Department of Fisheries
University of Dhaka
B.S. Curriculum
(2020-2021 to 2024-2025)

1. Introduction to the Department of Fisheries

Considering the importance of fisheries sector in food security, nutrition, employment generation, foreign exchange earnings and contributions to the National economy, the Department of Fisheries has started its activities under the Faculty of Biological Sciences, University of Dhaka from the academic year of 1997-1998.

The Department of Fisheries is amongst the leading fisheries education and research institutions in Bangladesh and South-Asia under the University of Dhaka – the first, largest and number one ranked university of Bangladesh. The Department's vision is to advance the fisheries and aquaculture sectors by supplying high-quality human resources and research-based knowledge and technologies.

The Department currently has more than two hundred undergraduate, masters, MPhil and PhD students. It has 23 faculty members most of whom have higher degrees from renowned institutions across the world. It has two premises at the Curzon hall area of the university. A five-storied Professor Mohammed Shafi Fisheries Building is the home to its undergraduate programme – BS honours in Fisheries (4 years) and the main office. The eastern part of the main Curzon hall building is home to its three master's programmes – MS in Aquaculture, MS in Fisheries Biology and Genetics and MS in Fisheries Management. The department produces high-quality graduates through state-of-the-art teaching along with practical and fieldwork activities.

The Department produces high-quality graduates and research outputs which have created major impacts to advance the fisheries sector. The graduates are employed by top employers such as universities, Bangladesh Civil Service (BCS), Bangladesh Fisheries Research Institute (BFRI), Department of Fisheries of the government of Bangladesh, fisheries related industries, national and international NGOs and private sectors. A considerable number of the graduates are studying or completed their higher studies from renowned universities in Asia, Australia, Europe and North America.

The Department has seven research labs namely Aquaculture genomics lab, Aquatic lab, Fish population dynamics, ecology and climate change lab, Fish nutrition and quality control lab, Fisheries management and water quality lab, Fisheries microbiology lab, and Fisheries genetics and biotechnology lab. It also has a computer lab, an auditorium, indoor and outdoor aquaculture and fisheries research facilities and a seminar library with more than two thousand books.

One of the key strengths of the Department is its collaboration with other departments, institutes, and centers of the Dhaka University, which has given the opportunity to conduct cutting edge interdisciplinary fisheries and aquaculture research related to aquatic plants, aquatic zoology, biodiversity, biotechnology, business, chemistry, climate change, economics, entrepreneurship genetic engineering, marine science, microbiology, pollution, social science, and so on. The

Department also collaborates with other institutions in Bangladesh and foreign countries such as Belgium, China, Germany, India, Japan, Korea, USA, and UK. The Department conducts basic, applied and action research in the related fields.

2. Introduction to the Programme

Title of the programme: B.S. (Honours) in Fisheries

Duration of the programme: The duration of B.S. (Hon's) programme of the Department of Fisheries is of 4 (four) academic years with minimum 140 credits. Each academic year consists of maximum 42 working weeks.

Eligibility for Admission: Students will be admitted to the undergraduate programme in the Department of Fisheries under the Faculty of Biological Sciences as per the existing rules of the University of Dhaka.

3. Structure of Curriculum

Credit hours- wise courses:

First Year B.S. Honours

Course No.		Course Name	Credits	
FSH	101	Fisheries Zoology	3	Departmental
FSH	102	Aquatic Ecology	3	Departmental
FSH	103	Biostatistics	4	Extra-Departmental
FSH	104	Ichthyology	3	Departmental
FSH	105	Limnology	3	Departmental
Biochem-11		Biochemistry-I	4	Extra-Departmental
FSH	101P	Fisheries Zoology	1.5	Departmental
FSH	102P	Aquatic Ecology	1.5	Departmental
FSH	104P	Ichthyology	1.5	Departmental
FSH	105P	Limnology	1.5	Departmental
FSH	106	Viva-voce	2	Departmental
Total:			**28 Credits**	

Second Year B.S. Honours

Course No.		Course Name	Credits	
FSH	201	Aquatic Pollution and Ecotoxicology	2	Departmental
FSH	202	Fisheries Systematics and Evolution	3	Departmental
FSH	203	Inland Aquaculture	3	Departmental
FSH	204	Aquaculture Nutrition	2	Departmental
FSH	205	Fisheries Microbiology and Quality Control	4	Extra-Departmental
FSH	206	Fisheries Mathematics	2	Departmental
FSH	207	Rural Sociology	2	Departmental
Biochem-12		Biochemistry-II	4	Extra-Departmental

FSH	201P	Aquatic Pollution and Ecotoxicology	1	Departmental
FSH	202P	Fisheries Systematics and Evolution	1.5	Departmental
FSH	203P	Inland Aquaculture	1.5	Departmental
FSH	204P	Aquaculture Nutrition	1	Departmental
FSH	206P	Fisheries Mathematics	1	Departmental
FSH	207P	Rural Sociology	1	Departmental
FSH	208	Viva-voce	2	Departmental

Total: **31 Credits**

Third Year B.S. Honours

Course No.		**Course Name**	**Credits**	
FSH	301	Coastal Aquaculture	3	Departmental
FSH	302	Fish Physiology	2	Departmental
FSH	303	Fish Genetics	3	Departmental
FSH	304	Fish Pathology and Parasitology	3	Departmental
FSH	305	Fisheries Economics	2	Departmental
FSH	306	Fish Harvesting and Handling	3	Departmental
FSH	307	Fish Population Dynamics	3	Departmental
FSH	308	Fisheries Extension	2	Departmental
FSH	309	Fisheries and Environmental Impact Assessment	2	Departmental
FSH	301P	Coastal Aquaculture	1.5	Departmental
FSH	302P	Fish Physiology	1	Departmental
FSH	303P	Fish Genetics	1.5	Departmental
FSH	304P	Fish Pathology and Parasitology	1.5	Departmental
FSH	305P	Fisheries Economics	1	Departmental
FSH	306P	Fish Harvesting and Handling	1.5	Departmental
FSH	307P	Fish Population Dynamics	1.5	Departmental
FSH	308P	Fisheries Extension	1	Departmental
FSH	309P	Fisheries and Environmental Impact Assessment	1	Departmental
FSH	310	Internship	1.5	Departmental
FSH	311	Viva-voce	2	Departmental

Total: **38 Credits**

Fourth Year B.S. Honours

Course No.		**Course Name**	**Credits**	
FSH	401	Fisheries Resources Management	3	Departmental
FSH	402	Oceanography and Marine Biology	3	Departmental
FSH	403	Fish Breeding and Hatchery Management	3	Departmental
FSH	404	Fish Processing and Preservation	3	Departmental
FSH	405	Aquaculture Engineering	3	Departmental
FSH	406	Fish Feed Management	2	Departmental
FSH	407	Fisheries Marketing	2	Departmental
FSH	408	Aquatic Biodiversity and Conservation	2	Departmental
FSH	409	Fish Pharmacology	3	Departmental

FSH	410	Research Methodology	2	Departmental
FSH	401P	Fisheries Resources Management	1.5	Departmental
FSH	402P	Oceanography and Marine Biology	1.5	Departmental
FSH	403P	Fish Breeding and Hatchery Management	1.5	Departmental
FSH	404P	Fish Processing and Preservation	1.5	Departmental
FSH	405P	Aquaculture Engineering	1.5	Departmental
FSH	406P	Fish Feed Management	1	Departmental
FSH	407P	Fisheries Marketing	1	Departmental
FSH	408P	Aquatic Biodiversity and Conservation	1	Departmental
FSH	409P	Fish Pharmacology	1.5	Departmental
FSH	410P	Research Methodology	1	Departmental
FSH	411	Project	2	Departmental
FSH	412	Viva-voce	2	Departmental
Total:			**43 Credits**	

4. Assessment system

Number of in-course and final examination

In-course Assessment (Theory Courses)

In-course tests of minimum one-hour duration shall be conducted and evaluated by the course teacher. There will be at least 2 (two) written tests for both 3 and 4 credit courses and at least 1 (one) written test for 2-credit courses. Five percent marks will be allocated for class attendance for theoretical courses.

Make-up Test: Make-up test may be arranged for a student who fails to appear in in-course tests, under certain circumstances. Absence in any in-course test will usually be counted as zero for calculating the average in in-course test for that course. However, a student can apply to the Chairman of the Department for the make-up test. The Chairman will only place the application before the academic committee if the particular student met with an accident or his/her parents has expired or he/she has gone through a surgical procedure or any other situation which the Academic Committee feels can be considered. The make-up test must be held during the course period.

Assignment: Each 3rd and 4th year course will have one assignment bearing 5% of the total mark of the respective course and will be evaluated by the course teacher. Each assignment will have 1,500-2,000 words excluding references, cover page and table of contents.

The Course Final Examination (Theory Courses): The course final examinations will be of 3 hours duration for 4-credit courses, 2.5 hours for 3-credit courses and 2 hours for 2-credit courses. For evaluation of the course final examination there will be two examiners: one internal (will be the course teacher/teachers) and other external (will preferably be within the department/university provided that he/she was not a course teacher for the course paper to be examined). Under double-examiner system and in case of difference of more than 20% of marks there will be a 3rd examiner. Average of the marks of the nearest two examiners will be considered as final marks.

Assessment of Internship Course: In the 3rd year an internship report for 25 marks and presentation for 12.5 marks will be evaluated by the respective examination committee.

Assessment of Project Course: It is a research project of 50 marks in the 4th year which includes 35 marks for the dissertation and 15 marks for the presentation. Each dissertation will be evaluated by the two external examiners and the presentations will be evaluated by the respective examination committee and supervisor.

Viva-voce/Oral examination: Viva-voce/Oral examination will be conducted by the respective examination committee approved by the University.

Types of questions:
Questions for in-course tests should preferably be the objective type subjected to the approval of the Academic Committee of the Department. Additional assessments may be made by a course teacher as determined by him/her. In such cases the marks distribution for these assessments will be determined by the respective Academic Committee. The course teacher will show the examined in-course scripts to the students.

The course final examination will be conducted centrally by the Controller of Examinations as per existing system. Patterns of theory questions will be decided by the respective Academic Committee of the department. However, there will be no objective part.

5. Academic guidelines

Detail guidelines are available at faculty website.

Grading system:

Marks obtained (%)	Corresponding letter grade	Grade point
80 or above	A+	4.00
75 to less than 80	A	3.75
70 to less than 75	A-	3.50
65 to less than 70	B+	3.25
60 to less than 65	B	3.00
55 to less than 60	B-	2.75
50 to less than 55	C+	2.50
45 to less than 50	C	2.25
40 to less than 45	D	2.00
Less than 40	F	0.00

Note: The fractional total marks for a course will be rounded up to next higher mark.

Practical Examination
Students' performance will be evaluated in In-course examination and final examination. Five percent marks will be allocated for class attendance for practical courses.

Requirements for Degree/Diploma: To graduate with a Bachelor degree, a minimum total of 140 credits must be earned by a student within 4-6 academic years after his/her enrollment and must also have earned the minimum required CGPA 2.5 on a 4.00 scale.

6. Structure of Course:

The structure of each course of each academic year is provided in the following sections.

FSH 101 Course title: Fisheries Zoology Credit: 3 Credit hours: 45

Introduction to the course:

Aquatic animals are important for fisheries sector as live food for fish and also as human food. Therefore, this course is designed to give an overview about the classification, morphology, food, feeding and reproduction of invertebrates having economic importance in fisheries sector. This course covers all aquatic animals playing important role in aquatic ecosystems.

Specific objectives:

i. To get acquainted with invertebrate and vertebrate phyla;
ii. To enable understand morphological structures, behavior and development of the invertebrate and vertebrate aquatic and semi-aquatic animals; and
iii. To get acquainted with the biology of culturable aquatic and semi-aquatic animals.

Course content

Theoretical

Part 1: Non-chordate

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 culturable invertebrates**: Tubificid worm, Pearl oyster, Rotifer, Artemia/ brine shrimp, Crabs, Prawn, Shrimp
4. **Economic importance of each of the invertebrate phyla with special emphasis on fisheries.**

Part 2: Chordate

1. Introduction, Major features of chordates, classification of the major Chordate groups with special emphasis on the aquatic ones, Chordates evolution in geological timescale.
2. **Study of Cephalochordata-** Characteristics, classification up to class, external morphology, mode of life.
3. **Study of Vertebrates:**

Amphibia: Classification up to order, morphological features, life cycle and parental care in amphibians**.**

Reptilia: Classification up to order, morphological features, biology of turtle, tortoise and crocodiles, parental care in reptiles.

Aves: Classification up to order, food and feeding, adaptation of aquatic birds.

Mammalia: Classification of aquatic mammals up to order, food and feeding, adaptations of aquatic mammals**.**

Pisces/Fishes will be discussed in the FSH 105 (Ichthyology) course.

4. Economic importance of various groups of chordates with special reference to fisheries.

Unit-wise learning outcome:

At the end of the course students will be able to-

i. Define invertebrate and vertebrate;
ii. Classify aquatic and semi-aquatic invertebrate and vertebrate phyla;
iii. Describe the morphology, food, feeding and reproduction of Protozoans, Sponges, Corals, Rotifers, Oligochaetes, Crustaceans and mollusks;
iv. Describe coral reef formation and coral bleaching;
v. Explain the larval development of crustaceans and echinoderms;
vi. Describe the biology of the culturable invertebrates;
vii. Learn adaptation strategies of different aquatic animals to environment; and
viii. Link the evolution of different adaptations in chordates for different mode of life.

Unit-wise title, subtitle and number of classes

Chapter	**Unit wise Title**	**Sub-title**	**No. of classes**
Part 1: Chordate			
1	**Classification**	Protozoa	**1**
		Porifera	**1**
		Cnidaria	**1**
		Annelida	**1**
		Platyhelminthes	**1**
		Arthropoda	**1**

		Mollusca	**1**
		Echinodermata	**1**
2	**Morphology, feeding, reproduction**	**Protozoans**: Body covering and skeletal structures, locomotory organelles and locomotion, nutrition, reproduction and development	**2**
		Sponges: Body walls with description of cell types, skeletal structure, canal system, reproduction and development	**2**
		Coral and coral reefs: Polymorphism, physical structure, food and feeding, reproduction, theory of coral reef formation, coral bleaching, significance and conservation	**2**
		Rotifers: External and internal body structure, food, feeding and reproduction	**1**
		Oligochaetes: External and internal body structure, food, feeding and reproduction	**1**
		Crustaceans	**3**
		Body structure, digestive system	
		Respiratory system	
		Circulatory system	
		Reproductive system and larval development	
		Gastropods: External and internal body structure, food, feeding and reproduction	**1**
		Pelecypods: External and internal body structure, shell structure and pearl formation, feeding and reproduction	**1**
		Cephalopods: External and internal body structure, locomotion, adaptive diversity, feeding and reproduction	**1**
		Aquatic Insects: Aquatic insects of different orders and their significance in fisheries	**1**
		Echinoderms: Skeletal structure, modification of water vascular system in different classes, locomotion, reproduction and larval development	**2**
3	**Biology of culturable invertebrates**	Tubifex worms, Pearl oyster, Rotifer, Artemia/ brine shrimp and Crabs	**3**
4	**Economic importance**	Economic importance of each of the invertebrate Phyla with special emphasis on fisheries	**1**
Part 2: Chordate			
1	**Introduction and classification**	Major features of chordates. Classification of the major Chordate groups with special emphasis on the aquatic ones**.** Chordates evolution in geological timescale.	**2**

2	**Study of Cephalochordate**	Characteristics, classification up to class, external morphology, mode of life.	**2**
3	**Study of Vertebrates**	**Amphibia:** Classification up to order, morphological features	**1**
		Life cycle and parental care in amphibians	**2**
		Reptilia: Classification up to order, morphological features,	**1**
		Differences between crocodile, alligator and gharial, turtle and tortoise, parental care, biology of turtle, tortoise and crocodiles.	**2**
		Aves: Classification up to order and morphological features	**1**
		Food and feeding and adaptation of aquatic birds.	**1**
		Mammalia: Classification of aquatic mammals up to order	**1**
		Food and feeding, adaptations of aquatic mammals**.**	**2**
4	**Economic importance of various groups of chordates with special reference to fisheries**		**1**
		Total	**45**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

1. Jordan, E.L. and Verma, P.S. 2001. Invertebrate Zoology, S. Chand and Company. Ramnagar, New Delhi.
2. Kotpal, R.L. 2005. Modern Textbook of Zoology, Vertebrate (Animal Biodiversity-II). Rastosi Publications, Meerut, India.
3. Kotpal, R.L. 2007. Modern Textbook of Zoology, Invertebrate (Animal Biodiversity –II). Capital Offset Press, New Delhi, India.
4. Parker, T.G. and Haswell, W.S. 1960. Textbook of Zoology Vol. 1 & 11 (7^{th} Ed.) Macmillan Co. Ltd., London.
5. Parker, T.G. And W.S. Haswell, 1960. Textbook of Zoology Vol. 1 & 11 (7^{th} Ed.) Macmillan Co. Ltd., London.
6. Robert, T. Orr. 1982. Vertebrate Biology. Saundars College Publishing.
7. Sinha, A.K., Adhikari, S., Ganguly, B.B. and Gowshami, B.C.B. 2004. Biology of Animals (Vol.II). Central Book Agency Pvt.

8. Storer, T.I. and R.L. Usinger, 1972. General Zoology McGraw Hill Book Co. New York.
9. Young, J.Z. 1981. The Life of Vertebrates (3rd edition). Oxford University press.

FSH 102 Course title: Aquatic Ecology Credit: 3 Credit hours: 45

Introduction to the course:

An understanding of fish ecology requires an awareness of the relationship between fishes and their environment. The purpose of this course is to introduce the ecology of fishes by describing the inter-relationship between fishes and the aquatic habitats they occupy. Therefore, this course has been designed to exchange and disseminate information, ideas, practical experience and proper knowledge on all matters relating to the fish ecology. This course will able to provide knowledge on habitat use, species interactions, migration, feeding, population dynamics and reproduction in relation to the major habitats occupied by fishes. Its emphasis is on descriptive rather than quantitative ecology. It is assumed that the student will be familiar with the basic ecology of fishes. They will be able to understand the ecological and evolutionary processes impacting on individuals, populations and species.

Specific objectives:

i. To get understand aquatic ecology;
ii. To develop positive attitudes toward conservation of organisms and protection of environment;
iii. To get acquainted with the diversity, morphological, behavioral and life history variability of different fishes;
iv. To enable understand how the fishes interact with its biotic and abiotic environment;
v. To get understand the migration, territoriality and shoaling in fishes;
vi. To develop an idea on eco-morphology of feeding, trophic categories; utilization of food consumption in different environments like riverine, lakes, estuaries, marine ecosystem; and
vii. To get know the traits and concept of trade-offs; breeding patterns of riverine, lake, estuarine and marine fishes.

Course Contents

Theoretical

1. **Introduction:** Definition, ecology, scope of ecology, sub-division of ecology, Principles and concept of ecology. Concept of fish ecology, environment- organism relationship. Properties of water, diversity of fishes, morphology and adaptation, behavioral and life history variability.
2. **Bio-geo-chemical cycles and Tropic structure:** Carbon cycle, Nitrogen cycle, Food chain, Food web, Ecological pyramids.
3. **Habitat:** Classification, "r"- and "k"-selection. Ecological niche: realized niche, niche overlap, Gause's competitive exclusion principle, resource partitioning, Life history traits and concept of trade-offs; breeding patterns of riverine fishes, lake fishes, estuarine fishes, marine fishes, population characteristics, dynamics of fish populations.

4. **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.
5. **Biotic factors and community development**: Inter-specific interactions, community structure in rivers, lakes, estuaries, sea, coral reefs, open sea and deep sea; ecological succession, concept of climax, ecotone, edge effect.
6. **Migration, territoriality and shoaling in fishes:** Basic pattern of migration, Swimming capacity and energy costs; Patterns and site attachment and social interactions; Fish movements in rivers, lakes, sea, diadromy, homing, mechanism of homing, home range, territoriality.
7. **Feeding and growth:** Concept of feeding and growth, feeding ecology in riverine environments, lakes, estuaries, sea; Detection and selection of food in detritivores, herbivores, carnivores, foraging. Ecomorphology of feeding, Ecomorphology hypothesis Trophic categories; utilization of food consumption, nutrient budget, effect of food and other environmental identities on growth, growth measurement, ageing and age determination.
8. **Life-histories and population dynamics:** Life history traits and concept of trade-offs; breeding patterns of riverine fishes, lake fishes, estuarine fishes, marine fishes, population characteristics, dynamics of fish populations.
9. **Biomes:** Terrestrial, Wetland & Freshwater, Coastal and Marine biomes. Biogeographic regions, Evolution and conservation.
10. **Applied ecology of fishes:** Concept of applied ecology, problems in applied ecology; applied fish ecology of rivers, lacustrine, sea. Aquatic environmental degradation and management.

Unit-wise learning outcomes:

At the end of the unit students will be able to-

i. Define ecology and ecosystem;
ii. Describe different Bio-geo-chemical cycles;
iii. Analyze the interrelationship between the elements of a pond ecosystem, the competition among species for the same limiting resource;
iv. Identify how to maintain the water quality of a pond;
v. Understand the roles of different bacteria in aquatic ecosystem;
vi. Establish the inter-relationship between food chain and food web; and
vii. Demonstrate significant awareness in ensuring positive attitudes towards conservation of pond ecosystem.

Unit wise title and sub-title, learning outcomes and number of classes per unit

Chapter	Unit wise Title	Sub-title	No. of classes
1	**Introduction**	Definition, ecology, scope of ecology, sub-division of ecology, Principles and concept of ecology.	**2**
		Concept of fish ecology, environment- organism relationship.	**1**

		Properties of water, diversity of fishes, morphology and adaptation, behavioral and life history variability.	**2**
2	**Bio-geo-chemical cycles and Tropic structure**	Carbon cycle, Nitrogen cycle, Food chain, Food web, Ecological pyramids.	**3**
3	**Habitat**	Ecological niche: realized niche, niche overlap, Gause's competitive exclusion principle, resource partitioning	**1**
		Classification, "r"- and "k"-selection.	**1**
		Life history traits and concept of trade-offs; breeding patterns of riverine fishes, lake fishes, estuarine fishes, marine fishes, population characteristics, dynamics of fish populations.	**2**
4	**Abiotic environmental identities on fish distribution**	Effect of abiotic identities, temperature, oxygen content, salinity, water movement	**1**
		Abiotic factors and distribution of river fishes, fishes in lakes, estuaries, marine waters.	**2**
5	**Biotic factors and community development**	Inter-specific interactions: Predation, pathogens, competition, mutualism	**2**
		Biotic interactions and community structure in rivers, lakes, estuaries, sea, coral reefs and open sea	**2**
		Ecological succession, concept of climax, ecotone, edge effect.	**1**
6	**Migration, territoriality and shoaling in fishes**	Basic pattern of migration, swimming capacity and energy costs, patterns and site attachment and social interactions;	**2**
		Fish movements in rivers, lakes, sea, diadromy	**2**
		Homing, mechanism of homing, home range, territoriality	**2**
7	**Feeding and growth**	Concept of feeding and growth, feeding ecology in riverine environments, lakes, estuaries, sea	**2**
		Detection and selection of food in detritivores, herbivores, carnivores, foraging. ecomorphology of feeding, ecomorphology hypothesis, trophic categories	**2**
		Utilization of food consumption, nutrient budget, effect of food and other environmental identities on growth, growth measurement, ageing and age determination.	**3**
8	**Life-histories and population dynamics**	Life history traits and concept of trade-offs	**2**
		Breeding patterns of riverine fishes, lake fishes, estuarine fishes, marine fishes	**2**

		Population characteristics, dynamics of fish populations	**2**
9	**Applied ecology of fishes**	Concept of applied ecology, problems in applied ecology	**2**
		Applied fish ecology of rivers, lacustrine, sea.	**2**
		Aquatic environmental degradation and management	**2**
		Total	**45**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

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

FSH 103 Course title: Biostatistics Credit: 4 Credit hours: 60

Introduction to the course:

This is an introductory course. It introduces modern theory and methodology of statistics and their application in biology. The topics to be covered include basic concepts of descriptive statistics, probability, correlation, regression, statistical inference, design and analysis of experiment.

Specific objectives:

i. To get understand variable and data;
ii. To get acquainted with the use of statistical concepts for application in fishery science;
iii. To get understand the application of common tools such as mean, standard deviation, probabilities, various statistical distribution tables such as standard normal table, t-table;
iv. To get acquainted with correlation and regression models, test their accuracy and interpret them for use in real life scenarios; and
v. To get know hypothesis related to goodness of fit, t-test, 1-way and 2-way ANOVA.

Course contents

Theoretical (80 Marks)

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 probability theory:** Laws of probability, additive and multiplicative laws of probability and Baye's theorem, random variables, probability distribution, 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. **Correlation and regression:** 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-square 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 covariance in a completely randomized design.

Unit-wise learning outcomes:

At the end of the unit students will be able to-

i. Define and understand the variable, data, accuracy and precision;
ii. Construct different graphical and tabular presentation of data;
iii. Understand and apply probability theories;
iv. Select study and sampling designs;
v. Synthesis statistical data;
vi. Analyze collected data; and
vii. Interpret analyze data.

Unit wise title, sub title and number of classes per unit

Chapter	Unit wise Title	Sub-title	No. of classes
1	**Definition and scope of Biostatistics**	Bio-statistics, data, variable, accuracy, precision	**2**
		Classification of variables and data	**2**
		Construction of frequency distribution and graphical representation of data	**2**
		Measures of central tendency	**2**
		Measures of dispersion	**2**
		Moments, skewness and kurtosis.	**2**

2	**Elementary probability theory**	Laws of probability, additive and multiplicative laws of probability	**3**
		Baye's theorem, random variables, probability distribution	**3**
		Properties and uses of Binomial, Poisson and Normal distribution	**3**
		Fitting Binomial, Poisson and Normal distribution to observed data	**3**
3	**Population and sampling**	The concept of statistical population and random sample	**2**
		Preliminary idea on sampling distribution	**2**
		Definition and use of standardized normal variate	**2**
4	**Correlation and regression**	Product moment correlation coefficient to measure the relationship between variables in bi-variate distribution	**4**
		Fitting simple linear regression to observed data by the method of least squares	**4**
5	**Hypothesis**	Test of hypothesis, type I and type II errors and level of significance	**2**
		Preliminary idea on t-test, F-test, Chi-square test and their application	**2**
		Testing hypothesis regarding population mean, equality of two means, population variance, equality of two population variances	**4**
		Goodness of fit and independence of two attributes in a contingency table	**2**
		Test of significance of correlation coefficient and regression coefficient(s)	**2**
6	**Principles of experimental design**	Field layout and analysis of variance in completely randomized design	**4**
		Randomized block design and	**2**
		Latin square design	**2**
		Analysis of covariance in a completely randomized design	**2**
Total			**60**

Practical (20 Marks)

a. Frequency table construction and graphical representation of data. Calculation of various measures of central tendency and various measures of dispersion.
b. Fitting Binomial, Poisson 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. Application of 'R' statistics in fisheries

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

Practical: Final
Oral test: Final

References

1. Arora, P. N. and Malhan, P. K. 2010. Biostatistics. Himalaya Publishing House, India.
2. Bancroft, H. 1957. Introduction to Biostatistics. Paul B. Hoeber, Inc., New York, 172.
3. Croxton, F. E., Cowden, D. J. and Klein, S. 1975. Applied General Statistics. Prentice-Hall of India Pvt. Ltd., New Delhi, India.
4. Goldstein, A. 1968. Biostatistics: An Introductory Text. MacMillan Co., New York.
5. Gupta, S. C. and Kapoor, V. K. 1994. Fundamentals of mathematical statistics. Sultan Chand and Company Ltd., Ramnagar, New York.
6. Mahajan, B. K. 1989. Methods in Biostatistics. Jaypeebrothers publishers, New Delhi India.
7. Singh, Y. K. 2006. Fundamental of research methodology and statistics. New Age International. New Delhi.

FSH 104 Course title: Ichthyology Credit: 3 Credit hours: 45

Introduction to the course:

This course is designed to provide basic knowledge on the biology and taxonomy of fishes. During lecture sessions, students will be introduced to the taxonomy, major groups, general morphology, physiology, and natural history of fishes. In the laboratory sessions, students will gain "hands-on" training on fish morphology and anatomy. Students will gain knowledge on local aquatic habitats and associated fish fauna.

Specific Objectives:

i. To enable knowing living and extinct groups of fishes with their distribution;
ii. To get understand the morphology of fishes;
iii. To get understand the functions of different body parts of fishes;
iv. To get know the evolution and adaptive radiation in fishes;
v. To get understand the migration and homing patterns of fish;
vi. To get understand the breeding pattern of fish; and
vii. To get acquainted with the aquatic environment with respect to the biology of fish

species.

Course Contents

Theoretical

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 barbels, 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, 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:**

i) Digestive system: Digestive Systems of freshwater and marine fish: Structure, functions, glands and enzymes. Different group of fish based on diet; modification of mouth, teeth and digestive tract; mechanical and chemical actions of ingestion and digestion of food.
ii) Respiratory organs: Gill structure and function, air-breathing fishes: lungs and lungfishes.
iii) Circulatory System: Heart and accessory pumps; blood vessels of the gills and head, blood vessels of the body, lymphatic system.
iv) Reproductive system.
v) Endocrine organs.
vi) Kidney and excretory system.
vii) Nervous and sensory system of fish: Nervous System, Sensory System, Sense organs and their functions in fishes, lateral line system

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

Unit-wise learning outcomes:

At the end of the unit students will be able to-

i. Define Ichthyology;
ii. Understand species variation and evolution, distribution of fishes;
iii. Understand different feeding behavior, respiration pattern, circulatory system, reproductive system, endocrinology of different species of fish;
iv. Develop skill in demonstration lab works;
v. Understand schooling and shoaling behavior of fish; and
vi. Manage of fisheries, and conservation of species and the aquatic environment.

Unit wise title and sub title, learning outcomes and number of classes per unit

Chapter	Unit wise Title	Sub-title	No. of classes
1	**Introduction**	Ichthyology and importance of studying Ichthyology.	**1**
		Major groups of living and extinct fishes and their characterization with special reference to those of Bangladesh.	**3**
2	**External morphology**	Body from, body covering, appendages, openings, sensory organs.	**3**
3	**Integument**	Structure and functions of skin, scales shape, type, derivatives use.	**2**
		Other derivatives of Skin dermal fin rays, flaps and barbels, light organs, poisonous glands, coloration Thayer's principle, sources of color, functions of coloration.	**3** **1**
4	**Skeleton**	Cartilage and bone, exoskeleton, endoskeleton, membranous skeleton, notochord, axial skeleton, appendicular skeleton, visceral skeleton, origin of limbs and girdles.	**4**
5	**Muscle**	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.	**4**
6	**Internal organs**	Digestive system: Digestive Systems of freshwater and marine fish: Structure, functions, glands and enzymes.	**4**
		Respiratory organs: Gill structure and function, air-breathing fishes: lungs and lungfishes.	**4**
		Circulatory System: Heart and accessory pumps; blood vessels of the gills and head, blood vessels of the body, lymphatic system.	**4**
		Kidney and excretory system Reproductive system Endocrine organs Nervous and sensory system of fish: Nervous System, Sensory System, Sense organs and their functions in fishes, lateral line system, Fish nerve cells, Olfaction, Gustation, Nociception, Visual Sensitivity and Signal Processing, auditory nerve	**1** **1** **1** **3**
7	**Evolution and adaptive radiations in fishes**		**3**
8	**Fish fauna of Bangladesh**		**3**
		Total	**45**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

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.
5. Bone, Q and R. H. Moore. 2008. Biology of Fishes. Third Edition.

FSH 105 Course title: Limnology Credit: 3 Credit hours: 45

Introduction to the Course:

Limnology is the interdisciplinary study of inland waters including lakes, wetlands, ground water, and streams. The theoretical portion of this course will assist as an overview to the geological, physical, chemical, and biological processes that form and uphold these aquatic systems. Students will acquire hands on field and laboratory skills in sampling aquatic systems, assessing and inferring important limnological variables, and identifying aquatic organisms throughout the practical sessions of the course.

Specific Objectives:

i. To get understand the basic terminology used by limnologists and other aquatic scientists;
ii. To get acquainted with multidisciplinary ideas to comprehend how aquatic systems work;
iii. To get know how living organisms endure and intermingle in aquatic environments;
iv. To get enabled to identify common aquatic organisms, predominantly algae, zooplankton, and macroinvertebrates; and
v. To get acquainted with the methods of collecting, analyzing and reporting limnological data.

Course Contents

Theoretical

1. **Limnology:** concepts and definition, history and development, limnology in 21st century, importance and scope of limnology; physical, chemical and biological limnology, the present and future of limnology
2. **Inland water-bodies:** definition of lake, reservoir, river, stream, wetlands, , general features of lakes and drainage basins, origin and age of lakes, lake morphology and morphometry,

zonation in lakes, classification of lakes, lakes as an ecosystem, remarkable inland water-bodies of bangladesh and world

3. **The physical properties of inland waters:** water as a medium, light below and above of the water surface, color, turbulence in surface waters, reynolds number, richardson number, diel variations of temperature, ph, viscosity of inland water, laminar vs turbulent flow, heat balance in aquatic ecosystem, thermal stratification, vertical and horizontal circulation/mixing in inland aquatic ecosystem, stability of stratification, thermocline depth and shape, ecological significance of the metalimnion and importance of meromixis, intrusion in lakes and reservoirs
4. **The chemical characteristics of inland waters:** dissolved substances in water, alkalinity of inland waters, major dissolved gases, air-water interactions and the solubility of gases in water, the carbon-di-oxide system, carbonates precipitation and solubilization, inorganic carbon and ph, sources and sinks of oxygen, seasonal and diurnal variation of oxygen and carbon-di-oxide, major nutrients: n p k, nitrogenous compounds; chemical stratification, vertical distribution of nutrients, nutrient cycling in freshwater aquatic system, role of nutrients in primary production
5. **Soil and sediments**: definitions, characteristics of bottom soil, soil ph, organic matter, origin and distribution of sediments, sedimentation and sediment traps, sinking velocities and sedimentation rates, profundal sediment characteristics, Paleolimnology, C/N ratio, soil-water interactions and productivity
6. **Organisms and communities in inland aquatic ecosystems:** ecological classification of freshwater organisms, limiting and controlling factors in diversity and distribution of aquatic communities; spatial organization of aquatic communities, fish and water birds, aquatic insects, bio indicators organisms, bacteria, phytoplankton, zooplankton and benthos relations; planktons and fish relationships,
7. **Phytoplankton:** general features, classification, characteristics of major groups, distribution, seasonal succession and culture techniques of phytoplankton; eutrophication and limiting nutrients, empirical nutrient-phytoplankton relationship, acidification, brownification, phytoplankton bloom, red tide; periphyton
8. **Bacterioplankton:** bacterial size, forms and metabolism; abundance, biomass and distribution; heterotrophic bacterial abundance and environmental factors; the microbial food web, photosynthetic bacteria, heterotrophic sediment bacteria
9. **Primary production:** definitions, light attenuation and photosynthesis, light and primary production, biotic and abiotic factors affecting primary production; estimation of primary production of phytoplankton, model of primary production of phytoplankton, methods for measuring the primary production of periphyton, P/B ratio, fishery production and its correlation with primary production, the secchi disc and its utility, limitations of the secchi disc,
10. **Zooplankton:** general features, major groups, seasonal variation, feeding, reproduction, vertical migration, cyclomorphosis, top-down control of zooplankton, nutrient cycling and zooplankton, culture techniques
11. **Aquatic plant populations and communities:** kinds and significance of aquatic vascular plants, macrophyte distribution and species richness, macrophyte biomass and its determinants,
12. **Benthos:** classification of benthic region, benthic macroinvertebrates: qualitative and quantitative distribution, factors affecting the distribution

Unit-wise learning outcomes:

At the end of the unit students will be able to-

i. Define Limnology;
ii. Understand the functioning and dynamics of surface freshwater ecosystems;
iii. Understand the relations between hydrological, geomorphologic, biogeochemical and ecological components;
iv. Understand the interdisciplinary information and handle complexity; and
v. Define and discuss the potential impacts human activities have on the various aquatic ecosystems.

Unit-wise title and sub-title and number of classes per unit:

Chapter	Chapter title	Chapter sub-title	No. of classes
1	**Limnology**	concepts and definition, history and development, limnology in 21st century, importance and scope of limnology; physical, chemical and biological limnology, the present and future of limnology	**2**
2	**Inland waterbodies**	definition of lake, reservoir, river, stream, wetlands, , general features of lakes and drainage basins, origin and age of lakes,	**3**
		lake morphology and morphometry, zonation in lakes, classification of lakes, lakes as an ecosystem, remarkable inland water-bodies of bangladesh and world	**2**
3	**The physical properties of inland waters**	water as a medium, light below and above of the water surface, color, turbidity turbulence in surface waters, reynolds number, richardson number, , diel variations of temperaturetemperature, ph, viscosity of inland water, laminar vs turbulent flow,	**2**
		heat balance in aquatic ecosystem, thermal stratification, vertical and horizontal circulation/mixing in inland aquatic ecosystem, stability of stratification,	**2**
		thermocline depth and shape, ecological significance of the metalimnion and importance of meromixis, intrusion in lakes and reservoirs	**2**
4	**The chemical characteristics of inland waters**	dissolved substances in water, alkalinity of inland waters, major dissolved gases, air-water interactions and the solubility of gases in water, the carbon-di-oxide system,	**2**
		carbonates precipitation and solubilization, inorganic carbon and ph, sources and sinks of oxygen, seasonal and diurnal variation of oxygen and carbon-di-oxide, major nutrients: n p k, nitrogenous compounds;	**2**
		chemical stratification, vertical distribution of	**3**

		nutrients, nutrient cycling in freshwater aquatic system, role of nutrients in primary production	
5	**Soil and sediments**	definitions, characteristics of bottom soil, soil pH, organic matter,	**1**
		origin and distribution of sediments, sedimentation and sediment traps, sinking velocities and sedimentation rates, profundal sediment characteristics,	**1**
		Paleolimnology, C/N ratio, soil-water interactions and productivity	**1**
6	**Organisms and communities in inland aquatic ecosystems**	ecological classification of freshwater organisms, limiting and controlling factors in diversity and distribution of aquatic communities;	**2**
		spatial organization of aquatic communities, fish and water birds, aquatic insects, bio indicators organisms, bacteria, phytoplankton, zooplankton and benthos relations; planktons and fish relationships,	**1**
7	**Phytoplankton**	general features, classification, characteristics of major groups, distribution, seasonal succession and culture techniques of phytoplankton;	**2**
		eutrophication and limiting nutrients, empirical nutrient-phytoplankton relationship, acidification, brownification, phytoplankton bloom, red tide; periphyton	**3**
8	**Bacterioplankton**	bacterial size, forms and metabolism; abundance, biomass and distribution; heterotrophic bacterial abundance and environmental factors;	**1**
		the microbial food web, photosynthetic bacteria, heterotrophic sediment bacteria	**1**
9	**Primary production**	definitions, light attenuation and photosynthesis, light and primary production, biotic and abiotic factors affecting primary production; estimation of primary production of phytoplankton,	**1**
		model of primary production of phytoplankton, methods for measuring the primary production of periphyton, P/B ratio, fishery production and its correlation with primary production, the secchi disc and its utility, limitations of the secchi disc,	**2**
10	**Zooplankton**	general features, major groups, seasonal variation, feeding, reproduction, vertical migration, cyclomorphosis,	**2**
		top-down control of zooplankton, nutrient cycling and zooplankton, culture techniques	**2**
11	**Aquatic plant populations and communities**	kinds and significance of aquatic vascular plants, macrophyte	**2**
		distribution and species richness, macrophyte	**1**

		biomass and its determinants,	
12	**Benthos**	classification of benthic region, benthic macroinvertebrates:	**1**
		qualitative and quantitative distribution, factors affecting the distribution	**1**
			45

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

1. Welch, P.S. 1952. Limnology. McGraw-Hill Book Co. New York.
2. Wetzel, R. G. 2001. Limnology: lake and river ecosystems. gulf professional publishing.
3. American Public Health Association. 1987. Standard methods for examination of water and wastewater. 11th edition. American Public Health Association, New York.
4. Boyd, C.E. 1979. Water quality in warm water fishponds. Auburn. Uni. Albama.
5. Tundisi, J.G. and Tundisi, T.M., 2012. Limnology. CRC Press.
6. Kalff J. Limnology: inland water ecosystems. 2002.

Biochem-11 (BMB 11) Course title: Basic Biochemistry-I Credit: 4 Credit hours: 60

Introduction to the course:

The Basic Biochemistry-I (Course No. BMB11) is for first-year students and is a four-credit course. The course includes brief introduction to the major biomolecules and their functions from metabolic aspects. The learning outcomes of this course will be met by providing students with a comprehensive yet dynamic overview of this field with both laboratory and lecture components and by encouraging critical, independent and creative thinking.

Specific objectives:

The discipline of biochemistry is an incredibly diverse field of research that touches nearly all aspects of our lives. Students will understand and be able to demonstrate how knowledge of biochemistry is applied in every aspect of life science in addressing major challenges the society is facing. They will be able to appreciate the breadth and depth of professional opportunities in biochemistry after their graduation.

Intended Learning Outcome

At the end of the unit students will be able to-

i. Define biochemistry;

ii. Explain the basic concepts of acid-base and thermodynamics and how they work in a human body;
iii. Describe the structure and function of major biomolecules e.g. amino acids, protein, carbohydrate, nucleotides and lipids;
iv. Describe the basic aspects of biological catalysts and Michaelis-Menten kinetics ;
v. Explain the importance of different cellular organelles along with their structural features;
vi. Explain the basic chemistry of nucleosides and nucleotides, distinguish between DNA and RNA and describe the basic principle of inheritance at the molecular level;
vii. Describe the roles of common vitamins in normal physiology;
viii. Identify the occurrence and deficiency symptoms of water soluble and fat-soluble vitamins in human; and
ix. Apply practical skills in fundamental biochemical techniques and analyze and interpret the results obtained using these techniques.

Course Content/ Syllabus
Theoretical (80 Marks):
Group A:

1. **Acid, base, and buffer:** Ion product of water, acid, base, pH, pH indicators, buffer solution and buffer capacity.
2. **Thermodynamics:** First law of thermodynamics, enthalpy, Hess's law; second 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, color tests and methods of estimation, isolation from natural sources and representative examples of each class with a 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.

Group B:

1. **Amino acids and peptides**: Structural features, optical activity and classification of amino acids, ionization in solution, isoelectric behavior, color tests, isolation of amino acids from protein hydrolysates, peptide bonds and biologically important peptides.
2. **Proteins**: General introduction, classification based on shape, structure and biological properties, isolation from natural sources, different levels of structural organization (in brief).
3. **Enzymes**: Chemical nature, effect of substrate, temperature and pH on its activity, Km and Vmax, enzyme inhibition, digestive enzymes.
4. **Nucleosides and nucleotides**: Basic chemistry of nucleosides and nucleotides, polynucleotides.
5. **Vitamins**: Classification, occurrence, deficiency symptoms, biological functions, vitamins as coenzymes.

Laboratory Work (20 Marks):

1. Preparation of standard solution and standardization of HCl.

2. Estimation of calcium in biological sample.
3. Determination of ascorbic acid content of a biological sample.
4. Color tests for biomolecules.
2. Determination of lactose content of milk.
3. Determination of phosphorus content of the supplied solute.

Practical

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 notebook 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:

Assessment

In-course examination: 40% marks
Final examination: 60% Marks

FSH 101P Course title: Fisheries Zoology Credit: 1.5 Credit hours: 22.5

Contents

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.
d. Collection and identification of representative chordates (vertebrates).
e. Morphological study and classification of chordate specimens (fresh and preserved specimens).

FSH 102P Course title: Aquatic Ecology Credit: 1.5 Credit hours: 22.5

Contents

a. Study of pond as a lentic ecosystem, community composition and classification.
b. Study of river as a lotic ecosystem, community composition and classification.
c. Understanding the fish biodiversity and distribution in different aquatic ecosystems.
d. Assessment of human interferences on the alteration of aquatic ecology.
e. Ecological risk assessment

FSH 104P Course title: Ichthyology Credit: 1.5 Credit hours: 22.5

Contents

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 in fish: (i) Weberian ossicles of cypriniform fishes (ii) Eye muscles, (iii) Central nervous system, (iv) PG, (v) Kidney, (vi) Liver, (vii) Spleen, (viii) Accessory respiratory organs etc.

FSH 105P Course title: Limnology Credit: 1.5 Credit hours: 22.5

Contents

a. Studies of water-body morphometry; shoreline surveys of ponds, lakes; stream survey methods; water level recording procedures; map construction and interpretation; method for determining area and volume of ponds, lakes and reservoirs.
b. Recordings of temperature, turbidity, color, 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.
f. Identification of phytoplankton, zooplankton and benthos.

FSH 201 Course title: Aquatic Pollution and Ecotoxicology Credit: 2 Credit hours: 30

Introduction to the course:

Pollution in aquatic environment is not only a serious concern for aquatic organisms but also for the public health safety. An understanding of the physical, chemical and biological processes involved during contamination of water is essential to effectively monitor and control the effects of pollution. A huge range of pollutants may be released into the aquatic environment during everyday activities and many of these contaminants are potentially harmful to human health and the environment. In this course, we will focus on the origins, pathways and consequences of various pollutants in the aquatic environment as well as discussing the approaches to pollution control and remediation.

Specific objectives:

i. To get understand the basic concepts of aquatic pollution and ecotoxicology;
ii. To get know the types and sources of aquatic pollutants;
iii. To get understand fate and transport of various pollutants in aquatic ecosystems and possible mechanisms of its toxic action on living organisms;
iv. To get understand the importance of water quality management in terms of fisheries and aquaculture;
v. To get acquainted with the methods of assessing toxic responses of individuals, communities and ecosystems in the aquatic environment;

vi. To get familiar with the concept of risk assessment and to extend its use to assess ecological risks resulting from aquatic pollution;
vii. To get understand how pollution can affect fisheries production and how to prevent and control aquatic pollution; and
viii. To get acquainted with the national and international environmental safety issues regarding aquatic pollution.

Course contents

Theoretical

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.

Unit-wise Learning Outcomes:

At the end of the unit students will be able to-

i. Define pollution and ecotoxicology;
ii. Describe the major aquatic pollutants, their chemical behavior and properties in the context of their biochemical and ecological impacts;
iii. Identify the sources of aquatic pollution;
iv. Know the impacts of aquatic pollution;
v. Explain the toxicological effects of aquatic pollution focusing on fate and transport of xenobiotics; xenobiotic accumulation, dynamics, and toxicity in aquatic organisms;
vi. Assess ecological risk of aquatic pollution;
vii. Control or prevent the aquatic pollution;
viii. Explain water quality management; and
ix. Maintain standard water quality variables to enhance fish production.

Unit wise title and subtitle and number of classes per unit

Chapter	Title	Sub-title	No. of classes
1	**Introduction**	General introduction to aquatic pollution and eco-toxicology, description of toxicants- Metals, Pesticides, POPs, lethal and sub-lethal effects.	**2**
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.	**2** **2** **3**
3	**Sediment in aquatic ecosystems**	Accumulation of metals, organometallic and organic compounds in sediments Sediment toxicity and ecological effects of contaminated sediments.	**1** **2**
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.	**3** **2**
5	**Endocrine Disruptors**	Introduction, source, mode of action and toxicity. Cause and consequence of endocrine disruptions in fish and shellfish.	**2** **2**
6	**Ecological Risk Assessment**	General Principles, application and interpretation of biomarker assays and toxicity tests in aquatic ecosystem.	**3**
7	**Environmental Safety**	General information on international and national environmental protection agency International environmental protocols and regulations. Environmental protection regulations and problems in Bangladesh.	**2** **2** **2**
		Total	**30**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. One in-course exam – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

Reference

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

2. Fundamentals of Ecotoxicology, 2nd Edn. 2003. M.C. Newman & M.A. Unger, Lewis Publishers, Florida.
3. Principles of Ecotoxicology, 2006. C. H. Walker. CRC Press.
4. Principles of Ecotoxicology. 3rd Edition, 2006. C.H. Walker, S.P. Hopkin, R.M. Sibly & D.B. Peakall (Eds.), Taylor & Francis, New York, NY.

FSH 202 Course title: Fisheries Systematics and Evolution Credit: 3 Credit hours: 45

Introduction to the course:
Fisheries Systematics is the study of the diversification of fish and other aquatic organisms, both past and present, and the relationships among them through time. Relationships are visualized as evolutionary trees. Systematics is used to understand the evolutionary history of life on Earth. This course is designed to acquire fundamental knowledge of systematics, diversity, evolution, relationships and identification of the fishes, the most diverse of all vertebrate groups and the dominant group of vertebrates in aquatic habitats. After completion of the course students will develop a positive attitude towards the taxonomy of aquatic species.

Specific objectives:
i. To get understand taxonomy, history of taxonomy, different technical terms and measurements;
ii. To get know zoological nomenclature;
iii. To get acquainted with the methods of collections, preservation, curating, storage of aquatic specimen;
iv. To get acquainted with the trends in biosystematics;
v. To enable knowing speciation;
vi. To get understand molecular taxonomy;
vii. To get understand Major Histocompatibility Complex Genes in the Study of Fish Phylogeny;
viii. To get understand fish evolution and adaptation;
ix. To get acquainted with larval taxonomy; and
x. To develop skill in E-taxonomy.

Course content:
Theoretical
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. **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.
7. **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.
8. **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.
9. **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.
10. **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.
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 maintaining information networks.

Learning outcomes:

At the end of this course students will be able to-

i. Define taxonomy and explain history of taxonomy, different technical terms and measurements;
ii. Describe zoological nomenclature;
iii. Explain collection methods, preservation, curating, storage of specimen;
iv. Explain different types of classification, Linnean Hierarchy, phenetics and cladistics
v. Establish taxonomic keys;
vi. Explain the trends in biosystematics;
vii. Describe different types of speciation;
viii. Describe molecular taxonomy;
ix. Describe Major Histocompatibility Complex Genes in the Study of Fish Phylogeny
x. Analyse the fish evolution and adaptation;
xi. Apply larval taxonomy to identify ichthyoplankton; and
xii. Create database using E-taxonomy.

Unit-wise title and sub-title and number of classes per unit

Chapter	Title	Sub-title	No. of classes
1	**Introduction to taxonomy**	Brief history of taxonomy;	**2**
		Methods used in taxonomy studies;	**1**
		Technical terms and measurements.	**1**
2	**Zoological nomenclature**	History, ICZN and Rules of nomenclature.	**3**
3	**Taxonomic collection**	Collection methods, preservation, Curating, storage, cataloguing and maintaining.	**3**
4	**Classification and its types**	Types of classification.	**1**
		Taxonomic collection & the processes of identification, taxonomic characters.	**2**
		Types of variations (qualitative and quantitative) within a single population,	**1**
		Methods of arriving at taxonomic decisions on species level; Linnean Hierarchy.	**2**
		Preparation and use of taxonomic keys.	**1**
5	**Phenetics and Cladistics**	Phylogenetic tree construction.	**2**
6	**Speciation**	Concept of species and implications; Speciation types: Mechanism of genetic differentiation; Allopatric speciation sympatric speciation, Phyletic speciation.	**2**
		Species selection: Process of species selection, Example of species selection; Speciation through Geological time scale.	**2**
7	**Fish evolution and adaptation**	Diversification, Ecological differentiation, Adaptive radiation.	**2**
		Extinction: Ecological processes, Extinction in the fossil record.	**1**
		Theory of continental drift; Tectonic history; Climatic and biogeographic consequences of plate tectonics; Glaciations and biogeographic dynamics.	**2**
8	**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.	**3**
9	**Molecular taxonomy**	Molecular data based Phylogenetic Relationships among Populations, Species, and Genera of different fishes.	**3**

		Molecular data based biogeographic Analysis of fishes.	**2**
		Combining Molecular and Morphological Data in Fish Systematics: Examples from the Cyprinodontiformes.	**2**
10	**Major Histocompatibility Complex Genes**	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.	**2**
11	**Larval taxonomy**	Forms and their evolutionary significance; Morphometric and meristic description of major commercial ichthyoplankton of Bangladesh.	**2**
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 maintaining information networks.	**3**
		Total	**45**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

1. Kappor, V. C. 2008. Theory and Practice of Animal Taxonomy. Oxford & IBH Publishing Co. Pvt Ltd. NewDelhi.
2. Jayaram K. C. 2008. Fundamentals of Fish Taxonomy. Narendra Publishing House. Delhi, India.
3. Bandyapaddaya A. 2004. Fish and Fisheries taxonomy. Kabir Publications. Dhaka, Bangladesh
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FSH 203 Course title: Inland Aquaculture Credit: 3 Credit hours: 45

Introduction to the Course:

Aquaculture accounted for 56% of the total country's fish yield. Therefore, knowledge on the aspects of aquaculture and culture technology is required to resolve the problems facing by the

farmers in the fields arising from climate change and other drivers. Therefore, this course is designed to teach students current production systems, factors affect aquaculture production, contribution of aquaculture in economic and sustainable development goal, liberate information on culture of finfish and shellfishes, induced breeding, transportation of live fishes and integrated fish farming in Bangladesh.

Specific Objectives:

i. To get understand the definition, types of aquaculture production systems, types of aquatic weeds and their control, and pond management;
ii. To enable knowing culture techniques of freshwater commercial fishes, liming and fertilizing the ponds;
iii. To get understand and enable induced breeding of carps, catfishes and tilapia;
iv. To get understand live fish transportation in Bangladesh;
v. To get acquainted with biology, seed production and culture technology of freshwater prawn; and
vi. To get understand the integrated farming systems of fish in Bangladesh.

Course Contents

Theoretical

1. **Introduction:** Definitions and aim of aquaculture; history, general principles, scope and importance of aquaculture.
2. **Aquaculture production systems:** Extensive, semi-intensive and intensive culture, monoculture, polyculture, management practices. Recirculatory aquaculture system, biofloc fish culture and aquaponics.
3. **Fish culture in ponds:** Preparation of nursery, rearing and grow-out ponds with pre-stocking, stocking, and post stocking management.
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 and catfishes.
7. **Transportation fish seed and brood fish:** Definition of fish seed and their types, types of transportations, 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, Thai punti, climbing perch and small indigenous species (SIS), culture of ornamental fish.
9. **Prawn culture:** Origin and history of freshwater prawn farming in Bangladesh and in the world; local and global status of freshwater prawn farming, culture technique of prawn (hatchery, nursery and and grow-out phase, classification of culture systems, feeds and feeding of the larvae and post larvae, health management etc.), rice prawn system and carp prawn polyculture.
10. **Integrated fish farming:** Principles of integrated fish farming, concept and definition of integrated fish farming, culture of fish in rice fields, poultry fish system, duck cum fish culture.

11. **Good aquaculture practice (GAP):** Introduction, importance, GAP in fish farm construction and management.
12. **Fish farm registration and traceability system.**

Learning Outcomes:

At the end of the course students will be able to-

i. Define aquaculture;
ii. Understand aquaculture systems, control of unwanted fish and aquatic weeds;
iii. Acquainted with fertilizers and their application doses;
iv. Develop skill in inducing fishes for reproduction;
v. Understand culture techniques of carps, catfishes, tilapia, SIS species and prawn;
vi. Develop skill in designing live fish transportation;
vii. Demonstrate skill in solving problems encountered by the farmers; and
viii. Create sustainable link or bridges between the input suppliers/distributors/producers and end users.

Unit-wise title and sub-title and number of classes per unit:

Chapter	Title	Sub-title	No. of classes
1	**Introduction**	Definition and aim of aquaculture	**1**
		History and general principles of aquaculture	**1**
		Scope and importance of aquaculture	
		Global and local production status and trends	**1**
		Bacteria and nutrient recycling	**1**
		Natural productivity	**1**
2	**Aquaculture systems**	Extensive, semi-intensive and intensive culture, monoculture, polyculture	**1**
	Aquaculture production systems	RAS, Biofloc and aquaponics	**2**
3	**Fish culture in ponds**	Pre-stocking: Eradication of aquatic weeds, unwanted fishes	**1**
		Eradication of unwanted fishes: Use of fish toxicants, Eradication of aquatic insects	**1**
		Fertilization of ponds	**1**
		Stocking of nursery, rearing and grow out ponds	**1**
		Post stocking managements: Feeding, periodic fertilization, pond environment monitoring, fish health monitoring	**1**
		Fish diseases	**1**
4	**Fertilization and liming**	Definition of fertilizer and manure	**1**
		Organic and inorganic fertilizers used in fish ponds	**1**
		Types of lime used in aquaculture, liming of pond	**1**

5	**Aquatic weeds**	Common aquatic weeds and methods of their control; algal blooms, preparation of compost with aquatic weeds	**1**
6	**Induced breeding**	Anatomy of fish pituitary and hypophysation	**1**
		Hormonal control of fish reproduction	**1**
		Determining sexual maturity	**1**
		Capture, handling, transportation and induced spawning of Indian major carps	**1**
		Common carp propagation	**1**
		Catfishes breeding	**1**
		Human chorionic gonadotropin (HCG) and other ovulating agents	**1**
7	**Transportation fish seed and brood fish**	Definition of transportation, problems of transport, considerations before transport, mediums of transport, causes of mortality during and after transport, types of transport, types of fish seeds, conditioning, factors control DO during transport, aeration, liberation of pure compressed oxygen	**2**
		Use of anesthetics, antiseptics and antibiotics in live fish transport	**1**
8	**Fish culture**	Carp polyculture	**1**
		Culture of pangasius catfish	**1**
		Culture of tilapia	**1**
		Culture of Thaipunti	**1**
		Culture of SIS	**1**
		Culture of climbing perch, walking catfish and stinging catfish	**1**
		Culture of ornamental fishes	**1**
9	**Prawn culture**	History and origin of freshwater prawn farming in Bangladesh and in the globe	**1**
		Biology of prawn	**1**
		Hatchery phase of prawn	**1**
		Nursery phase of prawn	**1**
		Grow-out phase	**1**
		Carp-prawn polyculture	**1**
10	**Integrated fish farming**	Principles, concept and definition of integrated fish farming	**1**
		Culture of fish in rice fields	**1**
		Duck cum fish farming	**1**
		Poultry fish system	**1**
11.	**Good aquaculture practice (GAP)**	Introduction, importance, GAP in fish farm construction and management.	**1**
12.	**Fish farm registration and traceability system.**		**1**

Total	**45**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

1. Acketers, H., Hunes, JV and kanikoff, M. 1994. Introduction to the general principles of Agriculture food product prawn.
2. Chondar, S.L. 1980 Hypophysation of Indian major carps. Shatish Book Enterprise, Motokatra, Agra-3, India.
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4. Halwart M and Gupta MV 2004. Fish culture in Rice fields. FAO, World Fish Center.
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11. Pillay, TVR and Kutty, MN. 2005. Aquaculture Principles and Practices. Blackwell Publishing.
12. Tidwell, JH (edt). 2012. Aquaculture Production Systems. World Aquaculture Society.
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FSH 204 Course title: Aquaculture Nutrition Credit: 2 Credit hours: 30

Introduction to the Course:

Aquaculture production is a major industry in many countries, and it will continue to grow as the demand for fisheries products increases and the supply from natural sources decreases. As in more traditional forms of animal production, nutrition plays a critical role in intensive aquaculture because it influences not only production costs but also fish growth, health and waste production. To develop nutritious, cost-effective diets we must know nutritional

requirements of a species and meet those requirements with balanced diet formulations and appropriate feeding practices. So, development of our knowledge regarding the nutritional requirements of cultured fishes. This course provides an overview of the general principles of nutrition of fish and shellfish as they relate to aquaculture.

Specific Objectives:

i. To get understand the importance of nutrition and feeds for sustainable aquaculture;
ii. To get understand the digestive physiology and energetics;
iii. To get acquainted with macro and micronutrients requirements for fish nutrition;
iv. To get understand the influence of nutrients and feeds in maintaining fish health;
v. To get understand the relationship between feed ingredients and feed technology, and quality of fish and diets;
vi. To get acquainted with the experimental methods and designs in fish nutritional studies; and
vii. To get develop an awareness of the current trends and research priorities in aquaculture nutrition.

Course Contents

Theoretical

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

2. **Nutrition of aquatic animals**: Feeding behavior and regulation of food intake; Gross juvenile and adult anatomy, Digestive organ and digestive physiology of fishes, nutrient digestibility; Control and regulation of digestion, Rate of metabolism in fishes, Sources of nutrients, natural, supplementary and complete artificial diet of fish.

3. **Nutrition and fish health:** Factors affecting fish health, Dietary components influencing fish health, feeding practices affecting fish health

4. **Nutritional energetic**: History of nutritional energetics, Partitioning of energy; Energy exchange in biological system, Energy utilization and requirements in fish; Factors affecting metabolic waste output, Heat increment of feeding, recovered energy and growth, Energy retention.

5. **Protein nutrition:** Characteristics of protein metabolism in fish; Amino acid metabolism, Requirements of protein and essential amino acids; Measuring protein accretion and degradation, Protein deficiency symptoms; Evaluation of dietary protein.

6. **Lipid nutrition**: Lipid metabolism in fishes; Fatty acid and dietary energy, Essential fatty acid requirements; deficiency symptoms; Importance of lipids in fish diet; Influence of dietary lipids on body composition and fish carcass quality; Influence of dietary lipid composition on the immune system and disease resistance of finfish; Fatty acid peroxidation, Sources of lipids for farmed fish feed, Evaluation of lipid quality.

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

8. **Vitamin nutrition**: Historical introduction, Vitamin characteristics and classification; Requirements and sources; Deficiency symptoms.

9. **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; Requirements and sources, Deficiency symptoms.

10. **Larval nutrition**: Utilization of yolk: transition from endogenous to exogenous nutrition in fish larvae, Feeding behavior of larval fish, Nutritional requirements of fish and shrimp larvae; Dietary lipids and stress tolerance of larval fish; Nutritional quality of live prey; Characteristics of artificial food for larvae, Effects of larval nutrition on development.

11. **Brood-stock nutrition**: Energy partitioning for reproduction;; Effective feeding periods for optimum broodstock performance; Importance of adequate feed intake on spawning performance; Nutrient requirements and their effects on reproductive physiology and egg quality; Effect of dietary quality on reproductive output.

12. **Methods used in studies on fish nutrition**: Experimental methods and designs in fish nutritional studies; Performance measure; Growth, growth prediction and survival; Methods for assessing embryonic and larval growth in fish; Criteria for egg and larval quality; Food utilization, temperature and water quality factors; Assessing diets and flesh quality.

Unit-wise learning outcomes:
At the end of the unit students will be able to-

i. Define aquaculture nutrition;
ii. Understand the concepts of nutritional requirements of fish;
iii. Understand feeding behavior of fish and shellfish;
iv. Understand fish growth and maintenance;
v. synthesize the major applications of nutritional energetics in fish, importance of different components of nutritional energetics in fish;
vi. Characterize vitamins and species;
vii. Understand metabolic role of vitamins in fish, function of vitamins and antivitamins in fish, required vitamins and their feeding standards, specific deficiencies resulting from lack of vitamins in fish;
viii. Understand the roles of macro and micro minerals in fish nutrition, interactions between environment, nutritional supply and requirements, specific deficiencies resulting from lack of minerals in fish;
ix. Demonstrate the importance of larval diets including artificial formulated and the natural diets; and
x. Design experiment o measure performance, fish growth and survival, feed utilization efficiency.

Unit-wise title and sub-title and number of classes per unit

Chapter	Unit-wise title	Sub-title	Number of classes
1	**Introduction of fish nutrition and aquaculture**	Origin of nutritional characteristics of fish and crustaceans; Terminology in aquaculture nutrition;	**1**
		Comparison of feeding fish and land animals, Relationship between fish nutrition and fish culture	**1**
2	**Nutrition of aquatic animals**	Feeding behavior and regulation of food intake; Gross juvenile and adult anatomy,	**1**
		Digestive organ and digestive physiology of fishes, nutrient digestibility ; Control and regulation of digestion,	**1**
		Rate of metabolism in fishes, Sources of nutrients, natural, supplementary and complete artificial diet of fish	**1**
3	**Nutrition and fish health:**	Factors affecting fish health, Dietary components influencing fish health,	**1**
		Feeding practices affecting fish health	**1**
4	**Nutritional energetic**	History of nutritional energetics, Partitioning of energy; Energy exchange in biological system, Energy utilization and requirements in fish;	**1**
		Factors affecting metabolic waste output, Heat increment of feeding, recovered energy and growth, Energy retention	**1**
5	**Protein nutrition**	Characteristics of protein metabolism in fish; Amino acid metabolism, Requirements of protein and essential amino acids;	**1**
		Measuring protein accretion and degradation, Protein deficiency symptoms; Evaluation of dietary protein	**1**
6	**Lipid nutrition**	Lipid metabolism in fishes; Fatty acid and dietary energy, Essential fatty acid requirements; deficiency symptoms;	**1**
		Importance of lipids in fish diet; Influence of dietary lipids on body composition and fish carcass quality; Influence of dietary lipid composition on the immune system and disease resistance of finfish;	**1**
		Fatty acid peroxidation, Sources of lipids for farmed fish feed, Evaluation of lipid quality	**1**
7	**Carbohydrate nutrition**	Importance and limits of energetic role of carbohydrate; Diet and carbohydrate metabolism,	**1**
		Glucose metabolism in fish; Synthesis and	**1**

		metabolism of glycogen; Improvement of carbohydrate utilization in fish	
8	**Vitamin nutrition**	Historical introduction, Vitamin characteristics and classification;	**1**
		Requirements and sources; Deficiency symptoms	**1**
9	**Mineral nutrition**	Characteristics of mineral nutrition in fish; Interactions between environment, nutritional supply and requirements;	**1**
		Nutritional role of macro-minerals and trace elements in fish; Requirements and sources, Deficiency symptoms	**2**
10	**Larval nutrition**	Utilization of yolk: transition from endogenous to exogenous nutrition in fish larvae, Feeding behavior of larval fish,	**1**
		Nutritional requirements of fish and shrimp larvae; Dietary lipids and stress tolerance of larval fish; Nutritional quality of live prey; Characteristics of artificial food for larvae, Effects of larval nutrition on development	**2**
11	**Brood-stock nutrition**	Energy partitioning for reproduction;; Effective feeding periods for optimum broodstock performance; Importance of adequate feed intake on spawning performance;	**2**
		Nutrient requirements and their effects on reproductive physiology and egg quality; Effect of dietary quality on reproductive output	**1**
12	**Methods used in studies on fish nutrition**	Experimental methods and designs in fish nutritional studies; Performance measure; Growth, growth prediction and survival;	**1**
		Methods for assessing embryonic and larval growth in fish; Criteria for egg and larval quality; Food utilization, temperature and water quality factors; Assessing diets and flesh quality.	**2**
		Total	**30**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.

II. Final exam: Only written.

III. Oral test.

Practical: In course and final

Oral test: Final

References:
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FSH 205 Course title: Fisheries Microbiology & Quality Control Credit: 4 Credit hours: 60

Introduction to the Course:
Microbiology is the study of microscopic organisms, such as bacteria, viruses, archaea, fungi and protozoa. This discipline includes fundamental research on the biochemistry, physiology, cell biology, ecology, evolution and clinical aspects of microorganisms, including the host response to these agents. Studying microbiology and quality control will help the students to develop a variety of subject-specific skills.

Specific Objectives:

i. To get understand prokaryotic and eukaryotic cell structure and their function
ii. To get acquainted with microbes and their general characteristics, classifications of microorganisms: bacteria, molds, yeast and viruses; aquatic microorganisms, microbes in extreme environment, attached microbial communities
iii. To get understand the effect of temperature, oxygen other environmental factors on fish growth
iv. To get know different conventional culture techniques for the isolation of microorganisms and confirmation by biochemical and molecular techniques
v. To get acquainted with heat resistance of microorganisms
vi. To get know food poisoning and infection,
vii. To get acquainted with different types of antibiotics and their mode of action, antiseptics and disinfectants, mechanisms of antimicrobial action
viii. To get acquainted with general principles of quality control, microbiological standards of different water uses and for fish and fishery products; HACCP Principles and application in fisheries

Course contents
Theoretical (80 Marks)

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:** Scope of aquatic microbiology, history of microbiology and aquatic microbiology
3. **Aquatic bacteriology, mycology and virology:** General characteristics of bacteria, classification and culture of aquatic bacteria; Nutrition and growth of bacteria; General characteristics and classification aquatic fungi; Importance of aquatic virology, Characteristics and classification of viruses, life cycle of major aquatic viruses.
4. **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.
5. **Attached microbial communities**: Biofilm, formation and function, impacts in fisheries-fish diseases and fish processing sector.
6. **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).
7. **Heat resistance of microorganisms:** factors affecting heat resistance; effects of low and high temperature on microorganisms.
8. **Food poisoning and infection**: Bacterial food poisoning and intoxication; non-bacterial intoxication (Aflatoxin, Patulin, Ochratoxin, viral toxin and chemical poisoning), shellfish poisoning, ciguatera and puffer poisoning.
9. **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.
10. **Antiseptics and disinfectants**: Different types of antiseptics and their application in fishery science. Mechanisms of antimicrobial action.
11. **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
12. **Microbiological standards:** Microbiological standards of different water uses and for fish and fishery products.
13. **Hazard Analysis Critical Control Point (HACCP):** Potential hazards (Biological hazards, Chemical hazards and Physical hazards), HACCP Principles and application in fisheries.
14. **National residue control plan:** Introduction, background, residue monitoring programme.

Unit-wise learning outcomes

At the end of the unit students will be able to-

i. Define microbiology, fisheries microbiology and quality control;
ii. Describe prokaryotic and eukaryotic cell structure and functions;
iii. Describe microbes and their general characteristics, classifications of microorganisms: bacteria, molds, yeast and viruses;
iv. Describe biofilm, formation, function, impacts in fisheries-fish diseases and fish processing sector;
v. Demonstrate conventional culture techniques for isolation of microorganisms;

vi. Understand contamination and spoilage of fish and other sea foods; spoilage of refrigerated, canned and other processed food;
vii. Understand bacterial food poisoning and intoxication; non-bacterial intoxication, shellfish poisoning, ciguatera and puffer poisoning;
viii. Understand mode of action, different types of antibiotics with their role and side effects, antifungal antibiotics and application of antibiotics in fisheries;
ix. Describe different types of antiseptics and their application in fishery science. Mechanisms of antimicrobial action; and
x. Understand general principles of quality control;
xi. To gain knowledge on potential hazards, HACCP principles and application in fisheries.

Unit-wise title and sub-title and number of classes per unit

Chapter	Title	Sub-title	No. of classes
1	**Cell structure and function**	Prokaryotic and eukaryotic cell structure, cell membrane, cell wall,	**2** **1**
		Proteins, nucleic acids- structure,	**1**
		properties and functions	**1**
2	**Scope and history of microbiology**	Scope of aquatic microbiology, history of microbiology and aquatic microbiology	**2**
3	**Aquatic bacteriology, mycology and virology**	General characteristics of bacteria	**1**
		Classification and culture of aquatic bacteria	**2**
		Nutrition and growth of bacteria	**1**
		General characteristics and classification aquatic fungi	**1**
		Importance of aquatic virology	**1**
		Characteristics and classification of viruses life cycle of major aquatic viruses	**4**
4	**Aquatic microorganisms**	Microbial community on freshwater, marine and estuarine environment	**2**
		Microbial dependency on physical, chemical and biological factors of the environment classification of aquatic microorganisms, microbes in extreme environment	**2** **1**
		Role of microorganisms in biogeochemical cycles	**1**
5	**Attached**	Biofilm, formation and function	**2**

	microbial communities	Impacts in fisheries-fish diseases and fish processing sector	**1**
6	**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	**2** **3** **2**
7	**Heat resistance of microorganisms**	Factors affecting heat resistance Effects of low and high temperature on microorganisms	**1** **1**
8	**Food poisoning and infection**	Bacterial food poisoning and intoxication non-bacterial intoxication (Aflatoxin, Patulin, Ochratoxin, viral toxin and chemical poisoning), Shellfish poisoning, ciguatera and puffer poisoning	**1** **3** **2**
9	**Antibiotics**	Different types of antibiotics and mode of actions role and side effects	**4**
10	**Antiseptics and disinfectants**	Different types of antiseptics and their application in fishery science. Mechanisms of antimicrobial action	**2**
11	**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	**1** **2** **1**
12	**Microbiological standards**	Microbiological standards of different water use and for fish and fishery products	**2**
13	**Hazard Analysis Critical Control Point (HACCP)**	Potential hazards (Biological hazards, Chemical hazards and Physical hazards), HACCP Principles and application in fisheries	**2** **3**
14	**National residue control plan**	Introduction, background, residue monitoring programme.	**2**
		Total	**60**

Practical (20 Marks)

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.
   Preparation of fish fillet, fish paste, FPC, fish meal, fish oil, FPI and their quality assessment.

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. One in-course exam– question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

Practical: Final
Oral test: Final

References

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.

FSH 206 Course title: Fisheries Mathematics Credit: 2 Credit hours: 30

Introduction to the Course:

Any quantitative analyses require mathematics. Department of fisheries is committed to offer a comprehensive, collective and complete education for students/researchers. It is obvious that in many stages of life sciences, ideas of mathematics are required. Therefore, this course including basic ideas of calculus (differentiation and integration) and differential equations is offered for sophomores in the Department of Fisheries.

Specific Objectives:

i. To get understand the basic ideas of function, limit, continuity and their real-world applications.
ii. To get understand the basic ideas of differentiation, partial differentiation, integration and their real-world applications.
iii. To get understand how differential equations arise and how to solve them to predict/visualize the physical phenomena.
iv. To get understand different software package that can be applied in fisheries sector

Course Contents
Theoretical

1. **Function, Limit and Continuity:** Introduction, Types of Functions, Operation on Functions, Various Business Functions, Definition of Limit, Determination of Limit of Different Types of Functions, Determination of Continuity of Different Functions.
2. **Differentiation:** Differentiation of Algebraic Functions, Transcendental Functions, Definition of Transcendental Functions, Geometric interpretation of dy/dx and marginal concept analysis. Partial Differentiation, Homogeneous Function. Higher Order Partial Derivatives.
3. **Integration:** Introduction, Geometric Interpretation of Integration, Different Rules of Integration, Indefinite and Definite Integral, Calculation of Area of Irregular Curves.
4. **Differential Equations:** Introduction, Order and Degree of Differential Equations, Verification of the Solutions of Differential Equations. Solutions of Differential Equations of First Order and First Degree, Differential Equations of the Second Order with Constant Coefficients, Applications of differential equations in Fisheries Problems.
5. **Applications of Mathematics in Fisheries Problems:** Fisheries Bioeconomics, Schaefer Logistic Growth Model, Basic Bioeconomic Models, Deriving Revenue and Cost Functions, Maximization of Economic Yield. Fisheries Management.
6. **Computer Programming:** Introduction to package software (Matlab/Mathematica) in visualizing and solving mathematical problems, Introduction of programming language (Fortran/Matlab) required for Modeling/Solving Fisheries Problems.

Unit-wise learning outcomes

At the end of the unit students will be able to-

i. Define fisheries mathematics;
ii. Define different terms of fisheries mathematics;
iii. Understand integration and its application in fisheries;
iv. Understand different mathematical equations; and
v. Apply different mathematical equation, tools and models/software in fisheries.

Unit-wise title and sub-title and number of classes per unit

Chapter	Title	Sub-title	No. of classes
1.	**Function, Limit and Continuity**	Introduction, Types of Functions, Operation on Functions, Various Business Functions Definition of Limit, Determination of Limit of Different Types of Functions Determination of Continuity of Different Functions.	**1** **1** **1** **1** **1**
2.	**Differentiation**	Differentiation of Algebraic Functions Transcendental Functions, Definition of Transcendental Functions Geometric interpretation of dy/dx and marginal concept analysis	**1** **2** **2**

		Partial Differentiation, Homogeneous Function. Higher Order Partial Derivatives.	**2**
3.	**Integration**	Introduction, Geometric Interpretation of Integration Different Rules of Integration, Indefinite and Definite Integral Calculation of Area of Irregular Curves.	**1** **1** **1** **1**
4.	**Differential Equations**	Introduction, Order and Degree of Differential Equations Verification of the Solutions of Differential Equations Solutions of Differential Equations of First Order and First Degree Differential Equations of the Second Order with Constant Coefficients Applications of differential equations in Fisheries Problems.	**1** **1** **1** **1** **1**
5.	**Applications of Mathematics in Fisheries Problems**	Fisheries Bioeconomics, Schaefer Logistic Growth Model Basic Bioeconomic Models Deriving Revenue and Cost Functions Maximization of Economic Yield. Fisheries Management.	**1** **1** **1** **2**
6.	**Computer Programming**	Introduction to package software (Matlab/Mathematica) in visualizing and solving mathematical problems Introduction of programming language (Fortran/Matlab) required for Modeling/Solving Fisheries Problems.	**2** **2**
		Total	**30**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. One in-course exams– question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

1. Calculus Early Transcendentals, Anton, Bivens, Davis, 2012, 10th Ed., Laurie Rosatone, USA
2. Mathematics for Biological Scientists, Mike Aitken, Bill Broadhurst, Steve Hladky, 2010, Garland Science, London, UK.
3. Differential Equations, Shepley L. Ross, 2004, 3rd Ed., John Wiley and Sons, UK.

4. Bioeconomic Modelling and Fisheries Management, Colin W. Clark, 1985, Wiley,1st Ed., UK.
5. Fortran for Scientists and Engineers, Stephen J. Chapman, 2018, McGraw Hill, 4th Ed., USA.

FSH 207 Course title: Rural Sociology Credit: 2 Credit hours: 30

Introduction to the Course:

Human dimension is an important aspect of fisheries. For managing the fisheries resources and ensuring development, equity and sustainability, we need to have a clear understanding of the fishers, fish farmers, fish processors, fish traders and their families and societies. Since most of the fisheries and aquaculture related activities occur in the rural areas, we need to specifically know the rural societies. The course 'Rural Sociology' focuses on this aspect.

Specific Objectives:

i. To get understand the rural sociology;
ii. To get acquainted with community structure;
iii. To get understand social groups and stratification;
iv. To get know social changes and social mobility;
v. To get acquainted with the social issues in fisheries in Bangladesh; and
vi. To get know the method of collecting social data from rural areas using different tools.

Course contents

Theoretical

1. **Introduction:** definition, origin and growth of sociology. Scope, nature and value of rural sociology in the perspective of fisheries and aquaculture. Modern Pioneers in Sociology. Conceptualizing Power, Culture and Society. Science vs social science.
2. **Community**: community sentiment, rural demography, village community, rural cultures, rural festivals. Institution and Co-operation. Fishing community.
3. **Human Population, Society & Environment:** Theories about human population size and control; socio-economic causes of environmental degradation; solutions to the environmental crisis.
4. **Social Groups:** classification of groups, characteristics of group life, primary group, secondary group, social control in groups. Social groups in fishing community.
5. **Social stratification: c**oncepts, types and characteristics of Caste, Class, Race and Ethnicity. Theories of prejudice & discrimination, institutional discrimination, social exclusion. Social class in fisheries sector. Social stratification and its effects in fisheries sector.
6. **Social Change:** Theories of social change, social movements, social evolution and social revolutions. Factors of social change, levels of adaptation, natural selection, social selection, social change & technology, social effects of technology. Social change in fisheries sector. Case study of successful social movement.
7. **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. Social mobility for poor fishers. Social Cohesion.

8. **Social Interactions and Processes:** definition of social interactions, basic condition of social interactions, disjunctive process, conflict & competition, contravention, conjunctive process, assimilation, co-operation, integration.
9. **Gender and Society:** sex vs. gender; gender identity; gender as culture & stratification; theories of gender formation; gender inequality and its effects in men and women, gender pay gap, glass ceiling & the sticky floor. Solutions to gender discrimination generally and in fisheries sector. Women and development.
10. **Rural Livelihood and Sustainability:** definition of livelihood, sustainable livelihood framework and changing socio-economic activities. Rural development and GO and NGO activities, nature of rural poverty, rural development models. Political economy. SGDs, fisheries and livelihoods.

Unit-wise learning outcomes:

At the end of this course students will be able to –

i. Know what rural sociology is and the pioneers of sociology;
ii. Understand the elements and nature of society, community, fishing community, rural cultures, institution and co-operation;
iii. Gain knowledge on how different environmental conditions and society interact, social evolution, family & kinship, rural livelihood and sustainability, social stratification and social groups;
iv. Describe different social phenomena such as elements and nature of society, community, fishing community, rural cultures, institution and co-operation;
v. Explain social change, social mobility & social progress, social interactions and processes, rural women and gender issues;
vi. Analyse social problems that effect on development of fisheries sector and identify their solutions; and
vii. Write original report based on data collected from rural areas.

Unit-wise title and sub-title and number of classes per unit

Chapter	Title	Sub-title	No. of classes
1	**Introduction**	Definition, origin and growth of sociology. Scope, nature and value of sociology. Modern Pioneers in Sociology. Conceptualizing Power, Culture and Society. Science vs social science.	**1** **1** **1**
2	**Community**	Community sentiment, rural demography, village community, rural cultures, rural festivals. Institution and Co-operation. Fishing community.	**2**
3	**Human Population, Society & Environment**	Theories about human population size and control; socio-economic causes of environmental degradation; solutions to the environmental crisis.	**2**
4	**Social Groups**	Classification of groups, characteristics of group life, primary group, secondary group, social control in groups.	**2**

		Social groups in fishing community.	
5	**Social stratification**	Concepts, types and characteristics of Caste, Class, Race and Ethnicity. Theories of prejudice & discrimination, institutional discrimination, social exclusion. Social class in fisheries sector. Social stratification and its effects in fisheries sector.	**2** **1** **1**
6	**Social Change**	Theories of social change, social movements, social evolution and social revolutions. Factors of social change, levels of adaptation, natural selection, social selection, social change & technology, social effects of technology. Social change in fisheries sector. Case study of successful social movement.	**1** **1** **2**
7	**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. Social mobility for poor fishers. Social Cohesion.	**3**
8	**Social Interactions and Processes**	Definition of social interactions, basic condition of social interactions, disjunctive process, conflict & competition, contravention, conjunctive process, assimilation, co-operation, integration.	**2**
9	**Gender and Society**	Sex vs. gender; gender identity; gender as culture & stratification; theories of gender formation; gender inequality and its effects in men and women, gender pay gap, glass ceiling & the sticky floor. Solutions to gender discrimination generally and in fisheries sector. Women and development.	**3** **1**
10	**Rural Livelihood and Sustainability**	Definition of livelihood, sustainable livelihood framework and changing socio-economic activities. Rural development and GO and NGO activities, nature of rural poverty, rural development models. Political economy. SGDs, fisheries and livelihoods.	**2** **1** **1**
		Total	**30**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. One in-course exam – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

1. Alejandro Portes. 2015 “The Sociology of Development: From Modernization to the “Institutional Turn.” Sociology of Development, Vol. 1, No. 1, pp. 20-42.
2. Etienne, G. 1998. Rural Change in South Asia: India, Pakistan and Bangladesh. UPL, Dhaka.
1. Hans Bakker. 2016. Rural Sociologists at Work. New York: Routledge
3. Lobao, L. 2007. “Rural Sociology,” The Handbook of 21st Century Sociology, Sage Publications
4. Rahman, H. Z. 1995. Rethinking Rural Poverty: Bangladesh as a case study. UPL, Dhaka.
5. Shamim, H. 1997. Why Women Count: Essays in Development on Bangladesh. UPL, Dhaka.
6. Sharma R.K. 1996. Fundamentals of Sociology, Atlantic publishers and Distributors, New Delhi, India.
7. Tickamyer, Ann R. "Sex, Lies, and Statistics: Can Rural Sociology Survive Restructuring? (or) What Is Right with Rural Sociology and How Can We Fix It 1." Rural sociology 61, no. 1 (1996): 5-24.

Biochem-12 (BMB-12) Course title: Basic Biochemistry-II Credit: 4 Credit hours: 60

Introduction to the course:

Biomolecules are the building blocks of living organisms, which include proteins, carbohydrates, lipids, and nucleic acids. This course will provide an overview of how in our body, energy is stored in and extracted from biomolecules found in the food sources. Thorough understanding of the metabolic pathways and their interrelationships are crucial to the understanding of life. Dysregulation of these pathways results in diseases, treating of which seeks the knowledge of this course. Many of these metabolic disorders are inherited; others result from lack of nutrition. Thus, this course also offers the basic concepts of nutrients and inheritable genetic information stored in DNA/RNA. Finally, this course connects both theoretical knowledge and hands-on experience to enable students for designing new projects/solving problems in the field of biochemistry and molecular biology. The course is appropriate for students who had taken the BMB11 course and gained an understanding of the biomolecules and bioenergetics.

Specific Objectives:

i. To get know in detail how glucose can be completely oxidized in human body;
ii. To get understand the mechanism of synthesis and degradation of glycogen;
iii. To get acquainted with the processes of glucose metabolism through pentose phosphate pathway;
iv. To get know how fatty acids can be synthesized and degraded in human body;
v. To get know how/under what circumstances the ketone bodies are formed and their function in human body;
vi. To get acquainted with the mechanism of protein turnover/synthesis and degradation of amino acids;
vii. To get understand the processes of DNA replication, transcription and translation; and
viii. To get understand the basic concepts of macro and micronutrients.

Course contents:

Theoretical (80 Marks)

1. **Carbohydrate metabolism:** Glycolysis, pentose phosphate pathway, glucuronic acid pathway, oxidation reduction reactions and redox potential, electron transport chain, oxidative phosphorylation, inhibition and uncoupling of oxidative phosphorylation, citric acid cycle, gluconeogenesis, glycogenolysis, and glycogen synthesis.
2. **Lipid metabolism:** Fatty acid oxidation and the related energetic, 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, transamination, deamination, decarboxylation and synthesis of single carbon unit, synthesis of biologically active molecules from amino acids, urea cycle.
4. **Central dogma:** DNA as genetic material, replication of DNA, transcription, 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 and iron.

Laboratory Work (20 Marks):

(a) Determination of saponification number of an oil.
(b) Determination of iodine number of an oil.
(c) Determination λ-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 content of serum.
(g) Determination of creatine content of urine.

Unit-wise learning outcomes:

At the end of this course students will be able to-

i. Recognize the flow of energy on earth, from sun to animals via plant;
ii. Compute ATP production from metabolism of dietary carbohydrates, proteins, and fats in humans;
iii. Compare cellular respiration in the presence and absence of oxygen;
iv. Identify flow of electrons through electron carriers starting from diet to ultimate ATP and water production;
v. Apply their knowledge on enzymes and regulations in understanding metabolic pathways;
vi. Understand the storage molecules, glycogen, fat, and ketone bodies, in short- and long-term fasting;
vii. Differentiate the term transamination, deamination and decarboxylation;
viii. Describe different pathways including TCA cycle and Urea cycle;
ix. Understand the concept of DNA as genetic material and its double helical structure;
x. Know the mechanism /steps of DNA replication, RNA synthesis (transcription) and their types;
xi. Explain how genetic information in mRNA can be translated into proteins (translation), post-translation modification of proteins etc.;
xii. Understand the basic concepts of protein, fat and carbohydrate as nutrients, their nutritional values including energy content; and

xiii. Understand the roles of micronutrients in disease condition.

Instructional strategies:
Participatory teaching-learning method, buzz group, visual aid, questioning strategies, Classroom assignments technique etc.

References:

1. Lehninger's Principles of Biochemistry by David L. Nelson and Michael M. Cox
2. Biochemistry by Dr. U Satyanarayana
3. Lippincott Illustrated Reviews: Biochemistry, 6th Edition.

Practical

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 notebook 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 following courses.

Assessment
In-course examination: 40% marks
Final examination: 60% Marks

FSH 201P Course title: Aquatic Pollution and Ecotoxicology Credit: 1 Credit hours: 15

Contents
a. Lethal and sub lethal effects of pollutants on aquatic organisms, evaluation of toxicity tolerance, bioassay.
b. Methods of bioassay, determination of LC50, LD50; Probit analysis.
c. Determination of pollutants in water

FSH 202P Course title: Fisheries Systematics and Evolution Credit: 1.5 Credit hours: 22.5

Contents
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.
e. Molecular identification of fish and shellfish using Barcoding technique

FSH 203P Course title: Inland Aquaculture Credit: 1.5 Credit hours: 22.5

Contents

a. Identification of aquatic weeds and algae in ponds.
b. Induced spawning: Hands on training on hatchery operations of Indian, Chinese and European carps, pangasius, pabda and *Mystus* species and tilapia.
c. Preparation, fertilization and management of nursery, rearing and grow out ponds
d. Rearing pond: Preparation, fertilization and management.
e. Field trips: Visit to hatchery and fish farms.

FSH 204P Course title: Aquaculture Nutrition Credit: 1 Credit hours: 15

Contents

a. Proximate analysis of carcass, feed ingredients and compounded feed samples (moisture, protein, lipid, ash, crude fiber and nitrogen free energy).
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.

FSH 206P Course title: Fisheries Mathematics Credit: 1 Credit hours: 15

Contents

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 management.
d. Mathematical modeling in fisheries management
e. Application of STATA and MATLAB in fisheries

FSH 207P Course title: Rural Sociology Credit: 1 Credit hours: 15

Contents

a. Preparation of questionnaire/interview schedule for collection of different types of data from fishers' community on socio-economic condition and preparation of report.
b. Preparation of participatory tools (PRA, RRA, FGD, LGD etc.) to collect data from rural areas, analyze the data and write report.
c. Field trip to rural areas to observe rural fisheries dependent people's livelihoods and collection of data and write report.

FSH 301 Course title: Coastal Aquaculture Credit: 3 Credit hours: 45

Introduction to the Course:
In Fisheries education, knowledge of coastal aquaculture has lots of importance to imply them in the field. It is essential to study about different culture techniques to enhance production, to solve the constraints of a culture method as well as to improve management practices. The topic of coastal aquaculture is considered as a number of key biological research themes in this discipline including disease, nutrition, reproduction and genetics. In addition, the knowledge applies biological principles to production systems for finfish, crustacean and mollusks. This course consists of lectures and laboratory-based sessions which aim to develop practical skills and techniques in the relevant research themes.

Specific Objectives:

i. To get understand coastal aquaculture;
ii. To get acquainted with the constraints of a culture method and proper management practices; and
iii. To get understand different culture techniques.

Course contents
Theoretical
1. Introduction: Present status of brackish water aquaculture and mariculture of the world. Scope, present trends, social and economic 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. Sea weeds: Use of sea weeds, culture techniques, potential in Bangladesh
9. Mangrove fisheries: Mangrove ecosystem, energy flow in mangrove swamp, impact of deforestation, and present prospect of fish and shellfish culture in mangrove areas.
10. Impact of coastal aquaculture: Impact of coastal aquaculture on environment, wastewater discharge, its quality and quantity; impacts of effluents on ecosystems, chemical degradation of soil and water.
11. Good aquaculture practice (GAP): GAP for shrimp farm construction, management, shrimp hatchery operation and inspection.

Unit-wise learning outcomes
At the end of this course students will be able to-

i. Define coastal aquaculture

ii. Understand various farming systems as well as the construction of coastal fish farm.
iii. Learn about brackish water ponds management, shrimp cultural practices, problems and future prospects of shrimp farming in Bangladesh.
iv. Understand the cultivation techniques of mollusks like mussels, clams and edible oysters
v. Develop knowledge on the techniques of pearl culture, marine finfish culture, algae and zooplankton culture
vi. Understand the impact of coastal aquaculture on environment

Unit-wise title and sub-title and number of classes per unit

Chapter	Title	Sub-title	No. of classes
1	**Introduction**	Present status of brackish water aquaculture and mariculture of the world	**1**
		Scope, present trends, social and economic importance of coastal aquaculture in Bangladesh	**2**
2	**Construction of coastal fish farm**	Site selection, Various farming systems: Extensive, Semi-intensive and Intensive	**2**
		Cage culture	**1**
		Pen culture	**1**
		Raft culture	**1**
3	**Crustacean Farming**	Shrimp farming techniques; traditional, extensive, semi intensive and intensive methods	**3**
		Life cycles of cultivable shrimp species	**2**
		Brackish water ponds management, shrimp cultural practices, problems and future prospects of shrimp farming in Bangladesh	**3**
		Shrimp culture regulation of Bangladesh	**1**
		Crab fattening	**2**
4	**Molluscan farming**	Life cycles of cultivable mollusks	**1**
		Mussel culture	**1**
		Clam culture	**1**
		Oyster culture	**1**
5	**Pearl culture**	Techniques of pearl culture	**1**
6	**Finfish farming**	Culture techniques of marine finfishes (seabass, seabream and yellowtail, etc.)	**2**
7	**Live feed culture**	Culture of algae, rotifers, brine shrimp (*Artemia*)	**2**
		Culture of Diatom, Copepods	**2**
		Culture of *Cylops*, *Daphnia* and *Moina*	**2**
8	**Sea weeds**	Use of sea weeds	**1**

		Culture techniques Potential in Bangladesh	**1** **1**
8	**Mangrove fisheries**	Mangrove ecosystem, energy flow in mangrove swamp, impact of deforestation	**2**
		Present prospect of fish and shellfish culture in mangrove areas	**1**
9	**Impact of coastal aquaculture**	Impact of coastal aquaculture on environment, wastewater discharge, its quality and quantity	**2**
		Impacts of effluents on ecosystems, chemical degradation of soil and water	**2**
10	**Good aquaculture practice (GAP**	GAP for shrimp farm construction, management, shrimp hatchery operation and inspection.	**2**
11	**Good aquaculture practice (GAP)**	GAP for shrimp farm construction, management, shrimp hatchery operation and inspection.	**1**
		Total	**45**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

1. Abdullah, A.N., Myers, B., Stacey, N., Zander, K.K. and Garnett, S.T., 2017. The impact of the expansion of shrimp aquaculture on livelihoods in coastal Bangladesh. Environment, Development and Sustainability, 19(5), pp.2093-2114.
2. DoF (2017) National Fish Week 2017 Compendium (in Bengali). Department of Fisheries, Ministry of Fisheries and Livestock, Dhaka, Bangladesh. pp. 144.
3. Hoq, M., E. 2008. Sundarbans mangrove: Fish & Fisheries, Graphic media, Dhaka.
4. Islam, S.D.U. and Bhuiyan, M.A.H., 2016. Impact scenarios of shrimp farming in coastal region of Bangladesh: an approach of an ecological model for sustainable management. Aquaculture international, 24(4), pp.1163-1190.
5. Landau, M. 1992. Introduction to Aquaculture. John Wiley & Sons, INC. New York.
6. Marianne Holmer, Kenny Black, 2008. Aquaculture in the Ecosystem, Springer publishers.
7. Milne, P. H. 1979. Fish and shellfish farming in coastal waters. Fishing news books ltd. Farnham. Surrey, England.

8. Perumal, S., Thirunavukkarasu, A.R. and Pachiappan, P. eds., 2015. Advances in marine and brackishwater aquaculture. Springer India.
9. Saha, S.K., 2017. Socio-economic and environmental impacts of shrimp farming in the south-western coastal region of Bangladesh.
10. Santhanam, R., N. Ramanathan and G. Jogathoesan, 1990. Coastal Aquaculture in India, CBS Publishers & Distributors.
11. Training manual on good aquaculture practice. 2012. DoF
12. Venugopal, S. 2005. Aquaculture, Pointer Publishers, Jaipur, India.

FSH 302 Course title: Fish Physiology Credit: 2 Credit hours: 30

Introduction to the Course:

The course Fish Physiology focuses on physiological processes in fish including metabolism, digestion, blood and cardiovascular system, respiration, circulation, osmoregulation and ionic regulation, endocrinology, swimming and buoyancy, sensory physiology, energetics and growth, reproduction. Along with this basic physiology this course also put emphasis on the mechanism of stress control of fish. It presents an introduction to physiological adaptations in fish in relation to their environment. As a student of fisheries s/he must have this brief knowledge in their future career.

Specific Objectives:

i. To get understand physiology and fish physiology;
ii. To get acquainted with the different physiological processes of fishes; and
iii. To get acquainted with the knowledge of histology

Course contents

Theoretical

1. **Introduction:** Physiology and fish physiology; Poikilothermy and homoeothermy, fish as poikilothermic 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. **Locomotion:** Muscles in locomotion; forces acting for swimming; other methods of locomotion.
5. **Blood and cardiovascular system:** Composition, formation and functions of blood; polymorphism in hemoglobin; 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 heartbeat, blood pressure, cardiac cycle and cardiac output; factors affecting cardiovascular system.

6. **Respiration:** Respiratory organs in fishes, Efficiency of gill for respiration; respiratory pattern in fishes; mechanism and physiology of respiration; transport of gases.
7. **Excretion and Osmoregulation**: Excretory organs, Chloride cells, Physiology of excretion; water and salt balance in marine and freshwater fishes, endocrine control of osmoregulation.
8. **Endocrine system**: Origin and functions of endocrine glands; role of hormones in the life process of fishes**,**
9. **Reproduction and development**: Types of reproduction, reproductive endocrinology, Spermatogenesis, Oogenesis, sex differences, sexual maturity, reproductive behavior, larval development, metabolic changes during oogenesis and spermatogenesis.
10. **Immune system**: Introduction, innate and adaptive immune system, Immune organs in fish, Elements of immune response in fish, Immune response to infectious diseases in fish, Fish as the model to study the development and differentiation of immune molecules
11. **Stress in fishes:** Fish behavior, Physiological responses to environmental contaminants, temperature, oxygen. Response to handling; immunological response to stress,
12. **Histology:** Cells of the various organs of fishes.

Unit wise Learning outcomes

At the end of this course the student will be able to -

i. Define physiology, poikilothermy, homeothermy
ii. Understand the physiology of digestion, respiration, blood circulation and reproduction in fishes.
iii. Relate metabolism with growth
iv. Explain the importance of osmoregulation
v. Evaluate the role of sensory organs
vi. Develop skill to prepare permanent histological slides

Unit-wise title and sub-title and number of classes per unit

Chapter	Title	Sub-title	No. of classes
1	**Introduction**	Physiology and fish physiology, Poikiothermy and homoithermy, Fish as poikilothermous animal, Adaptation of fish for aquatic environment	**1** **1**
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	**1** **1**
3	**Metabolism and Growth**	Anabolism and catabolism of carbohydrate, protein and fat metabolism, Growth: types of growth, physiology of growth, factors of growth, determination of growth	**1** **1**

4	**Locomotion**	Muscles in locomotion, forces acting for swimming, other methods of locomotion	**1**
5	**Blood and cardiovascular system**	Composition, formation and functions of blood polymorphism in hemoglobin Structure of heart, arterial and venous system, Mechanism and physiology of circulation, Heartbeat or rate, blood pressure, cardiac cycle and cardiac output, electrocardiogram Regulation of heartbeat, blood pressure, cardiac cycle and cardiac output, Factors affecting cardiovascular system	**1** **1** **1** **1**
6	**Respiration**	Respiratory organs in fishes, Efficiency of gill for respiration Respiratory pattern in fishes Mechanism and physiology of respiration Transport of gases	**1** **1** **1** **1**
7	**Excretion and Osmoregulation**	Excretory organs, Chloride cells, Physiology of excretion, Water and salt balance in marine and freshwater fishes, Endocrine control of osmoregulation	**1** **1** **1**
8	**Reproduction and development**	Types of reproduction, spermatogenesis Oogenesis, sex differences Sexual maturity, reproductive behavior, Larval development Metabolic changes during oogenesis and Spermatogenesis	**1** **1** **1**
9	**Endocrine system**	Origin and functions of endocrine glands Role of hormones in the life process of fishes.	**1**
10	**Immune system**	Introduction, innate and adaptive immune system Immune organs in fish Elements of immune response in fish Immune response to infectious diseases in fish Fish as the model to study the development and differentiation of immune molecules	**1** **1** **2**
11	**Stress in fishes**	Fish behavior Physiological responses to environmental contaminants, temperature and oxygen. Response to handling; immunological response to stress,	**1** **1** **1**
12	**Histology**	Cells of the various organs of fishes	**1**
		Total	**30**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

1. Brown, M.E (Ed.) 1957. The Physiology of fishes Vols, I and II. Academic Press, New York and London.
2. Evans, D.H and Claiborne, J.B 2005. The physiology of fishes, CRC Press, Florida.
3. Fish Physiology: Sensory Systems Neuroscience. Copyright © 2020 Elsevier Inc. ISBN: 978-0-12-350449-4
4. Hoar, W.S. and Randall D.J. and J.R. Drett 1984. Fish Physiology, Academic Press London.
5. Khanna, S. S. and Singh H. R. 2011. A Textbook of Fish Biology and Fisheries, Narendra Publishing House, Delhi.
6. Kumar, S. and Tembhre, M. 1996. Anatomy and Physiology of Fishes, Vikas Publishing House Pvt ltd, New Delhi.
7. Lagler, K. F. J.E., Bardach. R.R. Miller and D.R.M. Passino, 1977. Ichthyology. John Wiley and Sons. Inc. New York.

FSH 303 Course title: Fish Genetics Credit: 3 Credit hours: 45

Introduction to the course:

In the past few decades, molecular genetics has become one of the fastest growing fields in the life sciences. The molecular biology of fish has been intensively investigated in all aspects of fisheries, including diseases, genetics, nutrition, ecology, conservation, breeding and natural resource management. With the expansion of the application of molecular tools, it has become crucial that all biologists have a basic understanding of molecular biology, and the application of molecular tools. Rather than providing an overview of classical genetics, the aim of the course is to provide an understanding of the molecular principles underpinning the genetics, thus allowing an assessment of the potential of molecular approaches to specific questions in Fisheries Science.

Specific objectives:

i. To get understand the basic principles of molecular genetics;
ii. To get acquainted with the basic molecular methods to apply in fisheries science; and
iii. To enable genetic data interpretation in an applied context.

Course contents

Theoretical

1. **Fundamentals of Genetics:** Introduction, Brief History of genetics, Chromosome and its Structure, Definition and scopes of molecular genetics in fisheries, Gene and genome, Molecular definition of gene. Mitosis and Meiosis; Mendelian Laws of Inheritance, Linkage; Crossing Over, Chromosomal aberrations, deletion, duplication, inversion, translocation; cytoplasmic Inheritance, Sex Determination; Sex Linked Inheritance.
2. **Effects of genes**: Single gene trait, Molecular understanding of quantitative and qualitative traits, Causes of genetic variance, Heritability.

3. **Functional genomics:** Introduction and definition; Physico-chemical structure of DNA and RNA, properties; DNA replication, Gene expression and translation to protein; Epigenetics; Regulation of gene expression; Post-translational modification of proteins, Gene silencing and knockout; Microarrays and other tools for functional genomics research.
4. **Molecular genetics methods and applications**: Cloning of Recombinant DNA, cloning vectors; Reverse transcription and creation of DNA library, Creation of genomic DNA library; Molecular methods to determine genetic variance (Protein polymorphism, DNA markers, PCR based techniques); Molecular genetics for fish stock assessment and conservation, DNA barcoding, Phylogenetic tree construction.
5. **Genetic modification of Fish:** GMO fish; Recombinant construction and delivery of transgene, and regulations, Creation of a gene construct, methods of gene transfer. Application of genetic engineering technique to produce fish with enhanced growth, disease resistance and cold tolerance.
6. **Fish genomics:** Introduction, Shotgun and Hierarchical genome sequencing**,** Use of bioinformatics tools for fish molecular genetics study.
7. **Applied Chromosomal Genetics:** Theory, Meiosis and polar bodies, Meiotic gynogenesis, Mitotic gynogenesis, Androgenesis, Techniques of inducing polyploidy in aquatic species, Triploidy in tilapia; Evaluating polyploidy induction.
8. **Inheritance of qualitative and quantitative traits:** Qualitative traits: Features, Mendelian genetics of qualitative traits: Dominance and Additive gene action, inheritance of color trait in fish, Quantitative Traits: Main Features and Principles of Inheritance, Factors affecting allele frequencies, Genetic Analysis of Quantitative Traits, Concept of Heritability: Estimating and predicting heritability: Parent-offspring (PO) regression, Realized heritability, Sib analysis; Detection and Analysis of Quantitative Trait Loci (QTL) for Economic Traits in Aquatic Species, Linkage analysis.
9. **Sex Determination and Control:** Genetics of sex determination in fish, Genetic and environmental influences, Homogametic monosex stocks, Heterogametic monosex stocks

Unit-wise learning outcome:

At the end of this course the student will be able to -

i. Understand the scopes and application of molecular genetics in fisheries.
ii. explain the effects of gene in phenotype and causes of variance in fish population.
iii. Understand the principles of the flow of genetic information of life and its regulation.
iv. Understand different molecular genetics techniques and use in fisheries.
v. Understand the application of recombinant technology in GMO fish production.
vi. Develop knowledge on fish genome sequencing methods.

Unit-wise title and subtitle and number of classes per unit

Chapter	Title	Sub-title	No. of classes
1	**Fundamentals of genetics**	Introduction, Brief History of genetics, Chromosome and its Structure	**1**
		Introduction, definition and scopes of molecular genetics in fisheries, gene and genome, Molecular definition of gene.	**1**

		Mitosis and Meiosis; Mendelian Laws of Inheritance, Linkage	**2**
		Crossing Over, Chromosomal aberrations, deletion, duplication, inversion, translocation;	**1**
		cytoplasmic Inheritance, Sex Determination; Sex Linked Inheritance.	**1**
2	**Effects of genes**	Single gene trait, Molecular understanding of quantitative traits	**1**
		Molecular understanding of qualitative traits	**2**
		Genetic variance, heritability	**2**
3	**Functional genomics**	Introduction and definition	**1**
		Physico-chemical structure of DNA and RNA, properties	**1**
		DNA replication, Gene expression and translation to protein	**2**
		Regulation of gene expression, Epigenetics	**1**
		Post-translational modification of proteins, Gene silencing and knockout	**1**
		Microarrays and other tools for functional genomics research	**1**
4	**Molecular genetics methods and applications**	Cloning of Recombinant DNA, Cloning vectors; reverse transcription and creation of DNA library, creation of genomic DNA library	**2**
		Molecular methods to determine genetic variance (Protein polymorphism, DNA markers, PCR based techniques) FISH (fluorescent *in situ* hybridization)	**2**
		Molecular genetics for fish stock assessment and conservation	**1**
		DNA barcoding, Phylogenetic tree construction.	**1**
5	**Genetic modification of Fish**	GMO fish; Creation of a gene construct, methods of gene transfer. Application of genetic engineering technique to produce fish with enhanced growth, disease resistance and cold tolerance.	**3**
		Application and regulations of GMO fish.	**1**
6	**Fish genomics**	Introduction, Shotgun and Hierarchical genome sequencing	**2**
		Bioinformatics tools for fish molecular genetics study	**1**
7	**Applied Chromosomal Genetics**	Theory, Meiosis and polar bodies, Meiotic gynogenesis, Mitotic gynogenesis, Androgenesis	**2**
		Mechanics of inducing polyploidy in aquatic	**2**

		species. Triploidy in tilapia; Evaluating polyploidy induction	
8	**Inheritance of qualitative and quantitative traits**	Qualitative traits: Features, Mendelian genetics of qualitative traits: Dominance and Additive gene action, inheritance of color trait in fish	**3**
		Quantitative Traits: Main Features and Principles of Inheritance, Factors affecting allele frequencies, Genetic Analysis of Quantitative Traits, Concept of Heritability: Estimating and predicting heritability: Parent-offspring (PO) regression, Realized heritability, Sib analysis; Detection and Analysis of Quantitative Trait Loci (QTL) for Economic Traits in Aquatic Species, Linkage analysis	**4**
9	**Sex Determination and Control**	Sexual dimorphism, Genetic basis of sex determination in fish, environmental influences on sex determination, Homogametic monosex stocks, Heterogametic monosex stocks creation	**3**
		Total	**45**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

Books Recommended:

1. Boris Gomelsky, 2011, Fish Genetics- Theory and Practice. Dr. Muller GmbH and co. Germany.
2. Hochachka, P.W. and Mommsen, T.P., 1993. Biochemistry and Molecular Biology of Fishes. Elsevier Science Publishers, Amsterdam.
3. Hoelzel, A.R., 1998. Molecular Genetics Analysis of Populations: A Practical Approach. Oxford University Press.
4. Meyers, R.A., 1995. Molecular Biology and Biotechnology. VCH Publishers, New York.
5. T A Brown, 2012, Introduction to Genetics: A Molecular Approach, Garland Science, Taylor & Francis group, LLC.
6. Tave, D 1995. FAO FISHERIES TECHNICAL PAPER 352 Selective breeding programmes for medium-sized farms. FAO.
7. Tave, D. 1999. Inbreeding and brood stock management. FAO FISHERIES TECHNICAL PAPER 392. 122 PP.

8. Tave, D., 1996. Genetics for Fish Hatchery Managers (3rd edition) Van Nostrand Reinhold, New York

FSH 304 Course title: Fish Pathology and parasitology Credit: 3 Credit hours: 45

Introduction to the course:

Disease is the third most important aspect of successful aquaculture after seed and feed. Disease is the most common cause of bankruptcy in aquaculture business. Due to disease outbreaks, huge losses in terms of food security and economy occur worldwide. So, this is very important to know the various diseases and their preventive and control measures. This course will provide students with an introduction to the diseases of fish and shellfish, especially shrimp. During lecture sessions, students will be introduced to the taxonomy of major groups of pathogen and parasites, also their preventive and control measures. During laboratory sessions, students will gain "hands-on", practical knowledge to identify specific fish and shrimp pathogens.

Specific Objectives:

i. To get acquainted with bacterial, viral, fungal and parasitic diseases of fish and shellfish;
ii. To get know the methods to diagnose pathogens through understanding of their morphology, classical and molecular methods; and
iii. To get acquainted with laboratory and field level experiences to combat diseases by prevention and control measures.

Course Contents

Theoretical

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, etiology, 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, tumors, growth abnormalities.
7. **Shellfish pathogens and disease:** Methods for detection of pathogens of fish and shellfish.
8. **Parasitology in the field of fisheries:** Major groups of fish parasites and their characteristics**,** Interaction of parasites with fish and shellfish**:** symbiosis and parasitism; morphological adaptation of parasites to their mode of life; host-parasite relationship.
9. **Physiological factors in fish diseases:** Host's reaction to parasites, cell and tissue reactions, host specificity.
10. **Distribution of parasites in aquatic habitats:** Dynamic changes in parasitic fauna of ponds, lakes and reservoirs.

11. **Life cycle**: Some representative protozoan, trematode, cestode, nematode, acanthocephalan and crustacean parasites.
12. **Public health and fish consumption:** Fish as carrier of human parasitic diseases and their control.

Unit-wise learning outcomes:

At the end of the course, the students will be able to-

i. Define and classify various pathogens of fish and shrimp;
ii. Explain the disease epizootiology, distribution, etiology, symptoms and pathology of common disease of fish and shellfish;
iii. Demonstrate the methods to diagnose fish pathogens through various classical and molecular techniques; and
iv. Evaluate and apply various measures to prevent and control diseases.

Unit-wise title and sub-title and number of classes per unit

Chapter	Title	Sub-title	No. of classes
1	**Introduction**	Definition, health and disease, source of infection: factors producing disease in fish, general symptoms of diseased fish.	**2**
2	**Viral fish pathogens**	Epizootiology, distribution, etiology, diagnosis, symptoms and pathology of common viral disease of fish	**5**
3	**Bacterial fish pathogens**	Characteristics, epizootiology, distribution, etiology, diagnosis, symptoms and pathology of common bacterial disease of fish	**5**
4	**Fungal fish pathogens**	Characteristics, epizootiology, distribution, etiology, diagnosis, symptoms and pathology of common fungal disease of fish.	**5**
5	**Dietary deficiency diseases in fish**	Pathological changes and symptoms of dietary deficiency in fish Significance of nutrition in maintaining resistance to infection.	**3** **2**
6	**Fish diseases and stress**	Environmental stress and their effect on fish and pathogens Hereditary fish diseases, tumors, growth abnormalities	**2** **3**
7	**Shellfish pathogens and disease**	Methods for detection of pathogens of fish and shellfish.	**5**
8	**Parasitology in the field of fisheries**	Major groups of fish parasites and their characteristics Interaction of parasites with fish and shellfish**:** symbiosis and parasitism;	**1** **2**

		Morphological adaptation of parasites to their mode of life Host-parasite relationship	**1** **1**
9	**Physiological factors in fish diseases**	Host's reaction to parasites cell and tissue reactions host specificity.	**1** **1** **1**
10	**Distribution of parasites in aquatic habitats**	Dynamic changes in parasitic fauna of ponds, lakes and reservoirs.	**2**
11	**Life cycle**	Some representative protozoan, trematode, cestode, nematode, acanthocephalan and crustacean parasites.	**5**
12	**Public health and fish consumption**	Fish as carrier of human parasitic diseases and their control.	**3**
		Total	**45**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References:

1. Cheng, T. C.General Parasitology. Academic Press.
2. Larry S. Roberts & John Janovy Jr. Wm C. Foundations of Parasitiology. 8th edition, 2010. Brown Publishers.
3. Moller, H. & Anders, K. Diseases and Parasites of Marine Fishes. Scanner - Studio - Nord. Germany.
4. Ribelin, W. E &Migaki, G. The Pathology of Fishes. The University of Wisconsin Press.
5. Schaperclaus, W. &Balkema, A. A. 1992. Fish Diseases, Vol. 1&2.

FSH 305 Course title: Fisheries Economics Credit: 2 Credit hours: 30

Introduction to the Course:

Fisheries Economics course is designed to enhance students' knowledge in economics principles for application to fisheries. This course imparts knowledge and skills that would enable students to run their enterprises based on sound economic principles. For Fisheries to contribute significantly to food security and poverty alleviation, there is need to pursue fisheries as business entities. This course aims to deliver a clear understanding of the production and marketing concepts applicable for fisheries products. An understanding of how effective and efficient

production and marketing systems are performing will help the stakeholders diagnose economic problems in fisheries sectors (culture, capture and marine fisheries) for sound decision making.

Specific objectives:

i. To get understand fisheries economics;
ii. To get understand relationships among consumers' income/budget, equilibrium, utility maximization, demand and marginal utility;
iii. To get acquainted with the theory of demand and supply;
iv. To get understand the application of knowledge of economics in fisheries science;
v. To get understand the economic importance of culture, capture and marine fisheries sectors of Bangladesh; and
vi. To enable responsive to the current trends and research priorities in fisheries economics.

Course Contents

Theoretical

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.

Unit-wise learning outcomes:

At the end of this course the student will be able to -

i. Understand the basic concepts and ideas in economics.
ii. Identify the relationships among consumers' income/budget, equilibrium, utility maximization, demand and marginal utility
iii. Explain and apply the theory of demand and supply, in marketing of fish and fish products.
iv. Describe the input–output relationship in fisheries and apply knowledge of production functions in production of fish.

v. Describe the economic importance of culture, capture and marine fisheries sectors of Bangladesh
vi. Response to the current trends and research priorities in fisheries economics.

Unit-wise title and sub-title and number of classes per unit:

Chapter	Title	Sub-title	No. of classes
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; Difference between Micro and Macro-economic;	**2**
2	**Consumer behavior**	Indifference curve, utility, law of diminishing marginal utility, consumer budget, consumer equilibrium;	**2**
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;	**1** **1** **1** **2** **1** **1** **1**
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;	**1** **1** **2** **1** **1**
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;	**2** **2** **1**
6	**Money and Capital**	Time value of money; Internal rate of return; BCR; banking system and financing;	**4**
7	**Economic importance of fisheries sectors of Bangladesh**	Culture fisheries; capture fisheries; marine fisheries	**3**

Total	**30**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. One in-course exam – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References:

1. Anderson L.G. (1986) The Economics of Fisheries Management, The Johns Hopkins University Press, Baltimore, Maryland.
2. Dominick S. (1992). Schaum's outline of Theory and Problems of Microeconomic Theory. 3rd Edition. McGrew-Hill Book Co, Singapore.
3. Jolly C.M. and Clonts H.A. (1981) Economics of Aquaculture, Food Production Press, New York.
4. Roger A. Arnold. (2008) Economics, Thomson Higher Education, USA.
5. Samuelson, P.A. and Nordhaus, W.D. (1989). Economics. 13th edn.Megraw-Hill, New York.
6. Shang, Y.C. (1981) Aquaculture Economics: Basic Concepts and Methods of Analysis, Westview Press, London.

FSH 306 Course title: Fish Harvesting and Handling Credit: 3 Credit hours: 45

Introduction to the Course:

Open water fisheries is a major contributor in fish production in Bangladesh. This course focuses on open water fish harvesting and handling techniques. This includes principle of fishing, different fishing crafts, gears and their mode of operation, fish finding and harvesting techniques, onboard handling and storage techniques up to displaying in market. This course gives emphasis on both artisanal and industrial crafts and gears used in fishery of Bangladesh.

Specific Objectives:

i. To get understand the principle of fish harvesting and handling;
ii. To get acquainted with the methods of open water fish harvesting and handling;
iii. To get acquainted with different fishing gears and materials used for fishing;
iv. To get understand the ways to differentiate harvesting materials in laboratory and in field; and
v. To enable with proper handling process from catching to marketing.

Course contents

Theoretical

1. Introduction: History of fishing, fishing down food web; principles and modern trends in fishing; maximum sustainable yield (MSY) and its limitations; optimum sustainable yield-maximum economic yield (MEY), saving cost in commercial fishing.

2. Fishing crafts and gears: Artisanal and industrial fishing crafts of Bangladesh; classification of fishing gears, fishing net making materials, terminology, numbering systems, relative efficiencies of nets of different materials; fishing nets of Bangladesh; beam and otter trawl net, net preservation methods, fishing traps.
3. Fishing ground and Fish reconnaissance: Fishing grounds in the Bay of Bengal; eco-sounding, visual methods, remote sensing and infrared photography for fish reconnaissance.
4. Methods of harvesting: Trawling methods to harvest pelagic, demersal and mid-water fishes, harvesting of Shrimps, seines, gill net, long line fishing, choosing mesh size, towing speed of trawl net; use of fish behavior in fishing- artificial lures, fish aggregating device (FAD), light fishing, chemical stimuli, tactile and acoustic methods; present status of fishing, problems of open water fishing in Bangladesh, ghost fishing, bycatch/trash fish, gear adaptations to reduce bycatch.
5. Fish handling: Handling of fresh fish and shrimps on board, sorting, washing slime, gutting, evisceration, filleting, salting, storage; cause of fish decomposition, rigor mortis, shelf life of fish, characteristics of fresh condition of fish, handling fish on shore and presentation in market, importance of icing and estimating required ice for chilling the harvest.

Unit wise Learning outcomes:
At the end of this course the student will be able to

i. Acquire knowledge on fishing history and current trends and options for harvesting fish stock.
ii. Develop understanding on different inland and marine fishing gears and crafts.
iii. Develop knowledge on fishing grounds of Bangladesh and understand fish reconnaissance techniques.
iv. Understand different fishing methods and mode of operation of gears and crafts to explore the fish stock.
v. Identify the problems during fish handling on board and shore as well as means to avoid quality compromise.

Unit-wise title and sub-title and number of classes per unit

Chapter	Title	Sub-title	No. of classes
1	**Introduction**	History of fishing, fishing down food web; principles and modern trends in fishing; Maximum sustainable yield (MSY) and its limitations; Optimum sustainable yield- maximum economic yield (MEY), saving cost in commercial fishing.	**3** **3**
2	**Fishing crafts and gears**	Artisanal and Industrial fishing crafts of Bangladesh; Classification of fishing gears, Fishing net making materials, terminology, numbering systems, relative efficiencies of nets of different materials; Fishing nets of Bangladesh; beam and otter trawl net, net preservation methods, fishing traps.	**3** **3** **3**
3	**Fishing ground**	Fishing grounds in the Bay of Bengal; eco-sounding,	**4**

	and Fish reconnaissance	visual methods, remote sensing and infrared photography for fish reconnaissance.	
4	**Methods of harvesting**	Trawling methods to harvest pelagic, demersal and mid-water fishes, harvesting of Shrimps, seines, gill net, long line fishing, choosing mesh size, towing speed of trawl net; use of fish behavior in fishing- artificial lures, fish aggregating device (FAD), light fishing, chemical stimuli, tactile and acoustic methods; present status of fishing, problems of open water fishing in Bangladesh, ghost fishing, bycatch/trash fish, gear adaptations to reduce bycatch.	**2** **3** **3** **4**
5	**Fish handling**	Handling of fresh fish and shrimps on board, sorting, washing slime, gutting, evisceration, filleting, salting, storage; cause of fish decomposition, rigor mortis, shelf life of fish, characteristics of fresh condition of fish, handling fish on shore and presentation in market, importance of icing and estimating required ice for chilling the harvest.	**3** **3** **3** **2** **2**
		Total	**45**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. One in-course exam – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

1. Ahmed, N. 1970, Fishing Craft of East Pakistan, East Pakistan Government Press, Dacca
2. Clusas, I. J. (Editor) 1985, Fish Handling, Preservation and Processing in the tropics, Part I & II, Tropical development & Research Institute London.
3. Clusas, I.J. Sutcliffe, P.J. 1981, An introduction to fish Handling and Processing, Tropical Products Institute, London
4. Das, B. and Bandayapaddaya, O. 2000, Fish Harvesting Technology, Bangla Academy, Dhaka.
5. Fisherman's Workbook, Fishery Industries Division, FAO, Fishing News Books, Oxford 1990
6. Garner, J. 1988. Modern Deep Sea Trawling Gear, Hartnolls Limited, Bodmain, Cornwall.
7. Neilsen, L. A. and Johnson, D. L 1985. Fisheries Techniques, Southern Printing Company Inc, Blacksburg, Virginia.

FSH 307 Course title: Fish Population Dynamics Credit: 3 Credit hours: 45

Introduction to the course:

Fishery graduates must have knowledge on the population, cohort, estimation of size and recruitment for decisions to manage the fished fishery/fisheries. Understanding the stock assessment, growth, mortality and other population growth is necessary to decide the fishery quota and fishing effort. Analysis of the stock, growth parameters from length frequency data is required for a fishery scientist for better management. Determination of the growth from hard parts of the fishes and mortality from catch curve is another pre-requisite for a fishery scientist. Assessment of the stock size and mortality from mark-recapture in other words tagging and marking is equally important to know as a fishery graduate.

Specific objectives:

i. To get acquainted the concept of stock, population, population growth, factors that affect fish population density and growth, features of population distribution, carrying capacity and environmental resistance to the students;
ii. To get understand model, basic principles and steps of models, holistic and analytical models;
iii. To understand the concept of abundance, methods of determining the abundance, sampling survey and mark-recapture method, depletion method;
iv. To get understand the stock-recruit relationships;
v. To enable to develop knowledge on tagging and marking of fish;
vi. To get understand the ways to determine the stages of maturation, Gonado-somatic index (GSI), fecundity, and analyzing stomach contents; and
vii. To enable to demonstrate skill in using different computer-based length-frequency data analysis software particularly FiSAT.

Course contents

Theoretical

1. **Introduction** – background of fish population dynamics, concept of stock, unit stock, definition of fish population, population growth, factors that affect fish population density and growth, features of population distribution, carrying capacity.
2. **Abundance** – concept of abundance, methods of determining the abundance, sampling survey and mark-recapture method, depletion estimates of closed and open population size.
3. **Factors that increase biomass** – growth, absolute and relative growth, Variation in growth, length-weight relationship, Ford-Walford growth transformations, von Bertalanffy growth equations, determination of the growth parameters from length frequency data and tagging information, determination of growth from hard parts and back calculation of the growth from scale length, different condition indices, stomach content analysis.
4. **Virtual Population Analysis (VPA) and Cohort Analysis** – general principles, age and length-based VPA analysis, application of VPA to fisheries management, cohort analysis.
5. **Stock Recruitment Relationships** – properties of "good" stock recruitment relationships, data requirements (spawning stock, recruitment), three classical stock-recruitment relationships, basic principles and their biological assumptions/implications.

6. **Factors that decrease biomass** – mortality, determination of the mortality from age-based and length-based catch curve.
7. **Predator/pray ratios** – adult forage fish and carnivore fish (F/C) ratio and young forage fish-carnivore fish (Y/C) ratio in a pond fish population.
8. **Tagging and marking** – Tagging and marking of fish and shellfish.
9. **Length Frequency Analysis (LFA)** – different computer-based length-frequency data analysis software particularly FiSAT.
10. **Models** – basic principles and steps of models, characteristics of mathematical models, types of model structure, holistic and analytical models.

Learning outcomes

i. Students can define population, stock and dynamics of fish populations
ii. Will be well understood the assessment of stock, population and growth parameters
iii. Explain the population and growth parameters into components
iv. Determine the population parameters from length frequency data and catch survey data
v. Determine growth from hard parts and length from scale length by back calculation
vi. Establish the relationship between recruitment and stock size
vii. Evaluate the role of a fishery investigator in fishery management
viii. Demonstrate significance awareness in ensuring sustainable fishery management and maximum sustainable yield
ix. Analyze the length frequency, CPUE and fishing effort data to determine the catch size of fish population each year
x. Show competency in analysing data by using FiSAT computer-based software

Unit-wise title and sub-title and number of classes per unit

Chapter	Title	Sub-title	No. of classes
1	**Introduction**	Definitions: Population, Community, Ecosystem, k-selection, r-selection concept of stock, unit stock, definition of fish population	**3**
		Exponential and logistic growth	**2**
		Factors that affect fish population density and growth	**2**
		Features of population distribution, carrying capacity	**1**
2	**Abundance**	Concept of abundance, absolute abundance, relative abundance, methods of determining the abundance	**2**
		Sampling survey and mark-recapture method, depletion method.	**2**
3	**Factors that increase biomass**	Growth, absolute and relative growth, length-weight relationship,	**2**
		Ford-Walford growth transformations,	**1**
		Von Bertalanffy growth equations	**2**
		Determination of the growth parameters from length frequency data	**2**
		Determination of the growth parameters from tagging information	**1**
		Determination of growth from hard parts and back	**1**

		calculation of the growth from scale length	
		Determination of the condition factor from length and weight data.	**1**
		Stomach content analysis	**1**
4	**VPA**	Estimation of population from virtual population analysis (VPA),	**1**
		Age-based VPA analysis.	**1**
		Length based VPA analysis	**1**
5	**Stock Recruitment Relationship**	Three classical stock-recruit relationships	**2**
6	**Factors that decrease biomass**	Mortality, Instantaneous mortality, survival	**2**
		Determination of the mortality from age-based catch curve.	**2**
		Length-based catch curve.	**1**
7	**Predator/pray ratios**	Definitions- forage fish, carnivore fish, F/C ratio, Y/C ratio	**3**
8	**Tagging and marking**	Tagging and marking	**2**
9	**LFA**	Different computer-based length-frequency data analysis software particularly FiSAT.	**4**
10	**Models**	Model, basic principles and steps of models	**2**
		Holistic and analytical models	**1**
		Total	**45**

Instructional strategies: Languages will be both Bengali and English, 2-way communications, First five of ever lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions.

Assessment

a. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
b. Final exam: Only written.
c. Oral test.

References

1. Gulland. J. A. 1982 Fish Stock Assessment.
2. Haddon, M. (2010). Modelling and quantitative methods in fisheries. CRC press.
3. Hilborn, R., & Walters, C. J. (Eds.). (2013). Quantitative fisheries stock assessment: choice, dynamics and uncertainty. Springer Science & Business Media.
4. Jennings S., Kaiser M. J. and Reynolds J. D.2001. Marine Fisheries Ecology. Blackwell Publishing.
5. King, M 1996. Fisheries Biology, Assessment and Management. Fishing News Books, Blackwell Science Ltd. UK

6. Pauly. D. 1981. Fish Population Dynamics in Tropical Waters.
7. Quinn, T. J., & Deriso, R. B. (1999). Quantitative fish dynamics. oxford university Press.
8. Rounsefell, G.A. and W.H. Everhart. 1953. Fishery Science: Its Methods and Applications. John Willey & Sons. Inc. New York. 444p.
9. Sparre, P &Venema, S.C. 1992. Introduction to tropical fish stock assessment. FAO Fish Tech. Pup. 306/ 1 Rev. 1.

FSH 308 Course title: Fisheries Extension Credit: 2 Credit hours: 30

Introduction to the course:
This course is designed to acquire theoretical and practical knowledge on Fisheries Extension. Students will learn how to disseminate research information to fishermen. Students can help aqua farmers and fishing communities to improve their socioeconomic condition and quality of life by making improvement in their farming practices resulting in increased fish production and income.

Specific Objectives:

i. To get acquainted with the detailed knowledge on fisheries extension;
ii. To get understand how to discover and analyze fishermen's problems and identify the felt needs;
iii. To enable to disseminate research outputs among fisheries stakeholders; and
iv. To get understand the methods of collection and transmission of feedback information for solving management problems.

Course contents
Theoretical

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, and 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 biodiversity, fishing fight.
11. **Conservation**: common property fisheries.

Unit-wise learning outcomes:

At the end of the course students will be able to-

i. Describe fisheries extension principles, levels, functions and objectives.
ii. Analyze the need for fisheries extension works for fisheries development,
iii. Explain principles of Learning, Behavior, Attitudes, Perception.
iv. Explain the basic function of communication, types, models of extension communication, barriers of communication.
v. Describe visual and audio-visual aids, importance and use.
vi. Explain possible solution, rural youth in extension work, past and present programmes for development of fisheries and related agricultural development activities, awareness programme for biodiversity, fishing fight.

Unit wise title and subtitle, learning outcomes and number of classes per unit

Chapter	Title	Sub-title	No. of classes
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.	**3**
2	**Extension as educational process**	Teaching in extension, learning in extension, principles of Learning, Behavior, Attitudes, Perception	**3**
3	**Extension objectives**	Motivation, Need identification, Concept of need, Maslow's need theory, Change in behavior, attitude and perception	**3**
4	**Leadership**	concept, types and groups, recognition for good leadership	**2**
5	**Communication in extension for fisheries**	Basic function of communication, types, models of extension communication, Barriers of communication.	**4**
6	**Extension communication methods and aids**	Individual methods, group and mass methods, visual and audio-visual aids, importance and use.	**3**
7	**Extension programme**	procedures, concept, planning, implementation, evaluation, and importance.	**3**
8	**Innovation**	decision process, transfer of technologies, diffusion, adoption, factors affecting the	**3**

		transfer of technologies	
9	**Organization for extension work**	Main features, Categories of personnel, Supervision and co-ordination in extension work	**3**
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 biodiversity, fishing fight.	**2**
11	**Conservation**	common property fisheries	**1**
		Total	**30**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. One in-course exam – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

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. Ray, G. L. Extension Communication and Management.
5. Regers, E.M. 1983. Diffusion of Innovations, New York: The Free Press of Glenco.
6. Singh, Ranjit, 1987. A Text Book of Extension Education. Ludhiana. India: Shahityakala Prakashan.
7. Supe, S.V. 1983. An Introduction of Extension Education. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd.

FSH 309 Course title: Fisheries and Environmental Impact Assessment Credit: 2 Credit hours: 30

Introduction to the course:

Many development projects have impacts on fisheries, environment and society. On the other hand, many fisheries related projects have impact on environment and society. The course 'Environmental and Fisheries Impact Assessment' focuses on these impacts in order to identify the ways of addressing them. It has included a range of case studies which will help the students to learn about these impacts in the real world.

Specific Objectives:

i. To get acquainted with the holistic understanding of environmental impact assessment (EIA);
ii. To get understand the broad theoretical and specific practical knowledge of EIA for fisheries sector; and
iii. To enable understanding in conducting EIA in the real world.

Course contents
Theoretical

1. **Environmental Impact Assessment (EIA):** Introduction and overview of EIA; Law, policy and institutional arrangements for EIA systems; EIA process. Public involvement; Screening; Scoping; Detailed impact analysis; Social impact assessment; Strategic environmental assessment; Mitigation and impact management; Reporting; Review of EIA quality; Decision making; Implementation and follow-up; EIA projects management; Case studies: EIA for national, international, government, private and donor projects.
2. **Fisheries Impact Assessment:** EIA for fisheries sector. Impact assessment for fisheries and related projects on environment, economy and society such as freshwater aquaculture, shrimp culture, fish processing, feed and other fisheries related industries. Mitigation measures. Impact assessment of new and existing projects on fisheries and aquaculture. Impact assessment for dam (e.g. Farakka barrage), pollution (e.g. agro-chemicals and industrial), land use change, destruction of aquatic habitat etc. Assessment of migratory fish stock, economic assessment of fisheries resources, expected changes in project impact area, assessment of social impact of the project. Realistic estimates of production and biodiversity from capture and culture fisheries in with-project and without-project conditions. Case studies on the existing projects (FCD/I and other projects): impact on people, impact on economy; mitigation measures. Evaluation of EIA projects.

Unit-wise learning outcomes:
After completion of unit, the students will be able to -

i. Gain knowledge on the concept and importance of EIA
ii. Understand the legal and institutional aspects of EIA
iii. Describe the steps of conducting EIA for development and fisheries related projects
iv. Identify mitigation and impact management for EIA
v. Develop scholarship and skills in carrying out EIA in the real world especially that are related to fisheries.
vi. Evaluate EIA projects

Unit-wise title and sub-title and number of classes per unit

Chapter	**Title**	**Sub-title**	**No. of classes**
1.	**Environmental Impact Assessment**	Introduction, history and concept of EIA	**1**
		Law, policy and institutional arrangements for EIA systems	**1**
		EIA process overview	**1**
		Public involvement	**1**

		Screening	**1**
		Scoping	**1**
		Detailed impact analysis	**1**
		Mitigation and impact management	**1**
		Reporting	**1**
		Review of EIA quality	**1**
		Decision making; Implementation and follow-up	**1**
		EIA projects management	**1**
		Case studies: EIA for national, international, government, private and donor projects	**2**
2.	**Fisheries Impact Assessment**	Overview of EIA for fisheries sector Impact assessment for fisheries and related projects on environment, economy and society such as freshwater aquaculture, shrimp culture, fish processing, feed and other fisheries related industries	**3**
		Mitigation measures and management for fisheries and related projects. Impact assessment of new and existing development projects on fisheries and aquaculture	**2**
		Impact assessment for dam (e.g. Farakka barrage), pollution (e.g. agro-chemicals and industrial), land use change, destruction of aquatic habitat etc.	**2**
		Assessment of migratory fish stock, economic assessment of fisheries resources, expected changes in project impact area, assessment of social impact of the project	**2**
		Realistic estimates of production and biodiversity from capture and culture fisheries in with-project and without-project conditions	**1**
		Case studies on the existing projects (FCD/I and other projects): impact on fish; impact on people, impact on agriculture and economy	**6**
		Mitigation measures and impact management for development projects	**1**
		Evaluation of EIA projects	**1**
		Total	**30**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. One in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

1. Barry Sadler and Mary McCabe (Editors). 2002. Environmental Impact Assessment Training Resource Manual. Second Edition. UNEP.
2. FAP 17. 1992. Fisheries Impact Assessment, ODA, Dhaka.
3. GEO Resource Book: A Training Manual on Integrated Environmental Assessment and Reporting. 2007. United Nations Environment Programme and the International Institute for Sustainable Development.
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.

Practical

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 notebook 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 following courses.

Assessment

In-course examination: 40% marks
Final examination: 60% Marks

FSH 301P Course title: Coastal Aquaculture Credit: 1.5 Credit hours: 22.5

Contents

a. Collection and identification of marine fishes
b. Design and construction of shrimp hatchery and farms.
c. 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.
h. Field trips to coastal aquafarm

FSH 302P Course title: Fish Physiology Credit: 1 Credit hours: 15

Contents

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.

FSH 303P Course title: Fish Genetics Credit: 1.5 Credit hours: 22.5

Contents

a. Karyotyping of fishes, methods of chromosome preparation in fishes.
b. Extraction of DNA, RNA and protein from fish sample (Phenol-Chloroform Extraction/Trizol/Tri-reagent based extraction, and other techniques)
c. Separation of protein and DNA from fish sample and spectrophotometric measurement of concentrations.
d. Agarose gel electrophoresis of fish DNA samples.
e. cDNA synthesis from RNA, PCR and RT-PCR
f. Gene expression study
g. Use of bioinformatic tools (Blast, MEGA etc.) for sequence query and retrieving useful information.

FSH 304P Course title: Fish Pathology and Parasitology Credit: 1.5 Credit hours: 22.5

Contents

a. Laboratory techniques (classical and molecular approaches: PCR, quantitative PCR, sequencing) for the detection of aquatic pathogens from fish, shellfish and water bodies.
b. Study of physiological and biochemical characteristics of bacteria, viruses, fungi, etc. related to fish and shellfish 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, and identification of parasites.
e. Recording basic data of the fish to be examined, length, weight, age, sex, etc. gut content, investigation of parasites, presentation of data, and examination of fish faces and use of laboratory record book.

FSH 305P Course title: Fisheries Economics Credit: 1 Credit hours: 15

Contents

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

FSH 306P Course title: Fish Harvesting and Handling Credit: 1.5 Credit hours: 22.5

Contents

a. Acquaintance with the different types of fishing crafts and gears in Bangladesh.
b. Examination of net materials.
c. Determination of mesh size, net depth and length, knot spacing and hanging ratio.
d. Techniques of net preservation.
e. Freshness test of fish and shellfish (appearance, eye condition odor, flesh, gill condition, skin).
f. Determination of required horsepower (Hp), passenger load and weight capacity of a mechanized fishing craft.
g. Fish acoustic devices
h. On-board handling on fishing trawl

FSH 307P Course title: Fish Population Dynamics Credit: 1.5 Credit hours: 22.5

Contents

a. Demonstration and lab work - Study of fecundity, estimation of population by mark-recapture method, determination of fish age from scale, determination of fish length from scale length by back calculation, determination of length-weight relationship and condition factor.
b. Hands-on training on FiSAT and ELEPAN packages.
c. Use of 'R' statistics for fish population dynamics

FSH 308P Course title: Fisheries Extension Credit: 1 Credit hours: 15

Contents

a. An orientation to different organization related to fisheries development.
b. Preparation of training programme and practice training, lecture, small group discussion, Philips 66 methods, symposium, panel discussion, brain storming and demonstrations using flip chart, poster and video.
c. Liaise with GO's and NGO's
d. Extension field trip to rural areas to observe rural development activities in the field situation (Upazilla, districts) with emphasis on fisheries.

FSH 309P Course title: Fisheries and Environmental Impact Assessment Credit: 1 Credit hours: 15

Contents

a. Impact assessment of hypothetical project (project deign and EIA).
b. Case studies on some FCD/I projects for impact assessment for example, Chalan beel Project, Teesta river project, Narsingdi-Narayanganj FCDI project, Halda river project.
c. Case studies on some impacts of dams on fisheries.
d. Case studies on some impacts of industries on fisheries.
e. Case studies on some impacts of land use change and fish habitat destruction due to development projects (for example Rampal coal-based power plant at Rampal, Bagerhat).
f. Field trips to different development projects and study the EIA of those projects
g. Assessment report writing

FSH 310 Course title: Internship Credit: 1.5 Credit hours: 22.5

The students will have to work in industries related to fisheries such as fish farm, processing industry, feed mill, hatchery, aqua drug company etc. They are expected to gather knowledge on specific area. The duration of the internship will be determined by the academic committee of the department. After finishing the internship each student will be required to submit a report on the work he or she performed during the period. A proof of certificate will also be needed to submit along with the report.

A presentation will also be required where the students will present their work in front of the examination committee.

FSH 401 Course title: Fisheries Resources Management Credit: 3 Credit hours: 45

Introduction to the Course:
Bangladesh has considerable fisheries resources. However, the fish production per unit is lower, biodiversity is decreasing, and conditions of dependent people are not satisfactory. Shortcomings in management are amongst the main reasons for these. This course is designed to acquire fundamental knowledge of fisheries resources management. Fisheries management is the activity of protecting fishery resources through sustainable exploitation of resources. It is expected that students will be exposed to learn the methodologies for identification of fisheries resources and problems in river, flood plains, haor, baor and marine fisheries sector.

Specific Objectives:

i. To get familiar with fisheries resources, potential of fisheries and economic importance of fisheries resources in Bangladesh;
ii. To get understand the importance, dimensions, phases, principles, strategies and problems of fisheries managements;
iii. To get understand the importance of collection of fisheries management data, habitat restoration and improvement;
iv. To get understand the enforcement of fisheries regulation and policies; and
v. To get acquainted with fisheries resources management in the laboratory and in the field.

Course Contents:
Theoretical

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; National shrimp policy, Fish Acts of Bangladesh, Marine Fisheries Ordinance of Bangladesh, Code of conduct for responsible fisheries,
10. **Fisheries management strategy**: stock enhancement scheme, fish sanctuary, CBFM and CBFM policy, EEZ (exclusive economic zone) of Bay of Bengal, International Convention on sea., Remote sensing & GIS application in fisheries management.
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.

Unit-wise learning Outcomes:

At the end of the course, the students will be able to-

i. Define fisheries resources and management;
ii. Understand the fisheries resources and fish biodiversity of Bangladesh;
iii. Relate the potential economic importance to development;
iv. Understand the importance of fisheries data for management;
v. analysis the regulatory and economic techniques;
vi. develop skill in frame working for institutional management of inland and marine resources;
vii. Select management strategies; spawning, development, constrains and future prospects of hilsha fishery;
viii. Resolve the problems faced by the fishers in brackish and marine fisheries management; and
ix. Identify fisheries resources and problems in river, flood plains, haor, baor and marine fisheries sector.

Unit-wise title and sub-title and number of classes per unit:

Chapter	Title	Sub-title	No. of classes
1	**Introduction**	Importance in Asia, world and Bangladesh fish population, Bangladesh position in world	**2**
		potential of fisheries in Bangladesh	**1**
2	**Fisheries resources in Bangladesh**	physical resources in Bangladesh (rivers, floodplains, haor, baors, beel, lake, estuary and sea)	**2**

		fish biodiversity in Bangladesh (rivers, floodplains, haor, baors, beel, lake, estuary and sea)	**2**
3	**Economic importance of fisheries resources**	Manpower involved in fisheries sector	**1**
4	**Fisheries management**	Definition, necessity, dimensions, phases of fisheries management	**1**
		Principle and context of management	**1**
		Management of natural populations: objectives and goals	**1**
		Regulation of fishing effort, technology creep	**1**
5	**Data required in fishery management**	Importance of collection of data	**1**
		Importance of life history data in management	**1**
6	**Habitat restoration and improvement**	Removal of obstruction, modification of existing obstacles, dams, shelter, lotic waters	**2**
7	**Fisheries regulations**	purpose, types, input and output control	**2**
		enforcement of regulation, regulatory authority	**1**
		Economic analysis of regulatory techniques	**1**
8	**Problems of management**	prediction of abundance, role of nutrients	**1**
		natural balance and environmental monitoring	**1**
9	**Fisheries management policy of Bangladesh**	institutional frameworks, inland and marine	**2**
		process of developing fisheries management policy, Jalmahal policy	**2**
		New fisheries management policy (NFMP), National fisheries policy	**2**
		Fish Acts of Bangladesh, Marine Fisheries Ordinance of Bangladesh	**2**
10	**Fisheries management strategy**	stock enhancement scheme, fish sanctuary	**2**
		CBFM, EEZ (exclusive economic zone) of Bay of Bengal	**2**
		International Convention on sea	**2**
11	**Management of river fisheries**	Major spawning grounds of major carps	**2**
		Hilsha fishery management, spawning, development, constrains and future prospects of hilsha fishery	**3**
		Floodplain, haor, Lake fisheries management	**2**
		brackish and marine fisheries management	**2**
		Total	**45**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

1. Ameen, M. U. (1987). *Fisheries resources and opportunities in freshwater fish culture in Bangladesh*. PAT, NRD-II/DANIDA.
2. Anderson L.G. (1986). *The Economics of Fisheries Management*. The Johns Hopkins University Press, Baltimore, Maryland.
3. FRSS, 2017, 2018, 2019, 2020. Fisheries Statistical Report of Bangladesh. Fisheries Resources Survey System (FRSS), Department of Fisheries, Bangladesh.
4. King, M (1996). *Fisheries Biology, Assessment and Management*. Fishing News Books, Blackwell Science Ltd. UK.
5. Rounsefell, G.A. and Everhart, W.H. 1983. *Fishery Science*. John Willey and Sons, New York

FSH 402 Course title: Oceanography and Marine Biology Credit: 3 Credit hours: 45

Introduction to the Course:

This course is designed to deliver basic knowledge of oceanography and marine biology to students. This course enables the students to have basic knowledge about ocean and oceanic environment and its resources in all aspects- physical, chemical and biological. For fisheries, ocean and marine environment is very important because ocean is the main source of aquatic resources in the world. For the sustainable utilization the understanding of ocean and oceanic environment is essential. Moreover, in the context of blue economy concept the knowledge about marine organisms and their ecological understanding is obvious for the fisheries students. This course helps the students to get preliminary knowledge about oceanography and marine ecology which in future help them to be qualified for further oceanographic study and research and contribute to the fisheries sector for sustainable utilization of marine resources and also in policy making for the oceanographic decisions.

Specific Objectives:

i. To get understand the basic concepts and definitions of oceanography;
ii. To get understand the topography and topographical structures of oceanic environment;
iii. To study the physical-chemical properties of ocean water;
iv. To get understand the important physical and chemical mixing process of ocean;
v. To get understand the ecological and biogeochemical cycles of the marine environment;
vi. To gain knowledge on the major ecological groups of marine organisms and their interactions;

vii. To get understand the adaptability of marine organisms; and
viii. To get acquire knowledge on the important features of Bay of Bengal, its topography and fishery.

Course Contents:

Theoretical

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:

7. **The sea as a biological environment:** Zonation of the marine environment; primary productivity, determination of primary production, factors influencing phytoplankton production
8. **Biogeochemical cycle in the ocean**: carbon cycle, nitrogen cycle, phosphorus cycle, Silica cycle, food wave and food chain
9. **Major marine ecological groups**–zooplankton, phytoplankton, benthos, nekton and macrophytes, characteristics, their relationships with the physicochemical properties of the sea
10. **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
11. **Bay of Bengal:** Origin and history of basin development, topography, hydrological and physical characteristics, St. Martin Islands, major fishery, fishing grounds

Unit-wise learning outcomes:

At the end of the course students will be able to-

Oceanography

i. Define ocean and oceanography;
ii. Understand the scope of oceanography;
iii. Understand the ocean topography and various topographical structures along with their formation and development;

iv. Understand the process of marine sedimentation and distribution;
v. Understand the distribution and influencing factors regarding the physical properties of ocean water;
vi. Estimate the chemical properties of sea water;
vii. Evaluate the role of nutrient in terms of marine production; and
viii. Understand the mixing processes of the ocean.

Marine Biology

i. Define marine biology;
ii. Understand the ecology and zonation of marine environment;
iii. Determine the primary productivity of the ocean;
iv. Understand the influence of different factors of primary production and phytoplankton production;
v. Understand the carbon, nitrogen, phosphorus and silica cycles in marine environment;
vi. Gain knowledge about major ecological groups- phytoplankton, zooplankton, benthos, nekton, macrophytes; know their characteristics, interrelationships, and adjustment with ocean water properties;
vii. Understand the morphological and physiological adaptation of major groups of organisms- invertebrates, fish, birds, mammals, macrophytes in relation to physico-chemical properties of ocean water; and
viii. Know the origin and history of Bay of Bengal development, topography, hydrological and physical characteristics, St. Martin Island, major fishing grounds of BOB, fishery, EEZ.

Unit-wise title and sub-title and number of classes per unit:

Chapter	Title	Sub-title	No. of classes
1	**Introduction**	Definition, Scope and History of ocean and oceanography	**1**
		Classification of oceanography, Origin of earth and ocean	**1**
		Theories of ocean development	**1**
2	**Ocean topography**	Continental shelf, slope, rise and abyssal plain	**1**
		Different topographical structures of ocean	
3	**Marine sediments**	Sediments texture	**1**
		Developments of sediments	**1**
		Types of sediments	
		Sedimentary deposits	**1**
4	**Physical properties of sea water**	Salinity	**1**
		Conductivity	**1**
		Temperature	**1**
		Density	**1**
		Light	**1**
5	**Chemistry of**	Constancy of composition	**1**

	sea water	Dissolved gases and their distribution	**1**
		Nutrients in marine water, Nutrients cycling	**1**
		Factors influencing nutrients distribution	**1**
		Role of nutrients in marine productivity	**1**
6	**Mixing processes in the ocean**	Waves: properties, types, causes	**1**
		Tsunami: causes and effects	**1**
		Tides: types, causes, tide producing forces, theories of tide formation	**1**
		Currents: types, causes, major ocean currents in the world	**1**
		Eddy diffusion	
		Upwelling	**1**
		Horizontal and vertical ocean circulation	**1**
		Role of mixing in ocean productivity	**1**
		El Nino	**1**
		La Nina ENSO	**1**
7	**The sea as a biological environment**	Zonation	**1**
		Primary productivity	**1**
		Determination of primary productivity	**1**
		Factors influencing phytoplankton production	**1**
8	**Biogeochemical cycle in the ocean**	Carbon cycle	**1**
		Nitrogen cycle	**1**
		Phosphorus cycle	
		Silica cycle	**1**
9	**Major marine ecological groups**	Phytoplankton	**1**
		Zooplankton	**1**
		Benthos	**1**
		Nekton	**1**
		Macrophytes	**1**
10	**Adaptation of marine organisms**	Morphological and physiological adaptation of marine fish	**1**
		Mammals	**1**
		Invertebrates	**1**
		Macrophytic halophytes	**1**
11	**Bay of Bengal**	Origin and history of basin development	
		Topography, Hydrological and physical characteristics	**1**
		St Martin island, Major fishery	**1**
		Total	**45**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

Practical: In course and final
Oral test: Final

References:

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.

FSH 403 Course title: Fish Breeding and Hatchery Management Credit: 3 Credit hours: 45

Introduction to the Course:

The purpose of this course is to give insight on the breeding and hatchery management related to fish and fisheries. This course will not only give background information but also principles and concepts underpinning genome technologies. Students will be able to get knowledge on classical genetics such as Mendelian genetics and its applications on fisheries. Seed is the first input in aquaculture and culture-based fisheries. Quality of fish seed is a prerequisite for successful fish production. Therefore, this course is designed to provide clear understanding of fish reproductive biology, genetics and breeding techniques in the second section, while hatchery management and larval rearing has been included in third section.

Specific objectives:

i. To get understand fish breeding and principles of hatchery management;
ii. To get acquainted with the different aspects of gynogenesis, androgenesis, polyploidy and triploidy;
iii. To get understand the dominance effects in Inbreeding, crossbreeding and hybridization;
iv. To get understand fish reproductive biology, genetic basis of sex determination in fish; and
v. To get acquainted with fish hatchery design and operation, management of brood stock and different life history stages of fish and shellfish.

Course Contents

Section A: Fish Breeding

1. **Reproduction in fishes**: fish reproductive cycle, control of reproduction, maturation of the gonads
2. **Selection:** Objectives of Fish Selection, Methods of Fish Selection: natural selection, artificial selection; directional, stabilizing, disruptive selection, individual or mass selection, selection based on relatives: pedigree data, progeny testing, family selection; Genetic marker and Marker-Assisted Selection (MAS), Gene assisted selection (GAS)
3. **Inbreeding**: Genetic relationships, inbreeding, effective population size, effect of inbreeding on genetic variance, inbreeding depression.

4. **Cross breeding**: Introduction, Heterosis, interspecies and intraspecies hybridization
5. **Initiating breeding programs**: Basis of a breeding program, Establishment of a base population, Breeding goal, Registration of records.

Section B: Hatchery Management

6. **Fish hatchery**: Definition, types, essential components of a hatchery, structural features of brood and other fish ponds, placement of different ponds in a hatchery.
7. **Design and construction of a model carp and shrimp hatchery**: 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.
8. **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.
9. **Spawning and egg handling**: Natural and artificial spawning methods, Stages of maturity of adult carps, prawn and shrimps, determining readiness for spawning, control of spawning time, egg incubation: Types of incubators, factors affecting egg development, hatching success and fry survival.
10. **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.

Unit-wise Learning Outcomes

At the end of this course the student will be able to -

i. Understand the structure and other important aspects chromosomal genetics.
ii. Understand the key theories and principles regarding gynogenesis, androgenesis, polyploidy and triploidy.
iii. Analyze the relations between genetic effects and genetic variations.
iv. Understand the inheritance of qualitative and quantitative traits of fish.
v. SUnderstand selection methods for breeding fish and applications of QTL, MAS, GAS.
vi. Understand reproductive biology of fish.
vii. Develop skill in construct, design and managing fish and shrimp hatchery.
viii. Demonstrate different breeding techniques of commercially important fish.

Unit-wise title and subtitle and number of classes per unit:

Chapter	**Title**	**Sub-title**	**No. of classes**
Part A	**Fish Breeding**		
1	**Reproduction in fishes**	Fish reproductive cycle, control of reproduction, maturation of the gonads	**3**
2	**Selection**	Objectives of Fish Selection, Methods of Fish Selection: natural selection, artificial selection; Types of selection:	**2** **2**

		directional, stabilizing, disruptive selection, individual or mass selection, selection based on relatives: pedigree data, progeny testing, family selection; Genetic marker and Marker-Assisted Selection (MAS), Gene assisted selection (GAS)	**3**
3	**Inbreeding**	Genetic relationships, inbreeding, effective population size, effect of inbreeding on genetic variance, inbreeding depression.	**3**
4	**Cross breeding**	Heterosis, interspecies and intraspecies hybridization	**2**
5	**Initiating breeding programs**	Basis of a breeding program, Establishment of a base population, Breeding goal, Registration of records in fish breeding program.	**3**
Part B	**Hatchery Management**		
6	**Fish Hatchery**	Definition, types, essential components of a hatchery, structural features of brood and other fish ponds, placement of different ponds in a hatchery.	**1** **1** **2**
7	**Design and construction of a model carp and shrimp hatchery**	Site selection for hatchery construction, estimation of brood fish requirement, and calculation of area required for brood fish rearing tank	**3**
		Calculation of area required for nursery tank, estimation of water requirement, packing and marketing unit, operation of the hatchery.	**2**
8	**Brood stock management**	Brood stock management and seed quality- General considerations, Sperm Physiology and quality; egg quality	**2**
		Preservation of gametes, biotechnical approaches to brood stock management.	**2**
9	**Spawning and egg handling**	Natural and artificial spawning methods, Stages of maturity of adult carps, prawn and shrimps, determining readiness for spawning, control of spawning time, egg incubation: Types of incubators, factors affecting egg development, hatching success and fry survival.	**2** **2** **1** **2**
10	**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	**1** **1** **1**

		advanced fry and fingerlings in nursery, food selectivity, food preference and feeding success, feeding frequency, feed particle size and feeding methods, rearing pond management.	**1** **2** **1**
		Total	**45**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References:

1) Liu, Zhanjiang. 2007. Aquaculture genome technologies. Blackwell Publishing Ltd. Oxford.
2) Clark, David P. Molecular biology. 2010. Academic Press. London.
3) Gomelsky, Boris. Fish Genetics: Theory and Practice. 2011. VDM Verlag Dr. Muller GmbH & Co. KG, Germany
4) Tave, Douglas. Genetics for Fish Hatchery Manager. 1993. Springer US

FSH 404 Course title: Fish Processing and Preservation Credit: 3 Credit hours: 45

Introduction of the Course:

Fish processing and preservation is one of the most vital courses in fisheries science. This course is designed to acquire scientific knowledge in fin fish and shellfish processing and preservation so that post-harvest loss of fish and fisheries products could be reduced. Students will learn the general principles, post-mortem changes, nature of spoilage and some important methods of finfish and shellfish processing and preservation.

Specific objectives:

i. To get understand the importance and necessity of fish processing and preservation;
ii. To get understand the problems of post-harvest losses and their management and technological measures;
iii. To get acquainted with methods of finfish and shellfish processing and preservation; and
iv. To get develop skills on maintaining the quality of fisheries products and byproducts.

Course content

Theoretical

1. **Introduction of fish processing and preservation:** General principles of food preservation with special emphasis of fin fish and shellfish; 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 equipment; 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

Unit- Wise learning outcomes:

At the end of the course students will be able to:

i. Define fish preservation and processing;
ii. Get an insight the importance and necessity of fish processing and preservation;
iii. Understand the problems of post-harvest losses and their management and technological measures;
iv. Identify suitable methods of fin fish and shellfish processing and preservation;
v. Evaluate quality of products and byproducts quality;
vi. Examine the postmortem changes in preserved fish and fish products; and
vii. Design appropriate storage system.

Unit-wise title and sub-title and number of classes per unit:

Chapter	Title	Sub-title	No. of classes
1	**Introduction of fish processing and preservation**	General principles of food preservation with special emphasis of fin fish and shellfish	**2**
		Physical structure of fish and shellfish	**1**

		Chemical composition of fish and its application in fish preservation	**2**
2	**Post-mortem changes in fish and the nature of spoilage**	Biochemical changes in fish during rigor mortis	**1**
		Glycolysis; Hydrolytic changes; Changes in fat	**1**
		Role of protease and bacteria on the spoilage of fish	**2**
		Spoilage Indices	**1**
		Freshness test of fish: organoleptic, bacteriological and chemical test	**1**
3	**Chilling of fish**	Preservation effect and changes in fish during chilling with ice	**1**
		Other methods of chilling	**1**
		Factors affecting the quality	**1**
4	**Fish freezing**	Principles of refrigeration, freezing curve; freezing rate	**1**
		Freezing methods and equipment	**1**
		Cold store design	**1**
		Changes associated with freezing and cold storage of fish	**1**
		Packaging requirements for frozen fish	**1**
5	**Drying and dehydration of fish**	Methods and processing technology	**1**
		Drying of salt treated fish	**1**
		Freeze-drying	**1**
		Quality aspect of dried fish and shrimps	**1**
6	**Smoking of fish**	Preservative effect and changes during smoking	**1**
		Quality aspects of smoked fish.	**1**
7	**Salting of fish**	Types, technological aspects of salting	**1**
		Process and characteristic features of salting,	**1**
		Effect of salt quality on the shelf life of salted fish	**1**
8	**Fish Canning**	Definition, history, Principles, advantages	**1**
		Outline of canning operation	**1**
		Types and availability of can materials	**1**
		Influence of canning on the quality of foods	**1**
		Problems associated with canned fishery products	**1**
9	**Fermented fish products**	Fish sauce	**1**
		Fish paste	**1**
		Fish pickle, marinades	**1**
10	**Irradiation of fish**	Sources of radiation, food irradiation process	**1**
		Effect of radiation on fish and fish products	**1**
		Toxicological aspects of food irradiation	**1**
11	**Packaging**	Function of packaging, package selection packaging materials	**1**
		Packaging regulations, future of packaging.	**1**
		Modified atmosphere packaging	**1**
12	**Fishery byproducts**	Food by-products	**1**
		Non-food by products	**1**

		Fish meal	**1**
		Total	**45**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References:

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

FSH-405 Course title: Aquaculture Engineering Credit: 3 Credit hours: 45

Introduction to the course:

This course is designed for the students in Fisheries and Aquaculture. The course will provide knowledge on aquaculture engineering. This course will develop valuable skill to the students in order to enhance their hands-on engineering of fish farm. Topics to be covered include; Hydrological information for design and operation of aquaculture systems, soil engineering for designs of ponds, canals and dams, design and construction of fish farms, hydraulic formulas used in designing fish farms, maintenance of aquafarms, pond construction engineering, design and construction of fish cages, tanks, and other impounding structures, classification and design of different types of water pumps, types of aeration and filtration devices, their design and construction, waste management techniques in aquaculture production, biofiltration system, type of aerators, degassing etc., water Recirculating systems.

Specific objectives:

i. To get acquainted with designing aquaculture systems;
ii. To get acquainted with designing water pumps for different aquaculture systems;
iii. To get enabled to design and construct fish cages, tanks and other fish enclosure structures;

iv. To get develop skills on to design aerators, filters and water recirculatory systems for aquaculture; and
v. To get know the methods of waste management in aquaculture production systems.

Course contents

Theoretical

1. **Introduction:** Definition, 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.

Unit-wise learning outcomes

At the end of the course, the student will be able to-

i. Define aquaculture engineering;
ii. Understand and design fish farms and mechanical, gravitational, biological and chemical filter, centrifugal, reciprocating, rotary and airlift pumps and different types of aerator;
iii. Evaluate different aquaculture farm design and their constructions; and
iv. Know the functions of water pumps, aerators and filters in aquaculture systems.

Unit wise title and subtitle, learning outcomes and number of classes per unit

Chapter	Title	Sub-title	No. of classes
1	**Introduction**	Importance, working fields of aquaculture engineering.	**1**
		Criteria for site selection-ecological, biological, chemical and social criteria	**1**
		Mechanical, structural, hydrological,	**2**

		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** **4**
3	**Water**	Source of water supply, qualities of water for fresh water and brackish water ponds and hatcheries.	**4**
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	**2** **2** **2**
5	**Cages and Pens**	Types of cage, engineering considerations in cage and pen design.	**4**
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).	**2** **2**
7	**Pumps and the measurement of flow**	Classification of pumps and flow measurement, centrifugal, reciprocating, and rotary and airlift pumps. Measuring discharges from open pipes and channels.	**3** **1**
8	**Aeration**	Principles of aeration, theory of gas transfer, aerator system requirements Mechanism of different types of aerator use in aquaculture.	**3** **1**
9	**Maintenance of aqua-farm and hatchery**	Economic aspects of aquaculture planning, aquafarm construction and maintenance.	**4**
		Total	**45**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

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

FSH 406 Course title: Fish Feed Management Credit: 2 Credit hours: 30

Introduction to the course:
Feed is the single most important aspect of aquaculture. Knowledge on fish feed management is, therefore, necessary for a fisheries graduate to achieve the higher aquaculture production. However, this course has been designed to exchange and disseminate information, ideas, practical experience and proper knowledge on all aspects relating to the fish feed management. Fish feeds make up the highest expenditure for fish farmers. Use of proper feeds and its management can play an important role in reducing the overall cost of fish production, ensuring good culture environment and ensuring good health in the farmed fish. There are various considerations that need to be taken into account to ensure good fish feed management which include selection for the right feed and feeding method, feed handling and storage, selecting the right time according to the weather condition when to feed the fish, proper calculation of the feeding cost and ensuring cost effective feeding. Furthermore, performance measures should be considered.

Specific objectives:
i. To get understand the status, trends and importance of aqua feeds;
ii. To get understand the impact of rising feed cost and environmental impact on aquaculture;
iii. To get understand the effect of temperature, oxygen and other environmental factors on fish growth;
iv. To get understand the dietary requirements, types of fish feed, feed processing and manufacture;
v. To get develop skill on feeding technique, feed handling and storage methods; and
vi. To get know the methods to estimate the growth performance of fish and shrimp.

Course contents
Theoretical
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:** different feed ingredients, Criteria for the selection of ingredients for feed preparation, Nutrient analysis; Measurement of energy value; methods of feed formulation: best buy method, least cost method, linear programming in

feed formulation, Factors influencing feed formulation; Strategies for minimizing cost 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. **Feed Quality control**: Quality control in fish feed manufacturing industry
6. **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.
7. **Feed handling and storage:** Optimum conditions for feed storage and prevention of spoilage from rancidity; Fungus formation and associated toxins.
8. **Performance measures**: Food conversion; Growth prediction; Growth pattern; Diet and flesh quality.
9. **Good aquaculture feed manufacturing and feed and feeding management in fish and shrimp culture.**

Unit-wise learning outcomes:

At the end of the course, the student will be able to-

i. Define fish feed management;
ii. Understand the environmental consequences of aqua feeds;
iii. Achieve knowledge on feeding behavior, effect of temperature, oxygen other environmental factors on fish growth;
iv. Understand the dietary requirements for fish;
v. Understand different feed ingredients;
vi. Understand proper feeding technique;
vii. Determine growth performance of fish and shellfish; and
viii. Reduce production cost by better management.

Unit wise title and subtitle and number of classes per unit

Chapter	Title	Sub-title	No. of classes
1	**Introduction**	Status, trends and importance of aqua feeds in global aquaculture	**1**
		Types and composition of aqua feeds	**1**
		Impact of rising feed cost in aquaculture	**1**
		Aquaculture feed and the environment	**1**
2	**Feeding, temperature and water quality**	Feeding behavior	**1**
		Feeding and metabolic rate	**2**
		Effect of temperature and Oxygen depletion	**1**
		Waste control	**1**
3	**Types of feed**	Pellets, flakes, powdered; Micro-particulate diets	**1**
		Micro-encapsulated diets, micro-coated diets, micro-bound diets and nano-diets	**1**

4	**Feed processing and manufacture**	Different feed ingredients, criteria for the selection of ingredients for feed preparation, Nutrient analysis; Measurement of energy value; methods of feed formulation: best buy method, least cost method, linear programming in feed formulation	**1** **1** **1**
		Factors influencing feed formulation; Strategies for minimizing utilization of fish meal and oil in diets	**1**
		Feed manufacturing units and processes; Pulverizer, grinder, mixer, pelletizer, crumbler, drier, extruder/ expander, Vacuum coater, Fat spryer; Gelatinization, Extrusion technology	**2**
		Pellet dressing with heat labile nutrients; Effects of processing on the nutritional quality of feed; Feed quality assessment.	**2**
5	**Feed quality control**	Quality control in fish feed manufacturing industry	**1**
6	**Feeding technique**	Feeding devices; Feeding rate; Feeding frequency; Feeding period; Restricted and compensatory feeding	**2**
		Feed rations and schedules; Ration size; Rations and growth; Growth-ration curve	**1**
7	**Feed handling and storage**	Optimum conditions for feed storage and prevention of spoilage from rancidity	**2**
		Fungus formation and associated toxins	**1**
8	**Performance measures**	Food conversion; Growth prediction	**1**
		Growth pattern; Diet and flesh quality	**1**
9	**Good aquaculture feed manufacturing and feed and feeding management in fish and shrimp culture.**		**2**
		Total	**30**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. One in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

1. Goddars, S. 1996: Feed Management in Intensive Aquaculture. Chapman and Hall, New York.
2. Guillaume, J., Kaushik, S., Bmgot, P. and Metailler, R. 2001. Nutrition and Feeding of Fish and Crustaceans. Spinger – Praxis Publishing, UK.

3. Halver J. E and Hardy R. W (Editor) 2002. Fish Nutrition, Third Edition, Academic Press. USA.
4. Lovell, T. 1989. Nutrition and Feeding of Fish. Van Nostrand Rainhod, New York.
5. Tacon, A.G.J. 1990: Standard Methods for the Nutrition and Feeding of Farmed Fish and Shrimp. Argent Laboratories Press. Washington.
6. Training manual on good aquaculture practice. 2012. DoF

FSH 407 Course title: Fisheries Marketing Credit: 2 Credit hours: 30

Introduction to the Course:
Fisheries Marketing is a course that will introduce the students to the Marketing aspect of Fisheries and Aquaculture. As a student of fisheries needs to have clear knowledge about marketing of fish in rural, urban and also in international market, marketing chain and supply chain management. As fish is a perishable product so the course gives emphasis on the demand and supply of different fishes. Along with this it also gives importance on consumer behavior and also the role of advertisement in both national and international markets.

Specific Objectives:
i. To get understand fisheries marketing;
ii. To get understand economic constraints in fisheries development, free access to fisheries, sustainable yield curve and total revenue curve, bioeconomic equilibrium, factor rents, welfare economic theory and its relevance for fisheries externalities; and
iii. To get acquainted skills on fish market survey through questionnaire.

Course contents:
Theoretical
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.

Unit-wise learning outcomes:

At the end of this course the student will be able to-

1. Define fisheries marketing;
2. Identify marketing principles, marketing concept;
3. Describe market infrastructure and facilities in rural and urban area;
4. List of types of retail and wholesale market;
5. Explain objectives, strategy, evaluating effectiveness of advertisement;
6. Explain lifecycle and marketing strategies of new product;
7. Analyze value chain to gain profitability using swat analysis; and
8. Conduct market survey.

Unit-wise title and sub-title and number of classes per unit

Chapter	Title	Sub-title	No. of classes
1	**Introduction**	Marketing principles and process. Aquaculture and Fisheries Marketing concepts. Concept of product, service and brand.	**1** **2** **1**
2	**Market infrastructure and facilities**	Types of Markets in urban and rural areas. Marketing channels and supply chain management: Types of channels, channel management	**1** **2**
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.	**2** **1** **1**
4	**Retailing and whole selling**	Types of retailing and wholesaling marketing decision, current trends, Advertising: Objectives, strategy, evaluating effectiveness. Sales promotion: Objectives, tools and development of the program, New product marketing strategies.	**3** **2**
5	**Consumer behavior**	Factors affecting behavior, types of behavior and buyer decision process.	**3**
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.	**3**

		Enterprise Variations and Logistics analysis.	
7	**Credits analysis**	3'R' of the Credits, Principles of aquaculture insurance, institutions involved in aquaculture financing.	**3**
8	**Policies, Regulation, Strategies and Research**	Policies and regulation regarding fisheries marketing in Bangladesh Fish marketing strategies of Government organizations Fish marketing strategies of private organizations Fish marketing strategies of Non-Government organizations International Seafood trade legislation, Marketing research planning and methodologies	**1** **1** **1** **1** **1**
		Total	**30**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. One in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

1. Chaston, I. 1983. Marketing in fisheries and Aquaculture. Fishing News Books, UK. (Ctlg No: SL-1081)
2. Engle, Carole Ruth, 2006. Aquaculture marketing handbook. Blackwell Publishing Ltd. UK. (Ctlg No: SL-1613, Science library-664.940688 ENA)
3. Kotlar, P and Armstrong, G. 2007. Principles of Marketing. Prentice Hall, NewYork.
4. The handling, processing and marketing of fish in Bangladesh.

FSH 408 Course title: Aquatic Biodiversity and Conservation Credit: 2 Credit hours: 30

Introduction to the course:

This course will provide students an understanding of aquatic biodiversity and importance of its conservation. They will also learn how aquatic biodiversity is threatened and what can be done to protect it.

Specific objectives:

i. To get understand the major issues in aquatic biodiversity and its conservation;

ii. To get understand how biodiversity is measured and what are the major patterns of diversity;
iii. To get understand the structural and functional biodiversity and their relationship; and
iv. To get acquainted with the issue concerning conservation of aquatic biodiversity.

Course contents:

Theoretical

1. **Biodiversity basics:** Concepts, types, levels, importance, issues and conservation needs. Objectives and strategies for biodiversity conservation. Species diversity, Biological and phylogenetic species concept. Basic concepts of speciation, species extinction. Concept of genetic diversity, gene and germ-plasm banks.
2. **Current status of aquatic biodiversity and ecosystem:** Inland (ponds, oxbow lakes, depression, rivers, streams, lakes, floodplain, hill stream etc.), Estuarine, Mangroves, Coral reefs and Marine: Fishes, Mollusca, Crustacean, Birds, Reptiles and Mammals.
3. **Bangladesh biodiversity hotspots:** The Sundarbans reserve forest, Tanguar haor, Chalan beel, Halda river, Swatch-of-no-Ground, Nijhum Dwip and Saint Martin‘s Island ecosystem and biodiversity.
4. **Threats to aquatic biodiversity and ecosystem:** Land use change, siltation, overfishing, destructive fishing, pollution, climate change, dams (both national and trans-boundary), exotic species, tourism, socio-economic issues, lack of governance etc.
5. **Biodiversity assays:** Methods of biodiversity assessment. Criteria for good biodiversity indicators. Various species diversity indices, calculations and interpretations.
6. **Biodiversity related conventions and legislations:** International efforts to conserve biodiversity (CBD and Aichi Biodiversity Targets, CITES, CMS, Ramsar Convention, International Whaling Commission etc.). Biodiversity legislation, treaties and convention in Bangladesh (e.g. National Biodiversity Strategy and Action Plan, Bangladesh Wildlife (Preservation) Act, Wildlife (Conservation and Security) Act, Bangladesh Environment Conservation Act and Rules, National Environment Management Action Plan (NEMAP) etc.)
7. **Protection and conservation of biodiversity:** Principles of conservation biology, *Ex situ* and *In situ* methods of conservation, Traditional knowledge and biodiversity conservation.
8. **Approaches for conservation of biological diversity:** Concept of threatened species. Concepts of protected areas. Ecological critical area and coastal and marine protected areas, Wild life sanctuaries. SDGs and biodiversity. Threatened and endangered aquatic species of Bangladesh. IUCN red listing. Application of Nature-based solution, Ecosystem Approaches to Fisheries Management, Ecosystem-based Adaptation for aquatic biodiversity conservation.

Unit-wise learning outcomes:

At the end of the course, the student will be able to-

i. Define aquatic biodiversity and conservation;
ii. Know how aquatic biodiversity is measured and over different scales;
iii. Be familiar with the major patterns of aquatic biodiversity;
iv. Understand the factors which control patterns of aquatic biodiversity such as geological and evolutionary history;

v. Understand the difference between species-accumulation and species area relationships;
vi. Understand key conservation issues for aquatic biodiversity; and
vii. Increase presentation and scientific debating skills related to issues concerning aquatic biodiversity and conservation.

Unit wise title and subtitle and number of classes per unit

Chapter	Title	Sub-title	No. of classes
1	**Biodiversity basics**	Concepts, types, levels, importance, issues and conservation needs. Objectives and strategies for biodiversity conservation.	**2**
		Species diversity, Biological and phylogenetic species concept. Basic concepts of speciation, species extinction. Concept of genetic diversity, gene and germ-plasm banks.	**2**
2	**Current status of aquatic biodiversity and ecosystem**	Inland (ponds, oxbow lakes, depression, rivers, streams, lakes, floodplain, hill stream etc.), Estuarine, Mangroves, Coral reefs and Marine: Fishes, Mollusca, Crustacean, Birds, Reptiles and Mammals.	**3**
3	**Bangladesh biodiversity hotspots**	Tanguar haor, Chalan beel, Halda river, The Sundarbans reserve forest ecosystem and biodiversity.	**2**
		Swatch-of-no-Ground, Nijhum Dwip and Saint Martin‘s Island ecosystem and biodiversity.	**2**
4	**Threats to aquatic biodiversity and ecosystem**	Land use change, siltation, overfishing, destructive fishing, pollution, climate change, dams (both national and trans-boundary), exotic species, tourism, socio-economic issues, lack of governance etc.	**2**
5	**Biodiversity assays**	Methods of biodiversity assessment. Criteria for good biodiversity indicators. Various species diversity indices, calculations and interpretations.	**3**
6	**Biodiversity related conventions and legislations**	International efforts to conserve biodiversity (CBD and Aichi Biodiversity Targets, CITES, CMS, Ramsar Convention, International Whaling Commission etc.).	**2**
		Biodiversity legislation, treaties and convention in Bangladesh (e.g. National Biodiversity Strategy and Action Plan, Bangladesh Wildlife (Preservation) Act, Wildlife (Conservation and Security) Act, Bangladesh Environment Conservation Act and Rules, National Environment Management Action Plan (NEMAP) etc.)	**2**

7	**Protection and conservation of biodiversity**	Principles of conservation biology, *Ex situ* and *In situ* methods of conservation.	**2**
		Traditional knowledge and biodiversity conservation.	**1**
8	**Approaches for conservation of biological diversity**	Concept of threatened species. Concepts of protected areas. Ecological critical area and coastal and marine protected areas, Wild life sanctuaries.	**2**
		SDGs and biodiversity.	**1**
		Threatened and endangered aquatic species of Bangladesh. IUCN red listing.	**2**
		Application of Nature-based solution, Ecosystem Approaches to Fisheries Management, Ecosystem-based Adaptation for aquatic biodiversity conservation.	**2**
		Total	**30**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

1. Ameen, M. 1987. Fisheries Resources and Opportunities in Freshwater Fish Culture in Bangladesh., Zoological Society of Bangladesh, Dhaka, 244 pp.
2. Anne Elizabeth Maczulak 2020. Biodiversity: Conserving Endangered Species
3. Biodiversity Conservation and Habitat Management (Vols. 1-2) Editors: Francesca Gherardi, Claudia Corti, and Manuela Gualtieri, eISBN: 978-1-905839-20-9, 978-1-905839-21-6 ISBN: 978-1-84826-920-0, 978-1-84826-921-7
4. Biodiversity: Structure and Function (Vols. 1-2). Editors: Wilhelm Barthlott, Rheinische Friedrich-WilhelmsK. Eduard Linsenmair, Stefan Porembski, eISBN: 978-1-905839-34-6, 978-1-905839-35-3 ISBN: 978-1-84826-934-7, 978-1-84826-935-4
5. IUCN 2015. Red Data Book
6. Karim, M. 1978. Status and Potential of Bangladesh Fisheries, Ministry of Fisheries and Livestock, Govt. of Bangladesh, Dhaka, 125 pp.
7. Khan, M.G. and M. A. Latif. 1995. Potential, constrains and strategies for conservation and management of open water, brackish water and marine fisheries resources. Proc. Nat. Sem. on Fish. Res. & Dev. & Mang. DOF, FAO, ODA. Dhaka.
8. King, M., 1995. Fisheries Biology, assessment and management. Fishing news Books, UK.
9. MacClaurin J and Sterelny 2008. What is Biodiversity?National Academy Press. 1988.

10. Primack, R.B. 1998. Essentials of Conservation Biology, 2nd edition, Sinauer Associates Inc., Boston, USA, 659 pp.
11. Rounsefell, G.A. and Everhart, W.H., 1953. Fishery Science, its methods and applications, John Willey and Sons, New York, USA. 444 pp.

FSH 409 Course title: Fish Pharmacology Credit: 3 Credit hours: 45

Introduction to the Course:

Disease is one of the most important risk factors with serious consequences for the aquaculture sector in Bangladesh. Disease prevention and mitigation, therefore, is a matter of utmost importance for Bangladesh. In this specific context, the need for professionals who are well informed about aquatic pharmacology is of vital importance for the continued development of aquaculture sector. This course is so designed to provide the students with knowledge on aquatic pharmacology which is needed to enable professionals to deal with disease and pharmaceutical substances. During lecture sessions, students will be introduced to different groups of drugs and their pharmacokinetics, pharmacodynamics properties and usage. During lab sessions, students will gain 'hands-on', practical knowledge to identify dose-response of various drugs against specific fish and shrimp pathogens.

Course Objectives:

i. To get familiar with various kinds of therapeutic drugs, medicine, chemicals used in aquaculture;
ii. To get understand pharmacology of aquatic medicine, pharmacokinetics and pharmacodynamics properties of various drugs;
iii. To get introduced with law and regulations of drug use, safety issues, adverse effects, impacts of drugs on non-target organisms, environment and the development of anti-microbial resistance (AMR); and
iv. To get acquainted with skills on laboratory and field level techniques of drug use to combat diseases.

Course Contents

Theoretical

1. **Introduction:** Scope, history and importance of pharmacology in aquaculture; pharmacological terms and definitions, dose, dosage, bioequivalent; selection criteria of appropriate drugs, sources of drugs, aqua-drug companies and trade, and generic names of major aqua-drugs, classification of aqua drugs,
2. **Pharmacokinetics:** Principles of drug activities, absorption, distribution, metabolism (biotransformation) and elimination of drugs, bioavailability of drugs
3. **Pharmacodynamics:** Concept of drug-receptor, dose-response relationship, half-life and withdrawal period, Maximum Residue Limit (MRL), factors affecting drug effect and dosage; molecular mechanisms of drug action, drug resistance, pharmacogenetics
4. **Methods of drugs administration:** Various routes- water, in-feed medication, gavage, injection and topical application; considerations in selecting specific routes, advantages and disadvantages of various methods; drug administration against bacterial, viral, fungal and parasitic diseases
5. **Anti-pathogenic/Chemotherapeutic agents:** Antibacterial, antiviral, antifungal,

antiparasitic agents; major groups of antibiotics, their uses, abuses, mode of actions, factors influencing the clinical use of antibiotics, pharmacokinetics of major drugs used in aquaculture; antiseptic and disinfectant

6. **Anesthetics:** Introduction, basic principles and application, anesthetic agents and desirable features, mode of actions and pharmacokinetics; methods and guidelines for euthanasia in aquatic organisms, stages of anesthesia and recovery; hypnotics and sedatives
7. **Drugs used in hatchery operations**: Drugs used in finfish, shrimp, prawn, crab hatcheries; breeding inducing agents, sex control agents, dose and dosage, mechanisms of action, withdrawal periods; chemicals used to maintain biosecurity in hatcheries
8. **Preventive medicine/ Health beneficiary products/ Prophylaxis products:** Pre- and Pro-biotics, immunostimulants, herbal medicines; vaccines and adjuvants (types, development, production, mechanism of action, administration, potency/ efficacy, marketing), commercially available vaccines; antimicrobial peptides and their potential use as therapeutics in aquaculture
9. **Safety of aquatic medicine**: Food safety regulations, toxic effects (toxicology), anti-microbial resistance (AMR) issues- safety and welfare aspects of target species, operator, consumer and environment; immunosuppressive drugs; drug control acts, regulations and legislations in Bangladesh, and international standards for compliance; list of approved and prohibited aqua-drugs/medicines, guidelines for the control of aquaculture medicinal products (AMPs), drug control and certification authorities
10. **Prescription writing**: Principles, types and parts of an ideal prescription, rational use of drugs, rational and irrational prescribing, drug incompatibilities and adverse effects (reactions and interactions), drug abuse

Unit-wise learning outcomes:

At the end of the course, students will be able to-

i. Explain the basic concepts of fish pharmacology;
ii. Apply various methods of drugs administration processes for disease control in the aquatic environment;
iii. Describe the process by which a drug is absorbed, distributed, metabolized and eliminated by the body;
iv. Describe the interactions of a drug and the receptors responsible for its action in the body;
v. Compare various anti-microbial agents those are useful to protect from diseases; choose and ensure approved drugs and recognize illegal aqua drugs with their consequences;
vi. Describe the use of various preventive medicines and health beneficiary products to aquatic organisms;
vii. Implement different acts, rules, legislations, national and international laws regarding the safe use of aqua drugs and chemicals; and
viii. Write the prescription for various diseases of aquatic organisms suggesting specific drugs and chemicals.

Unit-wise title and sub-title and number of classes per unit

Chapter	Title	Sub-title	No. of classes

1	**Introduction**	Scope, history and importance of pharmacology in aquaculture	**1**
		pharmacological terms and definitions, dose, dosage, bioequivalent	**1**
		selection criteria of appropriate drugs, sources of drugs	**1**
		aqua-drug companies and trade, and generic names of major aqua-drugs, classification of aqua drugs	**1**
2	**Pharmacokinetics**	Principles of drug activities	**1**
		Drug absorption,	**1**
		Drug distribution	**1**
		Drug metabolism (biotransformation)	**1**
		Elimination of drugs, bioavailability of drugs	**1**
3	**Pharmacodynamics**	Drug-receptor interaction Molecular mechanisms of drug action dose-response relationship, half-life and withdrawal period, Maximum Residue Limit (MRL), factors affecting drug effect and dosage. pharmacogenetics	**1** **1** **1** **1**
4	**Methods of drugs administration**	Various routes- water, in-feed medication, gavage, injection and topical application; considerations in selecting specific routes, advantages and disadvantages of various methods; drug administration against bacterial, viral, fungal and parasitic diseases	**2**
5	**Anti-pathogenic/ Chemotherapeutic agents**	Antibacterial agents: Use, mode of action, safety aspects and pharmacokinetics	**3**
		Antiviral agents	**2**
		Antifungal agents: Use, mode of action, safety aspects and pharmacokinetics	**2**
		Antiparasitic agents: Use, mode of action, safety aspects and pharmacokinetics	**2**
		factors influencing the clinical use of antibiotics; antiseptic and disinfectant	**1**
6	**Anesthetics**	Introduction, basic principles and application anesthetic agents and desirable features, mode of actions and pharmacokinetics; methods and guidelines for euthanasia in aquatic organisms, stages of anesthesia and recovery; hypnotics and sedatives	**1** **2** **1**
7	**Drugs used in hatchery operations**	Drugs used in finfish, shrimp, prawn, crab hatcheries;	**1**

		breeding inducing agents, sex control agents, dose and dosage, mechanisms of action, withdrawal periods; chemicals used to maintain biosecurity in hatcheries	**1** **1**
8	**Preventive medicine/ Health beneficiary products/Prophylaxis products**	Pre- and Pro-biotics, immunostimulants, herbal medicines; **vaccines and adjuvants:** Definition, types, commercially available vaccines and adjuvents development, production, mechanism of action, administration, potency/ efficacy, marketing of vaccines	**1** **1** **2** **1**
		antimicrobial peptides and their potential use as therapeutics in aquaculture	**1**
9	**Safety of aquatic medicine**	Food safety regulations, toxic effects (toxicology), anti-microbial resistance (AMR) issues safety and welfare aspects of target species, operator, consumer and environment; immunosuppressive drugs; drug control acts, regulations and legislations in Bangladesh, and international standards for compliance; list of approved and prohibited aqua-drugs/medicines, guidelines for the control of aquaculture medicinal products (AMPs), drug control and certification authorities	**1** **1** **1** **2**
10	**Prescription writing**	Principles, types and parts of an ideal prescription, rational use of drugs, rational and irrational prescribing, drug incompatibilities and adverse effects (reactions and interactions), drug abuse	**2**
		Total	**45**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. Two in-course exams – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

1. Bondad-Reantaso, M.G., Arthur, J.R., Subasinghe, R.P., 2012. Improving biosecurity through prudent and responsible use of veterinary medicines in aquatic food production. FAO Fisheries and Aquaculture technical paper 547.
2. Brown, L., 1994. Aquaculture for Veterinarians: Fish Husbandry and Medicine. Pergamon Press, Oxford.
3. Noga, E.J., 1996. Fish Disease - Diagnosis and Treatment. Mosby-Year book Inc., St. Louis, Missouri.
4. Smith, S.A., 2019. Fish Diseases and Medicine. CRC press, Taylor & Francis Group.
5. Stoskopf, M.K., 1993. Fish Medicine. W B Saunders Company, Philadelphia.
6. Treves-Brown, K.M., 2000. Applied Fish Pharmacology**.** Kluwer Academic Publishers, Dordrecht.

FSH 410 Course title: Research Methodology Credit: 2 Credit hours: 30

Introduction to the course:

Prior to do any research, a student must have knowledge on the concept of research, research types, process, study and sampling designs. Understanding of the methods of data collection and development of conceptual framework and methodologies is a pre-requisite for a undergraduate student. Understanding the selection methods of data collection tools and finally writing research proposal and reports are the final steps in learning.

Specific objectives:

i. To get understand the definition and concept, types, process of research and steps in formulating a research problem;
ii. To develop skills in designing study and sampling;
iii. To enable to select tools and methods of data collection and analyses; and
iv. To enable the students in writing research proposal and report.

Course Contents

Theoretical

1. **Introduction**: Definition, objectives, significance and types of research.
2. **The research process**: an eight-step model.
3. **Reviewing the literature**.
4. **Formulating a research problem.**
5. **Identifying variables.**
6. **Constructing hypothesis**.
7. **Research design**: definition, concept of research design, function of a research design, types of study designs, experimental research designs CRD, RCBD and Latin square design, selecting a study design.
8. **Measurement and Scaling**: classifications of measurement scales, scaling, basis of classification and scaling techniques.

9. **Methods of data collection:** introduction, experiments and surveys, structured and semi-structured surveys, development of questionnaire, collection of primary data, collection of secondary data, case study method.
10. **Sampling:** introduction, concept of sampling, principles of sampling, types of sampling, survey versus census.
11. **Social and participatory methods**: PRA/PLA, group methods, surveys and interviews, visualizing and diagramming, temporal methods, spatial methods.
12. **Writing a research proposal**: Introduction, Materials and Methods, Review of literatures, Work plan and activity chart, Financial summary.
13. **Writing a research report**: thesis, scientific papers.

Unit-wise learning outcomes:

At the end of the course, students will be able to-

i. Define research;
ii. Explain steps of research process;
iii. Identify research problems;
iv. Write research proposals;
v. Selects the tools required to collect data;
vi. Analyze the collected data; and
vii. Write the research report.

Unit wise title and subtitle and number of classes per unit

Chapter	Title	Sub-title	No. of classes
1	**Introduction**	Definition, characteristics of research, types of research	**1**
2	**The research process**	an eight-step model	**1**
3	**Reviewing the literature**		**1**
4	**Formulating a research problem**		**1**
5	**Identifying variables**		**1**
6	**Constructing hypothesis**		**1**
7	**Research design**	Definition, concept of research design, function of a research design	**1**
		Types of study designs, experimental research designs	**2**
		CRD, RCBD and selecting a study design	**2**
8	**Measurement and Scaling**	Classifications of measurement scales, scaling, basis of classification and scaling techniques	**2**
9	**Methods of data collection**	Introduction, experiments and surveys, structured and semi-structured surveys	**2**
		Development of questionnaire, collection of primary data, collection of secondary data, case study method	**2**
10	**Sampling**	Introduction, concept of sampling, principles	**2**

		of sampling, types of sampling	
11	**Social and participatory methods**	PRA/PLA methods: History of RRA/PRA methods	**2**
		Surveys and interviews	**2**
		Temporal methods, spatial methods	**2**
12	**Writing a research proposal**	Introduction, Materials and Methods, Review of literatures, Work plan and activity chart, Financial summary	**2**
13	**Writing a research report**	Thesis, scientific papers	**3**
		Total	**30**

Instructional strategies: Language will be English, 2-way communications, first five minutes of every lecture – review of the previous class, then lecture for 40 minutes aided with the Multimedia projector, last five minutes – answer and questions and title of the next lectures.

Assessment:

I. One in-course exam – question type: matching, gap filling, MCQ, true/false.
II. Final exam: Only written.
III. Oral test.

References

1. Day, Robert A. 1995. How to write and publish a scientific paper. Cambridge University Press. 4th Edition.
2. Huda, Enamul. 1999. People's participation in development Application of PRA/PLA and training (in Bangla).
3. Kothari, CR and Garg, G. 2015. Research methodology methods and techniques. New age International (P) Limited, New Delhi, India.
4. Kumar, Ranjit. 2014. Research methodology. Pearson, India.
5. Niogy, Mozammel Haque and Babul, Mahmud Hasan. 2004. PRA/PLA Theory and application (in Bangla). Saki Publications club.
6. Participatory Methods in Community-based Coastal Resource management. Volume 2 Tools and methods. 1998. IIRR.

Practical

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 notebook 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:

Assessment

In-course examination: 40% marks
Final examination: 60% marks

FSH 401P Course title: Fisheries Resources Management Credit: 1.5 Credit hours: 22.5

Contents

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.
e. Field trips: visit major rivers, haors, baors, beels and coastal areas to observe management system.
f. Use of software and tools (e.g. Ecopath with Ecosim) to manage fisheries resources.

FSH 402P Course title: Oceanography and Marine Biology Credit: 1.5 Credit hours: 22.5

Contents

a. Museum study of ocean sediments, common minerals and sedimentary rocks
b. Study of physico-chemical properties of sea water
c. Study of marine sediments
d. Study of marine planktons
e. Determination of primary productivity (Gran Method/Chlorophyll a method)
f. Collection, preservation and identification of sea weeds
g. Collection, preservation and identification of marine flora and fauna
h. Field trip to coastal areas of Bangladesh

FSH 403P Course title: Fish Breeding and Hatchery Management Credit: 1.5 Credit hours: 22.5

Contents

a. Estimation of genetic variation by electrophoresis using RFLA, RAPD, AFLP and microsatellite.
b. Layout of typical fish and shrimp hatchery.
c. Artificial breeding of finfish and shellfish
d. Fish sperm motility test.
e. Fish egg fertilization rate determination.
f. Visit to commercial fish and shrimp hatcheries.

FSH 404P Course title: Fish Processing and Preservation Credit: 1.5 Credit hours: 22.5

Contents

a. Study on the chemical composition of fish (moisture, lipid, ash, protein and non-protein nitrogenous substances, amino acids, fatty acids and minerals).
b. Postmortem changes, determination of rigor index (ATP, Cp (creative phosphate), pH and lactate content during rigor mortis period).
c. Fraction of fish muscle protein and heat activation (kd value) of myofibriller protein by determining Ca2+ ATPase activity.
d. 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.

e. Quality assessment of traditional sun dried and solar tent dried fish by organoleptic, bacteriological and chemical methods.
f. Technique of fish salting and determination of slat concentration with time interval.
g. Field trips: Visit to fish processing plants.

FSH 405P Course title: Aquaculture Engineering Credit: 1.5 Credit hours: 22.5

Contents

a. Observation and classification of soil, soil properties (texture, pH etc.)
b. Quantification of water requirements
c. Design and construction of fish farms (pond, RAS, Biofloc etc.)
d. Demonstration of water supply, brackish water pond construction, cage design and construction, hatchery (carp and shrimp) design and construction, construction of inlets and outlets, design and construction of bio-filter
e. Water treatment methods
f. Use of different software for fish farm and hatchery design

FSH 406P Course title: Fish Feed Management Credit: 1 Credit hours: 15

Contents

a. Field trips to aquafeed industry
b. Fish Feed Formulation, preparation and nutrient analysis.
c. Evaluation of fish growth performance.
d. Physical, chemical and biological properties of feed eg. Floatibility, water stability, bulk density, expansion rate, hardness, durability etc. and how to measure using different instrument
e. Use of linear programming, feed calculator for formulation of fish feed

FSH 407P Course title: Fisheries Marketing Credit: 1 Credit hours: 15

Contents

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.
d. Supply chain of fish and fish products

FSH 408P Course title: Aquatic Biodiversity and Conservation Credit: 1 Credit hours: 15

Contents

a. Assessment of biodiversity using different indices (Shannon-Weiner index, Simpson's index, Margalef's index, Menhinick's index, Brillouin index, McIntosh's index, Berger-Parker index etc.)
b. Assessment of threatened species
c. Visit and exploration to the aquatic biodiversity hotspots
d. Case study on threats to biodiversity
e. Case study on conservation of biodiversity

FSH 409P Course title: Fish Pharmacology Credit: 1.5 Credit hours: 22.5

Contents

a. Practical application of various drugs and dose preparations; demonstration of drug administration: oral, injection, immersion and pond treatment, manufacturing medicated feed
b. Studies of pharmacokinetics of various aqua-drugs (e.g. tetracycline, chloramphenicol, quinolones etc.).
c. Demonstration, identification and use of different antibiotics used in aquatic animal treatment; antibiotic residual assays; antibiotic resistance/sensitivity tests
d. Demonstration of the use and mode of action of important anesthetics, probiotics, immunostimulants, vaccines on aquatic organisms
e. Studies on histopathological changes caused due to chemotherapy
f. Survey on commercial aqua medicines and health beneficiary products
g. Collection, identification and use of common indigenous medicinal plants important for aquaculture
h. Field trip and internships to aqua farms (monitoring of fish and pond health status) and pharmaceutical companies for practical exposures

FSH 410P Course title: Research Methodology Credit: 1 Credit hours: 15

Contents

a. Data entry, analysis and interpretation
b. Use of statistical software (Spreadsheet, SPSS, R) for data analysis

FSH 411 Course title: Project Credit: 2 Credit hours: 30

Each student needs to complete a research project that will make an original contribution to the field of fisheries. Each project will be supervised by a member of faculty and assessed via a dissertation and presentation.