NEW AND RESTRUCTURED POST-GRADUATE CURRICULA & SYLLABI

Fisheries Science

Education Division
Indian Council of Agricultural Research
New Delhi

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Contents

EXECUTIVE SUMMARY

The Country-level exercise undertaken by the ICAR aims to address certain concerns with respect to acceptability, transferability of the knowledge and skills and employability of the postgraduates receiving Agricultural Education in the Country. The overall aim is to infuse quality, excellence and relevance in Agricultural Education.

The proposed curricula and syllabi are utilitarian, futuristic, incorporate modern science and cutting-edge technologies, lay emphasis on experiential learning, and would equip students to become entrepreneurs as well as professionals.

At present, besides the Central Institute of Fisheries education (CIFE), Mumbai which is a Deemed University, postgraduate education in the Discipline of Fisheries Science is offered by 10 Fisheries Colleges in the country. Six Colleges are offering both M.F.Sc. and Ph.D. Degree programmes, while 4 Colleges are offering only M.F.Sc. programme. Most of the Colleges offer a few specializations (M.F.Sc. 1 to 8 and Ph.D. up to 5), whereas the maximum number of specializations is offered by CIFE – 9 in Masters and 8 in Doctoral programmes. The Curricula and Syllabi in the Broad Subject Matter Area (BSMA) of Fisheries Science were reviewed by a Committee (BSMAC) and a total of 14 Courses for the M.F.Sc. and 11 Courses for the Ph.D. programmes were identified. Their salient features are as follows:

1. Aquaculture

- Aquaculture as a specialization is taught by all the Institutes offering postgraduate programme in Fisheries, in view of its importance in terms of contribution to fish production and employment generation.
- After studying the courses offered under Aquaculture by various Colleges and CIFE, a synthesis was made taking into consideration the level of exposure required for the students at Masters and Doctoral levels and in keeping with current knowledge and future needs.
- Courses on culture of finfish and shellfish in fresh, brackish and marine waters are included, besides ornamental fish culture.
- Courses on nutrition, seed production, health management, biotechnology and genetics have also been included.

2. Aquatic Environment Management

- The name of this Subject Matter Area is new and has been adopted keeping in view the environmental constraints faced by the fisheries and aquaculture sectors.
- Both Masters and Doctoral programmes lay emphasis on management of the aquatic environment.
- New and innovative Courses such as Integrated Coastal Zone Management, Environmental Biotechnology, Environmental Toxicology, etc at Masters level and Environment Impact Assessment, Ecotoxicology, Restoration Ecology, etc. at Doctoral level have been included.

3. Aquatic Animal Health

- The name of this Subject Matter Area is also new and has been adopted in preference to Fish Pathology and Microbiology.
- The Subject Area aims to develop expertise necessary to understand the health problems encountered in aquatic animals and to cater to the needs of the aquaculture industry.
- In addition to the traditional courses pertaining to Microbiology, Parasitology and Pathology, modern subjects such as Fish Immunology, Fish Virology and Cell Culture and Clinical Pathology have been included at Masters level, while Fish and Shellfish Virology, Fish Pharmacology, etc. have been incorporated at the Doctoral level.

4. Business Management

- This is a recently introduced Masters Degree programme and an innovation in the discipline of Fishery Science.
- The aim is to train professional fisheries postgraduates to manage the fisheries enterprises.
- The new courses include Managerial Economics, Marketing Management, HR Management, Forecasting Methods and Operations Research, Introduction to WTO and IPR, Export and Import Management, etc.

5. Fish Biotechnology

- The existing subject area of Fish Genetics and Biotechnology at Masters and Doctoral levels has been bifurcated and an independent programme of Fish Biotechnology has been proposed in view of the great strides made in the field of biotechnology and the availability of biotechnological tools for development of fisheries and aquaculture.
- New Courses introduced include Genetic Engineering and its Application in Fisheries, Bioinformatics, Marine Biotechnology, Aquaculture Biotechnology, etc. in M.F.Sc. and Functional Genomics and Proteomics, RNAi Technology, etc. in Ph.D.

6. Fish Genetics and Breeding

- At present Masters and Doctoral Courses are being offered in the discipline of Fish Genetics and Biotechnology and Ph.D in Fish Genetics at CIFE, Mumbai. The combination of Fish Genetics and Breeding is, therefore, a new one.
- New Courses under M.F.Sc. programme include Population Genetics, Quantitative Genetics, Molecular Genetic Markers, Cytogenetics, etc. and under the Doctoral programme Application of Genetics in Commercial Aquaculture, Transgenic Production and GMOs, etc.

7. Fish Nutrition and Feed Technology

- At present the specialization of Nutrition and Biochemistry is being offered at CIFE, Mumbai. However, it was felt necessary to bring it under the new nomenclature.
- Feed Technology component has attained great importance in recent years as feed employed in the culture of fish and shellfish is becoming a limiting factor in terms of economics as well as availability of quality ingredients.
- Nutrition and feed not only play a crucial role in enhancing the growth of fish, but also in breeding and health management.
- It is aimed at training professionals to manage the numerous feed plants established in the country, as well as develop newer and cheaper feeds for the farmed species.
- All these aspects have been considered in selecting courses recommended both at M.F.Sc. and Ph.D. levels.

8. Fish Physiology and Biochemistry

- Fish Physiology is an emerging area and it was felt logical to include this as a separate specialisation in combination with Biochemistry at the Masters level to start with.
- Various aspects of physiology, including Ecophysiology of Fishes, Reproductive Physiology and Endocrinology, Physiology of Fish Behaviour, Diagnostic Biochemistry, etc. have been incorporated to disseminate the available current knowledge.

9. Fish Processing Technology

- This is an ongoing programme both at Masters as well as Doctoral levels in quite a few Fisheries Colleges, although under the nomenclature of Post Harvest Technology at some places. Certain new courses have been included keeping in view the recent trends in the sector.
- New Courses at the Masters level include Quality Assurance, Management and Certification; Handling, Storage and Transport of Fresh Fish; Additives in Fish Processing; Fish By-products and Waste Utilization, etc.
- New Courses at the Doctoral level include Quality Management Systems, Lipids of Aquatic Origin, Toxins and Contaminants, Environmental Impact of Fishery Industries, etc.

10. Fisheries Economics

- This is an important discipline which is presently being offered only at the Masters level in a few Fisheries Colleges in the country. Development of the Curriculum and Syllabus for the introduction of Ph.D. Programme in Fisheries Economics is a progressive step.
- Some of the important subjects covered include Fisheries Resource Economics, Environmental Economics, Econometrics, Indian Economy, Aquaculture Production Economics, Fisheries Governance and Socio-Economics, etc.

11. Fisheries Engineering and Technology

- This is a course being offered at the Masters level to start with.
- The Course is meant to train postgraduates with the knowledge and skills necessary to design, manage and maintain the fishing craft and gear which are vital components in the fisheries industry.
- The new subjects introduced include Responsible Fishing, Engineering Graphics, Fishing Harbour and Fleet Management, Environmental Engineering and Pollution Control, etc.

12. Fisheries Extension

- This major area of study is presently being offered only in a couple of Fisheries Colleges that too at the Masters level only.
- In view of the importance of Extension in the overall development of the fisheries and aquaculture sectors, the course is proposed to be offered at the Ph.D. level also.
- Some of the new Courses include Participatory Approaches in Fisheries Extension; Community Mobilization and Organizational Development; Gender, Livelihood and Development; Indigenous Traditional Knowledge in Fisheries at the Masters level and Monitoring and Evaluation of Development Programmes, Measurement and Scaling Techniques, Ergonomics, etc. at Doctoral level.

13. Fisheries Resource Management

- By and large the core subject matter of this discipline at the undergraduate level is traditionally dealt under the title of Fishery Biology with emphasis on Taxonomy, Biology, Physiology, Fish Stock Assessment, etc. At the postgraduate level the discipline has been renamed as Fisheries Resource Management.
- For the Masters porogramme the new subjects introduced include Marine Ecosystems, Biodiversity and Conservation; Fisheries Regulations; Remote Sensing and GIS for Fisheries Management; Aquatic Floral Resources, etc.
- For the Doctoral programme the new subjects introduced include Assessment of Aquatic Biodiversity, Conservation and Management of Exploited Fisheries Resources, Coral Reef Management, Fisheries Environment Assessment, etc.

14. Supporting Courses

- Introduction of Compulsory Supporting Courses (total 5 Credits) common to all disciplines both at Masters and Doctoral levels is a new feature.
- In order to make the students proficient in Experimental Design for undertaking meaningful and reliable research one Course on Statistical Methods and another Course on Research Methodology have been introduced at the Masters level.

With the restructuring of Curricula and Syllabi there is a need to strengthen infrastructure, especially in terms of equipment for conducting practicals and carrying out research. One of the criticisms in the industry is that Fisheries graduates have less exposure to hands-on-training. This should be overcome by creating better practical facilities for all the subjects/courses. Field training in the form of experiential learning is recommended at the M.F.Sc. level. Also, faculty should have opportunities to upgrade knowledge through short term training programmes. A grant of Rs. 100 lakhs may be provided to strengthen education at Masters level and another Rs. 100 lakhs at Doctoral level to each of the Colleges offering these programmes, especially to add laboratory facilities pertaining to the new Courses. These measures would help in improving the quality of postgraduates and make them better employable. Further, well trained and competent human resource will be able to implement Fisheries Development programmes more effectively, which would not only ensure nutritional security in the country, but also contribute to the economic growth of the sector from which the society at large would derive benefit.

BSMA Committee on Fisheries

(Fishery Sci, Inland Aq, Maricul, Fresh Water Aq, Post Harv. Tech/Fish Process. Tech/Aq. Fish Biol./Fish Micro/Fish Hydrography/Fish Extn)

(Constituted by ICAR vide Office order No. F. No. 13 (1)/2007- EQRdated January 14, 2008)

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PREAMBLE

Fisheries has been in limelight during the past three decades as the fastest growing food production system. Capture and Culture Fisheries are vibrant economic activities contributing to agricultural (4.6% GDP) and national economy (1.3% GDP), livelihood and nutritional security, employment generation (11 million people) and foreign exchange earnings (Rs. 8364 crore in 2006-07). Aquaculture sector has witnessed spectacular production increases over the past two decades, driven by technological developments and increased demand for fish. The overriding challenges facing the fisheries sector have been and still are production of adequate and cheap food fish for all and improve the quality of life of fishers and farmers. This could be achieved only by addressing the issues of underutilization and low productivity in inland water bodies, sustainability of capture fisheries, huge post-harvest losses, poor quality and low value addition, unregulated domestic markets and protective global markets, and the low level of domestic fish consumption. However, the extent and quality of development is largely conditioned by the given policy environment and the quality of available Human Resources.

Lack of comprehensive and enabling policy framework at Central and State levels, lack of adequate and professionally skilled human resource resulting in poor implementation of development and welfare programmes, ineffective and redundant services delivery systems, and poor infrastructure development have almost limited the scope of fisheries development in India. Ironically, the importance of policy and HRD has not been given sufficient attention so far. In this context, generating competent professional human resource would be one of the most critical inputs in driving the engine of sustainable fisheries and further development of aquaculture by realising the immense potential for horizontal and vertical expansion.

Globalisation like in other sectors has thrown up opportunities and risks in the fisheries sector also, necessitating changes in policy and governance in order to maximize benefits and minimize risks through sustainable and responsible fisheries management and production. Further, it is having a profound effect on education too, transforming the economies into knowledge based service and innovation economies. Agricultural education in general and fisheries education in particular is no exception. For higher education leaders in India (SAUs/DUs), this new environment holds both threats and opportunities. To benefit from the opportunities as well as address the challenges, fisheries education system should be subjected to constant innovations and reforms, particularly with respect to redesigning of curricula and syllabi, innovative pedagogy, developmental orientation, entrepreneurship, soft skill development, etc. This is a necessary condition to prepare the graduates and equip them to not only effectively respond to the emerging needs and challenges, but also to become creative and proactive partners in piloting this knowledge-led revolution.

Keeping this in view, the ICAR which is vested with responsibilities of guiding and coordinating agricultural education in the country took several steps to ensure quality education to meet the ever changing national and global scenario in fisheries sciences. One of these steps was to set up an Accreditation Board, which among other things is required to periodically assess the curricula of various educational programmes offered by National Agricultural Education System and suggest modifications. Fisheries education in India, since the establishment of the Central Institute of Fisheries Education in 1961 for in-

service training and later the establishment of the first Fisheries College at Mangalore under the SAU system in 1969, has grown manifold and evolved in the last four decades as a professional discipline consisting of Bachelors, Masters and Doctoral programmes in various branches of Fisheries Science. At present, 16 Fisheries Colleges offer four-year degree programme in Bachelor of Fisheries Science (B.F.Sc.), while 10 of them offer Masters and 6 Doctoral programmes. The undergraduate curricula and syllabi were periodically revised and the most recent exercise was undertaken in 2006. All the Fisheries Colleges are in the process of adapting these, bringing in parity of standards between Colleges.

Restructuring of postgraduate curricula and syllabi to upgrade the competence and standard of human resource in fisheries has been felt for quite some time. Only one such exercise was carried out in 2002 to revise the Masters curricula and syllabi, but not that of Doctoral programme. Even the revised Masters syllabi have not been adapted by majority of the Fisheries Colleges. The present exercise of revising and reorienting the postgraduate curricula was initiated by ICAR in 2007 through the constitution of a National Core Group, drawing experts from various fields of Agriculture. Further, in early 2008, eighteen Broad Subject Matter Area (BSMA) Committees were constituted to carry out the massive exercise of restructuring the curricula and syllabi of various Masters and Doctoral programmes. One of the BSMA committees was for Fisheries Science which had its first meeting in March 2008 at CIFE, Mumbai to decide on the nomenclature and number of specializations to be offered at Masters and Doctoral levels and also the broad curricula. Taking into consideration the specializations presently being offered by different Fisheries Colleges and CIFE, 14 M.F.Sc. and 11 Ph.D. specialisations were identified. The criteria for identification of these were their role in fish production and importance in the current scenario of job opportunities; keeping future in view even emerging areas such as Physiology have been included. Different groups were formed to draw up draft syllabi for the different specializations with one member of BSMA as leader. These groups had a series of online discussions and consultations and came out with the draft syllabi. A 2-day consultative workshop of all stakeholders was conducted in April 2008 at CIFE, Mumbai where the syllabi and curricula were discussed extensively. All the useful suggestions that emerged from various stakeholders were incorporated and the draft document widely circulated and further refined through online discussions. Following the meeting of Conveners and Member Secretaries of BSMAs with the Chairman of the National Core Group at Delhi in June 2008, the draft was modified as per the Template finalized in that meeting.

The reviewer's observations have been addressed and as per his suggestion Fisheries Microbiology specialisation has been dropped. The revised draft was presented at the final meeting of the National Core Group in November 2008 and finalised taking into consideration all the suggestions. Compulsory Supporting Courses common to all disciplines have been introduced both at Masters and Doctoral levels.

The restructured curricula and syllabi with more emphasis on hands on training are expected to improve the skills of postgraduates, making them more competent, providing broader employment opportunities. Effective implementation of the new curricula and syllabi would require improved infrastructure facilities, including equipment for carrying out practicals and research. Also, there is a need to upgrade knowledge of the faculty through short term training. Therefore, it is imperative that ICAR provide special funds towards these. An initial grant of Rs. 100 lakhs each for Masters and Ph.D programmes

may be released for strengthening postgraduate education at each of the Fisheries Colleges offering postgraduate education.

We are thankful to all the members of the BSMA Committee on Fisheries Science and the participants of consultative workshop for their valuable suggestions and contributions for the development of the curricula and syllabi. We are grateful to Dr. J. C. Katyal, Vice-Chancellor, CCSHAU and Chairman, National Core Group for Restructuring of Masters and Doctorate Course Curricula and Syllabi, for providing guidance and encouragement in this endeavour. Our thanks are due to Dr. Mangla Rai, D.G., ICAR, Secretary, DARE and Chairman of the Accreditation Board and Dr. S.P. Tewari, DDG (Edn.), for their support in bringing out this document. The extensive help rendered by Dr. P.S. Ananthan, Scientist, CIFE, Mr. P. Krishnan, Scientist, CARI and Ph.D Scholar at CIFE and Mr. U. Kanagarajan, Research Scholar, CIFE in compiling and editing is highly appreciated. We also thank Dr. K. Ravindranath, Member Secretary, BSMA, for his untiring assistance throughout the consultation process till final documentation. We hope that this document will serve as a guide and help in achieving uniformly high standards in postgraduate education in Fisheries Science across the country.

ORGANIZATION OF COURSE CONTENTS
&
CREDIT REQUIREMENTS

Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600-series to Doctoral level. A Ph. D. student must take a minimum of two 600 series courses, but may also take 500-series courses if not studied during Master's programme.
- Credit seminar for Master's level is designated by code no. 591, and the two seminars for Doctoral level are coded as 691 and 692, respectively.
- Similarly, 599 and 699 codes have been given for Master's research and Doctoral research, respectively.

Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not unequivocally exclude other such reference material that may be recommended according to the advancements and local requirements.
- A list of journals pertaining to the discipline is provided at the end which may be useful as study material for 600-series courses as well as research topics.
- E-Resources - for quick update on specific topics/events pertaining to the subject.
- Broad research topics provided at the end would facilitate the advisors for appropriate research directions to the PG students.

Minimum Credit Requirements

Subject	Master's programme	Doctoral programme
Major	20	15
Minor	09	08
Supporting	05	05
Seminar	01	02
Research	20	45
Total Credits	**55**	**75**
Compulsory Non Credit Courses	See relevant section	

Major subject: The subject (department) in which the students takes admission

Minor subject: The subject closely related to students major subject (e.g., if the major subject is Entomology, the appropriate minor subjects should be Plant Pathology & Nematology).

Supporting subject: The subject not related to the major subject. It could be any subject considered relevant for student's research work.

Non-Credit Compulsory Courses: Please see the relevant section for details. Six courses (PGS 501-PGS 506) are of general nature and are compulsory for Master's programme. Ph. D. students may be exempted from these courses if already studied during Master's degree.

AQUACULTURE
Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
AQC 501*	SUSTAINABLE AQUACULTURE	2+1
AQC 502*	SOIL AND WATER QUALITY MANAGEMENT IN AQUACULTURE	2+1
AQC 503*	NUTRITION AND FEED TECHNOLOGY	2+1
AQC 504*	AQUATIC ANIMAL HEALTH MANAGEMENT	2+1
AQC 505	SEED PRODUCTION AND HATCHERY MANAGEMENT OF FINFISHES	2+1
AQC 506	SEED PRODUCTION AND HATCHERY MANAGEMENT OF SHELLFISHES	1+1
AQC 507	APPLIED GENETICS IN AQUACULTURE	2+1
AQC 508	NON-FOOD AQUACULTURE	1+1
AQC 509	COASTAL AQUACULTURE	2+1
AQC 510	FRESHWATER AQUACULTURE	2+1
AQC 511	LARVAL NUTRITION AND CULTURE OF FOOD ORGANISMS	1+1
AQC 512	AQUACULTURE ENGINEERING	2+1
AQC 591	MASTER'S SEMINAR	1+0
AQC 599	MASTER'S RESEARCH	20
AQC 601**	ADVANCES IN AQUACULTURE PRODUCTION SYSTEMS	2+1
AQC 602**	ADVANCES IN SEED PRODUCTION AND HATCHERY MANAGEMENT	2+1
AQC 603**	AQUACULTURE AND ECOSYSTEM MANAGEMENT	2+1
AQC 604	AQUATIC ANIMAL HEALTH MANAGEMENT AND QUARANTINE	1+1
AQC 605	FISH AND SHELLFISH PHYSIOLOGY AND ENDOCRINOLOGY	1+1
AQC 606	ADVANCES IN FISH GENETICS	2+1
AQC 607	INTENSIVE FARMING SYSTEMS FOR TILAPIA AND CATFISHES	1+1
AQC 608	AQUACULTURE DEVELOPMENT PLANNING AND MANAGEMENT	1+1
AQC 609	APPLIED BIOTECHNOLOGY	1+1
AQC 691	DOCTORAL SEMINAR I	1+0
AQC 692	DOCTORAL SEMINAR II	1+0
AQC 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme; ** Compulsory for Doctoral programme

AQUACULTURE
Course Contents

AQC 501 SUSTAINABLE AQUACULTURE 2+1

Objective

To gain in depth knowledge and field exposure on sustainable aquaculture practices.

Theory

UNIT I

Present scenario and problems: Trends in global and Indian aquaculture; different farming systems; intensive systems and constraints - environmental degradation and disease outbreaks.

UNIT II

Sustainability and development: Systems approach and its application in aquaculture with special reference to resource-poor systems; Role of aquatic resources in food and nutrition; Aquatic resource and livelihood systems.

UNIT III

Environmental issues: Exotic species introduction; escapement; contamination of indigenous gene pool; salinization of soil and water; environmental impact; over exploitation of wild stocks; mangrove deforestation.

UNIT IV

Socio-economic issues: Conflicts over water and land use; conflicts of interest between aqua farmers and fishermen; resistance from local public; anti-dumping duties.

UNIT V

Strategies for sustainability: Sustainability concept; food security; biosecurity; organic farming; integrated farming; responsible aquaculture; rotational aquaculture; bioremediation; role of biotechnology, traceability. Application of renewable energy in aquaculture - solar energy, wind, and tidal energy, Seed certification, Sustainable use of antibiotics.

UNIT VI

Economic viability: export vs. domestic marketing, value addition.

UNIT VII

Guiding principles to sustainable aquaculture development: Coastal Aquaculture Guidelines Source Book, FAO Code of Conduct for Responsible Fisheries; Holmenskollen Guidelines for Sustainable Aquaculture.

Practical

Visit to conventional aquafarm to see the management of used water; Survey on environmental impact nearby aquaculture farms; Setting model for sustainable aquaculture (organic farm, integrated farm); Applications of remote sensing and GIS (geographical information system); Economic evaluation of aquaculture practices.

Suggested Readings

Bardach JE. 1997. *Sustainable Aquaculture*. John Willey & Sons.

Bardach JE, Rhyther JH & Mc. Larney WO. 1972. *Aquaculture Farming and Husbandry of Freshwater and Marine Organisms*. John Wiley & Sons.

Beets WC. 1990. *Raising and Sustaining Productivity of Small-Holder Farming Systems in the Tropics*. Agbe Publ.
Edwards P, Little DC & Demaine H. (Eds.). 2002. *Rural Aquaculture*. CABI.
FAO 2001. *Planning and Management for Sustainable Coastal Aquaculture Development*. FAO.
Imai T. 1978. *Aquaculture in Shallow Seas. Progress in Shallow Sea Culture*. Amerind Publ.
James PM. 1983. *Handbook of Mariculture*. Vol. I. *Crustacean Aquaculture*. CRC Press.
Leung P, Lee CS & O'Bryen JP. (Eds.). 2007. *Species and System Selection for Sustainable Aquaculture*. Blackwell Publ.
Midlen & Redding TA. 1998. *Environmental Management for Aquaculture*. Chapman & Hall.
Selvamani BR & Mahadevan RK. 2008. *Aquaculture, Trends and Issues*. Campus Books International.

AQC 502 SOIL AND WATER QUALITY MANAGEMENT IN AQUACULTURE 2+1

Objective

To learn effective soil and water quality management practices.

Theory

UNIT I

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.

UNIT II

Soil and water quality monitoring: soil and water quality standards; soil and water quality monitoring and management.

UNIT III

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.

UNIT IV

Soil and water quality management: Cat clay/pyrite soil, seepage, water treatment, water filtration devices, aeration, chlorination, ozonization and UV radiation, Algal bloom control, eutrophication, Aquatic weed management, Waste water treatment practices, Water quality management in hatcheries, Waste discharge standards, Role of microorganisms in fish production, fish health and fish safety; Microbial load and algal blooms.

Practical

Equipment used in soil and water analysis; Soil sampling, determination of soil moisture and bulk density; 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 and

chlorophyll; Application of fertilizers and pond liming; Analysis of toxic elements; Microbial techniques; Visit to effluent treatment plant; Design and operation of biological filters.

Suggested Readings

Adhikari S & Chatterjee DK. 2008. *Management of Tropical Freshwater Ponds*. 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, D. C.

Boyd, C. E. and Tucker, C. S. 1992. Water Quality and Pond Soil Analyses for Aquaculture, Alabama Agricultural Experimental Station, Auburn University.

Boyd CE. 1979. *Water Quality in Warm Water Fish Ponds*. Auburn University.

ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.

Parsons TR, Maita Y & Lalli CM. 1984. *A Manual of Chemical and Biological Methods for Seawater Analysis*. Pergamon Press.

Rajagopalsamy CBT & Ramadhas V. 2002. *Nutrient Dynamics in Freshwater Fish Culture System*. Daya Publ.

Sharma LL, Sharma SK, Saini VP & Sharma BK. (Eds.). 2008. *Management of Freshwater Ecosystems*. Agrotech Publ. Academy.

AQC 503 NUTRITION AND FEED TECHNOLOGY 2+1

Objective

To create basic understanding on the nutritional requirements of fish/shellfish and feed manufacture.

Theory

UNIT I

Fish nutrition: Principles of fish nutrition and terminologies, nutritional requirements of cultivable finfish and shellfish: larvae, juveniles and adults.

UNIT II

Nutritional biochemistry: Classification, nutrient quality and evaluation of proteins, lipids and carbohydrates.

UNIT III

Role of nutrients: amino acids, fatty acids, proteins, lipids, carbohydrates, vitamins and minerals.

UNIT IV

Nutritional bioenergetics: Fish as an open thermodynamic system, Energy requirement of fishes, protein to energy ratio, digestible energy, nitrogen balance index, protein sparing effect, high energy feeds, isocaloric diets, Optimal foraging theory, Mathematical modeling of ingestion, Metabolic rate, Energy budgets, Energetic efficiency of fish production.

UNIT V

Nutritional physiology: Digestion, accretions and nutrient flow, Factors affecting digestibility.

UNIT VI

Nutritional pathology: Antinutritional factors and antimetabolites, microbial toxins, methods of elimination, nutrient deficiency and symptoms.

UNIT VII

Feed Resources: Nutritional value of feed ingredients and live feed, Contribution from natural food to nutrient requirements of fish, Feed additives (attractants, growth stimulants and probiotics and binders), and Feed resources assessment.

UNIT VIII

Feed Manufacture: Feed formulation and processing, On-farm feed manufacture, Commercial feed manufacture, Feed storage.

UNIT IX

Feeding Practices: Supplementary feed–theory and practice, Complete diet - theory and practice, Feeding methods and scheduling, ration size, feed performance and economics.

Practical

Formulation and preparation of a balanced fish feed; Feeding trials; Proximate analysis- moisture, crude protein, crude lipid ,ash , acid insoluble ash content of feed; Estimation of crude fibre, nitrogen free extract, calcium and phosphorus content of feed; Estimation of protein and lipid quality; Determination of gross energy content of feed and feed ingredients; Determination of the digestibility of feed using markers; Estimation of FCR from feeding trials and preparation of feeding table; Estimation of growth parameters from feeding trials; Analysis of mycotoxins from feed ingredients/feed; Gut content analysis to study artificial and natural food intake. Visit to feed manufacturing units.

Suggested Readings

ADCP (Aquaculture Development and Co-ordination Programme). 1980. *Fish Feed Technology*. ADCP/REP/80/11. FAO.

Cyrino EP & Bureau D & Kapoor BG. 2008. *Feeding and Digestive Functions in Fishes.* Science Publ.

D' Abramo LR, Conklin DE & Akiyama DM. 1977. *Crustacean Nutrition: Advances in Aquaculture*. Vol. VI. World Aquaculture Society, Baton Roughe.

De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall Aquaculture Series.

Elena M. 2003. *Nutrition, Physiology and Metabolism in Crustaceans*. Science Publishers.

Guillame J, Kaushik S, Bergot P & Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis Publ.

Halver J & Hardy RW. 2002. *Fish Nutrition*. Academic Press.

Halver JE & Tiews KT. 1979. *Finfish Nutrition and Fishfeed Technology*. Vols. I, II Heenemann, Berlin.

Hertrampf JW & Pascual FP. 2000. *Handbook on Ingredients for Aquaculture Feeds*. Kluwer.

Houlihan D, Boujard T & Jobling M. 2001. *Food Intake in Fish*. Blackwell.

Lavens P & Sorgeloos P. 1996. *Manual on the Production and Use of Live Food for Aquaculture*. FAO Fisheries Tech. Paper 361, FAO.

Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Chapman & Hall.

New MB. 1987. *Feed and Feeding of Fish and Shrimp. A Manual on the Preparation and Preservation of Compound Feeds for Shrimp and Fish in Aquaculture*. FAO – ADCP/REP/87/26.

NRC (National Research Council). 1993. *Nutrient Requirements of Fish*. National Academy Press, Washington.
Ojha JS. 2005. *Aquaculture Nutrition and Biochemistry*. Daya Publ.

AQC 504 AQUATIC ANIMAL HEALTH MANAGEMENT 2+1

Objective

To provide holistic knowledge on fish and shellfish pathogens and their control measures.

Theory

UNIT I

Basics of fish and shellfish health management: Host-pathogen-environment relationship, Management of culture systems, Environmental stress.

UNIT II

Defence system in fish and shellfish: Defence systems in fish, innate and acquired immunity, inflammation response to diseases. Antibody and cell mediated immunity in fish and shellfish.

UNIT III

Parasitic and mycotic diseases: General characteristics, Epizootiology, Diagnosis, Life cycle, Prevention and treatment.

UNIT IV

Infectious bacterial and viral diseases: General characteristics, Epizootiology, Diagnosis, Prevention and treatment.

UNIT V

Non-infectious Diseases: Nutritional diseases, water, soil, environmental parameters and their effects on fish health. Disease in hatcheries and grow-out systems.

UNIT VI

Techniques in health management: Microbiological, haematological, histopathological, immunological and molecular techniques. Disease surveillance and reporting.

UNIT VII

Disease control and management: Environment management, chemotherapeutic agents, host management, prophylaxis- vaccines, adjuvants, immunostimulants and probiotics. Use and abuse of antibiotics and chemicals in health management. Fish health and quarantine systems. Seed certification, SPF and SPR stocks - development and applications.

Practical

General procedures for disease diagnosis; Taxonomy and identification of fish parasites; Sampling, preparation of media and culture of pathogenic bacteria; Techniques for bacterial classification; Histological techniques for disease diagnosis; Molecular and immunological techniques; Biochemical tests; PCR; ELISA; Agglutination test; Challenge tests; Purification of virus; Stress related study of fish and shellfish; Disease treatments.

Suggested Readings

Aline W. 1980. *Fish Diseases*. Springer Verlag.
Andrews C, Excell A & Carrington N. 1988. *The Manual of Fish Health*. Salamander Books.
Austin B & Austin DA. 1987. *Bacterial Fish Pathogens* (Diseases in Farm and Wild). Ellis Harward.

Felix S, Riji John K, Prince Jeyaseelan MJ & Sundararaj V. 2001. *Fish Disease Diagnosis and Health Management*. Fisheries College and Research Institute, T.N. Veterinary and Animal Sciences University. Thoothukkudi.

Inglis V, Roberts RJ & Bromage NR. 1993. *Bacterial Diseases of Fish*. Blackwell.

Iwama G & Nakanishi T. (Eds.). 1996. *The Fish Immune System - Organism, Pathogen and Environment*. Academic Press.

Roberts RJ. 2001. *Fish Pathology*. 3nd Ed. WB Saunders.

Schaperclaus W. 1986. *Fish Diseases*. Vols. I, II. Oxonian Press.

Shankar KM & Mohan CV. 2002. *Fish and Shellfish Health Management*. UNESCO Publ.

Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish*. Vols. I, II. 2nd Ed. Academic Press.

Walker P & Subasinghe RP. (Eds.). 2005. *DNA Based Molecular Diagnostic Techniques: Research Needs for Standardization and Validation of the Detection of Aquatic Animal Pathogens and Diseases*. FAO Publ.

Wedmeyer G, Meyer FP & Smith L. 1999. *Environmental Stress and Fish Diseases*. Narendra Publ. House.

AQC 505 SEED PRODUCTION AND HATCHERY OF FINFISHES 2+1

Objective

To learn seed production and hatchery management of commercially important cultivable fishes.

Theory

UNIT I

Introduction: History, constraints and current status of natural seed collection and hatchery seed production.

UNIT II

Reproductive biology: Physiology and morphology; Molecular and physiological basis of reproduction, Overview of current developments in reproductive biology.

UNIT III

Gamete maturation and development: Spermatogenesis and oogenesis, Hormonal pathways and mode of control.

UNIT IV

Environmental and endocrine control of reproduction: Reproductive cycles, Seasonality (Photoperiod, change in water quality and quantity, temperature, lunar cycle, etc.), Environmental and exogenous hormonal stimuli.

UNIT V

Induced spawning: Methods of natural and artificial fertilization, GnRH and Linpe models, evaluation of milt and egg, cryopreservation technique, use of different synthetic hormones and analogues for induced spawning, Egg staging, Stripping and fertilization.

UNIT VI

Hatchery technology for different species: Indian major and minor carps, Exotic carps, Catfishes, Tilapia, Masheer, Trout, etc.

UNIT VII

Marine fish seed production: Seabass, milkfish, mullets, sea breams, rabbitfish, grouper, yellowtail, eel, cobia, etc.

UNIT VIII

Hatchery design and management: Criteria for site selection of hatchery and nursery, Design and function of incubators, Jar hatchery, Chinese hatchery and other hatchery systems- design and operation, hatchery protocols, larval rearing stages, rearing technology, packaging and transport of seed.

UNIT IX

Seed supply in aquaculture: Relationship between fry supply and grow-out, Macro-planning of fry production to stimulate grow-out, Marketing and economics of fish seed.

Practical

Study of gonadal development in carps and other cultivable finfishes; Identification of carp and catfish seed; Collection and identification of cultivable brackishwater finfish seed; Packing and transportation of cultivable finfish seed; Induced breeding of fishes through various inducing agents; Evaluation of carp milt and egg; Design and operation of Chinese hatchery; Preparation of brood and larval feed for different cultivable finfish; Rearing of carp spawn and fry; Visit to different finfish hatcheries.

Suggested Readings

FAO. 1992. *Manual of Seed Production of Carps*. FAO Publ.

ICAR. 2006. *Hand Book of Fisheries and Aquaculture*. ICAR.

Jhingran VG & Pullin RSV. 1985. *Hatchery Manual for the Common, Chinese and Indian Major Carps*. ICLARM, Philippines.

Jhingran VG. 1991. *Fish and Fisheries of India*. Hindustan Publ.

Landau M. 1992. *Introduction to Aquaculture*. John Wiley & Sons.

Mcvey JP. 1983. *Handbook of Mariculture*. CRC Press.

Pillay TVR & Kutty MN. 2005. *Aquaculture- Principles and Practices*. Blackwell.

Rath RK. 2000. *Freshwater Aquaculture*. Scientific Publ.

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

AQC 506 SEED PRODUCTION AND HATCHERY MANAGEMENT OF SHELLFISHES 1+1

Objective

To provide overall knowledge of seed production and hatchery management of commercially important cultivable crustaceans and molluscs.

Theory

UNIT I

Introduction: Current status; problems and prospects.

UNIT II

Seed resources: Site selection and techniques of collection; identification and segregation of shellfish seed.

UNIT III

Reproductive biology: Gonad anatomy, endocrinology and reproductive mechanisms in prawns, shrimps, crabs, lobsters, mussels, oysters, scallops and clams; age at first maturity; factors affecting maturation and spawning.

UNIT IV

Broodstock: availability; improvement; nutritional requirements; transport; captive rearing and maturation; induced spawning; physical and chemical inducing agents; physiology and techniques of eyestalk ablation.

UNIT V

Seed production: Seed production of commercially important prawns, shrimps, crabs, lobsters, mussels, edible oysters, pearl oyster, scallops, clams and sea cucumber.

UNIT VI

Hatchery technology and management: Site selection and facilities required; culture and use of different live feed in shellfish hatcheries; larval diseases and their management; different chemicals and drugs used; water quality and feed management; Hatchery standards and biosecurity; sanitary and phytosanitary (SPS) measures; better management practices (BMPs); packaging and transport of seed.

UNIT VII

Economics of seed production.

Practical

Layout and design of prawn and shrimp hatcheries; Study of gonad development in different cultivable crustaceans and molluscs; Collection and identification of shellfish seed; Packing and transportation of shellfish seed; Eyestalk ablation technique; Identification of larval stages of shrimp, prawn, crab, mussel and oyster; Culture techniques of microalgae and other live feed used in shellfish hatcheries; Artemia hatching technique; Visit to different shellfish hatcheries; Economic analysis of shellfish hatcheries.

Suggested Readings

CMFRI Bulletin. 1987. *National Seminar on Shellfish Resources and Farming*.

FAO. 2007. *Manual for Operating a Small Scale Recirculation Freshwater Prawn Hatchery*.

ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.

Jhingran VG. 1991. *Fish and Fisheries of India*. Hindustan Publ. Corp.

Landau M. 1992. *Introduction to Aquaculture*. John Wiley & Sons.

Mcvey JP. 1983. *Handbook of Mariculture*. CRC Press.

Pillay TVR & Kutty MN. 2005. *Aquaculture - Principles and Practices*. Blackwell.

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

AQC 507 APPLIED GENETICS IN AQUACULTURE 2+1

Objective

To impart knowledge on genetic basis of inheritance and breeding plans for commercially important fishes.

Theory

UNIT I

Introduction: Origin and advancement in genetics; physical basis of heredity; genetic correlation, domestication and local adaptation.

UNIT II

Chromosome manipulation: Ploidy induction methods - triplody and tetraploidy, advantages and disadvantages of polyploids, androgenesis and gynogenesis.

UNIT III

Sex determination: Sex differentiation and sex reversal in fishes, sex control and its role in aquaculture.

UNIT IV

Selection: Scope, application and methods of selection, marker assisted selection-biochemical and molecular markers. Molecular tools for stock differentiation for selection.

UNIT V

Hybridization: Heterosis, hybrid vigour, introgression.

UNIT VI

Inbreeding: Methods of estimation, inbreeding depression and consequences, measures to reduce inbreeding in hatcheries.

UNIT VII

Conservation genetics: Genetic resources of India and conservation, endangered species, cryopreservation of fish gametes.

UNIT VIII

Cytogenetics: Importance and karyotyping.

UNIT IX

Fish breeding: History and advancement of fish breeding, mode of reproduction, basic breeding methods and breeding programmes and goals.

UNIT X

Genetic management strategies: Environmental impacts, Lessons from the green revolution, Bioprospecting, GMOs and their detection.

Practical

Estimation of gene and genotype frequencies; Exercises on Hardy-Weinberg equation; Estimation of inbreeding coefficient; Protocol of androgenesis and gynogenesis; Protocol of cryopreservation of milt; Karyotypic studies; Isolation of DNA from fish blood.

Suggested Readings

Carvalho GR & Pitcher TJ. (Eds.). 1995. *Molecular Genetics in Fisheries*. Chapman & Hall.

Falconer DS & Mackay. 1996. *Introduction to Quantitative Genetics*. 4th Ed. Longman.

Kanakaraj P. 2001. *A Text Book on Animal Genetics*. International Book Distributing Co.

Nair PR. 2008. *Biotechnology and Genetics in Fisheries and Aquaculture*. Dominant Publ.

Padhi BK & Mandal RK. 2000. *Applied Fish Genetics*. Fishing Chimes.

Pandian TJ, Strüssmann CA & Marian MP. 2005. *Fish Genetics and Aquaculture Biotechnology*. Science Publ.

Purdom CE. 1993. *Genetics and Fish Breeding*. Chapman & Hall.

Reddy PVGK. 2005. *Genetic Resources of Indian Major Carps*. FAO Publ.

Reddy PVGK, Ayyappan S, Thampy DM & Krishna G. 2005. *Text book of Fish Genetics and Biotechnology*. ICAR.

Ryman N & Utter F. (Eds.). 1988. *Population Genetics and Fishery Management*. Washington Sea Grant Programmes, USA.

Tave D. 1996. Genetics for Fish Hatchery Managers. 2nd Ed. AVI Publ.

Thorpe JE, Gall GAE, Lannan JE & Nash CE. (Eds.). 1995. *Conservation of Fish and Shellfish Resources, Managing Diversity*.

AQC 508 NON-FOOD AQUACULTURE 1+1

Objective

To impart knowledge on ornamental fish production, pearl production, bait fish culture and aquatic ornamental plant propagation.

Theory

UNIT I

Aquarium fish trade: Present status; potential; major exporting and importing countries; species-wise contribution of freshwater and marine fishes; contribution of culture and capture; marketing strategies; anesthetics, packing and transportation.

UNIT II

Breeding techniques: Reproductive biology, captive breeding and rearing of freshwater, brackishwater, marine ornamental fishes and invertebrates.

UNIT III

Aquarium keeping: Design and construction of tanks; species-wise tank size requirement; heating, lighting, aeration and filtration arrangements; decorations used; common aquarium plants and their propagation; Feed, health and water quality management; prophylaxis; quarantine.

UNIT IV

Value addition: Colour enhancement; genetic manipulation and production of new strains; hybrids; acclimatization strategies for marine ornamental fish to freshwater.

UNIT V

Pearl Production: Overview of pearl trade, pearl oysters and mussels of commercial importance; anatomy, biology and seed production, techniques of implantation, method of rearing and harvesting of pearl, Mable pearl production, processing and quality evaluation of pearls, pearl production by tissue culture.

UNIT VI

Bait fish culture: Scope and importance, bait fish species (minnows, silver heads, etc.), farming practices.

UNIT VII

Ornamental aquatic plants: Propagation methods, nutrient and environmental requirement, cropping methods, packing and transport.

Practical

Identification of common freshwater aquarium fishes and breeding trials of selected freshwater fishes; Identification of common brackish water and marine aquarium fishes; Aquarium fabrication, setting and maintenance; Preparation of powdered and pelleted feed for ornamental fishes; Visit to ornamental fish farms; Study of bacterial, viral, fungal diseases of ornamental fishes and their control; Prophylactic and quarantine measures; Nuclei implantation in pearl oyster; Identification of ornamental aquatic plants.

Suggested Readings

Axelrod HR & Vorderwinkler W. 1978. *Encyclopaedia of Tropical Fishes*. TFH Publ.

Axelrod HR & Sweenen ME. 1992. *The Fascination of Breeding Aquarium Fishes*. TFH Publ.

Axelrod HR. 1967. *Breeding Aquarium Fishes*. TFH Publ.

ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.

Mills D. 1981. *Aquarium Fishes*. Kingfisher Books.
Sanford G & Crow R. 1991. *The Manual of Tank Busters*. Salamander Books.
Saxena A. (Ed.). 2003. *Aquarium Management*. Daya Publ.
Spotte S. 1979. *Fish and Invertebrate Culture*. John Wiley & Sons.
Thabrow De WV. 1981. *Popular Aquarium Plants*. Thornbill Press.

AQC 509 COASTAL AQUACULTURE 2+1

Objective

To gain knowledge in establishing and managing different fish/shellfish farming systems in coastal waters.

Theory

UNIT I

Introduction: An overview of the status of coastal aquaculture; Present trend and scope in India.

UNIT II

Different farming systems: Cage and pen culture – type, site selection, construction, specifications for different species; Raft and rack culture – site selection, design and construction.

UNIT III

Important cultivable finfishes: Distribution, biology, seed collection, nursery rearing, culture techniques, problems and prospects (seabass, milkfish, mullets, pearlspot, sea breams, rabbitfish, grouper, yellowtail, eel, cobia, salmon, flatfish).

UNIT IV

Culture of marine molluscs and echinoderms: Present status and scope in India, Species cultured (mussels, oysters, pearl oysters, scallops, clams, cockles, abalones, sea cucumber) distribution, biology, practices followed in India, farming methods - off-bottom and on-bottom culture; Problems and prospects.

UNIT V

Culture of crustaceans: Shrimp farming: systems of farming – extensive, semi-intensive and intensive; site selection, infrastructure requirement, design and construction of culture systems, pond preparation, stocking, feed and water quality management, disease prevention and treatment; harvesting and handling; freshwater farming of tiger shrimp, shrimp farming in un-drainable ponds, low and zero water exchange systems; Mud crab fattening, production of soft-shell crabs; Lobster culture; Crayfish culture.

UNIT VI

Seaweed culture: Major seaweed species of commercial importance; methods of culture; farming of agar, algin, carrageenan yielding species; emerging trends in their farming in open seas; Integration with other farming systems.

Practical

Identification of cultivable marine and brackishwater finfish and shellfish; Identification of cultivable seaweeds; Designing of different farming systems – cages, pens, rafts and racks; Visit to coastal aqaufarms.

Suggested Readings

Bardach EJ, Rhyther JH & Mc Larney WO. 1972. *Aquaculture the Farming and Husbandry of Freshwater and Marine Organisms*. John Wiley & Sons.

FAO. 2001. *Planning and Management for Sustainable Coastal Aquaculture Development*. FAO Publ.

Gilbert B. 1990. *Aquaculture*. Vol. II. Ellis Horwood.

ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.

Pillay TVR. 1990. *Aquaculture, Principles and Practices*. Fishing News Books.

Pillay TVR & Kutty MN. 2005. *Aquaculture: Principles and Practices*. 2nd Ed. Blackwell.

Shepherd J & Bromage N. 1990. *Intensive Fish Farming*. B.S.P. Professional Books.

AQC 510 FRESHWATER AQUACULTURE 2+1

Objective

To gain knowledge on fish and prawn farming in different culture systems.

Theory

UNIT I

Introduction: Present status, problems and scope of fish and prawn farming in global and Indian perspective.

UNIT II

Aquaculture systems: Extensive, semi-intensive and intensive culture of fish, Pen and cage culture in lentic and lotic water bodies, polyculture, composite fish culture.

UNIT III

Fish farming: Nursery and grow-out, pond preparation, stocking, feeding and water quality management in the farming of major and minor carps, magur, singhi, murrels, tilapia, pangasius, freshwater turtle, etc.; Stunted seed production and culture practice.

UNIT IV

Freshwater prawn farming: Monoculture practice of prawn in ponds, all-male culture and its advantages, polyculture with carps, prawn farming in inland saline soils. Nursery rearing, sex segregation, pond preparation, stocking, feeding and water quality management, disease prevention and treatment; harvesting and handling.

UNIT V

Integrated farming systems: Design, farming practices, constraints and economics of IFS of fish with paddy, cattle, pig, poultry, duck, rabbit, etc.

UNIT VI

Wastewater-fed aquaculture: Water treatment methods, species selection, culture practices, harvesting and depuration process.

UNIT VII

Economics of different fish farming systems.

Practical

Identification of commercially important cultivable fish and prawn species; Assessment of seed quality- stress test; Calculating carrying capacity of pond and stocking density; Check tray assessment and feed ration calculation; Sampling procedure and growth assessment; Lime and

fertilizer requirement calculations; Farm visits; Modeling of different culture systems.

Suggested Readings

AAHRI. 1998. *Health Management in Shrimp Ponds*. Aquatic Animal Health Research Institute (AAHRI), Department of Fisheries, Thailand.

Agarwal SC. 2008. *A Handbook of Fish Farming*. 2nd Ed. Narendra Publ. House.

Beveridge MCM & Mc Andrew BJ. 2000. *Tilapias: Biology and Exploitations*. Kluwer.

De Silva SS. (Ed.). 2001. *Reservoir and Culture Based Fisheries: Biology and Management*. ACAIR Proceedings.

FAO. 2007. *Manual on Freshwater Prawn Farming*.

Midlen & Redding TA. 1998. *Environmental Management for Aquaculture*. Kluwer.

New MB. 2000. *Freshwater Prawn Farming*. CRC Publ.

Pillay TVR. 1990. *Aquaculture: Principles and Practices*. Fishing News Books, Cambrige University Press, Cambridge.

Venugopal S. 2005. *Aquaculture*. Pointer Publ.

Welcomme RL. 2001. *Inland Fisheries: Ecology and Management*. Fishing News Books.

AQC 511 LARVAL NUTRITION AND CULTURE OF FISH FOOD ORGANISMS 1+1

Objective

To impart basic understanding of the nutritional requirements of fish/shellfish larvae and knowledge on mass culture and enrichment of live food organisms.

Theory

UNIT I

Larval nutrition: Larval stages, nutritional requirements of fish and shellfish larvae, quality requirements of larval feeds (particle size, digestibility), natural food and its importance in aquaculture, nutritional quality of commonly used fish food organisms, bioenrichment, biofilm/periphyton and its use, culture of single cell proteins and their nutritional quality, formulation and preparation of artificial feeds for larval rearing, microparticulate diets.

UNIT II

Fish food organisms: Bacterioplankton, phytoplankton and zooplankton and their role in larval nutrition.

UNIT III

Mass culture techniques: Methods of collection, maintenance and rearing of fish food organisms, Different media used in culture, Mass culture of fish food organisms and their application in hatcheries, culture of important microalgae, rotifers, artemia, cladocerans, copepods, oligochaetes, nematodes and insect larvae.

Practical

Collection, identification and isolation of live food organisms using various techniques; Preparation of various culture media; Preparation and maintenance of stock microalgal culture; Preparation of artificial feed for rearing finfish and shellfish larvae; Mass culture of microalgae; Mass

culture of cladocerans, copepods and rotifers; Culture of Artemia nauplii, infusoria – freshwater and marine; Culture of earthworms and chironomid larvae.

Suggested Readings

CIFE. 1993. *Training Manual on Culture of Live Food Organisms for AQUA Hatcheries*. Central Institute of Fisheries Education, Versova, Mumbai.

Finn RN & Kapoor BG. 2008. *Fish Larval Physiology*. Science Publ.

Hagiwara A, Snell TW, Lubzens E & Tamaru CS. 1997. *Live Food in Aquaculture*. Proceedings of the Live Food and Marine Larviculture Symposium. Kluwer.

MPEDA. 1993. *Handbook on Aqua Farming - Live Feed. Micro Algal Culture.* MPEDA Publication.

Muthu MS. 1983. *Culture of Live Feed Organisms*. Tech. Paper 14. Summer Institute in Hatchery Production of Prawns Seeds. CMFRI, Cochin.

Ojha JS. 2005. *Aquaculture Nutrition and Biochemistry*. Daya Publ.

Santhanam R, Ramnathan M & Venkataramanujum. 1997. *A Manual of Methods in Plankton*. Fisheries College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Tuticorin.

Sorgeloos P & Pandian KS. 1984. *Culture of Live Food Organisms with Special Reference to Artemia Culture*. CMFRI Spl. Publ. No. 15.

Tonapi GT. 1980. *Freshwater Animals of India*. Oxford & IBH.

AQC 512 AQUACULTURE ENGINEERING 2+1

Objective

To learn the basic aspects of successful farm designing for effective management and optimum yield.

Theory

UNIT I

Introduction: Technical components of farm designing, future trends in aquaculture engineering.

UNIT II

Aquaculture facilities: Planning process, site selection and evaluation, design, components and construction of tanks, ponds, cages and hatcheries.

UNIT III

Water intake and outlet: Pipe line, water flow and head loss, pumps.

UNIT IV

Water treatment: Equipment used for water treatment, filters, ultraviolet light, ozone, heating and cooling and other processes of disinfection.

UNIT V

Aeration and oxygenation: Design and fabrication of aerators, oxygen injection system

UNIT VI

Recirculation and water use system: Definition, components and design.

UNIT VII

Feeding system: Different types of feeding equipment, feed control systems, dynamic feeding systems.

UNIT VIII

Instrumentation and monitoring: Instruments for measuring water quality.

Practical

Visit to aqua farms; Contour survey and mappings; Evaluation of performance of seepage controlling devices; Designing of fresh and brackish water fin and shellfish farms; Designing of fresh and brackish water fin and shellfish hatcheries; Estimation of construction cost of FRP and cement hatchery units, inlets, outlets, sluice gate, monks, hatchery sheds, supply channel and drainage systems, gravitational flow; Design and construction of effluent treatment plant for hatchery; Evaluation of capacity of aeration devices.

Suggested Readings

Thomas L. 1995. *Fundamentals of Aquacultural Engineering*. Chapman & Hall.

Wheaton FW. 1977. *Aquacultural Engineering*. John Wiley & Sons.

Ivar LO. 2007. *Aquaculture Engineering*. Daya Publ. House.

AQC 601 ADVANCES IN AQUACULTURE PRODUCTION SYSTEMS 2+1

Objective

To impart essential knowledge and skills regarding advanced technologies of different aquaculture production systems.

Theory

UNIT I

An overview of aquaculture production systems: Present status, constraints and future perspectives of aquaculture production systems in India and the world.

UNIT II

Advances in design and construction: Hatcheries; Earthen ponds; Concrete tanks; Pens and cages; Rafts; Racks.

UNIT III

Aquatic plant production systems: Ornamental aquatic plants; microalgae and seaweeds; Long line production system.

UNIT IV

Aquaculture production management: Monitoring of water quality; feeding and monitoring, sampling and harvesting of finfishes and shellfishes.

UNIT V

Advances in farming systems: Enhancing carrying capacity; integrated farming systems; semi-intensive and intensive culture systems; Recirculatory system; Flow-through system.

UNIT VI

Code of conduct for responsible and sustainable aquaculture. Cluster farming, Organic Farming, Satellite Farming and Co-operative farming.

Practical

Soil and water quality monitoring; Basic software packages for designing aquaculture systems; Preparing a model layout for advanced production system; Working out the economic feasibility of construction and maintenance of different fish production systems; Preparation of project proposal for fish production systems.

Suggested Readings

Dubey SK. 2006. *Fish Farming*. Dominant Publ.

Jhingran VG. 1991. *Fish and Fisheries of India*. Hindhustan Publ. Corp.

Pandey N & Davendra SM. 2008. *Integrated Fish Farming*. Daya Publ. House.
Pillay TVR & Kutty MN. 2005. *Aquaculture: Principles and Practices*. 2nd Ed. Blackwell.
Rath RK. 2000. *Freshwater Aquaculture*. Scientific Publ.
Selvamani BR & Mahadevan RK. 2008. *Fish Farming Systems*. Campus Books International.
Shepherd J & Brommage N. 1990. *Intensive Fish Farming*. B.S.P. Professional Books.
Sinha VRP & Ramachandran V. 1985. *Freshwater Fish Culture*. ICAR.

AQC 602 ADVANCES IN SEED PRODUCTION AND HATCHERY MANAGEMENT 2+1

Objective

To impart knowledge of the various requirements for seed production of commercially important finfish and shellfish.

Theory

UNIT I

Reproductive biology of important fishers, crustaceans and molluscs. Anatomy and morphology of reproductive organs. Reproductive behavior of fishes. Sex determination in fishes.

UNIT II

Reproductive endocrinology: Anatomy and physiology of endocrine glands. Biochemical characteristics of endocrine hormones. Role of endocrine hormone in reproduction.

UNIT III

Broodstock management: Factors affecting the maturation and spawning of fin fishes and shell fishes. Nutritional and environmental requirement for broodstock. Nutritional and environmental manipulation for early maturation. Criteria for the selection of brood stock. Selective breeding strategies; Tagging; Transportation of brood stock. Natural and synthetic anesthetics for transport. Vaccines and therapeutics for health management of broodstock.

UNIT IV

Induced Spawning: Biochemical characteristics of synthetic hormone analogues and their applications. Comparative evaluation of commercially available inducing agents. Artificial insemination in crustaceans and molluscs. Cryopreservation of gametes and embryos.

UNIT V

Seed production and hatchery technology: Advances in seed production of commercially important finfishes and shellfishes. Seed production of ornamental fishes. Artificial propagation of seaweeds.

UNIT VI

Hatchery management: Water quality management in hatcheries - Chemical, Physical and Biological approaches. Nutritional requirement of larvae and post larvae. Live feed culture. Nutritional enrichment of live feed. Formulation of artificial diets. Strategies to control diseases in hatcheries. Diagnosis, quarantine and seed certification. Use of Probiotics and Immunostimulants in hatcheries, SPF and SPR. Effluent treatment in Hatcheries. Seed transportation methods.

Practical

Insemination; Cryopreservation of fish and shellfish gametes; Project preparation for constructing hatchery; Quantitative and qualitative determination of fish gametes like sperm motility, viability, counts; Digital equipments in broodstock management; Methods to identify quality seeds - stress test, microscopic examination.

Suggested Readings

Bardach EJ, Rhyther JH & Mc Larney WO. 1972. *Aquaculture. The Farming and Husbandry of Freshwater and Marine Organisms*. John Wiley & Sons.

Chakraborty C & Sadhu AK. 2000. *Biology Hatchery and Culture Technology of Tiger Prawn and Giant Freshwater Prawn*. Daya Publ. House.

Diwan AD, Joseph S & Ayyappan S. 2008. *Physiology of Reproduction, Breeding and Culture of Tiger Shrimp*. Narendra Publ. House.

Gilbert B. 1990. *Aquaculture*. Vol. II. Ellis Harwood.

Jhingran VG & Pullin RSV. 1985. *Hatchery Manual for the Common, Chinese and Indian Major Carps*. ICLARM, Philippines.

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

AQC 603 AQUACULTURE AND ECOSYSTEM MANAGEMENT 2+1

Objective

To impart knowledge on interactions between aquaculture and the environment.

Theory

UNIT I

Aquaculture and ecosystem relationship: Ecosystems and productivity, biotic interaction within ecosystems and ecological homeostasis.

UNIT II

Climate: Weather elements of concern in aquaculture, Green house gases, global warming and their impact.

UNIT III

Impact of environment on aquaculture: Raw water source, physical and chemical characteristics, contaminants and pollutants (algae, pathogens, heavy metals, pesticides) and their effect on productivity.

UNIT IV

Impact of aquaculture on environment: Waste water discharge, its quality and quantity; impacts of effluents on ecosystems, chemical degradation of soil and water.

UNIT V

Environment monitoring: Problems and preventive measures of antibiotic and drug residues, salination of soil and water, Eutrophication, Environment impact assessment and environmental audit, Biosensors in aquatic environment, toxicity assessment, Ecolabelling and traceability.

UNIT VI

Environment management: Introduction of exotics and escape of farmed fish, Pathogens in aquatic environment, Safety of aquaculture products, Role of microbes in aquatic environment; assessment of probiotic impact in aquaculture.

Practical

Waste water analysis; Environment impact assessment; Environmental audit; Toxicity assessment studies; Ecolabelling and traceability; Isolation, enumeration and Identification of bacterial population; Physical and chemical characteristics of soil; Design and construction of effluent treatment plant.

Suggested Readings

Holmer M, Black K, Duarte CM, Marba N & Karakassis I. (Eds.). 2008. *Aquaculture in the Ecosystem*. Daya Publ. House.

Lagler KP, Bardach JE, Miller RR & Passino MDR. 1977. *Ichthyology*. John Wiley & Sons.

Midlen & Redding TA. 1998. *Environmental Management for Aquaculture*. Chapman & Hall.

Nikolsky GV. 2008. *The Ecology of Fishes*. Academic Press.

Upadhyay AR. 2004. *Aquatic Plants for the Wastewater Treatment*. Daya Publ. House.

AQC 604 AQUATIC ANIMAL HEALTH MANAGEMENT AND QUARANTINE 1+1

Objective

To impart and update knowledge for combating pathogenic diseases in aquatic environment and its management.

Theory

UNIT I

Defence mechanism in fish and shellfish: Specific and non-specific defence mechanism, immunogenicity, immune cells, immune suppressant, ontogeny of immune system; cellular adaptation, pathogen specificity.

UNIT II

Disease diagnostics tools: Histopathological methods, tools used in different types of PCR, Immunoassay, Biochemical assay, Monoclonal and polyclonal based antibody assay, Electron microscopy, Serological techniques.

UNIT III

Disease prevention and therapeutics: Vaccines and bactericins, development of vaccines like DNA vaccine, adjuvants, etc; administration and mode of action of pathogen specific drugs, drug resistance, antiviral drugs, drug regulation in India, pharmacokinetics and pharmacodynamics, immunostimulants.

UNIT IV

Quarantine: Biosecurity principles, SPF and SPR, quarantine protocols, and facilities, broodstock and seed quarantine measures, Quarantine of Aquatic Animals and Premises.

Practical

Analysing and reporting legal problems relating to quarantine; Microscopic techniques; Immunisation techniques; Necropsy examination to study internal organs of fish; PCR; ELISA; Agglutination test; Gel electrophoresis; Histopathology; Determination of dosages of chemicals and drugs for treating common diseases.

Suggested Readings

Andrews C, Excell A & Carrington N. 1988. *The Manual of Fish Health*. Salamander Books.

Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish*. Vols. I, II. 2nd Ed. Academic Press.

Jorge E, Helmut S, Thomas W & Kapoor BG. 2008. *Fish Diseases*. Science Publ.

Felix S, Riji John K, Prince Jeyaseelan MJ & Sundararaj V. 2001. *Fish Disease Diagnosis and Health Management*. Fisheries College and Research, Institute, T. N. Veterinary and Animal Sciences University. Thoothukkudi.

Humphrey J, Arthur JR, Subasinghe RP & Phillips MJ**.** 2005. *Aquatic Animal Quarantine and Health Certification in Asia.* FAO Publ.

Inglis V, Roberts RJ & Bromage NR. 1993. *Bacterial Diseases of Fish*. Blackwell.

Iwama G & Nakanishi T. (Eds.). 1996. *The Fish Immune System - Organism, Pathogen and Environment*. Academic Press.

Roberts RJ. 2001. *Fish Pathology*. 3nd Ed. WB Saunders.

Shankar KM & Mohan CV. 2002. *Fish and Shellfish Health Management*. UNESCO Publ.

Wedmeyer G, Meyer FP & Smith L. 1999. *Environmental Stress and Fish Diseases*. Narendra Publ. House.

Woo PTK & Bruno DW. (Eds.). 1999. *Fish Diseases and Disorders*. Vol. III. *Viral, Bacterial and Fungal Infection*. CABI.

AQC 605 FISH AND SHELLFISH PHYSIOLOGY AND ENDOCRINOLOGY 1+1

Objective

To learn functional physiology of fish and shellfish.

Theory

UNIT I

General physiology and endocrinology: Physiology of migration and behaviour, chemical nature of hormones, storage, release and control of hormones, serochemistry, structure and function of neuro-endocrine system, biotic and abiotic factors influencing homeostasis, ecophysiology, endocrine control of growth.

UNIT II

Nutritional and digestive physiology: Mechanism of chemo, electro and mechanorecption, gustation, digestive enzymes and isozymes, nutrient tansporters, gut microbial digestion, excretion.

UNIT III

Neurophysiology: Neurosecretory system in fishes, crustaceans and molluscs, neurotransmitters, ecdysis.

UNIT IV

Reproductive physiology: Maturation and spawning, spermatogenesis, oogenesis, yolk formation, mechanism of sex reversal.

UNIT V

Respiratory physiology: Structure and chemical composition of respiratory pigments, gas exchange concept, osmoregulation.

UNIT VI

Stress physiology: stress response, stress hormones, stress adaptation.

Practical

Hormone assay –RIA (Radio Immuno Assay); Dissection of fin and shellfish to study endocrine glands; Histological techniques to study endocrine cells; Identification of moult stages; Serological analysis; Application of Electrocardiogram and respirometer.

Suggested Readings

Adiyodi KG & Adiyodi RG. 1971. *Endocrine Control of Reproduction in Decapod Crustacea*. Biology Reviews.

Agarwal NK. 2008. *Fish Reproduction*. APH Publ.

Bell TA & Lightner TA. 1988. *A Handbook of Normal Penaeid Shrimp Histology*. World Aquaculture Society.

Ghosh R. 2007. *Fish Genetics and Endocrinology*. Swastik Publ. & Distr.

Hoar WS, Randall DJ & Donaldson EM. 1983. *Fish Physiology*. Vol. IX. Academic Press.

Maria RJ, Augustine A & Kapoor BG. 2008. *Fish Reproduction*. Science Publ.

Matty AJ. 1985. *Fish Endocrinology*. Croom Helm.

Mente E. 2003. *Nutrition, Physiology and Metabolism in Crustaceans*. Science Publ.

Nikolsky GV. 2008. *The Ecology of Fishes*. Academic Press.

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

AQC 606 ADVANCES IN FISH GENETICS 2+1

Objective

To provide knowledge in genetics for improving qualitative and quantitative traits in fish.

Theory

UNIT I

Scope of applied fish genetics: Inheritance of qualitative and quantitative traits in fish; chromosomal polymorphism.

UNIT II

Non chromosomal inheritance: Mitochondrial inheritance.

UNIT III

Chromosome manipulation: Gynogenesis and androgenesis; production of super-males and transgenic fish.

UNIT IV

Inbreeding and genetic drift: Estimation of genetic parameters.

UNIT V

Selective breeding: Qualitative and quantitative traits for selection, methods of selection- individual selection, mass selection, family selection and combined selection; Designing of breeding programmes.

UNIT VI

Genetic markers: Use of biochemical and molecular genetic markers in hybridization, selective breeding.

UNIT VII

Diallele crossing: Genetic improvement of particular trait (disease resistance) in fish.

UNIT VIII

Chromosome banding techniques: C-banding, G-banding, NOR-banding, FISH.

UNIT IX

Genotoxicity assay: Comet assay, sister chromatid exchange, MNT, etc.

Practical

Chi-square test; Estimation of heritability and repeatability; Assessment of genetic gain through selection; Calculation of selection differential; Calculation of selection response; Estimation of inbreeding coefficient and path coefficient; Karyotypic studies; C-banding (hetero chromatin banding); NOR- banding (nucleolar organizer region banding); G-banding (Giemsa banding); Ploidy determination methods.

Suggested Readings

Das P & Jhingran AG. 1976. *Fish Genetics in India*. Today & Tomorrow Publ.

Douglas T. 1998. *Genetics for Fish Hatchery Managers*. Kluwer.

Dunham RA. 2004. *Aquaculture and Fisheries Biotechnology Genetic Approaches*. CABI.

Malvee S. 2008. *Fish Genetics*. SBS Publ.

Nair PR. 2008. *Biotechnology and Genetics in Fisheries and Aquaculture*. Dominant Publ.

Padhi BJ & Mandal RK. 2000. *Applied Fish Genetics*. Fishing Chimes.

Pandian TJ, Strüssmann CA & Marian MP. 2005. *Fish Genetics and Aquaculture Biotechnology*. Science Publ.

Reddy PVGK. 2005. *Genetic Resources of Major Indian Carps*. Daya Publ.

Reddy PVGK, Ayyappan S, Thampy DM & Gopalakrishna. 2005. *Text Book of Fish Genetics and Biotechnology*. ICAR.

Sinnot EW, Dunn L & Dobzansky T. 1989. *Principles of Genetics*. Mc Graw Hill.

AQC 607 INTENSIVE FARMING SYSTEMs FOR TILAPIA AND CATFISHES 1+1

Objective

To learn the techniques of intensive farming of tilapia and catfishes.

Theory

UNIT I

Intensive Farming Systems: Status and future prospectus of catfishes and tilapia in India, Need for intensification, Development of intensive farming. Disease and its control, constraints in intensive farming.

UNIT II

Catfish: Commercially important catfishes, Different culture systems, Means of intensifying catfish culture, polyculture of catfish with other species, Water quality management in catfish culture, feeds and feeding, Economics of culture.

UNIT III

Tilapia: Commercially important tilapia, Different culture systems, Means of intensifying tilapia culture, polyculture of tilapia, Water quality management in tilapia culture, feeds and feeding, Techniques of sex

reversal in tilapia, mass production of monosex seed and hybrids, Production of red tilapia, Economics of culture.

Practical

Study of aerators and blowers; Experience in breeding and culture of catfish; Experience in breeding and culture of tilapia; Seed production of catfish and tilapia; Formulation of feeds for catfish and tilapia; Stocking density manipulation and fish production; Economics of intensive farming of catfish and tilapia.

Suggested Readings

Bardach EJ, Rhyther JH & Mc. Larney WO. 1972. *Aquaculture The Farming and Husbandry of Freshwater and Marine Organisms*. John Wiley & Sons.

Beveridge MCM & Mc Andrew BJ. 2000. *Tilapias: Biology and Exploitations*. Kluwer.

Gilbert B. 1990. *Aquaculture*. Vol II. Ellis Harwood.

Jayaram KC. 2006. *Catfishes of India*. Narendra Publ. House.

Pillay TVR. 1990. *Aquaculture, Principles and Practices*. Fishing News Books.

Rath PK. 2000. *Freshwater Aquaculture*. Scientific Publ

AQC 608 AQUACULTURE DEVELOPMENT PLANING AND MANAGEMENT 1+1

Objective

To understand different aspects of planning and management processes specific to aquaculture development.

To acquire competency to plan, implement, monitor and evaluate aquaculture development programmes.

Theory

UNIT I

Importance, principles and processes in developing aquaculture programmes; Planning for sustainable development; Types of planning; Planning strategies at various levels - Top down and bottom up approaches. Role and relevance of Panchayati Raj institutions in aquaculture development; Plan allocation and performance of FFDA, BFDA and other aquaculture related programmes over the different plan-periods in India.

UNIT II

Project preparation and project appraisal in terms of social benefit analysis, shadow prices; Project management techniques - PERT and CPM; Logical framework approach (LFA), Stakeholder analysis; Participatory Monitoring and evaluation (PROME); People's participation in aquaculture programmes, significance, importance and approaches .

UNIT III

Critical analysis of aquaculture and rural development programmes; design, operation, institutional mechanism and socio-cultural and economic impact of programmes such as NREGA; labour market relations; Fisheries development *vis-à-vis* fisheries for development; Livelihood Frameworks.

Practical

Need assessment, setting objectives, developing plan of work, Success indicators, Impact assessment of aquaculture development programmes, SWOT analysis; Exercises on PERT and CPM. Fisheries and Aquaculture

policies of select countries; Study visits to selected aquaculture project areas – FFDA/ BFDA/ SAUs/ICAR institutes.

Suggested Readings

Agarwal SC. 2004. *Fishery Management*. APH Publ. Corp.

Agarwal SC & Johal S. 2003. *Fishery Development*. Narendra Publ.

Felix S. 2007. *Aquaculture Management Techniques*. Daya Publ. House.

Singh B. 2007. *Fishery Management: Planning and Objectives*. Vista International Publ. House.

Sinha VRP. 2005. *Fisheries Research Planning and Management in Developing Countries*. Narendra Publ. House.

AQC 609 APPLIED BIOTECHNOLOGY 1+1

Objective

To learn various biotechnological applications for enhancing production through sustainable eco-friendly culture.

Theory

UNIT I

Introduction: Scope of biotechnology in fisheries and aquaculture research.

UNIT II

Transgenics: Principles of transgenic technology and its application in fisheries.

UNIT III

Feed biotechnology: Probiotics, single cell proteins, Nutraceuticals.

UNIT IV

Recombinant proteins of commercial importance: enzymes, hormones, bioactive compounds, therapeutic proteins.

UNIT V

Biotechnological approaches in environmental management: Bioremediation, biosensors, biofouling, treatment of waste water.

UNIT VI

Anti microbial Peptides and their applications.

UNIT VII

Vaccination in fishes- DNA vaccines, sub UNIT vaccines and Biofilm Vaccines.

UNIT VIII

Applications of biotechnological tools: Recombinant DNA, Monoclonal antibodies, Cell lines and stem cell culture, DNA markers and MAS.

UNIT IX

Biotechnological instrumentation in Aquaculture.

Practical

Cell culture and cell lines; Development of hybridoma and production of monoclonal antibodies; Collection, handling and observation of gametes of finfish and shellfish; Preparation of chromosomes from embryos and young fish; Ploidy determination by RBC measurement and chromosome numbers; Gene transfer experiments: northern blotting and southern blotting for integration and expression of transgenes.

Suggested Readings

Felix S. 2007. *Molecular Diagnostic Biotechnology in Aquaculture*. Daya Publ. House.

Fingerman M, Nagabhushanam R & Thompson MF. 1997. *Recent Advances in Marine Biotechnology*. Vols. I-III. Oxford & IBH.

Glick BR & Pasternak JJ. 1999. *Molecular Biotechnology: Principles and Applications of Recombinant DNA Technology*. ASM Press.

Nagabhushanam R, Diwan AD, Zahurnec BJ & Sarojini R. 2004. *Biotechnology of Aquatic Animals*. Science Publ.

Nair PR. 2008. *Biotechnology and Genetics in Fisheries and Aquaculture*. Dominant Publ.

Pandian TJ, Strüssmann CA & Marian MP. 2005. *Fish Genetics and Aquaculture Biotechnology*. Science Publ.

Primrose SB. 1989. *Modern Biotechnology*. Blackwell.

Ramesh RC. (Ed.). 2007. *Microbial Biotechnology in Agriculture and Aquaculture*. Vol. II. Science Publ.

Reddy PVGK, Ayyappan S, Thampy DM & Gopalakrishna. 2005. *Text Book of Fish Genetics and Biotechnology*. ICAR.

Singh B. 2006. *Marine Biotechnology and Aquculture Development*. Daya Publ. House.

Zhanjiang JL. 2007. *Aquaculture Genome Technologies*. Blackwell.

AQUACULTURE
List of Journals

- Animal Feed Sciences and Technology
- Animal Nutrition and Feed Technology
- Annals of Nutrition and Metabolism
- Annual Review of Nutrition
- Annual Review of Physiology
- Applied Aquaculture
- Applied Engineering in Agriculture
- Applied Fisheries and Aquaculture
- Aquacultural Engineering
- Aquaculture
- Aquaculture and Fisheries Management
- Aquaculture Asia
- Aquaculture Economics and Management
- Aquaculture International
- Aquaculture Nutrition
- Aquaculture Research
- Asian Fisheries Science
- Asian Journal of Microbiology Biotechnology Environmental Science
- Chromosoma
- Comparative Biochemistry and Physiology
- Diseases of Aquatic Organisms
- Fish and Shellfish Immunology
- Fish Physiology and Biochemistry
- Fisheries Research
- Fisheries Science
- Fishing Chimes
- Genetics
- Heredity
- Hydrobiologia
- Indian Journal of Animal Nutrition
- Indian journal of Environmental Health
- Israeli Journal of Aquaculture – Bamidgeh
- Journal of Animal Breeding and Genetics
- Journal of Animal Genetics
- Journal of Applied Aquaculture
- Journal of Aquaculture and Aquatic Science
- Journal of Aquaculture in the Tropics
- Journal of Biotechnology
- Journal of Environmental Research
- Journal of Fish Diseases
- Journal of Ichthyology
- Limnology and Oceanography
- Pesticides Research
- Theoretical and Applied Genetics
- Toxic Environmental Chemistry
- Tropical Aquaculture
- Tropical Aquarium
- Tropical Science
- World Aquaculture
- Yojana

AQUACULTURE

Suggested Broad Areas for Master's and Doctoral Research

- Adverse effects of chemical fertilizer application
- Alternative protein sources
- Antibiotic residues in the culture systems
- Aquaculture in inland salt affected areas
- Automated live food production systems
- Bioactive compounds and Bioremediation
- Bioenrichment of live food
- Biofertilizers in pond productivity
- Breeding and rearing of indigenous brackish water and marine ornamental fishes
- Breeding performance of different stocks of brood
- Cage and pen culture for marine finfish
- Carbon-nitrogen ratio in pond productivity
- Cell lines and stem cell culture
- Conservation of endangered species
- Control of bioluminescent bacteria (LB) in aquaculture systems
- Control of Cyanobacteria through nutrient manipulation
- Cryopreservation of gametes and embryos
- Culture of live feed for larval rearing
- Defense mechanisms and immunity
- Designing low cost effluent treatment plant
- Designing of novel integration systems
- Development of fish and shrimp maturation diets
- Development of genetically improved broodstock
- Development of inert feeds for larvae
- Development of vaccines Drug resistance
- Development of vaccines for larvae
- Disease control in ornamental fishes
- Efficiency of oxygen transfer through different aeration devices
- Endocrine control of respiration and osmoregulation
- Energy requirement of different cultivable species
- Environmental manipulation and hatching rate
- Evaluation of ITKs in seed transport
- Extra hypothalamo-hypophysial control of reproduction
- Hybridization of cultivable species
- Impact of aquaculture development
- Impact of extreme climate on aquaculture
- Impact of probiotics on environment
- Multiple breeding of catfishes
- Nutraceuticals for aquaculture feed
- Ontogeny of digestive system in fish larvae
- Organic farming of fish and shrimp
- Participatory aquaculture development models
- Performance of commercially important catfishes in intensive systems
- Performance of monosex tilapia in intensive systems
- Pigment enhancement of selected ornamental fishes
- Production and evaluation of stunted fingerlings
- Quantification of phosphorus as a limiting factor in different types of soils
- Renewable energy in aquaculture
- Replacement of *Artemia* by formulated larval diets
- Role of disruptors in aquaculture
- Shrimp culture in zero-water exchange system
- Single cell proteins as feed ingredients
- Specific requirement of amino and fatty acids.
- Standardization of chemicals used in controlling diseases
- Strategies for sustainable aquaculture
- Study of nutrient dynamics in ponds

AQUATIC ENVIRONMENT MANAGEMENT
Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
AEM 501*	AQUATIC ENVIRONMENT AND BIODIVERSITY	2+1
AEM 502*	CHEMICAL INTERACTIONS IN THE AQUATIC ENVIRONMENT	2+1
AEM 503*#	INTEGRATED COASTAL ZONE MANAGEMENT	2+1
AEM 504*	AQUATIC POLLUTION AND WASTEWATER MANAGEMENT	2+1
AEM 505	ECOLOGY AND MANAGEMENT OF LIMNETIC ENVIRONMENT	2+1
AEM 506	ENVIRONMENTAL BIOTECHNOLOGY	1+1
AEM 507	ENVIRONMENTAL TOXICOLOGY	1+1
AEM 508	ANALYTICAL TECHNIQUES IN ENVIRONMENTAL SCIENCES	1+1
AEM 509	PLANKTONOLOGY	1+1
AEM 510	FISHERIES OCEANOGRAPHY	1+1
AEM 511	AQUATIC MICROBIOLOGY	2+1
AEM 591	MASTER'S SEMINAR	1+0
AEM 599	MASTER'S RESEARCH	20
AEM 601**	ADVANCES IN AQUATIC ENVIRONMENTAL STUDIES	2+1
AEM 602**	BIOTECHNOLOGY FOR CLEANER ENVIRONMENT	2+1
AEM 603**	BENTHIC ECOLOGY	1+1
AEM 604	ESTUARINE AND COASTAL OCEANOGRAPHY	2+1
AEM 605	ORGANIC PRODUCTION AND PLANT PIGMENTS	2+1
AEM 606	ENVIRONMENT IMPACT ASSESSMENT	1+1
AEM 607	MANAGEMENT AND UTILIZATION OF WASTEWATER	2+1
AEM 608	APPLICATION OF REMOTE SENSING AND GIS IN FISHERIES	2+1
AEM 609	DISPERSAL AND FATE OF POLLUTANTS IN THE OCEAN	1+1
AEM 610	RESTORATION ECOLOGY	1+1
AEM 691	DOCTORAL SEMINAR I	1+0
AEM 692	DOCTORAL SEMINAR II	1+0
AEM 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme; ** Compulsory for Doctoral programme
#AEM 503 cross listed with Fisheries Resource Management FRM 507

AQUATIC ENVIRONMENT MANAGEMENT

Course Contents

AEM 501 AQUATIC ENVIRONMENT AND BIODIVERSITY 2+1

Objective

To acquaint the students with the theoretical and practical aspects of the aquatic environment and biodiversity.

Theory

UNIT I

Concepts in aquatic environment: Aquatic environment/ecosystem – components-structure and functions; Ecological concepts – succession, homeostasis, natality and mortality, r and k selection; Concepts of habitat and ecological niche; carrying capacity.

UNIT II

Environmental concerns: Environmental concerns – population explosion, industrialization, urbanization, and natural calamities; Overexploitation of resources; Environmental stresses; Global Warming; Ozone Depletion.

UNIT III

Biodiversity: Biodiversity – Definition and concept; 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); Economic appraisal of biodiversity; Global diversity patterns and loss of biodiversity.

Practical

Collection of fauna and flora from different ecosystems; Analysis of Biodiversity at community, population and species levels through different methods; Case studies.

Suggested Readings

Carter RWG. 1998. *Coastal Environments: An Introduction to the Physical, Ecological and Cultural Systems of Coastlines*. Academic Press.

Kormondy E.J. 1986. *Concepts of Ecology*. Prentice-Hall.

Park CC. 1980. *Ecology and Environmental Management*. Butterworths.

Simon J, Kaiser MJ & Reynolds JD. 2001. *Marine Fisheries Ecology*. Blackwell.

AEM 502 CHEMICAL INTERACTIONS IN THE AQUATIC ENVIRONMENT 2+1

Objective

To acquaint the students with basic principles of chemical interactions in the aquatic environment.

Theory

UNIT I

Basic chemistry principles: Chemical reaction kinetics, chemical equilibria and redox chemistry, solubility concept, dissolution kinetics, processes controlling elemental cycling in the earth's crust, oceans and atmosphere.

UNIT II

Soil properties: Soil structure and texture; Composition of oxide and silicate minerals in relation to surface chemical processes; Charge and double layer, and mineral equilibrium; Silicate weathering, transformation, weathering products; Ion exchange - concept and source of cation exchange capacity (CEC), adsorption on to clay minerals of major cations, specific adsorption of major and minor nutrients, and heavy metal ions.

UNIT III

Nutrient dynamics: Chemistry of soil-nutrient interactions and water permeability; Organic substances - biological processes in the degradation and conversion of organic matter; Humus and biogeochemical substances - structure, reactivity, solubility and mobility; Transport of substances - nutrients (*e.g.,* phosphate, nitrate, ammonia, Ca and K), Soil-water interactions – availability of nutrients and productivity of aquatic ecosystem.

UNIT IV

Pollutant dynamics: Pollutant cycling, bio-accumulation, bio-availability, speciation and transport of contaminants (*e.g.,* pesticides and heavy metals).

Practical

Sample Collection techniques; Determination of physicochemical parameters of soil and water - pH, electrical conductivity, redox potential, soil texture, bulk density, particle density, porosity, hydraulic conductivity, organic carbon, total and available nitrogen, phosphorus, potassium and micronutrients; C/N ratio; clay colloids in the soil; CEC; Adsorption/fixation of ions on clay minerals.

Suggested Readings

Lindsay WL. 1979. *Chemical Equilibria in Soils*. John Wiley & Sons.

Manahan SE. 2000. *Environmental Chemistry*. Lewis Publ.

McBride MB. 1994. *Environmental Chemistry of Soils*. Oxford University Press.

Stumm W & Morgan JJ. 1996. *Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters*. John Wiley & Sons.

Tan KH. 1998. *Principles of Soil Chemistry*. CRC Press.

AEM 503 INTEGRATED COASTAL ZONE MANAGEMENT 2+1

Objective

To impart knowledge on the coastal resources, integrated coastal zone management strategies and disaster management.

Theory

UNIT I

Coastal resources: Coastal natural resources systems: flora and fauna, trophic relationship, nutrient production, cycle and transport; Mangrove ecosystem - species diversity and distribution of mangroves in India, Other inter-tidal system- Seagrass system, Coral reef system, Sandy beach system, Lagoon and estuary system.

UNIT II

Developmental activities and biodiversity loss: Ecological issues, Non-sustainable development, Pollution, threats to biodiversity, habitat destruction, Depletion of fisheries resources, impacts of global environment changes, Multiple uses of the Coastal Zone, Urban settlement, Industrial

development, waste disposal, Shore protection works, ports and marine transportation. Land transportation infrastructure, Water control and supply projects, sea fisheries, Aquaculture, Coastal forest industries, Coastal agriculture, industries.

UNIT III

Coastal Zone Management: Integrated Coastal Zone Management (ICZM): its need and benefits, Principles, Goals and objectives of the ICZM programme; Scope, Extent of jurisdiction, Boundaries of the coastal zone, policies and planning for coastal resource management; Management mechanisms- Pollution control, Protected areas (sanctuaries, marine parks and biosphere reserves), Protection from natural hazards; Socioeconomic impacts and its assessment, Disaster management for coastal environment.

UNIT IV

Coastal tourism: Beach resorts, restaurants and parks within the coastal zone as per existing rules and regulations. Impact of pollution on coastal resources.

Practical

Analysis of soil and water characteristics of coastal areas where man made impacts have established; Assessment of damages of water quality; Collection, preservation and identification of coastal biological communities; Survey of different coastal zones; Visit to the protected areas.

Suggested Readings

Brahtz JFP. 1972. *Coastal Zone Management*. UN Department of International Economic & Social Affairs, New York.

Cairns J Jr. 1994. *Implementing Integrated Environmental Management* Virginia Tech. University.

Clark JR. 1992. *Integrated Management of Coastal Zones*. FAO Fisheries Tech. Paper No. 327, Rome.

Coastal Area Management and Development 1982. UN Department of International Economic & Social Affairs, New York.

David S & Jeremy P. 2001. *Inshore Fisheries Management. Methods and Technologies in Fish Biology and Fisheries*. Vol. II. Kluwer.

Khanna BK. 2000. *All You Wanted to Know About Disasters*. New India Publ. Agency.

AEM 504 AQUATIC POLLUTION AND WASTEWATER MANAGEMENT 2+1

Objective

To impart fundamental and advanced knowledge on different aspects of Aquatic pollution and waste water management.

Theory

UNIT I

Aquatic pollution and its management: Aquatic pollution – sources, types and their impacts; Pollution problems of groundwater resources –sources of contamination, management issues.

UNIT II

Pollutants - Sewage, pesticides, oils, metals, radioactive wastes, biomedical wastes, etc. Common transport processes of pollutants in the aquatic environment; dispersal of pollutants; Algal blooms and their management, Methods of pollution surveys.

UNIT III

Waste disposal and water quality criteria used in different parts of world - national and international standards; ISO-14000(EMS), EIA, Management strategies.

UNIT IV

Wastewater management: Wastewaters - classification and characteristics of sewage and industrial effluents; treatment methods for water and waste water; Principles of aeration, chlorination, ozonation and U.V. irradiation.

UNIT V

Waste recycling and utilization in aquaculture; Design and construction of water filtration devices; aerobic and anaerobic treatment of wastewater.

UNIT VI

Wastes from fish processing units and their treatment; solid waste management; removal of nitrogen and phosphorus from waste water; Role of aquatic macrophytes in treatment of wastewater.

Practical

Collection and preservation of wastewater samples; Physicochemical analysis of wastewater - total dissolved and suspended solids, DO, BOD, COD, H_2S,, NH_3–N, NO_2-N, NO_3-N, PO_4-P, CH_4, heavy metals and pesticides; Use of algae for waste water treatment; Visit to a sewage treatment plant, fish processing unit and other industries; Exercise on interpretation of water quality data for evaluation of aquatic health.

Suggested Readings

Baird DJ, Beveridge MCM, Kelly LA & Muir JF. 1996. *Aquaculture and Water Resources Management*. Blackwell.

Cheremisinoff NP. 2002. *Handbook of Water and Waste Water Treatment Technologies*. Butterworth – Heinemann.

Eckenfelder WW. 2000. *Industrial Water Pollution Control*. McGraw Hill.

Gray NF. 2004. *Biology of Wastewater Treatment*. Oxford University Press.

Trivedy RK. 1998. *Advances in Wastewater Treatment Technologies*. Global Science.

AEM 505 ECOLOGY AND MANAGEMENT OF LIMNETIC ENVIRONMENT 2+1

Objective

To educate the students on the ecology of limnetic wetlands and to impart skill and knowledge on the sustainable management of the limnetic ecosystems.

Theory

UNIT I

Types: Categorization of different limnetic fisheries resources - lacustrine, riverine and coldwater systems; Wetlands, Floodplain wetlands, swamps - characteristics, flora and fauna.

UNIT II

Characteristics: Physical and chemical characteristics of limnetic environment and its relationship with the organisms; influence on metabolism, behavior and orientation of animals; Biological productivity in

relation to fishery potential; Trophic relationships in the wetland ecosystem - nutrient production, and transport, Trophic succession; Dynamics of lentic and lotic systems; Water budgeting in limnetic ecosystems.

UNIT III

Conservation and Management: Functions of wetlands; Habitat degradation- causative factors and controlling/management measures; Destruction of wetlands - causes and consequences; Restoration, conservation and management of wetlands; Resource enhancement; Management of water bodies for economy-driven activities; Management through Biomanipulation studies- top-down and Bottom-up methods; Integrated Environment Management (IEM) Programme-involvement of human element; River continuum concept and new paradigm shift; River linking; International conventions - Ramsar; Environmental laws and regulations; Index of Biotic Integrity (IBI); modeling studies; Wetland mapping using remote sensing; Geographical Information System (GIS)-Definition, Concepts and application.

Practical

Collection, preservation and analysis of flora and fauna (including phytoplankton, zooplankton and benthos) of wetland ecosystem; Case studies on soil and water quality assessment; Survey and sampling of lentic and lotic waters; Calculation of shoreline development index and morphometry; Determination of carrying capacity; Field visits to selected reservoirs, lakes/wetlands and rivers.

Suggested Readings

Allan JD. 1995. *Stream Ecology: Structure and Function of Running Waters*. Chapman & Hall.

Dodds WK. 2002. *Freshwater Ecology: Concepts and Environmental Applications*. Academic Press.

Good RE, Whigham DF & Simpson RL. 1978. *Fresh Water Wetlands: Ecological Processes and Management Potential*. Academic Press.

Hynes HBN. 1970. *Ecology of Running Waters*. Liverpool University Press, Liverpool.

Mitsh WJ & Gosselink JG. 1996. *Wetlands*. John Wiley & Sons.

Nath S. (Ed.). 2008. *Recent Advances in Fish Ecology Limnology and Eco Conservation*. Vol. VII. Narendra Publ. House.

Pattern BC. 1990. *Wetlands and Shallow Continental Water Bodies*. SPB Academic Press.

Scheffer NM. 1998. *Ecology of Shallow Lakes*. Chapman & Hall.

Talling J & Lemoalle J. 1998. *Ecological Dynamics of Tropical Inland Waters*. Cambridge University Press, London.

Wong MH. 2004. *Wetland Ecosystems in Asia: Functions and Management*. Elsevier.

AEM 506 ENVIRONMENTAL BIOTECHNOLOGY 1+1

Objective

To impart basic knowledge on biotechnological applications of microorganisms and demonstration of their potential for environmental management.

Theory

UNIT I

Fundamentals of environmental biotechnology: Environmental biotechnology- concepts and scope; conventional and modern approaches, Interrelationship of xenobiotics with other environmental variables; IPR issues related to environmental biotechnology.

UNIT II

Genetically-improved strains: Genetically-improved strains - basic concepts, application in waste management, pesticide degradation, heavy metal remediation, oil removal; Nitrogen fixation; Phosphate solubilization; Cellular and molecular markers of environmental pollution monitoring and management.

UNIT III

Microbial consortia: Consortia of microbes for environmental protection – Concept, scope and feasibility.

UNIT IV

Biological treatment and utilization of wastes: Bioreactors – principles and application in nitrification, denitrification, reduction of BOD; Production of biofuels, fermented products and biogas from wastes, Nutrient uptake by aquatic organisms.

Practical

Genomic and plasmid DNA isolation; PCR and gel electrophoresis, Cloning; Single-cell protein production; Case studies on wastewater treatment/recirculatory systems; Quantification of N fixation, nitrification; Screening of microbes for biodegradation properties.

Suggested Readings

Buck RP, Hatfield WE, Umana M & Bowden EF. 1990. *Biosensor Technology - Fundamentals and Applications*. Marcel Dekker.

Fujita M & Ike M. 1994. *Wastewater Treatment Using Genetically Engineered Microorganisms*. Technomic Publ. Co.

Kingsman SM & Kingsman AJ. 1988. *Genetic Engineering: An Introduction to Gene Analysis and Exploitation in Eukaryotes*. Blackwell.

Sambrook J & Russel DW. 2001. *Molecular Cloning: A Laboratory Manual*. CSHL Press.

Sayler GS, Sanseverino J & Kimberely DL. 1997. Biotechnology in Sustainable Environment. Plenum Press.

AEM 507 ENVIRONMENTAL TOXICOLOGY 1+1

Objective

To impart knowledge on toxicological aspects of various pollutants.

Theory

UNIT I

Toxicity and metabolism: Factors influencing toxicity- environmental, genetic and nutritional; Measurement and evaluation of the ecological effects of toxicants; Metabolism of toxic substances by aquatic organisms - consequences, synergistic and antagonistic effects; Acute poisons and accumulative poisons; Bioaccumulation and biomagnification; Systemic

effects of toxic metals, pesticides and herbicides; Effect of select toxicants on aquatic life and detoxification.

UNIT II

Toxicity evaluation: Toxicity Testing - Microcosm and Mesocosm Tests, Dose-Response Relationships, Toxicity Bioassay.

Practical

Toxicity evaluation of heavy metals on selected organisms by bioassay techniques; Toxicity assessment of pesticides, PCBs and oil on selected organisms; Analysis of heavy metals from aquatic ecosystems; Toxicity testing methods.

Suggested Readings

Hoffman DJ. 1995. *Handbook of Ecotoxicology*. Lewis Publ.

Kumar A. (Ed.). 2008. *Aquatic Environment and Toxicology.* Daya Publ. House.

Mayer H. 1977. *Aquatic Toxicology and Hazards Evaluation*. ASTM Publ.

Rand GM & Petrocelli SR. 1994. *Fundamentals of Aquatic Toxicology*. Hemisphere Publ. Corp.

Raymond JM, Neisink RJM, de Vries J & Hollinger MA. 1996. *Toxicology: Principles and Applications*. CRC Press.

Ware GW. 2002. *Review of Environmental Contamination and Toxicology*. Springer Verlag.

AEM 508 ANALYTICAL TECHNIQUES IN ENVIRONMENTAL SCIENCES 1+1

Objective

To impart knowledge and skills in analytical techniques employed in environmental studies.

Theory

UNIT I

Overview and concepts: An overview of qualitative and quantitative analytical techniques used in environmental science; Sampling techniques and procedures; Factors affecting the choice of an analytical technique; Interferences and their removal, Field kits and their application.

UNIT II

Photometric techniques: Theory, instrumentation and application of colorimetry and spectrophotometry.

UNIT III

Separation techniques: Chromatography – theory, instrumentation and applications of thin layer, paper, ion-exchange, size exclusion, high performance liquid and gas; Methods of preparing biological samples for chromatographic analysis; Theory and applications of electrophoresis; Principles and uses of ultracentrifugation.

UNIT IV

Tracer techniques: Scintillation counters and radio isotopes in environmental research.

Practical

Quantitative estimation of organic and inorganic pollutants and toxicants by UV-Visible spectrophotometer, AAS, HPLC, GC.

Suggested Readings

Eaton AD, Clesceri LS, Rice EW & Greenberg AE. 2005. *Standard Methods for the Examination of Water and Wastewater*. APHA-AWWA-WEF, Washington DC.

Fishbein L. 1973. *Chromatography of Environmental Hazards: Metals, Gaseous and Industrial Pollutants*. Elsevier.

Jeffery GH, Basset J, Mendham J & Denney RC. (Eds.). 1989. *Vogel's Textbook of Quantitative Chemical Analysis*. Longman.

Sparks DL, Page AL, Helmke PA, Loeppert RH, Soltanpour PN, Tabatabai MA, Johnston CT & Sumner ME. (Eds.). 1996. *Methods of Soil Analysis*: Part 3. *Chemical Methods*. SSSA-ASA, Madison.

Welch PS. 2003. *Limnological Methods*. Narendra Publ. House.

Wilson K & Walker J. 2002. *Practical Biochemistry: Principles and Techniques*. Cambridge University Press, Oxford.

AEM 509 PLANKTONOLOGY 1+1

Objective

To impart knowledge on plankton, their ecology and significance.

Theory

UNIT I

Plankton diversity and productivity: Classifications of plankton; Primary and secondary production - estimation, significance, affecting factors; Production - biomass (P/B ratio); Indices of productivity; Community interrelationships.

UNIT II

Ecology of phytoplankton: Phytoplankton (freshwater and marine) - methods of assessment, spatial and temporal variations, succession, diversity; Nanoplankton; Algal blooms; Role in carbon sequestration.

UNIT III

Ecology and life history of zooplankton: Zooplankton (freshwater and marine) – ecology of the major taxa, their food and feeding, reproduction of important zooplankton, life history stages; swarms; Indicator species; Predator-prey relationship; Impact of grazing in the aquatic ecosystem; Vertical migration of zooplankton; Larval ecology of benthic invertebrates.

UNIT IV

Sampling and preservation techniques: Plankton nets and recorders, catching efficiency of various nets; Plankton fixatives and preservatives.

Practical

Collection, preservation and quantitative estimation of phytoplankton and zooplankton; Identification and classification of various phytoplankton and zooplankton; Preparation of permanent slides; Logging, cataloguing and sorting procedures.

Suggested Readings

Fasset NG. 1997. *A Manual of Aquatic Plants*. Allied Scientific Publ.

Lund HC & Lund JWG. 1995. *Freshwater Algae*. Biopress Ltd.

Mitra A. 2006. *Introduction to Marine Phytoplankton*. Narendra Publ.

Pillai NK. 1986. *Introduction to Planktonology*. Himalaya Publ. House.

Sournia A. 1978. *Phytoplankton Manual*. UNESCO Publ.

Tomas CR. 1997. *Identifying Marine Phytoplankton*. Academic Press.

AEM 510 FISHERIES OCEANOGRAPHY 1+1

Objective

To educate the students on the oceanographic concepts related to fisheries and impart skill to operate oceanographic equipment.

Theory

UNIT I

Oceanographic factors in fisheries: Effects of physicochemical and biological oceanographic factors on adaptation, behaviour, abundance and production of aquatic organisms; Space and time scales in oceanographic analysis; Speed and magnitude of short-term changes in the ocean; Synoptic oceanographic analysis – currents, waves, tides, amplitudes, stratification, related chemical factors, upwelling and circulation patterns.

UNIT II

Forcasting systems: Fisheries forecasts – interpretation and use of ocean thermal structure in fisheries; Fisheries forecasting system in India and other countries – remote sensing; Global Positioning System (GPS). Application of Remote Sensing in fisheries; Application of echo-sounders and SONAR.

UNIT III

Coastal fishery: Coastal fishery and hydrography- introduction, scope and factors affecting; shoreline protection and influence of developmental activities on coastal hydrography.

UNIT IV

Factors affecting marine fisheries: Environmental factors influencing the seasonal variations in fish catches in the Arabian Sea and the Bay of Bengal.

Practical

Oceanographic data analysis – water temperature, salinity, pH, nutrients, benthos and sediment characteristics; Fisheries forecasting systems; Oceanographic equipment and fish finding devices.

Suggested Readings

Grasshoff K, Ehrhardt M & Kremling V. 1983. *Methods of Seawater Analysis*. Verlag Chemie.

Kennish MJ. 1989. *Practical Handbook of Marine Science*. CRC Press.

Laevastu T & Hayes ML. 1981. *Fisheries Oceanography and Ecology*. Fishing News Books.

Lalli CM & Parsons TR. 1993. *Biological Oceanography: An Introduction*. Elsevier.

Miller CB. 2004. *Biological Oceanography*. Blackwell.

Reddy MPM. 2007. *Ocean Environment and Fisheries*. Science Publ.

AEM 511 AQUATIC MICROBIOLOGY 2+1

Objective

To impart knowledge on aquatic microorganisms with reference to their role in the aquatic environment and bioprospecting.

Theory

UNIT I

Cell structure and function: Prokaryotic and eukaryotic cell structure, cell membrane, cell wall, proteins, nucleic acids - structure, properties and interactions, microbial growth.

UNIT II

Distribution and classification: Microbial community in freshwater, estuary and marine environment (types and abundance). Microbial dependency on physical, chemical and biological factors of the environment; Classification of aquatic microorganisms, Microbes in extreme environments and their significance - thermophiles, psychrophiles, halophiles and barophiles.

UNIT III

Microbial interaction with matter: Microbial interaction - role of microbial population on the biogeochemical cycles (C, N, P, S, Si and Fe), Xenobiotic and inorganic pollutants; Microbial degradation of natural and synthetic compounds.

UNIT IV

Microorganisms and public health: Water-borne pathogens of public health importance - protozoans, bacteria, enteroviruses; Microbial toxins; Microbial standards for different water uses.

UNIT V

Microbes and aquatic environment: Principles and applications of bioprocesses – bioremediation, biofertilization, biofilms, bio-leaching, bio-corrosion, bio-fouling; Microorganisms as bioindicators, bioremediators and biosensors; Microbial biomass production - single cell protein; Bioprospecting.

Practical

Sampling methods; Isolation, identification and enumeration of algae and bacteria from diverse aquatic habitats; growth kinetics; Management of algal and bacterial cultures; Quantification of microbial activities in nutrient cycles; Microbial sensitivity testing; Demonstration of biofilms.

Suggested Readings

Dhevendaran K. 2008. *Aquatic Microbiology*. Daya Publ. House.

Frobisher M, Hinsdill RD, Crabtree KT & Goodheart CR. 1974. *Fundamentals of Microbiology*. WB Saunders.

Geesey G, Lewandowski Z & Flemming HC. (Eds.). 1994. *Biofouling and Biocorrosion in Industrial Water Systems*. CRC Press.

Prasad AB & Vaishampayan A. 1994. *Nitrogen Fixing Organisms – Problems and Prospects*. Scientific Publ.

Rheinheimer G. 1992. *Aquatic Microbiology*. John Wiley & Sons.

Stanier R, Ingraham JL & Adelberg EA. 1976. *General Microbiology*. MacMillan.

Vernam AH & Evans M. 2000. *Environmental Microbiology*. Blackwell.

AEM 601 ADVANCES IN AQUATIC ENVIRONMENTAL STUDIES 2+1

Objective

To impart knowledge on various aspects of advances in aquatic environment studies.

Theory

UNIT I

Factors effecting productivity of aquatic ecosystems and their interactions; phosphorus, nitrogen and silica cycles; minor metallic elements; organic matter in lake waters. Dynamics of flowing water; Indices of productivity; pollution index –usefulness and limitations.

UNIT II

Eutrophication – causative factors, effects on water quality, fish and other biota; measures to control the lake degradation due to eutrophication.

UNIT III

Biomanipulation: Concept and approaches- studies on Planktivorous, Benthivorous and Omnivorous fish. Biological control of macrophyte and eutrophication.

UNIT IV

Biomonitoring of aquatic environment, scope and process; Bioindicator organisms and its Characteristics; Assessment of water quality through bioindicators.

UNIT V

Global warming and green house effects- process and impact on aquatic environment; Integrated environment management (IEM), Role of human element in IEM, Analytical Behavior Analysis Approach (ABAA) for IEM.

UNIT VI

Natural disasters: formation, causes and effects; effects on aquatic habitat and coastal population; Concerns and management; mitigation process; preparedness, Anthropogenic activities leading to environmental disasters. Man-made aquatic environmental degradation; effects on aquatic life.

Practical

Analysis of ions; Calculation of shoreline development index and other indices of lake productivity; Studies on eutrophication in natural waters-tanks and ponds; Collection, preservation and estimation (quantitative and qualitative) of bioindicator organisms in polluted water. Demonstration of Biomanipulation experiment; Preparation of disaster kits for coastal fisher; Interaction of the Govt. and Non-Govt. Organizations engaged for disaster management.

Suggested Readings

Brudtland GH. 1987. *Our Common Future: World Commission on Environment and Development*. Oxford University Press.

Gates DM. 1993. *Climate Change and its Biological Consequences*. Saunderland.

Goudie A. 1993. *The Human Impact on the Natural Environment*. MIT Press.

IUCN, UNEP, WWE. 1991. *Caring for the Earth: Strategies for Sustainable Living*. Earthscan.

Sakhare VB. (Ed.). 2007. *Advances in Aquatic Ecology* Vol. I. Daya Publ.

WCMC. 1992. *Global Biodiversity: Status of the Earth's Living Resources*. Chapman & Hall.

AEM 602 BIOTECHNOLOGY FOR CLEANER ENVIRONMENT 1+1

Objective

To educate the learners about the application of biotechnology in aquatic environment management.

Theory

UNIT I

Pollution Control: Cleaner technologies, Reducing environmental impact of industrial effluents, Toxic site reclamation.

UNIT II

Microbial transformation of toxic metals, Removal of spilled oil and grease deposits, 'Biorational' or 'Environmentally Safe' weed and pest control, Bio-fertilizers, Bio-sensors and biochips to detect environmental pollutants.

UNIT III

Application of biotechnological tools in biomonitoring of aquatic environment; Renewable or bio-energy and bio-fuels from aquatic environment, Energy and fuel production using micro-organisms; Production of food: Single cell protein, Algal biotechnology for production of food; Use of microbes for improving soil fertility, biodegradation.

UNIT IV

Biodiversity and its conservation: Current levels of biodiversity, alpha and beta biodiversity, i*n situ* and *ex situ* conservation-gene banks, species conservation. Intellectual Property Rights (IPR) and protection (IPP): IPP and aquatic genetic resources (AGR).

Practical

Quantification of faunal changes in polluted water; Gel electrophoresis; Total DNA isolation; Mitrochondial DNA isolation, Separation and detection of fragments, Comet assay, Micronucleus test, Sister Chromatid exchange; Assessing the molecular and cellular level changes in the Aquatic organisms; Genomic libraries and the development of species specific probes. Southern hybridization; RFLP analysis, PCR mechanics.

Suggested Readings

Buck RP, Hatfield WE, Umana M & Bowden EF. 1990. *Biosensor Technology - Fundamentals and Applications*. Marcel Dekker.

Crespi RS. 1991. *Biotechnology and Intellectual Property*. Parts 1, 2. TIBTECH 9.

Moo-Young M, Anderson WA & Chakrabarty AM. 2006. *Environmental Biotechnology: Principle and Applications*. Kluwer.

Sambrook J & Russel DW. 2001. *Molecular Cloning: A Laboratory Manual*. CSHL Press.

Sayler GS, Sanseverino J & Kimberely DL. 1997. *Biotechnology in Sustainable Environment*. Plenum Press.

Yoxen E. 1988. *The Gene Business: Who should Control Biotechnology*. Oxford University Press.

AEM 603 BENTHIC ECOLOGY 1+1

Objective

To impart theoretical and practical knowledge of benthic ecology.

Theory

UNIT I

Benthic habitat- rocks, reefs, marshes and sediments that form the habitat; recycling of nutrients and the burial and storage of organic matter.

UNIT II

Community ecology; Physical, chemical and biological factors effecting benthic population; abundance and distribution of benthic communities-major groups- their life cycles, food and feeding habits and ecological significance; Role in maintaining ecological balance; Recruitment dynamics; Predator prey interaction; Invasive species.

UNIT III

Human impacts; modification of coastal habitats, and major alterations of biogeochemical cycles; contaminants; Benthic organisms as pollution indicators and biomonitors.

Practical

Collection and analysis of soil and water of nearby benthic habitat; collection, identification and preservation of macro and micro benthos; study of food and feeding habit of some benthic population.

Suggested Readings

APHA (American Public Health Association). 1989. *Standard Methods for the Examination of Water and Wastewater*. 17th Ed. American Public Health Association, Washington, D.C.

Clegg J & Anthon H. 1968. *Pond and Stream Life*. Blandford Press.

Cole GA. 1988. *Textbook of Limnology*. 3rd Ed. Waveland Press.

Cuffney TF, Gurtz ME & Meador MR. 1993. *Methods for Collecting Benthic Invertebrate Samples as Part of the National Water-Quality Assessment Programme*. U.S. Geological Survey Open-File Report 93-406. U.S.G.S., Raleigh, North Carolina.

Dawson CL & Hellenthal RA. 1986. *A Computerized System for the Evaluation of Aquatic Habitats Based on Environmental Requirements and Pollution Tolerance Associations of Resident Organisms*. EPA/600/S3-86/019. Environmental Research Laboratory, U.S. Environmental Protection Agency, Corvallis, Oregon.

Downing JA & Rigler FH. (Eds.). 1984. *A Manual on Methods for the Assessment of Secondary Productivity in Fresh Waters*. 2nd Ed. IBP Handbook 17. Blackwell.

Elliott JM. 1977. *Some Methods for the Statistical Analysis of Samples of Benthic Invertebrates*. 2nd Ed. Freshwater Biological Association Scientific Publication No. 25.

Whitton BA. (Ed.). 1975. *River Ecology*. University of California Press, Berkeley, California.

AEM 604 ESTUARINE AND COASTAL OCEANOGRAPHY 2+1

Objective

To impart knowledge on the dynamics of coastal environment.

Theory

UNIT I

Definition of an estuary; Buoyancy input as freshwater.

UNIT II

Dynamics of the gravitational circulation; Mixing of fresh and salt water; Sources of energy for mixing. Estuarine circulation, Richardson number. Contributions to the salt flux.

UNIT III

Simplified salt balance using the steady state salinity distribution to predict the concentration of a pollutant. Freshwater fraction. The flushing time of an estuary and methods of determining it.

UNIT IV

Waves in shallow waters, transformation, refraction and reflection; Mass transport. Return flow. Rip current. Long shore currents. Momentum balance.

UNIT V

Sediment transport. Base studies on sedimentation in Estuaries effects of man –made structures and breakwaters on coastal sedimentation. Standing waves and harbor resonance.

Practical

Measurement of tidal currents in estuaries - analyses of tidal heights – Net flow and residence time computations. Computation of salt and nutrient flux. Construction of wave refraction diagrams. Computation of longshore currents and sediment drift beach profiles.

Suggested Readings

Carter RWG. 1998. *Coastal Environments: An Introduction to the Physical, Ecological and Cultural Systems of Coastlines*. Academic Press.

Clark JR. 1992. *Integrated Management of Coastal Zones*. FAO Fisheries Tech. Paper No. 327.

Kormondy EJ. 1986. *Concepts of Ecology*. Prentice-Hall.

Park CC. 1980. *Ecology and Environmental Management*. Butterworths.

AEM 605 ORGANIC PRODUCTION AND PLANT PIGMENTS 2+1

Objective

To impart advance knowledge on primary productivity and pigments.

Theory

UNIT I

Concepts of production; measurements of rate of production – oxygen technique, radiotracer technique (C14), in-situ measurements.

UNIT II

Phytoplankton production in an isolated, non isolated communities in flowing and standing waters, measurement of rates of production from changes in phytoplankton biomass.

UNIT III

Measurement of photosynthesis under laboratory conditions; factors regulating aquatic production; The role of Enzymes in relation to photosynthesis; The photosynthetic pigments, their location in the chloroplast, The role of accessory pigments during photosynthesis; Molecular organisation of chlorophylls, phycobilins and carotenoids; Pigment degradation products – phaeopigments – phaeophytin and phaeophorbides.

UNIT IV

Chloroplast – structure and function of grana and lamellae. Structure of chloroplast membrane – in relation to energy coupling and transport.

UNIT V

Application of remote sensing in studies on chlorophyll and other pigments.

UNIT VI

Production rates – direct measurement of zooplankton reproduction – marking populations. Laboratory measurements of physiology of zooplankton – feeding, respiration and excretion.

Practical

Estimation of primary production in waters –by Light and Dark Bottle method and radioactive carbon C14 technique. Laboratory studies to understand the impact of nutrients and light on primary production using selected algal cultures. Laboratory studies on the oxygen consumption, filtration and grazing by selected zooplankters. Collection of water samples from selected aquatic environments for the estimation of different plant pigments – chlorophylls and carotenoids; Estimation of pigments in some of the selected aquatic weeds.

Suggested Readings

Eaton AD, Clesceri LS, Rice EW & Greenberg AE. 2005. *Standard Methods for the Examination of Water and Wastewater*. APHA-AWWA-WEF, Washington DC.

Fishbein L. 1973. *Chromatography of Environmental Hazards: Metals, Gaseous and Industrial Pollutants*. Elsevier.

Talling J & Lemoalle J. 1998. *Ecological Dynamics of Tropical Inland Waters*. Cambridge University Press.

AEM 606 ENVIRONMENT IMPACT ASSESSMENT 1+1

Objective

To impart theoretical and practical knowledge of environment impact assessment for sustainable development.

Theory

UNIT I

Environmental Impact Assessment (EIA): Process, evaluation and methodology; Social Impact Assessment (SIA) as a part of EIA-principals and process; EIA of aquacultural projects, coastal industries and other developmental activities.

UNIT II

Environmental audit: Concept, setting up an audit programme, typical audit process, carrying out the audit, benefits of environmental auditing, Environmental audit programme in India.

UNIT III

International and national environmental protection standards; Environmental quality monitoring; ISO-14000-Environment Management System (EMS)-present status; Impacts on developing countries.

Practical

Field visits for EIA and SIA of certain aquacultural projects; EIA report preparation; Setting up of Environmental audit programme.

Suggested Readings

Canter LW. 1994. *Environmental Impact Assessment*. Mc-Graw Hill.

Grilbert M & Gould R. 1998. *Achieving Environmental Standards*. Pitman Publ.

Wathern P. (Ed.). 1988. *Environmental Impact Assessment: Theory and Practice*. World Research Institute, Routledge, London.

AEM 607 MANAGEMENT AND UTILIZATION OF WASTEWATER 2+1

Objective

To impart theoretical and practical knowledge on management and utilization of wastewater for sustainable development.

Theory

UNIT I

Advance treatment methods-Principles and procedures; ozonation, U.V. irradiation etc; Oxidation of sediment; Aerobic and anaerobic treatment process; Role of aquatic macrophytes in biological treatment of waste water; Wastewater treatment through the use of solar energy; Basic design of water and wastewater treatment plants. Removal of nitrogen and phosphorus from wastewater.

UNIT II

Waste recycling and waste management in aquaculture; Design and construction of water filtration devices; Utilization of wastewater for mass cultivation of algae and other fish food organisms; Utilization of waste water for aquaculture and Agriculture.

UNIT III

Waste disposal criteria used in different parts of world - national and international standards; Production of biogas from sewage; Advances in Pollution prevention, Environmental management.

Practical

Estimation of physico-chemical characteristics of wastewater. Estimation of nutrients and contaminant of wastewaters. Analysis of living communities associated with treatment processes; Demonstration of wastewater treatments (ozonisation, chlorination, aeration, precipitation, coagulation etc.).

Suggested Readings

Baird DJ, Beveridge MCM, Kelly LA & Muir JF. 1996. *Aquaculture and Water Resources Management*. Blackwell.

Cheremisinoff NP. 2002. *Handbook of Water and Waste Water Treatment Technologies*. Butterworth-Heinemann.

Eckenfelder WW. 2000. *Industrial Water Pollution Control*. McGraw Hill.

Fujita M & Ike M. 1994. *Wastewater Treatment using Genetically Engineered Microorganisms*. Technomic Publ. Co.

Gray NF. 2004. *Biology of Wastewater Treatment*. Oxford University Press.

Trivedy RK. 1998. *Advances in Wastewater Treatment Technologies*. Global Science.

AEM 608 APPLICATION OF REMOTE SENSING AND GIS IN FISHERIES 1+1

Objective

To impart theoretical knowledge and practical skill on application of remote sensing and GIS in oceanographic studies and aquatic environment management planning.

Theory

UNIT I

General consideration, Survey planning, Position fixing; Sampling frequency and duration, Data storage and transmission;

UNIT II

Sensors for temperature and salinity (Via conductivity); The measurement of depth (via pressure); CTD units for estuarine and open ocean work; Sensor calibration techniques; Sensors for measuring flow; Tracking of

drogue buoys. Acoustic Doppler current measurements; Optical measurements; transmittance and subsurface reflectance;

UNIT III

In situ fluorescence for the determination of pigment concentration; Remote sensing optical methods; Satellite measurements of temperature (via thermal I.R.), the interpretation of Microwave (geotropic currents, waves, surface winds).

UNIT IV

Geographical Information System (GIS): Definition, Concepts, Spatial data management. Data base management system. Data Capture, Digitization, Data integration, Projection and Registration, Data Structure, Data Modeling. Visual Image Interpretation; Applications of GIS in aquatic Resource identification; Digital Image Processing (DIP): Different Methods and Approaches

Practical

Position fixing techniques. Operation of C.T.D. units and their calibrations. Various types of current meters and measurement of currents. Wave recorders and measurements. Determination of pigment concentrations. Remote sensors – interpretation of data. Practical on visual interpretation of data from map, Practical on Digital Image Processing (DIP). Field practical on the Application of GPS. Mapping of aquatic environment resources through GIS softwares (ARCVIEW, MAPINFO etc.).

Suggested Readings

Elangovan K. 2005. *GIS: Fundamentals, Applications and Implementations*. New India Publ. Agency.

ESRI. 2007. *Understanding GIS, The ARC/INFO Method*. Environmental System Research Org, USA.

Lillesand TM, Kiefer RW, Chipman JW. 2004. *Remote Sensing and Image Interpretation*. John Wiley & Sons.

Meaden GJ & Do Chi T. 1996. *Geographical Information System: Applications to Marine Fisheries*. FAO Tech. Paper No. 356.

Meaden GJ & Kapetsky JM. 1991. *Geographical Information System and Remote Sensing in Inland Fisheries and Aquaculture*. FAO Tech. Paper No. 318.

AEM 609 DISPERSAL AND FATE OF POLLUTANTS IN THE OCEAN 1+1

Objective

To impart theoretical and practical knowledge on dispersal and fate of pollutants.

Theory

UNIT I

Common transport processes of pollutants in the ocean.

UNIT II

Influence of winds, tides, Waves and currents on the dispersal of pollutants, mixing due to waves and Wave induced currents; Principles of design of marine waste disposal system.

UNIT III

Pollutant dispersion in coastal waters and estuaries, dispersion near outfall sites; Methods of pollutant dispersal dye diffusion studies.

Practical

Techniques of computation of dispersion coefficients; Calculation of Richardson number, tidal exchange calculation at the estuarine mouth; Numerical analysis of estuarine dispersion; Simple plume experiments – designs of waste discharge and thermal systems.

Suggested Readings

John J, William R & Feiss GP. 1998. *People and the Earth: Basic Issues in the Sustainability of Resources*. Cambridge University Press.

Laevastu T, Clancy M & Stroud A. 1974. *Computation of Tides, Currents and Dispersal of Pollutants in Lower Bay and Approaches to New York with Fine Medium Grid Size Hydrodynamical-Numerical Models*. Part 3. National Technical Information Service Springfield, Virginia.

Roy MH. (Ed.). 1982. *Pollution: Causes, Effects and Control*. The Royal Society of Chemistry, England.

Wlodzimierz C & Pawel R. 2005. *Water Quality Hazards and Dispersion of Pollutants*. Springer.

AEM 610 RESTORATION ECOLOGY 1+1

Objective

To acquire theoretical and practical knowledge on ecological restoration.

Theory

UNIT I

Ecological restoration- Need, concept and definition; Approaches; Rationale for restoration; Differences between conservation and restoration; critical ranges of variability in biodiversity.

UNIT II

Ecological processes and structures, regional and historical contexts, and sustainable cultural practices; Ecosystem integrity; community ecological principles; Disturbance, Succession, Fragmentation, Ecosystem auditing; Ecosystem function.

UNIT III

Emerging concepts-Assembly, Stable states; Biotic and abiotic flows and cultural interactions; Application of theory-Invasion, competitive dominance and resource use; IV Restoration planning; Wetland assessment, Delineation, and regulation; Recovery process, Mitigation, Rehabilitation and Reclamation; Dynamics and restoration of degraded wetlands; Removal of threats to the health and integrity of the restored ecosystem.

UNIT IV

Individuals participation in a restoration programme; different human participatory programme; Sustainable cultural practices; constraints and opportunities; Economics of recovery process.

Practical

Collection and segregation of native and non native species from a damaged environment; Making list of historical and cultural interactions; Status of assemblages; calculation of Index of Biotic Integrity; Listing of the threats to the integrity of the ecosystem; Organizing different participatory programme.

Suggested Readings

Jordan WR, Gilpin ME & Aber JD. (Eds.). 1987. *Restoration Ecology: A Synthetic Approach to Ecological Research*. Cambridge University Press.

Luken JO. 1990. *Directing Ecological Succession*. Chapman & Hall.

Perrow MR & Davy AJ. (Eds.). 2002. *Handbook of Ecological Restoration*. Vol. I. *Principles of Restoration*. Cambridge University Press.

SER. 2004. *The SER Primer on Ecological Restoration*. Version 2. Society for Ecological Restoration Science and Policy Working Group.

Temperton VK, Hobbs RJ, Nuttle T & Halle S. (Eds.). 2004. *Assembly Rules and Restoration Ecology: Bridging the Gap Between Theory and Practice*. Island Press.

Van Andel J & Aronson J. (Eds.). 2006. *Restoration Ecology*. Blackwell.

Wilson EO. 1988. *Biodiversity*. National Academy. Washington DC.

Young TP. 2000. *Restoration Ecology and Conservation Biology*. Biological Conservation.

AQUATIC ENVIRONMENT MANAGEMENT

List of Journals

- Acta Oecologica – International Journal of Ecology
- Agriculture, Ecosystem and Management
- Analytica Chemica
- Applied Environmental Microbiology
- Applied Microbiology and Biotechnology
- Applied Soil Ecology
- Aquaculture
- Aquaculture Engineering
- Aquatic Microbial Ecology
- Australian Journal of Ecology
- Australian Journal of Soil Research
- Biology and Fertility of Soils
- Bioresource Technology
- Bulletin of Environmental Contamination and Toxicology
- Canadian Journal of Fisheries and Aquatic Sciences
- Coastal Aquaculture
- Communication in Soil and Water analysis
- Current Opinion in Biotechnology
- *Ecological Restoration*- Journal published by the University of Wisconsin Press
- Ecotoxicology and Environmental Safety
- Environment and Ecology
- Environmental Pollution
- Environmental Science
- Environmental Studies
- Environmental Technology
- Environmental Toxicology
- Estuarine, Coastal and Shelf Science
- FEBS Letters
- FEMS Microbiology Ecology
- FEMS Microbiology Letters
- FEMS Microbiology Reviews
- Fisheries Oceanography
- Fisheries Science
- Functional Ecology
- Geo-Marine Letters
- Hydrobiologia
- Indian Journal of Environment and Toxicology
- Indian Journal of Marine Sciences
- International Journal of Ecology and Environmental Sciences
- Journal of Aquatic Botany
- Journal of Chromatography
- Journal of Ecotoxicology
- Journal of Environmental Quality
- Journal of Marine Research USA
- Journal of Phycology

- Journal of Plankton Research
- Journal of Sustainable Agriculture
- Limnology and Oceanography
- Marine Biology
- Marine Ecology
- Marine Pollution Bulletin
- Oceans
- Restoration Ecology
- Science of the Total Environment
- Seaweed Research and Utilization
- Society for Ecological Restoration International
- Soil Science Society of America Journal
- Spill Science and Technology Bulletin
- Systematic and Applied Microbiology
- Toxicon
- Trends in Biotechnology
- Water Research
- World Journal of Microbiology and Biotechnology

Suggested Broad Areas for Master's and Doctoral Research

- Soil- water – nutrient interaction
- Nutrients in fish productivity
- Pollutant cycling in aquatic environment
- Coastal pollution assessment
- Conservation of ecologically important species
- Impact of coastal zone regulations and policies on coastal zone
- Resource assessment through remote sensing and GIS
- Genetic improvement of microbes
- Bioaccumulation of toxicant
- Effects of toxicant on aquatic biota
- Development of methods for efficient and rapid analysis
- Comparison of different analytical techniques
- Documentation of planktons in diverse aquatic habitats
- Diversity analysis and algal indices of pollution load
- Evaluation of plankters for fish food
- Marine pollution and fisheries production
- Seasonality of fish catch and meteorological factors
- Application of GPS and remote sensing in marine fisheries
- Bioactive compounds from sea
- Microbial pollution indicators
- Biomonitoring of aquatic environment
- Microbial indicators of pollution
- Use of microbes for improving soil fertility
- Factors effecting benthic population
- Abundance and distribution of benthic communities
- Benthic organisms as pollution indicators and biomonitors
- Measurement of tidal currents in estuaries

- Dynamics of estuarine circulation
- Measurement of rates of production from changes in phytoplankton biomass
- Application of remote sensing in studies on chlorophyll and other pigments
- Principles and practices of EIA
- Preparation of environmental audit
- Role of aquatic macrophytes in biological treatment of wastewater
- Removal of nitrogen and phosphorus from wastewater
- Utilization of wastewater for mass cultivation of algae
- Effect of selected toxicants on aquatic life and detoxification mechanism
- Toxicity assessment of pesticides and oil on selected organisms
- Applications of GIS in aquatic resource identification
- Application of remote sensing and GIS in oceanographic studies
- Computation of dispersion coefficients
- Analysis of estuarine dispersion
- Design of marine waste disposal systems
- Dynamics and restoration of degraded wetlands
- Removal of threats to the health and integrity of the restored ecosystem

AQUATIC ANIMAL HEALTH
Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
AAH 501*	VIRAL AND BACTERIAL DISEASES OF FINFISH AND SHELLFISH	2+1
AAH 502*	PARASITIC DISEASES OF FINFISH AND SHELLFISH	2+1
AAH 503*	HEALTH MANAGEMENT IN AQUACULTURE	2+1
AAH 504*	SYSTEMIC FISH PATHOLOGY	2+1
AAH 505	FISH IMMUNOLOGY	2+1
AAH 506	MICROBIOLOGICAL TECHNIQUES	1+1
AAH 507	FISH VIROLOGY AND CELL CULTURE	2+1
AAH 508	CLINICAL PATHOLOGY	1+1
AAH 509	NON-INFECTIOUS AND FUNGAL DISEASES	1+1
AAH 510	AQUATIC ENVIRONMENT AND FISH HEALTH	1+1
AAH 511	DIAGNOSTIC TECHNIQUES	1+1
AAH 591	MASTER'S SEMINAR	1+0
AAH 599	MASTER'S RESEARCH	20
AAH 601**	FISH AND SHELLFISH VIROLOGY	2+1
AAH 602**	ADVANCES IN PARASITOLOGY	2+1
AAH 603**	MOLECULAR MECHANISMS IN DISEASE PROCESS	2+1
AAH 604	CRUSTACEAN PATHOLOGY	1+1
AAH 605	FISH PHARMACOLOGY	2+1
AAH 606	BIOTECHNOLOGICAL TOOLS IN DISEASE DIAGNOSIS	1+1
AAH 607	PUBLIC HEALTH MICROBIOLOGY AND EPIDEMIOLOGY	2+1
AAH 608	MOLECULAR TECHNIQUES IN MICROBIOLOGY	1+1
AAH 609	FISH MYCOLOGY AND VIROLOGY	1+1
AAH 691	DOCTORAL SEMINAR I	1+0
AAH 692	DOCTORAL SEMINAR II	1+0
AAH 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme; ** Compulsory for Doctoral programme

AQUATIC ANIMAL HEALTH
Course Contents

AAH 501 VIRAL AND BACTERIAL DISEASES OF FINFISH AND SHELLFISH 2+1

Objective

To impart knowledge of viral and bacterial infections, their replication strategies and pathogenesis in fish and shellfish.

Theory

UNIT I

Virology: General biology of viral infections, virus classification, virus replication. OIE Notifiable diseases.

UNIT II

Aetiology, pathogenesis, epidemiology, treatment and control, immunology and molecular biology of viruses/viral diseases of finfishes with emphasis on the following: Epizootic haematopoietic Necrosis (EHN), Infectious Haematopoietic Necrosis (IHN), Oncorhynchus Masou Virus (OMV), Viral Encephalopathy and Retinopathy (VER), Spring Viraemia of Carp (SVC), Viral Haemorrhagic Septicaemia (VHS),Lymphocystis and Infectious Pancreatic Necrosis (IPN).

UNIT III

Major viral pathogens of commercially important cultured crustaceans with special reference to shrimp and freshwater prawn: viral and bacterial; Biology, morphology, diagnostic methods, clinical signs and pathological changes associated with these pathogens; Viruses: WSSV, YHV, TSV, IHHNV, MBV, HPV, BP, BMN, LOVV, GAV, MrNV.

UNIT IV

Pathogenesis, virulence mechanisms, epidemiology, treatment and control measures of the bacterial diseases of finfish and shell fish with emphasis on Furunculosis, Haemorrhagic septicemia, Columnaris disease, Tail and fin rot, Bacterial gill disease, Vibriosis, Mycobacteriosis, Nocardiosis, Haemophilosis, Edwardsiellosis, enteric red mouth.

UNIT V

Bacterial diseases of shellfish such as Vibriosis; Necrotizing hepatopancreatitis, rickettsial diseases, mycobacteriosis.

Practical

Examination of moribund fish for viral and bacterial diseases; Sampling techniques, culture techniques, bioassay methods; Serological techniques in disease diagnosis, microbial identification.

Suggested Readings

Austin B & Austin DA. 1993. *Bacterial Fish Pathogens. Disease in Farmed and Wild Fish*. 2nd Ed. Ellis Horwood.

Eiras J, Segner H, Wahli T & Kapoor BG. 2008. *Fish Diseases*. Science Publ.

Inglis V, Roberts RJ & Bromage NR. 1993. *Bacterial Diseases of Fish*. Blackwell.

Noga EJ. 1996. *Fish Disease Diagnosis and Treatment*. Mosby-Year Book.

Roberts RJ. 2001. *Fish Pathology*. 3nd Ed. W.B. Saunders.

Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish*. Vols. I, II. 2nd Ed. Academic Press.

Stoskopf MK. 1993. *Fish Medicine*. WB Saunders.
Wolf K. 1988. *Fish Viruses and Viral Diseases*. Cornell University Press.

AAH 502 PARASITIC DISEASES OF FINFISH AND SHELLFISH 2+1

Objective

To comprehend the taxonomy, morphology, pathology and host-parasite relation of common parasites of aquatic organisms and to understand the significance of parasites in fish health.

Theory

UNIT I

Parasite taxonomy and morphology: Protozoan and metazoan parasites of fish and shellfish.

UNIT II

Life cycle of fish and shellfish parasites.

UNIT III

Parasite pathology: Pathology, treatments and control of the disease caused by protozoan parasites: *Costia necatrix*, *Trypanosoma*, *Trypanoplasma, Ichthyophthirius*, Urceolariid ciliates, Microsporidians, Myxozoans.

UNIT IV

Parasite pathology: Pathology treatments and control of the disease caused by Metazoan parasites: Trematodes: *Dactylogyrus, Gyrodactylus, Diplozoan, Sanguinicola, Neascus cuticola,* Cestodes: *Diphyllobothrium latum, Caryophyllaeus, Ligula*; Nematodes: *Capillaria, Camallanus.*

UNIT V

Parasite pathology: Pathology treatments and control of disease caused by Acanthocephalan parasites, Crustacean parasites: *Lernea, Argulus, Ergasilus*, fish leeches.

UNIT VI

Shellfish parasites: Pathology, treatment and control of the disease caused by Microsporidians, Haplosporidians, Ciliates and Cephaline gregarines.

Practical

Collection and identification of parasites; Preparation of permanent slides, micrometry and diagrams of parasites; Histopathological slide preparation of parasite-infected tissues; Processing for study of helminths and their larval stages; Examination of intermediate host for larval stages; Processing and study of the arthropods and their larval stages; Fixation staining and study of the protozoans; Examination of biopsy material, examination of tissue sections for parasites.

Suggested Readings

Ferguson HW. (Ed). 2006. *Systemic Pathology of Fish: A Text and Atlas of Normal Tissues in Teleosts and their Responses in Disease*. 2nd Ed. Scotian Press.
Lom J & Dykova I. 1992. *Protozoan Parasites of Fishes*. Elsevier.
Noga EJ. 1996. *Fish Disease. Diagnosis and Treatment*. Mosby-Year Book.
Rhode K. 2005. *Marine Parasitology*. Steven Simpson Books.
Roberts RJ. 2001. *Fish Pathology*. 3rd Ed. WB Saunders.
Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish.* Vols. I, II. 2nd Ed. Academic Press.
Stoskopf MK. 1993. *Fish Medicine*. WB Saunders.
Woo PTK & Bruno DW. (Eds.). 1999. *Fish Diseases and Disorders*. CABI.

AAH 503 HEALTH MANAGEMENT IN AQUACULTURE 2+1

Objective

To understand the essential principles of aquatic animal health management, biosecuirty and specific issues associated with the system.

To appreciate the significance of national and international instruments in quarantine, disease reporting and surveillance and their application in transboundary movement of aquatic organisms.

Theory

UNIT I

Review of various diseases of finfish and shellfish significant to aquaculture; diagnostic procedures and their application in aquaculture.

UNIT II

Disease monitoring, surveillance, epidemiology, quarantine, certification and import risk analysis.

UNIT III

Prophylaxis, hygiene and therapy of fish and shellfish diseases.

UNIT IV

Commonly used drugs/chemicals in aquaculture, drug delivery.

UNIT V

Vaccines and vaccination, probiotics and bioremedial measures; immunostimulants and their role.

UNIT VI

Application of health management protocols and biosecurity principles in aquaculture.

UNIT VII

Longterm strategy in health management; Advances in disease control and management; Principles of SPF/SPR.

Practical

Demonstration of different diagnostic tools. Sampling procedures for disease investigation; methods of chemical/drug delivery/application; case study.

Suggested Readings

David SA, Lee CS & O'Bryen PJ. 2006. *Aquaculture Biosecurity-Prevention, Control and Eradication of Aquatic Animal Diseases*. World Aquaculture Society. Blackwell.

Felix S, Riji John K, Prince Jeyaseelan MJ & Sundararaj V. 2001. *Fish Disease Diagnosis and Health Management*. Fisheries College and Research Institute, T.N. Veterinary and Animal Sciences University. Thoothukkudi.

Humphrey J, Arthur JR, Subasinghe RP & Phillips MJ. 2005. *Aquatic Animal Quarantine and Health Certification in Asia*. FAO.

John P. 1999. *Health Maintenance and Principal Microbial Diseases of Cultured Fishes*. 2nd Ed. Blackwell.

Noga EJ. 1996. *Fish Disease. Diagnosis and Treatment*. Mosby-Year Book.

Shankar KM & Mohan CV. 2002. *Fish and Shellfish Health Management*. UNESCO.

Stoskopf MK. 1993. *Fish Medicine*. WB Saunders.

AAH 504 SYSTEMIC FISH PATHOLOGY 2+1

Objective

To understand the various systems of fishes and shrimps with specific reference to their pathological significance.

Theory

UNIT I

Introduction: Anatomy and physiology of teleost Integumentary, musculoskeletal, respiratory, circulatory, reticuloendothelial, renal, excretory and digestive systems.

UNIT II

Pathophysiology: Stress and general adaptation syndrome, inflammatory response, necrosis and types, stages.

UNIT III

Integumentary system: Cuticular, epidermal dermal and hypodermal changes, hyperplasia and ulceration.

UNIT IV

Respiratory system: Lamellar oedema, lamellar hyperplasia and lamellar fusion.

UNIT V

Blood vascular system: Pathology of heart, vessels, blood composition, cellular components of blood and haemopoietic tissue.

UNIT VI

Digestive system: Digestive tract and its pathology; hepatic necrosis, lipid infiltration, hepatic granuloma, cirrhosis, pancreatic atrophy, neoplasia; epithelial sloughing of intestine.

UNIT VII

Excretory system: Kidney and its pathology, renal tubules and collecting ducts.

UNIT VIII

Nervous system: Pathology of brain, spinal cord, peripheral nerves, meninges, sense organs.

UNIT IX

Musculoskeletal and Endocrine system: Pathological changes in red and white muscle bone and cartilages. Endocrine systems and pathology.

UNIT X

Systemic pathology in shrimp: Integument, respiratory, digestive and nervous system and its pathology.

Practical

Necropsy techniques, Systemic pathology of different organs and their identification.

Suggested Readings

Andrews C, Excell A & Carrington N. 1988. *The Manual of Fish Health*. Salamander Books Ltd.

Eiras J, Segner H, Wahli T & Kapoor BG. 2008. *Fish Diseases*. Science Publ.

Ferguson HW. (Ed). 2006. *Systemic Pathology of Fish: A Text and Atlas of Normal Tissues in Teleosts and their Responses in Disease*. 2nd Ed. Scotian Press.

Roberts RJ. 2001. *Fish Pathology*. 3rd Ed. WB Saunders.

Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish.* Vols. I, II. 2nd Ed. Academic Press.

AAH 505 FISH IMMUNOLOGY 2+1

Objective

To teach basic principles of fish and shellfish immunology.

Theory

UNIT I

Introduction to fish immunology and terminologies; historical developments; Phylogeny of fish immune system.

UNIT II

Lymphoid tissues and cellular components of immune system.

UNIT III

Non specific humoral and cellular defence mechanisms.

UNIT IV

Specific defence mechanisms; Memory function and immunological tolerance.

UNIT V

Complement system, function, components, complement activation.

UNIT VI

Antigens and antigenicity; structure of antibody. Types of antibodies, Theories of antibody formation, Antibody mediated immune response: general characteristics, immunoglobulin classes, structure and function and synthesis.

UNIT VII

Phagocytic systems; Lymphoid systems; Antigen processing and major histocompatibility complex.

UNIT VIII

Cell mediated immune response and its components; Hypersensitivity reactions.

UNIT IX

Invertebrate defence mechanisms.

Practical

Preparation of antigen; Raising of antibodies; Antigen-antibody reactions; Agglutination tests; Precipitation tests: gel diffusion; Immunoelectrophoresis, counter immunoelectrophoresis; Isolation of antibody from serum; ELISA; Western blotting; Isolation of lymphocytes and blastogenesis; Non-specific immune response (NBT and prophenoloxidase).

Suggested Readings

Ellis AE. 1988. *Fish Vaccination*. Academic Press.

Iwama G & Nakanishi T. 1996. *The Fish Immune System. Organism, Pathogen and Environment*. Academic Press.

Janis K. 1997. *Immunology*. 3rd Ed. WH Freeman.

Swain P, Sahoo PK & Ayyappan S. 2005. *Fish and Shellfish Immunology: An Introduction*. Narendra Publ. House.

AAH 506 MICROBIOLOGICAL TECHNIQUES 1+1

Objective

To comprehend different microbiological techniques used in research.

Theory

UNIT I

Techniques in sterilization; Preparation of media. Safety in microbiology laboratory, bio-safety levels.

UNIT II

Microscopy: bright field, fluorescence, phase contrast, dark field and electron microscope.

UNIT III

Stains, staining and its chemistry.

UNIT IV

Isolation and culture of different types of bacteria; Techniques for identification: biochemical, serological and molecular techniques.

UNIT V

Techniques for isolation and identification of fungi; Basics of mycological and virological techniques.

Practical

Practical on microscopic techniques; Antibiotic sensitivity testing; Identification of microorganisms, anaerobic bacteria, mycological and virological techniques.

Suggested Readings

Chakraborthy P. 1995. *A Text Book of Microbiology*. New Central Book Agency.

Criusted J. 1986. *Methods in Microbiology*. Academic Press.

Harry WSJR, Paul JV & John JL. 2000. *Microbes in Action*. Freeman & Co.

James M. 1978. *Modern Food Microbiology*. 2nd Ed. D. Van Nostrand Co.

Michael J, Pelizar JR & Chan ECS. 1998. *Microbiology*. Tata McGraw Hill.

Paul JH. 2001. *Marine Microbiology - Methods in Microbiology*. Vol. XXX. Academic Press.

Samuel CP & Dunn CG. 1959. *Industrial Microbiology*. McGraw Hill.

Silliker JH, Elliof RP, Baired AC & Boyan FL. 1980. *Microbial Ecology of Foods*. Vol. II (ICMSF). Academic Press.

William CF & Westhoff DC. 2000. *Food Microbiology*. Tata Mc Graw Hill.

AAH 507 FISH VIROLOGY AND CELL CULTURE 2+1

Objective

To understand classification and structure of viruses and methods of their culture.

Theory

UNIT I

Virus taxonomy, viral structure, viral genetics.

UNIT II

Replication of viruses, host-virus interaction, viral vectors, bacteriophages, propagation of viruses.

UNIT III

Principles of cell culture, development of primary cell culture, maintenance of cell lines.

UNIT IV

Scaling up of cell culture, characterization and preservation of cell lines.

UNIT V

Hybridoma and monoclonal antibody production.

Practical

Virus isolation techniques, virus propagation, viral quantitation, neutralization techniques, electron microscopy, cell culture characterization (counting, staining), karyotyping, cell culture preservation, viable cell counts, MTT assay.

Suggested Readings

Alan C. 2005. *Molecular Virology*. Academic Press.

David MK, Peter MH, Diane EG, Robert AL, Malcolm AM, Bernard R & Stephen ES. 2007. *Fields Virology*. 5th Ed. Lippincott Williams & Wilkins.

Dimmock N, Easton A & Leppard K. 2006. *Introduction to Modern Virology*. 6th Ed. Blackwell.

Freshney IR. 2005. *Culture of Animal Cells: A Manual of Basic Technique*. 3rd Ed. John Wiley & Sons.

John RK & Rosalind GM. 2004. *Finfish and Shellfish Diseases* (Practical Manual). Fisheries College and Research Institute, TANUVAS, Thoothukkudi.

Mothersill C & Austin B. 2000. *Aquatic Invertebrate Cell Culture*. Springer Praxis.

Roberts RJ. 2001. *Fish Pathology*. 3nd Ed. WB Saunders.

AAH 508 CLINICAL PATHOLOGY 1+1

Objective

To teach methods in clinical pathology of aquatic organisms.

Theory

UNIT I

Detailed study of normal and abnormal constituents of blood with reference to pathogenic condition.

UNIT II

Stress induced conditions in fishes and their pathology.

UNIT III

Physiological effects of stressors on fish, tolerance level (pH, ammonia, oxygen, temperature, handing stress, crowding, transportation, chemicals and bacterial toxins).

UNIT IV

Cellular response to stress, response to some specific disease.

Practical

Study of cellular components of blood: T.E.C., D.L.C., T.L.C., haemoglobin, total protein, glucose and other parameters, cholesterol, lipid profile, creatinine, urea and enzymes in blood during disease conditions.

Suggested Readings

Ferguson HW. (Ed.). 2006. *Systemic Pathology of Fish: A Text and Atlas of Normal Tissues in Teleosts and their Responses in Disease*. 2nd Ed. Scotian Press.

Noga EJ. 1996. *Fish Disease. Diagnosis and Treatment*. Mosby-Year Book.

Roberts RJ. 2001. *Fish Pathology*. 3nd Ed. WB Saunders.

Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish.* Vols. I, II. 2nd Ed. Academic Press.
Stoskopf MK. 1993. *Fish Medicine*. WB Saunders.
Wedmeyer G, Meyer FP & Smith L. 1999. *Environmental Stress and Fish Diseases*. Narendra Publ. House.
Leatherland JF & Woo PTK. 1998. *Fish Diseases and Disorders*. Vol. II. *Non-Infectious Diseases*. CABI.

AAH 509 NON-INFECTIOUS AND FUNGAL DISEASES 1+1

Objective

To comprehend the etiology and management of different non-infectious and fungal diseases.

Theory

UNIT I

Studies on the causes, pathogenesis, pathology, diagnosis and differential diagnosis of various diseases due to nutritional imbalance and avitaminosis, anorexia, mineral deficiency and toxicity.

UNIT II

Metabolic diseases in finfish and shellfish. Genetic diseases and neoplastic lesions.

UNIT III

Fungal diseases of finfish and shellfish- External and internal fungal infections.

UNIT IV

Epizootic ulcerative syndrome (EUS) in fishes- Etiology, epidemiology, pathogenesis diagnosis and management.

UNIT V

Fungal diseases of shellfish, larval mycosis, fusarium disease, Crayfish plague.

Practical

Study of gross and histopathological changes due to various metabolic diseases and nutritional disorders. Isolation of fungal pathogens.

Suggested Readings

Leatherland JF & Woo PTK. 1998. *Fish Diseases and Disorders*. Vol. II. *Non-Infectious Diseases*. CABI.
Lim C & Webster CD. 2001. *Nutrition and Fish Health*. Haworth Press.
Roberts RJ. 2001. *Fish Pathology*. 3nd Ed. WB Saunders.
Stoskopf MK. 1993. *Fish Medicine*. WB Saunders.

AAH 510 AQUATIC ENVIRONMENT AND FISH HEALTH 1+1

Objective

To comprehend the basic principles of aquatic animal health management in relation to their environment.

Theory

UNIT I

Environmental variables related to fish health; Water quality and sediment characteristics.

UNIT II

Nature and type of pollutants. Impact of pollutants on environment and fish health.

UNIT III

Biological indicators and indices of water quality. Sanitation in aquaculture systems.

UNIT IV

Algal blooms and environmental microflora. Microbial toxins.

UNIT V

Probiotics and bioremedial measures. Nitrogen balance in aquatic ecosystem.

Practical

Estimation of major pollutants using spectrophotometry. Hematological, histoptathological and biochemical analysis of fish exposed to specific pollutants. Testing the efficacy of aquaculture sanitizers.

Suggested Readings

Braunbeck T, Hinton DE & Streit B. 1998. *Fish Ecotoxicology*. Birkhäuser.

Noga EJ. 1996. *Fish Disease. Diagnosis and Treatment*. Mosby-Year Book.

Vernam AH & Evans M. 2000. *Environmental Microbiology*. Blackwell Publ.

Wedemeyer GA. 1996. *Physiology of Fish in Intensive Culture Systems*. Springer.

AAH 511 DIAGNOSTIC TECHNIQUES 1+1

Objective

To learn the principles and protocols of diagnostic tests used in the diagnosis of fish diseases.

Theory

UNIT I

Common bacterial pathogens of fishes. Handling of diseased fish for bacteriological examination, Withdrawal of blood and materials from internal organs for bacteriological examination. Diagnosis and infection experiments, Cultural and biochemical identification procedures. Mycological techniques.

UNIT II

Culture media for isolation of pathogens, non-selective, enriched, enrichment and selective media. Inoculation and purification techniques. Staining methods.

UNIT III

Serology of microbial disease – agglutination precipitation and ELISA methods in disease diagnosis. Processing tissue samples for virological examination. Techniques for isolation of viruses. Serological tests for identification of viruses.

Practical

Methods for examination and analysing fish for health certification/diagnosis of disease condition, techniques for sample collection and processing for bacteriological, mycological and virological agents, methods for isolation of various bacterial, fungal and viral pathogens by conventional methods, rapid nucleic acid based methods and serological procedures.

Suggested Readings

de la Maza LM, Pezzlo MT & Baron EJ. 2000. *Diagnostic Microbiology*.

2nd Ed. WB Saunders.
Koneman EW. 2005. *Color Atlas and Textbook of Diagnostic Microbiology*. 6th Ed. Lippincott Williams & Wilkins.
OIE. 2006. *Manual of Diagnostic Tests for Aquatic Animals*. 5th Ed.

AAH 601 FISH AND SHELLFISH VIROLOGY 2+1

Objective

To understand the etiology and pathogenesis of common fish and shell fish viral diseases.

Theory

UNIT I

Molecular virology and pathogenesis of selected viruses infecting fish and shellfish such as IPN, VHS, IHN, VHS.

UNIT II

Nodavirus infection of fish and freshwater prawns, WSSV, YHV.

UNIT III

Antiviral drugs, viral vaccines, emerging viruses and evolution of new viruses.

Practical

Molecular detection and sequence analysis of fish/shellfish viruses; Collection and analysis of molecular information of various viruses using sequence information available in public domain.

Suggested Readings

Alan C. 2005. *Molecular Virology*. Academic Press.
David MK, Peter MH, Diane EG, Robert AL, Malcolm AM, Bernard R & Stephen E S. 2007. *Fields Virology*. 5th Ed. Lippincott Williams & Wilkins.
Dimmock N, Easton A & Leppard K. 2006. *Introduction to Modern Virology*. 6th Ed. Blackwell.
Flint SJ, Enquist LW, Krug RM, Racaniello VR & Skalka AM. 2000. *Principles of Virology, Molecular Biology, Pathogenesis and Control*. American Society of Microbiology.
Freshney IR. 2005. *Culture of Animal Cells: A Manual of Basic Technique*. 5th Ed. John Wiley & Sons.
Roberts RJ. 2001. *Fish Pathology*. 3rd Ed. WB Saunders.

AAH 602 ADVANCES IN PARASITOLOGY 2+1

Objective

To understand the pathobiology of parasitic infection in fishes.

Theory

UNIT I

Environmental parasitology: Macro-environmental and micro-environmental influence on parasite incidence.

UNIT II

Host parasite interaction: Pathological changes induced in host due to parasitic infection.

UNIT III

Molecular parasitology; Parasite biochemistry.

UNIT IV

Evolution of parasites; Hyperparasitism.

UNIT V

Antiparasitic drugs applied in aquaculture and their action.

UNIT VI

Parasitic immunity.

Practical

Isolation techniques of parasites. Molecular characterization of parasites. Use of molecular probes for identification of parasites and tracking life stages of parasites.

Suggested Readings

Lewis EE, Campbell JF & Sukhdeo MVK. 2002. *The Behavioural Ecology of Parasites*. CABI.

Poulin R & Grimes LR. 2007. *Evolutionary Ecology of Parasites*. Princeton University Press.

Theodor VB. 1974. *Biochemistry of Parasites*. 2nd Ed. Academic Press.

AAH 603 MOLECULAR MECHANISMS IN DISEASE PROCESS 2+1

Objective

To understand the molecular mechanism of common diseases and methods for studying them.

Theory

UNIT I

Uptake of macromolecules by cells. Viral gene expression. Channelising the cellular events to study the cell viability, cell proliferation, cell lineage.

UNIT II

Biological performance of each cell, i.e., changes in mitochondrial junction, morphology, Ca+ metabolism, vesicle trafficking; membrane transport system; protein molecule dynamics and expression profile of each cell.

UNIT III

RNA interfering mechanisms.

Practical

FISH technique, TUNEL assay, MTT assay, NO assay, COMET assay to detect apoptosis. FRET and FRAP microscopy techniques.

Suggested Readings

Alan C. 2005. *Molecular Virology*. Academic Press.

David MK, Peter MH, Diane EG, Robert AL. Malcolm AM, Bernard R & Stephen ES. 2007. *Fields Virology*. 5th Ed. Lippincott Williams & Wilkins.

Flint SJ, Enquist LW, Kru RM, Racaniello VR & Skalka AM. 2000. *Principles of Virology, Molecular Biology, Pathogenesis and Control*. American Society of Microbiology.

AAH 604 CRUSTACEAN PATHOLOGY 2+1

Objective

To understand the microscopic pathology associated with various diseases of crustaceans.

Theory

UNIT I

Normal histology of different organs of crustaceans with special reference to penaeid shrimp.

UNIT II

Major pathogens of commercially important cultured crustaceans with special reference to shrimp and freshwater prawn pathogens: viral, bacterial, fungal and parasites.

UNIT III

Biology, morphology, diagnostic methods, clinical signs and symptoms and pathological changes associated with these pathogens.

UNIT IV

Bacterial diseases: Vibriosis; necrotizing hepatopancreatitis, rickettsial diseases, mycobacteriosis.

UNIT V

Fungal diseases: Larval mycosis, fusarium disease; Parasitic diseases: Microsporidians, Haplosporidians, Ciliates, Cephaline gregarines. Diseases of non infectious etiology: gas bubble disease, hemocytic enteritis.

Practical

Detailed study on normal histology of different organs/tissues of crustaceans. Diagnostic procedures: field level diagnostic methods (direct microscopic observation, tissue impression, smear and routine staining methods); Histopathology of different diseases of crustaceans. Serological methods; Electron microscopy; Gene probe and dot blot assay; *In-situ* hybridization (ISH) and polymerase chain reaction (PCR).

Suggested Readings

Bell AT & Lightner DV. 1988. *A Handbook of Normal Penaeid Shrimp Histology*. World Aquaculture Society, Lousiana, USA.

Lightner DV. 1996. *A Handbook of Shrimp Pathology and Diagnostic Procedures for Diseases of Cultured Penaeid Shrimp*. World Aquaculture Society, Lousiana, USA.

AAH 605 FISH PHARMACOLOGY 2+1

Objective

To understand the principles and application of pharmacodynamic compounds applied in aquaculture. To elucidate the pharmacodynamics of important chemicals/drugs applied in aquaculture.

Theory

UNIT I

Introduction to pharmacology, pharmacological terms and definitions, sources of drugs.

UNIT II

Principles of drug activity, pharmacokinetics. Absorption, distribution, biotransformation and excretion of drugs.

UNIT III

Pharmacodynamics, concept of drug receptor, dose response relationship, half-life and withdrawal period, factors affecting drug effect and dosage, principles of drug safety in terms of species and environment.

Practical

Antibiogram preparations; Antibiotic residual assays; Studies on histopathololgical changes caused due to chemotherapy. Important anesthetics and their mode of action.

Suggested Readings

Brown KMT. 2000. *Applied Fish Pharmacology*. Aquaculture Series 3, Kluwer.

Noga EJ. 1996. *Fish Disease, Diagnosis and Treatment*. Mosby-Year Book.

Richard DH, Mary JM, Richard AH & Pamela CC. 2005. *Pharmacology.* Lippincott Williams & Wilkins.

Stoskopf MK. 1993. *Fish Medicine*. WB Saunders.

AAH 606 BIOTECHNOLOGICAL TOOLS IN DISEASE DIAGNOSIS 1+1

Objective

To understand the principles and applications of different biotechnological tools used for disease diagnosis.

Theory

UNIT I

Advances in disease diagnostic procedures in aquaculture.

UNIT II

Molecular diagnostic methods such as *in situ* hybridization, nucleic acid probe-based diagnosis; Choice and characteristics of probe, Probe labeling.

UNIT III

Hybridization: Hybridization strategies, factors affecting the rate of hybridization, Immobilization of nucleic acid on filters. Types of hybridization: Southern, Northern, Dot/Slot blot hybridization.

UNIT IV

Various types of polymerase chain reaction (PCR) such as conventional one step, nested and semi-nested PCR, RT-PCR, real-time PCR; LAMP.

UNIT V

DNA Microarrays: DNA chips, preparations of DNA arrays, label and applications; other related molecular techniques.

UNIT VI

Monoclonal antibody-based diagnostics.

Practical

Nucleic acid extraction, PCR detection of various pathogens. Monoclonal antibody-based diagnostic application. Protein profiling, DNA fingerprinting.

Suggested Readings

Altman A. 1997. *Agricultural Biotechnology*. CRC Press.

Noga EJ. 1996. *Fish Disease, Diagnosis and Treatment*. Mosby-Year Book.

Sambrook J & Russel D. 2001. *Molecular Cloning*. 3rd Ed. Cold Spring Harbour Laboratory.

AAH 607 PUBLIC HEALTH MICROBIOLOGY AND EPIDEMIOLOGY 2+1

Objective

To learn the zoonotic importance of fish pathogens and toxins produced by aquatic organisms.

Theory

UNIT I

Introduction to food-borne diseases – Classification; food-borne infection and intoxication- microorganisms important in food borne diseases and food toxicity – economic importance of food - borne illness.

UNIT II

Factors influencing food-borne disease outbreaks; Sources and transmission of pathogens in foods: human, animal, and environmental reservoirs; crosscontamination; food associations; Microbial detection and indicator organisms:approach and techniques; pathogen indicators; bacteria responsible for food borne infection and intoxication; bacterial toxin and miscellaneous toxic factors; factors affecting toxin production in foods; fungal toxins, aflatoxin, ochratoxin and other fungal toxins; factors affecting fungal toxin production in food; marine toxins PSP, ASP, NSP, ciguatera poisoning and other marine toxins; histamines and other bioamines toxicity.

UNIT III

Zoonoses: Zoonoses of different origins – rare, new, and emerging zoonoses; trematode, cestode and nematode zoonoses; food borne viruses; prevention and control of food toxicity and food-borne diseases. Government Agency and Food Safety Policy: HACCP, Risk Assessment, New pathogens and emerging food borne diseases. Current Food Safety Topic: antibiotic resistance.

Practical

Isolation and identification of toxin producing microorganisms and other potent human pathogens in fish and fishery products – detection of toxins using biological and immunological techniques.

Suggested Readings

Doyle MP & Buechat LR. 2007. *Food Microbiology*. 3rd Ed. ASM Press.

Huss HH, Ababouch L & Gram L. 2004. *Assessment and Management of Fish Safety and Quality*. FAO Fisheries Tech. Paper 444.

James MJ. 2005. *Modern Food Microbiology*. 7th Ed. Springer.

FAO. 2004. *Marine Biotoxins Food and Nutrition.* Paper 80.

AAH 608 MOLECULAR TECHNIQUES IN MICROBIOLOGY 1+1

Objective

To understand the molecular techniques used in genetic manipulation.

Theory

UNIT I

Techniques for isolation of DNA for gram positive bacteria, gram negative bacteria, fungal cells, animals cells, DNA detection, purification, quantification. Plasmid DNA and techniques for isolation and purification of plasmids.

UNIT II

Determination of G+C content of DNA: Chromatographic technique, spectrophotometric method, isopycinic bouyant density gradient centrifugation.

UNIT III

Restriction fragment length polymorphism: Different types of restriction enzymes, their target sites, digestion patterns, chromosomal DNA-RFLP,

plasmid DNA, PCR-RFLP, Pulsefield gel electrophoresis and its applications.

UNIT IV

Methods of gene transfer: Transformation, plasmid DNA as cloning vectors, electroporation.

UNIT V

Gene transfer by conjugation: Conjugative plasmids and their application in recombinant DNA technology Gene transfer by transduction: application of bacteriophages in cloning.

Practical

Isolation of DNA and RNA; Quantification of DNA and RNA, gene amplification, primer designing, gene cloning-restriction digestion, ligation and transformation, gene sequencing, gene expression, immunoblotting, design and application of gene probes.

Suggested Readings

Brown TA. (Ed.). 2002. *Essential Molecular Biology*. Vols. I, II. 2nd Ed. Oxford University Press.

Lewin B. 2003. *Gene VIII*. Oxford University Press.

Sambrook J & Russel D. 2001. *Molecular Cloning*. 3rd Ed. Cold Spring Harbour Laboratory.

AAH 609 FISH MYCOLOGY AND VIROLOGY 1+1

Objective

To study the characteristics of fungal and viral agents causing diseases in fish and shellfish and their control measures.

Theory

UNIT I

Fungi and environment, role of fungi in food processing and aquaculture, the growth of yeasts and molds in fishes – effect of heat, chilling, freezing and chemical preservatives on common fungi associated with fishes. Mycotoxins – source and conditions effecting their production. Techniques for isolation and identification of yeasts and molds.

UNIT II

General properties of viruses. Viruses associated with fishes and water characteristics. Effect of heat and freezing on food-borne viruses. Techniques for cultivation of viruses, tissue culture.

Practical

Isolation and identification of aquatic fungi, fungi involved in food spoilage and diseases, application of fungi, detection of mycotoxins, isolation of viruses using cell culture, molecular identification of viral diseases.

Suggested Readings

George P. 1987. *Textbook of Fish Health*. 2nd Ed. TFH Publ.

Hoole D, Bucke D, Burgess P & Wellby I. 1991. *Diseases of Carps and Other Cyprinid Fishes*. Wiley-Blackwell.

Roberts RJ. 2001. *Fish Pathology*. 3nd Ed. W.B Saunders.

Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish.* Vols. I, II. 2nd Ed. Academic Press.

Woo PTK & Bruno DW. (Eds.). 1999. *Fish Diseases and Disorders*. Vol. III. *Viral, Bacterial and Fungal Infections*. CABI.

AQUATIC ANIMAL HEALTH

List of Journals

- Applied Bacteriology
- Aquaculture
- Aquaculture Research
- Asian Fisheries Science
- Bulletin of the European Association of Fish Pathologists
- Developmental and Comparative Immunology
- Diseases of Aquatic Animal Health
- Diseases of Aquatic Organisms
- European Journal of Pharmacology
- Fish and Shellfish Immunology
- Fish Pathology
- Fish Veterinary Journal
- Fishfish and Shellfish Immunology
- Indian Journal of Pharmacology
- International Journal for Parasitology
- Journal of Applied Microbiology
- Journal of Aquatic Animal Health
- Journal of Clinical Pharmacology
- Journal of Fish Diseases
- Journal of General Virology
- Journal of Invertebrate Pathology
- Journal of Parasitology
- Journal of Virological methods
- Journal of Virology
- Letters in Applied Microbiology
- Methods in Cell Science
- Microbiology
- Molecular and Biochemical Parasitology
- Parasitology
- Parasitology Today
- The Veterinary Record
- Trends in Biotechnology
- Veterinary Record
- Veterinary Research

Suggested Broad Areas for Master's and Doctoral Research

- Characterization of viral and bacterial etiological agents of fish and shellfish infections
- Prophylactic and therapeutic measures to control infectious diseases of fish and shellfish
- Characterization of parasites infecting fish and shellfish
- Host-parasite relation of various parasites and their biology
- Therapeutic approaches for control of infections
- Histopathological investigations of specific disease conditions
- Ultra structural changes in the specific tissues following infections
- Host immune responses against candidate antigens, immunomodulation, inflammatory responses against specific stress factors, ontogeny of immune system, immunotolerance.
- Isolation and identification of bacterial and fungal agents of infection.
- Characterisation of viral agents of infections, improved diagnostic methods including PCR, nucleic acid probes and monoclonal based techniques.
- Development and characterisation of fish cell lines
- Biochemical changes of blood and enzyme parameters due to stress
- Stress induced physiological changes in fish
- Nutritional diseases, pathological investigations following toxicity, genetic disorder
- Stress induced changes in the physiological parameters, effect of sublethal concentrations of pollutants in fish, elimination of toxic chemicals by fish
- Changes in the blood chemistry following adverse water quality
- Bioremediation measures to reduce pollution loads
- Control of blooms and nitrogen pollution in ponds
- Identification and characterization of common fish and shellfish viruses
- Development and characterization of fish vaccines
- Molecular characterization of parasites infecting finfish/shellfish
- Development of molecular probes for parasites
- Application of molecular tools in ecological studies related to parasites
- Channelizing the cellular events to study the cell viability
- Characterization of endemic, exotic and emerging diseases of crustaceans, especially penaeid shrimp and freshwater prawns.
- Microscopic and ultrastructural studies related to viral diseases
- Effect of chemicals, disinfectants, antibiotics in fish
- Pharmacodynamics of drugs in fish, drug delivery systems, excretion of drugs, residual assays, herbal compounds as therapeutic drugs
- Development of improved diagnostic techniques using molecular and immunological methods

BUSINESS MANAGEMENT
Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
FBM 501*	MANAGERIAL ECONOMICS	2+1
FBM 502*#	MARKETING MANAGEMENT	2+1
FBM 503*	HUMAN RESOURCE MANAGEMENT	2+1
FBM 504*	FINANCE AND ACCOUNTING FOR MANAGERS	2+1
FBM 505*	ORGANIZATIONAL BEHAVIOUR	2+1
FBM 506*	FORECASTING METHODS AND OPERATIONS RESEARCH	2+1
FBM 507	BUSINESS COMMUNICATION SKILLS	0+2
FBM 508	INTRODUCTION TO WTO AND IPR	1+1
FBM 509	INDIAN AND GLOBAL FISHERIES INDUSTRY	1+1
FBM 510	ENTREPRENEURSHIP DEVELOPMENT	1+1
FBM 511#	INTERNATIONAL ECONOMICS AND TRADE	1+1
FBM 512	EXPORT AND IMPORT MANAGEMENT	1+1
FBM 513	INTRODUCTION TO GIS	0+2
FBM 514#	PROJECT FORMULATION AND MANAGEMENT	1+1
FBM 591	MASTER'S SEMINAR	1+0
FBM 599	MASTER'S RESEARCH	20

* Compulsory for Master's programme

FBM 502, FBM 511 and FBM 514 cross listed with Fisheries Economics FEC 505, FEC 508 and FEC 507 respectively.

BUSINESS MANAGEMENT
Course Contents

FBM 501 MANAGERIAL ECONOMICS 2+1

Objective

To familiarise the students with the basic concepts and analytical tools of economics as applied to management decisions.

To provide an interface between economics and management decisions.

Theory

UNIT I

Introduction to managerial economics: Microeconomics, Macroeconomics, Demand analysis - types of demand, determinants of demand; elasticity of demand. Analysis of costs - nature of costs, cost-output relationship in short and long term, profit maximization.

UNIT II

Theory of production - production function, laws of production; laws of returns, returns of scale, economies of scale. Production relationship: factor-product, factor-factor and product-product.

UNIT III

Market structure and price determination; perfect and imperfect competitions. Monopoly, price discrimination; monopolistic competition and oligopoly.

UNIT IV

Types of economy, Measuring performance of the economy. Consumption, saving and investment function. Income and employment determination. Aggregate demand and supply, general equilibrium; multiplier.

UNIT V

Money - functions of money, theory of money and price, Inflation, Balance of payment and Exchange rate.

Practical

Demand - supply relationship. Elasticity - price, income, cross. Exercises in factor-product, factor-factor and product-product relationships. Production costs and their relationship, Break-even point, National income accounting. Multiplier. Inflation. Case studies on different micro and macro-economic variables in fisheries sector.

Suggested Readings

Ahuja HL. 2005. *Macroeconomics- Theory and Practice*. S. Chand & Co.

Dewett KK. 2005. *Modern Economic Theory*. S. Chand & Co.

Dwivedi DN. 2000. *Managerial Economics*. Vikash Publ. House.

Koutsoyiannis A. 2000. *Modern Microeconomics*. The Mc Millan Press.

Mankar VG. 1984. *Business Economics - Micro Analysis*. Himalaya Publ. House.

Samuelson PA & Nordhaus WD. 2001. *Economics.* Tata McGraw Hill.

Thomas CR & Maurice SC. 2006. *Managerial Economics*. Tata McGraw-Hill.

FBM 502 MARKETING MANAGEMENT 2+1

Objective

To familiarize the students with the basic concepts and principles of marketing as applied to fisheries.

To provide an interface between marketing and management decision.

Theory

UNIT I

Marketing management - Introduction and overview. Marketing system and environment Market opportunity identification- Customer analysis. Market segmentation, market positioning and consumer behaviour, Competition analysis, Market assessment, Marketing environment.

UNIT II

Demand assessment and forecasting, Designing the offer-product decision and pricing decision, product decision and strategies, product life cycle, new product development, branding and packaging decisions, Delivering the offer- distribution management, sales management and communication strategy management – Salesmanship.

UNIT III

Product management. Pricing policies and practices. Distribution strategy - channels of distribution, physical distribution.

UNIT IV

Marketing information system. Marketing communication - advertising, publicity, personal selling, sales promotion.

UNIT V

Marketing research and information system, Marketing research and its application in fisheries marketing strategy, planning and organisation, emerging issues in marketing, e-marketing.

Practical

Marketing mix, marketing strategy, segmentation, pricing methods, consumer behaviours, new product development, marketing research, measuring effectiveness of marking mix, performance evaluation, efficiency analysis.

Suggested Readings

Adcock D, Bradfield R, Halborg A & Ross C. 1995. *Marketing Principles and Practice*. Pitman Publ.

Amarchand D & Varadharajan B. 1979. *An Introduction to Marketing*. Vikas Publ.

Chaston I. 1983. *Marketing in Fisheries and Aquaculture*. Fishing News Books.

Dennis A, Brandfield R, Al Halhorg & Ross C. 2004. *Marketing Principles and Practice*. Pitman Publ.

Ian C. 1984. *Marketing In Fisheries and Aquaculture*. Fishing News Books.

Jolson MA. 2004. *Marketing Management*. Macmillan Publ.

Kotler P. 2005. *Marketing Management*. Prentice Hall of India.

Kotler P & Armstrong GM. 2006. *Marketing: An Introduction*. Prentice Hall.

Phillip K & Armstrong G. 2007. *Principles of Marketing*. Prentice Hall.

Phillip K. 2008. *Marketing Management*. 12th Ed. Prentice Hall of India.

FBM 503 HUMAN RESOURCE MANAGEMENT 2+1

Objective

To familiarize the students with the basic concepts of Human Resource Management with special reference to organizations in fisheries sector.

Theory

UNIT I

Concept of management: Definition, Management process (planning, organising, staffing, leading and controlling), Managerial levels and roles. Evolution of management theories: Scientific management school, Classical organization theory school, Behavioural school, Management science school.

UNIT II

Concept of Human Resource Management (HRM), Primary activities of HRM (staff, training and development, motivation, maintenance), HR process (HRP, recruitment, selection, socialization, training and development, performance appraisal, promotion, transfer, demotion, separation).

UNIT III

HR outsourcing, Understanding equal opportunity: Guarding against discriminatory practices, glass ceiling, Managing careers: Concept of career, individual and organisational perspective, career development versus employee development, internal, external events and career stages, mentoring and coaching.

UNIT IV

Compensation dynamics: Contracts for compensation, efficiency wages, wage earning and sharing, ownership options, screening, signalling, designing of contract, types of rewards, job evaluation and establishing pay structure, executive, international and special compensation plans, employee benefits, safety and health programmes, labour relations and collective bargaining. Corporate social responsibility.

Practical

Applying management functions in a real setting; developing managerial games; creativity and problem solving techniques; understanding different perceptions and avoiding perceptual distortions; analysing different needs of a diverse work place; performance evaluation; psychometric testing; developing training module for leadership and motivation; exercises on time management.

Suggested Readings

Alan P. 2000. *Principles of Human Resource Management*. Blackwell.

Bratton J. 1999. *Human Resource Management: Theory and Practice*. MacMillan.

Decenzo DA & Robbins SP. 1993. *Human Resource Management*. John Wiley & Sons.

Ferris GR. 1995. *Handbook of Human Resource Management*. Blackwell.

Milgrom P & Robert J. 1992. *Economics Organization and Management*. Prentice Hall.

Schuler RS & Jackson S. 1997. *Strategic Human Resource Management*. Blackwell.

FBM 504 FINANCE AND ACCOUNTING FOR MANAGERS 2+1

Objective

To familiarise the students with the concept and practice of finance, accounting and financial management.

To make the students understand the various accounting practices prevalent in fisheries organizations.

Theory

UNIT I

Overview of Financial management, Financial systems, Financial statements, taxes and cash flow, Analysing financial performance, Break even analysis and leverage, Time value of money, valuation bonds and stocks, Risk and return, Capital budgeting, techniques of capital budgeting, Cost of capital, Sources of long term finance, Dividend decisions, Debt analysis and management, Leasing hire purchase and project finance, Inventory management, Working capital management,, merger, acquisitions and restructuring Stock exchange, Mutual fund ,Banking systems.

UNIT II

Accounting: Theoretical concept of accounting, Meaning and scope of accounting, accounting principles, journalising transactions, ledger posting and trial balance, negotiable instruments, Final accounts, Depreciation provisions and reserves, single entry systems double entry system, inventory valuation, joint stock company, shares and capital, debentures, management accounting: nature and scope, financial statements analysis and interpretation, ratio analysis, classification of ratios, fund flow and cash flow statements.

Practical

Case studies and practicals on financial management and accounting, Familiarisation and application of Tally software.

Suggested Readings

Anthony RN & Reece JS. 1970. *Accounting Principles*. AITBS Publ.

Chandra P. 2005. *Fundamentals of Financial Management*. Tata Mc Graw Hill.

Frank W & Alan S. 2008. *Business Accounting*. 8th Ed. Prentice Hall.

Maheshwari SN & Maheshwari SK. 2000. *Accountancy*. Vikash Publ. House.

Xavier GF. 2003. *Business Accounting and Financial Analysis*. Macmillan.

FBM 505 ORGANISATIONAL BEHAVIOUR 2+1

Objective

To familiarize the students with the basics of organizational behaviour and its relevance and application in the fisheries sector.

Theory

UNIT I

Introduction: Concept and definition, Contributing disciplines to OB, Challenges and opportunities, Basic organizational behaviour model. Individual: Foundations of individual behaviour, Biographical characteristics, values, attitudes and job satisfaction, personality and emotions, perception, basic motivation concepts, concept of motivation, early and contemporary theories of motivation.

UNIT II

Group: Concept of groups, stages of group development, group decision making techniques, foundations of group behaviour, work teams - types of teams, creating effecting teams.

UNIT III

Leadership: concept of leadership, trait, behavioural and contingency theories, concept of trust, types of trust, conflict and negotiations - concept, transition and conflict thoughts, conflict process, negotiation and its process, bargaining strategies, third party negotiation, conflict management techniques, power and politics - concept of power, bases of power, dimension of power tactics, power coalitions, unequal power at work place.

UNIT IV

Organization structure: Concept, work specialization, departmentalization, chain of command, span of control, centralization and decentralization, formalization, common organizational designs. Organizational dynamics: Change management - concept of change, forces of change, managing planned change, resistance to change, over coming resistance to change, Stress management – concept, causes and its management.

Practical

Role play on motivation, microtromics management simulation on leadership, psychometric testing on personal approach to leadership, conflict management, team exercises in team building, analysing group effectiveness, biases and ethics in decision making, evaluation of MPS, building effective work teams, personality and stress, methodologies to measure stress, case study on organisational behaviour in public and private enterprises; case studies on stress and conflict management. Case study on conflict management in fisheries sector.

Suggested Readings

Buchanan D & Huczynski A. 2000. *Organizational Behaviour: An Introductory Text*. Prentice Hall.

Gordon J. 2002. *Organisational Behaviour: A Diagnostic Approach*. Prentice Hall.

Mullins LJ. 2005. *Management and Organisational Behaviour*. Prentice Hall.

Robbins S. 2007. *Organisation Behaviour*. Prentice Hall.

Wilson F. 2004. *Organizational Behaviour - A Critical Introduction*. Oxford University Press.

FBM 506 FORECASTING METHODS AND OPERATIONS RESEARCH 2+1

Objective

To familiarize students with various forecasting techniques of time series data in business application.

To acquaint the students to various tools and techniques of optimization in fish business planning and management.

Theory

UNIT I

Forecasting, needs and uses of forecasting; Current status of forecasting techniques; Fundamentals of quantitative forecasting. Time series methods: smoothing, averaging and exponential smoothing methods, decomposition

methods - trend fitting, ratio to moving average method, decomposition analysis.

UNIT II

Regression and Economic Methods; Multiple regression, multicollinearity, auto correlation and heteroscedasticity, Econometric models and forecasting. Stationary and non-stationary time series data; Seasonal and non-seasonal models; Auto-regressive moving average (ARMA) and Auto regressive integrated moving average (ARIMA) models.

UNIT III

Historical development of operations research, concepts and applications in fish business management. Optimization; Inequality constraints; Formulation of linear programming, general statement of linear programming, assumptions underlying linear programming, solution to linear programming problems using graphic method; Simplex method, conditions for application of simplex method, solution to dual programme.

UNIT IV

Transportation and Assignment problem. Sequencing and inventory management.

Practical

Smoothing and decomposition methods, trend fitting, ratio to moving average, regression and econometric methods, fitting of ARMA and ARIMA models. Exercises on optimization, linear and non-linear programming, dynamic programming, transportation, assignment, sequencing and inventory management.

Suggested Readings

Armstrong JS. 2002. *Principles of Forecasting – A Handbook for Researcher and Practitioners.* Springer Series.

Brinson R & Naadimuthu G. 1997. *Schaum's Outline of Operations Research*. McGraw-Hill.

Cliffs E. 1994. *Time-Series Analysis, Forecasting and Control*. Prentice Hall.

Haley KB. 1978. *Operational Research*. Elsevier.

Lieberman H. 2001. *Introduction to Operations Research*. Tata McGraw-Hill.

Makridakis S, Wheelwright SC & Hyndman RJ. 2003. *Forecasting Methods and Applications*. 3rd Ed. John Wiley & Sons.

Nigel S, Stuart C & Robert J. 2007. *Operations Management*. 4th Ed. Prentice Hall.

Philip HF. 1998. *Time Series Models for Business and Economic Forecasting*. Cambridge University Press.

Pindyck RS & Daniel LR. 1997. *Econometric Models and Economic Forecasts*. McGraw-Hill.

Priestley MB. 1994. *Spectral Analysis and Time Series*. Academic Press.

Taha HA. 2003. *Operational Research: An Introduction*. Prentice Hall.

FBM 507 COMMUNICATION SKILLS 0+2

Objective

To equip the students with effective communication and presentation skills.

To motivate and build self confidence among the students.

Practical

Communication and communication skills - context, message, audience and purpose analysis - listening, interviewing and note taking - verbal and non-verbal communication; Reading skills: reading and interpreting interviews, business / technical articles - case analysis - book review.

Writing skills: Writing persuasive messages / letters, e-mail, and resumes - developing and refining personal and group vision statements - writing situation analyses and minutes of the meeting; Writing technical reports - report planning and research (information acquisition, data sources, questionnaire, analysis and interpretation), writing abstract, executive summary, introduction, conclusions, recommendations and references; report organization and presentation.

Oral presentation skills: Voice culture; basic oral presentation techniques; developing and presenting synopses and detailed project proposals - impromptu presentations and audience management - conducting mock interviews.

Communicating in groups; Event management - conducting workshop, write-shop, seminar and public meeting; using audio and visual aids; designing a website; selecting and integrating media into multi-media presentations; brainstorming session on career opportunities in fisheries sector.

Suggested Readings

Lesiskar RV & Pettit JD. 1979. *Business Communication*. 8th Ed. Tata Mc Graw- Hill.

Locker KO & Kaczmarek SK. 2004. *Business Communication-Building Critical Skills*. Tata McGraw Hill.

FBM 508 INTRODUCTION TO WTO AND IPR 1+1

Objective

To familiarize the students with the regulatory framework and implications of WTO and IPR regime for the fisheries sector.

Theory

UNIT I

Globalisation: dimensions and driving forces; Introduction to GATT and WTO; WTO Framework, its key subjects, principles and privileges.

UNIT II

Agreement on Sanitary and Phytosanitary Measures (SPS) and its implications; Regulations in EU, USA and Japan for seafood Exports; Technical Barriers to Trade (TBT) and other Types of Non-Tariff Barriers (NTBs); Fisheries Subsidies and WTO; Agreement on Anti-Dumping and Fisheries Trade.

UNIT III

Introduction to Intellectual Property Rights (IPR); Seven forms of IPRs; Property Rights framework under TRIPS Agreement; TRIPS and Patents: Patentable subject matter; patenting process and procedure; Importance of Patent Cooperation Treaty (PCT).

UNIT IV

Patenting in India before and after the Patents Act, 1970; Features of Indian Patents (Amendment) Act, 2005; Patents in Indian fisheries sector; Patent searches.

UNIT V

Critical Issues in WTO: Fisheries Trade and Environment, Fisheries Trade and Food Security; Understanding protests against globalisation and WTO. Critical Issues in IPRs: Patenting of life forms; GMOs in fisheries; Protection of traditional knowledge, benefit sharing and bio-piracy.

Practical

Case studies on (ab)use of SPS / TBT measure. Case studies on dumping and anti-dumping measures in seafood trade; SWOT analysis of WTO; Case studies on competitiveness of Indian fish and fish products under WTO regime; Case studies on disputes in TRIPS; Case studies on patents / IPRs in agriculture sector; Online retrieval of patent information; Exercise in drafting a patent application; Group discussion on patenting of life forms.

Suggested Readings

CMA / IIMA. 2001. *Implications of WTO Agreements for Indian Agriculture*. Oxford and IBH.

Ganguli P. 1998. *Gearing Up for Patents: The Indian Scenario*. Orient Longman.

Sikdar S. 2003. *Contemporary Issues in Globalisation- an Introduction to Theory and Policy in India*. Oxford University Press.

www.wto.org; www.wipo.org; www.patentoffice.nic.in; www.greenpeace.org

FBM 509 INDIAN AND GLOBAL FISHERIES INDUSTRY 1+1

Objective

To familiarize the student with the evolution, growth and performance of different sub sectors of the Indian and global fish industry.

Theory

UNIT I

Growth and evolution of Indian fisheries industry; size, organisation, structure and ownership in fishing, hatchery, feed, health management, cold storage, processing and allied sectors. Growth of aquaculture as industry. Manufacturers and merchant traders. Wholesale and retail sectors. Investments, innovations and productivity in Indian fisheries industry.

UNIT II

Global fisheries industry: Growth and evolution; major features; Size, organisation, structure and ownership in global fisheries industry. World fishing industry: Fresh, frozen, cured, canned, meat and oil. Fisheries industry in US, Japan, European Union, Thailand, China, Vietnam, Indonesia, Bangladesh and Sri Lanka.

UNIT III

Regulation of the fishing industry in major fisheries economies. Support measures, subsidies and protectionism in global fisheries industry. Globalisation and changing facets of global and Indian fisheries industry. Emerging sectors: Ecotourism and aqua-tourism.

Practical

Case studies on world shrimp, tuna, salmon and cephalopod industries. Trend analysis of fisheries production and productivity of major producers. SWOT analysis of fisheries industry of major producers.

Suggested Readings

FAO. *Fisheries Statistics*. Rome (Various years).

FAO. *Globefish Commodity Updates*. Rome (Various years).

Ministry of Agriculture. *Handbook of Fisheries Statistics*. New Delhi (Various years).

Oscar JB. 1999. *Export Competitiveness in South-East Asia: Policy Initiatives and Corporate Actions in Marine Products Industry*. Wheeler Publ.

Porter G. 1998. *Fisheries Subsidies – Over fishing and Trade*. Geneva.

FBM 510 ENTREPRENEURSHIP DEVELOPMENT 1+1

Objective

To make the students understand concepts and practices of entrepreneurship skills.

To identify a business idea and develop it into a business proposal.

Theory

UNIT I

Assessing overall business environment in the Indian economy. Overview of Indian social, political and economic systems and their implications for decision making by individual entrepreneurs. Globalisation and the emerging business / entrepreneurial environment. Overview of aqua inputs and fish processing industry.

UNIT II

Concept of entrepreneurship; entrepreneurial characteristics; managerial skills and risk taking behaviour; managing an enterprise; motivation and entrepreneurship development; importance of planning, monitoring, evaluation and follow up in entrepreneurship; managing competition development; entrepreneurship development programmes; Generation, incubation and commercialization of ideas and innovations. Role and promotion of leadership, collective action and stakeholder cooperation.

UNIT III

Project, project cycle, project formulation, monitoring and evaluation methods - NPV, BCR and IRR; Guidelines for project formulation.

UNIT IV

Government schemes and incentives for promotion of entrepreneurship. Government policy on Small and Medium Enterprises (SMEs) / SSIs. Venture capital. Contract farming. Social Responsibility of Business.

Practical

Spotting business opportunities and exploring entrepreneurial possibilities in different sectors of fisheries industry; developing a pilot project based on identified business; case studies of successful and failed entrepreneurs. Critical review of Agri business clinics and e-chaupals. Case studies from aqua industry / fish processing industry. Exercises in business environmental Analysis. Hands on training and experiential learning – developing and testing a business plan.

Suggested Readings

Bartlett C & Piramal G. 2000. *World Class in India: A Case Book of Companies in Transformation*. Penguin India.

FICCI. 2000. *A Pictorial History of Indian Business*. Oxford University Press.

Krueger NF. 2002. *Entrepreneurship – Critical Perspectives on Business Management.* Taylor & Francis.

Ojha SN & Salim SS. 2000. *Entrepreneurship Development and Project Formulation*. CIFE, Mumbai.

FBM 511 INTERNATIONAL ECONOMICS AND TRADE 1+1

Objective

To familiarize the students with the basic concepts and principles of economics as applied to international trade.

Theory

UNIT I

International trade: Nature of international trade, difference between domestic and foreign trade; Theories of international trade: absolute and comparative advantage, modern theories of international trade - Hecksher Ohlin theorem.

UNIT II

Concepts of terms of trade, free trade, protection, tariffs, quantitative restrictions and other non-tariff measures.

UNIT III

Exchange rate, devaluation and depreciation, balance of payments, international capital movements, state trading.

UNIT IV

International gold standard; International Monetary Fund and World Bank; Multi National Corporations and international trade; India's foreign trade and balance of payment.

Practical

Pattern and Performance of India's Seafood Exports; Case studies on product and market diversification. Case studies on competitiveness of Indian fish and fish products. Case studies on exports of value added seafood products; Case study of a seafood export firm; Case studies on (ab)use of SPS / TBT measure; Case studies on non-tariff barriers in fisheries trade; Case studies on dumping and anti-dumping measures in seafood trade; SWOT analysis of WTO; Case Studies on disputes in TRIPS.

Suggested Readings

Appleyard DR & Field A. J. 2001. *International Economics*. 4th Ed. McGraw Hill.

Dennis A. 2001. *Trade Theory and Practice*. Irwin Publ.

Francis C. 2008. *International Economics*. Tata McGraw Hill.

Krugman PR & Obstfeld M. 1991. *International Economics: Theory and Policy*. Harper Collins Publ.

Mithani JP.1998. *International Economics*. Tata McGraw Hill.

Samuelson P & Nordhaus WD. 2001. *Economics*. Tata McGraw Hill.

FBM 512 EXPORT AND IMPORT MANAGEMENT 1+1

Objective

To familiarise the students with the basic processes and procedures in fisheries export and import management.

Theory

UNIT I

Introduction to Exports/Imports; Organisation of export and import firms and business planning; Planning and preparations for export/import operations; Registration process; Selection of products and markets; Export-import logistics and transportation; Export/import pricing, terms of sale and settlement; sampling, inspection and detention; INCO terms; Documentation – standardized preshipment documents, commercial and regulatory documents; Port and customs clearance – Specialised service providers. Export/Import credit instruments and procedures - meaning and importance of Letters of credit; cargo and credit insurance – role of ECGC - Trade finance and EXIM bank.

UNIT II

Export/Import Promotional measures - EPCG scheme – Duty Exemption/Remission scheme –central excise and sales tax exemption; OGL, negative list, canalisation and counter trade. Present export/import policy. Role of Export Promotion Councils, MPEDA – DCIS – DGFT – ITC (HS) Classification. Export Oriented Units – Export Processing Zones - Special Economic Zones – Deemed Exports. Market access and trade liberalisation. WTO and trade policy reviews.

Practical

Export Composition and destination of Indian agricultural commodities and seafood products. Import composition and Origin. Case studies of seafood export firms.

Suggested Readings

Exporters Encyclopedia. 2004. Dun & Bradstrect Publ., USA.

IIFT. Background Papers on Export Procedures and Documentation, New Delhi. (Various years).

ITC. 2002. *Import Management: Handbook of Import Documentation.* UNCTAD, Geneva.

Ramakrishna S. 1992. *Quality Control and Preshipment Inspection for Exports*. S. Chand & Co.

FBM 513 INTRODUCTION TO GIS 0+2

Objective

To familiarize the students with the basic concepts and practices of GIS.

Practical

Fundamentals concepts of GIS, GIS Subsystems, Components of GIS, GIS data models, Spatial Data and attribute data, Vector and raster models, Spatial data relationships, Attribute data models-tabular and relational models (RDBMS), Remote sensing as an input to GIS, Manual digitizing and Automatic scanning, Data editing and quality assurance, Map features – point, line, polygon, area, Map characteristics, map projection and co-ordinate system, Creation of thematic layers, Introduction to GIS software.

Familiarization with GIS software and use of GPS; Map scanning and geo-registration of topo-sheet, satellite image and administrative map, Image classification , Digitization of different features from topo-sheet and satellite image, Creation of attribute table , joining of tables , Creation of different thematic layers.

Suggested Readings

Course Manual of Winter School on *Remote Sensing and GIS Applications in Fisheries Research and Management*, 5-25 January, 2005, CIFE, Mumbai.

Floyd FS. 2007. *Remote Sensing: Principles and Interpretation*. WH Freeman & Co.

James BC. 2002. *Introduction to Remote Sensing*. Taylor & Francis.

Michael ND. 2005. *Fundamentals of Geographic Information Systems*. John Wiley & Sons.

Peter MA & Nicholas JT. (Eds.). 2005. *Advances in Remote Sensing and GIS Analysis*. John Wiley & Sons.

Thomas ML & Ralph K. 1987. *Remote Sensing and Image Interpretation*. John Wiley & Sons.

FBM 514 PROJECT FORMULATION AND MANAGEMENT 1+1

Objective

To familiarize the students with the basic concepts and principles of project formulation and management techniques.

To prepare the students to exploit business opportunities in fisheries and aquaculture.

Theory

UNIT I

Concept, scope and definition of project, difference between plan and project, project types - advantages and limitations, elements of project cycle - aspects of project preparation and analysis, project cost and benefits – comparisons – tangible and intangible cost and benefits.

UNIT II

Financial and economic aspects of projects: Feasibility analysis – undiscounted measures of project worth, ranking by inspection, pay back period, average annual proceeds per unit of outlay, time value of money, discounted measures–discounted pay back period, derivation of incremental net benefit, net present worth, BC ratio, IRR, net benefit investment ratio, project alternatives, risk and uncertainties, sensitivity analysis. Farm planning, budgeting – complete and partial budgeting - farm business analysis and appraisal techniques – ratio analysis, asset valuation and depreciation. Financial analysis-balance sheet, cash flow analysis, profit loss statements.

UNIT III

Guidelines for project preparation report – objective, rational, area, organization, production, markets and financial results, benefits. Sources of institutional assistance for project preparation and formulation, bilateral and multilateral assistance. Project implementation – objective and tasks, economic aspects of project evaluation. Project management – management techniques – bar chart, milestone chart, activity slack bar chart, PERT, CPM, inventory management and control, management information system and project monitoring.

Practical

Case studies: Ratio analysis, computing depreciation, valuation of project inventories, complete and partial Budgeting, cash flow analysis, balance sheet / net worth statement, profit–loss statement/income statement,

undiscounted and discounted measures, net work techniques, bar charts, milestone chart and activity slack bar chart, PERT and CPM - project preparation for capture, culture and processing sectors - sensitivity analysis, project monitoring and evaluation, case studies and feasibility evaluation.

Suggested Readings

Chaudhary S. 1988. *Project Management*. Tata McGraw Hill.

Fisheries Project Formulation. FAO Tech. Paper No.334.

Gittenger P. 1972. *Economic Analysis of Agricultural Projects*. Johns Hopkins University Press.

Ojha SN & Salim SS. 2000. *Entrepreneurship Development and Project Formulation*. CIFE, Mumbai.

Rodney J, Turner S & Simister J. (Eds.). 2007. *Project Management*. Infinity Books.

Salim SS, Biradar RS & Pandey SK. 2004. *Economic Analysis of Fisheries Projects*. CIFE, Mumbai.

Shang YC. 1990. *Aquaculture Economic Analysis - An Introduction*. World Aquaculture Society, USA.

BUSINESS MANAGEMENT
List of Journals

- Agricultural Economics Research Review
- Aquaculture International
- Business India
- Economic and Political Weekly
- European Journal of Operational Research
- Extension Review
- Face-to-Face Communication Skills – Newsletters
- Fishing Chimes
- Geographical and Environmental Modeling
- ICFAI Journal of Finance and Accounting
- ICFAI Journal of Marketing
- Indian Journal of Agricultural Economics
- Indian Journal of Agricultural Marketing
- Indian Journal of Foreign Trade
- International Entrepreneurship and Management Journal
- International Journal for Geographical Information Science
- International Journal of Forecasting
- International Journal of Remote Sensing
- International Small Business Journal
- Journal of Cooperative Communication Skills
- Journal of Entrepreneurship Development
- Journal of Fisheries Technology
- Journal of Geographical Systems
- Journal of Indian Seafood Export Association
- Journal of the Operational Research Society
- Journal on Export and Import management
- Operations Research
- Vikalpa
- WTO Review

Suggested Broad Areas for Master's and Doctoral Research

- Appraisal of the different fisheries projects
- Barriers in developing effective communication skills among fisheries graduates
- Characteristics of a successful entrepreneur
- Communications pattern and processes in fisheries organizations and industry
- Comparative performance of fisheries industries
- Comparative study of accounting practices followed by Indian fisheries Industry
- Consumer behaviour of value added fish products
- Developing decision support system using RS and GIS for management of reservoirs, floodplains, etc.
- Developing forecasting models for growth in fish demand, supply and consumption of fish
- Economic analysis of aquaculture practices
- Economic and financial analysis of fisheries project proposals
- Economic evaluation of different fishing techniques
- Export performance and potential of fish and fish products
- HRM practices of various state fisheries departments, NGOs
- Market structure and price determination
- Organization pattern and dynamics of change in service delivery agencies
- Potential for organized fish retailing
- Preparation of model commercial project proposals
- Study of non-tariff and customs related restrictions in major fish trading countries

FISH BIOTECHNOLOGY
Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
FBT 501*	FUNDAMENTALS OF MOLECULAR BIOLOGY	2+1
FBT 502*	BASIC CONCEPTS OF CELL BIOLOGY	2+1
FBT 503*	GENE STRUCTURE AND REGULATION OF EXPRESSION	2+1
FBT 504*	GENETIC ENGINEERING AND ITS APPLICATION IN FISHERIES	2+1
FBT 505#	MOLECULAR AND IMMUNOGENETICS	1+1
FBT 506#	BIOINFORMATICS	1+1
FBT 507#	CELL AND TISSUE CULTURE	1+1
FBT 508	MARINE BIOTECHNOLOGY	1+1
FBT 509	AQUACULTURE BIOTECHNOLOGY	1+1
FBT 591	MASTER'S SEMINAR	1+0
FBT 599	MASTER'S RESEARCH	20
FBT 601**	ADVANCES IN MOLECULAR AND CELL BIOLOGY	2+1
FBT 602**	GENETIC ENGINEERING OF EUKARYOTES	2+1
FBT 603**	GENETIC ENGINEERING OF BACTERIA AND VIRUSES	2+1
FBT 604	BIOSAFETY AND PATENT LAWS	2+0
FBT 605	FUNCTIONAL GENOMICS AND PROTEOMICS	1+1
FBT 606	PROTEIN CHEMISTRY AND ENGINEERING	1+1
FBT 607	RNAI TECHNOLOGY	1+1
FBT 608	BIOPROCESS TECHNOLOGY	1+1
FBT 691	DOCTORAL SEMINAR I	1+0
FBT 692	DOCTORAL SEMINAR II	1+0
FBT 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme; ** Compulsory for Doctoral programme
#FBT 505, FBT 506 and FBT 507 cross listed with Fish Genetics and Breeding FGB 507, FGB 510 and FGB 512 respectively

FISH BIOTECHNOLOGY
Course Contents

FBT 501 FUNDAMENTALS OF MOLECULAR BIOLOGY 2+1

Objective

To provide knowledge of basic molecular processes involving nucleic acids and protein structure, synthesis and maintenance within a living cell.

Theory

UNIT I

Nucleic Acids: Genetic material, Structures of DNA and RNA; Stereochemistry of bases and secondary structures; Organisation of the nucleic acids - chromatin structure.

UNIT II

DNA replication: Models of DNA replication in prokaryotes and eukaryotes; Mechanics of DNA replication; Enzymes; Structure and function of DNA polymerases; Types of priming.

UNIT III

Transcription: Prokaryotes – Bacterial RNA polymerase, initiation, elongation and termination, types of RNA polymerases; Eukaryotes – enzymes and mechanics, post transcriptional modifications; Structure and synthesis of rRNA and tRNA.

UNIT IV

Translation: Genetic code, codon bias, types and structures of ribosomes, tRNA structure, Wobble hypotheisis, mechanisms of initiation, elongation, termination, and post-translational modifications in prokaryotes and eukaryotes and the factors involved in various steps, concept of polysomes and protein structure.

UNIT V

DNA recombination: Molecular models – homologous and site-specific recombination; crossing over; Holliday junction; transposition.

UNIT VI

Mutations: Types, mutagens – nitrous acid, UV, aflatoxin, bleomycin.

UNIT VII

DNA Repair: Types and mechanisms.

UNIT VIII

Gene transfer: Molecular mechanisms of conjugation, transduction, transfection and transformation.

Practical

Nucleic acid isolation (genomic/plasmid DNA and RNA); Agarose gel electrophoresis; Nucleic acid quantification; Protein purification and separation in polyacrylamide gel electrophoresis (SDS-PAGE); Preparation of competent cells and transformation.

Suggested Readings

Boyer R. 1999. *Concepts in Biochemistry*. Cole Publ. Co.

Glick BR & Pasternak JJ. 2005. *Molecular Biotechnology: Principles and Applications of Recombinant DNA Technology*. ASM Press.

Lewin B. 2008. *GENES – IX*. Jones & Bartlet Publ.

Primrose SB. 1987. *Modern Biotechnology*. Blackwell.

Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R & Inglis C. 2007. *Molecular Biology of the Gene*. 6th Ed. Benjamin Cummings Publ.

FBT 502 BASIC CONCEPTS OF CELL BIOLOGY 2+1

Objective

To outline the basic structure, growth and differentiation of prokaryotic and eukaryotic cell, sub cellular components and their function.

Theory

UNIT I

Prokaryotic and eukaryotic cell architecture: Cell theory; diversity of cell size and shape.

UNIT II

Organization and function of sub-cellular organelles: Cell membrane; cytoplasm; endoplasmic reticulum; Golgi apparatus; lysosomes; mitochondria; nucleolus; peroxisomes and sub-nuclear structures.

UNIT III

Principles of membrane transport: Active/passive membrane transport (Case study - Osmoregulation in freshwater and marine fishes) ion channels; carrier proteins; cell signaling.

UNIT IV

Cell division: Cell cycle and its regulation; Cell growth and differentiation.

UNIT V

Cell motility: Actin-myosin filaments; flagella; cilia.

UNIT VI

Protein sorting: Secretion and targeting; vesicular traffic; endocytosis; exocytosis; protein translocation and secretary pathways.

Practical

Microscopic techniques- bright field, phase contrast and fluorescent microscopy; Microtomy; Sub-cellular fractionation and their functional integrity; Chromosome preparation; Histochemical techniques.

Suggested Readings

Alberts B, Johnson A, Lewis J, Raff M, Roberts K & Walter P. *2002*. *Molecular Biology of the Cell*. 4th Ed.Science Publ.

Lodish H, Berk A, Matsudaira P, Kaiser CA, Krieger M, Scott MP, Zipursky L & Darnell J. 2004. *Molecular Cell Biology*. 5th Ed. WH Freeman.

Scott FG. 1998. *Developmental Biology*. 2nd Ed. Sunderland Sianuer Associates.

Wilson EB. 1900. *The Cell in Development and Inheritance*. 2nd Ed. The MacMillan Co.

FBT 503 GENE STRUCTURE AND REGULATION OF EXPRESSION 2+1

Objective

To understand the structure of genes in prokaryotes and eukaryotes and the significance of cis and trans acting genetic elements in the regulation of gene expression.

Theory

UNIT I

Gene structure: Promoters, UTRs, ORFs, exons, introns, termination signal, mono- and polycistronic genes, Gene clustering; Overlapping genes in (Phi X174 virus).

UNIT II

Bacteriophage genome: Organization and life cycle of Lambda and M13.

UNIT III

Regulation of gene expression in Prokaryotes: Operon concept (Lac/Trp); SOS response, bidirectional promoters.

UNIT IV

Regulation of gene expression in Eukaryotes: DNA protein interactions (zinc fingers, leucine zippers, helix turn helix, Z-DNA); transcription factors, promoters, enhancers, repressors, insulators, attenuators, IRES, alternative splicing.

UNIT V

RNA in gene regulation : Antisense RNA, microRNA, ribozymes.

UNIT VI

Case study: Molecular regulation of growth hormone expression in carp/or Molecular regulation of Na+K+ ATPase in gills and kidney cells of freshwater and marine fishes.

UNIT VII

Expression analysis – Techniques to test the up and down regulation of specific genes like Micro array and Real time PCR.

UNIT VIII

Epigenetics - DNA methylation, genetic imprinting, histone modifications, chromatin remodeling.

UNIT IX

Inhibitors of transcription and translation : Mode of function and resistance mechanism – Actinomycin D, α–amanitin, Rifampicin, Tetracyclin, Streptomycin, Chloramphenicol, Kanamycin, Cyclohaxamide, Diptheria toxin, Ricin.

UNIT X

Site-directed mutagenesis and its applications.

Practical

Expression studies of a gene controlled by lacz promoter – Induction, blue/white selection, cell extract separation by PAGE and western blotting; lambda plaque formation on E. coli lawn; Seperation of gill extract on PAGE and histochemical staining of Na+ K+ ATPase of fish kept at different salinities; retrieval of gene information from ensemble and NCBI, BLAST.

Suggested Readings

Boyer R. 1999. *Concepts in Biochemistry*. Cole Publ. Co.

Lewin B. 2008. *GENES IX*. Jones & Bartlet Publ.

Primrose SB & Twyman RM. 2006. *Principles of Gene Manipulation and Genomics*. 7th Ed. Blackwell.

FBT 504 GENETIC ENGINEERING AND ITS APPLICATION IN FISHERIES 2+1

Objective

To detail the basic steps in recombinant DNA technology and its application in optimization of production, health and environment in fisheries.

Theory

UNIT I

Recombinant DNA technology: DNA modifying enzymes - types of restriction endonucleases (Type I, II and III), DNA/RNA modifying enzymes (alkaline phosphatases, kinases, exonucleases, ligases, terminal transferases); Vectors - plasmids (replication, copy number control and compatibility), phagemids, cosmids, high capacity vectors (eg. BAC), shuttle vectors; Adapters, linkers, ligation, transformation and selection.

UNIT II

Hosts: Prokaryotic (selected *E. coli* strains) and eukaryotic (selected yeast strains).

UNIT III

DNA amplification: PCR – principle, types and applications; T/A cloning of amplified products; Structure and function of DNA polymerase and reverse transcriptase.

UNIT IV

Genomic DNA library: Construction, screening (PFGE) and applications; chromosome walking.

UNIT V

cDNA library: Construction, screening (PFGE) and clone characterization.

UNIT VI

DNA and protein sequencing: Principle, types and applications.

UNIT VII

Application of rDNA technology : Transgenesis – fish as a model organism, target genes, methods of gene transfer, transgenic screening techniques; Production of diagnostics and vaccines; biofactories, biosensors, waste water treatment, probiotics, GMOs - Biosafety regulations and ethical issues related to biotechnological products; patent laws and IPR issues.

UNIT VIII

Optimization of recombinant protein expression in prokaryotes and eukaryotes.

UNIT IX

Nucleic acid hybridization: Southern, Northern and Western blotting; DNA probes and their labeling.

Practical

Cloning strategies – insert and vector preparation, ligation, preparation of competent cells, transformation, clone confirmation techniques (horizontal slot lysis/colony PCR); Southern hybridization, probe Labeling methods; Primer designing; DNA sequencing and analysis.

Suggested Readings

Brown TA. 1998. *Recombinant DNA*. Academic Press.

Brown TA. 2002. *Genomes*. 2nd Ed. John Wiley & Sons.

Lewin B. 2008. *GENES IX*. Jones & Bartlet.

Primrose SB, Twyman RM. 2006. *Principles of Gene Manipulation and Genomics*. 7th Ed. Blackwell.

Sambrook J & Russel WD. 1989. *Molecular Cloning: A Laboratory Manual*. Vols. I-III.Cold Spring Harbour.

FBT 505 MOLECULAR AND IMMUNOGENETICS 1+1

Objective

To acquaint the students with techniques used to estimate genetic variation among individuals and populations for various purposes and DNA diversity generated by somatic recombination of immunoglobulin genes.

Theory

UNIT I

Biochemical markers: Allozyme polymorphism and its application in estimating population genetic parameters.

UNIT II

Molecular markers: RAPD, RFLP, AFLP, EST, SNP, Minisatellites and Microsatellites and application in population genetic analysis and gene mapping, FISH – principle and application.

UNIT III

Analysis: Interpretation of gels and data analysis using various softwares. DNA sequence polymorphism and related software for alignment and analysis.

UNIT IV

Immunogenetics: Molecular biology of Ig synthesis, genetic basis of antibody diversity, humoral B-cell immunoglobulins, T-cell receptors and MHC.

Practical

Biochemical markers: Allozyme polymorphism. Molecular Markers: RAPD, RFLP, AFLP, Minisatellites and Microsatellites.Interpretation of gels and data analysis.

Suggested Readings

Caetano-Anolles G & Gresshoff PM. 1998. DNA *Markers: Protocols, Applications and Overviews*. Wiley-VCH.

Pasteur N, Pasteur G, Bonhomme F, Catalan J & Britton-Davidian J. 1988. *Practical Isozyme Genetics*. John Wiley & Sons.

Sambrook J & Russel WD. 1989. *Molecular Cloning: A Laboratory Manual*. Vols. I-III.Cold Spring Harbour.

FBT 506 BIOINFORMATICS 1+1

Objective

To learn the application of information technology for the fish genetics studies.

Theory

UNIT I

Introduction to bioinformatics: history, definition, scope and applications; Fields related to bioinformatics.

UNIT II

Data base: mining tools, submission of DNA sequences; Sequence alignment and database searching, similarity search, FASTA, BLAST.

UNIT III

Information networks: internet; Gene bank sequence database, EBI-net; NCBI, Genome net.

UNIT IV

Genomics: genome diagnostics, genome projects, genome analysis.

UNIT V

Proteomics: protein information resources, primary and secondary protein data bases, analysis packages, predictive methods, ESTs.

UNIT VI

Phylogenetic analysis; Comparative genome analysis; Microarray bioinformatics.

Practical

Internet search: retrieving information from different data base like NCBI, protein information sources; Preparation of data base; Use of genome analysis packages: genetics data base; Searching by similarity; Phylogenetic analysis; Accessing and submission to gene banks; BLAST, sequence alignments, comparisons.

Data base: mining tools, submission of DNA sequences; Sequence alignment and database searching, similarity search, FASTA, BLAST.

Suggested Readings

Attwood TK & Smith DJP. 1999. *Introduction to Bioinformatics*. Addison Wesley Longman.

Baxevanis AD & Ouellettee BF. 2002**.** *Bioinformatics, A Practical Guide to the Analysis of Genes and Proteins*. John Wiley & Sons.

Brown SM. 2000. *Bioinformatics: A Biologist's Guide to Biocomputing and the Internet*. Eaton Publ.

Campbell MA & Heyer LJ. 2003. *Discovering Genomics, Proteomics, and Bioinformatics***.** Benjamin Cummings.

Lesk AM. 2008**.** *Introduction to Bioinformatics***.** Oxford University Press.

Mount DW. 2001. *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor Press.

Rashidi HH & Buehler LK. 2005. *Bioinformatics Basics: Applications in Biological Sciences and Medicine*. CRC Press.

FBT 507 CELL AND TISSUE CULTURE 1+1

Objective

To impart knowledge on cell and tissue culture techniques and their application in health management, gene banking and genetic characterization.

Theory

UNIT I

Introduction: Structure and Organization of animal cell; Equipments and materials for animal cell culture technology.

UNIT II

Cell lines and media: Primary and established cell line cultures; media supplements – their metabolic functions; serum and protein free defined media and their application.

UNIT III

Cell culture: Basic techniques of cell culture in vitro; development of primary cultures, cell separation, maintenance of cell lines; biology of cultured cells, transformation and differentiation of cell cultures.

UNIT IV

Characterization of cell lines: Measurement of viability and cytotoxicity assays; measuring parameters of growth; karyotyping, isozyme assays, cryopreservation, assessment of contaminants.

UNIT V

Cell cloning: Micromanipulation, cell transformation, application of fish cell culture, scaling-up of cell culture.

UNIT VI

Stem cells: Stem cell cultures, embryonic stem cells and their applications; cell culture based vaccines, organ and histotypic cultures; measurement of cell death; apoptosis; three dimensional culture and tissue engineering.

UNIT VII

Cell hybridization: Somatic cell fusion, hybridoma technology, Production and Application of monoclonal antibodies.

Practical

Principles of sterile techniques and cell propagation; Preparation of different cell culture media; Primary cell culture techniques; Establishing cell lines: isolation, characterization identification of cell lines; Pure culture techniques; Maintenance and preservation of cell lines; Propagation of cells in suspension cultures; Hybridoma technology: strategy and techniques; Production of monoclonal antibodies.

Suggested Readings

Barnes D & Mathur PJ. 1998. *Methods in Cell Biology*. Vol. 57. *Animal Cell Culture Methods*. Academic Press.

Basega R. (Ed.). 1989. *Cell Growth and Division: A Practical Approach*. IRL Press.

Butler M & Dawson M. (Ed.). 1992. *Cell Culture*. Bios Scientific Publ.

Clynes M. 1998. *Animal Cell Culture Techniques*. Springer.

Freshney I. 1994. *Culture of Animal Cells: A Manual of Basic Techniques*. 4th Ed. Wiley-Liss.

Harrison AM, Rae FI & Harris A. 1997. *General Techniques of Cell Culture*. Cambridge University Press.

Lan FR. 1994. *Culture of Animal Cells*. 3rd Ed. Wiley-Liss.

Masters RW. 2000. *Animal Cell Culture-Practical Approach*. Oxford University Press.

FBT 508 MARINE BIOTECHNOLOGY 1+1

Objective

To outline an overview on the potential marine resources for bioactive compounds, pharmaceuticals and the application of biotechnological tools to combat marine pollution.

Theory

UNIT I

Introduction: Historical background, overview of the present status of marine biotechnology, commercially important and potential species, micro-algae, macro-algae, aquaculture.

UNIT II

Marine Resources: Biodiversity, marine natural products, valuable chemicals, biomedical and bioactive compounds from marine organisms, commercial bio-products from marine organisms; green fluorescent protein from jelly fish and its application, marine organisms as a source of polysaccharides, antiviral, anticancer and anti-inflammatory compounds; and commercially important enzymes - Xylanase, agarase, proteases, chitinases, amylase, lipases, cellulase, phytase.

UNIT III

Environmental Biotechnology: Marine biotechnology for economic development and environmental problem solving, bio-film and bio-remediation, bio-sensor and transgenic marine organisms; unculturable bacteria- occurrence, characteristics, characterization and exploitation; metagenomic library of unculturable bacteria, marine pollution and its control; genetically engineered microbes for waste water treatment; Red sea tide and its control, biofouling and prevention.

UNIT IV

Gene mining : Identification of genes responsible for novel proteins, rDNA technology for the large scale production of novel proteins, pharmaceutical, cosmetic and neutraceuticals and their use in drug designing - for various finfish and shellfish bacterial and fungal toxins.

UNIT V

Fermentation technology: Types – batch, continuous; Down stream processing of commercially important compounds.

Practical

Extraction of bioactive compounds from seaweeds, microalgae, sponges and test their efficiency microbiology, biochemistry and molecular assays, isolation of marine algae, plankton and its culture method, methods for isolation of viable and unculturable bacteria from sea, recombinant DNA technology to produce commercially important enzymes.

Suggested Readings

Colwell RD. 1984. *Biotechnology in the Marine Sciences*. Proceedings of the First Annual MIT Sea Grant Lecture and Seminar.

Fingerman M, Nagabushana M & Thompson R. 1998. *Recent Advances in Marine Biotechnology*. Vol.II. Science Publ.

Fusetani N. 2000. *Drugs From Sea*. Karger Publ.

Kamely D, Chakraborty A & Omenn GS. 1990. *Biotechnology and Biodegradation*. Portfolio Publ. Co.

Karl DM. 1995. *Microbiology of Deep Sea Hydrothermal Vents*. CRC Press.

Omura S. 1992. *The Search for Bioactive Compounds from Microorganisms*. Springer.

FBT 509 AQUACULTURE BIOTECHNOLOGY 1+1

Objective

To provide an overview of the application of biotechnological tools in fish breeding, feed, health, processing and other facets in fisheries.

Theory

UNIT I

Fish Breeding: Synthetic hormones for induced breeding- GnRH analogue structure and function.

UNIT II

Transgenesis : Methods of gene transfer in fishes, single gene traits, screening for transgenics, site of integration, applications, regulation of GMOs, IPR, Evaluation of GFP transgenics.

UNIT III

Gene Bank and conservation: Cryopreservation of gametes and embryos.

UNIT IV

Feed Technology: Micro encapsulated feeds, micro coated feeds, micro-particulate feeds and bio-encapsulated feeds, mycotoxins and their effects on feeds.

UNIT V

Health Management: DNA and RNA vaccines, molecular diagnosis of viral diseases, PCR, Dot-blot, ribotyping of pathogenic microbes, RNAi, Biofilms and its impact on health management, genetically modified micro-organisms as probiotics, immunostimulants, bioremediation of soil and water.

UNIT VI

Algal Biotechnology: Microalgae - indoor and mass culture methods, biotechnological approaches for production of important microalgae, single cell protein from Spirulina, raceway system of micro algae culture, vitamins, minerals and omega3 fatty acids from micro algae, enrichment of micro algae with micronutrients.

UNIT VII

Post harvest biotechnology: Delaying of spoilage, detection of toxic substances and pathogenic microbes, biosensors for toxins.

UNIT VIII

Application of nanotechnology in aquaculture.

Practical

Induced breeding of carps, *Spirulina* culture, identification of selected algae, cryopreservation of gametes, diagnosis of WSSV, micro-encapsulation, ribotyping, HAACP methods, preparation of agar, PCR amplification and cloning of growth hormone gene, transgenesis, chromosomal manipulation- androgenesis, gynogenesis, triploidy, tetraploidy.

Suggested Readings

Lakra WS, Abidi SAH, Mukherjee SC & Ayyappan S. 2004. *Fisheries Biotechnology*. Narendra Publ. House.

Nagabhushanam R, Diwan AD, Zahurnec BJ & Sarojini R. 2004. *Biotechnology of Aquatic Animals*. Science Publ.

Nair PR. 2008. *Biotechnology and Genetics in Fisheries and Aquaculture*. Dominant Publ.

Pandian TJ, Strüssmann CA & Marian MP. 2005. *Fish Genetics and Aquaculture Biotechnology*. Science Publ.
Reddy PVGK, Ayyappan S, Thampy DM & Gopalakrishna. 2005. *Text Book of Fish Genetics and Biotechnology*. ICAR.

FBT 601 ADVANCES IN MOLECULAR AND CELL BIOLOGY 2+1

Objective

To provide a deeper understanding of the molecular and cellular processes involved in the functioning, maintenance and death of living cells.

Theory

UNIT I

Content of the genome: Genome size and complexity, C-value paradox, repetitive and non- repetitive DNA, Cot curve, evolution of interrupted genes, cluster and repeats, gene families, pseudogenes, evolutionary clock.

UNIT II

Protein localization and trafficking: Co-translational and post-translational translocation, post-translational modifications; Protein transport through ER - Golgi system; Anterograde and retrograde transport; Exo- and endocytosis; Clathrin coated vesicles; membrane fusion and protein localization; Ubiquitin pathway for protein degradation.

UNIT III

Signal transduction: Active and passive transport, carrier proteins (uniporter/ symporter/antiporter), ion channels (ligand and voltage gated channels), G-proteins, signaling pathways (Ras/MAPK, JAK-STAT).

UNIT IV

Cell cycle and growth regulation: Cell cycle check points, cyclins, CDKs (Cycline dependent kinases); Cell differentiation; Apoptosis: programmed cell death – genetic pathways for PCD, anti and proapoptotic proteins.

UNIT V

Epigenetics : DNA imprinting, histone modifications, histone code.

UNIT VI

Oncogenes and tumour suppressor genes: Viral and cellular oncogenes, tumour suppressor genes; Structure, function and mechanism of action of pRB and p53 tumour suppressor proteins.

UNIT VII

RNA interference: History, molecular mechanisms and applications of antisense RNA, microRNA, siRNA and Ribozymes.

Practical

DNA sequence analysis for identification of cis acting elements – kozak sequence, intron-exon boundaries, poly A signal, terminators, promoters, transcription factor binding sites, zinc finger motif, cellular localization signals using bioinformatics softwares available online; multiple alignment, tandem repeat identification, promoter analysis, antisense/siRNA design.

Suggested Readings

Alberts B, Johnson A, Lewis J, Raff M, Roberts K & Walter P. *2002. Molecular Biology of the Cell*. 4th Ed. Science Publ.
Boyer R. 1999. *Concepts in Biochemistry*. Cole Publ. Co.
Lewin B. 2008. *GENES IX*. Jones & Bartlet.

Lodish H, Berk A, Matsudaira P, Kaiser CA, Krieger M, Scott MP, Zipursky L & Darnell J. 2004. *Molecular Cell Biology*. 5th Ed. WH Freeman.

Scott GF. 1998. *Developmental Biology*. 2nd Ed. Sunderland Sianuer Associates.

Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R & Inglis C. 2007. *Molecular Biology of the Gene*. 6th Ed. Benjamin Cummings Publ.

Wilson EB. 1900. *The Cell in Development and Inheritance.* 2nd Ed. The MacMillan Co.

FBT 602 GENETIC ENGINEERING OF EUKARYOTES 2+1

Objective

To provide in-depth knowledge on the techniques available for genetic engineering of eukaryotes and strategies to optimize recombinant protein production in eukaryotic expression systems.

Theory

UNIT I

Eukaryotic expression systems: Yeast expression system - host strains, special features, types of vectors (yeast episomal vectors, integrating vectors and YACs), yeast two hybrid system.

UNIT II

Insect cell expression system: Special features, types, baculoviral expression vectors, polyhedron promoters.

UNIT III

Mammalian cell expression system: Special features, selectable markers; Transfection: principle, types, selection; transduction by viral vectors, construct design (strong and constitutive promoters, inclusion of introns).

UNIT IV

Fish cell expression systems: Tissue specific promoters, constitutive promoters and applications.

UNIT V

Strategies for optimizing recombinant gene expression in eukaryotic systems; Downstream processing of recombinant proteins.

UNIT VI

Transgenesis : Fish as a model organism, methods of gene transfer, strategies for gene targeting (homologous sites/ cre-lox recombination system); specialized vectors for high efficiency transgenesis – eukaryotic transposon vectors, retroviral vectors, etc., Transgene: integration and detection techniques, an overview of transgenics developed in fisheries sector – food/or ornamental; Fish as biosensors and biofactories.

UNIT VII

Gene function analysis: Gene knock-outs, gene silencing by RNAi, morpholinos, etc; site directed and transposon mediated mutagenesis.

Practical

Gene transfer experiments (electroporation, microinjection); Northern blotting, Western, Southern blotting for confirming integration and expression of transgene; Gene library: construction of cDNA and genomic DNA libraries; Screening: DNA hybridization, immunological assay and protein activity.

Suggested Readings

Boyer R. 1999. *Concepts in Biochemistry*. Cole Publ. Co.
Brown TA. 2002. *Genomes*. 2nd Ed. John Wiley & Sons.
Lewin B. 2008. *GENES IX.* Jones & Bartlet.
Sambrook J & Russel WD. 1989. *Molecular Cloning: A Laboratory Manual.*Vols. I-III. Cold Spring Harbour.

FBT 603 GENETIC ENGINEERING OF BACTERIA AND VIRUSES 2+1

Objective

To provide knowledge on various techniques available to produce genetically engineered microbes and their application, design of viral vectors for efficient gene delivery.

Theory

UNIT I

Recombinant protein expression in Bacteria: Optimization of expression; fusion proteins, purification of recombinant proteins - inclusion bodies, extracellular targeting, engineering of signal sequences, electroporation.

UNIT II

Scope and application of genetic engineering in bacteria: Engineered microorganisms for bioremediation, biofouling, biosensing, biofermentation, probiotics and single cell protein.

UNIT III

Molecular biology of fish DNA/RNA viruses: Major groups of DNA/RNA viruses; their cis acting genetic elements and regulation of protein expression.

UNIT IV

Genetic engineering of Virus: Use of animal viruses like vaccinia, herpes, retrovirus, baculovirus and adenovirus as cloning vectors, design of viral vectors - special features, cis acting regulatory elements; strategies to optimize recombinant protein production, pro's and con's of using viral vectors as gene delivery vehicles; vectors based on bacteriophage lamda, P1 and M13, special features and their application in optimizing recombinant protein production.

UNIT V

Scope and application of genetic engineering in Virus : Efficient gene delivery strategies, host-pathogen interaction, antigenic proteins, vaccination approaches, DNA vaccines, diagnostics : methods for detection of viral infection, estimation of viral load by Real Time PCR, etc.

Practical

Transformation of bacteria by electroporation, Southern and dot-blot transfer techniques; Restriction mapping of DNA; labeling of DNA probes; PAGE analysis for recombinant proteins. Preparation of primary and secondary monolayer cell culture, use of cell culture in virus cultivation and assay; Viral DNA isolation and restriction analysis; Culture and maintenance of bacteriophages; RT-PCR.

Suggested Readings

Boyer R. 1999. *Concepts in Biochemistry*. Cole Publ. Co.
Brown TA. 2002. *Genomes*. 2nd Ed. John Wiley & Sons.
Lewin B. 2008. *GENES IX.* Jones & Bartlet.

Sambrook J & Russel WD. 1989. *Molecular Cloning: A Laboratory Manual.*Vols. I-III. Cold Spring Harbour.

FBT 604 BIOSAFETY AND PATENT LAWS 2+0

Objective

To provide an overview on the current status of genetically modified organisms and patent laws, biosafety guidelines and regulatory mechanisms involved.

Theory

UNIT I

Safety and ethical issues: Guidelines for research on genetically modified organisms (GMOs), quality control of biologicals produced by rDNA technology, safety in the contained use and release of transgenic animals, ecological risk of engineered organisms/plants and remedial measures, ethical issues related to biotechnology products.

UNIT II

Biosafety regulations: Guidelines for environmental release of GMOs, guidelines for import and shipment of GMOs, mechanism of implementation of biosafety guidelines at Institutional, national and international level, Role of national agencies in regulating GMOs; Acts and treaties related to bisafety of GMOs, Public awareness, perception and acceptance of products of biotechnology.

UNIT III

Patent laws: Global scenario of genetically modified organisms, Intellectual Property Rights (IPR), patent laws at institutional, national and international level.

Suggested Readings

DBT. 1998. *Background Document for Workshop on Biosafety issues Emanating from Use of Genetically Modified Organisms (GMOs).* Bangalore.

Subbaram NR. 1998. *Handbook of Indian Patent Law and Practice*. Viswanathan Printers & Publ.

Tzotzos GT. 1995. *Genetically Modified Organisms - A Guide to Biosafety*. CABI.

FBT 605 FUNCTIONAL GENOMICS AND PROTEOMICS 1+1

Objective

To give an introduction to application of modern techniques for functional genome analysis.

Theory

UNIT I

Whole genome analysis: Preparation of ordered cosmid libraries, BAC libraries, Shotgun libraries and sequencing, conventional and automated sequencing.

UNIT II

DNA Microarray: Printing of oligonucleotides and PCR products on glass slides, nitrocellulose paper, genome analysis for global patterns of gene expression using fluorescent labeled cDNA or end-labeled RNA probes, analysis of SNP using DNA chips.

UNIT III

Proteome analysis: Two dimensional separation of total cellular proteins, isolation and sequence analysis of individual protein spots by mass spectroscopy, protein microarrays, advantage and disadvantage of DNA and protein microarrrays,

UNIT IV

Subtractive hybridization and differential display for identification of genes expressed in specific conditions.

Practical

Analysis of SNP using DNA chips, printing of oligonucleotides and PCR products on glass slides, nitrocellulose paper, conventional and automated sequencing of DNA, protein sequencing by mass spectroscopy, protein microarrays.

Suggested Readings

Brenner SE & Levitt M. 2000. *Functional Genomics: A Practical Approach*. Oxford University Press.

Peruski LF & Peruski LH. 1997. *The Internet and New Biology:Tools for Genomic and Molecular Research*. ASM Press.

Schena M. (Ed.).1999. *DNA Microarrays: A Practical Approach*. Oxford University Press.

FBT 606 PROTEIN CHEMISTRY AND ENGINEERING 1+1

Objective

To provide an insight into the structure and function of proteins with a focus on state-of-the-art protein engineering to design novel proteins and their application.

Theory

UNIT I

Chemical and physical characteristics of proteins: Properties of amino acids, peptides, and proteins, chemical modification of proteins, Post-translational modification of proteins, forces that determine protein structures, Secondary tertiary and quaternary structures of proteins, protein folding patterns, protein modules, protein structure based drug design.

UNIT II

Structure Function Relationship of Proteins : DNA binding proteins, prokaryotic and eukaryotic transcription factors, DNA polymerases, membrane proteins and receptors, bacteriohodosin, photosynthetic centres, epidermal growth factor, insulin and ODGF receptors and their interaction with effectors, protein phosphorylation, immunoglobulins, nucleotide binding proteins, enzyme serine proteases, ribonuclesase, lysozyme.

UNIT III

Protein-Protein and Protein-DNA Interactions: Biochemical, biophysical and computational methods to Study Protein-Protein Interactions and Protein-DNA Interactions.

UNIT IV

Protein and DNA Sequence Analysis: Web-based Literature Search, Sequence Retrieval and Sequence Analysis, Activities and Regulation of Protein Enzymes: Functions and Regulation of Enzymes, Regulation of the Activities of Enzymes and Other Proteins, Phosphorylation and Dephosphorylation.

UNIT V

Protein Engineering and Protein Design : Protein data base analysis, methods to alter primary structure of proteins, examples of engineered proteins, protein design, principles and examples.

UNIT VI

Proteolysis in Cellular Regulation: Mechanism of Protein Degradation and Proteolysis Pathways.

Practical

Proteomics and sequence analysis tools - Identification and characterization (Aldente, FindMod, Popitam, Phenyx, pI/Mw, ProtParam), DNA -> Protein, similarity searches (BLAST), pattern and profile searches (ScanProsite), post-translational modification and topology prediction, primary structure analysis, secondary and tertiary structure tools (Swiss-PdbViewer), alignment and phylogenetic analysis, DNA mobility shift assay.

Suggested Readings

Creighton TE. 1992. *Protein: Structure and Molecular Properties*. 2nd Ed. WH Freeman.

Liebler DC. 2007. *Introduction to Proteomics: Tools for the New Biology*. Humana Press.

Twyman RM. 2004. *Advanced Text: Principles of Proteomics*. Garland Science/BIOS Scientific Publ.

FBT 607 RNA*i* TECHNOLOGY 1+1

Objective

To comprehend the basic process of RNAi and issues involved in their applications.

Theory

UNIT I

Introduction : Regulation of gene expression in prokaryotes and eukaryotes, types of RNA – rRNA, mRNA, tRNA, miRNA, siRNA, shRNA, tncRNA, gene knock down, gene knock out, co-suppression post transcriptional gene silencing, quelling, RNAi in *C. elegans* – landmark events in the discovery of RNAi components – dsRNA, Dicer, RISC complex, argonaute protein; mechanism of RNAi, miRNA pathway, RNAi and origin of heterochromatin.

UNIT II

Ribonuclease II super family: Forms and functions in RNA, maturation, decay and gene silencing, RNA dependent RNA polymerase in gene silencing, RNAi in invertebrates – antiviral immunity by dsRNA in shrimps.

UNIT III

Delivery of RNAi : Bio-distribution, delivery and application, delivery reagents, target validation, detection methods, delivery systems – viral and nonviral delivery, RNAi as a tool against animal and human diseases – HIV, cancer; gene therapy.

Practical

Softwares to design siRNA and target validation – ERNAi, optiRNAi, iRNAi; different methods of delivery – vector based, naked siRNA, chemically modified siRNA, gene expression analysis techniques after RNAi delivery – Real time PCR, hybridization techniques.

Suggested Readings

Hannon GJ. 2003. *RNAi, A Guide to Gene Silencing*. CHSL Press.

Schepers U. 2005**.** RNA *Interference in Practice. Principles, Basics, and Methods for Gene Silencing in C. elegans, Drosophils, and Mammals.* WILEY-VCH Verlag, GmbH.

Twyman RM. 2004. *Advanced Text: Principles of Proteomics*. Garland Science, BIOS Scientific Publ.

FBT 608 BIOPROCESS TECHNOLOGY 1+1

Objective

To learn the techniques for bulk processing, production and purification of biologicals.

Theory

UNIT I

Raw materials for bioprocessing, comparison of chemical and biochemical processing based on energetics and environmental issues. Development of inocula, kinetics of enzymatic and microbial processes, optimisation studies, sterilization of media, air and equipment, modes of cell cultivation, general principles of bioreactor design and their operation -Downstream processing, separation and purification techniques, quality assurance testing, representative examples of microbial products, vaccines and vaccine development.

UNIT II

Immobilization of cells and enzymes: Principles, methodology and applications, disintegration of cells, separation of solid and liquid phases, isolation and purification techniques for proteins and other products based on different physico-chemical properties, eg., precipitation, adsorption, chromatographic separations, bio-affinity based methods -Principles of bioprocess control, bioprocess auto mation and application of computers in bioprocessing, recombinant products with representative examples, biosafety and environmental monitoring of GEMs, Introduction to patents, Intellectual Property Rights in Biotechnology.

Practical

Downstream processing, separation and purification of compounds, Preparation of vaccines, Purification of protein and enzymes by precipitation, adsorbtion, chromatography and bioaffinity based methods.

Suggested Readings

Ratledge C & Kristiansen B. (Eds.). 2006. *Basic Biotechnology*. Cambridge University Press.

Renneberg R. 2007. *Biotechnology for Beginners*. Academic Press.

Waites MJ, Morgan NL, Rockey JS & Higton G. 2001. *Industrial Microbiology: An Introduction*. Wiley-Blackwell.

FISH BIOTECHNOLOGY
List of Journals

- Animal Biotechnology
- Applied Biochemistry and Biotechnology
- Biochemical Genetics
- Bioinformatics
- Biology of the Cell
- Biotechnology Advances
- Biotechnology and Applied Biochemistry
- Biotechnology and Bioengineering
- Briefings in Bioinformatics
- Cell
- Cell and Tissue Research
- Cell Biology International
- Cell Death and Differentiation
- Cell Growth and Differentiation
- Cell Research
- Critical Reviews in Biotechnology
- Current Bioinformatics
- Current Opinion in Biotechnology
- Current Opinion in Cell Biology
- Current Stem Cell Research and Therapy
- European Journal of Immunogenetics
- Experimental Cell Research
- Gene Expression Patterns
- Gene Structure and Expression
- Genome Research
- Journal of Animal Law and Ethics
- Journal of Biochemistry and Molecular Biology
- Journal of Biotechnology
- Journal of Cell Biology
- Journal of Cell Science
- Journal of Commercial Biotechnology
- Journal of Computational Biology
- Journal of Industrial Microbiology and Biotechnology
- Journal of Marine Biotechnology
- Journal of Molecular Biology
- Journal of RNAi and Gene Silencing
- Marine Biotechnology
- Microbial Biotechnology
- Molecular Biology of the Cell
- Molecular Biotechnology
- Molecular Cell Research
- Molecular Genetics and Genomics

- Molecular Marine Biology and Biotechnology
- Molecular Phylogenetics and Evolution
- Nature Biotechnology
- Nature Cell Biology
- Nature Structural and Molecular Biology
- Nucleic Acids Research
- Proteins, Structure, Function, and Bioinformatics
- Recent Patents on Biotechnology
- Reviews in Environmental Science and Biotechnology
- Reviews in Molecular Biotechnology
- Trends in Biotechnology
- Trends in Cell Biology

Suggested Broad Areas for Master's and Doctoral Research

- Site directed mutagenesis to identify functional motifs and to optimize recombinant protein production
- Homologous and site specific recombination methods in genetic engineering
- Mutagenic effects of different chemicals
- Temporal and spatial expression kinetics of specific genes involved in regulatory pathways
- Identification of developmentally regulated genes
- Characterization of promoter regions
- Identification of commercially important genes
- Identification of transcription factor binding sites
- Development of genetically modified microorganisms to serve specific purposes like biosensors and bio-indicators etc
- Molecular genetic studies for estimating genetic variation and other genetic parameters in among stocks and species
- Molecular tools for taxonomic identification
- Use of molecular markers to identify specific pathogens
- Computer applications in analyzing biological data
- In silico analysis of regulatory elements
- Phylogenetic analysis of different populations
- Production of monoclonal antibodies
- Development of primary cell culture for different finfish and shellfish species
- Characterization of cell lines
- Identification of genes that produce commercially important bioactive compounds
- Functional characterization of the toxins from marine organisms
- Genetically modified organisms to combat marine pollution
- Large scale production of novel proteins and pharmaceuticals through rDNA technology
- Transgenic fishes for commercially important traits
- Cryopreservation of fish gametes
- Production of all male population
- Molecular tools for disease diagnosis
- RNAi therapy to combat viral diseases of fin fish and shellfish

- Identification of genes responsible for cancer cell proliferation
- Functional analysis of genes by creating knock-outs
- Development of transgenic fish for various purposes
- Site directed and transposon mediated mutagenesis to create mutant lines
- Development of tissue specific cell expression systems
- Genetically engineered microorganisms for recombinant protein production
- Design of viral vectors for efficient gene delivery
- Expression of antigenic proteins
- IPR issues related to GMOs
- Analysis of biosafety laws in different countries
- Identification of genes up/down regulated at specific stimulus
- Development of BAC/cosmid libraries
- Functional characterization of genes involved in specific pathways
- Identification of novel proteins by proteomics tools
- RNAi technology in viral disease management
- Functional characterization of specific genes by siRNA based silencing
- Development of delivery strategies for RNAi based therapy

FISH GENETICS AND BREEDING
Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
FGB 501*	PRINCIPLES OF GENETICS AND BREEDING	2+1
FGB 502*	POPULATION GENETICS	2+1
FGB 503*	QUANTITATIVE GENETICS	2+1
FGB 504*	PRINCIPLES OF SELECTION AND SELECTION METHODS	2+1
FGB 505	FISH BREEDING	2+1
FGB 506	FISH GENETIC RESOURCES AND CONSERVATION	2+1
FGB 507#	MOLECULAR AND IMMUNOGENETICS	1+1
FGB 508	MOLECULAR GENETICS	1+1
FGB 509	CYTOGENETICS	1+1
FGB 510#	BIOINFORMATICS	1+1
FGB 511	COMPUTER APPLICATIONS IN FISH GENETICS	1+1
FGB 512#	CELL AND TISSUE CULTURE	1+1
FGB 591	MASTER'S SEMINAR	1+0
FGB 599	MASTER'S RESEARCH	20
FGB 601**	ADVANCES IN FISH BREEDING	2+1
FGB 602**	SELECTION INDEX METHODOLOGIES	2+1
FGB 603**	APPLICATION OF GENETICS IN COMMERCIAL AQUACULTURE	2+1
FGB 604	RESEARCH METHODOLOGY IN FISH GENETICS	1+1
FGB 605	ADVANCES IN CYTOGENETICS	2+1
FGB 606	MOLECULAR BREEDING	2+1
FGB 607	TRANSGENIC PRODUCTION AND GMOS	1+1
FGB 608	LINEAR MODELS IN FISH GENETICS	2+1
FGB 691	DOCTORAL SEMINAR I	1+0
FGB 692	DOCTORAL SEMINAR II	1+0
FGB 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme; ** Compulsory for Doctoral programme
# FGB 507, FGB 510 and FGB 512 cross listed with Fish Biotechnology FBT 505, FBT 506 and FBT 507 respectively

FISH GENETICS AND BREEDING

Course Contents

FGB 501 PRINCIPLES OF GENETICS AND BREEDING 2+1

Objective

To understand the basic principles of genetics and breeding and their application to fisheries management and aquaculture.

Theory

UNIT I

Historical development of genetics and physical basis of heredity; Mendelian principles: scope, limitation, probability of Mendelian inheritance; Modifications to Mendelian ratios.

UNIT II

Genetic variation: Causes and measurement; Chromosome theory of inheritance: genetic basis of determination of sex.

UNIT III

Chromosome manipulation: Ploidy induction, sex reversal, gynogenesis and androgenesis; Multiple alleles.

UNIT IV

Linkage and crossing over, recombination, interference.

UNIT V

Modern concept of gene; DNA as genetic material, genetic code and protein synthesis, transfer and regulation of genetic information.

UNIT VI

Pleiotropy; Penetrance; Gene and genotypic frequency and factors affecting them, application of selection for performance improvement.

UNIT VII

Mutation: natural and induced, mutagens fate of mutant allele in the population; Cross breeding and genetic drift.

Practical

Exercises on Mendelian laws, multiple alleles and epistasis; Practical demonstration of chromosome manipulations, Linkage and crossing over, ploidy induction; Induction of gynogenesis and androgenesis; Sex reversal.

Suggested Readings

Kirpichnikov VS. 1981. *Genetic Basis of Fish Selection*. Springer-Verlag.

Lakra WS, Abidi SAH, Mukherjee SC & Ayyappan S. 2004. *Fisheries Biotechnology*. Narendra Publ. House.

Lutz CG. 2003. *Practical Genetics for Aquaculture*. Wiley-Blackwell.

Lynch M & Walsh B. 1997. *Genetics and Analysis of Quantitative Traits*. Sinauer, Sunderland.

Purdom CE. 1993. *Genetics and Fish Breeding*. Chapman & Hall.

Snustad DP & Simmons MJ. 1999. *Principles of Genetics*. 2nd Ed. John Wiley & Sons.

Stansfield WD. 1991**.** *Theory and Problems of Genetics*. McGraw-Hill.

Tave D. 1993. *Genetics for Fish Hatchery Managers*. 2nd Ed. Chapman & Hall.

FGB 502 POPULATION GENETICS 2+1

Objective

Understanding the concepts of population and its structure for fisheries management and aquaculture.

Theory

UNIT I

Genetics of population: Individual *vs.* population, genetic structure of random mating populations.

UNIT II

Hardy Weinberg principles: Test of equilibrium, application and properties of equilibrium populations; Change in gene frequency under migration, mutation and selection; Effect of small population on gene frequency.

UNIT III

Estimation of HW principle/equilibrium using various population genetic tools: phenotypic, protein, and DNA markers.

UNIT IV

Coefficient of genetic differentiation – F_{ST}, R_{ST}, Q_{ST}, G_{ST} - their relative merits and demerits, Genetic similarity and distance.

UNIT V

Genetic bottleneck and concept of Mutation drift equilibrium; Null alleles; Theory of path coefficients and analysis.

UNIT VI

Basis of relationships: Independent and correlated causes; Inbreeding: types, methods of estimation and consequences; Genetic drift; Effective population size.

Practical

Exercises on various statistical procedures with emphasis on non-parametric distributions; Estimation of gene and genotype frequencies; Estimation of effect of mutation, migration and selection on equilibrium; Equilibrium in sex linked genes; Estimation of effective population size, rate of inbreeding, inbreeding co-efficient, path coefficient; Building of pedigree files; Statistical analysis in relation to genetic stock structure analysis with dominant and co-dominant markers; Type I and Type II markers, protein, mtDNA and nuclear DNA markers, EST markers.

Suggested Readings

Doolittle DP. 1987. *Population Genetics: Basic Principles*. Springer-Verlag.

Falconer DS & Markay TFC. 1996. *An Introduction to Quantitative Genetics*. 4th Ed. Addison Wesley Longman.

Hartl D. 1988. *A Primer in Population Genetics*. Sunderland.

Hartl D & Clarke AG. 2007. *Principles of Population Genetics*. 4th Ed. Sunderland.

Li CC. 1955. *Population Genetics*. University of Chicago Press.

Pirchner F. 1983. *Population Genetics in Animal Breeding*. Plenum Press.

FGB 503 QUANTITATIVE GENETICS 2+1

Objective

Understanding the concepts of quantitative genetics and its applications.

Theory

UNIT I

Quantitative genetics: Scope and applications; Polygenes and major genes; Polygenic segregation and linkage.

UNIT II

Quantitative and qualitative traits: Mode of inheritance and continuous variation; Components of phenotypic value: population mean, genotypic value, average effect of gene and gene substitution.

UNIT III

Breeding value: Dominance and interaction deviations; Components of variation: additive and non additive interaction; Biometrical relationship among relatives.

UNIT IV

Genetic parameters: Introduction, repeatability, heritability and genetic, phenotypic and environment correlations.

UNIT V

Selection: Effect on population structure, intensity of selection, response to selection, methods of selection; Genetic gain and correlated response; Utilisation of non-addtive genetic variance.

UNIT VI

Heterosis: Theories and estimation; Maternal effects; Diallele crossing; General and specific combining ability; Recurrent and reciprocal recurrent selection; Scale effects and their estimation; Progeny testing.

Practical

Properties of Variance, Covariance, Correlation and regression; ANOVA in genetic parameter estimation; Analysis of genetic variance; Estimation of heritability by half-sib, full-sib and mid-parent analyses; Repeatability and their accuracies; Estimation of genetic gain and their relative efficiencies; Procedures for estimating breeding values; Analysis of diallele crossing.

Suggested Readings

Doolittle DP. 1987. *Population Genetics: Basic Principles*. Springer-Verlag.

Falconer DS & Markay TFC. 1996. *An Introduction to Quantitative Genetics*. 4th Ed. Addison Wesley Longman.

Li CC. 1955. *Population Genetics*. University of Chicago Press.

Lynch M & Walsh B. 1997. *Genetics and Analysis of Quantitative Traits*. Sinauer, Sunderland.

Pirchner F. 1983. *Population Genetics in Animal Breeding*. Plenum Press.

Turner HN & Young SSY. 1969. *Quantitative Genetics in Sheep Breeding*. Cornell University Press.

FGB 504 PRINCIPLES OF SELECTION AND SELECTION METHODS 2+1

Objective

To learn the application of genetic tools for genetic improvement of aquatic species.

Theory

UNIT I

Selection: Scope, application, role of genetics in fish selection and breeding; National and International scenario of selective breeding programmes in fish.

UNIT II

Selection: Basis of selection, genetic gain; Response to selection and factors affecting response; Accuracy of selection; Selection limits;

Renewed selection gain; Bidirectional selection; Aids to selection; Methods of selection; QTL and MAS.

UNIT III

Construction of selection indices; Sire and dam evaluation; Realized heritability, repeatability and genetic correlations.

UNIT IV

Mating systems and genetic consequences; Inbreeding depression: causes and methods to overcome; Selection for threshold characters; Small stock and inbreeding effects; Out breeding: crossbreeding, utilization of heterotic effects.

UNIT V

Application of genetic parameter information in formulation of breeding plans; Stock improvement plans; Development of new strains/synthetic population; Crossbreeding and hybridization.

UNIT VI

Selection and mating designs for select traits: growth, disease resistance, color enhancement, fin characters,; Application of markers in selection programmes, status and their relevance.

UNIT VII

Development of breeding plans for different population sizes and environments; Trends in fish breeding research. Domestication and inadvertent selection; Genotype x Environment interaction and its role in fish/shellfish breeding.

Practical

Estimation of genetic parameters; and construction of selection indices; Estimation of genetic, phenotypic and environmental correlations; Analysis of GCA and SCA; Estimation of heterosis and inbreeding depression; Estimation of G X E interaction; Designing and conducting the challenge test for disease resistance. Selection: basis of selection, genetic gain; Response to selection and factors affecting response; Accuracy of selection; Selection limits; Renewed selection gain; Bidirectional selection; Aids to selection; Methods of selection; QTL and MAS.

Suggested Readings

Cameron ND. 1997. *Selection Indices and Prediction of Genetic Merit in Animal Breeding*. CABI.

Doolittle DP. 1987. *Population Genetics: Basic Principles*. Springer-Verlag.

Falconer DS & Markay TFC. 1996. *An Introduction to Quantitative Genetics*. 4th Ed. Addison Wesley Longman.

Li CC. 1955. *Population Genetics*. University of Chicago Press.

Lynch M & Walsh B. 1997 *Genetics and Analysis of Quantitative Traits*. Sinauer, Sunderland.

Pirchner F. 1983. *Population Genetics in Animal Breeding*. Plenum Press.

Turner HN & Young SSY. 1969. *Quantitative Genetics in Sheep Breeding*. Cornell University Press.

FGB 505 FISH BREEDING 2+1

Objective

To learn the applications of genetic techniques for stock improvement.

Theory

UNIT I

Historical development of fish breeding and domestication; Current status of aquaculture in world and India; Tagging and maintaining breeding records.

UNIT II

Performance: Growth, disease resistance, productive and reproductive traits and their inheritance; Study of growth curves and their components; Influence of non-genetic factors on growth.

UNIT III

Endocrine control of reproduction; Synchronization of spawning.

UNIT IV

Effect of breeding programme on genetic diversity of farmed animals; Present status of breeding, cross breeding in aquaculture; Broodstock management; Inbreeding depression and heterosis in various economic characters; Role of Breeders' associations in national breeding programmes.

UNIT V

National breeding policy; Economic analyses of national breeding programmes.

UNIT VI

Reproductive cycle, sex determination, age of maturity, hormone induced ovulation; Gonad developmental stages in fin/shellfish and levels of hormonal intervention; Seed quality and fish seed certification; Biosecurity.

Practical

Tagging methods; Construction of growth curves; Standardization of the performance records for genetic parameters estimations, Record keeping of stock; Breeding plan and design of breeding programme from successful case studies; Morphometric analysis; Practicals on synchronization of spawning.

Suggested Readings

Hoar WS & Randall DJ.1988. *Fish Physiology*. Academic Press.

Kinghorn BP. 1981. *Quantitative Genetics in Fish Breeding*. University of Edinburgh.

Kshirsagar MA & Smith WB. 1995 .*Growth Curves*. CRC Press.

Purdom CE. 1993. *Genetics and Fish Breeding*. Chapman & Hall.

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

Weatherely AH & Gill HS. 1988. *The Biology of Fish Growth*. Blackwell Synergy.

FGB 506 FISH GENETIC RESOURCES AND CONSERVATION 2+1

Objective

To impart knowledge on application of genetic principles in conservation and management of aquatic resources.

Theory

UNIT I

Fish genetic resources: Survey and distribution; Genetic diversity - importance, estimation and influencing factors.

UNIT II

Characterization and evaluation: Taxonomical, biochemical and molecular tools; Threatened aquatic species of India and world.

UNIT III

Conservation and preservation of aquatic species: Issues and strategies, endangered species as per the guidelines of IUCN; Breeding strategies of threatened species for restocking and live gene bank.

UNIT IV

Data bank and Gene bank: Concepts, objectives, resources, uses; Institutes and Societies associated with conservation; Impact of inbreeding on genetic diversity and conservation; Evolutionary potential and heritability.

UNIT V

Importance of mutation, migration and their interaction with selection in conservation; Application of molecular genetic tools for management of small population for conservation.

UNIT VI

Genetics and management of wild and captive populations; Genetic management for reintroduction; *In-situ* and *ex-situ* conservation; Cryopreservation of sperm, eggs and embryos.

UNIT VII

Effective population size and population structure; Factors threatening indigenous species; IPR issues and patenting of genetic resources; Regulations regarding introduction of exotic germplasm; Export import rules and regulations on conservation of aquatic genetic resources; Fish quarantine – status, procedures, scope and significance; Convention on Biodiversity and Biodiversity Authority of India.

Practical

Tagging methods for population; Estimation of gene and genotypic frequencies; Estimation of genetic diversity and relatedness using molecular information; Application of molecular genetic markers for estimation of effective population size, rate of inbreeding and genetic bottleneck; Analysis of genetic variance in population; Morphometric analysis of stocks; Milt quality analysis; Cryopreservation of milt.

Suggested Readings

Allendorf FW. 2007. *Conservation and the Genetics of Populations*. Blackwell.

Cloud JG & Thorgaard GH. 1993. *Genetic Conservation of Salmonid Fishes*. NATO ASI Series, Life Sciences, Springer.

Frankham R, Ballou JD & Briscoe DA. 2004. *A Primer of Conservation Genetics*. Cambridge University Press.

Frankham R. 1995. *Introduction to Conservation Genetics.* Annual Reviews of Genetics.

Hartl D. 1988. *A Primer in Population Genetics*. Sunderland.

FGB 507 MOLECULAR AND IMMUNOGENETICS 1+1

Objective

To aquaint the students with techniques used to estimate genetic variation among individuals and populations for various purposes and DNA diversity generated by somatic recombination of immunoglobulin genes.

Theory

UNIT I

Biochemical markers: Allozyme polymorphism and its application in estimating population genetic parameters.

UNIT II

Molecular markers: RAPD, RFLP, AFLP, EST, SNP, Minisatellites and Microsatellites and application in population genetic analysis and gene mapping, FISH – principle and application.

UNIT III

Analysis: Interpretation of gels and data analysis using various softwares. DNA sequence polymorphism and related software for alignment and analysis.

UNIT IV

Immunogenetics: Molecular biology of Ig synthesis, genetic basis of antibody diversity, humoral B-cell immunoglobulins, T-cell receptors and MHC.

Practical

Biochemical markers: Allozyme polymorphism. Molecular Markers: RAPD, RFLP, AFLP, Minisatellites and Microsatellites.Interpretation of gels and data analysis.

Suggested Readings

Caetano-Anolles G & Gresshoff PM. 1998. *DNA Markers: Protocols, Applications and Overviews*. Wiley-VCH.

Pasteur N, Pasteur G, Bonhomme F, Catalan J & Britton-Davidian J. 1988. *Practical Isozyme Genetics*. Ellis Horwood.

Sambrook J & Russel WD. 1989. *Molecular Cloning: A Laboratory Manual*. Vols. I-III. Cold Spring Harbor.

FGB 508 MOLECULAR GENETICS 1+1

Objective

To understand the basic concepts of molecular genetics

Theory

UNIT I

Gene structure of DNA, replication, Protein synthesis; Operon concept, genetics of mitochondria and plasmids, transposons and intervening sequences, minisatellites and macro satellites.

UNIT II

Mutations: Molecular mechanism of spontaneous and induced mutations, site directed mutagenesis, recombination in bacteria, fungus and virus.

UNIT III

Recombination: Molecular mechanism of genetic recombination, transduction, transformation and conjugation.

UNIT IV

Genetic code, mechanism of translation and its control, post translation modification. Control of gene expression in prokaryotes and eukaryotes.

Practical

DNA isolation, Plasmid isolation, Gel electrophoresis and its type, AGE, PAGE,SDS-PAGE, PCR, Cloning.

Suggested Readings

Caetano-Anolles G & Gresshoff PM. 1998. *DNA Markers: Protocols, Applications and Overviews*. Wiley-VCH.

Lehninger LA, Nelson DL & Cox MM. 2008. *Principles of Biochemistry*. 4th Ed. WH Freeman.

Lewin B. 2004. *Genes VII*. International Ed. John Wiley & Sons.

Pasteur N, Pasteur G, Bonhomne F, Catalan J & Britton–Davidian J. 1988. *Practical Isozyme Genetics*. Ellis Horwood.

Sambrook J & Russel WD. 1989. *Molecular Cloning: A Laboratory Manual*. Vols. I-III. Cold Spring Harbor.

Stryer L, Berg JM & Tymocz KJL. 2004. *Biochemistry*. 5th Ed. WH Freeman.

FGB 509 CYTOGENETICS 1+1

Objective

To understand chromosome as the basic unit of heredity

Theory

UNIT I

Introduction, historical background, importance, improved cytogenetic techniques.

UNIT II

Chromosome theory of inheritance: chromosomal models and their ultra structure; Chromosomal movements and position effect.

UNIT III

Sex determination and differentiation, sex chromatin and Lyon's hypothesis; Chromosome numbers in fish and karyotyping.

UNIT IV

Chromosomal aberrations: Genetic and evolutionary implications; Chromosome banding techniques; FISH.

UNIT V

Cytogenetics and evolution; Genotoxicity assays (single cell electrophoresis, MNT, SCE).

Practical

Preparation of chromosome spreads; Karyotyping; Banding techniques; MNT, SCE, Comet Assay.

Suggested Readings

Lakra WS, Abidi SAH, Mukherjee SC & Ayyappan S. 2004. *Fisheries Biotechnology*. Narendra Publ. House.

Pisano E. 2007. *Fish Cytogenetics*. Science Publ.

Reddy PVGK, Ayyappan S, Thampy DM & Krishna G. 2005. *Fish Genetics and Biotechnology*. ICAR.

FGB 510 BIOINFORMATICS 1+1

Objective

To learn the application of information technology for the fish genetics studies.

Theory

UNIT I

Introduction to bioinformatics: history, definition, scope and applications; Fields related to bioinformatics.

UNIT II

Data base: mining tools, submission of DNA sequences; Sequence alignment and database searching, similarity search, FASTA, BLAST.

UNIT III

Information networks: internet; Gene bank sequence database, EBI-net; NCBI, Genome net.

UNIT IV

Genomics: genome diagnostics, genome projects, genome analysis.

UNIT V

Proteomics: protein information resources, primary and secondary protein data bases, analysis packages, predictive methods, ESTs.

UNIT VI

Phylogenetic analysis; Comparative genome analysis; Microarray bioinformatics.

Practical

Internet search: retrieving information from different data base like NCBI, protein information sources; Preparation of data base; Use of genome analysis packages: genetics data base; Searching by similarity; Phylogenetic analysis; Accessing and submission to gene banks; BLAST, sequence alignments, comparisons. Data base: mining tools, submission of DNA sequences; Sequence alignment and database searching, similarity search, FASTA, BLAST.

Suggested Readings

Attwood TK & Smith DJP. 1999. *Introduction to Bioinformatics*. Addison Wesley Longman.

Baxevanis AD & Ouellettee BF. 2002**.** *Bioinformatics, A Practical Guide to the Analysis of Genes and Proteins*. John Wiley & Sons.

Brown SM. 2000. *Bioinformatics: A Biologist's Guide to Biocomputing and the Internet*. Eaton Publ.

Campbell MA & Heyer LJ. 2003. *Discovering Genomics, Proteomics, and Bioinformatics***.** Benjamin Cummings.

Lesk AM. 2008**.** *Introduction to Bioinformatics***.** Oxford University Press.

Mount DW. 2001. *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor Press.

Rashidi HH & Buehler LK. 2005. *Bioinformatics Basics: Applications in Biological Sciences and Medicine*. CRC Press.

FGB 511 COMPUTER APPLICATIONS IN FISH GENETICS 1+1

Objective

To comprehend the use of software packages for genetic data analyses

Theory

UNIT I

File Transfer Protocols; Work stations; Application of spreadsheets in maintaining fish breeding records; Fish breeding data bases.

UNIT II

Introduction to various computer packages used in genetic analyses: SAS, AsREML, PEST, SelAction; Hendersons' models in breeding experiments.

UNIT III

Software for molecular genetics data analysis; Bioinformatics; Bioinformatic applications and tools in fish genetics and breeding; 'R' statistical package.

Practical

Data input, import, export, modification; Spread sheet in breeding data management; Use of ML and Reml packages for various component estimation; Estimation of genetic parameters using various statistical packages like SAS, AsREML, PEST;, SelAction; Molecular data analysis using softwares like GENEPOP.

Suggested Readings

Brown SM. 2000. *Bioinformatics: A Biologist's Guide to Biocomputing and the Internet*. Eaton Publ.

Cody RP & Smith JF. 1997. *Applied Statistics and SAS Programming Language*. Elsevier**.**

Delviche LD & Slaughter JS. 2003. *The Little SAS Book- A Primer*. 3rd Ed. SAS Publ.

Dutkowski G & Gilmour A. 2005. *AsReml Cook Book*. Statistical Software Package.

Littell RC, Milliken GA, Stroup WW & Wolfinger RD. 1996. *SAS System for Mixed Models*. SAS Institute.

Lynch M & Walsh B. 1997. *Genetics and Analysis of Quantitative Traits*. Sinauer, Sunderland.

Saxton AM. 2004. *Genetic Analysis of Complex Traits Using SAS*. SAS Publ.

FGB 512 CELL AND TISSUE CULTURE 1+1

Objective

To impart knowledge on cell and tissue culture techniques and their application in health management, gene banking and genetic characterization.

Theory

UNIT I

Introduction: Structure and Organization of animal cell; Equipments and materials for animal cell culture technology.

UNIT II

Cell lines and media: Primary and established cell line cultures; media supplements – their metabolic functions; serum and protein free defined media and their application.

UNIT III

Cell culture: Basic techniques of cell culture in vitro; development of primary cultures, cell separation, maintenance of cell lines; biology of cultured cells, transformation and differentiation of cell cultures.

UNIT IV

Characterization of cell lines: Measurement of viability and cytotoxicity assays; measuring parameters of growth; karyotyping, isozyme assays, cryopreservation, assessment of contaminants.

UNIT V

Cell cloning: Micromanipulation, cell transformation, application of fish cell culture, scaling-up of cell culture.

UNIT VI

Cell hybridization: Somatic cell fusion, hybridoma technology, Production and Application of monoclonal antibodies.

Practical

Principles of sterile techniques and cell propagation; Preparation of different cell culture media; Primary cell culture techniques; Establishing cell lines: isolation, characterization identification of cell lines; Pure culture techniques; Maintenance and preservation of cell lines; Propagation of cells in suspension cultures; Hybridoma technology: strategy and techniques; Production of monoclonal antibodies.

Suggested Readings

Barnes D & Mathur PJ. 1998. *Methods in Cell Biology*. Vol. 57. *Animal Cell Culture Methods*. Academic Press.

Basega R. (Ed.). 1989. *Cell Growth and Division: A Practical Approach*. IRL Press.

Butler M & Dawson M. (Ed.). 1992. *Cell Culture*. Bios Scientific Publ.

Clynes M. 1998. *Animal Cell Culture Techniques*. Springer.

Freshney I. 1994. *Culture of Animal Cells: A Manual of Basic Techniques*. 4th Ed. Wiley-Liss.

Harrison AM, Rae FI & Harris A. 1997. *General Techniques of Cell Culture*. Cambridge University Press.

Lan FR. 1994. *Culture of Animal Cells*. 3rd Ed. Wiley-Liss.

Masters RW. 2000. *Animal Cell Culture-Practical Approach*. Oxford University Press.

FGB 601 ADVANCES IN FISH BREEDING 2+1

Objective

To learn the recent advances and development of breeding plans.

Theory

UNIT I

Broodstock management; Controlled breeding and reproduction in commercially important fish and shellfish species.

UNIT II

Endocrine control of reproduction; Artificial insemination in shrimp; Synchronisation of spawning; Cryopreservation of gametes.

UNIT III

Estimation of heritability and repeatability; Phenotypic, genetic and environmental correlations; Tagging and maintaining breeding records; Growth curves and their components.

UNIT IV

Influence of non-genetic factors on growth; Factors influencing production and reproductive traits; Crossbreeding and hybridization; Threshold characters and their selection procedure.

UNIT V

Breeding plans to exploit additive and non-additive genetic variation; Maternal influence and its estimation, genetic mechanisms in adaptation, measurement and adaptability indices; G x E interaction.

UNIT VI

Consequences of inbreeding and management of genetic variation in fish breeding programme.

Practical

Heritability estimation; Correlation between different traits; Selection and genetic gains; Inbreeding; Preservation of gametes; Synchronization of spawning; The focus will be on critical review of contemporary applied breeding programmes and journal articles - students are also expected to prepare a term paper for submission at the end of the semester.

Suggested Readings

Doolittle DP. 1987. *Population Genetics: Basic Principles*. Springer-Verlag.

Falconer DS & Markay TFC. 1996. *An Introduction to Quantitative Genetics*. 4th Ed. Addison Wesley Longman.

Kshirsagar MA & Smith WB. 1995 .*Growth Curves*. CRC Press.

Li CC. 1955. *Population Genetics*. University of Chicago Press.

Pirchner F. 1983. *Population Genetics in Animal Breeding*. Plenum Press.

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

FGB 602 SELECTION INDEX METHODOLOGIES 2+1

Objective

To impart knowledge on the efficiency of different selection methods.

Theory

UNIT I

Introduction: Past and present status of fish breeding.

UNIT II

Strain comparison; Factors affecting the rate of genetic improvement; Performance testing.

UNIT III

Correction and standardization of animal breeding data; Simultaneous prediction of breeding values for several animals; Recurrent and Recurrent Reciprocal Selection.

UNIT IV

Prediction of breeding values and environmental effects; LS, BLUP, REML methods, Multivariate Breeding Value Prediction.

UNIT V

Selection based on gene of known large effect: QTL and MAS; Breeding values for binary traits; Selection and breeding for disease resistance and survival analysis; Partial diallele analysis; Selection for single trait and multiple traits.

Practical

Diallele crossing; Estimation of breeding values; Construction of selection index; Least squares and BLUP methods for estimation of genetic and non genetic parameters; Application of various computer software for genetic analyses: SAS, AsREML, PEST, and SelAction; Estimation of genetic parameter, heritability, building of pedigree information.

Suggested Readings

Cameron ND. 1997. *Selection Indices and Prediction of Genetic Merit in Animal Breeding*. CABI.

Doolittle DP.1987. *Population Genetics: Basic Principles*. Springer-Verlag.

Falconer DS & Markay TFC. 1996. *An Introduction to Quantitative Genetics*. 4th Ed. Addison Wesley Longman.
Li CC. 1955. *Population Genetics*. University of Chicago Press.
Lynch M & Walsh B. 1997. *Genetics and Analysis of Quantitative Traits*. Sinauer, Sunderland.
Pirchner F. 1983. *Population Genetics in Animal Breeding*. Plenum Press.
Turner HN & Young SSY. 1969. *Quantitative Genetics in Sheep Breeding*. Cornell University Press.

FGB 603 APPLICATION OF GENETICS IN COMMERCIAL AQUACULTURE 2+1

Objective

To provide knowledge on genetic improvement programmes to critically evaluate the impact on commercial aquaculture.

Theory

UNIT I

Evaluation of international genetic improvement programs like GIFT Tilapia, Norwegian Salmon, Hungarian carp, Pacific White Shrimp *L. vannamei*, etc.

UNIT II

Evaluation of national genetic improvement programs like Jayanti Rohu, Common Carp, Tiger Shrimp *P. monodon*, etc.

UNIT III

Socio-economic impact, technological adoption, increased production.

UNIT IV

Environmental impact of different breeding programmes on indigenous flora and fauna.

Practical

Developing the protocols for evaluating the various genetic improvement programs and their impacts; Preparation of questionnaire to survey; Survey on impact of the programme on farmers; Survey on impact of the programme on the consumers.

Suggested Readings

Kirpichnikov VS. 1981. *Genetic Basis of Fish Selection*. Springer Verlag.
Lutz CG. 2003. *Practical Genetics for Aquaculture*. Wiley-Blackwell.
Lynch M & Walsh B. 1997. *Genetics and Analysis of Quantitative Traits*. Sinauer, Sunderland.
Purdom CE. 1993. *Genetics and Fish Breeding*. Chapman & Hall

FGB 604 RESEARCH METHODOLOGY IN FISH GENETICS 1+1

Objective

To understand integration of the methodologies under various genetic approaches.

Theory

UNIT I

Probability, binomial distribution, multinomial distribution, normal distribution, chi square distribution, student's t distribution, and f distribution.

UNIT II

Testing of genetic hypothesis, test of hypothesis, test for significance, test for significance ratio, detection and estimation of linkage.

UNIT III

Path coefficient and calculation of inbreeding coefficient and relationship, analysis of variance, one way estimation of mean and variance, multiple comparison among means designed contrast, all pair with comparison, comparison with control partition of variance.

UNIT IV

Hierarchical classification.

UNIT V

Component of variance, multi-invested models, factorial experiment-mixed classification single covariate in experimental design; Analysis of multivariate data and non orthogonal data.

UNIT VI

Basic matrix algebra, least square procedure, multiple, regression and correlation.

Practical

Problems in probability, use of chi square, t distribution and f distribution in test statistics, problems in path coefficient and calculation of inbreeding coefficient, ANOVA, single and multiple ways.

Suggested Readings

Biradar RS. 2002. *Course Manual on Fisheries Statistics*. 2nd Ed. CIFE, Mumbai.

Keller G. 2001. *Applied Statistics with Microsoft Excel*. Duxbury.

Kothari CR. 1998. *Research Methodology*. 2nd Ed. Vishwa Prakashan.

Levin RL & Rubin DS. 1983. *Statistics for Management*. Prentice-Hall of India.

Panse VG & Sukhatme PV. 1978. *Statistical Methods for Agricultural Workers*. ICAR.

Siegel, S & Castellan NJ Jr. 1988. *Non Parametric Statistical Methods*. John Wiley & Sons.

FGB 605 ADVANCES IN CYTOGENETICS 2+1

Objective

To understand the advances in cytogenetics and their applications in genetic programmes.

Theory

UNIT I

Chromosomal theory of sex determination, sex differentiation; Diploid number of chromosome in finfish and shellfish; Karyotyping.

UNIT II

Chromosomal aberrations: inherited and induced, structural and numerical; *In-vitro* techniques for chromosome handling.

UNIT III

Chromosome banding: Advanced chromosome banding including Restriction Enzyme banding, fluorescent banding, CMAS3 staining, replication banding; FISH.

UNIT IV

Genotoxicity assays including Sister chromatid exchanges, MNT, commet assay.

UNIT V

Cytogenetics and fish evolution; Cytoplasmic inheritance; Cytogentic application in fish breeding programmes.

Practical

Preparation of chromosome spreads using *in-vivo* and *in-vitro* methods; Karyotyping; Banding methods: G, C NOR, Restriction Enzyme banding; Fluorescent banding, CMAS3 staining, replication banding; Screening the brooders for cytogenetic defects.

Suggested Readings

Lakra WS, Abidi SAH, Mukherjee SC & Ayyappan S. 2004. *Fisheries Biotechnology*. Narendra Publ. House.

McGregor HC & Varley JM. 1983.*Working with Animal Chromosomes*. John Wiley & Sons.

Pisano E. 2007. *Fish Cytogenetics*. Science Publ.

Sharma AK & Sharma A. 1980. *Chromosome Techniques: Theory and Practice*. Butterworths.

Sumner AT. 1990. *Chromosome Banding*. Unwin Hyman.

FGB 606 MOLECULAR BREEDING 2+1

Objective

To learn the advances in molecular breeding and their incorporation in genetic improvement programmes.

Theory

UNIT I

Exploitation of non additive genetic variance; Breeding for disease resistance; Survival analysis.

UNIT II

Application of markers in fish breeding; Identification of QTLs and MAS.

UNIT III

Cryopreservation of gametes and its applications.

UNIT IV

Chromosome and gene manipulation; Cross breeding and hybridization; Maintenance of variation; Radiation hazards.

UNIT V

Genetic evaluation of exotics and quarantine procedures; Patenting methods, IPR issues related to fish genetic innovations.

Practical

Identification of QTLs; Gene mapping; molecular identification of stock; Radiation hazards and effect on genetic compoments, pedigree assigning using molecular data, estimation of genetic parameters using molecular data.

Suggested Readings

Fuller BJ, Benson EE & Lane N. 2004. *Life in the Frozen State*. CRC Press.

Lynch M & Walsh B. 1997. *Genetics and Analysis of Quantitative Traits*. Sinauer, Sunderland.

Nair PR. 2008. *Biotechnology and Genetics in Fisheries and Aquaculture*. Dominant Publ.

Weller JI. 2001. *Quantitative Trait Loci Analysis in Animals*. CABI.

FGB 607 TRANSGENICS PRODUCTION AND GMOs 1+1

Objective

To acquaint with the current status in development of transgenics and their potential commercialisation.

Theory

UNIT I

Principles of transgenic technology and transgenic production, Its application to fisheries; Risk assessment; GMOs and biosafety regulations, gene therapy, designer ornamental fish strains; Biotechnological interventions in fish breeding.

UNIT II

Ethical Issues in GMOs: Cartigan protocol, National regulations on GMOs, Impact assessment of GMOs, transgenic containment.

Practical

Gene transfer experiments; Northern blotting, Southern blotting for integration and expression of transgene; Demonstration of the electropration, microinjection, expression of the marker genes.

Suggested Readings

Celis JE. 1998. *Cell Biology: A Laboratory Handbook*. Academic Press.

Pinkert CA. 1994. *Transgenic Animal Technology: A Laboratory Handbook*. Academic Press.

Stickney RR. 2005. *Aquaculture: An Introductory Text*. CABI.

FGB 608 LINEAR MODELS IN FISH GENETICS 2+1

Objective

To learn the application of linear models in fish breeding data.

Theory

UNIT I

Matrix operations: Determinants, inverse of matrix, linear equations, the matrix algebra of regression analysis.

UNIT II

Analysis of non-orthogonal and multivariate data.

UNIT III

Linear models: Fixed effects, random effects; Mixed models: their application in estimation of genetic parameters; Model building and simulations.

Practical

Matrix operation, matrix inversion, matrix algebra of regression analysis; Analysis of non orthogonal and multivariate data; Least Square analysis in the one way classification; One way classification with regression and covariance; Two way classification with and without interactions; Multiple and nested classification; Maximum likelihood estimation of genetic parameters under linear and non linear models; Use of various statistical packages for genetic parameter estimations: SAS, REML, PEST, SelAction.

Suggested Readings

Dutkowski G & Gilmour A. 2005. *AsReml Cook Book*. Statistical Software Package.

Littell RC, Milliken GA, Stroup WW & Wolfinger RD**.** 1996. *SAS System for Mixed Models*. SAS Institute.

Lynch M & Walsh B. 1997. Genetics and Analysis of Quantitative Traits. Sinauer, Sunderland.

Saxton AM. 2004. *Genetic Analysis of Complex Traits Using SAS*. SAS Publ.

FISH GENETICS AND BREEDING
List of Journals

- Acta Cytologica
- Advances in Genetics Incorporating Molecular Genetic Medicine
- Animal Genetic Resource Information
- Animal Genetics
- Annual Review of Genetics
- Bioinformatics
- Biological Conservation
- BMC Bioinformatics
- BMC Molecular Biology
- Breeding Science
- Briefings in Bioinformatics
- Briefings in Functional Genomics and Proteomics
- Cancer Genetics and Cytogenetics
- Conservation Biology
- Conservation Genetics
- Cytogenetics
- In Silico Biology
- Indian Journal of Agricultural Statistics
- Indian Journal of Cytology and Genetics
- Indian Journal of Genetics and Plant Breeding
- Indian Journal of Statistics
- Journal of Animal Breed and Genetics
- Journal of Animal Science
- Journal of Applied Statistics
- Journal of Bio-Chemistry and Molecular Biology
- Journal of Computational and Graphical Statistics
- Journal of Genetics
- Journal of Heredity
- Journal of Molecular Biology
- Journal of Official Statistics
- Journal of Statistical Software
- Journal of Statistics Education
- Journal of Tissue Culture Methods
- Molecular Cytogenetics
- Molecular and Cellular Biology

Suggested Broad Areas for Master's and Doctoral Research

- Cryopreservation of gametes of species of commercial importance
- Estimation of gene and genotype frequencies using various population genetic tools (markers)
- Estimation of effective population size, inbreeding accumulation rate in a breeding population

- Genetic stock structure analysis; genetic variability studies of species of commercial importance
- Estimation of genetic parameters in species of commercial importance
- Developing breeding plans for different commercial fish and prawn species
- Estimation of genetic parameters in species of commercial importance
- Estimation of heterosis and Inbreeding depression in breeding population
- Construction of growth curves for different commercial fish and prawn species
- Developing breeding plans for different commercial fish and prawn species
- Cryopreservation of gametes of species of commercial importance
- Application of molecular genetic markers for estimation of effective population size, rate of inbreeding
- Estimation of genetic diversity and relatedness using molecular information
- Morphometric analysis of stocks
- Milt quality analysis and cryopreservation of milt
- Estimation of linkage disequilibrium using molecular genetic data
- Application of molecular genetic markers for estimation of effective population size, rate of inbreeding
- Estimation of genetic diversity and relatedness using molecular information
- QTL Analysis and application in selective breeding
- Estimation of linkage disequilibrium using molecular genetic data
- Application of molecular genetic markers for estimation of effective population size, rate of inbreeding
- Estimation of genetic diversity and relatedness using molecular information
- QTL Analysis and application in selective breeding
- Chromosome mapping for different commercial fish and prawn species
- Karyotyping and chromosome spread preparation for different commercial fish and prawn species
- Estimation of genetic parameters using various statistical packages like SAS, AsREML, PEST
- Molecular data analysis using softwares like GENEPOP
- Establishing cell lines
- Construction of growth curves for different commercial fish and prawn species
- Estimation of genetic and non-genetic parameters
- Developing breeding plans for different commercial fish and prawn species
- Cryopreservation of gametes of species of commercial importance
- Developing breeding plans for different commercial fish and prawn species
- Estimation of genetic parameters in species of commercial importance
- Estimation of genotype-environment Interaction
- Estimation of heterosis and Inbreeding depression in breeding population
- Socio-economic impact studies for genetically improved varieties
- Evaluation of International genetic improvement programmes
- Chromosome mapping for different commercial fish and prawn species
- Karyotyping and chromosome spread preparation for different commercial fish and prawn species
- Pedigree assigning using molecular data
- Estimation of genetic parameters using molecular data
- Estimation of genetic and non-genetic parameters using various statistical packages like SAS, AsREML, PEST

FISH NUTRITION AND FEED TECHNOLOGY

Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
FNB 501*	FISH NUTRITION	2+1
FNB 502*#	FISH BIOCHEMISTRY	2+1
FNB 503*	FEED FORMULATION AND FEED TECHNOLOGY	2+1
FNB 504*	NUTRITIONAL ENERGETICS	2+1
FNB 505	NUTRITIONAL REQUIREMENTS AND FEEDING MANAGEMENT	1+1
FNB 506	FEED INGREDIENTS AND ADDITIVES	1+1
FNB 507	NUTRITION AND FEEDING OF CRUSTACEANS	1+1
FNB 508	DIGESTIVE PHYSIOLOGY	1+1
FNB 509	PROTEIN NUTRITION	1+1
FNB 510	LIPID NUTRITION	1+1
FNB 511	CARBOHYDRATE NUTRITION	1+1
FNB 512	VITAMIN AND MINERAL NUTRITION	1+1
FNB 591	MASTER'S SEMINAR	1+0
FNB 599	MASTER'S RESEARCH	20
FNB 601**	BIOENERGETICS	2+1
FNB 602**	ADVANCES IN FEED TECHNOLOGY	2+1
FNB 603**	LARVAL AND BROOD STOCK NUTRITION	2+1
FNB 604	ADVANCES IN NUTRITION	1+1
FNB 605	BIOCHEMICAL ENDOCRINOLOGY	1+1
FNB 606	NUTRIGENOMICS	1+1
FNB 607	NUTRACEUTICALS	1+1
FNB 608	FEED INTAKE AND FEEDING BEHAVIOUR	1+1
FNB 691	DOCTORAL SEMINAR I	1+0
FNB 692	DOCTORAL SEMINAR II	1+0
FNB 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme; ** Compulsory for Doctoral programme
# FNB 502 cross listed with Fish Physiology and Biochemistry FPB 503

FISH NUTRITION AND FEED TECHNOLOGY

Course Contents

FNB 501 FISH NUTRITION 2+1

Objective

To understand the basic principles of fish nutrition and the function of individual nutrients.

To create awareness on feed additives in aquafeed.

Theory

UNIT I

Protein nutrition of fish and shellfish: Introduction, function and metabolism of protein, amino acids and their classification, specific function, protein deficiency symptoms, evaluation criteria of dietary protein.

UNIT II

Lipid nutrition: Introduction, function, metabolism, Fatty acids and their classification, specific functions of essential fatty acids, deficiency symptoms, evaluation of lipid quality.

UNIT III

Carbohydrate nutrition: Introduction, function, metabolism, improvement of carbohydrate utilization by fish.

UNIT IV

Vitamin and mineral nutrition: Introduction, classification, source, functions, deficiency symptoms.

UNIT V

Energy nutrition: Definition, energetics, expression of energy value of feed (gross energy, digestible energy, metabolizable energy, net energy), partitioning of energy, protein energy ratio.

UNIT VI

Larval nutrition: Importance of live feed and artificial feed, Different types of feed available for larvae, constraints and scope; Larval gut morphology and mode of nutrition.

UNIT VII

Brood stock nutrition: Nutrients required for reproduction, egg and sperm quality.

UNIT VIII

Feed additives: Classification, function, and specific use for economic and quality fish and shellfish production.

Practical

Identification of common feed ingredients; Proximate analysis: Moisture, Crude Protein, Crude Lipid, Ash, Acid insoluble ash, Nitrogen free extract of feed fish tissue, Fatty acid analysis, Calcium, Phosphorus content of feed.

Suggested Readings

ADCP (Aquaculture Development and Co-ordination Programme). 1980. *Fish Feed Technology*. ADCP/REP/80/11. FAO, Rome.

De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall.

Guillame J, Kaushik S, Berqot P & Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis.
Halver JE. 1989. *Fish Nutrition*. Academic Press.
Halver JE & Hardy RW. 2002. *Fish Nutrition*. Academic Press.
Halver JE & Tiews KT. 1979. *Finfish Nutrition and Fishfeed Technology*. Vols. I, II. Heenemann.
Hepher B. 1988. *Nutrition of Pond Fishes*. Cambridge University Press.
Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Kluwer.

FNB 502 FISH BIOCHEMISTRY 2+1

Objective

To acquaint students with the biochemical functions of different biomolecules.

Theory

UNIT I

Carbohydrates: Definition, classification and biological significance; Chemical reactions; stereoisomerisms and mutarotation, structure and properties of monosaccharides, disaccharides, polysaccharides and mucopolysaccharides.

UNIT II

Proteins: Definition, classification, biological significance; Structure: primary, secondary, tertiary and quaternary; denaturation. Amino acids: Structure, classification, acid-base properties, stereoisomerisms and chemical reactions.

UNIT III

Lipids: Definition, classification, biological significance. Fatty acids: structure, properties and chemical reactions; steroids; saponification and iodine number, peroxide value of fats. Phospholipids: Structure, properties and functions; prostaglandins, PUFA (polyunsaturated fatty acids).

UNIT IV

Nucleic acids: Structure, functions and properties. Structure of purines, pyrimidine; DNA and RNA; different type of DNA and RNA, Watson and Crick model of DNA.

Practical

Extraction and purification of tissue proteins and lipids. Isolation, purification and characterization of nucleic acids from tissue extract. Qualitative and quantitative analysis of proteins, lipids, carbohydrates and nucleic acids. Quantitative estimation of biomolecules by spectrophotometric methods.

Suggested Readings

Berg JM, Tymoczko JL & Stryer L. 2002. *Biochemistry*. WH Freeman.
Houlihan DF, Carter CG, McCarthy ID & Hochachka PW. 1995. *Biochemistry and Molecular Biology of Fishes*. Elsevier.
Murray RK, Granner DK, Mayes PA & Rodwell VW. 2000. *Harper's Biochemistry*. Appleton & Lange.
Nelson DL & Cox MM. 2005. *Principles of Biochemistry*. WH Freeman.
Voet D, Voet JG & Pratt CW. 2006. *Fundamentals of Biochemistry*. John Wiley & Sons.

FNB 503 FEED FORMULATION AND FEED TECHNOLOGY 2+1

Objective

To learn basic concepts of feed formulation and different feed processing techniques.

Theory

UNIT I

Feed formulation: General principles, different steps of feed formulation, classification of feed ingredients; Energy and protein sources; Evaluation of ingredient quality.

UNIT II

Methods of feed formulation - Pearson's method, quadratic equation, linear programming, limitations.

UNIT III

Types of feed: Dry (pellets, flakes, powdered, micro-encapsulated, micro-bound and micro-coated diets) and non-dry.

UNIT IV

Feed manufacturing units and processes: Pulverizer, grinder, mixer, pelletizer, crumbler, drier, Extruder/ Expander, Vacuum coater, fat sprayer.

UNIT V

Feed storage: Hydro-stability of feed and their storage; Prevention of spoilage from rancidity, fungus and associated toxins; Fish disease vectors in feed and quality control; Feed value in relation to processing; Use of natural and synthetic carotenoids: Feed additives.

UNIT VI

Computerized least cost formula and criterions for aquafeed formulation; Enzyme based fish feeds and their role.

UNIT VII

Feed economics and evaluation criteria: FCR, PER, NPU, EAAI, chemical score, biological value. Aqua feed industries in India.

Practical

Feed formulation exercise; Processing of the ingredients, formulation and preparation of isocaloric and isonitrogenous feeds; Preparation of feeds with various binders in order to determine their hydro-stability; Estimation of trypsin inhibitors, Tannin and HCN in the feed ingredients; Determination of vitamin C and carotenoids in feeds; Preparation of mineral and vitamin premix.

Suggested Readings

ADCP (Aquaculture Development and Co-ordination Programme). 1980. *Fish Feed Technology*. ADCP/REP/80/11. FAO.

D' Abramo LR, Conklin DE & Akiyama DM. 1977. *Crustacean Nutrition: Advances in Aquaculture*. Vol. VI. World Aquaculture Society, Los Angeles.

De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall.

Guillame J, Kaushik S, Berqot P & Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis.

Halver JE & Tiews KT. 1979. *Finfish Nutrition and Fishfeed Technology*. Vols. I, II. Heenemann.

Halver JE. 1989. *Fish Nutrition*. Academic Press.

Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Kluwer.

Muir JF & Robert D. (Eds.). 1968. *Recent Advances in Aquaculture*. Vol. II. Blackwell.

New MB. 1987. *Feed and Feeding of Fish and Shrimp*. *A Manual on the Preparation and Preservation of Compound Feeds for Shrimp and Fish in Aquaculture*. ADCP/REP/87/26 FAO.

FNB 504 NUTRITIONAL ENERGETICS 2+1

Objective

To learn metabolism of different macromolecules and interlinking of different energy producing pathways.

Theory

UNIT I

Introduction to nutritional energetics: Energy budget equation, energy flow in fish and shellfish; Gross energy, digestible energy, metabolizable energy, net energy, heat increment; Factors influencing ingestion, absorption, excretion, respiration, and metabolism and their effect.

UNIT II

Energy requirement: Energy requirement of fish and factors influencing it; Estimation of energy content of feed components based on chemicals composition, indirect and direct methods.

UNIT III

Production and growth : Relationship between feeding and growth; energy exchange in biological system; Methodology for estimating maintenance requirement; growth and reproduction; limitation and prospective of bioenergetics.

UNIT IV

Carbohydrate metabolism: Glycolysis - overview, key structures and reactions, control of glycolysis; TCA cycle: different steps, stoichiometry and control of cycle; Alternate pathways of carbohydrate metabolism: pentose phosphate pathway and gluconeogenesis, glycogen metabolism, regulation of blood glucose.

UNIT V

Lipid metabolism: Fatty acid oxidation and biosynthesis, Generation of acetyl CoA, NADH/NADPH and FADH2, oxidation of unsaturated fatty acids; control of fatty acid metabolism, oxidative phosphorylation: redox potential, respiratory chain and its enzyme system, ATP synthesis.

UNIT VI

Protein and amino acid metabolism: Oxidative degradation of amino acids, transmission and deamination, ammonia carriers and excretion; biosynthesis of non-essential amino acids.

UNIT VII

Intermediary metabolism: Integration of carbohydrate, lipid and protein metabolism.

Practical

Estimation of gross and digestive energy of feed and feed ingredients; Estimation of digestibility of nutrients, Bomb- calorimetry; Energy budget equation based on experiential data supplied; Determination of standard metabolism in fish; End product estimation of aerobic and anaerobic carbohydrates metabolism; Enzyme assay of LDH, aminotransferases, acid phospatase, protease and nucleases; Fatty acid analysis of fish lipids.

Suggested Readings

Berg JM, Tymoczko JL & Stryer L. 2002. *Biochemistry*. WH Freeman.

De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall.

Devlin TM. 1997. *Textbook of Biochemistry with Clinical Correlations*. Wiley-Liss.

Evans DH & Claiborne JB. 2006. *The Physiology of Fishes*. CRC Press.

Florkin M & Mason HS. 1963. *Comparative Biochemistry*. Academic Press.

Halver J & Hardy RW. 2002. *Fish Nutrition*. Academic Press.

Houlihan D, Boujard T & Jobling M. 2001. *Food Intake in Fish*. Blackwell.

Jobling M. 1994. *Fish Bioenergetics*. Chapman & Hall.

Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Kluwer.

Murray RK, Granner DK, Mayes PA & Rodwell VW. 2000. *Harper's Biochemistry*. Appleton & Lange.

Nelson DL & Cox MM. 2005. *Lehninger Principles of Biochemistry*. WH Freeman.

Voet D, Voet JG & Pratt CW. 2006. *Fundamentals of Biochemistry*. John Wiley & Sons.

FNB 505 NUTRITIONAL REQUIREMENT AND FEEDING MANAGEMENT 1+1

Objective

To learn nutritional requirements of commercially important fish and shellfish.

To learn the feeding methods and feed management.

Theory

UNIT I

Experimental diets: Reference diet, purified and semi-purified diet. Methods for studying nutritional requirements in finfish and shellfish; Nutrient requirements of warm water and cold water fish and shellfish, larvae and broodstock of commercially important shellfish and finfish; Requirement of essential and non-essential amino acids and essential fatty acids; Factors affecting nutritional requirements of fish and shellfish.

UNIT II

Body composition of fish and shellfish; Nutritive value of live feed.

UNIT III

Growth evaluation: FCR, absolute growth, relative growth. SGR, % weight gain.

UNIT IV

Feed influence on body composition and quality; Effect of rations on fecundity and egg quality.

UNIT V

Feeding devices, ration size/feeding rate, feeding frequency, restricted feeding and compensatory feeding; Nutritional studies and the problem of applying research findings to farming systems.

UNIT VI

Designing of nutritional experiments: Analysis of experimental data employing complete Random Block Design (CRD), Random Block Design (RBD), t- test and analysis of variance; Experimental culture systems.

Practical

Determination of food intake in fry and fingerlings to ascertain the ration. Purified diet for a fish/prawn to determine protein and lipid requirements. Estimation of growth parameters for biological evaluation. Measures of protein quality. (FCR, PER, NPU, B.V). Mineral mixtures and vitamin premix and exercise on feeding.

Suggested Readings

D' Abramo LR, Conklin DE & Akiama DM 1977. *Crustacean Nutrition: Advances in Aquaculture*. Vol. VI. World Aquaculture SocietyLos Angeles.

De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall.

Guillame J, Kaushik S, Berqot P & Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis.

Halver JE. 1989. *Fish Nutrition*. Academic Press.

Halver JE & Hardy RW. 2002. *Fish Nutrition*. Academic Press.

Halver JE & Tiews KT. 1979. *Finfish Nutrition and Fishfeed Technology*. Vols. I, II. Heenemann.

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Houlihan D, Boujard T & Jobling M. 2001. *Food Intake in Fish*. Blackwell.

Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Kluwer.

New MB. 1987. *Feed and Feeding of Fish and Shrimp*. *A Manual on the Preparation and Preservation of Compound Feeds for Shrimp and Fish in Aquaculture*. ADCP/REP/87/26 FAO. Rome.

NRC (National Research Council). 1993. *Nutrient Requirements of Fish*. National Academy Press, Washington.

FNB 506 FEED INGREDIENTS AND ADDITIVES 1+1

Objective

To learn the requirement and availability of ingredients for aqua-feeds and different types of additives used.

Theory

UNIT I

Introduction: National and international scenario; present production trend and future requirements of feed ingredients.

UNIT II

Ingredient classification: Conventional feed ingredients - protein sources, energy sources; Unconventional feed ingredients - by-products of agro-industry, slaughter house, fruit processing units, seafood industry and forest; Single cell proteins; leaf protein concentrates, gluten meal and grain by-products.

UNIT III

Proximate composition; International coding of feed ingredients; Amino acid profile.

UNIT IV

Anti-nutritional factors: Methods of detection and detoxification.

UNIT V

Feed Processing: Methods; effect of processing on nutritional quality and utilization.

UNIT VI

Storage and quality control: Storage methods; effect of storage on ingredient quality; Factors affecting quality of ingredients; toxins.

Practical

Proximate composition; Estimation of Tannin, Protease inhibitors, HCN, Aflatoxin, Available lysine; Storage studies.

Suggested Readings

ADCP (Aquaculture Development and Co-ordination Programme). 1980. *Fish Feed Technology*. ADCP/REP/80/11. FAO. Rome.

D' Abramo LR, Conklin DE & Akiyama DM. 1977. *Crustacean Nutrition: Advances in Aquaculture.* Vol. VI. World Aquaculture Society, LA.

De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall.

Guillame J, Kaushik S, Berqot P & Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis.

Halver JE & Hardy RW. 2002. *Fish Nutrition*. Academic Press.

Joachim WH & Pascual FP. 2000. *Handbook on Ingredients for Aquaculture Feeds*. Kluwer.

Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Kluwer.

Rechcigl M. 1977. *CRC Handbook Series in Nutrition and Food*. CRC Press.

Rechcigl M. 1983. *Handbook of Nutritional Supplements*. CRC Press.

FNB 507 NUTRITION AND FEEDING IN CRUSTACEANS 1+1

Objective

To study crustacean nutritional requirements, feed formulation and feeding strategy.

Theory

UNIT I

Nutritional requirements: Protein, carbohydrate, lipid, vitamin, mineral, essential amino acid, fatty acid and energy requirements; Requirement changes during various life stages; Methods for determining and factors affecting nutritional requirements.

UNIT II

Food and Feeding : Food and feeding habits, natural food organisms, micro-particulate diets (MBD, MCD, MED, MEM, PARA) for hatcheries; Grow-out and finisher feeds; Broodstock feeds for conditioning and maturation; Role of feed additives in crustacean nutrition.

UNIT III

Digestion and Metabolism: Digestive system of crustaceans; Digestive organs and their role in digestion; Feed ingestion and feeding mechanism; Gastro-intestinal motility; Digestion, absorption and assimilation of nutrients; Digestive enzymes and their role; Factors affecting digestibility.

UNIT IV

Feeding management: Feeding ration, rate and frequency; Feed dispensing methods and devices.

Practical

Study of digestive system of crustaceans; Estimation of digestive enzymes: proteases, amylases and lipases; Feed formulation and preparation; Hydro-stability of feed; *In- vitro* digestibility; Aflatoxin analysis.

Suggested Readings

D' Abramo LR, Conklin DE & Akiama DM 1977. *Crustacean Nutrition: Advances in Aquaculture*. Vol. VI. World Aquaculture SocietyLos Angeles.

De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall.

Guillame J, Kaushik S, Berqot P & Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis.

Halver JE. 1989. *Fish Nutrition*. Academic Press.

Halver JE & Hardy RW. 2002. *Fish Nutrition*. Academic Press.

Halver JE & Tiews KT. 1979. *Finfish Nutrition and Fishfeed Technology*. Vols. I, II. Heenemann.

Hepher B. 1988. *Nutrition of Pond Fishes*. Cambridge University Press.

Houlihan D, Boujard T & Jobling M. 2001. *Food Intake in Fish*. Blackwell.

Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Kluwer.

New MB. 1987. *Feed and Feeding of Fish and Shrimp*. *A Manual on the Preparation and Preservation of Compound Feeds for Shrimp and Fish in Aquaculture*. ADCP/REP/87/26 FAO. Rome.

NRC (National Research Council). 1993. *Nutrient Requirements of Fish*. National Academy Press, Washington.

FNB 508 DIGESTIVE PHYSIOLOGY 1+1

Objective

To learn digestive system of fish and their function.

To learn the basic mechanism of feed intake and digestion process.

Theory

UNIT I

Digestive system of fish and shellfish : Digestive organs and their role; anatomy and histology of alimentary canal; Feed ingestion, feeding mechanism, gastro-intestinal motility.

UNIT II

Digestion and absorption: Digestion of proteins, lipids and carbohydrates; digestibility; absorption and assimilation of energy nutrients, minerals and vitamins.

UNIT III

Digestive enzymes and their kinetics; Transport of nutrients in the body and their conversion; Physiological energetics.

UNIT IV

Regulation of digestion: Digestive hormones and their role in fish and shellfish; Factors affecting digestibility; Acid-base regulation, osmotic and ionic regulation; Nitrogen metabolism and excretion.

UNIT V

Gustatory stimulants and role of feed attractants.

Practical

Dissection and examination of digestive and excretory organs; Histological preparation of digestive organs; Assays of enzyme activity of carbohydrate,

protein and lipid digestion; Determination of digestion and assimilation rates; *In vitro* digestibility study.

Suggested Readings

D' Abramo LR, Conklin DE & Akiyama. DM. 1977. *Crustacean Nutrition: Advances in Aquaculture.* Vol. VI. World Aquaculture Society, LA.

De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall.

Guillame J, Kaushik S, Berqot P & Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis.

Halver JE & Hardy RW. 2002. *Fish Nutrition*. Academic Press.

Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Kluwer.

FNB 509 PROTEIN NUTRITION 1+1

Objective

To understand the importance of protein in aquafeed and relationship of protein with energy.

Theory

UNIT I

Protein and amino acid metabolism - Biosysnthesis of protein; oxidative and non-oxidative degradation of amino acids, transamination and deamination; urea cycle; biosynthesis of non-essential amino acids.

UNIT II

Metabolism: digestion, absorption, digestibility, Factors affecting protein digestibility.

UNIT III

Protein energy inter-relationship (P/E Ratio).

UNIT IV

Protein sources and requirement: Conventional and non-conventional; dietary non-protein nitrogen; Protein requirement for maintenance, growth and reproduction; Factors affecting protein requirement; Methods of requirement study.

UNIT V

Amino acid requirements: Qualitative and quantitative; Synthetic amino acids.

UNIT VI

Evaluation of protein quality (PER, NPU, BV, ANPU, PPV), Amino acid antagonism; Protein deficiency symptoms.

Practical

Extraction and purification of protein. Qualitative and quantitative analysis of proteins; Estimation of crude protein by Microkjeldahl method; Estimation of protein by Lowry's method; Estimation of NPN (urea), total free amino acid, available lysine, amino acids; *In-vitro* protein digestibility.

Suggested Readings

De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall.

Halver JE & Hardy RW. 2002. *Fish Nutrition*. Academic Press.

Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Kluwer.

Wilson K & Walker J. 1995. *Principles and Techniques of Practical Biochemistry*. Cambridge University Press.

FNB 510 LIPID NUTRITION 1+1

Objective

To understand the importance of lipids in aqua feed and the relationship of dietary lipid and tissue lipid.

Theory

UNIT I

Lipid metabolism**:** Biosynthesis and beta oxidation of fatty acids; generation of acetyl CoA, NADH/NADPH and FADH2; control of fatty acid metabolism.

UNIT II

Sources of lipids and fatty acids, lipid digestibility, transport, storage, mobilization, protein sparing effect.

UNIT III

Requirement: Qualitative and quantitative requirement of essential fatty acids, total lipids.

UNIT IV

Role of essential fatty acids, influence of dietary lipid on flesh quality, evaluation of lipid quality, antioxidants, deficiency symptoms.

UNIT V

Concept of designer fish.

Practical

End product estimation of aerobic and anaerobic carbohydrate metabolism (pyruvate and lactate). Enzyme assay for LDH, MDH, ALT, estimation of phospholipids; Estimation of total lipid and free fatty acid, peroxide value, saponification number, iodine value, Estimation of individual fatty acid by GCMS.

Suggested Readings

Berg JM, Tymoczko JL & Stryer L. 2002. *Biochemistry*. WH Freeman.

De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall.

Halver J & Hardy RW. 2002. *Fish Nutrition*. Academic Press.

Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Kluwer.

Murray RK, Granner DK, Mayes PA & Rodwell VW. 2000. *Harper's Biochemistry*. Appleton & Lange.

NRC (National Research Council). 1993. *Nutrient Requirements of Fish*. National Academy Press, Washington.

Voet D, Voet JG & Pratt CW. 2006. *Fundamentals of Biochemistry*. John Wiley & Sons.

FNB 511 CARBOHYDRATE NUTRITION 1+1

Objective

To understand the importance of carbohydrate in aquafeed and the relationship of dietary carbohydrate and lipid.

Theory

UNIT I

Carbohydrate metabolism: Glycolytic pathway, TCA cycle and Pentose phosphate pathways, Gluconeogenesis, glycogenesis and glycogenolysis.

UNIT II

Sauces of carbohydrates, digestibility, Factors affecting starch utilization, carbohydrate and interaction with other nutrients and protein sparing effect.

UNIT III

Constraints of carbohydrate utilization in fish, Strategy to enhance carbohydrate utilization: gelatinization, exogenous amylases, glucose intolerance, carbohydrates and immunity.

UNIT IV

Carbohydrate utilization for low cost feed.

Practical

Estimation of starch gelatinization in different feed processing methods; Blood glucose estimation; *In vitro* starch digestibility; Available lysine estimation, Estimation of crude fibre, cellulose and lignin content of feed.

Suggested Readings

D' Abramo LR, Conklin DE & Akiama DM 1977. *Crustacean Nutrition: Advances in Aquaculture*. Vol. VI. World Aquaculture SocietyLos Angeles.

De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall.

Guillame J, Kaushik S, Berqot P & Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis.

Halver JE. 1989. *Fish Nutrition*. Academic Press.

Halver JE & Hardy RW. 2002. *Fish Nutrition*. Academic Press.

Halver JE & Tiews KT. 1979. *Finfish Nutrition and Fishfeed Technology*. Vols. I, II. Heenemann.

Hepher B. 1988. *Nutrition of Pond Fishes*. Cambridge University Press.

Houlihan D, Boujard T & Jobling M. 2001. *Food Intake in Fish*. Blackwell.

Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Kluwer.

New MB. 1987. *Feed and Feeding of Fish and Shrimp. A Manual on the Preparation and Preservation of Compound Feeds for Shrimp and Fish in Aquaculture*. ADCP/REP/87/26 FAO. Rome.

NRC (National Research Council). 1993. *Nutrient Requirements of Fish*. National Academy Press, Washington.

FNB 512 VITAMIN AND MINERAL NUTRITION 1+1

Objective

To learn the structure and functions of different vitamins and minerals.

Theory

UNIT I

Vitamins:Structure and properties of water and fat soluble vitamins; Vitamin as coenzymes and prosthetic groups of enzymes.

UNIT II

Vitamin requirements for different species, Dietary sources of vitamins, Factors affecting vitamin requirements, Losses of vitamin during feed processing.

UNIT III

Metabolic changes associated with hypo- and hyper-vitaminosis. Biosynthesis of vitamins; Manifestation of vitamin deficiency; Vitamin – mineral interactions.

UNIT IV

Minerals: Macro, micro and toxic minerals.

UNIT V

Mineral requirements for different aquaculture species, Dietary sources of minerals, Factors affecting mineral requirement, Nutrient-minerals interaction; Manifestation of mineral deficiency.

Practical

Estimation of calcium, phosphorus, magnesium, Iron, Vitamin C, Preparation of vitamin and mineral premix, Estimation of vitamion and mineral loss due to leaching.

Suggested Readings

Berg JM, Tymoczko JL & Stryer L. 2002. *Biochemistry*. WH Freeman.

Conn EE & Stumpf PK. 1966. *Outlines of Biochemistry*. John Wiley & Sons.

Devlin TM. 1997. *Textbook of Biochemistry with Clinical Correlations*. Wiley-Liss.

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Murray RK, Granner DK, Mayes PA & Rodwell VW. 2000. *Harper's Biochemistry.* Appleton & Lange.

Nelson DL & Cox MM. 2005. *Principles of Biochemistry*. WH Freeman.

Smith EL, Hill RL, Lehman IR, Lefkowitz RJ, Handler P & White A. 1983. *The Principles of Biochemistry*. McGraw-Hill.

Voet D, Voet JG & Pratt CW. 2006. *Fundamentals of Biochemistry*. John Wiley & Sons.

FNB 601 BIOENERGETICS 2+1

Objective

To understand metabolism of biomolecules, metabolic process and energy production.

Theory

UNIT I

Energy requirements of fish: Principles and methods; factors affecting energy requirement; energy budgeting, metabolic rate and factors affecting it; respiration and metabolism; metabolic scope.

UNIT II

Energetics of feeding and digestion; relationship between feeding and growth; Energy requirements for reproduction; energy content of gonads and gametes; Energetics of gonadal maturation and gamete production.

UNIT III

Scope of intermediary metabolism - triglycerides as energy source; *de novo* synthesis, transport and modification of fatty acids in finfish and shellfish; enzymes required for oxidation of poly-unsaturated fatty acids, formation of propionyl CoA in oxidation of odd chain fatty acids, biosynthesis of n-3 and n-6 fatty acids; role of desaturases and elongases; biosynthesis of triglycerides, phospholipids, sphingolipids and cholesterol.

UNIT IV

Coordinated regulation of glycogen synthesis and breakdown; glycogen targeting protein; glycolysis and its control by phosphorylase, phosphofructokinase, hexokinase and pyruvate kinase; feeder pathways for glycolysis; TCA cycle and anabolism; gluconeogenesis and its regulation;

relationship between glyoxylate and TCA cycle; oxidative and non-oxidative pentose phosphate pathway; electron transport chain and its enzyme system. ATP synthesis.

UNIT V

Oxidative degradation of amino acids; transmination and deamination; ammonia carriers, excretion and urea cycle; biosynthesis of non-essential amino acids and catabolic pathways for amino acids; synthesis of deoxy and ribonucleotides; uric acid production; derivation of nucleotide groups of CoA, NAD, FAD from ATP; integration and regulation of lipid carbonhydrate and protein metabolism in fishes.

Practical

Estimation of oxygen consumption; Estimation of gross energy and digestible energy of feed; Comparision of energy requirements of carnivorous, herbivorous and omnivorous fish; Extraction, hydrolysis and fractionation of proteins and lipids; Assay of mitochondrial and cytoplasmic enzymes; Estimation of total and free cholesterol.

Suggested Readings

De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall.

Evans DH & Claiborne JB. 2006. *The Physiology of Fishes*. CRC Press.

Halver JE & Hardy RW. 2002. *Fish Nutrition*. Academic Press.

Houlihan D, Boujard T & Jobling M. 2001. *Food Intake in Fish*. Blackwell.

Jobling M. 1994. *Fish Bioenergetics*. Chapman & Hall.

Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Kluwer.

FNB 602 ADVANCES IN FEED TECHNOLOGY 2+1

Objective

To study the quality of feed ingredients and their uses in feed preparation.

To understand production of different types of feeds.

Theory

UNIT I

Feed formulation: Least cost formulation, linear programming; quality of feed ingredients and their biochemical composition; protein and energy supplements; premixes of vitamins and minerals; antioxidants in diets; toxins in feeds; exogenous enzymes; in feed probiotics and their role. Feed additives. Water stability of diets.

UNIT II

Feed processing machineries; feed manufacture: processing of feed mixtures, steam pelleting, extrusion marumarization spray beadlts; stability of nutrients; factors affecting feed manufacture; effects of processing on the nutritional value of feeds; processes of reducing anti-nutritional factors; feed mills and their design; quality control of feed; storage of feed and feed deterioration; economics of feed manufacturing.

Practical

Analysis of anti-nutritional and toxic substances in feed ingredients and feed;formation of diets using software. Preparation of different types of feed and their quality evaluation; Effect of feed storage on nutritional value of feed.

Suggested Readings

ADCP (Aquaculture Development and Co-ordination Programme). 1980. *Fish Feed Technology*. ADCP/REP/80/11. FAO. Rome.

D' Abramo LR, Conklin DE & Akiama DM 1977. *Crustacean Nutrition: Advances in Aquaculture*. Vol. VI. World Aquaculture SocietyLos Angeles.

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Muir JF & Robert D. (Eds.). 1968. *Recent Advances in Aquaculture*. Vol. II. Blackwell.

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NRC (National Research Council). 1993. *Nutrient Requirements of Fish*. National Academy Press, Washington.

FNB 603 LARVAL AND BROODSTOCK NUTRITION 2+1

Objective

To understand critical phase of larval rearing and specific role of nutrients in reproduction.

Theory

UNIT I

Nutrient requirement of larvae and broodstock; live feed and their nutritional quality; nutrient enrichment of live feed; ontogeny of digestive enzymes in larvae; different types of artificial feed; larval artificial diets - microencapsulated, microbound, microcoated; feeding management; feeding devices and strategies.

UNIT II

Feeding methods: manual, mechanical and automatic feeding; factors affecting feeding behavior (Gustatory stimulants, feeding deterrents, weaning); larval development, deficiency deformities and survival. Economics of larval and broodstock feed and feeding.

Practical

Preparation of larval feed. Methods of feeding larvae and calculation of FCR. Nutritional analysis of live food organisms. Estimation of proteases in larvae. Estimation of gonado-somatic index and fecundity.

Suggested Readings

CIFE. 1993. *Training Manual on Culture of Live Food Organisms for Aqua Hatcheries*. Central Institute of Fisheries Education, Versova, Mumbai.

De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall.
Guillame J, Kaushik S, Berqot P & Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis.
Hagiwara A, Snell TW, Lubzens E & Tamaru CS. 1997. *Live Food in Aquaculture*. Proceedings of the Live Food and Marine Larviculture Symposium. Kluwer.
Halver JE & Hardy RW. 2002. *Fish Nutrition*. Academic Press.
Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Kluwer.

FNB 604 ADVANCES IN NUTRITION 1+1

Objective

To study the mechanism of feed intake, feeding behavior and the concept eco-friendly feed.

Theory

UNIT I

Feeding behavior; feed intake and environment; techniques of measuring feed intake. Regulation of feed intake by neuropeptides and hormones; stimulatory peptides, inhibitory peptides; identification of gustatory feeding stimulants; Nutrient receptors and transporters hormonal control of metabolism.

UNIT II

Low cost and eco-friendly diets; optimization of carbohydrates in diets; strategies for improving protein retention; Feeding standards. Tracer techniques in fish nutrition.

UNIT III

n-3 and n-6 fatty acids, their functions and deficiencies, fatty acid oxidation and antioxidants; phospholipids; Feed and flesh quality.

UNIT IV

Effect of artificial diets on digestive processes in larvae and juveniles; dietary role in growth and reproduction.

UNIT V

Recent advances in feed additives, product quality. Feeds for flesh quality.

Practical

Protein quality estimation (PER, NPU). Digestibility studies. Estimation of fatty acids.

Suggested Readings

ADCP (Aquaculture Development and Co-ordination Programme). 1980. *Fish Feed Technology*. ADCP/REP/80/11. FAO. Rome.
De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall.
Guillame J, Kaushik S, Berqot P & Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis.
Halver JE. 1989. *Fish Nutrition*. Academic Press.
Halver JE & Hardy RW. 2002. *Fish Nutrition*. Academic Press.
Halver JE & Tiews KT. 1979. *Finfish Nutrition and Fishfeed Technology*. Vols. I, II. Heenemann.
Hepher B. 1988. *Nutrition of Pond Fishes*. Cambridge University Press.
Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Kluwer.

FNB 605 BIOCHEMICAL ENDOCRINOLOGY 1+1

Objective

To understand the biochemical mechanism of endocrine function.

To understand the role of hormones on growth and metabolism.

Theory

UNIT I

Biochemical structures and properties of different hormones; Endocrine glands in fish and shellfish.

UNIT II

Hormonal regulation of calcium and phosphorous metabolism; Role of ecdysone in moulting.

UNIT III

Reproductive hormones (hypothalamus, pituitary, gonads), digestive and metabolic hormones; Role of pineal hormones; Mechanism of hormone action; Role of c-AMP, c-GMP and calcium in hormone action; Hormonal imbalances.

Practical

Gross and histological studies of finfish and shellfish endocrine glands; Characterization of growth hormone gene from pituitary genomic DNA.

Suggested Readings

Fingerman M, Nagabhushanam R & Thompson MF. 1997. *Recent Advances in Marine Biotechnology*. Vols.I-III. Oxford & IBH.

Hoar WS & Randal DJ. 1969. *Fish Physiology*. Academy Press.

Lehninger AL. 1984. *Principles of Biochemistry*. CBS.

Primrose SB. 1989. *Modern Biotechnology*. Blackwell.

Rodney B. 1998. *Concepts in Biochemistry*. Cole Publ. Co.

FNB 606 NUTRIGENOMICS 1+1

Objective

To study nutritionally important genes and their interactions with nutrients.

To acquaint with the basics in molecular nutrition.

Theory

UNIT I

Relevance of molecular studies in nutrition; terminologies in molecular nutrition; cell culture; nutritionally important genes; gene regulation by lipids and carbohydrates; metabolic control analysis; methodologies in molecular nutrition.

UNIT II

Tanscriptomics, proteomics and metabolomics; Nutrient-gene interaction and expression; reverse transcription and cDNA biosynthesis; Fluorescent labelled probe preparation; microarray technique.

UNIT III

Use of robotics in microarray; microarray nitrocellulose hybridization and labelling with P^{32} probes; quantitative real time polymerase chain reaction. (qRT PCR); gene expression software; relative expression software tool (REST); interpretation of microarray data; cloning technique.

Practical

RNA extraction and isolation; Purification and preparation of m-RNA from RNA pool by Oligo dT; DNAse treatment for quality improvement of

RNA; cDNA synthesis by reverse transcription; Elution of PCR product for gene sequencing; Cloning.

Suggested Readings

Fingerman M, Nagabhushanam R & Thompson MF. 1997. *Recent Advances in Marine Biotechnology*. Vols. I-III. Oxford & IBH.

Glick BR & Pasternak JJ. 1999. *Molecular Biotechnology: Principles and Applications of Recombinant DNA Technology*. ASM Press.

Hoar WS & Randal DJ. 1969. *Fish Physiology*. Academy Press.

Lehninger AL. 1984. *Principles of Biochemistry*. CBS.

Primrose SB. 1989. *Modern Biotechnology*. Blackwell.

Rodney B. 1998. *Concepts in Biochemistry*. Cole Publ. Co.

FNB 607 NUTRACEUTICALS 1+1

Objective

To get a comprehensive knowledge about nutraceuticals used in aquaculture and their delivery system.

Theory

UNIT I

Definition, classification and role of different neutraceticals; mode of application; functions of acidifiers (citric acid, propionic acid, benzoic acid).

UNIT II

Exogenous enzymes (phytase, carbohydrase, proteinase) and nutrient utilisation; prebiotics and probiotics; Single cell proteins as nutraceuticals; antioxidants and their functions.

UNIT III

Chemoattractants for fish and shellfish; fish based neutraceticals and their application; designer fish.

UNIT IV

Immunostimulants and their functions (nucleotide, manan oligosaccharides, beta glucan, levan, bovine lactoferine, sodium alginate, levamisol).

Practical

Estimation of phytase and phytate. Effect of acidifiers on pH in different parts of GI tract. Estimation of antioxidants vitamin E and vitamin C. Estimation of n-3 fatty acid.

Suggested Readings

De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall.

Guillame J, Kaushik S, Berqot P & Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis.

Halver JE & Hardy RW. 2002. *Fish Nutrition*. Academic Press.

Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Kluwer.

FNB 608 FEED INTAKE AND FEEDING BEHAVIOUR 1+1

Objective

To learn different methods of analyzing feed intake and effect of nutritional factors.

Theory

UNIT I

Gustation and feeding behaviour: peripheral gestation sensation, gustatory pathways in the central nervous system, taste and feeding behavior.

UNIT II

Feed intake: different techniques of feed intake: stomach content analysis, chemical markers, direct observation and video recording, demand feeder, X-radiography, Factors affecting feed intake, effect of feeding time on feed intake and growth, Effect of nutritional factors and feed characteristics on feed intake.

UNIT III

Regulation of feed intake: Nuropeptides and hormones, Inhibitory peptides, stimulator peptides, growth hormones.

UNIT IV

Physiological effect of feeding: Different methods of feeding, short terms effects of meal, tissue metabolic physiology, long term effect of food intake; feeding frequencies.

Practical

Measurement of feed intake by chemical marker, Feed intake measurement with respect to temperature, Experiment on feeding stimulant, Feed intake and blood glucose co-relation, Comparative intake of natural vs artificial feed.

Suggested Readings

De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman & Hall.

Guillame J, Kaushik S, Berqot P & Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis.

Halver JE. 1989. *Fish Nutrition*. Academic Press.

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Hepher B. 1988. *Nutrition of Pond Fishes*. Cambridge University Press.

Houlihan D, Boujard T & Jobling M. 2001. *Food Intake in Fish*. Blackwell.

Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Kluwer.

FISH NUTRITION AND FEED TECHNOLOGY

List of Journals

- Analytical Biochemistry
- Animal Feed Sciences and Technology
- Animal Nutrition and Feed Technology
- Annals of Nutrition and Metabolism
- Annual Review of Nutrition
- Annual Review of Physiology
- Applied Aquaculture
- Aquaculture
- Aquaculture Nutrition
- Aquaculture Research
- Asia-Austalasian Journal of Animal Science
- British Journal of Nutrition
- Canadian Journal of Biochemistry
- Gene and Development
- Indian Journal of Animal Nutrition
- Israel Journal of Aquaculture- Bamidgeh
- 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

Suggested Broad Areas for Master's and Doctoral Research

- Quantitative estimation of feed intake: natural vs artificial feed
- Digestibility of natural and artificial feed
- Energetics of utilization of natural and artificial feed
- Energetics of utilization of animal vs plant ingredients
- Energetics of growth vs reproduction
- Feeding standards for cultivable species
- Feeding strategy to eliminate waste
- Utilization of refinery waste as single cell protein
- Farmer friendly methods for detoxification of anti-nutritional factors
- Immunostimulants and growth promoters
- Redefining protein-energy ratio in shrimp diet with respect to salinity
- Digestibility due to plant to animal ingredient ratio
- Enhancement of digestibility of plant feed ingredients
- Reduction of dietary protein content through amino acid balance
- Optimizing protein to lipid, protein to carbohydrate content in fish and shrimp diets
- Dietary lipid source and flesh lipid quality

- Optimizing PUFA and HUFA content in individual species
- Impact of lipid peroxidation on growth and flesh quality
- Starch utilization and immunity status
- Optimization of gelatinized to non-gelatinized starch content in feed
- Sources of carbohydrate and their utilization
- Study the key enzymes for carbohydrate metabolism
- Development of species specific vitamin and mineral premix
- Energy utilization from carbohydrate sources
- Enzyme coating and feed additives in pelleted feed
- Low cost microencapsulated, microcoated and microbound diets
- Fortification of larval and broodstock diets
- Utilization of unconventional ingredients
- Nutritional contribution of natural food for growth
- Nutritional comparison of natural and artificial feed
- Biochemical mechanism of endocrine function
- Hormonal regulation of calcium and phosphorous metabolism
- Immunostimulants/ Immunomodulators
- Gene regulation by lipids and carbohydrates
- Fasting , feed intake and nutrient utilization

FISH PHYSIOLOGY AND BIOCHEMISTRY

Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
FPB 501*	PHYSIOLOGY OF DIGESTION, GROWTH AND ENERGETICS	2+1
FPB 502*	REPRODUCTIVE PHYSIOLOGY AND ENDOCRINOLOGY	2+1
FPB 503*#	FISH BIOCHEMISTRY	2+1
FPB 504*	METABOLISM OF BIOMOLECULES	2+1
FPB 505	CARDIOVASCULAR SYSTEM AND RESPIRATORY PHYSIOLOGY	2+1
FPB 506	IMMUNOBIOLOGY	1+1
FPB 507	CELLULAR AND MOLECULAR PHYSIOLOGY	2+1
FPB 508	SENSORY PHYSIOLOGY	1+1
FPB 509	PHYSIOLOGY OF FISH BEHAVIOUR	1+1
FPB 510	PHARMACO-BIOLOGY OF AQUACULTURE DRUGS	1+1
FPB 511	PHYSIOLOGY OF EXCRETION AND OSMOREGULATION	1+1
FPB 512	ECOPHYSIOLOGY OF FISHES	1+1
FPB 513	TOOLS AND TECHNIQUES IN BIOCHEMISTRY	1+1
FPB 514	BIOCHEMISTRY OF ENZYMES, VITAMINS, MINERALS AND HORMONES	2+1
FPB 515	DIAGNOSTIC BIOCHEMISTRY	1+1
FPB 591	MASTER'S SEMINAR	1+0
FPB 599	MASTER'S RESEARCH	20

* Compulsory for Master's programme

FPB 503 cross listed with Fish Physiology and Biochemistry FNB 502

FISH PHYSIOLOGY AND BIOCHEMISTRY

Course Contents

FPB 501 PHYSIOLOGY OF DIGESTION, GROWTH AND ENERGETICS 2+1

Objective

To acquaint students with the various aspects of growth and energy budget in fish and shellfish.

Theory

UNIT I

Growth: Concept of growth, Determination of age and growth, Growth curve, Correlation of growth with body weight and length, Metabolism (anabolism and catabolism) and growth, Biotic and abiotic factors affecting growth, Role of minerals, vitamins and hormones in the regulation of growth, Influence of nutrients in growth stimulation.

UNIT II

Food and feeding biology: Components of balanced food, Ingestion of food and feeding mechanism.

UNIT III

Digestive system in fish and shell fish: Anatomy, histology and functions of different parts of gastro-intestinal tract in herbivores and carnivores, Modification of digestive system in relation to growth.

UNIT IV

Physiology of Digestion: Digestion of carbohydrates, lipid and proteins, Digestive enzymes and regulation of their secretions, Absorption and assimilation of nutrients, Role of hormones in the regulation of digestion, Factors affecting digestion and transport of nutrients.

Practical

Analysis of gut content; Estimation of amylase, AST and ALT; Estimations of pH in different parts of GI tract. Estimation of carbohydrate, protein and lipid splitting enzymes. Determination of growth and age by otolith and fish scale analysis.

Suggested Readings

Evans DH & Claiborne JB. 2006. *The Physiology of Fishes*. CRC Press.

Hoar WS & Randall DJ.1988. *Fish Physiology*. Academic Press.

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

Prosser CL. 1950. *Comparative Animal Physiology*. WB Saunders.

Shadwick RE & Lauder GV. 2006. *Fish Biomechanics*. Academic Press.

FPB 502 REPRODUCTIVE PHYSIOLOGY AND ENDOCRINOLOGY 2+1

Objective

To understand the basic concepts of reproduction in fish and reproductive technology.

Theory

UNIT I

Anatomy and histology of testes and ovary in fish and shellfish.

UNIT II

Sexual dimorphism, primary and secondary sex characters, bisexual reproduction, inter-sexes, hermaphroditism, Sex differentiation and factors affecting sex differentiation. Sex reversal in fish, factors affecting sex reversal.

UNIT III

Development of gonad, oogenesis; spermatogenesis, metabolic changes during oogenesis and spermatogenesis, vitellogenesis and gonadal steroidogenesis.

UNIT IV

Annual reproductive cycle and breeding patterns in male and female. Pheromones and reproductive behaviour, parental care.

UNIT V

Regulation of seasonal reproduction: Role of environment (photoperiod, temperature, rainfall), Role of hypothalamo-hypophyseal system and pineal gland, role of peripheral endocrine system, role of nutrition. Mechanism of oocyte maturation and ovulation.

UNIT VI

Reproductive technology: Hypophysation and Induced breeding, cryopreservation of gametes and artificial fertilization. Application of biotechnology for accelerating gonadal growth and manipulation of the duration of spawning. *In vitro* maturation of oocyte and transgenic fish. Neuro-endocrine system in crustacean and molluscs and its role in the regulation of reproduction.

Practical

Dissection and display of reproductive system (male and female). Identification of primary and secondary sex characters. Estimation of fecundity, gonadosomatic index (GSI), extraction of hormones, isolation, purification and characterization.

Suggested Readings

Evans DH & Claiborne JB. 2006. *The Physiology of Fishes*. CRC Press.

Hoar WS & Randall DJ.1988. *Fish Physiology*. Academic Press.

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

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

FPB 503 FISH BIOCHEMISTRY 2+1

Objective

To acquaint students with the biochemical functions of different biomolecules.

Theory

UNIT I

Carbohydrates: Definition, classification and biological significance; Chemical reactions; stereoisomerisms and mutarotation, structure and properties of monosaccharides, disaccharides, polysaccharides and mucopolysaccharides.

UNIT II

Proteins: Definition, classification, biological significance; Structure: primary, secondary, tertiary and quaternary; denaturation. Amino acids:

Structure, classification, acid-base properties, stereoisomerisms and chemical reactions.

UNIT III

Lipids: Definition, classification, biological significance. Fatty acids: structure, properties and chemical reactions; steroids; saponification and iodine number, peroxide value of fats. Phospholipids: Structure, properties and functions; prostaglandins, PUFA (polyunsaturated fatty acids).

UNIT IV

Nucleic acids: Structure, functions and properties. Structure of purines, pyrimidine; DNA and RNA; different type of DNA and RNA, Watson and Crick model of DNA.

Practical

Extraction and purification of tissue proteins and lipids. Isolation, purification and characterization of nucleic acids from tissue extract. Qualitative and quantitative analysis of proteins, lipids, carbohydrates and nucleic acids. Quantitative estimation of biomolecules by spectrophotometric methods.

Suggested Readings

Berg JM, Tymoczko JL & Stryer L. 2002. *Biochemistry.* WH Freeman.

Houlihan DF, Carter CG, McCarthy ID & Hochachka PW. 1995. *Biochemistry and Molecular Biology of Fishes*. Elsevier.

Murray RK, Granner DK, Mayes PA & Rodwell VW. 2000. *Harper's Biochemistry*. Appleton & Lange.

Nelson DL & Cox MM. 2005. *Principles of Biochemistry*. WH Freeman.

Voet D, Voet JG & Pratt CW. 2006. *Fundamentals of Biochemistry*. John Wiley & Sons.

FPB 504 METABOLISM OF BIOMOLECULES 2+1

Objective

To learn the metabolism of different biomolecules.

Theory

UNIT I

Carbohydrate metabolism :Glycogenesis, glycolysis and their control, TCA cycle: different steps, stoichiometry and control, Alternate pathways of carbohydrate metabolism, Pentose phosphate pathway and guconeogenesis, Glycogen metabolism, Regulation of blood glucose level, Oxidative phosphorylation, Redox potential, Respiratory chain and its enzyme system; ATP synthesis.

UNIT II

Lipid metabolism: Biosynthesis and beta oxidation of fatty acids, Generation of acetyl CoA, NADH/NADPH and $FADH_2$, Control of fatty acid metabolism.

UNIT III

Protein and amino acid metabolism: Biosynthesis of protein; Oxidative and non-oxidative degradation of amino acids, transamination and deamination, Urea cycle, Biosynthesis of non-essential amino acids.

UNIT IV

Nucleic acids metabolism: Purine and pyrimidine metabolism, Biosynthesis of deoxyribonucleotides and ribonucleotides.

UNIT V

Intermediary metabolism: Integration of carbohydrate, lipid and protein metabolism.

Practical

End product estimation of aerobic and anaerobic carbohydrate metabolism (pyruvate and lactate). Enzyme assay for LDH, MDH, ALT and nucleases. Estimation of phospholipids. Estimation of tissue protein. Estimation of blood glucose. Estimation of tissue lipid.

Suggested Readings

Conn EE & Stumpf PK. 1987. *Outline of Biochemistry*. Wiley.

Houlihan DF, Carter CG, McCarthy ID & Hochachka PW. 1995. *Biochemistry and Molecular Biology of Fishes*. Elsevier.

Murray RK, Granner DK, Mayes PA & Rodwell VW. 2000. *Harper's Biochemistry*. Appleton & Lange.

Nelson DL & Cox MM. 2005. *Principles of Biochemistry*. WH Freeman.

FPB 505 CARDIO-VASCULAR SYSTEM AND RESPIRATORY PHYSIOLOGY 2+1

Objective

To impart knowledge on the dynamics of cardiovascular system and adaptation of the salt transporting mechanism in fish and their physiology.

Theory

UNIT I

Types of heart, morphological structure, blood vascular system. Lymph and lymphatic circulation. Regulation of cardiac activity, Neural and autoregulatory control of heart and haemodynamics, cardiac output, circulation time, blood pressure.

UNIT II

Definition of respiration, basal metabolic rate (BMR), external respiration, internal respiration. Types of respiratory organs, gill structure.

UNIT III

Respiratory pigments and their functions.

UNIT IV

Mechanism of gaseous exchange, CO_2 transport, countercurrent principle, water flow across the gills, respiratory pumps, pump musculature and skeleton, ammonia quotient. Chloride cells and their role in respiration.

UNIT V

Respiratory metabolism, energy budget and expenditure in relation to environmental conditions and stress.

UNIT VI

Metabolic effects in response to environmental factors (biotic and abiotic).

UNIT VII

Hypoxia and metabolic rate, anoxic layers and habitats. Oxygen requirements at larval stages.

Practical

Assay of Na^+-K^+ ATPase activity. Study of rate of oxygen consumption in relation to abiotic factors (pH, temperature, salinity). Differential count of blood cells and estimation of haemoglobin concentration, haematocrit value.

Suggested Readings

Chavin W. (Ed.). 1973. *Responses of Fish to Environmental Changes***.** Charles C Thomas Publ**.**

Evans DH & Claiborne JB. 2006. *The Physiology of Fishes*. CRC Press.

Hoar WS & Randall DJ. 1988. *Fish Physiology*. Academic Press.

Prosser CL. 1950. *Comparative Animal Physiology*. WB Saunders.

Rankin JC & Pitcher TJ.1983. *Control Processes in Fish Physiology*. Springer.

FPB 506 IMMUNOBIOLOGY 1+1

Objective

To understand different aspects of immunostimulants and their effect on fish immunity, stress resistance and disease resistance.

Theory

UNIT I

Basic principles of immune system in fishes and shell fishes.

UNIT II

Cell and organ involved in immunity.

UNIT III

Humoral and cell mediated immunity, Mechanism of immunity. Cytokines, interferon, lymphokine, chemokines, their role in immune response.

UNIT IV

Immunoprophylaxis, toxin, toxoid and vaccines. Immuno-stimulant, immunomodulation.

UNIT V

Biosynthesis of antibody. Endocrine control of immune system.

UNIT VI

Role of nutraceuticals *viz.,* levan, β-glucan, w_3- fatty acid, levanisole, nucleotide, alginates, bovine lactoferine, etc. on fish/ shellfish immunity and mechanism of their action.

UNIT VII

Principles of stress resistance, stress tolerance. Challenge study.

Practical

Lysozyme activity. Estimation of NBT. Estimation of CBC. Estimation of prophenol oxidase. Estimation of superoxide dismutase. Estimation of IgM.

Suggested Readings

Conn EE & Stumpf PK. 1987. *Outline of Biochemistry*. Wiley.

Evans DH & Claiborne JB. 2006**.** *The Physiology of Fishes*. CRC Press.

Houlihan DF, Carter CG, McCarthy ID & Hochachka PW. 1995. *Biochemistry and Molecular Biology of Fishes.* Elsevier.

Iwama G & Nakanishi T. 1996. *The Fish Immune System. Organism, Pathogen and Environment*. Academic Press.

Murray RK, Granner DK, Mayes PA & Rodwell VW. 2000. *Harper's Biochemistry*. Appleton & Lange.

Van Oss CJ & Van Regenmortel MHV. 1994. *Immunochemistry*. CRC Press.

FPB 507 CELLULAR AND MOLECULAR PHYSIOLOGY 2+1

Objective

To acquaint students with the cellular signaling cascades and other various molecular physiology.

Theory

UNIT I

Protein sequencing, cell signaling and trafficking.

UNIT II

Sensor molecules and bioactive peptides; C-reactive protein.

UNIT III

Structure, functions and expression of heat shock; antifreeze and metallothionenes proteins.

UNIT IV

Cross protection, mechanism of action of cross protection.

UNIT V

Biochemical mechanism of thermogenesis.

UNIT VI

Adaptation mechanism during thermal extremes; metabolic reactions during starvation and stress.

UNIT VII

Molecular signaling, gene splicing, duplication and mutation, Gene expression and regulation mechanism, Zinc finger, leucine zipper. DNA probes and nucleotide sequencing; gene expression and cloning; recombinant DNA and DNA fingerprinting. DNA damage. Factors affecting gene expression. Fish cell culture and stem cells.

Practical

Quantification of HSP.DNA damage by Comet assay. Quantification of C-reactive protein. Gene sequencing. Amino acid sequencing.

Suggested Readings

Fiege U, Morimoto R & Yahara I. 1996. *Stress- Inducible Cellular Responses*. Birkhäuser.

Houlihan DF, Carter CG, McCarthy ID & Hochachka PW. 1995. *Biochemistry and Molecular Biology of Fishes*. Elsevier.

Shadwick RE & Lauder GV. 2006. *Fish Biomechanics*. Academic Press.

FPB 508 SENSORY PHYSIOLOGY 1+1

Objective

To learn the different sensory organs and their functional mechanism in fish and shellfish.

Theory

UNIT I

Overview of sense organs and their functions in fishes and shell fishes.

UNIT II

Action potential, synapse, Neurotransmitters, impulse transmission, Excitation-contraction coupling.

UNIT III

Hearing mechanism and specialization. Hearing threshold. Auditory behavior and ecology.

UNIT IV

Olfactory system and role in feeding, reproduction and migration.

UNIT V

Electroreception, chemoreception in fish.

UNIT VI

Physiology of photoreceptors and pineal gland.

UNIT VII

Effector and motor function, Motor behavior and locomotion.

UNIT VIII

Bioluminescence, Chromatophores.

Practical

Practical on chemoreception using different feeding attractants. Behavioral studies with respect to temperature and noise. Study of reflex action. Effect of spinal nerve transection on melanophore behaviour. Effect of optic nerve transection on melanophore behaviour in response to background colour. Chromatophores response in relation to background colour, light, temperature, etc. Chromatophores responses in relation to eye stalk ablation.

Suggested Readings

Bullock TH, Hopkins CD, Popper AN & Fay RR. 2005. *Electroreception*. Birkhäuser.

Evans DH & Claiborne JB. 2006. *The Physiology of Fishes*. CRC Press.

Hara T. 1996. *Fish Physiology*. Vol. 25. *Sensory Systems Neuroscience*. Elsevier.

Hoar WS & Randall DJ.1988. *Fish Physiology*. Academic Press.

Northcutt RG & Davis RE. 1983. *Fish Neurobiology*. University of Michigan Press.

FPB 509 PHYSIOLOGY OF FISH BEHAVIOUR 1+1

Objective

To understand physiology of behaviour.

Theory

UNIT I

Concepts on fish behavior and regulatory mechanism-alarm reaction-transduction mechanism.

UNIT II

Domestication processes in communicative behavior. Locomotion behavior. Sexual behavior. Behavior due to environmental partition.

UNIT III

Predatory avoidance.

UNIT IV

Parental and neonatal behavior.

UNIT V

Chemical signals to evoke feeding behavior.

UNIT VI

Adaptation mechanism in altered environment.

Practical

Tagging studies. Audio visual recording of behavior in simulated experiment.

Suggested Readings

Brown C, Laland KN & Krause J. 2006. *Fish Cognition and Behavior***.** Blackwell**.**

Evans DH & Claiborne JB. 2006. *The Physiology of Fishes*. CRC Press.

Pitcher TJ. 1993. *Behaviour of Teleost Fishes*. Springer.

FPB 510 PHARMACO-BIOLOGY OF AQUACULTURE DRUGS 1+1

Objective

To acquaint students with the aquaculture drugs and their delivery mechanism.

Theory

UNIT I

An introduction to pharmaco-dynamic agents.

UNIT II

Anaesthetics.

UNIT III

Chemotherapeutic agents: antiprotozoal agents, ectoparasiticide, antihelmenthic.

UNIT IV

Antibacterial, antifungal and antiparsitic drugs.

UNIT V

Delivery system of drugs, Nanotechnology and nanoparticles.

UNIT VI

ISO standards of levels of drugs. GMO, GLP, IPR.

Practical

Estimation of residual level of different drugs .Pharamaco-kinetics.

Suggested Readings

Brown KMT. 2000. *Applied Fish Pharmacology*. Springer.

Noga EJ. 1996. *Fish Disease: Diagnosis and Treatment.* Blackwell.

Stockoff MK. 1993. *Fish Medicine*. WB Saunders.

FPB 511 PHYSIOLOGY OF EXCRETION AND OSMOREGULATION 1+1

Objective

To understand the physiology of excretion and osmoregulation in fish and shellfish.

Theory

UNIT I

Definition of excretion and osmoregulation.

UNIT II

Excretory organs in fish and shellfish and their functions.

UNIT III

Mechanism of excretion of nitrogenous waste, water and ion balance.

UNIT IV

Urea cycle, chloride shift mechanism.

UNIT V

Mechanism of osmotic and ionic regulation. Osmoregulation in migratory animals. Endocrine control of osmoregulation.

UNIT VI

Stenohaline and Euryhaline animals and their tolerance capacity.

Practical

Estimation of osmolarity in blood samples. Estimation of osmolarity in relation to different salinities. Estimation of ammonia in blood and water samples.

Suggested Readings

Evans DH & Claiborne JB. 2006. *The Physiology of Fishes*. CRC Press.
Hoar WS & Randall DJ.1988. *Fish Physiology*. Academic Press.
Prosser CL. 1950. *Comparative Animal Physiology*. WB Saunders.

FPB 512 ECOPHYSIOLOGY OF FISHES 1+1

Objective

To acquaint students with an insight into physiology of fish in response to changes in the aquatic environment both in the wild and captivity.

Theory

UNIT I

Fish and shellfish habitats in different ecological niches.

UNIT II

Effects of Environmental factors and Endocrine disruptors on fish physiology.

UNIT III

Adaptive and detoxification mechanism, Global warming and its impact on fish and shellfish physiology.

UNIT IV

Thermal stress in fish and heat shock protein (HSP), Response of fish and shellfish during hypoxia and the role of cardiovascular and ventillary system. Physiological adaptations during migration.

UNIT V

Natural and anthropogenic sources of radioactivity in the aquatic environment.

UNIT VI

Use of radioisotopes in tracer techniques for metabolic studies. Distribution of radioactive substances in water. International radiological limits for the export and import of aquatic products.

UNIT VII

The role of food chains in concentration of radionucleides in aquatic organisms. Effect of radioactive substances on fish. Threat of radioactive contamination to aquatic animal life.

Practical

Estimate threshold of thermal tolerance and salinity tolerance. Estimation of LC_{50} of pollutants. Estimation of stress enzymes, isozymes. Estimation of cortisol in serum/plasma. Use of isotopes in tracer techniques for metabolic studies. Quantification of Tritium and other radioisotope levels in fish/ shellfish tissues and in aquatic environment.

Suggested Readings

Alan GH. 1995. *Water Pollution and Fish Physiology*. CRC Press.
Chavin W. (Ed.). 1973. *Responses of Fish to Environmental Changes*. Charles C Thomas Publ.
Evans DH & Claiborne JB. 2006. *The Physiology of Fishes*. CRC Press.
Fiege U, Morimoto R & Yahara I. 1996. *Stress- Inducible Cellular Responses*. Birkhäuser.
Jobling M. 1995. *Environmental Biology of Fishes*. Springer.
Pickering AD. 1981. *Stress and Fish*. Academic Press.
Rankin JC & Jensen FB. 1996. *Fish Ecophysiology.* Chapman & Hall.

Schlesinger MJ, Ashburner M & Tissieres A. (Eds.). 1982. *Heat Shock Proteins from Bacteria to Man*. Cold Spring Harbor.

FPB 513 TOOLS AND TECHNIQUES IN BIOCHEMISTRY 1+1

Objective

To learn different experimental techniques in fish Biochemistry.

Theory

UNIT I

Theory and application of colorimetry and spectrophotometry: Beer-Lambert's law; Calibration plot; UV-visual, fluorescent, IR, CD spectroscopy, Atomic mass spectroscopy and NMR.

UNIT II

Basic principles of chromatography: Theory and applications of paper, affinity, column, thin layer, ion-exchange, size exclusion and gas chromatography.

UNIT III

HPLC (High Pressure Liquid Chromatography); Factors affecting chromatographic resolutions, resolving power and retention time; Methods of preparing biological samples for chromatographic analysis.

UNIT IV

Radioimmunoassay (RIA) and Enzyme-linked immunosorbent assay (ELISA): Basic principle and application in quantitative estimation of biological analytes.

UNIT V

Theory and applications of electrophoresis; Gel electrophoresis of proteins and nucleic acids.

UNIT VI

Determination of molecular weight of proteins and nucleic acids; Principle and uses of ultracentrifugation; Types of rotors and their applications X-ray crystallography, MALDI-TOS.

UNIT VII

Beta and gamma scintillation counters, autoradiography and uses of radio isotopes in fisheries research.

Practical

Quantitative estimation of biomolecules by spectrophotometric methods; Estimation of proteins by different methods (Lowry, Biuret, Bradford); Separation of amino acids by paper chromatography Qualitative and quantitative estimation of fatty acids by gas chromatography; Separation of proteins and nucleic acids by gel electrophoresis; Application of swing out and fixed angle rotors in ultra centrifugation.

Suggested Readings

Brewer JM, Pesce AJ & Ashworth RB. 1974. *Experimental Techniques in Biochemistry*. Prentice-Hall.

Diamond PS & Denman RF. 1966. *Laboratory Techniques in Chemistry and Biochemistry*. Butterworths.

Schreck CB & Moyle PB. 1990. *Methods for Fish Biology*. American Fisheries Society, USA.

FPB 514 BIOCHEMISTRY OF ENZYMES, VITAMINS, MINERALS AND HORMONES 2+1

Objective

To acquaint students with different aspects of enzymes, vitamins, minerals and hormones.

Theory

UNIT I

Enzymes: Nomenclature, classification and structure of enzymes, Active site; Concepts of activation energy, Transition state and enzyme-substrate complex, Units of enzyme activity, Factors affecting enzyme activity, Enzyme kinetics; K_m and V_{max} values; Lineweaver and Burke Plots, Competitive and noncompetitive inhibition, Ribozymes; Immobilized and restriction enzymes.

UNIT II

Vitamins: Chemical structure, sources, biosynthesis and properties of water and fat soluble vitamins, Metabolic changes associated with hypo and hyper-vitaminosis.

UNIT III

Minerals: Biological significance of calcium, phosphorous, magnesium, zinc, manganese, selenium, cobalt, sodium, potassium, iron.

UNIT IV

Hormones: Classification and functional properties of different hormones; Chemical structure of peptide and steroid hormones; Biosynthesis, secretion and metabolic role of thyroid, adrenal, gonadal, pancreatic, hypothalamic and hypophyseal hormones, Hormone receptors and their regulation, Mechanism of hormone action at cellular level.

Practical

Assay of enzyme activity (alkaline phosphatase, transaminases); Quantitative estimation of vitamin A; Estimation of serum calcium and phosphorous; Analysis of peptides from fish pituitary homogenate.

Suggested Readings

Conn EE & Stumpf PK. 1987. *Outline of Biochemistry*. Wiley.

Houlihan DF, Carter CG, McCarthy ID & Hochachka PW. 1995. *Biochemistry and Molecular Biology of Fishes*. Elsevier.

Murray RK, Granner DK, Mayes PA & Rodwell VW. 2000. *Harper's Biochemistry*. Appleton & Lange.

Nelson DL & Cox MM. 2005. *Principles of Biochemistry*. WH Freeman.

FPB 515 DIAGNOSTIC BIOCHEMISTRY 1+1

Objective

To acquaint students with different aspects of biochemical diagnostic Techniques.

Theory

UNIT I

OIE (Office of the international epizootics) listed diseases of finfish and shellfish in the world and their approved diagnostic methods.

UNIT II

Enzymes and isoenzymes of clinical significance; Metabolic disorders related to carbohydrate, lipid, protein and nucleic acid metabolism in fishes.

UNIT III

Biochemical markers for EUS, viral haemorrhagic septicaemia, enteritis and spring viraemia in carp; Bacterial kidney diseases (BKD) and WSSV diagnosis; Biochemical indicators for stress.

UNIT IV

Biochemical techniques for identification of liver diseases, bone disorder and pesticide poisoning.

UNIT V

Molecular basis of autoimmunity; Detoxification mechanisms of gill, liver and kidney.

UNIT VI

DNA fingerprinting and its applications in clinical biochemistry.

Practical

Specimen collection, identification, transport, delivery, preparation and preservation of samples; Estimation of blood glucose, albumin and globulin; Identification of pathogens by PCR and DNA fingerprinting in finfish and shellfish; Disease diagnosis by histopathology, histochemistry and X-ray techniques; Liver and plasma enzyme assay (GOT, GPT, ALP and AChE); Analysis of stress proteins.

Suggested Readings

Brewer JM, Pesce AJ & Ashworth RB. 1974. *Experimental Techniques in Biochemistry*. Prentice-Hall.

Conn EE & Stumpf PK. 1987. *Outline of Biochemistry*. Wiley.

Diamond PS & Denman RF. 1966. *Laboratory Techniques in Chemistry and Biochemistry*. Butterworths.

Houlihan DF, Carter CG, McCarthy ID & Hochachka PW. 1995. *Biochemistry and Molecular Biology of Fishes*. Elsevier.

Murray RK, Granner DK, Mayes PA & Rodwell VW. 2000. *Harper's Biochemistry*. Appleton & Lange.

Nelson DL & Cox MM. 2005. *Principles of Biochemistry*. WH Freeman.

Schreck CB & Moyle PB. 1990. *Methods for Fish Biology*. American Fisheries Society, USA.

FISH PHYSIOLOGY AND BIOCHEMISTRY

List of Journals

- Chemical Senses
- Comparative Biochemistry and Physiology
- Environmental Contamination and Toxicology
- European Journal of Pharmacology
- Experientia
- Fish and Shellfish Immunology.
- Fish Physiology and Biochemistry
- General and Comparative Endocrinology
- Immunopharmacology
- Journal of Neuroscience
- Journal of Animal Ecology
- Journal of Animal Physiology and Animal Nutrition
- Journal of Biology
- Journal of Comparative Neurology
- Journal of Ecology, Ecosystems and Ecophysiology
- Journal of Ecophysiology and Occupational Health
- Journal of Experimental Biology
- Journal of Fish and Shellfish Immunology
- Journal of Fish Behaviour
- Journal of Fish Biology
- Journal of Fish Diseases
- Journal of Fish Physiology and Biochemistry
- Journal of Immunopharmacology
- Journal of Muscle Research and Cell Motility
- Journal of Research Methods and Methodological Issues
- Journal of Thermal Biology
- Toxicology Letters

Suggested Broad Areas for Master's and Doctoral Research

- Role of hormones and growth factors in the regulation of growth
- Diurnal rhythymicity of food intake and growth rate
- Environmental and hormonal control of fish reproduction
- Isolation and characterization of gonadotropin
- Nutritional strategies for fish reproduction
- Isolation and characterization of genes
- Role of carbohydrates, lipids and proteins on metabolism during stress.
- Mechanism of gaseous exchange
- Hypoxia as endocrine disrupters
- Identification and application of nutraceuticals on immunity
- Endocrine control of immunity.
- Identification and characterization of thermo tolerance gene
- Adaptive mechanism to altered environment
- Bioluminiscence, chromatophores

- Chromatophore responses in relation to eye stalk ablation.
- Behavioural studies during reproduction
- Behavioural pattern in altered environment.
- Metabolism and pharmaco- kinetics of drugs
- Protein requirement studies based on nitrogen excretion
- Osmotic and ionic regulation in altered environment
- Development of new methods for quantification of biomolecules
- Role vitamin and hormone on growth and reproduction
- Development of vaccines against common diseases

FISH PROCESSING TECHNOLOGY
Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
FPT 501*	TECHNOLOGY OF FREEZING AND STORAGE	2+1
FPT 502*	THERMAL PROCESSING OF FISHERY PRODUCTS	2+1
FPT 503*	QUALITY ASSURANCE, MANAGEMENT AND CERTIFICATION	2+1
FPT 504*	APPLIED FISH BIOCHEMISTRY	2+1
FPT 505	TECHNIQUES IN MICROBIOLOGY	1+1
FPT 506	CURED, DEHYDRATED AND SMOKED FISHERY PRODUCTS	1+1
FPT 507	HANDLING, STORAGE AND TRANSPORT OF FRESH FISH	1+1
FPT 508	TECHNOLOGY OF MINCE-BASED FISH PRODUCTS	1+1
FPT 509	ADDITIVES IN FISH PROCESSING	1+1
FPT 510	FISH BY-PRODUCTS AND WASTE UTILIZATION	1+1
FPT 511	MICROORGANISMS OF PUBLIC HEALTH SIGNIFICANCE	1+1
FPT 512	DESIGN, MAINTENANCE OF FISH PROCESSING PLANTS AND INSTRUMENTATION	1+1
FPT 513	PACKAGING OF FISH AND FISHERY PRODUCTS	1+1
FPT 591	MASTER'S SEMINAR	1+0
FPT 599	MASTER'S RESEARCH	20
FPT 601**	BIOCHEMICAL TECHNIQUES IN FISH ANALYSIS	2+1
FPT 602**	FUNCTIONAL PROPERTIES OF PROTEINS FROM FISH AND SHELLFISH	2+1
FPT 603**	QUALITY MANAGEMENT SYSTEMS	2+1
FPT 604	LIPIDS OF AQUATIC ORIGIN	2+1
FPT 605	MICROBIAL HAZARDS IN FISH PROCESSING	2+1
FPT 606	VITAMINS, MINERALS AND FLAVOUR BEARING COMPONENTS IN AQUATIC ORGANISMS	2+1
FPT 607	TOXINS AND CONTAMINANTS	2+1
FPT 608	NUTRITIONAL ASPECTS AND NUTRITION LABELING	2+1
FPT 609	ENVIRONMENTAL IMPACT OF FISHERY INDUSTRIES	2+1
FPT 610	BY-PRODUCTS, SPECIALTY PRODUCTS AND VALUE ADDED PRODUCTS	2+1
FPT 691	DOCTORAL SEMINAR I	1+0
FPT 692	DOCTORAL SEMINAR II	1+0
FPT 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme; ** Compulsory for Doctoral programme

FISH PROCESSING TECHNOLOGY
Course Contents

FPT 501 TECHNOLOGY OF FISH FREEZING AND FROZEN STORAGE 2+1

Objective

To give detailed insight into various aspects of freezing of fish.

To provide understanding on chemical, bacterial and sensory changes during freezing.

Theory

UNIT I

Freezing: Structure of water and ice, Influence of solutes on the structure of water and ice, phase equlibria and freezing curves of pure water and binary solutions, freezing curve for fish. Determination of freezing points from time- temperature plots, calculation of freezing time.

UNIT II

Crystallization, homogeneous and heterogeneous nucleation, super cooling, crystal growth, eutectic point, location of ice crystals in tissue, physical changes during freezing.

UNIT III

Technological aspects of freezing: Slow and rapid freezing, Methods of freezing, comparison of various freezing methods, selection of a freezing method, product processing, packaging and different types of freezers.

UNIT IV

Chemical treatment prior to freezing: antioxidants, cryoprotectants and other additives, theories of cryopreservation, glazing.

UNIT V

Frozen storage: Physical and chemical changes - freezer burn and recrystallisation, different types of recrystallisation.

UNIT VI

Chemical changes in lipids, proteins and nucleotides, freeze denaturation and theories on denaturation, changes in pH, bacterial changes, sensory changes, texture, taste, odour, effect of post-mortem condition on sensory qualities.

UNIT VII

Water holding capacity, time temperature tolerance, temperature and duration of storage on quality and shelf life.

UNIT VIII

Arrangements within a cold storage, handling and stacking systems, space requirement, precautions to reduce temperature increase in a cold storage.

UNIT IX

Filleting of fish, treatments, glazing, packaging and freezing. Processing of prawns, lobster, squid, cuttle fish, crab etc. for freezing.

UNIT X

Different methods of thawing frozen fish, advantages and disadvantages. Recent advances in fish thawing.

Practical

Filleting of fish, treatments, glazing, packaging, freezing, Processing of Prawns, Lobster, Squid, Cuttle Fish, Crab etc. in different styles, Packaging

and Freezing, Freezing curve, determination of freezing point. Studies on physical, chemical and sensory changes.

Suggested Readings

Andrew CC. 1990. *Food Refrigeration Processes*. Elsevier.

Balachandran KK. 2001. *Post-harvest Technology of Fish and Fish Products*. Daya Publ. House.

Clucas IJ. 1981. *Fish Handling, Preservation and Processing in the Tropics.* Parts I, II. FAO.

Fennema K, Powrie WD & Marth EH. 1973. *Low Temperature Preservation of Foods and Living Matter*. Marcel Dekker.

Gopakumar K. (Ed.). 2002. *Text Book of Fish Processing Technology*. ICAR.

Hall GM. (Ed). 1992. *Fish Processing Technology*. Blackie.

Nambudiri DD. 2006. *Technology of Fishery Products*. Fishing Chimes.

Regenssein JM & Regenssein CE. 1991. *Introduction to Fish Technology*. Van Nostrand Reinhold.

Rudolf K. 1969. *Freezing and Irradiation of Fish*. Fishing News (Books).

Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ.

FPT 502 THERMAL PROCESSING OF FISHERY PRODUCTS 2+1

Objective

To provide information on various aspects of thermal / heat processing.

To compare cold sterilization with thermal processing.

To impart knowledge on various types of packaging techniques and materials used in thermal processing.

Theory

UNIT I

Principles of thermal processing. Mechanism of heat transfer: conduction, convection, radiation and dielectric and microwave heating, unsteady state of transfer, heat resistance of bacteria and spores, decimal reduction time, thermal death time, "Z" and "F" values, 12D concept, heat penetration, cold point, can size, shape, contents etc. on heat penetration, determination of process time. Significance of thermal death curve, graphical, formula, nomogram methods – F_0 value, cook value, D value, integrated F value and their inter-relationship. Heating equipment.

UNIT II

Classification of foods: low acid, medium acid and acidic foods, absolute sterility, statistical sterility, commercial sterility, pasteurisation and sterilisation.

UNIT III

Canning process, steps involved, process flow, additives, HTST processing and aseptic canning, principles and process details, canning machinery and equipment, canning process for fish/shellfish, value added and ready to use canned products.

UNIT IV

HACCP and Safety of canned foods and unreliability of post process sampling of canned foods to ensure sterilization. Status of a batch of canned foods identifying CCPs and their monitoring by specially trained personnel.

UNIT V

Spoilage of canned food, physical, chemical and microbial, Thermobacteriology, death of bacteria, autosterilisation bacteriology of canned/heat processed fishery products, examination of cans and seams.

UNIT VI

Canning plant location: Practical considerations, canning plant facilities, layout design.

UNIT VII

Flexible packing, retort pouch processing of fish and fishery products principles and techniques. Combination and synergistic effects.

UNIT VIII

Hurdle technology: Combination with heat, heat and hydrostatic pressure, heat and low pH, heat and NaCI and nitrite, combination with ionising radiation, irradiation and hydrostatic pressure, irradiation and NaCI, irradiation and other adjuncts, heat and irradiation, irradiation and low temperature, low pH and specific acids, low a_w and adjuncts like Nisin to reduce severity of heat processing.

UNIT IX

Irradiation: Radiation sources, units, dose levels, radappertization, radicidation, radurization, effects of irradiation on protein, lipids, vitamins, bacteriological aspects, physical properties, shelf life and irradiated fish products.

Practical

Evaluation of pasteurisation and sterilisation, determination of TDT and F value Examination of canned foods, can seams, testing sterility, isolation of Bacillus and *Clostridium* Spp., spore staining, heat penetration curve and cooling curve, canning operations for different fish/shellfish products. Double seam profile, Heat Penetration Curve, F_0 Value, Z value, Process time, Canning of table fishes, Bivavles, Crustaceans in different containers, Operation of over pressure autoclave, Canned culinary preparations, Examination of canned fishery products.

Suggested Readings

Balachandran KK. 2002. *Fish Canning Principles and Practices*. CIFT, Cochin.

Gopakumar K. 2002. *Text Book of Fish Processing Technology*. ICAR.

Hall GM. (Ed). 1992. *Fish Processing Technology*. Blackie.

Hersom AC & Hulland ED. 1980. *Canned Foods*. Chemical Publ. Co.

Larousse J & Brown BE. 1997. *Food Canning Technology*. Wiley VCH.

Nambudiri DD. 2006. *Technology of Fishery Products*. Fishing Chimes.

Stumbo. 1973. *Thermo Bacteriology in Food Processing*. CRC, Academic Press.

Thorne S. 1991. *Food Irradiation*. Elsevier.

Venugopal V. 2006. *Seafood Processing*. Taylor & Francis.

Warne D. 1988. *Manual on Fish Canning*. FAO Fisheries Tech. Paper 285.

Zeathen P. 1984. *Thermal Processing and Quality of Foods*. Elsevier.

FPT 503 QUALITY ASSURANCES, MANAGEMENT AND CERTIFICATION 2+1

Objective

To understand various aspects of quality assurance system, quality management and national / international certification system.

To learn factory sanitation and hygiene, water quality and standard

Theory

UNIT I

Quality management, total quality concept and application in fish trade.

UNIT II

Quality assessment of fish and fishery products - physical, chemical, organoleptic and microbiological quality standards.

UNIT III

Inspection and quality assurance: Fish inspection in India, process water quality in fishery industry, product quality.

UNIT IV

Water quality and standards.

UNIT V

Sensory evaluation of fish and fish products, basic aspects, different methods of evaluation, taste panel selection and constitution, statistical analysis.

UNIT VI

HACCP and Good manufacturing practices. HACCP principles, practical aspects of planning and implementation, verification, validation and audit.

UNIT VII

National and International standards: ISO 9000: 2000 series of quality assurance system, *Codex alimentarius,* USFDA and EU regulations for fish export trade, IDP and SAT formations in certification of export worthiness of fish processing units, regulations for fishing vessels, pre-processing and processing plants, EU regulations. ISO 22000:2006.

UNIT VIII

Factory sanitation and hygiene: National and international requirements, SSOP, Sanitary and Phytosanitary measures.

UNIT IX

Food laws in India, integrated food law.

Practical

Evaluation of fish / fishery products for organoleptic, chemical and microbial quality. Methods for analysis for bacterial quality parameters, chemical parameters and filth. Evaluation of sanitary conditions in fish processing units. Analysis of typical hazards. Study of correction and corrective action. SQC: Introduction, statistical principles involved, process control, control charts, variable and attribute control charts, Acceptance sampling, basic ideas, sampling by attributes single and double sampling plants, Basic concepts of decision making. Familiarization with water quality analysis.

Suggested Readings

Anthony TT. 1988. *Handbook of Natural Toxins. Marine Toxins and Venom*. Vol. III. Marcel Dekker.

Balachandran KK. 2001. *Post Harvest Technology of Fish and Fish Products*. Daya Publ. House.

Connell JJ. 1995. *Control of Fish Quality*. Fishing News Books.
Fennema K, Powrie WD & Marth EH. 1973. *Low Temperature Preservation of Foods and Living Matter*. Marcel Dekker**.**
Gopakumar K. (Ed.). 2002. *Text Book of Fish Processing Technology*. ICAR.
Hall GM. (Ed). 1992. *Fish Processing Technology*. Blackie.
Hui YH, Merle DP & Richard GJ. (Eds.). 2001. *Food Borne Disease Handbook. Seafood and Environmental Toxins*. Vol. IV. Marcel Dekker.
Huss HH, Jakobsen M & Liston J. 1991. *Quality Assurance in the Fish Industry*. Elsevier.
John DEV. 1985. *Food Safety and Toxicity*. CRC Press.
Krenzer R. 1971. *Fish Inspection and Quality Control*. Fishing News.
Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ.
Vincent K & Omachonu JER. 2004. *Principles of Total Quality.* CRC Press.

FPT 504 APPLIED FISH BIOCHEMISTRY 2+1

Objective

To impart knowledge on macro and trace constituents and nutritive value of fish.

To create basic understanding about toxins and toxic substances and their toxic effects.

To give a detailed insight into experimental techniques used in food analysis.

Theory

UNIT I

Seafood proteins: Classification. Sarcoplasmic proteins: Heme proteins, Myoglobin, Hemocyanins, parvalbumins, antifreeze proteins, pigments, enzymes- hydrolases, oxidoreductases, and other enzymes.

UNIT II

Myofibrillar proteins: Myosin – isolation, sub-unit composition, actin, allergins, tropomyosin, troponins, paramyosin, connectin.

UNIT III

Stroma proteins: Connective tissue in the muscle, collagen in fish muscle and skin: location, characteristics of seafood collagen, collagen on the quality of seafoods, gaping.

UNIT IV

Functional properties of seafood proteins: Solubility, emulsification, viscosity, water holding, stability, gelation, texture profile analysis.

UNIT V

Changes in proteins during processing: Denaturation- At high and low temperatures and kinetics, dissociation / aggregation / coagulation, reversibility, significance to processing and quality. Hydrolysis and hydrolysates: Process and applications, proteinases.

UNIT VI

Post mortem biochemical changes, rigor mortis, K-value, TMAO and its decomposition products, demethylase.

UNIT VII

Non-protein nitrogenous compounds: Free amino acids, peptides, nucleotides, guanidins, urea, quarternary ammonium compounds etc.

UNIT VIII

Seafood lipids: Composition and nutritive value, lipid types and their variations, lipid fractionation, estimation of lipid fractions, triglycerides, phospholipids, non-saponifiables including sterols and vitamins. Polyunsaturated fatty acids and prostaglandins- beneficial effects on human health.

UNIT IX

Fatty acid composition of fish liver and body oils, auto-oxidation of fatty acids, rancidity, lipasas and phospholipases, pro- and anti-oxidants, oxidation indices, lipid-protein interactions, oxidized lipids-protein interactions and their impact on quality.

UNIT X

Macro and trace elements in fish and shellfish; Vitamins and Minerals of nutritional significance, toxic metals and their harmful effects and metallothionines.

UNIT XI

Flavour and pigments; amines, volatile fatty acids, carbonyls, sulphur containing compounds, carotenoids, isoprenoids in fish.

UNIT XII

Biogenic amines, Aflatoxins in cured fish.

UNIT XIII

Principles and methods involved in the separation and analysis of fish muscle constituents: Thin layer, paper and column chromatography, spectrophotometry, colorimetry, flame photometry, atomic absorption spectrophotometry, paper, disc and slab electrophoresis.

Practical

Molarity, normality, acid-base, redox titration, buffers. Lipids – Fractionation by TLC and other chromatographic techniques. Fatty acid composition by GLC, Amino acid analysis by HPLC. Protein purification methods: (NH4)2SO4/solvent precipitation. Ultracentrifugation, dialysis and ultrafiltration, gel filtration, electrophoresis, PAGE and SDS-PAGE, Marine polysaccharides for food use, molecular biology techniques in fish and bacterial identification, and topical subjects.

Suggested Readings

George MP & Barbec WT. 1990. *Seafood: Effects of Technology and Nutrition*. Marcel Dekker.

Joe MR & Carrie ER. 1984. *Food Protein Chemistry*. Academic Press.

Lehninger AL. 1982. *Principle of Biochemistry*. Worth Publ.

Michael ENA. 1990. *Biochemistry of Foods*. Academic Press.

Nettleton J. 1985. *Seafood Nutrition*. Van Nojhand Reinhold.

Owen RF. 1996. *Food Chemistry*. Marcel Dekker.

Pare JRJ & Belanger JMR. 1997. *Instrumental Methods in Food Analysis*. Elsevier.

Pomeranz Y & Meloan CE. 1994. *Food Analysis Theory and Practice*. AVI Publ.

Rao R. 1980. *Textbook of Biochemistry*. 2nd Ed. Prentice Hall of India.

Regenstein JM & Regenstein CE. 1984. *Food Protein Chemistry*. Academic Press.
Robert GA. 1989. *Marine Biogenic Lipids Fats and Oils.* Vol. II. CRC Press.
Roy EM & George JF. 1990. *The Sea Food Industry*. Van Nostrand Reinhold.
Roy EM, Geroge JF & Donn RW. 1982. *Chemistry and Biochemistry of Marine Food*. Van Nostrand Reinhold.
Shahidi F & Botta JR. 1994. *Seafoods: Chemistry, Processing Technology and Quality*. Blackie.
Smith EL, Hill RL, Lehman IR, Lefkowitz RJ, Handler P & White A. 1983. *The Principles of Biochemistry*. McGraw-Hill.
Stewart KK. (Ed). 1984. *Modern Methods of Food Analysis*. AVI Publ.
Suzuki 1981. *Fish and Krill Protein Processing Technology*. Applied Science Publ.
Whitaker JR & Tannenbaum SR. 1977. *Food Proteins*. AVI Publ

FPT 505 TECHNIQUES IN MICROBIOLOGY 1+1

Objective

To learn basic techniques in Microbiology.

Theory

UNIT I

Safety in Microbiology laboratory – Prevention of contamination, aerosol sampling, disinfection and evaluation of disinfectants.

UNIT II

Microscopy – bright-field, fluorescence, phase-contrast, dark ground and electron microscope.

UNIT III

Staining techniques – Types of stains and chemistry of staining.

UNIT IV

Sterilisation – Principles of various physical and chemical methods of sterilisation.

UNIT V

Nutritional requirements of microorganisms – constituents of growth media, requirement of fastidious organisms alternate nutrition, different types.

UNIT VI

Isolation, enumeration, preservation and maintenance of cultures - growth curve, different types of cultures, population estimation techniques.

UNIT VII

Routine tests for identification of bacteria - morphological, cultural, biochemical and serological. Anaerobic bacteria - methods of anerobiosis. Basics of mycological and virological techniques. Introduction to molecular techniques in Microbiology.

Practical

Microscopic techniques, isolation, enumeration and identification of microorganisms, serological techniques, anaerobic bacteria, mycological, virological and molecular techniques.

Suggested Readings

Chakraborthy P. 1995. *A Text Book of Microbiology*. New Central Book Agency.

Criusted J. 1986. *Methods in Microbiology*. Academic Press.

Harry WSJR, Paul JV & John JL. 2000. *Microbes in Action*. Freeman & Co. II (ICMSF). Academic Press.

James M. 1978. *Modern Food Microbiology*. 2nd Ed. D. Van Nostrand Co.

Michael J, Pelizar JR & Chan ECS. 1998. *Microbiology.* McGraw Hill.

Paul JH. 2001. *Marine Microbiology- Methods in Microbiology*. Vol. XXX. Academic Press.

Samuel CP & Dunn CG. 1959. *Industrial Microbiology*. McGraw Hill.

Silliker JH, Elliof RP, Baired AC & Boyan FL. 1980. *Microbial Ecology of Foods*. Vol.II. (ICMSF). Academic Press.

William CF & Dennis CW. 2000. *Food Microbiology*. McGraw Hill.

FPT 506 CURED, DEHYDRATED, SMOKED FISHERY PRODUCTS 1+1

Objective

To create understanding on various scientific preservation techniques of fish.

To impart knowledge on changes during storage of products.

Theory

UNIT I

Free and bound water in foods, water activity and sorption behaviours of foods, storage characteristics, microbial spoilage, effects of water activity on chemical deterioration, enzymatic reaction, non-enzymatic browning, lipid oxidation, reaction between lipids and proteins, dry fish, control of micro-organisms.

UNIT II

Principles of drying and dehydration: Psychometrics, drying calculation, constant rate and falling rate, drying time in air, moisture transport mechanism, natural drying, solar drying and mechanical drying. Different types of dryers: tunnel drier, vacuum drier, drum drier, solar drier etc.

UNIT III

Freeze drying, preparation and its nutritive value.

UNIT IV

Dehydration of fish products: dehydration ratio, precautions to be taken in fish drying; denaturation of fish protein.

UNIT V

Cured fish, types of salt curing, use of salt, factors affecting salt uptake by fish, lean and fatty fish, whole, gutted or split open, type and size of salt crystals, source of salts and impurities in salts, effect of impurities on salt penetration, temperature of salting.

UNIT VI

Spoilage of dried / cured fish, physical, chemical and microbiological changes, methods to prevent / control spoilage, extension of shelf life.

UNIT VII

Fermented products: different methods of fermentation, indigenous products and their principles of preservation.

UNIT VIII

Smoke curing, chemistry of smoke, composition and properties, smoking methods: cold and hot method, use of smoke liquids, production of smoke, type of wood used, methods of smoke generation, carcinogens in smoke, smoke kilns.

UNIT IX

Marinades: Principles; processing of cold, cooked and fried marinades, shelf life and spoilage.

UNIT X

Fish and shellfish pickles: production, shelf life.

UNIT XI

Packaging requirements for dry, cured and fermented products.

Practical

Preparation of dried, cured and fermented fish products, examination of salt, protein, moisture in dried / cured products, examination of spoilage of dried / cured fish products, marinades, pickles, sauce.

Suggested Readings

Gopakumar K. 2002. *Text Book of Fish Processing Technology*. ICAR.

Hall GM. 1992. *Fish Processing Technology*. Blackie.

Hui YH, Merle DP & Richard JG. 2001. *Food Borne Disease Handbook. Seafood and Environmental Toxins*. Vol.IV. Marcel Dekker.

Oefjen G, Wilhelm H & Peter. 2004. *Freeze Drying*. Wiley-VCH GmbH & Co.

Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ.

Wheaton FW & Lawson TB. 1985. *Processing Aquatic Food Products*. John Wiley & Sons.

FPT 507 HANDLING, STORAGE AND TRANSPORT OF FRESH FISH 1+1

Objective

To teach scientific techniques of handling, storage and transport of fresh fish.

To teach various post harvest changes during chill storage of fish.

Theory

UNIT I

Structure of fish myosystems, Postmortem changes - Structural and chemical.

UNIT II

Fish as raw material for processing: Body structure, physical properties, shape, specific weight, bulk weight, angle of slip, weight composition.

UNIT III

Factors affecting quality of fresh fish: intrinsic and extrinsic factors.

UNIT IV

Handling of fish onboard fishing vessels, Unit operations.

UNIT V

Unloading fish, Fish pumps.

UNIT VI

Post-harvest Fishery losses, Methods to reduce losses.

UNIT VII

Handling of fish in landing centers, defects and modifications needed.

UNIT VIII

Chill storage of fish: Heat load calculation, storage methods. insulated boxes and insulation thickness, different types of ice, physical, chemical, microbiological and sensory changes during chill storage, iced storage shelf life, cold shock, physical, chemical and sensory methods of analysis.

UNIT IX

Different types of ice and their advantages.

UNIT X

Sous-vide technology.

UNIT XI

Melanosis and its prevention, discolouration in aquatic products, non-enzymatic browning.

UNIT XII

Depuration of bivalves.

UNIT XIII

Transportation: Live fish/shell fish, Transportation of raw fish to local markets and processing centres, Improvements needed in transportation, Refrigerated transport systems, Classification of transport vehicles, Cold chain.

Practical

Chill storage studies: Chemical, physical and sensory analysis, determination of shelf life. Handling of fish, bivalves, prawns, mollusks, Depuration, treatment with chemicals, evaluation of freshness of fish.

Suggested Readings

Aitken A, Mackie M, Merritt SH & Windsor ML. 1982. *Fish Handling and Processing*. Ministry of Agriculture, Fisheries and Food, Edinburgh.

Anon. 1965. *Fish Handling and Preservation*. Proc. Meeting on Fish Technlogy, Scheveningen. Organisation for Economic Co-operation and Development, Paris.

Balachandran KK. 2001. *Post Harvest Technology of Fish and Fish Products*. Daya Publ.

Connell JJ. 1980. *Advances in Fish Sciences and Technology*. Farnhan Surrey.

George MH. 1992. *Fish Processing Technology*. VCH Publ.

Gopakumar K. (Ed.). 2002. *Text Book of Fish Processing Technology*. ICAR.

Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ.

FPT 508 TECHNOLOGY OF MINCE BASED FISH PRODUCTS 1+1

Objective

To provide knowledge on basic principles and advanced technologies in processing of mince based fish products.

Theory

UNIT I

Composition of muscle proteins in fish and their role in emulsification and elasticity formation.

UNIT II

Factors influencing denaturation of muscle proteins and their theories. Methods to testing protein denaturation.

UNIT III

Factors influencing elasticity formation and theories of gel formation. Minced meat preparation from different varieties of fresh water and marine water fishes.

UNIT IV

Improvement of colour of meat using bleaching and certain additives. Use of anti-denaturants to prevent denaturation of proteins of fish mince during storage. Changes in meat during mincing and mixing operations and cooking and setting phenomena.

UNIT V

Technology of processing and preservation of gel forming fish flour (AFPP), its property and utilisation. Unit operations in analog product preparation- Crab sticks analogs, moulded lobsters and crabs.

UNIT VI

Battered and breaded products: different types and their preparation, nutritional and economic significance of products.

UNIT VII

Use of emulsifiers, binders, seasonings, spices, antioxidants, smoke extract, Preservatives, natural and artificial casings, nitrites and nitrates. Fortification of fish products with vitamins and minerals. Quality standards and recent developments.

Practical

Measurement of viscosity of fish proteins by Ostwald viscometer, effect of water washing on the quality of meat, colour fixation of red colour meat and estimation of nitrite. Studies on setting of fish meat. Estimation of starch in the final paste product. Fundamentals of controlled stress Rheometer. Effect of two stage heating of fish sol on gel strength.

Suggested Readings

Balachandran KK. 2001. *Post Harvest Technology of Fish and Fish Products*. Daya Publ.

Bligh EG. 1992. *Seafood Science and Technology*. Fishing News Book.

Lanier TC & Lee C. 1992. *Surimi Based Product Technology*. Marcel Dekker.

Matsumato JJ. 1980. *Chemical Deterioration of Proteins*. American Chemical Society, Washington.

Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ.

Suzuki. 1981. *Fish and Krill Protein Processing Technology*. Applied Science Publ.

FPT 509 ADDITIVES IN FISH PROCESSING 1+1

Objective

To familiarize with the use of different additives, their effects, levels and detection.

Theory

UNIT I

Introduction to food additives-definition-technical benefits of food additives-intentional and incidental additives.

UNIT II

Relationship of great revolutions in history to the development of food additives – Agricultural Revolution-Industrial revolutions – urbanization.

UNIT III

Intentional additives – use of specific nutrients as food additives – Requirements and considerations. Minerals, vitamins, amino acids and nutrient concentrates as additives, Incidental additives.

UNIT IV

Policy considerations in the use of food additives. Flavours and colour as additives.

UNIT V

Antioxidants – Mechanism of antioxidants; commercial antioxidants and selections.

UNIT VI

Analytical methods for antioxidants.

UNIT VII

Acidulants in food processing; Sequestrants in food processing; Polyphosphates in fish processing.

Practical

Determination of food additives such as preservatives, antioxidants, curing agents, chelating agents, acidulants and phosphates in various food products. Detection of certain intentional and unintentional food additives in foods.

Suggested Readings

Branen AL, Davidson PM & Salmiven S. 1990. *Food Additives*. Marcel Dekker.

Middle KRD & Shubik P. 1989. *International Food Regulation Handbook*. Marcel Dekker.

Rahman MS. 2007. *Handbook of Food Preservation*. 2nd Ed. CRC Press.

Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ.

Wheaton FW & Lawson TB. 1985. *Processing Aquatic Food Products*. John Wiley & Sons.

FPT 510 FISH BY-PRODUCTS AND UTILIZATION OF FISHERY WASTE 1+1

Objective

To provide information on various fish by-products, utilization of fishery wastes and their nutritional value.

Theory

UNIT I

Fish meal: Production - dry and wet process, machinery, control of quality of products, specifications, packaging and storage.

UNIT II

Fish body and liver oils: Extraction, purification, preservation and storage, industrial and nutritional applications of fish oils. Vitamin A and D.

UNIT III

Essential fatty acid functions of fish oils, poly-unsaturated fatty acid (PUFA), production of concentrates of polyunsaturated fatty acids, preparation of fatty alcohol and amides.

UNIT IV

Utilisation of shark: Processing of shark meat, removal of urea in meat, filleting, curing and dehydration, extraction of shark liver oil, Vitamin A, D, squalene, ambergris, curing and tanning of shark skin, shark cartilage.

UNIT V

Shrimp waste, crab shell and squilla utilisation: Resources and composition, conventional uses, feeds and manure, conversion to useful materials like chitin, chitosan, glucosamine hydrochloride, shrimp extract, commercial production, production and use of protein isolates from squilla and shrimp waste.

UNIT VI

Fish protein concentrate: Different methods of production, functional properties, different types of FPC, texturised products and comparison of FPC to fish meal.

UNIT VII

Fish silage: Acid silage and fermented silage, advantages over fish meal, nutritional value of silage.

UNIT VIII

Fish hydrolysates: Production and utilisation, biochemical composition and importance in food and nutrition.

UNIT IX

Miscellaneous by-products: Fish maws and isinglass, pearl essence, fertilizer, beche-de-mer, processing of snail meat and jelly fish.

Practical

Preparation of fish meal, FPC, fish oils, chitin, chitosan, glucosamine hydrochloride, fish maws, isinglass, agar, alginic acid, , glue, pearl essence, fish sauce.

Suggested Readings

Balachandran KK. 2001. *Post Harvest Technology of Fish and Fish Products*. Daya Publ.

Gopakumar K. (Ed.). 2002. *Text Book of Fish Processing Technology*. ICAR.

Hall GM. (Ed.). 1992. *Fish Processing Technology*. Blackie.

Nambudiri DD. 2006. *Technology of Fishery Products*. Fishing Chimes.

Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ.

Wheaton FW & Lawson TB. 1985. *Processing Aquatic Food Products*. John Wiley & Sons.

Windsor M & Barlow. 1981. *Introduction to Fishery Byproducts*. Fishing News (Books).

FPT 511 MICROORGANISMS OF PUBLIC HEALTH SIGNIFICANCE 1+1

Objective

To acquaint students regarding bacteria, virus and parasites; food-borne diseases and their prevention.

Theory

UNIT I

Infection and immunity; diseases and their classification, spreading and contamination, host resistance.

UNIT II

Bacteria of public health significance in fish/fishery products/environments - *Salmonella, Clostridia, Staphylococcus, E. coli*, *Streptococcus, Vibrio, Aeromonas, Listeria, Yersinia, Bacillus*. Laboratory techniques for detection and identification of food poisoning bacteria.

UNIT III

Food-borne bacterial infections. Food infections by *Salmonella, Clostridium perfringens, Vibrio parahaemoliticus*, Enteropathogenic *E. coli*, *Aeromonas hydrophila* etc., the nature of causative agent, its source, incidence, foods involved, the diseases, conditions for outbreak and prevention. The etiology of diseases: Conditions for outbreak and prevention.

UNIT IV

Botulism and staphylococcal food poisoning, organism responsible and their origin, growth and toxin production, nature of toxins, incidence of poisoning, foods involved.

UNIT V

Food borne non-bacterial infections and intoxications: Aflatoxins, patulin, ochratoxin and other fungal toxins found in food, toxin producer, source, nature of toxin, toxicity and significance in foods.

UNIT VI

Virus and Parasites found in foods.

Practical

Laboratory techniques to detect and identify pathogens in fish - *E.coli, Staphylococcus aureus, Streptococus faecalis, Clostridium perfrigens, Clostridium botulinum, Salmonella, Listeria, Vibrio cholera, Vibrio parabaemolyticus, V. vulnificus*, Animal bio-assay of bacterial toxins.

Suggested Readings

Anon. 2001. *Food Borne Disease Handbook*. 2nd Ed. Vol. IV. *Seafood and Environmental Toxins*. Marcel Dekker.

Davis BD, Dulbecco R, Eiser HN & Ginsberg HS. 1980. *Microbiology.* Harpar & Row.

Doyle MP, Beuchat LR & Montville TJ. 1997. *Food Microbiology - Fundamentals and Frontiers.* American Society for Microbiology.

Harry WSJR, Paul JV & John JL. 2000. *Microbes in Action*. Freeman & Co.

Michael J, Pelizar JR & Chan ECS. 1998. *Microbiology*. McGraw Hill.

Samuel CP & Dunn CG. 1959. *Industrial Microbiology*. McGraw Hill.

Silliker JH, Elliof RP, Baired AC & Boyan FL. 1980. *Microbial Ecology of Foods*. Vol. II. (ICMSF). Academic Press.

William CF & Dennis CW. 2000. *Food Microbiology*. McGraw Hill.

FPT 512 DESIGN, MAINTENANCE OF FISH PROCESSING PLANTS AND INSTRUMENTATION 1+1

Objective

To expose the students to design, maintenance of fish processing plant, machinery and the instruments used in fish processing plants.

Theory

UNIT I

Plant design: Fundamentals of processing plant design: Site selection, design and preparation of layout of processing plants - freezing plant, cold storage, canning plant, dryers etc.

UNIT II

Functions and construction of refrigeration system: Tests and inspection, Operation and handling, P-H diagram and basic calculation - Application of P-H diagram, size and required power of compressor, maintenance of refrigerating machine, troubles and causes.

UNIT III

Preventive maintenance of machinery and equipment of fish processing plants, IQF, Canning plant, sausage plant, artificial dryers, smoking chambers etc., safety controls for freezing and canning plant.

UNIT IV

Effluent treatment: Legislation and standards of effluent discharge, water pollution control measures in the food industry, waste water treatment process; dissolved air floatation, sedimentation, chemical treatment, biological treatment, aeration, carbon adsorption, granular media filtration and sludge handling. Boilers - Classification and selection of boilers, Boiler mounting and accessories.

UNIT V

Measurement techniques**;** Sensors, active and passive sensors, characteristic of sensors for the measurement of temperature, relative humidity, a_w value, gel strength, moisture, freshness, pH, conductivity, DO, redox potential, salinity, air velocity, solar energy and brine concentration.

UNIT VI

Thermometers: Different types of thermometers, characteristics and application.

UNIT VII

Instrumentation techniques: General configuration of instrumentation system. Instrumentation for measurement of a_w value, temperature, pH, freshness, gel strength, salinity, brine concentration.

UNIT VIII

Thermal properties of foods: Calorie, heat loss, heat gain, specific heat, Newton's laws of cooling, heat transfer, latent heat, laws of fusion, thermal conductors, thermal diffusivity.

Practical

Design and Maintenance of Fish Processing Plants; Operation and maintenance of machinery and equipment for cold storage plant, freezing plant, canning plant, sausage making, dryers, boilers etc. Assembly of a refrigeration unit and charging refrigerant. Instrumentation; Measurement of temperature inside cold storage / freezer, fish during freezing and thawing. Estimation of Gel strength. Measurement of solar radiation, air velocity, air temperature. Measurement of salinity, conductivity, pH. Estimation of water activity.

Suggested Readings

Chupakhim V & Dormenko V. 1985. *Fish Processing Equipments*. MIR Publ.

Heid JL & Joslyn MA. 1980. *Food Processing Operations*. AVI Publ.

Slade FH. 1997. *Food Processing Plants*. Leonard Hill.
Wheaton FW & Lawson TB. 1985. *Processing Aquatic Food Products*. John Wiley & Sons.

FPT 513 PACKAGING OF FISH AND FISHERY PRODUCTS 1+1

Objective

To learn about different packaging materials, their appropriate use and benefits.

Theory

UNIT I

Food packaging, its purposes and procedures; technological aspects of packaging fishery products; packing of fresh and frozen fish for consumers; packaging for transport, shipping and institutional supplies; packaging standards for domestic and international trade.

UNIT II

Packaging materials; basic films and laminates, their manufacture and identification; resistance of packaging materials; development of protective packaging for fishery products.

UNIT III

Methods of testing for packaging materials for their physical properties; containers and their testing and evaluation; package designs; resistance of packages to hazards in handling; transport and storage.

UNIT IV

Modified atmosphere packaging, controlled packaging and aseptic packaging.

UNIT V

Labelling and printing of packaging materials.

Practical

Assessment of quality parameters such as moisture permeability, grease resistance, thickness/guage of basic plastic films and laminates. Quality assessment of paper and board and the products prepared from them. Evaluation of packages with regard to the resistance to handling, transportation and storage.

Suggested Readings

Balachandran KK. 2001. *Post Harvest Technology of Fish and Fish Products*. Daya Publ.
Gopakumar K. 1993. *Fish Packaging Technology - Materials and Methods*. Concept Publ.

FPT 601 BIOCHEMICAL TECHNIQUES IN FISH ANALYSIS 2+1

Objective

To provide knowledge on various biochemical techniques in fish analysis.

Theory

UNIT I

General principles of separation of micro and macro molecules, selection of appropriate tools for analysis of fish samples. Outlines of common techniques involved in biochemical analysis.

UNIT II

Centrifugation techniques: types of centrifugation, concept of Svedberg unit, analytical ultracentrifuge.

UNIT III

Filtration technique: different types of filtration, types of filters and means of using them.

UNIT IV

Spectroscopic techniques: Principles, UV, Visible and IR spectroscopy, spectro-fluorimetry, flame photometry, atomic absorption spectrophotometry, ICP- AES, mass spectrometer.

UNIT V

Electrophoretic techniques: General principles, Classification, Paper electrophoresis, Native and reduced PAGE, IEF, capillary electrophoresis, 2D Gel electrophoresis.

UNIT VI

Chromatographic Techniques: General principles, types of chromatography - adsorption, partition, ion-exchange, molecular sieve, affinity, gas chromatography, thin layer chromatography.

UNIT VII

Gas chromatography: Theory and instrumentation.

UNIT VIII

High performance Liquid chromatography, LC MS-MS: Theory and instrumentation.

Practical

Isolation of proteins: sarcoplasmic, myofibrillar, and stromal. Estimation of proteins: Biuret, Lowry and Dye binding technique. Amino acid analysis, non-protein nitrogen. Extraction and estimation of lipids: Measurement of oxidation and hydrolysis of lipids, Fatty acid profile. Minerals and heavy metals: Estimation by Atomic Absorption Spectroscopy and flame photometer. HPLC- determination of histamine Demonstration of GC-MS-MS, Separation of protein by electrophoresis.

Suggested Readings

Ewing GW. 1997. *Analytical Instrumentation Handbook*. Marcel Dekker.

Jean IJ & Ikim WJ. 1995. *Analysis of Food for Nutrition Labeling and Hazard Contaminants*. Marcel Dekker.

Lampman P & Saunder K. 1979. *Introductive Spectroscopy*. College Publ.

Larsen BS & McEwen CN. 1988. *Mass Spectrometry of Biological Materials*. Marcel Dekker.

Pare JRJ & Belanger JMR. 1997. *Instrumental Methods in Food Analysis*. Elsevier.

Peary JA. 1981. *Introduction to Analytical Gas Chromatography*. Marcel Dekker.

Robyt JF & White BJ. 1990. *Biochemical Techniques - Theory and Practice*. Waveland Press.

Wilson K & Walker J. 2000. *Practical Biochemistry - Principles and Techniques*. Cambridge University Press.

Wilson RH. 1994. *Spectroscopic Techniques for Food Analysis*. VCH Publ.

FPT 602 FUNCTIONAL PROPERTIES OF PROTEINS FROM FISH AND SHELLFISH 2+1

Objective

To provide knowledge on those biochemical properties known to affect product property.

Theory

UNIT I

Definition of functional properties and their importance in proteins from fish. Typical functional properties of proteins in food system.

UNIT II

Protein structure and function: Protein folding and non-covalent forces stabilizing protein structure with special reference to hydrophobic interactions. Free energy and entropy concept in relation to hydrophobic interaction. Surface hydrophobicity and its relation to functional properties. Estimation of surface hydrophobicity and total hydrophobicity.

UNIT III

Solubility and water sorption of proteins: Factors affecting protein hydration. Viscosity in relation to protein hydration: Methods of estimating viscosity.

UNIT IV

Gelation: Definition of gel, mechanism of formation of gel, factors affecting the gel formation. Evaluation of gelling capacity- thermal, rheological and microscopy.

UNIT V

Surfactant properties: emulsifying and foaming. Importance of emulsifying properties of proteins. Theoretical concept of emulsion capacity and stability. Interfacial properties, adsorption from solution. Methods of estimating surface tension.

UNIT VI

Emulsion instability: Creaming, sedimentation, aggregation vs Brownian aggregation. DLVO theory, microemulsions. Methods for estimation of emulsion capacity and stability.

UNIT VII

Macromoleculear absorption and different stages of foaming. Foam stability in relation to proteins structure. Foaming ability of different protein systems with case studies.

UNIT VIII

Denaturation and functionality: Changes in functional properties of proteins as affected by icing, freezing, drying, salting and heating. Modification of proteins for improving functionality- Succinylation and acetylation procedures.

Practical

Evaluation of different functional properties like water absorption, fat absorption,, gelling, emulsification capacity and stability of fish/shell fish proteins. Effect of pH, temperature and ionic strength on various functional properties. Prediction of functional properties using model compounds.

Suggested Readings

Cherry JP. 1991. *Protein Functionality in Foods*. American Chemical Society. Washington. D. C.

Damodaran S & Paraf A. 1997. *Food Proteins and Their Applications*. Marcel Dekker.

Hill SE, Ledward DA & Mitchell JR. 1998. *Functional Properties of Food Macromolecules*. 2nd Ed. Aspen Publ.

Nakai S & Modler HW. 1996. *Food Proteins Properties and Characterisation*. VCH Publ.

Phillips LG, Whitehead DM & Kinsella J. 1994. *Structure, Function Properties of Food Proteins*. Academic Press.
Suzuki. 1981. *Fish and Krill Protein Processing Technology*. Applied Science Publ.
Venugopal V. 2006. *Seafood Processing*. Taylor & Francis.

FPT 603 QUALITY MANAGEMENT SYSTEMS 2+1

Objective

To familiarize students with different aspects of quality management systems and evaluation techniques for seafood.

To teach Seafood Quality Assurance and Quality Assurance Systems.

Theory

UNIT I

Quality Management Systems: The concept of total quality management. The principles of TQM. Zero defect planning, Quality circle, Quality link, Quality culture. Statistical Quality Control. Quality as related to preprocess handling, transportation, processing and storage.

UNIT II

Quality evaluation techniques for seafood: Physical, chemical. Bacteriological and Instrumental methods of quality evaluation. Sensory evaluation.

UNIT III

Quality standards: National and International – Codex, USFDA, EU norms, ISO, BIS etc. standards for fish and fishery products.

UNIT IV

Seafood Quality Assurance and Quality Assurance Systems: Good Manufacturing (GMP) and Good Hygiene Practices (GHP) - Codex guidelines. The concept of HACCP in seafood safety. HACCP team Management role and CCPs and implementation procedure for HACCP-ISO 22000 FSMS. ISO 9000 series of standards. Cold schedule and hotschedule for handling perishable commodities.

UNIT V

Validation of methods for quality assurance- Method selection, Quality check, inter-lab comparision, proficiency testing. Primary standards. Reference standards. Reference material (RM), Certified Reference Material (CRM) and Standard Reference Material (SRM), Uncertainty and Calculation of Uncertainty of Measurements.

UNIT VI

Sample Accountability: Sampling plan -probability sampling and non-probability sampling.

Practical

Developing flow charts and exercises in identification of hazards-preparation of hazard analysis worksheet, plan form and corrective action procedures in processing of fish. Analysis of typical hazards, study of correction and corrective action. Detection and estimation of important toxic chemicals in food, quality defects.

Suggested Readings

Anon. 1992. *TQM in New Product Manufacturing*. McGraw Hill.
Anon. 1994. *Introduction of Total Quality*. Prentice Hall.
Anon. 1994. *Principles of Total Quality*. St. Leuie Press.

Gorbutt J. 1997. *Essentials of Food Microbiology*. Arnold Hodder Headline Group.
Huss HH. 2003. *Assessment and Management of Seafood Safety and Quality*. FAO Tech. Paper No. 444.
Kanduri L & Eckhartt RA. 2002. *Food Safety in Shrimp Processing*. Fishing News Books.
Kreuzer R. 1971. *Fish Inspection and Quality Control*. Fishing News Books.
Shukla RK. 2006. *Total Quality Management Practicing Manager*. New Royal Book.

FPT 604 LIPIDS OF AQUATIC ORIGIN 2+1

Objective

To impart knowledge on aquatic originated lipids, their metabolic activities and biological significance.

Theory

UNIT I

Lipid classification: Triglycerides, phospholipids, steroids and other lipids. Lipid micelles and bilayer.

UNIT II

Fatty acids: Classification, stereochemistry, nutritional significance of fatty acids.

UNIT III

Source of lipids: Biosynthesis of lipids, lipid metabolism including that of phospholipids, typical properties of marine lipids.

UNIT IV

Lipids in Biological membranes: Membrane proteins, lipoproteins, transport across membranes.

UNIT V

Lipid metabolism: Fatty acid oxidation, ketone bodies, lipid biosynthesis, regulation of cholesterol metabolism. Biological significance of marine lipids. Ether lipids and Eicosanoids- their significance.

UNIT VI

Modern analytical techniques employed in lipid chemistry. Methods of extracting poly-unsaturated fatty acids.

Practical

Extraction and fractionation of lipids. Fatty acid composition of different lipid fractions. Evaluation of oxidation product of fish lipid during processing and storage.

Suggested Readings

Akoh CC & Min DB. 1998. *Food Lipids*. Marcel Dekker.
Gurr MI, Harwood JL & Frayn KN. 2002. *Lipid Biochemistry*. 5th Ed. Blackwell.
Jnsel P, Turna RE & Ross D. 2001. *Nutrition*. Jones & Bartlet.
Simpson DS. 1987. *Food Biochemistry and Nutritional Value*. Longman.
Voet D, Voet JG & Praff CD. 1998. *Fundamentals of Biochemistry*. John Wiley.

FPT 605 MICROBIAL HAZARDS IN FISH PROCESSING 2+1

Objective

To provide theoretical and practical knowledge on various microbiological related hazards in fish processing.

Theory

UNIT I

Public health microbiology- Food borne pathogens: *Salmonella, Shigella,* Entero-pathogenic *E. coli, Clostridium botulinum, Listeria monocytogenes, Staph aureus* and *Vibrio cholerae, V. parahemolyticus*. Emerging food-borne pathogens. Water- borne, Air-borne and food-borne diseases.

UNIT II

Microbial virulence- infectious diseases. Virulence.

UNIT III

Microbial toxin production-opportunists and true pathogens.

UNIT IV

Methods for detection: Rapid detection and indirect detection methods of pathogens and parasites. Method validation.

UNIT V

Antimicrobial systems and food preservation: ecological concepts: Lactoperoxidase. Nisin, Lysozyme, Bacteriocins.

UNIT VI

Norms for using antimicrobial systems in food processing and preservation. Food Safety, Risk analysis. Potential health hazards and risks associated with fish products.

UNIT VII

Packaging and modified atmosphere on the microbiology and shelf life of fishery products.

UNIT VIII

Predictive modeling in quality and safety assurance of fishery products.

Practical

Antibiotic assay, sensitivity tests, evaluation of antibacterial properties. Analysis of fish product constituents. MIC, MCC, Risk analysis of seafood.

Suggested Readings

Cary JW, Linz JE & Bhatnagar D. 2000. *Microbial Food Borne Diseases*. Technomic Publ.

Doyle MP, Beuchat LR & Montville TJ. 1997. *Food Microbiology - Fundamentals and Frontiers*. American Society for Microbiology.

FPT 606 VITAMINS, MINERALS AND FLAVOUR BEARING CONSTITUENTS OF AQUATIC ORGANISMS 2+1

Objective

To study the compounds responsible for flavor and colour of fish and shellfish.

Theory

UNIT I

Vitamins, minerals, pigments, flavour bearing constituents and other components in aquatic organisms.

UNIT II

Vitamins: Metabolic functions of vitamins, water-soluble and fat-soluble vitamins. Vitamins from sea food.

UNIT III

Minerals: Role of trace elements in metabolism, trace elements of seafood, toxic heavy metals in seafood.

UNIT IV

Pigments and flavour bearing compounds of aquatic origin, chemistry, biochemical role, changes during processing of seafood.

UNIT V

Metabolic functions of hormones.

UNIT VI

Nucleoprotein, nucleic acids, nucleotides, nucleosides.

Practical

Modern methods for analysis of vitamins, minerals and nucleic acids. Organoleptic evaluation of flavours and pigments. Extraction of flavours and pigments and evaluation.

Suggested Readings

Ashrust PR. 1999. *Food Flavourings*. 3rd Ed. Aspen Publ.

Belitz HD & Grosch W. 1999. *Food Chemistry*. 2nd Ed. Springer.

Hutching JB. 1999. *Food Colour and Appearance*. 2nd Ed. Aspen Publ.

Teranishi R, Buttery RG & Shahidi F. 1989. *Flavour Chemistry - Trends and Developments*. American Chemical Society, Washington, D. C.

FPT 607 TOXINS AND CONTAMINANTS 2+1

Objective

To understand various types of toxins and contaminants and their tolerance limit.

To understand various analytical methods to estimate toxins and contaminants.

Theory

UNIT I

Public health problems due to food borne contaminants.

UNIT II

Factors contributing to outbreaks of food poisoning.

UNIT III

Aflatoxins in fishery products. PAH in smoked fish. Biogenic amines and its significance to human health, Different types of marine bio-toxins such as Ciguatoxin, Paralytic shellfish toxins diarrhetic shell fish toxins, DSP toxins, Scomberotoxins, Brevitoxins, etc. Symptoms, treatment, pharmacology, detection.

UNIT IV

Overview of toxicity of marine animals.

UNIT V

Analytical methods for different types of marine toxins and its tolerance limits: Stability, bioassays, pharmacology assays, immunoassays, Instrumental methods.

UNIT VI

Contaminants of the aquatic environment - Heavy metals (Hg, Cd, Pb, Cr, Ni, As etc.).

UNIT VII

Pesticide contaminants: PCB, organochlorine etc., their source, bioaccumulation, magnification and toxicity. Persistent pollutants. Toxicity evaluation. Measurement of LC_{50} and factors affecting LC_{50}, Animal tissue analysis.

Practical

Analysis of bacterial and fungal toxins, Analysis of heavy metals and common pesticides. Biogenic amine estimation, Estimation of LC_{50}.

Suggested Readings

Anon. 1988. *Handbook of Natural Toxins*. Vol. III. *Marine Toxins and Venom*. Marcel Dekker.

Anon. 1988. *Handbook of Natural Toxins*. Vol. IV. *Bacterial Toxins*. Marcel Dekker.

Anon. 2001. *Food borne Disease Handbook*. 2nd Ed. Vol. IV. *Seafood and Environmental Toxins*. Marcel Dekker.

Edward PR. 1984. *Seafood Toxins*. American Chemical Society, Washington, D.C.

Hashimoto Y. 1979. *Marine Toxins and Other Bioactive Marine Metabolites*. Scientific Society Press, Tokyo.

Moss J, Iglewski B, Vaughan M & Ju AT. 1995. *Bacterial Toxins and Virulence Factors in Disease*. Vol. VIII. Marcel Dekker.

FPT 608 NUTRITIONAL ASPECTS AND NUTRITION LABELING 2+1

Objective

To create basic understanding about labeling of different products, guidelines and enforcement.

Theory

UNIT I

Labeling requirements - national and international, legislation on labeling.

UNIT II

Labeling for product traceability.

UNIT III

Components of traceability code – nutrition facts and nutrition labeling, specific requirements of nutrition labeling, food meant for specific age groups and convalescing people.

UNIT IV

Serving size, calculation of nutrition facts based on nutrient composition and serving size.

UNIT V

Type of labeling for organic foods, specific foods like organic foods, GM foods, irradiated foods, vegetarian and non-vegetarian foods.

UNIT VI

Label design specification – size, colour.

UNIT VII

Major nutrients Minor nutrients, Essential nutrients, Function (or note) of nutrients - (providing energy, tissue building) Nutritional research - Nutritional aspects of fish proteins, lipids, vitamins and free minerals Functional foods/ Neutraceuticals for health, Effect of food processing on

nutritive values of foods. Antinutritional factors, Nutrition labeling, (Energy value of foods).

Practical

Analysis of major and minor nutrients, calculation of nutrition facts, preparation of labels for typical food items. Analysis for total calorie, calorific value of fats, protein and carbohydrates. PER, BV, NPU analysis of different products.

Suggested Readings

Jnsel P, Turna RE & Ross D. 2001. *Nutrition.* Jones & Bartlet.

Seshadri V. 1998. *Introduction to Clinical Nutrition and Nutritional Labelling*. Marcel Dekker.

Simpson DS. 1987. *Food Biochemistry and Nutritional Value*. Longman.

FPT 609 ENVIRONMENTAL IMPACTS OF FISHERIES INDUSTRIES 2+1

Objective

To provide theoretical and practical exposure on Environmental Management Systems in fisheries industry.

Theory

UNIT I

Environmental Management Systems: Environmental issues, (Ozone depletion, global warming etc.) pollution, long term ecosystem degradation etc in aquaculture and processing industries.

UNIT II

Environmental impact assessment studies of fisheries industry and control measures, Sources of environmental concerns (physical, chemical and microbiological).

UNIT III

Techniques for the identification of environmental aspects. IS/ISO 14000 and its relevance to Environmental Management System in fisheries industry: Background, policy and planning, implementation, checking and review, International and European Laws for Environmental Protection, National Environmental Laws.

Practical

Composition analysis of fish processing waste, analysis of pollution aspects of solid and liquid wastes – bacterial load, TDS, BOD, COD, pH, temperature, oil and grease . Resident time analysis for processing waste at the site of disposal.

Suggested Readings

Anon. 2000. *Manual of Chemical Methods*. 2nd Ed. Bureau of Indian Standards: IS/ISO 14000:1996 on Environmental Management System US-EPA.

Cesceri LS. 1998. *Standard Methods for Examination of Water and Waste Water*. APHA.

Hurst CJ. 2002. *Manual of Environmental Microbiology*. 2nd Ed. ASM Press.

Wise DL. 1994. *Process Engineering for Pollution Control and Waste Minimization*. Marcel Dekker.

FPT 610 FISHERY BY-PRODUCTS, SPECIALTY PRODUCTS AND VALUE ADDED PRODUCTS 2+1

Objective

To explain the preparation of products from low cost fish.

Theory

UNIT I

Nutritional importance of fish meal and quality requirements -Raw material quality and changes during processing and storage.

UNIT II

Nutritional importance of fish oil and methods to impart stability to fish oils on storage, Unsaponifiables in fish liver oils.

UNIT III

Production of fish flour, quality standards and applications.

UNIT IV

Different methods of production of FPC, Different types of FPC, and their specifications.

UNIT V

Enzyme hydrolysis of fish, fish hydrolysates, fish peptones, hydrolysates enriched food beverages.

UNIT VI

Food flavour from tiny prawns and non-penaeid prawns.

UNIT VII

Formulation of pet food.

UNIT VIII

Chitin, Chitosan and protein extract from shrimp and crab shell and squilla, Quality requirements and assessment of chitin and chitosan, Application of chitin and chitosan. Conversion of chitin and chitosan to high value products – glucosamine hydrochloride, glucosamine sulphate and their use.

UNIT IX

Extraction of collagen from fish processing wastes, properties and application. Preparation of biological membranes using collagen and chitosan for biomedical applications.

UNIT X

Value added products: Present market trends, scope of value addition, Types of value addition, Important value added products.

UNIT XI

Coated products – Principles and type of coating, coating functions, in gradients, batter classification, mechanical properties of batter, bread crumbs, flavorings, seasonings and hydrocolloids in coatings, Fat and oils in coated food and their chemistry, Trouble shooting techniques for batter and breading systems, application of batters and breading to seafood.

Practical

Preparation of glucosamine hydrochloride and glucosamine sulphate. Preparation of isinglass, collagen powder and collagen and chitosan. Preparation of fish wafers, fish fingers, cutlets etc.

Suggested Readings

Balachandran KK. 2001. *Post Harvest Technology of Fish and Fish Products*. Daya Publ.

Gopakumar K. (Ed.). 2002. *Text Book of Fish Processing Technology*. ICAR.

Hall GM. (Ed.). 1992. *Fish Processing Technology.* Blackie.
Hui YH., Merle DP & Richard JG. (Eds.). 2001. *Food Borne Disease Handbook. Seafood and Environmental Toxins.* Vol. IV. Marcel Dekker.
Nambudiri DD. 2006. *Technology of Fishery Products*. Fishing Chimes.
Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ.
Wheaton FW & Lawson TB. 1985. *Processing Aquatic Food Products*. John Wiley & Sons.

FISH PROCESSING TECHNOLOGY
List of Journals

- Advances in Applied Microbiology
- Annual Review of Microbiology
- Canadian Journal of Microbiology
- Fishery Technology
- Food Microbiology
- Indian Journal of Agricultural Biochemistry
- Indian Journal of Meat Science and Technology
- Indian Journal of Microbiology
- Indian Journal of Microbiology
- International Journal of Food Microbiology
- International Journal of Food Science and Technology
- Journal of Food Processing and Preservation
- Journal of Food Science and Technology
- Letters in Applied Microbiology
- Meat Science

Suggested Broad Areas for Master's and Doctoral Research

- Macro and micromoelcular changes in muscle during freezing
- Interaction of food protein with other food constituents during freezing and frozen storage
- Structural and functional changes of fat and protein
- Development of method to improve shelf life
- Freezing and frozen storage of novel product
- Micromolecular interactions during thermal processing
- Thermal processing in novel packaging materials.
- Study of nutrient losses during thermal processing and/or storage
- Study of combination effect of irradiation and thermal processing.
- Study of hurdle effect in canned preservation.
- Evaluation of quality standards of processing plants
- Establishment of critical limits for novel hazards and development of corrective action in HACCP protocol
- Interactions between protein and lipid
- Molecular markers development for identification of products
- Development of sensors for quality detection
- Antimicrobial agents in fish and fishery products.
- Effects of processing methods on micro-organisms
- Use of combination additives in cured product for better shelf life
- Establishing scientific basis for traditionally cured fish products.

- Effect of good handling practices and proper storage techniques and transportation on fish quality.
- Processing of different type of products using advanced technology.
- Development of Molecular methods to detect pathogens in food.
- Survival strategy of pathogens in processed food.
- Designing of instruments used in fish processing plants
- Biological and chemical treatment of fish processing wastes
- Effect of different packaging materials on quality and shelf-life of fish and fish products
- Development of suitable packaging for fish products
- Biochemical characterization of macro molecules with respect to processing requirements
- Structural and functional changes of fat and protein during processing
- Use of chemicals and biochemicals for modifying functional properties
- Modification of proteins for processing needs
- Rheology of fish and shellfish proteins
- Evaluation of quality standards of processing plants
- Establishment of critical limits for novel hazards and development of corrective action in HACCP protocol
- Changes in lipid during processing and storage
- Microbial alterations of lipid during fermentation
- Distribution of vitamins and minerals in commercially important tropical fishes.
- Changes in vitamin and mineral during processing
- Extractable flavouring components in fish and shellfish waste
- Anthropogenic contaminants in fish and their residence time
- Development of methods for detection of toxins and contaminants
- Risk assessment of seafood with respect to algal, fungal and biological toxin
- Modern methods for nutritional evaluation of foods
- Effect of pollutants on pre-harvest fish quality
- New methods of waste treatment from processing industries

FISHERIES ECONOMICS
Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
FEC 501*	MICROECONOMICS	2+0
FEC 502*	MACROECONOMICS	2+0
FEC 503*	ECONOMICS OF DEVELOPMENT AND PLANNING	2+1
FEC 504*	FISHERIES RESOURCE ECONOMICS	2+1
FEC 505#	MARKETING MANAGEMENT	1+1
FEC 506	ENVIRONMENTAL ECONOMICS	2+1
FEC 507#	PROJECT FORMULATION AND MANAGEMENT	1+1
FEC 508#	INTERNATIONAL ECONOMICS AND TRADE	1+1
FEC 509	FISHERIES FINANCING AND COOPERATION	1+1
FEC 510	INTRODUCTION TO ECONOMETRICS	1+1
FEC 511	INDIAN ECONOMY	2+0
FEC 591	MASTER'S SEMINAR	1+0
FEC 599	MASTER'S RESEARCH	20
FEC 601**	ADVANCED ECONOMIC ANALYSIS	2+1
FEC 602**	ADVANCED MARKETING AND PRICE ANALYSIS	2+1
FEC 603**	ADVANCED ECONOMETRICS	2+1
FEC 604	FISHERIES PLANNING AND POLICIES	1+1
FEC 605	AQUACULTURE PRODUCTION ECONOMICS	1+1
FEC 606	MARINE RESOURCE ECONOMICS	1+1
FEC 607	ADVANCED INTERNATIONAL ECONOMICS AND TRADE	1+1
FEC 608	FISHERIES GOVERNANCE AND SOCIO ECONOMICS	1+1
FEC 609	RESEARCH METHODOLOGY FOR SOCIAL SCIENCES	1+1
FEC 691	DOCTORAL SEMINAR I	1+0
FEC 692	DOCTORAL SEMINAR II	1+0
FEC 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme; ** Compulsory for Doctoral programme

#FEC 505, FEC 507 and FEC 508 cross listed with Business Management FBM 502, FBM 514 and FBM 511 respectively

FISHERIES ECONOMICS

Course Contents

FEC 501 MICROECONOMICS 2+0

Objective

To familiarize with the basic concepts and principles of microeconomics, including the analytical tools.

Theory

UNIT I

Concept of demand, Law and determinants of demand, Demand elasticities, Price, income and cross elasticities of demand. Supply – Supply concepts, Law, determinants of supply, cob web theorem, shifts in demand and supply.

UNIT II

Theory of consumer behaviour – Cardinal and ordinal utility – Law of Diminishing marginal utility – Indifference curve theory – Revealed preference theory – consumer surplus.

UNIT III

Theory of cost - Traditional, Modern theory, Engineering cost curves, Analysis of economies of scale, Production function, Theory of production – factors of production – production function analysis.

UNIT IV

Theory of product pricing, cost and cost curves, Revenue and revenue curves – objectives of business firms, profit maximization, Equilibrium of a firm, TR and TC approach, Market and market structure, Types of factor and product markets, price discrimination.

UNIT V

General Equilibrium theory, Welfare Economics, Theory of factor pricing – Distribution Rent, wages, Interest, Profit, Welfare economics.

Practical

Demand - supply relationship. Elasticity - price, income, cross. Factor-product, factor- factor and product-product relationships. Production costs and their relationship.

Suggested Readings

Ahuja HL. 2005. *Macroeconomics - Theory and Practice*. S. Chand & Co.

Dewett KK. 2006. *Modern Economic Theory*. S. Chand & Co.

Dwivedi DN. 2005. *Managerial Economics*. Vikas Publ.

Koutsoyiannis A. 2000. *Modern Microeconomics*. The McMillan Press.

Mankar VG. 1984. *Business Economics-Micro Analysis*. Himalaya Publ.

Mankiw NG. 1997. *Principles of Micro and Macroeconomics*. Dryden Press.

Samuelson PA & Nordhaus WD. 2001. *Economics*. Tata McGraw Hill.

Thomas CR & Maurice CS. 2006. *Managerial Economics*. Tata Mc Graw Hill.

FEC 502 MACROECONOMICS 2+0

Objective

To understand the basic concepts and principles of macroeconomics including the analytical tools used for them.

Theory

UNIT I

Macroeconomics: National Income Accounting – definition and concepts of NI, different components of national Income, and methods of national income accounting, Macro economics – National Income accounting – Determination of national income.

UNIT II

Classical Theory of income and employment, Keynes theory of employment, Theories of consumption – consumption function – Investment function – concepts of multiplier and accelerator.

UNIT III

Consumption function, Theories of consumption, Multiplier, Inducement to invest and marginal efficiency of capital, Classical theory of output and employment – Keynesian theory of income, output and employment.

UNIT IV

IS-Lm Curve Model, Aggregate Demand, Aggregate Supply, Unemployment and Full Employment, ISLM model – Hicks Hansen synthesis - Aggregate demand and supply – unemployment.

UNIT V

Inflation – causes and control measures - Business cycle – Money, banking and public finance – Nature and functions of money – Balance of payment.

UNIT VI

Money Supply and its determinants, Economic stabilizations-Fiscal and Monetary policy, Public Finance, Public revenue and taxation, Balance of Payment, Foreign Exchange, Fiscal and monetary policies – trade policies – public finance – public revenue and taxation – economic growth.

Practical

National income accounting, consumption and investment function, inflation, money supply balance of payment, foreign exchange.

Suggested Readings

Colander D. 2007. *Macroeconomics*. McGraw Hill.

Gardner A. 1978. *Macro Economics: Theory and Policy*. MacMillan.

Hahn F & Solow RM. 1997. *A Critical Essay on Modern Macroeconomic Theory*. MIT Press.

Keynes JM. 1976. *A Treatise of Money*. AMS Press.

Mankiw NG. 2002. *Macroeconomics.* Worth Publ.

Samuelson PA & Nordhaus WD. 2001. *Economics*. Tata McGraw Hill.

Thomas FD & McDougall DD. 1963. *Macro-Economics*. McGraw Hill.

FEC 503 ECONOMICS OF DEVELOPMENT AND PLANNING 1+1

Objective

To acquaint the students with the concept of development and planning.

Theory

UNIT I

Economics of development: concepts and approaches, economic growth

and income distribution, Characteristics of an under developed country , Obstacles to economic development ; Rostow's stages of economic development.

UNIT II

Economic growth, Meaning and characteristics of modern economic growth, Adam smith theory, The Ricardian theory, The Malthusian theory, The classical theory, Lewis's theory of unlimited supply of labor, The Marxin theory, The Harrod- Domar Model, The Solow Model of long run growth, The Mahalanobis Model.

UNIT III

Growth models in Indian planning, Capital formation and economic Development, Monetary policy in economic development, Fiscal policy in Economic development, Price policy in Economic development, Economic planning, Types of planning, Input-output analysis.

UNIT IV

Fisheries development policy and planning – Fisheries development during 5 year plans.

Practical

Physical Quality of Life Indices, Human Development index, Leontieff model of Input Output model, Analysis of the different growth models across the different plan periods; Lorenz curve, Gini Ratio.

Suggested Readings

Agrawal AN & Lal K. 1994. *Economics of Development and Planning*. Vikas Publ.

Jhingan ML. 1978. *Economics of Development and Planning*. Vikas Publ.

Subrahmanya KN. 1985. *Economic Development and Planning in India*. Deep & Deep Publ.

Todarao MP. 1989. *Economic Development of the Third World*. Longman.

FEC 504 FISHERIES RESOURCE ECONOMICS 2+1

Objective

To familiarise with the concept and application of economics to the different resource based production systems.

Theory

UNIT I

Marine fishery resources of India – characteristic features of marine capture fisheries - status of marine fisheries in India; Inland fishery resources of India - status and prospects.

UNIT II

Production economics catch and effort studies – methodological issues in the estimation of fish catch and fishing effort – dimensions of fishing effort – costs of and returns from fishing – cost components – employment and earnings of fishermen in relation to technological options – production function in marine capture fisheries; Maximum Economic Yield- Productivity in capture and culture Fisheries-An introduction to TFP in fisheries.

UNIT III

Population equilibrium analysis – sustainable yield curves – overfishing and underfishing – open access equilibrium yield – maximum sustainable yield and maximum social yield – Comparative static models – changes in

cost; changes in productivity; changes in price of fish. Management of fisheries in an environment of risk and uncertainty – challenges in the management of global fisheries – resource management issues – conflict management – socioeconomic issues and marine policy.

UNIT IV

Introduction – aquaculture production process – aquaculture systems in India – factors affecting the economics of aquaculture.

UNIT V

Production concepts applied to aquaculture – cost concepts and cost functions – Returns concepts – least-cost combination of inputs – optimization of aquaculture production.

UNIT VI

planning and budgeting – lineal programming – economies of scale – production function analysis – management of aquaculture production process – aquaculture management decisions – resource management – labour and personnel management – financial management – management of risk and uncertainty in aquaculture – economics of different aquaculture systems – socioeconomic issues in aquaculture development.

Practical

Estimation of costs and returns of different aquaculture systems – planning and budgeting – linear programming production function analysis – cost function analysis – financial and farm business analysis – risk programming – case studies – visit to fish farms, prawn farms and hatcheries – discussion on socioeconomic issues in aquaculture development. Data collection on cost and returns of different fishing methods (instead of economics of capture fisheries); Structural Change in the seafood export of India-Estimation of DRC, NPC for selected groups of exports.

Suggested Reading

Clarke CW. 1976. *Mathematical Bio-economics: The Optimal Management of Renewable Resources*. John Wiley.

Cunningham S, Dunn MR & Whitmarsh D. 1985. *Fisheries Economics*. St. Martin's Press.

Dunne EB. 1990. *Fisheries Economics - An Introduction*. Mansell Publ.

Grafton QR, Kirkley J, Kompas T & Squire D. 2006. *Economics for Fisheries Management*. Ashgate Publ. Co.

Hartwick JM & Olewiler ND. 1998. *Economics of Natural Resource Use*. 2nd Ed. Addision Wesley.

Munro GR & Scott A. 1984. *The Economics of Fisheries Management*. University of British Columbia.

Palanisamy K, Paramasivam P & Renganathan CR. 2002. *Agricultural Production Economics, Analytical Methods and Applications*. Associated Publ. Co.

Shang YC. 1981. *Aquaculture Economics*. Westview Press.

FEC 505 MARKETING MANAGEMENT 2+1

Objective

To familiarize with the basic concepts and principles of marketing as applied to fisheries.

To provide an interface between marketing and management decision.

Theory

UNIT I

Marketing management - Introduction and overview. Marketing system and environment Market opportunity identification- Customer analysis. Market segmentation, market positioning and consumer behaviour, Competition analysis, Market assessment, Marketing environment.

UNIT II

Demand assessment and forecasting, Designing the offer-product decision and pricing decision, product decision and strategies, product life cycle, new product development, branding and packaging decisions, Delivering the offer- distribution management, sales management and communication strategy management – Salesmanship.

UNIT III

Product management. Pricing policies and practices. Distribution strategy - channels of distribution, physical distribution.

UNIT IV

Marketing information system. Marketing communication - advertising, publicity, personal selling, sales promotion.

UNIT V

Marketing research and information system, Marketing research and its application in fisheries marketing strategy, planning and organisation, emerging issues in marketing, e-marketing.

Practical

Marketing mix, marketing strategy, segmentation, pricing methods, consumer behaviours, new product development, marketing research, measuring effectiveness of marking mix, performance evaluation, efficiency analysis.

Suggested Readings

Adcock D, Bradfield R, Halborg A & Ross C. 1995. *Marketing Principles and Practice*. Pitman Publ.

Amarchand D & Varadharajan B. 1979. *An Introduction to Marketing*. Vikas Publ.

Chaston I. 1983. *Marketing in Fisheries and Aquaculture*. Fishing News Books.

Dennis A, Brandfield R, Al Halhorg & Ross C. 2004. *Marketing Principles and Practice*. Pitman Publ.

Ian C. 1984. *Marketing In Fisheries and Aquaculture*. Fishing News Books.

Jolson MA. 2004. *Marketing Management*. Macmillan Publ.

Kotler P. 2005. *Marketing Management*. Prentice Hall of India.

Kotler P & Armstrong GM. 2006. *Marketing: An Introduction*. Prentice Hall.

Phillip K & Armstrong G. 2007. *Principles of Marketing*. Prentice Hall.

Phillip K. 2008. *Marketing Management*. 12th Ed. Prentice Hall of India.

FEC 506 ENVIRONMENTAL ECONOMICS 2+1

Objective

To introduce the students to different concepts of environmental economics, its relevance, and tools of measurement.

Theory

UNIT I

Ecology and economics - principles of environmental economics - public goods, club goods and theory of common property - property rights and ownership incentives equimarginal principle -discounting and risk, user cost, existence value - substitution between capital and natural resources - environmental externalities. Population question and theory of demographic transition - poverty, development and environment – environment and trade - concept and practice of sustainability.

UNIT II

Market and non-market valuation of natural resources - measurement of environmental harm and benefit - contingent valuation - difficulties in application of a supply/demand or benefit/cost framework - application of a cost-effectiveness or cost-minimization framework. Criteria for evaluating environmental policies – market based / incentive based strategies like emission taxes and subsidies, transferable discharge permits - polluter pays principle. Kyoto Protocol, carbon trading, CDM and GEF - environmental policies in major industrialised and industrialising countries - international environmental agreements.

UNIT III

Concept and principles of EIA; methodologies for EIA in fisheries and aquaculture sector; Institutional (International/National/Stale/Local) arrangements and strategies for estimation, amelioration and compensation for impacts; Aquaculture Authority Bill and AAI. Environment related conflicts and dispute resolution; Coasian theorem and stakeholder decision making process. Economic theory of fish resource exploitation - absent property rights in fisheries sector - common property resource use and management - scarcity and competitive exploitation in fisheries sector - concepts of Maximum Sustainable Yield (MSY), M/NEY, OSY, Static and Dynamic MEY, and their interrelationships.

Practical

Case studies on environmental economics of shrimp farming (intensive/ semi-intensive/ extensive) and polyculture farms - Application of Extended Domestic Resource Cost Ratio and Policy Analysis Matrix for aquaculture - Case studies on the sustainability of various capture fishery systems - Economics of inland water and marine pollution - economics of pollution control - economics of climate change, global warming and fisheries development - Gordon-Schaefer growth model, Dynamic Poll model and Bioeconomic model of fisheries resource management.

Suggested Readings

Bhattacharya R. 1997. *Environmental Economics: An Indian Perspective*. Oxford University Press.

Cunningham S, Dunn MR & Whitmarsh D. 1985. *Fisheries Economics - An Introduction*. Mansell Publ.

Gadgil M. 1997. *Ecological Journeys: The Science and Politics of Conservation in India*. Orient Longman.

Prasad M & Biswas AK. 1999. *Conducting Environmental Impact Assessment for Developing Countries*. Oxford University Press.

Sankar U. (Ed.). 2001. *Environmental Economics*. Oxford University Press.

Tietenberg T. 1984. *Environmental and Natural Resource Economics*. Scott Foreseman & Co.

Ulph A. 2000. *Environmental Policy, International Agreements and International Trade*. Oxford University Press.

FEC 507 PROJECT FORMULATION AND MANAGEMENT 1+1

Objective

To familiarize the students with the basic concepts and principles of project formulation and management techniques.

To prepare the students to exploit business opportunities in fisheries and aquaculture.

Theory

UNIT I

Concept, scope and definition of project - difference between plan and project – project types - advantages and limitations – elements of project cycle - aspects of project preparation and analysis - project cost and benefits – comparisons – tangible and intangible cost and benefits; Social cost benefit analysis – concepts.

UNIT II

Financial and economic aspects of projects: feasibility analysis – undiscounted measures of project worth - ranking by inspection, pay back period, average annual proceeds per unit of outlay - time value of money - discounted measures – discounted pay back period, derivation of incremental net benefit, net present worth, BC ratio, IRR, net benefit investment ratio, project alternatives - risk and uncertainties - sensitivity analysis. Farm planning, budgeting – complete and partial budgeting - farm business analysis and appraisal techniques – ratio analysis, asset valuation and depreciation. Financial analysis-balance sheet, cash flow analysis, profit loss statements.

UNIT III

Guidelines for project preparation report – objective, rational, area, organization, production, markets and financial results, benefits. Sources of institutional assistance for project preparation and formulation – bilateral and multilateral assistance. Project implementation – objective and tasks, economic aspects of project evaluation. Project management – management technique – bar chart, milestone chart, activity slack bar chart, PERT, CPM, inventory management and control, management information system and project monitoring.

Practical

Practical and Case studies: Ratio analysis, computing depreciation, valuation of project inventories, complete and partial Budgeting, cash flow analysis, balance sheet / net worth statement, profit–loss statement/income statement–undiscounted and discounted measures – net work techniques - bar charts, milestone chart and activity slack bar chart, PERT and CPM - project preparation for capture, culture and processing sectors - sensitivity analysis - project monitoring and evaluation – case studies and feasibility evaluation.

Suggested Readings

Chaudhary S. 1988. *Project Management*. Tata McGraw Hill.

Fisheries Project Formulation. FAO Tech. Paper No.334.

Gittenger P. 1972. *Economic Analysis of Agricultural Projects*. Johns Hopkins University Press.
Ojha SN & Salim SS. 2000. *Entrepreneurship Development and Project Formulation*. CIFE, Mumbai.
Rodney J, Turner S & Simister J. (Eds.). 2007. *Project Management*. Infinity Books.
Salim SS, Biradar RS & Pandey SK. 2004. *Economic Analysis of Fisheries Projects*. CIFE, Mumbai.
Shang YC. 1990. *Aquaculture Economic Analysis - An Introduction*. World Aquaculture Society, USA.

FEC 508 INTERNATIONAL ECONOMICS AND TRADE 1+1

Objective

To familiarise the students with the basic concepts and principles of economics as applied to international trade.

Theory

UNIT I

International trade: Nature of international trade, difference between domestic and foreign trade; Theories of international trade: absolute and comparative advantage, modern theories of international trade - Hecksher Ohlin theorem

UNIT II

Concepts of terms of trade, free trade, protection, tariffs, quantitative restrictions and other non-tariff measures

UNIT III

Exim policy – Export Import procedure – Role of ECGC.

UNIT IV

Growth of marine product exports – MPEDA and its development programmes – WTO in dispute settlement.

Practical

Pattern and Performance of India's Seafood Exports; Case studies on product and market diversification. Case studies on competitiveness of Indian fish and fish products. Case studies on exports of value added seafood products; Case study of a seafood export firm; Case studies on (ab)use of SPS / TBT measure; Case studies on non-tariff barriers in fisheries trade; Case studies on dumping and anti-dumping measures in seafood trade; Case studies on disputes in TRIPS.

Suggested Readings

Appleyard DR & Field A. J. 2001. *International Economics*. 4th Ed. McGraw Hill.
Dennis A. 2001. *Trade Theory and Practice*. Irwin Publ.
Francis C. 2008. *International Economics*. Tata McGraw Hill.
Krugman PR & Obstfeld M. 1991. *International Economics: Theory and Policy*. Harper Collins Publ.
Mithani JP.1998. *International Economics*. Tata McGraw Hill.
Samuelson P & Nordhaus WD. 2001. *Economics*. Tata McGraw Hill.

FEC 509 FISHERIES FINANCING AND COOPERATION 1+1

Objective

To understand the basic concepts and practices of fisheries financing and cooperation.

Theory

UNIT I

Fisheries finance – definition and principles – importance and scope. Fisheries credit system in India – Basic considerations for providing fisheries credit financial management tools. Financial management tools – information flows – income statement – financial statement – Tools for forward planning – financial ratios. Enterprise budgeting – cash flows – fisheries credit appraisal – 3 R's of credit – Banking institutions in India – Commercial Banks. Regional Rural Banks and Co-operatives. Service area approach – Reasons for over dues – procedure for recovery – Role of NABARD and nationalized Banks in Fisheries Finance – credit policies for Fisheries development. .

UNIT II

Fisheries Cooperatives: Principles and scope of cooperative; Development of fisheries cooperative in India, Structure and functions of fisheries cooperative; Evaluation of the performance fisheries cooperatives. Managerial aspects of cooperative societies; cooperative marketing in fisheries, State fisheries cooperative Federations, Fisheries Corporation, Self Help Groups in fisheries.

Practical

Financial statement analysis – Income statement Analysis – important financial records – Different case studies on fisheries co-operative societies and their performance.

Suggested Readings

Bhatia BS, Verma HL & Mahesh CH. 2001. *Encyclopaedia of Co-operative Management* Vols. I-IV. Deep & Deep Publ.

FAO. 1971. *Manual on Fishermen's Co-operatives*. Rome.

FISHCOPFED. 1989**.** *Fish Co-operatives*, New Delhi.

Proctor T. 2005. *Essentials of Marketing Research*. Financial Times Prentice Hall.

Rajagopalan R. 1997. *Rediscovering Cooperation*. Vols. I-III. IRMA Anand.

FEC 510 INTRODUCTION TO ECONOMETRICS 1+1

Objective

To familiarize with the fundamental principles of econometrics.

To apply the theoretical knowledge in econometrics to analysing empirical phenomenon.

Theory

UNIT I

Econometrics Introduction relationship with other disciplines Matrix algebra,

UNIT II

Assumptions in the classical linear regression model; Consequences of multicollinearity, heteroscedasticity, autocorrelation and remedial measures

UNIT III

Econometric model specification criteria, specification errors, measurement errors of dependent and explanatory variables, Different model specification criteria

UNIT IV

Time series econometric models, Basic ideas in fitting non-linear regression models

Practical

Exercises on fitting classical linear regression models, detection of multicollinearity, heteroscedasticity and autocorrelation in the given data sets, Model selection using R^2, AIC and SIC criteria; Hands on using econometric packages like SPSS, SAS and SHAZAME

Suggested Readings

Acharya SS & Madnani GMK. 1988. *Applied Econometrics for Agricultural Economists*. Himanshu Publ.

Eniya T. 1985. *Advanced Econometrics*. Basil Blackwell.

Gujarati D. 2004. *Basic Econometrics*. McGraw-Hill.

Maddala GS. 1977. *Econometrics*. McGraw Hill.

Stewart J & Gill L. 1998. *Econometrics*. Prentice Hall.

Thomas RL. 1985. *Introductory Econometrics: Theory and Applications*. Longman.

FEC 511 INDIAN ECONOMY 2+0

Objective

To acquaint the students with the different facets of the Indian economy.

Theory

UNIT I

Underdevelopment and the Indian economy, National income of India, Human resources and economic development Social cost benefit analysis-concepts.

UNIT II

Analysis of contribution of different sectors to the Indian Economy-Economic development in India through plan periods; Human development in India, Occupational structure and economic development, Planning and Economic development, Objectives and strategy of economic planning, Industrial policy and Indian planning.

UNIT III

Capital formation in different sectors of the Indian economy by public and private; Public sector and Indian planning, Disinvestment of public enterprises, Private sector, joint sector and Indian planning, privatization and economic reform.

UNIT IV

Foreign trade of India, India's balance of payment, Indian currency system, Indian financial system, the problem of capital formation, Indian public finance, Government subsidies in India.

Suggested Readings

Dutt R & Sundaram KPM. 2002. *Indian Economy*. S. Chand & Co.

Gittenger P. 1972. *Economic Analysis of Agricultural Projects*. Johns Hopkins University Press.

Mozoomdar A. 2002. *The Indian Economy: A Different View*. Har-Anand Publ.

Vaidyanathan A. 1995. *The Indian Economy: Crisis, Response, and Prospects*. Orient Blackswan.

FEC 601 ADVANCED ECONOMIC ANALYSIS 2+1

Objective

To develop an analytical framework to understand the inter-linkages among the crucial microeconomic and macroeconomic variables and various segments of the economy.

To provide an interface between tools and its application in the economy.

Theory

UNIT I

Theory of consumer behaviour: concepts, analytical approaches, limitations and applications, demand theory, demand functions-derivations analytical approaches, limitations and applications and elasticity decomposition analysis, Recent developments in the theory of demand – linear expenditure system, constant elasticity demand function, dynamic versions of demand functions distributed lag models, Houthakker's and Taylor's dynamic models; utility functions - separable and additive, homogenous and homothetic functions, direct and indirect.

UNIT II

Basic theory of the firm: concepts, production functions, isoquants derivations and applications, optimization behaviour – alternative models, short run and long run cost functions; total price effect-substitution effect, output effect and profit maximization effect decomposition analysis-analytical approaches, joint products-concepts and constrained optimization.

UNIT III

Extended theory of the firm: homogenous production functions; constant elasticity of substitution production functions-concepts, properties, equilibrium analysis and applications; duality in production, production under uncertainty, linear production functions for single and multi output cases.

UNIT IV

Commodity market equilibrium-short run, long run, differential cost conditions; theory of cost and empirical evidence on the shape of cost functions, taxation applications. Theory welfare: - Criteria of social welfare, Determination of welfare maximizing out put-mix, Commodity distribution and resources allocation.

UNIT V

Concept and measurement: national income, Consumption, Investment Function and Multiplier Price level, inflation, CPI, WSPI, in the economy. The concept of full employment, inflationary gap. The theory of income determination and multiple market economic systems, Multiplier and accelerator analysis, Monetary and fiscal policies, Taxes and expenditure.

Practical

Demand function and it's derivation, computation of demand and supply elasticity, Derivation of cost function, Measurement of National income accounts multiplier price level, inflation, CPI, WSPI.

Suggested Readings

Dernburg TF. 1985. *Macroeconomics: Concepts, Theories and Policies*. McGraw Hill.

Edwin M. 1989. *Applied Micro Economics*. WW Norton.

Ferguson CE. 1989. *Micro Economic Theory*. AITBS.

Gardner A. 1963. *Macroeconomics: Theory and Policies*. MacMillan.

Henderson JM & Quandt RE. 1972. *Micro Economic Theory - A Mathematical Approach*. McGraw Hill.

Koutsoyiannis A. 1979. *Modern Microeconomics*. MacMillan Press.

Richard HL & Eckert DR. 1962. *The Price System and Resource Allocation*. The Dryden Press, Halt Saunders.

Shapiro EJ. 1989. *Macroeconomic Analysis*. Harcourt Brace Jovanovich.

Skaggs NT & Carlson JL. 1996. *Macroeconomics*. Blackwell.

William HB. 1977. *Macroeconomics Theory and Policy*. Harper & Row.

FEC 602 ADVANCED MARKETING AND PRICE ANALYSIS 2+1

Objective

To familiarize the students with the basic concepts and principles of marketing as applied to management decisions.

To provide an interface between marketing and management decision.

Theory

UNIT I

Fisheries marketing definition and scope, functions of fish marketing, Markets and market structure, Government and Co-operative in fisheries marketing , integration, marketing efficiency, marketing cost and price spread, marketing planning, marketing strategy, marketing research, Marketing infrastructure, Marketing regulations, constraints and approaches to fish marketing development.

UNIT II

Supply Chain Management Concepts and Evolution, value addition in fish marketing. Constraints and approaches to SCM in fisheries sector. Vertical integration and its effect on price determination. Domestic and external markets for fisheries products**.** Indian fisheries intervention.

UNIT III

Developing marketing strategies. Advanced studies of marketing information system and e-marketing, fish-business. Dynamics and innovations in fisheries marketing system. Applications of econometric methods of analysis for the study of market behaviours. Computer application in marketing management; market intelligence, its need, analysis and dissemination.

UNIT IV

Principles of price determination. Price difference and variability, price analysis, price elasticities, Price determination of fish and fishery products, characteristics of demand and supply of fish and fishery product , supply responses, seasonality, future trading, price support measures. Price stabilisation policies.

UNIT V

Seafood and aquaculture markets world-wide, Marketing channels, Economies of scale, Economics of processing, Economic feasibility and Business Plan Development. Policies and regulations that affect

aquaculture marketing and distribution. Indian seafood and aquaculture marketing environment.

Practical

Price determination of fish and fishery products, Price difference and variability, price analysis, price elasticities, Price determination, Market integration and marketing efficiency, Case studies of supply chains in urban and rural fish markets, and exported product and domestically traded product. Country Risk Analysis: case studies of comparative risk positions of various countries as export markets for fish products. Export composition and destination of Indian agricultural commodities and seafood products. Import composition and origin. Analysing trade performance before and after WTO; Analysis of international price trends and volatility; Case studies of seafood export firms. Case studies of economics of shrimp farms (intensive/ semi-intensive/ extensive) and polyculture farms. Extended domestic cost resource ratio and policy analysis matrix for Shrimp farming. Case studies e-marketing dynamics and innovations in fisheries marketing.

Suggested Readings

Adeock D & Brandfield R. 1998. *Marketing Principles and Practice*. Pitman Publ.

Amarchand D & Varadharajan B. 1979. *An Introduction to Marketing*. Vikas Publ.

Branson RE & Dougla N. 1983. *Introduction to Agricultural Marketing*. McGraw Hill.

Chaston I. 1983. *Marketing in Fisheries and Aquaculture*. Fishing News Books.

Jolson MA. 1978. *Marketing Management*. Macmillan Publ.

Kotler P & Armstrong G. 2004. *Principles of Marketing*. Prentice Hall.

Kotler P. 2005. *Marketing Management*. Prentice Hall of India.

Shephard GS. 1963. *Agricultural Price Analysis*. Iowa State University Press.

Taha HA. 2003. *Operational Research: An Introduction*. Prentice Hall.

FEC 603 ADVANCED ECONOMETRICS 2+1

Objective

To familiarize with the basic tools and techniques as applied to economic decisions.

To provide an interface between applied Econometrics and decision making.

Theory

UNIT I

Economics, Statistics and Econometrics. Representation of economic phenomenon, relationship among economic variables, linear and non-linear economic models. Regression and Correlation; Partial correlation; The normality assumption (Classical Normal Linear regression Model Nature of Regression Analysis – Simple regression, multiple regression and their assumptions.

UNIT II

Basic concepts of matrix algebra, differentiation, integration and probability distribution theory; Correlation matrix, residual variance, co-efficient of multiple correlation, standard errors of co-efficient estimates

and their uses in regression, analysis of partial correlation and its uses in interpreting regression co-efficients.

UNIT III

Hypothesis testing, Estimation inference; Ordinary least squares – deriving normal equations, assumptions and properties of OLS; Estimation and interpretation coefficients; Large sample properties – Maximum Likelihood Estimation; Violation of basic assumption of OLS and remedies.

UNIT IV

Multicollinearity, Heteroscedasticity, Autocorrelation, Normality assumption; Use of Dummy Variables – Simultaneous equation model; Time Series Analysis; Basic Econometric Modeling.

Practical

Application of OLS; application of generalised least square; Tests for Multicollinearity, Heteroscedasticity, Autocorrelation, and Normality assumption. Estimation of Economic Parameters.

Suggested Readings

Anthony RN & Reece JS. 1975. *Accounting Principles*. AITBS.

Bendrey M, Bendrey M, Hussey R & West C. 2003. *Essentials of Financial Accounting in Business*. Cengage Learning EMEA.

Chandra P. 2005. *Fundamentals of Financial Management*. Tata McGraw Hill.

Maheshwari SN & Maheshwari SK. 2006. *A Textbook of Accounting for Management*. Vikas Publ.

McLaney E. 2006. *Business Finance: Theory and Practice*. Financial Times, Prentice Hall.

Wood F & Sangster A. 2005. *Business Accounting*. Prentice hall.

FEC 604 FISHERIES PLANNING AND POLICIES 1+1

Objective

To understand the planning and policy tools and techniques.

Theory

UNIT I

Planning in India-Objectives, allocation, achievements and bottlenecks of Indian plans, Strategy of Indian planning, resource Mobilization.

UNIT II

Fisheries Development and policy under the plans, Fisheries schemes; Centrally and State sponsored schemes. Different sectoral schemes, Agriculture policies, Need for a separate fishery policy. Leasing policies for inland water bodes and brackish water bodies in different states, Input Policy, Financing and Credit Policy, fish marketing and pricing policy, Export –Import Policy.

UNIT III

Types of planning, Stages in the planning process, Planning models. Planning for utilization of surplus resources including manpower.

UNIT IV

Subsidies in Fisheries, regional disparities, poverty and unemployment in India with respect to the fisherfolk. Policies, sectoral study of capture and culture fisheries.

Practical

Performance appraisal of the different sectors over the years; Developing policy framework for the fisheries sector.

Suggested Readings

Benjamin HH. 1968. *Economic Development, Problems, Principles and Policies*. WW Norton.

Gerald MM. 1984. *Leading Issue in Economic Development*. Oxford University Press.

Herrick BH & Charles PK. 1983. *Economic Development*. McGraw-Hill.

Michael PT. 1989. *Economic Development in the Third World*. Orient Longman.

FEC 605 AQUACULTURE PRODUCTION ECONOMICS 1+1

Objective

To learn the basic concepts and principles of economics as applied to aquaculture.

To gain an understanding of the different types of economic concepts and the analytical tools used for them.

Theory

UNIT I

Production economics- nature and scope, approaches terms and concepts Different production relationship – factor- product, factor - factor, product-product Farm management. Risk and uncertainty, productions and cost concept.

UNIT II

Mathematical analysis of production relationship – concept of production function, different types, characteristics, economics Implications, economic optimum and physical optimum, decision make with multiple variables.

UNIT III

Decision making with no risk, with risk, Technology, Input use and factor share, Farm business analysis economic efficiency in fish production, yield gap, yield penalties and yield declines.

UNIT IV

Economic aspects of different aquaculture production systems in India and abroad.

Practical

Estimation of the different production relationships, Farm business analysis, mathematical analysis of production relationship, Estimation of physical and economic optimum, Inclusion of risk and uncertainty in aquaculture systems, Incorporation of technology as a component in the production function, Estimation of yield gap and factor shares.

Suggested Readings

Cunningham S, Dunn MR & Whitmarsh D. 1985. *Fisheries Economics – An Introduction*. Mansell Publ.

Gujarati DN. 1995. *Basic Econometrics*. McGraw Hill.

Heady EO & Dillon JL. 1961. *Agricultural Production Functions*. Kalyani.

Heady EO. 1960. *Economics of Agricultural Production and Resource Use*. Prentice Hall.

Lawson RM. 1984. *Economics of Fisheries Development*. Frances Pinter & Publisher.

Salim SS, Biradar RS & Pandey SK. 2004. *Fisheries Economics and Marketing: An Introduction.* CIFE, Mumbai.

Sankhayan PL.1988. *Introduction to the Economics and Agricultural Production*. Prentice Hall.

Shang YC. 1990. *Aquaculture Economic Analysis – An Introduction*. World Aquaculture Society, USA.

FEC 606 MARINE RESOURCE ECONOMICS 1+1

Objective

To familiarize with the basic concepts and principles of economics as applied to marine resources.

To gain an understanding of the different types of economics concepts and the analytical tools used for them.

Theory

UNIT I

Historical background and characteristics of different forms of production functions, derivatives, alternative algebric forms of production functions and their applications, choice and functions in empirical analysis.

UNIT II

Optimisation and resource allocation. Multiple product relationships. Production possibility curves. Choice between products and resource use. Spatial and temporal allocation of resources. Resource-use efficiency: size, productivity and returns to scale, measurement of production efficiency.

UNIT III

Problem formulation for programming, preparation of input-output matrix, objective functions and constraint equations. Assumptions of L.P. Basic and non-basic solutions; feasible and infeasible solutions. Simplex method and its application for solving fisheries problems, use of artificial factors, problems of degeneracy, inconsistency, infeasible and unbounded solutions. The generalized simplex method; the dual method; the dual simplex method.

UNIT IV

Measurement of risk and optimization under risk.

Practical

Application of linear programming for solving practical problems in farming with the help of following: Variable resource programming, Variable price programming, Integer Programming, Recursive programming. Theory of games and application of linear programming for solving game problems in farm decision making. Transport models, Dynamic programming.

Suggested Readings

Dholakia AD. 2004. *Fisheries and Aquatic Resources of India*. Daya Publ. House.

Gujarati DN. 1995. *Basic Econometrics*. McGraw Hill.

Heady EO & Dillon JL. 1961. *Agricultural Production Functions*. Kalyani.

Heady EO. 1960. *Economics of Agricultural Production and Resource Use*. Prentice Hall.

Sankhayan PL. 1988. *Introduction to the Economics and Agricultural Production*. Prentice Hall.

Shanbhogue SL. 2000. *Marine Fisheries of India*. ICAR.

FEC 607 ADVANCED INTERNATIONAL ECONOMICS AND TRADE 1+1

Objective

To gain conceptual clarity on the important linkages between domestic economy and its external sector.

To incorporate international issues in designing strategies in the changing environment.

Theory

UNIT I

Concept and Theories of international trade – Classical theories, Reciprocal demand, Offer curve technique; concepts of terms of trade, gains from trade, international trade as a substitute for growth, theory of immesirising growth; Modern theory of international trade – Hecksher-Ohlin theory, factor price equalization theory, Stopler Samuelson theory, Robinsky theorem, recent theories of international trade Specific Factors Model, Capital and Labor Mobility, and Intermediate Goods, Competitiveness Analysis.

UNIT II

Developing Countries' Concerns of Balance of payment; Rate of exchange; International capital movements; Free trade Vs Protection, types of protection; Anti-dumping measures and trade.

UNIT III

International Financial institutions (WTO, WB, IMF); International Monetary Systems: International Business Environment, European Monetary System and Emergence of Euro.

UNIT IV

GATT and WTO, transition from GATT to WTO, WTO provision and its agreements: Agreement on Agriculture (AoA), Agreement on SPS measures and its salient features, Role of Codex Alimentarius Commission (CAC) and Agreement in Trade Related Intellectual Property rights (TRIPs). Challenges, strategies and opportunities in seafood exports. Need for Agreement on Fisheries. Export/Import regulations; entry process for imports, Export promotion: New Avenues and measures. Market Access and Trade liberalisation. Trade and Environment; Trade and labour standards; WTO and Indian Business.

Practical

Determination of absolute and comparative advantage. Gains from trade with fixed exchange rates. Estimation of terms of trade. Derivation of offer curves and effects of technological change and factor supply. Estimation of protection coefficients. Measurement of effects of tariff imposition. Effects of tariff and non-tariff barriers on domestic supply and imports. Preparation of BOP. Performance of Export/import accounts.

Suggested Readings

Charles PK. 1968. *International Economics*. Richard D. Irwin.

Ethier WJ. 1995. *Modern International Economics*. Norton International Ed.

Francis C. 1999. *International Economics*. Tata McGraw Hill.

Kemp MC. 1964. *Pure Theory of International Trade*. Prentice Hall.

Walterjngo & Kaaj A. 1981. *International Economics*. 3rd Ed. Prentice Hall.

FEC 608 FISHERIES GOVERNANCE AND SOCIO ECONOMICS 1+1

Objective

To familiarize with the underlying importance of proper governance of the fisheries sector.

To review status of fisherfolk in the country.

Theory

UNIT I

Importance of fisheries sector in Indian economy; Fisheries administrative set up at Centre and States - sphere of responsibilities of Central and State governments/agencies for fisheries development. Fisheries legislation in India: background, Indian Fisheries Act of 1897 and subsequent Amendments.

UNIT II

Marine capture fisheries: comparative study of Marine Fishery Regulation Acts of coastal Indian States – licensing/registration of vessels and mechanisation – declaration of closed season, protection of endangered species, prohibition of destructive fishing methods, regulation of mesh size, filing of return on fish catch and income. Features of MPEDA Act and Rules, 1972 – guidelines for operation of Indian deep sea fishing vessels in Indian EEZ – Maritime Zone of India (regulation of fishing by foreign vessels) Act 1981 - aquatic exotics and quarantine regulations - Marine Fisheries Policy, 2004. Coastal Aquaculture Authority.

UNIT III

Aquaculture: Guidelines under CRZ notification of 1991 and its Amendments, land leasing policies, regulations on use of chemicals and antibiotics - features of Aquaculture Seed (Quality Control) Relevant Central/state legislative provisions of Environment, Wildlife, Water, Biodiversity: (riverine, reservoir and aquaculture), processing in different States.

UNIT IV

Economic theories and growth models of fish resource development and exploitation; Fishery resource management; Maximum Sustainable Yield (MSY), Maximum and Net Economic Yield (M/NEY), Optimum Sustainable Yield (OSY), Static Maximum Economic Yield (SMEY), Dynamic Maximum Economic Yield (DMEY) Socioeconomics – An overview of the socio economic status of the fisherfolk in India, overview of various welfares schemes, Disaster management. Role of fisheries co-operatives, corporation and NGOs in the development of the fisherfolk. Social, economic and cultural context in which NREGA is implemented Labour market relation: wage, work opportunity, migration, livelihood security, income generation.

Practical

Licensing/registration of vessels. Estimation of socio-economic parameter of fisherfolk in India. Computation of various resources efficiency measures.

Suggested Readings

Gaisford JD & Kerr WA. 2001. *Economic Analysis for International Trade Negotiations*. John Wiley & Sons.

Green D & Griffith M. 2002. *Dumping on the Poor: The Common Agricultural Policy, the WTO and International Development.* CAFOD, London.

Sikdar S. 2003. *Contemporary Issues in Globalisation - An Introduction to Theory and Policy in India*. Oxford University Press.

Tussie D & Glover D. 2000. *The Developing Countries in World Trade - Policies and Bargaining Strategies*. Lynne Rienner.

Weber ML. 2001. *From Abundance to Scarcity: A History of U.S. Marine Fisheries Policy*. Island Press**.**

FEC 609 RESEARCH METHODOLOGY FOR SOCIAL SCIENCES 1+1

Objective

To acquaint the students with the basic concepts of research methods, processes and tools.

To provide hands on training in data collection and analysis.

Theory

UNIT I

Social science - definition, goals and functions. Role of social science research in agriculture. Fisheries economics research-induction and deduction, sources of information, review of literature.

UNIT II

Identification of problem, and formulation of objectives and hypothesis. Types of hypothesis. Testing of hypothesis. Research design. Type of data and their sources, methods of data collection- formal (sampling) and informal (PRA, RRA) survey techniques preparation of questionnaire, interview method, mail order method, cost accounting method.

UNIT III

Analysis of data - methods of analysis. Selection of appropriate tools for analysis. Introduction to statistical software for social sciences.

UNIT IV

Report writing-methods of reporting. Use of tables, graphs, diagram, etc. in reports using computers.

Practical

The students will identify a problem in agricultural economics and work on the problem during the semester as trained in theory classes by intensively using personal computers.

Suggested Readings

Kothari CR. 1998. *Research Methodology*. 2nd Ed. Vishwa Prahashan.

Kothari CR. 2000. *Quantitative Techniques*. 3rd Ed. Vikas Publ.

Kumar R. 1996. *Research Methodology: a Step-by-Step Guide for Beginners*. Sage Publ.

Mukerjee N. 1993. *Participatory Rural Appraisal: Methodology and Applications*. Concept Publ. Co.

FISHERIES ECONOMICS

List of Journals

- AgExporter
- Agricultural Economics Research Review
- Agrimarketing
- American Journal of Agricultural Economics
- Aquaculture International
- Asian Development Review
- Asian Economic Review
- Australian Journal of Agricultural and Resource Economics
- Co-operator
- Ecological Economics
- Econometrica
- Economic and Political Weekly
- Economic Perspectives
- Economic Survey
- Economic Theory
- Empirical Economics
- Environment and Development Economics
- European Journal of Research Methods for the Behavioral and Social Sciences
- Experimental Economics
- Fisheries Technology
- Food Outlook
- Indian Co-operative Review
- Indian Journal of Agricultural Economics
- Indian Journal of Agricultural Marketing
- Indian Journal of Fisheries
- Indian Journal of Foreign Trade
- Indian Seafood Journal
- International Advances in Economic Research
- International Economics and Economic Policy
- International Entrepreneurship and Management Journal
- International Environmental Agreements: Politics, Law and Economics
- International Journal of Social Research Methodology
- International Review of Economics.
- Journal of Co-operative Management
- Journal of Industry, Competition and Trade: From Theory to Policy
- Journal of International Entrepreneurship
- Journal of Management and Governance
- Marine Policy
- Marine Products Export Review (Financial Year)
- Monthly Monitoring of Indian Economy
- MPEDA Newsletter
- PRIME of MPEDA
- Report of the Directorate General of Commercial Intelligence and Statistics

- Review of Agricultural Economics
- Seafood Export Journal
- Statistics of Marine Products Export
- Survey Research Methods
- The Indian Economic Journal
- Vikalpa

Suggested Broad Areas for Master's and Doctoral Research

- Profitability and comparative performance of different aquaculture systems
- Investment pattern and capital flow in fisheries sector over the years
- Price spread / consumer surplus, and marketing efficiency of different marketing channels in fisheries marketing
- Opportunities and challenges for organised fish retail markets
- Impact of mechanization / modernization in coastal fisheries on productivity , sustainability and livelihood
- Cost benefit analysis of different aquaculture production systems
- Capital formation and fisheries development in different plans
- Social and ecological impact of coastal aquaculture
- Social and ecological benefit of waste water based aquaculture systems
- Preparation of model commercial project proposals
- Economic and financial analysis of fisheries project proposals
- Export performance and potential of fish and fish products3
- WTO and its implications on the fisheries trade
- Forecasting of the structure and pattern of Indian seafood trade
- Export competitiveness of Indian fish and fish products
- Status and performance of fisheries co-operatives in marine and inland fisheries sectors
- Financial appraisal of the different co-operatives
- Estimation of credit requirement of Indian fishing community
- Economic evaluation of the fisheries cooperatives –case studies
- Contribution of agriculture and fisheries to Indian economy over the years
- Capital formation In Indian Agriculture and allied sectors
- Demand and supply projections for fish and fish products
- Consumer preference and market segmentation in domestic and export markets for fish products
- Policy gaps and anomalies in Indian fisheries and aquaculture
- Science an d politics of monsoon ban in coastal fisheries
- Production constraints in different aquaculture production systems
- Yield gap analysis of the different aquaculture production systems
- Impact of trade and environment with respect to high value export oriented fisheries
- Analysing the MSY, MEY and SOY of the different marine resources
- Comparative advantage and competitiveness of Indian fish products in relation to major exporting countries
- Impact of anti-dumping and subsidies on Indian fish exports
- Comparative study of land leasing policies in different States

FISHERIES ENGINEERING AND TECHNOLOGY

Course Sturcture - at a Glance

CODE	COURSE TITLE	CREDITS
FET 501*	ADVANCED FISHING GEAR TECHNOLOGY	2+1
FET 502*	ADVANCED FISHING CRAFT TECHNOLOGY	2+1
FET 503*	RESPONSIBLE FISHING	2+1
FET 504*	REFRIGERATION AND ELECTRICAL ENGINEERING	2+1
FET 505	MARINE ENGINEERING	1+1
FET 506	AQUACULTURAL ENGINEERING	1+1
FET 507	ENGINEERING GRAPHICS	0+1
FET 508	FISHING HARBOUR AND FLEET MANAGEMENT	1+1
FET 509	ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL	1+1
FET 510	SEA SAFETY AND DISASTER MANAGEMENT	1+0
FET 511	FISH PROCESSING MACHINERY	1+1
FET 512	ACOUSTICS, NAVIGATION AND SEAMANSHIP	1+1
FET 591	MASTER'S SEMINAR	1+0
FET 599	MASTER'S RESEARCH	20

* Compulsory for Master's programme

FISHERIES ENGINEERING AND TECHNOLOGY

Course Contents

FET 501 ADVANCED FISHING GEAR TECHNOLOGY 2+1

Objective

To learn advanced fishing gear technology, design modification of existing fishing gears and selectivity studies of various fishing gears.

Theory

UNIT I

Fishing gear design – Conventional and current practice for the representation of fishing gear by scale drawing; The use of computers in the scale drawing of fishing gear to determine the defects in gear, design to develop new gears.

UNIT II

Selection of fishing gear, analysis of the parameters of specific fishing gears and the derivation of empirical relationships for use in the design process.

UNIT III

Design of bottom, mid-water and surface trawl; gill nets and tangle nets; types of gill nets-single-walled gill nets, framed gill nets tangle nets and their technical characteristics, two and three walled trammel nets, combined gill nets; traps – their classification and general principles of construction.

UNIT IV

Design of stake nets; fyke nets; purse seine, hooks and lines, long lines and trolling gear.

UNIT V

Attraction of fish – fishing with electricity; Light fishing, fish pumps; operation and mechanization of long lining.

UNIT VI

Factors to be considered in gill netting in selection of meshes for the different fishes. Aimed fishing using the modern electronic devices like echo sounder, Sonar and trawl eye.

UNIT VII

The selectivity of trawl fishing gears, design of otter boards for various types of trawl fishing.

UNIT VIII

Case studies relating towed, surrounding and static fishing gear and their energy consumption.

UNIT IX

Fishing gear testing – full scale and model testing in flume tanks, methods of testing a fishing gear.

UNIT X

The influence of design features on the overall economic performance of fishing gears.

Practical

Exercises on scale drawing of different types of fishing gears. Use of cadnet programme in the design of trawl gears. Model net calculations, Calculations of energy requirements of different gears. Onboard experience of different fishing methods. Use of net monitoring instruments. Study of fishing gears through models of nets and field study. Making sketches.

Reading of gear designs. – Trawl nets, Purse seines, Gill net and Long line. Familiarization with design drawing soft ware. Design of otter boards and other accessories. Survey of gears and preparation of designs according to scale by taking measurements from a net.

Suggested Readings

Baranov FI. 1969. *Selected Works on Fishing Gear*. Vol. I. *Commercial Fishing Techniques*. Israel Programme for Scientific Translations, Jerusalem.

Baranov FI. 1977. *Selected Works on Fishing Gear*. Keterpress Enterprises. Israel.

Ben-Yami M. 1994. *Purse Seining Manual*. FAO Fishing Manual.

Biswas KP. 1996. *Harvesting Aquatic Resources*. Daya Publ. House.

Bjordal A & Lokkeborg S. 1998. *Long Lining*. Fishing News Books.

Brandt AV. 1984. *Fish Catching Methods of the World*. Fishing News Books.

FAO. 1987. *Small Scale Fishing Gear*.

Fridman AL. 1986. *Calculations for Fishing Gear Designs*. FAO Fishing Manual. Fishing News Books.

Garner J. 1988. *Modern Deep Sea Trawling Gear*. Fishing News Books.

Hameed SM & Boopendranath MR. 2000. *Modern Fishing Gear Technology*. Daya Publ. House.

Kristionsson H. 1975. *Modern Fishing Gear of the World*. The White Friars Press.

Sreekrishna Y & Shenoy L. 2001. *Fishing Gear and Craft Technology*. ICAR.

FET 502 ADVANCED FISHING CRAFT TECHNOLOGY 2+1

Objective

To understand advanced aspects of fishing craft such as better design and modification of existing craft layout.

Theory

UNIT I

Different types of fishing crafts-purse seiner, trawler, stern and side trawler, long liner, gill netter, etc; main differences in the method of construction and design; consideration regarding the speed and other fishing requirements. Deck layout and deck equipments of fishing vessels based on the fishing method; Planning internal capacities of fish hold, engine room, crew accommodation, fuel tanks and freshwater tanks.

UNIT II

Engine installation in fishing vessels; engine bearers for wooden boats; alignment of shaft; stern gear assembly; length of shafts; intermediate shafts; reverse and reduction gear assembly.

UNIT III

Principles of operating steering arrangement; remote control; mast and derrick arrangements; fish hold; - Rudder principles; helm – design details. Principal dimensions of a boat. Importance of shape of under water hull, classification and description of hull forms based on shape and speed – length ratio.

UNIT IV

Theory of waves; rolling, pitching and heaving; wall sides formula; resistance and motion – wave and eddy creating resistance, fluid resistance.

Safety and stability aspects of fishing vessels – factors affecting stability, stability information to be carried on vessels, hydrostatic curves, and static stability curves and safety measures on fishing vessels.

UNIT V

Barnaby's tables; speed length ratios; effects of wetted surfaces on speed; angle of entrance, parallel body, propeller action; types of propellers; design data; D/P values. Powering of fishing boats, different types of resistance and their calculations, power requirements of various types of fishing boats, auxiliary power, propulsive efficiency, type of propellers, and use of kort nozzle.

UNIT VI

Rudder design and principles of operation; model test etc. Boat fastenings and fittings used in boat construction.

UNIT VII

Biodeterioration of wood – marine fouling and boring organisms, preventive measures.

UNIT VIII

Raw materials, properties and construction of FRP, Aluminum, Ferro-cement and Steel boats. Corrosion – types, fundamentals, measurement and preventive measures.

UNIT IX

Construction of a wooden boat – Various stages of construction, description of various machines and tools used in boat building yard, layout of a typical wooden boat building yard.

UNIT X

Inspection of fishing boat under construction and in operation. Care and maintenance of wooden boats – factors causing damage, hull protection methods and maintenance schedule

Practical

Visit to boat building yards for on – the – spot study of different stages of wooden boat construction and to study the layout. Identification of various tools and machines used in boat building. Study of various stages of boat construction with the help of boat models and making their sketches. Calculation of various dimensions; Study of deck lay outs of different types of fishing vessels and preparation of sketches; Visit to dry dock

Suggested Readings

Fyson JF. (Ed). 1985. *Design of Small Fishing Vessels*. Fishing News Books.

Marine Institute. 1988. Proc. World Symposium on Fishing Gear and Fishing Vessel Design, The Newfoundland and Labrador Institute of Fisheries and Marine Technology, St. John's, Newfoundland, Canada.

Pike D. 1992. *Fishing Boats and Their Equipments*. Fishing News Books.

Ponnambalam A. 2003. *Fishing Craft Technology*. CIFNET, Cochin.

Sanisbury JC. 1996. *Commercial Fishing Methods-An Introduction to Vessels and Gear*. Fishing News Books.

Shenoy L. 1988. *Course Manual in Fishing Technology*. CIFE, Mumbai.

Sreekrishna Y & Shenoy L. 2001. *Fishing Gear and Craft Technology*. ICAR.

Traung T. 1967. *Fishing Boats of the World*. Fishing News Books.

Yadav YS. 2002. *Traditional Fishing Craft of the Bay of Bengal*. BOBP, Chennai.

FET 503 RESPONSIBLE FISHING 2+1

Objective

To learn various responsible fishing techniques which cause less damage to the environment and biodiversity and to understand methods for reducing bycatch in trawl net.

Theory

UNIT I

Scope and objectives of FAO Code of conduct for Responsible Fisheries. Articles of CCRF-Description of the code.

UNIT II

Elaboration of Article 8-Fishing operations; By-catch and discards – Definitions, bycatch reduction devices, Turtle excluder devices, finfish and shrimp excluder devices.

UNIT III

Selective fishing gear and practices – Selectivity of trawls, gill nets and lines-Environmental friendly fishing – Energy conservation and resource enhancement.

UNIT IV

Fish Aggregation devices (FADs) – Objectives and types of FADs. Design and construction of FADs.

UNIT V

Energy optimization in fisheries – methods of energy conservation in fish harvesting.

UNIT VI

Application of Remote sensing and PFZ and GIS in fisheries.

UNIT VII

Illegal, Unregulated and Unreported fishing methods (IUU); Destructive and prohibited fishing systems and practices.

UNIT VIII

Eco friendly fishing methods and fishing gears.

UNIT IX

Effect of fishing on nontarget species – Effect of bottom trawl on benthic fauna and habitats. Conservation methods issues and implications for biodiversity.

Practical

Study of design and operation of BRDs and TEDs; Preparation of document listing and prohibited fishing practices; compilation of package of practices for energy conservation; iInterpretation of SST and Ocean colour charts, study of Potential Fishing Zone (PFZ) maps; problems on fishing gear selectivity; studies on impact of various fishing gears on environment and biodiversity.

Suggested Readings

Bergstrom M. 1983. *Review of Experiences with and Present Knowledge about Fish Aggregating Devices*, BOBP/WP/23 Bay of Bengal Programme, Madras.

CIFNET MODULE III & IV. Code of Conduct for Responsible Fisheries.

FAO. 1995. *Code of Conduct for Responsible Fisheries*, Rome.

FAO. 1996. *Fishing Operations. FAO Training Guidelines for Responsible Fisheries*. No. 1. Rome.

FAO. 2003. *Fisheries Management. The Ecosystem Approach to Fisheries*. FAO Technical Guidelines for Responsible Fisheries. No.4, Suppl.2, Rome.

Kaiser MJ & de Groot SJ. 2000. *Effect of Fishing on Non-Target Species and Habitats*. Blackwell.

FET 504 REFRIGERATION & ELECTRICAL ENGINEERING 2+1

Objective

To impart knowledge on engineering aspects of refrigerators, freezers and heat-load calculation etc and to teach electrical aspects of fishing vessel.

Theory

UNIT I

Principles of refrigeration – Vapour Compression system, Vapour adsorption system – Refrigeration cycle.

UNIT II

Application of Refrigeration in fisheries Refrigeration in sea food processing plant coefficient of Performance (CoP).

UNIT III

Types of freezers and their efficiency, Heat load calculations – Insulations. Frosting and defrosting in freezers and cold stores.

UNIT IV

Refrigeration in Factory Trawlers. Refrigerated Transport.

UNIT V

Sources of energy; General structure of electrical power systems, Power transmission and distribution via overhead lines and underground cables, Steam, Hydel, Gas and Nuclear power generation.

UNIT VI

Principal and application of DC Networks, single phase AC Circuits, three phase AC circuits, magnetic, transformers, induction motor, DC Motors etc.

UNIT VII

Electrical Measuring Instruments: DC PMMC instruments shunt and multipliers, multimeters, moving iron ammeters and voltmeters, dynamometer, wattmeter, AC watt-hour meter, extension of instrument ranges.

UNIT VIII

Principles and working; electronic components; Audio; R.F. circuits; electron tubes, transistors; principles of electronic circuits; amplifiers, oscillators, rectifier, tuned circuits – transmission of reception.

UNIT IX

Classification of waves according to frequency and their propagation through different media.

UNIT X

Principles of working of radio, radio telephone, radio direction finder, echo sounder, sonar, radar, GPS etc.

Practical

Visit to refrigeration plants, heat load calculations. Handling and operation of refrigeration equipments – compressor, condenser, evaporator, liquid return system, gas purging, oil drain, oil charging, refrigerant charging, defrosting; ice making and harvesting; study of various automatic control devices; expansion valves, L.P. and H.P. switches, solenoid valves. Study of various types of fish processing machineries; electrical motors, transformers, GPS, SONAR etc.

Suggested Readings

Ayyappan VP. 2002. *Elements of Electrical Technology*. CIFNET, Cochin.

Joshy CD & Devadhason M. 2001. *Basic Electronics and Fish Finding Equipments*. CIFNET, Cochin.

Shawyer M & Pizzali AFM. 2003. *The Use of Ice on Small Fishing Vessels*. FAO Tech. Paper No. 436. Rome.

Sternin UG, Nikonorou IV & Yu BK. 1976. *Electrical Fishing*. Keter Publ. House.

FET 505 MARINE ENGINEERING 1+1

Objective

To learn engineering aspects of marine engines for effective utilization during fishing and propulsion system of fishing vessels.

Theory

UNIT I

Engine characteristics – capacity of cylinders, IHP, BHP, FHP, BMEP, torque determinations; SFC values. IC engines – working cycles – Indicator diagrams – Performance number – Supercharging – Engine performance curves – Duel-fuel engines. Handling of IC engine and maintenances – Engine and boiler room arrangements – Steering gears – auxiliary engines – Heat exchangers – Propeller Shaft driver steam generators.

UNIT II

Compression ratio and thermal efficiency; volumetric efficiency; mechanical efficiency different ratings – continuous, peak, intermittent. Feel and lubricant – Strokes – Cooling method – Running characteristics – Size weight – Power requirement.

UNIT III

Propulsion system – Combinations of engine, power transmission and propeller.

UNIT IV

Function of main engine, friction, clutch, hydraulic coupling, gearbox, thrust; bearing, shafting, propeller.

UNIT V

Auxiliary machinery systems – Requirements of a winch, windlass, line and net hauler – estimation of their driving torque and power; Operation of a hydraulic steering gear; Rudder torque. Floating offshore structures – Diving underwater vehicles. Diving – Underwater vehicles. Estimation grower requirement for various types of fishing – Efficiency group of fishing techniques – Resistance group of fishing methods – Computation of engine power.

Practical

Study of basic machine parts, shafts, keys, couplings, levers, joints, pulleys, belts, gears and bearings. Study of Engine parts, engine testing,

dissembling and assembling a running condition marine engine; study of marine diesel engines, fuel consumption testing with load; Propeller calculations using the computers; calculations related to engine power.

Suggested Readings

Calder N. 1992. *Marine Diesel Engines*. Waterline Books.
CIFNET. 2004. *Fishery Engineering*. Cochin.
Morgan N. 1990. *Marine Technology Reference Book*. Butterworths.
Rajput RK. 2006. *Thermal Engineering*. Laxmi Publ.
Rethinadhas C. 2002. *Marine Engineering*. CIFNET, Kochi.
Watson GO & Harvey RA. 1971. *Steering Gear*. Butterworths.

FET 506 AQUACULTURAL ENGINEERING 1+1

Objective

To familiarize engineering aspects of fish farm and hatchery, farm machinery operation and maintenance.

Theory

UNIT I

Site selection for aquaculture; surveying and leveling, earthwork calculations. Design of dykes, sluice, channels.

UNIT II

Tide fed farms; studies on water supply; aquaculture in open systems-design of cages, rafts, pens, rakes, ropes etc.

UNIT III

Fluid mechanics, pumps, flow estimation and measurement; aquaculture in ponds, raceways and tanks.

UNIT IV

Recirculating aquaculture system; aeration, sterilization and disinfection, ponds, tanks and other impounding structures; filtration. Aeration – Gases in water. Gas transfer – Theory of oxygenation – Types of aerations. Efficiency of Aerators. Recirculation and water – Reuse systems – water exchange – water reuse methods – Recirculation – Advantage – Designs of re-use systems.

UNIT V

Fundamentals of concrete; building materials, cement, RCC. Engineering aspects of fish and shrimp hatchery. Farm machinery operation and maintenance. Pond sealing techniques. Shapes roof design – Load carrying system. Floors, walls, ventilation.

UNIT VI

Automatic feeding system – Feed dispensers – Demand feeders. Design and construction of aquaculture system pond construction – water transportion system – Pump houses – Inlet and outlet structures – Water treatment plants.

Practical

Visit to hatcheries and farms; Instruments used in aquaculture; Operations of aerators, filters, water supply systems. Calculations related to earth requirement aerated efficiency and pump selection. Pump installations .Design of pump house. Computation of water requirement, pump, and pumping rates.

Suggested Readings

Bose AN,Ghosh SN, Yang CT & Mitra A. 1991. *Coastal Aquaculture Engineering*. E. Arnold.

Ivar LO. 2007. *Aquaculture Engineering*. Daya Publ. House.
Lawson TB. 1997. *Fundamentals of Aquaculture Engineering*. CBS.
Wheaton EW. 1970. *Aquaculture Engineering*. Wiley-Interscience.

FET 507 ENGINEERING GRAPHICS 0+1

Objective

To gain knowledge on practical aspects of computer aided engineering graphic.

Practical

UNIT I

Introduction to engineering graphics – Drawing instruments and their use – Different types of lines – Lettering & dimensioning – Familiarisation with current India Standard Code of Practice for Engineering Drawing.

UNIT II

Introduction to scales. Introduction to orthographic projections – Horizontal, vertical and profile planes – First angle and third angle projections – Projection of points in different coordinates – Projections of lines inclined to one of the reference planes.

UNIT III

Projections of lines inclined to both the planes – True lengths of the lines and their angles of inclination with the reference planes – Traces of lines. Projection of plane laminae of geometric shapes inclined one of the reference planes – inclined to both the planes – auxiliary projections.

UNIT IV

Projections of polyhedra and solids of revolution – Frustum – projection of solids with axis parallel to one of the planes and parallel or perpendicular to the other plane – Projections with the axis inclined to one of the planes. Projections of solids with axis inclined to both the planes – Projection of spheres. Sections of solids by planes perpendicular to at least one of the reference planes – True shapes of sections, Developments.

Suggested Readings

Bhatt ND. 2002.*Elementary Engineering Drawing*. Charotar Publ. House, Anand.

Rising JS & Almfeldt MW. 1964. *Engineering Graphics: An Integration of Engineering Drawing, Descriptive Geometry and Engineering Problems Solution*. WC. Brown.

Venugopal K. 2004. *Engineering Drawing and Graphics*. New Age International.

FET 508 FISHING HARBOUR AND FLEET MANAGEMENT 1+1

Objective

To learn fishing harbour Engineering, fishing fleet management and manning regulations.

Theory

UNIT I

FAO classification of fishing vessels. Indigenous fishing boats of India – fishing boats of maritime states of India, fishing boats used in the inland and brackish waters, account of mechanized boats introduced in India.

UNIT II

Personnel management, planning of fishing cruises. Fishing fleet capacity, fleet registration, fleet insurance, seaworthiness assessment, tonnage measurements.

UNIT III

Statutory rules and regulations under MSA, classified societies, manning regulations and requirements; regulations to prevent collisions at sea.

UNIT IV

Classification and functions of fishing harbour. Facilities – waterside and landside facilities, services and utilities provided, layout of a modern fishing harbour, stages in the planning of fishing harbours. Dredging. Economic evaluation on fishing harbour project.

UNIT V

Dry docks and slipway –.Fishing harbour management and maintenance.

Practical

Visit to dry dock; Visit to fishing harbour, study of boats with the help of boat models and making sketches; Visit to various vessel types of fishing vessel.

Suggested Readings

FAO. 1960. *Report to Government of India on Fishing Harbours Based on the Work of C. G. B. Juke and C.R.B. Juke.* FAO Report No. 1242. Rome.

FAO. 1962. *Second Report to Government of India on Fishing Harbour Based on the Work of B. W. Johnson.* FAO Report No. 1538. Rome.

Ramakrishnan TK. 2007. *Ocean Engineering*. Gene Tech Books.

Sciortino SA, Barcali A & Carlesi M. 1995. *Construction and Maintenance of Artisanal Fishing Harbours and Village Landingss*. FAO, Rome.

Sreekrishna Y & Shenoy L. 2001. *Fishing Gear and Craft Technology*. ICAR.

FET 509 ENVIRONMENTAL ENGINEERING AND POLLUTION 1+1

Objective

To understand engineering aspects of environment to protect the environment from pollution.

Theory

UNIT I

Introduction – Quality of water – Quantity of water – conveyance of water – treatment of water – filtration of water – Disinfections of water – water softening.

UNIT II

Distribution system of water. Collection and conveyance of refuse – pumps – sewage disposal – primary and secondary treatment of sewage.

UNIT III

Environmental Pollution – Ecological Balances – Ozone layer – Green House effect – Fossil Fuels. Atmosphere pollution – water pollution. Marine oil pollution – Cause – Oil filtering equipment. Oil record book and controlling monitoring of marine pollution. Bunkering. MORPOL regulations.

UNIT IV

Air pollution – Control of Air pollution. Air pollution causes, Setting chambers, Cyclone Filters. Solid waste disposal. Sources of Pollutants – Classification. Air- pollution – Emission of harmful touchils. Littering of the sea – Plastics – Foods – Papers – Metals – Garbage – Regulation.

UNIT V

Low cost waste treatment systems and their Design. Ballest water management in ships. Discharge of ballast water – Problems of ballast water – Log book maintenance – Managing ballast water. Waste water and treatment, Industrial waste water management – Solid waste disposal. Environment and corrosion, Mathematical modeling for environment pollution control.

Practical

Visit to various pollution control stations. Familiarization of pollution control instrument. Pollution control in Fishing harbours. Pollution control in aquacultural farms.

Suggested Readings

Bist DS. 2000. *Safety and Security at Sea - A Guide to Safer Voyages*. Butterworth- Heinemann.

Salvato JA, Nemerow NL & Agardy FJ. 2004. *Environmental Engineering*. John Wiley & Sons.

Sciortino JA & Ravikumar R. 1999. *Fishery Harbour Manual on the Prevention of Pollution*. BOBP. Chennai.

FET 510 SEA SAFETY AND DISASTER MANAGEMENT 1+0

Objective

To learn theoretical aspects of sea safety and disaster management, water warning signal and bad weather preparations.

Theory

UNIT I

Introduction to sea safety – Safe navigation procedures for fishing vessels; Distress signals; Distress signals.

UNIT II

Accidents associated with marine environment-crossing surf, bad weather, poor visibility storms, loss of power at sea, loss of way, grounding, collisions. Injuries from fish, animals and machinery. Man overboard and capsizing.

UNIT III

Signals for fishing vessel safety; agencies involved in fishing vessel rescue operations. Keeping watch at sea – Preventing collusions – Heavy weather preparations crow management.

UNIT IV

Fire onboard and Fire fighting equipments. First aid at sea; Weather warning signals and weather reporting system for fishing vessels; Bad weather preparations for fishing vessels.

UNIT V

Stranding and beaching of fishing vessels and refloatation procedures; Measures to enhance sea safety; International conventions related to sea safety.

UNIT VI

Types of natural and man made hazards in fisheries – Cyclone, tsunami etc. Characteristics and impact of various disasters. Preparedness for disasters at sea. Mass evacuation, storm shelters and survival platforms.

Suggested Readings

Bist DS. 2000. *Safety and Security at Sea - A Guide to Safer Voyages*. Butterworth-Heinemann.

FAO. 1975. *Code of Safety for Fisherman and Fishing Vessels*. International Maritime Organization, London.

International Convention for the Safety of Life at Sea. 1974. Universal Publ. Corp. Mumbai.

Larkin FJ. 1998. *Basic Coastal Navigation.* 2nd Ed. Sheridan.

Prakasan U. 1997. *Rule of the Road Signal and Voyage*. CIFNET, Cochin.

Sreekrishna Y & Shenoy L. 2001. *Fishing Gear and Craft Technology*. ICAR.

FET 511 FISH PROCESSING MACHINERY 1+1

Objective

To familiarize with engineering aspects of various equipments related to fish processing and design and layout of factory vessels and processing factories.

Theory

UNIT I

Theory of machines; mechanisms; transmission of power; friction wheels; toothed gears; belt drive.

UNIT II

Processing equipments on board the fishing vessels. Belt drivers, graders, deskinners, freezers, and canning machineries.

UNIT III

Study of fish meal plant equipments; freeze drying and dehydrating equipments.

UNIT IV

Types of boilers and their auxiliary equipments used in fish processing industries.

UNIT V

Twin screw extruders, driers, grading two filtering machines, Packing machines–Equipment Maintenance and safety.

Practical

Study of various types fish processing machineries; calculation of power requirements. Study of boilers and its operation, canning equipments, Twin screw extruders.

Suggested Readings

EIRI. 2000. *Modern Packaging Technology*. Engineers India Research Institute, New Delhi.

Gopakumar K. 2002. *Text Book of Fish Processing Technology*. ICAR.

Heldman DR. 1975. *Food Process Engineering*. AVI Publ.

Kondrashova NG. 1986. *Shipboard Refrigeration and Fish Processing Equipment*. Balkema, Leiden.

Novikov VM. 1982. *Handbook of Fishery Technology*. Vol. I. Amerind Publ.

Slade FH. 1997. *Food Processing Plants*. Leonard Hill Books.
Stansby ME. 1963. *Industrial Fishery Technology*. Reinhold Publ.

FET 512 ACOUSTICS, NAVIGATION AND SEAMANSHIP 1+1

Objective

To understand engineering aspects of fish acoustics equipment, navigation and seamanship for fishing vessel safety.

Theory

UNIT I

Basic principles of acoustic fish detection. Acoustic surveys, acoustic equipments used in fishing.

UNIT II

Echo sounder – major components, specifications and uses; Sonar – specifications, types; instruments used for evaluation of underwater gear performance.

UNIT III

Global positioning system (GPS); vessel monitoring systems (VMS); communication systems – VHF, SSB, Immarsat system; safety devices – SART, EPIRB, GMDSS.

UNIT IV

Navigation – types, navigational equipments, RADAR, Radio direction finder, Decca, LORAN, OMEGA, Autopilot, Fixing of vessel position, Navigational charts, Satellite; Navigator - Navigation and fishing lights, distress signals; Rules of the Road.

UNIT V

Ship and its main parts; ropes – their types, handling; strength and preservation; knots and splices; measurement of speed; maintenance of log sheet; anchoring mooring; steering; rolling and pitching; Morse code; accidents; marine compass and its uses; sextant; chart reading positions – simple position lines.

Practical

Chart work; operation of echo sounder, Sonar, GPS, Radar and communication systems like VHF, SSB; familiarization with safety devices like SART, EPIRB and GMDSS; identification and study of navigation and fishing lights, distress signals and navigational equipments like compass, chronometer, aneroid barometer, sextant and logs.

Suggested Readings

CIFNET. 2004. *Fishery Engineering*. Cochin.

FAO. 1998. *Fishing Operations. Vessel Monitoring Systems*. FAO Technical Guidelines for Responsible Fisheries No. 1. Suppl. 1, Rome.

Joshy CD & Devadhason M. 2001. *Basic Electronics and Fish Finding Equipments*. CIFNET, Cochin.

Larkin FJ. 1998. *Basic Coastal Navigation*. 2nd Ed. Sheridan.

MacLennan DN & Simmonds EJ. 1992. *Fisheries Acoustics*. Fish and Fisheries Series 5. Chapman & Hall.

Mitson RB. 1983. *Fisheries Sonar*. Fishing News Books.

Sreekrishnan Y & Shenoy L. 2001. *Fishing Gear and Craft Technology*. ICAR.

FISHERIES ENGINEERING AND TECHNOLOGY

List of Journals

- Aquacultural Engineering
- Aquaculture
- Environmental Science
- Fish and Fisheries
- Fisheries Research
- Fisheries Science
- Fishing Technology
- Indian Journal of Ecology
- Indian Journal of Marine Sciences
- Journal of Indian Ocean studies

Suggested Broad Research Areas for Master's Research

- Design upgradation of existing fishing gears for better catch
- Development of new fishing gear design and efficiency studies
- Design upgradation of fishing crafts
- Fouling effects on fishing crafts and prevention methods
- Problems of wooden crafts with boring organisms
- Energy organization of fishing crafts
- Design of BRD and TED their efficiency studies
- Studies on remote sensing and PFZ
- Heat load calculations design and layout upgradation of processing plants.
- Marine engine power ratings under various load conditions
- Design and layout studies of fish farms.
- Design of various fish farm, equipments through engineering graphics
- Low cost waste treatment systems and their design
- Management options for ballast water
- Disaster management strategies
- Use of IT in disaster preparedness
- Study of power requirements for different processing machinery
- Factors determining the selection of processing machinery
- Modern tools for navigation
- Application of eco-sounder in locating fish shoals

FISHERIES EXTENSION
Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
FEX 501*	PERSPECTIVES AND PRACTICES OF FISHERIES EXTENSION	2+1
FEX 502*	EXTENSION COMMUNICATION AND METHODS	2+1
FEX 503*	PARTICIPATORY APPROACHES IN FISHERIES EXTENSION	2+1
FEX 504*	TRAINING FOR HUMAN RESOURCE DEVELOPMENT	2+1
FEX 505	COMMUNITY MOBILISATION AND ORGANISATIONAL DEVELOPMENT	1+1
FEX 506	DIFFUSION AND ADOPTION OF INNOVATIONS IN FISHERIES	1+1
FEX 507	MULTIMEDIA CREATIONS AND APPLICATIONS	0+2
FEX 508	PLANNING AND MANAGEMENT OF DEVELOPMENT PROGRAMMES	1+1
FEX 509	HUMAN RESOURCE MANAGEMENT	1+1
FEX 510	GENDER, LIVELIHOOD AND DEVELOPMENT	1+1
FEX 511	DEVELOPMENT JOURNALISM	1+1
FEX 512	INDIGENOUS TRADITIONAL KNOWLEDGE IN FISHERIES	1+1
FEX 513	COMMUNITY BASED DISASTER MANAGEMENT	1+1
FEX 591	MASTER'S SEMINAR	1+0
FEX 599	MASTER'S RESEARCH	20
FEX 601**	ADVANCES IN FISHERIES EXTENSION MANAGEMENT	2+1
FEX 602**	MONITORING AND EVALUATION OF DEVELOPMENT PROGRAMMES	2+1
FEX 603**	MEASUREMENT AND SCALING TECHNIQUES	2+1
FEX 604	EXTENSION SERVICE SYSTEM MANAGEMENT	1+1
FEX 605	ADVANCES IN TRAINING METHODS AND EDUCATION TECHNOLOGY	1+1
FEX 606	SOCIAL AND GENDER ISSUES IN FISHERIES	1+1
FEX 607	INFORMATION AND COMMUNICATION TECHNOLOGY FOR FISHERIES DEVELOPMENT	1+1
FEX 608	INTERNATIONAL EXPERIENCES IN FISHERIES EXTENSION	2+0
FEX 610	ERGONOMICS	1+1
FEX 691	DOCTORAL SEMINAR I	1+0
FEX 692	DOCTORAL SEMINAR II	1+0
FEX 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme ; ** Compulsory for Doctoral programme

FISHERIES EXTENSION

Course Contents

FEX 501 PERSPECTIVES AND PRACTICES OF FISHERIES EXTENSION 2+1

Objective

To gain insights intodifferent concepts, principles, praxis, recent changes and emerging challenges in fisheries extension.

To acquire skills required to practice various fisheries extension approaches.

Theory

UNIT I

Overview of fisheries and aquaculture sector in India and world; Special characteristics of fisheries sector and its stakeholders; Understanding extension education, research, and service; Overview of fisheries research, development and extension systems in India; Scope and importance of fisheries and aquaculture extension.

UNIT II

Critical review of philosophy, principles, concepts, and practices of fisheries extension systems and approaches; Teaching, learning and co-learning; Epistemology of knowledge in fisheries – ITK *vis-à-vis* lab generated knowledge.

UNIT III

Fisheries extension – advantages and limitations of present welfare and subsidy oriented extension systems; Development and extension approaches as practiced by public agencies like Department of Fisheries, KVKs, Agricultural Technology Management Agency (ATMA), NGOs, FAO, Bay of Bengal Programme (BOBP-IGO), and by the private sector; participatory fisheries extension approaches.

UNIT IV

Aquaculture extension system - review of extension approach as practiced by DoF, FFDA, and BFDA; Market led extension approaches; Importance of Information and Communication Technology (ICT) in fisheries extension system.

Practical

Exercises on development of extension and field manuals; Exercises on participatory learning / co-learning; Case study of extension approaches practiced by select State Departments of Fisheries, FFDAs / BFDAs, select NGOs, AMUL model; case study of market led extension approaches like e-choupal choupal, Agri Business Clinics, etc.; Critical review of experiences and lessons from fisheries extension practices from across the world; case study on the use of ICT for fisheries development; Field exposure by visiting established extension projects.

Suggested Readings

Chandrasekhar CS. (Ed.). 2004. *Privatization of Agricultural Extension in India*. MANAGE, Hyderabad.

Kumar D. 1996. *Aquaculture Extension Services Review: India*. FAO Fisheries Circular No. 906, Rome.

Malhotra SP & Sinha VRP. 2007. *Indian Fisheries and Aquaculture in a Globalizing Economy*. Part II. Narendra Publ. House.

Ramchandran C. 2004. *Teaching not To F(in)ish: A Constructivist Perspective on Reinventing a Responsible Marine Fisheries Extension System*. CMFRI, Kochi.

Ray GL. 2006. *Extension, Communication and Management*. 6th Ed. Kalyani.

Rivera WM. 2000. *Agricultural Extension: Worldwide Institutional Evolution and Forces for Change*. Elsevier.

FEX 502 EXTENSION COMMUNICATION AND METHODS 2+1

Objective

To learn different communication strategies used in mass, group and personal contact methods of extension programme.

To get hands on training in application of extension methods and communication aids.

Theory

UNIT I

Communication - meaning, process, theories and models; Traditional communication; Individual, group and mass communication, levels of communication; non-verbal communication; AV aids – selection and use.

UNIT II

Communicator - role of communicator in extension education, communicator's behaviour; communication skills; fidelity of communication; communication competence and empathy; communication effectiveness and credibility; improving oral and written communication; message – meaning, dimensions, characteristics, treatment and effectiveness, distortion of message; simulation exercises; channels of communication – meaning, dimensions, classification, selection, efficiency, credibility, use; audience or receivers; feedback; communication behaviour; social network – homophily and heterophily.

UNIT III

Communicating with fishers and fish farmers; barriers in communication; communication and social change; futuristic shape of communication technologies.

UNIT IV

Recent communication technologies – Internet based technologies, video and teleconferencing, computer assisted instructions, Information kiosks, Village Resource Centres, Community networks, WAN, MAN, AGRINEt, e-Governance; Cyber extension and e-learning.

Practical

Exercises in written and oral communication; documenting and presenting success stories in fisheries, AV aids - rationale and preparation of AV aids with local resources; public speaking and presentation skills; organising meetings, guided discussions; organizing field demonstrations and field-days; preparation of information, education and communication materials on various aspects of fisheries; instructional video and ICT; Practicing tele and video conferencing, case study of a community radio, tele-centres and farmer discussion groups; designing a website on fisheries and aquaculture;

developing a script and shooting a video film as an extension aid; Development and use of e-learning modules.

Suggested Readings

Lesiskar RV & Pettit JD. 2004. *Business Communication*. 8th Ed. Tata McGraw-Hill.

Locker KO & Kaczmarek SK. 2004. *Business Communication*-Building Critical Skill. Tata McGraw Hill.

Mathur KB. 1994. *Communication for Development and Social Change*. Allied Publ.

Moakley FX. 1973. *Handbook of Audio-Visual Aids*. Harcourt Brace Jovanovich.

Samanta RK. 1990. *Development Communication for Agriculture*. DK Publ.

Singh R. 1993. *Communication Technology for Rural Development*. BR Publ.

Van Den Ban AW. 1985. *Communication for Rural Innovation: Rethinking Agricultural Extension*. Blackwell.

FEX 503 PARTICIPATORY APPROACHES IN FISHERIES EXTENSION 2+1

Objective

To gain knowledge on participatory approaches in fisheries extension programmes.

To gain practical experience in participatory approaches and techniques.

Theory

UNIT I

Participatory approaches for aquatic resources management and development: need, importance and guiding principles; Community mobilization methods - Farmer-First Approach; Trickle Down System – concept, method and processes; Knowledge Driven Extension System – concept and method.

UNIT II

Community based fisheries management and Fisheries co-management – concept, origin, importance, types, method, processes, stakeholder rights, responsibilities and participation, institutional mechanisms, implementation constraints, experiences from other countries; conflict resolution and management; Public-Private-Community Partnership.

UNIT III

Participatory Learning Approach (PLA) including role-plays, case studies, brainstorming, and ranking of priority issues, discovery-based experiential learning, participatory education methods like FGD; Participatory appraisal techniques - census mapping, resource mapping, social mapping; selection of participatory methods and their uses; Farmer Field Schools for Aquaculture.

Practical

Conducting Participatory Rural Appraisal in select villages and developing action plans; Conducting focused group discussion and developing action plan; Facilitating group formation based on the felt needs and to implement the action plans / plan of work; Reviewing national and international case studies on participatory approach to aquaculture research and development;

case studies and simulation exercises on fisheries co-management / community based fisheries management.

Suggested Readings

Brown D, Derek S & Simon FS. 2005. *Mainstreaming Fisheries Co-Management in the Asia-Pacific*. Asia-Pacific Fishery Comm. Rep. Publ. 2005/24, FAO, United Nations Regional Office for Asia and the Pacific, Bangkok.

Chambers R, Arnold P & Thrupp LA. 1989. *Farmers First: Farmer Innovation and Agricultural Research*. Intermediate Technology Publ.

Chambers R. 1983. *Rural Development Putting the Last First*. Longman.

Edwards P, Little DC & Demaine H. 2002. *Rural Aquaculture*. CABI.

Kumar D. 1999. *Trickle Down System (TDS) of Aquaculture Extension for Rural Development*. RAP Publ.

Robert SP. 2005. *Fisheries Co-Management: A Practical Hand Book*. CABI.

FEX 504 TRAINING FOR HUMAN RESOURCE DEVELOPMENT 2+1

Objective

To learn the design and methods of conducting training programmes for the trainers, fishers and fish farmers.

To acquire hands-on practice in use of training aids and tools.

Theory

UNIT I

Human Resource Development – Concept and significance; Education, learning and training; Instructional design and educational technology; Theories of learning - **r**adical behaviorism, cognitivism, constructivism; training and development; Gender sensitive training.

UNIT II

Types of Training - Induction, on-the-job, off-the-job, in-service, customized, inception, trainers', participatory, web-based, fishers/fish farmers', farmer-led, vocational and echo-training; Training tools like T-Group, Fish bowl exercise, ice-breakers, team-building exercises and games; workshop and writeshop.

UNIT III

Preparation of Training Manuals- content writing; Training cycle - training need assessment, developing training objectives and outcome, developing training modules and lesson plan, logistic management and evaluation of training programme, follow-up and action plan.

UNIT IV

Facilitating Community Mobilization Process - Perception of service delivery system, level of expertise and capacity amongst the community to facilitate such services, willingness of the community to match individual interests with community interest, facilitation of resources for mobilizing community; Promoting Public-Private-Community Participation.

Practical

Training need assessment for different clientele groups; Designing training tools and manuals on fisheries; Organising and conducting fisheries

training programmes; Evaluation of training; Impact studies in terms of results (output, outcome and impact); Team building exercises.

Suggested Readings

Donald LK. 1998. *Evaluating Training Programmes: The Four Levels*. Berrett-Koehler.

Kumar D, Ojha SN & Biradar RS. 2006. Public-Private and Community Participation for Sustainable Rural Livelihood Development through Fisheries. In: *National Convention on Knowledge Driven Agricultural Development: Management of Change*. AR Scientists' Forum 24-26 March 2006, New Delhi.

Lynton RP & Pareek U. 1973. *Training for Development*. Sage Publ.

Misra DC. 1990. *New Directions in Extension Training*. Directorate of Extension, Ministry of Agriculture, New Delhi.

Phillips JJ. 1998. *Handbook of Training Evaluation and Measurement Methods*. Gulf Publ.

Singh RP, Thamtani A & Singh P. 1996. *Training Management*. Jain Publ.

FEX 505 COMMUNITY MOBILISATION AND ORGANISATION DEVELOPMENT 1+1

Objective

To gain insights into the relevant know-how on the structure and functions of community institutions.

To acquire competency and confidence to bring about desirable social change by organizing communities.

Theory

UNIT I

Sociological and psychological perspectives of social institutions, culture, community and community organization; functions of community; rural sociology and its relevance to extension education; social stratification; social changes, conflict in rural society.

UNIT II

Communities as vehicles of change; community mobilization - entering, submerging, empowering and governance; outreach, community centres and services; models of community organization in developing countries; social action; challenges in mobilization, advocacy, coalition building and networking, facilitation and mediation; role of NGOs.

UNIT III

Rural development – rural context and livelihood, rural poverty, policies, programmes and interventions; rural local self governance – Panchayati Raj; rural-urban migration, social problems, displacement and rehabilitation; rights of indigenous communities; community participation for natural resources management; strategies of developmental intervention; international processes and implications for local communities; leader and leadership – types, role, theories and its implication for development; motivation – theories, types and importance; social perceptions, influence and relationships; attitudes; emotion and stress.

Practical

Approach to and strategies of community organizing – study of specific cases/illustrations of strategies and efforts on a range of issues that have

been effective; exercises on community organisation; identification of village leaders and their role in community development; cases on social, cultural and technological changes; Preparing investigative report of fishing/fish farming village considering culture, language, values, norms, institutions, social organization, groups, social stratification, social conflict, etc.

Suggested Readings

Chitambar JB. 1990. *Introductory Rural Sociology*. Wiley Eastern.

Haralambos M, Heald RM & Holborn M. 1995. *Sociology: Themes and Perspectives*. Collins Educ.

Morgan CT & King RA. 1975. *Introduction to* Psychology. Tata McGraw Hill.

Sinha VRP. 1999. *Rural Aquaculture in India*. FAO, United Nations, Thailand. RAP Publ.

FEX 506 DIFFUSION AND ADOPTION OF INNOVATIONS IN FISHERIES 1+1

Objective

To impart knowledge on diffusion of fisheries innovations.

To be able to critically analyse the innovation decision processes in the fisheries sector.

Theory

UNIT I

Elements of diffusion; diffusion research – history, typology, contributions and criticisms; generalising diffusion via meta research; innovations in fisheries – innovation development process, socio-economic status, equality and innovation development, converting research into practice; Critique on Rogers' innovation decision process, innovation attributes and adopter categories.

UNIT II

Opinion leadership – meaning, characteristics, types and their measurement; diffusion networks; social learning theory; Change agent – meaning, roles, factors of success, change agent contact; centralised and decentralised diffusion systems; innovation in organisations - contract farming – merits and demerits; consequences of innovations – model and classification, equality in the consequences; recent studies in innovation decision process.

Practical

Case study of the diffusion process of select fisheries innovations; Analysing the factors influencing adoption and rejection of fisheries technologies and practices; case studies of select innovation diffusion models like AMUL, Grameen Bank, and WADI-NABARD/BAIF; case study of decision making pattern in fisher villages and the role of men, women and youth; case studies on opinion leaders and change agents in transfer of fisheries technologies; field visit to study select models of ToT.

Suggested Readings

Louise G. 1998. *Working with Indigenous Knowledge*. International Development Research Centre, Canada.

Rogers EM. 2003. *Diffusion of Innovation*. 5th Ed. Free Press.

Stephen D. 1979. *The Diffusion of Process Innovations*. Cambridge University Press.

Warren DM, Slikkerveer LJ & Brokensha D. (Eds.). 1995. *The Cultural Dimension of Development: Indigenous Knowledge Systems*. Intermediate Technology Publ.

FEX 507 MULTIMEDIA CREATIONS AND APPLICATIONS 0+2

Objective

To acquire competence and hands-on skills on preparation and application of various multimedia tools.

Practical

Multimedia Environment - Multimedia hardware devices, Multimedia software tools, Multimedia content creation and integration process; Graphics and effects – scanner, other image capture methods; Image editing and 2D Animation using Photoshop; Vector graphics using Corel Draw; Digital Audio - Basic features and digitization, audio recording and dubbing, audio card, non-linear editing and mixing of different audio formats, audio editing and composing of music, special effects; Script development and Story board preparation; Digital Video - analog and digital video, video recording, capturing and conversion into different video file formats, video editing, special effects; Organization of content - choice of media, categorization of photographs, queuing of audio and video clips, logical sequencing, text entry; Multimedia Authoring - concepts, navigation planning and hyper linking; User friendly tools - MS Office Power point, Macromedia Director; Preparation of multimedia presentation; CD/DVD writing, labeling and presentation.

Suggested Readings

http://www.good-tutorials.com/
http://www.myphotoshoptuts.com
http://www.w3schools.com/
http://audacity.sourceforge.net/help/tutorials/
http://www.mediacollege.com/video/editing/
http://www.animationsforvideo.com

FEX 508 PLANNING AND MANAGEMENT OF FISHERIES DEVELOPMENT PROGRAMMES 1+1

Objective

To understand different aspects of planning processes.

To acquire competency to plan, implement, monitor and evaluate extension and development programmes.

Theory

UNIT I

Importance, principles and processes in developing extension programmes; Planning for sustainable development, Economic Planning- types of planning; Planning strategies at various levels- Top down and bottom up approaches. Panchayati Raj institutions; Execution of various programmes, Plan allocation and performance of fisheries over the different plan-periods in India.

UNIT II

Project preparation and project appraisal in terms of social benefit analysis, shadow prices; Project Management Techniques - PERT and CPM; Logical Framework Approach (LFA), Stakeholder analysis; Participatory Monitoring and Evaluation (PROME); People's participation in extension programmes, significance, importance and approaches.

UNIT III

Critical analysis of Agriculture, Fisheries and Rural Development Programmes; design, operation, institutional mechanism and socio-cultural and economic impact of programmes such as NREGA; labour market relations; Fisheries development *vis-à-vis* fisheries for development; Livelihood Frameworks.

Practical

Need assessment, setting objectives, developing plan of work, Success indicators, Impact assessment of fisheries development programmes, SWOT analysis; Exercises on PERT and CPM Presentation of Fisheries and Aquaculture policies of select countries; Study visits to selected extension project areas – DOE, KVKs, SAUs, and ICAR institutes.

Suggested Readings

Haq BU & Kullenberg G. (Eds.). 1997. *Coastal Zone Management Imperative for Maritime Developing Nations*. Springer.

Jhingan ML. 1978. *Economics of Development and Planning*. Vikas Publ.

FEX 509 HUMAN RESOURCE MANAGEMENT 1+1

Objective

To familiarize the students with the basic concepts of Human Resource Management with special reference to organizations in fisheries sector.

Theory

UNIT I

Concept of management: Definition, Management process (planning, organising, staffing, leading and controlling), Managerial levels and roles. Evolution of management theories: Scientific management school, Classical organization theory school, Behavioural school, Management science school.

UNIT II

Concept of Human Resource Management(HRM), Primary activities of HRM (staff, training and development, motivation, maintenance), HR process (HRP, recruitment, selection, socialization, training and development, performance appraisal, promotion, transfer, demotion, separation).

UNIT III

HR out sourcing, Understanding equal opportunity: Guarding against discriminatory practices, glass ceiling, Managing careers: Concept of career, individual and organisational perspective, career development versus employee development, internal, external events and career stages, mentoring and coaching.

UNIT IV

Compensation dynamics: Contracts for compensation, efficiency wages, wage earning and sharing, ownership options, screening, signalling, designing of contract, types of rewards, job evaluation and establishing pay

structure, executive, international and special compensation plans, employee benefits, safety and health programmes, labour relations and collective bargaining. Corporate social responsibility.

Practical

Applying management functions in a real setting; developing managerial games; creativity and problem solving techniques; understanding different perceptions and avoiding perceptual distortions; analysing different needs of a diverse work place; performance evaluation; psychometric testing; developing training module for leadership and motivation; exercises on time management.

Suggested Readings

Alan P. 2002. *Principles of Human Resource Management*. Blackwell.

Bratton J. 1999. *Human Resource Management: Theory and Practice*. MacMillan Press.

Decenzo DA & Robbins SP. 1997. *Human Resource Management*. John Wiley & Sons.

Ferris GR. 2003. *Handbook of Human Resource Management*. Blackwell.

Milgrom P & Robert J. 1992. *Economics Organization and Management*. Prentice Hall.

Schuler RS & Jackson S. 2006. *Strategic Human Resource Management*. Blackwell.

FEX 510 GENDER, LIVELIHOOD AND DEVELOPMENT 1+1

Objective

To gain knowledge on issues related to gender, livelihood and development.

To understand the trade off between gender, livelihood and development.

Theory

UNIT I

Theoretical foundations of gender: Social construction of gender, patriarchy, family and household; Gender and Livelihood - Concept of livelihood, work, access and control of natural resources, Livelihoods in transition; Gender and Development - women in development (WID), women and development (WAD) gender in development (GID), gender and development (GAD).

UNIT II

Indicators of status- Physical Quality of Life Indices (PQLI), Human Development Index (HDI); Rural-urban migration; Impact of fisheries development on men and women, Development strategies, Integrated model of development, microfinance, SHGs, vocational training and development , equality, constitutional protection; Planning and development for change.

Practical

Developing case studies on social and gender issues in fisheries; Case studies on Rural –urban migration; Assessment of the social indicators – PQLI and HDI; Evaluation of the performance of the SHGs; Exercises on social and gender sensitive policies; Case studies on gender relations in fisheries / rural development programmes such as NREGA.

Suggested Readings

Agarwal B. 1986. *Women, Poverty and Agricultural Growth in India*. JPS.

Agarwal B. 1994. *A Field of One's Own: Gender and Land Rights in South Asia*. Cambridge University Press.
Bhasin K. 2000. *Understanding Gender.* Kali for Women, New Delhi.
Bhatt ER, Desai A, Thamarajakshi R, Pande M, Arunachalam J & Kohli V. 1988. *Shramashakti: Report of National Commission on Self Employed Women*. Government of India, New Delhi.
Menon N. 1999. *Gender and Politics in India*. Oxford.

FEX 511 DEVELOPMENT JOURNALISM 1+1

Objective

To gain critical awareness and reflective ability necessary to identify, articulate and analyse major issues in fisheries development.
To gain knowledge on the different skills applicable in journalism.

Theory

UNIT I

Media industry, concepts and theories in practice of news writing; relating theories of journalism to professional practice; Development journalism – meaning, principles, importance and scope; Basics of news production - gathering and selecting news, writing news for newspapers, magazines, farm bulletins and folders, editorial writing, feature writing, headline and cutline writing, news collection and interview, photography and art, copyediting and proofreading, word processing, computer layout and design.

UNIT II

Editing and design - introduction to news selection and emphasis; techniques and skills for editing print news media; critical analysis of layout and design conventions of print news media.

UNIT III

Magazine journalism - profile and feature writing; Radio and television journalism - principles and practices of gathering, writing and producing news for radio and television; Photo journalism - visual language, skills and techniques; New media journalism – websites and blogs, writing, editing and site design skills for online journalism; Responsible journalism - fairness and balance, libel, and the commercial nature of the media, constructive criticism; advertisements – principles and practice; careers in journalism.

Practical

Identification, articulation and analysis of major issues related to fisheries development; critical analysis of fisheries related news stories and feature articles from development magazines / news papers; Gathering and writing news stories, feature articles and editorials; Designing, editing and publishing campus news letters; interface with editors of journals and magazines; Critical analysis of fisheries related radio news stories; Producing radio news items for broadcast; digital photography and image editing; designing and developing a theme based website / blog; Visits to select printing presses, media organizations and news agencies.

Suggested Readings

Aggarwal VB & Gupta VS. 1991. *Handbook of Journalism and Mass Communication*. Concept Publ.
Bond FF. 2002. *An Introduction to Journalism*. The MacMillan Co.

David W. 2001. *Journalism Made Simple*. Rupa & Heinmann.
Kamat MV. 1992. *Professional Journalism*. Vikas Publ.
Ray GL. 2005. *Journalism*. Kalyani.
Roland W. 1994. *Journalism in Modern India*. Asia Publ.

FEX 512 INDIGENOUS TRADITIONAL KNOWLEDGE IN FISHERIES 1+1

Objective

To learn different indigenous knowledge systems and their importance in fisheries.

Theory

UNIT I

Indigenous knowledge - historical perspective, terminologies, concepts, systems, Importance, Relevance and roles in fisheries sector; Reasons for the non adoption of technical knowledge; Indigenous *vis-a-vis* scientific knowledge.

UNIT II

Types of indigenous knowledge; Information, practices and technologies; Beliefs, tools, materials, documentation, validation and dissemination of ITK; Peoples' Biodiversity Register; Accessing the indigenous knowledge; Constraints of indigenous knowledge, conserving ITK.

UNIT III

Issues in protection of traditional knowledge / ITK - understanding Indian Biological Diversity Act and National Biodiversity Authority, - limits to benefit sharing – IPR, PIC, TRIPS vs. CBD; Blending indigenous knowledge and modern technologies.

Practical

Documentation of ITK in fisheries; Development of case studies of ITK in fisheries; Institutions and NGOs involved in ITK collection and validation.

Suggested Readings

Anon. 1998. *Aquatic Sciences and Fisheries Abstracts*. United Nations Department of Economic and Social Affairs, Information Retrieval Limited, Cambridge Communications Corporation.

Berkes F, Mahon R, McConney P, Pollnac R & Pomeroy R. 2001. *Managing Small-Scale Fisheries: Alternative Directions and Methods*. IDRC, Canada.

Inglis J. 1993. *Traditional Ecological Knowledge: Concepts and Cases*. IDRC, Canada.

Robert SP & Rebecca RG. 2006. *Fishery Co-Management: A Practical Handbook*. CABI.

FEX 513 COMMUNITY BASED DISASTER MANAGEMENT 1+1

Objective

To familiarize with different disasters and their impact.

To get acquainted with the strategies and methods to cope up with disasters.

Theory

UNIT I

Basic concepts: Hazard, risk, vulnerability, disaster, capacity building. Multi-hazard and disaster vulnerability of India.

UNIT II

Types of natural and manmade hazards in fisheries and aquaculture - cyclones, floods, droughts, tsunami, El-nino, *la nina*, algal blooms, avalanches, pollution, habitat destruction, over fishing, introduction of exotic species, landslides, epidemics, loss of bio-diversity.

UNIT III

Climate change and global warming; Issues related to depletion of water resources; Causes, characteristics and impact of various disasters.

UNIT IV

Management strategies: pre-disaster, during disaster and post-disaster; Pre-disaster - prevention, preparedness and mitigation; different ways of detecting and predicting disasters; early warning, communication and dissemination, community based disaster preparedness, structural and non-structural mitigation measures; During disaster: response and recovery systems at national, state and local, coordination between different agencies, international best practices; Post-disaster: Methods for assessment of initial and long term damages, reconstruction and rehabilitation.

UNIT V

Prevalent national and global management practices in disaster management. Agencies involved in monitoring and early warnings at district, state, national and global level; Sea safety and health.

Practical

Methods for assessment of initial and long term damages. Preparedness in pre, during and post disasters. Acquaintance with fire-fighting devices. Life saving appliances and first-aid. Operation and usage of communication channels and media. Uses of distress signals and technologies. Relief and rehabilitation measures, trauma counseling. Field visits and case studies. Group discussion.

Suggested Readings

An Earthquake Preparedness Guide: A Ready Reckoner for Home Dwellers. 2005. National Disaster Management Division, Ministry of Home Affairs, Government of India, New Delhi.

Comfort LK. 2005. *Managing Disaster: Strategies and Policy Perspectives*. Duke Press Policy Studies.

Gupta MC & Sharma VK. *Orissa Super Cyclone '99*. 2000. National Institute of Disaster Management, Ministry of Home Affairs, Government of India, New Delhi.

Manual on Natural Disaster Management in India. 2001. National Institute of Disaster Management, Ministry of Home Affairs, Government of India, New Delhi.

Natural Disaster Response Plan. 2001. National Institute of Disaster Management, Ministry of Home Affairs, Government of India, New Delhi.

Sinha A. 2001. *Disaster Management*. National Institute of Disaster Management, Ministry of Home Affairs, Government of India, New Delhi.

FEX 601 ADVANCES IN FISHERIES EXTENSION MANAGEMENT 2+1

Objective

To learn about the recent development in extension management in terms of concepts, approaches and methods.

Theory

UNIT I

Approaches of Fisheries and Aquaculture Extension: A critical analysis of different approaches; Extension programmes of corporate sector, the concept importance and implications of livelihood extension, Technology Base of Aqauculture Extension : Importance and relevance of indigenous knowledge system, identification and documentation of ITK, Integration of ITK system with formation research, Agricultural Knowledge and Information System (AKIS); significance of theories of social learning for extension practice; Cyber Extension: Concept of cyber extension, national and international cases on extension projects using ICT and their impacts.

UNIT II

Economics of Fisheries and Aquaculture extension: National investments in extension, impacts of fisheries / aquaculture extension, alternative methods of financing fisheries / aquaculture extension, privatization of fisheries / aquaculture extension – scope, limitations and experiences and cases; Implications of GATT agreement for extension services, re-orientation of extension services for agri-business and marketing activities, GOI-NGO collaboration to improve

UNIT III

Efficiency of extension. Extension and contemporary issues: issues related to rural poverty, environmental protection of farm and home, bio-diversity, sustainable development, food and nutritional security, recent advances in biotechnology. Analysis of ITK system, cases on integration of ITK and formal research; Analysis of cases on cyber extension and privatization of extension: pattern and success stories.

Practical

Critical analysis of the management aspects. Study and preparation of case material on selected dimensions of management through visits to various fisheries development organisations and to study their management effectiveness.

Suggested Readings

Chandrasekhar CS. (Ed.). 2004. *Privatization of Agricultural Extension in India*. MANAGE, Hyderabad.

Kumar D. 1996. *Aquaculture Extension Services Review: India*. FAO Fisheries Circular No. 906, Rome.

Malhotra SP & Sinha VRP. 2007. *Indian Fisheries and Aquaculture in a Globalizing Economy*. Part II. Narendra Publ. House.

Ramchandran C. 2004. *Teaching not To F(in)ish: A Constructivist Perspective on Reinventing a Responsible Marine Fisheries Extension System*. CMFRI, Kochi.

Ray GL. 2006. *Extension, Communication and Management*. 6th Ed. Kalyani.

Rivera WM. 2004. *Agricultural Extension: Worldwide Institutional Evolution and Forces for Change*. Elsevier.

FEX 602 MONITORING AND EVALUATION OF DEVELOPMENT PROGRAMMES 2+1

Objective

To understand about the concept and types of impact studies.

Theory

UNIT I

Monitoring, evaluation and impact assessment - importance and scope in fisheries programmes; conceptual frameworks, results frameworks and logic models; Quantitative and qualitative indicators – characteristics and their selection criteria; indicators and information systems for sustainable fisheries development - testing and improving indicators; Integration of M and E systems into development programmes.

UNIT II

Difference between outcome and impact; Types of impact assessment: Climate impact assessment; Demographic impact assessment; Development impact; assessment; Ecological impact assessment; Economic and fiscal impact assessment; Environmental auditing; Environmental impact assessment; Environmental management systems; Health impact assessment; Project evaluation; Public consultation; Public participation ; Risk assessment; Social impact assessment; Strategic impact assessment; Technology assessment, Equality impact assessment.

UNIT III

Impact assessment methods: Types-Within-without; Before-after; Case study; Participatory; Social Auditing; Steps: Quantifying the impact parameters; Identification of data sources and their types; Sampling design; Data generation; Analysis; Report writing

Practical

Development of M and E plan and procedures for fisheries using participatory approach. Preparing M and E plan for some fisheries programmes. Developing indicators and information system for sustainable fisheries development.

Analysis of different reports, conducting impact assessment exercises, case studies.

Suggested Readings

Capturing Experience: Evaluation, Evaluation and Impact Assessment Methods, http://web.mit.edu/urbanupgrading/upgrading/resources/bibliography/Evaluation-Impact.html

Equality Impact Assessment, http://www.scotland.gov.uk/Resource/Doc/1032/0041879.doc

Evaluating Development Operations: Methods for Judging Outcomes and Impacts. Operations Evaluation Department, The World Bank. Lessons and Practice Number 10, July 1997.

John P, Peter R & Simon Z. 1995. *Social Auditing for Small Organizations: The Workbook*. New Economics.

Louisa G & Edwards M. 1995. *Toolkits: A Practical Guide to Assessment, Monitoring, Review and Evaluation*. Gosling, Development Manual 5, Save the Children, UK.

Resources on Impact Assessment, http://www.gdrc.org/ uem/eia/define.html

FEX 603 MEASUREMENT AND SCALING TECHNIQUES IN FISHERIES EXTENSION 2+1

Objective

To acquire skills in different measurement concepts and techniques.

To acquire skills in important techniques of scaling techniques in social science research.

Theory

UNIT I

Measurement - concept, importance, levels and their properties; Reliability: concept, importance, types - split half, parallel form, test-retest reliability; interpretation of reliability coefficients; Validity: concept and types - content, criterion related, construct, concurrent and predictive validity.

UNIT II

Development and standardisation of tests and scales - knowledge test, types of time test; Difficulty index, discrimination index, point biserial correlation and scoring; Item analysis: concept and use in behavioural research; interpretation of research data; Intelligence tests: definition, types and scoring method; Projective tests: Thematic Apperception Test, Rorschach's ink plot test, words association test, etc.

UNIT III

Content analysis - method and scope; Critical incident technique - method and application; Sociometry – concept, types like sociogram, sociometric indices and matrices, their applications; Semantic differential technique; Psychometric analysis; Q Methodology; H-Technique.

UNIT IV

Scaling techniques; concept, construction and use of attitude statements; Method of Paired Comparison - Thurstone's Contribution, development of scale with 'F' 'P' and 'Z' Martices, calculation of scale values, tests of significance, administration and scoring; Method of Equal Appearing Intervals - rational, development, sorting procedures, calculation of scale and 'Q' values, administration and scoring; Method of Successive Intervals - rational, development, estimating intervals widths, determining scale values, internal consistency check, administration and scoring; Method of Summated Rating - rational, development and procedure for selection of items, interpretation of 'T' scores and administration.

UNIT V

Scalogram Analysis – rational, unidimensionality of the scale, Cornell technique and other methods of scalogram analysis, coefficient of reproduciability, scale and non-scale types and their administration; Scale Discrimination Technique - development of this technique, obtaining scale and 't' values and advantages of scale discrimination technique.

UNIT VI

Non-Parametric Tests - meaning and types, one sample runs test of randomness, sign test, wilcoxon signed rank test, wilcoxon-Mann-Whitney test, Cochran Q test, Spearman rank order correlation coefficient, Kendall rank order correlation coefficient and Kendall's coefficient of concordance.

Practical

Exercises on measurement and frequency distributions. Problems on reliability and validity and interpretation of the results. Problems on

transformation of scores. Exercises on difficulty index, discriminant on power. Exercise on point biserial correlation. Exercises on interpretation of scores correlation coefficients and its interpretations. Interpretation of multiple correlation coefficient (R) and R2. Interpretation of path coefficients, direct and indirect effects, etc. Discriminant function analysis - Results and Interpretation; Review of techniques and other procedures including scales developed with special reference to Extension Education research. Assignments for different scaling procedures based on the class discussion by using the hypothetical or actual data. Practical exercises on how to compute reliability and validity measures for test scores. Method of paired comparison. Method of equal appearing intervals. Method of successive intervals. Method of summated ratings. Scalogram analysis. Scale discrimination technique; Exercises on Non-parametric tests.

Suggested Readings

Goode WJ & Hatt PF. 1985. *Methods in Social Research*. Mc Graw-Hill.

Junker BH. 1979. *Field Work: An Introduction to the Social Sciences*. University of Chicago Press.

Kerlinger FN. 2000. *Foundation of Behavioural Research*. Globe Offset Press.

Kothari CR. 1998. *Research Methodology*. Vishwa Prakashan.

Young PV. 1997. *Scientific Social Surveys and Research*. Prentice Hall of India.

FEX 604 EXTENSION SERVICE SYSTEM MANAGEMENT 1+1

Objective

To gain an understanding of structure, organisation and working of fisheries extension service system at various levels.

To acquire competency to critically evaluate the performance of extension service agencies.

Theory

UNIT I

Meaning and scope of extension service system and its management; Public administration and bureaucracy - concepts, origin and development; Marxian, Weberian and Gandhian thoughts on bureaucracy; bureaucratic vs. developmental organisation.

UNIT II

Processes of management- POSDCORB; Structure, organisation, function, working and management of public extension service agencies like DoFs, FFDA, BFDA, MPEDA, NFDB, NABARD, Fisheries Development Corporations, State Fish Seed Development Corporations, KVKs, SAUs, Fisheries Co-operatives, international agencies, corporate sector, private organizations and MNCs.

UNIT III

Delegation of power, autonomy and organisational communication and conflicts in governmental, UN agencies, non-governmental and private extension service organisations; Conflicting roles and responsibilities of extension agents.

UNIT IV

Organisational communication – meaning, methods, types and techniques; functions and importance in motivation and control; formal and informal

communication networks in GOs, NGOs and POs; behaviour of individuals in organisations; Organisational change and communication; patterns of communication of organisational communication; managing organisational communication in fisheries sector.

UNIT V

Research, extension and client systems linkages; linkages and coordination between Dept. of Fisheries and other line Depts. like Irrigation / Water Resources, Environment, Forestry, Agriculture at grassroots, District, State and Central levels; HRD policy in governmental, non-governmental and private extension service organizations. Strengthening governance - transparency, accountability and people's participation.

Practical

Case study and analysis of State Departments of Fisheries in selected States; Case studies in structure organization, staffing, career advancement, quality of service delivery at grassroots level in governmental, non-governmental and private extension service organisations like DoFs, FFDA, NABARD, State Fish Seed Development Corporations, KVKs, Fisheries Co-operatives, NGOs, and private sector organisations; Study of patterns of communication and effectiveness of Fisheries Development Organisation; Study visit to DoF, Maharashtra, NGOs, NABARD, private sector agencies involved in fisheries extension.

Suggested Readings

Kumar D. 1996. *Aquaculture Extension Services Review: India*. FAO Fisheries Circular No. 906, Rome.

Ramchandran C. 2004. *Teaching not To F(in)ish: A Constructivist Perspective on Reinventing a Responsible Marine Fisheries Extension System*. CMFRI, Kochi.

Ray GL. 2006. *Extension, Communication and Management*. 6th Ed. Kalyani.

Roling N. 1988. *Extension Science: Information Systems in Agricultural Development*. Cambridge University Press.

Swanson BE, Bentz RP & Sofranko AJ. 1997. *Improving Agricultural Extension. A Reference Manual*. FAO, Rome.

FEX 605 ADVANCES IN TRAINING METHODS AND EDUCATION TECHNOLOGY 1+1

Objective

To understand the relevant and emerging areas in training.

To learn the latest tools in training programmes.

Theory

UNIT I

Training tools: Expectation setting, Course design, Icebreakers, climate setting and team building exercises, Monitoring and evaluation, Follow up. Commodity System Assessment Methodology: Formation of interdisciplinary team; Developing preproduction, production, post harvest, marketing and service delivery strategies; Workshops: Coordination committee; Expected output; Institutional support; baseline document; Resource persons; Selection of participants; Developing workshop agenda; Conducting the workshop.

UNIT II

Collection of missing information; Checklist for organizing a workshop; Training Manual-Documenting Good Management Practices: challenges, emerging knowledge; Indigenous knowledge, synthesis.

UNIT III

Distance Learning: Identification of potential learners; Defining learning objectives; Designing learning materials; marketing; Implementation; Monitoring and evaluation; Designing programmes for community radio; Farmer field school: Origins of the Farmer field school; Description of a typical Farmer field school; FAO support for Farmer field schools in Asia; Costs and benefits of the Farmer field school.

UNIT IV

Teaching and learning process in extension education. Its characteristics, steps in extension education process, setting up of learning situation, guides to effective extension teaching; Recent research findings in instructional technology; Manpower planning in fisheries – administration -teaching – research and extension activities. Research studies in fisheries training.

Practical

Simulated exercises on Commodity System Assessment Methodology, Planning a Workshops, Documenting Good Management Practices, Designing materials for Distance Learning, and using icebreakers, climate setting and team building exercises. Preparing script for Radio, Press and TV. Computer graphics, practicing folk methods. Taking photos for popular and scientific publications. Practicing the use of different projectors –systems of multimedia projection. Visit to inland fish farm, marine villages and industrial units and identification of technological problems in selecting extension methods and programmes.

Suggested Readings

Farming Freshwater Prawns. A Manual for the Culture of the Giant River Prawn (Macrobrachium rosenbergii). 2004. FAO Fisheries Tech. Paper No. 428, Rome.

Jerry LG. 1990. *A Commodity Systems Assessment Methodology for Problem and Project Identification. Post Harvest Institute for Perishables*. College of Agriculture, University of Idaho.

Loretta S. 2005. *Good Agricultural Practices Standards: A Way Towards Safe and Sustainable Agriculture*? Seminar on Certification and Regulations for Food Safety, 31 May 2005, Wageningen.

Scott M. 2001. *Distance Education and Distance Learning: A Framework for the Food and Agriculture Organization of the United Nations*. Sustainable Development Department, FAO.

FEX 606 SOCIAL AND GENDER ISSUES IN FISHERIES 1+1

Objective

To acquire an understanding of fishers society, culture and livelihood and identify different issues of concerning them.

Theory

UNIT I

Social life of fishers: Family, religion and caste among others; Economic, political and cultural organisation of fishers; demographic aspects; Social stratification, poverty and economic equality among fishers; social mobility

and migration; social and economic relationship between fishers and non-fishers, Capacity development and social capital.

UNIT II

Rural development in India - concept and history; role of fisheries in rural development; Leadership and leaders in fisheries – types, their roles and function; identification, training and development of local leaders; Role of change agents; Indicators of social change and their measurement; Review of significant research findings.

UNIT III

Social change and social conflict in fisheries: concept and theories of social change; modernisation and social change in fisheries; impact of urbanisation; impact of trade liberalisation and globalisation; forms and content of social conflict in fisheries; conflict between traditional/small scale and modern mechanised fishers; conflict over inland and coastal aquatic resources; role of the State and international community in aquatic resources management and conflict resolution; extension and development programmes for fishers; role and functions of FFDA, BFDA and fisheries research institutes/colleges.

UNIT IV

Gender issues in fisheries: concept of gender; feminist movements, theories of gender inequality, empowerment discourse; division of labour between men and women; relationship between social class and gender; gender differences in socialisation, educational attainment and social mobility. Women and men in small scale fisheries and processing sector, Ergonomics and health issues; fishers and coastal resources management; technological changes and their implications for fishers; fishery cooperatives and empowerment; development programmes for fishers; globalisation and women fishers; policy issues.

Practical

Case studies on social and gender issues in fisheries; Case studies on social conflicts and their resolution; Tools and frameworks for gender awareness planning; Book review; Exercises in social and gender sensitive policies; Use of different methods of identifying village leaders – observation sociometry, key informant technique, etc.; Indexing leaders by leadership index; Identifying the indicators of social change and their measurement; Analysing the change agents role; Studying the consequences of social change.

Suggested Readings

Haq MU. 2002. *Human Development in South Asia: Globalisation and Human Development*. Oxford University Press.

Kishwar M. 1999. *Off the Beaten Track: Rethinking Gender Justice for Indian Women*. Oxford University Press.

NCAER 1998. *Human Development Report: West and Central India*. Oxford University Press.

Rairkar P. 2000. *Indian Peasant Women Speak Up*. Orient Longman.

Singh K & Tewari R. 2002. *Women in Fisheries*. Indian Society of Fisheries Professionals, Mumbai.

FEX 607 INFORMATION AND COMMUNICATION TECHNOLOGY FOR FISHERIES DEVELOPMENT 1+1

Objective

To learn the extent of utility and relevance of ICT in fisheries development and draw lessons from case studies.

Theory

UNIT I

Concept of information communication technology and its role in fisheries development. Information communication technologies –print and electronic media, email, Internet, video and teleconferencing, computer assisted instructions, touch screens, micro computers and web technologies. Information kiosks. Networking system of information- type of network-PAN, LAN, Can, MAN, WAN, AGRINEt, e-Governance. Cyber extension. Extension through virtual mode, e-learning. Agricultural technology Information Centres (ATIC), technology parks. Management Information System in fisheries extension. Use of expert system in fisheries extension.

UNIT II

Internet in fisheries extension with specific reference to communication technology Internet – email – voicemail – teletext – videotext – tele and video conferencing and its application.

Practical

Study of different kinds of information technologies. Print and electronic media. Practicing tele and video conferencing. Development of computer assisted instructions. Touch screens and information kiosks. Study of computer networks and its applications in fisheries. Development and use of e-learning modules in fisheries. Audio aids – wireless public address system; multimedia Projectors; Audio recording – video recording –Audio cassette – Compact Disc (CD) production in fisheries; Various types of cameras – video format – digital cameras ; Video - video editing system - use of computer for video editing - non-linier editing; Power point software – designing slides – using templates. Digital photography – techniques application in extension; Study of various public address systems, Systems of Multimedia Projection, Practice and creation of interactive CDs in fisheries, Study and practice of various kinds of video editing systems. Practice and use of digital photography.

Suggested Readings

Batchelor S, Evangelista S, Hearn S, Peirce M, Sugden S & Webb M. 2003. *ICT for Development: Contributing to the Millennium Development Goals: Lessons Learned from Seventeen Info Dev Projects*. World Bank, Wasingten D. C.

NIC. 2005. *Good Governance through ICT*. NIC, Ministry of IT, Government of India, New Delhi.

NISG. 2004. *ICT for Development: Make ICT Work for People*. Compilation of ICT Cases in India, NISG, Hyderabad.

FEX 608 INTERNATIONAL EXPERIENCES IN FISHERIES EXTENSION 2+0

Objective

To gain knowledge on different international agencies of development.

To appraise the extension systems of the leading fisheries countries of the world.

Theory

UNIT I

Understanding fisheries and aquaculture extension and development systems in South Asian countries and South East Asian countries - Thailand, Indonesia, Malaysia, Vietnam, Myanmar, China; Extension system in Japan; Linkages between Research and Development system in these countries; Status of fishing communities in these countries.

UNIT II

Analysing mission, approaches and achievements of fisheries development organizations: World Fish Centre, International Collective in Support of Fish Workers (ICSF), International Fishmeal and Oil Manufacturers Association (IFOMA), Asian Fisheries Society (AFS), National Marine Fisheries Service of USA, Fisheries Division of FAO, World Fish Forum, Asia-Pacific Fisheries Commission (APFIC), Committee for Inland Fisheries and Aquaculture of Africa (CIFAA) Commission for Inland Fisheries of Latin America (COPESCAL), European Inland Fisheries Advisory Commission (EIFAC), General Fisheries Commission for the Mediterranean (GFCM), Indian Ocean Tuna Commission (IOTC), Regional Commission for Fisheries (RECOFI), Western Central Atlantic Fishery Commission (WECAFC);

Suggested Readings

Kumar D. 1999. *Trickle Down System (TDS) of Aquaculture Extension for Rural Development*. RAP Publ. FAO, Bangkok, Thailand.

Pomeroy R & Berkes F. 1997. *Two to Tango: The Role of Government in Fisheries Co-management*. Marine Policy, Vol. 21. Belhaven Press, London.

Sen S & Nielsen JR. 1996. *Fisheries Co-management: A Comparative Analysis*. Marine Policy, Vol. 20. Belhaven Press, London.

FEX 609 ERGONOMICS 1+1

Objective

To familiarize the students with the fundamentals of ergonomics and its application.

Theory

UNIT I

Introduction to ergonomics and its multidisciplinary approach.

UNIT II

Human machine - environment interface, work study, posture, ergonomics aspects of environment: illumination, sound, temperature, humidity, radiant heat, air velocity, body dimensions, anthropometry and workplace design, fatigue, occupational health studies.

UNIT III

Application of ergonomics in fisheries and agriculture sector.

Practical

Physical environment study, assessment of body composition and dimensions, measurement of grip strength, measurement of physiological work by heart rate method and RPE, posture analysis by flexi curve,

psycho- physiological tests; designing of ergonomics tool/product/system for fisheries sector; review paper on ergonomics and fisheries/agriculture.

Suggested Readings

Astrand PO, Rodahl K, Dahl H & Stromme S. 1994. *A Textbook of Work Physiology*. Human Kinetics Publ.

Grandjean E. 1988. *Fitting the Task to the Man: An Ergonomic Approach*. 4th Ed. Taylor & Francis.

Karwowski W & Marras WS. (Eds.). 2003. *Occupational Ergonomics: Principles of Work Design*. CRC Press.

Pheasant S. 1991. *Ergonomics, Work and Health*. Aspen Publ.

Wilson JR & Corlett EN. (Eds.). 2005. *Evaluation of Human Work: A Practical Ergonomics Methodology*. 3rd Ed. CRC Press.

FISHERIES EXTENSION

List of Journals

- Agricultural Economic Research Review
- Agricultural Extension Review
- American Journal of Evaluation
- British Journal of Educational Technology
- Disaster Management and Response
- Disaster Prevention and Management
- Down To Earth
- Economic and Political Weekly
- Ergonomics
- Evaluation Journal of Australasia
- Extension Review
- Gender and Society
- Gender, Work and Organization
- Honey Bee
- Indian Journal of Agricultural Extension
- Indian Journal of Extension Education
- Indian Journal of Mass Communication
- Indian Journal of Public Administration
- Indian Journal of Social Science Research
- Indian Journal of Social Work
- Indian Journal of Traditional Knowledge
- Indian Journal of Tropical Biodiversity
- Indian Research Journal of Extension Education
- International Journal of Agricultural Extension
- International Journal of Education and Development using ICT
- International Journal of Project Management
- International Journal of Social Research Methodology
- International Journal of Training and Development
- Journal of Communication
- Journal of Computer Assisted Learning
- Journal of Extension Education
- Journal of Extension Systems
- Journal of Rural Development
- Journal of Social Work
- MANAGE Extension Research Review
- Politics and Gender
- R&D Journal of Graphic Design
- R&D Journal of Information and Communication Technologies
- R&D Journal of Multimedia
- Rural Sociology
- The journal of disaster studies, policy and management
- The Journal of Gender Studies
- The Journal of Vocational Education and Training
- The Project Management Journal
- Vikalpa

Suggested Broad Areas for Master's and Doctoral Research

- Comparative study on performance of public, private and market led extension systems
- Performance and impact of ATMA model of service delivery / knowledge dissemination
- Communication effectiveness of different media
- Impact of community radio and ICT led extension systems
- Case studies on co-management and community based fisheries management experiences in India
- Training need assessment of State Department of Fisheries
- Recruitment policy and career advancement in State Department of Fisheries
- Role and importance of PRIs and NGOs in implementing fisheries development programmes
- Critical factors in successful development of community based organisations
- Reach and impact of fisheries innovations
- Stakeholder analysis of fisheries innovations
- Developing effective interactive e-learning and multimedia products
- Reach and impact of fisheries innovations
- Socio-economic impact assessment of development programmes
- HRM practices of various State Fisheries Departments, NGOs and private consultancies
- Division of labour and gender equity among fishing communities
- Content analysis of development oriented articles / features in print /electronic media for their reach, readability, and persuasion and conviction
- Political economy of mass media and development journalism
- Case studies on documentation and validation of ITK practices in fisheries sector
- Impact of Tsunami 2005 on fishers livelihoods and fisheries
- Pattern of rehabilitation work and its impact
- Returns to investment in fisheries and aquaculture extension
- Evolving participatory result oriented monitoring and evaluation system for fisheries development programmes in developing countries.
- Developing appropriate scaling technique for measuring the attitude of fishers towards conservation technologies
- Professionalism in Service Delivery System
- Performance of public and NGO led extension systems
- Developing and field testing of effective training tools for trainers
- Conflict between small scale fishers and large scale fishers and in(adequacy) of the present resolution mechanism.
- Social change, mobility and integration in fishing communities
- Case studies on success stories in use of ICT for fisheries development
- Limiting factors in effective use of ICT for Development
- Comparative study of effectiveness / performance of extension systems in India and Indonesia / Thailand
- Levels of workload among Fishers and their impact on health

FISHERIES RESOURCE MANAGEMENT
Course Structur - at a Glance

CODE	COURSE TITLE	CREDITS
FRM 501*	INLAND FISHERIES RESOURCES	2+1
FRM 502*	MARINE FISHERIES RESOURCE MANAGEMENT	2+1
FRM 503*	MARINE ECOSYSTEMS, BIODIVERSITY AND CONSERVATION	2+1
FRM 504*	TROPICAL FISH STOCK ASSESSMENT	2+1
FRM 505	FISHERIES REGULATIONS	2+1
FRM 506	REMOTE SENSING AND GIS FOR FISHERIES MANAGEMENT	1+1
FRM 507#	INTEGRATED COASTAL ZONE MANAGEMENT	2+1
FRM 508	AQUATIC FLORAL RESOURCES	2+1
FRM 509	FEEDING AND REPRODUCTIVE BIOLOGY OF FINFISH AND SHELLFISH	2+1
FRM 510	DEVELOPMENTAL BIOLOGY OF FINFISH AND SHELLFISH	2+1
FRM 511	FISHING AND ALLIED TECHNOLOGIES	2+1
FRM 512	MODERN TECHNIQUES IN ICHTHYOTAXONOMY	2+1
FRM 591	MASTER'S SEMINAR	1+0
FRM 599	MASTER'S RESEARCH	20
FRM 601**	ASSESSMENT OF AQUATIC BIODIVERSITY	2+1
FRM 602**	APPLICATIONS OF FISHERIES MODELS IN STOCK ASSESSMENT	2+1
FRM 603**	CONSERVATION AND MANAGEMENT OF EXPLOITED FISHERIES RESOURCES	2+1
FRM 604	CORAL REEF MANAGEMENT	2+1
FRM 605	DATA COLLECTION AND ESTIMATION OF EXPLOITED FISHERIES RESOURCES	0+2
FRM 606	FISHERIES ENVIRONMENTAL ASSESSMENT	2+1
FRM 607	ISSUES IN CAPTURE FISHERIES	1+1
FRM 691	DOCTORAL SEMINAR I	1+0
FRM 692	DOCTORAL SEMINAR II	1+0
FRM 699	DOCTORAL RESEARCH	45

* Compulsory for Master's programme; ** Compulsory for Doctoral programme
#FRM 507 cross listed with Aquatic Environment Management AEM 503

FISHERIES RESOURCE MANAGEMENT

Course Contents

FRM 501 INLAND FISHERIES RESOURCES 2+1

Objective

To understand the present exploitation and future potential of inland Fisheries.

To learn the methodologies for assessments of Inland Fisheries Resources.

Theory

UNIT I

Categorization of different freshwater fisheries resources: Ponds, lakes, bheels, tanks, estuaries, brackish water lagoons, wetlands, biosphere reserves and mangroves and derelict water bodies their problems and management aspects.

UNIT II

Bheel fisheries resources of India: Open and closed bheels, productivity conditions, Capture scenario, prospects of culture based systems.

UNIT III

Riverine fisheries resources: Present trend of dwindling fisheries resources, direct and Indirect effects of human intervention in rivers, habitat modification and improvement (rehabilitation of channels and flood plains), protection and restoration of fish movements (different types of fish passes and enhancement of fish migration), management and repair of riverine vegetation, stock enhancement strategies like introduction of new species, pre- and post- stocking management, potential risk of stocking.

UNIT IV

Cold water fisheries of India: Present trends, problems due to habitat destruction, management aspects, prospects of sports fisheries in India.

UNIT V

Reservoir Fisheries: Classification of reservoirs, present productivity levels, management practices.

UNIT VI

Estuarine fisheries: classification of estuaries- present productivity level-potential; Problem – management practices.

UNIT VII

Assessment of carrying capacity of different inland water bodies; Water budgeting. Community participation in fishery resource management.

Practical

Freshwater fish identification – tagging – different types of tags – Visit to nearest freshwater body; catching methods – catch data analysis on major freshwater resource – Estuaries - Reservoirs – Major lakes - of India – Biodiversity indices – Gear selectivity.

Suggested Readings

Blaber JM. 1997. *Fish and Fisheries in Tropical Estuaries*. Chapman & Hall.

FAO. Technical Papers on Freshwater Fisheries.

Jhingran VG & Pathak V. 1987. Ecology and Management of Bheels in Assam: A case study of Dhir Bheel. In: *Workshop on Development*

of Bheel Fisheries in Assam, held at Assam Agricultural University, Guwahati from 21st to 22nd April.

Jhingran VG & Sehgal KL. 1978. *Cold Water Fisheries of India*. J. Inland. Fish. Soc. India. Sp. Publ.

Jhingran VG. 1991. *Fish and Fisheries of India*. 3rd Ed. Hindustan Publ.

Sugunan VV. 1997. *Reservoir Fisheries of India*. Daya Publ. House.

FRM 502 MARINE FISHERIES RESOURCE MANAGEMENT 2+1

Objective

To know the present level of exploitation of marine resources and to impart knowledge on conservation measures.

To learn the recent methodologies of sustainable exploitation of renewable resources.

Theory

UNIT I

Major fishing nation of the world, major fishing regions, present trend of marine capture fisheries.

UNIT II

Important finfish and shellfish resources in demersal and pelagic systems; conservation strategies.

UNIT III

Principles of management of fisheries resources objectives of management, issues and challenges of managing multi-gear fisheries.

UNIT IV

Mud bank fishery- wedge bank fishery-Commonly used tools for input and output regulation.

UNIT V

Sustainability: Principles, social economic ecological biological and legal issues Fisheries co-management.

UNIT VI

Marine Biodiversity of selected areas including coral reef conservation.

UNIT VII

Fisheries and fishing methods in open waters: Inshore fisheries (up to 50 m depth), offshore fisheries (50-200 m depth) High sea fisheries (beyond 200m) up to outer limit of EEZ and in International waters.

UNIT VIII

Conservation aspects: Biodiversity principles, categorization of species into endangered; Indeterminate and extinct varieties- managing the highly exploited fishery resources.

UNIT IX

Case studies of fisheries conflicts depending on problems in different states.

Practical

Marine fishery resources – visit to nearest marine landing center – length frequency analysis – catching method – catch data analysis on marine fishery resources of India– closed season studies – gear selectivity.

Suggested Readings

Bal DV & Rao KV. 1990. *Marine Fishes of India*. 1st Revised Ed. Tata McGraw Hill.

Chandra P. 2007. *Fishery Conservation, Management and Development*. SBS Publ.
Dholakia AD. 2004. *Fisheries and Aquatic Resources of India*. Daya Publ. House.
FAO. Technical Papers on Marine Fisheries.
Kurian CV & Sebastian VO. 1986. *Prawns and Prawn Fisheries of India*. Hindustan Publ. Corp.
Peter BM & Joseph JC. Jr. 2000. *Fishes- An Introduction to Ichthyology*. 4th Ed. Prentice Hall.
Samuel CT. 1968. *Marine Fisheries in India*. Narendra Publ. House.
Shanbhogue SL. 2000. *Marine Fisheries of India*. ICAR.
Yadav BN. 1997. *Fish and Fisheries.* 2nd Ed. Daya Publ. House.

FRM 503 MARINE ECOSYSTEMS, BIODIVERSITY AND CONSERVATION 2+1

Objective

To study the biodiversity of flora and fauna and its assessment using the various biodiversity indices for conservation of aquatic resources.
To understand the ecological impacts on various resources.

Theory

UNIT I

Biology of selected endangered species of sponges, corals, gastropods, bivalves, sea cucumbers, fishes, sea snakes, turtles, birds and marine mammals.

UNIT II

IUCN criteria –- Red List, Wild life protection act, International treaties and conventions, Marine Protected Areas, Sanctuaries and Biosphere reserves. Establishment of National marine parks, *in situ* and *ex situ* conservation.

UNIT III

Marine and Coastal Ecosystems – Overview; physico-chemical environment; ecological notions; plankton; benthos, mangroves; sea grasses and corals.

UNIT IV

Human impact on ecosystem.

UNIT V

Marine biodiversity: threats, planning and management, tools for conservation.

Practical

Identification of scheduled aquatic organisms- Predators of endangered animals. Observation of stranded marine mammals, corals, seafans and other endangered aquatic Organisms, Visit to various aquatic ecosystem for recording the biodiversity and richness indices, Conservation planning.

Suggested Readings

Balakrishnan Nair N & Thampy DM. 1980. *A Text Book of Marine Ecology*. The MacMillan Co.
Castro P & Huber ME. 1997. *Marine Biology*. 2nd Ed. Mc-Graw Hill.
Duxbury AC, Duxbury AB & Sverdrup KA. 2000. *An Introduction to the World's Oceans.* 6th Ed. McGraw Hill.
Gross G. 1993. *Oceanography: A View of the Earth*. 6th Ed. Prentice Hall.

Iversen ES. 1996. *Living Marine Resources*. Chapman & Hall.
McCormick JM & Thiruvathaakal JV. 1976. *Elements of Oceanography*. WB Saunders.
Nybakken JW. 1997. *Marine Biology - An Ecological Approach*. 4th Ed. Addison Wesley.
Raymont JEG. 1973. *Plankton and Productivity in the Oceans*. Pergamon Press.
Sverdrup HV, Johnson MW & Fleming RH. 1959. *The Oceans - Their Physics, Chemistry and General Biology*. Prentice Hall.

FRM 504 TROPICAL FISH STOCK ASSESSMENT 2+1

Objective

To understand the application of various models to estimate fish population.

To get an idea of the interaction of tropical fish population in the ecosystem.

Theory

UNIT I

Stock concept.

UNIT II

Estimation of growth parameters and mortality rates.

UNIT III

Virtual population methods.

UNIT IV

Gear selectivity. Sampling of commercial catches.

UNIT V

Yield per recruit model.

UNIT VI

Surplus production model. Swept area method - Box model.

UNIT VII

Stock recruitment relationship – Stochastic model – estimation of technical reference point MSY and other yield base reference point.

UNIT VIII

Multispecies, ecosystem and economic and social reference points. Eumetric fishing.

UNIT IX

Ecopath and Ecocism models.

Practical

Data collection and estimation of growth and mortality parameters. Gear selection – Yield per recruit – Analytical and holistic models – growth parameters – Cohort analysis – Jones method. Gill net, trawl selectivity – Swept area method. MSY- Stock recruitment relationship.

Suggested Readings

Beverton RJH & Holt SJ. 2004. *On the Dynamics of Exploited Fish Population*. The Blackburn Press.
Callucci VG, Saila SB, Gustafson DJ & Rothschild BJ. 1996. *Stock Assessment, Quantitative Methods and Applications for Small Scale Fisheries*. Lewis Publ.
Gulland JA. 1977. *Fish Population Dynamics*. John Wiley & Sons.

Gulland JA. 1992. *A Review of Length Based Approaches to Assessing Fish Stocks*. FAO Tech. Paper No. 323, Rome.

Nickolskhi GV. 1980. *Theory of Fish Population Dynamics as the Biological Background for Rational Exploitation and Management of Fishery Resources*. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Ricker WE. 1971. *Methods for the Assessment of Fish Production in Freshwaters*. Blackwell, Oxford & IBH.

Sparre P & Venema SC. 1998. *Introduction to Tropical Fish Stock Assessment*. Part 1 Manual. FAO. Fisheries Tech. Paper No. 301, Rome.

FRM 505 FISHERIES REGULATIONS 2+1

Objective

To understand the importance of enforcement of fisheries regulations and policies.

Theory

UNIT I

Fisheries regulatory and developmental setup in Centre and States and their spheres of responsibility; need for fisheries management; regulatory, legal and enforcement regimes.

UNIT II

Monitoring, Control and Surveillance (MCS) systems for capture fisheries: definition; components; role in fisheries management; design considerations; operational procedures such as data collection, fisheries patrols, boarding, inspection procedures, verification of catches, verification of position, transshipment, Port State control and FAO "flagging arrangement", and fisheries prosecutions.

UNIT III

Regulatory and developmental issues concerning deep sea fishing – Guidelines for operation.

UNIT IV

Indian deep sea fishing vessels in Indian EEZ. Maritimes Zones of India Act 1981 (Regulation of fishing by Foreign vessels). Draft Marine Fisheries Policy.

UNIT V

Marine fisheries legislations in various States of India; Land Reforms Act; Coastal Aquaculture legislations, (Environmental Protection Act, Biodiversity Act, Aquaculture Authority Act) regulations concerning discharge of effluents in water bodies.

UNIT VI

International Law of the Sea: Historical perspectives; international negotiations and settlements over open seas; conflict management; shared stocks.

UNIT VII

Code of Conduct for Responsible Fishing.

UNIT VIII

Management needs associated with aquaculture development; Coastal Regulation Zone (CRZ) in the context of aquaculture. Sustainability, Integrated Coastal Zone Management and ecosystem management.

UNIT IX

Inland Fisheries Regulation and Development: Inland fisheries governance, Inland Fisheries Act, Inland property regime, leasing policies for waterbodies. Issues of property rights in Inland water bodies.

UNIT X

National Water Policy; water needs for agriculture, industry, potability and fisheries, fishing rights in open waters; and role of fisheries cooperatives, aqua/ecotourism. Concepts and implication of Interlinking of rivers on fisheries and biodiversity.

Practical

Given a real life or imaginary set of MCS situation data for a specific area, to formulate a management plan (with the help of prevailing legislation) with the following objectives : (1) Resource (2) Environment (3) Biodiversity (4) Technology (5) Society (6) Economics and (7) Conflicts; compilation of these into an overall management plan. Visit to appropriate Government/NGO and preparation of working report. Mesh size studies for trawl, gillnets and purse seine. Comparative studies on the Fisheries Acts of any two states of India and preparation of a report.

Suggested Readings

Anon. 1998. *Maritime Law of India in the International Context*. Bhadarkar Publ.

Brahtz JFP. 1972. *Coastal Zone Management*. U.N. International Economic and Social Affairs, New York.

Churchill RR & Lowe AV. 1988. *Law of the Sea*. Manchester University Press.

Henkin L, Pugh RC & Smit H. 1993. *International Law: Cases and Materials*. West Publ. Co.

Sinha RK. (Ed.). 1996. *Marine Resources and Applicable Laws* (World Environmental Series - 009). Commonwealth Publ.

Verghese CP. 1989. *Fishing Regulation in India's Territorial Waters*. World Fishing.

FRM 506 REMOTE SENSING AND GIS FOR FISHERIES MANAGEMENT 1+1

Objective

To know the satellite information and its application in fisheries resource management.

Theory

UNIT I

Basic terms and concepts; Electromagnetic radiation and its properties, atmospheric interactions, target interactions.

UNIT II

Sensor platforms – boats, balloons, air-crafts and satellites, Sensor systems – global acquisition systems and sequential acquisition systems.

UNIT III

Environmental satellites – The Landsat series, NOAA and IRS; Digital image processing and interpretation.

UNIT IV

Elements of GIS, Application of remote sensing and GIS to fisheries and aquaculture planning and development.

Practical

Study of satellite information, interpretation of satellite pictures for resource management, case studies on remote sensing and GIS applications.

Suggested Readings

Decker D. 2000. *GIS Data Sources*. Riley & Sons.

Jeff Thurston Thomas K Poiker & J Patrick Moore. 2000. *Integrated Geospatial Technology - A Guide to GPS, GIS and Data Logging*. John Wiley & Sons.

Kraak MJ & Ferjan O. 2003. *Cartography, Visualization of Spatial Data*. Prentice Hall.

Meaden GJ & Kaptesky JM. 1991. *Geographical Information Systems and Remote Sensing in Inland Fisheries and Aquaculture*. FAO Fisheries Tech. Paper No. 318, Rome.

Patel AN & Singh S. 1992. *Remote Sensing – Principles and Applications*. Scientific Publ.

Valavanis VD. 2002. *GIS System in Oceanography and Fisheries*. Taylor & Francis.

FRM 507 INTEGRATED COASTAL ZONE MANAGEMENT 2+1

Objective

To impart knowledge on the coastal resources, integrated coastal zone management strategies and disaster management.

Theory

UNIT I

Coastal resources: Coastal natural resources systems: flora and fauna, trophic relationship, nutrient production, cycle and transport; Mangrove ecosystem - species diversity and distribution of mangroves in India, Other inter-tidal system- Seagrass system, Coral reef system, Sandy beach system, Lagoon and estuary system.

UNIT II

Developmental activities and biodiversity loss: Ecological issues, Non-sustainable development, Pollution, threats to biodiversity, habitat destruction, Depletion of fisheries resources, impacts of global environment changes, Multiple uses of the Coastal Zone, Urban settlement, Industrial development, waste disposal, Shore protection works, ports and marine transportation. Land transportation infrastructure, Water control and supply projects, sea fisheries, Aquaculture, Coastal forest industries, Coastal agriculture, industries.

UNIT III

Coastal Zone Management: Integrated Coastal Zone Management (ICZM): its need and benefits, Principles, Goals and objectives of the ICZM programme; Scope, Extent of jurisdiction, Boundaries of the coastal zone, policies and planning for coastal resource management; Management mechanisms- Pollution control, Protected areas (sanctuaries, marine parks and biosphere reserves), Protection from natural hazards; Socioeconomic impacts and its assessment, Disaster management for coastal environment.

UNIT IV

Coastal tourism: Beach resorts, restaurants and parks within the coastal zone as per existing rules and regulations. Impact of pollution on coastal resources.

Practical

Analysis of soil and water characteristics of coastal areas where man made impacts have established; Assessment of damages of water quality; Collection, preservation and identification of coastal biological communities; Survey of different coastal zones; Visit to the protected areas.

Suggested Readings

Brahtz JFP. 1972. *Coastal Zone Management*. U. N. Department of International Economic and Social Affairs, New York.

Cairns J Jr. 1994. *Implementing Integrated Environmental Management*. Virginia Tech. University.

Clark JR. 1992. *Integrated Management of Coastal Zones*. FAO Fisheries Tech. Paper No. 327, Rome.

Coastal Area Management and Development. 1982 U. N. Department of International Economic and Social Affairs, New York.

David S & Jeremy P. 2001. *Inshore Fisheries Management. Methods and Technologies in Fish Biology and Fisheries*. Vol. II. Kluwer.

Khanna BK. 2000. *All You Wanted to Know About Disasters*. New India Publ. Agency.

FRM 508 AQUATIC FLORAL RESOURCES 2+1

Objective

To gain in-depth knowledge on the categorization, utilization, conservation and management of aquatic floral resources.

Theory

UNIT I

Taxonomy and phenology of freshwater microphytes and macrophytes; their importance in resource management.

UNIT II

Brackishwater flora – micro and macrophytes; their taxonomy, phenology and ecological importance and conservation practices.

UNIT III

Marine algal resources; Taxonomy, biodiversity, life history, ecological and economical importance and conservation techniques.

UNIT IV

Seagrass resources; Taxonomy, biodiversity, life history, ecological and economical importance and conservation techniques.

UNIT V

Commercially important aquatic floral resources.- Agar-algin-phytocolloids- food grade algal resource- other uses like pollution treatment, fodder, fertilizer production, etc.

Practical

Collection and identification of freshwater and brackishwater plants and seaweeds. Phenological observations of aquatic flora, seaweed resources and preparation of charts – Herbaria preparation.

Suggested Readings

Chapman VJ & Chapmen DJ. 1980. *Seaweeds and Their Uses*. Chapman & Hall.

Chapman VJ. 1976. *Mangrove Vegetation*. J. Cramer.

Chaudhuri AB. 2007. *Biodiversity of Mangroves*. Daya Publ. House.

Firth FE. 1971. *The Encyclopedia of Marine Resources*. Von Nostrand Reinholt.

Iversen ES. 1996. *Living Marine Resources*. Chapman & Hall.

Petr T. 2000. *Interactions Between Fish and Aquatic Macrophytes in Inland Waters- A Review*. FAO Fisheries Tech. Paper No. 396, Rome.

Richmond A. (Ed.). 2004. *Handbook of Microalgal Culture*. Blackwell.

Sundaralingam VS. 1990. *Marine Algae (Morphology, Reproduction and Biology).* Bishen Singh Mahendra Pal Singh, Dehra Dun.

FRM 509 FEEDING AND REPRODUCTIVE BIOLOGY OF FINFISH AND SHELLFISH 2+1

Objective

To study the role of feeding and reproductive biology in the context of fisheries resources.

To learn the application of biological inferences for the management of finfish and shellfish resources.

Theory

UNIT I

Food of different types of fin and shell fishes.

UNIT II

Feeding types- filter feeders, carnivores, omnivores and their trophic levels. – Ontogenic changes in feeding- Forage theory- Mismatch hypothesis of Cushing.

UNIT III

Morphological and anatomical adaptation for feeding; feeding behavior of wild and cultured species.

UNIT IV

Techniques in the analysis of gut contents and indices, digestion rates, food consumption rates etc.

UNIT V

Mode of reproduction: Asexual, hermaphroditism, protoandric, protogynic, sexual.

UNIT VI

Reproductive cycles - Semalparity and iteroparity-maturation and spawning periodicity and maturity stages.

UNIT VII

Factors influencing reproduction-Biotic and abiotic.

UNIT VIII

Migration- various types of spawning migration.

UNIT IX

Assessment of mean trophic level and prey - predator relationship.

Practical

Morphological and anatomical features of fin fishes and shellfishes with different feeding habits. Analysis of gut contents. Use of indices in feeding, digestion and food consumption rates of fishes. Identification of spawning season, maturity stages, estimation of gonadosomatic index and intraovarian periodicity.

Suggested Readings

Adiyodi KG & Adiyodi RG. 2000. *Reproductive Biology of Invertebrates*: Vol. X. Part B. *Progress in Developmental Endocrinology*. John Wiley & Sons.

Agarwal NK. 1996. *Fish Reproduction*. APH Publ. Corp.

Barrington EJW. 1981. *Invertebrate Structure and Function*. 2nd Ed. The English Language Book Society & Nelson.

Bone Q, Marshall NB & Blaxter JHS. 1995. *Biology of Fishes*. 2nd Ed. Blackie.

Carl EB. 1979. *Biology of Fishes*. 2nd Ed. John Wiley & Sons.

Hoar WS & Randall DJ. (Ed.) 1969. *Fish Physiology*. Vol. III. Academic Press.

Jobling M. 1995. *Environmental Biology of Fishes*. Chapman & Hall.

Khanna SS. 1993. *An Introduction to Fishes*. Central Book Depot.

Maria JR, Augustine A &. Kapoor BG. 2006. *Fish Reproduction*. Science Publ.

Nikolsky GV. 1983. *Fisheries Biology*. Academic Press.

Saxena AB. 1996. *Life of Crustaceans*. Recent Advance in Entomology Series-10. Anmol Publ.

Venkataramanujam K & Ramanathan N. 1994. *Manual of Finfish Biology*. Oxford & IBH.

FRM 510 DEVELOPMENTAL BIOLOGY OF FINFISH AND SHELLFISH 2+1

Objective

To impart knowledge on the collection and identification of eggs and larvae of commercially important finfish and shellfish.

Theory

UNIT I

Identification of eggs and larvae of commercially important finfishes, crustaceans, molluscs and echinoderms.

UNIT II

Quantitative samplings of fish eggs and larvae; spatial and temporal distribution, dispersion of eggs and larvae in food webs, effect of environmental parameters on eggs and larvae.

UNIT III

Natural food of shell fish and finfish larvae from egg to adult (commercially important shellfishes and finfishes).

Practical

Identification of commercially important species of crustacean, molluscan eggs and larvae, spat. Morphometry of eggs and larvae of finfishes, identification keys. Quantitative sampling- shellfish and finfish larvae; food and feeding habits of larval stages of shell and finfishes.

Suggested Readings

Barrington EJW. 1981. *Invertebrate Structure and Function*. 2nd Ed. The English Language Book Society & Nelson.

Diwan AP & Dhakad NK. 2004. *Embryology of Fishes*. Recent Advances in Embryology Series-1. Anmol Publ.

Ede DA. 1978. *An Introduction to Developmental Biology*. Blackie.

Hoar WS & Randall J. (Ed.). 1988. *Fish Physiology*. Vol XI. *The Physiology of Developing Fish*. Part B. *Viviparity and Post hatching Juveniles*. Academic Press.

Jobling M. 1995. *Environmental Biology of Fishes*. Chapman & Hall.

Khan SA, Raffi SM & Lyla PS. 2003. *Larvae of Decapod Crustaceans*. Centre of Advanced Study in Marine Biology, Parangipettai, Tamil Nadu.

Silas EG. 1983. *Development of Penaeid Prawns*. CMFRI Bull. No. 28.

FRM 511 FISHING AND ALLIED TECHNOLOGIES 2+1

Objective

To gain knowledge on the design, fabrication and operation of fishing gear and operation of fish finding equipments.

Theory

UNIT I

Design, fabrication and operation of various fishing gears: trawls (pelagic and bottom), purse seine, gillnets, trammel nets, dol nets, FADs (Floating and bottom – artificial reefs), traps and lines.

UNIT II

Harvesting methods in inland water bodies and their improvisation: Gillnets, cast nets, lines, dragnets, bag nets etc.

UNIT III

Destructive and prohibited fishing practices.

UNIT IV

By-catch reduction devices: Definition of bycatch, types of bycatch reduction devices and the principles of operation.

UNIT V

Turtle Excluder Devices: Definition, types of TEDs – soft and hard types, materials used for their construction and maintenance.

UNIT VI

Acoustics: Acoustic surveys for fishing, acoustic aids in fishing and acoustic measurements.

UNIT VII

Safety at sea: Safety devices – Accidents associated with marine environment, boat design and navigation, mitigation measures.

UNIT VIII

GMDSS and other safety devices. Advanced communication Systems – VHF, SSB, INMARSAT System.

UNIT IX

Vessel Monitoring Systems (VMS): Importance, uses, role in fisheries management.

UNIT X

Satellite navigation system: GPS – Components of GPS, working, functions, hand held GPS, important applications of GPS in fisheries and aquaculture.

UNIT XI

Fishing harbours: Classification, facilities, layout of a typical fishing harbour, stages in the planning of fishing harbours.

UNIT XII

Code of Conduct for Responsible Fishing (CCRF): Articles of CCRF, Elaboration of Article 8: Fishing Operations.

Practical

Drawing and reading gear designs - Field visits to fishing harbour and preparation of drawing of its lay out - Training onboard fishing vessels in fishing techniques, familiarization with navigation and communication equipments -Study of layout and operation of a fish landing centre; Study of fish aggregating devices -Familiarization with various safety devices.

Suggested Readings

Duncan A. 1980. *A Fisherman's Guide to Ecosounding and Sonar Equipment. Acoustic Fish Detection Instruments*. University of Rhode Island. Marine Bull. 41.

FAO. 1972. *Catalogue of Fishing Gear Designs*. Fishing News Books.

FAO. 1980. *Definition and Classification of Fishery Vessel Types*. FAO Fisheries Tech. Paper No. 267, Rome.

John S. 1996. *Commercial Fishing Methods - An Introduction to Vessels and Gear*. Fishing News Books.

Nirgess K. 1966. *Fishing Boats and Equipments*. Fishing News Books.

Sreekrishna Y & Shenoy L. 2001. *Fishing Gears and Craft Technology*. ICAR.

Traung JO. 1955. *Fishing Boats of the World*. 1. Fishing News Books.

Traung JO. 1960. *Fishing Boats of the World*. 2. Fishing News Books.

Traung JO. 1967. *Fishing Boats of the World*. 3. Fishing News Books.

Tucker DG. 1967. *Sonar in Fisheries - a Forward Look*. Fishing News Books.

FRM 512 MODERN TECHNIQUES IN ICHTHYOTAXONOMY 2+1

Objective

To enable the students in differentiating genera/ species up to stock level using classical, molecular and computer based techniques.

Theory

UNIT I

Identification of stocks based on classical and modern taxonomical methods.

UNIT II

Classical taxonomy – morphometrics – meristics.

UNIT III

Modern taxonomical tools – Electrophoretic studies (muscle myogen, eyelens protein, enzyme pattern and serology), Karyotyping.

UNIT IV

Molecular markers – PCR, RAPD, RFLP, Microsatellites, mini satellites and Mitochondrial DNA, and their application in fish phylogenetic studies.

Practical

PAGE – Muscle myogen, eyelens proteins, enzymes of different species of finfishes; fish chromosomes preparation and identification DNA Isolation and quantification, PCR techniques Statistical software used in fish molecular studies.

Suggested Readings

Cooksey K. 1997. *Molecular Approaches to the Study of the Oceans*. Chapman & Hall.

FAO. 2000. *DNA Based Molecular Diagnostic Techniques*.

Kocher TD & Carol AS. (Ed.). 1997. *Molecular Systematics of Fishes*. Academic Press.

Le Gal Y & Halvorson HO. 1998. *New Development in Marine Biotechnology*. Plenum Press.

Mayer E. 1977. *Principle of Systematic Zoology*. Tata McGraw Hill.

Ponniah AG & George J. 1998. *Fish Chromosome Atlas*. National Bureau of Fish Genetic Resources (NBFGR), Lucknow.

Whitmore DH. 1990. *Electrophoretic and Isoelectric Focusing Techniques in Fisheries Management*. CRC Press.

FRM 601 ASSESSMENT OF AQUATIC BIODIVERSITY 2+1

Objective

To impart in-depth knowledge on aquatic biodiversity, its assessment and conservation methods.

To understand the ecological impact of various aquatic resources.

Theory

UNIT I

Definitions and measurement: Methods, scales and indices of biodiversity assessment.

UNIT II

Biodiversity (microalgae to aquatic vertebrates) of any three of the following or similar ecosystem: Chilka Lake, Narmada river system, Gangetic system, Jaykwadi reservoir, Himalayan lake, Himalayan river, Hooghly Maltah estuarine system, Coramandondal coast, Gulf of Mannar, Gulf of Kutch, Malabar upwelling, Bhitarkanika.

UNIT III

Threats to biodiversity: Overexploitation, land reclamation, pollution, habitation, conversion of agricultural land and aquacultural farms (case studies pertaining to any sensitive marine/estuarine/freshwater hot spots).

UNIT IV

Conservation and Restoration: Declaration of mangrove sanctuaries and mangrove afforestation, marine protected areas, Ganga Action Plan, introduction of exotic species and their implications; potential consequences and conflicts of linking rivers.

UNIT V

Impacts of anthropogenic intervention on aquatic biodiversity: Damming of rivers, construction of sea walls, micro hydel power stations, oil rigs.

UNIT VI

Legal regimes of biodiversity: International and national conventions and Acts for biodiversity.

UNIT VII

Institutionalization of biodiversity conservation (Such as creation of Biodiversity Boards/Authority.

Practical

Preparation of records and inventories of biodiversity of any three critically important ecosystem based on secondary data and field visits- Compilation

of all important International and National laws and conventions related to biodiversity

Suggested Readings

Brian G. 1992. Global Biodiversity - Status of the Earth's Living Resources. Chapman & Hall.

Denton TE. 1973. *Fish Chromosome Methodology*. Charles Thomas Publ.

Elliott AN. (Ed.). 1993. *Global Marine Biological Diversity*. Inland Press.

Gunderson DR. 1993. *Surveys of Fisheries Resources*. John Wiley & Sons.

Khanna DR, Chopra AK & Prasad G. 2005. *Aquatic Biodiversity in India*. Daya Publ. House.

Kumar U & Asija M. J. 2000. *Biodiversity Principles and Conservation*. Agrobios.

Lakra WS, Abidi R, Singh AK, Sood N, Rathore G & Swaminathan TR. 2000. *Fish Introductions and Quarantine: Indian Perspective*. National Bureau of Fish Genetic Resources (NBFGR), Lucknow.

Lambshead PJD, Paterson GLJ & Gage JD. 1997. *Biodiversity Professional*. Version 2. National History Museum and the Scottish Association of Marine Science.

Magurran AE. 1988. *Ecological Diversity and its Measurement*. Taylor & Francis.

Mahanta PC & Tyagi LK. 2003. *Participatory Approach for Fish Biodiversity Conservation in North East India*. National Bureau of Fish Genetic Resources (NBFGR), Lucknow.

Ponniah AG & Gopalakrishnan A. (Eds.). 2000. *Endemic Fish Diversity of Western Ghats*. National Bureau of Fish Genetic Resources (NBFGR), Lucknow.

Zoological Survey of India. 2007. *National Symposium on Conservation and Valuation of Marine Biodiversity*.

FRM 602 APPLICATIONS OF FISHERIES MODELS IN STOCK ASSESSMENT 2+1

Objective

To study the application of various dynamics and holistic models used in fish stock assessment.

Theory

UNIT I

History and development of analytical models; Analytical models; its history and development.

UNIT II

Application of Beverton and Holt's, Thompson and Bell models in trophics.

UNIT III

Logistic models of Schaefer and Fox.

UNIT IV

Prey predator models. 4. Stock recruitment models of Ricker, Beverton and Holt.

UNIT V

Bioeconomic modeling.

UNIT VI

Ecopath and ecosim models.

Practical

Application of logistic and analytical models in marine, riverine and estuarine systems. Ecopath modeling based on secondary data.

Suggested Readings

Beverton RJH & Holt SJ. 2004. *On the Dynamics of Exploited Fish Population*. The Blackburn Press.

Edwards EF & Megrey BA. 1989. *Mathematical Analysis of Fish Stock Dynamics*. American Fisheries Society, Maryland.

Gulland JA. (Ed.). 1977. *Fish Population Dynamics*. John Wiley & Sons.

Nickolskhi GV. 1980. *Theory of Fish Population Dynamics as the Biological Background for Rational Exploitation and Management of Fishery Resources*. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Ray H & Carl JW. 1992. *Quantitative Fisheries Stock Assessment Choice, Dynamics and Uncertainty*. Kulwer.

Ricker WE. 1971. *Methods for the Assessment of Fish Production in Freshwaters*. Blackwell, Oxford & IBH.

FRM 603 CONSERVATION AND MANAGEMENT OF EXPLOITED FISHERIES RESOUCES 2+1

Objective

To apprise the students on the various conservation and management strategies of exploited fisheries resources.

Theory

UNIT I

Marine parks, marine protected areas, biosphere reserves, closed seasons.

UNIT II

Cryopreservation of exploited and endangered species.

UNIT III

Fishing regulation policies - A critique on the draft Indian Fisheries policy. A critical appraisal of Inland Fisheries Legislation of any two states of India.

UNIT IV

Protection of habitat of corals, mangrove, seaweeds, sea grass beds. Implementation of square cod end mesh – to reduce by-catch.

UNIT V

Legal proceedings / implementation for protection of exploited and endangered fishery resources.

UNIT VI

Total allowable catch, regulation of mesh size for conservation of exploited fishery resources.

UNIT VII

Management of major reservoirs of India; optimal stocking and production of cultivable resources.

UNIT VIII

A comparative study of the marine regulation acts of any two neighboring countries with reference to Environmental Protection Act (EPA).

UNIT IX

Compile the rules relating to marine fisheries exploitation included in the final UNCLOS III treaty.

Practical

Based on the existing policy, suggest and draft ideal inland and marine fishery legislation for any one Indian State. With reference to the laws of the sea (UNCLOS III) treaty, recommend ways and means to solve dispute of shared stocks. Develop a framework for conflict resolution of traditional and mechanized fisheries.

Suggested Readings

Mahanta PC & Tyagi LK. 2003. *Participatory Approach for Fish Biodiversity Conservation in North East Inidia*. National Bureau of Fish Genetic Resources (NBFGR), Lucknow.

Menon AGK. 2004. *Threatened Fishes of India and their Conservation*. Fishries Survey of India.

Michael RR. 1997. *Fisheries Conservation and Management*. Prentice Hall.

Pascoe S. 2005. *Bycatch Management and the Economics of Discarding*. Daya Publ. House.

Thorpe JE, Talbot C & Miles MS. (Ed.) 1995. *Conservation of Fish and Shell Fish Resource; Managing Diverisity*. Academic Press.

FRM 604 CORAL REEF MANAGEMENT 2+1

Objective

To learn identification and classification of different corals and their habitats.

To impart knowledge on the conservation and management of coral resources.

Theory

UNIT I

Type of coral reefs and their distribution.

UNIT II

Origin of coral reefs – coral reefs of the world.

UNIT III

Ecology of coral reefs; factors influencing growth; productivity of coral reefs; plants and animals associates of living reef corals and fringing reefs.

UNIT IV

Nutrition, production, larval dispersal and settlement of corals.

UNIT V

Soft coral type and their ecology.

UNIT VI

Bioactive substances of soft and hard corals, sedimentation in coral reef environment.

UNIT VII

Economic importance of coral reefs.

UNIT VIII

Management and conservation of coral reefs and soft corals.

Practical

Collection and identification of soft and hard corals; Survey of corals and mapping; identification of associated organisms; preparation of checklist and associated organisms of Indian coast. Predatory animals of corals, Extraction of bioactive substances from soft and hard corals. Observations of destructive methods of corals and coral reef fishes.

Suggested Readings

Bakus GJ. 1994. *Coral Reef Ecosystem*. Oxford & IBH.

Bayer FM, Manfred G & Jakob V. 1983. *Illustrated Trilingual Glossary of Morphological and Anatomical Terms Applied to Octocorallia*. Leiden.

Biswas KP. 2008. *Corals of Tropical Oceans*. Daya Publ. House.

James PSBR. 1986. *Recent Advances in Marine Biology*. Today & Tomorrow.

Peter S. (Ed.).2006. *Coral Reef Fishes: Dynamics and Diversity in a Complex Ecosystem*. Academic Press.

Polunin NVC & Roberts CM. 1996. *Reef Fisheries*. Chapman & Hall.

Rogers CS. 1994. *Coral Reef Monitoring Manual for the Caribbean and Western Atlantic*. National Park Service, Virgin Islands.

Rosenberg E & Loya Y. (Eds.). 2004. *Coral Health and Disease*. Springer.

Talbot F & Wilkinson C. 2001. *Coral Reefs, Management and Seagrasses. A Source Book for Managers*. Australian Institute of Marine Suck Australia.

FRM 605 DATA COLLECTION AND ESTIMATION OF EXPLOITED FISHERIES RESOURCES **0+2**

Objective

To learn in detail the sampling designs and estimation of catch and effort data.

Practical

Collection of fishery data at landing centres from different gears separately. Details of craft and gear of landing centres. Recording of data in the entry forms. Definition of length for various groups of fish/crustaceans/molluscs. Collection of length frequency data of fishes at landing centres. Estimation of age and growth based frequency data.

Growth, mortality, population and stock parameters employing FiSAT, Length structured VPA, Thompson and Bell yield stock prediction for single and multifleet version. Beverton and Holt yield-per-recruit model; biomass-per-recruit. Relative yield-per-recruit model and yield isopleth diagram.

Suggested Readings

Beverton RJH & Holt SJ. 2004. *On the Dynamics of Exploited Fish Population*. The Blackburn Press.

Callucci VG, Saila SB, Gustafson DJ & Rothschild BJ. 1996. *Stock Assessment. Quantitative Methods and Applications for Small Scale Fisheries*. Lewis Publ.

Gulland JA. 1977. *Fish Population Dynamics*. John Wiley & Sons.

Gulland JA. 1992. *A Review of Length Based Approaches to Assessing Fish Stocks*. FAO Tech. Paper. 323.

Nickolskhi GV. 1980. *Theory of Fish Population Dynamics as the Biological Background for Rational Exploitation and Management of Fishery Resources*. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Ricker WE. 1971. *Methods for the Assessment of Fish Production in Freshwaters*. Blackwell, Oxford & IBH.

Sparre P & Venema SC. 1998. *Introduction to Tropical Fish Stock Assessment*. Part 1 *Manual.* FAO Fisheries Tech. Paper No. 301, Rome.

FRM 606 FISHERIES ENVIRONMENTAL ASSESSMENT 2+1

Objective

To know the probable impacts of environmental factors on fishery resources and gain knowledge on the standard methods applicable in fisheries environmental assessment.

Theory

UNIT I

Critically important climatic factors (temperature, rainfall and wind pattern / monsoon influencing aquatic (inland and marine) productivity and production.

UNIT II

Remotely sensed SST, Chlorophyll and Wind pattern features of Indian seas used in locating Potential Fish Zones (PFZ).

UNIT III

Influence of rainfall intensity, its seasonal and annual variations on fish migration, breeding, recruitment and production. (Correlation of rainfall data from IMD and catch data on fishes from same region for bringing out the impact of rain on production).

UNIT IV

Optimum water quality parameters prescribed for various water bodies (marine and inland) for different user groups including fisheries.

UNIT V

Environmental Impact Assessment of various anthropogenic causes; domestic and industrial water discharge into waters and their impact on fisheries. Tannery discharge and its impact on fisheries.

UNIT VI

Status, structure and trophic profile (at primary, secondary and tertiary levels) of four typical water bodies: i) Marine, ii) Estuarine iii) Reservoir iv) River in relation to nutrient profile, plankton profile and oxygen profile in spatial and temporal terms.

Practical

Preparation of isoclines of temperature, rainfall and chlorophyll pattern of data gathered from satellites and demarcation of the PFZ's. Development of a graphic picture of the vertical and horizontal profiles of various nutrients, temperature, oxygen, plankton and fish density of any well defined aquatic system.

Suggested Readings

Canter LW. 1994. *Environmental Impact Assessment*. Mc-Graw Hill.

Grilbert M & Gould R. 1998. *Achieving Environmental Standards*. Pitman Publ.

Peter W. (Ed.). 1988. *Environmental Impact Assessment: Theory and Practice*. World Research Institute, Routledge, London.

FRM 607 ISSUES IN CAPTURE FISHERIES 1+1

Objective

To get comprehensive knowledge on the major issues / challenges faced in capture fisheries.

Theory

UNIT I

Over- capacity (excessive fishing efforts); Over exploitation. By-catch and Discards.

UNIT II

IUU (Illegal, Unregulated and Unreported) Fishing. Problems encountered in Monitoring, Control and Surveillance (MCS).

UNIT III

Ghost fishing, destructive fishing practices.

Practical

Assessment of fishing capacity; stages of overexploitation, case studies and field visits.

Suggested Readings

Bal DV & Rao KV. 1990. *Marine Fishes of India*. 1st Revised Ed. Tata McGraw Hill.

Chandra P. 2007. *Fishery Conservation Management and Development*. SBS Publ.

Dholakia AD. 2004. *Fisheries and Aquatic Resources of India*. Daya Publ. House.

Kurian CV & Sebastian VO. 1986. *Prawns and Prawn Fisheries of India*. Hindustan Publ. Corp.

Moyle PB & Joseph JC Jr. 2000. *Fishes – An Introduction to Ichthyology*. 4th Ed. Prentice Hall.

Samuel CT. 1968. *Marine Fisheries in India*. Oceanographic Laboratory, University of Kerala.

Shanbhogue SL. 2000. *Marine Fisheries of India*. ICAR.

Yadav BN. 1997. *Fish and Fisheries*. 2nd Ed. Daya Publ. House.

FISHERIES RESOURCE MANAGEMENT

List of Journals

- Aquaculture Nutrition
- BioTechniques.
- Bulletin of Mathematical Biology
- Conservation
- Conservation Biology
- Conservation Letters
- Coral Reefs
- Ecological Management and Restoration
- Ecology of Freshwater Fish
- Ecosystem Health
- Environmental Biology of Fishes
- Environmental Management
- Estuaries and Coasts
- Fish and Fisheries
- Fisheries Management and Ecology
- Fisheries Research
- Fisheries Science
- Freshwater Biology
- Gene
- Hydrobiologia
- Indian Journal of Ecology
- Indian Journal of Marine Sciences
- Journal of Biosciences
- Journal of Evolutionary Biology
- Journal of Fish Biology
- Journal of Ichthyology and Aquatic Biology
- Journal of Indian Ocean studies
- Journal of Mathematical Biology
- Journal of the Marine Biological Association of India.
- Lakes and Reservoirs: Research andManagement
- Limnology and Oceanography
- Marine Ecology
- Molecular Ecological Notes
- Molecular Marine Biology and Biotechnology
- Natural Resource Modeling
- Plant Biology
- Reviews in Fish Biology and Fisheries
- Plant Breeding
- www.barcodinglife.org
- www.reefbase.org

Suggested Broad Areas for Master's and Doctoral Research

- Mapping of fisheries resources in different freshwater bodies
- Estimation of biodiversity and abundance of various freshwater fishes
- Fish stock assessment in different freshwater bodies using FiSAT
- Analysis of productivity in different freshwater bodies
- Fish stock assessment in various marine ecosystems using FiSAT

- Assessment of bycatch from trawl, bottom set gill net
- Sea ranching and effect of ranching in the marine ecosystem
- Estimation of biodiversity and abundance of endangered species of sponges, corals, gastropods, bivalves, sea cucumbers, fishes, sea snakes, turtles, birds and marine mammals
- Effect of conservation measures on the restoration of depleting fish stocks
- Estimation of biomass in various marine ecosystems
- Estimation of MSY in various marine ecosystems
- Fish stock assessment in various marine ecosystems using FiSAT
- Development of proper guidelines for commercial deep sea fishing
- Impact of Coastal Regulation Zone on the stock replenishment
- Monitoring, Control and Surveillance (MCS) systems for inland and marine capture fisheries
- Collection of satellite information on various aquatic resources and ground truthing
- Interpretation of satellite pictures for resource management
- Use of remote sensing for Potential Fish Zone
- Estimation of floral/ faunal diversity of mangroves and coral reefs.
- Estimation of fleets and catches at landing sites for effective fisheries management
- Studies on biodiversity estimates for coastal resources
- Estimation of biodiversity of aquatic floral resources.
- Catalogue preparation of commercially important aquatic floral resources
- Neurohormones controlling the reproduction of commercial crustacean species
- Identification of commercially important species of finfish and shellfish eggs and larvae, spat.
- Forcasting the fishery potential through the study of abundance of finfish and shellfish eggs and larval in the marine ecosystem.
- Food and feeding habits of larval stages of shell and finfishes.
- Stock assessment of individual freshwater and marine fish using FiSAT
- Assessment of By catch from trawl, bottom set gill net
- Catalogue preparation of commercially important fishes (FW , BW Marine)
- Studies on biodiversity estimates for coastal resources, fresh water bodies.
- Food and feeding habit of commercially important group of fishes and shellfishes.
- Microsatellite base identification of commercial fishes
- Karyotaxonomy of commercially important fishes and shellfishes
- Studies on biodiversity estimates for fisheries resources in various aquatic ecosystem.
- Stock assessment of individual freshwater and marine fish using FiSAT
- Assessment of By catch from trawl, bottom set gill net
- Ecopath modelling for minor reservoir, small waterbody
- Conservation biology and marine pollution
- Coral reef reproduction, assessment, monitoring and management
- Coral reef resilience, restoration and interaction with associated fauna and flora
- Remote sensing and geospatial analysis of coral reef ecosystem.
- Biogeochemical cycles in coral reef environments.
- Estimation of biomass in various marine ecosystems
- Estimation of MSY in various marine ecosystems
- Fish stock assessment in various marine ecosystems using FiSAT
- Fishery Independent survey for coral resource estimation
- Estimation of Taxonomic distinctness for major finfish and shellfish resources
- Mapping of various marine and inland fisheries resources
- Estimation of biodiversity of various marine and inland fisheries resources
- Analysis of Catch composition by gear and craft in marine and inland water bodies
- Fish stock assessment in various marine and inland ecosystems using FiSAT
- Assessment of bycatch from trawl, bottom set gill net

COMMON SUPPORTING COURSES

CODE	COURSE TITLE	CREDITS
STM 501	STATISTICAL METHODS	2+1
STM 502	RESEARCH METHODOLOGY	1+1
STM 601	ADVANCED STATISTICAL METHODS	2+1
STM 602	SOFTWARE FOR FISHERIES DATA ANALYSIS AND MANAGEMENT	0+2

Course Contents

STM 501 STATISTICAL METHODS 2+1

Objective

To acquaint the students with various statistical methods and techniques

To provide hands on training in data analysis through statistical software.

Theory

UNIT I

Sampling distribution for mean and proportion, standard error, confidence interval for mean and proportion; Test of hypothesis: type I and type II errors, level of significance, tests based on Z, t, X^2 and F distribution.

UNIT II

Properties of estimators: unbiasedness, efficiency, sufficiency and consistency.

UNIT III

Simple correlation and regression, Spearman's rank correlation.

UNIT IV

Basic concepts of sampling techniques: simple random, stratified, systematic, cluster and two stage sampling and their applications in fisheries.

UNIT V

Analysis of variance: one way and two way classification; Non-parametric test, advantages and disadvantages over parametric tests; Run test and Sign test.

Practical

Tests of hypothesis based on Z, t, X^2 and F; Simple correlation and regression, Rank correlation; Analysis of variance: one way and two way; Simple random, stratified, systematic, cluster and two stage sampling; Sign test, Run test; Hands on experience in using the statistical software packages MS Excel, Systat and SPSS in data analysis and interpretation.

Suggested Readings

Biradar RS. 2002. *Course Manual on Fisheries Statistics*. 2nd Ed. CIFE, Mumbai.

Keller G. 2001. *Applied Statistics with Microsoft Excel*. Duxbury.

Kothari CR. 1998. *Research Methodology*. 2nd Ed. Wishwa Prahashan.

Levin RL & Rubin DS. 1983. *Statistics for Management*. Prentice-Hall of India.

Panse VG & Sukhatme PV. 1978. *Statistical Methods for Agricultural Workers*. ICAR.
Siegel S & Castellan NJ. Jr. 1988. *Non Parametric Statistical Methods*. John Wiley & Sons.

STM 502 RESEARCH METHODOLOGY 1+1

Objective

To acquaint the students with basic concepts of research methods and processes.

To develop research skills for planning, designing, conduct and reporting of research.

Theory

UNIT I

Elements of scientific method; Research - purpose, relevance and scope; Generalization and transferability of research data; Objectivity and value-neutrality in scientific research; ethical dilemmas in research.

UNIT II

Types of research - basic, applied, strategic, anticipatory and adaptive research; historical, descriptive and experimental research; Qualitative and quantitative research methods; Experimental and ex-post facto approaches, survey research, action research, participatory research, case study method, content analysis.

UNIT III

Steps involved in research process; Identifying and defining researchable problems; Formulation of research objectives; Hypothesis - meaning, types, development of hypothesis and its testing; Constructs; Nature and type of variables; Types and levels of measurement; Types of reliability and validity and their measurement.

UNIT IV

Methods of observation and data collection for biological and social sciences research; Selection of appropriate tools for analysis of biological and social sciences research data;

UNIT V

Formats of research report - writing thesis/dissertation, research articles - abstracts, literature review, materials and methods, results and discussion, summary and references.

Practical

Exercises on identification of a problem and formulation of research questions and hypothesis; use of data base systems and online resources; Preparing a mock synopsis / outline of research work; Exercises on case study research / developing case studies; Exercises on reliability and validity; Review and evaluation of research articles, books, theses and their presentation; Conduct of a mock research including designing a research programme, conducting experiment / field research, data collection, analysis, report writing and presentation; Writing a research article; Writing a winning research proposal.

Suggested Readings

Kerlinger FN. 1983. *Foundations of Behavioural Research*. Surjeet Publ.
Kothari CR. 1998. *Research Methodology*. 2nd Ed. Vishwa Prahashan.

Kumar R. 1996. *Research Methodology: a Step-by-Step Guide for Beginers*. Sage Publ.

Rossiter DG. 2003. *Preparation for M.Sc. Thesis Research*. ITC, Netherlands.

Walliman N. 2001. *Your Research Project: a Step-by-Step Guide for the First Time Researcher*. Sage Publ.

STM 601 ADVANCED STATISTICAL METHODS 2+1

Objective

To expose the students to advanced statistical methods and hands on training in the analysis of data using statistical software.

Theory

UNIT I

Introduction to matrix algebra, Bayes' theorem and its application, mathematical expectation.

UNIT II

Probability distribution: Negative, Binomial, Hyper-geometric and Exponential and their application in fisheries; Multivariate normal distribution; Multiple and Partial correlation and regression.

UNIT III

Multivariate ANOVA; Likelihood Methods; Concept of Principal component analysis; Canonical correlation and Path coefficients; Discriminant analysis; Factor analysis and Cluster analysis; Transformations; Analysis of Covariance.

UNIT IV

Linear programming: Objective function, graphical solution of linear programming problem, Simplex method.

UNIT V

Non parametric test: Wilcoxon test, Mann-Whitney U-test, Kruskal and Wallis test and Friedman's test; Use of computer software for data analysis; Survival analysis.

Practical

Exercises on Bayes' theorem; Negative, Binomial distribution; Hyper-geometric distributions; Exponential distribution; Multiple and partial correlation and regression analysis; Principal component analysis; Canonical correlation and path coefficients; Discriminant analysis; Factor analysis and Cluster analysis; Transformations; Covariance analysis; Wilcoxon test, Mann-Whitney test, Kruskal and Wallis test and Friedman's test and linear programming; Use of computer software.

Suggested Readings

Anderson TW. 1984. *An Introduction to Multivariate Statistical Analysis*. Wiley Series in Probability and Statistics, Singapore.

Biradar RS. 2002. *Course Manual on Fisheries Statistics*. 2nd Ed. CIFE, Mumbai.

Ghosh S. 1999. *Multivariate Analysis, Design of Experiments and Survey Sampling*. Marcel Dekker.

Keller G. 2001. *Applied Statistics with Microsoft Excel*. Duxbury.

William RD & Matthew G. 1984. *Multivariate Analysis, Methods and Applications*. John Wiley & Sons.

STM 602 SOFTWARE FOR FISHERIES DATA ANALYSIS AND MANAGEMENT 0+2

Objective

To provide hands on training on the use of various statistical packages in data analysis.

Practical

Introduction to computer software: SPSS, SAS, SYSTAT and STATISTICA for analysis and presentation of fisheries data; Basic concepts of database management systems; Introduction to MS-ACCESS, ORACLE (RDBMS); Exercises on analysis of data using MS-EXCEL, SPSS, SAS, FISAT, SYSTAT and STATISTICA; Creation of Database using MS-ACCESS, ORACLE.

Suggested Readings

Kettell 2003. *MS Office: The Complete Reference*.

Khattree R & Naik D. 2000. *Multivariate Data Reduction and Discrimination with SAS Software*. SAS Institute North Carolina.

SPSS Base 11.0: User's Guide. SPSS Inc., Bangalore.

STATISTICA : The Small Book User Guide. StatSoft, USA.

Steven F. 2001. *Oracle PL / SQL Best Practices: Optimising Oracle Code*. SPD/O'Reilly Reprints.

Systat 8.0: Getting Started Manual.

COMPULSORY NON-CREDIT COURSES

(Compulsory for Master's programme in all disciplines; Optional for Ph.D. scholars)

CODE	COURSE TITLE	CREDITS
PGS 501	LIBRARY AND INFORMATION SERVICES	0+1
PGS 502	TECHNICAL WRITING AND COMMUNICATIONS SKILLS	0+1
PGS 503 (e-Course)	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1+0
PGS 504	BASIC CONCEPTS IN LABORATORY TECHNIQUES	0+1
PGS 505 (e-Course)	AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1+0
PGS 506 (e-Course)	DISASTER MANAGEMENT	1+0

Course Contents

PGS 501 LIBRARY AND INFORMATION SERVICES 0+1

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS 0+1

Objective

To equip the students/scholars with skills to write dissertations, research papers, etc.

To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical

Technical Writing - Various forms of scientific writings- theses, technical papers, reviews, manuals, etc; Various parts of thesis and research

communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article.

Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

Suggested Readings

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.

Collins' Cobuild English Dictionary. 1995. Harper Collins.

Gordon HM & Walter JA. 1970. *Technical Writing*. 3rd Ed. Holt, Rinehart & Winston.

Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.

James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.

Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.

Mohan K. 2005. *Speaking English Effectively*. MacMillan India.

Richard WS. 1969. *Technical Writing*. Barnes & Noble.

Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language*. Abhishek.

Sethi J & Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.

Wren PC & Martin H. 2006. *High School English Grammar and Composition*. S. Chand & Co.

PGS 503 (e-Course) **INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE** **1+0**

Objective

The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and bio-diversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material

transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

Erbisch FH & Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.

Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.

Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.

Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. *Technology Generation and IPR Issues*. Academic Foundation.

Rothschild M & Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.

Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES 0+1

Objective

To acquaint the students on the basics of commonly used techniques in laboratory.

Practical

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

Suggested Readings

Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.

Gabb MH & Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

PGS 505 (e-Course) **AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES** **1+0**

Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II

Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

Bhalla GS & Singh G. 2001. *Indian Agriculture - Four Decades of Development*. Sage Publ.

Punia MS. *Manual on International Research and Research Ethics*. CCS, Haryana Agricultural University, Hisar.

Rao BSV. 2007. *Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives*. Mittal Publ.

Singh K.. 1998. *Rural Development - Principles, Policies and Management.* Sage Publ.

PGS 506 (e-Course) **DISASTER MANAGEMENT** **1+0**

Objectives

To introduce learners to the key concepts and practices of natural disaster management; to equip them to conduct thorough assessment of hazards, and risks vulnerability and capacity building.

Theory

UNIT I

Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches,

Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion

UNIT II

Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.

UNIT III

Disaster Management- Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations.

Suggested Readings

Gupta HK. 2003. *Disaster Management*. Indian National Science Academy. Orient Blackswan.

Hodgkinson PE & Stewart M. 1991. *Coping with Catastrophe: A Handbook of Disaster Management*. Routledge.

Sharma VK. 2001. *Disaster Management*. National Centre for Disaster Management, India.