



PUBLICATION NO. ICAR/ED(A)/PUB-22/4-2002

**CURRICULA AND SYLLABI FOR
MASTER'S DEGREE PROGRAMS
IN
FISHERIES SCIENCES**

**FISHERIES RESOURCE MANAGEMENT
AQUACULTURE (INLAND & MARICULTURE)
MICROBIOLOGY & BIOTECHNOLOGY
POST HARVEST TECHNOLOGY**

**ACCREDITATION BOARD SECRETARIAT
EDUCATION DIVISION
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
KRISHI ANUSANDHAN BHAVAN-II, PUSA,
NEW DELHI-110 012**

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Aquaculture (Inland & Mariculture)
Microbiology and Biotechnology
Post Harvest Technology**



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PREFACE

Fisheries sector plays an important role in the socio-economic development of the country in view of its potential contribution to national income, food security, social objectives and sustainable large export earning. The annual fish catch in India is close to about 3 million tonnes, of which pelagic species contribute nearly 52 per cent, the rest being demersal species. There are nearly 6 millions fishermen in the country, of which 2.40 millions are full-time, 1.45 million part time and rest occasional. There are about 2.20 lakhs traditional craft, 40 thousands traditional motorized craft and 52 thousand mechanized boats. They use a wide range of fishing gear, including seines, stake nets, lines, bag nets, encircling nets and lift nets.

India's future fisheries development plans aim at increasing fish production, improving the welfare of fishermen, promoting export earning and providing food security. In this context, the trained manpower has been identified as a critical input to fisheries development. Fisheries education under the SAUs system started in 1969 with the establishment of first Fisheries College at Manglore. Fisheries education per se, is thus less than four decades old as compared to agriculture and animal husbandry, which are now almost a century old. The fisheries colleges, numbering 13, offer four-year degree programs in Bachelor of Fisheries Science (B.F. Sc.) and other four institutions are offering specialized courses for fisheries education. Master's of Fisheries Science programs are offered by seven institutions.

To face the future challenges, higher education in Agricultural and Allied Sciences, including fisheries science has to be improved so that our graduates & postgraduates are comparable to the best in the world. 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 agriculture and allied 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 programs offered by National Agricultural Education System and suggest modifications.

The undergraduate curricula for various academic programs were revised and implemented from the academic year, 1998-99. This was followed by restructuring of PG curricula, for which 16 Broad Subject Matter Area (BSMA) Committees were constituted vide ICAR Office Order No.1-3/98-Acdn./Edn. Dated 30.11.1998, including one on Fisheries Science. Dr S.A.H. Abidi, the then Director, Central Institute of Fisheries Education, Mumbai was the Coordinator with other eight leading Fisheries Scientists as Members (Annexure - I). The Coordinator with the help of Committee Members and other concerned prepared the base paper taking into consideration the curricula of some of the leading institutions in India and abroad. This was discussed in first meeting-cum-workshop held at CIFE, Mumbai on 7-8th May, 1999. In this workshop, the draft curricula and syllabi were prepared which were circulated to all institutions offering PG programs in Fisheries Science under ICAR-SAU system for their comments. Several comments were received which were incorporated in modifying the draft curricula and syllabi. After Dr. Abidi left the CIFE to join ASRB as

Member, Dr. S. Ayyappan, who was a member of the committee and who succeeded Dr. Abidi, took over the coordinarorship of the committee. Dr. Ayyapan arranged another workshop on 20-21 October 2000 at CIFE, Mumbai, where modified document was discussed among other things. Based on the suggestions received in the workshop, earlier document was fine-tuned, keeping in view the approved academic regulations, which is now before you in form of this publication.

We are thankful to all the members of the BSMA Committee on Fisheries Science and the participants of both meeting-cum-workshops for their valuable suggestions and contributions for the development of the curricula and syllabi.

We are grateful to Dr R.S. Paroda, former D.G., ICAR and Chairman of the Accreditation Board, and Dr. S.L. Mehta, & Dr. (Mrs.) Tej Verma, former DDG(Edn), ICAR for providing guidance and encouragement in this endeavor. Our thanks are also due to Dr. Panjab Singh, D.G., ICAR and Chairman of the Accreditation Board and Dr. J.C. Katyal, DDG(Edn) for their support in bringing out this publication.

Our thanks are due to Dr. A. D. Diwan, ADG(Fy.), ICAR, Dr. G. Venkateshwarlu, Senior Scientist & Coordinator, Academic Cell, CIFE and Mr. Biswamitra Patro, & Mr. RB Pramod Kiran, Ph D Students, CIFE for their help in finalizing this document.

We hope that this document will serve as a guid and help in achieving uniformly high standards of postgraduate education in the Fisheries Science. The Accreditation Board Secretariat will appreciate comments and suggestions for improving and updating this publication in future.

March,2002
New Delhi

S. Ayyappan
S.A.H. Abidi
N.L. Maurya
G. D. Diwakar

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1. FISHERIES RESOURCE MANAGEMENT

A. Major Courses

| | | |
|--|-------|-------------------|
| A.1 Core Courses | | 12 Credits |
| 1. Freshwater fisheries resources and management | 2 + 1 | |
| 2. Brackish water fisheries resources and management | 2 + 1 | |
| 3. Marine finfish resources and management | 2 + 1 | |
| 4. Marine shellfish resources and management | 2 + 1 | |
| Seminar | 0 + 1 | 1 Credit |

A.2 Optional Courses

| | | |
|--|-------|-------------------|
| | | 12 Credits |
| 1. Fish population dynamics, stock assessment and modeling | 2 + 1 | |
| 2. Fish processing technology | 2 + 1 | |
| 3. Application of remote sensing and GIS for fisheries resource management | 1 + 1 | |
| 4. Human resources development and manpower planning in fisheries | 1 + 1 | |
| 5. Fisheries legislation for resource management | 2 + 1 | |
| 6. Fisheries project formulation, implementation and evaluation | 2 + 1 | |
| 7. Aquatic pollution and fisheries management | 2 + 1 | |
| 8. Fishing technologies and resource management | 2 + 1 | |

B. Supporting courses

| | | |
|---|-------|-------------------|
| | | 10 Credits |
| 1. Information retrieval and technical literature | 2 + 1 | |
| 2. Fisheries economics and marketing | 2 + 1 | |
| 3. Socio-economics and fisheries extension | 2 + 1 | |
| 4. Computer applications in fisheries | 1 + 1 | |
| Any other course(s) suggested by Student Advisory Committee | | |

Total **35 Credits**

A. MAJOR COURSES

A1. CORE COURSES

1. Freshwater Fisheries Resources and Management 2 + 1

Limnology and its impacts on the basis productivity levels of an aquatic ecosystem. Nutrient cycles. Ecology and classification of aquatic ecosystems. Effects of environment on fishes, productivity and its indices. Study of fish fauna from different aquatic ecosystems. Biology of inland waters. Plankton and other aquatic communities in different aquatic ecosystems. Sampling techniques and analysis. Inland capture fisheries - Riverine and reservoir fisheries. Ecology of rivers. Different river systems and their fisheries. Fish migration, dams, weirs and their effects on riverine fisheries, construction of fish ladders. Catch composition of riverine fisheries in India. Conservation and development of riverine fisheries. Reservoir fisheries in India. Productivity and fishery potential of reservoirs. Strategies adopted in other countries for development of reservoir fisheries. Case studies on the capture fisheries and management problems in selected inland water bodies.

Practical

Analysis of water, plankton and bottom samples. Preparation of relevant charts and graphs. Preparation of reports and seminars on conservation and management.

Suggested Readings

Hutchinson, G. E. 1957. A Treatise on Limnology, John Willey and Sons, Inc., London.

Robert, G. W. 1983. Limnology. Sounders College Publishing, New York.

Templeton, R. G. K. 1995. Freshwater Fisheries Management. Fishing News Books.

2. Brackish Water Fisheries Resources and Management 2 + 1

Major estuaries, lagoons, backwaters and brackish water impoundments in India and their fishery resources. Productivity and ecology of estuarine and brackish water lagoons, wet lands, biosphere reserves and mangroves. Conservation and development of estuaries and lagoon fisheries. Strategies adopted in other countries for development of estuarine and lagoon fisheries. Issues and challenges of management of brackish water fisheries. Case studies, management systems and models. Multi species fisheries management, territorial use rights, fishery conflicts, competition with other water use and irrational fishing. Future management options.

Practical

Classification and identification of brackishwater fishes and shellfishes. Preparation of relevant charts and graphs. Case studies on the capture fisheries and management problems.

Suggested Readings

Bardach, J. E., Ryther, J. H. and Larney, Mc W. O. 1972. Aquaculture — The farming and husbandry of freshwater and marine organisms. John Wiley & Sons, New York.

Iverson, E. S. 1976. Farming the edge of the sea, Academic Press, London.

Korringa, P. 1976. Farming marine fishes and shrimps, Elsevier, New York.

3. Marine Finfish Resources and Management

2 + 1

Review of living finfish resource of various oceans. Major fishing nations and fluctuations in catches. Major fishing regions of the world. Present status and future of world's finfish fisheries. Biological basis of marine finfish fisheries management. Current areas of concern. Development and application of yield models, objectives of management; bioeconomic models, maximum sustainable yield; techniques of management and conservation of resources.

Practical

Review of the world finfish fisheries. Preparation of charts and graphs. Case studies and seminars on fisheries resources and management.

Suggested Readings

Fisher, W. and White, P. T. P. Species identification sheets for fisheries purpose FAO, Rome.

Laevastu, T. 1965. Manuals and methods in fisheries biology fascicles, 1,2,9 & 10. FAO, Rome.

Lagler, K. F., Bardach, J. E. and Miller, R. R. 1962. Ichthyology, John Wiley, New York.

Pillai, V. N. and N. G. Menon. 2000. Marine Fisheries Research and Management. CMFRI, Kochi.

4. Marine Shellfish Resources and Management

2 + 1

Important groups of crustaceans and molluscs of the world and India. Commercially important species and their fisheries. Importance of shellfish resources in the world trade of aquatic products. Past, present and future of capture fisheries of these groups. Management of shellfish resources. Objectives of management, methods of management and problem areas. Current areas of concern. Development and application of yield models, bioeconomic models, maximum sustainable yield and conservation of resources.

Practical

Review of world shellfish resources and fisheries. Preparation of charts and graphs. Case studies and seminars on shellfish resources and management.

Suggested Readings

Garcia, S. and L. Le Reste. 1981. Life cycles, dynamics, exploitation and management of coastal shrimp stocks. FAO Fish. Tech. Pap. 203.

Jones, S. 1969. The prawn fishery resources of India. FAO Fish Rep. 57(2).

Kabo, I. 1956. A review of biology and systematic of shrimp and prawns of Japan. Proc. Indo Pacific Fish Coun, 6(3).

Roper, C. F. E., Sweeney, M. J. and Nauen, C. E. 1984. FAO species catalogue Vol. 3. Cephalopods of the world. An annotated and illustrated catalogue of species of interest of fisheries. FAO Fish. Synop.125, Vol. 3.

A2. OPTIONAL COURSES

1. Fish Population Dynamics, Stock Assessment and Modeling 2 + 1

Age determination - length frequency analysis, model progression methods, scattarogram, ELEFAN, growth check, hard parts - daily rings, half-year rings, annual hyaline and opaque zones, marginal growth, graphic methods of determination of periodicity of ring formation, back calculation. Tag recovery studies for age and growth. Growth curves - VBGF and Gompert. Estimation of total mortality from age structure and length structure. Estimation of z for short-lived stocks, estimates of F and M , tag-recovery estimation of F . Exploitation rate and exploitation ratio. Gill net selection, hook selection, trawl selection, selection parameters. Analytical models - Beveston and Holt and Thompson and Bul; Surplus production models - schaefer and fox.

Practical

Length frequency method of age determination, scales and otoliths in age determination. Fitting of growth curve. Mortality estimates. Selection curves for different gear types of fitting analytical and surplus production. models.

Suggested Readings

Gulland, J.A., 1983. Fish Stock Assessment. A manual of Basic Methods, John Wiley & Sons, Singapore.

King, M., 1995. Fisheries Biology, Assessment and Management. Fish News Book, Blackwell Science, Inc. Cambridge, MA.

Pitcher, T.J. and Hart, P.J.B. 1982. Fisheries Ecology. The Avi Publishing Co. Westport, Connecticut.

Sparre, P. and Venma S.C. 1992. Introduction to tropical fish stock assessment. FAO Fisheries technical Paper 306/1. FAO, Rome.

2. Fish Processing Technology 2 + 1

Harvesting of freshwater fish: Grading of fish, whole fish quality evaluation (subjective scope); Packing, storage and transportation. Introduction to freezing and chilling: Historical development; principles of chilling and freezing, methods of chilling; transportation and marketing of chilled and frozen fish. Freezing fish : Methods of freezing, changes during freezing fish; Packaging of frozen fish; Marketing; Cold chain and export trade; Transportation and marketing of frozen products. Quality control during freezing and chilling. Fundamentals of fish preservation, drying, smoking, curing, salting, fermentation, marinating and pickles.

Introduction to fish canning, principles of thermal processing, changes during canning, problems related to fish canning. Value addition in freshwater fish. Introduction to fish paste products (fish sausage and ham, etc.). Fish protein concentrate, fish hydrolysate, etc. Additives and preservatives; Fishery by-products : Fish meal, bone meal, fish oil, surgical sutures from intestine, chitin and chitosan; Fishery product packaging and packaging materials; Marketing and economics of fish processing.

Practical

Whole fish quality evaluation. Visit to fish market and processing plants. Preparation of fishery products and by-products; Quality control in fresh fish; Physico-chemical analysis of fish and fishery product; Microbiological analysis of fishery products; Sensory evaluation of fish and fishery products.

Suggested Readings

Balachandran K. K. 2001. Post harvest technology of fish and fish products. Daya Publishing House, New Delhi.

Govindan, T. K. 1985. Fish Processing Technology. Oxford & IBH Pub. Co. Pvt. Ltd., New Delhi.

Zeathen, P. 1984. Thermal processing and quality of foods. Elsevier applied science publishers, London

3. Application of Remote Sensing and GIS for Fisheries Resource Management 1 + 1

Principles of remote sensing; sonic, light and electro-magnetic sensors. Principles of cartography, aerial photography. Satellite images. Sensor bands of NOAA and IRS satellites. Use of remote sensing for resource mapping and mariculture planning. Elements of GIS.

Practical

Study of satellite information. Interpretation of satellite pictures for resource management. Data analysis. Digital data entry, preparation of thematic maps and applications.

Suggested Readings

Butter, M.J.A., Mouchot, M.C., Barale, V. and Le Blanc, C. 1988. The application of remote sensing technology to marine fisheries: An introductory manual , FAO Fisheries Tech. Paper 295, Rome.

Meaden, G.J. and Do Chi, T., 1996. Geographical Information Systems: applications to marine fisheries. FAO fisheries technical paper No. 356, Rome.

Meaden, G.J. and Kapetsky, J.M., 1991. Geographical Information Systems and Remote Sensing in Inland Fisheries and Aquaculture. FAO fisheries technical paper No. 318, Rome.

Sabins, F.F., 1997. Remote Sensing. Principles and Interpretation, W. H. Freeman and Co., New Delhi.

Schowengerdt, R.A., 1997. Remote Sensing. Models and Methods for image processing, Academic Press, London.

4. Human Resources Development and Manpower Planning in Fisheries **1 + 1**

Manpower planning and recruitment, Performance appraisal of personnel in fisheries organisations, organisational development, training and management development; motivation, leadership, team work and communication. Human resource development and its role in the context of fisheries sector, manpower requirement for various activities of fisheries sector; Raising the required manpower for fisheries developmental programmes; important institutions involved in human resource development for fisheries sector.

Practical

Estimation of manpower needs of fisheries sector. Visit to various organisations where fisheries activities occur.

Suggested Readings

Buffa, E.S. 1984. Modern production and operations management, Wiley Eastern Ltd., New Delhi.

Buffa, E.S. and Dyer, J.S. 1981. Management science / Operations research : Model formulation and solution methods, Wiley, York.

Kale, N.G. and Ahmed, M. 1994. Management and human resource development, Vipul Prakashan, Mumbai.

5. Fisheries Legislation for Resource Management **2 + 1**

Legislative jurisdiction over marine fisheries and aquaculture; Constitutional jurisdiction; private property, and public. Common property and open access rights over coastal fisheries and coastal zones. Legal and economic aspects of coastal zone management. Institutions for the implementation of fisheries and coastal zone management plans. Aquaculture leases; duration, rent, renewal, assignability and transferability. Important provisions of the Land Reforms Act and its impact on aquaculture development. International negotiations and settlements over open seas and conflict management over deep sea resources.

Practical

Exercises in cases and materials in fisheries, aquaculture, CRZ notifications and Coastal Zone Management Plans (CZMPS). International cases on the settlement of conflicts over deep sea resources. Case studies and seminar.

Suggested Readings

Coupes, A. and Edgar, H. 1987. The marine environment and sustainable development; law, policy and science. Law of the Sea Institute, Honolulu.

Neler, A. P., Ragnar Arneson and Nina Mollett. 1997. Rights Based Fishing. Kluner Academic Publisher.

O'Connell, D. P. 1982. The international law of the sea. Clarendon Press.

6. Fisheries Project Formulation, Implementation and Evaluation 2 + 1

The National Plan. GNP and national income accounting Fisheries sector plan. Linkages between policies, plans and projects. Project approach to fisheries and formulation of projects. Resource management issues, technical issues, credit issues, organisation and management issues, social and environmental issues. Measurement of the value of the projects, basic concepts of project appraisal, techniques of project appraisals; investment criterion, inter-relationship between net present value, internal rate of return and benefit cost ratio; financial and economic appraisal, monitoring and evaluation.

Practical

Methods of National Income Accounting, GNP and Augmented GNP concepts, circular flow of income, aggregate demand and planning, the multiplier concept, Government and aggregate demand, Government budget, Foreign trade and income determination.

Suggested Readings

Andrew, P. 1999. Fish business management: strategy, marketing - Development, fishing News Books, London.

Rao, P.S. 1983. Fisheries economics and management in India. Pioneer Publishers and Distributors.

Shaug, Y.C. 1981. Aquaculture economics : Basic concepts and methods of analysis, Groom Helm Ltd., Great Britain.

7. Aquatic Pollution and Fisheries Management 2 + 1

Different sources of pollution; Industrial, domestic, agricultural, etc.. Effect of pollution on

aquatic ecosystem; Pollution abatement measures; Bioassay studies for fixing tolerance limit; Biological indicators and indices of pollution; Regional, national and International standards; Pollution Control bodies and their functioning. Greenhouse effect, acid rain.

Practical

Estimation of BOD, COD; Determination for chemical pollutants; Acute toxicity tests; Median lethal concentration (LC 50) values; Chronic toxicity tests. Case studies and seminar.

Suggested Readings

Albaiges, J. 1986. Marine Pollution - Hemisphere Publishing Corporation, New York.
Edward A. Laws, 2000. Aquatic Pollution : An Introductory Text John Wiley & Sons, Inc., New York.
Hynes, H. B. N. 1996. The Biology of Polluted waters, Liverpool University Press, Liverpool.
Richard, Lloyd, 1989. Pollution and freshwater fish-Fishing News Books, London.
Sindermann, C. J. 1976. Ocean Pollution: Effects on Living Resources and Human, CRC Press,

8. Fishing Technologies and Resource Management 2 + 1

Classification of fish catching methods of the world by A. Von Brandt, basic principles of fish catching; Factors determining the selection of gear; Fishing gears of India, Natural and synthetic materials in fishing gear; Choice of netting materials for different gears; Numbering of yarn; Construction and types of twines and ropes; Different types of floats, sinkers, anchors and buoys; Fabrication of fishing gears; Drawing and reading the gear designs; Description and operation of fishing gears - trawls, purse seines, gill nets and lines; Treatment and preservation of fishing gear. Fishing technology and resource management.

Practical

Knots, bends and hitches; Construction of netting yarn; Shaping of webbing while weaving; Tailoring of webbing and cutting process; Mending and repairing of nets; Joining and mounting of webbing; Identification of fishing materials. Fishing technology as a tool for resource management.

Suggested Readings

Brandt, A. V. 1984. Fish catching methods of the world. Fishing News Books Ltd., London.
John, F. 1985. Design of small fishing vessels. Fishing News Books Ltd., London.
John, S. 1996. Commercial fishing method - An introduction to vessels and gear. Fishing News Books Ltd., London.

Klust, G. 1982. Netting materials for fishing gear. FAO fishing manuals West Byfleet survey, Fishing News Books.

Shenoy, L. 1988. Course manual in Fishing Technology. CIFE, Mumbai.

Sreekrishna, Y. and Shenoy L. 2001. Fishing gear and craft technology. Indian Councilo of Agricultural Research, New Delhi.

B. SUPPORTING COURSES

1. Information Retrieval and Technical Literature

2 + 1

General Orientation to the Library: Introduction to library functions and services; Information flow and transfer; Types of catalogues, documents, their role and how to use them. Methods to locate information through documentary resources : Nature and format of various documentary, Introduction to reference systems like encyclopedia, year books, statistical sources. Introduction to scanning of current awareness services (CAS). Selective Dissemination of Information (SDI) and reprographic / micrographic methods. Journals and books as sources of information; Periodicals and books as vital sources of information. Methods to locate information with special reference to aquatic sciences and fishery science. Use of bibliographical sources; Concept of bibliography and its use. Compilation of references as per standardized formats; Methods of indexing and abstracting, Retrieving information from catalogues through subject / author / title indices available in the Library. Information retrieval systems and net works; Concept and usefulness of different systems for retrieval; Computer application in documentation - storage and retrieval; Documentation / information systems like CD ROM (Computer Disc - Read only Memory) and UNESCO CDS / ISIS system, (Integrated set of information systems), Net work documentation and information services both national and international. Scientific and technical reporting: Concept of generation of data, data processing and presentation. Structure of scientific and technical papers. Presentation of scientific and technical papers. Popular articles. Reviews.

Practical

Introduction to scanning of current awareness services. Library system and services. Computer applications in information retrieval and other modern uses.

Suggested Readings

Davis, Elisahen B. and Schmidt, Diane 1995. Using the biological literature : A practical guide, 2nd ed. Marcel Dekker, Inc., New York.

Gupta, B. M. et.al. 1987. Hand book and libraries, Archives and information centres in India. Vol. 5: Information Technology, Industry and Net works. Information Industry Publications, New Delhi.

Lancaster, F. W. 1998. Indexing and abstracting in theory and practice - 2nd ed. Library Association Publishing, London.

Lannon, J. M. 1982. Technical writing, Little Brown and Company, Boston.

Michael, Alley, 1996. The craft of scientific writing, Springer

Weisman, H. M. 1975. Tech. Report writing, Charles, E. Merrill Publishing Company, Columbus.

2. Fisheries Economics and Marketing

2 + 1

Nature and scope of natural resource economics, bio-economic analysis of fisheries. Growth, development and natural resource interrelationships. Pricing and optimal resource use over time under different market situations - role of market structure, interest rate, property rights in fisheries exploitation. Concept of externality - positive and negative externalities. Physical, legal and economic incentives to internalise the externalities. Fishery resource management policies - markets, taxes, subsidies, permits, direct controls, distributional effects of fisheries development.

Nature and scope of aquaculture economics, production principles; Factor-Product, cost principles, Factor-factor. Product-product and law of comparative advantage, law of equi-marginal returns, returns to scale and farm size, Homogeneous production functions; Cobb-Douglas and quadratic production functions. Risks and uncertainty; strategies for meeting risks and uncertainty. Economics of intensive, semi-intensive aquaculture. Role of marketing in fisheries and aquaculture, markets over space, intramarket price relationships. Market-structure-conduct and performance. Developing marketing mix, product, pricing, place and promotion. Fisheries marketing organisations.

Practical

Bioeconomic analysis, socially optimal harvesting strategies, appraisal of resources using production functions.

Suggested Readings

Andrew, P. 1999. Fish business management: strategy, marketing - Development, fishing News Books, London.

FAO, 1995. Fisheries technical paper, 351. Economic engineering applied to the fishery industry.

Paul, A.S. 1973. Economics. Mc Graw Hill Kogakusha Ltd., Tokyo.

Rao, P.S.1983. Fisheries economics and management in India. Pioneer Publishers and Distributors.

Seijo, J.C. Defeo, D., Salas, S. 1998. FAO Fisheries technical paper 368. Fisheries bioeconomics – Theory, modeling and management. FAO, Rome.

Shaug, Y.C. 1981. Aquaculture economics : Basic concepts and methods of analysis, Groom Helm Ltd., Great Britain.

3. Socio-economics and Fisheries Extension

2 + 1

Nature and scope of socio-economic analysis, Meaning and measurement of socio-economic variables. Factors determining development. Role of sociology in the process of fisheries development. PRA and RRA for studying socio-economic problems, stake holder analysis.

Practical

PRA and RRA, stake holder analysis with fishing communities.

Suggested Readings

Anon. 1980. Seminar on fisheries extension, status report and background papers, CMFRI, Kochi.

Dahama, O. P. 1993. Extension and rural welfare. Ramprasad and Sons, Agra.

Dhote, A. K. 1989. Fisheries management and extension: Inland fisheries, instructional-cum-practical manual (VI), National Council of Educational Research and Training, New Delhi.

Lynton, P. R. and Pareek, U. 1978. Training for development Kumarian Press, 29 Bishop Road, West Hartford, Connecticut 06119.

Rao, T. V. 1991. Readings in human resource development. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.

Ray, G. L. 1991. Extension communication and management, Naya Prakash, Calcutta.

Supe, S. V. 1986. An introduction to Extension Education, Oxford and IBH Publishing Co., New Delhi.

4. Computer applications in Fisheries

1 + 1

Introduction to computers, Types of computers - PC, Mini and Main frames; Computer generations; Concepts of Input, Processing and Output; Input, output devices; Need for an operating system, Introduction to MS DOS and Windows operating systems; Introduction to Word processing (MS Word), Spread sheets (MS Excel) and presentation (MS Powerpoint); Flow chart; Elements of Basic programming; Application of computerized information and data analysis in fisheries; Introduction to E-mail and Internet.

Practical

Binary number system, DOS commands and Windows basics, Word processing using MS Word, Creation of spread sheet, analysis and graphical representation of data using MS Excel and presentation using MS Powerpoint, Exercises on Basic programming and hands on experience using E-mail and Internet.

Suggested Readings

Balagurusamy, E. 1989. Programming in ANSI C, Tata McGraw - Hill Publishing Co., New Delhi.

Megrey, B.A. and Moksness, E. 1996. Computers in Fisheries Research, First Edition, Chapman and Hall, U.K.

Sandler, C., Badgett, T. and Weingarten, J. 1997. Office 97 for Windows, BPB publications, New Delhi.

Trevor, A. 1995. Information Technology, Pitman Publishing Co.

2. AQUACULTURE

2.1 INLAND AQUACULTURE

A. Major Courses

A.1 Core Courses 12 Credits

| | | |
|---|-------|-----------------|
| 1. Freshwater Finfish Culture | 2 + 1 | |
| 2. Shellfish Breeding and Culture | 2 + 1 | |
| 3. Nutrient Management in Aquaculture | 2 + 1 | |
| 4. Fish and Shellfish Health Management | 2 + 1 | |
| Seminar | 0 + 1 | 1 Credit |

A.2 Optional Courses 12 Credits

| | | |
|---|-------|--|
| 1. Breeding and Hatchery Management of Freshwater Finfishes | 1 + 1 | |
| 2. Fish Nutrition, Biochemistry and Feed Technology | 2 + 1 | |
| 3. Breeding and Culture of Brackish Water Finfishes and Shellfishes and Coastal Aquaculture | 2 + 1 | |
| 4. Advanced Fishery Biology | 1 + 1 | |
| 5. Fish Genetics | 1 + 1 | |
| 6. Instrumentation and Research Methodology | 1 + 1 | |
| 7. Project Planning and Management | 1 + 1 | |
| 8. Ornamental and Sport Fisheries | 1 + 1 | |
| 9. Inland Aquatic Ecosystem and their Management | 1 + 1 | |
| 10. Fish Physiology and Endocrinology | 1 + 1 | |

B. Supporting Courses 10 Credits

| | | |
|---|-------|--|
| 1. Fish Biotechnology | 2 + 1 | |
| 2. Post-harvest Technology | 1 + 1 | |
| 3. Aquaculture Economics, Marketing & Cooperatives | 1 + 1 | |
| 4. Computer Applications and Information Technology | 1 + 1 | |
| 5. Aquaculture Engineering-I | 1 + 1 | |
| 6. Ecotoxicology and Pollution Management | 1 + 1 | |
| 7. Statistics and Design of Experiment | 1 + 1 | |
| 8. Aquaculture Extension | 1 + 1 | |
| Any other course(s) suggested by students Advisory Committee | | |

Total

35 Credits

A. MAJOR

A1. CORE COURSES

1. Freshwater Finfish Culture

2 + 1

History of carp culture, Present status of carp culture in India with reference to global scenario, Selection of candidate species. Three tire systems of carp culture, nursery and rearing pond management. Intensive carp culture in pond. Culture of medium and minor carps. Pond fertilisation : Aeration, water exchange and supplementary feeding in carp culture. Present status of catfish farming in India with perticular reference to global scenario. Problems and prospects of catfish culture. Culture of magur and singhi : pond preparation and prestocking management, stocking, supplementary feeds and feeding, water management, disease and health management, harvesting.

Integrated fish farming: principles, Poultry-cum-fish culture, Duck-cum-fish culture, Pig-cum- fish culture, Paddy-cum-fish culture, Mushrum-cum-fish culture, Vermicomposting-cum-fish culture, Fish-cum-horticulture, Sewage-fed fish culture: Fish-cum-sericulture, Aquatic Plant-cum-fish culture, livestock management in relation to fish culture. Design and construction of cage and pen; Carp culture in cage and pen. Running water recirculatory system of aquaculture for industrial production: Exotic fish species and their impact on Indian freshwater aquaculture.

Practical

Identification of cultivable carps: major, medium and minor carps: Identification of predatory and weed fishes, aquatic insects, different aquatic macrophytes: Preparation of nursery, rearing and stocking ponds, liming and fertilization, analysis of water quality parameters, preparation of feeds and feeding, stocking, examination of plankton from culture ponds. Growth and survival assessment. Pond preparations for culture for nurseries and table size production of common catfishes. Organic recycling in aquaculture.

Suggested Readings

Agarwal, V.P. 1999. Recent trends in aquaculture. Publisher Society of Biosciences, Muzaffarnagar.

Goldman, C.R. and Alexander J. H. 1983. Limnology, McGraw Hill International.

Hutchinson, G.E. 1957. A Treatise on Limnology, John, Willey and Sons. London.

Goneshvar, C. and Sudhakar, C. 1997. Aquaculture in India, Publisher Sir Sai Publishing, Bhimawaram.

Pillai, T.V.R., 1990. Aquaculture principles and practices, Fishing News Books.

Paul, S. Welch. 1952. Limnology, McGraw Hill International Book Co. Inc. p.538.

Robert, G. W. 1983. Limnology, Sounders College Publishing, New York.

Templeton, R.G.K. 1995. Freshwater fisheries management, Fishing News Book.

2. Shellfish Breeding and Culture

2 + 1

Present status of prawn farming in India with reference to global scenario, key to the identification of penaeid and non-penaeid prawns and different species : Biology of two important freshwater prawns, *Macrobrachium rosenbergii* and *M. malcolmsonii*. Food and feeding, Age and growth migration, maturation and breeding; Natural seed availability and collection, brood stock management, selection of spawners, induced spawning of two commercially important species, larval rearing, operation of prawn hatchery, water quality management, feeding management, culture of live food organisms like artemia, rotifers and cladocerans, algal culture. Nursery rearing of post larvae.

Culture of freshwater prawn : pond preparation and prestocking management, stocking, water quality management, supplementary feed and feeding, disease management, aeration, water exchange, harvesting, polyculture of prawn along with carps : Problems and prospects of freshwater prawn culture. Culture of other crustaceans. Important freshwater mussels to production of pearls, key to the identification of different pearl producing mussel species, principles of pearl formation, techniques of pearl production : Collection of mussel and pre-operative culture, surgery, post operative care, harvesting, enhancing the rate of pearl formation : Structure and composition of pearl materials : Post harvest operations; Processing and value addition : Pearl trade in India.

Practical

Identification of common freshwater prawn and molluscan species, sexing and maturation process, breeding and hatchery operation of the two important prawn species : Live feed culture; Pre-stocking management and stocking for culture of prawns in nurseries and grow-out ponds. Collection of mussel species for implantation, graft tissue preparation, surgery, postoperative care: Fabrication of nylon bags and crates for culture of implanted pearl mussels: Pond culture.

Suggested Readings

Jhingran, V.G. 1982. Fish and fisheries of India. Hindustan Pub. Corporation, Delhi.

John, E. Bardech, John, H. Ryther and William, O. Mclancy, 1972. Aquaculture - The farming and husbandry of freshwater and marine organisms. John Wiley and Sons, New York.

Lee, D.O.C. and Wickine. J.F. 1992. Crustacean farming. Published by Blackwell Scientific Publications, London.

3. Nutrient Management in Aquaculture

2 + 1

Soil and water quality, sediment - water nutrient interactions, physical properties of soil, soil reaction, nutrient availability in relation to pond productivity, factors influencing nutrient management, nutrient dynamics, significance of humus in aquatic ecosystem, fertilization measures, Major and micronutrients, heavy metals and pesticides and their effects on fish production. Trophic components and pathways, interactions and production efficiencies, aquatic macrophytes and biotic communities, classification and functional significance of microorganisms, microbial communities with reference to productivity and pollution, kinetics of bacterial populations in nutrient cycling, enumeration and identification of bacteria, estimation of bacterial biomass, microbial interactions and their role in organic production and decomposition.

Practical

Analysis of water and soil quality parameters, major and micronutrients, heavy metals and pesticide residues in water, soil and fish tissues, estimation of photosynthetic pigments, primary production and organic decomposition, isolation enumeration and identification of bacterial populations in water and sediment samples, assays of bacterial enzymes in water and sediment samples, caloric contents of trophic components for pathway characterisation, productivity amelioration measures.

Suggested Readings

- Brule, J. N. and Cronin, L.E. 1981. Estuaries and nutrients. Humana Press, Clifton, New Jersey. P.643.
- Cloude, E. Boyd. 1982. Water quality management for pond fish culture, Elsevier Publications.
- Claude, E. B. 1995. Bottom Soils, Sediment and Pond Aquaculture Pub. Chapman and Hall, New York.
- Gilbert, B. Aquaculture, Ellis Horwood, New York.
- Robert, R. Stickney. Principles of aquaculture. John Wiley and Sons. Inc., New York.

4. Fish and Shellfish Health Management

2 + 1

Introduction to pathology, cellular pathology, general pathology. Host-pathogen-environment relationship, host susceptibility, different types of pathogens, environmental stress, mechanism of disease outbreak and the balancing role of aquatic environment. Methods of treatments of diseases in fish. Significance of preventive regulatory and control measures of communicable diseases. Importance of quarantine measures in aquaculture. Viral, bacterial and fungal fish pathogens, their general biology and taxonomy, detection and isolation techniques, symptoms, pathology : Diagnosis of known bacterial, viral and fungal diseases. Isolation and characterisation plan for pathogenic bacteria and fungi. Prophylactic and control measures.

Biological and chemical treatment of diseases. Commonly employed chemicals, their dosages and methods of administration for different diseases.

General Immunology, Antibody classes and structure cell mediated immunity, origin of T & B cells and T & B cell interaction, interaction of specific immune response in fishes, characterization of antigens, Immunization in fish, principles of various immunodiagnostic techniques, Role of immunostimulants in aquaculture. Taxonomy of fish parasites, their morphology, life cycle and ecology, common protozoan, helminths, acanthocephala, crustacean, and anelid diseases : symptoms and diagnosis. Nutritional deficiency diseases and diseases due to environmental degradation. Non-infectious and metabolic disorders. Disease due to algal toxins. Clinical pathology.

Practical

Necropsy examination and preparation of five complete case study with detailed report, Collection of blood samples for hematology study: Differential leucocytic count, Total Leucocyte count, Total erythrocyte count, PCV, MCV, MCHC, ESR, Serum collection for blood chemistry : Protein, Glucose; Cholesterol, Preparation of glasswares : Cleaning, packing, sterilization, Sample collection technique for bacteriological and mycological study, Preparation of media and sterilization, Plating and tubing techniques, Isolation and characterization of bacterial / fungal isolates and their identification methods, Colony counting and total bacterial cell count in a sample, Preparation and processing of tissue samples for histopathological study, Staining set preparation and staining techniques, Examination of histological slides and interpretation, Agglutination test, precipitation test, Agar gel immunodiffusion test, ELISA and NBT, Western blotting, Dot-Blot ELISA.

Suggested Readings

Ahne, W.1980. Fish diseases. Springer - Verlag, Berlin Heidelberg, New York.

Schaperclaus, W. 1986. Fish diseases (Vol. 1 & 2), Oxonian Press Pvt. Ltd., New Delhi, Calcutta. Vol. I (1986) p. 594 and Vol.II p. 1398.

Principle diseases of marine fish and shellfish, Academic Press Inc. Vol. I San Diego, New York, Toronto : p. 521.

Wedmeyer, G. Meyer, F. P. and Smith, L. 1999. Environmental Stress and Fish Diseases. Narendra Publishing House, Delhi. P.192.

A 2. OPTIONAL COURSES

1. Breeding and Hatchery Management of Freshwater Finfishes 1 + 1

Breeding habits of different cultivable carp species, brood pond management for culturable indigenous and exotic carps, raising and rearing of brood carps for traditional and multiple breeding, gonadal maturity, factors responsible for induced breeding. Hypophysation, mechanism of endocrine action on carp spawning, use of different synthetic hormones, their formulation and mechanism action; Bundh breeding, hapa breeding. Formulation and operation of different types of hatcheries, multiple breeding of carp embryo development. Evaluation of carp milt: volume of milt, spermatocrit value, sperm count value, motility value, utilization of cryopreserved milt.

Brood stock management of magur, (*Clarias batrachus*) and singhe (*Heteropneustes fossilis*), Selection of spawners, preparation and administration of different hormones, breeding operation, Incubation, embryonic development. C Larval rearing: Water management, preparation of larval feeds, live feed culture, fry and fingerlings rearing. Seed production and culture of large catfishes, Wallago attu, *Pangasius pangasius*, *mystus* spp. Etc. Seed production and culture of other live fishes like murrels, koi, etc.

Practical

Collection and preservation of carp pituitary glands, preparation of pituitary extract, sex identification, selection of brood, evaluation of maturation status of female brood, evaluation of milers. Induced breeding: spontaneous breeding and hatchery operation, stripping, incubation in different types of hatcheries.. Observation of embryological development stages. Assessment of breeding success and fertilization rate. Professional brood handling, tagging of brood. Seed production out of preserved milt. Packing and forwarding of spawn, Identification of common catfish and other live fish species. Identification of spawners and evaluation of different maturity stages. Breeding and hatchery operation of magur, singhi and other species. Live feed culture.

Suggested Readings

Jhingran, V.G. 1982. Fish and fisheries of India . Hindustan Pub. Corporation, Delhi. P.666.

Jhingran, V.G. & Pullin, R.S.V. 1985. A hatchery manual for the common, Chinese and Indian major carps, Asina Development Bank.

John, E. Bardech, John, H. Ryther and William, O. Mclancy, 1972. Aquaculture - The farming and husbandry of freshwater and marine organisms. John Wiley and Sons New York. Chichester, Brishane, Toronto. P.868.

Michael, Bernard New and Wagner, Cotroni Valenti 2000. Freshwater prawn culture. The farming

of *Microbrachium rosenbergii* edited. Blackwell Science. P.443.

Templeton. R.G.K. 1995. Freshwater fisheries management, Fishing News Book.

2. Fish Nutrition, Biochemistry and Feed Technology

2 + 1

Principles of nutrition and historical background, physiological roles of nutrients. Food and feeding habits of freshwater fishes. Digestion and assimilation of nutrients, role of digestive enzymes. Introduction to chemistry of carbohydrate, lipid, protein and nucleic acid, metabolism of carbohydrate, glycolysis, TCA-cycle, pentose phosphate pathways, gluconeogenesis, glycogenolysis; metabolism of lipids, metabolism of protein and amino acids, oxidative phosphorylation, nucleic acid metabolism, nutritional bioenergetics.

Proteins - their source, protein digestion and assimilation, essential amino acids, protein quality, nitrogen balance, protein requirement and evaluation of protein quality. Lipids - the source, digestion of lipids and their absorption, phospholipids and fatty acids - their function, their requirements. Carbohydrates - their sources and utilization by fish/prawn, energy requirement, factors affecting energy utilization. Vitamins - their role in metabolism, deficiency symptoms, their requirements. Mineral nutrition in fish and shellfish, probiotics. Nutrient requirements for various growth stages of fish and shellfishes, various conventional and non-conventional feed sources, presence of anti-nutritional factors and their removal procedures. Feed formulation methodologies, feed processing and manufacture and evaluation. Storage and quality control of feeds. Feed dispensing methods.

Practical

Preparation of standard solution. Sampling and processing of feed for proximate composition analysis. Determination of dry matter content. Assay of protein by Kjeldahl's method and Lowry's method. Lipid extraction using Soxhlet/Soxhlet system and estimation of lipid content by gravimetry. Determination of ash content and assay of Ca and P from ash after mineral extract. Determination of gross energy by bomb calorimetry. Determination of crude fibre content. Assay of vitamin-C and vitamin-A content in fish feed/tissues. Feed formulation, processing and feed manufacture.

Suggested Readings

Albert G.J. T. 2000. Standard Methods for the Nutrition and feeding of farmed fish and shrimp Vol 1-3., Argent Laboratories Press, Washington, USA.

John, E. Halver. 1988. Fish Nutrition, Academic Press, INC. California.

John, E. Bardach, John, H. Ryther, and William, O. M. 1972. Aquaculture - The farming and Husbandry of freshwater and marine organisms, John Wiley & Sons. New York.

Lovell, R.T. 1989. Nutrition and feeding of fish, New York; Van Nostrand Reinhold.

Robert, R. Stickney, 1994. Principles of Aquaculture. John Wiley & Sons, INC. New York.

Sena, S. Desilva and Trevor A. Anderson. 1995. Fish Nutrition in Aquaculture, Chapman and Hall, London.

3. Breeding and Culture of Brackishwater Finfishes and Shellfishes and Coastal Aquaculture 2 + 1

An overview of the status of brackishwater aquaculture of finfishes and shellfishes in the world — major species cultured, technologies, countrywise production, recent advances and problems. Present status and potentials of culture of brackishwater finfishes and shellfishes in India. Breeding and hatchery management of common shrimps species. Brood stock management, inducing maturation, selection of spawners, induced spawning of different shrimp species including *Penaeus monodon* and *P. indicus*. Larval rearing, closed and open type of hatchery, hatchery design and management. Nursery and growout productions under different culture systems. Breeding and culture of major lobster and crab species.

Finfish culture in brackishwater ponds - milkfish, grey mullet, sea-bass, pearl spot, etc. Natural seed collection. Induced breeding and seed production of common cultivable species of finfishes. Grow-out production of common fish species. Cage and pen culture in coastal waters. Culture of yellow tail, sea bream and salmon in cages. Seed production and culture of marine molluscs, edible oysters, pearl oysters, mussels, clams, cockles, scallops etc. Different culture methods, their advantages and disadvantages. Different groups of seaweeds and their economic importance, different methods of propagation, culture of important seaweed species in different parts of the world and in India.

Practical

Identification of common species of cultivable finfishes, crustaceans, molluscs and seaweeds culture of live food organisms. Visits to different hatcheries and collection sites. Preparation of charts, plan and layout of brackishwater farms, models etc.

Suggested Readings

Frederick, S. R. and Mourice Y., Advances in marine biology, Academic Press.

FAO, Species Identification sheets for fishery purposes - Western Indian Ocean Fishing Area , FAO, Rome.

Jhingran, V.G. 1982. Fish and Fisheries of India. Hindustan Pub. Corporation., Delhi. P.666.

Sena, S. De Silva, 1992. Tropical aquaculture, Academic Press, San Diego, Lon, Boston, New York. P.487.

4. Advanced Fishery Biology 1 + 1

Taxonomy and identity of economically important marine, brackishwater and freshwater fishes and shell fishes of India and their distribution. Life history, reproduction, age and growth, food

and feeding, migration and behaviour of fish and shell fish. Principles of population dynamics, unit stock, age and size composition of population, abundance and density, recruitment, growth, mortality (fishing and natural), capture and re-capture method, simple models for stock assessment, yield curves, optimum yield potential resources. Environment and its relation to Fish Biology.

Practical

Identification of important species of concerned group (fin fishes and shell fishes) identification of sex, important larval and juvenile stages, classification of maturity stages, estimation of fecundity, growth and age determination, gut content analysis and mark recovery experiments. Analysis of data pertaining to unit stock age and size composition, abundance and density, recruitment, growth and mortality, simple models of stock assessment.

Suggested Readings

Day, F. William 1958. Fishes of India, Vol.1-2, Dawson & Sons Ltd., London.

Harry M. K. 1992. The Biology of Fishes, Daya Pub. House, Delhi. P.396.

Shepherd, C. J. and Bromage, N.R. 1992. Intensive Fish Farming, Pu. Oxford Blackwell Scientific Publication, London, Edinburgh, Boston. P.404.

William, F. R. 1962. Introduction to the Practice of Fishery Science, Academic Press. P-428.

5. Fish Genetics

1 + 1

Principles of fish genetics: hybridization, sex determination and sex reversal in fishes. Cytogenetics: Chromosomes and genes, karyotyping, mapping, Robertsonian rearrangements and banding. Chromosomal engineering: Genome, gynogenesis, androgenesis, polyploidy, production of monosex population and super male by combination of endocrine, sex reversal techniques. Biochemical genetics : Isozymes for genetic characterization.

Quantitative genetics: Genotype, phenotype, environment and genotype interactions, Hardy-Weinberger law, variation, heritability, population, effective population size, inbreeding, selective breeding: methods and type of selection, selection response. Genetic materials: Prokaryotes/eukaryotes, DNA and RNA structure, replication, transcription, translation, regulation of gene expression. Gene mutations: Definition, types of mutation, chemical mutagens, mutation by ultraviolet and ionising radiation, DNA repair mechanism, consequences of mutation. Recombination in bacteria: Transformation, transduction, conjugation, gene mapping, breakage and reunion as the mechanism of recombination in bacteria, Plasmids and episomes, transposable genetic elements.

Practical

Preparation of fish chromosomes, collection and observation of gametes of freshwater finfishes.

Demonstration of techniques of chromosome manipulation : gynogenesis, androgenesis, triploidy, tetraploidy, hybridization, ploidy evaluation using erythrocyte measurements and chromosome numbers. Culture of lymphocytes. Selective and tagging procedures.

Suggested Readings

Das, P. and Jhingran, A. G. 1976. Fish Genetics in India, Today and Tomorrow Publishers, New Delhi.

Douglas, T. 1998. Genetics for Fish Hatchery Managers, Kluwer Academic Publishers, Boston.

Falconer, D.S. 2000. An Introduction to Quantitative Genetics - ELBS Publisher, England.

Lakra, W. S. 2000. Fish Genetics and Biotechnology, CIFE, Mumbai.

Sinnot, E.W; Dunn. L.C. and Dobzhansky T. 1989. Principles of Genetics - McGraw Hill Publishing Company Ltd. New Delhi.

6. Instrumentation and Research Methodology

1 + 1

Principles of microscopes, bright field, dark field and phase contrast microscopy, fluorescent microscopy, electron microscopy, photomicrography, colorimetry, Spectrophotometry (UV - visible, infra-red and double beam), Radio active measurement (Scientillation counters, Geiger-Muller counter), Radio-immuno assay, Bomb calorimetry. PH and Eh meter, Oxygen and temperature probes, Conductivity meter, Salinometer and refractometer, Atomic absorption spectrophotometer. Paper chromatography, Thin layer chromatography, Liquid chromatography, HPLC, Electrophoresis - principles, different electrophoretic techniques. Microtechniques: Microtome, cryostat, preparation of tissue material for histological studies. Collection of research literature, planning research projects, analysis, compilation and presentation of research data, preparation of transparencies, research papers, dissertations, oral and visual delivering of results.

Practical

Operation and use of different microscope, spectrophotometer, bomb calorimeter, use of different instruments for measuring pH, oxygen, conductivity, salinity, etc.; use of gas chromatograph and HPLC; separation of amino acids by paper chromatography and thin layer chromatography; preparation of slides for histological studies. Collection of literature, indexing, preparation of scientific paper and review, preparation research project, proof reading, use of audio visual aids, seminars and discussion.

Suggested Readings

Bernad, L. Oser, 1976. Hawk's Physiological chemistry, Tata Mc Graw Hill Publishing Co.Ltd., Bombay.

Jennings, W. G. 1993. Analytical gas chromatography, Academic Press, Orlando.

Sadasivam, S. and Manickam, A. 1999. Biochemical methods, New Age International Publishers.

7. Project Planning and Management

1 + 1

Concept, scope and definition of project and project cycle: Project classification; Social development and investment oriented; Multi-agency, single agency and project components; Verifiable objectives, compatibility with national / agency goals, finite Time frame, explicit programme outline and manpower, materials, services, special regulatory legal needs, budgetary requirements, source of funds, implementation organisation, viability - fiscal, social and economic. Project planning: Origin/identification: goals, beneficiary/target populace/areas, benefits; Preproposals - Prefeasibility and Feasibility - legal and regulatory, technical, input (manpower, services, materials) availability, social, cultural, environmental and funding , product distribution/disposal/utility; Financial & Economic viability - social development goal, return to investment, Discounted Pay Back, Discounted Cash flow (DCF), Net Present value (NPV), Internal Rate of Return (IRR), Turnover/investment rates, Break even point. Project Appraisal: Capital, fixed and variable costs, funding schedule, fundability, morataruim, special concession, fund flow system, Project Implementation Monitoring and Control, Management Information System (MIS), Midterm evaluation, corrective provision, Management Techniques : Milestones Flow chart, CPM, PERT techniques, Inventory control, Fiscal control - budgetary, personnel management - incentives/deterrents, worker participation, group decision, decentralised decision process, MIS & control systems, Project management, market research, marketing strategy.

Practical

CPM/PERT, DCF, IRR/NPV; Group decision making.

Suggested Readings

Andrew, P. 1999. Fish business management: strategy, marketing and Development, Fishing News Books, London.

FAO, 1995. Fisheries technical paper, 351. Economic engineering applied to the fishery industry.

Paul, A.S. 1973. Economics. Mc Graw Hill Kogakusha Ltd., Tokyo.

Rao, P.S.1983. Fisheries economics and management in India. Pioneer Publishers and Distributors.

Seijo, J.C. Defeo, D. and Salas, S. 1998. FAO Fisheries technical paper 368. Fisheries bioeconomics - Theory, modeling and management. FAO, Rome.

Shaug, Y.C. 1981. Aquaculture economics: Basic concepts and methods of analysis, Groom Helm Ltd., Great Britain.

8. Ornamental and Sport Fisheries

1 + 1

Present status of ornamental fish trade; Different species of ornamental freshwater species, their breeding habit and natural history; rearing of larvae and adults, feeds and feeding; Types of aquaria and maintenance. Common aquarium plants and their multiplication. Ornamental objects, aerators and filters; Common disease of aquarium fishes and their control. Packaging and transport of aquarium species; Setting of aquarium of different sizes. Important coldwater fisheries of sports or commercial importance. History of coldwater fisheries and culture in India. Development and operation of hatcheries of cold water species of commercial importance like trout, mahseer etc. Present status and future prospects. Conservation of importance cold water species in upland systems.

Practical

Identification of different species of ornamental fishes; Breeding and rearing; Study of common aquarium plants and their multiplication; Setting and maintenance of aquaria; Diagnosis of common aquarium fish diseases and treatment. Identification of common coldwater fish species. Visit to trout hatcheries.

Suggested Readings

Field, J. R. M. 1934. Fly fishing for Mahseer, J. Bio. Nat. Hist. Soc., 41 : 670-672.

Jhingran, V. G. and Sehgel, K. H. 1978. Coldwater fisheries of India, Inland Fish. Soc., India, pp. 239.

Sehgel, K. H. Sports fisheries of India, ICAR, Publication, New Delhi, pp. 126.

9. Inland Aquatic Ecosystems and their Management

1 + 1

Classification of inland aquatic ecosystems: Different agroclimatic zones; Lentic and lotic habitats; River zonation and concept of river condition; Productivity of rivers/reservoirs, estuaries and lakes; Fish and other fauna from different aquatic ecosystems; Fishes and their relationship with abiotic and biotic environment; Effect of environment on breeding, growth and survival. Physico-chemical and biological characteristics of inland aquatic systems and their management; Holistic approach in inland fisheries management for socio-economic benefit. Ecology of rivers and their environment : Different river systems and their fishery potential; Catch composition of riverine fisheries in India; Exploitation of fisheries in rivers and its effect; Conservation and development of riverine fisheries. Reservoir fisheries in India, Productivity and fishery potential of reservoirs; Stocking policy and optimum exploitation; Strategies adopted in other countries for development of reservoir fisheries. Major estuaries, lagoons, backwaters and brackishwater impoundments in India and their fishery resources. Productivity and ecology of estuarine and brackishwater lagoons, wetlands, biosphere reserves and mangroves; Conservation and development of estuaries and lagoon fisheries; Strategies adopted in other countries for development of estuarine and lagoon fisheries.

Practical

Study of biodiversity especially, phytoplankton, zooplankton, benthos and primary productivity. Estimation of physico-chemical parameters of soil and water, with respect to environmental management and pollution abatement viz.- pH, DO, CO₂, BOD, COD, NH₄-N, NO₂, NO₃, PO₄, etc.

Suggested Readings

Dykyjova, D. and Kvet, J. 1978. Pond Littoral Ecosystems, structure and functioning Springer-Verlag, Bestons Heidelberg, New York.

Hillary, S. E. and Cloude, E. B. 1997. Dynamics of pond aquaculture, CBC Press, Boca Raton, New York.

Kare, Pecl, 1990. The Illustrated Guide to fishes of Lakes and Rivers. Treasure Press, London.

Nikolsky. 1963. The Ecology of fishes, G.V.T.F.H.Publications Inc. Ltd., Academic press, London.

Odum, E.P. 1983. Basic Ecology, Sounders College Pulishing, Holt Sanders.

Prasad, M.K.D. & Pitchaiah, P.S. 1999. Inland water resources - India Vol. I Discovery Publishing House, New Delhi.

Shellby, D. Gerking, 1978. Ecology of freshwater fish production, Ed.. Blackwell Scientific Publications.

Srivastava, U.K. & Vathsala, S., 1984. Strategy for development in Inland Fishery Resources in India Pub. Concept Publishing, New Delhi.

Talwar, P. K. 1990. Inland fishes of India and adjacent countries, vol-I, II, New Delhi, Oxford IBH publication Co.

10. Fish Physiology and Endocrinology

1 + 1

Feeding mechanism, anatomy and histology of alimentary canal, digestive fluids and enzymes. Digestion of lipid, protein, carbohydrate and absorption and digestive energy physiological studies on fish gastro-intestinal motility, excretion of nitrogen. Control of digestive function. Digestive system of shellfish and process of digestion.

The respiratory gases, respiratory organs, medium for respiratory transport, accessory respiratory organs, physiology of respiration, respiration in shellfish. Circulatory physiology. Heart and circulation, blood, red blood cells and their role in transport of nutrients, gases and hormone etc. Structure and anatomy of reproductive organ, types and mode of reproduction in finfishes and shellfishes, sexual dimorphism and secondary sexual characters, intersex and bisexuality, sex differentiation and determination. Endocrine system (structure and function of pineal, thyroid, ovary, testes and pituitary gland) in finfish. Hormonal control of oogenesis,

spermatogenesis, final oocyte maturation, spermiation, spawning, fecundity and spawning recovery. Environmental factors influencing gonadal maturation. Reproductive cycle of finfish and shellfish. Neurosecretory system and neuroendocrine regulation of reproduction in finfish and shellfish. Role of pheromones in reproduction.

Practical

Dissection and examination of digestive, respiratory, circulatory and reproductive organs, collection of pituitary gland, thyroid and inter-renals; Histology of pituitary, thyroid, ovary, testes and inter-renals, study of secondary sexual characters in finfishes and shellfishes; Hormonal manipulation of advancing maturity and breeding of fish, blood cell types and hemoglobin determination.

Suggested Readings

- Hoar, W. S. and Randall, D. J. 1984. Fish Physiology, Vol. 2,4 & 9 (Part A & B)
Linwood, S. 1999. Introduction to Fish Physiology, Narendra Pub.Co, New Delhi
Matty, A. J. 1985. Fish Endocrinology, Croom Helm,

B. SUPPORTING COURSES

1. Fish Biotechnology

2 + 1

Introduction; Definition and historical perspectives of biotechnology; Genetic engineering; Cloning, restriction / modification enzymes, plicing of DNA, plasmid vectors, phage vectors, DNA libraries, probes; hybridization, chromosome walking, polymerase chain reaction, sequencing. Fish tissue culture; Historical perspectives, tissue culture, cell culture, organ culture, cell lines, primary and secondary culture, culture media, culture vessels. Hybridoma techniques and monoclonal antibodies. Trnasgenesis : Definition, transgenic fish, detection of transgenes and application. DNA fingerprinting : Principles and applications; RFGP, RAPD; Recombinant vaccines : Development of disease resistance stock.

Probiotics and single cell protein (SCP) in aquaculture. Bioconversion of lignocellulosic wastes. Cryopreservation of gametes and embryos. Hormonal manipulation in advancing maturity and reproduction. Biofertilization, biofermentation and biofiltration. Reproductive and hormonal biotechnology, Hormonal biotechnology in aquaculture product enhancement. Isolation and purification of hormones. Principles of protein synthesis and sequencing. Introduction to hormone gene regulation and expression.

Practical

Agarose and polyacrylamide gel electrophoresis; Plasmid DNA isolation; Purification of plasmid DNA by cesium chloride - ethidium bromide ultracentrifuge; Isolation of DNA from fish blood; Restriction digestion of DNA; Ligation reaction; Bacterial transformation by calcium chloride method; Polymerase chain reaction; Elution of bands from the gel and purification; Radioimmuno assay of hormones; Cryopreservation of milt. Culture, enumeration and maintenance of probiotic cultures, isolation and chracterization of bacterial/algal cultures as inoculents and biofertilizations, immobilization of bacterial cultures for biofiltration. Radio-active isotops, principle and measurements, saftey aspects of use and handing of radioisotops; radio receptor assay, ELISA technique in hormone measurement and quantification. Electrophoresis and chromatography in hormone purification, hormone immunization and antibody development.

Suggested Readings

Fingerman, M., Nagabhushanam R. and Thompson M. F. 1997. Recent Advances in Marine Biotechnology (Vol 1-3) Oxford and IBH Publishing Co. PVT. Ltd. New Delhi

Gal, Y. Le and Halvorson, H. O. 1978. New Developments in Marine Biotechnology, Plenum Press NY.

Glick, B. R. and Pasternak, J.J. 1999 Molecular Biotechnology: Principles and Applications of Recombinant DNA Technology, A S M Press, Washington, D C.

Julio E. C. 1985. Cell Biology: A laboratory Handbook, Vol 1-3, Academic Press, New York.

Hoar, W. S. and Randal, D. J. 19 Fish Physiology, Academic Press, New York.

Lehninger, A. L. 1984. Principles of Biochemistry, C B S Publishing, New Delhi.

Primrose, S. B. 1989. Modern Biotechnology, Blackwell Scientific, Oxford.

Rodney, B. 1998. Concepts in Biochemistry, Cole Publishing Company, London.

2. Post-harvest Technology

1 + 1

Harvesting of freshwater fish. Grading of fish; Whole fish quality evaluation Packing, storage and transportation. Introduction to freezing and chilling: Historical development; principles of chilling and freezing, methods of chilling: Transportation and marketing of chilled and frozen fish. Freezing of fish: Methods of freezing, changes during freezing fish; Packaging of frozen fish; Marketing; Cold chain and export trade; Transportation and marketing of frozen products. Quality control during freezing and chilling. Fundamentals of fish preservation, drying, smoking, curing, salting, fermentation, marinating and pickles. Introduction to fish canning, principles of thermal processing, changes during canning, problems related to fish canning. Value addition in freshwater fish. Introduction to fish paste products (fish sausage and ham, etc.). Fish protein concentrate, fish hydrolysate, etc. Additives and preservatives; Fishery by-products : Fish meal, bone meal, fish oil, surgical sutures from intestine, chitin and chitosan; Fishery product packaging and packaging material; Marketing and economics of fish processing.

Practical

Whole fish quality evaluation. Visit to fish market and processing plants. Preparation of fishery products and by-products; Quality control in fresh fish; Physico-chemical analysis of fish and fishery product; Microbiological analysis of fishery products; Sensory evaluation of fish and fishery products.

Suggested Readings

Balachandran K. K. 2001. Post harvest technology of fish and fish products. Daya Publishing House, New Delhi.

Govindan, T. K. 1985. Fish Processing Technology. Oxford & IBH Pub. Co. Pvt. Ltd., New Delhi.

Zeathen, P. 1984. Thermal processing and quality of foods. Elsevier applied science publishers, London

3. Aquaculture Economics, Marketing and Co-operatives

1 + 1

Economic structure of aquaculture: Resources and potentials. Contribution of aquaculture in

national and world economy. Planning and policies for aquaculture development in different plan periods. Aquaculture farm management: Principles involved in farm management decisions. Three stages of production, principles of variable proportion and laws of diminishing return, cost principles; principle of factor substitution; law of equimarginal return, opportunity cost principle; principle of combining enterprises; Isoquant and Isoproduct curve; Iso-cost and Iso-revenue line; Returns to scale and determination of optimum size of aquaculture farm. The comparison principle. Limitations of the principles of farm-management.

Principles of Resources allocation and optimisation; Least cost resource combination and optimum product combination under limited and unlimited capital. Techniques/Tool for optimisation - Farm planning and budgeting, introduction to production function analysis and linear programming analysis. Farm business analysis - Method of asset valuation and computing depreciation. Networth statements. Concept of costs, returns and efficiency in aquaculture. Methods of working out various efficiency measures; Breaks even analysis. Profitability of different culture systems/technologies in India. Project management: Criteria for project planning, formulation, financing and evaluation, cost benefit and financial analysis (NPV, IRR, PBP, DC ratio, etc.) of aquaculture project; Procedure for preparation of bankable projects.

Risk and uncertainty in aquaculture. Decision making under uncertainty - Diversification and fish insurance schemes in India. Economic principles and techniques applied in aquaculture credit analysis - '3R' of the credit; Principles of fish insurance; Institutions involved in aquaculture financing. Market equilibrium and Price analysis : Price in perfectly competitive, Monopoly, oligopoly, and monopolistic market; Price policy models - estimation and projection of demand for and supply of Aquaculture products. Theory of distribution and factor pricing in aquaculture : Marginal productivity theory and employment, labour intensive vs capital intensive technologies in relation to consumer and producers surplus. Marketing of aquaculture products: Functions and problems in aquaculture marketing; Marketing channels and price spread; Marketing structure, conduct and performance and its relation to marketing efficiency; Government intervention in aquaculture marketing; Co-operative marketing. Concept and measurement of technological development in aquaculture; sustainability concept and environmental issues - techniques for measurement.

Practical

Demonstration of farm management principles in optimum allocation of resources and optimum combination of different enterprises. Production function and linear programming application for optimisation. Exercise for working out depreciation, costs, returns and efficiency measures in aquaculture farm. Exercise in estimation and projection of demand and supply for aquaculture products. Exercise on working out price spread and marketing efficiency for alternate marketing channels. Formulation of aquaculture project; cost-benefit and financial analysis (NPV, IRR, PBP, DC ratio, etc.). Assignment for preparation of bankable project. Measurement of technological change and sustainability through alternative approaches.

Suggested Readings

Andrew, P. 1999. Fish business management: strategy, marketing and Development, fishing

News Books, London.

FAO, 1995. Fisheries technical paper, 351. Economic engineering applied to the fishery industry.

Paul, A.S. 1973. Economics. Mc Graw Hill Kogakusha Ltd., Tokyo.

Rao, P.S.1983. Fisheries economics and management in India. Pioneer Publishers and Distributors.

Seijo, J.C. Defeo, D., Salas, S. 1998. FAO Fisheries technical paper 368. Fisheries bioeconomics - Theory, modeling and management. FAO, Rome.

Shaug, Y.C. 1981. Aquaculture economics: Basic concepts and methods of analysis, Groom Helm Ltd., Great Britain.

4. Computer Applications and Information Technology 1 + 1

Introduction to computers, Types of computers – PC, Mini and Main frames; Computer generations; Concepts of Input, Processing and Output; Input, output devices; Need for an operating system, Introduction to MS DOS and Windows operating systems; Introduction to Word processing (MS Word), Spread sheets (MS Excel) and presentation (MS Powerpoint); Flow chart; Elements of Basic programming; Application of computerized information and data analysis in fisheries; Introduction to E-mail and Internet.

Practical

Binary number system, DOS commands and Windows basics, Word processing using MS Word, Creation of spread sheet, analysis and graphical representation of data using MS Excel and presentation using MS Powerpoint, Exercises on Basic programming and hands on experience using E-mail and Internet.

Suggested Readings

Balagurusamy, E., 1989. Programming in ANSI C, Tata McGraw - Hill Publishing Co., New Delhi.

Megrey, B.A. and Moksness, E., 1996. Computers in Fisheries Research, First Edition, Chapman and Hall, U.K.

Sandler, C., Badgett, T. and Weingarten, J., 1997. Office 97 for Windows, BPB publications, New Delhi.

Trevor, A., 1995. Information Technology, Pitman Publishing Co.

5. Aquaculture Engineering–I 1 + 1

Site selection for aquaculture projects: Water supply - surface and ground water investigations,

computations for water requirements, soil type - physical and chemical investigations including soil mechanics, topography - engineering site surveys, environmental considerations, seed and other biological requirements, socio-economic consideration. Aquafarm design and construction: Types of ponds - orientation of ponds, shape, size and depth of ponds; design of embankments - soil properties, stability, dyke erosion; Water supply and drainage systems - open channel, inlet structures, drainage and water exchange structures, energy dissipating structures, sluices; layout designing and planning; design consideration for aquafarms integrated with agriculture, horticulture and animal husbandry.

Design and construction of aqua-hatcheries: Carp hatcheries, prawn hatcheries, catfish hatcheries. Aeration in aquaculture: Principles of aeration, aeration, requirements, types of aeration devices, design of aeration systems, aeration equipments. Pumps: Concept of energy transfers, types of water pumps, wind mill, design of pumps, selection of pumps. Other aquaculture equipments: Automatic feeders, demand feeders, weed control equipments, harvesting equipments, handling, preservation and transportation equipments. Design and construction of intensive aquaculture facilities: Carps, flow-through systems, recirculatory systems. Repair and maintenance of aquafarms : Repair of dykes, water channels, inlet and drainage structures, seepage control, disposal of wastewater, wastewater treatment, aquaculture equipments, electrical installations.

Practical

Engineering surveys: Principles of surveying equipments, chain survey, campus survey, levelling, contouring. Preparation of designs and drawings: Farm layout, hatchery layout, embankment design, open channel design, inlets and drainage structures. Estimating: Quality and cost estimation for fish pond construction, open channel construction, inlets and outlets. Visit to the existing farms and hatcheries.

Suggested Readings

Upadyay A. S. 1995. Hand book on Coastal Aquafarming, Academic Press London.

Thomas B. Lawson. 1985. Fundamentals of Aquacultural Engineering, CBS pub.

6. Ecotoxicology and Pollution Management

1 + 1

Bioassay - biological methods for the assessment of pollution; Ecotoxicology - the study of pollutants in the ecosystems - effects on individual organisms, indicator species, prediction of ecological effects, experimental ecosystem modifications, comprehensive ecosystem analysis. Monitoring, effects of pesticides, oils, heavy metal, organic and inorganic wastes on fishes, crustaceans and molluscs. Influence of environmental conditions on the toxicity of pollutants, acute toxicity problems. Pollution - definition, sources - sewage, industrial wastes, pesticides, oils, metals, thermal and others. Effects of pollution on fish, shellfish and fish food organisms, pollution in inland waters, estuaries and coastal environment and their management.

Environmental hazard evaluation and prediction. Aerobic and anaerobic decomposition of organic matter systems and their impact on nutrient regeneration. Eutrophication due to sewage pollution; BOD and COD as tools to assess organic load of a system. Biological indicators of pollution in natural waters. Infectious agents commonly present in polluted ecosystem. Biomagnification and bioconcentration, Biochemical pathways of degradation.

Practical

Bioassay trials with different organisms. Toxicity assessment with pesticides and heavy metals, Analysis of water and animal tissue for toxicity study. Estimation of decomposition rates of model substrates, determination of oxygen consumption during decomposition process of organic matter. Study of different physico-chemical parameters and biota from polluted environments like sewage, industrial effluents, etc. Visits to industrial establishments for an on spot study of generation of effluents and their treatments.

Suggested Readings

- Albaiges, J. 1986. Marine Pollution, Hemisphere Publishing Co., New York.
- Edward, A. L., 2000. Aquatic Pollution: An Introductory Text, John Wiley & Sons, Inc., New York.
- Hynes, H. B. N. 1996. The Biology of Polluted waters, Liverpool University Press, Liverpool.
- Richard, Lloyd, 1989. Pollution and freshwater fish - Fishing News Books, London.
- Sindermann, C. J. 1976. Ocean Pollution: Effects on Living Resources and Human, CRC Press,

7. Statistics and Design of Experiment

1 + 1

Fundamentals of probability and its definition, addition and multiplication theorem of probability; Random variable and probability distributions Binomial, poisson and normal concept of sampling distribution; hypothesis testing (students 1 distribution x2 - distribution, /f-distribution); Correlation and regression; Designs of experiments (completely randomized block design, randomized block design; Latin square design and factorial design); Sampling techniques (random sampling, stratified random sampling, cluster sampling, systematic sampling and purposive sampling).

Practical

Exercises in probability and distributions; problems in tests of significance - normal t, x2and F; problems in analysis of variance and co-variance, correlation and regression; basic concepts of design of experiments; problems to determine correlation coefficient and regression; exercise in design and evaluation of experiments.

Suggested Readings

Biradar, R.S., 1986. Course manual on Fisheries Statistics. Central Institute of Fisheries Education, Mumbai.

Panse, V.G. and Sukhatme, P.V., 1978. Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi

Raghava Rao, D., 1983. Statistical techniques in Agricultural and Biological Research, Oxford & IBH Publishing Co., Bombay.

Sokal, R.R. and Rohlf, F.J., 1998. Biometry, Freeman and Company, New Delhi.

Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Ashok, C., 1984. Sampling theory of surveys with applications. Iowa State University Press, Ames Iowa, USA

8. Aquaculture Extension

1 + 1

Programme planning process - collection of facts, situation analysis, problem identification, objective setting, planning of work, execution of plan, evaluation of progress, restructuring of planning strategy for improvement. Importance of extension programme, characteristics of good programme, participation of organisation in programme planning, involvement of people in programme planning. Training strategy in transfer of technology in aquaculture; Training strategy for training extension personnel; Role of farmers - extension and research linkage; Participatory approach in technology demonstration. Concept and function of communicator, importance of communicator in extension work, communication models, communication channels - clarification, nature and feed back in communication - its role in extension education and its effect in communication of information; problems in communication - types and nature. Diffusion of innovations; Characteristics of innovation, innovation decision process, Elements in the diffusion of innovation. Innovation and their rate of adoption, Characteristics of adoption categories. The change agents and factors in change agents success. LLP, ORP, IVLP, KVK/TTC, Voluntary organisation.

Practical

Surveys for identification of technology gaps; PRA; Skill demonstration; Preparation of leaflets, pamphlets, maps, charts, etc.; Technology input assessment survey.

Suggested Readings

Anon, 1980. Seminar on fisheries extension, status report and background papers, CMFRI, Kochi.

Dahama, O. P. 1993. Extension and rural welfare. Ramprasad and Sons, Agra.

Dhote, A. K. 1989. Fisheries management and extension : Inland fisheries, instructional-cum-practical manual (VI), National Council of Educational Research and Training, New Delhi.

Lynton, P. R. and Pareek, U. 1978. Training for development Kumarian Press, 29 Bishop Road, West Hartford, Connecticut 06119.

Ray, G. L. 1991. Extension communication and management, Naya Prakash, Calcutta.

Rao, T. V. 1991. Readings in human resource development. Oxford and IBH Publishing Co. Pvt. Ltd. New.

Supre, S. V. 1986. An introduction to Extension Education, Oxford and IBH Publishing Co., New Delhi.

2. ACQUACULTURE

2.2 MARICULTURE

A. Major Courses

A.1 Core Courses

| | | |
|----|---|-------------------|
| | | 12 Credits |
| 1. | Physiology, Pathology and Cytogenetics of finfish and shellfish | 2 + 1 |
| 2. | Culture of Crustacea | 2 + 1 |
| 3. | Culture of Mollusca | 2 + 1 |
| 4. | Culture of finfishes and sea cucumbers | 2 + 1 |
| | Seminar | 0 + 1 |
| | | 1 Credit |

A.2 Optional Courses

| | | |
|-----|--|-------------------|
| | | 12 Credits |
| 1. | Ecology of Culture Systems | 2 + 1 |
| 2. | Culture and utilization of seaweeds | 1 + 1 |
| 3. | Gametogenesis, Spawning & Embryonic development | 2 + 1 |
| 4. | Induced Maturation and Cryopreservation of gametes | 2 + 1 |
| 5. | Physical & Chemical basis of Genetics | 2 + 1 |
| 6. | Genetic Engineering | 2 + 1 |
| 7. | Quantitative Genetics | 2 + 1 |
| 8. | Nutritional Requirements | 2 + 1 |
| 9. | Evaluation of Feeds | 2 + 1 |
| 10. | Fish and Shellfish Diseases | 2 + 1 |
| 11. | Hygiene, Treatment of Diseases and Fish Health | 2 + 1 |
| 12. | Immunology | 2 + 1 |

B. Supporting Courses

| | | |
|----|---|-------------------|
| | | 10 Credits |
| 1. | Biostatistics and Computer Application | 1 + 1 |
| 2. | Instrumentation and Microtechniques | 2 + 1 |
| 3. | Biochemistry and Nutrition of finfish and shellfish | 2 + 1 |
| 4. | Mariculture Economics, Extension and Management | 2 + 1 |
| 5. | General aspects and Ecophysiology of reproduction | 2 + 1 |
| 6. | Aquaculture Feed Formulation & Production Technology | 2 + 1 |
| 7. | Aquaculture Engineering-II | 2 + 1 |
| | Any other course(s) suggested by Student Advisory Committee | |

Total

35 Credits

A. MAJOR COURSES

A1. CORE COURSES

1. Physiology, Pathology and Cytogenetics of Finfish and Shellfish 2 + 1

Physiology: Comparative physiology of respiratory, digestive, excretory and circulatory respiratory, digestive excretory and circulatory systems; Osmo-regulation; Hormonal control of osmotic and ionic regulation; Organisation of the neurons and neuro-muscular system; Mechanism of neurons co-ordination; Sense organs - receptor mechanisms and effector systems; Biological rhythms. Ecophysiology - Environmental requirements; effect of salinity, oxygen and other abiotic factors on metabolism, moulting and growth; Effect of environmental factors on acid-base regulation; Biotic interaction; Bioassay and its implication in mariculture. Endocrinology -general morphology, structure and function of neurosecretory system. Reproductive physiology - anatomy of male and female reproductive systems and secondary sexual characters; Process of gametogenesis; neuroendocrine control of reproduction; Hermaphroditism; Parasitic castration.

Pathology : History; Intrinsic and extrinsic causes of diseases; Basic vascular and cellular alterations; disturbances in circulation, cell metabolism and cell growth, necrosis, inflammation; defenses of the body against injury; Healing and neoplasms. Microbial diseases - viral, bacterial and fungal diseases and their control. Parasitology - protozoan and metazoan parasites, nutritional diseases, toxic diseases; Prophylactic and control measures, biological and chemical treatment of diseases, vaccination, integrated disease management.

Cytogenetics: Components of animal cell and their functions; Mitosis and meiosis; Methodology of chromosome preparation; Chromosomal rearrangements; Polymorphism and evolution; Sex determination mechanism and sex chromosomes; Marine genetics, hybridization and hybrids, polyploidy, kinogenesis, androgenesis.

Practical

Determining the rate of particle filtration in a bivalve at two different salinities; Volume and weight changes in *Onchidium* in heterosmotic medium; effect of salinity on oxygen uptake in a prawn / fish; effect of partial pressure of oxygen on oxygen uptake in a prawn / fish; Short term bioassay studies to determine LC50 levels of selected pesticides / heavy metals - demonstration. Dissection of neuroendocrine organs of a candidate species; Preparations of chromosomes from a fish.

Suggested Readings

Bliss, D.E, 1983. The Biology of Crustacea, Vol.1-10. Academic Press, New York.

- Evans, D.H., 1998. The Physiology of Fishes. CRC Press, Boca Raton, USA.
- Gunter Obe, 1987. Cytogenetics- Basic and Applied Aspects. Springer Verlag, New York.
- Hoar, W.S., Randall, D.J. and Donaldson, E.M., 1969-1983. Fish Physiology, Vol.2, 4 and 9 (Part A and B). Academic Press, New York.
- Lagler, K.F., Bardach, J.E., Miller, R.R. and May Passino, D.R., 1977. Ichthyology. John Wiley and Sons, New York.
- Matty, A.J., 1985. Fish Endocrinology. Timber Press, Portland.
- Potts, G.W. and Wotton, R.J., 1984. Fish Reproduction: Strategies and Tactics, Academic Press, London.
- Roberts, R.J., 1991. Fish Pathology. Bailliere Jindall, London.
- Schaperclaus, W., 1991. Fish Diseases, Vol. 1 & 2. Oxonian Press Pvt. Ltd., New Delhi.
- Sinderman, C., 1990. Principal Diseases of Marine Fish and Shellfish. Academic Press, New York.

2. Culture of Crustacea

2 + 1

Overview of crustacean culture in the world: Major species used, production trends, technologies and problems; crustacean culture in India: historical background and recent advances; species cultured, potential species, general biology and characteristics of their suitability for aquaculture; prawn seed production - natural seed resources, their distribution and abundance; collection and transportation; hatchery production of seed, brood stock management and breeding under controlled conditions, induced breeding, larval rearing techniques and mass production for seed; recent advances in seed production technology for crabs and lobsters; nursery phase; different kinds of grow-out culture systems; traditional and modern farming techniques; extensive, semi-intensive, intensive and super-intensive shrimp farming in different maritime states and production details, prawn culture in salt-pan reservoirs, raceways, cages, pens and recirculating systems, sea ranching of prawns; culture practices and potentials for crabs and lobsters.

Practical

Identification of larval, postlarval, juvenile and adult stages of cultivable prawns, lobsters and crabs; dissection of the female reproductive system and determination of maturity stages of the penaeid prawn; examination of mature sperm and ovum; hatchery observation of induced breeding, spawning, egg hatching and rearing of nauplius to postlarvae; observation on prawn filtration practice; participation in a modern prawn culture operation and assessing growth and production rates.

Suggested Readings

- Bardach, J.E., Ryther J.H. and Mc Larney, W.O., 1972. Aquaculture -The Farming and Husbandry of Freshwater and Marine organisms. John Wiley & Sons, New York.
- Fast, A.W. and Lester, L.J., 1992. Marine Shrimp Culture-Principles and Practices. Elsevier Science Publishers, Amsterdam.
- Iverson, E. S., 1976. Farming the edge of the sea. Fishing News Books, London.
- James M.P., 1993. Handbook of Mariculture, Second edition. Vol.1. Crustacean Aquaculture, CRC Press, Florida.
- Korringa, P., 1976. Farming marine fishes and shrimps. Elsevier Science Publishers, New York.
- Milne, P. H., 1972. Fish and Shellfish Farming in Coastal Waters. Fishing News Books, London.
- MPEDA (Marine Products Export and Development Authority), 1996. A Manual of Shrimp farming. MPEDA, Kochi, India.
- Pillay, T.V.R., 1970. Coastal Aquaculture in the Indo-Pacific Region. Fishing News Books, London.

3. Culture of Mollusca

2 + 1

Overview of culture of molluscs in the worlds; Major species of oysters, pearl oysters, mussels, clams, cockles, scallops and abalones in aquaculture, countries, culture systems and principles, modern developments; Culture of molluscs in India: Historical background, present status and potential; Candidate species and the criteria for their selection for culture; Seed production - natural seed resources, their distribution and abundance, collection techniques; Hatchery production of seed - brood stock management, induced maturation and spawning, larval rearing techniques, spat settlement and spat collection, water quality, disease control and transportation of seed; Oyster farming - site selection, farm structure, farming techniques, monitoring growth and condition index, control of predators and harvesting of edible oysters and pearl oysters; Techniques of pearl production - conditioning of oysters, nucleus implantation and post-operative care, pearl sac theory and pearl production; Inventory of an edible oyster and a pearl oyster farm; Biofouling in oyster farms and control measures; Mussel culture methods; Monitoring growth and condition index and harvesting; Clam and cockle culture methods; Abalone culture methods and sea ranching; Experimental culture of cephalopods; Effect of toxic algal blooms on cultured molluscs and human beings; present processing technology for cultured molluscs.

Practical

Determination of maturity stages in a bivalve, identification of larvae of cultivable molluscs setting up of spat collectors; Identification of nanoplankters; Breeding techniques and development of pearl oyster and edible oyster; Raft construction and fabrication of box-net

cages for oyster culture; Estimation of growth and condition index in oysters; Pearl oyster surgery for nucleus implantation; Depuration of oysters; field visit to a mussel/oyster farm and observe culture practices; Collection and identification of foulers and predators in an oyster farm.

Suggested Readings

Alagarswami, K., 1991. Production of cultured pearls. ICAR, New Delhi.

Gosling, E., 1992. The Mussel *Mytilus*: Ecology, Physiology, Genetics and Culture. Developments in Aquaculture and Fisheries Science, Vol. 25. Elsevier Publication, London.

Hikoaida, C. P., 1992. The Giant clam: an ocean culture manual. Published by Australian Center for International Agricultural Research, Canberra.

James, P.S.B.R. and Narasimham, K. A., 1991. Molluscs, MPEDA, Cochin.

Korringa, P., 1976. Farming the cupped oysters of the genus *Crassostrea*. Elsevier Science Publishers, New York.

Lutz, R.A., 1980. Mussel culture and Harvest: A North American Perspective. Elsevier Publication, New York.

Quayle, D. B. and Newkirk, G.F., 1989. Farming Bivalve Molluscs: Methods for Study and Development. World Aquaculture Society, Baton Rouge, LA

Shummway, E. S., 1992. Scallops: Biology, Ecology and Aquaculture. Elsevier Publication.

4. Culture of Finfishes and Sea Cucumbers

2 + 1

Finfish culture: Overview of marine and brackishwater finfish culture in the world -major species cultured, technologies, country-wise production, recent advances, problems. Finfish culture in India: Historical background and recent advances, marine and brackishwater species cultured, characteristics and criteria for selection of species for mariculture. Seed production: Natural seed resources, their distribution, abundance, collection, acclimatisation and transportation of seed. Hatchery technology: Brood stock management and breeding under controlled conditions, induced breeding, egg incubation, larval rearing and mass production of seed. Nursery and rearing phase: Pond preparation. Water quality management. Live feed culture and feeding regime. Different kinds of grow-out culture systems: Traditional and improved farming practices in different maritime states and production trends; Their advantages and disadvantages. Operational details of monoculture and polyculture of selected species like milkfish, mullets, seabass; Finfish mariculture in cages, pens, raceways and running water systems; Sea ranching of finfish; Integrated farming. Marine ornamental finfish culture: Breeding and culture of selected marine ornamental finfishes; Prospects and trade potential. Sea cucumber culture: Present status of sea cucumber culture in the world; natural resources. Recent advances in breeding, seed production and culture of sea cucumbers in India.

Practical

Identification of cultivable marine and brackishwater finfish and marine ornamental finfishes. Collection and identification of fish seed from nature. Determination of maturity stages in a finfish. Observation on techniques of induced breeding and larval rearing on cultivable ornamental fishfishes. Field observation on culture operations of finfish in ponds, cages and pens. Identification of cultivable species of sea cucumbers and their larvae. Visit to a sea cucumber farm. Observation on sea cucumber breeding and larval rearing techniques.

Suggested Readings

Bardach, J.E., Ryther J.H. and Mc Larney, W.O., 1972. Aquaculture - The Farming and Husbandry of Freshwater and Marine organisms. John Wiley & Sons, New York.

Brown, E.E., Gratzek, J.B., 1980. Fish Farming Handbook. AVI Publishing Company, Westport, USA.

CMFRI (Central Marine Fisheries Research Institute), 1994. Proceedings of the national workshop on Bache-de-mer. Bulletin No. 46, CMFRI, Cochin, India.

Huet, M., 1972. Textbook of Fish Culture: Breeding and Cultivation of Fish. Fishing News Books, London.

James M.P., 1983. Handbook of Mariculture, CRC Press, Florida

Oren, O.H., 1981. Aquaculture of Grey Mulletts. Cambridge University Press, London.

Pillay, T.V.R., 1995. Aquaculture: Principles and Practices, Second Edition. Fishing News Books, London.

A2. OPTIONAL COURSES

1. Ecology of Culture Systems (Ponds & Open Sea)

2 + 1

Physical characteristics of water: Role of temperature, salinity, light turbidity, depth and wind in coastal water bodies; circulation and mixing pattern in ponds; density dependent factors and carrying capacity in aquatic systems; effect of monsoons on open sea and pond culture systems. Chemical characteristics of water: Coastal ecosystem analysis; carbon-dioxide system; dissolved oxygen; hydrogen ion concentration; nitrogen and phosphorus cycles; and organic cycling in coastal culture ecosystems. Sediment-water interactions: Classification, physical and chemical properties of soil / sediments; sedimentation process; alkalinity, hardness, COD, BOD, Redox potential, minerals and trace elements in culture ponds. Primary and Secondary production in coastal ecosystems: Phytoplankton, benthic algae, primary production, estimation of primary production, pigment analysis, eutrophication; zooplankton, secondary production, limiting factors, ecological energetics and conversion ratio.

Microbiology of culture ecosystems: Classification of aquatic micro-organisms, sampling, isolation and purification of major groups of microbes from culture systems; identification and enumeration of major microbial groups; Types of bacteria, fungi, actinomycetes in culture systems; growth and reproduction in bacteria; factors influencing microbial population. Pathogenic bacteria, role of bacteria in regeneration of nutrients and hydrogen sulphide production.

Pollution aspects and water quality management: Nitrogen and ammonia toxicity; sledge accumulation, aerobic and anaerobic degradation of organic matter; sulphur cycle in pond bottom; effect of organic and inorganic fertilizers on pond productivity; optimum ecological factors and water quality management in culture systems.

Practical

Analysis of water samples for physical, chemical properties, analysis of sediments, size-wise, identification of fauna, estimation of COD and BOD, methods of estimating primary production, enumeration of various zooplankton organisms, biomass estimation; identification and enumeration of major microbial groups, types of bacteria, fungi and actionomycetes identification with special reference to pathogenic bacteria, estimation of pollutants and water quality management in culture systems.

Suggested Readings

Clesceri, L.S., Greenberg, A.E. and Eaton, A.D., 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. American Public Health Association, Washington.

Cushing, D.H., 1976. The Ecology of the Seas. Blackwell Scientific Publication, London.

Gerking, S.D., 1978. Ecology of Freshwater Fish Production. Blackwell Scientific Publications,

London.

Igna, H.S. and Boyd, C.E., 1997. Dynamics of Pond Aquaculture. CRC Press, New York.

Karel, P., 1990. The Illustrated Guide to Fishes of Lakes and Rivers. Treasure Press, London.

Nikoisky, G.V., 1963. The Ecology of Fishes. Academic Press, London.

Raymont, J.E., 1980 & 1983. Plankton and Productivity in the Oceans, Vol. 1 & 2. Pergamon Press, New York.

2. Culture and utilization of Seaweeds

1 + 1

Systematics and biology of seaweeds: Introduction to marine plants. A review of marine plants in India and elsewhere; Taxonomy of economic seaweeds; Seaweed morphology, histology; reproduction and life cycle; Growth of seaweeds and factors affecting it. Other physiological aspects in seaweeds. Resources and distribution: Resource potential in India and in the world. Distribution of seaweeds in India, factors influencing distribution. Methods for estimation of standing crop and production.

Seaweed culture: Present status of seaweed culture in the world; Seaweed culture in India - site selection, design of culture ponds and transplanting; Determining growth pattern and environmental monitoring, problems and prospects. Small scale and commercial scale culture operations. Utilization of seaweeds: Post-harvest technology of cleaning, washing, drying and storage; Chemical composition of seaweeds; Processing and extraction of agar, alginic acid, mannitol and carrageenan. Uses of agar, algin, manitol, carrageenan and other uses of seaweeds.

Seagrasses: Importance of seagrasses; Research on seagrass ecosystems in the world; Resources and distribution of seagrasses in India; Production ecology and physiology of seagrass beds; Ecology of seagrass environment, importance of seagrass beds as nursery grounds.

Practical

Identification of economic seaweeds and their reproductive bodies; Field study of distribution and zonation of seaweeds; Preparation of media; Collection of seaweed material. Initiation of cultures; Visit to a small-scale seaweed farm, learning construction of frames, seeding and measurement of production; Field visit to observe harvesting methods; Visit to a commercial extraction unit and observe its operation and extraction of algin and agar; Identification of common seagrasses.

Suggested Readings

Bird, K.T. and Benson, P.H., 1987. Seaweed Cultivation for Renewable Resources. Elsevier Science Publishers, New York.

Chapman, A.R.O., 1992. Fourteenth International Seaweed Symposium. Kluwer Academic Press, London.

- Chapman, V. J. and Chapman D. J., 1980. Seaweed and their uses. Methuen & Co., London.
- CMFRI (Central Marine Fisheries Research Institute), 1987. Seaweed research and utilization in India. CMFRI Bulletin No. 41, CMFRI, Cochin, India.
- FAO (Food & Agriculture Organization), 1975. Seaweed Resources of Indian Ocean, FAO Tech. Pap. No. 1. FAO, Rome.
- Lobban, C.S., 1985. The Physiological Ecology of Seaweeds. Cambridge University Press, London.
- Luning, K., 1990. Seaweeds. John Wiley & Sons, New York.
- Mc Roy, C.P., 1977. Seagrass Ecosystems. Marcel Dekker Inc, New York.

3. Gametogenesis, Spawning & Embryonic development **2 + 1**

Reproductive organs, their morphology, anatomy and histology; Maturation process, maturity stages, fecundity; Spermatogenesis, oogenesis; Environmental factors influencing gonadal maturation; Breeding periodicity; Mating and insemination; Fertilization, sperm transport, penetration of egg membrane, polyspermy; Embryogenesis - morphological and chemical changes during embryonic development

Practical

Reproductive organs- fish, crustacean, mollusc and maturity stages. Determination of gonadosomatic index (GSI). Estimation of fecundity of a finfish or crustacean. Histological examination of any one type species for studying gametogenesis. Study of sperm structure in fish, crustacean and molluscs. Studying embryonic development in an easily spawnable species (location - Tuticorin / Mandapam / Cochin).

Suggested Readings

- Bruce, T.J., 1984. Evolutionary Genetics of Fishes. Plenum Press, New York.
- Douglas, T., 2001. Genetics for Fish Hatchery Managers, Second Edition. Kluwer Academic Publishers, Baton.
- Purdom, C.E., 1993. Genetics and Fish Breeding. Chapman & Hall, London.
- Schroder, J.H., 1973. Genetics and Mutagenesis of Fish. Springer Verlag, New York.

4. Induced Maturation and Cryopreservation of gametes **2 + 1**

Neurosecretory and endocrine systems in fishes and shellfishes, their organisation, morphology and structure - sinus gland complex and 'x' organ, 'y' organ and androgenic gland in crustaceans, neurosecretory cells in molluscs, pituitary and endocrine organs of fish. Neurosecretory substances and hormones, their storage, release and control of reproduction. Sex reversal

phenomenon, hermaphroditism and parasitic castration; Biochemical aspects of hormone actions; Moulting, growth and reproduction in crustaceans.

Induced maturation and spawning in finfish, crustaceans and molluscs, induced ovarian maturation and spawning through physical, chemical and biological methods, use of hormonal analogues, hypophysation in finfishes. Eyestalk ablation technique - its principles and application in crustacean hatcheries, Broodstock development and maintenance, acceleration of maturation of broodstock through environmental and nutritional factors, water quality and disease management, special facilities - cages, pens, polyhouses, land-based tanks etc. Cryopreservation, short-term preservation and cryogenic preservation. Artificial insemination, in-vitro fertilization.

Practical

Dissection of neuroendocrine system of a shrimp and a mollusc; eyestalk ablation in shrimp, cryopreservation of gametes and electroejaculation of spermatophores; dissection of endocrine organs of fish.

Suggested Readings

Lutz, C.G., 2001. Practical Genetics for Aquaculture. Fishing News Books, London.

Muir, J.F. and Roberts, R.J., 1992. Recent Advances in Aquaculture, Vol. IV, Blackwell Scientific Publishers, London.

Jamieson, B.G.M., 1991. Fish Evolution and Systematics. Evidence from Spermatozoa, Cambridge University Press, UK.

5. Physical and Chemical basis of Genetics

2 + 1

Classical genetics: Dominance and its variations, Multiple alleles, Epistasis, Additive gene action, Linkage and crossing over of genes, Lethal and deleterious genes. Cytogenetics: Chromosomal individuality, Chromosome abnormalities, Changes in chromosome number (ploidy). Biochemical genetics: Concept of biochemical genetics, Isozymes, Allozymes, Electrophoresis technique, Analysis of electrophoretic data. Molecular genetics: Structure of nucleic acids viz., primary and secondary structure of DNA and RNA, Genetic code, Organization, regulation and expression of gene. Mutation: Mutation types, Molecular basis of mutation, Spontaneous mutations, Induced mutations, Reversion analysis.

Practical

Preparation of metaphase plates, Extraction of proteins and enzymes; polyacrylamide gel electrophoresis and staining techniques.

Suggested Readings

Das, P. and Jhingran, A.G., 1989. Fish Genetics in India. Today and Tomorrow's Publishers, New

Delhi.

Gardner, E.J., 1964. Principles of Genetics. John Wiley & Sons, London.

Gosden, J.R., 1994. Chromosome Analysis Protocols, Vol.29. Humana Press, Totowa.

Lehninger, A.L., 1984. Principles of Biochemistry. CBS Publishing Co, New Delhi.

Pasteur, N., Pasteur, G., Catalan, J. and Britton, D.J., 1988. Practical Isozyme Genetics. John Wiley & Sons, New York.

Sharma, A.K. and Sharma, A., 1985. Advances in Chromosome and Cell Genetics. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Sinnot, E.W., Mc Graw, L.C.D. and Dobghansky, T., 1953. Principles of Genetics. McGraw Hill Publishing Company Ltd., New Delhi.

6. Genetic Engineering

2 + 1

Isolation and analysis of nucleic acids: Isolation of Nuclear DNA, mt DNA, plasmid DNA and mRNA; Restriction mapping, blotting and hybridization, DNA sequencing. Outline of gene manipulation: Enzymes for gene manipulation, Gene cloning, Vectors for cloning, Principle of recombinant DNA techniques, cDNA and DNA probes, Gene libraries; Artificial synthesis of DNA and In-vitro chemical amplification of DNA (PCR), Development of transgenic fish. Manipulation of chromosome sets: Induction of ploidy, Gynogenesis and androgenesis, Genetic control of sex. Cryopreservation of gametes and embryos: Extenders, Cryoprotectants, Equilibration, Thawing, Ice-seeding, Vitrification, Problems and prospects of fish embryo cryopreservation, blastomere isolation and freezing.

Practical

Basic biochemical calculations, Methods in microbiology, Isolation of total DNA from fish, shellfish and bacterial pathogens, Isolation of plasmid DNA from bacteria and mt DNA from fishes, Nucleic acid electrophoresis and fluorescent staining techniques, Restriction enzyme analysis of nucleic acid.

Suggested Readings

Boyer, R., 1999. Concepts in Biochemistry. Cole Publishing Company, London.

Fingerman, M., Nagabhushanam, R. and Thonpson, M.F., 1999. Recent Advances in Marine Biotechnology (Vol. 1-3). Oxford and IBH Publishing Co. Ltd., New Delhi.

Gal, Y.L. and Halvorson, H.O., New Developments in Marine Biotechnology., Plenum Press, New York.

Glick, B.R. and Pasternak, J.J., Recombinant DNA Technology. ASM Press, Washington, D C

Innis, M.A., 1990. PCR Protocols-A Guide to Methods and Applications, Academic Press, New York.

Padhi, B.K. and Mondal, R.K., 2000. Applied Fish Genetics. Fishing Chimes, Vishakhapattanam

Primrose, S.B., 1987. Modern Biotechnology. Blackwell Scientific Publication, Oxford.

Watson, J.D., 1987. Molecular Biology of the Gene. The Benjamin Cummings Publishing Co., UK.

7. Quantitative Genetics

2 + 1

Characteristics of quantitative traits: Concept of value - phenotypic value, genotypic value and its components; Variance and its components - Genotypic environmental and interactions variance; Partitioning of genotypic variance; Heritability. Gene frequency: Hardy Weinberg equilibrium and factors affecting gene frequency. Selection: Artificial selection, Genetic effects of selection, Basis of selection for quantitative traits - Individual selection, pedigree selection, progeny testing, selection on the basis of collateral relatives; Selection for combining ability - Recurrent selection and Recurrent reciprocal selection; Methods of selection - Tandem selection, independent culling methods, selection index. Breeding systems: Inbreeding - Inbreeding and relationship, genetic and phenotypic effects of inbreeding, uses of inbreeding. Outbreeding - Concept of out crossing, cross breeding and species hybridization, systems of cross breeding; Genetic and phenotypic effects of out breeding.

Practical

Analysis of variance of half sib and full sib data and estimation of heritability, estimation of coefficient of relationship, Estimation of inbreeding coefficient, Estimation of allelic frequency.

Suggested Readings

Burns, G.W., 1989. The Science of Genetics, Sixth edition. Mac Millan Publication, New York.

Falconer, D.S., 1989. An Introduction to Quantitative Genetics, Third edition. ELBS Publisher, England.

Gall, G.A.E. and Busack, C.A., 1986. Genetics in aquaculture. Elsevier Science Publishers, Amsterdam.

Kripichnikov, V.S., 1981. Genetic Bases of Selection in Fishes. Springer Verlag, Berlin.

Simmons, M.J. and Snustad, D.P., 2000. Principles of Genetics. John Wiley Publication, New York.

Tiews, K., 1986. Selection, Hybridization and Genetic Engineering in Aquaculture, Vol.2., Springer Verlag, Berlin.

8. Nutritional Requirements

2 + 1

Body composition; Gross protein requirements; Nitrogen balance; Essential and non-essential amino acids and their quantitative requirements; Protein metabolism and synthesis; Energy utilization - Sources; Metabolism and calorimetry; Energy- protein rations; Lipids- functions and requirements; Carbohydrates, their sources and requirements; Requirements of vitamins and minerals; Larval and broodstock. Nutrition. Food and feeding behaviour, feeding strategies, feed delivery systems; Anatomy and physiology of the digestive tract; Mechanisms crustaceans and molluscs; Mechanisms of digestion and absorption; Food assimilation and digestive enzymes; Physiological energetics; Active transport of nutrients and their conversion; Nutritional factors and growth; Environmental factors and growth; Growth rates and models.

Practical

Proximate composition analysis of feeds and feed ingredients viz., moisture, crude protein, crude fat, crude fibre, ash, acid insoluble ash and nitrogen free extractives. Determination of the energy content of feeds by bomb calorimetry. Culture of artemia and determination of hatching efficiency. Dissection of the digestive system of a herbivorous, carnivorous and omnivorous finfish and shrimp. Determination of gut contents. Estimation of a protease, lipase and amylase in fish. Exercises to calculate energy budget.

Suggested Readings

CMFRI (Central Marine Fisheries Research Institute), 1982. Manual of Research Methods for fish and Shellfish Nutrition, CMFRI Special Publication No.8, CMFRI, Cochin, India.

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

Halver, J.E., 1989. Fish Nutrition. Academic Press, California.

Love, R.M., 1980. The Chemical Biology of Fishes Vol. 1 and 2., Academic Press, London.

NRC (National Research Council) 1983. Nutrient requirements of warm water fishes and shellfishes. In: Nutrient Requirements of Domestic Animals VIII. National Academy Press, Washington D.C

NRC (National Research Council) 1993. Nutrient requirements of fish. National Academy Press, Washington D.C

Stickney, R.R., 1994. Principles of Aquaculture. John Wiley & Sons, New York.

Tacon, A. G.J., 1990. Standard Methods for the Nutrition and Feeding of Farmed Fish and Shrimp, Vol.1-3. Argent Laboratories Press, Washington D.C.

9. Evaluation of Feeds

2 + 1

Fish husbandry techniques and designs of experiments; evaluation of feeds, chemical methods of evaluation, biological methods of evaluation - PER, BV, NPU, NPR and FCR; Digestibility of feeds in fish and shellfish; Methods of determining digestibility coefficients; Single cell protein in aquaculture feeds; Recent advances in nutrition research.

Practical

Determination of iodine number, anisidine value, saponification number and fatty acids and cholesterol in feeds. Calculation of the essential Amino acid Index and chemical score. Animal experiments with fish / shrimp to determine the PER, BV and FCR. Estimation of the digestibility coefficient employing chromic oxide.

Suggested Readings

ADCP (Aquaculture Development and Coordination Programme), 1980. Fish Feed Technology, ADCP/REP/80/11. FAO. Rome.

Cho, C.Y., Cowey, C.B. and Watanabe, T., 1985. Finfish Nutrition in Asia, Methodological Approaches to Research and Development, Publication No.IDRC-233e. International Development Research Centre, Ottawa

Cowey, C.B. and Mackie, A.M., 1985. Nutrition and Feeding in Fish, Academy Press, London.

D' Abramo, L.R., Conklin, D.E. and Akiyama, D.M., 1997. Crustacean Nutrition: Advances in Aquaculture, Vol.6. World Aquaculture Society, Baton Rouge, LA.

Goddard, S., 1996. Feed management in intensive aquaculture. Chapman & Hall New York.

Guillaume, J., Kaushik, S., Bergot, P. and Metailler, R., 2001. Nutrition and Feeding of Fish and Crustaceans. Springer Praxis Publishing, Chichester, UK.

Lovell, R.T., 1989. Nutrition and feeding of fish. Van Nostrand Reinhold, New York.

10. Fish and Shellfish Diseases

2 + 1

Causes of diseases: Etiology; Classification of diseases; Role of abiotic and biotic factors; Intrinsic factor such as generic, species and strain; Extrinsic factors - environment and nutritional status. Viral, bacterial and fungal diseases; Diseases caused by protozoans, worms, crustaceans; Environmental and nutritional diseases; Tumours in fishes; toxic diseases and other emerging diseases. 'EUS' and other ulcerative dermal necrosis; Gad-bubble diseases; Low-temperature diseases; Water-borne irritants; Blue sac, white spot and yolk-sac deformity disease of larvae; Colouration anomalies in cultured marine flat fish; Sunburn and effect of U.V. radiation; Traumatic injuries.

Nutritional disease; Deficiencies and imbalances of major dietary components; Toxic components of the diets. Role of stress in disease process and its control measures. Microbial

Biotechnology in Fish Pathology: Marine biotechnology origin and prospects in fish Pathology. Recent advancement in detection of pathogens in shellfish and finfish; PCR principle and its application in rapid detection of disease; Use of DNA probes; Tissue cell lines for detection of viruses in shrimp; Plasmids and its isolation. Environmental Bio-remediation and disease management. Drugs and chemicals used in Aquaculture: Immunostimulants, Probiotics, DMS, Drugs and Chemicals.

Practical

Procedure for collection of diseased specimen; Examination of fish; Selection of fish; Duthamasias; Post-mortem procedure; Selection and sampling of material; Diagnosis by examination of infected samples; Wet mounts; Stained smears; Cultural techniques for confirmed diagnosis; Isolation of bacteria; Selective media; Non-selective media; Incubation-Temperature, time and O₂ conditions; Identification of bacteria; Gram-positive, gram-negative and acid test; Purification of mixed cultures by "Plating out" procedures; Selective media for fish bacterial pathogens; Serological methods.

Suggested Readings

Austin, B. and Austin, D.A., 1987. Bacterial fish pathogens: Diseases in farmed and wild fish. Ellis Horwood, New York.

Austin, B. and Austin, D.A., 1989. Methods for microbiological examination of fish and shellfish. John Wiley & Sons, New York.

Ellis, A.E., 1985. Fish and Shellfish Pathology. Academic Press, London.

Kabata, Z., 1985. Parasites and diseases of fish cultured in the tropics. IDRC, Taylor & Francis, London.

Kinne, O., 1980. Diseases of Marine Animals, Vol. I-IV. John Wiley & Sons, Chichester, UK.

Leatherland, J.F., Woo, P.T.K. and Bruno, D.W., 1998. Fish Diseases and Disorders, Vol. I-III. CABI Publishing, Oxon, UK.

11. Hygiene, Treatment of Diseases and Fish Health

2 + 1

Influence of pond sanitation on fish health and public health; Importance of fish health in aquaculture; Factors favouring occurrence of diseases among cultivated fishes and shellfishes - effect of overcrowding, malnutrition and unfavourable water quality.

Methods of treatment: Chemical treatment through water, chemical treatment through feed and treating fish with chemical directly; Criteria for selection of chemicals for disease control; Ratio between lethal dose for pest and fish, safety of handling, effect on pond's productivity, fish etc., commonly employed chemicals, their dosages and methods of administration for different diseases; precautions needed; National and international aspects of disease control;

Coordination and managements; Significance of preventive, regulatory and control measures of communicable diseases; Importance of health inspection and certifications.

Practical

Sterilization of equipments used in ponds; Preparation of disinfectants and preparing protocols for their application to prevent viral, bacterial and fungal diseases outbreak; Visits to culture ponds and monitoring water quality, assessing health of stocked organism by bacteriological histopathological methods; Preparing protocols for correction of water quality; Preparing protocols for antibacterial and antifungal treatment.

Suggested Readings

Ellis, A.E., 1988. Fish vaccination. Academic Press, New York.

Humphrey, J., 1997. Aquatic Animal Quarantine and Health Certification in Asia. FAO Fisheries Tech. Pap. 373, FAO, Rome.

Perkins, F.O. and Cheng, T.C, 1990. Pathology in Marine Science. Academic Press, London.

Stoskopf, M.K., 1993. Fish Medicine. W. B. Saunders Company, Philadelphia.

Tacon, A.G.J., 1992. Nutritional fish pathology. Morphological signs of nutrient deficiency and toxicity in farmed fish. FAO Fish Technical Paper No.330. FAO, Rome.

12. Immunology

2 + 1

Nonspecific immunity: Agglutinins and precipitins, C-reactive protein, complement in fish, phagocytosis; acquired immunity: Cell mediated immunity - Role of thyones, T-Cell receptors, mechanism of cell mediated immunity, cytokines, T-helper function, role of macrophages; Recirculation and ecotaxis of T-Cells; T-cell markers; Humoral immunity - Origin of B-Cells, differentiation of B-cells into plasma cells, T-and B-cell interaction; Antigenic stimulation; memory cells; Structure of antibody; Types of antibodies produced in fish; Types of immune reaction; Genetic control of immune response; Different theories of immune specificity; Techniques to demonstrate immune reactions; Immune complex mediated inflammatory reactions; Defective immune mechanisms; Auto-immune reactions; Interaction of antibody with antigen and applications in laboratory investigations; Immunization in fish and vaccination; Defense mechanism in invertebrate animals.

Practical

Collection, separation and identification fish leucocytes and invertebrate haemocytes; Analysis of phagocytic activity both by invitro and invivo methods; Erythrocyte rosette formation demonstration; Raising of antibodies in laboratory animals and fish; Agglutination test to detect antibodies; Gel diffusion techniques.

Suggested Readings

Hergenberg, L.A., weir, D.M., Hergenberg, L.A. and Blackwell, C., 1996. Weir's handbook of experimental immunology, Vol.4: The Integrated Immune System. Blackwell Science Ltd, USA.

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

Stolen, J.S., Feltcher, T.C., Anderson, D.P., Roberson, B.S. and Van Muiswinkel, 1990. Techniques in Fish Immunology, SOS Publication.

B. SUPPORTING COURSES

1. Bio-statistics and Computer Application

1 + 1

Elements of probability - definition - Addition theorem - Multiplication theorem - condition probability - Probability distributions - random variables - discrete and continuous variables - Binomial, Poisson and Normal distributions. Standard normal distribution- Properties of the distributions. Sampling distribution - z, t, χ^2 , F distributions - Statistical concept of estimates- unbiased estimates - point and interval estimations. Test of significance- concept of statistical hypothesis- null hypothesis- alternative hypothesis- Type I and Type II error- critical region- levels of significance of tests. Tests based on z, t, χ^2 , F. Analysis of variance and covariance- One-way classification, two-way classification with single observation per cell, two-way classification with multiple equal observations in cells. Covariance analysis for one-way classification. Correlation and regression - Concept of correlation and regression - Linear regression- method of least squares- curvilinear regression- transformation- Person's coefficient of correlation- Rank correlation- tests of significance of regression and correlation coefficients. Concept of multiple regression- regression with two independent variables- partial regression coefficient.

Design of experiments- Principles of experimentation- Randomization, Replication and local control. Simple designs and analysis: CRD, RBD & LSD. Elements of sampling- Sampling Vs Census- probability sampling. Simple random sampling - Stratified random sampling; Cluster sampling; Systematic and two stage sampling; Sampling design for estimating marine fish production.

Computer applications- Introduction to computers- Fundamentals of DOS and WINDOWS operating systems. Worksheet solutions to statistical analysis using the statistical routines in MSEXCEL.

Practical

Simple problems in probability using addition and multiplication theorems. Fitting of Binomial, Poisson and Normal distributions. Fitting linear regression. Estimation of coefficient of correlation. Statistical tests of significance - z, t, χ^2 , and F distributions. Problem in analysis of data from CRD, RBD and LSD designs. Preparation of tables and charts using MS-EXCEL.

Suggested Readings

Balagurusamy, E., 1989. Programming in ANSI C, Tata McGraw - Hill Publishing Co., New Delhi.

Megrey, B.A. and Moksness, E., 1996. Computers in Fisheries Research, First Edition, Chapman and Hall, U.K.

Sandler, C., Badgett, T. and Weingarten, J., 1997. Office 97 for Windows, BPB Publications,

New Delhi.

Snedecor, G.W., 1961. Statistical Methods. Allied Pacific Pvt. Ltd., Bombay.

Steele, J.H., 1977. Fisheries Mathematics. Academic Press, London.

Trevor, A., 1995. Information Technology, Pitman Publishing Co.

2. Instrumentation and Microtechniques

2 + 1

Colorimetry, Spectrophotometry (U.V. Visible, infrared and double beam): Radioactivity measurements (Scintillation Counter, Geiger-Muller Counter), Radioimmunoassay. Bomb calorimetry. pH and Eh meter; Oxygen and temperature probes; Conductivity meter; Salinometer and refractometer; Atomic absorption spectrophotometer, acoustic and electronic equipments for behavioural studies.

Basic methods involved in protein purification; Dialysis, ultrafiltration, salting-in and salting-out, chromatography; Absorption and partition chromatography; Ion exchange and affinity chromatography; Gas liquid and high performance liquid chromatography; General principles and different gel material for electrophoresis; Different electrophoretic techniques. Microscopy - Principles of microscopy; Brightfield, darkfield and phase contrast microscopy, Fluorescence microscopy, photomicrography, electron micrography, principles of electron microscopy, ultrastructure studies using electron microscopy.

Microtechniques - Fixation of invertebrates, larvae and embryos; fixation of tissues, organs, monolayers of cells, isolated cells and bacteria; Dehydration methods, embedding, clearing and sectioning including cryosectioning; Staining of sections, preparation of wholemounts; Histochemical methods for locating carbohydrates, lipids and proteins, Fixation and processing of tissues for electron microscopy studies.

Practical

Preparation of standard graph using bovine serum albumin; Determination of absorption coefficients of carotenoids at three wavelengths- demonstration; Radioactivity estimation using scintillation counter - demonstration; Determination of calorific value using macro bomb calorimeter - demonstration; Preparation of buffer and adjustment of pH; Oxygen analysis, temperature probe, conductivity meter, salinometer and refractometer - demonstration; Gas chromatograph and high performance liquid chromatography - demonstration; Purification of enzyme - demonstration; Separation of amino acids by paper chromatography and thin layer chromatography. Separation of muscle proteins by disc electrophoresis - demonstration.

Operation of phase contrast, darkfield and fluorescent microscopes and optimisation; Operation of photomicrography system - demonstration.

Preparation of microslides including wholemounts for valuation during the practical examination covering fixation, dehydration, clearing, embedding of tissues and preparation of blocks; Sectioning, affixing the section, staining and mounting; Preparation of wholemounts.

Suggested Readings

- Bergmeyer, H. U., 1974. *Methods in Enzyme Analysis*, Verlagchemie GmbH, Weinheim.
- Gupta, R. N., 1981. *CRC Handbook of Chromatography*, Vol. 1. CRC Press, Florida.
- Jennings, W.G. *Analytical Gas Chromatography*. Academic Press, Orlando, FL.
- Oser, B.L., 1965. *Hawk's Physiological Chemistry*, Fourteenth Edition. Tata McGraw Hill Publishing Co. Ltd., Bombay.
- Sadasivam, S. and Manickam, A., 1997. *Biochemical methods*. New Age International Publishers, New Delhi.

3. Biochemistry and Nutrition of Finfish and Shellfish

2 + 1

Biochemistry: Enzymes and their kinetics - Types of enzymes, Metabolism of carbohydrate- Glycolysis, TCA cycle, pentose phosphate pathway, gluconeogenesis, glycogen synthesis and glycogen lysis; Metabolism of lipids - fatty acid breakdown, fatty acid synthesis, biosynthesis of certain important lipids, Metabolism of proteins- amino acid breakdown and synthesis, ammonia formation and excretion, replication of DNA, transcription and translation process, regulation of protein synthesis, mutations, Immunology - immune response, Antigen- antibody formation, Bioenergetics of metabolism- oxidative phosphorylation and electron transport chain.

Nutrition: Nutritional physiology, principles of nutrition and historical background; Adaptations to various types of feeding in finfish, crustaceans and molluscs; Mechanism of food capture, food ingestion and role of feeding stimulants; Digestion, assimilation and conversion of nutrients; Role of gut microbes in digestion; Nutritional bioenergetics in finfish and shellfish. Nutritional requirements- Gross protein requirements; Nitrogen balance; Essential and non-essential amino acids and their quantitative requirements; Protein quality and sources; Lipids; their functions; Essential fatty acids; Phospholipids and sterol requirements; Protein sparing action of lipids; Negative aspects of lipids; Carbohydrates; Their sources and utilization; Gross energy requirements; factors altering energy requirements; Water and fat soluble vitamins; Their positive functions, deficiency and hyperdosage syndromes, antivitamin factors; Mineral requirements, importance of minerals, recommended dietary allowances, deficiency and hyperdosage syndromes; Nutritional requirements of brood stock; factors influencing nutritional requirements. Feed ingredients and feed technology - classification of feedstuff and international feed information system, conventional and non-conventional sources of feed ingredients; Antinutritional factors in feed ingredients, Their effect on finfish and shellfish, Binders, antioxidants, mould inhibitors, Their use in feeds; Anabolic agents in fish and shellfish feed, Feed formulation strategies and methods; Feed manufacture processes; Storage and quality control of feeds; Management of fish feed mills. Larval nutrition - Nutritional requirements of finfish, crustacean and molluscan larvae; Nutritive value of cladocerans and rotifers, their mass culture, Nutritive value of artemia, their mass culture and cyst production; Microdiets for larvae, Recent advances in larval nutrition. Evaluation of feeds: Feeding strategies - Chemical methods of evaluation; Biological methods of evaluation, feed dispensing methods; Feeding strategies

for larvae and postlarvae in hatcheries and nurseries; Feed dispensing methods and feeding strategies for finfish and crustaceans in intensive and semi-intensive grow out systems; artificial feeding and pond sanitation.

Practical

Quantitative estimation of carbohydrates, protein, amino-acid and lipids; Enzyme assay, determination of amylase activity; Dissection of digestive system and analysis of gut contents in an omnivorous finfish and a prawn; Exercises to determine energy budget based on experimental data supplied; Determination of food intake in a fry and fingerling- determination. Preparation of purified diet for prawn/ fish to determine protein/ lipid requirement. Identification of common feed ingredients; Determination of crude protein; Determination of gross energy of a few feed ingredients. Feed formulation exercises; Preparation of a compounded feed, Grinding, sieving, pelleting and drying.

Suggested Readings

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

Halver, J.E and Tiews, K.T., 1979. Finfish nutrition and fishfeed technology. Vols. 1 and 2. Heenemann, Berlin.

Hepher, B., 1988. Nutrition of pond fishes. Cambridge University Press, New York.

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

Lehninger, A.L., 1984. Principles of Biochemistry. CBS Publishing Co, New Delhi.

New, M.B., 1987. Feed and feeding of fish and shrimp. FAO/ACDP/REP/87/26, FAO, Rome.

4. Mariculture Economics, Extension and Management

2 + 1

Mariculture economics: Application of production economics in aquaculture: Law of diminishing returns; Definition and application; Marginal analysis- total products, average product, marginal product curves and formulae; Factor-product relationship. Factor- factor relationship; Producer decision criteria, profit maximisation; Cost fractions - determining maximum profit level of production, opportunity costs, fixed costs, variable costs, full costs; Revenue functions, total, average marginal; Production functions in aquaculture- Cob-Douglas production function; Empirical problems relating to estimation of production function for aquaculture systems. Investment, financial planning and market analysis: Investment- definition, autonomous and induced investment; Choice and formulation of aquaculture investment projects; Factors influencing investment decisions; Feasibility analysis of aquaculture projects; Enterprise budget and partial budget for aquaculture enterprises; Income, cash flow and net worth statements. Ration analysis; Supply and demand functions for aquaculture products;

Consumer surveys for aquaculture products; Market analysis. Guidelines for formulation and evaluation of feasibility reports.

Mariculture extension: Objectives, principles and philosophy of fisheries extension in the Indian context, process of diffusion and adoption, process and models of communication, extension methods, process of technology generation, assessment, refinement and transfer, characteristics of technology generation, transfer and clientele systems in the fisheries sector. Socio-psychology data and demographic features of the marine fisheries sector, comparative studies of the socio-psychological and demographic features of the marine fisheries sector in other developed and developing countries. Basic concepts in rural sociology, psychology, viz. Social structure, stratification, concepts on leadership, psychology of human behaviour, motivation, process of teaching and learning, training methods, training and assessment, principles of human resource development. Principles of participatory planning and development, PRA techniques (Participatory Rural Appraisal), participatory communication, programme planning and evaluation.

Administration and management of organisation, organisational structure and functions of agencies / institutions for fisheries research education and development, elements of organisational behaviour.

Practical

Preparation of a v aids; visit to State / Central Govt. Fisheries organisations; organising village level programmes such as meetings; demonstrations, group discussions etc.; application of RRA / PRA techniques in identification of problems in villages.

Suggested Readings

Cunningham, S., Dunn, M.R. and Whitmarsh, D., 1985. Fisheries Economics: An Introduction. St. Martin's Press, New York.

Fort, R. S., 1961. Fishery Management, Faber & Faber, London.

Lawson, R.L., 1984. Economics of Fisheries Development. Fances Printed Publishers, London.

Rao, P.S., 1978. Fishery Economics and Management in India. PS Rao, Bombay.

Rao, S.N., 1986. Economics of Fisheries. Daya Publishing House, Delhi.

Shang, C.Y., 1981. Aquaculture Economics: Basic concepts and Methods of Analysis. Westview Press, London.

Supe, S.V., 1983. An Introduction to Extension Education. Oxford & IBH Publishing Co., New Delhi.

5. General Aspects and Ecophysiology of Reproduction

2 + 1

Reproduction and development of finfishes and shellfishes; Structure and function of

reproduction organs. Structure and function of neuroendocrine organs associated with reproduction. Sexual dimorphism; Secondary sexual characters; Sex determination and differentiation.

Fecundity, gonadosomatic index, sex ratio, maturity, spawning season, spawning periodicity, ovidiameter frequency and maturity stages of finfish and shellfish. Reproductive biology of mullets, groupers, seabass, *Penaeus* sp. and *Loligo* sps. Influence of environmental, meteorological and biological factors on reproduction and embryogenesis. Effects of nutrition on reproduction. Parental care.

Practical

Dissection and identification of male and female reproductive systems of mullets, groupers, penaeus and loligo sp.; maturity staging based on morphology and histology; ova diameter frequency distribution; estimation of fecundity; gonadosomatic index studies; histological studies on ovary/ testis; histochemistry studies on ovary / testis.

Suggested Readings

Adiyodi, K.G., 1983. Reproductive Biology of Invertebrates, Vol. II, John Wiley & Sons, New York.

Arthur, C., 1987. Reproduction of Marine Invertebrates. Blackwell Scientific Publication, California.

Carlisle, D.B., 1959. Endocrine Control in Crustaceans. Cambridge University Press, London.

Matty, A.J., 1985. Fish Endocrinology. Timber Press, Portland.

Potts, G.W. and Wotton, R.J., 1984. Fish Reproduction: Strategies and Tactics, Academic Press, London.

6. Aquaculture Feed Formulation & Production Technology 2 + 1

Live and artificial feeds, forms of feeds, feed formulation strategies and methods; Least cost formulations and linear and quadratic programming of computer formulation of least cost feed; Feed manufacture - requirements and processes Conventional and non-conventional sources of feed ingredients; Essential aminoacids; Polyunsaturated fatty acids and vitamin composition of feeds; Feed management.

Production of water stable feeds; Effect of natural and synthetic binders on feed stability; Anabolic agents in feeds; Anti-nutritional factors; Feed influence on body composition and quality in fish; Fish disease vectors in feed; Use of natural and synthetic carotenoids; Feed value in relation to processing; Feed storage. Economics of formulated feeds.

Practical

Identification of various conventional and non-conventional feed ingredients. Exercises in least

formulations and linear and quadratic programming. Formulation and preparation of feeds by various methods and their proximate analysis. Determination of water stability of feeds. Determination of ascorbic acid in feeds in order to determine losses in relation to processing.

Suggested Reading

ADCP (Aquaculture Development and Coordination Programme), 1980. Fish Feed Technology, ADCP/REP/80/11. FAO. Rome.

D' Abramo, L.R., Conklin, D.E. and Akiyama, D.M., 1997. Crustacean Nutrition: Advances in Aquaculture, Vol.6. World Aquaculture Society, Baton Rouge, LA.

Guillaume, J., Kaushik, S., Bergot, P. and Metailler, R., 2001. Nutrition and Feeding of Fish and Crustaceans. Springer Praxis Publishing, Chichester, UK.

Halver, J.E and Tiews, K.T., 1979. Finfish nutrition and fishfeed technology. Vols. 1 and 2. Heenemann, Berlin.

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

NRC (National Research Council) 1993. Nutrient requirements of fish. National Academy Press, Washington D.C

Tacon, A. G.J., 1990. Standard Methods for the Nutrition and Feeding of Farmed Fish and Shrimp, Vol.1-3. Argent Laboratories Press, Washington D.C.

7. Aquaculture Engineering-II

2 + 1

Water sources, supply and control: Water hydrology, run-off and utilization, factors affecting run-off; Qualitative and quantitative water requirements. Canal-water and tide-water comparisons; Engineering applications of hydrostatics; Conditions of stability of bunds, dykes etc; Fluid pressure and its measurements; hydrokynamatics; Rates of discharge and type of flows; Bernoulli's equation and its applications; Discharge measurements, notches, weirs, flumes and related measuring devices; Flow through pipes and nozzles; Flow through open channels of different shapes; Principles of tides, waves and currents, Water flow and control structures; Monks, spillways, sluice gates, water flow and level measurement; Storage tanks; Types, fittings and accessories; Water requirement calculations.Physical and mechanical properties of soil: Types of soils, structure and textural classification; Grain size distribution, bearing strength, methods of physical and mechanical analyses and their impact on qualitative appraisal of soils; Atterberg limits, saturated and unsaturated soils, credibility, compaction and permeability; Physico-chemical properties and their impact on construction and maintenance of ponds.

Equipment and selection of materials: Selection of materials for enclosure, support, retention and other structures based on their physical, mechanical, thermal and chemical properties; Principles, operation and maintenance of pumps, blowers, compressors, wind and

solar energy systems, Principles, operation and maintenance of filters and aerators; Earth moving equipment; Feed preparation and dispensing equipment; Simple machines; leverages, work, power, energy, efficiency, elastic properties, hand tools, manually / mechanically operated equipment, Types of corrosion including stress cracking and development of brittleness, fouling and their control.

Site selection, survey and farm layout: Analysis of sites and factors important in site selection; Importance of engineering survey in layout and construction; Methods of survey, necessity of topographic map, micro level surveys and their comparison; Layout of different farms and their relative advantages; Pond dimensions and orientation; Access ways and structures; Site selection for hatcheries; Survey and location of suitable sites for hatcheries. Farm design, estimation, construction and maintenance: Ponds, rafts, racks, long lines, cages, pens and their designs, Design considerations of farms for various ecosystems; Design concepts for raceways and recirculatory system; Flow process diagram, data analysis, work study, work centres, layout, product flow, utilities, installation and alignments; Design concepts for open sea farming and construction in general; Factors influencing of waves to structure, Pollution and their effects on marine structures; Wash off characteristics of bed as well as open sea structures, Artificial reefs, Weather elements and coastal hydrodynamics; Facilities for open sea farming. Design and construction of hatcheries and nurseries: Design and layout, Material selection and construction; Rearing facilities, Aeration.

Practical

Exercises on water quality estimations; Water conveyance, discharge and distribution; Determination of coefficient of water discharge, Preparation of drawings of cross sections of canals; Balancing depth calculations and estimation of most economic cross sections; Calculation to estimate conditions for maximum discharge, Tide and discharge calculations at sluice gates; Handling of geological and meteorological instruments - demonstration, Field work on sample collection, Recording of soil topography; Physical features of slopes, plains and beaches. Qualitative appraisal of soils based on physical and chemical parameters; Determination of indices of soil mass; Determination of course, medium and fine grained constituents. Field study of pumps sets, blowers, compressors, windmills, solar pumps; Small aerators, filters, nets, dykes, sluice gates, traps; Observations on corrosion and fouling. Identification of different materials used in mariculture; Operation and maintenance of mechanical / electrical equipment used in mariculture.

Visit to different types of farms and other places of coastal areas to collect data on various topographic features and to map and interpret them; Carry out reconnaissance and chain survey; Carry out plane table and prismatic survey, Carry out hydrographic survey and contouring; Exercises to calculate the area, volume and cost of ponds; Drifting, computing and estimating for pond construction; Dimensional drawings of perpendicular isometric and orthographic projections; Reading of maps and calculating areas; Enlarging and concising maps; Exercises on layout formation. Exercises related to design of farms and bunds; Exercises related to design of channels and sluice gates; Exercises related to design of rafts, pens, cages; Exercises related

to construction of raceways and recirculatory systems; Exercises related to construction of hatcheries and nurseries; Preparation of flow process diagram, work study, works centre layout; Fabrication of model rafts, pens, cages, channels, sluice gate demonstration.

Suggested Readings

Thomas, B. L., 1995. Fundamentals of Aquaculture Engineering. Chapman & Hall, New York.

Upadhyay, A.S., 1994. Handbook on Design, Construction and Equipments in Coastal Aquaculture (Shrimp Farming). Allied Publishers, Bombay.

Wheaton, F.W., 1977. Aquaculture Engineering. John Wiley & Sons, New York.

3. MICROBIOLOGY AND BIOTECHNOLOGY

Major Courses

| | | |
|--|-------|-------------------|
| A.1 Core Courses | | 12 Credits |
| 1. Microbiological techniques | 1 + 2 | |
| 2. Principles of Molecular Biology | 1 + 2 | |
| 3. Techniques of Genetic Engineering | 1 + 2 | |
| 4. Diagnostic Microbiology of Fish Diseases | 1 + 2 | |
| Seminar | 0 + 1 | 1 Credit |
| A.2 Optional Courses | | 12 Credits |
| 1. Microbial diseases of fish and shellfish | 2 + 2 | |
| 2. Microbiology of Fish Processing and quality assurance | 2 + 2 | |
| 3. Biotechnology in Fish Health Management | 1 + 2 | |
| 4. Microbial taxonomy | 1 + 2 | |
| 5. Aquatic Biotechnology | 2 + 2 | |
| 6. Microbiology of freshwater systems | 1 + 2 | |
| 7. Microbiology of estuarine and marine systems | 1 + 2 | |
| 8. Inland aquatic system and their management | 1 + 1 | |
| 9. Fish Biotechnology | | |
| B. Supporting Courses | | 10 Credits |
| 1. Biotechnology of Environmental Management | 1 + 2 | |
| 2. Environmental Microbiology | 1 + 2 | |
| 3. Microbial toxins | 1 + 2 | |
| 4. Fish Mycology and Virology | 1 + 2 | |
| 5. Statistics and design of experiment | 1 + 1 | |
| 6. Aquaculture extension | 1 + 1 | |
| 7. Curing, dehydration and value added products | 2 + 1 | |
| Any other course(s) suggested by Student Advisory Committee | | |
| Total | | 35 Credits |

A. MAJOR COURSES

A1. CORE COURSES

1. Microbiological Techniques 1 + 2

Safety in microbiology laboratory, biosafety levels and workstations, aerosol sampling, disinfection and evaluation. Microscopy - fluorescence, phase-contrast, dark ground and electron microscope. Staining and its chemistry.

Practical

Techniques of sterilisation, preparation of media, isolation of different types of organisms, techniques for identification, biochemical, serological. Enumeration of microorganisms. Techniques for isolation and identification of anaerobic bacteria. Basics of mycological and virological techniques.

Suggested Readings

- Austin, B. 1999. Methods in Aquatic Microbiology. John Wiley & Sons, New York.
- Barleson, Chambers and Weidbrank. 1992. Virology - A laboratory manual. Academic Press, New York.
- Criusted, J. 1986. Methods in Microbiology, Academic Press, London.
- Diliello. 1979. Clinical Microbiology. Avi Publishing Co., Connecticut.
- Harry W.S. 2000. Microbes in Action - A laboratory manual. John Wiley & Sons, New York.
- Paul F. Kemp. 1993. Handbook of methods in Aquatic Microbial Ecology. Lewis Publishers, London.

2. Principles of Molecular Biology 1 + 2

Genetic elements, DNA structure and replication, RNA structure and functions, gene expression and its regulation, mutations, gene transfer and recombination, Bacteriophages and their replication, viruses and their replication. Protein structure and function, post translational modifications of proteins, proteins localisation in cells. Organisation of prokaryotic and eukaryotic cells. Gene mapping and DNA sequencing, polymerase chain reactions (PCR) and DNA fingerprinting.

Practical

Isolation of chromosomal DNA, plasmids, RNA, agarose gel electrophoresis of nucleic acids, restriction mapping, identification of mutations, isolation of proteins, electrophoresis - denaturing and non denaturing gels. Southern blot, northern blot and western blot. DNA sequencing. Study of bacteriophages and their replication.

Suggested Readings

- Boyer, Rodney. 1998. Concepts in Biochemistry. Cole Publishing Company, London.
- Glick, B. R. and Pasternak, J.J.. 1998. Molecular Biotechnology Principles and Applications of Recombinant DNA Technology. A S M Press, Washington, D C.
- Lehninger, A. L. 1984. Principles of Biochemistry. C B S Publishing, New Delhi.
- Primrose, S. B. 1987. Modern Biotechnology. Blackwell Scientific Publish, Oxford.
- Sambrook, J., Fritsch, E.F. and Maniatis, T. 1989. Molecular Cloning: A Laboratory Manual - Cold Spring Harbour, USA.

3. Techniques of Genetic Engineering 1 + 2

Gene isolation and identification. Cloning vectors, basic steps in cloning, detection of recombinant DNA and clones, expression vectors, detection of gene expression. Site directed mutagenesis, application of genetic engineering, transgenic animals, cloning mammals. Environmental concerns of genetically engineered organisms.

Practical

Restriction digestion and modification of DNA, ligation, transformation, electroporation, detection of recombinants, detection of protein expression by Western blotting.

Suggested Readings

- Glick, B. R. and Pasternak, J.J. 1998. Molecular Biotechnology Principles and Applications of Recombinant DNA Technology. A S M Press, Washington, D C.
- Primrose, S. B. 1989. Modern Biotechnology. Blackwell Scientific Publish, Oxford.
- Sambrook, J., Fritsch, E.F., and Maniatis, T. 1989. Molecular Cloning: A Laboratory Manual - Cold Spring Harbour, USA.

4. Diagnostic Microbiology of Fish Diseases 1 + 2

Examination of moribund fish, clinical symptoms, sampling techniques for microbiological investigations, microscopic study of fish parasites, techniques isolation and identification of fish

pathogens, histopathology, mycological techniques. Monoclonal and polyclonal antibody based methods for diagnosis of diseases, Nucleic acid based methods in diagnosis - gene probes, polymerase chain reaction. Detection of bacterial, viral and fungal pathogens.

Practical

Isolation and identification of bacterial, viral, fungal pathogens, fish parasites. Applications of antibody and nucleic acid based methods in fish disease diagnosis.

Suggested Readings

Austin, B. 1999. Bacterial Fish Pathogen - Disease of farmed and wild fish, Paraxis publishing Ltd. U.K.

Iwama, G. 1996. The Fish immune system : Organism, Pathogen and Environment, Academic Press, London.

Plumb, J. A. 1999. Health maintenance and principal microbial diseases of cultured fishes, Iowa State University, Florida

Roberts, R. J. 1978. Fish Pathology, Baillere Tindall, London

Schaperclaus, W. 1991. Fish diseases Lulab Primalain Oxoinan Press, New Delhi.

Woo, P.T.K. and Leatherland, F. 1998. Fish diseases and disorders, CABI Publishers, Wallingford.

A 2. OPTIONAL COURSES

1. Microbial Diseases of Fish and Shellfish 2 + 2

Microbial flora of fish and shellfish, commensals and pathogens. Bacterial, viral, fungal and parasitic diseases of fish and shellfish. Taxonomy and characters of pathogens. Pathogenesis and pathology of diseases. Environmental factors affecting fish health, disease management strategies-chemotherapy, pond management. Prevention of diseases, water quality management, immunoprophylaxis, role of vaccines, immunostimulants, probiotics.

Practical

Isolation and identification of fish pathogenic bacteria, viruses, fungi and parasites. Histopathology of diseases, study of water quality of aquatic systems, chemotherapeutic sensitivity testing.

Suggested Readings

Austin, B. 1999. Bacterial Fish Pathogen - Disease of farmed and wild fish, Paraxis publishing Ltd. U.K.

Iwama, G. 1996. The Fish immune system: Organism, Pathogen and Environment, Academic Press, London.

Plumb, J.A. 1999. Health maintenance and principal microbial diseases of cultured fishes - Iowa State University - Florida

Roberts, R. J. 1978. Fish Pathology, Baillere Tindall, London

Schaperclaus, W. 1991. Fish diseases Lulab Primalain Oxoinan Press, New Delhi.

Woo, P.T.K. and Leatherland F. 1998. Fish diseases and disorders, CABI Publishers, Wallingford.

2. Microbiology of Fish Processing and Quality Assurance 2 + 2

Microorganisms responsible for fish spoilage - their responses to fish processing techniques like chilling, freezing, canning, salting, smoking, drying and fermentation. Special features of psychrophilic, thermophilic and osmophilic bacteria, molds and yeasts. Microbiology of modified atmosphere packaging of fish. Sanitation in fish processing. Pathogens associated with fish, fish processing environments and prevention of contamination. Microbiological aspects of HACCP based fish quality assurance. Rapid and automatic microbiological methods in fish quality assurance.

Practical

Assessment of microbiological quality of water, ice, fish and fishery products. Isolation and identification of pathogens, HACCP based quality assurance methods.

Suggested Readings

Connell, J. J., 1995. Control of fish quality. Fishing news books.

Gopakumar, K. 1993. Fish packaging technology. Concept Publishing Company, New Delhi.

Huss, H. H., Jakobsen, M. and Liston, J., 1991. Quality assurance in the fish industry. Elsevier Publishing, London, New York.

John, D. E. V., 1985. Food safety and toxicity - CRC Press, New York, London, Tokyo. Seafood science and technology - BLISH.

Krenzer, R., 1971. Fish inspection and quality control. Fishing News Ltd., London.

3. Biotechnology in Fish Health Management

1 + 2

Health Management in Aquaculture - Interaction between the host, pathogen and environment. Basic principles of immunology - specific and non specific defence mechanisms, humoral and cellular immunity, cells involved and molecular mechanisms of immune response. Antigen-antibody reactions and their applications. Fish immune system, lymphoid organs and their ontology. Principles of vaccination and immunoprophylaxis, factors affecting immune response. Techniques of fish and shellfish vaccination.

Invertebrate immunity - cellular and humoral aspects, immunoprophylaxis in crustaceans and molluscs. Biotechnology for water quality management in aquaculture, probiotics and bioremediators, treatment of fish farm effluents and environmental management.

Practical

Study of fish leucocytes, non specific humoral factors such as lysozyme, complement, phagocytic activity. Antigen antibody reactions; techniques of fish vaccination and study of immune response.

Suggested Readings

Ellis, A.E. 1988. Fish Vaccination. Academic Press, London.

Karunasagar, Karunasagar and Reilly. 1999. Aquaculture and Biotechnology. Oxford & IBH Pub. Co. Ltd., New Delhi.

Nelson, A Hand book of Drugs and Chemicals used in the treatment of Fish Diseases. Charles C. Thomas Pub.

4. Microbial Taxonomy

1 + 2

Classification of bacteria based on phenotypic characters, numerical taxonomy, chemotaxonomy, molecular methods in taxonomy - G+C content, DNA-DNA reassociation, ribosomal RNA sequencing. Evolutionary relationships in bacterial groups, major groups of bacteria, Archaea. Techniques for typing microorganisms -ribotyping, PCR based methods, DNA fingerprinting, RFLP, phage typing. Classification of viruses and fungi.

Practical

Microbial identification and typing by conventional and molecular methods.

Suggested Readings

Austin, B. 1999. Bacterial Fish Pathogen Diseases of farmed and wild fish, Paraxis publishing Ltd. U.K.

Roberts, R. J. 1978. Fish Pathology, Baillere Tindall, London

Schaperclaus, W. 1991. Fish diseases Lulab Primalain Oxoinan Press, New Delhi.

Woo, P.T.K. and Leatherland F. 1998. Fish diseases and disorders, CABI Publishers, Wallingford.

5. Aquatic Biotechnology

2 + 2

Biotechnology in aquaculture - genetic improvement of brood stock, hybridisation, production of transgenic animals, biotechnology in feed development, in water quality management and health management. Natural products such as biomedical, antimicrobial and anticancer compounds from marine organisms, cell and tissue culture, hybridoma technology, cloning and expression of genes from marine organisms, genetic improvement of marine organisms, bioremediation and role of genetically engineered organisms. Role of biotechnology in improving aquaculture production.

Practical

Cloning and expression of genes from aquatic animals, microinjection and transfection. Screening organisms for production of bioactive compounds, identification of their genes, genetic improvement in such strains.

Suggested Readings

Fingerman, M. R., Nagabhusanam and Mary F. T. 1997. Recent advances in Marine Biotechnology (Vol. 1-3). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Le Gal, Y. and Halvorson, H. O.1998. New Developments in Marine Biotechnology. Plenum Press, New York.

6. Microbiology of Freshwater Systems

1 + 2

Microbial community in freshwater - colonisation, Kinetics of microbial population - effects of environmental factors. Ecology and physiology of photosynthetic bacteria. Role of bacteria in self-purification of water. Microbial conversion of carbon, nitrogen and other elements in freshwater. Biofertilisation. Microbial interaction, symbiosis, antagonism and commensalism. Bacteriology of interfaces.

Practical

Enumeration of microbial communities in water and sediment from fresh water habitats such as ponds, river, lakes etc. qualitative assessment of microbial communities in fresh water aquatic systems and their role in various biological activities, isolation and enumeration of microorganisms involved in nitrogen cycle. Carbon cycle, sulphur cycle, Phosphorus cycle and Iron cycle, role of microorganisms in degradation of organic matter, study of fresh water cyanobacteria and fungi, organisms of public health significance, study of bacteriophages.

Suggested Readings

Austin, B. 1988. Methods in Aquatic Bacteriology. John Wiley & Sons, New York.

Rheinheimer, G. 1980. Aquatic Microbiology. John Wiley & Sons, New York.

Rodina, A.G. 1972. Methods in Aquatic Microbiology. University Park Press, Baltimore.

7. Microbiology of Estuarine and Marine systems

1 + 2

Microbes of estuarine and marine environment - their interaction with salinity, temperature and hydrostatic pressure. Special techniques for sample collection and enumeration of microorganisms. Role of microorganisms in nitrogen cycle and cycling of organic matter in the sea. Geo-microbiological activities of microorganisms. Role of these microorganisms in spoilage of fish and fishery products, public health and environmental risks.

Practical

Analysis of water and sediments for the isolation, enumeration and characterisation of microorganisms from estuaries, mangroves, coastal water and of shore marine habitats, study of mangrove ecology with reference to nutrient cycles and pathogens, study of viable non-culturable bacteria by direct epifluorescence microscopy, isolation of bacteriophages, detection of microorganisms with special physiological activities, autotrophs and anaerobes, chemosynthetic organisms, marine cyanobacteria and fungi, microorganisms of public health significance.

Suggested Readings

Kriss, A.E. 1963. Marine Microbiology. Oliver & Boyd Pub, Edinburgh.

Paul, J.H. 2001. Methods in Microbiology Vol 30. Marine Microbiology, Academic Press, San Diego.

Rheinheimer, G.1980. Aquatic Microbiology. John Wiley & Sons, New York.

8. Inland aquatic system and their management

1 + 1

Classification of inland aquatic ecosystems : Different agroclimatic zones; Lentic and lotic habitats; River zonation and concept of river condition; Productivity of rivers/reservoirs, estuaries and lakes; Fish and other fauna from different aquatic ecosystems; Fishes and their relationship with abiotic and biotic environment; Effect of environment on breeding, growth and survival. Physico-chemical and biological characteristics of inland aquatic systems and their management; Holistic approach in inland fisheries management for socio-economic benefit. Ecology of rivers and their environment : Different river systems and their fishery potential; Catch composition of riverine fisheries in India; Exploitation of fisheries in rivers and its effect; Conservation and development of riverine fisheries. Reservoir fisheries in India, Productivity and fishery potential of reservoirs; Stocking policy and optimum exploitation; Strategies adopted in other countries for development of reservoir fisheries. Major estuaries, lagoons, backwaters and brackishwater impoundments in India and their fishery resources. Productivity and ecology of estuarine and brackishwater lagoons, wetlands, biosphere reserves and mangroves; Conservation and development of estuaries and lagoon fisheries; Strategies adopted in other countries for development of estuarine and lagoon fisheries.

Practical

Study of biodiversity especially, phytoplankton, zooplankton, benthos and primary productivity. Estimation of physico-chemical parameters of soil and water, with respect to environmental management and pollution abatement viz.- pH, DO, CO₂, BOD, COD, NH₄-N, NO₂, NO₃, PO₄, etc.

Suggested Readings

Dykyjova, D. and Kvet, J. 1978. Pond Littoral Ecosystems, structure and functioning Springer-Verlag, Bestons Heidelberg, New York.

Hillary, S. E. and Cloude, E. B. 1997. Dynamics of pond aquaculture edited. CBC Press, Boca Raton, New York.

Kare, P., 1990. The Illustrated Guide to fishes of Lakes and Rivers. Treasure Press, London.

Nikolsky. 1963. The Ecology of fishes, G.V.T.F.H.Publications Inc. Ltd., Academic press, London.

Odum, E.P. 1983. Basic Ecology, Sounders College Publishing, Holt Sanders.

Prasad, M.K.D. and Pitchaiah, P.S. 1999. Inland water resources - India Vol. I Discovery Publishing House, New Delhi.

Shellby, D. Gerking, 1978. Ecology of freshwater fish production, Ed.. Blackwell Scientific Publications.

Srivastava, U.K. & Vathsala, S., 1984. Strategy for development in Inland Fishery Resources in India Pub. Concept Publishing, New Delhi.

Talwar, P. K. 1990. Inland fishes of India and adjacent countries, vol-I, II, New Delhi, Oxford IBH publication Co.

9. Fish Biotechnology

2 + 1

Introduction; Definition and historical perspectives of biotechnology; Genetic engineering; Cloning, restriction / modification enzymes, plicing of DNA, plasmid vectors, phage vectors, DNA libraries, probes; hybridization, chromosome walking, polymerase chain reaction, sequencing. Fish tissue culture; Historical perspectives, tissue culture, cell culture, organ culture, cell lines, primary and secondary culture, culture media, culture vessels. Hybridoma techniques and monoclonal antibodies. Trnasgenesis : Definition, transgenic fish, detection of transgenes and application. DNA fingerprinting : Principles and applications; RFGP, RAPD; Recombinant vaccines : Development of disease resistance stock.

Probiotics and single cell protein (SCP) in aquaculture. Bioconversion of lignocellulosic wastes. Cryopreservation of gametes and embryos. Hormonal manipulation in advancing maturity and reproduction. Biofertilization, biofermentation and biofiltration. Reproductive and hormonal biotechnology, Hormonal biotechnology in aquaculture product enhancement. Isolation and purification of hormones. Principles of protein synthesis and sequencing. Introduction to hormone gene regulation and expression.

Practical

Agarose and polyacrylamide gel electrophoresis; Plasmid DNA isolation; Purification of plasmid DNA by cesium chloride - ethidium bromide ultracentrifuge; Isolation of DNA from fish blood; Restriction digestion of DNA; Ligation reaction; Bacterial transformation by calcium chloride method; Polymerase chain reaction; Elution of bands from the gel and purification; Radioimmuno assay of hormones; Cryopreservation of milt. Culture, enumeration and maintenance of probiotic cultures, isolation and chracterization of bacterial/algal cultures as inoculents and biofertilizations, immobilization of bacterial cultures for biofiltration. Radio-active isotops, principle and measurements, saftey aspects of use and handing of radioisotops; radio receptor assay, ELISA technique in hormone measurement and quantification. Electrophoresis and chromatography in hormone purification, hormone immunization and antibody development.

Suggested Readings

Fingerman, M., Nagabhushanam R. and Thompson M. F. 1997. Recent Advances in Marine Biotechnology (Vol 1-3) Oxford and IBH Publishing Co. PVT. Ltd. New Delhi

Gal, Y. Le and Halvorson, H. O. 1978. New Developments in Marine Biotechnology, Plenum Press NY.

Glick, B. R. and Pasternak, J.J. 1999 Molecular Biotechnology: Principles and Applications of Recombinant DNA Technology, A S M Press, Washington, D C.

Julio E. C. 1985. Cell Biology: A laboratory Handbook, Vol 1-3, Academic Press, New York.

Hoar, W. S. and Randal, D. J.19 Fish Physiology, Academic Press, New York.

Lehninger, A. L. 1984. Principles of Biochemistry, C B S Publishing, New Delhi.

Primrose, S. B. 1989. Modern Biotechnology, Blackwell Scientific, Oxford.

Rodney, B. 1998. Concepts in Biochemistry, Cole Publishing Company, London.

B. SUPPORTING COURSES

1. Biotechnology of Environmental Management 1 + 2

Environmental problems due to industrial and organic effluents, role of microorganisms in degradation of pollutants, genetic engineering of microorganisms, bioremediation, its applications in oil spills, pesticides, herbicides and other xenobiotic degradations. Hazards of genetically engineered organisms, environmental concerns and biosafety issues.

Practical

Degradation of oil, pesticide, herbicides in micocosms, study of microorganisms involved, degradative plasmids and their engineering.

Suggested Readings

Le Gal, Y. and Halvorson, H. O.1998. New Developments in Marine Biotechnology. Plenum Press, New York.

Primrose,S. B. 1987. Modern Biotechnology. Blackwell Scientific Publish, Oxford.

2. Environmental Microbiology 1 + 2

Microorganisms associated with aquatic environment. Pollution - nature and types, microbial changes induced by inorganic and organic pollutants, industrial effluents and domestic sewage. Water-borne pathogens, enteroviruses, standards for various types of water-for drinking, shellfish and finfish culture, food processing. Environmental impact of aquaculture and its assessment, wastes from fish processing units and their treatment. Biological pollution, algal blooms and their effects on fish production and public health. Role of microorganisms in degradation of pollutants, bioremediation.

Practical

Detection of indicator and pathogenic microorganisms. Water quality determination, antibiotic resistance and its determination.

Suggested Readings

Harry, W. Seeley, J.R., Paul,J.V and John,J.L. 2000. Microbes in action. W.H.Freeman and Co., New York.

Rheinheimer, G. 1980. Aquatic Microbiology. John Wiley & Sons, New York.

Rodina, A. G. 1972. Methods in Aquatic Microbiology. University Park Press, Baltimore.

3. Microbial Toxins

1 + 2

Microorganisms important in food toxicity. Types of toxins, exotoxins, endotoxins and miscellaneous toxic factors. Factors affecting toxin production in food. Food-borne diseases - factors influencing their outbreaks. Preventive measures to control food toxicity and food-borne diseases. Methods of toxin and antitoxin production. Types of toxins, methods of isolation and detection of toxins produced by various pathogenic bacteria. Staphylococcus aureus, Clostridium botulinum, Clostridium perfringens, Bacillus cereus, Vibrio Salmonella, Escherichia coli, etc. Fungal toxins - aflatoxins, ochratoxins, etc. Marine toxins, Histamine toxicity.

Practical

Methods for detection of endotoxins and exotoxins, purification and characterisation of endotoxin and exotoxins from different bacteria, biological and serological methods to study toxin, setting up enzyme linked immunosorbent assay, dot blot immunoassay, western blots to study exotoxins, extraction and detection of aflatoxins and histamines. Applications of HPLC in toxin analysis.

Suggested Readings

Harry, W. Seelay J.R., Paul, J. V. and John J L. 2000. Microbes in Action - A laboratory manual. John Wiley & Sons, New York.

Karunasagar, Karunasagar and Reilly. 1999. Aquaculture and Biotechnology. Oxford & IBH Pub. Co. Ltd., New Delhi.

Paul, F. Kemp. 1993. Handbook of methods in Aquatic Microbial Ecology. Lewis Publishers, London.

4. Fish Mycology and Virology

1 + 2

Aquatic fungi and their role in causing diseases of aquatic animals, spoilage of fish and fishery products. Methods for isolation and identification of fungi, mycotoxins. General properties of viruses, viruses associated with fish, shellfish and water, their role in fish diseases, isolation and identification of viruses. Molecular techniques in virology. Human pathogenic viruses associated with aquatic animals.

Practical

Isolation and identification of aquatic fungi, fungi involved in fish spoilage, detection of mycotoxins, detection of viruses.

Suggested Readings

Roberts, R. J. 1978. Fish Pathology. Baillere Tindall, London

Schaperclaus, W. 1991. Fish diseases Lulab Primalain Oxoinan Press, New Delhi.

Stanislas and Herbart. Fungal diseases of fishes. T. F. H. Publications.

Woo, P.T.K. and Leatherland F. 1998. Fish diseases and disorders, CABI Publishers, Wallingford.

5. Statistics and Design of Experiment

1 + 1

Definition and scope of statistics; collection and presentation of data; Frequency distribution and its graphical presentation; Measures of central tendency; Measures of dispersion; Estimation and hypothesis testing (students 1 distribution χ^2 - distribution, / f-distribution); Correlation and regression; Designs of experiments (completely randomised block design, randomised block design; lattin square design and factorial design); Sampling techniques (random sampling, stratified random sampling, cluster sampling, systematic sampling and purposive sampling); Fundamentals of population dynamics and estimation of fish population; Investment, production and export. Fisheries Statistics of India; Status of Inland Fisheries Statistics in India.

Practical

Exercises in probability and distributions; problems in tests of significance - normal t, χ^2 and F; problems in analysis of variance and co-variance, correlation and regression; basic concepts of design of experiments; problems to determine corelation coefficient and regression; exercise in design and evaluation of experiments.

Suggested Readings

Biradar, R.S., 1986. Course manual on Fisheries Statistics. Central Institute of Fisheries Education, Mumbai, p. 230.

Panse, V.G. and Sukhatme, P.V., 1978. Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi.

Raghava Rao, D., 1983. Statistical techniques in Agricultural and Biological Research, Oxford & IBH Publishing Co., Bombay.

Sokal, R.R. and Rohlf, F.J., 1998. Biometry, Freeman and Company, New Delhi.

Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Ashok, C., 1984. Sampling theory of surveys with applications. Iowa State University Press, Ames Iowa, USA.

6 Aquaculture Extension

1 + 1

Programme planning process - collection of facts, situation analysis, problem identification, objective setting, planning of work, execution of plan, evaluation of progress, restructuring of planning strategy for improvement. Importance of extension programme, characteristics of good programme, participation of organisation in programme planning, involvement of people in

programme planning. Training strategy in transfer of technology in aquaculture; Training strategy for training extension personnel; Role of farmers - extension and research linkage; Participatory approach in technology demonstration. Concept and function of communicator, importance of communicator in extension work, communication models, communication channels - clarification, nature and feed back in communication - its role in extension education and its effect in communication of information; Problems in communication - types and nature. Diffusion of innovations; Characteristics of innovation, innovation decision process, elements in the diffusion of innovation. Innovation and their rate of adoption, Characteristics of adoption categories. The change agents and factors in change agents success. LLP, ORP, IVLP, KVK/TTC, Voluntary organisation.

Practical

Surveys for identification of technology gaps; PRA; Skill demonstration; Preparation of leaflets, pamphlets, maps, charts, etc.; Technology input assessment survey.

Suggested Readings

- Anon. 1980. Seminar on fisheries extension, status report and background papers, CMFRI, Kochi.
- Dahama, O. P. 1993. Extension and rural welfare. Ramprasad and Sons, Agra.
- Dhote, A. K. 1989. Fisheries management and extension : Inland fisheries, instructional-cum-practical manual (VI), National Council of Educational Research and Training, New Delhi.
- Lynton, P. R. and Pareek, U. 1978. Training for development. Kumarian Press, 29 Bishop Road, West Hartford, Connecticut.
- Rao, T. V. 1991. Readings in human resource development. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
- Ray, G. L. 1999. Extension communication and management, Naya Prakash, Calcutta.
- Supe, S. V. 1986. An introduction to Extension Education, Oxford and IBH Publishing Co., 66 Janpath, New Delhi - 01, India.

7. Curing and Dehydration & Value Added Products

2 + 1

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.

Principles of drying and dehydration: Psychometrics, drying calculation, constant rate and falling rate, drying time in air, moisture transport mechanism, nature drying, solar drying and mechanical drying, different types of dryers, tunnel drier, vacuum drier, rum drier, solar drier etc., Freeze drying, principles, application of phase rule, triple point of water, sublimation of

ice, accelerated freeze drying (AFD), shelf life and specialties of AFD products, machinery and equipment for freeze drying, process flowchart, Dehydration of fish products : Dehydration ratio, precautions to be taken in fish drying; denaturation of fish protein, Cured fish, 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, Methods of salting, dry/kench/wet and pickling, brine salting, Spoilage of dried/cured fish, physical, chemical and microbiological changes, methods of prevent/control spoilage, extension of shelf life, Smoke curing, chemistry of smoke, composition and properties, smoking methods, cold, hot and use of smoke liquids, production of smoke, type of wood used, methods of smoke generation, carcinogens in smoke, smoke kilns, Colombo curing, specialty of the process.

Marinades: Principles; processing of cold, cooked and fried marinades, shelf life and spoilage, Fish and shellfish pickles : Production, shelf life, Fermented fish products : Fish ensilage, fermentation using acids (formic acid / lactic acid) and enzymes, properties, storage and associated changes uses, animal feed formulations, Fish sauces : Boiled fish products, Packaging requirements for dry, cured and fermented products.

Value added products: Minced fish: Equipment for mince preparation, freezing, frozen storage characteristics, effect of mincing on physical and chemical properties, Surimi : Basic concepts, process elements, washing process, strainer, dehydrator, cryoprotectants, packaging, freezing and storage, gel formation, gel structure, type of gels, Products : Kamaboko type products, fish burger, cutlet, texturised products, moulded products, formulated products, Battered and breaded products : Present and future market, ingredient for batter system, functionality of corn in coatings, fats and oils, flavourings and seasonings in batter and breading systems, factors affecting performance characteristics of wheat flour batters, hydro-colloids in batter, breadings, functional properties and classification, microwavable coated foods, batter and breading process, equipment, application of batters and breadings to sea foods, trouble shooting, technique for batter and breading systems, Rheology : Flow behaviour of fluid system, Newtonian fluids, non-Newtonian fluids, deformation behaviour of solid food materials. Hookean and non-Hookean behaviour, elastic behaviour, plastic behaviour, visco-elastic behaviour, strength of food material, applications. Measurement of properties of surimi products. IQF products, AFD products, fish balls, paste, Fish sausage: Ingredients, emulsion and emulsion stability production methods, product control, Different marine products for export from India.

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, sausage etc. Preparation of fish mince, surimi, evaluation of physical and chemical properties, gel strength, colour, formulation of different products, Battered and breaded products from prawns, fish, bivalves etc. IQF products, fish sausage, burger, fish balls, cutlet, paste.

Suggested Readings

Balachandran, K. K. 2001. Post harvest technology of fish and fish products. Daya Publishing House, New Delhi.

Bligh, E. G. 1992. Seafood science and technology, Fishing News Books.

Borgstrom, G. 1961. Fish as food Vol. I,II,III & IV Academic Press, New York.

Govindan, T. K. 1985. Fish processing technology. Exford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Roller, T. and Christian. 1995. Water activity and food, Academic Press.

Seow, C. C. 1986. Food Preservation by moisture control. Elsevier Applied Science, New York.

4. POST HARVEST TECHNOLOGY

A. Major Courses

| | | |
|---|--------------|-------------------|
| A1. Core Courses | | 12 Credits |
| 1. Pre-process Handling, Chill Storage and Transportation | 2 + 1 | |
| 2. Applied Fish Biochemistry | 2 + 1 | |
| 3. Applied Microbiology | 2 + 1 | |
| 4. Freezing and Frozen Storage | 2 + 1 | |
| Seminar | 0 + 1 | 1 Credit |
| A2. Optional Courses | | 12 Credits |
| 1. Essentials of design and maintenance of Fish Processing plants and Instrumentation | 2 + 1 | |
| 2. Thermal processing and packing of fish product | 2 + 1 | |
| 3. Quality Assurance and Management & Bacteria of Public Health Significance | 2 + 1 | |
| 4. By-products and Speciality Products | 2 + 1 | |
| 5. Curing, Dehydration and Value Added Products | 2 + 1 | |
| 6. Post-harvest Technology | | |
| 7. Fishing technology | 2 + 1 | |
| B. Supporting courses | | 10 Credits |
| 1. Biochemistry | 2 + 1 | |
| 2. Fishery Economics and Marketing | 2 + 1 | |
| 3. Fisheries Extension & Education | 2 + 1 | |
| 4. Computer and Mathematical Applications | 2 + 1 | |
| 5. Project Planning and Management | 2 + 1 | |
| 6. Advances in Biology and Physiology | 2 + 1 | |
| Any other course(s) suggested by Student Advisory Committee | | |
| Total | | 35 Credits |

A. MAJOR COURSES

A1. CORE COURSES

1. Pre- Process Handling, Chill Storage and Transportation 2 + 1

Structure of fish myosystems, Structural and chemical changes associated with postmortem, Fish as raw material for processing: Body structure, physical properties, shape, specific weight, bulk weight, angle of slip, weight composition, Factors affecting quality of fresh fish: intrinsic and extrinsic factors, Handling of fish onboard fishing vessels, Unit operations, unloading fish, Fish pumps, Post-harvest Fishery Losses, Methods to reduce losses, Handling Fish in Landing Centres, Defects and Modifications needed , Chill storage of fish: Heat load calculation, storage methods, insulated boxes and insulation thickness, different types of ice, physical, chemical and sensory changes during chill storage, iced storage shelf life, cold shock, physical, chemical and sensory methods of analysis, Different types of ice and their manufacture , Flow ice, Melanosis and its prevention, Discolouration in aquatic products, Depuration of bivalves, Modified atmosphere packaging.

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, Storage for transport, Cold chain, Packing systems

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 quality of fresh fish from local markets

Suggested Readings

Aitken, A., Mackie, M., Merritt S. H. and Windsor, M. L. 1982. Fish handling and processing. Ministry of Agriculture, Fisheries and Food, Torry Research Station, Edinburgh.

Balachandran, K. K., 2001. Post harvest technology of fish and fish products. Daya Publishing House, New Delhi.

Borgstrom, G. , 1961. Fish as food Vol. I,II,III & IV Academic Press, New York.

Connell, J. J., 1980. Advances in fish sciences and technology. Farnham Survey England.

George, M. Hall, 1992. Fish processing technology. VCH Publications, Inc., New York.

Gopakumar K., 1993. Fish packaging technology. Concept Publishing Company, New Delhi.

Johnston, W. A. and Necholson, F. J., 1994. Freezing and refrigerated storage in fisheries. FAO technical paper No. 340.

Ruiter, A., 1995. Fish and fishery products composition, Nutritive properties and stability. CAB International Wallingford, Oxon - U. K.

2. Applied Fish Biochemistry

2 + 1

Seafood Proteins: Sarcoplasmic Proteins: Classification, Enzymes, Hydrolases, Oxidoreductases, Other enzymes, Pigments, Heme Proteins, Myoglobin, Hemocyanins, Parvalbumins, Antifreeze proteins. Myofibrillar Proteins: Myosin - Isolation, Sub-unit composition, Stability, Gelation, Actin, Tropomyosin, Troponins, Paramyosin, Connectin. Collagen in fish muscle and skin: Location, connective tissue in the muscle, Characteristics of seafood collagen, Collagen on the quality of seafoods, gaping, Functional properties of seafood proteins: Solubility, emulsification, viscosity, water holding, gelation, Denaturation: By high and low temperatures and kinetics, dissociation/ aggregation/coagulation etc., reversibility, significance to processing and quality, Hydrolysis and hydrolysates: Process and applications, Nutritional evaluation: Digestibility methods, availability, PER, NPU, BV, and effect of processing, anti-nutritional factors, Non-protein nitrogenous compounds: Free amino acids, Peptides, Nucleotides, Guanidins, Urea, Quarternary ammonium compounds, TMAO and its decomposition products, demethylase

Seafood Lipids: Composition and nutritive value, Lipid types and their variations fatty acid composition of fish liver and body oils, lipid fractionation, triglycerides, phospholipids, non-saponifiables including sterols and vitamins, Polyunsaturated fatty acids, prostaglandins, Beneficial effects on human health, estimation of lipid fractions, auto-oxidation of fatty acids, pro and anti oxidants, oxidation indices, lipid-protein interactions and their impact on quality, rancidity, lipases and phospholipases. Macro and trace elements in fish and shellfish ; Minerals of nutritional significance, toxic metals and their harmful effects, metallothionines

Flavour bearing compounds in fish, Flavour, taste and odour, basic tastes, chemical basis of flavour perception, Nucleotides: Post mortem degradation, K - value, Free amino acids, amines, volatile fatty acids, carbonyls, sulphur containing compounds, carotenoids, isoprenoids, Influence of processing on flavour

Toxins and toxic substances in fish and shell fish: Naturally occurring: PSP, saxitoxin, tetrodotoxins, etc., Introduced by human activities: Pesticides, heavy metals, hydrocarbons, bio-magnification, permissible limits, assay methods, Biogenic amines, Aflatoxins in cured fish.

Experimental techniques in food analysis: Theoretical aspects, Chromatography: Principles, Types - Paper, TLC, GLC, IEC, HPLC, LC, Affinity, Perfusion etc. GC-MS, Electrophoresis, ultracentrifugation, atomic emission/absorption spectroscopy, IR spectroscopy, Colourmetry : Beer Lambert Law , Principles of colourimeters, absorption of light by coloured media, laws of absorption of radiation, Spectrophotometry: Absorption of light by colourless media, UV&IR spectrophotometry , Principles of UV/VIS, DB/DW spectrophotometers, FTIR, and molecular absorption, Element of atomic absorption, Principle of operation, mercury and cold vapour absorption mercury analyzer, atomic emission spectrophotometry and ICP. Post-

mortem changes in fish muscle, Glycolysis, rigor mortis, rigor resolution, technological significance, spoilage indices, Bioactive materials from aquatic sources.

Practical

Molarity, normality, acid-base, redox titration, buffers, Lipids - Soxhlet/Bligh and Dyer, fractionation by TLC, PV, FFA, TBA, Fatty acid composition by GLC. Amino acid Analysis by HPLC. Protein purification methods: (NH₄)₂SO₄/solvent precipitation, ultracentrifugation, dialysis & ultrafiltration, gel filtration, electrophoresis, PAGE and SDS-PAGE, Estimation of metals - using AAS/ICP. Separation of selected amino acids/sugars using TLC/paper chromatography. Molecular weight determination of proteins, Enzyme assay techniques - ATPase assay, Carbohydrate metabolism, lipid metabolism, marine polysaccharides for food use, molecular biology techniques in fish and bacterial identification, and topical subjects

Suggested Readings

Gorge, M. P. and Barbec, W. T., 1990. Sea food effects of technology and nutrition. Marcel Dekker Inc., New York.

Joe, M. R. and Carrie, E. R., 1984. Food protein chemistry. Academic press Inc. New York.

Michael Eskin N. A., 1990. Biochemistry of foods. Academic Press Inc., New York.

Owen, R. F. 1996. Food chemistry. Marcel Dekker, Inc., New York.

Robert, G. A., 1989. Marine, Biogenic Lipids Fats and oils Vol. II CRC Press Inc., Boca Raton, Florida.

Roy, E. M. and George, J. F., 1990. The sea food industry - Van Nostrand Reinhold, New York.

Roy, E. M., Geroge, J. F. and Donn, R. W., 1982. Chemistry and Biochemistry of marine food products. AVI publishing company, Westport, Connecticut.

3. Applied Microbiology

2 + 1

Fundamentals in Microbiology: Morphology of bacteria, yeast and molds, microscopy, dyes and stains, staining of bacteria. Gram staining, Acid fast staining, bacterial cell staining. Nutrition of bacteria, culture of bacteria, culture media, effect of environment on bacteria, pH. Gaseous environment, temperature, Growth-phase of bacteria. Laboratory techniques in bacteriology. Pure culture techniques in bacteriology. Nature and activity of microbes in fish and fishery products: Microbiology of marine, brackish and freshwater fish/shell fish, microbiology of spoilage and preservation, microbial changes during icing, freezing and curing, chemical control of microbial spoilage, effect of preservatives and antibiotics on microflora, development of resistant microflora.

Industrial Microbiology: Industrial microbiology: Definition and scope, screening of microorganisms, detection and assay of products of fermentation, preparation and use of

fermentation media, starter culture, preparation and maintenance of stock cultures. Fermentation equipment: Batch wise and continuous, Important fermented products and methods of production: Bread, liquors, vinegar. Fermented fish products - patties, ensilage, etc. Production of protein, enzyme and other useful products by fermentation. Immobilization of microbial cells and their use.

Practical

Staining and microscopy of bacteria, yeast and molds, Motility, sterilization, preparation of culture media, nutrient agar, nutrient broth, sugar broth, selective and differential media, enumeration and isolation of bacteria, biochemical reactions, identification of bacteria, identification of common bacterial cultures. Sampling for TPC, fresh, iced and frozen fish, selection of bacterial groups in iced fish, isolating psychotrophic bacteria, gelatin and casein hydrolysis by bacteria, isolation of fish spoiling bacteria, enumeration of halophilic bacteria from salted fish, antibiotic and drug sensitivity of bacterial culture. Fermentation by selected microbes. Assay of products formed. Determination of optimum conditions for maximum rate of fermentation. Determination of the effect of certain activities on rate of fermentation.

Suggested Readings

- Chakraborty, P., 1995. A text book of microbiology. New Central Book Agency (P) Ltd.
- Harry W.S.J.R., Paul, J. V. and John, J. L., 2000. Microbes in action. Freeman and Company, New York.
- Michael, J. Pelizar, J. R., Chan, E. C. S., 1998. Microbiology. Tata McGraw Publishing Company, Delhi.
- Samuel, C. P. and Dunn C. G., 1959. Industrial microbiology, MC Grow Hill Book Company Ltd.
- Silliker, J. H., Elliof, R. P., Baird A. C. and Boyan, F. L., 1980. Microbial ecology of foods Vol. II (ICMSF). Academic Press, New York.
- William, C. Frazier and Dennis C. Westhoff, 2000. Food microbiology. Tata Mc Graw Hill Publishing Company Ltd., New Delhi.

4. Freezing and Frozen Storage

2 + 1

Freezing: Structure of water and ice, Influence of solutes on the structure of water and ice, phase equilibrium and freezing curves of pure water and binary solution, freezing curves for fish, determination of freezing points from time-temperature plots, calculation of freezing time, crystallization, nucleation, homogeneous and heterogeneous nucleation, super cooling, crystal growth, eutectic point, location of ice crystals in tissue, changes during freezing.

Technological aspects of freezing: Methods of freezing, comparison of various freezing

methods, selection of a freezing method, product processing and packaging, chemical treatment prior to freezing, antioxidants, cryoprotectants and other additives, Cryoprotectants: Mechanism of freezing injury and cryoprotection, various hypothesis glazing. Frozen storage: Physical changes - freezer burn and recrystallisation, different types of recrystallisation.

Chemical changes - lipids, proteins, 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, Water holding capacity, Time temperature tolerance, temperature and duration of storage on quality and shelf life. Arrangements within a cold storage, handling and stacking systems, space requirement filleting of fish, Treatments, Glazing, Packaging, Freezing, Processing of prawns, Lobster, Squid, Cuttle Fish, Crab etc. Different frozen marine products for export from India.

Practical

Filleting of fish, treatments, glazing, packaging, freezing. Processing of Prawns, Lobster, Squid, Cuttle Fish, Crab etc., Packaging and Freezing, Freezing curve, determination of freezing point.

Suggested Readings

Balachandran, K. K., 2001. Post harvest technology of fish and fish products. Daya Publishing House, New Delhi.

Bligh, E. G., 1992. Seafood science and technology, Fishing News Books.

Borgstrom, G., 1961. Fish as food Vol. I, II, III & IV Academic Press, New York.

Fredrick, W. W., Thomas B. L., 1985. Processing aquatic food products. Wiley, Interservice publication, New York.

Govindan, T. K., 1985. Fish processing technology. Exford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Hall, G. M., 1992. Fish processing technology. VCH publishers, Inc., New York.

Johnston, W. A. and Nicholson F. J., 1994. Freezing and refrigerated storage in fisheries. FAO technical paper No. 340.

Regenssein, J. M. and Regenssein, C. E., 1991. Introduction to fish technology. Van : Nostrand Reinhold, New York.

A2. OPTIONAL COURSES

1. Essentials of Design and Maintenance of Fish Processing Plants and Instrumentation 2 + 1

Instrumentation: Measurement Techniques, Sensors, Active and passive sensors, characteristic of sensors for the measurement of temperature, relative humidity, aw-value, gel strength, moisture, freshness, pH, conductivity, DO, redox potential, salinity, air velocity, solar energy and brine concentration, Thermometers: Different types of thermometers, characteristics and application. Instrumentation techniques: General configuration of instrumentation system. Instrumentation for measurement of aw value, temperature, pH, freshness, gel strength, salinity, brine concentration. 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

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 aw value.

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. 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. 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. 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.

Practical

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.

Suggested Readings

Hayakawa, I., 1995. Food processing by ULTRA / High pressure twin screw extrusion.

Technomic publishing Co., Inc., BASEL.

Heid and Joslyn. 1980. Food processing operations, AVI Publishing Co. INC., New York.

Slade. 1997. Food processing plants, Leonard Hill Books, London.

Chupakhim and Dormenko. 1985. Fish processing equipments. MIR Publishers.

2. Thermal Processing and Packaging of Fish Products

2 + 1

Principles of thermal processing Mechanism of heat transfer: conduction, convection, radiation and dielectric and microwave heating, unsteady state transfer, heat resistance of bacteria and spores, decimal reduction time, thermal death time, "Z" and "F" values, 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 - Fo value, cook value, D value, integrated F value and their inter-relationship determination of adequate process method. Heat processing and heat equipment, Acidity classification of foods - definition of canning, absolute sterility, commercial sterility, pasteurisation Vs sterilization

Canning process, steps involved, process flow, additives, HTST processing and aseptic canning, principles and process details, Can manufacture, lacquers AR and SR lacquers, retortable pouches, Canning machinery and equipment, Canning process for fish/shellfish, Value added canned products, 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 Canning plant location:

Practical considerations, canning plant facilities, lay out design, Retort pouch processing of fish and fishery products principles and techniques. Combination and synergistic effects (Hurdle Technology): Combination with heat, heat and hydrostatic pressure, heat and low pH, heat, NaCl and nitrite, Combination with ionising radiation, irradiation and hydrostatic pressure, irradiation and NaCl, irradiation and other adjuncts, heat and irradiation, irradiation and low temperature, low pH and specific acids, low aw and adjuncts. Irradiation: Radiation sources, units, dose levels radappertization, radacidation, radurization, effects of irradiation on protein, lipids, vitamins, bacteriological aspects, physical properties, shelf life.

Importance of packaging in Fish Processing, Production of kraft paper, Aluminium foil, corrugated fibre board and various flexible plastic films, Laminations and Co-extrusions, properties of various packaging materials, Retort pouch packaging, Advantages and Disadvantages, Biodegradable films, Vacuum Packaging, Polymeric Packaging Materials and their safe use in food contact application, OTS cans, Different types of lacquers, thermoformed containers. Packaging requirements of fresh fish, Frozen fish, Canned Fish, Dehydrated Fish and various value added products etc. Insulated boxes. Accelerated shelf testing.

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 parameters, Heat Penetration Curve, f_0 Value, Z value, Process time, Canning of table fishes, Bivalves, Crustaceans in different containers, Operation of over pressure autoclaves, Canned culinary preparations, Examination of Canned fishery products.

Determination of grammage of paper and board, bursting strength, burst factor, puncture resistance, water proofness , stiffness of the board, ring stiffness of paper and board, flat crush, tensile strength and elongation at break of plastic films, density of plastic films, breaking length, impact strength of plastic films, tearing strength of paper and plastic films, water vapour transmission rate, oxygen transmission rate, heat seal strength, suitability of plastic films for food contact applications, evaluation of retort pouch, identification of plastic films.

Suggested Readings

Balachandran, K. K., 2001. Post harvest technology of fish and fish products. Daya Publishing House, New Delhi.

Govindan, I. K., 1985. Fish processing technology, Oxford and IBH Publishing Company.Pvt. Ltd., New Delhi.

Herson and Hulland, 1981. Canned foods. Chemical Publishing Company, Inc., New York.

Larousse, J. and Brown, E. B., 1997. Food canning technology, Wiley, VCH, New York.

Progstrom, G. 1961. Fish as food, Vol. I, II, III and IV. Academic Press, New York.

Zeathen, P. 1984. Thermal processing and quality of foods. Elsevier Applied Science Publishers. London.

3. Quality Assurance and Management & Bacteria of Public Health Significance

2 + 1

Quality Assurance and Management

Quality management, total quality concept and application in fish trade. Quality assessment of fish and fishery products - physical, chemical, organoleptic and microbiological. Quality standards. Quality Assurance. Inspection and quality assurance: Fish inspection in India, process water quality in fishery industry, product quality, water analysis, treatments, chlorination, ozonisation, UV radiation, reverse osmosis, techniques to remove pesticides and heavy metals. Sensory evaluation of fish and fish products, basic aspects, different methods of evaluation, taste panel selection & constitution, statistical analysis

Quality problem in fishery products: good manufacturing practices. HACCP and ISO 9000 series of quality assurance system, validation and audit. national and international standards, EU regulation 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. Factory sanitation and hygiene: National and international requirements, SSOP. Hazards in sea foods: Sea food toxins, biogenic amines, heavy metals and industrial pollutants.

Practical

Evaluation of fish / fishery products for organoleptic, chemical and microbial quality. Methods for analysis for bacterial quality parameters, chemical parameters and filth. Water analysis. Evaluation of sanitary conditions in fish processing units. Analysis of typical hazards.

Quality assurance & operations research SQC : Introduction. Statistical Principles involved, process control, control charts, variable and attribute control charts, Cusum charts, acceptance sampling, basic ideas, sampling by attributes single and double sampling plants, Applications in the real context.

Infection and immunity, Microbial food poisoning, 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. Mycotoxins in cured fish, bacteria associated with fish disease.

Bacteria of Public Health Significance

Infection and immunity, Microbial food poisoning, 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. Mycotoxins in cured fish, bacterial associated with fish disease.

Food-Borne diseases: Food-borne bacterial infections and intoxication. Botulism and staphylococcal food poisoning, organism responsible and their origin, growth and toxin production, nature of toxins, incidence of poisoning, foods involved. The etiology of diseases: Conditions for outbreak & prevention.

Food infections by Salmonella, Clostridium perfringens, Vibrio parahaemolyticus, Enteropathogenic E. coli, etc., the nature of causative agent, its source, incidence, foods involved, the diseases, conditions for outbreak and prevention. 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. Virus and some parasites found in foods. Poisoning by chemicals: Heavy metals, pesticides, non-metals, occurrence in food and toxic effects. Biological toxins occurring in sea foods: Scombroid poisoning, histamine problem, shell fish poisoning, ciguatera poisoning, puffer fish poison.

Practical

Laboratory techniques to detect and identify pathogens in fish - E.coli, Staphylococcus aureus, Streptococcus faecalis, Clostridium perfringens, Clostridium botulinum, Salmonella, Listeria, Vibrio cholera, Vibrio parahaemolyticus, V. vulnificus, Animal bio assay of bacterial toxins. Electrical circuits-faults and remedies. Safety controls for freezing and canning plant machinery. Detection and estimation of important toxins. Demonstration of toxic effects of some toxins in laboratory animals. Detection and estimation of important toxic chemicals in food.

Suggested Readings

- Connell, J. J., 1995. Control of fish quality. Fishing news books.
- Gopakumar, K. 1993. Fish packaging technology. Concept Publishing Company, New Delhi.
- Huss, H. H., Jakobsen, M. and Liston, J., 1991. Quality assurance in the fish industry. Elsevier Publishing, London, New York.
- John, D. E. V., 1985. Food safety and toxicity - CRC Press, New York, London, Tokyo. Seafood science and technology - BLISH.
- Krenzer, R., 1971. Fish inspection and quality control. Fishing News Ltd., London.

4. By-products and Specialty Products

2 + 1

Fish meal: Production - dry and wet process, machinery, control of quality of products, specifications, packaging and storage, Fish body and liver oils: Extraction, purification, preservation and storage, industrial and nutritional applications of fish oils. Vitamin A & D. 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, 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 in shark liver oils, curing and tanning of shark skin, shark cartilage, Shrimp waste and squilla utilisation: Resources and composition, conventional uses, feeds and manure, conversion to useful materials like chitin, chitosan, , commercial production, production and use of protein isolates from squilla and shrimp waste.

Fish protein concentrate: Different methods of production, functional properties, different types of FPC, texturised products. Sea weeds and their utilisation: Different species, occurrence, processing, conversion to agar, alginic acid, sodium alginate, carrageenan, agarose, agaropectin. Fish silage: Acid silage and fermented silage production, advantages over fish meal, nutritional value of silage, Fish hydrolysates: Production and utilisation, biochemical composition and importance in food and nutrition, Miscellaneous by-products: Fish maws and isinglass, pearl essence, fertiliser, beche-demer.

Practical

Preparation of fish meal, FPC, fish oils, chitin, chitosan, glucosamine, fish maws, isinglass, agar, alginic acid, feed, glue, pearl essence, etc., Fish enriched sauce, Detection and identification of ambergris. Feed formulation: Digestive system and digestion of food in cultivable fish/shell fish, feed ingredients, their potential nutritive value, antinutritional factors in feeds manufacture of feeds, storage and quality control, micro particulate and micro encapsulated diets, feeds for larvae of prawns, energy content of feeds, identification of natural binding materials in imparting water stability to this feeds. Preparation of feeds, formulation, encapsulation, experimental diets, nutritional evaluation, biochemical composition, evaluation of FCR & PER of feeds.

Suggested Readings

Balachandran, K. K., 2001. Post harvest technology of fish and fish products. Daya Publishing House, New Delhi.

Grantham, G. J., 1981. Minced fish technology. FAO Fisheries Technical paper No. 216. FAO, Rome.

Kreuzer, R., 1974. Fishery products. Fishing News Books Ltd.

Suzuki, T., 1981. Fish and krill protein technology. Applied Science publisher, London.

5. Curing, Dehydration and Value Added Products

2 + 1

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. 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, rum drier, solar drier etc.

Freeze drying, principles, application of phase rule, triple point of water, sublimation of ice, accelerated freeze drying (AFD), shelf life and specialties of AFD products, machinery and equipment for freeze drying, process flowchart.

Dehydration of fish products: Dehydration ratio, precautions to be taken in fish drying; denaturation of fish protein. Cured fish, 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. Methods of salting, dry/kench/wet and pickling, brine salting, Spoilage of dried/cured fish, physical, chemical and microbiological changes, methods to prevent/control spoilage, extension of shelf life Smoke curing, chemistry of smoke, composition and properties, smoking methods, cold, hot and use of smoke liquids, production of smoke, type of wood used, methods of smoke generation, carcinogens in smoke, smoke kilns, Colombo curing, specialty of the process.

Marinades: Principles, processing of cold, cooked and fried marinades, shelf life and spoilage. Fish and shellfish pickles: Production, shelf life. Fermented fish products: Fish ensilage, fermentation using acids (formic acid/lactic acid) and enzymes, properties, storage and associated changes uses, animal feed formulations. Fish sauces: Boiled fish products, Packaging requirements for dry, cured, and fermented products.

Value Added Products: Mince, surimi and their products, Minced fish: Equipment for mince preparation, freezing, frozen storage characteristics, effect of mincing on physical and chemical properties. Surimi: Basic concepts, process elements, washing process, strainer, dehydrator, cryoprotectants, packaging, freezing and storage, gel formation, gel structure, type of gels.

Products: Kamaboko type products, fish burger, cutlet, texturised products, moulded

products, formulated products. Battered and breaded products: Present and future market, ingredient for batter system, functionality of corn in coatings, fats and oils, flavourings and seasonings in batter and breading systems, factors affecting performance characteristics of wheat flour batters, hydro-colloids in batter, breadings, functional properties and classification, microwavable coated foods, batter and breading process, equipment, application of batters and breadings to sea foods, trouble shooting, technique for batter and breading systems.

Rheology: Flow behaviour of fluid system, Newtonian fluids, non-Newtonian fluids, deformation behaviour of solid food material, Hookean and non-Hookean behaviour, elastic behaviour, plastic behaviour, visco-elastic behaviour, strength of food material, applications. Measurement of properties of surimi Products. IQF products, AFD products, fish balls, paste. Fish sausage: Ingredients, emulsion and emulsion stability production methods, product control. Different marine products for export from India.

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, sausage etc. Preparation of fish mince, surimi, evaluation of physical and chemical properties, gel strength, colour, formulation of different products. Battered and breaded products from prawns, fish, bivalves etc. IQF products, fish sausage, burger, fish balls, cutlet, paste.

Suggested Readings

Balachandran, K. K. 2001 Post harvest technology of fish and fish products. Daya Publishing House, New Delhi.

Bligh, E. G. 1992. Seafood science and technology, Fishing News Books.

Borgstrom, G. 1961. Fish as food Vol. I- IV Academic Press, New York.

Govindan, T. K. 1985. Fish processing technology. Exford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Roller, T. and Christian. 1995. Water activity and food, Academic Press, London

Seow, C.C. 1986. Food Preservation by moisture control, Elsevier Applied Science, New York.

6. Post-harvest Technology

1 + 1

Harvesting of freshwater fish. Grading of fish; Whole fish quality evaluation Packing, storage and transportation. Introduction to freezing and chilling: Historical development; principles of chilling and freezing, methods of chilling: Transportation and marketing of chilled and frozen fish. Freezing of fish: Methods of freezing, changes during freezing fish; Packaging of frozen fish; Marketing; Cold chain and export trade; Transportation and marketing of frozen products. Quality control during freezing and chilling. Fundamentals of fish preservation, drying,

smoking, curing, salting, fermentation, marinating and pickles. Introduction to fish canning, principles of thermal processing, changes during canning, problems related to fish canning. Value addition in freshwater fish. Introduction to fish paste products (fish sausage and ham, etc.). Fish protein concentrate, fish hydrolylate, etc. Additives and preservatives; Fishery by-products : Fish meal, bone meal, fish oil, surgical sutures from intestine, chitin and chitosan; Fishery product packaging and packaging material; Marketing and economics of fish processing.

Practical

Whole fish quality evaluation. Visit to fish market and processing plants. Preparation of fishery products and by-products; Quality control in fresh fish; Physico-chemical analysis of fish and fishery product; Microbiological analysis of fishery products; Sensory evaluation of fish and fishery products.

Suggested Readings

Balachandran K. K. 2001. Post harvest technology of fish and fish products. Daya Publishing House, New Delhi.

Govindan, T. K. 1985. Fish Processing Technology. Oxford & IBH Pub. Co. Pvt. Ltd., New Delhi.

Zeathen, P. 1984. Thermal processing and quality of foods. Elsevier applied science publishers, London

7. Fishing Technology

2 + 1

Fishing boat and factory vessels. Principal dimensions and terms relating to fishing boats, FAO classification of fishing boats. Modern navigational equipment, life saving appliances and emergency kits. Factory vessels, distant water and deep sea fishing vessels: General layout, net and fish handling machinery on vessels, construction and characteristics of fish holds, Equipment and machinery for handling and storage on board. MAPROL regulations relating to waste disposal from factory vessels.

Contamination fish in contact with corroded metal surfaces, wood treated with preservatives; requirements for storage of potable water in fishing boats, familiarization of reverse osmosis system. Modern commercial fishing methods: trawling, purse seining, gillnetting, long lining; Resources specific fishing gears: Inshore, offshore and deep-sea fishery resources. Selectivity in fishing gear, By-catch Reduction Devices (BRDs), Turtle Excluder Devices (TEDs), Fish Aggregating Devices (FADs), artificial reef, etc. Electronic equipment for fisheries and oceanographic research: Fisheries acoustics and electronic aids like echosounder, fishfinder, sonar, netsonde, Integrated Trawl Information (ITI) system, scanner etc.

Practical

Onboard experience in fishing vessels and participation in multi-day fishery and oceanographic

research ships. Preparation of a catalogue on International Standard Classification of fishing boats. Preparation of glossary of terms (about 300 terms) on fishing craft and gear. Determine the parameters of EU requirements in fishing boats. Mechanical strength testing of craft, gear and packaging materials.

Suggested Readings

Brandt, A. V. 1984. Fish catching methods of the world. Fishing News Books Ltd., London. pp. 418.

Fyson, J. 1985. Design of small fishing vessels. Fishing News Books Ltd., London. pp.320.

Klust, G. 1982. Netting materials for fishing gear. FAO fishing manuals West Byfleet survey, Fishing News Books. pp. 175.

Shenoy, L.1988. Course manual in Fishing Technology. CIFE, Mumbai (1:88) pp. 91.

Sainsbury, J. 1996. Commercial fishing method - An introduction to vessels and gear. Fishing News Books Ltd., London. pp. 359.

Sreekrishna, Y. and Shenoy, L. 2001. Fishing gear and craft technology. Indian Councilo of Agricultural Research, New Delhi. pp. 342.

B. SUPPORTING COURSES

1. Biochemistry

2 + 1

Carbohydrates: Sources, types and terminology, Importance of dietary carbohydrate, Caloric value and digestibility, structure and nomenclature: Monosaccharides, Oligosaccharides, Polysaccharides, Glycosides, Reductones; Chemical Reactions; Oxidative browning, Non oxidative browning, Caramelization, Sugar-ammonia reactions. Functional properties of polysaccharides, Starch: Molecular structure, Swelling of the starch granule; Glycogen

Amino acids: Structure, classification, supplementation, amphoteric nature, pKa, common and derived amino acids. Proteins Structure, primary, secondary, tertiary, quaternary, sequence, synthesis, Lipids; Definition, classification, structure, major oil types, Enzymes Classification: EC numbers, factors affecting activity, activity expression. Kinetics: v, VM, Km, inhibition types, activation, Mechanism of action, regulation

Vitamins Fat and water soluble groups, chemical nature, role in metabolism, sources, concentration in fish, deficiency diseases, effects of processing. Pigments: myoglobin, hemoglobin, carotenoids

Practical

Analysis of sugar, Amino Acids, Peptides, Enzymes, Neutral lipids, Fatty acids, Triglycerides, Phospholipids, Pigments, Aroma compounds, Dietary fiber, Colourants, Preservatives, Synthetic Antioxidants, Identification of irradiate foods.

Suggested Readings

George, M. P. and Barbee, W. T., 1990. Sea food effects of technology and nutrition. Marcel Dekker Inc., New York.

Joe, M. R. and Carrier, E. R., 1984. Food protein chemistry. Academic Press Inc., London.

Michael, E. N. A., 1990. Biochemistry of foods. Academic Press Inc., New York.

Owen, R. F., 1996. Food chemistry. Marcel Dekker, Inc., New York.

Robert, G. A., 1989. Marine biogenic lipids fats and oils Vol.II. CRC Press, Inc., Boca Raton, Florida.

Roy, E. M. and George, J. F., 1990. The sea food industry. Van Nostrand Reinhold, New York.

Roy, E. M., George, J. F. and Donn, R. W., 1982. Chemistry and biochemistry of marine food products. AVI publishing company, Westport, Connecticut.

2. Fishery Economics and Marketing

2 + 1

Introduction to Fisheries Economics: General Economics and Fisheries Economics; Basic concepts of Economics as applicable to fisheries; Contribution of fisheries in the National Economy. General Classification of the Fishing Industry: Main Industry and Ancillary Industries - primary, secondary and tertiary sectors. Ancillary Industries and their components - an empirical picture. Employment scenario in the main and ancillary industries.

Economics of Capture and Culture Fisheries: Cost and earning of different types of fishing units in marine and inland fisheries. Estimation of Breakeven Point and comparative profitability. Investment; Autonomous and Induced Investment. Factors influencing investment decisions. Choice and formulation of aquaculture investment projects. Net worth statement or balance sheet, Cash flow analysis, Farm budgeting ratio analysis.

Marketing: Types of markets. Classification of markets. Different approaches to the study of fish marketing. Marketing functions. Demand for fish and farm product. Price behaviours. Marketing costs. Marketing channels. Marketing margins and price spread. Determination of price. Role of co-operative fish marketing. Trends of export marketing, product diversification and promotional efforts, Socio-economic status of fisherfolk

Practical

Preparation of schedule for collecting data on Costs and earnings of different capture and culture fishing techniques, Market surveys, Socio-economic surveys. Field level data collection, Tabulation, Analysis and Report writing.

Suggested Readings

Andrew, P. 1999. Fish business management - Strategy marketing - development, Fishing News Books, London.

Curtis, M.J. and Howard, A. C. 1997. Economics of aquaculture. Food products press, New York.

FAO, 1995, Fisheries technical paper, 351. Economic engineering applied to the fishery industry.

Paul, A.S. 1973. Economics. McGraw Hill Kogakusha Ltd., Tokyo.

Shaug, Y.C., 1981. Aquaculture economics - Basic concepts and methods of analysis, Groom Helm Ltd., Great Britain.

Seijo, J.C., Defeo, D.S. 1996. FAO fisheries technical paper 368. Fisheries bioeconomics - Theory, modeling and management, FAO, Rome.

3. Fisheries Extension & Education

2 + 1

Historical Perspective, Concept of Extension Education, Fisheries Extension Functionaries, Communication, Diffusion of Innovations, Extension Methods, A-V aids, Programme Planning, Training, HRD, Entrepreneur-ship Development Process, Extension Administration, Recent

Approaches in Extension, Extension Research Methodology

Practical

Communication skills; planning and preparation of Extension literatures, methods A-V aids, script for radio/TV/Video programmes, photography, Use of Multimedia, Visit to Air, DD, Leading newspapers, Socio-economic survey.

Suggested Readings

Dahama, O. P. 1993. Extension and rural welfare. Ramprasad and Sons, Agra.

Dhote, A. K. 1989. Fisheries management and extension : Inland fisheries, instructional-cum-practical manual (VI), National Council of Educational Research

Lynton, P. R. and Pareek, U. 1978. Training for development Kumarian Press, 29 Bishop Road, West Hartford, Connecticut 06119.

Rao, T. V. 1991. Readings in human resource development. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.

Ray, G. L. 1991. Extension communication and management, Naya Prakash, 206, Bidhan Sarani, Calcutta.

Supe, S. V. 1986. An introduction to Extension Education, Oxford and IBH Publishing Co., New Delhi.

4. Computer and Mathematical Applications

2 + 1

Flow charting and programming: System symbols, Programm symbols, flow charting, decision table, debugging, testing, syntax errors, execution errors, logical errors, structural programming, C programming: Principles of object oriented programming; Basic structure of C programming; programming styles, constant, variables and data types; object oriented system development; simple C++ programming and its applications. Introduction of FORTRAN-77. Measures of dispersions, relative measures of dispersions, Use of random number table. Theory of probability: frequency and axiomatic approach, Two way ANOVA, Time series analysis: Estimation of trend, seasonal variations, cyclical and irregular fluctuations, Numerical analysis: Solution of non-linear equations using bisection method, method of false positions (regular false) and Newton's method, solution of systems of equations using Gauss elimination method Introduction to graphs; method of designing graphs for those of known functions, $y = kf(x)$, $y = f(kx)$, $y=f(x) + k$ and $y = f(x+k)$; Graph of $y = ax^n$, $y = ex$, $y = \log e x$, empirical laws and curve fitting, graphical method $y = mx + c$, method of lease squares, to fit the parabola. Numerical integration - trapezoidal rule (without proof). Simpon's rule (without proof) and their applications. Mathematical logic and applications, logical and logical statement, truth value of a statement, truth tables, negation of a statement, compound statement, conjunction, disjunction, logical implication, validity of arguments.

Practical

Exercises in C programming, Analysis and interpretation of data based on statistical designs, Statistical quality control, Statistical estimation of marine fish.

Suggested Readings

Balagurusamy, E., 1989. Programming in ANSI C, Tata McGraw Hill Publishing Co., New Delhi.

Megrey, B.A. and Moksness, E., 1996. Computers in Fisheries Research, First Edition, Chapman and Hall, U.K.

Sandler, C., Badgett, T. and Weingarten, J., 1997. Office 97 for Windows, BPB publications, New Delhi.

Trevor, A., 1995. Information Technology, Pitman Publishing Co.

5. Project Planning and Management

2 + 1

Concept, scope and definition of Project and Project Cycle: Project classification: Social development and investment oriented Project Planning: Origin/Identification: goals, beneficiary/target populace/areas, benefits; Pre-proposal - Pre-feasibility and Feasibility - legal and regulatory, technical, input (manpower, service, materials) availability, social, cultural, environmental and funding, product distribution/disposal/utility: Financial & Economic viability - social development goal, return to investment, Discounted Pay Back Discounted Cash Flow (DCF), Net Present Value (NPV), Internal Rate of Return (IRR), Turnover/investment rates, Break even point. Project Appraisal: Capital, fixed and variable costs, funding schedule, fundability, moratorium, special concession, fund flow system, Project Implementation Monitoring and Control, Management Information System (MIS), Midterm evaluation, corrective provision, Management Techniques: Milestones Flow Chart, CPM, PERT techniques, Inventory control, Fiscal control - budgetary, personnel management - incentives/deterrents, worker participation , group decision, decentralised decision process.

Practical

Samples examples of CPM/PERT, DCF, IRR/NPV; Group decision making.

Suggested Readings

Andrew, P. 1999. Fish business management: strategy, marketing - Development, fishing News Books, London.

FAO, 1995. Fisheries technical paper, 351. Economic engineering applied to the fishery industry.

Paul, A.S. 1973. Economics. Mc Graw Hill Kogakusha Ltd., Tokyo.

Rao, P.S.1983. Fisheries economics and management in India. Pioneer Publishers and Distributors.

Seijo, J.C. Defeo, D. and Salas, S. 1998. FAO Fisheries technical paper 368. Fisheries bioeconomics - Theory, modeling and management. FAO, Rome.

Shaug, Y.C. 1981. Aquaculture economics: Basic concepts and methods of analysis, Groom Helm Ltd., Great Britain.

6. Advances in Biology and Physiology

2 + 1

Fish Biology

Taxonomy and identity of economically important marine, brackishwater and freshwater fishes and shellfishes of India and their distribution. Life history, reproduction, age and growth, food and feeding, migration and behavior of fish and shell fish. Principles of population dynamics, unit stock, age and size composition of population, abundance and density, recruitment, growth, mortality (Fishing and natural), capture and re-capture method, simple models for stock assessment, yield curves, optimum yield potential resources. Environment and its relation to Fish Biology.

Practical

Identification of important species of concerned group (fin fishes and shell fishes) identification of sex, important larval and juvenile stages, classification of maturity stages, estimation of fecundity, growth and age determination, gut content analysis and mark recovery experiments. Analysis of data pertaining to unit stock age and size composition, abundance and density, recruitment, growth and mortality, simple models of stock assessment.

Fish Physiology

Digestive Physiology: Alimentary canal, its anatomy and histology; digestive fluids and enzymes; feeding mechanism; digestion of lipid, protein carbohydrate and absorption; control of digestive function; digestive system of shell fish and process of digestion. Excretory Physiology: Excretion of nitrogen and other wastes in finfish and shellfish and mechanism of excretion. Respiratory Physiology: The respiratory gases; respiratory organs; medium of respiratory transport; accessory respiratory organs; physiology of respiration; respiration in shell fish. Circulatory Physiology: Heart and circulation; blood and red blood and red blood cells and their role in transport of nutrients, gases and hormones to various parts of the body.

Reproductive Physiology: Structure and anatomy of reproductive organs; sexual dimorphism and secondary sexual characters; inter sex and bisexuality; sex differentiation and determination. Endocrine glands, their structure and function; hormonal control of oogenesis, spermatogenesis, final oocyte maturation, ovulation, spermiation and spawning; reproductive cycle, types and mode of reproduction in finfishes and shell fishes. Neuro-secretory system and neuroendocrine regulation of reproduction in finfishes and shellfishes. Role of pheromones in fish reproduction.

Practical

Dissection and examination of digestive, respiratory, circulatory, excretory and reproductive organs; Histology of pituitary, thyroid, ovary, testes and inter-renals; study of secondary sexual characters in breeding of fish; blood cell types study and haemoglobin determination.

Suggested Readings

Cushing, D. H. 1968. Fisheries Biology: A study of population dynamics. Univ. Wisconsin Press, Madison. WIS. 200p.

Lagler, K. F., Bardach, J. E. and Miller, R. R. 1962. Ichthyology. John Wiley, New York. 545 p.

Sparre, P., Ursin E. and Venema S. C. 1989. Introduction to tropical fish stock assessment. Part - I Manual. FAO Fish. Tech. Pap. No. 306.1 Rome, FAO.

Annexure-I

List of the Board Subject Matter Area Committee Members of Fisheries Science.

- | | | |
|----|--|-------------|
| 1. | Dr S. A. H. Abidi Director, CIFE, Mumbai 400 058 | Coordinator |
| 2. | Dr S. L. Shanbhogue D.I., Fisheries College, UAS, Manglore 575 002 | Member |
| 3. | Dr S. Ayyappan Director, CIFA, Bhubaneswar 751 002 | Member |
| 4. | Dr I. Karunasagar Prof., Fisheries College, UAS, Manglore 575 002 | Member |
| 5. | Dr V. Ramayyan Prof., Marine Biology, CAS, Parangipettai 608 502 | Member |
| 6. | Dr M. Devaraj Director, CMFRI, Cochin 692 014 | Member |
| 7. | Dr T. S. G. Iyer Principal Scientist, CIFT, Cochin 682 029 | Member |
| 8. | Dr B.K. Sinha Asso. Dean & Principal, College of Fisheries, Dholi (Muzaffarpur), Bihar | Member |
| 9. | Dr M. Ravindran, Director, CIFT, Cochin 682 029 | Member |

Annexure-II

List of the Participants in the Meeting-cum-Workshop on Broad Subject Matter Area of Fish and Fisheries Science held at CIFE, Mumbai during 7-8 May 1999.

| | | |
|-----|--------------------------|-------------|
| 1. | Dr. S. L. Mehta, | Chairman |
| 2. | Dr. S. A. H. Abidi | Coordinator |
| 3. | Dr. S. L. Shanbhogue | Member |
| 4. | Dr. I. Karunasagar | Member |
| 5. | Dr. V. Ramayyan | Member |
| 6. | Dr. T. S. G. Iyer | Member |
| 7. | Dr. J. P. George | Invittee |
| 8. | Dr. C. Suseelan | Invittee |
| 9. | Dr. J. K. Jena | Invittee |
| 10. | Dr. K. R. Prasad | Invittee |
| 11. | Dr. Pradip Tagore | Invittee |
| 12. | Mr. Shekhar Bhatsavale | Invittee |
| 13. | Mr. Ajit Patil | Invittee |
| 14. | Dr. Geetanjali Deshmukhe | Invittee |

Annexure-III

List of participants in the workshop on Broad Subject Matter Area of Fisheries Science for restructuring of Master's degree programme at CIFE, Mumbai on 20-21 Oct., 2000.

1. Dr. S. L. Mehta Deputy Director General (Education), ICAR, New Delhi
2. Dr. K. Gopakumar Deputy Director General (Fisheries), ICAR, New Delhi
3. Dr. S. A. H. Abidi Member, ASRB, New Delhi
4. Dr. M. Y. Kamal Vice Chancellor, SKUAST, Srinagar
5. Dr. S. N. Dwivedi Director General, MPCST, Bhopal
6. Prof. H. P. C. Shetty Former Director of Instruction, College of Fisheries, Mangalore.
7. Dr. S. D. Tripathi Former Director, Central Institute of Fisheries Education, Mumbai.
8. Sri. J. V. H. Dixitulu Editor, Fishing Chimes, Vishakhapatnam
9. Dr. N. R. Menon Director, School of Marine Sciences, CUSAT, Kochi
10. Shri. M. B. Appalwar Commissioner of Fisheries, Govt. of Maharashtra, Mumbai
11. Shri B. S. Saharan Director of Fisheries, Govt. of Haryana, Chandigarh
12. Shri. D. S. Murthy Commissioner of Fisheries, Govt. of Andhra Pradesh, Hyderabad
13. Dr. H. S. Nainawatee ADG (Education), ICAR, New Delhi.
14. Dr. S. Ayyappan Director, CIFE, Mumbai.
14. Dr. M. Sinha Director, CICFRI, Barackpore
15. Dr. G. R. M. Rao Director, CIBA, Chennai
16. Dr. M. Mohan Joseph Director, CMFRI, Kochi
17. Dr. K. Devadasan Director, CIFT, Kochi
18. Dr. C. Saha Director, CIFA, Bhubaneswar
19. Dr. K. K. Vass Director, NRCCWF, Bhimtal
20. Dr. A. G. Ponnaiah Director NBFGR, Lucknow
21. Dr. M. Sakthivel President, AFI, Chennai

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|-----------------------------|---|
| 22. Dr. K. R. Prasad | President, CIAWO, Vishakhapatnam |
| 23. Dr. V. Venugopal | Senior Scientist, BARC, Mumbai |
| 24. Dr. P. C. Thomas | Former Director, College of Fisheries, OUAT, Rangailunda |
| 25. Dr. S. L. Shanbhogue | Dean, College of Fisheries, mangalore |
| 25. Dr.D. M. Thampy | Dean, College of Fisheries, Kochi |
| 26. Dr. K. Gopal Rao | Assoc. Dean, College of Fisheries Science ANGRAU, Nellore |
| 27. Dr. P. C. Raje | Dean, College of Fisheries, Ratnagiri |
| 29. Dr. Chandge | College of Fisheries, Ratnagiri |
| 30. Dr. V. Sundararaj | Dean, College of Fisheries, Tuticorin |
| 31. Dr. H. S. Murthy | President, Federation of All India Fisheries Graduate Associations, Mangalore. |
| 32. Sri. S. K. Panda | President, Students' Union, CIFE, Mumbai |
| 33. Dr. V. S. Somvanshi | Director General, Fishery Survey of India, Mumbai |
| 34. Dr. I. Karunasagar | Professor, College of Fisheries, mangalore |
| 35. V. K. Kumar | Professor, Indian Institute of Management, Kozhikode |
| 36. Dr. A. E. Eknath | Vice President, Genomar, Norway |
| 37. Dr. M. A. Upare | General Manager, NABARD, Mumbai |
| 38. Dr. M. D. Zingde | Deputy Director, BRC of NIO, Mumbai |
| 39. Dr. B. S. Saxena | Former Professor, CIFE, Mumbai |
| 40. Dr. S.C. Mukherjee | Joint Director, CIFE, Mumbai |
| 41. Dr. M. P. S. Kohli | Principal Scientist, CIFE, Mumbai |
| 42. Dr. R. S. Biradar | Principal Scientist, CIFE, Mumbai |
| 43. Dr. C. S. Purushothaman | Principal Scientist, CIFE, Mumbai |
| 44. Dr. S. D. Singh | Principal Scientist, CIFE, Mumbai |
| 45. Dr. W. S. Lakra | Principal Scientist, CIFE, Mumbai |
| 46. Dr. S. Paul Raj | PGPC, CMFRI, Kochi |
| 47. Dr. Balachandran | PGPC, CIFA, Bhubaneswar |
| 48. Dr. S. Basu | Senior Scientist, CIFE, Mumbai |
| 49. Dr. G. Venkateshwarlu | Senior Scientist, CIFE, Mumbai. |

Annexure IV

Common Academic Regulations for Post Graduate Education in SAUs, DUs and CAU

| S.No. (1) | Particulars (2) | Master's Degree (3) | Doctoral Degree (4) |
|--------------|------------------------------------|---|---|
| 1. | System of Education | Semester | Semester |
| 2. | Semester duration | 110 working days including examination days | 110 working days including examination days |
| 3. | Duration of the program | | |
| | (1) Minimum | 4 Semesters (2 Academic Years) | 6 Semesters (3 Academic Years) |
| | (2) Maximum | 8 Semesters (4 Academic Years) | 12 Semesters (6 Academic Years) |
| 4. | Eligibility for admission | (1) Bachelor's degree in respective/related subjects (2) 7.0/10 or equivalent OGPA /equivalent percentage of marks at Bachelor's degree | (1) Master's degree in respective/related subjects (2) 7.0/10 or equivalent OGPA /equivalent percentage of marks at Master's degree |
| 5. | Mode of Admission | Entrance -cum-Academic performance | Entrance -cum-Academic performance |
| | Weightage | (i) Entrance - 60% (ii) Undergraduate - 20% (iii) 12th standard - 10% (iv) 10 standard - 10% | (i) Entrance - 60% (ii) Master's degree - 30% (iii) Bachelor's degree - 10% |
| 6. | Minimum credit requirement | | |
| | (1) Course work | | |
| | Major* | 20-25 Credits | 10-15 Credits |
| | Supporting (outside discipline) | 10-15 Credits | 10-15 Credits |
| | Sub Total | 35 Credits | 25 Credits |
| | (2) Thesis | 15 Credits | 45 Credits |
| | Total | 50 Credits | 70 Credits |

* 1. Core courses to the extent of 9-12 credits for Masters and 3-5 credits for Doctoral programs have to be taken up out of major courses.

| S.No. (1) | Particulars (2) | Master's Degree (3) | Doctoral Degree (4) |
|----------------------------|---|---|---|
| 7. | Permissible work load | 15 Credits/Semester | 15 Credits/Semester |
| 8. | Attendance requirement | 80% | 80% |
| 9. | Advisory Committee | 3 Members (Minimum) (2 from major area including Chairman and one from supporting areas) | 4 Members (Minimum) (3 from major area including Chairman and one from Supporting areas) |
| 10. | Examination | | |
| | (1) Course Work | | |
| | (i) Core courses Final theory | External | External |
| | (ii) Remaining | Internal | Internal |
| | (2) Comprehensive qualifying examination (after completion of 75% of Major and Supporting Courses separately. | Written | Written |
| | (i) Question paper setting | External | External |
| | (ii) Evaluation | Internal | Internal |
| | (iii) Viva-voce | Internal | External |
| | (3) Research and Thesis ** | | |
| | (i) Evaluation | External - 1 Examiner | External - 2 Examiners |
| | (ii) Viva-voce | Internal - Advisory Committee | External - Advisory Committee with one External Examiner |
| 11. | Grading | | |
| | (1) Scale | 10 Points | 10 Points |
| | (2) Minimum Passing Grade in a course | 6.00 Points | 6.00 Points |
| | (3) Minimum OGPA to obtain degree | 6.50 Points | 6.50 Points |

- ** 1. To be graded as Satisfactory (S) or Unsatisfactory (US)
2. Ph.D. students should write and submit two research papers on their research work in reputed journals before submitting the thesis.