M.Sc. AQUACULTURE

		Max. Marks
I SEMESTER		
THEORY		
Paper I	(AC 101): Limnology	70
Paper II	(AC 102): Aquaculture Engineering	70
Paper III	(AC 103): Taxonomy and Functional Anatomy of Shellfish	70
Paper IV	(AC 104): Taxonomy and Anatomy of Finfish	70
PRACTICALS		
Practical I	(ACP 1): Limnology and Aquaculture Engineering	50
Practical II	(ACP 2): Taxonomy and Anatomy of finfish and shellfish	50
II SEMESTER		
THEORY		
Paper V	(AC 201): Marine and Brackish water Ecology	70
Paper VI	(AC 202): Fish Physiology	70
Paper VII	(AC 203): Aquatic Microbiology	70
Paper VIII	(AC 204): Nutrition and Feed Technology	70
Non-core Paper	: Aquaculture – An Entrepreneurship Approach	70
PRACTICALS		
Practical III	(ACP 3): Marine & Brackish water Ecology and Fish Physiology	50
Practical IV	(ACP 4): Aquaculture Microbiology and Feed Technology	50
Project Work, Field Training and Viva – Voce		300
III SEMESTER		
THEORY		
Paper IX	(AC 301): Tools and Techniques in Biology	70
Paper X	(AC 302): Aquaculture Economics and Fisheries Extension	70
Paper XI	(AC 303): Water Quality Management	70
Paper XII	(AC 304): Fish and Shellfish Pathology	70
Non-core Paper	: Aquaculture Management	70
PRACTICALS		
Practical V	(ACP 5): Tools & Techniques and Aquaculture Economics	50
Practical VI	(ACP 6): Water Quality Management and Fish Pathology	50
IV SEMESTER		
THEORY		
Paper XIII	(AC 401): Principles and Practices of Aquaculture	70
Paper XIV	(AC 402): Fish Processing Technology	70
Paper XV	(AC 403): Aquaculture Biotechnology	70
Paper XVI	(AC 404): Fish and Shellfish Immunology	70
PRACTICALS		
Practical VII	(ACP 7): Aquaculture and Fish Processing Technology	50
Practical VIII	(ACP 8): Aquaculture Biotechnology and Immunology	50
Project Work, Field Training and Viva – Voce		300

M.Sc. AQUACULTURE
I – SEMESTER
PAPER – I: LIMNOLOGY
CODE No. AC 101

UNIT – I

1. **Definition and facets** of Limnology; Limnology as an applied science.
2. **Inland water types:** Lentic and lotic habitats – their identities and distribution, ponds and lakes, streams and rivers; Major rivers and lakes of India.
3. Origin and classification of lakes.
4. **Anomalous properties of water**, their influence on biota in inland waters.
5. **Temperature and Light:** Thermal stratification and its overall impact, thermal classification of lakes; Factors affecting light penetration in natural waters.

UNIT – II

1. **Dissolved oxygen:** Sources, losses and distribution patterns.
2. Identification of oxygen depletion problems and control mechanisms in fish ponds.
3. **Carbon dioxide:** Sources, losses and distribution patterns; role of carbon dioxide in chemical buffering.
4. **Bio-geochemical cycles:** General account of nutrients; Nitrogen and Phosphorus cycles.

UNIT – III

1. **Plankton:** Composition, classification and distribution patterns in lakes and rivers.
2. **Benthos:** Composition, classification and distribution of benthos in lakes and rivers.
3. **Nekton** and its significance.
4. **Large Aquatic Plants:** Classification, distribution and limnological significance.

UNIT – IV

1. **Productivity:** Concept of productivity; methods for the estimation of primary, secondary and tertiary productivity; Classification of lakes based on productivity; indices of productivity in lakes
2. **Turbidity:** Causes, consequences and control.
3. **Eutrophication:** Causes, consequences and control mechanisms.
4. **Bio-manipulation Concept:** Zooplankton as a tool in lake management.

REFERENCE BOOKS

1. Allan JD. 1995. *Stream Ecology: Structure and Function of Running Waters.* Chapman & Hall
2. Cole GA. 1983. *Text book of Limnology,* C.V Mosby Company, St. Louis, Missouri, USA.
3. Goldman CR. and Horne AJ. 1983. *Limnology.* Mc Graw-Hill International Book Company.
4. Golterman, HL. 1975. *Physiological Limnology*. Elsevier Publishing Co., Amsterdam.
5. Hutchinson,GE. 1957. *A Treatise on Limnology*: Vol I. *Geography, physics and chemistry*. John Wiley and Sons, Inc., New York.
6. Hutchinson GE. 1967. *A Treatise on Limnology*, Vol II. *Introduction to lake Biology and the Limnoplankton.* John Wiley and Sons, Inc., New York.
7. Reid GR.1961. *Ecology and Inland waters and Estuaries*. Rein Hold Corp., New York.
8. Ruttner F. 1953. *Fundamentals of Limnology*, Uni. of Toronto press, Toronto.
9. Welch PS. 1952. *Limnology*, 2nd Ed. Mc Graw-Hill Book Co., New York.
10. Wetzel RG. 1975. *Limnology,* W.B. Sanders Company, Philadelphia.

M.Sc. AQUACULTURE
I – SEMESTER
PAPER – II: AQUACULTURE ENGINEERING
CODE No. AC 102

UNIT – I

1. **Planning and Aquaculture Development:** Priorities, resources, technology, human resources, legal and environmental factors and organization of aquaculture.
2. **Selection of Sites for Aquaculture:** Criteria for site selection of fresh water and brackish water farms - land based and open water farms; quantity and quality of water, sources of pollution and conflicts.
3. Farm/Hatchery standards and biosecurity; sanitary and phytosanitary (SPS) measures; Better management practices (BMPs)

UNIT – II

1. **Freshwater Fish Farm** - Design and construction: Layout of farm, size of the farm, division of the farm area; size, shape and depth of ponds; dike design, pond bottom and harvesting sump; water supply and drainage system of pond – pipes, sluice, monk, turn-down pipe; aerators and method of construction.
2. **Brackish water Shrimp Farm** - Design and construction: Layout designs, design of water management systems, design of water control structures, design of peripheral and internal dikes, water supply and drainage, method of construction.

UNIT – III

1. **Fish Hatchery -** Design, construction: Criteria for site selection of hatchery and nursery; Design and construction of Jar hatchery and Chinese hatchery system.
2. **Shrimp Hatchery** – Design and construction: Site selection and facilities required – maturation tanks, spawning tanks, larval rearing tanks, live food culture tanks, water storage and filtration tank, aeration, seawater supply and piping system; Lay-out and construction.

UNIT – IV

1. **Cages and Rafts:** Design and construction.
3. **Pens and Enclosures:** Design and construction
2. **Raceway Farms:** Design and construction.

REFERENCE BOOKS

1. Bose AN. *et al*., 1991. *Coastal Aquaculture Engineering*. Oxford & IBH Publishing Company, Pvt. Ltd.
2. Chakraborty C & Sadhu AK. 2000. *Biology Hatchery and Culture Technology of Tiger Prawn and Giant Freshwater Prawn*. Daya Publ. House
3. CIFE. 1993. *Training Manual on Culture of Live Food Organisms for Aqua Hatcheries*. CIFE, Versova, Mumbai
4. FAO. 2007. *Manual for Operating a Small Scale Recirculation Freshwater Prawn Hatchery*
5. Hepher B & Pruginin Y. 1981. *Commercial Fish Farming*. John-Willey & Sons Inc.
6. ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.
7. Ivar LO. 2007. *Aquaculture Engineering*. Daya Publ. House.
8. Jhingran VG & Pullin RSV. 1985. *Hatchery Manual for the Common, Chinese and Indian Major Carps*. ICLARM, Philippines.
9. MPEDA. 1993. *Handbook on Aqua Farming - Live Feed. Micro Algal Culture.* MPEDA Publication
10. Pilley, TVR & Dill, WMA. 1979. *Advances in Aquaculture*. Fishing News Books, Ltd. England.
11. Pillay TVR & Kutty MN. 2005. *Aquaculture- Principles and Practices*. Blackwell.
12. Stickney RR. 1979. *Principles of Warm water Aquaculture*. John-Willey & sons Inc.
13. Thomas L. 1995. *Fundamentals of Aquacultural Engineering*. Chapman & Hall
14. Thomas PC, Rath SC & Mohapatra KD.2003.*Breeding and Seed Production of Finfish and Shellfish.* Daya Publ.
15. Wheaton FW. 1977. *Aquacultural Engineering*. John Wiley & Sons.

M.Sc. AQUACULTURE
I – SEMESTER
PAPER–III: TAXONOMOMY AND FUNCTIONAL ANATOMY OF SHELLFISH
CODE No. AC 103

UNIT – I

1. **Classification of Crustacea:** Major groups up to orders and their important characters.
2. **Classification of Mollusca:** Major groups up to orders and their important characters.

UNIT – II

1. **Feeding in Crustacea:** Food, feeding habits and adaptations of cultured crustaceans – Branchiopoda and Malacostraca.
2. **Feeding in Mollusca:** Food, feeding habits and adaptations of cultured molluscs – Gastropoda and Bivalvia.

UNIT – III

1. **Respiratory system in Crustacea:** Structure and function of respiratory organs in crustaceans.
2. **Respiratory system in Mollusca:** Structure and function of respiratory organs in molluscs.
3. **Excretory system:** Structure and function of excretory organs in crustaceans and molluscs.

UNIT – IV

1. **Endocrine system:** Structure and function of endocrine organs in crustaceans and their role in reproduction.
2. **Reproductive system in Crustacea:** Reproductive patterns, reproductive organs, gonad maturity, spawning and fertilization.
3. **Reproductive system in Mollusca:** Reproductive patterns, reproductive organs, gonad maturity, spawning and fertilization.

REFERENCE BOOKS

1. Barrington EJW. *Invertebrate Structure and Function.* 1976. Thomas Nelson and Sons Ltd.London
2. Hyman LH. *The Invertebrates*, 1955. Vol.1 to 8, McGrw Hill Co., New York.
3. Borradile & RA Potts. 1962. *The Invertebrates*. Asia Publishing House.
4. Kaestner A. 1967. *Invertebrate Zoology*. Vol. I - III. John Willey & Sons.
5. Barrington EJW. 1971. *Invertebrates: Structure and Function*. ELBS.
6. Kurian CV & Sabastian VO. 1976. *Prawns and Prawn Fisheries of India*. Hindustan Publ.Co.
7. Fretter V & Graham A. 1976. *The Functional Anatomy of Invertebrates*. Academic Press Inc.
8. Parker TJ & Haswell WA. 1992. *The Text Book of Zoology. Vol. I. Invertebrates*. (Eds: A.J. Marshall & W.D. Willimas), ELBS & McMillan & Co.
9. Ruppert EE, Fox RS & **Barnes RD.** 2004. *Invertebrates Zoology*, 7th edition, Thomson, Brooks/Cole.

M.Sc. AQUACULTURE
I – SEMESTER
PAPER – IV: TAXONOMY AND ANATOMY OF FINFISH
CODE No. AC 104

UNIT – I

1. **Classification of fishes:** Major groups up to subclass and their important characters.
2. **Skin:** Structure and function of skin in fishes.
3. **Scales:** Structure of placoid, cycloid, ctenoid, cosmoid and ganoid scales.

UNIT – II

1. **Age and Growth:** Methods of determination of age; Methods for studying growth, Length-Weight relationship and Condition factor.
2. **Feeding in fishes**: Natural food of fishes; feeding habits - predators, grazers, strainers, suckers and parasites; feeding adaptations and stimuli for feeding.
3. **Respiratory system:** Structure of gills and accessory respiratory organs.

UNIT – III

1. **Cardiovascular system:** Structure of cardiovascular system in fishes.
2. **Nervous system:** Structure and function of brain and cranial nerves.
3. **Excretory system and Osmoregulation:** Structure and function of kidneys in fishes.

UNIT – IV

1. **Endocrine system:** Structure and function of pituitary gland, thyroid gland, ultimobranchial glands, chromaffin tissue, adrenocortical tissue and corpuscles of stannous.
2. **Reproductive system:** Reproductive structures in teleosts; maturity stages of gonads.
3. Fecundity and Gonado-somatic Index (GSI).

REFERENCE BOOKS

1. Bond E. Carl. 1979. *Biology of Fishes*, Saunders.
2. Halver JE. 1972. *Fish Nutrition.* Academic Press.
3. Hoar WS and Randall DJ. 1970. *Fish Physiology*, Vol. I-IX, Academic Press, New York.
4. Lagler KF, Bardach, JE, Miller, RR, Passino DRM. 1977. *Ichthyology*, 2nd Ed. John Wiley & Sons, New York.
5. Lovell J. 1989. *Nutrition and Feeding of Fish.* Van Nostrand Reinhold, New York.
6. Moyle PB and Joseph J. Cech Jr. 2004. *Fishes: An Introduction to Ichthyology*. 5th Ed. Prentice Hall.
7. Nikolsky GV. 1963. *Ecology of Fishes*, Academic Press.
8. Norman JR and Greenwood PH. 1975. *A History of Fishes*, Halsted Press.
9. Potts GW and Wootten RJ. 1984. *Fish Reproduction: Strategies and Tactics*, Academic Press.

M.Sc. AQUACULTURE

I - SEMESTER

PRACTICAL – I: LIMNOLOGY AND AQUACULTURE ENGINEERING

CODE No. ACP 01

Limnology

1. Estimation of pH and turbidity.
2. Estimation of total alkalinity.
3. Estimation of dissolved oxygen.
4. Estimation of total hardness.
5. Estimation of phosphates.
6. Estimation of iron.
7. Estimation of primary productivity (light and dark bottle method).

Aquaculture Engineering

8. Design and layout of freshwater and brackish water farm.
9. Design and construction of Fish and shrimp hatchery.
10. Rates of calculation of water flow through pipes of different diameters and of pumps of different HP (horse power).
11. Estimations and calculations of production costs of fish/shrimp farm.

M.Sc. AQUACULTURE

I - SEMESTER

PRACTICAL - 1I: TAXONOMY AND ANATOMY OF FINFISH AND SHELLFISH

CODE No. ACP 02

1. Collection, preservation and identification of a fish: general description of a fish, recording biometric data and identification up to genus level using taxonomic key.
2. Identification of commercially important freshwater, brackish water and marine water fishes.
2. Identification of the stages of maturation of gonads in fishes.
3. Dissection and mounting of pituitary gland.
4. Dissection of digestive systems of fishes with different feeding habits.
5. Mounting of fish scales.
6 Identification and systematics of estuarine and marine shell fish of commercial importance.
7. Identification of different stages of shrimp/prawn seed.
8. Dissection of digestive system of shrimp/prawn.
9. Identification and mounting of appendages of shrimp/prawn.

M.Sc. AQUACULTURE
II – SEMESTER
PAPER – V: MARINE AND BRACKISH WATER ECOLOGY
CODE No. AC 201

UNIT – I: Marine Ecology
1. Classification of the marine environment and salient features of different zones.
2. Classification of marine organisms and their characteristic features.
3. Shore environment: Physico-chemical and biological factors of intertidal zone; distribution of life on rocky, sandy, mud shores and their characteristic features; fauna and their adaptations.

UNIT – II
1. Organic production of the sea: Primary, secondary and tertiary production; factors affecting primary production; measurement of organic production.
2. Marine food chains and food webs.
3. Human impact and management of coastal ecosystems.

UNIT – III: Brackish water Ecology
1. Classification of brackish water habitats and salient features of different zones: Estuaries, mangroves, lakes, lagoons and marshes/ wetlands.
2. Ecology of some typical brackish water habitats of India: Estuaries – Hooghly-Matlah, Mahanadi, Godavari, Krishna, Cauvery and west coast estuaries; lakes and coastal lagoons – Chilka, Pulicat, Kerala backwaters, Kaliveli lake, Rann of Kutch.

UNIT – IV
1. Structure and function of estuarine ecosystems: Physico-chemical features, mineral cycling (CNP), biotic communities, estuarine food webs and energy flow.
2. Estuarine fauna and their adaptations.
3. Human impact and management of estuarine ecosystems.

REFERENCE BOOKS

1. Balakrishnan Nair N and Thampi DM. 1980. *A Text Book of Marine Ecology*. Macmilaan Company of India Ltd. Delhi.
2. Clark JR. 1992. *Integrated Management of Coastal Zones*. FAO Fisheries Tech. Paper No. 327, Rome.
3. Goudie A. 1993. *The Human Impact on the Natural Environment.* MIT Press.
4. Lewis JR. 1964. *The Ecology of Rocky Shores*. The English Universities Press Ltd. London.
5. Reid GK and Wood RD. 1976. *Ecology of Inland waters and Estuaries*. Van Nostrand Company.
6. Sverdrup HV, Johnson MW and Fleming RH.1942. *The Oceans: their physics, chemistry and general biology.* Prentice Hall, Inc. New York.
7. Santhanam R and Srinivasan A. 1994. *A Manual of Marine Zooplankton*. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.

M.Sc. AQUACULTURE
II – SEMESTER
PAPER – VI: FISH PHYSIOLOGY
CODE No. AC 202

UNIT – I

1. **Digestion:** Digestion of carbohydrates, lipids and proteins; Digestive enzymes and regulation of their secretions; Absorption and assimilation of nutrients; Role of hormones in the regulation of digestion; Factors affecting digestion and transport of nutrients.
2. **Metabolism:** Pathways of cellular metabolism.

UNIT – II

1. **Respiration:** Definition of respiration; external respiration and internal respiration.
2. Mechanism of gaseous exchange, CO_2 transport, countercurrent principle, water flow across the gills, respiratory pumps.
3. **Circulation:** Role of blood in transport of gases; composition and function of blood.

UNIT – III

1. **Sensory organs:** Structure and function of chemo-, photo- and phonoreceptor, lateral line sense organs.
2. Action potential, synapse, neurotransmitters, impulse transmission.
3. **Osmoregulation:** Mechanism of osmotic and ionic regulation; endocrine control of osmoregulation

UNIT – IV

1. **Excretion:** Mechanism of excretion of nitrogenous waste, water and ion balance.
2. **Reproduction and Endocrinology:** Development of gonad, oogenesis, spermatogenesis, metabolic changes during oogenesis and spermatogenesis; hormonal control of reproduction in fish.
3. Neuro-endocrine system in crustacean and its role in the regulation of reproduction.

REFERENCE BOOKS

1. Adiyodi KG & Adiyodi RG. 1971. *Endocrine Control of Reproduction in Decapod Crustacea.* Biology Reviews.
2. Agarwal NK. 2008. *Fish Reproduction*. APH Publ.
3. Brown ME. 1966. *Physiology of fishes*. Vol. I and II Academic Press. New York.
4. Halver JE. 1972. *Fish nutrition.* Acaemic Press, New York.
5. Hoar WS. 1984. *General and Comparative physiology.* Printice-Hall of India Pvt. Ltd. New Delhi.
6. Hoar WS, Randall DJ & Donaldson EM. 1983. *Fish Physiology*. Vol. IX. Academic Press, New York
7. Lagler KF, Bardach, JE, Miller, RR, Passino DRM. 1977. *Ichthyology*, 2nd Ed. John Wiley & Sons, New York.
8. Matty AJ. 1985. *Fish Endocrinology*. Croom Helm.
9. Mente E. 2003. *Nutrition, Physiology and Metabolism in Crustaceans*. Science Publ.
10. Moyle PB. 1982. *Fishes: An introduction to ichthyology*. Printice-Hall, Englewood cliffs.
11. Patts, GW. 1984. *Fish reproduction. Stratingies and tactics.* Academic Press, London.
12. Prosser CL. 1973. *Comparative animal physiology*. W.B. Saunders, Philadelphia.

M.Sc. AQUACULTURE
II – SEMESTER
PAPER – VII: AQUATIC MICROBIOLOGY
CODE No. AC 203

UNIT – I

1. **Cell Structure:** Prokaryotic and eukaryotic cell structure; Cell membrane, cell wall, proteins, nucleic acids – structure, properties and interactions.
2. **Distribution and classification**: Microbial community in freshwater, estuary and marine environment - types and abundance.
3. **Microbial Growth:** Factors influencing microbial growth - Physical, chemical and biological conditions of the environment.

UNIT – II

1. **Microbial interaction:** Role of microbial population in biogeochemical cycles (C, N, P, S, Si and Fe), xenobiotic and inorganic pollutants.
2. Microbial degradation of natural and synthetic compounds.
3. Microbial toxins.

UNIT – III

1. **Bioprocesses:** Principles and applications of bioprocesses - Bioremediation, biofertilization, biofilms, bio-leaching, bio-corrosion, bio-fouling.
2. Microorganisms as bioindicators, bioremediators and biosensors.
3. Microbial biomass production – single cell protein; Bioprospecting.
4. Nutritional requirements of microorganisms – constituents of growth media.

UNIT – IV

Microbiological Techniques:

1. Sterilization and media preparation; Isolation, enumeration, preservation; maintenance of cultures – growth curve, different types of cultures, population estimation techniques.
2. Routine tests for identification of bacteria – morphological, cultural, biochemical and serological.
3. Basics of mycological and virological techniques.
4. Introduction to molecular techniques in microbiology.

REFERENCE BOOKS

1. Dhevendaran K. 2008. *Aquatic Microbiology,* Daya Publ. House.
2. Frobisher M, Hinsdill RD, Crabtree KT & Goodheart CR. 1974. *Fundamentals of Microbiology.* WB Saunders.
3. Geesey G, Lewandowski Z & Flemming HC. (Eds.). 1994. *Biofouling and Biocorrosion in Industrial Water Systems.* CRC Press.
4. Prasad AB & Vaishampayan A. 1994. *Nitrogen Fixing Organisms – Problems and Prospects*. Scientific Publ.
5. Rao AS. 1997. *Introduction to Microbiology*. Printice-Hall, New Delhi.
6. Rheinheimer G. 1992. *Aquatic Microbiology*. John Wiley & Sons.
7. Stanier R, Ingraham JL & Adelberg EA. 1976. *General Microbiology*. MacMillan.
8. Vernam AH & Evans M. 2000. *Environmental Microbiology*. Blackwell.

M.Sc. AQUACULTURE
II – SEMESTER
PAPER - VIII: NUTRITION AND FEED TECHNOLOGY
CODE No. AC 204

UNIT – I

1. **Fish Nutrition:** Principles of fish nutrition and terminologies; Nutritional requirements of cultivable finfish and shellfish.
2. **Nutritional Biochemistry:** Classification of nutrients, nutrient quality and evaluation of proteins, lipids and carbohydrates.

UNIT – II

1. **Nutritional Bioenergetics:** Energy requirement of fishes, protein to energy ratio, digestible energy, nitrogen balance index, protein sparing effect, high energy feeds, isocaloric diets.
2. Metabolic rate; Energy budgets; Energy efficiency of fish production.

UNIT – III

1. **Natural food:** Importance in aquaculture; Fish food organisms – Bacterioplankton, phytoplankton and zooplankton and their role in larval nutrition.
2. **Supplementary feeds:** Types of feeds - Wet feed, moist feed, dry feed, mashes, pelleted feeds - floating and sinking pellets, microencapsulated diets.
3. **Feed additives:** Binders, antioxidants, enzymes, pigments, growth promoters, feed stimulants; use of preservatives.

UNIT – IV

1. **Feed manufacture:** Feed formulation and processing; Feed machinery units: Pulverizer, grinder, mixer, pelletizer, crumbler, drier, extruder/expander, vacuum coater and fat sprayer.
2. **Feeding strategies:** Feeding devices, feeding schedules and ration size.
3. **Feed evaluation:** Feed conversion efficiencies and ratios. Feed storage methods.

REFERENCE BOOKS

1. ADCP(AquacultureDevelopment&Co-ordinationProgram).1980.*Fish Feed Technology*.ADCP/REP/80/11FAO
2. Cyrino EP, Bureau D & Kapoor BG. 2008. *Feeding and Digestive Functions in Fishes*. Science Publ.
3. D' Abramo LR, Conklin DE & Akiyama DM. 1977. *Crustacean Nutrition: Advances in Aquaculture.* Vol. VI. World Aquaculture Society, Baton Roughe.
4. De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall Aquaculture Series.
5. Elena M. 2003. *Nutrition, Physiology and Metabolism in Crustaceans*. Science Publishers.
6. Guillame J, Kaushik S, Bergot P & Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans.* Springer Praxis Publ.
7. Halver J & Hardy RW. 2002. *Fish Nutrition*. Academic Press.
8. Halver JE & Tiews KT. 1979. *Finfish Nutrition and Fish feed Technology*. Vols. I, II Heenemann, Berlin.
9. Hertrampf JW & Pascual FP. 2000. *Handbook on Ingredients for Aquaculture Feeds*. Kluwer.
10. Houlihan D, Boujard T & Jobling M. 2001. *Food Intake in Fish*. Blackwell.
11. Jobling M. 1994. *Fish Bioenergetics*. Chapman & Hall.
12. Lavens P & Sorgeloos P. 1996. *Manual on the Production and Use of Live Food for Aquaculture.* FAO Fisheries Tech. Paper 361, FAO.
13. Nelson DL & Cox MM. 2005. *Lehninger Principles of Biochemistry*. WH Freeman.
14. New MB. 1987. *Feed and Feeding of Fish and Shrimp. A Manual on the Preparation and Preservation of Compound Feeds for Shrimp and Fish in Aquaculture.* FAO – ADCP/REP/87/26
16. Ojha JS. 2005. *Aquaculture Nutrition and Biochemistry.* Daya Publ.

M.Sc. AQUACULTURE
II – SEMESTER
NON – CORE PAPER: AQUACULTURE - AN ENTREPRENEURSHIP APPROACH

UNIT – I

Introduction to freshwater aquaculture species; Intensive, semi-intensive, extensive cultures; Requirements for life; Desirable characteristics of aquaculture species; Culture technologies; sewage fed fish culture; Invasive alien species; Brood stock management and quarantine.

UNIT – II

Larviculture and nursery rearing; Nutrition, feed formulation and feeding practices; Monitoring of freshwater physico - chemical parameters; Life histories of selected cultured species; Onshore aquaculture; Freshwater fish diseases and control; New methodologies and technologies in freshwater aquaculture; Integrated fish farming; Biotechnological applications.

UNIT – III

Aquaculture: cages; rope culture; Feed supply; Offshore aquaculture; Fish handling; Transport; grading; Harvesting; Production system limitations; Costs, benefits and trade offs.

UNIT – IV

Recirculation aquaculture systems; pumps; filtration; disinfection & sterilization; oxygenation & aeration; monitoring & alarms; implementation of health and safety in offshore installations; The business environment for innovation (cost, benefit and risk of technical developments).

REFERENCE BOOKS

1. Bardach, JE *et al*. 1972. *Aquaculture – The farming and husbandry of freshwater and marine organisms*, John Wiley & Sons, New York.
2. Chakraborty C & Sadhu AK. 2000. *Biology Hatchery and Culture Technology of Tiger Prawn and Giant Freshwater Prawn.* Daya Publ. House.
3. FAO. 2007. *Manual on Freshwater Prawn Farming.*
4. Huet J. 1986. *A text Book of Fish Culture*. Fishing News Books Ltd.
5. ICAR. 2006. *Hand Book of Fisheries and Aquaculture*. ICAR.
6. Jhingran V.G. 1991. *Fish and Fisheries of India*. Hindustan Publ. Corporation, India.
7. Landau M. 1992. *Introduction to Aquaculture*. John Wiley & Sons.
8. Mcvey JP. 1983. *Handbook of Mariculture*. CRC Press.
9. MPEDA: *Handbooks on culture of carp, shrimp, etc.*
10. New MB. 2000. *Freshwater Prawn Farming*. CRC Publ.
11. Pillay TVR. 1990. *Aquaculture- Principles and Practices*, Fishing News Books Ltd., London.
12. Pillay TVR & Kutty MN. 2005. *Aquaculture- Principles and Practices*. 2nd Ed. Blackwell
13. Rath RK. 2000. *Freshwater Aquaculture*. Scientific Publ.
14. Stickney RR. 1979. *Principles of Warmwater Fish Culture*, John Wiley & Sons.

M.Sc. AQUACULTURE
II – SEMESTER
PRACTICAL - III: MARINE AND BRACKISH WATER ECOLOGY AND FISH PHYSIOLOGY
CODE No. ACP 3

Marine and Brackish Water Ecology

1. Analysis of soil – determination of soil texture, soil pH, conductivity, available nitrogen, available phosphorus and organic carbon.
2. Estimation of water salinity and pH.
3. Estimation of primary productivity (light and dark bottle method).
3. Estimation of COD and BOD.
4. Estimation of oxygen consumption.

Fish Physiology

5. Qualitative identification and estimation of ammonia and urea.
6. Estimation of glycogen.
7. Estimation of proteins.
8. Estimation of lipids.
9. Estimation of haemoglobin.
10. Estimation of tissue somatic index.

M.Sc. AQUACULTURE
II – SEMESTER
PRACTICAL - IV: AQUACULTURE MICROBIOLOGY AND NUTRITION & FEED TECHNOLOGY
CODE No. ACP 4

Aquaculture Microbiology

1. Preparation of different types of media for bacterial cultures.
2. Standard Plate Count of Bacteria (SPC).
3. Isolation of bacteria – coliforms, *Staphylococcus aureus, Salmonella typhi, E. coli.*

Nutrition and Feed Technology

4. Proximate composition of aquaculture feeds – Proteins, carbohydrates, lipids, moisture, ash content.
5. Calculation of surface area and calorific needs of fish, calculation of feed rations, dosage of chemicals etc. for treatment in culture ponds and cost estimates.
6. Estimation of amylase and lipase activity.

M.Sc. AQUACULTURE
III – SEMESTER
PAPER – IX: TOOLS AND TECHNIQUES IN BIOLOGY
CODE No. AC 301

UNIT – I

1. **Microscopies:** Working principle and types of Optical Microscopy – dark-field, phase-contrast, interference, polarization and fluorescence microscopy; Working principle and types of Electron Microscopy – Transmission electron microscopy (TEM), Scanning electron microscopy (SEM) and Scanning-Transmission electron microscopy (STEM); Different fixation and staining techniques for electron microscopy.
2. **Spectroscopies:** Working principle of UV-Visible spectrophotometry, IR spectroscopy, Atomic Absorption Spectroscopy (AAS), Fluorescence and Phosphorescence spectroscopy, Electron Spin Resonance (ESR) spectroscopy, mass spectrometry, X-ray crystallography and Nuclear Magnetic Resonance (NMR) spectroscopy.

UNIT – II

1. **Chromatography:** Principles and applications of Gel filtration, Paper, Column, Ion-exchange, Affinity, Thin layer (TLC), Gas liquid (GLC) and High Performance Liquid Chromatography (HPLC).
2. **Electrophoresis:** Agarose gel electrophoresis, Pulsed Field Gel Electrophoresis (PFGE), Polyacrylamide Gel Electrophoresis (PAGE), Sodium Dodecyl Sulphate Polyacrylamide Gel Electrophoresis (SDS-PAGE), Two-dimensional electrophoresis - Iso-electric focusing (IEF).

UNIT – III

1. **Nucleic acid blotting techniques:** Southern blotting, Northern blotting and Western blotting; Polymerase Chain Reaction (PCR); DNA fingerprinting; Genomics and Proteomics.
2. **Sequences and nomenclature:** IUPAC symbols, nomenclature of DNA sequences, nomenclature of protein sequences, directionality of sequences, types of sequences used in bioinformatics.
3. **Information sources:** NCBI, GDB, MGB, data retrieval tools, database similarity searching, resources for gene level sequences, use of bioinformatics tools in analysis.

UNIT – IV

1. **Bio-statistics:** Measures of central tendency and dispersal – mean, median and mode; Probabity distributions - binomial, poisson and normal; Sampling distribution.

2 Standard deviation, standard error and confidence interval; Regression and Correlation.

3. **Tests of significance:** Levels of significance, X^2 test, t-test and Analysis of Variance (ANOVA). Usage of Statistical Package for Social Sciences (SPSS).

REFERENCES BOOKS

1. Brewer JM, Pesce AJ & Ashworth RB. 1974. *Experimental Techniques in Biochemistry*. Prentice-Hall.
2. Diamond PS & Denman RF. 1966. *Laboratory Techniques in Chemistry and Biochemistry*. Butterworths
3. Dubey, R.C., 2006. *A Text Book of Biotechnology*. S. Chand & Company Ltd., New Delhi.
4. Eaton AD, Clesceri LS, Rice EW & Greenberg AE. 2005. *Standard Methods for the Examination of Water and Wastewater*. APHAAWWA-WEF, Washington DC.
5. Fishbein L. 1973. *Chromatography of Environmental Hazards: Metals, Gaseous and Industrial Pollutants.* Elsevier.
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8. Murray RK, Granner DK, Mayes PA & Rodwell VW. 2000. *Harper's Biochemistry*. Appleton & Lange.
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10. Satyanarayana, U. 2005. *Biotechnology.* Books and Allied (P) Ltd., Kolkata, India.
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12. Welch PS. 2003. *Limnological Methods*. Narendra Publ. House.
13. Wilson K & Walker J. 2002. *Practical Biochemistry: Principles and Techniques*. Cambridge University Press, Oxford.
14. Anderson TW.1984. *An Introduction to Multivariate Statistical Analysis.*Wiley Series in Probability and Statistics, Singapore
15. Biradar RS. 2002. *Course Manual on Fisheries Statistics*. 2nd Ed. CIFE, Mumbai.
16. Ghosh S. 1999. *Multivariate Analysis, Design of Experiments and Survey Sampling*. Marcel Dekker.
17. Keller G. 2001. *Applied Statistics with Microsoft Excel*. Duxbury.
18. William RD & Matthew G. 1984. *Multivariate Analysis, Methods and Applications.* John Wiley & Sons .

M.Sc. AQUACULTURE
III – SEMESTER
PAPER – X: AQUACULTURE ECONOMICS AND FISHERIES EXTENSION
CODE No. AC 302

UNIT – I: Economics

1. The basis of production; Interrelationships of aquaculture systems.
2. **Production Economics:** Basic economic principles applied to aquaculture production; the input-output relationships, maximum level of input, least-cost combination of inputs, maximum level of out put, combination of products, economies of size.
3. **Cost-Benefit Analysis:** Production costs - fixed costs, variable costs, gross revenue, economic analysis; Partial budget analysis; Cash flow analysis.

UNIT – II

1. **Marketing Economics**: Fish marketing methods in India; Basic concepts in demand and price analysis; demand, supply and fish prices, elasticity of demand (price elasticity of demand, income elasticity of demand, cross elasticity of demand).
2. **Economic feasibility of investment analysis:** Methods of feasibility analysis; the payback period, average rate of return, discounting method, Net Present Value, Benefit-cost Ratio, Internal Rate of Return.

UNIT – III

1. Economics of carp production farm (Unit costs).
2. Economics of a shrimp farm.
3. Economics of a freshwater prawn farm.

UNIT – IV: Fisheries Extension

1. Fisheries training and Education in India: Training Institutes, Universities, Research organizations.
2. Institutional funding to fisheries and aquaculture sector.
3. Socio-economic conditions of fishermen and fish farmers.
4. Fishermen Co-operative societies.

REFERENCE BOOKS

1. Adcock D, Bradfield R, Halborg A & Ross C. 1995. *Marketing Principles and Practice*. Pitman Publ.
2. Allen, et al.(Eds). 1984. *Bio-Economics of Aquaculture*. Elsevier Publ.
3. Chaston I. 1984. *Business Management in Fisheries and Aquaculture,* Fishing News Books.
4. Hepher B and Pruginin Y. 1989. *Commercial Fish Farming*. Wiley-Interscience.
5. Ian C. 1984. *Marketing in Fisheries and Aquaculture*. Fishing News Books.
6. Kumar D. 1996. *Aquaculture Extension Services Review: India*. FAO Fisheries Circular No. 906, Rome.
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8. Pillay TVR. 1990. *Aquaculture Principles and Practices*. Fishing News Books Ltd. London
9. Ray GL. 2006. *Extension, Communication and Management*. 6th Ed. Kalyani Publ. Delhi.
10. Shang YC. 1990. *Aquaculture Economic Analysis - An Introduction.* World Aquaculture Society, USA.

M.Sc. AQUACULTURE
III – SEMESTER
PAPER – XI: WATER QUALITY MANAGEMENT
CODE No. AC 303

UNIT – I

1. **Water quality:** Constituents of water, Water quality parameters – optimal levels and their management in freshwater fish and brackish water shrimp culture.
2. **Fertilizers and manures:** Different kinds of fertilizers and manures, fertilizer grade, source, rate and frequency of application; Ecological changes taking place after fertilizing; Biofertilizers; Role of inorganic, organic and biofertilizers in aquaculture practices; Utilization of bioactive compounds by microorganisms.
3. **Liming:** Properties of liming materials, lime requirements and application of liming materials to ponds, effects of liming on pond ecosystem.

UNIT – II

1. **Dynamics of dissolved oxygen:** Dial changes in dissolved oxygen concentration, oxygen budget of culture ponds; algal die-off, overturns, identification of oxygen problems.
2. **Aeration:** Principles of aeration, emergency aeration, destratification and practical considerations.

UNIT – III

1. **Hatchery management:** Fish hatchery - Hatchery protocols, seed rearing technology; Packaging and transport of seed. Shrimp hatchery – Larval rearing; culture and use of different live feed; different chemicals and drugs used; water quality and feed management. Water discharge standards; Effluent treatment in hatcheries.
2. **Aquatic weed management:** Common weeds and problems in culture ponds; Chemical, biological and mechanical control methods; Algal bloom control.

UNIT – IV

1. **Chemical treatments:** Potassium permanganate, hydrogen peroxide, calcium hydroxide; reduction of pH, control of turbidity, salinity, hardness, chlorides, water exchange, chlorine removal; rotenone, formalin and malachite green; methods of applying chemicals.
2. Pollution in relation to aquaculture practices.

REFERENCE BOOKS

1. Adhikari S & Chatterjee DK. 2008. *Management of Tropical Freshwater Ponds.* Daya Publ.
2. Boyd CE and Tucker CS. 1992. *Water Quality and Pond Soil Analyses for Aquaculture*. Alabama Agricultural Experimental Station, Auburn University.
3. Boyd CE. 1979. *Water Quality in Warm Water Fish Ponds*. Auburn University
4. Boyd, CE. 1982. *Water Quality Management for Pond Fish Culture*. Elsevier Sci. Publ. Co.
5. Hepher B & Pruginin Y. 1981. *Commercial Fish Farming*. John-Willey & Sons Inc.
6. Jhingran VG. 1982. *Fish and Fisheries of India.* Hindustan Publishing Corporation, India.
7. Midlen & Redding TA. 1998. *Environmental Management for Aquaculture*. Kluwer.
8. Pillay TVR & Dill WMA.1979.*Advances in Aquaculture*. Fishing News Books, Ltd.England.
9. Rajagopalsamy CBT & Ramadhas V. 2002. *Nutrient Dynamics in Freshwater Fish Culture System.* Daya Publ.
10. Sharma LL, Sharma SK, Saini VP & Sharma BK. 2008. *Management of Freshwater Ecosystems.* Agrotech Publ. Academy.
11. Stickney RR. 1979. *Principles of Warm water Aquaculture*. John-Willey & sons Inc.
12. Tucker C.S. 1985. *Channel Catfish Culture*. Elsevier.

M.Sc. AQUACULTURE
III – SEMESTER
PAPER - XII: FISH AND SHELLFISH PATHOLOGY
CODE No. 304

UNIT – I: Viral diseases

1. **Fish Diseases: C**linical symptoms, pathology and control measures of Viral Hemorrhagic Septicemia (VHS) and Infectious Hematopoietic Necrosis (IHN).
2. **Shrimp Diseases:** Pathology, clinical symptoms, prevention and treatment of Monodon Baculoviral disease (MBV), Infectious Hypodermal and Hematopoietic Necrosis (IHHN), Hepato Pancreatic Parvovirus disease (HPPV), Yellow-head virus disease, Taura syndrome and White spot syndrome.

UNIT – II: Bacterial and Fungal diseases

1. **Fish Diseases:** Clinical symptoms, pathology, prevention and control measures of Bacterial Hemorrhagic Septicemia (BHS), Bacaterial gill disease and Tail and fin rot.
2. Pathology, clinical symptoms, prevention and control measures of Saprolegniasis and Branchiomycosis.
3. **Shrimp Diseases:** Clinical symptoms, pathology, prevention and control measures of Black gill disease, Filamentous bacterial gill disease.
4. Clinical symptoms, pathology, prevention and control measures of *Lagenidium* disease (Larval Mycosis) and Brown gill disease.

UNIT – III: Protozoan, Helminthic and Crustacean diseases

1. **Fish Diseases:** Clinical symptoms, pathology and control measures of Ichthyophthiriasis, Enterococcidiasis, Whirling disease and Nodular disease.
2. Clinical symptoms, pathology and control measures of Gyrodactylosis and Dactylogyrosis.
3. Clinical symptoms, pathology and control measures of Argulosis and Lernaeasis.
4. **Shrimp Diseases:** Etiology, morphology and control measures of ectocommensal protozoa – *Zoothamnium* and *Acineta.*
5. Clinical symptoms, pathology and control measures of Microsporidiasis.

UNIT – IV: Nutritional and Ecological diseases

1. **Fish Diseases:** Diseases of vitamin deficiency and Fatty liver degeneration.
2. Clinical symptoms, pathology and control measures of gas bubble disease and lack of oxygen.
3. **Shrimp Diseases:** Clinical symptoms, pathology and control measures of Cramped tails, Muscle Necrosis, Gas bubble disease, Black death disease, Chronic soft shell syndrome and Blue shell syndrome.

REFERENCE BOOKS

1. Cheng TC. 1964. *The Biology of Animal Parasites*. W.B. Saunders Company, Philadelphia, Pennsylvania, USA.
2. Conroy CA and Herman RL. 1968. *Text book of Fish Diseases*. TFH (Great Britain) Ltd, England.
3. Lightner DV. 1996. *A Handbook of Shrimp Pathology and Diagnostic Procedures for Diseases of Cultured Penaeid Shrimp*. World Aquaculture Society, Lousiana, USA.
4. Reichenbach KH. 1965. *Fish Pathology*. TFH (Gt. Britain) Ltd, England.
5. Ribelin WE and Miguki G. 1975. *The Pathology of Fishes.* The Univ. of Wisconsin Press Ltd, Great Russel Street, London, UK.
6. Shuzo Egusa.1978. *Infectious Diseases of Fish*. Oxonian Press Pvt. Ltd. New Delhi.
7. Van Duijn, C. 1973. *Diseases of Fishes.* Cox and Wyman Ltd. London.

M.Sc. AQUACULTURE
III – SEMESTER
NON - CORE PAPER: AQUACULTURE MANAGEMENT

UNIT – I

Selection of site, designing, layout and construction of aqua farms; Soil properties; Water supply and drainage systems; Design and construction of aqua – hatcheries; aeration; Aquaculture types and design; Equipments, automatic feeders.

UNIT – II

Standard guidance for choosing cultivable species; Seaweeds, crustaceans – prawns and lobsters; Mollusks - clams, cockles, mussels and oysters; fishes; Biological criteria; Environmental adaptability and compatibility; adaptability to intensive culture; Economic importance; Economics; Market values; By-products and availability in adjacent region.

UNIT – III

Traditional, extensive systems; composite fish culture; Paddy-cum-fish culture; Integrated fish culture; Sewage water fish culture; Raceway culture; Pen and rack culture; Culture system management - pond preparation, production and economics.

UNIT – IV

Sources of pollution, biological and chemical oxygen demand; Aquatic contaminants and their biodegradation; Impact of pollution on fish health and fisheries; Water quality management - temperature, salinity, pH, O_2, CO_2 levels; Nutrients and trace elements; control of parasites; Predators; Weeds and diseases in culture ponds; Disease diagnosis - ELISA, Western blotting - DNA based diagnosis of diseases and fish vaccines.

REFERENCE BOOKS

1. Bardach, JE *et al*. 1972. *Aquaculture – The farming and husbandry of freshwater and marine organisms*, John Wiley & Sons, New York.
2. Chakraborty C & Sadhu AK. 2000. *Biology Hatchery and Culture Technology of Tiger Prawn and Giant Freshwater Prawn.* Daya Publ. House
3. FAO. 2007. *Manual on Freshwater Prawn Farming.*
4. Huet J. 1986. *A text Book of Fish Culture*. Fishing News Books Ltd.
5. ICAR. 2006. *Hand Book of Fisheries and Aquaculture*. ICAR.
6. Jhingran V.G. 1991. *Fish and Fisheries of India*. Hindustan Publ. Corporation, India.
7. Landau M. 1992. *Introduction to Aquaculture*. John Wiley & Sons.
8. Mcvey JP. 1983. *Handbook of Mariculture*. CRC Press.
9. MPEDA: *Handbooks on culture of carp, shrimp, etc*.
10. New MB. 2000. *Freshwater Prawn Farming*. CRC Publ.
11. Pillay TVR. 1990. *Aquaculture- Principles and Practices*, Fishing News Books Ltd., London.
12. Pillay TVR & Kutty MN. 2005. *Aquaculture- Principles and Practices*. 2nd Ed. Blackwell
13. Rath RK. 2000. *Freshwater Aquaculture*. Scientific Publ.
14. Stickney RR. 1979. *Principles of Warmwater Fish Culture*, John Wiley & Sons.

M.Sc. AQUACULTURE
III – SEMESTER
PRACTICAL – V: TOOLS AND TECHNIQUES IN BIOLOGY AND AQUACULTURE ECONOMICS
CODE No. ACP 5

Tools and Techniques in Biology

1. Microscopy - description and working methodology.
2. Spectrophotometry - principle and working methodology.
3. Paper chromatography - separation of molecules.
4. Thin layer chromatography - isolation of molecules.
5. Calculation of mean, median, mode, standard deviation and standard error.
6. Analysis of Variance (ANOVA).

Aquaculture Economics

7. Estimation of the unit cost of freshwater prawn farm.
8. Unit cost estimates for 1 ha shrimp farming.
9. Unit cost estimates for 1 ha carp farming.

M.Sc. AQUACULTURE
III – SEMESTER
PRACTICAL - VI: WATER QUALITY MANAGEMENT AND FISH & SHELLFISH PATHOLOGY
CODE No. ACP 6

Water Quality Management

1. Determination of temperature, pH, salinity in the pond water sample.
2. Estimation of total alkalinity and total hardness.
3. Estimation of dissolved oxygen and free carbondioxide.
4. Estimation of phosphates and nitrites.
5. Estimation of COD and BOD.

Fish and Shrimp Diseases

5. External examination of the diseased fish – diagnostic features and procedure.
6. Exploration of the skin smear
7. Exploration of the gill smear
8. Autopsy of fish – Examination of the internal organs.
9. Maceration and squash preparation of organs for microscopic observation of pathogens.
10. Collection and mounting of some important ecto- and endoparasites of fish.
11. Identification of fish diseases.
12. Identification of common shrimp diseases.
13. Preparation of paraffin blocks for the study of histology of internal organs - gills, kidney and intestine.

M.Sc. AQUACULTURE
IV – SEMESTER
PAPER – XIII: PRINCIPLES AND PRACTICES OF AQUACULTURE
CODE No. AC 401

UNIT - I

1. Basics of Aquaculture: Definition, significance and classification; History of aquaculture; Cultivable species – freshwater, brackish water and marine; A knowledge of inland water bodies suitable for culture in India.
2. Criteria for the selection of a species for culture.
3. Culture practices of fish and shrimp: Traditional, extensive, modified extensive, semi-intensive and intensive cultures.
4. Concept of monoculture, polyculture and integrated fish farming.

UNIT-II

1. Bundh breeding and Induced breeding of carp by hypophysation and use of synthetic hormones.
2. Culture of Indian major carps – nursery, rearing and production ponds.
3. Culture of air-breathing fishes in India.
4. Culture of giant fresh water prawn, *Macrobrachium rosenbergii*

UNIT-III

1. Culture of milk fish, *Chanos chanos*.
2. Culture of Asian sea bass, *Lates calcarifer*.
3. Culture of shrimp, *Penaeus monodon.*
4. Culture of crab, *Scylla serrata.*

UNIT-IV

1. Sewage-fed fish culture.
2. Culture of ornamental fishes.
3. Culture of pearl oysters.
4. Culture of sea weeds: Major seaweed species of commercial importance; methods of culture.

REFERENCES BOOKS

1. Bardach, JE *et al*. 1972. *Aquaculture – The farming and husbandry of freshwater and marine organisms*, John Wiley & Sons, New York.
2. Chakraborty C & Sadhu AK. 2000. *Biology Hatchery and Culture Technology of Tiger Prawn and Giant Freshwater Prawn.* Daya Publ. House.
3. FAO. 2007. *Manual on Freshwater Prawn Farming.*
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7. Landau M. 1992. *Introduction to Aquaculture*. John Wiley & Sons.
8. Mcvey JP. 1983. *Handbook of Mariculture*. CRC Press.
9. MPEDA: *Handbooks on culture of carp, shrimp, etc.*
10. New MB. 2000. *Freshwater Prawn Farming*. CRC Publ.
11. Pillay TVR. 1990. *Aquaculture- Principles and Practices*, Fishing News Books Ltd., London.
12. Pillay TVR & Kutty MN. 2005. *Aquaculture- Principles and Practices*. 2nd Ed. Blackwell
13. Rath RK. 2000. *Freshwater Aquaculture*. Scientific Publ.
14. Stickney RR. 1979. *Principles of Warmwater Fish Culture*, John Wiley & Sons.

M.Sc. AQUACULTUE
IV - SEMESTER
PAPER - XIV: FISH PROCESSING TECHNOLOGY
CODE No. 402

UNIT – I: Process Biochemistry

1. Major and minor constituents of fish, their distribution and function - moisture, proteins, lipids, carbohydrates, vitamins and minerals.
2. Post-mortem biochemical changes in fish - rigor mortis, autolysis, auto-oxidation and their significance.
3. Toxins and toxic substances in fish.

UNIT – II: Microbiology

1. Biochemical and microbial spoilage of fish; factors affecting spoilage of fish.
2. Role of bacteria and moulds in fish preservation - pathogenic organisms encountered in fish products, faecal indicator organisms.

UNIT – III: Handling and Fish Preservation

1. Handling, storage and transport of fresh fish, sanitary and phyto-sanitory requirements for maintenance of quality.
2. Principles of fish preservation; preservation of fish by curing, drying, salting and smoking; chilling and freezing of fish; canning of fish and fish products.
3. Modern techniques employed in fish preservation: Accelerated Freeze Drying (AFD), Irradiation.
4. Fishery by-products and waste utilization.

UNIT – IV: Quality Management and Certification

1. HACCP (Hazard Analysis and Critical Control Points) and Good Manufacturing Practices: HACCP Principles, Practical aspects of planning and implementation, Verification, Validation and Audit.
2. National and International Standards - ISO 9000 Series, 2000 Series of Quality Assurance System, Codex Alimentarius Commission, Food Safety and Standards Act of India 2006.

REFERENCE BOOKS

1. Balachandran KK. 2001. *Post-harvest Technology of Fish and Fish Products*. Daya Publ.
2. Bond, et al. 1971. *Fish Inspection and Quality Control.* Fishing News Books, England.
3 Clucas IJ. 1981. *Fish Handling, Preservation and Processing in the Tropics*. Parts I, II. FAO.
4. Gopakumar K. (Ed.). 2002. *Text Book of Fish Processing Technology*. ICAR.
5. Govindan, TK. 1985. *Fish Processing Technology,* Oxford-IBH.
6. Hall GM. (Ed). 1992. *Fish Processing Technology*. Blackie.
7. Huss HH, Jakobsen M & Liston J. 1991. *Quality Assurance in the Fish Industry.* Elsevier.
8. John DEV. 1985. *Food Safety and Toxicity*. CRC Press.
9. Krenzer R. 1971. *Fish Inspection and Quality Control.* Fishing News.
10. Larousse J & Brown BE. 1997. *Food Canning Technology*. Wiley VCH.
11. Nambudiri DD. 2006. *Technology of Fishery Products*. Fishing Chimes.
12. Regenssein JM & Regenssein CE.1991. *Introduction to Fish Technology*.Van Nostrand Reinhold.
13. Rudolf K. 1969. *Freezing and Irradiation of Fish.* Fishing News (Books).
14. Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ.

M.Sc. AQUACULTURE
IV – SEMESTER
PAPER – XV: AQUACULTURE BIOTECHNOLOGY
CODE No. AC 403

UNIT – I

1. **Biotechnology:** Origin, definition and knowledge of different branches.
2. **Genetic Engineering:** Recombinant DNA technology; Tools of genetic engineering – cloning vectors, restriction endonucleases, DNA ligases, topoisomerases, methylases, nucleases, polymerases, reverse transcriptase and their functions.
3. Screening analysis of recombinants: Colony hybridrization technique, immunological tests.
4. **Transgenics:** Principles of Transgenic technology and its applications in fisheries.

UNIT – II

1. **Fish breeding:** Synthetic hormones for induced breeding – GnRH analogue structure and function; Selective breeding for improving fish stocks - hybridization in Indian fishes.
2. Androgenesis, Gynogenesis, Polyploidy and Sex reversal.
3. Hormonal regulation of reproduction and molting in important cultivable crustaceans.
4. **Gene bank and Conservation:** Cryopreservation of gametes and embryos. Embryo transfer technology.

UNIT – III

1. **Feed technology:** Micro encapsulated feeds; micro coated feeds; micro particulate feeds and bio-encapsulated feeds; mycotoxins and their effects on feeds.
2. **Algal biotechnology:** Biotechnological approaches for production of important microalgae; single cell protein from *Spirulina;* vitamins, minerals and omega3 fatty acids from micro algae; enrichment of micro algae with micronutrients.
3. Application of Nanotechnology in aquaculture; A general knowledge of tissue culture.

UNIT – IV

1. **Health management:** DNA and RNA vaccines; molecular diagnosis of viral diseases; Biofilms and its impact on health management; genetically modified microorganisms as probiotics, immunostimulants, bioremediation of soil and water.
2. Nitrogen fixation in aquatic environment and Biofertiizers.
3. **Post-harvest biotechnology:** Delaying of spoilage; biosensors.

REFERENCE BOOKS

1. Bhattacharya S. 1992. *Hormones in Pisciculture*. Biology Education,Vol. 9 No.1 pp.31- 41.
2. CIFE. 1998. Summer School Manuals, Mumbai.
   i). *Recent Developments in Biotechnology: Applications to Aquaculture & Fisheries.*
   ii). *Genetics and Biotechnolical Tools in Aquaculture and Fisheries.*
3. Felix S. 2007. *Molecular Diagnostic Biotechnology in Aquaculture*. Daya Publ. House.
4. ICAR. 1992. *Biotechnology in Aquaculture.* Training Manual. C.I.F.A, Kausalyaganga, Bhubaneswar, Orissa.
5. Lakra WS, Abidi SAH, Mukherjee SC & Ayyappan S. 2004. *Fisheries Biotechnology*. Narendra Publ. House.
6. Nagabhushanam R, Diwan AD, Zahurnec BJ & Sarojini R. 2004. *Biotechnology of Aquatic Animals.* Science Publ.
7. Nair PR. 2008. *Biotechnology and Genetics in Fisheries and Aquaculture.* Dominant Publ.
8. Pandian TJ, Strüssmann CA & Marian MP. 2005. *Fish Genetics and Aquaculture Biotechnology*. Science Publ.
9. Ramesh RC. 2007. *Microbial Biotechnology in Agriculture and Aquaculture*. Vol. II. Science Publ.
10. ReddyPVGK, AyyappanS, ThampyDM & Gopalakrishna 2005.*Text Book of Fish Genetics and Biotechnol*.ICAR
11. Singh B. 2006. *Marine Biotechnology and Aquculture* Development. Daya Publ. House

M.Sc. AQUACULTURE
IV – SEMESTER
PAPER – XVI: FISH AND SHELLFISH IMMUNOLOGY
CODE No. AC 404

UNIT – I

1. **Fish immunology:** Introduction, historical developments, phylogeny of fish immune system.
2. **Antigens:** Chemical nature of antigens, haptens, epitopes, paratopes, binding forces of antigen and antibody – affinity, avidity, bonus effect and cross reactivity.
3. **Immunoglobulins:** Basic structure of the immunoglobulin; structure and biological properties of IgG, IgA, IgM, IgD and IgE in humans and IgM, IgD and IgT in fishes.

UNIT – II

1. **Cells of the immune system:** Origin of the cells, stem cells; lymphoid lineage – T lymphocytes, B lymphocytes, null cells; myeloid lineage - monocytes, polymorpphonuclear leucocytes, accessory cells.
2. **Lymphoid tissues** of fish.
3. **Innate immunity:** Non specific humoral and cellular defence mechanisms, phagocytic systems.
4. **Acquired immunity:** Specific defence mechanisms; Memory function and immunological tolerance.

UNIT – III

1. **Major Histocompatibility Complex (MHC):** Nomenclature, antigens of MHC, HLA typing, functions of MHC, antigen processing.
2. **Vaccination:** Vaccines and immunostimulants of fish.
3. **Crustacean immune system:** Crustacean defence mechanisms.

UNIT – IV

Immunological Techniques:

1. Immunodiffusion - simple diffusion/single diffusion, radial immunodiffusion and double immunodiffusion.
2. Immunoelectrophoresis, counter immunoelectrophoresis and rocket immunoelectrophoresis.
3. Radioimmunoassay (RIA): Competitive R.I.A. and Excess reagent R.I.A.; Immunoblotting.
4. Enzyme Linked Immuno Sorbent Assay (ELISA), Hybridoma technology.

REFERENCE BOOKS

1. Ellis AE. 1988. *Fish Vaccination*. Academic Press.
2. Goldsby AR, Kindt TJ and Osborne BA. 2000. *KUBY Immunology*, W.H. Freeman and Company, New York.
3. Ivon M. Roitt. 2001. *Essential Immunology*, Blackwell Science Ltd, Mishawaka, IN, USA.
4. Iwama G & Nakanishi T. 1996. *The Fish Immune System. Organism, Pathogen and Environment*. Acad. Press.
5. Joshi KR and Osamo NO. 1994. *Immunology*, Agro Botanical Publishers, India.
6. Manning MJ and Tatner MF. 1985. *Fish Immunology*, Academic Press, London, UK.
7. Nandini Shetty. 2008. *Immunology Introductory Text*, Wiley Eastern Limited, New Age International Publishers, New Delhi.
8. Rajasekara Pandian M and Senthil Kumar B. 2007. *Immunology and Immunotechnology*, Panima Publishing Corporation, New Delhi, India.
9. Swain P, Sahoo PK & Ayyappan S. 2005. *Fish and Shellfish Immunology: An Introduction*. Narendra Publ.

M.Sc. AQUACULTURE
IV – SEMESTER
PRACTICAL - VII: AQUACULTURE AND FISH PROCESSING TECHNOLOGY
CODE No. ACP 7

Practices of Aquaculture

1. Identification of important cultivable species of fin fish and shell fish.
2. Common unwanted (weed and predatory) fishes in culture ponds – identification and their impact in aquaculture.
3. Dissection of pituitary gland and preparation of pituitary extract. Method of dosage preparation and injection of pituitary extract for induced breeding of fish.
4. Collection, preservation and identification of common phytoplanktonic organisms in ponds.
5. Collection, preservation and identification of common zooplanktonic organisms in ponds – Rotifers, Cladocerans and Copepods.
6. Identification of aquatic insects and molluscs in ponds.
7. Common floating, emergent and submerged aquatic vegetation in ponds.

Fish Processing Technology

8. Evaluation of fish/ fishery products for organoleptic, chemical and microbial quality.
9. Spoilage microorganisms: isolation of pathogenic bacteria associated with fish and fishery products.
10. Design and maintenance of fish processing plants.

M.Sc. AQUACULTURE
IV - SEMESTER
PRACTICAL – VIII: AQUACULTURE BIOTECHNOLOGY AND IMMUNOLOGY
CODE No. ACP 8

Biotechnology

1. Isolation of DNA from blood sample.
2. Isolation of DNA from saliva.
3. Cloning vectors – diagrams, properties and functions.
4. Transgenic animals – photographs.

Immunology

5. Haemagglutination – detection of blood group antigens.
6. Immunodiffusion – detection of antigen-antibody reaction.
7. Estimation of total RBC count.
8. Estimation of total WBC count.
9. Estimation of differential leucocytes count (DLC).
10. ELISA test – qualitative determination of antigens or antibodies.