

Unit 1

Major fisheries resources of the world, global trends in production. Distribution, composition, trends and dynamics of major exploited fishery resources in hill streams, rivers, reservoirs, lakes, etc. Endangered and threatened species, in-situ and ex-situ conservation; Status and impact of exotic species, accidental introductions; Guidelines and policies for exotics. Reproductive biology, maturity stages, fecundity, ova diameter studies and breeding cycles, developmental biology; Length weight relationship; Condition factor, gonado-somatic index; Taxonomy of major fish groups; Modern tools in ichthyo-taxonomy; Concept of Stock and its characterization; Age and growth studies- method for determination of age, study of growth rates, direct and indirect methods. Applications of Remote Sensing (RS) and GIS in fisheries, resource mapping and forecasting; Mechanisms, methods and status of fish yield data acquisition; Ecosystem-based fisheries management tools: Productivity models, ECOPATH with ECOSIM; Monitoring, control and surveillance (MCS) systems for major fisheries. Computer softwares in stock assessment; Use of Virtual Population Analysis and Predictive models.

Unit 2

Relevance of capture fisheries in food, nutrition, employment, income and livelihood securities of fishers; Vulnerability and marginalization of fishers, small scale processors and traders to changes in resource availability, diversification, exploitation and utilization patterns; Impact of dams, river linking and fisheries regulations on the fisher communities; Land and water body use issues in fisheries; Role of extension in fisheries, mechanisms and modes of extension and their impact on capture fisheries and fishers' livelihood, alternative livelihood options; Vulnerability of fishers to natural disasters and coping mechanisms in disaster management; Block chain Technology; Fisheries co-operatives; Institutional support for fisheries development. Modes of fisheries management: Open access, regulated, advisory, participatory, user rights; International fishery regulations, treaties and instruments; Input control measures such as access control, size, type, number and power of boats, duration of fishing; Output control measures such as total allowable catch, catch quotas, licensing, technical control measures such as size limitations, closed fishing areas, closed seasons, size of nets and mesh size regulations, limited entry; Impediments to fisheries governance; UNCLOS, FAO Code of Conduct for Responsible Fisheries.

Unit 3

Composition and nutritive value, lipid types and their variations, fatty acid composition of fish liver and body oils; Triglycerides and phospholipids; Polyunsaturated fatty acids and their beneficial effects on human health; Auto-oxidation of fatty acids, pro- and anti-oxidants, oxidation indices, lipid protein interactions, rancidity, lipases and phosphor-lipases. Enzymes in fish: Their classification and mechanism of action; Vitamins in fish: vitamin deficiency diseases; Minerals and trace elements in fish; Toxins and toxic substances in fish, their bioaccumulation and bio magnification; Biogenic amines; Seafood flavours and pigments, chemical basis of flavor perception, influence of processing on flavours. Postmortem changes, factors affecting quality of fresh fish(intrinsic and extrinsic factors);Depuration of bivalves; Chilled storage of fish, different types of ice, changes during chill storage, melanosis and its prevention; Freezing of fish and shellfish: structure of water and ice, phase equilibria and freezing curves for fish, crystallization, nucleation- homogeneous and heterogeneous nucleation; Super cooling, crystal growth, eutectic point, location of ice crystals in tissue, changes during freezing; Technological aspects of freezing, packing of fresh and frozen fish for consumers, modified atmosphere packaging, controlled packaging; Frozen storage: Physical, chemical, bacterial, sensory changes; Prevention of quality loss during frozen storage, theories of cryoprotection, glazing (importance and methods).

Unit 4

Microbial changes during icing, freezing and curing, chemical control of microbial spoilage, effect of preservatives on microflora; Fermentation: Batch wise and continuous; Important fermented products, microbial injury, inactive physiological states;Microorganisms of public health significance- Sources of pathogens in seafood, infection and intoxication; Microbial food poisoning, bacteria of public health significance in fish& fishery products;Epidemiology; Botulism and staphylococcal food poisoning, food infections by *Salmonella*, *Clostridium perfringens*, *Vibrio parahaemolyticus*, *V. vulnificus*, pathogenic *E. coli*, *Listeria monocytogenes*, *Campylobacter*, *Arcobacter*(Virulence mechanisms, sources, incidences, foods involved and prevention measures); Histamine poisoning, aflatoxins, patulin, ochratoxin and other fungal toxins found in food, virus and parasites found in foods. Export documentation and certification: Certificate for export (CFE), health certificate and other certifications; Traceability issues for farm reared and wild aquatic products in

international trade; Dealing with returned consignments; Foreign trade policy of Fish and Fishery Products in Indian and World contexts; Foreign trade regulations in India.

Unit 5

History and scope of aquaculture; Aquaculture practices in different parts of the world; Status of world aquaculture: production trend, consumption scenario and emerging trends, important cultivable species of finfish and shellfish, aquatic plants and their culture practices; Extensive, semi-intensive and intensive culture of fish and prawn. Different systems of Aquaculture: Traditional, extensive, semi-intensive, intensive; Farming methods: Ponds, pens, cages, raceway, raft rope rack, monoculture, polyculture, composite culture; Culture based capture fisheries; Integrated multi-trophic Aquaculture (IMTA); Integrated fish farming; Organic aquaculture; Sewage fed aquaculture; Hi-tech aquaculture systems: Biofloc, aquaponics, RAS systems and flow through systems; Aquaculture practices for freshwater fish (carps, catfishes, snake heads, feather backs, tilapia, murrels, mahseer, trouts, etc.), freshwater prawn, brackishwater and marine shrimp and fish (seabass, milkfish, mullets, pearlspot, cobia, pompano, grouper, snappers, breams, perches), lobsters, and freshwater.

Unit 6

Productivity and carrying capacity; Trophic relationships, energy flow and nutrient cycling; Ecological stability and homeostasis; Resistance and resilience; Categories of biodiversity: Species diversity, genetic diversity and habitat diversity; Disaster Management; Biodiversity hotspots, biosphere reserves, Carbon footprint in fisheries and aquaculture; Stratospheric ozone layer depletion: effect of UV radiation on human health and ecosystem; Adaptation and mitigation strategies of climate change; Carbon sequestration; Carbon credit; Green technology; Rain water harvesting; River linking; Water budget and its significance in water conservation; Constructed wetlands. soil and water quality standards; equipment used for soil and water quality estimations, automated systems for monitoring, quality checks and management, aeration system for water quality management.

Unit 7

Nutrient and soil quality, site selection; Pond preparations: Fertilization, micro-organisms and their role. Best Management Practices (BMP) in aquaculture; Environmental Impact Assessment (EIA), Responsible aquaculture; Ecosystem approach to aquaculture; CRZ implications, CAA and its role; Ecolabeling; Organic certification. Important live feeds and

their biological features, identification of new live feeds, live feed use in different forms, advantages and disadvantages. Important microalgae, rotifers, artemia, infusoria, cladocerans, copepods, oligochaetes, nematode and insect larvae. Bio-enrichment of live feed. Biofilm/periphyton and its use, culture of single cell proteins and their nutritional quality. Bio-enrichment of live feed. Biofilm/periphyton and its use, culture of single cell proteins and their nutritional quality. Aquatic pollution: Sources, types and their impact; Pollution problems of groundwater resources (arsenic, fluoride, nitrate, pesticides), sources of contamination and management issues; Sewage, radioactive wastes, biomedical wastes, hazardous chemicals, plastics, nanoparticles; Eutrophication; Ecological sanitation: closing the loop; Toxins from fish/aquatic organisms and fish poisoning; Factors influencing toxicity; Ecological effects of toxicants; Metabolism of toxic substances; Comparative toxicology; Genotoxicity; Neurotoxicity; Ecological engineering: concepts and applications, biomanipulation, bioremediation; Restoration ecology and rehabilitation.

Unit 8

Broodstock management and seed production technology: Natural seed resources and its management, collection techniques, holding, packaging and transportation; Reproductive physiology in fish and shellfish: Endocrine control of maturation, spermatogenesis, oogenesis, spawning and vitellogenesis; Assessment of gonadal maturation: evaluation of gamete quality; Improvement of seed quality through stock up-gradation, induced breeding, synthetic hormones and its analogues and their application; Incubation of eggs; cryopreservation of gametes; Seed production of carps, snakeheads, mahseer, trout, tilapia, pearlspot, cobia, grouper, pompano, tilapia, mullets, milkfish, snappers, breams, shrimps (*Penaeus monodon*, *P. indicus*, *P. semisulcatus*, *P. vannamei*), sand lobster, spiny lobster, mud crab (*Scylla serrata*) giant freshwater prawn (*Macrobrachium rosenbergii*), mussel, edible oyster, pearl oyster. Culture practices for marine molluscs and echinoderms; mussels, oysters, pearl oysters, clams, abalone, sea cucumber. Seaweed farming: Major seaweed species of commercial importance; methods of culture; farming of agar, algin and carageenan yielding species. Integrated farming systems: Design, farming practices, constraints and economics of IFS of fish with vegetables, fodder, paddy, cattle, pig, poultry, duck.

Unit 9

Morphology and reproductive physiology; gonad anatomy; histology of gonad; Hormonal pathways and mode of control; Spermatogenesis and oogenesis; gametology (evaluation of

milt and egg); Overview of current developments in reproductive biology of commercially important finfishes and shellfishes. Genetic improvement of aquaculture candidates through selective breeding/ hybridisation. Induced spawning: Brooder development, quality and its health management, transportation of brooders, hormonal and environmental stimulation, use of different natural, synthetic hormones and analogues and their application; GnRH and LINPE models, PIT tagging, Canulation and volitional spawning, Estimation of spawning efficiency, cryopreservation of gametes. Hatchery seed production and management. Live feed culture: Microalgae, rotifers, artemia, copepods etc & bioenrichment. World trade of ornamental fish and export potential. Common varieties of exotic and indigenous ornamental fishes, their breeding & culture. Water filtration system-biological, mechanical and chemical. Types of filters, aquarium plants and their propagation methods. Lighting and aeration. Application of genetics and biotechnology for producing quality strains.

Unit 10

Definition of health and disease in fish: Pre-disposing factors, biotic and abiotic factors, stress and general adaptation syndrome; Host-pathogen-environment interaction; Role of physical (injuries, health, cold), chemical (pH, salinity, toxins, ammonia, nitrogenous waste, endogenous chemical metabolites, free radicals, oxidants) Immune systems in fish: Organization and ontogeny of lymphoid system in fish, haematopoiesis; Innate and acquired immunity, antibody and cell mediated immunity in fish; Shellfish immune system: Organization, humoral and cellular factors and quasi immune response, trans-generational immune priming. Disease prophylaxis and therapeutics. Bacterial, fungal, viral diseases of fishes in farm ponds, natural waters, and incidental outbreaks, Nutritional disorders and environmental diseases, situations for disease outbreaks, natural immunity and disease control. Control measures for fish diseases, environmental and nutritional support methods for disease management, immune modulation, immunostimulation, use of vaccines and other preventive methods. Use of chemicals, antibiotics, conventional vaccines, viral vaccines, new antiviral compounds, prebiotics & probiotics, biochemical applications in disease control, DNA and RNA vaccines, recombinant vaccines, use of RNA interference, virus and gene therapy, SPF & SPR broodstock, certification, surveillance and reporting; Quarantine, biosecurity; Disease control through environmental management.

Unit 11

Modes of reproduction in fishes: Sex determination and differentiation, sexual dimorphism, primary and secondary sex characters, bisexual reproduction, inter-sexes, hermaphroditism; Sex reversal; Parental care in fishes; Oogenesis; Spermatogenesis; Mechanism of oocyte maturation and ovulation, spawning, gamete activation and fertilization, environmental and neuroendocrine regulation of reproduction in fish, neuroendocrine system in crustaceans; Synthetic hormones for breeding in aquaculture. Transgenesis in fish: Methods of gene transfer in fishes, screening for transgenics, applications of transgenic fishes, transgenic fishes as bioreactors; Basic requirements for animal cell culture technology: Media and supplements, basic aseptic techniques, primary cell culture, cell lines, types of cell lines and their applications, characterization and maintenance of cells; Fish cell line repositories. Cryopreservation of fish gametes and embryos. Probiotics, Nutraceuticals, Gnotobiotics. Recombinant proteins of commercial importance: enzymes, hormones, bioactive compounds, therapeutic proteins. Antimicrobial Peptides and their applications.

Unit 12

Definition of energy, basic fish bioenergetics, energy partitioning & different forms of energy, energy budget equation, metabolic scope, principles of energy estimation, estimation of gross energy of feed and feed ingredients; Sparing action of nutrients; P:E ratio; Role of nutrients on growth and flesh quality: Concept of growth, growth curve, correlation of growth with body weight and length, biotic and abiotic factors affecting growth, critical nutrients for improving flesh quality; Assessing nutritional requirement of larvae, fingerlings, young fish, grow-out of commercially important finfish and shellfish; Role of nutrients on reproduction. Principles and methods of feed formulation; Feed ingredients, classification, evaluation of ingredient quality; Feed additives/supplements: Classification, function, dietary inclusion level; Anti-nutritional factors and methods of detoxification. Digestive enzymes in fish. Digestive hormones, nutrient regulation of endocrine functions; Effects of broodstock diets on eggs and larval quality; Ontogeny of larval digestive physiology. Nutrients and their effects on fish health: Nutritional imbalances, nutritional deficiency, nutrients and immunity, hyper- and hypo-vitaminosis. Nutraceuticals: Role in immunity and disease resistance.