

1. AQUACULTURE

1. AQC 501. SUSTAINABLE AQUACULTURE 3(2+1)

Major courses

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; Setting model for sustainable aquaculture (organic farm, integrated farm); Applications of remote sensing and GIS (geographical information system); Economic evaluation of aquaculture practices.

2. AQC 502. SOIL AND WATER QUALITY MANAGEMENT IN AQUACULTURE 3(2+1)

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; 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; Microbial techniques; Visit to effluent treatment plant; Design and operation of biological filters.

3. AQC 503. NUTRITION AND FEED TECHNOLOGY 3(2+1)

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 feed—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.

4. AQC 504. AQUATIC ANIMAL HEALTH MANAGEMENT 3(2+1)

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 growout 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; Fish cell culture and techniques in virus isolation. Stress related study of fish and shellfish; Disease treatments.

5. AQC 506. SEED PRODUCTION AND HATCHERY MANAGEMENT OF SHELLFISHES 2(1+1)

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

Designing, estimation and layout preparation for shellfishes' hatcheries. Gonad development observation and fixing the stages: In different cultivable crustaceans and molluscs; Collection from wild and natural waters 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 feeds used in shellfish hatcheries; Artemia hatching technique; Visit to different shellfish hatcheries; Economic analysis of shellfish hatcheries. Identification of disease and disease causing pathogens in the hatcheries.

6. AQC 509. COASTAL AQUACULTURE 3(2+1)

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 – type, site selection, construction, specifications for different species; Raft and rack culture – 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 – 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 undrainable 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 – cages, pens, rafts and racks; Visit to coastal aquafarms.

7. AQC 511. LARVAL NUTRITION AND CULTURE OF FOOD ORGANISMS 3(2+1)

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.

UNIT IV

Bio-encapsulation techniques, Use of immunostimulants and probiotics in larval rearing, safety concerns in handling live feeds.

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 – freshwater and marine; Culture of earthworms and chironomid larvae.

2. AQUATIC ENVIRONMENT MANAGEMENT

1. AEM 501. AQUATIC ENVIRONMENT AND BIODIVERSITY 3(2+1)

Major courses

Theory

UNIT I

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

UNIT II

Environmental concerns: Environmental concerns – 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.

2. AEM 502. ECOLOGY AND MANAGEMENT OF LIMNETIC ENVIRONMENT 3(2+1)

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.

3. AEM 503. Planktonology 3(2+1)

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) – 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.

4. AEM 504. AQUATIC MICROBIAL ECOLOGY 3(2+1)

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 bioprocesses – bioremediation, biofertilization, biofilms, bio-leaching, biocorrosion, 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.

5. AEM 505. FISHERIES OCEANOGRAPHY 2(1+1)

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 – currents, waves, tides, amplitudes, stratification, related chemical factors, upwelling and circulation patterns.

UNIT II

Forecasting systems: Fisheries forecasts – interpretation and use of ocean thermal structure in fisheries; Fisheries forecasting system in India and other countries – 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 – water temperature, salinity, pH, nutrients, benthos and sediment characteristics; Fisheries forecasting systems; Oceanographic equipment and fish finding devices.

6. AEM 506. INTEGRATED COASTAL ZONE MANAGEMENT 3(2+1)

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, Nonsustainable 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.

7. AEM 507. AQUATIC POLLUTION AND WASTEWATER MANAGEMENT

3(2+1)

Theory

UNIT I

Aquatic pollution and its management: Aquatic pollution – sources, types and their impacts; Pollution problems of groundwater resources –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, H₂S,, NH₃-N, NO₂-N, NO₃-N, PO₄-P, CH₄, 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.

3. FISH PROCESSING TECHNOLOGY

1. FPT 501. TECHNOLOGY OF FISH FREEZING AND FROZEN STORAGE

3(2+1)

Major courses

Theory

UNIT I

Freezing: Structure of water and ice, Influence of solutes on the structure of water and ice, phase equilibria 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.

2. FPT 502. THERMAL PROCESSING OF FISHERY PRODUCTS 3(2+1)

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, value, cook value, D value, integrated F value and nomogram methods – F₀ 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 NaCl and nitrite, combination with ionising radiation, irradiation and hydrostatic pressure, irradiation and NaCl, 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 Value, Z value, Process 0 time, Canning of table fishes, Bivalves, Crustaceans in different containers, Operation of over pressure autoclave, Canned culinary preparations, Examination of canned fishery products.

3. FPT 503. QUALITY ASSURANCE, MANAGEMENT AND CERTIFICATION

3(2+1)

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 plans, Basic concepts of decision making. Familiarization with water quality analysis.

4. FPT 504. APPLIED FISH BIOCHEMISTRY 3(2+1)

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 – 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, quaternary 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, lipases 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 – Fractionation by TLC and other chromatographic techniques. Fatty acid composition by GLC, Amino acid analysis by HPLC. Protein purification methods: $(\text{NH}_4)_2\text{SO}_4$ /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.

5. FPT 505. TECHNIQUES IN MICROBIOLOGY 2(1+1)

Theory

UNIT I

Safety in Microbiology laboratory – Prevention of contamination, aerosol sampling, disinfection and evaluation of disinfectants.

UNIT II

Microscopy – bright-field, fluorescence, phase-contrast, dark ground and electron microscope.

UNIT III

Staining techniques – Types of stains and chemistry of staining.

UNIT IV

Sterilisation – Principles of various physical and chemical methods of sterilisation.

UNIT V

Nutritional requirements of microorganisms – 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.

6. FPT 508. TECHNOLOGY OF MINCE BASED FISH PRODUCTS 2(1+1)

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.

7. FPT 509. ADDITIVES IN FISH PROCESSING 2(1+1)

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 – Agricultural Revolution-Industrial revolutions – urbanization.

UNIT III

Intentional additives – use of specific nutrients as food additives – 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 – 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.

8. FPT 513. PACKAGING OF FISH AND FISHERY PRODUCTS 2(1+1)

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.

4. FISH QUALITY ASSURANCE AND MANAGEMENT

1. FQM 501. FISH QUALITY INDICES (1 + 1)

Major Courses

Theory

Fish quality – intrinsic and extrinsic factors; post-mortem changes in fish - rigor mortis, glycolysis, nucleotide breakdown, NPN degradation, protein degradation, aminoacid decarboxylation. Fish quality assessment - sensory – scales, grades, scores, taste panel; physical – water activity, pH, torrimeter, fish tester; biochemical – trimethyl amine (TMA), total volatile bases (TVB), ammonia, hypoxanthine (Hx), K-value, indole, formaldehyde, biogenic amines; fat degradation – hydrolytic and oxidative changes, antioxidants, pro-oxidants. Lipid quality assessment – free fatty acids (FFA), peroxide value (PV), thiobarbituric acid (TBA). Microbiological – total aerobic bacteria, specific spoilage organism (SSO), faecal indicator organisms – coliforms, *E. coli*, fecal streptococci; personal hygiene indicator organisms – *Staphylococcus aureus*, anaerobic sulphite reducing bacteria, total lactics.

Practical

Sensory quality evaluation. Physical quality evaluation - water activity, pH, O/R potential. Biochemical quality indices - TMA, TVB, Hx, indole, formaldehyde, biogenic amines; fat degradation indices – FFA, TBA. Microbial indices – aerobic plate count, coliforms, *E. coli*, total staphylococci, total streptococci, total lactics, H₂S producers, sulphite reducing clostridia.

2. FQM 502. CHEMICAL HAZARDS IN FISH (2 + 1)

Theory

Introduction, foodborne diseases of chemical etiology, types of chemicals involved in chemical hazards. Additives – intentional and unintentional; intentional – phosphates, citrates, sulfites, benzoates, borates, sorbates, tetracyclines; unintentional – heavy metals – mercury, cadmium, arsenic, lead, selenium; pesticides – organochlorine compounds, organophosphorus compounds, carbamates, dioxins, polychlorinated biphenyls (PCBs), herbicides, fungicides, insecticides. Antimicrobials- antibiotics- beta lactams, tetracyclines, aminoglycosides, macrolides, sulfanomides, nitofurans, chloramphenicols. Hydrocarbons – benzopyrene; radioisotopes. Biogenic amines – histamine, cadaverine, putrescine. Natural toxins – shellfish toxins – paralytic shellfish poisoning, diaheretic shellfish poisoning, venerupin shellfish poisoning, amnesic shellfish poisoning, neurotic shellfish poisoning and erythematous shellfish poisoning. Finfish toxins – puffer fish poisoning and ciguatera poisoning – occurrence,

importance, toxicological and prevention of chemical hazards. Mycotoxins- occurrence and prevention. Safety standards and maximum residue limits (MRLs).

Practical

Determination of intentional additives – phosphates, citrates, sulfites, borates, benzoates; determination of methyl mercury; determination of heavy metals; determination of chlorinated pesticides by gas chromatography; determination of benzopyrenes; estimation of antibiotic residues by microbial assay; spectrofluorometric estimation of histamine; detection of mycotoxins by TLC and fluorometer.

3. FQM 503. MICROBIAL HAZARDS IN FISH (1 + 2)

Theory

Bacterial hazards – *Salmonella*, *Vibrio cholerae*, *Listeria monocytogenes*, *Clostridium botulinum* - occurrence, pathogenicity and prevention; *V. parahaemolyticus*, *V. vulnificus*, *C. perfringens*, *Shigella*, *Staphylococcus aureus* and *Escherichia coli*. Bacterial pathogens growth and inactivation. Fungal hazards – epizootic ulcerative syndrome – importance, occurrence, toxicology and prevention. Viral hazards – enteroviruses - infectious hepatitis, polio myelitis, Norwalk virus, white spot syndrome virus, yellow head virus – occurrence, importance, pathogenicity and control. Parasitic hazards – trematodes, nematodes, cestodes, myxosporidians, copepods – occurrence and pathogenicity. FDA safety standards.

Practical

Isolation and identification of *Salmonella*, *Vibrio cholerae*, *V. parahaemolyticus*, *V. vulnificus*, *Listeria monocytogenes*, *Clostridium botulinum*, *C. perfringens*, *Shigella*, toxigenic strains of *E. coli*, coagulase-positive *Staphylococcus aureus*; isolation of *Aspergillus* sp.; detection of white spot syndrome virus and yellow head virus; detection of parasites by candling technique.

4. FQM 504. INSTRUMENTATION IN FISH QUALITY ASSESSMENT (1 + 2)

Theory

Centrifugation – principles and application. Spectroscopy – colorimeter, UV-Vis. spectrophotometer, spectrofluorometer, nuclear magnetic resonance (NMR) spectroscopy, infrared (IR) spectroscopy, atomic absorption spectroscopy (AAS), mass spectrometry (MS), inductively coupled plasma (ICP) analyser- principles and application. Chromatography – paper,

thin layer, liquid and gas chromatography, liquid chromatography-mass spectrometry-mass spectrometry (LC-MS/MS) – principles and application. Electrophoresis – polyacrylamide gel electrophoresis, SDS-PAGE, isoelectric focusing, agarose gel electrophoresis, immunoelectrophoresis - principles and application. Colour and texture analyzers – principles and application.

Practical

Cell fractionation by centrifugation; UV-Vis. Spectrophotometer analysis; spectrofluorometry analysis. Separation of sugars by paper chromatography; separation of lipids by thin layer chromatography; HPLC - operation; Gas chromatograph - operation; separation of protein by gel electrophoresis.

5. FQM 505. PROCESSING OF FISH AND THEIR QUALITY PROBLEMS (2 + 1)

Theory

Fish preservation methods – Chilling - icing (water ice, dry ice, gel ice), CSW, RSW; quality defects in chilled fish. Freezing – principle, types of freezing – plate, air blast, cryogenic; quality defects in frozen fish. Irradiation – principles and quality defects. Modern packaging methods – vacuum packaging, modified atmospheric packaging and their quality problems. Fish processing methods – Curing – drying, salting, smoking, freeze-drying, their principles; quality defects in cured fish. Canning – principle and quality defects; retortable pouch processing. Fermentation – principle and quality defects. Microwave heating- principle and quality problems. Value added fishery products – fish protein concentrate, fish pickles, fish wafers, minced fish and surimi based products, seafood analogs, extruded products, breaded and battered products, fish ham and sausage; quality defects in value added products.

Practical

Chilling of fish using different icing methods. Block/IQF freezing of fish. Vacuum and modified atmospheric packaging of fish. Canning of fish. Fish drying by different methods. Dry and wet salting of fish. Smoking of fish. Preparation of fish sauce, fish protein concentrate, fish pickle, breaded and battered products, fish wafers, fish cutlets, surimi products and extruded products. Assessing the quality problems of processed fish and fishery products.

6. FQM 506. FISH QUALITY STANDARDS (2 + 1)

Theory

Fish quality control – Definitions, objectives – quality assurance. Inspection and certification systems – objectives, methods and process- QCIA, IPQC, Self certification, end product inspection, voluntary inspection. Fish quality assurance. Standards – national- Bureau of Indian Standards (BIS), Export inspection agency (EIA); international – Codex Alimentarius Commission of FAO, USFDA, EU hygienic regulations, ICMSF, ISO 9000 standards, ISO 14000 standards, ISO 22000 standards, WHO standards. HACCP concept – principles; seafood hazard categories – applications; CCP decision tree, HACCP audit. Integrated food safety laws of India 2006 – Food Safety and Standards Authority of India.

Practical

Preparation of HACCP manual for chilled, frozen, canned, cured and value added products and their processes. Inspection of fishery products. Visit to EIA, BIS and other food standards organizations.

7. FQM 507. FISH SANITATION AND HYGIENE (2 + 1)

Theory

Cleaning – cleaners – types, properties, mechanism of action; cleaning schedule. Sanitizers – chlorine compounds, iodophors, ozone, UV radiation; properties and mechanism of action. Sanitary schedule – sanitary standard operating procedures (SSOP), sanitary control procedure (SCP). Sanitary practices in on-board and in-shore. Plant sanitation and hygiene – personnel, plant hygiene and pest control; good hygienic practices (GHP). Food hygiene law and food safety regulations. Design and construction of ideal fish processing plant. Water quality – standards, treatment of water; waste disposal – solid and liquid wastes. Effluent treatment plant (ETP) – primary, secondary, tertiary. Utilization of liquid and solid wastes – aquaculture and agriculture.

Practical

Determination of sanitary status by swab technique - plant, on-board and landing centre; determination of phenol coefficient of disinfectant; determination of available chlorine and active iodine; determination of personnel hygiene. Utilization of fish waste by composting. Study on the efficacy of biological treatment of waste waters. Visit to ETP.

5. FISHERIES RESOURCE MANAGEMENT

1. FRM 501. INLAND FISHERIES RESOURCES 3(2+1)

Major courses

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

2. FRM 502. MARINE FISHERIES RESOURCE MANAGEMENT 3(2+1)

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

3. FRM 503. MARINE ECOSYSTEMS, BIODIVERSITY AND CONSERVATION 3(2+1)

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 -- 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 – 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.

4. FRM 504. TROPICAL FISH STOCK ASSESSMENT 3(2+1)

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 – Stochastic model – 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 – Yield per recruit – Analytical and holistic models – growth parameters – Cohort analysis – Jones method. Gill net, trawl selectivity – Swept area method. MSY- Stock recruitment relationship.

5. FRM 506. REMOTE SENSING AND GIS FOR FISHERIES MANAGEMENT 2(1+1)

Theory

UNIT I

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

UNIT II

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

UNIT III

Environmental satellites – 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.

6. FRM 509. FEEDING AND REPRODUCTIVE BIOLOGY OF FINFISH AND SHELLFISH 3(2+1)

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 - Semelparity 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.

7. FRM 512. MODERN TECHNIQUES IN ICHTHYOTAXONOMY 3(2+1)

Theory

UNIT I

Identification of stocks based on classical and modern taxonomical methods.

UNIT II

Classical taxonomy – morphometrics – meristics.

UNIT III

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

UNIT IV

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

Practical

PAGE – 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.

6. FISHERIES ECONOMICS

FEM 501. MICROECONOMICS 2(2+0)

Major Courses

Theory

UNIT I

Concept of demand, Law and determinants of demand, Demand elasticities, Price, income and cross elasticities of demand. Supply – Supply concepts, Law, determinants of supply, cob web theorem, shifts in demand and supply.

UNIT II

Theory of consumer behaviour – Cardinal and ordinal utility – Law of Diminishing marginal utility – Indifference curve theory – Revealed preference theory – consumer surplus.

UNIT III

Theory of cost - Analysis of economies of scale, Production function, Theory of production – factors of production – production function analysis.

UNIT IV

Theory of product pricing, cost and cost curves, Revenue and revenue curves – objectives of business firms, profit maximization, Equilibrium of a firm, TR and TC approach, Market and market structure, Types of factor and product markets, price discrimination.

UNIT V

Welfare Economics, Theory of factor pricing – Distribution, Rent, wages, Interest, Profit, Welfare economics.

2. FEM 502. MACROECONOMICS 2(2+0)

Theory

UNIT I

Macroeconomics: National Income Accounting – definition and concepts of NI, different components of national Income - Determination of national income.

UNIT II

Classical Theory of income and employment, Keynes theory of employment, Theories of consumption – consumption function – Investment function – concepts of multiplier and accelerator.

UNIT III

Consumption function, Multiplier, Inducement to invest and marginal efficiency of capital, Classical theory of output and employment – Keynesian theory of income, output and employment.

UNIT IV

IS-Lm Curve Model, Aggregate Demand, Aggregate Supply, Unemployment and Full Employment, ISLM model – Hicks Hansen synthesis.

UNIT V

Inflation – causes and control measures - Business cycle – Money, banking and public finance – Nature and functions of money – Balance of payment.

UNIT VI

Money Supply and its determinants -Fiscal and Monetary policy, Public revenue and taxation, Foreign Exchange – trade policies – economic growth.

3. FEM 503. AQUACULTURE PRODUCTION ECONOMICS 3(2+1)

Theory

Unit I

Introduction – Aquaculture production process – Factors affecting the economics of aquaculture.

Unit II

Production concepts applied to aquaculture – Cost concepts and cost functions – Returns concepts.

Unit III

Least-cost combination of inputs.

Unit IV

Optimization of aquaculture production.

Unit V

Planning and budgeting – Linear programming – Economies of scale – Production function analysis.

Unit VI

Management of aquaculture production process – Aquaculture management decisions – Resource management – Labour and personnel management – Financial management.

Unit VII

Management of risk and uncertainty in aquaculture – Economics of different aquaculture systems – Socioeconomic issues in aquaculture development.

Practical

Estimation of costs and returns of different aquaculture systems – Planning and budgeting – Linear programming - Production function analysis – Cost function analysis – Financial and farm business analysis – Risk programming – Case studies – Visit to fish farms, shrimp/prawn farms and hatcheries – Discussion on socioeconomic issues in aquaculture development.

4. FEM 504. MARINE FISHERIES RESOURCE ECONOMICS 2(1+1)**Theory****Unit I**

Marine fishery resources of India – Status and prospects.

Unit II

Production function in marine capture fisheries – Appropriate form of production function for marine capture fisheries – Fish catch and fishing effort and its dimensions – catch per unit effort – Methodological issues in the estimation of fish catch and fishing effort.

Unit III

Fishing costs and returns – Estimation of economics of marine capture fisheries – Methodological issues in the estimation of costs and returns in marine capture fisheries – Methodological issues in the estimation of the economic analysis of marine capture fisheries.

Unit IV

Sustainable yield – sustainable yield curves – over fishing and under fishing – The problem of overfishing.

Unit V

Basic economic model of a fishery - Open access equilibrium yield – Maximum economic yield – Maximum social yield – Resource Rent – consequences of free and open access fishery - Changes in the open access equilibrium position of a fishery due to change in fishing costs, price of fish and fish productivity.

Unit VI

Fisheries Regulations – Imperative need for the regulation of marine fisheries in India – Need for and types of fishery regulations – possible objectives of fisheries regulations – Fisheries regulations followed in the maritime states of India – Choice of and economics aspects of fisheries regulations – Fisheries enforcement.

Unit VII

Fisheries Management – objectives, Techniques and criteria for fisheries management – Basic options for fisheries management – Formulation and Implementation of management measures.

Practical

Design of a survey schedule for capture fisheries economics – Catch and effort surveys – Estimation of costs and returns per fishing trip – Unit cost of production of fish – Economics of capture fisheries market surveys - Rate of growth of exports of marine products – Case studies of fishing, fish processing and marketing firms.

5. FEM 505. FISHERIES MARKETING MANAGEMENT 3(2+1)**Theory****UNIT I**

Marketing management - Introduction and overview. Marketing system and environment Market opportunity identification- Customer analysis. Market segmentation, market positioning and consumer behaviour, Competition analysis, Market assessment, Marketing environment.

UNIT II

Demand assessment and forecasting, Designing the offer-product decision and pricing decision, product decision and strategies, product life cycle, new product development, branding and packaging decisions, Delivering the offer- distribution management, sales management and communication strategy management – Salesmanship.

UNIT III

Product management. Pricing policies and practices. Distribution strategy - channels of distribution, physical distribution.

UNIT IV

Marketing information system. Marketing communication - advertising, publicity, personal selling, sales promotion.

UNIT V

Marketing research and information system, Marketing research and its application in fisheries marketing strategy, planning and organisation, emerging issues in marketing, e-marketing.

Practical

Marketing mix, marketing strategy, segmentation, pricing methods, consumer behaviours, new product development, marketing research, measuring effectiveness of marketing mix, performance evaluation, efficiency analysis.

6. FEM 506. ENVIRONMENTAL ECONOMICS 2(2+0)

Theory

UNIT I

Ecology and economics - principles of environmental economics – public goods, club goods and theory of common property - property rights and ownership incentives - substitution between capital and natural resources - environmental externalities - poverty, development and environment – environment and trade - concept and practice of sustainability.

UNIT II

Market and non-market valuation of natural resources - measurement of environmental harm and benefit - contingent valuation - difficulties in application of a supply/demand or benefit/cost framework - application of a cost-effectiveness or cost-minimization framework. Criteria for evaluating environmental policies – market based / incentive based strategies like emission taxes and subsidies, transferable discharge permits - polluter pays principle. Kyoto Protocol, carbon trading, CDM and GEF.

UNIT III

Concept and principles of EIA; methodologies for EIA in fisheries and aquaculture sector; Institutional (International/National/State/Local) arrangements and strategies for estimation, amelioration and compensation for impacts; Aquaculture Authority Bill and AAI. Environment related conflicts and dispute resolution; Coasian theorem and stakeholder decision making process. Economic theory of fish resource exploitation – absent property rights in fisheries sector - common property resource use and management.

Practical

Case studies on environmental economics of shrimp farming (intensive/ semi-intensive/ extensive) and polyculture farms - Case studies on the sustainability of various capture fishery systems - Economics of inland water and marine pollution - economics of pollution control - economics of climate change, global warming and fisheries development.

7. FEM 507. Human Resource Management 2(2+0)

Theory

UNIT I

Concept, scope and definition of project - difference between plan and project – project types - advantages and limitations – elements of project cycle - aspects of project preparation and analysis - project cost and benefits – comparisons – tangible and intangible cost and benefits; Social cost benefit analysis – concepts.

UNIT II

Financial and economic aspects of projects: feasibility analysis – undiscounted measures of project worth - ranking by inspection, pay back period, average annual proceeds per unit of outlay - time value of money - discounted measures – discounted pay back period, derivation of incremental net benefit, net present worth, BC ratio, IRR, net benefit investment ratio, project alternatives - risk and uncertainties – sensitivity analysis. Farm planning, budgeting – complete and partial budgeting – farm business analysis and appraisal techniques – ratio analysis, asset valuation and depreciation. Financial analysis-balance sheet, cash flow analysis, profit loss statements.

UNIT III

Guidelines for project preparation report – objective, rational, area, organization, production, markets and financial results, benefits. Sources of institutional assistance for project preparation and formulation – bilateral and multilateral assistance. Project implementation – objective and tasks, economic aspects of project evaluation. Project management – management technique –

bar chart, milestone chart, activity slack bar chart, PERT, CPM, inventory management and control, management information system and project monitoring.

Practical

Practical and Case studies: Ratio analysis, computing depreciation, valuation of project inventories, complete and partial Budgeting, cash flow analysis, balance sheet / net worth statement, profit–loss statement/income statement–undiscounted and discounted measures – net work techniques - bar charts, milestone chart and activity slack bar chart, PERT and CPM - project preparation for capture, culture and processing sectors – sensitivity analysis - project monitoring and evaluation – case studies and feasibility evaluation.

8. FEM 508. FINANCE AND ACCOUNTING FOR MANAGERS 2(1+1)

Theory

UNIT I

Overview of Financial management, Financial systems, Financial statements, taxes and cash flow, Analysing financial performance, Break even analysis and leverage, Time value of money, valuation bonds and stocks, Risk and return, Capital budgeting, techniques of capital budgeting, Cost of capital, Sources of long term finance, Dividend decisions, Debt analysis and management, Leasing hire purchase and project finance, Inventory management, Working capital management,, merger, acquisitions and restructuring Stock exchange, Mutual fund ,Banking systems.

UNIT II

Accounting: Theoretical concept of accounting, Meaning and scope of accounting, accounting principles, journalising transactions, ledger posting and trial balance, negotiable instruments, Final accounts, Depreciation provisions and reserves, single entry systems double entry system, inventory valuation, joint stock company, shares and capital, debentures, management accounting: nature and scope, financial statements analysis and interpretation, ratio analysis, classification of ratios, fund flow and cash flow statements.

Practical

Case studies and practicals on financial management and accounting, Familiarisation and application of Tally software.

9. FEM 509. INTRODUCTION TO ECONOMETRICS 2(1+1)

Theory

UNIT I

Econometrics Introduction relationship with other disciplines Matrix algebra,

UNIT II

Assumptions in the classical linear regression model; Consequences of multicollinearity, heteroscedasticity, autocorrelation and remedial measures

UNIT III

Econometric model specification criteria, specification errors, measurement errors of dependent and explanatory variables, Different model specification criteria

UNIT IV

Time series econometric models, Basic ideas in fitting non-linear regression models.

Practical

Exercises on fitting classical linear regression models, detection of multicollinearity, heteroscedasticity and autocorrelation in the given data sets, Model selection using R^2 , AIC and SIC criteria; Hands on using econometric packages like SPSS, SAS and SHAZAME

7. FISHERIES EXTENSION

1. FEX. 501. PERSPECTIVES AND PRACTICES OF FISHERIES EXTENSION

3(2+1)

Major courses

Theory

UNIT I

Overview of fisheries and aquaculture sector in India and world; Special characteristics of fisheries sector and its stakeholders; Understanding extension education, research, and service; Overview of fisheries research, development and extension systems in India; Scope and importance of fisheries and aquaculture extension.

UNIT II

Critical review of philosophy, principles, concepts, and practices of fisheries extension systems and approaches; Teaching, learning and co learning; Epistemology of knowledge in fisheries – ITK *vis-à-vis* lab generated knowledge.

UNIT III

Fisheries extension – advantages and limitations of present welfare and subsidy oriented extension systems; Development and extension approaches as practiced by public agencies like Department of Fisheries, KVKs, Agricultural Technology Management Agency (ATMA), NGOs, FAO, Bay of Bengal Programme (BOBP-IGO), and by the private sector; and participatory fisheries extension approaches.

UNIT IV

Aquaculture extension system - review of extension approach as practiced by DoF, FFDA, and BFDA; Market led extension approaches; Importance of Information and Communication Technology (ICT) in fisheries extension system.

Practical

Exercises on development of extension and field manuals; Exercises on participatory learning / co-learning; Case study of extension approaches practiced by select State Departments of Fisheries, FFDA's / BFDA's, select NGOs, AMUL model; case study of market led extension approaches like e-choupal choupal, Agri Business Clinics, etc.; Critical review of experiences and lessons from fisheries extension practices from across the world; case study on the use of ICT for fisheries development; Field exposure by visiting established extension projects.

2. FEX. 502. EXTENSION COMMUNICATION AND METHODS 3(2+1)

Theory

UNIT I

Communication - meaning, process, theories and models; Traditional communication; Individual, group and mass communication, levels of communication; non-verbal communication; AV aids – selection and use.

UNIT II

Communicator - role of communicator in extension education, communicator's behaviour; communication skills; fidelity of communication; communication competence and empathy; communication effectiveness and credibility; improving oral and written communication; message – meaning, dimensions, characteristics, treatment and effectiveness, distortion of message; simulation exercises; channels of communication – meaning, dimensions, classification, selection, efficiency, credibility, use; audience or receivers; feedback; communication behaviour; social network – homophily and heterophily.

UNIT III

Communicating with fishers and fish farmers; barriers in communication; communication and social change; futuristic shape of communication technologies.

UNIT IV

Recent communication technologies – Internet based technologies, video and teleconferencing, computer assisted instructions, Information kiosks, Village Resource Centres, Community networks, WAN, MAN, AGRINet, e-Governance; Cyber extension and e-learning.

Practical

Exercises in written and oral communication; documenting and presenting success stories in fisheries, AV aids - rationale and preparation of AV aids with local resources; public speaking and presentation skills; organizing meetings, guided discussions; organizing field demonstrations and field days; preparation of information, education and communication materials on various aspects of fisheries; instructional video and ICT; Practicing tele and video conferencing, case study of a community radio, tele-centres and farmer discussion groups; designing a website on fisheries and aquaculture; developing a script and shooting a video film as an extension aid; Development and use of e-learning modules.

3. FEX. 503. PARTICIPATORY APPROACHES IN FISHERIES EXTENSION 3(2+1)

Theory

UNIT I

Participatory approaches for aquatic resources management and development: need, importance and guiding principles; Community mobilization methods - Farmer-First Approach; Trickle Down System –concept, method and processes; Knowledge Driven Extension System –concept and method.

UNIT II

Community based fisheries management and Fisheries co-management –concept, origin, importance, types, method, processes, stakeholder rights, responsibilities and participation, institutional mechanisms, implementation constraints, experiences from other countries; conflict resolution and management; Public-Private-Community Partnership.

UNIT III

Participatory Learning Approach (PLA) including role-plays, case studies, brainstorming, and ranking of priority issues, discovery-based experiential learning, participatory education methods like FGD; Participatory appraisal techniques - census mapping, resource mapping, social mapping; selection of participatory methods and their uses; Farmer Field Schools for Aquaculture.

Practical

Conducting Participatory Rural Appraisal in select villages and developing action plans; Conducting focused group discussion and developing action plan; Facilitating group formation based on the felt needs and to implement the action plans / plan of work; Reviewing national and international case studies on participatory approach to aquaculture research and development; case studies and simulation exercises on fisheries co-management /community based fisheries management.

4. FEX. 504. TRAINING FOR HUMAN RESOURCE DEVELOPMENT 3(2+1)

Theory

UNIT I

Human Resource Development – Concept and significance; Education, learning and training; Instructional design and educational technology; Theories of learning - radical behaviorism, cognitive, constructivism; training and development; Gender sensitive training.

UNIT II

Types of Training - Induction, on-the-job, off-the-job, in-service, customized, inception, trainers', participatory, web-based, fishers/fish farmers', farmer-led, vocational and echo-training; Training tools like TGroup, Fish bowl exercise, ice-breakers, team-building exercises endgames; workshop and write shop.

UNIT III

Preparation of Training Manuals- content writing; Training cycle - training need assessment, developing training objectives and outcome, developing training modules and lesson plan, logistic management and evaluation of training programme, follow-up and action plan.

UNIT IV

Facilitating Community Mobilization Process - Perception of service delivery system, level of expertise and capacity amongst the community to facilitate such services, willingness of the community to match individual interests with community interest, facilitation of resources for mobilizing community; Promoting Public-Private-Community Participation.

Practical

Training need assessment for different clientele groups; Designing training tools and manuals on fisheries; Organizing and conducting fisheries training programmes; Evaluation of training; Impact studies in terms of results (output, outcome and impact); Team building exercises.

5. FEX. 506. DIFFUSION AND ADOPTION OF INNOVATIONS IN FISHERIES 2(1+1)

Theory

UNIT I

Elements of diffusion; diffusion research – history, typology, contributions and criticisms; generalizing diffusion via meta research; innovations in fisheries – innovation development process, socio-economic status, equality and innovation development, converting research into practice; Critique on Rogers’ innovation decision process, innovation attributes and adopter categories.

UNIT II

Opinion leadership – meaning, characteristics, types and their measurement; diffusion networks; social learning theory; Change agent –meaning, roles, factors of success, change agent contact; centralised and decentralised diffusion systems; innovation in organizations - contract farming – merits and demerits; consequences of innovations – model and classification, equality in the consequences; recent studies in innovation decision process.

Practical

Case study of the diffusion process of select fisheries innovations; Analysing the factors influencing adoption and rejection of fisheries technologies and practices; case studies of select innovation diffusion models like AMUL, Grameen Bank, and WADI-NABARD/BAIF; case study of decision making pattern in fisher villages and the role of men, women and youth; case studies on opinion leaders and change agents in transfer of fisheries technologies; field visit to study select models of ToT.

6. FEX. 507. MULTIMEDIA CREATIONS AND APPLICATIONS 2(0+2)

Practical

Multimedia Environment - Multimedia hardware devices, Multimedia software tools, Multimedia content creation and integration process; Graphics and effects – scanner, other image capture methods; Image editing and 2D Animation using Photoshop; Vector graphics using Corel Draw; Digital Audio - Basic features and digitization, audio recording and dubbing, audio card, non-linear editing and mixing of different audio formats, audio editing and composing of music, special effects; Script development and Story board preparation; Digital Video - analog and digital video, video recording, capturing and conversion into different video file formats, video editing, special effects; Organization of content -choice of media, categorization of photographs, queuing of audio and video clips, logical sequencing, text entry; Multimedia Authoring - concepts, navigation planning and hyper linking; User friendly tools - MS Office Power point, Macromedia Director; Preparation of multimedia Presentation; CD/DVD writing, labeling and presentation.

7. FEX. 508. PLANNING AND MANAGEMENT OF FISHERIES DEVELOPMENT PROGRAMMES 2(1+1)

Theory

UNIT I

Importance, principles and processes in developing extension programmes; planning for sustainable development, Economic Planning- types of planning; Planning strategies at various levels- Top down and bottom up approaches. Panchayati Raj institutions; Execution of various programmes, Plan allocation and performance of fisheries 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); People's participation in extension programmes, significance, importance and approaches.

UNIT III

Critical analysis of Agriculture, Fisheries 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 fisheries development programmes, SWOT analysis; Exercises on PERT and CPM Presentation of Fisheries and Aquaculture policies of select countries; Study visits to selected extension project areas – DOE, KVKs, SAUs, and ICAR institutes.

8. FEX. 509. HUMAN RESOURCE MANAGEMENT 2(1+1)

Theory

UNIT I

Concept of management: Definition, Management process (planning, organising, staffing, leading and controlling), Managerial levels and roles. Evolution of management theories: Scientific management school, Classical organization theory school, Behavioral school, Management science school.

UNIT II

Concept of Human Resource Management(HRM), Primary activities of HRM (staff, training and development, motivation, maintenance), HR process (HRP, recruitment, selection, socialization, training and development, performance appraisal, promotion, transfer, demotion, separation).

UNIT III

HR out sourcing, Understanding equal opportunity: Guarding against discriminatory practices, glass ceiling, Managing careers: Concept of career, individual and organizational perspective, career development versus employee development, internal, external events and career stages, mentoring and coaching.

UNIT IV

Compensation dynamics: Contracts for compensation, efficiency wages, wage earning and sharing, ownership options, screening, signaling, designing of contract, types of rewards, job evaluation and establishing pay structure, executive, international and special compensation plans, employee benefits, safety and health programmes, labour relations and collective bargaining. Corporate social responsibility.

Practical

Applying management functions in a real setting; developing managerial games; creativity and problem solving techniques; understanding different perceptions and avoiding perceptual distortions; analyzing different needs of a diverse work place; performance evaluation; psychometric testing; developing training module for leadership and motivation; exercises on time management.