

**MAHATMA GANDHI UNIVERSITY**  
**PRIYADARSHINI HILLS, KOTTAYAM – 686 560**



**RESTRUCTURED CURRICULUM FOR POST GRADUATE PROGRAMME**

**IN**

**M.Sc. FISHERY BIOLOGY AND AQUACULTURE**

**(Effective from 2019 Admission onwards)**

## **M.Sc. Fishery Biology and Aquaculture**

### **Scope of the Programme**

The program is designed as a four semesters, 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 Fishery Biology, Fish Capture, Aquaculture and Processing. The focus areas of this programme are Biology and Systematics, Aquaculture Technology, Fish Capture Technology, Fish Processing and Quality Control. Semester I covers such aspects as Systematics and Biology, Ecology, Biochemistry and Biostatistics & Computer Applications. The practical paper focuses on Biochemistry, Biostatistics & Computer Applications. In Semester II, the topics covered are Capture Fisheries; Biophysics, Instrumentation and Research Methodology; Genetics and Biotechnology in Aquaculture; Fisheries Economics, Management & Extension. Practical paper assigned for this semester covers different aspects of Capture Fisheries, Instrumentation and Biotechnology. Semester III, theory courses offered include Principles of Aquaculture; Pathology, Microbiology and Immunology; Post Harvest Technology and Quality Control; Ornamental Fish Culture and Seaweed Culture. One practical paper offered in this semester includes topics relating to Aquaculture & Seaweed culture, Microbiology and Fish Processing. The courses offered in Semester IV include one theory paper in Culture of Finfishes and Culture of Shellfishes. The practical paper offered in the semester includes Water and Soil Quality Parameters. The students also have to select and study the elective papers in the allotted subjects as mentioned in the syllabus as an essential requirement of the curriculum. 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. Course selection for the programme ensures wholesome attainment of knowledge in Fisheries Science and 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. FISHERY BIOLOGY AND AQUACULTURE - ABSTRACT OF PROGRAMME**

	Code	Course	Hours /Week	Total Hrs	Credit
<b>SEMESTER- I</b>	AQ030101	Systematics, Cell and Molecular Biology	5	90	4
	AQ030102	Aquatic Ecology and Fishery Biology	5	90	4
	AQ030103	Biochemistry	5	90	4
	AQ030104	Biostatistics and Computer Applications	5	90	4
	AQ030105	Systematics & Fishery Biology	2.5	60	2
	AQ030106	Biochemistry, Biostatistics and Computer Applications	2.5	60	2
		<b>TOTAL</b>	<b>25</b>	<b>480</b>	<b>20</b>
<b>SEMESTER- II</b>	AQ030201	Capture Fisheries	5	90	4
	AQ030202	Biophysics, Instrumentation and Research Methodology	5	90	4
	AQ030203	Genetics and Biotechnology in Aquaculture	5	90	4
	AQ030204	Fisheries Economics, Management and Extension	5	90	4
	AQ030205	Capture Fisheries, Instrumentation & Biotechnology	5	60	3
		<b>TOTAL</b>	<b>25</b>	<b>420</b>	<b>19</b>
<b>SEMESTER- III</b>	AQ030301	Principles of Aquaculture	5	90	4
	AQ030302	Pathology, Microbiology and Immunology	5	90	4
	AQ030303	Post Harvest Technology and Quality Control	5	90	4
	AQ030304	Ornamental Fish Culture and Sea Weed Culture	5	90	4
	AQ030305	Aquariculture & Seaweed Culture, Microbiology and Fish Processing	5	60	3
		<b>TOTAL</b>	<b>25</b>	<b>420</b>	<b>19</b>
<b>SEMESTER- IV</b>	AQ030401	Culture of Fin Fishes and Shell Fishes	5	90	4
	AQ030402	Water and Soil Quality Parameters	5	60	3
	<b>ELECTIVES</b>	<b>GROUP A / GROUP B</b>	5	72	3
	<b>ELECTIVES</b>	<b>GROUP A / GROUP B</b>	5	72	3
	<b>ELECTIVES</b>	<b>GROUP A / GROUP B</b>	5	72	3
	AQ030403	Project*	-	-	2
	AQ030404	Comprehensive Viva Voce**	-	-	2
	AQ030405	On Job Training ***	-	-	2
		<b>TOTAL (Including Electives)</b>	<b>25</b>	<b>366</b>	<b>22</b>
		<b>Grand Total</b>			<b>80</b>

**ELECTIVES (Credit 3\*3=9)**

	<b>Groups</b>	<b>Code</b>	<b>Course</b>	<b>Hours /Week</b>	<b>Total Hours</b>	<b>Credit</b>
<b>ELECTIVES (Credit 3*3=9)</b>	<b>GROUP A</b>	<b>AQ840401</b>	<b>Aquatic Environment and Biodiversity</b>	<b>5</b>	<b>72</b>	<b>3</b>
		<b>AQ840402</b>	<b>Fish Nutrition</b>	<b>5</b>	<b>72</b>	<b>3</b>
		<b>AQ840403</b>	<b>Seed Production and Hatchery Management of Finfishes and Shellfishes</b>	<b>5</b>	<b>72</b>	<b>3</b>
	<b>GROUP B</b>	<b>AQ850401</b>	<b>Fishing Technology</b>	<b>5</b>	<b>72</b>	<b>3</b>
		<b>AQ850402</b>	<b>Aquatic Toxicology</b>	<b>5</b>	<b>72</b>	<b>3</b>
		<b>AQ850403</b>	<b>Conservation and Management of Exploited Fisheries Resources</b>	<b>5</b>	<b>72</b>	<b>3</b>

\* 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.

\*\*Comprehensive Viva Voce covering the entire topics in the Programme

\*\*\*Training for not less than TWO WEEKS and not more than 30 days must be attended by each student in a reputed government/research institution and a certified report along with attendance certificate may be produced

**SEMESTER- I**

<b>SEMESTER- I</b>	<b>AQ030101</b>	Systematics, Cell and Molecular Biology
	<b>AQ030102</b>	Aquatic Ecology and Fishery Biology
	<b>AQ030103</b>	Biochemistry
	<b>AQ030104</b>	Biostatistics and Computer Applications
	<b>AQ030105</b>	Systematics & Fishery Biology
	<b>AQ030106</b>	Biochemistry, Biostatistics and Computer Applications

**AQ030101- SYSTEMATICS, CELL AND MOLECULAR BIOLOGY****CREDIT: 4****90 HRS.****Module 1: TAXONOMY OF FISH****(38 hrs)**

- 1.1 Introduction to systematics, classification and taxonomy. (1 hr)
- 1.2 Different periods in the history and development of Ichthyology (1 hr)
- 1.3 The earlier (L. S. Berg, 1940) and modern schemes of Classification of fishes proposed by Greenwood et. al (1966) and Nelson, (1984). (2 hrs)
- 1.4 The subclass Chondrichthys – general features and adaptive radiation. Distinctive features of the super order squatio-morphi, Squalomorphi, Galeomorphi and Batoidea with emphasis on specie of economic importance . (9 hrs)
- 1.5 The lower teleost groups Clupeomorpha, Elopomorpha and Osteoglossomorpha. The general characters of these groups with special reference to distinctive feature of important orders and families under each group and their economic importance. (8 hrs)
- 1.6 The modern teleosts (Euteleosts). The super orders Ostariophysii Protacanthopterygii, Paracanthopterygii, Scopelomorpha and Acanthopterygii (Atherinomorpha and percomorpha ). The salient features of orders, suborders and families under each super order with examples of species of economic importance (8 hrs)
- 1.7 General feature of fish skeleton (axial and appendicular Skeleton) . Principal jaw suspensions in fishes, importance of osteological feature in the classification of fishes. (7 hrs)

**Module 2: TAXONOMY OF CRUSTACEA****(15 hrs)**

- 2.1 General classification of crustaceans with emphasis on commercially important groups. (3 hrs)

2.2 Peculiarities of non -malacostracans with emphasis on the classes Branchiopods, Ostracods and Maxillopods and special mention to the subclass Cladocera. (4 hrs)

2.3 Classification of malacostracans – emphasis on commercially important groups in decapods (crabs, prawns, lobsters, shrimps) with examples – the subclass Eumalacostraca , Distinctive features of the order decapoda with reference to important families in each groups ; the sub orders Dendrobranchiata and Pleocyemata. Characteristics of Stenopodidea and Caridea. (8 hrs)

**Module 3: TAXONOMY OF MOLLUSCA (8 hrs)**

3.1 General classification of Mollusca – salient features of major groups, emphasis on economically important forms in gastropods, bivalves and cephalopods. (4 hrs)

3.2 Classification of bivalves based on gill structure (Protobranches, Lamellibranches and Septibranches ) . Adaptive radiation in bivalves. (4 hrs)

**Module 4 : ADVANCES IN TAXONOMIC IDENTIFICATION (7 hrs)**

4.1 Numerical, Phenetic, Cladistic and Molecular. (3 hrs)

4.2 Molecular markers – PCR, RAPD, RFLP, microsatellites, mini satellites and Mitochondrial DNA, and their application in fish phylogenetic studies. (4 hrs)

**Module 5: CELL AND MOLECULAR BIOLOGY (22 hrs)**

5.1 The cell – structural organization: General organization of Prokaryotic and eukaryotic cell and viruses. (1 hr)

5.2 Cell membrane: molecular organization; molecular models of the cell membrane; cell permeability, diffusion; active transport. (2 hrs)

5.3 Cellular interactions: Microvilli and increased surface area; Gap junctions and intercellular communications; cell coat and Cell recognition. Cytoskeleton – tubulin, cilia, flagella, microfilaments, cell motility. (1 hr)

5.4 Endoplasmic reticulum: general morphology; biogenesis and functions; ribosomes; protein synthesis. (2 hrs)

5.5 Golgi complex and cell secretion. Lysosomes, endosomes, peroxisomes; phagocytosis and pinocytosis. (1hr)

5.6 Mitochondria: ultra structure, oxidative phosphorylation and electron transport. (2 hrs)

5.7 Chloroplasts and photosynthesis (1 hr)

5.8 Nucleus – nuclear envelope, chromatin, chromosomes, Karyotype. (1 hr)

5.9 Molecular organization of cell: water, ions, biomolecules, nucleic acids – DNA: structure, genes, gene organization, genetic code, gene regulation, gene amplification during oogenesis, recombinant DNA and genetic modification in aquatic organisms. (3 hrs)

5.10 RNA: structure, type, transcription, processing of RNA. (2 hrs)

5.11 Proteomics: protein structure, types, synthesis and folding. (2 hrs)

5.12 Cell differentiation in embryology, cell cycle – mitosis, meiosis and its significance in reproduction. (1 hr)

- 5.13 Antigens, antigen – antibody interaction: Immunologic. (1 hr)  
 5.14 Muscle cell and locomotion: neurons and transmission. (2 hrs)

## REFERENCES

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**AQ030102 AQUATIC ECOLOGY AND FISHERY BIOLOGY****CREDIT: 4****90 HRS.****Module 1 AQUATIC ECOLOGY****(45 hrs)**

1.1 Introduction to ecological studies, classification of aquatic environments, structure and function of ecosystems, theoretical considerations . Population and community ecology . Energy flow in ecosystems – food chains and food webs.

(5 hrs)

1.2 Fresh water ecology – Introduction – limnology – freshwater Environments – ecological classification . Lakes: origin, characteristics, classification and components . Ponds: origin, characteristics , physico – chemical aspects , nutrient cycling , primary production and biotic components ; Swamps, marshes and mangroves : type – permanent and seasonal – physico chemical conditions . Rivers : origin and characteristics , biological productivity , important river systems of India.

(12 hrs)

1.3 Brackish water ecology : Estuaries – structure and classification estuarine plants , animals and estuarine food webs.

(12 hrs)

1.4 Marine ecology :- classification of marine environments - biotic – abiotic factor influencing the distribution and abundance of animals , coastal environments . Plankton, nekton and benthos – components, adaptations , distribution and importance – methods of collection , preservation and identification – role of plankton in the economy of the sea .Tides , waves , currents , upwelling and red tides .

(12 hrs)

1.5 Pollution ecology : types of pollution – various types of pollutants in aquatic environments – pollution from sewage and other organic wastes – heavy metals, hydrocarbons, pesticides, oil pollution, eutrophication. Bio-security measures.

(4 hrs)

**Module 2 FISHERY BIOLOGY****35Hrs**

2.1 Digestive system: Structure, function and physiology of digestive system and associated glands.

(3hrs)

2.2 Food and feeding habits of finfish and shellfish.

(4hrs)

2.3 Respiratory system: Structure and function of respiratory system and accessory respiratory organs in fin fishes. Respiration in prawns and bivalves.

(4hrs)

2.4 Circulatory systems: Structure and function of circulatory system, Blood, blood cells, plasma, and plasma proteins in fin fishes.

(3hrs)

2.5 Excretory system: structure and functions, osmoregulation in fishes and prawns.

(3hrs)

2.6 Nervous system: Brain and nerves of fin fish and shell fish.

(3hrs)

2.7 Endocrine system: Structure and function of endocrine glands of fishes. Neuroendocrine system of prawns. Role of hormone in relation to reproduction in fishes and prawns.

(4hrs)

- 2.8 Reproductive system: Structure and function of reproductive systems of finfishes, prawns and bivalves. Gametogenesis- spermatogenesis and oogenesis, ovulation and fertilization. Gonadosomatic index. (5hrs)
- 2.9 Parental care in fin fishes. (2hrs)
- 2.10 Age and growth: Principles of age determination. Scale method. Otolith method. Other skeletal parts as age indicators. Length-frequency method. (4hrs)

**Module 3: DISTRIBUTION OF COMMERCIALY IMPORTANT FINFISH AND SHELLFISH IN INDIAN WATER 10Hrs**

- 3.1 Schooling, orientation and migration. Definition of mud banks, wedge bank and parr. Upwelling and its importance to fisheries. Distributional shifts of fishery stock, climate change. 10hrs

**References**

- J. R. Norman & W.P.C. Tenison. 1963 History of fishes. Asian Publishing Hse, Delhi
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- Kapoor V.C. (1991) Theory and practice of Animal Taxonomy. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
- Santhosh Kumar and Manju Tembhre (1996) Anatomy and Physiology of fishes. Vikas Publishing Co.
- Kotpal Mollusca.
- Kotpal. Arthropoda.

**AQ030103 BIOCHEMISTRY****CREDIT: 4****90 HRS.****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, Dextrans, Inulin, Pectin.

2.4 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,  $p$ ,  $K$  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 Primary structure of protein ( *e.g.* insulin).

3.3 Classification and properties of proteins. Conformation of proteins- chemical bonds involved.

3.4 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.

3.5 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.

4.4 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;

5.2 Protein-nucleic acid interaction. DNA regulatory proteins, folding motifs, conformation flexibilities, denaturation, renaturation, DNA polymerases, Restriction endonucleases.

5.3 Biological roles of nucleotides and nucleic acids.

**Module 6 Enzymes** **10 hrs**

6.1 Classification- (I.U.B.system), co-enzymes, iso-enzymes, ribozyme.

6.2 Enzyme specificity.

6.3 Mode of action of enzymes. Formation of enzyme substrate complex. Lowering of activation energy, Various theories, Active site.

6.4 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.

6.5 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<sup>+2</sup> 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.

7.4 Glycogen storage diseases, Lactose intolerance, Galactosuria.

**Module 8 Metabolism of Proteins** **10 hrs**

8.1 Amino acid metabolism-Deamination, Transamination and Trans-deamination. Formation and disposal of ammonia.

8.2 Urea cycle. Fate of carbon skeletons of aminoacids: glucogenic, ketogenic, partly glucogenic and ketogenic with examples.

8.3 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**

9.1 Beta oxidation, alpha oxidation and omega oxidation of fatty acids. *De novo* synthesis of fatty acids.

9.2 Metabolism of cholesterol, synthesis and its regulation. Biosynthesis of triglycerides.

9.3 Metabolism of ketone bodies - Ketogenesis, Ketolysis, Ketosis.

### **Module 10 Nucleic Acid and Mineral Metabolism**

**8 hrs**

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.

### **REFERENCES**

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**AQ030I04 BIOSTATISTICS AND COMPUTER APPLICATIONS****CREDIT: 4****90 HRS.****Module 1 Biostatistics****40hrs****1.1 Collection, compilation and analysis of the data****8 hrs**

Primary and secondary data- formation of length and weight frequency distribution, measures of central tendency-Mean, median and mode.Measures of dispersion – range, quartile deviation, mean deviation and standard deviation. Absolute and relative measures of dispersion.

**1.2 Correlation and Regression analysis****8hrs**

Scatter diagram- Karl Pearson's coefficient of correlation- Spearman's Rank Correlation coefficientcoefficient of determinationRegression analysis-Linear regression equations and their uses. Length – weight relationship and von Bertalanffy growth equation.

**1.3 Probability and Theoretical Distribution****8hrs**

Frequency approach and Axiomatic approach to probability - Mutually Exclusive and independent events - Addition and Multiplication theorems - Binomial, Poisson and Normal distribution

**1.4 Statistical Quality Control****6hrs**

Process control and product control – control chart for variables and attributes – mean and range charts, fraction defective chart ('p' chart) and 'c' charts – sampling inspection plans.

**1.5 Theory of Sampling and Inference****10hrs**

Population of sample, determination of the sample size – sampling techniques – estimation of marine fish landings in India. Null and alternative hypothesis-two types of errors in testing of hypothesis – large and small sample tests – 'Z', 't',  $X^2$  and F-tests- Analysis of variance Techniques – Single factor – ANOVA

**Module 2 Computer Application****50Hrs****2.1 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 Extensions; Temporary Files; Folder; GUI, Icon; Installation of Programs, Commands, Bios-setup, Date and Time, Memory Partitions, Registry, Default Operations; Defragmentation (Brief account only).

**2.2 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).

### **2.3 Software Basics**

**12 hrs**

System Software/Operating System -System Files; Working of OS; DOS, Widows, 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).

### **2.4 Computer Language and Programming**

**7 hrs**

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

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

### **2.5 Networking, Internet and Information Technology**

**10hrs**

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).

### **2.6 Computerized information systems in Fisheries**

**8hrs**

Remote sensing applications, GPS, Statistical data analysis packages, Aquaculture software.

### **References**

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- Thomas, R.M. 1992. DOS5, BPB publishers, New Delhi.
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- Gupta, C.B.1996. An Introduction to Statistical methods. Vikas Publications House Pvt, Ltd. New Delhi.
- Srestha, H.B.1989. Elementary statistical methods, Orient Longman Ltd, Calcutta.

**AQ030105 Systematics and Fishery Biology****Credit : 2**

Practical 1 Study on the morphology -scales, teeth, tails and fins of - commercially important Fin fish.

Practical 2 Study on the morphology of shell fishes-crustaceans and molluscs.

Practical 3 Dissection of alimentary canal and internal organs (Viscera) of a typical teleost fish and calculation of RGL.

Practical 4 Dissection of alimentary canal of a prawn.

Practical 5 Identification of commercially important fin fishes of the order Clupeiformes, Cypriniformes, Perciformes, Siluriformes, Pleuronectiformes

Practical 6 Identification of commercially important crustaceans

Practical 7 Identification of commercially important molluscs.

Practical 8 Identification of fish bones and study of skeletal system in fishes, a minimum of one cartilaginous fish and one bony fish.

Practical 9 Identification of eggs, larvae and post larvae of commercially important species of fishes, crustaceans and mollusks.

Practical 10 Qualitative and quantitative analysis of gut contents. Index of preponderance.

Practical 11 Determination of gonadosomatic index, fecundity and its relationship with length and weight.

**AQ030106 Biochemistry, Biostatistics and Computer Applications****Credit : 2**

Practical 1 Estimation of glucose, protein, total lipid, cholesterol in serum/tissue

Practical 2 Estimation of acid phosphatase, alkaline phosphatase in blood, serum/tissue

Practical 3 Chromatography (paper/TLC) for the separation and identification of amino acids

Practical 4 Polyacrylamide gel electrophoresis/paper electrophoresis for the separation of proteins

Practical 5 Micrometry

Practical 6 Phase contrast microscope, camera lucida, micro-photographic equipment

Practical 7 Preparation of permanent whole mounts

Practical 8 Preparation of double stained serial sections to study histological details (intestine/liver/gill).

Practical 9 Bio-statistics - problems (Measure of Dispersion, Correlation, Graphs and Diagrams, Problems in Tests of Significance- $\chi^2$ , t, z .

Practical 10 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**

<b>SEMESTER- II</b>	<b>AQ030201</b>	Capture Fisheries
	<b>AQ030202</b>	Biophysics, Instrumentation and Research Methodology
	<b>AQ030203</b>	Genetics and Biotechnology in Aquaculture
	<b>AQ030204</b>	Fisheries Economics, Management and Extension
	<b>AQ030205</b>	Capture Fisheries, Instrumentation & Biotechnology

**AQ030201 CAPTURE FISHERIES****Credit : 4****90Hrs****Module 1****(12 Hrs)**

Major inland waters of the world and of India, their fish fauna. Global inland fish production- Trends. Major inland fish producing countries and ecosystems. Theories of distribution of freshwater fishes in India. Categorization of different freshwater fisheries resources: Ponds, lakes, bheels, tanks, estuaries, brackish water lagoons, wetlands, biosphere reserves and mangroves and derelict water bodies.

**Module 2****(8 Hrs)**

Inland fisheries development in India, Freshwater fisheries research institutions in India (CIFRI, CIFA, NRCCWF).

**Module 3****(20 Hrs)**

Riverine fisheries: Ecology of river fisheries: fish fauna - size, abundance, subpopulation, migration, movements, feeding and reproduction. Major river systems of India and their fisheries. Development of inland fisheries Characteristics of fisheries: use, types of crafts and gear, preservation of fish, effects of other uses of river basins on fisheries. Assessment: fishery potential, fishery and fish stock. Direct and Indirect effects of human intervention in rivers, habitat modification and improvement (rehabilitation of channels and flood plains), protection and restoration of fish movements (different types of fish passes and enhancement of fish migration), management and repair of riverine vegetation, stock enhancement strategies like introduction of new species, pre- and post- stocking management, potential risk of stocking. Impacts of dams in riverine fisheries. Management of river systems for fisheries.

**Module 4**

(8 Hrs)

Reservoir fisheries: Introduction. Ecology and classification of reservoir fish fauna. Crafts and gears. Cage and pen culture. Pollution in reservoirs. Exotic fishes and their role in reservoir fisheries of India. Reservoir fisheries of Kerala. Management of reservoir fisheries. Culture based capture fisheries.

**Module 5**

(8 Hrs)

Lacustrine fisheries: Fish fauna of natural lakes. Management and conservation of fisheries of lakes.

**Module 6**

(8 Hrs)

Cold water fisheries of India. Management of cold water fishery. Development of sport fishing in India.

**Module 7**

(10 Hrs)

Estuarine fisheries: Introduction. Estuarine fishery resources of India in general and their management. Fisheries of major estuarine systems in India (short account). Fisheries of Hooghly-Matlah estuary. Brackishwater fishery resources of Kerala.

**Module 8**

(8 Hrs)

Swamps, marshes and rice fields fishery potential with special reference to mangroves. Importance of wetlands in fisheries resource management.

**Module 9**

(8 Hrs)

Brief history of Inland fishery management. Management and conservation of inland fishery resources. Fisheries legislation. Kerala inland fisheries bill. Government projects for enhancing Inland fish production

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16. Sharma A.P. 2012. *Management issues in Inland Fisheries and Aquaculture*. Narendra Publishing House, Delhi, 243pp.
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18. Srivastava, U.K & M.B. Reddy 1983. *Fisheries Development in India*. Concept Publishing Co. New Delhi, 606 pp.
19. Srivastava, C.B.L. 2001. *A Text Book of Fishery Science and Indian Fisheries*. Kitab Mahal, Delhi.
20. Sugunan, V.V. 1995. *Riverine Fisheries of India*. FAO Publication, 423 pp.
21. Sugunan V.V. 1997. *Reservoir Fisheries of India*. Daya Publ. House.
22. Templeton. R. 1995. *Freshwater Fisheries Management*. Fishing News Books, Oxford, 241 pp.
23. Wanganeo & Ashwani. 2006. *Trends in Biodiversity & Aquaculture*. Daya publishing house, Delhi, 472PP.
24. Welcomme, R.L. 1979. *Fisheries Ecology of Floodplain Rivers*. Longman Inc., NY, 315 pp.
25. Welcomme, R.L. 2007. *Inland Fisheries. Ecology and Management*. Discovery Publ. House., New Delhi, 358 pp

**AQ030202 BIOPHYSICS, INSTRUMENTATION AND RESEARCH METHODOLOGY****Credit : 4****90Hrs****MODULE 1 BIOPHYSICS****1.1 Diffusion and Osmosis****10 Hrs**

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

1.1.9 Osmosis : Vant Hoff Laws; Osmotic concentration and Osmotic pressure

1.9.3 Biological significance of osmosis in fishes

**1.2 Bioenergetics****6 Hours**

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

1.2.2 Photo Bioenergetics : Photosynthesis, photosynthetic reaction – light reaction and dark reaction – Redox potential.

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

**1.3 Radiation Biophysics****4Hours**

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

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

1.3.3 GM counter, liquid scintillation counter.

**MODULE 2 INSTRUMENTATION****60 Hours****2.1 Types of Microscopic Preparations****6 Hours**

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.

**2.2 Cytochemical Methods****5 Hours**

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

**2.3 Museum Preparations****7 Hours**

Preservation of animals, alizarin preparation, stuffing skeletal preparations.

**2.4 Microscopy: Principle, instrumentation and application****10 Hrs**

2.4.1 Light microscope, camera lucida, micrometry

- 2.4.2 Dark field microscope
- 2.4.3 Phase contrast microscope
- 2.4.4 Fluorescence microscope
- 2.4.5 Electron microscope (TEM and SEM)
- 2.4.6 Photomicrography
- 2.4.7 Autoradiography

**2.5 Chromatography: General principles and techniques 10 Hrs**

- 2.5.1 Column chromatography
- 2.5.2 Paper chromatography
- 2.5.3 Thin layer chromatography
- 2.5.4 Gas chromatography and GLC
- 2.5.5 Ion exchange chromatography
- 2.5.6 Gel filtration
- 2.5.7 HPLC
- 2.5.8 Affinity chromatography

**2.6 Electrophoresis**

**10 Hrs**

- 2.6.1 Paper electrophoresis
- 2.6.2 Gel electrophoresis
- 2.6.3 Polyacrylamide gel electrophoresis (SDS)
- 2.6.4 High voltage electrophoresis
- 2.6.5 Immuno-electrophoresis

**2.7 Spectroscopy, AAS**

**2 Hrs**

**2.8 NMR, RIA, ELISA**

**2 Hrs**

**2.9 Centrifugation**

**2 Hrs**

**2.9.1 Types of centrifuge**

**2 Hrs**

**2.9.2 Differential and Density Gradient Centrifugation**

**2 Hrs**

**2.10 pH Meter**

**2 Hrs**

**MODULE 3 RESEARCH METHODOLOGY**

**10 Hrs**

**3.1 Introduction**

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 sources critical literature reviews. 3 hrs.

**3.2 Data Collection and Analysis**

Collection of primary and secondary data, selection of appropriate methods of data collection, data preparation, important steps, types of analysis. 2 hrs.

**3.3 Interpretation and Report Writing**

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. 5hrs.

## **REFERENCES**

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## **AQ030203 GENETICS AND BIOTECHNOLOGY IN AQUACULTURE**

**Credit : 4**

**90Hrs**

### **MODULE 1 Genetics in Aquaculture**

**34hrs**

**1.1 Introduction to Genetics.** Fish cytogenetics, principles of genetics techniques in cytogenetics. Evolution of fish Karyotypes sex linked genes and sex. Limited phenotypes, quantitative phenotypes, pleiotropy, recent trends in genetic mutations. Types of mutations and mutagens. Gene expression and regulation. 10hrs

**1.2 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. 12hrs

**1.3 Hybridisation:** Types of hybridisation, naturally occurring and artificially produced cyprinid hybrids. Cultural traits of hybrids. 2Hrs

**1.4 Genetic improvement, selective breeding, domestication and strain evaluation :** Genetic manipulation: Sex-reversal and sex control, role of steroids in sex reversal, chromosomal manipulate, polyploidy. Androgenesis and Gynogenesis, cryopreservation of gametes, gametic manipulation. 10hrs

### **MODULE 2 Biotechnology in aquaculture**

**56hrs**

**2.1 Genetic Engineering and Biotechnology in aquaculture-** 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. 15hrs

**2.2 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.

**2.3 Biotechnological Applications in Pearl Culture** – genetic improvement, improvements in surgical techniques, biomineralization of nacre.

**2.4 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.

**2.5 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 – immunodiagnosics, nucleic acid based diagnostics. 12hrs

**2.6 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. Information networks: internet; Gene bank sequence database, EBI-net; NCBI, Genome net. 8hrs

**2.7 Marine Bioresources** – Bioactive compounds from the sea, marine natural products and metabolites. Microbes, micro and macro algae, diatoms, echinoderms, bryozoans, soft corals, sponges 6hrs

### References

- Yadav, B.V. 1995. Fish Endocrinology, Daya Publishing House, New Delhi.  
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 Tiews, K (Eds.) Selection, Hybridisation and Genetic Engineering in Aquaculture. Heenemann, Berlin. Das, P. and Jhingran A.G. (Eds.) Fish Genetics in India. 1989. Today and Tomorrows printers and publishers, new Delhi.  
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 Thomas, P.C. 1998. Shrimp Seed Production and Farming. Cosmo Publication.

**AQ030204 FISHERIES ECONOMICS, MANAGEMENT AND EXTENSION****Credit : 4****90Hrs****MODULE 1 FISHERY ECONOMICS****(35 hrs)**

Introduction to fisheries economics. General classification of fishery and ancillary industries – catching, processing, distribution, marketing . (5 hrs)

1.2 Economics of fisheries exploitation. Exploitation under common property and sale – ownership conditions. Profit and rent in the short run and the long run. (5 hrs)

1.3 Economics of fishing vessels : cost and earnings of fishing vessels – Break even points and profitability . Profitability and its relation to space, time, ownership, technology, resource and price . (5 hrs)

1.4 Economics of fish farms: cost and earnings. Economics importance. Profitability and its relation to farm size, species Stocked and input. (5 hrs)

1.5 Economics of fish processing units : Economics viability, factors affecting viability ; viability of the freezing , canning and curing units (5 hrs)

1.6 Managerial economics: The firm and its objects, decision making. Theory of consumer behavior. Demand forecasting – objectives and techniques . Product and cost analysis. Cost – revenue relationships . (5 hrs)

1.7 Economics of fish marketing Marketing function, Marketing Institutional and structure. Marketing of fish in India – supply, demand, pricing. Fish in International Trade – imports and exports. (5 hrs)

**MODULE 2: FISHERIES MANAGEMENT****(33 hrs)**

2.1 Concept of fishery management : Biological aspects, economics aspects, social aspects, property right . Management of hatcheries and farms. (5 hrs)

2.2 Organization and administration of fisheries at the central and state levels, responsibilities, management and conservation of resource . (4 hrs)

Need for management, management objectives, method of regulation. (3 hrs)

2.4 Availability of manpower and skilled labour in India ; personnel requirements and management; materials management ; energy requirements and management. (3 hrs)

2.5 Financial management (3 hrs)

2.6 Poaching and natural calamities. (3 hrs)

2.7 Water quality control for hatcheries and farms. (3 hrs)

2.8 Criteria and nature of data input needed for preparation of Feasibility report on hatcheries. (3 hrs)

2.9 Criteria and nature of data input needed for preparation for various type and scales of aquaculture (3 hrs)

2.10 Criteria and nature of data input needed for preparation of feasibility report on fish feed mill. (3 hrs)

**MODULE 3: FISHERIES EXTENSION****(22 hrs)**

- 3.1 Theory, principles and objectives of extension. (5 hrs)
- 3.2 Role of extension in community development. (3 hrs)
- 3.3 Rural development strategies: programmes for the weaker section of the community . Fisheries as a tool in rural development . Extension strategies and methodology. Adoption of villages for integrated rural development, socio – economics. (3 hrs)
- 3.4 Status of extension activities in fisheries; transfer of technology, behavior pattern of fishermen to structural changes. (3 hrs)
- 3.5 Extension teaching – learning process Extension communication, extension teaching methods and audiovisual aids. (2 hrs)
- 3.6 Extension programme planning . Training and evaluation. (3 hrs)
- 3.7 Transfer of technology programmes of I C A R , recognized extension systems , agencies involved in fisheries extension . (3 hrs)

**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
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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.

**AQ030205 CAPTURE FISHERIES, INSTRUMENTATION & BIOTECHNOLOGY****CAPTURE FISHERIES**

Basic principles of gear design and construction

Mesh size measurements

Shape Cutting

Baiting

Creasing

Tailoring

Fly Meshing

Hanging Coefficient

Mounting – Different methods.

Mending of nets

Preparation of glossary on fishing craft and gear (around 100 terms)

**INSTRUMENTATION**

Chromatography (Paper/TLC) for the separation and identification of amino acids.

Polyacrylamide gel electrophoresis/paper electrophoresis for the separation of proteins.

Conductivity meter, salinometer, refractometer demonstration.

**BIOTECHNOLOGY**

Nucleic acid isolation (genomic/plasmid DNA and RNA); Agarose gel electrophoresis; Nucleic acid quantification;

Southern hybridization, probe Labeling methods; Primer designing; DNA sequencing and analysis.

Internet search: retrieving information from different data base like NCBI, protein information sources;

Preparation of data base; Use of genome analysis packages: genetics data base; Searching by similarity;

Phylogenetic analysis; Accessing and submission to gene banks; BLAST, FASTA.

Extraction of bioactive compounds from seaweeds, microalgae, sponges and test their efficiency microbiology, biochemistry and molecular assays.

**SEMESTER- III**

<b>SEMESTER- III</b>	<b>AQ030301</b>	Principles of Aquaculture
	<b>AQ030302</b>	Pathology, Microbiology and Immunology
	<b>AQ030303</b>	Post Harvest Technology and Quality Control
	<b>AQ030304</b>	Ornamental Fish Culture & Sea Weed Culture
	<b>AQ030305</b>	Aquaculture & Seaweed Culture , Microbiology & Fish Processing

**AQ033T09 PRINCIPLES OF AQUACULTURE****Credit : 4****90Hrs****MODULE 1 SYSTEMS IN AQUACULTURE****(5 hrs)**

1.1 Types of aquaculture – intensive, semi intensive and Extensive – advantages and disadvantages. Mono culture, poly culture, integrated fish farming. Sewage fed fish culture. (2 hrs)

1.2 Major culture systems – ponds, reservoirs, running waters, cage and pen culture – water recirculation system, raceway culture. (3 hrs)

**MODULE 2 CONSTRUCTION OF FISH FARMS****(30 hrs)**

2.1 Site selection – principles of site selection for various kinds of fish farms – technical consideration, topography, soil texture, water supply and seed availability . Non – technical considerations – socio – economic and legal aspects. (5 hrs)

2.2 Design and mode of construction – layout plan, design and construction of aqua farms, water exchange structures, different type of drainage systems design of inlets and outlets, monks and sluice gates, water pumps, design of pumping units . Preparation of breeding pond, nursing and rearing ponds – hatcheries, incubation, filter devices and waste – water recycling . (10 hrs)

2.3 Management of fish farms – eradication of harmful insects, predators and weeds – mechanical , chemical and biological control measures . Pond fertilization – liming, ploughing, organic and inorganic fertilizers used in aquaculture.(10 hrs)

2.4 Harvest and post harvest technology – optimal size for harvesting – methods of harvesting, marketing. (5 hrs)

**MODULE 3 NUTRITION IN AQUACULTURE****(40hrs)**

3.1 Nutritional requirements – proteins, amino acids, fats, carbohydrates, vitamins and minerals – energy metabolism in fish – factors affecting energy requirements in fish. (8 hrs)

3.2 Natural diets – natural feed requirements. Natural feed for various stages – larvae , fry and adults . (6 hrs)

- 3.3 Mass culture of fish food organisms – culture of *Artemia*, *Chlorella*, cladocerans and rotifers. (10 hrs)
- 3.4 Prepared feed – formulation and preparation of artificial feeds – types, ingredients, diet formulation – Quality of prepared feeds – physical and chemical – economics and cost efficiency of prepared feeds – storage of feeds. (6 hrs)
- 3.5 Feed additives – growth promoters, antibiotics, pigments, antioxidants, probiotics . (3 hrs)
- 3.6 Feed energetic – feed efficiency – assimilation efficiency, conversion efficiency, digestibility, palatability, FCR . (3 hrs)
- 3.7 Feeding practices – feeding schedule – dispensing methods – feeding intensity. Different systems of fish feeding. (4 hrs)

**MODULE 4: HEALTH AND DISEASE MANAGEMENT IN AQUAFARMS (5 hrs)**

- 4.1 Problems related to stocking density, feeding intensity, water quality, algal blooms and pollutants . (3 hrs)
- 4.2 Integrated health management – prophylactic measures, immunization, farm disinfection. (2 hrs)

**REFERENCES**

- Beveridge, M.C.M. (1987) Cage aquaculture. Fishing News
- Davy E.B. and M.Graham Eds (1982) Bivalve culture in Asia and Pacific. IDRC Asia Regional Office Singapore.
- Milne.P.H (1972) Fish and shell fish farming in China. Fishing News
- Bardach, J.E.W (1972) Aquaculture farming and husbandry of freshwater and marine organisms
- Galtsoff, P.S., Culture methods for invertebrate animals
- Thomas P.C (Ed) Current and emerging trends in aquaculture
- Coche, A.G., Muir, J.F. Simple methods for aquaculture: Pond construction for freshwater.
- Introduction to aquaculture Pillai, T.V.R., Aquaculture principles and practices
- Jonathan Shepherd, C. (Ed) Intensive Fish Farming
- William Royce, F., An introduction to the practice of fishery science.
- Planning of Aquaculture Development. FAO, Fishing News Books
- Advances in Aquaculture. FAO, Fishing News Books.
- Pullin, R.S.V. and Chehadeh, Z.H. (Eds.). Integrated Agriculture-Aquaculture Farming Systems. ICLARM.
- Aquaculture Systems and Practices – A Selected Review. UNDP, FAO

**AQ030302 PATHOLOGY, MICROBIOLOGY AND IMMUNOLOGY****Credit : 4****90Hrs****MODULE 1 PATHOLOGY****45 Hrs**

1.1 Introduction to the study of pathology – Infectious and non infectious diseases – Epizootic and Enzootic infections . 1 hr

1.2 Parasites and parasitism – Ecto – meso – and endoparasites – parasitic adaptations – effect of parasitism – host – parasites relationships – factors influencing parasitism – Defense mechanism – Tissue reactions in parasitic diseases . 4 hrs

1.3 Fin fish diseases: Diseases caused by microbial pathogens. Viral diseases (Lymphocystis, IPN, VEN, IHN, VHS) – Bacterial diseases (Bacterial gill disease, columnaris disease, cold water disease, Enteric red mouth disease Furunculosis, vibriosis, bacterial kidney disease , mycobacteriosis) Fungal diseases (Saprolegniasis, Branchimycosis, Ichthyophthiriosis, Aspergillomycosis). 10 hrs

1.4 Diseases caused by protozoan parasites – ciliatesm Flagellates, Apicomplexa, Myxosporea and microsporidia - Habitat, morphology, lifecycle and pathogenicity of major protozoans infecting fishes. 8 hrs

1.5 Diseases caused by metazoan parasites . Helminth parasites (monogenea, Digenea, Cestoda, Nematoda and Acanthocephala) , Annelids, crustacean parasites (Branchiura , Copepoda, Isopoda) and molluscan parasites . Habitat, morphology , life cycle and pathogenicity of major metazoan parasites infecting fin fishes. 9 hrs

1.6 Shellfish disease – Diseases of shell fish caused by microbial pathogens . Viral diseases (monodon baculovirus, BMNV, IHHNV, HPV, YBV, WSV ) – Bacterial disease (Brown , spot disease Black gill disease ) – Fungal disease (Larval mycosis, Fusarium disease) Diseases caused by parasitic protozoa, Helminths and parasitic Crustaceans. 8 hrs

1.7 Neoplastic diseases – principal tumor types in fishes (epithelial, mesenchymal, neural, pigment cell and embryonal tumors) . Genetically and environmentally induced diseases, Nutritional diseases and pollution associated diseases in fin fish and shell fish. 5 hrs

1.8 Therapy of fish diseases – external, chemical treatment – systemic treatment via diet control . Parasites and disease out break in aquaculture systems. Biological control of parasites . Economic effects of fish diseases – zoonoses : fish parasites and public health significance. 5 hrs

**MODULE 2 MICROBIOLOGY****35Hrs**

- 2.1 Fundamental principles of bacteriology, -Morphology, size, reproduction and growth. Bacterial spores, staining of bacteria, various staining methods Effect of environment on growth of bacteria-classification of bacteria.
- 2.2 Intrinsic and extrinsic parameters affecting microbial growth in food.
- 2.3 Native bacterial flora of fish; Microbes causing fish spoilage; Spoilage microorganisms of fishery products; Psychrophilic and mesophilic microbes in processed fishery products. Effect of low temperature, high temperature, salting, drying and hurdle technology on bacteria. Fecal indicator organisms and bacterial pathogens viz. Pathogenic *E.coli*, *S. aureus*, Salmonella, Shigella, Pathogenic Vibrios, *L. monocytogenus*, *Clostridium* etc. in fish and fishery products.
- 2.4 Microbial analysis of water, fish contact surfaces, fish and fishery products including isolation and identification of various bacterial pathogens.
- 2.5 Biological hazards in seafood.

**MODULE 3 IMMUNOLOGY****10 Hrs**

- 3.1 Types of immunology – Innate, racial, acquired, local immunity, herd immunity, autoimmunity . Hypersensitivity and delayed hypersensitivity. 1 hr
- 3.2 Vaccines – bacterial, viral, bacterial products. Factors affecting immunity , environmental stress genetic aspects and disease resistance. 1 hr
- 3.3 Antigen – determinants of antigenicity , antibody structure, different classes of immunoglobulins, immunoglobulin specificity . 1 hr
- 3.4 Antigen – antibody reactions, methods for determination of antigen – antibody reaction , immunodiffusion, Electro – immunodiffusion, ELISA, / SDS - PAGE and western blot, conjugated antibodies 2 hrs
- 3.5 Agglutination reaction – complement fixation test, neutralization test, monoclonal antibodies . 1 hr
- 3.6 Non – specific defense mechanism, surface barriers (mucus, skin, gills, gut) . Non specific humoral factors (growth inhibitors, lysins, precipitins and agglutinin ) Non – specific cellular factors (Phagocytes, Eosinophils, Basophils and mast cells) Inflammation – control of inflammation and phagocytic activity. 2 hrs
- 3.7 Specific defense mechanism – Lymphocytes, Lymphoid organ (Thymus, kidney, spleen ) Antigen trapping – immunoglobulin , antibody responses . Cell mediated immunity – local immune, mucosal immune responses, immune memory, vaccination of fishes. 2 hrs

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- 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.](#)

**AQ030303 POST HARVEST TECHNOLOGY AND QUALITY CONTROL****Credit : 4****90Hrs****MODULE 1 FREEZING TECHNOLOGY****20Hrs**

1.1 Refrigeration, refrigeration load, refrigerants, cold storage of fish. Crystallization, freezing curves for pure water and water in fish, physical and chemical changes on freezing, effect of freezing on location and size of ice crystals 6 Hrs

1.2 Technological aspects of freezing: Slow freezing and quick freezing, Air blast freezing, tunnel freezing, fluidized bed freezing, spiral freezing, immersion freezing, contact plate freezing, cryogenic freezing and high pressure freezing. 6 Hrs

1.3 Freezing on board fishing vessels, IQF freezers, selection of a freezing method, cold store and cold storage, chemical, physical and sensory changes during freezing and cold storage. Chemical treatment of fish prior to freezing, TTT and PPP factors, packing of frozen products, processing and freezing of frozen sea food products for export from India. 8 Hrs

**MODULE 2 CANNING****15 Hrs**

2.1 Principles of canning: Heat transfer in canned fish, thermal destruction of bacteria, D and D<sub>0</sub> value, F<sub>0</sub> value, Z value, determination of process time, cook value, Aseptic packing, containers for canning, unit operations, equipment used for canning, canning of sardine, tuna, and prawns. Retort pouch packaging. 10 Hrs

2.2 Waste management in canning industry, defects of canned product 5 Hrs

**MODULE 3 CURING AND DRYING****8 Hrs**

3.1 Water content and water activity, water activity and microbial spoilage, drying of fish, constant rate and falling rate drying period, salting and salting methods, drying methods for fish, packaging and storage. Quality problems and solutions. Maillard reaction, lipid oxidation, microbial, fungal and insect's infestation. Packaging of dried products. 4 Hrs

3.2 Smoking: objectives, smoke production, smoke components, quality, safety and nutritive value, processing and equipment. 2 Hrs

3.3 Freeze drying of fish: Accelerated freeze drying. Packaging of freeze dried products. Modified Atmospheric Packaging. 2 Hrs

**MODULE 4 BY-PRODUCTS AND VALUE ADDITION****15Hrs**

4.1 Mince and surimi, freezing and storage. Fish protein concentrate, fish meal and oil, fish liver oil, fish hydrolysate, fish silage, Caviar, gelatin, glue, pearl essence, dehydrated jelly fish, squalene, fish maws and isinglass, Ambergris, Beche de mer. Chitin, chitosan, and glucosamine hydrochloride, Utilization of prawn waste and fish processing waste. Processing and extraction of algin, alginic acid, alginates, agar, manitol, and carragernan. 10 Hrs

4.2 Coated fish products, batter, bread crumbs, and general procedure for preparation of battered and breaded products, objectives, packaging and storage, equipment for making coated products, quality of coated products. 5 Hrs

**MODULE 5 QUALITY CONTROL****32Hrs**

5.1 TQM concept and application 3Hrs

5.2 Quality control and assessment in fish and fishery products 5Hrs

5.2.1 Organoleptic, Physical, Chemical and Microbiological quality

5.2.2 Quality standards

5.2.3 Quality Assurance

5.3 Inspection and Quality Control 8Hrs

5.3.1 Inspection and Inspection agencies in India

5.3.2 Process water quality in processing industry

5.3.3 Product quality

5.3.4 Water analysis and treatment: Chlorination, Ozonization, UV Radiation, Reverse Osmosis, Removal of pesticides and heavy metals

5.4 Sensory evaluation of fishery products 3Hrs

5.4.1 Different methods of evaluation

5.4.2 Taste panel selection and constitution

5.4.3 Statistical Analysis

5.5 Quality Standards and Problems in Fishery Products 6Hrs

5.5.1 GMP's

5.5.2 HACCP and ISO 9000 series of quality assurance

5.5.3 Validation and Audit

5.5.4 National and International Standards

5.5.5 EU Regulations on Fishery Products Export

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

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

5.6 Factory Sanitation and Hygiene 2Hrs

5.6.1 National and International requirements

5.6.2 SSOP	
5.7 Hazards in Sea Foods	5Hrs
5.7.1 Seafood toxins	
5.7.2 Biogenic amines	
5.7.3 Heavy metals and industrial pollutants	

## REFERENCES

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- Kreuzer, R. Freezing and irradiation of fish. Fishing News., London
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- Kreuzer, R. (Ed) Fishery products. Fishing News England.
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**AQ030304 ORNAMENTAL FISH CULTURE & SEA WEED CULTURE****Credit : 4****90Hrs****CONSTRUCTION AND MAINTENANCE OF AQUARIUM****45 Hours****Module 1 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
- 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 arium
- 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** 20 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.

**Module 7 Freshwater Plants** **10 Hrs**

- 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.

**SEAWEED CULTURE** **(5 Hrs)**

**Module 8** **(2 hrs)**

- 8.1 An over view of sea weed culture – economically important sea weeds – its taxonomy, distribution, growth, reproduction and factors affecting growth .
- 8.2 Culture technology of sea weeds. Species cultured, site selection, design of culture plots, rearing, monitoring of growth and environmental changes . Harvesting – size, weight, harvesting methods . Production – post harvest technologies – cleaning, washing, drying, storage & processing . Extraction of products. **(3 hrs)**

**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. Carcason, 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.
17. Maurice Melzak. Marine Aquarium Manual. B.T. Balsford Ltd., London.

## **AQ030305 AQUARICULTURE & SEAWEED CULTURE, MICROBIOLOGY AND FISH PROCESSING**

### **Aquariculture & Seaweed Culture**

1. Identification of common Fresh water aquarium fishes (15 Nos.)
2. Indigenous ornamental fishes of Kerala (5Nos.)
3. Construction of aquarium
4. Setting up of aquarium (maintained by students can be evaluated after one month )
5. Water quality management in aquariums
6. Aquarium plants and décor materials
7. Air pump and biological filter
8. Breeding of live bearers-Guppy
9. Breeding of egg layers- gold fishes
10. Breeding of bubble nest builder- Gourami
11. Control of snails in ornamental fish culture system
12. Ornamental fish farms- general description
13. Marine aquarium fishes and invertebrates
14. Setting up of reef aquarium
15. Diseases of aquarium fishes ( Symptoms and treatments)
16. Collection and identification of economically important seaweeds of India.

### **Microbiology**

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. Estimation of common bacteria of aquatic environment.

### **Fish Processing**

1. Filleting of fish, treatments, glazing, packaging and freezing.
2. Frozen storage studies.
3. Examination of canned fishery products.
4. Can seams
5. Testing sterility
6. Preparation of fish meal, FPC, fish oils, chitin, chitosan, glucosamine hydrochloride, fish maws, isin glass, agar, alginic acid etc.

**SEMESTER- IV**

<b>SEMESTER-IV</b>	<b>AQ030401</b>	<b>Culture of Finfishes and Shellfishes</b>
	<b>AQ030402</b>	<b>Water and Soil Quality Parameters</b>

	<b>Groups</b>	<b>Code</b>	<b>Course</b>	<b>Hours/Week</b>	<b>Total Hours</b>	<b>Credit</b>
<b>ELECTIVES (Credit 3*3=9)</b>	<b>GROUP A</b>	<b>AQ840401</b>	<b>Aquatic Environment and Biodiversity</b>	<b>5</b>	<b>72</b>	<b>3</b>
		<b>AQ840402</b>	<b>Fish Nutrition</b>	<b>5</b>	<b>72</b>	<b>3</b>
		<b>AQ840403</b>	<b>Seed Production and Hatchery Management of Finfishes and Shellfishes</b>	<b>5</b>	<b>72</b>	<b>3</b>
	<b>GROUP B</b>	<b>AQ850401</b>	<b>Fishing Technology</b>	<b>5</b>	<b>72</b>	<b>3</b>
		<b>AQ850402</b>	<b>Aquatic Toxicology</b>	<b>5</b>	<b>72</b>	<b>3</b>
		<b>AQ850403</b>	<b>Conservation and Management of Exploited Fisheries Resources</b>	<b>5</b>	<b>72</b>	<b>3</b>

**AQ030401 CULTURE OF FIN FISHES & SHELL FISHES****Credit : 4****90Hrs****FINFISH CULTURE****(48 hrs)****Module 1 INTRODUCTION****(4 hrs)**

- 1.1 Role and importance. Over view of fin fish culture in the world. (2 hrs)
- 1.2 Fin fish culture in India – background and recent developments. (2 hrs)

**Module 2 FRESHWATER FINFISH CULTURE****(24 hrs)**

- 2.1 Culture of Indian major carps – pre stocking management – predators, weeds, algal blooming and their control – seed stocking, post stocking management, feeding techniques – supplementary feeds and feeding, harvesting (5 hrs)

2.2 Culture of exotic fishes – common carp, silver carp, grass carp, Tilapia and Gourami . Species cultivated, seed procurement, methods of breeding stocking, nursing, rearing and grow out techniques. (8 hrs)

2.3 Culture of predatory and air breathing fishes – food and feeding habits, breeding techniques, rearing and culture methods of *Channa*, *Heteropneustes Clarius* and *Anabas* . (5 hrs)

Culture of cold water fishes and game fishes –practices followed and prospects, important hatcheries in India, important species propagated – distribution, feeding habits, growth and reproduction. Culture of Trouts, Mahaseer and salmon – spawning, nursing, rearing and grow out systems . (6 hrs)

### **Module 3 COASTAL FIN FISH CULTURE (12 hrs)**

3.1 Brackish water fish culture – breeding and culture of brackishwater fin fishes – milk fish, pearl spot and mullets – existing culture practices – monoculture and polyculture . (8 hrs)

3.2 Marine fin fish culture – culture in cages and pens. Sea ranching of fin fishes. (4 hrs)

### **Module 4 SEWAGE FED FISHERIES, INTEGRATED FISH FARMING (8 hrs)**

4.1 Sewage and its utilization in fish farming – treatment – friendly ecosystem through aquaculture . Problems in sewage fed fish farming . Status of sewage fed fish culture in India. (3 hrs)

4.2 Integrated fish farming – Paddy – cum – fish culture. Pokkali fields , fish – live stock farming : fish – cum duck, fish – cum poultry, fish – cum pig, Fish – cum cattle culture methods . Integrated culture methods practiced in India. (5 hrs)

### **CRUSTACEAN CULTURE (20 hrs)**

#### **Module 5 INTRODUCTION (4 hrs)**

5.1 Role and importance. Overview of shell fish culture in the world (2 hrs)

5.2 Shell fish culture in India–background and recent developments. (2 hrs)

#### **Module 6 CULTURE PRACTICES (16 hrs)**

6.1 Species and characteristics of shrimps, prawns, lobsters and crabs available in India for cultivation. (2 hrs)

- 6.2 Culture of fresh water prawn : cultivable species, characteristics, growth, culture of *M. rosenbergii* - collection of brood stock, spawning, reproduction . Traditional prawn culture practices in India . (4 hrs)
- 6.3 Shrimp culture : Traditional culture practice prevailing in India and in other countries – the advantages and disadvantages of these practices . Culture in rice fields along with compatible species. (2 hrs)
- 6.4 Culture – site selection, preparation of the field, fertilization, stocking manipulation, monitoring of stocked species, feeding techniques and recent advances in the culture of shrimps . (3hrs)
- 6.5 Lobster and crab culture : present status and prospects, rearing, stocking and sea ranching of lobsters, crab fattening, breeding techniques and larval rearing . (5 hrs)

**MOLLUSCAN CULTURE (22 hrs)**

**Module 7 INTRODUCTION (4 hrs)**

- 7.1 World aquaculture production of marine molluscs . Major species of oysters, pearl oysters, mussels, clams, cockles, scallops and abalones in aquaculture . Culture of molluscs in India – present status and future prospects . (2 hrs)
- 7.2 Recent advances in the culture of cephalopods. Induced spawning and rearing of larvae of cephalopods. (2 hrs)

**Module 8 CULTURE PRACTICES (18 hrs)**

- 8.1 Species and criteria for selection for culture with special reference to Indian conditions. (2 hrs)
- 8.2 Breeding and rearing of sea cucumber and ranching practices. (2 hrs)
- 8.3 Oyster farming : Rearing of larvae, grow out systems, bio fouling, growth and fattening . (2 hrs)
- 8.4 Pearl culture: site selection, collection of mother oysters, farming techniques, control of bio fouling, boring organisms and predators, monitoring of growth . Selection of pearl oysters for cultured pearl production, conditioning, nucleus implantation, growth of pearl production . (4 hrs)
- 8.5 Mussel culture: site selection, methods of farming, seeding of ropes, tubing of seed, thinning of crops of crops and transplantation. (4 hrs)
- 8.6 Clams and abalones culture: site selection and preparation, methods of farming, stocking density, predation, monitoring of growth. (4 hrs)

**REFERENCES**

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 Thomas P.C (Ed) Current and emerging trends in aquaculture  
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 Introduction to aquaculture Pillai, T.V.R., Aquaculture principles and practices  
 Jonathan Shepherd, C. (Ed) Intensive Fish Farming

William Royce, F., An introduction to the practice of fishery science.  
Planning of Aquaculture Development. FAO, Fishing News Books  
Advances in Aquaculture. FAO, Fishing News Books.  
Pullin, R.S.V. and Chehadeh, Z.H. (Eds.). Integrated Agriculture-Aquaculture  
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Sea Farming and Sea Ranching in China. FAO Fisheries Technical Paper 418  
Fishery Science – 2002- L.A. Fuiman and R.G. Werner. Blackwell Science  
Dynamics of pond aquaculture – 1999- H.S. Egna and C.E. Boyd- CRC Press  
[Water quality sampling and analysis. 2000. - Abbasi, S.A.](#)  
Stock assessment of inland fisheries – 2002- Cowx, I.G  
Feed management in intensive aquaculture – 2000- Goddard, S  
Aquaculture, Fish and shellfish farming – 2002- Southgate, P.C

**AQ030402 WATER AND SOIL QUALITY PARAMETERS**

1. Determination of salinity
2. Determination of water pH
3. Determination of alkalinity
4. Determination of hardness of water
5. Determination of dissolved oxygen
6. Estimation of primary productivity
7. Determination of organic carbon in pond soil
8. Determination of soil pH
9. Grain size analysis of soil
10. Calculation of lime requirement
11. Determination of Secchi disc transparency of water
12. Determination of nitrite / nitrate - demonstration
13. Determination of phosphate in pond water – demonstration

**Field visit:**

1. Visit to aqua farms for water and soil sample collection

## **ELECTIVES**

### **AQ840401 AQUATIC ENVIRONMENT AND BIODIVERSITY**

**CREDIT: 3**

**72 HRS.**

#### **Aquatic Environment**

**(36 Hours)**

##### **Module 1**

(6 Hours)

Concepts in aquatic environment: Aquatic environment/ecosystem – components-structure and functions; Ecological concepts – succession, homeostasis, natality and mortality, r and k selection; Concepts of habitat and ecological niche; carrying capacity.

##### **Module 2**

(10 Hours)

Natural Disasters- Meaning and nature of natural disasters, their types and effects. Population Explosion and Urbanization. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion

##### **Module 3**

(10 Hours)

Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, sea accidents.

##### **Module 4**

(10 Hours)

Disaster Management- Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations.

#### **AQUATIC BIODIVERSITY**

**(36 Hours)**

##### **Module 5**

(10 Hours)

Definitions and measurement: Methods, scales and indices of biodiversity assessment. Factors influencing aquatic biodiversity; Types of biodiversity - Species diversity in different ecosystems, Genetic Diversity, and Habitat Diversity; Biodiversity indices and their significance; Concepts of Index of Biotic Integrity (IBI); Economic appraisal of biodiversity; Global diversity patterns and loss of biodiversity.

##### **Module 6**

(10 Hours)

Biodiversity (microalgae to aquatic vertebrates) of any three of the following or similar ecosystem: Chilka Lake, Narmada river system, Gangetic system, Jaykwadi reservoir, Himalayan lake, Himalayan river, Hooghly Maltah estuarine system, Coramandondal coast, Gulf of Mannar, Gulf of Kutch, Malabar upwelling, Bhitarkanika.

**Module 7**

(6 Hours)

Threats to biodiversity: Overexploitation, land reclamation, pollution, habitation, conversion of agricultural land and aquacultural farms (case studies pertaining to any sensitive marine/estuarine/freshwater hot spots).

**Module 8**

(4Hours)

Conservation and Restoration: Declaration of mangrove sanctuaries and mangrove afforestation, marine protected areas, Ganga Action Plan, introduction of exotic species and their implications; potential consequences and conflicts of linking rivers.

**Module 9**

(4 Hours)

Impacts of anthropogenic intervention on aquatic biodiversity: Damming of rivers, construction of sea walls, micro hydel power stations, oil rigs.

**Module 10**

(2 Hours)

Legal regimes of biodiversity: International and national conventions and Acts for biodiversity.

**References**

Carter RWG. 1998. *Coastal Environments: An Introduction to the Physical, Ecological and Cultural Systems of Coastlines*. Academic Press. Kormondy E.J. 1986. *Concepts of Ecology*. Prentice-Hall.

Park CC. 1980. *Ecology and Environmental Management*. Butterworths. Simon J, Kaiser MJ & Reynolds JD. 2001. *Marine Fisheries Ecology*. Blackwell.

**AQ840402 FISH NUTRITION****CREDIT: 3****72 HRS.****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 3 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 4 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 5 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 6 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.
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- Hepher Balfour 1988. Nutrition of Pond Fishes. Cambridge University Press.
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## **AQ84040 SEED PRODUCTION AND HATCHERY MANAGEMENT OF FINFISHES AND SHELLFISHES**

**CREDIT: 3**

**72 HRS.**

### **Seed Production and Hatchery Management of Finfishes (36 Hours)**

#### **Module 1 (2 Hours)**

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

#### **Module 2 (6 Hours)**

Reproductive biology: Physiology and morphology; Molecular and physiological basis of reproduction, Overview of current developments in reproductive biology. Gamete maturation and development: Spermatogenesis and oogenesis, Hormonal pathways and mode of control.

#### **Module 3 (6 Hours)**

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

#### **Module 4 (6 Hours)**

Induced spawning: 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 5 (8 Hours)**

Hatchery technology for different species: Indian major and minor carps, Exotic carps, Catfishes, Tilapia, Masheer, Trout. Marine fish seed production: Seabass, milkfish, mullets, sea breams, rabbitfish, grouper, yellowtail, eel, cobia, etc.

#### **Module 6 (8 Hours)**

Hatchery design and management: 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. Marketing and economics of fish seed.

### **Seed Production and Hatchery Management of Shellfishes (36 Hours)**

#### **Module 7 (2 Hours)**

Introduction: Current status; problems and prospects.

**Module 8**

(4 Hours)

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

**Module 9**

(10 Hours)

Reproductive biology: 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. Broodstock availability, physiology and techniques of eyestalk ablation

**Module 10**

(10 Hours)

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

**Module 11**

(10 Hours)

Hatchery technology and management: 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. Economics of seed production.

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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.

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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.

CMFRI Bulletin. 1987. *National Seminar on Shellfish Resources and Farming*.

**AQ850401 FISHING TECHNOLOGY****CREDIT: 3****72 HRS.**

<b>Module 1 Fishing Crafts</b>	<b>20 Hours</b>
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	5hrs
1.3 Marine Diesel Engines and determinants in selection.	4hrs
1.4 Biofouling, corrosion and maintenance	4hrs
1.5 Marine propulsion systems	3hrs
<b>Module 2 Fishing Gears</b>	<b>20 Hours</b>
2.1 Classification of fishing gears.	2Hrs
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	5Hrs
2.6 Fishing accessories – Fishing gear accessories; Hooks and Baits; Fishing Rods; Fish finding devices.	3Hrs
<b>Module 3 Navigation, Seamanship and Rope work</b>	<b>20 Hours</b>
<b>Navigation</b>	<b>10Hours</b>
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;	2Hrs
3.4 Modern Techniques : Pilotage, Celestial Navigation, Radio Navigation, Radar Navigation, Satellite Navigation.	2Hrs
<b>Seamanship and Ropework</b>	<b>10Hours</b>
3.5 Ropework	2hrs
3.6 Ship handling and anchoring procedures	2hrs
3.7 First Aid and Safety; Firefighting procedures	4 hrs
3.8 Response to Emergency	2hrs
<b>Module 4 Capture Fisheries Management</b>	<b>12</b>
<b>Hours</b>	
4.1 Principles of capture fisheries resource conservation and management	3Hrs
4.2 Resource Conservation Devices – BRD, TED, FAD	2Hrs

4.3 Remote Sensing and its applications	2Hrs
4.4 GIS in Fisheries	2Hrs
4.5 Energy Optimization in Fishing	3Hrs

## **REFERENCES**

Hilmar Kristjonnsonn (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.

**AQ850402 AQUATIC TOXICOLOGY****CREDIT: 3****72 HRS.****Module 1**

(17 Hours)

Marine Diatoms: General characteristics. Classification. Morphology. Terminology. Description of taxa. Marine Dinoflagellates: General characteristics. Terminology and morphology. Classification. Identification of species. Sampling Techniques and estimation: Equipments. Techniques. Strategies.

**Module 2**

(10 Hours)

Seafood Poisoning: Paralytic shellfish poisoning. Diarrhetic shellfish poisoning. Amnesic shellfish poisoning. Ciguatera poisoning. Toxin analysis. Algal toxins. Bioassay methods.

**Module 3**

(8 Hours)

Ecology of harmful algal bloom: Environmental factors. Aquaculture. Cultural eutrophication. Unusual climatological conditions. Ships ballast water.

**Module 4**

(8 Hours)

Drugs from the Sea: Antibiotics. Anticancer compounds. Antimalarials. Analgesics. Immunomodulators. Cosmeceuticals.

**Module 5**

(17 Hours)

Toxicity and metabolism: Factors influencing toxicity- environmental, genetic and nutritional; Measurement and evaluation of the ecological effects of toxicants; Metabolism of toxic substances by aquatic organisms - consequences, synergistic and antagonistic effects; Acute poisons and accumulative poisons; Bioaccumulation and biomagnification; Systemic effects of toxic metals, pesticides and herbicides; Effect of select toxicants on aquatic life and detoxification.

**Module 7**

(6 Hours)

Toxicity evaluation: Toxicity Testing - Microcosm and Mesocosm Tests, Dose-Response Relationships, Toxicity Bioassay.

**Module 8**

(6 Hours)

Monitoring and management. Environmental monitoring. Monitoring seafood. Seafood safety regulation. Management of fishery resources.

## **References**

Hoffman DJ. 1995. *Handbook of Ecotoxicology*. Lewis Publ.

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Mayer H. 1977. *Aquatic Toxicology and Hazards Evaluation*. ASTM Publ.

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Raymond JM, Neisink RJM, de Vries J & Hollinger MA. 1996. *Toxicology: Principles and Applications*. CRC Press.

Ware GW. 2002. *Review of Environmental Contamination and Toxicology*. Springer Verlag.

**AQ850403 CONSERVATION AND MANAGEMENT OF EXPLOITED FISHERY RESOURCES**

**CREDIT: 3**

**72 HRS.**

**Module 1**

(8 Hours)

Marine parks, marine protected areas, biosphere reserves, closed seasons.

**Module 2**

(8 Hours)

Cryopreservation of exploited and endangered species.

**Module 3**

(8 Hours)

Fishing regulation policies - A critique on the draft Indian Fisheries policy. A critical appraisal of Inland Fisheries Legislation of any two states of India.

**Module 4**

(8 Hours)

Protection of habitat of corals, mangrove, seaweeds, sea grass beds.

Implementation of square cod end mesh – to reduce by-catch.

**Module 5**

(8 Hours)

Legal proceedings / implementation for protection of exploited and endangered fishery resources.

**Module 6**

(8 Hours)

Total allowable catch, regulation of mesh size for conservation of exploited fishery resources.

**Module 7**

(8 Hours)

Management of major reservoirs of India; optimal stocking and production of cultivable resources.

**Module 8**

(8 Hours)

A comparative study of the marine regulation acts of any two neighboring countries with reference to Environmental Protection Act (EPA).

### **Module 9**

(8 Hours)

Compile the rules relating to marine fisheries exploitation included in the final UNCLOS III treaty.

### **References**

C Mahanta PC & Tyagi LK. 2003. *Participatory Approach for Fish Biodiversity Conservation in North East India*. National Bureau of Fish Genetic Resources (NBFGR), Lucknow.

Menon AGK. 2004. *Threatened Fishes of India and their Conservation*.

Fisheries Survey of India.

Michael RR. 1997. *Fisheries Conservation and Management*. Prentice Hall.

Pascoe S. 2005. *Bycatch Management and the Economics of Discarding*.

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Thorpe JE, Talbot C & Miles MS. (Ed.) 1995. *Conservation of Fish and Shell Fish Resource; Managing Diversity*. Academic Press.

Compile the rules relating to marine fisheries exploitation included in the final UNCLOS III treaty.