

SYLLABUS FOR RECRUITMENT OF
ASSISTANT DIRECTOR OF FISHERIES
2022-23

1. AQUACULTURE

History of aquaculture: present global and national scenario; Systems of aquaculture: pond culture, pen culture, cage culture, running water culture and zero water exchange system; Extensive, semi-intensive, intensive and super intensive aquaculture in different types of water bodies; Organic aquaculture; Pre-stocking and post stocking pond management; Major candidate species for aquaculture: freshwater, brackish-water and marine; Monoculture, polyculture and integrated culture system.

Nursery rearing and grow-out ponds preparation and management; Control of aquatic weeds and algal blooms, predatory and weed fishes, liming, fertilization/manuring, use of biofertilizers, supplementary feeding; Traits of important cultivable fish and shellfish and their culture methods: Indian major carps, exotic carps, air breathing fishes, cold water fishes, freshwater prawns, mussels; Sewage-fed fish culture; Use of agro-industrial waste and biofertilizer in aquaculture; Composite fish culture system of Indian and exotic carps: competition and compatibility; Exotic fish species introduced to India. Culture of other freshwater species; Medium and minor carps, catfish and murels. Integration of aquaculture with agriculture/ horticulture; Integration of aquaculture with livestock; Cultivation of aquatic macrophytes with aquaculture (makahana); Paddy cum fish/shrimp culture.

Principal nutrients and nutritional requirements of cultivable fish and shellfish; Nutritional energetics: definition and forms of energy partitioning; Methods of feed formulation and manufacturing; Forms of feeds: wet feeds, moist feeds, dry feeds, mashes, pelleted feeds, floating and sinking pellets; Feed additives: binders, antioxidants, enzymes, pigments, growth promoters, feed stimulants; Feed evaluation: feed conversion ratio, feed efficiency ratio, protein efficiency ratio, net protein utilization and biological value; Feeding devices and methods; Digestive enzymes; Feed digestibility; Factors affecting digestibility; Nutritional deficiency diseases.

Developments in biochemistry and its transformation to molecular biology; Cell structure, water and major molecules of life. Carbohydrate chemistry: structure, classification, functions (mono, di and polysaccharides), isomerism and mutarotation. Metabolism of carbohydrates: glycolysis, gluconeogenesis, glycogenolysis, glycogenesis; TCA cycle, central role of TCA cycle in metabolism; Protein chemistry: classifications and functions; Classification, structure, function and properties of amino acids; Essential and non essential amino acids; Digestion and absorption of proteins; Essential fatty acids and phospholipids; Digestion and absorption of lipids. Lipid autooxidation. Significance of Omega-3 and Omega-6 fatty acids; Steroid and peptide hormones: chemistry and function. Structure and functions of fat and water soluble vitamins; Nucleic acids: structure function and importance genetic code.

Candidate species of phytoplankton and zoo-plankton as live food organisms of freshwater and marine species; Biology, culture requirements and methodology of important live food organisms; Green algae, blue-green algae, spirulina, diatoms, infusoria, rotifers, cladocerans, tubifex, brine shrimp, chironomids; Culture of earthworms, bait fish and forage fish.

World trade of ornamental fish and export potential; Fabrication, setting up and maintenance of freshwater and marine aquarium; Aquarium plants and their propagation methods; Breeding and rearing of ornamental fishes; Management practices of ornamental fish farms; Common diseases and their control; Conditioning, packing, transport and quarantine methods.

Traits of important cultivable fish and shellfish (seabass, mullet, milkfish, grouper, cobia, snappers, ayu, pearlspot, tiger shrimp, white shrimp, mud crab, mussel, clam, oysters (edible and pearl oyster), lobster, seaweeds; Shore based aquaculture system: traditional (pokkali, bheries, gazanis, khazans), semi-intensive, intensive aquaculture practice of commercially important species of fish and shellfish; Methods of shellfish culture, rafts, racks, cages, poles and ropes; Seaweed culture: Pearl culture: Sea ranching.

Salient features of reservoir limnology and their significance to fisheries development; management of small, medium and large reservoirs; present status and future prospects in reservoirs fish production. Role of cage and pen culture in enhancement of fish production from reservoirs; history of cage culture, advantages of cage culture: selection of suitable site of cage culture; cage materials, designs, shape, size and fabrication; cage frames and supporting system. History of pen culture, pen materials, fabrication; breeding of fish in pen; rearing of spawn in pen: grow-out from pens. Suitable species for culture in cages and pens; constraints in cage and pen culture: economics of cage and pen culture.

Principles of genetics and breeding; Gene and chromosome as basis of inheritance; Mendel's law of inheritance; Gene interactions: dominant and recessive epistasis; Sex linked genes, sex influenced and sex limited traits; Chromosome manipulation techniques - androgenesis, gynogenesis and polyploidy and identification of ploidy; Cross breeding (hybridization): types of cross breeding, heterosis and design of cross breeding programmes, hybridization in different fishes.

Biotechnology: Introduction to Biotechnology, scope and importance in fisheries/aquaculture; Structural organization of prokaryotic and eukaryotic cell: Concepts of gene and genetic code, transcription and translation, mutations and their implications. Post transcriptional modification and RNA processing; Gene regulation and expression in prokaryotes and eukaryotes; DNA sequencing; Recombinant DNA technology: vaccines; Transgenic fish and Gene transfer technology; Hybridoma technology; PCR: immunoblotting; ELISA; Principle of hybridization: Northern blotting; Western blotting; Southern blotting; DNA fingerprinting; Bioinformatics: Biological Databases and tools: Types of biological databases; Primary and secondary databases; PDB, NCBI, formats and contents.

Natural breeding of finfishes; Selection of riverine spawn collection sites, gears used and methods of collection; Spawn quality and quantity indices; Sexual maturity and breeding season of various cultivable species; Development of gametes in male and female; Fish egg and embryonic development; Methods of breeding: bundh breeding: wet and dry bundhs, collection and hatching of eggs, factors involved in bundh breeding; Induced breeding of warmwater finfishes, environmental factors affecting spawning, sympathetic breeding; Hypophysation of fishes; Fish pituitary gland: its structure, collection, preservation and preparation of extract for injection, dosages and methods of

injection; Synthetic hormones used for induced breeding of carps; Different types of fish hatcheries: traditional, Chinese, glass jar and modern controlled hatcheries; Use of anesthetics in fish breeding and transport. Breeding techniques for Indian major carps, exotic carps, mahaseers, trouts, tilapias, catfishes, grey-mullets, milk fish, pearl spot, sea bass, sea hourse, groupers, pacu, cobia, pompanos and indigenous fishes, etc.

Life cycle of important shellfish (*Penaeus monodon*, *P. indicus*, *Macrobrachium rosenbergii*, *P. Vannamei*, *Scylla serrata*, lobster, edible, oyster, pearl oyster, fresh water mussel, holothurians, horse-shoe carb, *Sepia*, *Loligo*, cray fish etc.). Maturation stages of *Macrobrachium rosenbergii* and *Penaeus monodon*. and *P. Vannamei*. Induced maturation in *Penaeus monodon* and *P. Vannamei* *P. Indicus* by eye stalk ablation. Breeding and hatchery management of *Penaeus monodo*, *Macrobrachium rosenbergii*, crabs, lobster, mussel, edible and pearl oyster.

2. AQUATIC ANIMAL HEALTH MANAGEMENT

Microbial Techniques: Types of media, types of sterilization: physical and chemical agents, cultivation of microorganisms, staining techniques: simple, differential, structural staining; enumeration of micro-organisms, culture preservation methods. Bacterial metabolism: Nutrient requirements, nutritional types, bacterial photosynthesis and their ecological significance. Microbial growth: Growth phases, measurement of cell growth, factors affecting growth: influence of physico-chemical factors: pH, temperature, moisture, light, osmotic pressure, fermentation: types and significance; Aquatic Microbiology: Introduction and scope of aquatic microbiology, aquatic environment as habitat for microorganisms: bacteria, cyanobacteria, fungi, algae, parasites and viruses; distribution of microorganisms and their biomass in rivers, lakes, sea and sediment. Nutrient cycles- carbon, nitrogen, sulphur, phosphorus, iron and manganese cycles. Sewage microbiology, self purification in natural waters, sewage treatment, drinking water microbiology, sanitary quality of water for aquaculture, bioremediators.

Significance of finFish and Shellfish diseases in aquaculture. Host, Pathogen and Environment Interaction. Disease development process; Pathogenicity mechanism of parasite, bacteria, virus and fungus. Casehistory and clinical sign in disease diagnosis. Nutritional diseases . Non-infectious diseases.

History to immunology. Types of immunity: Innate and adaptive immunity, cell mediated and humoral immunity, cells and organs of the immune system. Antigens – structure and types. epitopes, haptenes. Antibody:: fine structure, classes with structure and functions, antigenic determinants on immunoglobulins. MHC complex: types, structure, and functions. Antigen-antibody interactions: principle, antigenrecognition by B-cells and T cells. Antigen-antibody reaction: Defense mechanism in finfish and shellfish-specific and non specific immune system. Vaccines: types of vaccines: whole cell vaccine, purified macromolecules, recombinant: vector, DNA vaccines and multivalent subunit vaccines, modes of vaccine administration. Serological methods in disease diagnosis. Immunostimulants: types, mechanism of action, modes of administration. Immunoassays, immunodiffusion, ELISA, immunofluorescence, neutralization, radioimmunoassay, serotyping.

Pharmacology: History, Importance, Terms and Definitions, Drug development. Screening and Nomenclature, Scope of pharmacology in fishes. Source of Drugs. Pharmacokinetics: Biological membrane, absorption, distribution, biotransformation and Excretion of drugs. Factors modifying drug action, Adverse drug effects, drug interaction and Bioassay of drugs. Drugs used in fish transportation. Recent advances in Pharmacology, biostatistics in experimental Pharmacology, Pharmaceutical industry.

Scope and current scenario of therapeutics in aquaculture. Chemotherapy: History, definition, terms used and classification of AMA. Antibacterial agents, mode of action, general principles, classification, Antibiotics, different classes and their mode of action, properties etc. Biologics: Immuno-stimulants and Vaccines-Principles in preparation/ formulation, mechanism of action. Drug formulation for aquaculture-Principles in preparation/ formulation, mechanism of action, drug leaching, stabilizer, binders and dosage. Therapeutics in aquaculture: Classification, pesticides, fungicides/ algicides, hormones, anaesthetics, flesh color enhancers, Chemicals of therapeutic value. Law priority aquaculture drugs.

General Toxicology: Branches of Toxicology, Historical developments. Classification of poison. Types of poisoning, Toxicity testing, Chronicity factor. Untoward effects, Common causes, Diagnosis of poisoning, Factors modifying toxicity. Toxicokinetics, Toxicodynamics, General approaches to diagnosis and treatment of poisoning. Systemic Toxicology: Toxicity caused by metal and non-metals.

Disease surveillance and reporting. Quarantine and health certification in aquaculture. Health management strategies in Aquaculture: Vaccines, Immuno-stimulants. Bioremediation, Probiotics, Crop rotation, Good and Best management practices. SPF and SPR stocks: development and application. Bio-security principles, Sanitary and phytosanitary Agreement, Disease control through environmental management. Importance of Biofilm, Biofloc, Periphyton in aquatic Health Management, Zoonotic diseases.

3. FISHERIES RESOURCES MANAGEMENT

Principles of taxonomy. Nomenclature; Morphological, morphometric and meristic characteristics of taxonomic significance. Major taxa of inland and marine fishes up to family level. Commercially important freshwater and marine fishes of India and their morphological characteristics. Introduction to modern taxonomic tools: Karyotaxonomy, DNA barcoding, protein analysis and DNA polymorphism.

Study of external morphology and meristic characteristics of crustacea and mollusca. Classification of crustacea and mollusca up to the level of species with examples of commercially important species.

Study of external and internal anatomy of important groups of finfish. Digestive system and associated digestive glands. Food and feeding habits of commercially important fishes. Qualitative and quantitative methods of analysis of gut contents. Circulatory system, respiratory system, nervous system, urino-genital system, endocrine system, skeletal systems and sensory organs. Reproductive biology: maturity stages.

gonado-somatic index, ponderal index, fecundity, sex ratio and spawning. Eggs and larval stages and developmental biology.

Study of external and internal organization of commercially important crustaceans and molluscs. Digestive, respiratory, circulatory, nervous and reproductive systems. Food and feeding habits, growth, moulting, length: weight relationship. Reproductive biology, larval stages.

Global inland fish production data. Capture fishery resources of India. Problems in the estimation of inland fish catch data. Fishing crafts and gears. Major riverine and estuarine systems of India. Major brackish water lakes and their fisheries. Fisheries of major reservoirs/ natural lakes of India. Cold water fisheries of India.

Circulation; Excretion; Osmoregulation; Reproductive physiology; Muscle physiology; Sense organs; Energy and nutrient status of food; Nitrogen balance; Effect of environmental factors on physiology of fin and shellfishes.

Overview of marine fisheries resources of the world and India. Major exploited marine fisheries of India, their developmental history and present status. Important pelagic, demersal fish, shellfish and seaweed resources of India. Potential marine fishery resources of the India's EEZ. GIS and Remote sensing in marine capture fishery.

Segregation of stocks: principles of stock assessment; population age structure. Von Bertalanffy growth parameters. Estimation of total fishing and natural mortality; The concept of yield, yield in number and yield in weight, yield per recruit, yield curve; Yield models. The concept of Maximum Sustainable Yield and Maximum Economic Yield; Biological symptoms of under-fishing and over-fishing. Analytical models of fish stocks.

Selected aquatic mammal, reptile, amphibian and birds species of India relevant to fisheries: taxonomic status, identification characters, distribution, abundance, habitat, exploitation, threats and conservation. Biology of aquatic animals: Cetaceans (whales, dolphins, porpoises and narwal), Sirenia (manates and dugongs), Carnivora (seals, sea lions walruses, polar bear and otter), Sea turtles, tortoise, crocodiles, sea/freshwater snakes and amphibians; IUCN criteria: red list, Wild Life Protection Act.

4. AQUATIC ENVIRONMENT MANAGEMENT

Classical methods of analytical chemistry, volumetry and gravimetry. Composition of waters: surface water, ground water and sea water. Dissolved gasses: Measurement of temperature, transparency, turbidity, determination of pH, electrical conductivity, salinity, chlorinity, total solids (TDS, TSS, TVS, TVDS), dissolved oxygen, free carbon dioxide, total alkalinity, total hardness, Calcium, Magnesium, Inorganic Nitrogen (Ammonium and Nitrate) and phosphorus. Water quality criteria/ requirements for Aquaculture. Soil Chemistry: Physical properties of soil; soil colour, texture, structure, pore size, bulk density, water holding capacity. Soil types and their distribution. Soil chemistry: soil colloids, cation exchange, organic carbon, Carbon-Nitrogen ratio, soil fertility. Soil reaction: acidity, alkalinity, conductivity, redox potential.

Introduction to limnology: inland water types, their characteristics and distribution; ponds and lakes; streams and rivers; dynamics of lentic and lotic environments; Famous lakes of the world and India; Physical and chemical conditions and related phenomena; biological relations: influence of physical and chemical conditions on living organisms in inland waters. Plankton: planktonic organisms; seasonal changes of body form in planktonic organisms; primary productivity: Aquatic plants; Nekton; Benthos; Biological productivity of inland waters; trophic dynamics; successional phenomena; indices of productivity of lakes; artificial enrichment; ecological succession.

Divisions of marine environment: pelagic, benthic, euphotic, aphotic divisions and their subdivisions. Life in oceans: general account of major groups of phytoplankton, sea weeds, major zooplankton groups. Vertical migration of zooplankton, Phytoplankton-Zooplankton relationship, Inter tidal ecology: Rocky shore, sandy shore and mud flats. Mud banks; Boring and fouling organisms; Bioluminescence and indicator species. Blooms, Red tides.

Aquatic productivity, nutrient cycles, energy flow, food chain: animal associations: symbiosis, commensalisms, parasitism, prey-predator relationship, host parasite relationship. Ecological: lagoons, estuaries, mangroves, coral reefs, flood plains, coastal wet lands, bheels, oxbow lakes. Threats to biodiversity: habitat destruction, introduction of exotic species; marine parks and sanctuaries. Conservation programmes for endangered species, *ex situ* and *in situ* conservation, captive breeding and management of endangered species. Natural Resources: renewable and non-renewable: Ecosystems. Concept of an ecosystem, Solid Waste Management: causes, effects and control measures of urban and industrial wastes. Pollution case studies. Environmental ethics: Issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust; Environment Protection Act: Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act.

Introduction to Oceanography: classification; expeditions national and international. Earth and the ocean basin, distribution of water and land; relief of sea floor; Ocean Waves: Beaufort Scale; Tsunamis, Seiches, Ocean Tides, Ocean Currents. Ekman spirals, upwelling, sinking, gradient currents; thermohaline circulation: El-Nino; thermal properties of sea water; Residence time of constituents in seawater; transmission of sound; Salinity and temperature of surface layer, T-S diagram: Water masses of Indian oceans.

Estuaries, Wet lands and Lagoons, Living resources: Non living resources. Principles of remote sensing: Data Quality. Remote Sensing for Coastal Management. Geographical Information System (GIS); Coastal Regulation Zone (CRZ) Act. Coastal regulation zones for main land and island: Environmental policies, planning, administrative and regulations. CRZ mapping. Integrated Coastal Zone Management (ICZM); Environmental Impact Assessment (EIA): Hazard, risk, vulnerability, disaster, capacity building. Multi-hazard and disaster vulnerability of India. Types of natural and manmade hazards in fisheries and aquaculture: cyclones, floods, droughts, tsunami. El-nino, algal blooms, avalanches, pollution, habitat destruction, over fishing, introduction of exotic species, landslides, epidemics, loss of bio-diversity etc. Pre-disaster; During disaster; Post-disaster; Agencies involved in monitoring and early warnings at district, state, national and global levels. Sea safety and health.

Aquatic pollution, physical, chemical and biological classification of water pollution; Oxygen demand; BOD; COD; Oxygen budget; Organo-phosphorous compounds; Polychlorinated biphenyls (PCBs); Bioaccumulation and impact on aquatic fauna and human health; toxicology. Heavy metals: Interaction of heavy metals with water and aquatic organisms. Bioremediation and Phytoremediation. Oil pollution; Treatment of oil spills at sea: Beach Cleaning; Toxicity of Petroleum Hydrocarbons; Ecological Impact of Oil pollution: Transmission of Human Pathogenic Organisms; Zoonosis; Development of Antibiotic Resistance and its impact; Biofilms and Biocorrosion; Radioactivity, Radionuclide polluting, special effects of radioactive pollution.

5. FISHERIES ECONOMICS, STATISTICS AND EXTENSION

IT and its importance. IT tools, IT enabled services and their impact on society; Operating systems: basic concepts, introduction to WINDOWS and LINUX Operating Systems; Local area network (LAN), Wide area network(WAN), Internet and World Wide Web, HTML and IP; AV aids; video conferencing; communication process.

Census and sample surveys, Diagrammatic and graphical representation of data: bar diagrams, pie-diagram, histogram, frequency polygon, frequency curve; Mean deviation, Variance and Standard Deviation. Coefficient of variation; Normal Curve, Concepts of Skewness and kurtosis. Random variable, concepts of theoretical distribution; Binomial, Poisson and Normal distributions and their use in fisheries. Tests of significance based on Normal, t, and Chi-square distributions; Length weight relationship in fishes; applications of linear regression in fisheries.

Macroeconomics, Micro-economics; theories of demand, supply; market: equilibrium price, utility, Elasticity: price, income, cross, application of elasticity in fisheries managerial decision. Costs and returns: breakeven analysis of fish production system; marginal cost and return, law of diminishing marginal return, economies of scale and scope, revenue, Significance or importance of marginal cost; balance of payments, economic growth and sustainable development.

Extension education and fisheries extension; formal and informal education; Fisheries extension methods: transfer of technology process; important TOT programs in fisheries; role of NGOs and SHGs in fisheries; Fisheries co-management; Extension program planning and evaluation; Basic concepts in rural sociology and psychology and their relevance in fisheries extension; social change, gender issues in fisheries.

Role of credit for fisheries development, credit requirements of fishers, source and type of credit; returns, risk bearing ability and recovery in fisheries sector; role of NABARD in fisheries development; Basic accounting procedures, profit and loss account. core marketing concepts: market structure, functions and types, marketing channels and supply chain, marketing margins, marketing environment, marketing strategies, product development and product mix, consumer behavior and marketing research; fish business management; Organizational behavior, human resource planning, new dimensions in fish business environment and policies; processing, marketing and exports. Concept of entrepreneurship; entrepreneurial and managerial characteristics; Venture capital. Contract

farming and joint ventures, public-private partnerships. Fiscal and monetary policies and its impact on entrepreneurship.

Central and State responsibilities for fisheries development, organizational set up of fisheries administration; Functions and powers of functionaries of department of fisheries, corporations and cooperatives. Role of Central and State Government in the regulatory activities of Aquaculture and fisheries. Implementation of community based resource management plans. Fisheries legislation: Overview of fisheries and aquaculture legislations in India. Indian Fisheries Act, 1897. Environmental legislation: Water Act, Air Act and Environmental (Protection) Act. International environmental legislation and its impact on fisheries; Land reforms legislation as applicable to aquaculture. Judicial judgments relating to Aquaculture. Coastal Regulatory Zone (CRZ) and Aquaculture Authority of India. Brackishwater aquaculture act, Marine fisheries policy, International Law of the Seas and international commissions on fisheries and their impact.

Introduction to GATT and WTO; Agreement on Sanitary and Phytosanitary Measures (SPS), Seafood Export Regulations; Non-Tariff Barriers (NTBs) and Agreement on Anti-Dumping Procedures. Fisheries Subsidies and WTO. Fisheries Trade and Environment: protests against globalisation and WTO. Intellectual Property Rights (IPR) and different forms; Patents and patenting process.

6. PROCESSING TECHNOLOGY

Carbohydrates: Naturally occurring polysaccharides in foods. Seaweed polysaccharides – sources and uses; Lipids: metabolism of lipids, oxidation of fatty acids, lipoproteins; VLDL and HDL and their importance; Proteins: metabolism, deamination, decarboxylation, metabolic fate of amino acids, nitrogen balance. Amino acids of fish and shellfishes and importance of essential amino acids. Non-protein nitrogen substances in fishes. Vitamins in fish: water soluble, fat soluble; Minerals in fish: micro- and macro-elements, trace elements, significance in human nutrition. Food additives: types and their chemical nature, emulsifiers and antimicrobial additives, Chemistry of taste, flavour and odour components in foods, Assessment of quality of food; Nutritive value of foods: Nutritive value of proteins PER, BV digestibility coefficient, NPU values, pepsin digestibility.

Freezing technology; changes in fish after death, spoilage and pathogenic microorganism. Handling of fresh fish; sanitation in processing plants. Chilling of fish: methods and equipment for chilling; icing, refrigerated or chilled sea water, chilling rate; spoilage of fish during chilled storage; use of antibiotics and chemicals; freezing rate; methods of freezing, freeze drying, physico-chemical changes that occur during freezing, protein denaturation, fat oxidation, dehydration, drip; protective treatments: polyphosphate, glazing, antioxidants, packaging; thawing of frozen fish HACCP in freezing industry.

Advantages of canning in relation to preservation methods; commercial sterility. Absolute sterility, pasteurisation and sterilization; preparation of raw material, packing, pre-cooking, exhausting, seaming, retorting, cooling labelling and storage. Principles of

thermal processing; Cold spot and its importance, convection and conduction type of packs; estimation of F_0 value of the process (D-value, Z-Value TDT, F-value, lethal rate). Commercial sterilization, 12-D concept. Spoilage of canned foods, types, causes and preventive measures. Types of packaging materials for canned foods, metal containers (Tin Plate, TFS, Aluminium cans) and retortable pouches.

Processing of fish by traditional methods: salting, sun drying, smoking, marinading and fermentation. Packaging and storage of salted and dried fish. Fish preservation by smoking; Hurdle technology in fish preservation and processing. Marinaded and fermented fish products; Fish and prawn pickles, fish sauce and fish paste; Principles and methods of preparation of various fish paste products like fish sausage, fish ham, surimi, fish cake, kamaboko etc. Fish muscle structure, myofibrillar protein and their role in elasticity formation. Extruded products Value addition; Diversified fish products: battered and braided products: fish finger, fishcutlet, fishwafer and fish soup powder etc and imitation products. HACCP in safe products production.

Role and significance of microorganisms in nature and in foods. Sources and types of microorganisms in fish and fishery products. Enumeration of microorganisms in food by conventional and rapid techniques. Microbial principles of fish preservation and processing by application of low temperature, high temperature, drying, irradiation and chemicals. Microbiology and spoilage of fresh, semi processed and processed fish and fishery products. Food borne pathogens involved in infective and intoxication type of food poisoning; Marine toxins: shellfish toxins, scombroid toxins, ciguatera toxins and puffer fish toxins; mycotoxins, parasites and viruses.

Fish meal; packaging and storage; Fish oil, body oil, liver oil, extraction, purification, preservation, storage, application; Shrimp wastes: chitin, chitosan, production. uses. Fish protein concentrate. Fish hydrolysate, partially hydrolyzed and deodorized fish meat, functional fish protein concentrate and their incorporation to various products; Fish silage; Fish maws, shark leather, fish glue, fish gelatin, isinglass, pearl essence, shark fin rays, beach-de-mer, Utilization of seaweeds: agar agar, algin, carrageenan.

Importance of packaging in fish processing, functions, objectives and requirements; Packaging materials, basic and laminates; Properties of packaging materials and their use in protective packaging with special reference to food. Packaging equipment and machinery; Flexible packaging materials; rigid containers, thermo-form containers, glass containers, corrugated fiber boards, duplex cartons, edible packaging materials. Laminations and co-extrusions. Retort pouch packaging: advantages and disadvantages; vacuum packaging, MAP. Safety and legislation aspects of packing. Labeling and bar coding.

Quality dimensions of seafood: sensory, intrinsic, quantitative and affective parameters. Pre-harvest and post harvest factors affecting quality; Application of HACCP concept in surveillance and quality assurance programmes for raw, frozen, canned, cured, irradiated, cooked and chilled, modified atmosphere packaged and freeze dried products. Food laws and standards, Role of export inspection council and export inspection agency and MPEDA in fish and fishery products. Certification system for fish and fishery products. EU legislation on traceability of fish and fish products, FSSA, FDA, ISO.

7. FISHERIES ENGINEERING AND TECHNOLOGY

Laws of Thermodynamics, Laws of perfect gases, Thermodynamic processes. Application of First and Second law of Thermodynamics in refrigeration. Thermodynamics cycle, entropy, enthalpy; Types of refrigeration system: Air refrigeration, vapour absorption refrigeration system. Vapour compression refrigeration system: Refrigeration plant: Frozen product storage capacity of cold storage, usage of Ante-room; Refrigeration systems; Compressors; Evaporator; Condenser; Refrigerants; Types of Freezers; Refrigerated sea water (RSW), Chilled sea water (CSW). Refrigerated transport; Cooling load: Unit of refrigeration, coefficient of performance (C.O.P); Theory of machines; Study of equipments used in fish processing with particular reference to canning, sausage, freeze drying and irradiation.

Traditional fishing crafts of India. Basic geometric concepts and important terminologies of fishing vessel. Volume of displacement; centre of gravity (CG); centre of buoyancy (CB); vertical centre of gravity (VCB); longitudinal centre of gravity (LCB). Stability of fishing vessels: longitudinal and transverse. Various equilibrium of ships: stable, unstable and neutral; Light weight, Dead weight, Tonnage system: Gross Registered Tonnage (GRT), Net Registered Tonnage (NRT). Boat building materials: Choice of construction materials; Fundamental of heat, thermodynamics laws, classification of heat engines, comparison of Internal combustion engines and external combustion engine, Fuel supply system of marine diesel engine, petrol engine, Marine engine cooling system, Indirect cooling using heat exchanger; Types of Lubrication system, marine diesel engine lubrication system, power transmission system for inboard and outboard engines. Estimation of power for internal combustion engines such as IHP, BHP, FHP, efficiencies. Propeller Technology: Hull efficiency, Quasi-propulsive coefficient, propeller terminology, propeller selection, fixed pitch propeller, controllable pitch propeller.

Land Surveying; Chain surveying; Compass surveying; Leveling; Plane table surveying; Contour surveying; Simpson's rule, volume of regular and irregular shape as applied to stacks and heaps; Soil and its properties; Ponds: classification of ponds: excavated ponds, embankment ponds, barrage and diversion ponds; rosary system and parallel system. Planning of fish ponds; Dykes, types of dykes viz., peripheral dykes, secondary dyke, design of dykes, construction of dykes. Water distribution system: Water control structures; Water budget equation; Site selection, planning and construction of coastal aqua farms. Brackish water fish farms: tide fed, pump fed farms, site selection, topography, tidal amplitude, soil and water; Hatcheries: site selection, infrastructural facilities; water supply system, main hatchery complex Aerators; Pumps; Filters.

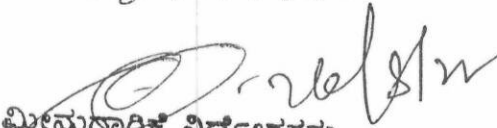
Development fishing gears and Fishing Technology: Evolution of Fishing gears: Mechanization of Fishing; Subsidiary and Auxiliary gears. Classification of fishing gears and methods: FAO classification of fishing gear and methods of the world: International Standard Statistical Classification of Fishing gear (ISSCFG). Fishing gear materials; Preparation of nylon (PA 6.66) material; Construction of twisted netting materials: Yarn, single yarns, folded yarns, netting twine, cable netting twine and cable netting twine of higher order; Construction of ropes and their higher order; construction of braided netting twines. Properties of netting material: physical properties- Density, twist and amount of twist, Breaking strength-tenacity: Classification of floats:

Sinkers: Choice of netting materials for trawl, gillnet and purse seine. Classification of trawl gears. 2 seam trawl; 4 seam trawl and wing trawl. Design and construction of wing trawl. Rigging of trawl gear: Arrangements of bridles, sweep lines and attachment of ground gears: tickler chain, bobbins and rock hoppers and attachment of otter board

Principles of navigation: terms and definitions, finding positions and method of position fixing magnetic Compass-parts and functions, cardinal, inter cardinal, three letter and lay points pelorus and azimuth mirror, method of observation. Types of speed logs: patent log, impeller log. Types of marine charts, Mercator and gnomonic projections great circles and rumba lines. chart collections and chart readings, chart observation and fixing positions. The IALA-buoy age systems, cardinal and lateral marks, meaning of shapes, colours and lights top marks and explanation of approaching, international code of signals, flag signals mars code and storm signals general system, brief system and extended system, storm signals stations Indian coasts, Fog signals, types and methods; Distress signals, methods, types and communication international regulations for preventing collision at sea and recognition of lights and shapes at sea. Observation of radar and parts and functions of radar, aneroid barometer, parts and functions of echo sounder, and sonar, observation of GPS; Principles of seamanship; Life saving appliances; Preparing vessel to face heavy weather.

Structure of various commercial fishing gears. Rigging of fishing gears: Bridles, sweep lines, otter boards, floats and ground gears arrangements; Otter door: Different types of otter doors. Fishing accessories; thimbles, shackles, C-links, rings, G-links, Kelly's eye, stopper, bottle screw, Deck layout of different fishing vessels. Trawling: Beam trawling; otter trawling; side trawling; twin trawling out rig trawling bull trawling and mid water trawling, Constructional details of single boat purse seine; two boat purse seine and method of operation; Types of gill net; Line fishing; long line, tuna long line, vertical long line, pole and line and trolling line. Operation of beach seine, boat seine and traps. Selectivity in fishing gear and by catch reducing devices; Deck equipments; Fishing equipment: Fish finder, GPS navigator, sonar, net sonde, gear monitoring equipment.

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ಬೆಂಗಳೂರು