# PONDICHERRY UNIVERSITY

# (A CENTRAL UNIVERSITY)



# **NEP REGULATIONS**

&

# **SYLLABUS & REGULATIONS FOR**

# B.Sc. (Honors) AQUACULTURE

(2023-24 onwards)

[Affiliated Colleges]

# BACHELOR OF SCIENCE IN AQUACULTURE

#### 1. DEFINITIONS

Terms used in the NEP Regulations shall have the meaning assigned to them as given below unless the context otherwise requires:

- i. **Credit:** A credit is the number of hours of instruction required per week for the given subjectin a given semester of 16-18 weeks. One credit is equivalent to 15 hours of teaching (lecture or tutorial) or 30 hours of practice or field work or community engagement and service per Semester.
- ii. Academic Year: Means the year starting on 1st day of July and ends on the 30th day of June succeeding year.
- iii. **Residence time:** Means the time a student spends for attending classes in the College/Institution (either Online/Offline) as a full-time student and enrolled in any Academic programme of the Institution.
- iv. **Semester:** Means 18 weeks (90 Working days) of teaching-learning session of which two weeks shall be set apart for examinations and evaluation.
- v. Grade: Means a letter grade assigned to a student in a course for his/her performance at academicsessions as denoted in symbols of: O(Outstanding), A+(Excellent), A(Very good), B+(Good),B(Above average), C(Average), P(Pass), F(Fail) and Ab( Absent) with a numeric value of O=10, A+=9, A=8, B+=7, B=6, C=5, P=4, and F=0, Ab=0.
- vi. **Grade Point Average (GPA):** Means an average of the Grades secured by a student in all coursesin a given academic session duly weighted by the number of credits associated to each of the courses.
- vii. **Cumulative GPA (CGPA):** Means the weighted average of all courses the student has taken in the entire programme of study.
- viii. **Common courses:** Means the set of courses that all students who are admitted are required to study; these courses include, Languages (English- Modern Indian languages), NEP specific courses viz. Understanding India, Environmental sciences/Education, Health and wellbeing/Yoga, and Digital & Technological solutions.
- ix. **Major Discipline Courses:** Means the core subjects mandatory for the Computer Science discipline. These courses are common across all specializations of Computer Science.

- x. **Minor Discipline Courses:** Means allied/elective/specialization specific subjects of Computer Science discipline. Based on the set of Minor Discipline Courses the candidate study, specialization in Computer Science will be awarded. e.g. B.Sc. (Computer Science) with minor discipline courses in Artificial Intelligence and Machine Learning will be awarded B.Sc. Computer Science with Specialization in Al&ML.
- xi. **Credit Requirements:** For a Degree/Diploma/Certificate Programme means the minimum number of credits that a student shall accumulate to achieve the status of being qualified to receive the said Degree, Diploma/Certificate as the case may be.
- xii. **Exit option:** Means the option exercised by the student, to leave the Programme at the end of any given Academic year.
- xiii. **Lateral entry:** Means a student being admitted into an ongoing Programme of the Universityotherwise than in the 1<sup>st</sup> year of the programme.
- xiv. Vocational Studies/Education: Means set of activities for participation in an approved project or practical or lab, practices of application of scientific theories, studio activities involving students in creative artistic activities, workshop-based activities, field-based shop-floor learning, and Community engagement services, etc. (These courses are expected to enable students to incorporate the learned skills in daily life and start up entrepreneurship.)
- xv. **Skill-based learning/project:** Means activities designed to understand the different socioeconomic contexts, first-hand understanding of the policies, regulations, organizational structures, processes, and programmes that guide the development process.
- xvi. **Work-based internship:** Means structured internships with Software Companies, Research and Higher Educational Institution Laboratories, Corporate offices, etc. which will further improve employability.

#### 2. AWARD OF UG DEGREE/DIPLOMA/CERTIFICATE

Four years B.Sc. Degree programme shall have options for earning a UG Certificate/ Diploma/ Degree/ Degree with Honors based on the exit option exercised by the candidates.

#### 3. DURATION OF THE COURSE

The Curriculum Framework designed by UGC for implementing NEP 2020 specifies that all Undergraduate (UG) degree programmes are to be for a period of either 3 years or 4 years leading to the award of UG Degree of UG(Hons) Degrees.

All UG courses shall focus on conceptual understanding and development of critical thinking in a given field of Study, incidentally the skills such as communication, teamwork, and leadership shall be embodied in Teaching-learning process to facilitate for career option in the given field of specialization.

# 4. AGE LIMIT

The rules as applicable to other Under Graduate courses as prevailing in Pondicherry University.

#### 5. ELIGIBILITY FOR ADMISSION

Candidates for admission to B.Sc./B.Sc. (Hons.) Zoology/ shall require to have passed H.Sc. (or +2) or its equivalent with Botany/Zoology/Biology as one of the subjects of study, conducted by the Government of Tamil Nadu or any other equivalent system recognized by the Government of Puducherry based on the admission criteria laid down by Pondicherry University are eligible to apply.

### 6. LATERAL ENTRY

As per NEP, students have a choice of entry into the Programme of study. UGC specifies that about 10% of seats over and above the sanctioned strength shall be allocated to accommodate the Lateral Entry students. The guidelines for lateral Entry are as follows:

- 1. Lateral Entry for II Year B.Sc. /B.Sc. (Hons.) Aquaculture:
  - Student should complete UG certificate in Aquaculture from any University.
- 2. Lateral Entry for III Year B.Sc. /B.Sc. (Hons.) Aquaculture Student should complete **UG Diploma course in** Aquaculture from any University.
- Lateral Entry for IV Year B.Sc. (Hons.) Aquaculture:
   Student should complete B.Sc. Aquaculture from any University.

# 7. PEDAGOGICAL APPROACHES

a) Lecture Courses	<ul> <li>Regular classroom lectures by qualified / experienced ExpertTeachers</li> <li>These Lectures may also include classroom discussion, demonstrations, case analysis</li> <li>Use of Models, Audio-Visual contents, Documentaries, and PPTsmay supplement.</li> </ul>
b) Tutorial Courses	Problem solving Exercise classes, guided discussion, supplementary readings, vocational training, etc.
c) Practical / Lab work	Practical Lab activity with Theoretical support Mini projects, Activity-based engagement, Program executions, Data processing, and presentation exercise.
d) Seminar Course	A course requiring students to design and participate in discussions, Group Discussions, Elocution and Debate, Oral CommunicationPaper presentations, Poster Presentation, Role play participation, Quiz competitions, Business plan preparation/presentation, etc.
e) Internship course	Courses requiring students to <i>Learn by Doing</i> in the workplace external to the educational Institutions. Internships involve working in Software Companies, Research and Higher Educational Institution Laboratories, Corporate Offices, etc. All Internships should be properly guided and inducted for focused learning.
f) Research Project	Students need to study and analyze the recent research publications from indexed/peer reviewed journals in their area of specialization. Outcome of the study and analysis need to be presented as a thesis or research report with necessary experimental results.

# 8. ACADEMIC AUDIT OF COURSES

Internal Quality Assurance Cell at every institution is expected to supervise the implementation of NEP Regulations in these programmes. Availability of required number of Classrooms, Faculty rooms, Labs, Library facilities, Computer Centre and recruitment of Faculty members, allocation of funds for running the Science Labs/Computer Centre etc., is the responsibility of the College Administration.

# 9. COURSE STRUCTURE

All Academic Programmes offered under NEP shall be offered in terms of credits. Each course/subject in a given Programme of study shall carry certain number of credits which will be awarded on completion of the said course.

**12.1 EXIT OF THE COURSE:** NEP 2020 introduces the facility to breakdown the Programme of study at Undergraduate (UG) level after completion of every year of study. The students will be awarded the following:

- 1. Students who opt to exit after completion of first year will be awarded **UG Certificate in Zoology** provided they have earned a minimum of 42 credits and in addition, they have to complete work based vocational course/internship of 4 credits during the summer vacation of the first year.
- 2. Students who opt to exit after completion of second year will be awarded **UG Diploma in Zoology** provided they have earned a minimum of 84 credits and in addition, they have to complete work based vocational course/internship of 4 credits during the summer vacation of the Second year.
- 3. Students who opt to exit after completion of third year will be awarded **UG degree (B.Sc. in Zoology)**, provided they have earned a minimum of 124 credits.
- 4. Students who exit after completion of fourth year will be awarded either **B.Sc. (Hons.) Zoology**, provided they have earned a minimum of 164 credits or **B.Sc. (Hons. with Research) Zoology**, provided they have earned a minimum of 164 credits with Research Project.

#### **10. MEDIUM OF INSTRUCTION**

The medium of instruction for B.Sc.Aquaculture shall be in English.

11. Break up of Credits and Courses:

NEP Framework has specified the minimum number of credits that a Bachelor student has to earn in <sup>3</sup>/<sub>4</sub> year period. Table I specifies the number of credits and number of courses that a 3 year UG student and a four year UG (Hons) Degree student is expected to complete in 3 and 4-year duration respectively.

# **TABLEI**

#### BREAKUP OF CREDITS AND

SI. No.	Component	3 Year Degree	4 Year Hons Degree
1.	Major Disciplinary Courses	60 Credits (15 Courses of 4 credits each)	80 Credits (20 Courses of 4 credits each)
2.	Minor Disciplinary Courses	24 Credits (6 Courses of 4 Credits each)	32 Credits (8 Courses of 4 credits each)
3.	Multi-Disciplinary Courses	9 Credits (3 courses of 3 credits each)	9 Credits (3 courses of 3 credits each)
4.	Ability Enhancement Courses	12 Credits (4 courses of 3 credits each)	12 Credits (4 courses of 3credits each)
5.	Skill Enhancement Courses	9 Credits (3 courses of 3 credits each)	9 Credits (3 courses of 3 credits each)
6.	Common Value-added courses	8 Credits (4course of 2credits each)	8 Credits (4 course of 2 credits each)
7.	Winter Project / Internship Community Engagement	2 Credits (1 field-based course)	2 Credits (1 field-based course)
8.	Research Dissertation Project		12 Credits (Project report & background subjects)
9.	Total credits required	124 Credits	164 Credits

Every Undergraduate (UG) programme offered by a College shall confirm to the Structure specified by the UGC's Framework, 2023. A student of 3 year UG programme is mandated to complete a minimum of 124 credits and the student of 4 year Honors degree shall complete 164 credits. An UG student shall complete the following courses under different heads as listed below:

- 1. Major Disciplinary Courses
- 2. Minor Disciplinary Courses
- 3. Multi Disciplinary Courses
- 4. Ability Enhancement Courses
- 5. Skill Enhancement Courses
- 6. Value added/Common Courses
- 7. Internships and Community Service based projects

### 12. NEP Classification of Courses:

# i. Major Disciplinary courses (MJD): (60/80 Credits)

Major disciplinary courses are subject specific compulsory subjects that a student has to complete to obtain the UG / UG (Hons) Degree in the given discipline. Major disciplinary courses shall constitute 50% of the total credits.

All discipline specific major courses shall be designed for 4 credits each with one/two additional hours or guidance of teaching at Tutorials/Practicals. UG programmes may be offered in a single major discipline or in Multiple Major disciplines giving equal weightage in credits. For example, a B.Sc. course may be in a single discipline like B.Sc. (Maths) or with multiple major disciplines like B.Sc. (Maths, Physics & Chemistry).

# i) Minor Disciplinary Course (MID): (24/32 Credits)

Minor disciplinary courses refer to those subjects which are Allied / Specialisation / Elective subjects to the Major discipline. These allied courses are expected to provide additional understanding of the subject in a specific focused area. For example, a B.A. (Political Science) student shall study allied subjects like Public Administration, Sociology as these subjects have inter linkages with the Major Disciplinary subjects.

# ii) Multi-Disciplinary Courses (MLD): (9 Credits)

All undergraduate students are mandated to pursue 9credits worth of courses in such Multi-disciplinary areas/Courses out of 9/10 NEP defined subjects. Colleges may identify any 3 multiple disciplinary streams listed below based on availability of resources and manpower.

- a) Natural Sciences
- b) Physical Sciences
- c) Humanities / Social Sciences

Students are expected to learn basic/introductory courses designed by other departments for this purpose. Colleges may list any 3 introductory courses (one each in Natural Sciences, Physical Sciences, Humanities) for uniform adoption of all UG students.

#### iii) Ability Enhancement (AEC) courses: (8 Credits)

All Undergraduate (UG)students are mandated to complete at least 8 Credits worth of Courses which focus on Communication and Linguistic skills, Critical reading, and writing skills. These courses are expected to enhance the ability in articulation and presentation of their thoughts at workplace. Colleges may design these ability enhancement courses tuned to the requirements of given major discipline. E.g. A course in Business Communication is more appropriate in place of literature/prose/poetry.

# a) English /Language

Ability Enhancement Course					
1. English Language	II. In	ndian Language (two courses)			
a. English Language & Literature – 1 and 2	a. In an	ndian language & Literature –1 nd 2			
<ul><li>b. Functional English–1&amp;2</li><li>c. Communicative English–1&amp;2</li></ul>	b. F c. C	Functional language–1 &2 Communicative language-1&2			

# iv) Skill Enhancement Course: (9 Credits)

These courses focus at imparting practical skills with hands-on Training. In order to enhance the employability of students, Colleges are expected to design such courses that they deem fit for their students for better employment/entrepreneurship/career development, et c. Colleges may also outsource the Skill Enhancement Courses to AICTE approved agencies for conducting short term Training Workshops, Skill India initiatives of GOI and approved Trades by Skill development of corporation are to be considered. Short term courses.

# v) Value Added Common courses (VAC): (8 Credits)

Under NEP, the UGC has proposed for 6 to 8 credits worth of common courses which are likely to add value to overall knowledge base of the students. These courses include:

- a) Understanding India
- b) Environmental Studies
- c) Digital Technologies
- d) Health, Wellness, Yoga Education, Sports & Fitness

The course structure and coverage of topics are suggested by UGC in its draft documents, University has hosted the Syllabus of the above courses in the University Website for reference of the colleges/Students.

# vi) Summer Internship (2 to 4 Credits)

As per the UGC guidelines all UG students should be exposed to 4 to 6-week Summer Internship in an industrial organizations / Training Centres / Research Institution, etc. Such Summer Internship is to be conducted in between 4<sup>th</sup> Semester and 5<sup>th</sup> semester. A review of report and award of grade based on Work based learning by students is to be recorded during the 5<sup>th</sup>Semester.

#### a) Community Engagement and Service (CES) (2 Credits)

All UG students are also mandated to participate in a 15 days community engagement activity during their winter vacation between 3<sup>rd</sup> and 4<sup>th</sup> Semesters. This Community engagement activity is expected to expose the students to social problems of neighbourhood village students may prepare a report on the activities carried out for a award of 2 credits.

# **13. EVALUATION:**

# Total Marks: 100

All Credit courses are evaluated for 100 marks. Internal Assessment component is for 25 marks and the End Semester University exam is for 75 marks. In case of Practicals, Project work, etc., it is 50:50 marks for Internal and End-Semester Exams.

#### Breakup of Internal Assessment Marks:

Total Internal Assessment mark for a theory subject is 25 marks. The breakup is:

a)	Mid Semester Exam (one) -20 Marks
b)	Percentage of Attendance-5 Marks
Total - 25Mark	ks

# Marks for Attendance are as follows:

Below75%	0
75%-80%	1
80%-85%	2
85%-90%	3
90%-95%	4
95%-100%	5

# Internal Test Scheme:

Principal of the College schedules the Mid-Semester Exam for all courses during 8/9<sup>th</sup> week of start of classes. All faculty members are expected to conduct this Mid-Semester exam for 1.30 hr duration and evaluate, upload the marks to Controller of Examinations of University. Colleges are also requested to preserve the answer books of Mid-Semester exams until declaration of results by the University.

Internal Assessment marks for Practicals / Project work / Internships subjects:

Faculty member in-charge of Lab practicals shall evaluate the practical subjects for 50 marks. The breakup is as follows:

a) Observation note / Demo note/ Work dairy / etc.	20
b) Practical Record/ Internship Report / etc.	30
Total	50

End-Semester University Exam:

Controller of Examinations (COE) of Pondicherry University schedules the End-Semester exams for all theory and practical subjects based on University calendar.

A detailed Exam Time Table shall be circulated to all Colleges at least 15 days before the start of exams mostly during 15/16<sup>th</sup> week of the Semester. Question Papers shall be set externally based on BOS approved syllabus. All students who

have a minimum of 70% attendance are eligible to attend the end-semester exams. The breakup of end semester marks:

<ul><li>a) Theory subjects:</li><li>(Sec A, Sec B and Sec C)</li><li>Questions from all units of syllabus</li></ul>	75marks
b) Practical/Internship Project Work subjects (Based on Practical Exams/Presentation/Viva)	50marks

Consolidation of Marks and passing Minimum:

Controller of Examinations of the University consolidates the Internal Assessment marks uploaded by the Colleges and marks secured by students in end-semester examination. The total marks will be converted into letter grades as shown in the following Table 2. As per NEP Regulations, the passing minimum is 50% marks (IA + End semester put together) However, Pondicherry University considers 40% marks as pass during first 3 years of study and students who secured less than 50 will be awarded 'P' (Pass Grade)

#### Arrear Exam:

A student who failed to secure 40% marks in aggregate is declared as Failed and he is eligible to take up supplementary examination by registering to the said course in the following Semester. All other candidates who failed due to shortage of attendance, those who are seeking to improve the grade shall repeat the course.

#### Letter Grades and Calculation of CGPA:

Total Marks Secured by a student in each subject shall be converted into a letter grade. UGC Framework has suggested a Country wide uniform letter grades for all UG courses. The following Table shows the seven letter grades and corresponding meaning and the grade points for calculation of CGPA.

Equivalent Letter Grade	Meaning	Grade Points for Calculation of CGPA
0	Outstanding	10
A+	Excellent	9
А	Very Good	8
B+	Good	7
В	Above average	6
С	Average	5
Р	Pass	4
F	Fail	0
Ab	Absent	0

#### TABLE-2

In order to work out the above letter grades, the marks secured by a student (Total of IA and Semester End) would be categorized for relative grading. The ranges of

marks for each grade would be worked as follows:Highest marks in the given subject= XCut of marks for grading purpose=50marksPassing mark (for 3 years of UG)=40Number of grades (excepting P grade) (O, A+, A, B+, B, C)=6Range of marks=Kr = 50

$$K = \frac{x - 50}{G}$$

The following table given the range of marks and letter grades. According to K value, one of the following grading schemes will be followed.

Table II					
Range of Marks in%	Letter Grade Points for	Letter Grade Points for			
X to (X-K) +1	0	10			
(X-K) to $(X-2K) + 1$	A+	9			
(X-2K) to (X-3K) +1	A	8			
(X-3K) to (X-4K) +1	B+	7			
(X-4K) to (X-5K) +1	В	6			
(X-5K) to 50	С	5			
40 - 49	Р	4			
Below 40	F	0			
Absent (Lack of Attendance)	Ab	0			

(i) If  $K \ge 5$ , then the grades shall be awarded as given in Table II.

(ii) If K < 5, then the grades shall be awarded as given in Table III.

Range of Marks in%	Letter Grade Points for	Letter Grade Points for
80-100	0	10
71-79	A+	9
66-70	A	8
61-65	B+	7
56-60	В	6
50-55	С	5
40-49	Р	4
Below40	F	0
Absent (lack of attendance)	Ab	0

Calculation of Semester Grade Point average and CGPA:

Semester Grade Point Average (SGPA) is calculated by taking a weighted average of all grade points secured by a candidate from all subjects registered by him/her in the given Semester. The weights being the number of credits that each subject carry.

Cumulative Grade Point Average (CGPA) CGPA shall be calculated as the weighted average of credits that course carries and the value of Grade points averaged for all subjects.

#### Computation of SGPA and CGPA

The following procedure shall be followed to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

The SGPA is the ratio of the sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student,

# i.e. **SGPA**(Si)= $\Sigma$ (CixGi)/ $\Sigma$ Ci

Where Ci is the number of credits of the i<sup>th</sup> course and Gi is the grade point scored by the student in the i<sup>th</sup>course.

(i)	Example for	Computation	of SGPA v	where c	andidate h	nas not	failed in	any course.
(-)							,	

Semester	Course	Credit	Letter Grade	Grade point	<b>Credit Point</b> (Credit x Grade)
Ι	Course1	3	А	8	3X8=24
Ι	Course2	4	B+	7	4X7=28
Ι	Course3	3	В	6	3X6=18
Ι	Course4	3	Ο	10	3X10=30
Ι	Course5	3	С	5	3X5=15
Ι	Course6	4	В	6	4X6=24
		20			139
	SGPA				139/20=6.95

(ii)Example for Computation of SGPA where candidate has failed in one course.

Semester	Course	Credits	Letter Grade	Grade point	Credit Point (Credit x Grade)
Ι	Course1	3	А	8	3X8=24
Ι	Course2	4	B+	7	4X7=28
Ι	Course3	3	В	6	3X6=18
Ι	Course4	3	0	10	3X10=30
Ι	Course5	3	С	5	3X5=15
Ι	Course6	4	F	0	4X0=00
		20			115
	SGPA				115/20=5.75

(ii) Example for Computation of SGPA where candidate has failed in

two courses.

Semester	Course	Credit	Letter Grade	Grade point	Credit Point (Credit x Grade)
Ι	Course1	3	А	8	3X8=24
Ι	Course2	4	B+	7	4X7=28
Ι	Course3	3	F	0	3X0=00
Ι	Course4	3	В	6	3X6=18
Ι	Course5	3	С	5	3X5=15
Ι	Course6	4	F	0	4X0=00
		20			85
	SGPA	•		•	85/20=4.25

The CGPA shall also be calculated in similar way as shown in examples (i),

(ii) and (iii) of SGPA for all subjects taken by the students in all the semesters. However, if any student fails more than once in the same subject, then while calculating CGPA, the credit and grade point related to the subject in which the student fails in multiple attempts will be restricted to one time only. The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

In case of audit courses offered, the students may be given (P) or (F) grade without any credits. This may be indicated in the mark sheet. Audit courses will not be considered towards the calculation of CGPA.

# **DELCATION OF RESULTS:**

Controller of Examinations (COE) of the University shall declare the results of given UG programme following the CGPA secured by students by the end of 6<sup>th</sup> Semester and 8<sup>th</sup> Semester.

# 1. CURRICULUM

	FIRST SEMESTER									
	Comp	Course		Hours/We						
S.No	onent	Code	Title of the Course	Credits	L	Т	P			
1	MJD 1	AQ1MJ01	Taxonomy of Fishes	4	3		2			
2	MID 1	AQ1MJ01	Invertebrate Zoology	4	3		2			
3	MLD 1	AQ1ML01	Natural Science (Syllabus available in the University Website)	3	4					
4	AEC 1	AQ1AE01	English - I	3	3		3			
5	SEC 1	AQ1SE01	Fishery by Products and Value Addition	3			4			
6	VAC 1	XX1VA01	Understanding India	2	4					
7	VAC 2	YY1VA02	Environmental Studies	2	4					
		21	30 Hours							

	SECOND SEMESTER										
	Comp	Course			H	Iours/	Week				
S.No	onent	Code	Title of the Course	Credits	L	Т	Р				
1	MJD 2	AQ2MJ02	Basic Principles of Aquaculture	4	3	1	2				
2	MID 2	AQ2ML02	Ecology of Aquatic Environment (Practical	4	4						
			& Theory)								
3	MLD 2		Physical Science (Syllabus available in	3	4						
			the University Website)								
4	AEC 2	AQ2AE02	Modern Indian Language I	3	3		3				
5	SEC 2	AQ2SE02	Breeding and Rearing of Aquarium Fishes	3			4				
6	VAC 3	XX2VA03	Digital Technologies	2	4						
7	VAC 4	CS2VA04	Health & Wellness/Yoga Education	2	4						
	Total					30 Hours					

	THIRD SEMESTER										
	Comp	Course			Η	Hours/Week					
S.No	onent	Code	Title of the Course	Credits	L	Т	Р				
1	MJD 3	AQ3MJ03	Biology of fishes	4	3	1	2				
2	MJD 4	AQ3MJ04	Vertebrate Zoology	4	3	1	2				
3	MID 3	AQ3MI03	Mariculture	4	4						
4	MLD 3		Humanities/Social Sciences (Syllabus available in the University Website)	3	2		2				
5	AEC 3	AQ3AE03	English - II	3	3		3				
6	SEC 3	AQ3SE03	Aquarium Fabrication and setting	3			4				
Total					28 Hours						

FOURTH SEMESTER										
S.No	Comp	Course	Title of the Course	Credits	Ho	Hours/Week				
	onent	Code			L	Т	Р			
1	MJD 5	AQ4MJ05	Aquaculture of Freshwater	4	3	1	2			
2	MJD 6	AQ4MJ06	Hatchery Technology and Management	4	4					
3	MJD 7	AQ4MJ07	Sea Food Processing Technology	4	3	1	2			
4	MID 4	AQ4MI04	Craft and Gear Technology	4	4					
5	AEC 4	AQ4AE04	Modern Indian Language II	3	3		3			
6	Project	AQ4PR01	Community Engagement and Service	2			6			
			Study Tour/Industrial training							
	Total					30 Hours				

FIFTH SEMESTER										
S.No	Compo	Course Code	Title of the Course	Credits	Но	Hours/Week				
	nent				L	Т	Р			
1	MJD 8	AQ5MJ08	Genetics & Biotechnology in	4	3	1				
			Aquaculture							
2	MJD 9	AQ5MJ09	Artificial Fish Feed	4	3	1				
3	MJD 10	AQ5MJ10	Aquaculture Engineering	4	3	1				
4	MID 5	AQ5MI05	Artificial Fish Feed	4	4					
5	MJD 11	AQ5MJ11	Summer Internship	4			6			
Total				20	28 Hours					

SIXTH SEMESTER										
S.No	Compo	Course Code	Title of the Course	Credits	Hours/Week					
	nent				L	Т	Р			
1	MJD 12	AQ6MJ12	Pond Preparation and Management	4	3	1	2			
2	MJD 13	AQ6MJ13	Fisheries Economics and Extension	4	3	1	2			
3	MJD 14	AQ6MJ14	Fish Pathology and Health Management	4	3	1	2			
4	MJD 15	AQ6MJ15	Planktonology and Algology	4	4					
5	MID 6	AQ6MI06	Bioinformatics	4	4					
Total					26 Hours					

S	SEVENTH SEMESTER (Honors)									
Compo nent	Course Code	Title of the Course	Credits	Hours/Wee		Veek P				
MJD 16	AQ7MJ16	Marine Biology	4	4		2				
MJD 17	AQ7MJ17	Aquatic Microbiology	4	3	1	2				
MJD 18	AQ7MJ18	Seaweed Culturing	4	3	1					
MID 7	AQ7MI07	Biodiversity Conservation and Management	4	3						
MID 8	AQ7MI08	Biostatistics	4	4						
Total			20	25	5 Ho	urs				

	EIGHTH SEMESTER B.Sc. Aquaculture (Hons)										
S.No	Compo	Course Code	]			Hours/Week					
	nent		Title of the Course	Credits	L	Т	Р				
1	MJD 19	AQ8MJ19	Cold Water Aquaculture	4	3	1					
2	MJD 20	AQ8MJ20	Research Methodology	4	3	1					
3	MJD 21	AQ8MJ21	Marine Drugs and Bioprospecting	4	3	1					
4	MJD 22	AQ8MJ22	Inland and Marine Fisheries	4	3	1					
5	MJD 23	AQ8MJ23	Marine Resource Management	4	3	1					
Total				20	24	Hour	·s				

ŀ	EIGTH SEMESTER – B.Sc. Aquaculture (Hons with Research										
I	Project)										
S.No	Compo	Course Code		Credits	Hours/Week						
	nent		Title of the Course		L	Т	Р				
1	MJD 19	AQ8MJ19	Cold Water and Integrated Trophic Aquaculture	4	3	1	2				
2	MJD 20	AQ8MJ20	Research Methodology	4	3	1	2				
3	MJD 24	AQ8MJ24	Research Project	4							
4	MJD 25	AQ8MJ25	Project Report	4							
5	MJD 26	AQ8MJ26	Project Viva-voce	4							
Total				20	24 ]	Hour	s				

# SEMESTER 1

# AQ1MJ01 TAXONOMY OF FISHES

#### Credits:4

#### Unit I:

Basic principles of taxonomy and phylogeny: History of taxonomy, nomenclature. International Code of Nomenclature: salient features, principles, important rules and recommendations, Provisions for the governance of the Code. Taxonomic hierarchy. Levels of taxonomy, Alpha, Beta and Gamma taxonomy. Type concepts.

#### Unit II:

Conventional taxonomic methods – morphological characteristics, morphometric measurements and meristic counts - truss morphometry. Use of dichotomous keys for identification. Modern taxonomical tools, Karyotyping, DNA Barcoding

#### Unit III:

Concept of Evolution. Lamarckism, Darwinism, Natural selection, Neo-Darwinism and Mutation theory. Variations- nature and types. Mechanisms that decrease and increase variations (natural selection, genetic drift, mutation, recombination and gene flow). Speciation: modes of speciation – allopatric/sympatric speciation, eco-phenotypic variation, isolating mechanisms, speciation in time.

#### Unit IV:

Macro and micro-evolution: definitions, mechanisms and importance. Phylogeny: introduction and concepts of phylogeny. Phylogenetic trees, cladistics and phylogenetic reconstructions, hierarchy of species, transitional forms and molecular phylogeny.

#### Unit V

Shellfish and finfish taxonomy. Taxonomic characters of molluscs, decapods crustaceans (prawns and crabs) and teleosts. Classification up to families. Collection, preservation, labeling and curation methods of major phyla: Sponges, annelids, molluscs, arthropods, echinoderms, fishes.

#### Unit VI

Major riverine, reservoir and estuarine fisheries. Marine fisheries- pelagic (sardines, mackerel, anchovies, ribbon fishes, tuna, seer fishes) and demersal (elasmobranchs, cephalopods, silver bellies, flat fishes, crabs, sciaenid's, pomfrets, Bombay duck, prawns, lobsters, molluscan resources).

### Text books and References

- 1. Crist, D.T. Scowcroft, G. and Harding Jr., J.M. 2009. World Ocean Census; a Global Survey of Marine Life, Firefly Books, New York: 256 pp.
- 2. Guido di Prisco, Peter Convey (auth.), Guido di Prisco, Cinzia Verde (eds.). 2012. Adaptation and Evolution in Marine Environments, Volume 1: The Impacts of Global Change on Biodiversity. Springer-Verlag Berlin Heidelberg 236 pp.
- 3. Quicke, Donald L.J. 1993. Principles and Techniques of Contemporary Taxonomy, Blackie Academic & Professional, London: 331 pp.
- 4. Schuh, R. T. and Brower, A. V. Z. 2009. Biological Systematics: Principles and Applications (2ndedn.). Cornell University Press: 311 pp.
- 5. Venkataraman K & C. Sivaperuman. 2014. Marine Faunal Diversity in India: Taxonomy,Ecology and Conservation. Academic Press 546 pp.

# AQIMIO1 INVERTEBRATE ZOOLOGY

#### Credits: 4

#### Unit I:

Principles of Taxonomy – Binomial nomenclature – Rules of nomenclature – Whittaker's five kingdom concept and classification of Animal Kingdom. **Protozoa:** General characters and classification up to classes with suitable examples of Indian context. Type study – *Paramecium.* 

# Unit II:

**Porifera**: General characters and classification up to classes with suitable examples of Indian context. Type study – *Leucosolenia*. **Coelenterates**: General characters and classification up to classes with suitable examples of Indian context. Type study – *Obelia*. **Ctenophora**: Classification, Salient features with suitable examples of Indian context.

#### Unit III:

**Platyhelminthes**: General characters and classification up to classes with suitable examples of Indian context. Type Study: *Taenia solium*. **Aschelminthes**: General characters and classification up to classes with suitable examples of Indian context. Type study: *Ascaris lumbricoidus* 

# Unit IV:

**Annelida**: General characteristics and Classification up to classes (Ruppert and Barnes, 1994). Excretion in Annelida through nephridia; Metamerism in Annelida. **Arthropoda**: General characteristics and Classification up to classes (Ruppert and Barnes, 1994); Insect Eye (Cockroach only). Respiration in Prawn and Cockroach; Metamorphosis in Lepidopteran Insects; Social life in Termite. Type study; *Penaeus monodon.* 

#### Unit V

**Onychophora**: General characteristics and Evolutionary significance. **Mollusca**: General characteristics and Classification up to classes (Ruppert and Barnes, 1994); Nervous system in *Pila sp.* Torsion in Gastropoda. Feeding and respiration in *Pila* sp.

#### Unit VI

**Echinodermata**: General characteristics and Classification up to classes (Ruppert and Barnes, 1994); Water vascular system in *Asterias*. Echinoderm larva and affinities with chordates. General characteristics of phylum Hemichordates. Relationship with non-chordates and chordates

#### PRACTICALS

#### I. DISSECTION

#### A. Prawn:

- 1. Digestive system
- 2. Nervous system

#### **B. Cockroach**

- 3. Digestive system
- 4. Nervous system

### **II. MOUNTING**

- 7. Mollusc- radula
- 8. Mouth parts of Mosquito
- 9. Sting apparatus of Honey bee
- 10. Prawn appendages

# **III - SPOTTERS (any 30 spotters)**

#### A- Classify giving reasons up to order:

- 1. Paramecium
- 2. Scypha
- 3. Aurelia
- 4. Fasciola
- 5. Ascaris
- 6. Neanthes
- 7. Penaeus
- 8. Lamellidens
- 9. Asterias

#### **B- Draw labeled sketches:**

- 10. L.S. Sponge
- 11. Obelia medusa
- 12. Physalia
- 13. Ephyra larva
- 14. Redia larva

- 15. Cercaria larva
- 16. Mysis larva
- 17. Alima larva
- 18. Bipinnaria larva

# C- Comment on Biological significance:

- 19. Entamoeba
- 20. Paramecium Conjugation
- 21. Plasmodium
- 22. Obelia colony
- 23. Velella
- 24. Fasciola Miracidium
- 25. Taenia Mature proglottid
- 26. Ascaris
- 27. Heteronereis
- 28. Trochophore larva
- 29. Chaetopterus
- 30. Peripatus
- 31. Hirudinaria
- 32. Limulus
- 33. Nauplius larva
- 34. Zoea larva
- 35. Chiton
- 36. Sepia
- 37. Octopus
- 38. Sacculina on crab
- 39. Sea anemone on Hermit crab

#### **D** – Relate structure and function:

- 40. Sponge Spicules
- 41. Sponge Gemmule
- 42. Taenia Scolex
- 43. Neanthes Parapodium
- 44. Earth worm Penial setae

- 45. Penaeus Petasma
- 46. Honey bee Sting apparatus
- 47. Scorpion Book lungs
- 48. Starfish Pedicellaria
- 49. Starfish Tube foot.

#### References

- Kotpal, R. L.,2000, Modern Text Book of Zoology –Invertebrates, 8th Revised e edition (Reprint), Rastogi Publications, Meerut – 250 002.
- 2. Ayyar, E.K. and T.N. Anandakrishnan, 1992.Manual of Zoology Vol. 1 (Invertebrate), Part I & II. S. Viswanathan (Printers and Publishers) Pvt Ltd., Madras, 991p.
- 3. Jordan, E.L. and P.S. Verma, 2010, Invertebrate Zoology, S. Chand & Co Ltd., Ram Nagar, New Delhi.
- 4. Barnes R.D (1992) Invertebrate Zoology IV Edn. Holt Saunders International Edn
- Jordan, E.L. and P.S. Verma, 2022, Invertebrate Zoology, S. Chand & Co Ltd., Ram Nagar, New Delhi. 1156p

#### AQ1ML01: COMPUTER APPLICATION IN BIOLOGY Credits:3

#### Unit I

Types of Computers. Binary Number System, Digital and Analog systems. Hardware/Software/Firmware. Basics of Computer Functioning- Booting; Formatting; File, File Extensions; Temporary Files; Folder; GUI, Icon; Installation of Programs, Commands, Bios-setup, Date and Time, Memory Partitions, Registry, Default Operations; Defragmentation (Brief account only).

#### Unit 2

Memory -Classification and Types of memory; memory devices; Units. Input Devices - Types, working and functions. Output Devices – Types, working and functions. CPU components Processors, Mother boards, SMPS, Accessory Cards – Graphic /Sound/ Networking/Bluetooth/Wifi (Brief account only).New Generation Computers - Servers, Laptop; Palmtop; Cyborgs; Robotics, Zoobotics (Brief account only).

#### Unit 3

System Software/Operating System -System Files; Working of OS; DOS, Widows, Linux and UNIX (Brief account only). Application Software -Programs and Packages, Calculator, MS Paint, MS Word, MS Excel, MS PowerPoint, Publisher, Acrobat Reader, E Book Reader, Explorer, Photoshop. Virus and Antivirus (Brief account only). Statistical Software (MS Excel, SPSS, R).

#### Unit 4

Computer Communication -Network Topology, Media of networking, Networking Protocols, PAN, LAN, WAN, MAN, INFLIBNET, Modem and Gateway. Internet and Internet Services - World Wide Web, Uploading, Downloading, Hosting, Portal, Search Engines, Firewall. Global Information System -BIOSIS, Medline and Medlars, AGRIS; E Journals and E Books Publishing. Cyber Crime and Cyber Laws (Brief account only).

#### Unit 5

Use of bar diagram, histogram, scatter plots, Graphical tools in EXCEL for presentation of data; Introduction to MS- WORD, word processor- editing, copying, moving, formatting, table insertion, drawing flow charts etc; Introduction to Power Point, preparation of presentations.

#### Unit 6

Remote sensing and GIS: Definition and principle of remote sensing and GIS. Sensing mechanism. Analysis of images and data. Fisheries forecasting system in India and other countries. GPS. Application of remote sensing and GIS in fisheries conservation and management of fish faunal diversity and exploitation of capture fisheries.

#### **Text Books**

- 1. Computers Today by Suresh K. Basandra 1999. Published by Galagotia Publications, Pvt. Ltd., New Delhi.
- 2. Shane Torbert.2011. *Applied Computer Science*. Springer-verlag, New York.
- 3. Sudipto Das.2010. *A Complete Guide to Computer Fundamentals*. Lakshmi Publishers (P) Ltd. New Delhi
- 4. Sundar Rao, P.S.S and J.Richard. 2006. *Introduction to Biostatistics and Research Methods* (4th edn). Prentice Hall, New Delhi.
- 5. WHO.2011. *Laboratory Quality Standards and Their Implementation*. WHO Regional Office. New Delhi.
- 6. Zar, Jerrold H. 2008 (3rd edn.). *Biostatistical Analysis*. Pearson Education Inc., Delhi.

# Q1SE01 FISHERY BY PRODUCTS AND VALUE ADDITION Credit: 3

# Unit 1

Overview of Value-added products; Present market trends and consumer preferences; Scope of value addition. Status of value addition in the Indian seafood sector, Types of value-added products. Significance and advantages of value addition in the seafood industry.

# Unit 2

Fish Mince Based Products Definition of Fish mince and Surimi. Raw materials used for surimi. Production of fish mince and Surimi including Flow chart Analog and fabricated products from fish mince. Different methods in assessing quality of surimi. Define cryoprotectants. Role of different cryoprotectants in surimi production.

# Unit 3

Battered and breaded fishery products and their applications. Packaging and storage of coated products. Quality evaluation Preparation of products viz. fish/prawn pickle, fish wafers, prawn chutney powder, fish soup powder, fish protein hydrolysate, fish stacks, fillets, and marinated products.

# Unit 4

Fishery By-products Production of chitin, chitosan and glucosamine hydrochloride from shrimp shell waste. Definition of fish silage, Types of fish silages and their preparation. Uses of silage. Isinglass, shark fin rays and gelatin from fish waste. Ambergris, beche-demer, squalene, fish meal and oil.

# Unit 5

Seaweed products - agar, alginic acid and carrageenan. Extraction of collagen from fish processing wastes, properties and application. Fish as raw material for processing: Factors affecting quality of fresh fish: intrinsic and extrinsic factors. Spoilage in thermal processed products – Quality evaluation of thermal processed products Curing and drying of fish – Spoilage in dry fish products.

# References

- 1. Govindan, T. K. (1985). Fish processing technology. Oxford & IBH.
- 2. Balachandran, K. K. (2001). Post-harvest technology of fish and fish products. Daya Books.
- 3. Venugopal, V. (Ed.). (2005). Seafood processing: adding value through quick

freezing, retortable packaging and cook-chilling. CRC press.

- 4. Hall, G. M. (Ed.). (1997). Fish processing technology. Springer Science & Business Media.
- 5. Sen, D. P. (2005). Advances in fish processing technology (Vol. 1). Allied Publishers.
- 6. Windsor, M., & Barlow, S. (1981). Introduction to fishery by-products. Fishing News Books Ltd..
- 8. Borgstrom, G. (Ed.). (2012). Fish As Food V4: Processing: Part 2. Elsevier.
- 9. Suzuki, T. (1981). Fish and krill protein: processing technology.

# XX1VA01 UNDERSTANDING INDIA

**CREDIT:2** 

University Web site

# YY1VA02 ENVIRONMENTAL STUDIES CREDIT; 2

University Web site

# **SEMESTER -II**

#### AQ2MJ02 BASIC PRINCIPLES OF AQUACULTURE Credits:4

#### Unit I

Scope and definition; origins and growth of aquaculture; biological and technological basis; Traditional, extensive, semi-intensive and intensive culture; monoculture, polyculture, composite culture, mixed culture, monosex culture; cage culture, pen culture, raft culture, raceway culture, culture in recirculatory systems; warm water and cold-water aquaculture; sewage – fed fish culture, integrated fish farming.

# Unit II

Survey and location of the suitable site – topography, soil characteristics, acid sulfate soils, water source, and hydro-meteorological data.– precipitation, direct runoff, stream inflow, groundwater inflow, regulated inflow; water loss – evaporation, seepage, outflow, consumptive use, water budgets of embankment ponds; water budget of an excavated pond; water exchange

#### Unit III

Types of ponds – design, layout, construction, water intake system, drainage system; aeration and aerators; sun drying, ploughing / tilling, desilting, liming and fertilization, eradication of weed fishes. Recent advances in aquaculture engineering; tips for better aquaculture practices; design and construction of hatcheries.;

#### Unit IV

Biological characteristics of aquaculture species; economic and market considerations; seed resources, collection and transportation. Acclimatization of seed and release; species combinations; stocking density; ratio

#### Unit V

Water and soil quality parameters required for optimum production, control of aquatic weeds and aquatic insects, algal blooms; specific food consumption, food conversion ratio (FCR), protein efficiency ratio, true net protein utilization, apparent net protein utilization, biological value of protein

#### Unit VI

Measurement of growth; length - weight relationship; methods of determination of age in fishes and shellfish based on length data and growth checks; ponderal index; growth hormones.

#### Practical FIELD VISIT AND SPECIMEN COLLECTION

- 1. Cultivable fin fishes/ crustaceans/ molluscs
- 2. Weed fishes/ predatory fishes
- 3. Aquatic insects from aquaculture ponds
- 4. Collection and identification of cultivable fishes and prawns

# Field visit:

- 1. Visit to coastal aquaculture farms
- 2. Visit to a shrimp hatchery
- 3. Visit to an ornamental fish farm/ aquarium

# **Text books and References**

- 2. Mathew Landau. 1995. Introduction to Aquaculture. Daya Publishing House, New Delhi.
- 3. Pillay, T. V. R. 1993. Aquaculture: Principles and Practices. Fishing News Books. Black Well Scientific Publications.
- 4. MPEDA, 1991. Hand Book on Shrimp Farming, Kochi, India.
- 5. Jhingran, V. G. 1982. Fish and Fisheries of India. Hindustan Publishing Corporation, New Delhi.
- 6. Chakrabarti, N. M. 1998. Biology, Culture and Production of Indian Major Carps. Narendra Publishing House, New Delhi.
- 7. Coche, A. G. and J. F. Muir. 1996. Pond Construction and Fresh Water Fish Culture Pond Farm Structures and Layouts Simple Methods for Aquaculture. FAO. Daya Publishing House, New Delhi.
- 8. Upadhyay, A. S. 1995. A Handbook on Design, Construction, and Equipment in Coastal Aquaculture (Shrimp Farming). Daya Publishing House, New Delhi.

# AQ2MI02 ECOLOGY OF AQUATIC ENVIRONMENT Credits: 4

# Unit I

Definition of ecology, organism, and environment; features of organism-environment relations; living and non-living environments; the ecosystem or habitat. Freshwater ecosystems - Lotic and Lentic ecosystems; Marine ecosystems - oceans and seas, zonation of the seas - rocky, sandy, and muddy shores; classification of marine habitat - pelagic, benthic, neritic, oceanic, littoral, and abyssal.

# Unit II

Physical characteristics of water: Light - penetration of sunlight into aquatic media, the effect of light on productivity, photoperiodicity in animals; Temperature - annual temperature cycles, thermal stratification of water bodies, thermal optimum, maximum and minimum, water movements, periodic and periodic current system; Turbidity - causes, variations, and effects.

# Unit III

Chemical characteristics of water: Atmosphere and atmospheric gases dissolved in water; Oxygen - oxygen and life, hypoxia, anoxia and hyperoxia, adaptations of animals to varying oxygen tensions; Carbon dioxide - sources of Co2, its ecological effects; pH or hydrogen ion concentration - its significance. total hardness and total alkalinity

# Unit IV

Biogeochemical cycles: Nitrogen cycle; phosphorus cycle; sulfur cycle; carbon cycle; trace elements - manganese and copper. Organic matter: Aquatic vegetation – zones of aquatic vegetation; Plankton - classification of plankton, factors affecting plankton distribution, plankton counting and sampling; phytoplankton - zooplankton relationship, plankton productivity; Benthos - phytobenthos and zoo benthos.

#### Unit V

Productivity: Concept of productivity – standing crop, rate of production and rate of removal; primary and secondary productivity; classification of water bodies on thebasis of productivity.

#### Unit VI

Dynamics of aquatic ecosystem: Principal steps and components – niches, trophic levels and relations; producers, consumers, decomposers and transformers; food chain and food web; pyramid of biomasses; pyramid of numbers; energy transfer in the ecosystem.

#### Text books and References

- 1. Pillai, N. K. 1993. Marine Biology and Ecology. Daya Publishing House, New Delhi.
- 2. Reid, G. K. and R. D. Wood. 1976. Ecology of Inland Waters and Estuaries D. Van Nostrand Company.
- 3. Kormondy, E. J. 1996. Concepts of Ecology. Prentice Hall of India Pvt. Ltd. New Delhi.
- 4. Cole, G. L. 1954. Text Book of Limnology. The C. V. Mosloy Co.,
- 5. Odum, E. P. 1996. Fundamentals of Ecology.3<sup>rd</sup> End. Natraj Publishers, Dehradun.
- 6. Santhanam, R. and A. Srinivasan. 1994. A Manual of Marine Zooplankton. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
- 7. Pillai, N. K. 1986. Introduction to Planktonology. Himalaya Publishing House, Mumbai.
- Balakrishnan Nair, N and D. M. Thampy. 1980. A Text Book of Marine Ecology. McMillan India Ltd.

#### UNIT 1

Overview of intellectual property Introduction and the need for intellectual property right (IPR). IPR in India – Genesis and Development. Some important examples of IPR.Patents Macro-economic impact of the patent system. Patent and kind of inventions protected by a patent. Patent document. How to protect your inventions? Granting of patent. Rights of a patent. How extensive is patent protection? Why protect inventions by patents. Searching a patent. Drafting of a patent. Filing of a patent

#### UNIT 2

What is copyright? What is covered by copyright? How long does copyright last? Why protect copyright? Related rights: What are related rights? Distinction between related rights and copyright. Rights covered by copyright.

#### UNIT 3

Definition of trademark. Rights of trademark. Kinds of signs that can be used as trademarks. Types of trademark. The function that a trademark performs. How is a trademark protected? How is a trademark registered? How long is a registered trademark protected for? How extensive is trademark protection? What are well-known marks and how are they protected? Domain name and how does it relate to trademarks

#### UNIT 4

What is a geographical indication? How is a geographical indication protected? Why protect geographical indications? What is an industrial design? How can industrial designs be protected? What kind of protection is provided by industrial designs? How long does the protection last? Why protect industrial designs?

#### UNIT5

Rationale for Intellectual Property Protection in Biotechnology. Concept of Novelty in Biotechnological Inventions. Patenting biological inventions. Patenting microorganisms. Patenting other biological processes and products. Protection of new varieties of plants. Justification for Protection. Biotechnology and International Treaties such as Convention on Biological Diversity and TRIPs.

#### References

1. T. M Murray, M.J. Mehlman. 2000. Encyclopaedia of Ethical, Legal and Policy issues in Biotechnology, John Wiley & Sons.

2. P.N. Cheremisinoff, R.P. Ouellette and R.M. Bartholomew.1985. Biotechnology Applications and Research, Technomic Publishing Co., Inc.

3. D. Balasubramaniam, C.F.A. Bryce, K. Dharmalingam, J. Green and K. Jayaraman,

- 2002. Concepts in Biotechnology, University Press (Orient Longman Ltd.).
- 4. Bourgagaize, Jewell and Buiser. 2000. Biotechnology: Demystifying the Concepts, Wesley Longman.
- 5. Ajit Parulekar, Sarita D' Souza. 2006. Indian Patents Law Legal & Business Implications; Macmillan India,
- 6. B.L. Wadehra. 2000. Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal Law Publishing Pvt. Ltd.
- 7. P. Narayanan. 2010. Law of Copyright and Industrial Designs; Eastern Law House.

8. N.S. Gopalakrishnan, T.G. Agitha. 2009. Principles of Intellectual Property. Eastern Book Company.

- 9. T. Ramakrishan (Ed.). 2003. Biotechnology and Intellectual Property Rights. CIPRA, NLSIU, Bangalore.
- 10 N.K. Acharya. 2012. Text Book on Intellectual Property Rights, 6th ed. Asia Law House.
- 11 M. M. S. Karki. 2009. Intellectual Property Rights: Basic Concepts. Atlantic Publishers.
- 12 N. S. Sreenivasalu. 2007. Intellectual Property Rights. Neha Publishers & Distributors.
- 13 Pal P. 2008.Intellectual Property Rights in India: General Issues and Implications. Regal Publications
AQ22AE02

University Web Site

#### AQ2SE02 BREEDING AND REARING OF AQUARIUM FISHES. Credits:3

- 1. Identification of common aquarium fishes
- 2. Indigenous ornamental fishes of Lakshadweep
- 3. Setting up of aquarium
- 4. Aquarium plants
- 5. Working of air pump and biological filter and other accessories.
- 6. Breeding of live breeding fish
- 7. Breeding of egg layers- gold fishes
- 8. Breeding of bubble nest builder- Gourami
- 9. Control of snails in ornamental fish culture system
- 10. Marine aquarium fishes and invertebrates
- 11. Disease of aquarium fishes (signs and causative agents and treatments)
- 12. Water quality management in aquariums
- 13. Construction of aquarium

## **Collection:**

Common aquarium fishes

Aquarium plants

## Field visit:

Visit to Ornamental fish farms

Visit to ornamental fish whole sale and retail outlets

## **Text books and References**

- 2. Biswas. S.P., J. N. Das, U. K. Sarkar and Lakra W.S. 2007 Ornamental fishes of NorthEast India: An Atlas: NBFGR
- 3. Marine Aquarium keeping: The Sciences, Animals and Art. John Wiley & Sons, New York
- 4. Ramachandran. A, Breeding, Farming and Management of Fishes, CUSAT
- 5. Madhusudan Kurupetal– Ornamental Fish Breeding, Farming and Trade CUSAT.
- 6. Jhingran, V. G. 1982. Fish and Fisheries of India. Hindustan Publishing Corporation, New Delhi.
- 7. Santhanam, R. and A. Srinivasan. 1994. A Manual of Marine Zooplankton. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

# XX2VA03 DIGITAL TECHNOLOGIES CREDIT:2

# CS2VA04 HEALTH & WELLNESS/YOGA EDUCATION CREDIT:2

University website

## AQ3MJ03

## **BIOLOGY OF FISHES**

## **Credits:4**

# Unit I

General characters of fishes, adaptations for swimming, body forms, fins. Structure and function of skin and mucous layer. Different types of scales and its modifications. Coloration in fishes. Bioluminescence in fishes. Sense organs in fishes –organs of smell, taste buds, lateral

line system. Ampullae of Lorenzini etc. Specialized organs in fishes – electric organs and toxins in fishes.

# Unit II

Food and feeding habits –herbivores, carnivores and omnivores. Feeding adaptations methods, employed in the study of gut content analysis- volumetric, gravimetric etc. Feeding indices- GSI. Age and growth –Techniques used in the study –use of scales and otoliths, length frequency analysis- VBGF, equations used for deriving growth rates

# Unit III

Reproduction –ovary and testes, structure, development of primary and secondary sexual characteristics. Sexual dimorphism in fishes. Maturation and spawning in fishes, factors affecting maturation and spawning. Fecundity, condition factor, size at first maturity. Oviparous, viviparous and ovoviviparous fishes. Parental care and breeding migration in fishes. Migration in fishes –anadromous and catadromous, homing, instinct and orientation.

# Unit IV

Digestive system –General morphological features of digestive system in fishes. Respiratory system –general description, aquatic respiration, respiratory gases, gaseous exchange, oxygen transport. Adaptations for air breathing in fishes. Cardiovascular system –General features of heart and blood circulation, circulatory system and oxygen transport in fishes.

# Unit V

Endocrine organs in fishes. Hormones and their role in control of reproduction in fishes. Endocrine system in crustacean and molluscs. Role of hormones in reproduction and molting in crustacean. Excretion and osmoregulation. Nitrogenous excretion freshwater and marine fishes. Water and salt balance.

# Unit VI

Principles of zoological classifications, binomial nomenclature of commercially important fishes, crustaceans and molluscs.

# Practical

- 1. Morphometric measurements of fishes
- 2. Fin forms of fish and swimming behaviour
- 3. Types of scales, placoid, cycloid & ctenoid
- 4. Examination of the structure of gill and assessment of feeding behavior–*Sardinella/ Channa* sp.
- 5. Mounting of appendages of Shrimp
- 6. Dissect and display of alimentary canal of fishes/prawns
- 7. Fecundity estimation in fishes/ shrimpand its relationship with length and weight
- 8. Gut content analysis: Volumetric methods

#### AQ3MJ04

#### VERTEBRATE ZOOLOGY

#### **Credits:4**

#### Unit I

General characteristics and outline classification of Phylum Chordata (Young, 1981). Protochordata: General characteristics and classification of sub-phylum Urochordata and Cephalochordata up to Classes (Young, 1981). Metamorphosis in *Ascidia*. Chordate Features, structure of pharynx and feeding in *Branchiostoma* 

## Unit II

Agnatha: General characteristics and classification of cyclostomes up to order (Young, 1981). Pisces: General characteristics and classification up to living sub classes (Young, 1981); Accessory respiratory organ, Migration in fishes; Parental care in fishes; Swim bladder in fishes.

#### Unit III

General characteristics and classification up to living Orders (Young, 1981); Metamorphosis, Paedomorphosis, Parental care in Amphibia

#### Unit IV

Reptilia: General characteristics and classification up to living Orders (Young, 1981); Poison apparatus and Biting mechanism in Snake. Poisonous & Non-Poisonous snake.

#### Unit V

Aves: General characteristics and classification up to living Sub-Classes (Young, 1981); Exoskeleton and migration in Birds; Principles and aerodynamics of flight.

#### Unit VI

General characters and classification up to living sub classes (Young, 1981); Exoskeleton derivatives of mammals; Adaptive radiation in mammals with reference to locomotory appendages; Echolocation in Micro chiropterans.

## PRACTICALS

## DISSECTION

Fish: Digestive, Nervous system, Male and female Reproductive system

# I. MOUNTING

- 1. Placoid scales.
- 2. Ctenoid scales.
- 3. Cosmoid scales

# III - SPOTTERS (any 30 spotters)

# A- Classify giving reasons up to order:

- 1. Balanoglossus
- 2. Herdmania (=Ascidian)
- 3. Branchiostoma (= Amphioxus)
- 4. Petromyzon
- 5. Scoliodon sorrakowah
- 6. Mugil oeur
- 7. Rana hexadactyla
- 8. Calotes versicolor
- 9. Columba livia
- 10. Oryctolagusc cuniculus

# **B** - Draw labeled sketches:

- *11. Amphioxus* T.S. through pharynx.
- 12. Doliolum
- 13. Salpa
- 14. Arboresant organ of cat fishes
- 15. Accessory respiratory organ of Anabas
- 16. Flight muscle of Birds
- 17. Poisonous apparatus of Snake
- 18. Narcine
- 19. Naja naja
- 20. Typhlops
- C- Comment on Biological significance:

- *21.* Tornaria larva
- 22. Ascidian Tadpole larva
- 23. Anabas scandens
- 24. Hippocampus
- 25. Echeneis
- 26. Rhacophorus
- 27. Ichthyophis
- 28. Amblystoma
- 29. Axolotle larva
- 30. Chamaeleon
- 31. Vipera russelli (Russel's viper)
- 32. Draco volans
- *33.* Bat
- **D** –Relate structure and function:
- 34. Fish air bladder
- 35. Fang of Snake
- 36. Placoid- Scale of Shark.
- 37. Filter feeding structure of Whale- Baleen plates
- 38. Quill Feather of pigeon
- 39. Aquatic mammals- limbs
- 40. Contour feather Text books and References

## **Text books and References**

- 1. Jordan EL, Verma PS. 2003. Chordate Zoology. S. Chand & Company Ltd. New Delhi.
- 2. Kent GC, Carr RK. 2001.Comparative anatomy of the Vertebrates. 9th Ed. Mc Graw Hill.48
- 3. Pough H, Christine MJ, Haiser B. 2002. Vertebrate life, VIII Edition, Pearson.
- 4. Romer AS, Parsons TS. 1986. The vertebrate body. 6th Ed. Saunders College Publishing
- 5. Sinha K S, Adhikari S, Ganguly BB. 2001. Biology of Animals. Vol. II. NCBA
- 6. Young J Z. 2004. The Life of Vertebrates. III Edition. Oxford University Press.

## AQ3MI03

#### MARICULTURE

#### Credit:4

#### Unit I

Introduction and present status of brackish water farming in India. Brackish water as a medium for aquaculture - ecological factors – abiotic and biotic factors. Selection of site. Traditional practices in India – paddy field prawn filtration in Kerala and Bhasabadha fisheries in West Bengal.

#### Unit II

Selection of cultivable species in brackish water systems, their biology and culture practices– monoculture and polyculture of – *Chanos chanos, Mugil cephalus, Etroplus suratensis, Oreochromis mossambicus*. Culture of carnivorous fishes – *Lates calcarifer*. Nursery, rearing and grow out in ponds, cages and pens. Sea ranching

#### Unit III

Species of shrimps cultured in brackish water and their biology – *Penaeus monodon, Feneropenaeus indicus* and *Penaeus vannamei*. Systems of shrimp farming. Species of crabs cultured and their biology, crab culture techniques, prospects in India. Culture of lobsters–experimental culture and prospects in India.

#### Unit IV

Various ecological subdivisions of the sea. Different designs of open sea farming structures– construction of cages – bioengineering problems and solutions – scope of open sea farming in India. Important fin fishes cultured in the open seas.

#### Unit V

Molluscan culture – species of edible oysters, mussels and clams cultured, culture techniques used for farming edible oysters and mussels. Important species of pearl oysters and method of artificial pearl production. Culture of seaweeds, common cultivated species, culture techniques and harvesting. Present status and recent developments in mariculture.

#### Unit VI

Environmental impact of brackish water and coastal aquaculture- effluent discharge, eutrophication, chemical residues including antibiotics, destruction of natural habitat including paddy field and mangroves. Salinity intrusion. Coastal zone management and CRZ. Regulation of coastal aquaculture and Coastal Aquaculture authority of India. Introduction of exotics, genetic erosion of indigenous stock.

## **Text books and References**

- 1. Pillai, N. K. 1993. Marine Biology and Ecology. Daya Publishing House, New Delhi.
- 2. Pillay, T. V. R. 1993. Aquaculture: Principles and Practices. Fishing News Books. Black Well Scientific Publications
- 3. Jhingran, V. G. 1982. Fish and Fisheries of India. Hindustan Publishing Corporation, New Delhi.
- 4. Milne P H. 1979 Fish and Shellfish farming in coastal waters
- 5. Kurian, C.V and Sebastian V.O. Prawn and Prawn fisheries of India

# AQ3ML03 FISHING CRAFT AND GEAR TECHNOLOGY Credits:4

## UNIT I

Fishing crafts: Fishing craft materials-introduction to fishing craft technology- Boat building material- wood, steel, aluminum, Ferro-cement, FRP (GRP)-advantages and disadvantages. Classification and description of different type of fishing crafts in India(inland and marine) traditional, motorized and mechanized. General arrangement and deck lay outs in different types of fishing boats, trawlers, gill netters, purse seiners, long liners, trollers, deep sea vessels. Classification of Marine corrosion

# UNIT II

Classification of fishing gear (FAO and A. Von Brandt). Fishing gear materials- natural, synthetic materials, properties and preservation, yarn numbering systems, direction of netting, type of knots, meshes, fly meshing. Mounting and webbing different methods, hanging co-efficient. Fishing gear accessories- floats, sinkers, otter board, hook and ropes.

## UNIT III

Active gears-Design and operation of – trawls, purse seines, ring seines, beach / shore seine, boat seine, pole and line, squid jigs, trolling. Passive Gears – Design and operation of- gill nets, long lines, hooks, traps, stake net, dol net, Chinese dip nets, cast nets. Destructive fishing methods like electrical fishing, poisoning and use of dynamites. Prohibited fishing practices. Factors affecting the design of fishing gears and fish catching methods

## **UNIT IV**

FAD's, Fish finding devices and conservation: Fish aggregating devices and artificial reefs; Impact of artificial reefs on fish stock improvement; Turtle Exclusion Devices (TED) – Bycatch Reduction Devices (BRD). Fish finder, GPS navigator, echosounders, sonar, net sonde, gear monitoring equipment; remote sensing

#### UNIT V

. Responsible Fisheries and Fisheries Legislation: Concept of Responsible Fisheries; Monsoon trawl ban, closed season, mesh size regulations, juvenile fishing, Exclusive Economic Zone (EEZ), Coastal Regulation Zone (CRZ), Integrated Coastal Zone Management (ICZM). MSY, MEY, Over fishing, Recruitment over fishing, Aqua-ranching. Indian fisheries Act.1897. MFRAs, Maritime zones of India Act.1981, The Environment (Protection) Act, 1986, Biological diversity Act,2002.

## References

- Brandt. A. v. (1984) Fish catching methods of the world. Fishing News Books Ltd., London: 432 p.
- Hameed, M.S. and Boopendranath, M.R. (2000) Modern Fishing Gear Technology, Daya Publishing House, Delhi:186 p.
- 3. Klust, G. (1982) Netting materials for fishing gear, FAO Fishing Manual, Fishing News Books (Ltd). Farnham, 192p.
- 4. Sreekrishna, Y. and Shenoy L. (2001) Fishing gear and craft technology, Indian Council of Agricultural Research, New Delhi.
- FAO (1997) Fisheries management. FAO Technical Guidelines for Responsible Fisheries. No. 4. Fishery Resources Division and Fishery Policy and Planning Division, FAO. Rome: 82p.
- FAO (1995) Code of Conduct for Responsible Fisheries, FAO, Rome: 41 p.4. FAO (1997) Inland fisheries. FAO Technical Guidelines for Responsible Fisheries. No. 6 Fisheries Department, FAO, Rome: 36 p.

# AQ3AE03 ARABIC/HINDI/MALAYALAM CREDIT; 3

University Web Site

# AQ3SE03 QUARIUM FABRICATION AND SETTING CREDIT; 3

## Unit 1

Definition of aquarium, scope and history, Fabrication of home aquarium Activity Design and construction of public fresh water and marine aquaria, Types of materials used in aquarium fabrication.

# Unit 2

Aerators and the different types. Different kinds of Filters and Lighting, Thermostat for Aquaria. Hand nets and other equipment. Aquarium gravels, pebbles, hood and aquarium plants.

**Unit 3** Aquarium Setting Site selection for Aquaria.Setting up of freshwater aquarium .Setting up of marine aquarium. Aquascaping

**Unit 4** Aquarium Maintenance-Water quality parameters, Cleaning of the aquarium, Control of algae and snails, Nutritional requirements of aquarium fishes, Different kinds of fish feeds.

**Unit 5** Types of Aquaria World aquarium trade and present status Criteria for selection of aquarium fishes

#### **Reference**s

- 1. John Dawes, 1995. Live bearing Fishes (A guide to their Aquarium care, Biology and Classification) Cassell Pvt., London, 240 pp.
- 2. Lieske, E, Myers, R. 1996. Coral Reef Fishes, Princeton University Press, Prenceton, New Jersey, 400 pp.
- 3. Walter H. Adey and Karen Loveland, 1998. Dynamic Aquaria Building Living Ecosystems. Academic Press, New Delhi, 498 pp.
- 4. Sebastian J. Kuravamveli, 2002. he Aquarium Handbook. Amity Aquatech Pvt. Ltd., Cochin 28.
- 5. Sundararaj, V. and J.M. Sathish, 2005. Tropical Marine Aquarium. Yegam Publications, Chennai,
- 6. Greg Jennings, 2006. 500 Freshwater aquarium fish: a visual reference to the most popular Species hardcover, Firefly Books, Limited, 528 Pages.

7. Matthew L. Wittenrich, 2007. The Complete Illustrated Breeder's Guide to Marine Aquarium Fishes - Microcosm/TFH (ca), 304 Pages.

8. Vincent Hargreaves, 2007. Complete Book of the Freshwater Aquarium: A Comprehensive Reference Guide to More Than 600 Freshwater Fish And Plants, Plus How to Set Up And Maintain an Aquarium, Thunder Bay Press, 304 Pages.

#### Semester 4

#### AQ4MJ05 FRESHWATER AQUACULTURE Credit: 4

#### Unit I

Scope and significance of aquaculture, comparison of aquaculture with capture fisheries. Different aquaculture systems. Global and Indian Scenario of Aquaculture. Criteria for the selection of species, common species cultured. Freshwater cultivable fishes.

## Unit II

General concepts of ecology, productivity, carrying capacity, food chain and food web. Ecology of culture ponds. Nutrient cycles -- Nitrogen, Phosphorous and Carbon cycles. Laws of limiting factor. Nutrient dynamics. Significance and important groups of phytoplankton, zoo plankton and benthos in culture ponds. algal blooms.

#### Unit III

Selection of site, types of ponds, nursery rearing, stocking ponds, preparation of ponds– liming, Different methods for the eradication of weed fishes, predators, aquatic insects and aquatic weeds, fertilization and manuring, , stocking and post stocking management, harvesting. Management of water and soil quality parameters.

## Unit IV

Cultivable species of freshwater prawns and their biology –culture of Macrobrachium rosenbergii, Culture of cray fish. Important freshwater molluscs–Biology and culture of *Lamellidens marginalis*. Freshwater pearl culture –Present status of freshwater pearl culture and production in India. Culture of air breathing fishes. Culture of cold water fishes in India. Sewage fed fish culture, sewage treatment–Sewage cum fish culture in India. Fish in relation to public health – Larvivorous fishes and mosquito eradication using fishes.

#### Unit V

Recent development in integrated farming –Rice cum fish culture, Duck cum fish culture, Poultry cum fish culture and Pig cum fish culture. Organic aqua farming. Aquaponics, Integrated Multitrophic Aquaculture (IMTA). Biofloc based aquaculture practices – C:N ratio-Fish culture in cages and pens. Running water fish culture. Culture of exotic species. Organizations involved in freshwater aquaculture research and development - CIFA, NBFGR, NACA, SEAFDEC, ADAK, FFDA

#### **Practical's**

- 1. Identification of cultivable aquatic organisms
- 2. Collection and identification of phyto and zooplankters (in aquaculture ponds)
- 3. Identification of different larval stages of penaeid and palaemonids shrimp
- 6. Identification of different live feed organisms
- 7. Enumeration of micro algae using hemocytometer
- 8. Trials of decapsulation and hatching of artemia
- 9. Preparation of artificial feed for aqua cultured organism

## **Text books and References**

- 1. Santhanam R., N. Sukumaran, P. Natarajan 1987. A Manual of Freshwater Aquaculture, South Asia Books
- Pillay, T. V. R. 1993. Aquaculture: Principles and Practices. Fishing News Books.
  Black Well Scientific Publications
- Jhingran, V. G. 1982. Fish and Fisheries of India. Hindustan Publishing Corporation, New Delhi.
- 4. Pillai, N. K. 1993. Marine Biology and Ecology. Daya Publishing House, New Delhi.

# AQ4MJ06 HATCHERY TECHNOLOGY AND MANAGEMENT Credits:4

# **Unit 1: Carp Hatcheries**

Hatchery management-seed production of carps. Hypophysation of Indian major carps and exotic carps, history of hypophysation. Pituitary gland. Collection and preservation of gland. Other ovulating agents. Brood stock management, sexing, dosage for injection, mechanism of ovulation. Development of carp eggs, different carp hatcheries. Nursery rearing of carp seed.

# Unit 2: Carp Production System

Production of common carp seeds, breeding techniques, Sundanese, Tjimindi, Rantjapaku and Central Sumatra methods. Methods followed in China and India. Transport of fish seed and broodfishes. Causes of mortality during transport, techniques of transport, open and closed systems, methods of transportation, use of anaesthetics. Bundh breeding- types, techniques and problems.

# **Unit 3: Seed Production of other Fishes**

Seed production and nursery rearing of trout, air-breathing fishes, mullets, tilapia, pearl spot, sea bass, and groupers.

# **Unit 5: Live Feeds for Larvae**

Culture of fish food organisms. Major phytoplankton groups- microalgal culture, laboratory methods- isolation, media preparation, kinds of culture- pure, crude, mass culture. Mass culture of *Chaetoceros. Artemia* – different strains, hatching, decapsulation, Production of Artemia cyst.

## **Unit 6: Hatchery Management**

Components and general design of hatcheries. Selection criteria for broodstock and brood stock management. Water quality monitoring and management. Quarantine and disease management in hatcheries. Quality assessment of seeds.

## **Text Books and References**

- 1. Coche, A. G. and J. F. Muir. 1996. Pond Construction and Fresh Water Fish Culture Pond Farm Structures and Layouts – Simple Methods for Aquaculture. FAO. Daya Publishing House, New Delhi
- 2. CMFRI Spl. Bul. Hatchery Operation of Penaeid Shrimps
- 3. CMFRI sp Bul Artificial Reefs and Sea Farming Techniques
- Jhingran VG 1998. Fish and Fisheries of India. Hindustan Publishing Corporation, NewDelhi
- 5 Pillay TVR, 1996. Aquaculture Principles and Practices, Fishing News Books Ltd.,

## AQ4MJ07 SEAFOOD PROCESSING TECHNOLOGY Credits:4

## Unit I

Fish as raw material for processing. Handling of fish onboard fishing vessels. Structural and chemical changes associated with postmortem. Factors affecting quality of fresh fish. Chill storage of fish. Discoloration in aquatic products, Depuration of bivalves. Live fish/shell fish Transportation to local markets and processing centers.

## Unit II

General Principles of food preservation. High temperature, low temperature, drying, radiation and chemicals. Microbial growth in food: intrinsic and extrinsic parameters and means of control (food formulations, cooking, preservatives, pH.aW)

## Unit III

Simple mechanical refrigeration systems. Ice plants, chilling, supper chilling, refrigerated and chilled seawater.

## Unit IV

Freezing, slow freezing, quick freezing, types of freezers, freezing time, freezing of fish and shell fish. Technological aspects of freezing: Methods of freezing, comparison of various freezing

## Unit V

Preparation of salted fishes, dried fish and smoked fish. Accelerated freeze drying. Canning: Principles of thermal processing Mechanism of heat transfer, canning in oil and brine. Filleting, breading etc. utilization of fishery wastes such as prawn shell, fish offal, fish meal, chitin, chitosan. Fish silage.

## Practicals

- 1. Determination of moisture content in fish and fishery products
- 2. General description freezing
- 3. Processing shrimp
- 4. Filleting of fish
- 5. Organoleptic analysis of fish
- 6. Preparation of fishery by products
- 7. Preparation/identification of fish maws, chitin, chitosan
- 8. Fish pickling
- 9. Value added fishery products, fish curry, cutlets fish finger, fish wafer.

#### **Text Books & References:**

- 1. Desrosier N.W. 2012 Fundamentals of Food Freezing
- 2. Brody J. Fishery Byproduct Technology
- 3. Chichester C.O. 2013. Microbial Safety of fishery Products, Academic Press.
- 4. Anthony T. Tu 1983. Handbook of Natural toxins.
- 5. Gopakumar K. Text Book of Fish Processing Technology.
- 6. Huss, H. H. et al. Quality assurance in the fish industry.
- 7. John, D. E. V. 1997. Food safety and toxicity, CRC Press.

#### AQ4MI04

#### **CRAFT AND GEAR TECHNOLOGY**

Credits:4

# UNIT I

Fishing crafts: Fishing craft materials-introduction to fishing craft technology- Boat building material- wood, steel, aluminum, Ferro-cement, FRP (GRP)-advantages and disadvantages. Classification and description of different type of fishing crafts in India(inland and marine) traditional, motorized and mechanized. General arrangement and deck lay outs in different types of fishing boats, trawlers, gill netters, purse seiners, long liners, trollers, deep sea vessels. Classification of Marine corrosion

## UNIT II

Classification of fishing gear (FAO and A. Von Brandt). Fishing gear materials- natural, synthetic materials, properties and preservation, yarn numbering systems, direction of netting, type of knots, meshes, fly meshing. Mounting and webbing different methods, hanging co-efficient. Fishing gear accessories- floats, sinkers, otter board, hook and ropes.

## **UNIT III**

Active gears-Design and operation of – trawls, purse seines, ring seines, beach / shore seine, boat seine, pole and line, squid jigs, trolling. Passive Gears - Design and operation of- gill nets, long lines, hooks, traps, stake net, dol net, Chinese dip nets, cast nets.

## **UNIT IV**

Destructive fishing methods like electrical fishing, poisoning and use of dynamites. Prohibited fishing practices. Factors affecting the design of fishing gears and fish catching methods.

#### UNIT V

FAD's, Fish finding devices and conservation: Fish aggregating devices and artificial reefs; Impact of artificial reefs on fish stock improvement; Turtle Exclusion Devices (TED) - Bycatch Reduction Devices (BRD). Fish finder, GPS navigator, echosounders, sonar, net sonde, gear monitoring equipment; remote sensing.

#### **UNIT VI**

Responsible Fisheries and Fisheries Legislation: Concept of Responsible Fisheries; Monsoon trawl ban, closed season, mesh size regulations, juvenile fishing, Exclusive Economic Zone (EEZ), Coastal Regulation Zone (CRZ), Integrated Coastal Zone Management (ICZM). MSY, MEY, Over fishing, Recruitment over fishing, Aqua-ranching. Indian fisheries Act.1897. MFRAs, Maritime zones of India Act.1981, The Environment (Protection) Act, 1986, Biological diversity Act,2002.

#### **Text Books and References**

- Brandt. A. v. (1984) Fish catching methods of the world. Fishing News Books Ltd., London:
  432 p.
- 8. Hameed, M.S. and Boopendranath, M.R. (2000) Modern Fishing Gear Technology, Daya Publishing House, Delhi:186 p.
- 9. Klust, G. (1982) Netting materials for fishing gear, FAO Fishing Manual, Fishing News Books (Ltd). Farnham, 192p.
- 10. Sreekrishna, Y. and Shenoy L. (2001) Fishing gear and craft technology, Indian Council of Agricultural Research, New Delhi.
- 11. FAO (1997) Fisheries management. FAO Technical Guidelines for Responsible Fisheries.No. 4. Fishery Resources Division and Fishery Policy and Planning Division, FAO. Rome: 82p.
- 12. FAO (1995) Code of Conduct for Responsible Fisheries, FAO, Rome: 41 p.4. FAO (1997)Inland fisheries. FAO Technical Guidelines for Responsible Fisheries. No. 6 FisheriesDepartment, FAO, Rome: 36 p.

AQ4AE04

**ENGLISH II** 

Credits:3

University Website

# AQ4PRO1 COMMUNITY ENGAGEMENT AND SERVICE/ STUDT TOUR/ INDUSTRIAL TRAINING

Credits:3

#### Semester 5

#### AQ5MJ08 GENETICS AND BIOTECHNOLOGY IN AQUACULTURE Credits:4

## UNIT I

Introduction to Fish and Shellfish Genetics – Gynogenesis, Androgenesis, hybridogenesis, polyploidy, euploidy, interspecific hybridization, intraspecific crossbreeding, Monosex strains and their importance, sex reversal – mechanisms and applications; protrandrous, protogynous species and their importance; genotype environment interactions.

## UNIT II

Genetic Engineering and Biotechnology in aquaculture- genetic improvement, selective breeding, transgenics and GMOs in aquaculture- reporter genes, AFP, disease resistance genes, growth hormone gene; gene transfer mechanisms, gene cloning.

## **UNIT III**

Marker assisted selection, markers and their role in aquaculture biotechnology, DNA markers- RAPD, AFLP, RFLP, phenotypic markers, protein markers; microsatellite markers

in fisheries research; gamete transfer mechanisms in crustaceans; artificial insemination and in-vitro fertilization in fishes and shellfishes; cryopreservation and its application.

#### **UNIT IV**

Biotechnological applications in pearl culture – genetic improvement, improvements in surgical techniques, biomineralization of nacre, tissue culture techniques.

## UNIT V

Development and application of probiotics, prebiotics, bioremediators, immunostimulants, immunomodulators and vaccines – biofilm vaccines, DNA vaccines, recombinant vaccines. Hybridoma techniques; PAB's and MAB's in aquatic animal health management, Diagnostics and their application in aquaculture health management – immunodiagnostics, nucleic acid based diagnostics.

## UNIT VI (10 hrs)

Introduction to Genomics and Proteomics; Bioethics with regard to biotechnological interventions in aquaculture sector-biodiversity and environment related issues, consumer issues associated with GMO's, economic issues, political issues, research issues, patents in biological research, biopiracy, Intellectual Property Rights (IPR) and their significance in aquaculture and fisheries science, documentation for patenting.

Practical

- 1. Enumeration of total RBC and WBC of fish
- 2. Estimation of hemoglobin content in fish
- 3. Barr bodies
- 4. Chromosomal aberrations (spotters)
- 5. Isolation of genomic DNA
- 6. Separation of DNA by Agarose gel Electrophoresis
- 7. Northern Blotting technique (Demonstration)

8. Southern Blotting technique (Demonstration)

#### **Text Books and References**

- 1. Fingerman et al., 1999, Marine Biotechnology (Vol 1, 2 and 3)-. Science PublishersInc, USA.
- Karunasagar et al., 1999,- Aquaculture and Biotechnology -- Oxford and IBH, New Delhi
- 3. Fisheries Biotechnology 2004 Lakra et al., Narendra Publishing House
- 4. A. R. Beaumont, 2003 Biotechnology and Genetics in Fisheries and Aquaculture
- 5. Adams, A ,2001 Immunodetection methods in aquaculture.-
- R.A. Dunham 2003, Aquaculture and fisheries biotechnology, a genetic approach 2003-

Credit 4

# Unit 1

Economic significance feed usage in Aquaculture, environmental considerations regarding fish feed in aquaculture. Feed Conversion Ratio(FCR) and food Efficiency Ratio(FER) Factors affecting digestibility, immunostimulants, growth promoters, and preservatives. Raw materials for artificial fish feed

# Unit 2.

Raw materials of plant origin, raw materials of animal origin, nonconventional materials -Protein and amino acid requirement, carbohydrate and lipid requirement, Essential fatty acids, Non-protein nitrogen sources. Vitamin and mineral requirements, vitamin C for fish and shellfish. Feed Formulation Techniques, types of feeds and measurement of calorific value

# Unit 3.

Principles of feed formulation – Pearson's square method, Linear programming, proximate analysis Activity – prepare different feed formulations with two ingredients using Pearson's square. Types of feeds- Wet feeds, dry feeds, moist feeds Larval feeds – Minced diets, microparticulate diets, spray dried diets, micro bound diets, micro coated diets and microencapsulated diets. Measurement of calorific value – Component analysis, wet oxidation, bomb calorimetry

# Unit 4.

Different forms of feed-fodders, mash, pellets, floating and sinking feeds. Feed formulation -Methods, square method. Feed manufacturing processes, Extrusion, Palletization, Different size and grades of fish/shrimp feeds - starter, grower and finisher feeds. Micro-bound feed, micro encapsulated feed. Storage and transportation of feeds. Quality problems- toxins, pests, rancidity

# Unit 5.

Additives – definitions, types – binders, antioxidants, pigments, anabolic agents, antimicrobials, and health supplements. Role of additives in immune health and stress reduction. Enzymes, probiotics, prebiotics. Importance of emulsifiers and stabilizers.

## Reference

- 1. Anderson, K., et al. (2020). Evaluation of Protein Sources in Aquafeed Formulations. Aquaculture Nutrition, 2020(12) :225-240.
- 2. Banerjee, S., and Keshavanath, P. (2017). Aquaculture and Fish Nutrition. BS Publications.
- 3. Bhakshi, Sanjeev. (2015) Fish Nutrition and Feed Technology. Daya Publishing House.
- 4. Brown, P. B., and Sindermann, C.J. (Eds.). (2003). Introduction to Aquaculture. Wiley-Blackwell.
- 5. Brown, R., et al. (2019). Fish Nutrition and Digestive Physiology. Journal of Aquatic Sciences, 2019(8) :45-62.
- 6. Das, Nilanjana, et al. (2016) Evaluation of locally available feed ingredients for formulating cost-effective feed for Indian major carps. Aquaculture, 452 :169-176.
- 7. Debnath, D. (2019). Aquaculture Principles and Practices. CRC Press.
- 8. Debnath, D., and Pal, A. K. (2019). Aquaculture: Principles and Practices. PHI Learning Pvt. Ltd.
- 9. Gupta, Sanjay, et al. (2018) Effect of different feed formulations on growth and nutrient utilization in Indian major carps. Aquaculture Research, 49 (10) :3321-3330.

# AQ5MJ10 AQUACULTURE ENGINEERING Credits:4

# UNIT 1:.

Criteria for the selection of site for aquaculture - Surveying – chain survey, plane table survey, leveling. Calculation of earthwork for the construction of ponds. Types of soil, soil sampling methods, prevention of erosion.

# **UNIT 2:**

Design of freshwater and brackish water farms. Project formulation and layout. Different components of aquafarms – peripheral dikes, secondary dikes, feeder canals, sluice gate and monks. Various farm equipment. Pumps in aquaculture, different type of pumps.

# **UNIT 3:**

Components and design of shrimp hatcheries – various components and infrastructure facilities required. Various hatchery equipment including aeration devices and pumps. Mechanical and biological filters.

# UNIT 4

Role of aeration in culture ponds. Paddle wheel aerators aspirators, compressors and blowers. Oxygen injection system.

## **UNIT 5:**

Feeding systems: different types of feeding equipment, feed control systems, dynamic feeding systems. Water treatment: Equipment used for water treatment, filters, ultraviolet light, ozone, heating and cooling and other processes of disinfection

## **Text Books and References**

- 1. Thomas B Lawson 2011. Fundamentals of Aquacultural Engineering, Springer
- 2. Wheaton, F.W. Aquacultural Engineering
- 3. Santhosh Kumar Garg 2018. Water supply Engineering
- 4. Bose et. al. 1991 Coastal Aquacultural Engineering

AQ5M105

Artificial Fish Feed

Credits:4

# Unit 1

Economic significance feed usage in Aquaculture, environmental considerations regarding fish feed in aquaculture. Feed Conversion Ratio(FCR) and food Efficiency Ratio(FER) Factors affecting digestibility, immunostimulants, growth promoters, and preservatives. Raw materials for artificial fish feed

# Unit 2.

Raw materials of plant origin, raw materials of animal origin, nonconventional materials -Protein and amino acid requirement, carbohydrate and lipid requirement, Essential fatty acids, Non-protein nitrogen sources. Vitamin and mineral requirements, vitamin C for fish and shellfish. Feed Formulation Techniques, types of feeds and measurement of calorific value

# Unit 3.

Principles of feed formulation – Pearson's square method, Linear programming, proximate analysis Activity – prepare different feed formulations with two ingredients using Pearson's square. Types of feeds- Wet feeds, dry feeds, moist feeds Larval feeds – Minced diets, microparticulate diets, spray dried diets, micro bound diets, micro coated diets and microencapsulated diets. Measurement of calorific value – Component analysis, wet oxidation, bomb calorimetry

# Unit 4.

Different forms of feed-fodders, mash, pellets, floating and sinking feeds. Feed formulation - Methods, square method. Feed manufacturing processes, Extrusion, Palletization, Different size and grades of fish/shrimp feeds - starter, grower and finisher feeds. Micro-bound feed, micro encapsulated feed. Storage and transportation of feeds. Quality problems- toxins, pests, rancidity

# Unit 5.

Additives – definitions, types – binders, antioxidants, pigments, anabolic agents, antimicrobials, and health supplements. Role of additives in immune health and stress reduction. Enzymes, probiotics, prebiotics. Importance of emulsifiers and stabilizers.

# Reference

- 1. Anderson, K., et al. (2020). Evaluation of Protein Sources in Aquafeed Formulations. Aquaculture Nutrition, 2020(12) :225-240.
- 2. Banerjee, S., and Keshavanath, P. (2017). Aquaculture and Fish Nutrition. BS Publications.
- 3. Bhakshi, Sanjeev. (2015) Fish Nutrition and Feed Technology. Daya Publishing House.
- 4. Brown, P. B., and Sindermann, C.J. (Eds.). (2003). Introduction to Aquaculture. Wiley-Blackwell.
- 5. Brown, R., et al. (2019). Fish Nutrition and Digestive Physiology. Journal of Aquatic Sciences, 2019(8) :45-62.
- 6. Das, Nilanjana, et al. (2016) Evaluation of locally available feed ingredients for formulating cost-effective feed for Indian major carps. Aquaculture, 452 :169-176.
- 7. Debnath, D. (2019). Aquaculture Principles and Practices. CRC Press.
- 8. Debnath, D., and Pal, A. K. (2019). Aquaculture: Principles and Practices. PHI Learning Pvt. Ltd.
- 9. Gupta, Sanjay, et al. (2018) Effect of different feed formulations on growth and nutrient utilization in Indian major carps. Aquaculture Research, 49 (10) :3321-3330.

AQ5MJ11

Summer Internship

Credit 4

Semester 6

## AQ6MJ12 POND PREPARATION AND MANAGEMENT Credits:4

#### UNIT I

Pisciculture – definition, scope and importance- major cultured freshwater fishes in India and world

## UNIT II

Production and trade, global scenario, current scenario of pisciculture in India

## UNIT-III

Types of fish ponds- Classification of ponds based on water resources – spring, rain water, flood water, well water and water course ponds - Functional classification of ponds – head pond, hatchery, nursery, rearing, production, stocking and quarantine ponds

## UNIT-IV

Pond preparation - Important factors in the construction of an ideal fish pond – site selection, topography, nature of the soil, water resources

## Unit V

Lay out and arrangements of ponds in a fish farm - Construction of an ideal fish pond – space allocation, structure and components of barrage pond.

## **UNIT-VI**

Pond management factors - Need of fertilizer and manure application in culture ponds; Role of nutrients; NPK contents of different fertilizers and manures used in aquaculture; and precautions in their application -Physico-chemical conditions of soil and water optimum for culture –Eradication of predators and weed control – advantages and disadvantages of weed, weed plants in culture ponds, aquatic weeds, weed fish, toxins used for weed control and control of predators.

#### **Text Books & References:**

- 1. Jhingran VG 1998. Fish and Fisheries of India. Hindustan Publishing Corporation, New Delhi
- 2. Pillay TVR, 1996. Aquaculture Principles and Practices, Fishing News Books Ltd., London
- 3. Pillay TVR & M. A. Dill, 1979. Advances in Aquaculture. Fishing News Books Ltd., London
- 4. Boyd CE 1982. Water Quality Management for Pond Fish Culture. Elsevier ScientificPublishing

# AQ6MJ13 FISHERIES ECONOMICS, EXTENSION Credits:4

# UNIT I

Economics- definition, meaning and scope of economics with reference to fisheries. Basic concepts of economics- goods, services, wants, utility. Demand and supply, value price, individual demand and market demand, elasticity of demand, law of diminishing marginal utility.

# UNIT II

Aquaculture economics – Application of economic principles to culture operations. Various inputs. Production function - the laws of returns, returns to scale. Average, marginal and total revenues. Pricing-various factors influencing the price of a product. its assumptions in aquaculture analysis. Least cost combination of inputs, laws of variable proportions.

# **UNIT III**

Cost and earnings of aquaculture systems – carp culture, different shrimp farming systems and hatcheries. Cost and earnings of mechanized and non mechanized fishing units and freezing plants. Socio- economic conditions of fishermen in India and Kerala. Contributions of fisheries to the national economy.

## **UNIT IV**

Extension education – its meaning, importance and scope in fisheries. Various methods of extension – individual, group and mass methods, farm and home visits, seminars, discussions, exhibition and personal contacts. Overview of fisheries and aquaculture sector in India and world; Special characteristics of fisheries sector and its stakeholders; Understanding extension education, research, and service; Overview of fisheries research, development and extension systems in India; Scope and importance of fisheries and aquaculture extension.

## UNIT V

Aquaculture extension system -review of extension approach as practiced by DoF, FFDA, and BFDA; Market led extension approaches; Importance of Information and Communication Technology (ICT) in aquaculture extension system. Critical review of philosophy, principles, concepts, and practices of fisheries extension systems and approaches; Teaching, learning and co- learning.

## Unit VI

Fisheries extension – advantages and limitations of present welfare and subsidy oriented extension systems; Development and extension approaches as practiced by public agencies like Department of Fisheries, KVKs, Agricultural Technology Management Agency (ATMA), NGOs, FAO, Bay of Bengal Programme (BOBP-IGO), and by the private sector; participatory fisheries extension approaches.
- 1. Badapanda, K.C. 2012. *Fishery Economics & Administration*. Narendra Publishing House, Delhi,427pp.
- Cunninghams, M., R. Dunn & D. Whilmarsh. 1985. Fishery Economics an introduction. Mansell publishing Ltd. London.
- 3. Dholakia, A.D. 2004. Fisheries and Aquatic Resources of India. Daya Publ., Delhi,
- 4. Dunne EB. 1990. Fisheries Economics An Introduction. Mansell Publ

### AQ6MJ14 FISH PATHOLOGY AND HEALTH MANAGEMENT Credits:4

### **Unit 1: Protozoan Diseases**

Introduction to fish diseases – pathology and parasitology – Definition and categories of diseases –Disease and environment. Protozoan diseases (finfish) – Ichthyophthiriasis, Costiasis, whirling diseases, trypanosomiasis. Shrimp diseases – Microsporidiosis, Gregaria disease, ecto- comensal protozoan.

## **Unit 2. Bacterial Diseases**

Bacterial disease (finfish) – furunculosis, columnaris, bacterial gill disease, gill rot, Enteroredmouts, Edwardsiellosis, vibriosis, tail and fin rot, EUS. Shrimp disease – brown spot, black gill, filamentous bacterial disease, luminous vibriosis.

### **Unit 3: Fungal and Viral Diseases**

Fungal diseases (finfish) – Saprolegniosis, Brachiomycosis, Ichthyophorus diseases, Lagenidium diseases – Fusarium disease.

### **Unit 4: Viral Diseases**

Viral diseases (finfish) – IPN, IHN, Viral Hemorrhagic Septicemia, Spring Viremia of carps, CCVD, Carp lymphocystis – Major shrimp viral diseases – *Bacculovirus penaeii*, Monodon Bacculovirus, Bacculoviral midgut necrosis, IHHNV, Hepatopancreatic parvo like virus, Yellow head bacculovirus, white spot baculovirus.

#### **Unit 5: Nutritional deficiency and Immunology**

Nutritional pathology – lipid liver degeneration, deficiency diseases due to vitamin A, D, E,K, B-Complex, C, pantothenic acid, folic acid, biotin, choline, minerals. Aflatoxin and dinoflagellates. Antibiotic and chemotherapentants. Nutritional cataract. Genetically and environmentally induced diseases. Immunology, defence mechanism in fish and shell fish, Application and development of vaccines, Diagnostic tools – microscopy, immune detection DNA/RNA techniques.

#### **Unit 6: Health Management**

General preventive methods and prophylaxis against the occurrence of diseases. Goodpond management practices- Eco-friendly and sustainable aquaculture. Quarantine. Methods of pathological examination of fish and infectious diseases. Production of disease-free seeds. Evaluation criteria of healthy seeds. Good Feed management for healthyorganisms. Zero water exchange. Probiotics in health management.

# **Text Books and References**

- 1. Biswas K.P. 2007 Prevention and control of fish and Prawn diseases –Narendra publishing House
- 2. B.K. Mishra, P. Swain, P.K.Sahoo, B.K.Das, N.Sarangi. Disease management in Fresh Water Pisciculture
- 3. Bose et al. 2019 Coastal Aquacultural Engineering
- 4. Roberts R.J. 2012. Fish Pathology.

# AQ6MJ15 PLANKTONOLOGY AND ALGOLOGY Credits:4

# Unit I

Plankton - classification, ecology and interrelationships. Sampling and preservation techniques. Plankton nets and recorders; catching efficiency of various nets and quantitative analysis. Plankton fixatives and preservatives.

# Unit II

Phytoplankton in the marine environment – classification, ecology, physiology, spatial and temporal distribution, changes in distribution patterns in different ocean ecosystems. Phytoplankton pigments, photosynthesis and primary production, Algal blooms. Role of phytoplankton in global carbon cycle – impacts of climate change.

# Unit III

Zooplankton in the marine environment – distribution and abundance, classification, major groups of zooplankton, micro-zooplankton, and secondary production, trophic structure, swarms, indicator species, predator-prey relationship; grazing in the aquatic ecosystem, vertical migration of zooplankton, DSL, bioluminescence, importance of meroplankton.

# Unit IV

Macro-algae of Indo-Pacific region. Major species, spatial and temporal distribution patterns. Zonation and adaptations. Seaweed culture. Economic uses.

# Unit V

Microalgal culture- techniques for the culture of Skeletonema, Chlorella, Arthrospira, Chaetoceros. Commercial application of microalgae.

## Text books and References

- 1. Colin Reynolds, David Thomas, Peter Williams. 2002. Phytoplankton Productivity: Carbon Assimilation in Marine and Freshwater Ecology.402 pp.
- Goswami, S.C. 2004. Zooplankton Methodology, Collection & identification A fieldmanual. NIO Goa.
- 3. Mitra, A. 2006. Introduction to Marine Phytoplankton. Narendra Publ.
- Pillai, N.K. 1986. Introduction to Planktanology. Himalaya Publ. House.
- Smith, DeBoyd L. 1996. A Guide to Marine Coastal Plankton and Marine InvertebrateLarvae. Dubuque, IA: Kendall/Hunt Publishing Company.
- 6. Tomas, C.R. 1997. Identifying Marine Phytoplankton. Academic Press.

## AQ6MI06 BIOINFORMATICS

## **CREDITS:4**

## UNIT-I

**Bioinformatics: an overview** - Introduction to Computational Biology and Bioinformatics; Role of internet and www in bioinformatics, Scope and relevance.

## UNIT – II

**Biological Databases**: Acquisition –Primary and Secondary databases. Types of Biological data bases – (Nucleotide, protein, organism and biodiversity databases) – examples and uses of each category of data bases.

## UNIT-III

**Nucleotide sequence databases**: Types of DNA sequences – genomic DNA, cDNA, recombinant DNA, Expressed sequence tags (ESTs), Genomic survey sequences (GSSs); RNA sequencing methods. Database searching (BLAST and FASTA).

### UNIT – IV

**Genomics and Proteomics** – definition & Scope, Fisheries databases and websites: FISHBASE, NACA, ICLARM, FAO.

### UNIT-V

**Phylogenetic analysis** – Phylogenetic representations – graphs, trees and cladograms; Steps in phylogenetic analysis; Neighbor Joining Method; Fitch/Margoliash method; Phylogenetic software – PHYLIP

### UNIT-VI

Applications of bioinformatics in Drug discovery: Structure based drug design. Mining

of sequence data: Mining data from marine sponges.

## **Text books & References**

- 1. Mount, D. Bioinformatics: Sequence and Genome Analysis; Cold Spring Harbor Laboratory Press, New York. 2004
- 2. Lesk, A.M. Introduction to Bioinformatics, First edition, Oxford University Press, UK.2002
- 3. Rastogi, S.C, Mendiratta. N and Rastogi. R. Bioinformatics: Concepts, Skills and Applications, CBS Publishers, New Delhi, India. 2006
- 4. Pevzner, P.A. Computational Molecular Biology; Prentice Hall of India Ltd, New Delhi.2004
- 5. Sensen, C.W. Essentials of Genomics and Bioinformatics. Wiley-VCH Publishers, USA. 2002
- 6. Andrew R. Leach Molecular Modeling Principles and Applications Second Edition, Prentice Hall, USA. 2001

# Semester 7

# AQ7MJ16 MARINE BIOLOGY Credits:4

### UNIT I

Intertidal ecology: Environmental factors. Adaptations. Intertidal community – Rocky, Sandy, Muddy shores: Environmental factors, Zonation, Feeding Biology, Community structure, Trophic structure. Tide pools.

## UNIT II

Structure and Types of Seaweeds - Indian Seaweed Resources. Economic importance of seaweeds. Seagrasses: Diversity, Distribution and Importance. Mangrove ecosystems-Distribution. Structure and adaptations. Environmental condition. Zonations. Fauna. Major mangrove ecosystems in India. Conservation.

## UNIT III

Deep Sea Biology: Environmental characteristics. Adaptations. Sampling strategy. Midwater community. Ecology. Zonation. Hydrothermal vents.

## **UNIT IV**

Harmful Algal blooms: Harmful Algae. Ecology of Algal Bloom. Monitoring Algal Bloom. Seafood poisoning. Management and Mitigation.

### Unit V

Marine reptiles - Adaptive radiation of marine reptiles – sea snakes and turtles. Marine birds– General characters, adaptation and importance of coastal and marine birds. Marine mammals - General characteristics, classification and evolution of cetaceans and sirenians. Distribution, adaptations and importance. Endangered marine mammals. Conservation strategies.

### UNIT VI

Marine Biodiversity: Status of Global Marine Biodiversity. Status of Marine Biodiversity in India. Threats- over-exploitation, physical alteration, pollution, alien species. Biosecurity. Protected areas.Marine Biosphere Reserves.

# Practicals

- 1. Determination of salinity by refractometer and titrimetric method.
- 2. Determination of water pH
- 3. Determination of alkalinity
- 4. Determination of hardness of water

- 5. Determination of dissolved oxygen
- 6. Determination of organic carbon in pond soil
- 7. Determination of nitrite / nitrate demonstration
- 8. Determination of phosphate in pond water demonstration
- 9. Determination of soil pH
- 10. Calculation of lime requirement
- 11. Testing of potential acid sulphate soil
- 12. Determination of Secchi disc transparency of water

## Text Books and References

- 1. Castro, P. and M.E. Huber, 1997. Marine Biology, Second Edition. Mc-Graw Hill Company.
- Greene, Thomas F. 2004. Marine Science: Marine Biology and Oceanography, 2nd Edition. Amsco School Publication, Inc.
- Jeffrey S. Levinton, 2001. CD Marine Biology: Function, Biodiversity, Ecology pp. 515.
- 4. Laws, E.A.,2000. Aquatic pollution, an introductory text. John Wiley and Sons, Inc., New York, 639 pp.
- Morrissey, J.F. and J.L. Sumich. 2012. *Introduction to the Biology of Marine Life*. Jones & Bartlett learning, U.K., 467pp.
- 6. Nybakken, J.W., and M.D. Bertness. 2004. Marine Biology An Ecological Approach. Sixth Edition. Benjamin Cummings.

# AQ7MJI7 AQUATIC MICROBIOLOGY Credits:4

# Unit I

General introduction to microbiology, Different members of the microbial community – General characteristics of bacteria, fungi, viruses, algae and protozoans. Ultrastructure of prokaryotic cell. Structure of fungi and yeast cell. Ultrastructure of virus, Life cycle bacteriophages - lytic and lysogenic cycle.

# UNIT II

Aquatic microbiology - importance and significance. Microflora of aquatic environment, Isolation and cultivation of microorganisms from water and sediment. Different culture techniques. Different types of media for isolation of bacteria and fungi. Identification based on Morphological, Physiological and Biochemical characteristics.

# UNIT III

Prokaryotic growth-characteristic features of bacterial growth curve-Effect of environmental factors on growth. Influence of physicochemical factors on the distribution and abundance of aquatic microorganisms. Microbial nitrogen fixation; Roles of microbes in biogeochemical cycles: Carbon, nitrogen and phosphorus cycle. Decomposition of organic matter.

# **UNIT IV**

Microbiology of culture pond – role of autotrophic and heterotrophic microorganisms in culture pond. Nutrient regeneration in pond, role of microbes in biogeochemical cycles – Nitrogen, phosphorus and sulphur cycles. Autochthonous and allochthonous microorganisms in culture pond.

# UNIT V

Indicator of Aquatic Pollution - Fecal coliforms; Prevention and control. Microbial communities in the aquatic environment. Biofilms and Biofouling. Biocorrosion. Microbial interactions, symbiosis and antagonism.

# UNIT VI

Microbial biodegradation - natural and synthetic material in the aquatic environment. Hydrocarbon, Heavy metals, Pesticides, Plastics, Lignin, Cellulose degradation. Marine Extremophiles: adaptive mechanisms in thermophilic, alkalophilic, osmophilic, barophilic, psychrophilic microorganisms. Hyperthermophiles and Halophiles,

# **Practical's**

- 1. Sterilization technique- dry heating, autoclaving
- 2. Media preparation

- 3. Isolation and maintenance of bacteria from fishes and water samples.
- 4. Gram staining of bacteria
- 5. Enumeration of bacteria by TPC method
- 6. Enumeration of total coliforms from the water sample.
- 7. Study of Bacterial motility

## **Text books and References**

- 1. Austin. B, and D.A Austin 1999. Bacterial Fish pathogens- Diseases of Farmed and WildFish. Springer.
- 2. Dhevendaran, K. 2008. Aquatic Microbiology. Southern Book Star, TVM, 242 pp.
- Dworkin MM, S Falkow, E Rosenberg, K-H Schleifer and E Stackebrandt (Eds). 2006. TheProkaryotes: A Handbook on the biology of Bacteria. Vol. 1-6. Springer and Verlag New York.
- 4. Kirchman, D.L. 2008. Microbial Ecology of the Oceans John Wiley and Sons.
- Pomerville & Jeffrey, 2011. *Alcamo's Fundamentals of Microbiology.* Johns & BartlettPublishers, Boston, 855pp
- 6. Salyers, A.A. & D.D. Whitt 2001. Microbiology, Diversity, Disease and the Environment. Fitzjerald Sci. Press, Maryland, 608 pp.
- Sigee & C. David. 2005. *Freshwater Microbiology*. John Wiley & sons Ltd., England,524pp.

Seaweed Culturing

Credit: 4

# Unit 1

Taxonomy, Morphology, and general structure of economically important seaweeds. Classification of economically important seaweeds, Green Algae (Chlorophyceae): Enteromorpha spp, Monostroma spp, Brown Algae (Phaeophyceae): Laminaria spp.Red Algae (Rhodophycea): Porphyra spp.

# Unit 2

Distribution of seaweeds. Sexual and asexual reproduction methods.Different propagation methods of seaweeds. Criteria for selection of site in open waters and ponds for seaweed culture.

# Unit 3

Monitoring Growth of seaweeds and factors affecting growth pattern, environmental monitoring causes of mortality. Small scale, commercial scale and largen culture operations.

# Unit 4

Types of seaweed culture -Fixed off bottom culture: Floating raft/cage culture: Bottom culture: Greenhouse culture: Spray culture: Raceway culture; IMTA-Integrated multi-trophic aquaculture

# Unit 5.

Chemical composition of seaweed Processing and extraction of algin, alginic acid and alginates, processing and extraction of agar, mannitol and carrageen. Application of seaweeds as Pharmaceuticals.

## Practical's

- 1. Identification of economically important seaweeds and their reproductive bodies.
- 2. Identification/preparation of culture models.
- 3. Field study of distribution and zonation of seaweeds, collection of sea weed material.
- 4. Visit to a Research Institution untaken seaweed culture
- 5 Visit to a Seaweed processing industry

- BhavanathJha, C. R.K. Reddy, Mukund C. Thakur, M. Umamaheswara Rao (2009). Seaweeds of India, The diversity and distribution of seaweeds of Gujarat coast. Developments of Indian Phycology, Spinger Publishers. 215p.
- 2. E. Dilipan, E.P. Nobi& J. Rajkumar(2021). Manual for Identification of Seagrasses of India, White Falcon Publishing; 1 edition, 98 p. ISBN-13: 9781636400891.
- Gulshad Mohammed, 2016. Current trends and Prospects of Seaweed Farming in India. In Imelda Joseph and Ignatius Boby (eds.), 2016. Winter School on Technological Advances in Mariculture for Production Enhancement and Sustainability. Course Manual, Central Marine Fisheries Research Institute, Kochi, 2016, pages 78-84.
- **4.** Haresh S. Kalasariya. (2019). A Beginners Guide For Seaweeds Identification, Educreation Publishing, 178 p; ISBN: 9789353731328, 9789353731328

# Unit I

Definition and types of biodiversity - Ecological, Genetic and organismal diversity; importance of biodiversity. Mega biodiversity countries, biodiversity hotspots – global and Indian.

# Unit II

Marine biodiversity. Present status of marine biodiversity in India. Island biodiversity. Causes of biodiversity loss. Measuring Biodiversity - Margalef species richness, Simpson's dominance, Pielou's evenness and Shannon-Weiner diversity indices. Software's forbiodiversity assessment. Biodiversity documentation.

# Unit III

Methods in documentation. Para taxonomy in biodiversity inventory. Extinct, endangered, threatened and vulnerable species – Red List. Zoological Survey of India (ZSI) and its role inmarine biodiversity documentation.

# **Unit IV**

Impact of alien species, GMOs and exotic species on endemic biota. Threats to marine biodiversity. Census of Marine Life. Conservation methods, ex-situ and in-situ conservation. Levels of conservation – alpha, beta and gamma.

# Unit V

Protected areas, national parks, wild life sanctuaries, reserves, MPAs. Marine National parks of India. Social, ethical and policy issues in biodiversity conservation.

# Unit VI

International treaties and global efforts for management of genetic resources relating to biodiversity. CBD, Ramsar Convention 1971, Indian Biodiversity Act 2002, National Biodiversity Authority of India. National bureaus dealing with genetic resources – NBPGR, NBAGR, NBAIM, NBAII and NBFGR. Organizations involved in protection and conservation– CITES, IUCN, WWF for Nature, UNEP.

## **Text books and References**

- 1. Carson, R. 1991. The Sea Around Us. Oxford University Press, 288 pp.
- Côté, I.M. and Reynolds, J. D. (Eds.) 2006. Coral Reef Conservation. ConservationBiology No. 13. Cambridge University Press.
- 3. Glover, L.K. and Earle, S. (Eds.) (2004). Defying ocean's end: an agenda for action. IslandPress, Washington D.C., 283 pp.
- 4. McLeod, K. and Leslie, H. (Eds.) 2009. Ecosystem-based Management for the Oceans, 2nd edn., Island Press, 392 pp.
- Norse, E.A. and Crowder, L.B. (Eds.) 2005. Marine Conservation Biology: The Science of Maintaining the Sea's Biodiversity,1st edn., Marine Conservation Biology Institute. Island Press, 496 pp.

# **AQ7MI08**

**BIOSTATISTICS** 

Credits:4

Unit I

Types of Biological Data, Data collection-primary and secondary data, sampling methods, organization of biological data, editing, classification and tabulation

## Unit II

Presentation of data - Diagrammatic representations of biological data – one-, twoand three-dimensional diagrams.

## Unit III

Measures of Central tendencies and its applications for biological variables. Measures of Dispersion and its applications - coefficient of variation.

# Unit IV

Skewness and Kurosis, Application of Skewness in Biological Data, Correlation and regression analysis in Biological Data, Probability, Permutation and Combinations.

## Unit V

Correlation and Regression, Distributions-Standard Error, Binomial, Poisson and Normal Applications in Biological Data, Hypothesis testing and its applications in biological data-Null and Alternate Hypotheses-Errors in Hypothesis testing. Large and small sample tests in Biological Data-Z, 't, and F tests- Chi Square Tests-Analysis of Variance applications in Biological Data-One- and Two-way ANOVA.

# References

1. Mitken, Mike, Braadhurst, Bill, Hladky, Steve. 2009. Mathematics for Biological Scientists.

Garland Science Publishing, New York, 208pp.

- 2. Elhance, D.N. & V. Elhanle 1983. Fundamentals of Statistics. Kitab Mahal Publ., India
- 3. Finney, D.J. 1978. Statistical Methods in Biology Assay. Charles Griffith Co. Ltd., England, 508
- 4. Ghosh S. 1999. Multivariate Analysis, Design of Experiments and Survey Sampling. Marcel Dekker.
- 5. Grafen, A. & R. Hails 2008. Modern Statistics for the Life Sciences. Oxford Univ. Press, NY, 351.
- 6. Kothari, C.R. 2011. Research Methodology: Methods & Techniques. New Age International. Publishers. New Delhi, 401pp.

#### Unit 1

Introduction: Status of cold-water fisheries in world with special reference to India. Major cold water fish species in India. Threats to cold water fish diversity/ Biology and captive breeding of snow trout, exotic trout's, mahseer and common carps.

### Unit 2.

Culture of Coldwater fishes. Culture of major trout species. Construction and management of cold-water fish farms, Polyculture of exotic carp in mid-hill region, post-harvest and harvest issues in trout with regards to cold-water species

### Unit 3.

Cold water fish seed production and nursery rearing. Potential and Innovative Strategies for the Development of Coldwater Aquaculture in India-

### Unit 4.

Aquaponics: concept, Principles, types and operation Bio-resource flow in integrated aquaculture system: Discharge of nutrient wastes from integrated aquafarms **Unit 5**.

Environmental effects, and potential for integrated multi-trophic aquaculture, An economic analysis of different integrated culture systems

#### PRACTICAL

- 1. Identification of cold-water fish species; Primary and secondary sexual characteristics of cold-water fishes
- 2. Different breeding methods for cold-water fishes
- 3. Dentification of larval stages of trout and mahseer;
- 4. Preparation of hatchery layout for cold-water fishes
- 5. Studies on different types of sports fishing equipment
- 6. Visit to cold water fish hatchery (Report)
- 7. Preparation of vermicompost; Analysis of nutrient value of different manures
- 8. Design of various integrated farming models
- 9. Different models of aquaponics; Nutrient analysis and management in aquaponics;

- 1. Boghen, A.D., 1989. Cold-water aquaculture in Atlantic Canada. Institut Canadien de recherche sur le development regional, Atlantic Coast, Canada
- 2. Jhingran VG. 1991. Fish and Fisheries of India. 3rd Ed. Hindustan Publ.
- 4. Mahanta, P.C., Sarma, D., 2010. Coldwater Fisheries Management. ICAR. Singh, H.R. and Lakra, W.S., 2008. Coldwater Aquaculture and Fisheries. Narendra Publishing House.
- Singh AK, Sarma D, Akhtar, MS and Baruah D. 2017. Souvenir National seminar on strategies, innovations and sustainable management for enhancing coldwater fisheries and aquaculture. ICAR-DCFR, Bhimtal.
- 6. Thomas PC, Rath SC and Mohapatra KD. 2003. Breeding and Seed Production of Finfish and Shellfish. Daya Publ.
- Ahilan, B., Ravaneshwaran, K., Kumaravel, P., 2011. Integrated Aquaculture. Daya Publishing House.
- 8. Little D, Edwards P. 2003. Integrated Livestock-fish Farming Systems. FAO Publ.
- Sherman RL, Arancon NQ and Edwards CA. 2010. Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management. CRC Press.

#### Unit I

Topic selection - Planning research – defining objectives - Preparation of work plans. Identification of suitable methodology - Preparation of project proposal – Summer Schools – Training in research institutes

#### Unit II

Collection of literature- News articles – Newsletters – Magazines – Books -Journals. Digital library and search of articles - Keywords and search - Internet – Google Scholar – PubMed – Inflibnet – Medline – Agricola – Science direct -Open access Journals - virtual sources – other sources. Short communications –review articles

## Unit III

Collection of protocols and selection of suitable methods according to work plan. Observational and experimental research. Data analysis – Construction of tables – headings - footer - Tabulation Presentation of results - Use of statistical software to analyze the results- SPSS.

#### **Unit IV**

Thesis structure –Components - Writing Introduction – review of literature – Materials & Methods – Presentation of results – Discussion of Results based on literature – Arriving at conclusions – Preparation of Summary/abstract – Arrangement of Bibliography and how to quotereference in thesis - Appendix.

#### Unit V

Publishing of Articles in newspapers /newsletters - Selection of journals – ISSN Number – Peer-reviewed Journals – Science citation index – impact factor and importance. Manuscripts preparation for Journals – components – Plagiarism -Submission and Publication – reprints and pdf formats. Paper presentation in Conferences.

- 1. Booth W. C. et al. 2016. The Craft of Research. University of Chicago Press.
- Gurumani, N. 2006. Research Methodology for Biological Sciences. MJP. Publishers.
- 3. Marczyk, G., DeMatteo, D., Festinger, D. 2005. Essentials of research design and methodology. John Wiley.
- Katz, M. J. 2009. From Research to Manuscript: A Guide to Scientific Writing. Springer.
- 5. Michael Alley. The Craft of Scientific Writing (3rd Edition) Publisher: Springer.
- Cargill, M., O.Connor, P. 2013. Writing Scientific Research Articles: Strategy andSteps. Wiley-Blackwell.

### AQ8MJ21 MARINE DRUGS and PROSPECTING Credit: 4

#### Unit I

Bioactive compounds, bioactive marine natural products – significance – antitumor – anti cancer – anti-inflammatory – analgesic – anti-viral agents – antibiotic – cytotoxic – antimicrobial compounds.

#### Unit II

Collection of marine organisms - Isolation and separation of marine natural products

frommarine flora and fauna

### Unit III

Diversity of bioactive metabolites in different groups of marine organisms- corals, sponges, marine fungi, bacteria, endosymbionts, marine algae etc.

#### Unit IV

Marine microorganisms as a source of biomedical resources – dinoflagellates as a source of bioactive molecules –marine toxins – saxitoxin – brevitoxin – ciguatoxin – tetradotoxin

#### Unit V

Nitrogen and non-nitrogen containing marine bioactive compounds – polyketides – prostanoids – polyethers – macrolides – terpenes. Commercial development of marine natural products – chitosan - algal products – SCPs -  $\beta$  carotene – vitamins

#### Unit VI

Biological and toxicological aspects of marine natural product drug discovery, Clinicalevaluation of MNPs in drug discovery.

- 1. Bakhuni, D.S. and Ravat, DS 2020. Bioactive marine natural products. Springer
- 2. Kornprobst Jean Michel, 2010. Encyclopedia for marine natural products. WileyBalckwell, 1680pp
- 3. Kiyota, H. 2020. Marine natural products. Springer Nature, 301pp.

### Unit 1

Major river systems of India and their fisheries. Current status, trend, and fishing methods of riverine fisheries. Estuarine fisheries resources of India, Fisheries of major estuarine systems in India. Flood-plain capture fishery- present status of their exploitation and future prospects. Bheel fisheries resources of India: Open and closed bheels. **Unit 2** 

Introduction to marine fisheries of the world=Major fishing zones of world and India. Global marine fish production trends. FAO status. Introduction to marine fisheries of India. Pelagic and demersal and deep-sea fishery resources **Unit 3**.

Pelagic fisheries of India: sardines, mackerels, anchovies, white baits, tuna, seer fish, carangids, ribbonfish, shads and other clupeids, barracudas, Bombay duck, pomfrets, mullets. Features and trends in the production of pelagic fisheries. Conservation of pelagic fish stock **Unit 4** 

Demersal fisheries of India: Elasmobranchs (sharks, rays and skates), perches, threadfin breams, groupers, snappers, Bull's eye, flat fishes, sciaenids, eels.Features and trends in the production of demersal fisheries. Conservation of demersal fish stock **Unit 5** 

Deep sea fishery resources - History of deep-sea fishing. Oceanic and deep-sea fisheries of India. Potential resources. Deep Sea Fishing Policy of India. Crustacean and molluscan fishery resources Crustacean fishery of India: Penaeid and non-penaeid shrimp fisheries, Lobster fishery, Crab fishery Molluscan fishery of India: Mussel fishery, Oyster fishery, Clam fishery. Cephalopod fishery,

#### AQ8MJ23 MARINE RESOURCE MANAGEMENT & ECOSYSTEM MODELLING Credits:4

#### Unit I

Fishery resources – stock concept – stock definition – unit stock – mixed stock – characteristics; problems in assessing the marine resources in tropical waters –Indian marine fishes.

#### Unit II

Growth parameters; mortality parameters and selection parameters. Length frequency distribution – Pauly's integrated method – resolution of modes – growth estimation. Growth equation - methods, estimation; growth characteristics – uses. Mortality parameters –total instantaneous mortality, fishing mortality, natural mortality, methods of estimation. Fishing gear selectivity - selection parameters – gill net selectivity – trawl selectivity – methods – estimation – uses.

#### Unit III

Fish stock assessment models – surplus production models – VPA analysis, cohort analysis; prediction models – Beaverton – Holt yield per recruit model – yield curves, Thompson - Bell model; FMSY, MEY, FMEY; Eumetric fishing, exploitation rate and ratio; estimation of potential yield.

#### Unit IV

Sampling techniques – types of sampling – sampling the fish units; fishing effort, standardization of fishing effort, catchability coefficient. Fishery management concepts, marine regulation acts relating to marine fisheries exploitation included in the final UNCLOS III treaty.

#### Unit V

Ecosystem modelling, ecosystem based fisheries management – principles; ECOPATH and ECOSIM models – estimation; simulation models –predator-prey model – NPZD model – software packages used in fish stock assessment and in ecosystem modelling

- 1. Chandra, P. 2007. Fishery Conservation Management and Development. SBS Publ.
- 2. Hall, S. J and B. Mainprize, Towards ecosystem-based fisheries management, Blackwell
- 3. Publishing Ltd. Fish and Fisheries, 5 (2004) 1-20.
- 4. Michael, R.R. 1997. Fisheries Conservation and Management. Prentice Hall.
- Moyle, P.B. and Joseph, J.C. Jr. 2000. Fishes An Introduction to Ichthyology. 4th edn. Prentice Hall.

### AQ8MJ19 Cold Water Aquaculture Credit: 4

#### Unit 1

Introduction: Status of cold-water fisheries in world with special reference to India. Major cold water fish species in India. Threats to cold water fish diversity/ Biology and captive breeding of snow trout, exotic trout's, mahseer and common carps.

### Unit 2.

Culture of Coldwater fishes. Culture of major trout species. Construction and management of cold-water fish farms, Polyculture of exotic carp in mid-hill region, post-harvest and harvest issues in trout with regards to cold-water species

## Unit 3.

Cold water fish seed production and nursery rearing. Potential and Innovative Strategies for the Development of Coldwater Aquaculture in India-

## Unit 4.

Aquaponics: concept, Principles, types and operation Bio-resource flow in integrated aquaculture system: Discharge of nutrient wastes from integrated aquafarms **Unit 5**.

Environmental effects, and potential for integrated multi-trophic aquaculture, An economic analysis of different integrated culture systems

### PRACTICAL

- 7. Identification of cold-water fish species; Primary and secondary sexual characteristics of cold-water fishes
- 8. Different breeding methods for cold-water fishes
- 9. Dentification of larval stages of trout and mahseer;
- 10. Preparation of hatchery layout for cold-water fishes
- 11. Studies on different types of sports fishing equipment
- 12. Visit to cold water fish hatchery (Report)
- 10. Preparation of vermicompost; Analysis of nutrient value of different manures
- 11. Design of various integrated farming models
- 12. Different models of aquaponics; Nutrient analysis and management in aquaponics;

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- 2. Jhingran VG. 1991. Fish and Fisheries of India. 3rd Ed. Hindustan Publ.
- 4. Mahanta, P.C., Sarma, D., 2010. Coldwater Fisheries Management. ICAR. Singh, H.R. and Lakra, W.S., 2008. Coldwater Aquaculture and Fisheries. Narendra Publishing House.
- Singh AK, Sarma D, Akhtar, MS and Baruah D. 2017. Souvenir National seminar on strategies, innovations and sustainable management for enhancing coldwater fisheries and aquaculture. ICAR-DCFR, Bhimtal.
- 6. Thomas PC, Rath SC and Mohapatra KD. 2003. Breeding and Seed Production of Finfish and Shellfish. Daya Publ.
- Ahilan, B., Ravaneshwaran, K., Kumaravel, P., 2011. Integrated Aquaculture. Daya Publishing House.
- 8. Little D, Edwards P. 2003. Integrated Livestock-fish Farming Systems. FAO Publ.
- 9. Sherman RL, Arancon NQ and Edwards CA. 2010. Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management. CRC Press.

#### Unit I

Topic selection - Planning research – defining objectives - Preparation of work plans. Identification of suitable methodology - Preparation of project proposal – Summer Schools – Training in research institutes

#### Unit II

Collection of literature- News articles – Newsletters – Magazines – Books -Journals. Digital library and search of articles - Keywords and search - Internet – Google Scholar – PubMed – Inflibnet – Medline – Agricola – Science direct -Open access Journals - virtual sources – other sources. Short communications –review articles

## Unit III

Collection of protocols and selection of suitable methods according to work plan. Observational and experimental research. Data analysis – Construction of tables – headings - footer - Tabulation Presentation of results - Use of statistical software to analyze the results- SPSS.

#### **Unit IV**

Thesis structure –Components - Writing Introduction – review of literature – Materials & Methods – Presentation of results – Discussion of Results based on literature – Arriving at conclusions – Preparation of Summary/abstract – Arrangement of Bibliography and how to quotereference in thesis - Appendix.

#### Unit V

Publishing of Articles in newspapers /newsletters - Selection of journals – ISSN Number – Peer-reviewed Journals – Science citation index – impact factor and importance. Manuscripts preparation for Journals – components – Plagiarism -Submission and Publication – reprints and pdf formats. Paper presentation in Conferences.

- 7. Booth W. C. et al. 2016. The Craft of Research. University of Chicago Press.
- Gurumani, N. 2006. Research Methodology for Biological Sciences. MJP. Publishers.
- 9. Marczyk, G., DeMatteo, D., Festinger, D. 2005. Essentials of research design and methodology. John Wiley.
- Katz, M. J. 2009. From Research to Manuscript: A Guide to Scientific Writing. Springer.
- 11. Michael Alley. The Craft of Scientific Writing (3rd Edition) Publisher: Springer.
- 12. Cargill, M., O.Connor, P. 2013. Writing Scientific Research Articles: Strategy and Steps. Wiley-Blackwell.

**RESEARCH PROJECT** 

**CREDITS 4** 

PROJECT REPORT

**CREDITS 4** 

PROJECT VIVA VOCE

**CREDITS 4**