INSTITUTE OF MARINE SCIENCES
Faculty of Marine Sciences and Fisheries
University of Chittagong, Chattogram 4331
Master of Science (M.S.) Degree Programs
Academic Year: 2023-2024 & 2024-2025
Total Marks: 900, Total Credits: 36

Syllabus for the M.S. in Marine Science

Course#	Course title	Thesis group	General group
Theoretical			
MS 501	Blue Economy and Sustainable Development	100(4)	100(4)
MS 502	Advanced Technologies in Marine Science	100(4)	100(4)
MS 503	Marine Ecosystem and Conservation	100(4)	100(4)
MS 504	Marine Biotechnology	100(4)	100(4)
MS 505	Marine Spatial Planning	100(4)	100(4)
MS 506	Ocean Policy and Governance	100(4)	100(4)
	Subtotal	600(24)	600(24)
Practical			
MS 507	Blue Economy and Sustainable Development Practical	-	25(1)
MS 508	Advanced Technologies in Marine Science Practical	-	25(1)
MS 509	Marine Ecosystem and Conservation Practical	-	25(1)
MS 510	Marine Biotechnology Practical	-	25(1)
MS 511	Marine Spatial Planning Practical	-	25(1)
MS 512	Ocean Policy and Governance Case Study	-	25(1)
	Subtotal	-	150(6)
MS 598	Project	-	50(2)
MS 599	Thesis	200(8)	-
MS 513	Project defense (Proposal 10, Final 40)	-	50(2)
MS 514	Thesis defense (Proposal 10, Final 40)	50(2)	-
MS 515	Viva-voce	50(2)	50(2)
	GRAND TOTAL	**900(36)**	**900(36)**

Syllabus for the M.S. in Marine Fisheries

Course#	Course title	Thesis group	General group
Theoretical			
MF 501	Blue Economy and Sustainable Development	100(4)	100(4)
MF 502	Advanced Technologies in Marine Science	100(4)	100(4)
MF 503	Marine Fisheries Management	100(4)	100(4)
MF 504	Mariculture	100(4)	100(4)
MF 505	Fisheries Post-Harvest Technology	100(4)	100(4)
MF 506	Fisheries Economics	100(4)	100(4)
	Subtotal	600(24)	600(24)
Practical			
MF 507	Blue Economy and Sustainable Development Practical	-	25(1)
MF 508	Advanced Technologies in Marine Science Practical	-	25(1)
MF 509	Marine Fisheries Assessment and Management Practical	-	25(1)
MF 510	Mariculture Practical	-	25(1)
MF 511	Fisheries Post-Harvest Technology Practical	-	25(1)
MF 512	Fisheries Economics Practical	-	25(1)
	Subtotal	-	150(6)
MF 598	Project	-	50(2)
MF 599	Thesis	200(8)	-
MS 513	Project defense (Proposal 10, Final 40)	-	50(2)
MS 514	Thesis defense (Proposal 10, Final 40)	50(2)	-
MF 515	Viva-voce	50(2)	50(2)
	GRAND TOTAL	**900(36)**	**900(36)**

Syllabus for the M.S. in Coastal and Marine Aquaculture

Course#	Course title	Thesis group	General group
Theoretical			
CMA 501	Blue Economy and Sustainable Development	100(4)	100(4)
CMA 502	Advanced Technologies in Marine Science	100(4)	100(4)
CMA 503	Seed Production and Hatchery Management	100(4)	100(4)
CMA 504	Aquaculture Systems	100(4)	100(4)
CMA 505	Aquaculture Nutrition	100(4)	100(4)
CMA 506	Sustainable Aquaculture	100(4)	100(4)
	Subtotal	600(24)	600(24)
Practical			
CMA 507	Blue Economy and Sustainable Development Practical	-	25(1)
CMA 508	Advanced Technologies in Marine Science Practical	-	25(1)
CMA 509	Seed Production and Hatchery Management Practical	-	25(1)
CMA 510	Aquaculture Systems Practical	-	25(1)
CMA 511	Aquaculture Nutrition Practical	-	25(1)
CMA 512	Sustainable Aquaculture Practical	-	25(1)
	Subtotal	-	150(6)
CMA 598	Project	-	50(2)
CMA 599	Thesis	200(8)	-
CMA 513	Project defense (Proposal 10, Final 40)	-	50(2)
CMA 514	Thesis defense (Proposal 10, Final 40)	50(2)	-
CMA 515	Viva-voce	50(2)	50(2)
	GRAND TOTAL	**900(36)**	**900(36)**

Syllabus for the M.S. in Marine Environmental Management

Course#	Course title	Thesis group	General group
Theoretical			
MEM 501	Blue Economy and Sustainable Development	100(4)	100(4)
MEM 502	Advanced Technologies in Marine Science	100(4)	100(4)
MEM 503	Advanced Marine Pollution	100(4)	100(4)
MEM 504	Marine Ecosystem Health Management	100(4)	100(4)
MEM 505	Marine Environmental Technology	100(4)	100(4)
MEM 506	Marine Environmental Law, Policy and Sustainability	100(4)	100(4)
	Subtotal	600(24)	600(24)
Practical			
MEM 507	Blue Economy and Sustainable Development Practical	-	25(1)
MEM 508	Advanced Technologies in Marine Science Practical	-	25(1)
MEM 509	Advanced Marine Pollution Practical	-	25(1)
MEM 510	Marine Ecosystem Health Management Practical	-	25(1)
MEM 511	Marine Environmental Technology Practical	-	25(1)
MEM 512	Marine Environmental Law, Policy and Sustainability Practical	-	25(1)
	Subtotal	-	150(6)
MEM 598	Project	-	50(2)
MEM 599	Thesis	200(8)	-
MEM 513	Project defense (Proposal 10, Final 40)	-	50(2)
MEM 514	Thesis defense (Proposal 10, Final 40)	50(2)	-
MEM 515	Viva-voce	50(2)	50(2)
	GRAND TOTAL	**900(36)**	**900(36)**

Syllabus for the M.S. in Fish Nutrition and Feed Technology

Course#	Course title	Thesis group	General group
Theoretical			
FNFT 501	Blue Economy and Sustainable Development	100(4)	100(4)
FNFT 502	Advanced Technologies in Marine Science	100(4)	100(4)
FNFT 503	Nutrition and Feeding of Fish and Shrimp	100(4)	100(4)
FNFT 504	Feed Ingredients and Feed Formulations	100(4)	100(4)
FNFT 505	Feed Technology and Feed Mill Management	100(4)	100(4)
FNFT 506	On-farm Feed Management	100(4)	100(4)
	Subtotal	600(24)	600(24)
Practical			
FNFT 507	Blue Economy and Sustainable Development Practical	-	25(1)
FNFT 508	Advanced Technologies in Marine Science Practical	-	25(1)
FNFT 509	Nutrition and Feeding of Fish and Shrimp Practical	-	25(1)
FNFT 510	Feed Ingredients and Feed Formulations Practical	-	25(1)
FNFT 511	Feed Technology and Feed Mill Management Practical	-	25(1)
FNFT 512	On-farm Feed Management Practical	-	25(1)
	Subtotal	-	150(6)
FNFT 598	Project	-	50(2)
FNFT 599	Thesis	200(8)	-
FNFT 513	Project defense (Proposal 10, Final 40)	-	50(2)
FNFT 514	Thesis defense (Proposal 10, Final 40)	50(2)	-
FNFT 515	Viva-voce	50(2)	50(2)
	GRAND TOTAL	**900(36)**	**900(36)**

Syllabus for the M.S. in Seafood Technology

Course#	Course title	Thesis group	General group
Theoretical			
SFT 501	Blue Economy and Sustainable Development	100(4)	100(4)
SFT 502	Advanced Technologies in Marine Science	100(4)	100(4)
SFT 503	Processing Technology	100(4)	100(4)
SFT 504	Hazard Analysis and Critical Control Point (HACCP)	100(4)	100(4)
SFT 505	Fisheries Microbiology	100(4)	100(4)
SFT 506	Seafood Safety and Quality Control	100(4)	100(4)
	Subtotal	600(24)	600(24)
Practical			
SFT 507	Blue Economy and Sustainable Development Practical	-	25(1)
SFT 508	Advanced Technologies in Marine Science Practical	-	25(1)
SFT 509	Processing Technology Practical	-	25(1)
SFT 510	Hazard Analysis and Critical Control Point (HACCP) Practical	-	25(1)
SFT 511	Fisheries Microbiology Practical	-	25(1)
SFT 512	Seafood Safety and Quality Control Practical	-	25(1)
	Subtotal	-	150(6)
SFT 598	Project	-	50(2)
SFT 599	Thesis	200(8)	-
SFT 513	Project defense (Proposal 10, Final 40)	-	50(2)
SFT 514	Thesis defense (Proposal 10, Final 40)	50(2)	-
SFT 515	Viva-voce	50(2)	50(2)
	GRAND TOTAL	**900(36)**	**900(36)**

Institute of Marine Sciences

Faculty of Marine Sciences and Fisheries

Syllabus for the M.S. in Marine Science

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Total Marks: 900, Total Credits: 36

M.S. in Marine Science

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MS 504	Marine Biotechnology	100(4)	100(4)
MS 505	Marine Spatial Planning	100(4)	100(4)
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MS 509	Marine Ecosystem and Conservation Practical	-	25(1)
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MS 511	Marine Spatial Planning Practical	-	25(1)
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	GRAND TOTAL	**900(36)**	**900(36)**

MS 501	**Blue Economy and Sustainable Development**	**100(4)**

Rationale

Bangladesh, being a maritime country, needs to adopt the blue economy as a top priority to promote socio-economic growth. A thrust in blue economic growth may come through sustainable resource management and ocean governance involving skilled and knowledgeable workforce, science-based planning, management tools and decision making. However, improvement of a strong human resource base is expected to contribute to the blue economy and sustainable development initiatives.

Objectives

The objective of this course is to provide students with knowledge on blue economy concepts and responsible use of ocean resources without compromising ecosystem health. The course also provides students with knowledge on blue economy sectors, SDGs interactions, economic resilience, ocean-based employment, relevant policies and pathway.

Learning outcomes

At the end of this course students are expected to be able to:

- understand ocean ecosystems and value of natural marine assets
- illustrate benefits of ocean ecosystem services to economy and society
- identify and prioritize challenges and opportunities for blue economy development
- manage ocean space in a more integrated manner
- define pathway in developing blue economy

Course contents

1. Growing ocean economy
   - 1.1 Global ocean economy
   - 1.2 Ocean ecosystem health
   - 1.3 Blue economy concept
   - 1.4 Blue economy indicators
2. Blue economy sectors
   - 2.1 Marine fisheries
   - 2.2 Marine trade
   - 2.3 Oil, gas and minerals
   - 2.4 Marine tourism
   - 2.5 Renewable energy
3. Marine fisheries interventions
   - 3.1 Extending the fishing horizon
   - 3.2 New fishing gears and techniques
   - 3.3 Discovering new fisheries
   - 3.4 Value addition and post-harvest loss reduction
   - 3.5 Fish stock assessment
4. Aquaculture and mariculture interventions
   - 4.1 Domestication
   - 4.2 Production intensification
   - 4.3 Innovation farming
   - 4.4 Live feeds for larviculture
   - 4.5 Disease and health management
5. Ecosystem-based management
   - 5.1 Elements of ecosystem
   - 5.2 Trophic interactions
   - 5.3 Coordination and integration of stakeholders
   - 5.4 Formulation of EBM plan
6. Global sustainability initiatives
   - 6.1 Brundtland Report 1987
   - 6.2 Earth Charter 1992
   - 6.3 Kyoto Protocol 1997
   - 6.4 UN Millennial Summit 2000 and MDGs
   - 6.5 UN Sustainable Development Goals (SDGs) 2015
7. Sustainable Development Goals (SDGs)
   - 7.1 Goals, targets and indicators
   - 7.2 Interactions among the 17 goals
   - 7.3 Interactions at target-level
   - 7.4 Knowledge gaps
   - 7.5 Science-policy interface
8. SDG 14: Life Below Water
   - 8.1 Key interactions, uncertainties and dimensions
   - 8.2 Prevent and reduce marine pollution
   - 8.3 Protect marine and coastal ecosystems
   - 8.4 Sustainable use of ocean resources
   - 8.5 Increase economic benefits
9. Climate change challenges
   - 9.1 Tropical cyclone and depression
   - 9.2 Sea-level rise
   - 9.3 Salinity incursion
   - 9.4 Ocean acidification
   - 9.5 Freshwater plume
   - 9.6 Hypoxic condition
10. Blue economy development framework
    - 10.1 Major sectors and stakeholders
    - 10.2 Capacity building

10.3 Design management plan
10.4 Implementation workflow
10.5 Monitoring and evaluation

Recommended readings

1. Rogers et al. 2008. An Introduction to Sustainable Development, Earthscan, London, UK. 416p.
2. Kuenkel, P. 2019. Stewarding Sustainability Transformations: An Emerging Theory and Practice of SDG Implementation, Springer, 321p.
3. UN Sustainable Development Goals Knowledge Platform (https://sustainabledevelopment.un.org/resourcelibrary)
4. Techera E, Winter G (eds.), 2019. Marine Extremes: Ocean Safety, Marine Health and the Blue Economy. Routledge, 255 pp.
5. Nicholls RJ, Hutton CW, Adger WN, Hanson SE, Rahman MM, Salehin M (eds.), 2018. Ecosystem Services for Well-Being in Deltas: Integrated Assessment for Policy Analysis. Palgrave macmillan, 615 pp.
6. Blewitt J, 2018. Understanding Sustainable Development. Earthscan, 427 pp.
7. Hossain MS, Chowdhury SR, Sharifuzzaman SM. 2017. Blue Economic Development in Bangladesh: A policy guide for marine fisheries and aquaculture. Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh, 32 pp.
8. ICSU, 2017. A guide to SDG interactions: from science to implementation. International Council for Science (ICSU), 239 pp. https://www.icsu.org/cms/2017/05/SDGs-Guide-toInteractions.pdf.
9. OECD, 2016. The Ocean Economy in 2030: Edition 2016 (Volume 2016). Organisation for Economic Co-Operation and Development (OECD), 256 pp.
10. Stylios C, Floqi T, Marinski J, Damiani L (eds.), 2015. Sustainable Development of SeaCorridors and Coastal Waters: The TEN ECOPORT project in South East Europe. Springer International Publishing, 253 pp.
11. Hossain, M.S, Chowdhury, S.R, Navera, U.K, Hossain, M.A.R, Imam, B, Sharifuzzaman, S.M., 2014. Opportunities and strategies for ocean and river resources management. Seventh Five Year Plan (2016-2020) background paper, Planning Commission of the Government of Bangladesh, 67 pp.
12. Griggs, D.J., Nilsson, M., Stevance, A., McCollum, D. (Eds.). 2017. A guide to SDG interactions: From science to implementation. International Council for Science (ICSU). https://www.icsu.org/cms/2017/05/SDGs-Guide-to-Interactions.pdf
13. Chowdhury, S.R., Hossain, M.S., Shamsuddoha, M. and Khan, S.M.M.H., 2012. Coastal Fishers' Livelihood in Peril: Sea Surface Temperature and Tropical Cyclones in Bangladesh. Foreign and Commonwealth Office through British High Commission and Centre for Participatory Research and Development (CPRD), Dhaka, Bangladesh, 66 pp.
14. Grafton RQ, Hilborn R, Squires D, Tait M, Williams M (eds.), 2010. Handbook of Marine Fisheries Conservation and Management. 785 pp

MS 502	ADVANCED TECHNOLOGIES IN MARINE SCIENCE	100(4)

Rationale

Marine science is increasingly become as a large part of an observational science. Our knowledge on the oceans has increased as we have increasingly gained the ability to make measurements and observe natural processes on, within, and under the oceans. To do so, marine scientists, graduates, professionals need appropriate tools and observational capabilities. They should be properly skilled and knowledgeable about the appropriate measurements. Technology for marine science research covers a wide spectrum, ranging from ships and satellites, underwater vehicles and buoys, sophisticated laboratory instrumentation etc. Providing the appropriate technologies and developing tools and new technologies for research constitute a complex process. However this course will introduce the graduates with the most up-to-date topics in science and technology used in coastal and marine research. It will help the graduate to improve the efficiency and accuracy of data collection, the scope and applicability of results, and ultimately, sustainable resource management. The knowledge and skills obtained during the course of study enable graduates to contribute to the development of technological solutions for existing and future marine technology-based research and development. The course of study also provides the foundation for a research career.

Objectives

The key objectives of this course are:

1. To gain basic knowledge on different tools and techniques used in ocean observation and ocean data analysis.
2. To Identify, define and analyze complex theoretical, technical and practical problems within marine science technology both independently and in a team.
3. To acquire advanced knowledge of core elements of marine technology, and a deep understanding of methods and tools for design, development, analysis, modelling, simulation, problem-solving, and innovation within the field of marine technology, including marine structures, systems and operations.

Learning outcomes

By the end of the module, students will be able to:

1. solve problems associated with research in marine sciences using recent and continuing advances in science and technology
2. evaluate the relative utility of a range of technologies in answering specific research questions
3. critique scientific literature utilizing current technology in coastal and marine research
4. plan and carry out technological projects and assignments independently and in a team
5. develop the expertise in advanced technologies in marine sciences achieving scientific-technological knowledge and a combined vision of field, laboratory and assessment tools.

Course Contents

1. Brief history of the development of oceanography leading to the era of modern technology and innovations
2. Advances in oceanic measurements: electronic sensors, digital technology, CTD, underway equipment, robotic and remotely operated instruments
3. Ocean observation satellites and remote sensing of the oceans
   3.1. Optical oceanography: visible and microwave
   3.2. Radar and scatterometry
   3.3. Ocean surface topography or satellite altimetry
   3.4. Remote sensing of temperature and salinity
   3.5. Lidar
4. Acoustic, hydrographic and geophysical advances
   4.1. Seafloor imaging and mapping; sonar technology
   4.2. Acoustic tomography for biological and fisheries applications
5. Advanced telemetry in ocean data collection: applications, platforms, parameters, realtime or near-real-time ocean observation
6. Advanced oceanographic platforms and vehicles
   6.1. Bouy, drifter, glider, Argo, etc.
   6.2. Submersibles and ROVs
7. Advances in computing and ocean modeling
8. Advances in data assimilation, storage, processing and delivery
   8.1. Emerging data formats
   8.2. Data repositories/warehouses and portals
   8.3. Data processing and visualization: online and offline
   8.4. Data access
9. Advances in submarine geology: plate tectonics, deep-sea explorations
10. Advances in marine biology and marine fisheries
11. Advances in operational oceanography and ocean forecasting: global ocean observing systems (GOOS), models and computational infrastructure, operational ocean data products

Recommended readings

1. Storch, H.v. and Hasselmann, K. 2010. Seventy Years of Exploration in Oceanography. Springer. 137p.
2. Jochum, M. and Murtugudde, R. 2006. Physical Oceanography: Developments since 1950. Springer. 250p.

3. Hekinian, R. 2014. Sea Floor Exploration: Scientific Adventures Diving Into the Abyss. Springer. 370p.
4. Martin, S. 2014. An Introduction to Ocean Remote Sensing. Cambridge University Press. 496p+plates.
5. Robinson, I.S. 2010. Discovering the Ocean from Space: The Unique Applications of Satellite Oceanography. Springer. 638p.
6. Barale, V., Gower, J. F. R. and Alberotanza, L. 2010. Oceanography from Space: Revisited. Springer. 374p.
7. Wang. Q. 2009. Remote Sensing of Coastal Environments. CRC Press. 423p+plates.
8. Schiller, A. and Brassington, G.B. 2011. Operational Oceanography in the 21st Century. Springer. 729p.
9. Pinardi, N. and Woods, J. 2010. Ocean Forecasting: Conceptual Basis and Applications. Springer. 472p.
10. Fu, L.L. and Cazenave, A. 2001. Satellite Altimetry and Earth Sciences: A Handbook of Techniques and Applications. Academic Press. 463p.
11. Medwin, H. 1998. Fundamentals of Acoustical Oceanography. Academic Press. 712p+plates.

MS 503 MARINE ECOSYSTEM AND CONSERVATION 100(4)

Rationale

The vast ocean of the earth which covers more than 70% of the planet is not only the most potential origin of oxygen to survive the lives but also the sources of food, medicines & therapeutic properties, clean energy etc. These marine reservoirs are the home to the greatest wealth of life containing unbounded natural resources, regulate the earth's climate greatly and contribute a remarkable percentage in the world economy as well as to the national GDP of Bangladesh. Transportation, tourism and huge opportunities of jobs are also provided by the oceans. Now *Blue economy* is a hot issue throughout the world and to our country as well. However, these immeasurable resources could be well functioned if its ecosystem would be well managed and conserved. Beyond any doubt, marine ecosystem determines our health taking part with all other ecosystems. To know and to utilize sustainably the marine resources, it is prerequisite to study and to have knowledge about the marine ecosystem and its conservation. The proposed course will enhance in-depth knowledge on marine ecosystem, interactions among its components, uses of marine and coastal resources, challenges and the ways how to conserve properly.

Objective

The key objectives of this course are:

- To gain basic knowledge on different terms used in marine ecosystem and conservation.
- To know about different individual ecosystems, interactions and challenges of marine ecosystem.
- To learn details about marine resources and its healthy uses, and
- To be well oriented for the conservation steps following national and international policies/acts and procedures.

Learning outcomes

By the end of the module, students will be able to:

- Know the marine and coastal environment, its biogeography, its different ecosystems like coral reefs, mangroves, sea grass, estuarine environments and related resources.
- Have knowledge on interactions connected to many types of marine and coastal ecosystems.
- Recognize marine resources and its worthwhile utilization
- Understand and aware about the challenges to the marine and coastal ecosystem like pollution, degradation, conflicts and impacts of climate change.
- Learn principles and methods for conservation of marine ecosystems
- Concern and explain relevant policies and acts related to marine ecosystem conservation.

Course Contents

1. Marine Ecosystems
   - 1.1 Zonal classification
   - 1.2 Marine biogeography
   - 1.3 Deep and high seas
   - 1.4 Continental shelves
   - 1.5 Coral reefs
   - 1.6 Mangrove forest
   - 1.7 Sea grass
   - 1.8 Estuaries and deltas
   - 1.9 Beaches and dunes
2. Ecosystems Interactions
   - 2.1 Energy flow in marine food chain
   - 2.2 Marine species adaptations
   - 2.3 Ecosystem goods and services
   - 2.4 Valuation of ecosystem goods and services
3. Marine Resource Use
   - 3.1 Fisheries
   - 3.2 Mariculture
   - 3.3 Eco-tourism
   - 3.4 Ports and shipping
   - 3.5 Renewable energy
   - 3.6 Oil and gas extraction
   - 3.7 Mineral extraction
4. Challenges to Marine Ecosystems
   - 4.1 Marine pollution
   - 4.2 Waste disposal
   - 4.3 Degradation of marine ecosystems
   - 4.4 Space use conflicts
   - 4.5 Overexploitation
   - 4.6 Diseases and health risks
   - 4.7 Climate change impacts (SST, pH, DO)
5. Marine Conservation
   - 5.1 Principles for conservation of marine ecosystems
   - 5.2 Conservation and restoration methods (MPAs, ECAs, MRs)
   - 5.3 Clean up methods of pollutants
   - 5.4 Modeling marine conservation hotspots
   - 5.5 Design and implementation of protected areas
   - 5.6 Management of protected areas
   - 5.7 Integration of economic, legal and social perspectives
6. Policy and legislation
   - 5.1 Marine law and policy
   - 5.2 Marine wildlife protection
   - 5.3 Sustainable fisheries
   - 5.4 Clean seas and beaches

Recommended readings

1. Wondolleck JM, Yaffee SL, 2017. Marine Ecosystem-Based Management in Practice: Different Pathways, Common Lessons. Island Press/Center for Resource Economics, 292 pp.
2. Olewiler N, Francisco HA, Ferrer AJE (eds.), 2016. Marine and Coastal Ecosystem Valuation, Institutions, and Policy in Southeast Asia. Springer Singapore, 382 pp.
3. Goreau TJ, Trench RK (eds.), 2013. Innovative Methods of Marine Ecosystem Restoration. CRC Press, 308 pp.
4. Solan M, Aspden RJ, Paterson DM, 2012. Marine biodiversity and ecosystem functioning : frameworks, methodologies, and integration. Oxford University Press, 257 pp.
5. UNEP, 2007. Marine and Coastal Ecosystems and Human Well-being: A Synthesis Report Based on the Findings of the Millennium Ecosystem Assessment. United Nations Environment Programme, 80 pp.
6. Sinclair M, Valdimarsson G, 2003. Responsible fisheries in the marine ecosystem. FAO/CABI, 423 pp.

7. United States National Research Council, 2001. Marine Protected Areas: Tools for Sustaining Ocean Ecosystem. Committee on the Evaluation, Design, and Monitoring of Marine Reserves and Protected Areas in the United States. Ocean Studies Board, Commission on Geosciences, Environment, and Resources. National Academy Press, Washington DC, 289 pp.

MS 504 MARINE BIOTECHNOLOGY 100(4)

Rationale

The essence of this course is to explore the chemical and biological diversity of our oceans as a source of novel materials and food. The main sources of marine biomass are species that are harvested from the wild and those that can be cultivated. There are emerging opportunity areas and completely new applications for marine-derived compounds. The health sector, which has targeted marine-derived molecules as new pharmaceutical entities, continues to emphasize the potential of marine-derived drug discovery materials. Target markets for marine lipids and proteins, including enzymes, pigments, and flavourings, include human and animal nutrition; industrial chemicals; cosmetics; pharmaceuticals; personal care; the agri-food sector; and many more.

Objectives

The goal of this course is to educate students in current biotechnology knowledge with a focus on the use of marine bio-resources, bioactive compounds, gene products, and marine raw materials. Students will be prepared for careers in marine business growth, innovation, and research.

Learning outcomes

Having successfully completed this module, students will be able to:

- understand the advanced knowledge about processes for the use of molecules with unique characteristics,
- advanced skills in genetic, biotechnological, and molecular biological techniques.
- understanding the importance of marine resource-based industries and the challenges and opportunities involved.
- advanced knowledge of current R&D issues and the related commercial potential, especially in marine biotechnology.
- a thorough understanding of natural marine resources as the foundation for the development of food, biochemicals, bioactive and medicinal components

Course Contents

1. Introduction to biotechnology
   - 1.1 Marine biotechnology: applications and scope, role in blue growth
   - 1.2 Marine organisms useful for biotechnology
   - 1.3 Present status of marine bioindustry and future prospects
   - 1.4 Challenges in marine biotechnology

2. Marine genetics and '-omics'
   - 2.1 Gene expression in eukaryotic organisms
   - 2.2 Recombinant DNA technology, cloning of a target gene
   - 2.3 Applications of '-omics' tools
   - 2.4 DNA barcoding of marine species
   - 2.5 Metagenomics and related techniques
   - 2.6 Proteomics techniques
3. Biotechnological tools in aquaculture health management
   - 3.1 Pathogen detection and disease diagnosis
   - 3.2 Pathogen control: probiotics, immunoprophylaxis, vaccine
4. Biofuels and biorenewables from marine microalgae
   - 4.1 Microalgal isolation and purification techniques
   - 4.2 Mutant strain development, genetic manipulation
   - 4.3 Photobioreactors for microalgae
   - 4.4 Production of biofuel and beneficial substances
   - 4.5 Industrial applications of microalgae

5. Marine bacteria for bioactive compounds
   5.1 Cultivation techniques of marine bacteria
   5.2 Development of biocatalysts
   5.3 Bioactive substances from bacteria
6. Natural products from marine organisms (fungi, corals, sponges etc.)
   6.1 Extraction of substances, fractionation
   6.2 Separation and purification of substances
   6.3 Structure analysis of natural products
   6.4 Example of substances with biomedical potential
7. Seaweed biotechnology
   7.1 Tissue culture, protoplast production in seaweed cells
   7.2 Cell fusion, gene manipulation
   7.3 Industrial applications of seaweeds
8. Marine-derived drugs and prospects; marine nutraceuticals and cosmeceuticals
9. Environmental aspects of marine biotechnology
10. Ethical issues in marine biotechnology

Recommended readings

1. Kim Se-K. 2019. Essentials of Marine Biotechnology. Springer. 477 p.
2. Bourlat SJ. 2016. Marine Genomics: Methods and Protocols. Humana Press. 265p.
3. Kim Se-K. 2015. Springer Handbook of Marine Biotechnology. Springer. 1512p.
4. Kim Se-K. 2015. Handbook of Marine Microalgae: Biotechnology Advances. Academic Press. 604p.
5. Gjedrem T, Baranski M. 2009. Selective Breeding in Aquaculture: An Introduction. Springer. 221p.
6. Lutz CG. 2001. Practical Genetics for Aquaculture. Fishing News Books. 262p.

MS 505	MARINE SPATIAL PLANNING	100(4)

Rationale

Number of human activities such as port development, maritime transportation, oil and gas development, offshore renewable energy, offshore aquaculture and waste disposal have been practiced since historic times. Usually this is done on a sector-by-sector, case-by-case basis without much consideration of effects either on other human activities or the marine environment. It may cause conflicts among: (1) human uses (i.e., user-user conflicts); and (2) human uses and the marine environment (i.e., user-environment conflicts). These conflicts weaken the ability of the ocean to provide the necessary ecosystem services. These ecosystem services can lead to more desirable social, economic, and environmental benefits. Marine spatial planning (MSP) is a future-oriented process, which can offer a way to address both these types of conflict and select appropriate management strategies to ensure sustainable use of coastal and ocean resources for a more desirable future of the marine environment as well as social welfare.

Objectives

This course aims to provide theoretical and methodological knowledge: (1) to create and establish a more rational organization of the use of marine space and the interactions between its uses, (2) to balance demands for development with the need to protect marine ecosystems, and (3) to achieve social and economic objectives in an open and planned way. This course will train the graduate students with necessary tools and techniques to allocate human activities to specific marine areas by objective (e.g., development or preservation areas etc.), or by specific uses (e.g., maritime transportation, offshore aquaculture or mariculture, wind farms, oil and gas explorations, minerals mining etc.).

Learning outcomes

The course offers background knowledge relevant to marine and coastal planning from scientific and practical perspectives towards sustainable blue growth. The students will carry out theoretical tasks related to guiding steps in MSP development along with practical applications for areas based coastal and marine resources use plans engaging concerned stakeholders. Emphasis is put on understanding the complex interaction between human intervention and environmental vulnerability, as well as monitoring and evaluating performance of the plan. After completion of this course, students will receive the skills for the development of sea-space and coastal land-space use plan.

Course Contents

1. Introduction and Concept of MSP
2. Guiding Steps for MSP adaptation
   - 2.1 Defining context and authority for MSP
   - 2.2 Obtaining financial support
   - 2.3 Organizing the MSP process through pre-planning
   - 2.4 Organizing stakeholder participation
   - 2.5 Defining and analyzing current conditions
   - 2.6 Defining and analyzing future conditions
   - 2.7 Developing a marine spatial plan
   - 2.8 Implementing and enforcing a marine spatial plan
   - 2.9 Monitoring and evaluating performance of the plan
   - 2.10 Adapting the marine spatial planning process
3. Engaging Stakeholders in MSP
4. The Connection between MSP and Global Governance Goals
5. Cross-border Cooperation in MSP
6. Good Practices for Science-based MSP
7. Toward Sustainable Blue Growth
8. Institutional Capacity Development for MSP
9. Ocean Planning in Areas Beyond National Jurisdiction
10. Priorities for the Next Decade and Concluding Remarks

Recommended readings

1. Brouwer, H. and Woodhill, J. 2016. The MSP Guide: How to design and facilitate multistakeholder partnership. Practical Action Publishing, UK. 180p.
2. Brouwer, H. and Woodhill, J. 2017. The MSP Tool Guide: Sixty Tools to facilitate multistakeholder partnership. Wageningen University & Research, Netherlands. 147p.
3. Kitsiou, D. and Karydis, M. (Eds). 2017. Marine Spatial Planning Methodologies, Environmental Issues and Current Trends. Nova Science Publishers, NY. 483p.
4. Schultz-Zehden, A., Gee, K. and Scibior, K. 2008. Handbook on Integrated Maritime Spatial Planning. European Union. 98p.
5. Ehler, C and Douvere, F. 2009. Marine Spatial Planning: A step-by-step approach toward Ecosystem-based management. UNESCO/IOC, 99p.
6. Ehler, C. 2014. A Guide to Evaluating Marine Spatial Plans. UNESCO/IOC. 84p.

MS 506	OCEAN POLICY AND GOVERNANCE	100(4)

Rationale

Ocean governance is a cohesive conduct of policies and actions pertaining to the sustainable use of coastal and marine resources safeguarding the health and wellbeing of marine ecosystems. The oceans and coasts are immensely significant ecologically and economically; however, the marine and coastal spaces are mostly vulnerable to overexploitation of its resources, climate consequences, geopolitical complexity and other anthropogenic pressures. Therefore, appropriate ocean governance measures, rightly implemented policies and integrated management are vital to ensure maritime development and obtain the benefits of blue economy.

Objective

This course provides comprehensive knowledge on international maritime legal regime, maritime zones and boundaries, basics of ocean governance, maritime defense and law enforcement, settlement of maritime disputes, policy framework for the blue economic growth etc. It also intends to build a strong background of the environmental, socio-economic, political, and legal effects of management decisions and their implications associated with coastal and marine systems.

Learning Outcome

Upon completion of the course, students will be able to:

- understand basic principles and the legal framework of coastal and ocean systems

- recognize roles of oceans to mankind
- understand the multiple uses of coastal and marine spaces
- deal with the social, ecological, economic, and legal complexities of ocean affairs
- comprehend the multifaceted factors influencing governance and management efforts
- analyze and evaluate the issues related to maritime governance, policies and management tools
- communicate effectively with professionals in various fields of marine sciences and affairs

Course Contents

1. Maritime Legal Regime
   a) Introduction to UNCLOS, its background and importance
   b) Institutions established by UNCLOS
   c) Key IMO conventions and international sources of maritime law
   d) National laws and legal provisions for maritime affairs
2. Rights, Jurisdiction and Legal provisions of Maritime Spaces
   a) Territorial sea
   b) Contiguous zone
   c) Straits used for international navigation
   d) Archipelagic waters
   e) Exclusive economic zone
   f) Continental shelf
   g) High seas
   h) Regime of islands
   i) The Area
3. Ocean Governance
   a) Basic frameworks
   b) Marine fisheries and conservation
   c) Marine biodiversity of areas beyond national jurisdiction
   d) Marine genetic resources
   e) Protection of the marine environment
   f) Maritime transport
   g) Marine renewable and non-renewable resources
   h) Deep-sea mining
   i) Marine scientific research
   j) International submarine cables and pipelines
   k) Marine and coastal tourism
   l) Integrated ocean and coastal management
   m) Global impacts of climate change on oceans
   n) Ocean governance in Bangladesh: Prospects and challenges
4. Maritime Defense and Law Enforcement
   a) Military use of the seas
   b) Combating maritime piracy and human trafficking across the seas
   c) Roles and jurisdiction of Bangladesh Navy and Bangladesh Coast Guard
5. Settlement of Maritime Disputes
   a) Dispute settlement by UNCLOS
   b) Roles of ITLOS and International Court of Justice
   c) Case studies:
      i) Dispute settlement of maritime boundaries of Bangladesh
      ii) Territorial disputes in the South China Sea
6. Governance for Blue Economy
   a) Basic concept of blue economy
   b) Current and potential sectors in blue economy
   c) Policy framework and future initiatives for the blue growth in Bangladesh

Recommended readings

1. Smith, H.D. (Ed). 2004. The Oceans: Key Issues in Marine Affairs. Heidelberg: Springer Science+Business Media.
2. Monaco, A. and Prouzet, P. (Eds) 2015. Governance of Seas and Oceans. London: ISTE Ltd.; New Jersey: John Wiley & Sons, Inc.
3. Patil, P.G. et al. 2018. Toward a Blue Economy: A Pathway for Sustainable Growth in Bangladesh. Washington, DC: The World Bank Group.

4. Paula, J. (Ed). 2015. Regional State of the Coast Report: Western Indian Ocean. Nairobi: United Nations Environment Programme.
5. Chang, Y. 2012. Ocean Governance: A Way Forward. Heidelberg: Springer Science+Business Media.
6. Churchill, R. R. and Lowe, A.V. 1999. The Law of the Sea. Manchester: Manchester University Press.
7. Open University Course Team. 1991. Case Studies in Oceanography and Marine Affairs. Milton Keynes: The Open University.

MS 507	BLUE ECONOMY AND SUSTAINABLE DEVELOPMENT PRACTICAL	25(1)

1. Prepare maritime zone map of Bangladesh and demarcate marine fishing zones
2. Study the shallow sea and deep-sea oil/gas exploration blocks in the EEZ of Bangladesh
3. Evaluate blue economy development activities in the coastal and marine ecosystems of Bangladesh
4. Determine trophic interaction of marine species
5. Formulate ecosystem-based marine fisheries management plan for Bangladesh
6. Assess the interactions among the sustainable development goals (SDGs)
7. Analyze the linkages of SDG 14 to the blue economy focus areas
8. Study cyclogenesis locations and cyclone tracks on the Bay of Bengal for the last 100 years
9. Mapping salinity incursion areas along Bangladesh coast and interpret ecosystem health
10. Measure ocean acidification effects on coastal ecosystems of Bangladesh
11. Analyze causes and effects of hypoxic characteristics in the Bay of Bengal
12. Formulate integrated blue economy development plan
13. Identify resilience elements and analyze their role on coastal community of Bangladesh
14. Visit coastal ecosystems of Bangladesh and evaluate climate change impacts on livelihoods

MS 508	ADVANCED TECHNOLOGIES IN MARINE SCIENCE PRACTICAL	25(1)

1. Field operation of major oceanographic instruments
2. Practices in ocean remote sensing: SST, SSS, ocean color, SSH
3. Basic practices in Ecogram analysis
4. Collection and preservation of water, sediment and biota samples from the marine water
5. Data discovery, download and analyses
6. Use of ocean data analysis software: ODV, Panoply, NC View, HDF View

MS 509	MARINE ECOSYSTEM AND CONSERVATION PRACTICAL	25(1)

1. Preparation of model showing marine ecosystem components
2. Mapping marine conservation/protected areas of Bangladesh
3. Modeling marine ecosystem hotspots for fisheries conservation
4. Collection, analyze and presentation of marine ecological data
5. Trophic interaction of keystone species in marine ecosystem
6. Estimation of biodiversity indices for marine species
7. Design of marine ecosystem monitoring programmes
8. Changing patterns of marine ecosystem health (e.g. SST, SSS, pH, DO)
9. Biodiversity conservation role on society and economy
10. Analyze conservation policies and legislations

MS 510	MARINE BIOTECHNOLOGY PRACTICAL	25(1)

1. DNA extraction, PCR and sequencing
2. Gel electrophoresis for separating and identifying DNA fragments
3. Isolation and identification of marine bacteria potential for antibiotics
4. Measurement of microbial growth, antimicrobial activity
5. Measurement of genetic biodiversity
6. Cell and tissue culture of seaweeds

MS 511	MARINE SPATIAL PLANNING PRACTICAL	25(1)

1. Understanding marine and coastal zone of Bangladesh
2. Creating and using marine geospatial data of Bangladesh
3. Mapping sea-space and coastal land-space uses in Bangladesh
4. Identifying stakeholders and space-use conflicts in the marine and coastal areas of Bangladesh
5. Planning space-use and coastal zone use under different scenarios of development
6. Studying MSPs from around the World

MS 512	OCEAN POLICY AND GOVERNANCE CASE STUDY	25(1)

1. Development of an ocean governance matrix comprising the basic frameworks (political, legal and operational) at national scale for blue economic sectors
2. Case studies
   2.1 Territorial disputes in the South China Sea
   2.2 Energy resources and security in Asia-Pacific
   2.3 Biodiversity in areas beyond national jurisdiction
   2.4 Dispute settlement of maritime boundaries of Bangladesh
   2.5 Integrated coastal and ocean management in Bangladesh with lessons from global practices

INSTITUTE OF MARINE SCIENCES

Faculty of Marine Sciences and Fisheries

University of Chittagong, Chattiogram 4331

Syllabus for the M.S. in Marine Fisheries

Academic Year: 2023-2024 & 2024-2025

Total Marks: 900, Total Credits: 36

M.S. in Marine Fisheries

Course#	Course title	Thesis group	General group
Theoretical			
MF 501	Blue Economy and Sustainable Development	100(4)	100(4)
MF 502	Advanced Technologies in Marine Science	100(4)	100(4)
MF 503	Marine Fisheries Assessment and Management	100(4)	100(4)
MF 504	Mariculture	100(4)	100(4)
MF 505	Fisheries Post-Harvest Technology	100(4)	100(4)
MF 506	Fisheries Economics	100(4)	100(4)
	Subtotal	600(24)	600(24)
Practical			
MF 507	Blue Economy and Sustainable Development Practical	-	25(1)
MF 508	Advanced Technologies in Marine Science Practical	-	25(1)
MF 509	Marine Fisheries Assessment and Management Practical	-	25(1)
MF 510	Mariculture Practical	-	25(1)
MF 511	Fisheries Post-Harvest Technology Practical	-	25(1)
MF 512	Fisheries Economics Practical	-	25(1)
	Subtotal	-	150(6)
MF 598	Project	-	50(2)
MF 599	Thesis	200(8)	-
MF 513	Project defense (Proposal 10, Final 40)	-	50(2)
MF 514	Thesis defense (Proposal 10, Final 40)	50(2)	-
MF 515	Viva-voce	50(2)	50(2)
	GRAND TOTAL	**900(36)**	**900(36)**

MF 501 BLUE ECONOMY AND SUSTAINABLE DEVELOPMENT 100(4)

Course contents

1. Growing ocean economy
   - 1.1 Global ocean economy
   - 1.2 Ocean ecosystem health
   - 1.3 Blue economy concept
   - 1.4 Blue economy indicators
2. Blue economy sectors
   - 2.1 Marine fisheries
   - 2.2 Marine trade
   - 2.3 Oil, gas and minerals
   - 2.4 Marine tourism
   - 2.5 Renewable energy
3. Marine fisheries interventions
   - 3.1 Extending the fishing horizon
   - 3.2 New fishing gears and techniques
   - 3.3 Discovering new fisheries
   - 3.4 Value addition and post-harvest loss reduction
   - 3.5 Fish stock assessment
4. Aquaculture and mariculture interventions
   - 4.1 Domestication
   - 4.2 Production intensification

4.3 Innovation farming
4.4 Live feeds for larviculture
4.5 Disease and health management

5. Ecosystem-based management
   5.1 Elements of ecosystem
   5.2 Trophic interactions
   5.3 Coordination and integration of stakeholders
   5.4 Formulation of EBM plan
6. Global sustainability initiatives
   6.1 Brundtland Report 1987
   6.2 Earth Charter 1992
   6.3 Kyoto Protocol 1997
   6.4 UN Millennial Summit 2000 and MDGs
   6.5 UN Sustainable Development Goals (SDGs) 2015
7. Sustainable Development Goals (SDGs)
   7.1 Goals, targets and indicators
   7.2 Interactions among the 17 goals
   7.3 Interactions at target-level
   7.4 Knowledge gaps
   7.5 Science-policy interface
8. SDG 14: Life Below Water
   8.1 Key interactions, uncertainties and dimensions
   8.2 Prevent and reduce marine pollution
   8.3 Protect marine and coastal ecosystems
   8.4 Sustainable use of ocean resources
   8.5 Increase economic benefits
9. Climate change challenges
   9.1 Tropical cyclone and depression
   9.2 Sea-level rise
   9.3 Salinity incursion
   9.4 Ocean acidification
   9.5 Freshwater plume
   9.6 Hypoxic condition
10. Blue economy development framework
   10.1 Major sectors and stakeholders
   10.2 Capacity building
   10.3 Design management plan
   10.4 Implementation workflow
   10.5 Monitoring and evaluation

Recommended readings

1. Rogers et al. 2008. An Introduction to Sustainable Development, Earthscan, London, UK. 416p.
2. Kuenkel, P. 2019. Stewarding Sustainability Transformations: An Emerging Theory and Practice of SDG Implementation, Springer, 321p.
3. UN Sustainable Development Goals Knowledge Platform (https://sustainabledevelopment.un.org/resourcelibrary)
4. Techera E, Winter G (eds.), 2019. Marine Extremes: Ocean Safety, Marine Health and the Blue Economy. Routledge, 255 pp.
5. Nicholls RJ, Hutton CW, Adger WN, Hanson SE, Rahman MM, Salehin M (eds.), 2018. Ecosystem Services for Well-Being in Deltas: Integrated Assessment for Policy Analysis. Palgrave macmillan, 615 pp.
6. Blewitt J, 2018. Understanding Sustainable Development. Earthscan, 427 pp.
7. Hossain MS, Chowdhury SR, Sharifuzzaman SM. 2017. Blue Economic Development in Bangladesh: A policy guide for marine fisheries and aquaculture. Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh, 32 pp.
8. ICSU, 2017. A guide to SDG interactions: from science to implementation. International Council for Science (ICSU), 239 pp. https://www.icsu.org/cms/2017/05/SDGs-Guide-toInteractions.pdf.
9. OECD, 2016. The Ocean Economy in 2030: Edition 2016 (Volume 2016). Organisation for Economic Co-Operation and Development (OECD), 256 pp.

10. Stylios C, Floqi T, Marinski J, Damiani L (eds.), 2015. Sustainable Development of SeaCorridors and Coastal Waters: The TEN ECOPORT project in South East Europe. Springer International Publishing, 253 pp.
11. Hossain, M.S, Chowdhury, S.R, Navera, U.K, Hossain, M.A.R, Imam, B, Sharifuzzaman, S.M., 2014. Opportunities and strategies for ocean and river resources management. Seventh Five Year Plan (2016-2020) background paper, Planning Commission of the Government of Bangladesh, 67 pp.
12. Griggs, D.J., Nilsson, M., Stevance, A., McCollum, D. (Eds.). 2017. A guide to SDG interactions: From science to implementation. International Council for Science (ICSU). https://www.icsu.org/cms/2017/05/SDGs-Guide-to-Interactions.pdf
13. Chowdhury, S.R., Hossain, M.S., Shamsuddoha, M. and Khan, S.M.M.H., 2012. Coastal Fishers' Livelihood in Peril: Sea Surface Temperature and Tropical Cyclones in Bangladesh. Foreign and Commonwealth Office through British High Commission and Centre for Participatory Research and Development (CPRD), Dhaka, Bangladesh, 66 pp.
14. Grafton RQ, Hilborn R, Squires D, Tait M, Williams M (eds.), 2010. Handbook of Marine Fisheries Conservation and Management. 785 pp

MF 502 ADVANCED TECHNOLOGIES IN MARINE SCIENCE 100(4)

Course Contents

1. Brief history of the development of oceanography leading to the era of modern technology and innovations
2. Advances in oceanic measurements: electronic sensors, digital technology, CTD, underway equipment, robotic and remotely operated instruments
3. Ocean observation satellites and remote sensing of the oceans
   3.1. Optical oceanography: visible and microwave
   3.2. Radar and scatterometry
   3.3. Ocean surface topography or satellite altimetry
   3.4. Remote sensing of temperature and salinity
   3.5. Lidar
4. Acoustic, hydrographic and geophysical advances
   4.1. Seafloor imaging and mapping; sonar technology
   4.2. Acoustic tomography for biological and fisheries applications
5. Advanced telemetry in ocean data collection: applications, platforms, parameters, real-time or near-real-time ocean observation
6. Advanced oceanographic platforms and vehicles
   6.1. Bouy, drifter, glider, Argo, etc.
   6.2. Submersibles and ROVs
7. Advances in computing and ocean modeling
8. Advances in data assimilation, storage, processing and delivery
   8.1. Emerging data formats
   8.2. Data repositories/warehouses and portals
   8.3. Data processing and visualization: online and offline
   8.4. Data access
9. Advances in submarine geology: plate tectonics, deep-sea explorations
10. Advances in marine biology and marine fisheries
11. Advances in operational oceanography and ocean forecasting: global ocean observing systems (GOOS), models and computational infrastructure, operational ocean data products

Recommended readings

1. Storch, H.v. and Hasselmann, K. 2010. Seventy Years of Exploration in Oceanography. Springer. 137p.
2. Jochum, M. and Murtugudde, R. 2006. Physical Oceanography: Developments since 1950. Springer. 250p.
3. Hekinian, R. 2014. Sea Floor Exploration: Scientific Adventures Diving Into the Abyss. Springer. 370p.
4. Martin, S. 2014. An Introduction to Ocean Remote Sensing. Cambridge University Press. 496p+plates.

5. Robinson, I.S. 2010. Discovering the Ocean from Space: The Unique Applications of Satellite Oceanography. Springer. 638p.
6. Barale, V., Gower, J. F. R. and Alberotanza, L. 2010. Oceanography from Space: Revisited. Springer. 374p.
7. Wang. Q. 2009. Remote Sensing of Coastal Environments. CRC Press. 423p+plates.
8. Schiller, A. and Brassington, G.B. 2011. Operational Oceanography in the 21st Century. Springer. 729p.
9. Pinardi, N. and Woods, J. 2010. Ocean Forecasting: Conceptual Basis and Applications. Springer. 472p.
10. Fu, L.L. and Cazenave, A. 2001. Satellite Altimetry and Earth Sciences: A Handbook of Techniques and Applications. Academic Press. 463p.
11. Medwin, H. 1998. Fundamentals of Acoustical Oceanography. Academic Press. 712p+plates.

MF 503 MARINE FISHERIES ASSESSMENT AND MANAGEMENT 100(4)

Rationale

Among all the exploited natural resources, fisheries constitute the largest. Marine fisheries sector plays a very vital role in the national economy of Bangladesh. Responsible marine fisheries assessment and management is a prerequisite to sustain ecosystem, ensure nutrition security, and enhance livelihood and income. The magnitude, dynamics and resilience of fish stocks pose great challenge to their assessment as well as management.

Objectives

Fisheries resources, although renewable, are exhaustible. The objective of this course is to learn fisheries assessment and management perspectives in the tropical ecosystems in terms of estimating marine fisheries resource abundance and drawing management plan for optimum harvest of it. Besides, meeting such objective, the course will also cater enhancing knowledge about sound stock assessment strategies, fish population dynamics and fisheries economics issues to the learners.

Learning outcomes

At the end of the course module, students will learn

- The basic concepts of marine fisheries resources, stocks, their importance, inherent characteristics and complexities
- Fish/shellfish stock assessment tools and techniques to assess the changes in stock and size of yields as function of both fishery dependent as well as fishery independent factors
- Fisheries economics and fisheries resource management planning
- Institutional arrangement, ecosystem-based management, compliance and enforcement regards to marine fisheries resource management in Bangladesh

Course content

1. Status of World marine fisheries
   1.1 'Global Fisheries Crisis'
   1.2 Regional examples of fisheries decline
   1.3 Status of marine fisheries in Bangladesh
2. Fisheries management: definition and key concepts
3. Marine fisheries stock assessment
   3.1 Concept of fish stock, single-fish and multi-species stocks
   3.2 Status of stock: virgin, fully fished, overfished, being-overfished, collapsed, depleted, depleting, bounced/restored
   3.3 Importance of stock assessment (scientific advice to fisheries management)
   3.4 Methods and models of stock assessment: Surplus production models, Delaydifference or Aggregate-matrix models, Age-based or integrated models, Length- and Age-based or Fully integrated models
   3.5 Stock assessment data requirement
   3.6 Ecosystem and holistic approach
   3.7 Advanced technologies in stock assessment
4. Inshore and offshore fisheries (small-scale/artisanal and meso-scale/industrial) management

4.1 Complexity of inshore fisheries management
5. Fisheries management and sustainability: SDG 14.4
6. Fisheries management and Blue Economy
7. Fisheries assessment and management in Bangladesh: instutional framework, facilities, data infrastructure, management cycle
8. Fisheries management tools/actions
   8.1 Input controls (fishing and fishing effort)
   8.2 Output control (catch: quota, size limit, rejection of gravid females)
   8.3 Ecosystem protection controls (EBFM/EAF, Protected areas, fishing closures
   8.4 Compliance and enforcement: MCS, IUU, VMS/AIS
9. Types of fisheries assessment and management: single stock and multispecies

Recommended readings

1. Clarke, C.W. 2006. The Worldwide Crisis in Fisheries: Economic models and human behaviour. Cambridge University Press. 263p.
2. Grafton, R.Q. et al. 2010. Handbook of Marine Fisheries Conservation and Management. Oxford University Press. 770p.
3. King, M.G. 2007. Fisheries Biology, Assessment and Management, 2nd Ed. Wiley. 382p.
4. Cochrain, K.L. and Garcia, S.M. (Eds) 2009. A Fishery Manager's Guidebook, 2nd Ed. FAOWilley-Blackwell. 518p.
5. Pomeroy, R.S. and Andrew, N.L. (Eds). 2011. Small-scale Fisheries Management: Frameworks and Approaches for the Developing World. CABI, 247p.
6. McClanahan, T.R. and Castilla, J.C. (Eds). 2007. Fisheries Management: Progress towards sustainability. Blackwell. 332p.
7. Anderson, L.G. and Seijo, J.C. 2010. Bioeconomics of Fisheries Management. WilleyBlackwell. 305p.

Rationale

Mariculture is expected to become the dominant form of aquaculture in the future due to freshwater scarcity in many parts of the world. It is a rapidly expanding global activity. This is because many wild fish stocks are overfished and catches are decreasing. At the same time, the global population is increasing, as is the demand for dietary protein. The expansion of mariculture can reduce pressure on wild fish, shrimp, and mollusks by lowering market prices and, as a result, investments in fishing fleets. Products obtained from mariculture are not only used for food but also as raw materials for, e.g., cosmetics, neutraceuticals, medicines, food additives and many more.

Objectives

The purpose of this course is to educate students about mariculture production systems, marine species selection, and the production of marine finfish, crustaceans, molluscs, and seaweeds. Students will be familiar with emerging challenges and long-term mitigation strategies, as well as factors to consider setting up a mariculture business, as well as innovation and research.

Learning outcomes

After completing this course, students will be able to:

- know the basic features, problems and importance of mariculture.
- recognize the finfish, crustaceans, molluscs and seaweed farming technology and equipment.
- oversee the mariculture farm design and construction, as well as the water quality.
- explain and take action against the diseases and parasite problems in mariculture.
- understand the climate change and mitigation, socio-economic and legal framework of mariculture

Course content

1. Mariculture production method
   - 1.1 Definition of mariculture
   - 1.2 Purposes of mariculture
   - 1.3 Classification of mariculture systems
   - 1.4 Common mariculture species
   - 1.5 Scale of operation
2. Mariculture interventions
   - 2.1 Ecosystem Approach Mariculture (EAM)
   - 2.2 Integrated multi-trophic mariculture
   - 2.3 Domestication of marine species
   - 2.4 Production intensification
3. Mariculture in cages
   - 3.1 Scope and Objectives
   - 3.2 Cage design and construction
   - 3.3 Cultivable species (e.g. sea bass, grey mullet, hilsa, grouper, breams)
   - 3.4 Natural and prepared feeds
   - 3.5 Feeding strategies
   - 3.6 Farming operation and management
4. Mollusc mariculture
   - 4.1 Selection of suitable sites
   - 4.2 Selection of leading species
   - 4.3 Identification of cultch-materials
   - 4.4 Spat collection sites and seasons
   - 4.5 Shallow water culture: Bottom, rack, tray and pole
   - 4.6 Deep water culture: Raft and long line
5. Seaweed mariculture
   - 5.1 Selection of suitable sites
   - 5.2 Selection of leading species
   - 5.3 Design of culture plots
   - 5.4 Methods of culture

5.5 Harvesting systems
5.6 Processing and preservation techniques

6. Impacts of mariculture on environment
   6.1 Interactions of escaped farmed stock with wild species
   6.2 Mariculture wastes (feeds, chemicals, faces)
   6.3 Types and sources of pollutants
   6.4 Fate of pollutants and effects on environment
   6.5 Effects of pollution on marine organisms and public health
   6.6 Diseases outbreak
7. Challenges for mariculture
   7.1 Area/space use conflicts (e.g. fishing zone, shipping route, marine wildlife habitat)
   7.2 Marine ecosystem health management
   7.3 Quality and safe food production
   7.4 Disease and health management (prevention and diagnosis)
   7.5 Climate change adaptation and mitigation
8. Socio-economic issues
   8.1 Resource use conflicts
   8.2 Ecosystem goods and services
   8.3 Worker safety and rights
   8.4 Market demand and access
   8.5 Harvest and transport techniques
   8.6 Post-harvest handling
   8.7 Economic analysis
9. Legal and policy frameworks
   9.1 Government policy
   9.2 FAO Code of conduct
   9.3 Codes of practice
   9.4 Best management practices (BMPs)
   9.5 Good mariculture practices

Recommended readings

1. Tidwell J, 2019. Largemouth Bass Aquaculture. 5m Publishing, 272 pp.
2. Creed R, 2018. Aquaculture Production and Engineering. Syrawood Publishing House, 234 pp.
3. Lien ME, 2015. Becoming Salmon: Aquaculture and the Domestication of a Fish. University of California Press, 232 pp.
4. Gudding R, Lillehaug A, Evensen O (Eds.), 2014. Fish Vaccination. Wiley-Blackwell, 404 pp.
5. Merrifield DL, Ringo E (eds.), 2014. Aquaculture Nutrition: Gut Health, Probiotics and Prebiotics. Wiley-Blackwell, 500 pp.
6. Soto D (ed.), 2009. Integrated mariculture: A global review. FAO Fisheries and Aquaculture Technical Paper 529. FAO Fisheries and Aquaculture Department Rome, Italy, 194 pp.
7. Cabrita E, Robles V, Herraez P, 2008. Methods in Reproductive Aquaculture: Marine and Freshwater Species (Marine Biology). CRC Press, 574 pp.
8. Secretariat of the Convention on Biological Diversity, 2004. Solutions for sustainable mariculture - avoiding the adverse effects of mariculture on biological diversity. CBD Technical Series no 12, Canada, 54 pp.
9. Støttrup JG, McEvoy LA (Eds.), 2003. Live Feeds in Marine Aquaculture. Wiley-Blackwell, 334 pp.
10. Stickney RR, McVey JP (Eds.), 2002. Responsible marine aquaculture. CABI, 407 pp.
11. De Silva SS, 1998. Tropical Mariculture. Academic Press, 497 pp.
12. Borgese EM, 1980. Seafarm The story of aquaculture. H. N. Abrams, 236 pp.

MF 505	FISHERIES POST-HARVEST TECHNOLOGY	100(4)

Rationale:

Correct/ accepted/ proper handling, processing and preservation of fisheries products is vital, not only for health and nutrition, but also for the fisheries industry and national & global economy.

To ensure the quality food item of this sector from harvesting to export, as well as from catch to dining table, careful handling must be well addressed. Maintaining every international guidance and rules followed by systematic trade policy, the fisheries sector could be a sustainable source of our nutrition, economy and employment with an attractive brand to international market.

Objectives:

1. To introduce the students about well handling, processing and preservation techniques of the fisheries products with relevant importance.
2. To enrich their knowledge regarding fisheries products processing technology following international quality assurance guidelines and trading policy
3. To contribute in national processing system of fisheries products making an expert team to employ.

Learning outcomes:

End of the course, the students will be able to learn;

- Basics of the spoilage of fisheries products and hazards associated with seafood.
- Importance and assurance of quality
- Different handling and processing methods of typed fisheries products
- Accurate preservation techniques
- International and national quality assurance guidelines and rules
- Proper packing methods and how to trace processed and traded products timely
- Value added fisheries products and uses
- Waste management of processing
- Economic use of processing by products
- Uses of updated molecular methods for assessing integrity of fishery products
- Safety of personal hygiene and environment

Course content

1. Introduction to fish/ seafood processing
   1.1 Fish spoilage, hazards associated with seafood
   1.2 Pre- and post-mortem handling, and primary processing
   1.3 Fish processing methods, and quality and safety assurance
2. On-board fish processing, chilling
   2.1 On-board processing and its advantages
   2.2 Quality issues related to on-board processing
   2.3 Super-chilling, post-mortem changes at chilled storage temperatures
3. Freezing of fish and fishery products
   3.1 Freezing process, storage temperatures, freezing time calculations
   3.2 Freezing systems: air-blast, immersion, plate and cryogenic freezers
   3.3 Storage life, thawing
4. Preservation by curing – drying, salting and smoking
   4.1 Basic relationship: water activity and spoilage, product quality
   4.2 Drying: methods, quality aspects, storage of dried products
   4.3 Salting: methods, processes for salted products, quality aspects
   4.4 Smoking: methods and equipment, quality aspects, storage
5. Canning fish and fishery products
   5.1 Principles of canning, packaging materials
   5.2 Pre-processing, exhausting, heat- and post-processing operations
   5.3 Canning of small pelagics, tuna, crustacea
6. Packing of fishery products – application of MAP, packaging materials
7. Seafood quality assessment
   7.1 Sensory, chemical and physical methods
   7.2 Microbiological examination
   7.3 Quality index method (QIM), life cycle assessment
8. HACCP and quality assurance of seafood

8.1 HACCP principles and methodology
8.2 Planning and implementing HACCP systems
8.3 Sanitation standard operating procedures (SSOPs)

9. Traceability of fish products
   9.1 Food supply chain, traceability in fish supply chain
   9.2 Standardization of information exchange, technologies
   9.3 Traceability in cold chain monitoring, food supply chain management
10. Molecular methods for assessing integrity of fishery products
   10.1 Methods in safety assessment of fishery products
   10.2 Molecular analysis of quality attributes in seafood
   10.3 Molecular tools applied to seafood authentication
11. Value-added seafood
12. Utilization of seafood processing by-products

Recommended readings

1. Borda D, Nicolau AI, Raspor P. 2018. Trends in Fish Processing Technologies. CRC Press/ Taylor & Francis. 356p.
2. Boziaris IS. 2014. Seafood Processing: Technology, Quality and Safety. Wiley-Blackwell. 508p.
3. Hall GM. 2011. Fish Processing - Sustainability and New Opportunities. Wiley-Blackwell. 296p.
4. Bremner HA. 2002. Safety and Quality Issues in Fish Processing. CRC press. 507p.
5. Hall GM. 1997. Fish Processing Technology. Springer. 292p.

MF 506	FISHERIES ECONOMICS	100(4)

Rationale

Endowment of natural resources has been considered as a central enquiry for economic science. Rational utilization and sustaining marine fisheries sector is receiving increasing attention. Fisheries economics studies contribute to students in understanding socio-ecological and economic complexities in the sector and to promote fisheries sector's contribution to Gross Domestic Product (GDP), to foreign exchange earnings, to domestic nutrition needs and employment generation.

Objectives

The course focuses on economics and strategic planning for fisheries sector in terms of biological and economic approach which can ensure sustainable management of it.

Learning outcomes

At the end of the course module, students will learn

- Basic concepts of fisheries economics, purpose, uses and types
- Bio-economic equilibrium concepts, theories and models of fisheries
- Sole ownership vs. open access efficiency in fisheries sector
- Economic theories of fisheries resource exploitation
- Price, market, cost, factor rents, demand and supply curves of marine fisheries and underlying risks and uncertainties in fisheries value chain.

Course content

1. Introduction to fisheries economics: concepts, types, purpose and uses, law of demand and supply
2. Inherent characteristics of fish stocks
   2.1 Optimal allocation of renewable resources: basic assumptions
   2.2 The failure in the optimal allocation of fishery resources
   2.3 Property regimes, property rights and externalities
   2.4 High exclusion costs
   2.5 Social trap in fisheries, and the free rider behaviour
   2.6 High transaction costs
   2.7 Fisheries management plans
3. Bio-economic models
   3.1 The Gordon-Schaefer model
   3.2 Marginal and average yields
   3.3 Effort levels at MSY, MEY and BE
   3.4 Model assumptions

3.5 Limitations
3.6 Fleet dynamics: a distributed-delay Smith's model
3.7 Yield-mortality models: a bio-economic approach
3.8 Logistic model
3.9 Exponential model
3.10 A precautionary bioeconomic approach
3.11 Yield-mortality models: a closing comment
3.12 Age-structured bioeconomic models
3.13 Intertemporal fisheries analysis
3.14 Intertemporal preferences
3.15 Neutral, positive and negative preferences
3.16 Present value and discount rate
3.17 The bioeconomic dynamic model and the price of time
3.18 The effect of δ in fisheries: an alternative view

4. Economic theory of fish resource exploitation
   4.1 Methods of fisheries management
   4.2 Managing small scale fisheries
   4.3 Management and allocation of economic rent
   4.4 Evaluation of management scheme
   4.5 Surveillance
5. Factors rent and the supply curve of a free access fishery
   5.1 Factor rents
   5.2 The sustainable yield curve when price varies
   5.3 The supply curve of a free access fishery
6. Sole ownership and efficiency
   6.1 Income distribution effect and of introducing sole ownership
   6.2 Fish stock and private property rights
   6.3 The economic consequence of extending national fishing limits
7. Economics of the fish market
   7.1 Price
   7.2 The effect of buffer stock on price
   7.3 Factors influencing the marketing system
   7.4 The effect of marketing constrains on production
   7.5 Fish marketing systems in developing countries
   7.6 Marine fisheries value chain
   7.7 Intervention in fish marketing
   7.8 Fish processing
8. Risk and uncertainties in fisheries sector
   8.1 Precautionary approach to fisheries management
   8.2 Sources of uncertainty in fisheries
   8.3 Management decisions without mathematical probabilities
   8.4 Management decisions with mathematical probabilities
   8.5 The Bayesian approach

Recommended readings

1. Seijo, J.C.; Defeo, O.; Salas, S. 1998. Fisheries bioeconomics: theory, modelling and management. FAO Fisheries Technical Paper No. 368. 108p.
2. Hannesson, R. 1978. Economics of Fisheries, An introduction. Columbia University Press limited, New York, USA.
3. Lawson, R. M. Economics of Fisheries Development. Frances Printers, London.
4. Fish Base (www. fishbase.org)

MF 507	BLUE ECONOMY AND SUSTAINABLE DEVELOPMENT PRACTICAL	25(1)

1. Prepare maritime zone map of Bangladesh and demarcate marine fishing zones
2. Study the shallow sea and deep-sea oil/gas exploration blocks in the EEZ of Bangladesh
3. Evaluate blue economy development activities in the coastal and marine ecosystems of Bangladesh
4. Determine trophic interaction of marine species
5. Formulate ecosystem-based marine fisheries management plan for Bangladesh

6. Assess the interactions among the sustainable development goals (SDGs)
7. Analyze the linkages of SDG 14 to the blue economy focus areas
8. Study cyclogenesis locations and cyclone tracks on the Bay of Bengal for the last 100 years
9. Mapping salinity incursion areas along Bangladesh coast and interpret ecosystem health
10. Measure ocean acidification effects on coastal ecosystems of Bangladesh
11. Analyze causes and effects of hypoxic characteristics in the Bay of Bengal
12. Formulate integrated blue economy development plan
13. Identify resilience elements and analyze their role on coastal community of Bangladesh
14. Visit coastal ecosystems of Bangladesh and evaluate climate change impacts on livelihoods

MF 508	ADVANCED TECHNOLOGIES IN MARINE SCIENCE PRACTICAL	25(1)

1. Field operation of major oceanographic instruments
2. Practices in ocean remote sensing: SST, SSS, ocean color, SSH
3. Basic practices in Ecogram analysis
4. Collection and preservation of water, sediment and biota samples from the marine water
5. Data discovery, download and analyses
6. Use of ocean data analysis software: ODV, Panoply, NCView, HDFView

MF 509	MARINE FISHERIES ASSESSMENT & MANAGEMENT PRACTICAL	25(1)

1. Examining and analyzing fisheries data: fisheries dependent catch and effort data, fisheries independent data
2. Determining fish population dynamics, biological and stock parameters
3. Practicing fish stock assessment methods and models
4. Determining fish stock status

MF 510	MARICULTURE PRACTICAL	25(1)

1. Analysis of interactions among mariculture intensification, production rate and environmental sustainability
2. Formulate ecosystem-based mariculture development plan for Bangladesh
3. Determination of carrying capacity of selected marine ecosystem
4. Determine trophic interaction of marine species
5. Evaluation of marine species domestication levels in Bangladesh
6. Preparation of mariculture cages using locally available materials
7. Design and layout of integrated multi-trophic aquaculture (IMTA) model
8. Assessment of mariculture impacts on environment (input identification, assessment and mitigation)
9. Economic analysis of mariculture interventions
10. Study tour to mariculture sites

MF 511	FISHERIES POST-HARVEST TECHNOLOGY PRACTICAL	25(1)

1. Fish post-mortem observations
2. Frozen fish inspection and monitoring
3. Salting, drying, smoking and canning of fish and shrimp
4. Seafood quality monitoring and assessment
5. Study tour to seafood processing facilities/industries

MF 512	FISHERIES ECONOMICS PRACTICAL	25(1)

1. Calculation of effort level at MSY, MEY and BE, fMSY, fMEY and fBE
2. Bio-economic models
3. Observation of fish marketing systems in Bangladesh
4. Fish processing cost measurements
5. Supply and demand curve in fisheries
6. Source of uncertainty in fisheries
7. Management decisions without mathematical probabilities
8. Management decisions with mathematical probabilities
9. Estimation of uncertainty in model Parameters

Institute of Marine Sciences
Faculty of Marine Sciences and Fisheries
University of Chittagong, Chattogram 4331
Syllabus for the M.S. in Coastal and Marine Aquaculture
Academic Year: 2023-2024 & 2024-2025
Total Marks: 900, Total Credits: 36

M.S. in Coastal and Marine Aquaculture

Course#	Course title	Thesis group	General group
Theoretical			
CMA 501	Blue Economy and Sustainable Development	100(4)	100(4)
CMA 502	Advanced Technologies in Marine Science	100(4)	100(4)
CMA 503	Seed Production and Hatchery Management	100(4)	100(4)
CMA 504	Aquaculture Systems	100(4)	100(4)
CMA 505	Aquaculture Nutrition	100(4)	100(4)
CMA 506	Sustainable Aquaculture	100(4)	100(4)
	Subtotal	600(24)	600(24)
Practical			
CMA 507	Blue Economy and Sustainable Development Practical	-	25(1)
CMA 508	Advanced Technologies in Marine Science Practical	-	25(1)
CMA 509	Seed Production and Hatchery Management Practical	-	25(1)
CMA 510	Aquaculture Systems Practical	-	25(1)
CMA 511	Aquaculture Nutrition Practical	-	25(1)
CMA 512	Sustainable Aquaculture Practical	-	25(1)
	Subtotal	-	150(6)
CMA 598	Project	-	50(2)
CMA 599	Thesis	200(8)	-
CMA 513	Project defense (Proposal 10, Final 40)	-	50(2)
CMA 514	Thesis defense (Proposal 10, Final 40)	50(2)	-
CMA 515	Viva-voce	50(2)	50(2)
	GRAND TOTAL	**900(36)**	**900(36)**

CMA 501	**BLUE ECONOMY AND SUSTAINABLE DEVELOPMENT**	**100(4)**

Course contents

1. Growing ocean economy
   - 1.1 Global ocean economy
   - 1.2 Ocean ecosystem health
   - 1.3 Blue economy concept
   - 1.4 Blue economy indicators
2. Blue economy sectors
   - 2.1 Marine fisheries
   - 2.2 Marine trade
   - 2.3 Oil, gas and minerals
   - 2.4 Marine tourism
   - 2.5 Renewable energy
3. Marine fisheries interventions
   - 3.1 Extending the fishing horizon
   - 3.2 New fishing gears and techniques
   - 3.3 Discovering new fisheries
   - 3.4 Value addition and post-harvest loss reduction
   - 3.5 Fish stock assessment
4. Aquaculture and mariculture interventions

4.1 Domestication
4.2 Production intensification
4.3 Innovation farming
4.4 Live feeds for larviculture
4.5 Disease and health management

5. Ecosystem-based management
   5.1 Elements of ecosystem
   5.2 Trophic interactions
   5.3 Coordination and integration of stakeholders
   5.4 Formulation of EBM plan
6. Global sustainability initiatives
   6.1 Brundtland Report 1987
   6.2 Earth Charter 1992
   6.3 Kyoto Protocol 1997
   6.4 UN Millennial Summit 2000 and MDGs
   6.5 UN Sustainable Development Goals (SDGs) 2015
7. Sustainable Development Goals (SDGs)
   7.1 Goals, targets and indicators
   7.2 Interactions among the 17 goals
   7.3 Interactions at target-level
   7.4 Knowledge gaps
   7.5 Science-policy interface
8. SDG 14: Life Below Water
   8.1 Key interactions, uncertainties and dimensions
   8.2 Prevent and reduce marine pollution
   8.3 Protect marine and coastal ecosystems
   8.4 Sustainable use of ocean resources
   8.5 Increase economic benefits
9. Climate change challenges
   9.1 Tropical cyclone and depression
   9.2 Sea-level rise
   9.3 Salinity incursion
   9.4 Ocean acidification
   9.5 Freshwater plume
   9.6 Hypoxic condition
10. Blue economy development framework
    10.1 Major sectors and stakeholders
    10.2 Capacity building
    10.3 Design management plan
    10.4 Implementation workflow
    10.5 Monitoring and evaluation

Recommended readings

1. Rogers et al. 2008. An Introduction to Sustainable Development, Earthscan, London, UK. 416p.
2. Kuenkel, P. 2019. Stewarding Sustainability Transformations: An Emerging Theory and Practice of SDG Implementation, Springer, 321p.
3. UN Sustainable Development Goals Knowledge Platform (https://sustainabledevelopment.un.org/resourcelibrary)
4. Techera E, Winter G (eds.), 2019. Marine Extremes: Ocean Safety, Marine Health and the Blue Economy. Routledge, 255 pp.
5. Nicholls RJ, Hutton CW, Adger WN, Hanson SE, Rahman MM, Salehin M (eds.), 2018. Ecosystem Services for Well-Being in Deltas: Integrated Assessment for Policy Analysis. Palgrave macmillan, 615 pp.
6. Blewitt J, 2018. Understanding Sustainable Development. Earthscan, 427 pp.
7. Hossain MS, Chowdhury SR, Sharifuzzaman SM. 2017. Blue Economic Development in Bangladesh: A policy guide for marine fisheries and aquaculture. Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh, 32 pp.
8. ICSU, 2017. A guide to SDG interactions: from science to implementation. International Council for Science (ICSU), 239 pp. https://www.icsu.org/cms/2017/05/SDGs-Guide-toInteractions.pdf.

9. OECD, 2016. The Ocean Economy in 2030: Edition 2016 (Volume 2016). Organisation for Economic Co-Operation and Development (OECD), 256 pp.
10. Stylios C, Floqi T, Marinski J, Damiani L (eds.), 2015. Sustainable Development of SeaCorridors and Coastal Waters: The TEN ECOPORT project in South East Europe. Springer International Publishing, 253 pp.
11. Hossain, M.S, Chowdhury, S.R, Navera, U.K, Hossain, M.A.R, Imam, B, Sharifuzzaman, S.M., 2014. Opportunities and strategies for ocean and river resources management. Seventh Five Year Plan (2016-2020) background paper, Planning Commission of the Government of Bangladesh, 67 pp.
12. Griggs, D.J., Nilsson, M., Stevance, A., McCollum, D. (Eds.). 2017. A guide to SDG interactions: From science to implementation. International Council for Science (ICSU). https://www.icsu.org/cms/2017/05/SDGs-Guide-to-Interactions.pdf
13. Chowdhury, S.R., Hossain, M.S., Shamsuddoha, M. and Khan, S.M.M.H., 2012. Coastal Fishers' Livelihood in Peril: Sea Surface Temperature and Tropical Cyclones in Bangladesh. Foreign and Commonwealth Office through British High Commission and Centre for Participatory Research and Development (CPRD), Dhaka, Bangladesh, 66 pp.
14. Grafton RQ, Hilborn R, Squires D, Tait M, Williams M (eds.), 2010. Handbook of Marine Fisheries Conservation and Management. 785 pp

CMA 502 ADVANCED TECHNOLOGIES IN MARINE SCIENCE 100(4)

Course Contents

1. Brief history of the development of oceanography leading to the era of modern technology and innovations
2. Advances in oceanic measurements: electronic sensors, digital technology, CTD, underway equipment, robotic and remotely operated instruments
3. Ocean observation satellites and remote sensing of the oceans
   3.1. Optical oceanography: visible and microwave
   3.2. Radar and scatterometry
   3.3. Ocean surface topography or satellite altimetry
   3.4. Remote sensing of temperature and salinity
   3.5. Lidar
4. Acoustic, hydrographic and geophysical advances
   4.1. Seafloor imaging and mapping; sonar technology
   4.2. Acoustic tomography for biological and fisheries applications
5. Advanced telemetry in ocean data collection: applications, platforms, parameters, realtime or near-real-time ocean observation
6. Advanced oceanographic platforms and vehicles
   6.1. Bouy, drifter, glider, Argo, etc.
   6.2. Submersibles and ROVs
7. Advances in computing and ocean modeling
8. Advances in data assimilation, storage, processing and delivery
   8.1. Emerging data formats
   8.2. Data repositories/warehouses and portals
   8.3. Data processing and visualization: online and offline
   8.4. Data access
9. Advances in submarine geology: plate tectonics, deep-sea explorations
10. Advances in marine biology and marine fisheries
11. Advances in operational oceanography and ocean forecasting: global ocean observing systems (GOOS), models and computational infrastructure, operational ocean data products

Recommended readings

1. Storch, H.v. and Hasselmann, K. 2010. Seventy Years of Exploration in Oceanography. Springer. 137p.
2. Jochum, M. and Murtugudde, R. 2006. Physical Oceanography: Developments since 1950. Springer. 250p.
3. Hekinian, R. 2014. Sea Floor Exploration: Scientific Adventures Diving Into the Abyss. Springer. 370p.
4. Martin, S. 2014. An Introduction to Ocean Remote Sensing. Cambridge University Press. 496p+plates.

5. Robinson, I.S. 2010. Discovering the Ocean from Space: The Unique Applications of Satellite Oceanography. Springer. 638p.
6. Barale, V., Gower, J. F. R. and Alberotanza, L. 2010. Oceanography from Space: Revisited. Springer. 374p.
7. Wang. Q. 2009. Remote Sensing of Coastal Environments. CRC Press. 423p+plates.
8. Schiller, A. and Brassington, G.B. 2011. Operational Oceanography in the 21st Century. Springer. 729p.
9. Pinardi, N. and Woods, J. 2010. Ocean Forecasting: Conceptual Basis and Applications. Springer. 472p.
10. Fu, L.L. and Cazenave, A. 2001. Satellite Altimetry and Earth Sciences: A Handbook of Techniques and Applications. Academic Press. 463p.
11. Medwin, H. 1998. Fundamentals of Acoustical Oceanography. Academic Press. 712p+plates.

CMA 503 SEED PRODUCTION AND HATCHERY MANAGEMENT 100(4)

Rationale

Aquaculture is the fastest-growing food production sector in the world. One of the key challenges to continued growth is the supply of quality seed from hatcheries. Demand of commercially important fish and shellfish seed at present is strong and expected to grow further. Therefore, it is necessary to understand how a hatchery functions successfully and how to use emerging technologies in improving hatchery production in order to promote sustainability of aquaculture.

Objectives

The objective of this course is to provide concepts of broodstock management, reproduction and larval rearing, varied aspects of nutrition and feeding, hatchery water supply and treatment systems, and modern technologies in enhancing hatchery production.

Learning outcomes

Having successfully completed this course student will be able to:

- Understand fish and shellfish seed production technology
- Select suitable hatchery sites
- Learn about larval rearing and seed quality management
- Address challenges in hatchery production of specific aquaculture species.

Course content

1. Introduction: Opportunities and challenges of hatcheries for aquaculture species 1.1 Marine Finfish (Sea Bass/Mullet/Milkfish/Grouper/Snapper)
   1.2 Freshwater Finfish (Tilapia, Catfish, Carps. Etc.
   1.3 Crustacean (Tiger shrimp, Fresh water prawn, Mud Crab)
   1.4 Shellfish & others (mussels, oysters, clams. Echinoderms)
2. Site Selection and seed resources
   2.1 Site selection and techniques of collection
   2.2 Identification and segregation of fish and shellfish
3. Reproductive biology
   3.1 Overview of current developments in reproductive biology
   3.2 Gonad anatomy, endocrinology and reproductive mechanisms in finfishes, prawns, shrimps, crabs, mussels, oysters, scallops and clams
   3.3 Age at first maturity
   3.4 Factors affecting maturation and spawning
   3.5 Reproductive cycles, Seasonality (Photoperiod, Change in water quality and quantity, temperature, lunar cycle, etc.)
   3.6 Environmental and exogenous hormonal stimuli
4. Broodstock: Broodstock selection and maintenance
   4.1 Availability; improvement; nutritional requirements; transport
   4.2 Captive rearing and maturation
   4.3 Induced spawning; Physical and chemical inducing agents; Physiology and techniques of eyestalk ablation. Methods of natural and artificial fertilization, GnRH and Linpe models, evaluation of

milt and egg, cryopJreservation techniques, use of different synthetic homones and analogues for induced spawning

4.4 Egg staging, Stripping and fertilization

5. Seed Production
   - 5.1 Seed production of commercially important fin fishes (Sea bass, milkfish, mullets)
   - 5.2 Seed production of commercially important crustaceans (Shrimps, prawns, crabs)
   - 5.3 Seed production of commercially important mollusks (mussels, edible oysters, pearl oyster, scallops, clams)
6. Hatchery design and management
   - 6.1 Criteria for site selection of hatchery and nursery
   - 6.2 Design and function of incubators
   - 6.3 Jar hatchery, Chinese hatchery and other hatchery systems-design and operation
   - 6.4 Hatchery protocols, larval rearing stages, rearing technology
7. Hatchery technology and management
   - 7.1 Hatchery facilities required
   - 7.2 Culture and use of different live feed in shellfish hatcheries
   - 7.3 Larval diseases and their management
   - 7.4 Different chemicals and drugs used
   - 7.5 Water quality and feed management
   - 7.6 Hatchery standards and biosecurity
   - 7.7 Sanitary and phytosanitary (SPS) measures
   - 7.8 Better management practices (BMPs.)
   - 7.9 Packaging and transport of seed
8. Seed supply in aquaculture
   - 8.1 Relationship between fry supply and grow-out
   - 8.2 Macro-planning of fry production to stimulate grow-out
   - 8.3 Marketing and economics of seed production

Recommended readings

1. Thomas, P.C et al, 2003, Breeding and seed production of finfish and shellfish, Daya publishing house, New Delhi
2. Mathew Landau, 1992. Introduction to Aquaculture, John Wiley and sons, INC, New York
3. James P Mcvey, 1983, Handbook of Mariculture, CRC press, Florida
4. Jhingran. VG, 1991, Fish and Fisheries of India, Hindustan Publishers
5. Pillay, T V R and M N Kutty, 2005, Aquaculture- principles and practices, Blackwell sciences, UK
6. FAO, 1992, Manual of seed production of carps
7. FAO, Manual for operating a small-scale recirculation freshwater prawn hatchery

CMA 504	AQUACULTURE SYSTEMS	100(4)

Rationale

The aquaculture sector overall is highly diverse with an ever-growing number of species cultured and production systems available to farmers. The types of production/culture/farming systems and their operational procedures are not simple and sometimes confusing to the novice. Therefore, a basic understanding of requirements to design and set up a functional, suitable, environmentally friendly production system is vital to the successful practice of aquaculture.

Objectives

This course is aimed at educating students on the huge diversity of production systems used in aquatic farming, their advantages and disadvantages, system designing techniques, and their operations and management.

Learning outcomes

Having successfully completed this course student will be able to:

- Learn about aquaculture systems used for raising commercial aquatic species such as fish, crustaceans, mollusks and seaweeds
- Plan, design, construct and operate different production systems, including offshore technologies, tank-based recirculating systems and ponds
- Understand how aquaculture production depends upon and interacts with its environment.

Course contents

1. Pond Culture
   - 1.1 Scope and objectives
   - 1.2 Types of ponds
   - 1.3 Design and construction: Selection of site, Layout and Construction
   - 1.4 Soil properties
   - 1.5 Water budget
   - 1.6 Fry Rearing Technique: Stocking rate and Carrying capacity, Routine pond management, Types of Culture
   - 1.7 Production rates in different culture systems
   - 1.8 Harvesting
   - 1.9 Economics aspects in different systems
2. Cage and Pen Culture
   - 2.1 Scope and Objectives
   - 2.2 Types of Cages/Pens
   - 2.3 Design and Construction: Selection of site, Layout, Construction
   - 2.4 Cultivable species
   - 2.5 Farming Operation and Management
   - 2.6 Economics of Cage and Pen culture
3. Mollusc Culture
   - 3.1 Background
   - 3.2 Criteria for selection of site
   - 3.3 Species suitable for culture
   - 3.4 Procurement of seed
   - 3.5 Bottom Culture
   - 3.6 Special pre-requisites, Shell beds, Rock beds
   - 3.7 Intertidal and shallow water culture: Rack culture, Tray culture, Pole (Bouchot) culture
   - 3.8 Deep-water culture: Raft culture, Long line
   - 3.9 Economics of different types of molluscs farming
4. Seaweed Culture
   - 4.1 Background
   - 4.2 Characteristics of seaweeds
   - 4.3 Selection of sites
   - 4.4 Design of culture plots
   - 4.5 Culture operation and Harvesting System
   - 4.6 Economic importance of seaweeds
5. Culture in Running Water and Recirculatory System
   - 5.1 Advantages and disadvantages
   - 5.2 Different types of Raceways and Recirculatory systems: Site selection, Construction, Sources of water, water treatment
   - 5.3 Culture operation and management
   - 5.4 Economics

CMA 505	AQUACULTURE NUTRITION	100(4)

Rationale

Nutrition is an integral part of aquaculture which determines effective utilization of feed, good growth, health and optimum yield of culture species. Accordingly, basic knowledge on dietary requirements of fish and shrimp, special diets for brood and larvae, dietary energy requirements, feed types, feeding strategies, management of feed, wastes derived from feed and aeration management is prerequisite for successful operation of an aquaculture farm.

Objectives

To develop the students' comprehensive understanding on nutritional and energy requirements of different culture species of fish and shrimp, special nutrient requirements of broodstock and larvae, feeding options, feed types and feed management, feed derived wastes and aeration management of culture ponds.

Learning outcomes

Upon completion of this course, students will be able to:

- Understand the nutrient requirements of different culture species
- Comprehend feeding options with their merits and demerits
- Recognize the special dietary needs of broodstock and larvae
- Gain knowledge on different types and their application
- Conceptualize the terms involved in effective management of feed
- Acquire knowledge on feed derived wastes and their management
- Determine the size and efficiency of an aerator for aquaculture pond

Course contents

1. Introduction
2. Feeding Options
   - 2.1 Fertilization
   - 2.2 Supplementary diet feeding
   - 2.3 Complete diet feeding
   - 2.4 Selection of supplementary feeds for use by rural farmers
   - 2.5 Feed formulation and natural productivity
3. Feed Types
   - 3.1 Wet and moist formulated feeds
   - 3.2 Dry feeds
   - 3.3 Commercial feeds
4. Dietary Requirements of Finfish
   - 4.1 Nutrients
   - 4.2 Proteins
   - 4.3 Lipids
   - 4.4 Carbohydrates
   - 4.5 Vitamins
   - 4.6 Minerals
5. Bloodstock nutrition
   - 5.1 Energy partitioning for reproduction
   - 5.2 Protein requirements
   - 5.3 Effect of dietary quality on reproductive output
   - 5.4 Specialized diets immediately prior to spawning
6. Nutrition of Penaeid shrimp larvae
   - 6.1 Ontogeny of the digestive tract
   - 6.2 Activity of digestive enzyme throughout development
   - 6.3 Nutritional requirements (proteins, lipids and vitamins)
   - 6.4 Practical feeding
7. Shrimp nutrition with special reference to the commercial feed industry
   - 7.1 Proteins
   - 7.2 Lipids
   - 7.3 Carbohydrates
   - 7.4 Vitamins
   - 7.5 Minerals
8. Larval feeding regimes in hatcheries
9. Nutrition energetics
   - 9.1 Introduction
   - 9.2 Partitioning of biological energy
   - 9.3 Factors affecting energy partitioning
   - 9.4 Energy requirements
   - 9.5 Formulating diets to satisfy energy needs
10. Feed waste production
    - 10.1 Effluent discharges
    - 10.2 Fertilizer derived wastes
    - 10.3 Residues of biocides
    - 10.4 Chemical residue

10.5 Hypernutrification and eutrophication
10.6 Oxygen depletion
11. Feeding and aeration
11.1 Principles of Oxygen transfer
11.2 Aerator efficiency measurement
11.3 Minimum oxygen requirements of shrimps
11.4 Aerator sizing
12. Farm Feed Management
12.1 Importance of feed types
12.2 Particle size of feeds
12.3 Feeding schedule
12.4 Feed rations

Recommended readings

1. Del Silva, S.S. and Anderson, T.A. 1994. Fish nutrition in aquaculture. Springer Science. 320p.
2. Goddard, S. 1996. Feed management in intensive aquaculture. Springer. 194p.
3. Midlen, A. and Redding, T.A. 1998. Environmental management for aquaculture. Springer Science. 224p.
4. Fast, A.W. and Lester, L.J. 1992. Marine shrimp culture: principles and practices. Elsevier. 862p.

CMA 506	SUSTAINABLE AQUACULTURE	100(4)

Rationale

Global population is on a trajectory towards 10 billion by the year 2050, intensifying the need for sustainable approaches to food production. Aquatic ecosystems offer vast potential for balancing sustainability challenges as a significant driver to reduce poverty, improve food security, enhance economic growth and employment. This curriculum will function as a living document to support responsible aquaculture practices from the scientific and technological, social, economic and policy perspectives.

Objectives

The objective of this course focuses on the concepts of sustainable aquaculture, advanced aquaculture practices, challenges for aquaculture sector, aquaculture impacts and mitigation, socio-economic issues, and policy frameworks.

Learning outcomes

Having successfully completed this course student will be able to:

- understand the concepts and applications of sustainable aquaculture
- alternative and advanced aquaculture practices in rural, urban, coastal and marine ecosystems
- acquire comprehensive knowledge on aquaculture impacts and mitigation measures
- achieve competence on existing and forthcoming challenges to aquaculture sector
- promote responsible aquaculture practices relevant to national, regional and global initiatives
- develop research interest to solve critical and emerging issues related to sustainable aquaculture

Course contents

1. Aquaculture and sustainability
1.1 Aquaculture production systems
1.2 Status of aquaculture production
1.3 Challenges of aquaculture
1.4 Sustainability definition and practice
1.5 Sustainability knowledge for aquaculture
1.6 SDG14: key interactions and dimensions
2. Sustainable rural aquaculture
2.1 Integrated aquaculture-agriculture
2.2 Aquaculture-sea salt rotation
2.3 Aquaculture-rice rotation
2.4 Integrated silvo-aquaculture

3. Sustainable urban and peri-urban aquaculture
   3.1 Wastewater-fed aquaculture
   3.2 Aquaponics
   3.3 Biofloc based aquaculture
4. Alternative and advanced aquaculture practices
   4.1 Ecosystem Approach Aquaculture (EAA)
   4.2 Mariculture in cages
   4.3 Periphyton-based aquaculture
   4.4 Integrated multi trophic aquaculture
   4.5 Multi-feeder polyculture
   4.6 Organic aquaculture
5. Aquaculture medicines
   5.1 Antibiotics
   5.2 Parasiticides
   5.3 Probiotics
   5.4 Vaccination
6. Impacts of aquaculture on the environment
   6.1 Land use change
   6.2 Intensive water use
   6.3 Nutrient loading
   6.4 Medicine waste
   6.5 Diseases spread
   6.6 Saltwater incursion
   6.7 Genetically modified species
7. Impacts of the environment on aquaculture
   7.1 Water quality
   7.2 Pathogens and parasites
   7.3 Predators
   7.4 Pollution
   7.5 Mangrove ecosystem
8. Mitigation environmental impacts
   8.1 Wastewater treatment
   8.2 Pond effluents treatment
   8.3 Water reuse
   8.4 Disease management and reporting
   8.5 Control of chemical and medicine use
   8.6 Control of feed quality
9. Challenges for aquaculture industry
   9.1 Domestication of marine species
   9.2 Ecological restoration and adaptation
   9.3 Quality and safe food supply
   9.4 Climate change adaptation and mitigation
10. Socio-economic issues
   10.1 Resource use conflicts
   10.2 Ecosystem goods and services
   10.3 Cost-benefit analysis
   10.4 Worker safety and rights
   10.5 Poverty alleviation
11. Legal and policy frameworks
   11.1 Government policy
   11.2 FAO Code of conduct
   11.3 Codes of practice
   11.4 Effluent limitations guidelines (ELGs)
   11.5 Best management practices (BMPs)
   11.6 Good aquaculture practices (GAPs)

Recommended readings

1. Hossain MS, Chowdhury SR, Sharifuzzaman SM. 2017. Blue Economic Development in Bangladesh: A policy guide for marine fisheries and aquaculture. Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh, 32 pp.
2. Patricia HM, Ivan PC (eds.), 2014. Sustainable Aquaculture Techniques. In Tech, 269 pp.
3. Merrifield DL, Ringo E (eds.), 2014. Aquaculture Nutrition: Gut Health, Probiotics and Prebiotics. Wiley-Blackwell, 500 pp.
4. Bunting SW, 2013. Principles of Sustainable Aquaculture Promoting Social, Economic and Environmental Resilience. Routledge, 321 pp.
5. Hayashida K, Fukaya K, Palstra AP, Ueda H, 2013. Swimming Physiology of Fish: Towards Using Exercise to Farm a Fit Fish in Sustainable Aquaculture. Springer-Verlag Berlin Heidelberg, 430 pp
6. Carvalho ED, David GS, Silva RJ (eds.), 2012. Health and Environment in Aquaculture. Intech, 428 pp.
7. OECD, 2010. Globalisation in Fisheries and Aquaculture: Opportunities and Challenges. Organisation for Economic Co-operation and Development (OECD), 162 pp.
8. Tucker CS, Hargreaves JA, 2008. Environmental Best Management Practices for Aquaculture. Wiley-Blackwell; U.S. Aquaculture Society, 594 pp
9. Leung PS, Lee CS, Patricia J. O'Bryen PJ (eds.), 2007. Species and System Selection for Sustainable Aquaculture. Wiley-Blackwell, 501 pp.
10. World Bank, 2007. Changing the Face of the Waters: The Promise and Challenge of Sustainable Aquaculture (Agriculture and Rural Development Series). World Bank Publications, 210 pp.
11. Costa-Pierce B, Desbonnet A, Edwards P, Baker D (eds.), 2005. Urban Aquaculture. Cabi Publishing, 304 pp.

CMA 507	BLUE ECONOMY AND SUSTAINABLE DEVELOPMENT PRACTICAL	25(1)

1. Prepare maritime zone map of Bangladesh and demarcate marine fishing zones
2. Study the shallow sea and deep-sea oil/gas exploration blocks in the EEZ of Bangladesh
3. Evaluate blue economy development activities in the coastal and marine ecosystems of Bangladesh
4. Determine trophic interaction of marine species
5. Formulate ecosystem-based marine fisheries management plan for Bangladesh
6. Assess the interactions among the sustainable development goals (SDGs)
7. Analyze the linkages of SDG 14 to the blue economy focus areas
8. Study cyclogenesis locations and cyclone tracks on the Bay of Bengal for the last 100 years
9. Mapping salinity incursion areas along Bangladesh coast and interpret ecosystem health
10. Measure ocean acidification effects on coastal ecosystems of Bangladesh
11. Analyze causes and effects of hypoxic characteristics in the Bay of Bengal
12. Formulate integrated blue economy development plan
13. Identify resilience elements and analyze their role on coastal community of Bangladesh
14. Visit coastal ecosystems of Bangladesh and evaluate climate change impacts on livelihoods

CMA 508	ADVANCED TECHNOLOGIES IN MARINE SCIENCE PRACTICAL	25(1)

1. Field operation of major oceanographic instruments
2. Practices in ocean remote sensing: SST, SSS, ocean color, SSH
3. Basic practices in Ecogram analysis
4. Collection and preservation of water, sediment and biota samples from the marine water
5. Data discovery, download and analyses
6. Use of ocean data analysis software: ODV, Panoply, NCView, HDFView

CMA 509	SEED PRODUCTION AND HATCHERY MANAGEMENT PRACTICAL	25(1)

1. Collection and identification of cultivable brackish water finfish, crustaceans and mollusk seed
2. Packing and transportation of cultivable finfish, shrimp and mollusk seed; Induced breeding of fishes through various inducing agents
3. Preparation of brood and larval feed for different cultivable finfishes and shrimps
4. Layout and design of fish and shrimp hatcheries
5. Eyestalk ablation technique
6. Identification of larval stages of shrimp, prawn, crab, mussel and oyster
7. Culture techniques of microalgae and other live feed used in shellfish hatcheries; Artemia hatching technique
8. Visit to different shellfish hatcheries; Economic analysis of shellfish hatcheries

CMA 510	AQUACULTURE SYSTEMS PRACTICAL	25(1)

1. Design and layout of model farm for marine species
2. Preparation of cage and pen for cultivable species
3. Preparation of raft for molluscs farming
4. Contour survey and mapping of a culture pond
5. Design rice-cum-fish farming system of Bangladesh
6. Estimation of lime and fertilizer requirement
7. Determination of water budget for farming of marine species
8. Analysis of soil and water quality parameters
9. Insemination and cryopreservation of fish gamets
10. Study tour to coastal aquaculture farms

CMA 511	AQUACULTURE NUTRITION PRACTICAL	25(1)

1. Determination of appropriate particle size of feed for fish larvae
2. Application of fertilizers and assessment of primary productivity
3. Gut content analysis to study natural food intake
4. Check tray assessment and feed ration calculation
5. Preparation of different types of feeds (moist pellet, dry pellet, micro-encapsulated egg diet)
6. Computer aid formulation of feeds for catfish and tilapia
7. Identification of common feeds and ingredients available in the market
8. Determination of digestibility coefficient
9. Study on the digestive system of fishes of different feeding habits
10. Study tour to different feed mills

CMA 512	SUSTAINABLE AQUACULTURE PRACTICAL	25(1)

1. Analysis of interactions among aquaculture intensification, production rate and environmental sustainability
2. Suitability determination of aquaculture farms (fish, shrimp, crab and molluscs)
3. Determination of carrying capacity of an aquatic ecosystem
4. Design integrated silvo-aquaculture system in the coastal environment of Bangladesh

5. Preparation of cage for mariculture practice
6. Design and layout of integrated multi-trophic aquaculture (IMTA) model for marine species
7. Assessment of environmental impacts on aquaculture (input identification, assessment and mitigation)
8. Assessment of aquaculture impacts on environment (input identification, assessment and mitigation)
9. Conversion of aquaculture pond effluents as organic manure
10. Evaluate domestication levels of marine species in Bangladesh
11. Economic analysis of coastal aquaculture farm
12. Study tour to conventional and integrated aquaculture farms to evaluate the management practices

INSTITUTE OF MARINE SCIENCES
Faculty of Marine Sciences and Fisheries
University of Chittagong, Chattogram 4331
Syllabus for M.S. in Marine Environmental Management
Academic Year: 2023-2024 & 2024-2025
Total Marks: 900, Total Credits: 36

M.S. in Marine Environmental Management

Course#	Course title	Thesis group	General group
Theoretical			
MEM 501	Blue Economy and Sustainable Development	100(4)	100(4)
MEM 502	Advanced Technologies in Marine Science	100(4)	100(4)
MEM 503	Advanced Marine Pollution	100(4)	100(4)
MEM 504	Marine Ecosystem Health Management	100(4)	100(4)
MEM 505	Marine Environmental Technology	100(4)	100(4)
MEM 506	Marine Environmental Law, Policy and Sustainability	100(4)	100(4)
	Subtotal	600(24)	600(24)
Practical			
MEM 507	Blue Economy and Sustainable Development Practical	-	25(1)
MEM 508	Advanced Technologies in Marine Science Practical	-	25(1)
MEM 509	Advanced Marine Pollution Practical	-	25(1)
MEM 510	Marine Ecosystem Health Management Practical	-	25(1)
MEM 511	Marine Environmental Technology Practical	-	25(1)
MEM 512	Marine Environmental Law, Policy and Sustainability Practical	-	25(1)
	Subtotal	-	150(6)
MEM 598	Project	-	50(2)
MEM 599	Thesis	200(8)	-
MEM 513	Project defense (Proposal 10, Final 40)	-	50(2)
MEM 514	Thesis defense (Proposal 10, Final 40)	50(2)	-
MEM 515	Viva-voce	50(2)	50(2)
	GRAND TOTAL	**900(36)**	**900(36)**

MEM 501	**BLUE ECONOMY AND SUSTAINABLE DEVELOPMENT**	**100(4)**

Course contents

1. Growing ocean economy
   1.1 Global ocean economy
   1.2 Ocean ecosystem health
   1.3 Blue economy concept
   1.4 Blue economy indicators
2. Blue economy sectors
   2.1 Marine fisheries
   2.2 Marine trade
   2.3 Oil, gas and minerals
   2.4 Marine tourism
   2.5 Renewable energy
3. Marine fisheries interventions
   3.1 Extending the fishing horizon
   3.2 New fishing gears and techniques
   3.3 Discovering new fisheries
   3.4 Value addition and post-harvest loss reduction
   3.5 Fish stock assessment
4. Aquaculture and mariculture interventions
   4.1 Domestication
   4.2 Production intensification
   4.3 Innovation farming

4.4 Live feeds for larviculture
4.5 Disease and health management

5. Ecosystem-based management
   5.1 Elements of ecosystem
   5.2 Trophic interactions
   5.3 Coordination and integration of stakeholders
   5.4 Formulation of EBM plan
6. Global sustainability initiatives
   6.1 Brundtland Report 1987
   6.2 Earth Charter 1992
   6.3 Kyoto Protocol 1997
   6.4 UN Millennial Summit 2000 and MDGs
   6.5 UN Sustainable Development Goals (SDGs) 2015
7. Sustainable Development Goals (SDGs)
   7.1 Goals, targets and indicators
   7.2 Interactions among the 17 goals
   7.3 Interactions at target-level
   7.4 Knowledge gaps
   7.5 Science-policy interface
8. SDG 14: Life Below Water
   8.1 Key interactions, uncertainties and dimensions
   8.2 Prevent and reduce marine pollution
   8.3 Protect marine and coastal ecosystems
   8.4 Sustainable use of ocean resources
   8.5 Increase economic benefits
9. Climate change challenges
   9.1 Tropical cyclone and depression
   9.2 Sea-level rise
   9.3 Salinity incursion
   9.4 Ocean acidification
   9.5 Freshwater plume
   9.6 Hypoxic condition
10. Blue economy development framework
    10.1 Major sectors and stakeholders
    10.2 Capacity building
    10.3 Design management plan
    10.4 Implementation workflow
    10.5 Monitoring and evaluation

Recommended readings

1. Rogers et al. 2008. An Introduction to Sustainable Development, Earthscan, London, UK. 416p.
2. Kuenkel, P. 2019. Stewarding Sustainability Transformations: An Emerging Theory and Practice of SDG Implementation, Springer, 321p.
3. UN Sustainable Development Goals Knowledge Platform (https://sustainabledevelopment.un.org/resourcelibrary)
4. Techera E, Winter G (eds.), 2019. Marine Extremes: Ocean Safety, Marine Health and the Blue Economy. Routledge, 255 pp.
5. Nicholls RJ, Hutton CW, Adger WN, Hanson SE, Rahman MM, Salehin M (eds.), 2018. Ecosystem Services for Well-Being in Deltas: Integrated Assessment for Policy Analysis. Palgrave macmillan, 615 pp.
6. Blewitt J, 2018. Understanding Sustainable Development. Earthscan, 427 pp.
7. Hossain MS, Chowdhury SR, Sharifuzzaman SM. 2017. Blue Economic Development in Bangladesh: A policy guide for marine fisheries and aquaculture. Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh, 32 pp.
8. ICSU, 2017. A guide to SDG interactions: from science to implementation. International Council for Science (ICSU), 239 pp. https://www.icsu.org/cms/2017/05/SDGs-Guide-toInteractions.pdf.
9. OECD, 2016. The Ocean Economy in 2030: Edition 2016 (Volume 2016). Organisation for Economic Co-Operation and Development (OECD), 256 pp.

10. Stylios C, Floqi T, Marinski J, Damiani L (eds.), 2015. Sustainable Development of SeaCorridors and Coastal Waters: The TEN ECOPORT project in South East Europe. Springer International Publishing, 253 pp.
11. Hossain, M.S, Chowdhury, S.R, Navera, U.K, Hossain, M.A.R, Imam, B, Sharifuzzaman, S.M., 2014. Opportunities and strategies for ocean and river resources management. Seventh Five Year Plan (2016-2020) background paper, Planning Commission of the Government of Bangladesh, 67 pp.
12. Griggs, D.J., Nilsson, M., Stevance, A., McCollum, D. (Eds.). 2017. A guide to SDG interactions: From science to implementation. International Council for Science (ICSU). https://www.icsu.org/cms/2017/05/SDGs-Guide-to-Interactions.pdf
13. Chowdhury, S.R., Hossain, M.S., Shamsuddoha, M. and Khan, S.M.M.H., 2012. Coastal Fishers' Livelihood in Peril: Sea Surface Temperature and Tropical Cyclones in Bangladesh. Foreign and Commonwealth Office through British High Commission and Centre for Participatory Research and Development (CPRD), Dhaka, Bangladesh, 66 pp.
14. Grafton RQ, Hilborn R, Squires D, Tait M, Williams M (eds.), 2010. Handbook of Marine Fisheries Conservation and Management.785 pp

MEM 502 ADVANCED TECHNOLOGIES IN MARINE SCIENCE 100(4)

Course Contents

1. Brief history of the development of oceanography leading to the era of modern technology and innovations
2. Advances in oceanic measurements: electronic sensors, digital technology, CTD, underway equipment, robotic and remotely operated instruments
3. Ocean observation satellites and remote sensing of the oceans
   3.1. Optical oceanography: visible and microwave
   3.2. Radar and scatterometry
   3.3. Ocean surface topography or satellite altimetry
   3.4. Remote sensing of temperature and salinity
   3.5. Lidar
4. Acoustic, hydrographic and geophysical advances
   4.1. Seafloor imaging and mapping; sonar technology
   4.2. Acoustic tomography for biological and fisheries applications
5. Advanced telemetry in ocean data collection: applications, platforms, parameters, realtime or near-real-time ocean observation 6. Advanced oceanographic platforms and vehicles 6.1. Bouy, drifter, glider, Argo, etc.
   6.2. Submersibles and ROVs
7. Advances in computing and ocean modeling
8. Advances in data assimilation, storage, processing and delivery
   8.1. Emerging data formats
   8.2. Data repositories/warehouses and portals
   8.3. Data processing and visualization: online and offline
   8.4. Data access
9. Advances in submarine geology: plate tectonics, deep-sea explorations
10. Advances in marine biology and marine fisheries
11. Advances in operational oceanography and ocean forecasting: global ocean observing systems (GOOS), models and computational infrastructure, operational ocean data products

Recommended readings

1. Storch, H.v. and Hasselmann, K. 2010. Seventy Years of Exploration in Oceanography. Springer. 137p.
2. Jochum, M. and Murtugudde, R. 2006. Physical Oceanography: Developments since 1950. Springer. 250p.
3. Hekinian, R. 2014. Sea Floor Exploration: Scientific Adventures Diving Into the Abyss. Springer. 370p.
4. Martin, S. 2014. An Introduction to Ocean Remote Sensing. Cambridge University Press. 496p+plates.
5. Robinson, I.S. 2010. Discovering the Ocean from Space: The Unique Applications of Satellite Oceanography. Springer. 638p.

6. Barale, V., Gower, J. F. R. and Alberotanza, L. 2010. Oceanography from Space: Revisited. Springer. 374p.
7. Wang. Q. 2009. Remote Sensing of Coastal Environments. CRC Press. 423p+plates.
8. Schiller, A. and Brassington, G.B. 2011. Operational Oceanography in the 21st Century. Springer. 729p.
9. Pinardi, N. and Woods, J. 2010. Ocean Forecasting: Conceptual Basis and Applications. Springer. 472p.
10. Fu, L.L. and Cazenave, A. 2001. Satellite Altimetry and Earth Sciences: A Handbook of Techniques and Applications. Academic Press. 463p.
11. Medwin, H. 1998. Fundamentals of Acoustical Oceanography. Academic Press. 712p+plates.

MEM 503 ADVANCED MARINE POLLUTION 100(4)

Rationale

The marine environment is indisputably a valuable part of our planet, which is in serious threat caused by human interventions, although it constitutes the fundamental pillar for many aspects of human activities, such as marine fisheries, sea traffic, offshore oil exploitation, urbanization, tourism, etc. Nowadays the various habitats of marine environment are threatened by various kinds of pollution, caused from peoples' activities on land and from technological disasters (oil spills, plastics, chemicals, etc.) both onshore and offshore. As a whole the environmental damage is enormous, impacting sea life and consequently humans' health. However, the enhancement of knowledge of the graduates on the inventory of major sources of marine pollution and their effects on marine environment and human health is crying need in today's world.

Objectives

- To understand the type of pollutants discharged into sea as a result of human activities, their sources and impact on marine life.
- To study the addition of conservative (radioactive pollutants, trace metals and pesticides), non-conservative pollutants (Oil and other organic wastes) and nutrient salts, their implications on human health and food resources and commercial interest.

Learning outcomes

Upon completion of this course, it is anticipated that students will have an understanding of:

- the multidisciplinary approach to defining the major types of chemical, physical, and biological pollutants that impact upon marine environments.
- the fundamentals of marine pollution particularly the types, sources and fates of marine pollutants, pollutant transport and transformation.
- examining the pathways, fates and effects of different pollutants on marine ecosystems and human health.
- examining different approaches to the design of monitoring programs for detecting pollutants, and techniques for controlling pollutants.
- gaining skills in sampling techniques and analysis of polluted samples.

Course contents

1. Environment, Environmental Science and Environmental Pollution :
   1.1 Definition & History
   1.2 Common types, characteristics and sources of pollutants
2. Marine Environment and Marine Pollution:
   2.1 Marine Environment: Definition, The marine environment as historical space, From Maritime history to marine environmental history, The marine environment and its physical, geological, chemical and biological characteristics and their interactions
   2.2 Marine Pollution: Definition, types and sources of marine pollution
   2.3 Lethal and sub-lethal effects of pollutants to marine organisms
   2.4 Coastal & Deep Sea Pollution
   2.5 Effects of Coastal & Marine Pollution on public health
3. Heavy Metals Pollution in the Marine Environment:
   3.1 Definition, types and sources of heavy metals
   3.2 Fate of heavy metals and their biological effects on marine organism
   3.3 General mechanisms of transport and transformation of heavy metals in water/sediment systems and within marine organisms.

4. Eutrophication & Harmful Algal Blooms (HAB's):
   4.1 Definition, types and sources of eutrophication
   4.2 Marine eutrophication processes and its effects on marine environment
   4.3 Harmful Algal Blooms (HAB's)
   4.4 Identification of harmful algal species
   4.5 Toxins produced by harmful algal species
   4.6 Effects of HAB's on living organisms
5. Impact of Coastal Aquaculture:
   5.1 Ecological Impacts of Coastal Aquaculture Developments: Enrichment; Disturbance of wildlife and habitat destruction; Interaction between escaped farmed stock and wild species; Discharge of inhibitory compounds in the aquatic environment; Development of antibiotic resistant microbial communities; Chemicals introduced via construction materials; Hormones and growth promoters
   5.2 implications for Human health: Outbreaks of disease associated with the consumption of ; The influence of fish pathogens on human ; Phycotoxins
6. Ocean acidification:
   6.1 Ocean acidification Process
   6.2 Causes and effects of ocean acidification
   6.3 Impact of ocean acidification on marine communities
7. Plastic Pollution
8. Radioactive wastes
   8.1 Composition of radioactive wastes
   8.2 Routes and fluxes into and within the oceans
   8.3 Natural background radiation
   8.4 Accumulation in sediments and marine organisms
   8.5 Routes to man and critical pathway analysis
   8.6 Consideration of the ocean as a disposal option.
9. Greenhouse gases and their effects on marine environment

MEM 504	MARINE ECOSYSTEM HEALTH MANAGEMENT	100(4)

Rationale

A healthy ecosystem is essential to provide the services that humans and the natural environment require and has tremendous ecological, social and economic value. To evaluate ecosystem health, it is necessary to quantify ecosystem conditions using a variety of indicators. For evaluating the health status of marine ecosystems we need a science-based, integrated Ecosystem Approach, that incorporates knowledge of ecosystem function and services provided that can be used to track how management decisions change the health of marine ecosystems. However, the management of marine ecosystems increasingly demands comprehensive and quantitative assessments of ocean health, but lacks a tool to do so. The proposed course will enhance the in-depth knowledge on ecosystem health assessment and management which is the primary goal of environmental management and ecological restoration.

Objectives

The key objectives of this course are:

- To gain basic knowledge on different terms used in ecosystem health assessment and management.
- To identify different ecosystem health indicators of measuring the integrated stress at individual, population, and ecosystem levels;
- To quantify the magnitude and effects of specific natural and anthropogenic stressors and the combinations of those stressors;
- To carry out environmental impact assessment independently through case studies and problem exercises.

Learning outcomes

By the end of the module, students will be able to:

- Understand the main principles and criteria for indicator selection, classification of indicators for different kinds of ecosystems, the most appropriate indicators for measuring ecosystem sustainability, and various methods and models for the assessment of ecosystem health.
- Have basic understanding of effects studies, environmental monitoring, and evaluation of risk and environmental state from a scientific, regulatory and industrial perspective.

- Describe and apply the basic framework of principles and practices that can be used to carry out good environmental impact assessments, accounting for climate change and associated impacts into the future.

Course contents

1. Concepts of Marine Ecosystem Health
   - 1.1 Conceptual Framework
   - 1.2 Health
   - 1.3 Ecosystem Health: Identify Symptoms; Identify and Measure Vital Signs; Provisional Diagnosis; Tests to Verify Diagnosis; Make a Prognosis for the Bay; Treatment
   - 1.4 Marine Ecosystem Health
   - 1.5 Ecological or Ecosystem Integrity
   - 1.6 Ecological Change
   - 1.7 Marine Environmental Quality (MEQ)
   - 1.8 Sustainability of Marine Ecosystems
   - 1.9 Human Health and Marine Ecosystem Health
2. Indicators for Assessing Marine Ecosystem Health
   - 2.1 Monitoring Approaches
   - 2.2 Indicators and Indices
   - 2.3 Status and Trends Analysis
3. Application of Indicators for the Assessment of Ecosystem Health
   - 3.1 Criteria for the Selection of Ecological Indicators for EHA
   - 3.2 Classification of Ecosystem Health Indicators
   - 3.3 Indices Based on Indicator Species
   - 3.4 Indices Based on Ecological Strategies
   - 3.5 Indices Based on the Diversity Value
   - 3.6 Indicators Based on Species Biomass and Abundance: Indicators Integrating All Environment Information
4. Environmental Risk Assessment of Marine Activities
   - 4.1 Qualitative Vs. Quantitative Risk Assessment Approaches: Qualitative Risk Assessment; Quantitative Risk Assessment
   - 4.2 Risk Evaluation
   - 4.3 Risk characteristics & estimation
5. Assessment of Karnaphuli River Ecosystem Health
6. Assessment of Bay of Bengal Large Ecosystem Health
7. Environmental Impact Assessment (EIA)
   - 7.1 Environmental impact assessment (EIA)
   - 7.2 Characteristics and function of EIA
   - 7.3 Purposes of EIA
   - 7.4 Nexus between development and environment
   - 7.5 EIA in project planning and implementation, selection of appropriate procedures
   - 7.6 EIA process, scoping, impact prediction, mitigation measures, monitoring
   - 7.7 Environment Management Plan
   - 7.8 Project cycle- IEE and EIA
   - 7.9 Methodologies (Adhoc, checklist, matrices, network diagram, overlays and mathematical modelling), social impact assessment, EIA reporting and review
   - 7.10 Case studies (water quality impact, Impacts of Farrakka barrage on coastal region of Bangladesh, tourism development; industrial development, Aquaculture development)

MEM 505	MARINE ENVIRONMENTAL TECHNOLOGY	100(4)

Rationale

Marine environmental could make significant contributions in the exploitation of marine resources sustainably addressing key marine environmental problems. However, the biotic and abiotic resources of marine environment throughout the world are being impacted by stresses from population and technological growth, contamination and mismanagement, along with global climate change. The proposed Marine Environmental Technology module program will provide the necessary skills, education and training required to take on the responsibilities of a

graduate as an engineering technologist in the management, protection, development and use of marine water resources.

Objectives

The core objectives of the module are to-

- demonstrate knowledge and insight in the basic biological, chemical and physical principles of environmental technology;
- demonstrate qualitative and quantitative insight in the most important environmental technologies for treatment of sewage, solid wastes, polluted soil, wastewater and contaminated seawater;
- demonstrate insight in how to abate or prevent environmental pollution by use of simple measures,

carry out experimental laboratory research into a number of treatment processes

Learning outcomes

The course will enrich the knowledge of the students on the introduction to environmental technology and its role in sustainable development, taking the nature and background of environmental and sustainability issues into account. Lectures deal with the various fields of application of environmental technology: sewage and solid waste treatment, water pollution and wastewater treatment, spilled oil treatment, soil and seawater contamination and remediation technology, and the collection, management, conversion and re-use of wastes. The most relevant state-of-the-art technology, as well as promising new technological developments will be discussed. Focus is on the biological, chemical and physical principles of the processes, as well on the design of process apparatuses and engineered natural systems. Sustainability criteria will be used to evaluate alternative processes.

Course contents

1. Introduction to marine environmental technology
2. Definition, scope and recent advances of marine environmental technology
3. Marine environmental biotechnology
   - 3.1 Definition and scope of marine environmental biotechnology
   - 3.2 Bio-fouling, Marine fouling and boring organisms-their biology, Alien/ Invasive Species; Antifouling and antiboring treatments; corrosion process and control of marine structures.
4. Treatment and recycling of sewage and sludge
   - 4.1 Physical treatment
   - 4.2 Chemical treatment
   - 4.3 Biological treatment
   - 4.4 Recycling of sewage and sludge
5. Wastewater treatment and waste management
   - 5.1 Primary wastewater treatment
   - 5.2 Secondary wastewater treatment
   - 5.3 Tertiary wastewater treatment
   - 5.4 Solid waste management
   - 5.5 Wastewater bio treatment: BOD, COD; Biosensors; Biomolecules; membrane and transducer; Bioaugmentation-estimation of microbial load; Methods of Inorganic and Organic waste removal
6. Treatment and recycling of spilled oil
   - 6.1 Physical treatment
   - 6.2 Chemical treatment
   - 6.3 Biological treatment
   - 6.4 Recycling of bilge, ballast water and spilled oil
   - 6.5 Oil spill management
7. Bioremediation
   - 7.1 Definition, types and characteristics of bioremediation
   - 7.2 Application of bioremediation in pollution control
   - 7.3 Biomaterial interaction: Biodegradation and Bioremediation; Biodegradation of natural and synthetic waste materials; Bioremediation; Separation, purification and bio removal of pollutants
8. Biomarkers as tools for pollution assessment
   - 8.1 Definition, types and characteristics of biomarkers

8.2 Marine pollution detection through biomarkers
8.3 Molecular Biomarkers: Their significance and application in marine pollution monitoring.
8.4 Biomarkers and Integrated Environmental Risk Assessment

9. Environmental monitoring and modeling
9.1 Tools and techniques used in environmental monitoring
9.2 Basics in environmental modeling
9.3 Principles and operational procedure of different models (DREAM, OWM, OSCAR, Par Track, Deep Blow, B-jet etc.)

MEM 506 MARINE ENVIRONMENTAL LAW, POLICY AND SUSTAINABILITY 100(4)

Rationale

The development of the modern law of the sea and the growing concern for the condition of the oceans have given rise to a number of legal regimes addressing problems of the marine environment including pollution, loss of biodiversity, protection of endangered species, and marine mammals. The international law of the sea provides a foundation for continuing progress. The future of marine conservation depends upon the ability and willingness of states to cooperate in these common objectives and the capacity of individual states to prescribe and enforce their own marine conservation laws. However, the specialization in marine environmental law provides students with expertise in a dynamic area of law and policy focused on marine environment & resource protection that will continue to grow in importance. The course is of particular relevance to people working in environmental and resources sectors, professionals in government, legal practitioners and those with a broader philosophical or practical interest.

Objectives

The key objectives of this course are:

- to acquire knowledge on the contemporary Marine Environmental Law and Policy.
- to apply and disseminate knowledge on different legal issues and policy framework for protection and conservation of biotic and resources of the marine environment for achieving the major objectives of SDG_{14}.

Learning outcomes

After the successful completion of the course the graduates will be able to acquire a concise account of the legal and policy framework underlying international marine environmental issues, and of the fundamental concepts and strategies that are important to the protection of the marine environment. Some of the topics are explored include: the prevention of marine pollution caused by land based activities, ships, and offshore hydrocarbon and mineral resources exploration; the conservation and management of marine living resources through the legal practices.

Course contents

1. Environmental Laws and Policies in Bangladesh
1.1 Environmental Laws and Policies during the Post-Independence Era in Bangladesh
1.2 Institutional Development of Environmental law in Bangladesh
1.3 Environmental Issues in Bangladesh and its Legal Mechanism.

2. International Environmental Laws
2.1 Evolution and development of International Environmental laws with reference to Stockholm Conference,
Nairobi Declaration, Rio Conference, Rio+5 and the Rio+10
2.1 Global environmental issues and International laws to control Global warming, Ozone depletion, Acid rains, Hazardous waste, CITES etc.
2.2 UN Framework Convention on Climate Change, 1992; Kyoto Protocol, 1997
2.3 Multinational authorities and agreements, future of International laws.

3 Maritime Organizations for Ocean Governance
3.1 International Maritime Organization (IMO)
3.2 International Oceanographic Commission (IOC)
3.3 International Court of Justice (ICJ)
3.4 International Tribunal for the Law of the Sea (ITLOS) 3.5 United Nations Division of the Law of the Seas (UNDOLAS)

3.6 United Nations Environment Programme (UNEP).

4 International Laws/ Conventions on Marine environment Protection
- 4.1 UN Convention on the Law of the Sea (UNCLOS), 1982
- 4.2 International Convention for the Prevention of Pollution of the Sea by Oil (OILPOL), 1958
- 4.3 International convention on the prevention of marine pollution by the dumping of wastes or other matter (London Convention, 1972)
- 4.4 International Convention for the prevention of pollution from ships (MARPOL,1973/1978)
- 4.5 International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004
- 4.6 Paris Convention for the Prevention of Marine Pollution from Land based Sources, 1974

5 International Laws/ Conventions on Marine Biodiversity Conservation
- 5.1 Role of the Convention on Biological Diversity (CBD)
- 5.2 Cartagena Protocol on Bio-safety
- 5.3 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
- 5.4 Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)
- 5.5 Convention on the Conservation of Migratory Species (CMS)
- 5.6 International Union for Conservation of Nature (IUCN)
- 5.7 United Nations Framework Convention on Climate Change (UNFCCC) towards sustainable development of oceanic environment and its resources

Recommended readings

1. Bridgman, H. 1990. Global Air Pollution, John Wilay & Sons.
2. Lyons, T. and Scott, B. 1992. Principles of Air Pollution Methodology. CBS Pub. & Distributions, New Delhi.
3. Seinfild, J.H. 1998. Atmospheric Chemistry & Physics. John Wiley & Sons.
4. Environmental Water Pollution and Control. Anmol Pub. New Delhi
5. Tripallhi, A.K. 1990. Water Pollution, Astish Pub. New Delhi.
6. Mishra, S.R. 1996. Assessment of Water Pollution. APH Pub. New Delhi.
7. Haslam, S.M. 1990.River Pollution–an ecology perspective. CBS Pub. & Distributor. New Delhi.
8. APHA, 1996. Standard Methods for the Examination of Water & Wastewater, APHA, Washington. D.C.

MEM 507	BLUE ECONOMY AND SUSTAINABLE DEVELOPMENT PRACTICAL	25(1)

1. Prepare maritime zone map of Bangladesh and demarcate marine fishing zones
2. Study the shallow sea and deep-sea oil/gas exploration blocks in the EEZ of Bangladesh
3. Evaluate blue economy development activities in the coastal and marine ecosystems of Bangladesh
4. Determine trophic interaction of marine species
5. Formulate ecosystem-based marine fisheries management plan for Bangladesh
6. Assess the interactions among the sustainable development goals (SDGs)
7. Analyze the linkages of SDG 14 to the blue economy focus areas
8. Study cyclogenesis locations and cyclone tracks on the Bay of Bengal for the last 100 years
9. Mapping salinity incursion areas along Bangladesh coast and interpret ecosystem health
10. Measure ocean acidification effects on coastal ecosystems of Bangladesh
11. Analyze causes and effects of hypoxic characteristics in the Bay of Bengal
12. Formulate integrated blue economy development plan
13. Identify resilience elements and analyze their role on coastal community of Bangladesh
14. Visit coastal ecosystems of Bangladesh and evaluate climate change impacts on livelihoods

MEM 508	ADVANCED TECHNOLOGIES IN MARINE SCIENCE PRACTICAL	25(1)

1. Field operation of major oceanographic instruments
2. Practices in ocean remote sensing: SST, SSS, ocean color, SSH
3. Basic practices in Ecogram analysis
4. Collection and preservation of water, sediment and biota samples from the marine water

5. Data discovery, download and analyses
6. Use of ocean data analysis software: ODV, Panoply, NCView, HDFView

MEM 509	ADVANCED MARINE POLLUTION PRACTICAL	25(1)

1. Sampling & Analytical techniques for marine environmental monitoring.
2. Physicochemical and biological test of water quality.
3. Study on equipment and software used in toxicity test.
4. Methods for evaluation of acute and chronic toxicity: Experimental design, sample preparation, controls, reference toxicant test, test initiation, monitoring, terminating, data handling and test acceptability.
5. Selected biological methods for the assessment of marine pollution: Bioassay test on shrimp, mollusc and fish.
6. Determination of some heavy/trace metals of water, sediment and marine biota.
7. Detection of harmful algae and algal toxins.

MEM 510	MARINE ECOSYSTEM HEALTH MANAGEMENT PRACTICAL	25(1)

1. Practice on data collection and analysis of physico-chemical parameters for ecosystem health assessment.
2. Practice on data collection and analysis of different biotic communities for ecosystem health assessment.
3. Use of bio-indicators for ecosystem health assessment.
4. Practices on different indices used for ecosystem health assessment.
5. Application of ecological indicators for assessing environmental quality of the coastal and oceanic environment.
6. A comparative study on polluted and non-polluted area for ecosystem health management.
7. Drawing and labeling of EIA tools.
8. Impact Assessments and Modelling on: Coastal aquaculture (shrimp farming); Industrial Establishment; Construction of Embankment/Dams and the establishment other mega development projects in the coastal areas: Mangrove Ecosystems and other sensitive coastal/marine habitats (Estuaries, Coral Reefs etc.)

MEM 511	MARINE ENVIRONMENTAL TECHNOLOGY PRACTICAL	25(1)

1. Study on the effluent characteristics of different industries.
2. Preparation of the flow chart for sewage/industry effluent treatment.
3. Design of settling and aeration tank.
4. Experiment on heavy metal removal using biological agent.
5. Identification of organisms involved in fouling and boring.
6. Experiment on prevention of fouling and boring using test panels.
7. Identification and screening of industrially important microorganisms used in sewage and effluent treatment.
8. Industrial visits for acquainted with different treatment technologies used in Sugar, Distillery, Dairy, Textile, Pulp and Paper, Pharmaceutical, Chemical, Food Processing, Agrochemical, Fertilizer, Bone mill etc.
9. Application of biomarkers and bioremediation in marine pollution studies.
10. Study on bilge and ballast water treatment technologies.

MEM 512	MARINE ENVIRONMENTAL LAW, POLICY AND SUSTAINABILITY CASE STUDY	25(1)

1. A case study on the inventory of usefulness, drawbacks and successful implementation of maritime laws for sustainable development
2. A case study on the exploration of successful strategies for sustainable harvesting of oceanic resources of the Bay of Bengal
3. To practice on the present status of the implementation of existing maritime laws in Bangladesh for sustainable management of coastal and marine environment
4. Case study on Bangladesh commitments towards the implementation of SDG14 and sustainable Management of Bay of Bengal (BoB)

INSTITUTE OF MARINE SCIENCES
Faculty of Marine Sciences and Fisheries
University of Chittagong, Chattogram 4331

Syllabus for the M.S. in Fish Nutrition and Feed Technology
Academic Year: 2023-2024 & 2024-2025
Total Marks: 900, Total Credits: 36

M.S. in Fish Nutrition and Feed Technology

Course#	Course title	Thesis group	General group
Theoretical			
FNFT 501	Blue Economy and Sustainable Development	100(4)	100(4)
FNFT 502	Advanced Technologies in Marine Science	100(4)	100(4)
FNFT 503	Nutrition and Feeding of Fish and Shrimp	100(4)	100(4)
FNFT 504	Feed Ingredients and Feed Formulations	100(4)	100(4)
FNFT 505	Feed Technology and Feed Mill Management	100(4)	100(4)
FNFT 506	On-farm Feed Management	100(4)	100(4)
	Subtotal	600(24)	600(24)
Practical			
FNFT 507	Blue Economy and Sustainable Development Practical	-	25(1)
FNFT 508	Advanced Technologies in Marine Science Practical	-	25(1)
FNFT 509	Nutrition and Feeding of Fish and Shrimp Practical	-	25(1)
FNFT 510	Feed Ingredients and Feed Formulations Practical	-	25(1)
FNFT 511	Feed Technology and Feed Mill Management Practical	-	25(1)
FNFT 512	On-farm Feed Management Practical	-	25(1)
	Subtotal	-	150(6)
FNFT 598	Project	-	50(2)
FNFT 599	Thesis	200(8)	-
FNFT 513	Project defense (Proposal 10, Final 40)	-	50(2)
FNFT 514	Thesis defense (Proposal 10, Final 40)	50(2)	-
FNFT 515	Viva-voce	50(2)	50(2)
	GRAND TOTAL	**900(36)**	**900(36)**

FNFT 501 BLUE ECONOMY AND SUSTAINABLE DEVELOPMENT 100(4)

Course contents

1. Growing ocean economy
   - 1.1 Global ocean economy
   - 1.2 Ocean ecosystem health
   - 1.3 Blue economy concept
   - 1.4 Blue economy indicators
2. Blue economy sectors
   - 2.1 Marine fisheries
   - 2.2 Marine trade
   - 2.3 Oil, gas and minerals
   - 2.4 Marine tourism
   - 2.5 Renewable energy
3. Marine fisheries interventions
   - 3.1 Extending the fishing horizon
   - 3.2 New fishing gears and techniques
   - 3.3 Discovering new fisheries
   - 3.4 Value addition and post-harvest loss reduction
   - 3.5 Fish stock assessment
4. Aquaculture and mariculture interventions
   - 4.1 Domestication
   - 4.2 Production intensification
   - 4.3 Innovation farming

4.4 Live feeds for larviculture
4.5 Disease and health management

5. Ecosystem-based management
   5.1 Elements of ecosystem
   5.2 Trophic interactions
   5.3 Coordination and integration of stakeholders
   5.4 Formulation of EBM plan
6. Global sustainability initiatives
   6.1 Brundtland Report 1987
   6.2 Earth Charter 1992
   6.3 Kyoto Protocol 1997
   6.4 UN Millennial Summit 2000 and MDGs
   6.5 UN Sustainable Development Goals (SDGs) 2015
7. Sustainable Development Goals (SDGs)
   7.1 Goals, targets and indicators
   7.2 Interactions among the 17 goals
   7.3 Interactions at target-level
   7.4 Knowledge gaps
   7.5 Science-policy interface
8. SDG 14: Life Below Water
   8.1 Key interactions, uncertainties and dimensions
   8.2 Prevent and reduce marine pollution
   8.3 Protect marine and coastal ecosystems
   8.4 Sustainable use of ocean resources
   8.5 Increase economic benefits
9. Climate change challenges
   9.1 Tropical cyclone and depression
   9.2 Sea-level rise
   9.3 Salinity incursion
   9.4 Ocean acidification
   9.5 Freshwater plume
   9.6 Hypoxic condition
10. Blue economy development framework
    10.1 Major sectors and stakeholders
    10.2 Capacity building
    10.3 Design management plan
    10.4 Implementation workflow
    10.5 Monitoring and evaluation

Recommended readings

1. Rogers et al. 2008. An Introduction to Sustainable Development, Earthscan, London, UK. 416p.
2. Kuenkel, P. 2019. Stewarding Sustainability Transformations: An Emerging Theory and Practice of SDG Implementation, Springer, 321p.
3. UN Sustainable Development Goals Knowledge Platform (https://sustainabledevelopment.un.org/resourcelibrary)
4. Techera E, Winter G (eds.), 2019. Marine Extremes: Ocean Safety, Marine Health and the Blue Economy. Routledge, 255 pp.
5. Nicholls RJ, Hutton CW, Adger WN, Hanson SE, Rahman MM, Salehin M (eds.), 2018. Ecosystem Services for Well-Being in Deltas: Integrated Assessment for Policy Analysis. Palgrave macmillan, 615 pp.
6. Blewitt J, 2018. Understanding Sustainable Development. Earthscan, 427 pp.
7. Hossain MS, Chowdhury SR, Sharifuzzaman SM. 2017. Blue Economic Development in Bangladesh: A policy guide for marine fisheries and aquaculture. Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh, 32 pp.
8. ICSU, 2017. A guide to SDG interactions: from science to implementation. International Council for Science (ICSU), 239 pp. https://www.icsu.org/cms/2017/05/SDGs-Guide-toInteractions.pdf.
9. OECD, 2016. The Ocean Economy in 2030: Edition 2016 (Volume 2016). Organisation for Economic Co-Operation and Development (OECD), 256 pp.

10. Stylios C, Floqi T, Marinski J, Damiani L (eds.), 2015. Sustainable Development of SeaCorridors and Coastal Waters: The TEN ECOPORT project in South East Europe. Springer International Publishing, 253 pp.
11. Hossain, M.S, Chowdhury, S.R, Navera, U.K, Hossain, M.A.R, Imam, B, Sharifuzzaman, S.M., 2014. Opportunities and strategies for ocean and river resources management. Seventh Five Year Plan (2016-2020) background paper, Planning Commission of the Government of Bangladesh, 67 pp.
12. Griggs, D.J., Nilsson, M., Stevance, A., McCollum, D. (Eds.). 2017. A guide to SDG interactions: From science to implementation. International Council for Science (ICSU). https://www.icsu.org/cms/2017/05/SDGs-Guide-to-Interactions.pdf
13. Chowdhury, S.R., Hossain, M.S., Shamsuddoha, M. and Khan, S.M.M.H., 2012. Coastal Fishers' Livelihood in Peril: Sea Surface Temperature and Tropical Cyclones in Bangladesh. Foreign and Commonwealth Office through British High Commission and Centre for Participatory Research and Development (CPRD), Dhaka, Bangladesh, 66 pp.
14. Grafton RQ, Hilborn R, Squires D, Tait M, Williams M (eds.), 2010. Handbook of Marine Fisheries Conservation and Management. 785 pp

FNFT 502 ADVANCED TECHNOLOGIES IN MARINE SCIENCE 100(4)

Course Contents

1. Brief history of the development of oceanography leading to the era of modern technology and innovations
2. Advances in oceanic measurements: electronic sensors, digital technology, CTD, underway equipment, robotic and remotely operated instruments
3. Ocean observation satellites and remote sensing of the oceans
   3.1. Optical oceanography: visible and microwave
   3.2. Radar and scatterometry
   3.3. Ocean surface topography or satellite altimetry
   3.4. Remote sensing of temperature and salinity
   3.5. Lidar
4. Acoustic, hydrographic and geophysical advances
   4.1. Seafloor imaging and mapping; sonar technology
   4.2. Acoustic tomography for biological and fisheries applications
5. Advanced telemetry in ocean data collection: applications, platforms, parameters, realtime or near-real-time ocean observation
6. Advanced oceanographic platforms and vehicles
7. 6.1. Bouy, drifter, glider, Argo, etc.
   6.2. Submersibles and ROVs
7. Advances in computing and ocean modeling
8. Advances in data assimilation, storage, processing and delivery
   8.1. Emerging data formats
   8.2. Data repositories/warehouses and portals
   8.3. Data processing and visualization: online and offline
   8.4. Data access
9. Advances in submarine geology: plate tectonics, deep-sea explorations
10. Advances in marine biology and marine fisheries
11. Advances in operational oceanography and ocean forecasting: global ocean observing systems (GOOS), models and computational infrastructure, operational ocean data products

Recommended readings

1. Storch, H.v. and Hasselmann, K. 2010. Seventy Years of Exploration in Oceanography. Springer. 137p.
2. Jochum, M. and Murtugudde, R. 2006. Physical Oceanography: Developments since 1950. Springer. 250p.
3. Hekinian, R. 2014. Sea Floor Exploration: Scientific Adventures Diving Into the Abyss. Springer. 370p.
4. Martin, S. 2014. An Introduction to Ocean Remote Sensing. Cambridge University Press. 496p+plates.
5. Robinson, I.S. 2010. Discovering the Ocean from Space: The Unique Applications of Satellite Oceanography. Springer. 638p.

6. Barale, V., Gower, J. F. R. and Alberotanza, L. 2010. Oceanography from Space: Revisited. Springer. 374p.
7. Wang. Q. 2009. Remote Sensing of Coastal Environments. CRC Press. 423p+plates.
8. Schiller, A. and Brassington, G.B. 2011. Operational Oceanography in the 21st Century. Springer. 729p.
9. Pinardi, N. and Woods, J. 2010. Ocean Forecasting: Conceptual Basis and Applications. Springer. 472p.
10. Fu, L.L. and Cazenave, A. 2001. Satellite Altimetry and Earth Sciences: A Handbook of Techniques and Applications. Academic Press. 463p.
11. Medwin, H. 1998. Fundamentals of Acoustical Oceanography. Academic Press. 712p+plates.

FNFT 503 NUTRITION AND FEEDING OF FISH AND SHRIMP 100(4)

Rationale

Nutrition and feeding of fish and shrimp are directly connected to the production and profitability of aquaculture. A strong knowledge base on feeding behavior, dietary and energy requirements, special nutritional requirements of larvae and broodstock, effect of dietary quality on larval growth and reproductive output, and practical feeding guidelines etc. is essential not only for manufacturing nutritionally balanced feed but also to achieve optimum yield from production unit. Developing expertise in this field will therefore be beneficial for our aquaculture sector and the national economy.

Objectives

To develop the students with basic concepts on nutrition of fish and shrimp in terms of their feeding behavior, dietary intake and energy requirements, nutrition of broodstock and larvae, influence of diet quality on larval development and reproductive performance of brood, practical feeding guidelines, feed wastes and their impacts.

Learning outcomes

Upon successful completion of this course, students will be able to:

- Recognize the feeding behavior and feed intake pattern of fish and shrimp
- Learn about major nutrients and their dietary requirements
- Understand specific nutritional requirement of larvae and broodstock
- Comprehend the ontogeny of larvae and activity of digestive enzymes
- Explain the importance of fulfilling energy requirements in diet formulation
- Gain knowledge on feed derived wastes and their impacts

Course contents

1. Introduction
2. Feeding behavior and food intake of fish and crustaceans
   - 2.1 Types of feeding, mouth structure and stomach size, food preferences in different life stages
   - 2.2 Central and peripheral control of feed intake
   - 2.3 Measurement of voluntary intake
   - 2.4 Factors affecting voluntary intake
3. Dietary requirements of fish and shrimp
   - 3.1 Proteins
   - 3.2 Lipids
   - 3.3 Carbohydrates
   - 3.4 Vitamins
   - 3.5 Minerals
4. Nutrition of fish and penaeid shrimp larvae
   - 4.1 Dietary requirements
   - 4.2 Ontogeny and larval development
   - 4.3 Activity of digestive enzymes throughout development
   - 4.4 Transition from endogenous to exogenous feeding
   - 4.5 Quality of larvae related to nutrition
5. Broodstock nutrition of fish and shrimp

5.1 Energy partitioning for reproduction
5.2 Protein requirements
5.3 Specialized diets prior to spawning
5.4 Effect of dietary quality on reproductive output

6. Nutritional energetics
   6.1 Energy requirements
   6.2 Formulating diets to satisfy energy needs
   6.3 Partitioning of biological energy
   6.4 Factors affecting energy partitioning
7. Nutritional immunology
   7.1 Immune system components in fish and shellfish
   7.2 Cells and organs involved in immune response
   7.3 Factors affecting the immune response
   7.4 Role of nutrients and functional feeds in promoting immunity
8. Nutritional strategies for immune enhancement
   8.1 Nutraceuticals and bioactive compounds, and their immunomodulatory effects
   8.2 Feeding strategies to optimize immune function in aquaculture
9. Feed waste production
   9.1 Effluent discharges
   9.2 Fertilizer derived wastes
   9.3 Residues of biocides
   9.4 Chemical residue
   9.5 Hypernutrification and eutrophication

FNFT 504 FEED INGREDIENTS AND FEED FORMULATIONS 100(4)

Rationale

Feed ingredients and feed formulations are the most integral part of applied nutrition for fish and shrimp. Precise understanding of the quality of various ingredients, criteria for selection, presence of anti-nutrients and their minimizing techniques, steps in feed formulation, balancing protein and energy value in feeds, different methods of formulation, feed for larvae and broodstock, storage conditions and their impacts on quality all are crucial for their correct application. Comprehensive knowledge combined with practical skill is therefore necessary for formulating nutritionally balanced feed at least cost which will maximize profitability of feed mills as well as commercial aquaculture of our country.

Objectives

To develop the students' basic concept and skill on feed formulation, different feed processing techniques, quality evaluation of feeds and feed ingredients, types of feed and their application, optimum storage conditions, and factors affecting nutritional quality at storage.

Learning outcomes

Upon successful completion of this course, students will be able to:

- Learn about various feed ingredients and their nutrient composition
- Classify feed ingredients into different nutrient groups
- Gain knowledge about larval and broodstock feed manufacturing
- Apply feed formulation technique to produce nutritionally balanced diet at least cost
- Prepare diets based on specific formulation

Course contents

1. Introduction
2. Feed ingredients
   2.1 Different feedstuffs (plant and animal sources)
   2.2 Biochemical composition
   2.3 Protein and energy supplements
   2.4 Premixes of vitamins and minerals
   2.5 Anti-nutrients
   2.6 Exogenous enzymes

2.7 Feed probiotics
2.8 Unconventional feed ingredients

3. Selection and evaluation of ingredients
   3.1 Criteria for the selection
   3.2 Novel techniques of minimizing anti-nutritional factors, anti-metabolites and toxins
   3.3 Minimizing use of fish meal and oil in feed
   3.4 Evaluations of ingredients' quality (proximate analysis, measurement of energy value)
   3.5 Quality assurance
   3.6 Purchasing of ingredients
4. Feed formulation
   4.1 General principle
   4.2 Steps in feed formulation
   1.1 Balancing protein and energy values in feed (Iso-caloric and iso-nitrogenous diets)
   4.3 Methods: Pearson's method, least cost formulation, linear programming, advantages and limitations
   4.4 Factors influencing feed formulation and economics
   4.5 Effects of feed formulation on feed manufacturing and pellet quality
   4.6 Formulated feeds suitable for application in different aquaculture systems
   4.7 Farm made aquafeeds
5. Feed additives
   5.1 Definition, types, classification, importance
   5.2 Criteria for selection
   5.3 Use of natural and synthetic feed additives
   5.4 Aquafeed nutraceuticals
6. Diet preparation
   6.1 Practical diet for fish and shrimp
   6.2 Supplementary, commercial, and experimental diets
   6.3 Performance evaluation
7. Larval and broodstock diet
   7.1 Micro-encapsulated diet (MED), Micro-bound diet (MBD), Particle assisted rotationally agglomerated microparticulate diet (PARA), Marumerized extruded microparticulate diet (MEM), Nano diets
   7.2 Feed quality vs reproductive performance (fecundity, embryonic growth, fertilization, larval quality)
   7.3 Nutrient requirements of different brood species (amino acids, fatty acids, vitamins, carotenoids)
   7.4 Nutritional state and gonad development
8. Storage
   8.1 Shelf life
   8.2 Optimum storage conditions for feeds and feed ingredients
   8.3 Effect of storage on nutritional quality: insect infestation, micro-organisms and associated toxins, fish disease vectors, rancidity

FNFT 505	**FEED TECHNOLOGY AND FEED MILL MANAGEMENT**	**100(4)**

Rationale

Feed technology and management of feed mill is the core area of commercial aquafeed industry. Complete knowledge on the materials flow, milling process, effects of different processing techniques on the nutritional value of feed, quality control, common machineries and equipment, overall management, and good manufacturing practices etc. is highly required for successful operation of a feed factory. Therefore, clear understanding on feed manufacturing process, economics and skill in planning a feed mill are essential for the development of our aquafeed sector.

Objectives

To develop the students' basic concept on materials flow, process of feed milling, effect of processing on nutritional value of feeds, quality control procedure, equipment and their

functions, mill management, and economics of feed manufacturing. Moreover, the course aimed to build-up practical skill in planning and designing a feed mill project.

Learning outcomes

Upon completion of this course, students will be able to:

- Learn about materials flow in a feed mill
- Understand different steps in milling process
- Acquire knowledge on quality control and effect of processing on feeds
- Recognize feed mill equipment and their functions
- Plan and design a feed mill project
- Conceptualize the economics of feed manufacturing

Course contents

1. **Materials flow in feed manufacturing**
   - 1.1 Introduction
   - 1.2 Receiving
   - 1.3 Processing
   - 1.4 Packaging
   - 1.5 Storage and distribution
2. **Feed milling processes**
   - 2.1 Grinding: hammer mills, attrition mills, cutters, screening
   - 2.2 Mixing: horizontal mixers, vertical mixers, liquid mixers, other mixers
   - 2.3 Pelleting: application, influence of feed composition, cooling and drying, crumbles, screening and grading, use of hard pellets, hazards of feeding hard pellet, pellet hardness and stability, floating and sinking pellets
3. **Effects of processing on the nutritional value of feed**
   - 3.1 Heat treatment
   - 3.2 Grinding
   - 3.3 Pelleting and crumbling
   - 3.4 Processing to destroy naturally occurring toxins and inhibitors
   - 3.5 Effects of processing on moulds, salmonella and other harmful substances
   - 3.6 Effects of processing on the availability and nutritional value of vitamins and trace elements
4. **Quality control in feed manufacturing**
   - 4.1 Quality control procedure: raw materials and finished products
   - 4.2 Qualitative analysis: protein, fat, ash, moisture, crude fiber, antimetabolites and toxins in feed, hydrostability
5. **Feed mill equipment**
   - 5.1 Working principle
   - 5.2 Units and processes: pulverizer, grinder, mizer, pelletizer, crumbler, drier, extruder marumerizers, agglomerators, expander, vacuum coater, fat sprayer
   - 5.3 Grading and packaging machineries
   - 5.4 Manual, semi-automated and automated feed dispensers
   - 5.5 Particles size reducers
   - 5.6 Feed driers
6. **Feed mill management**
   - 6.1 Personnel management
   - 6.2 Maintenance of machineries, components of different units
   - 6.3 Storage condition: losses and deteriorative changes, causes and preventive measures
   - 6.4 Scheduling
   - 6.5 Feed mill safety
   - 6.6 Good Manufacturing Practices and HACCP
   - 6.7 Feed recalls
   - 6.8 Feed mill inspection
7. **Guideline for the establishment of a feed mill**
   - 7.1 Concept
   - 7.2 Requirements of a feed mill

7.3 Planning the project (site selection, production capacity, type of feed to manufacture, transportation, lay-out design)

7.4 Economics of feed manufacturing

8. **Aquafeed industries in Bangladesh**

FNFT 506	**ON-FARM FEED MANAGEMENT**	**100(4)**

Rationale

On-farm management of feed is the area which determines effective utilization of feed resulting in fast growth, good health and optimum yield of fish and shrimp. Therefore, basic knowledge on feeding options or strategy, feed types, feed rations, feeding frequency and period, feeding methods, relation between feeding and aeration, growth performance measurements, feedings trial and cost incurring factors is mandatory for successful operation of aquaculture farms. Since, feed accounts for more than 60 percent operational cost, wise management of feed based on scientific knowledge is utmost important to minimize feed cost and maximize economic benefits from an aquaculture farm.

Objectives

To develop the students' precise understanding on feed and feeding management practiced in the farm context including feeding strategy, feed types, feed rations, feeding frequency and period, feeding methods, relation between feeding and aeration, growth performance measurements, and cost incurring factors. In addition, the course is also aimed to improve skill in planning feeding trial with layout design.

Learning outcomes

Upon completion of this course, students will be able to:

- Gain knowledge on different feeding options, feed types and their application
- Comprehend feed rations and related feeding terms
- Estimate growth performance and feed utilization parameters
- Plan and design the layout of an experimental feeding trial
- Recognize the cost factors involved in feed and feeding

Course contents

1. Introduction
2. Feeding option
   - 2.1 No fertilizer or feed input
   - 2.2 Fertilization
   - 2.3 Supplementary diet feeding
   - 2.4 Complete diet feeding
   - 2.5 Selection of supplementary feeds by rural or subsistence farmers
   - 2.6 Formulated feed and natural productivity
3. Feed and feeding
   - 3.1 Feed types: wet and moist feeds, dry feeds, commercial feed
   - 3.2 Feed ration: ration size, ration and growth, ration curve, estimation of ration size
   - 3.3 Feeding frequency and feeding period
   - 3.4 Compensatory feeding
4. Feeding methods
   - 4.1 Feeding methods for fish and shrimp
   - 4.2 Feeding methods and growth variation
5. Feeding and aeration
   - 5.1 Oxygen requirements of different species
   - 5.2 Feeding and metabolic rate
   - 5.3 Oxygen depletion
   - 5.4 Water exchange and aeration
   - 5.5 Principles of oxygen transfer
6. Growth performance measures
   - 6.1 Sampling of fish

6.2 Growth parameters: Length and weight gain, percent weight gain specific growth rate (SGR), condition factor (K)

6.3 Feed utilization: feed conversion ratio (FCR), feed conversion efficiency (FCE,), average daily growth (ADG), protein efficiency ratio (PER), net protein utilization (NPU), chemical score, biological value (BV), apparent protein digestibility, EAAI

6.4 Growth patterns, growth recording, growth prediction

6.5 Survival

7. Feeding trial
   - 7.1 Experiential design and lay out
   - 7.2 Experimental fish, stocking density, dietary treatments and replication, control and experimental diets
   - 7.3 Water quality parameters: temperature, DO, pH, NH_3 etc.
   - 7.4 Significance test of dietary between treatments
   - 7.5 Statistics
8. Cost factors
   - 8.1 Selection of feed
   - 8.2 Cost-effective ration
   - 8.3 Wastage of feed
   - 8.4 Cost analysis of production

Recommended readings

1. ADCP (Aquaculture Development and Co-ordination Programme), 1980, Fish Feed Technology, ADCP/REP/80/11, FAO, Rome
2. D' Abramo, LR., Conkin, D.E and Aklyama. D.M. 1977, Crustacean Nutrition: Advances in Aquaculture Vol. 6, World Aquaculture Society, Baton Roughe, L.A
3. Guillame, J., Kaushik, S., Bergot Pl, and Metallier, R., 2001, Nutrition and feeding of fish and crustaceans, Springer Praxis Publishing, Chichester, Uk
4. Halver J.E. 1989, Fish Nutrition, Academic Press, San Diego, CA
5. Harver, J.E, and Tlews, K.T. 1979. Finifish nutrition and fishfeed technology vol. I and II Heenemann, Berlin.
6. Lovell, T., 1988. Nutrition and Feeding of Fish. Kluwer Academic Publishers.
7. Muir J.F., and Robert Donald (Eds.) 1968. Recent Advances in Aquaculture Vol.II., Blackwell Science.
8. New, M.B. 1987. Feed and feedling of Fish and shrimp. A manual on the preparation and preservation of compound feeds
   for shrimp and fish in aquaculture. F.A.O. RomeADCP/REP/87/26
9. Sena S.De Silva, Trevor A.Anderson. 1995. Fish Nutrition in Aquaculture, Chapman & Hall Aquaculture Series, London.
10. Lovell, R.T. 1998. Nutrition and Feedling of Fishes, Chapman & Hall, New York
11. Hertrampf, W.J. and Pascual-Piedad, F. 200. Handbook on Ingredients for Aquaculture Feeds. ISBN 978-1-4020-1527-4 DOI
    10.1007/978-94-011-4018-8, Springer Science.

FNFT 507	BLUE ECONOMY AND SUSTAINABLE DEVELOPMENT PRACTICAL	25(1)

1. Prepare maritime zone map of Bangladesh and demarcate marine fishing zones
2. Study the shallow sea and deep-sea oil/gas exploration blocks in the EEZ of Bangladesh
3. Evaluate blue economy development activities in the coastal and marine ecosystems of Bangladesh
4. Determine trophic interaction of marine species
5. Formulate ecosystem-based marine fisheries management plan for Bangladesh
6. Assess the interactions among the sustainable development goals (SDGs)
7. Analyze the linkages of SDG 14 to the blue economy focus areas
8. Study cyclogenesis locations and cyclone tracks on the Bay of Bengal for the last 100 years
9. Mapping salinity incursion areas along Bangladesh coast and interpret ecosystem health
10. Measure ocean acidification effects on coastal ecosystems of Bangladesh
11. Analyze causes and effects of hypoxic characteristics in the Bay of Bengal
12. Formulate integrated blue economy development plan
13. Identify resilience elements and analyze their role on coastal community of Bangladesh
14. Visit coastal ecosystems of Bangladesh and evaluate climate change impacts on livelihoods

FNFT 508	ADVANCED TECHNOLOGIES IN MARINE SCIENCE PRACTICAL	25(1)

1. Field operation of major oceanographic instruments
2. Practices in ocean remote sensing: SST, SSS, ocean color, SSH
3. Basic practices in Ecogram analysis
4. Collection and preservation of water, sediment and biota samples from the marine water
5. Data discovery, download and analyses
6. Use of ocean data analysis software: ODV, Panoply, NCView, HDFView

FNFT 509	NUTRITION AND FEEDING OF FISH AND SHRIMP PRACTICAL	25(1)

1. Application of fertilizers and assessment of primary productivity
2. Gut content analysis of fish to study natural food intake
3. Identification and estimation of natural foods in the grow out pond
4. Practical feeding of selected fishers
5. Learning the technique of blood collection from fish and separation of serum & corpuscles
6. Determination of digestibility coefficient
7. Formulation of feeds for catfish and tilapia
8. Study on the morphological features of digestive cycle of herbivorous, carnivorous fishes
9. Calculation of gross energy content of feed and feed ingredients

NFT 510	FEED INGREDIENTS AND FEED FORMULATIONS PRACTICAL	25(1)

1. Collection, identification and isolation of micro-algae
2. Study on various culture media and culture technique of micro-algae
3. Culture of earthworms/tubificid worms
4. Determination of hatching efficiency of Artemia
5. Decapsulation of Artemia
6. Storage of decapsulated cysts in brine and test for viability Learning of Artemia enrichment technique Use of Artemia in hatcheries (calculation of cysts required to feed the larvae in a tank of known volume; hydration, disinfection, and counting the Artemia nauplii per ml; calculation the number of nauplii remaining or will be adding to the LRT).
7. Visit to different fish and shrimp hatcheries to study culture techniques of microalgae and other livefeeds
8. Preparation of micro-encapsulated whole egg fish larval diet

FNFT 511	FEED TECHNOLOGY AND FEED MILL MANAGEMENT PRACTICAL	25(1)

1. Identification of different types of aquaculture feeds and feed ingredients available in the market
2. Processing of the feed ingredients
3. Quality evaluation of feed ingredients
4. Study of the utensils used in feed production at rural level
5. Formulation and preparation of isocaloric and isonitrogenous feeds
6. Determination of stability of commercial feeds available in the market
7. Analysis of anti-nutritional and toxic substances in feed ingredients and feeds
8. Preparation of different types of feeds (moist pellet, and dry pellet)
9. Visit to feed manufacturing units to study different unit of machineries and their function
10. Determination of vitamin C from feed items

FNFT 512	ON-FARM FEED MANAGEMENT PRACTICAL	25(1)

1. Estimation of survival of fish in grow out pond for estimating ration size check tray assessment and feed ration calculation
2. Calculation of ration size based on the amount of feed intake by the fish
3. Practice on calculating different parameters of feed management
4. Trail on different feeding methods
5. Conducting feeding trials
6. Estimation of FCR and FCE from feeding trials
7. Estimation of growth parameters from feeding trials
8. Learning the procedure of aerator sizing for a grow out shrimp pond
9. Conducting survey to ascertain primary productivity level in different culture pond
10. Visit to fish farm to observe feed management technique

INSTITUTE OF MARINE SCIENCES
Faculty of Marine Sciences and Fisheries
University of Chittagong, Chattogram 4331
Syllabus for the M.S. in Seafood Technology
Academic Year: 2023-2024 & 2024-2025
Total Marks: 900, Total Credits: 36

M.S. in Seafood Technology

Course#	Course title	Thesis group	General group
Theoretical			
SFT 501	Blue Economy and Sustainable Development	100(4)	100(4)
SFT 502	Advanced Technologies in Marine Science	100(4)	100(4)
SFT 503	Processing Technology	100(4)	100(4)
SFT 504	Hazard Analysis and Critical Control Point (HACCP)	100(4)	100(4)
SFT 505	Fisheries Microbiology	100(4)	100(4)
SFT 506	Seafood Safety and Quality Control	100(4)	100(4)
	Subtotal	600(24)	600(24)
Practical			
SFT 507	Blue Economy and Sustainable Development Practical	-	25(1)
SFT 508	Advanced Technologies in Marine Science Practical	-	25(1)
SFT 509	Processing Technology Practical	-	25(1)
SFT 510	Hazard Analysis and Critical Control Point (HACCP) Practical	-	25(1)
SFT 511	Fisheries Microbiology Practical	-	25(1)
SFT 512	Seafood Safety and Quality Control Practical	-	25(1)
	Subtotal	-	150(6)
SFT 598	Project	-	50(2)
SFT 599	Thesis	200(8)	-
SFT 513	Project defense (Proposal 10, Final 40)	-	50(2)
SFT 514	Thesis defense (Proposal 10, Final 40)	50(2)	-
SFT 515	Viva-voce	50(2)	50(2)
	GRAND TOTAL	**900(36)**	**900(36)**

SFT 501	**BLUE ECONOMY AND SUSTAINABLE DEVELOPMENT**	**100(4)**

Course contents

1. Growing ocean economy
   - 1.1 Global ocean economy
   - 1.2 Ocean ecosystem health
   - 1.3 Blue economy concept
   - 1.4 Blue economy indicators
2. Blue economy sectors
   - 2.1 Marine fisheries
   - 2.2 Marine trade
   - 2.3 Oil, gas and minerals
   - 2.4 Marine tourism
   - 2.5 Renewable energy
3. Marine fisheries interventions
   - 3.1 Extending the fishing horizon
   - 3.2 New fishing gears and techniques
   - 3.3 Discovering new fisheries
   - 3.4 Value addition and post-harvest loss reduction
   - 3.5 Fish stock assessment
4. Aquaculture and mariculture interventions

4.1 Domestication
4.2 Production intensification
4.3 Innovation farming
4.4 Live feeds for larviculture
4.5 Disease and health management

5. Ecosystem-based management
   5.1 Elements of ecosystem
   5.2 Trophic interactions
   5.3 Coordination and integration of stakeholders
   5.4 Formulation of EBM plan
6. Global sustainability initiatives
   6.1 Brundtland Report 1987
   6.2 Earth Charter 1992
   6.3 Kyoto Protocol 1997
   6.4 UN Millennial Summit 2000 and MDGs
   6.5 UN Sustainable Development Goals (SDGs) 2015
7. Sustainable Development Goals (SDGs)
   7.1 Goals, targets and indicators
   7.2 Interactions among the 17 goals
   7.3 Interactions at target-level
   7.4 Knowledge gaps
   7.5 Science-policy interface
8. SDG 14: Life Below Water
   8.1 Key interactions, uncertainties and dimensions
   8.2 Prevent and reduce marine pollution
   8.3 Protect marine and coastal ecosystems
   8.4 Sustainable use of ocean resources
   8.5 Increase economic benefits
9. Climate change challenges
   9.1 Tropical cyclone and depression
   9.2 Sea-level rise
   9.3 Salinity incursion
   9.4 Ocean acidification
   9.5 Freshwater plume
   9.6 Hypoxic condition
10. Blue economy development framework
    10.1 Major sectors and stakeholders
    10.2 Capacity building
    10.3 Design management plan
    10.4 Implementation workflow
    10.5 Monitoring and evaluation

Recommended readings

1. Rogers et al. 2008. An Introduction to Sustainable Development, Earthscan, London, UK. 416p.
2. Kuenkel, P. 2019. Stewarding Sustainability Transformations: An Emerging Theory and Practice of SDG Implementation, Springer, 321p.
3. UN Sustainable Development Goals Knowledge Platform (https://sustainabledevelopment.un.org/resourcelibrary)
4. Techera E, Winter G (eds.), 2019. Marine Extremes: Ocean Safety, Marine Health and the Blue Economy. Routledge, 255 pp.
5. Nicholls RJ, Hutton CW, Adger WN, Hanson SE, Rahman MM, Salehin M (eds.), 2018. Ecosystem Services for Well-Being in Deltas: Integrated Assessment for Policy Analysis. Palgrave macmillan, 615 pp.
6. Blewitt J, 2018. Understanding Sustainable Development. Earthscan, 427 pp.
7. Hossain MS, Chowdhury SR, Sharifuzzaman SM. 2017. Blue Economic Development in Bangladesh: A policy guide for marine fisheries and aquaculture. Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh, 32 pp.
8. ICSU, 2017. A guide to SDG interactions: from science to implementation. International Council for Science (ICSU), 239 pp. https://www.icsu.org/cms/2017/05/SDGs-Guide-toInteractions.pdf.

9. OECD, 2016. The Ocean Economy in 2030: Edition 2016 (Volume 2016). Organisation for Economic Co-Operation and Development (OECD), 256 pp.
10. Stylios C, Floqi T, Marinski J, Damiani L (eds.), 2015. Sustainable Development of Sea Corridors and Coastal Waters: The TEN ECOPORT project in South East Europe. Springer International Publishing, 253 pp.
11. Hossain, M.S, Chowdhury, S.R, Navera, U.K, Hossain, M.A.R, Imam, B, Sharifuzzaman, S.M., 2014. Opportunities and strategies for ocean and river resources management. Seventh Five Year Plan (2016-2020) background paper, Planning Commission of the Government of Bangladesh, 67 pp.
12. Griggs, D.J., Nilsson, M., Stevance, A., McCollum, D. (Eds.). 2017. A guide to SDG interactions: From science to implementation. International Council for Science (ICSU). https://www.icsu.org/cms/2017/05/SDGs-Guide-to-Interactions.pdf
13. Chowdhury, S.R., Hossain, M.S., Shamsuddoha, M. and Khan, S.M.M.H., 2012. Coastal Fishers' Livelihood in Peril: Sea Surface Temperature and Tropical Cyclones in Bangladesh. Foreign and Commonwealth Office through British High Commission and Centre for Participatory Research and Development (CPRD), Dhaka, Bangladesh, 66 pp.
14. Grafton RQ, Hilborn R, Squires D, Tait M, Williams M (eds.), 2010. Handbook of Marine Fisheries Conservation and Management. 785 pp

SFT 502	ADVANCED TECHNOLOGIES IN MARINE SCIENCE	100(4)

Course Contents

1. Brief history of the development of oceanography leading to the era of modern technology and innovations
2. Advances in oceanic measurements: electronic sensors, digital technology, CTD, underway equipment, robotic and remotely operated instruments
3. Ocean observation satellites and remote sensing of the oceans
   3.1. Optical oceanography: visible and microwave
   3.2. Radar and scatterometry
   3.3. Ocean surface topography or satellite altimetry
   3.4. Remote sensing of temperature and salinity
   3.5. Lidar
4. Acoustic, hydrographic and geophysical advances
   4.1. Seafloor imaging and mapping; sonar technology
   4.2. Acoustic tomography for biological and fisheries applications
5. Advanced telemetry in ocean data collection: applications, platforms, parameters, real-time or near-real-time ocean observation
6. Advanced oceanographic platforms and vehicles
   6.1. Bouy, drifter, glider, Argo, etc.
   6.2. Submersibles and ROVs
7. Advances in computing and ocean modeling
8. Advances in data assimilation, storage, processing and delivery
   8.1. Emerging data formats
   8.2. Data repositories/warehouses and portals
   8.3. Data processing and visualization: online and offline
   8.4. Data access
9. Advances in submarine geology: plate tectonics, deep-sea explorations
10. Advances in marine biology and marine fisheries
11. Advances in operational oceanography and ocean forecasting: global ocean observing systems (GOOS), models and computational infrastructure, operational ocean data products

Recommended readings

1. Storch, H.v. and Hasselmann, K. 2010. Seventy Years of Exploration in Oceanography. Springer. 137p.
2. Jochum, M. and Murtugudde, R. 2006. Physical Oceanography: Developments since 1950. Springer. 250p.
3. Hekinian, R. 2014. Sea Floor Exploration: Scientific Adventures Diving Into the Abyss. Springer. 370p.
4. Martin, S. 2014. An Introduction to Ocean Remote Sensing. Cambridge University Press. 496p+plates.

5. Robinson, I.S. 2010. Discovering the Ocean from Space: The Unique Applications of Satellite Oceanography. Springer. 638p.
6. Barale, V., Gower, J. F. R. and Alberotanza, L. 2010. Oceanography from Space: Revisited. Springer. 374p.
7. Wang. Q. 2009. Remote Sensing of Coastal Environments. CRC Press. 423p+plates.
8. Schiller, A. and Brassington, G.B. 2011. Operational Oceanography in the 21st Century. Springer. 729p.
9. Pinardi, N. and Woods, J. 2010. Ocean Forecasting: Conceptual Basis and Applications. Springer. 472p.
10. Fu, L.L. and Cazenave, A. 2001. Satellite Altimetry and Earth Sciences: A Handbook of Techniques and Applications. Academic Press. 463p.
11. Medwin, H. 1998. Fundamentals of Acoustical Oceanography. Academic Press. 712p+plates.

SFT 503 SEAFOOD PROCESSING TECHNOLOGY 100(4)

Rationale

Fish is a perishable food that begins to spoil as soon as it is caught, and possibly even before it is removed from the water. The spirit of this course is to demonstrate how we can care for fish and shellfish products during harvesting and throughout the supply chain to preserve nutritional attributes, avoid contamination, loss, and waste, and deliver high-quality fish products. Various processing methods, such as salting, drying, and smoking, are used across continents, regions, and countries to increase shelf life and diversify products. Processing reduces food waste and loss, reducing pressure on fisheries resources and promoting sector sustainability.

Objectives

The goal of this course is to teach students about various post-harvest changes and fish and shellfish handling, plant design, function, and maintenance of fish processing plants, and safety standards. To learn scientific techniques for fish processing and value addition, as well as the utilization of fish and shellfish by products.

Learning outcomes

After completing the course, students will be able to:

- outline the chemical composition of fish and shellfish, describe the microbiology of fresh and processed fish.
- specify methods of fish and shellfish handling.
- explain canning, curing, and freezing processes of fish.
- develop skills and knowledge in the processing and preservation of fish and shellfish; food safety, packaging, and labeling; and food product and process innovation
- undertake subjects to support the wide range of technical positions required by the food industry

Course contents

1. World Fisheries
   1.1 Fish as food
   1.2 Employment
   1.3 Utilization
2. Fish as a Food as Material: Chemical Aspects
   2.1 Elements
   2.2 Atoms and molecules
   2.3 Fish flesh components
   2.4 Analysis of major components
3. Fish as a Food Material: Nutritional Aspects
   3.1 The provision of energy
   3.2 Protein in the diet; Fats; Minerals
   3.3 Effects of cooking and processing fish
4. The Physical Structure and Chemical Composition of Fish
   4.1 Physical structure
   4.2 Chemical composition

5. Introduction to Post-Mortem Changes in Fish and the Nature of Spoilage; Why fish spoil?
   5.1 Autolytic Spoilage
   5.2 Bacterial Spoilage
   5.3 Oxidation of Fat
6. Preservation and Processing: Broad Aims
   6.1 Preservation methods
   6.2 Processing methods
7. FISH PROCESSING: THE BROAD AIMS AND SOCIO-ECONOMIC ASPECTS:
   7.1 The profit motive Financing fisheries and fish processing operation
   7.2 The economics of processing
8. Instruments
   8.1 Thermometers; Balances and Scales; Timers; Pressure gauges; Hydrometers; Hygrometers and moisture meters; Flow meters; Smoke meters.
9. Wet Fish Handling and Preparation
   9.1 Definition of some terms used in fish preparation
   9.2 Gutting fish
   9.3 Filleting
   9.4 Hygiene
   9.5 Requirements for fish handling premises knives
10. Handling Raw Material
   10.1 Key to good practice.
11. Live Carriage of Fish and Handling Live Fish
   11.1 Physical needs of fish
   11.2 Carriage of Sea fish
   11.3 Carriage of freshwater fish
   11.4 The practicalities of Carriage
   11.5 Eating quantify of fish sold live
   11.6 Molluscs; Crustaceans
   11.7 Carriage of exotic aquarium fish by air
   11.8 Handling and preservation of live fish at the fishing ground
   11.9 Transport of live fish; Transport by Water, Transport by Railway, Transport by Road; Transport by Air
   11.10 Transport, Reception and Storage of Raw Fish; Unchilled Transport; Chilled Transport
   11.11 Landing fish
   11.12 Assessing the Catch
   11.13 Transport to Storage of processing
   11.14 Storage before processing
   11.15 Estimating the qualify of raw fish
12. Chilling
   12.1 The manufacture of Ice
   12.2 Types of Ice and Icemakers
   12.3 Making ice from Seawater
   12.4 Storage of ice
   12.5 Planning for ice manufacture
   12.6 Using ice at Sea
   12.7 Some alternatives to direct icing
   12.8 Refrigerated seawater (RSW)
   12.9 Chilled seawater (CSW)
   12.10 Some examples of seawater chilling systems
13. Large-scale fish landing facilities
   13.1 Suitability of site
   13.2 Unloading Systems
14. Small-Scale Landing Facilities
   14.1 Design and Operation
   14.2 Sitting fishing communities
   14.3 Facilities needed at modern fish landings
   14.4 Management of Small fish landings
   14.5 Basic Components

15. Marketing
    15.1 The Basic components of marketing System
16. Retail Sale Facilities
    16.1 Sales of Wet fish
    16.2 Sales of frozen fish
    16.3 Sales of live fish and Crustacean
    16.4 Sales of smoked and dry fish 17. Ship Hygiene and Safety Precautions.
18. Transportation of Fisheries Items
    18.1 Water transport
    18.2 Land transport
    18.3 Air transport

SFT 504	HAZARD ANALYSIS AND CRITICAL CONTROL POINT (HACCP)	100(4)

Rationale

Consumers are safer when a HACCP plan is in place because it helps eliminate or greatly reduce the likelihood of harmful contaminants in food. Also, it reduces the need to recall goods that might have been spoiled by contamination during processing or due to human error. With the help of HACCP, restaurants and other food service providers can proactively address potential threats to customer health.

Objectives

The goal of this course is to properly identify potential hazards in a food manufacturing business and to implement appropriate controls to keep these potential hazards at acceptable levels. This course applies to the entire food chain, from raw material production to finished product distribution. It provides the learners who are food handlers with HACCP knowledge and skills for the safe operation of food businesses.

Learning outcomes

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

- explain the HACCP Principles and show their effectiveness in the prevention of food safety hazards at the end of this course.
- establish HACCP program documentation for a food process with hazards controlled by GMPs, one or more CCPs (Critical Control Points), and/or uncontrolled hazards.
- perform a quantitative hazard analysis to determine a Critical Control Point.
- understand the FDA's, EU Regulation (EC) and NACMF's hazard control rules and regulations.
- analyze data from a food processing plant to develop sampling plans for use in a HACCP plan.
- describe the validation process for a HACCP program.
- improve decision-making skills and develop the ability to apply analytical tools in real-world situations by preparing solutions to various case studies.

Course contents

1. Introduction to course and HACCP
2. Hazards: Biological Chemical and Physical
3. Preliminary Steps and Prerequisite Programs
4. Commercial Processing: Example: IQF Cooked Shrimp
5. Principles of HACCP
    5.1 Principle I. Hazard Analysis and Preventive Measures
    5.2 Principle II. Identification at Critical Control Points
    5.3 Principle III. Establish Critical Limits
    5.4 Principle IV. Critical Control Point Monitoring
    5.5 Principle V. Corrective Actions
    5.6 Principle VI. Record-keeping Procedures
    5.7 Principle VII. Verification Procedures
6. The Seafood HACCP Regulation
7. FDA'S (Federal Food and Drug Administration) Seafood HACCP Rule

8. NACMCF (National Advisory Committee of Microbiological Criteria in Foods)
9. Questions and Sample worksheets
10. Hazard Found in Seafood
11. More Information of HACCP
12. Model Hazard Analysis work sheet
13. Field Visits and observations in Post-Harvest Handing and case
14. Future Needs and Recommendation

SFT 505	FISHERIES MICROBIOLOGY	100(4)

Rationale

Various microorganisms are responsible for spoilage of food. Also, pathogenic bacteria contaminating from water, soil and other sources can affect the safety and quality of food meant for human consumption. Therefore, it is necessary to acquire knowledge of the microbiology of fish and fisheries products, including spoilage bacteria, quality control and quality monitoring throughout the value chain, and international standards for fisheries products.

Objectives

This course is aimed at educating students about the spoilage and pathogenic bacteria of fish and fisheries products, factors that determine the nature and extent of microbial growth and survival in the product, qualitative and quantitative biochemical indicators of spoilage, product assessment and quality control, and safety standards and regulations.

Learning outcomes

Having successfully completed this course student will be able to:

- Learn about the role of microorganisms in spoilage
- Identify the contamination routes of specific spoilage organisms
- Understand the intrinsic and extrinsic factor associated with bacteria growth in the product
- Monitor and control the product quality throughout the value chain
- Familiarize with the national and international standards for fisheries products

Familiarize.

Course contents

1. Introduction to Fisheries Microbiology
2. Microbiology of Food
   - 2.1 Morphology, Structure and growth of bacteria
   - 2.2 Microbial Classification of bacteria yeast Molds
   - 2.3 Culturing bacteria
   - 2.4 Properties of food effecting Microbial growth
3. Microbiology of Fish Spoilage
   - 3.1 Post-mortem bacterial growth
   - 3.2 Factors affecting Spoilage
   - 3.3 Chemical changes caused by microorganisms
   - 3.4 Methods of Controlling Spoilage
   - 3.5 Tests for assessing microbial spoilage
4. Fish Diseases
   - 4.1 Bacterial, Viral, Fungal and Protozoan diseases
   - 4.2 Causes and effects of diseases
   - 4.3 Control and treatment of diseases
5. Public Health Microbiology
   - 5.1 Organisms which cause infection in man
   - 5.2 Indicators organisms
   - 5.3 Food borne infection and intoxications
   - 5.4 Bacterial toxins and mycotoxins
   - 5.5 Inspection of pathogenic micro-organisms from the fish and fisheries products
6. Quality Control of Fish And Shellfish

6.1 Nutritive value of fish
6.2 Quality criteria-flavors, Odor, Texture, Quality Specifications and Standards
6.3 Methods of assessing and Selecting Quality

7. Analytical Methods
   7.1 Sampling of fish for analysis proximate composition
   7.2 Group tests for freshness
   7.3 Methods of evaluating freshness of fish and shellfish
8. Chemical and Physical Methods of Quality Assessments
   8.1 Attributes of the hypothetical ideal method
   8.2 Precautions applicable to any quality assessment operation
   8.3 Chemical methods
   8.4 Physical methods
9. Organoleptic (Sensory) Measurement of Spoilage
   9.1 Quality assessment methods
   9.2 Classification of sensory characteristics
   9.3 Taste panels
   9.4 Some commodity used to test design
10. Intentional Standards for Fisheries Products
    10.1 Food laws
    10.2 International standards
    10.3 National standards
11. Inspection of Fish and Fishery Products
    11.1 The organization of a fish inspection system
    11.2 Principle of quality control of fish products
    11.3 The development of regulatory standards for products and for processing plants
12. Hygienic and Safety Aspects of Quality Control

Recommended readings

1. Tacon, A.G. 1990. Standard methods for the Nutrition and Feeding of farmed Fish and Shrimp. Argent Laboratory Press. 208p.
2. FAO. 1980. Fish Feed Technology, FAO. 395p.
3. FAO, 1983. Fish Feeds and Feeding in Developing Countries - An Interim Report on the ADCP Feed Development Programme.

SFT 506	SEAFOOD SAFETY AND QUALITY CONTROL	100(4)

Rationale

Safe and quality seafood is the prime focus of the global seafood industries today. To ensure safety and quality of seafood, basic understanding on seafood supply-chain and processing methods, sources of contamination in seafood chain, prevention and control of foodborne hazards, seafood traceability, functions and guidelines of international standardization organizations is essential. Consistent production, high quality and keeping compliance with international standards are the key factors to sustainour seafood products in the global market and contribute to the national economy.

Objectives

To build-up the students' comprehensive knowledge on seafood supply chain, seafood sanitation, contaminants and hazards in seafood and their identification techniques, methods for seafood quality determination, good practices from production to consumers, validation of analytical methods and traceability of seafood. In addition, the course aimed to develop clear understanding on the structure, guidelines and recommendation of the international organizations for standardization regarding food safety and quality management.

Learning outcomes

Upon completion of this course, students will be able to:

- Understand the seafood supply chain and the factors contributing to contamination
- Comprehend seafood sanitation and its application

- Recognize chemical contaminants, natural toxins and pathogens in seafood and their identification techniques
- Apply different chemical methods for determining the quality of seafood
- Gain knowledge on good practices from production to consumers
- Conceptualize the importance for validation of analytical methods
- Identify the features of seafood traceability and implementation
- Acquire knowledge on the structure, core functions and guidelines of international organizations for setting standards on food safety and quality control issues

Course contents

1. The seafood supply-chain and seafood processing
2. Seafood sanitation and safety
   2.1 Factors contributing to physical, chemical and biological contamination in seafood chain,
   2.2 Prevention and control of food borne hazards, definition and regulation of seafood sanitation,
   2.3 Sources of contamination, personal hygiene-food handlers, cleaning compounds, sanitation methods, waste disposal strategy (solid and liquid waste) and pest control.
3. Contaminants and/or hazardous substances in seafood
4. Chemical contaminants in seafood
   4.1 Pesticide residues, veterinary drug residues, environmental contaminants, seafood processing contaminants, migrants from packaging materials, unapproved food additives and adulterants
   4.2 Analysis of known chemical contaminants
   4.3 Investigate analytes using mass spectrometry (MS), combination of MS with gas chromatography (GC-MS), liquid chromatography-mass spectrometry (LC-MS), Tandem MS (MS/MS), GC-MS/MS, LC-MS/MS, HPLC, ICP, TLC, nuclear magnetic resonance (NMR) spectroscopy
   4.4 Identification of unknown chemical contaminants
5. Marine toxins in seafood
   5.1 Phycotoxins and toxic algae (or microalgae)
   5.2 Tetrodotoxin poisoning and scombroid poisoning (or histamine poisoning)
   5.3 Detection of natural toxins and test methods
   5.4 Safety guidelines for consumers
6. Microbiological hazards in seafood
   6.1 Food-borne pathogens related to seafood
   6.2 Traditional and molecular detection of pathogens in seafood
   6.3 Rapid methods for the identification of seafood micro-organisms
7. Chemical methods of determining seafood quality
   7.1 Chemical oxidation of lipids in seafood and analytical methods [peroxide value (PV), thiobarbituric acid (TBA)]
   7.2 Determination of hydrogen ion concentration (pH), trimethylamine oxide-nitrogen (TMAO-N), trimethylamine-nitrogen (TMA-N), total volatile base nitrogen (TVB-N)
   7.3 Volatile base components as quality control index
8. Codex Alimentarius Commission (CODEX):
   8.1 Standards, codex of practice, guidelines and recommendations
   8.2 Applying codex standards, core functions of National Codex Contact Point
   8.3 National Codex Committee of Bangladesh
9. International Organization of Standardization (ISO)
   9.1 Overview, structure, interpretation and case studies of food safety and Quality management including ISO-22000, ISO-9001:2000, ISO 22000:2005, ISO 17025/CODES/GLP,
   9.2 Retailers standards: IFS, SQF: 1000, SQF: 2000.
10. Good Manufacturing Practices (GMP), Good Hygienic Practices (GHP), Good Aquaculture Practice (GAP), Better Manufacturing Practice (BMP), Storage and distribution of food, sanitation and safety in food services.
11. Validation of analytical methods
    11.1 Good Laboratory Practices (GLP)- history of GLP, areas of application, facilities, test systems, test and reference items,
    11.2 Standard Operating Procedure (SOP), study performance and reporting.
12. Predictive models for the shelf-life and safety of seafood
    12.1 Predicting contamination
    12.2 Predicting microbiological safety, spoilage and shelf-life in chilled and frozen storage

13. Seafood traceability
    13.1 Traceability from older times to the present
    13.2 Traceability data

Recommended readings

1. Boziaris, I.S. (Ed). 2014. Seafood processing: technology, quality and safety. John Wiley & Sons. 508p.
2. Alasalvar, A. et al (Eds). 2011. Handbook of seafood quality, safety and health applications. John Wiley & Sons. 544p.
3. Rehbein, H. and Oehlenschläger, J. (Eds). 2009. Fishery products: quality, safety and authenticity. Wiley-Blackwell. 496p.
4. Nollet, L.M.L and Toldra, F. 2009. Handbook of seafood and seafood products analysis. CRC Press. 928p.
5. Børresen, T. (Ed). 2008. Improving seafood products for the consumer, 1st edition.. Woodhead Publishing. 585p.
6. Huss, H.H., Ababouch, L., Gram, L. 2003. Assessment and management of seafood safety and quality. FAO Fisheries Technical Paper. No. 444. 432p.

SFT 507	BLUE ECONOMY AND SUSTAINABLE DEVELOPMENT PRACTICAL	25(1)

1. Prepare maritime zone map of Bangladesh and demarcate marine fishing zones
2. Study the shallow sea and deep-sea oil/gas exploration blocks in the EEZ of Bangladesh
3. Evaluate blue economy development activities in the coastal and marine ecosystems of Bangladesh
4. Determine trophic interaction of marine species
5. Formulate ecosystem-based marine fisheries management plan for Bangladesh
6. Assess the interactions among the sustainable development goals (SDGs)
7. Analyze the linkages of SDG 14 to the blue economy focus areas
8. Study cyclogenesis locations and cyclone tracks on the Bay of Bengal for the last 100 years
9. Mapping salinity incursion areas along Bangladesh coast and interpret ecosystem health
10. Measure ocean acidification effects on coastal ecosystems of Bangladesh
11. Analyze causes and effects of hypoxic characteristics in the Bay of Bengal
12. Formulate integrated blue economy development plan
13. Identify resilience elements and analyze their role on coastal community of Bangladesh
14. Visit coastal ecosystems of Bangladesh and evaluate climate change impacts on livelihoods

SFT 508	ADVANCED TECHNOLOGIES IN MARINE SCIENCE PRACTICAL	25(1)

1. Field operation of major oceanographic instruments
2. Practices in ocean remote sensing: SST, SSS, ocean color, SSH
3. Basic practices in Ecogram analysis
4. Collection and preservation of water, sediment and biota samples from the marine water
5. Data discovery, download and analyses
6. Use of ocean data analysis software: ODV, Panoply, NCView, HDFView

SFT 509	SEAFOOD PROCESSING TECHNOLOGY PRACTICAL	25(1)

1. Evaluation of whole fish and fish products quality
2. Practice on gutting and filleting of fish
3. Determination of extent of spoilage of fish at different temperature by sensory method
4. Evaluation of IQF fished products
5. Preparation of fishery products and by products.
6. Packaging of fish in chilled condition for transportation
7. Evaluation of freezed fish / fishery products for organoleptic and chemical (TMA, TVN etc.) test
8. Control of black spot formation in raw shrimp
9. Visit to fish landing center, fish market and processing plants for studying different aspects of fish processing
10. Determination of dressing weight of different fish species
11. Livelihood study of fish processing industry workers.

SFT 510	HAZARD ANALYSIS AND CRITICAL CONTROL POINT (HACCP) PRACTICAL	25(1)

1. Developing flow charts and exercises in identification of hazards
2. Preparation of hazard analysis worksheet
3. Detection and estimation of important toxic chemicals in food
4. Identification of quality defects of processed fishery items
5. Analysis of typical hazards
6. Visit of processing plant ad study of various types fish processing machineries
7. Practice of HACCP based quality assurance methods
8. Learning the methods controlling product quality and safety
9. Study on the effect of temperature on the extent of spoilage of shrimp.
10. Identification of filth in processed products.

SFT 511	FISHERIES MICROBIOLOGY PRACTICAL	25(1)

1. Microscope techniques, isolation, enumeration and identification of microorganisms
2. Isolating and identification of psychotrophic bacteria from fish, iced and frozen fish and fishery products
3. Enumeration of halophilic bacteria from salted fish
4. Isolation and identification of public health significance bacteria E. Coli, Staphylococcus, Streptococcus, Salmonela, Vibrio etc in fish / fishery products
5. Study on the international standard for processed fishery products
6. Assessment of microbiology quality of water and ice used in processing plant
7. Study and evaluation of sanitary status of the fish processing units
8. Detection and quantification of histamine problem in finished products.

SFT 512	SEAFOOD SAFETY AND QUALITY CONTROL PRACTICAL	25(1)

1. Chemical composition analysis of seafood (moisture, ash, protein, lipid, salt)
2. Assessing the quality of seafood (Chemical and sensory quality changes)
3. Microbiological hazard identification and characterization
4. Case study on shrimp processing, and seafood safety problems in Bangladesh
5. Case study related to traceability and crisis management
6. Case study on total quality management (TQM) in the sea