vegetation studies; marine plants in environmental monitoring; sustainable utilization of marine plant resources; blue carbon ecosystems and future prospects in marine botany.
Practicals
Identification of phytoplankton and marine algae; preparation of algal herbarium; study of seaweed morphology and reproductive structures; observation of mangrove and seagrass adaptations; estimation of chlorophyll and primary productivity; phytoplankton counting methods; field visit to mangrove, seagrass or intertidal ecosystem; preparation of marine floral diversity records.
References
International References

1. Lee, R. E. *Phycology*. Cambridge University Press.
2. Lobban, C. S. & Harrison, P. J. *Seaweed Ecology and Physiology*. Cambridge University Press.

3. Larkum, A. W. D., Orth, R. J. & Duarte, C. M. *Seagrasses: Biology, Ecology and Conservation*. Springer.
4. Rao, P. S. N., Gupta, R. K. *A Checklist of Indian Marine Algae (excluding Diatoms & Dinoflagellate).* Botanical Survey of India
4. Kathiresan, K. & Bingham, B. L. *Biology of Mangroves and Mangrove Ecosystems*. Advances in Marine Biology.

Major III: Marine Microbiology
Credits: 3+1 = 4
Course Objectives

- To introduce marine microorganisms and their ecological significance;
- To understand microbial processes in marine ecosystems;
- To familiarize students with applied aspects of marine microbiology.

Unit I: Introduction to Marine Microbiology
History and scope of marine microbiology; microbial diversity in marine environments; classification of marine microorganisms; marine bacteria, archaea, fungi, algae and viruses; marine microbial habitats.
Unit II: Marine Microbial Physiology and Metabolism
Microbial nutrition and growth; microbial metabolism; aerobic and anaerobic processes; microbial enzymes; extremophiles in marine systems; microbial adaptation to salinity, pressure and temperature.
Unit III: Marine Microbial Ecology
Microbial food webs; nutrient cycling by microorganisms; decomposition and mineralization; symbiotic associations; biofilms and microbial mats; microbial interactions with marine organisms; harmful algal blooms and microbial diseases.
Unit IV: Applied Marine Microbiology
Marine microbes in biotechnology; probiotics in aquaculture; bioremediation and biodegradation; marine microbial products; antibiotics and bioactive compounds; industrial applications of marine microorganisms.
Unit V: Environmental and Public Health Aspects
Microbial pollution indicators; water quality assessment; pathogens in marine systems; seafood microbiology; microbial monitoring methods; public health importance; microbial management in marine environments.
Practicals
Isolation and culture of marine microorganisms; preparation of culture media; staining techniques; microbial growth studies; water quality microbial analysis; identification of marine microbes; observation of microbial interactions; preparation of microbiological reports.
References

1. Munn, C. *Marine Microbiology: Ecology and Applications*. Garland Science.
2. Kirchman, D. L. *Microbial Ecology of the Oceans*. Wiley-Blackwell.
3. Madigan, M. T. et al. *Brock Biology of Microorganisms*. Pearson.
4. A Textbook of Microbiology
   Dubey, R. C. & Maheshwari, D. K. *A Textbook of Microbiology*. S. Chand.
5. Central Marine Fisheries Research Institute marine microbiology publications.

Major IV: Animal Physiology and Plant Physiology
Credits: 3+1 = 4
Course Objectives

- To understand physiological processes in marine animals and marine plants; to study functional adaptations of organisms to marine environments
- To introduce physiological responses to environmental variations in marine ecosystems
- To provide foundational knowledge relevant to marine biology, aquaculture and environmental sciences.

Unit I: Physiological Adaptations in Marine Organisms
Scope and importance of physiology in marine sciences; homeostasis in marine organisms; adaptations to salinity, temperature, pressure and dissolved oxygen variations; osmotic regulation in marine invertebrates and fishes; physiological adaptations in intertidal organisms; buoyancy and locomotion in marine animals; physiological responses to tidal and seasonal changes.
Unit II: Marine Animal Physiology
Digestive physiology in marine organisms; feeding mechanisms in suspension feeders, grazers and predators; respiration and respiratory pigments in marine animals; circulation and transport systems; excretion and osmoregulation in marine fishes and invertebrates; nervous coordination and endocrine regulation; reproductive physiology and larval development in marine organisms.
Unit III: Physiology of Marine Plants and Primary Producers
Photosynthesis in marine environments; pigments in phytoplankton and marine algae; nutrient uptake and transport in seaweeds and seagrasses; physiology of marine phytoplankton; productivity and carbon fixation; physiological adaptations of mangroves to saline conditions; water balance and gas exchange in mangroves and seagrasses; environmental factors influencing marine plant productivity.
Unit IV: Environmental and Stress Physiology in Marine Ecosystems
Physiological responses to environmental stress; hypoxia and thermal stress; stress physiology in coral reef organisms; physiological impacts of pollution and ocean acidification; oxidative stress and stress biomarkers; ecophysiology of estuarine and coastal organisms; physiological responses to climate variability and habitat changes.
Unit V: Applied Marine Physiology
Physiology in aquaculture and fisheries; nutrition and growth physiology; reproductive physiology in aquaculture species; physiological basis of fish migration; bioenergetics in marine ecosystems; physiological indicators in environmental monitoring; applications in marine biotechnology and conservation physiology; future perspectives in marine physiological research.
racticals
Study of osmosis and diffusion in marine organisms; estimation of dissolved oxygen consumption; observation of respiratory structures in marine organisms; estimation of chlorophyll and photosynthetic pigments; experiments on salinity stress responses; physiological measurements in marine algae and aquatic organisms; preparation of physiological adaptation records; field observations in estuarine or coastal habitats.
References
Verified References
Major IV: Animal Physiology and Plant Physiology (Marine Environment Focus)

1. Animal Physiology
Hill, R. W., Wyse, G. A. & Anderson, M. *Animal Physiology*. Sinauer Associates.

2. Environmental Physiology of Marine Animals Vernberg, F. J. & Vernberg, W. B. *Environmental Physiology of Marine Animals*. Springer-Verlag.
3. Environmental Physiology of Animals Willmer, P., Stone, G. & Johnston, I. *Environmental Physiology of Animals*. Wiley-Blackwell.
4. Falkowski, P. G. & Raven, J. A. *Aquatic Photosynthesis*. Princeton University Press.
5. Taiz, L. et al. *Plant Physiology and Development*. Sinauer Associates. Standard plant physiology text useful for seagrass, mangrove and marine plant physiology.
6. Satyanarayana, U. & Chakrapani, U. *Biochemistry*. Elsevier India.
7. CMFRI publications on fish physiology, marine productivity, stress physiology and aquaculture physiology.
8. CIFE manuals and publications related to aquatic animal physiology, fish endocrinology and aquaculture physiology.

Semester V

Major I: Marine Ecological Dynamics and Marine Environment Assessment
Credits: 3+1 = 4
Course Objectives
To understand ecological processes and dynamics in marine ecosystems; to introduce marine environmental assessment methods; to familiarize students with ecosystem monitoring, environmental indicators and habitat evaluation approaches.

Unit I: Marine Ecosystem Dynamics
Structure and functioning of marine ecosystems; ecological interactions in marine food webs; trophic dynamics; energy flow and ecological efficiency; ecological succession in marine habitats; population and community dynamics; ecosystem stability and resilience; carrying capacity in marine ecosystems.
Unit II: Coastal and Oceanic Ecosystem Processes
Ecological dynamics in estuaries, mangroves, coral reefs and seagrass ecosystems; nutrient cycling and productivity; benthic-pelagic coupling; microbial interactions in marine systems; seasonal and spatial variability in marine ecosystems; ocean-atmosphere interactions influencing ecosystem dynamics.
Unit III: Marine Environmental Assessment Methods
Principles of environmental assessment; environmental indicators and bioindicators; biodiversity assessment methods; ecological sampling techniques; water and sediment quality assessment; habitat mapping and ecological monitoring; environmental impact assessment in marine systems; environmental baseline studies.
Unit IV: Marine Environmental Changes and Ecosystem Responses
Natural and anthropogenic disturbances in marine ecosystems; eutrophication and habitat degradation; invasive species impacts; climate variability and ecosystem responses; coral bleaching and habitat shifts; ecological restoration and rehabilitation approaches.
Unit V: Applied Marine Ecology and Sustainable Management
Integrated coastal zone management; ecosystem-based fisheries management; marine protected areas; blue carbon ecosystems; remote sensing and GIS applications in marine environmental assessment; conservation planning; sustainable marine resource management.
Practicals
Assessment of biodiversity indices; ecological sampling methods; plankton and benthos analysis; estimation of ecological parameters; water and sediment quality analysis; habitat mapping exercises; preparation of environmental impact reports; field visits to estuarine or coastal ecosystems.
References
International References

1. Kaiser, M. J. et al. *Marine Ecology: Processes, Systems, and Impacts*. Oxford University Press.
2. Lalli, C. M. & Parsons, T. R. *Biological Oceanography: An Introduction*. Butterworth-Heinemann.
3. Castro, P. & Huber, M. E. *Marine Biology*. McGraw-Hill Education.
4. National Centre for Sustainable Coastal Management coastal management and environmental assessment manuals.
5. Central Marine Fisheries Research Institute ecosystem assessment and coastal ecology publications.

Major II: Marine Pollution and Ecotoxicology
Credits: 3+1 = 4
Course Objectives

- To understand sources and impacts of marine pollution;
- To introduce ecotoxicological principles and pollutant interactions in marine ecosystems;
- To familiarize students with monitoring and management of marine pollution.

Unit I: Introduction to Marine Pollution
Concept and types of marine pollution; point and non-point sources; physical, chemical and biological pollutants; marine debris and plastics; oil pollution; sewage and industrial discharge; eutrophication; pollutant transport and fate in marine systems.
Unit II: Marine Contaminants and Toxic Substances
Heavy metals; pesticides and persistent organic pollutants; hydrocarbons and petroleum compounds; radionuclides; pharmaceutical residues and emerging contaminants; bioaccumulation and biomagnification; sediment contamination and contaminant cycling.
Unit III: Principles of Ecotoxicology
Scope and importance of ecotoxicology; toxicokinetics and toxicodynamics; exposure pathways; biomarkers in marine organisms; physiological and biochemical responses to pollutants; oxidative stress and cellular damage; toxicity testing methods and bioassays.
Unit IV: Ecotoxicological Impacts on Marine Ecosystems
Effects of pollutants on plankton, benthos, fishes and marine mammals; endocrine disruption; coral reef degradation; impacts on mangroves and seagrasses; microbial responses to pollution; ecological risk assessment; human health implications through seafood contamination.
Unit V: Monitoring, Management and Environmental Regulations
Marine pollution monitoring techniques; environmental quality standards; bioremediation and pollution mitigation; wastewater treatment basics; environmental legislation and conventions; coastal pollution management; sustainable approaches to marine environmental protection.

Practicals
Analysis of water quality parameters; estimation of dissolved oxygen and nutrients; heavy metal analysis demonstrations; toxicity bioassays; assessment of bioindicators; preparation of pollution monitoring reports; field survey of polluted coastal habitats.
References

1. Clark, R. B. *Marine Pollution*. Oxford University Press.
2. Landis, W. G. & Yu, M.-H. *Introduction to Environmental Toxicology*. CRC Press.
3. Walker, C. H. et al. *Principles of Ecotoxicology*. CRC Press.
4. National Institute of Oceanography marine pollution and environmental monitoring publications.
5. Central Pollution Control Board coastal water quality and pollution manuals.

Major III: Integrative Fish Taxonomy
Credits: 3+1 = 4
Course Objectives
To understand taxonomy, classification and biology of fishes; to introduce fish morphology, physiology and ecological adaptations; to familiarize students with economically important marine fishes and fisheries biology.

Unit I: Introduction to Fish Biology and Systematics
Origin and evolution of fishes; principles of fish taxonomy and nomenclature; classification of fishes; phylogenetic relationships; diversity and distribution of marine fishes; adaptive radiation in fishes.

Unit II: Fish Morphology and Functional Anatomy
External morphology and morphometric characters; integumentary system; skeletal and muscular systems; digestive and respiratory systems; circulatory and nervous systems; sensory organs and adaptations in fishes.

Unit III: Classical Approaches in Fish Taxonomy

Taxonomic characters and species concepts; meristic and morphometric analyses; osteological and anatomical characters in fish classification; identification keys and taxonomic descriptions; collection, preservation and curation of fish specimens; museum techniques and reference collections.

Unit IV: Molecular Systematics and Integrative Taxonomy

Principles of molecular taxonomy; DNA barcoding and molecular markers; phylogenetic reconstruction and species delimitation; next-generation sequencing approaches; cryptic species and species complexes; integration of morphological, ecological and molecular datasets in fish taxonomy.

Unit V: Applications and Contemporary Trends in Fish Taxonomy

Biodiversity assessment and fish inventories; taxonomy for conservation and fisheries management; environmental DNA (eDNA) and metabarcoding; biogeography and evolutionary patterns in fishes; taxonomic databases and bioinformatics tools; challenges and future prospects in integrative fish taxonomy.

Practicals
Identification and classification of fishes; morphometric and meristic studies; dissection and anatomical observations; study of fish scales and otoliths; estimation of fish diversity indices; preparation of taxonomic records; field visits to fish landing centres.

References

1. Moyle, P. B. & Cech, J. J. *Fishes: An Introduction to Ichthyology*. Pearson.
2. Helfman, G. et al. *The Diversity of Fishes*. Wiley-Blackwell.
3. Allen, G. & Swainston, R. *Marine Fishes of South-East Asia*. Tuttle Publishing.
4. Upadhyay, A & Joshi, Bhuwan. (2014). Text Book of Marine Fisheries, Biotech Books
5. Central Marine Fisheries Research Institute fish biology and fisheries publications.

Major IV: Biostatistics, Data Analysis and Introduction to Artificial Intelligence & Machine Learning

Credits: 3+1 = 4

Course Objectives

- To introduce statistical tools and biological data analysis;
- To familiarize students with computational approaches, artificial intelligence and machine learning applications in biological and marine sciences.

Unit I: Fundamentals of Biostatistics

Types of biological data; sampling methods; data collection and organization; measures of central tendency and dispersion; probability concepts; distributions and hypothesis testing; correlation and regression analysis.

Unit II: Statistical Analysis and Data Visualization

Analysis of variance; chi-square test; non-parametric tests; graphical representation of data; interpretation of biological datasets; statistical software basics; spreadsheet analysis and visualization methods.

Unit III: Introduction to Programming and Data Science

Basics of programming concepts; introduction to R or Python; data structures and biological datasets; introduction to databases; data cleaning and management; exploratory data analysis.

Unit IV: Introduction to Artificial Intelligence and Machine Learning

Concepts of artificial intelligence; supervised and unsupervised learning; classification and clustering methods; neural networks basics; machine learning workflow; applications of AI and ML in marine biodiversity, fisheries and environmental assessment.

Unit V: Applications in Marine and Environmental Sciences

Statistical modelling in marine sciences; ecological and fisheries data analysis; GIS and remote sensing data interpretation; predictive modelling in marine ecology; AI applications in species identification and environmental monitoring; ethical issues and limitations of AI in biological sciences.

Practicals

Descriptive statistical analysis; preparation of graphs and charts; use of spreadsheet and statistical software; basic programming exercises; regression and correlation analysis; introduction to machine learning demonstrations; interpretation of marine datasets.

References

1. Zar, J. H. *Biostatistical Analysis*. Pearson.
2. James, G. et al. *An Introduction to Statistical Learning*. Springer.
3. McKinney, W. *Python for Data Analysis*. O'Reilly Media.
4. Arora, P. N. & Malhan, P. K. *Biostatistics*. Himalaya Publishing House.
5. Indian National Centre for Ocean Information Services data analytics and ocean observation publications.

Major V: Genomics, Proteomics and Metabolomics
Credits: 3+1 = 4
Course Objectives

- To introduce modern molecular genetics and omics technologies;
- To understand genome organization, protein expression and molecular mechanisms;
- To familiarize students with applications in marine biology, biotechnology and environmental sciences.

Unit I: Molecular Genetics and Genome Organization
DNA structure and replication; gene organization; chromosomes and genome architecture; transcription and translation; regulation of gene expression; mutations and DNA repair mechanisms.
Unit II: Genomics and Genome Analysis
Genome sequencing methods; structural and functional genomics; comparative genomics; metagenomics; genome annotation; molecular markers and DNA barcoding; genome databases and bioinformatics tools.
Unit III: Proteomics and Protein Analysis
Protein structure and folding; proteome organization; protein separation methods; electrophoresis and chromatography; mass spectrometry basics; protein-protein interactions; functional proteomics and biomarker discovery.
Unit IV: Molecular Biotechnology and Omics Applications
Recombinant DNA technology; CRISPR and gene editing basics; transcriptomics and metabolomics; molecular diagnostics; marine biotechnology applications; genomics in aquaculture and fisheries; environmental genomics.
Unit V: Ethical, Environmental and Applied Perspectives
Ethical issues in genomics and biotechnology; biosafety and biosecurity; genetic conservation; molecular approaches in biodiversity conservation; personalized medicine concepts; future trends in omics sciences and marine biotechnology.
Practicals
DNA and RNA extraction; PCR demonstrations; gel electrophoresis; protein estimation methods; bioinformatics database exercises; sequence analysis; molecular marker analysis; preparation of molecular biology reports.
References

1. Watson, J. D. et al. *Molecular Biology of the Gene*. Pearson.
2. Lesk, A. *Introduction to Genomics*. Oxford University Press.
3. Twyman, R. *Principles of Proteomics*. BIOS Scientific Publishers.
4. Walker, J. M. & Rapley, R. *Molecular Biology and Biotechnology*. Royal Society of Chemistry, Indian Edition.
5. National Institute of Biomedical Genomics genomics and molecular biology publications.

Semester VI

Major I: Deep Sea Ecology and Biodiversity
Credits: 3+1 = 4
Course Objectives

- To introduce deep sea ecosystems and biodiversity;
- To understand ecological processes in deep ocean environments;
- To familiarize students with deep ocean exploration and Deep Ocean Mission initiatives.

Unit I: Introduction to Deep Sea Environment
Definition and extent of deep sea; history of deep-sea exploration; bathymetric zones of oceans; physical characteristics of deep-sea including pressure, temperature, light and salinity; deep ocean circulation; geological features of deep oceans; trenches, abyssal plains and hydrothermal vents.
Unit II: Deep Sea Biodiversity
Diversity of deep-sea microorganisms; deep sea invertebrates and vertebrates; benthic and pelagic deep-sea fauna; adaptations to deep sea conditions; bioluminescence; gigantism and dwarfism; trophic interactions in deep sea ecosystems; chemosynthetic communities. Deep sea bioresources and fishery resources.
Unit III: Deep Sea Ecosystem Processes
Deep sea food webs and nutrient cycling; marine snow and organic matter deposition; microbial ecology in deep oceans; hydrothermal vent ecosystems; cold seep ecosystems; deep sea carbon cycling; ecological connectivity between deep and shallow marine systems.
Unit IV: Deep Ocean Exploration and Technology
Deep Ocean Mission (DOM); objectives, institutional frameworks and relevance in ocean governance, ecosystem conservation and sustainable resource management; deep sea sampling methods; submersibles and remotely operated vehicles; deep sea sensors and observatories; ocean mapping techniques; polymetallic nodules and marine mineral resources; deep sea biotechnology prospects.
Unit V: Conservation and Sustainable Management
Threats to deep sea ecosystems; deep sea mining impacts; marine litter and pollution in deep oceans; climate change impacts on deep sea systems; legal and ethical issues in deep sea resource utilization; conservation of deep ocean biodiversity; international governance of deep-sea resources.

Practicals
Identification of deep-sea organisms from images and collections; analysis of bathymetric maps; deep sea biodiversity database exercises; interpretation of oceanographic datasets; sediment analysis demonstrations; preparation of deep-sea ecosystem reports.
References
International References

1. Gage, J. D. & Tyler, P. A. *Deep-Sea Biology: A Natural History of Organisms at the Deep-Sea Floor*. Cambridge University Press.
2. Castro, P. & Huber, M. E. *Marine Biology*. McGraw-Hill Education.
3. Smith, C. R. & Branch, T. A. *Deep-Sea Ecology*. Oxford University Press.
4. National Institute of Ocean Technology Deep Ocean Mission publications.
5. National Centre for Polar and Ocean Research deep sea and polar marine ecosystem publications.

Major III: Blue Economy, Carbon Sequestration and Carbon Credit Systems
Credits: 3+1 = 4
Course Objectives

- To introduce blue economy concepts and sustainable marine resource utilization
- To understand marine carbon sequestration processes
- To familiarize students with carbon credit systems and climate mitigation approaches.

Unit I: Blue Economy Concepts and Marine Resources
Definition and scope of blue economy; marine living and non-living resources; fisheries, aquaculture and marine biotechnology; marine renewable energy; ocean tourism and maritime trade; sustainable ocean development; blue economy initiatives in India
Unit II: Marine Carbon Cycling and Carbon Sequestration
Global carbon cycle; oceanic carbon sinks; biological carbon pump; carbon sequestration in mangroves, seagrasses and salt marshes; blue carbon ecosystems; carbon burial in marine sediments; ocean-atmosphere carbon exchange.
Unit III: Climate Change and Carbon Management
Greenhouse gases and climate systems; ocean warming and acidification; climate mitigation strategies; ecosystem-based carbon management; carbon accounting methods; carbon footprint assessment; marine ecosystem restoration for climate resilience.
Unit IV: Carbon Credit Systems and Environmental Economics
Carbon markets and trading mechanisms; carbon credit certification systems; voluntary and compliance carbon markets; valuation of ecosystem services; blue carbon finance; environmental economics and sustainability indicators; policy frameworks for carbon management.
Unit V: Governance, Policy and Sustainable Future
International climate agreements; blue economy governance; marine spatial planning; sustainable development goals and blue economy; community participation and livelihood security; emerging technologies and future prospects in blue economy and carbon management.
Practicals
Estimation of carbon content in sediments or biomass; carbon footprint exercises; analysis of blue carbon ecosystems using case studies; interpretation of climate datasets; preparation of carbon accounting reports; GIS-based blue economy mapping exercises.
References
International References

1. Pauli, G. *The Blue Economy*. Paradigm Publications.
2. Laffoley, D. & Grimsditch, G. *The Management of Natural Coastal Carbon Sinks*. IUCN.
3. Gibson, R. N. et al. *Oceanography and Marine Biology: An Annual Review*. CRC Press.
4. Ministry of Earth Sciences blue economy and climate publications.
5. National Centre for Sustainable Coastal Management blue carbon and coastal ecosystem reports.

Major V: Marine Capture and Culture Fisheries
Credits: 3+1 = 4
Course Objectives

- To understand principles and practices of capture and culture fisheries
- To introduce fisheries resources, fishing technologies and aquaculture systems
- To familiarize students with sustainable fisheries management.

Unit I: Introduction to Fisheries Science
Scope and importance of fisheries; marine fisheries resources; fisheries sectors in India; capture fisheries and culture fisheries; fisheries productivity and economics; fishery resources of Indian waters.
Unit II: Marine Capture Fisheries
Fishing crafts and gears; traditional and modern fishing methods; trawling, purse seining and longlining; fish finding technologies; fishery resource assessment; bycatch and discards; fisheries regulations and management.
Unit III: Marine Aquaculture and Mariculture
Principles of aquaculture; coastal aquaculture systems; mariculture practices; shrimp farming; molluscan culture; seaweed culture; ornamental fish culture; hatchery management; feed and nutrition in aquaculture.
Unit IV: Fisheries Biology and Health Management
Fish growth and reproduction; fish nutrition and metabolism; fish diseases and pathogens; aquatic animal health management; probiotics and biosecurity; environmental impacts of aquaculture; sustainable aquaculture practices.
Unit V: Fisheries Management and Blue Economy
Fisheries governance and policies; ecosystem-based fisheries management; fish processing and value addition; sustainable seafood marketing, traceability and supply-chain management; seafood certification and ecolabelling, including Marine Stewardship Council (MSC) standards; fisheries economics, domestic and international seafood markets and global trade logistics; climate change impacts on fisheries; livelihood security and sustainable fisheries development.
Practicals
Identification of fishing gears; fish catch composition analysis; hatchery and aquaculture farm visits; feed formulation demonstrations; fish disease observation; fish morphometric studies; preparation of fisheries management reports.
References
International References

1. King, M. *Fisheries Biology, Assessment and Management*. Wiley-Blackwell.
2. Lucas, J. S. & Southgate, P. C. *Aquaculture: Farming Aquatic Animals and Plants*. Wiley-Blackwell.
3. Jennings, S. et al. *Marine Fisheries Ecology*. Blackwell Science.
4. ICAR. *Handbook of Fisheries and Aquaculture*. Indian Council of Agricultural Research.
5. Central Marine Fisheries Research Institute fisheries and mariculture publications.

Elective I: ICZM and Marine Protected Areas
Credits: 4+0 = 4
Course Objectives

- To introduce principles and practices of Integrated Coastal Zone Management and Marine Protected Areas
- To understand coastal ecosystem conservation, marine governance and sustainable coastal resource management.

Unit I: Coastal Ecosystems and ICZM
Characteristics and importance of coastal ecosystems; estuaries, mangroves, coral reefs, seagrasses and lagoons; coastal resources and ecosystem services; anthropogenic pressures on coastal systems; concept, principles and objectives of Integrated Coastal Zone Management; sustainable coastal development.
Unit II: Coastal Processes and Marine Spatial Planning
Coastal processes including tides, waves, currents and sediment transport; shoreline dynamics and coastal erosion; coastal vulnerability assessment; marine spatial planning concepts; resource mapping; remote sensing and GIS applications in coastal management; environmental impact assessment in coastal areas.
Unit III: Marine Protected Areas and Biodiversity Conservation
Concept and categories of Marine Protected Areas; biodiversity conservation strategies; habitat restoration; coral reef and mangrove conservation; ecological monitoring; protected area management planning; role of MPAs in fisheries management and climate resilience.
Unit IV: Governance, Policies and Community Participation
Coastal legislation and policies in India; Coastal Regulation Zone notification; international conventions on marine conservation; institutional frameworks in coastal governance; stakeholder participation; traditional knowledge systems; community-based coastal management; blue economy and sustainable livelihoods.
Unit V: Climate Change, Coastal Management and Case Studies
Climate change impacts on coastal ecosystems; sea level rise and coastal vulnerability; coastal disaster management; marine pollution management; ecosystem restoration and resilience; case studies of ICZM and MPAs in India and global coastal systems; future perspectives in coastal governance.

References

1. Cicin-Sain, B. & Knecht, R. W. *Integrated Coastal and Ocean Management: Concepts and Practices*. Island Press.
2. Hoyt, E. *Marine Protected Areas for Whales, Dolphins and Porpoises*. Earthscan.
3. Hinrichsen, D. *Coastal Waters of the World: Trends, Threats and Strategies*. Island Press.
4. National Centre for Sustainable Coastal Management coastal management manuals and reports.
5. Ministry of Environment, Forest and Climate Change CRZ notifications and coastal management publications.

Elective I: Climate Change and Ocean Acidification
Credits: 4+0 = 4
Course Objectives

- To introduce climate change processes and ocean acidification;
- To understand impacts on marine ecosystems, biodiversity and fisheries;
- To familiarize students with climate adaptation, mitigation and policy frameworks relevant to marine environments.

Unit I: Climate Systems and Global Change
Weather and climate systems; atmosphere-ocean interactions; greenhouse gases and global warming; causes of climate change; carbon cycle and climate regulation; evidence of climate variability and change; global and regional climate trends.
Unit II: Ocean Warming and Ocean Acidification
Ocean heat absorption and thermal stratification; sea surface temperature changes; chemistry of ocean acidification; carbonate buffering system; pH changes in marine environments; effects on calcification processes; ocean deoxygenation and associated environmental changes.
Unit III: Impacts on Marine Ecosystems and Biodiversity
Climate change impacts on marine biodiversity; coral bleaching and reef degradation; impacts on mangroves, seagrasses and phytoplankton; shifts in species distribution and productivity; impacts on fisheries and aquaculture; ecological and physiological responses of marine organisms.
Unit IV: Climate Adaptation, Mitigation and Blue Carbon
Climate adaptation strategies in coastal ecosystems; ecosystem-based adaptation; blue carbon ecosystems including mangroves, seagrasses and salt marshes; carbon sequestration and climate mitigation; restoration of coastal ecosystems; sustainable management approaches for climate resilience.
Unit V: Climate Modelling, Governance and Policy Frameworks
Climate modelling and prediction basics; climate monitoring systems; IPCC assessments and global climate agreements; ocean governance and climate policy; disaster risk reduction and coastal vulnerability assessment; climate action and sustainable development goals; future perspectives in marine climate science.

References

1. Gattuso, J.-P. & Hansson, L. *Ocean Acidification*. Oxford University Press.
2. Barange, M. et al. *Impacts of Climate Change on Marine Ecosystems*. Oxford University Press.
3. Intergovernmental Panel on Climate Change assessment reports and climate publications.
4. Ministry of Earth Sciences climate and ocean science reports.
5. Indian National Centre for Ocean Information Services ocean climate and coastal vulnerability publications.

Elective I: Telecommunication Systems in Ocean Sciences
Credits 4+0 = 4
Course Objectives

- To introduce telecommunication systems used in ocean sciences; to understand underwater and satellite communication technologies;
- To familiarize students with marine navigation, telemetry and ocean observation systems used in marine research, fisheries and disaster management.

Unit I: Fundamentals of Telecommunication Systems
Basics of telecommunication; components of communication systems; signal transmission and reception; analog and digital communication; electromagnetic waves and propagation; communication networks; applications of telecommunication in marine sciences.
Unit II: Underwater and Marine Communication Systems
Principles of underwater communication; acoustic communication systems; sonar and echo sounding; underwater sensors and monitoring systems; remotely operated vehicles and autonomous underwater vehicles; limitations and challenges in underwater communication.
Unit III: Satellite Communication and Marine Navigation
Satellite communication systems; satellite remote sensing in oceanography; Global Positioning System and navigation principles; marine navigation systems; Automatic Identification System; communication technologies in ships and research vessels; marine mapping and positioning techniques.
Unit IV: Ocean Observation Networks and Telemetry
Ocean observation systems and buoys; telemetry in ocean sciences; real-time ocean monitoring; marine meteorological observation systems; wireless sensor networks; data transmission and management; applications in fisheries forecasting and oceanographic research.
Unit V: Applications in Fisheries, Disaster Management and Coastal Monitoring
Communication technologies in fisheries management; Potential Fishing Zone advisory systems; tsunami and cyclone warning systems; coastal surveillance and monitoring; disaster communication networks; GIS applications in coastal management; emerging technologies and future prospects in marine telecommunication systems.

References

1. Roddy, D. *Satellite Communications*. McGraw-Hill Education.
2. Hodges, R. P. *Underwater Acoustics: Analysis, Design and Performance of Sonar*. Wiley.
3. Gower, J. *Remote Sensing of the Marine Environment*. CRC Press.
4. Indian National Centre for Ocean Information Services ocean observation and communication system publications.
5. National Institute of Ocean Technology marine instrumentation and ocean technology publications.

Elective I: Spectroscopic Techniques for Natural Product Analysis
Credits: 4+0 = 4
Course Objectives

- To introduce spectroscopic and chromatographic techniques used in natural product analysis;
- To understand structure elucidation of marine natural products;
- To familiarize students with analytical applications in marine bioprospecting and biotechnology.

Unit I: Fundamentals of Spectroscopy and Natural Products
Principles of spectroscopy; electromagnetic spectrum; interaction of radiation with matter; natural products and marine bioactive compounds; basics of structure elucidation; sample preparation methods; analytical approaches in marine natural product chemistry.
Unit II: UV-Visible and Infrared Spectroscopy
Principles and instrumentation of UV-Visible spectroscopy; absorption spectra and chromophores; applications in biomolecule analysis; principles of infrared spectroscopy; molecular vibrations and functional group identification; interpretation of IR spectra; applications in marine compound characterization.
Unit III: NMR Spectroscopy and Mass Spectrometry
Principles of nuclear magnetic resonance spectroscopy; chemical shifts and spin interactions; proton and carbon NMR; interpretation of NMR spectra; principles of mass spectrometry; ionization techniques and fragmentation patterns; molecular weight determination and structural analysis.
Unit IV: Chromatographic Separation Techniques
Principles of chromatography; thin layer chromatography; column chromatography; gas chromatography; high-performance liquid chromatography; separation and purification of marine natural products; hyphenated analytical techniques; analytical workflow in marine bioprospecting.
Unit V: Applications in Marine Bioprospecting and Biotechnology
Structure elucidation of marine secondary metabolites; analysis of marine toxins and pigments; analytical approaches in pharmaceutical and nutraceutical research; applications in marine biotechnology; quality control and standardization; future perspectives in marine natural product analysis.

References

1. Spectrometric Identification of Organic Compounds
   Silverstein, R. M., Webster, F. X. & Kiemle, D. J. *Spectrometric Identification of Organic Compounds*. Wiley.
2. Organic Spectroscopy
   Kemp, W. *Organic Spectroscopy*. Palgrave Macmillan.
3. Marine Natural Products
   Scheuer, P. J. *Marine Natural Products: Chemical and Biological Perspectives*. Academic Press.
4. Central Salt and Marine Chemicals Research Institute marine natural product and analytical chemistry publications.
5. CSIR-National Institute of Oceanography marine bioprospecting and analytical chemistry reports.

Elective II: Marine Mammals and Megafauna
Credits: 4+0 = 4
Course Objectives

- To introduce marine mammals and marine megafauna;
- To understand their ecology, physiology and conservation;
- To familiarize students with management and protection of threatened marine species.

Unit I: Introduction to Marine Mammals and Megafauna
Classification and diversity of marine mammals; cetaceans, pinnipeds and sirenians; marine turtles, sharks and rays; evolutionary adaptations to marine life; distribution patterns and habitats of marine megafauna.
Unit II: Physiology and Adaptations
Anatomical and physiological adaptations to aquatic environments; respiration and diving physiology; thermoregulation; buoyancy and locomotion; sensory systems and communication; feeding mechanisms and trophic ecology.
Unit III: Migration, Behaviour and Ecology
Migration patterns and navigation; reproductive behaviour; social organization and communication; marine megafauna ecology and trophic interactions; habitat utilization; ecological roles in marine ecosystems.
Unit IV: Conservation Biology and Threats
Threats from bycatch, overfishing, pollution and habitat degradation; ship strikes and noise pollution; climate change impacts; endangered marine species; conservation biology principles; marine mammal strandings and rescue approaches; Biodiversity assessment methods of marine mammals
Unit V: Protected Species Management and Policy
Protected species legislation and international conventions; marine protected areas and megafauna conservation; monitoring and tagging methods; ecotourism and sustainable management; case studies from Indian and global marine ecosystems.

References

1. Jefferson, T. A., Webber, M. A. & Pitman, R. L. *Marine Mammals of the World: A Comprehensive Guide to Their Identification*. Academic Press.
2. Hoelzel, A. R. *Marine Mammal Biology: An Evolutionary Approach*. Blackwell Publishing.
3. Spotila, J. R. *Sea Turtles: A Complete Guide to Their Biology, Behavior, and Conservation*. Johns Hopkins University Press.
4. Wildlife Institute of India marine megafauna conservation publications.
5. International Union for Conservation of Nature species assessment and conservation reports.

Elective II: Marine Data Analysis
Credits: 4+0 = 4
Course Objectives

- To introduce data analysis methods used in marine sciences;
- To familiarize students with marine datasets, statistical tools and computational approaches;
- To develop skills in visualization and interpretation of marine biological and oceanographic data.

Unit I: Marine Datasets and Data Management
Types of marine datasets; oceanographic and biological databases; data collection and management; metadata concepts; quality control and validation; marine biodiversity and fisheries datasets; data storage and retrieval systems.
Unit II: Statistical Analysis and Visualization
Descriptive and inferential statistics; probability distributions; correlation and regression analysis; multivariate analysis basics; graphical representation of marine datasets; oceanographic data visualization methods; interpretation of scientific data.
Unit III: GIS, Remote Sensing and Spatial Analysis
Fundamentals of GIS and remote sensing; satellite oceanography; spatial mapping of marine ecosystems; bathymetric and habitat mapping; spatial analysis methods; applications in fisheries and biodiversity studies.
Unit IV: Introduction to Modelling and Machine Learning
Introduction to modelling approaches in marine sciences; predictive models in fisheries and ecology; basics of machine learning; supervised and unsupervised learning; AI applications in marine biodiversity and environmental monitoring; limitations and ethical considerations.
Unit V: Applications in Marine and Fisheries Sciences
Analysis of fisheries datasets; biodiversity informatics; climate and oceanographic data interpretation; ecological modelling; decision support systems in marine management; future trends in marine data science and computational oceanography.
References

1. McKinney, W. *Python for Data Analysis*. O'Reilly Media.
2. James, G. et al. *An Introduction to Statistical Learning*. Springer.
3. Zar, J. H. *Biostatistical Analysis*. Pearson.
4. Indian National Centre for Ocean Information Services oceanographic data and GIS publications.
5. National Centre for Sustainable Coastal Management coastal GIS and spatial analysis reports.

Elective II: Bioinformatics for Marine Natural Products
Credits: 4+0 = 4
Course Objectives

- To introduce bioinformatics tools and computational approaches used in marine natural product research;
- To understand databases, sequence analysis and molecular docking;
- To familiarize students with applications in marine bioprospecting and biotechnology.

Unit I: Introduction to Bioinformatics
Scope and importance of bioinformatics; biological databases; sequence databases and structure databases; data retrieval systems; computational biology concepts; applications in marine sciences and biotechnology.
Unit II: Sequence Analysis and Comparative Bioinformatics
DNA, RNA and protein sequence analysis; sequence alignment methods; phylogenetic analysis; molecular markers and DNA barcoding; comparative genomics approaches; interpretation of sequence data.
Unit III: Structural Bioinformatics and Molecular Docking
Protein structure prediction basics; molecular visualization tools; principles of molecular docking; ligand-receptor interactions; computational screening methods; applications in marine drug discovery.
Unit IV: Metabolomics and Marine Natural Product Discovery
Metabolomics databases and analytical platforms; marine secondary metabolites; computational approaches in marine bioprospecting; cheminformatics and virtual screening; AI applications in marine natural product research.
Unit V: Applications and Future Perspectives
Bioinformatics in marine biotechnology; pharmaceutical and nutraceutical applications; marine microbial genomics; biodiversity informatics; ethical and data management issues; future trends in marine computational biology.
References

1. Pevsner, J. *Bioinformatics and Functional Genomics*. Wiley-Blackwell.
2. McClintock, J. B. & Baker, B. J. *Marine Chemical Ecology*. CRC Press.
3. Lesk, A. *Introduction to Bioinformatics*. Oxford University Press.
4. Institute of Bioinformatics bioinformatics databases and research publications.
5. CSIR-National Institute of Oceanography marine biotechnology and marine natural product publications.

Elective II: Ocean Policy, Governance and Areas Beyond National Jurisdiction (ABNJ)
Credits: 4+0 = 4

Course Objectives

- To introduce ocean governance and marine policy frameworks;
- To understand international law related to Areas Beyond National Jurisdiction;
- To familiarize students with marine diplomacy, governance mechanisms and sustainable management of global oceans.

Unit I: Introduction to Ocean Policy and Governance

Concept and scope of ocean governance; evolution of marine policy; law of the sea principles; maritime zones and jurisdiction; institutional frameworks in ocean governance; sustainable ocean management concepts.

Unit II: UNCLOS and International Ocean Law

United Nations Convention on the Law of the Sea; territorial sea, exclusive economic zone and continental shelf; freedom of navigation; marine resource rights and obligations; dispute settlement mechanisms; international maritime organizations and conventions.

Unit III: Areas Beyond National Jurisdiction and Deep-Sea Governance

Definition and significance of ABNJ; governance challenges in high seas and deep oceans; biodiversity beyond national jurisdiction agreements; impact assessment and governance of deep-sea mining; marine genetic resources; environmental impact assessment in ABNJ.

Unit IV: Marine Spatial Planning and Blue Economy Governance

Marine spatial planning principles; blue economy policies; fisheries governance; marine protected areas in international waters; climate governance and ocean diplomacy; stakeholder participation and international cooperation.

Unit V: Emerging Issues and Future Perspectives

Marine pollution governance; plastic pollution treaties; climate change and ocean governance; maritime security and geopolitics; sustainable development goals and oceans; future trends in global ocean governance and diplomacy.

References

1. Tanaka, Y. *The International Law of the Sea*. Cambridge University Press.
2. Jacques, P. & Smith, Z. A. *Ocean Politics and Policy*. ABC-CLIO.
3. United Nations UNCLOS and BBNJ agreement documents.
4. Ministry of Earth Sciences ocean governance and blue economy reports.
5. Indian Society of International Law maritime law and ocean governance publications.

Semester VII

Major I: Island Ecology and Artificial Reefs
Credits: 3+1 = 4
Course Objectives
To understand island ecosystems and ecological processes; to introduce coral reef ecology and artificial reef systems; to familiarize students with island biodiversity conservation, reef restoration and sustainable island management.

Unit I: Fundamentals of Island Ecology
Concept and scope of island ecology; island biogeography theory, species colonization, extinction and endemism; physical and ecological characteristics of oceanic and continental islands; island biodiversity and ecosystem functioning; ecological interactions in island ecosystems; island productivity and nutrient cycling.
Unit II: Coral Reef Ecology and Island Ecosystems
Coral reef formation and types, fringing reefs, barrier reefs and atolls; reef-building corals and zooxanthellae associations; reef biodiversity, reef trophic interactions, reef productivity and nutrient cycling; coral reef associated flora and fauna; reef fish communities; ecological importance of coral reefs in island ecosystems.
Unit III: Artificial Reefs and Reef Restoration
Concept and types of artificial reefs, natural materials and engineered reef structures; ecological functions of artificial reefs; artificial reefs for fisheries enhancement and habitat restoration; reef transplantation techniques, coral gardening and reef rehabilitation; monitoring and assessment of reef restoration projects; ecological and socioeconomic benefits of artificial reefs.
Unit IV: Threats and Environmental Challenges in Island Ecosystems
Climate change impacts on islands, sea level rise and coastal erosion; coral bleaching and ocean acidification; invasive species in island ecosystems; marine pollution and tourism impacts; habitat fragmentation and biodiversity loss; disaster vulnerability in island ecosystems; resilience and adaptation strategies.
Unit V: Conservation and Sustainable Island Management
Island conservation biology; marine protected areas and island ecosystem management; integrated island management approaches; sustainable fisheries and tourism; blue economy in island ecosystems; policy frameworks for island conservation; case studies from Lakshadweep, Andaman and Nicobar Islands and global island ecosystems.
Practicals
Identification of coral reef organisms, reef fish and associated biodiversity; mapping of reef habitats; assessment of artificial reef structures; coral bleaching assessment exercises; biodiversity estimation methods; preparation of island ecosystem reports; field visits to reef or island ecosystems.
References

1. Loya, Y. et al. *Coral Reef Ecology*. Springer.
2. Castro, P. & Huber, M. E. *Marine Biology*. McGraw-Hill Education.
3. MacArthur, R. H. & Wilson, E. O. *The Theory of Island Biogeography*. Princeton University Press.
4. Zoological Survey of India coral reef and island biodiversity publications.
5. National Centre for Sustainable Coastal Management Island ecology and reef management reports.

Major II: Polar Marine Biology
Credits: 3+1 = 4
Course Objectives

- To introduce polar marine ecosystems and biodiversity;
- To understand ecological and physiological adaptations of polar organisms;
- To familiarize students with polar climate processes, conservation and polar research initiatives.

Unit I: Introduction to Polar Marine Environments
Arctic and Antarctic marine environments, polar oceans and sea ice systems; physical characteristics of polar oceans, temperature, salinity and ice dynamics; polar ocean circulation; seasonality and productivity in polar regions; history of polar exploration and research.
Unit II: Polar Marine Biodiversity
Polar phytoplankton and microbial communities, krill and zooplankton diversity; polar benthic communities and fishes; seabirds and marine mammals in polar ecosystems; food webs and trophic interactions; endemic and keystone species in polar marine ecosystems.
Unit III: Adaptations and Ecophysiology of Polar Organisms
Physiological and biochemical adaptations to cold environments, antifreeze proteins and membrane adaptations; adaptations to seasonal darkness and ice cover; reproductive and feeding adaptations; ecological resilience and survival strategies in polar marine organisms.
Unit IV: Climate Change and Polar Ecosystems
Polar climate systems and global climate regulation; melting sea ice and glacier dynamics; impacts of climate change on polar biodiversity and productivity; ocean acidification in polar oceans; invasive species and ecosystem shifts; conservation challenges in polar regions.
Unit V: Polar Governance, Research and Conservation
International governance of polar regions, Antarctic Treaty System and Arctic governance; marine protected areas in polar oceans; polar research programmes and technologies; India's polar research initiatives; future perspectives in polar marine biology and conservation.
Practicals
Identification of polar marine organisms from collections and images; interpretation of polar oceanographic datasets; food web analysis; analysis of climate and sea ice data; preparation of polar ecosystem reports and case studies.
References
International References

1. Smith, W. O. *Polar Oceanography*. Academic Press.
2. Castro, P. & Huber, M. E. *Marine Biology*. McGraw-Hill Education.
3. Elias, S. A. *Biology of the Polar Regions*. Oxford University Press.
4. National Centre for Polar and Ocean Research polar biology and Antarctic research publications.
5. Ministry of Earth Sciences polar science reports and publications.

Major III: Marine Litter and Debris: Mitigation and Management
Credits: 3+1 = 4
Course Objectives

- To understand marine litter and debris in marine ecosystems;
- To introduce sources, impacts and monitoring approaches;
- To familiarize students with mitigation strategies, waste management and marine policy frameworks.

Unit I: Introduction to Marine Litter and Debris
Concept and classification of marine litter, macroplastics, microplastics and abandoned fishing gear; sources and pathways of marine debris; distribution and transport in marine environments; global and regional status of marine litter.
Unit II: Ecological and Environmental Impacts
Impacts on marine biodiversity, fishes, seabirds, turtles and marine mammals; ingestion and entanglement; microplastics in food webs and sediments; toxicological impacts and contaminant transfer; habitat degradation and ecological consequences.
Unit III: Monitoring and Assessment Methods
Marine litter sampling techniques, beach surveys and floating debris assessment; microplastic analysis methods; remote sensing and GIS applications; citizen science approaches; data analysis and environmental monitoring protocols.
Unit IV: Mitigation, Waste Management and Restoration
Waste management systems and circular economy concepts; plastic waste reduction strategies; recycling and biodegradable materials; clean-up programmes and restoration approaches; fishing gear management; sustainable coastal waste management practices.
Unit V: Governance, Policies and Future Perspectives
National and international marine litter policies; MARPOL convention and plastic regulations; blue economy and sustainable consumption; stakeholder participation and awareness programmes; innovations in marine debris management; future perspectives in marine litter mitigation.
Practicals
Beach litter assessment exercises, microplastic extraction demonstrations; data analysis and mapping of marine debris; waste characterization studies; preparation of marine litter monitoring reports; field visits to coastal waste management facilities.
References
International References

1. Bergmann, M., Gutow, L. & Klages, M. *Marine Anthropogenic Litter*. Springer.
2. Clark, R. B. *Marine Pollution*. Oxford University Press.
3. United Nations Environment Programme marine litter and plastic pollution reports.
4. Central Pollution Control Board coastal and marine plastic pollution reports.
5. National Centre for Sustainable Coastal Management marine debris and coastal pollution publications.

Major IV: Marine Enzymes, Drug Development and Industrial Applications
Credits: 3+1 = 4
Course Objectives

- To introduce marine bioactive compounds and marine enzymes;
- To understand marine drug discovery and industrial applications;
- To familiarize students with marine biotechnology and pharmaceutical developments.

Unit I: Marine Bioactive Compounds and Marine Enzymes
Marine biodiversity as a source of bioactive compounds; marine microorganisms, algae, sponges and invertebrates producing bioactive metabolites; marine enzymes and their characteristics, extremozymes and cold-adapted enzymes; enzyme kinetics and specificity.
Unit II: Marine Drug Discovery and Development
Natural product screening methods, extraction and purification techniques; marine pharmaceuticals and secondary metabolites; antimicrobial, antiviral and anticancer compounds from marine organisms; drug discovery pipeline and clinical development processes.
Unit III: Industrial and Biotechnological Applications
Applications of marine enzymes in food, pharmaceutical and cosmetic industries; marine enzymes in bioremediation and biofuel production; nutraceuticals and cosmeceuticals from marine resources; marine biotechnology and blue biotechnology concepts.
Unit IV: Analytical and Molecular Approaches
Chromatography and spectroscopic techniques in marine natural product analysis; molecular docking and computational screening; genomics and metabolomics in marine drug discovery; bioinformatics applications in marine biotechnology.
Unit V: Sustainability, Ethics and Commercialization
Sustainable utilization of marine bioresources; bioprospecting and intellectual property rights; marine conservation and ethical issues; commercialization and entrepreneurship in marine biotechnology; future prospects in marine drug development.
Practicals
Extraction of bioactive compounds from marine organisms; enzyme activity assays; chromatography demonstrations; interpretation of spectroscopic data; screening of antimicrobial activity; preparation of marine biotechnology reports.
References

1. Kim, S.-K. *Marine Biotechnology: Trends and Applications*. Wiley-Blackwell.
2. Kobayashi, J. & Kubota, T. *Handbook of Marine Natural Products*. Springer.
3. McClintock, J. B. & Baker, B. J. *Marine Chemical Ecology*. CRC Press.
4. CSIR-Central Salt and Marine Chemicals Research Institute marine biotechnology and enzyme research publications.
5. CSIR-National Institute of Oceanography marine natural product and marine biotechnology reports.

Major V: Bioinformatics and Computational Marine Biology
Credits: 3+1 = 4
Course Objectives
To introduce bioinformatics and computational tools used in marine biology; to understand sequence analysis, marine databases and computational modelling; to familiarize students with applications in marine biodiversity, genomics and biotechnology.

Unit I: Fundamentals of Bioinformatics and Computational Biology
Scope and importance of bioinformatics; biological databases, nucleotide and protein databases; computational biology concepts; sequence retrieval and management; applications of bioinformatics in marine sciences.
Unit II: Sequence Analysis and Molecular Phylogenetics
DNA, RNA and protein sequence analysis, sequence alignment and similarity searches; molecular phylogenetics and phylogenetic tree construction; molecular markers and DNA barcoding; comparative genomics and biodiversity informatics.
Unit III: Structural Bioinformatics and Computational Modelling
Protein structure prediction and visualization; molecular modelling and docking; computational approaches in marine drug discovery; ligand-receptor interactions; simulation methods and computational screening techniques.
Unit IV: Marine Genomics and Data Science
Marine genomics and metagenomics; omics approaches in marine biology; biodiversity databases and environmental datasets; machine learning and artificial intelligence applications in marine sciences; computational ecology and fisheries modelling.
Unit V: Applications and Emerging Trends
Applications in marine biotechnology, aquaculture and conservation biology; computational approaches in climate and ecosystem studies; ethical issues and data management; cloud computing and big data in marine sciences; future trends in computational marine biology.
Practicals
Sequence database searches, sequence alignment exercises; phylogenetic tree construction; protein visualization and docking demonstrations; analysis of marine genomic datasets; bioinformatics software applications; preparation of computational biology reports.
References

1. Pevsner, J. *Bioinformatics and Functional Genomics*. Wiley-Blackwell.
2. Lesk, A. *Introduction to Bioinformatics*. Oxford University Press.
3. Sunagawa, S. *Marine Genomics*. Springer.
4. Institute of Bioinformatics bioinformatics and computational biology publications.
5. CSIR-National Institute of Oceanography marine genomics and computational marine biology reports.

Semester VIII

Major I: Marine Spatial Planning and Ecosystem Services
Credits: 3+1 = 4
Course Objectives

- To introduce marine spatial planning principles and ecosystem service approaches
- To understand sustainable marine resource management and ocean governance
- To familiarize students with spatial tools, ecosystem valuation and planning strategies in marine ecosystems.

Unit I: Fundamentals of Marine Spatial Planning
Concept and scope of marine spatial planning; principles and objectives of MSP; marine ecosystems and marine resource use patterns; stakeholder participation and governance; ecosystem-based management approaches; spatial conflicts in marine environments; sustainable ocean planning concepts.
Unit II: Marine Ecosystems and Ecosystem Services
Marine ecosystem structure and functioning, coral reefs, mangroves, seagrasses, estuaries and deep-sea ecosystems; ecosystem services classification, provisioning, regulating, cultural and supporting services; ecological and economic importance of marine ecosystem services; blue carbon ecosystems and carbon sequestration.
Unit III: Spatial Tools and Marine Resource Mapping
Marine spatial data and databases; GIS and remote sensing applications in marine sciences; habitat mapping and spatial analysis; marine zoning and suitability analysis; oceanographic and biodiversity datasets; marine environmental monitoring; spatial modelling approaches.
Unit IV: Ecosystem Valuation and Sustainable Management
Economic valuation of ecosystem services; natural capital and ecological economics; fisheries and coastal resource management; marine protected areas and conservation planning; cumulative impact assessment; climate change and coastal vulnerability; marine ecosystem restoration approaches.
Unit V: Policy, Governance and Future Perspectives
Marine governance frameworks; marine spatial planning policies and international guidelines; blue economy and sustainable development goals; integrated coastal and ocean management; marine conflicts and policy interventions; case studies in MSP from India and global marine regions; future trends in marine planning and ecosystem management.
Practicals
Marine habitat mapping exercises; GIS-based marine zoning demonstrations; ecosystem service valuation exercises; interpretation of spatial datasets; preparation of marine spatial planning reports; case study analysis and policy interpretation; field visit to coastal planning or conservation sites.
References

1. Ehler, C. & Douvere, F. *Marine Spatial Planning: A Step-by-Step Approach Toward Ecosystem-Based Management*. UNESCO-IOC.
2. Kaiser, M. J. et al. *Marine Ecology: Processes, Systems, and Impacts*. Oxford University Press.
3. Haines-Young, M. & Potschin, M. *Routledge Handbook of Ecosystem Services*. Routledge.
4. National Centre for Sustainable Coastal Management marine spatial planning and ecosystem management publications.
5. Indian National Centre for Ocean Information Services marine spatial data and coastal mapping reports.

Major II: Advanced Blue Biotechnology and Genetic Engineering
Credits: 3+1 = 4
Course Objectives

- To introduce advanced concepts in blue biotechnology and genetic engineering;
- To understand molecular manipulation techniques and marine biotechnological applications;
- To familiarize students with industrial, pharmaceutical and environmental applications of marine biotechnology.

Unit I: Fundamentals of Blue Biotechnology
Scope and importance of blue biotechnology; marine bioresources and biodiversity; marine microorganisms, algae and invertebrates in biotechnology; marine biomolecules and bioactive compounds; blue biotechnology and sustainable bioresource utilization.
Unit II: Genetic Engineering and Molecular Tools
Principles of genetic engineering; recombinant DNA technology; cloning vectors and host systems; gene transfer methods; CRISPR and genome editing techniques; PCR and molecular diagnostics; transgenic organisms and molecular markers.
Unit III: Marine Genomics and Omics Technologies
Marine genomics and metagenomics; transcriptomics, proteomics and metabolomics; genome sequencing technologies; bioinformatics applications in marine biotechnology; molecular approaches in marine biodiversity and conservation.
Unit IV: Industrial and Pharmaceutical Applications
Marine enzymes and extremozymes; marine pharmaceuticals and nutraceuticals; vaccine development and biomedical applications; aquaculture biotechnology; marine biofuels and bioproducts; bioremediation and environmental biotechnology; industrial applications of marine microorganisms.
Unit V: Biosafety, Ethics and Future Perspectives
Biosafety and biosecurity in biotechnology; ethical issues in genetic engineering; intellectual property rights and bioprospecting; commercialization of marine biotechnological products; blue economy and biotechnology entrepreneurship; future trends in marine genetic engineering and synthetic biology.

Practicals
DNA isolation and PCR demonstrations; cloning and electrophoresis demonstrations; enzyme assays and microbial culture techniques; bioinformatics analysis exercises; interpretation of genomic datasets; preparation of biotechnology reports and case studies.
References
International References

1. Kim, S.-K. *Marine Biotechnology: Trends and Applications*. Wiley-Blackwell.
2. Glick, B. R., Pasternak, J. J. & Patten, C. L. *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. ASM Press.
3. Primrose, S. B. & Twyman, R. *Principles of Gene Manipulation and Genomics*. Blackwell Publishing.
4. CSIR-National Institute of Oceanography marine biotechnology and marine genomics publications.
5. Department of Biotechnology biotechnology guidelines and research publications.

Elective Group III

---

1. Blue Carbon and Nature-based Solutions
Credits: 4+0 = 4

Course Objectives

- To introduce blue carbon ecosystems and carbon sequestration processes
- To understand nature-based solutions for climate adaptation and mitigation
- To familiarize students with ecosystem restoration and sustainable coastal management approaches.

Unit I: Fundamentals of Blue Carbon
Concept and importance of blue carbon; global carbon cycle and oceanic carbon sinks; coastal blue carbon ecosystems, mangroves, seagrasses and salt marshes; carbon sequestration and storage mechanisms; blue carbon productivity and nutrient cycling.

Unit II: Blue Carbon Ecosystems and Ecological Functions
Mangrove ecology and carbon burial; seagrass ecosystem productivity and sediment carbon storage; salt marsh dynamics and carbon accumulation; microbial role in carbon cycling; ecosystem services of blue carbon habitats; biodiversity and climate regulation.

Unit III: Nature-based Solutions and Ecosystem Restoration
Nature-based solutions for climate resilience; ecosystem-based adaptation approaches; mangrove and seagrass restoration; coastal protection and shoreline stabilization; habitat rehabilitation and ecological engineering; blue-green infrastructure concepts.

Unit IV: Carbon Assessment and Climate Mitigation
Carbon stock assessment methods; carbon accounting and valuation; GIS and remote sensing applications in blue carbon assessment; climate mitigation strategies; blue carbon finance and carbon credit systems; ecosystem monitoring and reporting.

Unit V: Governance, Policy and Future Perspectives
International climate agreements and blue carbon initiatives; policy frameworks and coastal governance; community participation and sustainable livelihoods; blue economy and ecosystem conservation; future perspectives in blue carbon science and management.

References

1. Laffoley, D. & Grimsditch, G. *The Management of Natural Coastal Carbon Sinks*. IUCN.
2. Perillo, G. M. E. et al. *Coastal Wetlands: An Integrated Ecosystem Approach*. Elsevier.
3. Intergovernmental Panel on Climate Change climate and blue carbon assessment reports.
4. National Centre for Sustainable Coastal Management blue carbon and coastal ecosystem reports.
5. Ministry of Environment, Forest and Climate Change climate mitigation and coastal ecosystem publications.

2. Marine Spatial Planning
Credits: 4+0 = 4
Course Objectives

- To introduce marine spatial planning concepts and tools;
- To understand marine resource management and spatial governance;
- To familiarize students with ecosystem-based marine planning approaches.

Unit I: Introduction to Marine Spatial Planning
Concept and objectives of marine spatial planning; marine ecosystem structure and resource use patterns; stakeholder participation; ecosystem-based management approaches; spatial conflicts and marine governance.
Unit II: Marine Spatial Data and Mapping
Marine spatial datasets and databases; GIS and remote sensing applications; habitat mapping and marine zoning; oceanographic and biodiversity datasets; spatial analysis techniques and marine mapping methods.
Unit III: Marine Resource Management and Ecosystem Services
Marine ecosystem services and valuation; fisheries and coastal resource management; marine protected areas; blue economy and sustainable ocean use; cumulative impact assessment and environmental planning.
Unit IV: Climate Change and Coastal Planning
Climate change impacts on marine ecosystems; coastal vulnerability assessment; marine pollution and habitat degradation; restoration and resilience planning; ecosystem-based adaptation strategies.
Unit V: Policy, Governance and Case Studies
Marine governance frameworks and international guidelines; marine spatial planning policies in India; integrated coastal and ocean management; case studies in marine spatial planning; future perspectives in sustainable marine management.
References

1. Ehler, C. & Douvere, F. *Marine Spatial Planning: A Step-by-Step Approach Toward Ecosystem-Based Management*. UNESCO-IOC.
2. Kaiser, M. J. et al. *Marine Ecology: Processes, Systems, and Impacts*. Oxford University Press.
3. Humphreys, J. & Clark, R. *Marine Protected Areas and Ocean Conservation*. Earthscan.
4. National Centre for Sustainable Coastal Management marine spatial planning reports.
5. Indian National Centre for Ocean Information Services marine GIS and spatial data publications.

3. Artificial Intelligence Applications in Marine Sciences
Credits: 4+0 = 4
Course Objectives

- To introduce artificial intelligence and machine learning applications in marine sciences;
- To understand computational approaches in oceanography, fisheries and biodiversity studies;
- To familiarize students with marine data analytics and predictive modelling.

Unit I: Fundamentals of Artificial Intelligence and Data Science
Concepts of artificial intelligence and machine learning; types of machine learning; marine datasets and databases; data preprocessing and visualization; programming basics and computational tools.
Unit II: Machine Learning in Marine Biology and Ecology
Species identification using AI; biodiversity informatics; ecological modelling; fisheries stock prediction; marine habitat classification; image analysis and pattern recognition in marine systems.
Unit III: AI Applications in Oceanography and Climate Studies
Oceanographic data analysis; satellite and remote sensing applications; ocean forecasting and climate modelling; AI in weather prediction and disaster warning systems; marine pollution monitoring using AI approaches.
Unit IV: Marine Robotics and Smart Technologies
Autonomous underwater vehicles and remotely operated systems; smart sensors and telemetry; AI-assisted ocean exploration; marine observation networks; computational ocean monitoring systems.
Unit V: Ethics, Challenges and Future Perspectives
Limitations and ethical considerations in AI; data security and management; decision support systems in marine governance; future trends in marine artificial intelligence and computational ocean sciences.
References

1. Russell, S. & Norvig, P. *Artificial Intelligence: A Modern Approach*. Pearson.
2. McKinney, W. *Python for Data Analysis*. O'Reilly Media.
3. James, G. et al. *An Introduction to Statistical Learning*. Springer.
4. Indian National Centre for Ocean Information Services ocean data and forecasting publications.
5. National Institute of Ocean Technology marine robotics and ocean technology reports.

4. Marine Environmental Impact Assessment
Credits: 4+0 = 4
Course Objectives

- To introduce principles and methodologies of Environmental Impact Assessment in marine ecosystems;
- To understand environmental monitoring and risk assessment;
- To familiarize students with marine environmental regulations and sustainable management approaches.

Unit I: Fundamentals of Environmental Impact Assessment
Concept and scope of EIA; environmental management principles; stages of environmental impact assessment; baseline environmental studies; screening and scoping methods; environmental indicators and monitoring approaches.
Unit II: Marine Ecosystems and Impact Assessment
Marine ecosystem structure and functioning; assessment of impacts on estuaries, mangroves, coral reefs and coastal ecosystems; biodiversity assessment methods; habitat evaluation and ecological indicators; cumulative impact assessment.
Unit III: Marine Pollution and Risk Assessment
Sources and impacts of marine pollution; ecotoxicological assessment; environmental risk analysis; oil spills and coastal contamination; climate change impacts and vulnerability assessment; environmental auditing and compliance.
Unit IV: EIA Tools, Modelling and Regulatory Frameworks
GIS and remote sensing applications in EIA; modelling approaches in environmental assessment; environmental management plans; Environmental Impact Assessment Notification in India; international environmental conventions and policies.
Unit V: Sustainable Development and Case Studies
Coastal infrastructure and developmental projects; fisheries and aquaculture impact assessment; marine renewable energy projects; stakeholder participation and public consultation; case studies in marine EIA; future perspectives in marine environmental management.
References

1. Canter, L. W. *Environmental Impact Assessment*. McGraw-Hill.
2. Glasson, J., Therivel, R. & Chadwick, A. *Introduction to Environmental Impact Assessment*. Routledge.
3. Kaiser, M. J. et al. *Marine Ecology: Processes, Systems, and Impacts*. Oxford University Press.
4. Ministry of Environment, Forest and Climate Change EIA notifications and environmental guidelines.
5. National Centre for Sustainable Coastal Management coastal environmental assessment reports.

5. Advanced Blue Biotechnology
Credits: 4+0 = 4
Course Objectives

- To introduce advanced marine biotechnology and blue biotechnology applications;
- to understand marine genetic engineering, industrial biotechnology and marine drug development;
- to familiarize students with omics technologies and marine bioresource utilization.

Unit I: Marine Bioresources and Blue Biotechnology
Marine biodiversity as a biotechnological resource; marine microorganisms, algae and invertebrates in biotechnology; marine biomolecules and bioactive compounds; blue biotechnology concepts and applications.
Unit II: Molecular and Genetic Engineering Approaches
Recombinant DNA technology; cloning vectors and gene transfer methods; CRISPR and genome editing; molecular markers and diagnostics; transgenic approaches and marine genomics.
Unit III: Marine Omics and Bioinformatics
Genomics, transcriptomics, proteomics and metabolomics; sequencing technologies; marine bioinformatics and computational biology; molecular screening and biomarker discovery.
Unit IV: Industrial and Pharmaceutical Applications
Marine enzymes and extremozymes; marine pharmaceuticals and nutraceuticals; marine drug discovery; aquaculture biotechnology; marine biofuels and bioremediation; industrial biotechnology applications.
Unit V: Biosafety, Commercialization and Future Perspectives
Bioprospecting and intellectual property rights; biosafety and ethical issues; blue economy and biotechnology entrepreneurship; commercialization of marine biotechnology products; future perspectives in synthetic biology and marine biotechnology.
References

1. Kim, S.-K. *Marine Biotechnology: Trends and Applications*. Wiley-Blackwell.
2. Glick, B. R., Pasternak, J. J. & Patten, C. L. *Molecular Biotechnology*. ASM Press.
3. Primrose, S. B. & Twyman, R. *Principles of Gene Manipulation and Genomics*. Blackwell Publishing.
4. CSIR-National Institute of Oceanography marine biotechnology and genomics publications.
5. Department of Biotechnology biotechnology guidelines and marine biotechnology reports.

Elective Group IV

---

1. Ecosystem Services Valuation
Credits: 4+0 = 4
Course Objectives

- To introduce ecosystem services and valuation approaches;
- To understand ecological economics and natural capital concepts;
- To familiarize students with valuation methods and sustainable ecosystem management.

Unit I: Fundamentals of Ecosystem Services
Concept and classification of ecosystem services, provisioning, regulating, cultural and supporting services; ecosystem structure and functioning; ecological processes and ecosystem productivity; natural capital and sustainability concepts.
Unit II: Marine and Coastal Ecosystem Services
Ecosystem services of mangroves, seagrasses, coral reefs, estuaries and coastal wetlands; fisheries and aquaculture services; blue carbon ecosystems and climate regulation; biodiversity and ecosystem resilience; ecosystem degradation and loss of services.
Unit III: Valuation Methods and Ecological Economics
Economic valuation principles; direct and indirect valuation methods; market and non-market valuation; contingent valuation and willingness-to-pay approaches; cost-benefit analysis; environmental accounting and natural resource economics.
Unit IV: Spatial Tools and Ecosystem Assessment
GIS and remote sensing applications in ecosystem valuation; ecosystem service mapping; ecological indicators and monitoring; environmental modelling; climate change and ecosystem vulnerability assessment; decision support systems.
Unit V: Policy, Governance and Sustainable Management
Ecosystem-based management approaches; policy frameworks and environmental governance; payment for ecosystem services; blue economy and sustainable development goals; community participation and conservation planning; case studies in ecosystem valuation.

References

1. Kumar, P. *The Economics of Ecosystems and Biodiversity*. Earthscan.
2. Haines-Young, M. & Potschin, M. *Routledge Handbook of Ecosystem Services*. Routledge.
3. Daly, H. & Farley, J. *Ecological Economics: Principles and Applications*. Island Press.
4. National Centre for Sustainable Coastal Management ecosystem service and coastal valuation reports.
5. Ministry of Environment, Forest and Climate Change ecosystem assessment and environmental economics publications.

2. Advanced Statistical Modelling
Credits: 4+0 = 4

Course Objectives

- To introduce advanced statistical methods and modelling approaches used in biological and marine sciences;
- To familiarize students with predictive modelling, multivariate analysis and computational tools.

Unit I: Statistical Foundations and Data Structures
Probability distributions, sampling theory and hypothesis testing; biological and environmental datasets; experimental design and data quality assessment; statistical software and computational tools.

Unit II: Regression and Multivariate Analysis
Linear and nonlinear regression models; generalized linear models; correlation and covariance analysis; principal component analysis; cluster analysis; discriminant analysis; multivariate ecological datasets.

Unit III: Time Series and Spatial Modelling
Time series analysis in marine sciences; forecasting and trend analysis; spatial statistics and geostatistics; GIS-based statistical modelling; environmental and fisheries datasets; climate and oceanographic data analysis.

Unit IV: Machine Learning and Predictive Analytics
Machine learning concepts and algorithms; supervised and unsupervised learning; classification and clustering techniques; predictive modelling in ecology and fisheries; neural networks and artificial intelligence applications.

Unit V: Applications in Marine and Environmental Sciences
Ecological and fisheries modelling; biodiversity and habitat suitability modelling; environmental impact prediction; statistical approaches in genomics and bioinformatics; decision support systems and future perspectives in marine data science.

References

International References

1. Johnson, R. A. & Wichern, D. W. *Applied Multivariate Statistical Analysis*. Pearson.
2. James, G. et al. *An Introduction to Statistical Learning*. Springer.
3. Crawley, M. J. *The R Book*. Wiley.
4. Arora, P. N. & Malhan, P. K. *Biostatistics*. Himalaya Publishing House.
5. Indian National Centre for Ocean Information Services oceanographic data analysis publications.

3. Conservation Genetics and Genomics
Credits: 4+0 = 4
Course Objectives

- To introduce genetic and genomic approaches in biodiversity conservation;
- To understand population genetics, molecular markers and conservation genomics;
- To familiarize students with applications in marine biodiversity management.

Unit I: Fundamentals of Conservation Genetics
Genetic diversity and population structure; Hardy-Weinberg equilibrium; inbreeding and genetic drift; gene flow and population connectivity; molecular evolution and adaptation; conservation genetics concepts.
Unit II: Molecular Markers and Genetic Analysis
DNA markers, microsatellites, SNPs and mitochondrial DNA; DNA barcoding and phylogenetics; population genetic analysis; molecular taxonomy and biodiversity assessment; genetic monitoring methods.
Unit III: Conservation Genomics and Omics Approaches
Genome sequencing technologies; comparative genomics; transcriptomics and proteomics in conservation biology; environmental DNA and metagenomics; bioinformatics tools in conservation genomics.
Unit IV: Applications in Marine Conservation
Genetic management of endangered species; fisheries genetics and stock structure analysis; marine protected areas and connectivity studies; invasive species genetics; climate change and adaptive genomics; restoration genetics.
Unit V: Ethics, Policies and Future Perspectives
Ethical issues in conservation genetics; genetic resource governance and intellectual property rights; biodiversity conventions and policies; future trends in conservation genomics and molecular ecology.
References

1. Allendorf, F. W., Luikart, G. & Aitken, S. N. *Conservation and the Genetics of Populations*. Wiley-Blackwell.
2. Frankham, R. et al. *Introduction to Conservation Genetics*. Cambridge University Press.
3. Freeland, J. R. *Molecular Ecology*. Wiley-Blackwell.
4. National Bureau of Fish Genetic Resources fisheries genetics and biodiversity publications.
5. CSIR-National Institute of Oceanography marine genomics and biodiversity reports.

4. Genetic Engineering
Credits: 4+0 = 4

Course Objectives

- To introduce principles and applications of genetic engineering;
- To understand recombinant DNA technology and molecular manipulation techniques;
- To familiarize students with biotechnology applications in marine and environmental sciences.

Unit I: Fundamentals of Genetic Engineering
Principles of molecular biology; recombinant DNA technology; enzymes used in genetic engineering, restriction enzymes and ligases; vectors and cloning systems; host organisms and gene transfer methods.

Unit II: Molecular Cloning and Gene Expression
DNA cloning strategies; polymerase chain reaction; gene libraries and screening methods; gene expression systems; sequencing technologies; molecular diagnostics and marker-assisted analysis.

Unit III: Genome Editing and Advanced Molecular Techniques
CRISPR-Cas systems and genome editing; transgenic organisms; RNA interference; synthetic biology concepts; omics technologies and bioinformatics approaches in genetic engineering.

Unit IV: Applications in Marine and Environmental Sciences
Marine biotechnology and aquaculture applications; genetically modified organisms in fisheries and aquaculture; marine bioactive compounds and pharmaceutical biotechnology; environmental biotechnology and bioremediation.

Unit V: Biosafety, Ethics and Regulations
Biosafety and biosecurity; ethical issues in genetic engineering; intellectual property rights and patenting; biotechnology regulations and governance; public perception and policy frameworks; future trends in genetic engineering.

References

1. Glick, B. R., Pasternak, J. J. & Patten, C. L. *Molecular Biotechnology*. ASM Press.
2. Primrose, S. B. & Twyman, R. *Principles of Gene Manipulation and Genomics*. Blackwell Publishing.
3. Watson, J. D. et al. *Recombinant DNA: Genes and Genomes*. W.H. Freeman.
4. Department of Biotechnology biotechnology regulations and biosafety guidelines.
5. CSIR-National Institute of Oceanography marine biotechnology and genetic engineering publications.

5. Marine Biotechnology Ethics, Regulations and Intellectual Property
Credits: 4+0 = 4

Course Objectives
To introduce ethical, legal and regulatory aspects of marine biotechnology; to understand intellectual property rights and bioprospecting governance; to familiarize students with biosafety and commercialization issues in marine biotechnology.

Unit I: Fundamentals of Marine Biotechnology Ethics
Ethics in biotechnology and marine bioprospecting; ethical issues in marine genetic resource utilization; environmental ethics and sustainable resource use; biosafety and biosecurity concepts.

Unit II: Intellectual Property Rights and Patents
Principles of intellectual property rights; patents, copyrights and trademarks; patenting of marine biological resources and bioactive compounds; patent databases and patent search methods; technology transfer and commercialization.

Unit III: Regulations and Governance
National and international biotechnology regulations; Convention on Biological Diversity and Nagoya Protocol; biosafety regulations and risk assessment; governance of marine genetic resources and areas beyond national jurisdiction.

Unit IV: Marine Bioprospecting and Commercialization
Bioprospecting approaches and access benefit sharing; marine pharmaceuticals and industrial biotechnology; entrepreneurship and start-up concepts; commercialization pathways in marine biotechnology.

Unit V: Emerging Issues and Future Perspectives
Synthetic biology and genome editing ethics; digital sequence information governance; public engagement and science communication; future trends in marine biotechnology governance and policy.

References

1. Talbot, M. *Bioethics: An Introduction*. Cambridge University Press.
2. Bouchoux, D. E. *Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets*. Cengage Learning.
3. Convention on Biological Diversity Nagoya Protocol and ABS guidelines.
4. Department of Biotechnology biotechnology ethics and biosafety guidelines.
5. Council of Scientific and Industrial Research intellectual property and marine biotechnology publications.

6. Scientific Review Writing, Professional Skills and Seminar

Credits: 2 (0+2)

Course Objectives

The course aims to:

1. Develop skills in critical reading, evaluation and synthesis of scientific literature.
2. Familiarize students with the structure, organization and preparation of scientific review articles.
3. Develop skills in scientific writing, referencing, scientific communication and presentation.
4. Introduce students to research grant and project proposal writing.
5. Develop professional communication, networking and career-readiness skills relevant to marine biology and allied sectors.
6. Train students in preparation of professional CVs, LinkedIn profiles, interviews and scientific presentations.
7. Provide practical experience in presenting and defending scientific information before an academic and professional audience.

Unit I: Scientific Literature and Critical Reading

Nature and types of scientific literature; primary research articles, review articles, systematic reviews, meta-analyses, technical reports and policy documents; structure of scientific publications; identification of reliable scientific sources; literature-search strategies; use of scholarly databases; formulation of search terms and Boolean operators; citation tracking; critical reading and evaluation of scientific papers; assessment of objectives, methodology, results and conclusions; identification of strengths, limitations, inconsistencies and research gaps.

Practical/Activity:

Literature search on a selected marine biology topic; critical appraisal of research articles; preparation of an annotated bibliography and literature matrix.

Unit II: Scientific Review Writing

Types and structure of scientific reviews; selection and formulation of a review topic; defining scope and objectives; organization and synthesis of scientific literature; thematic analysis and comparison of published evidence; identification of knowledge gaps; development of conceptual frameworks; preparation of scientific tables, figures and graphical abstracts; scientific argumentation and logical flow; paraphrasing and appropriate citation; plagiarism and research integrity; responsible use of digital and AI-assisted tools in scientific writing; preparation of title, abstract, keywords, introduction, thematic sections, discussion, conclusion and future perspectives.

Practical/Activity:

Preparation of a structured review outline; literature synthesis table; drafting of selected sections of a scientific review; preparation of a graphical abstract/conceptual figure.

Unit III: Scientific Communication and Research Proposal Writing

Principles of scientific writing and editing; preparation of scientific abstracts, summaries and research highlights; formulation of research questions, hypotheses and objectives; development of research rationale; introduction to **research grant and project proposal writing**; components of a research proposal; project justification, methodology, work plan, timeline, budget, expected outcomes and deliverables; preparation of academic and industry-oriented project concept notes; communicating scientific information to non-specialist audiences.

Practical/Activity:
Preparation of a mini research proposal/industry project concept note; preparation of a one-page research proposal summary.

Unit IV: Professional Skills and Career Readiness
Professional communication in academic, research and industry environments; preparation of academic and industry-oriented CVs/resumes; **LinkedIn profile development and optimization**; professional email communication; personal branding and professional digital identity; career opportunities in marine biology, fisheries, aquaculture, marine biotechnology, conservation, environmental consultancy, ocean technology and blue economy sectors; professional networking strategies; interaction with alumni, researchers, industry professionals and potential employers; workplace etiquette, teamwork and professional conduct.
Practical/Activity:
CV preparation and peer review; LinkedIn profile development; professional email-writing exercise; alumni/industry interaction and networking session.

Unit V: Scientific Seminar and Interview Skills
Principles of effective scientific presentation; organization and delivery of scientific seminars; preparation of presentation slides; scientific figures, tables and visual communication; communicating complex scientific information clearly; scientific poster preparation; handling questions and scientific discussions; seminar etiquette; peer review and constructive feedback; **mock interviews**; group discussions; interview etiquette; communication of academic qualifications, research experience and professional competencies; presentation of scientific and professional profiles before academic and industry audiences.
Practical/Activity:
Scientific seminar presentation; poster/graphical abstract presentation; mock interview; group discussion; peer evaluation of presentations.

Suggested Assessment Scheme

Component	**Marks**
Literature search, critical appraisal & annotated bibliography	10
Scientific review/mini-review	25
Research/industry project proposal	15
Scientific seminar	20
Scientific poster/graphical abstract	10
CV and LinkedIn profile	5
Mock interview/group discussion	10
Professional networking activity	5
Total	**100**

Semester IX

Major I: Marine Protected Area Design and Management
Credits: 3+1 = 4
Course Objectives

- To develop advanced understanding of marine protected area science, ecosystem-based conservation planning and adaptive management;
- To integrate ecological, socioeconomic and governance dimensions in marine conservation.

Unit I: Advanced Concepts in Marine Protected Areas
Evolution of marine conservation paradigms; ecological theory underlying protected area design; connectivity theory, metapopulation dynamics and larval dispersal; resilience and resistance in marine ecosystems; ecological thresholds and tipping points; ecosystem service approaches in MPA planning; climate-smart marine conservation.
Unit II: Spatial Ecology and Protected Area Design
Advanced marine spatial planning approaches; habitat suitability modelling; ecological niche modelling; systematic conservation planning; GIS and remote sensing applications in biodiversity prioritization; seascape ecology and connectivity analysis; ecological risk assessment; decision-support tools in marine conservation.
Unit III: Monitoring, Assessment and Adaptive Management
Advanced biodiversity monitoring methods, ecological indicators and long-term ecological observatories; fisheries-independent assessment approaches; restoration ecology and coral reef rehabilitation; adaptive management frameworks; ecosystem modelling and cumulative impact assessment; climate change adaptation in MPAs.
Unit IV: Governance, Policy and Socioecological Systems
Polycentric governance and co-management frameworks; socioecological resilience and community-based conservation; ecosystem-based fisheries management within MPAs; legal frameworks under CBD, UNCLOS and BBNJ agreements; environmental justice and marine resource conflicts; economics of marine conservation.
Unit V: Emerging Frontiers and Global Case Studies
High seas protected areas and deep-sea conservation; blue carbon and nature-based solutions within MPAs; AI and autonomous monitoring systems in conservation; evaluation of management effectiveness; global case studies in large-scale MPA networks; future directions in marine conservation science.
Practicals
Spatial prioritization exercises using GIS; biodiversity and habitat connectivity analysis; ecological modelling and conservation planning exercises; interpretation of satellite and oceanographic datasets; MPA effectiveness assessment; preparation of advanced conservation management plans and policy reports.
References

1. Humphreys, J. & Clark, R. *Marine Protected Areas and Ocean Conservation*. Earthscan.
2. Norse, E. A. & Crowder, L. B. *Marine Conservation Biology*. Island Press.
3. Kaiser, M. J. et al. *Marine Ecology: Processes, Systems, and Impacts*. Oxford University Press.
4. National Centre for Sustainable Coastal Management marine conservation and spatial planning publications.
5. Wildlife Institute of India marine protected area management reports.

Major II: Blue Economy Pathways and Sustainable Development
Credits: 3+1 = 4
Course Objectives

- To critically evaluate blue economy frameworks and sustainable ocean development strategies;
- To integrate ecological economics, governance and technological innovations in marine resource management.

Unit I: Advanced Concepts in Blue Economy
Blue economy paradigms and critiques; ocean sustainability and planetary boundaries; ecological economics and natural capital accounting; ecosystem services and blue growth; marine resource governance and socioecological systems; sustainable development goals and ocean policy integration.
Unit II: Emerging Marine Industries and Innovation Systems
Advanced fisheries and aquaculture systems; offshore renewable energy technologies, including offshore wind and tidal energy; ecological impacts and safeguards; environmental assessment and marine spatial planning for renewable energy development; marine biotechnology and biopharmaceutical industries; deep sea mining and seabed resource governance; maritime logistics and smart ports; digital ocean economy and innovation ecosystems.
Unit III: Climate Change, Blue Carbon and Sustainability Transitions
Blue carbon ecosystems and carbon sequestration dynamics; climate adaptation and resilience pathways; circular economy and low-carbon marine industries; marine pollution mitigation technologies; ecosystem restoration and nature-based solutions; climate finance and carbon markets.
Unit IV: Ocean Governance and Environmental Economics
Marine spatial planning and integrated ocean governance; valuation of marine ecosystem services; environmental impact assessment and strategic environmental assessment; blue finance, carbon credit systems and sustainable investment frameworks; international ocean governance and policy instruments; translation of scientific evidence into policy recommendations for ocean governance and sustainable marine resource management.
Unit V: Future Pathways and Global Perspectives
Artificial intelligence and automation in blue economy sectors; sustainable entrepreneurship and innovation; geopolitical dimensions of ocean resources; ethics and equity in blue economy development; future scenarios in ocean sustainability and global marine governance.

Practicals
Blue economy policy analysis; ecosystem service valuation exercises; GIS-based marine resource mapping and spatial planning exercises for offshore renewable energy development; assessment of potential ecological impacts and environmental safeguards.; carbon accounting and sustainability assessment; analysis of environmental and economic datasets; Preparation of strategic blue economy frameworks, evidence-based policy briefs and policy recommendations for ocean governance and sustainable marine resource management.
References

1. Pauli, G. *The Blue Economy*. Paradigm Publications.
2. Daly, H. & Farley, J. *Ecological Economics: Principles and Applications*. Island Press.
3. de Langen, P. W. & Merk, O. *The Blue Economy and Ports*. OECD Publishing.
4. NITI Aayog blue economy policy framework documents.
5. Ministry of Earth Sciences blue economy and ocean sustainability reports.


KERALA UNIVERSITY OF FISHERIES & OCEAN STUDIES - KUFOS
Est 2010

Major III: Nanobiotechnology and Marine Functional Products
Credits: 3+1 = 4
Course Objectives
To introduce advanced nanobiotechnology and marine-derived functional products; to understand nano-enabled marine biotechnology, biomaterials and translational applications in pharmaceuticals, diagnostics and industry.

Unit I: Advanced Nanobiotechnology and Marine Nanomaterials
Principles of nanobiotechnology; physicochemical properties of nanomaterials; synthesis and characterization of nanoparticles; marine biomineralization and nano-biomaterials; nanoformulations and nanocarriers; marine microorganisms and algae in nanoparticle biosynthesis.
Unit II: Marine Functional Biomolecules and Bioactive Products
Marine secondary metabolites and functional biomolecules; marine peptides, polysaccharides and pigments; marine-derived antioxidants and nutraceuticals; bioactive compounds from algae, sponges and marine microbes; metabolomics approaches in marine product discovery.
Unit III: Nano-enabled Drug Delivery and Biomedical Applications
Nanocarriers and targeted drug delivery systems; marine biomaterials in tissue engineering and regenerative medicine; biosensors and nano-diagnostics; nano-encapsulation technologies; marine compounds in anticancer and antimicrobial therapeutics; translational marine biotechnology.
Unit IV: Industrial Biotechnology and Environmental Applications
Marine enzymes and extremozymes in nanobiotechnology; industrial biocatalysis and bioprocess engineering; nano-enabled aquaculture and fisheries technologies; nanotechnology in marine pollution remediation and environmental monitoring; bioresource valorization and waste-to-value approaches.
Unit V: Nanotoxicology, Commercialization and Future Perspectives
Nanotoxicology and environmental safety; biosafety and ethical considerations; intellectual property rights and commercialization of marine nanoproducts; regulatory frameworks in nanobiotechnology; synthetic biology and future trends in marine functional product development.
Practicals
Nanoparticle synthesis and characterization demonstrations; extraction and purification of marine bioactive compounds; spectroscopic and chromatographic analyses; molecular docking and computational screening exercises; nanoformulation case studies; preparation of marine biotechnology product reports.
References

1. Niemeyer, C. M. & Mirkin, C. A. *Nanobiotechnology: Concepts, Applications and Perspectives*. Wiley-VCH.
2. Kim, S.-K. *Marine Biotechnology: Trends and Applications*. Wiley-Blackwell.
3. Kobayashi, J. & Kubota, T. *Handbook of Marine Natural Products*. Springer.
4. CSIR-Central Salt and Marine Chemicals Research Institute marine nanotechnology and marine biomaterials publications.
5. CSIR-National Institute of Oceanography marine biotechnology and marine natural product reports.

Elective Group V

---

1. Ocean Governance and Maritime Law
Credits: 4+0 = 4

Course Objectives

- To introduce ocean governance systems and maritime law;
- To understand international legal frameworks related to oceans and marine resources;
- To familiarize students with marine policy, governance and maritime security issues.

Unit I: Fundamentals of Ocean Governance
Concept and evolution of ocean governance; law of the sea principles; maritime zones and jurisdiction; marine resource governance; institutional frameworks in ocean management; sustainable ocean governance concepts.

Unit II: Maritime Law and International Conventions
United Nations Convention on the Law of the Sea, territorial sea, EEZ and continental shelf; navigation rights and maritime boundaries; marine environmental protection laws; fisheries and biodiversity conventions; dispute settlement mechanisms.

Unit III: Governance of Marine Resources and ABNJ
Governance of fisheries and marine biodiversity; deep sea mining regulations; marine genetic resources; biodiversity beyond national jurisdiction agreements; marine protected areas in international waters; blue economy governance.

Unit IV: Maritime Security, Coastal Management and Environmental Governance
Maritime security and piracy; marine pollution governance; climate change and ocean governance; marine spatial planning and integrated coastal management; geopolitical dimensions of ocean resources. National Centre for Sustainable Coastal Management (NCSCM), objectives, institutional frameworks and relevance to coastal and marine ecosystem conservation, sustainable resource management and ocean governance. National Coastal Mission from 2025 - 2031

Unit V: Emerging Issues and Future Perspectives
Ocean diplomacy and international cooperation; marine environmental justice; digital governance and marine data systems; sustainable development goals and ocean governance; future trends in maritime policy and governance.

References

1. Tanaka, Y. *The International Law of the Sea*. Cambridge University Press.
2. Scarff, J. P. *Ocean Politics and Policy*. Routledge.
3. United Nations UNCLOS and BBNJ agreement documents.
4. Indian Society of International Law maritime law and ocean governance publications.
5. Ministry of Earth Sciences ocean governance reports.

2. Water Quality Management
Credits: 4+0 = 4
Course Objectives

- To understand principles of water quality assessment and management;
- To introduce physicochemical and biological monitoring methods;
- To familiarize students with marine and coastal water quality standards and treatment approaches.

Unit I: Fundamentals of Water Quality
Water quality parameters, temperature, salinity, pH, dissolved oxygen and nutrients; physical, chemical and biological characteristics of marine and estuarine waters; water quality standards and indices.
Unit II: Marine Pollution and Water Contamination
Sources of marine pollution, sewage, industrial effluents, plastics and oil spills; eutrophication and harmful algal blooms; heavy metals and toxic contaminants; microbial contamination and public health concerns.
Unit III: Water Quality Monitoring and Assessment
Sampling techniques and monitoring methods; biological indicators and bioassays; remote sensing and GIS applications; environmental impact assessment and ecological indicators; statistical analysis of water quality data.
Unit IV: Water Treatment and Management Approaches
Wastewater treatment systems; desalination technologies; bioremediation and phytoremediation; integrated coastal water management; aquaculture water quality management; pollution control measures.
Unit V: Climate Change and Sustainable Water Management
Climate change impacts on marine water quality; ocean acidification and hypoxia; sustainable water resource management; policy frameworks and environmental regulations; future perspectives in marine water quality management.

References

1. Clark, R. B. *Marine Pollution*. Oxford University Press.
2. APHA. *Standard Methods for the Examination of Water and Wastewater*. American Public Health Association.
3. Chapman, D. *Water Quality Assessments*. UNESCO/WHO/UNEP.
4. Central Pollution Control Board coastal water quality manuals and reports.
5. National Institute of Oceanography marine water quality publications.

3. Community-based Coastal Management
Credits: 4+0 = 4
Course Objectives

- To introduce participatory coastal management approaches;
- To understand community engagement, traditional knowledge and sustainable livelihood systems;
- To familiarize students with socioecological governance in coastal ecosystems.

Unit I: Fundamentals of Community-based Coastal Management
Concept and principles of participatory coastal management; coastal communities and livelihood systems; traditional ecological knowledge; social and ecological dimensions of coastal ecosystems.
Unit II: Coastal Resource Use and Livelihoods
Fisheries and aquaculture livelihoods; tourism and coastal economies; resource dependency and sustainability; gender dimensions in coastal management; socioeconomic assessment methods.
Unit III: Participatory Governance and Conflict Resolution
Stakeholder participation and co-management; institutional frameworks in coastal governance; community-based conservation approaches; conflict resolution in coastal resource management; environmental justice and equity.
Unit IV: Climate Change and Coastal Resilience
Climate vulnerability in coastal communities; disaster risk reduction and adaptation; ecosystem-based resilience approaches; community participation in restoration and conservation programmes.
Unit V: Policy Frameworks and Case Studies
Integrated coastal zone management and policy frameworks; sustainable development goals and blue economy; case studies from Indian and global coastal communities; future perspectives in participatory coastal governance.
References

1. White, A. T. et al. *Community-Based Coastal Resource Management in Asia and the Pacific*. ICLARM.
2. Clark, J. R. *Integrated Coastal Management*. Island Press.
3. Carter, L. *Coastal Governance*. CRC Press.
4. National Centre for Sustainable Coastal Management community-based coastal management reports.
5. M. S. Swaminathan Research Foundation coastal livelihood and resilience publications.

4. Conservation Genetics and Genomics
Credits: 4+0 = 4

Course Objectives
To introduce advanced genetic and genomic tools in conservation biology; to understand population genetics, adaptive genomics and biodiversity conservation strategies.

Unit I: Population Genetics and Genetic Diversity
Population structure and genetic variation; Hardy-Weinberg equilibrium; genetic drift, inbreeding and gene flow; adaptive evolution and population connectivity.
Unit II: Molecular Markers and Genomic Approaches
Microsatellites, SNPs and mitochondrial DNA markers; DNA barcoding and phylogenetics; comparative genomics and metagenomics; environmental DNA approaches.
Unit III: Conservation Genomics and Biodiversity Assessment
Genome sequencing technologies; transcriptomics and proteomics; biodiversity informatics; ecological genomics and climate adaptation studies.
Unit IV: Applications in Marine Conservation
Genetics of threatened marine species; fisheries stock assessment and connectivity; invasive species genetics; restoration genetics and assisted evolution approaches.
Unit V: Ethics, Governance and Future Perspectives
Genetic resource governance; biodiversity conventions and policies; ethical issues in conservation genomics; future perspectives in molecular conservation biology.
References

1. Allendorf, F. W. et al. *Conservation and the Genetics of Populations*. Wiley-Blackwell.
2. Frankham, R. et al. *Introduction to Conservation Genetics*. Cambridge University Press.
3. Freeland, J. R. *Molecular Ecology*. Wiley-Blackwell.
4. National Bureau of Fish Genetic Resources fisheries genetics publications.
5. CSIR-National Institute of Oceanography marine genomics reports.

Elective Group VI

---

5. Threatened Marine Species Management
Credits: 4+0 = 4

Course Objectives
To introduce conservation and management approaches for threatened marine species; to understand ecological threats, recovery planning and biodiversity conservation strategies.

Unit I: Threatened Marine Biodiversity
Concept of threatened species; IUCN categories and red listing; threatened marine mammals, turtles, sharks, corals and fishes; endemic and keystone marine species.

Unit II: Threats and Ecological Impacts
Habitat degradation and fragmentation; overexploitation and bycatch; climate change and ocean acidification; invasive species and pollution impacts; disease outbreaks and ecological imbalance.

Unit III: Monitoring and Conservation Approaches
Species monitoring and tagging methods; population assessment and demographic analysis; marine protected areas and species recovery programmes; captive breeding and restoration approaches.

Unit IV: Governance and Conservation Policies
Wildlife protection laws and conventions; CITES and Convention on Biological Diversity; ecosystem-based conservation; community participation and citizen science.

Unit V: Emerging Technologies and Future Perspectives
Genomics and AI applications in conservation; conservation planning tools; marine spatial planning for threatened species; future directions in marine biodiversity conservation.

References

1. Norse, E. A. & Crowder, L. B. *Marine Conservation Biology*. Island Press.
2. Soulé, M. E. *Conservation Biology*. Sinauer Associates.
3. International Union for Conservation of Nature threatened species assessment reports.
4. Wildlife Institute of India marine species conservation publications.
5. Zoological Survey of India marine biodiversity assessment reports.

6. Marine Biofuels and Functional Foods
Credits: 4+0 = 4
Course Objectives

- To introduce marine biofuels and marine-derived functional foods;
- To understand bioresource utilization, bioprocessing and nutraceutical applications.

Unit I: Marine Biomass and Biofuel Resources
Marine algae and microbial biomass; biofuel feedstocks; biodiesel, bioethanol and biogas production; biomass productivity and cultivation systems.
Unit II: Biofuel Production Technologies
Pretreatment and extraction methods; fermentation and transesterification processes; algal bioreactors and cultivation technologies; bioprocess optimization and scale-up approaches.
Unit III: Marine Functional Foods and Nutraceuticals
Marine bioactive compounds and nutraceuticals; omega-3 fatty acids, pigments and peptides; marine probiotics and functional ingredients; food safety and quality control.
Unit IV: Industrial Applications and Sustainability
Marine biorefineries and circular economy; waste valorization and integrated bioprocessing; environmental impacts and sustainability assessment; commercialization of marine biofuels and foods.
Unit V: Future Perspectives and Innovations
Synthetic biology and metabolic engineering; advanced marine biotechnology approaches; policy frameworks and blue economy perspectives; future trends in marine bioenergy and nutraceutical industries.
References

1. Pandey, A. et al. *Biofuels from Algae*. Elsevier.
2. Kim, S.-K. *Marine Nutraceuticals*. CRC Press.
3. Marangoni, A. G. *Algal Biorefineries*. Springer.
4. CSIR-Central Salt and Marine Chemicals Research Institute algal biotechnology publications.
5. Department of Biotechnology marine biotechnology and biofuel reports.

7. Marine Bioremediation and Environmental Biotechnology
Credits: 4+0 = 4
Course Objectives

- To introduce environmental biotechnology and marine bioremediation approaches
- To understand microbial and enzymatic remediation processes in marine ecosystems.

Unit I: Fundamentals of Environmental Biotechnology
Concept and scope of environmental biotechnology; marine microorganisms and enzymes; biodegradation and biotransformation processes; environmental microbiology basics.
Unit II: Marine Pollution and Remediation Processes
Oil spills and hydrocarbon degradation; plastic and microplastic biodegradation; heavy metal remediation; nutrient removal and wastewater treatment technologies.
Unit III: Biotechnological Tools and Applications
Bioreactors and biofilm systems; genetically engineered microorganisms; biosensors and environmental monitoring; omics approaches in environmental biotechnology.
Unit IV: Ecosystem Restoration and Sustainability
Bioremediation in mangroves, estuaries and coastal systems; phytoremediation and algal remediation; ecosystem restoration and resilience; circular bioeconomy approaches.
Unit V: Regulations and Future Perspectives
Environmental policies and biosafety regulations; commercialization of environmental biotechnology; future innovations in marine bioremediation and sustainability science.
References

1. Rittmann, B. E. & McCarty, P. L. *Environmental Biotechnology*. McGraw-Hill.
2. Crawford, R. L. & Crawford, D. L. *Bioremediation: Principles and Applications*. Cambridge University Press.
3. Clark, R. B. *Marine Pollution*. Oxford University Press.
4. National Institute of Oceanography marine environmental biotechnology publications.
5. Central Pollution Control Board marine pollution and remediation reports.

8. Intellectual Property and Commercialization
Credits: 4+0 = 4

Course Objectives

- To introduce intellectual property systems and commercialization pathways in biotechnology and marine sciences;
- To understand patents, technology transfer and entrepreneurship.

Unit I: Fundamentals of Intellectual Property

Concept and types of intellectual property rights; patents, copyrights, trademarks and trade secrets; intellectual property in marine biotechnology and biodiversity research.

Unit II: Patent Systems and Technology Transfer

Patent filing and patent databases; patent analysis and freedom-to-operate concepts; technology transfer and licensing; innovation management and commercialization pathways.

Unit III: Marine Bioprospecting and Entrepreneurship

Commercialization of marine natural products; biotechnology start-ups and incubation systems; marine pharmaceuticals and industrial biotechnology; blue economy entrepreneurship.

Unit IV: Regulations, Ethics and Governance

Biosafety and biosecurity regulations; Convention on Biological Diversity and Nagoya Protocol; access and benefit sharing; ethical issues in marine biotechnology and commercialization.

Unit V: Emerging Trends and Innovation Systems

Digital sequence information and data governance; artificial intelligence and innovation systems; global biotechnology markets; future perspectives in marine commercialization and innovation management.

References

1. Bouchoux, D. E. *Intellectual Property*. Cengage Learning.
2. Poltorak, A. I. & Lerner, P. J. *Essentials of Intellectual Property*. Wiley.
3. World Intellectual Property Organization intellectual property guidelines and reports.
4. Department for Promotion of Industry and Internal Trade intellectual property and patent guidelines.
5. Council of Scientific and Industrial Research technology transfer and commercialization publications.

Semester X

DISSERTATION

Credits: 20
Hours: Full Semester
Project Work

The project work shall be carried out during the Fourth Semester in a relevant area of Marine Biology or allied disciplines. The first three semesters shall be devoted to coursework, laboratory training, field studies and skill development. The dissertation shall provide an opportunity for students to undertake independent research, apply scientific methods, analyse and interpret data, and present the findings in the form of a scientific dissertation.

Each student shall undertake an independent research project under the supervision of a regular or contract faculty member of Kerala University of Fisheries and Ocean Studies (KUFOS). Scientists or researchers from recognized national or international research institutions, universities, government organizations, industries, or other approved organizations working in relevant disciplines may also serve as the Project Guide, subject to the approval of the Department. In such cases, a regular or contract faculty member of KUFOS shall act as the Co-guide to facilitate academic supervision and ensure compliance with university regulations.

The dissertation shall demonstrate the student's ability to identify a research problem, critically review scientific literature, formulate objectives and hypotheses, design and execute appropriate research methodologies, analyse and interpret results using suitable statistical tools, and present scientific findings in a clear, logical and professionally acceptable format.

Submission

The dissertation shall be submitted to the Head of the Department on or before the date notified by the University.

Each student shall submit:

- Three hard-bound copies of the dissertation (A4 size).
- One soft copy in searchable PDF format.

The dissertation shall conform to the format prescribed by the Board of Studies/Academic Council, as amended from time to time.

Late submission may be permitted only under exceptional circumstances with the approval of the Head of the Department on payment of the prescribed late fee, subject to the regulations of the University.

Evaluation

The dissertation shall be evaluated by a Board constituted by the Head of the Department consisting of:

- Head of the Department (Chairperson)
- Supervising Guide (Internal Examiner)
- External Examiner

The evaluation shall comprise:

- Assessment of the dissertation
- Seminar presentation
- Viva Voce examination

The dissertation shall undergo independent evaluation by the Internal and External Examiners. The final award of marks shall be made in accordance with the University regulations.

Dissertation Attendance and Submission Requirements

Students undertaking the dissertation work, whether at the Department of Marine Biosciences, KUFOS or at any recognized external institution/organization approved by the Department, shall maintain a minimum attendance of 75% during the dissertation period.
A student who fails to secure the prescribed minimum attendance shall not be eligible to submit the dissertation thesis for evaluation. At the time of dissertation submission, every student shall submit an Attendance Certificate, duly signed and certified by the Head/Supervisor of the host institution/organization where the dissertation work was carried out, to the Course Coordinator. The attendance certificate shall be treated as a mandatory document for acceptance of the dissertation thesis. Only after the successful completion of the dissertation evaluation shall the student be permitted to appear for the Dissertation Presentation and Viva-Voce Examination.

Distribution of Marks

Component	Internal Assessment	External Assessment
Dissertation / Thesis	80	160
Seminar Presentation	10	20
Viva Voce	10	20
Total	100	200

Grand Total: 300 Marks

Dissertation Format

The dissertation shall normally be arranged in the following order:

1. Title Page
2. Declaration by the Candidate
3. Certificate from the Supervising Guide
4. Certificate from the Head of the Department
5. Acknowledgements
6. Table of Contents
7. List of Tables
8. List of Figures
9. List of Abbreviations
10. Abstract
11. Introduction
12. Review of Literature
13. Materials and Methods
14. Results
15. Discussion
16. Summary and Conclusions

17. References
18. Appendices (if any)
19. Publications arising from the dissertation (if any)

Dissertation Specifications

- Paper Size: A4
- Font: Times New Roman
- Title: 16 pt, Bold
- Chapter Headings: 14 pt, Bold
- Text: 12 pt
- Line Spacing: 1.5
- Text Alignment: Justified
- Margins: Left – 3 cm; Right, Top and Bottom – 2.5 cm
- Page Numbering: Bottom Centre or Bottom Right
- Binding: Hard Bound
- Length: Normally 60–120 pages, excluding preliminary pages, appendices and publications.

Referencing

The dissertation shall follow the APA Publication Manual (7th Edition) for both in-text citations and reference list.

Students are encouraged to use reference management software such as Mendeley, Zotero, EndNote or RefWorks to ensure consistency in citation and referencing.

General Guidelines

- The dissertation shall be based on original work carried out by the student.
- Ethical guidelines applicable to laboratory, field, animal or human studies shall be strictly followed, and prior approvals shall be obtained wherever necessary.
- Scientific names shall be written in italics and SI units shall be used throughout the dissertation.
- Tables, figures and photographs shall be properly numbered and captioned.
- The dissertation shall be certified by the Supervising Guide and approved by the Head of the Department before submission.
- The similarity index shall conform to the plagiarism regulations of the University/UGC.
- Publications arising from the dissertation, if any, may be included as an appendix.