Vidyasagar University
Midnapore-721102, West Bengal

The SYLLABUS for
POST-GRADUATE Programme

in

FISHERIES SCIENCE

Under Choice Based Credit System (CBCS)
(Semester Programme)



[w.e.f. 2022-23]

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PREFACE

Fisheries sector plays an important role in the socio-economic development of the country in view of its potential contribution to national income, food security, social objectives and sustainable large export earnings. India's future fisheries development plans aim at increasing fish production, improving the welfare of fishermen, promoting export earnings and providing food security. In this context, the trained manpower has been identified as a critical input to fisheries development. The mandate of the Vidyasagar University is to plan, undertake, aid, promote and co-ordinate education, research and extension in Fisheries Science for the livelihood generation of a large section of the region and our university will play a key role in fisheries education and research in the state of West Bengal, in particular and India or outside India in general.

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GENERAL INSTRUCTIONS

1. M.Sc. in Fisheries Science course is of two years duration and is divided into four semesters consisting of 1200 Marks (Total 24 Courses; 22 Core Courses and 2 Elective Courses). Each course has 4 credits (Total 96 Credits).

2. Each semester has 300 Marks (24 credits). Semester I, II & III has 6 courses/papers each (4 Theory courses and 2 Practical courses). The Semester-IV has Job training, Dissertation thesis and Grand Viva particularly on the hands on training and field aspects. Each theory course is subdivided into two units of 25marks each (2 credits). Each practical course of I, II, and III semesters are of 50 marks (4 credits), whereas each courses of Semester IV having 8 credit each.

3. There is Elective Course of 100 Marks in the semester – II (50 Marks = 4 credits) and Semester – III (50 Marks = 4 credits).

4. There is a special paper, 'Aquaculture' in semester III & IV having two Theory papers = 8 credits and one practical paper = 4 credit. The dissertation work related to special paper (8 credits) is in the Semester -IV.

5. Each theory course is to be evaluated by internal assessment – 10 marks and University semester examination - 40 marks. For each theory course/paper, there will be two internal assessment examinations which will be evaluated by written test. The practical course/ paper of each semester will bear 50 marks.

6. There is no theory paper in semester IV. So, there are field base job training/skill development programme, field/laboratory based dissertation thesis and identify the performance of overall knowledge in subject through grand viva. The students have to carry out an individual dissertation paper of 100 marks (8 credits).This paper will be evaluated by a project report, seminar presentation and *viva- voce* examination.

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PROGRAM OUTCOME

The M.Sc. in Fisheries Science programme is designed to impart knowledge and technical skills to understand this rapidly changing field of modern Aquaculture. It also aims to empower students to understand the recent trends and challenges of farming society in the field of Aquaculture and get confidence to work on different kinds of aquaculture practices. The programme has been structured in a way that the students will be acquainted with both basic and applied aspects of Aquaculture. The course also has a strong lab and Project component, where the students can acquire practical knowledge and hands-on training in the field to handle any challenging task in aquaculture and employable skills. Students would also become aware of the socio-economic and environmental significance of aquaculture and their relevance to the national economy.

The programme based on choice-based credit system is designed to ignite the inquisitive mind to enter into research in interdisciplinary areas. Keeping in view of the CSIR-UGC-NET and ICAR Exams, the syllabus was framed in all the courses to enable the students to determine their career in the fields of research, teaching and scientific positions in research institutes and aquaculture-based Industries.

After successful completion of M.Sc. in Fisheries Science programme, the students have a good understanding of the culture techniques of various aquatic organisms which would be helpful for the production of healthy food for human consumption in a sustainable manner. The programme will open up several avenues for students in terms of research and employability. Students would sufficiently be skilled in using relevant tools and techniques for the better management of culture ponds and hatcheries with reference to water quality, diseases, nutrition and supplementary feeds as well as marketing and fish processing. This programme will make them suitably knowledgeable to become entrepreneurs or to undertake jobs in different sectors of aquaculture such as in farms, hatcheries, analytical laboratories, feed industries, fish processing industries, marketing, etc. The broad skills and the deeper knowledge in the field would make them highly successful aquaculturists.

The department of Fishery Sciences, Vidyasagar University was to undertake and encourage the education, research and extension in Fisheries Science for the livelihood generation of a magnanimous segment of the Southern region of the West Bengal state particularly in the weaker sections of the communities. The course curriculum of the Fisheries Science was design in such a manner that will directly help to the passed out students for recruitment in the corporate as well as in the Govt. sectors. Therefore, thrust areas included in the syllabus are: Aquatic resources and their management, aquatic environment management and climate change, biomechanics, physiology, biochemistry of fishes, aquatic microbiology and public health fishery, genetic engineering and biotechnology, fish pathology and disease management, fisheries technology and harbor engineering are the major one. Moreover, detailed course of each unit of the all semesters will directly support to the career orientation of student for placement in the arena of the fisheries sectors.

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COURSE CURRICULUM DESIGN
FOR M. Sc. IN FISHERIES SCIENCE

TOTAL MARKS - 1200 (96 Credits)	**1st SEMESTER- 300 (24 credits)**	**6 Core courses (4 Theory + 2 Practical courses)**
	2nd SEMESTER-300 (24 credits)	**5 Core courses (3 Theory + 2 Practical courses) and 1 Elective course**
	3rd SEMESTER-300 (24 credits)	**5 Core courses (3 Theory + 2 Practical courses) and 1 Elective course**
	4th SEMESTER-300 (24 credits)	**3 skill based Core courses (field based practical) i.e. job training / skill development programme, dissertation thesis and grand viva.**

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FRAME OF THE SYLLABUS

FIRST SEMESTER

300 Marks - 24 Credits

[Core courses (Theory) - 200; Core courses (Practical) - 100]

University Examination - 80%; Internal Assessment - 20%

THEORY PAPER	UNIT	TOPIC	CREDITS	MARKS
FSC-101 (Core course)	UNIT-1	Fisheries Resource and Management	4(3-1-0)	25
	UNIT- 2	Fisheries Legislation & Bioinformatics		25
FSC-102 (Core course)	UNIT-1	Fish Taxonomy, Biology and Conservation	4(3-1-0)	25
	UNIT- 2	Geographic distribution, Adaptation and Evolutionof fishes		25
FSC-103 (Core course)	UNIT-1	Anatomy and Physiology of finfish and shell fish	4(3-1-0)	25
	UNIT- 2	Fisheries Technology andHarbour Engineering		25
FSC-104 (Core course)	UNIT-1	Pollution, Eco-toxicology andAquatic Microbiology	4(3-1-0)	25
	UNIT- 2	Oceanography, Remote sensing & GIS and DisasterManagement		25

PRACTICAL PAPER	TOPIC	CREDITS	MARKS
FSC-195 (Core course)	Based on FSC -101 and FSC -102	4 (0-0-8)	50
FSC-196 (Core course)	Based on FSC -103 and FSC -104	4 (0-0-8)	50

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SECOND SEMESTER

300 Marks - 24 Credits

[Core courses (Theory) - 150; Elective course (Theory) - 50;Core courses (Practical) - 100]

* University Examination - 80%; Internal Assessment - 20%

THEORY PAPER	UNIT	TOPIC	CREDITS	MARKS
FSC-201 (Core course)	UNIT-1	Aquatic Ecology and Ecosystem Management	4 (3-1-0)	25
	UNIT- 2	Fish Processing Technology and Quality Assurance		25
FSC-202 (Core course)	UNIT-1	Reproduction in Finfish & Shellfish	4 (3-1-0)	25
	UNIT- 2	Fish Breeding, Hatchery Design & Management		25
FSC-203 (Core course)	UNIT-1	ish Diseases and Management	4 (3-1-0)	25
	UNIT- 2	Fisheries Extension, Economics and Marketing		25
FSC-204 (Elective course forCBCS)	UNIT-1	Fundamentals of Fisheries Science	4 (3-1-0)	25
	UNIT- 2	Aquaculture Management		25

PRACTICAL PAPER	TOPIC	CREDITS	MARKS
FSC-295 (Core course)	Based on C -201 and FSC -202	4 (0-0-8)	50
FSC-296 (Core course)	Based on FSC -202 and FSC -203	4 (0-0-8)	50

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THIRD SEMESTER

300 Marks - 24 Credits

[Core courses (Theory) - 150; Elective course (Theory) - 50;Core courses (Practical) - 100]

University Examination - 80%; Internal Assessment - 20%

THEORY PAPER	UNIT	TOPIC	CREDITS	MARKS
FSC-301 (Core course)	UNIT-1	Fisheries Statistics andResearch Methodology	4 (3-1-0)	25
	UNIT- 2	Immunology, GeneticEngineering and Bioinstrumentation		25
FSC-302 (Core course) Special paper: Aquaculture	UNIT-1	Fish Genetics and Biotechnology	4 (3-1-0)	25
	UNIT- 2	Aquaculture Engineeringand Management		25
FSC-303 (Core course) Special paper: Aquaculture	UNIT-1	Aquaculture Practices	4 (3-1-0)	25
	UNIT- 2	Fish Nutrition & Bioenergetics		25
FSC-304 (Elective course forCBCS)	UNIT-1	Aquaculture Technology	4 (3-1-0)	25
	UNIT- 2	Fisheries Entrepreneurship Development		25

PRACTICAL PAPER	TOPIC	CREDITS	MARKS
FSC-395 (Core course) General paper	Based on FSC -301	4 (0-0-8)	50
FSC-396 (Core course) Special paper: Aquaculture	Based on FSC -302 and FSC -303	4 (0-0-8)	50

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FOURTH SEMESTER

300 Marks - 24 Credits

[Core courses (Practical) - 300]

PRACTICAL PAPER	TOPIC	CREDITS	MARKS
FSC-491 (Core course)	**Job training / Skill development programme through data collection from different aquaculture related fields/farms/Market, report writing, presentation and viva-voce**	**8 (0-0-16)**	**100**
FSC-492 (Core course) Special paper: Aquaculture	**Dissertation Thesis (Project work)**	**8 (0-0-16)**	**100**
FSC-493 (Core course)	**Grand viva will be based on the overallunderstanding of the subject**	**8 (0-0-16)**	**100**

Distinctive features of the courses:

- **Value-added course:**
  FSC-201.2, FSC-295, FSC-296, FSC-202, FSC-302, FSC-202, FSC-295, FSC-296, FSC-395, FSC-396
- **Ethics, gender, human values, environment & sustainability:**
  FSC-203.2, FSC-295, FSC-296

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1st SEMESTER

(24 credits: 300 Marks)

Core course (Theory) - 200 Marks + Core course (Practical) - 100 Marks

FSC-101

(Core course - 4 credits: 50 Marks)

[University Examination - 40 and Internal Assessment-10]

UNIT- 1: Fisheries Resource and Management: (2 credits): 20+5 =25 Marks

Scenario of world fisheries. Major fishing nations and major fishing regions of the world. Trends of Indian fisheries. Major river systems of India and their fisheries. Current status, trend and problems of riverine fisheries. Effect of human intervention in rivers. Classification of reservoirs, present productivity levels and fishery potentials. Problems and prospects of reservoir fisheries in India. Measures to increase their production and economic management of reservoirs. Coldwater resources of India. Important cold-water fish species. Status of cold-water fisheries in India - Mahseer, Trout and sports fisheries in India. Brackish water fishery resources of India. Estuaries of India and their fisheries. Problems and management practices; present trend of marine capture fisheries of India; Management of marine fisheries in Indian context. Important finfish and shellfish resources in demersal and pelagic systems. Important groups of finfishes and shellfishes having commercial importance.

Course outcome: To understand the present state of exploitation and future potential of fisheries resources, student will gain knowledge on the different water resources of India. Inland fish biodiversity, which is important to ecosystem function and services, is threatened by many pressures, making inland fisheries one of the most endangered groups of species in the world. Learning the methodologies for assessments of inland fisheries resources is utmost necessary for the formulation of conservation methods and to adopt practices to enhance fish production. Estuarine as well as marine fisheries of India are major contributor for livelihood security and earning of foreign exchange by exporting fish and fishery products. This part will help in understanding the present level of exploitation, understanding the major problems, and to impart knowledge on recent methodologies of sustainable exploitation of renewable resources. As this sector provides major employment in culture, post-harvest processing, export, crafts and gear industries, student will be benefit immensely by studying various resources and their management practices.

Reference Books:

1. Coldwater Fisheries of India. Edited by V. G. Jhingran and K. L. Sehgal, IFSI, Kolkata.
2. Fish and Fisheries of India by V.G. Jhingran 3rd Edn. Hindustan Publishing Corporation. 1991.
3. Handbook of Fisheries and Aquaculture. ICAR Publication New Delhi, 2016.
4. Management Systems for Riverine Fisheries. FAO Fisheries Technical Paper. FAO, 1986.
5. Reservoir Fisheries of India. by V.V. Sugunnan. FAO, 1995.

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UNIT- 2: Fisheries Legislation and Bioinformatics: (2 credits): 20+5 =25 Marks

Fisheries administrative setup at central and states. Indian Fisheries Act, 1897; The MPEDA Act, 1972; The Maritime Zone of India (regulation of fishing by foreign vessels) Act 1981; Marine Fisheries Policy, 2004; The Coastal Aquaculture Authority Act, 2005; Marine fisheries legislation in the maritime states of India; Code of Conduct for Responsible Fishing; Inland Fisheries Act; Indian wildlife (protection) Act, 1972; The Merchant Shipping Act, 1958; The Coast Guard Act, 1978. Introduction and scope of Bioinformatics. Concepts, brief history and its role and importance in fisheries and aquaculture. Field of application and common biological database. Major bioinformatics resources; Knowledge of various database. Important bioinformatics tools used in fisheries and aquaculture. Computational analyses of genomes and proteomes. Basic concepts in computational phylogenetic analysis. Role of ICT in Aquaculture sector. AI in aquafarming.

Course outcome: To familiarize with the underlying importance of proper governance of the fisheries sector in India and to understand the status of fisher folk in the country, various administrative setup in the fisheries sector will help the student to understand the fisheries governance in the country. The student shall able to know about the fisheries legislation in India: background, Indian Fisheries Act and subsequent amendments. The existing laws on marine fisheries sector as well as in the inland fisheries sector. This part will also provide knowledge on modern communication techniques such as Internet based technologies, video and teleconferencing, computer assisted instructions, community networks, cyber extension and e-learning and also provide knowledge to understand various database and bioinformatics tools.

Reference Books:

1. Bioinformatics - A Beginners Guide by Claverie & Notredame, Wiley-Dreamtech India Pvt Ltd.
2. Bioinformatics: Concepts, Skills and Applications by Rastogi et al 2003.. CBS
3. Bioinformatics: Principles and Applications by Harshawardhan P.B. Tata McGraw Hill Publishing Company Ltd.
4. Biological Sequence Analysis. by Durbin R., Eddy S., Krogh A. and Mithchison G. Cambridge University Press. 2007.
5. Fisheries Governance and legislation in India. Edited by D.K. Pandey and H.K. De. NPH, New Delhi.

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FSC-102

(Core course - 4 credits: 50 Marks)

[University Examination - 40 and Internal Assessment- 10]

UNIT- 1: Taxonomy, Classification, Biology, Biodiversity & Conservation of fishes: (2 credits): 20+5 =25 Marks

Definition and basic concepts of biosystematics, taxonomy and classification. ICZN and scientific nomenclature. Taxonomic keys. Modern tools and techniques in Ichthyo-taxonomy. Types and molecular approaches of taxonomy. Classification of finfishes and shellfishes (Vertebrate up to Order and Invertebrate up to Sub-class). Method employed in phylogenic studies. DNA bar-coding and cataloguing. Definition and concept of fish biology study. Biology of commercially important freshwater, brackish water and marine finfishes & shellfishes; Factors influencing aquatic biodiversity; Types of biodiversity - Species diversity in different ecosystems; Genetic Diversity and Habitat Diversity; Biodiversity indices and their significance; Concepts of Index of Biotic Integrity (IBI); Global fish diversity and loss of fish biodiversity. Endangered species as per the guidelines of IUCN; Threatened aquatic species of India; Issues and strategies of conservation of aquatic species; Factors threatening indigenous species; *In-situ* and *Ex-situ* conservation mode. Regulations regarding introduction of exotic and invasive aquatic species and their impact on aquatic ecosystem.

Course outcome: This course helpful to our student to identify the fishes and study their characteristics. These basic ideas are directly related to research and aquaculture productivity. Biology, Biodiversity conservation. This portion helps to our students to study the feeding habit, breeding habit, diversity pattern. This portion also helps to study the conservation mode of aquatic animals. This knowledge is very much helpful to aquaculture related different aspects..

Reference Books:

1. Burukovskii, R.N. 1982. Key to Shrimps and Lobsters. Oxonian Press Pvt. Ltd., Delhi.
2. Day, F. 1989. Fishes – Vol.I. Today and Tomorrow's Printers and Publishers, New Delhi.
3. Day, F. 1994. Fishes – Vol.II. Jagmander Book Agency, New Delhi.
4. Dobson, Andrew P. 1995. Conservation and biodiversity. Scientific American Library, New York.
5. Gunther, A.C.L.G. 1993. An Introduction to The Study of Fishes. Discovery Publishing House, New Delhi.
6. Hochachka, W.P. 1983. The Mollusca (Vol II). Academic Press, London.
7. Jayaram, K.C. 1998 .The Freshwater fishes of the Indian Region. Narendra Publishing House, Delhi.
8. Kapoor, V.C. 2019. Theory And Practice Of Animal Taxonomy And Biodiversity. 8th Edition. Oxford & IBH Publishing.
9. Kotpal, R.L. 1992. Mollusca. Rastogi Publications, Meerut.
10. Krishnamurthy, K V. 2006. An advanced textbook on biodiversity : principles and practice. Oxford and IBH Publishing, New Delhi.

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11. Kurian, K.V. and Sebastian, V.O. 1993. Prawns and Prawn Fisheries of India. Hindustan Publishing Corporation, New Delhi.
12. Lagler, K.F. et al. 1977. Ichthyology.1st Edition. John Wiley & Sons, Inc., New York.
13. Narasimham, K.A. 2005. Molluscan Fisheries of India. B. R. Publishing, Delhi.
14. Narendran, T C. Balakrishnan, M. 2008. Systematics and biodiversity conservation. Agrobios (India), Jodhpur.
15. Nelson, J.S. 1994. Fishes of The World. 3rd Edition. John Wiley & Sons, Inc., New York.
16. Simpson, G.G. 1961. Principles of Animal Taxonomy. Columbia University Press, Columbia. ISBN: 9780231888592
17. Subba Rao, N.V.S. 1989. Handbook, Fresh Water Molluscs of India. ZSI, Calcutta.

UNIT-2: Geographic distribution, Adaptation and Evolution of fishes (2 credits): 20+5 =25 Marks

Definition, concept, types of zoo-geographical realms. Geographical distribution of freshwater, brackish water and marine water fishes in India and abroad. Adaptation: Definition, types and mechanism of adaptation in freshwater, brackish water and marine water fishes. General accounts of Agnathan fishes, Chimeras and Dipnoans. Migration of fishes. Origin and evolution of major groups of fishes, Evolutionary strategies and morphological innovation. Evolutionary genetics. Living fossils of fishes.

Course outcome: Thrust of this unit is distribution, adaptation and evolution of fishes which is very baseline information for the student of Fisheries Science required to face at the time of any interview either entry in higher study or job recruitment.

Reference Books:

1. Gene Helfman, Bruce B. Collette, Douglas E. Facey and Brain W. Bowen. The Diversity of Fishes: Biology, Evolution, and Ecology (2nd Edition). WILEY-BLACKWELL.
2. Jeffry B. Graham. Air-Breathing Fishes, Evolution, Diversity and Adaptation: Academic Press.
3. Richard Swann Lull. Organic Evolution: Rarebooksclub.com
4. Philip A. Hastings, H. J. Walker and Grantly R. Garland: Fishes- A Guide to their Diversity: University of California Press.
5. Derek & Margaret Burton: Essential Fish Biology: Diversity, Structure and Functions: South Asia Edition: Oxford Press

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FSC-103

(Core course - 4 credits: 50 Marks)

[University Examination – 40 and Internal Assessment- 10]

UNIT- 1: Anatomy and Physiology of fin fish and shell fish: (2 credits): 20+5 = 25 Marks

Anatomical structure and physiology of digestive, respiratory, circulatory, excretory and endocrine system of finfish and shell fishes. Associated digestive gland and their functions. Mechanism of digestion and assimilation of food materials and nutrients. Aquatic and aerial respiratory mechanisms of fishes. Osmoregulation in finfish and shell fishes. Types of respiratory organs, gill structure of different finfish and shell fishes. Mechanism of gaseous exchange and their transport. Types and morphological structure of heart, cardiovascular physiology and haematology of finfish and shell fishes. Anatomical structure and physiology of reproductive system of finfish and shell fishes. Gametogenesis, fertilization, organogenesis and embryonic development of finfish and shell fishes. Skeleton system, Endocrine gland and neuro-endocrine system of fishes.

Course outcome: The foremost area of this unit is anatomy and physiology of fishes which is very much essential those are recruited in aquafarming system of Indian major carp culture as well as in shrimp farming.

Reference Books:

1. Alan GH. 1995. *Water Pollution and Fish Physiology*. CRC Press.
2. Barrington EJW. 1981. *Invertebrate Structure and Function*. 2nd Ed. The English Language, Book Society and Nelson.
3. Bernier, N, Kraak, GVD. Farrell, A.P. and Brauner, C.J. 2009. *Fish Physiology: Fish Neuroendocrinology*. Elsevier. 529 pp.
4. Bone, Q. N.B.Marshall and J.H.S.Blaxter, 1995. *Biology of Fishes* (2nd edition) Black ie Academic and professional, New york. 332 p.
5. Carl E. Bond. 1979. *Biology of Fishes* (2nd edition). Saunders college publishing Harcount Brace college publishers, New york. 750 p.
6. Diwan AP and Dhakad NK. 2004. *Embryology of Fishes*. Recent Advances in Embryology, Series-1. Anmol Publ.
7. Diwan, 2007. *Physiology of Marine White Shrimp: Fenneropenaeusindicus*. Delhi Narendra Publishing House: “x, 245p.” ISBN: 81-85-375-93-3
8. Ede DA. 1978. *An Introduction to Developmental Biology*. Blackie.
9. Evans DH and Claiborne JB. 2006. *The Physiology of Fishes*. CRC Press.
10. Evans. 2014. *Physiology of fishes.* Boca Raton CRC Press 2014 Edition: 4th:
11. Ghosh R. 2007. *Fish Genetics and Endocrinology*. Swastik Publ. and Distr.
12. Hoar, W.S. and D.J Randall (Ed.) 1969. *Fish Physiology* vol.III Academic press, New york. 415p.
13. Hoar WS, Randall DJ and Donaldson EM. 1983. *Fish Physiology*. Vol. IX. Academic Press.
14. Hoar WS and Randall J. (Ed.). 1988. *Fish Physiology*. Vol XI. The Physiology of Developing Fish. Part B. Viviparity and Post hatching Juveniles. Academic Press.

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15. Jobling M. 1995. *Environmental Biology of Fishes*. Chapman and Hall.
16. Johnston, 2014. *Fish physiology* (Series 1-35 volumes) New Delhi Reed Elsevier India Pvt Ltd.
17. Nielsen , 1983. *Animal Physiology: Adaption and Environment* New York Cambridge University Press Edition: 3rd: "xii, 619p"
18. Northcutt RG and Davis RE. 1983. *Fish Neurobiology*. University of Michigan Press
19. Pickering AD. 1981. *Stress and Fish*. Academic Press.
20. Rankin JC and Jensen FB. 1996. *Fish Ecophysiology.* Chapman and Hall.
21. Reinecke , 2006. *Fish Endocrinology*, Vol.1 & 2": Enfield "Science Publishers,
22. Rocha, 2008. *Fish reproduction*. Enfield "Science Publishers, Inc. xiii, 629p" ISBN: 978-157808-331-2
23. Samantaray, 2015. *Physiology of Finfish and Shellfish*.: New Delhi New India Publishing Agency Scharrer E. 1963. *Neuroendocrinology*. Columbia University Press.
24. Silas EG. 1983. *Development of Penaeid Prawns*. CMFRI Bull. No. 28.8.Werner A. Muller, 1996. Developmental Biology, Springer. 328p.
25. Smith, Lynwood S." 1999. *Introduction to Fish Physiology*. Narendra Publishing House
26. Thomas PC, Rath SC and Mohapatra KD. 2003. *Breeding and Seed Production of Finfish and Shellfish*. Daya Publ. House.
27. Venkataramanujam, K. and N. Ramanathan 1994. *Manual of Finfish Biology*. Oxford and IBH publishing Co. pvt. Ltd 1108.

UNIT- 2: Fisheries Technology and Harbour Engineering: (2 credits): 20+5 =25 Marks

Principles and operation of different types of Crafts and Gears used in inland and marine fishing. Design and fabrication of various fishing gears; Different types of gear materials. Traditional and mechanical vessels. Inland and marine crafts; Types of mechanization of crafts. Trawlers and technique of trawling. Preservation of Crafts and Gears. By-catch Reduction Devices (BRD); Turtle Exclusion Device (TED) and Fish Aggregation Devices (FAD); Acoustics; Safety devices; Vessel Monitoring Systems; Satellite navigation systems; Advanced communication Systems. IUU - Illegal, Unregulated and Unreported fishing methods. Principles and site selection for construction of fishing harbour. Classification and functions of fishing harbor. Design and layout of a modern fishing harbour. Harbours and their relationship with environment and fishing harbour management.

Course outcome: The thrust area of this unit is fisheries technology and harbour engineering which is essential those are recruited in fishing harbor related services in India and abroad.

Reference Books:

1. Baranov FI. 1969. *Selected Works on Fishing Gear* Vol. I *Commercial Fishing Techniques*, Programme for Scientific Translations, Jerusalem, 631p.
2. Baranov FI. 1977. *Selected Works on Fishing Gear*. Keterpress Enterprises. Israel: 259 p.
3. Ben-Yami M. 1994. Purse seining manual, FAO Fishing manual, 416p.
4. Biswas KP. 1996. *Harvesting Aquatic Resources*. Daya Publishing House – Delhi: 207 p.
5. Bjordal and Lokkeborg S. 1998. *Long Lining*, Fishing News Books Ltd. Farnham, 208p.
6. Brandt AV. 1984. *Fish Catching Methods of the World*. Fishing news books Ltd., London, 432p.

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7. FAO. 1962. *Second Report to Government of India on Fishing Harbour Based on the Work of BW Johnson*. FAO Report No. 1538 EPTA, pp. 99.
8. FAO. 1987. *Small Scale Fishing Gear*: 19 – 44pp.
9. Fridman AL. 1986. *Calculations for Fishing Gear Designs*, FAO Fishing manual, Fishing News Books, Ltd., Farnham, 264p.
10. Fyson JF. (ed). 1985. *Design of Small Fishing Vessels*, Fishing News Books, Oxford.
11. John Garner. 1988. *Modern Deep-Sea Trawling Gear*. Fishing News Books Ltd. England: 91p
12. Kristionsson H. 1975. *Modern Fishing Gear of the World*. The White Friars Press Limited. London: 594 p.
13. Marine institute. 1988. *Proceedings of the World Symposium on Fishing Gear and Fishing Vessel Design*, The Newfoundland and Labrador Institute of Fisheries and Marine Technology, St. John's, Newfoundland, Canada, 610p.
14. Ponnambalam A. 2003. *Fishing Craft Technology*. CIFNET. Cochin: 158p.
15. Ramakrishnan TK. 2007. *Ocean Engineering*. Gene – Tech Books. New Delhi: 233p.
16. Sanisbury JC. 1996. *Commercial Fishing Methods-an Introduction to Vessels and Gear*, Fishing News Books Ltd., Farnham, 352p.
17. Sciortino SA, Barcali A and Carlesi M. 1995. *Construction and Maintenance of Artisanal Fishing Harbours and Village Landingss*. FAO. Rome: 136p.
18. Shaul Hameed M and Boopendranath MR. 2000. *Modern Fishing Gear Technology*: 193p.
19. Shenoy Latha. 1988. *Course Manual in Fishing Technology*, CIFE, Mumbai, 95p.
20. Sreekrishna Y and Shenoy Latha. 2001. *Fishing Gear and Craft Technology*. Indian Council of Agricultural Research. New Delhi, 342p.
21. Sreekrishna Y and Shenoy Latha. 2001. *Fishing Gear and Craft Technology*. Indian Council of Agricultural Research, New Delhi, 342p.
22. Tan-olofTraung. 1967. *Fishing Boats of the World*. Fishing News (book) limited. London. 635p.
23. Yadav YS. 2002. *Traditional Fishing Craft of the Bay of Bengal*. BOBP. Chennai: 55p.

FSC-104

(Core course - 4 credits: 50 Marks)

[University Examination – 40 and Internal Assessment - 10]

UNIT- 1: Pollution, Eco-toxicology and Aquatic Microbiology: (2 credits): 20+5 =25 Marks

Definition, types, sources of pollutants. Common transport process of pollutants in the aquatic environment. Eutrophication and their impact on aquaculture. EIA and its impact on aquaculture. Impact of pollution on fish health. Prevention and control of different aquatic pollution. Role of central and state government in pollution control. Pollution indicator species. Definitions and concepts of ecotoxicology. Toxicokinetics and toxicodynamics. General idea of xenobionts and their properties. Toxicity testing and bioassay. Factors modifying toxicity. Toxicity caused by heavy metal and their treatment, Phytotoxins and toxicity caused by agrochemicals. Maximum Residual Limits (MRL) of various drugs and chemicals in fish metabolism. Effect of selected toxicants on aquatic life. Biotransformation of xenobionts. Immunotoxicology and Environmental Genotoxicology. Introduction and scope of aquatic microbiology. Influence of

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physico-chemical and biological factors on aquatic micro-organisms. Microbial growth and its measurement. Types of media used for isolation and enumeration of aquatic microorganisms. Methods for identification of aquatic microbes (morphological, cultural, biochemical and molecular approach). Methods of control of microbial growth (physical and chemical). Concept of probiotics and prebiotics in aquaculture. Microbial biofilms and its significance. Microbial bioremediation. Role of microbes in biogeochemical cycle.

Course outcome: Aquatic pollution and ecotoxicology : In this portion student get idea about the pollution aspects of water, waste water recycling process, impact of toxic chemicals in fish and environment. This ideas is highly essential those student work in the Government job in fisheries field. Aquatic Microbiology & Public health fisheries : This portion helps to our student to identification of aquatic microbes and their role in fish production, Water purification process through microbes, probiotics etc. Student get job in company either as technologist or fishery microbiologist.

Reference Books:

1. Alan, G. Heath. 1995. Water pollution & Fish physiology: 2nd edition. Lewis publishers, Bocaraton, New York, London, Tokyo.
2. APHA. 1995. Standard Methods for the Examination of Water and Wastewater. 19th Edition, American Public Health Association, Washington.
3. APHA. 2012. Standard Methods for the Examination of Water and Waste water: 22nd edition.
4. Aravind Kumar. 2008. Aquatic Environment and Toxicology. Daya Publishing House, New Delhi.
5. Bonell, A.O. 1994. Quality Assurance in Seafood Processing: A practical Guide. Chapman and Hall, New York.
6. Boudou, Alain., Ribeyre, Francis. 1989. Aquatic ecotoxicology : fundamental concepts and methodologies. CRC Press , New York.
7. Buchanan, R.E. and Gibbons, N.E. (Co-Eds.). 1975. Bergey's Manual of Determinative bacteriology. The Williams & Wilkins Company, Baltimore.
8. Burgess, et al. 1982. Fish Inspection and Quality Control. Fishing News Books Ltd England.
9. Chhatwal, G.R., M.C. Mehra, T. Katyal, M. Satake, Mohan, K. and T. Nagahiro. 1995.Environmental Water Pollution and its Control. Anmol Publications Pvt. Ltd., NewDelhi.
10. Clark, R.B. 1994. Marine Pollution. Clarendon Press, Oxford.
11. Connell, J.J. 1980. Control of Fish Quality. Springer – Verlag, NewYork.
12. Edward A. Laws. 1993. Aquatic Pollution. Second Edition. Wiley Interscience, JohnWiley & Sons Inc., New York.
13. Huss, H.H. 1994. Assurance of Seafood Quality. FAO Fisheries Technical Paper 334, FAO, Rome, Italy.
14. Huss, H.H., et al.1992. Quality Assurance in the Fish Industry. Elsever Science Publishers, B.V., Amsterdam, Netherlands.
15. Hynes, H.B.N. 1978.The Biology of Polluted Waters. Liverpool University Press, UK.
16. Maduri Sharma and Govind Pandey. 2014. Toxicity and Treatment in Fish. Narendra Publishing House, New Delhi.
17. Moriarty, F. 2006. Ecotoxicology : the study of pollutants in ecosystems. 3rd edition. Elsevier India , New Delhi.
18. Pelczar, Michael J. 1993. Microbiology. Tata McGraw-Hill publishing Company Ltd., New Delhi.
19. Quality Assurance in sea food Processing. 2005. Published by CIFT, Cochin.

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20. Richard, T. Digiulio, David, E. Hinton. 2008. The Toxicology of fish. CRC Press, London, New York.
21. Subba Rao, M.V. 1998. A Manual of Practical Methods in Environmental Science. Andhra University, Visakhapatnam.
22. Volk, A.W. and Wheeler, M.F. 1980. Basic Microbiology. J.B. Lippincott Company, London.
23. Walker, C.H., Hopkin, S.P., Sibly, R.M., Peakall, D.B., 2006. Principles of ecotoxicology. 3rd edition. Taylor and Francis, New York.

UNIT- 2 : Oceanography, Remote sensing & GIS and Disaster Management: (2 credits): 20+5 =25 Marks

Definition and concept of oceans, geological, physical, chemical, biological oceanographic analysis. Zonation of ocean. Ocean currents, waves and tides. Renewable and non- renewable ocean energy. Anthropogenic activities and their monitoring and regulation through government and nongovernment organization. Sustainable management of Ocean. Definition and principles of Remote Sensing and GIS. Sensing mechanism. Analysis of images and data. Fisheries forecasting system. Global Positioning System (GPS). Application of Remote Sensing & GIS in conservation, management of fish faunal diversity and exploitation of capture fisheries. Application of Remote Sensing and GIS in coastal resource management and aquaculture. Basic concepts of disaster vulnerability in India. Different ways of detecting and predicting disaster. Natural and manmade hazards impact on fisheries and aquaculture sector in India. Pre disaster prevention and post disaster management in aquaculture sector. Measures to enhance sea safety.

Course outcome: Oceanography, Remote sensing & GIS : In this portion we want to give idea about the ocean resources, management. It is also help to study the techniques of Remote sensing to used for coastal zone and ocean areas management. Student get job in ocean research and remote sensing. With the help of modern technology of Remote sending aquaculturists learn about different disaster and safe guard the aquaculture through proper management.

Reference Books:

1. Reddy, M.P.M. 2000. Descriptive Oceanography. Oxford I.B.H. Ltd., New Delhi.
2. Sverdrup, H.U., Martin W. and Richard, H. Flemming. 1962. The Oceans: Their Physics, Chemistry, and General Biology. Asia Publishing House, Bombay.
3. Grant Gross, M. 1985. Oceanography. Charles E. Merrill Publishing Company, Columbus.
4. Sharma, R.C. and M. Vatal (Mrs. M. Hukku). 1992. Oceanography for Geographers. Chaitanya Publishing House, Allahabad.

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FSC-195
PRACTICAL PAPER
(Core course - 4 credits: 50 Marks)
[University Examination – 50]

1. Identification of common finfishes available from different aquatic resources of India.
2. Identification of common shellfishes available from different aquatic resources of India.
3. Identification of Agnathan fishes, Chimera, Dipnoan and Coelacanth fishes.
4. Study of distribution and adaptive modifications of different groups of fishes.
5. Study of migratory behavior of fishes
6. Study the morphometry of different fishes.
7. Preparation of taxonomic key.
8. Construction of chart regarding study of the phylogenetic tree/evolutionary tree.
9. Preparation of fish bar-coding.
10. Study of the Length-Weight relationship, Relative gut length, Gastro-Somatic index of fish.
11. Study of the feeding behavior, mouth-parts modification and gut content analysis from different fish groups.
12. Analysis of different biodiversity indices. (Community analysis through communitymap).
13. Biological studies of selected finfishes and shellfishes from different aquatic resources.
14. Field visit.

Course outcome: Fish and shellfish identification is the basic requirement of fisheries students. These are very much helpful for their research oriented activity. Fish Bar coding study in one of the job oriented programme in or Private sector. Taxonomic key and evolutionary tree preparation are necessary in different evolutionary research study.

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FSC-196
PRACTICAL PAPER
(Core course - 4 credits: 50 Marks)
[University Examination - 50]

1. Study of the digestive and circulatory systems of common species of finfishes.
2. Study of the urinogenital and nervous system of locally availablefinfishes.
3. Study of the digestive and nervous system of shellfishes.
4. Accessory respiratory organs of fishes.
5. Study of different endocrine glands of fishes and shellfishes.
6. Study of fish histology.
7. Estimation of fish yield potential.
8. Fisheries forecasting system; Remote sensing equipment. PFZ analysis.
9. Preparation of fish-skeletons.
10. Identification of traditional and modern fishing crafts and gears used in different aquatic system of India.
11. Identification of fishing gear accessories
12. Study of the different fish finding and safety devices used in fishing vessels.
13. Identification of different fouling organisms.
14. Isolation and culture of aquatic microbes
15. Staining of microbes.
16. Study of toxicity bioassay technique.
17. Identification of different aquatic pollution indicator species.
18. Studies on important bioinformatics tools and AI in fisheries
19. Database development through the survey, collection and analysis of data from fish market/fish cooperative societies/fish farm/NGOs etc.

Course outcome: The whole course curricula of the said paper fully based on the FSC - 103) and FSC - 104) which is required for the practical experience of the students those are selected in the research field as well as farming areas.

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2nd SEMESTER
(24 credits: 300 Marks)
Core course (Theory) - 150 Marks + Elective course (Theory) - 50 Marks
Core course (Practical) - 100 Marks

FSC-201
(Core course - 4 credits: 50 Marks)
[University Examination - 40 and Internal Assessment-10]

UNIT- 1: Aquatic Ecology and Ecosystem Management: (2 credits): 20+5 =25 Marks

Definition, Types and structure of Lentic and Lotic aquatic ecosystems. Physico-chemical characteristics of different water. Classification and thermal stratification of different water bodies. Coastal ecology. Adaptive modifications of aquatic organisms in different aquatic ecosystem. Definition, structure and management of pond, reservoir, riverine, mangrove, wetland, estuarine and marine ecosystems. Fisheries potentialities of different aquatic ecosystem. Restoration, Conservation and management of different aquatic ecosystem for sustainable uses. Productivity of aquatic ecosystems: Primary, Gross and Net productivity. Biomass, Food chain, Food web, Energy flow and Ecological pyramids. Ecology and Life history of Phytoplankton and Zooplankton. Role of plankton in water colour development.

Course outcome: The focused area of this unit is aquatic ecology which cover health of different aquatic environment where sustain the aquatic life. Information of these areas are very much important those are recruited in IMC based farming system and in shrimp farming system especially tiger prawn or vannamei.

Reference Books:

1. APHA (American Public Health Association). 2017. *Standard Methods for the Examination* Edition. American Public Health Association, Washington, D.C. *of Water and Wastewater*.
2. Baird DJ, Beveridge MCM, Kelly LA and Muir JF. 1996. *Aquaculture and Water Resources Management.* Blackwell Science Ltd., Oxford.
3. Beer T. 2017. *Environmental oceanography*. CRC Press
4. Cairns J Jr. 1994. *Implementing Integrated Environmental Management* Virginia Tech University.
5. Carter RWG. 1998. *Coastal Environments: An Introduction to the Physical, Ecological and Cultural Systems of Coastlines*. Academic Press, London.
6. Clark JR. 1992. *Integrated Management of Coastal Zones*. FAO Fisheries Technical Paper No. 327, Rome.
7. Clark RB. 2001. *Marine Pollution*. Oxford University Press.
8. *Coastal Area Management and Development* 1982. U.N. Department of International Economic and Social Affairs, New York.
9. Czernuszenko W and Rowinski P. 2005. *Water quality hazards and dispersion of pollutants*. Springer Science and Business Media.

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10. David S and Jeremy P. 2001. *Inshore Fisheries Management. Methods and Technologies in Fish Biology and Fisheries* (vol. 2). Kluwer Academic publishers, London.
11. Eden C and Iske A. eds., 2019. *Energy Transfers in Atmosphere and Ocean*. Springer.• Kormondy EJ. 1986. *Concepts of Ecology*. Prentice-Hall, New Delhi.
12. Gray NF. 2004. *Biology of Wastewater Treatment.* Oxford University Press, London.
13. Khanna BK. 2000. *All You Wanted to Know About Disasters*. New India Publishing Agency.
14. Mason C. 2002. *Biology of Freshwater Pollution*. 4th edition, Benjamin Cummings, 400 pp.
15. Park CC. 1980. *Ecology and Environmental Management.* Butterworths, London.
16. Ramkumar M, James A, Menier D, Kumarswamy K. 2018. *Coastal Zone Management: Global Perspective*, Regional Processes, Local Issue. Elsevier.
17. Sharma LL, Sharma SK, Saini VP and Sharma BK. (Eds.). 2008. *Management of Freshwater Ecosystems*. Agrotech Publ. Academy.
18. Trivedy RK. 1998. *Advances in Wastewater Treatment Technologies*. Global Science, Aligarh.
19. Vallega A. 1992. *Sea Management A Theoretical Approach*. Elsevier Science Publishers Ltd.
20. Vallega A. 1999. *Fundamentals of Integrated Coastal management,* Kluwer Academic Publishers

UNIT- 2: Fish Processing Technology and Quality Assurance: (2 credits): 20+5 =25 Marks

Methods of fish handling and transportation. Proximate composition of fishes. Post mortem biochemical changes in fishes. Rigor mortis and freshness test. Spoilage of fishes. Spoilage indices. Freshness test by organoleptic method. Icing process of finfish and shellfishes. Types of ice, Storage and calculation of ice requirements. Principles of fish freezing. Freezing curve. Types of freezing employed in fish preservation. Drip loss and Thawing of frozen fish. Concept of fish packaging. Definition, composition, methods of preparation and uses of different fish byproducts having commercial importance. Definition and methods of preparation of different value-added fishery products. Antioxidant, pharmaceutical and nutraceuticals products. Concept of food safety in fishery products. Microbes and their role in food spoilage. Botulism and their impact on human health. Sanitary control of processing industry and standards of sanitation and hygiene. Quality assurance and quality control of fish and fishery products. Principles of HACCP. Formation of HACCP team and their functioning.

Course outcome: The foremost area of this unit is fish processing technology and quality assurance which explicitly required for the students those are recruited in fish processing or allied industry.

Reference Books:

1. Alasalvar C, Miyashita K, Shahidi F and Wanasundara U. 2011. *Handbook of Seafood Quality, Safety and Health Applications*, Wiley-Blackwell (Oxford).
2. Anthony TT. 1988. *Handbook of Natural Toxins. Marine Toxins and Venom*. Vol. III. Marcel Dekker.
3. Balachandran KK. 2001. *Post Harvest Technology of Fish and Fish Products*. Daya Publ. House.
4. Clucas IJ. 1981. *Fish Handling, Preservation and Processing in the Tropics*. Parts I, II. FAO.
5. Connell JJ. 1995. *Control of Fish Quality*. Fishing News Books.

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6. Fennema K, Powrie WD and Marth EH. 1973. *Low Temperature Preservation of Foods and Living Matter*. Marcel Dekker.
7. Gopakumar K. (Ed.). 2002. *Text Book of Fish Processing Technology*. ICAR.
8. H. Allan Bremner 2002, *Safety and Quality Issues in Fish Processing*
9. Hall GM. (Ed). 1992. *Fish Processing Technology*. Blackie.
10. Hall GM. (Ed). 2011. *Fish Processing –Sustainability and New Opportunities.* WileyBlackwell.
11. Hui YH, Merle DP and Richard GJ. (Eds.). 2001. *Food Borne Disease Handbook. Seafood and Environmental Toxins*. Vol. IV. Marcel Dekker.
12. Huss 2007. *Assessment and Management of Seafood Safety and Quality.* Daya Publishing House (Delhi).
13. Huss HH, Jakobsen M and Liston J. 1991. *Quality Assurance in the Fish Industry*. Elsevier.
14. John DEV. 1985. *Food Safety and Toxicity*. CRC Press.
15. Judith A. Evans. 2008. *Frozen Food Science and Technology*, Blackwell Publishing Inc. (Malden) SEAFDEC manual
16. Nalan Gokoglu, Pinar Yerlikaya. 2015. *Seafood Chilling, Refrigeration and Freezing: Science and Technology*, John Wiley and Sons (Chichester).
17. Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ.
18. Venugopal V. 2006. *Seafood Processing*. Taylor and Francis.

FSC-202

(Core course - 4 credits: 50 Marks)

[University Examination -40 and Internal Assessment-10]

UNIT- I: Reproduction in Finfish and Shellfish: (2 credits): 20+5 =25 Marks

Sexuality in fishes, Style of reproduction. Sexual dimorphism. Courtship and mating. Reproductive strategies, Reproductive cycle, fecundity and spawning. Development of gonads, Gametogenesis. Stages of oocytes. Gonad anatomy and reproductive mechanisms in important finfish and shellfish species. Environmental influence and control. Structure of pituitary gland and its secretion. Endocrine and neuroendocrine regulation of reproduction in finfish and shellfish. Role of pineal hormone. Role of pheromones in reproduction. Factors affecting maturation and spawning. Mechanism of ovulation, fertilization and hatching. Artificial propagation technique. Brood husbandry. Brood availability, transport, brood raising, captive rearing and maturation. Nutritional and environmental requirement for broodstocks. Nutritional and environmental manipulation for early maturation and brood health care and stress management.

Course outcome: In recent years, major problems facing aquaculture today is the lack of knowledge of complete life cycles and mass production of seedling of targeted species. So, there is need of domestication of diversified aquaculture species. As there is a depletion of natural fish resources for various reasons, there is a need for evolving species specific technologies to culture commercially important finfish and shellfish species. The basic requirement of successful culture of any species of fish is the availability of healthy seedling in desired quantity. As the availability of seed primarily depends on the efficient functioning of the reproductive organs, it is utmost necessary for the students to understand the basic concepts of reproduction in fish and reproductive technology.

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Reference Books:

1. Fish Neuroendocrinology by Reinecke, Zaccone & Kapoor. CRC Press. 2006.
2. Fish Physiology, (Vol. IX B) by Hoar, Randall & Donaldson. Academic Press, New York, 1983.
3. Fish Reproduction by Arukwe, Kapoor and Rocha, CRC Press, NW. 2008.
4. Fish Reproduction by N.K. Agarwal. APH publication New Delhi. 2008.
5. Fish Reproductive Biology by Jacobsen. John Wiley. 2016.

UNIT- II: Fish Breeding, Hatchery Design and Management: (2 credits): 20+5 = 25 Marks

Natural breeding and collection of fish seed. Bundh breeding. Hypophysation technique. Alternate inducing agents for induced spawning. GnRH based inducing agents. Sympathetic breeding. Advances in fish breeding. Multiple breeding. Artificial breeding and seed production of commercially important finfish and shellfishes. Breeding techniques for major aquarium fishes. Types of eggs and larvae in fishes. Embryonic and larval development. Improvement of seed quality. Cryopreservation of gametes. Types of hatchery. Criteria for site selection of hatchery. Design and construction of modern hatchery. Operation, management and hatchery technology for seed production of important finfish and shell fish species. Monitoring of pH, temperature, dissolved oxygen, alkalinity, salinity, free CO_2 etc. in hatcheries for seed production. Aeration system and water exchange. Different chemicals and drugs used. Hatchery standards and bio-security. Sanitary and phytosanitary measures. Disease management and their control in the hatchery systems. SPF and SPR. Seed certification. Better management practices (BMPs). Seed packaging and transportation methods. Economics of seed production.

Course outcome: Healthy seedling are the key to successful aquaculture. An important factor that has contributed to the collapse of large scale farming of species traced to the deficiencies of hatchery management. This part will help the student to understand the methods of construction of different efficient hatchery unit, different techniques to achieve successful breeding and target seed production and methods of adoption of various better management practices in hatchery system to produce quality seed and their transportation. Biosecurity measures in hatchery system is an important criteria for all hatchery and will help impacting knowledge for the production of certified finfish and shellfish seed in our country. Student will get benefitted by having expertise in these fields and will help them to become successful entrepreneur by establishing hatchery or can achieve a successful career in the fish seed industry.

Reference Books:

1. Handbook of Fisheries and Aquaculture. ICAR Publication New Delhi, 2016
2. Breeding and Seed Production of Fin Fish and Shell Fish by Thomas, Rath & Mohapatra. Daya Publishers, New Delhi. 2014.
3. Induced Fish Breeding: A Practical Guide for Hatcheries by N.R. Chattopadhyay. Academic Press. 2016.
4. Text Book of Breeding and Hatchery Management of Carps. NPH, New Delhi. 2008
5. Cryopreservation of Fish Gametes by Betsy & Kumar. Springer. 2020.

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FSC-203

(Core course - 4 credits: 50 Marks)

[University Examination - 40 and Internal Assessment - 10]

UNIT- 1: Fish Disease and Management: (2 credits): 20+5 =25Marks

Principles of disease diagnosis, epidemiological and clinical diagnosis, microbiological and post mortem examination of fin fishes in fresh water, brackish water and marine water environment. Causative agents, symptoms, prophylaxis and histo-pathological studies of viral, bacterial fungal diseases of freshwater, brackish water and marine water finfishes, shellfishes and ornamental fishes. Non infectious diseases of fish and shell fishes. General characteristics; Epizootiology; Diagnosis; Life cycle of crustacean, helminthes, protozoon and metazoan parasites in freshwater and saline water fishes. Host-parasite interaction; Host-pathogen- environment relationship. Management of culture system and environmental stress. Prevention and control of different parasitic diseases. Aquaculture medicines and its importance in fisheries. Rules and regulation for use of aquaculture medicine.

Course outcome: Fish pathology and disease management : In this course we give ideato student about different disease problem faced by farmers and possible control measure, different modern aquaculture medicine. Student get job in company and Government to enrich the fish farmers about fish disease. The control of diseases and parasites in aquaculture is essential to meet the requirements of animal welfare and economic production. Parasites are not only dangerous pathogens in captive fish but also introduced parasites from other continents may pose a serious threat to fish species in wild.

Reference Books:

1. Bell, T.A. and Lightner, D.V. 1988. A Handbook of Normal Penaeid Shrimp Histology. World Aquaculture Society, Baton Rouge, Louisiana.
2. Brian Austin and Dawn Austin. 2007. Bacterial fish pathogendiseases of Farmed and WildFish: 4th edition. Praxis Publications, Chichester,UK.
3. Edward, J. Noga. 2010. Fish diseases Diagnosis & Treatment: 2nd edition. Wliiey Blackwell publications.
4. Ferguson, H. 1989. Systematic Pathology of Fish. Lowa State University Press, Lowa.
5. Gopalakannan, A., A Uma, Felix, S. 2018. Fish Diseases and Management. Daya Publishing House, New Delhi.
6. Jorge C. Eiros, et al. 2008. Fish diseases: Vol.II. Science publishers.
7. Lightner, D.V. 1996. A handbook of Shrimp Pathology and Diagnostic Procedures for Diseases of Cultured Penaeid Shrimp. World Aquaculture Society, Baton Rouge, Louisiana.
8. Roberts, R.J. (Ed.). 1989. Fish Pathology. Bailliere Tindall, New York.
9. Schaperclaus, W. et al, 1991. Fish diseases: Vol.I. Oxonian press pvt.ltd, New Delhi.
10. Shozo Egusa. 1991. Infectious diseases offish. Oxonian press pvt.ltd. New Delhi.
11. Takash Hibiya. 1982. An Atlas of Fish Histology: Normal and Pathological Features. Kodansha Ltd., Tokyo

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UNIT- 2: Fisheries Extension, Economics and Marketing: (2 credits): 20+5 =25 Marks

Introduction to extension education and fisheries extension-concepts, objectives and principles. History and role of fisheries extension in fisheries development; Fisheries extension methods - individual, group and mass contact methods and their effectiveness; Role of NGO's and SHGs in fisheries. Adoption and diffusion of innovations. Extension programme planning and evaluation - steps and importance. 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. Financial Assistance available to fishery sector from Government, Commercial Banks, NABARD and other NGO's. Socio-Economic analysis, socio demographic profiles of fishermen. Role of woman in fisheries development and their empowerment through socioeconomic upliftment. Planning and strategies for aquaculture development. Role of FFDA, BFDA and other aquaculture related program. Aquaculture project, project cycle and appraisal of project. Entrepreneurship development. 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. Exports and imports of fish and fishery products. Contribution of MPEDA and other associates in exports of fish and fishery products. Marketing system and environment market opportunity identification-customer analysis. Marketing policy and market assessment.

Course outcome: Fisheries extension, economics and marketing : In this course student get idea about transfer the technology to the rural people, economic principle and marketing process of fisheries product. Socioeconomic status development of women. This type of syllabus directly related government job.

Reference Books:

1. Adivi Reddy, A. 1987. Extension Education. Sree Lakshmi Press, Bapatla, A.P.
2. Bhatia and Bhatia. 1992. A Text Book of Educational Psychology. Boaba House, Delhi.
3. Chaston, I. 1987. Marketing in Fisheries and Aquaculture. Fishing News Books, England.
4. Chitambar, J. B. 1990. Introductory Rural Sociology. Wiley Eastern Ltd., New Delhi.
5. Das, Puspita. 2016. Self Help Groups: Problems Opportunities and Challenges Ahead. Biotech Books.
6. Dewett, K.K. and Varma, J.D. 1993. Elementary Economic Theory. S. Chand, New Delhi.
7. Jayaraman, R. 1996. Fisheries Economics. Tamil Nadu Veterinary and Animal Science University, Tuticorn.
8. Pandey, S.K. 1997.Teaching Communication. Common Wealth Publishers, New Delhi.
9. Rao, N. Subba. 1986. Economics of Fisheries. Daya Publishing House, Delhi.
10. Ravishankar, C.N. 2021. Fishpreneurship Present Status, Challenges and Opportunities. Biotech Books.
11. Saxena, Amita. 2011. Fisheries Extension. Daya Publishing House, New Delhi.
12. Singh, R.K.P. 2003. Economics of Aquaculture. Daya Publishimg House, New Delhi.
13. Supe, S.V. 1997. An Introduction to Extension Education. Second Edition. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

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FSC-204

(Elective course - 4 credits: 50 Marks)

[University Examination - 40 and Internal Assessment-10]

UNIT-1: Fundamental of Fisheries Science: (2 credits): 20+5 =25 Marks

Definition and morphometric characteristics of fishes. Classification of fishes. Commercially important fin fishes and shellfishes of Indian water and study their biology. Basics of aquaculture - definition and scope. Aims and objectives of aquaculture. Benefits of aquaculture from human prospective. Present global and national scenario of aquaculture production. Aquaculture *vs* Agriculture. Aquatic resources of India and their conservation and management in different water bodies.

Course outcome: The course content prepared for the CBCS student of different department to get idea about the basic information regarding fishes and their importance, gathering knowledge about importance of aquaculture.

Reference Books:

1. Ayyappan, S., 2011.Handbook of Fisheries and Aquaculture, ICAR Publications, New Delhi.
2. Khanna S. S., Singh H.R. 2015. A Textbook of Fish Biology and Fisheries. Narendra Publishing House, New Delhi.
3. Rath, R.K., 2011. Fresh water Aquaculture, Scientific publications.

UNIT-2: Aquaculture Management: (2 credits): 20+5 =25 Marks

Systems of aquaculture: pond culture, tank culture, pen culture, cage culture, running water culture and sewage fed aquaculture. Hi-tech aquaculture production system: Integrated Multi-Trophic Aquaculture (IMTA), Aquaponics, Recirculating Aquaculture System (RAS), Organic farming and Biofloc culture, Partitioned Aquaculture Systems (PAS).Management of aquaculture pond. Monoculture and polyculture. Integrated culture systems. Backyard aquaculture. Fish for therapeutic measures. Angling as a sport. Different varieties of exotic and indigenous ornamental fishes. Culture of freshwater and saline water ornamental fishes, Management of home aquaria and their accessories. Trade of ornamental fish and export potential.

Course outcome: The course content prepared for the CBCS student of different department to get idea about the basic information regarding aquaculture management and exploitation of aquatic resources.

Reference Books:

1. Ayyappan, S., 2011. Handbook of Fisheries and Aquaculture, ICAR Publications, New Delhi.
2. C.B.L Srivastava. 2006. A Text Book Of Fishery Science And Indian Fisheries. Kitab Mahal, New Delhi
3. Khanna S. S., Singh H.R. 2015. A Textbook of Fish Biology and Fisheries. Narendra Publishing House, New Delhi.
4. Rath, R.K., 2011. Fresh water Aquaculture, Scientific publications.

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FSC-295
PRACTICAL PAPER
(Core course - 4 credits: 50 Marks)
[University Examination - 50]

1. Determination of soil texture, Organic Carbon, Phosphorus, Potassium, Nitrogen, C/N ratio, pH etc.

2. Study of the physico-chemical characteristics of water: pH, Temperature, Dissolved oxygen, Productivity, Free CO_2, Hardness, Salinity, Alkalinity, Transparency, Turbidity etc.

3. Identification of different macrophytes collected from freshwater ecosystem.

4. Study of benthic community, aquatic insects from different aquatic ecosystems.

5. Analysis of phytoplankton and zooplankton from different aquatic ecosystems.

6. Dissection & display of reproductive system (male and female) of fish.

7. Dissection and display of pituitary gland and preparation and preservation of PGE.

8. Study of reproductive phase, gonado-somatic index and condition factor of fish.

9. Study of fecundity, ova diameter of different fishes.

10. Study of fish handling and different fish preservation techniques.

11. Calculation of ice requirement for short term freezing.

12. Preparation of fish fillets.

13. Preparation of fish byproducts and value added products.

14. Isolation and identification of fish spoilage causing microbes and their culture.

15. Seminar presentation.

Course outcome: Water and soil quality parameter study are the basic practical for the students. These studies help them to aqua farm management either as company technician or as a researcher. Aquatic insect, zooplankton, phytoplankton study helps to students for condition of aqua farm study. Fish seed production related practical helps to technical knowledge development and they are developed themselves as entrepreneur.

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FSC-296
PRACTICAL PAPER
(Core course - 4 credits: 50 Marks)
[University Examination - 50]

1. Identification of common bacterial, viral, protozoan and fungal diseases of finfishes & shellfishes.
2. Identification of common parasites & parasitic diseases of finfishes and shellfishes.
3. Studies of commonly used aquaculture medicines in West Bengal farms.
4. Hatchery layout and identification of equipment's.
5. Evaluation of quality of fish gametes.
6. Study of maturity status of fish by histology and histochemistry of gonads and related organs.
7. Study of induced breeding technique by natural and synthetic hormones.
8. Cryopreservation of fish gametes.
9. Breeding and larval care of finfish and shellfishes.
10. Preparation of project proposal through chart/ model for different fish production systems.
11. Fish market and market survey.
12. Socioeconomic analysis of fishers.
13. Field visit.

Course outcome: The whole course curricula of the said paper fully based on the FSC - 202 and FSC - 203 which is required for the practical experienceof the students those are selected for higher studies as well as aquaculture sectors. Toxicity study of chemical, Microbiological analysis helps the students to engage in research in company or in Government sector Laboratories, Aquaculture Professionals, Aqua farm Technicians.

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3rd SEMESTER
(24 credits: 300 Marks)
Core course (Theory) - 150 Marks + Elective course (Theory) - 50 Marks + Core course (Practical) - 100 Marks

FSC-301
(Core course - 4 credits: 50 Marks)
[University Examination - 40 and Internal Assessment-10]

UNIT- 1: Fisheries Statistics and Research Methodology & esthetics: (2 credits): 20+5 =25Marks

Frequency distribution; Variance; Histogram; Pie- diagram; Bar-diagrams and Frequency curves. Concept of sample and population. Mean; Median; Mode; Standard Deviation (SD) and Standard Error of Mean (SEM). Normal and binomial distribution. Scope and objectives of fisheries statistics. Sample; Survey; Probability calculation; Chi-squire (X^2) test; Test of significance; ANOVA; Liner regression and correlation. Analysis of Variance. Fitting curves and index numbers. Statistical analysis of biological data. Identification of problem, and formulation of objectives and hypothesis. Types of hypothesis. Testing of hypothesis. Variables, data types: qualitative, quantitative; Experimental design. Application of statistical methods in Research. Use of tables, graphs, diagram, etc. in reports using computers. Definition of Research Methodology, Different kinds of Research Style of Referencing and Bibliography, Reviewing Articles and Books, writing a good Research Proposal. Ethics with respect to science and research, scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP), duplicate and overlapping publications. Publication ethics: definition, introduction and importance Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types, Violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, Predatory publishers and journals.

Course outcome: Fisheries statistics and research methodology: Students get idea about statistical methods and their application in aquaculture research. They also benefited about the research methods. Student engages in fisheries research and development of different Government plan or in company. This portion give a valued idea on publication ethics

Reference Books:

1. Essentials of Biostatistics & Research Methodology, by Indranil Shah (Author), Boddy Paul (Author), third edition, Academic Publishers (1 January 2020).
2. Biostatistics and Research Methodology, by G. Nageswara Rao (Author), Pharma Med Press / BSP Books; 1st edition (1 January 2018).
3. Comprehensive textbook of biostatistics and research methodology, by Dr. S. Kartikeyan, Dr. R. M. Chaturvedi, Mr. R. M. Bhosale, 1 first edition, 2016, Bhalani Publishing House, Parel, Mumbai 400 012, Maharashtra, India.
4. Biostatistics & Research Methodology, by Dr. Richa Agarwal, Dr. Sukhbir Singh, Dr.

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Neelam Sharma & Dr. Tania Bose, first edition 2021 R. Narain Publishers & Distributors.
5. Research Methods and Statistics: An Integrated Approach, By: Janie H. Wilson and Joye, first edition 2017, AGE Publications, Inc.

UNIT- II: Immunology, Genetic Engineering and Bioinstrumentation: (2 credits): 20+5 =25 Marks

Introduction to fish immunology. Defense system in fish. Innate and acquired immunity. Cell mediated and humoral immunity. Lymphoid tissues and cellular components of immune systems. Non-specific humoral and cellular defense mechanisms. Hypersensitivity reactions. Structures and functions of antibody. Fish vaccines and strategies for fish vaccination and vaccine production. Principles of genetic engineering; recombinant DNA technology and gene cloning; Sequencing and DNA fingerprinting; Recombinant vaccines and transgenic fish; genomic DNA library, Gene mapping; DNA amplification and; Gene therapy. Microscopy, Centrifugation, Electrophoresis, Isoelectric focusing, chromatography. Polymerase Chain Reaction (PCR), ELISA, Northern blotting and Southern blotting.

Course outcome: This part provides knowledge of basic molecular processes involving nucleic acids and protein structure, synthesis and maintenance within a living cell. The principles and practices of various instruments basically which are used in separation as well as analytical techniques used in the practical and fisheries research. The students will able to understand the working principle of laboratory instruments and various molecular techniques useful for identification of fish pathogens. The bio-techniques used in the study of modern biology will help the student to register for higher education after passing out. This chapter also impact knowledge in basic principles of fish immunology, an important topic to understand the production of specific pathogen free and resistant fishes and production of vaccines useful for fishes to achieve higher production.

Reference Books:

1. Fundamental immunology by Paul, William E. Lippincott Williams & Wilkins, 2012.
2. Kuby Immunology by Judith, Punt, and Stranford. WH Freeman New York, 2013.
3. Molecular Biology of the Cell by Bruce Alberts. WW Norton & Company, 2017.
4. Practical Biochemistry: Principles and Techniques by Wilson & Walker. Cambridge University Press, 2000.
5. Principles of Fish Immunology by Buchmann & Secombes. Springer Nature Switzerland. 2022.
6. Text Book of Fish Immunology by D. P. Anderson, NPH, New Delhi, 2003

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FSC-302

SPECIAL PAPER (Aquaculture) (Core course - 4 credits: 50 Marks)

[University Examination - 40 and Internal Assessment - 10]

UNIT-I: Fish Genetics and Biotechnology: (2 credits): 20+5 =25 Marks

Chromosome structure; Current techniques of fish cytogenetics; Evolution of fish karyotypes; History and advancement of fish breeding, basic breeding methods and breeding programmes; Inbreeding and cross breeding; Hybridization in fishes; Selecting breeding; Chromosome manipulation. Chromosomal manipulation: Androgenesis and Gynogenesis, Polyploidy. Genetic resources of India and conservation. Production of monosex population and super males. Hormonal manipulation in advancing maturity and reproduction. Methods of sex reversal. Role of steroid in sex reversal. Application of biotechnology in aquaculture and fisheries management. Recombinant DNA, protein of commercial importance; Transgenesis. Molecular markers used in fisheries and aquaculture. IPR issues related to fish biotechnology.

Course outcome: This part shall impart knowledge on genetic basis of inheritance and breeding plans for commercially important fishes which covers chromosome manipulation, hybridization, selective breeding, transgenesis. This will help the student to understand the production of genetically improved and transgenic fishes which is able to give higher fish production by the application of modern biotechnological procedures. The students also get an idea about the legal rights and their advantages for the innovations of different intellectualproperty created by scientific communities.

Reference Books:

1. Reproductive Biotechnology in Finfish Aquaculture by Lee & Donaldson. Elsevier. 2001.
2. Fish Genetics and Aquaculture Biotechnology by T.J. Pandian. CRC Press. 2005.
3. Principles of Genetics by Snustad & Simmons. John Wiley & Sons. 2015.
4. Recent Updates in Molecular Endocrinology and Reproductive Physiology of Fish by Kumar et al., Springer Singapore, 2021.
5. Advances in Fisheries Biotechnology by Pandey & Parhi. Springer Singapore, 2021.

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UNIT-2: Aquaculture Engineering and Management: (2 credits): 20+5 =25 Marks

Trends in global and Indian aquaculture. Intensification of aquaculture and technological innovation in pond, tank, pen and cage culture. Hi-tech aquaculture production system: Integrated Multi-Trophic Aquaculture (IMTA), Aquaponics, Recirculating Aquaculture System (RAS), Organic farming and Biofloc culture, Partitioned Aquaculture Systems (PAS) and Aquamimicry systems. Design, farming practices, constraints of integrated farming systems (fish with paddy, cattle, pig, poultry, duck, rabbit, etc). Site selection, components and construction of different aquafarms. Design and layout of different aqua farms and aqua house. Construction and design of pond dyke, sluice gate, water supply and drainage system. Water treatment, design and fabrication of automatic feeder, aerator and bio-filter, instruments for measuring water quality. Physical and chemical properties of soil and water. Soil and water quality standards. Different kinds of fertilizers, Biofertilizers and manures and their application and their impact on environment.

Course outcome: The important area of this unit is aquaculture engineering & management which directly related to the policy of environmental health. This topic is very relevant to the aspirants those are recruited in engineering field related to fisheries as well as public health areas of NGO and Govt. sectors.

Reference Books:

1. Adhikari S and Chatterjee DK. 2008. *Management of Tropical FreshwaterPonds*. Daya Publ. APHA, AWWA, WPCF. 1998. Standard Methods for the Examination of Water and Wastewater, 20th Ed. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, Washington, DC.
2. Boyd, C. E. and Tucker, C. S. 1992. *Water Quality and Pond Soil Analyses for Aquaculture*, Alabama Agricultural Experimental Station, Auburn University.
3. Boyd CE. 1979. *Water Quality in Warm Water Fish Ponds.* Auburn University.
4. ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.
5. Mcvey JP. 1983. *Handbook of Mariculture*. CRC Press.
6. Parsons TR, Maita Y and Lalli CM. 1984. *A Manual of Chemical and Biological Methods for Seawater Analysis*. Pergamon Press.
7. Rajagopalsamy CBT and Ramadhas V. 2002. *Nutrient Dynamics inFreshwater Fish Culture System*. Daya Publ.
8. Bardach JE. 1997. *Sustainable Aquaculture*. John Willey and Sons.
9. Bardach JE, Rhyther JH and Mc. Larney WO. 1972. *Aquaculture Farming and Husbandry of Freshwater and Marine Organisms*. John Wiley and Sons.
10. Beets WC. 1990. *Raising and Sustaining Productivity of Small- Holder Farming Systems in the Tropics*. Agbe Publ.
11. Edwards P, Little DC and Demaine H. (Eds.). 2002. *Rural Aquaculture*. CABI.
12. FAO 2001. *Planning and Management for Sustainable Coastal Aquaculture Development*. FAO.

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13. Imai T. 1978. *Aquaculture in Shallow Seas. Progress in ShallowSea Culture*. Amerind Publ.
14. James PM. 1983. *Handbook of Mariculture*. Vol. I. Crustacean Aquaculture. CRC Press.
15. Leung P, Lee CS and O'Bryen JP. (Eds.). 2007. *Species and System Selection for Sustainable Aquaculture*. Blackwell Publ.
16. Midlen and Redding TA. 1998. *Environmental Management for Aquaculture*. Chapman and Hall.
17. Creed R. 2017. *Aquaculture and Fish Farming*. Syrawood Publ.
18. Bose AN. 1991. *Coastal Aquaculture Engineering*. Oxford and IBH Publ.
19. Ivar LO. 2007. *Aquaculture Engineering*. Daya Publ. House.
20. Lekang OI. 2013. *Aquaculture Engineering*. Wiley-Blackwell Publ.
21. Pillay TVR and Kutty MN. 2005. *Aquaculture- Principles and Practices*. Blackwell.
22. Thomas L. 1995. *Fundamentals of Aquacultural Engineering*. Chapman and Hall.
23. Wheaton FW. 1977. *Aquacultural Engineering*. John Wiley and Sons.

FSC-303

SPECIAL PAPER (Aquaculture) (Core course - 4 credits: 50 Marks)

[University Examination -40 and Internal Assessment-10]

UNIT-1: Aquaculture Practices: (2 credits): 20+5 =25 Marks

Present status, problems and scope of fish and prawn farming in global and Indian perspective. Important cultivable freshwater species. Farming of commercially important finfish and shellfishes. Nursery and grow-out culture, pond preparation, stocking, feeding, water quality and disease management in the farming of important cultivable finfish and shellfish species. Stunted seed production and culture practice. Wastewater-fed aquaculture. Guidelines of sustainable aquaculture. Different farming systems. Important cultivable finfishes. Farming of commercially important finfish and shell fishes. Present status and scope of culture of marine mollusks in India, farming methods. Seaweed culture; emerging trends in their farming in open seas. Present status, potential of aquarium fish trade; major exporting and importing countries. Species-wise contribution of freshwater and marine fishes; marketing strategies. Aquarium management. Colour enhancement. Introduction of exotic fishes and their management. Rearing of live bearer and egg laying fishes. Problems and prospects of ornamental fish culture. Live fish feed and their importance.

Course outcome: The focused area of this unit is aquaculture practices which are the most important areas of aquaculture sectors and major recruitment took place in this areas especially in corporate house.

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Reference Books:

1. AAHRI. 1998. *Health Management in Shrimp Ponds*. Aquatic Animal Health Research Institute (AAHRI), Department of Fisheries, Thailand.
2. Agarwal SC. 2008. *A Handbook of Fish Farming*. 2nd Ed. Narendra Publ. House.
3. Ahilan, B., Felix, N., Santhanam, R., 2008. *Textbook of Aquariculture*. Daya Publishing House, Delhi.
4. Appukuttan KK, Asokan PK, Mohamed KS, Subramaniam S and G Joseph GK. 2003. *Manual on Mussel Farming*. CMFRI Technical Bulletin 3.
5. Avnimelech Y. 2015. *Biofloc Technology- a Practical Guidebook*. 3rd edition. World Aquaculture Society.
6. Axelrod HR and Sweenen ME. 1992. *The Fascination of Breeding Aquarium Fishes*. TFH Publ.
7. Axelrod HR and Vorderwinkler W. 1978. *Encyclopaedia of Tropical Fishes*.TFH Publ.
8. Axelrod HR. 1967. *Breeding Aquarium Fishes*. TFH Publ.
9. Bardach EJ, Rhyther JH and Mc Larney WO. 1972. *Aquaculture the Farming and Husbandry of Freshwater and Marine Organisms*. John Wiley and Sons.
10. Beveridge MCM and Mc Andrew BJ. 2000. *Tilapias: Biology and Exploitations*. Kluwer.
11. Beveridge MCM. (Ed.). 2004. *Cage Aquaculture*, 3
12. Burnell G, Allan G. 2009. *New Technologies in Aquaculture*. 1 Edition. Woodhead Publishing House.
13. De Silva SS. (Ed.). 2001. *Reservoir and Culture Based Fisheries: Biology and Management*. ACAIR Proceedings.
14. FAO Publ. Gilbert B. 1990. *Aquaculture*. Vol. II. Ellis Horwood.
15. FAO. 2001. *Planning and Management for Sustainable Coastal Aquaculture Development*.
16. FAO. 2007. *Manual on Freshwater Prawn Farming*.
17. Ghosh, P.K., 2010. *Brackishwater Aquaculture*. Agrobios (India)
18. ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.
19. James PM. 1983. *Handbook of Mariculture*. Vol. I. *Crustacean Aquaculture*. CRC Press.
20. Midlen and Redding TA. 1998. *Environmental Management for Aquaculture*.Kluwer.
21. New MB. 2000. *Freshwater Prawn Farming*. CRC Publ.
22. NFDB, 2018. *Guidelines for sea cage farming in India*.
23. *Pillay TVR and Kutty MN. 2005. Aquaculture: Principles and Practices. 2nd Ed. Blackwell.*
24. Pillay TVR. 1990. *Aquaculture, Principles and Practices. Fishing News Books.*
25. Pillay TVR. 1990. *Aquaculture: Principles and Practices*. Fishing News Books, Cambrige University Press, Cambridge.
26. Saxena A. (Ed.). 2003. *Aquarium Management*. Daya Publ.
27. *Shepherd J and Bromage N. 1990. Intensive Fish Farming. B.S.P. Professional Books.*
28. Soderberg RW. 1995. *Flowing Water Fish Culture*. Lewis Publishers.
29. *Syda Rao G, Imelda-Joseph, Philipose KK and Suresh Kumar M, 2013. Cage aquaculture in India. CMFRI Publ.*
30. Syda Rao G, Imelda-Joseph, Philipose KK and Suresh Kumar M, 2013. *Cage Aquaculture in India*. CMFRI Publ.
31. Tidwell JH. (Ed.). 2012. *Aquaculture Production Systems*. Wiley-Blackwell.
32. Tidwell JH. (Ed.). 2012. *Aquaculture Production Systems*. Wiley-Blackwell.
33. Venugopal S. 2005. *Aquaculture*. Pointer Publ.
34. Welcomme RL. 2001. *Inland Fisheries: Ecology and Management*. Fishing News Books.

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UNIT-2: Fish Nutrition & Bioenergetics: (2 credits): 20+5 =25 Marks

Principles of fish nutrition, nutritional requirements of cultivable finfish and shellfish. Classification and metabolism of proteins, lipids and carbohydrates. Role of nutrients like amino acids, fatty acids, proteins, lipids, carbohydrates, vitamins and minerals. Energy requirement of fishes; Bioenergetics; Factors affecting bioenergetics of fish. Optimal foraging theory, Metabolic rate, Energy budgets, Energetic efficiency of fish production. Digestion, accretions and nutrient flow; Factors affecting digestibility. Anti- nutritional factors and anti-metabolites. Microbial toxins, methods of elimination, nutrient deficiency and symptoms. Nutritional value of feed ingredients and live feed. Contribution from natural food to nutrient requirements of fish. Classification of feed ingredients. General principle of feed formulation; Methods of feed formulation: Pearson's method, quadratic equation linear programming, limitations. Types of feed. Hydro-stability of feed and their storage and prevention of spoilage from rancidity. Feed additives: - Classification, function, and their specific use. Feed evaluation through the study of growth performance, FCR and PER analysis. Feeding practices and feeding management of finfish and shellfishes.

Course outcome: Fish nutrition & Bioenergetics: In this course student get idea about the feeding habit of fish, nutritional components, composition of fish feed, process of fish feed formulation. From this study students joint in fish feed company and aquaculture oriented job.

Reference Books:

1. Leninger, A.L. 1990. Biochemistry, CBS publishers and Distributors Pvt. Ltd., Shahdara, Delhi.
2. Lovell Tom. 2nd Edition. Nutrition and Feeding of Fish. Springer, India, Private Ltd.
3. Meera Vashishit . 1998. Food nutrition and processing –Anmol publication pvt. Ltd.
4. Ronald W. Hardy, Sadasivam J. Kaushik. 2021. 4th edition. Fish Nutrition. Academic Press.
5. S.S. de Silva. T.A. Anderson. 1994. Fish Nutrition in Aquaculture. Springer Science & Business Media.
6. Swaminathan, M. 1985. Hand book of Food and Nutrition – The Bangalore Printing and Publishing Company, Ltd. Mysore road.
7. Wilson, K. and Walker, J. 2000. Practical Biochemistry:Principles and Techniques. University of Cambridge, UK.

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FSC-304

(Elective course - 4 credits: 50 Marks)

[University Examination -40 and Internal Assessment-10]

UNIT-1: Aquaculture Technology: (2 credits): 20+5 =25 Marks

Different types of fishing crafts gears and their accessories. Active and passive fishing gears; Fishing crafts and gears used in inland and marine fisheries of India. Maintenance and storage of gears and gear building materials. Fish finding devices, BRD, TED, FAD and advance communication system; Nutritional value of fishes. Fish processing technology, byproducts and value added products of economic importance. Fish breeding, hybridization of fish and transgenic fishes.

Course outcome: Thrust areas of this course is aquaculture technology that was prepared for CBCS students to learned information about modern as aspects of aquaculture technology, culture procedure etc. From getting this knowledge student working in the field of aquaculture in different company.

Reference Books:

1. Ayyappan, S., 2011.Handbook of Fisheries and Aquaculture, ICAR Publications, New Delhi.
2. C.B.L Srivastava. 2006. A Text Book Of Fishery Science And Indian Fisheries. Kitab Mahal, New Delhi.
3. Khanna S. S., Singh H.R. 2015. A Textbook of Fish Biology and Fisheries. Narendra Publishing House, New Delhi.
4. Rath, R.K., 2011. Fresh water Aquaculture, Scientific publications.

UNIT-2: Fisheries Entrepreneurship Development: (2 credits): 20+5 = 25 Marks

Fisheries extension and education in India. Fishery as a tool for rural development and employment potentiality. Different fisheries development plan/schemes in India. Role of Government, NGOs, fisheries co-operatives and other agencies engaged in fisheries sector. Different fishery related laws in India. Planning and design of different projects related to aquaculture and their economic analysis.

Course outcome: The foremost areas of this unit is fisheries entrepreneurs development which is frame for CBCS students to get idea about how to development of entrepreneur, role of aquaculture in rural development. Role of Government and different Government plan. Students may be developed themselves as entrepreneur in the field of fisheries sector.

Reference Books:

1. Ayyappan, S., 2011.Handbook of Fisheries and Aquaculture, ICAR Publications, New Delhi.
2. Rath, R.K., 2011. Fresh water Aquaculture, Scientific publications.
3. Khanna S. S., Singh H.R. 2015. A Textbook of Fish Biology and Fisheries. Narendra Publishing House, New Delhi.
4. C.B.L Srivastava. 2006. A Text Book Of Fishery Science And Indian Fisheries. Kitab Mahal, New Delhi.

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FSC-395

GENERAL PRACTICAL
(Core course - 4 credits: 50 Marks)
[University Examination - 50]

1. Estimation of DNA, RNA and protein and enzyme by standard method.
2. Design and layout of different aquaculture farm.
3. Design and constructions of pond, pen, cage, Biofloc unit etc.
4. Study of physical and chemical properties of soil and water.
5. Study of various equipment's used in different hatchery.
6. Study of the heamatological parameters of fish.
7. Biochemical analysis of organs and fish immunity study.
8. Protein profiling study of different fish tissues.
9. Study of the principles & applications of instruments used in modern biology.
10. Collection of data and presentation of data. Testing of Goodness of fit; Chi squire (X^2) test and Student's t-test.
11. Operation of MS-Excel, tabulation of biological data, simple computation of different groups of data, making chart with MS-Excel, Bar-diagram, Line-diagram, Pie-diagram. Preparation of Power Point presentation on any topics on fisheries.
12. Seminar presentation.

Course outcome: The whole course curricula of the said paper fully based on the FSC - 301 and FSC - 302 which is required for the practical experience of the students those are selected in the research field as well as farming areas. Study of fishmicrobiology, study of fish and shellfish disease, fish immunity study are very much essential for students those who will working as Field assistant or Field Technicians. Study of haematology is helpful to students those are working in the research oriented job. Fish finding device, fish catch instruments are very much related practical those student engage in such type of research.

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FSC-396
SPECIAL PAPER PRACTICAL (Aquaculture)
(Core course - 4 credits: 50 Marks)
[University Examination - 50]

1. Identification of common aquarium fishes (Indigenous and exotic).
2. Different aquarium plants and decorative materials identification.
3. Identification of weed fishes and predatory fishes.
4. Construction of home aquarium and decoration and management.
5. Culture of live fish food organisms.
6. Identification of eggs/fry/life stages of important finfish & shellfish.
7. Methods of chromosome preparation and other cytogenetic techniques.
8. Identification of stages of fish oocytes/sperm cells
9. Study of hormonal manipulation in fish.
10. Study of different transgenic and hybrid fish.
11. Study of hybridization in fish
12. Identification of common fish feed ingredients.
13. Proximate analysis of feed ingredients.
14. Feed formulation in the laboratory.
15. Study the carotenoids in fish and fish feed for colour retention.
16. Estimation of the energy from fish feed ingredients and prepared feed.
17. Analysis of the growth, FCR, PER
18. Design and layout of different aquaculture system through computer.
19. Analysis of the aquaculture project: site, water supply, soil type, topography, drainage system, computations for water requirement, seepage and evaporation. Types of ponds and their designs.
20. Identification and working of various equipments used in aquafarm and hatchery.
21. Field visit.

Course outcome: The whole course curricula of the said paper fully based on the FSC - 302 (Unit- 2) and FSC -303 (Unit- 1 & 2) which is required for the practical experience of the students those are selected for higher studies as well as aquaculture sectors. Ornamental fish is one of the popular items in fishery business. Student themselves act as entrepreneurs in this field. Feed formulation and their ingredients study are very much related to company professional job, various research jobs.

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4th SEMESTER
(24 credits: 300 Marks)
Core course (Practical) - 100 Marks each

FSC-491
(Core course - 8 credits: 100 Marks)

Job training/Skill development programme through data collection from different aquaculture related field /farm /market, report writing and viva-voce. 100 marks are divided into 30 (Company/Institute assessment) +30 (Report writing) +20 (Presentation of the work) +20 (Viva-voce on the work)

FSC-492
Dissertation paper
(Core course - 8 credits: 100 Marks)

1. Dissertation work Report: 60 Marks:

Each student shall have to carry out a dissertation work (laboratory based or field based) under the guidance of a teacher for a period of minimum 3 months. Students shall have to prepare the dissertation report in a standard format and to submit the same in triplicate before the date of examination. (Date will be announced by the department).

2. Evaluation of dissertation work: 40 Marks:

The dissertation work will be evaluated on the basis of the seminar delivered by the student as well as *Viva Voce* on the dissertation work.

Course outcome: The individual dissertation paper is very much required to develop practical knowledge in different aspects of the fishery field that was theoretically studied. This will very much helpful to the students those are implacable future research as well as corporate job. Dissertation work will motivate to engage in research oriented job.

FSC-493
(Core course - 8 credits: 100 Marks)

Grand viva will be based on the overall understanding of the subject in front of external and internal examiners.

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VALUE ADDED COURSE

SOIL AND WATER QUALITY MANAGEMENT IN AQUACULTURE POND
(Four Weeks)

Theory:

Soil and water interaction: Physical and chemical properties of soil and water, Productivity vs. nutrient quality and quantity of soil and water; Aquatic microorganisms and their role in carbon, Nitrogen, Phosphorus and sulphur cycles and impact on aquatic habitats and species. Soil and water quality monitoring: Soil and water quality standards; Equipment used for soil and water quality estimations, Automated systems for monitoring, Quality checks and management, aeration system for water quality management. Fertilizers and manures: Different kinds of fertilizers and manures, Fertilizer grade, source, rate and frequency of application, Biofertilizers, Use of treated sewage for pond fertilization, Ecological changes taking place after fertilizing, primary production, degradation of molecules in aquatic environment, Utilization of bioactive compounds by microorganisms. Soil and water conditioners: Biological indicators, Chemical and physical method of conditioning, Prebiotics, Probiotics, Minerals, Micro-nutrients and additives. Development of suitable soil and water quality: Cat clay/pyrite soil, Seepage, water treatment, Water filtration devices, Aeration, Chlorination, Ozonization and UV radiation, Algal bloom control, Eutrophication, Aquatic weed management.

Practical:

Preparation of water quality charts and maintenance; Equipment used in soil and water analysis; Soil sampling, Process of pond filling, Analyses of mud acidity and soil texture; Measurements of temperature, pH, conductivity, salinity, transparency, turbidity and solids; Analyses of dissolved oxygen, alkalinity and hardness, phosphorus, nitrogen; Estimation of primary productivity; Application of fertilizers and pond liming; Analysis of toxic elements, microbial techniques.

Rreferences // Suggested Reading

1. Adhikari S and Chatterjee DK. 2008. *Management of Tropical FreshwaterPonds*. Daya Publ. APHA, AWWA, WPCF. 1998. Standard Methods for the Examination of Water and Wastewater, 20th Ed. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, Washington, DC.
2. Boyd, C. E. and Tucker, C. S. 1992. *Water Quality and Pond Soil Analyses for Aquaculture*, Alabama Agricultural Experimental Station, Auburn University.
3. Boyd CE. 1979. *Water Quality in Warm Water Fish Ponds.* Auburn University.
4. ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.
5. Mcvey JP. 1983. *Handbook of Mariculture*. CRC Press.

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6. Parsons TR, Maita Y and Lalli CM. 1984. *A Manual of Chemical and Biological Methods for Seawater Analysis*. Pergamon Press.
7. Rajagopalsamy CBT and Ramadhas V. 2002. *Nutrient Dynamics inFreshwater Fish Culture System*. Daya Publ.
8. Sharma LL, Sharma SK, Saini VP and Sharma BK. (Eds.). 2008. *Management of Freshwater Ecosystems*. Agrotech Publ. Academy.

List of suggested e-resources

- https://www.icar.org.in/
- http://www.fao.org/home/en/
- https://www.worldfishcenter.org/
- http://epubs.icar.org.in/ejournal/
- https://lib.icar.gov.in/full_text_ebooks.html
- https://lib.icar.gov.in/Open_Access_Journal.html
- https://www.aquaculturealliance.org/
- https://www.sciencedirect.com/
- http://www.ciba.res.in/
- http://www.cmfri.org.in/
- http://www.cife.edu.in/
- http://cifa.nic.in/
- http://www.nbfgr.res.in/ http://www.dcfr.res.in/
- http://www.cift.res.in/
- http://www.tnjfu.ac.in/
- https://www.was.org/
- https://www.asianfisheriessociety.org/
- https://www.aquaeas.eu/
- https://www.curtin.edu.au/
- https://www.tp.edu.sg/
- https://www.arizona.edu/
- https://mpeda.gov.in/MPEDA/
- http://dof.gov.in/
- http://www.caa.gov.in/
- http://www.fao.org/fishery/statistics/en
- http://kufos.ac.in/
- http://www.auburn.edu/
- https://www.stir.ac.uk/
- https://www.ugent.be/en
- https://oregonstate.edu/
- https://www.dtu.dk/english
- https://www.utas.edu.au/
- http://cifa.nic.in/node/47
- http://people.tamu.edu/~tdewitt/wfsc448/index.html
- https://www.ufl.edu/academics/programs/
- https://www.nord.no/en
- https://www.uib.no/en

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• http://www.fish.kagoshima-u.ac.jp/efish/field/aqu.html
• https://www.ccac.ca/en/training/modules/fish-stream.html
• https://www.u-tokyo.ac.jp/en/
• https://www.bio.mie-u.ac.jp/en/
• https://www.ntu.edu.tw/english/
• https://en.ctu.edu.vn/
• https://en.uit.no/startsida
• http://www.ncbi.nlm.nih.gov/
• http://www.genome.gov
• http://web.utk.edu/~rstrange/wfs550/html-con-pages/l-heart.html
• www.barnesandnoble.com › fishpathology-ronald-j-roberts
• www.springer.com › book
• http://bioinfo.ut.ee/primer3-0.4.0/
• https://all-about-molecular-biology.jimdo.com/
• https://www.molbiolcell.org/
• http://www.web-books.com/MoBio/
• https://npsa-prabi.ibcp.fr/cgi-bin/npsa_automat.pl?page=/NPSA/npsa_sopma.html
• http://www.bioinformatics.nl/cgi-bin/primer3plus/primer3plus.cgi
• https://www.sciencedaily.com/terms/molecular_biology.htm
• https://plato.stanford.edu/entries/molecular-biology/#toc
• https://molbiol-tools.ca/Alignments.htm
• https://molbiol-tools.ca/Phylogeny.htm
• http://evolution.genetics.washington.edu/phylip/software.html
• https://www.addgene.org

List of suggested Journals

•*Aquaculture*
• *Aquacultural Engineering*
• *Aquaculture International*
• *Aquaculture Nutrition*
• *Aquaculture Research*
• *Reviews in Aquaculture*
• *Aquaculture Economics and Management*
• *Journal of the World Aquaculture Society*
• *Journal of Fish Diseases*
• *Fisheries Science*
• *Fisheries Research*
• *Fish and Fisheries*
• *Fish and Shellfish Immunology*
• *Fisheries Management and Ecology*
• *FEMS Microbiology Ecology*
• *FEMS Microbiology Letters*
• *Current Science*
• *Canadian Journal of Fisheries and Aquatic Sciences*

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• *British Journal of Environment and Climate Change*
• *Biotechnology Letters*
• *Asian Fisheries Science*
• *Asian Journal of Animal Sciences*
• *Aquatic Sciences*
• *Aquatic Toxicology*
• *African Journal of Aquatic Science*
• *Turkish Journal of Fisheries and Aquatic Sciences*
• *Indian Journal of Animal Nutrition*
• *Journal of Fish Physiology and Biochemistry*
• *Journal of Applied Icthyology*
• *Journal of Aquaculture in Tropics*
• *Journal of Aquatic Living Resources*
• *Journal of Biotechnology*
• *Journal of Fish Physiology and Biochemistry*
• *Annual Review of Nutrition*
• *Annual Review of Physiology*
• *Journal of Plankton Research*
• *Water Research*
• *World Journal of Microbiology and Biotechnology*
• *Ecotoxicology and Environmental Safety*
• *Environment and Ecology*
• *Environmental Pollution*
• *Environmental Science*
• *Environmental Studies*
• *Environmental Technology*
• *Environmental Toxicology*
• *Indian Journal of Agricultural Statistics*
• *Indian Journal of Cytology and Genetics*• *Turkish Journal of Fisheries and Aquatic Sciences*
• *Indian Journal of Animal Nutrition*
• *Journal of Fish Physiology and Biochemistry*
• *Journal of Applied Icthyology*
• *Journal of Aquaculture in Tropics*
• *Journal of Aquatic Living Resources*
• *Journal of Biotechnology*
•*Advances in Marine Biology*
• *Fish Physiology and Biochemistry*
• *General and Comparative Endocrinology*
• *Frontiers in Aquatic Physiology*
• *Frontiers of Physiology*
• *American Journal of Physiology*
• *Scientific Reports*
• *Plos One*
• *Journal of Experimental Biology*
• *Journal of Comparative Physiology*
• *Comparative Biochemistry and Physiology*

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- *Endocrinology*
- *Journal of Endocrinology*
- *Reproduction*
- *Biology of Reproduction*
- *Reproductive Sciences*
- *Journal of Endocrinology*
- *Animal Reproduction Science*
- *Molecular Reproduction and Development*
- *Reproduction Fertility and Development*
- *Journal of Fish Biology*
- *Canadian Journal of Aquatic Science*
- *Journal of Physiology and Biochemistry*
- *Current Research in Physiology*
- *Journal of Physiology and Pathophysiology*
- *Indian Journal of Physiology and Pathophysiology*
- *Journal of Cellular Physiology*
- *Cellular Physiology and Biochemistry*
- *Histology and Histopathology*
- *American Journal of Physiology - Endocrinology and Metabolism*
- *Annual Review of Cell and Developmental Biology*
- *Climate Change*
- *Climate Change and Environmental Sustainability*
- *Developmental Biology*
- *International Journal for Vitamin and Nutrition Research*
- *International Journal of Food Sciences and Nutrition*
- *Journal of Animal Physiology and Animal Nutrition*
- *Journal of Nutritional Biochemistry (Nutrition Reports International)*
- *Journal of Nutritional Science and Vitaminology*
- *Aquaculture Nutrition*
- *Aquaculture Research*
- *Fish and Fisheries*
- *Fish and Shellfish Immunology*
- *Fisheries and Fisheries*
- *Fisheries management and ecology*
- *Fisheries Research*
- *Indian Journal of Fisheries*
- *Journal of Biology*
- *Journal of Comparative Neurology*
- *Journal of Environment and Bio-sciences*
- *Journal of Environmental Biology*
- *Journal of Fish Behaviour*
- *Molecular Marine Biology and Biotechnology*

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