UNIVERSITY OF AGRICULTURE, FAISALABAD
Department of Zoology, Wildlife and Fisheries
BS Fisheries and Aquaculture (4 Years)

Vision

To be a leading program in fisheries and aquaculture education, empowering students with the knowledge, skills, and innovative approaches needed to drive sustainable development, enhance food security (UN SDG # 2), and improve livelihoods globally (UN SDG # 1). Our graduates will be equipped with the knowledge to address the challenges of modern aquaculture, contribute to scientific advancements, and promote environmentally responsible and socially equitable practices in the fisheries industry (UN SDG # 14).

Mission

The mission of the BS Fisheries and Aquaculture Degree Program is to provide a comprehensive education that combines theoretical knowledge with practical skills in fisheries and aquaculture. We aim to

- Equip students with expertise in sustainable fish farming practices through precision management and control of diseases.
- Foster critical thinking and innovation through thematic trans-disciplinary research in aquatic farming and preventive medicine having hands-on experiences.
- Promote environmental stewardship and responsible resource management in the fisheries industry.
- Prepare human resource to address global challenges in the food security, poverty alleviation, and sustainable development.
- Cultivate leaders who will contribute to the advancement of the fisheries and aquaculture sectors both locally and globally.

Program Educational Objectives (PEOs)

After 4 years of graduation i.e. BS Fisheries and Aquaculture, the graduates will be able to;

1. Establish themselves as competent professionals in the fields of fisheries and aquaculture, utilizing their knowledge and skills to enhance industry practices.
2. Contribute to the development and implementation of sustainable aquaculture and fisheries management practices, ensuring the long-term viability of aquatic resources.
3. Engage in research and innovation to address current and emerging challenges in fisheries and aquaculture, contributing to scientific and technological advancements in the field.
4. Assume leadership roles in their professions and communities, advocating for policies and practices that promote environmental stewardship and social responsibility.
5. Commit to lifelong learning and professional development, staying updated with advancements in technology, regulations, and best practices in fisheries and aquaculture.
6. Apply their expertise to contribute to global efforts in food security, poverty alleviation, and the sustainable development of aquatic ecosystems.

Program Learning Outcomes (PLOs) (Graduate Attributes)

Graduates of the BS Fisheries and Aquaculture Degree Program will be able to:
Demonstrate Knowledge: on the principles of fisheries biology, aquaculture systems, aquatic ecosystem husbandry, preventive management, and control.
Apply Skills: through utilization of modern techniques and technologies for sustainable fish farming and effective fisheries management.
Conduct Research: through designing, executing, and analyzing independent thematic trans-disciplinary research projects addressing current issues and innovations in fisheries and aquaculture farming and preventive disease management.
Solve Problems: related to fish health, water quality, and resource management making farming cost-effective and eco-friendly.
Promote Sustainability: through environmentally responsible practices and policies that support the conservation and sustainable use of aquatic resources.
Communicate Effectively: to the diverse audiences, including stakeholders, policymakers, and the public related to the scientific and technical information of precision aquaculture and fisheries.
Work Collaboratively: in interdisciplinary teamwork to address challenges in fisheries and aquaculture through maximum utilization of the resources.
Exhibit Ethical Practices: in all aspects of fisheries and aquaculture activities to ensure environment friendly farming systems.
Ensure Lifelong Learning: through professional development and stay abreast of advancements in the field to adapt to evolving industry needs.

Eligibility Criteria

Intermediate Science (Pre-Medical/Pre-Engineering), Three-year Diploma of Associate Engineer (DAE) in Food Technology / Food Processing & Preservation securing 45% marks, i.e., 495/1100 Intermediate (Pre-Agriculture) with a CGPA of 2.20

Entry Test Streams

1. English, Physics, Chemistry and Biology
2. English, Physics, Chemistry and Mathematics

Fee Structure

Semester wise Fee for Session 2024-2025 (Main Campus UAF)-Morning Group			
Sr. No.	**UNDERGRADUATE DEGREE PROGRAMS**	**1st Semester**	**Subsequent Semesters**
1.	BS Fisheries and Aquaculture	46,050	37,500

Scheme of Studies for BS Fisheries and Aquaculture (4 year), 2024

HEC COURSE CATEGORY	**UAF SELECTION FOR BS ZOOLOGY**		
	COURSE CODE	**COURSE TITLE**	**CREDIT HOURS**
GENERAL- I	FA-310	INTRODUCTION TO ART AND HUMANITIES	2(2-0)
GENERAL- II	PY-307	FUNDAMENTALS OF NATURAL SCIENCES	3(2-1)
GENERAL- III	SOC-311	INTRODUCTION TO SOCIOLOGY	2(2-0)
GENERAL- IV	ENG-313	FUNCTIONAL ENGLISH	3(3-0)
GENERAL- V	ENG-314	EXPOSITORY WRITING	3(3-0)
GENERAL- VI	MATH-408	QUANTITATIVE REASONING I	3(3-0)
GENERAL- VII	STAT-408	QUANTITATIVE REASONING II	3(3-0)
GENERAL- VIII	IS-401/ SSH-306	ISLAMIC STUDIES/ ETHICS	2(2-0)/ 2(2-0)
GENERAL- IX	SSH-303	IDEOLOGY AND CONSTITUTION OF PAKISTAN	2(2-0)
GENERAL- X	CS-305	APPLICATIONS OF INFORMATION AND COMMUNICATION TECHNOLOGIES	3(2-1)
GENERAL- XI	BMS-402	ENTREPRENEURSHIP	2(2-0)
GENERAL- XII	EDU-306	CIVICS AND COMMUNITY ENGAGEMENT	2(2-0)
GENERAL- XIII	IS-402/SSH-403	INTERFAITH HORMNY ترجمہ ٔ قرآن /	1(1-0)
GENERAL- XIV	IS-403	روحانیت	1(1-0)
	TGM	TUTORIAL GROUP MEETING	NON CREDIT
Total Credit Hours			**32**
ALLIED-I	BBA-403	FUNDAMENTALS OF AGRIBUSINESS MANAGEMENT	3(3-0)
ALLIED-II	ES-301	INTRODUCTION TO ENVIRONMENTAL SCIENCE	3(3-0)
ALLIED-III	BOT-403	CELL BIOLOGY, GENETICS AND EVOLUTION	4 (3-1)
ALLIED-IV	ABG-510	GENERAL GENETICS	4(3-1)
ALLIED-V	BIOCHEM-300	ESSENTIAL OF BIOCHEMISTRY	3(3-0)
ALLIED-VI	ZOOL-604	FUNDAMENTALS OF MOLECULAR BIOLOGY	3(2-1)

Total Credit Hours			**20**
MAJ0R-I	FISH-301	AQUATIC BIODIVERSITY	3(2-1)
MAJ0R-II	FISH-302	ICHTHYOLOGY-I	3(2-1)
MAJ0R-III	FISH-401	ICHTHYOLOGY-II	3(2-1)
MAJ0R-IV	FISH-402	PRINCIPLES OF FISH CULTURE	3(2-1)
MAJ0R-V	FISH-403	FISH CULTURE SYSTEMS	3(2-1)
MAJ0R-VI	FISH-404	FISH ECOLOGY	3(2-1)
MAJ0R-VII	FISH-405	FISH BEHAVIOR	3(2-1)
MAJ0R-VIII	FISH-406	AQUACULTURE RESOURCE ECONOMICS	3(2-1)
MAJ0R-VIV	ZOOL-603	DEVELOPMENTAL BIOLOGY	4(3-1)
MAJ0R-X	FISH-501	ORNAMENTAL FISHERIES	3(2-1)
MAJ0R-XI	FISH-502	AQUACULTURE ENGINEERING	3(2-1)
MAJ0R-XII	FISH-503	LIMNOLOGY	3(2-1)
MAJ0R-XIII	FISH-504	FISH NUTRITION AND FEED TECHNOLOGY	3(2-1)
MAJ0R-XIV	FISH-505	SHELLFISH PRODUCTION TECHNOLOGY	3(2-1)
MAJ0R-XV	FISH-506	FISH AND AQUATIC TOXICOLOGY	3(2-1)
MAJ0R-XVI	FISH-507	FISHERIES BIOTECHNOLOGY	3(2-1)
MAJ0R-XVII	FISH-508	FISH MICROBIOLOGY AND IMMUNOLOGY	3(2-1)
MAJ0R-XVIII	FISH-509	INLAND FISHERIES MANAGEMENT AND CONSERVATION	3(2-1)
MAJ0R-XIX	FISH-510	FISH BREEDING AND GENETICS	3(2-1)
MAJ0R-XXI	FISH-601	FISH PARASITOLOGY AND ONE HEALTH	3(2-1)
MAJ0R-XXII	FISH-602	FISH HEALTH MANAGEMENT	3(2-1)
MAJ0R-XXIII	FISH-603	FISH POST-HARVEST TECHNOLOGY AND QUALITY ASSURANCE	3(2-1)
MAJ0R-XXIV	FISH-604	FISHERIES POLICY AND REGULATIONS	2(2-0)
MAJ0R-XXIV	FISH-605	SOIL AND WATER CHEMISTRY	3(2-1)
MAJ0R-XXV	FISH-606	SEAFOOD AND PUBLIC HEALTH	2(2-0)
Total Credit Hours			**74**
INTERNSHIP	FISH-621	INTERNSHIP	3(0-3)

CAPSTONE PROJECT	FISH-622	TECHNICAL REPORT	3(0-3)
Total Credit Hours			**06**
GRAND TOTAL: 32+20+74+06 =132 Credit Hours			

UNIVERSITY OF AGRICULTURE, FAISALABAD

Department of Zoology, Wildlife and Fisheries

Scheme of Study B.S. Fisheries and Aquaculture

FIRST SEMESTER

COURSE CODE	**COURSE TITLE**	**CREDIT HOURS**
FA-310	INTRODUCTION TO ART AND HUMANITIES	2(2-0)
SOC-311	INTRODUCTION TO SOCIOLOGY	2(2-0)
ENG-313	FUNCTIONAL ENGLISH	3(3-0)
MATH-408	QUANTITATIVE REASONING I	3(3-0)
SSH-303	IDEOLOGY AND CONSTITUTION OF PAKISTAN	2(2-0)
BBA-403	FUNDAMENTALS OF AGRIBUSINESS MANAGEMENT	3(3-0)
FISH-301	AQUATIC BIODIVERSITY	3(2-1)
TGM	TUTORIAL GROUP MEETING	NON CREDIT
	TOTAL CREDIT S	**18**

SECOND SEMESTER

COURSE CODE	**COURSE TITLE**	**CREDIT HOURS**
ENG-314	EXPOSITORY WRITING	3(3-0)
STAT-408	QUANTITATIVE REASONING II	3(3-0)

BMS-402	ENTREPRENEURSHIP	2(2-0)
ES-301	INTRODUCTION TO ENVIRONMENTAL SCIENCE	3(3-0)
BOT-403	CELL BIOLOGY, GENETICS AND EVOLUTION	4 (3-1)
FISH-302	ICHTHYOLOGY-I	3(2-1)
ZOOL-604	FUNDAMENTALS OF MOLECULAR BIOLOGY	3(2-1)
TGM	TUTORIAL GROUP MEETING	NON CREDIT
	TOTAL CREDIT HOURS	**21**

THIRD SEMESTER

COURSE CODE	**COURSE TITLE**	**CREDIT HOURS**
PY-307	FUNDAMENTALS OF NATURAL SCIENCE	3(2-1)
IS-401/ SSH-306	ISLAMIC STUDIES/ ETHICS	2(2-0)/ 2(2-0)
CS-305	APPLICATIONS OF INFORMATION AND COMMUNICATION TECHNOLOGIES	3(2-1)
IS-402/ SSH-403	INTERFAITH HORMNY ترجمہ ٔ قرآن /	1(1-0)
ABG-510	GENERAL GENETICS	4(3-1)
BIOCHEM-300	ESSENTIAL OF BIOCHEMISTRY	3(3-0)
FISH-401	ICHTHYOLOGY-II	3(2-1)
TGM	TUTORIAL GROUP MEETING	NON CREDIT
	TOTAL CREDIT HOURS	**19**

FOURTH SEMESTER

COURSE CODE	COURSE TITLE	CREDIT HOURS
IS-403	روحانیت	1(1-0)
EDU-306	CIVICS AND COMMUNITY ENGAGEMENT	2(2-0)
FISH-402	PRINCIPLES OF FISH CULTURE	3(2-1)
FISH-403	FISH CULTURE SYSTEMS	3(2-1)
FISH- 404	FISH ECOLOGY	3(2-1)
FISH-405	FISH BEHAVIOR	3(2-1)
FISH-406	AQUACULTURE RESOURCE ECONOMICS	3(2-1)
TGM	TUTORIAL GROUP MEETING	NON CREDIT
	TOTAL CREDITS HOURS	**18**

FIFTH SEMESTER

COURSE CODE	COURSE TITLE	CREDIT HOURS
ZOOL-603	DEVELOPMENTAL BIOLOGY	4(3-1)
FISH-501	ORNAMENTAL FISHERIES	3(2-1)
FISH-502	AQUACULTURE ENGINEERING	3(2-1)
FISH-503	LIMNOLOGY	3(2-1)
FISH-504	FISH NUTRITION AND FEED TECHNOLOGY	3(2-1)
FISH-505	SHELLFISH PRODUCTION TECHNOLOGY	3(2-1)
TGM	TUTORIAL GROUP MEETING	NON CREDIT
	TOTAL CREDIT HOURS	**19**

SIXTH SEMESTER

COURSE CODE	COURSE TITLE	CREDIT HOURS
FISH-506	FISH AND AQUATIC TOXICOLOGY	3(2-1)
FISH-507	FISHERIES BIOTECHNOLOGY	3(2-1)

FISH-508	FISH MICROBIOLOGY AND IMMUNOLOGY	3(2-1)
FISH-509	INLAND FISHERIES MANAGEMENT AND CONSERVATION	3(2-1)
FISH-510	FISH BREEDING AND GENETICS	3(2-1)
TGM	TUTORIAL GROUP MEETING	NON CREDIT
	TOTAL CREDIT HOURS	**15**

SEVENTH SEMESTER

COURSE CODE	**COURSE TITLE**	**CREDIT HOURS**
FISH-601	FISH PARASITOLOGY AND ONE HEALTH	3(2-1)
FISH-602	FISH HEALTH MANAGEMENT	3(2-1)
FISH-603	FISH POST-HARVEST TECHNOLOGY AND QUALITY ASSURANCE	3(2-1)
FISH-604	FISHERIES POLICY AND REGULATIONS	2(2-0)
FISH-605	SOIL AND WATER CHEMISTRY	3(2-1)
FISH-606	SEAFOOD AND PUBLIC HEALTH	2(2-0)
TGM	TUTORIAL GROUP MEETING	NON CREDIT
	TOTAL CREDIT HOURS	**16**

EIGHTH SEMESTER

COURSE CODE	**COURSE TITLE**	**CREDIT HOURS**
FISH-620	INTERNSHIP	3(0-3)
FISH-621	RESEARCH PROJECT AND SCIENTIFIC WRITING AND PRESENTATION / TECHNICAL REPORT	3(0-3)

TGM	TUTORIAL GROUP MEETING	NON CREDIT
	TOTAL CREDIT HOURS	**06**

Total Credit Hours for BS Fisheries and Aquaculture (4-Year)

Sem. I	**Sem. II**	**Sem. III**	**Sem. IV**	**Sem. V**	**Sem. VI**	**Sem. VII**	**Sem. VIII**	**Total**
18	21	19	18	19	18	16	06	**132**

DETAIL COURSE CONTENTS

FISH-301 AQUATIC BIODIVERSITY 3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Explain the types and characteristics of different aquatic ecosystems.
2. Discuss the ecological roles and importance of aquatic biodiversity in maintaining ecosystem health and stability.
3. Use morphological characteristics to identify and classify a wide range of aquatic organisms.
4. Employ various techniques for sampling and identifying aquatic species diversity.
5. Discuss the major threats to aquatic biodiversity and propose conservation strategies.

Theory

Introduction to aquatic ecosystems; Importance of aquatic biodiversity; Types of aquatic ecosystems (freshwater, marine, estuarine); Classification and evolutionary history of aquatic organisms; Adaptations of aquatic organisms to their environment; Phytoplankton, its characteristicsand classification , role of phytoplankton in aquatic food webs; Zooplankton, its types and classification,e cological roles of zooplankton, impact of environmental changes on zooplankton populations; Aquatic plants,algae and their classification; Ecological significance of aquatic vegetation; Importance of invertebrates in aquatic ecosystems;, major groups of aquatic invertebrates (mollusks, crustaceans, insects) their adaptations and life cycles; Classification and diversity of fish species,morphological and physiological adaptations of fish; Diversity and classification of aquatic amphibians and reptiles, role of amphibians and reptiles in aquatic food webs; Overview and ecological role of aquatic birds and mammals,

adaptations for life in aquatic environments; Types and classification of aquatic microorganisms (bacteria, archaea, viruses), ecological functions of microorganisms in aquatic systems, role of microorganisms in biogeochemical cycles; Conservation and management of aquatic organisms; Threats to aquatic biodiversity (pollution, climate change, habitat destruction, exploitation); Conservation strategies and management practices; Role of marine protected areas and conservation reserves; Role of captive breeding and reintroduction programs; International efforts and policies for protecting aquatic biodiversity.

Practical

Demonstration of aquatic sampling techniques, methods for sampling and identifying different aquatic organisms; Morphological characteristics of major aquatic taxa; Biodiversity assessment techniques; Estimation of species richness and diversity indices; Field surveys in different aquatic habitats (rivers, lakes, ponds, dams, barrages, wetlands, and estuaries, etc.); Demonstration of techniques for habitat restoration (planting aquatic vegetation, erosion control).

Suggested readings

1. Dobson, M. and C. Frid. 2009. Ecology of Aquatic Systems (2nd Ed.). Oxford University Press, Oxford, UK.
2. Dodds, W.K. and M.R. Whiles. 2010. Freshwater Ecology: Concepts and Environmental Applications of Limnology (2nd Ed.). Academic Press, Burlington, MA, USA.
3. Humphreys J. and R. Clark. (eds.). 2019. Conservation of Marine Resources and Biodiversity. Springer, Cham, Switzerland.
4. Kaiser M.J., M.J. Attrill, S. Jennings, D.N. Thomas, and D.K.A. Barnes. 2011. Marine Ecology: Processes, Systems, and Impacts (2nd Ed.). Oxford University Press, Oxford, UK.
5. Martens, K. (ed). 2016. Aquatic Biodiversity: A Celebratory Volume in Honour of Henri J. Dumont. Springer, Dordrecht, Netherlands.

FISH-302 ICHTHYOLOGY-I 3(2-1)

Course Learning Outcomes

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

1. Identify and classify fishes, at least up to the generic level.
2. Describe the structure and functions of different body systems of fish.
3. Assess the age of fish using different methods.
4. Identify the factors behind the distribution of fish in various aquatic ecosystems.

Theory

Introduction to Ichthyology; Evolutionary history and classification of fishes; Biological features of fishes: Morphology, anatomy, ecology, and distribution); Scales in fishes: Structure, types, importance, identification, classification, and age determination; Fish skeletal and muscular system: locomotion, and energetics of swimming; Respiration in fish, exchange surfaces (gills, skin, mouth, gut, lungs, and swim bladder); Fish oxygen requirements; Cardiovascular system: Blood, and its circulation, anatomy of the heart and cardiac flow, evolution of the heart in fishes; Buoyancy and thermal regulation; Air bladder, its modifications and function; Osmoregulation and ionic regulation in different fish groups; Stress responses freezing resistance and acid-base balance; Modes of feeding in fish; Physiology of digestion; Feeding habits, Feeding adaptations; Zoogeography of freshwater fishes, characteristics of different fish taxa.

Practical

Identification of commercially important fish of Pakistan; Museum survey; Study of external features and skeleton of fish; Preparation of a permanent slide of fish scales; Dissection of fish to expose its internal features especially digestive, circulatory, respiratory, excretory, and reproductive systems; Age calculation of fish using scales and skeleton.

Suggested readings

1. Hart, P. J. B., and J. D. Reynold. (eds.). 2010. The Handbook of Fish Biology and Fisheries (Vol II). Blackwell Publishing, New York, USA.
2. Lagler, K. F., J. E. Baradach, and R. R. Miller. 2012. Ichthyology (2nd Ed.). John Wiley and Sons, Inc., New York, USA.
3. Lawrence, M., and M. B. Brooks. 2020. Field Guide to Freshwater Fishes (2nd Ed.). Intl Kindle, UK.
4. Moyle, P. B., and J. J. Cech. 2008. Fishes: An Introduction to Ichthyology (6th Ed.). Prentice Hall, New Jersey, USA.
5. Pinnock, W. 2022. A Catechism of Ichthyology (3rd Ed.). Leopold Classics, USA.

FISH-401 ICHTHYOLOGY-II 3(2-1)

Course Learning Outcomes

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

1. Apprehend the evolutionary affinities and taxonomy of fish.
2. Explain knowledge regarding fish excretion, osmoregulation, reproduction, sensory systems, migrations, and communication.
3. Correlate the anatomical features with the physiology of different body systems in fish.
4. Identify the differential behavior of fish taxa in relation to the environment.

Theory

Systematic position of fish; Fish excretory system, excretion and osmoregulation, renal system role of gills in excretion, differences between freshwater and marine fishes, control of kidney function in fishes; Growth in fishes, factors affecting growth, growth regulation and its determination methods; Reproduction in fish, sexual dimorphism, maturity; fecundity, breeding habits and parental care, reproductive adaptations, mating systems and alternative reproductive strategies; Sensory perception in fish, sensory system and communication, acoustico-lateralis system, sound reception and production; Equilibrium and balance; Migration and migratory behavior of fish (shoaling, feeding, and aggressive behavior), environmental factors and their effects on fish behavior; Process of aestivation in fish; Communication signals (auditory, chemical, and electrical; zoogeography of marine fishes); Characteristics comparison of different fish taxa.

Practical

Classification of fishes of selected fish species; Study of fish anatomy; Physiology and adaptations; Fish dissections for demonstration of excretory and reproductive systems; Study of fish habitats and local fish fauna; Study of environmental, ecological, and economic importance of fishes; Study of ornamental fishes; Field visits to fish hatcheries.

Suggested readings

1. David, H. 2003. The Physiology of Fishes (3rd Ed.). CRC Press, UK.
2. Lagler, K. F., J. E. Baradach, and R. R. Miller. 2009. Ichthyology. John Wiley and Sons, Inc., New York, USA.
3. Moyle, P. B., and J. J. Cech. 2008. Fishes: An Introduction to Ichthyology (6th Ed.). Prentice Hall, New Jersey, USA.
4. Smith, L. S. 2002. Introduction to Fish Physiology (2nd Ed.). Argent Labs, Washington DC, USA.

FISH-402 PRINCIPLES OF FISH CULTURE 3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Explain the requirements and ecological dynamics of fish culture systems.
2. Identify the culturable fishes and cater to their requirements for production.
3. Apply locally available resources, such as land, water, feed ingredients, and fertilizers, in raising fish.

Theory

Historical developments in fish culture; Significance of fish meat; Fish culture and its current practices; Criteria for selection of site for fish ponds; Construction of fish ponds; Types of fish ponds; Characteristics of culturable fish species; Biological production cycle of fish ponds; Preparation of fish ponds for stocking, liming, fertilization and natural food development; Organic and inorganic fertilizers; Supplementary feeding in fish culture; Fish feeding methods; Components of fish feed; Commonly available feed ingredients; Preparation and feed storage methods; Important water quality parameters of fish ponds; Fish enemies and their control, summer mortality and its management, control of vegetation in fish ponds, integrating fish culture, maintenance of fish quality during transportation, storage and marketing.

Practical

On-site demonstration of fish pond design, identification and morphological characteristics of locally cultivable fish species, physico-chemical analyses of water from various ponds, dose calculation and use of different organic and inorganic fertilizers and feed in fish ponds.

Suggested readings

1. Boyd, C. E., and A. A. McNevin. 2014. Aquaculture, Resource Use, and the Environment. Wiley-Blackwell, New York, USA.
2. Chen, X., and Y. Zohu. 2020. Brief Introduction to Fisheries. Springer, Singapore.
3. Einarsson, A., and A. D. Oladottir. 2020. Fisheries and Aquaculture: The Food Security of the Future (1st Ed.). Academic Press, USA.
4. Lerner, K. L., and B. W. Lerner. 2017. Water Science (Vol. 2). Publishing House, London, UK.
5. Lucas, J. S., P. C. Southgate, and C. S. Tucker. 2019. Aquaculture: Farming Aquatic Animals and Plants (3rd Ed.). Wiley-Blackwell, London, UK.

FISH-403 FISH CULTURE SYSTEMS 3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Describe the principles and types of fish culture systems and their operations.
2. Design and construct various adaptable aquaculture systems.
3. Manage water quality and fish growth effectively under different systems.
4. Implement sustainable practices in fish culture to enhance production.

Theory

Introduction to fish culture systems; Types of fish culture systems based on different criteria; Extensive, semi-intensive and intensive culture systems; Open and closed culture systems; Pond culture, types of ponds; Design principles and construction techniques, cage and pen culture; Design and materials used for construction; Site selection and environmental considerations during cage culture; Recirculating aquaculture system (RAS), principle, components, design, advantages and challenges of RAS; Raceway and flow-through systems, design and operational principles of raceway systems, site selection and water requirements; Aquaponics, design and species selection; Role of bacteria in nitrification and mineralization; Optimizing nutrient availability for plant growth; Fish species selection and compatibility and cultivation techniques; Integrated fish farming, rationale and objectives, benefits and challenges of integrating fish farming with other systems; Biofloc aquaculture system and its principles, its formation/design, dynamics and management, microbial community in biofloc, role of bacteria, fungi and protozoa in biofloc formation; Environmental impact on fish culture systems, pollution and waste management; Different strategies for sustainable aquaculture.

Practical

Survey of different culture systems; Designing and constructing a fish pond model; Designing and constructing model cages; Setting up a small-scale RAS; Setting up a small biofloc model; Collecting growth and production data from different culture systems; Analyzing data to evaluate the performance of different fish culture systems.

Suggested readings

1. Marta, C. M., and Rui, M. S. 2021. Sustainable Aquaculture: Techniques and Technologies. CRC Press, Boca Raton, FL, USA.
2. Stickney, R. R. 2009. Principles of Aquaculture. Wiley-Blackwell, Hoboken, NJ, USA.
3. Tidwell, J. H. (Ed.). 2012. Aquaculture Production Systems. Wiley-Blackwell, Hoboken, NJ, USA.
4. Timmons, M. B., and J. M. Ebeling. 2010. Recirculating Aquaculture Systems. Ithaca Publishing Company, Ithaca, NY, USA

FISH- 404 FISH ECOLOGY 3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Examine the interaction of fish and the aquatic environment.
2. Describe the effects of biotic and abiotic factors on fish populations in aquatic ecosystems.
3. Summarize knowledge regarding fish population dynamics.

4. Incorporate the effect of assimilated cycles on planktonic biomass of fish.

Theory

Introduction to fish ecology; Basic components of aquatic ecosystems; Inter-relationship between fish and their abiotic and biotic environments; Adaptations of fish to abiotic environmental factors such as density, pressure, salinity, temperature, salt content of water, dissolve gases, and light. Sound and other vibrations; Bottom deposits and particles suspended in water; Water flow and modes of fish movements; Biotic inter-relationships among fishes, including intra-specific relationships between fishes and bacteria, viruses, aquatic flora and fauna; Competition and predation in freshwater communities; Fundamental links in the life cycle of fishes, including reproduction, development, population dynamics, movement, migration, and colonization; Spawning, feeding, over-wintering migrations, and hibernation in fishes; Feeding competition relationships among fishes.

Practical

Study of fishes with special reference to food; Feeding habits and adaptations in fish; Fish population estimation; Study of fish with special reference to changes in ecological conditions.

Suggested Readings

1. Francisco, A., and M. Sanchez. 2022. Holistic Approach to Ecosystem-Based Fisheries Management (1st Ed.). Springer, Singapore.
2. Fritjoff, C., and L. Lucy. 2014. Ecology: The System of Life. John Wiley and Sons, New York, USA.
3. Kaui, B. L. 1999. Advances in Fish and Wildlife Ecology and Biology. Daya Publishing House, Delhi.
4. Maria, E. A., and L. G. N. David. 2021. The Behaviour, Ecology and Evolution of Cichlid Fishes. Springer, Netherlands.
5. Tyus, H. M. 2011. Ecology and Conservation of Fishes. CRC Press, Taylor & Francis Group, USA.

FISH-405 FISH BEHAVIOR 3(2-1)

Course Learning Outcomes

After studying this course, students will be able to:

1. Explain the foraging, predatory, antipredator, reproductive, and migratory behavior of fish.
2. Understand the learning capabilities of fish.
3. Recognize the role of fish learning skills in fisheries and aquaculture.

Theory

Introduction to fish behavior, importance of studying fish behavior, evolution of fish behavior; Sensory systems in fish, vision in fish, chemoreception (smell and taste), and the lateral line system and electroreception; Communication in fish, visual signals and displays, chemical communication, sound production and acoustic communication; Foraging and feeding, foraging strategies, diet and food preferences, and predation and anti-predator behavior; Reproductive behavior, courtship and mating systems, parental care strategies, and spawning and nest building; Social behavior and organization, schooling and shoaling behavior, territoriality and dominance hierarchies, and cooperative behavior; Migration and orientation, types of fish migration, mechanisms of navigation, and environmental influences on migration; Environmental and human influences on fish behavior; Impact of habitat changes, effects of pollution and aquatic climate change, behavioral adaptations to captivity.

Practical

Compare the boldness and exploratory behavior of wild and captive-reared fish; Study behavioral changes related to artificial noise exposure; Determine if a goldfish can be trained to associate the sound of a bell with feeding time; Assess the motor behavior function of fish in response to toxicant exposure; Study the learning capability of fish.

Suggested Readings

1. Brown, C., K. N. Laland, and J. Krause. 2010. Fish Cognition and Behavior. Blackwell Science, UK.
2. Grubb, T. C. Jr. 2003. The Mind of the Trout. University of Wisconsin Press, Madison.
3. Lucas, C. M., and E. Baras. 2002. Migration of Freshwater Fishes. Blackwell Science Ltd., UK.
4. Reebs, S. 2001. Fish Behavior in the Aquarium and in the Wild. Cornell University Press, USA.
5. Sloman, K. A., R. W. Wilson, and S. Balshine. 2006. Behavior and Physiology of Fish. Elsevier, Netherlands.

FISH-406 AQUACULTURE RESOURCE ECONOMICS 3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Analyze production economics and make informed decisions on resource management.
2. Develop effective marketing strategies for aquaculture products.
3. Evaluate the economic implications of various policies and regulations affecting aquaculture.

4. Assess the economic impacts of environmental factors on aquaculture operations.
5. Perform economic evaluations of different aquaculture systems, focusing on sustainability and efficiency.

Theory

Introduction to Aquaculture Economics; Definition, scope, importance and role of economics in aquaculture; Basic economic principles; Supply and demand, price determination and market structures; Cost concepts and production economics; Fixed, variable and total costs; Production functions and economic efficiencies; Resource management and sustainability; Economic principles of resource use; Sustainable aquaculture practices; Investment analysis in aquaculture; Capital budgeting techniques; Risk assessment and management; Benefit-cost analysis of aquaculture production; Profitability and value addition; Marketing and distribution; Market analysis for aquaculture products; Marketing strategies and channels; Policy and regulation in Aquaculture; Regulatory frameworks affecting aquaculture; International trade and aquaculture; Trade dynamics and policies on aquaculture; Global market trends; Environmental economics in Aquaculture; Valuation of environmental impacts; Policy instruments for environmental management; Financial management in aquaculture; Financial statements and ratios; Budgeting and financial planning; Economic evaluation of aquaculture systems; Comparative analysis of different aquaculture systems.

Practical

Methods for collecting economic data; Basic data analysis techniques; Practical exercises in performing cost-benefit analyses; Simulating production scenarios; Analyzing economic outcomes; Creating and evaluating marketing plans for aquaculture products; Practical applications of investment analysis techniques.

Suggested Readings

1. Engle, C. 2020. Aquaculture Businesses: A Practical Guide to Economics and Marketing. 5m Books Ltd.
2. Engle, C. R. 2010. Aquaculture Economics and Financing: Management and Analysis. Wiley-Blackwell.
3. Hatch, U. 2021. Aquaculture: Models and Economics. Routledge.
4. Jolly, C. M., and H. A. Clonts. 2020. Economics of Aquaculture. CRC Press.
5. Upadhyay, A. D., A. K. Roy, and P. K. Pandey. 2021. Fisheries and Aquaculture Economics. Routledge

FISH-501 ORNAMENTAL FISHERIES 3(2-1)

Course Learning Outcomes

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

1. Acquire knowledge of the status of world and Pakistani ornamental fish farming and trade.

2. Identify various commercially important freshwater and marine ornamental fishes.
3. Fabricate, set up, and maintain freshwater and marine aquaria.
4. Demonstrate skills for breeding and larval rearing of ornamental fishes.
5. Develop commercial production units for large-scale production of ornamental fishes and aquarium plants and their trade.

Theory

Major freshwater ornamental fish resources, methods of live fish collection, and the benefits of ornamental fishkeeping as a hobby. Taxonomy and biology of various freshwater ornamental fish varieties (including goldfish, koi, barbs, danios, gouramis, bettas, tetras, livebearers, angelfish, cichlids, catfish, and loaches) alongside their natural habitats; Aquarium management aspects such as fabrication, setup, maintenance, lighting, aeration, plant propagation, decoration, water quality management, filtration systems, fish feeds, disease diagnosis, treatment, and control of snails and algae; Breeding and rearing techniques for livebearers, egg layers, and other ornamental fish species; Genetics and biotechnology for quality strain production; Commercial aspects include the establishment and design of production units; Mass production of ornamental fish and aquarium plants, conditioning, packing, transport, quarantine methods, and retail marketing and export strategies.

Practical

Identification of common freshwater aquarium fishes; Constructing a glass aquarium and setting up and maintaining an aquarium for evaluation after one month; Water quality management in both freshwater and marine aquariums; Aquarium plants; Live food organisms and decorative items; Aerators and types of filters used in aquarium systems; Breeding techniques for egg layers; Ornamental fish diseases, their diagnosis, treatment, and the calculation of medicine or chemical treatment dosages.

Suggested Readings

1. Biswas, S. P., J. N. Das, U. K. Sarkar, and W. S. Lakra. 2007. Ornamental Fishes of North East India: An Atlas. ICAR, National Bureau of Fish Genetic Resources, Lucknow, India.
2. Cato, J. C., and C. L. Brown (Eds.). 2008. Marine Ornamental Species: Collection, Culture and Conservation. John Wiley & Sons.
3. Kurup, B. M., M. Harikrishnan, and C. R. Renjithkumar. 2012. Breeding, Farming and Trade of Ornamental Fishes in India-Prospects and Challenges. Souvenir-Ornamentals Kerala 2012.
4. Olivier, K. 2003. World Trade in Ornamental Species (pp. 49-63). Iowa State Press.
5. Sirajudheen, T. K., S. S. Salim, A. Bijukumar, and B. Antony. 2014. Problems and Prospects of Marine Ornamental Fish Trade in Kerala, India. J. Fish. Eco. Dev., 1151:14-30.

FISH-502 AQUACULTURE ENGINEERING 3(2-1)

Course Learning Outcomes

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

1. Understand the principles of aquaculture facility design and engineering.
2. Learn about the various components of aquaculture systems and their functions.
3. Explore the design considerations for different types of aquaculture systems, including ponds, tanks, and RAS, biofloc.
4. Deliver practical skills in the operation and maintenance of aquaculture equipment and infrastructure.
5. Develop sustainable ecosystem-based models through aquaculture engineering.

Theory

Introduction to Aquaculture Engineering encompasses the historical background, global significance, and key principles of aquaculture engineering, focusing on the fundamental concepts; It delves into the definition and objectives of fish farms, categorizing them into freshwater, brackish water, and marine farms, and discusses the critical criteria for site selection through pre-investment surveys; The course also covers land surveying techniques, including chain surveying, prismatic compass and surveyor compass usage, and plane table surveying, along with methods of leveling and earthwork calculations involving soil properties, sampling, area and volume calculations, and contour mapping; Special topics include hatcheries, raceway culture, water distribution and control systems, and the construction and management of fish ponds.

Practical

Evaluation of potential site for aquaculture; Land survey chain surveying, compass surveying, leveling, plane table surveying and contouring; Soil analysis for farm construction; Design and layout plan of fresh water and brackish water farms and hatcheries; Design of farm structure, ponds, dykes and channels; Visit to different types of farms models on campus.

Suggested Readings

1. Lekang O.I. 2021. Aquaculture Engineering (3rd Ed.). Wiley-Blackwell, West Sussex. UK.
2. Martin O. 2019. Handbook of Aquaculture Engineering. Syrawood Publishing House, New York, USA.
3. Patterson M, 2015. Aquaculture Engineering. Delve Publishing LLC, Burlington, Canada.
4. Tanveer M., M.H. Chnadrakant and B.C. Mal. 2021. Practical Manual for Aquacultural Engineering. Narendra Publishing House, Delhi, India.

5. Verma A.K. and M.H. Chandrakant. 2018. Aquacultural Engineering: Principles & Practices. Narendra Publishing House, Delhi, India.

FISH-503 LIMNOLOGY 3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Describe the types, characteristics, and classification of different freshwater bodies.
2. Evaluate the importance of physical and chemical properties of freshwater.
3. Correlate the impact of physico-chemical properties of freshwater with the survival and distribution of fauna and flora.
4. Analyze the aquatic fauna and flora both in qualitative and quantitative terms.

Theory

Diversity of aquatic ecosystems, quantitative and qualitative aspects of water resources, comparison among freshwater, brackish, and marine ecosystems; Unusual and extreme habitats, hydrology, physiography, and physical properties such as temperature, light, turbidity, clarity, currents, and density, emphasizing their interactions with aquatic life; Chemical properties like dissolved oxygen, carbon dioxide, pH, alkalinity, hardness, inorganic and organic substances their distribution, dynamics, and influence on the aquatic ecosystem; The status and forms of nutrients, such as nitrogen, sulfur, phosphorus, and carbon, in surface waters, their use and remineralization in the aquatic ecosystem; Organization and energetic apportioning of freshwater communities, concepts of trophic state and aquatic productivity, managing eutrophication, biodiversity of freshwaters, ecological classification of aquatic biota, limnological importance of biota, adaptations and characteristics of aquatic life, and quantitative and qualitative changes in spatial and temporal distribution of aquatic biota, including the origin of lakes and applied limnology.

Practical

Water sampling and preservation techniques for physico-chemical and biological analyses; Estimation of physical characteristics of water such as temperature, density, light penetration, and turbidity, as well as chemical characteristics like dissolved oxygen, carbon dioxide, pH, total alkalinity, total hardness, bicarbonates, chlorides, calcium, magnesium, and total dissolved solids; Collection, preservation, and study of fauna and flora from various water bodies.

Suggested Readings

1. Dodds, W. K., and M. R. Whiles. 2010. Freshwater Ecology: Concepts and Environmental Applications of Limnology. Academic Press.
2. Lampert, W., and U. Sommer. 2007. Limnoecology: The Ecology of Lakes and Streams. Oxford University Press.
3. Moss, B. 2010. Ecology of Fresh Waters. John Wiley & Sons Inc.

4. Moss, B. R. 2017. Ponds and Small Lakes: Microorganisms and Freshwater Ecology. Pelagic Publishing Ltd.
5. Ruttner, F. 2020. Fundamentals of Limnology. Walter de Gruyter.

FISH-504 FISH NUTRITION AND FEED TECHNOLOGY 3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Name and describe important types of feeds used in fisheries.
2. Formulate different types of feed and evaluate their relative efficiency.

Theory

Fundamentals of aquaculture nutrition; Metabolism of water, carbohydrates, proteins, lipids, vitamins and minerals; Role of macro and micro-nutrients in aquatic feeds; Nutrient requirements of cultivable fish and shrimp; Description of fish growth and important nutrients required for fish growth, feed types (Wet feeds, moist feeds, mashes, pelleted feeds, floating and sinking pellets); Methods of feed formulation and manufacturing; Nutrient levels and variability in feed materials; Role of binders, antioxidants, enzymes, pigments growth promoters and feed stimulants and functional feed additives in aquaculture feeds; Use of non-conventional feed ingredients in fish feed formulation, anti-nutritional factors and their management, digestive enzymes, feed digestibility and factors affecting digestibility; Digestibility, palatability and utilization of plant protein meals; Feed conversion ratio, feed efficiency, net protein utilization and biological value; Nutritional deficiency disorders, symptoms and nutrition related diseases in fish, aquaculture feed industry.

Practical

Proximate composition of fish feed ingredients and diets; Formulation and preparation of different types of fish feeds; Methods of feed storage.

Suggested readings

1. Halver, J. E. 2013. Fish Nutrition. 4th ed. Academic Press, USA.
2. Obedd, G. 2010. Fish Nutrition. Blackwell Publishing, USA.
3. Parker, R. O. 2004. Aquaculture Science. 4th ed. Delmar Learning, UK.
4. Steinberg, C. E. 2022. Aquatic Animal Nutrition: Organic Macro-and Micronutrients. SpringerLink.

FISH-505 SHELLFISH PRODUCTION TECHNOLOGY 3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Identify and evaluate suitable sites, environmental parameters, and grow-out systems for shellfish farming.
2. Apply various techniques for shellfish culture, including hatchery management, seed production, and nutrition strategies.
3. Diagnose and manage health issues, diseases, and implement effective harvesting and post-harvest handling techniques.
4. Analyze economic aspects, regulatory frameworks, and sustainability principles in shellfish production.

Theory

Introduction to shellfish production; Types and classification of shellfish; Biology and life cycles of commercially important shellfish species; Site selection and environmental parameters for shellfish farming; Techniques and methods of shellfish culture; Hatchery management and seed production; Grow-out systems and management practices; Shellfish nutrition and feeding strategies; Health management and disease control in shellfish; Harvesting techniques and post-harvest handling; Economic aspects of shellfish production; Regulatory frameworks and sustainability in shellfish aquaculture.

Practical

Identification of commercially important shellfish species; Site assessment for shellfish farming; Setting up and managing hatchery operations; Monitoring and maintaining water quality parameters; Feeding practices and feed formulation for shellfish; Disease diagnosis and treatment in shellfish; Techniques for harvesting shellfish; Post-harvest handling and processing; Economic evaluation of shellfish farming operations; Case studies on successful shellfish production systems.

Suggested readings

1. Allen, S. K., G. Burnell, and J. M. Kafka. 2021. Shellfish Culture: Principles and Practices (2nd ed.). CRC Press.
2. Brennan, P., and K. Fitzsimmons (Eds.). 2020. Advances in Shellfish Research: Global Status and Emerging Innovations. Springer.
3. Gosling, E. 2019. Marine Bivalve Molluscs (2nd ed.). Wiley-Blackwell.
4. Shumway, S. E., and G. E. Rodrick (Eds.). 2022. Shellfish Aquaculture and the Environment (2nd ed.). Wiley-Blackwell.
5. Southgate, P. C., and J. S. Lucas (Eds.). 2023. Aquaculture: Farming Aquatic Animals and Plants (3rd ed.). Wiley-Blackwell.

FISH-506 FISH AND AQUATIC TOXICOLOGY 3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Recall knowledge regarding the fundamentals of bioaccumulation, biomagnification, and biotransformation.
2. Identify potential aquatic pollutants and their current status.
3. Assess methods to determine the damage to fish fauna by different toxicants.
4. Paraphrase methods for monitoring toxins with special reference to fish.

Theory

Introduction, major classes of pollutants; inorganic pollutants, organic pollutants, sources and routes of transport of these pollutants to aquatic ecosystems, effects of pollutants/chemicals on ecosystems; Chemistry of toxicants, interactions between natural environmental factors and toxicity, origin and sources of aquatic toxicants; Classification, transport, entry, and fate of toxicants in water bodies and pollution cycles; Biological surveillance of aquatic toxicants; Measuring toxicity and assigning risk; Aquatic toxicity testing assays and experimental organisms; Determining responses to varying doses of substances, routes, and time of exposure; Parameters and procedures of toxicity testing; Fish as targets and models in organ system toxicology; Teratogenesis, mutagenesis, and carcinogenesis in aquatic animals; Risk assessment and bioremediation; Monitoring and water pollution control through stabilization, recycling, and treatment; Role of modeling in fish and fishery ecotoxicology; Acute and chronic effects of waterborne and dietary toxicants; Bioaccumulation, biomagnification, and biotransformation of toxins; Primary biotransformation: hydrolysis, oxidation, reduction, secondary metabolism, glutathione conjugation; Mechanisms of toxicity; Chemical, biochemical, and genetic toxins.

Practical

Collection of water, fish, sediment, and plankton samples from different water bodies; Determination of heavy metals through Atomic Absorption Spectrophotometry; Experimental designs for aquatic toxicity testing; Estimation of lethal and sub-lethal effects of toxicants on fish; Studies on behavioral responses of fish to toxicants.

Suggested Readings

1. Hauser-Davis, R. A., & Parente, T. E. 2018. Ecotoxicology: Perspectives on special issues. CRC Press, Taylor and Francis Group, UK.
2. Lawrence, T. V. 2017. Ecological risk assessment, innovative field and laboratory studies. CRC Press, Taylor and Francis Group, UK.
3. Blasco, J., Chapman, P. M., Campana, O., & Hampel, M. 2016. Marine ecotoxicology: Current knowledge and future issues. Academic Press, London, UK.
4. Karen, E. S., & Brown, T. M. 2015. Principles of toxicology. CRC Press, Taylor and Francis Group, UK.
5. Nikinmaa, M. 2014. An introduction to aquatic toxicology. Academic Press, Elsevier, UK.

FISH-507 FISHERIES BIOTECHNOLOGY 3(2-1)

Course Learning Outcomes

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

1. Understand the principles and applications of biotechnology in fisheries.
2. Demonstrate genetic and molecular techniques used in fish genomics.
3. Apply biotechnological methods for disease diagnosis and management in fisheries.
4. Identify the role of biotechnology in enhancing fish production and sustainability.
5. Develop skills to apply biotechnological tools for solving problems in fisheries science.

Theory

Overview of biotechnology in fisheries; Scope, historical developments and milestones; Concepts in biotechnology; Basic techniques: PCR, gel electrophoresis, genotyping and DNA sequencing; Major issues in fisheries and aquaculture in relation to biotechnology; Genetic techniques in fish breeding; Genetic improvement and selective breeding; Case studies of genetically improved fish species; Molecular markers and genetic mapping; Types of molecular markers, allozymes, RFLP, RAPD, AFLP, microsatellites, SNPs, ESTs; Applications in genetic mapping and breeding programs; Marker-assisted selection (MAS); Transgenesis in fish; promoters, gene constructs and methods of gene transfer; Case studies of transgenic fish; Applications and ethical considerations; Biotechnology in fish health management; Disease diagnosis and monitoring; Diagnostic techniques; ELISA, PCR, qPCR, DNA microarrays, vaccines and immunostimulants; Principles of fish immunology; Development and application of vaccines; Use of immunostimulants in disease prevention; Biotechnological approaches to disease control; Antimicrobial peptides and probiotics; RNA interference (RNAi) technology; Genetic resistance to diseases; DNA barcoding and its applications in fish breeding and conservation; Bioremediation and environmental biotechnology; Principles of bioremediation and its applications in aquaculture and fisheries; Aquatic biosensors and monitoring Systems; Development of biosensors for water quality monitoring; Applications in aquaculture systems; advancements in biosensor technology; Genomics and proteomics in fisheries; Applications of genomics in fisheries research; Proteomics and its applications in fish biology; Metagenomics and microbiome studies; Applications in studying fish gut microbiome; Nutrigenomics; Implications for fish health and nutrition; Biotechnology in fish feed development; Development of genetically modified feed ingredients; Use of enzymes and probiotics in fish feed; Impact on growth and health of cultured species; Biotechnology for sustainable fisheries; Fisheries biotechnology and ethical issues.

Practical

DNA isolation from fish; Electrophoresis; Agarose and polyacrylamide gel electrophoresis; Demonstration of DNA amplification through PCR; Development of bacterial inoculum for biofloc culture; Application of phytase for improving feed for fish; Mining the DNA and protein sequence database for different bioinformatic applications.

Suggested Readings

1. Beaumont, A., P. Boudry, and K. Hoare. 2010. Biotechnology and Genetics in Fisheries and Aquaculture. Wiley-Blackwell Publishing, New York, USA.
2. Dunham, R. A. 2023. Aquaculture and Fisheries Biotechnology: Genetic Approaches (3rd ed.). CABI Publishing, Wallingford, UK.
3. Liu, Z. J. 2011. Next Generation Sequencing and Whole Genome Selection in Aquaculture. Blackwell Publishing Ltd., New York, USA.
4. MacKenzie, S., and S. Jentoft. 2016. Genomics in Aquaculture. Academic Press, Cambridge, UK.
5. Montet, D., and R. C. Ray. 2017. Aquaculture Microbiology and Biotechnology (2nd vol.). CRC Press, New York, USA.

FISH-508 FISH MICROBIOLOGY AND IMMUNOLOGY 3(2-1)

Course Learning Outcomes

After studying this course, the students would be able to:

1. Describe general morphology and classification of aquatic microbes.
2. Correlate environmental factors with the presence and abundance of aquatic microbes.
3. Explain the role of microorganisms in biogeochemical cycles, bioremediation and biodegradation.
4. Know the Specific immune system (cellular defenses, humoral defenses) of fish.
5. Describe the functions of immune organs.

Theory

Introduction and historical perspective of aquatic microbiology; General classification and characteristics of archaea, bacteria, viruses and fungi; Microbial communities in the aquatic environment; Distribution; Nutrients, oxygen, and pH gradients; Microbial flora of surface and ground waters; Nature of aquatic environment; Extremophiles; Halophilic, psychrophilic and barophilic bacteria; Nutrient cycling at hydrothermal vents; Role of microbes in biogeochemical cycles; Biodegradation and bioremediation of organic and inorganic pollutants; Metagenomics of the microbes; Pathogenic bacterial species (Vibrio, Salmonella, *E.coli*, Pseudomonas spp.) of fish or aquaculture of public health importance and its prevention; General concepts in immunology, fish immunology, cells and tissues of the immune system of fish, the non-specific immune system (cellular defenses, humoral defenses), specific immunesystem (cellular defenses, humoral defenses), primary immune response, secondary immune response, difference in primary and secondary immune response, lymphocytes, B-cells and T- cells, ontogeny of immune response, ontogeny of lymphoid organ development; Environmental factors in fish immunology; Immunostimulation, immunosuppression.

Practical

Introduction to basic techniques for sterilization/disinfection, isolation, culture, purification, and preservation; Dilution plate technique, mean plate count, enumeration of coliform bacteria and fungi from water; Isolation and characterization of bacterial or microbial communities from fish meat (market, farm, natural reservoirs); Study of the innate immune response of fish before and after challenge to pathogens; Study of the immune response of fish after feeding immunostimulant.

Suggested readings

1. Beaumont, A., P. Boudry, and K. Hoare. 2010. Biotechnology and Genetics in Fisheries and Aquaculture. Wiley-Blackwell Publishing, New York, USA.
2. Dunham, R. A. 2023. Aquaculture and Fisheries Biotechnology: Genetic Approaches (3rd ed.). CABI Publishing, Wallingford, UK.
3. Liu, Z. J. 2011. Next Generation Sequencing and Whole Genome Selection in Aquaculture. Blackwell Publishing Ltd., New York, USA.
4. MacKenzie, S., and S. Jentoft. 2016. Genomics in Aquaculture. Academic Press, Cambridge, UK.
5. Montet, D., and R. C. Ray. 2017. Aquaculture Microbiology and Biotechnology (2nd Vol.). CRC Press, New York, USA.

FISH-509 INLAND FISHERIES MANAGEMENT AND CONSERVATION 3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Understand the nature of inland water and inland fish populations.
2. Learn fishing techniques, inland fishery resource evaluation, and inland fisheries management.
3. Become accustomed to biodiversity and conservation issues.

Theory

The nature of inland waters includes lakes, reservoirs, rivers, floodplains, swamps, marshes, rice fields, and lagoons; The nature of inland fish populations, fisheries, and fishing communities encompasses fishing techniques, inland fishery resource evaluation, and inland fisheries management; Key topics include habitat management, inland fisheries enhancement, and the mitigation and rehabilitation of inland fisheries; Biodiversity and conservation issues, management of fish feeding, nutritional fish diseases, factors affecting fecundity, and ecological conditions for gonad development are covered; Aquatic insects and their control, common freshwater aquatic weeds and their control, conservation strategies for threatened and endangered species, sustainable use of fisheries resources, stock replenishment programs, management of natural resources (lakes, reservoirs, dams, and rivers), habitat management practices, biological conservation policy, and national, regional, and international conventions; Rules and regulations for the conservation of natural resources, Awareness programs and community participation.

Practical

Assessment of age and growth with the help of fish scale, operculum, and otolith; computation of length-weight relationship and condition factor; techniques of fish tagging and recovery; fish stock assessment and report writing; field survey of different natural aquatic habitats; methods of conservation of natural resources.

Suggested readings

1. Helfman, G., Collette, B.B., Facey, D.E., 2009. Diversity of Fishes: Biology, Evolution, and Ecology. John Wiley & Sons, Singapore.
2. Bone, Q. and Moore, R., 2008. Biology of Fishes. Garland Science, USA.
3. Moyle, P.B. and Cech, J.J, 2004. Fishes: An Introduction to Ichthyology.5thed. Pearson Prentice Hall, USA.
4. Kapoor, B.G. and Khanna, B., 2004. Ichthyology Handbook. Springer Science & Business Media.
5. Lagler, K.F., Baradach, J.E. and Miller, R.R., 2003. Ichthyology. John Wiley and Sons, USA.

FISH-510 FISH BREEDING AND GENETICS 3(2-1)

Course Learning Outcomes

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

1. Understand the fundamentals of fish genetics and breeding.
2. Learn about various breeding systems and genetic improvement techniques.
3. Compare the efficiency of different methods of fish breeding.
4. Determine the role of hormones in artificial breeding of fish.
5. Develop skills in designing and managing breeding programs for fish species

Theory

History of domestication of cultured aquatic species; Stock comparisons methods and mating designs; Genetic basis for selection of fish for breeding; Estimation of breeding values from different methods and source of information; Fish breeding principles; Objectives of fish breeding; Selection methods: Phenotypic, genetic, and marker-assisted selection; Breeding Systems; Inbreeding and its effects; Outbreeding and hybrid vigor (heterosis); Crossbreeding systems; Genetic improvement programs; Selection programs: Mass, family, and individual selection; Genetic gain and heritability; Breeding value estimation; Breeding techniques; Controlled breeding, natural and artificial breeding; Techniques for induced breeding; Hormonal induction; Stripping and fertilization; Rearing of hatchlings in nursery; Environmental manipulation; Broodstock management; Selection and maintenance of broodstock; Tagging methods used in fish breeding; Nutrition and health management; Hatchery management: Egg handling and incubation; Larval rearing techniques; Nursery management; Quantitative genetics in fish breeding, Quantitative Trait Loci (QTL); identification and applications in

fish breeding; Genetic correlations and breeding values; Selection index and breeding programs; Multi-trait selection; Economic trait selection; Practical applications in breeding programs; Ploidy manipulations and sex reversal; Gynogenesis and androgenesis; Ethical issues in fish breeding; Genetic diversity conservation; Strategies for sustainable breeding practices; National and international regulations on fish breeding and genetics; Breeding strategies for threatened species for restocking and live gene bank (LGB); In-situ and ex-situ conservation; Conservation and preservation of aquatic species; Fish seed certification and quarantine.

Practical

Study of gonadal development in carps and other cultivable finfishes; Collection and identification of cultivable freshwater finfish seed; Packing and transportation of fish seed; Induced breeding (injection, striping and fertilization) of fishes through various inducing agents; Evaluation of carp milt and egg; estimation of fecundity, fertilization and hatching success; Preparation of brood and larval feed for different cultivable finfish; Problems related to Mendelian inheritance, gene interaction, gene mapping; Calculation of genetic diversity and inbreeding values for given fish stock; Problems relating to genetic exchange fish stocks; Problems related to gene frequencies and Hardy Weinberg equilibrium.

Suggested Readings

1. Beaumont, A., P. Boudry and K. Hoare. 2010. Biotechnology and Genetics in Fisheries and Aquaculture. Wiley-Blackwell Publishing, New York, USA.
2. Dunham, R.A. 2023. Aquaculture and Fisheries Biotechnology: Genetic Approaches (3rd Ed.) CABI Publishing, Wallingford, UK.
3. Gjedrem T. and M. Baranski. 2009. Selective Breeding in Aquaculture: An Introduction.Springer, New York, USA.
4. Gjedrem, T., 2005. Selection and Breeding Programs in Aquaculture. Springer, Netherlands.
5. Piferrer F. and H. Wang. 2021. Epigenetics in Aquaculture. Wiley-Blackwell, New York, USA.

FISH-601 FISH PARASITOLOGY AND ONE HEALTH 3(2-1)

Course Learning Outcomes

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

1. Have knowledge of important ecto and endo parasites of fish.
2. Know about the lifestyle of parasites and their intermediate hosts.
3. Correlate their knowledge of fish parasites with the environmental and public health.

Theory

Definitions and importance of parasitology, one health, zoonosis, anthroponosis, public health etc. Overview of fish parasites and their significance in fish production systems; Classification, general characteristics, life cycles, pathogenicity, diagnosis and transmission of some protozoa e.g., *Ichthyophthirius multifiliis, Cryptocaryon irritans*, monogenean trematodes e.g., *Gyrodactylus, Dactylogyrus* etc., digenean trematodes e.g., *Diplostomum, Sanguinicola* etc., cestodes, e.g., *Ligula intestinalis, Bothriocephalus*, nematodes e.g., *Anisakis, Camallanus*, etc., acanthocephalans e.g., Acanthocephalus, Myxosporea, etc., and arthropods e.g., crustaceans; One Health Approach in fish parasitology; Zoonotic parasites and one health implications, case studies of fish-borne zoonoses, preventive measures and risk management; Environmental factors influencing parasite prevalence, impact of parasites on fish populations and ecosystems; Role of aquaculture practices in parasite transmission; Parasite management strategies (Biological control methods, Environmental management and biosecurity measures). Future directions in fish parasitology and One Health.

Practical

Safety protocols in the aquatic preventive veterinary medicine lab; Introduction to lab equipment and materials; Fish necropsy examination for parasites, Collection, preservation, transportation and microscopic examination of the samples or specimens for fish protozoa, monogeneans, digeneans, cestodes, nematode, acanthocephalans, or arthropod parasites for taxonomic identification; Case Studies and sample analysis; Field visits, surveys and case reports.

Suggested Readings

1. Abbas, F., M. Hafeez-ur-Rehman, N. Mubeen, A. Bhatti, and I. Daniel. 2023. Parasites of Fish and Aquaculture and Their Control. In R. H. M. Rizwan and M. S. Sajid (Eds.), Parasitism and Parasitic Control in Animals: Strategies for the Developing World. CABI International.
2. Imran, M., M. S. Sajid, S. O. Swar, M. K. Khan, M. A. Malik, and A. Ahmad. 2021. Parasitic Disease of Fish. In R. Z. Abbas and A. Khan (Eds.), Veterinary Pathobiology and Public Health. Unique Scientific Publishers.
3. Secombes, C. J., and A. E. Ellis. 2012. The Immunology of Teleosts. In Fish Pathology (4th ed.). Blackwell.
4. Sitjà-Bobadilla, A., and M. C. Piazzon (Eds.). 2021. Fish Parasites: A Handbook of Protocols for Their Isolation, Culture and Transmission. 5m Books Ltd.
5. Woo, P. T., and K. Buchmann. 2012. Fish Parasites. CABI.

FISH-602 AQUATIC ANIMAL HEALTH MANAGEMENT AND THERAPEUTICS 3(2-1)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Understand the principles of fish health management and disease prevention in aquaculture and fisheries.

2. Learn about common fish diseases, their causes, symptoms, and transmission pathways.
3. Explore methods for disease diagnosis, including clinical examination, laboratory tests, and molecular techniques.
4. Gain knowledge of treatment options for fish diseases, including pharmaceuticals, vaccines, and alternative therapies.
5. Develop practical skills in disease prevention, biosecurity measures, and health monitoring in fish populations.

Theory

Overview of common infectious and noninfectious fish diseases and their impact on production; Clinical signs and symptoms of common fish diseases; Major groups of fish pathogens: Bacteria, viruses, parasites, and fungi. Transmission pathways for fish diseases; Factors influencing disease susceptibility and resistance in fish populations; Strategies for disease prevention, biosecurity, sanitation, and hygiene practices; Diagnostic techniques for fish disease detection, including physical examination, histopathology, and microbiological analysis; Chemotherapy; Antibacterial agents, resistance; Antiseptics and disinfectants; Antiparasiticides, Integrated parasitic management approaches for managing parasitic infections; Antibiotics, Vaccination and immunostimulation techniques for disease control; Therapeutants in fisheries and aquaculture, classification, pesticides, fungicides/ algicides, hormones, anesthetics, flesh color enhancers; Chemicals of therapeutic value; Law priority aquaculture drugs; List of the drugs used in fisheries and aquaculture; Introduction to Antimicrobial Resistance (AMR); Advances in fish health monitoring technologies; Sensors, remote sensing, and data analytics; Innovations in disease diagnosis and treatment; Future directions and challenges in fish health management.

Practical

Hands-on experience in fish health assessment techniques, including gross and necropsy examination. Laboratory exercises in disease diagnosis, including microscopic examination of tissue samples and microbiological culturing. Introduction to molecular diagnostic methods, such as PCR and ELISA. Field trips to fish farms, hatcheries, or research facilities for disease surveillance and health assessment.

Suggested readings

1. Kibenge, F. S., and M. D. Powell (Eds.). 2020. Aquaculture Health Management: Design and Operation Approaches. Academic Press.
2. Noga, E. J. 2010. Fish Disease: Diagnosis and Treatment (2nd ed.). Wiley-Blackwell.
3. Plumb, J. A., and L. A. Hanson. 2010. Health Maintenance and Principal Microbial Diseases of Cultured Fishes. John Wiley & Sons.
4. Sitjà-Bobadilla, A., and M. C. Piazzon (Eds.). 2021. Fish Parasites: A Handbook of Protocols for Their Isolation, Culture and Transmission. 5m Books Ltd.
5. Woo, P. T., and K. Buchmann. 2012. Fish Parasites. CABI.

FISH-603 FISH POST-HARVEST TECHNOLOGY AND QUALITY ASSURANCE 3(2-1)

Course Learning Outcomes

After studying this course, students will be able to:

1. Use fish post-harvest technology in fisheries.
2. Perform the handling, preservation, processing, and control of fish quality.
3. Describe methods of quality control and processing of fish.

Theory

Nutritive value of fish, concept of freshness and quality, hygiene and sanitation, fish spoilage, traditional and modern methods of fish preservation (drying, salting, fermentation, smoking, canning, ice-storage, cold-storage, freezing), convenient fish food, quality control of fish and fishery products, food safety management system; Fish icing procedures; Offloading; Onshore/On farm handling; Transportation to fish markets; Various ways of fish disposal; Effects of feed on product: Flavor, taints, and texture; Fish preservation and processing methods; Chilled storage life, freezing and frozen storage, chemistry of freezing, pickling, fish filleting and packing, and shelf life of fish food products. Quality dimensions of seafood sensory, intrinsic, quantitative, and affective parameters. Pre-harvest and post-harvest factors affecting quality; Assessment of quality changes in fresh and iced fish, quality changes during processing; Prerequisites to HACCP and its application in quality assurance programs for raw, frozen, canned, cured, cooked, and chilled products; Principles of plant hygiene and sanitation, pest control, personnel hygiene, planning and layout, equipment construction and design; National and international food laws and standards for quality assurance, mandatory and non-mandatory standards; Standards for seafood - FDA, ISO, FSSAI, GOI notifications; Role of export inspection council & export inspection agency and MPEDA in fish and fishery products; Certification system for fish & fishery products in Pakistan; Legal basis for monitoring products related Pakistan requirements; Labelling requirements - national and international, legislation on labelling; Components of traceability; Specific requirements of nutrition labelling; Use of additives in seafood processing as quality enhancers; Seafood safety, authenticity, and traceability.

Practical

Hands-on activities to reinforce their understanding of fish quality assessment and preservation methods; Preparation of a brief report on the quality of fish collected from the market; Exploration various methods of fish preservation; Determination of the proximate composition of fish and shellfish, and assessment of the quality of fresh fish using sensory, biochemical, and instrumental methods; Chlorination and hardness estimations, and conduct quality analysis of frozen, cured, and pickled fish products; Quality tests for tin, corrugated containers, plant, equipment sanitation, and personnel hygiene; Detection of filth and extraneous matter in traditional processed products.

Suggested Readings

1. Balachandran, K. K. 2001. Post-Harvest Technology of Fish and Fish Products. Daya Books.
2. Bonnell, A. D. 2012. Quality Assurance in Seafood Processing: A Practical Guide. Springer Science & Business Media.
3. Huss, H. H., A. Reilly, and H. A. Bremner. 1997. Quality and Quality Changes in Fresh Fish. FAO Fisheries Technical Paper No. 348.

4. Nambudiri, D. D. 2012. Advances in Harvest and Post-Harvest Technology of Fishes. NIPA GENX electronic resources & solutions P. Ltd.

FISH-604 FISHERIES POLICY AND REGULATIONS 2(2-0)

Course Learning Outcomes

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

1. Understand the principles and processes of fisheries policy development and governance.
2. Learn about the role of regulatory frameworks in fisheries management and conservation.
3. Explore the socioeconomic, environmental, and cultural dimensions of fisheries policy and regulation.
4. Gain knowledge of international agreements, treaties, and conventions governing fisheries resources.
5. Develop practical skills in policy analysis, stakeholder engagement, and regulatory compliance assessment.

Theory

Historical perspectives and current trends in fisheries policy development; Importance of fisheries policy in sustainable fisheries management; Overview of fisheries governance frameworks; Rights-based, ecosystem-based, and community-based management; Principles of fisheries regulation and enforcement; Licensing, quotas, and gear restrictions; Fisheries management approaches total allowable catches (TACs), marine protected areas (MPAs), and co-management arrangements; Case studies of successful fisheries management regimes and challenges in enforcement; Ecosystem-based approaches to fisheries management; Ecosystem services, marine spatial planning, and integrated coastal zone management; International agreements governing fisheries resources; UNCLOS, FAO Code of Conduct for responsible fisheries, and regional fisheries management organizations (RFMOs); Case studies of transboundary fisheries management agreements and cooperation mechanisms; Challenges and opportunities in implementing international fisheries agreements; Socioeconomic impacts of fisheries policies on coastal communities, livelihoods, and food security; Gender considerations in fisheries management and policy development; Indigenous and traditional fishing rights and their integration into fisheries policies; Importance of stakeholder engagement in fisheries policy processes; Role of advocacy groups, NGOs, and civil society in influencing fisheries policy and regulation; Legislative and policy gaps in fisheries and aquaculture; Policy analysis exercises; Reviewing and critiquing fisheries policy documents, legislation, and regulations.

Suggested Readings

1. Anonymous. 2016. The Punjab Fisheries Rules, 1965 (Amended Upto 2016). Government of The West Pakistan Agriculture Department Notification, Govt. of Pakistan.
2. Anonymous. 2022. The State of World Fisheries and Aquaculture: Towards Blue Transformation. Food and Agriculture Organizations of the United Nations, Rome, Italy.

3. Chuenpagdee, R., and S. Jentoft (Eds.). 2019. Transdisciplinarity for Small-Scale Fisheries Governance. Springer International Publishing, Gewerbestrasse, Cham, Switzerland.
4. Henriksen, T., G. Honneland, and A. Sydnes. 2006. Law and Politics in Ocean Governance. Martinus Nijhoff Publishers, Leiden, The Netherlands.
5. Pandey, D. K., and H. K. De. 2014. Fisheries Governance and Legislation in India. Narendra Publishing House, Delhi, India.
6. Thang, H. V. 2018. Rethinking Fisheries Governance. Springer International Publishing, Gewerbestrasse, Cham, Switzerland.

FISH-605 SOIL AND WATER CHEMISTRY 3(2-1)

Course Learning Outcomes

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

1. Learn the origin and formation of soils along with different sources of waters on the earth.
2. Comprehend the physical and chemical properties of soils and waters.
3. Basic chemical principles and processes taking place in soils and waters.
4. Identify and analyze the basic characteristics of soils and waters. Apply knowledge of soil and water chemistry to identify different problems and devise their solutions.

Theory

Definition of soil, land, and earth; Introduction to soil science, geology, and disciplines of soil science; Parts/spheres of earth: atmosphere, lithosphere, hydrosphere, biosphere, and pedosphere; Rock formation and types of rocks: igneous, sedimentary, and metamorphic rocks; Soil minerals: primary and secondary minerals and their properties; Weathering: types of weathering, processes, and factors; Soil parent material: types of parent material; Soil formation: processes and factors; Soil profile description; Soil classification; Soil texture and structure: concept, types, and importance; Soil porosity and density: concept, types, and importance; Soil and water pollution: sources, effects, and management; Soil colloids; Ion exchange: types, properties, factors affecting ion exchange, and importance; Soil pH: concept and importance; Buffering capacity: concept and importance; Soil organic matter (OM): sources, factors affecting OM, and importance; Green manuring and composting: concept and importance; Plant essential nutrients: sources and functions; Nitrogen, phosphorus, and potassium cycles; Salt-affected and waterlogged soils: types, properties, and reclamation/management; Biological nitrogen fixation: concept, types, and importance.

Practical

Soil and water sampling; water analysis (pH, EC, TSS, carbonate, bicarbonate, chlorides, calcium plus magnesium, sodium, sodium adsorption ratio, residual sodium carbonate) and report writing; soil texture analysis; soil carbon and organic matter; Chemical Oxygen Demand (COD); Biochemical Oxygen Demand (BOD); turbidity of water.

Suggested readings

1. Bleam, W. F. 2011. Soil and Environmental Chemistry. Elsevier Science.
2. Essington, M. E. 2015. Soil and Water Chemistry: An Integrative Approach. CRC Press.
3. Sparks, D. L., B. Singh, and M. G. Siebecker. 2022. Environmental Soil Chemistry. Elsevier.
4. VanLoon, G. W., and S. J. Duffy. 2017. Environmental Chemistry: A Global Perspective. Oxford University Press.

FISH-606 SEAFOOD AND PUBLIC HEALTH 2(2-0)

Course Learning Outcomes

By the end of this course, students will be able to:

1. Describe the significance and scope of aquatic food in human health.
2. Identify the role of aquatic food in health promotion and disease prevention.
3. Devise and assess public health programs, policies, and strategies related to aquatic food.
4. Demonstrate the ability to conduct surveys for assessing the impact of aquatic food on health and nutrition, and to intervene for improvement.

Theory

Aquatic food in public health; Overview, concepts, determinants, and foundations; Nutritional value of aquatic food; Macronutrients, micronutrients, and bioactive compounds; Disease burden and control; Role of aquatic food in the prevention and management of diseases; Health promotion and disease prevention; Strategies involving aquatic food; Modes of Intervention; Monitoring, and surveillance; Public health interventions related to aquatic food, nutritional surveillance, and health monitoring; Safety and health in aquatic food production; Ensuring safety in harvesting, processing, and consuming aquatic food; Public health nutrition assessment and programs; Evaluating and developing programs that incorporate aquatic food; Nutritional surveillance and growth monitoring; Methods and importance in the context of aquatic food; Public health policies and strategies; Policies related to the production, marketing, and consumption of aquatic food; Nutrition programs in public; Strategies for promoting aquatic food for public health; Field practices and case studies; Aquatic food nutritionist; Competencies, responsibilities, duties, ethics.

Suggested readings

1. Love, D. C., J. P. Fry, J. Cabell, and R. A. Neff. 2017. Aquaculture, Food Security, and Public Health. 1st Ed. Wiley-Blackwell, Hoboken, NJ, USA.
2. Lim, C., and C. D. Webster (Eds.). 2006. Nutrition and Fish Health. 1st Ed. Food Products Press.
3. Papanikolaou, Y., and F. Calder. 2015. Marine Nutraceuticals and Functional Foods. 3rd Ed. CRC Press, Taylor & Francis, Boca Raton, FL, USA.
4. Shahidi, F. 2012. Nutritional Benefits of Aquatic Food Products. 2nd Ed. Springer, New York, NY, USA.
5. Tokunaga, T. 2018. Aquatic Food Production and Human Health. 1st Ed. Academic Press, London, UK.