

**ANNAMALAI UNIVERSITY  
ANNAMALAINAGAR**

**HAND BOOK**

**DEGREE OF MASTER OF SCIENCE  
MARINE BIOLOGY AND OCEANOGRAPHY  
(CHOICE BASED CREDIT SYSTEM)**

**2018 - 2019**

**ANNAMALAI UNIVERSITY  
ANNAMALAI NAGAR**

**DEGREE OF MASTER OF SCIENCE**

**MARINE BIOLOGY AND OCEANOGRAPHY  
(CHOICE BASED CREDIT SYSTEM)**

**2018 – 2019**

**FACULTY OF MARINE SCIENCES**

**REGULATIONS**

**MASTER'S PROGRAMME**

A Master's Programme consists of a number of courses. Master's Programme consists of a set of Core Courses and elective Courses.

Core courses are basic courses required for each programme. The number and distribution of credits for core courses will be decided by the faculty.

Elective courses will be suggested by the respective departments, and they may be distributed in III and IV semesters.

A course is divided into five units to enable the students to achieve modular and progressive learning.

**SEMESTERS**

An academic year is divided into two semesters, Odd Semester and Even Semester. The normal semester periods are:

Odd Semester: July to November (90 Working days)

Even Semester: December to April (90 Working days)

**CREDITS**

The term credit is used to describe the quantum of syllabus for various programmes and hours of study. It indicates differential weightage given according to the contents and duration of the courses in the curriculum design.

The minimum credit requirement for a two year Master's Programme shall be 94.

The core courses shall carry 88 credits and the elective courses shall carry 6 credits.

## **ELIGIBILITY**

A undergraduate degree in Zoology / B.F.Sc. / Industrial Fish and Fisheries (with Zoology as a subsidiary subject) / Advanced Zoology and Biotechnology with a minimum of 50% of marks in Part III or any other degrees recognized equivalent to Zoology.

[M.Sc. Marine Biology and Oceanography (with B.Sc. Zoology as major) awarded by Annamalai University is equivalent to M.Sc. Zoology (G.O. (Ms.) No. 116 dated 22.07.2014)]

## **COURSES**

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

## **COURSE WEIGHT**

Core and elective courses may carry different weightage. For example, a course carrying one credit for lectures, will have instruction of one period per week during the semester, if three hours of lecture is necessary in each week for that course then 3 credits will be the weightage. Thus normally, in each of the courses, credits will be assigned on the basis of the lectures / laboratory work and other form of learning in a 15 week schedule:

- (i) One credit for each lecture period per week.
- (ii) One credit for every three periods of laboratory or practical work per week.
- (iii) One credit for 3 contact hours of project work in a week.
- (iv) One credit for every two periods of seminar.

## **GRADING SYSTEM**

The term Grading System indicates a 10-point scale of evaluation of the performance of students in terms of marks, grade points, letter grade and class.

## **DURATION**

The duration for completion of a two year Master's Programme is four semesters.

## **STRUCTURE OF THE PROGRAMME**

The Master's Programme will consist of:

- (i) Core courses which are compulsory for all students.

- (ii) Elective courses which students can choose from amongst the courses offered the faculty as well as by Departments of other faculties (Arts, Science, Education and Indian Language).
- (iii) The Elective subjects will be allotted by counseling by a committee of the respective Heads of the Departments under the Chairmanship of the Dean of the Faculty.
- (iv) Dissertation / Project work / Practical training / Field work can be done in an organization (Government, Industry, Firm, Public Enterprise etc.) approved by the concerned department.

## **ATTENDANCE**

Every teaching faculty handling a course shall be responsible for the maintenance of attendance register for candidates who have registered for the course.

The teacher of the course must intimate the Head of the Department at least Seven Calendar days before the last instruction day in the semester about the attendance particulars of all students.

Each student should fulfil the attendance requirement of 75% as prescribed by the University, to be eligible to appear for the University Examinations.

## **EXAMINATIONS**

The internal assessment for each course carries 25% marks and is based on two sessional tests. The pattern of question paper will be decided by the faculty. The tests are compulsory.

There will be one End Semester Examination (75% marks) of 3 hours duration for each course. The pattern of question paper will be decided by the faculty.

The Internal assessment for each practical course carries 40% of marks while the end semester practical examination of 3 hours duration carries 60% of marks.

## **EVALUATION**

The performance of a student in each course is evaluated in terms of Percentage of Marks (PM) with a provision for conversion to Grade Point (GP). The total performance in each semester will be rated by Grade Point Average (GPA) while the continuous performance from the 2<sup>nd</sup> Semester onwards will be marked by Overall Grade Point Average (OGPA).

## **MARKS AND GRADING**

A student cannot repeat the assessment of Sessional Test I and Sessional Test II. However, if for any compulsive reason, the student could not attend the test, the prerogative of arranging a special test lies with the teacher in consultation with the Head of the Department.

A student has to secure 50% minimum in the End Semester Examination.

The student who has not secured a minimum of 50% of marks (sessional plus end semester examination) in a course shall be deemed to have failed in that course.

A candidate who has secured a minimum of 50% marks in all the papers prescribed in the programme and earned a minimum of 94 credits will be considered to have passed the Master's Programme.

## GRADING

A ten point rating scale is used for the evaluation of the performance of the student to provide letter grade for each course and overall grade for the Master's Programme.

| Marks        | Grade | Letter grade | Class        |
|--------------|-------|--------------|--------------|
| 90 and Above | 10    | S            | Exemplary    |
| 85 – 89      | 9.0   | D            | Distinction  |
| 80 – 84      | 8.5   | D            | Distinction  |
| 75 – 79      | 8.0   | D            | Distinction  |
| 70 – 74      | 7.5   | A            | First Class  |
| 65 – 69      | 7.0   | A            | First Class  |
| 60 – 64      | 6.5   | A            | First Class  |
| 55 – 59      | 6.0   | B            | Second Class |
| 50 – 54      | 5.5   | C            | Second Class |
| 49 or Less   | -     | F            | Fail         |

The successful candidates are classified as follows:

I Class – 60% Marks and above in overall percentage of Marks (OPM).

II Class – 50-59% Marks in overall percentage of marks.

Candidates who obtain 75% and above but below 90% of marks (OPM) shall be deemed to have passed the examination in FIRST CLASS (Distinction) provided he / she passes all the papers prescribed for the programme at the first appearance.

For the Internal Assessment Evaluation, the details shall be as follows:

|                |   |          |
|----------------|---|----------|
| Test (2 tests) | - | 15       |
| Assignment     | - | 5        |
| Seminar        | - | 5        |
|                |   | -----    |
| Total          | - | 25 Marks |
|                |   | -----    |

## COURSE – WISE LETTER GRADES

The percentage of marks obtained by a candidate in a course will be indicated in a letter grade.

A student is considered to have completed a course successfully and earned the credits if he / she secures an overall letter grade other than F. A letter grade F in any course implies a failure in that course. A course successfully completed cannot be repeated for the purpose of improving the Grade point.

The F grade once awarded in the grade card of the student is not deleted even when he / she completes the course successfully later. The grade acquired later by the student will be indicated in the grade sheet of the odd / even semester in which the candidate has appeared for clearance of the arrears.

A student who secures F grade in any course which is listed as a core course has to repeat it compulsorily when the examination is held next. If it is an Elective course, the student has the option to repeat it when it is offered next or to choose a new elective if he / she so desires in order to get a successful grade. When new elective is chosen in the place of failed elective, the failed elective will be indicated as dropped in the subsequent grade card.

If a student secures F grade in the Project Work / Field Work / Practical Work / Dissertation, he / she shall improve it and resubmit it if it involves only rewriting incorporating the clarifications of the evaluators or he / she can re-register and carry out the same in the subsequent semesters for evaluation.

**M. Sc. MARINE BIOLOGY & OCEANOGRAPHY**  
**(M. Sc. BRANCH VII – A)**

**CHOICE BASED CREDIT SYSTEM - 2018 – 2019**

**I SEMESTER**

|      |     |                                   |
|------|-----|-----------------------------------|
| MBOC | 101 | Invertebrates and Prochordates    |
| MBOC | 102 | Vertebrates                       |
| MBOC | 103 | Cytology, Genetics and Immunology |
| MBOC | 104 | Marine Microbiology               |
| MBOC | 105 | Physiology and Biochemistry       |
| MBOC | 106 | Computer Application - I          |
| MBOC | 107 | Communication Skills              |
| MBOP | 108 | Practical – I (MBOC 101)          |
| MBOP | 109 | Practical – II (MBOC 102)         |
| MBOP | 110 | Practical – III (MBOC 103)        |
| MBOP | 111 | Practical – IV (MBOC 104)         |
| MBOP | 112 | Practical – V (MBOC 105)          |

**II SEMESTER**

|      |     |                                  |
|------|-----|----------------------------------|
| MBOC | 201 | Physical Oceanography            |
| MBOC | 202 | Chemical Oceanography            |
| MBOC | 203 | Biological oceanography          |
| MBOC | 204 | Coastal Aquaculture              |
| MBOC | 205 | Fisheries Science and Statistics |
| MBOP | 206 | Practical – VI (MBOC 201)        |
| MBOP | 207 | Practical – VII (MBOC 202)       |
| MBOP | 208 | Practical – VIII (MBOC 203)      |
| MBOP | 209 | Practical – IX (MBOC 204)        |
| MBOP | 210 | Practical – X (MBOC 205)         |

**III SEMESTER**

|      |     |  |
|------|-----|--|
| MBOC | 301 | Marine Ecology & Zoogeography                          |
| MBOC | 302 | Marine Biotechnology, Bioinformatics & Instrumentation |
| MBOC | 303 | Pollution and Toxicology                               |
| MBOC | 304 | Ocean Management                                       |
| MBOC | 305 | Elective – I   |
| MBOP | 306 | Practical – XI (MBOC 301)                              |
| MBOP | 307 | Practical – XII (MBOC 302)                             |
| MBOP | 308 | Practical – XIII (MBOC 303)                            |

**IV SEMESTER**

|      |     |               |
|------|-----|---------------|
| MBOC | 401 | Elective – II |
| MBOC | 402 | Project Work  |

## M.Sc. MARINE BIOLOGY & OCEANOGRAPHY

### CREDITS, INTERNAL ASSESSMENT MARKS AND ENDSEMESTER EXAM MARKS

| Course Code<br>Theory/Practical                                 | Credit<br>Points | Int.<br>Ass. | End Sem.<br>Exam<br>Marks | Total<br>Marks |
|---|------------------|--------------|---------------------------|----------------|
| <b>I SEMESTER</b>   |                  |              |                           |                |
| MBOC 101 Invertebrates and Prochordates                         | 3                | 25           | 75                        | 100            |
| MBOC 102 Vertebrates  | 3                | 25           | 75                        | 100            |
| MBOC 103 Cytology, Genetics and Immunology                      | 3                | 25           | 75                        | 100            |
| MBOC 104 Marine Microbiology                                    | 3                | 25           | 75                        | 100            |
| MBOC 105 Physiology and Biochemistry                            | 3                | 25           | 75                        | 100            |
| MBOC 106 Computer Application – I                               |                  | 25           | 75                        | <b>100</b>     |
| MBOC 107 Communication Skills                                   |                  | 25           | 75                        | <b>100</b>     |
| MBOP 108 Practical – I (MBOC 101)                               | 2                | 40           | 60                        | 100            |
| MBOP 109 Practical – II (MBOC 102)                              | 2                | 40           | 60                        | 100            |
| MBOP 110 Practical – III (MBOC 103)                             | 2                | 40           | 60                        | 100            |
| MBOP 111 Practical – IV (MBOC 104)                              | 2                | 40           | 60                        | 100            |
| MBOP 112 Practical - V (MBOC 105)                               | 2                | 40           | 60                        | 100            |
| Total   | <b>25</b>        |              |                           |                |
| <b>II SEMESTER</b>  |                  |              |                           |                |
| MBOC 201 Physical Oceanography                                  | 3                | 25           | 75                        | 100            |
| MBOC 202 Chemical Oceanography                                  | 3                | 25           | 75                        | 100            |
| MBOC 203 Biological Oceanography                                | 3                | 25           | 75                        | 100            |
| MBOC 204 Coastal Aquaculture                                    | 3                | 25           | 75                        | 100            |
| MBOC 205 Fisheries Science and Statistics                       | 3                | 25           | 75                        | 100            |
| MBOP 206 Practical – VI (MBOC 201)                              | 2                | 40           | 60                        | 100            |
| MBOP 207 Practical – VII (MBOC 202)                             | 2                | 40           | 60                        | 100            |
| MBOP 208 Practical – VIII (MBOC 203)                            | 2                | 40           | 60                        | 100            |
| MBOP 209 Practical – IX (MBOC 204)                              | 2                | 40           | 60                        | 100            |
| MBOP 210 Practical - X (MBOC 205)                               | 2                | 40           | 60                        | 100            |
| Total   | <b>25</b>        |              |                           |                |
| <b>III SEMESTER</b>   |                  |              |                           |                |
| MBOC 301 Marine Ecology & Zoogeography                          | 3                | 25           | 75                        | 100            |
| MBOC 302 Marine Biotechnology, Bioinformatics & Instrumentation | 3                | 25           | 75                        | 100            |
| MBOC 303 Pollution and Toxicology                               | 3                | 25           | 75                        | 100            |
| MBOC 304 Ocean Management                                       | 3                | 25           | 75                        | 100            |
| MBOE 305 Elective – I   | 3                | 25           | 75                        | 100            |
| MBOP 306 Practical – XI (MBOC 301)                              | 2                | 40           | 60                        | 100            |
| MBOP 307 Practical – XII (MBOC 302)                             | 2                | 40           | 60                        | 100            |
| MBOP 308 Practical – XIII (MBOC 303)                            | 2                | 40           | 60                        | 100            |
| Total   | <b>21</b>        |              |                           |                |
| <b>IV SEMESTER</b>  |                  |              |                           |                |
| MBOE 401 Elective – II  | 3                | 25           | 75                        | 100            |
| MBOC 402 Project Work   | 20               | 25           | 75                        | 100            |
| Total   | <b>23</b>        |              |                           |                |



Students have to choose courses for 6 credits (2 courses) out of the elective courses offered in other departments / faculties of the University. The elective papers are for students of other departments / faculties of the University.

**Credit**

| <b>Core</b> | <b>Optional</b> | <b>Total Credit</b> |
|-------------|-----------------|---------------------|
| <b>88</b>   | <b>6</b>        | <b>94</b>           |

Suggested Electives

1. Marine Food Technology
2. Ornamental Fish Culture & Aquarium Keeping
3. Molecular Virology
4. Plant and Animal Cell Culture Technology
5. Microbial Technology
6. Bioprocess Engineering & Technology
7. Biostatistics
8. Genomics & Proteomics
9. Vaccines
10. Remote sensing & GIS

## **I SEMESTER**

### **MBOC 101 – INVERTEBRATES AND PROCHORDATES (Functional morphology, Palaeontology and Evolution)**

#### **Objectives :**

In marine & brackish water realm, invertebrate fauna forms a major constituent both in terms of faunal diversity & density. Moreover, many of them stand as economically important both in terms of fishery and byproducts. The ecological role played by invertebrates is manifold. Hence studies pertaining to marine invertebrates is a prerequisite. In this context, the syllabus covers aspects such as classifications/systematics, various aspects of biology with special emphasis on larval development & life history, evolution & palaeontology, adaptive radiation and phylogenetic relationship.

#### **UNIT 1 – Protozoa and Coelenterata**

Classification – Morphology – Reproduction - life history and phylogenetic relationships of Protozoa and sponges.

Coelenterate – polymorphism, life history, theories on coral reefs, distribution. Structure, Ecosystem & formation.

#### **UNIT 2 – Minor phyla**

Functional morphology, development and evolution: Nemertinea, Endoprocta, Ectoprocta, Phoronida and Pogonophora.

Chaetognatha – classification, distribution, morphology, anatomy, embryology and evolution. Brachiopoda - classification, morphology, palaeontology and evolution.

#### **UNIT 3 – Crustacea and Polychaeta**

Crustacea: Classification, comparative morphology, crustacean appendages, larval forms, evolution and palaeontology.

Polychaeta – classification, morphology, feeding methods - reproduction and adaptive radiation.

#### **UNIT 4 - Mollusca**

Classification, general characters, torsion, palaeontology, phylogenetic relationships and adaptive radiation, reproduction and embryology.

#### **UNIT 5 – Echinodermata and Prochordata**

Echinodermata – Classification, structure and function, water vascular system, regeneration, reproduction and larval forms.

Prochordata – classification and comparative morphology, reproduction and early development, larval metamorphosis.

### **PRACTICAL I : MBOP 108 – Invertebrates and Prochordates**

1. Identification of locally available invertebrate fauna
2. Mounting of gastropod radula
3. Digestive system in gastropods and bivalves
4. Crystalline style of bivalves
5. Identification of sex in crustaceans and molluscs
6. Mouth parts of *Squilla* and *Balanus*.
7. Study of digestive, nervous, reproductive systems and different ovarian maturity stages in Shrimp
8. Appendages of prawns, shrimps and crabs
9. Study of water vascular system, tube feet and Aristotle's lantern in sea stars

### **REFERENCE BOOKS**

1. Hyman, I., 1967. The Invertebrates Vols, I to VI. McGraw Hill Book Co. Ltd., New York, 792 pp.
2. Kaestner, A., 1967-1970 Invertebrate Zoology Vols. 1-(1967-472pp), Vol.2(1968-472pp) Vol.3(1970-523pp). Wiley Interscience Publishers, New York.
3. Barnes, R.D., 1980. Invertebrate Zoology. 4<sup>th</sup> Edition. Saunders College Publishers, Philadelphia, 534 pp.
4. Ruppert, E.E. and R.D. Barnes, 1994. Invertebrate Zoology 6<sup>th</sup> Edition. Saunders College Publishers, Philadelphia, 1056 pp.
5. Adiyodi, K.G. and K.G. Adiyodi, 1994. Reproductive Biology of Invertebrates, Vol - 5, John Wiley & Sons, New York 542 pp.
6. Ruppert, E.E., R.S. Fox and R.D. Barnes., 2006. Invertebrate Zoology. 7<sup>th</sup> Edition. Saunders College Publishers, Philadelphia, 828 pp.
7. Kotpal, R.L. 2009. Modern Text book of Zoology invertebrates. 10<sup>th</sup> Edition. Rostogi publications, Meerut.
8. Nair N. C., S. Leelavathy, N. Soundrapandian, T. Murugan, N. Arumugam, 2010. A text book of Invertebrates. Saras Publication, Nagercoil. 752 pp.

**MBOC 102 – VERTEBRATES**  
**(Functional morphology, Palaeontology, Developmental Biology and Evolution)**

**Objectives :**

The marine environment is rich not only in the invertebrate fauna but also in the vertebrate faunal resources. Further, the sea water is a good medium that supports life right from its origin from the single celled organism to the multicellular marine mammals. This paper is planned to study the origin and evolution of species and also to understand the reproductive mechanisms in vertebrates.

**UNIT 1 – Origin of chordates**

Geological time scale – progression of vertebrates through time, chordate features and theories on the origin of chordates.

**UNIT 2 –Bony fishes and Amphibia**

Characteristic features of ancestral vertebrates – classification and evolution of jawless and primitive vertebrates. Evolution and adaptive radiation of elasmobranchs and bony fishes. Connecting link (Dipnoi).

Origin and distribution of amphibia – anatomical peculiarities and affinities of Urodela and Apoda.

**UNIT 3 – Reptiles and Marine birds**

Origin of reptiles – adaptive radiation of contemporary reptiles, turtles, amphibian and reptilian features of *Seymouria*, mammal-like reptiles, rise and fall of dinosaurs including mesozoic marine reptiles.

Mosasaurus, the giant marine lizards. Marine Crocodile: Estuarine/Salt water crocodile, Sea snakes

Importance of marine birds, adaptations to the marine environment, migration.

**UNIT 4 – Evolution of Mammals and human**

General characters of mammals – classification and evolution of monotremes, marsupials and placentals, human evolution, aquatic mammals – classification, adaptations and evolution of Cetacea and Sirenia. Seals, Walruses and Sea otters.

Aquatic adaptations for respiratory and circulatory mechanisms – comparative anatomy of skin derivatives.

**UNIT 5 – Developmental Biology**

Gametogenesis, fertilization, cleavage, development upto gastrulation in Amphioxus. Embryology (with special reference to marine vertebrates viz., fish, bird and mammal).

## **PRACTICAL II : MBOP 109 - Vertebrates**

1. Functional morphology of respiratory organs- aquatic animals - gills of cartilagenous and bony fishes
2. Study of important vertebrates specimen representing phylum Pisces to Mammalia
3. Early embryonic developmental stages of fish .- Larval stages
4. Mounting of scales of fishes.
5. Baleen plates of whales
6. Osteological observation of fishes and marine mammals
7. Marine turtles
  - a. Green turtle
  - b. Oliver ridley turtle
  - c. Hawksbill turtle
  - d. Leathery turtle
  - e. Loggerhead turtle
8. Preparation of field report.

## **REFERENCE BOOKS**

1. Robert T. Orr, 1976. Vertebrate Biology. 3<sup>rd</sup> Edition, W.B. Saunders Company, Philadelphia p. 472.
2. Young, J.Z., 1981. The Life of Vertebrates. Oxford University Press, New York, 568 pp.
3. Minkoff, E.C., 1983. Evolutionary Biology, Addison Wesley Publishing Company, Massachusetts, 627 pp.
4. Romer, A.S. and T.S.Parsons, 1986. The Vertebrate body, 6<sup>th</sup> edition, Philadelphia Soundrs VII + 679pp.
5. Colbert, Edwin, H. 1989. Evolution of the vertebrates. Wiley Eastern Ltd., New Delhi. P. 535.
6. Strickberger, W. Monroe, 1996. Evolution. Jones and Barlett Publishers, Massachusetts, p. 670.
7. Gilbert, F. Scott, 2000. Developmental Biology, 6<sup>th</sup> edition, Sinauer Associates, Inc., Publishers, Massachusetts, p. 749.
8. Kenneth Kardong, 2001. Vertebrates; Comparative anatomy function, evolution. McGraw Hill Science 3<sup>rd</sup> edition, 784pp.
9. Edward, J.Z., 2006. Comparative Vertebrate anatomy: a laboratory dissection guide. McGraw Hill, 226p.

## **MBOC 103 - CYTOLOGY, GENETICS AND IMMUNOLOGY**

### **Objectives :**

The paper is aimed at teaching the students of marine biology on varied aspects of cytology, genetics and immunology. The objectives of this paper include the knowledge about the modern trends in cell biology, prospects of chromosomal manipulations and the latest techniques of cytology, genetics and immunological aspects in fish.

### **UNIT I – Microscopy and cellular organisation**

Microscopy - light, phase contrast and interference, darkfield, fluorescence, confocal, electron (TEM and SEM), electron tunneling and atomic force microscopy.

Structural organization of cells-nucleus, ultrastructure of cytoskeleton, microtubules, micro-filaments, mitochondria, endoplasmic reticulum, golgi apparatus, lysosomes and peroxisomes and extracellular matrix – collagen, elastin, fibrillin, fibronectin, laminin and proteoglycans.

### **UNIT II – Genetic techniques**

Principles of genetics, environmental influences, practical applications of genetics – hybridization of fishes, recent trends and techniques in hybridization, selective breeding, cross breeding, development of disease resistance and high quality new strains, transgenic fish production.

Chromosome manipulation –androgenesis, gynogenesis, sex reversal and ploidy. aquaculture applications, Cryopreservation, conservation of germplasm.

### **UNIT III- Model genetics systems**

Model genetic systems – T4 and  $\lambda$  phages; Neurospora; *E.coli* and *Saccharomyces cerevisiae*; *Drosophila*; Zebra fish – advantages.

Normal and transformed cell lines as model genetic systems – advantages.

### **UNIT IV – Immunology – Invertebrates (Crustaceans)**

Non-specific immune response; Immunological factors – humoral and clotting; Cellular components; *Chemical constituents* – haemocyanin and total protein; Osmality and electrolytes; Glucose and other energy components, acid-base balance, tissue enzymes and hormones.

### **UNIT V – Immunology – Vertebrates (fish)**

Elements of Immunology; Antigen, antigenicity, epitope and haptens; Cells of lymphoreticular system; Antibody production; *Immunoglobulins* – structure, function, classes, allotypes and isotypes; Innate and acquired immunity; Vaccines; Monoclonal and polyclonal antibodies.

### **PRACTICAL III : MBOP 110 – Cytology, Genetics and Immunology**

1. Demonstration and operation of principles of light, compound, phase contrast and electron microscope
2. Giant chromosomal preparation (Squash)
3. Types of Cells
4. Preparation of stages of cell division
5. Cell organelles (Slides)
6. Fish chromosome mounting
7. Blood cell count and identification of lymphoid cells in blood smears
8. Antigen and antibody reaction & Haemagglutination
9. Immuno electrophoretic techniques
10. ELISA
11. Cell division – Mitosis and Meiosis
12. Calibration and use of Stage and Ocular Micrometers and Measuring microscopic organisms

### **REFERENCE BOOKS**

1. Strachan,T. and A.P.Read, 2004. Human Molecular Genetics, 3<sup>rd</sup> Edition, Wiley Publications, 674pp.
2. Gahalain,S.S., 2004 Fundamentals of Genetics, Anmol Publications Pvt. Ltd., 603pp.
3. Sambamurthy, A.V.V.S. 2005, Genetics, Alpha Science International, 9003 pp.
4. Male,D., Brostoff,J., Roth,D.B., Roitt, M.I. 2006 Immunology, Elsevier Publications, 552pp, 7<sup>th</sup> Edition.
5. Prakash,M. 2007 Molecular Genetics, Discovery Publishing House, New Delhi, 332pp.
6. Lodish, Harvey F. 2008, Molecular Cell Biology, W.H.Freeman & Company, 973pp.
7. Gerald Karp, 2009, Cell and Molecular Biology, Wiley Publications, 832pp.
8. Peter, J.D. and I.M. Roitt,2011. Roitt's essential Immunology, Wiley – Blackwell, 12<sup>th</sup> edition, 546 pp.
9. Abdul K.appas, Andrew H.Lichtman, S.Pillai, 2011 Cellular and Molecular Immunology, Elsevier Publications, 592pp.
10. Pandian, T.J., 2011. Sex determination in fish., CRC Press London, 277pp.

## **MBOC 104 : MARINE MICROBIOLOGY**

### **Objectives**

The paper is aimed at teaching the students of marine biology on varied aspects of microbiology. This subject provides a strong foundation for students to build up the knowledge of marine microbes. The objectives of this paper include the knowledge about the biology of microbes and their distribution, ecological role and economic importance.

### **Unit I - Ecology of marine bacteria**

Occurrence and distribution, structure and biology, ecological role, economic significance.

### **Unit II - Ecology of marine cyanobacteria**

Occurrence and distribution, structure and biology, ecological role, economic significance.

### **Unit III - Ecology of marine actinomycetes**

Occurrence and distribution, structure and biology, ecological role, economic significance.

### **Unit IV - Ecology of marine fungi**

Occurrence and distribution, structure and biology, ecological role, economic significance.

### **Unit V - Ecology of marine viruses**

Occurrence and distribution, structure and biology, ecological role, economic significance.

### **PRACTICAL IV : MBOP 111 – Marine Microbiology**

1. Preparation of Media
2. Estimation of bacterial population from marine samples
3. Pure culture techniques
  - Phase streaking
  - Continuous streaking
  - 'T' streaking
  - Radial streaking
4. Identification of unknown bacteria
  - Motility of bacteria – hanging drop method/semisolid medium
  - Gram's staining
  - IMViC
  - Triple sugar iron agar
  - Starch hydrolysis
  - Casein hydrolysis
  - Carbohydrate utilization test
5. Isolation of cyanobacteria
6. Identification of cyanobacteria - morphological



7. Isolation of actinomycetes
8. Identification of actinomycetes – morphological
9. Isolation of fungi from marine samples
10. Identification of fungi – morphological
11. Isolation of bacteriophages
12. One step growth of bacteriophages
13. Preparation of bacteriophage stocks
14. Titration of bacteriophages
15. Purification of phage

#### **REFERENCE BOOKS**

1. Lederberg, H., 1992. Encyclopedia of Microbiology, Vol.1-4., Academic Press, NY. 1154 pp.
2. Dube, H.C., 1994. A Textbook of Fungi, Bacteria and Viruses, Vikas Publishing House, India 240 pp.
3. Mckane, L. and J.Kandel, 1996. Microbiology, Essentials and Applications. McGraw Hill Inc., New York, 843 pp.
4. Austin B. and D.A. Austin, 1996 Bacterial Fish Pathogens- Diseases of Farmed and Wild Fish, Springer Praxis Publishing, 457 pp.
5. Stickney, B.R., 2000. Encyclopedia of Aquaculture. John Wiley & Sons, Inc, US. 1063 pp.
6. Munn, C.B. 2004. Microbial ecology: ecology and applications. BIOS Sci., Pub., US., 282pp.
7. Kirchman, D.L., 2008. Microbial ecology of the oceans John Wiley & sons US 593pp.

## **MBOC 105 – PHYSIOLOGY AND BIOCHEMISTRY**

### **Objectives :**

Study of physiology of marine animals is the fundamental knowledge to culture shrimps, fishes, pearls, oysters etc., because this paper deals with digestive enzymes, ionic regulation, endocrine system, biorhythm etc. This paper also enables to understand physiological mechanism involved in different oceanic environment (cold, warm oceans and deep sea environment)

Study of biochemistry will be helpful to know the structure of proteins, carbohydrates, lipids and vitamins role in physiology.

### **UNIT 1 – Physiology of Feeding and Respiration**

Physiology of feeding, feeding mechanisms, passage of food, digestive enzymes and their role with food habits. Respiratory structures and functions – Accessory respiratory organs, swim/air bladders, factors affecting respiration, structure and function of blood pigments, role of transport of O<sub>2</sub> and CO<sub>2</sub>.

### **UNIT 2 – Osmoregulation and Biorhythms**

Physiology of ionic and osmoregulations – ions in body fluids, mechanism of ionic regulation, responses to osmotic conditions, types of osmoregulatory adaptations.

Physiology of rhythms – circadian, tidal and lunar rhythms in marine and estuarine animals, environmental factors responsible for biorhythms, significance of biorhythms. Tidal, vertical and horizontal migration of larvae, larval release rhythm and larval behaviour of crustaceans, crustacean larval phototaxis & its functional significance. Physiology of bioluminescence in marine organisms – its significance.

### **UNIT 3 – Nervous and Endocrine systems**

Physiology of nervous system – autonomic nervous system in elasmobranchs and bony fishes, impulse generation and conduction, interneuronic transmission, integration of information. Physiology of Endocrine system – hormones, neurohormones, hormones of reproduction in finfishes and shell fishes, hormone induced colour change in crustaceans. Moulting in crustaceans.

### **UNIT 4 – Biomolecules**

Major biomolecules - classification – carbohydrates, proteins, amino acids, lipids and fatty acids – structure properties and function. Enzymes - nature, classification and mechanism of action, factors affecting enzyme activity, enzyme kinetics. Nucleic acids – composition, structure and function.

### **UNIT 5 – Metabolism and Biosynthesis**

Metabolism of carbohydrates - Glycolysis, glyconeogenesis, citric acid cycle. Metabolism of amino acids - Nitrogen transamination, determination and Urea cycle. Fatty acid metabolism – Oxidation and biosynthesis. Biosynthesis of nucleic acids.

## **PRACTICAL V : MBOP 112 – Physiology and Biochemistry**

1. Chromatophore change due to light and dark adaptations in intertidal crabs.
2. Effect of hydrogen ion concentration on amylase activity of the crystalline style from bivalve.
3. Effect of temperature – the rate of particle transport in bivalves
4. Effect of salinity on respiration of fish/bivalve
5. Effect of salinity on osmotic concentration (osmoregulation) of fish.
6. Display of Neuroendocrine organs in a crustacean.
7. Estimation of total protein, carbohydrates, lipids, moisture content, calorific value and ash content.
8. Separation of phospholipid using thin layer chromatography.
9. Separation of free and bound amino acids using paper chromatography.

## **REFERENCE BOOKS**

1. Prosser, C.L., 1973. Comparative Animal Physiology, 3<sup>rd</sup> edition, W.B.Saunders, Philadelphia, 966 pp.
2. Vernberg, F.J. and W.B.Vernberg, 1974. Pollution and Physiology of Marine Organisms. Academic Press, NY. 492 pp.
3. Palmer, J.D., F.A. Brown and L.N. Edmunds, 1976. An Introduction of Biological Rhythms. Academic Press Inc., New York. 375pp.
4. Vernberg, F.J and W.B.Vernberg, 1983. The Biology of Crustacea vol. 8 , Environmental adaptations, Academic Press New York. 383 pp.
5. Withers, P.C., 1992. Comparative Animal Physiology. Fostworth, TX: Saunders College Publishing, Philadelphia 949pp.
6. Lehninger, A.L., D.L. Nelson and M.M. Cox, 1993. Principles of Biochemistry. CBS Publishers & Distributors, New Delhi, 1013 pp.
7. Baldwin, E., 1996. Dynamic Aspects of Biochemistry. Cambridge University press, London. 554pp.
8. Denniston, K.J., J.J.Topping and R.L.Caret, 2004. General, Organic and Biochemistry, McDraw Hill New York, 880 pp.
9. Nelson, D.L and M.M.Cox, 2005. Lehninger Principles of Biochemistry, W.H Freeman, London. 1119 pp
10. Forward, R.B.Jr and J.H. Cohen, 2010. Vertical migration of aquatic animals in Encyclopedia of animal behavior, ( Breed M.D. and Moore J. (eds.), Academic Press, 3:485-490pp.

## **MBOC 106 –COMPUTER APPLICATION - I**

### **Objectives:**

This course will offers exposure to the hardware, terminology and functions of the personal computer. Hands on experience using popular software will allow exploration and basic introduction to windows and word processing. It also offers internet, web designing and multimedia operations.

### **UNIT – I**

Introduction to Computers – Application of Computers – Concepts of Data and Information – A Typical Computer System – Memory Concepts – History of Computers – Types of Computers.

Input –Output Devices – Data Storage Devices – Software – The Definition – The Role of Software – Housekeeping.

### **UNIT – II**

The Computer Internals – Typical PC Configuration – Booting – Virus, Anti-virus, Vaccine – Versions of Software.

Operating System – Definition – Classification – Basics of MSDOS – Introduction to Windows Operating System – Features of Windows OS – Desktop and Desktop Icons – Starting Programs – Browsing and Managing Windows Explorer – Setting – Taskbars and Creating Shortcuts.

### **UNIT – III**

Introduction to Internet – Client Server Basics, e-mail, Telnet and Archie – FTP – Gopher, Jughead and Veronica – WAIS and World Wide Web.

Fundamentals of HTML, TCP/IP and E-commerce.

### **UNIT – IV**

Issues involved in Web Site Management – Addressing – Designing Web Sites and Front Page.

### **UNIT – V**

Multimedia – Concept, Requirements, Applications and Future – Hardware and Software Requirement for Multimedia Development and Deliver Platforms – Multimedia Methodologies, Fundamentals and Use of Hypertext, Hypermedia, Sound, Images, Animation, Video.

Using Multi Media: Multimedia Interface, Planning and Development of Multimedia projects.

## REFERENCE BOOKS

1. Computer Fundamentals and Windows with Internet Technology, by Krishnan, Scitech Publications (India) Pvt. Ltd., Chennai.
2. Windows and MS-OFFICE 2000 with database Concepts, by Krishnan, Scitech Publications (India) Pvt. Ltd., Chennai.
3. Stephen Nelson – Field Guide to the Internet.
4. James Meade, David Growder, Rhonda Growder – Microsoft DHTML.
5. RosenBrog – A Guide to Multimedia.
6. Ned Snel – The Internet Strater kit in 24 hours Techmedia, 1998.
7. Michael Goodwin – Making Multimedia Works, Coomdex, 1995.

## **MBOC 107 Communication Skills**

### **Unit - I**

#### **Process of communication**

Concept of effective communication- Setting clear goals for communication; Determining outcomes and results; Initiating communication; Avoiding breakdowns. Creating value in conversation; Barriers to effective communication; Non verbal communication- Interpreting non verbal cues; Importance of body language, Power of effective listening; recognizing cultural differences.

### **Unit - II**

#### **Presentation skills**

Formal presentation skills; Preparing and presenting using Over Head Projector, Power Point; Defending Interrogation; Scientific poster preparation and presentation; Participating in group discussions.

### **Unit - III**

#### **Technical Writing Skills**

Types of reports; Layout of a formal report; Scientific writing. Problems in the preparation of a scientific document; Plagiarism; Scientific Publication Writing: Elements of a Scientific paper including Abstract, Introduction, Materials and Methods, Results, Discussion, References; Drafting titles and framing abstracts.

### **Unit - IV**

#### **Computing Skills for Scientific Research**

Web browsing search engines Hidden Web and its importance in Scientific research; Internet as a medium of interaction of scientists; Effective e-mail strategy using the right tone and conciseness

### **REFERENCE BOOKS**

1. Wren & Martin, 2000. A Simple course of English Grammer and Composition. S. Chand Publishers, 376 pp.
2. Ruby Lavel, 2001. Writing and Grammer – Communication in Aesian Prentice Hall Inc, 950 pp.
3. Mohan Krishna and N.P. Singh.2009, Speaking English Effectively, Macmillan Publishers India.248pp.
4. Lonidray, D. 2011. Scientific writing – Thinking in words, CSIRO, India publishing. 546pp.

## **II Semester**

### **MBOC 201 : PHYSICAL OCEANOGRAPHY**

#### **Objectives :**

This paper is intended to give students a view to the history and origin of Ocean, the physical properties of seawater and how wind, radiation, gravity, friction and the Earth's rotation determine the ocean's temperature, salinity patterns and currents. Some important process we will study include heat budget of the oceans, exchange of heat with the atmosphere and the role of the ocean in climate, surface mixed layer, waves and tides in the Ocean. Students will learn how to explain physical features of the ocean ranging from microscopic turbulence to global circulation, characteristics of estuaries and marine sediments.

In addition to learning facts and concepts, the students should gain some skills such as collection of water and sediment samples from the marine environment for laboratory analysis and they will be able to measure the light, temperature, pressure and current pattern of the ocean waters.

#### **UNIT I - Introduction to Oceanography**

History of Oceanography, Origin of Oceans, bottom topography, abyssal hills and plains, submarine canyons & oceanic trenches, underwater volcanoes.

#### **UNIT II - Physical Properties of sea water**

Temperature, density, pressure, conductivity, surface tension, viscosity and their interrelationship, temperature distribution in the sea, hot water springs, heat budget of the oceans, Sea level rise and global warming, UV radiation, sound and light in the sea, Pressure.

#### **UNIT III – Dynamics of the ocean**

Currents, forces causing surface and deep currents, trade winds and monsoon, wind driven and thermohaline circulation boundary currents, Langmuir circulation, geotropic currents, turbidity currents & up welling. Arctic & Antarctica circulation.

Waves – formation and properties, breakers and surf - internal and standing waves, catastrophic waves, tsunamis or seismic waves, storm waves or surges.

Tides – tide generating forces and theories, types of tides, tidal effects in coastal areas. Utilization of Wave / tide energy

#### **UNIT IV - Estuaries**

Origin and classification of estuaries, estuarine circulation, estuarine zonation, lagoons.

## UNIT V - Marine sediments

Origin and physical properties of sediments, classification of marine sediments (lithogenous, biogenous, hydrogenous and cosmogenous), distribution and transport of sediments, determination of age of sediments.

### Satellite Oceanography

Tsunami warning system in India and other countries. ELNINO, ROV, Surfer, Recent research development in Deep sea Research and Institutions involved.

## PRACTICAL VI – MBOP 206 : Physical Oceanography

1. Determination of density of liquids using specific gravity bottle.
2. Measurement of salinity of seawater by refractometer
3. Determination of salinity of seawater by conductivity
4. Determination of salinity of seawater by salinometer
5. Relationship between salinity and density
6. Relationship between salinity and viscosity
7. Determination of surface tension by capillary method
8. Relationship between salinity and surface tension
9. Determination of viscosity by ostwald viscometer
10. Determination of turbidity using turbidity meter,
11. Water sampling Devices:
  - a) Mayer's Water Sampler
  - b) Knudsen Water sampler
  - c) Nansen Water sampler
  - d) Universal Water sampler
  - e) Horizontal Water sampler
  - f) Bacteriological Water sampler
12. Sediment sampling Devices
  - a) Ekman's Dredge
  - b) Petersen grab
  - c) Mud snapper
  - d) Vertical Gravity Corer
  - e) Ooze Sucker
13. Temperature and depth measuring devices
  - f) Towing Surface Thermometer
  - g) Six's Maximum and Minimum Thermometer
  - h) Reversing Thermometer
  - i) Bathythermograph
  - j) Fortin's Barometer
14. Light measuring devices
  - a) Secchi Disc
  - b) Lux Meter
15. Current measuring devices
  - a) Watt's Current Meter
  - b) Direct Reading Current Meter



16. Depth measuring devices
17. Wave and Tide recorder

## **REFERENCE BOOKS**

1. Sverdrup, H.U., M.W. Johnson and R.H. Flemming 1958. The Oceans – their Physics, Chemistry and General Biology. Prentice – Hall Inc. New Jersey, 1087 pp.
2. McCormick, J.M. and J.V. Thiruvathakal, 1976. Elements of Oceanography. 2<sup>nd</sup> edition, W.B. Saunders, Philadelphia, 346 pp.
3. Neshyba, S. 1987. Oceanography: perspectives on a fluid earth. John Wiley & Sons, New York, 506 pp.
4. Gross, G. 1993. Oceanography: A view of the earth (sixth edition). Prentice – Hall Inc., New Jersey, 446 pp.
5. Pickard, G.L. and W.J. Emery, 1995. Descriptive Physical Oceanography – an Introduction (fifth edition). Pergamon Press, London, 520 pp.
6. Stowe, K., 1996. Exploring Ocean Science. John Wiley Sons Inc, NewYork 426 pp.
7. Duxbury, A.C., A.B. Duxbury and K.A. Sverdrup, 2000. An Introduction To The World's Oceans. Wm. C. Brown Publishers,UK. 528 pp.
8. Harold V.Thurman, 2004. Introductory Oceanography. 10<sup>th</sup> edition, Prentice Hall Inc, New Jersey, 624 pp.
9. Genny Anderson, 2009. Tools of the Oceanography: Sampling equipments, measuring equipment, online marine science; Santa Barbara, California, USA.

## **MBOC 202 – CHEMICAL OCEANOGRAPHY**

### **Objectives :**

The ocean is the largest and most complex habitat on our planet and has played a vital role in the development and growth of civilization. Ocean chemistry, i.e. the properties and composition of the substance found in the ocean world is affected by biological, chemical and physical processes. Oceanography is an interdisciplinary science and it is essential to learn the natural chemical processes that take place in the marine environment and also the effect of anthropogenic activity on these natural processes. Therefore this paper on chemical oceanography is essential to understand the basics as it forms a stepping stone for studies of other subjects like fisheries, agriculture and pollution.

### **UNIT 1 - Introduction to marine chemistry**

Ocean as a chemical system, origin of ocean salts, physical and chemical properties of water, structure of water molecules, differences between freshwater and seawater.

### **UNIT 2 - Chemical composition of seawater**

Ionic composition of seawater, major and minor constituents, constancy of ionic composition and factors affecting constancy, major and minor elements, trace elements, their importance and distribution, analytical chemistry of seawater constituents.

Concept of chlorinity and salinity of seawater – methods of measurement – desalination. Marine corrosion.

### **UNIT 3 - Dissolved gases**

Origin, importance and distribution - Carbon dioxide, oxygen, nitrogen, hydrogen sulphide, noble gases and methane.

### **UNIT 4 - Organic matter**

Dissolved and particulate, sources, classification, composition, estimation, distribution and seasonal variation, ecological significance, growth promoting and growth inhibiting effects & humic substances.

### **UNIT 5 - Nutrients**

Inorganic plant nutrients, origin, role in the fertility of the sea.

Kinds of nitrogen, phosphorus and silicate in the sea, analytical methods, distribution and cycling, N:P ratio and significance.

Mineral wealth of the sea – salts, glauconite, petroleum, phosphorite, manganese nodules, potential and economics of extraction.

## **PRACTICAL VII - MBOP 207 – Chemical Oceanography**

### **Titrimetric Procedures**

1. Salinity
2. Alkalinity
3. Dissolved oxygen
4. Calcium and Magnesium

### **Colorimetric Procedures of pollutants**

5. Bromide, fluoride and iodide
6. Nitrite
7. Nitrate
8. Inorganic phosphate
9. Hydrogen Sulphide
10. Ammonia
11. Organic nitrogen
12. Silicate (Reactive)
13. Total dissolved phosphorus

### **REFERENCE BOOKS**

1. Riley, J.P. and R. Chester, 1971. Introduction to Marine Chemistry. Academic Press, London, 465 pp.
2. Strickland, J.D.H. and T.R. Parsons, 1972. A Practical Handbook of Seawater Analysis. Fisheries Board of Canada, Ottawa, Bulletin, 167:311pp.
3. Riley, J.P and G. Skirrow, 1975 – 1984. Chemical Oceanography, Vols. 1 to 8. Academic Press, London, 606 pp.
4. Blackburn, T.H and J. Sorensen (Eds.), 1988. Nitrogen Cycling in Coastal Marine Environments, John Wiley & Sons. New York, 338pp.
5. Fergusson, J.E., 1990. The Heavy Elements: Chemistry, Environmental Impact and Health Effects. Pergamon Press, London 612 pp.
6. Pilson, M.E.Q., 1990. An Introduction to the Chemistry of the Sea. Prentice Hall, New Jersey, 680 pp.
7. Baretta – Bekker, J.G., E.K. Duursma and B.R. Kuipers (Eds.), 1992. Encyclopedia of Marine Sciences. Springer - Verlag. Berlin Heidelberg, New York, London, 311 pp.
8. Fernando, Olivia J, 1999. Sea Water Properties and Dynamics, Dhanesh Publications, Thanjavur.
9. Ghosh, A.K. and R. Mukhopadhyay, 1999. Mineral Wealth of the Ocean. Oxford and IBH Publishing Co, New Delhi 255 pp.
10. Duxbury, A.C., A.B. Duxbury and K.A. Sverdrup, 2000. An Introduction to the World's Oceans. 6<sup>th</sup> Edition. McGraw Hill Companies Inc, NY, 528 pp.

## **MBOC 203 – BIOLOGICAL OCEANOGRAPHY**

### **Objectives :**

Sea has in itself quite rich in renewable living resources that supplies food and wealth to the mankind. After depleting the living and non-living resources on the land the attention of the human beings has been turned towards the sea. Further, the sea is serving as a very good living place for the plant and animals ranging from microscopic to macroscopic size of planktonic to nektonic forms. Hence this paper is aimed with the objectives of making the students to learn about the biotic and abiotic components of marine environment, to get knowledge on the importance of plankton vis-à-vis fishery production and creating awareness about the ecological & economic importance seagrasses, seaweeds and mangroves.

### **UNIT 1 – Marine Biocycle**

Sea as a biological environment

Plankton - classification of plankton based on size, mode of life and habitat.

### **UNIT 2 – Plankton**

Phytoplankton and zooplankton - methods of collection, estimation of standing crop, Numerical methods, wet and dry weight estimations, plankton volume, settlement and displacement methods, determination of plankton biomass, oxidation as carbon (as organic matter). Inter relationships and vertical migration.

Adaptations of plankton through structural (Weight, increase of surface area for flotation) and physiological (specific gravity, water content, fat content, mono and divalent ions, and gas vacuoles) mechanisms.

### **UNIT 3 - Organic production**

Primary and secondary productions, methods of estimation of primary production, factors affecting primary production, spatial and temporal differences in primary and secondary productions, red tide phenomenon its causes and effects.

### **UNIT 4 – Seaweeds and Seagrasses**

Seaweeds – occurrence and distribution in India, their economic importance. Interaction between reefs and seaweeds.

Seagrasses – morphological and anatomical adaptations, their ecological role.

### **UNIT 5 – Mangroves, salt marshes and sand dunes**

Distribution, types, adaptations (morphological, anatomical and physiological), ecological role, uses, need for conservation.

## **PRACTICAL VIII : MBOP 208 – Biological Oceanography**

1. Identification of phytoplankton and zooplankton (diatoms, dinoflagellates, hydromedusae, copepods, pteropods, Chaetognatha, Thaliaceae and larvae of fin and shell fishes).
2. Identification of locally available seaweeds, seagrasses, sand dune spp. and halophytes including mangrove plants / vegetation (herbs, shrubs and woody plants)
3. Primary productivity studies – light and dark bottle method, extraction and identification of plant pigments (chlorophylls) including phaeopigments from water samples of estuary, sea and mangroves (Acetone method)
4. Field collection – submission of herbarium sheets.

## **REFERENCE BOOKS**

1. Wimpenny, R.S., 1966. Plankton of the Sea. Feber and Feber Limited, London, 426 pp.
2. Raymont, J.E.G., 1973. Plankton and Productivity in the Oceans. Oxford Pergamon Press, London, 660pp.
3. Chapman, V.J., 1976. Mangrove Vegetation. J. Gramer, Berlin, 292 pp.
4. Chapman, V.J. and D.J. Chapman, 1980. Seaweeds and Their Uses. Chapman & Hall London Ltd.334pp.
5. Spoel S. Vander and R.P. Heyman, 1983. Comparative Atlas of Zooplankton Biological Patterns in the Oceans. Springer - Verlag, Berlin, 186 pp.
6. Tomilson, P.B., 1986. The Botany of Mangroves. Cambridge University Press.London,413pp.
7. Nybakken, J.W., 2001. Marine Biology – An Ecological Approach.. Addison wesley Edu. Pub. Inc,London, 516 pp.
8. Kinne, O., 2004. Marine Ecology: Comprehensive integrated treatise on life in oceans and coastal waters, Wiley-interscience, New York Volume 1 -5 (1970 – 1984).
9. Miller, C.B.2004. Biological Oceanography Wiley-Blackwell US 402pp.
10. Kathiresan, K and S.Z. Qasim, 2005. Biodiversity of Mangrove Ecosystems. Hindustan Lever Limited, India,251 pp.
11. Jeffrey S.Levinton, 2008. Marine Biology: Function, Biodiversity, Ecology, 3<sup>rd</sup> ed.oxford university press ,USA 640pp.

## **MBOC 204: COASTAL AQUACULTURE**

### **Objectives :**

The objective of the paper is to teach the post graduate students of coastal aquaculture about biology and culture of fin and shellfishes. Without understanding the biology of cultivable species, culturing them is highly impossible scientifically. Therefore, the present paper deals both biology and culture together. This paper is planned to teach in the lines of understanding the candidate species of important cultivable fin and shellfishes, gaining knowledge in the food and feeding habits and life history of the candidate species, investigating the natural seed potential and artificial fish seed production through hatcheries, farm management and their detailed methods of farming, giving information on market value of fishes and their cost of production and providing scope for employment opportunities in aquaculture activities.

### **UNIT I - Introduction to coastal aquaculture**

Overview – Importance of Coastal aquaculture, global scenario, present status in India - prospects and scope.

### **UNIT II - Brackishwater farms**

Selection of site: topography, water availability and supply, soil conditions. Designing and layout, farm structure and construction.

### **UNIT III - Biology of important cultivable species**

Criteria for choosing cultivable species – fish, crustaceans, molluscs and seaweeds - biological criteria - environmental adaptability - compatibility of species - adaptability to intensive culture - economic criteria - market value - availability in adjacent regions.

### **UNIT IV – Seed resource survey and Seed & Feed production**

Natural seed resources – distribution and abundance, methods of collection and segregation. Artificial seed production - breeding under controlled condition, techniques of induced breeding, larval rearing, packing and transportation.

Larval and adult feeds. - Live feed – Micro algae, rotifers, copepods and artemia. Formulation of feed – conventional and non-conventional ingredients, additives, feed attractants, formulation protocol.

### **UNIT V – Culture systems and their management**

Culture practices – traditional, extensive, semi – intensive and intensive systems, monoculture and polyculture, raceways, cages, pens, raft and racks.

Culture system management: Pond preparation –production and economics.

Water quality management, Health management: Control of predators, parasites and diseases.

Disease diagnosis: Concepts - ELISA, Western blotting: DNA based diagnosis of diseases – fish vaccines.

### **PRACTICAL IX : MBOP 209 – Coastal Aquaculture**

1. Field trip to coastal aquaculture farms, hatcheries, raceways and Rack & Raft and procuring plants and Submission of Report
2. Spat collection techniques
3. Dissection of reproductive systems of fish and shrimp.
4. Identification of eggs, larvae, seeds, and juveniles of cultivable species.
5. Seed collection techniques – velon screen, Throw net, other scoop nets
6. Induced breeding and maturation techniques in fishes.
7. Identification of cultivable species of crustaceans, molluscs, finfishes and seaweeds.
8. Identification of live feed (Microalgae, rotifers, copepods and *Artemia*).
9. Western blotting
10. PCR Demonstration
11. Types of diseases – Observation
12. Identification of different larval stages in shrimps
13. Fabrication of Rack & Raft (floating and fixed), rope culture and spat collectors (rens).

### **REFERENCE BOOKS**

1. Pillay, T.V.R., 1990. Aquaculture – Principles and Practices. Fishing News Books.575pp.
2. Samuel Paulraj, 1994. Shrimp Farming Techniques: Problems and Solutions. Palani pub.
3. Stickney, 1995. Introduction to Aquaculture. John Wiley & Sons, New York.
4. Coche, G. and J.F. Muir, 1996. Simple Methods for Aquaculture Pond Construction for Freshwater Fish Culture : Pond farm structures and layouts. Daya Pub, 214 pp.
5. Conroy, D.A. and R. L. Herman, 1997. Text Book of Fish Disease. Narendra Pub, 302 pp.
6. John E. Bardach, 1997. Sustainable Aquaculture. John Wiley & Sons, New York.
7. James, W. Meade, 1998. Aquaculture Management, CBS pub., New Delhi.
8. Robert R. Stickney (ed.), 2000. Encyclopedia of Aquaculture. John Wiley and Sons, Inc., New York.
9. Joachim W. Hertrampf and Felicitas Piedad – Pascal, 2000. Hand Book on Ingredients for Aquaculture Feeds. Kluwer Academic Publishers, London.
10. Velayutham, T.S., Kripa, V.and H. Nithin, 2007. Mariculture of Mussels in India. Manual of CMFRI, Cochin.

## **MBOC 205 – FISHERIES SCIENCE AND STATISTICS**

### **Objectives :**

There is a theory and science behind fishing. Statistics has been extensively and advantageously used in studying the population of fishes and in finding out the maximum sustainable yield. Knowledge about the general morphology of the fishes, their classification and identification goes a long way in assessing the population of all the organisms. More over information about the biology of the fishes goes a long way in managing the fishery resources and their sustainable utilization. Suitable methods are also to be engaged for their exploitation. As fishes constitute perishable commodity, preservation and processing are also quite essential. Therefore the objective of this paper is to impart knowledge on all the above aspects.

### **UNIT I – Ecobiology of fishes**

General morphology and outline of classification of fishes – major groups of fishes of the world and their characteristics, identification of fishes of Parangipettai.

Basic anatomy of fish – digestive, circulatory, respiratory, nervous and reproductive systems of fish. Maturation and spawning habits of marine fishes – process of maturation, methods to determine spawning, biotic and abiotic factors affecting spawning in fishes. Food and feeding, fecundity and GSI

### **UNIT II - Population dynamics**

Fundamental principles of population dynamics, unit stock, recruitment, growth, mortality, migration, fish tagging and marking. Ecosystem Based Management of Marine fisheries.

### **UNIT III – Methods of Fishery Survey**

Marine fisheries of India, methods of surveying the fishery resources – acoustic method, aerial method (Remote Sensing – PFZ) - survey of fish eggs and larvae, gear selectivity, trawl net and Gill net, mesh size selection

### **UNIT IV – Crafts and Gears**

Principal methods of exploitation of sea fishes – indigenous and modern gears and crafts. Principal methods of fish preservation and processing in India – types of fish spoilage, causative factors. Marketing and economics.

### **UNIT V – Statistics in fisheries**

Sampling techniques – Biometry of fish - Collection and analysis of biological data – mean, median, mode, standard deviation, standard error, coefficient of variation, student ‘t’ test, skewness, kurtosis, chi – square, correlation regression and analysis of variance. Fisheries Statistic Software ( ECOPATH, PRIMER, FISH STAT)



## **PRACTICAL X : MBOP 210 – Fisheries Science and Statistics**

1. Identification of common fin and shell fishes of Parangipettai waters.
2. Dissection of 9<sup>th</sup> and 10<sup>th</sup> cranial nerves of teleost fishes
3. Food and feeding habits of fishes through Gut content analysis and Digestive system in fishes, Structure of gill filament and gill rakers.
4. Study of food and feeding habits of fishes using gut-content analysis, Dissection and display of digestive system of fishes of different feeding habits.
5. Study of reproductive system of teleost fishes
6. Fecundity estimation and ova – diameter studies, GSI values
7. Life history stages of fishes: eggs and larvae.
8. Morphometric and meristic data of fishes population
9. Collection of cost of different fishes (primary and secondary) and pattern of marketing
10. Economics of fishing of trawler.
11. Growth determination using scales: vertebrates & otoliths
12. Morphometric and meristic characters of a teleost fish
13. Dissection and display of inner ear in a fish, Weberian apparatus in a cat fish
14. Dissection and display of swim bladder of fishes
15. Observation on fish parasites
16. Visits to ice factory and nearby fish processing Units.
17. Methods of sampling and Data collection
18. Calculation of Mean, Mode, Standard Deviation, Standard Error, Co-efficient, Variation
19. Calculation of correlation of co-efficiency & ANNOVA

## **REFERENCE BOOKS**

1. Lagler, K.F., J.E. Bardach and R.R. Miller, 1962. *Ichthyology*. John Wiley & Sons Inc., New York, 545 pp.
2. Bal, D.V. and K.V. Rao, 1990. *Marine Fisheries of India*. Tata McGraw Hill Publishing Company Limited, New York, 472 pp.
3. Shanmugam, K., 1990. *Fishery Biology and Aquaculture*. Leo Pathippagam, Madras, India. 698pp.
4. King, M., 1995. *Fisheries Biology, Assessement and Management*. Fishing News Books, Black well science Ltd., 341 pp.
5. Biswas, K.P., 1996. *A Text Book of Fish, Fisheries and Technology*, II ED. Narendra Publishing House, Delhi, India, 396 pp.
6. Srivastava , C.B.L., 1999. *Fish Biology*. Narendra Publishing House, Delhi (India), 304 pp.
7. Mohan Joseph, M and A.A.Jayaprakash, 2003. *Status of Exploited Marine fishery resources of India*, 308 pp.
8. Dholakia, A.D., 2004. *Fisheries and Aquatic resources of India*. Daya Publishing House, Delhi. 413 pp.
9. Nelson, J.S, 2006. *Fishes of the World*, 4<sup>th</sup> edition, John Wiley & Sons, Inc., Hobaken, New Jersy, USA, 601 pp.

10. Bore, Q and Richard H. Moore, 2008. *Biology of fishes*, 3<sup>rd</sup> edition, Taylor and Francis Groups, New York, 478 pp.

### **III Semester**

#### **MBOC 301 – MARINE ECOLOGY AND ZOOGEOGRAPHY**

##### **Objectives :**

The marine biology and zoogeography, the particular topic well growing stage in our country. The knowledge about the marine environment (including the divisions), various ecosystems and biodiversity also informative. Further this paper deals with the population growth density and independent factors, the structure, composition and adaptations of community ecology, besides studying the animal associations and the distribution importance and assessments techniques of marine biodiversity.

##### **UNIT 1 – Classification of Marine Environment**

Marine environment – ecological factors – light, temperature, salinity, pressure. Classification of marine environment – pelagic environment, planktonic and nektonic adaptations, benthic environment – intertidal, interstitial and deep – sea adaptation. Other coastal environments – coral reefs, estuaries, mangroves, seagrass beds, kelp forests, polar seas and hydrothermal vent. Marine zoogeography. Barriers, Centre of dispersal, Bipolarity, Endemism, Island fauna.

##### **UNIT 2 - Marine ecosystem**

Concept - ecosystem structure and function, functional attributes food chain, food – web, ecological pyramid, energy flow. recycling of nutrients.

Systems ecology and modeling- System structure, feed-back, loops and types of models, characteristics and behavior of a system. Ecosystem services.

##### **UNIT 3 - Population ecology**

Group attributes, population density variation, age structure sex ratio population growth, carrying capacity, dispersal, density dependent and independent factors. prey – predator relationship, Intraspecific & Interspecific competition, survivorship curve, r/k selection,

##### **UNIT 4 - Community ecology**

Structure composition and stratification, diversity and stability, concept of niche, edge effect – abundance of diversity, resilience, succession, community-wise adaptation (e.g. fouling and boring community, animal association in the sea).

##### **UNIT 5 - Marine biodiversity**

Definition and importance, biodiversity assessment techniques, threats to marine biodiversity, over-exploitation, physical alteration, pollution, alien species. Biosecurity.

## **PRACTICAL XI : MBOP 306 – Marine Ecology and Zoogeography**

1. Population analysis of *Cerithidea cingulata*, *Uca sp.*: Quadrant and Transect method
2. Sex ratio of *Uca sp.*
3. Collection and identification of animal and community studies of different environments
  - i) Pelagic
  - ii) Muddy shore
  - iii) Sandy shore
  - iv) Rocky shore
  - v) Interstitial
  - vi) Oyster bed community
  - vii) Phytoplankton community (Seaweed and seagrass).
  - viii) Fouling and boring organisms
  - ix) Assessment of biodiversity of any one of the above communities
4. Preparation of a Field Report.

## **REFERENCE BOOKS**

1. Briggs, J.C., 1974. Marine Zoogeography. McGraw Hill, New York, 475 pp.
2. Nair, N.B. and D.M. Thampy, 1980. A Text Book of Marine Ecology. The Macmillan Co. India Ltd., New Delhi, 352 pp.
3. Odum, E.P. 1987. Basic Ecology. Saunders College Publication, Philadelphia, 895 pp.
4. Heywood, V.H. and R.T. Watson (Eds.), 1995. Global Biodiversity Assessment. UNEP Cambridge University Press. 765pp.
5. Hawksworth, D.L. 1996. Biodiversity Measurement and Estimation. Chapman Hall, 140 pp.
6. Ormond, F.G.R., J.D. Cane and M.V. Angel (Eds.) 1997. Marine Biodiversity: Patterns and Processes. Cambridge university press, London 449 pp.
7. Barnes, R.S.K. and R.N. Hughes. 1999. An Introduction to Marine Ecology (Third edition), Blackwell Science, US. 286 pp.
8. Townsend C.R., J.L. Harper and M. Begon. 2000. Essentials of Ecology. Blackwell Science, US. 552 pp.
9. Nybakken, J.W. 2001. Marine Biology – An ecological approach (Fourth edition) Addison Wesley Edu. Pub. Inc, US. 516 pp.
10. Jeffrey S. Levinton, 2008. Marine Biology: Function, Biodiversity, ecology, 3<sup>rd</sup> edition Oxford University press US. 640 pp.

## **MBOC 302 – MARINE BIOTECHNOLOGY, BIOINFORMATICS AND INSTRUMENTATION**

### **Objectives :**

. This paper deals with application of marine biology based on genetical, pharmacological and immunological potential in relation to the instruments used for the application.

### **UNIT1 – Tools and Techniques**

Introduction to marine biotechnology & genetic engineering

Tools & Techniques: PCR, blotting, Gene probes, gene sequencing : RAPD, RFLP & ELISA

Electrophoresis – Paper, agarose, PAGE, PFGE & Iso – Electric Focusing.

### **UNIT 2 - Marine Pharmacology**

Prospects – Bioactive compounds from marine environment: isolation, purification and identification of compounds.

### **UNIT 3 – Marine Microbial Technology**

Recombinant protein production in microbes ; Commercial issues pertaining to the production of recombinant products from microbes; Downstream processing approaches; Industrial microbes as cloning hosts (Streptomyces/Yeast)

### **UNIT 4 - Bioinformatics**

Definition and history

Internet basics: Internet connection, Web browsing and URL; Data bases – Nucleic acid sequence databases (NCBI, EMBL, DDJB), protein sequence database (SWISS – PROT).

Database searching (BLAST); protein prediction – structure and function prediction of proteins.

Molecular visualization and tools for molecular visualization (RASMOL and MOLMOL).

## UNIT 5 – Chromatography & Spectroscopy

Chromatography: Principles of paper, thin layer, ion-exchange, affinity, gas-liquid chromatography and HPLC.

Spectroscopy: Absorption and emission principles, UV-vis, Atomic absorption and emission spectrophotometers, fluorescence spectrophotometer, NMR and Mass spectrometer.

### **PRACTICAL XII : MBOP 307 – Marine Biotechnology, Bioinformatics and Instrumentation**

1. Extraction and quantification of Nucleic acid and proteins
2. Electrophoresis – Agarose gel electrophoresis and PAGE.
3. Blotting (Southern & Western) & PCR
4. Tissue culture techniques- Preparation and maintenance of plant and animal cell lines
5. Chromatography
  - a. Paper
  - b. Column
  - c. TLC
6. Basic principles and application of atomic absorption Spectrophotometer, Inductively coupled plasma spectrophotometer, GC, FT-IR, GC-MS, HPLC, UV-Visible spectrophotometer and fluorescence spectrophotometer
7. BLAST search for similar nucleotide sequences
8. Protein secondary structure, tertiary structure and Motifs prediction.
9. Visualizing 3D structure of macromolecules using RASMOL.
10. Isolation and extraction of bioactive compounds from marine organisms

### **REFERENCE BOOKS**

1. Alan T.Bull, Geoffrer Holt and Malcolm D.Lilly, 1983. Biotechnology International Trends and Perspectives. Oxford & IBH Publishing Co., New York, 84 pp.
2. Ewing, G.W., 1988. Instrumental methods of chemical analysis, McGraw-Hill Book Company, NY.538 pp.
3. Skoog, D.A. and J.J. Leary, 1992. Principles of instrument analysis. 4<sup>th</sup> edition. Saunders College publishers, Philadelphia, 700 pp.
4. David H. Attaway and R. Oskar, 1993. Marine Biotechnology. Vol. I. Pharmaceutical and Bioactive Natural Products. Plenum Press, New York & London, 500 pp.
5. Pat Vaughan, 2000. Methods in Molecular Biology: DNA Repair protocols: Prokaryotic Systems , Human press, Totowa, New Jersey. P. 209.
6. Baxevanis, A.D. and B.F. Francis Quellette, 2002. Bioinformatics: Practical Guide to the analysis of genes and proteins, John Wiley and Sons, NY 470 pp.

## **MBOC 303 – POLLUTION AND TOXICOLOGY**

### **Objectives:**

The objective of this course is to provide students with an understanding of the sources, links and biological effects of major classes of pollutants in the marine environment. The course will help prepare students for careers in academic programs, research centers and consulting firms by providing them with an in-depth understanding of causes, consequences and methods of assessment of marine pollution.

### **UNIT 1 - Basics in Marine Pollution**

Marine Pollution – Definition of GESAMP - Major pollutants – sources, transport path, dynamics. monitoring methods, bioindicators, bioaccumulators and hot spots

Toxicology – Lethal and Sub-lethal effects of pollutants to marine organisms bioconcentration, bioaccumulation and biomagnification, methods of toxicity testing, factors influencing toxicity, synergistic and antagonistic effects, role of microcosms & mesocosms.

### **UNIT 2 - Major Pollutants – Sewage and Detergent**

Sewage; industrial, agricultural and domestic discharges. Composition of Sewage - impact on marine environment, treatment methods (primary, secondary and tertiary).

Detergents – composition – eutrophication and ecological significance, interference in the sewage treatment system.

### **UNIT 3 – Major pollutants – Heavy metals & pesticide**

Heavy metal pollution – sources, distribution, fate, toxicity and diseases (Minamata, itai-itai etc.)

Pesticide pollution, classification and composition – sources, transport, distribution, fate and ecological impacts in the marine environment – endocrine disrupters.

### **UNIT 4 – Major Pollutants - Oil**

Oil pollution – composition, sources and fate of spilled oil, biodegradation, biological impact of oil on marine organisms.

### **Unit 5 – Minor Pollutants**

Thermal pollution – sources – waste heat disposal, uses of waste heat, role of biocides (Chlorine), ecological impacts.

Radioactive pollution, sources (natural and artificial), distribution, biological effects of radiation.

Plastics and litter – impact of mining and dredging operations in the marine environment.

## **PRACTICAL XII : MBOP 308 –Pollution and Toxicology**

Analysis and estimation of critical pollutants.

- a) Estimation of Ammonia (NH<sub>3</sub>)
- b) Estimation of Hydrogen sulphide (H<sub>2</sub>S)
- c) Estimation of BOD
- d) Estimation of COD
- e) Pesticide residues in sea water and selected beverages
- f) Petroleum hydrocarbons in sea water
- g) Heavy metals (Cu, Cd, Pb, Hg) in seawater, sediments & animal tissues
- h) Preparation of solution (Standard, Normal, Molar) for toxicological studies
- i) Methodology of toxicity testing – acute and chronic tests (demonstration)
- j) Use of LC<sub>50</sub> values – sublethal effects of critical pollutants on fish and shellfish.

## **REFERENCE BOOKS**

1. Johnston, R. (Ed.), 1976. Marine Pollution. Academic Press, London, 729 pp.
2. Pantin, S.A., 1982. Pollution and the Biological Resources of the Oceans. Butterworth Scientific Co., London.
3. Clark, R.B., 1992. Marine Pollution. 3<sup>rd</sup> Edition. Clarendon Press, Oxford, UK 172 pp.
4. Carl J. Sindermann, 1995. Ocean Pollution: Effects on Living Resources and Humans 7/176 – CRC Press, Boca Raton Tokyo 275pp.
5. Michael J. Kennish., 1996. Estuarine and Marine Pollution. (524 pp.) 07/002 CRC Press, New York.
6. Michael J. Kennish, 1997. Pollution Impacts on Marine Biotic Communities (310pp) 7/77, CRC press, New York.
7. David J. Hoffman, Barnett A. Rattner, G. Allen Burton, Jr. Johan Cairns, Jr., 1997. Hand Book of Ecotoxicology (755pp) – 7/018. Lewis publishers, Tokyo.
8. Trivedi, R.K. 2001. Aquatic Toxicology and Toxicology (239 pp) 7/157 – ABD publishers, Jaipur
9. Michael C. Newman, Morris H. Roberts, Jr. Robert C. Hale, 2001. Coastal and Estuarine Risk assessment (347pp) 07/125 Lewis publishers, New York
10. Yasunori Murakami, Kei Nakayama, Shin – Kitamura., 2008. Biological Response to Chemical pollutants. Terra pub, Tokyo, 372 pp.



## **MBOC 304: Ocean Management**

### **Objectives:**

Students will gain an understanding of the interrelationships between the marine sciences (including the issues, research areas and the scientists) and public policy through exploration of the concepts and implementation processes of integrated coastal and ocean management. Through this effort, students will learn how the needs of the science and the understanding of marine science principles pertaining to the needs of policy development, resource use and regulation/management. The paper will allow the student to synthesize information from a variety of sources and explore some aspect of public policy from the perspective of a marine scientist.

### **Unit – I: Law of the sea**

Law of the sea – the Geneva convention – UNCLOS series – the Antarctic treaty and its importance – the sea bed treaty – scientific, economic and geo-political aspects of seabed exploration and mining – earth summit (UNCED).

Role of International, National Agencies and Organizations in Ocean Management

### **Unit – II: Biodiversity and Conservation**

Biodiversity from a global and national view – current status of marine biodiversity – biodiversity conservation – endangered marine animals – CITES convention – marine biosphere reserves – marine parks - Marine Protected Areas - Biodiversity Act, 2002 - National – Biodiversity Authority.

### **Unit – III: Developmental Activities and Impacts**

Coastal zone importance – coastal developmental activities such as mariculture, tourism, shorefront construction and their impacts – global and national coastal problems such as loss of habitat, sea level change, degradation of water quality and fisheries resource depletion.

### **Unit – IV: Coastal zone management issues**

Coastal zone management issues – major ecological, social and economic trend and their importance – coastal zone regulations-91, aquaculture authority bill - CZM programs – Integrated Coastal Zone Management – categorization – coastal management zones - CRZ Notification 2011 - Comparison between developed and developing countries, temperate and tropical countries and their CZM.

### **Unit – V: Remote sensing & GIS**

RS & GIS Technologies – Application in marine resources exploration, satellites and airborne remote sensing, GIS in marine & Coastal zone management – Mapping & monitoring of pollution, changes in Coastal zone. – Application in disaster management – Tsunami types & causes – Post – Tsunami damage assessment and rehabilitation.

## REFERENCES BOOKS

1. Ross, D.A., 1980. Opportunities and Uses of the Ocean. Springer Verlag, New York
2. Roonwal, G.D. (Ed.) 1986. The Indian Ocean, Exploited Mineral and Petroleum Resources, Springer-Verlag, Berlin, 198 pp.
3. Miller, B.T and J.G. Catena, 1991. The Living Ocean Understanding & Protecting Marine Biodiversity.
4. Sharma, R.C. and P.C. Sinha, 1994. India's Ocean Policy, Khama Publishers, New Delhi.
5. Glowka, L., Guitman, F.B & H. Syрге, 1994, A. Guide to the Convention on Biological Diversity, IUCN. The World Conservation Union.
6. Rajagopalan, R. (Ed.), 1996. Voices for the Oceans – A Report to the Independent World Commission on the Oceans. International Ocean Institute, Operation Centre, Madras, India.
7. Sabins, F.F., 1996. Remote Sensing Principles and Interpretation. Third edition. W.H. Freeman & Company, New York, 494 pp.
8. Qasim, S.Z. and G.S. Roonwal, 1998. India's Exclusive Economic Zone. Omega Scientific Publishers, New Delhi.
9. Qasim, S.Z., 1999. The Indian Ocean – Images and Realities. Oxford & IBH Publishing Company, India, 340 pp.
10. Duxbury, A.C., A.B. Duxbury and K.A. Sverdrup, 2000. An Introduction to the World's Oceans. 6<sup>th</sup> Edition. McGraw Hill Companies, 528 pp.

**MBOC 305 Elective – I**

## IV SEMESTER

**MBOC 401 - Elective – II**

**MBOC 402 - Project Work**

## SUGGESTED ELECTIVES

### MBOE 01 Marine Food Technology

#### Unit I

Preservation and processing – chilling methods, phenomena of rigor mortis, spoilage changes – causative factors. Drying – conventional methods. Salt curing, pickling and smoking. Freezing and cold storage, Canning procedures. Role of preservatives in processing.

#### Unit II

Packing – handling fresh fish, frozen packs, IQF, layered and shatter packs. Fishery by – products, cannery waste, feeds, silage, fish gelatin, fish glue, chitin and chitosan, pearl essence, fertilizer.

#### Unit III

Seafood microbiology – factors influencing microbial growth and activity. Seafood borne pathogens – bacteria, fungi, viruses. Spoilage factors in seafood. Toxins influencing food spoilage. Microbes as food – SCP, microbial nutraceuticals.

#### Unit IV

Quality management – concepts, planning, system, quality control, quality assurance, quality improvement. Certification standards – ISO and HACCP. Principles of quality related to food sanitation, contamination, pest control, human resource and occupational hazards.

#### Unit V

Novel product development, marketing and sea food export – MPEDA, marketing, government policies, export finance, economic importance. Novel products – nutrition promotion, consumer studies qualitative and quantitative research methods

### REFERENCE BOOKS

1. Kreuzer, R., 1974. Fishery Products, FAO Fishing News (Books) Ltd., England, 280 pp.
2. Anon, 1979. Handling, Processing and Marketing of Tropical Fish. Tropical Products Institute, London.
3. Miller, M.D., 1990. Ciguatera Seafood Toxins, CRC Press New York.
4. Carison, V.R. and R.H. Graves, 1996. Aseptic Processing and Packing of Food : A Food Industry Perspective, CRC Press, New York.
5. Gopakumar, K., 1997. Tropical Fishery Products. Oxford & IBH Publications, New Delhi, 190 pp.
6. Chandran, K.K., 2000. Post Harvest Technology of Fish and Fishery Products, Daya Publishing House, New Delhi, 440 pp.
7. Wilson, C.L., S. Droby, 2000. Microbial food contamination, CRC Press, New York.
8. Balachandran, K.K., 2001. Post Harvest Technology of fish and fish products, Daya Publishing House, New Delhi 440 pp.
9. Novak, J.S., G.M. Sapses and V.K. Juneja, 2002. Microbial safety of minimally processed foods, CRC Press, New York.
10. Weidenborner, M., 2003. Encyclopedia of food mycotoxins, Springer Verlag, USA.

## **MBOE 02. Ornamental Fish Culture & Aquarium Keeping**

### **Unit I**

#### ***Introduction***

Fresh and marine water aquaria - Global and Indian status of aquarium keeping - Ornamental fish trade Advantages and benefits - Criteria for choosing aquarium fishes - Common aquarium fishes - collection techniques.

### **Unit II**

#### ***Culture and hatchery production***

Breeding of fresh and marine water ornamental fishes - collection - conditioning - brood stock development -feeding - spawning - larval rearing - Live feeds - stock and mass culture.

### **Unit III**

#### ***Designing, Aeration, filtration and lightings***

In door and out door aquaria - Tank designs - fabrication - choosing of right tank - Air pumps - filters biofilters - devices - aquarium lights - water quality maintenance - test kits.

### **Unit IV**

#### ***Setting up of aquarium***

Fresh and marine water set up - aquascaping - adding decorative materials - aquarium plants - community aquarium.

### **Unit V**

#### ***Health management***

Basic diets - pellet feeds - formulation - Diseases - diagnosis and health management - treatment methods Colour enhancement - induced breeding

## **REFERENCE BOOKS**

1. Dawes, J., 1995. Live bearing Fishes (A guide to their Aquarium care, Biology and Classification). 1<sup>st</sup> Edition, Cassell Pvt., London . 240 pp.
2. Adey, W. H. and K. Loveland, 1998. Dynamic Aquaria Building Living Ecosystems. 2<sup>nd</sup> Edition, Academic Press, US. 498 pp.
3. Axelrod, H. R and L. P. Schultz, 2000. Hand book of tropical aquarium Fishes. 1<sup>st</sup> Edition, orinocobooks - Sheffield SYK United Kingdom. 717 pp.
4. Grist, C., D. Mills and A. Caine, 2002, The Practical Encyclopedia Of The Marine Aquarium. Interpet Publishing-US. 208 pp.
5. Kuravamveli, S. J., 2002. The Aquarium Handbook. 1<sup>st</sup> Edition, Amity Aquatech pvt. Ltd Cochin. 256 pp.
6. Hemdal J.F., 2003. Aquarium Fish Breeding. 1<sup>st</sup> Edition, Barron's Educational Series-US. 176 pp.

7. Stephen Spotte, 2005 . Marine Aquarium Keeping the Science Animals and Art. las vegas, 1<sup>st</sup> Edition, NV, USA. 171 pp.
8. Sundararaj, V and J.M. Sathish, 2005. Tropical marine aquarium. 1<sup>st</sup> Edition, Yegam publications, Chennai. 160 pp.
9. Fletche,r A.M., 2006. unusual aquarium Fishes. 1<sup>st</sup> Edition, Mishawaka, IN, USA. 397 pp.
10. Yoan, N., 2011. Live-Bearing Aquarium Fish. 1<sup>st</sup> Edition, Miss Press,US. 52 pp.

## MBOE 03. Molecular Virology

### Unit I

Economic losses due to important viruses; Types of plant viruses, DNA viruses, RNA viruses, satellite viruses, satellite RNA, satellite DNA, viroids, virusoids; Disease symptoms, local and systemic symptoms, necrosis, hypoplasia, hyperplasia; Vectors for virus transmission; Cell to cell and systemic movement of viruses, plasmodesmata and virus movement.

### Unit II

Genome Organization of DNA viruses; *Caulimovirus* – eg. *Cauliflower mosaic virus*, Replication of CaMV, Badnavirus – *Rice tungro virus* (RTBV); *Geminiviridae* – *Bean golden mosaic virus*,  $\beta$ - DNAs of geminiviruses, rolling circle replication, *Nanovirus* – *Banana bunchy top virus*

### Unit III

Genome Organization of positive-stranded RNA viruses – *Potyviridae*, Potato virus Y (PVY), processing of polyprotein, *Comoviridae*, *Citrus tristeza virus*; *Bromoviridae*, *Alfalfa mosaic virus*; *Tuboviridae*, *Tobacco mosaic virus*, Replication of TMV, *Tobacco rattle virus*.

### Unit IV

Genome Organization of negative-stranded RNA viruses; *Rhabdoviridae*, *Sonchus yellow net virus*; *Bunyaviridae*, *Tomato spotted wilt virus*; *Tenuivirus*, *Rice stripe virus*; Double-stranded RNA viruses, *Reoviridae*, *Rice dwarf virus*.

### Unit V

Virus detection and diagnosis; Infectivity assays – Sap transmission, insect vector transmission, agroinfection (using *Agrobacterium*); Ultracentrifugation, electron microscopy, serological methods, immunoelectrophoresis in gels, direct double-antibody sandwich method, Dot ELISA, Immunosorbent electron microscopy (ISEM), Decoration technique, Polymerase chain reaction; DNA and oligonucleotide microarray; Gene silencing, PTGS & TGS, viral suppressors of gene silencing.

## REFERENCE BOOKS

1. Walkey, D.G.A, 1991. (Ed.), Applied Plant Virology, 2<sup>nd</sup> Edition, Chapman & Hall, London, 338 pp.
2. C.L. Mandahar, 1999. (Ed.), Molecular Biology of Plant viruses, Kluwer Academic Publishers, Dordrecht, 281 pp.
3. Roger Hull, 2002 (Ed), Mathews Plant Virology, 4<sup>th</sup> Edition, Academic Press, San Diego, 1001 pp.

## MBOE 04. PLANT AND ANIMAL CELL CULTURE TECHNOLOGY

### Unit I

Structure and organization of animal cell - Cell proliferation – Cell differentiation – Cell adhesion – Senescence – Cell transformation

### Unit II

Cell culture media: Components, physicochemical properties – Serum: Components, advantages and disadvantages, serum free media – Use of Antibiotics – Primary cell culture: Initiation of cell culture, mechanical and enzymatic disaggregation – Cell lines: Development, characterization, maintenance – Cell separation

### Unit III

Adherent & non adherent cell lines – Culture methods – Subculture – Cryopreservation – Contamination in animal cell culture – Quantification and cytotoxicity – Embryonic stem cells – cancer stem cells.

### Unit IV

Plant tissue culture – Introduction, cellular totipotency, basic requirements for plant tissue culture laboratory, tissue culture media (constituents and preparations), types of culture – cell, protoplast, callus, suspension culture and its applications.

### Unit V

Explant, surface sterilization, plant growth hormones, micropropagation (direct and indirect method), somatic hybridization, plant transformation technique using *Agrobacterium tumefaciens*, applications of plant tissue culture.

### REFERENCE BOOKS

1. Razdan, M. K., 2003. Introduction to plant tissue culture (2<sup>nd</sup> Edition), Science Publishers, USA. 375 pp.
2. Martin Clynes, 1998. Animal Cell Culture Techniques. Ed. Springer, NY, 618 pp.
3. Rudolf Endreb, 2004. Plant cell biotechnology –Springer publications, NY, 368 pp.
4. Robert N. Trigiano and Dennis J. Gray, 2004. Plant tissue culture concepts and laboratory exercises (2<sup>nd</sup> Edition), CRC, USA, 454 pp.
5. Gerald Karp, 2008. Cell and Molecular Biology, Wiley Press, USA, 843 pp.

## **MBOE 05 Microbial Technology**

### **Unit I**

Isolation and screening of industrially important microbes; Large scale cultivation of industrial microbes; Strain improvement to improve yield of selected compounds e.g. antibiotics, enzymes or recombinant proteins.

### **Unit II**

Basic principles of bioprocess as applied to selected microbes; Process optimization of selected products.

### **Unit III**

Recombinant protein production in microbes ; Commercial issues pertaining to the production of recombinant products from microbes; Downstream processing approaches; Industrial microbes as cloning hosts (Streptomyces/Yeast)

### **Unit IV**

Environmental application of microbes; Ore leaching; Toxic waste removal; soil remediation.

### **Unit V**

Microbial application in food and healthcare industries; Food processing and food preservation; Antibiotics and enzymes of pharmaceutical use.

## **REFERENCE BOOKS**

1. Peter F. Stanbury, 1999, Principles of Fermentation Technology, Butterworth-Heinemann Publishing, UK, 376 pp.
2. Young M.M ,2004.Comprehensive Biotechnology: The Principles, Applications and Regulations of Biotechnology in Industry, Agriculture and Medicine, Vol 1, 2, 3 and 4., Elsevier India Private Ltd, India.
3. Glazer and Nikaido, 2007, Microbial Biotechnology, 2nd Edition, Cambridge University Press, UK, 576 pp.



## **MBOE 06 Bioprocess Engineering and Technology**

### **Unit I**

#### **Basic principle of Biochemical engineering**

Isolation, screening and maintenance of industrially important microbes; Microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); Strain improvement for increased yield and other desirable characteristics.

### **Unit II**

#### **Concepts of basic mode of fermentation processes**

Bioreactor designs; Types of fermentation and fermenters; Concepts of basic modes of fermentation - Batch, fed batch and continuous; Conventional fermentation v/s biotransformation; Solid substrate, surface and submerged fermentation; Fermentation economics; Fermentation media; Fermenter design- mechanically agitated; Pneumatic and hydrodynamic fermenters; Large scale animal and plant cell cultivation and air sterilization; Upstream processing: Media formulation; Sterilization; Aeration and agitation in bioprocess; Measurement and control of bioprocess parameters; Scale up and scale down process.

### **Unit III**

#### **Downstream processing**

Bioseparation - filtration, centrifugation, sedimentation, flocculation; Cell disruption; Liquid-liquid extraction; Purification by chromatographic techniques; Reverse osmosis and ultra filtration; Drying; Crystallization; Storage and packaging; Treatment of effluent and its disposal.

### **Unit IV**

#### **Applications of enzymes in food processing**

Mechanism of enzyme function and reactions in process techniques; Enzymic bioconversions e.g. starch and sugar conversion processes; High-Fructose Corn Syrup; Interesterified fat; Hydrolyzed protein etc. and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.

#### **Applications of Microbes in food process operations and production**

Fermented foods and beverages; Food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; Microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; Bacteriocins from lactic acid bacteria – Production and applications in food preservation.

## **Unit V**

Enzyme kinetics; Two-substrate kinetics and pre-steady state kinetics; Allosteric enzymes; Enzyme mechanism; Enzyme inhibitors and active site determination

Production, recovery and scaling up of enzymes and their role in food and other industries; Immobilization of enzymes and their industrial applications.

### **REFERENCE BOOKS**

1. Aiba S, Humphrey AE and Millis NF 1973, Biochemical Engineering, 2nd Edition, University of Tokyo press, Tokyo. 434 pp.
2. Baily, J.E. and Ollis, D.F., 1986, Biochemical Engineering fundamentals, 2nd Edition, McGraw-Hill Book Co., New York, 984 pp.
3. Jackson AT.,1991. Bioprocess Engineering in Biotechnology, Prentice Hall, Engelwood Cliffs.
4. Stanbury R.F. and Whitaker A.,1997. Principles of Fermentation Technology, Pergamon press, Oxford, 357 pp.
5. Shuler ML and Kargi F., 2002. Bioprocess Engineering: Basic concepts, 2nd Edition, Prentice Hall, Engelwood Cliffs. 171 pp.
6. Young M.M ,2004. Comprehensive Biotechnology: The Principles, Applications and Regulations of Biotechnology in Industry, Agriculture and Medicine, Vol 1, 2, 3 and 4., Elsevier India Private Ltd, India.
7. Mansi EMTEL, Bryle CFA 2007. Fermentation Microbiology and Biotechnology, 2nd Edition, Taylor & Francis Ltd, UK, 308 pp.

## MBOE 07 Biostatistics

### Unit I

Applications of statistics in biological sciences and genetics; Descriptive statistics; Mean; Variance; Standard deviation and coefficient of variation(CV); Comparison of two CVs; Skewness; Kurtosis

### Unit II

Probability – axiomatic definition; Addition theorem; Conditional probability; Bayes theorem; Random variable; Mathematical expectation; Theoretical distributions – Binomial, Poisson, Normal, Standard normal and Exponential distributions; Sampling- parameter, statistic and standard error; Census sampling methods; Probability and non-probability sampling; Purposive sampling; Simple random sampling; Stratified sampling.

### Unit III

Testing of hypothesis; Null and alternative hypothesis; Type I and type II errors; Level of significance; Large sample tests; Test of significance of single and two sample means; Testing of single and two proportions - Small sample tests: F-test – testing of single mean; Testing of two sample means using independent t test, paired t test; Chi square test: Test for goodness of fit - association of attributes – testing linkage – segregation ratio.

### Unit IV

Correlation – Pearson’s correlation coefficient and Spearman’s rank correlation; Partial and multiple correlation  
– Regression analysis; Simple linear and non linear regression; Multiple regression.

### Unit V

Analysis of variance – definition – assumptions – model; One way analysis of variance with equal and unequal replications; Two way analysis of variance; Non parametric tests – sign test – Mann Whitney ‘U’ test – Kruskal Wallis test.

## REFERENCE BOOKS

1. Chandel, S.R.S,1999. A Hand Book of Agricultural Statistics, Achal Prakashan Mandir, Kanpur, 588 pp.
2. Rangaswamy, R, 2000. A text book of Agricultural Statistics, New Age International (P) Ltd., New Delhi. 500 pp.
3. Gupta S.P, 2005. Statistical Methods, Sultan Chand & Sons, New Delhi, 1425 pp.
4. Panse V.G. Panse, Sukhatme P.V, 2000. Statistical methods for Agricultural Workers, ICAR Publications, New Delhi.
5. Jerrold H. Zar, 2003. Bio Statistical Analysis, Tan Prints(I) Pvt. Ltd., New Delhi, 620 pp.
6. Sundar Rao P.S.S, P.H.Richard and J.Richard, 2003. An introduction to Bio-statistics, Prentice Hall of India (P) Ltd., New Delhi, 272 pp.

## **MBOE 08. Genomics and Proteomics**

### **Unit I**

#### **Introduction**

Structural organization of genome in Prokaryotes and Eukaryotes; Organelle DNA-mitochondrial, chloroplast; DNA sequencing-principles and translation to large scale projects; Recognition of coding and non-coding sequences and gene annotation; Tools for genome analysis-RFLP, DNA fingerprinting, RAPD, PCR, Linkage and Pedigree analysis-physical and genetic mapping.

### **Unit II**

#### **Genome sequencing projects**

Microbes, plants and animals; Accessing and retrieving genome project information from web; Comparative genomics, Identification and classification using molecular markers-16S rRNA typing/sequencing, ESTs and SNPs.

### **Unit III**

#### **Proteomics**

Protein analysis (includes measurement of concentration, amino-acid composition, N-terminal sequencing); 2-D electrophoresis of proteins; Microscale solution isoelectricfocusing; Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; SAGE and Differential display proteomics, Protein-protein interactions, Yeast two hybrid system.

### **Unit IV**

#### **Pharmacogenetics**

High throughput screening in genome for drug discovery-identification of gene targets, Pharmacogenetics and drug development

### **Unit V**

#### **Functional genomics and proteomics**

Analysis of microarray data; Protein and peptide microarray-based technology; PCR-directed protein in situ arrays; Structural proteomics

### **REFERENCE BOOKS**

1. Glick BR & Pasternak JJ,1998. Molecular Biotechnology, 3rd Edition, ASM Press, 683 pp.
2. Voet, D., Voet, J.G. and Pratt, C.W., 2006. Fundamentals of Biochemistry, 2<sup>nd</sup> Edition. Wiley, USA. 931 pp.
3. Brown, T.A., 2006. Genomes, 3<sup>rd</sup> Edition. Garland Science, New York. 736 pp.
4. Primrose, S., and Twyman, R., 2006. Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell, 390 pp.
5. Campbell, A.M. and Heyer, L.J., 2007. Discovering Genomics, Proteomics and Bioinformatics, 2<sup>nd</sup> Edition. Benjamin Cummings, 447 pp.

## **MBOE 09. Vaccines**

### **Unit I**

Innate Immunity; Activation of the Innate Immunity through TLR mediated signaling; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Protective immune response in bacterial; Viral and parasitic infections; Correlates of protection

### **Unit II**

Vaccination and immune response; Appropriate and inappropriate immune response during infection: CD4+ and CD8+ memory T cells; Memory B cells; Generation and Maintenance of memory T and B cells; Dendritic cells in immune response

### **Unit III**

Adjuvants in Vaccination; Induction of Th1 and Th2 responses by using appropriate adjuvants; Microbial, Liposomal and Microparticles as adjuvant; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and mucosal Immunity

### **Unit IV**

Conventional vaccines; Bacterial vaccines; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine

### **Unit V**

New Vaccine Technologies; Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination; Vaccines for specific targets; Tuberculosis Vaccine; Malaria Vaccine; HIV vaccine

## **REFERENCE BOOKS**

1. Stefan H.E. Kaufmann (Ed.), 2004. Novel Vaccination Strategies, Wiley-VCH Verlag GmbH & Co. KgaA, 628 pp.
2. Topley and Wilson's, 2005. Microbiology and Microbial Infections Immunology Edited by Stefan H.E. Kaufmann and Michael W. Steward Holder Arnold, ASM Press, 1033 pp.
3. Charles A Janeway. Jr, Paul Travers, Mark Walport and Mark J. Shlomchik, 2005. Immuno Biology, The Immune system in health and Disease, 6<sup>th</sup> Edition, Garland Science, New York, 635 pp.

## **MBOE 10: REMOTE SENSING & GIS**

### **Unit – I**

Introduction to Remote Sensing: Definition of terms, Concepts and types of remote sensing; evolution of remote sensing technology- Electromagnetic spectrum- Atmospheric windows. Types of **Sensors**- passive sensors and active sensors; characteristics of optical sensors; Sensors resolution – spectral, spatial, radiometric and temporal; Thermal Remote sensing, Microwave Remote Sensing and Hyper-spectral Remote Sensing. Satellites and sensors: IRS, Landsat, NOAA, MODIS- LISS, AWIFS, AVHRR, TM, OCM, MODIS and Hypriyan.

### **Unit – II**

Application of remote sensing in the assessment of mangroves, coral reef, seaweed and sea grasses. Ocean Color Monitoring and productivity studies; Sea surface temperature and Oceanographic parameters: eddies, ocean circulation, upwelling and identification of Potential Fishing Zone (PFZ),

### **Unit- III**

Introduction to GIS: Definitions, Basic Concepts, Data- Types and Models: Spatial, Geometrical Data – Raster data, Vector data, Non-spatial, Attribute Data. Advantages and disadvantages of raster vector data formats. Models of data:- Basic Data Models- raster and vector, Spaghetti model and Topology model; Advanced data models – Grid model, TIN model and DEM.

Map scanning and digitizing, topology building, editing and cleaning. Data processing: Updation, corrections, modifications, scale change, geometric transformations and map projection transformations, conflation sliver removal, edge matching, interactive graphic editing, rubber sheeting.

### **Unit- IV**

Spatial Analysis, Integration and Modelling: Logic operations, general arithmetic operations, general statistical operations, geometric operations, query and report generation from attribute data, geometric data search and retrieval, classification reclassification, integrated geometry and attributes, overlay, buffer zones, raster data overlay. Definition and concept of Web GIS- advantage and limitations of Web GIS, overview of Web GIS.

### **Unit V**

Applications in Marine sciences: Marine resources exploration, Mapping and Marine Resources information System; GIS in Marine and Coastal Zone Management. Mapping and monitoring of pollution, changes in coastal zones, Applications in Disaster Management: Tsunami – types, causes, RS and GIS applications for post Tsunami damage assessment and rehabilitation. Creating custom GIS Software applications and user interface.

## REFERENCE BOOKS

1. Ramachandran, S., 2000. Marine remote sensing applications. Institute for Ocean Management, Anna University.
2. Lillesand, T.M. and R.W. Kefer, 2000. Remote Sensing and image interpretation. John Wiley & Sons. Inc.
3. Anji Reddy, M., 2000. Remote sensing and Geographical Information System. The Book Syndicate, Hydrabad.
4. Lucas, L.F. Janseen, Wim H. Bakker, Ben G.H. Gorte, John A. Horn, Christine Pohl, Anupma Prakash, Colin V. Reeves, Michael J.C. Weir, Tsehaie Woldai, 2001. Principals of Remote Sensing An Introductory Text Box, 2<sup>nd</sup> edition, ITC Educational Textbook Series.
5. Rolf A de By, Martin C. Willis, Yola Georgiadou, Wolfgang Kainz, Richard, A. Knippers, Menno-Jan Kraak, Mostafa M. Radwan, Edmund J. Sides, Yuxian Sun, Michael J.C. Weir and Cees J. van Westen, 2001. Principals of Geographic Information Systems: An introductory textbook. 2<sup>nd</sup> edition. , ITC Educational Textbook Series.
6. Yeqiao, Wang, 2009. Remote Sensing of coastal environments. Taylor & Francis, CRC Press, 457 pp.
7. Michael Kennedy, 2009. Introducing Geographic Information systems with ArcGIS: A workbook approach to learning GIS, 2<sup>nd</sup> edition, Wiley publications, 624 pp.
8. Pinde Fu and Jiulin Sun, 2010. Web GIS: Principles and Applications. ESRI, 312 pp.
9. Christian Harder, 2011. Understanding GIS: An ArcGIS Project workbook, ESRI, 378 pp.
10. Vasilis, D.Valavanis, 2011. Marine Geographical Information Systems: Theory and Applications (Advances in Geographic Information Science), Springer, 500 pp.