Department of Fisheries
Faculty of Fisheries

Curriculum
for
M. S. in Fisheries Management
Session: 2018-2019

University of Rajshahi
Rajshahi, Bangladesh

UNIVERSITY OF RAJSHAHI
DEPARTMENT OF FISHERIES
FACULTY OF FISHERIES

Curriculum for M. S. in Fisheries Management

Session: 2018-2019

Examinations: Semester-1(January-June) Examination: June, 2024
Semester-2 (July-December) Examination: December, 2024
Semester-3 (January-June) Examination: June, 2025

Part A

1. **Title of the Academic Program: M. S. inFisheries Management**
2. **Name of the University:** University of Rajshahi
3. **Vision of the University:**

   To pursue enlightenment and creativity for producing world-class human resources to cater for the needs of changing time.

4. **Mission of the University:**

   M1. To ensure a world-class curriculum with talented academicians and conducive academic and research environment for generation and dissemination of knowledge.

   M2. To maintain international standards in education with focus on both knowledge and skills, and humanitarian and ethical values to meet the needs of the society and state.

   M3. To develop strategic partnerships with leading national and international universities, and organizations for academic as well as research collaborations.

5. **Name of the Program Offering Entity (POE):** Department of Fisheries,
   Faculty of Fisheries, University of Rajshahi, Bangladesh.

6. **Vision of the Program Offering Entity (POE):**
   Vision of the M. S. in Fisheries Management Program

   Sustainable management and conservation of fisheries resources through standard academic and research programs.

7. **Mission of the Program offering Entity (POE):**
   Mission of the M. S. in Fisheries Management Program
   a) To promote teaching-learning and research for sustainable fisheries resources management.
   b) To develop management and conservation strategies for openwater bodies.
   c) To share knowledge through national and international collaborative research, training and conference.

8. **Objective of the Program Offering Entity (POE)**

   To offer fisheries education to obtain B. Sc. Fisheries (Hons.), Master of Science (MS in Fisheries Biology and Genetics, MS in Aquaculture, MS in Fisheries Management and MS in Fisheries Technology), MPhil and PhD degree in Fisheries; to conduct teaching and research in various fields of Fisheries to increase the fish production and to meet the nutrient requirement.

9. Name of the Degree: M. S. in Fisheries Management

10. Description of the Program:

The Department of Fisheries is established in 2000 under the Faculty of Agriculture in the University of Rajshahi. Later on the department is included under newly formed Faculty of Fisheries in 2020. This department was started with three academic and three non-academic staffs with limited infrastructure facilities by enrolling twenty students. At present, the number of seats for student admission in B. Sc. Fisheries (Honours) level is fifty per year. Now, there are twenty academic staff specialized in different aspects of fisheries sector to enrich education and research in this department. In addition, twenty non-academic staffs are currently working for supporting the department. The department has already demonstrated its outreach excellence through establishing linkages with different donors, associations and industries for research, extension and developmental activities in fisheries sector.

The academic curriculum of the department is being offered in English. The department introduced twelve theoretical and four presentation courses in M. S. in Fisheries Mnagement level including Inland Fisheries Management and Conservation, Advanced Fish Population Dynamics, Advanced Fish Stock Assessmentetc.

11. Graduate Attributes (Based on need assessment):

(a) Communicator,

(b) Innovator,

(c) Problem solver,

(d) Leader,

(e) Team builder,

(f) Self- motivated,

(g) Entrerpreneur,

(h) Ethically aware,

(i) Digitally skilled,

(j) Multi-tasker and

(k) Adaptable

12. Program Educational Objectives (PEO) of the M. S. in Fisheries Management program

PEO1:To give post graduate students a comprehensive insight into management and conservation of openwater bodies.

PEO2:To have basic understanding limnology, fish stock assessment and inland & marine fisheries management.

PEO3: To conduct basic and applied research in different aspects of fisheries management and conservation sector.

PEO4:To disseminate research findings on fisheries management for sustainable fisheries resource management.

13. Program Learning Outcomes (PLOs)

At the end of the M. S. in Fisheries Management Program, the graduates will be able to-

PLOs	Program Outcomes (POs)
PLO1	Explain different types of fisheries resources and their management, fish stock assessment, water productivity, fisheries resources conservation issues and climate change in fisheries sector.
PLO2	Apply appropriate research methods, statistical tests, information technologies in scientific studies in fisheries management sector.
PLO3	Skills in oral and written presentation of results from fisheries resource management and conservation in popular scientific and academic context

14. Mapping between Mission and PEO

Mission	Program Educational Objectives (PEOs)			
	PEO1	PEO2	PEO3	PEO4
M1	X	X	●	●
M2	X	X	●	●
M3	X	X	X	X

X Strong contribution ● Weak contribution ☐ No contribution

15. Mapping PLOs with the PEOs

PEOs	Program Learning Outcomes (PLOs)		
	PLO1	PLO2	PLO3
PEO1	X	●	X
PEO2	X	●	X
PEO3	●	X	X
PEO4		●	X

X Strong contribution ● Weak contribution No contribution

16. Mapping courses with PLOs

Course Code	Course Title	PLOs		
		PLO1	PLO2	PLO3
FMMC-541	Inland Fisheries Management and Conservation	X	●	X
FMMC-542	Advanced Fish Population Dynamics	X	●	X
FMMC-543	Advanced Aquatic Ecology	X	●	X
FMMC-544	Advanced Limnology	X	●	X
FMMO-545	Wetland Ecosystem and Fisheries Biodiversity	X	●	X
FMMO-546	Research Methodology in Fisheries Management	X	X	X
FMMO-547	Advanced Oceanography	X	●	X
FMMO-548	Aquatic Soil Science	X	●	X

FMMR- 549	Research Defence-1	●	**X**	●
FMMC-641	Advanced Fish Stock Assessment	X	●	X
FMMC-642	Coastal & Marine Fisheries Management and Conservation	X	●	X
FMNC-643	Mangrove Fisheries Management and Conservation	X	●	X
FMMC-644	Advanced Aquatic Pollution and Toxicology	X	●	X
FMMO-645	Climate Change and Fisheries Management	X	●	X
FMMO-646	Community Based Fisheries Management	X	●	X
FMMO-647	Ecology of Fishes	X	●	X
FMMO-648	Water Quality and Environmental Impact	X	●	X
FMMR- 649	Research Defence-2	●	**X**	●
FMMT-741	Thesis	●	**X**	●
FMMD-742	Thesis Defense	●	**X**	●

X Strong contribution ● Weak contribution ☐ No contribution

Part B
17. Structure of the curriculum

The M. S. in Fisheries Managementcourses shall consist of compulsory, optional, research defence, thesis, and thesis defence. The compulsory courses are of 16 credits, optional courses 8 credits, research defence 4 credits, thesis 8 credits, and thesis defence 4 credits with an aggregate credit of 40 credits. The research work of the thesis should be carried out from the beginning of Semester-1.

M. S. in Fisheries Management Semester-1 Examination shall be held at the end of the First Semester having 14 credits, covering six theoretical courses (four compulsory and two optional) including class test and attendance. In addition, a research defence on the problem statement, hypothesis, objectives, expected outcomes, and methodology of the proposed research work will be held at the end of the semester having 2 credits.

M. S. in Fisheries Management Semester-2 Examination shall be held at the end of the Second Semester having 14 Credits covering six theoretical courses (four compulsory and two optional) including class test and attendance. In addition, a research defence on findings or progress of proposed research work will be held at the end of the semester having 2 Credits.

M. S. in Fisheries Management Semester-3 Examination shall be held at the end of the Third Semester having 12 Credits, covering thesis and thesis defence performances based on research work.

18. Semester wise distribution of courses

DETAILED BREAKS UP OF COURSES

M. S. in Fisheries Management Semester-1 Examination, June 2024

Course Code	Course Title	Credit
Compulsory		
FMMC-541	Inland Fisheries Management and Conservation	**2**
FMMC-542	Advanced Fish Population Dynamics	**2**
FMMC-543	Advanced Aquatic Ecology	**2**
FMMC-544	Advanced Limnology	**2**
Optional (any two)		
FMMO-545	Wetland Ecosystem and Fisheries Biodiversity	**2**
FMMO-546	Research Methodology in Fisheries Management	**2**
FMMO-547	Advanced Oceanography	**2**
FMMO-548	Aquatic Soil Science	**2**
Research Work		
FMMR- 549	Research Defence-1	**2**
	Total	**14**

M. S. in Fisheries Management Semester-2 Examination, December 2024

Course Code	Course Title	Credit
Compulsory		
FMMC-641	Advanced Fish Stock Assessment	**2**
FMMC-642	Coastal & Marine Fisheries Management and Conservation	**2**
FMMC-643	Mangrove Fisheries Management and Conservation	**2**
FMMC-644	Advanced Aquatic Pollution and Toxicology	**2**
Optional (any two)		
FMMO-645	Climate Change and Fisheries Management	**2**
FMMO-646	Community Based Fisheries Management	**2**
FMMO-647	Ecology of Fishes	**2**
FMMO-648	Water Quality and Environmental Impact	**2**
Research Work		
FMMR- 649	Research Defence-2	**2**
	Total	**14**

M. S. in Fisheries Management Semester-3 Examination, June 2025

Course Code	Course Title	Credit
FMMT-741	Thesis	**8**
FMMD-742	Thesis Defense	**4**
	Total	**12**
	Grand Total	**40**

Part C

19. Description of the courses

M. S. in Fisheries Management Semester-1 Examination, June 2024

COMPULSORY COURSES

FMMC-541: Inland Fisheries Management and Conservation

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Six questions to be set and five to be answered)

Course Description:

This course is a basic theoretical course and prerequisite to complete one and half year MS in Fisheries Management degree. The course coverers fisheries resources and its management, sectoral policies and programmes on fisheries, current five-year development activities of the Ministry of Fisheries, present status of fish seed production from natural and artificial sources, relations of flood and monsoon to inland and marine capture fisheries of Bangladesh, agro-ecological zoning system, recreational use of water resources and fisheries resource survey system (FRSS) of Bangladesh. The course is designed to strengthen the student's existing knowledge on Inland fisheries resources management and conservation.

Learning Outcomes:

At the end of the course, the students will be able to: i) Know about different types of fisheries resources and their management, habitat improvement technique both for lentic and lotic water habitat; ii) Know about the open water fisheries management& iii) Know the rules and regulations for the conservation of the fisheries resources.

At theend of this course, the students will be able to-

COs	Course Outcomes	Lectures
CO1	Describe rationale and expected outcome.	2
CO2	Describe waterbodies (ponds and lakes, rivers, canals, floodplains, beels, haors, baors, estuaries, and Bay of Bengal) and their origin and morphology.	3
CO3	Describes the biodiversity of fishes, introduced fish species (exotics), non-piscine fisheries organisms, other aquatic living resources of commercial and economic importance	3
CO4	Describe Present status of water bodies, nature, and extent of utilization, potentials for future management, sectoral policies and programmes	2
CO5	Describe present status of fish seed production from natural and artificial sources, diversity of ichthyo-plankton and seeds of other non-conventional aquatic fauna in the natural habitats.	2
CO6	Describe the relations of flood and monsoon to inland capture fisheries of Bangladesh.	2
CO7	Describe Fisheries resource survey system (FRSS) of Bangladesh	2
CO8	Ecosystem approaches in fisheries Managemenr (EAFM) and small scale fisheries.	6

Mapping CLOs with PLOs

CLOs	PLOs		
	PLO1	PLO2	PLO3
CLO1	X	●	X
CLO2	X	●	X
CLO3	X	●	X
CLO4	X	●	X
CLO5	X	●	X
CLO6	X	●	X
CLO7	X	●	X
CLO8	X	●	X

X Strong contribution ● Weak contribution ☐ No contribution

Lesson Plan

COs	Course Contents	Teaching Strategy	Assessment Strategy
CO1	Introduction, rationale and expected outcome.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CO2	Physical resources of Bangladesh: (a) Waterbodies - ponds and lakes, rivers, canals, floodplains, beels, haors, baors, estuaries, and Bay of Bengal - their origin and morphology; (b) other physical resources- organizations, institutions, private entrepreneurs, manpower, capital, and finance (Banks, NGOs), fish seed multiplication farms and hatcheries.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CO3	Biological resources: Biodiversity of fishes, introduced fish species (exotics), non-piscine fisheries organisms, other aquatic living resources of commercial and economic importance.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CO4	Present status of water bodies, nature, and extent of utilization, potentials for future management, sectoral policies and programmes on fisheries and wetland habitats of different ministries and departments, current five-year development activities of the Ministry of Fisheries.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CO5	Present status of fish seed production from natural and artificial sources, availability of shrimp seeds and crab juveniles, diversity of ichthyo-plankton and seeds of other non-conventional aquatic fauna in the natural habitats.	- Lectures followed by discussion - Participatory question-answer - Online resources - Video demonstration	

CO6	Relations of flood and monsoon to inland and marine capture fisheries of Bangladesh, changes of water bodies due to natural influences and human activities and their impacts of fish population or stocks, GIS and agro-ecological zoning system, surface water modeling, mapping of vulnerable areas for fisheries.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CO7	Fisheries resource survey system (FRSS) of Bangladesh: Present status of fisheries statistics, methods used in FRSS, weakness, the scope of further development.	- Lectures followed by discussion - Participatory question-answer	
CO8	Ecosystem approaches in fisheries Managemenr (EAFM) and small scale fisheries.	- Lectures followed by discussion - Participatory question-answer	

Recommended books/literature:

- Cushing, D.H., 1977. Science and the Fisheries. Edward Arnold Publishers Ltd., Hill Street, London.\, 60 pp.
- Gulland, J.A. (ed.), 1983. Fish Stock Assessment: A Manual of Basic Methods. Chichester, U.K., Wiley Interscience, FAO/Wiley series on food and agriculture, Vol. 1. 223 pp.
- Gulland, J.A. (ed.), 1988. Fish Population Dynamics. Second edition. John Wiley & Sons, Inc., New York.
- Lagler, K.F., 1956. Freshwater Biology, Second edition, William C. Brown Co. Dubuque, Iowa. 421 pp.
- Nikolskii, G.V., 1982. Theory of fish population dynamics. Bishen Singh, Mahendra Pal Singh and Otto Koeltz, Sci. Publishers, 323 pp.
- Parker, N.C., Albert, E.G., Roy, C.H., Douglas, Jr.J.B., Eric, D.P. and Gary, A.W., 1990. Fish Marking Techniques. Amer. Fish. Soc. Symp.-7, 876 pp.
- Ricker, W.E., 1968. Methos of assessment of fish production in freshwaters. Blackwell Scientific Publications, Oxford, 321 pp.

FMMC-542: Advanced Fish Population Dynamics

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Six questions to be set and five to be answered)

Course Description:

This course is a basic theoretical course and prerequisite for understanding the courses related to advances fish population dynamics and its scope and application in fisheries management. The course is designed to strengthen the student's existing knowledge of population's distribution and abundance and related influencing factors, relationships between different linear dimensions, best condition factor and gear selections. This course is also designed for understanding the methods for determination of ageand growth, growth performance index, longevity or life-span of fishes, size at sexual maturity, spawning- and peak-spawning season, recruitment pattern and mortality. Additionally, this course covers basic understanding the estimation of fish production methods, marking and tagging techniques, migration and life history patterns of fishes for fisheries management.

Learning Outcomes:

At the end of the course, the students will be able to: i) Know about the distribution and abundance, growth pattern, reproduction, recruitment, migration and mortality of fish; ii) Explain the relationship length-length and length weight relationship, condition factors of fishes, growth- and mortality-parameters.

At the end of this course, in specific, the students will able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Know the advanced fish population dynamics and its rationale, and expected outcomes.	1
CLO2	Know the scope of fish population dynamics and theories of fish population dynamics.	2
CLO3	Estimate the catch per unit effort as an index of stock in numbers or weight used for studies spatial distribution, temporal distribution, bathymetric distribution. Also can know the factors affecting distributions, relative abundance, marking and tagging, the absolute abundance of fish populations and their estimationsthrough sampling surveys, mark-recapture methods and Depletion methods.	2
CLO4	Calculate the Linear regression, Length-length (LLR), andLength-weight relationships (LWR),Condition(Fulton's, Relative, Allometric), Relative weight, Form factor of fish populations and the uses of ANCOVA. Also know the gear selectivity by covered codend& alternate haul experiments, and gill net selectivity.	2
CLO5	Understand the methods for determination of ageand growth (von Bertalanffy, Pauly&Gaschutz, Robertson and Gompertz growth models), growth performance index (Pauly and Munro model), longevity or life-span of fishes (Taylor, Munro models).	2
CLO6	Determine the timing of reproduction, ovarian maturation, length & age at first sexual maturity (GSI-based), mean length at sexual maturity (Logistic models), frequency of spawning,fecundity (total, relative, absolute, batch, annual fecundity & their relationships with length & weight).	3
CLO7	Calculate the timing of recruitment, length and age at recruitment, factors affecting recruitment and stock-recruitment relationships.	2
CLO8	Identify the factors causing mortality and get the concept of mortality equation, estimation of total mortality (age-based & length-based catch curves, Beverton& Holt equations, and Weatherall plots), natural (Pauly's empirical models) and fishing mortality.	2
CLO9	Know the concepts, estimation of production by mark and recapture method, by Alln's graphical method and numerically by exponential models of growth and mortality.	2
CLO10	Describe the trapping, the selectivity of nets and methods of fishing effects on commercial fish population and on population structure.	2
CLO11	Analyse the effect of fishing, stocks and migrations, collection of basic data, availability and gear selectivity, recruitment, stock size, survival, mortality, growth and yield models.	2

Mapping CLOs with PLOs

CLOs	PLOs		
	PLO1	PLO2	PLO3
CLO1	X	●	X
CLO2	X	●	X
CLO3	X	●	X
CLO4	X	X	X
CLO5	X	X	X
CLO6	●	X	X
CLO7	●	●	X
CLO8	●	●	X
CLO9	●	●	X
CLO10	●	●	X
CLO11	●	X	X

X Strong contribution ● Weak contribution ☐ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction, rationale, and expected outcome.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Scope of fish population dynamics and recent theories of fish population dynamics.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO3	Distribution and abundance: Catch per unit effort as an index of stock in numbers or weight, spatial distribution, temporal distribution, bathymetric distribution, factors affecting distributions, relative abundance, marking and tagging, the absolute abundance of fish populations and their estimations through Sampling surveys, mark-recapture methods, Depletion methods.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO4	Biometrics of fish population: Linear regression, Length-length (LLR), andLength-weight relationships (LWR) and application of ANCOVA, and Condition (Fulton's, Relative, Allometric), Relative weight, the Form factor of fish populations; Gear selectivity by covered codend& alternate haul experiments, gill net selectivity.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO5	Age and Growthmodeling: Concepts, recent methods of determining ageand growth (von Bertalanffy, Pauly&Gaschutz, Robertson and Gompertz growth models), growth performance index (Pauly and Munro model), and estimation of the longevity of fishes (Taylor, Munro models).	- Lectures followed by discussion - Participatory question-answer - Online resources - Video demonstration	
CLO6	Reproduction: Concepts, the timing of reproduction, ovarian maturation, length & age at first sexual maturity (GSI-based), mean length at sexual maturity (Logistic models), frequency of spawning,fecundity (total, relative, absolute, batch, annual fecundity & their relationships with length & weight).	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO7	Recruitment: Definition, the timing of recruitment, length and age at recruitment, factors affecting recruitment and stock-recruitment relationships.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO8	Mortality: Factors causing mortality, the concept of mortality equation; estimation of total mortality (age-based & length-based catch curves, Beverton& Holt	- Lectures followed by discussion - Participatory question-answer - Online resources	

	equations, and Weatherall plots), natural (Pauly's empirical models) and fishing mortality.		
CLO9	Production: Concepts, estimation of production by mark and recapture method, by Alln's graphical method and numerically by exponential models of growth and mortality.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO10	Effect of Fishing on Fish Population: Trapping, the selectivity of nets and methods of fishing effects on commercial fish population and on population structure.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO11	Analysis of Exploited Population: Effect of fishing, stocks and migrations, collection of basic data, availability and gear selectivity, recruitment, stock size, survival, mortality, growth and yield models.	- Lectures followed by discussion - Participatory question-answer - Online resources	

Recommended books/literature:

- Cushing, D.H., 1977. Science and the Fisheries. Edward Arnold Publishers Ltd. 25, Hill Street, London, 60 pp.
- Dwiponggo, A., 1986. Growth, mortality, and recruitment of commercially important fishes and penaeid shrimps in Indonesian waters. Filipiniana Specialist, Manila. 91 pp. FAO. 2001. Yearbook of fishery. Statistics of catches and landings.
- Gulland, J.A. (ed.), 1983. Fish Stock Assessment: A Manual of Basic Methods. Chichester, U.K., Wiley Interscience, FAO/Wiley series on food and agriculture, Vol. 1. 223 pp.
- Gulland, J.A. (ed.), 1988. Fish Population Dynamics. Second edition. John Wiley & Sons, Inc., New York.
- King, M., 1995. Fisheries Biology, Assessment and Management. Fishing News Books, 342 p.
- Lagler, K.F., 1956. Freshwater Biology, Second edition, William C. Brown Co. Dubuque, Iowa. 421 pp.
- Nikolskii, G.V., 1982. Theory of fish population dynamics. Bishen Singh, Mahendra Pal Singh and Otto Koeltz, Sci. Publishers, 323 pp.
- Ricker, W.E., 1968. Methos of assessment of fish production in freshwaters. Blackwell Scientific Publications, Oxford, 321 pp.
- Ricker, W.E., 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382 p.
- Solomon, M.E. 1976. Population dynamics. Second edition, Arnold (Publishers) Ltd. 67 pp.
- Rounsefell, G.A. and Everhart, W.H., 1953. Fishery Science: Its methods and application. John Wiley & Sons, Inc., New York. 444 pp.
- Sparre, P., Ursin, E. and Venema, S.C., 1989. Introduction to tropical fish stock assessment. Part 1. Manual. FAO Fisheries Technical Paper. No. 306.1. Rome, FAO. 337 pp.

FMMC-543: Advanced Aquatic Ecology

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Six questions to be set and five to be answered)

Course Description:

This course is a compulsory course of MS in Fisheries Management degree. The course covers different branches of ecology and effects of different limiting factors on ecosystem. The course is designed to strengthen the student's existing knowledge on nutrient exchange, production, decomposition, lentic, lotic and estuarine habitat. This course can also teach them about production and decomposition in nature; food chain and food web of ecosystem, concept of population and different population parameters, physical and chemical features of

lentic & lotic water. A number of further topics, like energy flow, modification and productivity of floodplain ecosystem will be also focused in the course.

Learning Outcomes:

At the end of the course, the students will be able to understand about nutrient exchange, production, decomposition, lentic, lotic and estuarine habitat.

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

CLOs	Course Outcomes	Lectures
CLO1	Describe scope and importance of aquatic ecology	2
CLO2	Explain modern concept, functional and evolutionary perspectives; and history of ecology.	2
CLO3	Discuss about nutrient pools and exchanges; production and decomposition in nature; food chain and food web of ecosystem	3
CLO4	Describe concept of population and different population parameters.	3
CLO5	Explain limiting factors of freshwater ecosystem and ecological classification of freshwater organisms.	3
CLO6	Compare between lake and pond and describe characteristic of lentic habitat.	2
CLO7	Discuss about physical and chemical features of lotic water.	2
CLO8	Explain energy flow, modification and productivity of floodplain ecosystem	2
CLO9	Discuss features, productivity and liming factors of estuarine ecosystem.	2

Mapping CLOs with PLOs

CLOs	PLOs		
	PLO1	PLO2	PLO3
CLO1	X	●	X
CLO2	X	●	X
CLO3	●	●	X
CLO4	X	●	X
CLO5	X	●	X
CLO6	X	●	X
CLO7	X	●	X
CLO8	●	X	X
CLO9	X	●	X

X Strong contribution ● Weak contribution ☐ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction, rationale, and expected outcome.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20)
CLO2	**General ecological theory**: Modern concepts and scope - descriptive, functional and evolutionary perspectives; the history of ecology; levels of	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	

	integration; methods and approaches.		Final Examination (70)
CLO3	**Aquatic ecosystem**: Types; nutrient pools and exchanges; production and decomposition in nature; food chain and food web, trophic structure and ecological pyramids; concepts of habitat selection and ecological niche	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO4	**Population ecology**: Concepts of the population; population group properties - density, natality, mortality, age distribution, biotic potential, environmental resistance, growth form, carrying capacity, population dispersal, population dispersion, and isolation and territoriality	- Lectures followed by discussion - Participatory question-answer	
CLO5	**Freshwater Ecology**: Limiting factors; ecological classification of freshwater organisms, lakes and other water bodies; general models of production in lentic and lotic habitats; trophic relationship	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO6	**Ecology of Lentic water**: Differences between Lake and pond. Classification and characteristics of the lake, nature of lentic environment.	- Lectures followed by discussion - Participatory question-answer	
CLO7	**Ecology of Lotic water**: Physical and chemical feature of stream, fast stream structure. Communities of fast stream, slow stream, and river structure submerged plants in the river ecosystem; plant bed management of Lentic water: Classification and characteristics of the lake., nature of lotic environment	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO8	**Ecology of floodplains**: Characteristics and types of floodplains, energy flow in floodplains, floodplain fisheries and modification of floodplain ecosystems	- Lectures followed by discussion - Participatory question-answer	
CLO9	**Estuarine ecology**: Concepts and nature of estuary, classification, biota and productivity, tidal marshes and mangrove swamps	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	

Recommended books/literature:

- Krebs, C.J. 1985. Ecology: The Experimental Analysis of Distribution and Abundance. 3rd Edition. Harper & Row Publishers, New York. 800 pp.
- Clarke, G.L. 1966. Elements of Ecology, Revised edition. jhon Wiley & Sons, Inc., New York. 560pp.
- Moss, B. 1998. Ecology of Freshwaters Man and Medium, Past to Future. 3rd Edition. Blackwell Science, London.
- Odum, E.P. 1971. Fundamentals of Ecology. W.B. Sounders Co. 574 pp.
- Dobson, M. and C. Frid. 1998. Ecology of Aquatic Systems. Addison Wesley Longman Ltd., England.
- Doods, W. and M.R. Whiles. 2010. Freshwater Ecology, 2nd Edition: Concepts and Environmental Applications of Limnology. Academic Press, London.
- Khanna, D.R. 1993. Ecology and Pollution of Ganga River. Ashish Publishing, New Delhi. 241 pp.

- Kumar, H.D. 1995. Modern Concepts of Ecology. 18th Edition. Vikash Publishing House Pvt. Ltd. 255 pp.
- Laevastu, T. and H.A. Larking. 1991. Marine Fisheries Ecosystem. Blackwell Scientific Publications Inc. 176 pp.
- Reid, G.K. 1961. Ecology of Inland Waters and Estuaries. Van Nostrand Reinhold Company. 375 pp.
- Smith, R.L. 1977. Elements of Ecology and Fish Biology. Haper& Row Publishers. 497 pp.

FMMC-544: Advanced Limnology

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Six questions to be set and five to be answered)

Course Description:

This course is a compulsory course of MS in Fisheries Management degree. The course covers different types of physical and chemical factors and describe the effects of different physical and chemical parameters on biological production. The course is designed to strengthen the student's existing knowledge on soil water interaction, bio-geochemical cycle, productivity and interrelations between plankton and fish in inland waterbodies. This course can also teach them about growth factors and seasonal succession of phytoplankton, eutrophication and phytoplankton bloom, toxic and noxious phytoplankton. A number of further topics, like zooplankton, benthos, primary and secondary production of inland waterbodies will be also focused in the course.

Learning Outcomes:

At the end of the course, the students will be able to understand i) abundance and distribution of algae, zooplankton, benthos ii) effect of soil-water interaction on productivity iii) role of bio-geochemical cycle and iv) ecological interaction and interrelationship between plankton and fish.

At theend ot this course, the students will be able to-

CLOs	Course Outcomes	Lectures
CLO1	Define limnology and biological limnology; describe justification of biological limnology and its expected outcomes.	2
CLO2	Compare the different types of physical and chemical factors and its optimum range; describe theeffects of different physical and chemical parameters on biological production	2
CLO3	Define soil and kinds of soil; Discuss about Soil-water interaction; explain the effects of soil water interaction on the productivity, water quality parameters in different soil types of Bangladesh	3
CLO4	Describe the role of Bio-geochemical cycles in aquatic environment with particular emphasis on phosphorus, nitrogen, silicon, calcium, sulfur, iron and carbon cycles.	3
CLO5	Define phytoplankton; Explain about major groups, growth factors and seasonal succession of phytoplankton; Describes and compares eutrophication and phytoplankton bloom. Discuss about toxic and noxious phytoplankton.	3
CLO6	Define zooplankton, Explain major groups of zooplankton, life cycle and cyclomorphosis of zooplankton; describe food & feeding habit and migration of zooplankton.	2
CLO7	Discuss about major groups and factors affecting the abundance and distribution of benthos; explain the role of benthos in aquatic environment.	2
CLO8	Define primary and secondary production; Estimate the primary production; explain the different factors affecting primary production; estimate the secondary production; describe reclamation of derelict bodies	2
CLO9	Define Eutrophicationandtypes of eutrophication; differentiate between Eutrophic and oligotrophic lakes; explain control and preventive measures of eutrophication.	2
CLO10	Discuss and compare interrelationship between different plankton and fish.	2

Mapping CLOs with PLOs

CLOs	PLOs		
	PLO1	PLO2	PLO3
CLO1	X	●	X
CLO2	●	**X**	X
CLO3	●	●	X
CLO4	●	●	X
CLO5	●	X	X
CLO6	●	●	X
CLO7	X	●	X
CLO8	●	X	X
CLO9	X	●	X
CLO10	●	X	X

X Strong contribution ● Weak contribution ☐ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction, rationale, and expected outcome.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Water as an environment: Physical and chemical factors and their effects on biological production.	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO3	Soil-water interaction: The effects of soil water interaction on the productivity, water quality parameters in different soil types of Bangladesh	- Lectures followed by discussion - Participatory question-answer	
CLO4	Bio-geochemical cycles in aquatic environment with particular emphasise on phosphorus, nitrogen, silicon, calcium, sulfur, iron and carbon cycles.	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO5	Phytoplankton: Seasonal succession and distribution, phytoplankton bloom; causes and effects of bloom.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO6	Zooplankton: Cyclomorphosis, migration of zooplankton, phytoplankton-zooplankton relations.	- Lectures followed by discussion - Participatory question-answer	
CLO7	Benthos: Benthic regions, benthic organisms, distribution of benthos, significance of benthos.	- Lectures followed by discussion - Participatory question-answer	
CLO8	Production: Estimation of primary and secondary production, factors affecting primary production; reclamation of	- Lectures followed by discussion - Participatory question-answer	

	derelict water bodies.		
CLO9	Eutrophication: Eutrophic and oligotrophic lakes; types of eutrophication; control and preventive measures of eutrofication.	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO10	Plankton-fish population relationships.	- Lectures followed by discussion - Participatory question-answer	

Recommended books/literature:

- Horne, A.J. and C.R. Goldman. 1994. Limnology. Mcgray Inc. New York. 576 pp.
- Hutchinson, G.E. 1975. A Treatise on Limnology, Vols I. II and III, John Wiley and Sons, Inc. New York.
- Rahman, M.S. 1992. Water Quality Management in Aquarium. BARC Prokashona, Mohakhali, Dhaka. 92 pp.
- Boney A.D. 1976. Phytoplankton Studies in Biology, No. 52. Edward Arnold (Publishers) Ltd., 25 Hill Street, London. 115 pp.
- Boyd, C.E. 1988. Water quality management for pond fish culture. Elsevier Science Publishers B.V., Amsterdam. 318 pp.
- Downing, J.A. and F.H. Rigler 1984. A Manual on methods for the assessment of secondary productivity in freshwaters. Second edition. Blackwell Scientific Publications.
- Shinha, V.R.P. and H.C. Srivastiva (eds).1991. Aquaculture Productivity. Oxford and IBH Publishing Co. Pvt. Ltd.
- Welch, P.S. 1952. Limnology. McGraw Hill Book Company, New York. 538 pp.
- Wetzel, R.G., 1983. Limnology. Second edition. Saunders College Publishing. 767 pp.
- Wetzel, R.G. and G.E. Likens. 1991. Limnological Analysis. Second edition. Springer-Verlag. 391 PP.

OPTIONAL COURSES

FMMO-545: Wetland Ecosystem and Fisheries Biodiversity

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Six questions to be set and five to be answered)

Course Description:

This course is a basic theoretical course and prerequisite to complete one and half year MS inFisheries Management degree. The course coverers types of wetlands, restoration andRehabilitation of wetlands; wetlands management, present status of aquatic biodiversity and itsconservation, impacts of the introduction of exotic fish fauna on native fishes. The course isdesigned to strengthen the student's existing knowledge on wetland ecosystem and fisheriesbiodiversity.

Learning Outcomes:

At the end of the course, the students will be able to know about different types of wetlands, its biodiversity, degradation of wetlands and its restoration and rehabilitation.

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

CLOs	Course LearnmingOutcomes	Lectures
CLO1	Describe rationale, and expected outcome.	2
CLO2	Know the kinds of wetlands, history and heritage of wetlands, importance of wetlands in Bangladesh,socio-economic values and legislation.	4
CLO3	Know restoration and rehabilitation of wetlands; wetlands management.	4
CLO4	Describe basic concepts of biodiversity; present status of aquatic biodiversity of	3

	piscine and non-piscine organisms: Important bio-diversification of aquatic vegetation in Bangladesh	
CLO5	Know the impacts of the introduction of exotic fish fauna on native fishes: sources, reasons andpossible solutions.	3
CLO6	Describe degradation of aquatic biodiversity: causes and its mitigation measures.	3
CLO7	Know conservation of aquatic biodiversity.	3

Mapping CLOs with PLOs

CLOs	**PLOs**		
	PLO1	**PLO2**	**PLO3**
CLO1	X	●	X
CLO2	●	●	X
CLO3	●	●	X
CLO4	●	X	X
CLO5	●	X	X
CLO6	X	●	X
CLO7	X	●	X

X Strong contribution ● Weak contribution ☐ No contribution

Lesson Plan

CLOs	**Course Contents**	**Teaching Strategy**	**Assessment Strategy**
CLO1	Describe rationale, and expected outcome.	- Lectures followed by discussion - Participatory question-answer	**Total: 100**Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Kinds of wetlands, history and heritage of wetlands, importance of wetlands in Bangladesh, socio-economic values and legislation.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO3	Restoration and rehabilitation of wetlands; wetlands management.	- Lectures followed by discussion - Participatory question-answer	
CLO4	Basic concepts of biodiversity; present status of aquatic biodiversity of piscine and non-piscine organisms: commercially important bio-diversification of aquatic vegetation in Bangladesh	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO5	Impacts of the introduction of exotic fish fauna on native fishes: sources, reasons and possible solutions.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO6	Degradation of aquatic biodiversity: causes and its mitigation measures.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO7	Conservation of aquatic biodiversity.	- Lectures followed by discussion - Participatory question-answer	

Recommended books/literature:

- Clarke, G.L. 1966. Elements of Ecology, Revised edition. jhon Wiley & Sons, Inc., New York. 560pp.
- Moss, B. 1998. Ecology of Freshwaters Man and Medium, Past to Future. 3rd Edition. Blackwell Science, London.
- Odum, E.P. 1971. Fundamentals of Ecology. W.B. Sounders Co. 574 pp.
- Biswas, K.P. 1995. Ecological and Fisheries Development in Wetlands: A Study of Chilka Lagoon. Daya Publishing, Delhi, Vol. 13. 192 pp.
- Dobson, M. and C. Frid. 1998. Ecology of Aquatic Systems. Addison Wesley Longman Ltd., England.
- Doods, W. and M.R. Whiles. 2010. Freshwater Ecology, 2nd Edition: Concepts and Environmental Applications of Limnology. Academic Press, London.
- Kumar, H.D. 1995. Modern Concepts of Ecology. 18th Edition. Vikash Publishing House Pvt. Ltd. 255 pp.
- Laevastu, T. and H.A. Larking. 1991. Marine Fisheries Ecosystem. Blackwell Scientific Publications Inc. 176 pp.
- Reid, G.K. 1961. Ecology of Inland Waters and Estuaries. Van Nostrand Reinhold Company. 375 pp.
- Smith, R.L. 1977. Elements of Ecology and Fish Biology. Haper& Row Publishers. 497 pp.

FMMO-546: Research Methodology in Fisheries Management

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Six questions to be set and five to be answered)

Course Description:

This course is a basic theoretical course and prerequisite for understanding the research, problems in research, research design, samplings, selection of appropriate statistical test, writing scientific papers, thesis and project and application of computer in research. The course is designed to strengthen the student's existing knowledge of research and its and application to fisheries management-based research with appropriate data analyses and statistical test. Additionally, this course covers basic understanding on how to write scientific paper/ Thesis/ Project proposal, related to fisheries management.

Learning Outcomes:

At the end of the course, the students will be able to: i) Know how to deal with fisheries management research with appropriate data analyses and statistical test, (ii) know how to write scientific paper/ Thesis/ Project proposal, and (iii) use the computers for good research.

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

CLOs	Course Learning Outcomes	Lectures
CLO1	Know the research methodology in fisheries management and its rationale, and expected outcomes.	1
CLO2	Know the scope of research, itsobjectives, motivation, approaches, significance, importance of knowing how research is done, research process, criteria of good research.	2
CLO3	Explore the research problem, selecting the problem, necessity of defining the problem, technique involved in defining a problem, problems encountered by researchers in Bangladesh.	2
CLO4	Describe the meaning of research design, need for research design, features of a good design, important concepts relating to research design, different research designs, basic principles of experimental designs, developing a research plan.	2
CLO5	Know the collection of primary data, observation method, interview method, collection of data through questionnaires, collection of data through schedules, difference between questionnaires and schedules, some other methods of data collection, collection of secondary data, selection of appropriate method for data collection, case study method.	2
CLO6	Know the Processing operations, problems in Processing, Elements/Types of Analysis	3

	and can understand on how to deal with Statistics in Research. And also be able to estimate the Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), Measures of Relationship, Simple Regression Analysis, Multiple Correlation and Regression, Partial Correlation, Association in Case of Attributes, Other Measures.	
CLO7	Explore the Needs for Sampling, Some Fundamental Definitions, Important Sampling Distributions, Concept of Standard Error. And can be able to estimate the Population Mean, Population Proportion, Sample Size, and its Determination and will be able to apply the Chi-square as a Test for Comparing Variance, Chi-square as a Non-parametric Test, Student t-test, Characteristics of Distribution-free or Non-parametric Tests, Mannan-Whitney U-test, Analysis of Variance (ANOVA), Kruskal-Wallis test, Regression analysis and Analysis of Co-variance (ANOCOVA) in fisheries management related research.	2
CLO8	Know how to write the Report/Thesis/ Scientific paper / Project proposal, and can be also able to make Oral and poster Presentation.	2
CLO9	Know the Computer, and Computer Technology, The Computer System, Important Characteristics, The Binary Number System, Computer Applications, Computers, and Researcher.	2

Mapping CLOs with PLOs

CLOs	**PLOs**		
	PLO1	**PLO2**	**PLO3**
CLO1	●	**X**	X
CLO2	●	X	X
CLO3	●	X	X
CLO4	●	X	X
CLO5	●	X	X
CLO6	●	**X**	X
CLO7	●	**X**	X
CLO8	●	●	X
CLO9	●	●	X

X Strong contribution ● Weak contribution ☐ No contribution

Lesson Plan

CLOs	**Course Contents**	**Teaching Strategy**	**Assessment Strategy**
CLO1	Rationale, importance and expected outcomes of learning research methodology in aquaculture.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	**Introduction to research methodology:** Aquaculture research and terminologies, Research advisor, Problems on research, Importance and Scope of studying of research methodology.	- Lectures followed by discussion - Participatory question-answer	

CLO3	**Research design:** Principle, field layout, Sampling design, Measurement and Scaling technique, Methods of Data collection etc.	- Lectures followed by discussion - Participatory question-answer	
CLO4	**Fieldworks:** Access to the field, Site visit, Data/Sample collection, Data records and Sample preservation etc.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO5	**Lab works:** Sample maintenance, Marking/Tagging, Dissecting, Different measurements etc.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO6	**Research proposal writing/Synopsis writhing:** Research background including importance, problem statement and objective, Methodology including a time frame, Expected findings, citation.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO7	**Thesis writing:** Abstract, introduction, methodology, review of literature, results, discussion, Recommendation and citation	- Lectures followed by discussion - Participatory question-answer	
CLO8	**Scientific article writing:** Abstract, introduction, methodology, results and discussion, Recommendation and citation.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CO10	Project proposal writing, Project progress report and final report writing.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CO11	**Reference writing:** journal papers, books, proceedings, conference paper, electronic documents, unpublished documents, etc.	- Lectures followed by discussion - Participatory question-answer - Online resources	

Recommended books/literature:

1. Kothari CR (2004) Research Methodology - Methods and Techniques (2nd Edition). New Age International Publishers.
2. Kumar R (2010) Research Methodology: A Step-by-Step Guide for Beginners (Third Edition). SAGE Publications Ltd.
3. Bhattacherjee A (2012) Social science research: principles, methods and practices. University of South Florida. Florida.
4. Burrows T (2011) Writing research articles for publication. Thailand: The Asian
5. Burton S and Steane P (eds) (2004) Surviving your thesis. London: Routledge
6. Dawson C (2002) Practical research methods: a user-friendly guide to mastering research techniques and projects. Oxford: How To Books Ltd.
7. Given LM (ed) (2008) The Sage encyclopedia of qualitative research methods, volumes 1 & 2. California, Thousand Oaks: Sage Publications.
8. De Leeuw ED, Hox JJ and Dillman DA (eds) (2008) International handbook of survey methodology. EAM.
9. Walliman N (2011) Research methods: the basics. Oxon: Routledge.
10. SeltmanHj (2014) Experimental design and analysis. Carnegie Mellon University.
11. Neergaard H and Ulhoi JP (eds) (2007) Handbook of qualitative research methods in entrepreneurship. UK. Edward Elgar Publishing Ltd.
12. Modern Language Association of America (2009) MLA handbook for writers of research papers. 7th ed. New York: Modern Language Association of America.

FMMO-547: Advanced Oceanography
Credit: 2
Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]
Time: 3 hours (Six questions to be set and five to be answered)

Course Description:
This course is a basic theoretical course and prerequisite for understanding physical, chemical and biological oceanography. The course is designed to strengthen the student's existing knowledge on bottom topography; importance of continental shelf in marine fish production and marine algae an zooplankton. This course can also teach them about physic-chemical properties of sea water, ichthyoplankton and Marine climate, weather, and fisheries.

Learning Outcomes:
At the end of the course, the students will be able to understand about world's ocean, fisheries oceanography, ocean tides, waves and current.

At theend of this course, the students will be able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Know ocean bottom topography and importance of continental shelf in marine fish production	2
CLO2	Describe physico-chemical properties of seawater	2
CLO3	Explain oceanic survey design, Biological aspects and statistical aspects of ocean.	3
CLO4	Describe about marine algae and seaweeds; and their limiting factors in marine environment.	3
CLO5	Know about marine zooplankton especially their Occurrence and distribution.	3
CLO6	Explore about Ichthyoplankton and their sampling systems, assessment of exploitable population from ichthyoplankton data.	2
CLO7	Describe fisheries oceanography and fisheries management.	2
CLO8	Explain marine climate, weather, and fisheries in details.	2

Mapping CLOs with PLOs

CLOs	PLOs		
	PLO1	PLO2	PLO3
CLO1	X	●	X
CLO2	X	X	X
CLO3	●	X	X
CLO4	X	●	X
CLO5	●	●	X
CLO6	●	X	X
CLO7	●	●	X
CLO8	●	●	X

X Strong contribution ● Weak contribution ☐ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Ocean bottom topography; importance of continental shelf in marine fish production	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Physico-chemical properties of seawater: Temperature, light, salinity, dissolved gases, nutrients; role of different factors influencing the distribution of nutrients; surface runoff and flushing of nutrients in the coastal waters; effects of mixing processes (i.e. tides, waves, currents, etc) on marine fisheries.	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO3	Oceanic survey design: Biological aspects, statistical aspects.	- Lectures followed by discussion - Participatory question-answer	
CLO4	Marine algae: Phytoplankton and seaweeds; seasonal succession and distribution of phytoplankton; harmful algal blooms; photosynthesis and growth of phytoplankton in the sea; the kinetics of nutrient uptake.	- Lectures followed by discussion - Participatory question-answer	
CLO5	Zooplankton: Occurrence and distribution; phytoplankton-zooplankton relationships.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO6	Ichthyoplankton: Terminology, importance of ichthyoplankton surveys; sampling systems, assessment of exploitable population from ichthyoplankton data; larval and juvenile fish survival and recruitment in a fishery.	- Lectures followed by discussion - Participatory question-answer	
CLO7	Oceanography and fisheries; oceanography and fisheries management; utilization of oceanographic knowledge in locating of fishing grounds, detection of unutilized fishery resources, improvement of fishing tactics and future forecasting of a fishery.	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO8	Marine climate, weather, and fisheries: Coastal weather, weather forecasting, forecast availability and accuracy; surface current, their changes and effects on fish distribution, migration and recruitment; diurnal behaviour of fish in relation to weather.	- Lectures followed by discussion - Participatory question-answer	

Recommended books/literature:

- Harrison, P. and T. Parsons (eds.). 2001. Fisheries Oceanography. Blackwell Science Ltd, UK. 360 pp.
- Mann, K.H. and J.R.N. Lazier. 2006. Dynamics of Marine Ecosystems: Biological-Physical Interactions in the Oceans. Third Edition. Blackwell Publishing, UK. 512 pp.
- Miller, C.B. 2004. Biological Oceanography. Blackwell Science Ltd, UK. 416 pp.
- Reddy, M.P.M. 2007. Ocean Environment and Fisheries. Science Publishers, Enfield, NH, USA. 550 pp.
- Bakus, G.J. 1990. Quantitative Ecology and Marine Biology. A.A. Balkema, Rotterdam. 157 pp.
- BOBP. 1993. Studies of Interactive Marine Fisheries of Bangladesh. BOBP/WP/89. Bay of Bengal

Programme, Madras, India.
- Levinton, J.S. 2008. Marine Biology: Function, Biodiversity, Ecology. Oxford University Press, USA. 640 pp.
- Gunderson, D.R. 1993. Surveys of Fisheries Resources. John Wiley and Sons, Inc., New York. 233 pp.
- Laevastu, T. 1993. Marine Climate, Weather and Fisheries. Blackwell Scientific Publications, Inc., England. 204 pp.
- Parsons, T.R., Takahashi and B. Hargrave. 1984. Biological Oceanographic Process. Pergamon Press, England. 330 pp.

FMMO-548: Aquatic Soil Science

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Six questions to be set and five to be answered)

Course Description:

This course is a basic theoretical course and prerequisite for Soil, and soil science. The course is designed to strengthen the student's existing knowledge on physical and chemical properties of soil. This course can also teach them about classification of soil water, soil water constants, factors affecting soil water retention, infiltration, leaching, percolation.

Learning Outcomes:

At the end of the course, the students will be able to understand about physical and chemical properties of soil and significance of soil in the field of fisheries

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

CLOs	Course Learning Outcomes	Lectures
CLO1	Know about aquatic soil science and its significance in the field of fisheries.	2
CLO2	Describe physical properties of soil.	2
CLO3	Explain Chemical properties of soil.	3
CLO4	Describe Problems and solutions and relations to productivity.	3
CLO5	Know about classification of soil water, soil water constants, factors affecting soil water retention, infiltration, leaching, percolation.	3
CLO6	Explore about Soil-water interactions and productivity.	2
CLO7	Describe physico-chemical factors affecting release and retention of nutrients from bottom mud of waterbody..	2
CLO8	Explain Saline soils and acid sulphate soils.	2

Mapping CLOs with PLOs

CLOs	PLOs		
	PLO1	PLO2	PLO3
CLO1	X	●	X
CLO2	●	●	X
CLO3	●	●	X
CLO4	X	●	X
CLO5	●	●	X
CLO6	●	X	X
CLO7	●	X	X
CLO8	●	●	X

X Strong contribution ● Weak contribution ☐ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Soil, soil science; aquatic soil science and its significance in the field of fisheries.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Physical properties of soil: Soil texture - textural classes, suitability of soil textural classes for fish culture and production, pond construction and fisheries management; soil temperature, soil temperature, and productivity, soil colour, soil consistency, sticky point, swelling and shrinkage; soil textural classes and productivity.	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO3	Chemical properties of soil: Soil pH and buffering of soil, cation and anion exchange and adsorption soil colloids – clay and humus, soil fertility and soil productivity.	- Lectures followed by discussion - Participatory question-answer	
CLO4	Very sandy soils: Problems and solutions and relations to productivity.	- Lectures followed by discussion - Participatory question-answer	
CLO5	Soil water: Classification of soil water, soil water constants, factors affecting soil water retention, infiltration, leaching, percolation.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO6	Soil-water interactions and productivity: Bioturbation, benthic organisms responsible for bioturbation, effects of bioturbation on physico-chemical properties of overlying water.	- Lectures followed by discussion - Participatory question-answer	
CLO7	Bottom-mud: Bottom-mud as a store-house of nutrients needed for phytoplankton production; physico-chemical factors affecting release and retention of nutrients from/to bottom mud of waterbody.	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO8	Saline soils and acid sulphate soils: Characteristics, reclamation and impacts in coastal aquaculture and mangrove fisheries	- Lectures followed by discussion - Participatory question-answer	

Recommended books/literature:

- Boyd, C.E. 1988. Water Quality Management for Pond Fish Culture. Elsevier Science Publishers B.V. Amsterdam. 318 pp.
- Donahue, R.L., R.W. Miller and F.C. Shickluna. 1990. Soils – An Introduction to Soils and Plants Growth. Fifth edition. Prentice Hall of India private Ltd. New Delhi. 667 pp.
- Golterman, H.L. (ed.) 1976. Interactions between sediments and freshwater. Proceedings of an International Symposium held at Amsterdam, the Netherlands, September 6-10, 1976.
- Buckman, H.O. and N.C. Brady. 1988. The Nature and Properties of Soils. Ninth edition. S. Chand and Company (Pvt.) Ltd. Inc. 750 pp.
- Coche, A.G. 1985. Methods for aquaculture: Soil and freshwater fish culture. FAO Training Series. FAO Rome.
- Fitzpatrick, E.A. 1986. Soils their formation, classification, and distribution. English Language Book Society. Longman, England. 353 pp.
- Rahman M.S. 1992. Water Quality Management in Aquaculture. BARC, Prokashana, Dhaka. 92 pp.
- Tamhane, R.V., D.P. Motiramoni and Y.P. Bali. 1970. Soils: Their Chemistry and Fertility in Tropical Asia. Third edition. Prentice Hall Int. Inc. 475 pp.
- Thompson L.M. and F.R. Troch. 1978. Soils and Soil Fertility. Fourth edition. McGraw Hill Book Co., New York. 516 pp.

Research Work

FMMR-549: Research Defence-1

Credit: 2

Full Marks: 100

At the beginning of Semester-1, all students will be attached to the academic staff as a supervisor. Students/They will face a research defence based on the problem statement, hypothesis, objective, expected outputs and limitations, review of literature and methodology of the proposed research.

Learing Outcomes:

At the end of the research defence, intensive and constructive discussions of proposed research projects from definition of problem statement, hypothesis and research objectives through different scientific approaches, research design and expected data analysis will enable student to develop critical thinking and scholarly skills in developing research proposal.

M.S. in Fisheries Management Semester-2 Examination, December 2024

COMPULSORY COURSES

FMMC-641: Advanced Fish Stock Assessment

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Six questions to be set and five to be answered)

Course Description:

This course is a basic theoretical course and prerequisite for understanding the courses related to stock, unit-stock and its identification and segregation through multiple methods. The course is designed to strengthen the student's existing knowledge of growth parameters from length-frequency data, mark-recapture data and hard parts analyses through multi-models and its best selection of a unit-stock, exploitation rate, maximum sustainable yield and maximum economic yield. This course is also designed for understanding the methods for determination of fish production using equilibrium and non-equilibrium models. Additionally, this course covers basic understanding the relationships between population parameter, stock assessment, and fisheries management; effects of fishing on target species, non-target species, environment and ecosystems.

Learning Outcomes:

At the end of the course, the students will be able to: i) Know about the unit-stocks identification, stock parameters, exploitation rate of fish stocks; ii) estimate the maximum sustainable yield and, Biomass.

At the end of this course, in specific, the students will able to-

CLOs	Course Learning Outcomes	Lectures
CLO1	Know the stock, unit-stock, scope, purpose and importance of the studying of fish stock Assessment.	3
CLO2	Identify and segregate the unit stocks of fishes through multiple methods and confirmation by DNA and molecular studies.	3
CLO3	Estimate the growth parameters from length-frequency data, mark-recapture data and hard parts analyses through multi-models and its best selection. Also be able to know the reproduction and recruitment of a fish stock.	3
CLO4	Estimate the mortality through different conventional methods and be able to calculate	3

	the exploitation rate.	
CLO5	Calculate the maximum sustainable yield and be able to know the Maximum economic yield.	4
CLO6	Know Equilibrium models (surplus production models), non-equilibrium models (process-error and observation-error methods), potential yield estimators, biomass models, delay-difference models, virtual population and cohort analysis, yield per recruit model, Thomson and Bell model, simulation and ecosystem models.	3
CLO7	Make and explore the relationships between population parameter estimations, stock assessment, and fisheries management; effects of fishing on target species, non-target species, environment and ecosystems.	3

Mapping CLOs with PLOs

CLOs	**PLOs**		
	PLO1	**PLO2**	**PLO3**
CLO1	X	●	X
CLO2	X	●	X
CLO3	●	X	X
CLO4	●	X	X
CLO5	●	X	X
CLO6	●	X	X
CLO7	X	X	X

X Strong contribution ● Weak contribution ☐ No contribution

Lesson Plan

CLOs	**Course Contents**	**Teaching Strategy**	**Assessment Strategy**
CLO1	Introduction, scope, scope, expected outcomes and importance.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Stock structure and abundance: Concept population and unit stocks, methods of identification and segregation of unit stocks, abundance of fish stocks.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO3	Factors that increases biomass: Size and growth, growth from length-frequency data, mark-recapture data and hard parts analyses, reproduction, recruitment	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO4	Factors that decreases biomass: Conceptualization of mortality estimation equation; various conventional models for estimating fishing and natural mortalities.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO5	Stock assessment: Purpose of stock assessment; concept of maximum sustainable yield.	- Lectures followed by discussion - Participatory question-answer - Video demonstration	
CLO6	Yield: Equilibrium models (surplus	- Lectures followed by discussion	

	production models), non-equilibrium models (process-error and observation-error methods), potential yield estimators, biomass models, delay-difference models, virtual population and cohort analysis, yield per recruit model, Thomson and Bell model, simulation and ecosystem models.	- Participatory question-answer - Online resources	
CLO7	Conclusion: Relationships between population parameter estimations, stock assessment, and fisheries management; effects of fishing on target species, non-target species, environment and ecosystems.	- Lectures followed by discussion - Participatory question-answer	

Recommended books/literature:

- Cushing, D.H., 1977. Science and the Fisheries. Edward Arnold Publishers Ltd. 25, Hill Street, London. 60 pp.
- Dwiponggo, A., 1986. Growth, mortality, and recruitment of commercially important fishes and penaeid shrimps in Indonesian waters. Filipiniana Specialist, Manila. 91 pp. FAO. 2001. Yearbook of fishery. Statistics of catches and landings.
- Gulland, J.A. (ed.), 1983. Fish Stock Assessment: A Manual of Basic Methods. Chichester, U.K., Wiley Interscience, FAO/Wiley series on food and agriculture, Vol. 1. 223 pp.
- Gulland, J.A. (ed.), 1988. Fish Population Dynamics. Second edition. John Wiley & Sons, Inc., New York.
- King, M., 1995. Fisheries Biology, Assessment and Management. Fishing News Books, 342 p.
- Lagler, K.F., 1956. Freshwater Biology, Second edition, William C. Brown Co. Dubuque, Iowa. 421 pp.
- Nikolskii, G.V., 1982. Theory of fish population dynamics. Bishen Singh, Mahendra Pal Singh and Otto Koeltz, Sci. Publishers, 323 pp.
- Ricker, W.E., 1968. Methos of assessment of fish production in freshwaters. Blackwell Scientific Publications, Oxford, 321 pp.
- Ricker, W.E., 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382 p.
- Solomon, M.E. 1976. Population dynamics. Second edition, Arnold (Publishers) Ltd. 67 pp.
- Rounsefell, G.A. and Everhart, W.H., 1953. Fishery Science: Its methods and application. John Wiley & Sons, Inc., New York. 444 pp.
- Sparre, P., Ursin, E. and Venema, S.C., 1989. Introduction to tropical fish stock assessment. Part 1. Manual. FAO Fisheries Technical Paper. No. 306.1. Rome, FAO. 337 pp.

FMMC-642: Coastal & Marine Fisheries Management and Conservation

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Six questions to be set and five to be answered)

Course Description:

This course is a basic theoretical course and prerequisite to complete one and half year MS in Fisheries Management degree. The course coverers concepts of marine fisheries management; marine fisheries resources, their economic importance, and management. ecosystem conservation and fisheries management, national and international policies for marine fisheries management; role of government and NGOs in coastal fisheries management; property rights and coastal fisheries; role of fishers' community; Bay of Bengal programme (BOBP), Socio-economic aspects, climate change and marine fisheries management. The course is designed to strengthen the student's existing knowledge on wetland ecosystem and fisheries biodiversity

Learning Outcomes:

At the end of the course, the students will be able to know about different typesofinland and marine fisheries resources and its conservation and management.

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

CLOs	Course Learning Outcomes	Lectures
CLO1	Overview: Concepts of marine fisheries management; marine fisheries resources, their economic importance, and management.	2
CLO2	Environment and fisheries management: Factors influencing fish life in marine water; habitat, food and feeding habits, competition, predation, migration, spawning, pollution, and salinity; coastal weather, weather forecast; surface currents, their changes and effects on fish distribution, migrationand recruitment; diurnal behaviour of fish in relation to weather.	2
CLO3	Fishing gear and fisheries management: Marine fishing gears and their impacts on fisheries resources; complexity of multigear and multispecies fisheries management; reduction of fishing effort in estuarine set bag-net (ESBN) fishery; banning of particular gear; management of industrial trawl fishery.	2
CLO4	Ecosystem conservation and fisheries management: Conservation of biodiversity in fisheries management; minimizing bycatch of sensitive species groups; unreported fishing; ecosystem modeling and fisheries management; conservation rules and regulations; institutional strengthening and infrastructural development.	2
CLO5	Policies and Programmes: National and international policies for marine fisheries management, role of government and NGOs in coastal fisheries management; property rights and coastal fisheries, role of fishers community, Bay of Bengal programme (BOBP).	2
CLO6	Socio-economic aspects: Existing problems in marine fisheries and their solutions; fishing rights and conflicts; socioeconomic conditions of fisherfolk and their role in marine fisheries management.	2
CLO7	Climate change and marine fisheries management: Impacts of climate change on coastal and marine fisheries resources; fisheries management and conservation strategies in changing climate.	2

Mapping CLOs with PLOs

CLOs	PLOs		
	PLO1	PLO2	PLO3
CLO1	X	●	X
CLO2	X	●	X
CLO3	X	●	X
CLO4	X	●	X
CLO5	X	●	X
CLO6	●	X	X
CLO7	●	X	X

X Strong contribution ● Weak contribution ☐ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Overview: Concepts of marine fisheries management; marine fisheries resources, their economic importance, and management.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Environment and fisheries management: Factors influencing fish life inmarine water; habitat, food and feeding habits, competition, predation,migration, spawning, pollution, and salinity; coastal weather, weatherforecast; surface currents, their changes and effects on fish distribution,migration and recruitment; diurnal behaviour of fish in relation toweather.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO3	Fishing gear and fisheries management: Marine fishing gears and their impacts on fisheries resources; complexity of multigear and multispecies fisheries management; reduction of fishing effort in estuarine set bag-net (ESBN) fishery; banning of particular gear; management of industrial trawl fishery.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO4	Ecosystem conservation and fisheries management: Conservation of biodiversity in fisheries management; minimizing bycatch of sensitive species groups; unreported fishing; ecosystem modeling and fisheries management; conservation rules and regulations; institutional strengthening and infrastructural development.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO5	Policies and Programmes: National and international policies for marine fisheries management, role of government and NGOs in coastal fisheries management; property rights and coastal fisheries, role of fishers community, Bay of Bengal programme (BOBP).	- Lectures followed by discussion - Participatory question-answer - Online resources - Video demonstration	
CLO6	Socio-economic aspects: Existing problems in marine fisheries and their solutions; fishing rights and conflicts; socioeconomic conditions of fisherfolk and their role in marine fisheries management.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO7	Climate change and marine fisheries management: Impacts of climate change on coastal and marine fisheries resources; fisheries management and conservation strategies in changing climate	- Lectures followed by discussion - Participatory question-answer	

Recommended books/literature:

- BOBP. 1993. Studies of Interactive Marine Fisheries of Bangladesh. BOBP/WP/89. Bay of Bengal Programme, Madras, India.
- Levinton, J.S. 2008. Marine Biology: Function, Biodiversity, Ecology. Oxford University Press, USA. 640 pp.
- Gunderson, D.R. 1993. Surveys of Fisheries Resources. John Wiley and Sons, Inc., New York. 233 pp.
- Laevastu, T. 1993. Marine Climate, Weather and Fisheries. Blackwell Scientific Publications, Inc., England. 204 pp.
- Glantz, M.H. (ed.). 2005. Climate Variability, Climate Change, and Fisheries. Cambridge University Press. 460 pp.

- Parsons, T.R., Takahashi and B. Hargrave. 1984. Biological Oceanographic Process. Pergamon Press, England. 330 pp.
- King, M., 1995. Fisheries Biology, Assessment and Management. Fishing News Books, 342 p.
- Prawn and Prawn Fisheries of India, C. V. Kurian and V. O. Sebastian (1976), Hindustan Publ. Co., New Delhi.

FMMC-643: Mangrove Fisheries Management and Conservation

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Six questions to be set and five to be answered)

Course Description:

This course is a compulsory course of MS in Fisheries Management degree. The course covers aquaculture practices, conflict and constraints in mangrove ecosystem and their conservation issues. The course is designed to strengthen the student's existing knowledge on mangrove fisheries management and conservation issues. This course can also teach them about mangrove ecology; importance and status of mangrove fisheries in Bangladesh, brackish water and mangrove environment, aquaculture practices in mangrove area and Nutrients and plankton in mangrove environment. A number of further topics, like use of mangrove ecosystem, soil acidity, acid sulfate problem reclamation; harmful and beneficial plants for aquaculture in mangrove area will be also focused in the course.

Learning Outcomes:

At the end of the course, the students will be able to understand about importance, present status of mangrove fisheries, conflict and constraints in aquaculture practice in mangrove ecosystem.

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

CLOs	Course Learning Outcomes	Lectures
CLO1	Describe scope, types and importance of Mangrove fisheries	1
CLO2	Explain status of mangrove fisheries in Bangladesh.	2
CLO3	Discuss about processes in mangrove forests	2
CLO4	Describe population parameters of mangrove forest.	2
CLO5	Explain nutrients and plankton population and their interrelation in mangrove environment.	2
CLO6	Discuss about relation among Brackish water and mangrove environment.	2
CLO7	Discuss about different aquaculture practices in mangrove area	2
CLO8	Explain conflict of mangrove aquaculture with other uses of coastal zone	2
CLO9	Discuss constraints of aquaculture in mangrove area.	2
CLO10	Describe environmental economics and use of mangrove resources	2

Mapping CLOs with PLOs

CLOs	PLOs		
	PLO1	PLO2	PLO3
CLO1	X	●	X
CLO2	X	●	X
CLO3	X	●	X
CLO4	X	X	X

CLO5	●	X	X
CLO6	X	●	X
CLO7	●	●	X
CLO8	X	●	X
CLO9	X	●	X
CLO10	X	●	X

X Strong contribution ● Weak contribution ☐ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction, rationale, and expected outcome.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Concept of mangrove ecology; importance and status of mangrove fisheries in Bangladesh.	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO3	Ecosystem processes in mangrove forests	- Lectures followed by discussion - Participatory question-answer	
CLO4	Population parameters in relation to aging of mangrove	- Lectures followed by discussion - Participatory question-answer	
CLO5	Nutrients and plankton in mangrove environment	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO6	Brackish water and mangrove environment.	- Lectures followed by discussion - Participatory question-answer	
CLO7	Aquaculture practices in mangrove area	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO8	Use of mangrove ecosystem, simulation in fisheries management and research; conflict of mangrove aquaculture with other uses of coastal zone	- Lectures followed by discussion - Participatory question-answer	
CLO9	Constraints of aquaculture in mangrove area, soil acidity, acid sulfate problem reclamation; harmful and beneficial plants for aquaculture in mangrove area	- Lectures followed by discussion - Participatory question-answer	
CLO10	Environmental economics and use of mangrove resources	- Lectures followed by discussion - Participatory question-answer	

Recommended books/literature:

- Aksornkoae, S. 1993. Ecology and management of mangroves. IUCN, Bangkok, Thailand, 175 pp.
- FAO. 1982. Management and utilization of mangrove in Asia and the Pacific. FAO Environment Paper 3. Food and Agriculture Organization of the United Nations, Rome.
- Hussain, Z. and G. Acharya. 1994. Mangroves of the Sundarbans. IUCN, Bangkok Thailand. 252 pp.
- Barg, U.C. 1992. Guidelines for the promotion of environmental management of coastal aquaculture development. FAO Fisheries Technical Paper 328. Food and Agriculture Organization of the United Nations, Rome. 122 pp.
- Chaffey, D.R., F.R. Miller, and J.H. Sandom. 1985. A forest inventory of Sundarbans, Bangladesh. Project

Report 140, Overseas Development Administration (ODA), UK.
- CMFRI, 1978. Breeding and rearing of marine prawns. Central Marine Fisheries Research Institute, Cochin, Special Pub. No. 3, 128 pp.
- Daugherty, H.E. 1975. Human impact on the mangrove forests of El Salvador. In: Walsl, G.E., S.C. Snedaker and H.J. Teas (eds.), Proceedings of International Symposium on Biology and Management of Mangroves. University of Florida, Gainesville. 816-824 pp.
- Hill, B.J. 1974. Salinity and temperature tolerance of zoeae of the portunid crab *Scyllaserrata*. Mar. Biol., Vol. No. 25.
- Kanapathy, K. 1975. The reclamation and improvement of acid sulphate soils for aquaculture. Malaysian Agric. J. 50: 264-270.
- Macnae, W. 1968. A general account of the funa and flora of mangrove swamps and forests in the Indo-West Pacific region. Adv. Mac. Biol., 6: 73-270.
- Macnae, W. 1974. Mangrove forests and fisheries. Indian Ocean Programme Pub. No. 34. India Ocean Fishery Commission, Rome I OFC/DEV. 70/34, 35 pp.

FMMC-644: Advanced Aquatic Pollution and Toxicology

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Six questions to be set and five to be answered)

Course Description:

This course is a compulsory course of MS in Fisheries Management degree. The course covers sources of pollution in aquatic environment and their impact on aquatic organisms. The course is designed to strengthen the student's existing knowledge on different category of aqua toxins with their sources and biological aspects of toxic algae and their implication on human health. This course can also teach them about concept of aquatic pollution and toxicology, sources and types of pollution and impact of pollution in aquaculture, harmful algal bloom and toxicity, epidemiological issues of harmful algae and their relation with some human diseases. A number of further topics, like lethal and sub-lethal effects of heavy metal on aquatic biota and organic and inorganic materials in aquatic habitats and their harmful effects on aquatic will be also focused in the course.

Learing Outcomes:

At the end of the course, the students will be able to understand about different category of aqua toxins with their sources and biological aspects of toxic algae and their implication on human health.

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

CLOs	Course Learning Outcomes	Lectures
CLO1	Describe scope and importance of aquatic pollution and toxicology	2
CLO2	Explain concept of aquatic pollution and toxicology	2
CLO3	Discuss about sources and types of pollution and impact of pollution in aquaculture	2
CLO4	Describe harmful algal bloom and toxicity.	3
CLO5	Explain epidemiological issues of harmful algae and their relation with some human diseases	3
CLO6	Describe lethal and sub-lethal effects of heavy metal on aquatic biota.	2
CLO7	Discuss about organic and inorganic materials in aquatic habitats and their harmful effects on aquatic ecosystem	2
CLO8	Explain indicator organisms; uptake of pollutant and use of bio-markers for toxicity determination	2
CLO9	Discuss instrumental methods for the determination of aqua-toxins	2

Mapping CLOs with PLOs

CLOs	PLOs		
	PLO1	PLO2	PLO3
CLO1	●	●	X
CLO2	●	●	X
CLO3	●	**X**	X
CLO4	X	●	X
CLO5	X	●	X
CLO6	●	X	X
CLO7	X	●	X
CLO8	X	●	X
CLO9	●	**X**	X

X Strong contribution ● Weak contribution ☐ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction, rationale, and expected outcome.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	**Concept of aquatic pollution and toxicology**: Purpose of studying aquatic pollution and toxicology; different toxic substances on aquatic organisms and their potential impact on human health	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO3	**Environmental pollution**: Sources of pollution; types of pollutant; industrial effluents (tanneries, refineries, dying and textiles); agricultural (pesticides, fertilizers, jute retting, poultry wastes); impacts on aquaculture (ichthyotoxins, chemicals, faecal and feed wastes, farm effluents); oils and surfactants; domestic and municipal sewage	- Lectures followed by discussion - Participatory question-answer	
CLO4	**Harmful algal blooms and toxicity**: Some biological aspects of toxic algae (Cyanobacterians, Diatoms, Dinoflagellates, etc); ecological implications of algal toxins in aquatic food webs; mode of action of toxins in seafood poisoning, Paralytic Shellfish Poisoning (PSP); Diarrhetic Shellfish Poisoning (DSP); *Ciguatera* Fish Poisoning (CFP); measurement of toxins from different groups of toxic algae; mechanisms of toxin production and	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	

	Toxicity		
CLO5	**Harmful algal epidemiology and public health**: Epidemiological issues and harmful algae, relation of some human diseases with harmful and toxic algal proliferation; algal toxin in waters of domestic use	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO6	Lethal and sub-lethal effects of heavy metal on aquatic biota: Effects on domestic animals; public health hazards	- Lectures followed by discussion - Participatory question-answer	
CLO7	Loading organic and inorganic materials in aquatic habitats and their harmful effects on aquatic ecosystem	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO8	**Aquatic bio-markers**: Indicator organisms; uptake of pollutant; distribution and excretion of toxic compounds; effects on molecular, cellular, individual and population levels; use of bio-markers for toxicity determination	- Lectures followed by discussion - Participatory question-answer	
CLO9	**Instrumental methods for the determination of aqua-toxins**: Determination of toxins using TLC and HPLC; Enzyme-Linked Immunosorbent Assay (ELISA)	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	

Recommended books/literature:

- Rand, G.M. and S.R. Petrocelli (eds.). 1985. Fundamentals of Aquatic Toxicology. Hemisphere, Washington, D.C.
- Calow, P. (ed.) 1995. Handbook of Ecotoxicology. Vols 1&2. Blackwell Scientific Publication, Inc., Cambridge.
- Forbes, V.E. and T. L. Forbes. 1994. Ecotoxicology in Theory and Practice. Chapman and Hall Publishers. London. UK.
- Pillay, T.V.R. 1992. Aquaculture and the Environment. Fishing News Books, UK. 189 pp.
- Furness, R.W. and P.S. Rainbow (eds.) 1990. Heavy Metals in the Marine Environment. CRC Press, Inc., Florida. 256 pp.
- Furness, R.W. and P.S. Rainbow (eds.) 1993. Ecotoxicology of Metals in Invertebrates. Lews Publishers, Florida. 461 pp.
- Vymazal, J. 1995. Algae and Element Cycling in Wetlands. CRC Press, Inc., Florida. 689 pp.
- Moriarty, F. 1993. Ecotoxicology: The Study of Pollutants in Ecosystems. Academic Press, London. 289 pp.
- Calhoun, Y. 2005. Water Pollution. Chelsea House Publishers. 164 pp.
- Chorus, I. (ed.) 2001. Cyanotoxins – Occurrence, Causes, Consequences. Springer. 357 pp.
- Falconer, I.R. 1993. Algal Toxins in Sea Food and Drinking Water. Academic Press. 224 pp.
- Laws, E.A. 2000. Aquatic Pollution: An Introductory Text. 3rd Edition. Wiley. 639 pp.
- Smol, S. 2005. Pollution of Lakes and Rivers. A Hodder Arnold Publication.

OPTIONAL COURSES

FMMO-645: Climate Change and Fisheries Management

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Six questions to be set and five to be answered)

Course Description:

This course is a basic theoretical course and prerequisite for understanding the courses related to climate change and its historical and future trends, global warming, causes of climate change, greenhouse effects, human effects on climate. The course is designed to strengthen the student's existing knowledge on the vulnerability to climate change and adaptation with excessive rainfalls and floods, storms, hurricanes, and tropical cyclones, sea level rise, salinity intrusion and land subsidence. This course is also designed for understanding the Inland fisheries, small-scale and artisanal marine fisheries, large-scale marine fisheries, potential positive and negative impacts, vulnerability of regions, groups and hot spots (national, global), adaptation of fisheries management, the role of institutions in adaptation. Additionally, this course covers basic understanding the Global negotiations on climate changelessons from Montreal and Kyoto protocols, Copenhagen declaration, IPCC, CCIA, compliance of the rich and poorer countries including position of Bangladesh.

Learning Outcomes:

At the end of the course, the students will be able to: i) Know about the climate change in fisheries; and ii) adaptation and mitigation of climate change in fisheries of Bangladesh.

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

CLOs	Course Learning Outcomes	Lectures
CLO1	Know the climate, climate change and its rationale, and expected outcome.	3
CLO2	Know the historical trends and future climate change, global warming, causes of climate change, greenhouse effects, human effects on climate; ecosystem impacts of climate change, predicting climate change.	3
CLO3	Describe the vulnerability to climate change and adaptation responses:Extremes of temperatures, droughts, changes in precipitation and excessive rainfalls and floods, storms, hurricanes, and tropical cyclones, sea level rise, salinity intrusion and land subsidence, impacts to the livelihood of the communities.	3
CLO4	Describe the physical basis in freshwater, brackish water, and marine systems, heat content and temperature, inland waters, ocean ecosystems, ocean salinity, density and stratification, coastal upwelling, ocean acidification and changes in other chemical properties.	3
CLO5	Know the Primary production, secondary production, food web impacts from plankton to fish, physiological effects, spawning, growth and recruitment processes, species invasions and diseases.	3
CLO6	Describe the Inland fisheries, small-scale and artisanal marine fisheries, large-scale marine fisheries, potential positive and negative impacts, vulnerability of regions, groups and hot spots (national, global), adaptation of fisheries management, the role of institutions in adaptation.	3
CLO7	Know the food fish production and needs, aquaculture production, impacts of climate change on aquaculture (both freshwater and coastal), potential impacts of aquaculture on climate change, estimating aquaculture's contribution to climatic change, other adaptive measures.	3
CLO8	Know the Global negotiations on climate changelessons from Montreal and Kyoto protocols, Copenhagen declaration, IPCC, CCIA, compliance of the rich and poorer countries including position of Bangladesh.	1

Mapping CLOs with PLOs

CLOs	PLOs		
	PLO1	PLO2	PLO3
CLO1	X	●	X
CLO2	●	X	X
CLO3	●	**X**	X
CLO4	X	●	X
CLO5	●	●	X
CLO6	X	●	X
CLO7	●	X	X
CLO8	●	●	X

X Strong contribution ● Weak contribution ☐ No contribution

Lesson Plan:

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Know Introduction, rationale, and expected outcome.	-Lectures followed by discussion -Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination(70)
CLO2	Introduction to climate change: Historical trends and future climate change, global warming, causes of climate change, greenhouse effects, human effects on climate; ecosystem impacts of climate change, predicting climate change.	-Lectures followed by discussion -Participatory question-answer -Online resources	
CLO3	Vulnerability to climate change and adaptation responses:Extremes of temperatures, droughts, changes in precipitation and excessive rainfalls and floods, storms, hurricanes, and tropical cyclones, sea level rise, salinity intrusion and land subsidence, impacts to the livelihood of the communities.	-Lectures followed by discussion -Participatory question-answer	
CLO4	Climate change: The physical basis in freshwater, brackish water, and marine systems, heat content and temperature, inland waters, ocean ecosystems, ocean salinity, density and stratification, coastal upwelling, ocean acidification and changes in other chemical properties.	-Lectures followed by discussion -Participatory question-answer -Online resources	
CLO5	Climate variability and changes on ecosystem and fish production processes: Primary production, secondary production, food web impacts from plankton to fish, physiological effects, spawning, growth and recruitment processes, species invasions and diseases.	-Lectures followed by discussion -Participatory question-answer -Online resources -Video demonstration	

CLO6	Climate change and capture fisheries: Inland fisheries, small-scale and artisanal marine fisheries, large-scale marine fisheries, potential positive and negative impacts, vulnerability of regions, groups and hot spots (national, global), adaptation of fisheries management, the role of institutions in adaptation.	-Lectures followed by discussion -Participatory question-answer -Online resources	
CLO7	Climate change and aquaculture: Food fish production and needs, aquaculture production, impacts of climate change on aquaculture (both freshwater and coastal), potential impacts of aquaculture on climate change, estimating aquaculture's contribution to climatic change, other adaptive measures.	-Lectures followed by discussion -Participatory question-answer -Online resources	
CLO8	Global negotiations on climate change:lessons from Montreal and Kyoto protocols, Copenhagen declaration, IPCC, CCIA, compliance of the rich and poorer countries including position of Bangladesh.	-Lectures followed by discussion -Participatory question-answer -Online resources	

Recommended books/literature:

- Climate change implications for fisheries and aquaculture. (2009), fisheries and aquaculture technical paper-530
- Laevastu, T. 1993. Marine Climate, Weather and Fisheries. Blackwell Scientific Publications, Inc., England. 204 pp.
- Glantz, M.H. (ed.). 2005. Climate Variability, Climate Change, and Fisheries. Cambridge University Press. 460 pp.
- Middendorp. H.A.J., P.M. Thomson and R.S. Pomeroy (eds.). 1999. Sustainable Inland Fisheries Management in Bangladesh. ICLARM Conference Proceedings No. 58: 280 pp.
- Tsai, C. and M.Y. Ali. 1997. Open-water Fisheries of Bangladesh. The University Press Ltd., Dhaka. 212 pp.
- Valbo-Jørgensen J. and P.M. Thompson. 2007. Culture-based fisheries in Bangladesh: A socioeconomic perspective. FAO Fisheries Technical Paper No. 499, Rom. 41 pp.
- Foundation of Climatology. E.T. Stringer. 1989. Delhi: Surjeet Publications.

FMMO-646: Community Based Fisheries Management

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Six questions to be set and five to be answered)

Course Description:

This course is a compulsory course of MS in Fisheries Management degree. The course covers the scope and role of CBFM, different group formation, inter-sectoralcooperation,fishing rights and fishery conflicts, economic and social impact of the CBFM. The course is designed to strengthen the student's existing knowledge on institutional and legal issues of CBFM and economic and social impact of the CBFM. This course can also teach them about private initiative and GOB support; differentiate between nature and extent of implementation of CBFM and the role of fishers and community members.

Learing Outcomes:

At the end of the course, the students will be able to understand i Concept, scope, and importance of CBFM, ii) Institutional and legal issues, iii) CBFM indifferent waterbodies and iv) Economic and social impact of the CBFM.

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

CLOs	Course Learning Outcomes	Lectures
CLO1	Define community based fisheries management; describe justification of community based fisheries management and its different outcomes.	1
CLO2	Discuss Concept, scope, and importance of CBFM; describe the overview of community based fisheries management (CBFM) in Asian countries and global perspectives, its relevance to Bangladesh.	2
CLO3	Discuss community identification, discuss about different group formation; describe about job description in the group and distribution of benefits	2
CLO4	Explain Institutional and legal issues; discuss about the ownership of waters and land; describe the different leasing arrangements; discuss about users rights and conflict prevention; discuss and compare among the inter-sectoral cooperation.	3
CLO5	Describe the different factors to be considered for CBFM; define organization and motivation of fishers, villagers and other stakeholders, private initiative and GOB support; differentiate between nature and extent of implementation of CBFM; discuss the role of fishers and community members.	3
CLO6	Discuss about CBFM in rivers, Oxbow lakes, beels, haors, floodplains, Flood Control Drainage (FCD) and Flood Control Drainage and Irrigation (FCDI) systems; mode of operation and sustainability.	3
CLO7	Describe and compare linkage among fish, fishers, and communities along the waterbodies; fishers and fishing communities; managing fisheries; fishing rights and fishery conflicts; implications of culture-based fishery.	2
CLO8	Explain Economic and social impact of the CBFM; discuss various support services by GOB, donors, NGOs, and community-based organizations; explain the role of fishers and various stakeholders; future potential	2

Mapping CLOs with PLOs

CLOs	PLOs		
	PLO1	PLO2	PLO3
CLO1	X	●	X
CLO2	X	●	X
CLO3	X	●	X
CLO4	X	●	X
CLO5	X	●	X
CLO6	X	●	X
CLO7	X	●	X
CLO8	X	X	X

X Strong contribution ● Weak contribution ☐ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Introduction, rationale, and expected	- Lectures followed by discussion	**Total: 100**

	outcome.	- Participatory question-answer	Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Concept, scope, and importance; overview of community based fisheries management (CBFM) in Asian countries and global perspectives, its relevance to Bangladesh.	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO3	Models of CBFM: Community identification, group formation, job description in the group and distribution of benefits.	- Lectures followed by discussion - Participatory question-answer -	
CLO4	Institutional and legal issues; ownership of waters and land; leasing arrangements; users rights and conflict prevention; inter-sectoral cooperation.	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO5	Factors to be considered for CBFM; organization and motivation of fishers, villagers and other stakeholders, private initiative and GOB support; nature and extent of implementation of CBFM; role of fishers and community members	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO6	CBFM in rivers, Oxbow lakes, beels, haors, floodplains, Flood Control Drainage (FCD) and Flood Control Drainage and Irrigation (FCDI) systems; mode of operation and sustainability.	- Lectures followed by discussion - Participatory question-answer	
CLO7	Linkage among fish, fishers, and communities along the waterbodies; fishers and fishing communities; managing fisheries; fishing rights and fishery conflicts; implications of culture-based fishery.	- Lectures followed by discussion - Participatory question-answer	
CLO8	Economic and social impact of the CBFM; support services by GOB, donors, NGOs, and community-based organizations; role of fishers and various stakeholders; future potential	- Lectures followed by discussion - Participatory question-answer	

Recommended books/literature:

- DOF. 1999. Community Based Fisheries Management and Future Strategies for Inland Fisheries in Bangladesh. Proceedings of the Workshop Organized by DOF and ICLARM, Supported by the Ford Foundation. 92pp.
- Middendorp. H.A.J., P.M. Thomson and R.S. Pomeroy (eds.). 1999. Sustainable Inland Fisheries Management in Bangladesh. ICLARM Conference Proceedings No. 58: 280 pp.
- Tsai, C. and M.Y. Ali. 1997. Open-water Fisheries of Bangladesh. The University Press Ltd., Dhaka. 212 pp.
- Valbo-Jørgensen J. and P.M. Thompson. 2007. Culture-based fisheries in Bangladesh: A socioeconomic perspective. FAO Fisheries Technical Paper No. 499, Rom. 41 pp.
- Pinkerton, E. 1989. Co-management and Small-scale Fisheries: A Policy Brief. ICLARM, Manila.
- Ali, M.Y. 1997. Fish, Water and People: Reflections on Inland Openwater Fisheries Resources of Bangladesh. The University Press Ltd., Dhaka.154pp.
- Berkes, F. and M.F. Farvar. 1989. Introduction and Overview. *In* F. Berkes (ed.) Common Property Resources: Ecology and Community Based Sustainable Development. Bellhaven Press, London. pp.1-17.
- Berkes, F. 1994. Property rights and coastal fisheries. *In* R.S. Pomeroy (ed.) Community Management and Common Property of Coastal Fisheries in Asia and the Pacific: Concepts, Methods and Experiences. ICLARM Conference Proceedings No. 45: 51-52.

- Ali, N.Y. 1990. Towards sustainable development: Fisheries resources of Bangladesh. Ministry of Environment and Forest, Bangladesh. 96 pp.

FMMO-647: Ecology of Fishes

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Six questions to be set and five to be answered)

Course Description:

This course is a basic theoretical course and prerequisite for understanding fish and aquatic ecosystems. The course is designed to strengthen the student's existing knowledge on Intra- and inter relationships among fishes and other biota in ecosystems. This course can also teach them food stuffs and feeding ecology of fishes, and reproductive ecology with time and space. A number of further topics, like spawning, feeding and over wintering migrations of fishes will be also focused in the course.

Learning Outcomes:

At the end of the course, the students will be able to understand about Intra- and inter relationships among fishes and other biota in ecosystems, feeding and reproductive ecology and life story patterns of fishes.

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

CLOs	Course Learning Outcomes	Lectures
CLO1	Describe fish and aquatic ecosystems	2
CLO2	Explain Intra- and inter relationships among fishes and other biota in ecosystems	2
CLO3	Discuss about food stuffs and feeding ecology of fishes	3
CLO4	Describe reproductive ecology with time and space, environmental influences on reproductive cycle	3
CLO5	Explain spawning, feeding and over wintering migrations of fishes	3
CLO6	Explain life story patterns of fishes.	2

Mapping CLOs with PLOs

CLOs	PLOs		
	PLO1	PLO2	PLO3
CLO1	X	●	X
CLO2	●	X	X
CLO3	●	X	X
CLO4	●	X	X
CLO5	X	●	X
CLO6	X	●	X

X Strong contribution ● Weak contribution ☐ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Fish and aquatic ecosystems; Winberg and Brett equations	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Intra- and inter relationships among fishes and other biota in ecosystems	- Lectures followed by discussion - Participatory question-answer	
CLO3	Food stuffs and feeding ecology; prey detection and predator avoidance; ontogenic changes and habitat shifts, ontogenic changes in nutrient transport	- Lectures followed by discussion - Participatory question-answer	
CLO4	Reproductive ecology with time and space, reproductive diversity, environmental influences on reproductive cycle, terminology of fish ontogeny	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO5	Spawning, feeding and over wintering migrations of fishes with special reference to hilsa shad; hibernation	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO6	Life story patterns; Match-mismatch hypothesis	- Lectures followed by discussion - Participatory question-answer	

Recommended books/literature:

- Diana, J.S. 2004 Ecology of fishes. Biological Science Press, 498 pp.
- Jobling, M. 1994. Environmental Biology of Fishes. Springer, 476 pp.
- Wootton, R.J. 1998.Ecology of Teleost Fishes. 2nd Edition. Kluwer, Dordrecht, 392 pp.
- Nikolsky, G.V. 1965. Ecology of fishes. Academic press, London. 352 pp.
- Payne, A.L. 1986. The ecology of tropical lakes and rivers. John Wiley & Sons. Inc. New York. 301 pp.
- Wootton, R.J. 1992.Fish Ecology. Blackie, Glasgow & London, 212 pp.
- Clarke, G.L. 1966. Elements of Ecology. Revised edition. John Wiley & Sons, Inc., New York. 560 pp.
- Islam M.A. 1993. MacherPanirParisbeshtatya. Bangla Academy, Dhaka. 230 pp.
- Kumar, H.D. 1996. Modern concepts of ecology. Vikas Publishing House. Pvt. Ltd. 478 pp.
- Laevastu, T. and M.L. Hayes. 1995. Fisheries Oceanography and Ecology. Fishing News Books Ltd. UK.
- Odum, E.P. 1971. Fundamentals of Ecology. W.B. Saunders Co. 574 pp.
- Pitcher, T.J. and J.B. Hart. 1982. Fisheries Ecology. CroomHehn.

FMMO-648: Water Quality and Environmental Impact

Credit: 2

Full Marks: 100 [Theory 70, Class Test 20 (written and/or oral) and Attendance 10]

Time: 3 hours (Six questions to be set and five to be answered)

Course Description:

The course covers concept of water quality and Environmental & fisheries resources degradation issues. The course is designed to strengthen the student's existing knowledge water quality problems and their management in aquatic ecosystem. This course can also teach them about environmental issues and marine fisheries especially causes of degradation of marine environment of the Bay of Bengal.

LearingOutcomes:

At the end of the course, the students will be able to understand water quality problems and their management in aquatic ecosystem, environmental and fisheries resources degradation issues, environmental legislation, declaration of Earth Summit, and environmental quality standards.

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

CLOs	Course Learning Outcomes	Lectures
CLO1	Explain key concept of water qualityand link among water quality, stress, and disease	2
CLO2	Discuss water quality problems and their management in aquatic ecosystem.	2
CLO3	Describeenvironmental and fisheries resources degradation issues	2
CLO4	Explain impact of freshwater aquaculture on culture practice, water quality and public health	3
CLO5	Describe environmental impact on coastal shrimp farming	3
CLO6	Discuss about environmental issues and marine fisheries especially causes of degradation of marine environment of the Bay of Bengal	3
CLO7	Explain environmental legislation, declaration of Earth Summit, and environmental quality standards	3

Mapping CLOs with PLOs

CLOs	PLOs		
	PLO1	PLO2	PLO3
CLO1	●	X	X
CLO2	●	X	X
CLO3	●	X	X
CLO4	●	X	X
CLO5	X	X	X
CLO6	●	X	X
CLO7	●	X	X

X Strong contribution ● Weak contribution ☐ No contribution

Lesson Plan

CLOs	Course Contents	Teaching Strategy	Assessment Strategy
CLO1	Key concept of water quality: Goals of water quality management; link among water quality, stress, and disease; implications of differences in sensitivity to environmental change among different fish species and aquatic organisms.	- Lectures followed by discussion - Participatory question-answer	**Total: 100** Attendance (10) In course Examination/ Tutorial/Quiz/ Class Test (20) Final Examination (70)
CLO2	Water quality problems: Requirements for maintenance of fish health, problems associated with oxygen regime; pH fluctuation; ammonical and nitrite nitrogen; eutrophication; heavy metals; turbidity and sedimentation; evaporation and salinization.	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO3	Environmental and fisheries resources degradation: Water development projects, impact of water abstraction and irrigation, barrages, roads, highways and embankments, siltation, impacts of inland capture fisheries	- Lectures followed by discussion - Participatory question-answer	

	and strategies for improvement.		
CLO4	Impacts of freshwater aquaculture: Culture practices; inputs use (feed, fertilizers, chemicals), reduction in biodiversity and use of exotics species, water quality deterioration and public health, nutrient accumulation and eutrophication, drainage effect on the adjacent areas and waterbodies	- Lectures followed by discussion - Participatory question-answer - Demonstration picture	
CLO5	Environmental impact on coastal shrimp farming: Loss of mangrove forests, agricultural lands, livestock pastures, depletion of groundwater, salinity intrusion, eutrophication; problems associated with shrimp and other fish processing industries and their measures.	- Lectures followed by discussion - Participatory question-answer - Online resources	
CLO6	Environmental issues and marine fisheries: Causes of degradation of marine environment of the Bay of Bengal; oil spillage, industrial waste, ship breaking activities, municipal wastes, disposal of solid wastes; impact of marine fisheries**.**	- Lectures followed by discussion - Participatory question-answer	
CLO7	Environmental management: Environmental legislation (national and international), declaration of Earth Summit, environmental quality standards, and testing methods, monitoring methods, strategy of waste management.	- Lectures followed by discussion - Participatory question-answer	

Recommended books/literature:

- Alabaster, J.S. and R. Lloyd. 1982. Water Quality Criteria for Freshwater Fish. Second Edition. Butterfly Scientific Publisher, London.
- Boyd, C.E. 1998. Water Quality Management for Pond Fish Culture. Elsevier Scientific Publisher B.V., Amsterdam. 318 pp.
- Lloyd, R. 1992. Pollution and Freshwater Fish. Fishing News Books, Oxford, UK. 176 pp.
- Muller, R. and R. Lloyd. 1994. Sublethal and chronic effects of pollution on freshwater fish. Fishing News Books, UK. 288 pp.
- Calow, P. 1995. A Handbook of Ecotoxicology. Vol. 1-2. Blackwell Scientific Publications. UK.
- Forbes, V.E. and T.L. Forbes.1994. Ecotoxicology in Theory and Practice. Chapman and Hall Publishers, London, UK.
- Haslam, S.M. 1991. River Pollution: An Ecological Perspective. CBS Publishers & Distributors (Pvt.) Ltd.
- Nishant, A., Z. Hossain, M.K. Roy and A. Karim (eds.). 1993. Freshwater Wetlands in Bangladesh: Issues and Approaches for Management. IUCN, Gland, Switzerland. 383 pp.
- Pullin, R.S.V., H. Rosenthal and J.L. Maclean. 1993. Environment and Aquaculture in Developing Countries. ICLARM Conference Proceedings 31. 359 pp.
- Pillay, T.V.R. 1992. Aquaculture and Environment. Fishing News Books, UK.
- Rand, G.M. and S.R. Petrocelli (eds.). 1985. Fundamentals of Aquatic Toxicology. Hemisphere, Washington, D.C.

Research Work

FMMR-649: Research Defence-2
Credit: 2
Full Marks: 100

Students will face defence based on their research progress or findings of the research work.

Learing Outcomes:
At the end of the research progress presentation, the students will be able to respond comments and questions from the peers and faculties about their research efforts and can identify strength and weakness in ongoing research and presentations.

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FMMT-741: Thesis
Credit: 8

Full Marks: 100 (Abstract 10, Introduction 25, Methodology 20, Results and Discussion 20, Conclusion and Recommendation 5 and Reference cited 20 Marks)

Thesis may be consist of Abstract, introduction (including problem statement, hypothesis, importance, objectives, limitations, and review of literature), methodology, results & discussion, conclusion & recommendation, and reference cited.

Learning Outcomes:
At the end of the writing thesis, the student will demonstrate their ability to conduct own research project, select relevant literature, apply methodologies, process and analysis of data, make critical interpretation and answer to questions raised in the problem statement.

FMMD-742: Thesis Defense
Credit: 4
Full Marks: 100

Students will face defence based on research findings including problem statement, hypothesis, importance, objectives, limitations, methodology, results & discussion and recommendation.

Learnig Outcomes:
At the end of the writing thesis, the student will be able to i) present research findings in brief ii) develop their presentation skills iii) develop skills to accept and response to relevant and constructive feedback in a meaningful way.

Part D

20. Grading/Evaluation:

Eligibility for the semester final examination:

Candidates having less than 60% attendance will not be allowed to fill up the examination form. Candidates having less than 75% to 60% attendance will be allowed to fill up the examination form on special grounds on such documentary evidence and the approval of special permission of Academic Committee but students will have to pay in addition to the examination fees, the requisite fee prescribed by the syndicate for the purpose. Attendance marks will be allotted based on the following Table –

Earned Percentage*	90 and above	85 to less than 90	80 to less than 85	75 to less than 80	70 to less than 75	65 to less than 70	60 to less than 65	less than 60
Marks	10	9	8	7	6	5	4	0

* Earned percentage should be calculated in the round figure according to the regular statistical method.

Semester final results will be published in GPA out of 4 on the basis of all courses and final result for the MS in Aquaculture degree will be published in CGPA out of 4 on the basis of all semester final examinations.

Grades will be awarded in accordance with provisions shown in the table as –

Numerical grade*	Letter Grade	Grade Point
80% or its above	A^+ (A plus)	4.00
75% to less than 80%	A (A regular)	3.75
70% to less than 75%	A^- (A minus)	3.50
65% to less than 70%	B^+ (B plus)	3.25
60% to less than 65%	B (B regular)	3.00
55% to less than 60%	B^- (B minus)	2.75
50% to less than 55%	C^+ (C plus)	2.50
45% to less than 50%	C (C regular)	2.25
40% to less than 45%	D	2.00
Less than 40%	F	0.00
Incomplete**	I	-

* Earned numerical grade should be calculated in round figure (oncein a course) according to roundup statistical method.

** Absence from the final examination will be considered as incomplete with the letter grade "I".