Department of Fisheries
University of Dhaka

Syllabuses for B. S. Hon's Course
(from Session: 2011-12)

First Year B. S. Honours

Course No.	Course Name	Credits	
FISH 101	Fisheries Zoology I: Non-chordates	3	Departmental
FISH 102	Fisheries Zoology II: Chordates	2	Departmental
FISH 103	General Ecology	2	Departmental
FISH 104	Biostatistics	3	Departmental
FISH 105	Ichthyology	3	Departmental
FISH 106	Limnology	3	Departmental
Biochem-11	Biochemistry-I	4	Extra-Departmental
FISH 107	Practical and Field Work	4	Departmental
FISH 108	Viva-voce	2	Departmental
Total:		**26 Credits**	

Second Year B.S. Honours

Course No.	Course Name	Credits	
FISH 201	Aquatic Pollution and Ecotoxicology	2	Departmental
FISH 202	Fish Physiology	3	Departmental
FISH 203	Aquaculture Nutrition	3	Departmental
FISH 204	Fisheries Extension	2	Departmental
FISH 205	Inland Aquaculture	4	Departmental
FISH 206	Fisheries Microbiology & Quality Control	4	Departmental
FISH 207	Fisheries Mathematics	2	Departmental
Biochem-12	Biochemistry-II	4	Extra-Departmental
FISH 208	Practical and Field Work	4	Departmental
FISH 209	Viva-voce	2	Departmental
Total:		**30 Credits**	

Third Year B. S. Honours

Course No.	Course Name	Credits	
FISH 301	Coastal Aquaculture	3	Departmental
FISH 302	Fish Genetics and Molecular Biology	3	Departmental
FISH 303	Aquaculture Engineering	3	Departmental
FISH 304	Fisheries Economics	2	Departmental
FISH 305	Fisheries Systematics	3	Departmental
FISH 306	Fish Harvesting and Handling	2	Departmental
FISH 307	Fish Population Dynamics	4	Departmental
FISH 308	Rural Sociology	2	Departmental
FISH 309	Fish Feed Management	2	Departmental
FISH 310	Practical and Field Work	8	Departmental
FISH 311	Viva-voce	2	Departmental
Total:		**34 Credits**	

Fourth Year B. S. Honours

Course No.	Course Name	Credits	
FISH 401	Fisheries Resources Management	4	Departmental
FISH 402	Oceanography and Marine Biology	4	Departmental
FISH 403	Fish Breeding and Hatchery Management	4	Departmental
FISH 404	Fish Processing and Preservation	3	Departmental
FISH 405	Fish Pathology and Parasitology	4	Departmental
FISH 406	Environmental & Fisheries Impact Assessment	2	Departmental
FISH 407	Fisheries Marketing	2	Departmental
FISH 408	Fish Ecology	3	Departmental
FISH 409	Research Methodology	2	Departmental
FISH 410	Practical and Field Work	6	Departmental
FISH 411	Internship	2	Departmental
FISH 412	Viva-voce	2	Departmental
Total:		**38 Credits**	

FISH 101 Fisheries Zoology I: Non-chordates 3 Credits

1. Classification of all invertebrate Phyla up to Class.
2. Discussion of the following groups:
   - **(a) Protozoans**: Body covering and skeletal structures, locomotory organelles and locomotion, nutrition, reproduction and development.
   - **(b) Sponges**: Body walls with description of cell types, skeletal structure, canal system, reproduction and development.
   - **(c) Coral and coral reefs**: Polymorphism, physical structure, food and feeding, reproduction, theory of coral reef formation, coral bleaching, significance and conservation.
   - **(d) Rotifers**: External and internal body structure, food, feeding and reproduction.
   - **(e) Oligochaetes:** External and internal body structure, food, feeding and reproduction.
   - **(f) Crustaceans:** Body structure, digestive, respiratory, circulatory and reproductive system and larval development.
   - **(g) Gastropods:** External and internal body structure, food, feeding and reproduction.
   - **(h) Pelecypods:** External and internal body structure, shell structure and pearl formation, feeding and reproduction.
   - **(i) Cephalopods:** External and internal body structure, locomotion, adaptive diversity, feeding and reproduction.
   - **(j) Aquatic Insects:** Aquatic insects of different orders and their significance in fisheries.
   - **(k) Echinoderms:** Skeletal structure, modification of water vascular system in different classes, locomotion, reproduction and larval development.
3. Biology of the following culturable invertebrates:
   (a) Tubificid worm
   (b) Pearl oyster
   (c) Rotifer
   (d) Artemia/ brine shrimp
   (e) Crabs
   (f) Prawn
   (g) Shrimp
4. Economic importance of each of the invertebrate phyla with special emphasis on fisheries.

Books Recommended:

1. Jordan, E.L. and Verma, P.S. 2001. Invertebrate Zoology, S. Chand and Company. Ramnagar, New Delhi.
2. Kotpal, R.L. 2007. Modern Text Book of Zoology, Invertebrate (Animal Biodiversity –II). Capital Offset Press, New Delhi, India.
3. Parker, T.G. and Haswell, W.S. 1960. Text Book of Zoology Vol. 1 & 11 (7^{th} Ed.) Macmillan Co. Ltd., London.

4. Storer, T.I. and. Usinger, R.L. 1972. General Zoology McGraw Hill Book Co. New York.

FISH 102 Fisheries Zoology II: Chordates 2 Credits

1. Classification of the Phylum Chordate upto Order with special emphasis on the aquatic ones.
2. Study of Protochordates and Hemichordates - Characteristics, external morphology, habit and habitat.
3. Urochordata- Characteristics, external morphology, mode of life and reproduction.
4. Cephalochordata- Characteristics, external morphology and mode of life.
5. Vertebrates:
    a) Amphibia: External morphology, internal structure, life cycle and parental care in amphibians.
    (a) Reptilia: External morphology, internal structure including reproductive system, differences between crocodile, alligator and gharial, turtle and tortoise, Snake bite mechanism, parental care in reptilian, biology of turtle, tortoise and crocodiles.
    b) Aves: Classification, food and feeding and adaptation of aquatic birds.
    c) Mammalia: Classification of aquatic mammals, food and feeding, adaptations of aquatic mammals.
    (b) Pisces: General discussion of fishes and fish like vertebrates, biology of Carps, tilapia, climbing perch and pungus.
6. Economic importance of various groups of chordates with special reference to fisheries.

Books Recommended:

1. Kotpal, R.L. 2005. Modern Text Book of Zoology, Vertebrate (Animal Biodiversity-II). Rastosi Publications, Meerut, India.
2. Parker, T.G. And W.S. Haswell, 1960. Text Book of Zoology Vol. 1 & 11 (7^{th} Ed.) Macmillan Co. Ltd., London.
3. Robert, T. Orr. 1982. Vertebrate Biology. Saundars College Publishing.
4. Sinha, A.K., Adhikari, S., Ganguly, B.B. and Gowshami, B.C.B. 2004. Biology of Animals (Vol.II). Central Book Agency Pvt.
5. Storer, T.I. and R.L. Usinger, 1972. General Zoology McGraw Hill Book Co. New York.
6. Young, J.Z. 1981. The Life of Vertebrates (3^{rd} edition).Oxford University press.

FISH 103 General Ecology 2 Credits

1. **Introduction:** definition, ecology, scope of ecology, sub-division of ecology, Principles and concept of ecology.

2. **Bio-geo-chemical cycles:** Carbon cycle, Nitrogen cycle.

3. **Trophic structure:** Food chain, Food web, Ecological pyramids.

4. **Habitat:** classification, "r"- and "k"-selection. Ecological niche: realized niche, niche overlap, Gause's competitive exclusion principle, resource partitioning.

5. **Population:** Population processes, diagramatic and conventional life-tables, Age and Growth, Inter-specific interactions, competition and coexistence, nature and characteristics of intraspecific competition, Population structures.

6. **Community:** Concept, composition, structure, ecological succession, concept of climax, ecotone, edge effect, competition, predation, disturbance, instability, habitat size and diversity in community structure.

7. **Ecosystem:** concept of ecosystem, types, components of ecosystem, Structure and function of an ecosystem, Major ecosystems.

8. **Biomes:** Terrestrial, Wetland & Freshwater, Coastal and Marine biomes.

9. **Biogeography:** Biogeographic regions, Evolution and conservation.

10. **Homeostasis and ecological balance**

Books Recommended:

1. Ecology: principles and applications. J. L. Chapman and M. J. Reiss (Cambridge Univ. press)
2. Odum, E.P. 1971. Fundamentals of Ecology. W.B. Saunders C.
3. Verma, P.S. and V.K. Agarwal 1983. Principles of Ecology, S. Chand & Co. Ltd. Delhi, India.
4. Poole R. W. An introduction to quantitative ecology (Mac'Graw Hill, New York)

FISH 104 Biostatistics 3 Credits

1. **Definition and scope of Biostatistics**: discrete and continuous variables, classification, construction of frequency distribution and graphical representation of data, measures of central tendency, measures of dispersion, moments, skewness and kurtosis.

2. **Elementary theory probability:** laws of probability, additive and multiplicative laws of probability and Bay's theorem, random variables, probability distribution, derivation, properties and uses of Binomial, Poisson and Normal distribution, fitting Binomial, Poisson and Normal distribution to observed data.

3. **Population and Sampling:** The concept of statistical population and random sample, preliminary idea on sampling distribution, definition and use of standardized normal variate.

4. Product moment correlation coefficient to measure the relationship between variables in bi-variate distribution, fitting simple linear regression to observed data by the method of least squares.

5. **Hypothesis**: test of hypothesis, type I and type II errors and level of significance, preliminary idea on t-test, F-test, Chi-quare test and their application, testing hypothesis regarding population mean, equality of two means, population variance equality of two population variances. goodness of fit and independence of two attributes in a contingency table and test of significance of correlation coefficient and regression coefficient(s).

6. **Principles of experimental design**: field layout and analysis of variance in completely randomized design, randomized block design and latin square design; analysis of co-variance in a completely randomized design.

FISH 105 Ichthyology 3 Credits

1. **Introduction:** Ichthyology and importance of studying Ichthyology. Major groups of living and extinct fishes and their characterization with special reference to those of Bangladesh.
2. **External morphology:** Body from, body covering, appendages, openings, sensory organs.
3. **Integument:** Structure and functions of skin, scales shape, type, derivatives uses ; other derivatives of Skin dermal fin rays, flaps and barbells, light organs, poisonous glands, coloration Thayer's principle, sources of color, functions of coloration.
4. **Skeleton:** Cartilage and bone, exoskeleton, endoskeleton, membranous skeleton, notochord, axial skeleton, appendicular skeleton skeleton, visceral skeleton, origin of limbs and girdles.

5. **Muscles:** Classification, muscle terminology, head muscles branchial musculature, eye muscles, trunk median and paired fin musculature, sonic muscles, electric organ muscles, smooth muscles, and cardiac muscles.
6. **Internal organs:**

   Digestive system: Digestive Systems of freshwater and marine fish: Structure, functions, glands and enzymes.
   Respiratory organs: Gill structure and function, air-breathing fishes: lungs and lungfishes.

   Circulatory System: Heart and accessory pumps; blood vessels of the gills and head, blood vessels of the body, lymphatic system.

   Reproductive system
   Endocrine organs
   Kidney and excretory system

7. **Evolution and adaptive radiations in fishes.**
8. **Fish fauna of Bangladesh.**

Books Recommended:

1. Jhingran, V.G. 1988. Fish and Fisheries of India. Hindustan Publishing Corporation (India), Delhi.
2. Lagler, K.F. 1952. Freshwater Fishery biology. IOWA Press Inc. U.S.A.
3. Lagler, K.F. J.E. Bardach. R.R. Miller and D.R.M. Passino. 1977. Ichthyology. John Wiley & Sons, Inc. New York.
4. Moyle, B.P. 2003. Fishes: An Introduction to Ichthyology, Benjamin Cummings, San Francisco, California, United States.

FISH 106 Limnology 3 Credits

1. **Limnology:** Definition and scope; physical, chemical and biological limnology; ecological classification of freshwater organisms, inland water bodies, classification of lakes

2. **The physico-chemical characteristics of inland waters**: Light, color, turbidity, temperature, pH, viscosity, thermal and chemical stratification, mixing, major dissolved gases; major nutrients: N P K, nitrogenous compounds; role of nutrients in primary production, nutrient cycling in fresh water aquatic system. Influences of physical and chemical factors on aquatic biota. Bacteria, phytoplankton, zooplankton and benthos relations; planktons and fish relationships.

3. **Soil**: Definitions, characteristics of bottom soil, soil pH, organic matter, C/N ratio, Soil-Water interactions and productivity.

4. **Phytoplankton**: Definitions, classification, characteristics of major groups, distribution, seasonal succession, eutrophication and phytoplankton bloom, factors and effects, red tide, culture techniques.

5. **Zooplankton**: Definition, major groups, seasonal variation, feeding, reproduction, vertical migration, cyclomorphosis, culture techniques.

6. **Benthos**: Benthic organisms, qualitative and quantitative distribution and factors affecting the distribution.

7. **Primary production**: Definitions, Biotic and abiotic factors affecting primary production; estimation of primary production.

8. **Aquatic vascular plants**: kinds and their significance.

Books Recommended:

1. Welch, P.S. 1952. Limnology. McGraw-Hill Book Co. New York.
2. Wetzel, Robert.G.1983.Limnology. Saunders College Publishing. NewYork. USA.
3. American Public Health Association. 1987. Standard methods for examination of water and waste water. 11th edition. American Public Health Association, New York.
4. Boyd, C.E. 1979. Water quality in warm water fish ponds. Auburn. Uni. Albama.

Biochemistry-11 (Biochem I) 4 Credits

Theory:

1. Acid, base & buffer: Ion Product of water; acid, base, pH; pH indicators; buffer solution & buffer capacity.
2. Thermodynamics : 1st law of thermodynamics, enthalpy, Hess's law, 2nd law of thermodynamics, entropy, free energy, standard states, spontaneous, reversible. irreversible and non-equilibrium reactions, steady state.
3. Cell: Cell, sub-cellular particles and their functions.
4. Carbohydrates: Nomenclature, classification, optical properties, general reactions, colour tests and methods of estimation, isolation from natural sources and representative examples of each class with note on characteristics.
5. Lipids : Nomenclature, classification, reactions of fatty acids, sterols and methods of estimation ; structure and biological functions of different classes of lipids.
6. Amino acids & Peptides: Structural features, optical activity and classification of amino acids, ionization in solution, isoelectric behaviour,

colour tests, isolation of amino acids from protein hydrolytes, peptide bonds and biologically important peptides.

7. Proteins: General introduction; classification based on shape, structure & biological properties; isolation from natural sources; different levels of structural organisation (in brief). Enzymes chemical nature; effects of substrate, temperature and pH on its activity, K_m values & V_{max}; enzyme inhibition; digestive enzymes.

8. Nucleosides & nucleotides: Basic chemistry of nucleosides and nucleotides; polynucleotides.

9. Vitamins: Classification, occurrence, deficiency sysptoms, biological functions, vitamins as coenzymes.

Practical:

(a) Preparation of standard solution and standardization of HCI.
(b) Estimation of calcium in biological sample
(c) Determination of ascorbic acid content of a biological sample.
(d) Colour tests for biomolecules.
(e) Determination of phosphorus content of the supplied solution

Books Recommended:

1. AOAC 1984: Association of Official Agricultural Chemists. Washington D.C.
2. Con, E.E. and Stumpf, P.K. 1987 Outlines of Biochemistry, 5th ed. J. Wiley and Sons, New York.
3. Lehninger A.I. 1976. Text Book of biochemistry. 2nd ed. Worth Publishers, New York.
4. Lehninger, A.I. 1980 Practical Biochemistry for students, Laypec Brothrs, New Delhi.
5. Martin, D.W. Mayes, P.A. and Rodwell, V.W. 1981: Harper's Review of Biochemistry 18th ed. Lange Medical Pub. California.
6. Mehler, H.R., Cordes, E.H. 1971: Biological Chemistry. Harper and Row, New York.
7. Oser, B.L. 1979: Hawk's Physiological chemistry. 14th ed. Tata McGraw Hill, New York.
8. Strong, F.M. 1965: Biochemistry Lab. Manual. William C Brown Co, Iowa.
9. Voet; D, ard Boet, J. 1009. Biochemistry. John Wiley and Sons, New York.
10. West, E.S. Todd' W.R; Manson, S.M. Van Bruggen; J.T. 1967: Text Book of Biochemistry. MacMillan Co., New York.
11. White, A., Handler, P and Smith, E.L. 1976: Principles of Biochemistry, 6th ed. McGraw Hill co., New York.

FISH 107 Practical and Field Work 4 Credits

Students shall be required to show a good knowledge of the topics included in the theoretical portion of the course. They shall maintain a record of everything done in the practical classes/field trips in a practical note book to be signed and checked by teacher(s) concerned. The practical works of the students shall closely follow the theoretical lectures as far as possible and shall include the followings:

Fisheries Zoology -I (Non chordate)

(a) Collection and identification of representative invertebrates.
(b) Morphological study of invertebrate museum specimens (fresh and preserved).
(c) Study of internal and external structure of shrimp, prawn, crabs and mollusks.

Fisheries Zoology -II (Chordate)

(a) Collection and identification of representative chordates (vertebrates).
(b) Morphological study (external and internal) of chordate specimens (fresh and preserved specimens).

General Ecology

(a) Study of pond as a lentic ecosystme, community composition and classification.
(b) Study of stream as a lotic ecosystem, community composition and classification.

Biostatistics

(a) Frequency table construction and graphical representation of data. Calculation of various measures of central tendency, quantity, various measures of dispersion.
(b) Fitting Binomial, Poison and Normal distribution to observed data and use of standardized normal variable.
(c) Calculation of correlation coefficient and fitting simple linear regression to observed data.
(d) Testing hypothesis regarding population mean, testing significance of simple correlation coefficient and regression coefficient(s). Use of Chi-square of attributes in a contingency table.
(e) Field layout, analysis of variance and interpretation of data collected in completely randomized design, randomized block design and latin square

design. Examples of covariance analysis in a completely randomized design.

Ichthyology

(a) Comparative studies of gross external morphologies of major groups of fishes with particular reference to the representatives of fish orders available in Bangladesh.
(b) Microscopic study of the structures of fish scales.
(c) Comparative studies of the following internal organs:
  (i) Skeleton
  (ii) Gills
  (iii) Digestive tract
  (iv) Air bladder
(d) Dissection of the following organs:
  (i) Weberian ossicles of cypriniform fishes
  (ii) Occulomotor muscles
  (iii) Central nervous system
  (iv) Endocrine master gland.

Limnology

(a) Studies of water-body morphometry; shoreline surveys of ponds, lakes; stream survey mothods; water level recording procedures; map construction and interpretation; method for determining area and volume of ponds, lakes and reservoirs.
(b) Recordings of temperature, turbidity, colour, light penetration and flow.
(c) Methods of sampling bottom soil, determination of pH, moisture content, cation exchange capacity, organic carbon, total nitrogen, available N,P,K, Ca, Zn, Mg and rapid test for N, P and K of aquatic soil.
(d) Chemical analysis of water sampling methods; determination of dissolved oxygen, free carbon dioxide, pH, alkalinity, total hardness, phosphate, nitrate, nitrite, ammonia, iron, silicate and salinity.
(e) Procedures of removing turbidity; lime application, other treatment measures in the culture systems and fish hatcheries in case of environmental degradation and emergency.

FISH 201 Aquatic Pollution and Toxicology 2 Credits

1. **Introduction:** General introduction to aquatic pollution and ecotoxicology, description of toxicants- Metals, Pesticides, POPs, lethal and sub-lethal effects.

2. **Sources of toxic chemical in aquatic environment:** Overview of natural and industrial sources of toxic chemical in inland and marine aquatic environment. Major polluting industries, pollutants discharge from tanneries, textiles and other industries. Routes of various pollutants circulation in aquatic ecosystems and possible mechanisms of its toxic action on living organisms.

3. **Sediment in aquatic ecosystems:** Accumulation of metals, organometallic and organic compounds in sediments, sediment toxicity and ecological effects of contaminated sediments.

4. **Bioavailability, bioaccumulation and biomagnifications:** Definitions, Major classes of Pollutants: fate and transport, bioavailability, and modifying factors, effects of bioaccumulation in fish, shellfish and other aquatic organisms.

5. **Endocrine Disruptors:** Introduction, source, mode of action, and toxicity. Cause and consequence of endocrine disruptions in fish and shellfish.

6. **Ecological Risk Assessment:** General Principles, application and interpretation of biomarker assays and toxicity tests in aquatic ecosystem.

7. **Environmental Safety:** General information on international and national environmental protection agency, international environmental protocols and regulations. Environmental protection regulations and problems in Bangladesh.

Books Recommended:

1. Principles of Ecotoxicology. 3rd Edition, 2006. C.H. Walker, S.P. Hopkin, R.M. Sibly & D.B. Peakall (Eds.), Taylor & Francis, New York, NY.

2. Environmental Toxicology. 2002. D.A. Wright and P. Welbourn. Cambridge University Press, New York, NY.

3. Fundamentals of Ecotoxicology, 2nd Edn. 2003. M.C. Newman & M.A. Unger, Lewis Publishers, Florida.

4. Principles of Ecotoxicology, 2006. C. H.Walker. CRC Press.

FISH 202 Fish Physiology 3 Credits

1. **Introduction:** Physiology and fish physiology; Poikiothermy and homoithermy, fish as poikilothermous animal; adaptation of fish for aquatic environment.
2. **Digestion:** Different group of fish based on diet; modification of mouth, teeth and digestive tract; mechanical and chemical actions of ingestion and

digestion of food; basic mechanism, functions and enzymatic process of digestion of carbohydrate, protein and fat; absorption of carbohydrate, protein and fat.

3. **Metabolism and Growth:** Anabolism and catabolism, carbohydrate, protein and fat metabolism, Growth: types of growth, physiology of growth, factors of growth, determination of growth.
4. **Blood and cardiovascular system:** Composition, formation and functions of blood; structure of heart; arterial and venous system; mechanism and physiology of circulation; heart beat or rate, blood pressure, cardiac cycle and cardiac output, electrocardiogram, regulation of heart beat, blood pressure, cardiac cycle and cardiac output; factors affecting cardiovascular system.
5. **Respiration:** Respiratory organs in fishes, efficiency of gill for respiration; respiratory pattern in fishes; mechanism and physiology of respiration; transport of gases.
6. **Excretion and Osmoregulation**: Excretory organs, chloride cells, Physiology of excretion; water and salt balance in marine and fresh water fishes, endocrine control of osmoregulation.
7. **Reproduction and development**: Types of reproduction, Spermatogenesis, Oogenesis, sex differences, sexual maturity, reproductive behavior, larval development, metabolic changes during oogenesis and spermatogenesis.
8. **Endocrine system**: Origin and functions of endocrine glands; role of hormones in the life process of fishes.
9. **Sensory physiology:** Nervous System, Sensory Systems, Sense organs and their functions in fishes, lateral line system.
10. **Stress in fishes:** Fish behavior, physiological stress response, physiological responses to environmental contaminants.
11. **Histology:** Cells of the various organs of fishes; role of cells in physiology.

Books Recommended:

1. Brown, M.E (Ed.) 1957 The Physiology of fishes Vols, I and II. Academic Press, New York and London.
2. Hoar, W.S. and Randall D.J. and J.R. Drett 1984. Fish Physiology, Academic Press London.
3. Evans, D.H and Claiborne, J.B 2005, The physiology of fishes, CRC Press, Florida.
4. Kumar, S. and Tembhre, M. 1996. Anatomy and Physiology of Fishes, Vikas Publishing House Pvt ltd, New Delhi.
5. Lagler, K. F. J.E., Bardach. R.R. Miller and D.R.M. Passino, 1977. Ichthyology. John Wiley and Sons. Inc. New York.

FISH 203 Aquaculture Nutrition 3 Credits

1. **Introduction of fish nutrition and aquaculture:** Origin of nutritional characteristics of fish and crustaceans; Terminology in aquaculture nutrition; Relationship between fish nutrition and fish culture.

2. **Nutrition of aquatic animals:** Feeding behavior and regulation of food intake; Digestive physiology and nutrient digestibility of fishes; Sources of nutrients, natural, supplementary and complete artificial diet of fish.

3. **Nutritional energetic:** Partitioning of energy; Energy requirements of fish; Energy retention.

4. **Protein nutrition of fish and shellfish:** Characteristics of protein metabolism in fish**;** Requirements of protein and essential amino acids**;** Protein deficiency symptoms**;** Evaluation of dietary protein.

5. **Lipid nutrition:** Lipid metabolism in fishes; Essential fatty acid requirements**;** deficiency symptoms; Importance of lipids in fish diet; Influence of dietary lipids on body composition and fish carcass quality; Evaluation of lipid quality.

6. **Carbohydrate nutrition:** Importance and limits of energetic role of carbohydrate; Glucose metabolism in fish; Synthesis and metabolism of glycogen; Improvement of carbohydrate utilization in fish.

7. **Vitamin nutrition:** Vitamin characteristics and classification; Requirements and sources**;** Deficiency symptoms.

8. **Mineral nutrition:** Characteristics of mineral nutrition in fish; Interactions between environment, nutritional supply and requirements; Nutritional role of macro-minerals and trace elements in fish; Deficiency symptoms.

9. **Larval nutrition:** Nutritional requirements of fish and shrimp larvae; Nutritional quality of live prey; Characteristics of artificial food for larvae.

10. **Brood-stock nutrition:** Energy partitioning for reproduction; Protein requirements for brood stock; Effect of dietary quality on reproductive output.

11. **Methods used in studies on fish nutrition:** Experimental methods and designs in fish nutritional studies; Performance measure; Growth, growth prediction and survival; Food utilization, temperature and water quality actors; Assessing diets and flesh quality.

Books Recommended:

1. Halver J. E and Hardy R. W (Editor) 2002. Fish Nutrition, Third Edition, Academic Press. USA.

2. Guillaume J, Kaushik S, Bargot P and Metailler R (Editors) 1999. Nutrition and Feeding of Fish and Crustaceans. Praxis Publishing, UK.

3. De Silva S.S and Anderson T. A 1995. Fish Nutrition in Aquaculture, Chapman and Hall, London.

4. Tacon A. G. J. 1990. Standard Methods for the Nutrition and Feeding of Farmed Fish and Shrimp. Argent Laboratories Press, Washington.

5. Lovell, T. 1989. Nutrition and Feeding of Fish. Van Nostrand Rainhod, New York.

6. Steffers W. 1989. Principles of Fish Nutrition. Ellis Horwood Limited. John Wiley and Sons New York 1384 pp.

Fish 204 Fisheries Extension 2 Credits

1. **Introduction:** Extension and Fisheries extension, Fisheries extension principles, levels, functions and objectives, Need for fisheries extension works for fisheries development, Gradual growth of extension work in Bangladesh.

2. **Extension as educational process:** Teaching in extension, learning in extension, principles of Learning, Behavior, Attitudes, Perception.

3. **Extension objectives:** Motivation, Need identification, Concept of need, Maslow's need theory, Change in behavior, attitude and perception.

4. **Leadership:** concept, types and groups, recognition for good leadership

5. **Communication in extension for fisheries:** Basic function of communication, types, models of extension communication, Barriers of communication.

6. **Extension communication methods and aids:** individual methods, group and mass methods, visual and audio-visual aids, importance and use.

7. **Extension programme:** procedures, concept, planning, implementation, evaluation, and importance.

8. **Innovation:** decision process, transfer of technologies, diffusion, adoption, factors affecting the transfer of technologies.

9. **Organization for extension work:** Main features, Categories of personnel, Supervision and co-ordination in extension work.

10. **Extension problems for fisheries development: P**ossible solution, rural youth in extension work, past and present programmes for development of fisheries and related agricultural development activities, awareness programme for bio-diversity, fishing fight.

11. **Conservation**: common property fisheries.

Books Recommended:

1. Mashem.M.A. 1992 Samorasaran Biggan (Extension Science). Dhaka: The Bangladesh packing Press.
2. Mosher, A.T. 1978. An Introduction Extension. New York Agricultural Development Council.
3. Oakley, P. and Garforth C. 1985. Guide to Extension Training. Rome; Food and Agriculture Organization of the United Nations.
4. Regers, E.M. 1983. Diffusion of Innovations, New York: The Free Press of Glenco.
5. Singh, Ranjit, 1987. A Text Book of Extension Education. Ludhiana. India: Shahitya kala Prakashan.
6. Supe, S.V. 1983. An Introduction of Extension Education. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd.
7. G. L. Ray. Extension Communication and Management.

Fish 205 Inland Aquaculture 4 Credits

1. **Introduction:** Definitions and aim of aquaculture; history, general principles, scope and importance of aquaculture.

2. **Aquaculture system:** Extensive, semi-intensive and intensive culture, monoculture, polyculture, management practices.

3. **Fish culture in ponds:** Preparation of nursery, rearing and stocking ponds with pre-stocking, stocking, stocking formula, stocking ratio and post stocking management. Management of derelict ponds for fish culture.

4. **Fertilization and liming:** Definition of fertilizer and manure, organic and inorganic fertilizers used in fish ponds, liming of pond, types of lime used in aquaculture.

5. **Aquatic weeds:** Common aquatic weeds and methods of their control; algal blooms, preparation of compost with aquatic weeds.

6. **Induced breeding:** Fish pituitary gland hypophysation, human chorionic gonadotropin (HCG) and other ovulating agents, induced breeding of carps, catfishes and prawn.

7. **Transportation fish seed and brood fish:** Definition of transportation, methods of packing and transport of fry and brood fish, causes of mortality of fry, fingerlings and brood fishes during transportation, use of anesthetics, antiseptics and antibiotics in live fish transport.

8. **Fish culture:** Culture techniques of carps, catfishes, tilapia, Thaipunti, climbing perch and important indigenous species.

9. **Prawn culture:** History and global status of freshwater prawn farming, culture technique of prawn (brood stock, nursery and grow-out system management, nutritional, feeds and feeding, water quality, soil and health management etc.), rice prawn farming, sustainability of freshwater prawn culture.

10. **Integrated fish farming:** Concept and definition of integrated fish farming, rice fish culture, poultry cum fish culture, livestock cum fish culture, sewage and aquaculture, ornamental fish.

Books Recommended:

1. Kumer, D. 1992. Fish culture in undrainable ponds a manual for extension. FAO fisheries technical paper no. 325. Rome.

2. Huet. M. 1979. Text Book of fish culture breeding and cultivation of fish. Fishing News Book Ltd. Farnham, Surrey, England.

3. Chondar, S.L. 1980 Hypophysation of Indian major carps. Shatish Book Enterprise, Motokatra, Agra-3, India.

4. Harvey, B, Carosfeld, J and Donaldson, EM 1993. Induced breeding in tropical fish culture. International Development Research Center. 144 pp.

5. FAO. 1990. Farming systems. Developments, guidelines for the conduct of a training course ing farming systems development. FAO-United Nations.

6. New, M. B and W. C. Valenti. 2000. Freshwater prawn culture, the farming of *Macrobrachium rosenbergii* . Blackwell science publishers.

FISH 206 Fisheries Microbiology & Quality Control 4 Credits

1. **Cell structure and function**: prokaryotic and eukaryotic cell structure, cell membrane, cell wall, proteins, nucleic acids- structure, properties and functions.
2. **Scope and history of microbiology:** Microbes and their general characteristics, classifications of microorganisms: bacteria, molds, yeast and viruses. Nutrition and growth of microorganisms.
3. **Aquatic microorganisms**: Microbial community on freshwater, marine and estuarine environment, microbial dependency on physical, chemical and biological factors of the environment; classification of aquatic microorganisms, microbes in extreme environment, role of microorganisms in biogeochemical cycles.
4. **Attached microbial communities**: Biofilm, formation, function, impacts in fisheries-fish diseases and fish processing sector.
5. **Techniques for the study of aquatic microorganisms**: Conventional culture techniques for isolation of microorganisms, confirmation by biochemical and molecular techniques (PCR, RAPD, Fluorescent Antibody technique), application of PCR in identification of fish and shrimp pathogen.
6. **Contamination and spoilage:** Contamination and spoilage of fish and other sea foods; spoilage of refrigerated, canned and other processed food.
7. **Fish Freshness test**: Organoleptic, chemical and bacteriological test of fresh and preserved fish and fish products.
8. **Heat resistance of microorganisms:** factors affecting heat resistance; effects of low and high temperature on microorganisms.
9. **Food poisoning and infection**: Bacterial food poisoning and intoxication; non bacterial intoxication (Aflatoxin, Patulin, Ochratoxin, viral toxin and chemical poisoning), shell fish poisoning, ciguatera and puffer poisoning.
10. **Antibiotics:** types, mode of action, different types of antibiotics with their role and side effects (Penicillin, Streptomycin, Tetracycline, Chloramphenicol, Nitrofurans etc.), antifungal antibiotics; application of antibiotics in fisheries.
11. **Antiseptics and disinfectants**: Different types of antiseptics and their application in fishery science. Mechanisms of antimicrobial action.
12. **Quality contro**l: General principles of quality control, quality of supplied water, hygienic and sanitation plants and workers, inspection and quality control in fish processing plant
13. **Microbiological standards:** Microbiological standards of different water uses and for fish and fishery products.
14. **Hazard Analysis Critical Control Point (HACCP):** Potential hazards (Biological hazards, Chemical hazards and Physical hazards), HACCP Principles and application in fisheries.

Books Recommended:

1. Carter, S.J. 1986. Cooper and Gunn's Tutorial Pharmacy. CBS Publication and Distribution.
2. Ford, T.E. 1993. Aquatic Microbiology. Blackwell Scientific Publication.
3. Frazier, W.C. and D.C. Westhoff. 2000. Food Microbiology. McGraw Hill Book Co., N.Y. and London.
4. Jay, J.M. 1986. Modern Food Microbiology. Van Nostrand Reinhold, New York.
5. Pelczer, Jr, M.J., Chan, E.C.S. and Kring, N.R. 1998. Microbiology. Tata McGraw Hill Publishing.

FISH 207 Fisheries Mathematics 2 Credits

1. **Function, Limit and Continuity of a Function:** introduction; Types of Functions, Operation on Functions, Determination and Derivation of Different business function. Definition of Limit. Determination of Limit of different types of functions. Determination of continuity of different functions.

2. **Differentiation and use in fisheries problems:** Differentiation of Algebraic functions, transcendental function. Definition of transcendental functions Geometric interpretation of dy/dx and marginal concept analysis.

3. **Partial differentiation:** Introduction, fist partial differentiation, Higher order partial derivatives, Concept of Homogeneous function. Total differentiation Application to fisheries problem.

4. **Integration and use in fisheries problems:** Introduction, Different rules of integration, Indefinite and Definite integral, calculation of area of irregular curves and figures-Analysis of total concept by integration.

5. **Differential Equations:** Introduction, Order and degree of differential equations-Solution of Differential equations of first order and first degree. Verification of the solutions of differential equations-Differential equations of the second order with constant coefficients. Application of differential equations in the problems of fisheries and management.

Books Recommended:

1. Foster, P.C. (1998) *Easy Mathematics for Biologists*, Harwood Academic Publishers (ISBN: 90-5702-339-3).

2. Cann, AJ (2003) *Maths from Scratch for Biologists*, Wiley (ISBN: 0-471-49835-1).

3. Mike Aitken, Bill Broadhurst, Stephen Hladky (2009) Mathematics for Biological Scientists. Garland Science. 482 pp.

4. Bittinger, ML, Brand, N & Quintanilla, J (2005), *Calculus for Biology and Life Sciences*, Addison Wesley (ISBN: 0321279352).

5. Stroud, KA & Booth, DJ (2009), *Foundation Mathematics*, Palgrave Macmillan (ISBN: 0230579078).

Biochemistry-12 (Biochem II) 4 Credits

Theory:

1. Carbohydrate metabolism : glycolysis-aerobic and anaerobic; pentose phosphate pathway; glucoronic acid pathway, oxidation reduction reactions and redox potential, electron transport chain and oxtdative phosphorilation; inhibition and uncouplling of oxidative phosphorilation, citric acid cycle, gluconeogenesis, glycogeneolysis and glycogen synthesis.

2. Lipid metabolism: B-oxidation and the related energetics; basic concept of lipoproteins; synthesis of fatty acids; Ketone bodies and their formation.

3. Amino acid metabolism: Different methods for the degradation of amino acids-transamintion, deamination, decarbosylation and sysnthesis of single carbon unit; synthesis of biologically active molecules from amino acids; urea cycle.

4. Central dogma: DBA as genetic material; replication of DNA; transcription and different types of RNAs; protein synthesis and inhibitors of protein synthesis.

5. Nutrition: Basic concept; protein, fat and carbohydrates as nutrients; basic concept on micronutrients like iodine, zinc, magnesium, iron.

Practical works:

(a) Determination of saponification number of oil
(b) Determination of iodine number of oil
(c) Determination of n-max and verification of Beer Lambert's law
(d) Estimation of total protein content of serum
(e) Determination of serum glucose content
(f) Determination of cholesterol and
(g) Determination of creatinine content of urine.

Books Recommended: Same as for Biochem-11.

FISH 208 Practical and Field Work 4 Credits

Fish Ecology

(a) Impact of human interference on the alteration of aquatic environments.

Fish Physiology

(a) Effects of temperature and salinity on the rate of metabolism of fish.
(b) Effects of salinity on survivability of fish.
(c) Determination of rate of respiration.
(d) Serological tests of fish blood.
(e) Histology of seasonal variations in the conditions of gonads.
(f) Histology of skin, stomach, intestine, gonads, gills, liver and kidney.
(g) Observation of breeding and feeding behavior of fish.

Aquaculture Nutrition

(a) proximate analysis of carcass, feed ingredients and compounded feed samples, protein, lipid, ash and grade fibre.
(b) Digestibility studies of protein, lipid and carbohydrate using various external dietary markers such as, chromic oxide, silica, cellulose etc.
(c) Analysis of responses and conversion efficiencies.
(d) Techniques for faecal collection and
(e) Estimation of calorific value of various foods stuff by Bomb colorimetry.

Fish Feed Formulation

(a) Feed formulation, processing of feed ingredients, assessing of fish feed quality.
(b) Measures of protein quality (FCR, PER, NPU).

Inland Aquaculture

(a) Induced spawning: Selection of brood fish, collection and preservation of pituitary gland (PG).
(b) Nursery pond: Preparation, fertilization and management.
(c) Rearing pond: Preparation, fertilization and management.
(d) Grow out pond: Preparation, liming, fertilization and management.
(e) Aquatic weeds: Identification and control of aquatic weeds and algae in pond and
(f) Field trips: Visit to hatchery and fish farms.

Fisheries Microbiology

(a) Preparation of culture media.
(b) Collection of water, fish and shellfish sample, preservation, processing and cultivation of bacteria (aerobic and anaerobic), mold and yeasts.

(c) Methods of microbial examination of food; sampling, total bacteria count, standard plate count, test for Coliforms; *Salmonella*, *Shigellae*, *Clostridium* and *Staphylococcus*, *E. coli*, Vibrios and other bacteria.
(d) Biochemical and molecular tests for confirmation of different bacterial methods of obtaining pure culture.
(e) Various staining procedures for bacteria.
(f) Preparation of frozen fish and shrimp and their quality assessment.
(g) Preparation of cured fishery products and fermented fishery products.
(h) Preparation of fish fillet. Fish past, FPC, fish meal, fish oil, FPI and their quality assessment.

Fisheries Mathematics

(a) Partial and total differentiation Application to fisheries problem.
(b) Integration and use in fisheries problems.
(c) Application of differential equations in the problems of fisheries and management.

Fish 301 Coastal Aquaculture 3 Credits

1. **Introduction:** Present status of brackish water aquaculture and mariculture of the world. Scope, present trends, social and economical importance of coastal aquaculture in Bangladesh.

2. **Construction of coastal fish farm:** Site selection, Various farming systems: Extensive, Semi-intensive and Intensive; Cage, Pen and raft culture. Need for intensification and development of intensive farming in Bangladesh.

3. **Crustacean Farming:** Shrimp farming techniques; traditional, extensive, semi intensive and intensive methods. Life cycles of cultivable shrimp species. Brackish water ponds management, shrimp cultural practices, problems and future prospects of shrimp farming in Bangladesh. Shrimp culture regulation of Bangladesh, Crab fattening.

4. **Molluscan farming:** Life cycles of cultivable mollusks, culture of mussels, clams and oysters.

5. **Pearl culture:** Techniques of pearl culture.

6. **Finfish farming:** Culture techniques of marine finfishes (seabass, seabream and yellowtail etc.).

7. **Live feed culture:** Culture of algae, rotifers, brine shrimp (*Artemia*) and other fish food organisms (Diatom, Copepods, *Cylops*, *Daphnia* and *Moina*).

8. **Mangrove fisheries:** Mangrove ecosystem, energy flow in mangrove swamp, impact of deforestation, and present prospect of fish and shellfish culture in mangrove areas.

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

Books Recommended:

1. Marianne Holmer, Kenny Black, 2008. Aquaculture in the Ecosystem, Springer publishers.

2. Santhanam, R., N. Ramanathan and G. Jogathoesan, 1990. Coastal Aquaculture in India, CBS Publishers & Distributors.

3. Milne, P. H. 1979. Fish and shellfish farming in coastal waters. Fishing news books ltd. Farnham. Surrey, England.

4. Venugopal, S. 2005. Aquaculture, Pointer Publishers, Jaipur, India.

FISH 302 Fisheries Genetics and Molecular Biology 3 Credits

1. **Fundamentals of Genetics:** Introduction, Brief History, Chromosome and its Structure, Mitosis and Meiosis; Laws of Inheritance; Linkage; Crossing Over; Chromosome Map; chromosomal aberrations, deletion, duplication, inversion, translocation; Cytoplasmic Inheritance; Sex Determination; Sex Linked Inheritance.

2. **Applied Chromosomal Genetics:** Theory, Meiosis and polar bodies, Meiotic gynogenesis, Mitotic gynogenesis, Androgenesis; Mechanics of inducing polyploidy in aquatic species. Triploidy in tilapia; Evaluating polyploidy induction.

3. **Inheritance of Quantitative Traits:** Theory, Genetic effects and phenotypic variation, Average effects and dominance deviations, Attributing observed variation to genetic effects, Utility of estimates of genetic variation.

4. **Selection and Realized Heritability:** Theory, Estimating and predicting heritability, in aquatic organisms; Applying selection, Correlated responses, Multi-trait approaches, Complicating and constraining factors, Improving selection efficiency in aquatic organisms; Using family data in aquatic organisms.

5. **Inbreeding, Crossbreeding and Hybridization:** Dominance effects and multi-locus traits, Population genetics and dominance effects, Molecular genetics and

dominance effects, Utilizing dominance effects for genetic improvement for aquatic organisms.

6. **Sex Determination and Control:** Homogametic monosex stocks, Heterogametic monosex stocks, Minor genetic and environmental influences.

7. **Transgenic Aquatic Organisms:** Microinjection, Electroporation, Biolistics, Lipofection, Incorporation and integration.

8. **Mapping Genomes:** Linkage Mapping in Aquaculture Species, Detection and Analysis of Quantitative Trait Loci (QTL) for Economic Traits in Aquatic Species, Marker-Assisted Selection for Aquaculture Species. Bacterial Artificial Chromosome Libraries and BAC-based Physical Mapping of Aquaculture Genomes, Physical Characterization of Genomes Through BAC End Sequencing, Genomic Analyses Using Fluorescence *In Situ* Hybridization, Radiation Hybrid Mapping in Aquatic Species.

9. **Analysis of Genome Expression and Function**: Transcriptome Characterization Through the Analysis of Expressed Sequence, Microarray Fundamentals: Basic Principles and Application in Aquaculture, Salmonid DNA Microarrays and Other Tools for Functional Genomics Research, Computational Challenges for the Analysis of Large Datasets Related to Aquatic Environmental Genomics.

Books Recommended:

1. Liu, Zhanjiang. 2007. Aquaculture genome technologies. Blackwell Publishing Ltd. Oxford.
2. Clark, David P. Molecular biology. 2010. Academic Press. London.

Fish 303 Aquaculture Engineering 3 Credits

1. **Introduction:** Importance, working fields of aquaculture engineering. criteria for site selection-ecological, biological, chemical and social criteria; mechanical, structural, hydrological, meteorological, electrical and economic aspects related to aquaculture practices.

2. **Soil:** Soil types, soil topography and its survey, soil sampling methods, soil texture, structure, consistency, permeability and miscellaneous properties of soil.

3. **Water:** Source of water supply, qualities of water for fresh water and brackish water ponds and hatcheries.

4. **Ponds and Hatchery**: Pond types, construction of ponds for fish and shellfish, earthen and concrete ponds, pond dykes, slopes, pond inlets and outlets (sluices, monks and spillway). Hatchery design and layout for fish and shrimp.

5. **Cages and Pens**: Types of cage, engineering considerations in cage and pen design.

6. **Filtration and water treatment:** Types of filter commonly use in aquaculture system (mechanical, gravitational, biological and chemical filter) and sterilization and disinfection methods (UV irradiation, Ozonation, Chlorination).

7. **Pumps and the measurement of flow:** Classification of pumps and flow measurement, centrifugal, reciprocating, rotary and airlift pumps. Measuring discharges from open pipes and channels.

8. **Aeration:** Principles of aeration, theory of gas transfer, aerator system requirements, mechanism of different types of aerator use in aquaculture.

9. Maintenance of aqua-farm and hatchery. Economic aspects of aquaculture planning, aquafarm construction and maintenance.

Books Recommended:

1. Landau, M. 1992. Introduction to Aquaculture. John Wiley & Sons, INC. New York.
2. Lawson, T. B. 1997. Fundamental of Aquaculture Engineering. CBS Publishers & Distributors, 4596/1 A, 11-Daryaganj, New Delhi-110002.
3. Coche, A. G. & J. F. Muir, 1992. Pond construction for freshwater fish culture. FAO training series 20/2, Rome.
4. Simple methods for aquaculture. Soil and Freshwater fish culture, FAO training series 6.

FISH 304 Fisheries Economics 2 Credits

1. **Basic Concepts and Ideas:** Definition and Relevance; Positive and Normative Economics; Preliminary introduction to Great Schools of Economic Thoughts - Classical, Neo-classical, Keynesian, Marxist; the Difference between Micro and Macro-economics.

2. **Consumer behavior:** indifference curve, utility, law of diminishing marginal utility, consumer budget, consumer equilibrium.

3. **Law of demand and supply:** factors of fish demand and supply, Definition and Structure of Market; Characteristics of Different Markets; Perfectly Competitive Market and Imperfectly Competitive Markets (Monopoly, Duopoly, Oligopoly and Monopolistic Markets); Determination of Equilibrium Price and Output in Different Markets; Price Discrimination and Distortions; Elasticity, Factors of price elasticity of fish supply and demand.

4. **Production:** factors of production, PPF (production possibility frontier), Production function in a fishery; total product, average product, marginal product, production stages of firm, Maximum Economic Yield (MEY), basic economic model of a fishery.

5. **Cost analysis:** fixed cost, variable cost, marginal cost and total cost, isoquant, isocost line, producer equilibrium, short run cost curve, long run cost curve (LAC), linear programming; cost minimization, profit maximization.

6. **Money and Capital:** time value of money, Internal rate of return, BCR, banking system and financing.

7. **Economic importance** of culture, capture and marine fisheries sectors of Bangladesh.

Books Recommended:

1. Jolly C.M. and Clonts H.A. (1981) Economics of Aquaculture, Food Production Press, New York.
2. Samuelson, P.A. and Nordhaus, W.D. (1989). Economics. 13th edn. Megraw-Hill, New York.
3. Anderson L.G. (1986) The Economics of Fisheries Management, The Johns Hopkins University Press, Baltimore, Maryland.
4. Dominick S. (1992). Schaum's outline of Theory and Problems of Microeconomic Theory. 3rd Edition. McGrew-Hill Book Co, Singapore.
5. Shang, Y.C. (1981) Aquaculture Economics: Basic Concepts and Methods of Analysis, Westview Press, London.

FISH 305 Fisheries Systematics 3 Credits

1. **Introduction to taxonomy:** a brief history of taxonomy; Methods used in taxonomy studies; Technical terms and measurements.

2. **Zoological nomenclature:** History, ICZN and Rules of nomenclature.

3. **Taxonomic collection:** Collection methods, preservation, Curating, storage, cataloguing and maintaining.

4. **Classification and its types:** Methods of classification : taxonomic collection & the processes of identification, taxonomic characters; types of variations (qualitative and quantitative) within a single population, methods of arriving at taxonomic decisions on species level; preparation and use of taxonomic keys; Linnean Hierarchy.

5. **Phenetics and Cladistics:** Phylogenetic tree construction.

6. **Trends in biosystematics:** concepts of different conventional and newer aspects. (a) Chemotaxonomy (b) Cytotaxonomy (c) Molecular taxonomy (d) Elementary idea about sound based identification and classification.

7. **Molecular taxonomy:** Molecular data based Phylogenetic Relationships among Populations, Species, and Genera of different fishes; Molecular data based biogeographic Analysis of fishes; Combining Molecular and Morphological Data in Fish Systematics: Examples from the Cyprinodontiformes.

8. Major Histocompatibility Complex Genes in the Study of Fish Phylogeny Major Histocompatibility Complex (Mhc): Structure and Function, Mhc as a Source of Systematic Information, Sequences as a Source of Phylogenetic and Systematic Information, Cladistic Analysis with Macromutations, Mhc Gene Frequencies in Populations.

9. **Speciation:** Concept of species and implications; Speciation types: Mechanism of genetic differentiation; Allopatric speciation sympatric speciation, Phyletic speciation; Species selection: Process of species selection, Example of species selection; Speciation through Geological time scale.

10. **Fish evolution and adaptation:** Diversification, Ecological differentiation, Adaptive radiation; Extinction: Ecological processes, Extinction in the fossil record; Theory of continental drift; Tectonic history; Climatic and biogeographic consequences of plate tectonics; Glaciations and biogeographic dynamics.

11. **Larval taxonomy:** forms and their evolutionary significance; Morphometric and meristic description of major commercial ichthyoplankton of Bangladesh.

12. **E-taxonomy:** database creation and retrieval; digital publication: Taxonomic description; sketching using software, preparation of taxonomic publications following taxonomic rules; reviewing references; final publication in the web; building and maintaing information networks.

Books Recommended:

1. Thomas D. Kocher, Carol A. Stepien 1997. Molecular systematics of fishes. Academic Press. USA.

2. Kappor, VC. 2008. Theory and Practice of Animal Taxonomy. Oxford & IBH Publishing Co. Pvt Ltd. NewDelhi.

Fish 306 Fish Harvesting and Handling 2 Credits

1. **Introduction:** Principles and theory of fishing; history of fishing; sustainable harvest; carrying capacity; MSY; Optimum sustainable yield; maximum economic yield; modern trends in fishing; fishing techniques other than using gears.

2. **Fishing gears:** Classification materials, terminology, numbering systems; relative efficiencies of nets of different materials; net preservation; net making and mending, knot less net; use of different nets in fishing; spear-fishing, line-fishing, traps and their operation.

3. **Fishing crafts:** Trawlers, seiners, traditional and mechanized crafts and their operation in Bangladesh; deep sea, mid sea and offshore fishing.

4. **Methods of harvesting**: Harvesting of pelagic, demersal and mid-water fishes; harvesting of Shrimps; survey of fishing grounds in the Bay of Bengal, present status of fishing; problem of trash fish and joint ventures in fish harvesting.

5. **Fishery reconnaissance:** Location and detection of fish and shell fish, hydro-graphic observation, fishing charts, eco-sounding, infra-red photography, ghost fishing, Katha fisheries.

6. **Fish behavior:** Response to stimuli, attraction concentration, frightening by artificial lures, light and sound.

7. **Fish handling:** Handling of fresh fish and shrimps on board and shore; ideal/ Careful handling of different types of catches; sorting, washing slime, gutting, evisceration, filleting, salting, shelf life of fish, cause of fish decomposition; characteristics of fresh condition of fish, prevention of mechanical damage in fish.

Books Recommended:

1. Ahmed, N. 1970, Fishing Craft of East Pakistan, East Pakistan Government Press, Dacca
2. Clusas, I.J. Sutcliffe, P.J. 1981, An introduction to fish Handling and Processing, Tropical Products Institute, London
3. Clusas, I. J. (Editor) 1985, Fish Handling, Preservation and Processing in the tropics, Part I & II, Tropical development & Research Institute London.
4. Das, B. and Bandayapaddaya, O. 2000, Fish Harvesting Technology, Bangla Academy, Dhaka.
5. Garner, J. 1988. Modern Deep Sea Trawling Gear, Hartnolls Limited, Bodmain, Cornwall.
6. Neilsen, L. A. and Johnson, D. L 1985. Fisheries Techniques, Southern Printing Company Inc, Blacksburg, Virginia.

FISH 307 Fish Population Dynamics 4 Credits

1. **Stock**: abundance, limiting factors, measurement, fluctuation in the catch; indicators of fluctuating populations.

2. **A cohort**: concept, dynamics of cohort ; unit stock, population density, density dependent characteristics of fish population, population structure, situations unlike unit stock or unit fishery, separation of stock, shift in fishing grounds; theory of fishing, parameters and their estimation.

3. **Need for assessment of stock:** Models, basic principle, basic steps, model graphs, holistic, analytical; assessment of migratory stock.

4. **Stock-recruitment relationship**: classical S/R considerations, overfishing, growth overfishing, recruitment overfishing, types of S/R, Beverton & Halt, Ricker.

5. **Mortality:** causes of mortality, methods for estimating total fishing and natural mortalities; rates of survivality and mortality.

6. **Estimation** of fish and shrimp population size, methods.

7. **Analysis of exploited populations**: ecological concept and principle, migrations, collection basic data, availability and gear selectivity, mesh size, hanging ratio, catch per unit effort, exploitation ration.

8. **Tagging** and marking of fish and shrimps, Types materials and duration of tags and marks, principles and techniques.

9. **Prey-predator relationship**: adult forage fish carnivore (F/C) ratio, young forage fish-carnivore (Y/C) ratio.

10. **Age and growth of fish populations**: methods of estimation of age and growth, back-calculation of growth, growth parameters, the Von Bertalanffy growth equation, Walford's growth transformation curve. K, L_∞, Q (phiprime) and to growth curves, types, length-weight relationship, condition factor, instantaneous rate of growth.

11. **Maturation** stages, gonado-somatic index, fecundity method of estimation; brood stock reproductive biology, spawning, breeding, season factors (internal and external), colouration, courtship, size at recruitment and firs maturity, production of hatchings and fish fry.

12. **Food of fishes and shrimps**: types and analysis of stomach contents, methods of analysis.

13. COMPLEAT ELEFAN package, o-v, definitions.

Books Recommended:

1. Lagler, K.F. 1956: Freshwater Fishery Biology. Second Edition, William C. Brown Co., Dubuque Iowa. 421 p.
2. Rounsefell, G.A. and W.H. Everhart. 1953; Fishery Science: Its Mehods and Applications. John Willey & Sons. Inc. New York. 444p.
3. King, M 1996. Fisheries Biology, Assessment and Management. Fishing News Books, Blackwell Science Ltd. UK.
4. Gulland. J. A. 1982 Fish Stock Assessment.
5. Pauly. D. 1981. Fish Population Dynamics in Tropical Waters.
6. Sparre, P & Venema, S.C. 1992. Introduction to tropical fish stock assessment. FAO Fish Tech. Pup. 306/ 1 Rev. 1.

FISH 308 Rural Sociology 2 Credits

1. **Introduction:** definition, origin and growth of sociology, scope, nature and value of sociology. Modern Pioneers in Sociology, Auguste Comte, Emile Durkheim, Max Weber, Talcot Parsons, Karl Marx.

2. **Society:** definition, element of society, nature of society.

3. **Community**: community sentiment, rural demography, rural-urban settings, village community, rural cultures, rural festivals. Institution and Co-operation.

4. **Society & Environment:** types of environment, influence of geographical environment, influence of plains, influence of hills, and influence of deserts.

5. **Social Groups:** classification of groups, characteristics of group life, primary group, secondary group, social control in groups.

6. **Social stratification:** definition of caste system, theories of the origin of caste system, features of caste system, social class.

7. **Family & Kinship:** characteristics of family, social importance of family, origin of family, type of family, function of family, religion and family, changes in family, problems in family, disorganization of modern family, joint family, advantages & disadvantages of joint family. Kinship, Kinds of kinship.

8. **Social Evolution:** characteristics of social evolution, culture & civilization, cultural growth, cultural lag.

9. **Social Change:** factors of social change, levels of adaptation, natural selection, social selection, social change & technology, social effects of technology.

10. **Social Mobility & Social Progress:** dimensions of social mobility, determinants of social mobility, social progress, influence of social values on progress, criteria of progress, principles of Social progress.

11. **Social Interactions and Processes:** definition of social interactions, basic condition of social interactions, disjunctive process, conflict & competition, contravention, conjunctive process, assimilation, co-operation, integration.

12. Rural Livelihood and Sustainability: Definition of livelihood and changing socio-economic activities. Rural development and GO and NGO activities, nature of rural poverty, rural development models.

13. **Rural Women and Gender Issues:** Women and development, gender inequality, rural social planning.

Books Recommended:

1. Sharma R.K. 1996. Fundamentals of Sociology, Atlantic publishers and Distributors, New Delhi, India.
2. Sharma R.K. 1997. Rural Sociology, Atlantic publishers and Distributors, New Delhi, India.
3. Koenig. S. 1957. Sociology, Barnes and Noble Inc. New York.
4. Rahman, H. Z. 1995. Rethinking Rural Poverty: Bangladesh as a case study. UPL, Dhaka.
5. Etienne, G. 1998. Rural Change in South Asia: India, Pakistan and Bangladesh. UPL, Dhaka.
6. Shamim, H. 1997. Why Women Count: Essays in Development on Bangladesh. UPL, Dhaka.

FISH 309 Fish Feed Management 2 Credits

1. **Introduction:** Status, trends and importance of aqua feeds in global aquaculture; Types and composition of aqua feeds; Impact of rising feed cost in aquaculture; Aquaculture feed and the environment.

2. **Feeding, temperature and water quality**: Feeding behavior: Feeding and metabolic rate; effect of temperature: Oxygen depletion; Waste control.

3. **Types of feed:** Pellets, flakes, powdered; Micro-particulate diets, micro-encapsulated diets, micro-coated diets, micro-bound diets and nano diets.

4. **Feed processing and manufacture:** Criteria for the selection of ingredients for feed preparation, Nutrient analysis; Measurement of energy value; least cost feed; Factors influencing feed formulation; Strategies for minimizing utilization of fish meal and oil in diets; Feed manufacturing units and processes; Pulverizer, grinder, mixer, pelletizer, crumbler, drier, extruder/ expander, Vacuum coater, Fat spryer;

Gelatinization, Extrusion technology; Pellet dressing with heat labile nutrients; Effects of processing on the nutritional quality of feed; Feed quality assessment.

5. **Feeding technique:** Feeding devices; Feeding rate; Feeding frequency; Feeding period; Restricted and compensatory feeding; Feed rations and schedules; Ration size; Rations and growth; Growth-ration curve.

6. **Feed handling and storage:** Optimum conditions for feed storage and prevention of spoilage from rancidity; Fungus formation and associated toxins.

7. **Performance measures**: Food conversion; Growth prediction; Growth pattern; Diet and flesh quality.

Books Recommended:

1. Guillaume, J., Kaushik, S., Bmgot, P. and Metailler, R. 2001. Nutrition and Feeding of Fish and Crustaceans. Spinger – Praxis Publishing, UK.

2. Goddars, S. 1996: Feed Management in Intensive Aquaculture. Chapman and Hall, New York.

3. Lovell, T. 1989. Nutrition and Feeding of Fish. Van Nostrand Rainhod, New York.

4. Tacon, A.G.J. 1990: Standard Methods for the Nutrition and Feeding of Farmed Fish and Shrimp. Argent Laboratories Press. Washington.

5. Halver J. E and Hardy R. W (Editor) 2002. Fish Nutrition, Third Edition, Academic Press. USA.

FISH 310 Practical and Field Work 8 Credits

Coastal Aquaculture

(a) Construction of coastal shrimp farm.
(b) Preparation of shrimp plots, transportation of larval and post-larval shrimp.
(d) Demonstration of spat collection techniques.
(e) Live Food: Culture of live foods in the laboratory.
(f) Natural collection of brackish water fish and shrimp seed and their rearing techniques and
(g) Culture techniques of oysters, mussels, clams and sea weeds.

Fish Genetics and Molecular Biology

(a) Location and removal of pituitary gland.
(b) Preservation of pituitary gland, mitta freeze, preparation gland and administration of the extract.
(c) Induced breeding of fish-brood fish care and maintenance, selection of breeders, selection of inducing agent and hatching techniques.
(d) Karyology of fishes, methods of chromosome preparation in fishes.
(e) Estimation of genetic variation by enzyme electrophoresis.

Aquaculture Engineering

(a) Soil, classification/ properties.
(b) Quantification of water requirements.
(c) Case study for fresh water pond construction.
(d) Case study for water supply.
(e) Case study for brackish water pond construction.
(f) Case study for cage design, construction.
(g) Case study of hatcheries (carp and shrimp).
(h) Case study for construction of inlets and outlets.
(i) Case study for design and construction of bio-filter.

Fisheries Economics

(a) Estimation of elasticity of supply and demand.
(b) Cost analysis of a firm.
(c) Linear Programming; Profit maximization and cost minimization problems.

Fisheries Systematics

(a) Collection and identification of commercially important freshwater and marine fishes of Bangladesh.
(b) Study of their morphology and classification.
(c) Identification of preserved specimens of fishes.
(d) Collection and identification of crustaceans and molluscs of commercially important groups.

Fish Harvesting and Handling

(a) Acquaintance with the different types of fishing crafts and gears in Bangladesh.
(b) Examination of net materials, marketing and mending of nets.
(c) Techniques of net preservation.
(d) Catching techniques of commercially important inland and brackish water fish and shell fish of Bangladesh.
(e) Freshness test of fish and shell fish (appearance, eye condition odor, flesh, gill condition, skin).

(f) Determination of required horse power, passenger load and weight capacity of a mechanized fishing craft.
(g) Basic net design, determination of mesh size, net depth and length, knot spacing and hanging ratio.

Fish Population Dynamics

(a) Study of fecundity.
(b) Population estimation of pond fish by marks and recapture methods.
(c) Study of catch per unit effort.
(d) Age determination of fishes.
(e) Estimation of growth rates in fish, back calculation of growth; Studies of length- weight relation ship and condition factor in fishes.

Aquatic Pollution and Ecotoxicology

(a) Lethal and sub lethal effects of pollutants on aquatic organisms, evaluation of toxicity tolerance, bioassay.
(b) Methods of bioassay, determination of LC_{50}, $LD_{50;}$ Probit analysis

Fisheries Extension

(a) An orientation to different organization related to fisheries development.
(b) Preparation of questionnaire/interview schedule for collection of data from village on fisheries condition and preparation of survey report.
(c) Preparation of training programme and practice training, lecture, small group discursion, Philips 66 methods, symposium, panel discussion, brain storming and demonstrations.
(d) Extension field trip to rural areas to observe rural development activities in the field situation (Thana, districts) with emphasis on fisheries.

FISH 401 Fisheries Resources and Management 4 Credits

1. **Introduction:** importance in Asia, world and Bangladesh fish pupation, Bangladesh position in world, potential of fisheries in Bangladesh.

2. **Fisheries resources in Bangladesh:** physical resources and fish biodiversity in Bangladesh (rivers, floodplains, haor, baors, beel, lake, estuary and sea.).

3. **Economic importance of fisheries resources**: manpower involved in fisheries sector.

4. **Fisheries management**: definition, necessity, dimensions, phases of fisheries management, principle and context of management. Management of natural populations: objectives and goals, regulation of fishing effort, technology creep.

5. **Data required in fishery management**: importance of collection of data, importance of life history data in management.

6. **Habitat restoration and improvement**: (removal of obstruction, modification of existing obstacles, dams, shelter), lotic and lentic waters.

7. **Fisheries regulations**: purpose, types, input and output control, enforcement of regulation, regulatory authority, economic analysis of regulatory techniques.

8. **Problems of management**: prediction of abundance, natural balance and environmental monitoring, role of nutrients.

9. **Fisheries management policy of Bangladesh**: institutional frameworks, inland and marine; process of developing fisheries management policy, Jalmahal policy, New fisheries management policy (NFMP), National fisheries policy; Fish Acts of Bangladesh.

10. **Fisheries management strategy**: stock enhancement scheme, fish sanctuary, CBFM, EEZ (exclusive economic zone) of Bay of Bengal, International Convention on sea.

11. **Management of river fisheries**: Major spawning grounds of major carps, Hilsha fishery management, spawning, development, constrains and future prospects of hilsha fishery; Floodplain, haor, Lake, brackish and marine fisheries management.

Books Recommended:

1. King, M 1996. Fisheries Biology, Assessment and Management. Fishing News Books, Blackwell Science Ltd. UK.
2. Anderson L.G. (1986). The Economics of Fisheries Management, The Johns Hopkins University Press, Baltimore, Maryland.
3. Rounsefell, G.A. and Everhart, W.H. 1983. Fishery Science. John Willey and Sons, New York.

FISH 402 Oceanography and Marine Biology 4 Credits

Oceanography:

1. **Introduction**: Definition of ocean and oceanography, scope, history and classification of oceanography, origin of earth and ocean, theories of origin of ocean,

2. **Ocean Topography:** Continental shelf, slope, rise and abyssal plain, different topographical structures of ocean

3. **Marine sediments:** Sediment texture, development of sediments (sediment transportation, preservation, lithification), types of sediments and sedimentary deposits, sedimentary rocks

4. **Physical properties of sea water:** Salinity, conductivity, temperature, density, light and pressure, their role in the distribution of fish and other aquatic organisms.

5. **Chemistry of sea water:** Constancy of composition, dissolved gases and their distribution in the sea; nutrients in marine water, nutrients cycling, factors influencing nutrients distribution, role of nutrients in marine productivity.

6. **Mixing processes in the ocean:** Waves: properties, types and causes. Tsunami: causes and effects. Tides: types, causes, tide producing forces, theories of tide formation. Currents: types, causes, major ocean currents in the world, Eddy diffusion and Upwelling, horizontal and vertical ocean circulation. Role of mixing process in ocean productivity. El Nino, ENSO and La Nina.

Marine Biology:

1. **The sea as a biological environment:** Zonation of the marine environment; primary productivity, determination of primary production, factors influencing phytoplankton production.

2. **Biogeochemical cycle in the ocean**: carbon cycle, nitrogen cycle, phosphorus cycle, Silica cycle, food wave and food chain.

3. **Major marine ecological groups**–zooplankton, phytoplankton, benthos, nekton and macrophytes, characteristics, their relationships with the physicochemical properties of the sea

4. **Adaptation of marine organism**: Morphological and physiological adaptation of marine fish, mammals, invertebrates and macrophytic halophytes in relation to physico-chemical properties of the sea.

5. **Bay of Bengal:** Origin and history of basin development, topography, hydrological and physical characteristics, St. Martin Islands, major fishery, fishing grounds.

Books Recommended:

1. Duxbury, A. B. and Duxbury, A.C. 1999. Fundamentals of Oceanography. WCB/McGrawHill Publishing Company.
2. Pickard, G.L. 1963. Description Physical Oceanography. Pergamon Press, London.
3. Plummer, C.C., McGraw, D. and Calson, D.H. 2001. Physical Geology. McGraw Hill Higher Education.

4. Thurman, H.V. 1994. Introductory Oceanography. 7th edition, Macmillam Publishing.

FISH 403 Fish Breeding and Hatchery Management 4 Credits

Section A: Fish breeding

1. **Reproduction in fishes**: Introduction, sexuality in fishes, sexual dimorphism, reproductive cycle, control of reproduction.

2. **Fish Reproductive endocrinology**: Introduction, Anatomy of the pituitary and hypothalamus, gonadotropin-releasing hormone, Effect of GnRH on GtH release, Inhibition of GtH release, Fish GtHs and their actions, maturation of the gonads, Oogenesis, yolk formation, ovulation, gamete maturation and release in male fishes.

3. **Basic genetics:** Introduction, genes, effects of genes, single gene trait, quantitative trait, qualitative traits, genetic variance, heritability and hybridization.

4. **Inbreeding:** Genetic relationships, inbreeding, effective population size, effect of inbreeding on genetic variance, inbreeding depression.

5. **Cross breeding:** Introduction, Heterosis.

6. **Pure breeding**

7. **Selection breeding:** Introduction, Natural selection, Artificial selection, Response to selection, Selection differential.

8. **Selection methods:** Introduction, Factors affecting allele frequencies, Choice of selection method, Individual selection, Family selection, between family selections, within family selection, Progeny testing.

9. **Initiating breeding programs:** Introduction, Basis of a breeding program, Establishment of a base population, Breeding goal, Registration of records.

10. **Breeding strategies:** Introduction, Inbreeding, Cross breeding, Pure breeding.

11. **Marker assisted selection:** Types of marker assisted selection, Gene assisted selection (GAS).

Section B: Hatchery Management

1. **Fish hatchery**: Definition, types, essential components of a carp hatchery, Hatchery proper, structural features of brood and other fish ponds, placement of different ponds in a hatchery.

2. **Design and construction of a model carp hatchery:** Introduction, Site selection for hatchery construction, estimation of brood fish requirement, and calculation of area required for brood fish rearing tank, calculation of area required for nursery tank, estimation of water requirement, packing and marketing unit, operation of the hatchery.

3. **Brood stock management:** Brood stock management and seed quality-General considerations, Sperm Physiology and quality; egg quality, Preservation of gametes, biotechnical approaches to brood stock management, Selective breeding and Inbreeding and brood stock management.

4. **Anesthetics and their use in fish propagation and live transport: E**quipment, water quality, handing, loading and stocking and shipping. Transportation of fish eggs, fish larvae and young fry, fish fingerlings and brood fish.

5. **Spawning and egg handling:** Natural and artificial spawning methods, Stages of maturity of adult carps, determining readiness for spawning, control of spawning time, egg incubation, factors affecting egg development, hatching success and fry survival

6. **Types of incubators**: Hatching trays, troughs, baskets, jars, circular tank, incubators, montona hatching box and vertical tray.

7. **Rearing of post larvae and Fry:** Feeding habits of fish larvae, fry and fingerling, time of initial feeding, feeding regime and larval food requirements, starter feeds for hatchlings and fry, feeding advanced fry and fingerlings in nursery, food selectivity, food preference and feeding success, `feeding frequency, feed particle size and feeding methods, rearing pond management.

Books Recommended:

1. Bromage, N R and Roberts, RJ 1995. Broodstock management and egg and larval quality. Blackwell Science, 424pp.

2. Woynarovitch, E and Horvath, L. 1984. FAO FISHERIES TECHNICAL PAPER 201. The artificial propagation of warm-water finfishes: A manual for extension.

3. Chondar, SL Induced carp breeding. CBS Publishers and Distributors. 142 PP.

4. Tave, D 1993. Genetics for Fish hatchery managers. An AVI Book, New York. 413 PP.

5. Gjedrem, T and Baranski, M. 2009. Selective breeding in Aquaculture: An Introduction. Springer, 220 pp.

6. Harvey, B, Carosfeld, J and Donaldson, EM 1993. Induced breeding in tropical fish culture. International Development Research Center. 144 pp.

7. Tave, D 1995. FAO FISHERIES TECHNICAL PAPER 352 Selective breeding programmes for medium-sized farms. FAO.

8. Piper, G et al. 1998. Fish Hatchery Management. United States Department of the Interior Fish and Wildlife Service, Washington, DC.

9. Jhingran V.G. and R.S.V. Pullin. 1985. A Hatchery Manual for the Common, Chinese and Indian Major Carps. Asian Development Bank and International Centre for Living. Aquatic Resources Management, Manila, Philippnes.

10. Tave, D. 1999. Inbreeding and brood stock management. FAO FISHERIES TECHNICAL PAPER 392. 122 PP.

FISH 404 Fish Processing and Preservation 3 Credits

1. **Introduction of fish processing and preservation:** General principles of food preservation with special emphasis of fin fish and shell fish; Physical structure of fish and shellfish; Chemical composition of fish and its application in fish preservation

2. **Post-mortem changes in fish and the nature of spoilage:** Biochemical changes in fish during rigor mortis; Glycolysis; Hydrolytic changes; Changes in fat; Role of protease and bacteria on the spoilage of fish; Spoilage Indices; Freshness test of fish: organoleptic, bacteriological and chemical test.

3. **Chilling of fish:** Preservation effect and changes in fish during chilling with ice; other methods of chilling, factors affecting the quality.

4. **Fish freezing:** Principles of refrigeration, freezing curve; freezing rate; Freezing methods and equipments; Cold store design; Changes associated with freezing and cold storage of fish; Packaging requirements for frozen fish.

5. **Drying and dehydration of fish:** Methods and processing technology; Drying of salt treated fish; Freeze-drying; Quality aspect of dried fish and shrimps.

6. **Smoking of fish:** preservative effect and changes during smoking, quality aspects of smoked fish.

7. **Salting of fish:** types, technological aspects of salting, process and characteristic features of salting, effect of salt quality on the shelf life of salted fish.

8. **Fish Canning:** Definition, history, Principles, advantages; Outline of canning operation; Types and availability of can materials; Influence of canning on the quality of foods; Problems associated with canned fishery products.

9. **Fermented fish products:** Fish sauce, Fish paste, fish pickle, marinades.
10. **Irradiation of fish:** sources of radiation, food irradiation process, Effect of radiation on fish and fish products, Toxicological aspects of food irradiation.
11. **Packaging:** function of packaging, package selection packaging materials, packaging regulations, future of packaging. Modified atmosphere packaging.
12. **Fishery byproducts:** food by-products, non-food by products, fish meal.

Books Recommended:

1. Clusas, I. J. (editor) 1985. Fish Handling, Preservation and Processing in the tropics. Part I & II. Tropical Development and Research Institute. London.
2. Cutting, C. L. 1999. Fish Processing and Preservation. Agro botanical Publishers (India)
3. Balachandran, K.K 2001.Post-hervest Technology of Fish and Fish Products. Daya Publishing House, Delihi.
4. Nawsad, AKM. A. 2007. Participatory Training of Trainers: A new Approach Applied in Fish Processing. Bangladesh Fisheries Research Forum (Dhaka).
5. Borgstrom, G. (editor). 1965. Fish as Food Vols. I-IV. Academic press, London.
6. Govindah. T.K. 1985. Fish Processing Technology Oxford & IBH Publ. Co., New Delhi.
7. Wheaton, E.W. and Lawson, TB. 1985. Processing of Aquatic Food production. Wiley inter Science, New York.
8. Kreuzer, R. (Editor) 1969. Freezing and Irradiation of Fish. Fishing News (Books) Ltd., London.

FISH 405 Fish Pathology and Parasitology 4 Credits

1. **Introduction:** Definition, health and disease, source of infection: factors producing disease in fish, general symptoms of diseased fish.
2. **Viral fish pathogens and their classification:** epizootiology, distribution, eetiology, diagnosis, symptoms and pathology of common viral disease of fish.
3. **Bacterial fish pathogens:** characteristics, epizootiology, distribution, etiology, diagnosis, symptoms and pathology of common bacterial disease of fish.

4. **Fungal fish pathogens:** characteristics, epizootiology, distribution, etiology, diagnosis, symptoms and pathology of common fungal disease of fish.

5. **Pathological changes and symptoms of dietary deficiency in fish:** significance of nutrition in maintaining resistance to infection.

6. **Fish diseases and stress:** environmental stress and their effect on fish and pathogens; hereditary fish diseases, tumours, growth abnormalities.

7. **Shell fish pathogens and disease:** methods for detection of pathogens of fish and shell fish.

8. **Scope of parasitology in the field of fisheries:** major groups of fish parasites and their characteristics.

9. **Classification of parasites of fish and shell fish:** symbiosis and parasitism; morphological adaptation of parasites to their mode of life; host-parasite relationship.

10. **Physiological factors in fish diseases:** host's reaction to parasites, cell and tissue reactions, host specificity.

11. **Distribution of parasites in aquatic habitats:** dynamic changes in parasitic fauna of ponds, lakes and reservoirs.

12. **Life cycle**: Some representative protozoan, trematode, cestode, nematode, acanthocephalan and crustacean parasites.

13. **Public health and fish consumption:** fish as carrier of human parasitic diseases and their control.

Book Recommended:

1. Schaperclaus, W. & Balkema, A. A. 1992. Fish Diseases, Vol. 1&2.

2. Ribelin, W. E & Migaki, G. The Pathology of Fishes. The University of Wisconsin Press.

3. Moller, H. & Anders, K. Diseases and Parasites of Marine Fishes. Scanner - Studio - Nord. Germany.

4. Larry S. Roberts & John Janovy Jr. Wm C. Foundations of Parasitiology. 8th edition, 2010. Brown Publishers.

5. Cheng, T. C. General Parasitology. Academic Press.

FISH 406 Environmental and Fisheries Impact Assessment 2 Credits

1. **Environmental Impact Assessment:** Introduction and overview of EIA; Law, policy and institutional arrangements for EIA systems; Public involvement; Screening; Scoping; Impact analysis; Mitigation and impact management; Reporting; Review of EIA quality; Decision making; Implementation and follow-up; EIA project management; Social impact assessment; Strategic environmental assessment. Case studies.

2. **Fisheries Impact Assessment:** Case studies, Full flood control, partial flood control and controlled flooding projects, variability in flooding impacts of existing FCDI structures, impact on fish; impact on people, recommended mitigation measures, case study of the existing projects, impact of agro-chemicals and industrial pollution. Realistic estimates of production from capture and culture fisheries in with-project and without- project conditions. Impact of farakka barrage on fisheries, difficulties, reliable statistics of diversity of fish habitats and fish species in Bangladesh. Assessment of migratory fish stock, the economic assessment of fish resources, economic impact of shrimp culture, expected changes in project impact area, assessment of social impact of the project.

Books Recommended:

1. Barry Sadler and Mary McCabe (Editors). 2002. Environmental Impact Assessment Training Resource Manual. Second Edition. UNEP.
2. GEO Resource Book: A Training Manual on Integrated Environmental Assessment and Reporting. 2007. United Nations Environment Programme and the International Institute for Sustainable Development.
3. FAP 17. 1992. Fisheries Impact Assessment, ODA, Dhaka.
4. Morgan, R.M. 1998, Environmental Impact Assessment, Kluwer Academic Publishers, Dordrecht, Netherlands.
5. Smith, L. G. 1993. Impact Assessment & Sustainable Resource Management, Longman Scientific & Technical, Inc, Essex, England.

FISH 407 Fisheries Marketing 2 Credits

1. **Introduction:** Marketing principles and process. Aquaculture and Fisheries Marketing concepts. Concept of product, service and brand.

2. **Market infrastructure and facilities:** Types of Markets in urban and rural areas. Marketing channels and supply chain management: Types of channels, channel management.

3. **Market equilibrium and Price analysis:** Price in perfectly competitive, Monopoly, oligopoly, and monopolistic market; Price policy models: estimation and projection of demand for and supply of Aquaculture products. Theory of distribution and factor pricing in aquaculture.

4. **Retailing and whole selling:** types, marketing decision, current trends. Advertising: Objectives, strategy, evaluating effectiveness. Sales promotion: Objectives, tools and development of the program; New product marketing strategies.

5. **Consumer behavior:** Factors affecting behavior, types of behavior and buyer decision process.

6. **Value chain analysis:** Key Elements of Value Chain Analysis; Barriers to entry, mobility and exit; Price linkages analysis; Financial Costs and Profitability; Policy Analysis Matrix; Enterprise Variations; Logistics analysis.

7. **Credits analysis**: 3`R' of the Credits; Principles of aquaculture insurance; Institutions involved in aquaculture financing.

8. **Policies, Regulation, Strategies and Research:** Policies and regulation regarding fisheries marketing in Bangladesh. Fish marketing strategies of Government organizations, private enterprise and NGO's in Bangladesh. International Seafood trade legislation. Marketing research planning and methodologies.

Books Recommended:

1. Kotlar, P and Armstrong, G. 2007. Principles of Marketing. Prentice Hall, NewYork.
2. Engle, Carole Ruth, 2006. Aquaculture marketing handbook. Blackwell Publishing Ltd. UK.

FISH 408 Fish Ecology 3 Credits

1. **Environment, organisms and relationships:** Properties of water, diversity of fishes and relationships.

2. **Abiotic environmental identities on fish distribution:** Effect of abiotic identities, temperature, oxygen content, salinity, water movement; abiotic factors and distribution of river fishes, fishes in lakes, estuaries, marine waters.

3. **Biotic factors and the structure of fish communities:** Predation, pathogens, competition, mutualism; Biotic interactions and community structure in rivers, lakes, estuaries, sea, coral reefs and open sea.

4. **Migration, territoriality and shoaling in fishes:** swimming capacity and energy costs; Patterns and site attachment and social interactions; Fish movements in rivers, lakes, sea, diadromy, homing.

5. **Feeding:** Feeding ecology in riverine environments, lakes, estuaries, sea; Detection and selection of food in detritivores, herbivores, carnivores, foraging. Ecomorphology of feeding; Trophic categories ; utilization of food consumption.

6. **Life-histories:** Traits and concept of trade-offs; Breeding patterns of riverine fishes, lake fishes, estuarine fishes, marine fishes.

7. **Applied ecology of fishes:** Problems in applied ecology; Applied fish ecology of rivers, lacustrine fishes, marine fishes, environmental degradations.

Books Recommended:

1. R.J. Wooton. 1992. Fish Ecology. Chapman and Hall New York.
2. Nilolsky, G.V. 1963. The Ecology of Fishes. Academic Press. London.
3. Brian A. McKeown. 1984. Fish Migration. 2nd ED. Timber Press, Portland, Oregon.
4. Nath, D. 1989. Recent Advances in fish Ecology, Co-Conservation. Creative Publishers, New Delhi.

FISH 409 Research Methodology 2 Credits

1. **Introduction:** Definition, objectives, importance and types of research.

2. **Approaches**: Methodology and limitation of research.

3. **Research design:** Features of good design, concept and development of research plan: Sampling design–sampling strategy, methodology and types of design of the program, sampling and survey, census.

4. **Measurement and scaling techniques:** Analysis, simulation, and interpretation.

5. **Methods of data collection:** primary data, selection of appropriate data.

6. **Guidelines for interviewing, questionnaire and schedule.**

7. **Social and participatory methodologies in peoples' participation.**

8. **Data processing and analysis:** problems, types of statistics, interpretation of results, graphical representation and tabulation.

9. **Manuscript preparation, rules of quotation and bibliography**

10. **Report writing**: Scientific reports, reviews, short communication, case studies, web page, booklet and leaflet.

Books Recommended:

1. E. B. Wilson (1962) An Introduction to Scientific Research. McGraw-Hill Book Co.
2. Stephen S. Carey (2011) A Beginer's Guide to Scientific Method, 4th Edition. Wadsworth, USA.
2. JB Valera (1989) Research Methodology and Applied Statistics.

FISH 410 Practical and Field Work 6 Credits

Fisheries Resources and Management

(a) Questionnaire development for identification of fisheries resources and problems in river, flood plains, haor, baor and marine fisheries sectors.
(b) Methods of habitat improvement.
(c) Observation of effects of regulatory measures on a fishery.
(d) Study of fishing problems in selected localities.

Oceanography and Marine Biology

(a) Study of ocean sediments (common minerals and sedimentary rocks).
(b) Determination of primary productivity (Gran Method and Chlorophyll a method).
(c) Field trip to coastal areas of Bangladesh for acquaintance with sea ecology and of sea water.
(d) Study their physico-chemical properties of sea water.
(e) Study of marine planktons.
(f) Use of common oceanographic equipments.
(g) Collection, preservation and identification of sea weeds and
(h) Collection, preservation and identification of sea shore fauna and flora
(i) Use of common oceanographic equipments '

Fish Breeding and Hatchery Management

(f) Location and removal of pituitary gland.
(g) Preservation of pituitary gland, mitta freeze, preparation gland and administration of the extract.
(h) Induced breeding of fish-brood fish care and maintenance, selection of breeders, selection of inducing agent and hatching techniques.
(i) Karyology of fishes, methods of chromosome preparation in fishes.
(j) Estimation of genetic variation by enzyme electrophoresis.
(k) Determination of soil texture and textual classification.
(l) Plane table and contour survey.
(m) Construction of mini earthen and concrete ponds and hatchery.
(n) Construction of re-circulating system in laboratory.
(o) Culture of algae, plankton in mini earthen and concrete tanks.
(p) Layout of typical fish and shrimp hatchery.
(q) Selection of Breeders, handling and their management.

(r) Use of incubators and hatching of eggs.
(s) Visit to commercial and shrimp hatcheries.

Fish Preservation and Processing

(a) Study on the chemical composition of fish (moisture, lipid, ash, protein and non-protein nitrogenous substances.
(b) Post mortem changes, determination of rigor index.
(c) ATP (adenosine triphosphate).
(d) Cp (creative phosphate).
(e) pH and lactate content during rigor mortis period.
(f) Fraction of fish muscle protein and heat activation (kd value) of myofibriller protein by determining ca^{2+} ATPase activity.
(g) Assessment of quality changes in fish during chilling and freezing by determining the solubility and remaining ATPase activity of both white and red muscle fish.
(h) Quality assessment of traditional sun dried and solar tent dried fish by organoleptic, bacteriological and chemical methods.
(i) Technique of fish salting and determination of slat concentration with time interval.

Fish Pathology and parasitology

(a) Laboratory techniques for determination of fish pathogen from fish and water bodies.
(b) Study of physiological and biochemical characteristics of bacteria, viruses, fungi, etc. related to fish and shell fish diseases.
(c) Histological techniques to investigate nature of disease and pathological changes in fish tissue and organs.
(d) Preparation of parasites for study cleaning, killing and fixing, preservation, staining, identification, examination of a bony fish.
(e) Recording basic data of the fish to be examined, length, weight, age, sex, etc. gut content, investigation of parasites, presentation of data, examination of fish faces and use of laboratory record book.

Rural Sociology

(a) An orientation to different GO's and NGO's related to fisheries development.
(e) Preparation of questionnaire/interview schedule for collection of data from village on socio-economic condition and preparation of survey report.
(f) Extension field trip to rural areas to observe rural development activities (Thana, districts) with emphasis on fisheries.

Fisheries and Environmental Impact Assessment

(a) Visit to some FCD/I projects for impact assessment for example, Baral Basin Project including Char ghat regulator; Narsingdi-Narayanganj FCDI project.
(b) Visit to fish pass at Maulaivi Bazar/Tangail.

Fisheries Marketing

(a) Visit to whole sale market fish auction centers in and around Dhaka.
(b) Visit to a co-operative society operating in coastal area to observe organization and management.
(c) Study of transport and marketing of fish to Dhaka from outside.

FISH 411 Internship and Field Work 2 Credits

Student shall carry out their internship in different GO's, Quasi-GO's, NGO's, donor agencies and private organizations involved in research and business. They have to carry out their internship for minimum 15 days. Student shall have to submit a report after the completion of internship and present their findings in the final exam.