Annexure C

Post-graduate course curriculum:

The curriculum of M.F.Sc and Ph.D in Fisheries will be as per ICAR recommendations.

AQUACULTURE

CODE	COURSE TITLE	CREDITS
AQC 501*	SUSTAINABLE AQUACULTURE	2+1
AQC 502*	SOIL AND WATER QUALITY MANAGEMENT IN AQUACULTURE	2+1
AQC 503*	NUTRITION AND FEED TECHNOLOGY	2+1
AQC 504*	AQUATIC ANIMAL HEALTH MANAGEMENT	2+1
AQC 505	SEED PRODUCTION AND HATCHERY MANAGEMENT OF FINFISHES	2+1
AQC 506	SEED PRODUCTION AND HATCHERY MANAGEMENT OF SHELLFISHES	1+1
AQC 507	APPLIED GENETICS IN AQUACULTURE	2+1
AQC 508	NON-FOOD AQUACULTURE	1+1
AQC 509	COASTAL AQUACULTURE	2+1
AQC 510	FRESHWATER AQUACULTURE	2+1
AQC 511	LARVAL NUTRITION AND CULTURE OF FOOD ORGANISMS	1+1
AQC 512	AQUACULTURE ENGINEERING	2+1
AQC 591	MASTERôS SEMINAR	1+0
AQC 599	MASTERôS RESEARCH	20
AQC 601**	ADVANCES IN AQUACULTURE PRODUCTION SYSTEMS	2+1
AQC 602**	ADVANCES IN SEED PRODUCTION AND HATCHERY MANAGEMENT	2+1
AQC 603**	AQUACULTURE AND ECOSYSTEM MANAGEMENT	2+1
AQC 604	AQUATIC ANIMAL HEALTH MANAGEMENT AND QUARANTINE	1+1
AQC 605	FISH AND SHELLFISH PHYSIOLOGY AND ENDOCRINOLOGY	1+1
AQC 606	ADVANCES IN FISH GENETICS	2+1
AQC 607	INTENSIVE FARMING SYSTEMS FOR TILAPIA AND CATFISHES	1+1
AQC 608	AQUACULTURE DEVELOPMENT PLANNING AND MANAGEMENT	1+1
AQC 609	APPLIED BIOTECHNOLOGY	1+1
AQC 691	DOCTORAL SEMINAR I	1+0
AQC 692	DOCTORAL SEMINAR II	1+0
AQC 699	DOCTORAL RESEARCH	45

* Compulsory for Masterôs programme; ** Compulsory for Doctoral programme

Course Contents

AQC 501 SUSTAINABLE AQUACULTURE 2+1

Objective

To gain in depth knowledge and field exposure on sustainable aquaculture practices.

Theory

UNIT I

Present scenario and problems: Trends in global and Indian aquaculture; different farming systems; intensive systems and constraints - environmental degradation and disease outbreaks.

UNIT II

Sustainability and development: Systems approach and its application in aquaculture with special reference to resource-poor systems; Role of aquatic resources in food and nutrition; Aquatic resource and livelihood systems.

UNIT III

Environmental issues: Exotic species introduction; escapement; contamination of indigenous gene pool; salinization of soil and water; environmental impact; over exploitation of wild stocks; mangrove deforestation.

UNIT IV

Socio-economic issues: Conflicts over water and land use; conflicts of interest between aqua farmers and fishermen; resistance from local public; anti-dumping duties.

UNIT V

Strategies for sustainability: Sustainability concept; food security; biosecurity; organic farming; integrated farming; responsible aquaculture; rotational aquaculture; bioremediation; role of biotechnology, traceability. Application of renewable energy in aquaculture - solar energy, wind, and tidal energy, Seed certification, Sustainable use of antibiotics.

UNIT VI

Economic viability: export vs. domestic marketing, value addition.

UNIT VII

Guiding principles to sustainable aquaculture development: Coastal Aquaculture Guidelines Source Book, FAO Code of Conduct for Responsible Fisheries; Holmenskollen Guidelines for Sustainable Aquaculture.

Practical

Visit to conventional aquafarm to see the management of used water; Survey on environmental impact nearby aquaculture farms; Setting model for sustainable aquaculture (organic farm, integrated farm); Applications of remote sensing and GIS (geographical information system); Economic evaluation of aquaculture practices.

Suggested Readings

Bardach JE. 1997. *Sustainable Aquaculture*. John Willey & Sons.

Bardach JE, Rhyther JH & Mc. Larney WO. 1972. *Aquaculture Farming and Husbandry of Freshwater and Marine Organisms*. John Wiley & Sons.

Beets WC. 1990. *Raising and Sustaining Productivity of Small-HolderFarming Systems in the Tropics*. Agbe Publ.

Edwards P, Little DC & Demaine H. (Eds.). 2002. *Rural Aquaculture*.CABI.

FAO 2001. *Planning and Management for Sustainable Coastal Aquaculture Development*. FAO.

Imai T. 1978. *Aquaculture in Shallow Seas. Progress in Shallow Sea Culture*. Amerind Publ.

James PM. 1983. *Handbook of Mariculture*. Vol. I. *Crustacean Aquaculture*. CRC Press.

Leung P, Lee CS & O'Bryen JP. (Eds.). 2007. *Species and System Selection for Sustainable Aquaculture*. Blackwell Publ.

Midlen & Redding TA. 1998. *Environmental Management for Aquaculture*. Chapman & Hall.

Selvamani BR & Mahadevan RK. 2008. *Aquaculture, Trends and Issues*. Campus Books International.

AQC 502 SOIL AND WATER QUALITY MANAGEMENT IN AQUACULTURE 2+1

Objective

To learn effective soil and water quality management practices.

Theory

UNIT I

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

UNIT II

Soil and water quality monitoring: soil and water quality standards; soil and water quality monitoring and management.

UNIT III

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

UNIT IV

Soil and water quality management: Cat clay/pyrite soil, seepage, water treatment, water filtration devices, aeration, chlorination, ozonization and UV radiation, Algal bloom control, eutrophication, Aquatic weed management, Waste water treatment practices, Water quality management in hatcheries, Waste discharge standards, Role of microorganisms in fish production, fish health and fish safety; Microbial load and algal blooms.

Practical

Equipment used in soil and water analysis; Soil sampling, determination of soil moisture and bulk density; pond filling, analyses of mud acidity and soil texture; Measurements of temperature, pH, conductivity, salinity, transparency, turbidity and solids; Analyses of dissolved oxygen, alkalinity and hardness, phosphorus, nitrogen; Estimation of primary productivity and chlorophyll; Application of fertilizers and pond liming; Analysis of toxic elements; Microbial techniques; Visit to effluent treatment plant; Design and operation of biological filters.

Suggested Readings

Adhikari S & Chatterjee DK. 2008. *Management of Tropical Freshwater Ponds*. Daya Publ.

APHA, AWWA, WPCF. 1998. Standard Methods for the Examination of Water and Wastewater, 20th Ed. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, Washington, D. C.

Boyd, C. E. and Tucker, C. S. 1992. Water Quality and Pond Soil Analyses for Aquaculture, Alabama Agricultural Experimental Station, Auburn University.

Boyd CE. 1979. *Water Quality in Warm Water Fish Ponds*. Auburn University. ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.

Parsons TR, Maita Y & Lalli CM. 1984. *A Manual of Chemical and Biological Methods for Seawater Analysis*. Pergamon Press. Rajagopalsamy CBT & Ramadhas V. 2002. *Nutrient Dynamics in Freshwater Fish Culture System*. Daya Publ.

Sharma LL, Sharma SK, Saini VP & Sharma BK. (Eds.). 2008. *Management of Freshwater Ecosystems*. Agrotech Publ. Academy.

AQC 503 NUTRITION AND FEED TECHNOLOGY 2+1

Objective

To create basic understanding on the nutritional requirements of fish/shellfish and feed manufacture.

Theory

UNIT I

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

UNIT II

Nutritional biochemistry: Classification, nutrient quality and evaluation of proteins, lipids and carbohydrates.

UNIT III

Role of nutrients: amino acids, fatty acids, proteins, lipids, carbohydrates, vitamins and minerals.

UNIT IV

Nutritional bioenergetics: Fish as an open thermodynamic system, Energy requirement of fishes, protein to energy ratio, digestible energy, nitrogen balance index, protein sparing effect, high energy feeds, isocaloric diets, Optimal foraging theory, Mathematical modeling of ingestion, Metabolic rate, Energy budgets, Energetic efficiency of fish production.

UNIT V

Nutritional physiology: Digestion, accretions and nutrient flow, Factors affecting digestibility.

UNIT VI

Nutritional pathology: Antinutritional factors and antimetabolites, microbial toxins, methods of elimination, nutrient deficiency and symptoms.

UNIT VII

Feed Resources: Nutritional value of feed ingredients and live feed, Contribution from natural food to nutrient requirements of fish, Feed additives (attractants, growth stimulants and probiotics and binders), and Feed resources assessment.

UNIT VIII

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

UNIT IX

Feeding Practices: Supplementary feedï theory and practice, Complete diet - theory and practice, Feeding methods and scheduling, ration size, feed performance and economics.

Practical

Formulation and preparation of a balanced fish feed; Feeding trials; Proximate analysis- moisture, crude protein, crude lipid ,ash , acid insoluble ash content of feed; Estimation of crude fibre, nitrogen free extract, calcium and phosphorus content of feed; Estimation of protein and lipid quality; Determination of gross energy content of feed and feed ingredients; Determination of the digestibility of feed using markers; Estimation of FCR from feeding trials and preparation of feeding table; Estimation of growth parameters from feeding trials; Analysis of mycotoxins from feed ingredients/feed; Gut content analysis to study artificial and natural food intake. Visit to feed manufacturing units.

Suggested Readings

ADCP (Aquaculture Development and Co-ordination Programme). 1980. *Fish Feed Technology*. ADCP/REP/80/11. FAO.

Cyrino EP & Bureau D & Kapoor BG. 2008. *Feeding and Digestive Functions in Fishes.* Science Publ.

Dô Abramo LR, Conklin DE & Akiyama DM. 1977. *Crustacean Nutrition: Advances in Aquaculture*. Vol. VI. World Aquaculture Society, Baton Roughe.

De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall Aquaculture Series.

Elena M. 2003. *Nutrition, Physiology and Metabolism in Crustaceans*. Science Publishers.

Guillame J, Kaushik S, Bergot P & Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis Publ. Halver J & Hardy RW. 2002. *Fish Nutrition*. Academic Press.

Halver JE & Tiews KT. 1979. *Finfish Nutrition and Fishfeed Technology*. Vols. I, II Heenemann, Berlin.

Hertrampf JW & Pascual FP. 2000. *Handbook on Ingredients for Aquaculture Feeds*. Kluwer.

Houlihan D, Boujard T & Jobling M. 2001. *Food Intake in Fish*. Blackwell. Lavens P & Sorgeloos P. 1996. *Manual on the Production and Use of Live Food for Aquaculture*. FAO Fisheries Tech. Paper 361, FAO.

Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Chapman & Hall.

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*. FAOï ADCP/REP/87/26.

NRC (National Research Council). 1993. *Nutrient Requirements of Fish*. National Academy Press, Washington.

Ojha JS. 2005. *Aquaculture Nutrition and Biochemistry*. Daya Publ.

AQC 504 AQUATIC ANIMAL HEALTH MANAGEMENT 2+1

Objective

To provide holistic knowledge on fish and shellfish pathogens and their control measures.

Theory

UNIT I

Basics of fish and shellfish health management: Host-pathogen-environment relationship, Management of culture systems, Environmental stress.

UNIT II

Defence system in fish and shellfish: Defence systems in fish, innate and acquired immunity, inflammation response to diseases. Antibody and cell mediated immunity in fish and shellfish.

UNIT III

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

UNIT IV

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

UNIT V

Non-infectious Diseases: Nutritional diseases, water, soil, environmental parameters and their effects on fish health. Disease in hatcheries and grow- out systems.

UNIT VI

Techniques in health management: Microbiological, haematological, histopathological, immunological and molecular techniques. Disease surveillance and reporting.

UNIT VII

Disease control and management: Environment management, chemotherapeutic agents, host management,

prophylaxis- vaccines, adjuvants, immunostimulants and probiotics. Use and abuse of antibiotics and chemicals in health management. Fish health and quarantine systems. Seed certification, SPF and SPR stocks - development and applications.

Practical

General procedures for disease diagnosis; Taxonomy and identification of fish parasites; Sampling, preparation of media and culture of pathogenic bacteria; Techniques for bacterial classification; Histological techniques for disease diagnosis; Molecular and immunological techniques; Biochemical tests; PCR; ELISA; Agglutination test; Challenge tests; Purification of virus; Stress related study of fish and shellfish; Disease treatments.

Suggested Readings

Aline W. 1980. *Fish Diseases*. Springer Verlag.

Andrews C, Excell A & Carrington N. 1988. *The Manual of Fish Health*.
Salamander Books.

Austin B & Austin DA. 1987. *Bacterial Fish Pathogens* (Diseases in Farm and Wild). Ellis Harward.

Felix S, Riji John K, Prince Jeyaseelan MJ & Sundararaj V. 2001. *Fish Disease Diagnosis and Health Management*. Fisheries College and Research Institute, T.N. Veterinary and Animal Sciences University. Thoothukkudi.

Inglis V, Roberts RJ & Bromage NR. 1993. *Bacterial Diseases of Fish*. Blackwell.

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

Roberts RJ. 2001. *Fish Pathology*. 3nd Ed. WB Saunders. Schaperclaus W. 1986. *Fish Diseases*. Vols. I, II. Oxonian Press.

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

Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish*. Vols. I, II. 2nd Ed. Academic Press.

Walker P & Subasinghe RP. (Eds.). 2005. *DNA Based Molecular Diagnostic Techniques: Research Needs for Standardization and Validation of the Detection of Aquatic Animal Pathogens and Diseases*. FAO Publ.

Wedmeyer G, Meyer FP & Smith L. 1999. *Environmental Stress and Fish Diseases*. Narendra Publ. House.

AQC 505 SEED PRODUCTION AND HATCHERY OF FINFISHES 2+1

Objective

To learn seed production and hatchery management of commercially important cultivable fishes.

Theory

UNIT I

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

UNIT II

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

UNIT III

Gamete maturation and development: Spermatogenesis and oogenesis, Hormonal pathways and mode of control.

UNIT IV

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.

UNIT V

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.

UNIT VI

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

UNIT VII

Marine fish seed production: Seabass, milkfish, mullets, sea breams, rabbitfish, grouper, yellowtail, eel, cobia, etc.

UNIT VIII

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.

UNIT IX

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

Practical

Study of gonadal development in carps and other cultivable finfishes; Identification of carp and catfish seed; Collection and identification of cultivable brackishwater finfish seed; Packing and transportation of cultivable finfish seed; Induced breeding of fishes through various inducing agents; Evaluation of carp milt and egg; Design and operation of Chinese hatchery; Preparation of brood and larval feed for different cultivable finfish; Rearing of carp spawn and fry; Visit to different finfish hatcheries.

Suggested Readings

FAO. 1992. *Manual of Seed Production of Carps*. FAO Publ. ICAR. 2006. *Hand Book of Fisheries and Aquaculture*. ICAR.

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

Jhingran VG. 1991. *Fish and Fisheries of India*. Hindustan Publ. Landau M. 1992. *Introduction to Aquaculture*. John Wiley & Sons.

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

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

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

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

AQC 506 SEED PRODUCTION AND HATCHERY MANAGEMENT OF SHELLFISHES

1+1

Objective

To provide overall knowledge of seed production and hatchery management of commercially important cultivable crustaceans and molluscs.

Theory

UNIT I

Introduction: Current status; problems and prospects.

UNIT II

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

UNIT III

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.

UNIT IV

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

UNIT V

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

UNIT VI

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.

UNIT VII

Economics of seed production.

Practical

Layout and design of prawn and shrimp hatcheries; Study of gonad development in different cultivable crustaceans and molluscs; Collection and identification of shellfish seed; Packing and transportation of shellfish seed; Eyestalk ablation technique; Identification of larval stages of shrimp, prawn, crab, mussel and oyster; Culture techniques of microalgae and other live feed used in shellfish hatcheries; Artemia hatching technique; Visit to different shellfish hatcheries; Economic analysis of shellfish hatcheries.

Suggested Readings

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

FAO. 2007. *Manual for Operating a Small Scale Recirculation Freshwater Prawn Hatchery*.

ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.

Jhingran VG. 1991. *Fish and Fisheries of India*. Hindustan Publ. Corp. Landau M. 1992. *Introduction to Aquaculture*. John Wiley & Sons. Mcvey JP. 1983. *Handbook of Mariculture*. CRC Press.

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

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

AQC 507 APPLIED GENETICS IN AQUACULTURE 2+1

Objective

To impart knowledge on genetic basis of inheritance and breeding plans for commercially important fishes.

Theory

UNIT I

Introduction: Origin and advancement in genetics; physical basis of heredity; genetic correlation, domestication and local adaptation.

UNIT II

Chromosome manipulation: Ploidy induction methods - triplody and tetraploidy, advantages and disadvantages of polyploids, androgenesis and gynogenesis.

UNIT III

Sex determination: Sex differentiation and sex reversal in fishes, sex control and its role in aquaculture.

UNIT IV

Selection: Scope, application and methods of selection, marker assisted selection-biochemical and molecular markers. Molecular tools for stock differentiation for selection.

UNIT V

Hybridization: Heterosis, hybrid vigour, introgression.

UNIT VI

Inbreeding: Methods of estimation,inbreeding depression and consequences, measures to reduce inbreeding in hatcheries.

UNIT VII

Conservation genetics: Genetic resources of India and conservation, endangered species, cryopreservation of fish gametes.

UNIT VIII

Cytogenetics: Importance and karyotyping.

UNIT IX

Fish breeding: History and advancement of fish breeding, mode of reproduction, basic breeding methods and breeding programmes and goals.

UNIT X

Genetic management strategies: Environmental impacts, Lessons from the green revolution, Bioprospecting, GMOs and their detection.

Practical

Estimation of gene and genotype frequencies; Exercises on Hardy- Weinberg equation; Estimation of inbreeding coefficient; Protocol of androgenesis and gynogenesis; Protocol of cryopreservation of milt; Karyotypic studies; Isolation of DNA from fish blood.

Suggested Readings

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

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

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

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

Padhi BK & Mandal RK. 2000. *Applied Fish Genetics*. Fishing Chimes. Pandian TJ, Strüssmann CA & Marian MP. 2005. *Fish Genetics and Aquaculture Biotechnology*. Science Publ.

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

Reddy PVGK. 2005. *Genetic Resources of Indian Major Carps*. FAO Publ. Reddy PVGK, Ayyappan S, Thampy DM & Krishna G. 2005. *Text book of Fish Genetics and Biotechnology*. ICAR.

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

Tave D. 1996. Genetics for Fish Hatchery Managers. 2nd Ed. AVI Publ. Thorpe JE, Gall GAE, Lannan JE & Nash CE. (Eds.). 1995. *Conservation of Fish and Shellfish Resources*, *Managing Diversity*.

AQC 508 NON-FOOD AQUACULTURE 1+1

Objective

To impart knowledge on ornamental fish production, pearl production, bait fish culture and aquatic ornamental plant propagation.

Theory

UNIT I

Aquarium fish trade: Present status; potential; major exporting and importing countries; species-wise contribution of freshwater and marine fishes; contribution of culture and capture; marketing strategies; anesthetics, packing and transportation.

UNIT II

Breeding techniques: Reproductive biology, captive breeding and rearing of freshwater, brackishwater, marine ornamental fishes and invertebrates.

UNIT III

Aquarium keeping: Design and construction of tanks; species-wise tank size requirement; heating, lighting, aeration and filtration arrangements; decorations used; common aquarium plants and their propagation; Feed, health and water quality management; prophylaxis; quarantine.

UNIT IV

Value addition: Colour enhancement; genetic manipulation and production of new strains; hybrids; acclimatization strategies for marine ornamental fish to freshwater.

UNIT V

Pearl Production: Overview of pearl trade, pearl oysters and mussels of commercial importance; anatomy, biology and seed production, techniques of implantation, method of rearing and harvesting of pearl, Mable pearl production, processing and quality evaluation of pearls, pearl production by tissue culture.

UNIT VI

Bait fish culture: Scope and importance, bait fish species (minnows, silver heads, etc.), farming practices.

UNIT VII

Ornamental aquatic plants: Propagation methods, nutrient and environmental requirement, cropping methods, packing and transport.

Practical

Identification of common freshwater aquarium fishes and breeding trials of selected freshwater fishes; Identification of common brackish water and marine aquarium fishes; Aquarium fabrication, setting and maintenance; Preparation of powdered and pelleted feed for ornamental fishes; Visit to ornamental fish farms; Study of bacterial, viral, fungal diseases of ornamental fishes and their control; Prophylactic and quarantine measures; Nuclei implantation in pearl oyster; Identification of ornamental aquatic plants.

Suggested Readings

Axelrod HR & Vorderwinkler W. 1978. *Encyclopaedia of Tropical Fishes*. TFH Publ.

Axelrod HR & Sweenen ME. 1992. *The Fascination of Breeding Aquarium Fishes*. TFH Publ.

Axelrod HR. 1967. *Breeding Aquarium Fishes*. TFH Publ. ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.

Mills D. 1981. *Aquarium Fishes*. Kingfisher Books.

Sanford G & Crow R. 1991. *The Manual of Tank Busters*. Salamander Books.

Saxena A. (Ed.). 2003. *Aquarium Management*. Daya Publ.

Spotte S. 1979. *Fish and Invertebrate Culture*. John Wiley & Sons.

Thabrow De WV. 1981. *Popular Aquarium Plants*. Thornbill Press.

AQC 509 COASTAL AQUACULTURE 2+1

Objective

To gain knowledge in establishing and managing different fish/shellfish farming systems in coastal waters.

Theory

UNIT I

Introduction: An overview of the status of coastal aquaculture; Present trend and scope in India.

UNIT II

Different farming systems: Cage and pen culture ï type, site selection, construction, specifications for different species; Raft and rack culture ï site selection, design and construction.

UNIT III

Important cultivable finfishes: Distribution, biology, seed collection, nursery rearing, culture techniques, problems and prospects (seabass, milkfish, mullets, pearlspot, sea breams, rabbitfish, grouper, yellowtail, eel, cobia, salmon, flatfish).

UNIT IV

Culture of marine molluscs and echinoderms: Present status and scope in India, Species cultured (mussels, oysters, pearl oysters, scallops, clams, cockles, abalones, sea cucumber) distribution, biology, practices followed in India, farming methods - off-bottom and on-bottom culture; Problems and prospects.

UNIT V

Culture of crustaceans: Shrimp farming: systems of farming ï extensive, semi-intensive and intensive; site selection, infrastructure requirement, design and construction of culture systems, pond preparation, stocking, feed and water quality management, disease prevention and treatment; harvesting and handling; freshwater farming of tiger shrimp, shrimp farming in un- drainable ponds, low and zero water exchange systems; Mud crab fattening, production of soft-shell crabs; Lobster culture; Crayfish culture.

UNIT VI

Seaweed culture: Major seaweed species of commercial importance; methods of culture; farming of

agar, algin, carrageenan yielding species; emerging trends in their farming in open seas; Integration with other farming systems.

Practical

Identification of cultivable marine and brackishwater finfish and shellfish; Identification of cultivable seaweeds; Designing of different farming systems ï cages, pens, rafts and racks; Visit to coastal aqaufarms.

Suggested Readings

Bardach EJ, Rhyther JH & Mc Larney WO. 1972. *Aquaculture the Farming and Husbandry of Freshwater and Marine Organisms*. John Wiley & Sons.

FAO. 2001. *Planning and Management for Sustainable Coastal Aquaculture Development*. FAO Publ.

Gilbert B. 1990. *Aquaculture*. Vol. II. Ellis Horwood.

ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.

Pillay TVR. 1990. *Aquaculture, Principles and Practices*. Fishing News Books.

Pillay TVR & Kutty MN. 2005. *Aquaculture: Principles and Practices*. 2nd Ed. Blackwell.

Shepherd J & Bromage N. 1990. *Intensive Fish Farming*. B.S.P. Professional Books.

AQC 510 FRESHWATER AQUACULTURE 2+1

Objective

To gain knowledge on fish and prawn farming in different culture systems.

Theory

UNIT I

Introduction: Present status, problems and scope of fish and prawn farming in global and Indian perspective.

UNIT II

Aquaculture systems: Extensive, semi-intensive and intensive culture of fish, Pen and cage culture in lentic and lotic water bodies, polyculture, composite fish culture.

UNIT III

Fish farming: Nursery and grow-out, pond preparation, stocking, feeding and water quality management in the farming of major and minor carps, magur, singhi, murrels, tilapia, pangasius, freshwater turtle, etc.; Stunted seed production and culture practice.

UNIT IV

Freshwater prawn farming: Monoculture practice of prawn in ponds, all- male culture and its advantages, polyculture with carps, prawn farming in inland saline soils. Nursery rearing, sex segregation, pond preparation, stocking, feeding and water quality management, disease prevention and treatment; harvesting and handling.

UNIT V

Integrated farming systems: Design, farming practices, constraints and economics of IFS of fish with paddy, cattle, pig, poultry, duck, rabbit, etc.

UNIT VI

Wastewater-fed aquaculture: Water treatment methods, species selection, culture practices, harvesting and depuration process.

UNIT VII

Economics of different fish farming systems.

Practical

Identification of commercially important cultivable fish and prawn species; Assessment of seed quality-stress test; Calculating carrying capacity of pond and stocking density; Check tray assessment and feed ration calculation; Sampling procedure and growth assessment; Lime and fertilizer requirement calculations; Farm visits; Modeling of different culture systems.

Suggested Readings

AAHRI. 1998. *Health Management in Shrimp Ponds*. Aquatic Animal Health

Research Institute (AAHRI), Department of Fisheries, Thailand. Agarwal SC. 2008. *A Handbook of Fish Farming*. 2nd Ed. Narendra Publ. House.

Beveridge MCM & Mc Andrew BJ. 2000. *Tilapias: Biology and Exploitations*. Kluwer.

De Silva SS. (Ed.). 2001. *Reservoir and Culture Based Fisheries: Biology and Management*. ACAIR Proceedings.

FAO. 2007. *Manual on Freshwater Prawn Farming*.

Midlen & Redding TA. 1998. *Environmental Management for Aquaculture*. Kluwer.

New MB. 2000. *Freshwater Prawn Farming*. CRC Publ.

Pillay TVR. 1990. *Aquaculture: Principles and Practices*. Fishing News Books, Cambrige University Press, Cambridge. Venugopal S. 2005. *Aquaculture*. Pointer Publ.

Welcomme RL. 2001. *Inland Fisheries: Ecology and Management*. Fishing News Books.

AQC 511 LARVAL NUTRITION AND CULTURE OF FISH FOOD ORGANISMS 1+1

Objective

To impart basic understanding of the nutritional requirements of fish/shellfish larvae and knowledge on mass culture and enrichment of live food organisms.

Theory

UNIT I

Larval nutrition: Larval stages, nutritional requirements of fish and shellfish larvae, quality requirements of larval feeds (particle size, digestibility), natural food and its importance in aquaculture, nutritional quality of commonly used fish food organisms, bioenrichment, biofilm/periphyton and its use, culture of single cell proteins and their nutritional quality, formulation and preparation of artificial feeds for larval rearing, microparticulate diets.

UNIT II

Fish food organisms: Bacterioplankton, phytoplankton and zooplankton and their role in larval nutrition.

UNIT III

Mass culture techniques: Methods of collection, maintenance and rearing of fish food organisms, Different media used in culture, Mass culture of fish food organisms and their application in hatcheries, culture of important microalgae, rotifers, artemia, cladocerans, copepods, oligochaetes, nematodes and insect larvae.

Practical

Collection, identification and isolation of live food organisms using various techniques; Preparation of various culture media; Preparation and maintenance of stock microalgal culture; Preparation of artificial feed for rearing finfish and shellfish larvae; Mass culture of microalgae; Mass culture of cladocerans, copepods and rotifers; Culture of Artemia nauplii, infusoria ï freshwater and marine; Culture of earthworms and chironomid larvae.

Suggested Readings

CIFE. 1993. *Training Manual on Culture of Live Food Organisms for AQUA Hatcheries*. Central Institute of Fisheries Education, Versova, Mumbai.

Finn RN & Kapoor BG. 2008. *Fish Larval Physiology*. Science Publ. Hagiwara A, Snell TW, Lubzens E & Tamaru CS. 1997. *Live Food in Aquaculture*. Proceedings of the Live Food and Marine Larviculture Symposium. Kluwer.

MPEDA. 1993. *Handbook on Aqua Farming - Live Feed. Micro Algal Culture.* MPEDA Publication.

Muthu MS. 1983. *Culture of Live Feed Organisms*. Tech. Paper 14. Summer Institute in Hatchery Production of Prawns Seeds. CMFRI, Cochin.

Ojha JS. 2005. *Aquaculture Nutrition and Biochemistry*. Daya Publ.

Santhanam R, Ramnathan M & Venkataramanujum. 1997. *A Manual of Methods in Plankton*. Fisheries College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Tuticorin.

Sorgeloos P & Pandian KS. 1984. *Culture of Live Food Organisms with Special Reference to Artemia Culture*. CMFRI Spl. Publ. No. 15.

Tonapi GT. 1980. *Freshwater Animals of India*. Oxford & IBH.

AQC 512 AQUACULTURE ENGINEERING 2+1

Objective

To learn the basic aspects of successful farm designing for effective management and optimum yield.

Theory

UNIT I

Introduction: Technical components of farm designing, future trends in aquaculture engineering.

UNIT II

Aquaculture facilities: Planning process, site selection and evaluation, design, components and construction of tanks, ponds, cages and hatcheries.

UNIT III

Water intake and outlet: Pipe line, water flow and head loss, pumps.

UNIT IV

Water treatment: Equipment used for water treatment, filters, ultraviolet light, ozone, heating and cooling and other processes of disinfection.

UNIT V

Aeration and oxygenation: Design and fabrication of aerators, oxygen injection system

UNIT VI

Recirculation and water use system: Definition, components and design.

UNIT VII

Feeding system: Different types of feeding equipment, feed control systems, dynamic feeding systems.

UNIT VIII

Instrumentation and monitoring: Instruments for measuring water quality.

Practical

Visit to aqua farms; Contour survey and mappings; Evaluation of performance of seepage controlling devices; Designing of fresh and brackish water fin and shellfish farms; Designing of fresh and brackish water fin and shellfish hatcheries; Estimation of construction cost of FRP and cement hatchery units, inlets, outlets, sluice gate, monks, hatchery sheds, supply channel and drainage systems, gravitational flow; Design and construction of effluent treatment plant for hatchery; Evaluation of capacity of aeration devices.

Suggested Readings

Thomas L. 1995. *Fundamentals of Aquacultural Engineering*. Chapman & Hall.

Wheaton FW. 1977. *Aquacultural Engineering*. John Wiley & Sons. Ivar LO. 2007. *Aquaculture Engineering*. Daya Publ. House.

AQC 601 ADVANCES IN AQUACULTURE PRODUCTION SYSTEMS 2+1

Objective

To impart essential knowledge and skills regarding advanced technologies of different aquaculture production systems.

Theory

UNIT I

An overview of aquaculture production systems: Present status, constraints and future perspectives of aquaculture production systems in India and the world.

UNIT II

Advances in design and construction: Hatcheries; Earthen ponds; Concrete tanks; Pens and cages; Rafts; Racks.

UNIT III

Aquatic plant production systems: Ornamental aquatic plants; microalgae and seaweeds; Long line production system.

UNIT IV

Aquaculture production management: Monitoring of water quality; feeding and monitoring, sampling and harvesting of finfishes and shellfishes.

UNIT V

Advances in farming systems: Enhancing carrying capacity; integrated farming systems; semi-intensive and intensive culture systems; Recirculatory system; Flow-through system.

UNIT VI

Code of conduct for responsible and sustainable aquaculture. Cluster farming, Organic Farming, Satellite Farming and Co-operative farming.

Practical

Soil and water quality monitoring; Basic software packages for designing aquaculture systems; Preparing a model layout for advanced production system; Working out the economic feasibility of construction and maintenance of different fish production systems; Preparation of project proposal for fish production systems.

Suggested Readings

Dubey SK. 2006. *Fish Farming*. Dominant Publ.

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

Pandey N & Davendra SM. 2008. *Integrated Fish Farming*. Daya Publ. House.

Pillay TVR & Kutty MN. 2005. *Aquaculture: Principles and Practices*. 2nd Ed. Blackwell.

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

Selvamani BR & Mahadevan RK. 2008. *Fish Farming Systems*. Campus Books International.

Shepherd J & Brommage N. 1990. *Intensive Fish Farming*. B.S.P. Professional Books.

Sinha VRP & Ramachandran V. 1985. *Freshwater Fish Culture*. ICAR.

AQC 602 ADVANCES IN SEED PRODUCTION AND HATCHERY MANAGEMENT 2+1

Objective

To impart knowledge of the various requirements for seed production of commercially important finfish and shellfish.

Theory

UNIT I

Reproductive biology of important fishers, crustaceans and molluscs. Anatomy and morphology of reproductive organs. Reproductive behavior of fishes. Sex determination in fishes.

UNIT II

Reproductive endocrinology: Anatomy and physiology of endocrine glands. Biochemical characteristics of endocrine hormones. Role of endocrine hormone in reproduction.

UNIT III

Broodstock management: Factors affecting the maturation and spawning of fin fishes and shell fishes. Nutritional and environmental requirement for broodstock. Nutritional and environmental manipulation for early maturation. Criteria for the selection of brood stock. Selective breeding strategies; Tagging; Transportation of brood stock. Natural and synthetic anesthetics for transport. Vaccines and therapeutics for health management of broodstock.

UNIT IV

Induced Spawning: Biochemical characteristics of synthetic hormone analogues and their applications. Comparative evaluation of commercially available inducing agents. Artificial insemination in crustaceans and molluscs. Cryopreservation of gametes and embryos.

UNIT V

Seed production and hatchery technology: Advances in seed production of commercially important finfishes and shellfishes. Seed production of ornamental fishes. Artificial propagation of seaweeds.

UNIT VI

Hatchery management: Water quality management in hatcheries - Chemical, Physical and Biological approaches. Nutritional requirement of larvae and post larvae. Live feed culture. Nutritional enrichment of live feed. Formulation of artificial diets. Strategies to control diseases in hatcheries. Diagnosis, quarantine and seed certification. Use of Probiotics and Immunostimulants in hatcheries, SPF and SPR. Effluent treatment in Hatcheries. Seed transportation methods.

Practical

Insemination; Cryopreservation of fish and shellfish gametes; Project preparation for constructing hatchery; Quantitative and qualitative determination of fish gametes like sperm motility, viability, counts; Digital equipments in broodstock management; Methods to identify quality seeds - stress test, microscopic examination.

Suggested Readings

Bardach EJ, Rhyther JH & Mc Larney WO. 1972. *Aquaculture. The Farming and Husbandry of Freshwater and Marine Organisms*. John Wiley & Sons.

Chakraborty C & Sadhu AK. 2000. *Biology Hatchery and Culture Technology of Tiger Prawn and Giant Freshwater Prawn*. Daya Publ. House.

Diwan AD, Joseph S & Ayyappan S. 2008. *Physiology of Reproduction, Breeding and Culture of Tiger Shrimp*. Narendra Publ. House.

Gilbert B. 1990. *Aquaculture*. Vol. II. Ellis Harwood.

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

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

AQC 603 AQUACULTURE AND ECOSYSTEM MANAGEMENT 2+1

Objective

To impart knowledge on interactions between aquaculture and the environment.

Theory

UNIT I

Aquaculture and ecosystem relationship: Ecosystems and productivity, biotic interaction within ecosystems and ecological homeostasis.

UNIT II

Climate: Weather elements of concern in aquaculture, Green house gases, global warming and their impact.

UNIT III

Impact of environment on aquaculture: Raw water source, physical and chemical characteristics, contaminants and pollutants (algae, pathogens, heavy metals, pesticides) and their effect on productivity.

UNIT IV

Impact of aquaculture on environment: Waste water discharge, its quality and quantity; impacts of effluents on ecosystems, chemical degradation of soil and water.

UNIT V

Environment monitoring: Problems and preventive measures of antibiotic and drug residues, salination of soil and water, Eutrophication, Environment impact assessment and environmental audit, Biosensors in aquatic environment, toxicity assessment, Ecolabelling and traceability.

UNIT VI

Environment management: Introduction of exotics and escape of farmed fish, Pathogens in aquatic environment, Safety of aquaculture products, Role of microbes in aquatic environment; assessment of probiotic impact in aquaculture.

Practical

Waste water analysis; Environment impact assessment; Environmental audit; Toxicity assessment studies; Ecolabelling and traceability; Isolation, enumeration and Identification of bacterial population; Physical and chemical characteristics of soil; Design and construction of effluent treatment plant.

Suggested Readings

Holmer M, Black K, Duarte CM, Marba N & Karakassis I. (Eds.). 2008. *Aquaculture in the Ecosystem*. Daya Publ. House.

Lagler KP, Bardach JE, Miller RR & Passino MDR. 1977. *Ichthyology*. John Wiley & Sons.

Midlen & Redding TA. 1998. *Environmental Management for Aquaculture*. Chapman & Hall.

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

Upadhyay AR. 2004. *Aquatic Plants for the Wastewater Treatment*. Daya Publ. House.

AQC 604 AQUATIC ANIMAL HEALTH MANAGEMENT AND QUARANTINE 1+1

Objective

To impart and update knowledge for combating pathogenic diseases in aquatic environment and its management.

Theory

UNIT I

Defence mechanism in fish and shellfish: Specific and non-specific defence mechanism, immunogenicity, immune cells, immune suppressant, ontogeny of immune system; cellular adaptation, pathogen specificity.

UNIT II

Disease diagnostics tools: Histopathological methods, tools used in different types of PCR, Immunoassay, Biochemical assay, Monoclonal and polyclonal based antibody assay, Electron microscopy, Serological techniques.

UNIT III

Disease prevention and therapeutics: Vaccines and bactericins, development of vaccines like DNA vaccine, adjuvants, etc; administration and mode of action of pathogen specific drugs, drug resistance, antiviral drugs, drug regulation in India, pharmacokinetics and pharmacodynamics, immunostimulants.

UNIT IV

Quarantine: Biosecurity principles, SPF and SPR, quarantine protocols, and facilities, broodstock and seed quarantine measures, Quarantine of Aquatic Animals and Premises.

Practical

Analysing and reporting legal problems relating to quarantine; Microscopic techniques; Immunisation techniques; Necropsy examination to study internal organs of fish; PCR; ELISA; Agglutination test; Gel electrophoresis; Histopathology; Determination of dosages of chemicals and drugs for treating common diseases.

Suggested Readings

Andrews C, Excell A & Carrington N. 1988. *The Manual of Fish Health*. Salamander Books.

Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish*. Vols. I, II. 2nd Ed. Academic Press.

Jorge E, Helmut S, Thomas W & Kapoor BG. 2008. *Fish Diseases*. Science Publ.

Felix S, Riji John K, Prince Jeyaseelan MJ & Sundararaj V. 2001. *Fish Disease Diagnosis and Health Management*. Fisheries College and Research, Institute, T. N. Veterinary and Animal Sciences University. Thoothukkudi.

Humphrey J, Arthur JR, Subasinghe RP & Phillips MJ. 2005. *Aquatic Animal Quarantine and Health Certification in Asia.* FAO Publ. Inglis V, Roberts RJ & Bromage NR. 1993. *Bacterial Diseases of Fish.* Blackwell.

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

Roberts RJ. 2001. *Fish Pathology*. 3nd Ed. WB Saunders.

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

Wedmeyer G, Meyer FP & Smith L. 1999. *Environmental Stress and Fish Diseases*. Narendra Publ. House.

Woo PTK & Bruno DW. (Eds.). 1999. *Fish Diseases and Disorders*. Vol. III. *Viral, Bacterial and Fungal Infection*. CABI.

AQC 605 FISH AND SHELLFISH PHYSIOLOGY AND ENDOCRINOLOGY 1+1

Objective

To learn functional physiology of fish and shellfish.

Theory

UNIT I

General physiology and endocrinology: Physiology of migration and behaviour, chemical nature of hormones, storage, release and control of hormones, serochemistry, structure and function of neuro-endocrine system, biotic and abiotic factors influencing homeostasis, ecophysiology, endocrine control of growth.

UNIT II

Nutritional and digestive physiology: Mechanism of chemo, electro and mechanorecption, gustation, digestive enzymes and isozymes, nutrient tansporters, gut microbial digestion, excretion.

UNIT III

Neurophysiology: Neurosecretory system in fishes, crustaceans and molluscs, neurotransmitters, ecdysis.

UNIT IV

Reproductive physiology: Maturation and spawning, spermatogenesis, oogenesis, yolk formation, mechanism of sex reversal.

UNIT V

Respiratory physiology: Structure and chemical composition of respiratory pigments, gas exchange concept, osmoregulation.

UNIT VI

Stress physiology: stress response, stress hormones, stress adaptation.

Practical

Hormone assay ï RIA (Radio Immuno Assay); Dissection of fin and shellfish to study endocrine glands; Histological techniques to study endocrine cells; Identification of moult stages; Serological analysis; Application of Electrocardiogram and respirometer.

Suggested Readings

Adiyodi KG & Adiyodi RG. 1971. *Endocrine Control of Reproduction in Decapod Crustacea*. Biology Reviews. Agarwal NK. 2008. *Fish Reproduction*. APH Publ.

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

Ghosh R. 2007. *Fish Genetics and Endocrinology*. Swastik Publ. & Distr. Hoar WS, Randall DJ & Donaldson EM. 1983. *Fish Physiology*. Vol. IX. Academic Press.

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

Matty AJ. 1985. *Fish Endocrinology*. Croom Helm.

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

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

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

AQC 606 ADVANCES IN FISH GENETICS 2+1

Objective

To provide knowledge in genetics for improving qualitative and quantitative traits in fish.

Theory

UNIT I

Scope of applied fish genetics: Inheritance of qualitative and quantitative traits in fish; chromosomal polymorphism.

UNIT II

Non chromosomal inheritance: Mitochondrial inheritance.

UNIT III

Chromosome manipulation: Gynogenesis and androgenesis; production of super-males and transgenic fish.

UNIT IV

Inbreeding and genetic drift: Estimation of genetic parameters.

UNIT V

Selective breeding: Qualitative and quantitative traits for selection, methods of selection- individual selection, mass selection, family selection and combined selection; Designing of breeding programmes.

UNIT VI

Genetic markers: Use of biochemical and molecular genetic markers in hybridization, selective breeding.

UNIT VII

Diallele crossing: Genetic improvement of particular trait (disease

resistance) in fish.

UNIT VIII

Chromosome banding techniques: C-banding, G-banding, NOR-banding, FISH.

UNIT IX

Genotoxicity assay: Comet assay, sister chromatid exchange, MNT, etc.

Practical

Chi-square test; Estimation of heritability and repeatability; Assessment of genetic gain through selection; Calculation of selection differential; Calculation of selection response; Estimation of inbreeding coefficient and path coefficient; Karyotypic studies; C-banding (hetero chromatin banding); NOR- banding (nucleolar organizer region banding); G-banding (Giemsa banding); Ploidy determination methods.

Suggested Readings

Das P & Jhingran AG. 1976. *Fish Genetics in India*. Today & Tomorrow Publ.

Douglas T. 1998. *Genetics for Fish Hatchery Managers*. Kluwer.

Dunham RA. 2004. *Aquaculture and Fisheries Biotechnology Genetic Approaches*. CABI.

Malvee S. 2008. *Fish Genetics*. SBS Publ.

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

Padhi BJ & Mandal RK. 2000. *Applied Fish Genetics*. Fishing Chimes. Pandian TJ, Strüssmann CA & Marian MP. 2005. *Fish Genetics and Aquaculture Biotechnology*. Science Publ.

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

Reddy PVGK, Ayyappan S, Thampy DM & Gopalakrishna. 2005. *Text Book of Fish Genetics and Biotechnology*. ICAR.

Sinnot EW, Dunn L & Dobzansky T. 1989. *Principles of Genetics*. Mc Graw Hill.

AQC 607 INTENSIVE FARMING SYSTEMs FOR TILAPIA AND CATFISHES 1+1

Objective

To learn the techniques of intensive farming of tilapia and catfishes.

Theory

UNIT I

Intensive Farming Systems: Status and future prospectus of catfishes and tilapia in India, Need for intensification, Development of intensive farming. Disease and its control, constraints in intensive farming.

UNIT II

Catfish: Commercially important catfishes, Different culture systems, Means of intensifying catfish culture, polyculture of catfish with other species, Water quality management in catfish culture, feeds and feeding, Economics of culture.

UNIT III

Tilapia: Commercially important tilapia, Different culture systems, Means of intensifying tilapia culture, polyculture of tilapia, Water quality management in tilapia culture, feeds and feeding, Techniques of sex reversal in tilapia, mass production of monosex seed and hybrids, Production of red tilapia, Economics of culture.

Practical

Study of aerators and blowers; Experience in breeding and culture of catfish; Experience in breeding and culture of tilapia; Seed production of catfish and tilapia; Formulation of feeds for catfish and tilapia; Stocking density manipulation and fish production; Economics of intensive farming of catfish and tilapia.

Suggested Readings

Bardach EJ, Rhyther JH & Mc. Larney WO. 1972. *Aquaculture The Farming and Husbandry of Freshwater and Marine Organisms*. John Wiley & Sons.

Beveridge MCM & Mc Andrew BJ. 2000. *Tilapias: Biology and Exploitations*. Kluwer.

Gilbert B. 1990. *Aquaculture*. Vol II. Ellis Harwood.

Jayaram KC. 2006. *Catfishes of India*. Narendra Publ. House.

Pillay TVR. 1990. *Aquaculture, Principles and Practices*. Fishing News Books.

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

AQC 608 AQUACULTURE DEVELOPMENT PLANING AND MANAGEMENT 1+1

Objective

To understand different aspects of planning and management processes specific to aquaculture development.

To acquire competency to plan, implement, monitor and evaluate aquaculture development programmes.

Theory

UNIT I

Importance, principles and processes in developing aquaculture programmes; Planning for sustainable development; Types of planning; Planning strategies at various levels - Top down and bottom up approaches. Role and relevance of Panchayati Raj institutions in aquaculture development; Plan

allocation and performance of FFDA, BFDA and other aquaculture related programmes over the different plan-periods in India.

UNIT II

Project preparation and project appraisal in terms of social benefit analysis, shadow prices; Project management techniques - PERT and CPM; Logical framework approach (LFA), Stakeholder analysis; Participatory Monitoring and evaluation (PROME); Peopleôs participation in aquaculture programmes, significance, importance and approaches .

UNIT III

Critical analysis of aquaculture and rural development programmes; design, operation, institutional mechanism and socio-cultural and economic impact of programmes such as NREGA; labour market relations; Fisheries development *vis-à-vis* fisheries for development; Livelihood Frameworks.

Practical

Need assessment, setting objectives, developing plan of work, Success indicators, Impact assessment of aquaculture development programmes, SWOT analysis; Exercises on PERT and CPM. Fisheries and Aquaculture policies of select countries; Study visits to selected aquaculture project areas ï FFDA/ BFDA/ SAUs/ICAR institutes.

Suggested Readings

Agarwal SC. 2004. *Fishery Management*. APH Publ. Corp.

Agarwal SC & Johal S. 2003. *Fishery Development*. Narendra Publ.

Felix S. 2007. *Aquaculture Management Techniques*. Daya Publ. House. Singh B. 2007. *Fishery Management: Planning and Objectives*. Vista International Publ. House.

Sinha VRP. 2005. *Fisheries Research Planning and Management in Developing Countries*. Narendra Publ. House.

AQC 609 APPLIED BIOTECHNOLOGY 1+1

Objective

To learn various biotechnological applications for enhancing production through sustainable eco-friendly culture.

Theory

UNIT I

Introduction: Scope of biotechnology in fisheries and aquaculture research. Transgenics: Principles of transgenic technology and its application in fisheries.

UNIT II

Feed biotechnology: Probiotics, single cell proteins, Nutraceuticals. Recombinant proteins of commercial importance: enzymes, hormones, bioactive compounds, therapeutic proteins.

UNIT III

Biotechnological approaches in environmental management: Bioremediation, biosensors, biofouling, treatment of waste water. Anti microbial Peptides and their applications. Vaccination in fishes- DNA vaccines, sub UNIT vaccines and Biofilm Vaccines.

UNIT IV

Applications of biotechnological tools: Recombinant DNA, Monoclonal antibodies, Cell lines and stem cell culture, DNA markers and MAS. Biotechnological instrumentation in Aquaculture.

Practical

Cell culture and cell lines; Development of hybridoma and production of monoclonal antibodies; Collection, handling and observation of gametes of finfish and shellfish; Preparation of chromosomes from embryos and young fish; Ploidy determination by RBC measurement and chromosome numbers; Gene transfer experiments: northern blotting and southern blotting for integration and expression of transgenes.

Suggested Readings

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

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

Glick BR & Pasternak JJ. 1999. *Molecular Biotechnology: Principles and Applications of Recombinant DNA Technology*. ASM Press. Nagabhushanam R, Diwan AD, Zahurnec BJ & Sarojini R. 2004. *Biotechnology of Aquatic Animals*. Science Publ.

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

Pandian TJ, Strüssmann CA & Marian MP. 2005. *Fish Genetics and Aquaculture Biotechnology*. Science Publ. Primrose SB. 1989. *Modern Biotechnology*. Blackwell.

Ramesh RC. (Ed.). 2007. *Microbial Biotechnology in Agriculture and Aquaculture*. Vol. II. Science Publ.

Reddy PVGK, Ayyappan S, Thampy DM & Gopalakrishna. 2005. *Text Book of Fish Genetics and*

Biotechnology. ICAR.
Singh B. 2006. *Marine Biotechnology and Aquculture Development*. Daya Publ. House.

FISHERIES RESOURCE MANAGEMENT

CODE	COURSE TITLE	CREDITS
FRM 501*	INLAND FISHERIES RESOURCES	2+1
FRM 502*	MARINE FISHERIES RESOURCE MANAGEMENT	2+1
FRM 503*	MARINE ECOSYSTEMS, BIODIVERSITY AND CONSERVATION	2+1
FRM 504*	TROPICAL FISH STOCK ASSESSMENT	2+1
FRM 505	FISHERIES REGULATIONS	2+1
FRM 506	REMOTE SENSING AND GIS FOR FISHERIES MANAGEMENT	1+1
FRM 507#	INTEGRATED COASTAL ZONE MANAGEMENT	2+1
FRM 508	AQUATIC FLORAL RESOURCES	2+1
FRM 509	FEEDING AND REPRODUCTIVE BIOLOGY OF FINFISH AND SHELLFISH	2+1
FRM 510	DEVELOPMENTAL BIOLOGY OF FINFISH AND SHELLFISH	2+1
FRM 511	FISHING AND ALLIED TECHNOLOGIES	2+1
FRM 512	MODERN TECHNIQUES IN ICHTHYOTAXONOMY	2+1
FRM 591	MASTERôS SEMINAR	1+0
FRM 599	MASTERôS RESEARCH	20
FRM 601**	ASSESSMENT OF AQUATIC BIODIVERSITY	2+1
FRM 602**	APPLICATIONS OF FISHERIES MODELS IN STOCK ASSESSMENT	2+1
FRM 603**	CONSERVATION AND MANAGEMENT OF EXPLOITED FISHERIES RESOURCES	2+1
FRM 604	CORAL REEF MANAGEMENT	2+1
FRM 605	DATA COLLECTION AND ESTIMATION OF EXPLOITED FISHERIES RESOURCES	0+2
FRM 606	FISHERIES ENVIRONMENTAL ASSESSMENT	2+1
FRM 607	ISSUES IN CAPTURE FISHERIES	1+1
FRM 691	DOCTORAL SEMINAR I	1+0
FRM 692	DOCTORAL SEMINAR II	1+0
FRM 699	DOCTORAL RESEARCH	45

* Compulsory for Masterôs programme; ** Compulsory for Doctoral programme
#FRM 507 cross listed with Aquatic Environment Management AEM 503

Course Contents

FRM 501 INLAND FISHERIES RESOURCES 2+1

Objective

To understand the present exploitation and future potential of inland Fisheries.
To learn the methodologies for assessments of Inland Fisheries Resources.

Theory

UNIT I

Categorization of different freshwater fisheries resources: Ponds, lakes, bheels, tanks, estuaries, brackish water lagoons, wetlands, biosphere reserves and mangroves and derelict water bodies their problems and management aspects.

UNIT II

Bheel fisheries resources of India: Open and closed bheels, productivity conditions, Capture scenario, prospects of culture based systems.

UNIT III

Riverine fisheries resources: Present trend of dwindling fisheries resources, 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.

UNIT IV

Cold water fisheries of India: Present trends, problems due to habitat destruction, management aspects, prospects of sports fisheries in India.

UNIT V

Reservoir Fisheries: Classification of reservoirs, present productivity levels, management practices.

UNIT VI

Estuarine fisheries: classification of estuaries- present productivity level- potential; Problem ï management practices.

UNIT VII

Assessment of carrying capacity of different inland water bodies; Water budgeting. Community participation in fishery resource management.

Practical

Freshwater fish identification ï tagging ï different types of tags ï Visit to nearest freshwater body; catching methods ï catch data analysis on major freshwater resource ï Estuaries - Reservoirs ï Major lakes - of India ï Biodiversity indices ï Gear selectivity.

Suggested Readings

Blaber JM. 1997. *Fish and Fisheries in Tropical Estuaries*. Chapman & Hall.
FAO. Technical Papers on Freshwater Fisheries.
Jhingran VG & Pathak V. 1987. Ecology and Management of Bheels in Assam: A case study of Dhir Bheel. In: *Workshop on Development of Bheel Fisheries in Assam*, held at Assam Agricultural University, Guwahati from 21st to 22nd April.
Jhingran VG & Sehgal KL. 1978. *Cold Water Fisheries of India*. J. Inland. Fish. Soc. India. Sp. Publ.
Jhingran VG. 1991. *Fish and Fisheries of India*. 3rd Ed. Hindustan Publ. Sugunan VV. 1997. *Reservoir Fisheries of India*. Daya Publ. House.

FRM 502 MARINE FISHERIES RESOURCE MANAGEMENT 2+1

Objective

To know the present level of exploitation of marine resources and to impart knowledge on conservation measures.
To learn the recent methodologies of sustainable exploitation of renewable resources.

Theory

UNIT I

Major fishing nation of the world, major fishing regions, present trend of marine capture fisheries.

UNIT II

Important finfish and shellfish resources in demersal and pelagic systems;
conservation strategies.

UNIT III

Principles of management of fisheries resources objectives of management, issues and challenges of managing multi-gear fisheries.

UNIT IV

Mud bank fishery- wedge bank fishery-Commonly used tools for input and output regulation.

UNIT V

Sustainability: Principles, social economic ecological biological and legal issues Fisheries co-management.

UNIT VI

Marine Biodiversity of selected areas including coral reef conservation.

UNIT VII

Fisheries and fishing methods in open waters: Inshore fisheries (up to 50 m depth), offshore fisheries (50-200 m depth) High sea fisheries (beyond 200m) up to outer limit of EEZ and in International waters. UNIT VIII

Conservation aspects: Biodiversity principles, categorization of species into endangered; Indeterminate and extinct varieties- managing the highly exploited fishery resources.

UNIT IX

Case studies of fisheries conflicts depending on problems in different states.

Practical

Marine fishery resources ï visit to nearest marine landing center ï length frequency analysis ï catching method ï catch data analysis on marine fishery resources of Indiaï closed season studies ï gear selectivity.

Suggested Readings

Bal DV & Rao KV. 1990. *Marine Fishes of India.* 1st Revised Ed. TataMcGraw Hill.

Chandra P. 2007. *Fishery Conservation, Management and Development*. SBS Publ.

Dholakia AD. 2004. *Fisheries and Aquatic Resources of India*. Daya Publ. House.

Kurian CV & Sebastian VO. 1986. *Prawns and Prawn Fisheries of India*. Hindustan Publ. Corp.

Peter BM & Joseph JC. Jr. 2000. *Fishes- An Introduction to Ichthyology*. 4th Ed. Prentice Hall.

Samuel CT. 1968. *Marine Fisheries in India*. Narendra Publ. House. Shanbhogue SL. 2000. *Marine Fisheries of India*. ICAR.

Yadav BN. 1997. *Fish and Fisheries.* 2nd Ed. Daya Publ. House.

FRM 503 MARINE ECOSYSTEMS, BIODIVERSITY AND CONSERVATION 2+1

Objective

To study the biodiversity of flora and fauna and its assessment using the various biodiversity indices for conservation of aquatic resources.

To understand the ecological impacts on various resources.

Theory

UNIT I

Biology of selected endangered species of sponges, corals, gastropods, bivalves, sea cucumbers, fishes, sea snakes, turtles, birds and marine mammals.

UNIT II

IUCN criteria ï - Red List, Wild life protection act, International treaties and conventions, Marine Protected Areas, Sanctuaries and Biosphere reserves. Establishment of National marine parks, *in situ* and *ex situ* conservation.

UNIT III

Marine and Coastal Ecosystems ï Overview; physico-chemical environment; ecological notions; plankton; benthos, mangroves; sea grasses and corals.

UNIT IV

Human impact on ecosystem.

UNIT V

Marine biodiversity: threats, planning and management, tools for conservation.

Practical

Identification of scheduled aquatic organisms- Predators of endangered animals. Observation of stranded marine mammals, corals, seafans and other endangered aquatic Organisms, Visit to various aquatic ecosystem for recording the biodiversity and richness indices, Conservation planning.

Suggested Readings

Balakrishnan Nair N & Thampy DM. 1980. *A Text Book of Marine Ecology*. The MacMillan Co.

Castro P & Huber ME. 1997. *Marine Biology*. 2nd Ed. Mc-Graw Hill. Duxbury AC, Duxbury AB & Sverdrup KA. 2000. *An Introduction to the World's Oceans.* 6th Ed. McGraw Hill.

Gross G. 1993. *Oceanography: A View of the Earth*. 6th Ed. Prentice Hall.

Iversen ES. 1996. *Living Marine Resources*. Chapman & Hall.

McCormick JM & Thiruvathaakal JV. 1976. *Elements of Oceanography*.WB Saunders.

Nybakken JW. 1997. *Marine Biology - An Ecological Approach*. 4th Ed.Addison Wesley.

Raymont JEG. 1973. *Plankton and Productivity in the Oceans*. Pergamon Press.

Sverdrup HV, Johnson MW & Fleming RH. 1959. *The Oceans - TheirPhysics, Chemistry and General Biology*. Prentice Hall.

FRM 504 TROPICAL FISH STOCK ASSESSMENT 2+1

Objective

To understand the application of various models to estimate fish population.
To get an idea of the interaction of tropical fish population in the ecosystem.

Theory

UNIT I

Stock concept.

UNIT II

Estimation of growth parameters and mortality rates.

UNIT III

Virtual population methods.

UNIT IV

Gear selectivity. Sampling of commercial catches.

UNIT V

Yield per recruit model.

UNIT VI

Surplus production model. Swept area method - Box model.

UNIT VII

Stock recruitment relationship ï Stochastic model ï estimation of technical reference point MSY and other yield base reference point.

UNIT VIII

Multispecies, ecosystem and economic and social reference points. Eumetric fishing.

UNIT IX

Ecopath and Ecocism models.

Practical

Data collection and estimation of growth and mortality parameters. Gear selection ï Yield per recruit ï Analytical and holistic models ï growth parameters ï Cohort analysis ï Jones method. Gill net, trawl selectivity ï Swept area method. MSY- Stock recruitment relationship.

Suggested Readings

Beverton RJH & Holt SJ. 2004. *On the Dynamics of Exploited Fish Population*. The Blackburn Press.

Callucci VG, Saila SB, Gustafson DJ & Rothschild BJ. 1996. *Stock Assessment, Quantitative Methods and Applications for Small Scale Fisheries*. Lewis Publ.

Gulland JA. 1977. *Fish Population Dynamics*. John Wiley & Sons.

Gulland JA. 1992. *A Review of Length Based Approaches to Assessing Fish Stocks*. FAO Tech. Paper No. 323, Rome.

Nickolskhi GV. 1980. *Theory of Fish Population Dynamics as the Biological Background for Rational Exploitation and Management of Fishery Resources*. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Ricker WE. 1971. *Methods for the Assessment of Fish Production in Freshwaters*. Blackwell, Oxford & IBH.

Sparre P & Venema SC. 1998. *Introduction to Tropical Fish Stock Assessment*. Part 1 Manual. FAO. Fisheries Tech. Paper No. 301, Rome.

FRM 505 FISHERIES REGULATIONS 2+1

Objective

To understand the importance of enforcement of fisheries regulations and policies.

Theory

UNIT I

Fisheries regulatory and developmental setup in Centre and States and their spheres of responsibility; need for fisheries management; regulatory, legal and enforcement regimes.

UNIT II

Monitoring, Control and Surveillance (MCS) systems for capture fisheries: definition; components; role in fisheries management; design considerations; operational procedures such as data collection, fisheries patrols, boarding, inspection procedures, verification of catches, verification of position, transshipment, Port State control and FAO ñflagging arrangementò, and fisheries prosecutions.

UNIT III

Regulatory and developmental issues concerning deep sea fishing ï Guidelines for operation.

UNIT IV

Indian deep sea fishing vessels in Indian EEZ. Maritimes Zones of India Act 1981 (Regulation of fishing by Foreign vessels). Draft Marine Fisheries Policy.

UNIT V

Marine fisheries legislations in various States of India; Land Reforms Act; Coastal Aquaculture legislations, (Environmental Protection Act, Biodiversity Act, Aquaculture Authority Act) regulations concerning discharge of

effluents in water bodies.

UNIT VI

International Law of the Sea: Historical perspectives; international negotiations and settlements over open seas; conflict management; shared stocks.

UNIT VII

Code of Conduct for Responsible Fishing.

UNIT VIII

Management needs associated with aquaculture development; Coastal Regulation Zone (CRZ) in the context of aquaculture. Sustainability, Integrated Coastal Zone Management and ecosystem management.

UNIT IX

Inland Fisheries Regulation and Development: Inland fisheries governance, Inland Fisheries Act, Inland property regime, leasing policies for waterbodies. Issues of property rights in Inland water bodies.

UNIT X

National Water Policy; water needs for agriculture, industry, potability and fisheries, fishing rights in open waters; and role of fisheries cooperatives, aqua/ecotourism. Concepts and implication of Interlinking of rivers on fisheries and biodiversity.

Practical

Given a real life or imaginary set of MCS situation data for a specific area, to formulate a management plan (with the help of prevailing legislation) with the following objectives : (1) Resource (2) Environment (3) Biodiversity (4) Technology (5) Society (6) Economics and (7) Conflicts; compilation of these into an overall management plan. Visit to appropriate Government/NGO and preparation of working report. Mesh size studies for trawl, gillnets and purse seine. Comparative studies on the Fisheries Acts of any two states of India and preparation of a report.

Suggested Readings

Anon. 1998. *Maritime Law of India in the International Context*. Bhadarkar Publ.

Brahtz JFP. 1972. *Coastal Zone Management*. U.N. International Economic and Social Affairs, New York.

Churchill RR & Lowe AV. 1988. *Law of the Sea*. Manchester University Press.

Henkin L, Pugh RC & Smit H. 1993. *International Law: Cases and Materials*. West Publ. Co.

Sinha RK. (Ed.). 1996. *Marine Resources and Applicable Laws* (World Environmental Series - 009). Commonwealth Publ.

Verghese CP. 1989. *Fishing Regulation in India's Territorial Waters*. World Fishing.

FRM 506 REMOTE SENSING AND GIS FOR FISHERIES MANAGEMENT 1+1

Objective

To know the satellite information and its application in fisheries resource management.

Theory

UNIT I

Basic terms and concepts; Electromagnetic radiation and its properties, atmospheric interactions, target interactions.

UNIT II

Sensor platforms ï boats, balloons, air-crafts and satellites, Sensor systemsï global acquisition systems and sequential acquisition systems.

UNIT III

Environmental satellites ï The Landsat series, NOAA and IRS; Digital image processing and interpretation.

UNIT IV

Elements of GIS, Application of remote sensing and GIS to fisheries and aquaculture planning and development.

Practical

Study of satellite information, interpretation of satellite pictures for resource management, case studies on remote sensing and GIS applications.

Suggested Readings

Decker D. 2000. *GIS Data Sources*. Riley & Sons.

Jeff Thurston Thomas K Poiker & J Patrick Moore. 2000. *Integrated Geospatial Technology - A Guide to GPS, GIS and Data Logging*. John Wiley & Sons.

Kraak MJ & Ferjan O. 2003. *Cartography, Visualization of Spatial Data.* Prentice Hall.

Meaden GJ & Kaptesky JM. 1991. *Geographical Information Systems and Remote Sensing in Inland Fisheries and Aquaculture.* FAO Fisheries Tech. Paper No. 318, Rome.

Patel AN & Singh S. 1992. *Remote Sensing – Principles and Applications*. Scientific Publ.

Valavanis VD. 2002. *GIS System in Oceanography and Fisheries*. Taylor & Francis.

FRM 507 INTEGRATED COASTAL ZONE MANAGEMENT 2+1

Objective

To impart knowledge on the coastal resources, integrated coastal zone management strategies and disaster

management.

Theory

UNIT I

Coastal resources: Coastal natural resources systems: flora and fauna, trophic relationship, nutrient production, cycle and transport; Mangrove ecosystem - species diversity and distribution of mangroves in India, Other inter-tidal system- Seagrass system, Coral reef system, Sandy beach system, Lagoon and estuary system.

UNIT II

Developmental activities and biodiversity loss: Ecological issues, Non- sustainable development, Pollution, threats to biodiversity, habitat destruction, Depletion of fisheries resources, impacts of global environment changes, Multiple uses of the Coastal Zone, Urban settlement, Industrial development, waste disposal, Shore protection works, ports and marine transportation. Land transportation infrastructure, Water control and supply projects, sea fisheries, Aquaculture, Coastal forest industries, Coastal agriculture, industries.

UNIT III

Coastal Zone Management: Integrated Coastal Zone Management (ICZM): its need and benefits, Principles, Goals and objectives of the ICZM programme; Scope, Extent of jurisdiction, Boundaries of the coastal zone, policies and planning for coastal resource management; Management mechanisms- Pollution control, Protected areas (sanctuaries, marine parks and biosphere reserves), Protection from natural hazards; Socioeconomic impacts and its assessment, Disaster management for coastal environment. UNIT IV

Coastal tourism: Beach resorts, restaurants and parks within the coastal zone as per existing rules and regulations. Impact of pollution on coastal resources.

Practical

Analysis of soil and water characteristics of coastal areas where man made impacts have established; Assessment of damages of water quality; Collection, preservation and identification of coastal biological communities; Survey of different coastal zones; Visit to the protected areas.

Suggested Readings

Brahtz JFP. 1972. *Coastal Zone Management*. U. N. Department of International Economic and Social Affairs, New York.

Cairns J Jr. 1994. *Implementing Integrated Environmental Management*. Virginia Tech. University.

Clark JR. 1992. *Integrated Management of Coastal Zones*. FAO Fisheries Tech. Paper No. 327, Rome.

Coastal Area Management and Development. 1982 U. N. Department of International Economic and Social Affairs, New York.

David S & Jeremy P. 2001. *Inshore Fisheries Management. Methods and Technologies in Fish Biology and Fisheries*. Vol. II. Kluwer.

Khanna BK. 2000. *All You Wanted to Know About Disasters*. New India Publ. Agency.

FRM 508 AQUATIC FLORAL RESOURCES 2+1

Objective

To gain in-depth knowledge on the categorization, utilization, conservation and management of aquatic floral resources.

Theory

UNIT I

Taxonomy and phenology of freshwater microphytes and macrophytes;
their importance in resource management.

UNIT II

Brackishwater flora ï micro and macrophytes; their taxonomy, phenology and ecological importance and conservation practices.

UNIT III

Marine algal resources; Taxonomy, biodiversity, life history, ecological and economical importance and conservation techniques.

UNIT IV

Seagrass resources; Taxonomy, biodiversity, life history, ecological and economical importance and conservation techniques.

UNIT V

Commercially important aquatic floral resources.- Agar-algin- phytocolloids- food grade algal resource- other uses like pollution treatment, fodder, fertilizer production, etc.

Practical

Collection and identification of freshwater and brackishwater plants and seaweeds. Phenological observations of aquatic flora, seaweed resources and preparation of charts ï Herbaria preparation.

Suggested Readings

Chapman VJ & Chapmen DJ. 1980. *Seaweeds and Their Uses*. Chapman & Hall.

Chapman VJ. 1976. *Mangrove Vegetation*. J. Cramer.

Chaudhuri AB. 2007. *Biodiversity of Mangroves*. Daya Publ. House.
Firth FE. 1971. *The Encyclopedia of Marine Resources*. Von Nostrand Reinholt.
Iversen ES. 1996. *Living Marine Resources*. Chapman & Hall.
Petr T. 2000. *Interactions Between Fish and Aquatic Macrophytes in Inland Waters- A Review*. FAO Fisheries Tech. Paper No. 396, Rome.
Richmond A. (Ed.). 2004. *Handbook of Microalgal Culture*. Blackwell.
Sundaralingam VS. 1990. *Marine Algae (Morphology, Reproduction and Biology).* Bishen Singh Mahendra Pal Singh, Dehra Dun.

FRM 509 FEEDING AND REPRODUCTIVE BIOLOGY OF FINFISH AND SHELLFISH 2+1

Objective

To study the role of feeding and reproductive biology in the context of fisheries resources.
To learn the application of biological inferences for the management of finfish and shellfish resources.

Theory

UNIT I

Food of different types of fin and shell fishes.

UNIT II

Feeding types- filter feeders, carnivores, omnivores and their trophic levels. Ontogenic changes in feeding- Forage theory- Mismatch hypothesis of Cushing.

UNIT III

Morphological and anatomical adaptation for feeding; feeding behavior of wild and cultured species.

UNIT IV

Techniques in the analysis of gut contents and indices, digestion rates, food consumption rates etc.

UNIT V

Mode of reproduction: Asexual, hermaphroditism, protoandric, protogynic, sexual.

UNIT VI

Reproductive cycles - Semalparity and iteroparity-maturation and spawning periodicity and maturity stages.

UNIT VII

Factors influencing reproduction-Biotic and abiotic.

UNIT VIII

Migration- various types of spawning migration.

UNIT IX

Assessment of mean trophic level and prey - predator relationship.

Practical

Morphological and anatomical features of fin fishes and shellfishes with different feeding habits. Analysis of gut contents. Use of indices in feeding, digestion and food consumption rates of fishes. Identification of spawning season, maturity stages, estimation of gonadosomatic index and intraovarian periodicity.

Suggested Readings

Adiyodi KG & Adiyodi RG. 2000. *Reproductive Biology of Invertebrates*: Vol. X. Part B. *Progress in Developmental Endocrinology*. John Wiley & Sons.
Agarwal NK. 1996. *Fish Reproduction*. APH Publ. Corp.
Barrington EJW. 1981. *Invertebrate Structure and Function.* 2nd Ed. The English Language Book Society & Nelson.
Bone Q, Marshall NB & Blaxter JHS. 1995. *Biology of Fishes*. 2nd Ed. Blackie.
Carl EB. 1979. *Biology of Fishes*. 2nd Ed. John Wiley & Sons.
Hoar WS & Randall DJ. (Ed.) 1969. *Fish Physiology*. Vol. III. Academic Press.
Jobling M. 1995. *Environmental Biology of Fishes*. Chapman & Hall.
Khanna SS. 1993. *An Introduction to Fishes*. Central Book Depot.
Maria JR, Augustine A &. Kapoor BG. 2006. *Fish Reproduction*. Science Publ.
Nikolsky GV. 1983. *Fisheries Biology*. Academic Press.
Saxena AB. 1996. *Life of Crustaceans*. Recent Advance in Entomology Series-10. Anmol Publ.
Venkataramanujam K & Ramanathan N. 1994. *Manual of Finfish Biology*. Oxford & IBH.

FRM 510 DEVELOPMENTAL BIOLOGY OF FINFISH AND SHELLFISH 2+1

Objective

To impart knowledge on the collection and identification of eggs and larvae of commercially important finfish and shellfish.

Theory

UNIT I

Identification of eggs and larvae of commercially important finfishes, crustaceans, molluscs and echinoderms.

UNIT II

Quantitative samplings of fish eggs and larvae; spatial and temporal distribution, dispersion of eggs and larvae in food webs, effect of environmental parameters on eggs and larvae.

UNIT III

Natural food of shell fish and finfish larvae from egg to adult (commercially important shellfishes and finfishes).

Practical

Identification of commercially important species of crustacean, molluscan eggs and larvae, spat. Morphometry of eggs and larvae of finfishes, identification keys. Quantitative sampling- shellfish and finfish larvae; food and feeding habits of larval stages of shell and finfishes.

Suggested Readings

Barrington EJW. 1981. *Invertebrate Structure and Function*. 2nd Ed. The English Language Book Society & Nelson.

Diwan AP & Dhakad NK. 2004. *Embryology of Fishes.* Recent Advances in Embryology Series-1. Anmol Publ.

Ede DA. 1978. *An Introduction to Developmental Biology*. Blackie.

Hoar WS & Randall J. (Ed.). 1988. *Fish Physiology*. Vol XI. *The Physiology of Developing Fish*. Part B. *Viviparity and Post hatching Juveniles*. Academic Press.

Jobling M. 1995. *Environmental Biology of Fishes*. Chapman & Hall.

Khan SA, Raffi SM & Lyla PS. 2003. *Larvae of Decapod Crustaceans*. Centre of Advanced Study in Marine Biology, Parangipettai, Tamil Nadu.

Silas EG. 1983. *Development of Penaeid Prawns*. CMFRI Bull. No. 28.

FRM 511 FISHING AND ALLIED TECHNOLOGIES 2+1

Objective

To gain knowledge on the design, fabrication and operation of fishing gear and operation of fish finding equipments.

Theory

UNIT I

Design, fabrication and operation of various fishing gears: trawls (pelagic and bottom), purse seine, gillnets, trammel nets, dol nets, FADs (Floating and bottom ï artificial reefs), traps and lines.

UNIT II

Harvesting methods in inland water bodies and their improvisation: Gillnets, cast nets, lines, dragnets, bag nets etc.

UNIT III

Destructive and prohibited fishing practices.

UNIT IV

By-catch reduction devices: Definition of bycatch, types of bycatch reduction devices and the principles of operation.

UNIT V

Turtle Excluder Devices: Definition, types of TEDs ï soft and hard types, materials used for their construction and maintenance.

UNIT VI

Acoustics: Acoustic surveys for fishing, acoustic aids in fishing and acoustic measurements.

UNIT VII

Safety at sea: Safety devices ï Accidents associated with marine environment, boat design and navigation, mitigation measures.

UNIT VIII

GMDSS and other safety devices. Advanced communication Systems ï VHF, SSB, INMARSAT System.

UNIT IX

Vessel Monitoring Systems (VMS): Importance, uses, role in fisheries management.

UNIT X

Satellite navigation system: GPS ï Components of GPS, working, functions, hand held GPS, important applications of GPS in fisheries and aquaculture.

UNIT XI

Fishing harbours: Classification, facilities, layout of a typical fishing harbour, stages in the planning of fishing harbours.

UNIT XII

Code of Conduct for Responsible Fishing (CCRF): Articles of CCRF, Elaboration of Article 8: Fishing Operations.

Practical

Drawing and reading gear designs - Field visits to fishing harbour and preparation of drawing of its lay out - Training onboard fishing vessels in fishing techniques, familiarization with navigation and communication

equipments -Study of layout and operation of a fish landing centre; Study of fish aggregating devices - Familiarization with various safety devices.

Suggested Readings

Duncan A. 1980. *A Fisherman's Guide to Ecosounding and Sonar Equipment. Acoustic Fish Detection Instruments*. University of Rhode Island. Marine Bull. 41.
FAO. 1972. *Catalogue of Fishing Gear Designs*. Fishing News Books. FAO. 1980. *Definition and Classification of Fishery Vessel Types*. FAO
Fisheries Tech. Paper No. 267, Rome.
John S. 1996. *Commercial Fishing Methods - An Introduction to Vessels and Gear*. Fishing News Books.
Nirgess K. 1966. *Fishing Boats and Equipments*. Fishing News Books. Sreekrishna Y & Shenoy L. 2001. *Fishing Gears and Craft Technology.*
ICAR.
Traung JO. 1955. *Fishing Boats of the World.* 1. Fishing News Books. Traung JO. 1960. *Fishing Boats of the World*. 2. Fishing News Books. Traung JO. 1967. *Fishing Boats of the World*. 3. Fishing News Books. Tucker DG. 1967. *Sonar in Fisheries - a Forward Look*. Fishing News
Books.

FRM 512 MODERN TECHNIQUES IN ICHTHYOTAXONOMY 2+1

Objective

To enable the students in differentiating genera/ species up to stock level using classical, molecular and computer based techniques.

Theory

UNIT I

Identification of stocks based on classical and modern taxonomical methods.

UNIT II

Classical taxonomy ï morphometrics ï meristics. UNIT III

Modern taxonomical tools ï Electrophoretic studies (muscle myogen, eyelens protein, enzyme pattern and serology), Karyotyping.

UNIT IV

Molecular markers ï PCR, RAPD, RFLP, Microsatellites, mini satellites and Mitochondrial DNA, and their application in fish phylogenetic studies.

Practical

PAGE ï Muscle myogen, eyelens proteins, enzymes of different species of finfishes; fish chromosomes preparation and identification DNA Isolation and quantification, PCR techniques Statistical software used in fish molecular studies.

Suggested Readings

Cooksey K. 1997. *Molecular Approaches to the Study of the Oceans*. Chapman & Hall.
FAO. 2000. *DNA Based Molecular Diagnostic Techniques*.
Kocher TD & Carol AS. (Ed.). 1997. *Molecular Systematics of Fishes*. Academic Press.
Le Gal Y & Halvorson HO. 1998. *New Development in Marine Biotechnology*. Plenum Press.
Mayer E. 1977. *Principle of Systematic Zoology*. Tata McGraw Hill. Ponniah AG & George J. 1998. *Fish Chromosome Atlas*. National Bureau of Fish Genetic Resources (NBFGR), Lucknow.
Whitmore DH. 1990. *Electrophoretic and Isoelectric Focusing Techniques in Fisheries Management*. CRC Press.

FRM 601 ASSESSMENT OF AQUATIC BIODIVERSITY 2+1

Objective

To impart in-depth knowledge on aquatic biodiversity, its assessment and conservation methods.
To understand the ecological impact of various aquatic resources.

Theory

UNIT I

Definitions and measurement: Methods, scales and indices of biodiversity assessment.

UNIT II

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.

UNIT III

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).

UNIT IV

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.

UNIT V

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

UNIT VI

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

UNIT VII

Institutionalization of biodiversity conservation (Such as creation of Biodiversity Boards/Authority.

Practical

Preparation of records and inventories of biodiversity of any three critically important ecosystem based on secondary data and field visits- Compilation of all important International and National laws and conventions related to biodiversity

Suggested Readings

Brian G. 1992. Global Biodiversity - Status of the Earthôs Living Resources. Chapman & Hall.

Denton TE. 1973. *Fish Chromosome Methodology*. Charles Thomas Publ.

Elliott AN. (Ed.). 1993. *Global Marine Biological Diversity*. Inland Press.

Gunderson DR. 1993. *Surveys of Fisheries Resources*. John Wiley & Sons.

Khanna DR, Chopra AK & Prasad G. 2005. *Aquatic Biodiversity in India*. Daya Publ. House.

Kumar U & Asija M. J. 2000. *Biodiversity Principles and Conservation*. Agrobios.

Lakra WS, Abidi R, Singh AK, Sood N, Rathore G & Swaminathan TR. 2000. *Fish Introductions and Quarantine: Indian Perspective*. National Bureau of Fish Genetic Resources (NBFGR), Lucknow.

Lambshead PJD, Paterson GLJ & Gage JD. 1997. *Biodiversity Professional*. Version 2. National History Museum and the Scottish Association of Marine Science.

Magurran AE. 1988. *Ecological Diversity and its Measurement*. Taylor & Francis.

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

Ponniah AG & Gopalakrishnan A. (Eds.). 2000. *Endemic Fish Diversity of Western Ghats*. National Bureau of Fish Genetic Resources (NBFGR), Lucknow.

Zoological Survey of India. 2007. *National Symposium on Conservation and Valuation of Marine Biodiversity*.

FRM 602 APPLICATIONS OF FISHERIES MODELS IN STOCK ASSESSMENT 2+1

Objective

To study the application of various dynamics and holistic models used in fish stock assessment.

Theory

UNIT I

History and development of analytical models; Analytical models; its history and development.

UNIT II

Application of Beverton and Holtôs, Thompson and Bell models in trophics.

UNIT III

Logistic models of Schaefer and Fox.

UNIT IV

Prey predator models. 4. Stock recruitment models of Ricker, Beverton and Holt.

UNIT V

Bioeconomic modeling.

UNIT VI

Ecopath and ecosim models.

Practical

Application of logistic and analytical models in marine, riverine and estuarine systems. Ecopath modeling based on secondary data.

Suggested Readings

Beverton RJH & Holt SJ. 2004. *On the Dynamics of Exploited Fish Population*. The Blackburn Press.

Edwards EF & Megrey BA. 1989. *Mathematical Analysis of Fish Stock Dynamics*. American Fisheries Society, Maryland.

Gulland JA. (Ed.). 1977. *Fish Population Dynamics*. John Wiley & Sons. Nickolskhi GV. 1980. *Theory of Fish Population Dynamics as the Biological Background for Rational Exploitation and Management of Fishery Resources*. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Ray H & Carl JW. 1992. *Quantitative Fisheries Stock Assessment Choice, Dynamics and Uncertainty*. Kulwer.

Ricker WE. 1971. *Methods for the Assessment of Fish Production in Freshwaters*. Blackwell, Oxford & IBH.

FRM 603 CONSERVATION AND MANAGEMENT OF EXPLOITEDFISHERIES RESOUCES 2+1

Objective

To apprise the students on the various conservation and management strategies of exploited fisheries resources.

Theory

UNIT I

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

UNIT II

Cryopreservation of exploited and endangered species.

UNIT III

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

UNIT IV

Protection of habitat of corals, mangrove, seaweeds, sea grass beds. Implementation of square cod end mesh ï to reduce by-catch.

UNIT V

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

UNIT VI

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

UNIT VII

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

UNIT VIII

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

UNIT IX

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

Practical

Based on the existing policy, suggest and draft ideal inland and marine fishery legislation for any one Indian State. With reference to the laws of the sea (UNCLOS III) treaty, recommend ways and means to solve dispute of shared stocks. Develop a framework for conflict resolution of traditional and mechanized fisheries.

Suggested Readings

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

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

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

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

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

FRM 604 CORAL REEF MANAGEMENT 2+1

Objective

To learn identification and classification of different corals and their habitats.

To impart knowledge on the conservation and management of coral resources.

Theory

UNIT I

Type of coral reefs and their distribution.

UNIT II

Origin of coral reefs ï coral reefs of the world.

UNIT III

Ecology of coral reefs; factors influencing growth; productivity of coral reefs; plants and animals associates of living reef corals and fringing reefs.

UNIT IV

Nutrition, production, larval dispersal and settlement of corals.

UNIT V

Soft coral type and their ecology.

UNIT VI

Bioactive substances of soft and hard corals, sedimentation in coral reef environment.

UNIT VII

Economic importance of coral reefs.

UNIT VIII

Management and conservation of coral reefs and soft corals.

Practical

Collection and identification of soft and hard corals; Survey of corals and mapping; identification of associated

organisms; preparation of checklist and associated organisms of Indian coast. Predatory animals of corals, Extraction of bioactive substances from soft and hard corals. Observations of destructive methods of corals and coral reef fishes.

Suggested Readings

Bakus GJ. 1994. *Coral Reef Ecosystem*. Oxford & IBH.
Bayer FM, Manfred G & Jakob V. 1983. *Illustrated Trilingual Glossary of Morphological and Anatomical Terms Applied to Octocorallia*. Leiden.
Biswas KP. 2008. *Corals of Tropical Oceans*. Daya Publ. House.
James PSBR. 1986. *Recent Advances in Marine Biology*. Today & Tomorrow.
Peter S. (Ed.).2006. *Coral Reef Fishes: Dynamics and Diversity in a Complex Ecosystem*. Academic Press.
Polunin NVC & Roberts CM. 1996. *Reef Fisheries*. Chapman & Hall. Rogers CS. 1994. *Coral Reef Monitoring Manual for the Caribbean and Western Atlantic*. National Park Service, Virgin Islands.
Rosenberg E & Loya Y. (Eds.). 2004. *Coral Health and Disease*. Springer. Talbot F & Wilkinson C. 2001. *Coral Reefs, Management and Seagrasses. A Source Book for Managers*. Australian Institute of Marine Suck Australia.

FRM 605 DATA COLLECTION AND ESTIMATION OF EXPLOITED FISHERIES RESOURCES 0+2

Objective

To learn in detail the sampling designs and estimation of catch and effort data.

Practical

Collection of fishery data at landing centres from different gears separately. Details of craft and gear of landing centres. Recording of data in the entry
forms. Definition of length for various groups of fish/crustaceans/molluscs.
Collection of length frequency data of fishes at landing centres. Estimation of age and growth based frequency data.
Growth, mortality, population and stock parameters employing FiSAT, Length structured VPA, Thompson and Bell yield stock prediction for single and multifleet version. Beverton and Holt yield-per-recruit model; biomass-per-recruit. Relative yield-per-recruit model and yield isopleth diagram.

Suggested Readings

Beverton RJH & Holt SJ. 2004. *On the Dynamics of Exploited Fish Population*. The Blackburn Press.
Callucci VG, Saila SB, Gustafson DJ & Rothschild BJ. 1996. *Stock Assessment. Quantitative Methods and Applications for Small Scale Fisheries*. Lewis Publ.
Gulland JA. 1977. *Fish Population Dynamics*. John Wiley & Sons.
Gulland JA. 1992. *A Review of Length Based Approaches to Assessing Fish Stocks*. FAO Tech. Paper. 323.
Nickolskhi GV. 1980. *Theory of Fish Population Dynamics as the Biological Background for Rational Exploitation and Management of Fishery Resources*. Bishen Singh Mahendra Pal Singh, Dehra Dun.
Ricker WE. 1971. *Methods for the Assessment of Fish Production in Freshwaters*. Blackwell, Oxford & IBH.
Sparre P & Venema SC. 1998. *Introduction to Tropical Fish Stock Assessment*. Part 1 *Manual.* FAO Fisheries Tech. Paper No. 301, Rome.

FRM 606 FISHERIES ENVIRONMENTAL ASSESSMENT 2+1

Objective

To know the probable impacts of environmental factors on fishery resources and gain knowledge on the standard methods applicable in fisheries environmental assessment.

Theory

UNIT I

Critically important climatic factors (temperature, rainfall and wind pattern
/ monsoon influencing aquatic (inland and marine) productivity and production.

UNIT II

Remotely sensed SST, Chlorophyll and Wind pattern features of Indian seas used in locating Potential Fish Zones (PFZ).

UNIT III

Influence of rainfall intensity, its seasonal and annual variations on fish migration, breeding, recruitment and production. (Correlation of rainfall data from IMD and catch data on fishes from same region for bringing out the impact of rain on production).

UNIT IV

Optimum water quality parameters prescribed for various water bodies (marine and inland) for different user groups including fisheries.

UNIT V

Environmental Impact Assessment of various anthropogenic causes; domestic and industrial water discharge into waters and their impact on fisheries. Tannery discharge and its impact on fisheries.

UNIT VI

Status, structure and trophic profile (at primary, secondary and tertiary levels) of four typical water bodies: i)

Marine, ii) Estuarine iii) Reservoir iv) River in relation to nutrient profile, plankton profile and oxygen profile in spatial and temporal terms.

Practical

Preparation of isoclines of temperature, rainfall and chlorophyll pattern of data gathered from satellites and demarcation of the PFZôs. Development of a graphic picture of the vertical and horizontal profiles of various nutrients, temperature, oxygen, plankton and fish density of any well defined aquatic system.

Suggested Readings

Canter LW. 1994. *Environmental Impact Assessment*. Mc-Graw Hill. Grilbert M & Gould R. 1998. *Achieving Environmental Standards*. Pitman Publ.

Peter W. (Ed.). 1988. *Environmental Impact Assessment: Theory and Practice*. World Research Institute, Routledge, London.

FRM 607 ISSUES IN CAPTURE FISHERIES 1+1

Objective

To get comprehensive knowledge on the major issues / challenges faced in capture fisheries.

Theory

UNIT I

Over- capacity (excessive fishing efforts); Over exploitation. By-catch and Discards.

UNIT II

IUU (Illegal, Unregulated and Unreported) Fishing. Problems encountered in Monitoring, Control and Surveillance (MCS).

UNIT III

Ghost fishing, destructive fishing practices.

Practical

Assessment of fishing capacity; stages of overexploitation, case studies and field visits.

Suggested Readings

Bal DV & Rao KV. 1990. *Marine Fishes of India.* 1st Revised Ed. Tata McGraw Hill.

Chandra P. 2007. *Fishery Conservation Management and Development*. SBS Publ.

Dholakia AD. 2004. *Fisheries and Aquatic Resources of India*. Daya Publ. House.

Kurian CV & Sebastian VO. 1986. *Prawns and Prawn Fisheries of India*. Hindustan Publ. Corp.

Moyle PB & Joseph JC Jr. 2000. *Fishes – An Introduction to Ichthyology*. 4th Ed. Prentice Hall.

Samuel CT. 1968. *Marine Fisheries in India*. Oceanographic Laboratory, University of Kerala.

Shanbhogue SL. 2000. *Marine Fisheries of India*. ICAR.

Yadav BN. 1997. *Fish and Fisheries*. 2nd Ed. Daya Publ. House

AQUATIC ENVIRONMENT MANAGEMENT

CODE	COURSE TITLE	CREDITS
AEM 501*	AQUATIC ENVIRONMENT AND BIODIVERSITY	2+1
AEM 502*	CHEMICAL INTERACTIONS IN THE AQUATIC ENVIRONMENT	2+1
AEM 503*#	INTEGRATED COASTAL ZONE MANAGEMENT	2+1
AEM 504*	AQUATIC POLLUTION AND WASTEWATER MANAGEMENT	2+1
AEM 505	ECOLOGY AND MANAGEMENT OF LIMNETIC ENVIRONMENT	2+1
AEM 506	ENVIRONMENTAL BIOTECHNOLOGY	1+1
AEM 507	ENVIRONMENTAL TOXICOLOGY	1+1
AEM 508	ANALYTICAL TECHNIQUES IN ENVIRONMENTAL SCIENCES	1+1
AEM 509	PLANKTONOLOGY	1+1
AEM 510	FISHERIES OCEANOGRAPHY	1+1
AEM 511	AQUATIC MICROBIOLOGY	2+1
AEM 591	MASTERõS SEMINAR	1+0
AEM 599	MASTERõS RESEARCH	20
AEM 601**	ADVANCES IN AQUATIC ENVIRONMENTAL STUDIES	2+1
AEM 602**	BIOTECHNOLOGY FOR CLEANER ENVIRONMENT	2+1
AEM 603**	BENTHIC ECOLOGY	1+1
AEM 604	ESTUARINE AND COASTAL OCEANOGRAPHY	2+1
AEM 605	ORGANIC PRODUCTION AND PLANT PIGMENTS	2+1
AEM 606	ENVIRONMENT IMPACT ASSESSMENT	1+1
AEM 607	MANAGEMENT AND UTILIZATION OF WASTEWATER	2+1
AEM 608	APPLICATION OF REMOTE SENSING AND GIS IN FISHERIES	2+1
AEM 609	DISPERSAL AND FATE OF POLLUTANTS IN THE OCEAN	1+1
AEM 610	RESTORATION ECOLOGY	1+1
AEM 691	DOCTORAL SEMINAR I	1+0
AEM 692	DOCTORAL SEMINAR II	1+0
AEM 699	DOCTORAL RESEARCH	45

* Compulsory for Masterõs programme; ** Compulsory for Doctoral programme
#AEM 503 cross listed with Fisheries Resource Management FRM 507

Course Contents

AEM 501 AQUATIC ENVIRONMENT AND BIODIVERSITY 2+1

Objective

To acquaint the students with the theoretical and practical aspects of the aquatic environment and biodiversity.

Theory

UNIT I

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

UNIT II

Environmental concerns: Environmental concerns ï population explosion, industrialization, urbanization, and natural calamities; Overexploitation of resources; Environmental stresses; Global Warming; Ozone Depletion.

UNIT III

Biodiversity: Biodiversity – Definition and concept; 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.

Practical

Collection of fauna and flora from different ecosystems; Analysis of Biodiversity at community, population and species levels through different methods; Case studies.

Suggested Readings

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.

AEM 502 CHEMICAL INTERACTIONS IN THE AQUATIC ENVIRONMENT 2+1

Objective

To acquaint the students with basic principles of chemical interactions in the aquatic environment.

Theory

UNIT I

Basic chemistry principles: Chemical reaction kinetics, chemical equilibria and redox chemistry, solubility concept, dissolution kinetics, processes controlling elemental cycling in the earth's crust, oceans and atmosphere.

UNIT II

Soil properties: Soil structure and texture; Composition of oxide and silicate minerals in relation to surface chemical processes; Charge and double layer, and mineral equilibrium; Silicate weathering, transformation, weathering products; Ion exchange - concept and source of cation exchange capacity (CEC), adsorption on to clay minerals of major cations, specific adsorption of major and minor nutrients, and heavy metal ions.

UNIT III

Nutrient dynamics: Chemistry of soil-nutrient interactions and water permeability; Organic substances - biological processes in the degradation and conversion of organic matter; Humus and biogeochemical substances - structure, reactivity, solubility and mobility; Transport of substances - nutrients (*e.g.,* phosphate, nitrate, ammonia, Ca and K), Soil-water interactions ï availability of nutrients and productivity of aquatic ecosystem.

UNIT IV

Pollutant dynamics: Pollutant cycling, bio-accumulation, bio-availability, speciation and transport of contaminants (*e.g.,* pesticides and heavy metals).

Practical

Sample Collection techniques; Determination of physicochemical parameters of soil and water - pH, electrical conductivity, redox potential, soil texture, bulk density, particle density, porosity, hydraulic conductivity, organic carbon, total and available nitrogen, phosphorus, potassium and micronutrients; C/N ratio; clay colloids in the soil; CEC; Adsorption/fixation of ions on clay minerals.

Suggested Readings

Lindsay WL. 1979. *Chemical Equilibria in Soils*. John Wiley & Sons.

Manahan SE. 2000. *Environmental Chemistry*. Lewis Publ.

McBride MB. 1994. *Environmental Chemistry of Soils*. Oxford University Press.

Stumm W & Morgan JJ. 1996. *Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters*. John Wiley & Sons.

Tan KH. 1998. *Principles of Soil Chemistry*. CRC Press.

AEM 503 INTEGRATED COASTAL ZONE MANAGEMENT 2+1

Objective

To impart knowledge on the coastal resources, integrated coastal zone management strategies and disaster management.

Theory

UNIT I

Coastal resources: Coastal natural resources systems: flora and fauna, trophic relationship, nutrient production, cycle and transport; Mangrove ecosystem - species diversity and distribution of mangroves in India, Other inter-tidal system- Seagrass system, Coral reef system, Sandy beach system, Lagoon and estuary system.

UNIT II

Developmental activities and biodiversity loss: Ecological issues, Non- sustainable development, Pollution, threats to biodiversity, habitat destruction, Depletion of fisheries resources, impacts of global environment changes, Multiple uses of the Coastal Zone, Urban settlement, Industrial development, waste disposal, Shore protection works, ports and marine transportation. Land transportation infrastructure, Water control and supply projects, sea fisheries, Aquaculture, Coastal forest industries, Coastal agriculture, industries.

UNIT III

Coastal Zone Management: Integrated Coastal Zone Management (ICZM): its need and benefits, Principles, Goals and objectives of the ICZM programme; Scope, Extent of jurisdiction, Boundaries of the coastal zone, policies and planning for coastal resource management; Management mechanisms- Pollution control, Protected areas (sanctuaries, marine parks and biosphere reserves), Protection from natural hazards; Socioeconomic impacts and its assessment, Disaster management for coastal environment.

UNIT IV

Coastal tourism: Beach resorts, restaurants and parks within the coastal zone as per existing rules and regulations. Impact of pollution on coastal resources.

Practical

Analysis of soil and water characteristics of coastal areas where man made impacts have established; Assessment of damages of water quality; Collection, preservation and identification of coastal biological communities; Survey of different coastal zones; Visit to the protected areas.

Suggested Readings

Brahtz JFP. 1972. *Coastal Zone Management*. UN Department of International Economic & Social Affairs, New York.

Cairns J Jr. 1994. *Implementing Integrated Environmental Management* Virginia Tech. University.

Clark JR. 1992. *Integrated Management of Coastal Zones*. FAO Fisheries Tech. Paper No. 327, Rome.

Coastal Area Management and Development 1982. UN Department of International Economic & Social Affairs, New York.

David S & Jeremy P. 2001. *Inshore Fisheries Management. Methods and Technologies in Fish Biology and Fisheries*. Vol. II. Kluwer.

Khanna BK. 2000. *All You Wanted to Know About Disasters*. New India Publ. Agency.

AEM 504 AQUATIC POLLUTION AND WASTEWATER MANAGEMENT 2+1

Objective

To impart fundamental and advanced knowledge on different aspects of Aquatic pollution and waste water management.

Theory

UNIT I

Aquatic pollution and its management: Aquatic pollution ï sources, types and their impacts; Pollution problems of groundwater resources ï sources of contamination, management issues.

UNIT II

Pollutants - Sewage, pesticides, oils, metals, radioactive wastes, biomedical wastes, etc. Common transport processes of pollutants in the aquatic environment; dispersal of pollutants; Algal blooms and their management, Methods of pollution surveys.

UNIT III

Waste disposal and water quality criteria used in different parts of world - national and international standards; ISO-14000(EMS), EIA, Management strategies.

UNIT IV

Wastewater management: Wastewaters - classification and characteristics of sewage and industrial effluents; treatment methods for water and waste water; Principles of aeration, chlorination, ozonation and U.V. irradiation.

UNIT V

Waste recycling and utilization in aquaculture; Design and construction of water filtration devices; aerobic and anaerobic treatment of wastewater.

UNIT VI

Wastes from fish processing units and their treatment; solid waste management; removal of nitrogen and phosphorus from waste water; Role of aquatic macrophytes in treatment of wastewater.

Practical

Collection and preservation of wastewater samples; Physicochemical analysis of wastewater - total dissolved and suspended solids, DO, BOD, COD, H_2S,, NH_3ï N, NO_2-N, NO_3-N, PO_4-P, CH_4, heavy metals and pesticides; Use of algae for waste water treatment; Visit to a sewage treatment plant, fish processing unit and other industries; Exercise on interpretation of water quality data for evaluation of aquatic health.

Suggested Readings

Baird DJ, Beveridge MCM, Kelly LA & Muir JF. 1996. *Aquaculture and Water Resources Management*. Blackwell.

Cheremisinoff NP. 2002. *Handbook of Water and Waste Water Treatment Technologies*. Butterworth ï Heinemann.

Eckenfelder WW. 2000. *Industrial Water Pollution Control*. McGraw Hill. Gray NF. 2004. *Biology of Wastewater Treatment*. Oxford University Press.

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

AEM 505 ECOLOGY AND MANAGEMENT OF LIMNETIC ENVIRONMENT 2+1

Objective

To educate the students on the ecology of limnetic wetlands and to impart skill and knowledge on the sustainable management of the limnetic ecosystems.

Theory

UNIT I

Types: Categorization of different limnetic fisheries resources - lacustrine, riverine and coldwater systems; Wetlands, Floodplain wetlands, swamps - characteristics, flora and fauna.

UNIT II

Characteristics: Physical and chemical characteristics of limnetic environment and its relationship with the organisms; influence on metabolism, behavior and orientation of animals; Biological productivity in relation to fishery potential; Trophic relationships in the wetland ecosystem- nutrient production, and transport, Trophic succession; Dynamics of lentic and lotic systems; Water budgeting in limnetic ecosystems.

UNIT III

Conservation and Management: Functions of wetlands; Habitat degradation- causative factors and controlling/management measures; Destruction of wetlands - causes and consequences; Restoration, conservation and management of wetlands; Resource enhancement; Management of water bodies for economy-driven activities; Management through Biomanipulation studies- top-down and Bottom-up methods; Integrated Environment Management (IEM) Programme-involvement of human element; River continuum concept and new paradigm shift; River linking; International conventions - Ramsar; Environmental laws and regulations; Index of Biotic Integrity (IBI); modeling studies; Wetland mapping using remote sensing; Geographical Information System (GIS)- Definition, Concepts and application.

Practical

Collection, preservation and analysis of flora and fauna (including phytoplankton, zooplankton and benthos) of wetland ecosystem; Case studies on soil and water quality assessment; Survey and sampling of lentic and lotic waters; Calculation of shoreline development index and morphometry; Determination of carrying capacity; Field visits to selected reservoirs, lakes/wetlands and rivers.

Suggested Readings

Allan JD. 1995. *Stream Ecology: Structure and Function of Running Waters*. Chapman & Hall.

Dodds WK. 2002. *Freshwater Ecology: Concepts and Environmental Applications*. Academic Press.

Good RE, Whigham DF & Simpson RL. 1978. *Fresh Water Wetlands: Ecological Processes and Management Potential*. Academic Press.

Hynes HBN. 1970. *Ecology of Running Waters*. Liverpool University Press, Liverpool.

Mitsh WJ & Gosselink JG. 1996. *Wetlands*. John Wiley & Sons.

Nath S. (Ed.). 2008. *Recent Advances in Fish Ecology Limnology and EcoConservation*. Vol. VII. Narendra Publ. House.

Pattern BC. 1990. *Wetlands and Shallow Continental Water Bodies*. SPB Academic Press.

Scheffer NM. 1998. *Ecology of Shallow Lakes*. Chapman & Hall.

Talling J & Lemoalle J. 1998. *Ecological Dynamics of Tropical Inland Waters*. Cambridge University Press, London.

Wong MH. 2004. *Wetland Ecosystems in Asia: Functions and Management*. Elsevier.

AEM 506 ENVIRONMENTAL BIOTECHNOLOGY 1+1

Objective

To impart basic knowledge on biotechnological applications of microorganisms and demonstration of their potential for environmental management.

Theory

UNIT I

Fundamentals of environmental biotechnology: Environmental biotechnology- concepts and scope; conventional and modern approaches, Interrelationship of xenobiotics with other environmental variables; IPR issues related to environmental biotechnology.

UNIT II

Genetically-improved strains: Genetically-improved strains - basic concepts, application in waste management, pesticide degradation, heavy metal remediation, oil removal; Nitrogen fixation; Phosphate solubilization; Cellular and molecular markers of environmental pollution monitoring and management.

UNIT III

Microbial consortia: Consortia of microbes for environmental protection ï Concept, scope and feasibility.

UNIT IV

Biological treatment and utilization of wastes: Bioreactors ï principles and application in nitrification, denitrification, reduction of BOD; Production of biofuels, fermented products and biogas from wastes, Nutrient uptake by aquatic organisms.

Practical

Genomic and plasmid DNA isolation; PCR and gel electrophoresis, Cloning; Single-cell protein production; Case studies on wastewater treatment/recirculatory systems; Quantification of N fixation, nitrification; Screening of microbes for biodegradation properties.

Suggested Readings

Buck RP, Hatfield WE, Umana M & Bowden EF. 1990. *Biosensor Technology - Fundamentals and Applications*. Marcel Dekker.

Fujita M & Ike M. 1994. *Wastewater Treatment Using Genetically Engineered Microorganisms*. Technomic Publ. Co.

Kingsman SM & Kingsman AJ. 1988. *Genetic Engineering: An Introduction to Gene Analysis and Exploitation in Eukaryotes*. Blackwell.

Sambrook J & Russel DW. 2001. *Molecular Cloning: A Laboratory Manual*. CSHL Press.

Sayler GS, Sanseverino J & Kimberely DL. 1997. Biotechnology in Sustainable Environment. Plenum Press.

AEM 507 ENVIRONMENTAL TOXICOLOGY 1+1

Objective

To impart knowledge on toxicological aspects of various pollutants.

Theory

UNIT I

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.

UNIT II

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

Practical

Toxicity evaluation of heavy metals on selected organisms by bioassay techniques; Toxicity assessment of pesticides, PCBs and oil on selected organisms; Analysis of heavy metals from aquatic ecosystems; Toxicity testing methods.

Suggested Readings

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

Kumar A. (Ed.). 2008. *Aquatic Environment and Toxicology.* Daya Publ. House.

Mayer H. 1977. *Aquatic Toxicology and Hazards Evaluation*. ASTM Publ. Rand GM & Petrocelli SR. 1994. *Fundamentals of Aquatic Toxicology*. Hemisphere Publ. Corp.

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.

AEM 508 ANALYTICAL TECHNIQUES IN ENVIRONMENTAL SCIENCES 1+1

Objective

To impart knowledge and skills in analytical techniques employed in environmental studies.

Theory

UNIT I

Overview and concepts: An overview of qualitative and quantitative analytical techniques used in environmental science; Sampling techniques and procedures; Factors affecting the choice of an analytical technique; Interferences and their removal, Field kits and their application.

UNIT II

Photometric techniques: Theory, instrumentation and application of colorimetry and spectrophotometry.

UNIT III

Separation techniques: Chromatography ï theory, instrumentation and applications of thin layer, paper, ion-exchange, size exclusion, high performance liquid and gas; Methods of preparing biological samples for chromatographic analysis; Theory and applications of electrophoresis; Principles and uses of ultracentrifugation.

UNIT IV

Tracer techniques: Scintillation counters and radio isotopes in environmental research.

Practical

Quantitative estimation of organic and inorganic pollutants and toxicants by
UV-Visible spectrophotometer, AAS, HPLC, GC.

Suggested Readings

Eaton AD, Clesceri LS, Rice EW & Greenberg AE. 2005. *Standard Methods for the Examination of Water and Wastewater*. APHA- AWWA-WEF, Washington DC.

Fishbein L. 1973. *Chromatography of Environmental Hazards: Metals, Gaseous and Industrial Pollutants*. Elsevier.

Jeffery GH, Basset J, Mendham J & Denney RC. (Eds.). 1989. *Vogel's Textbook of Quantitative Chemical Analysis*. Longman.

Sparks DL, Page AL, Helmke PA, Loeppert RH, Soltanpour PN, Tabatabai MA, Johnston CT & Sumner ME. (Eds.). 1996. *Methods of Soil Analysis*: Part 3. *Chemical Methods*. SSSA-ASA, Madison.

Welch PS. 2003. *Limnological Methods*. Narendra Publ. House.

Wilson K & Walker J. 2002. *Practical Biochemistry: Principles and Techniques*. Cambridge University Press, Oxford.

AEM 509 PLANKTONOLOGY 1+1

Objective

To impart knowledge on plankton, their ecology and significance.

Theory

UNIT I

Plankton diversity and productivity: Classifications of plankton; Primary and secondary production - estimation, significance, affecting factors; Production - biomass (P/B ratio); Indices of productivity; Community interrelationships.

UNIT II

Ecology of phytoplankton: Phytoplankton (freshwater and marine) - methods of assessment, spatial and temporal variations, succession, diversity; Nanoplankton; Algal blooms; Role in carbon sequestration.

UNIT III

Ecology and life history of zooplankton: Zooplankton (freshwater and marine) ï ecology of the major taxa, their food and feeding, reproduction of important zooplankton, life history stages; swarms; Indicator species; Predator-prey relationship; Impact of grazing in the aquatic ecosystem; Vertical migration of zooplankton; Larval ecology of benthic invertebrates.

UNIT IV

Sampling and preservation techniques: Plankton nets and recorders, catching efficiency of various nets; Plankton fixatives and preservatives.

Practical

Collection, preservation and quantitative estimation of phytoplankton and zooplankton; Identification and classification of various phytoplankton and zooplankton; Preparation of permanent slides; Logging, cataloguing and sorting procedures.

Suggested Readings

Fasset NG. 1997. *A Manual of Aquatic Plants*. Allied Scientific Publ. Lund HC & Lund JWG. 1995. *Freshwater Algae*. Biopress Ltd.

Mitra A. 2006. *Introduction to Marine Phytoplankton*. Narendra Publ.

Pillai NK. 1986. *Introduction to Planktonology*. Himalaya Publ. House.

Sournia A. 1978. *Phytoplankton Manual*. UNESCO Publ.

Tomas CR. 1997. *Identifying Marine Phytoplankton*. Academic Press.

AEM 510 FISHERIES OCEANOGRAPHY 1+1

Objective

To educate the students on the oceanographic concepts related to fisheries and impart skill to operate oceanographic equipment.

Theory

UNIT I

Oceanographic factors in fisheries: Effects of physicochemical and biological oceanographic factors on adaptation, behaviour, abundance and production of aquatic organisms; Space and time scales in oceanographic analysis; Speed and magnitude of short-term changes in the ocean; Synoptic oceanographic analysis ï currents, waves, tides, amplitudes, stratification, related chemical factors, upwelling and circulation patterns.

UNIT II

Forcasting systems: Fisheries forecasts ï interpretation and use of ocean thermal structure in fisheries; Fisheries forecasting system in India and other countries ï remote sensing; Global Positioning System (GPS). Application of Remote Sensing in fisheries; Application of echo-sounders and SONAR.

UNIT III

Coastal fishery: Coastal fishery and hydrography- introduction, scope and factors affecting; shoreline protection and influence of developmental activities on coastal hydrography.

UNIT IV

Factors affecting marine fisheries: Environmental factors influencing the seasonal variations in fish catches in the Arabian Sea and the Bay of Bengal.

Practical

Oceanographic data analysis ï water temperature, salinity, pH, nutrients, benthos and sediment characteristics; Fisheries forecasting systems; Oceanographic equipment and fish finding devices.

Suggested Readings

Grasshoff K, Ehrhardt M & Kremling V. 1983. *Methods of Seawater Analysis*. Verlag Chemie.
Kennish MJ. 1989. *Practical Handbook of Marine Science*. CRC Press.
Laevastu T & Hayes ML. 1981. *Fisheries Oceanography and Ecology*. Fishing News Books.
Lalli CM & Parsons TR. 1993. *Biological Oceanography: An Introduction*. Elsevier.
Miller CB. 2004. *Biological Oceanography*. Blackwell.
Reddy MPM. 2007. *Ocean Environment and Fisheries*. Science Publ.

AEM 511 AQUATIC MICROBIOLOGY 2+1

Objective

To impart knowledge on aquatic microorganisms with reference to their role in the aquatic environment and bioprospecting.

Theory

UNIT I

Cell structure and function: Prokaryotic and eukaryotic cell structure, cell membrane, cell wall, proteins, nucleic acids - structure, properties and interactions, microbial growth.

UNIT II

Distribution and classification: Microbial community in freshwater, estuary and marine environment (types and abundance). Microbial dependency on physical, chemical and biological factors of the environment; Classification of aquatic microorganisms, Microbes in extreme environments and their significance - thermophiles, psychrophiles, halophiles and barophiles.

UNIT III

Microbial interaction with matter: Microbial interaction - role of microbial population on the biogeochemical cycles (C, N, P, S, Si and Fe), Xenobiotic and inorganic pollutants; Microbial degradation of natural and synthetic compounds.

UNIT IV

Microorganisms and public health: Water-borne pathogens of public health importance - protozoans, bacteria, enteroviruses; Microbial toxins; Microbial standards for different water uses.

UNIT V

Microbes and aquatic environment: Principles and applications of bioprocessesï bioremediation, biofertilization, biofilms, bio-leaching, bio- corrosion, bio-fouling; Microorganisms as bioindicators, bioremediators and biosensors; Microbial biomass production - single cell protein; Bioprospecting.

Practical

Sampling methods; Isolation, identification and enumeration of algae and bacteria from diverse aquatic habitats; growth kinetics; Management of algal and bacterial cultures; Quantification of microbial activities in nutrient cycles; Microbial sensitivity testing; Demonstration of biofilms.

Suggested Readings

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

AEM 601 ADVANCES IN AQUATIC ENVIRONMENTAL STUDIES 2+1

Objective

To impart knowledge on various aspects of advances in aquatic environment studies.

Theory

UNIT I

Factors effecting productivity of aquatic ecosystems and their interactions; phosphorus, nitrogen and silica cycles; minor metallic elements; organic matter in lake waters. Dynamics of flowing water; Indices of productivity; pollution index ï usefulness and limitations.

UNIT II

Eutrophication ï causative factors, effects on water quality, fish and other biota; measures to control the lake degradation due to eutrophication.

UNIT III

Biomanipulation: Concept and approaches- studies on Planktivorous, Benthivorous and Omnivorous fish. Biological control of macrophyte and eutrophication.

UNIT IV

Biomonitoring of aquatic environment, scope and process; Bioindicator organisms and its Characteristics; Assessment of water quality through bioindicators.

UNIT V

Global warming and green house effects- process and impact on aquatic environment; Integrated environment management (IEM), Role of human element in IEM, Analytical Behavior Analysis Approach (ABAA) for IEM.

UNIT VI

Natural disasters: formation, causes and effects; effects on aquatic habitat and coastal population; Concerns and management; mitigation process; preparedness, Anthropogenic activities leading to environmental disasters. Man-made aquatic environmental degradation; effects on aquatic life.

Practical

Analysis of ions; Calculation of shoreline development index and other indices of lake productivity; Studies on eutrophication in natural waters- tanks and ponds; Collection, preservation and estimation (quantitative and qualitative) of bioindicator organisms in polluted water. Demonstration of Biomanipulation experiment; Preparation of disaster kits for coastal fisher; Interaction of the Govt. and Non-Govt. Organizations engaged for disaster management.

Suggested Readings

Brudtland GH. 1987. *Our Common Future: World Commissionon Environment and Development*. Oxford University Press.
Gates DM. 1993. *Climate Change and its Biological Consequences*. Saunderland.
Goudie A. 1993. *The Human Impact on the Natural Environment*. MIT Press. IUCN, UNEP, WWE. 1991. *Caring for the Earth: Strategies for Sustainable Living*. Earthscan.
Sakhare VB. (Ed.). 2007. *Advances in Aquatic Ecology* Vol. I. Daya Publ. WCMC. 1992. *Global Biodiversity: Status of the Earth's Living Resources*. Chapman & Hall.

AEM 602 BIOTECHNOLOGY FOR CLEANER ENVIRONMENT 1+1

Objective

To educate the learners about the application of biotechnology in aquatic environment management.

Theory

UNIT I

Pollution Control: Cleaner technologies, Reducing environmental impact of industrial effluents, Toxic site reclamation.

UNIT II

Microbial transformation of toxic metals, Removal of spilled oil and grease deposits, ôBiorationalô or ôEnvironmentally Safeô weed and pest control, Bio-fertilizers, Bio-sensors and biochips to detect environmental pollutants. UNIT III

Application of biotechnological tools in biomonitoring of aquatic environment; Renewable or bio-energy and bio-fuels from aquatic environment, Energy and fuel production using micro-organisms; Production of food: Single cell protein, Algal biotechnology for production of food; Use of microbes for improving soil fertility, biodegradation.

UNIT IV

Biodiversity and its conservation: Current levels of biodiversity, alpha and beta biodiversity, i*n situ* and *ex situ* conservation-gene banks, species conservation. Intellectual Property Rights (IPR) and protection (IPP): IPP and aquatic genetic resources (AGR).

Practical

Quantification of faunal changes in polluted water; Gel electrophoresis; Total DNA isolation; Mitrochondial DNA isolation, Separation and detection of fragments, Comet assay, Micronucleus test, Sister Chromatid exchange; Assessing the molecular and cellular level changes in the Aquatic organisms; Genomic libraries and the development of species specific probes. Southern hybridization; RFLP analysis, PCR mechanics.

Suggested Readings

Buck RP, Hatfield WE, Umana M & Bowden EF. 1990. *Biosensor Technology - Fundamentals and Applications*. Marcel Dekker. Crespi RS. 1991. *Biotechnology and Intellectual Property*. Parts 1, 2.TIBTECH 9.

Moo-Young M, Anderson WA & Chakrabarty AM. 2006. *EnvironmentalBiotechnology: Principle and Applications*. Kluwer.

Sambrook J & Russel DW. 2001. *Molecular Cloning: A LaboratoryManual*. CSHL Press.

Sayler GS, Sanseverino J & Kimberely DL. 1997. *Biotechnology in Sustainable Environment*. Plenum Press.

Yoxen E. 1988. *The Gene Business: Who should Control Biotechnology*.Oxford University Press.

AEM 603 BENTHIC ECOLOGY 1+1

Objective

To impart theoretical and practical knowledge of benthic ecology.

Theory

UNIT I

Benthic habitat- rocks, reefs, marshes and sediments that form the habitat; recycling of nutrients and the burial and storage of organic matter.

UNIT II

Community ecology; Physical, chemical and biological factors effecting benthic population; abundance and distribution of benthic communities- major groups- their life cycles, food and feeding habits and ecological significance; Role in maintaining ecological balance; Recruitment dynamics; Predator prey interaction; Invasive species.

UNIT III

Human impacts; modification of coastal habitats, and major alterations of biogeochemical cycles; contaminants; Benthic organisms as pollution indicators and biomonitors.

Practical

Collection and analysis of soil and water of nearby benthic habitat; collection, identification and preservation of macro and micro benthos; study of food and feeding habit of some benthic population.

Suggested Readings

APHA (American Public Health Association). 1989. *Standard Methods for the Examination of Water and Wastewater*. 17th Ed. American Public Health Association, Washington, D.C.

Clegg J & Anthon H. 1968. *Pond and Stream Life*. Blandford Press. Cole GA. 1988. *Textbook of Limnology*. 3rd Ed. Waveland Press.

Cuffney TF, Gurtz ME & Meador MR. 1993. *Methods for Collecting Benthic Invertebrate Samples as Part of the National Water-Quality Assessment Programme*. U.S. Geological Survey Open-File Report 93-406. U.S.G.S., Raleigh, North Carolina.

Dawson CL & Hellenthal RA. 1986. *A Computerized System for the Evaluationof Aquatic Habitats Based on Environmental Requirements and Pollution Tolerance Associations of Resident Organisms*. EPA/600/S3-86/019. Environmental Research Laboratory, U.S. Environmental Protection Agency, Corvallis, Oregon.

Downing JA & Rigler FH. (Eds.). 1984. *A Manual on Methods for the Assessment of Secondary Productivity in Fresh Waters*. 2nd Ed. IBP Handbook 17. Blackwell.

Elliott JM. 1977. *Some Methods for the Statistical Analysis of Samples of Benthic Invertebrates*. 2nd Ed. Freshwater Biological Association Scientific Publication No. 25.
Whitton BA. (Ed.). 1975. *River Ecology*. University of California Press, Berkeley, California.

AEM 604 ESTUARINE AND COASTAL OCEANOGRAPHY 2+1

Objective

To impart knowledge on the dynamics of coastal environment.

Theory

UNIT I

Definition of an estuary; Buoyancy input as freshwater.

UNIT II

Dynamics of the gravitational circulation; Mixing of fresh and salt water; Sources of energy for mixing. Estuarine circulation, Richardson number. Contributions to the salt flux.

UNIT III

Simplified salt balance using the steady state salinity distribution to predict the concentration of a pollutant. Freshwater fraction. The flushing time of an estuary and methods of determining it.

UNIT IV

Waves in shallow waters, transformation, refraction and reflection; Mass transport. Return flow. Rip current. Long shore currents. Momentum balance.

UNIT V

Sediment transport. Base studies on sedimentation in Estuaries effects of man ï made structures and breakwaters on coastal sedimentation. Standing waves and harbor resonance.

Practical

Measurement of tidal currents in estuaries - analyses of tidal heights ï Net flow and residence time computations. Computation of salt and nutrient flux. Construction of wave refraction diagrams. Computation of longshore currents and sediment drift beach profiles.

Suggested Readings

Carter RWG. 1998. *Coastal Environments: An Introduction to the Physical, Ecological and Cultural Systems of Coastlines*. Academic Press.
Clark JR. 1992. *Integrated Management of Coastal Zones*. FAO Fisheries Tech. Paper No. 327.
Kormondy EJ. 1986. *Concepts of Ecology*. Prentice-Hall.
Park CC. 1980. *Ecology and Environmental Management*. Butterworths.

AEM 605 ORGANIC PRODUCTION AND PLANT PIGMENTS 2+1

Objective

To impart advance knowledge on primary productivity and pigments.

Theory

UNIT I

Concepts of production; measurements of rate of production ï oxygen technique, radiotracer technique (C14), in-situ measurements.

UNIT II

Phytoplankton production in an isolated, non isolated communities in flowing and standing waters, measurement of rates of production from changes in phytoplankton biomass.

UNIT III

Measurement of photosynthesis under laboratory conditions; factors regulating aquatic production; The role of Enzymes in relation to photosynthesis; The photosynthetic pigments, their location in the chloroplast, The role of accessory pigments during photosynthesis; Molecular organisation of chlorophylls, phycobilins and carotenoids; Pigment degradation products ï phaeopigments ï phaeophytin and phaeophorbides.

UNIT IV

Chloroplast ï structure and function of grana and lamellae. Structure of chloroplast membrane ï in relation to energy coupling and transport.

UNIT V

Application of remote sensing in studies on chlorophyll and other pigments. UNIT VI

Production rates ï direct measurement of zooplankton reproduction ï marking populations. Laboratory measurements of physiology of zooplankton ï feeding, respiration and excretion.

Practical

Estimation of primary production in waters ï by Light and Dark Bottle method and radioactive carbon C14 technique. Laboratory studies to understand the impact of nutrients and light on primary production using selected algal cultures. Laboratory studies on the oxygen consumption, filtration and grazing by selected zooplankters. Collection of water samples from selected aquatic environments for the estimation of different plant pigments ï chlorophylls and carotenoids; Estimation of pigments in some of the selected aquatic weeds.

Suggested Readings

Eaton AD, Clesceri LS, Rice EW & Greenberg AE. 2005. *Standard Methods for the Examination of Water and Wastewater*. APHA- AWWA-WEF, Washington DC.

Fishbein L. 1973. *Chromatography of Environmental Hazards: Metals, Gaseous and Industrial Pollutants*. Elsevier.

Talling J & Lemoalle J. 1998. *Ecological Dynamics of Tropical Inland Waters*. Cambridge University Press.

AEM 606 ENVIRONMENT IMPACT ASSESSMENT 1+1

Objective

To impart theoretical and practical knowledge of environment impact assessment for sustainable development.

Theory

UNIT I

Environmental Impact Assessment (EIA): Process, evaluation and methodology; Social Impact Assessment (SIA) as a part of EIA-principals and process; EIA of aquacultural projects, coastal industries and other developmental activities.

UNIT II

Environmental audit: Concept, setting up an audit programme, typical audit process, carrying out the audit, benefits of environmental auditing, Environmental audit programme in India.

UNIT III

International and national environmental protection standards; Environmental quality monitoring; ISO-14000-Environment Management System (EMS)-present status; Impacts on developing countries.

Practical

Field visits for EIA and SIA of certain aquacultural projects; EIA report preparation; Setting up of Environmental audit programme.

Suggested Readings

Canter LW. 1994. *Environmental Impact Assessment*. Mc-Graw Hill. Grilbert M & Gould R. 1998. *Achieving Environmental Standards*. Pitman Publ.

Wathern P. (Ed.). 1988. *Environmental Impact Assessment: Theory and Practice*. World Research Institute, Routledge, London.

AEM 607 MANAGEMENT AND UTILIZATION OF WASTEWATER 2+1

Objective

To impart theoretical and practical knowledge on management and utilization of wastewater for sustainable development.

Theory

UNIT I

Advance treatment methods-Principles and procedures; ozonation, U.V. irradiation etc; Oxidation of sediment; Aerobic and anaerobic treatment process; Role of aquatic macrophytes in biological treatment of waste water; Wastewater treatment through the use of solar energy; Basic design of water and wastewater treatment plants. Removal of nitrogen and phosphorus from wastewater.

UNIT II

Waste recycling and waste management in aquaculture; Design and construction of water filtration devices; Utilization of wastewater for mass cultivation of algae and other fish food organisms; Utilization of waste water for aquaculture and Agriculture.

UNIT III

Waste disposal criteria used in different parts of world - national and international standards; Production of biogas from sewage; Advances in Pollution prevention, Environmental management.

Practical

Estimation of physico-chemical characteristics of wastewater. Estimation of nutrients and contaminant of wastewaters. Analysis of living communities associated with treatment processes; Demonstration of wastewater treatments (ozonisation, chlorination, aeration, precipitation, coagulation etc.).

Suggested Readings

Baird DJ, Beveridge MCM, Kelly LA & Muir JF. 1996. *Aquaculture and Water Resources Management*. Blackwell.

Cheremisinoff NP. 2002. *Handbook of Water and Waste Water Treatment Technologies*. Butterworth-Heinemann.

Eckenfelder WW. 2000. *Industrial Water Pollution Control*. McGraw Hill. Fujita M & Ike M. 1994. *Wastewater Treatment using Genetically Engineered Microorganisms*. Technomic Publ. Co.

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

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

AEM 608 APPLICATION OF REMOTE SENSING AND GIS IN FISHERIES 1+1

Objective

To impart theoretical knowledge and practical skill on application of remote sensing and GIS in oceanographic studies and aquatic environment management planning.

Theory

UNIT I

General consideration, Survey planning, Position fixing; Sampling frequency and duration, Data storage and transmission;

UNIT II

Sensors for temperature and salinity (Via conductivity); The measurement of depth (via pressure); CTD units for estuarine and open ocean work; Sensor calibration techniques; Sensors for measuring flow; Tracking of drogue buoys. Acoustic Doppler current measurements; Optical measurements; transmittance and subsurface reflectance;

UNIT III

In situ fluorescence for the determination of pigment concentration; Remote sensing optical methods; Satellite measurements of temperature (via thermal I.R.), the interpretation of Microwave (geotropic currents, waves, surface winds).

UNIT IV

Geographical Information System (GIS): Definition, Concepts, Spatial data management. Data base management system. Data Capture, Digitization, Data integration, Projection and Registration, Data Structure, Data Modeling. Visual Image Interpretation; Applications of GIS in aquatic Resource identification; Digital Image Processing (DIP): Different Methods and Approaches

Practical

Position fixing techniques. Operation of C.T.D. units and their calibrations. Various types of current meters and measurement of currents. Wave recorders and measurements. Determination of pigment concentrations. Remote sensors ï interpretation of data. Practical on visual interpretation of data from map, Practical on Digital Image Processing (DIP). Field practical on the Application of GPS. Mapping of aquatic environment resources through GIS softwares (ARCVIEW, MAPINFO etc.).

Suggested Readings

Elangovan K. 2005. *GIS: Fundamentals, Applications and Implementations*. New India Publ. Agency.

ESRI. 2007. *Understanding GIS, The ARC/INFO Method*. Environmental System Research Org, USA.

Lillesand TM, Kiefer RW, Chipman JW. 2004. *Remote Sensing and Image Interpretation*. John Wiley & Sons.

Meaden GJ & Do Chi T. 1996. *Geographical Information System: Applications to Marine Fisheries*. FAO Tech. Paper No. 356.

Meaden GJ & Kapetsky JM. 1991. *Geographical Information System and Remote Sensing in Inland Fisheries and Aquaculture*. FAO Tech. Paper No. 318.

AEM 609 DISPERSAL AND FATE OF POLLUTANTS IN THE OCEAN 1+1

Objective

To impart theoretical and practical knowledge on dispersal and fate of pollutants.

Theory

UNIT I

Common transport processes of pollutants in the ocean. UNIT II

Influence of winds, tides, Waves and currents on the dispersal of pollutants, mixing due to waves and Wave induced currents; Principles of design of marine waste disposal system.

UNIT III

Pollutant dispersion in coastal waters and estuaries, dispersion near outfall sites; Methods of pollutant dispersal dye diffusion studies.

Practical

Techniques of computation of dispersion coefficients; Calculation of Richardson number, tidal exchange calculation at the estuarine mouth; Numerical analysis of estuarine dispersion; Simple plume experiments ï designs of waste discharge and thermal systems.

Suggested Readings

John J, William R & Feiss GP. 1998. *People and the Earth: Basic Issues in the Sustainability of Resources*. Cambridge University Press.

Laevastu T, Clancy M & Stroud A. 1974. *Computation of Tides, Currents and Dispersal of Pollutants in Lower Bay and Approaches to New York with Fine Medium Grid Size Hydrodynamical-Numerical Models*. Part 3. National Technical Information Service Springfield, Virginia.

Roy MH. (Ed.). 1982. *Pollution: Causes, Effects and Control*. The Royal Society of Chemistry, England.

Wlodzimierz C & Pawel R. 2005. *Water Quality Hazards and Dispersion of Pollutants*. Springer.

AEM 610 RESTORATION ECOLOGY 1+1

Objective

To acquire theoretical and practical knowledge on ecological restoration.

Theory

UNIT I

Ecological restoration- Need, concept and definition; Approaches; Rationale for restoration; Differences between conservation and restoration; critical ranges of variability in biodiversity.

UNIT II

Ecological processes and structures, regional and historical contexts, and sustainable cultural practices; Ecosystem integrity; community ecological principles; Disturbance, Succession, Fragmentation, Ecosystem auditing; Ecosystem function.

UNIT III

Emerging concepts-Assembly, Stable states; Biotic and abiotic flows and cultural interactions; Application of theory-Invasion, competitive dominance and resource use; IV Restoration planning; Wetland assessment, Delineation, and regulation; Recovery process, Mitigation, Rehabilitation and Reclamation; Dynamics and restoration of degraded wetlands; Removal of threats to the health and integrity of the restored ecosystem.

UNIT IV

Individuals participation in a restoration programme; different human participatory programme; Sustainable cultural practices; constraints and opportunities; Economics of recovery process.

Practical

Collection and segregation of native and non native species from a damaged environment; Making list of historical and cultural interactions; Status of assemblages; calculation of Index of Biotic Integrity; Listing of the threats to the integrity of the ecosystem; Organizing different participatory programme.

Suggested Readings

Jordan WR, Gilpin ME & Aber JD. (Eds.). 1987. *Restoration Ecology: A Synthetic Approach to Ecological Research*. Cambridge University Press.

Luken JO. 1990. *Directing Ecological Succession*. Chapman & Hall.

Perrow MR & Davy AJ. (Eds.). 2002. *Handbook of Ecological Restoration*. Vol. I. *Principles of Restoration*. Cambridge University Press.

SER. 2004. *The SER Primer on Ecological Restoration.* Version 2. Society for Ecological Restoration Science and Policy Working Group.

Temperton VK, Hobbs RJ, Nuttle T & Halle S. (Eds.). 2004. *Assembly Rules and Restoration Ecology: Bridging the Gap Between Theory and Practice*. Island Press.

Van Andel J & Aronson J. (Eds.). 2006. *Restoration Ecology*. Blackwell. Wilson EO. 1988. *Biodiversity*. National Academy. Washington DC.

Young TP. 2000. *Restoration Ecology and Conservation Biology*. Biological Conservation.

FISH PROCESSING TECHNOLOGY

CODE	COURSE TITLE	CREDITS
FPT 501*	TECHNOLOGY OF FREEZING AND STORAGE	2+1
FPT 502*	THERMAL PROCESSING OF FISHERY PRODUCTS	2+1
FPT 503*	QUALITY ASSURANCE, MANAGEMENT AND CERTIFICATION	2+1
FPT 504*	APPLIED FISH BIOCHEMISTRY	2+1
FPT 505	TECHNIQUES IN MICROBIOLOGY	1+1
FPT 506	CURED, DEHYDRATED AND SMOKED FISHERY PRODUCTS	1+1
FPT 507	HANDLING, STORAGE AND TRANSPORT OF FRESH FISH	1+1
FPT 508	TECHNOLOGY OF MINCE-BASED FISH PRODUCTS	1+1
FPT 509	ADDITIVES IN FISH PROCESSING	1+1
FPT 510	FISH BY-PRODUCTS AND WASTE UTILIZATION	1+1
FPT 511	MICROORGANISMS OF PUBLIC HEALTH SIGNIFICANCE	1+1
FPT 512	DESIGN, MAINTENANCE OF FISH PROCESSING PLANTS AND INSTRUMENTATION	1+1
FPT 513	PACKAGING OF FISH AND FISHERY PRODUCTS	1+1
FPT 591	MASTERôS SEMINAR	1+0
FPT 599	MASTERôS RESEARCH	20
FPT 601**	BIOCHEMICAL TECHNIQUES IN FISH ANALYSIS	2+1
FPT 602**	FUNCTIONAL PROPERTIES OF PROTEINS FROM FISH AND SHELLFISH	2+1
FPT 603**	QUALITY MANAGEMENT SYSTEMS	2+1
FPT 604	LIPIDS OF AQUATIC ORIGIN	2+1
FPT 605	MICROBIAL HAZARDS IN FISH PROCESSING	2+1
FPT 606	VITAMINS, MINERALS AND FLAVOUR BEARING COMPONENTS IN AQUATIC ORGANISMS	2+1
FPT 607	TOXINS AND CONTAMINANTS	2+1
FPT 608	NUTRITIONAL ASPECTS AND NUTRITION LABELING	2+1
FPT 609	ENVIRONMENTAL IMPACT OF FISHERY INDUSTRIES	2+1
FPT 610	BY-PRODUCTS, SPECIALTY PRODUCTS AND VALUE ADDED PRODUCTS	2+1
FPT 691	DOCTORAL SEMINAR I	1+0
FPT 692	DOCTORAL SEMINAR II	1+0
FPT 699	DOCTORAL RESEARCH	45

* Compulsory for Masterôs programme; ** Compulsory for Doctoral programme

Course Contents

FPT 501 TECHNOLOGY OF FISH FREEZING AND FROZEN STORAGE 2+1

Objective

To give detailed insight into various aspects of freezing of fish.

To provide understanding on chemical, bacterial and sensory changes during freezing.

Theory

UNIT I

Freezing: Structure of water and ice, Influence of solutes on the structure of water and ice, phase equlibria and freezing curves of pure water and binary solutions, freezing curve for fish. Determination of freezing points from time- temperature plots, calculation of freezing time.

UNIT II

Crystallization, homogeneous and heterogeneous nucleation, super cooling, crystal growth, eutectic point, location of ice crystals in tissue, physical changes during freezing.

UNIT III

Technological aspects of freezing: Slow and rapid freezing, Methods of freezing, comparison of various freezing methods, selection of a freezing method, product processing, packaging and different types of freezers.

UNIT IV

Chemical treatment prior to freezing: antioxidants, cryoprotectants and other additives, theories of cryopreservation, glazing.

UNIT V

Frozen storage: Physical and chemical changes - freezer burn and recrystallisation, different types of recrystallisation.

UNIT VI

Chemical changes in lipids, proteins and nucleotides, freeze denaturation and theories on denaturation, changes in pH, bacterial changes, sensory changes, texture, taste, odour, effect of post-mortem condition on sensory qualities.

UNIT VII

Water holding capacity, time temperature tolerance, temperature and duration of storage on quality and shelf life.

UNIT VIII

Arrangements within a cold storage, handling and stacking systems, space requirement, precautions to reduce temperature increase in a cold storage.

UNIT IX

Filleting of fish, treatments, glazing, packaging and freezing. Processing of prawns, lobster, squid, cuttle fish, crab etc. for freezing.

UNIT X

Different methods of thawing frozen fish, advantages and disadvantages. Recent advances in fish thawing.

Practical

Filleting of fish, treatments, glazing, packaging, freezing, Processing of Prawns, Lobster, Squid, Cuttle Fish, Crab etc. in different styles, Packaging and Freezing, Freezing curve, determination of freezing point. Studies on physical, chemical and sensory changes.

Suggested Readings

Andrew CC. 1990. *Food Refrigeration Processes*. Elsevier.

Balachandran KK. 2001. *Post-harvest Technology of Fish and Fish Products*. Daya Publ. House.

Clucas IJ. 1981. *Fish Handling, Preservation and Processing in the Tropics.* Parts I, II. FAO.

Fennema K, Powrie WD & Marth EH. 1973. *Low Temperature Preservation of Foods and Living Matter*. Marcel Dekker. Gopakumar K. (Ed.). 2002. *Text Book of Fish Processing Technology*.ICAR.

Hall GM. (Ed). 1992. *Fish Processing Technology*. Blackie.

Nambudiri DD. 2006. *Technology of Fishery Products*. Fishing Chimes. Regenssein JM & Regenssein CE. 1991. *Introduction to Fish Technology*. Van Nostrand Reinhold.

Rudolf K. 1969. *Freezing and Irradiation of Fish*. Fishing News (Books). Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ.

FPT 502 THERMAL PROCESSING OF FISHERY PRODUCTS 2+1

Objective

To provide information on various aspects of thermal / heat processing. To compare cold sterilization with thermal processing.

To impart knowledge on various types of packaging techniques and materials used in thermal processing.

Theory

UNIT I

Principles of thermal processing. Mechanism of heat transfer: conduction, convection, radiation and dielectric and microwave heating, unsteady state of transfer, heat resistance of bacteria and spores, decimal reduction time, thermal death time, "Z" and "F" values, 12D concept, heat penetration, cold point, can size, shape, contents etc. on heat penetration, determination of process time. Significance of thermal death curve, graphical, formula, nomogram methods ï F_0 value, cook value, D value, integrated F value and their inter-relationship. Heating equipment.

UNIT II

Classification of foods: low acid, medium acid and acidic foods, absolute sterility, statistical sterility, commercial sterility, pasteurisation and sterilisation.

UNIT III

Canning process, steps involved, process flow, additives, HTST processing and aseptic canning, principles and process details, canning machinery and equipment, canning process for fish/shellfish, value added and ready to use canned products.

UNIT IV

HACCP and Safety of canned foods and unreliability of post process sampling of canned foods to ensure sterilization. Status of a batch of canned foods identifying CCPs and their monitoring by specially trained personnel.

UNIT V

Spoilage of canned food, physical, chemical and microbial, Thermobacteriology, death of bacteria, autosterilisation bacteriology of canned/heat processed fishery products, examination of cans and seams.

UNIT VI

Canning plant location: Practical considerations, canning plant facilities, layout design.

UNIT VII

Flexible packing, retort pouch processing of fish and fishery products principles and techniques. Combination and synergistic effects.

UNIT VIII

Hurdle technology: Combination with heat, heat and hydrostatic pressure, heat and low pH, heat and NaCI and nitrite, combination with ionising radiation, irradiation and hydrostatic pressure, irradiation and NaCI, irradiation and other adjuncts, heat and irradiation, irradiation and low temperature, low pH and specific acids, low a_W and adjuncts like Nisin to reduce severity of heat processing.

UNIT IX

Irradiation: Radiation sources, units, dose levels, radappertization, radicidation, radurization, effects of irradiation on protein, lipids, vitamins, bacteriological aspects, physical properties, shelf life and irradiated fish products.

Practical

Evaluation of pasteurisation and sterilisation, determination of TDT and F value Examination of canned foods, can seams, testing sterility, isolation of Bacillus and *Clostridium* Spp., spore staining, heat penetration curve and cooling curve, canning operations for different fish/shellfish products. Double seam profile, Heat Penetration Curve, F_0 Value, Z value, Process time, Canning of table fishes, Bivavles, Crustaceans in different containers, Operation of over pressure autoclave, Canned culinary preparations, Examination of canned fishery products.

Suggested Readings

Balachandran KK. 2002. *Fish Canning Principles and Practices*. CIFT, Cochin.

Gopakumar K. 2002. *Text Book of Fish Processing Technology*. ICAR. Hall GM. (Ed). 1992. *Fish Processing Technology*. Blackie.

Hersom AC & Hulland ED. 1980. *Canned Foods*. Chemical Publ. Co. Larousse J & Brown BE. 1997. *Food Canning Technology*. Wiley VCH. Nambudiri DD. 2006. *Technology of Fishery Products*. Fishing Chimes. Stumbo. 1973. *Thermo Bacteriology in Food Processing*. CRC, AcademicPress.

Thorne S. 1991. *Food Irradiation*. Elsevier.

Venugopal V. 2006. *Seafood Processing*. Taylor & Francis.

Warne D. 1988. *Manual on Fish Canning*. FAO Fisheries Tech. Paper 285. Zeathen P. 1984. *Thermal Processing and Quality of Foods*. Elsevier.

FPT 503 QUALITY ASSURANCES, MANAGEMENT AND CERTIFICATION 2+1

Objective

To understand various aspects of quality assurance system, quality management and national / international certification system.
To learn factory sanitation and hygiene, water quality and standard

Theory

UNIT I

Quality management, total quality concept and application in fish trade.

UNIT II

Quality assessment of fish and fishery products - physical, chemical, organoleptic and microbiological quality standards.

UNIT III

Inspection and quality assurance: Fish inspection in India, process water quality in fishery industry, product quality.

UNIT IV

Water quality and standards.

UNIT V

Sensory evaluation of fish and fish products, basic aspects, different methods of evaluation, taste panel selection and constitution, statistical analysis.

UNIT VI

HACCP and Good manufacturing practices. HACCP principles, practical aspects of planning and implementation, verification, validation and audit.

UNIT VII

National and International standards: ISO 9000: 2000 series of quality assurance system, *Codex alimentarius,* USFDA and EU regulations for fish export trade, IDP and SAT formations in certification of export worthiness of fish processing units, regulations for fishing vessels, pre-processing and processing plants, EU regulations. ISO 22000:2006.

UNIT VIII

Factory sanitation and hygiene: National and international requirements, SSOP, Sanitary and Phytosanitary measures.

UNIT IX

Food laws in India, integrated food law.

Practical

Evaluation of fish / fishery products for organoleptic, chemical and microbial quality. Methods for analysis for bacterial quality parameters, chemical parameters and filth. Evaluation of sanitary conditions in fish processing units. Analysis of typical hazards. Study of correction and corrective action. SQC: Introduction, statistical principles involved, process control, control charts, variable and attribute control charts, Acceptance sampling, basic ideas, sampling by attributes single and double sampling plants, Basic concepts of decision making. Familiarization with water quality analysis.

Suggested Readings

Anthony TT. 1988. *Handbook of Natural Toxins. Marine Toxins and Venom*. Vol. III. Marcel Dekker.

Balachandran KK. 2001. *Post Harvest Technology of Fish and Fish Products*. Daya Publ. House.

Connell JJ. 1995. *Control of Fish Quality*. Fishing News Books.

Fennema K, Powrie WD & Marth EH. 1973. *Low Temperature Preservation of Foods and Living Matter*. Marcel Dekker**.**

Gopakumar K. (Ed.). 2002. *Text Book of Fish Processing Technology*. ICAR.

Hall GM. (Ed). 1992. *Fish Processing Technology*. Blackie.

Hui YH, Merle DP & Richard GJ. (Eds.). 2001. *Food Borne Disease Handbook. Seafood and Environmental Toxins*. Vol. IV. Marcel Dekker.

Huss HH, Jakobsen M & Liston J. 1991. *Quality Assurance in the Fish Industry*. Elsevier.

John DEV. 1985. *Food Safety and Toxicity*. CRC Press.

Krenzer R. 1971. *Fish Inspection and Quality Control*. Fishing News. Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ. Vincent K & Omachonu JER. 2004. *Principles of Total Quality.* CRC Press.

FPT 504 APPLIED FISH BIOCHEMISTRY 2+1

Objective

To impart knowledge on macro and trace constituents and nutritive value of fish.
To create basic understanding about toxins and toxic substances and their toxic effects.
To give a detailed insight into experimental techniques used in food analysis.

Theory

UNIT I

Seafood proteins: Classification. Sarcoplasmic proteins: Heme proteins, Myoglobin, Hemocyanins, parvalbumins, antifreeze proteins, pigments, enzymes- hydrolases, oxidoreductases, and other enzymes.

UNIT II

Myofibrillar proteins: Myosin ï isolation, sub-unit composition, actin, allergins, tropomyosin, troponins, paramyosin, connectin.

UNIT III

Stroma proteins: Connective tissue in the muscle, collagen in fish muscle and skin: location, characteristics of seafood collagen, collagen on the quality of seafoods, gaping.

UNIT IV

Functional properties of seafood proteins: Solubility, emulsification, viscosity, water holding, stability, gelation, texture profile analysis.

UNIT V

Changes in proteins during processing: Denaturation- At high and low temperatures and kinetics, dissociation / aggregation / coagulation, reversibility, significance to processing and quality. Hydrolysis and hydrolysates: Process and applications, proteinases.

UNIT VI

Post mortem biochemical changes, rigor mortis, K-value, TMAO and its decomposition products, demethylase.

UNIT VII

Non-protein nitrogenous compounds: Free amino acids, peptides, nucleotides, guanidins, urea, quarternary ammonium compounds etc.

UNIT VIII

Seafood lipids: Composition and nutritive value, lipid types and their variations, lipid fractionation, estimation of lipid fractions, triglycerides, phospholipids, non-saponifiables including sterols and vitamins. Polyunsaturated fatty acids and prostaglandins- beneficial effects on human health.

UNIT IX

Fatty acid composition of fish liver and body oils, auto-oxidation of fatty acids, rancidity, lipasas and phospholipases, pro- and anti-oxidants, oxidation indices, lipid-protein interactions, oxidized lipids-protein interactions and their impact on quality.

UNIT X

Macro and trace elements in fish and shellfish; Vitamins and Minerals of nutritional significance, toxic metals and their harmful effects and metallothionines.

UNIT XI

Flavour and pigments; amines, volatile fatty acids, carbonyls, sulphur containing compounds, carotenoids, isoprenoids in fish.

UNIT XII

Biogenic amines, Aflatoxins in cured fish.

UNIT XIII

Principles and methods involved in the separation and analysis of fish muscle constituents: Thin layer, paper and column chromatography, spectrophotometry, colorimetry, flame photometry, atomic absorption spectrophotometry, paper, disc and slab electrophoresis.

Practical

Molarity, normality, acid-base, redox titration, buffers. Lipids ï Fractionation by TLC and other chromatographic techniques. Fatty acid composition by GLC, Amino acid analysis by HPLC. Protein purification methods: (NH4)2SO4/solvent precipitation. Ultracentrifugation, dialysis and ultrafiltration, gel filtration, electrophoresis, PAGE and SDS-PAGE, Marine polysaccharides for food use, molecular biology techniques in fish and bacterial identification, and topical subjects.

Suggested Readings

George MP & Barbec WT. 1990. *Seafood: Effects of Technology and Nutrition*. Marcel Dekker.

Joe MR & Carrie ER. 1984. *Food Protein Chemistry*. Academic Press. Lehninger AL. 1982. *Principle of Biochemistry*. Worth Publ.

Michael ENA. 1990. *Biochemistry of Foods*. Academic Press. Nettleton J. 1985. *Seafood Nutrition*. Van Nojhand Reinhold. Owen RF. 1996. *Food Chemistry*. Marcel Dekker.

Pare JRJ & Belanger JMR. 1997. *Instrumental Methods in Food Analysis*. Elsevier.

Pomeranz Y & Meloan CE. 1994. *Food Analysis Theory and Practice*. AVI Publ.

Rao R. 1980. *Textbook of Biochemistry*. 2nd Ed. Prentice Hall of India.

Regenstein JM & Regenstein CE. 1984. *Food Protein Chemistry*. Academic Press.

Robert GA. 1989. *Marine Biogenic Lipids Fats and Oils.* Vol. II. CRC Press.

Roy EM & George JF. 1990. *The Sea Food Industry*. Van Nostrand Reinhold.

Roy EM, Geroge JF & Donn RW. 1982. *Chemistry and Biochemistry of Marine Food*. Van Nostrand Reinhold.

Shahidi F & Botta JR. 1994. *Seafoods: Chemistry, Processing Technology and Quality*. Blackie.
Smith EL, Hill RL, Lehman IR, Lefkowitz RJ, Handler P & White A. 1983. *The Principles of Biochemistry*. McGraw-Hill.
Stewart KK. (Ed). 1984. *Modern Methods of Food Analysis*. AVI Publ. Suzuki 1981. *Fish and Krill Protein Processing Technology*. Applied Science Publ.
Whitaker JR & Tannenbaum SR. 1977. *Food Proteins*. AVI Publ

FPT 505 TECHNIQUES IN MICROBIOLOGY 1+1

Objective

To learn basic techniques in Microbiology.

Theory

UNIT I

Safety in Microbiology laboratory ï Prevention of contamination, aerosol sampling, disinfection and evaluation of disinfectants.

UNIT II

Microscopy ï bright-field, fluorescence, phase-contrast, dark ground and electron microscope.

UNIT III

Staining techniques ï Types of stains and chemistry of staining.

UNIT IV

Sterilisation ï Principles of various physical and chemical methods of sterilisation.

UNIT V

Nutritional requirements of microorganisms ï constituents of growth media, requirement of fastidious organisms alternate nutrition, different types.

UNIT VI

Isolation, enumeration, preservation and maintenance of cultures - growth curve, different types of cultures, population estimation techniques.

UNIT VII

Routine tests for identification of bacteria - morphological, cultural, biochemical and serological. Anaerobic bacteria - methods of anerobiosis. Basics of mycological and virological techniques. Introduction to molecular techniques in Microbiology.

Practical

Microscopic techniques, isolation, enumeration and identification of microorganisms, serological techniques, anaerobic bacteria, mycological, virological and molecular techniques.

Suggested Readings

Chakraborthy P. 1995. *A Text Book of Microbiology*. New Central Book Agency.
Criusted J. 1986. *Methods in Microbiology*. Academic Press.
Harry WSJR, Paul JV & John JL. 2000. *Microbes in Action*. Freeman & Co. II (ICMSF). Academic Press.
James M. 1978. *Modern Food Microbiology*. 2nd Ed. D. Van Nostrand Co.
Michael J, Pelizar JR & Chan ECS. 1998. *Microbiology.* McGraw Hill. Paul JH. 2001. *Marine Microbiology- Methods in Microbiology*. Vol.XXX. Academic Press.
Samuel CP & Dunn CG. 1959. *Industrial Microbiology*. McGraw Hill. Silliker JH, Elliof RP, Baired AC & Boyan FL. 1980. *Microbial Ecology of Foods*. Vol.II. (ICMSF). Academic Press.
William CF & Dennis CW. 2000. *Food Microbiology*. McGraw Hill.

FPT 506 CURED, DEHYDRATED, SMOKED FISHERY PRODUCTS 1+1

Objective

To create understanding on various scientific preservation techniques of fish.
To impart knowledge on changes during storage of products.

Theory

UNIT I

Free and bound water in foods, water activity and sorption behaviours of foods, storage characteristics, microbial spoilage, effects of water activity on chemical deterioration, enzymatic reaction, non-enzymatic browning, lipid oxidation, reaction between lipids and proteins, dry fish, control of micro-organisms.

UNIT II

Principles of drying and dehydration: Psychometrics, drying calculation, constant rate and falling rate, drying time in air, moisture transport mechanism, natural drying, solar drying and mechanical drying. Different types of dryers: tunnel drier, vacuum drier, drum drier, solar drier etc.

UNIT III

Freeze drying, preparation and its nutritive value.

UNIT IV
Dehydration of fish products: dehydration ratio, precautions to be taken in fish drying; denaturation of fish protein.
UNIT V
Cured fish, types of salt curing, use of salt, factors affecting salt uptake by fish, lean and fatty fish, whole, gutted or split open, type and size of salt crystals, source of salts and impurities in salts, effect of impurities on salt penetration, temperature of salting.
UNIT VI
Spoilage of dried / cured fish, physical, chemical and microbiological changes, methods to prevent / control spoilage, extension of shelf life.
UNIT VII
Fermented products: different methods of fermentation, indigenous products and their principles of preservation.
UNIT VIII
Smoke curing, chemistry of smoke, composition and properties, smoking methods: cold and hot method, use of smoke liquids, production of smoke, type of wood used, methods of smoke generation, carcinogens in smoke, smoke kilns.
UNIT IX
Marinades: Principles; processing of cold, cooked and fried marinades, shelf life and spoilage.
UNIT X
Fish and shellfish pickles: production, shelf life.
UNIT XI
Packaging requirements for dry, cured and fermented products.

Practical

Preparation of dried, cured and fermented fish products, examination of salt, protein, moisture in dried / cured products, examination of spoilage of dried / cured fish products, marinades, pickles, sauce.

Suggested Readings

Gopakumar K. 2002. *Text Book of Fish Processing Technology*. ICAR. Hall GM. 1992. *Fish Processing Technology*. Blackie.
Hui YH, Merle DP & Richard JG. 2001. *Food Borne Disease Handbook. Seafood and Environmental Toxins*. Vol.IV. Marcel Dekker.
Oefjen G, Wilhelm H & Peter. 2004. *Freeze Drying*. Wiley-VCH GmbH & Co.
Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ. Wheaton FW & Lawson TB. 1985. *Processing Aquatic Food Products*. John Wiley & Sons.

FPT 507 HANDLING, STORAGE AND TRANSPORT OF FRESH FISH 1+1

Objective

To teach scientific techniques of handling, storage and transport of fresh fish.
To teach various post harvest changes during chill storage of fish.

Theory

UNIT I
Structure of fish myosystems, Postmortem changes - Structural and chemical.
UNIT II
Fish as raw material for processing: Body structure, physical properties, shape, specific weight, bulk weight, angle of slip, weight composition.
UNIT III
Factors affecting quality of fresh fish: intrinsic and extrinsic factors.
UNIT IV
Handling of fish onboard fishing vessels, Unit operations.
UNIT V
Unloading fish, Fish pumps.
UNIT VI
Post-harvest Fishery losses, Methods to reduce losses.
UNIT VII
Handling of fish in landing centers, defects and modifications needed.
UNIT VIII
Chill storage of fish: Heat load calculation, storage methods. insulated boxes and insulation thickness, different types of ice, physical, chemical, microbiological and sensory changes during chill storage, iced storage shelf life, cold shock, physical, chemical and sensory methods of analysis.
UNIT IX
Different types of ice and their advantages.

UNIT X

Sous-vide technology.

UNIT XI

Melanosis and its prevention, discolouration in aquatic products, non- enzymatic browning.

UNIT XII

Depuration of bivalves.

UNIT XIII

Transportation: Live fish/shell fish, Transportation of raw fish to local markets and processing centres, Improvements needed in transportation, Refrigerated transport systems, Classification of transport vehicles, Cold chain.

Practical

Chill storage studies: Chemical, physical and sensory analysis, determination of shelf life. Handling of fish, bivalves, prawns, mollusks, Depuration, treatment with chemicals, evaluation of freshness of fish.

Suggested Readings

Aitken A, Mackie M, Merritt SH & Windsor ML. 1982. *Fish Handling and Processing*. Ministry of Agriculture, Fisheries and Food, Edinburgh.

Anon. 1965. *Fish Handling and Preservation*. Proc. Meeting on Fish Technlogy, Scheveningen. Organisation for Economic Co-operation and Development, Paris.

Balachandran KK. 2001. *Post Harvest Technology of Fish and Fish Products*. Daya Publ.

Connell JJ. 1980. *Advances in Fish Sciences and Technology*. Farnhan Surrey.

Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ.

FPT 508 TECHNOLOGY OF MINCE BASED FISH PRODUCTS 1+1

Objective

To provide knowledge on basic principles and advanced technologies in processing of mince based fish products.

Theory

UNIT I

Composition of muscle proteins in fish and their role in emulsification and elasticity formation.

UNIT II

Factors influencing denaturation of muscle proteins and their theories. Methods to testing protein denaturation.

UNIT III

Factors influencing elasticity formation and theories of gel formation. Minced meat preparation from different varieties of fresh water and marine water fishes.

UNIT IV

Improvement of colour of meat using bleaching and certain additives. Use of anti-denaturants to prevent denaturation of proteins of fish mince during storage. Changes in meat during mincing and mixing operations and cooking and setting phenomena.

UNIT V

Technology of processing and preservation of gel forming fish flour (AFPP), its property and utilisation. Unit operations in analog product preparation- Crab sticks analogs, moulded lobsters and crabs.

UNIT VI

Battered and breaded products: different types and their preparation, nutritional and economic significance of products.

UNIT VII

Use of emulsifiers, binders, seasonings, spices, antioxidants, smoke extract, Preservatives, natural and artificial casings, nitrites and nitrates. Fortification of fish products with vitamins and minerals. Quality standards and recent developments.

Practical

Measurement of viscosity of fish proteins by Ostwald viscometer, effect of water washing on the quality of meat, colour fixation of red colour meat

and estimation of nitrite. Studies on setting of fish meat. Estimation of starch in the final paste product. Fundamentals of controlled stress Rheometer. Effect of two stage heating of fish sol on gel strength.

Suggested Readings

Balachandran KK. 2001. *Post Harvest Technology of Fish and Fish Products*. Daya Publ.

Bligh EG. 1992. *Seafood Science and Technology*. Fishing News Book. Lanier TC & Lee C. 1992. *Surimi Based Product Technology*. Marcel Dekker.

Matsumato JJ. 1980. *Chemical Deterioration of Proteins*. American Chemical Society,

Washington.
Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ. Suzuki. 1981. *Fish and Krill Protein Processing Technology*. Applied Science Publ.

FPT 509 ADDITIVES IN FISH PROCESSING 1+1

Objective

To familiarize with the use of different additives, their effects, levels and detection.

Theory

UNIT I

Introduction to food additives-definition-technical benefits of food additives-intentional and incidental additives.

UNIT II

Relationship of great revolutions in history to the development of food additives ï Agricultural Revolution-Industrial revolutions ï urbanization.

UNIT III

Intentional additives ï use of specific nutrients as food additives ï Requirements and considerations. Minerals, vitamins, amino acids and nutrient concentrates as additives, Incidental additives.

UNIT IV

Policy considerations in the use of food additives. Flavours and colour as additives.

UNIT V

Antioxidants ï Mechanism of antioxidants; commercial antioxidants and selections.

UNIT VI

Analytical methods for antioxidants.

UNIT VII

Acidulants in food processing; Sequestrants in food processing; Polyphosphates in fish processing.

Practical

Determination of food additives such as preservatives, antioxidants, curing agents, chelating agents, acidulants and phosphates in various food products. Detection of certain intentional and unintentional food additives in foods.

Suggested Readings

Branen AL, Davidson PM & Salmiven S. 1990. *Food Additives*. Marcel Dekker.
Middle KRD & Shubik P. 1989. *International Food Regulation Handbook*. Marcel Dekker.

Rahman MS. 2007. *Handbook of Food Preservation*. 2nd Ed. CRC Press. Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ.
Wheaton FW & Lawson TB. 1985. *Processing Aquatic Food Products*. John Wiley & Sons.

FPT 510 FISH BY-PRODUCTS AND UTILIZATION OF FISHERY WASTE 1+1

Objective

To provide information on various fish by-products, utilization of fishery wastes and their nutritional value.

Theory

UNIT I

Fish meal: Production - dry and wet process, machinery, control of quality of products, specifications, packaging and storage.

UNIT II

Fish body and liver oils: Extraction, purification, preservation and storage, industrial and nutritional applications of fish oils. Vitamin A and D.

UNIT III

Essential fatty acid functions of fish oils, poly-unsaturated fatty acid (PUFA), production of concentrates of polyunsaturated fatty acids, preparation of fatty alcohol and amides.

UNIT IV

Utilisation of shark: Processing of shark meat, removal of urea in meat, filleting, curing and dehydration, extraction of shark liver oil, Vitamin A, D, squalene, ambergris, curing and tanning of shark skin, shark cartilage.

UNIT V

Shrimp waste, crab shell and squilla utilisation: Resources and composition, conventional uses, feeds and manure, conversion to useful materials like chitin, chitosan, glucosamine hydrochloride, shrimp extract, commercial production, production and use of protein isolates from squilla and shrimp waste.

UNIT VI

Fish protein concentrate: Different methods of production, functional properties, different types of FPC,

texturised products and comparison of FPC to fish meal.

UNIT VII

Fish silage: Acid silage and fermented silage, advantages over fish meal, nutritional value of silage.

UNIT VIII

Fish hydrolysates: Production and utilisation, biochemical composition and importance in food and nutrition.

UNIT IX

Miscellaneous by-products: Fish maws and isinglass, pearl essence, fertilizer, beche-de-mer, processing of snail meat and jelly fish.

Practical

Preparation of fish meal, FPC, fish oils, chitin, chitosan, glucosamine hydrochloride, fish maws, isinglass, agar, alginic acid, , glue, pearl essence,
fish sauce.

Suggested Readings

Balachandran KK. 2001. *Post Harvest Technology of Fish and Fish Products*. Daya Publ.
Gopakumar K. (Ed.). 2002. *Text Book of Fish Processing Technology*. ICAR.
Hall GM. (Ed.). 1992. *Fish Processing Technology*. Blackie.
Nambudiri DD. 2006. *Technology of Fishery Products*. Fishing Chimes. Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ. Wheaton FW & Lawson TB. 1985. *Processing Aquatic Food Products*. John Wiley & Sons.
Windsor M & Barlow. 1981. *Introduction to Fishery Byproducts*. Fishing News (Books).

FPT 511 MICROORGANISMS OF PUBLIC HEALTH SIGNIFICANCE 1+1

Objective

To acquaint students regarding bacteria, virus and parasites; food-borne diseases and their prevention.

Theory

UNIT I

Infection and immunity; diseases and their classification, spreading and contamination, host resistance.

UNIT II

Bacteria of public health significance in fish/fishery products/environments- *Salmonella, Clostridia, Staphylococcus, E. coli*, *Streptococcus, Vibrio, Aeromonas, Listeria, Yersinia, Bacillus*. Laboratory techniques for detection and identification of food poisoning bacteria.

UNIT III

Food-borne bacterial infections. Food infections by *Salmonella, Clostridium perfringens, Vibrio parahaemoliticus*, Enteropathogenic *E. coli*, *Aeromonas hydrophila* etc., the nature of causative agent, its source, incidence, foods involved, the diseases, conditions for outbreak and prevention. The etiology of diseases: Conditions for outbreak and prevention.

UNIT IV

Botulism and staphylococcal food poisoning, organism responsible and their origin, growth and toxin production, nature of toxins, incidence of poisoning, foods involved.

UNIT V

Food borne non-bacterial infections and intoxications: Aflatoxins, patulin, ochratoxin and other fungal toxins found in food, toxin producer, source, nature of toxin, toxicity and significance in foods.

UNIT VI

Virus and Parasites found in foods.

Practical

Laboratory techniques to detect and identify pathogens in fish - *E.coli, Staphylococcus aureus, Streptococus faecalis, Clostridium perfrigens, Clostridium botulinum, Salmonella, Listeria, Vibrio cholera, Vibrio parabaemolyticus, V. vulnificus*, Animal bio-assay of bacterial toxins.

Suggested Readings

Anon. 2001. *Food Borne Disease Handbook*. 2nd Ed. Vol. IV. *Seafood and Environmental Toxins*. Marcel Dekker.
Davis BD, Dulbecco R, Eiser HN & Ginsberg HS. 1980. *Microbiology.* Harpar & Row.
Doyle MP, Beuchat LR & Montville TJ. 1997. *Food Microbiology - Fundamentals and Frontiers.* American Society for Microbiology.
Harry WSJR, Paul JV & John JL. 2000. *Microbes in Action*. Freeman & Co.
Michael J, Pelizar JR & Chan ECS. 1998. *Microbiology*. McGraw Hill.
Samuel CP & Dunn CG. 1959. *Industrial Microbiology*. McGraw Hill.
Silliker JH, Elliof RP, Baired AC & Boyan FL. 1980. *Microbial Ecology of Foods*. Vol. II. (ICMSF). Academic Press.

William CF & Dennis CW. 2000. *Food Microbiology*. McGraw Hill.

FPT 512 DESIGN, MAINTENANCE OF FISH PROCESSING PLANTS AND INSTRUMENTATION 1+1

Objective

To expose the students to design, maintenance of fish processing plant, machinery and the instruments used in fish processing plants.

Theory

UNIT I

Plant design: Fundamentals of processing plant design: Site selection, design and preparation of layout of processing plants - freezing plant, cold storage, canning plant, dryers etc.

UNIT II

Functions and construction of refrigeration system: Tests and inspection, Operation and handling, P-H diagram and basic calculation - Application of P-H diagram, size and required power of compressor, maintenance of refrigerating machine, troubles and causes.

UNIT III

Preventive maintenance of machinery and equipment of fish processing plants, IQF, Canning plant, sausage plant, artificial dryers, smoking chambers etc., safety controls for freezing and canning plant.

UNIT IV

Effluent treatment: Legislation and standards of effluent discharge, water pollution control measures in the food industry, waste water treatment process; dissolved air floatation, sedimentation, chemical treatment, biological treatment, aeration, carbon adsorption, granular media filtration and sludge handling. Boilers - Classification and selection of boilers, Boiler mounting and accessories.

UNIT V

Measurement techniques**;** Sensors, active and passive sensors, characteristic of sensors for the measurement of temperature, relative humidity, a_W value, gel strength, moisture, freshness, pH, conductivity, DO, redox potential, salinity, air velocity, solar energy and brine concentration.

UNIT VI

Thermometers: Different types of thermometers, characteristics and application.

UNIT VII

Instrumentation techniques: General configuration of instrumentation system. Instrumentation for measurement of a_W value, temperature, pH, freshness, gel strength, salinity, brine concentration.

UNIT VIII

Thermal properties of foods: Calorie, heat loss, heat gain, specific heat, Newton's laws of cooling, heat transfer, latent heat, laws of fusion, thermal conductors, thermal diffusivity.

Practical

Design and Maintenance of Fish Processing Plants; Operation and maintenance of machinery and equipment for cold storage plant, freezing plant, canning plant, sausage making, dryers, boilers etc. Assembly of a refrigeration unit and charging refrigerant. Instrumentation; Measurement of temperature inside cold storage / freezer, fish during freezing and thawing. Estimation of Gel strength. Measurement of solar radiation, air velocity, air temperature. Measurement of salinity, conductivity, pH. Estimation of water activity.

Suggested Readings

Chupakhim V & Dormenko V. 1985. *Fish Processing Equipments*. MIR Publ.
Heid JL & Joslyn MA. 1980. *Food Processing Operations*. AVI Publ.
Slade FH. 1997. *Food Processing Plants*. Leonard Hill.
Wheaton FW & Lawson TB. 1985. *Processing Aquatic Food Products*. John Wiley & Sons.

FPT 513 PACKAGING OF FISH AND FISHERY PRODUCTS 1+1

Objective

To learn about different packaging materials, their appropriate use and benefits.

Theory

UNIT I

Food packaging, its purposes and procedures; technological aspects of packaging fishery products; packing of fresh and frozen fish for consumers; packaging for transport, shipping and institutional supplies; packaging standards for domestic and international trade.

UNIT II

Packaging materials; basic films and laminates, their manufacture and identification; resistance of packaging materials; development of protective packaging for fishery products.

UNIT III

Methods of testing for packaging materials for their physical properties; containers and their testing and

evaluation; package designs; resistance of packages to hazards in handling; transport and storage.

UNIT IV

Modified atmosphere packaging, controlled packaging and aseptic packaging.

UNIT V

Labelling and printing of packaging materials.

Practical

Assessment of quality parameters such as moisture permeability, grease resistance, thickness/guage of basic plastic films and laminates. Quality assessment of paper and board and the products prepared from them. Evaluation of packages with regard to the resistance to handling, transportation and storage.

Suggested Readings

Balachandran KK. 2001. *Post Harvest Technology of Fish and Fish Products*. Daya Publ.

Gopakumar K. 1993. *Fish Packaging Technology - Materials and Methods*. Concept Publ.

FPT 601 BIOCHEMICAL TECHNIQUES IN FISH ANALYSIS 2+1

Objective

To provide knowledge on various biochemical techniques in fish analysis.

Theory

UNIT I

General principles of separation of micro and macro molecules, selection of appropriate tools for analysis of fish samples. Outlines of common techniques involved in biochemical analysis.

UNIT II

Centrifugation techniques: types of centrifugation, concept of Svedberg unit, analytical ultracentrifuge.

UNIT III

Filtration technique: different types of filtration, types of filters and means of using them.

UNIT IV

Spectroscopic techniques: Principles, UV, Visible and IR spectroscopy, spectro-fluorimetry, flame photometry, atomic absorption spectrophotometry, ICP- AES, mass spectrometer.

UNIT V

Electrophoretic techniques: General principles, Classification, Paper electrophoresis, Native and reduced PAGE, IEF, capillary electrophoresis, 2D Gel electrophoresis.

UNIT VI

Chromatographic Techniques: General principles, types of chromatography- adsorption, partition, ion-exchange, molecular sieve, affinity, gas chromatography, thin layer chromatography.

UNIT VII

Gas chromatography: Theory and instrumentation.

UNIT VIII

High performance Liquid chromatography, LC MS-MS: Theory and instrumentation.

Practical

Isolation of proteins: sarcoplasmic, myofibrillar, and stromal. Estimation of proteins: Biuret, Lowry and Dye binding technique. Amino acid analysis, non-protein nitrogen. Extraction and estimation of lipids: Measurement of oxidation and hydrolysis of lipids, Fatty acid profile. Minerals and heavy metals: Estimation by Atomic Absorption Spectroscopy and flame photometer. HPLC- determination of histamine Demonstration of GC-MS-MS, Separation of protein by electrophoresis.

Suggested Readings

Ewing GW. 1997. *Analytical Instrumentation Handbook*. Marcel Dekker. Jean IJ & Ikim WJ. 1995. *Analysis of Food for Nutrition Labeling and Hazard Contaminants*. Marcel Dekker.

Lampman P & Saunder K. 1979. *Introductive Spectroscopy*. College Publ.

Larsen BS & McEwen CN. 1988. *Mass Spectrometry of Biological Materials*. Marcel Dekker.

Pare JRJ & Belanger JMR. 1997. *Instrumental Methods in Food Analysis*. Elsevier.

Peary JA. 1981. *Introduction to Analytical Gas Chromatography*. Marcel Dekker.

Robyt JF & White BJ. 1990. *Biochemical Techniques - Theory and Practice*. Waveland Press.

Wilson K & Walker J. 2000. *Practical Biochemistry - Principles and Techniques*. Cambridge University Press.

Wilson RH. 1994. *Spectroscopic Techniques for Food Analysis*. VCH Publ.

FPT 602 FUNCTIONAL PROPERTIES OF PROTEINS FROM FISH AND SHELLFISH 2+1

Objective

To provide knowledge on those biochemical properties known to affect product property.

Theory

UNIT I

Definition of functional properties and their importance in proteins from fish. Typical functional properties of proteins in food system.

UNIT II

Protein structure and function: Protein folding and non-covalent forces stabilizing protein structure with special reference to hydrophobic interactions. Free energy and entropy concept in relation to hydrophobic interaction. Surface hydrophobicity and its relation to functional properties. Estimation of surface hydrophobicity and total hydrophobicity.

UNIT III

Solubility and water sorption of proteins: Factors affecting protein hydration. Viscosity in relation to protein hydration: Methods of estimating viscosity.

UNIT IV

Gelation: Definition of gel, mechanism of formation of gel, factors affecting the gel formation. Evaluation of gelling capacity- thermal, rheological and microscopy.

UNIT V

Surfactant properties: emulsifying and foaming. Importance of emulsifying properties of proteins. Theoretical concept of emulsion capacity and stability. Interfacial properties, adsorption from solution. Methods of estimating surface tension.

UNIT VI

Emulsion instability: Creaming, sedimentation, aggregation vs Brownian aggregation. DLVO theory, microemulsions. Methods for estimation of emulsion capacity and stability.

UNIT VII

Macromoleculear absorption and different stages of foaming. Foam stability in relation to proteins structure. Foaming ability of different protein systems with case studies.

UNIT VIII

Denaturation and functionality: Changes in functional properties of proteins as affected by icing, freezing, drying, salting and heating. Modification of proteins for improving functionality- Succinylation and acetylation procedures.

Practical

Evaluation of different functional properties like water absorption, fat absorption,, gelling, emulsification capacity and stability of fish/shell fish proteins. Effect of pH, temperature and ionic strength on various functional properties. Prediction of functional properties using model compounds.

Suggested Readings

Cherry JP. 1991. *Protein Functionality in Foods*. American Chemical Society. Washington. D. C.

Damodaran S & Paraf A. 1997. *Food Proteins and Their Applications*. Marcel Dekker.

Hill SE, Ledward DA & Mitchell JR. 1998. *Functional Properties of Food Macromolecules*. 2nd Ed. Aspen Publ.

Nakai S & Modler HW. 1996. *Food Proteins Properties and Characterisation*. VCH Publ.

Phillips LG, Whitehead DM & Kinsella J. 1994. *Structure, Function Properties of Food Proteins*. Academic Press.

Suzuki. 1981. *Fish and Krill Protein Processing Technology*. Applied Science Publ.

Venugopal V. 2006. *Seafood Processing*. Taylor & Francis.

FPT 603 QUALITY MANAGEMENT SYSTEMS 2+1

Objective

To familiarize students with different aspects of quality management systems and evaluation techniques for seafood.

To teach Seafood Quality Assurance and Quality Assurance Systems.

Theory

UNIT I

Quality Management Systems: The concept of total quality management. The principles of TQM. Zero defect planning, Quality circle, Quality link, Quality culture. Statistical Quality Control. Quality as related to preprocess handling, transportation, processing and storage.

UNIT II

Quality evaluation techniques for seafood: Physical, chemical. Bacteriological and Instrumental methods of quality evaluation. Sensory evaluation.

UNIT III

Quality standards: National and International ï Codex, USFDA, EU norms, ISO, BIS etc. standards for fish and fishery products.

UNIT IV

Seafood Quality Assurance and Quality Assurance Systems: Good Manufacturing (GMP) and Good Hygiene Practices (GHP) - Codex guidelines. The concept of HACCP in seafood safety. HACCP team

Management role and CCPs and implementation procedure for HACCP- ISO 22000 FSMS. ISO 9000 series of standards. Cold schedule and hotschedule for handling perishable commodities.

UNIT V

Validation of methods for quality assurance- Method selection, Quality check, inter-lab comparision, proficiency testing. Primary standards. Reference standards. Reference material (RM), Certified Reference Material (CRM) and Standard Reference Material (SRM), Uncertainty and Calculation of Uncertainty of Measurements.

UNIT VI

Sample Accountability: Sampling plan -probability sampling and non- probability sampling.

Practical

Developing flow charts and exercises in identification of hazards- preparation of hazard analysis worksheet, plan form and corrective action procedures in processing of fish. Analysis of typical hazards, study of correction and corrective action. Detection and estimation of important toxic chemicals in food, quality defects.

Suggested Readings

Anon. 1992. *TQM in New Product Manufacturing*. McGraw Hill. Anon. 1994. *Introduction of Total Quality*. Prentice Hall.

Anon. 1994. *Principles of Total Quality*. St. Leuie Press.

Gorbutt J. 1997. *Essentials of Food Microbiology*. Arnold Hodder Headline Group.

Huss HH. 2003. *Assessment and Management of Seafood Safety and Quality*. FAO Tech. Paper No. 444.

Kanduri L & Eckhartt RA. 2002. *Food Safety in Shrimp Processing*. Fishing News Books.

Kreuzer R. 1971. *Fish Inspection and Quality Control*. Fishing News Books.

Shukla RK. 2006. *Total Quality Management Practicing Manager*. New Royal Book.

FPT 604 LIPIDS OF AQUATIC ORIGIN 2+1

Objective

To impart knowledge on aquatic originated lipids, their metabolic activities and biological significance.

Theory

UNIT I

Lipid classification: Triglycerides, phospholipids, steroids and other lipids. Lipid micelles and bilayer.

UNIT II

Fatty acids: Classification, stereochemistry, nutritional significance of fatty acids.

UNIT III

Source of lipids: Biosynthesis of lipids, lipid metabolism including that of phospholipids, typical properties of marine lipids.

UNIT IV

Lipids in Biological membranes: Membrane proteins, lipoproteins, transport across membranes.

UNIT V

Lipid metabolism: Fatty acid oxidation, ketone bodies, lipid biosynthesis, regulation of cholesterol metabolism. Biological significance of marine lipids. Ether lipids and Eicosanoids- their significance.

UNIT VI

Modern analytical techniques employed in lipid chemistry. Methods of extracting poly-unsaturated fatty acids.

Practical

Extraction and fractionation of lipids. Fatty acid composition of different lipid fractions. Evaluation of oxidation product of fish lipid during processing and storage.

Suggested Readings

Akoh CC & Min DB. 1998. *Food Lipids*. Marcel Dekker.

Gurr MI, Harwood JL & Frayn KN. 2002. *Lipid Biochemistry*. 5th Ed. Blackwell.

Jnsel P, Turna RE & Ross D. 2001. *Nutrition*. Jones & Bartlet.

Simpson DS. 1987. *Food Biochemistry and Nutritional Value*. Longman.

Voet D, Voet JG & Praff CD. 1998. *Fundamentals of Biochemistry*. JohnWiley.

FPT 605 MICROBIAL HAZARDS IN FISH PROCESSING 2+1

Objective

To provide theoretical and practical knowledge on various microbiological related hazards in fish processing.

Theory

UNIT I

Public health microbiology- Food borne pathogens: *Salmonella, Shigella,* Entero-pathogenic *E. coli,*

Clostridium botulinum, Listeria monocytogenes, Staph aureus and *Vibrio cholerae, V. parahemolyticus*. Emerging food- borne pathogens. Water- borne, Air-borne and food-borne diseases.

UNIT II

Microbial virulence- infectious diseases. Virulence.

UNIT III

Microbial toxin production-opportunists and true pathogens.

UNIT IV

Methods for detection: Rapid detection and indirect detection methods of pathogens and parasites. Method validation.

UNIT V

Antimicrobial systems and food preservation: ecological concepts: Lactoperoxidase. Nisin, Lysozyme, Bacteriocins.

UNIT VI

Norms for using antimicrobial systems in food processing and preservation. Food Safety, Risk analysis. Potential health hazards and risks associated with fish products.

UNIT VII

Packaging and modified atmosphere on the microbiology and shelf life of fishery products.

UNIT VIII

Predictive modeling in quality and safety assurance of fishery products.

Practical

Antibiotic assay, sensitivity tests, evaluation of antibacterial properties. Analysis of fish product constituents. MIC, MCC, Risk analysis of seafood.

Suggested Readings

Cary JW, Linz JE & Bhatnagar D. 2000. *Microbial Food Borne Diseases*. Technomic Publ.

Doyle MP, Beuchat LR & Montville TJ. 1997. *Food Microbiology - Fundamentals and Frontiers*. American Society for Microbiology.

FPT 606 VITAMINS, MINERALS AND FLAVOUR BEARING CONSTITUENTS OF AQUATIC ORGANISMS 2+1

Objective

To study the compounds responsible for flavor and colour of fish and shellfish.

Theory

UNIT I

Vitamins, minerals, pigments, flavour bearing constituents and other components in aquatic organisms

UNIT II

Vitamins: Metabolic functions of vitamins, water-soluble and fat-soluble vitamins. Vitamins from sea food.

UNIT III

Minerals: Role of trace elements in metabolism, trace elements of seafood, toxic heavy metals in seafood.

UNIT IV

Pigments and flavour bearing compounds of aquatic origin, chemistry, biochemical role, changes during processing of seafood.

UNIT V

Metabolic functions of hormones.

UNIT VI

Nucleoprotein, nucleic acids, nucleotides, nucleosides.

Practical

Modern methods for analysis of vitamins, minerals and nucleic acids. Organoleptic evaluation of flavours and pigments. Extraction of flavours and pigments and evaluation.

Suggested Readings

Ashrust PR. 1999. *Food Flavourings*. 3rd Ed. Aspen Publ.

Belitz HD & Grosch W. 1999. *Food Chemistry*. 2nd Ed. Springer. Hutching JB. 1999. *Food Colour and Appearance*. 2nd Ed. Aspen Publ. Teranishi R, Buttery RG & Shahidi F. 1989. *Flavour Chemistry - Trends and Developments*. American Chemical Society, Washington, D. C.

FPT 607 TOXINS AND CONTAMINANTS 2+1

Objective

To understand various types of toxins and contaminants and their tolerance limit.

To understand various analytical methods to estimate toxins and contaminants.

Theory

UNIT I

Public health problems due to food borne contaminants.

UNIT II

Factors contributing to outbreaks of food poisoning.

UNIT III

Aflatoxins in fishery products. PAH in smoked fish. Biogenic amines and its significance to human health, Different types of marine bio-toxins such as Ciguatoxin, Paralytic shellfish toxins diarrhetic shell fish toxins, DSP toxins, Scomberotoxins, Brevitoxins, etc. Symptoms, treatment, pharmacology, detection.

UNIT IV

Overview of toxicity of marine animals.

UNIT V

Analytical methods for different types of marine toxins and its tolerance limits: Stability, bioassays, pharmacology assays, immunoassays, Instrumental methods.

UNIT VI

Contaminants of the aquatic environment - Heavy metals (Hg, Cd, Pb, Cr, Ni, As etc.).

UNIT VII

Pesticide contaminants: PCB, organochlorine etc., their source, bioaccumulation, magnification and toxicity. Persistent pollutants. Toxicity evaluation. Measurement of LC_{50} and factors affecting LC_{50}, Animal tissue analysis.

Practical

Analysis of bacterial and fungal toxins, Analysis of heavy metals and common pesticides. Biogenic amine estimation, Estimation of LC 50.

Suggested Readings

Anon. 1988. *Handbook of Natural Toxins.* Vol. III. *Marine Toxins and Venom*. Marcel Dekker.

Anon. 1988. *Handbook of Natural Toxins*. Vol. IV. *Bacterial Toxins*. Marcel Dekker.

Anon. 2001. *Food borne Disease Handbook*. 2nd Ed. Vol. IV. *Seafood and Environmental Toxins*. Marcel Dekker.

Edward PR. 1984. *Seafood Toxins*. American Chemical Society, Washington, D.C.

Hashimoto Y. 1979. *Marine Toxins and Other Bioactive Marine Metabolites*. Scientific Society Press, Tokyo.

Moss J, Iglewski B, Vaughan M & Ju AT. 1995. *Bacterial Toxins and Virulence Factors in Disease*. Vol. VIII. Marcel Dekker.

FPT 608 NUTRITIONAL ASPECTS AND NUTRITION LABELING 2+1

Objective

To create basic understanding about labeling of different products, guidelines and enforcement.

Theory

UNIT I

Labeling requirements - national and international, legislation on labeling.

UNIT II

Labeling for product traceability.

UNIT III

Components of traceability code ï nutrition facts and nutrition labeling, specific requirements of nutrition labeling, food meant for specific age groups and convalescing people.

UNIT IV

Serving size, calculation of nutrition facts based on nutrient composition and serving size.

UNIT V

Type of labeling for organic foods, specific foods like organic foods, GM foods, irradiated foods, vegetarian and non-vegetarian foods.

UNIT VI

Label design specification ï size, colour.

UNIT VII

Major nutrients Minor nutrients, Essential nutrients, Function (or note) of nutrients - (providing energy, tissue building) Nutritional research - Nutritional aspects of fish proteins, lipids, vitamins and free minerals Functional foods/ Neutraceuticals for health, Effect of food processing on nutritive values of foods. Antinutritional factors, Nutrition labeling, (Energy value of foods).

Practical

Analysis of major and minor nutrients, calculation of nutrition facts, preparation of labels for typical food items. Analysis for total calorie, calorific value of fats, protein and carbohydrates. PER, BV, NPU analysis of different products.

Suggested Readings

Jnsel P, Turna RE & Ross D. 2001. *Nutrition.* Jones & Bartlet.
Seshadri V. 1998. *Introduction to Clinical Nutrition and Nutritional Labelling*. Marcel Dekker.
Simpson DS. 1987. *Food Biochemistry and Nutritional Value.* Longman.

FPT 609 ENVIRONMENTAL IMPACTS OF FISHERIES INDUSTRIES 2+1

Objective

To provide theoretical and practical exposure on Environmental Management Systems in fisheries industry.

Theory

UNIT I

Environmental Management Systems: Environmental issues, (Ozone depletion, global warming etc.) pollution, long term ecosystem degradation etc in aquaculture and processing industries.

UNIT II

Environmental impact assessment studies of fisheries industry and control measures, Sources of environmental concerns (physical, chemical and microbiological).

UNIT III

Techniques for the identification of environmental aspects. IS/ISO 14000 and its relevance to Environmental Management System in fisheries industry: Background, policy and planning, implementation, checking and review, International and European Laws for Environmental Protection, National Environmental Laws.

Practical

Composition analysis of fish processing waste, analysis of pollution aspects of solid and liquid wastes ï bacterial load, TDS, BOD, COD, pH, temperature, oil and grease . Resident time analysis for processing waste at the site of disposal.

Suggested Readings

Anon. 2000. *Manual of Chemical Methods*. 2nd Ed. Bureau of Indian Standards: IS/ISO 14000:1996 on Environmental Management System US-EPA.
Cesceri LS. 1998. *Standard Methods for Examination of Water and Waste Water*. APHA.
Hurst CJ. 2002. *Manual of Environmental Microbiology*. 2nd Ed. ASM Press.
Wise DL. 1994. *Process Engineering for Pollution Control and Waste Minimization*. Marcel Dekker.

FPT 610 FISHERY BY-PRODUCTS, SPECIALTY PRODUCTS AND VALUE ADDED PRODUCTS 2+1

Objective

To explain the preparation of products from low cost fish.

Theory

UNIT I

Nutritional importance of fish meal and quality requirements -Raw material quality and changes during processing and storage.

UNIT II

Nutritional importance of fish oil and methods to impart stability to fish oils on storage, Unsaponifiables in fish liver oils.

UNIT III

Production of fish flour, quality standards and applications.

UNIT IV

Different methods of production of FPC, Different types of FPC, and their specifications.

UNIT V

Enzyme hydrolysis of fish, fish hydrolysates, fish peptones, hydrolysates enriched food beverages.

UNIT VI

Food flavour from tiny prawns and non-penaeid prawns.

UNIT VII

Formulation of pet food.

UNIT VIII

Chitin, Chitosan and protein extract from shrimp and crab shell and squilla, Quality requirements and assessment of chitin and chitosan, Application of chitin and chitosan. Conversion of chitin and chitosan to high value products ï glucosamine hydrochloride, glucosamine sulphate and their use.

UNIT IX

Extraction of collagen from fish processing wastes, properties and application. Preparation of biological membranes using collagen and chitosan for biomedical applications.

UNIT X

Value added products: Present market trends, scope of value addition, Types of value addition, Important value added products.

UNIT XI

Coated products ï Principles and type of coating, coating functions, in gradients, batter classification, mechanical properties of batter, bread crumbs, flavorings, seasonings and hydrocolloids in coatings, Fat and oils in coated food and their chemistry, Trouble shooting techniques for batter and breading systems, application of batters and breading to seafood.

Practical

Preparation of glucosamine hydrochloride and glucosamine sulphate. Preparation of isinglass, collagen powder and collagen and chitosan. Preparation of fish wafers, fish fingers, cutlets etc.

Suggested Readings

Balachandran KK. 2001. *Post Harvest Technology of Fish and Fish Products*. Daya Publ.

Gopakumar K. (Ed.). 2002. *Text Book of Fish Processing Technology*. ICAR.

Hall GM. (Ed.). 1992. *Fish Processing Technology.* Blackie.

AQUATIC ANIMAL HEALTH

CODE	COURSE TITLE	CREDITS
AAH 501*	VIRAL AND BACTERIAL DISEASES OF FINFISH AND SHELLFISH	2+1
AAH 502*	PARASITIC DISEASES OF FINFISH AND SHELLFISH	2+1
AAH 503*	HEALTH MANAGEMENT IN AQUACULTURE	2+1
AAH 504*	SYSTEMIC FISH PATHOLOGY	2+1
AAH 505	FISH IMMUNOLOGY	2+1
AAH 506	MICROBIOLOGICAL TECHNIQUES	1+1
AAH 507	FISH VIROLOGY AND CELL CULTURE	2+1
AAH 508	CLINICAL PATHOLOGY	1+1
AAH 509	NON-INFECTIOUS AND FUNGAL DISEASES	1+1
AAH 510	AQUATIC ENVIRONMENT AND FISH HEALTH	1+1
AAH 511	DIAGNOSTIC TECHNIQUES	1+1
AAH 591	MASTERôS SEMINAR	1+0
AAH 599	MASTERôS RESEARCH	20
AAH 601**	FISH AND SHELLFISH VIROLOGY	2+1
AAH 602**	ADVANCES IN PARASITOLOGY	2+1
AAH 603**	MOLECULAR MECHANISMS IN DISEASE PROCESS	2+1
AAH 604	CRUSTACEAN PATHOLOGY	1+1
AAH 605	FISH PHARMACOLOGY	2+1
AAH 606	BIOTECHNOLOGICAL TOOLS IN DISEASE DIAGNOSIS	1+1
AAH 607	PUBLIC HEALTH MICROBIOLOGY AND EPIDEMIOLOGY	2+1
AAH 608	MOLECULAR TECHNIQUES IN MICROBIOLOGY	1+1
AAH 609	FISH MYCOLOGY AND VIROLOGY	1+1
AAH 691	DOCTORAL SEMINAR I	1+0
AAH 692	DOCTORAL SEMINAR II	1+0
AAH 699	DOCTORAL RESEARCH	45

* Compulsory for Masterôs programme; ** Compulsory for Doctoral programme

Course Contents

AAH 501 VIRAL AND BACTERIAL DISEASES OF FINFISH AND SHELLFISH 2+1

Objective

To impart knowledge of viral and bacterial infections, their replication strategies and pathogenesis in fish and shellfish.

Theory

UNIT I

Virology: General biology of viral infections, virus classification, virus replication. OIE Notifiable diseases.

UNIT II

Aetiology, pathogenesis, epidemiology, treatment and control, immunology and molecular biology of viruses/viral diseases of finfishes with emphasis on the following: Epizootic haematopoietic Necrosis (EHN), Infectious Haematopoietic Necrosis (IHN), Oncorhynchus Masou Virus (OMV), Viral Encephalopathy and Retinopathy (VER), Spring Viraemia of Carp (SVC), Viral Haemorrhagic Septicaemia (VHS),Lymphocystis and Infectious Pancreatic Necrosis (IPN).

UNIT III

Major viral pathogens of commercially important cultured crustaceans with special reference to shrimp and freshwater prawn: viral and bacterial; Biology, morphology, diagnostic methods, clinical signs and pathological changes associated with these pathogens; Viruses: WSSV, YHV, TSV, IHHNV, MBV, HPV, BP, BMN, LOVV, GAV, MrNV.

UNIT IV

Pathogenesis, virulence mechanisms, epidemiology, treatment and control measures of the bacterial diseases of finfish and shell fish with emphasis on Furunculosis, Haemorrhagic septicemia, Columnaris disease, Tail and fin rot, Bacterial gill disease, Vibriosis, Mycobacteriosis, Nocardiosis, Haemophilosis, Edwardsiellosis, enteric red mouth.

UNIT V

Bacterial diseases of shellfish such as Vibriosis; Necrotizing hepatopancreatitis, rickettsial diseases, mycobacteriosis.

Practical

Examination of moribund fish for viral and bacterial diseases; Sampling techniques, culture techniques, bioassay methods; Serological techniques in disease diagnosis, microbial identification.

Suggested Readings

Austin B & Austin DA. 1993. *Bacterial Fish Pathogens. Disease in Farmed and Wild Fish*. 2nd Ed. Ellis Horwood.

Eiras J, Segner H, Wahli T & Kapoor BG. 2008. *Fish Diseases*. Science Publ.

Inglis V, Roberts RJ & Bromage NR. 1993. *Bacterial Diseases of Fish*. Blackwell.

Noga EJ. 1996. *Fish Disease Diagnosis and Treatment*. Mosby-Year Book. Roberts RJ. 2001. *Fish Pathology*. 3nd Ed. W.B. Saunders.

Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish*. Vols. I, II. 2nd Ed. Academic Press.

Stoskopf MK. 1993. *Fish Medicine*. WB Saunders.

Wolf K. 1988. *Fish Viruses and Viral Diseases*. Cornell University Press.

AAH 502 PARASITIC DISEASES OF FINFISH AND SHELLFISH 2+1

Objective

To comprehend the taxonomy, morphology, pathology and host-parasite relation of common parasites of aquatic organisms and to understand the significance of parasites in fish health.

Theory

UNIT I

Parasite taxonomy and morphology: Protozoan and metazoan parasites of fish and shellfish.

UNIT II

Life cycle of fish and shellfish parasites.

UNIT III

Parasite pathology: Pathology, treatments and control of the disease caused by protozoan parasites: *Costia necatrix*, *Trypanosoma*, *Trypanoplasma, Ichthyophthirius*, Urceolariid ciliates, Microsporidians, Myxozoans.

UNIT IV

Parasite pathology: Pathology treatments and control of the disease caused by Metazoan parasites: Trematodes: *Dactylogyrus, Gyrodactylus, Diplozoan, Sanguinicola, Neascus cuticola,* Cestodes: *Diphyllobothrium latum, Caryophyllaeus, Ligula*; Nematodes: *Capillaria, Camallanus.*

UNIT V

Parasite pathology: Pathology treatments and control of disease caused by Acanthocephalan parasites, Crustacean parasites: *Lernea, Argulus, Ergasilus*, fish leeches.

UNIT VI

Shellfish parasites: Pathology, treatment and control of the disease caused by Microsporidians, Haplosporidians, Ciliates and Cephaline gregarines.

Practical

Collection and identification of parasites; Preparation of permanent slides, micrometry and diagrams of parasites; Histopathological slide preparation of parasite-infected tissues; Processing for study of helminths and their larval stages; Examination of intermediate host for larval stages; Processing and study of the arthropods and their larval stages; Fixation staining and study of the protozoans; Examination of biopsy material, examination of tissue sections for parasites.

Suggested Readings

Ferguson HW. (Ed). 2006. *Systemic Pathology of Fish: A Text and Atlas of Normal Tissues in Teleosts and their Responses in Disease*. 2nd Ed. Scotian Press.

Lom J & Dykova I. 1992. *Protozoan Parasites of Fishes*. Elsevier.

Noga EJ. 1996. *Fish Disease. Diagnosis and Treatment*. Mosby-Year Book.

Rhode K. 2005. *Marine Parasitology*. Steven Simpson Books. Roberts RJ. 2001. *Fish Pathology*. 3rd Ed. WB Saunders.

Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish.* Vols. I, II. 2nd Ed. Academic Press. Stoskopf MK. 1993. *Fish Medicine*. WB Saunders.

Woo PTK & Bruno DW. (Eds.). 1999. *Fish Diseases and Disorders*. CABI.

AAH 503 HEALTH MANAGEMENT IN AQUACULTURE 2+1

Objective

To understand the essential principles of aquatic animal health management, biosecuirty and specific issues associated with the system.

To appreciate the significance of national and international instruments in quarantine, disease reporting and surveillance and their application in transboundary movement of aquatic organisms.

Theory

UNIT I

Review of various diseases of finfish and shellfish significant to aquaculture; diagnostic procedures and their application in aquaculture.

UNIT II

Disease monitoring, surveillance, epidemiology, quarantine, certification and import risk analysis.

UNIT III

Prophylaxis, hygiene and therapy of fish and shellfish diseases.

UNIT IV

Commonly used drugs/chemicals in aquaculture, drug delivery.

UNIT V

Vaccines and vaccination, probiotics and bioremedial measures; immunostimulants and their role.

UNIT VI

Application of health management protocols and biosecurity principles in aquaculture.

UNIT VII

Longterm strategy in health management; Advances in disease control and management; Principles of SPF/SPR.

Practical

Demonstration of different diagnostic tools. Sampling procedures for disease investigation; methods of chemical/drug delivery/application; case study.

Suggested Readings

David SA, Lee CS & O'Bryen PJ. 2006. *Aquaculture Biosecurity- Prevention, Control and Eradication of Aquatic Animal Diseases*. World Aquaculture Society. Blackwell.

Felix S, Riji John K, Prince Jeyaseelan MJ & Sundararaj V. 2001. *Fish Disease Diagnosis and Health Management*. Fisheries College and Research Institute, T.N. Veterinary and Animal Sciences University. Thoothukkudi.

Humphrey J, Arthur JR, Subasinghe RP & Phillips MJ. 2005. *Aquatic Animal Quarantine and Health Certification in Asia*. FAO.

John P. 1999. *Health Maintenance and Principal Microbial Diseases of Cultured Fishes*. 2nd Ed. Blackwell.

Noga EJ. 1996. *Fish Disease. Diagnosis and Treatment*. Mosby-Year Book.

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

Stoskopf MK. 1993. *Fish Medicine*. WB Saunders.

AAH 504 SYSTEMIC FISH PATHOLOGY 2+1

Objective

To understand the various systems of fishes and shrimps with specific reference to their pathological significance.

Theory

UNIT I

Introduction: Anatomy and physiology of teleost Integumentary, musculoskeletal, respiratory, circulatory, reticuloendothelial, renal, excretory and digestive systems.

UNIT II

Pathophysiology: Stress and general adaptation syndrome, inflammatory response, necrosis and types, stages.

UNIT III

Integumentary system: Cuticular, epidermal dermal and hypodermal changes, hyperplasia and ulceration.

UNIT IV

Respiratory system: Lamellar oedema, lamellar hyperplasia and lamellar fusion.

UNIT V

Blood vascular system: Pathology of heart, vessels, blood composition, cellular components of blood and haemopoietic tissue.

UNIT VI

Digestive system: Digestive tract and its pathology; hepatic necrosis, lipid infiltration, hepatic granuloma, cirrhosis, pancreatic atrophy, neoplasia; epithelial sloughing of intestine.

UNIT VII

Excretory system: Kidney and its pathology, renal tubules and collecting ducts.

UNIT VIII

Nervous system: Pathology of brain, spinal cord, peripheral nerves, meninges, sense organs.

UNIT IX

Musculoskeletal and Endocrine system: Pathological changes in red and white muscle bone and cartilages. Endocrine systems and pathology.

UNIT X

Systemic pathology in shrimp: Integument, respiratory, digestive and nervous system and its pathology.

Practical

Necropsy techniques, Systemic pathology of different organs and their identification.

Suggested Readings

Andrews C, Excell A & Carrington N. 1988. *The Manual of Fish Health*. Salamander Books Ltd.

Eiras J, Segner H, Wahli T & Kapoor BG. 2008. *Fish Diseases*. Science Publ.

Ferguson HW. (Ed). 2006. *Systemic Pathology of Fish: A Text and Atlas of Normal Tissues in Teleosts and their Responses in Disease*. 2nd Ed. Scotian Press.

Roberts RJ. 2001. *Fish Pathology*. 3rd Ed. WB Saunders.

Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish.*Vols. I, II. 2nd Ed. Academic Press.

AAH 505 FISH IMMUNOLOGY 2+1

Objective

To teach basic principles of fish and shellfish immunology.

Theory

UNIT I

Introduction to fish immunology and terminologies; historical developments; Phylogeny of fish immune system.

UNIT II

Lymphoid tissues and cellular components of immune system.

UNIT III

Non specific humoral and cellular defence mechanisms.

UNIT IV

Specific defence mechanisms; Memory function and immunological tolerance.

UNIT V

Complement system, function, components, complement activation.

UNIT VI

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

UNIT VII

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

UNIT VIII

Cell mediated immune response and its components; Hypersensitivity reactions.

UNIT IX

Invertebrate defence mechanisms.

Practical

Preparation of antigen; Raising of antibodies; Antigen-antibody reactions; Agglutination tests; Precipitation tests: gel diffusion; Immunoelectrophoresis, counter immunoelectrophoresis; Isolation of antibody from serum; ELISA; Western blotting; Isolation of lymphocytes and blastogenesis; Non-specific immune response (NBT and prophenoloxidase).

Suggested Readings

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

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

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

Swain P, Sahoo PK & Ayyappan S. 2005. *Fish and Shellfish Immunology: An Introduction*. Narendra Publ. House.

AAH 506 MICROBIOLOGICAL TECHNIQUES 1+1

Objective

To comprehend different microbiological techniques used in research.

Theory

UNIT I

Techniques in sterilization; Preparation of media. Safety in microbiology laboratory, bio-safety levels.

UNIT II

Microscopy: bright field, fluorescence, phase contrast, dark field and electron microscope.

UNIT III

Stains, staining and its chemistry.

UNIT IV

Isolation and culture of different types of bacteria; Techniques for identification: biochemical, serological and molecular techniques.

UNIT V

Techniques for isolation and identification of fungi; Basics of mycological and virological techniques.

Practical

Practical on microscopic techniques; Antibiotic sensitivity testing; Identification of microorganisms, anaerobic bacteria, mycological and virological techniques.

Suggested Readings

Chakraborthy P. 1995. *A Text Book of Microbiology*. New Central Book Agency.
Criusted J. 1986. *Methods in Microbiology*. Academic Press.
Harry WSJR, Paul JV & John JL. 2000. *Microbes in Action*. Freeman & Co.
James M. 1978. *Modern Food Microbiology*. 2nd Ed. D. Van Nostrand Co. Michael J, Pelizar JR & Chan ECS. 1998. *Microbiology*. Tata McGraw Hill.
Paul JH. 2001. *Marine Microbiology - Methods in Microbiology*. Vol. XXX. Academic Press.
Samuel CP & Dunn CG. 1959. *Industrial Microbiology*. McGraw Hill. Silliker JH, Elliof RP, Baired AC & Boyan FL. 1980. *Microbial Ecology of Foods*. Vol. II (ICMSF). Academic Press.
William CF & Westhoff DC. 2000. *Food Microbiology*. Tata Mc Graw Hill.

AAH 507 FISH VIROLOGY AND CELL CULTURE 2+1

Objective

To understand classification and structure of viruses and methods of their culture.

Theory

UNIT I

Virus taxonomy, viral structure, viral genetics.

UNIT II

Replication of viruses, host-virus interaction, viral vectors, bacteriophages, propagation of viruses.

UNIT III

Principles of cell culture, development of primary cell culture, maintenance of cell lines.

UNIT IV

Scaling up of cell culture, characterization and preservation of cell lines.

UNIT V

Hybridoma and monoclonal antibody production.

Practical

Virus isolation techniques, virus propagation, viral quantitation, neutralization techniques, electron microscopy, cell culture characterization (counting, staining), karyotyping, cell culture preservation, viable cell counts, MTT assay.

Suggested Readings

Alan C. 2005. *Molecular Virology*. Academic Press.
David MK, Peter MH, Diane EG, Robert AL, Malcolm AM, Bernard R & Stephen ES. 2007. *Fields Virology*. 5th Ed. Lippincott Williams & Wilkins.
Dimmock N, Easton A & Leppard K. 2006. *Introduction to Modern Virology*. 6th Ed. Blackwell.
Freshney IR. 2005. *Culture of Animal Cells: A Manual of Basic Technique*. 3rd Ed. John Wiley & Sons.
John RK & Rosalind GM. 2004. *Finfish and Shellfish Diseases* (Practical Manual). Fisheries College and Research Institute, TANUVAS, Thoothukkudi.
Mothersill C & Austin B. 2000. *Aquatic Invertebrate Cell Culture*. Springer Praxis.
Roberts RJ. 2001. *Fish Pathology*. 3nd Ed. WB Saunders.

AAH 508 CLINICAL PATHOLOGY 1+1

Objective

To teach methods in clinical pathology of aquatic organisms.

Theory

UNIT I

Detailed study of normal and abnormal constituents of blood with reference to pathogenic condition.

UNIT II

Stress induced conditions in fishes and their pathology. UNIT III

Physiological effects of stressors on fish, tolerance level (pH, ammonia, oxygen, temperature, handing stress, crowding, transportation, chemicals and bacterial toxins).

UNIT IV

Cellular response to stress, response to some specific disease.

Practical

Study of cellular components of blood: T.E.C., D.L.C., T.L.C., haemoglobin, total protein, glucose and other parameters, cholesterol, lipid profile, creatinine, urea and enzymes in blood during disease conditions.

Suggested Readings

Ferguson HW. (Ed.). 2006. *Systemic Pathology of Fish: A Text and Atlas of Normal Tissues in Teleosts and their Responses in Disease*. 2nd Ed. Scotian Press.

Noga EJ. 1996. *Fish Disease. Diagnosis and Treatment*. Mosby-Year Book.

Roberts RJ. 2001. *Fish Pathology*. 3nd Ed. WB Saunders.

Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish.* Vols. I, II. 2nd Ed. Academic Press.

Stoskopf MK. 1993. *Fish Medicine*. WB Saunders.

Wedmeyer G, Meyer FP & Smith L. 1999. *Environmental Stress and Fish Diseases*. Narendra Publ. House.

Leatherland JF & Woo PTK. 1998. *Fish Diseases and Disorders*. Vol. II.*Non-Infectious Diseases*. CABI.

AAH 509 NON-INFECTIOUS AND FUNGAL DISEASES 1+1

Objective

To comprehend the etiology and management of different non-infectious and fungal diseases.

Theory

UNIT I

Studies on the causes, pathogenesis, pathology, diagnosis and differential diagnosis of various diseases due to nutritional imbalance and avitaminosis, anorexia, mineral deficiency and toxicity.

UNIT II

Metabolic diseases in finfish and shellfish. Genetic diseases and neoplastic lesions.

UNIT III

Fungal diseases of finfish and shellfish- External and internal fungal infections.

UNIT IV

Epizootic ulcerative syndrome (EUS) in fishes- Etiology, epidemiology, pathogenesis diagnosis and management.

UNIT V

Fungal diseases of shellfish, larval mycosis, fusarium disease, Crayfish plague.

Practical

Study of gross and histopathological changes due to various metabolic diseases and nutritional disorders. Isolation of fungal pathogens.

Suggested Readings

Leatherland JF & Woo PTK. 1998. *Fish Diseases and Disorders*. Vol. II. *Non-Infectious Diseases*. CABI.

Lim C & Webster CD. 2001. *Nutrition and Fish Health*. Haworth Press. Roberts RJ. 2001. *Fish Pathology*. 3nd Ed. WB Saunders.

Stoskopf MK. 1993. *Fish Medicine*. WB Saunders.

AAH 510 AQUATIC ENVIRONMENT AND FISH HEALTH 1+1

Objective

To comprehend the basic principles of aquatic animal health management in relation to their environment.

Theory

UNIT I

Environmental variables related to fish health; Water quality and sediment characteristics.

UNIT II

Nature and type of pollutants. Impact of pollutants on environment and fish health.

UNIT III

Biological indicators and indices of water quality. Sanitation in aquaculture systems.

UNIT IV

Algal blooms and environmental microflora. Microbial toxins.

UNIT V

Probiotics and bioremedial measures. Nitrogen balance in aquatic ecosystem.

Practical

Estimation of major pollutants using spectrophotometry. Hematological, histoptathological and biochemical analysis of fish exposed to specific pollutants. Testing the efficacy of aquaculture sanitizers.

Suggested Readings

Braunbeck T, Hinton DE & Streit B. 1998. *Fish Ecotoxicology*. Birkhäuser. Noga EJ. 1996. *Fish Disease. Diagnosis and Treatment*. Mosby-Year Book.

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

Wedemeyer GA. 1996. *Physiology of Fish in Intensive Culture Systems*. Springer.

AAH 511 DIAGNOSTIC TECHNIQUES 1+1

Objective

To learn the principles and protocols of diagnostic tests used in the diagnosis of fish diseases.

Theory

UNIT I

Common bacterial pathogens of fishes. Handling of diseased fish for bacteriological examination, Withdrawal of blood and materials from internal organs for bacteriological examination. Diagnosis and infection experiments, Cultural and biochemical identification procedures. Mycological techniques.

UNIT II

Culture media for isolation of pathogens, non-selective, enriched, enrichment and selective media. Inoculation and purification techniques. Staining methods.

UNIT III

Serology of microbial disease ï agglutination precipitation and ELISA methods in disease diagnosis. Processing tissue samples for virological examination. Techniques for isolation of viruses. Serological tests for identification of viruses.

Practical

Methods for examination and analysing fish for health certification/diagnosis of disease condition, techniques for sample collection and processing for bacteriological, mycological and virological agents, methods for isolation of various bacterial, fungal and viral pathogens by conventional methods, rapid nucleic acid based methods and serological procedures.

Suggested Readings

de la Maza LM, Pezzlo MT & Baron EJ. 2000. *Diagnostic Microbiology*. 2nd Ed. WB Saunders.

Koneman EW. 2005. *Color Atlas and Textbook of Diagnostic Microbiology*. 6th Ed. Lippincott Williams & Wilkins.

OIE. 2006. *Manual of Diagnostic Tests for Aquatic Animals*. 5th Ed.

AAH 601 FISH AND SHELLFISH VIROLOGY 2+1

Objective

To understand the etiology and pathogenesis of common fish and shell fish viral diseases.

Theory

UNIT I

Molecular virology and pathogenesis of selected viruses infecting fish and shellfish such as IPN, VHS, IHN, VHS.

UNIT II

Nodavirus infection of fish and freshwater prawns, WSSV, YHV.

UNIT III

Antiviral drugs, viral vaccines, emerging viruses and evolution of new viruses.

Practical

Molecular detection and sequence analysis of fish/shellfish viruses; Collection and analysis of molecular information of various viruses using sequence information available in public domain.

Suggested Readings

Alan C. 2005. *Molecular Virology*. Academic Press.

David MK, Peter MH, Diane EG, Robert AL, Malcolm AM, Bernard R & Stephen E S. 2007. *Fields Virology*. 5th Ed. Lippincott Williams & Wilkins.

Dimmock N, Easton A & Leppard K. 2006. *Introduction to Modern Virology*. 6th Ed. Blackwell.
Flint SJ, Enquist LW, Krug RM, Racaniello VR & Skalka AM. 2000. *Principles of Virology, Molecular Biology, Pathogenesis and Control*. American Society of Microbiology.

Freshney IR. 2005. *Culture of Animal Cells: A Manual of Basic Technique*. 5th Ed. John Wiley & Sons.

Roberts RJ. 2001. *Fish Pathology*. 3rd Ed. WB Saunders.

AAH 602 ADVANCES IN PARASITOLOGY 2+1

Objective

To understand the pathobiology of parasitic infection in fishes.

Theory

UNIT I

Environmental parasitology: Macro-environmental and micro- environmental influence on parasite incidence.

UNIT II

Host parasite interaction: Pathological changes induced in host due to parasitic infection.

UNIT III

Molecular parasitology; Parasite biochemistry.

UNIT IV

Evolution of parasites; Hyperparasitism.

UNIT V

Antiparasitic drugs applied in aquaculture and their action.

UNIT VI

Parasitic immunity.

Practical

Isolation techniques of parasites. Molecular characterization of parasites. Use of molecular probes for identification of parasites and tracking life stages of parasites.

Suggested Readings

Lewis EE, Campbell JF & Sukhdeo MVK. 2002. *The Behavioural Ecology of Parasites*. CABI.
Poulin R & Grimes LR. 2007. *Evolutionary Ecology of Parasites*. Princeton University Press.

Theodor VB. 1974. *Biochemistry of Parasites*. 2nd Ed. Academic Press.

AAH 603 MOLECULAR MECHANISMS IN DISEASE PROCESS 2+1

Objective

To understand the molecular mechanism of common diseases and methods for studying them.

Theory

UNIT I

Uptake of macromolecules by cells. Viral gene expression. Channelising the cellular events to study the cell viability, cell proliferation, cell lineage.

UNIT II

Biological performance of each cell, i.e., changes in mitochondrial junction, morphology, Ca+ metabolism, vesicle trafficking; membrane transport system; protein molecule dynamics and expression profile of each cell.

UNIT III

RNA interfering mechanisms.

Practical

FISH technique, TUNEL assay, MTT assay, NO assay, COMET assay to detect apoptosis. FRET and FRAP microscopy techniques.

Suggested Readings

Alan C. 2005. *Molecular Virology*. Academic Press.
David MK, Peter MH, Diane EG, Robert AL. Malcolm AM, Bernard R & Stephen ES. 2007. *Fields Virology*. 5th Ed. Lippincott Williams & Wilkins.

Flint SJ, Enquist LW, Kru RM, Racaniello VR & Skalka AM. 2000. *Principles of Virology, Molecular Biology, Pathogenesis and Control*. American Society of Microbiology.

AAH 604 CRUSTACEAN PATHOLOGY 2+1

Objective

To understand the microscopic pathology associated with various diseases of crustaceans.

Theory

UNIT I

Normal histology of different organs of crustaceans with special reference to penaeid shrimp.

UNIT II

Major pathogens of commercially important cultured crustaceans with special reference to shrimp and freshwater prawn pathogens: viral, bacterial, fungal and parasites.

UNIT III

Biology, morphology, diagnostic methods, clinical signs and symptoms and pathological changes associated with these pathogens.

UNIT IV

Bacterial diseases: Vibriosis; necrotizing hepatopancreatitis, rickettsial diseases, mycobacteriosis.

UNIT V

Fungal diseases: Larval mycosis, fusarium disease; Parasitic diseases: Microsporidians, Haplosporidians, Ciliates, Cephaline gregarines. Diseases of non infectious etiology: gas bubble disease, hemocytic enteritis.

Practical

Detailed study on normal histology of different organs/tissues of crustaceans. Diagnostic procedures: field level diagnostic methods (direct microscopic observation, tissue impression, smear and routine staining methods); Histopathology of different diseases of crustaceans. Serological methods; Electron microscopy; Gene probe and dot blot assay; *In-situ* hybridization (ISH) and polymerase chain reaction (PCR).

Suggested Readings

Bell AT & Lightner DV. 1988. *A Handbook of Normal Penaeid Shrimp Histology*. World Aquaculture Society, Lousiana, USA.

Lightner DV. 1996. *A Handbook of Shrimp Pathology and Diagnostic Procedures for Diseases of Cultured Penaeid Shrimp.* World Aquaculture Society, Lousiana, USA.

AAH 605 FISH PHARMACOLOGY 2+1

Objective

To understand the principles and application of pharmacodynamic compounds applied in aquaculture. To elucidate the pharmacodynamics of important chemicals/drugs applied in aquaculture.

Theory

UNIT I

Introduction to pharmacology, pharmacological terms and definitions, sources of drugs.

UNIT II

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

UNIT III

Pharmacodynamics, concept of drug receptor, dose response relationship, half-life and withdrawal period, factors affecting drug effect and dosage, principles of drug safety in terms of species and environment.

Practical

Antibiogram preparations; Antibiotic residual assays; Studies on histopathololgical changes caused due to chemotherapy. Important anesthetics and their mode of action.

Suggested Readings

Brown KMT. 2000. *Applied Fish Pharmacology*. Aquaculture Series 3, Kluwer.

Noga EJ. 1996. *Fish Disease, Diagnosis and Treatment*. Mosby-Year Book.

Richard DH, Mary JM, Richard AH & Pamela CC. 2005. *Pharmacology.* Lippincott Williams & Wilkins.

Stoskopf MK. 1993. *Fish Medicine*. WB Saunders.

AAH 606 BIOTECHNOLOGICAL TOOLS IN DISEASE DIAGNOSIS 1+1

Objective

To understand the principles and applications of different biotechnological tools used for disease diagnosis.

Theory

UNIT I

Advances in disease diagnostic procedures in aquaculture.

UNIT II

Molecular diagnostic methods such as *in situ* hybridization, nucleic acid probe-based diagnosis; Choice and characteristics of probe, Probe labeling.

UNIT III

Hybridization: Hybridization strategies, factors affecting the rate of hybridization, Immobilization of nucleic acid on filters. Types of hybridization: Southern, Northern, Dot/Slot blot hybridization.

UNIT IV

Various types of polymerase chain reaction (PCR) such as conventional one step, nested and semi-nested PCR, RT-PCR, real-time PCR; LAMP.

UNIT V

DNA Microarrays: DNA chips, preparations of DNA arrays, label and applications; other related molecular techniques.

UNIT VI

Monoclonal antibody-based diagnostics.

Practical

Nucleic acid extraction, PCR detection of various pathogens. Monoclonal antibody-based diagnostic application. Protein profiling, DNA fingerprinting.

Suggested Readings

Altman A. 1997. *Agricultural Biotechnology*. CRC Press.

Noga EJ. 1996. *Fish Disease, Diagnosis and Treatment*. Mosby-Year Book.

Sambrook J & Russel D. 2001. *Molecular Cloning*. 3rd Ed. Cold Spring Harbour Laboratory.

AAH 607 PUBLIC HEALTH MICROBIOLOGY AND EPIDEMIOLOGY 2+1

Objective

To learn the zoonotic importance of fish pathogens and toxins produced by aquatic organisms.

Theory

UNIT I

Introduction to food-borne diseases ï Classification; food-borne infection and intoxication-microorganisms important in food borne diseases and food toxicity ï economic importance of food - borne illness.

UNIT II

Factors influencing food-borne disease outbreaks; Sources and transmission of pathogens in foods: human, animal, and environmental reservoirs; crosscontamination; food associations; Microbial detection and indicator organisms:approach and techniques; pathogen indicators; bacteria responsible for food borne infection and intoxication; bacterial toxin and miscellaneous toxic factors; factors affecting toxin production in foods; fungal toxins, aflatoxin, ochratoxin and other fungal toxins; factors affecting fungal toxin production in food; marine toxins PSP, ASP, NSP, ciguatera poisoning and other marine toxins; histamines and other bioamines toxicity.

UNIT III

Zoonoses: Zoonoses of different origins ï rare, new, and emerging zoonoses; trematode, cestode and nematode zoonoses; food borne viruses; prevention and control of food toxicity and food-borne diseases. Government Agency and Food Safety Policy: HACCP, Risk Assessment, New pathogens and emerging food borne diseases. Current Food Safety Topic: antibiotic resistance.

Practical

Isolation and identification of toxin producing microorganisms and other potent human pathogens in fish and fishery products ï detection of toxins
using biological and immunological techniques.

Suggested Readings

Doyle MP & Buechat LR. 2007. *Food Microbiology*. 3rd Ed. ASM Press. Huss HH, Ababouch L & Gram L. 2004. *Assessment and Management of Fish Safety and Quality*. FAO Fisheries Tech. Paper 444. James MJ. 2005. *Modern Food Microbiology*. 7th Ed. Springer. FAO. 2004. *Marine Biotoxins Food and Nutrition.* Paper 80.

AAH 608 MOLECULAR TECHNIQUES IN MICROBIOLOGY 1+1

Objective

To understand the molecular techniques used in genetic manipulation.

Theory

UNIT I

Techniques for isolation of DNA for gram positive bacteria, gram negative bacteria, fungal cells, animals cells, DNA detection, purification, quantification. Plasmid DNA and techniques for isolation and purification of plasmids.

UNIT II

Determination of G+C content of DNA: Chromatographic technique, spectrophotometric method, isopycinic bouyant density gradient centrifugation.

UNIT III

Restriction fragment length polymorphism: Different types of restriction enzymes, their target sites, digestion patterns, chromosomal DNA-RFLP, plasmid DNA, PCR-RFLP, Pulsefield gel electrophoresis and its applications.

UNIT IV

Methods of gene transfer: Transformation, plasmid DNA as cloning vectors, electroporation.

UNIT V

Gene transfer by conjugation: Conjugative plasmids and their application in recombinant DNA technology Gene transfer by transduction: application of bacteriophages in cloning.

Practical

Isolation of DNA and RNA; Quantification of DNA and RNA, gene amplification, primer designing, gene cloning-restriction digestion, ligation and transformation, gene sequencing, gene expression, immunoblotting, design and application of gene probes.

Suggested Readings

Brown TA. (Ed.). 2002. *Essential Molecular Biology*. Vols. I, II. 2nd Ed. Oxford University Press.
Lewin B. 2003. *Gene VIII*. Oxford University Press.

Sambrook J & Russel D. 2001. *Molecular Cloning*. 3rd Ed. Cold Spring Harbour Laboratory.

AAH 609 FISH MYCOLOGY AND VIROLOGY 1+1

Objective

To study the characteristics of fungal and viral agents causing diseases in fish and shellfish and their control measures.

Theory

UNIT I

Fungi and environment, role of fungi in food processing and aquaculture, the growth of yeasts and molds in fishes ï effect of heat, chilling, freezing and chemical preservatives on common fungi associated with fishes. Mycotoxins ï source and conditions effecting their production. Techniques for isolation and identification of yeasts and molds.

UNIT II

General properties of viruses. Viruses associated with fishes and water characteristics. Effect of heat and freezing on food-borne viruses. Techniques for cultivation of viruses, tissue culture.

Practical

Isolation and identification of aquatic fungi, fungi involved in food spoilage and diseases, application of fungi, detection of mycotoxins, isolation of viruses using cell culture, molecular identification of viral diseases.

Suggested Readings

George P. 1987. *Textbook of Fish Health*. 2nd Ed. TFH Publ.
Hoole D, Bucke D, Burgess P & Wellby I. 1991. *Diseases of Carps and Other Cyprinid Fishes*.

Wiley-Blackwell.

Roberts RJ. 2001. *Fish Pathology*. 3nd Ed. W.B Saunders.

Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish.* Vols. I, II. 2nd Ed. Academic Press.

Woo PTK & Bruno DW. (Eds.). 1999. *Fish Diseases and Disorders*. Vol. III. *Viral, Bacterial and Fungal Infections*. CABI.