Learning Outcomes-based Curriculum Framework (LOCF) for Post-graduate Programme

Name of the Programme:

M.Sc. Applied Aquaculture

(Syllabus effective from 2020 Admission)

UNIVERSITY OF KERALA

Department of Aquatic Biology & Fisheries

2020

PREAMBLE

The role of higher education is vital in securing the gainful employment and providing further access to higher education comparable to the best available in the world-class institutions elsewhere. The improvement in the quality of higher education, therefore, deserves to be given top-most priority to enable the young generation of students to acquire skill, training and knowledge to enhance their thinking, comprehension and application abilities and prepare them to compete, succeed and excel globally. Sustained initiatives are required to reform the present higher education system for improving and upgrading the academic resources and learning environments by raising the quality of teaching and standards of achievements in learning outcomes across all undergraduate programs in science, humanities, commerce and professional streams of higher education.

One of the significant reforms in the undergraduate education is to introduce the Learning Outcomes-based Curriculum Framework (LOCF) which makes it student-centric, interactive and outcome-oriented with well-defined aims, objectives and goals to achieve. The University Grants Commission (UGC) took the initiative of implementing the LOCF in the Colleges and the Universities of the country. Accordingly, the University of Kerala has decided to implement the LOCF in all its departments under the auspices of Internal Quality Assurance Cell (IQAC). A series of teacher training workshops were organised by IQAC and the office of the Credit and Semester System (CSS), and the departments have revised the syllabus accordingly, through workshops and in consultation with academic experts in the field.

GRADUATE ATTRIBUTES (GAs)

The Graduate Attributes (GAs) reflect particular qualities and abilities of an individual learner including knowledge, application of knowledge, professional and life skills, attitudes and human values that are required to be acquired by the graduates of University of Kerala. The graduate attributes include capabilities to strengthen one's professional abilities for widening current knowledge and industry-ready skills, undertaking future studies for global and local application, performing creatively and professionally, in a chosen career and ultimately playing a constructive role as a socially responsible global citizen. The Graduate Attributes define the characteristics of learners and describe a set of competencies that are beyond the study of a particular area and programme.

The GAs of University of Kerala

- Continue life-long learning as an autonomous learner
- Continuously strive for excellence in education
- Apply and nurture critical and creative thinking
- Promote sustainable development practices
- Promote co-operation over competition
- Balance rights with responsibilities
- Understand and respect diversity & difference
- Not be prejudiced by gender, age, caste, religion, or nationality.
- Use education as a tool for emancipation and empowerment of humanity

BRIEF HISTORY OF THE DEPARTMENT

One of the oldest teaching-cum-research departments of the University of Kerala, the Department of Aquatic Biology & Fisheries was founded as Marine Biology Laboratory and Aquarium of the University of Travancore in the erstwhile princely state of Travancore (now southern part of Kerala) in 1938. Since then the Department has transformed itself in many ways.

After inception at Shanghumugham Beach, Thiruvananthapuram, Fishery Development Scheme was successfully implemented in this laboratory during1946. In 1958, the laboratory started a two-year M.Sc. Programme in Marine Biology and Oceanography. Subsequently, a full-fledged new Department of Marine Biology and Oceanography was started at Cochin during 1962 with the view of expanding the research activities of the laboratory. After the formation of the Cochin University of Science and Technology, the Department of Marine Biology and Oceanography at Cochin was transferred to it. The Marine Biology Laboratory along with its Fishery Technology Section and Aquarium remained under the University of Kerala. In 1968, based on the recommendations of Prof. N. Balakrishnan Nair, who took charge as Professor and Head of the department, the laboratory was renamed as the Department of Aquatic Biology and Fisheries and it diversified its research activities to various aspects of freshwater, brackish water and marine habitats.
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The department has started receiving support from the University Grants Commission based on the remarkable contributions in aquatic biology and fisheries. The department received the grant from UGC DRS Programme (1978), UGC Special Assistance Programme under Phase I, II and III (1985, 1994, and 2000 respectively) and Centre of Advanced Study scheme Phase I and Phase II (2008 and 2013 respectively). The department also received the financial support from the Department of Science and Technology, Govt. of India under FIST during 2003.

The department is currently offering M.Sc. (started in 1985), M.Phil. (started in 1978) and PhD courses in Aquatic Biology & Fisheries, M.Phil. in Marine Science and Technology and proposed a new M.Sc. programme in Applied Aquaculture. The department serves as a centre of excellence in teaching and research in the fields of aquatic biology and fisheries and has substantially contributed towards human resource development in this field. This multidisciplinary programme aims at equipping students with up-to-date knowledge on various theoretical and practical aspects of aquatic , aquaculture and fisheries science.

Eligibility for Post-Graduate Programmes in Applied Aquaculture: BSc., Zoology/Marine Biology/BFSc., Fisheries Science and Aquaculture/Industrial Fisheries with a minimum of 50% aggregate marks in the final examination.
Selection: Based on the marks scored in degree course and scores obtained in the entrance examination conducted by University of Kerala. One seat super numerary seat will be allotted to the children of fishermen in Kerala.
Seats: 10

UNIVERSITY OF KERALA

Syllabus for M.Sc. Applied Aquaculture

Programme-Specific Outcomes (PSO) for M.Sc. Applied Aquaculture

PS O1	Understand the basic principles of aquaculture.
PS O2	Conceptualize, design, develop and manage traditional and commercial aquaculture units.
PS O3	Develop leadership abilities for managing aquaculture operations and providing consultancy services to farmers.
PS O4	Acquire hands-on training in the grow-out culture activities in freshwater, brackishwater and marine environments.
PS O5	Gain expertise in the seed production technology for cultured finfishes and crustaceans.
PS O6	Appreciate the global, national and regional regulations governing the aquaculture sector and follow strict biosecurity protocols in operations
PS O7	Enhanced skills and attitudes for becoming a better learner, thinker, professional and skilled person
PS O8	Ability to identify socially relevant research problems in the field, develop research proposals, carry out controlled experiments and publish results.

Programme Structure of M.Sc. Applied Aquaculture

Semester	Course Code	Name of the Course	Credits
Semester 1		**Core Courses (CC)**	
	AAQ-CC-511	Principles of Aquaculture	2
	AAQ-CC-512	Fish Nutrition	2
	AAQ-CC-513	Biology of Fish and Shellfish	4
	AAQ-CC-514	Aquaculture Engineering	2
	AAQ-CC-515	Soil and Water Quality Management	2
	AAQ-CC-516	Practical 1: Fish Biology, Nutrition and Water Quality Management	3
		Discipline-Specific Elective (DE)	
	AAQ-DE-517	Environmental Impact Assessment for Aquaculture	2
Semester 2		**Core Courses (CC)**	
	AAQ-CC-521	Live Feed Technology	2
	AAQ-CC-522	Ornamental Fish Culture and Management	2
	AAQ-CC-523	Freshwater Aquaculture	4
	AAQ-CC-524	Coastal Aquaculture and Mariculture	4
	AAQ-CC-525	Practical 2: Aquaculture	3
		Discipline-Specific Elective (DE)	
	AAQ-DE-526	Post-Harvest Technology	2
	AAQ-DE-527	Biostatistics for Aquatic Sciences	2

Semester 3	**Core Courses (CC)**		
	AAQ-CC-531	Aquaculture Business Management	**3**
	AAQ-CC-532	Fish Health Management	**3**
	AAQ-CC-533	Intensive Culture Systems	**2**
	AAQ-CC-534	Practical 3: Disease Control, Intensive Aquaculture and Business Management	**3**
	AAQ-CC-535	Industrial Attachment	**5**
	Discipline-Specific Elective (DE)		
	AAQ-DE-536	Research Methodology for Aquatic Sciences	**2**
Semester 4	**Core Courses (CC)**		
	AAQ-CC-541	Internship	**6**
	AAQ-CC-542	Research Project	**6**
Any semester (I-IV)	**Skill Enhancement Elective (SE)**		
	AAQ-SE-501	Soft Skills	2
	AAQ-SE-502	Data Presentation Techniques	2
	AAQ-SE-503	Underwater Research & Recreation	2

SEMESTER I	Course Code: AAQ-CC-511	Credits: 2
NAME OF THE COURSE: **PRINCIPLES OF AQUACULTURE**		

COURSE OUTCOMES (CO)

CO 1: Understand the nature, status and scope of aquaculture at national and international levels and to acquire knowledge on the importance of aquaculture

CO 2: Identify significant types of aquaculture systems with particular emphasis on its operation and management options

CO 3: Understand and gain knowledge on integrating aquaculture with agriculture and animal husbandry

CO 4: Demonstrate knowledge and understanding of candidate species, their diversity, and biology.

CO 5: Develop a comprehensive knowledge ofmajor steps involved in aquaculture

CO 6: Critically evaluate the problems faced in aquaculture and its possible solutions and to inculcate thorough knowledge on the prospects and importance of aquaculture

Tagging course outcomes:

CO	CO Statement	PO/PSO	CL	KC
CO 1	U, R	1	U, R	F
CO 2	Ap	2, 3	Ap	P
CO 3	E, Ap	3, 4	E, Ap	P
CO 4	U, Ap	4, 5	U, Ap	C
CO 5	An	2, 4, 5	An	P
CO 6	E, Ap	8	E, Ap	M

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create, KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Module I: Aquaculture: Definition. History of aquaculture. Status of aquaculture: International and national. Aquaculture Vs Agriculture. Indigenous and Scientific methods.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Explain the international and national status of aquaculture (Understand)

MO 2: State the history of aquaculture (Remember)

MO 3: Analyse various scientific methods of aquaculture (Evaluate)

Module II: Types of aquaculture: Traditional, Extensive, Semi-Intensive, Intensive, Super Intensive. Classification based on water type: Freshwater, brackish water, open sea farming, wastewater aquaculture. Types of Aquaculture systems: pond, tanks, cage, pen, raft, raceways, aquaponics, RAS, Biofloc. Running water, periodic water exchange and zero water exchange systems.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Classify different types of aquaculture based on technology (Understand)

MO 2: Illustrate outline classification of aquaculture based on water type (Understand)

MO 3: Outline different types of aquaculture systems (Remember)

MO 4: Review the principles of RAS (Evaluate)

Module III: Integrated aquaculture systems: Rice cum fish culture, polyculture, Poultry cum fish, Livestock cum fish farming. Problems and prospects. Case studies of integrated systems, including prawn filtration and below sea level farming and aquaculture in Kuttanad, Kerala. Aquatourism.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Explain the importance of integrated aquaculture (Understand)

MO 2: Critically evaluate various types of integrated aquaculture systems employed (Evaluate)

MO 3: Illustrate the Problems and prospects of integrated aquaculture (Understand)

MO 4: Develop skills in operating integrated farming systems (Perform)

MODULE IV: Candidate species for aquaculture from finfishes, prawns/ shrimps, crabs, oysters, mussels, bivalves and seaweeds. Diversification of species for aquaculture. Criteria required for the selection of candidate species in aquaculture.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Explain major candidate finfish species for aquaculture (Understand)

MO 2: Identify major crustacean candidate species suitable for aquaculture (Understand)

MO 3: Evaluate diversification of species in Aquaculture (Understand)

MO 4: Appraise the positive criteria required for candidate species in aquaculture (Evaluate)

MO 5: Understand the techniques involved in hatchery management

Module V: Major steps involved in Aquaculture: criteria for site selection, Pond preparation. Bio-security measures. Stocking. Water quality management, feed management, disease management, Growth Assessment. Harvesting. Post harvesting.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Explain criteria involved in site selection for aquaculture grow out (Understand)

MO 2: List various steps involved in aquaculture (Remember)

MO 3: Sketch the importance of water quality management and feed management (Apply)

MO 4: Analyse the post-harvesting process and evaluate its economics (Evaluate)

Module VI: Problems faced in aquaculture and its possible solutions. Prospects and importance of aquaculture for food security, employment generation and entrepreneurship. Role of government departments, institutes and organisations involved in promoting aquaculture. Sustainable aquaculture practices.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Discuss the problems faced in aquaculture and its possible solutions. (Understand)

MO 2: Illustrate the prospects and importance of aquaculture (Analyse)

MO 3: Explain the role of various organisations involved in promoting aquaculture (Understand)

MO 4: Analyse the role of employment generation and entrepreneurship (Analyse)

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Classroom Activities:

- Assignments
- Seminar Presentation on selected topics
- Debates
- Quiz
- Demonstration and use of software
- Fieldwork and survey

LEARNING RESOURCES

References

Ackefors, H., Konikoff, M. and Huner, J., 2017. Introduction to the General Principles of Aquaculture. CRC Press, 172pp.

Agarwal, S.C., 2007. A Handbook of Fish Farming. Narendra Publ. Hse., New Delhi, 133pp.

Badapanda, K.C., 2012. *Aquaculture Vol.* . Narendra Publishing House, Delhi, 496pp.

Bardach, J.E. J.H. Rhyther and W.O. McLarney 1972. Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms. Wiley Intersci., NY, 868pp.

Beaumont, A., Boudry, P., Hoare, K., 2010. Biotechnology and Genetics in Aquaculture. Wiley, 216pp.

Christenson, K. 2019. Aquaculture- Introduction to Aquaculture for small farmers (3rd Ed). CreateSpace Independent Publishing Platform, USA, 104pp.

Craig, S.T. and J.A. Hargreaves (editors), 2008.Environmental Best Management Practices for Aquaculture. Blackwell Publishing Ltd. 578pp

Das, A.K., K.K. Vass, N.P. Shrivastava and P.K. Katiha. 2009. Cage Culture in Reservoirs in India. (A Handbook) WorldFish Center Technical Manual No. 1948. The WorldFish Center, Penang, Malaysia, 24pp.

Davison, A. 2019. Recirculating aquaculture systems- a guide to farm design and operations. Independently Published, 255pp.

De Silva, S.S, Davy, F.B., 2009. Success Stories in Asian Aquaculture. Springer Netherlands, 218pp.

Dube, S.K. 2010. *Fish Farming*. Wisdom Press, New Delhi, 330pp.

Dunham, R.A., 2011. Aquaculture and Fisheries Biotechnology: Genetic Approaches. CABI Publisher, pp. 495.

Felix, S. 2007. Aquaculture Management Techniques. Narendra Publ. Hse., New Delhi, 166 pp.

Ghosh, P.K. 2006. Agro'sDictionary of Aquaculture. Agrobios, India, 406pp.

Huet, M. 1986. Textbook of Fish culture. Breeding and Cultivation of Fish. 2nd ed. Fishing News Books, Oxford, 437 pp.

Huguenin, J.E. and J. Colt .1989. Design and operating guide for aquaculture seawater systems, Elsevier Scientific Publishing Co., Amsterdam, 264 pp.

Hussain, S.M. 2002. Encyclopedia of Fish Culture. Vol. 1. APH Publ. Co., New Delhi, 528 pp.

ICAR, 2011. Handbook of Fisheries and Aquaculture. ICAR, New Delhi, 1116 pp.

Imai, T. 1977. Aquaculture in Shallow Seas. Progress in Shallow Sea Culture. Amerind Publ. Co. Pvt. Ltd., New Delhi, 615 pp.

Lawrence, 2005 . Ecological Aquaculture. Permanent Publications, 149 pp.

Lawson, T. 1995 . Fundamentals of Aquacultural Engineering. Chapman and Hall. Hutchinson,

Lekang, O.2008. Aquaculture Engineering, Blackwell Publishing, 340 pp.

McLarney, W. 2013. Freshwater Aquaculture. Echo Point Books & Media, USA, 594 pp.

Meehan, W.E. 2002. Fish Culture in Ponds and Other Inland Waters. H.R. Publ. Hse., Piliani, 287 pp.

Midlen and T.A. Redding. 1998. *Environmental Management for Aquaculture*. Kluwer Publ.

New, M.B. 1982. Giant Prawn Farming. Elsevier Sci. Publ. Co., NY, 532 pp.

New, M.B. and S. Singholka. 1985. Freshwater Prawn Farming. A manual for the culture of *Macrobrachiumrosenbergii*. FAO Fisheries Technical Paper, 225 pp.

Pandey, B.N., S. Deshpandey and P.N. Pandey. 2007. Aquaculture. APH Publ. Corpn., New Delhi, 236 pp.

Parker, R., 2011. Aquaculture Science. Cengage Learning. 672pp.

Pillay, T.V.R. and M.N.Kutty. 2005. Aquaculture-Principles and Practices. 2nd ed. Blackwell Publ. Ltd., UK, 624 pp.

Smith, M. 2017. A beginner's guide to fish farming and pond construction. CreateSpace Independent Publishing Platform, USA, 42 pp.

Southern, A. and W.King. 2017. The Aquaponics Farmer- A complete guide to building and operating commercial aquaponic system. New society Publishers, Canada, 304 pp.

Stickney, R.R. 1994. Principles of Aquaculture. Wiley publishers.520pp

Stickney, R.R. 2000. *Encyclopedia of Aquaculture*. John Wiley & Sons, Inc., Canada, 1063pp.

Stickney, R.R. 2005. Aquaculture: An introductory Text-3rd edition. CAB International 321pp

Timmons, M.B.,T.M. Losordo (editors). (1994), Aquaculture water reuse systems: engineering design and management, Elsevier Scientific Publishing Co., Amsterdam, 333 pp.

Trushenski, J. 2019. Understanding Aquaculture. 5m Publishing, UK, 268 pp.

Tucker, C.S., Lucas, J.S., and Southgate, P.C., 2019. Aquaculture: Farming Aquatic Animals and Plants. Wiley, pp.664

Wedemeyer, G.A., 1996. Physiology of Fish in Intensive Culture Systems. Springer, US. 232pp.

Wheaton, F.W. 1977. Aquaculture Engineering. Wiley Interscience, New York, 708 pp.

Online references

www.fao.org

www.cmfri.org.in/

www.ciba.org.in

www.cifa.org.in

www.caa.gov.in

www.kerala.gov.in › adak

ww.fao.org › FAO Home › Fisheries & Aquaculture

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).

60% End-semester/Summative Assessment: 3 hour written Exam

SEMESTER I	Course Code: AAQ-CC-512	Credits: 2
NAME OF THE COURSE: **FISH NUTRITION**		

COURSE OUTCOMES (CO):

CO 1: Appreciate the role of nutrition in commercial aquaculture and promote the use of prepared feeds in the field

CO 2: Gain knowledge to provide consultancy to the fish feed industry and take up feed marketing jobs.

CO 3: Capability to manage the nutritional needs of cultured organisms of different trophic levels and avoid deficiency diseases.

CO 4: Understand the cost of feeding in aquaculture and take appropriate management decisions

CO 5: Gain capability to design novel formulated feeds and test them at lab and field.

Tagging course outcomes

CO	CO Statement	PO/PSO	CL	KC
CO 1	U, Ap	3, 4, 7	U, Ap	M
CO 2	Ap, An	2, 3, 8	Ap, An	P, M
CO 3	U, Ap	4, 5, 8	U, Ap	F, P
CO 4	Ap, An	1, 4	Ap, An	C, P
CO 5	Ap, Cr	2, 8	Ap, Cr	P, M

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create,

KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Module I: Major nutrients: Proteins, Lipids, Carbohydrates, Vitamins, Minerals. Metabolism: Carbohydrates, lipids, proteins. Nutritional requirements of cultured aquatic organisms.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Understand the importance of protein in fish nutrition and apply the same in formulating feeds (Evaluate)

MO 2: Gain knowledge on the dietary requirement of different nutrients at various life stages of the cultured organism and apply the same for developing specific feeds

MO 3: Estimate the proximate composition of fish feeds and apply the knowledge in decision making at farm (Apply).

MO 4: Understand the importance of micronutrients in fish feed and apply them to prevent deficiency diseases during aquaculture operations.

Module II: Digestive system of cultured fishes: herbivores, detritivores, omnivores and carnivores. Digestion and absorption. Digestive enzymes. Digestive physiology of cultured aquatic organisms.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Understand the difference in the digestive systems of cultured aquatic organisms and design feeds accordingly.

MO 2: Understand the physiology of digestion and absorption in cultured aquatic organisms and apply the knowledge in feed formulation.

MO 3: Understand the digestive enzymes cultured organisms and apply the knowledge in feed formulation.

MO 4: Apply the knowledge on digestive physiology of different species for effective management of polyculture.

Module III: Nutritional Energetics: Energy budget, gross energy, digestive energy, metabolizable energy.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Understand the concept of bioenergetics in aquaculture systems and apply the knowledge in feed management.

MO 2: Gain knowledge on the gross energy of nutrients and feed ingredients so as to apply them in feed manufacture.

MO 3: Understand the importance of environmental stressors in ensuring maximum growth

MO 4: Gain knowledge on the digestibility of ingredients used in fish feed manufacture.

Module IV: Feed formulation: Methods of feed formulation, Forms of feeds: wet feeds, moist feeds, dry feeds, mashes, pelleted feeds, floating and sinking pellets. Common ingredients in fish feeds. Feed additives, antimetabolites, antinutritional factors

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Classify fish feeds and make decisions to effective feed management in fish farms

MO 2: Understand the different methods of feed formulation and formulate feeds for farming different species according to nutritional requirements

MO 3: Understand the nutrient availabilities in common fish feed ingredients and select them according to local availability and price (Analyse)

MO 4: Understand the role of various food additives used in fish feeds and determine their doses for practical feeds (Understand)

MO 5: List out the antimetabolites and antinutritional factors in fish feed (Remember)

Module V: Feed Manufacture:Parts of a feed mill, Pelleted Feeds, Extruded Pellets. Storage and Distribution. Status of global and Indian fish feed industry.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO1. Understand the parts of a feed mill and ability to design a feed mill according to the requirement of the farm organism

MO 2. Manufacture of pelleted feeds and ability to prepared them according to requirement

MO 3. Understand the manufacture of extruded pellet feeds and their apply it in aquaculture

MO 4. Understand the parameters for evaluation of feed quality and apply them in the field

MO 5. Understand the status of Indian fish feed mills in comparison to the global scenario

Module VI: Evaluation of manufactured feeds: experimental and reference diet, purified and semi-purified diet, FCR, PER, NPU, chemical score, biological value, SGR, percentage weight gain. Water stability. Digestibility. Feed management: Feed ration, Automatic feeders, Cost of feed manufacture, Cost of feeding in aquaculture. Deficiency diseases in cultured aquatic organisms.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Evaluation of fish feed using the growth perform and to make appropriate management decisions

MO 2: Prepare experimental diets and conduct feeding trials for aquatic organisms

MO 3: Understand different types of feeding methods in aquaculture and select the right method for different farms

MO 4: Estimate the cost of feeding in aquaculture and make appropriate management decisions

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Activities

Assignments

- Seminar Presentation on selected topics
- Quiz
- Demonstration and use of software
- Field work and survey

LEARNING RESOURCES

References

Chandrasekhar, Y.S. 2013. *Fish Nutrition in Aquaculture*. Swastick Publications, Delhi.

Cowey, C.B. et al. 1985. *Nutrition and Feeding in Fish*. Academic Press, New York

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

Halver, J.E. 1972. *Fish Nutrition*. Academic Press, London.

Hasan, M.R. 2007. *Economics of Aquaculture Feeding Practices in selected Asian countries*. FAO of the UN, Rome

Hasan, M.R. 2007. *Study and analysis of feeds and fertilizers for sustainable aquaculture development*. FAO of the UN, Rome

Holt, G.J. 2011. *Larval Fish Nutrition*. Springer-Verlag, New York

ICAR, 2006 & 2011. *Handbook of Fisheries and Aquaculture*. ICAR, New Delhi.

Leiwes, E.W. 1984. *Culture, Feeding and Diseases of Commercial flatfish species*. Oxford and IBH Publishing Company Pvt. Ltd., New Delhi.

Lim, C., Webster, C.D. and Lee, C.S. 2008. *Alternative Protein Sources in Aquaculture Diets*. The Haworth Press, New York.

Long, A.C. 2012. *Fish feeding and integrated fish farming*. Cybertech Publications, Delhi.

Lovell, T., 2012. Nutrition and Feeding of Fish (2nd Ed.). Springer, US. 267pp.

Nates, S.F., 2015. Aquafeed Formulation. Elsevier Science, 302pp.

Ninawe, A.S. and Khedkar, G.D. 1995. *Nutrition in Aquaculture*. Narendra Publishing House, Delhi.

Paulraj, R. *Aquaculture Feed*, MPEDA, Cochin.

Pillay, T.V.R. and Kutty, M.N. 2005. *Aquaculture: Principles and Practices*. Blackwell Publishing, USA.

Raghunath, M.R. 2013. *Nutrition and Feeding of Fishes*. Swastik Publishing House, Delhi.

Stickney, R.R. 2000. *Encyclopedia of Aquaculture*. John Wiley & Sons, New York

Surendra Nath. 2002. *Food, Feeding habits and Alimentary canal of fishes*. Vinod Publishers and Distributors, India.

ADDITIONAL REFERENCES

http://edis.ifas.ufl.edu/topic_fish_nutrition
http://www.glfc.org/pubs/SpecialPubs/sp83_2/pdf/chap8.pdf
https://nofima.no/en/forskningsomrade/nutrition-and-feed-technology/fish-nutrition/
https://thefishsite.com/articles/principles-of-fish-nutrition

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).
60% End-semester/Summative Assessment: 3 hour written Exam.

SEMESTER I	Course Code: AAQ-CC-513	Credits: 4
NAME OF THE COURSE: **BIOLOGY OF FISH AND SHELLFISH**		

COURSE OUTCOMES (CO):

CO 1: Gain an overview of integrative taxonomy of cultured aquatic organisms

CO 2: Understand the anatomy and physiology of cultured aquatic organisms

CO 3: Understand the reproductive biology of cultured organisms for critical evaluation and possible manipulation.

CO 4: Develop necessary understanding in fish biology for performing technical responsibilities as an entrepreneur/ manager/ consultant / administrator/ extension worker

Tagging course outcomes:

CO	CO Statement	PO/PSO	CL	KC
CO 1	U, R	1, 4, 5	U, R	F
CO 2	U, R	1, 4, 5	U, R	F
CO 3	E, Ap	5, 7, 8	E, Ap	F, P
CO 4	Ap, E	2, 7	Ap, E	C

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create,

KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Module I: Morphology of cultured organisms: body shape, parts and form. Comparative accounts. Identification of cultured fishes (IMC, Chinese carps, Cat fishes, Mullets, Milkfish, Cichlids, Exotic fishes, Important cultured marine fishes). Identification features of cultured shellfishes: *Penaeus monodon*, *Fenneropenaeus indicus*, *Litopenaeusvannamei*, *Macrobrachiumrosenbergii*, *Scylla serrata*, sand lobster and spiny lobster, mussels, edible and pearl oysters and common clams. Integrative taxonomy and species confirmation.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Understand body parts of cultured organisms

MO 2: Familiarize with the taxonomic position of cultured organisms

MO 3: Gain expertise in the field identification of cultured organisms

Module II: Food and feeding of fish and shellfish: Digestive system, glands and hormones in various taxa- comparative accounts. Digestion, absorption and assimilation. Food and feeding analyses. Ontogenetic dietary shifts in fish. Growth patterns in fish. Factors affecting growth, growth hormones. Respiration of fish and shellfish: Gaseous exchange. Counter current flow. Respiratory pigments and metabolism. Energetics and swimming. Circulatory System of fish and shellfish: Blood and circulation- comparative account in fish and shellfish.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Identify the gut contents and analyse the feeding pattern of fish (Analyse)

MO 2: Determine the growth patterns in relation to length and weight (Understand)

MO 3: Recognise gas exchange mechanism in fish and shellfish (Understand)

MO 4: Familiarize with respiratory metabolism and energy budget (Understand)

MO 5: Critically observe the properties of blood / hemolymph

Module III: Excretory structures in fish and shellfish: comparative account. Comparative study of nephron in different fishes. Pathways of excretion and hormones. Osmoregulation- mechanism, pathways and hormones. Endocrine system in fish and shellfish: Neurosecretions of shellfish concerning moulting and reproduction. Stress hormones and proteins. Biological clocks. Fish behaviour and hormonal regulation. Colour change and its regulation. Physiology of migration.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: List out various structures involved in excretion in fish and shellfish (Remember)

MO 2: Compare the physiology and mechanism of osmoregulation in fishes and appreciate its importance in aquaculture (Analyse)

MO 3: Identify the products of excretion and their route (Understand)

MO 4: Know different types of endocrine organs and their secretion (Understand)

MO 5: Appreciate the hormonal action concerning moulting and reproduction of shrimps

Module IV: Sexuality in fishes, Sexual dimorphism, Reproductive cycle, Modes of reproduction, Semelparity, viviparity, Spawning, Fecundity (Total, Relative and Absolute), GSI, Ova diameter frequency. Endocrine and neuroendocrine control of reproduction in culture finfishes. Hormones in reproduction. Testes- Spermatogenesis, spermiation and hydration. Ovaries - Oogenesis, vitellogenesis and ovulation. Maturity stages in male and females.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Identify male and female fish (Analyse)

MO 2: Understand the various modes of reproduction observed in fishes (Analyse)

MO 3: Understand the role of Hypothalamus - Pituitary - Adrenal (HPA axis) in fish reproduction

MO 4: Understand the biochemical nature of reproductive hormones in fishes

MO 5: Examine fishes and ascertain in its maturity stage

Module V: Spawning Migration, Courtship and mating, fertilization and development. Development of eggs and embryos. Hatching. Larval stages. Larval Nutrition. Parental care. Pheromones. Induced Breeding: Biochemical characteristics of synthetic hormone analogues and their applications. Comparative evaluation of commercially available inducing agents. Cryopreservation technique: Principles, Quality of milt, Protocols and Advantages. Cryopreservation of eggs and gametes. Cryopreservation of invertebrate larvae.

Module Outcomes (MO)

MO 1: Understand the physiological control of courtship and mating

MO 2: Recognise fertilization strategies in fishes and manipulate same for mass seed production

MO 3: Understand the developmental stages of eggs and embryos

MO 4: Understand the hormonal control of parental care.

MO 5: Understand the principles of cryopreservation techniques for milt and eggs.

Module VI: Reproductive biology of cultured shrimps, freshwater prawns, mud crabs, oysters, mussels and clams. Artificial insemination in crustaceans and molluscs.

Module Outcomes (MO)

MO 1: Understand the reproductive biology of cultured shrimps (*P. monodon* and *L. vannamei*)

MO 2: Familiarize with the induced breeding techniques for shrimps and apply them for controlled seed production.

MO 3: Familiarize with the reproductive biology of mud crabs

MO 4: Familiarize with the induced breeding techniques for cultured molluscs.

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Activities

- Assignments
- Seminar Presentation on selected topics
- Quiz
- Demonstration and use of software
- Field work and survey

LEARNING RESOURCES

References

Alcock, A. 1968. Materials for a carcinologicalfanua of India. *Verlag Von J.Cramer, New York.*

Bardach, J.E. J.H. Rhyther and W.O. McLarney 1972. Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms. Wiley Intersci., NY, 868 pp.

Bensam, P. and P. Vasudeva. 1993. *Hand Book on Aquafarming: Seafishes Oceanic Cage*

culture. Manual. MPEDA, Cochin, Kerala.

Biswas, K.P. 2011. *Marine Prawns & Shrimps*. Daya Publishing House, Delhi, 329pp.

Biswas, S.P. 1993. Manual of Methods in Fish Biology. South Asian Publ. Pvt. Ltd., New Delhi, 157 pp.

Bone & Marshall. 1975. Biology of Fishes. Blackie & Son Ltd., London, 253 pp.

Bone, Q and R.H. Moore. 2008 (Third Ed.). Biology of fishes. Taylor & Francis Group, New York.

Burton Derek and Burton Margaret, 2018. Essentials of fish biology: Diversity. Structure and Function. Oxford University Press

Datta Munshi, J.S., J. Ohja, & T.K. Ghosh 2003. Advances in Fish Research. Vol. 3. Narendra Publ. Hse., India, 306 pp.

Datta Munshi,, J.S. & H.R. Singh 2006. Advances in Fish Research. Vol. 4. Narendra Publ. Hse., India, 312 pp.

Evans, D.H. 1998. The Physiology of Fishes. 2nd ed. CRC Press, NY, 519 pp.

Fagen, R. M et al, 2019. Fish cognition and behavior. Excelic Press

Farrell, Anthony P. (Ed) 2011. *Encyclopedia of Fish Physiology*. Elsevier, New York, 2163pp

Felix, S. 2009. *Advances in shrimp Aquaculture Management*. Daya Publishing House, Delhi, 192pp.

Fischer, W. and G. Bianchi. (Eds.) 1984. FAO species Identification sheets for Fishery Purposes, Western Indian Ocean (Fishing Area 51). FAO, 1983. Species Identification sheets.

Ghosh, P.K. 2006. Agro's Dictionary of Aquaculture. Agrobios (India), 406 pp.

Greenwood, B.H. 1963. A History of Fishes. 2nd ed. Ernst Benn Ltd., London, 398 pp.

Helfman, G.S., Collette, B.B., Facey, D.E. and Bowen, B.W. 2009. The Diversity of Fishes. Biology, Evolution and Ecology. John Wiley & Sons Ltd, Oxford.

Hoar, W.S. 1993. General and Comparative Physiology. Prentice Hall of India Pvt. Ltd., New Delhi, 851 pp.

Hoar, W.S. and D.J. Randall. 1971. Fish Physiology. Vols. I to V. Academic Press, New York.

Huet, M. 1972. Text book of fish culture: Breeding and cultivation of fish. Fishing News (Books) Ltd. Farnham, Surrey, U.K. 436 pp.

Ian AJ & Hoar WS. 2001. *Muscle Development and Growth*. Academic Press, New York.

ICAR 2011. Handbook of Fisheries and Aquaculture. ICAR, New Delhi, 1116 pp.

Imai, T. 1977. Aquaculture in Shallow Seas. Oxford & IBH Publ. Co., New Delhi, 651 pp.

Jayachandran, K.V. 2001. *Palaemonid prawns. Biodiversity, Taxonomy, Biology and Management,* Oxford and IBH Publ. Co.Pvt. Ltd. New Delhi

Jayaram, K.C. 1999. The Freshwater Fishes of the Indian Region. Narendra Publ. Co., New Delhi, 551 pp.

Jayaram, K.C. 2006. The Catfishes of India. Narendra Publ. Hse., India, 383 pp.

Jhingran, V.G. 1983. Fish and Fisheries of India. Hindustan Publ. Corpn. (India), Delhi, 666 pp.

Joseph S. Nelson et al., 2016. Fishes of the World. 4th ed. John Wiley & sons, Inc.

Kaliaperumal, N and D.B. James. 1993. Handbook on Aquafarming. Seaweed, Sea Urchin, Sea Cucumber. MPEDA, Cochin.

Karunasagar, I., I. Karunasagar&A.Reilly 1999. Aquaculture and Biotechnology. Oxford & IBH Publ. Co. Pvt. Ltd., New Delhi, 186 pp.

Kasturi Samantaray, 2015. Physiology of finfish and shellfish. New India Publishing Agency, New Delhi

Khanna, S.S. & H.R. Singh 2006. A Textbook of Fish Biology and Fisheries. Narendra Publ. Hse., India, 524 pp.

Kuriyan, C.V. and V.O Sebastian 1993. Prawns and prawn fisheries of India (4th edn.) Hindustan Publ. Corp., Delhi pp 267.

Lagler, K.F., J.E. Bardach& R.E. Miller 1963. Ichthyology. John Wiley & Sons, Inc., NY, 545 pp.

MBAI, 1982. Proceedings of the Symposium on coastal Aquaculture. Part 1. Prawn Culture. Marine Biological Association of India, 425 pp.

McVey, J.P. 1993. CRC Handbook of Mariculture. Vol. 1: Crustacean Aquaculture. CRC Press, Boca Raton, 526 pp.

Misra, K.S. An Aid to the Identification of the Common Commercial Fishes of India and Pakistan. Narendra Publ. Hse., India, 320 pp.

Moyle, P.B & J.C. Cech 1988. Fishes. An Introduction to Ichthyology. 2nd ed. Prentice Hall, NJ, 559 pp.

New M.B. & W.C. Valenti 2000. Freshwater Prawn Culture: The Farming of *Macrobrachium rosenbergii*. Blackwell Sci. Ltd. Oxford, UK, 443 pp.

Nikolski, G.V. 1963. Ecology of Fishes. Acd. Press, London, 351 pp.

Paul J.B. Hart and John D. Reynolds Handbook of Fish Biology and Fisheries. Volume 1 Fish Biology.

Paul J.B. Hart and John D. Reynolds., 2004. Handbook of Fish Biology and Fisheries. Volume 2. Blackwell Publishing.

Peter K. L. Ng, DanièleGuinot& Peter J. F. Davie (2008). "Systema Brachyurorum: Part I. An annotated checklist of extant Brachyuran crabs of the world" (PDF). *Raffles Bulletin of Zoology* 17: 1–286.

Philipose, KK, L. Jayasree, S.R. Krupesha and D. Damodaran eds. 2012. *Handbook on Opensea Cage Culture.* Central Marine Fisheries Research Institute, Karwar, 143pp.

Pillai, N.G.K. 2011. *Marine Fisheries & Mariculture in India*. Narendra Publishing House, Delhi, 352pp.

Pillay, T.V.R. & M.N. Kutty 2005. Aquaculture: Principles and Practices. Blackwell Publ. Ltd., Oxford, UK, 624 pp.

Prosser CL. 1950. *Comparative Animal Physiology*. WB Saunders. Publishing House, Delhi, 352pp.

Purdom& Colin. 2009. *Genetics & Fish Breeding*. Chapmann & Hall Ltd., London 277pp.

Rao, G Syda and Imelda, Joseph and Radhakrishnan, E.V. 2011. *Handbook of Prawns*. CMFRI, Cochin. 125pp.

Philippose, K K and Mojjada, Suresh Kumar. 2013. *Cage Aquaculture in India.* Central Marine Fisheries Research Institute, Kochi.

Sakai, T.1976. Crabs of Japan and adjacent seas. *Publ. KodamshaTokya, Japan (1976)* 461pp.

Scharrer E. 1963. *Neuroendocrinology.* Columbia University Press

Sethuramalingam, S. and Ajmal Khan, S. (l991). Brachyuran crabs of Parangipettai coast, CAS in Marine Biology publication, Annamalai University, India, 92pp.

Shadwick RE & Lauder GV. 2006. *Fish Biomechanics*. Academic Press. Shagufta. 2012. Singh, H.R. 2006. Advances in Fish Research. Vol. 1. Narendra Publ. Hse., India, 400 pp.

Smyth & Lynwood. 2003. *Introduction to Fish Physiology*. Narendra

Srivastava, C.B.L. 2008. Fish Biology. Narendra Publ. Hse., India, 329 pp.

Stickney, R. R. 1979. Principles of warmwater aquaculture. John Wiley & Sons, New York, Wiley Interscience, 376 pp.

Thomas PC, Rath SC & Mohapatra KD. 2003. Breeding and Seed Production of Finfish and Shellfish. Daya Publ. House.

Wheaton, F.W. 1977. Aquaculture Engineering. Wiley Interscience, New York, 708 pp.

Online Resources

www.abctaxa.be
www.aldrin.tripod.com/biochemistry
www.catalogueoflife.org/annual-checklist/2017/
www.discoveryeducation.com/teachers/free-lesson-plans/animal-classification.cfm
www.eol.org/
www.fish.cgiar.org/
www.fishbase.org
www.marinespecies.org
www.med.wikidot.com/biochemistry-online-links
www.researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp
www.sp2000.org/
www.the-aps.org/mm/Education/K-12/EducationProjects/FrontiersinPhys/Teaching-Resources
www.wiley.com/legacy/college/boyer/0470003790/animations/animations.htm
www.worldfishcenter.org/
www.wyzant.com/resources/physiology

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).
60% End-semester/Summative Assessment: 3 hour written Exam

SEMESTER I	Course Code: AAQ-CC-514	Credits: 2
NAME OF THE COURSE: **AQUACULTURE ENGINEERING**		

COURSE OUTCOMES (CO)

CO 1: Fundamental information on surveying and levelling

CO 2: Familiarity on the equipment's used in hatchery and grow-out systems

CO 3: Comprehensive awareness on aquaculture engineering

CO 4: Proficiency in pond designing and preparation

CO 5: Detailed knowledge on water quality monitoring systems

CO 6: Basic information on intensive aquaculture techniques

Tagging course outcomes:

CO	CO Statement	PO/PSO	CL	KC
CO 1	U, R	1, 2	U, R	F, C
CO 2	U, Ap	4, 5	U, Ap	F, P
CO 3	R, U	1	R, U	C
CO 4	Ap, Cr	2, 4	Ap, Cr	P
CO 5	R, An	4, 5	R, An	P
CO 6	U, Ap	2, 4	U, Ap	P

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create, KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Module I: Surveying and preparation of ponds- Land survey, area calculation of plane surface of regular and irregular surface. Preliminary survey and site selection- principles of surveying, Classification. Volume calculation of tanks and ponds.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO1: Identify the importance and applications of surveying and levelling (Understand)

MO 2: Review the philosophy and principles of land management for better production (Understand)

MO 3: Enumerate the different types of surveying suitable for different topographical areas (Evaluate)

MO 4: Calculate volume of different water bodies (Apply)

Module II: Layout and construction of ponds- Classification and earth work calculation for dykes, ponds, canals and roads. Maintenance of ponds- pond drainage system, seepage and its control. Inlet/outlet types and construction.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO1: Design ponds for fish farming (Apply)

MO 2: Comprehend effective utilisation of land for earth works (Understand)

MO 3: Enumerate the significance of different inlet/outlet design (Evaluate)

MO 4: Identify the importance of pond drainage system (Understand)

Module III: Design of hatcheries &Fish Farm: Broodstock ponds, water supply system, main hatchery complex, spawning tanks, incubation/hatching tanks, artemia hatching unit, live feed unit, water storage tanks. Tide fed/pump fed farms, creeks, estuarine and marine water source utilization.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Design hatcheries and farms (Evaluate)

MO 2: Recognize the effective utilisation of natural resources for a farm (Understand)

MO 3: Set up a live feed unit for hatchery (Apply)

MO 4: Calculate the water management system effectively (Understand)

Module IV: Instrumentation in Fish Farming: Aeration- principles, classification, placement. Pumps- types, total head, horse power, Protein skimmer, Ozoniser, UV sterilizer, filters- types and construction

Module Outcomes (MO):

After completion of this module, the student should be able to:

MO 1: Enumerate the various instruments needed in a hatchery (Remember)

MO 2: Identify quality control measures for various instruments used in fish farming (Understand)

MO 3: Identify the differences in various filters used in different aquaculture systems (Analyse)

MO 4: Explore the different aerators and its application (Understand)

MO 5: Assess critically the different pumps available in the market (Understand)

MO 6: Provide extension services to farmers regarding the instrumentation in aquaculture (Apply)

Module V: Monitoring Systems: Water quality monitoring systems, online monitoring devices, electricity backup systems- solar/Uninterrupted power supply- battery- charging and discharging, generator capacity, power demand and back up ratio.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Identify the different types of water quality monitoring devices (Understand)

MO 2: Execute the calculation of power requirement and back up ratio (Perform)

MO 3: Identify the different back up devices available for fish farming (Analyse)

MO 4: manage online water quality monitoring devices (Evaluate)

Module VI: Design of culture systems: Re-circulating Aquaculture System, Biofloc Technology, Aquaponics, Integrated Farming Systems, cage culture.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Recognize the fundamental designs of different fish culture systems (Understand)

MO 2: Identify site-specific intensive system suitable to available resources (Evaluate)

MO 3: Analyse plant and fish component ratio in aquaponics (Understand)

MO 4: Design the structural stability for cages suitable for strong water current areas (Perform)

MO 5: Provide extension services to farmers on deign/maintenance of culture systems (Understand)

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Classroom Activities:

- Assignments
- Seminar Presentation on selected topics
- Debates
- Quiz
- Demonstration of simple experiments
- Field work and survey

LEARNING RESOURCES

References

Lekang, O, (2008). Aquaculture Engineering, Blackwell Publishing, 340 pp.

Lawson, T., (1995). Fundamentals of Aquacultural Engineering. Chapman and Hall. Hutchinson,

Lawrence, (2005). Ecological Aquaculture. Permanent Publications, 149 pp.

Huguenin, J.E. and Colt, J., (1989), Design and operating guide for aquaculture seawater systems, Elsevier Scientific Publishing Co., Amsterdam, 264 pp.

Timmons, M.B., Losordo, T.M., editors, (1994), Aquaculture water reuse systems: engineering design and management, Elsevier Scientific Publishing Co., Amsterdam, 333 pp.

Wheaton, F.W., (1977), Aquacultural Engineering, Wiley, New York, 708 pp.

On-line resources:

http://www.fao.org/3/x5744e/x5744e00.htm

http://www.fao.org/3/AC014E/AC014E07.htm

http://www.fao.org/3/a-i4626e.pdf

http://www.fao.org/3/a-y5098e.pdf

Reference Journal:

Aquaculture Engineering (https://www.journals.elsevier.com/aquacultural-engineering)

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).

60% End-semester/Summative Assessment: 3 hour written Exam.

SEMESTER I	Course Code: AAQ-CC-515	Credits: 2
NAME OF THE COURSE: **SOIL AND WATER QUALITY MANAGEMENT**		

COURSE OUTCOMES (CO)

CO 1: Fundamental information on characteristics of water

CO 2: Familiarity on the properties of soil chemistry

CO 3: Comprehensive awareness on aquaculture engineering

CO 4: Proficiency in pond designing and preparation

CO 5: Practical knowledge on water quality monitoring systems

Tagging course outcomes:

CO	CO Statement	PO/PSO	CL	KC
CO 1	U, R	1, 4	U, R	F
CO 2	U, R	1, 4	U, R	F
CO 3	U, Ap	3, 4	U, Ap	P
CO 4	Ap	3, 4, 7	Ap	C, P
CO 5	E	4, 5	E	C

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create, KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Module I: Water and analysis- characteristics of water- physical/chemical of fresh and seawater. Dissolved gases in water. Sources of water- surface, ground, seawater. Water quality parameters- ISO standards, permissible limits for aquaculture.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Identify the characteristics of water (Understand)

MO 2: Identify the water quality parameters (Understand)

MO 3: Enumerate the permissible limits of water quality levels of water for farming (Evaluate)

MO 4: Review several water quality parameters of different sources of water (Apply)

MO 5: Provide extension services to farmers for reviewing water quality parameters (Apply)

Module II: Soil: physical and chemical properties- Depth, colour, texture, pore size, bulk density, water holding capacity, Soil colloids, Soil fertility, soil conductivity, soil redox potential. Types of soil.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO1: Enumerate the physical and chemical properties of water (Evaluate)

MO 2: Understand the role of soil characters in aquaculture ponds (Evaluate)

MO 3: Classify various kinds of soils based on its properties (Understand)

MO 4: Gain practical knowledge on soil properties of aquaculture systems (Apply)

Module III: Water quality criteria – Optimum condition of water and soil for aquaculture. Physical and Chemical parameters and their effects. Sewage contents from Aquaculture. Treatment protocols before discharge.

Module Outcomes(MO)

After Completion of this module, the student should be able to:

MO 1: Identify the optimum water conditions suitable for aquaculture (Evaluate)

MO 2: Review physical and chemical parameters and their effects on physiology (Understand)

MO 3: Review the sewage treatment plant designs to effectively reduce pollution. (Understand)

MO 4: Identify different sewage treatment protocols (Evaluate)

Module IV: Instrumentation- water quality monitoring devices, Sensors- probe based/biochemical kits. Design of online monitoring system- SMS alerts, live monitoring devices.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Enumerate different instruments required for water quality monitoring (Remember)

MO 2: Design online monitoring of water quality parameters (Understand)

MO 3: Explore different modes of water quality monitoring in intensive aquaculture systems (Apply)

Module V: Water quality management- adjusting alkalinity, pH, Dissolved oxygen, metals (Iron), ammonia, nitrite and nitrate toxicity. (Perform)

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Evaluate correction measures of water quality parameters (Understand)

MO 2: Execute adjusting different water quality parameters (Perform)

MO 3: Provide extension services for farmers to adjust the water quality parameters (Analyse)

Module VI: Correlation of water quality and aquaculture- effect of alkalinity, pH, salinity variations on biology of fish and other water quality parameters. Synergistic effects of water quality.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Correlate several water quality parameters and their effects (Understand)

MO 2: Gain knowledge on synergistic effects of different parameters (Evaluate)

MO 3: Evaluate effect of variation of water quality on physiology of cultured organism (Remember)

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Activities

- Assignments
- Seminar Presentation on selected topics
- Debates
- Quiz
- Demonstration of simple experiments
- Field work and survey

LEARNING RESOURCES

References

Arakeri, H.R., (1967). Soil Management in India. Asia Publishing House.

Bandyopadhyay, P.C., (2007).Soil Analysis. Gene – Tech Books.

Bishop, A.W., (1962). Measurement of Soil Properties. Edward Arnold.

Chattopadhyay, G.N., (1990). Chemical Analysis of Fish Pond Soil and Water. Agro Botanical.

Chattopadhyay, G.N., (1998). Chemical analysis of Fish Pond Soil. Daya Publishing House.

Claude, E.B., (1995). Bottom Soil, Sediment and Pond Aquaculture. Chapman and Hall, New York

De, S.K., (1962). Method of Soil Analysis. National Book Trust.

De, S.K., (1996). Methods of Soil Analysis. National Bureau of Fish Genetic Resources

Essington, M.E., (2015). Soil and Water Chemistry: An Integrative Approach (2nd Ed.). CRC Press.

Heath, A,G., (1995). Water Pollution and Fish Physiology. CRC Press.

Miller, L.M.C.E., (2008). Fundamentals of Soil Science. Biotech Books.

Raheja, P.C., (1966). Soil Productivity and Crop Growth. Asia Publishing House

Russell W.E., (1961). Soil Conditions and Plant Growth. Longman Publishers.

Saxena, M.M., (1990). Environmental Analysis Water soil and Air. Agro Botanical.

Soderberg, R.W., (2017). Aquaculture Technology: Flowing water and Static Water Fish Culture. CRC Press.

Tahir, A., (2009). Manual of Soil Plant and Water Analysis. Daya Publishing House.

Troeh, F.R., (1993). Soils and Soil Fertility. Oxford University Press.

Online Resources

http://www.fao.org/3/a-t1623e.pdf

http://www.fao.org/3/AC183E/AC183E00.htm

http://www.fao.org/3/t0551e/t0551e09.htm

Reference Journal

Journal of Water Chemistry and Technology

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).

60% End-semester/Summative Assessment: 3 hour written Exam.

SEMESTER I	Course Code: AAQ-CC-516	Credits: 3
NAME OF THE COURSE: **PRACTICAL 1: FISH BIOLOGY, NUTRITION AND WATER QUALITY MANAGEMENT**		

COURSE OUTCOMES (CO)

CO 1: Demonstrate practical knowledge and understanding about cutivable species of fish and shellfish

CO 2: Demonstrate practical knowledge in identification of culturable aquatic organisms and its basic biology and physiology with special emphasis on reproductive biology

CO 3: Develop a comprehensive practical knowledge on aquaculture nutrition

CO 4: Develop skills in formulation feeds for aquaculture

CO 5: Critically evaluate the water quality parameters in aquaculture and its management

CO 6: Develop practical skills in analysing soil quality and soil texture in culture systems

CO 7: Develop practical skills in analysing plankton, weeds and pests in culture systems

Tagging course outcomes:

CO	CO Statement	PO/PSO	CL	KC
CO 1	Ap	1, 4, 5	Ap	P
CO 2	U	1, 5	U	P
CO 3	U, Ap	3, 4, 8	U, Ap	P
CO 4	Ap, E	3, 4, 8	Ap, E	P
CO 5	U, Ap	1, 3, 4	U, Ap	P
CO 6	U, Ap	1, 3, 4	U, Ap	P

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create, KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Fish Biology

Identification of candidate species in aquaculture

Morphometric and meristic studies of candidate species

Reproductive systems in fish and shell fish - maturity stages, fecundity and ova-diameter studies and GSI

Dissection and display of various body systems of fish and shellfish

Fish Nutrition

Proximate and microbial assessment of formulated feeds

Estimation of total protein, carbohydrates, lipids, moisture content, calorific valve and ash content.

Analysis of Amino acid, protein, lipid and carbohydrates using chromatography, Mass spectroscopy, Immunoassay (Radio, enzyme, fluorescence and chemical).

Familiarization of feed additives, antimetabolites, antinutritional factors

Shelf life studies on formulated feed

Water/Soil Quality Management

Demonstration and operation of instruments for aquaculture

Analysis of physico-chemical parameters of soil & water : Temperature, Salinity, pH, Oxygen Concentration, Nitrite, Nitrate, Ammonia, TOC, alkalinity, Phosphate, Silicate, Chlorophyll, Transparency.

Analyses of soil texture

Water quality monitoring devices and kits-operation

Adjustment of water quality parameters to optimum levels

Soil culture and water culture

Phytoplankton: Collection, Identification, qualitative and quantitative assessment

Report of field visit to farms and aquaculture institutes

LEARNING RESOURCES

References

Arakeri, H.R. (1967). Soil Management in India. Asia Publishing House.

Bandyopadhyay, P.C. (2007).Soil Analysis. Gene – Tech Books.

Bishop, A.W.(1962). Measurement of Soil Properties. Edward Arnold.

Biswas, S.P. 1993. Manual of Methods in Fish Biology. South Asian Publ. Pvt. Ltd., New Delhi, 157 pp.

Burton Derek and Burton Margaret, 2018. Essentials of fish biology: Diversity. Structure and Function. Oxford University Press

Chattopadhyay, G.N. (1998). Chemical analysis of Fish Pond Soil. Daya Publishing House.

Claude, E.B. (1995). Bottom Soil, Sediment and Pond Aquaculture. Chapman and Hall, Newyork

Datta Munshi, J.S. & H.R. Singh 2006. Advances in Fish Research. Vol. 3 and 4. Narendra Publ. Hse., India.

De, S.K., (1996). Methods ofSoil Analysis.National Bureau of Fish Genetic Resources

Essington, M.E. (2015). Soil and Water Chemistry: An Integrative Aproach (2nd Ed.). CRC Press.

Evans, D.H. 1998. The Physiology of Fishes. 2nd ed. CRC Press, NY, 519 pp.

Heath, A,G. (1995). Water Pollution and Fish Physiology. CRC Press.

Huguenin, J.E. and Colt, J. (1989), Design and operating guide for aquaculture seawater systems, Elsevier Scientific Publishing Co., Amsterdam, 264 pp.

Kuriyan, C.V. and V.O Sebastian 1993. Prawns and prawn fisheries of India (4th edn.) Hindustan Publ. Corp., Delhi pp 267.

Lawrence (2005). Ecological Aquaculture. Permanent Publications, 149 pp.

Lawson, T. (1995). Fundamentals of Aquacultural Engineering. Chapman and Hall. Hutchinson,

Lekang, O, (2008). Aquaculture Engineering, Blackwell Publishing, 340 pp.

Miller, L.M.C.E. (2008). Fundamentals of Soil Science. Biotech Books.

Misra, K.S. An Aid to the Identification of the Common Commercial Fishes of India and Pakistan. Narendra Publ. Hse., India, 320 pp.

Raheja, P.C. (1966). Soil Productivity and Crop Growth. Asia Publishing House

Russell W.E. (1961). Soil Conditions and Plant Growth. Longman Publishers.

Saxena, M.M. (1990). Environmental Analysis Water soil and Air. Agro Botanical.

Soderberg, R.W. (2017). Aquaculture Technology: Flowing water and Static Water Fish Culture. CRC Press.

Tahir, A. (2009). Manual of Soil Plant and Water Analysis. Daya Publishing House.

Timmons, M.B., Losordo, T.M., editors, (1994). Aquaculture water reuse systems: engineering design and management, Elsevier Scientific Publishing Co., Amsterdam, 333 pp.

Troeh, F.R. (1993). Soils and Soil Fertility. Oxford University Press.

Wheaton, F.W. (1977), Aquacultural Engineering, Wiley, New York, 708 pp.

Online sources

www.caa.gov.in
www.ciba.org.in
www.cifa.org.in
www.cmfri.org.in/
www.fao.org
www.kerala.gov.in › adak
www.worldfishcenter.org/
www.wyzant.com/resources/physiology

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).

60% End-semester/Summative Assessment: 3 hour written Exam

SEMESTER I	Course Code: AAQ-DE-517	Credits: 2
NAME OF THE COURSE: **ENVIRONMENTAL IMPACT ASSESSMENT FOR AQUACULTURE**		

COURSE OUTCOMES (CO)

CO1: Understanding environment and micro-environment.

CO2: Understanding ecosystem, ecosystem dynamics and homoeostasis

CO3: Develop capability to understand the regulations of EIA protocols

CO4: Understand and practice EIA procedure, methodologies and people interactions.

CO5: Create network with EIA framework and international organizations.

CO6: Enable to execute environmental impact assessment studies

Tagging course outcomes:

CO	CO Statement	PO/PSO	CL	KC
CO 1	R, U	1, 6	R, U	F, C
CO 2	U, An	2, 6, 8	U, An	F, C
CO 3	U, E	6	U, E	F, C
CO 4	R, U	6, 7, 8	R, U	F, C
CO 5	An, E	6, 7	An, E	P
CO 6	Ap, E	6, 7	Ap, E	P

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create, KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Module I: Ecosystem and Environment**:** Biosphere and Hydrosphere, Environment and micro-environment. Ecosystem Concept, Homoeostasis Food chain, web and niche. Population and Community Aquatic Ecosystems. Biodiversity, Ecosystem Services, Man and Environment, Pollution and sustainable development. Climate change.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Recognize and recollect basic principles of Ecology (Understand)

MO 2: Distinguish census and sampling methods (Create)

MO 3: Analyse data for using basic statistical techniques (Apply)

MO 4: Develop essential skills in data analysis (Apply)

MO 5: Develop overall idea on the concept and statistical research method (Analyse)

Module II: EIA Approaches: History and significance of EIA/EIS, terminologies, Impact, EIA and WCED and UNCED, Principles of EIA, Life cycle of EIA.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Recognize need to test hypothesis (Understand)

MO 2: Understand the basic and advance statistical tools to test hypothesis (Remember)

MO 3: Use and apply the statistical tools to biological data (Apply)

MO 4: Develop essential skills in data analysis (Apply)

MO 5: Develop overall idea on the concept and scope hypothesis testing (Analyse)

Module III: EIA Procedure and Methods: EI Statements, Scoping, ToR, Cost of EIA, EIA Auditing, Regional Environment Plans. EIA Methodologies – Optimization, Cost benefit and effectiveness analysis, Ecological evaluation, Judgment. Public Participation and mediation

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Recognise the methods of scientific research (Understand)

MO 2: Explain the types of research (Remember)

MO 3: Classify research based on various purpose and functions (Apply)

MO 4: Develop essential skills in content analysis (Apply)

MO 5: Develop overall idea on the concept and scope research (Analyse)

Module IV: EIA Framework: International organization- EC, Nordic Council, UNECE, OECD, Antarctic Treaty Nations, ESCAP, UNEP, ADB, World Bank, WHO, IAIA. National organizations –MoEF, NABET, NGT. |EIA notifications and regulations in India

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Recognize the importance of bibliographic types (Understand)

MO 2: Distinguish various indices in documenting research impact (Apply)

MO 3: Recognize the importance of research ethics and issues with plagiarism (Understand)

MO 4: Distinguish the principles in research project formulation (Apply)

MO 5: Develop skills in writing a research project (Remember)

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Classroom Activities:

- Assignments
- Seminar Presentation on selected topics
- Case studies
- Problem solving
- Analyses of research papers and reports

LEARNING RESOURCES

References

Abaza, H., R. Bisset and B. Sadler, 2004. Environmental Impact Assessment and Strategic Environmental Assessment: Towards an Integrated Approach. UNEP, 147pp.

Anjaneyulu, Y. And V. Manickam, 2007. Environmental Impact Assessment Methodologies (2 Ed.), BS Publications, Hyderabad, 428pp.

Anon, 2005. Handbook of Environmental Chemistry (Vol.5; Part F. Vol.2), Springer-Verlag. Berlin, 273pp.

Craik, N., 2008. The International Law of Environmental Impact Assessment: Process, Substance and Integration. Cambridge University Press, UK, 332pp.

Eccleston, C.H., 2011. Environmental Impact Assessment: A guide to best professional practices. CRC Press (Taylor & Francis Group), Boca Raton., 262pp.

Gilpin, A., 1995. Environmental Impact Assessment (EIA): Cutting Edge for the Twenty-first Century. Cambridge University Press, Cambridge (UK), 182pp.

Glasson, J., R. Therivel and A. Chadwick, 1999. Introduction to Environmental Impact Assessment (2 Ed.), (The Natural and Built Environment Series), UCL Press (Taylor & Francis Group), London, 448pp.

Glasson, J., R. Therivel and A. Chadwick, 2005. Introduction to Environmental Impact Assessment (3 Ed.), (The Natural and Built Environment Series), Routledge (Taylor & Francis Group), London, 448pp.

Glasson, J., R. Therivel and A. Chadwick, 2012. Introduction to Environmental Impact Assessment (4 Ed.), (The Natural and Built Environment Series), Routledge (Taylor & Francis Group), London, 392pp.

Lawrence, D.P., 2003. Environmental Impact Assessment: Practical solutions to recurrent problems. Wiley-Interscience Publication, New Jersey, 562pp.

Morris, P. And R. Therivel (Eds.), 2001. Methods of Environmental Impact Assessment (2 Ed.), (The Natural and Built Environment Series), Spon Press (Taylor & Francis Group), London, 492pp.

Morris, P. And R. Therivel (Eds.), 2009. Methods of Environmental Impact Assessment (3 Ed.), (The Natural and Built Environment Series), Routledge (Taylor & Francis Group), London, 560pp.

ODPM, 2000. Environmental Impact Assessment: A guide to procedures. Thomas Telford Publications, London, 114pp.

Schmidt, M., J. Glasson, L. Emmelin and H. Helbron (Eds.), 2008. Standards and Thresholds for Impact Assessment (Vol.3). Springer-Verlag, Heidelberg, 493pp.

Wathern, P. (Ed.), 1988. Environmental Impact Assessment: Theory and Practice. Routledge (Taylor & Francis Group), London, 332pp.

On-line Sources

http://www.fao.org

https://en.wikipedia.org

https://www.biologydiscussion.com

https://www.cbd.int/

https://www.cseindia.org/

https://www.dhigroup.com

https://www.drishtiias.com/

https://www.iisd.org

https://www.sciencedirect.com

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).

60% End-semester/Summative Assessment: 3 hour written Exam.

SEMESTER II	Course Code: AAQ-CC-521	Credits: 2
NAME OF THE COURSE: **LIVE FEED TECHNOLOGY**		

COURSE OUTCOMES (CO)

CO 1: Understand the importance of live feeds in mass production of fish seeds

CO 2: Understand the important live feeds used in aquaculture industry

CO 3: Learn the methodology for isolation and mass culture of live feeds

CO 4: Learn the methodology for maintaining axenic cultures of live feeds

CO 5: Learn the methodology for out-door culture of live feeds

CO 6: Understand the industrial uses of microalgae

Tagging course outcomes:

CO	CO Statement	PO/PSO	CL	KC
CO 1	R, U	1, 5	R, U	F, C
CO 2	R, U	1, 5	R, U	F, C
CO 3	U, Ap	5, 7	U, Ap	P
CO 4	U, Ap	5, 7	U, Ap	P
CO 5	U, Ap	5, 7	U, Ap	P
CO 6	Ap, E	5, 7, 8	Ap, E	F, P

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create, KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Module I: Algal culture techniques: Physical and chemical conditions required. Collection, identification and isolation of microalgae. Preparation of various culture media. Preparation and maintenance of stock microalgal culture. Out-door and indoor culture techniques

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: List out the requirement for various nutrients in algal culture media (Evaluate).

MO 2: Understand the role of temperature, light, aeration/mixing and pH in algal culture and use this information for standardizing mass culture technology (Apply)

MO 3: Recognise the principles collection, identification and isolation of microalgae and apply the knowledge in developing lab cultures (Evaluate)

MO 4: Understand the principles of stock culture preparation and apply the knowledge in preserving stock cultures in the laboratory (Understand)

MO 5: Apply the knowledge in designing indoor and outdoor algal culture units (Apply)

MO 6: Apply the knowledge in operating indoor and outdoor algal culture units on a time bound manner (Apply)

Module II: Algae in larval nutrition and their replacements: Quantification of Algal biomass. Harvesting and preservation cultured algae. Nutritional quality of commonly used fish food organisms, bio-enrichment of fish food organisms. Biofilm/periphyton and its use, culture of single cell proteins and their nutritional quality. Formulation and preparation of artificial feeds for larval rearing, microparticulate diets, particulate and microencapsulated diets. Cost of algal culture.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Estimate biomass in algal culture and harvest them for utilization in larval rearing tanks at predetermined concentration (Evaluate)

MO 2: Understand the nutritional quality and deficiencies of various cultured algae and device suitable bio-enrichment protocols ((Understand)

MO 3: Understand the principles behind the development of biofilm/periphyton (Understand)

MO 4: Understand the concept of single cell protein and apply them in fish culture (Understand)

MO 5: Preparation of alternative diets for larval culture in case of non-availability of microalgae (Apply)

MO 6: Estimation of cost of algal culture in commercial hatcheries (Evaluate)

Module III: Rotifer Culture- Morphology, biology and life history. Strains. General Culture conditions for freshwater and marine rotifers. Culture techniques. Enrichment.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Understand the life history and biology of rotifers and apply the same in maintaining mass cultures (Understand)

MO 2: Understand the strains of rotifers and apply it to the best use in seed production activities (Understand)

MO 3: Carry out mass culture of marine and freshwater rotifers for use in hatcheries (Apply)

MO 4: Carry out enrichment of rotifers for Vit C, HUFAs, Protein, etc. for the benefit of aquaculture (Apply)

Module IV: Utilization of Artemia in Aquaculture-Biology and Ecology of Artemia. Cyst Production. Biology of cyst. Hatching of cyst- decapsulation, harvesting. Nutritional quality of nauplii - enrichment for nutrients and disease control. On growing techniques for Artemia

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Understand biology and ecology of Artemia and utilization of information for cyst production (Understand)

MO 2: Assess commercial techniques for artemia cyst production and their preservation and packing (Evaluate)

MO 3: Understand the biology of cyst and apply them for hatching of cysts (Understand)

MO 4: Perform decapsulation technique for cysts and uses of decapsulated cysts (Apply)

MO 5: Assess nutritional quality of artemia nauplii, deficient nutrients and enrichment strategies (Apply)

Module V: Copepod Culture- Collection of wild zooplankton: Techniques. Zooplankton Nets. Grading. Transport and storage. Life cycle. Biometrics. Nutritional Quality. Mass Culture Techniques. Calanoids and Harpacticoida. Mesocosm Systems.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Gain expertise on the wild collection of zooplankton for larval feeding (Remember)

MO 2: Understand the biology and life cycle of copepods for designing mass culture techniques (Understand)

MO 3: Gain expertise on mass culture of calanoids/harpacticoids in fish hatcheries (Apply)

MO 4: Understand mesocosm systems used in mass culture of copepods for mass culture (Understand)

Module VI: Culture of cladocerans, Oligochaetes, Nematodes and Trochophore larvae- Daphnia and Moina- nutrition and mass production, uses.

Module Outcomes (MO)

MO 1: Understand the biology and life history of Daphnia and Moina and apply them in the mass culture of zooplankton (Understand)

MO 2: Manage the nutritional requirements of daphnia and moina during mass culture (Apply)

MO 3: Assess physico-chemical quality of water required for mass culture of zooplankton (Apply)

MO 4: Understand mass culture techniques for oligochaetes, nematodes and trochophore larvae (Understand)

MO 5: Assess nutritional quality of cultured zooplankton and their utilization in commercial hatcheries (Apply)

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Activities

- Assignments
- Seminar Presentation on selected topics
- Debates
- Quiz
- Demonstration of simple experiments
- Field work and survey

REFERENCES

Anderson RA (Ed.) (2005). Algal culturing techniques". Academic Press. 596p.

Anuraj A, J Raymond Jani Angel, Venkatesh R Thakur, , T Sivaramakrishnan, A K O Ratheesh, Arun Jyothi Baruah, Kirubasankar R and Dam Roy S (2015). Live food organisms in aquaculture. CIARI, Port Blair, p 23.

Holt G.J. (Ed) (2011). Larval Fish Nutrition. Wiley Blackwell. 435 p.

Josianne G. Støttrup and Lesley A. McEvoy. (Eds). (2003). Live Feeds in Marine Aquaculture. Blackwell Science. 337p.

Lavens P and Sorgeloos P (Eds.) (1996). Manual on the production and uses of live food for aquaculture. FAO Fisheries Technical Paper No. 361. Rome, FAO. 1996. 295 p.

Pronob Das, Sagar C. Mandal, S. K. Bhagabati, M. S. Akhtar and S. K. Singh. 2012. Frontiers in Aquaculture, Pages 69–86. Narendra Publishing House

Richmond, A. (Eds), 2004. Handbook of microalgal culture: Biotechnology and Applied Phycology. Blackwell Publishing, USA.

Perumal, S., Thirunavukkarasu, A.R. & Pachiappan, P. (Eds). 2015. Advances in marine Brackishwater Aquaculture, Springer, New Delhi.

Slocombe, S.P. & Benemann, J.R. (Eds)., 2017. Microalgal production for Biomass Production and High value products. CRC Press.

On-line Sources

http://eprints.cmfri.org.in/9713/1/G.Gopakumar.pdf
http://www.fao.org/3/x3980e/x3980e07.htm
https://shodhganga.inflibnet.ac.in/bitstream/10603/113205/8/08_chapter%203.pdf
https://www.aquaculturealliance.org/advocate/live-diets-for-larval-fish-shrimp-production-enrichment-feeding-strategies/
https://thefishsite.com/articles/phytoplankton-culture-for-aquaculture-feed
https://www.fau.edu/hboi/aquaculture/Livefeeds%20Pompano%20workshop%20ARC2013.pdf
http://ecoursesonline.iasri.res.in/course/view.php?id=440

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).
60% End-semester/Summative Assessment: 3 hour written Exam.

SEMESTER II	Course Code: AAQ-CC-522	Credits: 2
NAME OF THE COURSE: **ORNAMENTAL FISH CULTURE AND MANAGEMENT**		

COURSE OUTCOMES (CO)

CO 1: Fundamental information on ornamental fish industry

CO 2: Familiarity on diversity of ornamental fish and other species

CO 3: Comprehensive awareness on accessories used in aquarium industry

CO 4: Proficiency in culture and breeding of fresh and marine ornamental varieties

CO 5: Set up and maintain fresh and marine aquariums as hobby and commercial level

CO 6: Make a career in the field of ornamental industry as entrepreneur / manager / exporter

Tagging course outcomes:

CO	CO Statement	PO/PSO	CL	KC
CO 1	R, U	1	R, U	F, C
CO 2	R, U	1	R, U	F, C
CO 3	U, Ap	7	U, Ap	C, P
CO 4	U, Ap	3, 4, 5	U, Ap	P
CO 5	U, Ap	3, 5, 7	U, Ap	P
CO 6	Ap, Cr	3, 7	Ap, Cr	M

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create, KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Module I: Introduction to aquarium keeping and hobby, global and national scenario. Types of aquaria-Biotope aquarium. Vivarium, insectarium, terrarium, paludarium, oceanarium, dolphinarium. Reef aquarium. Nano aquariums.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Analyse the global production status of ornamental species (Apply)

MO 2: Identify different types of aquarium suitable for different sites (Understand)

Module II: Principles of setting up and maintenance of aquaria: Construction of fresh and marine aquarium. Aquarium accessories- aerators, filters, skimmers, chillers, lighting, decorates, etc. Latest trends in aquarium designs.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Identify suitable accessories for setting up of different types of aquaria (Understand)

MO 2: Perform fabrication of different types of filters (Apply)

MO 3: Fabricate fresh and marine aquarium (Perform)

MO 4: Creatively design aquarium suitable for different sites (Evaluate)

Module III: Diversity of ornamental fish and other species (fresh and marine). Sexual dimorphism. Feeding and nutrition. Breeding of ornamental fishes (One each for live bearer and egg layer). Live feed culture. Formulated feeds. Preparation of aquarium fish food. Colour enhancement techniques. Aquatic plants.

Module Outcomes (MO):

After completion of this module, the student should be able to:

MO 1: Identify indigenous and exotic ornamental species (Understand)

MO 2: Breed ornamental species (Apply)

MO 3: prepare quality formulated diets for different types of ornamental species (Perform)

MO 4: Grow and breed ornamental plants (Apply)

Module IV: Water quality management, packaging, transportation and marketing of aquarium fishes. Anaesthetics used in the trade. Problems in ornamental fish export. Preparation of artificial seawater. Common diseases and parasites of ornamental fish. Health management of aquarium fishes.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Conduct water quality parameters required for different ornamental species (Evaluate)

MO 2: Perform live transportation of different ornamental species (Perform)

MO 3: Use anaesthetics in ornamental industry for transportation/breeding/procedure (Apply)

MO 4: Identify common fish diseases (Understand)

Module V: Genetic improvement in ornamental fishes. Genetic manipulation and production of new strains; hybrids. Pedigree maintenance. Ornamental fishes as a biotechnological tool. Green certification. Case study: Zebra Fish

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Appreciate the role of genetic improvement in the development of new varieties of ornamental fishes for the industry.

MO 2: Gain knowledge to carry out development of strains and breeds of ornamental fishes

MO 3: Appreciate the importance of pedigree maintenance in ornamental fish production and develop customized protocols for the same

MO 4: Appreciate the growing role of ornamental fishes as a biotechnological tool and gain capability to support global research needs

MO 5: Familiarize with the green certification protocols in ornamental fisheries sector.

Module VI: Ornamental Fish Trade: Global Imports and Exports - Size and scope. Trade of wild collected indigenous fishes. Trade of cultured ornamental fishes. Use of anesthetics. Handling, Packaging, Transportation and Marketing of Ornamental fishes. Threats from Trade- Exotic Fishes, Depletion of wild stocks. Regulations in ornamental fish trade in India.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Gain knowledge on the general status of ornamental fish trade of the world and critically understand the areas Indian industry is lagging behind (Evaluate)

MO 2: Appreciate the importance of stress in ornamental fish transportation and familiarize with common anesthetics and chemicals used for its management (Understand)

MO 3: Standardise practices in packing and transportation of ornamental fishes and apply the same in the industry (Apply)

MO 4: Appreciate the threats from exotic fishes used in aquaria and develop conservation protocols in line with national regulations for breeding facilities (Understand)

MO 5: Familiarize with the regulations governing the trade of ornamental fishes and apply the same in managing trade as an entrepreneur / consultant (Evluate)

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Activities

- Assignments
- Seminar Presentation on selected topics
- Debates
- Quiz
- Demonstration of simple experiments
- Field work and survey

LEARNING RESOURCES

References

Ahilan. B, Felix. N. & Jameson, J.D., 2009. Goldfish. Daya Publishing House, New Delhi. 87 pp.

Ahilan. B, Felix. N. & Santhanam. R., 2008. Text book of Aquariculture. Daya Publishing House, New Delhi. 157 pp.

Alappat, H.J. & A. Biju Kumar 1996. Aquarium Fishes (A Colourful Profile). B.R. Publ., Delhi, 106 pp.

Alderton, D., 2019. Encyclopedia of aquarium and pond fish. DK Publishers, UK. 400 pp.

Bailey M., & Sanford, G., 2017. Aquarium fish- a definitive guide to identify and keeping freshwater and marine fishes. Smithmark Publishers, USA. 256 pp.

Biju Kumar, A. &Alappat, H.J., 1996. A Complete Guide to Aquarium Keeping. Books for All, Delhi, 80 pp.

Dholakia, A.D., 2009. *Ornamental fish Culture & Aquarium Management.* Daya Publishing House, Delhi, 313 pp.

Favre, H., 1977. Dictionary of the Freshwater Aquarium. Wardlock Ltd., London, 160 pp.

Frey, H., 1961. Illustrated Dictionary of Tropical Fish. TFH. Publ. Inc., NJ, 768 pp.

Geck, J., 2010. Nano-aquarium: A Complete Pet Owners Manual. Barrons Educational Series, USA. 128 pp.

Goldstein, R.J., 2012. Betas: A Complete pet owners manual (2nd Ed). Barron's Educational Series Inc.USA. 112 pp.

Gopakumar G., 2011. *Marine Ornamental fish Culture: Package of Practices*. CMFRI Cochin. 100pp.

ICAR 2011. Handbook of Fisheries and Aquaculture. ICAR, New Delhi, 1116 pp.

Innes, W.T., 1953. Exotic Aquarium Fishes. Innes Publ. Co., Philadelphia, 533 pp.

Jennings, G., 2017. 500 Freshwater Aquarium fish: A visual reference to the most popular species. Firefly Books Ltd., USA. 528 pp.

Kurup, M.B,. 2008. Ornamental Fish Farming, Breeding and Trade. Dept. Fish., Govt. Kerala, 280 pp.

Meenakshi, J., N.K. Yadava & Gupta, R.K., 2010. *Freshwater Ornamental Fishes.* Mangalam Pubications, Delhi, 397 pp.

Mills, D., 1984. A Fish Keepers Guide to the Tropical Aquarium. Salamander Books, Ltd., London, 115 pp.

Mills, D., 1981. The Tropical Aquarium. Salamander Books Ltd., London.

Mills, D., 1987. The Practical Encyclopedia of the Marine Aquarium. Salamander Books Limited, London.

Petrovicky, I., 1988. Aquarium Fish of the World. Hamlyn Publ. Group Ltd., London, 499 pp.

Rataj, K. &Zukal, R., 1971. Aquarium Fishes and Plants. The Hamlyn Publ. Group Ltd., London.

Riddlei, P., 1947. The Aquarium. Innes Publ. Co., Phil., 365 pp.

Sanford, G. and Crow, R., 1991. *The Manual of Tank Busters*. Salamander Books

Santhanam, R., N. Sukumaran & Natarajan, P., 1984. A Manual of Freshwater Aquaculture. Oxford & IBH Publ. Co. Pvt. Ltd., New Delhi, 193 pp.

Singh, T., & Dey, V.K., 2003. Ornamental fish trade runs into billions, *Info fish Int.,* 5:54-60.

Smart, J., 2001. Goldfish varieties and genetics. Fishing News Books. USA 216 pp.

Talwar, P.K. &Jhingran, A.G., 1991. Inland Fishes of India and Adjacent Countries, Vols. I & II. Oxford & IBH Publ. Co., Pvt. Ltd., New Delhi, 1158 pp.

Thabrow De W.V., 1981. *Popular Aquarium Plants*. Thornbill Press.

Wabnitz, C., M. Taylor, E. Green & Raza, T., 2003. From Ocean to Aquarium: Global trade in Marine Ornamental Species. UNEP World Conservation Monitoring Centre, Cambridge, U.K., 64 pp.

Wilkie, D., 1971. Aquarium Fish. Pelham Books Ltd., London, 214 pp.

On-line Sources

http://ecoursesonline.iasri.res.in/course/view.php?id=297

http://www.cmfri.org.in/

http://www.fisheries.kerala.gov.in/index.php?option=com_content&view=article&id=110&Itemid=73

http://www.ofish.org/

http://www.practicalfishkeeping.co.uk/

https://ornamentalfish.org/

https://tal.ifas.ufl.edu/extension-and-outreach/extension-publications/

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).

60% End-semester/Summative Assessment: 3 hour written Exam.

SEMESTER II	Course Code: AAQ-CC-523	Credits: 4
NAME OF THE COURSE: **FRESHWATER AQUACULTURE**		

COURSE OUTCOMES (CO)

CO 1: Familiarize with the seed production and culture technology for commercially important freshwater aquatic organisms

CO 2: Comprehensive awareness on sustainable farming techniques to perform responsibilities as entrepreneur / consultant / manager/ administrator/ extension worker

CO 3: Gain expertise in emerging technologies and practices in the sector so as to provide consultancy to farmer and improve the existing practices in farms

CO 4: Prepare bankable freshwater aquaculture project complying the existing regulations

Tagging course outcomes:

CO	CO Statement	PO/PSO	CL	KC
CO 1	R, U	1, 5	R, U	C, P
CO 2	An, Cr	2, 3, 7	An, Cr	M
CO 3	Ap, E	2, 3, 7	Ap, E	M
CO 4	Ap, An	2, 3, 7	Ap, An	C, P

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create,

KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Module I: Seed production and culture of carps: Indian Major Carps, Common carp and Chinese carps. Bundh Breeding, Hypophysation. Synthetic hormones for induced breeding. Broodstock maintenance, Spawning in breeding hapas, stripped spawning, Jar Hatchery, Eco hatchery, Larval and nursery rearing. Pond culture strategies. Site selection, Pond preparation, Grow-out culture, Nutrition, Harvesting. Polyculture. Composite fish culture. Production and economics.

Module Outcomes (MO)

MO 1: Gain expertise on seed production of carps and provide consultancy for farmers (Apply)

MO 2: Carry out induced breeding of carps using synthetic hormones (Apply)

MO 3: Familiarize with different hatchery systems used in carp seed production (Evaluate)

MO 4: Appreciate the advantages of composite fish culture of carps to utilize different ecological niches (Understand)

Module II: Catfish breeding and culture: *Clariasdussumieri*, *Heteropneustesfossilis*, *Pangasius pangasius*, *Wallago attu*, *Ompok* spp., *Mystus* spp. and *Horabagrus* spp. Problems faced due to exotic catfishes (African catfish and Sucker catfish).

Module Outcomes (MO)

MO 1: Gain expertise on the seed production of catfishes and provide consultancy to farmer (Apply)

MO 2: Familiarize with the grow-out techniques for indigenous catfishes and provide consultancy to farmers (Evaluate)

MO 3: Familiarize with the challenges faced due to exotic catfishes in country (Understand)

MO 4: Appreciate the demand for indigenous catfishes and implement mass production strategies to increase supply (Understand)

Module III: Seed production and culture of cichlids and Anabas: Tilapia- *Oreochromis mossambicus*, GIFT, Chitralada, MST. *Etroplussuratensis*, *Anabas testudineus*.

Module Outcomes (MO)

MO 1: Familiarize with the regulations and culture methods relating to GIFT and guide farmers to achieve better production (Apply)

MO 2: Familiarize with the varieties of tilapia seeds available in the market along with their culture specifications for the benefit of farmers (Evaluate)

MO 3: Gain expertise on the culture of *Etroplus suratensis* in freshwaters and provide consultancy to farmers in setting up freshwater seed production and culture units (Apply)

MO 4: Appreciate the advantages of Thi Koi and provide consultancy for farming the species (Apply)

Module IV: Freshwater Prawns- *Macrobrachium rosenbergii* and *M. malcomsonii*: reproductive biology, broodstock maintenance, maturation, mating, berried prawns, larval rearing and nutrition, hatchery set up and nursery rearing. Grow out techniques- water quality requirements, territorial habits, male social dominance hierarchy, cannibalism, health management.

Module Outcomes (MO)

MO 1: Familiarize with the reproductive biology of freshwater prawns to provide consultancy to farmers and hatchery owners (Apply)

MO 2: Gain expertise in the farming techniques for freshwater prawns so as to maximise growth and survival (Understand)

MO 3: Prepare bankable projects for establishing hatchery and grow-out units for freshwater prawns (Evaluate)

MO 4: Appreciate the problems and risks in undertaking the seed production and culture of freshwater prawns and advice the farmers accordingly (Evaluate)

Module V: Farming in open water systems: Reservoirs- stock enhancement, species enhancement, environmental enhancement, cage and pen culture, impact of exotic fishes in reservoirs, Impact of fish stocking in reservoirs. Cold water fish farming: exotic trouts and indigenous fishes. Leasing policy for open water systems.

Module Outcomes (MO)

MO 1: Appreciate the potential of fish farming in reservoirs and undertake fish farming activities (Apply)

MO 2: Familiarize with the problems associated with exotic fishes in reservoirs (Understand)

MO 3: Gain expertise in cage and pen culture in open waters to initiate entrepreneurial ventures and provide consultancy to farmers (Apply)

MO 4: Familiarize with the seed production of coldwater fishes and recognise the potential for the development of sport fisheries in the country (Evaluate)

Module VI: Integrated fish farming: Paddy-cum- fish culture, cattle-fish system, pig-fish system, poultry-fish system, duck-fish system. Wastewater aquaculture: treatment of raw sewage, wastewater fed aquaculture system, public health and wastewater aquaculture.

Module Outcomes (MO)

MO 1: Appreciate the potential of integrated aquaculture systems in ensuring sustainability of operations and promote multi-level integrations (Evaluate)

MO 2: Familiarize with the breeds and varieties of farmed animals, birds and plants that can be integrated with fish culture (Understand)

MO 3: Familiarize with the sewage treatment methods for reduction of solid waste and organic content for utilization in aquaculture ponds (Apply)

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Activities

- Assignments
- Seminar Presentation on selected topics
- Debates
- Quiz
- Demonstration of simple experiments
- Field work and survey

LEARNING RESOURCES

References

Agrarwal, S.C. 2007. A Handbook of Fish Farming. Narendra Publ. Hse., New Delhi, 133 pp.

Badapanda, K.C. 2012. Aquaculture Vol.1 . Narendra Publishing House, Delhi, 496pp.

Bardach, J.E. J.H. Rhyther& W.O. McLarney 1972. Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms. Wiley Intersci., NY, 868 pp.

Billard, R. 1990. Carp Biology and Culture. Springer, NY, 342 pp.

Chakravarthy, N.A. 1998. Biology, Culture and Production of Indian Major Carps. A Review. Narendra Publ. Hse., New Delhi, 175 pp.

Chakravarthy, N.M. 2006. Murrels and Murrel Culture. Narendra Publ. Hse., New Delhi, 112 pp.

Christenson, K. 2019. Aquaculture- Introduction to Aquaculture for small farmers (3rd Ed). CreateSpace Independent Publishing Platform, USA, 104 pp.

Das, A.K., K.K. Vass, N.P. Shrivastava, P.K. Katiha. 2009. Cage Culture in Reservoirs in India. (A Handbook) WorldFish Center Technical Manual No. 1948. The WorldFish Center, Penang, Malaysia, 24 pp.

Davison, A. 2019. Recirculating aquaculture systems- a guide to farm design and operations. Independently Published, 255 pp.

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

Dube, S.K. 2010. Fish Farming. Wisdom Press, New Delhi, 330pp.

Felix, S. 2007. Aquaculture Management Techniques. Narendra Publ. Hse., New Delhi, 166 pp.

Ghosh, P.K. 2006. Agro'sDicrionary of Aquaculture. Agrobios, India, 406.pp.

Halver, J.E. & R.W. Hardy 2002. Fish Nutrition. 3rd ed. Acad. Press, London, 824 pp.

Halver, J.E. 1972. Fish Nutrition, Acad. Press, NY, 713 pp.

Hoff, F.H. and Snell, T.W. 2007. Plankton culture manual (6th Ed.). Florida Aqua Farms, USA, 183 pp.

Huet, M. 1986. Textbook of Fish culture. Breeding and Cultivation of Fish. 2nd ed. Fishing News Books, Oxford, 437 pp.

Hussain, S.M. 2002. Encyclopedia of Fish Culture. Vol. 1. APH Publ. Co., New Delhi, 528 pp.

ICAR 2011. Handbook of Fisheries and Aquaculture. ICAR, New Delhi, 1116 pp.

Inito, M. & S. Sarig 1989. Fish Culture in Warm Water Systems: Problems and Trends. CRC Press Inc., Florida, 259 pp.

Jhingran, V.G. & R.S.V. Pullin 1985. A Hatchery Manual for the Common, Chinese and Indian Major Carps. Asian Development Bank, Manila and ICLARM, Manila.

Jhingran, V.G. 1983. Fish and Fisheries of India. Hindustan Publ. Corpn. (India), Delhi, 666 pp.

Jhingran, V.G. 1991. Fish and Fisheries of India. 3rd ed. Hindustan Publ. Corpn. (India), Delhi, 727 pp.

Joseph, M.M. 1990. Aquaculture in Asia. Asian Fish. Soc., Mangalore, 395 pp.

Khanna, D.R., R. Rajani, G. Matta. 2011. Ecology of Fish Pond. Daya Publishing House, New Delhi, 173pp.

Longsdon, G. 2016. Getting food from water- a guide to backyard aquaculture. Echo Point Books and Media, USA, 386 pp.

McLarney, W. 2013. Freshwater Aquaculture. Echo Point Books & Media, USA, 594 pp.

Meehan, W.E. 2002. Fish Culture in Ponds and Other Inland Waters. H.R. Publ. Hse., Piliani, 287 pp.

Midlen and TA Redding. 1998. Environmental Management for Aquaculture. Kluwer Publ.

Moe, M.A. 2009. Mine Aquarium handbook: Beginner to breeder. TFH Publications,USA, 352 pp.

New M.B. & W.C. Valenti 2000. Freshwater Prawn Culture: The Farming of Macrobrachiumrosenbergii. Blackwell Sci. Ltd. Oxford, UK, 443 pp.

New, M.B. & S. Singholka 1985. Freshwater Prawn Farming. A manual for the culture of *Macrobrachiumrosenbergii.* FAO Fisheries Technical Paper, 225 pp.

New, M.B. 1982. Giant Prawn Farming. Elsevier Sci. Publ. Co., NY, 532 pp.

Pandey, B.N., S. Deshpandey& P.N. Pandey. 2007. Aquaculture. APH Publ. Corpn., New Delhi, 236 pp.

Pillay, T.V.R. &Kutty, M.N. 2005. Aquaculture-Principles and Practices. 2nd ed. Blackwell Publ. Ltd., UK, 624 pp.

Raizada, S., Pravin, P., Kumar, A.T. & Jena J.K. (Eds.). ICAR Technologies- Breeding and Seed Production of Finfishes and shellfishes. 66 pp.

Smith, M. 2017. A beginner's guide to fish farming and pond construction. CreateSpace Independent Publishing Platform, USA, 42 pp.

Southern, A. And King, W. 2017. The Aquaponics Farmer- A complete guide to building and operating commercial aquaponic system. New society Publishers, Canada, 304 pp.

Stickney, R.R. 2000. Encyclopedia of Aquaculture. John Wiley & Sons, Inc., Canada, 1063pp.

Trushenski, J. 2019. Understanding Aquaculture. 5m Publishing, UK, 268 pp.

Welcomme R.L. 2001. Inland Fisheries: Ecology and Management. Fishing News Books.

Wheaton, F.W. 1977. Aquaculture Engineering. Wiley Interscience, New York, 708 pp.

Journals

Journal of Fish Biology

Aquaculture

Aquaculture Research

On-line Sources

http://www.fisheries.kerala.gov.in/kavil

https://kerala.gov.in/adak

http://www.fao.org/tempref/FI/CDrom/bobp/cd1/Bobp/Publns/MAG/013.pdf

http://www.fao.org/3/x5625e09.htm

http://cifa.nic.in/

http://www.cifri.res.in/

https://tal.ifas.ufl.edu/extension-and-outreach/extension-publications/

http://www.practicalfishkeeping.co.uk/

http://ecoursesonline.iasri.res.in/course/view.php?id=297

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations)- Record, field work reports, Viva

60% End-semester/Summative Assessment: 3 hour Practical Exam

SEMESTER II	Course Code: AAQ-CC-524	Credits: 4
NAME OF THE COURSE: **COASTAL AQUACULTURE AND MARICULTURE**		

COURSE OUTCOMES (CO)

CO 1: Understand and seed production and grow out technology for cultured brackishwater and marine organisms

CO 2: Design Commercial Hatcheries/ Work as Hatchery Manager or Supervisor/ Provide Consultancy Services to the Seed Production Sector

CO 3: Design and operate grow-out culture units (tanks, ponds, pens, cages, etc.) / provide consultancy services to the farmers

CO 4: Develop bankable projects for commercial seed production and grow-out of cultured brackishwater and marine organisms

CO 5: Develop research projects on development of strategies for seed production and grow out of cultured brackishwater and marine organisms

Tagging course outcomes:

CO	CO Statement	PO/PSO	CL	KC
CO 1	R, U	4, 5	R, U	C, P
CO 2	Ap, Cr	2, 3, 5, 7	An, Cr	M
CO 3	Ap, Cr	2, 3, 4, 7	Ap, Cr	M
CO 4	Ap, An	2, 3, 7	Ap, An	C, P
CO 5	An, E	7, 8	An, E	M

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create,

KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Module I: Overview of coastal aquaculture and mariculture- global and Indian perspective; scope, potential and emerging trends. Farming systems: Traditional- Pokkali, Basabadha; extensive, modified extensive, semi intensive and intensive. Principles of coastal aquaculture and mariculture. Aquaranching. Site selection for marine and brackishwater hatcheries and farms. Water: Source, Salinity, Physico-chemical properties. Flow-through and Recirculation systems. Brood stock management. Water treatment, Pumps, Aeration.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Gain an overview of site requirements for hatcheries and farms in the sector and apply the same for the development of commercial units (Apply)

MO 2: Assess the quality and quantity of local water sources and plan the supply of water for aquaculture operations (Evaluate)

MO 3: Set up both flow through and RAS systems of hatchery depending on water availability and requirement of the species (Apply)

MO 4: Understand the nutritional requirements of brood stock and ensure supply of broodstock feeds during operation (Evaluate)

MO 5: Estimate the requirements for the capacity of water treatment systems, pumps and aerators for safe operation of the hatchery (Apply)

Module II: Shrimp farming: Candidate Species (*Penaeus monodon*, *Litopenaeusvannamei*and *Fenneropenaeus indicus*). History of shrimp aquaculture in the Asian and South American countries. Shrimp Hatchery Technology: Reproductive Biology. Mating. Collection and rearing of broodstock. Eyestalk ablation. Spawning. Larval stages. Larval Nutrition. Health management. Packing and Transportation. Essential live feed technology. Grow-out technology. Emerging intensive shrimp farming technologies - biofloc.

Module Outcomes (MO)

MO 1: Understand the seed production technology for Indian penaeid shrimps (*Penaeus monodon* and *Litopenaeus vannamei*) and provide consultancy for the same (Apply)

MO 2: Understand the grow-out technology for exotic shrimp aquaculture in India and provide consultancy to farmers (Apply)

MO 3: Familiarize with eyestalk ablation and other induced breeding techniques used in shrimps apply them in hatchery operation (Evaluate)

MO 4: Understand the intensive grow-out technologies for shrimps in India and provide consultancy services (Apply)

MO 5: Design a shrimp hatchery/ grow-out unit, supervise its construction and manage operations (Evaluate)

Module III: Seed production and culture of fin fishes: *Chanoschanos*, *Mugil cephalus*, *Etroplussuratensis, Trachinotusblochii*, *Lates calcarifer*, *Rachycentron canadum*, groupers. SEmerging species in Mariculture.

Module Outcomes (MO)

MO 1: Understand the breeding biology of culturable brackishwater fishes of India and gain the ability to develop seed production strategies (Understand)

MO 2: Understand the seed production and culture technologies for *Lates calcarifer* and gain proficiency in rearing the seeds, size grading and minimising cannibalism (Evaluate)

MO 3: Familiarize with the seeds of *Chanos chanos* and *Mugil cephalus* and assist farmers in sourcing the seeds and rearing them in nursery and grow-out ponds (Apply)

MO 4: Understand the biology, seed production and farming technology of the state fish *Etroplus suratensis*and provide consultancy services establishing commercial units (Apply)

MO 5: Design and operate brackishwater fish farms as entrepreneur or manager (Apply)

Module IV: Seed production/collection of Mud crab, lobsters, clams, mussels, oysters, cephalopods and their grow out culture. Seed production of sea cucumbers.

Module Outcomes (MO)

MO 1: Understand various grow-out strategies for mud crabs and fulfill roles of entrepreneur or consultant (Understand)

MO 2: Understand the feeding biology seed production and grow-out technologies for different Indian lobsters (Remember)

MO 3: Understand the strategies for the wild collection of seeds and culture of bivalves in Indian waters and provide consultancy to farmers (Evaluate)

MO 4: Understand the production of natural and artificial pearls in oysters (Understand)

Module V: Design of hatcheries: Shrimp hatchery; Fin fish hatchery; Case studies. Bankable project preparation for commercial seed production of cultured species. Mariculture techniques and technological advancements- Cages, Pens, OSF. Feed Management. Pollution. Seaweed Culture.

Module Outcomes (MO)

MO 1: Assess the demand for shrimp seeds in the locality and design a commercial hatchery based on the numbers (Understand)

MO 2: Design broodstock rearing facility for fin fishes based on water availability (Evaluate)

MO 3: Interact with fish farmers, document their practices and provide clarifications and scientific suggestions for improvement (Evaluate)

MO 4: Prepare bankable projects for farmers and agencies complying with existing regulations (Apply)

MO 5: Understand the impacts of brackishwater aquaculture and mariculture on ecosystems and its management (Understand)

MO 6: Identify potentially culturable seaweeds, and mass culture them for extraction of useful products (Apply)

Module VI: Regulations governing seed production and grow-out of marine and brackishwater organisms in India. Seed Act. Coastal Aquaculture Authority. Regulations for Shrimp/ fish hatcheries. Sustainable aquaculture. FAO CCRF. Government schemes for the promotion of brackish water and marine fish seed production and aquaculture.

Module Outcomes (MO)

MO 1: Understand legislations governing coastal aquaculture and mariculture in India and participate in policy formulation (Understand)

MO 2: Understand the organisation, functioning and responsibilities of coastal aquaculture authority (Understand)

MO 3: Understand the principles of sustainable aquaculture and the recommendations of CCRF (Evaluate)

MO 4: Role of government agencies (CIBA, CMFRI and MPEDA) in promotion of aquaculture (Evaluate)

MO 5: Understand regulations governing coastal aquaculture activities in Kerala (Understand)

MO 6: Assess regulations governing the culture of exotic aquatic organisms in India (Understand)

MO 7: Provide consultancy services to ensure that their projects are in compliance to existing regulations (For farmers and funding agencies) (Apply)

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Activities

- Assignments
- Seminar Presentation on selected topics
- Debates
- Quiz
- Demonstration of simple experiments
- Field work and survey

LEARNING RESOURCES

REFERENCES

Bardach, J.E. J.H. Rhyther and W.O. McLarney 1972. Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms. Wiley Intersci., NY, 868 pp.

Biswas, K.P. 2011. *Marine Prawns & Shrimps*. Daya Publishing House, Delhi, 329pp.

Bensam, P. and P. Vasudeva. 1993. *Hand Book on Aquafarming: Seafishes Oceanic Cage culture.* Manual. MPEDA, Cochin, Kerala.

Felix, S. 2009. *Advances in shrimp Aquaculture Management*. Daya Publishing House, Delhi, 192pp.

Ghosh, P.K. 2006. Agro's Dictionary of Aquaculture. Agrobios (India), 406 pp.

Huet, M. 1972. Text book of fish culture: Breeding and cultivation of fish. Fishing News (Books) Ltd. Farnham, Surrey, U.K. 436 pp.

ICAR 2011. Handbook of Fisheries and Aquaculture. ICAR, New Delhi, 1116 pp.

Imai, T. 1977. Aquaculture in Shallow Seas. Oxford & IBH Publ. Co., New Delhi, 651 pp.

Jhingran, V.G. 1983. Fish and Fisheries of India. Hindustan Publ. Corpn. (India), Delhi, 666 pp.

Kaliaperumal, N and D.B. James. 1993. Handbook on Aquafarming. Seaweed, Sea Urchin, Sea Cucumber. MPEDA, Cochin.

Karunasagar, I., I. Karunasagar&A.Reilly 1999. Aquaculture and Biotechnology. Oxford & IBH Publ. Co. Pvt. Ltd., New Delhi, 186 pp.

MBAI, 1982. Proceedings of the Symposium on coastal Aquaculture. Part 1. Prawn Culture. Marine Biological Association of India, 425 pp.

McVey, J.P. 1993. CRC Handbook of Mariculture. Vol. 1: Crustacean Aquaculture. CRC Press, Boca Raton, 526 pp.

New M.B. & W.C. Valenti 2000. Freshwater Prawn Culture: The Farming of *Macrobrachiumrosenbergii*. Blackwell Sci. Ltd. Oxford, UK, 443 pp.

Philipose, KK, L. Jayasree, S.R. Krupesha and D. Damodaran eds. 2012. *Handbook on Opensea Cage Culture.* Central Marine Fisheries Research Institute, Karwar, 143pp.

Pillai, N.G.K. 2011. *Marine Fisheries & Mariculture in India*. Narendra Publishing House, Delhi, 352pp.

Pillay, T.V.R. & M.N. Kutty 2005. Aquaculture: Principles and Practices. Blackwell Publ. Ltd., Oxford, UK, 624 pp.

Purdom& Colin. 2009. *Genetics & Fish Breeding*. Chapmann& Hall Ltd., London 277pp.

Radhakrishnan, E.V. 2011. *Handbook of Prawns*. CMFRI, Cochin. 125pp.

Rao, G Syda and Imelda, Joseph and Philippose, K K and Mojjada, Suresh Kumar. 2013. *Cage Aquaculture in India.*Central Marine Fisheries Research Institute, Kochi.

Shagufta. 2012. *Fisheries Aquaculture & Biotechnology*. APH Publishing Corporation. New Delhi, 259pp.

Stickney, R. R. 1979. Principles of warmwater aquaculture. John Wiley & Sons, New York, Wiley Interscience, 376 pp.

Wheaton, F.W. 1977. Aquaculture Engineering. Wiley Interscience, New York, 708 pp.

Journals

Aquaculture

Aquaculture Research

Journal of World Aquaculture Society

Aquaculture International

Progressive Fish Culturist

Journal of Applied Aquaculture

Aquaculture and Fisheries Management

Aquaculture Economics and Management

Israeli Journal of Aquaculture – bamidgeh

Aquaculture Engineering

Journal of Aquaculture in the Tropics

Journal of Asian Fisheries Society

On-line Sources

http://www.fisheries.kerala.gov.in/kavil

https://kerala.gov.in/adak

http://www.practicalfishkeeping.co.uk/

http://ecoursesonline.iasri.res.in

http://www.cmfri.org.in/

http://www.rgca.org.in/

http://www.seafdec.org

https://enaca.org/

www.ciba.res.in

www.fao.org

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations)- Record, field work reports, Viva

60% End-semester/Summative Assessment: 3 hour Practical Exam

SEMESTER II	Course Code: AAQ-CC-525	Credits: 3
NAME OF THE COURSE: **PRACTICAL 2: AQUACULTURE**		

COURSE OUTCOMES (CO)

CO1: Demonstrate practical knowledge in identification of culturable aquatic organisms and their seeds, aquatic weeds and plants and pest and predators in culture systems

CO2: Demonstrate the ability to assess carrying capacity of culture systems and stocking density, pond management, stocking of fish, feed formulation, feed quality

CO3: Develop skills from visits to Hatcheries, Aquaculture systems and preparation of field reports

CO4: Develop skills in aquarium fabrication, maintenance and management

CO5: Develop expertise in inducing fish to breed, artificial propagation, cultivation of live feed organisms

Tagging course outcomes:

CO	CO Statement	PO/PSO	CL	KC
CO 1	R, U	4, 5	R, U	P
CO 2	Ap, E	1, 4, 5	Ap, E	P
CO 3	An, E	4, 5, 7	An, E	P
CO 4	Ap	7	Ap	P
CO 5	Ap, E	4, 7, 8	Ap, E	P

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create, KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Live feed Technology

Culture of live feed organisms

Preparation of various culture

media for Algal Culture

Indoor and Outdoor Algal Culture techniques

Rotifer culture

Artemia culture: Hatching of cyst, decapsulation, harvesting

Nutritional enrichment of live feeds

Aquarium Keeping and Ornamental Fish Rearing

Aquarium accessories-familiarization

Aquarium fabrication

Identification of common ornamental fishes and ornamental aquarium plants

Live feed culture and formulation of feed for ornamental fishes

Identification of common ornamental fishes and ornamental aquarium plants

Aquaculture

Identification of carp brooders

Induced breeding and hypophysation

Brood stock maintenance of shrimps

Lime and fertilizer requirement calculations

Biosecurity measures in aquaculture farms

Identification of aquatic weeds, pests and predators

Water quality management in Aquaculture

Field visit to "ChemmeenKettu"

Field visit to freshwater and brackish water farms

Field visit to shrimp hatchery and farm

Field visit to food/ornamental fish hatchery and farm

Calculating carrying capacity of pond and stocking density

Proximate composition of feed ingredients

LEARNING RESOURCES

References

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

Goulding, I.C, 2016. Manual on Assuring the Food Safety of Aquaculture Products. CRFM SpecialPublication. No.10. 15pp.

Halver, J.E. & R.W. Hardy 2002. Fish Nutrition. 3rd ed. Acad. Press, London, 824 pp.

ICAR 2011. Handbook of Fisheries and Aquaculture. ICAR, New Delhi, 1116 pp.

Jhingran, V.G. & R.S.V. Pullin 1985. A Hatchery Manual for the Common, Chinese and Indian Major Carps. Asian Development Bank, Manila and ICLARM, Manila.

Jhingran, V.G. 1991. Fish and Fisheries of India. 3rd ed. HindustanPubl. Corpn. (India), Delhi, 727 pp.

Pillay, T.V.R. & M.N. Kutty 2005. Aquaculture: Principles and Practices. Blackwell Publ. Ltd., Oxford, UK, 624 pp.

Stickney R.R. 2000. Encyclopedia of Aquaculture. John Wiley & Sons, New York.

On-line Sources

http://www.ciba.org.in

http://www.cmfri.org.in/ebooks

http://www.fao.org/3/a-az083e.pdf

https://www.oie.int/doc/ged/D9568.PDF

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations)- Record, field work reports, Viva

60% End-semester/Summative Assessment: 3 hour Practical Exam

SEMESTER II	Course Code: AAQ-DE-526	Credits: 2
NAME OF THE COURSE: **POST-HARVEST TECHNOLOGY**		

COURSE OUTCOMES (CO):

CO 1: Understand the nutritional value of fish and incorporate sufficient quantities of fish in everyday diet.

CO 2: Understand the advantages of fish as a source of dietary protein and the need for its preservation

CO 3: Understand the biochemistry of fish spoilage and methods for extending shelf life

CO 4: Understand icing and refrigeration preservation of fish and apply them in preservation of fish at home

CO 5: Understand the quality of fish products available in the market

CO 6: Understand the quality issues encountered in Indian fish market.

Tagging course outcomes:

CO	CO Statement	PO/PSO	CL	KC
CO 1	U, Ap	1, 7, 8	U, Ap	F, C
CO 2	U, Ap	7, 8	U, Ap	F, C
CO 3	U	1	U	C, P
CO 4	U, Ap	4, 7, 8	U, Ap	C, P
CO 5	U, E	4, 6	U, E	C
CO 6	U, E	4, 6	U, E	C, P

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create, KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Module I: Proximate Composition of Fish and Shellfish- Role of fish in human nutrition. Superiority over other meat products. Proteins: Myofibrillar proteins. Lipids: Unsaturated fatty acids; Vitamins: Fat soluble and water soluble vitamins; Minerals.

Module Outcomes (MO)

MO 1: Understand the nutritional content of different aquatic organisms and include them in human diet.

MO 2: Understand the proximate composition of fish.

MO 3: Understand the concentration of different types of proteins in fish muscle

MO 4: Understand the importance of fish as a source of poly unsaturated fatty acids (PUFA)

Module II: Post-mortem changes in fish- Rigor mortis. Saccharolysis and Nucleotidolysis. Autolysis. Bacterial Putrefaction. Autoxidation.

Module Outcomes (MO)

MO 1: Understand rigor mortis and its impacts on keeping quality of fish (Understand)

MO 2: Understand the importance of saccharolysis in muscle stiffening of fish muscle during rigor mortis (Understand)

MO 3: Understand ATP degradation in fish and its impact on freshness of fish (Evaluate)

MO 4: Understand the impact of autolytic enzymes in the spoilage of fish and its impacts on quality (Evaluate)

MO 5: Understand the importance of bacterial putrefaction of fish and its preventive measures (Understand)

MO 6: Understand the spoilage of fish lipids on storage and its impacts on quality (Understand)

Module III: Preservation of Freshness: Icing: Quality of ice, Methods of Icing, Shelf life of iced fish, safety of iced fish. Refrigerated fish: Methods, shelf life and safety. Frozen fish: Method, storage, shelf life and safety.

Module Outcomes (MO)

MO 1: Understand why freshness of fish should be preserved and common methods used (Understand)

MO 2: Understand use of ice as common method of fish preservation and shelf life of fish on ice (Evaluate)

MO 3: Importance of quality, type and quantity of ice needed for fish preservation and apply the knowledge in solving fish preservation problems at home (Evaluate)

MO 4: Understand how fish is to be refrigerated and apply it in everyday life (Apply)

MO 5: Understand the safety of freezing preservation of fish and its quality issues (Understand)

Module IV: Quality Assurance- Introduction to preserved fish products in the market and their safety. Adulteration in Fish Preservation: Use of sand. Use of Ammonia and Formalin. Antibiotic Residues. Certification.

Module Outcomes (MO)

MO 1: To familiarize with dried, salted, smoked and canned fishery products and use them safely (Understand)

MO 2: Familiarize with pickled, breaded and battered and mince-based products and use them safely (Understand)

MO 3: Familiarize with common adulterations in fish preservation and use the knowledge in selecting fish in the market (Evaluate)

MO 4: Understand the risk from residues of antibiotics and chemicals added in fish (Evaluate)

MO 5: Familiarize with quality certifications of fishery products and apply the knowledge in fish market (Apply)

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Activities

- Assignments
- Seminar Presentation on selected topics
- Debates
- Quiz
- Demonstration of simple experiments
- Field work and survey

LEARNING RESOURCES

REFERENCES

Balachandran, K.K. 2012. Post-harvest technology of fish and fishery products. Daya Publishing House, New Delhi, 440 pp.

Bremmer, H.A. 2002. Safety and Quality Issues in Fish Processing. Woodhead Publ. Ltd., England, 507 pp.

Gopakumar, K. 2002. Textbook of Fish Processing Technology. Indian Council of Agricultural Research, New Delhi, 491 pp.

Hall, G.M.1992. Fish Processing Technology. Chapman & Hall India, Madras, India, 309 pp.

ICAR 2006. Handbook of Fisheries and Aquaculture. Directorate of Information and Publication of Agriculture, ICAR, New Delhi, 755 pp.

ICAR 2011. Handbook of Fisheries and Aquaculture. Directorate of Knowledge Management in Agriculture, ICAR, New Delhi, 1116 pp.

Khuntia, B.K. 2009. Post mortem changes in fish. Daya Publishing House, Delhi, 133 pp.

Long, A.C. 2008. Fish Processing Technology. Cybertech Publ., New Delhi, 312 pp.

Moorjani, M.N. 1984. Fish Processing in India. Publ. Infor. Div., ICAR, New Delhi, 82 pp.

Ninawe, A.S. & K. Rathnakumar 2008. Fish Processing Technology and Product Development. Narendra Publ. Hse, New Delhi, 562 pp.

Pearson, A.M. & T.R. Dutson 1999. HACCP in Meat, Poultry and Fish Processing. In, Advances in Meat Research Series, Vol.10. Aspen Publication, Maryland, 393 pp.

Sen, D.P. 2005. Advances in Fish Processing Technology. Allied Publ. Pvt. Ltd., New Delhi. 818 pp.

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).

60% End-semester/Summative Assessment: 3 hour written Exam.

SEMESTER II	Course Code: AAQ-DE-527	Credits: 2
NAME OF THE COURSE: **BIOSTATISTICS FOR AQUATIC SCIENCES**		

COURSE OUTCOMES (CO)

CO 1: Understanding and application of the biostatistical concepts and tools

CO 2: Acquaint with elementary statistical tools and techniques

CO 3: Develop capability to sample and data analysis using statistical tools

CO 4: Understand the concept of measures of central tendency and dispersion

CO 5: Use and application correlation and regression

CO 6: Enable to develop and test hypotheses

CO 7: Basic knowledge in biostatistical investigation and scientific methods

Tagging course outcomes:

CO	CO Statement	PO/PSO	CL	KC
CO 1	R, U	1	R, U	F, C
CO 2	R, U	1, 4, 5	R, U	F, C
CO 3	U, Ap	4, 5	U, Ap	C, P
CO 4	Ap, E	4, 5, 7	Ap, E	C, P
CO 5	Ap, E	4, 5, 7	Ap, E	C, P
CO 6	Ap, E	4, 5, 7	Ap, E	C, P
CO 7	E, Cr	8	E, Cr	M

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create, KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Module I: Elementary Biostatistics: Significance and statistical investigation. Data Collection, Organization, Presentation, Analysis and Interpretation. Data distribution – Normal, Poisson and Binomial distribution. Kurtosis and Skewness.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Recognize and recollect basic principles of Biostatistics (Understand)

MO 2: Distinguish census and sampling methods (Create)

MO 3: Analyse data for using basic statistical techniques (Apply)

MO 4: Develop essential skills in identifying data distribution (Apply)

MO 5: Develop overall idea on the concept and statistical research method (Analyse)

Module II: Measures of Central tendencies – Mean, Median, Mode Harmonic and Geometric mean – Problem solving in mean, median and mode. Measures of Dispersion – Range, mean deviation, standard deviation and quartile deviation, variance. Problem solving in range, MD and SD.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Recognise importance of measures of averages and dispersion (Understand)

MO 2: Understand the basic and advance statistical tools estimate the measures(Remember)

MO 3: Use and apply the measures of average and dispersion to biological data (Apply)

MO 4: Develop essential skills in problem solving (Apply)

MO 5: Develop overall idea on concept and scope: measures of average and dispersion (Analyse)

Module III: Correlation and Regression: Correlation – Types and problem solving. Regression analysis – types of regression, regression lines and problem solving.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Recognise theory of correlation and regression (Understand)

MO 2: Explain the types of correlation and regression (Remember)

MO 3: Classify data for correlation and regression analysis (Apply)

MO 4: Develop essential skills in problem solving (Apply)

MO 5: Develop overall idea on the fitting of regression lines (Analyse)

Module IV: Scientific method. Test of Hypothesis: Hypothesis testing and brief introduction to parametric and non-parametric tools.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Recognize the importance of test of hypothesis (Understand)

MO 2: Distinguish null and alternate hypothesis (Apply)

MO 3: Recognize different types of tools to test hypothesis (Understand)

MO 4: Distinguish parametric and non-parametric tests (Apply)

MO 5: Develop skills in using hypothesis testing tools (Remember)

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Activities

- Assignments
- Seminar Presentation on selected topics
- Case studies
- Problem solving
- Analyses of research papers and reports

LEARNING RESOURCES

References

Aitken, Mike, Braadhurst, Bill, Hladky, Steve. 2009. *Mathematics for Biological Scientists*. Garland Science Publishing, New York, 208pp.

Anderson TW. 1984. An Introduction to Multivariate Statistical Analysis. Wiley Series in Probability and Statistics, Singapore.

Bailey, N.T.J. 1973. Statistical Methods in Biology. The English Univ. Press Ltd., London, 160 pp.

Biradar RS. 2002. Course Manual on Fisheries Statistics. 2nd Ed. CIFE, Mumbai.

Butler, M.J.A., M.C. Mouchot, V. Barale and C. LeBlanc. 1988. The application of remote sensing technology to marine fisheries: an introductory manual. FAO Fish. Tech.Pap. 295, 165 pp.

Chao, L.L. 1974. Statistics Methods and Analysis. McGraw Hill, London, 556 pp.

Elhance, D.N. & V. Elhanle 1983. Fundamentals of Statistics. Kitab Mahal Publ., India,

Finney, D.J. 1978. Statistical Methods in Biology Assay. Charles Griffith Co. Ltd., England, 508 pp.

Ghosh S. 1999. *Multivariate Analysis, Design of Experiments and Survey Sampling*. Marcel Dekker.

Grafen, A. & R. Hails 2008. Modern Statistics for the Life Sciences. Oxford Univ. Press, NY, 351 pp.

Keller G. 2001. *Applied Statistics with Microsoft Excel*. Duxbury.

Khattree R & Naik D. 2000. *Multivariate Data Reduction and Discrimination with SAS Software*. SAS Institute North Carolina.

Kothari, C.R. 2011. *Research Methodology: Methods & Techniques*. New Age International Publishers, New Delhi, 401pp.

Mathews, M.S. 1995. Microsoft Excel for Windows 95 Made Easy. 5th ed. Tata McGraw-Hill Publ, Ltd., New Delhi, 515 pp.

Meaden. G.J. and Chi, T.D. Geographical information systems Applications to marine fisheries. FAO Fisheries Technical Paper 356, FAO, Rome, 335pp.

Megrey, B.A. and E. Moksness. Computers in Fisheries Research (2nd Ed.). Springer.

Roy, A.K. & N. Sarangi 2008. Applied Biostatistics, Statistics and Economics in Fisheries Research. New India Publ. Agency, New Delhi, 605 pp.

SPSS Base 11.0: User's Guide. SPSS Inc., Bangalore.

STATISTICA : The Small Book User Guide. StatSoft, USA.

Steven F. 2001. *Oracle PL / SQL Best Practices: Optimising Oracle Code*.SPD/O'Reilly Reprints.

Subramanian, N. 1986. Introduction to Computers. Tata McGraw-Hill Publ. Co. Ltd., New Delhi, 239 pp.

Systat 8.0: Getting Started Manual.

Walpole, R.E. 1968. Introduction to Statistics. The MacMillan Co., NY, 365 pp.

William RD & Matthew G. 1984. *Multivariate Analysis, Methods and Applications*. John Wiley & Sons.

Yamane, T. 1973. Statistics. An Introductory Analysis. HarpirInternat.

Zar, J.H. 1974. Biostatistical Analysis. Prentice-Hall, Inc., NJ, 620 pp.

On-line Sources

www.spss.com

www. Fisat.in

www.r.ac.in

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).

60% End-semester/Summative Assessment: 3 hour written Exam.

SEMESTER III	Course Code: AAQ-CC-531	Credits: 3
NAME OF THE COURSE: **AQUACULTURE BUSINESS MANAGEMENT**		

COURSE OUTCOMES (CO)

CO 1: Gain capability to conceptualize, design and prepare aquaculture projects

CO 2: Develop expertise in successful implementation of aquaculture projects

CO 3: Undertake extension activities as part of NGOs and Government Agencies

CO 4: Prepare bankable aquaculture projects to fulfil responsibilities as entrepreneur or consultant

CO 5: Understand the concept of aquaculture cooperatives for inclusive development in the sector

CO 6: Appreciate the regulations and policies governing aquaculture development in the country.

Tagging course outcomes

CO	CO Statement	PO/PSO	CL	KC
CO 1	Ap, Cr	2, 3, 7	Ap, Cr	M
CO 2	Ap, An	3, 7	Ap, An	C, P
CO 3	U, E	3, 6, 8	U, E	F, P
CO 4	Ap, E	2, 3, 7	Ap, E	C, P
CO 5	U, Ap	6, 7	U, Ap	C, P
CO 6	U, Ap	6, 7	U, Ap	F, C

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create, KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Module I: Aquaculture Economics: Definition, principle, concept and scope of economics. Law of demand and supply, Law of diminishing returns. Stages of production, cost concepts. Contribution of fisheries sector to National GDP. Economics of different aquaculture systems. Factors affecting economics of aquaculture. Socio-economic issues in aquaculture development.

Module Outcomes (MO)

MO 1: Familiarize with the basic concepts of economics

MO 2: Appreciate the contribution of aquaculture sector to the National GDP along with its potential for expansion

MO 3: Gain expertise on the economics of different aquaculture systems and provide consultancy to farmers.

MO 4: Appreciate the socio- economic issues associated with aquaculture project development

Module II: Financial Assistance available to the aquaculture sector from State and Central Governments, Commercial Banks and NABARD. Regulations, Legislations and Policies governing aquaculture in the country- CAA, NFDB, MPEDA. Role of Research Institutions. Role of FFDA, BFDA and other aquaculture related programs.

Module Outcomes (MO)

MO 1: Familiarize with the funding opportunities from the government sector for aquaculture project implementation.

MO 2: Gain expertise in the preparation of bankable projects and provide consultancy services to entrepreneurs and farmers in securing bank loans

MO 3: Familiarize with the role of agencies providing services to the aquaculture sector in the state.

MO 4: Familiarize with the legislations and regulations governing the aquaculture sector of the country and promote compliance among fellow farmers.

Module III: Marketing in Aquaculture: Concept of market, marketing channels, marketing functions, market structure and conduct. Types of Market, types of competition. Contract farming and direct marketing. Price determination. Problems of fish marketing in India. Contribution of MPEDA and other agencies in export of fish and fishery products. Marketing policy and market assessment.

Module Outcomes (MO)

MO 1: Understand the importance of marketing in the aquaculture sector for easy decision making during commercial operations

MO 2: Familiarize with the marketing channels and structure in the locality for easy movement of the product

MO 3: Understand the factors influencing the price of cultured fishes and utilize the same for making maximum returns in farms.

MO 4: Appreciate the importance of national agencies like MPEDA in promoting export of cultured fishes and follow the regulations to find an easy market for the produce.

Module IV: Role of Cooperatives in Aquaculture: History of cooperatives in Indian Fisheries. Matsyafed. Farmers Cooperatives and NGOs in the Aquaculture sector. Kudumbashree. Case studies of farmers cooperatives initiated by government agencies.

Module Outcomes (MO)

MO 1: Appreciate the potential role of cooperatives in the aquaculture sector in India

MO 2: Gain an overview of the history and functioning of existing cooperatives in the fisheries sector

MO 3: Familiarize with Matsyafed and its role in promoting aquaculture in the state.

MO 4: Familiarize with the cooperative movements in the state like Kudumbashree Mission to use the for the benefit of aquaculture

MO 5: Understand the functioning of existing farmers cooperatives in the aquaculture sector of the state.

Module V: Fisheries Extension: Need for extension in fisheries and aquaculture. Introduction to extension education, research, and service; Review of philosophy, principles, concepts, and practices of fisheries extension systems and approaches. Advantages and limitations. mportance of Information and Communication Technology (ICT) in extension

Module Outcomes (MO)

MO1: Identify the importance and applications of extension services to farmers (Understand)

MO 2: Review the philosophy and principles of fisheries extension (Understand)

MO 3: Enumerate the various extension services available for farmers (Evaluate)

MO 4: Familiarize with the subsidy schemes for farmers and provide advice and consultancy services to the sector

MO 5: Identify the importance of ICT in extension services (Understand)

MO 6: Appreciate the potential for aqua-farmers cooperatives

Module VI: Project Formulation: Project Cycle- Identification, Preparation, Appraisal and Agreement, Implementation and Monitoring, Evaluation. Entrepreneurship development in Aquaculture.

Module Outcomes (MO)

MO 1**:** Identification of real and attainable targets in aquaculture sector and preparation of projects.

MO 2: Carry out the project and evaluate it for its success.

MO 3: Promote entrepreneurship development in aquaculture.

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Activities

- Assignments
- Seminar Presentation on selected topics
- Debates
- Quiz
- Demonstration of simple experiments
- Field work and survey

LEARNING RESOURCES

References

Badapanda, K.C. 2012. *Fishery Economics & Administration*. Narendra Publishing House, Delhi, 427pp.

Bjorndal, T., & Munro, G., (2012). The Economics and Management of World Fisheries. OUP Oxford. 288 pp.

Chaston I. 1983. *Marketing in Fisheries and Aquaculture*. Fishing News Books.

Cunninghams, M., R. Dunn & D. Whilmarsh. 1985. Fishery Economics - an introduction. Mansell publishing Ltd. London.

Dholakia, A.D. 2004. Fisheries and Aquatic Resources of India. Daya Publ. Hse., Delhi,

Dunne EB. 1990. *Fisheries Economics - An Introduction*. Mansell Publ.

Engle C.R., (2020). Aquaculture Business: A Practical Guide to Economics and Marketing.5m Publishing. 343 pp.

Engle, C.R., &Quagrainie, K., (2009). Aquaculture Marketing Handbook. Blackwell Publishing. 288 pp.

Engle, C.R., (2011). Aquaculture Economics and Financing: Management and Analysis. Wiley-Blackwell. 272 pp.

Engle, C.R., Quagrainie, K.K., & Dey, M.M., (2016). Seafood and Aquaculture marketing Handbook (2nd Ed). Wiley-Blackwell, 416 pp.

FAO, 2011. FAO *Code of Conduct for Responsible Fisheries.* Rome,. 91 pp.

Grafton QR, Kirkley J, Kompas T & Squire D. 2006. *Economics for Fisheries Management*. Ashgate Publ. Co.

Ian C. 1984. *Marketing In Fisheries and Aquaculture*. Fishing News Books.

Munro GR & Scott A. 1984. *The Economics of Fisheries Management*. University of British Columbia.

Palanisamy K, Paramasivam P &Renganathan CR. 2002. *Agricultural Production Economics, Analytical Methods and Applications*.Associated Publ. Co.

Quagrainie, K.K., (2013). The Market for Aquaculture products: Market Efficiency and Global Competitiveness. Routledge Publisher. 112 pp.

Rao, P.S. 1983 Fishery Economics and Management in India. Pioneer Publ. & Distributors.

Sathiadas, R. 2012. *Marine Fishery Marketing in India*. CMFRI, Cochin, 276pp.

Shang YC. 1981. *Aquaculture Economics*. Westview Press.

Upadhay, A.D., Roy, A.J., & Pandey P.K., (2019). Fisheries and Aquaculture Economics. New India Publishing Agency. 366 pp.

Online Resources

http://eprints.cmfri.org.in/10407/1/02_Shyam_S_Salim3.pdf

http://eprints.cmfri.org.in/4334/

http://www.fao.org/3/T0403E01.htm

http://www.fao.org/docrep/004/Y2876E/y2876e0i.htm

mpeda.gov.in/

www.fao.org/docrep/003/T0506E/T0506E00.HTM

www.fao.org/docrep/X5625E/x5625e0f.htm

www.seafish.org/

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).

60% End-semester/Summative Assessment: 3 hour written Exam

SEMESTER III	Course Code: AAQ-CC-532	Credits: 3
NAME OF THE COURSE: **FISH HEALTH MANAGEMENT**		

COURSE OUTCOMES (CO)

CO 1: Understand the pathogenic diseases occurring in wild and cultured aquatic organisms

CO 2: Understand and differentiate between the immune systems of fin fishes and shell fishes

CO 3: Identify stressful conditions in aquatic ecosystems and prevent health risk

CO 4: Choose appropriate diagnostic tools for identification of the disease-causing agent

CO 5: Device preventive strategies for commercial aquaculture units (Hatcheries, Farms, etc.)

CO 6: Control / Manage disease outbreaks to minimise economic loss

CO 7: Implement principles of biosecurity in commercial aquaculture units

CO 8: Develop research projects on emerging diseases in wild and cultured aquatic organisms

Tagging course outcomes

CO	CO Statement	PO/PSO	CL	KC
CO 1	R, U	4, 5, 8	R, U	F
CO 2	R	1	R	F
CO 3	An, E	4, 5, 6	An, E	P
CO 4	U, Ap	6, 7, 8	U, Ap	C, P
CO 5	E, Cr	6, 7, 8	E, Cr	M
CO 6	Cr	6, 7, 8	Cr	M
CO 7	Ap, Cr	6	Ap, Cr	M
CO 8	An, Cr	8	An, Cr	M

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create, KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Module I: Concepts of health. Theories of diseases in aquatic environment. Stress and General Adaptation Syndrome. Inflammation and Necrosis. Systematic Pathology – Skin, Gills, Liver, Kidney, Heart, Brain, etc. Neoplasia.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Identify stress in aquatic organisms and manage the causative reasons.

MO 2: Identify inflammation and types/stages of necrosis and decide on management strategies

MO 3: Differentiate the pathologic changes in organ systems from normal condition and advice the farmer on management strategies

MO 4: Differentiate neoplastic condition in different organs.

Module II: Immunology- Immunology of fin fishes – Non specific and specific defence mechanisms in finfishes. Immunology of shellfishes – Crustacean immune system. Immunostimulants.

Module Outcomes (MO)

After completion of this module, the student should be able to:

MO 1: Understand the non-specific and specific immune mechanisms in finfishes

MO 2: Understand the immune mechanisms in crustaceans

MO 3: Device use of immunostimulants in aquaculture

MO 4: Develop research projects based on immunological changes associated with diseases

Module III: Diseases of fin fishes- Communicable (Viral , Bacterial, fungal and parasitic) and non-communicable diseases

Module Outcomes (MO)

MO 1: Differentiate between bacterial, viral and fungal diseases of fin fishes

MO 2: Make management decisions on the event of a disease outbreak to minimise economic loss

MO 3: Differentiate between pathogenic and non-pathogenic diseases in fin fishes

MO 4: Identify common parasitic diseases in fin fishes and shell fishes

MO 5: Manage parasitic infections in fishes

Module IV: Shell fish diseases – shrimp diseases (Viral, bacterial, fungal and parasitic). Epicommensals. Major diseases of other shellfishes

Module Outcome:

After Completion of this module, the student should be able to:

MO 1: Differentiate between viral, bacterial and fungal diseases of shrimps (Evaluate)

MO 2: Differentiate between pathogenic and non-pathogenic diseases of shrimps (Understand)

MO 3: Make management decisions in aquaculture scenarios to minimise economic loss (

MO 4: Understand diseases causing economic losses in molluscs

MO 5: Understand important diseases of crustaceans cultured outside indian subcontinent

Module V: Disease Diagnosis. Drugs and Chemicals in aquaculture. Vaccines in Aquaculture. Probiotics and neutraceuticals.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Differentiate between chemicals used for disinfection, prophylaxis and treatment

MO 2: Understand various diagnostic techniques used and identify suitable methods for management of diseases in culture conditions

MO 3: Understand different strategies for vaccine development and vaccination protocols suitable for fish diseases

MO 4: Understand the principles behind the use of probiotic bacteria in aquaculture and select suitable commercial probiotic mixtures for farm management

MO 5: Strategically use nutraceuticals in aquaculture

MO 6: Understand regulations governing the use of chemicals and drugs in the country and apply this information in farm management

MO 7: Design research projects for development and testing of chemicals, drugs and probiotic bacteria

Module VI: Health management in Aquaculture. Quarantine, Biosecurity, SPF and SPR, Regulations in india and abroad

Module Outcomes (MO)

MO 1:Understand the principles of health management in aquaculture.

MO 2: Understand the principles of quarantine in disease prevention and its application in practical culture situations

MO 3: Understand the principles of biosecurity in aquaculture and its application in culture situations

MO 4: Develop of SPF and SPR stocks suitable for aquaculture

MO 5: Understand and apply the regulations governing disease management in India

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Class Room Activities:

- Assignments
- Seminar Presentation on selected topics
- Debates
- Quiz

- Demonstration of simple experiments
- Field work and survey

REFERENCES

Amlacher, E. 1997. Textbook of Fish Diseases. (Transl. D.A. Conroy & R.L. Herman), Narendra Publ. Hse., Delhi, 302 pp.

Anderson & Douglas. 2003. *Fish Immunology: Diseases of fishes.* Narendra Publishing House, Delhi, 239pp.

Archana, P. 2010. *Fish Immunology & Biotechnology*. Swastik Publications, Delhi, 311pp.

Biswas, K.P. 1992. Prevention and Control of Fish and Prawn Diseases. Narendra Publ. Hse., Delhi, 144 pp.

Chakrabarti, N.M. 1994. Diseases of Cultivable Freshwater Fishes and Their Control. Internat. Books Periodicals Supply Serv., Delhi, 149 pp.

Devashish Kar. 2016. Epizootic ulcerative fish disease syndrome. Academic Press, London. 314pp.

Egusa, S. 1991. Infectious Diseases of Fish. Oxonian Press, New Delhi, India, 696 pp.

Galina Jeney. 2017. Fish Diseases- Prevention and Control Strategies. Academic Press, London, 264 pp.

ICAR, 2006 & 2011. *Handbook of Fisheries and Aquaculture*. ICAR, New Delhi.

Kabata, Z. 1985. Parasites and Diseases of Fish Cultured in the Tropics. Taylor & Francis, London, 318 pp.

Kinne, O. 1980. Diseases of Marine Animals. Vol. I. General Aspects, Protozoa to Gastropoda. John Wiley & Sons, Cichester, 460 pp.

Kinne, O. 1985. Diseases of Marine Animals. Vol. 4. Part IV. Pisces. BiologischeAnstalt Helgoland, Hamburg, 541 pp.

Leatherland, J.F. & P.T.K. Woo 1998. Fish Diseases and Disorders: Non-infectious Disorders. Vol. 2. CABI Publ., Wallingford, 386 pp.

Lucky, Z. 1970. Methods for the Diagnosis of Fish Diseases. Amerind Publ. Co. Pvt. Ltd., New Delhi, 140 pp.

Mawdesley-Thomas, L.E. 1972. Diseases of Fish. Symp. Zool. Soc. London, 30, Acad. Press, NY, 380 pp.

Moller, H. & K. Anders 1986. Diseases and Parasites of Marine Fishes. Moller-Kiel, 365 pp.

Noga, E. 2000. Fish Disease Diagnostics and Treatment. Blackwell Publ. Co., Oxford, 316 pp.

Ramachandran, V. 2011. *Fish Pathology*. Blackprints, New Delhi, 253pp.

Reichenbach-Klinke, H.H. & E. Elkan 1965. The Principal Diseases of Lower Vertebrates. Acad. Press, London, 600 pp.

Roberts R.J. 2012. Fish Pathology. Wiley-Blackwell, New Delhi, 581pp

Schaperclaus, W. 1991. Fish Diseases. Vols. 1 & 2. 5th ed. Oxonian Press Pvt. Ltd., New Delhi, 1398 pp.

Sindermann, C.J. 1990. Principal Diseases of Marine Fish and Shellfish. Vols. 1 & 2. Acad. Press, NY, 521 pp.

Sinha, P., J.N. Gobia& V.K. Singh 2002. Diseases and Their Control. Sciencetech Publ., USA, 212 pp.

Stephen A. Smith. 2019. Fish Diseases and Medicine. CRC Press, London. 397pp.

Stickney R.R. 2000. Encyclopaedia of Aquaculture. John Wiley & Sons, New York.

Swain, P., P.K.Sahoo& S. Ayyappan. 2006. *Fish & shellfish Immunology: An Introduction*. Narendra Publishing House, Delhi, 296pp.

Woo, P.T.K. 2006. Fish Diseases and Disorders: Protozoan and Metazoan Infections. Fish Diseases and Disorders. Vol. 1. 2nd ed. CABI Publ., Wallingford, UK, 791 pp

Woo, P.T.K. & D.W. Bruno 1999. Viral, Bacterial and Fungal Infections. Fish Diseases and Disorders. Vol. 3. CABI Publ., Wallingford, UK.

Online Resources

www.caa.gov.in

www.fao.org

www.mpeda.gov.in

www.oie.int

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).

60% End-semester/Summative Assessment: 3 hour written Exam

SEMESTER III	Course Code: AAQ-DE-533	Credits: 2
NAME OF THE COURSE: **INTENSIVE CULTURE SYSTEMS**		

COURSE OUTCOMES (CO):

CO 1: Fundamental information on intensive farming techniques

CO 2: Familiarity on the properties of soil chemistry

CO 3: Comprehensive awareness on feed management for intensive aquaculture

CO 4: Proficiency in designing of instrumentation for intensive systems

CO 5: Detailed knowledge on online water quality monitoring system

CO 6: Basic information on effluent treatment protocols

Tagging course outcomes

CO	CO Statement	PO/PSO	CL	KC
CO 1	U, Ap	1, 4, 5	U, Ap	C, P
CO 2	R, U	1	R, U	F
CO 3	Ap, An	4, 5	Ap, An	C, P
CO 4	Cr	2, 7, 8	Cr	M
CO 5	U, Ap	1, 7	U, Ap	C, P
CO 6	R, U	1, 6, 7,	R, U	C

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create,

KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Module I: Design of Intensive Aquaculture Systems: water flow rate and component ratio in intensive systems. Water inlet –outlet ratio for RAS, size of biofilter in RAS, filtration flow patterns in mechanical filters. Intensive Aquaculture Systems- Cage, Aquaponics, Biofloc, RAS, Pond.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Review different designs intensive farming systems (Understand)

MO 2: Comprehend the inlet-outlet ratio of different filtration systems (Understand)

MO 3: Enumerate the size ratio of biofilter used in RAS (Evaluate)

Module II: Feed Management in Intensive Aquaculture: Effective feeding practices-timing, ratio, quality. Nutritional loss in a system. Saving feed cost- partial replacement with other feeds (Azolla), partial feeds, feeding chart.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO1: Enumerate different feeding practices involved in aquaculture (Evaluate)

MO 2: Enumerate the possible nutritional loss happening in a system (Evaluate)

MO 3: Explore effective utilization of feed by incorporating several modes (Understand)

MO 4: Prepare several alternative feeds to reduce the overall cost of feed (Perform)

Module III: Production in Intensive Aquaculture Systems: Ways to improve effective production-system component inclusion/improvement, strategic plans- multiple species/size stocking, monosex/sex reversal, ploidy induction, higher stocking density, crop rotation. Record keeping of feed and survival rate.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Identify the multiple options for improving the production of a system (Evaluate)

MO 2: Conduct triploidy induction in fishes (Perform)

MO 3: Review the improvement of components of a system for higher rate of production (Evaluate)

MO 4: Provide extension services to farmers to improve the production (Evaluate)

Module IV: Waste management in Intensive Aquaculture Systems: Improvement in modes of filtration to increase water conservation. Treatment of solid/liquid waste. ISO standards for Aquaculture Effluent, Site characteristics for discharge regulations, Effluent treatment scheme of Aquaculture Authority of India.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Conduct different filtration techniques to see the improvement in quality of water (Perform)

MO 2: Review different solid/liquid protocols used in aquaculture (Evaluate)

MO 3: Explore the ISO standards for aquaculture effluent (Remember)

Module V: Economics and marketing of Intensive Aquaculture Systems: Value addition of products- processed products, by-products, Ready to eat/cook products. Marketing strategies-online marketing, group of fish farmers, sale of fresh & live fish. Marketing through social media.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Explore the various means of online marketing (Understand)

MO 2: Compare several online marketing groups of farmers with/without processing (Evaluate)

MO 3: Review the economic analysis of fresh, processed and by-products (Analyse)

Module VI: Automation in Intensive Aquaculture Systems- Automatic Feeder- demand feeder. Online water quality monitoring and maintenance. Calculations for Uninterrupted power supply/generator- solar, battery.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Correlate the benefits and limitations of different types of automatic feeders (Understand)

MO 2: Calculate the power requirement and back up required to run the system (Evaluate)

MO 3: Design a system with online monitoring and maintenance (Remember)

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Activities

- Assignments
- Seminar Presentation on selected topics
- Debates
- Quiz
- Demonstration of simple experiments
- Field work and survey

LEARNING RESOURCES

References

Alday-Sanz, V., (2010). The Shrimp Book. Nottingham University Press. 200 pp.

Bandhopadhyay. S., (2008). Daya Publishing house, New Delhi.

Datta, S., (2019). Water & Soil Management Tips for Sustainable & Intensive Aquaculture: A Field Guide Book. Independently Published. 70 pp.

Goddard, S., (2012). Feed Management in Intensive Aquaculture. Springer Science & Business Media. 194 pp.

Hai, F.I., Visvanatan, C., &Boopathy, R., (2018). Sustainable Aquaculture. Springer. 326 pp.

Perschbacher, P.W. & Stickney, R.R. (Eds)., (2017). Tilapia in Intensive Co-culture. World Aquaculture Society, Wiley Blackwell.

Shepherd, C.J. &Bromage, N.R., (1992). Intensive Fish Farming. Wiley, 420 pp.

Online resources

http://www.fao.org/3/ca6702en/ca6702en.pdf

http://www.fao.org/3/t8598e/t8598e05.htm

http://www.fisheriesjournal.com/archives/2019/vol7issue5/PartD/7-4-44-679.pdf

https://krishi.icar.gov.in/jspui/bitstream/123456789/26376/1/Biofloc%20manual%20final%2024-28-9-19.pdf

Reference Journals

Aquaculture

Aquaculture Research

Journal of the World Aquaculture Society

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).

60% End-semester/Summative Assessment: 3 hour written Exam.

SEMESTER III	Course Code: AAQ-CC-534	Credits: 3
NAME OF THE COURSE: **PRACTICAL 3: DISEASE CONTROL, INTENSIVE AQUACULTURE AND BUSINESS MANAGEMENT**		

COURSE OUTCOMES (CO)

CO 1: Acquire practical knowledge to conceptualize, design and prepare aquaculture projects

CO 2: Develop skills in the preparation of bankable aquaculture projects so to fulfill responsibilities as entrepreneur or consultant

CO 3: Demonstrate the ability to implement principles of biosecurity in commercial aquaculture units

CO 4: Develop expertise in pathogenic diseases occurring in cultured aquatic organisms with special emphasis on its diagnosis, prophylaxis and control

CO 5: Understand the importance of biosecurity and management in advanced intensive aquaculture systems like biofloc technology, RAS etc.

Tagging course outcomes

CO	CO Statement	PO/PSO	CL	KC
CO 1	An, E	2, 3, 7	An, E	P
CO 2	An, E	2, 3, 6	An, E	P
CO 3	Ap, An	6	Ap, An	P
CO 4	U, Ap	1, 4, 5	U, Ap	P
CO 5	Ap, E	6	Ap, E	P

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create,

KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

Fish Health Management

Identification fish and shellfish pathogens/parasites

Diagnosis for viral diseases in shrimps by PCR

Histopathology of diseases, preparation of histopathology slides

Intensive Aquaculture

Water quality management in Different Intensive Aquaculture Systems

Field visit to model Biofloc aquaculture system

Field visit to Recirculating Aquaculture Systems (RAS)

Field visit to model Aquaponics unit

Hands on experience of Real time water quality assessment equipments and feed automation

Calculating carrying capacity of pond and stocking density

Aquaculture Business Management

Economics of different aquaculture systems.

Socio-economic issues in aquaculture development.

Case studies of farmers cooperatives initiated by government agencies.

Preparation of bankable projects for hatchery and different aquaculture systems

LEARNING RESOURCES

References

Amlacher, E. 1997. Textbook of Fish Diseases. (Transl. D.A. Conroy & R.L. Herman), Narendra Publ. Hse., Delhi, 302 pp.

Anderson & Douglas. 2003. *Fish Immunology: Diseases of fishes.* Narendra Publishing House, Delhi, 239pp.

Archana, P. 2010. *Fish Immunology & Biotechnology*. Swastik Publications, Delhi, 311pp.

Badapanda, K.C. 2012. *Fishery Economics & Administration*. Narendra Publishing House, Delhi, 427pp.

Biswas, K.P. 1992. Prevention and Control of Fish and Prawn Diseases. Narendra Publ. Hse., Delhi, 144 pp.

Bjorndal, T., & Munro, G., (2012). The Economics and Management of World Fisheries. OUP Oxford. 288 pp.

Chakrabarti, N.M. 1994. Diseases of Cultivable Freshwater Fishes and Their Control. Internat. Books Periodicals Supply Serv., Delhi, 149 pp.

Chaston I. 1983. *Marketing in Fisheries and Aquaculture*. Fishing News Books.

Cunninghams, M., R. Dunn & D. Whilmarsh. 1985. Fishery Economics - an introduction. Mansell publishing Ltd. London.

Devashish Kar. 2016. Epizootic ulcerative fish disease syndrome. Academic Press, London. 314pp.

Dholakia, A.D. 2004. Fisheries and Aquatic Resources of India. Daya Publ. Hse., Delhi,

Dunne EB. 1990. *Fisheries Economics - An Introduction*. Mansell Publ.

Egusa, S. 1991. Infectious Diseases of Fish. Oxonian Press, New Delhi, India, 696 pp.

Engle C.R., (2020). Aquaculture Business: A Practical Guide to Economics and Marketing.5m Publishing. 343 pp.

Engle, C.R., &Quagrainie, K., (2009). Aquaculture Marketing Handbook. Blackwell Publishing. 288 pp.

Engle, C.R., (2011). Aquaculture Economics and Financing: Management and Analysis. Wiley-Blackwell. 272 pp.

Engle, C.R., Quagrainie, K.K., & Dey, M.M., (2016). Seafood and Aquaculture marketing Handbook (2nd Ed). Wiley-Blackwell, 416 pp.

Galina Jeney. 2017. Fish Diseases- Prevention and Control Strategies. Academic Press, London, 264 pp.

ICAR, 2006 & 2011. *Handbook of Fisheries and Aquaculture*. ICAR, New Delhi.

Kabata, Z. 1985. Parasites and Diseases of Fish Cultured in the Tropics. Taylor & Francis, London, 318 pp.

Kinne, O. 1980. Diseases of Marine Animals. Vol. I. General Aspects, Protozoa to Gastropoda. John Wiley & Sons, Cichester, 460 pp.

Kinne, O. 1985. Diseases of Marine Animals. Vol. 4. Part IV. Pisces. BiologischeAnstalt Helgoland, Hamburg, 541 pp.

Leatherland, J.F. & P.T.K. Woo 1998. Fish Diseases and Disorders: Non-infectious Disorders. Vol. 2. CABI Publ., Wallingford, 386 pp.

Lucky, Z. 1970. Methods for the Diagnosis of Fish Diseases. Amerind Publ. Co. Pvt. Ltd., New Delhi, 140 pp.

Mawdesley-Thomas, L.E. 1972. Diseases of Fish. Symp. Zool. Soc. London, 30, Acad. Press, NY, 380 pp.

Moller, H. & K. Anders 1986. Diseases and Parasites of Marine Fishes. Moller-Kiel, 365 pp.

Noga, E. 2000. Fish Disease Diagnostics and Treatment. Blackwell Publ. Co., Oxford, 316 pp.

Ramachandran, V. 2011. *Fish Pathology*. Blackprints, New Delhi, 253pp.

Reichenbach-Klinke, H.H. & E. Elkan 1965. The Principal Diseases of Lower Vertebrates. Acad. Press, London, 600 pp.

Roberts R.J. 2012. Fish Pathology. Wiley-Blackwell, New Delhi, 581pp

Schaperclaus, W. 1991. Fish Diseases. Vols. 1 & 2. 5th ed. Oxonian Press Pvt. Ltd., New Delhi, 1398 pp.

Sindermann, C.J. 1990. Principal Diseases of Marine Fish and Shellfish. Vols. 1 & 2. Acad. Press, NY, 521 pp.

Sinha, P., J.N. Gobia& V.K. Singh 2002. Diseases and Their Control. Sciencetech Publ., USA, 212 pp.

Stephen A. Smith. 2019. Fish Diseases and Medicine. CRC Press, London. 397pp.

Stickney R.R. 2000. Encyclopaedia of Aquaculture. John Wiley & Sons, New York.

Swain, P., P.K.Sahoo& S. Ayyappan. 2006. *Fish & shellfish Immunology: An Introduction*. Narendra Publishing House, Delhi, 296pp.

Woo, P.T.K. & D.W. Bruno 1999. Viral, Bacterial and Fungal Infections. Fish Diseases and Disorders. Vol. 3. CABI Publ., Wallingford, UK.

Woo, P.T.K. 2006. Fish Diseases and Disorders: Protozoan and Metazoan Infections. Fish Diseases and Disorders. Vol. 1. 2nd ed. CABI Publ., Wallingford, UK, 791 pp

On-line Sources

http://www.ciba.org.in

http://www.ciba.org.in

http://www.cmfri.org.in/ebooks

http://www.fao.org/3/a-az083e.pdf

https://www.oie.int/doc/ged/D9568.PDF

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations)- Record, field work reports, Viva

60% End-semester/Summative Assessment: 3 hourPractical Exam

SEMESTER III	Course Code: AAQ-CC-535	Credits: 5
NAME OF THE COURSE: **INDUSTRIAL ATTACHMENT**		

COURSE OUTCOMES (CO)

CO 1: Integrate academic theory and 'real world' practice, engage in research that explores the relationship between the two, and gain hands-on experience in professional settings.

CO 2: Gain field experience and share insights on the subject.

CO 3: Develop an aptitude to take up independent work in aquaculture sector

CO 4: Demonstrate in a written work report a broad understanding of the organization for which the student worked

CO 5: Practice good work habits and interpersonal relationships

CO 6: Develop personal contacts and ability to work in a team during the attachment

CO 7: Develop a greater understanding about career options while more clearly defining personal career goals

Tagging course outcomes

CO	CO Statement	PO/PSO	CL	KC
CO 1	Ap, An	3, 7, 8	Ap, An	P
CO 2	An, E	3, 7	An, E	P
CO 3	An, Cr	2, 3, 7	An, Cr	P
CO 4	U	7, 8	U	P
CO 5	An, E	3, 6, 7	An, E	P
CO 6	E	7, 8	E	P
CO 7	An, E	3, 7	An, E	P

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create, KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

The industrial attachment experience provides the student with an opportunity to explore career interests while applying knowledge and skills learned in the classroom in a work setting. The experience also helps students gain a clearer sense of what they still need to learn and provides an opportunity to build professional networks in the field. This will also provide on-hand training in aquaculture and associated fields and associated skills.

The students will work in a public or private hatchery, fish farm, fish processing lab or company or work in association with a non-governmental organisation working in fisheries/aquaculture extension in India for a period of minimum ten working days, and gain practical knowledge on the subject.

REQUIREMENTS

In consultation with the Course Coordinator and Head of the Department, students may choose a hatchery, fish farm, fish processing company or lab in public or private sector or a non-governmental organisation working in fisheries extension. The students need to work for a minimum period of ten working days in the firm, following the working guidelines issued by the firm, and the contract between the student/department and the firm. Each student or the batch should produce anindustry attachment/work competency certificate from the firm. They also have to produce a report on internship and a workbook indicating the daily activities performed during the entire period under internship. Students are expected to conform to all attendance policies established by the firm.

Any student who fail to complete the internship in one firm, may work in another firm and complete the required number of working days. However, they need to submit the certificate from both the firms. The students can complete the internship in any period during the fourth semester.

ASSESSMENT

Certificate from the firm: 30%

Workbook: 20%

Demonstrate Learning Outcomes through presentation and viva: 50%

SEMESTER III	Course Code: AAQ-DE-536	Credits: 2
NAME OF THE COURSE: **RESEARCH METHODOLOGY FOR AQUATIC SCIENCES**		

COURSE OUTCOMES (CO)

CO 1: Understand the concept of research method and types of research

CO 2: Develop skills in framing a research question and design experiments.

CO 3: Develop understanding on sampling and data analyses tools

CO 4: Develop skills to operate instruments for biodiversity assessments in field

CO 5: Have basic awareness of developing and testing hypothesis

CO 6: Demonstrate the ability to prepare a research report/paper

CO 7: Basic knowledge in preparing a research proposal

Tagging course outcomes

CO	CO Statement	PO/PSO	CL	KC
CO 1	R, U	1, 8	R, U	F, C
CO 2	An, E	7, 8	An, E	C, P
CO 3	Ap, An	4, 5	Ap, An	C, P
CO 4	U	4, 5	U	P
CO 5	An, E	4, 5	An, E	P
CO 6	An, E	7, 8	An, E	C, P
CO 7	An, E	8	An, E	P

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create, KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT

Module I: Elements of scientific method, Research- purpose, inspiration, relevance and scope. Types of research - basic, applied, strategic, anticipatory and adaptive research, historical, descriptive and experimental research, qualitative and quantitative research methods, experimental

and ex-post facto approaches, survey research, action research, participatory research, case study method, content analysis.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Recognise the methods of scientific research (Understand)

MO 2: Explain the types of research (Remember)

MO 3: Classify research based on various purpose and functions (Apply)

MO 4: Develop essential skills in content analysis (Apply)

MO 5: Develop overall idea on the concept and scope reseach (Analyse)

Module II: Steps involved in research process, Identifying and defining researchable problems, Formulation of research objectives, Hypothesis - meaning, types, development of hypothesis and its testing, Constructs, Nature and type of variables, Types and levels of measurement, Types of reliability and validity and their measurement.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Analyse the reseach cycle and components (Understand)

MO 2: Develop skills in identifying research problems and hypothesis (Apply)

MO 3: Develop skills in framing research design following scientific methods (Apply)

MO 4: Design experiments for supporting hypothesis (Apply)

MO 5: Recognise the concept of variables and analyses of variables (Understand)

Module III: Methods of observation and data collection for biological and social sciences research. Selection of appropriate tools for analysis of biological and social sciences research data. Format of research paper: IMRAD.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Identify methods for data collection (Understand)

MO 2: Develop skills for identifying tools for data analyses (Apply)

MO 3: Enumerate biodiversity following scientific methods (Remember)

MO 4: Recognise the format of a research paper (Understand)

MO 5: Develop skills for preparing research paper and reports (Remember)

Module IV: Bibliographic database. Impact factor, citation index, H index, Ethics in research. Plagiarism and software for checking plagiarism. Principles in formulating a research projects. Components of a research proposal.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Recognise the importance of bibliographic database (Understand)

MO 2: Distinguish various indices in documenting research impact (Apply)

MO 3: Recognise the importance of research ethics and issues with plagiarism (Understand)

MO 4: Distinguish the principles in reseach project formulation (Apply)

MO 5: Develop skills in writing a research project (Remember)

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Activities:

- Assignments
- Seminar Presentation on selected topics
- Case studies
- Analyses of research papers and reports

LEARNING RESOURCES

References

Anderson, J., B.H. Durston& M. Poole 1970. Thesis and Assignment Writing. Wiley Eastern Pvt. Ltd., New Delhi, pp.

Briscoe, M.H. 1996. Preparing Scientific Illustrations. Springer, NY, 204 pp.

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India

Day, R.A. 1 979. How to Write and Publish s Scientific Paper. ISI Press, Pennsylvania, 160 pp.

Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed.Affiliated East-West Press.

Kerlinger FN. 1983. Foundations of Behavioural Research. Surjeet Publ.

Kothari, C.R. 2005. Research Methodology. Methods and Techniques. 2nd ed. New Age Internat. (P) Ltd., Publ., New Delhi, 401 pp.

Kumar R. 1996. Research Methodology: a Step-by-Step Guide for Beginers. Sage Publ.

Rossiter DG. 2003. Preparation for M.Sc. Thesis Research. ITC, Netherlands.

Sandhu, G.S. 1990. Research Techniques in Biological Sciences. Amol Publ., New Delhi, 388 pp.

Sinha VRP. 2005. Fisheries Research Planning and Management in Developing Countries. Narendra Publ. House.

von Normann, R.W. 1971. Experimental Biology. 2nd ed. Prentice Hall Inc., N.J., 269 pp.

Walliman N. 2001. Your Research Project: a Step-by-Step Guide for the First Time Researcher. Sage Publ.

On-line Sources

http://www.inflibnet.ac.in/ess/

http://www.urkund.com/en/

https://swayam.gov.in/ https://ndl.iitkgp.ac.in https://www.ugc.ac.in/

https://www.nature.com/scitable/topicpage/effective-writing-13815989

http://study.com/academy/lesson/research-methodology-approaches-techniques-quiz.html

https://explorable.com/research-methodology

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).

60% End-semester/Summative Assessment: 3 hour written Exam.

SEMESTER IV	Course Code: AAQ-CC-541	Credits: 6
NAME OF THE COURSE: **INTERNSHIP**		

COURSE OUTCOMES (CO)

CO 1: Integrate academic theory and 'real world' practice, engage in research that explores the relationship between the two, and gain hands-on experience in professional settings.

CO 2: Develop a field experience with an opportunity to share their insights on the subject.

CO 3: Demonstrate the links between academic preparation and their field work

CO 4: Develop an aptitude to carry out and implement an aquaculture project/start-up/self-employment scheme

CO 5: Recognize knowledge and skills related to the technical aspects of aquaculture

CO 6: Apply appropriate skills in the techniques of aquaculture operations and management and recognise career opportunities

CO 7: Demonstrate in a written work report a broad understanding of the organization for which the student worked

CO 8: Practice good work habits and interpersonal relationships

Tagging course outcomes:

CO	CO Statement	PO/PSO	CL	KC
CO 1	Ap, An	3, 7, 8	Ap, An	P
CO 2	An, E	3, 7	An, E	P
CO 3	An, E	3, 8	An, E	P
CO 4	An, Cr	2, 3, 7	An, Cr	P
CO 5	U	7, 8	U	P
CO 6	An, E	3, 7, 8	An, E	P
CO 7	An, E	7, 8	An, E	P
CO 8	Ap, An	3, 7	Ap, An	P

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create, KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

COURSE CONTENT (CO)

The internship experience provides the student with an opportunity to explore career interests while applying knowledge and skills learned in the classroom in a work setting. The experience also helps students gain a clearer sense of what they still need to learn and provides an opportunity to build professional networks in the field. This will also provide on-hand training in aquaculture and associated fields which is sure to develop their skills.

The students will work in a public or private aquaculture firm in India for a period of minimum ten working days, and gain practical knowledge on the subject.

REQUIREMENTS

In consultation with the Course Coordinator and Head of the Department, students may choose an aquaculture firm in public or private sector. The students need to work for a minimum period of ten working days in the firm, following the working guidelines issued by the firm, and the contract between the student/department and the firm. Each student or the batch should produce an internship completion/work competency certificate from the firm. They also have to produce a report on internship and a workbook indicating the daily activities performed during the entire period under internship. Students are expected to conform to all attendance policies established by the firm.

Any student who fail to complete the internship in one firm, may work in another firm and complete required number of working days. However, they need to submit the certificate from both the firms. The students can complete the internship in any period during the fourth semester.

ASSESSMENT

Certificate from the firm: 30%

Workbook: 20%

Demonstrate Learning Outcomes through presentation and viva: 50%

SEMESTER IV	Course Code: AAQ-CC-542	Credits: 6
NAME OF THE COURSE: **RESEARCH PROJECT**		

COURSE OUTCOMES (CO)

CO 1: Demonstrate the ability to conduct literature reviews and gather the critical scientific information related to the research proposal

CO 2: Identify a research hypothesis/problem and create a research proposal

CO 3: Undertake a short-term research project following precise research methodology.

CO 4: Develop skills in science writing for the preparation and submission of dissertation

CO 5: Experience in Science Communication and presentation of results, including for the better understanding of layman.

Tagging course outcomes

CO	CO Statement	PO/PSO	CL	KC
CO 1	An, E	7, 8	An, E	P
CO 2	An, E	7,8	An, E	P
CO 3	An, E	7, 8	An, E	P
CO 4	An, Cr	8	An, Cr	P
CO 5	An, E	7, 8	An, E	P

(CL-Cognitive Level: R-remember, U-understand, Ap-Apply, An-analyse, E-evaluate, Cr-create, KC-Knowledge Category: F-factual, C-Conceptual, P-Procedural, M-Metacognitive)

REQUIREMENTS

The student shall do an individual project work under the supervision of a teacher, preferably within the department, or in another research centre or industry organization (with or without a co-supervisor), the result of which shall be embodied in a dissertation of (30-50 pages) in prescribed format. Each student should make a progress presentation during mid-term of the fourth semester, clearly explaining the hypothesis and progress achieved against each objective. Project management shall be done professionally as per prescribed guidelines issued by the Dept. and shall include project planning in the third semester. The student shall demonstrate technical/scientific writing skills and critical mind in compiling the dissertation and articulating the same. The student

shall demonstrate professional presentation skills in presenting the work in a viva-voce. They shall also demonstrate overall knowledge related to the area of the project during the viva-voce. They shall summarize the work in a research paper format and produce the same along with dissertation, along with an abstract in their mother tongue.

ASSESSMENT

The evaluation will be based on the project work submitted and the viva voce- based on the presentation of research findings. The evaluation shall be done by both external and internal examiners.

SEMESTER	Course Code: AAQ-SE-501	Credits: 2

NAME OF THE COURSE: **SOFT SKILLS**

COURSE OUTCOMES (CO)

CO 1: Understand various aspects of personality, values and ethics

CO 2: Derive skills and motivation to develop personality.

CO 3: Develop skills to confidently speak English

CO 4: Develop skills in public speaking

CO 5: Better living skills

CO 6: Better skills for creative thinking and thinking

COURSE CONTENT

Module I: Personality: Skills, attitudes, body language, inter-personal skills, multiple intelligence etc.; values in life. Communication and personality. Skills in English speaking and writing.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Articulate different aspects of personality (Analyse)

MO 2: Critically evaluate our own Multiple Intelligent types (Evaluate)

MO 3:Explain and understand body language (Understand)

MO 4: Demonstrate the importance of values in life (Understand)

MO 5: Develop better attitude towards communicating more fluently and confidently in English (Create)

Module II: Public speaking skills. Skills in making presentations; Audio-visual aids in presentations multimedia presentations.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Articulate a healthy attitude towards English (Understand)

MO 2: Communicate fluently and confidently in English (Apply)

MO 3: Develop skills in public speaking (Create)

MO4: Develop skills in better multimedia presentations (Apply)

Module III: Living skills: Green living; healthy living; daily and independent life skills. Smart-Thinking Skills: Creativity: Various views on creativity- Habits of critical thinkers, stimulating

creativity, obstructions to creativity, creativity and innovation, creativity and craft, visual thinking through mind mapping, creativity exercises.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Identify and practice a few green living skills (Apply)

MO 2: List common habits of creative thinkers (Remember)

MO 3: Demonstrate various aspects of creativity and practice mind mapping (Apply)

MO 4: Judge to understand and practice independent life skills (Apply)

MO 5: Articulate and exemplify the concept of innovation (Apply)

Module IV: Basics of emotional intelligence, skills in emotional intelligence. Self-management, awareness, regulation, motivation and empathy. Skills for managing emotions and balancing optimism and pessimism. Mindfulness practices: Yoga and meditation.

Module Outcomes (MO):

After Completion of this module, the student should be able to:

MO 1: Recognize the basics of emotional intelligence (Remember)

MO 2: Develop skills in managing emotional intelligence (Apply)

MO 3: Understand the principles behind mindfulness

MO 4: Application of yoga and meditation as mindfulness practices (Apply)

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Class Room Activities

- Public speech
- Mock Interviews
- Communication Games
- Team Presentation on Multiple Intelligences
- Multi-media story board writing, making presentation and presenting it.
- Creativity exercises
- Developing Mind-Maps
- Critical Thinking exercises
- Yoga and meditation exercise

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).

60% End-semester/Summative Assessment: 3 hour written Exam.

References

Allen, R. (2005), Boost Your Creativity: Exercises and Advice for Great Creative

Billie Krstovic 2020. Using Mindfulness to Improve Learning ; 40 Meditation Exercises for School and Home. Routledge.

Burn, G. (2011), Motivation for dummies. John Wiley & Sons.

Caroselli,M.(2004), Quick Wits: 50 Activities for Developing Critical Thinking Skills,

Daniel Goleman, Annie McKee, Bill George, Herminia Ibarra 2020. HBR Emotional Intelligence. Harvard Business Review.

Glenn Cummings 2019. Emotional Intelligence: The Most Complete Blueprint to Develop and Boost Your EQ. Improve Your Social Skills, Emotional Agility and Discover Why it Can Matter More Than IQ.

Human Resource Development Press.

Innovation, Warner Books.

JohanatanSlane 2019. Emotional Intelligence for Leadership: 4 Week Booster Plan to Increase Your Self-Awareness, Assertiveness and Your Ability to Manage People.

Klaus, P. (2009), The Hard Truth about Soft Skills: Soft Skills for Succeeding in a Check

Laura Eberstadt 2019. Guided Yoga Class For Beginners: Practice Poses, Meditation & Mindfulness.

Mak, D.K., Mak, A.T., Mak, A.B. (2009), Solving Everyday Problems with the Scientific

Method: Thinking like a Scientist, World Scientific.

Oech, R.V. (1983), A Whack on the Side of the Head: How to Unlock Your Mind for

on net, HarperCollins.

Reddi, B. (2012), Soft Skills and Life Skills: The Dynamics of Success. BSC Publishers and Distributors.

Rob Nairn , Choden , Heather Regan-Addis 2019. From Mindfulness to Insight: Meditations to Release Your Habitual Thinking and Activate Your Inherent Wisdom. Shambhala.

Sherfield, R. M. (2009), Cornerstone: Developing Soft Skills. Pearson Education.

Smith, J. (1997), How to be a better time manager. Kogan Page.

Thinking., Anova Books

Williams Jame, W. 2020. Self-discipline Mastery.

SEMESTER	Course Code: AAQ-SE-502	Credits: 2

NAME OF THE COURSE: **DATA PRESENTATION TECHNIQUES**

COURSE OUTCOMES (CO)

CO 1: Understanding and application scientific data presentation techniques

CO 2: Develop expertise to prepare visual aids for scientific data

CO 3: Develop capability to use different software to prepare visual aids

CO 4: Understand the concept of data presentation styles

CO 5: Use and application of different visual aid models in scientific data

CO 6: Develop skills in preparing power point presentation

CO 7: Demonstrate knowledge and understanding of preparing a poster presentation

COURSE CONTENT

Module I: Research Methodology: Statistical investigation, Types of Research. Research Documentation and types of research reports.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Recognize and recollect basic principles of research (Understand)

MO 2: Distinguish research and statistical methods (Create)

MO 3: Analyse different research types (Apply)

MO 4: Develop essential skills in data collection (Apply)

MO 5: Develop overall idea on research documentation and research reports(Analyse)

Module II: Data Presentation: Variable,Data collection and data types, Data organization – Editing, Classification and Tabulation. Data presentation – Graphs, Charts, Diagrams and Cartographs.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Recognize need to present the data (Understand)

MO 2: Understand the basic and advanced presentation types(Remember)

MO 3: Use and apply the presentation styles to suit data (Apply)

MO 4: Develop essential skills in tabulation and presentation (Apply)

MO 5: Develop overall idea on the preparing visual aids(Analyse)

Module III: Graphical Software: Preparation of different types of graphs using MS Excel, SPSS, Statistica and other software.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Recognise the methods of different types of visual aids (Understand)

MO 2: Explain the graphical types and their uses (Remember)

MO 3: Classify graphs based on various purpose and functions (Apply)

MO 4: Develop essential skills in graph preparation using software (Apply)

MO 5: Understand and acquaint with different software (Analyse)

Module IV: Presentation: Oral and Poster Presentation, Preparation of Oral and poster presentations. Software: MS Power point

Module Outcomes (MO):

After Completion of this module, the student should be able to:

MO 1: Recognize the importance of data presentation (Understand)

MO 2: Distinguish oral and poster presentations (Apply)

MO 3: Recognize the importance of oral and poster presentations (Understand)

MO 4: Familiarize with software for data presentations (Apply)

MO 5: Develop skills in power point presentation preparation (Remember)

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Class Room Activities:

- Assignments
- Seminar Presentation on selected topics
- Case studies
- Problem solving
- Analyses of research papers and reports

ASSESSMENT

40% Continuous / Formative Assessment (see PG Regulations).

60% End-semester/Summative Assessment: 3 hour written Exam.

References

Anderson, J., B.H. Durston& M. Poole 1970. Thesis and Assignment Writing. Wiley Eastern

Pvt.Ltd., New Delhi

Briscoe, M.H. 1996. Preparing Scientific Illustrations. Springer, NY, 204 pp.

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India

Day, R.A. 1 979. How to Write and Publish s Scientific Paper. ISI Press, Pennsylvania, 160 pp.

Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed.Affiliated East-West Press.

Kerlinger FN. 1983. *Foundations of Behavioural Research*. Surjeet Publ.

Kothari, C.R. 2005. Research Methodology. Methods and Techniques. 2nd ed. New Age Internat. (P) Ltd., Publ., New Delhi, 401 pp.

Kumar R. 1996. *Research Methodology: a Step-by-Step Guide for Beginers*. Sage Publ.

Rossiter DG. 2003. *Preparation for M.Sc. Thesis Research*. ITC, Netherlands.

Sandhu, G.S. 1990. Research Techniques in Biological Sciences. Amol Publ., New Delhi, 388 pp.

Sinha VRP. 2005. *Fisheries Research Planning and Management in Developing Countries*. Narendra Publ. House.

von Normann, R.W. 1971. Experimental Biology. 2nd ed. Prentice Hall Inc., N.J., 269 pp.

Walliman N. 2001. *Your Research Project: a Step-by-Step Guide for the First Time Researcher*. Sage Publ.

On-line Sources

ftp://ftp.fao.org/docrep/fao/008/y6634e/y6634e00.pdf

http://envfor.nic.in/legis/awbi/awbi01.html

http://study.com/academy

http://www.inflibnet.ac.in/ess/

https://explorable.com/research-methodology

https://ndl.iitkgp.ac.in

https://www.nature.com/scitable/topicpage/effective-writing-13815989

https://www.ugc.ac.in/

SEMESTER	Course Code: AAQ-SE-503	Credits: 2

NAME OF THE COURSE: **UNDERWATER RESEARCH & RECREATION**

COURSE OUTCOMES (CO)

CO 1: Understanding need and scope of underwater research and recreation

CO 2: Enable to execute water recreation and make hobbies

CO 3: Develop capability to perform swimming and Scuba diving

CO 4: Understand the concept of drowning and first aid

CO 5: Demonstrate knowledge and understanding the applicationof first aid techniques for drowning

CO 6: Develop skills in under water observation and research

CO 7: Basic knowledge in first aid techniques.

COURSE CONTENT

Module I: Water Sports and recreation: Sport fishery, Eco tourism, Water sports –Pool sports, river/lake sports, underwater exploration and other oceanic sports. Adventure events.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Recognize and understand water sports and recreation (Understand)

MO 2: Distinguish ecotourism and aquatourism (Create)

MO 3: Analyse different aquatic championships and underwater explorations (Apply)

MO 4: Develop essential skills sport fishery (Apply)

MO 5: Develop overall idea oceanic and adventure sport events (Analyse)

Module II: Swimming and SCUBA: Swimming, method of swimming, swimming styles. Swimming pools and hygiene. Swimming sports events. SCUBA – Diving classification and forms of diving – Scuba apparatus and accessories – Training and safety – basic and advanced skills.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Recognise need for swimming and diving (Understand)

MO 2: Understand the basic and advance swimming and scuba diving techniques (Remember)

MO 3: Use and apply the safety procedures of swimming and diving (Apply)

MO 4: Develop essential skills in swimming and scuba diving (Apply)

MO 5: Illustrate overall knowledge on scuba apparatus and accessories (Analyse)

Module III: Physical Fitness and Water Hazards: Physical fitness for water sports, Aquatic Diving Hazards – Drowning, Salt water aspiration syndrome, hypothermia, infections, dangerous animals, pressure related diseases, other medical problems.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Recognise the need for physical fitness for water sports (Understand)

MO 2: Explain the types water sport hazards (Remember)

MO 3: Classify different syndromes and diseases due to diving (Apply)

MO 4: Develop essential skills in identifying symptoms of hazards (Apply)

MO 5: Develop overall idea on deep diving hazards (Analyse)

Module IV: First Aid: General first aid protocols, CPR, Injuries, Snake bite, First aid for Divers - first aid kit - Bleeding, shock, thermal and pressure management. Emergency oxygen, Other illness management.

Module Outcomes (MO)

After Completion of this module, the student should be able to:

MO 1: Recognize the importance of first aid (Understand)

MO 2: Distinguish various first aid techniques for drowning (Apply)

MO 3: Recognize the importance of deep diving diseases and syndromes (Understand)

MO 4: Distinguish the principles in CPR (Apply)

MO 5: Develop skills for use of first aid kits (Remember)

ACTIVITIES, LEARNING RESOURCES & ASSESSMENT

Suggested Class Room Activities

- Assignments
- Seminar Presentation on selected topics
- Case studies
- Problem solving
- Analyses of research papers and reports

LEARNING RESOURCES

References

Edmonds, C., B. McKenzie, R. Thomas and J. Pennefather, 2012. Diving Medicine for SCUBA Divers (4 Ed.), Carl Edmonds, Australia, 359pp.

France, R.L., 2012. Environmental Restoration and Design for Recreation and Ecotourism (Integrative Studies in Water Management and Land Development). CRC Press (Taylor & Francis Group), Boca Raton, 237pp.

Halls, M. and M. Krestovnikoff, 2006. Scuba Diving (Eyewitness Companions). DK Publishing, London, 344pp.

Halls, M., 2007. Go scuba dive. DK Publishing, London, 159pp.

Kato, N. and S. Kamimura (Eds.), 20. Bio-mechanisms of Swimming and Flying: Fluid Dynamics, Biomimetic Robots and Sports Science, Springer, Tokyo, 403pp.

Klutz, 1999. Swimming Pool Games (A Klutz Guide), Klutz Inc. USA, 12pp.

Orr, D. and E. Douglas, 2007. Scuba Diving Safety. Human Kinetics, USA, 194pp.

On-line Sources

http://www.swim.tj

https://matsyafed.in

https://nhcps.com

https://www.bonniercorp.com

https://www.enjoy-swimming.com

https://www.fina.org

https://www.liveabout.com

https://www.medicalnewstoday.com

https://www.padi.com

https://www.scubadiving.com/

https://www.topendsports.com

https://www.webmd.com

https://www.wikihow.com