

**MAHATMA GANDHI UNIVERSITY
PRIYADARSHINI HILLS, KOTTAYAM – 686560**



**RESTRUCTURED CURRICULUM FOR POST GRADUATE
PROGRAMME**

IN

M.Sc. APPLIED FISHERIES AND AQUACULTURE

(Effective from 2019 Admission onwards)

M.Sc. Applied Fisheries and Aquaculture

Scope of the Programme

The program is designed as a four semester, two year programme under the Credit and Semester System. The programme will cater to the higher study opportunity for under graduate programmes in the related fields, in this university and other universities within the country and abroad. The fishing industry is in need of highly skilled man power and this programme will create the necessary skill sets among the aspiring students. The general skill sets attained will relate to Biology, Capture, Culture and Management of fisheries. The focus areas of this programme are Aquaculture Technology, Fisheries Business Management, Fish Capture Technology and Fish Processing Technology. Semester I covers such aspects as Taxonomy of fishes, Biochemistry, Biophysics and Research Methodology and Biostatistics and Computer Applications. The practical paper includes topics from all the four theory papers. In Semester II, the topics covered are Ecology of Aquatic Ecosystems and Inland Aquaculture, Ornamental Fisheries, Genetics and Biotechnology and Health Management in Aquaculture. Only one practical paper is assigned for this semester covering the experimental aspects of inland aquaculture, ornamental fisheries and health management. In Semester III, three theory courses are offered including Mariculture, Fish Nutrition and Microbiology & Quality Management. Two practical papers are offered in this semester. The first practical is on Aquaculture and Fish Nutrition while the second practical is on Fishery Microbiology and Quality Control. In addition the students have to undergo training in a reputed hatchery to understand the nuances of breeding and rearing of aquarium fishes and food fishes. This training will enable the entrepreneurship skills of the students. The specialization papers in Semester IV include one theory paper in Post Harvest Technology and one practical paper in Fish Processing Technology. They also have to select the elective papers in the allotted subjects as mentioned in the syllabus as an essential requirement of the course. In addition, the students have to undergo On Job Training in a recognized institution offering such training or in reputed fish processing plants. This is to acquire the necessary skill sets expected by the industry. The students also have to complete and submit M.Sc. Project Work Report. As an outcome on completion of the programme the students are acquiring skills for self entrepreneurship, for pursuing a career in the industry as well as government jobs or for pursuing research.

M.Sc. Applied Fisheries and Aquaculture - Abstract of Programme

	Code	Course	Hours/ Week	Total Hours	Credit
SEMESTER- I	AQ010101	Systematics and Taxonomy of Cultivable Aquatic Organisms	5	90	4
	AQ010102	Biochemistry	5	90	4
	AQ010103	Biophysics, Instrumentation and Research Methodology	5	90	4
	AQ010104	Biostatistics and Computer Application	5	90	4
	AQ010105	Taxonomy, Biochemistry, Biophysics, Biostatistics and Computer Applications	5	90	3
		TOTAL	25	450	19
SEMESTER- II	AQ010201	Ecology of Aquatic Systems and Inland Aquaculture	5	90	4
	AQ010202	Ornamental Fisheries	5	90	4
	AQ010203	Genetics and Biotechnology in Aquaculture	5	90	4
	AQ010204	Health Management in Aquaculture	5	90	4
	AQ010205	Inland Aquaculture, Ornamental Fisheries and Fish Health Management	5	90	3
		TOTAL	25	450	19
SEMESTER- III	AQ010301	Mariculture	5	90	4
	AQ010302	Fish Nutrition	5	90	4
	AQ010303	Microbiology and Quality Management	5	90	4
	AQ010304	Aquaculture and Fish Nutrition	5	90	3
	AQ010305	Fishery Microbiology and Quality Control	5	90	3
	AQ010306	Hatchery Training*		-	2
		TOTAL	25	450	20
SEMESTER- IV	AQ010401	Post Harvest Technology	5	90	4
	AQ010402	Fish Processing Technology	5	90	3
	ELECTIVES	GROUP A / GROUP B	5	72	3
	ELECTIVES	GROUP A / GROUP B	5	72	3
	ELECTIVES	GROUP A / GROUP B	5	72	3
	AQ010404	Project**	-	-	2
	AQ010405	Viva Voce***	-	-	2
	AQ010406	On Job Training ****	-	-	2
		TOTAL (Including Electives)	25	396	22
Grand Total					80

	Groups	Code	Course	Hours/Week	Total Hours	Credit
ELECTIVES (Credit 3*3=9)	GROUP A	AQ800401	Fisheries Business Management	5	72	3
		AQ800402	Fish Capture Technology & Management	5	72	3
		AQ800403	Fish Immunology	5	72	3
	GROUP B	AQ810401	Seed Production and Hatchery Management of Finfishes	5	72	3
		AQ810402	Soil and Water Quality Management in Aquaculture	5	72	3
		AQ810403	Seed Production and Hatchery Management of Shellfishes	5	72	3

*Training on freshwater fish/Ornamental fish/shrimp hatchery extending a period not less than a week may be attended and a certified report may be submitted.

** Project may be undertaken either under the faculty of the Department or under an external faculty in collaborative guidance approved by the Department. Review works may be avoided. A paper published by the candidate as the first author in a peer reviewed national/international journal can be considered as equivalent to dissertation. Each student is expected to make a final power point presentation of their project work as part of the internal evaluation.

***A comprehensive Viva Voce covering the entire topics in the Programme

****A training for not less than TWO WEEKS and not more than 30 days must be attended in a reputed fish processing plant or a government /research institution and a certified report along with attendance certificate may be produced

SEMESTER I

SEMESTER-I	AQ010101	Systematics and Taxonomy of Cultivable Aquatic Organisms
	AQ010102	Biochemistry
	AQ010103	Biophysics, Instrumentation and Research Methodology
	AQ010104	Biostatistics and Computer Application
	AQ010105	Taxonomy, Biochemistry, Biophysics, Biostatistics and Computer Applications

AQ010101- SYSTEMATICS AND TAXONOMY OF CULTURABLE AQUATIC ORGANISMS

Credit: 4

90Hrs

MODULE 1 BIOSYSTEMATICS

30Hrs

1.1 Biological Classification

7hrs

Hierarchy of categories and higher taxa. Taxonomic Procedures-collection, preservation. Taxonomic characters of different kinds- quantitative and qualitative analysis of variation, Process of typification, different zoological types and their significance.

1.2 Methods of Biosystematics

10hrs

Classical and modern methods-Typological, Phenetics, Evolutionary, Phylogentic, Cladistics and Molecular Taxonomy. Phylocode, Tree of Life and Bar-coding of Life.

1.3 Taxonomic Publications

7hrs

Keys, types, use of keys, merits and demerits. International Code of Zoological Nomenclature (ICZN), Rules and formation of Scientific names of different taxa. Homonymy and Synonymy.

1.4 Concepts and Techniques in Systematics

6hrs

Concept of species- taxonomic diversity within species. Molecular Phylogeny-use of Proteins, DNA and RNA. Phylogenetic trees.

MODULE 2 TAXONOMY OF CULTIVABLE FISHES

30Hrs

2.1 Introduction

10hrs

Position of fishes in the Phylum-Chordata. Various trends in the classification of fishes.

2.2 Classification

10hrs

Major approaches to classification as discussed by Nelson (1994). General characters, evolution and classification of Fishes

2.3 Taxonomic features

10hrs

Study of external morphology of typical placoderms, elasmobranchs and teleosts.

MODULE 3 TAXONOMY OF CRUSTACEA

15Hrs

3.1 Classification

5hrs

Classification of major crustaceans up to Order.

3.2 Taxonomic features

10hrs

External characters of *P. monodon*, *Scylla serrata* and *Panilurus homarus*

MODULE 4 TAXONOMY OF MOLLUSCA

10Hrs

4.1 Classification

3hrs

Classification of phylum mollusca upto orders.

4.2 Taxonomic features

7hrs

External characters of Mussel, Oyster, Clam, Gastropods and Cephalopods.

MODULE 5 TAXONOMY OF ECHINODERMATA

5Hrs

5.1 Classification

5hrs

Classification of Phylum Echinodermata upto classes.

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AQ010102 BIOCHEMISTRY**Credit: 4****90Hrs****Module 1 Introduction****2 hrs**

Atoms, molecules and chemical bonds. Water: biological importance, pH and acid - base balance. Buffers - biological importance.

Module 2 Carbohydrates**10 hrs**

2.1 Monosaccharides: Classification and nomenclature; Biological importance; Structural representations of sugars-Acetal and hemiacetal, ketal and hemiketal linkages; Glucose, fructose, galactose, mannose and ribose. Isomerism – structural isomerism and stereoisomerism, optical isomerism, epimerism and anomerism. Mutarotation and inversion of sugars. Reactions of monosaccharides: Oxidation, reduction, ester formation, osazone formation. Glycosidic bond.

2.2 Disaccharides: Sucrose, Lactose, Maltose, Isomaltose, Cellobiose and Trehalose.

2.3 Polysaccharides: Homopolysaccharides- Starch, Glycogen, Cellulose, Chitin, Dextran, Inulin, Pectin. Heteropolysaccharides- Hyaluronic acid, Heparin, Chondroitin sulphate, Keratan sulphate, Dermatan sulphate and Agar-agar. Glycoproteins and Mucoproteins.

Module 3 Proteins**10 hrs**

3.1 Structure, classification and properties of amino acids: Amphoteric properties of amino acids, pK value and iso-electric point of amino acids. Peptide bond formation and peptides. Reactions (due to carboxyl group, amino group and side chains). Colour reactions of amino acids and proteins.

3.2 Structure, Classification and Properties of Proteins: Primary structure of protein (*e.g.* insulin). Classification and properties of proteins. Conformation of proteins- chemical bonds involved, Secondary structure- Alpha helix, Collagen helix, Beta pleated sheet, Ramachandran angles and Ramachandran map. Fibrous proteins- examples (Keratin, Collagen, Elastin, Resilin, Fibrous muscle proteins). Chaperons. Tertiary structure- *e.g.* Myoglobin. Quaternary structure – *e.g.* Haemoglobin.

Module 4 Lipids**10 hrs**

4.1 Classification of lipids: simple, compound and derived lipids. Biological importance of lipids. Fatty acids: classification, nomenclature.

4.2 Simple fats: Triacylglycerol (Triglycerides) - Physical properties. Reactions-Hydrolysis, Saponification, Rancidity. Acid number, Saponification number, Iodine number, Polenske number and Reichert- Meissl number of lipids. Waxes.

4.3 Compound lipids: Phospholipids- Lecithin, Phosphatidyl inositol, Cephalins, Plasmalogens. Glycolipids, Sphingolipids. Derived Lipids, Steroids: Biologically important steroids-cholesterol, Vitamin D, Bile acids, Ergosterol, Terpenes, Lipoproteins. Prostaglandins- structure, types, synthesis and functions.

Module 5 Nucleic Acids**10 hrs**

5.1 Structure of nucleic acids and nucleotides: Structural organization of DNA (Watson –Crick model) Characteristic features of A, B, C and Z DNA. Structural organization of tRNA; Protein-nucleic acid interaction. DNA regulatory proteins, folding motifs, conformation flexibilities, denaturation, renaturation, DNA polymerases, Restriction endonucleases.

5.2 Biological roles of nucleotides and nucleic acids.

Module 6 Enzymes**10 hrs**

6.1 Classification- (I.U.B.system), co-enzymes, iso-enzymes, ribozyme. Enzyme specificity. Mode of action of enzymes. Formation of enzyme substrate complex. Lowering of activation energy, Various theories, Active site.

6.2 Enzyme kinetics: Michaelis-Menten equation. Km value and its significance. Enzyme velocity and factors influencing enzyme velocity. Kinetics of enzyme inhibition, suicide inhibition and feedback inhibition.

6.3 Enzyme regulation: Allosteric regulations- Key enzymes, Covalent modification. Enzyme engineering.

Module 7 Carbohydrate Metabolism**12 hrs**

7.1 Major metabolic pathways - Glycolysis – Fate of pyruvate. Citric acid cycle and its significance; Central role of citric acid cycle. Oxidative and substrate level phosphorylation. Gluconeogenesis, Cori cycle.

7.2 Glycogen metabolism - Glycogenesis, Glycogenolysis, Adenylate cascade system, Ca⁺² Calmodulin-sensitive phosphorylase kinase. Regulation of glycogen synthesis .

7.3 Minor metabolic pathways of carbohydrates: Pentose Phosphate pathway, Glucuronic acid metabolism. Galactose metabolism. Inborn errors associated with carbohydrate metabolism. Glycogen storage diseases, Lactose intolerance, Galactosuria.

Module 8 Metabolism of Proteins**10 hrs**

Amino acid metabolism-Deamination, Transamination and Trans-deamination. Formation and disposal of ammonia. Urea cycle. Fate of carbon skeletons of aminoacids: glucogenic, ketogenic, partly glucogenic and ketogenic with examples. Synthesis of biologically significant compounds from different aminoacids with special reference to glycine, glutamic acid, phenylalanine, tyrosine and tryptophan.

Module 9 Metabolism of Lipids**8 hrs**

Beta oxidation, alpha oxidation and omega oxidation of fatty acids. *De novo* synthesis of fatty acids. Metabolism of cholesterol, synthesis and its regulation. Biosynthesis of triglycerides. Metabolism of ketone bodies - Ketogenesis, Ketolysis, Ketosis.

Module 10 Nucleic Acid and Mineral Metabolism**8hrs**

10.1 Catabolism of purines and pyrimidines.

10.2 Major and minor nutrients : Role of Calcium, Phosphorus, Magnesium, Sodium, Potassium, Chloride, Sulphur and Iron.

10.3 Free radicals and antioxidants : Generation of free radicals. Reactive oxygen species. Free radical scavenger systems. Lipid peroxidation. Preventive antioxidants.

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AQ010103 BIOPHYSICS, INSTRUMENTATION AND RESEARCH METHODOLOGY**Credit: 4****90Hrs****BIOPHYSICS****30Hrs****Module 1 Diffusion and Osmosis****10 Hours**

1.1 Diffusion

- 1.1.1 Kinetics of diffusion
- 1.1.2 Concentration gradient and Fick's law
- 1.1.3 Diffusion coefficient
- 1.1.4 Stokes-Einstein equation
- 1.1.5 Electrical gradient
- 1.1.6 Pressure gradient and Graham's law
- 1.1.7 Gibbs-Donnan equilibrium
- 1.1.8 Facilitated diffusion

1.2 Osmosis

- 1.2.1 Vant Hoff Laws
- 1.2.2 Osmotic concentration and Osmotic pressure
- 1.2.3 Biological significance of osmosis in fishes

Module 2 Bioenergetics**12 Hours**

2.1 Thermodynamics

2.1.1 Laws of thermodynamics, Entropy, Enthalpy, Free energy, Reversible thermodynamics, irreversible thermodynamics, isolated, closed and open systems.

2.2 Photo Bioenergetics

2.2.1 Photosynthesis, photosynthetic reaction – light reaction and dark reaction – Redox potential.

2.3 Chemo-bioenergetics (oxidative phosphorylation); Electron transport system redox couples – redox potential – chemiosmotic theory – ATP synthesis.

Module 3 Radiation Biophysics**8Hours**

3.1 Ionizing radiations, interaction of radiation with matter. Detection and measurement of radiation (Dosimetry).

3.2 Application of radioactive tracers. Biological effects of radiation. Radiation protection and therapy.

3.3 GM counter, liquid scintillation counter.

INSTRUMENTATION**45 Hrs****Module 4 Types of Microscopic Preparations****5 Hrs**

4.1 Fixation, preparation of temporary and permanent slides, whole mounts, smears, squashes and sections. Specimen preparations for TEM and SEM, shadow casting, freeze fracturing, freeze etching, negative staining.

Module 5 Cytochemical Methods**3 Hrs**

5.1 Cytochemistry of nucleic acids, detection of carbohydrates, lipids and proteins.

Module 6 Museum Preparations **4 Hrs**

6.1 Preservation of animals, alizarin preparation, stuffing skeletal preparations.

Module 7 Microscopy: Principle, Instrumentation and Application **10 Hrs**

7.1 Light microscope, camera lucida, micrometry

7.2 Dark field microscope

7.3 Phase contrast microscope

7.4 Fluorescence microscope

7.5 Electron microscope (TEM and SEM)

7.6 Photomicrography

7.7 Autoradiography

Module 8 Chromatography: General Principles and Techniques **7 Hrs**

8.1 Column chromatography

8.2 Paper chromatography

8.3 Thin layer chromatography

8.4 Gas chromatography and GLC

8.5 Ion exchange chromatography

8.6 Gel filtration

8.7 HPLC

8.8 Affinity chromatography

Module 9 Electrophoresis **5 Hrs**

9.1 Paper electrophoresis

9.2 Gel electrophoresis

9.3 Polyacrylamide gel electrophoresis (SDS)

9.4 High voltage electrophoresis

9.5 Immuno-electrophoresis

Module 10 Spectroscopy, AAS **2 Hrs**

Module 11 NMR, RIA, ELIZA **3 Hrs**

Module 12 Flame photometry **1 Hr**

Module 13 Colorimetry and Spectrophotometry **2 Hrs**

Module 14 Centrifugation **2 Hrs**

14.1 Types of centrifuges

14.2 Differential and density gradient centrifugation

Module 15 pH Meter **1 Hr**

RESEARCH METHODOLOGY **15 Hrs**

Module 16 Introduction **5 Hrs**

Meaning and importance of research, Types of research-selection and formulation of research problem. Research design-need-features, different research designs, concepts relating to research

design. Analysis of literature review, primary and secondary sources, web sourcescritical literature reviews.

Module 17 Data Collection and Analysis

3 Hrs

Collection of primary and secondary data, selection of appropriate methods of data collection, data preparation, important steps, types of analysis.

Module 18 Interpretation and Report Writing

7 Hrs

Meaning of interpretation, techniques of interpretation and precautions in interpretation. Significance of report writing, different steps in report writing. Types of reports; technical and popular. Lay out of research reports, preliminary pages, main text, and end matter. Reproduction of published materials-plagiarism-citation and acknowledgement, reproducibility and accountability.

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AQ010104 BIostatistics AND COMPUTER APPLICATION**Credit: 4****90Hrs****BIostatistics****40 Hrs****Module 1 Basics of Biostatistics****6 hrs**

Steps in Statistical Investigation, Data and Variable (Collection , Types , Sources).

Population, Sample, Sampling Methods (Random, Cluster, Stratified and Geographical) and Sampling Errors/Bias.

Organization of Data - Editing, Classification, Tabulation (forming a frequency distribution from raw data, types and characteristics of a Frequency Table).

Presentation of Data - types and characteristics of Tables and Visual aids – Graphs, Charts, Diagrams, Flow charts, Cartographs.

Statistical Analysis Tools-Parametric and Non-Parametric; Bivariate and Multivariate Analysis. Interpretation and Forecasting.

Module 2 Measures of Central Tendency**4hrs**

Introduction, Characteristics, Merits and Demerits of Mean, Median and Mode.

Calculations/Problems for different data (raw, frequency table).

Harmonic and Geometric Mean (Brief account only).

Module 3 Measures of Dispersion**5 hrs**

Introduction, Characteristics, Merits and Demerits of Range, Quartile Deviation,

Mean Deviation and Standard Deviation. Calculations/Problems for frequency table.

Standard Error and Relative Measures of Dispersion, Skewness and Kurtosis- (Brief account only).

Module 4 Correlation Analysis**3 hrs**

Correlation -types and methods of correlation analysis, Problems for Karl Pearson's correlation coefficient and Spearman's rank correlation.

Module 5 Regression Analysis**7 hrs**

Regression and Line of Best Fit, Types and methods of regression analysis.

Graphical Method (Scatter method, Curve fitting). Algebraic method (Fitting of straight line through regression equation).

Probit Analysis (Brief account only), Mathematical Models in Biology (Brief account only). Length - Weight Relationship. Von- Bertalanffy's Growth (VBG) Model.

Module 6 Theory of Probability.**4 hrs**

Measures of Probability and Theorems in Probability. Probability distributions – Binomial, Poisson and Normal (Brief Account only).

Module 7 Testing of Hypothesis**7 hrs**

Hypothesis and types, Confidence Interval, Sampling, Methods and Errors. Tests of significance (For large and small samples – Critical Ratio and P value). Z Test (Problem for small samples), Chi- Square Test (Problem for 2x2 table only). Student's 't' test (Problem for small samples comparing mean of two

variable). F-test and Analysis of Variance (ANOVA - One way) (Brief account only). Non-parametric tests: Mc Nemar and Mann Whitney U test (Brief account only).

Module 8 Computerised Information systems & Fisheries

4 hrs

Remote sensing applications, Global Positioning systems, GIS and Fisheries, Statistical data analysis packages.

COMPUTER APPLICATIONS

50 Hours

Module 9 Basics of Computers

6 hrs

Types of Computers. Binary Number System, Digital and Analog systems.

Hardware/Software/Firmware. Basics of Computer Functioning- Booting; Formatting; File, File Extensions; Temporary Files; Folder; GUI, Icon; Installation of Programs, Commands, Bios-setup, Date and Time, Memory Partitions, Registry, Default Operations; Defragmentation (Brief account only).

Module 10 Hardware Basics

7 hrs

Memory -Classification and Types of memory; memory devices; Units.

Input Devices -Types, working and functions. Output Devices –Types, working and functions. CPU components - Processors, Mother boards, SMPS, Accessory Cards – Graphic /Sound/ Networking/Bluetooth/Wifi (Brief account only).

New Generation Computers - Servers, Laptop; Palmtop; Cyborgs; Robotics, Zoobotics (Brief account only).

Module 11 Software Basics

12 hrs

System Software/Operating System -System Files; Working of OS; DOS, Windows, Linux and UNIX (Brief account only).

Application Software -Programs and Packages, Calculator, MS Paint, MS Word, MS Excel, MS PowerPoint, Publisher, Acrobat Reader, E Book Reader, Explorer, Photoshop.

Virus and Antivirus (Brief account only).

Statistical Software (MS Excel, PH Stat, SPSS, R).

Databases -MS Access (Brief account only).

Module 12 Computer Language and Programming

7 hrs

Computer language -Classification and types, HTML, C and Java

Programming concepts -Algorithm, Codes (Brief account only).

Module 13 Networking, Internet and Information Technology

8hrs

Computer Communication -Network Topology, Media of networking, Networking Protocols, PAN, LAN, WAN, MAN, INFLIBNET, Modem and Gateway.

Internet and Internet Services -World Wide Web, Uploading, Downloading, Hosting, Portal, Search Engines, Firewall.

Global Information System -BIOSIS, Medline and Medlars, AGRIS; E Journals and E Books Publishing. Cyber Crime and Cyber Laws (Brief account only).

Module 14 Computerised information systems in Fisheries

5hrs

Remote sensing applications, GPS, Statistical data analysis packages, Aquaculture soft wares.

Module 15 Bioinformatics**5 Hrs**

Introduction to bioinformatics: history, definition, scope and applications; Fields related to bioinformatics. Data base: mining tools, submission of DNA sequences; Sequence alignment and database searching, similarity search, FASTA, BLAST.

REFERENCES

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- Pradeep Sinha and Priti Sinha.2010.*Computer Fundamentals*. BPB Publications., New Delhi
- Rajathi A. and P. Chandran, 2010. *SPSS for You*. MJP Publishers, Chennai.
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- Zar, Jerrold H. 2008 (3rd edn.). *Biostatistical Analysis*. Pearson Education Inc., Delhi.

AQ010105 -TAXONOMY, BIOCHEMISTRY, BIOPHYSICS, FISHERIES STATISTICS & COMPUTER APPLICATIONS

1. Identification of commercially important species of fishes, crustaceans and mollusks.
i) 25 species from 12 families of fishes ii) Crustacea and Mollusca – 5 each
 2. Identification of fishes up to species level using dichotomous key
 3. Identification of eggs, larvae and post larvae of commercially important species of fishes, crustaceans and mollusks.
 4. Identification of fish bones and study of skeletal system in fishes, a minimum of one cartilaginous fish and one bony fish.
 5. Analysis of physico-chemical parameters of seawater, freshwater and brackish water.
 6. Estimation of glucose, protein, total lipid, cholesterol in serum/tissue
 7. Estimation of acid phosphatase, alkaline phosphatase in blood, serum/tissue
 8. Chromatography (paper/TLC) for the separation and identification of amino acids
 9. Polyacrylamide gel electrophoresis/paper electrophoresis for the separation of proteins
- Micrometry
10. Phase contrast microscope, camera lucida, micro-photographic equipment
 11. Preparation of permanent whole mounts
 12. Preparation of double stained serial sections to study histological details (intestine/liver/gill).
 13. Bio-statistics - problems (Measure of Dispersion, Correlation, Graphs and Diagrams, Problems in Tests of Significance- χ^2 , t, z.
 14. Computer application: Analysis of data, graphical representation and interpretation. Experience for students to solve simple statistical problems like Chi-square, t-test and to represent data in tables and graphics.

Semester II

SEMESTER- II	AQ010201	Ecology of Aquatic Systems and Inland Aquaculture
	AQ010202	Ornamental Fisheries
	AQ010203	Genetics and Biotechnology in Aquaculture
	AQ010204	Health Management in Aquaculture
	AQ010205	Inland Aquaculture, Ornamental Fisheries and Fish Health Management

AQ010201 - ECOLOGY OF AQUATIC SYSTEMS & INLAND AQUACULTURE

Credit: 4

90Hrs

Module 1 Ecology of Aquatic Systems

10Hrs

Physical and chemical characteristics of water: Role of physical parameters like depth, temperature, salinity, light, turbidity, and wind in ponds. Circulation and mixing patterns in ponds. Physical characteristics in relation to open sea farming. Effect of monsoon on pond physical conditions. Seasonal and diurnal variation in pond. Chemical characteristics with reference to carbon dioxide, dissolved oxygen distribution.

Module 2 Selection of Sites for Aquaculture

2 Hrs

- 2.1 Land-based farms
- 2.2 Open-water farms.

Module 3 Selection of species for Culture

6 Hrs

- 3.1 Biological characteristics of aquaculture species
- 3.2 Economic and market considerations
- 3.3 Exotic species
- 3.4 Common aquaculture species of commercial importance

Module 4 Culture systems development and Management

20 Hrs

- 4.1 Freshwater and brackish water aquaculture systems
- 4.2 Present status and potential for freshwater and brackish water aquaculture in India
- 4.3 Natural collection of seed- Carp, Mullet, Milk fish, Pearl spot, Tiger prawn
- 4.4 Pond preparation – Drying, liming and water intake
- 4.5 Natural food production by fertilization – organic and inorganic fertilizers
- 4.6 Principles of stocking: composition and proportion
- 4.7 Supplementary feeding
- 4.8 Sampling for growth estimation and stock assessment
- 4.9 Monitoring food availability – assessing phytoplankton production, Zooplankton qualitative and quantitative estimation
- 4.10 Monitoring health of stock
- 4.11 Disease management
- 4.12 Water quality management
- 4.13 Rate and time of water exchange
- 4.14 Harvest time and methods of harvest
- 4.15 Assessment of production rate
- 4.16 Acclimatization and transportation of live fish and fish seed
- 4.17 Organic aquaculture

4.18 Responsible Fisheries and aquaculture

Module 5 Control of weeds, pests and Predators**5 Hrs**

5.1 Common aquatic weeds

5.2 Methods of weed control and its impact on the ecosystem.

5.3 Control of predators, weed animals and pests

Module 6 Other Culture methods/systems**20 Hrs**

6.1 Monoculture

6.2 Polyculture

6.3 Integrated farming

6.4 Cage culture

6.5 Pen culture

6.6 Raft culture

6.7 Extensive culture

6.8 Semi-intensive culture

6.9 Intensive culture

6.10 Race way culture

6.11 Culture in recirculatory systems

6.12 Warm water and cold water aquaculture

6.13 Sewage fed fish culture

6.14 Recent advances – Aquaponics; Recirculatory Aquaculture Systems; Biofloc Technology in Aquaculture.

Module 7 Fin fish culture**10 Hrs**

7.1 Operational details of monoculture and polyculture of fishes.

7.2 Existing freshwater finfish culture operations

Module 8 Crustacean culture**7 Hrs**

8.1 Major species used in culture

8.2 Problems in crustacean culture

Module 9 Molluscan culture**10 Hrs**

9.1 Important freshwater mussels for the production of pearls

9.2 Edible Molluscan species and their culture

REFERENCES

1. Beveridge, M.C.M. (1987) Cage aquaculture. Fishing News
2. Davy E.B. and M.Graham Eds (1982) Bivalve culture in Asia and Pacific. IDRC Asia Regional Office Syngapore.
3. Milne.P.H (1972) Fish and shell fish farming in China. Fishing News
4. Bardach, J.E.W (1972) Aquaculture farming and husbandry of freshwater and marine organisms
5. Galtsoff, P.S., Culture methods for invertebrate animals
6. Thomas P.C (Ed) Current and emerging trends in aquaculture
7. Coche, A.G., Muir, J.F. Simple methods for aquaculture: Pond construction for freshwater
8. Introduction to aquaculture Pillai, T.V.R., Aquaculture principles and practices
9. Jonathan Shepherd, C. (Ed) Intensive Fish Farming
10. William Royce, F., An introduction to the practice of fishery science.
11. Planning of Aquaculture Development. FAO, Fishing News Books

12. Advances in Aquaculture. FAO, Fishing News Books.
13. Pullin, R.S.V. and Chehadeh, Z.H. (Eds.). Integrated Agriculture-Aquaculture Farming Systems. ICLARM.
14. Aquaculture Systems and Practices – A Selected Review. UNDP, FAO
15. Sea Farming and Sea Ranching in China. FAO Fisheries Technical Paper 418
16. Fishery Science – 2002- L.A. Fuiman and R.G. Werner. Blackwell Science
17. Dynamics of pond aquaculture – 1999- H.S. Eгна and C.E. Boyd- CRC Press
18. Water quality sampling and analysis. 2000. - Abbasi, S.A.
19. Stock assessment of inland fisheries – 2002- Cowx, I.G
20. Feed management in intensive aquaculture – 2000- Goddard, S
21. Aquaculture, Fish and shellfish farming – 2002- Southgate, P.C

AQ010202 ORNAMENTAL FISHERIES**Credit: 4** **90Hrs****CONSTRUCTION AND MAINTENANCE OF AQUARIUM****45 Hrs****Module I Construction of home/public aquarium****20 Hrs**

- 1.1 Materials used - wooden and metal frames, frameless tanks.
- 1.2 Sealants and gums.
- 1.3 Aerators and filters.
- 1.4 Handnets and other equipments.
- 1.5 Water quality requirements.
- 1.6 Temperature control.
- 1.7 Design and construction of public freshwater and marine aquaria.

Module 2 Setting up of aquarium**5 Hrs**

- 2.1 Gravel/pebbles and other materials
- 2.2 Aquarium plants
- 2.3 Ornamental objects and fishes
- 2.4 Selection of species.

Module 3 Nutritional requirements of aquarium fishes**10 Hrs**

- 3.1 Different kinds of feeds.
- 3.2 Culture of food organisms.
- 3.3 Preparation of dry feeds.
- 3.4 Feeding methods.

Module 4 Aquarium Management**10 Hrs**

- 4.1 Cleaning the aquarium
- 4.2 Maintenance of water quality.
- 4.3 Control of snail and algal growth.
- 4.4 Common diseases of aquarium fishes; diagnosis and treatment.

AQUARIUM FISHES AND PLANTS**45 HOURS****Module 5 Species of ornamental fishes, their taxonomy and biology****25 Hrs**

- 5.1 Freshwater species - live bearers and egg layers.
- 5.2 Maturation
- 5.3 Secondary sexual characters
- 5.4 Breeding habits
- 5.5 Spawning
- 5.6 Parental care
- 5.7 Fertilization and development of eggs.
- 5.8 Hatching, larval rearing and their health.
- 5.9 Larval feeds and feeding.
- 5.10 Induced breeding and production of monosex fish.
- 5.11 Use of pigments for colour enhancement.

Module 6 Marine ornamental fishes**10 Hrs**

- 6.1 Habitat and collection from nature.
- 6.2 Methods of collection.
- 6.3 Transportation of live fish.
- 6.4 Use of sedatives.
- 6.5 Other ornamental organisms - anemones, lobsters, shrimps, octopus, starfish etc.

Module 7 Freshwater Plants

10Hrs

- 7.1 Taxonomy and morphology.
- 7.2 Multiplication of aquarium plants. - different methods.
- 7.3 Provision of nutrients and optimum environmental conditions for their growth.

REFERENCES

1. Scott, P.W. The complete aquarium.
2. Bailey Mary, Sandford Gina Caring for your aquarium.
3. Janze, A.O. Aquarium techniques II Fishes and plants.
4. Dick Mills, You and Your Aquarium.
5. Brymer, J.M.P., A Guide to Tropical Fish Keeping.
6. Hawlins, A.D. (Ed). Aquarium Systems. Academic Press.
7. Hunnam, P. Ward Lock, Living Aquarium.
8. Ratjak, K. and Zukal, R., Aquarium Fishes and Plants.
9. Spotte and John Wiley, S., Seawater Aquariums.
10. Straughan, R.P.L. and Thomas Yoseloff. Salt water Aquarium in the Home.
11. Dick Mills, 1987. Illustrated Guide to Aquarium Fishes. Published by Galley and Price, an imprint of W.H. Smith and Sons Limited, England.
12. Stephen Spotte. Marine Aquarium Keeping. A Wiley-Interscience Publication.
13. Dick Mills and Gwynne Vevere. Tropical Aquarium Fishes. Published by Salamander Books Limited. London.
14. Carcacson, R.H. A field guide to the Coral Reef Fishes of the Indian and West Pacific Oceans.
15. Vincent B. Hargreaves. The Tropical Marine Aquarium. Mc-Graw-Hill Book Company. New York.
16. Guy N. Smith. Profitable Fish Keeping.
17. Maurice Melzak. Marine Aquarium Manual. B.T. Balsford Ltd., London.
18. Ornamental aquarium fishes of India- 1999- K.L.Tekrival and A.A. Rao.- TFH United Kingdom.
19. Marine Ornamental species (collection, culture and conservation) – J.C.Cato and C.L.Brown. Blackwell Science

AQ010203 GENETICS AND BIOTECHNOLOGY IN AQUACULTURE**Credit: 4****90Hrs****Module 1****8 Hours**

Introduction to Fish and Shellfish Genetics – Gynogenesis, Androgenesis, hybridogenesis, polyploidy, euploidy, interspecific hybridization, intraspecific crossbreeding, Monosex strains and their importance, sex reversal – mechanisms and applications; developmental biology in fishes and crustaceans; protrandrous, protogynous species and their importance; genotype environment interactions.

Module 2**10 Hours**

Endocrine and molecular control of genetics – enzymology of steroid production in fishes; cell types involved in sex steroid production; receptor mediated action of sex steroids; hormonal control of vitellogenesis; hormonal control of sexual maturation; neuroendocrine control of gonadal development

Module 3**20 Hours**

Genetic Engineering and Biotechnology in aquaculture- genetic improvement, selective breeding, domestication and strain evaluation; concept and techniques in the production of SPF, SPR and hi-health stocks in crustacean aquaculture; transgenics and GMO's in aquaculture- reporter genes, AFP, disease resistance genes, growth hormone gene and their regulation; gene transfer mechanisms, gene cloning.

Module 4**20 Hours**

Marker assisted selection, markers and their role in aquaculture biotechnology, DNA markers- RAPD, AFLP, RFLP, phenotypic markers, protein markers; microsatellite markers in fisheries research; linkage mapping; chromosomal engineering; gamete transfer mechanisms in crustaceans; artificial insemination and in-vitro fertilization in fishes and shellfishes; cryopreservation and its applications; biotechnological applications in pearl culture – genetic improvement, improvements in surgical techniques, biomineralization of nacre, tissue culture techniques

Module 5**12 Hours**

Biotechnology and Aquatic Animal health management – development and application of probiotics, prebiotics, bioremediators, immunostimulants, immunomodulators and vaccines – biofilm vaccines, DNA vaccines, recombinant vaccines; PCR in aquatic animal health management- designing primers for PCR, Hybridoma techniques; PAB's and MAB's in aquatic animal health management, Diagnostics and their application in aquaculture health management – immunodiagnostics, nucleic acid based diagnostics. General principles of cell and tissue culture, culture of primary cells secondary culture (subcultures) and cell lines, Fish cell culture development of cell lines and their applications.

Module 6**8 Hours**

Introduction to Genomics and Proteomics; Bioethics with regard to biotechnological interventions in aquaculture sector- biodiversity and environment related issues, consumer issues associated with GMO's, economic issues, political issues, research issues, patents in biological research, biopiracy, Intellectual Property Rights (IPR) and their significance in aquaculture and fisheries science, documentation for patenting .

Module 7**12 Hours**

Marine bioresources – bioactive compounds from the sea, marine natural products and metabolites- microbes, cyanobacteria and allied seaweeds, micro and macro algae, diatoms, echinoderms, bryozoans, soft corals, sponges.

REFERENCES

Marine Biotechnology (Vol 1, 2 and 3)- 1999 -Fingerman et al., Science Publishers Inc, USA.

Aquaculture and Biotechnology – 1999- Karunasagar et al., - Oxford and IBH, New Delhi

Fisheries Biotechnology – 2004 – Lakra et al., - Narendra Publishing House

Biotechnology and Genetics in Fisheries and Aquaculture -2003 – A.R. Beaumont and K. Hoare – Blackwell Science.

Fish in Research – Academic Press, London

Immunodetection methods in aquaculture.2001– Adams, A

Progress in reproductive endocrinology- 1999 – K.G. Adiyodi

Aquaculture and fisheries biotechnology, a genetic approach – 2003- R.A. Dunham

Aquaculture and Biotechnology – 2003- Karunasagar, I

Reproductive biotechnology in finfish aquaculture – 2002- Lee, C.S.

AQ010204 HEALTH MANAGEMENT IN AQUACULTURE**Credit: 4****90Hrs****Module 1****6 Hrs**

Relevance of aquatic animal disease with regard to aquaculture, types of diseases- bacterial, viral, protozoan, fungal, environmental, nutritional and miscellaneous. Water and soil quality management and diseases in aquaculture, Stress and its role in fish and shell fish diseases.

Module 2**8 Hrs**

Diseases in fin-fish culture- common diseases of fin-fishes; IHN, IPN, Spring Viraemia of Carps, VHS, Furunculosis, Lymphocystis, Bacterial Kidney Disease, EUS.

Module 3**16 Hrs**

Diseases of farmed crustaceans Shrimp Diseases- WSSV, IHNV, YHV, Taura Syndrome Virus, BMN, BP, MBV, LOPV, LOVV, GAV, RPS, HPV, Blue Shrimp Syndrome, Black Gill disease, Soft Shell syndrome, Black spot disease, Bacterial White Spot disease, Luminescent Bacterial Disease, diseases caused by Vorticella, Epistylis, and Zoothamnium, Microsporidian diseases; Mycosis, Cotton Wool Disease, Saprolegniasis; diseases of unknown etiology. Diseases of freshwater prawn- Mid Crop Mortality syndrome, Exuvia Entrapment disease, White Tail Disease, Bacterial Necrosis, Idiopathic Muscle Necrosis. Gaffaekemia in cultured Lobsters. Biosecurity requirements and establishment of biosecurity in shrimp aquaculture

Module 4**3 Hrs**

Introduction to diseases of cultured molluscs; Bonamiosis, Marteilirosis, Mikrocystosis.

Module 5**5 Hrs**

Immune system and response in fin-fishes and crustaceans.

Module 6**10 Hrs**

Techniques in Aquatic Animal Health – Gross observations, procedures for collection of diseased live and dead samples for analysis, preservation of tissues samples, record keeping in aquatic animal health management.

Module 7**15 Hrs**

Introduction to common techniques in bacteriology, virology, mycology, parasitology and histopathology with regard to identification of fish and shell fish pathogens of relevance to aquaculture, bioassays, Electron Microscopy.

Module 8**12 Hrs**

Immuno and Molecular Diagnostics in Aquatic Animal Health Care – Applications of PCR, RT-PCR, ELISA, Dot Blot Hybridisation, FAT, IFAT, RIA.

Module 9**10 Hrs**

Disease Management Tools – Immunostimulants, Probiotics, Bioremediators, Enzymes and nutritional supplements, Vaccines, Advanced drug delivery mechanisms, use of specific pathogen free (SPF) and specific pathogen resistant (SPR) broodstock.

Module 10**5 Hrs**

Policies and Regulatory issues with regard to use of antibiotics and drugs for treatment of fish and shellfish diseases, Role of HACCP and GMP in shrimp disease management, Quarantine and Health Certification issues.

REFERENCES

- Lionel E. Mawdesley-Thomas (1972) Diseases of Fish. Zoological Society of London.
- Ronald J. Roberts (1978) Fish Pathology. Cassell Ltd., London.
- Wedemeyer, Meyer and Smith (1999) Environmental Stress and Fish Diseases. Narendra Publishing House. New Delhi.
- Zdenek Lucky, M.V. (1977) Methods for the Diagnosis of Fish Diseases. Amerin Publishing Co. Pvt. Ltd.
- Snieszko, S.F. and Herbert R. Axelrod (1971) Diseases of Fishes. T.F.H. Publication
- Edward Kingsford, M.D. (1975) Treatment of Exotic Marine Fish Diseases. The Palmetto Publishing Company.
- Valerie Inglis, Ronald J. Roberts and Niall R. Bromage (1993) Bacterial Diseases of Fish. Balckwell Scientific Publication, London.
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- George Iwama and Teruyuki Nakanishi (Eds.) (1996) The Fish Immune System – Organism, Pathogen and Environment. Academic Press Publication.
- Carl J. Sandermann (1970) Principal Diseases of Marine Fish and Shellfish. Academic Press.
- Carl J. Sandermann (1990) Principal Diseases of Marine Fish and Shellfish Vol. 2 Second Edition. Academic Press.
- Woo, P.T.K. and Bruno, D.W. (Eds.) (1999) Fish Diseases and Disorders Vol. 3 – Viral, Bacterial and Fungal Infections. CAB International Publishing.
- Biology of benthic marine organisms – Oxford and IBH
- Health management in Asian aquaculture – 2000- FAO
- Fish and shellfish bacteriology manual – 2003- Whitman
- Immunodetection methods in aquaculture.2001– Adams, A

AQ010205 INLAND AQUACULTURE, ORNAMENTAL FISHERIES AND FISH HEALTH MANAGEMENT

1. Identification of major candidate species of fishes, crustaceans and mollusks for aquaculture.

Calculation of liming requirements.

2. Identification of weed and predatory fishes and insects.

3. Identification of exotic aquarium fishes

Guppies

Platies

Mollies

Sword tail

Gold fish

Gourami

Angel fish

Tetras

Oscars

Discus

4. Identification of indigenous aquarium fishes

Puntius fasciatus

Sahyadria denisoni

Dawkinsia filamentosa

Rasbora daniconius

Danio malabaricus

Pristolepis marginata

Barilius bakeri

Horobagrus nigricollaris

Garra mullya

Etroplus maculatus

Tetradon Travancorensis

5. Identification of marine ornamental fishes

Chaetodon collaris

Chaetodon auriga

Amphiprion percula

Heniochus acuminatus

Abudefduf saxatilis

Pterois volitans

Holocentrus samara

6. Identification of ornamental crustaceans and mollusks.

7. Identification of aquarium plants

Vallisnaria spiralis

Cabomba coroliniata

Ceratopteris sp.

Sagittaria sp.

Myriophyllum sp.

8. Setting up of aquarium tank – Freshwater and Marine.
9. Breeding and rearing of Guppy – a live bearer.
10. Breeding and rearing of Gold fish – an egg scatterer.
11. Breeding and rearing of Blue gourami – a bubble nest builder.
12. Identification of fish diseases and monitoring fish health.
13. Disease treatment and chemicals.

SEMESTER - III

SEMESTER- III	AQ010301	Mariculture
	AQ010302	Fish Nutrition
	AQ010303	Microbiology and Quality Management
	AQ010304	Aquaculture and Fish Nutrition
	AQ010305	Fishery Microbiology and Quality Control
	AQ010306	Hatchery Training*

AQ010301 MARICULTURE

Credit: 4

90Hrs

Module 1 Introduction

5 Hrs

Scope and Global status of Mariculture. Mariculture in India and progress.

Module 2 Crustacean culture

20 Hrs

Overview of the crustacean culture in the world. Major species of Spiny lobster, Sand Lobsters, Crabs and Shrimps. Seed production - Natural and Hatchery, Broodstock management, Techniques of Induced breeding. Traditional and modern farming techniques- Extensive, Intensive and Semi intensive. Sea ranching.

Module 3 Culture of Molluscs

25 Hrs

Overview of culture of molluscans of the world. Major species of edible oysters, Pearl oysters, Mussles, Clams, Cockles, Scallops, Abalons and Cephalopods used in aquaculture. Broodstock management, induced maturation and spawning. Seed production – Natural seed resources and collection techniques of oysters, Mussles and Clams. Hatchery production of seeds of Oysters mussles and clams. Mussle and Oyster farming – site selection, farm structure and farming techniques. Artificial pearl production techniques. Abalone culture methods, culture of cephalopods. Biofouling in molluscan farms and control measures. Effect of toxic algal blooms.

Module 4 Seaweed Culture

10 Hrs

Taxonomy of Economically important sea weeds. Seaweed morphology, Reproduction and life cycle. Seaweed propagation methods and culture. Seaweed utilization. Importance of sea grasses.

Module 5 Culture of Sea Cucumber

10 Hrs

Major species of sea cucumbers and their distribution. Seed production techniques and Culture methods, Culture of sea cucumbers in India.

Module 6 Culture of Finfishes

20 Hrs

Criteria for selection of fish for mariculture, Broodstock management, breeding under controlled conditions, Induced breeding and egg incubation of cobia, pompano and grouper. Natural seed resources, Collection acclimatization and transportation of seed, Hatchery production of seed. Larval rearing. Different kinds of grow out culture systems. Finfish mariculture in cages, pens and race ways and running water systems.

REFERENCES

- Applied fisheries /prasad,l
Applied ichthyology /sandhu,g
Fish diversity and dam ecosystem /shinde,s
Fish farming and fish products /naik,j
Fish hatchery management : 2nd edn /wedemeyer.g.
Fish, fisheries and aquaculture technology /naik,j
Fisheries and aquaculture technology /malik,a
Frontiers in aquaculture /sundaray,j.k
Handbook of fish and fisheries /sinha,r.k
Marine fish and fisheries /naik,j
Aquaculture in shallow seas: progress in shallow sea culture. Takeo imai.
Perspectives in Mariculture. Menon, N.G.
Development of marine fisheries science in India, Bensam P.
Breeding and seed production of fin fish and shell fish. Thomas P.C. et al.
Coastal aquaculture: mussel farming: progress and prospects. CMFRI Publ.
Seaweed research and utilization in India. CMFRI Publ.

AQ010302 FISH NUTRITION**Credit: 4****90Hrs****Module 1 Nutritional physiology****15 Hrs**

Principles of nutrition, Adaptations to various types of feeding in finfish, crustaceans and mollusks; Mechanism of food capture, food ingestion and role of feeding stimulants; Digestion assimilation and conversion of nutrients; Roles of gut microbes in digestion; Nutritional bioenergetics in finfish and shellfish.

Module 2 Nutritional requirements**25 Hrs**

Gross protein requirements; Nitrogen balance; Essential and non-essential amino acids and their quantitative requirements; Protein quality and sources; Lipid – their functions; Essential fatty acids; phospholipid & sterol requirements; Protein sparing action of lipids; Negative aspects of lipids; Carbohydrates – their sources and utilization; Gross energy requirements; Factors altering energy requirements; Water and fat soluble vitamins; Deficiency and hyper dosage syndromes; antivitamin factors; Mineral requirements, importance of minerals; recommended dietary allowances; deficiency and hyper dosage syndromes. Feed additives, proximate composition, apparent digestibility. Antinutritional factors and toxins. Nutritional requirements of brood stock; factors affecting nutritional requirements. Nutritional requirements of cultured species.

Module 4 Feed formulation, manufacture and quality control**20 Hrs**

Choosing feed ingredients; Feed formulation strategies and methods (Pearson's Square method and algebraic method); Practical formulations for carp, milkfish, tilapia, seabass, giant freshwater prawn, tiger shrimp. Feed manufacture processes- Small scale and Commercial feed manufacture. Storage and quality control of feeds.- factors controlling the feed quality; chemical and biological methods of evaluation. Different grades of feeds; cost effective feed formulations; feed conversion ratio; management of feed mills; economics.

Module 5 Management of feeding**10 Hrs**

Feeding strategies. Feeding equipments. Feeding rate and frequency. Recording of feeding and monitoring water quality. Feeding of commercially important species like milk fish, tilapia, carp, sea bass, tiger shrimp and *Macrobrachium rosenbergi*.

Module 6 Larval nutrition**15 Hrs**

Nutritional requirements of finfish, crustacean and molluscan larvae; Nutritive value of cladocerans, Copepods and rotifers and their culture. Artemia- Nutritive value, their mass culture and cyst production. Micro diets for larvae; Recent advances in larval nutrition. Method of collection and culture methods, various medias used in the culture of microalgae- *Chaetoceros*, *Chlorella*, *Tetraselmis*, *skeletonema* and *Isochrysis*.

Module 7 Nutritional diseases**5 Hrs**

Nutritional diseases of cultured varieties of fishes, mollusks and crustaceans and control measures.

REFERENCES

- Sena S. De Silva and Trevor Anderson. Fish Nutrition in Aquaculture. Chapman and Hall, Publ.
- Verreth, J. Fish Larval Nutrition. Chapman and Hall, Publ.
- Stephen Goddard, 1996. Feed Management in Intensive Aquaculture. Farm-made Aquafeeds. FAO Fisheries Technical Paper 343.
- Devadasan, K. (Ed.)1994. Nutrients and Bioactive substances in Aquatic Organisms.
- Kalver John, E. 1972. Fish Nutrition. Academic Press, London.
- Halver John E. and Tiews Klaus, 1979 Finfish Nutrition and Fish Feed Technology. Heenemann, Berlin.
- Hepher Balfour 1988. Nutrition of Pond Fishes. Cambridge University Press.
- Tyler Peter and Calow Peter, 1985. Fish Energetics. Croom Helin, London.
- Winberg, 1960. Rate of Metabolism and Food Requirements in Fishes. Fisheries Research Board of Canada.
- Shimeno Sadao, 1982. Studies on Carbohydrate Metabolism in Fish. Amerind Publishing Company, New Delhi.
- Cowey, C.B. et al. (Eds.) 1985. Nutrition and Feeding in Fishes. Academic Press, London

AQ010303 MICROBIOLOGY AND QUALITY MANAGEMENT**Credit: 4****90Hrs****MICROBIOLOGY****45 Hours****Module 1 Fundamentals in microbiology and advanced techniques**

- 1.1 Morphology of bacteria, yeasts and molds.
- 1.2 Staining of bacteria : Gram staining; Acid fast staining; Bacterial cell staining
- 1.3 Nutrition of bacteria
- 1.4 Culture of bacteria : Culture media and common ingredients; Environmental effect on bacteria; Growth phases of bacteria
- 1.5 Laboratory techniques in bacteriology : Pure culture techniques; Isolation and identification of cultured colonies
- 1.6 Commonly occurring bacteria in marine, brackish water and freshwater environment
- 1.7 Microbial activity in fish and fishery products; Microbiology of spoilage and preservation; Microbial changes during icing, freezing and curing; Chemical control of microbial spoilage
- 1.8 Effect of preservatives and antibiotics on microflora; Growth of resistant microflora
- 1.9 Scope and importance of industrial microbiology
- 1.10 Advances in fishery microbiology

QUALITY MANAGEMENT**45 HOURS****Module 2 Quality Control in Seafood Trade****2.1 TQM concept and application****2.2 Quality control and assessment in fish and fishery products**

2.2.1 Organoleptic, Physical, Chemical and Microbiological quality

2.2.2 Quality standards

2.2.3 Quality Assurance

2.3 Inspection and Quality Control

2.3.1 Inspection and Inspection agencies in India

2.3.2 Process water quality in processing industry

2.3.3 Product quality

2.3.4 Water analysis and treatment

2.3.4.1 Chlorination

2.3.4.2 Ozonization

2.3.4.3 UV Radiation

2.3.4.4 Reverse Osmosis

2.3.4.5 Removal of pesticides and heavy metals

2.4 Sensory evaluation of fishery products

2.4.1 Different methods of evaluation

2.4.2 Taste panel selection and constitution

2.4.3 Statistical Analysis

2.5 Quality Standards and Problems in Fishery Products

2.5.1 GMP's

2.5.2 HACCP and ISO 9000 series of quality assurance

2.5.3 Validation and Audit

2.5.4 National and International Standards

2.5.5 EU Regulations on Fishery Products Export

2.5.6 IDP and SAT formations in certification of export worthiness of processing units

2.5.7 Regulations for fishing vessels, pre-processing and processing units

2.5.7.1 EU Regulations

2.6 Factory Sanitation and Hygiene

2.6.1 National and International requirements

2.6.2 SSOP

2.7 Hazards in Seafood

2.7.1 Seafood toxins

2.7.2 Biogenic amines

2.7.3 Heavy metals and industrial pollutants

REFERENCES

Robinson, R.K. (1985) Microbiology of Frozen Foods. Elsevier Applied Science Publishers.

Devadasan, K., Mukundan, M.K., Antony, P.D. and Jos Joseph (1994) Nutrients and Bioactive substances in Aquatic Organisms. SOFT(I)

James Muil Leitch (1965) International Congress of Food Science and Technology – Biological and Microbiological Aspects of food. Gordon and Breach Science Publishers.

Slanetz, L.W., Chichester, C.O., Gaufin, A.R. and Ordal, N.J. (1963) Microbiological Quality of Foods. Academic Press, New York.

Bonnell, A.D. (1994) Quality Assurance in Seafood Processing. Chapman and Hall, USA.

Zeuthen, P., Cheftel, J.C., Eriksson, C., Gormley, T.R., Linko, P. and Paullis, K. (1990) Processing and Quality of Foods. Vol. 2 Food Biotechnology. Elsevier Science Publishers Ltd.

Heid, J.L. and Maynard A. Joslyn, B.S. (1981) Fundamentals of Food Processing Operations : Ingredients, Methods and Packaging. The AVI Publishing Co. Inc., USA.

T.S. Gopalakrishna Iyer, Kandoran M.K., Mary Thomas and Mathew P.T. (2000) Quality Assurance in Seafood Processing. SOFT(I).

Hersch Doerfer S.M (Ed.) (1967) Quality Control in Food Industry. Academic Press Inc. London.

Jose Miguel Aguilera and David W. Stanley (1990) Micro Structural Principles of Food Processing and Engineering. Elsevier Applied Science, London.

AQ010304 AQUACULTURE AND FISH NUTRITION

1. Dissection of female reproductive system and determination of maturity stages of penaeid prawn.
2. Identification of maturity stages of any one fish (*Mugil cephalus/ Lates calarifer/ Cyprinus carpio*).
3. Primary productivity based on Dissolved Oxygen method
4. Pituitary isolation and extraction of pituitary hormones.
5. Carp induced breeding using pituitary extract
6. Artemia cyst hatching and harvest.
7. Estimation of pH of Soil
8. Feed formulation using Pearson square method and feed preparation
9. Determination of proximate composition of prepared feed
10. Collection and identification of any six species of cultivable sea weed.

AQ010305 FISHERY MICROBIOLOGY AND QUALITY CONTROL

1. Formulation of different media.
2. Practice of standardization and disinfection.
3. Stains and staining techniques.
4. Aerobic and anaerobic culture techniques.
5. Isolation and identification techniques of bacterial culture.
6. Organoleptic tests of fish and fishery products.
7. Estimation of common bacteria of aquatic environment.
8. Estimation of fish spoilage indices.

SEMESTER – IV

SEMESTER – IV	AQ010401	Post Harvest Technology
	AQ010402	Fish Processing Technology

	Groups	Code	Course	Hours/Week	Total Hours	Credit
ELECTIVES (Credit 3*3=9)	GROUP A	AQ800401	Fisheries Business Management	5	72	3
		AQ800402	Fish Capture Technology & Management	5	72	3
		AQ800403	Fish Immunology	5	72	3
	GROUP B	AQ810401	Seed Production and Hatchery Management of Finfishes	5	72	3
		AQ810402	Soil and Water Quality Management in Aquaculture	5	72	3
		AQ810403	Seed Production and Hatchery Management of Shellfishes	5	72	3

AQ010401 POST HARVEST TECHNOLOGY**Credit: 4****90Hrs****Module 1 Freezing and Frozen Storage****15 Hours**

- 1.1 Freezing curves for fish
- 1.2 Determination of freezing points from time-temperature plots
- 1.3 Calculation of freezing time
- 1.4 Crystallization
- 1.5 Nucleation
- 1.6 Homogenous and Heterogeneous nucleation
- 1.7 Super cooling
- 1.8 Eutectic point
- 1.9 Changes during freezing
- 1.10 Technical aspects
- 1.11 Comparison of various methods of freezing
- 1.12 Chemical treatment prior to freezing
- 1.13 Glazing
- 1.14 Frozen Storage
- 1.15 Additives in Fishery Products
 - 1.15.1 Antioxidants
 - 1.15.2 Cryoprotectants

1.15. 3 Mechanism of freezing injury and cryoprotection

Module 2 Post Mortem Changes in Fish

15 Hours

2.1 Physical Changes

2.1.1 Freezer burn and recrystallization

2.1.2 Different types of recrystallization

2.2 Chemical Changes

2.2.1 Theories of denaturation

2.2.2 Lipids, proteins, nucleotides, freeze denaturation

2.2.3 Changes in pH

2.3 Bacterial Changes

2.4 Sensory Changes

2.4.1 Texture, taste and odour

2.4.2 Effect of post mortem condition on sensory qualities

2.4.3 Temperature and duration of storage on quality and shelf life

2.4.4 Frozen marine products export from India

Module 3 Thermal Processing of Fishery products

15 Hours

3.1 Principles of thermal processing

3.2 Mechanism of heat transfer

3.2.1 Conduction

3.2.2 Convection

3.2.3 Radiation

3.2.4 Dielectric and Microwave heating

3.2.5 Unsteady state transfer

3.3 Heat resistance of bacteria and spores

3.4 Decimal reduction time

3.5 Thermal death time

3.6 "Z" and "F" values

3.7 Heat penetration

3.8 Determination of process time

3.9 Significance of thermal death curve

3.10 Fo value, cook value, D value and integrated F value and significance

3.11 Canning

3.11.1 Absolute, Statistical and Commercial sterility

3.11.2 Pasteurization Vs Sterilization

3.11.3 Canning process

3.11.3.1 Steps

3.11.3.2 Process flow

3.11.3.3 Additives

3.11.3.4 Different types of cans

Module 4 Spoilage of canned foods **10 Hours**

- 4.1 Physical spoilage
- 4.2 Chemical spoilage
- 4.3 Microbial spoilage
- 4.4 Examination of cans and seams

Module 5 Packaging of Fish and Fishery Products **10 Hours**

- 5.1 Retort pouch processing of fish and fishery products
- 5.2 Irradiation preservation
- 5.3 Packaging and packaging materials in fish processing
- 5.4 Recent advances

Module 6 Curing and Dehydration **15 Hours**

- 6.1 Principles of drying and dehydration
- 6.2 Different types of dryers
 - 6.2.1 Tunnel dryer
 - 6.2.2 Vacuum dryer
 - 6.2.3 Drum dryer
 - 6.2.4 Solar dryer
- 6.3 Freeze drying
 - 6.3.1 Accelerated freeze drying and applications
- 6.4 Dehydration of fish products
 - 6.4.1 Dehydration ratio
 - 6.4.2 Precautions in fish drying
 - 6.4.3 Denaturation of fish protein
- 6.5 Spoilage of dried fish and control
- 6.6 Curing of fish
 - 6.6.1 Salt curing
 - 6.6.1.1 Type and size of salt crystals
 - 6.6.1.2 Factors affecting salt uptake by fish
 - 6.6.1.3 Sources and impurities in salt
 - 6.6.1.4 Methods
 - 6.6.1.4.1 Dry/kench/wet salting
 - 6.6.1.4.2 Pickling
 - 6.6.1.4.3 Brine salting
 - 6.6.1.5 Spoilage of salt cured fish and control measures
 - 6.6.2 Smoke curing

Module 7 Fishery By-products and Value Added Products **10 Hours**

- 7.1 Fish meal
- 7.2 Fish body and liver oils
- 7.3 By-products of shark
- 7.4 Utilization of shrimp waste and squilla
- 7.5 Utilization of Krill

- 7.6 Fish protein concentrate
- 7.7 Sea weed by-products
- 7.8 Fish silage
- 7.9 Fish Hydrolysates
- 7.10 Miscellaneous by-products and recent advances
- 7.11 Marinades
- 7.12 Fish and shellfish pickles
- 7.13 Fermented fish products
- 7.14 Fish sauces
- 7.15 Recent advances

REFERENCES

1. Brody, J Fishery products technology, West port
2. Burgess, G.H.S et al. Fish handling and processing HMSO London
3. Kreuzer, R. Freezing and irradiation of fish. Fishing News., London
4. Kreuzer, R. Ed Fish inspection and quality control. Fishing News New England
5. Kreuzer, R. (Ed) Fishery products. Fishing News England.
6. Greensmith, M Practical Dehydration. Food Trade Press.
7. Govindan T.K. Fish processing technology. IBH, New Delhi.
8. Windsor, M. and Barlow, Introduction to fishery by-products . Fishing News
9. Charles Cutting, L., Fish processing and preservation. AGRO Botanical Publishers (India).
10. Gopakumar K. Fish Packaging Technology – Materials and Methods.
11. Connell, J.J. (Ed.). 1980. Advances in Fishery Science and Technology. Fishing News Books Limited. England.
12. Wheaton, F.W. and Lawson, T.B. 1985. Processing Aquatic Food Products. Wiley and Interscience Publishers.
13. Borgstrom, G. 1962. Fish as Food. Vol 1 - 4. Academic Press. New York.
14. Saccharow, S. and Griffin, R.C. 1980. Principles of Food Packaging – 2nd Edition. AVI Publishing Company, Connecticut.

AQ010402 FISH PROCESSING TECHNOLOGY

1. Filleting of fish, treatments, glazing, packaging and freezing.
2. Frozen storage studies.
3. Canning of tables fishes, bivalves and crustaceans in different containers.
4. Examination of canned fishery products.
 - a. Can seams
 - b. Testing sterility
5. Preparation of fish meal, FPC, fish oils, chitin, chitosan, glucosamine hydrochloride, fish maws, isin glass, agar, alginic acid etc.
6. Preparation of feeds, encapsulation, experimental diets, nutritional evaluation, biochemical composition, evaluation of FCR and PER of feeds.

AQ800401 FISHERIES BUSINESS MANAGEMENT**Credit: 3****72Hours****Module 1 FISHERIES ECONOMICS, TRADE & COMMERCE****20 HOURS**

1.1 Definition of economics and application of economic principles to fisheries. Special characteristic features of fishery resources as common property resources. Theory of production, law of diminishing returns and risks and profits in fisheries. **5 Hrs**

1.2 Economics of fish markets, marketing and resource management. Co-operative and their importance in fish production and marketing; export oriented growth policies; fisheries projects and fish resources, institutional and management issues, planning and financing schemes for fisheries. **5 Hrs**

1.3 Economics of capture and culture fisheries – Cost and earnings of different types of fishing units in marine and inland fisheries. Estimation of break even point and comparative profitability. Investment – autonomous and induced investment. Factors influencing investment decisions. Balance sheet, cash flow analysis, Farm budgeting ratio analysis. **5 Hrs**

1.4 Trade and exports- export of marine products- trend and present status, tariff and non-tariff barriers. Shipping, insurance, trade control, export policies, export incentives, export documentation procedures. Role of MPEDA and Export Inspection Councils. **5 Hrs**

Module 2 FISHERIES RESOURCE MANAGEMENT**10 Hours**

2.1 Exploitation and management of Deep Sea Resources

2.2 Exploitation and Conservation of Coastal Resources

2.3 Management of brackish water resources

2.4 Management and conservation of freshwater resources

Module 3 HUMAN RESOURCE MANAGEMENT**10 Hours**

3.1 Manpower planning and recruitment. Performance appraisal of managers in fisheries organisations, organisation development, training and management development, motivation leadership and communication. **5 Hrs**

3.2 Human resources development and its role in the context of fisheries sector, manpower requirements for various activities of the fisheries sector. Raising the required manpower for fisheries developmental programmes. Important institutions involved in human resources development for the fisheries sector. **5 Hrs**

Module 4 PROCESSING SECTOR MANAGEMENT**7 Hours**

4.1 Organizational setup.

4.2 Line and Staff control

4.3 Managerial Functions

4.4 Management Strategy

4.5 Government policies

4.6 Other regulatory organizations

Module 5 MARICULTURE MANAGEMENT**15 Hours**

- 5.1 Administration and Legal Aspects
 - 5.1.1 Administrative structure at National and State levels
 - 5.1.2 Fisheries research, education and development organizations and their functions
 - 5.1.3 Fishery legislation and regulation
 - 5.1.4 Laws of the Sea
 - 5.1.4 Regulation on industrial effluents
 - 5.1.5 Laws and criteria for land and open water allotment for aquaculture
- 5.2 Planning and Development
 - 5.2.1 Overview of strategies and methods for promoting aquaculture development
 - 5.2.2 Review of planned aquaculture development around the world
 - 5.2.3 Training needs and facilities for aquaculture
 - 5.2.4 Coordination of development and responsibilities of different maritime states
 - 5.2.5 Fish seed syndicates, cooperatives and hatcheries at the state level
 - 5.2.5 Feed and fertilizer availability
 - 5.2.6 Facilities for storage and marketing
 - 5.2.7 Conflict between capture and culture fisheries
 - 5.2.8 Encroachment of nursery grounds
 - 5.2.9 Planning for the future
 - 5.2.10 Marine Stewardship Council
- 5.3 Management of Hatcheries and Farms
 - 5.3.1 Availability of manpower and skilled labour
 - 5.3.2 Personnel requirements and management
 - 5.3.4 Materials management
 - 5.3.5 Energy requirements and management
 - 5.3.6 Financial management
 - 5.3.7 Water quality management for hatcheries and farms
- 5.4 Environmental Impact Assessment and Management in Aquaculture

Module 6 PLANNING AND STRATEGIES FOR FUTURE FISHERIES DEVELOPMENT 5 Hours

Planning organisations for fisheries. Fisheries development in India during the plan periods. Drawbacks in implementation. Aquaculture Stewardship Council.

Module 7 PROJECT FORMULATION**5 Hours**

Project formulation; Process identification; Pre-feasibility - Technical, Economic and Social feasibility; Budgeting appraisal; Techniques of milestones, CPM, PERT, Schedule graphing, Decision making. Social and financial viability indicators - cash income, employment generation, rate of return, DCF, NPV, IRR, Sensitivity Analysis.

REFERENCES

1. Lackey, R.T. L.A. Nielson (1980) Fisheries Management . Blackwell Sci. Publ. Oxford.

2. Jhingran and Srivastava (1983) Fisheries Development in India. Concept Publishing Co. New Delhi, 606p
3. Srivastava and Vathsala (1984) Strategy for development of Inland fisheries resource of India. Concept Publishing Co. New Delhi
4. Panayotou, T. (1982) Management concepts for small scale fisheries Economic and Social aspects. Fisheries Tech. Tech. Pap. No. 228. Rome.
5. Cunningham, D and Whitmarsh, (1985) Fisheries economics, an introduction.
6. IRDC (1982) Aquaculture economic research in Asia. Singapore.
7. Anderson.L. (1977) The economics of fisheries management. John Hopkins.
8. Geoffrey Waugh. Fisheries Management – Theoretical developments and contemporary applications.
9. Ian Chaston. Managerial effectiveness in fisheries and aquaculture.
10. Colin Clark, W., Bioeconomic modeling and fisheries management.
11. Revin Crean and David Symes (Ed), Fisheries management in crisis.
12. Subba Rao, N., Fisheries development and management in India.
13. Ian Chaston, Business management in fisheries and aquaculture.
14. Rowena Lawson, Economics of fisheries development.
15. Pauly, D. and Murphy, G.I. (Ed), Theory and management of tropical fisheries.

AQ800402 FISH CAPTURE TECHNOLOGY & MANAGEMENT**Credit: 3****72Hours****Module 1 Fishing Crafts****19 Hours**

1.1 FAO Classification; Types of Marine and Inland Fishing Vessels	4hrs
1.2 Materials and methods of construction and deck layout of fishing vessels	4hrs
1.3 Marine Diesel Engines and determinants in selection.	4hrs
1.4 Biofouling, corrosion and maintenance	4hrs
1.5 Marine propulsion systems	3hrs

Module 2 Fishing Gears**21 Hours**

2.1 Classification of fishing gears.	3Hrs
2.2 Fisheries Hydrography : Effect of environmental stimuli (temperature, light, current, chemical environmental factors) on fish behaviour, Influence of upwelling on distribution of fish, Nature of bottom in relation to fish and fishing, Relation between fish and its food in the sea, Influence of Meteorological factors on fish and fishing.	4Hrs
2.3 Principles and methods of capture for different fishing gears.	3Hrs
2.4 Natural and Synthetic fishing gear materials and principles of construction	3Hrs
2.5 Design and construction of active and passive commercial fishing systems	4Hrs
2.6 Fishing accessories – Fishing gear accessories; Hooks and Baits; Fishing Rods; Fish finding devices.	4Hrs

Module 3 Navigation, Seamanship and Rope work**19 Hours****Navigation****11Hours**

3.1 Introduction; Navigation charts and Chart work	4Hrs
3.2 Navigation Communication : Distress-Urgency-Safety Calls, Transmission Procedure, Control of Distress Traffic, Distress Signals, International Code of Signals (Signal flags)	2Hrs
3.3 Navigation Essentials : Weather forecasts from daily observations; Sky and Weather Notation – Beaufort's Weather Notation, Beaufort's Wind Scale; Lights and Shapes;	3Hrs
3.4 Modern Techniques : Pilotage, Celestial Navigation, Radio Navigation, Radar Navigation, Satellite Navigation.	2Hrs

Seamanship and Ropework**8Hours**

3.5 Ropework	2hrs
3.6 Ship handling and anchoring procedures	2hrs
3.7 First Aid and Safety; Firefighting procedures	2 hrs
3.8 Response to Emergency	2hrs

Module 4 Capture Fisheries Management**13 Hours**

4.1 Principles of capture fisheries resource conservation and management	3Hrs
4.2 Resource Conservation Devices – BRD, TED, FAD	3Hrs
4.3 Remote Sensing and its applications	3Hrs
4.4 GIS in Fisheries	2Hrs
4.5 Energy Optimization in Fishing	2Hrs

REFERENCES

Hilmar Kristjonnson (Ed.) Vol 1 (1962), Vol 2 (1964) Vol. 3 (1971) Modern Fishing Gears of the World 3. Fishing News Books Ltd. England.

Jan-Olof- Traung (Ed.) Vol 1 (1955), Vol 2 (1966) Vol. 3 (1967).Fishing Boats of the World. Fishing News Books Ltd. England.

Subbarao, Mechanization of marine fisherman.

Srivastava, Impact of mechanization on small fishermen.

AQ800403 FISH IMMUNOLOGY**Credit: 3** **72Hours****Module 1. Introduction** **5 Hours**

1.1 Introduction to fish immunology and terminologies

1.2 Historical developments to fish immunology

1.3 Phylogeny of fish immune system.

Module 2. Lymphoid tissues and cellular components **5 Hours**

Lymphoid tissues and cellular components of immune system.

Module 3. Non Specific Defense Mechanisms **10 Hours**

3.1 Phagocytosis

3.2 Complement

3.3 Interferons

3.4 Natural killer cells

Module 4. Specific defence mechanisms **7 Hours**

Memory functions and immunological tolerance.

Module 5. Complement system **7 Hours**

Functions, components, complement activation.

Module 6. Antigens and Antibody **13 Hours**

Antigens and antigenicity; structure of antibody. Types of antibodies, Theories of antibody formation, Antibody mediated immune response: general characteristics, immunoglobulin classes, structure and function and synthesis.

Module 7. Immunological Systems **5 Hours**

Phagocytic systems; Lymphoid systems; Antigen processing and major histocompatibility complex.

Module 8. Cellular Immune Response **5 Hours**

Cell mediated immune response and its components; Hypersensitivity reactions.

Module 9. Non Chordate Defense Mechanisms **5 Hours**

Invertebrate defense mechanisms.

Module 10. Fish Vaccination**10 Hours****10.1** Optimizing factors for fish vaccination

10.1.1 Husbandry factors

10.1.2 Environmental factors

10.1.3 Vaccine related factors

10.1.4 Immunostimulants

References

Ellis AE. 1988. *Fish Vaccination*. Academic Press.

Iwama G & Nakanishi T. 1996. *The Fish Immune System. Organism, Pathogen and Environment*. Academic Press.

Janis K. 1997. *Immunology*. 3rd Ed. WH Freeman.

Swain P, Sahoo PK & Ayyappan S. 2005. *Fish and Shellfish Immunology:*

An Introduction. Narendra Publ. House.

Karunasagar. 1995. Principles of Immunology

AQ810401 SEED PRODUCTION AND HATCHERY MANAGEMENT OF FINFISHES**Credit: 3****72 HOURS****Module 1. Introduction to Hatchery Seed Production****5 Hours**

Introduction: History, constraints and current status of natural seed collection and hatchery seed production.

Module 2. Reproductive biology**5 Hours**

Physiology and morphology; Molecular and physiological basis of reproduction, Overview of current developments in reproductive biology.

Module 3. Gamete maturation and development**5 Hours**

Spermatogenesis and oogenesis, Hormonal pathways and mode of control.

Module 4. Environmental and endocrine control of reproduction**7 Hours**

Reproductive cycles, Seasonality (Photoperiod, change in water quality and quantity, temperature, lunar cycle, etc.), Environmental and exogenous hormonal stimuli.

Module 5. Induced spawning**5 Hours**

Methods of natural and artificial fertilization, GnRH and Linpe models, evaluation of milt and egg, cryopreservation technique, use of different synthetic hormones and analogues for induced spawning, Egg staging, Stripping and fertilization.

Module 6. Freshwater fish seed production**15 Hours**

Hatchery technology for different species: Indian major and minor carps, Exotic carps, Catfishes, Tilapia, Masheer, Trout, etc.

Module 7. Brackishwater and Marine fish seed production**15 Hours**

Seabass, milkfish, mullets, sea breams, rabbitfish, grouper, yellowtail, eel, cobia, etc.

Module 8. Hatchery design and management**10 Hours**

Criteria for site selection of hatchery and nursery, Design and function of incubators, Jar hatchery, Chinese hatchery and other hatchery systems- design and operation, hatchery protocols, larval rearing stages, rearing technology, packaging and transport of seed.

Module 9. Seed supply in aquaculture**5 Hours**

Relationship between fry supply and grow-out, Macro-planning of fry production to stimulate grow-out, Marketing and economics of fish seed.

References

FAO. 1992. *Manual of Seed Production of Carps*. FAO Publ.

ICAR. 2006. *Hand Book of Fisheries and Aquaculture*. ICAR.

Jhingran VG & Pullin RSV. 1985. *Hatchery Manual for the Common, Chinese and Indian Major Carps*. ICLARM, Philippines.

Jhingran VG. 1991. *Fish and Fisheries of India*. Hindustan Publ.

Landau M. 1992. *Introduction to Aquaculture*. John Wiley & Sons.

Mcvey JP. 1983. *Handbook of Mariculture*. CRC Press.

Pillay TVR & Kutty MN. 2005. *Aquaculture- Principles and Practices*.

Blackwell.

Rath RK. 2000. *Freshwater Aquaculture*. Scientific Publ.

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

AQ810402 SOIL AND WATER QUALITY MANAGEMENT IN AQUACULTURE**Credit: 3** **72 Hours****Module 1. Soil and water interaction** **20 Hours**

- 1.1 Physical properties of soil and water.
- 1.2 Chemical properties of soil and water.
- 1.3 Productivity vs nutrient quality and quantity of soil.
- 1.4 Productivity vs nutrient quality and quantity of water
- 1.5 Biogeochemical cycles
 - 1.5.1. Carbon cycle
 - 1.5.2. Nitrogen cycle
 - 1.5.3. Phosphorous cycle
 - 1.5.4. Sulphur cycle
 - 1.5.5. Oxygen cycle
 - 1.5.6. Water cycle
 - 1.5.7. Rock cycle
- 1.6 Aquatic microorganisms and their role in Biogeochemical cycles.
- 1.7 Impact of biogeochemical cycles on aquatic habitats and species.

Module 2. Soil and water quality monitoring **15 Hours**

- 2.1 Soil and water quality standards
- 2.2 Soil and water quality monitoring and management.

Module 3. Fertilizers and manures **17 Hours**

- 3.1 Different kinds of fertilizers and manures, fertilizer grade, source, rate and frequency of application, Biofertilizers
- 3.2 Use of treated sewage for pond fertilization
- 3.3 Ecological changes taking place after fertilizing; Primary production, degradation of molecules in aquatic environment
- 3.4 Utilization of bioactive compounds by microorganisms.

Module 4. Soil and water quality management **20 Hours**

- 4.1 Cat clay/pyrite soil, seepage, water treatment, water filtration devices, aeration,
- 4.2 chlorination, ozonization and UV radiation
- 4.3 Algal bloom control, eutrophication
- 4.4 Aquatic weed control and management
- 4.5 Waste water treatment practices, Waste discharge standards

4.6 Water quality management in hatcheries

4.7 Role of microorganisms in fish production, fish health and fish safety; Microbial load and algal blooms.

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

AQ810403 SEED PRODUCTION AND HATCHERY MANAGEMENT OF SHELLFISHES**Credit: 3** **72 Hours****Module 1. Introduction** **5 Hours**

Current status; problems and prospects.

Module 2. Seed resources **5 Hours**

Site selection and techniques of collection; identification and segregation of shellfish seed.

Module 3. Reproductive biology **20 Hours**

Gonad anatomy, endocrinology and reproductive mechanisms in prawns, shrimps, crabs, lobsters, mussels, oysters, scallops and clams; age at first maturity; factors affecting maturation and spawning.

Module 4. Broodstock Management **7 Hours**

Availability; improvement; nutritional requirements; transport; captive rearing and maturation; induced spawning; physical and chemical inducing agents; physiology and techniques of eyestalk ablation.

Module 5. Seed production **15 Hours**

Seed production of commercially important prawns, shrimps, crabs, lobsters, mussels, edible oysters, pearl oyster, scallops, clams and sea cucumber.

Module 6. Hatchery Technology and Management **15 Hours**

Site selection and facilities required; culture and use of different live feed in shellfish hatcheries; larval diseases and their management; different chemicals and drugs used; water quality and feed management; Hatchery standards and biosecurity; sanitary and phytosanitary (SPS) measures; better management practices (BMPs); packaging and transport of seed.

Module 7. Economics of Seed Production **5 Hours**

Economics of seed production and Hatchery Management

ReferencesCMFRI Bulletin. 1987. *National Seminar on Shellfish Resources and Farming.*FAO. 2007. *Manual for Operating a Small Scale Recirculation Freshwater Prawn Hatchery.*ICAR. 2006. *Handbook of Fisheries and Aquaculture.* ICAR.

Jhingran VG. 1991. *Fish and Fisheries of India*. Hindustan Publ. Corp.

Landau M. 1992. *Introduction to Aquaculture*. John Wiley & Sons.

Mcvey JP. 1983. *Handbook of Mariculture*. CRC Press.

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