

DEPARTMENT OF MARINE LIVING RESOURCES

Revised Syllabus

With effect from 2019-2020 admitted batch



Andhra University
Visakhapatnam

DEPARTMENT OF MARINE LIVING RESOURCES, ANDHRA UNIVERSITY
M.Sc. Marine Biology and Fisheries-I Semester- Scheme of Examination (With effect
from 2019-2020 admitted batch)

| Paper No | Paper Title | Maximum Marks | | | Credits | | |
|--|---|-------------------------|--------------------------|-------------|-----------|-----------|-----------|
| | | Theory (End exam + Mid) | Practical (Semester end) | Total marks | Theory | Practical | Total |
| 1.1 | Physical and Chemical Oceanography | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 1.2 | Biological Oceanography | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 1.3 | Marine Ecology | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 1.4 | Biostatistics | 80+20 | 50 | 150 | 4 | 2 | 6 |
| | Viva-voce | | 50 | 50 | | 2 | 2 |
| | Total marks | 400 | 250 | 650 | 16 | 10 | 26 |
| M.Sc. Marine Biology and Fisheries-II Semester | | | | | | | |
| | | Theory (End exam + Mid) | Practical (Semester end) | Total marks | Theory | Practical | Total |
| 2.1 | Estuaries & Coastal Zone Management | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 2.2 | Biology of Marine Organisms | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 2.3 | Fish Physiology | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 2.4 | Fishery Science | 80+20 | 50 | 150 | 4 | 2 | 6 |
| | Viva-voce | | 50 | 50 | | 2 | 2 |
| | Total marks | 400 | 250 | 650 | 16 | 10 | 26 |
| M.Sc. Marine Biology and Fisheries-III Semester | | | | | | | |
| | | Theory (End exam + Mid) | Practical (Semester end) | Total marks | Theory | Practical | Total |
| 3.1 | Fishing Technology and Fishery Management | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 3.2 | Aquaculture | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 3.3 | Fish Nutrition and Feed Technology | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 3.4 | Marine Pollution & Bio-deterioration | 80+20 | 50 | 150 | 4 | 2 | 6 |
| | Viva-voce | | 50 | 50 | | 2 | 2 |
| | Total marks | 400 | 250 | 650 | 16 | 10 | 26 |
| M.Sc. Marine Biology and Fisheries-IV Semester | | | | | | | |
| | | Theory (End exam + Mid) | Practical (Semester end) | Total marks | Theory | Practical | Total |
| 4.1 | Fish Processing Technology | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 4.2 | Fishery Economics & Extension | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 4.3 | Aquaculture Biotechnology | 80+20 | 50 | 150 | 4 | 2 | 6 |
| | Project Work | | 150 | 150 | | 6 | 6 |
| | Viva-voce | | 50 | 50 | | 2 | 2 |
| | Total marks | 300 | 350 | 650 | 12 | 14 | 26 |

DEPARTMENT OF MARINE LIVING RESOURCES, ANDHRA UNIVERSITY
M.Sc. Coastal Aquaculture and Marine Biotechnology-I Semester- Scheme of
Examination (With effect from 2019-2020 admitted batch)

| Paper No | Paper Title | Maximum Marks | | | Credits | | |
|---|--|-------------------------|--------------------------|-------------|-----------|-----------|-----------|
| | | Theory (End exam + Mid) | Practical (Semester end) | Total marks | Theory | Practical | Total |
| 1.1 | Oceanography and Marine Biology | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 1.2 | Fin Fish Culture | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 1.3 | Crustacean Farming | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 1.4 | Aquaculture Engineering | 80+20 | 50 | 150 | 4 | 2 | 6 |
| | Viva-voce | | 50 | 50 | | 2 | 2 |
| | Total marks | 400 | 250 | 650 | 16 | 10 | 26 |
| M.Sc. Coastal Aquaculture and Marine Biotechnology -II Semester | | | | | | | |
| | | Theory (End exam + Mid) | Practical (Semester end) | Total marks | Theory | Practical | Total |
| 2.1 | Molluscan & Seaweed Farming | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 2.2 | Soil & Water Quality Management in Aquaculture | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 2.3 | Seed Production & Hatchery Management | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 2.4 | Marine Microbiology | 80+20 | 50 | 150 | 4 | 2 | 6 |
| | Viva-voce | | 50 | 50 | | 2 | 2 |
| | Total marks | 400 | 250 | 650 | 16 | 10 | 26 |
| M.Sc. Coastal Aquaculture and Marine Biotechnology -III Semester | | | | | | | |
| | | Theory (End exam + Mid) | Practical (Semester end) | Total marks | Theory | Practical | Total |
| 3.1 | Biochemistry & Fish Nutrition | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 3.2 | Genetics in Aquaculture | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 3.3 | Molecular Biology | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 3.4 | Marine Pollution & Bio-deterioration | 80+20 | 50 | 150 | 4 | 2 | 6 |
| | Viva-voce | | 50 | 50 | | 2 | 2 |
| | Total marks | 400 | 250 | 650 | 16 | 10 | 26 |
| M.Sc. Coastal Aquaculture and Marine Biotechnology -IV Semester | | | | | | | |
| | | Theory (End exam + Mid) | Practical (Semester end) | Total marks | Theory | Practical | Total |
| 4.1 | Fish Pathology & Immunology | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 4.2 | Marine Biotechnology | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 4.3 | Bioactive Marine Natural Products | 80+20 | 50 | 150 | 4 | 2 | 6 |
| | Project Work | | 150 | 150 | | 6 | 6 |
| | Viva-voce | | 50 | 50 | | 2 | 2 |
| | Total marks | 300 | 350 | 650 | 12 | 14 | 26 |

DEPARTMENT OF MARINE LIVING RESOURCES, ANDHRA UNIVERSITY
M.Sc. Marine Biotechnology-I Semester- Scheme of Examination (With effect from
2019-2020 admitted batch)

| Paper No | Paper Title | Maximum Marks | | | Credits | | |
|---|--|-------------------------|--------------------------|-------------|-----------|-----------|-----------|
| | | Theory (End exam + Mid) | Practical (Semester end) | Total marks | Theory | Practical | Total |
| 1.1 | Oceanography and Marine Biology | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 1.2 | Biochemistry | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 1.3 | Reproductive Physiology & Endocrinology | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 1.4 | Molecular Biology | 80+20 | 50 | 150 | 4 | 2 | 6 |
| | Viva-voce | | 50 | 50 | | 2 | 2 |
| | Total marks | 400 | 250 | 650 | 16 | 10 | 26 |
| M.Sc. Marine Biotechnology -II Semester | | | | | | | |
| | | Theory (End exam + Mid) | Practical (Semester end) | Total marks | Theory | Practical | Total |
| 2.1 | Coastal Aquaculture | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 2.2 | Fish Genetics | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 2.3 | Marine Microbiology & Microbial Technology | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 2.4 | Cell & Tissue Culture | 80+20 | 50 | 150 | 4 | 2 | 6 |
| | Viva-voce | | 50 | 50 | | 2 | 2 |
| | Total marks | 400 | 250 | 650 | 16 | 10 | 26 |
| M.Sc. Marine Biotechnology -III Semester | | | | | | | |
| | | Theory (End exam + Mid) | Practical (Semester end) | Total marks | Theory | Practical | Total |
| 3.1 | Health Management in Aquaculture | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 3.2 | Immunology | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 3.3 | Enzymology & Enzyme Technology | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 3.4 | Marine Pollution & Bio-deterioration | 80+20 | 50 | 150 | 4 | 2 | 6 |
| | Viva-voce | | 50 | 50 | | 2 | 2 |
| | Total marks | 400 | 250 | 650 | 16 | 10 | 26 |
| M.Sc. Marine Biotechnology -IV Semester | | | | | | | |
| | | Theory (End exam + Mid) | Practical (Semester end) | Total marks | Theory | Practical | Total |
| 4.1 | Applications of Biotechnology in Aquaculture | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 4.2 | Genetic Engineering | 80+20 | 50 | 150 | 4 | 2 | 6 |
| 4.3 | Bioactive Marine Natural Products | 80+20 | 50 | 150 | 4 | 2 | 6 |
| | Project Work | | 150 | 150 | | 6 | 6 |
| | Viva-voce | | 50 | 50 | | 2 | 2 |
| | Total marks | 300 | 350 | 650 | 12 | 14 | 26 |

M.Sc. Marine Biology & Fisheries, I Semester
Paper 1.1: Physical & Chemical Oceanography

Dimensions of Oceans, Physical parameters of sea: Temperature, light, waves, currents, upwelling & sinking, density & pressures, tides, sound and its propagation in the sea. Heat budget of ocean. The sea as a suitable physical, chemical and biological environment.

Constancy of composition of sea water- salinity, chlorinity, definition and significance. Conservative behaviour of major elements, interaction of trace elements with marine organisms, factors affecting the distribution of trace elements in the sea.

Dissolved gases in sea water- basic concepts: Solubility of gases in sea water, air-sea gas exchange, processes affecting their distribution.

Dissolved oxygen in the oceans: Distribution & factors affecting its distribution

Carbon dioxide system: CO₂ equilibrium in the sea water, pH, alkalinity & buffering capacity of sea water, Calcium carbonate precipitation & dissolution phenomenon - its biological importance. Isocline and carbonate compensation depth.

Micro nutrient elements: N, P, Si in sea water - their forms in sea water, distribution & cycles. N:P ratios, uptake & regeneration of nutrient elements.

Chemistry of sea surface micro-layer - origin, thickness and collection of surface material, properties of the sea surface micro-layer.

National and International Institutes of marine research.

References:

- | | | |
|--------------------------------|--|----------------------|
| Riley, JP and Chester R | Introduction to marine chemistry | Academic Press |
| Riley JP and Skirrow, G | Chemical Oceanography (Vol.1,2,3 &8) | Academic Press |
| R.A.Wiley | Sea water: Its composition, properties & behaviour | The open University |
| Broecker and Peng, | Traces in the Sea Lamont-Dohery Geological Observatory, NY | |
| M.E.Q. Pilson | An introduction to the chemistry of the Sea | Cambridge Uni. Press |
| Burton <i>et al.</i>, | Dynamic processes in the chemistry of the upper ocean | Plenum Press |
| D. Satyanarayana | Introduction to marine chemistry | |

Practicals:

1. Determination of salinity by Harvey's and Kneudson's method
2. Determination of Dissolved Oxygen by titrimetric method
3. Determination of pH by pH meter method
4. Determination of alkalinity by titrimetric method
5. Calculation of tide time and tide height
6. Calculation of density of sea water using salinity and temperature data
7. Identifying the resulting phenomenon (Upwelling/sinking) by observing the vertical temperature cross-section data of a given layer of water column
8. Identification of water mass, determination of stability of water column using temperature and salinity data
9. Equipment : Nansen's water bottle, Niskin's water bottle, Secchi disc, Refractosalinometer, Reversing thermometer

Paper 1.2: Biological Oceanography

Introduction to plankton: General classification and composition of plankton. Floating mechanisms in plankton.

Collection of plankton: General account of instruments and nets employed. Methods of fixation and preservation; Analyses and enumeration of samples. Standing crop estimation methods.

Plankton in relation to fisheries: General account. Distribution of plankton in space and time, Horizontal distribution: neretic and oceanic plankton; geographical distribution and indicator species.

Vertical distribution: Vertical migrations, Seasonal changes in plankton. Phytoplankton and Zooplankton relationships.

Primary and Secondary (zooplankton) production: General account of productivity in different oceans.

Factors affecting primary and secondary production: Nutrients, light, temperature, organic micro-nutrients, inhibitors and grazing. Particulate and dissolved organic matter in the sea. Red tides and Mass-mortality in the seas.

General survey of marine food chains: Pelagic food chains. Pelagic food pyramid and factors affecting its production & stability.

References:

| | | |
|----------------------|--------------------------|----------|
| Angel MV | Biological Oceanography | Methuen |
| Friedrich H | Marine ecology | S & J |
| Raymont JEG | Plankton & Productivity | Pergamon |
| Ekman S | Zoogeography of the sea | S & J |
| Parsons et al | Biological Oceanographic | Pergamon |

Practicals:

1. Identification of Phytoplankton: Diatoms, Flagellates, Dinoflagellates, Coccolithophores and Toxic dinoflagellates
2. Identification of Zooplankton: Holoplankton, Neroplankton, Coastal and Oceanic plankton
3. Analysis and enumeration of Phytoplankton and Zooplankton: Biomass and standing crop estimation
4. Estimation of particulate organic matter in sea water
5. Chlorophyll estimation
6. Plankton nets

Paper 1.3: Marine Ecology

Classification of marine environment: general characters of the populations of the primary biotic divisions (plankton, nekton, benthos- shallow and deep sea).

Shore Environment: Distribution of life on rocky shore, sandy shore and muddy shore, Zonation and adaptations of organisms.

Biological significance of tides.

Zoogeography of seas with special reference to Indo-west Pacific region.

Ecology of coral reefs and mangrove habitats; their special features.

Benthos: Distribution of shallow water benthic organisms; Fauna of deep sea and hadal regions – their adaptations.

Larval Ecology: Types of larvae and their distribution. Chemical communications and settlement of larvae of marine benthic organisms.

Macro, micro and benthic fauna and their ecology, aerobic and anaerobic environments, Benthic and autotrophic production, chemical composition of Sediments, animal-sediment Relations.

Detritus based food chains.

Ecological importance and conservation of marine algae.

Ecological modelling.

References:

| | | |
|-----------------------------|-------------------------------|--------------------|
| Svedrup <i>et al</i> | The Oceans | Prentice Hall |
| Tait RV | Elements of marine ecology | Butterworths |
| Riley & Skirrow | Chemical Oceanography | Academic Press |
| Newell RC | Biology of intertidal animals | Logos Press |
| Kinne O (Ed) | Marine ecology | John Wiley & Sons |
| Marshall NB | Aspects of Deepsea Biology | Hutchinson |
| Ekman S | Zoogeography of the sea. | Sidgwick & Jackson |

Practicals:

1. Representative organisms of rocky shore, sandy shore and muddy shore with special reference to their ecological features, adaptations, economic importance.
2. Larvae of marine benthic organisms.
3. Ecological modelling of ecosystems
4. Analysis of sediment composition analysis
5. Field visit to rocky, sandy and muddy shores.
6. Computational species diversity indices using the data collected from rocky shore/zooplankton sample
7. Instruments: Cores, Grab sampler, dredge.

Paper 1.4: Biostatistics

Introduction to statistics: Sampling and sampling design Collection of primary and secondary data.

Classification and tabulation of data.

Diagrammatic (one dimensional & two dimensional) representation of data. Graphical representation (Histogram, frequency polygon, frequency curve, and ogive curve) of data

Measures of central tendency (Mean, median and mode).

Measures of dispersion: standard deviation, standard error, variance, Skewness, kurtosis and moments. Correlation and regression analyses Probability and distributions.

Estimation and testing of hypotheses; Tests of significance: Z test, t test, F test, Chi-square test, ANOVA (one way and two way), ANCOVA, multi-variate analyses

Computer applications: Analyses of data using Microsoft Excel in stock assessment, use of virtual population analysis and pedigree analysis and predictive models.

Applications of statistics in marine biology and fisheries: data collection analyses.

Types of errors, levels of significance.

References:

| | | |
|---------------------------|--------------------------------------|--------------|
| Arora & Malhan | Biostatistics | Himalaya |
| Ramakrishnan | Biostatistics | Saras |
| Gupta SC | Statistical methods | Sultan chand |
| Sokal & Rohlf | Biometry | Freeman |
| Jorgenson SE | Fundamentals of ecological modelling | Elsevier |

Practicals:

Problems on

- 1) Classification of data.
- 2) Diagrammatic representation & Graphical representation of data.
- 3) Measures of central tendency.
- 4) Measures of dispersion.
- 5) Correlation analysis.
- 6) Probability and distribution.
- 7) Estimation and confidence limits.
- 8) Parametric tests - Z, P, and F
- 11) Analysis of variance.
- 12) Chi-square test.
- 13) Case study on Marine Biological data
- 14) Analysis of secondary data- MS Excel.

M.Sc. Marine Biology & Fisheries, II Semester

Paper 2.1: Estuaries & Coastal Zone Management

Estuarine environment: Physico-chemical properties of estuaries

Classification of estuaries

Distribution of estuarine plankton, nekton and benthos. Estuarine plants: Distribution of mangroves

Estuarine birds and estuarine food web.

Coastal Zone Management: Coastal resources: finfish, shellfish, non-living Resources and their management.

Coastal Zone Regulations in the context of aquaculture, suitability, ICZM and estuarine management. Remote sensing applications in coastal zone management.

IUCN criteria- Red list, wild life protection act, international treaties and conventions. Marine protected areas, Sanctuaries and biosphere reserves, Establishment of National Marine parks. Insitu and exsitu conservation.

Elements of Geographic Information System and its applications in aquaculture.

Law of the Seas. International law of the seas, Historical perspectives, International negotiations and settlements over open seas, conflict management, sharing stocks.

References:

| | | |
|--------------------|------------------------------------|----------------|
| Mc Lusky DS | Ecology of estuaries | Hinmann |
| Green J | Biology of estuarine animals | S & J |
| Carter RWG | Coastal environments | Academic Press |
| Kinne O | Marine Ecology | John Wiley |
| D.K.Pandey, | Fisheries governance & Legislation | NPH |
| H.K.De | In India | |

Practicals:

1. Determination of sediment organic matter
2. Grain size analysis of estuarine sediment using ro-tap sieve shaker
3. Species diversity and ecological modelling of mangrove and estuarine organisms
4. Separation of total suspended matter and plotting with respect to location and tide
5. Typical estuarine and mangrove organisms.

Paper 2.2: Biology of Marine Organisms

Nutrition: Types of food, general mechanisms of feeding, digestion and digestive enzymes.

Excretion: Mode of nitrogen excretion and elimination of nitrogenous wastes.

Respiration: Respiratory mechanisms; factors affecting respiration (Salinity, temperature and oxygen tension); Respiratory pigments and their role in transport of gases.

Osmotic regulation and ion regulation: General account and mechanisms.

General survey of pigments and colour in marine animals; Colour changes- Chromatophores;

Bioluminescence: luminescent glands and organs; biochemistry of production of light, biological significance.

Endogenous rhythms: Biological clocks; Lunar periodicity

Physiology of sense organs: types of organs and functions.

Physiology of nervous system: structure and functions.

General account of reproduction in marine animals: Asexual , hermaphroditism, protandry and protogyny and sex reversal.

Reproductive cycles: maturation and spawning, semelparity, iteroparity. Periodicity of maturation. Factors influencing reproduction.

Marine animal associations: Commensalism, mutualism, Symbiosis, Parasitism and Predator – prey relationships.

References:

| | | |
|-----------------------|-------------------------------------|---------------|
| Nicol JAC | The Biology of marine animals | Pitman |
| Prosser CL | Comparative animal physiology | Saunders |
| Barnes RD | Invertebrate zoology | Saunders |
| Newell RC | Biology of intertidal animals | Logos press |
| Newell RC (Ed) | Adaptation to environment | Butterworth |
| Palmer JD | Biological clocks in mar. organisms | Wiley Eastern |

Practicals:

1. Dissection and display of digestive systems of Herbivorous, and Carnivorous Omnivorous shellfish and fin fish.
2. Dissection and display of reproductive system of fish, shrimp, sepia/loligo, cellana, squilla - Dissection
3. Mounting of radula of cellana, nerita
4. Mounting of gills of carnivore and herbivore fishes
5. Determination of gonadal stages and Gonadosomatic Index of fish and shell fish
6. Mouth parts and appendages of shrimp and crab

Paper 2.3: Fish Physiology

Physiology of digestion: Digestion of carbohydrates. Lipids & proteins, digestive enzymes and regulation of their secretions, absorption & assimilation of nutrients, role of hormones in the regulation of digestion, factors affecting digestion and transport of nutrients.

Physiology of respiration: definition of respiration, Basal Metabolic Rate (BMR), external respiration, internal respiration, types of respiratory organs, respiratory pigments & their function, respiratory metabolism, energy budget and expenditure in relation to environment conditions & stress. Chloride cells & their role in respiration. Oxygen requirement at larval stages.

Reproductive physiology: development of gonads, oogenesis, spermatogenesis, metabolic changes during oogenesis & spermatogenesis.

Neuro-hormones, endocrine glands of finfish and shellfish, their role in regulation of reproduction, moulting and growth.

References:

| | | |
|---------------------------|----------------------------|--------------------|
| Bardach JE et al | Aquaculture | Wiley Interscience |
| Conn & Stump | Outlines of Biochemistry | Wiley Eastern |
| Halver JE | Fish nutrition | Academic press |
| Hoar & Randall | Fish physiology (Vol.1-12) | Academic Press |

Practicals:

1. Dissect and display of respiratory, circulatory, reproductive and endocrine systems in shellfish and finfish.
2. Estimation of amylase, protease, lipase, P^H in different parts of GI tract.
3. Extraction & purification of tissue protein and lipids,
4. Estimation of blood glucose, albumin and globulin, Oxygen consumption by fish/shrimp – in relation to pH, temperature and salinity,
5. Histological observations of gonads- shellfish and finfish.
6. Estimation of total protein, lipid profile, creatinine, urea and enzymes in blood.

Paper 2.4: Fishery Science

General account of systematic classification of fishes. Classification based on degrees of movement, zones inhabited and manner of reproduction.

Economically important groups of fishes: General and brief account of elasmobranchs, clupeoids, salmonoids, scombroids, gadoids, heterosomata, sciaenids, carangids, trichiurids, catfish, crustaceans and mollusks.

Natural populations or stocks as biological entities: factors limiting abundance of stocks.

Criteria for distinguishing units or multi-stock species. Idea of unit stock- its relevance to tropical marine fish. Stock enhancement, strategies like introduction of exotic species, pre and post stocking management, potential risk of stocking.

Population dynamics: recruitment, growth and mortality. Length-weight relationship, Condition factor.

General account of life history of Indian fishes: oil sardines, Indian shad, mackerel, Bombay duck and Malabar sole.

General account of food and feeding habits of fishes and methods of assessment.

Age determination of fishes. Beverton and Holt yield per recruit model, Biomass- per – recruit.

General account of movement and migration in fishes: eels, salmon, Indian shad.

Marking and Tagging of fishes.

References:

| | | |
|-------------------------|--|--------------------------|
| Cushing DH | Fisheries biology Wisconsin | U. Press |
| Cushing DH | Marine ecology & Fisheries | Cambridge U. Press |
| Jhingran VG | Fish and fisheries of India | Hindusthan |
| Nelson JS | Fishes of the world | John Wiley |
| Royce WF | Introduction to fishery sciences | Academic Press |
| Peter B. | An Introduction to Ichthyology, | Prentice Hall. |
| Moyle, Joseph J. | | |
| Cech 1990 Fishes | | |
| Carl E. Bond | Biology of Fishes. | W.B.Saunders |
| Bensam, P., | Development of Marine Fisheries Science in India. | Daya Publishing House |

Practicals:

1. Systematic identification of finfish and shellfish upto species level based on morphometric and meristic data
2. Gut content analysis and method of assessment of feeding
3. Estimation of fecundity
4. Length-weight relationship
5. Size at first maturity
6. Age and growth estimation
7. Relative condition factor
8. Problems related to stock assessment

M.Sc. Marine Biology & Fisheries, III Semester

Paper 3.1: Fishing Technology & Fishery Management

Evolution of Fishing craft: boat types and their classification. Boats used in India.

Evolution of Fishing gear: Classification of fishing gear; Descriptions of hand-line, troll line and pole line. Description, design and fabrication of trawl nets, purse-seine and gill nets.

Pelagic, demersal and deep sea fishing, By catch reduction in trawl fishing, Turtle Excluder Devices.

Stock assessment: Collection of basic data; stock size, yield models (Methods).

Fishing regulations: Potential fishing zones, code of conduct for responsible fishing, duration of fishing output control measures, Total available catch, catch quotas, licensing, technical control measures such as size limitations, closed fishing areas, closed seasons, size of nets and mesh size regulations, limited entry.

The effects of exploitation: The over-fishing problem, Management techniques.

Modern navigation equipment life saving devices (Buoy, jacket, raft, SART, EPIRB, SCUBA).

References:

| | |
|----------------------|------------------------------------|
| Aitikin A | Fish handling & processing |
| Baranov F I | Selected works on fishing gear |
| Brandt AV | Fish catching methods of the world |
| Cushing DH | Marine ecology & fisheries |
| Sanisburry JC | Commercial fishing methods |

Practicals:

1. Fishing Crafts: Catamaran, Masula boat, Dugout Canoes, Rampani and Trawler
2. Fishing Gears: Gill net, Purse Seine, Cast net, Ottor Trawl net, Beam trawl net, Hook & Line, Traps, Stake net and Dip net.
3. Mesh size in different fishing gears
4. Fishing gear knots: Square knot, Clove Hitch knot, Fisherman's knot
5. Fishing Gear Material: Nylon, Terylene, Polyethylene, Polypropylene
6. Other Fishing devices: Floats, Sinkers, buoy, raft
7. Length-frequency analysis of marine fishery resources
8. Gear selectivity
9. MSY-Stock recruitment relationship.

Paper 3.2: Aquaculture

Significance of aquaculture. Global aquaculture scenario, production, Consumption and emerging trends.

Criteria for selection of species for aquaculture.

Technical and non-technical considerations in site selection.

Design & construction of ponds, cages, pens, racks, rafts and long lines.

Selection of material and equipment for aquaculture.

Monoculture, polyculture and integrated farming.

Seed production through finfish and shellfish hatcheries.

Culture practices of finfish (carps, mullets, Pampano, pearl spot and cobia), crustaceans (shrimps and prawns), mollusks (abalone, edible oysters, cephalopods) and seaweeds.

Sewage fed farming, integrated and multitrophic aquaculture, Recirculating Aquaculture Systems, Biofloc system, organic farming.

Viral, bacterial, fungal, parasitic, nutritional and environmental diseases of cultured fish and shellfish.

References:

| | | |
|--------------------------|--|--------------------|
| Bardach JE et al | Aquaculture | Wiley Interscience |
| Pillay & Dill | Advances in aquaculture | FAO |
| Stickney RR | Principles of Warmwater aquaculture | Wiley Interscience |
| Pillay TVR | Aquaculture: principles & practices | FNB |
| Alilis AE | Fish and shellfish pathology | Academic Press |
| Milne PH | Fish & shellfish farming in coastal waters | FNB |
| Stickney RR | Principles of aquaculture | Wiley & sons |
| Imai T | Aquaculture in shallow seas | Amerind |

Practicals:

1. Design and construction of shrimp hatchery
2. Design and construction of fish farm
3. Aquaculture equipment:
Nets (Cast net, Scissor net), Sand filters, FRP-tanks, Harvesting buckets, Secchi disc, P^H meter, Salinometer, Spectrophotometer)
4. General calculations in Aquaculture management:
Survival Rate, Specific growth rate, Quantifying the seed for transport, Calculation of amount of soil required for construction of dike.
5. Identification of Cultivable finfish, Shellfish and Sea weeds.
6. Identification of Predators, weed fishes, aquatic weeds and larval forms.
7. Fertilizers used in aquaculture.

Paper 3.3: Fish Nutrition & Feed technology

Fish nutrition: principles of fish nutrition and terminologies, nutritional requirements of cultivable finfish and shellfish: larvae, juveniles and adults

Nutritional biochemistry: classification, structure, quality evaluation of proteins, lipids, carbohydrates, vitamins and minerals.

Nutritional bioenergetics: fish as an open thermodynamic system, energy requirement of fishes, digestible energy, nitrogen balance index, protein sparing effect, optimal foraging theory, mathematical modeling of ingestion, metabolic rate, energy budgets, reproductive energetics in fish and shellfish.

Nutritional pathology: Anti nutritional factors and anti metabolites, microbial toxins, methods of elimination, nutrient deficiency and symptoms.

Feed Resources: Nutritional value of feed ingredients, feed additives (attractants, growth stimulants and probiotics and binders), high energy feeds, isocaloric diets.

Feed Manufacture: Feed formulation and processing, On-farm feed manufacture, Commercial feed manufacture, Feed storage

Feeding Practices: Supplementary feed–theory and practice, complete diet - theory and practice, Feeding methods and scheduling, ration size, feed performance.

References:

S. Athithan Practical book on fish nutrition and feed technology

Cyrino EP & bureau D & Kapoor BG Feeding & Digestive Functions in fishes

Science Publ.

De Silva SS & Anderson TA Fish Nutrition in aquaculture. Chapman & Hall

Elena M. Nutrition, Physiology and Metabolism in Crustaceans. Science Publishers

Halver J & Hardy RW. Fish Nutrition. Academic Press

Lovell RT. Nutrition and Feeding of Fishes Chapman & Hall

CIFE. 1993. *Training Manual on Culture of Live Food Organisms for AquaHatcheries.*

Hagiwara A, Snell TW, Lubzens E & Tamaru CS. 1997. *Live Food in Aquaculture.*

Proceedings of the Live Food and Marine Larviculture Symposium. Kluwer.

Halver JE & Hardy RW. 2002. *Fish Nutrition.* Academic Press.

Practicals:

1. Quantitative analysis: of protein, carbohydrate, and lipid from muscle of finfish and shell fish.
2. Fish feeds- Biochemical composition
2. Different types of feeds
3. Feed formulations
4. Calculation of FCR and FCE
5. Calculation of daily ration of feed

Paper 3.4: Marine Pollution and Bio-deterioration

Sources of marine pollution: dynamics, transport paths and agents.

Composition of domestic, industrial and agricultural discharges; their fate in the marine environment. Toxicity and treatment methods.

Wastes from fish processing units and their treatment- removal of nitrogen and phosphorus, Aquatic macrophytes in treatment of waste water.

Oil pollution: Sources, composition and its fate in marine habitats. Toxicity and treatment methods.

Thermal and radioactive pollution: sources, disposal systems of heated effluents, effects and treatment.

Solid dumping, mining and dredging operations: their effects on marine ecosystem, management of solid waste.

Biofouling and biodeterioration: Biofilm formation-primary, secondary, tertiary colonizers.

Effects of biofouling and control measures: manual, mechanical, and chemical

Borers: Effects and control measures.

Corrosion- definition, reactions, classification. Factors and preventive measures.

Global environmental monitoring methods: status, objectives and limitations.

Monitoring strategies of marine pollution: critical pathway approach and mass balancing

Assessment of damage and problems of measuring the impact. Environment Impact Assessment.

Role of biotechnology in marine pollution control and bio-deterioration.

References:

- Nielsen SE** Tropical pollution
Kinne O Marine Ecology Vol. V John Wiley
Johnson R (Ed) Marine pollution Academic Press
Patin SA Pollution and boil.Resources of oceans Butterworths
Goldberg, E. D. 1974. The Health of the oceans, UNESCO Press. Paris.
Park, P .K, Kester D.R., J.W. Deudall and B.H Ketchum, 1983. Wastes in the Ocean.
Vols. 1 to 3. Wiley Interscience Publishers, New York.
Eckenfelder WW. 2000. *Industrial Water Pollution Control.* McGraw Hill.
Gray NF. 2004. *Biology of Wastewater Treatment.* Oxford University Press.
Trivedy RK. 1998. *Advances in Wastewater Treatment Technologies.* Global Science.

Practicals:

1. Determination of BOD in the polluted sea water sample.
2. Determination of nutrients in the polluted sea water sample: nitrites, nitrates, silicates, phosphates
3. Determination of toxic elements in the polluted sea water sample: ammonia, sulphide
4. Estimation of particulate organic matter in the polluted sea water sample
5. Spotters: Foulers- primary, secondary and tertiary colonizers; Borers

M.Sc. Marine Biology & Fisheries, IV Semester

Paper 4.1: Fish Processing Technology

Microbiology of fresh and processed fish: Common bacterial pathogens in fish and fishery products- isolation and identification. Bacteria of sanitary significance.

Handling of fish: Spoilage of fish and shellfish; effect of temperature on fish spoilage; Use of ice; Solid carbondioxide and liquid nitrogen in fish preservation; Containers for packaging and transportation of fish

Use of chemical preservatives and irradiation in extending shelf-life of finfish and shellfish: effects of irradiation on protein, fat & vitamin, pulsed light technology.

Canning: principles of canning; can shapes, canning materials; handling and preparation of fish and shellfish for canning; spoilage of canned fish; chemical and microbiological spoilage and their prevention, process value calculation.

Curing: principles and practices of salting and drying the fish; microwave vacuum drying, pickling; smoking of fish; Spoilage of cured fish.

Freezing of fish: techniques of freezing; types of freezers; changes during Freezing: Crystalization, nucleation, crystal growth, high pressure processing.

Protection of frozen fish: glazing and wrapping; use of anti-oxidants; Thawing of frozen fish; double freezing of fish

Storage, transportation and distribution of frozen fish

Fishery By-products: processing of low cost fish; minced meat, fish oil, fish meal, Fish sausages, isinglass, glues, fish silage, chitosan, chitin pearl essence; Alginates, agar.

Quality problem in fishery products: good manufacturing practices, HACCP and ISO 9000 series of quality assurance system, validation and audit.

National and international standards, detection of antibiotics and heavy metals in the processed fishery products, Codex alimentarius, USFDA and EU regulations for fish export trade, IDP and SAT formations in certification of export worthiness of fish processing units, regulations for fishing vessels, pre-processing and processing plants, traceability, EU regulations; ISO22000:2006. Food laws in India, integrated food law (FSSAI).

References:

- Aitikin A** Fish handling & processing
- Borgstorm G** Fish as food Academic press
- Connell JJ** Advances in fish science & technology FNB
- Neha Charan** Assessment of fish quality
- Anon. 2001. *Food Borne Disease Handbook*. 2nd Ed. Vol. IV. *Seafood and Environmental Toxins*. Marcel Dekker.
- Balachandran KK. 2001.** *Post Harvest Technology of Fish and Fish Products*. Daya Publ.
- Sen DP. 2005.** *Advances in Fish Processing Technology*. Allied Publ.
- Wheaton FW & Lawson TB. 1985.** *Processing Aquatic Food Products*. John Wiley & Sons.
- Windsor M & Barlow. 1981.** *Introduction to Fishery Byproducts*. Fishing News (Books).

Practicals:

1. Estimation of moisture content in fish and shrimp muscle.
2. Estimation of Total Plate Count (TPC) in water and fish muscle sample.
3. Identification of Gram -ve and Gram +ve bacteria using Gram staining technique.
4. Assessment of freshness of fish and shrimp by using organoleptic characters.
5. Process of Canning- Flow chart.
6. Isolation of *Bacillus* and *Clostridium* species from sea food
7. Freezing curve and determination of freezing point
8. Visit to processing plant to learn the sanitary conditions to be maintained in fish preservation
9. Equipments and By-products

Paper 4.2: Fishery Economics and Extension

Contribution of fisheries to the National economy, Introduction to Economics and fisheries economics.

Demand and supply, Theories of factors production: Factor-factor and factor-product , product-product relationships.

Costs and income concepts in fisheries. Resource use efficiency analysis.

Role of financial institutions in fisheries. Fisheries credit and finance. Fishery cooperatives and rural development. Risks and uncertainties in fisheries.

Fisheries socioeconomics: Strategies and methods for promoting fisheries development. Linear programming, subsidies in fisheries, Factors affecting economics of aquaculture

Domestic and export marketing of fish and fish products. Modern marketing methods and channels , cold chain, storage.

WTO in Indian fisheries scenario. Role of extension in fisheries, mechanisms and modes of extension and their impact on capture fisheries and fisher's livelihood, alternative livelihood options. Women in fisheries: status, role, impact, future, vulnerability of fisher's to natural disasters and coping mechanisms in disaster management.

References:

Medwin Gale

Economics in Fisheries research

Grafton QR, Kirkley J, Kpmpas T & Squire D

Economics for fisheries Management

Cunningham S, Dunn MR & Whitmarsh D, 1985. Fisheries Economics. St. Martin's Press

Dunne EB, 1990.

Fisheries Exonomics- An Introduction.

Mansell Publ.

Shang YC, 1981.

Aquaculture Economics. Westview Press.

Shyam S. Salim, RS Birada and SK. Pandey, 2005. Fisheries economics and marketing- An

Introduction. CIFE

Practicals:

1. Estimation of different production relationships
2. Farm business analysis- Breakeven , Cost-benefit analysis
3. Mathematical analysis of production relationship
4. Estimation of Physical and economic optimum
5. Estimation of yield gap and factor shares
6. Linear programming- variable resource programming, Variable price programming and optimization techniques.

Paper 4.3: Aquaculture Biotechnology

Sources of food: natural and artificial feeds.

Feed biotechnology: Growth promoters, probiotics, nutraceuticals

Enzymes, hormones, therapeutic proteins.

Importance and use of anti-oxidants and antibiotics in feeds.

Reproductive Biotechnology: Induced breeding, Egg incubation and Larval rearing. Principles of genetics: fish cytogenetics; Application of genetics in aquaculture: genetic selection, hybridization, inbreeding, cross-breeding, sex control, cryopreservation, IN VITRO fertilization, artificial insemination, polyploidy and transgenesis, methods of gene transfer in fishes, screening, sites, applications. Development of disease- resistant and high quality strains.

Synthetic hormones for induced breeding - molecular endocrinology with emphasis on use of analogues for breeding like GnRH, pheromones, growth hormone signal peptide for secretion, biotechnological approaches for peptide synthesis.

Antimicrobial peptides and their applications

Live feed: culture of commercially important micro algal species (*Chaetoceros*, *Skeletonema*, *Isochrysis*, *Tetraselmis*, *Thalassiosira*, *Nannochloropsis*), single cell protein from *Spirulina*, Culture of Artemia, rotifers, cladocerans, chironomid larvae.

Environment and Health Management: DNA and RNA vaccines, molecular diagnosis of viral diseases, Dot-blot, RAPD, RFLP, immunostimulants.

Application of nanotechnology in aquaculture.

References:

Halver JE Fish Nutrition Wiley Interscience

Hoar & Randall Fish physiology Academic Press

Bardach JE et al Aquaculture Wiley Interscience

Conn & Stump Outlines of biochemistry Wiley Eastern

Italy, E (Eds). 1998, New Developments in Marine Biotechnology, Plenum Pub. Corp.

Milton Fingerman and Rachakonda Nagabhushanam, 1996, Molecular Genetics of Marine Organisms, Science Pub Inc.

Y. Le Gal and H.O. Halvorson 1998, New Developments in Marine Biotechnology. Springer.

Practicals:

1. Pituitary gland isolation and preparation of pituitary gland extract
2. Induced spawning - fish, shrimp, Seurchins and bivalves
4. Live feed cultures (microalgae)
5. Determination of concentration of microalgal cells in culture flasks using haemocytometer
6. Spotters of live feed organisms:
 - i. Animal live feed
 - ii. Plant live
7. Numericals on inbreeding, cross breeding and polyploidy
7. PCR Demo
8. Dot- Blot Demo

M.Sc. Coastal Aquaculture and Marine Biotechnology – I Semester

Paper 1.1: Oceanography and Marine biology

Dimensions of oceans; Physical parameters of sea: Tides, waves, light, temperature, currents, density, pressure & Heat budget of the oceans, sound and its propagation in the sea.

Chemical parameters of the sea: salinity, dissolved oxygen, carbon dioxide, pH, nutrients and trace elements.

Composition of seawater and brackishwater.

Classification of marine habitats and ecological divisions of the ocean.

Plankton, nekton, benthos and their adaptations.

Ecology of coral reefs and mangrove habitats; their special features.

Sea- ranching of economically important marine organisms.

Law pertaining to the seas: Historical perspectives in International negotiations and settlements over open seas. Modern law of the sea.

Remote sensing applications in oceanography and marine biology.

Elements of Geographic Information Systems (GIS) and its role in oceanography.

National and International Institutes of marine research.

References

| | | |
|----------------------------|-------------------------------|-------------------|
| Svedrup et al | The Oceans Prentice | Hall |
| Tait RV | Elements of marine ecology | Butterworths |
| Riley & Skirrow | Chemical Oceanography | Academic Press |
| Newell RC | Biology of intertidal animals | Logos Press |
| Kinne O (Ed) | Marine ecology | John Wiley & Sons |
| Mann KH | Ecology of coastal waters | |
| King CAH | Introd. Phys. & Biol. Oceang. | ELBS |

Practicals:

1. Determination of Salinity of the sea water sample adopting Harvey's Method
2. Determination of the Dissolved Oxygen concentration in the sea water adopting Winkler's Method
3. Determination of Alkalinity of the sea water sample following Titrimetric Method
4. Determination of pH of sea water sample using a digital pH meter.
5. Identification of Phytoplankton Zooplanktons Nekton, Intertidal and sub-tidal organisms, coral reefs and mangroves.

Paper 1.2: Finfish Culture

Important cultivable finfish species and their biology - milkfish, mullets, seabass, yellowtail, pearl spot, grouper, cobia, silver pompano, pacu, sea breams, salmon, rabbit fish and tilapia.

Criteria for selection of finfish for culture.

Classification of culture systems: ponds, pens, cages, raceways

Pond preparation and fertilization, eradication of weed and predatory finfishes.

Culture practices of milkfish, mullets, seabass, cobia and yellowtail.

Monoculture and polyculture: principles and practices. Integrated farming, organic farming and their management. Harvesting and post-harvesting technology of cultured finfish.

Production, quality control, marketing and economics.

Coastal Aquaculture Authority and its role.

References:

| | | |
|------------------------------|---------------------------------------|--------------------|
| Bardach JE et al | Aquaculture | Wiley Interscience |
| Huet & Timmermans | Textbook of fish culture | FNB |
| Pillay TVR | Aquaculture: principles and practices | FNB |
| Santhanam R et al | Coastal aquaculture | CBS |

Practicals:

1. Fish identification based on morphometric and meristic data.
2. Dissect and display the digestive system of herbivorous and carnivorous fish and reproductive system of fish
3. Important calculations in aquaculture: FCR and FCE, Daily ration of feed, Survival rate, Specific growth rate, Quantifying the seed for transport.
4. Identification:
 - A. Cultivable fishes
 - B. Predatory and weed fishes
 - C. Fertilizers
 - D. Supplementary feeds

Paper 1.3: Crustacean Farming

Status of crustacean farming in India and abroad.

Important cultivable species and their biology - *Penaeus monodon*, *P. indicus*, *P. vannamei*, *P. semisulcatus* and *Macrobrachium rosenbergii*; *Scylla serrata* and *Panilurus homarus*.

Types of farming practices: Traditional, extensive, semi-intensive, intensive, super-intensive and ultra-intensive.

Farming of prawn, shrimp, crab, lobster. Harvesting, handling, Marketing and economics.

Culture in: Cages, re-circulatory systems and rice fields.

Supplementary feeding: dry feeds, wet feeds, role of artificial feeds; feed ingredients and nutritional quality.

References:

| | | |
|-------------------|--|------------------------|
| Shigueno K | Shrimp culture of Japan | AITP, Tokyo |
| Milne PH | Fish & shellfish farming in coastal waters | FNB |
| McVey JP | Crustacean aquaculture | CRC handbook CRC press |
| Korringa P | Farming of marine fishes & shrimps | Elsevier |
| Walne PR | Culture of bivalve mollusks | PNB |

Practicals:

1. Identification of shrimp upto species level based on morphological characters.
2. Dissect and display the appendages of shrimp and crab.
3. Dissect and display the digestive system of shrimp, crab and lobster
4. Dissect and display the reproductive system of shrimp and squilla.
5. Identification:
 - A. Cultivable crustaceans
 - B. Larval forms
 - C. Shrimp and crab feed.

Paper 1.4: Aquaculture Engineering

Scope and importance of aquaculture engineering.

Types of soils, important soil properties; soil texture & structure, soil-water Relationships.

Computation of area by various survey methods (chain, plane table, magnetic compass

and leveling (auto leveler), earth work estimations.

Properties of fluids, computation of time to fill/drain pond/tank.

Fundamentals of waves & tides; their effects on aquaculture installations.

Engineering properties of materials. Types of materials used in aquaculture.

Technical considerations in site selection for hatchery/farm/cages

Design and construction of a hatchery (carp/shrimp), pond, cages, pens, raceways.

Different types of feeding equipment, feed control systems, dynamic feeding systems.

Water treatment: Filtration of water for aquaculture; water re-circulatory equipments.

Working principles of pH meter, salinometer, spectrophotometer, D.O. meter, Secchi disc,

heaters, ozonisers, UV filtration unit, pumps and aerators (types, selection and positioning).

References:

| | | |
|-------------------------|---------------------------------|------------------|
| Lawson TB | Fundm. Aquaculture engineering | CBS |
| Whaton FW | Aquaculture engineering | John Wiley |
| Timmon | Aquaculture engineering | Blackwell |
| Bose & Mitra | Coastal aquaculture engineering | Oxford & IBH |
| | Punnima Surveying | Laxmi publishers |
| AGOR | Elements of Civil Engg. | Khanna |
| BC mal | Soil & Water Conservation Engg. | Kalyani |

Practicals:

1. Determination of bulk and particulate density of soil
2. Land survey -chain, plane table, magnetic prism, autoleveler
3. Lay-out preparation of fish and shrimp hatchery
4. lay-out preparation of fish/shrimp farm
5. Designs of various monk sluices
6. Numericals on optimal height and width of dikes and earth work

M.Sc. Coastal Aquaculture and Marine Biotechnology – II Semester

Paper 2.1: Molluscan & Seaweed farming

Present status of molluscan farming

Life cycles of cultivable molluscs: mussels, clams, scallops, cockles and abalones

Oyster and mussel farming; growth, fattening and greening.

Culture of pearl oyster and pearl production

Culture of cephalopods.

Water quality management and biofouling.

Harvesting, post-harvest technology, management, production and economics.

Present status of seaweed farming

Seaweed species of commercial importance,

Life cycles of seaweeds of commercial importance: *Ulva* sp., *Geledium* sp., *Sargassum* sp., *Gracilaria* sp.

Culture practices of seaweeds in India and abroad. Farming of Agar, Algin, Carrageenan yielding seaweeds and green seaweeds.

Integration with other farming systems.

Breed improvement in sea weeds.

References:

| | | |
|--------------------------|---|--------------------|
| Bardach JE et al | Aquaculture | Wiley Interscience |
| Pillay TVR | Aquaculture: principles & practices | FNB |
| Imai T | Aquaculture in shallow seas | Amerind |
| Stickney RS | Principles of aquaculture | John Wiley |
| Pillay & Dill | Advances in aquaculture | FAO |
| Milne PH | Fish and shellfish farming in coastal waters | FNB |
| Walne PR | Culture of bivalve mollusks | PNB |
| Pillay & Dill | Advances in aquaculture | FAO |
| Korringa P | Farming of the oyster | Elsevier |

Practicals:

I. Dissections:

1. Digestive system of cephalopods and bivalves
2. Reproductive system of cephalopods and bivalves
3. Gill mounting of molluscs

II. Identification: A. Cultivable Molluscs B. Sea weeds and their by-products, C. Predators D. Models of Culture systems

Paper 2.2: Soil and water quality management in Aquaculture

Soil and water interaction: Physico - chemical properties of soil and water, Productivity vs nutrient quality and quantity of soil and water; aquatic microorganisms and their role in carbon, nitrogen, phosphorus and sulphur cycles and impact on aquatic habitats and species.

Soil and water quality standards in culture systems.

Fertilizers and manures: Different kinds of fertilizers and manures, fertilizer grade, source, rate and frequency of application, Bio-fertilizers, Use of treated sewage for pond fertilization, Ecological changes after fertilization, Primary production, degradation of molecules in aquatic environment.

Soil and water quality management: Cat clay/pyrite soil, seepage

Water treatment: Water filtration and devices, aeration and aerators, chlorination, ozonization and UV radiation; Waste water treatment practices, sludge disposal.

Algal bloom control, eutrophication, Aquatic weed management, Waste water discharge standards and role of microorganisms.

References:

- Adhikari S & Chatterjee DK. 2008.** *Management of Tropical Freshwater Ponds*. Daya Publ.
- APHA, AWWA, WPCF. 1998.** Standard Methods for the Examination of Water and Wastewater, 20th Ed. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, Washington, D. C.
- Boyd, C. E. and Tucker, C. S. 1992.** Water Quality and Pond Soil Analyses for Aquaculture, Alabama Agricultural Experimental Station, Auburn University.
- Boyd CE. 1979.** *Water Quality in Warm Water Fish Ponds*. Auburn University.
- ICAR. 2006.** *Handbook of Fisheries and Aquaculture*.
- ICAR. Parsons TR, Maita Y & Lalli CM. 1984.** *A Manual of Chemical and Biological Methods for Seawater Analysis*. Pergamon Press.
- Rajagopalsamy CBT & Ramadhas V. 2002.** *Nutrient Dynamics in Freshwater Fish Culture System*.
- Daya Publ. Sharma LL, Sharma SK, Saini VP & Sharma BK. (Eds.). 2008.** *Management of Freshwater Ecosystems*. Agrotech Publ. Academy.

Practicals:

1. Determination of soil texture and P^H.
2. Determination of DO, Alkalinity, hardness, transparency and Ammonia of water in culture ponds
3. Estimation of N, P, K in soil
4. Sediment analysis- physical, chemical, bacteriological and mycological
5. Harmful Algal Blooms in culture ponds
7. Numerical on dosage determination of chemicals and other additives in ponds
6. Lime and fertilizer requirement calculations

Paper 2.3: Seed production & Hatchery Management

Brood stock management of finfish and shellfish: Brood stock availability, transport, captive rearing and maturation, nutritional requirements, improvement, SPF and SPR brood stock certification.

Wild seed collection methods - mullets, milkfish, seabass, shrimps, crabs, lobsters, oysters, pearl-oysters, mussels and seaweeds.

Induced breeding: Methods of natural and artificial fertilization, synthetic hormones and its analogues, and its applications.

Hatchery management of mullets, milkfish, seabass, shrimps, crabs, lobsters, oysters, pearl-oysters, mussels and seaweeds.

Nutritional requirements of finfish and shellfish larvae: live feeds - *Spirulina*, micro algae, Artemia, chironomid larvae and artificial feeds - micro encapsulated feeds, pellets, flakes, powdered, micro coated, micro bound and liquid feeds.

Harvesting, packaging and transport of fish and shrimp seed.

Seed quality management: Testing and certification

Marketing and economics of seed production.

References:

- | | | |
|--------------------------------|---|--------------------|
| Bromage & Roberts | Broodstock management and egg and larval quality. | Blackwell |
| Bardach JE et al | Aquaculture | Wiley Interscience |
| Pillay TVR Aquaculture: | principles & practices | FNB |
| Santhanam R et al | Coastal aquaculture | CBS |
| Stickney RR | Principles of Aquaculture | John Wiley |

Practicals:

1. Collection and identification of cultivable Brackish water finfish and shellfish seed- Mullet, milkfish, seabass, shrimps, lobster, crab, mussels, oysters, seaweed
2. Evaluation of milkfish/ mullet/ seabass milt and egg
3. Design and operation of seabass/groupers hatchery
4. Visit to different finfish/shell fish hatcheries
5. Seed packing and transportation
6. Eye stalk ablation technique
7. Culture techniques of micro algae
8. Counting of micro algae cells-Sedzwick's Rafter Cell and Haemocytometer
9. Hatching of Artemia cysts and determination of percentage hatching
10. Identification of live feed organisms.

Paper 2.4: Marine Microbiology

Microbes in the sea: viruses, bacteria, fungi, microalgae and protozoans their classification and distribution in the marine environment. Microbes in extreme environments and their significance- thermophiles, psychrophiles, halophiles and barophiles.

Viruses: morphology, isolation, culture and classification.

Bacteria: morphology, enumeration, culture, classification and preservation.

Marine Fungi and protozoans: classification and culture.

Methods of controlling microbes: physical, chemical & chemotherapeutic methods.

Sterilization techniques employed in microbiological studies.

Roles of bacteria and moulds in fish preservation: Microorganisms in frozen, canned and dried products and their control, fish quality and evaluation and different indices of quality, quality management in sea food processing.

Concepts of total management, practical aspects of planning and implementing HACCP systems.

Hazards in sea foods , risk assessment, . National and International standards – ISO, 9000 series. ISO 22000. Roles of BIS, EIA, EIC, FSSAI. Traceability issues in International trade.

References:

Litchfield CD Marine microbiology Hutchinson & Ross

Pelczar ECS et al Microbiology Tata-McGraw Hill

Dheendaran K. 2008. *Aquatic Microbiology*. Daya Publ. House.

Frobisher M, Hinsdill RD, Crabtree KT & Goodheart CR. 1974. *Fundamentals of Microbiology*. WB Saunders.

Rheinheimer G. 1992. *Aquatic Microbiology*. John Wiley & Sons.

Stanier R, Ingraham JL & Adelberg EA. 1976. *General Microbiology*. MacMillan.

Vernam AH & Evans M. 2000. *Environmental Microbiology*. Blackwell.

Practicals:

1. Sterilization Techniques
2. Preparation of Different Bacterial, Fungal and Protozoal culture media
3. Taxonomical characterization of Bacterial isolates
4. Estimation of total heterophilic Bacterial counts in water and soil sediments
5. Estimation of total Vibrio counts in water and soil sediments
6. Isolation, Culture and identification of fungi, MPN of coliforms and confirmation
7. Antibiotic sensitivity tests

M.Sc. Coastal Aquaculture and Marine Biotechnology – III Semester

Paper 3.1: Biochemistry and Fish nutrition

Carbohydrates, proteins, lipids and their metabolism.

Biological membranes: transport of molecules.

Enzymes: classification, types, factors affecting enzyme catalysis, control of enzymatic action and immobilization of enzymes.

Nutritional requirements of cultivable finfish and shellfish: Nutritional value of commonly used fish as food.

Feed formulation: General principles, different steps of feed formulation, Pearson's method, quadratic equation linear programming, and limitations. Computerized least cost formula and criteria for aquafeed formulation. Feed additives - Use of natural and synthetic carotenoids

Texture and size of feed: Dry - pellets, flakes, powdered, micro-encapsulated, micro-bound and micro-coated diets, non-dry, Farm made feeds.

Experimental diets: Reference diet, purified and semi-purified diet, Compact pellet feed, floating and slow sinking pellet feeds, high energy diet, vacuum coating with lipid

Equipment used in feed manufacture - Pulverizer, grinder, mixer, pelletizer, crumbler, drier, Extruder/ Expander, Vacuum coater, fat sprayer in feed manufacture: Grinding, Dosing, Homogenization; Extrusion cooking; Complimentary processes; Drying, crumbling, coating; Use of binders.

Effects of processing on the nutritional value of feed: vitamins and trace minerals.

Quality control in fish feed manufacturing, Quality control procedures, raw materials, finished products.

Feed storage: Hydro-stability of feed and their storage; Prevention of spoilage from rancidity, fungus and associated toxins.

Feed economics and evaluation criteria: FCR, AFCR, SGR, PRE, ERE, PER, NPU.

References

Stryer H Biochemistry

Lehninger AL Principles of biochemistry CBS

Plummer An introduction to practical biochemistry

Practicals:

- 1) Determination of moisture in muscle of fish/shrimp.
- 2) Estimation of proteins, lipids and carbohydrates in fish/shrimp muscle
- 3) Different types of pelleted feeds and their proximate analysis.
- 4) Estimation of maltose by 3, 5- dinitrosalicylate reagent method.
- 5) Assay of amylase in saliva.
- 6) Preparation of feed table
- 7) Visit to feed manufacturing unit

Paper 3.2: Genetics in Aquaculture

Principles of Genetics: Mendelian principles, probability of Mendelian inheritance, modification to Mendelian ratios.

Chromosome theory of inheritance; genetic basis of determination of sex in fish and shellfish.

Chromosome manipulation: Induction of chromosomal ploidy, polyploidy & aneuploidy, gynogenesis, androgenesis, sex reversal, transgenesis and its applications in aquaculture.

Genome size in fishes, Mechanism of variations in genome size.

Sex control and its role in aquaculture, cryopreservation of gametes, in-vitro fertilization, artificial insemination.

Role of genetics in Aquaculture: Genetic selection, inbreeding, cross breeding, hybridization, karyotyping, heterosis, hybrid vigour, introgression.

Genetic tools for aquaculture applications: DNA markers in stock identification- allozymes, RFLP, RAPD, AFLP, Microsatellite, ESTs and SNPs, mt DNA.

References:

Carvalho GR & Pitcher TJ. (Eds.). 1995. *Molecular Genetics in Fisheries*. Chapman & Hall.

Falconer DS & Mackay. 1996. *Introduction to Quantitative Genetics*. 4th Ed. Longman.

Kanakaraj P. 2001. *A Text Book on Animal Genetics*. International Book. Distributing Co.

Nair PR. 2008. *Biotechnology and Genetics in Fisheries and Aquaculture*. Dominant Publ.

Padhi BK & Mandal RK. 2000. *Applied Fish Genetics*. Fishing Chimes.

Pandian TJ, Strüssmann CA & Marian MP. 2005. *Fish Genetics and Aquaculture Biotechnology*. Science Publ.

Purdom CE. 1993. *Genetics and Fish Breeding*. Chapman & Hall.

Reddy PVGK. 2005. *Genetic Resources of Indian Major Carps*. FAO Publ.

Reddy PVGK, Ayyappan S, Thampy DM & Krishna G. 2005. *Text book of Fish Genetics and Biotechnology*. ICAR.

Ryman N & Utter F. (Eds.). 1988. *Population Genetics and Fishery Management*. Washington Sea Grant Programmes, USA.

Tave D. 1996. *Genetics for Fish Hatchery Managers*. 2nd Ed. AVI Publ.

Thorpe JE, Gall GAE, Lannan JE & Nash CE. (Eds.). 1995. *Conservation of Fish and Shellfish Resources, Managing Diversity*.

Practicals:

1. Metaphase plate preparation of fish kidney/spleen
2. Numericals on inbreeding, cross breeding, ploidy and genetic selection
3. Karyotyping
4. Computational tools for RFLP, RAPD, AFLP analysis
5. Numericals on DNA markers
6. Chi- square test for verifying Mendelian ratios
7. Assessment of genetic gain through selection
8. Calculation of selection differential and selection response
9. Estimation of inbreeding and path co-efficient
10. C-banding from heterochromatin
11. G-banding from heterochromatin

Paper 3.3: Molecular Biology

Cell structure and function in prokaryotes and eukaryotes. Cell cycle and its regulation.

Biological membranes: cell membrane, nuclear membrane, ion transport, Na/K pump, Molecular basis of signal transduction.

Nucleic Acids: Structures of DNA and RNA; Stereochemistry of bases and secondary structures; Chromatin structure; Properties of DNA - Tm, hyperchromicity, kinetic classes, buoyant density.

DNA replication: Models of DNA replication in prokaryotes and eukaryotes; Mechanics of DNA replication; DNA methylation, Structure and function of DNA polymerases; Types of priming.

Transcription in Prokaryotes and eukaryotes – enzymes, initiation, elongation and termination. Post transcriptional modifications; Structure and synthesis of rRNA and tRNA.

Genetic code, codon bias, types and structures of ribosomes, Wobble hypothesis.

Translation in prokaryotes and eukaryotes: initiation, elongation, termination, and post-translational modifications, concept of polysomes and protein structure.

DNA recombination: Molecular models - homologous and site-specific recombination, crossing over, Holliday junction, transposition.

Types of mutations, Mutagens – nitrous acid, UV, aflatoxin, bleomycin, ethidium bromide.

Types and mechanisms of DNA damage and Repair

Regulation of gene expression in prokaryotes and eukaryotes - Operon concept, regulatory sequences and transacting factors.

Environmental regulation of gene expression.

References:

- Paul J** Cell Biology Hinemanu
Friedlander D Microbial genetics
Albert et al Molecular biology of Cells
DeRobertis Cell and molecular biology
Watson et al Molecular biology of the gene B Cummings

Practicals:

1. Plasmid DNA and Genomic DNA isolation & quantification: Plasmid mini-preparations
2. Agarose gel electrophoresis
3. Purification of DNA from an agarose gel
4. Restriction digestion of DNA
5. Preparation of competent cells
6. DNA ligation
7. Equipments in molecular biology

Paper 3.4: Marine Pollution and Bio-deterioration

Sources of marine pollution: dynamics, transport paths and agents.

Composition of domestic, industrial and agricultural discharges; their fate in the marine environment. Toxicity and treatment methods.

Wastes from fish processing units and their treatment- removal of nitrogen and phosphorus, Aquatic macrophytes in treatment of waste water.

Oil pollution: Sources, composition and its fate in marine habitats. Toxicity and treatment methods.

Thermal and radioactive pollution: sources, disposal systems of heated effluents, effects and treatment.

Solid dumping, mining and dredging operations: their effects on marine ecosystem, management of solid waste.

Biofouling and biodeterioration: Biofilm formation-primary, secondary, tertiary colonizers.

Effects of biofouling and control measures: manual, mechanical, and chemical

Borers: Effects and control measures.

Corrosion- definition, reactions, classification. Factors and preventive measures.

Global environmental monitoring methods: status, objectives and limitations.

Monitoring strategies of marine pollution: critical pathway approach and mass balancing

Assessment of damage and problems of measuring the impact. Environment Impact Assessment.

Role of biotechnology in marine pollution control and bio-deterioration.

References:

Nielsen SE Tropical pollution

Kinne O Marine Ecology Vol. V John Wiley

Johnson R (Ed) Marine pollution Academic Press

Patin SA Pollution and boil. Resources of oceans Butterworths

Goldberg, E. D. 1974. The Health of the oceans, UNESCO Press. Paris.

Park, P.K, Kester D.R., J.W. Deudall and B.H Ketchum, 1983. Wastes in the Ocean. Vols. 1 to 3. Wiley Interscience Publishers, New York.

Eckenfelder WW. 2000. *Industrial Water Pollution Control.* McGraw Hill.

Gray NF. 2004. *Biology of Wastewater Treatment.* Oxford University Press.

Trivedy RK. 1998. *Advances in Wastewater Treatment Technologies.* Global Science.

Practicals:

1. Determination of BOD in the polluted sea water sample.
2. Determination of nutrients in the polluted sea water sample: nitrites, nitrates, silicates and phosphates
3. Determination of toxic elements in the polluted sea water sample: ammonia, sulphide
4. Estimation of particulate organic matter in the polluted sea water sample
5. Spotters: Foulers- primary, secondary and tertiary colonizers; Borers

M.Sc. Coastal Aquaculture and Marine Biotechnology – IV Semester

Paper 4.1: Fish Pathology & Immunology

Disease diagnosis: Epidemiology, laboratory studies, microbiological and histopathological studies.

Viral, bacterial, fungal, protozoan, nutritional and environmental diseases of fish and shellfish, their control methods.

Chemotherapeutic agents: Types and mode of action. Chemicals, antibiotics, pre & probiotics in disease control. DNA and RNA vaccines. Recombinant vaccines, use of RNA interference. Biosecurity, disease control through environmental management.

Introduction to fish immunology - Historical developments; Phylogeny and ontogeny of immune system, Lymphoid tissues and cellular components of immune system, T and B cells.

Non specific immune system: Phagocytosis, Complement system - function, components, complement activation.

Specific defence mechanisms - Memory function and immunological tolerance.

Antigens and antigenicity, antigen processing, super antigens, haptens.

Antibody: Structure, types, theories of antibody formation, regulation of immune response.

Antibody mediated immune response: Polyclonal and monoclonal antibody production and application.

Basic concept of aptamers, aptabodies and edible antibodies

Immune genes and their regulation, Hypersensitivity reactions; Auto-immune Disorders.

Invertebrate defense mechanisms: quasi immune response.

References:

Schoperclans W Fish diseases Oxian press

Riott I M Essentials of immunology Blackwell

Practicals:

Procedure of disease diagnosis,

Tissue fixation, Microtomy and histology of various tissues,

Isolation and identification of pathogenic bacteria/fungi,

Disease diagnosis: Histological techniques for disease diagnosis- Necroscopy, Agglutination test.

Identification of various parasites and diseases of fin and shell fishes, PCR, Serological techniques.

Preparation of antigen, rising antibodies, immuno electrophoresis, Isolation from antibody from serum.

NBT and Prophenol Oxidase tests, ELISA, Antibiotic sensitivity test, haematological tests of fish/shrimp.

Paper 4.2: Marine Biotechnology

Introduction to marine biotechnology.

Microbial fermentation, microbes in decomposition and recycling processes,

Applications of biofermenters and biofertilizers, microbial transformations.

Gene targeting approaches in biotechnology, isolation of nuclear and extra nuclear DNA; gene modification techniques, Southern, northern and south-western blots, Colony hybridization.

Sequencing methods of proteins and nucleic acids: Sangers, Maxam and Gilbert; NGS, Types of Polymerase Chain Reaction and applications.

Transgenic biology, allopheny.

Cell and tissue culture: primary and secondary cultures, cell lines, callus culture, somaclonal culture, micropropagation, somatic embryogenesis, protoplast fusion, somatic hybridization and cybrids.

Stem cells and their applications in animal health.

References:

Litchfield CD Marine Microbiology DHR

Bye & Ponnaiah Application of genetics in aquaculture CMFRI

Travan et al Biotechnology Tata-McGraw

Practicals:

1. Microbial transformation of yeast/bacteria
2. DNA amplification using Thermocycler (Demo)
3. Horizontal Gel Electrophoresis (Demo)
4. Blotting techniques
5. Isolation of protoplasts from seaweeds and micro propagation.
6. Downloading of PDB IDs of enzymes from Protein Data Bank and structure prediction.

Paper 4.3: Bioactive Marine Natural products

Introduction: Significance of marine natural products.

Principle and applications of colorimeter, UV visible spectrophotometer, Fluorescence Spectrophotometer, Flame photometer; Atomic absorption spectrophotometer, Inductively Coupled plasma Spectrophotometer (ICP) in quantification of compounds.

Isolation techniques: Liquid - liquid extraction, membrane separation methods, chromatography techniques- Paper, Thin layer, Gas and liquid chromatography, HPLC, Ion-Exchange chromatography.

Characterization techniques: IR, UV, NMR, Mass Spectroscopy.

Types of important products: Antibiotic, anti-tumour, tumour-promotor, anti-inflammatory, analgesic, cytotoxic, anti-viral, anti-fouling compounds of marine origin.

Marine toxins: Saxitoxin, brevitoxin and ciguatoxin

Marine peptides & alkaloids: pyridoacridine, pyrrolocridine indole, pyrrole, isoquinoline, alkaloids.

Basic principles of pharmacology: Classification and action of antibiotics and other antimicrobials.

Green fluorescent protein from jelly fish and its applications.

Principles of drug activity, pharmacokinetics, absorption, distribution, biotransformation and excretion of drugs.

References:

David HA et al Marine Biotechnology Plenum

Scheur PJ Marine Natural Products Academic

DS Bhakuni DS Rawat Bioactive marine natural products Springer & Anamaya

Practicals:

1. Separation of amino acids by paper chromatography
2. Identification of amino acids by paper chromatography
3. Preparation of crude extract by methanol:hexane solvent from molluscs, sponges and mangrove plants
4. Separation of crude extract fractions by column chromatography
5. Separation of fractions/compounds by TLC
6. Testing of Anti-bacterial activity of crude extract
7. Bioautography testing.
8. Verification of Beer's law in spectrophotometer.
9. Organisms/plants having bioactive importance.

M.Sc. Marine Biotechnology – I Semester

Paper 1.1: Oceanography and Marine biology

Dimensions of oceans; Physical parameters of sea: Tides, waves, light, temperature, currents, density, pressure & Heat budget of the oceans, sound and its propagation in the sea. Chemical parameters of the sea: salinity, dissolved oxygen, carbon dioxide, P^H, nutrients and trace elements.

Composition of seawater and brackishwater.

Classification of marine habitats and ecological divisions of the ocean.

Plankton, nekton, benthos and their adaptations.

Ecology of coral reefs and mangrove habitats; their special features.

Sea-ranching of economically important marine organisms.

Law pertaining to the seas: Historical perspectives in International negotiations and settlements over open seas. Modern law of the sea.

Remote sensing applications in oceanography and marine biology.

Elements of Geographic Information Systems (GIS) and its role in oceanography.

National and International Institutes of marine research.

References:

| | | |
|----------------------------|-------------------------------|-------------------|
| Svedrup et al | The Oceans | Prentice Hall |
| Tait RV | Elements of marine ecology | Butterworths |
| Riley & Skirrow | Chemical Oceanography | Academic Press |
| Newell RC | Biology of intertidal animals | Logos Press |
| Kinne O (Ed) | Marine ecology | John Wiley & Sons |
| Mann KH | Ecology of coastal waters | |
| King CAH | Introd. Phys. & Biol. Oceang. | ELBS |

Practicals:

1. Determination of Salinity of the sea water sample adopting Harvey's Method
2. Determination of the Dissolved Oxygen concentration in the sea water adopting Winkler's Method
3. Determination of Alkalinity of the sea water sample following Titrimetric Method
4. Determination of pH of sea water sample using a digital pH meter.
5. Identification of Phytoplankton, Zooplankton, Nekton, Intertidal, sub-tidal organisms, corals and mangroves.

Paper 1.2: Biochemistry

Basic concepts of biochemistry: An overview, types of chemical bonds.
Structure & properties of biomolecules: Carbohydrates, lipids, proteins.
Proximate composition of fish and shellfish.
Metabolism of carbohydrates - Glycolysis, Gluconeogenesis, Krebs's cycle,
Oxidative phosphorylation; protein metabolism, lipid metabolism- Beta fatty acid oxidation.
Principles of Metabolic regulation- regulatory steps, signals and second messengers.
Bioenergetics: Basic principles, Equilibria and concept of free energy; Coupled processes
Structure and properties of Vitamins and hormones; Prostaglandins, leucotrienes, thromboxanes, interferons, interleukins
Types of antibiotics
Biological membranes: organization- sidedness and function, transport of biomolecules and cytoskeletal organization.
Biochemical pathway of photosynthesis and factors affecting.

References:

| | | |
|------------------------|--|---------|
| Stryer H | Biochemistry | Freeman |
| Lehninger AL | Principles of biochemistry | CBS |
| Voet & Voet | Biochemistry | |
| Plummer | An introduction to practical biochemistry. | |

Practicals:

1. Estimation of moisture in fish/shrimp muscle
2. Estimation of protein in fish/shrimp muscle by Lowry's method
3. Estimation of carbohydrate in fish/shrimp muscle by Anthrone method
4. Estimation of lipid in fish/shrimp muscle by Sulpho- Phospho vanillin method
5. Separation of proteins by Acrylamide GEL Electrophoresis
6. Estimation of glycine by formal titration
7. Analytical method to detect carbohydrates
8. Analytical method to detect amino acids-
9. Analytical method to detect proteins
10. Analytical method to detect lipids
11. Equipments in Biochemistry

Paper 1.3: Reproductive Physiology and Endocrinology

Anatomy and histology of gonads in fin fish and shellfish.

Development of gonad: oogenesis; spermatogenesis, metabolic changes during oogenesis and spermatogenesis and gonadal steroidogenesis.

Sex determination and differentiation, factors affecting sex differentiation.

Sexual dimorphism, primary and secondary sex characters, bisexual reproduction, inter-sexes, hermaphroditism

Sex reversal in fish and shellfish, factors affecting sex reversal.

Breeding biology and endocrine control of reproduction in finfish and shellfish.

Annual reproductive cycles and breeding patterns in fin fish and shell fish. Pheromones and reproductive behaviour.

Regulation of seasonal reproduction: Role of environment - photoperiod, temperature, rainfall

Role of hypothalamo-hypophyseal system and pineal gland, role of peripheral endocrine system, role of nutrition.

Breeding technology: Hypophysation and Induced breeding, cryopreservation of gametes and artificial fertilization.

Application of biotechnology for accelerating gonadal growth and manipulation of duration of spawning.

In vitro maturation of oocyte.

Neuro-endocrine systems in fish and shrimp and its role in the regulation of reproduction.

References:

Adiyodi KG & Adiyodi RG. 1971. Endocrine Control of Reproduction in Decapod Crustacea. Biology Reviews.

Agarwal NK. 2008. Fish Reproduction. APH Publ.

Bell TA & Lightner TA. 1988. A Handbook of Normal Penaeid Shrimp Histology. World Aquaculture Society.

Ghosh R. 2007. Fish Genetics and Endocrinology. Swastik Publ. & Distr.

Hoar WS, Randall DJ & Donaldson EM. 1983. Fish Physiology. Vol. IX. Academic Press.

Maria RJ, Augustine A & Kapoor BG. 2008. Fish Reproduction. Science Publ.

Matty AJ. 1985. Fish Endocrinology. Croom Helm.

Mente E. 2003. Nutrition, Physiology and Metabolism in Crustaceans. Science Publ.

Nikolsky GV. 2008. The Ecology of Fishes. Academic Press.

Thomas PC, Rath SC & Mohapatra KD. 2003. Breeding and Seed Production of Finfish and Shellfish. Daya Publ. House.

Practicals:

1. Dissection of reproductive system - fish, shrimp, Celina
2. Estimation of spawning season
3. Estimation of fecundity
4. Gonadal maturity stages in fish, shrimp, mollusca
5. Dissection and display of pituitary gland from fish
6. Preparation of pituitary gland extract
7. Estimation of GSI
8. Dissection and display of various endocrine organs of fish/shrimp

Paper 1.4: Molecular Biology

Cell structure and function in prokaryotes and eukaryotes with reference to nucleus, mitochondria, chromosomes and ribosomes.

Cell cycle and its regulation.

Nucleic Acids: Structures and properties of DNA and RNA

DNA replication, damage and repair in prokaryotes and eukaryotes

DNA recombination: Homologous and non-homologous, site specific recombination.

Transcription in Prokaryotes and Eukaryotes; Regulatory elements, processing of t-RNA and r-RNA; Genetic code, Translation and Translational machinery: Ribosomes, composition and assembly; Transport of proteins and molecular chaperones, Protein stability, Protein turn over and degradation. Post- translational modifications.

Regulation of gene expression in prokaryotes and eukaryotes.

Operon concept- Lac, Tryp, Ara, Gal and His.

DNA methylation, regulatory sequences and transacting factors, Environmental regulation of gene expression.

Mutations: Types, Physical, chemical and biological mutagens, Role of transposons in mutations. Oncogenes and tumor suppressor genes.

References:

| | | |
|---------------------|---------------------------|-------------|
| Lewin B | Genes IX | John Wiley |
| Watson et al | Molecular biology of gene | Benj. Cumm. |
| Frifielder D | Microbial genetics | |
| Lodish et al | Molecular cell biology | Freeman |

Practicals:

1. Qualitative analysis of Nucleic acids.
2. Quantitative analysis of nucleic acids.
3. Plasmid DNA and Genomic DNA isolation & quantitation: Plasmid mini preparations
4. Isolation of RNA from yeast cells/ fish
5. Purification of DNA from an agarose gel
6. Restriction digestion of DNA
7. Bacterial transformation

M.Sc. Marine Biotechnology – II Semester

2.1: Coastal Aquaculture

Definition, overview, status and importance.

Engineering aspects of aquaculture: Design and construction of pond and hatchery.

Types of culture systems: Ponds, cages, pens, race ways.

Criteria for selection of species for coastal aquaculture.

Types of culture practices: Traditional, extensive, semi-intensive, intensive, super intensive,

ultra intensive, mono- and poly culture, integrated and organic farming.

Biology and life cycles of *Penaeus vannamei*, *Macrobrachium rosenbergii*, *Panilurus homarus*, *Scylla serrata*, *Chanos chanos*, *Lates calcarifer*, *Crassostrea madrasensis*, *Pinctada fucata* and *Loligo sps*.

Fish culture: Milk fish, mullets, Asian sea bass.

Shell fish culture: Shrimps, prawns, crabs, lobsters, oysters, mussels, cephalopods.

Life cycle and culture of *Ulva sps*, *Kappaphycus sps*, *Gracillaria sps* and *Sargassum sps*.

References:

Raymont JEG Plankton & productivity of oceans Pergamon

Bardach JE et al. Aquaculture Wiley interscience

Pillay TVR Aquaculture: principles and practices FNB

Bardach, John.E. 1997 Sustainable Aquaculture. John Wiley and Sons.

Chapman, V.J., 1980. Seaweeds and their uses Chapman and Hall London.

Wheaton, F.W. 1977. Aquaculture Engineering. John Wiley and Sons, New York.

Stickney, 1995. Principles of Aquaculture, John Wiley & Sons.

Santhanam R et al Coastal aquaculture CBS

Practicals:

1. Identification of fish based on morphometric and meristic data.
2. Identification of shrimp based on morphological characters.
3. Dissect and display the digestive system of fish, shrimp, molluscs
4. Identification of cultivable organisms: Seaweeds, Crustaceans, Molluscs, Echinoderms and Finfish
5. Identification of larval forms of cultivable organisms: Crustaceans, Molluscs, Echinoderms and Finfish.
6. Aquaculture equipment.

Paper 2.2: Fish Genetics

Scope of fish genetics.

Mendelian inheritance, Non- chromosomal & Mitochondrial inheritance, genetic variation, chromosome theory, genetic basis for sex determination and sex linked genes in fish, linkage and crossing over.

Chromosomal polymorphism, Gynogenesis, androgenesis, production of super males.

Genetic improvement in fish.

Population genetics: Changes in allelic and genotypic frequency, effective population size, inbreeding and coefficients, Fitness, qualitative and quantitative traits, Components of variance- additive and non-additive variance.

Genetic variability and differentiation, Genetic similarity and Nei's genetic distance,

Genetic bottle neck and mutation drift equilibrium null alleles, population genomics, outlier loci and adaptive variation in trait-related genes.

DNA markers in stock identification: Allozymes, RFLP, RAPD, AFLP, Microsatellites, ESTs, SNps, Type I and Type II markers, mt DNA and nuclear DNA markers, Laboratory assay of markers.

Applications of markers for species identification, hybridization, stock identification, genetic diversity and conservation, Parentage, Linkage, QLT mapping and microarray genes.

Karyotyping and chromosome banding- C-banding, G-banding, NOR banding.

Fluorescence In-situ Hybridization (FISH), Transgenics, GMO and biosafety regulations, designer ornamental fish.

Genotoxicity assay: Comet assay, Sister chromatid exchange, MNT (Max's Next Tango).

References:

| | |
|--|---|
| Pandian TJ, Strussmann CA & Marian MP | Fish Genetics & Aquaculture SciencePub Biotechnology |
| Lakra/Singh | Fish genetic resources |
| Mirza Akbar Khan | Genetic Embryology and fishes |

Practicals:

1. Exercises on Mendelian laws
2. Estimation of gene and genotypic frequencies
3. Estimation of effective population size
4. Building of pedigree size
5. Protein, mt DNA and nuclear DNA extraction.
6. ANOVA in genetic variance
7. Estimation of heritability by half-sib, full-sib and mid-parent analysis.
8. Procedures for estimating breeding values/coefficient of inbreeding.
9. Estimation of genetic diversity and relatedness using molecular information.
10. Preparation of chromosome spreads; karyotyping, banding techniques, comet assay.

Paper 2.3: Marine Microbiology & Microbial Technology

Microscopy: Working principles of Light, Phase contrast and Transmission and Scanning electron microscopes.

Microbes in the sea: viruses, bacteria, fungi and protozoans their classification and distribution in the marine environment.

Microbes in extreme environments and their significance- thermophiles, psychrophiles, halophiles and barophiles.

Sterilization techniques employed in microbiological studies- physical and chemical methods.

Viruses: morphology, isolation, culture and classification.

Bacteria: morphology, enumeration, culture, classification and preservation.

Fungi and protozoans: classification and culture.

Bioreactors, fermentation and bioconversion by microorganisms.

Role of microbial population in bio-geo cycles (C, N, P, S & Fe)

Water borne pathogens of public health importance- protozoan, bacteria, enteroviruses, microbial toxins. Microbial standards for different water uses.

Role of bacteria and moulds in fish preservation.

Microorganisms in frozen, canned and dried products and their control.

Fish quality, evaluation and different indices of quality, quality management in sea food processing.

Concepts of total quality management.

HACCP: Practical aspects of planning and implementing HACCP systems.

Hazards in sea foods, risk assessment.

National and international standards – ISO 9000, ISO 22000.

Role of Bureau of Indian Standards, Export Inspection Agency, EIC and FSSAI. Traceability issues in international trade.

References:

| | | |
|---------------------------------|--------------------------|-------------|
| Pelczar et al | Microbiology | McGraw Hill |
| Cappuccino & Sherman | Microbiology- Lab manual | |
| Stainer RT et al | General Microbiology | MacMillan |
| Luria et al | General Virology | Wiley |
| Rehm & Reed | Biotechnology | |
| Reed G et al | Industrial microbiology | CBS |

Practicals:

1. Sterilization Techniques
2. Preparation of Different Bacterial, Fungal and Protozoal culture media,
3. Isolation, identification of Bacteria.
4. Estimation of total heterophilic Bacterial counts in water and soil sediments,
5. Estimation of total Vibrio counts in water and soil sediments,
6. Isolation, Culture and identification of fungi
7. Antibiotic sensitivity tests.
8. MPN of coliforms and confirmation
7. Detection of food borne pathogens – Salmonella, Listeria and schizella
8. Detection of antibiotic residues in Fish/Shrimp.
9. Measurement of bacterial growth.

Paper 2.4: Cell and Tissue culture

An overview of tissue culture, equipments and materials for tissue culture.

Culture media: Types and preparation.

Cell cultures: Primary, secondary cultures and their maintenance.

Cell lines: Primary and secondary cell lines establishment. Measurement of viability and cytotoxicity assay, measuring parameters of growth.

Pure culture: isolation, separation, characterization, identification, maintenance and preservation, Cloning of cell lines.

Development of cell lines of shrimp and fish.

Organ cultures, large scale cultures.

Stem cells: Stem cell differentiation, Blood cell formation, Fibroblasts and their differentiation,

Differentiation of cancerous cells and role of proto-oncogenes.

Stem cell cultures, embryonic stem cells and their applications; Measurement of cell death & apoptosis, Three dimensional culture and tissue engineering.

Culture techniques of marine macroalgae, mangroves, shrimps, mantle of molluscs & fishes.

Industrial applications of tissue culture.

References:

Gupta PK Biotechnology

Barnes D & Mathur PJ Animal cell culture methods Academic

Basega R Cell growth & division: a a IRL

Practical approach

Clynes Animal cell culture techniques Springer

Freshney I Culture of animal cells: a manual Wiley-Liss

Of basic techniques

Harrison et al General techniques of cell culture Cambrid. U.

Lan FR Culture of animal cells Wiley-Liss

Masters RW Animal cell culture: practical approach Oxford

Hoar & Randall Fish Physiology Vol V

Practicals:

1. Preparation of tissue culture media.
2. Preparation of Balanced Salt Solutions: DPBSA and Eagle's BSS.
3. Preparation of F2 and Convey's medium for microalgal culture.
4. Isolation of protoplast from seaweeds.
5. Tissue degradation by trypsinization- Warm/cold.
6. Cell count using Haemocytometer.
7. Spore culture of seaweeds.
8. Detection of dead and live cells using calcoflor white stain.

M.Sc. Marine Biotechnology – III Semester

Paper 3.1: Health management in Aquaculture

Disease: Definition, Host-pathogen-environment relationship, environmental stress, Inflammation response to diseases.

Parasitic and mycotic diseases: General characteristics, Epizootiology, Diagnosis, Life Cycle, Prevention and treatment.

Infectious bacterial and viral diseases: General characteristics, Epizootiology, Diagnosis, Prevention and treatment.

Non-infectious Diseases: Nutritional diseases, water, soil, environmental parameters and their effect on fish health.

Diagnostic techniques: Microbiological, haematological, histopathological, immunological and molecular techniques. Disease surveillance and reporting.

Disease control and management: Environment management, chemotherapeutic agents, host management, prophylaxis-vaccines, adjuvants, immunostimulants and probiotics.

Use and abuse of antibiotics and chemicals in health management.

Fish Health and quarantine systems. Seed certification, SPF and SPR stocks- development and applications.

References:

Bardach JE et al., Aquaculture Wiley- Interscience

Pillay TVR Aquaculture: Principles & practices FNB

Santhanam R et al ., Coastal aquaculture CBS

Inglis V, Roberts RJ and Bromage NR. Bacterial diseases of fish . Blackwell

Iwami G & Nakanishi T (Eds.). The fish immune system- organism, pathogen and environment. Academic Press.

Roberts RJ. Fish Pathology 3rd Ed. WB Saunders

Schaperclaus W. Fish diseases. Vols. I, II. Oxonian Press.

Shankar KM and Mohan CV. 2002. Fish and Shellfish Health Management. UNESCO Publ.

Sindermann CJ. Principal diseases of marine fish and shellfish. Vols. I, II. 2nd Ed. Academic Press.

Stickney RR. Principles of aquaculture Wiley & Sons

Practicals:

1. Procedure of disease diagnosis.
2. Tissue fixation, Microtomy and histology of various fish/shrimp tissues.
3. Isolation of pathogenic bacteria/fungi and their identification.
4. Disease diagnostic methods: Necroscopy, Agglutination tests.
5. Identification of various parasites
6. Diseases of fin fish and shell fishes.
7. PCR for disease diagnosis, serological techniques in disease diagnosis.
8. Diseased fish/shrimp specimens.
9. Fish/Shrimp haematological parameters- TEC, DLC, TLC, Hb, Total protein, lipid profile, creatine Urea and enzymes in blood.

Paper 3.2: Immunology

Immunity and types of immunity.

Fundamental concepts and anatomy of the immune system, components of innate and acquired

immunity, Phagocytosis, Complement and inflammatory responses, Organs and Cells of the immune system-primary and secondary lymphoid organs, Lymphatic system, Lymphocyte circulation, Lymphocyte homing, Mucosal and Cutaneous associated Lymphoid tissue (MALT & CALT); Mucosal immunity.

Antigens: Types and properties. Major Histocompatibility Complex(MHC) - MHC genes, Immune responsiveness and disease susceptibility and HLA typing.

Immunoglobulins: Structure, types and functions.

Immunogenetics: Genetic basis of antibody diversity.

Molecular biology of B and T cells. Complement proteins and cytokines.

Disorders of immune system: autoimmunity- types of autoimmune diseases.

Immunodeficiency- Primary immuno deficiencies, Acquired or secondary immuno deficiencies, hypersensitivity.

Immunotherapy, Immunostimulants-beta glucagons; vaccines- Live, killed, attenuated, sub unit vaccines and antibodies. Non-specific immunity of shellfish.

Active and passive immunization; hybridoma technology- mono and polyclonal antibodies.

ELISA, RIA and Immuno electrophoresis applications.

Transplantation- Immunological basis of graft rejection.

Tumor immunology- Tumor antigens; immune response to tumors and tumors evasion of the immune system, Cancer immunotherapy.

References:

| | | |
|----------------------|--------------------------------|----------------------|
| Eli Benjamini | Immunology – a short course | |
| I. Riott | Essentials of immunology | Blackwell |
| I Riott et al | Immunology | Molsby |
| Aruna B | Manual of practical immunology | Palani- paramount |

Practicals:

1. Preparation of antigens, Immunization and methods of bleeding, serum separation and storage.
2. Antibody titre by ELISA method.
3. Isolation and purification of Ig G from serum or Ig Y from chicken egg.
4. Blood smear identification of leucocytes by Giemsa stain.
5. Separation of leucocytes by dextran method.
6. Demonstration of phagocytosis.
7. Immuno electrophoresis, Isolation of antibody from serum, Nonspecific immune response (NBT and Prophenol oxidase tests).

Paper 3.3: Enzymology and Enzyme Technology

Nomenclature & classification of Enzymes.
Enzyme structure and properties, co-enzymes, co-factors.
Enzyme specificity; factors affecting enzyme action.
Mechanism of enzyme action: activation energy; characterization of active site; activators and inhibitors,
Enzyme kinetics: Michaelis- Menten Kinetics, steady state kinetics; single and multi substrate interactions, Competitive, non competitive and uncompetitive enzyme substrate kinetics.
Multi-enzyme complex; single and multi-substrate systems.
Regulatory enzymes: Allosterism, covalent modification and feedback mechanisms; ATPase, glutamine synthetase.
Haemoglobin and myoglobin.
Membrane-bound enzymes: Extraction, purification, assay and enzyme storage
Immobilization of enzymes: methods of enzyme immobilization; applications ; Merits and demerits of immobilized enzymes.
Biosensors and modifications.
Synthetic enzymes, isozymes and their importance.
Enzymes of industrial and diagnostic importance.

References:

| | | |
|------------------------|-----------------------------------|--------------|
| Boyer P D | The Enzymes | Freeman |
| Fersht A R | Enzyme structure & mechanism | Freeman |
| Palmer T | Enzymes | Horwood |
| Siseman | A Handbook of Enzyme technology | |
| Trevan M D | Immobilized enzymes | Wiley & Sons |
| Plowman K M | Enzyme kinetics | MacGraw Hill |
| Rehm & Reed | Biotechnology Vol II: Bioreactors | |

Practicals:

- 1) Preparation of maltose standard curve using 3, 5- Dinitrosalicylate reagent.
- 2) Assay of amylase in saliva.
- 3) Preparation of ammonia standard curve using Nessler's Reagent
- 4) Assay of urease activity.
- 5) Time course of enzyme activity.
- 6) Effect of temperature on enzyme activity.
- 7) Effect of pH on enzyme activity.
- 8) Common instruments used in enzymology

Paper 3.4: Marine Pollution and Bio-deterioration

The present status of coastal pollution in India and future strategies.
Sources of marine pollution, its dynamics, transport paths and agents.
Composition of domestic, industrial and agricultural discharges. Their fate in the marine environment. Wastes from fish processing units and their treatment- removal of nitrogen and phosphorus.
Role of aquatic macrophytes in treatment of waste water. Toxicity and treatment methods.
Oil pollution: Sources, composition and its fate in marine habitats. Toxicity and treatment methods.
Thermal and radioactive pollution: sources, effects and remedial measures.
Solid dumping, mining and dredging operations: their effects on marine ecosystem.
Biofouling and biodeterioration: Biofilm formation-primary, secondary, tertiary colonizers. Effects of biofouling and control measures.
Borers: Effects and control measures.
Corrosion- definition, reactions, classification. Factors and preventive measures.
Global environmental monitoring methods: status, objectives and limitations.
Monitoring strategies of marine pollution: critical pathway approach and mass balancing
Assessment of damage and problems of measuring the impact. Environment Impact Assessment.
Role of biotechnology in marine pollution control and bio-deterioration.

References:

- Nielsen SE** Tropical pollution
Kinne O Marine Ecology Vol. V John Wiley
Johnson R (Ed) Marine pollution Academic Press
Patin SA Pollution and Boil. Resources of oceans. Butterworths
Goldberg, E. D. 1974. The Health of the oceans, UNESCO Press. Paris.
Park, P .K, Kester D.R., J.W. Deudall and B.H Ketchum, 1983. Wastes in the Ocean. Vols. 1 to 3. Wiley Interscience Publishers, New York.
Eckenfelder WW. 2000. *Industrial Water Pollution Control*. McGraw Hill.
Gray NF. 2004. *Biology of Wastewater Treatment*. Oxford University Press.
Trivedy RK. 1998. *Advances in Wastewater Treatment Technologies*. Global Science.

Practicals:

1. Determination of BOD in the polluted sea water sample.
2. Determination of nutrients in the polluted sea water sample: nitrites, nitrates, silicates and phosphates
3. Determination of toxic elements in the polluted sea water sample: ammonia, sulphide
4. Estimation of particulate organic matter in the polluted sea water sample
5. Spotters: Foulers- primary, secondary and tertiary colonizers; Borers

M.Sc. Marine Biotechnology – IV Semester

Paper 4.1: Applications of Biotechnology in Aquaculture

Importance of biotechnology in aquaculture.

Natural and artificial feeds, probiotics, nutraceuticals, Growth promoters.

Energetics of food conversion.

Plant live feeds (*Chaetoceros*, *Isochrysis*, *Nannochloropsis* & *Tetraselmis*)- collection, isolation, culture and enumeration.

Animal live feeds (Artemia, Rotifers, Copepods): Collection, isolation and culture.

Artificial feeds: feed formulations, methods & strategies.

Importance and use of anti-oxidants and antibiotics in feeds.

Application of genetics in aquaculture: genetic selection, inbreeding, and cross-breeding, sex control, polyploidy and transgenesis, methods of gene transfer in fishes, screening, sites, applications.

Development of high quality strains.

Synthetic hormones for induced breeding - molecular endocrinology with emphasis on use of analogues for breeding like GnRH, pheromones, growth hormone signal peptide for secretion, biotechnological approaches for peptide synthesis. Antimicrobial peptides and their applications.

Microalgae-biotechnological approaches for the identification and production of commercially important compounds, single cell protein from Spirulina, Microalgae for nutrition and cosmetics.

DNA and RNA vaccines, molecular diagnosis of viral diseases, Dot-blot, ribotyping of pathogenic microbes, RNAi vaccines.

Application of nanotechnology in aquaculture.

References:

Colwell RR Biotechnology in Marine Science

Felix S. 2007. Molecular Diagnostic Biotechnology in Aquaculture. Daya Publ. House.

Fingerman M, Nagabhushanam R & Thompson MF. 1997. Recent Advances in Marine Biotechnology, Vols. I-III. Oxford & IBH.

Pandian TJ, Strusmann CA & Marian MP. 2005. Fish Genetics and Aquaculture Biotechnology, Science Publ.

Reddy PVGK, Ayyappan S, Thampy DM & Gopalakrishna. 2005. Text book of fish Genetics and Biotechnology, ICAR

Nair PR. 2008. Biotechnology and Genetics in Aquatic Biotechnology. Science Publ.

Practicals:

1. Hatching and production of Artemia nauplii for shrimp feed.
2. Dissection and display of various endocrine glands of fin fishes & shell fishes.
4. Isolation of pituitary gland from fish, and preparation of extract,
5. Types of various artificial fish and shrimp feed.
5. PCR for diagnosis of viral diseases (WSV, EHP, MBV)
6. Synthetic GnRH for induced breeding, in fish-preparation and dose determination.
7. Induced breeding in shrimp- Eyestalk ablation, cauterization, squeezing.
7. Induced breeding in bivalves and sea urchin.
8. Live feed organisms: animal & plant live feed.
9. Quantification of protein in *Spirulina* dry biomass.
10. Extraction of lipid from micro algae dry biomass.
11. Quantification and characterization of lipid by GCMS.

Paper 4.2: Genetic Engineering

Basic concepts: Restriction enzymes, DNA ligases, Klenow fragment, T4 DNA polymerase, cohesive & blunt ends ligation, autoradiography, Radio-active and non-radioactive probes, hybridization techniques (Southern, Northern, Western and colony hybridization).

DNA finger printing and DNA foot printing, Methyl interference assay, transposons.

Cloning vectors: Plasmids, bacteriophages- Lambda, M 13, cosmids, Yeast vectors, shuttle vectors.

Cloning methodologies: Insertion of foreign DNA into the host cells, Transfection techniques. Construction of Genomic and C-DNA libraries, Jumping and hopping libraries. Southwestern and farwestern cloning. Analysis of cloned genes.

PCR and its applications: Basic principles of PCR; types of PCR- Multiple, Nested, reverse transcriptase, real time, touchdown, hot start, colony.

Loop Mediated Isothermal Amplification (LAMP) Site specific mutagenesis, PCR based mutagenesis.

Sequencing and Gene-therapy methods: DNA sequencing- chemical, Enzymatic, automated. RNA sequencing. Next Generation Sequencing, CRISPER technology.

Gene silencing techniques- Si RNA, Si RNA technology, Micro RNA, Construction of RNA vectors. Gene Knock-outs and gene therapy- suicide gene therapy, gene replacement and gene targeting.

Bioinformatics: History, definition, scope and applications, Data base: mining tools; database searching, similarity search, FASTA, BLAST.

Information networks: Gene bank sequence database, EBI-net; NCBI, Genome net, Protein database.

Phylogenetic analysis; Comparative genome analysis; Microarray analysis.

References:

RW Old & SB Primrose Principles of Gene manipulation Blackwell

H Lodish et al Molecular cell biology Scientific American

RF Weaver & PW Hedrick Genetics WCB

S. Mitra Genetic Engineering

J Sambroo & DW Russel Molecular cloning- Lab manual Vol. 1-3

Practicals:

1. Quantitative isolation of DNA
2. PCR and Agarose Gel Electrophoresis
3. Restriction digestion, Ligation
4. Primer Designing
5. Generating Fasta Sequence from an Autoradiogram
6. Usage of various bioinformatic tools, software packages, web portals
7. Pair-wise Alignment (FASTA/BLAST)
8. Multiple Sequence Alignment (Clustal W)
9. Phylogenetic Tree Construction and Phylogenetic Analysis
10. Protein Structure Prediction
11. Amplification of viral/bacterial DNA

Paper 4.3: Bioactive Marine Natural products

Introduction: Significance of marine natural products.

Principle and applications of colorimeter, UV visible spectrophotometer, Fluorescence Spectrophotometer, Flame photometer; Atomic absorption spectrophotometer, Inductively Coupled plasma Spectrophotometer (ICP) in quantification of compounds.

Isolation techniques: Liquid - liquid extraction, membrane separation methods, chromatography techniques- Paper, Thin layer, Gas and liquid chromatography, HPLC, Ion-Exchange chromatography.

Characterization techniques: IR, UV, NMR, Mass Spectroscopy.

Types of important products: Antibiotic, anti-tumour, tumour-promotor, anti-inflammatory, analgesic, cytotoxic, anti-viral, anti-fouling compounds of marine origin.

Marine toxins: Saxitoxin, brevetoxin and ciguatoxin

Marine peptides & alkaloids: pyridoacridine, pyrrolocridine indole, pyrrole, isoquinoline, alkaloids.

Basic principles of pharmacology: Classification and action of antibiotics and other antimicrobials.

Green fluorescent protein from jelly fish and its applications.

Principles of drug activity, pharmacokinetics, absorption, distribution, biotransformation and excretion of drugs.

References:

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|----------------------------|-----------------------------------|----------------------|
| David HA et al | Marine Biotechnology | Plenum |
| Scheur PJ | Marine Natural Products | Academic |
| DS Bhakuni DS Rawat | Bioactive marine natural products | Springer& Anamaya |

Practicals:

1. Separation of amino acids by paper chromatography
2. Identification of amino acids by paper chromatography
3. Preparation of crude extract by methanol: hexane solvent from molluscs, sponges, mangrove plants
4. Separation of crude extract fractions by column chromatography
5. Separation of fractions/compounds by TLC
6. Testing of Anti-bacterial activity by crude extract
7. Bioautography testing