VIDYASAGAR UNIVERSITY

Midnapore, West Bengal

REVISED REGULATIONS, CURRICULUM & SYLLABUS

For

Bachelor of Fishery Science (Hons.)

(w.e.f. Academic Year 2025-2026)

Based on

Recommendations of VIth Dean's Committee of Indian Council of Agricultural Research (ICAR)

Preface

Building a skilled and capable human resource base is fundamental to driving forward research initiatives, advancing technologies, and establishing robust institutional frameworks to address emerging challenges and seize global opportunities. This is especially critical in the agriculture and allied sectors, where both challenges and technologies are evolving rapidly. There is a pressing need for well-trained manpower — professionals who are not only technically proficient but also socially aware and ethically grounded — to support agricultural growth amidst increasing constraints on natural resources like land and water, as well as the looming threats posed by climate change.

The Indian Council of Agricultural Research (ICAR), entrusted with overseeing, managing, and coordinating agricultural education across the nation, has been at the forefront of these efforts. Through the National Agricultural Research, Education, and Extension (NAREE) system, ICAR works in close partnership with 76 Agricultural Universities (AUs) — including State Agricultural Universities (SAUs), ICAR-Deemed Universities (DUs), Central Agricultural Universities (CAUs), and Central Universities (CUs) with agricultural faculties — to sustain and elevate the quality and relevance of higher education in agriculture. A key initiative towards this goal has been the periodic constitution of the Deans' Committee, tasked with curriculum revision and educational reforms to align with national priorities.

In line with the Government of India's vision outlined in the National Education Policy (NEP-2020), sweeping reforms are being introduced across all educational levels to create a knowledge-driven society. NEP-2020 emphasizes reimagining agricultural education around its five core pillars: Access, Equity, Quality, Affordability, and Accountability. It calls for the enhancement of both the capacity and quality of agricultural education, aiming to cultivate thoughtful, creative, and well-rounded individuals. Additionally, NEP-2020 highlights the importance of deep specialization, character development, ethical values, scientific temper, creativity, service orientation, and twenty-first-century skills.

Responding to these directives, ICAR constituted the **Sixth Deans' Committee** to reform undergraduate curricula in agriculture and allied sciences. Adopting a bottom-up approach, the committee engaged a wide range of stakeholders to redesign course content that prepares students to meet contemporary challenges and opportunities in agriculture. The Committee's primary objective was to define the competencies and skills required of future graduates and to reform the curriculum to enhance their employability, entrepreneurial capabilities, and innovation potential — thus transforming them into job creators rather than job seekers.

The report of the Sixth Deans' Committee is presented in two parts:

- **Part I** offers overarching recommendations regarding curriculum structure, credit requirements, admissions, and evaluation systems applicable across all agricultural disciplines and institutions.
- **Part II** provides discipline-specific curricula for thirteen ICAR-recognized undergraduate programs.

In accordance with NEP-2020, the revised structure allows for multiple entry and exit points:

- Students may exit after the first year with a UG Certificate or after the second year with a UG Diploma, following internships.
- Re-entry pathways are also available for certificate and diploma holders into later semesters.

Additionally, choice-based skill enhancement courses have been woven into the curriculum to foster entrepreneurship through in-plant training, internships, project work, and rural agricultural work experiences (RAWE). Common multidisciplinary, value-added, and ability-enhancement courses have been incorporated to nurture communication skills, personality development, and cross-sectoral collaboration.

Traditional knowledge systems, ethics, and wellness have been integrated through initiatives like Deeksharambh, NCC, NSS, and wellness programs. Furthermore, students will have the option to pursue online and elective courses based on their individual interests and local institutional expertise. Institutions are empowered to innovate and introduce new elective courses to meet regional needs.

Academic Bank of Credits (ABC) mechanisms are also being introduced, facilitating greater mobility and transfer of students across institutions. Moreover, emerging areas such as artificial intelligence, machine learning, robotics, nanobiotechnology, renewable energy, and information technology have been meaningfully embedded within the curricula.

This comprehensive curriculum reform is expected to drive academic innovation, institutional transformation, and ultimately, contribute to producing graduates who are ready for meaningful careers, global competition, and economic self-reliance.

In pursuant to the recommendations of the Sixth Deans' Committee of ICAR, Vidyasagar University constituted a syllabus review committee to revise the ongoing Bachelor of Fishery Science (B.F.Sc.) programme accordingly under Vidyasagar University. The Committee after series of interactions has proposed the revised syllabus and regulations of B.F.Sc. under Vidyasagar University with effect from academic session 2025-2026.

Executive Summary

Implementation of National Education Policy (NEP-2020) in Agricultural Education

The New Education Policy (NEP-2020) of India introduced numerous reforms across the country's education system, including higher agricultural education. To align agricultural education with NEP-2020, the Indian Council of Agricultural Research (ICAR) constituted a national-level committee tasked with formulating an implementation strategy. Additionally, ICAR established the **Sixth Deans' Committee** to restructure existing undergraduate curricula in agricultural education to meet the new policy directives.

Following NEP-2020 recommendations, the Sixth Deans' Committee proposed several initiatives to restructure undergraduate (UG) curricula:

Classification of Courses by Levels and Targeted Outcomes

The courses have been classified based on the level of teaching and the intended outcomes:

- **First Year (NHEQF Level 4.5):** Focuses on foundation courses, introductory subjects, skill enhancement training, and ability enhancement courses. Students are expected to develop basic knowledge in their disciplines along with foundational skills to support employment or entrepreneurship.
- **Second Year (NHEQF Level 5):** Includes basic core courses and additional skill-building modules. Students acquire deeper knowledge and improved skills aimed at middle-level employment, supervisory roles, or entrepreneurship.
- **Third Year:** Covers advanced core subjects and practical applications, promoting a deeper understanding of subjects and their real-world uses.
- **Fourth Year (NHEQF Level 6):** Students undertake specialization/elective courses along with advanced skill enhancement through projects and internships. This phase aims to equip students with advanced competencies, preparing them to become job creators and leaders in their respective fields.

Multiple Entry and Exit Options

Multiple entry and exit pathways have been introduced:

- After completing the **first year** (two semesters) and a 10-week internship (10 credits), students can exit with a **UG-Certificate**.
- After the **second year** (four semesters) and another 10-week internship (10 credits), students can exit with a **UG-Diploma**.
- A full **UG degree** will be awarded after successful completion of four years of study.
- No exit is permitted after the third year, considering the professional nature of the curriculum.

Lateral entry is allowed:

- **At the 3rd semester** for students holding a UG-Certificate or a Diploma (10^{th} & 3-year program) from recognized institutions.
- **At the 5th semester** for those with a UG-Diploma.

Introduction of New Courses and Initiatives

Deeksharambh (Induction-cum-Foundation Course): A non-graded two-week induction course at the beginning of the first semester aims to promote cultural integration, life skills, social values, teamwork, leadership, and creativity among students. It includes sessions by alumni, industry leaders, and university officials.

Common Courses across Disciplines: These courses enhance communication skills, personality development, and holistic understanding:

- Farming-based livelihood systems
- Entrepreneurship Development and Business Management
- Agricultural Marketing and Trade
- Communication Skills
- Personality Development
- Environmental Studies and Disaster Management
- Agricultural Informatics and Artificial Intelligence

Additionally, **Physical Education, First Aid, Yoga Practices, Meditation, NCC, and NSS** have been made compulsory for overall development.

New Age Courses: Modern topics like **Artificial Intelligence, Robotics, and Machine Learning** have been integrated into the curricula. Elective courses allow students to specialize further, encouraging creativity and innovation.

Online Courses: Students to complete a minimum of **10 credits** through online courses from diverse fields such as Basic Sciences, Humanities, Psychology, Business Management, Languages, Music, and more, to foster interdisciplinary knowledge.

Elective Courses: Institutions will offer a range of electives, providing students flexibility to choose based on their interests. Institutes are encouraged to develop new electives suited to regional needs and expertise.

Incorporation of Traditional Knowledge, Values, and Ethics

Courses like Deeksharambh, NCC, and NSS will emphasize Indian traditional knowledge systems, ethics, and values. **Study tours** across India are proposed to expose students to the country's socio-cultural and economic diversity, fostering a sense of national integration and respect for indigenous traditions.

Entrepreneurship Development and Skill Enhancement

The revamped curriculum focuses heavily on **entrepreneurship development**, aiming to encourage students to become self-reliant and create employment opportunities for others.

Skill enhancement is structured through:

- Skill development courses in the 1st and 2nd years.
- Internships tied to exit pathways (after 1st and 2nd years).
- Advanced training during the 4th year under **Student READY programs** (in-plant training, internships, or projects).

These initiatives are intended to make students industry-ready, entrepreneurial, innovative, and self-confident.

Skill Enhancement Courses: Skill enhancement courses will be **choice-based** and offered through collaborations with organizations, NGOs, progressive farmers, or industries. Institutions are encouraged to develop additional skill programs based on their strengths.

Internship Programs: Mandatory 10-week internships after the 1st and 2nd years are necessary for students opting for exit certifications. These internships will be preferably outside the parent institution to strengthen practical skills.

Project Work: Project components, integrated into select disciplines, will provide students with hands-on experience in research, entrepreneurship, and professional fields, encouraging critical thinking, creativity, and exploration of career opportunities.

Introduction of New Degree Programs

Two new undergraduate degree programs have been proposed:

1. **Natural Farming:** Based on the **Bhartiya Prakartik Krishi Paddhati (BPKP)** model, this program aims to enhance sustainable agriculture, soil health, water conservation, and rural livelihoods.

2. **Agribusiness Management:** This course focuses on developing entrepreneurial and managerial skills, preparing graduates to start their own ventures or pursue employment opportunities in the agribusiness sector.

Light but Tight Educational Structure

In line with NEP-2020 recommendations, the restructured programs are designed to be **"light but tight"**, ensuring a balanced workload while maintaining academic rigor. The total credit load is **182 credits** for B.F.Sc. (Hons.) programme with effect from 2025-26.

Restructuring of Undergraduate Programmes

Restructuring of UG Programs

The restructuring has been done based on the following NHEQF levels:

- Year 1, Certificate Course, NEP-NHEQF Level 4.5
- Year-2, Diploma Course, NEP-NHEQF Level 5.0
- Year 4, B.Sc. (Hons.)/ B. F. Sc. (Hons.)/ B. Tech. NEP-NHEQF Level 6.0

The restructured program for the undergraduate agriculture education with multiple entry and exit options is illustrated in Figure 1.

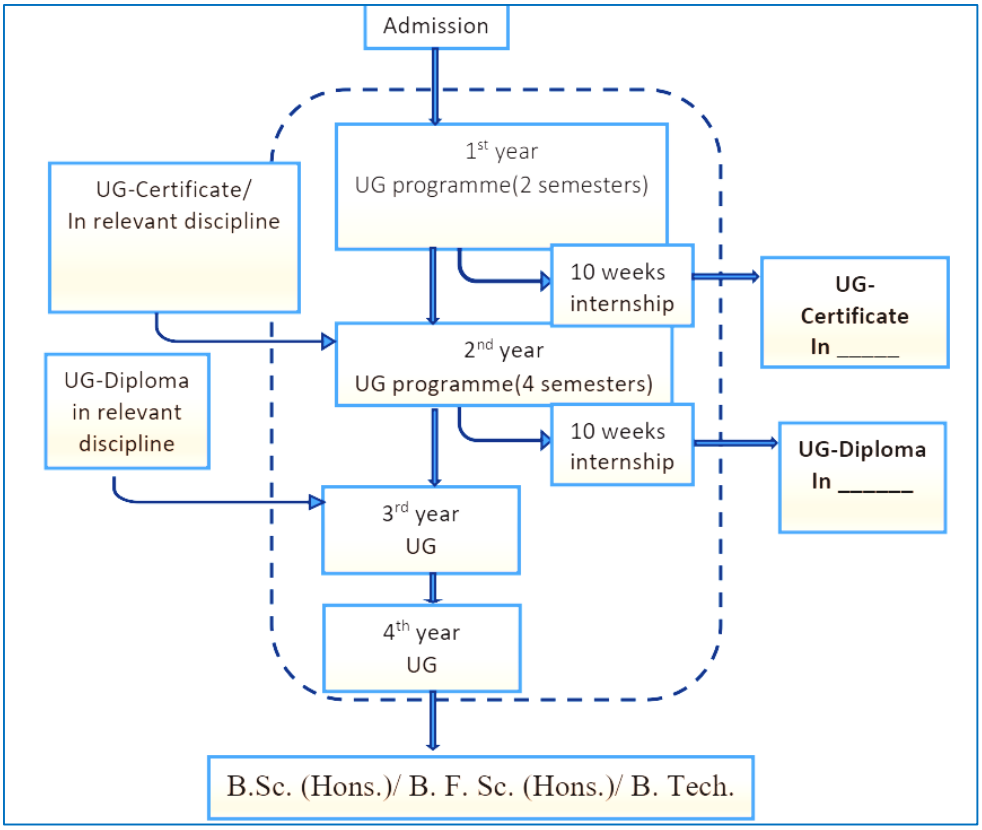

Fig. -1: Framework of Undergraduate Programmes

The 1st year of the programme will be having the foundation, introductory and skill enhancement courses. The 2nd year will be having basic core courses with some more options for skill enhancement. The 3rd year of the programme will have advanced core courses. The 4th year programme will emphasize more on the specialisation and elective courses as well as advanced skill enhancement through internship.

There will be exit options after 1st year and 2nd year for UG-Certificate and UG-Diploma. However, the students opting to exit with UG-Certificate or UG-Diploma will have to take up 10 weeks internship after the 1st year (2 semester) and 2nd year (4 semesters), respectively.

Table - 1 shows the restructured undergraduate programs.

Table – 1: Types of courses and learning outcomes for the restructured undergraduate programs.

Year	Types of Courses	Learning Outcome	Exit Option
Year 1 NHEQF Level 4.5	Foundation courses, introductory courses, skill enhancement training, ability enhancement courses	Students will acquire basic knowledge in their disciplines and develop skills in selected areas, enabling them for employment or entrepreneurship.	After completing 10 weeks of internship (10 credits), students can exit with a **UG-Certificate**.
Year 2 NHEQF Level 5	Basic core courses and additional skill enhancement in chosen areas	Students will acquire higher-level knowledge and enhanced skills in selected areas, preparing them for middle-level employment, supervisory roles, or entrepreneurship.	After completing 10 weeks of internship (10 credits), students can exit with a **UG-Diploma**.
Year 3	Advanced core subjects and their practical applications	Students will develop a deeper understanding of core subjects and their major application areas.	**No exit** allowed after the 3rd year due to professional course requirements.
Year 4 NHEQF Level 6	Specialization/elective courses and advanced skill enhancement through projects and internships	Students will gain advanced knowledge and skills in various areas to meet high-level societal and industry needs. They will be equipped to become job providers by establishing enterprises in their fields.	Award of **UG degree** in the concerned discipline.

INTRODUCTION

The fisheries sector is one of the fastest-growing and most vital allied sectors of agriculture in India. It plays a crucial role in contributing to the nation's income, export earnings, food and nutritional security, and employment generation. In the financial year 2022–23, India's total fish production reached approximately 17.54 million metric tons, with the inland sector contributing 13.11 million metric tons and the marine sector 4.43 million metric tons. Over the past five years, the sector has maintained an impressive average annual growth rate of 7%.

Beyond economic contributions, fisheries serve as a major source of food, nutrition, and livelihoods for millions. From 2015–16 to 2020–21, the sector recorded a remarkable growth rate of 9.03% at constant prices (2011–12 base year). In 2022–23, its share in the total Gross Value Added (GVA) was estimated at ₹137,716 crore, accounting for about 1.09% of the national GVA and 6.72% of the agricultural GVA. Globally, India stands as the third-largest fish-producing nation and the fourth-largest exporter of fish and fishery products, contributing 7.96% to global production—marking a strong presence in the international market under the banner of "Brand India."

The fisheries sector supports the livelihoods of around 28 million people across the country, including approximately 16 million men and 12 million women, both directly and indirectly engaged in various fisheries-related activities. For continued growth and sustainability, the sector relies heavily on a skilled, educated, and competent workforce. This highlights the importance of modernizing fisheries education with competitive, market-oriented, and employment-driven curricula. With fisheries colleges emerging across almost every Indian state, the need for a standardized, high-quality academic framework is urgent. Responding to this, a restructured undergraduate curriculum has been introduced, aligning with the vision of the National Education Policy (NEP) 2020.

As outlined in the Report of the ICAR Sixth Deans' Committee, the revised curriculum focuses on enhancing critical thinking, creativity, communication, and collaboration. It begins with a three-week immersion-cum-foundation program to develop life skills, ethical values, social awareness, leadership, and teamwork. The curriculum includes skill-enhancement courses, rural fisheries work experience, research projects, in-plant training, and industry attachments. Flexibility is also introduced through elective courses and online platforms like MOOCs and SWAYAM. Emphasis is placed on experiential learning and advanced skill development through project work and incubation.

In line with NEP-2020, the program structure includes multiple entry and exit points, allowing students to earn UG-Certificates, UG-Diplomas, or a B.F.Sc. (Hons.) degree based on their progression. The semester-wise curriculum was developed through multi-stage deliberations and consultations with academic institutions, industry experts, government bodies, and State Agricultural Universities (SAUs) and Central Agricultural Universities (CAUs).

Ultimately, the restructured curriculum aims to strengthen the academic and skill foundation of students, in line with the goals of NEP-2020.

HIGHLIGHTS

1. The B.F.Sc. (Hons.) undergraduate program comprises 182 credit hours, including 172 credit hours of coursework and 10 credit hours from online platforms like MOOCs/SWAYAM. The eligibility criteria for admission remain consistent with the existing norms followed by State Agricultural Universities (SAUs) and Central Agricultural Universities (CAUs).
2. Upon admission, students will participate in a two-week Deeksharambh program in the first semester. This orientation will cover academic frameworks, interactions with alumni, professionals, and faculty, and include sessions on personality development, ethics, communication skills, and leadership. The program also aims to assess student strengths and weaknesses and promote cultural integration.
3. Year 1 focuses on foundational knowledge and skill development in applied fisheries. Students who exit after completing two semesters and a 10-credit (10-week) internship/attachment will be awarded a UG-Certificate in Fisheries. Those continuing to the second year need not repeat the internship.
4. Year 2 builds on practical exposure and fundamental fisheries education, balancing theory with hands-on experience. After successful completion of four semesters and another 10-credit internship/attachment, students may exit with a UG-Diploma in Fisheries. Continuing students will proceed without another internship.
5. Skill Enhancement Courses (SECs) are integrated into the first and second years, allowing students to choose areas of interest based on local relevance. After a one-week orientation, students can select one or more SECs (maximum 4 credits per semester). Institutions may collaborate with external partners (NGOs, private companies, etc.) to deliver SECs, while maintaining control over content, delivery, and assessment.
6. Years 3 and 4 delve deeper into core and specialized subjects. In the 5th semester, students will participate in a 10–14-day study tour, valued at 2 non-gradial credits, offering field-level exposure.
7. During the 7th semester, students can choose elective/specialized courses totaling 20 credits, allowing them to pursue focused areas of interest. Universities may introduce additional electives and can revise up to 30% of course content to reflect regional priorities.
8. In the 8th semester, students undergo the Student READY (Rural Entrepreneurship Awareness Development Yojana) program, which includes Rural Fisheries Work Experience (RFWE), Experiential Learning (EL), In-Plant Training/Industrial Attachment, and Student Projects. This component emphasizes hands-on experience, entrepreneurial skill development, and the acquisition of Indigenous Technical Knowledge (ITK) for self-employment.
9. Students are encouraged to pursue 10 credits of non-credit online courses (from MOOCs, SWAYAM, etc.) throughout the program in subjects of personal interest, including agriculture, science, humanities, languages, business, and the arts. While these are non-gradial, records of completed courses will be maintained and listed on the student's final transcript.

REGULATIONS

1. Title and Commencement:

1.1 These Regulations shall be called The Academic Regulations for '**Bachelor of Fishery Science (Honours)** in abbreviation **B.F.Sc. (Hons.),** 4-YEAR UNDERGRADUATE DEGREE PROGRAMME, 2025-26 UNDER VIDYASAGAR UNIVERSITY' for obtaining Bachelor Degree in the Fishery Science under Semester system.

1.2 These Regulations shall apply to the students admitted in Bachelor of Fishery Science (B.F.Sc.) from the Academic Year **2025 – 2026** onwards.

2. Degree Nomenclature:

'Bachelor of Fishery Science (Honours)' in abbreviation B.F.Sc. (Hons.)

3. Duration of the Degree Programme

3.1 The duration of the Programme is **EIGHT (08)** consecutive **SEMESTERS** of six months each *i. e.,* **FOUR (04) YEARS**.

3.2 A candidate shall have to clear all the Semesters maximum within **SEVEN YEARS** from the academic year of his/her first admission and registration to the **Bachelor of Fishery Science (B.F.Sc.)**. Programme under Vidyasagar University failing which enrolment of the candidate shall stand cancelled.

3.3 **Entry and Exit Options:** Provision for multiple exit and entry into the UG programme in B.F.Sc. (Hons.) has been made in the light of **NEP-2020**. A student may exit after completion of 1st year and 2nd year requirements followed by 10 weeks of internship after 1st year and 2nd year, respectively, to get UG -certificate and UG-Diploma in Fishery Science. The entry and exit options for the UG programme in Agriculture and allied Science are shown in the Fig.-1 below.

4. Definitions

Academic Year: The 'Academic Year' shall ordinarily be formed as per Vidyasagar University rules.

Semester: An academic term consisting of not less than 90 instructional days, excluding days of final theory examinations.

Credit Hour: Each credit hour will be equivalent to one-hour lecture of theory or two hours of laboratory work for practical per week. It is also known as semester credit or credit.

Course: A course is a unit of instruction or a segment of subject to be covered in a semester. It has a specific number, title and credits.

Grade Point of a Course: Each course will be evaluated for 100 marks irrespective of the credits (theory or practical or theory and practical combined as per credits) for awarding grade point. The grade point shall be rounded to the second decimal place.

Credit Point of a Course: The product of credit hours and grade point obtained by the student in each course.

Grade Point Average (GPA): It is the quotient of the total credit points both in theory and practical of various courses obtained by a student at the end of each semester divided by the total evaluated credit hours taken by the student in that semester. The grading is done on a 10-point scale. The GPA is to be rounded to the second decimal place.

Overall Grade Point Average (OGPA): It is the quotient of credit points obtained by a student in all the subjects both in theory and practical examinations taken by him/her from the beginning of the first academic year of the degree course divided by the total evaluated credit hours of all the subjects which he/she had completed up to the end of a given semester. It determines the overall performance of a student in all the subjects taken during entire course curriculum. The OGPA is to be rounded to the second decimal place. The Overall Grade Point Average obtained by a student on a 10-point scale is converted to percentage of marks by dividing the OGPA by 10 and multiplying with 100.

Grade Card or Marksheet: Based on the grade earned, a grade card or marksheet shall be issued after every semester. The grade card shall display the course details (code, title, marks, number of credits, grade secured) along with GPA and OGPA where applicable.

5. Admission

5.1 The admission to undergraduate degree programmes in Bachelor of Fishery Science (B.F.Sc.) will be governed by the guidelines of the Vidyasagar University and that of the Department of Higher Education, Govt. of West Bengal as laid down from time to time.

5.2 Age: Not less than 17 years as on 31st December in the year of application.

5.3 The candidate must pass the Higher Secondary (10+2) or its equivalent examinations with **Physics, Chemistry, Biology/Mathematics and English** as compulsory subjects with individual pass marks (in both theory and practical wherever applicable) in all the above four subjects in regular class mode.

5.4 The selection of students for admission will be done as per the merit list. The merit list will be prepared according to percentage of total marks obtained in the subjects of H.S. (10+2) or its equivalent examinations as stated above or through Entrance Examination or as laid down by Vidyasagar University from time to time.

5.5 A candidate shall be allowed to pursue any one of the degree undergraduate programme of the university at a time, not more than one.

5.6 Admission to the 1st Semester shall not be considered after the commencement of the classes.

6. Registration

6.1 Registration is mandatory for prosecuting studies. The registration for UG Degree programme will be governed by the University Regulations relating to Registration.

6.2 A student shall have to submit Registration Form only once at the time of entry to the UG Courses. He / She shall not be required to renew the registration at any subsequent stage.

6.3 A candidate provisionally admitted to Bachelor of Fishery Science (B.F.Sc.) degree but not registered under Vidyasagar University shall not be allowed to sit for 1st Semester Examination.

6.4. A candidate not being able to complete the programme within the SEVEN subsequent Academic Years of his/her admission in 1st Semester of this programme, the Registration of the candidate shall be treated as cancelled.

6.5. The UG-Certificate/ UG-Diploma passed candidate will be eligible for admission into other university/institution offering B.F.Sc. (Hons.) programme in the country at appropriate level, as applicable. Institutional migration after 4th semester more convenient and according to the rules and regulations reconstructed by 6th Deans' Commission and existing rules and regulation of Vidyasagar University.

7. Attendance

7.1 A student having at least 75% attendance of scheduled theory and practical classes separately shall be allowed to sit for the concerned Semester Examination subject to the fulfilment of other conditions as laid down in the regulations.

7.2 Relaxation in attendance for NCC, NSS and Co-curricular activities is admissible as per University regulations subject to prior approval of College Authority.

7.3. The minimum attendance prescribed for Student READY programmes is 90%. Apart from medical ground no relaxation is allowed.

8. Course & Curriculum

8.1 Course of Study

The first year of the course program comprises skill development courses along with other fundamental courses of agricultural sciences. After satisfactory completion of 42 credits in two semesters (including skill training/ internship, subject to the condition of study of 10 credits (non-credit)) of industry/ institute training/ internship, the student will become eligible for the award of U.G.-Certificate in Agriculture on exit after the subsequent satisfactory completion of 10 credits (10-week) of internship. The students continuing the study further, would not have to attend the internship after 1st year.

The second year has been designed with the skill development courses, basic courses as well as fundamental courses in agriculture which have the basic principles and applications of agricultural sciences. After getting acquainted with the basic principles and practical training of agriculture sciences. After satisfactory completion of the courses (84 credits) during first two years and subsequent satisfactory completion of 10 credits (10-week) of internship, the student will also become eligible for the award of UG-Diploma in Agriculture on exit. The students continuing the study further would not have to attend the internship after 2nd year.

The third- and fourth- year courses have been designed to impart specialized knowledge to the students in the specific disciplines. During the 3rd semester, the students will have a study tour of 10-14 days duration, which will be Non-credit based. The students will preferably visit the leading

industries/ enterprises/ institutions/ organisations. During the 7th semester, the students will adequately select 20 credits from a basket of elective courses, each course being of 4 credits giving an opportunity to them to gain advanced knowledge in frontier areas of Fisheries science.

In the 8th semester of the course the major focus has been on strengthening of the knowledge and skill for developing confidence of the students to take entrepreneurship as their future career. For this they will undergo an advanced skill enhancement through Student READY: RAWE/ Industrial Attachment /Experiential Learning / Hands-on Training/ Project Work / Internship. A student will select option/s on choice to complete the degree and pursue future career with 20 credits. Each student will be attached to a mentor either from the institution or from an organization/ industry. A university or a college will have the freedom to select the options as referred above.

8.2 The details of the Courses, Credits and Syllabi are framed in concurrence with the Sixth Deans' Committee Recommendations by ICAR, 2024 and shall be prescribed by the University from time to time.

8.3 Medium of Instruction: Medium of instruction shall be English.

8.4 Advisory System: The students after admission to B.F.Sc. (Hons.) programme shall be divided into different batches of convenient size by the College Authority and each batch shall be assigned a Student Advisor, one faculty member designated for the same. Among other things, the Advisors shall help the students in planning their academic programme.

8.5 Curriculum and Credits Requirement: The Bachelor of Fishery Science -B.F.Sc. (Hons.) program will be of 182 credits, which will have 172 credits offered by the parent university and 10 credits of online courses taken by the student (through MOOC-SWAYAM) as per choice in consultation with Vidyasagar University. The respective College/ Institute shall arrange the Course Coordinator for such courses who will facilitate the students. The Course Coordinator shall also arrange the credit transfer of the respective courses to the Controller of Examinations of the University.

9. Examination and Evaluation System

9.1 Date of Examination:

Exact dates and the schedule of examination shall be notified by the Controller of Examinations, Vidyasagar University. In the event of any unforeseen exigency the Controller of Examinations shall be competent for any adjustment in the prescribed schedule.

9.2 Schedule of Examination:

The schedule of examinations of B.F.Sc. (Hons.) consists of Internal and External Examinations. End Semester Examination (External) shall be conducted at the end of the academic activities of the respective Semester. There shall be one Midterm (Internal) examination to be conducted by the Colleges offering the course after completing 60% of the course in a Semester.

9.3 Type of Examination / Assessment:

A. **Midterm (Internal) Examination**: There shall be one Midterm (Internal) examination comprising of objective and subjective questions in the ratio of 40:60. The midterm examination shall be conducted by the concerned college offering B.F.Sc. (Hons.) programme at least after 60% completion of respective course. The Principal/ Officer In-charge of the respective college shall be responsible for conducting examination and providing the marks to the Controller of the Exanimation, Vidyasagar University maintaining the confidentiality of the examination. The modalities of such assessment be recorded and documents will be preserved by the respective college and those must be placed before any committee or team constituted by the university for verification.

B. **End Semester (External) Examination**: The End Semester (External) Examination An examination conducted by the University in each course for which an external examiner shall set the question paper (based on the Syllabus/Lecture Outlines of the concerned course) and also evaluate the answer papers as per the schedule of examination during the period scheduled by the Vidyasagar University at the end of each semester. End Semester (External) Examinations shall be conducted by the University as per the examination rules & regulations of Vidyasagar University. The date and schedule of end semester examination shall be determined by the Controller of Examination, Vidyasagar University

C. **Quiz/Progressive Assessment:** Usually for any subject, there will be two quizzes within the semester, one before the midterm and one after fully organised by the College/ Department. There will be provision of corrections in between, i.e. the students scoring lower than 50% marks in any one quiz can opt for appearing for a third quiz to improve their grades. The assessment of the students through quizzes should focus on their critical thinking and creativity rather than rote reading. The quiz and progressive assessment can also be considered in form of group assignments (which should encourage creativity, critical thinking and problem-solving attitude). The Principal/ Officer In-charge of the respective college shall be responsible to provide the marks to the Controller of the Exanimation, Vidyasagar University maintaining the confidentiality of the examination.

D. **Practical Examination and Class Assessment/Assignment**: There shall be one Practical Examination in each course at the end of Semester before the end of instructional days. Practical examination shall be conducted in presence of expert/ evaluator nominated by the Vidyasagar University. The modalities of such assessment be recorded and documents will be preserved by the respective college and those must be placed before any committee or team constituted by the university for verification.

The details of examination are given below:

External Theory - 40%

Internal Theory + Practical - 60%

Course with both theory and practical: ***Total marks: 100***

- ***Theory*** **= 80 marks**
  - (i) End Semester Examination = 40 marks
  - (ii) Midterm / Internal Assessment = 20 marks
  - (iii) Quiz/Progressive Assessment = 20 marks
- ***Practical*** (End Semester) **= 20 marks**

Course with only theory: ***Total marks: 100***

(i) End Semester Examination: = 50 marks
(ii) Midterm / Internal Assessment: = 30 marks
(iii) Quiz/Progressive Assessment = 20 marks

Course with only Practical: ***Total marks: 100***

(i) End Semester Practical Examination = 50 marks
(ii) Midterm/Internal Assessment = 30 marks
(iii) Quiz/Progressive Assessment = 20 marks

9.4 Hour of End Semester Examination:

a. External Examination (**Theoretical) paper** of full marks upto **50,** duration **2** hours.
b. Quiz / Progressive Assessment **paper** of full marks upto **20,** duration **1** hours
c. Midterm Examination (**Theoretical)** papers of full marks upto **20,** duration **1** hour.
d. Practical Examination of full marks upto **20,** duration **2** hour.
e. Practical Examination of full marks upto **50,** duration **3** hour.

9.5 Question Pattern:

The End Semester written Examination shall carry 50 or 40 marks depending upon the nature of the paper and shall be of Two (2) hours duration. There shall be three types of questions e.g. Objective, Medium and Long type questions. The long questions shall be framed in such a manner so that each question consists of two parts where in the first part shall be on theory based and the rest part shall be on application based.

In general, the Question Papers to be prepared for the End Semester as per the following question pattern given in below table:

TOTAL MARKS	QUESTIONS TYPE	QUESTIONS TO ATTEMPT	MARKS PER QUESTION	MARKS	QUESTION OPTIONS
50	Objective	5	2	5X2=10	8
	Medium	6	5	6X5=30	10
	Long	1	10	1X10=10	2
40	Objective	5	2	5X2=10	8
	Medium	4	5	4X5=20	8
	Long	1	10	1X10=10	2

9.6 Eligibility criteria of examination and other essentials:

A candidate shall be eligible for appearing at any of the semester of examination fulfilling the following essential condition:

1. A student must have at least 75% class attendance (theory and practical separately).
2. Unless a student appears for the midterm examination and Progressive Assessment, the student should not be permitted to appear for the Semester Final Theory examinations in the course concerned.

3. Student shall have to fill-up the examination form of the University as notified prior to End Semester Examination.
4. **Examination Fee:** The examination fees and other fees prescribed by the University from time to time shall have to be paid by each student during University examination form-fill-up within the stipulated time of respective End Semester Examination after notification from the Controller of Examinations.
5. All the students who have completed the form fill-up and having the required percentage of attendance as prescribed above shall be permitted to appear in the End Semester Exam.
6. **Registration** is mandatory prior to form fill-up for the 1st Semester Examination.
7. **Admit Card:** Admit card for appearing at the End Semester Examination, will be issued by the Controller of Examinations after fulfilling eligibility criteria like attendance, registration etc. No student shall be allowed to appear for the End Semester Examination without a valid Admit Card.

9.7 Evaluation / Grading System:

Based on the performance of the students, each student will be awarded Grade in subjects at the end of the semester examination following grading system on the base of TEN (10). On the basis of Cumulative Grade Point Average the student shall be awarded the Division to corroborate with the traditional scoring system.

a) **Grade Point** in a course shall be the total marks obtained by a student out of 100 divided by 10
b) **Credit Point** is the Grade Point of the course multiplied by course credit.
c) **Total Credit Point** shall be the sum of credit point secured by the student.
d) **Grade Point Average (GPA)**shall be the sum of the total credit point earned divided by the sum of credit hours
e) Overall Grade Point Average (OGPA) shall be the grand total of credit points earned divided the grand sum of credit hours

Degree	Percentage of Marks Obtained	Conversion into Points
B.F.Sc. (Hons)	100	10 Points
	90 to <100	9 to <10
	80 to <90	8 to <9
	70 to <80	7 to <8
	60 to <70	6 to <7
	50 to <60	5 to <6
	<50 (Fail)	**<5**
	e.g. 80.76	8.076
	43.60	4.360
	72.50 (but shortage in attendance)	Fail (1 point)

GPA = Total points scored / Total credits (for 1 semester)
OGPA = ∑ Total points scored / Course credits
% of Marks = OGPA/10 x 100

Classification of Successful Candidates: The successful candidates who after completion of the graduation requirements, have secured a CGPA of 5.00 or more in the 10.00 point scale shall be classified as under:

OGPA	Division
5.00 – 5.99	Pass
6.00 – 6.99	II division
7.00 – 7.99	I division
8.00 and above	I division with distinction

9.8 Promotion:

i. A candidate has to secure **minimum of 50% marks** of each course including the **minimum of 30% marks in end semester theory examination and 50% marks in practical examination** in order to qualify for the next semester.

ii. Progression to the next higher semester shall be allowed with maximum upto 2 (two) supplementary courses in a semester which to be cleared in corresponding end semester examinations. Candidate shall have two consecutive chances after the first appearance in the End Semester Examination as fresh candidate to clear supplementary in the subsequent examinations.

iii. GPA will be built only after passing in all subjects in the respective semester.

iv. A candidate who fails to get promoted to next higher semester shall have to **repeat** the semester.

v. A candidate shall have to clear all the Semesters maximum within **SEVEN YEARS** from the academic year of his/her admission and registration to the B.F. Sc. (Hons) programme under Vidyasagar University failing which enrolment of the candidate shall stand cancelled.

vi. The candidates remaining absent in the end semester theory examination will be marked as **ABSENT** and shall be awarded with '0' mark. The marks obtained in Internal Assessment shall be retained for the entire duration of his/her enrolment.

vii. If a candidate secure pass marks in Practical Paper(s)/Project Work but fails to secure pass marks in theoretical papers, the marks of Practical Paper(s)/Project Work along with Internal Assessment of theoretical papers shall be retained. Fail in practical / project shall be treated as fail in the entire paper.

viii. All backlog papers from 1st Semester to 6th Semester must be cleared before being promoted to **7th Semester.** Only after clearance of the entire supplementary student shall qualify to attend the Student READY programme.

ix. Non-gradial courses shall be compulsory part of curriculum. Students shall have to qualify the nongradial courses in order to pass the semester.

x. A student must secure **OGPA more than 5.00 out of 10.00** at the end of the degree programme to be eligible to get **B.F.Sc. (Hons) Degree**.

10. Review:

A Regular and Backlog category student can apply for review of the results on theory papers only as per notification given from Controller of Examinations, Vidyasagar University, preferably within 20 days from the publication of results. The review process will not be allowed for candidates of final year and also who intend to appear in special supplementary examinations.

11. Supplementary Examination:

i. A candidate who fails to secure pass marks in one or more courses maximum upto two courses of a Semester may appear in those paper(s) during Supplementary Examination when the concerned End Semester Examination will be held next.
ii. A candidate must clear all supplementary paper(s) within a maximum of three consecutive chances, including the first appearance in the End Semester Examination, irrespective of whether any chance is availed, failing which, any unutilized chance(s) within this period shall be deemed to have lapsed.
iii. A **Special Supplementary** examination will be conducted for **3rd year students** who have arrear paper only for **6th semester** to qualify them for Student READY programme.

12. Post publication scrutiny of answer scripts:

A candidate pursing undergraduate programme may apply for Self Inspection or RTI of his / her one or more answer scripts irrespective of marks by paying requisite fees. Post publication scrutiny (Self Inspection) does not imply re-examination or re-assessment of scripts but involve verification of scripts and records.

13. Post publication review:

a. A student may apply for post-publication review of his/her answer scripts in the prescribed form and manner and a submission of requisite fees per paper within the date as per notification to be issued by the Controller of Examinations at the time of publication of the result. All such applications must be forwarded by the Principal of the college concerned. Post Publication Review is applicable only for theory papers of different End Semester Examinations. Review shall not be permissible for Internal Assessment, Practical Examination and Project work/Field work etc.
b. Post publication Review and post publication scrutiny (Self-inspection) of the same paper(s) in a subject shall not be allowed.
c. A student shall be allowed to apply for re-examination/review of not more than 2 (Two) theoretical papers in each semester.
d. In case of variation of marks for more than 5% equal weightage is to be given to marks awarded by the examiner appointed for Re-examination and original examiner and an average of two awards is to be taken into account for computing result of re-examination. Marks originally obtained and the marks obtained through re-examination be taken together to work out and average which will be considered as the award in that paper of the candidate concerned even if the average is more or less than the initial award of marks.
e. In case of variation of 5% marks or less between the original and re-examination process the change shall be ignored.
f. Incomplete and faulty application is liable to be rejected without assigning reason or without any intimation to the candidate and college concerned.

g. Under no circumstances fees for post publication Review [as notified from time to time by Controller of Examination (COE)] once paid shall be refunded.
h. Prayer for Post Publication Review in prescribed manner in respect of any examination cannot be related to the appearance of the next semester/ year's examination, as the case may be. Candidates applying for the Post Publication Review shall have to make necessary preparations for the next examination on the basis of his /her original results accordingly, even though they have applied for the same.

14. Accumulation of Credits:

Every student shall open an account in Academic Bank of Credit (ABC) which shall have to be provided during examination form fill-up. The Credit awarded to a student for the courses pursued in the University shall be accumulated in the Academic Bank Account of the student. The procedure for accumulation of credit earned, redemption of credits would be as per UGC and other relevant Regulations.

15. Interpretation:

If any question arises as to the interpretation of these Regulations, the same shall be decided by the Academic Council or the Vice-Chancellor. The Vice-Chancellor/ Executive Council shall have the power to issue clarification to remove any doubt(s) which may arise in regard to implementation of these Regulations

ACADEMIC PROGRAM

Semester-wise course distribution

Course Structure Table

Sl. No.	Course Code	Course Title	Credit Hours	Total Credit Hours
First Year				
		I Semester		**23 (10+13)**
1.	FSCCFC101	Deeksharambh (Induction-cum-Foundation course of 2 weeks) (FC)	2 (0+2) Non-Gradial	
2.	FSCCCC102	Taxonomy of Commercially Important Fish and Shellfish	3 (1+2)	
3.	FSCCCC103	Soil and Water Chemistry	3 (2+1)	
4.	FSCCCC104	Anatomy and Biology of Finfish and Shellfish	3 (2+1)	
5.	FSCCCC105	Fundamental Microbiology	2 (1+1)	
6.	FSCCCC106	Meteorology and Geography	2 (1+1)	
7.	FSCMDC107	Farming Based Livelihood Systems (MDC)	3 (2+1)	
8.	FSCAEC108	Communication Skills (AEC)	2 (1+1)	
9.	FSCAEC109	NCC-I/NSS-I (AEC)	1 (0+1)	
10.	FSCSEC110	Skill Enhancement Courses* (SEC-I)	2 (0+2)	
11.	FSCSEC111	Skill Enhancement Courses* (SEC-II)	2 (0+2)	
		II Semester		**24 (12+12)**
1.	FSCCCC151	Fish and Shellfish Breeding and Hatchery Management	3 (2+1)	
2.	FSCCCC152	Physiology of Finfish and Shellfish	3 (2+1)	
3.	FSCCCC153	Freshwater Aquaculture	3 (2+1)	
4.	FSCCCC154	Limnology	2 (1+1)	
5.	FSCMDC155	Entrepreneurship Development and Business Management (MDC)	3 (2+1)	
6.	FSCVAC156	Environmental Studies and Disaster Management (VAC)	3 (2+1)	
7.	FSCAEC157	Personality Development (AEC)	2 (1+1)	
8.	FSCAEC158	NCC-II/NSS-II (AEC)	1 (0+1)	
9.	FSCSEC159	Skill Enhancement Courses* (SEC-III)	2 (0+2)	
10.	FSCSEC160	Skill Enhancement Courses* (SEC-IV)	2 (0+2)	
		Post Semester-II (only for exit option for award of UG-Certificate)		
1.		Internship (for 10 weeks)	10** (0+10)	**10(0+10)**

CFC- Compulsory Foundation Course; *SEC: Skill Enhancement course; CCC: Compulsory Core Course; AEC: Ability Enhancement Course; VAC: Value Added Course; MDC: Multidisciplinary Course; NG: Non Gradial Course;

Sl. No.	Course Code	Course Title	Credit Hours	Total Credit Hours
Second Year				
		III Semester		**21 (10+11)**
1.	FSCCCC201	Coastal Aquaculture and Mariculture	3 (2+1)	
2.	FSCCCC202	Fish Nutrition and Feed Technology	3 (2+1)	
3.	FSCCCC203	Inland Fisheries	2 (1+1)	
4.	FSCCCC204	Fishing Craft Technology	2 (1+1)	
5.	FSCCCC205	Fundamentals of Biochemistry and Food Chemistry	2 (1+1)	
6.	FSCCCC206	Post-Harvest Handling and Preservation	3 (2+1)	
7.	FSCCCC207	Fisheries Extension	2 (1+1)	
8.	FSCAEC208	Physical Education, First Aid, Yoga Practice and Meditation (AEC)	2 (0+2)	
9.	FSCSEC209	Skill Enhancement Courses* (SEC-V)	2 (0+2)	
IV Semester				
1.	FSCCCC251	Breeding and Culture of Ornamental Fish	2 (1+1)	
2.	FSCCCC252	Live Food Organisms for Fish and Shellfish	2 (1+1)	
3.	FSCCCC253	Fish and Shellfish Diseases and Treatment	3 (2+1)	
4.	FSCCCC254	Marine Fisheries	2 (1+1)	
5.	FSCCCC255	Fishing and Gear Technology	3 (2+1)	
6.	FSCCCC256	Fish Products, By-products, Value Addition and Waste Management	3 (2+1)	
7.	FSCMDC257	Agriculture Marketing and Trade (MDC)	3 (2+1)	
8.	FSCVAC258	Agricultural Informatics and Artificial Intelligence (VAC)	3 (2+1)	
9.	FSCSEC259	Skill Enhancement Courses* (SEC-VI)	2 (0+2)	
a		**Online Courses (MOOCs / SWAYAM)**	4 (4+0) Non-gradial	**4 (4+0)+**
		Post Semester IV (Only for exit option for award of UG -Diploma)		**10*** (0+10)
1.		Internship (for 10 weeks)	10*** (0+10)	

Sl. No.	Course Code	Course Title	Credit Hours	Total Credit Hours
Third Year				
V Semester				**21 (12+9)**
1.	FSCCCC301	Fish Genetics and Breeding	2 (1+1)	
2.	FSCCCC302	Marine Biology	2 (1+1)	
3.	FSCCCC303	Fish Population Dynamics and Stock Assessment	2 (1+1)	
4.	FSCCCC304	Aquatic Ecology and Biodiversity	2 (1+1)	
5.	FSCCCC305	Pharmacology and Toxicology	3 (2+1)	
6.	FSCCCC306	Fish Freezing Technology	2 (1+1)	
7.	FSCCCC307	Fish Canning Technology and Packaging	2 (1+1)	
8.	FSCCCC308	Aquaculture Engineering	3 (2+1)	
9.	FSCCCC309	Fisheries Economics	3 (2+1)	
10.	FSCCCC310	Education Tour (2 Weeks)	NG	
VI Semester				**20 (11+9)**
1.	FSCCCC351	Fish Biotechnology and Bioinformatics	2 (1+1)	
2.	FSCCCC352	Fish Immunology	2 (1+1)	
3.	FSCCCC353	Therapeutics in Aquaculture	2 (1+1)	
4.	FSCCCC354	Coastal Zone Management	2 (1+1)	
5.	FSCCCC355	Microbiology of Fish and Fisheries Products	2 (1+1)	
6.	FSCCCC356	Refrigeration and Equipment Engineering	2 (1+1)	
7.	FSCCCC357	Navigation and Seamanship	2 (1+1)	
8.	FSCCCC358	Statistical Methods	3 (2+1)	
9.	FSCCCC359	Fisheries Policy and Laws	1 (1+0)	
10.	FSCCCC360	Fisheries Co-operative and Marketing	2 (1+1)	
b		**Online Courses (MOOCs / SWAYAM)**	4 (4+0) Non-gradial	**4 (4+0)+**

Sl. No.	Course Code	Course Title	Credit Hours	Total Credit Hours
Fourth Year				
VII Semester				**20**
1.	FSCDSE401 - 409	Elective Courses (Major)#	12	
2.	FSCDSE410 - 418	Elective Courses (Minor)##	8	
VIII Semester				
Student opting for 4-year B. F. Sc. (Hons.) a Student READY (Students Entrepreneurship Awareness Development Yojana) Program on In-plant/Industry Attachment / Rural Fisheries Work Experience (RFWE) Program/ Experiential Learning Program (ELP) / Project Work / Seminar will be undertaken as follows.				
1.	FSCCCC451	In-plant/ Industry Attachment (for 8 weeks)	5 (0+5)	**20 (0+20)**
2.	FSCCCC452	Rural Fisheries Work Experience (RFWE) Program (for 8 weeks)	6 (0+6)	
3.	FSCCCC453	Experiential Learning Program (ELP)	6 (0+6)	
4.	FSCCCC454	Project Work	2 (0+2)	
5.	FSCDSE455	Seminar	1 (0+1)	
c		**Online Courses (MOOCs / SWAYAM)**	2 (2+0) Non-gradial	**2 (2+0)+**

* From the basket of courses of Skill Enhancement Courses
** Mandatory requirement for UG-Certificate.
*** Mandatory requirement for UG-Diploma.

#Students have option to choose any Four Major Courses (12 credits) from the list of courses
Students have option to choose any Four Minor Courses (08 credits) from the list of courses

+ Non-gradial Online Courses

Basic Supporting Courses

Sl. No.	Course Category	Course Title	Credit Hours
1.	FC	*Deeksharambha*Induction-cum-Foundation course (2 weeks duration)	2 (0+2) Non-Gradial
2.	MDC	Farming-Based Livelihood Systems	3 (2+1)
3.	MDC	Entrepreneurship Development and Business Management	3 (2+1)
4.	MDC	Agriculture Marketing and Trade	3 (2+1)
5.	VAC	Environmental Studies and Disaster Management (	3 (2+1)
6.	VAC	Agricultural Informatics and Artificial Intelligence	3 (2+1)
7.	AEC	Communication Skills	2 (1+1)
8.	AEC	Personality Development	2 (1+1)
9.	AEC	Physical Education, First Aid, Yoga Practice and Meditation	2 (0+2)
10.	AEC	NSS/ NCC	2 (0+2)
11.		Educational Tour (2 Weeks Duration)	Non-Gradial

Summary of Credit Distributions

Type of courses		**Credits**
Core courses (Major and Minor/s)	:	117
Common courses (MDC+VAC+AEC)	:	23
Skill Enhancement Courses (SEC)	:	12
Internship/ Student READY	:	20
MOOCS/SWAYAM	:	10 non-gradial
Total	:	**172+10****

Table 1: Credits Allocation Scheme of UG Fisheries Science Programs (Credit Hours)

Semester	Core Courses (Major + Minor)	Multi-Disciplinary Course (MDC)	Value Added Course (VAC)	Ability Enhancement Course (AEC)	Skill Enhancement Course (SEC)	Internship/ Project/ Student READY	Total Credits	Non-Gradial	Internship	Online Courses/ MOOC
I	13	3 (2)	-	$1^{(3)} + 2^{(4)}$	4	-	23	$2^{(1)}$	-	-
II	11	3(5)	$3^{(6)}$	$1^{(3)} + 2^{(7)}$	4	-	24	-	-	$10^{(12)}$
III	17	-	-	$2^{(8)}$	2	-	21	-	-	-
IV	15	3(9)	$3^{(10)}$	-	2	-	23	-	$10^{(13)}$	10
V	21	-	-	-	-	-	21	$2^{(11)}$	-	-
VI	20	-	-	-	-	-	20	-	-	-
VII	10	-	-	-	-	20	20	-	-	-
VIII	-	-	-	1	-	-	1	-	-	-
Total	**117**	**9**	**6**	**8**	**12**	**20**	**172**	**4**	**10**	**10**

(1) *Deeksharambh* (Induction-cum-Foundation Course) of 2 credits (2 weeks duration).
(2) Farming based Livelihood systems
(3) NCC/NSS/NSO
(4) Communication Skills
(5) Entrepreneurship Development and Business Management
(6) Environmental Studies and Disaster Management
(7) Personality Development
(8) Physical Education, First Aid, Yoga Practices, and Meditation
(9) Agriculture Marketing and Trade
(10) Agricultural Informatics and Artificial Intelligence
(11) Study tour (10-14 days)
(12) Only for those opting for an exit with UG-Certificate
(13) Only for those opting for an exit with UG-Diploma

DETAILED SYLLABI

SEMESTER – I

FSCCFC101: Deeksharambh (Induction-cum-Foundation Program) 2 (NG)

The activities to be taken under Deeksharambh shall aim at creating a platform for students to

1. Help for cultural Integration of students from different backgrounds
2. Know about the operational framework of the academic process in the university
3. Instilling life and social skills
4. Social Awareness, Ethics and Values, Team Work, Leadership, Creativity, etc.
5. Identify the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenarios.

The details of activities will be decided by the parent universities. The structure shall include, but not restricted to:

- ✓ Discussions on the operational framework of the academic process in the university, as well as interactions with academic and research managers of the University
- ✓ Interaction with alumni, business leaders, perspective employers, outstanding achievers in related fields, and people with inspiring life experiences
- ✓ Group activities to identify the strength and weakness of students (with expert advice for their improvement) as well as to create a platform for students to learn from each other's life experiences
- ✓ Activities to enhance cultural Integration of students from different backgrounds
- ✓ Field visits to related fields/ establishments
- ✓ Sessions on personality development (instilling life and social skills, social awareness, ethics and values, team work, leadership, etc.) and communication skills

FSCCCC102: Taxonomy of Commercially Important Fish and Shellfish Credits: 3 (1+2)

Objectives

1. To identify the commercially important fish and shellfish species inhabiting aquatic environments.
2. To acquire knowledge of fish and shellfish species in various aquatic ecosystems.

Theory

Principles of taxonomy, nomenclature, and types; Classification and interrelationships among taxa; Criteria for generic and specific identification; Morphological, morphometric, and meristic characteristics of taxonomic significance; Major taxa of inland and marine fishes up to the family level; Commercially important freshwater and marine fishes of India and their morphological features; Introduction to modern taxonomic tools:Karyo-taxonomy, DNA barcoding, Protein analysis, DNA polymorphism; Study of external morphology and meristic characteristics of Crustacean and Mollusca; Classification of Crustacean and Mollusca up to the species level with examples of commercially important species.

Practical

Collection and identification of commercially important inland and marine fishes; Study of external morphology and diagnostic features; Use of modern taxonomic tools:Protein analysis and electrophoresis, Chromosome preparation and identification (Karyo-taxonomy), DNA barcoding and analysis of DNA polymorphism; Visits to fish landing centres to study commercially important fishes and catch composition; Study of external morphology of shellfish; Collection, preservation, and identification of commercially important prawns, shrimps, crabs, lobsters, bivalves, gastropods, and cephalopods from natural habitats; Field visits for collection and study of commercially important shellfish.

Suggested Readings

1. Bal D.V. & Rao K.V. (1990). *Marine Fishes of India*. 1st Revised ed., Tata McGraw Hill.
2. Day F. (1878). *The Fishes of India*. William Dawson and Sons Ltd.
3. FAO. (2000). *DNA-based Molecular Diagnostic Techniques*.
4. Fischer W. & Bianchi G. (1984). *FAO Identification Sheets for Fishery Purposes*. Vol. I–VI.
5. Hamilton F. (1822). *Fishes of the River Ganges and its Branches*. Edinburg.
6. Jayaram K.C. (2010). *The Freshwater Fishes of the Indian Region*, 2nd ed., Narendra Publishing House, New Delhi.
7. Kurian C.V. & Sebastian V.O. (1986). *Prawns and Prawn Fisheries of India*, Hindustan Publ. Corp.
8. Jayaraman K.C. (2002). *Fundamentals of Fish Taxonomy*.
9. Mayr E. (1977). *Principles of Systematic Zoology*, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
10. Nelson J.S. (2006). *Fishes of the World*, 4th ed., John Wiley and Sons.
11. Ponniah A.G. & George John. (1998). *Fish Chromosome Atlas*, NBFGR, Lucknow.
12. Talwar P.K. & Jhingran A.G. (1991). *Inland Fishes of India and Adjacent Countries*, Vol. I & II, Oxford and IBH Publishing Co. Pvt. Ltd., Delhi.
13. Talwar P.K. & Kacker R.K. (1984). *Commercial Sea Fishes of India*, ZSI, Kolkata.
14. Thomas D., Kocher & Carol A. Stepien (Eds.). (1997). *Molecular Systematics of Fishes*, Academic Press, New York.

FSCCCC103: Soil and Water Chemistry **Credits:**3 (2 + 1)

Objectives

1. To evaluate soil and water quality parameters in aquaculture systems for monitoring and managing the health of aquatic environments.
2. To understand how variations in soil and water quality affect fish and shellfish productivity.

Theory

Analytical Chemistry in Aquatic Systems: Principles, applications, and types of analytical chemistry; Classical methods: Volumetric and gravimetric analysis; Solution chemistry:

Preparation of standard solutions, titration techniques, indicators, and concentration units; Interpretation tools: Standard curve and nomograph. **Water Chemistry:** Structure and properties of the water molecule; Characteristics of pure, freshwater, and seawater; Composition of surface water, groundwater, and marine water; Dissolved gases: Factors affecting their concentration in natural waters; Acids, bases, salts; pH and buffer systems**. Water Quality Analysis:** Collection and preservation of water samples; Measurement of physical and chemical parameters:Temperature, transparency, turbidity, pH, electrical conductivity (EC), salinity, chlorinity, Total solids (TDS, TSS, TVS, TVDS), Dissolved oxygen (DO), free CO_2 , Total alkalinity, total hardness, calcium, magnesium, Inorganic nitrogen (ammonium and nitrate) and phosphorus, Water quality requirements and criteria for aquaculture**. Soil Chemistry:** Soil origin, nature, and classification; Physical properties: Color, texture, structure, porosity, bulk density, water holding capacity**;** Soil types and their geographic distribution**;** Soil chemical properties:Soil colloids, cation exchange capacity (CEC), organic carbon, C:N ratio**,** Soil pH, electrical conductivity, redox potential**,** Submerged soils and wetland chemistry: Methane and hydrogen sulphide formation**,** Special soil types: Saline, alkali, acid sulphate soils, iron pyrites; soil reclamation techniques**, Soil Quality Analysis:** Soil sampling and preparation; Analytical parameters: Texture, water holding capacity, pH, EC, organic carbon, nitrogen, phosphorus, lime requirement; Soil and water amendments: Use of lime, manures, fertilizers, micronutrients, zeolites, alum, gypsum; Environmental treatments: Chlorination, deodorants, bacterial additives; Soil quality benchmarks for aquaculture suitability

Practical

Analytical Techniques:Titrimetry, gravimetry, potentiometry, conductometry, refractometry, Colorimetry, turbidimetry, spectrophotometry (UV, visible, flame, AAS), Computer-based instrument systems; **Water Analysis Exercises**:Temperature, turbidity, pH, EC, Salinity, chlorinity, total solids, redox potential, DO, free CO_2 , Total alkalinity, hardness, inorganic nitrogen, and phosphorus; **Soil Analysis Exercises**:Soil texture, pH, EC, available nitrogen and phosphorus, organic carbon

Suggested Readings

1. APHA (2017) – *Standard Methods for the Examination of Water and Wastewater*, 23rd Ed.
2. Boyd, C.E., et al. (2002) – *Aquaculture Pond Bottom Soil Quality Management*, Oregon State University.
3. Ham, B.M. & MaHam, A. (2016) – *Analytical Chemistry: A Chemist and Laboratory Technician's Toolkit*, Wiley.
4. Cheremisinoff, N.P. (2002) – *Handbook of Water and Waste Water Treatment Technologies*, Butterworth–Heinemann.
5. Jeffery, G.H. et al. (1989) – *Vogel's Textbook of Quantitative Chemical Analysis*, Longman Publishers.
6. Sparks, D.L. et al. (1996) – *Methods of Soil Analysis: Part 3 - Chemical Methods*, SSSA-ASA, Madison.

FSCCCC104: Anatomy and Biology of Fish and Shellfish Objectives 3 (2+1)

1. To familiarize with the anatomy and biology of fish and shellfish
2. To understand the anatomy and developmental biology of fish and shellfish

Theory

Study of the external and internal anatomy of important groups of finfish. Study of oral region and associated structures. Digestive system and associated digestive glands. Food and feeding habits of commercially important fishes. Qualitative and quantitative methods of analysis of gut contents. Circulatory system, respiratory system, nervous system, urino-genital system, endocrine system, skeletal systems and sensory organs. Reproductive biology – maturity stages, gonado-somatic index, ponderal index, fecundity, sex ratio and spawning. Eggs and larval stages and developmental biology. Age and growth determination by direct and indirect methods. Fish migration - type and significance. Tagging and marking.

Study of external and internal organization of commercially important crustaceans and molluscs. Digestive, respiratory, circulatory, nervous and reproductive systems. Food and feeding habits, growth, moulting, length – weight relationship. Reproductive biology, larval stages. Age and growth determination by direct and indirect methods.

Practical

Study of internal organs – digestive, respiratory, circulatory, urino-genital system, nervous, skeletal systems and endocrine systems. Study of food and feeding habits. Analysis of gut contents. Estimation of age and growth by direct and indirect methods. Classification of maturity stages. Estimation of fecundity. Study of developmental stages. Tagging and marking.

Study of Internal Organs commercially important crustaceans and molluscs. Study of Digestive, respiratory, circulatory, nervous, and reproductive systems. Study of food and feeding habits - analysis of gut contents, age and growth, length - weight relationship and condition. Reproductive biology: maturity stages, spawning periodicity, fecundity, and larval stages.

Suggested Readings

1. Barrington, E.J.W. (1981). *Invertebrate Structure and Function* (2nd ed.). The English Language Book Society and Nelson.
2. Ede, D.A. (1978). *An Introduction to Developmental Biology*. Blackie.
3. Jobling, M. (1995). *Environmental Biology of Fishes*. Chapman and Hall.
4. Jobling, M. (1995). *Environmental Biology of Fishes*. Springer.
5. Khanna, S.S., & Singh, H.R. (2014). *Textbook of Fish Biology and Fisheries* (3rd ed.). Narendra Publishing House.
6. Paul, J., Hart, B., & Reynolds, J.D. (Eds.). (2002). *Handbook of Fish Biology and Fisheries: Volume 2 - Fisheries*. Blackwell Science Ltd.
7. Ray, S. (2015). *Physiology of Finfish and Shellfish*. New Delhi: New India Publishing Agency. xviii, 230p. ISBN: 978-93-83305-68-1.
8. Silas, E.G. (1983). *Development of Penaeid Prawns*. CMFRI Bulletin No. 28.
9. Müller, W.A. (1996). *Developmental Biology*. Springer. 328p.

10. Tembhre, M. (1996). *Anatomy and Physiology of Fishes*. Vikas Publishing House.
11. Venkataramanujam, K., & Ramanathan, N. (1994). *Manual of Finfish Biology*. Oxford and IBH Publishing Co. Pvt. Ltd.
12. Reece, W.O., & Rowe, E.W. (2017). *Functional Anatomy and Physiology*.

FSCCCC105: Fundamental Microbiology **Credits: 3 (2+1)**

Objectives

1. To provide foundational knowledge in microbiology and its role in aquatic environments.
2. To develop practical skills in microbial identification, cultivation, and diagnosis of microbial pathogens affecting aquatic organisms.

Theory

Historical Milestones in Microbiology - Contributions of pioneers like Antonie van Leeuwenhoek, Louis Pasteur, Robert Koch, Alexander Fleming, Joseph Lister, and Sergei Winogradsky. Microscopy - Principles and construction of brightfield, dark field, phase contrast, stereo, scanning electron microscope (SEM), and transmission electron microscope (TEM). Microbial Taxonomy - Overview of Bergey's Manual and molecular classification techniques. Types of Microorganisms - Prokaryotes: Morphology and ultrastructure of bacteria; cyanobacteria, actinomycetes, archaea, mycoplasma, and rickettsiae. Eukaryotes: Key features and roles of fungi and protozoa. Microbial Techniques - Media types; sterilization methods (physical and chemical); cultivation and staining techniques (simple, differential, structural); microbial enumeration; preservation techniques. Bacterial Metabolism - Nutritional requirements and types; bacterial photosynthesis and ecological relevance. Microbial Growth - Growth phases, measurement methods, and the influence of physicochemical factors (pH, temperature, light, moisture, osmotic pressure); fermentation types and significance. Microbial Genetics - Principles of genetic recombination—transformation, transduction, conjugation; types and roles of plasmids; types of mutations and their importance. Microbial Ecology - Types of microbial interactions, extremophiles and their significance. Aquatic Microbiology - Scope and importance; microbial diversity in freshwater and marine habitats including sediments; biofilms; roles in organic matter degradation, sedimentation, mineralization, and nutrient cycling (carbon, nitrogen, sulphur, phosphorus, iron, manganese). Applied Microbiology Sewage and drinking water microbiology; self-purification; bioremediation; water quality assessment for aquaculture; economic importance of aquatic microbes.

Practical

Microscopy: Handling, wet mounts, smears, hanging drops, micrometry using ocular and stage micrometers. Sterilization techniques: Filtration, dry and moist heat, and chemical methods. Microbial culture techniques: Media preparation, pure culture isolation, subculturing. Microbial observation: Fungi, blue-green algae, protozoa. Bacterial staining: Simple, differential, structural. Biochemical tests: Indole, methyl red, Voges-Proskauer, citrate, oxidase, catalase. Sample collection: Water and sediment for microbial analysis; Winogradsky column. Microbial enumeration and identification from aquatic environments. Study of nutrient-cycling bacteria and

biofilms. Water testing for potability, coliform enumeration. Antibiotic sensitivity testing via disc diffusion method.

Suggested Readings

1. Chakraborty, P. (1995). *A Textbook of Microbiology*. New Central Book Agency.
2. Criusted, J. (1986). *Methods in Microbiology*. Academic Press.
3. Harry, W. S. Jr., Paul, J. V., & John, J. L. (2000). *Microbes in Action*. Freeman & Co.
4. James, M. (1978). *Modern Food Microbiology* (2nd Ed.). D. Van Nostrand Co.
5. Pelczar, M. J., & Chan, E. C. S. (1998). *Microbiology*. Tata McGraw-Hill.
6. Paul, J. H. (2001). *Marine Microbiology - Methods in Microbiology*, Vol. XXX. Academic Press.
7. Samuel, C. P., & Dunn, C. G. (1959). *Industrial Microbiology*. McGraw-Hill.
8. Silliker, J. H. et al. (1980). *Microbial Ecology of Foods*, Vol. II (ICMSF). Academic Press.
9. William, C. F., & Westhoff, D. C. (2000). *Food Microbiology*. Tata McGraw-Hill.
10. Khuntia, B. K. (2021). *Basic Microbiology – An Illustrated Laboratory Manual*. Daya Publishing.

FSCCCC106: Meteorology and Geography **Credits: 3 (2+1)**

Objective

(1) To impart knowledge on meteorological phenomena and their geographical distribution and relevance.

Theory

Atmosphere and Heat Energy - Introduction to weather and climate; composition and structure of the atmosphere.Heat transmission in the atmosphere: methods of heat transfer, insulation, and factors causing uneven heating.Atmospheric temperature: measurement instruments, periodic and spatial variations, impact of vertical air motion; Humidity and Water Vapour - Temperature-humidity relationship; atmospheric water vapour distribution; processes of evaporation; Humidity measurement techniques and instruments; Condensation and Precipitation - Conditions and types of condensation; forms and mechanisms of precipitation; rainfall measurement and distribution patterns in India; Clouds and Thunderstorms - Cloud types and classification; cloud formation and identification; concepts of cloudiness and ceiling; characteristics of thunderstorms; Atmospheric Pressure and Wind Systems- Atmospheric pressure: gas laws, units, instruments; vertical and horizontal pressure variations, pressure gradients and isobars; Wind dynamics: measurement, representation, and influencing factors; Planetary wind systems: global pressure belts, secondary winds, land and sea breezes, monsoons, Tropical cyclones: classification, structure, pressure/wind systems, hurricane phenomena, storm surges and warning systems; Weather Forecasting and Climate Change- Weather forecasting techniques: local observations, satellite data, synoptic charts, Climate change impacts on fisheries; Introduction to Geography; Earth’s shape, size, and internal structure; understanding latitude, longitude, and great circles; Maps, projections, cartographic tools, and basic landscape concepts.

Practical

Graphical representation of atmospheric structure and layers; Use of temperature-measuring instruments: simple thermometers, Six's Max-Min thermometer, thermographs; Analysis of isotherms: global and Indian temperature patterns (Jan–July); Humidity instruments: hygrometer, psychrometer; calculating relative humidity and dew point; Observation of condensation and cloud types; depiction of sky conditions; Rainfall measurement using rain gauges; Mapping Indian monsoon patterns: south-west (June) and north-east (December) monsoons; use of isohyets; Measurement of atmospheric pressure: Fortin's barometer, aneroid barometer; plotting isobars for India (Jan–July); Wind measurement using wind vane and cup anemometer; Diagrammatic representation of planetary wind and pressure systems; Geography: visual representation of the Earth's shape, structure, zones, and coordinate system; Map reading and interpretation of typical landscapes; understanding geographical terminology.

Suggested Readings

1. Ahrens, C. Donald. *Essentials of Meteorology: An Invitation to the Atmosphere*, International Edition, Brooks/Cole.
2. Barry, Roger G. *Atmosphere, Weather and Climate*, Taylor and Francis.
3. Maury, Matthew Fontaine. *The Physical Geography of the Sea, and Its Meteorology*, Palala Publishing.
4. Naik, M. Ganapathi. *Meteorology and Geography*, Narendra Publishing House.
5. Spiridonov, V. *Fundamentals of Meteorology*, Springer.
6. Indian Meteorological Department (IMD). *Weather Instruments, Maps, and Charts*, In *Practical Geography* (2022–23).

FSCMDC107: Farming Based Livelihood Systems **Credits: 3 (2+1)**

Course Objectives:

1. To create awareness among students about farming-based livelihood systems in agriculture.
2. To impart knowledge and skills on how various farming-based systems can serve as sustainable sources of livelihood.

Theory

Status of Agriculture in India: Overview of the current status of agriculture across India and its states; income levels of farmers and rural populations. Livelihood Concepts: Definition, patterns in rural and urban areas, and key indicators used to study livelihood systems. Agricultural Livelihood Systems (ALS): Concept, approaches, and frameworks of ALS; definition and classification of farming and farming-based livelihood systems. Prevalent Farming Systems in India: Traditional and modern systems contributing to rural livelihoods. Components of Farming-Based Livelihood Systems: Crops and cropping systems, Livestock enterprises (Dairy, Piggery, Goatry, Poultry, Duckery, etc.), Horticultural crops, Agroforestry systems, Aquaculture-based integrations (e.g., Duck/Fish, Poultry/Fish, Dairy/Fish, Piggery/Fish), Small, medium, and large enterprises including value chains and secondary enterprises. Enterprise Integration: Factors

influencing the integration of various enterprises for sustainable livelihoods. Agro-Climatic Suitability: Feasibility of different farming systems in various agro-climatic zones. Livelihood Models: Commercial models promoted by NABARD, ICAR, and other organizations. Case Studies: Real-life examples of livelihood enterprises based on farming. Challenges and Opportunities: Risk and success factors in farming-based livelihoods. Central and State Government schemes and programs. Role of public and private organizations in promoting farming-based livelihoods. Emerging Relevance: Importance of farming-based enterprises in the 21st century in the context of circular economy, green economy, climate change, digital transformation, and evolving lifestyles.

Practical

Conducting surveys on farming systems and agriculturally-based livelihood enterprises.Studying key components of major farming-based livelihood models across agro-climatic zones.Analyzing production and profitability in crop-based, livestock-based, processing-based, and integrated models.Field visits to observe innovative and model farming systems.Visits to agri-based enterprises to study integration across production, processing, and distribution.Exploring agri-enterprises in industrial and service sectors (value chain models).Learning project formulation techniques including cost-benefit analysis.Case studies of agricultural start-ups and entrepreneurship models.

Suggested Readings

1. Agarwal, A. & Narain, S. (1989). *Towards Green Villages: A Strategy for Environmentally Sound and Participatory Rural Development*. Centre for Science and Environment, New Delhi.
2. Ashley, C. & Carney, D. (1999). *Sustainable Livelihoods: Lessons from Early Experience*. Department for International Development, UK.
3. Carloni, A. (2001). *Global Farming Systems Study: Challenges and Priorities to 2030 – Regional Analysis: Sub-Saharan Africa*. FAO, Rome.
4. Dixon, J., Gulliver, A., & Gibbon, D. (2001). *Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World*. FAO and World Bank.
5. Evenson, R.E. (2000). *Agricultural Productivity and Production in Developing Countries*. In: *The State of Food and Agriculture*. FAO, Rome.
6. Bhatt, B.P., et al. *Livelihood Improvement of Underprivileged Farming Community*. ICAR Research Complex for Eastern Region, Patna.
7. Panwar, et al. (2020). *Integrated Farming System Models for Agricultural Diversification, Enhanced Income and Employment*. ICAR, New Delhi.
8. Reddy, S.R. (2016). *Farming System and Sustainable Agriculture*. Kalyani Publishers, New Delhi.
9. Singh, J.P., et al. (2015). *Region Specific Integrated Farming System Models*. ICAR-Indian Institute of Farming Systems Research, Modipuram.
10. Walia, S.S. & Walia, U.S. (2020). *Farming System and Sustainable Agriculture*. Scientific Publishers, Jodhpur, Rajasthan.

FSCAEC108: Communication Skills – 2 (1+1)

Objectives

1. To develop proficiency in oral, written, and non-verbal communication.
2. To strengthen both personal and professional communication abilities.
3. To cultivate effective group communication and collaboration skills.

Theory

Communication Process - Understanding the art of effective communication; building confidence and overcoming communication-related fears. Concept and nature of communication; importance and functions of the communication process. Definitions, types (verbal and non-verbal), and various models of communication. Understanding linguistic and non-linguistic barriers; common causes of miscommunication and communication gaps. Core Communication Skills - Mastering Listening, Speaking, Reading, and Writing (LSRW) skills. Practice in precis writing, abstracting, and summarizing. Principles of technical writing and resume/CV drafting. Strategies to expand vocabulary, solving analogy-type questions. Grammar and Language Usage - Basic grammar and sentence construction: sentence structure, modifiers, phrases and clauses, use of verbals and connecting words. Cases: subjective, possessive, and objective. Correct usage of parts of speech – nouns, pronouns, adjectives, adverbs, and articles. Subject-verb agreement, verb tenses, moods, and voice. Common sentence errors and how to correct them.

Practical

Listening practice and note-taking techniques.Writing exercises: précis writing, summarization, and abstract writing.Reading and oral comprehension of technical and general texts.Micro and impromptu presentations, with peer and instructor feedback.Stage presence: grooming, body language, voice modulation, and pacing.Group discussions and public speaking.Vocabulary enhancement activities.Interview preparation and techniques.Event planning and coordination tasks.

Suggested Readings

1. Allport, G. W. (1937). *Personality: A Psychological Interpretation*. Holt, New York.
2. Brown, M., & Brandreth, G. (1994). *How to Interview and Be Interviewed*. Sheldon Press, London.
3. Carnegie, D. (1997). *The Quick and Easy Way to Effective Speaking*. Pocket Books, New York.
4. Francis, P. S. J. (2012). *Soft Skills and Professional Communication*. Tata McGraw Hill, New Delhi.
5. Kumar, S. & Lata, P. (2011). *Communication Skills*. Oxford University Press.
6. Neuliep, J. W. (2003). *Intercultural Communication: A Contextual Approach*. Houghton Mifflin Co, Boston.
7. Pease, A. (1998). *Body Language*. Sudha Publications, Delhi.
8. Raman, M., & Singh, P. (2000). *Business Communication*. Oxford University Press.

9. Seely, J. (2013). *Oxford Guide to Effective Writing and Speaking*. Oxford University Press.
10. Thomson, A. J., & Martinet, A. V. (1977). *A Practical English Grammar*. Oxford University Press.

FSCAEC109: National Cadet Corps (NCC-I) – 1 (0+1)

Objectives

1. To develop values of character, courage, camaraderie, discipline, leadership, secularism, a spirit of adventure and sportsmanship, and a commitment to selfless service in youth, preparing them to be responsible and valuable citizens.
2. To build a pool of organized, trained, and motivated young individuals capable of taking up leadership roles in various sectors, including the Armed Forces, and being ever-ready to serve the nation.

Practical / Awareness Activities

- ✓ Aims, objectives, organization of NCC and NCC song. DG's cardinals of discipline.
- ✓ Drill- aim, general words of command, attention, stands at ease, stand easy and turning.
- ✓ Sizing, numbering, forming in three ranks, open and close order march, and dressing.
- ✓ Saluting at the halt, getting on parade, dismissing, and falling out.
- ✓ Marching, length of pace, and time of marching in quick/slow time and halt. Side pace, pace forward and to the rear. Turning on the march and wheeling. Saluting on the march.
- ✓ Marking time, forward march, and halt. Changing step, formation of squad and squad drill.
- ✓ Command and control, organization, badges of rank, honours, and awards
- ✓ Nation Building- cultural heritage, religions, traditions, and customs of India. National integration. Values and ethics, perception, communication, motivation, decision making, discipline and duties of good citizens. Leadership traits, types of leadership. Character/ personality development. Civil defence organization, types of emergencies, fire fighting, protection. Maintenance of essential services, disaster management, aid during development projects.
- ✓ Basics of social service, weaker sections of society and their needs, NGO's and their contribution, the contribution of youth towards social welfare and family planning. Structure and function of human body, diet and exercise, hygiene and sanitation. Preventable diseases including AIDS, safe blood donation, first aid, physical and mental health. Adventure activities. Basic principles of ecology, environmental conservation, pollution and its control.

FSCAEC109: National Service Scheme (NSS-I) **Credits: 1 (0+1)**

Objective

Evoking social consciousness among students through various activities, viz., working together, constructive, and creative social work, to be skilful in executing democratic leadership, developing skill in program, to be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society.

Practical/ Awareness activities

- ✓ Orientation: history, objectives, principles, symbol, badge; regular programs under NSS
- ✓ Organizational structure of NSS, Code of conduct for NSS volunteers, points to be considered by NSS volunteers' awareness about health.
- ✓ NSS program activities. Concept of regular activities, special camping, day camps, basis of adoption of village/slums, conducting survey, analysing guiding financial patterns of scheme, youth programs/ schemes of GOI, coordination with different agencies and maintenance of diary. Understanding youth. Definition, profile, categories, issues and challenges of youth; and opportunities for youth who is agent of the social change.
- ✓ Community mobilization. Mapping of community stakeholders, designing the message as per problems and their culture; identifying methods of mobilization involving youth-adult partnership. Social harmony and national integration
- ✓ Indian history and culture, role of youth in nation building, conflict resolution and peacebuilding. Volunteerism and shramdaan. Indian tradition of volunteerism, its need, importance, motivation, and constraints; shaman as part of volunteerism
- ✓ Citizenship, constitution, and human rights. Basic features of constitution of India, fundamental rights and duties, human rights, consumer awareness and rights and rights to information. Family and society. Concept of family, community (PRIs and other community based organizations) and society.

SEMESTER – II

FSCCCC151: Fish and Shellfish Breeding and Hatchery Management 3 (2+1)

Objectives

1. To acquire knowledge and hands-on-training on the processes and practices of fish and shellfish breeding, hatchery management and quality seed production of different cultivable fish and shellfish species.
2. To develop the professional skill on the production of fish and shellfish seeds and hatchery management

Theory

Freshwater and marine fish seed resources. Natural breeding of finfishes. Selection of riverine spawn collection sites, gears used and methods of collection. Spawn quality and quantity indices. Advantages and disadvantages of riverine seed collection. Sexual maturity and breeding season of various cultivable species. Development of gametes in male and female. Fish egg and embryonic development. Methods of breeding; bundh breeding - wet and dry bundhs, collection and hatching of eggs, factors involved in bundh breeding, advantages, and disadvantages of bundh breeding. Induced breeding of warmwater finfishes, environmental factors affecting spawning, sympathetic breeding. Hypophysation of fishes. Fish pituitary gland – its structure, collection, preservation, and preparation of extract for injection, dosages, and methods of injection. Brood-stock management and transportation of brood fish. Synthetic hormones used for induced breeding of carps. Different types of fish hatcheries-traditional, Chinese, glass jar and modern controlled hatcheries. Causes of mortalities of eggs and spawn and remedies. Spawn rearing techniques. Use of anaesthetics in fish breeding and transport. Causes of mortalities of eggs and spawn and remedies. Spawn rearing techniques. Use of anaesthetics in fish breeding and transport. Breeding techniques for Indian major carps, exotic carp, mahseer, trout, tilapias, catfishes, grey-mullets, milk fish, pearl spot, sea bass, sea horse, groupers, pacu, cobia, pompanos and indigenous fishes, etc. Off-season and multiple breeding of carps. Natural seed resources, site selection and collection methods.

Life cycle of important shellfish (*Penaeus monodon, P. indicus, Macrobrachium rosenbergii, P. vannamei, Scylla serrata*, lobster, edible, oyster, pearl oyster, freshwater mussel, holothurians, horseshoe carb, Sepia, *Loligo*, cray fish etc.). Sexual maturity and breeding seasons of different species. Maturation stages of *Macrobrachium rosenbergii* and Penaeus monodon and *P. vannamei*. Induced maturation in *Penaeus monodon, P. vannamei* and *P. indicus* by eye stalk ablation. Reproductive physiology. Reproductive hormones in crustaceans. Brood stock management of *Penaeus monodon* and *Macrobrachium rosenbergii*. Breeding and hatchery management of *P. monodon* and *M. rosenbergii*. Breeding and hatchery management of crabs, lobster, mussels, edible and pearl oysters. Food and feeding of larval stages of important shellfishes. Health management in hatcheries.

Practical

Study of maturity stages in fishes. Collection and preservation of fish pituitary gland, preparation of PG extract, Hypophysation. Calculation of fecundity. Brood-stock maintenance and selection of breeders for injection. Histological studies of ovary and testes. Different fish hatchery systems, study of fish eggs and embryonic developmental stages. Identification of eggs, spawn, fry and fingerlings of different species. Preparation and management of fish nursery. Fish seed and brood-stock transportation, use of anaesthetics, disinfectants and antibiotics in fish breeding. Water quality monitoring in fish hatcheries and nurseries. Breeding and larval rearing of common finfishes.

Identification of brood stock and maturity stages of important crustaceans and molluscs. Observations on gonadal maturation of *Penaeus monodon* and *Macrobrachium rosenbergii*. Breeding and larval rearing of *Macrobrachium rosenbergii, Penaeus monodon,* and *P. vannamei*. Identification of larval stages of important crustaceans and molluscs. Demonstration of eyestalk ablation in *Penaeus monodon*. Collection, packing and transportation of shrimp/prawn seed and brood stock. Practice in the operation of shrimp and prawn hatcheries. Water treatment and management in shrimp and prawn hatcheries. Different chemicals and drugs used in shrimp/ prawn hatchery.

Suggested Readings

1. FAO. (1992). *Manual of Seed Production of Carps*. FAO Publications.
2. Gupta, S.D., Mohapatra, P.C., Routray, P., Sahoo, S.K., Verma, D.K., & Sarangi, N. (2008). *Textbook of Breeding and Management of Carps*. Narendra Publishing House.
3. ICAR. (2006). *Handbook of Fisheries and Aquaculture*. Indian Council of Agricultural Research.
4. Jhingran, V.G., & Pullin, R.S.V. (1985). *Hatchery Manual for the Common, Chinese and Indian Major Carps*. ICLARM, Philippines.
5. Pillay, T.V.R., & Kutty, M.N. (2005). *Aquaculture: Principles and Practices*. Blackwell Publishing.
6. Rath, R.K. (2000). *Freshwater Aquaculture*. Scientific Publishers.
7. Thomas, P.C., Rath, S.C., & Mohapatra, K.D. (2003). *Breeding and Seed Production of Finfish and Shellfish*. Daya Publishing House.
8. Kurian, C.V., & Sebastian, V.O. (1976). *Prawns and Prawn Fisheries of India*. Hindustan Publishing Corporation, Delhi.
9. CMFRI. (2009). *Training Manual on Breeding and Larval Rearing of Marine Finfishes and Shellfishes*. Central Marine Fisheries Research Institute.
10. Diwan, A.D., Joseph, S., & Ayyappan, S. (2008). *Physiology of Reproduction, Breeding and Culture of Tiger Shrimp*. Narendra Publishing House.
11. FAO. (2007). *Assessment of Freshwater Fish Seed Resources for Sustainable Aquaculture*. FAO Fisheries Technical Paper No. 501.
12. Chakraborty, C., & Sadhu, A.K. (2000). *Biology, Hatchery and Culture Technology of Tiger Prawn and Giant Freshwater Prawn*. Daya Publishing House.

FSCCCC152: Physiology of Finfish and Shellfish Objectives 3 (2+1)

1. To understand the physiological function of fish and shellfish
2. To understand concepts in physiology of fish and shellfish

Theory

Water as a biological medium. Gas exchange; Circulation; Excretion; Osmoregulation; Reproductive physiology; Muscle physiology; Sense organs; Energy and nutrient status of food; Nitrogen balance; Standard and active metabolism; Energy utilization; Effect of environmental factors on the physiology of fish and shellfish. Stress-related physiological changes. Structure and functions of important endocrine glands.

Practical

Estimation of oxygen consumption, Osmoregulation, ammonia excretion and carbon dioxide output. Influence of temperature and salinity on metabolism. Haematology of fin and shellfishes. Histological techniques.

Suggested readings

1. Diwan. 2007. Physiology of Marine White Shrimp: *Fenneropenaeus indicus*. Delhi Narendra Publishing House.
2. Evans DH and Claiborne JB. 2006. The Physiology of Fishes. CRC Press.
3. Evans, 2014. Physiology of Fishes. Boca Raton CRC Press 2014, 4th Edition.
4. Hoar WS and Randall DJ.1988. Fish Physiology. Academic Press.
5. Johnston, 2014. Fish Physiology (Series 1-35 volumes) New Delhi Reed Elsevier India Pvt. Ltd.
6. Ray Samanta. 2015. Physiology of Finfish and Shellfish. New Delhi, New India Pub. Agency.
7. Reinecke, 2006. Fish Endocrinology, Vol. 1. Enfield Science Publishers, Inc.
8. Reinecke, 2006. Fish Endocrinology, Vol. 2: Enfield Science Publishers, Inc.
9. Rocha 2008. Fish reproduction. Enfield Science Publishers, Inc.
10. Smith Lynwood S. 1999. Introduction to fish physiology. Narendra Publishing House.

FSCCCC153: Freshwater Aquaculture Credits:3 (2+1)

Objectives

1. To develop an understanding of modern advancements in freshwater aquaculture across various culture systems.
2. To provide knowledge of different aquaculture methods and commercially important freshwater finfish and shellfish species.

Theory

Overview of major cultured species, global production patterns, and future prospects. Freshwater aquaculture resources: ponds, tanks, lakes, reservoirs, etc. Preparation and management of nursery, rearing, and grow-out ponds including the control of aquatic weeds, algal blooms,

predatory and weed fishes. Practices of liming, fertilization/manuring, application of bio fertilizers, and supplementary feeding. Fundamentals of water quality management.Selection, handling, transportation, and acclimatization of fish seed. Characteristics and culture techniques of economically important freshwater fish and shellfish species including Indian major carps, exotic carps, air-breathing fishes, cold-water species, freshwater prawns, and mussels. Use and management of specialized pond types like wintering, quarantine, and isolation ponds. Sewage-fed aquaculture systems.Principles of organic nutrient cycling and the detritus-based food web. Utilization of agro-industrial by-products and biofertilizers in aquaculture. Composite fish culture involving Indian and exotic carps with emphasis on species compatibility. Overview of exotic fish introductions in India. Culture methods for other freshwater species including medium and minor carps, catfishes, and murrels.Species selection for integrated aquaculture systems. Integration of aquaculture with agriculture, horticulture, and livestock. Cultivation of aquatic macrophytes (e.g., makhana) in combination with aquaculture. Paddy-cum-fish and paddy-cum-shrimp culture systems.

Practical

Techniques for preparing and managing nursery, rearing, and grow-out ponds. Assessing the effects of liming, manuring, and fertilization on pond productivity and fish/shellfish growth. Identification and control measures for aquatic weeds, insect pests, predatory and weed fishes, fish eggs, and larvae. Management of algal blooms.Estimation and analysis of plankton and benthic organism biomass. Study of natural vs. supplementary feed contributions to fish growth. Economic evaluation of various freshwater aquaculture practices. Estimation of livestock input for integrated systems. Designing paddy plots for paddy-cum-fish culture, integrated fish and shrimp farming layouts, and livestock sheds on pond bunds. Economic analysis of different integrated farming systems.

Suggested Readings

1. Agarwal, S.C. (2008). *A Handbook of Fish Farming* (2nd ed.). Narendra Publishing House.
2. De Silva, S.S. (Ed.). (2001). *Reservoir and Culture-Based Fisheries: Biology and Management*. ACAIR.
3. FAO. (2007). *Manual on Freshwater Prawn Farming*.
4. Midlen, A. & Redding, T.A. (1998). *Environmental Management for Aquaculture*. Kluwer.
5. New, M.B. (2000). *Freshwater Prawn Farming*. CRC Press.
6. Pillay, T.V.R. & Kutty, M.N. (2005). *Aquaculture: Principles and Practices*. Blackwell.
7. Pillay, T.V.R. (1990). *Aquaculture: Principles and Practices*. Fishing News Books.
8. Rath, R.K. (2000). *Freshwater Aquaculture*. Scientific Publishers.
9. Venugopal, S. (2005). *Aquaculture*. Pointer Publishers.
10. Welcomme, R.L. (2001). *Inland Fisheries: Ecology and Management*. Fishing News Books.
11. ICAR. (2006). *Handbook of Fisheries and Aquaculture*.
12. Jhingran, V.G. (1991). *Fish and Fisheries of India* (3rd ed.). Hindustan Publishing Corporation.

FSCCCC154 – 204: Limnology **2 (1+1)**

Objectives

1. To study the limnetic environment
2. To understand the physico-chemical and biological characters of the limnetic environment

Theory

Introduction to limnology: inland water types, their characteristics and distribution; ponds and lakes; streams and rivers; dynamics of lentic and lotic environments. Lakes - their origin and diversity. Famous lakes of the world and India; nature of lake environment; morphometry, physical and chemical conditions and related phenomena; biological relations: influence of physical and chemical conditions on living organisms in inland waters. Plankton: planktonic organisms; classification of plankton; distribution of plankton: geographic, vertical, horizontal and seasonal distribution of phytoplankton and zooplankton; seasonal changes of body form in planktonic organisms; food of planktonic organisms; primary productivity: Aquatic plants: characteristics, classification, zonation, seasonal variations, quantity produced chemical composition distribution in different waters, limnological role. Nekton: composition, distribution, movements. Benthos: classification; periphyton; zonation; distribution; movements and migration; seasonal changes in benthos, profundal bottom fauna. Biological productivity: circulation of food material; classification of lakes based on productivity; laws of minimum; biotic potential and environmental resistance; quantitative relationships in a standing crop; trophic dynamics; successional phenomena; indices of productivity of lakes; artificial enrichment. Lotic environments: running waters in general; physical conditions; classification of lotic environments, biological conditions; productivity of lotic environments. influence of currents; plant growth; plankton; nekton; benthos; temporary and head waters streams; ecological succession.

Practical

Morphometry of lakes, ponds and streams. Determination of physical characteristics of lentic water bodies. Determination of chemical characteristics of lentic water bodies. Determination of physical characteristics of lotic water bodies. Determination of chemical characteristics of lotic water bodies. Collection and identification of freshwater phytoplankton. Enumeration and biomass estimation of freshwater phytoplankton. Estimation of primary productivity in freshwater bodies. Collection and identification of freshwater zooplankton. Enumeration and biomass estimation of freshwater zooplankton. Collection and identification of benthos from lakes and ponds, streams, and canals. Collection and identification of nekton/aquatic insects from freshwater bodies. Collection and identification of aquatic plants from different freshwater bodies. Field visit to lotic and lentic water bodies.

Suggested Readings

1. APHA. (2017). *Standard Methods for the Examination of Water and Wastewater*. American Public Health Association, Washington, D.C.

2. Ham, B.M., & MaHam, A. (2016). *Analytical Chemistry: A Chemist and Laboratory Technician's Toolkit*. Wiley.
3. Boyd, C.E. (1995). *Bottom Soils, Sediment, and Pond Aquaculture*. Chapman and Hall.
4. Cole, G.A., & Weihe, P.E. (2015). *Textbook of Limnology*. Waveland Press, Inc.
5. Datta Munshi, J. (2015). *Fundamentals of Limnology*. Daya Publishing House.
6. Dodds, W.K. (2002). *Freshwater Ecology: Concepts and Environmental Applications*. Academic Press, New York.
7. Edmondson, W.T. (2003). *Freshwater Biology*. Textbook Publishers. 1248 pp.
8. Essington, M.E. (2003). *Soil and Water Chemistry: An Integrated Approach*. CRC Press.
9. Fassett, N.G. (1997). *A Manual of Aquatic Plants*. Allied Scientific Publishers, Bikaner.
10. Tundisi, J.G., & Tundisi, T.M. (2011). *Limnology*. CRC Press, London. 888 pp.
11. Mitsch, W.J. (2009). *Wetland Ecosystems*. John Wiley and Sons. 295 pp.
12. Nath, S. (Ed.). (2008). *Recent Advances in Fish Ecology, Limnology and Eco Conservation* (Vol. 7). Narendra Publishing House, New Delhi.
13. Tan, K.H. (1998). *Principles of Soil Chemistry*. CRC Press Inc., Boca Raton.
14. Wetzel, R.G. (2010). *Limnology*. Saunders Publishing. 858 pp.

FSCMDC155: Entrepreneurship Development and Business Management 3 (2+1)

Objectives

1. To provide students an insight into the concept and scope of entrepreneurship
2. To expose the student to various aspects of the establishment and management of a small business unit
3. To enable the student to develop financially viable agribusiness proposal

Theory

Development of entrepreneurship, motivational factors, social factors, environmental factors, characteristics of entrepreneurs, entrepreneurial attributes/competencies. Concept, need for and importance of entrepreneurial development. Evolution of entrepreneurship, objectives of entrepreneurial activities, types of entrepreneurs, functions of entrepreneurs, importance of entrepreneurial development, and process of entrepreneurship development. Environment scanning and opportunity identification need for scanning–spotting of opportunity-scanning of environment– identification of product/service – starting a project; factors influencing sensing the opportunities. Infrastructure and support systems- good policies, schemes for entrepreneurship development; role of financial institutions, and other agencies in entrepreneurship development. Steps involved in functioning of an enterprise. Selection of the product/services, selection of form of ownership; registration, selection of site, capital sources, acquisition of manufacturing knowhow, packaging and distribution. Planning of an enterprise, project identification, selection, and formulation of project; project report preparation, Enterprise Management. Production management – product, levels of products, product mix, quality control, cost of production, production controls, Material management. Production management – raw material costing, inventory control. Personal management – manpower planning, labour turn over, wages/salaries. Financial management / accounting – funds, fixed capital and working capital, costing and pricing, long-term planning and short-term planning, book keeping, journal, ledger, subsidiary books,

annual financial statement, taxation. Marketing management- market, types, marketing assistance, market strategies. Crisis management- raw material, production, leadership, market, finance, natural etc.

Practical

Visit to small scale industries/aqua-industries, Interaction with successful entrepreneurs/ aqua-entrepreneurs. Visit to financial institutions and support agencies. Preparation of project proposals for funding by different agencies.

Suggested Readings

1. Charantimath, P.M. (2009). *Entrepreneurship Development and Small Business Enterprises*. Pearson Publications, New Delhi.
2. Desai, V. (2015). *Entrepreneurship: Development and Management*. Himalaya Publishing House.
3. Gupta, C.B. (2001). *Management Theory and Practice*. Sultan Chand and Sons.
4. Grover, I. (2008). *Handbook on Empowerment and Entrepreneurship*. Agrotech Public Academy.
5. Khanka, S.S. (1999). *Entrepreneurial Development*. S. Chand and Company.
6. Mehra, P. (2016). *Business Communication for Managers*. Pearson India, New Delhi.
7. Pandey, M., & Tewari, D. (2010). *The Agribusiness Book*. IBDC Publishers, Lucknow.
8. Singh, D. (1995). *Effective Managerial Leadership*. Deep and Deep Publications.
9. Singhal, R.K. (2013). *Entrepreneurship Development and Management*. Katson Books.
10. Tripathi, P.C., & Reddy, P.N. (1991). *Principles of Management*. Tata McGraw Hill.
11. Desai, V. (1997). *Small Scale Industries and Entrepreneurship*. Himalaya Publishing House.

FSCVAC156: Environmental Studies and Disaster Management 3 (2+1)

Objective

1. To expose and acquire knowledge on the environment and to gain the state-of-the-art – skill and expertise on management of disasters.

Theory

Introduction to Environment - Environmental studies - Definition, scope and importance - Multidisciplinary nature of environmental studies - Segments of Environment - Spheres of Earth - Lithosphere - Hydrosphere - Atmosphere - Different layers of atmosphere. Natural Resources: Classification - Forest resources. Water resources. Mineral resources Food resources. Energy resources. Land resources. Soil resources. Ecosystems - Concept of an ecosystem - Structure and function of an ecosystem - Energy flow in the ecosystem. Types of ecosystems. Biodiversity and its conservation: Introduction, definition, types. Biogeographical classification of India.

Importance and Value of biodiversity. Biodiversity hot spots. Threats and Conservation of biodiversity.

Environmental Pollution: Definition, cause, effects and control measures of: (a) Air pollution. (b) Water pollution. (c) Soil pollution. (d) Marine pollution. (e) Noise pollution. (f) Thermal pollution. (h) light pollution. Solid Waste Management: Classification of solid wastes and management methods, Composting, Incineration, Pyrolysis, Biogas production, Causes, effects and control measures of urban and industrial wastes. Social Issues and the Environment: Urban problems related to energy. Water conservation, rainwater harvesting, watershed management. Environmental ethics: Issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Environment Protection Act. Air (Prevention and Control of Pollution) Act. Water (Prevention and control of Pollution) Act. Wildlife Protection Act. Forest Conservation Act. Human Population and the Environment: Environment and human health: Human Rights, Value Education. Women and Child Welfare. Role of Information Technology in Environment and human health.

Disaster management - Disaster definition - Types - Natural Disasters - Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves. Man Made Disasters - Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, road accidents, rail accidents, air accidents, sea accidents. International and National strategy for disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, community-based organizations and media in disaster management. Central, state, district and local administration in disaster control; Armed forces in disaster response; Police and other organizations in disaster management.

Practical

Visit to a local area to document environmental assets river/forest/grassland/hill/mountain. Energy: Biogas production from organic wastes. Visit to windmill/hydropower / solar power generation units. Biodiversity assessment in farming system. Floral and faunal diversity assessment in polluted and unpolluted systems. Visit to local polluted site - Urban/Rural/Industrial/Agricultural to study of common plants, insects and birds. Environmental sampling and preservation. Water quality analysis: pH, EC and TDS. Estimation of Acidity, Alkalinity. Estimation of water hardness. Estimation of DO and BOD in water samples. Estimation of COD in water samples. Enumeration of E. coli in water sample. Assessment of Suspended Particulate Matter (SPM). Study of simple ecosystem – Visit to pond/river/hills. Visit to areas affected by natural disasters.

Suggested Readings

1. De, A.K. (2010). *Environmental Chemistry*. New Age International Publishers, New Delhi.
2. Dhar Chakrabarti, P.G. (2011). *Disaster Management – India's Risk Management Policy Frameworks and Key Challenges*. Centre for Social Markets (India), Bangalore. 36 pp.
3. Bharucha, E. *Textbook for Environmental Studies*. University Grants Commission, New Delhi.

4. Parthiban, K.T., Vennila, S., Prasanthrajan, M., & Umesh Kanna, S. (2023). *Forest, Environment, Biodiversity and Sustainable Development*. Narendra Publishing House, New Delhi, India. (In Press).
5. Prasanthrajan, M., & Mahendran, P.P. (2008). *A Textbook on Ecology and Environmental Science*. Agrotech Publishing Academy, Udaipur. ISBN: 81-8321-104-6.
6. Prasanthrajan, M. (2018). *Objective Environmental Studies and Disaster Management*. Scientific Publishers, Jodhpur, India. ISBN: 9789387893825. 146 pp.
7. Sharma, P.D. (2009). *Ecology and Environment*. Rastogi Publications, Meerut, India.
8. Miller, T., & Spoolman, S. (2009). *Living in the Environment: Concepts, Connections, and Solutions*. Brooks/Cole, Cengage Learning, Belmont, USA.

FSCAEC157: Personality Development **2(1+1)**

Objective

1. To make students realize their potential strengths, cultivate their inter-personal skills and improve employability

Theory

Personality Definition, Nature of personality, theories of personality and its types. The humanistic approach - Maslow's self-actualization theory, shaping of personality, determinants of personality, Myers-Briggs Typology Indicator, Locus of control and performance, Type A and Type B Behaviours, personality and Organizational Behaviour.

Foundations of individual behaviour and factors influencing individual behaviour, Models of individual behaviour, Perception and attributes and factors affecting perception, Attribution theory and case studies on Perception and Attribution. Learning: Meaning and definition, theories and principles of learning, Learning and organizational behaviour, Learning and training, learning feedback. Attitude and values, Intelligence- types of Intelligence, theories of intelligence, measurements of intelligence, factors influencing intelligence, intelligence and Organizational behaviour, emotional intelligence. Motivation- theories and principles, Teamwork and group dynamics.

Practical

MBTI personality analysis, Learning Styles and Strategies, Motivational needs, Firo-B, Interpersonal Communication, Teamwork and team building, Group Dynamics, Win-win game, Conflict Management, Leadership styles, Case studies on Personality and Organizational Behaviour.

Suggested Reading

1. Andrews, Sudhir. (1988). *How to Succeed at Interviews*. 21st (rep. ed.). New Delhi: Tata McGraw-Hill.
2. Heller, Robert. (2002). *Effective Leadership*. Essential Manager Series. DK Publishing.
3. Hindle, Tim. (2003). *Reducing Stress*. Essential Manager Series. DK Publishing.
4. Lucas, Stephen. (2001). *The Art of Public Speaking*. New Delhi: Tata McGraw-Hill.

5. Mile, D.J. (2004). *The Power of Positive Thinking*. Delhi: Rohan Book Company.
6. Kumar, Pravesh. (2005). *All About Self-Motivation*. New Delhi: Goodwill Publishing House.
7. Smith, B. (2004). *Body Language*. Delhi: Rohan Book Company.
8. Shaffer, D.R. (2009). *Social and Personality Development* (6th ed.). Belmont, CA: Wadsworth.

FSCAEC158**: National Cadet Corps (NCC-II)** **1 (0+1)**

Objectives

1. To develop qualities of character, courage, comradeship, discipline, leadership, secular outlook, spirit of adventure and sportsmanship and the ideals of selfless service among the youth to make them useful citizen
2. To create a human resource of organized trained and motivated youth to provide leadership in all walks of life including the Armed Forces and be always available for the service of the nation

Practical/ Awareness activities

Arms Drill- Attention, stand at ease, stand easy. Getting on parade. Dismissing and falling out. Ground/take up arms, examine arms. Shoulder from the order and vice-versa, present from the order and vice-versa. Saluting at the shoulder at the halt and on the march. Short/long trail from the order and vice- versa. Guard mounting, guard of honor, Platoon/Coy Drill. Characteristics ofrifle (.22/.303/SLR), ammunition, fire power, stripping, assembling, care, cleaning, and sight setting. Loading, cocking, and unloading. The lying position and holding.

Trigger control and firing a shot. Range Procedure and safety precautions. Aiming and alteration of sight. Theory of groups and snap shooting. Firing at moving targets. Miniature range firing. Characteristics of Carbine and LMG. Introduction to map, scales, and conventional signs. Topographical forms and technical terms. The grid system. Relief, contours, and gradients. Cardinal points and finding north. Types of bearings and use of service protractor. Prismatic compass and its use. Setting a map, finding north and own position. Map to ground and ground to map. Knots and lashings, Camouflage and concealment, Explosives and IEDs. Field defences obstacles, mines and mine lying. Bridging, waterman ship. Field water supplies, tracks and their construction. Judging distance. Description of ground and indication of landmarks. Recognition and description of target. Observation and concealment. Field signals. Section formations. Fire control orders. Fire and movement. Movement with/without arms. Section battle drill. Types of communication, media, latest trends and developments.

FSCAEC158: National Service Scheme (NSS- II) **1 (0+1)**

Objective

1. To evoke social consciousness among students through various activities viz., working together, constructive, and creative social work, to be skilful in executing democratic leadership, developing skill in program, to be able to seek self-employment, reducing gap

between educated and uneducated, increasing awareness and desire to help sections of society.

Practical/ Awareness activities

Importance and role of youth leadership. Meaning, types and traits of leadership, qualities of good leaders; importance and roles of youth leadership, Life competencies. Definition and importance of life competencies, problem-solving and decision-making, interpersonal communication. Youth development programs. Development of youth programs and policy at the national level, state level and voluntary sector; youth-focused and youth-led organizations. Health, hygiene and sanitation. Definition needs and scope of health education; role of food, nutrition, safe drinking water, waterborne diseases and sanitation (Swachh Bharat Abhiyan) for health; national health programs and reproductive health. Youth health, lifestyle, HIV AIDS and first aid. Healthy lifestyles, HIV AIDS, drugs and substance abuse, home nursing and first aid. Youth and yoga. History, philosophy, concept, myths, and misconceptions about yoga; yoga traditions and its impacts, yoga as a tool for healthy lifestyle, preventive and curative method.

Post-II semester

Internship (only for exit option for award of UG-Certificate) 10 (0+10)

Objectives

1. To make students capable of working in commercial establishments with ground-level knowledge
2. To make students capable of initiating entrepreneurship

Activity

1. 10 weeks of intensive training on any aspects of Fisheries.
2. The area of training may be in the hatchery, in culture farms or in processing setup to gain basic field-level knowledge to be part of any commercial setup.

SEMESTER – III

FSCCCC201: Coastal Aquaculture and Mariculture 2 (1+1)

Objectives

1. To gain knowledge on the culture of coastal and marine fish and shell-fish species
2. To acquire knowledge of coastal marine farming of fish and shellfish

Theory

An overview of sea farming and shore-based aquaculture in different parts of the world. Resources for shore-based aquaculture and sea farming in India. Traits of important cultivable fish and shellfish (seabass, mullet, milkfish, grouper, cobia, snappers, ayu, pearl spot, tiger shrimp, white shrimp, mud crab, mussel, clam, oysters (edible and pearl oyster), lobster). Seaweed culture. Seed resources. Shore-based aquaculture system: traditional (pokkali, bheries, gazanis, khazans), semiintensive, intensive aquaculture practice of commercially important species of fish and shellfish. Methods of Shellfish Culture: rafts, racks, cages, poles, and ropes. Water and soil quality management. Estimation of growth, survival, and pond productivity. Pearl culture. Sea ranching.

Practical

Identification of important cultivable species. Collection and identification of commercially important seeds of fish and shellfish. Types of fertilizers - Pond preparation. Seed selection, quality, and acclimatization. Water quality parameters. Estimation of seed survival. Pond biomass estimation. Material, apparatus and machinery for shore-based aquaculture and sea farming. Estimation of feed intake. Growth and health monitoring. Fouling organisms in cages and pens.

Suggested Readings

1. Appukuttan, K.K., Asokan, P.K., Mohamed, K.S., Subramaniam, S., & Joseph, G.K. (2003). *Manual on Mussel Farming*. CMFRI Technical Bulletin No. 3.
2. Bardach, E.J., Ryther, J.H., & McLarney, W.O. (1972). *Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms*. John Wiley & Sons.
3. De Silva, S.S. (Ed.). (1998). *Tropical Mariculture*. Academic Press. 487p.
4. FAO. (2001). *Planning and Management for Sustainable Coastal Aquaculture Development*.
5. Ghosh, P.K. (2010). *Brackishwater Aquaculture*. Agrobios (India).
6. Halwart, M., Soto, D., & Arthur, J.R. (Eds.). (2007). *Cage Aquaculture: Regional Reviews and Global Overview*. FAO Fisheries Technical Paper No. 498, 241p.
7. ICAR. (2006). *Handbook of Fisheries and Aquaculture*. Indian Council of Agricultural Research (ICAR).
8. James, P.M. (1983). *Handbook of Mariculture. Volume I: Crustacean Aquaculture*. CRC Press.
9. NFDB. (2018). *Guidelines for Sea Cage Farming in India*.

10. Ottolenghi, F., Silvestri, C., Giordano, P., Lovatelli, A., & New, M.B. (2004). *Capture-Based Aquaculture: The Fattening of Eels, Groupers, Tunas, and Yellowtails*. FAO Publication.
11. Pillay, T.V.R., & Kutty, M.N. (2005). *Aquaculture: Principles and Practices* (2nd ed.). Blackwell Publishing.
12. Pillay, T.V.R. (1990). *Aquaculture: Principles and Practices*. Fishing News Books.
13. Sekar, M., Ranjan, R., Xavier, B., & Ghosh, S. (2016). *Training Manual on Cage Culture of Marine Finfish*. CMFRI Publication.
14. Syda Rao, G., Imelda-Joseph, Philipose, K.K., & Suresh Kumar, M. (2013). *Cage Aquaculture in India*. CMFRI Publication.
15. Venugopal, S. (2005). *Aquaculture*. Pointer Publishers.

FSCCCC202: Fish Nutrition and Feed Technology 3 (2+1)

Objectives

1. To understand the basic principles of fish nutrition and the role of different nutrients
2. To learn the process of feed formulation and preparation for fish and shell-fish

Theory

Fundamentals of fish nutrition and growth in fish. Principal nutrients and nutritional requirements of cultivable fish and shellfish. Nutritional energetics: definition and forms of energy partitioning. Methods of feed formulation and manufacturing. Forms of feeds: wet feeds, moist feeds, dry feeds, mashes, pelleted feeds, floating and sinking pellets. Feed additives: binders, antioxidants, enzymes, pigments, growth promoters, feed stimulants. Feed storage: use of preservatives and antioxidants. Feed evaluation: feed conversion ratio, feed efficiency ratio, protein efficiency ratio, net protein utilization and biological value. Feeding devices and methods. Non-conventional feed ingredients and antinutritional factors. Digestive enzymes, feed digestibility. Factors affecting digestibility. Nutritional deficiency diseases.

Practical

Proximate composition analysis of feed ingredients and feeds. Preparation of artificial feeds using locally available feed ingredients. Formulation and preparation of moist feed by using locally available ingredients. Determination of sinking rate and stability of feeds. Effect of storage on feed quality. Estimation of the gross energy content of feed. Estimation of the digestible energy content of the feed. Equipments and machineries used in feed production. Visit to commercial feed plant.

Suggested Readings

1. ADCP (Aquaculture Development and Co-ordination Program). (1980). *Fish Feed Technology*. ADCP/REP/80/11. FAO, Rome.
2. De Silva, S.S., & Anderson, T.A. (1995). *Fish Nutrition in Aquaculture*. Chapman and Hall Aquaculture Series, London.
3. FAO. *Training Manual Related to Feed Analysis*. [Specific publication details may vary].

4. Guillaume, J., Kaushik, S., Bergot, P., & Metailler, R. (2001). *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis Publishing, Chichester, U.K.
5. Halver, J.E. (1989). *Fish Nutrition*. Academic Press, San Diego, California.
6. Halver, J.E., & Hardy, R.W. (2002). *Fish Nutrition*. Academic Press, London.
7. Halver, J.E., & Tiews, K.T. (1979). *Finfish Nutrition and Fish Feed Technology* (Vol. I & II). Heenemann, Berlin.
8. Hepher, B. (1988). *Nutrition of Pond Fishes*. Cambridge University Press, Cambridge.
9. Lovell, R.T. (1998). *Nutrition and Feeding of Fishes*. Kluwer Academic Publishers.
10. New, M.B. (1987). *Feed and Feeding of Fish and Shrimp: A Manual on the Preparation and Preservation of Compound Feeds for Shrimp and Fish in Aquaculture*. ADCP/REP/87/26. FAO, Rome.
11. Paulraj, R. (1993). *Aquaculture Feed*. CMFRI Publication, 84 pp.

FSCCCC203: Inland Fisheries **2 (1+1)**

Objectives

1. To understand the present exploitation and future potential of inland fisheries
2. To learn the methodologies for assessments of inland fisheries resources

Theory

Freshwater fishery regions of the world and their major fish species composition. Global inland fish production data. Capture fishery resources of India. Potential of inland water bodies with reference to the respective state. Problems in the estimation of inland fish catch data. Fishing crafts and gears. Major riverine and estuarine systems of India. Major brackish water lakes and their fisheries. Fisheries of major reservoirs / natural lakes of India. Flood-plain capture fishery-present status of their exploitation and future prospects. Cold water fisheries of India.

Practical

Analysis of species composition of commercial catches at landing and assembling centers, sampling and familiarization of commercially important groups. Observations and experimental operations of selected fishing crafts and gears in inland / estuarine waters. Maintenance of records on catch data. Visit to Dept. of fisheries, lakes and reservoirs, floodplain wetlands, cold-water bodies, net making yards.

Suggested Readings:

1. Blaber, J.M. (1997). *Fish and Fisheries in Tropical Estuaries*. Chapman and Hall.
2. FAO. *Technical Papers on Freshwater Fisheries*.
3. Kolding, J., Amarasinghe, U.S., Turpie, J., Brummett, R., Dugan, P., & Katiha, P. (2021). *Inland Fisheries and Aquaculture*.
4. Jhingran, V.G., & Pathak, V. (1987). *Ecology and Management of Bheels in Assam: A Case Study of Dhir Bheel*. In: Workshop on Development of Bheel Fisheries in Assam, Assam Agricultural University, Guwahati, April 21–22.
5. Jhingran, V.G., & Sehgal, K.L. (1978). *Cold Water Fisheries of India*. J. Inland Fish. Soc. India. Special Publication.

6. Jhingran, V.G. (1991). *Fish and Fisheries of India* (3rd edn). Hindustan Publishing.
7. Sugunan, V.V. (1997). *Reservoir Fisheries of India*. Daya Publishing House.
8. Ayyappan, S., Moza, U., Gopalakrishnan, A., Meenakumari, B., Jena, J.K., & Pandey, A.K. (2011). *Handbook of Fisheries and Aquaculture* (2nd edn). ICAR.
9. Chandra, P. (2007). *Fishery Conservation, Management and Development: Fisheries and Aquatic Resources of India*. Daya Publishing House.
10. Handbook on Fisheries Statistics (2022). Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India, New Delhi.
11. Jain, V., Sinha, R., Singh, L.P., & Tandon, S.K. (2016). *River Systems in India: The Anthropocene Context*. *Proceedings of the Indian National Science Academy*, 82(3), Special Issue, pp. 747–761.
12. Jayakumar, N., Ahilan, B., & Felix, S. (2019). *Inland Fisheries*. Narendra Publishing House, New Delhi.
13. Sakhare, V.B. (2013). *Inland Fisheries*. Daya Publishing House.
14. Welcomme, R.L. (2001). *Inland Fisheries – Ecology and Management*. Wiley-Blackwell, UK.

FSCCCC204: Fishing Craft Technology Objectives 2 (1+1)

1. To teach advanced aspects of fishing craft design
2. To learn about modification of existing craft layout

Theory

Introduction: History and development of fishing crafts. Traditional fishing crafts of India. Classification of fishing crafts based on fabrication dimension, nature of fishing, depth of operation. History and development of mechanization of fishing crafts. Basic geometric concepts and important terminologies of fishing vessel. Form coefficients, properties of irregular shapes Calculation of the longitudinal and transverse sectional area of fishing craft by using Trapezoidal rule and Simpson's rules. State of equilibrium; Volume of displacement; centre of gravity (CG); centre of buoyancy (CB); vertical centre of gravity (VCB); longitudinal centre of gravity (LCB). Stability of fishing vessels- longitudinal and transverse. Various equilibrium of ships-stable, unstable and neutral; Light weight, Dead weight, Tonnage system; Gross Registered Tonnage (GRT), Net Registered Tonnage (NRT). Boat building materials: Choice of construction materials: Wood, properties, advantages and disadvantages. Deck fitting. Maintenance of fishing vessels. Fouling and boring organisms; seasoning and preservation of wood. Constructional details of boat: Offset tables; Mould lofting; Backbone assembly of wooden boat. Constructional details of Steel, FRP, Ferro Cement and Aluminum boats. Introduction of Outboard and inboard engines.

Practical

Studies on traditional fishing crafts; Introduction to drawing and drawing instruments; Lettering, Geometrical construction, Curves. Projections; Projection of points, planes and Projection of solids; lines plan drawing. Drawing of back bone assembly. U and V bottom hull of wooden boat.General view of boat; Drawing of sheer plan, body plan and half breadth plan. Types of marineengines and their installation of engines. Visit to boat building yard and dry dock.

Suggested Readings

1. Fyson, J.F. (Ed.). (1985). *Design of Small Fishing Vessels*. Fishing News Books, Oxford.
2. Pike, D. (1992). *Fishing Boats and Their Equipment*. Fishing News Books, Oxford. 184p.
3. Ponnambalam, A. (2003). *Fishing Craft Technology*. CIFNET, Cochin. 158p.
4. Sainsbury, J.C. (1996). *Commercial Fishing Methods – An Introduction to Vessels and Gear*. Fishing News Books Ltd., Farnham. 352p.
5. Shenoy, Latha. (1988). *Course Manual in Fishing Technology*. CIFE, Mumbai. 95p.
6. Sreekrishna, Y., & Shenoy, Latha. (2001). *Fishing Gear and Craft Technology*. Indian Council of Agricultural Research (ICAR), New Delhi. 342p.
7. Yadav, Y.S. (2002). *Traditional Fishing Craft of the Bay of Bengal*. BOBP, Chennai. 55p.

FSCCCC205: Fundamentals of Biochemistry and Food Chemistry 3 (2+1)

Objectives

1. To create basic understanding on biochemical constituents of food fish and shell-fish
2. To develop skills on the analysis of chemical constituents in food

Theory

A brief introduction to developments in biochemistry and its transformation to molecular biology. Cell structure, water and major molecules of life. Composition of food and nutritional value. Moisture in foods. Biological oxidation, electron transport chain, P/0 ratio; oxidative phosphorylation. Carbohydrates: Structure, classification and functions of carbohydrate. Isomerism and mutarotation. Metabolism of carbohydrates: Glycolysis, gluconeogenesis, glycogenolysis, glycogenesis, TCA cycle, central role of TCA cycle in metabolism. Naturally occurring polysaccharides in foods. Seaweed polysaccharides – sources and uses. Browning reactions – enzymatic and non-enzymatic.

Lipids: Classification, structure, functions and properties of lipids. Essential fatty acids and phospholipids. Metabolism of lipids, oxidation of fatty acids, lipoproteins; VLDL and HDL and their importance. Lipid autooxidation. Significance of Omega-3 and Omega-6 fatty acids.

Proteins: Classification, structure, function and properties of proteins. Essential and nonessential amino acids. Biuret reaction and xanthoproteic reaction of protein detection. Metabolism, deamination, decarboxylation, metabolic fate of amino acids, nitrogen balance. Deamination reactions and nitrogen excretion with special reference to fish. Fish muscle proteins, chemical changes in muscle during contraction. Proteins in foods, role in hydration- native and denatured proteins, gel formation, functional properties of proteins, changes during heat treatment and processing. Texturized proteins.

Enzymes: Nomenclature; classification; specificity; mechanism of enzyme action; kinetics and regulation of enzyme activity. Steroid and peptide hormones: Chemistry and function. Vitamins and Minerals: Classification and functions. Structure and functions of fat and water-soluble vitamins. Minerals: Classification and functions minerals. Nucleic acids: Structure and function. Importance of genetic code.

Chemistry of taste, flavour and odour components in foods, flavour intensifiers, synthetic flavouring substances. The taste of fish and shellfish. Food additives - types and their chemical nature, emulsifiers and antimicrobial additives, sequestrants, flavour potentiators surface active agents; non-nutritive sweeteners, colour additives in food. Assessment of quality of food by instrumental and chemical methods. Nutritive value of foods. Energy value and energy requirements and their estimation. Water, electrolytic and acid-base balance. Nutritive value of proteins PER, BV digestibility coefficient, NPU values, pepsin digestibility. Role of fibre in human nutrition.

Practical

Preparation of normal solution of acid and base, buffers and reagents. Estimation of moisture, crude protein, fat, ash (including acid soluble) in fish sample. Estimation of carbohydrates in foods. Determination of energy value of fish. Estimation of glucose and salt content in foods. Colorimetric method of estimation of proteins and carbohydrates. Estimation of freshness quality indices such as TVBN, TMA, alpha-amino nitrogen, PV, FFA, TBA value of fish. Estimation of fibre in foods. Determination of specific gravity of oil. Determination of saponification value, iodine value and free fatty acid value.

Suggested Readings:

1. Ashrust, P.R. (1999). *Food Flavourings* (3rd ed.). Aspen Publishers.
2. Belitz, H.D., & Grosch, W. (1999). *Food Chemistry* (2nd ed.). Springer.
3. Berg, J.M., Tymoczko, J.L., & Stryer, L. (2002). *Biochemistry*. W.H. Freeman and Company.
4. Modi, H.A. (2012). *Food Additives*. Aavishkar Publishers Distributors (Jaipur).
5. Hutching, J.B. (1999). *Food Colour and Appearance* (2nd ed.). Aspen Publishers.
6. Wilson, K., & Walker, J. (2013). *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press.
7. Scotter, M.J. (2015). *Colour Additives for Foods and Beverages*. Woodhead Publishing Limited.
8. Murray, R.K., Granner, D.K., Mayes, P.A., & Rodwell, V.W. (2000). *Harper's Biochemistry*. Appleton and Lange.
9. NIIR Board. *Food Colours, Flavours and Additives Technology Handbook*. National Institute of Industrial Research (Delhi).
10. Samantaray, K. *Principles of Biochemistry (with Special Reference to Fishes)*. Narendra Publishing House.
11. Otles, S. (2012). *Methods of Analysis of Food Components and Additives*. CRC Press.
12. Teranishi, R., Buttery, R.G., & Shahidi, F. (1989). *Flavour Chemistry – Trends and Developments*. American Chemical Society, Washington D.C.
13. Voet, D., Voet, J.G., & Pratt, C.W. (2006). *Fundamentals of Biochemistry*. John Wiley and Sons, Inc.
14. Wilson, K., & Walker, J. (1995). *Principles and Techniques of Practical Biochemistry*. Cambridge University Press.

FSCCCC206: Post-Harvest Handling and Preservation 2 (1+1)

Objectives

1. To teach scientific techniques of handling, storage and transport of fresh fish
2. To teach various post-harvest changes during chill storage of fish

Theory

Structure of fish myosystems, Postmortem changes - Structural and chemical. 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 of fish in landing centers, defects and modifications needed. Chill storage of fish: Heat load calculation, storage methods. Insulated boxes and insulation thickness, different types of ice, physical, chemical, microbiological and sensory changes during chill storage, iced storage shelf life, cold shock, physical, chemical and sensory methods of analysis. Different types of ice and their advantages. Melanosis and its prevention, discolouration in aquatic products, nonenzymatic browning. Depuration of bivalves. Transportation: Live fish/shell fish, Transportation of raw fish to local markets and processing centres, Improvements needed in transportation, Refrigerated transport systems. Classification of transport vehicles. Cold chain.

Practical

Chill storage studies: Chemical, physical and sensory analysis, determination of shelf life. Handling of fish, bivalves, prawns, molluscs, Depuration, treatment with chemicals, evaluation of freshness of fish.

Suggested Readings

1. Aitken A, Mackie M, Merritt SH & and Windsor ML. 1982. Fish Handling and Processing.
2. Anon. 1965. Fish Handling and Preservation. Proc. Meeting on Fish Technology.,
3. Balachandran KK. 2001. Post Harvest Technology of Fish and Fish Products. Daya Publ.
4. Connell JJ. 1980. Advances in Fish Sciences and Technology. Farnhan Surrey.
5. George MH. 1992. Fish Processing Technology. VCH Publ.
6. Gopakumar K. (Ed.). 2002. Text Book of Fish Processing Technology. ICAR.
7. Ministry of Agriculture, Fisheries and Food, Edinburgh.
8. Scheveningen. Organisation for Economic Co-operation and Development, Paris.
9. Sen DP. 2005. Advances in Fish Processing Technology. Allied Publ.

FSCCCC207: Fisheries Extension 2(1+1)

Objectives

1. To help the students to appreciate the process of extension education
2. To cater the need of equipping the scholars with essential skills

Theory

Introduction to extension education and fisheries extension - concepts, objectives and principles; extension education, formal and informal education. History and role of fisheries extension in fisheries development. Fisheries extension methods- individual, group and mass contact methods and their effectiveness, factors influencing their selection and use; characteristics of technology, transfer of technology process. Important ToT programs in fisheries; role of NGOs and SHGs in fisheries. Fisheries co-management; Adoption and diffusion of innovations, adoption and diffusion process, adopter categories and barriers in the diffusion of fisheries innovations. Extension program planning and evaluation - steps and importance; participatory planning process. Basic concepts in rural sociology and psychology and their relevance in fisheries extension; social change, social control, social problems and conflicts in fisheries; gender issues in fisheries. Theories of learning, learning experience, learning situation.

Practical

Collection of socio-economic data from fishing villages; study of social issues/problems through participatory and rapid rural appraisal techniques. Stakeholders' analysis and needs assessment. Assessment of development needs of community and role of formal and non – governmental organizations through stakeholders' analysis. Case studies on social/gender issues and social conflicts in fisheries. Case studies on extension programs and Success stories. Practical exercises on conducting fish farmers meet.

Suggested Readings:

1. Adhikarya, R. (1994). *Strategic Extension Campaign – A Participatory-Oriented Method of Agricultural Extension*.
2. Agarwal, B. (1986). *Women, Poverty and Agricultural Growth in India*, JPS, New Delhi.
3. Antholt, C., & Zijp, W. (1994). *Participation in Agricultural Extension*. Washington, DC: The World Bank.
4. Berdegue, J.A., & Escobar, G. (2001). *Agricultural Knowledge and Information Systems and Poverty Reduction*. AKIS Discussion Paper. Washington, DC: The World Bank.
5. Bhasin, K. (2000). *Understanding Gender*, New Delhi: Kali for Women.
6. Birner, R., & Anderson, J.R. (2007). *How to Make Agricultural Extension Demand Driven–The Case of India's Agricultural Extension Policy*. IFPRI Discussion Paper. International Food Policy Research Institute. Washington, DC: IFPRI.
7. Daivadeenam, P. (2002). *Research Methodology in Extension Education*. Agro-Tech Publishers Academy.
8. Kerlinger, N. Fred. (2002). *Foundations of Behavioural Research*. Surjeet Publications.
9. Menon, Nivedita. (1999). *Gender and Politics in India*, New Delhi: Oxford University Press.
10. Patricia Uberoi. (2009). *Freedom and Destiny: Gender, Family, and Popular Culture in India*, Oxford University Press, New Delhi.
11. Ray, G.L., & Mondal, S. (1999). *Research Methods in Social Science and Extension Education*. Naya Prokash.

FSCAEC208: Physical Education, First Aid, Yoga Practices and Meditation Objectives

2 (0+2)

1. To make the students aware about Physical Education, First Aid and Yoga Practices
2. To disseminate the knowledge and skill how to perform physical training, perform first-aid and increase stamina and general wellbeing through yoga

Practical

Physical education; Training and Coaching - Meaning and Concept; Methods of Training; aerobic and aerobic exercises; Calisthenics, weight training, circuit training, interval training, Fartlek training; Effects of Exercise on Muscular, Respiratory, Circulatory and Digestive systems; Balanced Diet and Nutrition: Effects of Diet on Performance; Physiological changes due to ageing and role of regular exercise on ageing process; Personality, its dimensions and types; Role of sports in personality development; Motivation and Achievements in Sports; Learning and Theories of learning; Adolescent Problems and its Management; Posture; Postural Deformities; Exercises for good posture.

Yoga; History of Yog, Types of Yog, Introduction to Yog,

- ✓ Asanas (Definition and Importance) Padmasan, Gaumukhasan, Bhadrasan, Vajrajasan, Shashankasan, Pashchimotasan, Ushtrasan, Tadasan, Padhastasan, Ardhchandrasan, Bhujangasan, Utanpadasan, Sarvangasan, Parvatasan, Patangasan, Shishupalanasan – left legright leg, Pavanmuktasan, Halasan, Sarpasan, Ardhdhanurasan, Sawasan
- ✓ Suryanamskar Pranayama (Definition and Importance) Omkar, Suryabhedan, Chandrabhedan, AnulomVilom, Shitali, Shitkari, Bhastrika, Bhramari
- ✓ Meditation (Definition and Importance), Yogic Kriyas (Kapalbhati), Tratak, Jalneti and Tribandh
- ✓ Mudras (Definition and Importance) Gyanmudra, Dhyanmudra, Vayumudra, Akashmudra, Pruthvimudra, Shunyamudra, Suryamudra, Varunmudra, Pranmudra, Apanmudra, Vyanmudra, Uddanmudra
- ✓ Role of yoga in sports
- ✓ Teaching of Asanas – demonstration, practice, correction and practice.

History of sports and ancient games, Governance of sports in India; Important national sporting events; Awards in Sports; History, latest rules, measurements of playfield, specifications of equipment, skill, technique, style and coaching of major games (Cricket, football, table Tennis, Badminton, Volleyball, Basketball, Kabaddi and Kho-Kho) and Athletics.

Swimming: History, hazards in water and safety precautions; pool maintenance and water quality control. Learning swimming, understanding and practice of ducking the head, kicking action, holding breath under water and various strokes (free style, breast stroke, butterfly, back stroke). Competitive swimming-relays and medleys, lap time practice, swimming and floating aids and their uses; diving-styles of diving, rules, regulations, and precautions. Methods of life saving in water; Boating, canoeing, and sailing: types, maintenance, skill development, rules and regulations and practice. Need and requirement of first aid. First Aid equipment and upkeep. First AID Techniques. First aid related with respiratory system. First aid related with Heart, Blood and Circulation. First aidrelated with Wounds and Injuries. First aid related with Bones, Joints Muscle

related injuries. First aid related with Nervous system and Unconsciousness. First aid related with the Gastrointestinal Tract. First aid related with Skin, Burns. First aid related with Poisoning. First aid related with Bites and Stings. First aid related with Sense organs, Handling and transport of injured traumatized persons. Sports injuries and their treatments.

SEMESTER-IV

FSCCCC251: Breeding and Culture of Ornamental Fish Objectives 2 (1+1)

1. To gain knowledge on ornamental fish production technologies and aquarium building
2. To produce ornamental fish for marketing

Theory

World trade of ornamental fish and export potential. Different varieties of exotic and indigenous fishes. Principles of a balanced aquarium. Fabrication, setting up and maintenance of freshwater and marine aquarium. Water quality management. Water filtration system-biological, mechanical and chemical. Types of filters. Aquarium plants and their propagation methods. Lighting and aeration. Aquarium accessories and decorative. Aquarium fish feeds. Dry, wet and live feeds. Breeding and rearing of ornamental fishes. Broodstock management. Application of genetics and biotechnology for producing quality strains. Management practices of ornamental fish farms. Common diseases and their control. Conditioning, packing, transport, and quarantine methods. Trade regulations and wildlife act in relation to ornamental fishes.

Practical

Identification of common ornamental fishes and plants. Fabrication of all-glass aquarium. Setting up and maintenance of Aquarium accessories and equipment. Conditioning and packing of ornamental fishes. Preparation of feed. Setting up of breeding tank for live bearers, barbs, goldfish, tetras, chiclids, gouramis, fighters and catfishes. Identification of ornamental fish diseases and prophylactic measures.

Suggested Readings

1. Ahilan, B., Felix, N., & Santhanam, R. (2008). *Textbook of Aquariculture*. Daya Publishing House, Delhi.
2. Axelrod, H.R., & Sweenen, M.E. (1992). *The Fascination of Breeding Aquarium Fishes*. T.F.H. Publications.
3. Axelrod, H.R., & Vorderwinkler, W. (1978). *Encyclopaedia of Tropical Fishes*. T.F.H. Publications.
4. Axelrod, H.R. (1967). *Breeding Aquarium Fishes*. T.F.H. Publications.
5. Boyd, C.E. (1979). *Water Quality in Warm Water Fish Ponds*. Auburn University.
6. Crow, R., & Keeley, D. (1992). *A Practical Guide to Tropical Aquarium Fish*. Tiger Books International, London.
7. Mills, D. (1981). *Aquarium Fishes*. Kingfisher Books.
8. Sanford, G., & Crow, R. (1991). *The Manual of Tank Busters*. Salamander Books.
9. Saxena, A. (Ed.). (2003). *Aquarium Management*. Daya Publishing House.
10. Spotte, S. (1979). *Fish and Invertebrate Culture*. John Wiley & Sons.
11. Swain, S.K., Sarangi, N., & Ayyappan, S. (2010). *Ornamental Fish Farming*. ICAR.
12. Thabrow De, W.V. (1981). *Popular Aquarium Plants*. Thornbill Press.
13. Thomas, P.C., Rath, S.C., & Mohapatra, K.D. (2003). *Breeding and Seed Production of Finfish and Shellfish*. Daya Publishing House.

FSCCCC252: Live Food Organisms for Fish and Shellfish Objectives 2 (1+1)

1. To learn the nutritional requirements of fish and shell-fish larvae
2. Techniques the culture of live food organisms from fish and shell-fish larvae

Theory

Candidate species of phytoplankton and zooplankton as live food organisms of freshwater and marine species. Tropic potentials - proximate composition of live feed. Biology, culture requirements and methodology of important live food organisms; Green algae, blue-green algae, spirulina, diatoms, infusoria, rotifers, cladocerons, tubifex, brine shrimp, chironomids. Culture of earthworms, bait fish and forage fish.

Practical

Methods of collection and identification of different live food organisms. Laboratory scale culture of selected live food organisms (green algae, spirulina, chetoceros, rotifer, Moina, copepod). Evaluation of live food organisms. Proximate composition analysis of live feed organisms. Decapsulation and hatching method of brine shrimp cyst.

Suggested Readings

1. CIFE. (1993). *Training Manual on Culture of Live Food Organisms for Aqua Hatcheries.* Central Institute of Fisheries Education, Versova, Mumbai.
2. Gopinathan, C.P. (1993). *Handbook on Aqua Farming – Live Feed.* MPEDA Publication.
3. Hagiwara, A., Snell, T.W., Lubzens, E., & Tamaru, C.S. (1997). *Live Food in Aquaculture.* Proceedings of the Live Food and Marine Larviculture Symposium. Kluwer Academic Publishers.
4. Holt, J.G. (2011). *Larval Fish Nutrition.* Wiley-Blackwell Publishing.
5. Lavens, P., & Sorgeloos, P. (Eds.). (1996). *Manual on the Production and Use of Live Food for Aquaculture.* FAO Fisheries Technical Paper No. 361. Rome: FAO. 295 pp.
6. Lee, C.S., O'Bryen, P.J., & Marcus, N.H. (2005). *Copepods in Aquaculture.* Blackwell Publishing.
7. Rawat, M., & Dookia, S. (2012). *Biodiversity of Aquatic Resources.* Day Publishing House.
8. MPEDA. (1993). *Handbook on Aqua Farming – Live Feed: Micro Algal Culture.* MPEDA Publication.
9. Muthu, M.S. (1983). *Culture of Live Feed Organisms.* Technical Paper No. 14, Summer Institute in Hatchery Production of Prawn Seeds. CMFRI, Cochin.
10. Sorgeloos, P., & Pandian, K.S. (1984). *Culture of Live Food Organisms with Special Reference to Artemia Culture.* CMFRI Special Publication No. 15.

FSCCCC253: Fish and Shellfish Diseases and Treatment Objectives 3 (2+1)

1. To understand the recent advances in diseases of fish and shellfish and their remedial measures
2. Fish and Shellfish disease diagnosis and treatment

Theory

General characteristics, life cycle, diagnosis of pathogens. Prevention and treatment of parasitic, bacterial, fungal and viral diseases of finfish and shellfish. OIE listed diseases. Disease surveillance and reporting. Quarantine and health certification in aquaculture. Health management strategies in Aquaculture: Bioremediators, Biocontrol agents, Probiotics, Immunomodulators, Concepts of vaccination. Shrimp toilet. Management measures for the host. Specific pathogen-free (SPF), Specific pathogen-resistant (SPR) and Specific pathogen-tolerant (SPT). Developing management practices and biosecurity principles: Health maintenance, Better management practices (BMP), Good aquaculture practices (GAP), Hazard analysis and Critical control point (HACCP) and Biosecurity principles in aquaculture.

Disease control through environmental management: Importance of Biofilm and Bio-floc. Periphyton in aquatic health management. Zoonotic diseases. Principles of disease diagnosis: Conventional, molecular and antibody-based diagnostic methods. Rapid diagnostic methods.

Practical

General procedure for disease diagnosis. Methods of fish and shell-fish sampling for disease diagnosis. Taxonomy, lifecycle and identification of fish and shell-fish parasites. Sampling, preparation of media and culture of pathogenic bacteria. Techniques for bacterial classification. Techniques in disease diagnosis: Microbiological, haematological, histopathological, immunological, molecular techniques and biochemical tests. Agglutination test and Challenge tests; Purification of virus. Stress-related study of fish and shellfish. Prevention and treatment of parasitic, bacterial, fungal and viral diseases of finfish and shellfish.

Suggested Readings

1. Alan, C. (2005). *Molecular Virology.* Academic Press. 315 pp.
2. Austin, B., & Austin, A. (2007). *Bacterial Fish Pathogens.* Springer Publishers, U.K.
3. Bullock, L.G. (2014). *Diseases of Fishes.* NPH, Delhi.
4. Cox, F.E.G. (2005). *Parasitology.* Hodder Arnold, U.S.A.
5. Crosa, J.H. (1983). *Bacterial and Viral Diseases of Fish.* Washington Sea Grant Publication, Seattle.
6. Gupta, N. (2014). *Modern Parasitology.* Narendra Publishing House, Delhi.
7. Hadwin, G. (2017). *Diseases of Fishes: Bacterial Diseases of Fishes and Identification of Fish Pathogenic Bacteria.* Random Publications, New Delhi.
8. Iglewski, H.B., & Clark, V.L. (1009) *(Possibly a typo, confirm year). Molecular Basis of Bacterial Pathogenicity.* Academic Press.
9. Inglis, V. (1993). *Bacterial Diseases of Fish.* Blackwell Scientific Publications, London.
10. Roberts, R.J. (2012). *Fish Pathology* (4th ed.). W.B. Saunders.

FSCCCC254: Marine Fisheries Objectives **2 (1+1)**

1. To understand the present exploitation and future potential of marine fisheries
2. To learn the methodologies for assessments of marine fisheries resources

Theory

Classification and definition of fishery zones and fishery resources of world. Overview of marine fisheries resources of the world and India. Major exploited marine fisheries of India, their developmental history and present status. Important pelagic, demersal fish, shellfish and seaweed resources of India. Traditional, motorized and mechanized fisheries according to major gears. Potential marine fishery resources of India's EEZ. GIS and Remote sensing in marine capture fishery. Conservation and management of marine fisheries resources in India.

Practical

Visit to fish landing centres, Observation and analysis of catches by major crafts and gears. Field collection of fishes, crustaceans, molluscs and seaweeds and record keeping of relevant data. Participation in fishing cruises. GIS and remote sensing in marine capture fishery.

Suggested Readings

1. Blaber, J.M. (1997). *Fish and Fisheries in Tropical Estuaries.* Chapman and Hall.
2. Bal, D.V., & Rao, K.V. (1990). *Marine Fishes of India* (1st Revised Ed.). Tata McGraw-Hill.
3. Chandra, P. (2007). *Fishery Conservation, Management and Development: Fisheries and Aquatic Resources of India.* Daya Publishing House.
4. FAO. *Technical Papers on Marine Fisheries.*
5. Kurian, C.V., & Sebastian, V.O. (1986). *Prawns and Prawn Fisheries of India.* Hindustan Publishing Corporation.
6. Upadhyay, A.K., & Joshi, B.C. (2014). *Textbook of Marine Fisheries: Fisheries of World Oceans and India in Perspective.* Astral International Pvt. Ltd. 232 pp.
7. Mohan Joseph, M., & Pillai, N.G.K. (Eds.). (2007). *Status and Perspectives in Marine Fisheries Research in India.* CMFRI.
8. Pillai, V.N., & Menon, N.G. (Eds.). (2000). *Marine Fisheries Research and Management.* CMFRI. 914 pp.
9. Grafton, R.Q., Hilborn, R., Squires, D., Tait, M., & Williams, M.J. (Eds.). (2010). *Handbook on Marine Fisheries Conservation and Management.* Oxford University Press, USA.
10. Ramadoss, K. (2003). *Status of Exploited Marine Fishery Resources of India.* In: Joseph, M.M., & Jayaprakash, A.A. (Eds.), CMFRI, Kochi, pp. 201–210.
11. Sinclair, M., & Valdimarsson, G. (2003). *Responsible Fisheries in the Marine Ecosystem.* CABI Publishing. 426 pp.
12. Srivastava, C.B.L., & Srivastava, S. (2006). *Textbook of Fishery Science and Indian Fisheries* (Classic Edn.). Kitab Mahal. 551 pp.

FSCCCC255: Fishing and Gear Technology Objectives 3 (2+1)

1. To teach advanced fishing gear and fishing technology
2. To learn design modification and gear selectivity of fishing

Theory

Evolution of Fishing gears; Mechanization of Fishing; Basic classification of fishing gearsPrinciple, Subsidiary and Auxiliary gears. Classification of fishing gears and methods: FAO classification of fishing gear, methods of the world and International Standard Statistical Classification of Fishing gear (ISSCFG). Fishing gear materials: Natural materials and Synthetic netting materials and their classification. Types and important synthetic materials used in fishing gears. Raw-materials for synthetic material; Preparation of nylon (PA 6.66) material; Different types of fibres- continuous fibre; monofilament, staple and split fibers and production of single yarns. Identification of synthetic fishing gear materials: Visual observation, water test, solubility test, burning test and melting point test.

Construction of twisted netting materials: Yarn, single yarns, folded yarns, netting twine, cable netting twine and cable netting twine of higher order. Construction of ropes and their higher order. Construction of braided netting twines. Yarn numbering system - direct system: Tex system, Denier system and calculation of resultant tex value. Indirect system: British count, metric count, runnage system and their conversion. Methods of Preparation of knotted and knotless webbing, advantage and disadvantages of knotted and knotless webbings. Shape of mesh: diamond, square, hexagonal and their measurement. Properties of netting material: physical properties- Density, twist and amount of twist, breaking strength-tenacity, and tensile strength, breaking length, abrasion resistance, elasticity, extensibility, water absorption and shrinkage, sinking velocity, weather resistance, melting point and visibility. Chemical and Biological properties. Floats and buoys – its materials, types their properties. Classification of floats: based on shape and materials; calculation of buoyancy. Sinkers – types, materials, properties- negative buoyancy. Factors to be considered while designing /selection of fishing gears; Biological, Environmental, oceanographical, Vessel characteristics and mesh size regulation. Choice of netting materials for trawl, gillnet and purse seine. Classification of trawl gears. 2 seem trawl; 4 seam trawl and wing trawl. Design and construction of wing trawl. Rigging of trawl gear. Arrangements of bridles, sweep lines and attachment of ground gears: tickler chain, bobbins and rock hoppers and attachment of otter board.

Structure of various commercial fishing gears. Rigging of fishing gears: Bridles, sweep lines, otter boards, floats and ground gear arrangements. Otter door: Different types of otter doors. Behavior of otter doors in water: Angle of attack, angle of heel and angle of tilt. Fishing accessories – thimbles, shackles, C-links, rings, G-links, Kelly's eye, stopper, bottle screw, Deck layout of different fishing vessels. Trawling: Beam trawling; otter trawling; side trawling; twin trawling out rig trawling bull trawling and mid-water trawling. Constructional details of single-boat purse seine; two-boat purse seine and method of operation. Types of gill net – constructional details of simple gill net, trammel gill net, stick held gillnet, frame gillnet and vertical line gillnet, Operation of gillnet: set gillnetting; drift gillnetting; bottom, mid-water and pelagic gillnetting.

Line fishing: Types of hooks; structure and size of hooks. Constructional details of long line, tuna long line, vertical long line, pole and line and trolling line. Operation of long line: set and driftlong lining: bottom, mid-water and pelagic long lining; jigging. Operation of beach seine, boat seine and traps. Selectivity in fishing gear and by catch-reducing devices. Deck equipment – types of winches, net haulers, line haulers, triple drum, gurdy, power blocks, fish pumps. Fishing equipment: Fish finder, GPS navigator, sonar, net sonde, gear monitoring equipment.

Practical

Study of net making tools; Knots and hitches used in net making. Methods of net making: Hand braiding- Chain mesh method and loop methods of net making. Shaping of webbing: baiting, creasing and reducing mesh size step by step. Tailoring method: T and N direction of webbing; T-cuts, N-cuts, B-cuts and their combination. Joining of net pieces. Net mounting – hanging coefficient, hung depth and their calculation. Selvedging. Methods of net mounting: reeving, stapling and norselling. Mending and net shooter techniques.

Survey of fishing gears; Trawl; gillnet; long line and purse seine fishing gears. Rigging of trawl, purse seine, gillnet and hook and line. Commercial fishing techniques: Bottom trawling; purse seining; gillnetting and line fishing. Cast net fishing and trap fishing.

Suggested Readings

1. Ben-Yami, M. (1994). *Purse Seining Manual.* FAO Fishing Manual. 416 pp.
2. Biswas, K.P. (1996). *Harvesting Aquatic Resources.* Daya Publishing House, Delhi. 207 pp.
3. Bjordal, Å., & Løkkeborg, S. (1998). *Long Lining.* Fishing News Books Ltd., Farnham. 208 pp.
4. Brandt, A.V. (1984). *Fish Catching Methods of the World.* Fishing News Books Ltd., London. 432 pp.
5. FAO. (1987). *Small Scale Fishing Gear.* pp. 19–44.
6. FAO. (1996). *Fishing Operations: FAO Training Guidelines for Responsible Fisheries No. 1.* FAO, Rome. 26 pp.
7. Fridman, A.L. (1986). *Calculations for Fishing Gear Designs.* FAO Fishing Manual, Fishing News Books Ltd., Farnham. 264 pp.
8. Kristjonsson, H. (1975). *Modern Fishing Gear of the World.* The Whitefriars Press Ltd., London. 594 pp.
9. Sreekrishna, Y., & Shenoy, L. (2001). *Fishing Gear and Craft Technology*. Indian Council of Agricultural Research, New Delhi. 342 pp.

FSCCCC256: Fish Products, By-products, Value Addition and Waste Management Objectives 3 (2+1)

1. To understand the concepts of fish products and by-products
2. To teach concepts of value addition of fish products and waste management

Theory

Principle of fish preservation and processing. Processing of fish by traditional methods– salting, sun drying, smoking, marinading and fermentation. Theory of salting, methods of salting– wet salting and dry salting. Drying and dehydration- theory, importance of water activity in relation to microbial growth. Sun drying and artificial drying- solar dryer. Packaging and storage of salted and dried fish. Different types of spoilage in salt-cured fish. Quality standard for salted and dry fish.

Fish preservation by smoking-chemical composition of wood smoke and their role in preservation. Methods of smoking and equipment used for smoking. Carcinogenic compound in wood and methods to remove them. Hurdle technology in fish preservation and processing. Marinated and fermented fish products–role of acids in marinades, Fish and prawn pickles, fish sauce and Fish paste, traditional Indian fermented products. Principles and methods of preparation of various fish paste products like fish sausage, fish ham, surimi, fish cake, kamaboko etc. Fish muscle structure, myofibrillar protein and their role in elasticity formation. Extruded products: theory of extrusion, equipment used, advantages of extruded products, methods of preparation of extruded products. Value addition. Diversified fish products: battered and braided products-fish finger, fish cutlet, fish wafer, and fish soup powder etc. and imitation products. HACCP in safe product production. Fish meal: dry reduction and wet reduction methods, specification, packaging and storage. Fish oil: body oil, liver oil extraction, purification, preservation, storage, and application. Shrimp wastes: chitin, chitosan production, uses. Fish protein concentrate. Fish hydrolysate, partially hydrolyzed and deodorized fish meat, functional fish protein concentrates and their incorporation to various products. Fish silage, acid silage, fermented silage and their application. Fish maws, shark leather, fish glue, fish gelatin, isinglass, pearl essence, shark fin rays, beach-de-mer. Biochemical and pharmaceutical products. Utilization of seaweeds: agar agar, algin, carrageenan.

Practical

Preparation of salted fish, dried fish and smoked fish by different methods. Quality assessment of salted, dried and smoked fish. Preparation of prawn and fish pickles. Preparation of fermented fish sauce and marinade products. Preparation of surimi and surimi-based products. Preparation of diversified and value-added fish products. Quality assessment of market sample of dried and fermented fish products.

Preparation of fish meal, fish body oil, fish liver oil, fish maws, isinglass, fish silage, ensilage, fish glue, fish gelatin, fattice, pearl essence, chitin, chitosan and fish manure. Preparation of acid and fermented silage. Preparation of fish protein concentrate and fish hydrolysate.

Suggested Readings

1. Balachandran, K.K. (2001). *Post-Harvest Technology of Fish and Fish Products.* Daya Publishing House.
2. Elvevoll, E.O. *Fish Waste and Functional Foods.* Norwegian College of Fishery Science, Department of Marine Biotechnology, Norway. (Contact: edele@nfh.uit.no)
3. Shahidi, F. (2007). *Maximizing the Value of Marine By-Products.* CRC Press Inc., Florida.
4. Gopakumar, K. (Ed.). (2002). *Textbook of Fish Processing Technology.* Indian Council of Agricultural Research (ICAR).
5. Hall, G.M. (Ed.). (1992). *Fish Processing Technology.* Blackie Academic & Professional.

6. Nambudiri, D.D. (2006). *Technology of Fishery Products.* Fishing Chimes Publications.
7. Sen, D.P. (2005). *Advances in Fish Processing Technology.* Allied Publishers.
8. Borresen, T. (2008). *Improving Seafood Products for the Consumer.* Woodhead Publishing Limited, Cambridge.
9. Venugopal, V. (2005). *Seafood Processing: Adding Value Through Quick Freezing, Retort Packaging, and Cook-Chilling.* Taylor and Francis, Boca Raton.
10. Wheaton, F.W., & Lawson, T.B. (1985). *Processing Aquatic Food Products.* John Wiley and Sons.

FSCMDC257: Agriculture Marketing and Trade 3 (2+1)

Objectives

1. To understand the fundamentals of agricultural marketing and trade
2. To analyse the factors influencing supply and demand in agricultural markets
3. To explore different marketing channels and strategies in agriculture
4. To examine the role of government policies and regulations in agricultural markets

Theory

Agricultural Marketing: Concepts and definitions of market, marketing, agricultural marketing, market structure, marketing mix and market segmentation, classification and characteristics of agricultural markets; demand, supply and producer's surplus of agri commodities: nature and determinants of demand and supply of farm products, producer's surplus – meaning and its types, marketable and marketed surplus, factors affecting marketable surplus of agri-commodities; pricing and promotion strategies: pricing considerations and approaches – cost based and competition based pricing; market promotion – advertising, personal selling, sales promotion and publicity – meaning, merits and demerits; marketing process and functions: Marketing process concentration, dispersion and equalization; exchange functions – buying and selling; physical functions – storage, transport and processing; facilitating functions – packaging, branding, grading, quality control and labeling (Agmark); Market functionaries and marketing channels: Types and importance of agencies involved in agricultural marketing; meaning and definition of marketing channel; number of channel levels; marketing channels for different farm products; Integration, efficiency, costs and price spread: Meaning, definition and types of market integration; marketing efficiency; marketing costs, margins and price spread; factors affecting cost of marketing; reasons for higher marketing costs of farm commodities; ways of reducing marketing costs; Role of Government in agricultural marketing: Public sector institutions- CWC, SWC, FCI, CACP and DMI – their objectives and functions; cooperative marketing in India; Risk in marketing: Types of risk in marketing; speculation and hedging; an overview of futures trading; Agricultural prices and policy: Meaning and functions of price; administered prices; need for innovations in agricultural price policy; Trade: Concept of International Trade and its need, theories of absolute and comparative advantage. Present status and prospects of international trade in agri-commodities; WTO; Agreement on Agriculture (AoA) and its implications on Indian agriculture; IPR. Role of government in agricultural marketing. Role of APMC and its relevance in the present-day context.

Practical

Plotting and study of demand and supply curves and calculation of elasticities; Study of relationship between market arrivals and prices of some selected commodities; Computation of marketable and marketed surplus of important commodities; Study of price behaviour over time for some selected commodities; Construction of index numbers; Visit to a local market to study various marketing functions performed by different agencies, identification of marketing channels for selected commodity, collection of data regarding marketing costs, margins and price spread and presentation of report in the class; Visit to market institutions – NAFED, SWC, CWC, cooperative marketing society, etc. to study their organization and functioning; Application of principles of comparative advantage of international trade.

Suggested Readings

1. Acharya, S.S. & Agarwal, N.L. (2006). *Agricultural Marketing in India.* Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
2. Chinna, S.S. (2005). *Agricultural Economics and Indian Agriculture.* Kalyani Publishers, New Delhi.
3. Salvatore, D. *Microeconomic Theory*. (Publisher details not provided; please verify edition and publisher.)
4. Kohls, R.L. & Uhl, J.N. (2002). *Marketing of Agricultural Products.* Prentice-Hall of India Pvt. Ltd., New Delhi.
5. Kotler, P. & Armstrong, G. (2005). *Principles of Marketing.* Pearson Prentice-Hall.
6. Lekhi, R.K. & Singh, J. (2006). *Agricultural Economics.* Kalyani Publishers, Delhi.
7. Memoria, C.B., Joshi, R.L. & Mulla, N.I. (2003). *Principles and Practice of Marketing in India.* Kitab Mahal, New Delhi.
8. Pandey, M. & Tewari, D. (2004). *Rural and Agricultural Marketing.* International Book Distributing Co. Ltd., New Delhi.
9. Sharma, R. (2005). *Export Management.* Laxmi Narain Agarwal, Agra.

FSCVAC258: Agricultural Informatics and Artificial Intelligence Objectives 3 (2+1)

1. To acquaint students with the basics of computer applications in agriculture, multimedia, database management, application of mobile app and decision- making processes, etc.
2. To provide basic knowledge of computer with applications in agriculture
3. To make the students familiar with agricultural-informatics, its components and applications in agriculture

Theory

Introduction to Computers, Anatomy of Computers, Memory Concepts, Units of Memory, Operating System: Definition and types, Applications of MS-Office for creating, Editing and Formatting a document, Data presentation, Tabulation and graph creation, Statistical analysis, Mathematical expressions, Database, concepts and types, creating database, Uses of DBMS in Agriculture, Internet and World Wide Web (WWW): Concepts and components.

Computer programming: General concepts, Introduction to Visual Basic, Java, Fortran, C/ C++, etc. concepts and standard input/output operations. e-Agriculture, Concepts, design and development, Application of innovative ways to use information and communication technologies (IT) in Agriculture, Computer Models in Agriculture: Statistical, weather analysis and crop simulation models, concepts, structure, inputs-outputs files, limitation, advantages and application of models for understanding plant processes, sensitivity, verification, calibration and validation, IT applications for computation of water and nutrient requirement of crops, Computer-controlled devices (automated systems) for Agri-input management, Smartphone mobile apps in agriculture for farm advice: Market price, postharvest management etc.

Geospatial technology: Concepts, techniques, components and uses for generating valuable agri-information, Decision support systems: Concepts, components and applications in Agriculture, Agriculture Expert System, Soil Information Systems etc. for supporting farm decisions. Preparationof contingent crop-planning and crop calendars using IT tools, Digital India and schemes to promote digitalization of agriculture in India.

Introduction to artificial intelligence, background and applications, Turing test. Control strategies, Breadth-first search, Depth-first search, Heuristics search techniques: Best-first search, A* algorithm, IoT and Big Data; Use of AI in agriculture for autonomous crop management, and health, monitoring livestock health, intelligent pesticide application, yield mapping and predictive analysis, automatic weeding and harvesting, sorting of produce, and other food processing applications; Concepts of smart agriculture, use of AI in food and nutrition science etc.

Practical

Study of computer components, accessories, practice of important DOS Commands. Introduction of different operating systems such as Windows, Unix/ Linux, creating files and folders, File Management. Use of MS-WORD and MS Power-point for creating, editing and presenting a scientific document, MS-EXCEL - Creating a spreadsheet, Use of statistical tools, Writing expressions, Creating graphs, Analysis of scientific data, Handling macros. MS-ACCESS: Creating Database, preparing queries and reports, Demonstration of Agri- information system, Introduction to World Wide Web (WWW) and its components, Introduction of programming languages such as Visual Basic, Java, Fortran, C, C++, Hands-on practice on Crop Simulation Models (CSM), DSSAT/Crop-Info/Crop Syst/ Wofost, Preparation of inputs file for CSM and study of model outputs, computation of water and nutrient requirements of crop using CSM and IT tools, Use of smart phones and other devices in agro-advisory and dissemination of market information, Introduction of Geospatial Technology, Hands on practice on preparation of Decision Support System, Preparation of contingent crop planning, India Digital Ecosystem of Agriculture (IDEA).

Suggested Readings

1. Sethi, Dhabal Prasad & Manoranjan. *Concepts and Techniques of Programming in C.* Wiley India.
2. Rajaraman, V. *Fundamentals of Computer.*
3. Date, C.J. *Introduction to Database Management System.*
4. Pearson. *Introduction to Information Technology.*

5. Mahapatra, Subrat K. et al. *Introductory Agri-Informatics.* Jain Brothers Publication.

Post-IV semester

Internship (only for exit option for award of UG-Diploma) 10 (0+10)

General objective

1. To make students capable of working in the commercial establishments as a supervising or management staff
2. To make students capable of being an entrepreneur

Activity

- ✓ 10 weeks of intensive training on any aspects of Fisheries will help in broadening career aspects
- ✓ The area of training may be in the hatchery, in culture farms or in processing industries

SEMESTER-V

FSCCCC301: Fish Genetics and Breeding Objectives 2 (1+1)

1. To understand the basic principles of genetics and breeding and their application to fisheries
2. To improve the quality and quantity of fish and shell-fish species

Theory

Principles of genetics and breeding. Gene and chromosome as basis of inheritance. Mendel's law of inheritance – complete and incomplete dominance, monohybrid and dihybrid ratios. Gene interactions – dominant and recessive epistasis. Pleiotropism. Lethal genes. Mutation. Sex - linked genes, sex-influenced and sex-limited traits. Linkage and crossing over. Introduction to population genetics. Hardy - Weinberg law and its significance. Chromosomal structure and aberrations. Chromosome manipulation techniques - androgenesis, gynogenesis and polyploidy and identification of ploidy. Sex determination. Cross breeding (hybridization) – types of crossbreeding, heterosis and design of cross-breeding programs, hybridization in different fishes. Quantitative genetics – quantitative traits, polygenic traits, heritability. History and present status of selective breeding programs in aquaculture. Selection methods and mating designs. Design for selective breeding. Inbreeding and its consequences. Domestication methods. Seed certification and quarantine procedures. Cryopreservation of gametes.

Practical

Problems on Mendelian inheritance (qualitative genetics) - monohybrid and dihybrid ratios and epistasis. Problems on quantitative traits, response to selection and heritability. Estimation of rate of inbreeding and heterosis. Estimation of inbreeding coefficient. Preparation of Selection index for the selective breeding program. Mitotic and meiotic chromosome preparation. Demonstration of protocol of androgenesis, gynogenesis and polyploidy. Problems on gene and genotypic frequency. Gamete cryopreservation protocols and quality evaluation of fish milt. Study of risk factors in cryopreservation technique.

Suggested Readings

1. Ayyappan, S. (2004). *Fisheries Biotechnology.* Narendra Publishing House.
2. Gjedrem, Trygve et al. (2005). *Selection and Breeding Programs in Aquaculture.* Springer.
3. Kirpichnikov, V.S. (1981). *Genetic Basis of Fish Selection.* Springer-Verlag.
4. Lakra, W.S., Abidi, S.A.H., Mukherjee, S.C., & Lutz, C.G. (2003). *Practical Genetics for Aquaculture.* Wiley-Blackwell.
5. Lutz, C.G. (2003). *Practical Genetics for Aquaculture.* Wiley-Blackwell.
6. Lynch, M., & Walsh, B. (1997). *Genetics and Analysis of Quantitative Traits.* Sinauer, Sunderland.
7. Nagabhushanam, R., Diwan, A.D., Zahurnec, B.J., & Sarojini, R. (2004). *Biotechnology of Aquatic Animals.* Science Publishers.

8. Nair, P.R. (2008). *Biotechnology and Genetics in Fisheries and Aquaculture.* Dominant Publishers.
9. Purdom, C.E. (1993). *Genetics and Fish Breeding.* Chapman and Hall.
10. Snustad, D.P., & Simmons, M.J. (1999). *Principles of Genetics* (2nd ed.). John Wiley and Sons.
11. Stansfield, W.D. (1991). *Theory and Problems of Genetics.* McGraw-Hill.
12. Tave, D. (1993). *Genetics for Fish Hatchery Managers* (2nd ed.). Chapman and Hall.

FSCCCC302: Marine Biology Objectives 2 (1+1)

1. To understand the Marine life and its biology
2. To study the diversity of marine organism

Theory

Introduction to Marine Biology: Divisions of marine environment- pelagic, benthic, euphotic, aphotic divisions and their subdivisions. Life in oceans - general account of major groups of phytoplankton, zooplankton and seaweeds. Environmental factors affecting life in the oceanssalinity, temperature, light, currents, waves, tides, oxygen, and carbon dioxide. Vertical migration of zooplankton, Phytoplankton-Zooplankton relationship, geographical and seasonal variation in plankton production, plankton and fisheries. Inter tidal ecology: Rocky shore, sandy shore and mud flats, zonation, communities, and the adaptation. Mud banks: formation and characteristics. Estuaries: Classification, Physico-chemical factors, Biota and productivity, examples of some Indian Estuaries. Boring and fouling organisms. Nekton outline, composition of nekton, habitats of nekton. Bioluminescence and indicator species. Blooms, Red tides: cause and effects.

Practical

Study of common instruments used for collection of phytoplankton, zooplankton and benthos. Collection, preservation and analysis of phytoplankton, zooplankton, seaweeds and inter tidal organisms.

Suggested Readings

1. Cass-Dudley, V. L., Dudley, G., & Sumich, J.L. (2016). *Laboratory and Field Investigations in Marine Life* (11th ed.). Jones and Bartlett Learning.
2. Castro, P., & Huber, M.E. (2018). *Marine Biology.* McGraw Hill.
3. Burton, D., & Burton, M. (2017). *Essential Fish Biology: Diversity, Structure, and Function.* Oxford University Press.
4. Kennish, M.J. (1989). *Practical Handbook of Marine Science.* CRC Press, New York.
5. Laevastu, T., & Hayes, M.L. (1981). *Fisheries Oceanography and Ecology.* Fishing News Books, Farnham, U.K.
6. Lalli, C.M., & Parsons, T.R. (1993). *Biological Oceanography: An Introduction.* Elsevier Science Ltd., Oxford.
7. Miller, C.B. (2004). *Biological Oceanography.* Blackwell Publications, Oxford.
8. Pond, S., & Pickard, G.L. (2013). *Introductory Dynamical Oceanography.* Elsevier.
9. Reddy, M.P.M. (2007). *Ocean Environment and Fisheries.* Science Publishers, USA.

FSCCCC303: Fish Population Dynamics and Stock Assessment Objectives 2 (1+1)

1. To understand the stock concept and principles of fisheries management
2. To understand the application of various models and their applications in fisheries management

Theory

The concept of population and unit stock. Biological structure of fisheries resource in space and time. Indicators of dynamics in a fishery resource. Characteristics of unit and mixed stock. Data requirements for stock assessment. Segregation of stocks. Principles of stock assessment. Population age structure. Theory of life tables. Von Bertalanffy growth parameters. Graphical models. Monte Cario simulation model and ECOPATH model. Estimation of total fishing and natural mortality. The concept of yield, yield in number and yield in weight, yield per recruit, yield curve. Yield models. The concept of Maximum Sustainable Yield and Maximum Economic Yield. Biological symptoms of under-fishing and over-fishing. Growth over-fishing and recruitment over-fishing. Eumetric fishing. Open access fisheries. Fisheries regulations. CPUE. Trawl selection and gillnet selection. Analytical models of fish stocks.

Practical

Study of length – weight relationship, segregation of stock using direct methods. Study of analytical models: Beverton and Holt model. VBGF, Pauly's integrated methods, graphical models. Estimation of Z, F and M. Estimation of net selectivity coefficient. Fitting of surplus production model: Schaeffer model, Fox model. Study of yield isopleth diagrams. Micro-computer packages ELEFAN, FISAT.

Suggested Readings: Stock Assessment and Fish Population Dynamics

1. Callucci, V.G., Saila, S.B., Gustafson, D.J., & Rothschild, B.J. (1996). *Stock Assessment: Quantitative Methods and Applications for Small Scale Fisheries.* Lewis Publishers, Boca Raton. 527 p.
2. Devaraj, M. (1983). *Fish Population Dynamics: A Course Manual.* CIFE Bulletin 3(10), 98 p.
3. Gulland, J.A. (1977). *Fish Population Dynamics.* John Wiley & Sons, Chichester. 422 p.
4. Gulland, J.A. (1992). *A Review of Length-based Approaches to Assessing Fish Stocks.* FAO Technical Paper No. 323. 100 p.
5. Hilborn, R., & Walters, C.J. (1992). *Quantitative Fisheries Stock Assessment – Choice, Dynamics and Uncertainty.* Chapman and Hall. 570 p.
6. Pauly, D. (1980). *Selection of Simple Methods for the Assessment of Tropical Fish Stocks.* FAO Fish. Circ. No. 729. 54 p.
7. Quinn, T.J., & Deriso, R.B. (2003). *Quantitative Fish Dynamics.* Academic Press.
8. Ricker, W.E. (1971). *Methods for the Assessment of Fish Production in Freshwaters.* Blackwell, Oxford and IBH.
9. Sparre, P., & Venema, S.C. (1998). *Introduction to Tropical Fish Stock Assessment. Part 1: Manual.* FAO Fisheries Technical Paper No. 301, Rome.

10. Vivekanandan, E. (2005). *Stock Assessment of Tropical Marine Fishes.* Indian Council of Agricultural Research, New Delhi.

FSCCCC304: Aquatic Ecology and Biodiversity Objective 2 (1+1)

1. To enrich the knowledge on the ecology and biodiversity of aquatic environment
2. To assess the threats on the ecosystem and biodiversity of aquatic environment

Theory

Aquatic environment, Flora and fauna: Components of aquatic systems. Aquatic productivity, nutrient cycles, energy flow, food chain. Animal associations: Symbiosis, commensalisms, parasitism, prey-predator relationship, host-parasite relationship. Aquatic biodiversity-its importance, species diversity, genetic diversity, habitat diversity, diversity indices. Ecological and evolutionary processes. Ecological niches – lagoons, estuaries, mangroves, coral reefs, flood plains, coastal wet lands, bheels, oxbow lakes. Threats to biodiversity- habitat destruction, introduction of exotic species. Conservation of habitats: marine parks and sanctuaries. Conservation programs for endangered species, ex situ and in situ conservation, captive breeding and management of endangered species. Various national and international conventions and regulations concerning biodiversity, including use of selective gears and exclusion devices.

Practical

Collection of species of fishes and other organisms and studying the assemblages of organisms of rocky, sandy and muddy shores, lentic and lotic habitats. Observation of adaptive characters and interrelationships like commensalisms, symbiosis, parasitism and predation. Field visits to mangroves, marine parks, sanctuaries, coral reefs, rivers, hills, streams, lakes and reservoirs. Collection, identification, and preservation of mangrove plants. Working out biodiversity indices.

Suggested Readings

1. Ward, A.D., Trimble, S.W., Burckhard, S.R., & Lyon, J.G. (2015). *Environmental Hydrology.* CRC Press.
2. Barnes, R.S.K., & Mann, K.H. (Eds.) (2009). *Fundamentals of Aquatic Ecology.* John Wiley & Sons.
3. Carter, R.W.G. (1998). *Coastal Environments: An Introduction to the Physical, Ecological, and Cultural Systems of Coastlines.* Academic Press, London.
4. Dodds, W., & Whiles, M. (2010). *Freshwater Ecology, 2nd Edn: Concepts and Environmental Applications of Limnology.* Academic Press, London.
5. Dodds, W.K. (2002). *Freshwater Ecology: Concepts and Environmental Applications.* Academic Press, New York.
6. Norse, A.E. (Ed.) (1993). *Global Marine Biological Diversity.* Inland Press, Washington, D.C. 383 p.
7. Khanna, D.R., Chopra, A.K., & Prasad, G. (2005). *Aquatic Biodiversity in India.* Daya Publishing House.
8. Kormondy, E.J. (1986). *Concepts of Ecology.* Prentice-Hall, New Delhi.
9. Kumar, U., & Asija, M.J. (2000). *Biodiversity Principles and Conservation.* Agrobios.

10. Magurran, A.E. (1988). *Ecological Diversity and its Measurement.* Taylor and Francis.
11. Menon, A.G.K. (2004). *Threatened Fishes of India and their Conservation.* Fisheries Survey of India.
12. Mitsch, W.J. (2009). *Wetland Ecosystems.* John Wiley & Sons. 295 pp.
13. Nath, S. (Ed.) (2008). *Recent Advances in Fish Ecology, Limnology, and Eco Conservation, Vol. 7.* Narendra Publishing House, New Delhi.
14. Okuda, N., Watanabe, K., Fukumori, K., Nakano, S.I., & Nakazawa, T. (2014). *Biodiversity in Aquatic Systems and Environments: Lake Biwa.* Springer Japan.
15. Thorpe, J.E., Talbot, C., & Miles, M.S. (Eds.) (1995). *Conservation of Fish and Shellfish Resources: Managing Diversity.* Academic Press.

FSCCCC305: Pharmacology and Toxicology Objectives 3 (2+1)

1. To understand the application and impact of aquaculture drugs and chemicals in fisheries
2. To impart knowledge on the toxicity of drugs and chemicals on aquaculture and fisheries

Theory

Introduction to Pharmacology: History, Importance, Terms and Definitions, Drug development, Screening and Nomenclature, Scope of pharmacology in fishes. Route of Administration and Method of application to fish. Source of Drugs. Pharmacotherapeutic classification of drugs. Pharmacokinetics: Biological membrane, absorption, distribution, biotransformation, and excretion of drugs. Factors influencing drug metabolism. Pharmacodynamics: Principles of drug action, concept of drug receptor, nature, chemistry, classification. Functions of receptor. Transducer mechanism, second messenger, non-receptor mediated action. Dose Response Relationship, halflife withdrawal period, potency, efficacy, threshold dose, therapeutic dose, maximal dose, toxic dose, lethal dose. Factors modifying drug action, Adverse drug effects, drug interaction and Bioassay of drugs. Salient features in drug acting on digestive system, nervous system and cardiovascular system. Drugs used in fish transportation. Recent advances in Pharmacology, biostatistics in experimental Pharmacology, Pharmaceutical industry.

General Toxicology: Definitions, Branches of Toxicology, Historical developments, Classification and types of poison. Toxicity testing - Chronocity factor, Untoward effects, Common causes, Diagnosis of poisoning, Factors modifying toxicity, Toxicokinetic, Toxicodynamic, General approaches to diagnosis and treatment of poisoning.

Systemic Toxicology: Toxicity caused by metal and non-metals, Phytotoxins- Toxic principles of various alkaloids and toxic plants, Drug toxicity and toxicity caused by agrochemicals. Mycotoxins, Bacterial toxins. Collections and dispatch of specimens in Toxicological cases. Toxicity of drugs in Aquaculture: Maximum Residual Limits (MRL) of various drugs and chemicals in fish. Metabolism of toxic substances by aquatic organisms.

Practical

Metrology, Prescription Writing, Preparation of drug solution, Source and chemical nature of drugs. Incompatibility, Pharmaceutical technology, Bioassay of drugs, Animal models in Pharmacological experiments, Methods of application of drugs in fish.

Detection of heavy metal poisoning. Spot tests for metals. Group reaction for metals- Arsenic, Antimony, Lead (Pb), Mercury (Hg), Zinc (Zn), Barium (Ba), Iron (Fe^{3+}), Copper (Cu), Ammonia,Ammonium ($NH4^{+}$), Chloride (Cl^{-}), Phosphate (PO_4^{2-}) Sulphate (SO_4^{2-}), Fluoride (Fl^{-}). Qualitative detection of Nitrite and Nitrate. Detection of hydrocyanic acid. Detection and Estimation of Mycotoxins. Test for detection of alkaloids. Estimation of LD50 and ED50. Demonstration of drug toxicity.

Suggested Readings:

1. *Aquatic Toxicology.* American Society for Testing and Materials, Philadelphia, 1980.
2. Brown, K.M. (2000). *Applied Fish Pharmacology.* Kluwer Academic Press, London.
3. Derelanko, M.J. (1995). *CRC Handbook of Toxicology.* CRC Press, Boca Raton.
4. Hayes, A.W. (2008). *Principles and Methods of Toxicology.* CRC Press, U.S.A.
5. Herwig, N. (1979). *Handbook of Drugs and Chemicals Used in the Treatment of Fish Diseases.* Charles C. Thomas, Springfield.
6. Hoboken, N.J. (2010). *A Textbook of Modern Toxicology.* John Wiley & Sons.
7. Hyde, W. et al. (1977). *Analytical Toxicology Methods Manual.* Iowa State University Press, Ames.
8. Kram, D.J. (2001). *Toxicology Testing Handbook.* Marcel Dekker, Inc., New York.
9. Malins, D.C. (1994). *Aquatic Toxicology.* Lewis Publishers, Boca Raton.
10. Metelev, V.V. (1983). *Water Toxicology.* Amerind Publishing Co. Pvt. Ltd., New Delhi.
11. Niesink, R.J.M. (1996). *Toxicology Principles and Applications.* CRC Press, New York.
12. Pandey, B.N. (2011). *Fisheries and Fish Toxicology.* A P H Publishing Corporation, New Delhi.
13. Pandey, G. (2017). *Fish Pharmacology and Toxicology.* DPH, New Delhi.
14. Radostits, M. (2000). *Veterinary Medicine.* Book Power Publisher, China.
15. Rand, G.M. (1985). *Fundamentals of Aquatic Toxicology.* Hemisphere Publishing Corporation, Washington.
16. Singh, I.S.B. (2003). *Aquaculture Medicine.* Cochin University, 336p.
17. Stockopf, M.K. (1993). *Fish Medicine.* W.B. Saunders Company, London.
18. *The Toxicology of Fishes.* CRC Press, Boca Raton, 2008.

FSCCCC306: Fish Freezing Technology 2 (1+1)

Objectives

1. To gain knowledge on the mechanism of action of chilling and freezing methods for preservation of fish and shell-fish
2. To understand the mechanism of the freezing technology for preservation

Theory

Introduction to freezing technology; characteristics of fish and shellfish. Changes in fish after death, spoilage of fish, spoilage and pathogenic microorganism. Handling of fresh fish; sanitation in processing plants. Principles of low temperature preservations. Chilling of fish: methods and equipment for chilling; icing: quality of ice, ice making; refrigerated or chilled sea water, chilling rate; spoilage of fish during chilled storage; use of antibiotics and chemicals. Freezing of fish:

fundamentalaspects; heat units; freezing point depression, eutectic point; freezing rate; methods of freezing, freeze drying, physico–chemical changes that occur during freezing, mechanism of ice crystal formation; preparation of fish and shellfish for freezing. Changes that occur during frozen storage: microbiological, physical and chemical changes, protein denaturation, fat oxidation, dehydration, drip; protective treatments: polyphosphate, glazing, antioxidants, packaging; thawing of frozen fish and shellfish: methods of thawing. Transportation of frozen fish and shellfish, cold chain, quality control, HACCP in freezing industry.

Practical

Sanitation and plant housekeeping. Chilling and freezing equipment, instruments. Packages and product styles. Methods of icing fish; cooling rate. Preservation by chilled sea water; freezing and thawing curves. Freezing of different varieties of fish and shellfish; estimation of drip. Determination of quality changes during frozen storage. Inspection of frozen fishery products. Visits to ice plants, cold storages, and freezing plants.

Suggested Readings:

1. AOAC Manual
2. Balachandran, K.K. (2001). *Post-harvest Technology of Fish and Fish Products*. Daya Publishing House.
3. Clucas, I.J. (1981). *Fish Handling, Preservation and Processing in the Tropics, Parts I & II*. FAO.
4. Gopakumar, K. (Ed.). (2002). *Text Book of Fish Processing Technology*. ICAR.
5. SEAFDEC Manual
6. Gökoglu, N., & Yerlikaya, P. (2015). *Seafood Chilling, Refrigeration and Freezing: Science and Technology*. John Wiley & Sons (Chichester).
7. Sen, D.P. (2005). *Advances in Fish Processing Technology*. Allied Publishers.
8. Venugopal, V. (2006). *Seafood Processing*. Taylor and Francis.

FSCCCC307: Fish Canning Technology and Packaging 2 (1+1)

Objectives

1. To provide information on various aspects of thermal / heat processing, fish packaging materials, their appropriate use and benefits
2. To impart knowledge on canning technology, packaging and labeling

Theory

Fish Canning Technology: Introduction to canning and its historical developments. Advantages of canning in relation to other preservation methods. Raw materials, their characteristics and suitability for canning. Classification of foods based on pH, commercial sterility, absolute sterility, pasteurization and sterilization. Canning process: Process flow steps involved HTST and aseptic canning. General steps in canning procedure and importance, preparation of raw material, packing, pre-cooking, exhausting, seaming, retorting, cooling labelling and storage. Principles of thermal processing. Heat resistance of microorganisms, heat penetration studies, mechanism of heat transfer. Cold spot and its importance, convection and conduction type of packs. Process

calculation bygeneral/ graphical methods. Estimation of Fo value of the process (D-value, Z-Value TDT, F-value, lethal rate). Commercial sterilization, 12-D concept. Canning of commercially important fin fishes, shellfishes and cephalopods. Spoilage of canned foods, types, causes and preventive measures. Quality standards, plant layout, hygiene and sanitation and waste disposal.

Packaging: Introduction to packaging, Importance of packaging in fish processing, functions, objectives and requirements. Packaging materials, basic and laminates, principles of their manufacture and their identification. Properties of packaging materials and their use; Protective packaging with special reference to food. Printing for packaging and print identification. Closures of packaging, heat seals bottle closure. Principles of packaging: fresh produce handling and transportation. Packaging for retail sale and storage. Packaging equipment and machinery. Package design, evaluation and testing. Flexible packaging materials, rigid containers, thermoform containers, glass containers, corrugated fiber boards, duplex cartons, edible packaging materials. Laminations and co-extrusions. Retort pouch packaging - advantages and disadvantages. Biodegradable films, vacuum packaging, active packaging, Modified Atmosphere Packaging (MAP). Polymeric Packaging. Packaging requirements of fresh fish, frozen fish, canned fish. Transport worthiness of packaging materials, accelerated shelf testing. Safety and legislation aspects of packaging. Labelling and bar coding.

Practical

Types of cans, canning equipment and layout of cannery. Canning of different varieties of fish and shellfish. Cutout test of canned products. Examination of can double seam. Heat resistance of bacteria. Heat penetration in canned food, thermal process calculation by general method. Study of spoilage condition in canned products. Familiarization with various packaging materials and container for fish products.

Determination of grammage of paper and board, bursting strength, burst factor, punctures 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:

1. Mathur, A. (2012). *Food Processing, Packaging, Labelling and Marketing*. Anmol Publications Pvt. Ltd. (New Delhi).
2. Sun, D.-W. (2005). *Thermal Food Processing: New Technologies and Quality Issues*. Taylor and Francis (Boca Raton).
3. Gopakumar, K. (1993). *Fish Packaging Technology - Materials and Methods*. Concept Publishing.
4. Robertson, G.L. (2005). *Food Packaging: Principles and Practices*. Marcel Dekker, Inc. (New York).
5. Hall, G.M. (Ed.). (1992). *Fish Processing Technology*. Blackie.
6. Hersom, A.C., & Hulland, E.D. (1980). *Canned Foods*. Chemical Publishing Co.

7. D'Souza, J., & Pradhan, J. (2010). *Handbook of Food Processing Packaging and Labeling*. SBS Publishers and Distributors Pvt. Ltd. (New Delhi).
8. Larousse, J., & Brown, B.E. (1997). *Food Canning Technology*. Wiley VCH.
9. Ponnuswami, V. (2012). *Nano Food Packaging: A New Post-Harvest Venture*. Narendra Publishing House (Delhi).
10. Srinivasa Gopal, T.K. (2007). *Seafood Packaging*. Central Institute of Fisheries Technology (Cochin).
11. Subasinghe, S. (1999). *Retail Packaging of Fish and Fishery Products*. Info Fish.
12. Venugopal, V. (2006). *Seafood Processing*. Taylor and Francis.
13. Warne, D. (1988). *Manual on Fish Canning*. FAO Fisheries Tech. Paper 285.
14. Zeathen, P. (1984). *Thermal Processing and Quality of Foods*. Elsevier.
15. Holdsworth, S.D. (1997). *Thermal Processing of Packaged Foods*. Blackie Academic and Professional.

FSCCCC308: Aquaculture Engineering 3 (2+1)

Objectives

To acquire the knowledge of land survey, excavation of ponds, design and lay-out of fish/prawnfarms.

To understand the basic knowledge for the construction of Finfish and Shellfish farms andhatcheries.

Theory

Fish Farm: Definition, objectives, types of farms; fresh water, brackish water and marine farms. Selection of site for aqua farm: site selection criteria, pre-investment survey viz., accessibility, physical features of the ground, detailed survey viz., site condition, topography, soil characteristics. Land Surveying: definition, principles of surveying, classification of surveying, instruments used for chaining, chaining on uneven or sloping ground and error due to the incorrect chain length. Chain surveying: definition, instruments used for setting out right angles, basic problems in chaining, cross-staff survey. Compass surveying: definitions, bearing, meridians, whole circle bearing system, reduced bearing system, theory of magnetic compass, prismatic compass. Levelling: definitions, methods of levelling, levelling instruments, terms and abbreviations, types of spirit levelling. Plane table surveying: instruments required, working operation, methods. Contour surveying: definition, contour interval, characteristics of contour, contouring methods and uses of contour. Soil and its properties: classification of soil; soil sampling methods; three-phase system of soil, definitions of soil properties and permeability of soil. Ponds: classification of ponds; excavated ponds, embankment ponds, barrage and diversion ponds; rosary system and parallel system. Planning of fish pond: layout planning, materials planning, manual planning, comparison of square and rectangular ponds, large and small ponds. Types of ponds: nursery ponds, rearing ponds and stocking ponds. Design of ponds, pond geometry; shape, size, bottom slope of pond etc., construction ponds, marking, excavation. Dykes: types of dykes viz., peripheral dykes, secondary dyke, design of dykes, construction of dykes. Water distribution system: canal, types of canals; feeder canal, diversion canal etc., Pipe line system. Water control structures: types of inlets and outlets and their construction. Water budget

equation. Pond drainage system; seepage and the methods used for seepage control, evaporation; factors affecting evaporation, erosion of soil in dykes and its control. Site selection, planning and construction of coastal aqua farms. Brackish water fish farms: tide-fed, pump-fedfarms. Hatcheries: Site selection, infrastructural facilities; water supply system, main hatchery complex viz., Layout plan and design of hatcheries: brood stock ponds, artemia hatching tanks, sheds etc. Raceway culture system: site selection, layout plan, types of raceway culture system viz., parallel system, series system etc., Aerators: principles, classification of aerators and placement of aerators. Pumps: purpose of pumping, types, selection of pump, total head, horse power calculation. Filters: types and constructions.

Practical

Evaluation of potential site for aquaculture. Land survey – chain surveying, compass surveying, leveling, plane table surveying and contouring; soil analysis for farm construction. Design and layout plan of fresh water and brackish water farms and hatcheries. Design of farm structure: ponds, dykes and channels. Earth work calculations and water requirement calculations. Visit to different types of farms.

Suggested Readings:

1. Bose, A.N., Ghosh, S.N., Yang, C.T., & Mitra, A. (2009). *Coastal Aquaculture Engineering*. Cambridge University Press.
2. Mishra, R., & Dora, K.C. (2015). *A Text Book on Aquaculture Engineering*. Narendra Publishing House.
3. Lekang, O.-I. (Ed.). (2013). *Aquaculture Engineering*. John Wiley & Sons, Ltd.
4. Lekang, O.-I. (2020). *Aquaculture Engineering* (3rd ed.). Wiley-Blackwell.
5. Wheaton, F.W. (1993). *Aquaculture Engineering*. Krieger Publishing Co.

FSCCCC309: Fisheries Economics 3 (2+1)

Objectives

1. To teach economics theories for taking decisions by individual consumers, producers, and also farms.

Theory

Introduction to fisheries economics, basic economic terminologies – micro and macroeconomics, positive and normative economics, environmental economics, resource, scarcity, farm-firm relationships, production contribution of fisheries sector to the economic development of the country.

Micro-Economics: theories of demand, supply; market – equilibrium price, consumption, utility, Consumer surplus. Elasticity – price, income, cross, application of elasticity in fisheries managerial decision. Farm production economics – production functions in capture and culture fisheries; Costs and returns –breakeven analysis of fish production system; concepts of

externalities and social cost; factors of production, marginal cost and return, law of diminishing marginal return, returns to scale, economies of scale and scope, revenue, profit maximization, measurement of technological change, farm planning and budgeting. Significance or importance of marginal cost.

Macro-Economics: Introduction to national income, accounting, measurement and determinants of national income, the contribution of fisheries to GNP and employment; balance of payments, economic growth and sustainable development. Globalization: dimensions and driving forces. Introduction to GATT and WTO. WTO Framework – Key Subjects - Agreement on Sanitary and Phytosanitary Measures (SPS), Seafood Export Regulations; Non-Tariff Barriers (NTBs) and Agreement on Anti-Dumping Procedures. Fisheries Subsidies and WTO. Fisheries Trade and Environment; protests against globalization and WTO. Intellectual Property Rights (IPR) and different forms. Patents and patenting process, Agreement on TRIPS. Bio-piracy. GMOs in fisheries. Salient features of Indian Patent (Amendment) Act 2005. Overview of Patents in Indian fisheries sector.

Practical

Demand and supply functions of fish market – determination of equilibrium price for fish and fisheries products. Calculation of price, income and cross elasticities. Production function – production with one or two variable inputs. Shifting demand and surplus curve and its importance in fish price. Economic analysis on cost, return and breakeven of any two production units like fish farm/shrimp farm/seed production unit /fish processing plant/export unit.

Suggested Readings:

1. Kreps, D.M. (1990). *A Course in Microeconomic Theory*. Princeton University Press.
2. Dewitt, K.K. (2002). *Modern Economic Theory*. Sultan Chand and Co.
3. Geetika, G.P., & Choudhury, P.R. (2011). *Managerial Economics* (2nd ed.). Tata McGraw-Hill Education Pvt. Ltd. (New Delhi).
4. Jhingran, M.L. (2004). *Micro Economic Theory*. Vikash Publishing House Pvt. Ltd. (New Delhi).
5. Haran, J. (2012). *Managerial Economics*. Garima Publications (Jaipur).
6. Shrivastava, O.S. (2013). *Modern Managerial Economics: Including Micro and Macroeconomics*. Anmol Publications Pvt. Ltd. (New Delhi).
7. Silberberg, E., & Suen, W. (2001). *The Structure of Economics: A Mathematical Analysis*.

SEMESTER-VI

FSCCCC351: Fish Biotechnology and Bioinformatics Objective 2 (1+1)

1. To understand the basic principles of fish biotechnology and bioinformatics and its applications to fisheries

Theory

Introduction to Biotechnology –scope and importance in fisheries/ aquaculture. Structural organization of prokaryotic and eukaryotic cell. Nucleic acids -structure, function and types, Concepts of gene and genetic code, transcription and translation, mutations and their implications. Post-transcriptional modification and RNA processing. Gene regulation andexpression in prokaryotes and eukaryotes. DNA sequencing, Operons. Genetic engineering: Restriction enzymes, Gene isolation, Cloning vectors, Probes. Recombinant DNA technology – vaccines. Transgenic fish and Gene transfer technology, Animal Cell Culture, Hybridoma technology. Molecular and immunological techniques – PCR; immunoblotting; ELISA; Principle of hybridization; Northern blotting; Western blotting; Southern blotting; DNA fingerprinting; Restriction fragment length polymorphism. Biosensors. Concept of bioremediation of water, bioprocess engineering and bioprospecting. Bioinformatics: Introduction to Bioinformatics. Biological Databases and tools: Introduction, Types of biological databases: Primary and secondary databases; PDB, NCBI, formats and contents; Sequence retrieval, manipulation; Primer design; Restriction mapping; ORF finding; EMBOSS, Molecular visualization Sequence analysis.

Practical

Study of structure of prokaryote and Eukaryote Cells. Isolation of DNA and RNA. PCR amplification. Gel Electrophoresis. Study on Model of protein Synthesis. Study of models of DNA Technology. Cell Culture. Isolation of Nucleic Acids. Restriction enzymes. ELISA. DNA sequence analysis and comparison. Study of data search engines. Study of different databases.

Suggested Readings:

1. Diwan, A.D. (2018). *Biotechnology of Penaeid Shrimps*. Narendra Publishing.
2. Felix, S., & Ninawe, A.S. (2014). *Aquaculture Biotechnology*. Daya Publishing House.
3. Fletcher, G.L., & Rise, M.L. (2012). *Aquaculture Biotechnology*. Wiley Blackwell.
4. Gautam, N.C. (2007). *Comprehensive Biotechnology – Vol. 4: Aquaculture Biotechnology*. Shree Publishers and Distributors.
5. Green, M.R., & Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual* (4th ed.). Cold Spring Harbor Laboratory Press.
6. Greglutz, C. (2001). *Practical Genetics for Aquaculture*. Wiley Blackwell.
7. Klug, W.S., Cummings, M.R., Spencer, C.A., & Palladino, M.A. (2012). *Concepts of Genetics* (10th ed.). Pearson.
8. Lakra, W.S., Abidi, S.A.H., Mukherjee, S.C., & Ayyappan, S. (2014). *Fisheries Biotechnology*.
9. Montet, D., & Ray, R.C. (2009). *Aquaculture Microbiology and Biotechnology* (Vol. 1). Science Publishers.

10. Nair, P.R. (2008). *Biotechnology and Genetics in Fisheries and Aquaculture*. Dominant Publishing.
11. Pandian, T.J., Strüssmann, C.A., & Marian, P.P. (2005). *Fish Genetics and Aquaculture Biotechnology*. Science Publishing.
12. Primrose, S.B. (1989). *Modern Biotechnology*. Blackwell.
13. Reddy, P.V.G.K., Ayyappan, S., Thampy, D.M., & Krishna, G. (2005). *Fish Genetics and Biotechnology*. ICAR.
14. Reece, R. (2017). *Analysis of Genes and Genomes*.
15. Kim, S.-K. (2017). *Springer Handbook of Marine Biotechnology*.
16. R, Sunita. (2015). *Fish Biotechnology*. Random Publications.

FSCCCC352: Fish Immunology **2 (1+1)**

Objectives

1. To impart knowledge on basic principles of fish and shellfish immunology
2. To understand the immune responses to infection by various fish pathogens and to offer scope for the development of disease protective/prevention measures against bacteria, fungi, viruses and parasites of fish

Theory

Introduction, brief history to immunology. Types of immunity: Innate and adaptive immunity, cell-mediated and humoral immunity, cells and organs of the immune system. Antigens – structure and types, epitopes, haptenes. Antibody – fine structure, classes with structure and functions, antigenic determinants on immunoglobulins. MHC complex – types, structure, and functions. Antigen-antibody interactions- principle, antigen recognition by B-cells and T cells. Antigenantibody reaction - Precipitation and agglutination reactions. Microorganisms associated with fishes in health and disease. Defense mechanism in finfish and shellfish- specific and non-specific immune system. Pathogenicity and virulence. Sources of infection, transmission of disease-producing organisms, portals of infection. Immunity to bacteria, fungi and parasites. Role of stress and host defence mechanism in disease development. Vaccines - types of vaccines – whole-cell vaccine, purified macromolecules, recombinant –vector, DNA vaccines and multivalent subunit vaccines, modes of vaccine administration. Serological methods in disease diagnosis. Immunostimulants –types, mechanism of action, modes of administration. Immunoassays, immunodiffusion, ELISA, immunofluorescence, neutralization, radioimmunoassay, serotyping.

Practical

Collection, separation and identification of fish leucocytes. Separation of blood plasma and serum. Differential counting - RBC and WBC by Haemocytometer. Study of different types of leukocytes and isolation of macrophages. Precipitin reactions - Agglutination testimonies, diffusion, double immune-diffusion, radial immune-diffusion assay, ELISA. Methods of vaccine preparation and techniques of fish immunization.

Suggested Readings:

1. Abbas, A.K. (1991). *Cellular and Molecular Immunology*. Saunders Publisher, Philadelphia.
2. Anderson, D.P. (2003). *Textbook of Fish Immunology*. Narendra Publishing House, Delhi.
3. Cooper, E.L. (1982). *Immunology and Immunization of Fish*. Pergamon Press, New York.
4. Cooper, E.L. (1982). *General Immunology*. Pergamon Press, Oxford.
5. Elgert, K.D. (2009). *Immunology*. John Wiley and Sons, New York.
6. Fikrig, S.M. (1982). *Handbook of Immunology for Students and House Staff*. Verlag Chemie International, Florida.
7. Paul, W.E. (2008). *Fundamental Immunology*. Wolters Kluwer, USA.
8. Richard, C. (2015). *Immunology: A Short Course*. Wiley Blackwell, UK.
9. Sharma, D.K. (2015). *Immunology*. New India Publishing Agency, New Delhi.

FSCCCC353: Therapeutics in Aquaculture Objectives 2 (1+1)

1. To learn the principles and protocols of drugs in aquaculture
2. To impart knowledge of antibiotic used in aquaculture

Theory

Scope and current scenario of therapeutics in aquaculture. Chemotherapy: History, definition, terms used and classification of AMA. Antibacterial agents, mode of action, general principles, classification, Antibiotics, different classes and their mode of action, properties etc. Antibiotic resistance. Antiseptics and disinfectants. Antiparasiticides: Ectoparasites, Endoparasites and Protozoans. Antibiotics used in aquaculture. Biologics: Immuno-stimulants and VaccinesPrinciples in preparation/formulation, mechanism of action. Drug formulation for aquaculturePrinciples in preparation/formulation, mechanism of action, drug leaching, stabilizer, binders, and dosage. Therapeutants in aquaculture: Classification, pesticides, fungicides/ algicides, hormones, anesthetics, flesh color enhancers, Chemicals of therapeutic value. Law priority aquaculture drugs. Drugs used for structural material and substances for maintenance, substances connected with zoo technical practices. List of the drugs used in aquaculture with therapeutics.

Practical

Regulations of drug use. Introduction to antimicrobials. Preparation of potassium permanganate solution, preparation of weak Tincture Iodine. Minimum inhibitory concentration (MIC). Five plate screening test for the detection of antibiotic residue. Calculation of different disinfectants dosage in treating fish ponds. Generic name, patent name, dosage and indications of various aquaculture drugs used in fish health.

Suggested Readings:

1. Bryan, L.E. (1989). *Handbook of Experimental Pharmacology*, Vol. 91. Springer-Verlag, Berlin.
2. Brown, K.M. (2000). *Applied Fish Pharmacology*. Kluwer Academic Press, London.
3. Herwig, N. (1979). *Handbook of Drugs and Chemicals Used in the Treatment of Fish Diseases*. Charles C. Thomas, Springfield.

4. Khory, R.N. (1999). *Materia Medica of India and Their Therapeutics*. Komal Prakashan, Delhi.
5. Lancaster, R. (1980). *Pharmacology in Clinical Practice*. William Heinemann Medical Books Ltd., London.
6. Moini, J. (2009). *Fundamental Pharmacology*. Cengage Learning, New Delhi.
7. Pandey, G. (2017). *Fish Pharmacology and Toxicology*. DPH, New Delhi.

FSCCCC354: Coastal Zone Management Objectives 2 (1+1)

1. To impart knowledge on the importance of coastal zones for human society
2. To teach the students on the different management strategies for the conservation of coastal zones.
3. To impart fundamental and advanced knowledge on the sources of pollution and its controlling measures.

Theory

Estuaries, Wet lands and Lagoons, Living resources – Non-living resources. Principles of remote sensing: orbits, electromagnetic radiation, diffraction, electro-optical, and microwave systems. Data Input, Data Management, Data Quality. Remote Sensing for Coastal Management. Geographical Information System (GIS): Definition, Concepts, Data Acquisition and Data Management. Applications of GIS in aquatic resource identification. Coastal Regulation Zone (CRZ) Act, Coastal regulation zones for main land and islands – Environmental policies, planning, administrative and regulations. CRZ mapping. Integrated Coastal Zone Management (ICZM); concept, application, and case studies. Communication, research, integration, institutional arrangements, regulations, stakeholder participation, the role of the private sector in ICZM. Impacts of human activities on coastal and ocean areas: Challenges related to climate change, expanding tourism, declining fisheries, intensive shipping and biodiversity protection. Problems related to sectors such as tourism and fisheries in the ICZM context; Analysis of multiple use management problems typical for the coastal areas with the maritime industry. Environmental Impact Assessment (EIA): Principles and process. EIA of coastal industries. Evaluation and Methodology; Social Impact Assessment and other developmental activities.

Practical

Field visit to different coastal environments to study erosion of beaches. Identification of ecologically sensitive areas and protection. Study of CRZ, ICZM along the coastal belt. Study on implementation and violation of CRZ. Study of application of remote sensing and GIS. Collection of species of fishes and other organisms and studying the assemblages of organisms of rocky, sandy and muddy shores, lentic and lotic habitats. Observation of adaptive characters and interrelationships like commensalisms, symbiosis, parasitism and predation to combat disaster. Field visits to mangroves, marine parks, sanctuaries, coral reefs, rivers, hills, streams, lakes and reservoirs. Working out biodiversity indices. Project preparation of EIA.

Suggested Readings

1. Cairns, J. Jr. (1994). *Implementing Integrated Environmental Management*. Virginia Tech University.
2. Clark, J.R. (1992). *Integrated Management of Coastal Zones*. FAO Fisheries Technical Paper No. 327, Rome.
3. United Nations Department of International Economic and Social Affairs. (1982). *Coastal Area Management and Development*. New York.
4. Ramkumar, M., James, A., Menier, D., & Kumarswamy, K. (2018). *Coastal Zone Management: Global Perspective, Regional Processes, Local Issue*. Elsevier.

FSCCCC355: Microbiology of Fish and Fisheries Products 2 (1+1)

Objectives

1. To teach nature and activity of microbes in fish and fishery products, microbiological spoilage and preservation.
2. To teach in detail about food-borne microorganisms of human health significance, food-borne diseases and their prevention.

Theory

Introduction and history of microorganisms in foods. Role and significance of microorganisms in nature and in foods. Sources and types of microorganisms in fish and fishery products. Factors (intrinsic and extrinsic) affecting the growth and survival of microorganisms in food. Enumeration of microorganisms in food by conventional and rapid techniques. Microbial principles of fish preservation and processing by application of low temperature, high temperature, drying, irradiation and chemicals. Microbiology and spoilage of fresh, semi-processed, and processed fish and fishery products. Indicators of microbiological quality of fish and fishery products. Food-borne pathogens involved in infective and intoxication type of food poisoning – *Vibrio cholerae, Vibrio parahaemolyticus, E. coli, Salmonella, Listeria monocytogenes, Clostridium botulinum, C. perfringens, Campylobacter* and *Staphylococcus aureus* – their occurrence, growth, survival, pathogenicity and prevention. Other biological hazards associated with fish and fishery products-marine toxinsshellfish toxins, scombroid toxins, ciguatera toxins and puffer fish toxins; mycotoxins, parasites and viruses.

Practical

Sampling and processing of samples for microbiological investigation. Enumeration of microorganisms associated with finfish, shellfish, water and ice. Testing of water for potability. Isolation and identification of pathogenic bacteria associated with fish and fishery products - *Vibrio cholerae, Vibrio parahaemolyticus, E. coli, Salmonella, Listeria monocytogenes* and faecal streptococci. Biochemical tests for characterization of bacteria. Molecular methods for the detection of pathogenic microorganisms. Determination of MIC and MCC of chemical preservatives.

Suggested Readings

1. Anon. (2001). *Food Borne Disease Handbook* (2nd edn., Vol. IV). Seafood and Environmental Toxins. Marcel Dekker.
2. Baveja, C. P. (2022). *Textbook of Microbiology*. Arya Publishing Company.
3. Chakraborty, P. (1995). *A Textbook of Microbiology*. New Central Book Agency.
4. Cruickshank, J. (1986). *Methods in Microbiology*. Academic Press.
5. Doyle, M.P., Beuchat, L.R., & Montville, T.J. (1997). *Food Microbiology: Fundamentals and Frontiers*. American Society for Microbiology.
6. Aneja, K.R. (2008). *Textbook of Basic and Applied Microbiology*. New Age International Publishers, New Delhi.
7. Maheshwari, D.K. (1999). *A Textbook of Microbiology*. S. Chand Publishing.
8. Pelczar, M.J. Jr., & Chan, E.C.S. (1998). *Microbiology*. McGraw Hill.
9. Narayanan, R. (2013). *Food Microbiology: Basic and Applied with Laboratory Exercises*. New India Publishing Agency, New Delhi.
10. Roberts, D., Hooper, W., & Greenwood, M. (1995). *Practical Food Microbiology: Methods for the Examination of Food for Microorganisms of Public Health Significance*. Public Health Laboratory Service, London.

FSCCCC356: Refrigeration and Equipment Engineering 2 (1+1)

Objectives

1. To teach engineering aspects about refrigerators, freezers
2. To learn about heat load calculation and COP. To teach electrical aspects of fishing vessel

Theory

Fundamentals: Force, work, power, energy, volume, pressure, temperature. Heat, specific heat, sensible heat, latent heat, comparison between heat and work - A path function. Thermodynamics: Laws of Thermodynamics, Laws of perfect gases, Thermodynamic processes, application of First and Second law of Thermodynamics in refrigeration, Thermodynamics cycle, entropy, enthalpy. Refrigeration: History of refrigeration, definition, principle, classification, Types of refrigeration systems i.e., Air refrigeration, vapour absorption refrigeration system. Vapour compression refrigeration system. Refrigeration plant: Layout of refrigeration plant, Construction and insulating materials used for the cold storage construction, Frozen product storage, capacity of cold storage, usage of Anteroom. Refrigeration systems: Vapour compression refrigeration system advantages and disadvantages as compared to other refrigeration systems, Types of Vapour compression refrigeration cycles i.e., Theoretical Vapour compression refrigeration cycle, Actual refrigeration cycle. Compressors: Definition, Types of compressors, construction, working principle, advantages and disadvantages. Evaporator: Definition, Types of Evaporators, construction, working principle, advantages and disadvantages. Condenser: Definition, Types of Condensers, Cooling Towers, construction, working principle, advantages and disadvantages. Expansion valve: Definition, Types of Expansion valve, construction, working principle advantages and disadvantages. Refrigerant: Primary refrigerant, secondary refrigerant, properties, ideal refrigerant, leakage detection. Study of auxiliary equipment: Receiver, oil charging, refrigerant charging, gas purging, oil draining, types of defrosting. Ice-plant: Ice plant planning, Brine tank construction, preparation of brine. Types of ice, storing of ice, Equipment used in ice

plants. Freezers: Definition, Design, and construction of freezers i.e. Plate freezer, Blast freezer, Tunnel freezer, spray or immersion freezers, refrigerated fish rooms and fish hold. Alternative refrigeration technique arrangements used onboard the fishing vessel i.e., Refrigerated Sea water (RSW), Chilled Sea water (CSW). Refrigerated transport. Cooling load: Unit of refrigeration, coefficient of performance (C.O.P), Refrigeration effect, study, and use of Psychrometric chart. Cooling load estimation, introduction, components of cooling load, heat gain through walls, roofs, products, occupants, lighting equipment. Theory of machines: Transmission of power, friction wheels, shaft, gears, belt, and Chain drive. Study of equipment used in fish processing with reference to canning, sausage, freeze drying and irradiation. Maintenance: Definition, Types of maintenance, general maintenance of freezing plant, cold storage and ice plant.

Practical

Drawing of Refrigeration and Fish processing machineries, plant layout. Graphically represented symbols used in refrigeration. Handling and operation of compressors, condensers, evaporators expansion valves, low- and high-pressure switches. Study of auxiliary equipment: Receiver, oilharging, refrigerant charging, gas purging, oil draining, types of defrosting. Power transmission line diagram of different fish processing machineries. Visit to processing plant, refrigeration plant, ice plant. Visit to fishing harbor or landing center to study the fish hold, refrigerated fish rooms. Calculation on refrigeration effect and cooling load.

Suggested Readings

1. Ayyappan, V.P. (2002). *Elements of Electrical Technology*. CIFNET, Cochin. 96p.
2. Joshy, C.D., & Devadhason, M. (2001). *Basic Electronics and Fish Finding Equipment*. CIFNET, Cochin. 42p.
3. Shawyer, M., & Medina Pizzali, A.F. (n.d.). *The Use of Ice on Small Fishing Vessels*. FAO, Rome. 102p.
4. Sternin, U.G., Nikonorou, I.V., & Bumeister, Yu K. (1976). *Electrical Fishing*. Keter Publishing House, Jerusalem Ltd. 258p.

FSCCCC357: Navigation and Seamanship Objectives 2 (1+1)

1. To learn engineering aspects of fish acoustic equipment
2. To learn navigation and seamanship for fishing vessel safety

Theory

Principles of navigation –terms and definitions, finding positions and method of position fixing, magnetic Compass-parts and functions, cardinal, inter cardinal, three letter and lay points, pelorus and azimuth mirror, method of observation. Sextant -parts and functions, finding adjustable and nonadjustable errors and principles and use. Hand lead line – construction and markings and method of taking soundings. Types of speed logs –patent log, impeller log. Types of marine charts, Mercator and gnomonic projections great circles and rumba lines, chart collections and chart readings, chart observation and fixing positions. The IALA-buoy age systems, cardinal, and lateral marks, meaning of shapes, colours and lights top marks and explanation of approaching, international code of signals, flag signals mars code and storm signals general system, brief system

and extended system, storm signals stations Indian coasts, Fog signals, types and methods. Distress signals, methods, types and communication international regulations for preventing collision at sea and recognition of lights and shapes at sea. Observation of radar and parts and functions of radar, aneroid barometer, parts and functions of echo sounder, and sonar, observation of GPS. Principles of seamanship- Causes of fire at sea, fire prevention on board the vessel and method of firefighting at sea and recommended firefighting appliances. Lifesaving appliances – life jackets, life buoys and method of operations and contents, SART and EPIRB. Observations of storms, formation of storms and method of locating the eye of the storms and method of escaping from the center of the storms as per buys ballet law. Preparing vessels to face heavy weather. Temporary repairs for leaks constructions of the steering system and rigging emergency jury rudder. Types of anchors and their applications: selection of suitable anchorage, procedure for anchoring anchor watch and procedure to combating dragging of anchor, method of standing moor and running moor, open moor berthing procedures, axial thrust, transverse thrust mooring and securing the vessel to the jetty, rigging fenders and gangways, and method of leaving vessels from the berth.

Practical

Anchoring, coming alongside the berth and leaving. Practicing the different types of knots and wire splices. Use of magnetic compass, GPS, Echo-sounder. CHART WORK - Finding positions by latitudes and longitudes by position lines, by cross-bearing, horizontal sextant, angles, vertical sextant angle and by running fix. Finding position by speed, distance and time. Finding set and drift of current and finding course. Steering course and finding position by counter acting the current observation of RADAR.

Suggested Readings

1. CIFNET. (2004). *Fishery Engineering*, pp. 212–238.
2. FAO. (1998). *Fishing Operations – Vessel Monitoring Systems*, FAO Technical Guidelines for Responsible Fisheries No. 1, Suppl. 1, FAO, Rome.
3. Joshy, C.D. & Devadhason, M. (2001). *Basic Electronics and Fish Finding Equipment*. CIFNET, Cochin, pp. 31–42.
4. Larkin, F.J. (1998). *Basic Coastal Navigation* (2nd ed.). Sheridan House Inc., New York, 273 p.
5. MacLennan, D.N. & Simmonds, E.J. (1992). *Fisheries Acoustics*, Fish and Fisheries Series 5. Chapman and Hall, London, 323 p.
6. Mitson, R.B. (n.d.). *Fisheries SONAR*. Fishing News Books Ltd., England, 274 p.
7. Sreekrishnan, Y. & Shenoy, Latha. (2001). *Fishing Gear and Craft Technology*. Indian Council of Agricultural Research, New Delhi, 342 p.

FSCCCC358: Statistical Methods **3 (2+1)**

Objectives

1. To learn basic statistical methods for research data analysis
2. To teach statistical problems for analysis

Theory

Definition of statistics, Concepts of population, sample, Census and sample surveys. Classification of data, frequency and cumulative frequency table. Diagrammatic and graphical representation of data - bar diagrams, pie-diagram, histogram, frequency polygon, frequency curve and Ogives. Important measures of central tendency - arithmetic mean, median and mode. Relative merits and demerits of these measures. Important measures of dispersion - Range, Mean Deviation, Variance and Standard Deviation. Relative merits and demerits of these measures. Coefficient of variation; Normal Curve, Concepts of Skewness and kurtosis. Definitions of probability, mutually exclusive and independent events, conditional probability, addition and multiplication theorems. Random variable, concepts of theoretical distribution; Binomial, Poisson and Normal distributions and their use in fisheries. Basic concept of sampling distribution; standard error and central limit theorem. Introduction to statistical inference, general principles of testing of hypothesis, types of errors. Tests of significance based on Normal, t, and Chi-square distributions. Bivariate data, scatter diagram, simple linear correlation, measure and properties, linear regression, equation and fitting; relation between correlation and regression. Length-weight relationship in fishes; applications of linear regression in fisheries. Methodology for estimation of marine fish landings in India, Estimation of inland fish production in India and problems encountered.

Practical

Construction of questionnaires and schedules. Diagrams and frequency graphs. Calculation of arithmetic mean, median, mode, range, mean deviation, variance, standard deviation. Exercises on probability, Binomial and Poisson distributions, Area of normal curve, confidence interval for population mean, Test of hypothesis based on normal, t, and chi-square. Computation of Simple correlation and regression. Fitting of length-weight relationship in fishes.

Suggested Readings – Statistics

1. Illowsky, B. et al. (2022). *Introductory Statistics*. OpenStax Publishers.
2. Bruce, P., Bruce, A., & Gedeck. (2020). *Practical Statistics for Data Scientists*. Shroff/O'Reilly.
3. Das, N. G. (2017). *Statistical Methods* (Vol. 1 & 2). Tata McGraw Hill Education.
4. Gupta, C.B. (2009). *An Introduction to Statistical Methods* (23rd ed.). Vikas Publishing House.
5. Gupta, S. P. (2021). *Statistical Methods*. Sultan Chand and Sons.
6. Wasserman, L. (2004). *All of Statistics: A Concise Course in Statistical Inference*. Springer.

FSCCCC359: Fisheries Policy and Laws **1(1+0)**

Objectives

1. To familiarize various fisheries policy and laws of our country
2. To gain in-depth knowledge on the fisheries and aquaculture policies for sustainable development.

Theory

Introduction to public administration, principles of organization and management of public enterprise. Central and State responsibilities for fisheries development, organizational set up of fisheries administration at the Centre and state levels. Present relevance of past fisheries policies and recent policies in fisheries sector. Functions and powers of functionaries of the department of fisheries, corporations and cooperatives. Different central and state-level fisheries institutions. Role of Central and State Government in the regulatory activities of Aquaculture and fisheries. Implementation of community-based resource management plans. Historical review of fisheries development and management in India and world. International agencies/organizations for promotion of fisheries worldwide. Fisheries legislation: Overview of fisheries and aquaculture legislations in India. Indian Fisheries Act, 1897. Environmental legislation; Water Act, Air Act and Environmental (Protection) Act. International environmental legislation and its impact on fisheries.

Suggested Readings – Maritime and Fisheries Law

1. Anon. (1998). *Maritime Law of India in the International Context*. Bhadarkar Publications.
2. Brahtz, J.F.P. (1972). *Coastal Zone Management*. U.N. International Economic and Social Affairs, New York.
3. Burke, W. T. (1992). *Fisheries Regulations under Extended Jurisdiction and International Law*. FAO.
4. Churchill, R.R. & Lowe, A.V. (1988). *Law of the Sea*. Manchester University Press.
5. Dixit. (2013). *Regulating Oceanic Fishing: International Laws and Treaties*. Swastik Publications, Delhi. 264 pp. ISBN: 978-93-81991-04-6
6. Henkin, L., Pugh, R.C., & Smit, H. (1993). *International Law: Cases and Materials*. West Publishing Co.
7. Holden, M. & Garrod, D. (1996). *The Common Fisheries Policy: Origin, Evaluation and Future* (2nd edn.). Fishing News Books Ltd.
8. Kumar, U. *Biodiversity Principles and Conservation*. Narendra Publishing House.
9. Pandey. (2014). *Fisheries Governance and Legislation in India*. Narendra Publishing House, Delhi. 182 p. ISBN: 978-93-82471-85-1
10. Raval. (2013). *Combating Marine Pollution: International Laws and Regulations*. Cyber Tech Publications, New Delhi. 264 p. ISBN: 978-93-5053-150-1
11. Sinha, R.K. (Ed.). (1996). *Marine Resources and Applicable Laws* (World Environmental Series – 009). Commonwealth Publications.
12. Verghese, C.P. (1989). *Fishing Regulation in India's Territorial Waters*. World Fishing.

FSCCCC360: Fisheries Co-operatives and Marketing 2 (1+1)

Objective

1. To familiarize students with basic concepts and principles of co-operative and marketing with reference to fisheries

Theory

Principles and objectives of co-operation, co-operative movement in fisheries in India, structure, functions, status and problems of fisheries co-operatives management in relation to resources, production and marketing. Role of credit for fisheries development, credit requirements of fishers, source and type of credit/finance, micro-credit, indigenous and institutional finance, structure of institutional finance in fisheries; returns, risk bearing ability and recovery in fisheries sector; role of NABARD in fisheries development; role of insurance in fish and shrimp farming and industry. Basic accounting procedures, profit and loss account. Introduction to marketing management; core marketing concepts: market structure, functions and types, marketing channels and supply chain, marketing margins, marketing environment, marketing strategies, product development and product mix, consumer behaviour and marketing research. Fish markets and marketing in India, demand and supply of fish, market structure and price formation in marine and inland fish markets; cold storage and other marketing infrastructure in India; export markets and marketing of fish and fishery products; Trade liberalization in fisheries markets. Integrated marketing approach in fisheries. Sea food export case study on product and market diversification export and import policies (fisheries). New product development and market segmentation. Export and import policies relevant to fisheries sector.

Practical

Developing questionnaire and conducting market surveys, analysis of primary and secondary market data. Exercises on equilibrium price for fish and fishery products; estimation of demand and supply using simple regression. Analysis of credit schemes of banks and the government.

Case studies of cooperatives. Visit to co-operative societies, commercial banks and fish markets and organizations dealing with marketing of fish and fishery products. Pattern and Performance of India's Seafood Exports; Case studies on product and market diversification. Case studies on competitiveness of Indian fish and fish products.

Suggested Readings – Fisheries Economics and Marketing

1. ICAR. (2003). *Text Book of Agricultural Marketing and Cooperation*. Indian Council of Agricultural Research (ICAR).
2. Krugman, P.R. & Obstfeld, M. (1991). *International Economics: Theory and Policy*. Harper Collins Publishers.
3. Mahajan, K.A. (2003). *Cooperative Marketing*. Anmol Publications Pvt. Ltd.
4. Ministry of Agriculture. *Handbook of Fisheries Statistics*. Government of India, New Delhi.
5. Porter, G. (1998). *Fisheries Subsidies – Overfishing and Trade*. Geneva.

SEMESTER-VII

ELECTIVE COURSES

Elective (major/minor) courses for VII Semester

Sl. No.	Course Code	Course Title	Credit Hours
Major Courses (Students have the option to choose any Four Major Courses - 12 credits)			
1.	FSCDSE401	Open-water Aquaculture	3 (2+1)
2.	FSCDSE402	Smart Aquaculture Production Systems	3 (2+1)
3.	FSCDSE403	Fish and Shellfish Pathology	3 (2+1)
4.	FSCDSE404	Disease Diagnostic Techniques	3 (2+1)
5.	FSCDSE405	Sustainable Fisheries Management and Conservation	3 (2+1)
6.	FSCDSE406	Aquatic Pollution	3 (2+1)
7.	FSCDSE407	Fishery Oceanography	3 (2+1)
8.	FSCDSE408	Analytical Techniques in Aquatic Environmental Studies	3 (2+1)
9.	FSCDSE409	Quality Assurance of Fish and Fishery Products	3 (2+1)
Minor Courses (Students have the option to choose any Four Minor Courses - 8 credits)			
Sl. No.	**Course Code**	**Course Title**	**Credit Hours**
1.	FSCDSE410	Coldwater Aquaculture and Recreational Fisheries	2 (1+1)
2.	FSCDSE411	Aquatic Microbiology	2 (1+1)
3.	FSCDSE412	Climate Change and its Impact on Fisheries	2 (2+0)
4.	FSCDSE413	GIS and Remote Sensing in Fisheries	2 (1+1)
5.	FSCDSE414	Responsible and Sustainable Fishing Methods	2 (1+1)
6.	FSCDSE415	Principles and Techniques of Seafood Analysis	2 (1+1)
7.	FSCDSE416	Trade Regulations, Certification and Documentation in Export of Fish and Fishery Products	2 (1+1)
8.	FSCDSE417	Marketing Intelligence and Business Analysis	2 (1+1)
9.	FSCDSE418	ICT in Fisheries	2 (1+1)

Elective (Major) Courses

FSCDSE401: Open-Water Aquaculture Objective **3 (2+1)**

Objectives:

1. To learn about the open water resources and their enhancement of aquaculture production

Theory

Overview of global scenario of aquaculture in open waters, open water resources in India, Present status, Utilization, Prospects of production augmentation, Utilization of open water bodies for aquaculture to enhance production. Salient features of open water limnology and their significance to fisheries development; management of small, medium and large water bodies; present status

and future prospects in open water fish production. Recent advances in open water fisheries management; conservation measures in open water fisheries. Fish stocking in open water. Cage Culture: Role of cage in enhancement of fish production in reservoirs, estuaries, open sea and open water bodies; History of cage culture, advantages of cage culture; Cages for sea, estuaries, reservoirs, lakes and canals; Selection of suitable site of cage culture; cage materials, designs, shape, size and fabrication; cage frames and supporting system; Different designs of open sea farming structures-construction of cages-bioengineering problems and solutions, Species selection for open water aquaculture, Rearing of fingerlings, advanced fingerlings and table size fish in open water bodies; Constraints in cage culture; Economics of cage culture; Integration of cage culture with other farming systems. Pen Culture: History of pen culture, pen materials, fabrication; breeding of fish in pen; rearing of spawn in pen; grow-out from pens; Suitable species for culture in pens; constraints in pen culture; economics of pen culture. Practices: Ranching in open waters, species quality and quantity, Natural feed enhancement, Supplementary feeding in cages and pens, Stock assessment, Harvesting and conflicts with irrigation, Drinking water and hydroelectric projects on open water farming. Environmental impact of Open water Aquaculture: Salinity intrusion, Effluent discharge, Eutrophication, Chemical residues including antibiotics and hormones, Destruction of natural habitat including paddy field and mangroves. Social issues and conflicts with other users on resources.

Practical

Preparation of charts on the present situation of open water fisheries productivity. Different types of cage materials, fabrication of cages and pens and their installation. Determination of stocking density in cages and pens. Feeding in cages and pens. Stock assessment in cages and pens. Environmental impact of cages and pens. Case studies on cage and pen culture. Field visit to cage and pen culture site to acquaint with construction details and operation.

Suggested Readings

1. Beveridge, M. (2008). *Cage Aquaculture*. Oxford Publications.
2. Beveridge, M.C.M. (Ed.). (2004). *Cage Aquaculture* (3rd ed.). Blackwell Publishing.
3. Burnell, G., & Allan, G. (2009). *New Technologies in Aquaculture* (1st ed.). Woodhead Publishing.
4. Chiu Liao, I., & Kwei Lin, C. (2000). *Cage Aquaculture in Asia: Proceedings of the First International Symposium on Cage Aquaculture in Asia*. AFS and WAS Publications.
5. FAO. (2018). *The State of World Fisheries and Aquaculture: Meeting the Sustainable Development Goals*. Rome.
6. NFDB. (2018). *Guidelines for Sea Cage Farming in India*.
7. Syda Rao, G., Imelda-Joseph, Philipose, K.K., & Suresh Kumar, M. (2013). *Cage Aquaculture in India*. CMFRI Publication.

FSCDSE402: Smart Aquaculture Production Systems Objective 3 (2+1)

Objectives

1. To learn the advanced aquaculture production system research for different species globally

Theory

Introduction: An overview of global aquaculture production, demand- consumption scenario and emerging trends, Present status, Constraints and future prospects in India and the world, Aquaculture practices indifferent parts of the world, Enhancing carrying capacity in culture systems.

Biofloc technology: Principles of biofloc, Different carbon sources, Design of aeration system and biofloc reactor. Carrying capacity, C: N ratio, harvesting of biofloc, Biofloc quality and quantity, Biofloc as feed ingredient, Stocking of fish and shellfish species. Bioremediation in wastewater aquaculture. Minimal water exchange aquaculture systems: Principles of closed system farming, RAS, Components, design of mechanical and biological filters for the water reuse system, Sludge removal, disposal of wastes and control of pollution to the environment, Design of RAS, biofiltration and nitrifiers, Suitable cultivable species for indoor culture systems, polyhouses. Aquaponics: Principles, Components and design of different aquaponics systems, Components in aquaponics, ratio of fish and plants, Water quality and system maintenance, Resource utilization, Nutrient recycling and zero discharge of nutrients. Running water systems: Flow-through system, Raceways (IPR), IMTA, Partitioned Aquaculture Systems (PAS), Aquamimicry systems. Other farming methods: Cluster farming, Organic farming, Satellite farming, co-operative farming and conservation aquaculture, Network of production and marketing aspects, Economics of super intensive farming systems, Advantages and disadvantages.

Practical

Design, fabrication and performance evaluation of biofloc systems; Different equipment in closed grow-out system; Aerators, Biofilters, RAS, Raceways, IMTA, PAS and aquaponics systems; Plankton and microbial analysis of biofloc. Studies on different C: N ratio; Nutrient analysis in aquaponics; Visit to hatcheries with super-intensive models. Identification and understanding the network of the systems; Market analysis for the produces; Analysis of economic advantages, case studies.

Suggested Readings

1. Avnimelech, Y. (2015). *Biofloc Technology – A Practical Guidebook* (3rd ed.). World Aquaculture Society.
2. Chakrabarti, N.M. (2014). *Biology, Culture and Production of Indian Major Carps*.
3. Felix, S. (2008). *Biosecured Aquaculture – Principle and Prototype*. Agrobios (India).
4. Soderberg, R.W. (1995). *Flowing Water Fish Culture*. Lewis Publishers.
5. Tidwell, J.H. (Ed.). (2012). *Aquaculture Production Systems*. Wiley-Blackwell.

FSCDSE403: Fish and Shellfish Pathology Objective 3 (2+1)

Objectives:

1. To understand the structural and functional changes in cells, tissues and organs in relation to the development of various finfish and shellfish diseases.

Theory

General pathology: Brief introduction to finfish and shellfish anatomy and histology; General pathology of finfish and shellfish Pathophysiology of fish: Pathophysiology of finfish and shellfish; Stress and stressors; General adaptation syndrome; Types of cellular adaptations; Hypertrophy, hyperplasia, Atrophy and metaplasia, Neoplasia. Inflammation and cellular pathology: Reversible cellular changes and accumulations; Fatty changes and pigments; Inflammation; Causes of inflammation; Cellular responses to inflammation; Mediators; various patterns of inflammation; The difference between acute and chronic inflammation; Tissue repair; Cell death; Necrosis, Apoptosis, Autophagy; Necroptosis; Their mechanisms and different morphological patterns. Clinical pathology: Normal constituents of blood; Alterations in the haematological parameters and enzymes with reference to different pathological conditions in finfish; Haematology of shrimp and molluscans; Clotting mechanisms; other host defence mechanisms.Systemic pathology of finfish: Systemic pathology of finfish integumentary system, Respiratory system, Vascular system, Digestive system, Excretory system, Nervous system, Musculoskeletal and Endocrine system due to bacteria, Parasites and viruses. Systemic pathology of shellfish: Major pathological changes due to infectious diseases in the integumentary system, Lymphoid organ, Gill, Hepatopancreas, Gut and other organs of crustaceans; Major pathological changes due to diseases in molluscans.

Practical

Necropsy techniques. Collection and fixation of tissues. Complete histology and different staining techniques. Examination and interpretation of the pathological changes in fish tissues. Complete blood profile of finfish. Routes of blood collection from fish. Different staining techniques for blood cell visualization. Morphology of blood cells. Total leucocyte count. Differential leucocyte count.

Suggested Readings

1. Coleman, W.B., & Tsongalis, G.J. (2009). *Molecular Pathology*. Elsevier Publisher, Boston.
2. Ellis, A.E. (1985). *Fish and Shellfish Pathology*. Academic Press, London.
3. Ferguson, H.W. (2006). *Systematic Pathology of Fish*. Scotian Press, London.
4. Killeen, A.A. (2001). *Molecular Pathology Protocols*. Humana, U.S.A.
5. Lloyd, R.V. (2004). *Endocrine Pathology*. Humana Press, Totowa.
6. Roberts, R.J. (2012). *Fish Pathology*. Wiley-Blackwell, Chichester.
7. Salle, A.J. (1961). *Fundamental Principles of Pathology*. McGraw-Hill Co., New York.

FSCDSE404: Disease Diagnostic Techniques 3 (2+1)

Objective

1. To comprehend theoretical and practical aspects of different disease diagnostic techniques used in aquaculture and to take appropriate decisions on fish health management and appropriate choice of treatment

Theory

Introduction to fish disease diagnosis: Introduction to disease diagnosis; different roles and levels of diagnosis in aquaculture; The evolution of diagnostic techniques in aquaculture; A brief

introduction to diagnostic features of important diseases of finfish and shellfish. Microbiological techniques: Safety in microbiology laboratory; Bio-safety levels and risk groups; Techniques in sterilization; Preparation of microbiological media. Culture Microscopic techniques: Bright field, Darkfield, Phase contrast, Fluorescence and electron microscopy. Cell culture-based diagnostic methods: Introduction to cell culture techniques; Different cells used for virus isolation; CPE. Protein-based diagnostic methods: Antibody-based diagnostic methods (immunohistochemistry, ELISA, western blotting, lateral flow assay etc.), Hybridoma technology and monoclonal-antibodybased diagnosis Nucleic-acid based diagnostic methods: Nucleic acid amplification methods; Types of PCR: Reverse transcriptase-PCR, Real-time PCR and Other variants of PCR; In situ hybridization; Dot blot assay; LAMP etc.

Practical

Sample collection and preparation for microscopic, microbiological, virological and histopathological analysis. Culture of microorganisms using conventional methods. Antibiotic sensitivity testing. Serological techniques in disease diagnosis: SDS-PAGE, Western blotting, ELISA, etc. Cell culture techniques; Molecular techniques in disease diagnosis, Nucleic acid extraction, estimation and different PCR-based diagnosis. Familiarization of some of the commercially available diagnostic kits used in aquatic animal disease diagnosis.

Suggested Readings

1. *Infectious Disease in Aquaculture*. Woodhead Publishing Ltd., Philadelphia, 2012.
2. Lucky, Z. (1977). *Methods for the Diagnosis of Fish Diseases*. Amerind Publishing Co. Pvt. Ltd., New Delhi.
3. Sindermann, C.J. (1977). *Disease Diagnosis and Control in North American Marine Aquaculture*. Elsevier Scientific Publishing Company, Amsterdam.
4. Sugama, K. (1998). *Manual of Fish Diseases Diagnosis*. Nippon Veterinary and Animal Science University, Japan.
5. Walker, P. (2005). *DNA-based Molecular Diagnostic Techniques*. Daya Publishing House, Delhi.

FSCDSE405: Sustainable Fisheries Management and Conservation Objectives **3 (2+1)**

Objectives

1. To understand the major sustainability issues of inland and marine fisheries resources of the world and India
2. To understand the ways and means of conservation of fisheries resource

Theory

Inland fisheries: Major inland fisheries resource of the World-India-Overview. State of the fisheries- Fishing gears-and crafts- Catch composition. Marine fisheries: Major marine fisheries resources of the world and India. Overview- State of the fisheries -Fishing gears - Catch composition-pelagic, Demersal, Oceanic, Deep-sea. Sustainability issues in fisheries: Ghost fishingOverexploitation, Overcapacity, pollution, Habitat degradation/ biodiversity loss.

Damming of rivers. Interlinking of rivers, Environmental flows; Fishing Conflicts-Exotics; Trans-boundary issues, IUU fishing, inter-linking of rivers-Climate change, By-catch and discards. Sustainable fishing: Components of sustainability, Indicators and goals of sustainability, Eco-friendly fishing, Ecosystem Based Fisheries Management-resilient fishery system. Principle of fisheries ManagementManagement approaches-By catch reduction- Rebuilding fishery, Rebuilding stock, Co-management - right based fishing input control (fishing efforts, mesh regulations, fishing ban, licensing, capital investments, etc.) - output control (catch quotas, minimum legal size, etc.). Fishery reserve-technical measures. Spawning aggregates; trade agreement- Market-based instruments; Access right - Catch sharing-balanced Fishing-Subsidy-certification and Traceability-Sustainable management approach in lake, Reservoir and beels. Functions and importance of Aquatic habitats: Mangrove, Corals, Seagrass beds, and dunes, Turtle nesting grounds, horseshoe crab habitat; Role and functions of aquatic habitat; Human activities and pollution sources; Effects of Conservation Practices on Aquatic Habitats and Fauna. Aquatic habitat conservation: Freshwater habitat and Marine water habitat; Erosion and sediment control-transplantation-stocking-population stabilization. Fish refugee- *ex-situ* conservation. Responsible fishing practices Precautionary management -Fisheries co-management: Right-based fishing - Catch sharing access right - Balanced fishing. Technical Guidelines of CCRF for responsible fishing; National and International treaties (National policy on marine fisheries-2017; National policy on inland fisheries 2019; MFRA's; UNCLOS; UNFSA; IOTC).

Practical

Capture fisheries observation at lakes, reservoirs, river stretches, and marine landing centers. Species landings analysis. Interaction with manager's Co-operative societies and stakeholders. Fleet capacity assessment. Visit to fishery reserves to understand management. Field survey and observation of fisheries issues. Development of management plan. Suggest management plan for aquatic habitat protection- permit application form. Valuation of ecosystems – awareness on fisheries resource conservation. Visit to reservoir and assess the threats and developing plan for stock rebuilding.

Suggested Readings

1. Blaber, J.M. (1997). *Fish and Fisheries in Tropical Estuaries*. Chapman and Hall.
2. Chandra, P. (2007). *Fishery Conservation, Management and Development*. SBS Publications. Dholakia, A.D.
3. FAO.*Technical Papers on Freshwater Fisheries*.
4. Hilborn, R.C., & Walters, C.J. (1992). *Quantitative Fisheries Stock Assessment*. Chapman and Hall, New York.
5. Jhingran, V.G., & Pathak, V. (1987). *Ecology and Management of Bheels in Assam: A Case Study of Dhir Bheel*. In *Workshop on Development of Bheel Fisheries in Assam*, Assam Agricultural University, Guwahati, 21–22 April.
6. Samuel, C.T. (1968). *Marine Fisheries in India*. Narendra Publishing House.
7. Sugunan, V.V. (1997). *Reservoir Fisheries of India*. Daya Publishing House.
8. McClanahan, T.R. (2000). *Coral Reefs of the Indian Ocean: Their Ecology and Conservation*. Oxford University Press. 525p.

9. Nath, S. (Ed.). (2008). *Recent Advances in Fish Ecology, Limnology and Eco-Conservation* (Vol. VII). Narendra Publishing House.
10. Ramachandra, T.V. (2005). *Aquatic Ecosystems: Conservation, Restoration and Management*. Capital Publishing Company, New Delhi. 348p.
11. Young, T.P. (2000). *Restoration Ecology and Conservation Biology*. *Biological Conservation*.

FSCDSE406: Aquatic Pollution Objectives **3(2+1)**

Objectives:

1. To impart knowledge on different aspects of aquatic pollution
2. To impart fundamental and advanced knowledge on the sources of pollution and its controlling measures

Theory

Introduction to aquatic pollution, the sources of pollutants, toxic organic compounds and their impacts in the aquatic organisms and the abiotic environment. Classification of pollution; Physical, chemical and biological classification of water pollution- description of terminologies. Sewage and domestic wastes; composition and pollution effects, sewage treatment and its reuse. Agricultural wastes; organic detritus, nutrients, Adverse effects of oxygen demanding wastes: importance of dissolved oxygen; Oxygen demand (BOD, COD), Oxygen budget; Biological effects of organic matter. Excessive plant nutrients: Eutrophication; Red tides and fish kills. Pesticide types and categories; inorganic pesticides, Organo-chlorine compounds, Organo-phosphorous compounds; Polychlorinated biphenyls (PCBs); Bioaccumulation and impact on aquatic fauna and human health; toxicology. Heavy metals: Interaction of heavy metals with water and aquatic organisms. Bioremediation and Phytoremediation. Oil pollution; Crude oil and its fractions; Sources of oil pollution; Treatment of oil spills at sea; Beach Cleaning; Toxicity of Petroleum Hydrocarbons; Ecological Impact of Oil pollution - Case studies. Microbial pollution: Types of aquatic microbes; autotrophs and heterotrophs; saprotrophs and necrotrophs; Sewage Fungus Complex; Transmission of Human Pathogenic Organisms; Zoonosis; Development of Antibiotic Resistance and its impact; Biofilms and Biocorrosion; Radioactivity and background radiation of earth: Radionuclide polluting, special effects of radioactive pollution. Thermal pollution and its effects, Physical and chemical nature of possible effluents from major industries in India. Monitoring and control of pollution: Biological indicators of pollution. Solid waste management.

Practical

Estimation of physio-chemical characteristics of polluted waters: Colour, Odour, Turbidity, pH, salinity, total alkalinity, total hardness, BOD, COD, Hydrogen sulphone, phosphates, ammonia, nitrates, nitrites, heavy metals and Oil and grease in water. Determination of pH, conductivity, organic carbon, nitrogen, phosphorus, heavy metals in sediments. Bacteriological tests of waste water: Coliform tests, IMVIC test, standard platecount. Methods of enumerating bacterial biomass in waters and waste waters. Study of flora and fauna of polluted water, pollution indicator species (algae, protozoa and insect larva), bioassay and methods of toxicity study.

Suggested Readings

1. APHA (American Public Health Association). (2017). *Standard Methods for the Examination of Water and Wastewater* (23rd ed.). American Public Health Association, Washington, D.C.
2. Baird, D.J., Beveridge, M.C.M., Kelly, L.A., & Muir, J.F. (1996). *Aquaculture and Water Resources Management*. Blackwell Science Ltd., Oxford.
3. Clark, R.B. (2001). *Marine Pollution*. Oxford University Press.
4. Czernuszenko, W., & Rowinski, P. (2005). *Water Quality Hazards and Dispersion of Pollutants*. Springer Science and Business Media.
5. Gray, N.F. (2004). *Biology of Wastewater Treatment*. Oxford University Press, London.
6. Mason, C. (2002). *Biology of Freshwater Pollution* (4th ed.). Benjamin Cummings. 400 pp.

FSCDSE407: Fishery Oceanography **3 (2+1)**

Objectives

1. To educate the students on the oceanographic concepts related to fisheries and impart skill tooperate oceanographic equipment
2. To understand the role of different oceanographic parameters on fisheries production

Theory

Introduction to Oceanography: classification; expeditions national and international. Earth and the ocean basin, distribution of water and land; relief of sea floor; Major feature of topography and terminology; major divisions. Relief in Indian oceans. Ocean Waves: definition and terms; classification. Difference between surface and long waves; wave theories; surface wave generation; spreading growth; Beaufort Scale; spilling and breaking waves; long waves, Tsunamis, Seiches, internal waves. Ocean Tides: Definition; Tidal phenomenon, elementary tidal definition; tidal inequalities; tide producing forces types of tides tidal bores, tide prediction. Ocean Currents: Definitions and features; measurements of currents; direct and indirect methods forces acting on sea waters; drift currents, Ekman spirals, upwelling, sinking, gradient currents; thermohaline circulation; characteristics; course; and significance of some major ocean currents of the world. El Nino and Southern Oscillation. Physical properties of sea water: Salinity and chlorinity; temperature; thermal properties of sea water; colligative and other properties of sea water; Residence time of constituents in seawater. Properties of sea ice; transmission of sound; absorption of radiation; eddy conductivity; diffusivity and viscosity. General distribution of temperature, salinity and density: Salinity and temperature of surface layer (SST), subsurface; distribution of temperature and salinity; The T-S diagram; water masses of Indian oceans. Chemistry of sea water: Constancy of composition; elements present in sea water; artificial sea water; dissolves gases in sea water; CO2 system and alkalinity; inorganic agencies affecting composition of sea water distribution of phosphorus, nitrogen compounds, silicates and manganese in the oceans, factor influencing their distribution. Environmental factors influencing the seasonal variations in fish catch in the Arabian Sea and theBay of Bengal.

Practical

Field visits and operation of oceanographic instruments - Nansen reversing water sampler, Bathythermograph, Grabs, Corers, Current meters, Tidal gauges, Echo-sounder. Measurement of temperature, Transparency, pH. Determination of DO, Salinity, Ammonia, Nitrate, Nitrite, Phosphate and Silicate in sea water. Use of tide tables. Fisheries forecasting systems. Oceanographic equipment and fish-finding devices.

Suggested Reading:

1. Grasshoff, K., Ehrhardt, M., & Kremling, V. (1983). *Methods of Seawater Analysis*. Verlag Chemie, Weinheim.
2. Kennish, M. J. (1989). *Practical Handbook of Marine Science*. CRC Press, New York.
3. Laevastu, T., & Hayes, M. L. (1981). *Fisheries Oceanography and Ecology*. Fishing News Books, Farnham, U.K.
4. Lalli, C. M., & Parsons, T. R. (1993). *Biological Oceanography: An Introduction*. Elsevier Science Ltd., Oxford.
5. Miller, C. B. (2004). *Biological Oceanography*. Blackwell Publications, Oxford.
6. Pond, S., & Pickard, G. L. (2013). *Introductory Dynamical Oceanography*. Elsevier.
7. Reddy, M. P. M. (2007). *Ocean Environment and Fisheries*. Science Publishers, USA.
8. Tomczak, M., & Godfrey, J. S. (2013). *Regional Oceanography: An Introduction*. Elsevier.

FSCDSE408: Analytical Techniques in Aquatic Environmental Studies 3 (2+1)

Objective

1. To teach the student advance analytical techniques in aquatic environment studies

Theory

Qualitative and quantitative analytical techniques including Gravimetric and volumetric analyses used in environmental science, Sampling techniques and procedures, Factors affecting the choice of analytical techniques, Interferences and their minimization, Laboratory safety measures. Photometric techniques: Theory, instrumentation and application of spectrophotometry and spectroscopy, AAS, ICP-MS, Biosensor, Microscopic Techniques etc. Theory and applications of electrophoresis, Principles and uses of ultra-centrifugation, Tracer Techniques, Isotopes in environmental analysis. Separation techniques: Chromatography – theory, instrumentation and applications of thin layer, paper, ion-exchange, size exclusion, high performance liquid and gas chromatography. Methods of preparing biological samples for chromatographic analysis GC-MS Unit. Bio analysis techniques: Immunoassay – Principle, methods and applications and Biosensors – components, characteristics, applications, impacts and challenges. Nanotechnology: Preparation of nanoparticles, characterization and applications.

Practical

Eutrophication studies in natural waters - tanks and ponds Estimation of bio-indicator organisms in polluted waters. Bioremediation experiments using different bio-agents. Use of UVvisible Spectrophotometer for phosphate, nitrate other ions. AAS for analysis of heavy metals. Use of

HPLC and GC-MS for analysis of pesticide and other volatile and semi volatile organic substances.

Suggested Reading:

1. APHA (American Public Health Association). (2017). *Standard Methods for the Examination of Water and Wastewater* (23rd ed.). American Public Health Association, Washington, D.C.
2. Cheremisinoff, N. P. (2002). *Handbook of Water and Waste Water Treatment Technologies*. Butterworth-Heinemann, Woburn.
3. Cairns, J. E. (2017). *Biological Monitoring in Water Pollution*. Elsevier.
4. Sakhare, V. B. (Ed.). (2007). *Advances in Aquatic Ecology* (Vol. 1). Daya Publishing House, New Delhi.

FSCDSE409: Quality Assurance of Fish and Fishery Products 3 (2+1)

Objective

1. To familiarize students with different aspects of quality management systems and evaluation techniques for seafood

Theory

Quality dimensions of seafood – sensory, intrinsic, quantitative and affective parameters. Preharvest and post-harvest factors affecting quality. Assessment of quality changes in fresh and iced fish. Quality changes during processing. Importance of quality, definitions and terminologies. Application of HACCP concept in surveillance and quality assurance program for raw, frozen, canned, cured, irradiated, cooked and chilled, modified atmosphere packaged and freeze-dried products. Risk assessment, principles of plant hygiene and sanitation, pest control, personnel hygiene, planning and layout, equipment construction and design. Food laws and standards, national and international legislation, mandatory and non-mandatory standards. Role of export inspection council and export inspection agency and MPEDA in fish and fishery products. Executive instructions on fish and fishery products, Legislation for export quality assurance in India. Certification system for fish and fishery products. Legal basis for monitoring products related EU requirements. Scheme for approval and monitoring of establishments/factory vessels/ freezer vessels processing/storing fish and fishery products for export. Complaint handling procedure on fish and fishery products. Interpretation of test reports and limits on chemical residues. GOI notifications on fish and fishery products. General requirements for export of fish and fishery products to the EU. International regulatory framework for fish safety and quality. Prerequisites to HACCP. Labelling for product traceability and Labelling requirements - National and international, legislation on labelling, components of traceability codenutrition facts and nutrition labelling, specific requirements of nutrition labelling, food meant for specific age group and convalescing people. EU legislation on traceability of fish and fish products. Assessment of food safety program, The HACCP for seafood industries and protection of food from adulterants. Standards for sea foods. FSSAI, FDA, ISO. Use of additives in seafood processing as quality enhancers. Seafood safety, authenticity, traceability. Waste management in seafood processing.

Practical

Assessment of quality of fresh fish by sensory, biochemical, and instrumental methods. Chlorination and Hardness estimations. Quality analysis of canned, frozen, cured and pickledfish products. Quality tests for tin and corrugated containers. Assessment of plant, equipment sanitation and personnel hygiene. Detection of filth and extraneous matter in traditional processed products.

Suggested Readings

1. Alasalvar, C., Miyashita, K., Shahidi, F., & Wanasundara, U. (2011). *Handbook of Seafood Quality, Safety and Health Applications*. Wiley-Blackwell, Oxford.
2. Huss, H. (2007). *Assessment and Management of Seafood Safety and Quality*. Daya Publishing House, Delhi.
3. Kanduri, L., & Eckhartt, R. A. (2002). *Food Safety in Shrimp Processing*. Fishing News Books.
4. Kreuzer, R. (1971). *Fish Inspection and Quality Control*. Fishing News Books.
5. Shukla, R. K. (2006). *Total Quality Management Practicing Manager*. New Royal Book.

Elective (Minor) Courses

FSCDSE410: Coldwater Aquaculture and Recreational Fisheries Objectives 2 (1+1)

1. To learn about the breeding and culture of different cold-water fishes and their importance as sport fisheries or recreation fisheries
2. Eco-tourism and recreational aquaculture

Theory

Introduction: Status of coldwater fisheries in World with special reference to India, Biology, breeding and culture of trouts (*Oncorhynchus mykiss, Salmo trutta fario, Schizothoraichthys esocinus, S. longipinnis, S. niger, Schizothorax richadsonii*), mahseer *(Tor putitora, Tor tor, Tor khudree),* common carp *(Cypinus carpio cummuinis, Cyprinus carpio specularis)*. Specific environmental parameters pertaining to cold water fish culture and metabolic interaction, Feeds suitable for cold water aquaculture. Culture of cold-water fishes: Construction and management of cold-water fish farms, Effect of exotic fish introduction on indigenous fish fauna, Polyculture of exotic carp in mid hill region based on three Chinese carps, post-harvest and harvest issues in trout with regards to cold water species, Special factors for consideration in cold water fish seed production and nursery rearing. Introduction to sport fisheries: Sports fishes and their life history, Equipment for sports fishing, fishing methods, area suitable for sports fishing, etc. Management and conservation of sports fisheries through aquaculture, Sport fisheries and tourism, recreational aquaculture. Issues and Desired Interventions: Potential and Innovative Strategies for the Development of coldwater Aquaculture in India- problems encountered in fisheries development of rivers supporting cold water fisheries.

Practical

Identification of coldwater fish species. Primary and secondary sexual characters in cold water fishes. Different breeding methods for cold water fishes. Identification of larval stages of trout and mahseer. Preparation of hatchery layout for coldwater fishes. Studies on different types of sports fishing equipment. Visit to coldwater fish hatcheries and farms.

Suggested Reading

1. Boghen, A. D. (1989). *Cold-water Aquaculture in Atlantic Canada*. Institut Canadien de Recherche sur le Développement Régional, Atlantic Coast, Canada.
2. ICAR. (2006). *Handbook of Fisheries and Aquaculture*.
3. Jhingran, V. G., & Sehgal, K. L. (1978). *Cold Water Fisheries of India*. J. Inland Fish. Soc. India, Special Publication.
4. Mahanta, P. C., & Sarma, D. (2010). *Coldwater Fisheries Management*. ICAR.
5. Singh, H. R., & Lakra, W. S. (2008). *Coldwater Aquaculture and Fisheries*. Narendra Publishing House.
6. Singh, A. K., Sarma, D., Akhtar, M. S., & Baruah, D. (2017). *Souvenir – National Seminar on Strategies, Innovations, and Sustainable Management for Enhancing Cold Water Fisheries and Aquaculture*. ICAR-DCFR, Bhimtal.

FSCDSE411: Aquatic Microbiology **2 (1+1)**

Objective

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

Theory

Distribution and classification: Microbial community in freshwater; Estuarine and marine environment (types and abundance); Factors affecting microbial growth and abundance. Microbial interaction: Microbial degradation of persistent organic pollutants (POPs); Microorganisms and public health: Water-borne pathogens of public health importance - Protozoans, bacteria, enteroviruses; Microbial toxins; Algal toxins; Disinfection methods; Microbial standards for different water uses. Principles and applications of bioprocesses: Bioremediation, Biofertilization, Biofilms, Biofloc, Probiotics, Bio-leaching, Bio-corrosion, Bio-fouling; Microorganisms as Bioindicators and Biosensors. Methods of assessing microbial biomass production; Bioprospecting: Current practices in bioprospecting and biopiracy; Microbial metabolites and its industrial application.

Practical

Isolation, identification and enumeration of algae and bacteria from polluted aquatic habitats. Maintenance of algal and bacterial cultures. Microbial sensitivity testing. Bio-activity testing. Disinfection methods.

Suggested Reading:

2. Dhevendaran, K. (2008). *Aquatic Microbiology*. Daya Publishing House, New Delhi.
3. Droop, M. R., & Jannasch, H. W. (2012). *Advances in Aquatic Microbiology* (Volume One). Academic Press, 388 pp.
4. Frobisher, M., Hinsdill, R. D., Crabtree, K. T., & Goodheart, C. R. (1974). *Fundamentals of Microbiology*. WB Saunders Company, Philadelphia.
5. Maier, R. M., Pepper, I. L., & Gerba, C. P. (2009). *Environmental Microbiology* (2nd ed.). Academic Press, 624 pp.
6. Rheinheimer, G. (1992). *Aquatic Microbiology*. John Wiley and Sons.
7. Sigee, D. C. (2005). *Freshwater Microbiology*. Wiley Publisher, 517 pp.
8. Vernam, A. H., & Evans, M. (2000). *Environmental Microbiology*. Blackwell Publishing, U.K.

FSCDSE412: Climate Change and its Impact on Fisheries **2 (2+0)**

Objectives

1. To understand global warming, its impact on the aquatic environment and fisheries
2. To know about the different legislation across the country to combat climate change

Theory

Weather and climate, Greenhouse effect, Radiative balance, Climatic migration, Carbon Sequestration and trading, Projected trends of climate change and disasters. Climate change, its impacts, Aquatic ecosystem, Capture and culture fisheries, Carbon footprint in fisheries and aquaculture. Oceanographic factors in fisheries: Effects of physio-chemical and biological oceanographic factors on adaptation; Behaviour, abundance and distribution of aquatic organisms; Primary and secondary productivity in ocean under changing climate. Ocean acidification, Global Ocean circulation, Upwelling and circulation patterns, El Nino and Southern Oscillation, IPCC and its reports, UNFCCC, Kyoto Protocol, Politics of climate change. Forecasting systems: Fisheries forecasts – Interpretation and use of ocean thermal structure; Fisheries forecasting system in India and other countries: Application of Remote sensing and GIS in fisheries; Application of echosounders and SONAR; Potential fishing zones. Factors affecting marine fisheries. Adaptation and mitigation measures for Climate change; Vulnerability assessment; Climate-resilient aquaculture; Climate-smart villages.

Suggested Reading:

1. Grasshoff, K., Ehrhardt, M., & Kremling, V. (1983). *Methods of Seawater Analysis*. Verlag Chemie, Weinheim.
2. Kennish, M. J. (1989). *Practical Handbook of Marine Science*. CRC Press, New York.
3. Laevastu, T., & Hayes, M. L. (1981). *Fisheries Oceanography and Ecology*. Fishing News Books, Farnham, U.K.
4. Lalli, C. M., & Parsons, T. R. (1993). *Biological Oceanography: An Introduction*. Elsevier Science Ltd., Oxford.
5. Miller, C. B. (2004). *Biological Oceanography*. Blackwell Publications, Oxford.
6. Reddy, M. P. M. (2007). *Ocean Environment and Fisheries*. Science Publishers, USA.

7. Hulme, M. (2009). *Why We Disagree About Climate Change: Understanding Controversy, Inaction, and Opportunity*. Cambridge University Press.
8. Murphy, R. P., & Boomer, D. (2008). *An Appeal to Reason: A Cool Look at Global Warming* by Nigel Lawson. *Economic Affairs*, 28(4), 80-81.
9. Schmutter, K., Nash, M., & Dovey, L. (2017). *Ocean Acidification: Assessing the Vulnerability of Socioeconomic Systems in Small Island Developing States*. *Regional Environmental Change*, 17(4), 973-987.

FSCDSE413: GIS and Remote Sensing in Fisheries 2 (1+1)

Objective

1. To learn to use GIS and Remote sensing to foster the sustainable use of natural fisheries resource.

Theory

Aerial Photography: Basics of photography- terminologies- Photogrammetry - Stereoscopy - Principal points - Parallax and its measurement, Colours - Composite colour images. Remote Sensing - Electromagnetic Spectrum - Radiation laws - Interaction with atmosphere and surfaces, Spectral reflectance of earth materials and vegetation, Satellite Remote Sensing - Resolution - Scanning - Sensors, Land Observation Satellites - Visual image interpretation. Image and Data: Digital image processing, Image rectification and Image enhancement - Filtering - Band rationing, Image classification - Supervised and unsupervised classification, Remote sensing application in soil and water conservation. GIS - Types, raster, vector, Database management systems, Data types, Spatial - non-spatial, Spatial data models, Spatial referencing, Map projections, Data input, Editing, Encoding, Raster data analysis, Vector data analysis. Satellite Application: NOAA and IRSSatellites for Ocean and Fisheries studies, Digital image processing and interpretation, Application of remote sensing and GIS to fisheries and aquaculture planning and development. PFZ- Basics and application- Validation of PFZ data- INCOIS- Data Dissemination. Fishermen knowledge in PFZ.

Practical

Study of satellite information, interpretation of satellite pictures for resource management. Case studies on remote sensing and GIS applications. Development of GIS with local parameters related to fisheries. INCOIS data processing and interpretation. Collection and Validation of INCOIS and PFZ data. INCOIS data dissemination methods among coastal fishermen. Survey of effectiveness and usefulness of PFZ data.

Suggested Readings:

1. Bhatia, B. (2008). *Remote Sensing and GIS*. Oxford University Press, New Delhi.
2. FAO. *Technical Manuals on Remote Sensing and GIS in Fisheries and Aquaculture*.
3. Josef, G. (2005). *Fundamentals of Remote Sensing*. Universities Press (P) Limited, Hyderabad.

4. Kumar, S. (2005). *Basics of Remote Sensing and GIS*. Firewell Medi, Laxmi Publications, New Delhi.

FSCDSE414: Responsible and Sustainable Fishing Methods 2 (1+1)

Objectives

1. To teach various responsible fishing techniques for conservation of biodiversity.
2. To learn various fishing methods and gears for the sustainable exploitation of aquatic resources

Theory

CCRF: Scope and objectives of FAO Code of conduct for Responsible Fisheries, Articles of CCRF – Description of the code, Analysis of marine catch data (present and past); analysisof CCRF concept. Definition of sustainability, Rules and regulations for sustainable fishing, Properties of a sustainable fishery, Present scenario and problems of sustainable fishing, Trends in global and Indian fishery, Environmental defects. By-catch: Elaboration of Article 8 – Fishing operations; By-catch and discards – Definitions, By-catch estimation methods, by-catch reduction devices, turtle excluder devices, Finfish and shrimp excluder devices. Selective fishing gear and practices: Selectivity of trawls, gill nets and lines – Environmentally friendly fishing methods and fishing gears – Energy conservation and resource enhancement. Fish Aggregation Devices (FADs and Artificial reefs): Objectives, Types of FADs and artificial reefs; Design and construction of FADs and artificial reefs; Energy optimization in fisheries – Methods of energy conservation in fish harvesting. Remote Sensing and PFZ: Application of Remote sensing, PFZ and GIS in fisheries. IUU - Illegal, Unregulated and Unreported fishing methods; Destructive and prohibited fishing systems and practices. Effect of fishing on non-target species. Impacts of unsustainable fishing: Habitat degradation due to bottom trawling, purse seining, Habitat modification, changing the ecosystem balance, Climate change, Ocean pollution, Disease and toxin. Fisheries management, Ecosystem-based fisheries, Marine protected area, Laws and treaties, Conservation methods issues and implications for biodiversity. Remediation for sustainable fishery, Fisheries management, Ecosystem-based fisheries, Marine protected area, Laws and treaties, Awareness campaigns, Sustainable fishing gears and devices, designing of eco-friendly long line, Eco-friendly gillnet, Eco-friendly trawl net, Techniques reducing the risk of unsustainability, Eco-friendly fishing methods and gears.

Practical

Study of design and operation of BRDs and TEDs. Preparation of document listing and prohibited fishing practices. Compilation of package of practices for energy conservation. Designing of eco-friendly fishing devices, square mesh cod end, traps with escape vents, designing of longline with circular hooks. Interpretation of SST and Ocean colour charts. Study of Potential Fishing Zone (PFZ) maps. Problems on fishing gear selectivity. Studies on impact of various fishing gears on the environment and biodiversity.

Suggested Readings

1. CIFNET. *Module III and IV. Code of Conduct for Responsible Fisheries* (pp. 61-69).

2. FAO. (1995). *Code of Conduct for Responsible Fisheries*. FAO, Rome, 41 pp.
3. FAO. (1996). *Fishing Operations: FAO Training Guidelines for Responsible Fisheries No.1*. FAO, Rome, 26 pp.
4. FAO. (2003). *Fisheries Management 2: The Ecosystem Approach to Fisheries*. FAO.
5. Maheswari, K. (2011). *Sustaining Marine Fisheries*. Sonali Publication, New Delhi.
6. Kaiser, M., & Groot. *Effect of Fishing on Non-target Species and Habitats*. Blackwell Publishing.
7. Raval, N. B. (2013). *Combating Marine Pollution*. Cyber Tech Publication, New Delhi.
8. Sinha, P. C. (2007). *Fishing Conservation Management and Development*. SBS Publishers and Distributors Pvt. Ltd., New Delhi.
9. FAO. *Technical Guidelines for Responsible Fisheries – No.4, Suppl.2*. FAO, Rome.

FSCDSE415: Principles and Techniques of Seafood Analysis 2 (1+1)

Objective

1. To provide knowledge on various instrumental techniques in seafood analysis

Theory

Separation of molecules: General principles of separation of micro and macro-molecules, Selection of appropriate tools for analysis of fish samples, Outlines of common techniques involved in biochemical analysis. Filtration and centrifugation techniques: Different types of filtrations, Types of filters and means of using them; Types of centrifugations (preparative and analytical), concept of Svedberg unit, Selecting appropriate rotor, Relative centrifugal force. Viscoelastic properties, Rheology, Tribology, TPA; IR and FTIR spectrophotometry, Spectro-fluorimetry, ICP, Atomic absorption mass spectrometry, Tandem MS/MS. Microscopy: Fluorescence microscopy, SEM, TEM, XRD. Electrophoresis: General principles, types (native, denatured PAGE, 2D). Chromatographic techniques; General principle, Types of chromatography: adsorption, partition, ion-exchange, molecular sieve, affinity, liquid and gas chromatography (GC), thin layer chromatography, HPLC, GCMS, LCMSMS.

Practical

Characterization of proteins based on solubility: sarcoplasmic, myofibrillar, and stroma; Estimation of proteins - Biuret techniques, Lowry techniques, Dye binding technique and electrophoretic techniques. Amino acid analysis by HPLC. Fatty acid analysis by GC MS, Minerals and heavy metals by Atomic Absorption spectroscopy. Texture analysis by TPA. HPLC-determination of histamine. Demonstration of GC-MS-MS.

Suggested Reading:

1. Ewing, G. W. (1997). Analytical Instrumentation Handbook. Marcel Dekker.
2. Lakshmanan. (2010). Modern Analytical Techniques. Central Institute of Fisheries Technology (Cochin).
3. Leo, M. L., Nollet, L., & Toldra, F. (2010). Handbook of Seafood and Seafood Products Analysis. CRC Press Inc., Florida.
4. Otles, S. (2016). Handbook of Food Analysis Instruments. CRC Press.

5. Pare, J. R. J., & Belanger, J. M. R. (1997). Instrumental Methods in Food Analysis. Elsevier.
6. Robyt, J. F., & White, B. J. (1990). Biochemical Techniques - Theory and Practice. Waveland Press.
7. Wilson, K., & Walker, J. (2000). Practical Biochemistry: Principles and Techniques. Cambridge University Press.
8. Wilson, R. H. (1994). Spectroscopic Techniques for Food Analysis. VCH Publishing.

FSCDSE416: Trade Regulations, Certification and Documentation in Export of Fish and Fishery Products 2 (1+1)

Objective

1. To create basic understanding about Trade Regulations, Certification and documentation in export of fish and fishery products.

Theory

Trade policy and Legislation on labelling and other standards: Foreign Trade Policy of Fish and Fishery Products in Indian context and world context, labelling requirements of Fish and Fishery products stipulated by National and International Organizations. Regulations: Export documentation- certificates of origin. Other certificates for Shipment of specific goods, Export licenses; Import regulations, SPS-TBT agreement. Export Certification systems: Consignment-wise, in process Quality, Self-Certification, Food safety management system, Pre-shipment inspection, Voluntary food certification scheme, Certificate for export (CFE), Health certificate. Other certification, Traceability issues for farm reared and wild aquatic products; Dealing with returned consignments; foreign trade regulations in India.

Practical

Documentation protocol for approval of fishing vessel, processing unit and technologist in processing plants. Labelling codes for Traceability of products in Export trade. Preparation of BOL and LC. Preparation of documents for seafood export to different destinations. Study of documents on customs and port procedures for seafood export and import.

Suggested Readings

1. Batra GS and Kaur Narinder. 1995. Foreign Trade and Export Policy, Anmol Publications Pvt Ltd.
2. Cherian Jacob. 1997. Export Marketing, Himalaya Publishing House.
3. EIC, Export of Fresh, Frozen and Processed Fish and Fishery Products A Guide for Exporters, Export Inspection Council
4. Mittal AC. 1991. Export Management in India. Om Sons. Publications.
5. Rathore Kumkum. 1994. Export Marketing, Arihant Publishing House.

FSCDSE417: Marketing Intelligence and Business Analysis 2 (1+1)

Objective

1. To give an idea about the marketing intelligence and business analysis applied in the fisheries sector

Theory

Research methodology: The role of marketing intelligence in the firm, The process of marketing research, The difference between exploratory and confirmatory research, Secondary and primary data, Qualitative and quantitative research methodologies, Sampling theory. Requirements in business analysis: Management, Communication, Tracing, Configuration and change management, quality assurance, Development, Elicitation including stakeholders and/ or product requirements development, Specification. Business analytics: Business Analysis, Internal analysis, External analysis, Business need definition, Gap analysis, Solution proposal (including feasibility analysis), Solution delivery or maintenance program/project initiation. Business process definition, Business goals, Business needs, Business requirements, Limitations and assumptions. Modelling and forecasting: Solution modelling, validation and verification,Solution evaluation and optimization, Assessing the solution options (proposals), Evaluating performance of the solution, Solution/business process optimization, Model Volatility with ARCH and GARCH for Time Series Forecasting. Marketing research: Definitions of the various methodological concepts -Various steps involved in designing a research plan, Data collection methods; Characteristics, Structure, Sources, Value, and use of Big Data. The relationship between digital analytics and inbound marketing strategies, Consumer information and measurement services, Rules for designing a questionnaire. Data analysis in marketing research: Data sources for assessing consumer preferences, firm performance, and market condition and competitionanalyze enterprise data, especially for purposes of segmentation, targeting, positioning, and evaluating consumer value- process of organizing, writing, framing, and refining analytics reports- delivering effective presentations, and aligning analytic results with stakeholder needs and preferences.

Practical

Marketing Research – ethics, standards and issues. Utilization of Secondary Data Resources for Customer Segmentation Pricing and Elasticity. Linear Regression, Basics; Using Linear Regression to Forecast. Conjoint Analysis; Digital Marketing Metrics Customer Lifetime Value; Cluster Analysis. Finding and interpreting secondary data. Suggesting a methodology for fisheries marketing research. Tools and concepts of data visualization.

Suggested Readings

2. Carlson C.C., Wilmot, W.W. Innovation: The Five Disciplines for Creating What Customers Want, New York: Crown Business, 2006, ISBN: 0307336697 Edition, ISBN 13: 978-0-13- 608543-0
3. eNAM – National Agricultural Market https://enam.gov.in
4. Harrington H. James. 1991. Business Process Improvement: The Breakthrough Strategy for Total Quality, Productivity, and Competitiveness. Inspires Innovation, HarperCollins, 2009, ISBN 978-0061766084
5. Malhotra, Naresh. Marketing Research: An Applied Orientation, Sixth
6. MPEDA – Marine Products Export Development Agency – mpeda.gov.in

7. NFDB- National Fisheries Development Board – nfdb.gov.in.
8. Pearson Prentice Hall Analyzing the Target Market, Part 1: Chapter 3, Marketing Research, Harvard Business Publishing BEP 117, length 18 pages.

FSCDSE418: ICT for Development **2 (1+1)**

Objective

1. To orient students on advances in ICT initiatives, knowledge management process smart/ disruptive technologies and data analytics

Theory

ICTs – meaning, concepts, roles and initiatives, basics of ICTs, Global and National status, Types and functions of ICTs, Meaning of e-Governance, e-learning, m-Learning, Advantages andLimitations of ICTs. Knowledge management: Meaning, Approaches and Tools, Role of ICTs in Agricultural Knowledge Management, e-Extension, overview on Global and national e-Extension initiatives, Inventory of e-Extension initiatives in Agriculture and allied sectors from Central and State governments, ICAR, SAUs, private sector and NGOs in India**.** ICT applications: Knowledge centres (tele centres), CSC, Digital kiosks, Web portals, Community radio, Internet radio, Kisan call centres, Mobile based applications, INCOIS-PFZ advisories; Self-learning CDs on Package of practices, Augmented Learning, Virtual Learning, social media, Market Intelligence and Information Systems-e-NAM, Agmarknet, etc. Expert System/ Decision Support System/ Management Information Systems, Farm Health Management and Intelligence System for Plant /Animal/ Soil Health, Fishery, Water, Weather, etc., National e-Governance Plan in Agriculture (NeGP-A). Networks and policies: Global and regional knowledge networks, international information management systems, e-Learning platforms (MOOCS, Coursera, EduEx, etc.); Digital networks among extension personnel, Farmer Producers Organisations (FPOs) / SHGs/ Farmers Groups, Video conference, Live streaming and Webinars, types and functions of social media applications, Guidelines for preparing social media content, Engaging audience, Dataanalytics and Info graphics. Smart technologies for extension: Open technology computing facilities, System for data analytics/ mining/ modelling/ Development of Agricultural simulations; Remote Sensing, GIS, GPS, Information Utility (AIU). Disruptive technologies Analysis; Internet of Things (IoTs), Drones, Artificial intelligence (AI), Blockchain technology, Social media and Big Data analytics for extension.

Practical

Content and client engagement analysis. Case studies and exercises on ICT-based interventions in fisheries and agriculture. Designing extension content for ICTs; Creating and designing web portals, blogs, social media pages. Development and use of online and offline e-learning modules in fisheries. Live streaming extension programs and organizing webinars. Visit to KCC; Exercises on developing mobile-based applications. Developing social media pages for disseminating fisheriesrelated information. Writing for digital media. Developing video content related to fisheries. Conducting exercise on remote sensing and GIS.

Suggested Reading:

1. Grant, A. E., & Meadows, J. H. (Eds.). (2012). *Communication Technology Update and Fundamentals*. Focal Press, USA.
2. Batchelor, S., et al. (2003). *ICT for Development: Contributing to the Millennium Development Goals – Lessons Learned from Seventeen ICT Development Projects*. World Bank.
3. Donner, J., & Parikh, T. (Eds.). (2013). *ICTD2013: Proceedings of the Sixth International Conference on Information and Communication Technologies and Development*. Cape Town, South Africa.
4. Elder, L., Emdon, H., Fuchs, R., & Petrazzini, B. (Eds.). (2013). *Connecting ICTs to Development*. Anthem Press, London.
5. *ICTs for Development*. Retrieved from http://ict4dblog.wordpress.com.

SEMESTER-VIII

Student READY (Students Entrepreneurship Awareness Development Yojana) Program containing the following four components:

a) Rural Fisheries Work Experience (RFWE)
b) Experiential Learning Program (ELP)
c) In Plant Training/ Industrial Attachment
d) Students Projects
e) Seminar

a) Rural Fisheries Work Experience (RFWE) Program**:** Students will be attached in the fisher's villages for a minimum of 8 weeks to accustom with the rural fisheries activities like fish farming, fish breeding, hatchery operation, fishing in the river and seas, preparation of fishing crafts etc. It will be conducted with the help of the fisheries extension officers of the state Govt. of the respective states and teachers appointed by the Dean of the respective college. A total of 6 credits are allotted for the program and the evaluation of the same will be conducted by the Committee appointed by the Dean of the respective college/university and fisheries officers engaged for the program.
b) Experiential Learning Program (ELP): Students will be completing an ELP at least in two areas which should be decided by each university/college. Areas of specialization for Experiential Learning Program are (i) Ornamental fish culture, (ii) Seed Production, (iii) Trade and export management, (iv) Aqua-clinic, (v) Post Harvest technology, (vi) Aqua-farming. A total of 6 credits are allotted for Experiential Learning Program and the evaluation of the same will be conducted by the Committee appointed by the Dean of the respective college.
c) In-Plant training/Industrial Attachment**:** Students will be attached in the fish farms/ hatcheries/ feed plant/ fish processing plant etc. in the Govt./ Private/ NGO organizations for a minimum of 8 weeks. The company/farms/organization will be issued a courses completion certificate of each student after completion of the course. A total of 5 credits are allotted for the program and the evaluation of the same will be conducted by the Committee appointed by the Dean of the respective college/university.
d) Project work: Student will be selected relevant or interested area of specialization such as Ornamental Fish Production, Fish Genetics and Breeding, Fish Nutrition, Fish Pathology, Fish Health Diagnosis, Fish Pharmacology, Fish Toxicology, Fish Immunology, Fish Stock Assessment, Aquatic Pollution, Fish Value Addition, Fish Processing Waste Management, Quality Control and Quality Assurance of Fishery Products, Fish Products and By-products etc. He/she will prepare a research project plan and it will be presented in front of the committee appointed by the Dean of the respective college/university. Also, for each student, one advisor will be provided, who will guide the student in the completion of the proposed research plan. A total of 2 credits are allotted for project work and 1 credit for seminar (completed project work presentation). The evaluation for the same will be conducted by the committee appointed by the Dean of the respective college/university with the advisor of the student.

e) Seminar:

- ✓ Students will be offered Skill Enhancement Course (SEC) consisting of courses from different areas to provide intensive Hands-on-training on campus or off Campus. Students may choose SIX Skill Enhancement Courses from the basket of SEC in 1st to 4th Semesters.
- ✓ University may introduce more Skill Enhancement Courses based on the available facilities and prospect of local employment and entrepreneurship development as well as expertise/ resources available
- ✓ Students may opt UGC recommended short skill enhancement courses also (a list of skill development training areas as given in the main report).

Sl. No.	Course Title	Credit Hours
Aquaculture		
SEC-I	Fish/Shellfish Breeding and Hatchery Operation	2 (0+2)
SEC-II	Fish/Shellfish Seed Rearing	2 (0+2)
SEC-III	Fish/Shellfish Grow-out Production Management	2 (0+2)
SEC-IV	Breeding and Culture of Ornamental Fish	2 (0+2)
SEC-V	Integrated Fish Farming	2 (0+2)
SEC-VI	Non-conventional/Diversified Farming Practices (Pearl Farming/ Seaweed Farming/ Aquaponics/Microalgae Production, etc.)	2 (0+2)
SEC-VIII	Fish Feed Production and Marketing	2 (0+2)
SEC-XIII	Aquarium Making, Decoration and Management	2 (0+2)
Aquatic Environment Management		
SEC-VII	Analytical Techniques (Testing of Water, Soil, Feed etc.)	2 (0+2)
Aquatic Animal Health Management		
SEC-IX	Laboratory Techniques for Fish Pathogen Detection	2 (0+2)
Fish Processing Technology		
SEC-X	Preparation and Marketing of Value-Added Products	2 (0+2)
SEC-XII	Preparation of Fish By-Products and Waste Utilization	2 (0+2)
SEC-XVI	Fish Handling, Transportation and Preservation	2 (0+2)
SEC-XVII	Bio-chemical Analysis of Fish and fisheries products	2 (0+2)
Fishing Technology and Engineering		
SEC-XIV	Net Making and Mending	2 (0+2)
Fishery Extension, Economics and Statistics		
SEC-XV	Start-up and Incubation in Fisheries	2 (0+2)
SEC-XVIII	Data Analysis and Computation	2 (0+2)
SEC-XIX	Fish Market Survey and Value Chain Analysis	2 (0+2)
Others		
SEC-XX	Any other relevant to the region, which may be decided by the College	2 (0+2)

- ✓ SAUs/CAUs will be free to include more online courses of 10 credits (as per UGC guidelines for online courses) as a partial requirement for the B.F.Sc programme. Student will take in online mode, with approval from Dean of the SAU/CAU/College.

Indicative List of Online Courses on SWAYAM/MOOCs/Others

	Course Title	Duration	Credits
1.	Climate-smart fisheries and aquaculture (FAO)	16 weeks	1
2.	Food loss and waste in fish value chain (FAO)	12 weeks	1
3.	Biostatistics (SWAYAM)	14 weeks	4
4.	Econometric Analysis (SWAYAM)	15 weeks	4
5.	Fisheries Ecosystem Approach to Fisheries (FAO)	12 weeks	1
6.	Sustainable Management of Biodiversity (SWAYAM)	12 weeks	4
7.	Indian Agriculture Development (SWAYAM)	20 weeks	4
8.	Environment Sustainability (SWAYAM)	6 weeks	1
9.	Artificial Intelligence (SWAYAM)	15 weeks	4
10.	Communication Technology in Education (SWAYAM)	15 weeks	4
11.	Knowledge Society (SWAYAM)	15 weeks	3
12.	NGO'S and Sustainable Development	15 weeks	1
13.	Counseling Psychology	12 weeks	1
14.	Gender Sensitization: Society Culture and Change	16 weeks	1
15.	Psychology of Stress, Health and Well-being	12 weeks	1
16.	Environmental Law (SWAYAM)	20 weeks	4
17.	Food Microbiology and Food Safety (SWAYAM)	15 weeks	4
18.	Intellectual Property (SWAYAM)	15 weeks	4
19.	Introduction To R (SWAYAM)	14 weeks	4
20.	Research Methodology (SWAYAM)	15 weeks	4
21.	Nanotechnology Applications in Fisheries	8 weeks	1
22.	Personality Development and Communication Skills	8 weeks	1
23.	Public Speaking	8 weeks	1
24.	Personality Development	8 weeks	1
25.	Emotional Intelligence	8 weeks	1
26.	Yoga Practices 1	12 weeks	1
27.	Yoga Practices 2	12 weeks	1
28.	Ethics: Theories and Applications	12 weeks	1
29.	Information Sources and Library Services	6 weeks	1
30.	Qualitative Research Methods and Research Writing	12 weeks	1
31.	Extension and Communication Management	12 weeks	1

End