PONDICHERRY UNIVERSITY

SCHOOL OF LIFE SCIENCE

DEPARTMENT OF OCEAN STUDIES AND MARINE BIOLOGY

SYLLABUS

M. Sc., MARINE BIOLOGY (2019 ONWARDS)

Pondicherry University
School of Life Science
Department of Ocean Studies & Marine Biology

Master of Science in Marine Biology

Programme Objectives

The M.Sc., Programme in Marine Biology is conducted to provide the students:

1. Recent development in the field of Marine Biology.
2. Understand the overview structure and function of life in the marine environment.
3. Laboratory course offered for Practical knowledge on identification of various floral and faunal assemblages and their adaptations.
4. Exposure of students through field work involving sample collection, sea water sediment, biota and short term experiments as dissertations.
5. Creation of a skilled workforce in Marine biology for teaching, research and entrepreneurship.

Programme outcome

1. In depth knowledge on the basic and recent development in the field of Marine Biology.
2. Acquire skill on theoretical and experimental protocols in understanding the marine environment.
3. Possess knowledge for independent thinking, in writing scientific proposal, and its presentation.
4. Man power development for becoming successful researches and academicians.

M. Sc., Marine Biology Syllabus (2019 – 2020 Academic Year)
Semester - CBCS Pattern

Course Code	Theory / Practical	Assessment		Credit	Total Marks
		Internal	External		
	I SEMESTER				
MABO 401	Physical Oceanography	40	60	4	100
MABO 402	Chemical Oceanography	40	60	4	100
MABO 403	Biological Oceanography	40	60	4	100
MABO 404	Marine Ecology	40	60	4	100
MABO 405	Lab – I – Physical and Chemical Oceanography	40	60	2	100
MABO 406	Lab – II – Biological Oceanography & Marine Ecology	40	60	2	100
	II SEMESTER				
MABO 411	Marine Invertebrates	40	60	4	100
MABO 412	Marine Microbiology	40	60	4	100
MABO 413	Physiology and Biochemistry	40	60	4	100
MABO 414	Marine Fisheries	40	60	4	100
MABO 415	Lab – III – Marine Invertebrates & Marine Microbiology	40	60	2	100
MABO 416	Lab 1V- Physiology and Biochemistry & Marine Fisheries	40	60	2	100
	III SEMESTER				
MABO 501	Molecular Genetics	40	60	4	100
MABO 502	Aquaculture	40	60	4	100
MABO 503	Marine Vertebrates	40	60	4	100
MABO 505	Lab – V – Molecular Genetics & Aquaculture	40	60	2	100
MABO 521 527	Soft Core	40	60	2	100
	IV SEMESTER				
MABO 511	Ocean Policies and Management	40	60	4	100
MABO 512	Marine Biotechnology	40	60	4	100
MABO 513	Marine Pollution	40	60	4	100
MABO 599	Project	40	60	4	100
	Total			**72**	**2100**

SEMESTER - I

MABO - 401; PHYSICAL OCEANOGRAPHY

Course Objective: To understand the physical conditions and processes in the ocean including the motions and physical properties and ocean water.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 4 **TOTAL HOURS: 60**

UNIT - I **12 HOURS**

Introduction to Oceanography - history of Physical oceanography - expeditions, Marine Biological Institutions, Origin of Oceans - Bottom topography, abyssal hills-plains: submarine canyons - ocean trenches Ocean Sediments. Recent developments & Modern challenges in Oceanography science - satellite oceanography and remote sensing technology.

UNIT - II **10 HOURS**

Physical Properties of Seawater- density, conductivity, surface tension, viscosity and their relationship, Sound in the sea - Light in the Sea, UV radiation, temperature distribution in the sea - Ocean heat budget.

UNIT - III **14 HOURS**

Waves, Tides and Currents - theories of waves - tidal waves - formation of swells - internal and standing waves - tsunami - tide generating forces - tidal currents - tidal effects in coastal areas - importance of tide tables - tide and wave energy. Coastal Estuaries - structure - classification - estuarine circulation, Long term and short term sea level variation and tectonics.

UNIT - IV **12 HOURS**

Ocean circulation - surface circulation - wind and thermohaline circulation, forces causing currents, boundary currents, Langmuir circulation, geotropic currents, turbidity currents, Upwelling.

UNIT - V **12 HOURS**

Composition of Atmosphere, Atmospheric Circulation, Electromagnetic Radiation, Radiation Balance in the Atmosphere. Indian Ocean Monsoon, Trade winds, tropical cyclones and its impact on coastal zone, storm surges and climate change, El Nino and La Nino.

Text Books

1. Thurman, H., 2001. Introduction to Oceanography, Prentice Hall Inc. New Jersey.
2. Paul. R. Pinet, 2006. Invitation to Oceanography, 4th Edition. Jones and Bartlett, Sudbury, Massachusetts.

Reference Books

1. Sverdrup, H.U., Johnson, M.W. and Fleming, R.H., 1958. The Oceans- their Physics, Chemistry and General Biology, Prentice- Hall Inc. New Jersey.
2. Pickard, G.L. and Emery, W.J., 1995. Descriptive Physical Oceanography. Pergamon Press, London.

Course Outcome: Students will know the physical processes of the oceans.

MABO - 402; CHEMICAL OCEANOGRAPHY

Course Objective: To understand the chemical nature of seawater and its function for biological environment.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 4 **TOTAL HOURS: 60**

UNIT - I **10 HOURS**

Introduction to marine chemistry - ocean as a chemical system - origin of sea salts - properties of water molecules - differences between fresh and seawater.

UNIT - II **13 HOURS**

Chemical composition of seawater; ionic - major and minor constituents - constancy of ionic compositions and factors affecting constancy - major and minor elements - trace elements - their importance - distribution. Chemistry of seawater constituents - concept of chlorinity and salinity - methods of collections and measurements of seawater, sediment samples for chemical analysis.

UNIT - III **13 HOURS**

Radio nuclides in the sea - origin - distribution and use as tracers of water masses. Dissolved gases - Carbon dioxide - origin - importance and distribution, Oxygen - origin and factors governing the distribution - Nitrogen - Hydrogen Sulphide - Methane - methane hydrate.

UNIT - IV **14 HOURS**

Nutrients - inorganic - origin - distribution and important role in the fertility of the sea. Nitrogen - Phosphorus and Silicon in the sea - distribution - cycling - regeneration concept - "new and regenerated" production - N:P ratio. Mineral wealth of the sea – salts - gluconite - petroleum - phosphorite - manganese nodules - potential - economy of extraction. Desalination - recovery of chemicals.

UNIT - V **10 HOURS**

Organic matter - dissolved - particulate and colloidal species - sources - classification - composition - distribution - seasonal variation - ecological significance - growth promoting and growth inhibiting effects - biogeochemical cycle - carbon sequestration. Isotope chemistry - carbon isotope - oxygen isotope - sulphur isotope - hydrogen isotope - classification - estimation - uses of these isotopes in chemical oceanography.

Text Books

1. Millero, F.J., 2006. Chemical Oceanography. CRC Press, New York.
2. Pilson, M.E.Q., 1998. An introduction to the chemistry of the sea. Prentice Hall Inc., New Jersey.

Reference Books

1. Paul. R. Pinet, 2006. Invitation to Oceanography, 4th Edition. Jones and Bartlett, Sudbury, Massachusetts.
2. Grasshoff, K., 1999. Methods of Sea water Analysis. Wiley VCH, New York.

Course Outcome: Student understand the different chemical systems available in the marine waters and its important for the survival of biota.

MABO – 403; BIOLOGICAL OCEANOGRAPHY

Course Objective: To understand the diversity of organisms in the ocean and their importance.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 4 **TOTAL HOURS: 60**

UNIT - I **10 HOURS**

Sea as biological environment - divisions of marine environment - pelagic - benthic - coastal - oceanic - zones. Marine diversity - plankton - nekton – benthos - classification - composition - ecology.

UNIT - II **15 HOURS**

Planktonology - phytoplankton - methods of collection, identification, classification - estimation of standing crop, adaptation through structural and physiological mechanisms. Zooplankton - methods of collection - net samplers, biomass - settlement - displacement and gravimetric methods - abundance and species composition. Phytoplankton - Zooplankton - interrelationships - food chain.

UNIT - III **12 HOURS**

Organic production - Primary and Secondary production - methods of estimating primary productivity - light and dark bottle method, C^{14}, Pigment analysis, flow cytometer. Factors affecting productivity - productivity in different oceans - CO_2 sequestration. Harmful Algal Blooms (**HAB**) - Red tide phenomenon - causes and its effects.

UNIT - IV **14 HOURS**

Productivity - Sea weeds; general structure, types, distribution and economical importance - Mangroves - distribution, adaptation (morphological, anatomical) their importance. Sea grasses - their importance. Salt marshes; occurrence - their importance. Sand dunes; formation - types and their importance. Coral reefs; occurrence - distribution and economic importance.

UNIT - V **09 HOURS**

Biological resource assessment and management - using remote sensing techniques and Geographical Information System (GIS) for chlorophyll distribution. Critical habitats and biological hot spots.

Text Books

1. Sumich, J.L., 1999. Introduction to the Biology of Marine life. Seventh Edition. The Mc Graw Hill Companies Inc.
2. Hogarth P. 2007. The Biology of Mangroves and Seagrasses First Edition. Oxford Press.

Reference Books

1. Carmelo, T.R., 1997. Identifying Marine Phytoplankton by Academic Press.
2. ICES Zooplankton Methodology Manual Ed. by Harrish. R., P. Wiebe., J. Leng., H.R. Skyoldal., M. Huntley. Academic Press 2000.

Course Outcome: Students will understand the marine life – flora and fauna in the ocean.

MABO - 404; MARINE ECOLOGY

Course Objective: To understand the marine life habitat - population and interaction among the organisms – adaptation to abiotic and biotic environment.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 4 **TOTAL HOURS: 60**

UNIT - I **14 HOURS**

Marine environment - ecological factors - light - temperature - salinity - pressure. Classification of marine environment - pelagic environment - neritic, epipelagic, meso, bathyal and abyssal - planktonic and nektonic adaptations. Benthic environment - intertidal, shelf, deep sea habitat; Hydrothermal vents. Other coastal environments - estuaries, lagoons, mangroves, seagrass**,** coral reefs.

UNIT - II **12 HOURS**

Animal association in marine environment; endemism - inquilinism - phoresis - epizoism - mutualism - communalism - symbiosis - parasitism. Marine zoogeography with reference to Indo - West - Pacific Zone.

UNIT - III **12 HOURS**

Population ecology; population growth, density variations, concept of carrying capacity. Dispersal, competition, prey-predator relationships, density dependant & density independent factors.

UNIT - IV **12 HOURS**

Community ecology; structure and composition - diversity - stability - concept of niche - succession - community metabolism. Fouling, Boring communities - other invasive species - economic importance - anti-fouling measures and corrosion. Relation between fouling and corrosion.

UNIT - V **10 HOURS**

Marine Ecosystems; concepts - principal components. Marine food chains - trophic structure - food web - ecological pyramids - energy flow. Management of marine ecosystem - ecosystem modeling.

Text Books

1. Levinton, J.S., 2000. Marine ecology, Biodiversity and function. Oxford University Press.
2. Bertness, M.D, Gaines, S.D. and Hay, M.K., 2000. Marine Community Ecology Sinauer Associates.

Reference Books

1. Gage. J.D. and Tyler, P.A. 1991. Deep Sea Biology, Cambridge University Press, Cambridge.
2. William, C., 1991. Seashore life between the tides. Dover Publication.

Course Outcome: Students will understand the Economic importance and Conservation of Marine Ecosystems.

MABO - 405; Lab – I
PHYSICAL OCEANOGRAPHY AND CHEMICAL OCEANOGRAPHY

Course Objective: To understand the practical knowledge on operation of equipments and chemical analysis.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 2 **TOTAL HOURS: 30**

1. Navigational Device: Operation and application of GPS.
2. Measuring device - I Secchi Disc.
3. Operation and Principle of Refractometer.
4. Measuring device - II Wave measurement.
5. Measuring device - III Operation of Current meter.
6. Water sampling device: Niskin's Water Sampler.
7. Sediment sampling device - I Petersen Grab.
8. Sediment sampling device - II Corer.
9. Estimation of Salinity.
10. Estimation of Dissolved Oxygen.
11. Determination of Nitrite.
12. Determination of Nitrate.
13. Determination of Inorganic Phosphate.
14. Determination of Silica.
15. Determination of Bicarbonate.
16. Estimation of Particulate Organic Matter.

Lab Manuals:

1. Pickard, G.L. and Emery, W.J., 1995. Descriptive Physical Oceanography. Pergamon Press, London.

2. Grasshoff, K., 1999. Methods of Sea water Analysis. Wiley VCH, New York.

Course Outcome: Students will master the different techniques in physical and chemical oceanography.

MABO - 406; Lab – II
BIOLOGICAL OCEANOGRAPHY AND MARINE ECOLOGY

Course Objective: To understand the practical knowledge on biological organisms and the functioning in different ecosystem.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 2 **TOTAL HOURS: 30**

1. Identification of Phytoplankton; Diatoms and Dinoflagellates.
2. Identification of Zooplankton; Copepods.
3. Identification of Larval forms.
4. Identification of locally available Sea Grasses.
5. Identification of locally available Seaweeds.
6. Identification of locally available Mangroves.
7. Estimation of Chlorophyll-a.
8. Estimation of Primary productivity.

9. Rocky Shore Fauna; Collection and Identification.
10. Sandy Shore Fauna; Collection, Sorting and Identification.
11. Macrofaunal studies in seagrass and mangrove ecosystems.
12. Meiofaunal studies in seagrass and mangrove ecosystems.
13. Macrofaunal and Meiofaunal studies in mangrove sediments.
14. Biodiversity indices estimation.
15. Estimation of Population density in an Ecosystem.
16. Foulers and borers: Collection and identifications.

Lab Manuals:

1. Carmelo, T.R., 1997. Identifying Marine Phytoplankton by Academic Press.

2. Makoto, Omori and Tsutomu Ikeda, 1984. Methods in Marine Zooplankton Ecology, Wiley & Sons. Inc. Canada.

Course Outcome: Students will understand the biology of organisms and their adaptation to the environment.

SEMESTER - II

MABO - 411; MARINE INVERTEBRATES

Course Objective: To understand the Taxonomy, diversity and biology of marine Invertebrates including the prochordates.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 4 **TOTAL HOURS: 60**

UNIT - I **11 HOURS**

Protista - Phyla Ciliophora, Dinoflagellata, Stramenopila, Actinopoda, Granuloreticulosa. Phylum Porifera - classification, water current channels, sponge cell types, spicules, biology of sponges, reproduction and development. Cnidaria; classification, body structure, functional morphology, reproduction and development. Ctenophora, Minor phyla; Turbellaria.

UNIT - II **12 HOURS**

Taxonomic characters, classification, general morphology of Nemertea, Rotifera, Gastrotricha, Kinorhyncha, Nemotoda, Priapula, Entopracta, Gnathostomulida and Sipunculiida. Phylum Chaetognatha; characteristics, classification, vertical migration, feeding and digestion.

UNIT - III **13 HOURS**

Polychaeta - general morphology, classification, support and locomotion, feeding, reproduction and development - Siboglinidae - Echiuride. Oligochaeta Subphylum Crustacea - characteristics, classification, class Branchiopoda, Malacostraca, Maxillopoda - body plan and appendages, molting, larval forms. Class Pycnogonida and Merostomata - Xiphosura.

UNIT - IV **11 HOURS**

Phylum Mollusca - taxonomic history, classification, diversity and distribution, body plan, molluscan shell, torsion, locomotion, cephalopod colouration and ink, feeding - radula - types, sense organs, reproduction and development. Morphological characters and evolutionary relationship of Lophophorates - Ectoprocta, Phoronida and Brachiopoda.

UNIT - V **13 HOURS**

Phylum Echinodermata - taxonomic characters and classification - Crinoidea, Asteroidea, Ophiuroidea, Echinoidea, Holothuroidea and sea Daisies - water vascular system, support, locomotion, feeding, reproduction and development, types of larvae, phylogeny. Phylum Hemichordata, Urochordata and Cephalochordata; characteristics, classification.

Text Books

1. Meglitsch, P. 1991. Invertebrate Zoology. Oxford press, New York.
2. Pechenick, J.A. 2000. Biology of Invertebrates. Tata McGraw Hill.

Reference Books

1. Brusca, R.C. & G.J. Brusca, 2003. Invertebrates. Second Edition. Sinauer Associates, Inc., Publishers, Massachusetts.
2. Karleskint G., Turner R. and Janes W. Small, Jr. 2013. Introduction to Marine Biology. Brooks/Cole, Cengage Learning, Canada. 563pp.

Course Outcome: Students will know about the diversity, distribution and biology of marine Invertebrates and their ecological role in the marine environment.

MABO – 412; MARINE MICROBIOLOGY

Course Objective: To understand the role of microorganism in nutrient cycling and their importance in marine ecosystem.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 4 **TOTAL HOURS: 60**

UNIT - I **10 HOURS**

Introduction to microbial oceanography: Emergence of the field of microbial oceanography. Marine microorganisms: acinetobacter, cyanobacteria, photoheterotrophic bacteria, heterotrophic bacteria, marine archaea, heterotrophic protists, marine fungi, marine viruses, marine microbial habitats

UNIT - II **13 HOURS**

Importance of taxonomy - bacterial classification - Linnaean system. Whittaker's five kingdom classification - three domain concept of Carl Woese - Phylogenetic tree. - Conventional and molecular approach to microbial diversity in nature - PCR - RFLP - molecular phylogeny using 16S rRNA, G+C ratio - Fatty acid analysis and genome sequencing. Introduction to Metagenomics.

UNIT - III **13 HOURS**

Microbial processes of marine ecosystems- biogeochemical cycling of carbon, nitrogen, phosphorous, Sulphur. Extremophiles - thermophiles - halophiles - acidophiles - alkaliphiles - barophiles - baropsychrophiles - psychrophiles. Marine microbial interactions - bacterial invertebrates - symbiosis - Coral diseases and microbial associates. Deep-Sea microbes - bioluminescence.

UNIT - IV **12 HOURS**

Pathogenic microorganisms - finfish, shellfish - impact to human beings. Microbial spoilage of seafood - processing - preservation. Pollution microbiology - water quality - fecal and total coliforms. Microbial products - primary - secondary metabolites - antibiotics - enzymes.

UNIT - V **12 HOURS**

Microbial processes- biodegradation of natural and xenobiotics; biotransformation - bioaccumulation - bioremediation - biomineralization. Microbial biofilms - cyanobacterial mats. Microbial diversity in anoxic ecosystems - anaerobes - methanogens. Microbial - leaching of ore and metal corrosion - microbial fouling in marine environments.

Text books

1. Munn C.B.2004. Marine Microbiology: Ecology and Applications, Taylor & Francis Roultedge.
2. Kirchman, L., 2008. Microbial Ecology of the Oceans. Second edition, John Wiley and Sons.

Reference books

1. The Prokaryotes 2006. A Handbook on the Biology of Bacteria. Volume. I to IV. Springer & Verlag New York.
2. Paul. J 1999. Marine Microbiology. Elsevier.

Course Objective: students will understand the role of micro organisms in enriching the ocean for life to grow.

MABO – 413; PHYSIOLOGY AND BIOCHEMISTRY

Course Objective: To understand the basic physiological and biochemical processes in organisms.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 4 **TOTAL HOURS: 60**

UNIT - I **14 HOURS**

Physiology - Introduction - nutrition - nutritive types - feeding - mechanism of feeding, digestive enzymes and their role with food habits. Circulation - closed and open circulatory systems. Structure of heart-fishes, mammals-mode of circulation Respiratory organs - respiratory pigments - integumentary and branchial respiration - aquatic animals, gills -structure and function, shifts in O_2 dissociation curve, factors affecting respiration.

UNIT - II **12 HOURS**

Physiology of nervous system - structure and types of neuron. impulse generation - resting and action potentials, conduction, synaptic transmission, neurotransmitters, nervous system-invertebrates. Physiology of rhythms - circadian - tidal and lunar rhythms in marine and estuarine animals, environmental factors - significance of biorhythms. Physiology of osmoregulation - ions in body fluids - mechanism of regulation - types of osmoregulatory adaptation - marine invertebrates, vertebrates. Excretory system - organs of excretion - invertebrates - vertebrate kidney - excretion in fish.

UNIT - III **12 HOURS**

Biochemical basis of life Carbohydrates – Glycoconjugates - proteoglycans, glycoproteins, glycolipids. Carbohydrate catabolism - glycolysis, citric acid cycle, gluconeogenesis, pentose phosphate pathway, oxidative phosphorylation-ATP synthesis. Carbohydrate anabolism – biosynthesis - starch, sucrose, glycogen.

UNIT - IV **12 HOURS**

Proteins-amino acids, polypeptides. Structure of protein - organization, Ramachandran Plot – Protein - classification, denaturation, folding. Amino acid oxidation, urea production. Biosynthesis of amino acids–proline, glycine, valine, tryptophan, methionine, histidine. Enzymes - nomenclature, classification, structure, characteristics, functions. Enzyme kinetics-mechanism of action, modifiers.

UNIT - V **10 HOURS**

Lipids-structure-classification, oxidation of fatty acids - β oxidation, saturated, unsaturated, odd, even chain, Biosynthesis of lipids-synthesis of long chain fatty acids, unsaturated fatty acids, cholesterol - biosynthesis, regulation. Biochemical technique - Centrifugation - types, Chromatography - column, TLC, paper, HPLC.

Text Books

1. Hill, R.W., Wyse,G. A., Anderson, M.A., 2008, Animal Physiology. Sinuar Associate Inc., USA.
2. Nelson, D.L. and Cox, M.M., 2008. Principles of Biochemistry. W. H Freeman and Company, New York.

Reference Books

3. Nellsen, K.S., 2005. Animal Physiology, Cambridge University Press, Cambridge.
4. Berg, J.M, Tymoczko, J.L. and Styrer, 2002. Biochemistry. W.H Freeman & Co.

Course Outcome: Students will understand basic physiological and biochemical processes taking place in the organism.

MABO – 414; MARINE FISHERIES

Course Objective: To impart basic knowledge on fish biology, taxonomy as well as harvest and post – harvest technology.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 4 **TOTAL HOURS: 60**

UNIT - I **10 HOURS**

Introduction to marine fisheries - history of world and Indian Fisheries sector, Taxonomy and classification of fin and shell fishes with special reference to species of commercial importance.

UNIT - II **12 HOURS**

Methods in Fishery Biology - Food and feeding habits - feeding strategies and food analysis indices. Maturation and spawning - ova diameter, fecundity. Age and growth - estimation of growth parameters, Length - weight relationships - relative condition factor.

UNIT - III **12 HOURS**

Fishing craft and gear - classification, Fishing aids - Echo sounder, SONAR, GPS and Remote Sensing, Fish population dynamics - concepts of stock - factors affecting stock -physical - chemical-biological-fish stock assessment - MSY - MEY- overfishing, Fishery forecasting - Potential Fishing zone. Fishing regulations; closed seasons and protected areas. Migration; causes and methods used for study.

UNIT - IV **12 HOURS**

Marine fishery resources of India - pelagic, demersal, oceanic and deep-sea. Marine fishery resources of Andaman and Nicobar Islands. Fishery resource potential and present level of exploitation. Exploratory fishery surveys. Ancillary fishery resources - seaweeds, crab, lobsters, chank and bivalves. Socio-economics, extension and planning in fisheries.

UNIT - V **14 HOURS**

Fish handling onboard and landing centers. Fish preservation methods - freezing, drying, salting, smoking and canning. Fishery by products - fish meal, fish oil, fish protein concentrate, chitin, isinglass, shark fin, rays, Surimi and fish minced products.

Text Books

1. Peter B. Moyle and Joseph J. Cech. 2003. Fishes: An Introduction to Ichthyology. Benjamin Cummings.
2. Ayyappan, S., J. K. Jana, A. Gopalakrishnan and A. K. Pandey 2006. Handbook of fisheries and aquaculture. Indian Council of Agricultural Research.

Reference Books

1. Bal, D.V., and Rao, K.V. 1990. Marine Fisheries of India. Tata McGraw Hill Pub. Co.
2. Srivastava, C.B.L. and Mahal, K., 1999. A text book of fishery science and Indian fisheries. Shree Publishers.

Course Outcome: Students will develop skill to identify fishery resources, learn recent methods used in harvest and post –harvest technology in Marine Fisheries.

MABO - 415; Lab – III
MARINE INVERTEBRATES AND MARINE MICROBIOLOGY

Course Objective: To understand the practical knowledge on identification of marine micro and macro organisms.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 2 **TOTAL HOURS: 30**

1. Identification of Polychaetes.
2. Dissection and display of appendages: Decapoda.
3. Dissection of parapodia and seate of polychaetes.
4. Identification of Decapods.
5. Identification of Gastropods.
6. Identification of Bivalves.
7. Identification of Echinoderms.
8. Identification of Nematoda, Nemertea and Sipunculiids.

9. Different Techniques in Sterilization.
10. Bacterial population in Seafood - Water, Sediment, Shellfish and Finfish.
11. Isolation of bacteria from Seafood.
12. Isolation of pure colonies.
13. Identification of Microbes - Staining and Cell Morphology.
14. Preservation Techniques - Slant, Glycerol and Lyophilization.
15. Isolation of bacterial DNA.
16. Identification based on 16s RNA.

Lab Manuals:

1. Faushald, K. 1977. The polychaete worm definition and keys to the order, families and Genera. Natural History Museum of Los Angeles County, Science Series 28, 188 pp.

2. Buller N B., 2004. Bacteria from fish and other animals, A practical Identification manual. CABI.

Course Outcome: Students will be able to understand the identification of marine organisms and their importance in the environment.

MABO - 416; Lab – IV
PHYSIOLOGY AND BIOCHEMISTRY & MARINE FISHERIES

Course Objective: To understand the practical knowledge on physiological, biochemical composition of marine organisms – fishes and their morphology.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 4 **TOTAL HOURS: 30**

1. Effect of salinity on oxygen consumption in Fish.
2. Effect of temperature on oxygen consumption in Fish.
3. Paper chromatography.
4. Nervous System of Fish.
5. Estimation of Carbohydrate.
6. Estimation of Proteins.
7. Estimation of Lipids.
8. Chromatography: Separation of Amino acids.
9. Identification of Fishes.
10. Food and Feeding analysis of Fish.
11. Reproductive Biology of Fish - Maturity stages.
12. Length Weight Relationship of Fish.
13. Identification of common fishing craft and gear.
14. Fish population estimation.
15. Determination of age of fish.
16. Fish byproducts.

Lab Manuals:

1. Karp, G., 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons Ltd., NJ, USA.

2. FAO, 2005, Manuals for Finfish Identification.

Course Outcome: Students will be able to understand physiological and biochemical aspects of marine organisms with special reference to fishes.

SEMESTER - III

MABO – 501; MOLECULAR GENETICS

Course Objective: To understand the basic principles and processes in gene of prokaryotic and eukaryotic organisms in the molecular level.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 4 **TOTAL HOURS: 60**

UNIT - I **12 HOURS**

General genetics - DNA as genetic material - structure and types of DNA, RNA, Organization of prokaryotic and eukaryotic genomes. Genetics of bacteria and viruses - transformations - conjugation - F+ Hfr - transduction - generalized and specialized, Organelle DNA - chloroplast DNA, mitochondrial DNA.

UNIT - II **13 HOURS**

DNA Replication - replication models - role of different enzymes and accessory proteins in prokaryotic and eukaryotic DNA replication - semi conservative, rolling circle, theta replication, Phi x0174, SV40. Mechanism of replications - prokaryotes, eukaryotes.

UNIT - III **11 HOURS**

Mutation types, mutagens - physical, chemical-nitrous acid - hydroxylamine - alkylation agents - Intercalating agents and UV - mechanism of mutation - DNA repairs process types, photo reactivation, excision, recombination, SOS, transposons.

UNIT - IV **12 HOURS**

Transcription in prokaryotes: eukaryotes, RNAs types: functions. Genetic code -characteristics, Wobble base pairing, gene-protein relation. Translation in prokaryotes and eukaryotes.

UNIT - V **12 HOURS**

Regulations of gene expression in prokaryotes - the operon concept: Lac, Trp, positive and negative controls. Eukaryotic regulation: transcriptional, translational level regulations.

Text books

1. Malacinski G.M. and Friefeilder, D., 1998. Essentials of Molecular Biology, Bartlett Publishers.
2. Nelson, D.L. and Cox, M.M., 2008. Principles of Biochemistry. W. H Freeman and Company, New York.

Reference books

1. Watson, J.D., 1999. Molecular Biology of the Gene Volume I & II, Benjamin Cummings Publ.
2. Berg, J.M., Tymoczko, J.L. and Styrer, 2002. Biochemistry. W.H. Freeman & Co.

Course Outcome: Students will understand basic principles and processes in the genetic level.

MABO – 502; AQUACULTURE

Course Objective: To understand various techniques, developments and prospects in Aquaculture.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 4 **TOTAL HOURS: 60**

UNIT - I **12 HOURS**

Introduction to aquaculture - general principles and present status - scope and importance. World and Indian aquaculture production and trends. General characteristics of major cultivable fin and shellfish of India - estuarine and marine - finfishes (sea bass, groupers, mullets, milkfish etc.); shellfish (shrimps, crabs, lobsters, mussels, oysters, clams). Seaweed culture.

UNIT - II **12 HOURS**

Selection of suitable sites. Farm construction - pond preparation - fertilization - stocking - monitoring - harvesting. Feed management. Management practices - water management - control of predators - parasites – diseases.

UNIT - III **12 HOURS**

Farming of fin and shellfish – traditional, extensive, semi intensive, intensive: satellite culture practices. Monoculture, polyculture and Integrated farming. Pond – cage – pen – raft - rope culture. Composite culture, Aquaponics - Green water systems - Biofloc technology - Blue growth in aquaculture. Open water aquaculture: artificial reefs and fish aggregating devices. Sea ranching - Ecofriendly fish farming - ecolabelling.

UNIT - IV **14 HOURS**

Techniques in aquaculture - hybridization - selective breeding, in-breeding, out breeding and hybrid vigor. Sex control and sex reversal in fishes. Genetic manipulation - gynogenesis, androgenesis and polyploidy, transgenics. Cryopreservation of gametes.

UNIT - V **10 HOURS**

Hatchery facilities and management. Seed production techniques - breeding, hatchery and nursery phases. Brood stock management. Natural and induced breeding. Culture of live feed organisms - diatoms, artemia and rotifers.

Text Books:

1. Pillay, T. V. R. 2005. Aquaculture Principles and Practices. Blackwell Publishing Ltd.
2. Stickney, 2009. Aquaculture: An Introductory Text. CABI.

Reference Books:

1. Ayyappan, S., J. K. Jana, A. Gopalakrishnan and A. K. Pandey 2006. Handbook of fisheries and aquaculture. Indian Council of Agricultural Research.
2. Bardach, John E. 1997. Sustainable Aquaculture. John Wiley and Sons.

Course Outcome: The students learn basic aquaculture and hatchery practices along with recent developments for implementing in the field.

MABO - 503; MARINE VERTEBRATES

Course Objective: To understand the diversity, distribution and biology of marine vertebrates particularly the reptiles, birds and mammals.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 4 **TOTAL HOURS: 60**

UNIT - I **12 HOURS**

Origin of chordates - general characteristics of Vertebrata - marine reptiles - amniotic egg - physiological adaptations - sea turtles - diversity and distribution - adaptations to life at sea, behavior, feeding, nutrition, reproduction - courtship, nesting, development and hatching - turtle migrations - threats to sea turtles - endangered species - turtle exclusion device.

UNIT - II **11 HOURS**

Salt water crocodiles - diversity and distribution - adaptations, feeding, communication - growth and population. Marine Iguana - species and distribution, feeding and nutrition - behaviors - reproduction. Sea snakes - classification - habitats and distribution - adaptations - skin shedding - feeding, reproduction.

UNIT - III **13 HOURS**

Marine birds: classification - distribution - feeding - breeding biology - migration - conservation.

UNIT - IV **11 HOURS**

Marine mammals - classification and conservation - Indian marine mammals.

UNIT - V **13 HOURS**

Cetaceans - Evolution and general characters. Whales: Types, distribution, exploitation and conservation. Dolphins, and Porpoises. Conservation measures.

Text Books

1. Young J.Z. 1981. The Life of Vertebrates. Oxford University Press, New Delhi, 645pp.
2. Karleskint G., Turner R. and Janes W. Small, Jr. 2013. Introduction to Marine Biology. Brooks/Cole, Cengage Learning, Canada. 563pp.

Reference Books

1. Perrin W., Würsig B. and Thewissen J.G.M. (Eds.) 2017. Encyclopedia of Marine Mammals. Academic Press Imprint.1352 pp.
2. Berta A., Sumich J.L. and Kovacs K.M. 2015. Marine Mammals Evolutionary Biology. Elsevier Inc. 726 pp.

Course Outcome: Students will know about the diversity, distribution and biology of marine Vertebrates (reptiles, birds and mammals) and their ecological role in the marine environment.

MABO – 505; Lab – V
MOLECULAR GENETICS AND AQUACULTURE

Course Objective: To understand the molecular techniques and aquacultural practices.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 2 **TOTAL HOURS: 30**

1. Extraction of DNA from marine fish.
2. PCR Technique.
3. Study of mitosis from plant tissue.
4. Isolation of chloroplast DNA.
5. Isolation of plasmid.
6. Column Chromatography.
7. Gel Electrophoresis.
8. TLC.

9. Identification of Cultural Species for Aquaculture.
10. Identification of Larval Stages of Shell fish and Fin Fish.
11. Identification of Live Feed Organisms – Planktons.
12. Culturable Fish species.
13. Induced Breeding – Thermal Shock.
14. Preparation of Feed.
15. Identification of predators in aquaculture.
16. Identification of pathogens and parasites.

Lab Manuals:

1. David. T. Plummer, 2003. An Introduction to Practical Biochemistry 3rd Edition. Tata McGraw – Hill.

2. FAO, 2005, Manuals for Finfish Identification.

Course Outcome: Student will be able to understand various molecular techniques and various aquaculture practices.

SOFT CORE - MABO - 521 to MABO - 527

Course Code	Soft Core	Assessment		Credit	Total Marks
		Internal	External		
	III SEMESTER				
MABO 521	Benthic Ecology	40	60	2	100
MABO 522	Marine Environmental Impact Assessment	40	60	2	100
MABO 523	Marine Ornamental Fishes	40	60	2	100
MABO 524	Marine Zooplankton Ecology	40	60	2	100
MABO 525	Marine Biodiversity and Conservation	40	60	2	100
MABO 526	Marine Organisms Documentation and Submission	40	60	2	100
MABO 527	Conservation and Management of Mangrove and Corals	40	60	2	100

Each student is to select one of the soft core from the above. The soft core course requires a Minimum Five Students to opt for a particular soft core.

MABO – 521; BENTHIC ECOLOGY

Course Objective: To understand the basics on the benthic ecosystem and collection and processing of benthic organisms.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 2 **TOTAL HOURS: 30**

UNIT - I **6 HOURS**

Introduction - benthos - classification - importance - mussel watch program - benthos of coastal waters - deep ocean - mid-ocean ridge community - trophic dynamics - estuarine community - Environmental Impact.

UNIT - II **6 HOURS**

Methods of sampling and design of sampling - Sediment analysis - bulk benthic processes - bioturbation - sediment sculpting - animal sediment relationships.

UNIT - III **6 HOURS**

Macrofauna techniques - intertidal observation - collection - sampling gear - treatment - sorting of sample.

UNIT - IV **6 HOURS**

Meiofauna techniques - sampling - treatment - sorting of samples - extraction - sub-sampling - examination - determination of biomass.

UNIT - V **6 HOURS**

Phytobenthos - sampling techniques - separation of live populations - estimation of biomass.

Text Books:

1. Giere, O., 2009. Meiobenthology – The Microscopic Motile fauna of the aquatic sediments. Second Edition. Springer Publication.
2. Eleftheriou, A. and Mclntyre, A., 2005. Methods for the study of marine benthos. Third edition. Blackwell science Ltd., U.K.

Reference Books

1. Haynes, J.R. 1981. Foraminifera. Macmillan publishers Ltd., London.
2. Higgins, R.P. & Thiel, H. 1988. Introduction to the study of meiofauna. Smithsonian Institution Press, Washington, DC.

Course Outcome: Student will understand the basics on the benthic ecosystem and their collection and post collection processes of benthic organisms.

MABO - 522; MARINE ENVIRONMENTAL IMPACT ASSESSMENT

Course Objective: To understand the types, procedure and methods of marine Environmental Impact Assessment.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 2 **TOTAL HOURS: 30**

UNIT - I **6 HOURS**

Introduction - Environmental Impact Assessment (EIA) - types of EIA - rapid EIA - comprehensive EIA - environmental clearance process - coastal regulation zone - baseline studies - collection of primary and secondary data.

UNIT - II **6 HOURS**

Stages in prior environmental clearance - screening - scoping public consultation - appraisal - Terms of Reference - validity of EC - post environmental clearance monitoring - expert appraisal committee for different categories of projects.

UNIT - III **6 HOURS**

Structure environmental impact assessment - description of project, analysis of alternative site and technology, description of environment - land, water, marine, air, noise and socio-economic occupational health impact. Form I and II.

UNIT - IV **6 HOURS**

Anticipated environmental impact and mitigation - Environmental Monitoring Programme - methods and techniques of impact identification and prediction. Risk analysis and disaster management plan - rehabilitation and resettlement action plan - project benefits environmental management plan (EMP).

UNIT - V **6 HOURS**

A case study of environmental impact assessment for port and harbour. International treaties and Indian Acts relevant to port and harbour. Ecological quality measures - benthic indicators - Marine Biotic Indices. Assessment of coastal ecological quality status.

Text Books

1. Ghosh, A.K., Alfred, JRB and Jonathan, J.K. 1999. Manual Environmental Impact Assessment. Zoological Survey of India, Calcutta. 335pp.
2. Clark, R.B 1992. Marine pollution. Third edition Clavendron, Press Oxford.

Reference Books

1. Environmental guidelines for Ports and Harbour Projects - 1998. Ministry of Environment and Forest, Govt. India.
2. Borja A., and Perez, F.J.V., 2000.A marine Biotic Index to establish the ecological quality of soft-bottom benthos within European estuaries and coastal environments. Marine Pollution Bulletin, V.40.

Course Outcome: Students will gain knowledge about the types, procedure and methodology of marine EIA in India and will know about the environment clearance, environment management plan, impact identification and prediction.

MABO – 523; MARINE ORNAMENTAL FISHES

Course Objective: To study the importance of marine ornamental fish trade and the methods involved in Aquarium techniques.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 2 **TOTAL HOURS: 30**

UNIT - I **8 HOURS**

Introduction - marine ornamental fishes - distribution - importance - criteria for selection. Resource analysis - survey - species distribution - abundance.

UNIT - II **6 HOURS**

Life history traits of marine ornamental fishes - food spectrum - sex ratio - maturation - spawning - fecundity - length-weight relationships - distribution - habitat.

UNIT - III **4 HOURS**

Breeding and hatchery production of marine ornamental fishes - brood stock management - feeding - spawning - hatching - larval rearing. Models for breeding and rearing. Health management in marine aquaria. Stress and diseases - viral, bacterial, fungal, other parasites and protozoans.

UNIT - IV **8 HOURS**

Marine aquarium - basic concepts - merits - challenges. Aquarium management - feed formulation - feeding techniques - water quality maintenance. Types of aquaria - tropical - reef - community tank. Biotope - public aquaria.

UNIT - V **4 HOURS**

Marine ornamental fish trade - trends - prospects and issues - international and national trade potential - conservation management. Red data list of endangered - vulnerable - threatened fishes.

Text Books

1. Cato, J.C. and Brown, C.L., 2003. Marine ornamental species: collection, culture and conservation. Ballagh, International Inc.
2. Sunderraj, V., and Satheesh, J.M., 2005. Tropical marine aquarium. TRP publishers.

Reference Books

1. Doy, V.K. 1997. Hand book on aquafarming: Ornamental fishes. MPEDA.
2. Kurup, B.M., Boopendranath, M.R., Ravindram, K., Saira Banu and Gopalakrishnan, A., 2008. Ornamental fish breeding forming and trade. TRP publishers.

Course Outcome: The students will learn to identify the marine ornamental resources and the aquarium techniques and instrumentation involved.

MABO – 524; MARINE ZOOPLANKTON ECOLOGY

Course Objective: To understand the size and taxonomic composition: holoplankton and meroplankton - developmental biology - their biochemical profile.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 2 **TOTAL HOURS: 30**

UNIT - I **6 HOURS**

Definition - zooplankton - size - classification - habitat - depth distribution - length of planktonic life.

UNIT - II **6 HOURS**

Sampling methods - vertical - horizontal - oblique hauls - quantitative sampling - qualitative sampling - standard sampling - sampling of live plankton for laboratory experiment.

UNIT - III **6 HOURS**

Fixation and preservation of samples - storage - labeling - log sheets - splitting - sorting - counting individuals - observation - identification - dissection - staining - mounting technique - identification of species.

UNIT - IV **6 HOURS**

Processing and measurement - biomass - wet weight - dry weight - dry organic weight - body length - length and weight relationship. Biochemical composition - estimation of carbohydrate - protein - total lipid.

UNIT - V **6 HOURS**

Rearing and culture - rearing conditions - water quality - physico-chemical parameters - preparation of media - techniques for the culture of feed organisms - phytoplankton - zooplankton.

Text Books

1. Raymont, J.G.E., 1963. Plankton and Productivity in the Oceans. Pergamon press, New York.
2. Parsons,T.R., Takahashi, M. and Hargrave, B., 1977. Biological Oceanography, Second edition. Pergamon press, Oxford.

Reference Books

1. Makoto, Omori and Tsutomu Ikeda, 1984. Methods in Marine Zooplankton Ecology, Wiley & Sons. Inc. Canada.
2. Levinton, J.S., 1982. Marine Ecology. Prentice-Hall Inc., New Jersey.

Course Outcome: Students will know the live feed culturing techniques and its application to aquaculture.

MABO – 525; MARINE BIODIVERSITY AND CONSERVATION

Course Objective: To understand the biological diversity in the marine environment and conservation strategies for the protection of biodiversity.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 2 **TOTAL HOURS: 30**

UNIT - I **6 HOURS**

Introduction - marine biodiversity - importance - levels of biodiversity - biodiversity indices. Definition of extinction of marine bio-resources - rate of extinction - causes of extinction - island / intertidal biogeography - vulnerability to extinction.

UNIT - II **6 HOURS**

Conservation - essential concepts for small populations - problems of small population - applied population biology - establishment of new population conservation strategies - conservation categories of species - legal protection of species.

UNIT - III **6 HOURS**

Marine protected areas - designing of protected areas - managing protected areas - restoration ecology.

UNIT - IV **6 HOURS**

Impediments to marine biodiversity conservation - insufficient scientific information - inadequate transfer of information - cultural and biological diversity - differing benefits and costs harming aquatic life - jurisdictional gaps and overlaps - use of marine environment - immunity from public scrutiny - fragmented decision making.

UNIT - V **6 HOURS**

Conservation and sustainable development - traditional societies - Government action - local legislation - national laws - National Biodiversity Act and National Biodiversity Authority. International approaches to conservation and sustainable development - ongoing problems - possible responses - role of conservation biologists.

Text Books

1. Primack, R.B., 2004. A Primer of Conservation Biology, Sinaur Asso. Inc. Publ.
2. Sutherland, W.J., 2000. The Conservation Handbook: Research, Management and Policy. Blackwell Sci. Ltd.

Reference Books

1. Norse, E.A., 1993. Global Marine Biological Diversity; Island Press.
2. McManus, J.W., 1998. A Framework for future Training in Marine and Coastal Protected Area Management. ICLARM.

Course Outcome: Students will have knowledge on the rules and regulations on conservation of marine biodiversity.

MABO – 526; MARINE ORGANISMS DOCUMENTATION AND SUBMISSION

Course Objective: To understand the procedure of collection, identification of samples and submission.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 2 **TOTAL HOURS: 30**

UNIT - I **4 HOURS**

Field visit - Sampling in local habitats - aquatic - seafood industry - major community types - rocky and sandy intertidal - soft sediment - hard bottom - shallow sub tidal. Mangroves - Sea grass - Seaweeds - Coral reef - associates.

UNIT - II **6 HOURS**

Methods of sampling - collection of organisms using different techniques - Water samplers - Sediment samplers, Multiple nets, Diving systems - SCUBA - ADS (atmospheric diving system). Collection - Identification classification, documentation, preparation of Voucher specimens - herbarium and reporting center of site sampled datasets.

UNIT - III **6 HOURS**

Methods of Narcotization and preservation. Digitization of specimens - Maintenance - Museum specimens. DNA Bar-coding - Marine Barcode of life (**MABOL**) - barcode of life database - Protocol for marine specimens. Digital data banking. Digital submission to OBIS.

UNIT - IV **6 HOURS**

Global marine species assessment (**GMSA**) - Census Of Marine Life (**CoML**) - Ocean Biogeographic Information System (**OBIS**) - CORAL REEFS (**Creefs**) - Continental Margin Ecosystems of Worldwide Scale **(COMARGE)** - Census of Diversity of Abyssal Marine Life (**CeDAMar)** - Census of Marine Zooplankton (**CMarZ**).

UNIT - V **8 HOURS**

Global Census of Marine Life on Seamounts (**CenSeam**) - Chemosynthetic Ecosystem Science (**ChEss**) - Census of Antarctic Marine Life (**CAML)** - Arctic Ocean Diversity (**ArcOD)** - International Census of Marine Microbes (**IcoMM**) - Future of Marine Animal Populations (**FMAP**) - History of Marine Animal population **(HMAP)-** World Register of Marine Species **(WORMS).**

Text Books

1. Suthers. I. M. & Rissik, D., 2002. Plankton: A Guide to Their Ecology and Monitoring for Water Quality.
2. McIntyre A.D. 2010 Life in the World's Ocean- Diversity, Distribution and Abundance. Blackwell Publishing Ltd.

Reference Books

1. Mac, E. L., 2004. Ecology of Marine Invertebrates. CRC Press.
2. McCutcheon S & B. McCutcheon 2010. The Fact on File marine science handbook. Facts on File Inc. New York.

Course Outcome: Students will understand preservation and submission of marine organisms.

MABO – 527; CONSERVATION AND MANAGEMENT OF MANGROVE AND CORALS

Course Objective: To understand the biology of corals and mangroves and its ecosystem function along with the threats and conservation process.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 2 **TOTAL HOURS: 30**

UNIT - I **6 HOURS**

Mangroves introduction, occurrence distribution and ecology.

UNIT - II **6 HOURS**

Special features of mangroves. Flora and Fauna of mangrove ecosystem. Role of mangroves in Carbon sequestration.

UNIT - III **6 HOURS**

Coral reefs: Introduction; types: distribution and ecology

UNIT - IV **6 HOURS**

Coral reefs: monitoring. Floral and faunal association with coral reefs.

UNIT - V **6 HOURS**

Economic value of corals and mangroves. Conservation and management of mangroves and corals.

Text Books

1. Karlson, R.H. 1999. Dynamics of Coral Communities. Kluwer Academic Publishers.
2. McClanahan, T.R., Sheppard, C.R.C. and Obura, D.O., 2000. Coral Reefs of the Indian Ocean, their ecology and conservation. Oxford University Press.

Reference Books

1. Peter, F.S. 2006. Ecology of Fishes on Coral Reefs. First Edition, Academic Press.
2. Venkataraman, K., Satyanarayana, Ch., Alfred, J.R.B. and Wolstenholme, J. 2003. Handbook on Hard Corals of India. Zoological Survey of India, Kolkata, India.

Course Outcome: Student develop the knowledge on the basic research in science with special reference to marine biology.

SEMESTER - IV

MABO – 511; OCEAN POLICIES AND MANAGEMENT

Course Objective: To understand the different principles and management practice of Law of the Ocean and its management practices.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 4 **TOTAL HOURS: 60**

UNIT - I **5 HOURS**

Major oceans and their wealth: Three-major Oceans - importance. Historical evolution of open ocean as a common heritage of mankind.

UNIT - II **17 HOURS**

Law of the Sea. - Geneva conventions - UNCLOS - Exclusive Economic Zone (EEZ) - its significance. North Sea oil, gas and fishery - George Bank - Bombay High.

UNIT - III **13 HOURS**

The Regional Seas Programme of UN - global significance: policies and strategies. Antarctic treaty - importance. Endangered marine animals - CITES convention, marine protected areas - biosphere reserves - marine biosphere - marine parks.

UNIT - IV **10 HOURS**

Rules and regulations national and international: mineral deposits. Scientific economic - geo - political aspects of seabed exploration - mining - seabed treaty. Coastal Regulatory Zone Notification - importance - changes due to development - coastal management issues - comparison between temperate and tropical countries - Integrated coastal zone management - integrated management.

UNIT - V **15 HOURS**

Role of National and International agencies and organizations in ocean management Intellectual Property Right (IPR) Ocean policy (India**)**.

Text Books

1. Robert, K., 2009. Coastal Planning and management. CRB publication.
2. Roonwal, G.D. (Ed.) 1986. The Indian Ocean exploited mineral and petroleum resources, Springer Verlag, Berlin.

Reference Books

1. Borgeses, E.M. and Ginsburg, N. (Eds.) 1978. Ocean Year Books - I to XX. The University of Chicago Press, Chicago.
2. Juda, L., 1998. International Law and Ocean Use Management: The Evolution of Ocean Governance. Routledge.

Course Outcome: Student understand the different process of ocean management practices and its principles at national and international level.

MABO - 512; MARINE BIOTECHNOLOGY

Course Objective: To understand the application of different techniques and processes involving marine organism and explore their possible utilization.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 4 **TOTAL HOURS: 60**

UNIT - I **12 HOURS**

Marine Biotechnology - history of marine biotechnology - application in aquaculture, pharmaceutical, nutraceutical: bioremediation, biofouling, bio-corrosion, bioadhesives.

UNIT - II **14 HOURS**

Developmental biotechnology; induced breeding, in-vitro fertilization, early embryonic development and developmental processes in marine invertebrates (echinoderms, crustacean, mollusk), biotechnological methods - ELISA, FISH, PCR, Gene probes, dot-immuno binding activity, Principles of cloning - Transgenic Technology, Cryopreservation, Biosafety & Ethics.

UNIT - III **10 HOURS**

Algal biotechnology - marine algal products and their application in biotechnology, single cell protein. Marine Enzymes and bioreactors.

UNIT - IV **12 HOURS**

Bioactive marine natural products and their application - introduction to marine natural products.

UNIT - V **12 HOURS**

Bioinformatics - introduction, biological database. National Centre for Biotechnological Information, Protein structural analysis - identification of signature motifs in proteins and secondary structure prediction. Multiple sequence alignment and phylogenetic analysis.

Text Books

1. Y. Le Gal and H. O. Halvorson (Eds). 1997. New Developments in Marine Biotechnology, Plenum Pub. Corp.
2. Steven M. Colegate and Russel J. Molyneux. 2008. Bioactive Natural Products (II Ed.). CRC Press.

Reference Books

1. Scheper T. (Ed.). 2005. Marine Biotechnology (Vol. I), Springer (Germany).
2. Scheper T. (Ed.). 2005. Marine Biotechnology (Vol. II), Springer (Germany).

Course Outcome: Students will understand the development and application of biotechnology of marine organisms.

MABO – 513; MARINE POLLUTION

Course Objective: Types of marine pollution, sources and adverse effects of marine pollution to the marine biota/environment - UN definition and causes of Marine Pollution.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 4 **TOTAL HOURS: 60**

UNIT - I **10 HOURS**

Marine pollution - definition - role of GESAMP - major pollutant - sources - transport path - dynamics.

UNIT - II **12 HOURS**

Sewage - industrial - agricultural - domestic pollution - treatment methods: impact on marine environment - Detergents - composition - interference with eutrophication - impact on the marine environment.

UNIT - III **14 HOURS**

Heavy metal pollution - sources - distribution - fate - analytical approaches. Pesticide pollution - classification - sources - distribution - critical pollutants - Role of biocides - ecological impacts.

UNIT - IV **12 HOURS**

Oil Pollution - composition - sources - impacts on marine organisms - treatment techniques - bioremediation. Ballast water and bio-invasion. Aquatic noise. Thermal pollution - sources - uses of waste heat. Radioactive pollution - sources - natural - artificial - biological effects of radiation.

UNIT - V **12 HOURS**

Environmental monitoring methods - water quality assessment - objectives, status, limitations and biological indicators. Environmental Impact Assessment studies; types of EIA, Environmental Clearance: Environmental Management Plan.

Text Books

1. Clark, R.B., 1992. Marine pollution. Third edition Clarendron, Press Oxford.
2. Williams, 1996. Introduction to Marine Pollution Control. John Wiley.

Reference Books

1. Johnston, R., (Ed.), 1976. Marine Pollution, Academic Press, London.
2. Kennish, M.J., 1994. Practical handbook on estuarine and marine pollution. Elsevier.

Course Outcome: Students will understand various techniques involved in marine pollution – protection and various wastes discharged in the marine environment.

MABO - 599; PROJECT

Course Objective: To understand research in short term experiments, sample collection and interpretation.

Pre-requisite: Bachelor's level course in Life Sciences.

TOTAL CREDIT: 4 **TOTAL HOURS: 60**

Each Student will be allotted under a Faculty Member and the student will put in 60 hours of research work based on a particular topic. At the end of the semester, this work to be compiled and submitted as a dissertation. This will be evaluated and marks awarded.

Course Outcome: Students on completion of the dissertation will have knowledge on taking up research programmes.