

# **REGULATIONS M. Sc. MARINE BIOLOGY**

**(Effective from the Academic Year 2015 - 2016 onwards)**

## **AIM OF THE COURSE**

The M.Sc. Marine Biology course aims to develop man power in the field of Marine Biology. At the end of the course students are expected to have good working knowledge in Marine Biology.

## **ELIGIBILITY**

A pass in the B.Sc. Degree examination in Life Sciences (Zoology, Botany, Biochemistry, Microbiology, Biotechnology, Fisheries and Aquaculture) with not less than 55% of marks in Major and Ancillary subjects.

## **COURSE STRUCTURE**

Duration of the Master Programme in Marine Biology is two years consisting of four semesters. The academic year is divided into two semesters viz., Odd Semester: July to November (90 Working Days) and Even Semester: December to April (90 Working Days). The maximum duration to complete the course will be eight semesters.

## **COURSES**

Each course will consist of lectures / tutorials / laboratory work / practical training / seminar / project work / report / viva voce.

## **INTAKE**

52 (Fifty Two) + Super numeric seats, Govt. MHRD.

## **ADMISSION**

Selection is based on the marks obtained in the two hours written examination conducted by the University on the last week of May or in the first week of June at different centers. The question paper comprises of objective type questions based on the under graduate subjects mentioned under eligibility criteria.

## ATTENDANCE

Each faculty handling a course shall be responsible for the maintenance of attendance register of candidates registered for the course. Each student should put in 70% attendance in the courses of the particular semester, failing which he or she will not be permitted to sit for the end – semester examination and will be asked to repeat that course the next time when it is offered.

## EXAMINATIONS

Evaluation is based on 40% continuous / Sessional assessment, consisting of test, seminar, and assignments. For the internal assessment evaluation the break up marks shall be as follows:

	<b>Theory</b>	<b>Marks</b>	<b>Practical</b>	<b>Marks</b>
<b>1</b>	First test	15	First test	15
<b>2</b>	Second test	15	Pre exam test	15
<b>3</b>	Seminar & Assignments	10	Record Submission	10
	Total	<b>40</b>		<b>40</b>

There will be one end Semester Examination (60% marks) of 3 hours duration for each course. External examiner will set the question paper and an external panel of examiners will evaluate the answer papers. Board of studies will recommend the panel of Examiners for various papers

## QUESTION PATTERN

**Time 3 hours**

**Max Marks: 60**

### Section A

**(10 x 2 = 20 marks)**

Answer any **TEN** Questions each in not more than **50** words  
(*Twelve Questions to be given*)

### Section B

**(4 x 5 = 20marks)**

Answer any **FOUR** Questions each in not more than **200** words  
(*Six Questions to be given*)

### Section C

**(2 x 10 = 20 marks)**

Answer any **TWO** Questions each in not more than **800** words  
(*Four Questions to be given*)

## PASSING MARKS

Minimal mark needed to pass is 50% of total, inclusive of internal and external, as well as the candidate should also get minimum of 40% of marks in end semester examination.

## RESULTS

Students with a CGPA of 9.0 and above and did not fail in any of the courses taken by him / her shall be awarded Distinction.

A CGPA of 6.0 and above shall be placed in First class. Student who has secured less than 50% marks in any papers gets F Grade and he/she is treated as failed in that paper.

Toppers of the total marks are declared as First Rank Holder. Rank Declaration is only, if the candidate passes all the papers in single attempt.

## **STRUCTURE OF THE PROGRAMME CHOICE BASED CREDIT SYSTEM (CBCS)**

### **CREDITS, COURSE AND DEGREE**

One credit shall mean one period of teaching for theory or two periods for laboratory / practical course per week in a semester (of 16 weeks).

One teaching period shall be for 60 minutes duration including 10 minutes for discussion / movement.

One credit shall be assigned to one week of field training program where the students spend the entire duration in the field along with the faculty member(s).

One tutorial hour per week shall be conducted in addition to regular contact hours for both Hard core and Soft core theory Courses.

A candidate who has successfully completed all the Hard Core courses and a Project work, and accumulated not less than minimum number of Credits prescribed shall be eligible to receive the degree.

The courses offered under a Program of Study are designated as Hard Core and Soft Core.

A course designated as Hard Core for a particular Program of Study must invariably be completed by the student to receive the Degree in that program. The Hard Core Course cannot be substituted by any other course.

Each course may consist of lectures/ tutorials/ laboratory work / practical training / seminar / project work / report / viva voce, etc.

The normal duration of the course shall be 04 semesters. No student shall be permitted to graduate earlier than 03 semesters nor take more than 08 semesters.

## EVALUATION

Evaluation is based on 40% continuous / session assessment marks and it is based on two written sectional examinations spread periodically during the semester. The remaining 10% of the total marks shall be for assignments/quizzes/seminars. There will be a 3 hour end-semester examination (60% marks) of duration for each course.

## GRADING AND GRADE CARD

Performances of students in each paper are expressed in terms of Marks as well as in Letter Grades. In case of fractions the marks shall be rounded off to next higher integer. The Letter Grades, in a Six point scale, are awarded based on the percentiles as detailed below:

**Table**

<b>Range of Percentiles</b>	<b>Letter Grade</b>	<b>Points for Calculate of CGPA</b>
X to (X-K)+1	A+	10
(X-K) to (X-2K)+1	A	9
(X-2K) to (X-3K)+1	A-	8
(X-3K) to (X-4K)+1	B+	7
(X-4K) to (X-5K)+1	B	6
(X-5K) to 50	C	5
Below 50	F	0
Failure Due to Lack of Attendance	FA	0

Percentiles are to be calculated only for those who have passed the course by securing 50% or above.

If the number of students in a course is less than 10 then the grading may be based on the absolute marks secured by the students as detailed below:

<b>Range of Percentiles</b>	<b>Letter Grade</b>	<b>Points for Calculate of CGPA</b>
81-100	A+	10
71-80	A	9
66-70	A-	8
61-65	B+	7
56-60	B	6
50-55	C	5
Below 50	F	0

The GPA and CGPA will be calculated as weighted average of points secured by the student in all the papers registered by him / her. The weights are the number of credits for each paper. For example, a student getting A grade in 4 credit course, A- grade in 2 credit course, A+ grade in a 3 credit course and F grade in a 3 credit course will have a GPA as  $(9 \times 4 + 8 \times 2 + 10 \times 3 + 0 \times 3) / (4 + 2 + 3 + 3) = (36 + 16 + 30 + 0) / 12 = 82 / 12 = 6.83$  out of 10.0; GPA = 6.83. The CGPA shall also be calculated in similar lines taking all subjects taken by the students in all semesters.

## M. Sc., Marine Biology Syllabus

(From 2015 – 2016 Academic Year).

Course Code	Theory / Practical	Assessment marks		Credit	Total Marks
		Internal	External		
<b>I SEMESTER</b>					
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
<b>II SEMESTER</b>					
MABO 411	Taxonomy of Marine Organism	40	60	4	100
MABO 412	Marine Microbiology	40	60	4	100
MABO 413	Molecular Genetics	40	60	4	100
MABO 414	Fishery Biology	40	60	4	100
MABO 415	Lab – III - Taxonomy of Marine Organism and Marine Microbiology	40	60	2	100
MABO 416	Lab – IV - Molecular Genetics and Fishery Biology	40	60	2	100
<b>III SEMESTER</b>					
MABO 501	Physiology and Biochemistry	40	60	4	100
MABO 502	Aquaculture	40	60	4	100
MABO 503	Marine Pollution	40	60	4	100
MABO 504-510	Soft Core I	40	60	2	100
MABO 511	Lab – V - Physiology & Biochemistry & Aquaculture	40	60	2	100
MABO 512	Field Trip Report	40	60	2	100
<b>IV SEMESTER</b>					
MABO 521	Ocean Policies and Management	40	60	4	100
MABO 522	Marine Biotechnology	40	60	4	100
MABO 523-529	Soft Core II	40	60	2	100
MABO 599	Project	40	60	4	100
<b>Total</b>				<b>72</b>	<b>2200</b>

**Soft Core – I: (Any one of the following courses to be selected by the student).**

**MABO - 504** – Benthic Ecology.

**MABO - 505** – Marine Environmental Impact Assessment.

**MABO - 506** – Marine Ornamental Fishes.

**MABO - 507** – Methods in Marine Zooplankton Ecology.

**MABO - 508** – Marine Biodiversity and Conservation.

**MABO - 509** – Bacteriological Assessment of Seafood, Spoilage and Water  
Quality.

**MABO - 510** – Remote Sensing and GIS.

**Soft Core – II: (Any one of the following courses to be selected by the student).**

**MABO - 523** – Marine Parasitology.

**MABO - 524** – Biostatistics.

**MABO - 525** – Immunology of Aquatic Organisms.

**MABO - 526** – Ecotoxicology.

**MABO - 527** – Bioactive Marine Natural Products.

**MABO - 528** – Marine Organisms – Collection, Preservation and Submission.

**MABO - 529** – Coral and Mangrove Ecosystems.



# **SEMESTER - I**

# MABO - 401; PHYSICAL OCEANOGRAPHY

**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. Recent developments & Modern challenges in Oceanography science- satellite oceanography and remote sensing technology.

## **UNIT-II**

**10 HOURS**

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

## **UNIT-III**

**14 HOURS**

Waves, Currents and Tides – 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**

Dynamics of the ocean-general 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, 4<sup>th</sup> 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.

# MABO - 402; CHEMICAL OCEANOGRAPHY

**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 measurements.

## **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. Other gases - 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, 4<sup>th</sup> Edition. Jones and Bartlett, Sudbury, Massachusetts.
2. Grasshoff, K., 1999. Methods of Sea water Analysis. Wiley VCH, New York.

# MABO – 403; BIOLOGICAL OCEANOGRAPHY

**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 identification. Phytoplankton - Zooplankton – interrelationship - 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 weed – general structure, types, distribution and economical importance - Mangroves – distribution and adaptation (morphological, anatomical). Salt marsh – occurrence and 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. 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.

# MABO - 404; MARINE ECOLOGY

**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, interstitial, deepsea adaptation. Other coastal environments - estuaries, lagoons, mangroves, seagrass, coral reefs. Hydrothermal vents.

## **UNIT-II**

**12 HOURS**

Animal association in marine environment - endoecism - inquilinism - phoresis - epizoism - mutualism - communalism - symbiosis - parasitism. Marine zoogeography with reference to Indian - Arctic - Antarctic Oceans.

## **UNIT- III**

**12 HOURS**

Population ecology - population growth - density variations - concept of carrying capacity. Dispersal - competition - prey-predator relationship - density dependant - density independent factors.

## **UNIT-IV**

**12 HOURS**

Community ecology - structure and composition - diversity - stability - concept of niche – succession – community metabolism. Fouling and Boring community - 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 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.

**MABO - 405; Lab – I**  
**Physical Oceanography and Chemical Oceanography.**

**TOTAL CREDIT: 2**

**TOTAL HOURS:30**

1. Navigational Device: Operation and application of GPS.
2. Measuring device - I Secchi Disc.
3. Measuring device - II Turbidity Meter.
4. Measuring device - III Operation of Current meter.
5. Operation and Principle of Refractometer.
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.

## **MABO-406; Lab – II**

### **Biological Oceanography and Marine Ecology.**

**TOTAL CREDIT: 2**

**TOTAL HOURS:30**

1. Identification of Phytoplankton- Diatoms and Dinoflagellates.
2. Identification of Cyanobacteria.
3. Identification of Zooplankton- Copepods and Chaetognatha.
4. Identification of other Larval forms.
5. Identification of locally available Seaweeds.
6. Identification of locally available Mangroves.
7. Extraction and Estimation of Chlorophyll-a.
8. Extraction and Estimation of Primary productivity.
  
9. Rocky Shore Fauna – Collection and Identification.
10. Sandy Shore Fauna – Collection, Sorting and Identification.
11. Seagrass – Macrofauna – Collection, Sorting and Identification.
12. Seagrass – Meiofauna – Collection, Sorting and Identification.
13. Mangrove Sediment – Macrofauna – Collection, Sorting and Identification.
14. Mangrove Sediment – Meiofauna – Collection, Sorting and Identification
15. Estimation of Population density in an Ecosystem.
16. Sample Preservation Techniques.

#### **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.

## **SEMESTER - II**



# MABO – 411; TAXONOMY OF MARINE ORGANISM

**TOTAL CREDIT: 4**

**TOTAL HOURS:60**

## **UNIT-I**

**13 HOURS**

Science of Taxonomy – Classification of different organisms with example - Kingdom – Protista – Phylum – Sarcomastigophora, Ciliophora, Labyrinthomorpha - Kingdom – Animalia – Phylum – Porifera, Placozoa, Cnidaria, Ctenophora, Platyhelminthes.

## **UNIT-II**

**10 HOURS**

Phylum – Nemertina, Gastrotricha, Kinorhyncha, Gnathostomulida, Priapulida, Nematoda, Entoprocta, Ectoprocta, Phoronida, Brachiopoda.

## **UNIT-III**

**13 HOURS**

Phylum – Mollusca, Sipuncula, Echiurida, Pogonophora, Hemichordata, Chaetognatha, Annelida, Arthropoda, Merostomata, Pycnogonida.

## **UNIT-IV**

**13 HOURS**

Phylum – Crustacea, Echinodermata, Chordata – Subphylum - Urochordata, Cephalochordata.

## **UNIT-V**

**11 HOURS**

Phylum – Chordata – Subphylum – Vertebrata – Class - Reptilia, Aves, Mammalia.

### **Text Books**

1. Janet Moore, 2006. An Introduction to the Invertebrate. Cambridge press.
2. R. L. Kotpal (2013). Vertebrates- modern text book of Zoology. Rastogi Publication, New Delhi.

### **Reference Books**

1. Kaestner, A., 1967. Invertebrate Zoology. V. I - III. Willey Interscience Publishers, New York.
2. Colbert, 1991. Evolution of the Vertebrates. John Willey & Sons Inc., New York.

# MABO – 412; MARINE MICROBIOLOGY

**TOTAL CREDIT: 4**

**TOTAL HOURS: 60**

## **UNIT-I**

**10 HOURS**

Marine microorganisms- diversity - Archaea, Cyanobacteria, Bacteria, Acineteobacter, Fungi, Viruses - role in marine ecosystems.

## **UNIT-II**

**13 HOURS**

Importance of taxonomy - bacterial classification and the Linnaean system. Whittaker's five kingdom classification - three domain concept of Carl Woese- Phylogenetic tree. Unculturable - culturable bacteria - 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**

Microbes in ocean processes - biogeochemical cycling of carbon, nitrogen, phosphorous, sulphur. Extremophiles – thermophiles - halophiles - acidophiles – alkaliphiles - barophiles - baropsychrophiles - psychrophiles. Bacterial invertebrates symbiosis - Coral microbial associates. Hydrothermal vent bacteria - Deep-Sea microbes - bioluminescence.

## **UNIT- IV**

**12 HOURS**

Pathogenic microorganisms - fish, shellfish - impact to human beings. Microbial spoilage of seafood - processing - preservation. Pollution microbiology –water quality- fecal and total coliforms. Microbial technology - fermenters - batch - continuous culture - bench top - 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 – fouling in marine environments.

### **Text books**

1. Munn C.B.2004. Marine Microbiology: Ecology and Applications, Taylor & Francis Roultege.
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.

# MABO – 413; MOLECULAR GENETICS

**TOTAL CREDIT: 4**

**TOTAL HOURS:60**

## **UNIT-I**

**12 HOURS**

General genetics - DNA as genetic material – gene as a unit of mutation and recombination – Molecular nature of the gene – Organisation of prokaryotic and eukaryotic genomes – replication of DNA – role of different enzymes and accessory proteins in prokaryotic and eukaryotic DNA replication.

## **UNIT-II**

**11 HOURS**

Mutation and mutagenesis – mechanism of mutation – spontaneous mutations – induced mutations – reverse mutations – suppressor mutations – chemical mutagenesis – nitrous acid – hydroxylamine – alkylation agents – Intercalating agents and UV – Mechanism of DNA repairs process – photo reactivation – excision repair – recombinational repair – SOS pair mechanism and their regulations – heat shock response.

## **UNIT-III**

**13 HOURS**

DNA Replication – conservative – semiconservative – rolling circle – Cairn's model of replication – mechanism of replications – Okazaki fragments – role of different enzymes and accessory proteins – specific examples of replications – single stranded phage – double stranded – SV40 – OX174.

## **UNIT- IV**

**12 HOURS**

Genetics of bacteria and viruses – transformations – conjugation – F+Hfr – transduction – generalized and specialized – gene expression – DNA transcription in prokaryotic and eukaryotic system and its regulation – types of RNA and their function – translation – relation between genes and proteins – colinearity of the gene and polypeptide - elucidation of genetic code – wobble base pairing – suppression of nonsense – missense and frame shift mutations – overlapping genes.

## **UNIT-V**

**12 HOURS**

Regulations of gene expression – prokaryotes – the operon concept – positive – negative and as attenuation control – control sequences – promoter – operator 0 terminator and attenuator – lac and trp operons and translational regulation model – eukaryotes – regulation at the level of transcription – role of transcriptional factors – regulations of allosteric enzymes.

## **Text books**

1. Malacinski G.M. and Friefelder, 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 Styler, 2002. Biochemistry. W.H. Freeman & Co.

# MABO – 414; FISHERY BIOLOGY

**TOTAL CREDIT: 4**

**TOTAL HOURS:60**

## **UNIT-I**

**10 HOURS**

Introduction to marine fisheries – history of world and Indian Fisheries sector –Classification of fin and shell fishes with special reference to species of commercial importance.

## **UNIT –II**

**12 HOURS**

Digestive system of fishes - food and feeding habits - feeding strategies and food analysis indices. Reproductive system of fishes - maturation and spawning - methods of study – relative condition factor, fecundity. Circulatory and respiratory systems of fishes.

## **UNIT- III**

**12 HOURS**

Age and growth of fishes. Dimensions of growth – estimation of growth parameters. Length – weight relationships. Migration – causes and methods used for the study. Fish population dynamics – concepts of stock - fish stock assessment. Maximum sustainable yield and overfishing. Fishing regulations – closed seasons and protected areas. Fishery management and Economics.

## **UNIT-VI**

**12 HOURS**

Marine fishery resources of India – pelagic, demersal, oceanic and deep-sea. Fishery resources of Andaman and Nicobar Islands. Fishery resource potential and present level of exploitation. Exploratory fishery surveys. Estimation of exploited marine fishery resources. Ancillary fishery resources - seaweeds, chunk, crab, lobsters and bivalves.

## **UNIT –V**

**14 HOURS**

Fishing craft and gears: traditional and modern. Chart reading and position fixing for ground selection. Fishing aids – Echo-sounder, SONAR, GPS and Remote Sensing. Fishery forecasting – Potential Fishing Zone. Fresh 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.

**MABO-415; Lab – III**  
**Taxonomy of Marine Organism and Marine Micorbiology.**

**TOTAL CREDIT: 2**

**TOTAL HOURS:30**

1. Identification of Polychaetes.
2. Identification of Decapods.
3. Identification of Gastropods.
4. Identification of Echinoderms.
5. Respiratory organs of fish.
6. Morphology of integument and its derivative.
7. Developmental stages – gastrula and blastula
8. Identification of Minor Phyla – Nematoda, Nemertinea and Sipunculida.
  
9. Different Techniques in Sterilization.
10. Isolation of bacteria from Seafood – Shellfish and Finfish
11. Isolation of bacteria from Seafood – Water and Sediment
12. Separation of mixed cultures - isolation of pure colonies.
13. Identification of Microbes – Staining and Cell Morphology.
14. Preservation Techniques of Bacteria.
15. Isolation of bacterial DNA.
16. PCR based Identification of microbes.

**Lab Manuals:**

1. Brusca, R.C. & Brusca, G.J., 2003. Invertebrates. 2<sup>nd</sup> Edition, Sinauer Associates, Inc., Publishers, Massachusetts.
2. Buller N B., 2004. Bacteria from fish and other animals, A practical Identification manual. CABI.

**MABO-416;Lab – IV**  
**Molecular Genetics and Fishery Biology.**

**TOTAL CREDIT: 2**

**TOTAL HOURS:30**

1. Extraction of DNA.
2. Compilation of cDNA Library.
3. Study of mitosis.
4. Preparation of chloroplast.
5. Mounting of Polytene Chromosomes.
6. Column Chromatography techniques and Preparation.
7. Gel Electrophoresis.
8. TLC.
  
9. Taxonomy of fish.
10. Identification of fish scales.
11. Food and Feeding analysis of Fish.
12. Reproductive Biology of Fish - Maturity stages and Fecundity.
13. Length Weight Relationship of Fish.
14. Identification of common gears used in Indian waters.
15. Fish population estimation.
16. Determination of age of fish.

**Lab Manuals:**

1. Karp, G., 2010. Cell and Molecular Biology: Concepts and Experiments. 6<sup>th</sup> Edition. John Wiley & Sons Ltd., NJ, USA.
2. FAO, 2005, Manuals for Finfish Identification.

# **SEMESTER - III**

# MABO – 501; PHYSIOLOGY AND BIOCHEMISTRY

**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. Respiratory organs – respiratory pigments - integumentary and bronchial respiration - aquatic animals, gills-structure and function, over shift and chloride shift, factors affecting respiration. Animal adaptations-diving, buoyancy, swim bladder, gas liberation.

## **UNIT-II**

**12 HOURS**

Physiology of nervous system-structure and types of neuron. Neurotransmitter, impulse generation - nervous system-invertebrates. Physiology of rhythms-circadian- tidal and lunar rhythms in marine and estuarine animals - environmental factors responsible for biorhythms - 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 - Glycoconjugate - 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-aminoacids, polypeptides. Structure of protein – Ramchandra 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, function. Enzyme kinetic - mechanism of action – alosteric regulation, modifiers. Vitamins- biological role.

## **UNIT-V**

**10 HOURS**

Lipids-structure-classification, oxidation of fatty acids- saturated, unsaturated-  $\beta$  oxidation. Biosynthesis of lipids- synthesis of long chain fatty acids, unsaturated fatty acids, cholesterol- biosynthesis, regulation. Nucleic acid – metabolism. Biochemical Technique – Centrifugation, Chromatography, Colorimetry.

### **Text Books**

1. Hill, R.W., Wyse, G.A., Andersan, 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**

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



# MABO – 502; AQUACULTURE

**TOTAL CREDIT: 4**

**TOTAL HOURS:60**

## **UNIT-I**

**12 HOURS**

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

## **UNIT –II**

**12 HOURS**

Farming of fin and shellfish – traditional, extensive, modified extensive, semi intensive and intensive culture practices. Satellite farms Monoculture, polyculture and composite culture. Pond – cage – pen - raft - rope culture. Sea ranching.

## **UNIT –III**

**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- IV**

**14 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.

## **UNIT-V**

**10 HOURS**

Modern 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, transgenic. Cryopreservation of gametes. Eco-friendly fish farming - ecolabelling. Open water aquaculture - artificial reefs and fish aggregating devices.

### **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.

# MABO – 503; MARINE POLLUTION

**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 pollution - industrial - agricultural - domestic - impact on marine environment - treatment methods. Detergents - composition – interference with eutrophication - ecological impact. Marine debris - plastics - litter - impact in the marine environment.

## **UNIT –III**

**14 HOURS**

Heavy metal pollution - sources - distribution - fate - analytical approaches. Pesticide pollution - classification - sources - distribution - fate and ecological impacts with special reference to marine fishes, birds and mammals.

## **UNIT- IV**

**12 HOURS**

Oil Pollution - composition - sources - biological impacts on fishes, birds and mammals - treatment techniques - bioremediation. Ballast water and bio-invasion. Aquatic noise. Thermal pollution - sources - uses of waste heat. Role of biocides - chlorine - ecological impacts. Radioactive pollution - sources - natural - artificial -biological effects of radiation.

## **UNIT-V**

**12 HOURS**

Environmental monitoring methods - critical pollutants - objectives, status, limitations and biological indicators – bioaccumulation – bioconcentration - biomagnification - biotransformation - Mussel watch - water quality assessment. Use of analytical instruments - AAS - ICP - GC.

## **Text Books**

1. Clark, R.B., 1992. Marine pollution. Third edition Clarendon, 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.

# **SOFT CORE - I**

## **Papers Offered:**

**MABO - 504** (Benthic Ecology); **MABO – 505** (Marine Environmental Impact Assessment); **MABO - 506** (Marine Ornamental Fishes); **MABO - 507** (Methods in Marine Zooplankton Ecology); **MABO – 508** (Marine Biodiversity and Conservation); **MABO - 509** (Bacteriological Assessment of Seafood, Spoilage and Water Quality); **MABO – 510** (Remote Sensing and GIS).

**Each student is to select one out of the seven soft core papers mentioned above. For any individual soft core paper Minimum Three Students required to enroll for the paper, then only the particular soft core course will be offered.**

# **MABO - 504**

## **- BENTHIC ECOLOGY -**

**TOTAL CREDIT: 2**

**TOTAL HOURS:30**

### **UNIT-I**

**06 HOURS**

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

### **UNIT –II**

**06 HOURS**

Methods of sampling - photography - under water television - camera - diving - design of sampling programme - Sediment analysis - bulk benthic processes - bioturbation - sediment sculpting - animal sediment relationships.

### **UNIT –III**

**06 HOURS**

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

### **UNIT- IV**

**06 HOURS**

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

### **UNIT-V**

**06 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 McIntyre, 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.

**MABO - 505**  
**- MARINE ENVIRONMENTAL IMPACT ASSESSMENT -**

**TOTAL CREDIT: 2**

**TOTAL HOURS: 30**

**UNIT-I**

**05 HOURS**

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

**UNIT –II**

**05 HOURS**

Design and sample collection - Site selection - precision - size of samples - variability in biotic communities - appropriate spatial and temporal replication - data collection - field observation.

**UNIT –III**

**07 HOURS**

Marine environment – hydrodynamics (tides - tidal ranges - waves - current velocity) - water quality - physical (pH - temperature - salinity - total suspended solids - turbidity) - chemical (dissolved oxygen - BOD - nutrient analysis - heavy metals) - biological (Fecal coliforms - phytoplankton - zooplankton - benthos) - sediment quality - sand - silt - clay fraction analysis - wet sieving method - total organic carbon - organic matter estimation - wet oxidation - Loss On Ignition (LOI) methods.

**UNIT- IV**

**05 HOURS**

Identification of marine benthic invertebrates - polychaetes - gastropods - bivalves.

**UNIT-V**

**08 HOURS**

Ecological quality measures - univariate measures (species diversity indices) - multivariate measures (Bray-Curtis similarity - multivariate dispersion indices - principal component analysis - cumulative dominance curves or ABC curves). Biological indicators - benthic indicators - Marine Biotic Indices - [BENTIX, AMBI, Benthic Quality Index (BQI) - Ecological quality (EcoQ)] - Taxonomic Sufficiency (TS). Prediction of impacts - risk assessment - environmental management - monitoring - preparation of EIA report using computational software. (Field trip data collection - data interpretation).

**Text Books**

1. Eleftheriou, A., and McIntyre, A.D., 2005. Methods for the study of Marine Benthos. Blackwell Science Ltd.
2. Clark, R.B 1992. Marine pollution. Third edition Clarendon, 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.

**MABO - 506**  
**- MARINE ORNAMENTAL FISHES -**

**TOTAL CREDIT: 2**

**TOTAL HOURS: 30**

**UNIT- I**

**08 HOURS**

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

**UNIT - II**

**06 HOURS**

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

**UNIT - III**

**04 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- IV**

**08 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 protozoan's.

**UNIT-V**

**04 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.

## **MABO - 507**

### **- METHODS IN MARINE ZOOPLANKTON ECOLOGY -**

**TOTAL CREDIT: 2**

**TOTAL HOURS: 30**

#### **UNIT-I**

**06 HOURS**

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

#### **UNIT –II**

**06 HOURS**

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

#### **UNIT –III**

**06 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**

**06 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**

**06 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.

**MABO - 508**  
**- MARINE BIODIVERSITY AND CONSERVATION -**

**TOTAL CREDIT: 2**

**TOTAL HOURS:30**

**UNIT-I**

**06 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**

**06 HOURS**

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

**UNIT –III**

**06 HOURS**

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

**UNIT- IV**

**06 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**

**06 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.



**MABO – 509**  
**- BACTERIOLOGICAL ASSESSMENT OF SEAFOOD,  
SPOILAGE AND WATER QUALITY -**

**TOTAL CREDIT: 2**

**TOTAL HOURS:30**

**UNIT-I**

**04 HOURS**

Safe working practices in Laboratory - risk assessment - categorization and containment of pathogens.

**UNIT –II**

**04 HOURS**

Bacteria - diseased from farm and wild - Fish and other Aquatic animals - characteristics of the disease – gram positive - gram negative – detection - diagnosis – control.

**UNIT –III**

**08 HOURS**

Bacterial contamination of seafood - water - sampling enumeration - culturing of bacteria in air - water - sediment - fishes – bivalves, seaweeds.

**UNIT- IV**

**08 HOURS**

Bacterial examination of seafood - spoilage – Fish freshness and quality assessment - quality assurance programs - HACCP - quality standards - codex alimentarius - International food standards.

**UNIT-V**

**06 HOURS**

Assessment of pathogens - Waste water and Public health. Drinking water criteria - National and International standards.

**Text Books**

1. Fernandes R 2009. Microbiology handbook of fish and seafood Printed and bound by Biddles Ltd., King's Lynn.
2. Alasalvar. C., F Shahidi., K. Miyashita., U Wanasundara 2011. Handbook of Seafood Quality, Safety and Health Applications John Wiley & Sons,

**References**

1. Whitman, K.A., 2000. Finfish and Shellfish Bacteriology Manual Techniques and Procedures. Iowa state press.
2. Austin, B. and Austin, D.A., 2004. Bacterial Fish Pathogens. Praxis publication UK.

# **MABO - 510**

## **- REMOTE SENSING AND GIS -**

**TOTAL CREDIT: 2**

**TOTAL HOURS:30**

### **UNIT-I**

**04 HOURS**

Introduction - scope of remote sensing in natural resources survey - developments in aerial photography - modern developments - advantages - limitations.

### **UNIT –II**

**07 HOURS**

Earth resource satellites - early history of space imaging - landsat programme - sensors onboard - polar orbiting - geostationary - ocean monitoring satellites. Thermal - multispectral scanning - blackbody radiation - radiation from real materials - atmospheric effects - thermal energy detectors - interpretation of thermal scanner imagery.

### **UNIT –III**

**07 HOURS**

Digital Image Processing - Image rectification and restoration - image enhancement - spatial feature manipulation - multi image manipulation - image classification - supervised image classification - unsupervised classification - data merging. Image interpretation - elements interpretation - tools and techniques - image Processing Software - application in coastal studies.

### **UNIT- IV**

**06 HOURS**

Geographical Information Systems (GIS) - definition - development - data sources - data structures - raster and vector - data capturing - pre-processing. Data base management systems in GIS - data manipulations - product generation - environmental GIS. Data acquisition system using GPS - on line GPS applications.

### **UNIT-V**

**06 HOURS**

Geographical Information System - spatial data - sources of error - data quality - database design - convention - mapping concepts - coordinate systems. Methods of spatial interpolations in GIS - visualizations in GIS.

### **Text Books**

1. Agarwal, C. S. and Garg, P. K., 2000. Textbook on Remote Sensing in Natural Resources Monitoring and Management. Wheeler Publishing, New Delhi.
2. Heywood, I., 2006. An Introduction to Geographical Information Systems. Prentice Hall.

### **Reference Books**

1. Lilisand, T.M. 2003. Remote Sensing and Image Interpretation. John Wiley and Sons.
2. Martin, S. 2004. An Introduction to Ocean Remote Sensing. Cambridge.

**MABO – 511; Lab – V**  
**Physiology & Biochemistry and Aquaculture.**

**TOTAL CREDIT: 2**

**TOTAL HOURS:30**

1. Effect of salinity on oxygen consumption in Fish.
2. Effect of temperature on oxygen consumption in Fish.
3. Determination of filtration rate in bivalves.
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 Cultural Species for Aquaculture.
10. Identification of Larval Stages of Shell and Fin Fishes.
11. Identification of Live Feed Organisms – Phytoplankton.
12. Identification of Live Feed Organisms – Zooplankton.
13. Induced Breeding – Thermal Shock.
14. Preparation of Feed.
15. Identification of predator in aquaculture.
16. Identification of diseased animal in aquaculture.

**Lab Manuals:**

1. David. T. Plummer, 2003. An Introduction to Practical Biochemistry 3<sup>rd</sup> Edition. Tata McGraw – Hill.
2. FAO, 2005, Manuals for Finfish Identification.

## **MABO-512 FIELD TRIP REPORT**

**TOTAL CREDIT: 2**

**TOTAL DAYS: 14**

### **Submission of Field Trip Report.**

**Two field trips (One in Each Year) will be conducted along with the Faculties for observation, analysis and its interpretation. A consolidated, typed report, along with photographs has to be submitted at the end of third semester. This will be evaluated by the programme committee and the grade / mark will be awarded.**

# **SEMESTER - IV**

# **MABO – 521; OCEAN POLICIES AND MANAGEMENT.**

**TOTAL CREDIT: 4**

**TOTAL HOURS:60**

## **UNIT-I**

**05 HOURS**

Scientific expeditions - ascertaining the wealth of the sea. Three-major Oceans - importance. Historical evolution of ideas on ocean as a common heritage of mankind.

## **UNIT –II**

**17 HOURS**

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

## **UNIT –III**

**13 HOURS**

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

## **UNIT- IV**

**10 HOURS**

Beach sand - mineral deposits with special reference to India - marine metalliferous mud - placer 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 - policies - programmes.

## **UNIT-V**

**15 HOURS**

Role of National and International agencies and organizations in ocean management - ICAR - MoEF - MoES - NBA - MPEDA - IMO - FAO - UNEP - INMARSAT - IUCN - SCAR - SCOR - GOOS. Intellectual Property Right (IPR ) – Bioethics - Ocean policy (India) - research and management. Geographical Information System (GIS) - uses of GIS in ocean management. Water leasing policy.

### **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.

# MABO - 522; MARINE BIOTECHNOLOGY.

**TOTAL CREDIT: 4**

**TOTAL HOURS:60**

## **UNIT-I**

**12 HOURS**

Biotechnology in marine science - history of marine biotechnology – application in aquaculture, pharmaceuticals, nutritional, environment remediation, biofouling, bio-corrosion, bioadhesives. Molecular genetic techniques.

## **UNIT –II**

**14 HOURS**

Developmental biotechnology; induced breeding, in-vitro fertilization, cryopreservation, early embryonic development and developmental processes in marine invertebrates (sea urchin, horseshoe crab), biotechnological methods - ELISA, FISH, PCR, Gene probes, dot-immuno binding activity, monoclonal antibodies; Principles of cloning - Transgenic Technology, Biosafety & Ethics.

## **UNIT-III**

**10 HOURS**

Algal biotechnology – marine algae and their role in biotechnology, single cell protein, hydrocolloids, agarose, carrageen, alginates and other by products. Marine Enzymes – sources and their applications – Marine Lipids - sources and their applications.

## **UNIT-IV**

**12 HOURS**

Bioactive marine natural products – introduction to marine natural products- anti tumor-tumor promoting-anti inflammatory-analgesic - anti viral agents – antibiotic – cytotoxic - antimicrobial compounds. Isolation techniques: liquid-liquid extraction - chromatography and conventional techniques for bioactive marine natural products like labile proteins - marine toxins. Commercial development of marine natural products - chitin, chitosan, LAL.

## **UNIT-V**

**12 HOURS**

Bioinformatics – introduction, biological database. European Bioinformatics Institute, National Centre for Biotechnological Information, DNA Data Bank of Japan. Protein structural analysis - identification of signature motifs in proteins and secondary structure prediction, Multiple sequence alignment and phylogenetic analysis. Systems Biology.

## **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).

## **SOFT CORE - II**

### **Papers Offered:**

**MABO – 523** (Marine Parasitology); **MABO – 524** (Biostatistics); **MABO – 525** (Immunology of Aquatic Organisms); **MABO - 526** (Ecotoxicology); **MABO - 527** (Bioactive Marine Natural Products); **MABO - 528** (Marine Organisms – Collection, Preservation and Submission); **MABO - 529** (Coral and Mangrove Ecosystems).

**Each student is to select one out of the seven soft core papers mentioned above. For any individual soft core paper Minimum Three Students required to enroll for the paper, then only the particular soft core course will be offered.**



**MABO - 523**  
**- MARINE PARASITOLOGY -**

**TOTAL CREDIT: 2**

**TOTAL HOURS:30**

**UNIT-I**

**06 HOURS**

Parasitology - definition, nature of parasitism, kinds of parasites, kinds of host, adaptations, ecology, host – parasite relationships, symbiotic relationships, marine parasites.

**UNIT-II**

**06 HOURS**

Protozoan parasites, crustacean parasites-copepods, isopod, cirripedia. Helminth parasites - Turbellaria, ectoparasitic flukes, endoparasitic flukes. Marine hyperparasites, Parasites in other metazoans-annelids, molluscs.

**UNIT-III**

**06 HOURS**

Behavioral aspects-parasite induced changes-host behavioral morphology, cleaning interactions, mutualism, transmission of marine parasites. Population concepts-factors affecting parasitic population, dispersion concept, dynamics of population growth-density dependant and independent factors.

**UNIT-IV**

**06 HOURS**

Ecological niches, structure of parasitic community-parasites in intertidal organism. introduced parasites. Parasitism-immunology, pathology, biochemistry, host resistance, predation avoidance.

**UNIT-V**

**06 HOURS**

Zoogeography- latitudinal, longitudinal, depth gradients, parasites as indicators, deep sea parasites. Economic and environmental importance.

**Text Books**

1. Rohde, K., 2005, Marine Parasitology, CABI publishing, UK
2. Poulin, R. 2002, Parasites in marine systems, Cambridge University Press, UK

**Reference Books**

1. Bush, A.O., Fernandez, J.C., Esc, G.W., Seed, J.R., 2001, Parasitism- The Diversity and Ecology of Animal parasites. Cambridge University Press, UK
2. Rohde, K., 1982, Ecology of Marine parasites, Univ. of Queensland Press.

# **MABO - 524**

## **- BIOSTATISTICS -**

**TOTAL CREDIT: 2**

**TOTAL HOURS:30**

### **UNIT-I**

**05 HOURS**

Introduction - scope of biostatistics - population - sample - variable - parameter. Collection - organization - presentation of data – Types of samplings - random – stratified – systematic. Tabulation - frequency distribution - cumulative frequency curves - graphic representation.

### **UNIT –II**

**06 HOURS**

Measures of central tendency - mean - median - mode. Measures of dispersion - variability - range - mean deviation - standard deviation – coefficient of variation - skewness – kurtosis.

### **UNIT- III**

**06 HOURS**

Correlation – types - coefficient of correlation – Pearson’s correlation – testing the significance of the correlation coefficient. Regression analyses - simple linear - nonlinear - multiple regression. Test of hypothesis - Null hypothesis - Type I and type II errors - level of significance. Tests of significance - Chi-square test - variation ratio F-test - Student’s t-test - ANOVA.

### **UNIT-VI**

**06 HOURS**

Probability rules and theoretical distributions - basic probability rules – expectation - conditional probability. Probability distributions - Binomial, Poisson, normal and log-normal distributions.

### **UNIT –V**

**07 HOURS**

Scope of computers in marine sciences. Internet - applications. Introduction - MS excel - use of worksheet to enter data. Use of in-built basic statistical functions for computations - graphical representation - bar diagram – histogram - scatter plots - pie-chart – box plot. Biological data analysis – univariate measures - species diversity indices - Margalef’s diversity - Shannon-Wiener Index - evenness index – Multivariate techniques – similarity coefficients - principal component analysis – cluster analysis. Data analysis using MS Excel - SPSS - PCord - PRIMER.

### **Text Books**

1. Kushwaha K.S. and Rajeshkumar. 2009. The theory of Sample Surveys and Statistical Decisions. New India Publishing Agency, New Delhi
2. Mitchell, K. and Glover, T. 2001. Introduction to Biostatistics. McGraw Hill, Publishing Co.

### **Reference Books**

1. Gould, J.F. and Gould, G.F. 2001. Biostatistics Basics: A Student Hand Book. First edition. W.H. Freeman Company.
2. Wayne W. Daniel, 2004. Biostatistics, Wiley.

**MABO - 525**  
**- IMMUNOLOGY OF AQUATIC ORGANISMS -**

**TOTAL CREDIT: 2**

**TOTAL HOURS:30**

**UNIT-I**

**04 HOURS**

Introduction to Immunology. Blood types – Blood groups in aquatic organisms. Antigen – Antibody – structure and functions.

**UNIT –II**

**06 HOURS**

Internal defence mechanisms in fishes – cellular, humeral and anti-microbial and anti – viral substances. Immunity – antigens – antibodies complement – reactive proteins – interferon lysozyme - Cell mediated immunity – Adaptive immunity – Immunisation. Immune systems in relation to parasitic infections. Cellular basis of immunity.

**UNIT –III**

**08 HOURS**

Stress – general adaptations – Bacterial, fungal and viral diseases of aquatic organisms. Parasitic diseases – protozoan, sporozoan, helminth and crustacean. Genetic and environmentally induced abnormalities.

**UNIT- IV**

**06 HOURS**

Nutritional pathology – Deficiency syndromes, toxic components of diet – aflatoxins, dinoflagellates – antibiotics and chemotherapeutics, binders – Neoplasia in aquatic organisms. Disease therapy – vaccines - treatments – external, through diet and injection.

**UNIT-V**

**06 HOURS**

Methods in Immunology – Monoclonal and polyclonal antibodies production - Flow cytometry - ELISA - Enzyme linked immunosorbent immunosorbent assay - RIA – Radio immunosorbent assay - IP – immunoprecipitation immunoprecipitation - Western blot, immunofluorescence - Blood group typing - Coombs test (direct and indirect) - Affinity chromatography - Other techniques: Haematopoietic cells concentration, complement fixation test, contact precipitation, gel immunodiffusion, protein electrophoresis

**Text Books:**

1. Anderson, W.L, 1999, Immnology. Fence Creek Publishing (Blackwell).
2. Balaraman, D. Sakthivel, M. and Balamurugan, S. 2000. Marine Fish Immunology and Immunotechnology. Marine Fish Immune Organs, Non-Specific Immune Response, ELISA & NBT. Publisher: LAMBERT.

**Reference Books:**

1. Edwin, L.C. 2014, Comparative Immunology. Originally published by Prentice Hall,
2. Sharon, J. 1998, Basic immunology. Williams and Wilkins, Baltimore MD. First edition, 1998.

# **MABO - 526**

## **- ECOTOXICOLOGY -**

**TOTAL CREDIT: 2**

**TOTAL HOURS:30**

### **UNIT-I**

**06 HOURS**

Introduction - toxicology - pollution monitoring - role of GESAMP - mass balance model - bioindicators.

### **UNIT –II**

**06 HOURS**

Toxicity testing methods - fixed dose procedure - factors influencing toxicity - exposure routes - synergistic - antagonistic effects acute toxicity - chronic toxicity - subchronic toxicity - carcinogenicity.

### **UNIT –III**

**06 HOURS**

Study of LC<sub>50</sub> - lethal - sublethal effects - ecotoxicological studies - experimental ecosystems - types of mesocosms and microcosms - role of micro and mesocosms - effects of toxicants to plankton - fish and shell fish.

### **UNIT- IV**

**06 HOURS**

Methods of sampling - seawater - sediments - biological samples. Estimation of pesticides - heavy metals - hydrocarbon. Harmful Algal Bloom. Bioconcentration, bioaccumulation, biomagnifications, biotransformation. Degradable - non-degradable toxicants.

### **UNIT-V**

**06 HOURS**

Methods for analyzing pesticides - heavy metals - hydrocarbon - data analysis - interpretation.

### **Text Books**

1. Wayne, G.L. and Ming-Hoyo, 2003. Introduction to environmental toxicology. Taylor and Francis.
2. Aravind Kumar, 2003. Aquatic Environment & Toxicology. Daya Publishing House.

### **Reference Books**

1. Williams, 1996. Introduction to Marine Pollution control, John Wiley.
2. Hayes, W.J. and Laws E.R., 1991. Handbook of Pesticide Toxicology, V. I to III, Academic Press, New York.

**MABO - 527**  
**- BIOACTIVE MARINE NATURAL PRODUCTS -**

**TOTAL CREDIT: 2**

**TOTAL HOURS:30**

**UNIT-I**

**06 HOURS**

Introduction - bioactive marine natural products - significance. Examples of following products with the details of source marine organism(s) - Anti tumor - anti inflammatory - analgesic - anti viral agents - antibiotic - cytotoxic - antimicrobial compounds.

**UNIT –II**

**06 HOURS**

Isolation and characterization of secondary metabolites from marine organisms. Characterization techniques - IR - UV - NMR - GCMS - FABMS - LCMS.

**UNIT –III**

**06 HOURS**

Marine microorganisms as a source of biomedical resources - dinoflagellates as a source of bioactive molecules - chemistry and pharmacology of marine toxins - saxitoxin - brevitoxin - ciguatoxin - tetrodotoxin.

**UNIT- IV**

**06 HOURS**

Nitrogen and non-nitrogen containing marine bioactive compounds - polyketides - prostanooids - polyethers - macrolides - terpenes.

**UNIT-V**

**06 HOURS**

Marine natural products and its Commercial Development- chitosan as biomaterial - algal products - SCPs -  $\beta$ -carotene - vitamins.

**Text Books**

1. Colegate, S.M. and Molyneux, R.J. 2008. Bioactive natural products (Third Edition) CRC press.
2. Attaway, D.H. 2001. Marine Biotechnology. V.I, Pharmaceutical and bioactive natural products.

**Reference Books**

1. Scheper, T., (Ed.), 2005. Marine Biotechnology. Springer.
2. Encyclopedia of Marine Natural Products, 2010. Willey and Blackwell. No. I to III.

**MABO - 528**  
**- MARINE ORGANISMS – COLLECTION,  
PRESERVATION AND SUBMISSION -**

**TOTAL CREDIT: 2**

**TOTAL HOURS: 30**

**UNIT-I**

**06 HOURS**

Classification of marine life based on major taxonomic groups major categories of aquatic life (Plankton - Nekton - Benthos).

**UNIT –II**

**06 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**

**06 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**

**08 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**) - 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**)

**UNIT-V**

**04 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. .

**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.

**MABO - 529**  
**- CORAL AND MANGROVE ECOSYSTEMS -**

**TOTAL CREDIT: 2**

**TOTAL HOURS: 30**

**UNIT-I**

**06 HOURS**

Coral reefs and Mangroves - introduction - types. Formation and zones. Occurrence and distribution - biology - adaptive characters - reproduction. Environmental parameters of coral reef and mangroves habitats.

**UNIT-II**

**06 HOURS**

Reef classification - types - stony (hard) and soft coral. Biodiversity - ecology - Darwin's paradox - solution - retention and recycling - coral survey methods. Biodiversity of mangrove ecosystems.

**UNIT-III**

**06 HOURS**

Coral reef and Mangroves associates - fish - invertebrates - algae - seabirds - others. Coral reefs and Mangroves in India. Great barrier reef, Sundarbans.

**UNIT-IV**

**06 HOURS**

Ecological roles of coral reefs and mangroves. Threats to corals - tourism - poison fishing - alteration of coastline/island habitats - over exploitation - sedimentation - coral harvesting - dynamite fishing - diseases. Climate change - coral bleaching and recovery - bio-shield. Threats to mangroves.

**UNIT-V**

**06 HOURS**

Economic value of corals and mangroves. Conservation and management strategies - organizations involved - artificial reefs.

**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.

## **MABO-599; PROJECT**

**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 by the experts and marks awarded.**