AC/2024/RS 2

College of Arts, Science & Commerce (Empowered Autonomous)

SIES

RISE WITH EDUCATION

NAAC REACCREDITED "A" GRADE

(*Affiliated to University of Mumbai)*

Faculty: Science

Program: M.Sc.- II

SUBJECT: ZOOLOGY

SPECIALIZATION: OCEANOGRAPHY AND FISHERY SCIENCE

Academic Year: 2024 – 2025

Revised Syllabus under
Choice Based Credit System (CBCS)
Approved by the Board of Studies in Zoology
Effective from Academic year: 2024-25
Under the aegis of National Education Policy (NEP)

Preamble

"Where the mind is without fear and the head is held high …."

A poem written by Nobel Laureate Rabindranath Tagore (Nobel Prize in Literature in 1913), the poem represents Tagore's vision of a new and awakened India (it is quoted in this preamble in the context of National Education Policy).

Our institution was one of the lead colleges, affiliated to University of Mumbai in implementing India's National Education Policy 2020 (NEP 2020) in academic year 2023-24. Moreover, we were also conferred with 'Empowered Autonomous Status' in 2023-24, which becomes all the more relevant, in terms of our contribution as an educational institution to fulfill the visionary and transformative objectives of National Education Policy. Under the aegis of academic autonomy, the Department of Zoology has the privilege of 'academic freedom' to revise its course and curriculum, however, it is also aware of the fact that 'academic freedom' needs to be justified with 'academic excellence'. One of the ways to achieve this is through fine-tuning the curriculum. Thus, in addition to enable students to acquire an in depth knowledge of the Core/Mandatory subject, the current syllabus also attempts to integrate a few courses under Department Specific Electives, which will help students to be equipped with the necessary skills to enhance their core competencies in understanding synergism of pure and applied sciences, in order to make them self-sufficient and build a future.

Some of the key features of this revised syllabus with specialization in Animal Physiology are as follows:

- ✓ *Research project/Dissertation – to inculcate research aptitude and to develop an open, inquiring mind that is willing to explore new territories and learn new things; to encourage the spirit of curiosity of students, who are not just learners but also potential problem solvers and scientific investigators.*
- ✓ *Physical, Chemical and Biological Oceanography – to familiarize students the nature of life in the sea and our relationship to that life; to familiarize students with physical aspects of Oceanography such as tides, waves and currents that not only influence aquatic life but also life on the terrestrial realm.*
- ✓ *Aquaculture methods and practices – to introduce to the students the field of aquaculture and know its immense potential for generating employment; to acquire knowledge for wise management of aquatic resources to minimize production costs and gain profit; to consider aquaculture as a subsidiary in the income of someone having a taste for it and also to inculcate an entrepreneurial culture.*
- ✓ *Marine Fisheries – to give students knowledge of marine finfish and shell fish resources that opens an avenue for bioeconomics; to give them insights about current trends in global as well as national capture fishery; to make them aware of the significance of fishermen communities, agencies which focus on development of fish farmers and fishery extension programs.*
- ✓ *Fishery Science and Fish Processing Technology – to impart knowledge of the vast array of opportunities offered by fish processing industry by acquainting them to various methods of fish processing; to make the students familiar and get acquainted with different methods and materials required in traditional and recent methods in fish processing.*
- ✓ *Department Specific Electives in the form of Marine Biodiversity & Conservation; Marine Biotechnology & Toxicology – A course which has been restructured, whereby, it will make students aware of the fact that the ultimate measure of our wisdom in managing the environment of our planet will be, how well we have collectively done in maintaining the biodiversity and unique character of life in our oceans; to make the students understand the principles of toxicology, various toxicants, and their adverse effects on marine environment; to familiarize learners with promising marine bioactive compounds and their immense potential in various fields of sciences.*

This revised syllabus is a collective and constructive effort of the faculty, experts from research institutions, alumni and the board members whose valuable suggestions and expertise were instrumental in materializing this syllabus. The comments and recommendations of the contributors and reviewers have been carefully considered and incorporated wherever feasible.

For effective teaching-learning, teachers are advised not to follow the syllabus too rigidly, but to exercise their professional discretion and judgment in implementing it. After all teaching is also about creating a conducive environment for learners to sustain enthusiasm about the subject. We sincerely hope that this revised syllabus will encourage critical thinking, instill analytical skills, besides inculcating interdisciplinary approach amongst student's to make learning more meaningful, thereby pursuing academic excellence. To conclude, especially in the context of Oceanography, let me quote French Oceanographer, Filmmaker & Writer, Jacques Yves Cousteau

"The sea, the great unifier, is man's only hope. Now, as never before, the old phrase has a literal meaning:
We are all in the same boat" – Jacques Yves Cousteau

(1910-1997; Co-invented the first successful Aqua-Lung, SCUBA: Self-Contained Underwater Breathing Apparatus).

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M.Sc. Part II – Zoology (Oceanography and Fishery Science) Syllabus (Empowered Autonomous)
Semester III
Credit Based Semester and Grading System (With effect from academic year 2024-25)

THEORY			
Course name and code	**Unit**	**Topic Headings**	**Credits**
SEMESTER III			
A) Major			
a) Mandatory Papers			
Paper 1: Core Course 1: Principles and Disciplines of Oceanography			
SIPZOOCC611	1	General Oceanography	**4**
	2	Physical Oceanography	
	3	Chemical Oceanography	
	4	Biological Oceanography	
Paper 2: Core Course 2: Aquaculture- Methods and Practices			
SIPZOOCC612	1	Introduction to Aquaculture	**4**
	2	Shellfish culture	
	3	Fin Fish and other cultures	
	4	Marketing and Finance	
b) Electives			
Paper 3: Department Specific Elective: Marine Biodiversity, Conservation and Management			
SIPZOOEL611	1	Marine Biodiversity and Conservation	**3**
	2	Biodiversity Conservation laws and Marine protected areas of India	
	3	Environment Impact Assessment and Coastal Regulatory Zones	
B) Research Project			
Paper 4: Research Project			
SIPZOORP611		**No Theory Paper**	**6**
PRACTICAL			
SIPZOOCCP611		Based on Core Course 1	**2**
SIPZOOCCP612		Based on Core Course 2	**2**
SIPZOOELP611		Based on Department Specific Elective	**1**
		Total	**22**

M.Sc. Part II – Zoology (Oceanography and Fishery Science) Syllabus (Empowered Autonomous)
Semester IV
Credit Based Semester and Grading System (With effect from academic year 2024-25)

THEORY			
Course name and code	**Unit**	**Topic Headings**	**Credits**
SEMESTER IV			
A) Major			
a) Mandatory Papers			
Paper 1: Core Course 1: Marine Fisheries			
SIPZOOCC621	1	Marine Finfish resources	**4**
	2	Marine Shellfish resources	
	3	Trophodynamics in aquatic systems	
	4	Marine fishery- Economics and Conservation	
Paper 2: Core Course 2: Fish Processing Technology			
SIPZOOCC622	1	Logistics in fish processing	**4**
	2	Traditional fish processing	
	3	Modern fish processing	
	4	Quality assurance norms and methods	
b) Electives			
Paper 3: Department Specific Elective: Marine Biotechnology, Toxicology and Pathology			
SIPZOOEL621	1	Marine Biotechnology	**3**
	2	Marine Toxicology	
	3	Fish Pathology	
B) Research Project			
Paper 4: Research Project			
SIPZOORP621		**No Theory Paper**	**6**
PRACTICAL			
SIPZOOCCP621		Based on Core Course 1	**2**
SIPZOOCCP622		Based on Core Course 2	**2**
SIPZOOELP621		Based on Department Specific Elective	**1**
		Total	**22**

SIES College of Arts, Science and Commerce (Empowered Autonomous)
Sion (West), Mumbai – 400 022

Programme: Master of Science, M.Sc. Part 2 – Zoology

"Tell me and I forget, teach me and I may remember, Involve me and I learn."
- Benjamin Franklin

The characteristic Post-graduate attributes comprising of Programme Outcomes, Programme Specific Outcomes and Course Outcomes for a science post graduate in the subject of Zoology are as follows:

Note the list of abbreviations:
PO: Programme Outcome, PSO: Programme Specific Outcome, CO: Course Outcome
Cognitive Levels: R: Remember, U: Understand, Ap: Apply, An: Analyze, E: Evaluate, C: Create

Serial Number	Details of Programme Outcomes (POs)
PO1 *(Skill Level)*	**Problem Solving Ability *(U, Ap)*** • Apply the knowledge of various courses learned under a program to break down complex problems into simple components. • Adopt and assimilate problem-based learning models and apply one's learning to solve real life problem situations.
PO2 *(Skill Level)*	**Critical Thinking *(U, An, E)*** • Develop critical thinking based on a rationale to identify assumptions, verifying the accuracy and validity of assumptions, and making informed decisions. • Inculcate the ability of logical reasoning to question the rationale behind concepts, ideas, and perspectives.
PO3 *(Skill Level)*	**Effective Communication Skills *(Ap, C)*** • Improve written and oral communication skills so as to express thoughts and ideas effectively. • Demonstrate the ability to listen carefully and imbibe soft skills to convey and receive instructions clearly. • Develop presentation skills to present complex information in a clear, lucid and concise manner.
PO4 *(Skill Level)*	**Proficiency with Information and Communication Technology *(U, An, E)*** • Demonstrate ability to access, evaluate and use a variety of relevant information resources inclusive of internet and electronic media for the purpose of collating and analyzing data. • Understand the scope and limitations of tools or software used in Information and Communication Technology.
PO5 *(Skill Level)*	**Leadership Skills and Team Work *(U, Ap, An, C)*** • Demonstrate leadership skills formulating an inspiring vision, thereby building a team, motivating, and inspiring team members to engage and achieve that vision. • Develop management skills to guide people in takings tasks to their logical conclusion. • Inculcate the ability to facilitate coordinated effort as a group or team in the interests of common cause and recognize the contribution of team members.
PO6 *(Attitude Level)*	**Self-directed and Lifelong Learning *(U, Ap, An)*** • Demonstrate the ability to work independently and take responsibility for one's actions. • Acquire the ability to explore and evolve by becoming self-sufficient and self-reliant. • Adapt lifelong learning approaches to broaden one's horizons for personal growth
PO7 *(AttitudeLevel)*	**Ethical Values and Environmental Concerns *(U, Ap, E)*** • Embrace moral or ethical values in conducting one's life and implement ethical practices in all aspects of life. • Create awareness and concern for environmental and sustainability issues. • Understand and realize the significance and relevance of co-habitation and co-evolution in attaining the needs of sustainable development.

PO8 *(AttitudeLevel)*	Gender Sensitization and Community Service *(U, Ap, An)* • Respect gender sensitivity, gender equity and gender justice. • Encourage mutual understanding and express empathetic social concern towards different value systems and different strata of society. • Engage in community service through Institutional Social Responsibility.

Serial Number	**Details of Programme Specific Outcomes (PSOs) (Oceanography and Fishery Science)**
PSO1	**Conceptual Understanding and Emerging Applications *(R, U, Ap, An)*** • Inculcate conceptual and coherent understanding of Oceanography and Fishery Science, and demonstrate a broad understanding of different aspects of Oceanography and to learn about the general features of the earth's surface under water. • Understand the in-depth concepts of different areas of Oceanography and Fishery science such as, Aquaculture, Fish processing technology, Marine Biotechnology, Marine Toxicology, Fish Pathology, Marine Biodiversity and Conservation, so as to recognize the current scenario and apply appropriate methodologies with cutting edge tools/techniques to seek solutions to emerging problems faced by mankind. • Demonstrate the relevance of the procedural subject knowledge that creates different types of professionals related to the disciplinary/subject area of zoology, including professionals engaged in research and development, teaching and government/public service.
PSO2	**Analytical reasoning and Scientific Inquiry *(U, An, E)*** • Inculcate a sense of inquiry and capability for asking relevant or appropriate questions, articulating problems or concepts or questions. • Encourage the ability to analyze, interpret and draw conclusions from qualitative/quantitative data and critically evaluate ideas, experiences, theories and concepts by following scientific approach to knowledge development from an open minded and reasoned perspective. • Develop analytical skills involving paying attention to detail and imbibe the ability to construct logical arguments using correct technical language related to the relevant subject. • Analyze and interpret data/information collected or related to experiments or investigations, using appropriate methods involving Biostatistics, Bioinformatics among others and report accurately the findings of the experiment/investigations while relating the conclusions/ findings to relevant theories of zoology.
PSO3	**Laboratory Skills and Fieldwork *(R, U, E, C)*** • Understand and apply standard operating procedures as per Good Laboratory Practices so as to develop laboratory skills and qualities required for successful career in teaching, research, industry, etc. • Demonstrate awareness regarding animal ethics, human ethics, conservation of flora and fauna, so as to promote safe environment and ecosystem, in the pursuit of disciplinary knowledge.
PSO4	**Research Aptitude and Interdisciplinary Approach *(Ap, An, E, C)*** • Inculcate and adapt to research aptitude and culture, integrate research-based knowledge in an interdisciplinary framework, and realize the relevance of choosing research as an alternative career option. • Demonstrate the awareness regarding compliance with research ethics, awareness about conflicts of interests and Intellectual Property Rights, and avoiding unethical behavior such as fabricating, falsifying, or misrepresenting data or to committing plagiarism. • Inculcate the ability to recognize cause and effect relationships, formulate hypothesis, reporting the results of an experiment or investigation, andapplication of research tools for analysis and interpretation of data. • Inculcate an interdisciplinary approach, to understand and consolidate fundamental concepts through inquiry-based curriculum, develop critical thinking and problem-solving ability required to solve different types of biology related problems with well-defined solutions, and tackle open-ended problems that may cross disciplinary-area boundaries.

Course Outcomes for M.Sc. Part 2 Zoology (Oceanography and Fishery Science)

At the root of all (science) education (Core Learning Outcome):

"The imaginative and original mind need not be overawed by the imposing body of present knowledge or by the complex and costly paraphernalia which today surround much of scientific activity. The great shortage in science now is not opportunity, manpower, money, or laboratory space. What is really needed is more of that healthy skepticism which generates the key idea – the liberating concept."– *P.H. Abelson*

Purity of mind leads to clarity in thought and action for creation of an original archaic work. As well, to consciously attempt the basic pursuit of understanding human existence.

Oceanography and Fishery Science
Semester III – Theory

Core Course 1 (Paper 1): Principles and Disciplines of Oceanography
Course Code: SIPZOOCC611
The study of this course will accomplish the following outcomes:

Unit 1: General Oceanography

Course Outcomes (CO)	Cognitive Level	Affinity with PO/ PSO
CO1: • To give a brief introduction to acquaint students with the different aspects of Oceanography. • To understand the 'Timeless Universe' with the aid of Geological Time Scale and momentous events in the history of Earth. • To appreciate the monumental events in the history of oceanography that have influenced the current understanding of the subject. • Get acquainted to the field of Satellite Oceanography and Remote Sensing Technology to understand its extensive applications in Oceanography. • To learn about the general features of the earth's surface under water with reference to the ocean waters of the Indian subcontinent.	*R, U*	*PO2, PO4, PO6, PO7* *PSO1*

Unit 2: Physical Oceanography

Course Outcomes (CO)	Cognitive Level	Affinity with PO/ PSO
CO2: • To analyze the physical attributes of sea water and comprehend their influence on aquatic life • To throw light on ocean circulation, seasonal changes in the direction of prevailing winds of the region and their role as a key regulator of climatic changes. • To comprehend the relationship between Climate change and Ocean warming. • To get acquainted to the phenomenon responsible for propelling of water around the globe in sweeping 'currents', transferring the energy across entire ocean basins through 'waves', and tides to reliably flood and ebb every single day.	*R, U, An*	*PO2, PO4, PO6, PO7* *PSO1, PSO2*

Unit 3: Chemical Oceanography

Course Outcomes (CO)	Cognitive Level	Affinity with PO/ PSO

CO3: • To study inorganic constituents – the chemicals that make up the ocean and their role in nurturing oceanic life. • To study the role of dissolved gases and nutrients in marine environment, their availability, distribution in order to appreciate the influence of these factors on aquatic as well as terrestrial life • To value the mineral resources those are obtained from the oceans and their large-scale applications.	*R, U, An*	*PO2, PO4, PO6, PO7* *PSO1, PSO2*
Unit 4: Biological Oceanography		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
CO4: • To understand the extent and division of marine environment owing to prevalent physical factors and to analyze their influence on marine biotic diversity • To appreciate the vast array of marine biotic diversity from plankton to large nekton. • To get enlightened by the plethora of adaptations and associations exhibited by varied marine organisms with changing climatic conditions so as to draw appropriate conservation measures. • To understand and analyze the effects of pollution on marine life and the ways to mitigate them.	*R, U*	*PO2, PO4, PO6, PO7* *PSO1, PSO2*

Core Course 2 (Paper 2): Aquaculture- Methods and Practices **Course Code: SIPZOOCC612** The study of this course will accomplish the following outcomes:		
Unit 1: Introduction to Aquaculture		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
CO1: • To introduce aquaculture to know its immense potential for generating employment • To acquire knowledge for wise management of aquatic resources to minimize production costs and gain profit. • To consider aquaculture as a subsidiary in the income of someone having a taste for it. • To attain a clear perception of the present status of sea farming in India and to compare it with worldwide production and trends • To impart essential knowledge and skills regarding advanced technologies of different aquaculture production systems.	*R, U*	*PO2, PO4, PO6, PO7, PO8* *PSO1, PSO2*
Unit 2: Shellfish culture		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
CO2: • To familiarize the learners about breeding, raising, and harvesting of shellfish • To acquire the knowledge for management of crab culture, its present status, prospects, problems, and development in India • To understand the breeding and rearing practices for brackish water prawns • To understand the techniques used in the artificial production of pearls using pearl oysters and its commercial significance.	*R, U, An, Ap*	*PO2, PO4, PO6, PO7, PO8* *PSO1, PSO2*

Unit 3: Fin Fish and other cultures		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
CO3: • To familiarize learners about hatchery and grow out practices for the culture of fresh water and brackish water fishes having commercial value • To understand the techniques involved in the culture of seaweeds in order to meet its increasing demand in pharmaceutical and nutraceutical industries • To realize the potency of allied branches of aquaculture such as integrated aquaculture and sewage fed fishery.	*R, U, An, Ap*	*PO2, PO4, PO6, PO7, PO8* *PSO1, PSO2*
Unit 4: Marketing and Finance		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
CO4: • To inculcate an entrepreneurial culture by acquainting students to marketing and finance sector in aquaculture. • To understand the professional ethics in global marketing and export-import procedures involved in aquaculture. • To impart knowledge about finance, fund raising, schemes, subsidies and the role of corresponding authorities involved.	*R, U, An, Ap*	*PO2, PO4, PO6, PO7, PO8* *PSO1, PSO2*

Department Specific Elective (Paper 3): Marine Biodiversity, Conservation and Management **Course Code: SIPZOOEL611** The study of this course will accomplish the following outcomes:		
Unit 1: Marine Biodiversity and Conservation		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
CO1: • To make students mindful of the marine biodiversity and its conservation • To inculcate the awareness about rich faunal diversity, its distribution, adaptations, and conservation measures in marine ecosystems. • To get acquainted to the significant marine habitats and the associated conservation challenges and potential solutions.	*R, U, An*	*PO2, PO5, PO6, PO7* *PSO1, PSO2, PSO3*
Unit 2: Biodiversity Conservation laws and Marine protected areas of India		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
CO2: • To get the information about the legislative measures and the norms designed by the government to encourage biodiversity conservation. • To ensure the conservation of biological diversity, sustainable use of its components and fair usage of its resources in order to prevent overuse or eventual destruction of biodiversity. • To broaden the perspective of biodiversity conservation using Anthropology- a scientific study of human culture and society. • To safeguard and foster the cardinal marine habitats and representative marine life by designing Marine Protected Areas (MPAs) thereby restoring the productivity of the oceans and avoid further degradation. • To gain an insight into international approaches to conservation and	*R, U, An, Ap*	*PO2, PO5, PO6, PO7* *PSO1, PSO2*

sustainable development, ongoing Problems, possible responses, role of conservation biologists.		
Unit 3: Environmental Impact Assessment and Coastal Regulatory Zone		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
CO3: • *EIA (Environment Impact Assessment):* • To analyze, evaluate, predict, and mitigate the potential environmental effects that could occur from the anthropogenic activities before they are put into action. • To develop a tool for promoting sustainable development, ensuring the protection of the environment, analyzing potential environmental impacts, integrating environmental considerations into project planning, and enabling public participation. • *CRZ (Coastal Regulatory Zone):* • To ensure the protection of ecologically sensitive Areas like mangroves, coral reefs which act as a shield against tsunami and cyclone. • To perk up the lives of coastal communities like fishing communities • To have resilient measures for mitigating impacts of climate change and high-intensity cyclones. • To balance development with conservation of the coastal environment. • To get acquainted to the Ocean Policies and governance using scientific, Economic and Geo-political aspects of ocean exploration with special reference to India.	*R, U, An, Ap*	*PO2, PO5, PO6, PO7* *PSO1, PSO2*

Research Project (Paper 4) **Course Code: SIPZOORP611** The study of this course will accomplish the following outcomes:		
NO THEORY PAPER		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
• To inculcate research aptitude and develop an open, inquiring mind amongst the students. • To encourage students to explore new territories and learn new things. • To encourage the spirit of curiosity of students and to think of research as potential career option. • To motivate and inspire students to come up with solutions for real life problems facing the society and nation.	*R, U, An, Ap, E, C*	*PO1, PO2, PO3, PO4, PO5, PO6* *PSO1, PSO2, PSO3, PSO4*

PRACTICAL

"*Study nature not books.*" – An old dictum.

The practical course in Zoology is designed for first hand study of animal life through observation of preserved specimens, *in situ* organ systems, microscopic examination of permanent slides, etc. as well as to perform experiments to strengthen the concept base.

It is an effort to invigorate a thought process that can analyze and reason for the sake of awareness, hence to reach a valid answer.

Oceanography and Fishery Science
Semester III – Practical

Practical I based on Core Course 1 SIPZOOCC611
Course Code: SIPZOOCCP611
The study of this course will accomplish the following outcomes:

Course Outcomes (CO)	Cognitive Level	Affinity with PO/ PSO
1) *Identification of Oceanographic instruments:* To identify and describe various oceanographic instruments used in analyzing different properties of sea water. Also, to identify and describe various devices practiced in the sampling of marine organisms. 2) *Determination of physico-chemical parameters:* To determine various physico-chemical parameters of sea water such as salinity, Dissolved O_2, CO_2, Nitrites-Nitrates, Silicates, Phosphates etc., in order to analyze their relationship with prevalence of marine organisms. 3) *Estimation of primary productivity by light and dark bottle* To estimate the primary productivity of given sample water in order to understand the energy conversions in organisms. 4) *Identification of intertidal organisms:* To identify and describe various intertidal organisms based on types of substrata they inhabit (rocky, sandy, muddy) in order to understand the differences in their morphological, anatomical, and behavioral adaptations. 5) *Students Activity:* Shore walks to observe and appreciate the parallel universe which emerges when the tide recedes. Also, to combine experiential learning in laboratory with actual observations on field. 6) *Visit to institutes involved in Marine Biology or Oceanography Research:* To gain knowledge about potential areas in oceanographic research, research trends, methodology, instrumentation, facilities in order to inculcate a research-based attitude.	*R, U, An, Ap, E*	*PO1, PO2, PO6, PO7* *PSO2, PSO3*

Practical II based on Core Course 2 SIPZOOCC612
Course Code: SIPZOOCCP612
The study of this course will accomplish the following outcomes:

Course Outcomes (CO)	Cognitive Level	Affinity with PO/ PSO
1) *Identification of commercially important fishes in aquaculture:* To identify, classify and describe commercially important fishes with respect to aquaculture 2) *Identification of commercially important crustaceans in aquaculture:* To identify, classify and describe commercially important crustaceans with respect to aquaculture 3) *Identification of various farm equipment:* To identify and describe various farm equipment employed in an aquaculture farm in order to facilitate fish farming. 4) *Identification of various culture models:* To identify and describe various systems employed in aquaculture. 5) *Fecundity, Maturation studies in fish and plotting frequency polygon by Ova diameter measurement.* To measure the reproductive capacity of a female fish, which in turn elucidates the population dynamics, racial characteristics, production, and stock recruitment problems. To measure the diameter and plotting the frequency polygon to interpret the growth and maturation in fish. 6) *Estimation of physico-chemical parameters of pond water:* To determine various physico-chemical parameters of pond water such	*R, U, An, Ap, E*	*PO1, PO2, PO3, PO6, PO7* *PSO2, PSO3*

as turbidity, hardness, COD/BOD, chlorophyll etc., in order to analyze their relationship with the well-being of cultured species. 7) *Identification of Aquaculture feed:* To identify and describe various feed (natural and formulated) used in aquaculture practices and to understand the importance of dosage in feeding. 8) *Students Activity:* Visit to fresh water hatchery/aquaculture farm to combine experiential learning in laboratory with actual observations on field.		
Practical III based on Department Specific Elective SIPZOOEL611 **Course Code: SIPZOOELP611** The study of this course will accomplish the following outcomes:		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
1) *Identification of Foraminiferan shells:* To gain an insight into the world of Micropaleontology which studies microfossils, its morphology, its characteristic details, and commercial importance. 2) *Identification of marine fauna:* To appreciate diverse marine fauna (Birds, reptiles, and mammals), their distribution, adaptations migration and conservation. 3) *Case studies based on EIA and CRZ notifications:* To practically apply the knowledge and understanding of the facts regarding EIA and CRZ to a real-world situation. 4) *Identification of common mangrove species and associates:* To cherish these unsung heroes of aquatic ecosystems. To understand their diversity, distribution, adaptations, and conservation. 5) *Identification of common corals species:* To gain an insight into these esteemed wonders of marine ecosystems, their diversity, distribution, adaptations, and conservation. 6) *Identification and preparing permanent mountings of zooplankton:* To appreciate the enormous world of these microscopic splendors and develop a skill of preparing permanent mountings of organisms. 7) *Student's activity: Visit to coastal and mangrove areas:* To observe and appreciate the marine marvels and protectors of estuaries in their natural habitat. To combine experiential learning in laboratory with actual observations on field. 8) *Student's activity: On field observation of Molluscan shells and Marine algae* To carry out an elaborate study involving identification, characterization, and preservation of molluscs and algae. *(Note: Only abandoned molluscan shells and washed ashore algae specimen is to be studied)*	*U, An, Ap, C*	*PO2, PO6, PO7* *PSO1, PSO2, PSO3*

Oceanography and Fishery Science **Semester IV – Theory**		
Core Course 1 (Paper 1): Marine Fisheries **Course Code: SIPZOOCC621** The study of this course will accomplish the following outcomes:		
Unit 1: Marine Finfish resources		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
CO1: • To gain knowledge of Fishery Science that opens an avenue for bioeconomics.	*R, U, An*	*PO2, PO6, PO7*

• To gain in depth knowledge of marine finfish resources in pelagic and demersal systems. • To understand the fluctuations in Oil sardine fishery in India and to get acquainted to the utilization of oil sardine. • To study commercially important fish species, their distribution, crafts, and gears operated, utilization and recent data on their landing.		*PSO1, PSO2*
Unit 2: Marine Shellfish resources		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
CO2: • To gain knowledge of Fishery Science that opens an avenue for bioeconomics. • To gain in depth knowledge of marine shellfish resources in pelagic and demersal systems. • To get an insight into crustacean fisheries, commercially important species, distribution, methods of capture, recent data on their catch. • To get an insight into crustacean fisheries, commercially important species, distribution, methods of capture, recent data on their catch.	*R, U, An*	*PO2, PO6, PO7* *PSO1, PSO2*
Unit 3: Trophodynamics in aquatic systems		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
CO3: • To learn the dynamics of nutrition and the flow of energy in aquatic food webs. • To study various indices involved in the food and feeding analysis. • To understand the use of trophodynamics as a tool for the study of aquatic ecosystem. • To understand the effect of fishing on prey-predator relationship in marine environment in order to obtain maximum sustainable yield.	*R, U, An, E*	*PO1, PO2, PO6, PO7* *PSO1, PSO2*
Unit 4: Marine fishery- Economics and Conservation		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
CO4: • To know about the current trends in global as well as national capture fishery. • Concept of management and conservation of wild stock, conservation of genetic and ecological diversity • To get acquainted to the significance of Fishermen communities in fishery, agencies which focus on development of fish farmers and Fishery Extension Programs. • To understand the impact of unsustainable fishing practices and overfishing across the globe. Hazards of using fishing gears without using escape tools for non-commercial and endangered species.	*R, U, An, E*	*PO2, PO6, PO7* *PSO1, PSO2*

Core Course (Paper 2): Fish Processing Technology **Course Code: SIPZOOCC622** The study of this course will accomplish the following outcomes:		
Unit 1: Logistics in fish processing		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**

CO1: • To familiarize learners about the vast array of opportunities offered by fish processing industry by acquainting them to various methods of fish processing. • To impart knowledge about logistics, skill of handling and methods used in the transportation of fish in hygienic conditions at various levels before subjecting to processing. • To study methods involved in assessing the freshness of fish. • To analyze the relationships between physical parameters in fish transportation	*R, U, An*	*PO2, PO4, PO6, PO7, PO8* *PSO1, PSO2*
Unit 2: Traditional fish processing		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
CO1: • To familiarize learners about the vast array of opportunities offered by fish processing industry by acquainting them to various methods of fish processing. • To impart knowledge about logistics, skill of handling and methods used in the transportation of fish in hygienic conditions at various levels before subjecting to processing. • To study methods involved in assessing the freshness of fish. • To analyze the relationships between physical parameters in fish transportation. • To get acquainted to different indigenous methods and materials implemented in fish processing. • To realize the potential of traditional methods prevalent in fish processing and to understand their industrial modernization to meet the augmenting demand of consuming processed foods. • To impart the knowledge and inculcate professional ethics about major equipment used in fish processing.	*R, U, An*	*PO2, PO4, PO6, PO7, PO8* *PSO1, PSO2*
Unit 3: Modern fish processing		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
CO2: • To cope up with current trends in fish processing by understanding modern fish processing techniques. • To understand the processing of fish to make various fishery products by using advanced technology. • To realize the plethora of advanced techniques currently existing in fish processing industry which have unfolded new career prospects thereby inculcating an entrepreneurial approach.	*R, U, An, Ap*	*PO2, PO4, PO6, PO7, PO8* *PSO1, PSO2*
Unit 4: Quality assurance norms and methods		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
CO3: • To give in depth knowledge of recent methods in quality control and their norms and ethics. • To understand various changes that occur during storage of fish and fish products and their corresponding protective measures. • To understand and value the professional ethics involved in testing of various fish and fish products. • To gain an understanding of various legislative measures in terms of National, International, Integrated food laws and corresponding	*R, U, An*	*PO2, PO4, PO6, PO7, PO8* *PSO1, PSO2*

regulating authorities.		

Department Specific Elective (Paper 3): Marine Biotechnology, Toxicology and Pathology
Course Code: SIPZOOEL621
The study of this course will accomplish the following outcomes:

Unit 1: Marine Biotechnology

Course Outcomes (CO)	Cognitive Level	Affinity with PO/ PSO
CO1: • To understand the history of biotechnology and to gain knowledge of applications of biotechnology in various fields of marine biology to improve human values. • To learn advanced techniques used in cryopreservation of fish gametes and understand the steps involved in developing the transgenic fish. • To study the gene transfer technique in fish species like common carp and channel fish. • To get acquainted to the emerging field of Seaweed Biotechnology and to know its immense potential towards the betterment of mankind.	*R, U, An, Ap*	*PO1, PO2, PO4, PO7* *PSO1, PSO2*

Unit 2: Marine Toxicology

Course Outcomes (CO)	Cognitive Level	Affinity with PO/ PSO
CO2: • To establish the relationship of toxicology with other sciences by studying history and scope of toxicology and understanding the dose response relationships, sources, and movements of toxicants. • To understand the primary classification of toxicants, terminologies used and types of toxicants • To learn about the factors determining the degree of toxicity and common effects. • To impart basic conceptual understandings of heavy metal toxicity, toxicity caused by agrochemicals in fishes and their effects.	*R, U, An, E*	*PO1, PO2, PO4, PO7* *PSO1, PSO2*

Unit 3: Fish Pathology

Course Outcomes (CO)	Cognitive Level	Affinity with PO/ PSO
CO3: • To get familiarized with fish pathology with respect to pollutants and adverse biological factors in the aquatic environment. • To study fish parasitology by understanding types of parasites, the sites of infection in various fish species. • To learn the various pathogenic bacteria, their habitat, epizootiology and treatment. • To get conceptual understanding of the mycology of fish by studying various types of oomycetes.	*R, U, An, Ap*	*PO1, PO2, PO4, PO7* *PSO1, PSO2*

Research Project (Paper 4) **Course Code: SIPZOORP621** The study of this course will accomplish the following outcomes:		
NO THEORY PAPER		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
• To inculcate research aptitude and develop an open, inquiring mind amongst the students. • To encourage students to explore new territories and learn new things. • To encourage the spirit of curiosity of students and to think of research as potential career option. • To motivate and inspire students to come up with solutions for real life problems facing the society and nation.	*R, U, An, Ap, E, C*	*PO1, PO2, PO3, PO4, PO5, PO6* *PSO1, PSO2, PSO3, PSO4*

PRACTICAL

"*Study nature not books.*" – An old dictum.

The practical course in Zoology is designed for first hand study of animal life through observation of preserved specimens, *in situ* organ systems, microscopic examination of permanent slides, etc. as well as to perform experiments to strengthen the concept base.

It is an effort to invigorate a thought process that can analyze and reason for the sake of awareness, hence to reach a valid answer.

Oceanography and Fishery Science **Semester IV – Practical**		
Practical I based on Core Course 1 SIPZOOCC621 **Course Code: SIPZOOCCP621** The study of this course will accomplish the following outcomes:		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
1) *Study of food and feeding habits in fish:* To elucidate the factors which influence distribution, migration, and growth of fish by studying their feeding habits. It provides a key to \ understand many aspects of fish biology, physiology, and behavior and their conservation. 2) *Identification of crafts and gears:* To identify and describe various crafts and gears operated along the coast of India. 3) *Identification and practicing of various Knots and Hitches used in fisheries:* To identify and practice various knots and hitches which serve as a reliable tool that enhances the safety and efficiency especially in the fields of Oceanography and Fishery Science. 4) *Biometric studies of fish/prawn:* To provide crucial information on fish population growth and aquatic habitat well- being. 5) *Identification of commercially important crustaceans:* To identify, classify and describe commercially important crustaceans with respect to capture fishery, their distribution, commercial value, crafts, and gears operated. 6) *Identification of commercially important molluscs:* To identify, classify and describe commercially important molluscans with respect to capture fishery, their distribution, commercial value, crafts, and gears operated. 7) *Identification and classification of marine fish:* To identify, classify and describe commercially important fishes with respect to capture fishery, their distribution, commercial value, crafts,	*U, An, Ap, E*	*PO2, PO6, PO7* *PSO1, PSO2, PSO3*

and gears operated. 8) *Student's activity:* Visit to local Fish landing centres, Local fish markets, Fishermen villages in and around Mumbai.		
Practical II based on Core Course 2 SIPZOOCC622 **Course Code: SIPZOOCCP622** The study of this course will accomplish the following outcomes:		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
1) Organoleptic tests to evaluate the freshness of the given fish specimen: • To maximize the value of the fishes, freshness quality must be maintained which has become a global concern in fishing industry. • To increase the acceptability of the fish product, the method of quality assessment must be known. • To avoid the ingestion of contaminated food; to evaluate the nutritive value of food by detecting the presence of biological, chemical, and physical hazards and in the end to ensure the safety of the consumer. *2) Dressing and Grading of Shrimps and dressing and filleting of given fish species:* • To acquire a skill of dressing and grading of given shrimp/prawn species. • To develop a holistic approach to work at an industrial level wherein whole raw shrimp on receipt are first graded for size and then dressed. Also, to inculcate a culinary approach which accounts for the interdisciplinary of the course. *3) Preparation of Prawn pickle, Fish Burger, Surimi:* • To prepare value added products for human consumption in order to increase the utilization of underutilized low value fishes which are rich in nutrients. *4) Identification of various equipment used in fish processing:* • To promote a practical, professional, and procedural knowledge required for carrying out professional or highly skilled tasks related to advanced thermal and non-thermal technologies in fish processing.	*R, U, An, Ap, E*	*PO1, PO2, PO4, PO6, PO7* *PSO2, PSO3*
Practical III based on Department Specific Elective SIPZOOEL621 **Course Code: SIPZOOELP621** The study of this course will accomplish the following outcomes:		
Course Outcomes (CO)	**Cognitive Level**	**Affinity with PO/ PSO**
1) Detection of Heavy metals: • To detect the presence of heavy metals in given sea water sample, understand and analyze their effects on marine life. *2) Identification of Gene transfer technology in fish:* • To identify and describe various gene transfer technologies practiced in marine biotechnology, equipment used, advantages and disadvantages. *3) Identification of fish pathogens:* To identify, classify and describe various fish pathogens, their clinical pathology and treatment. *4) Determination of LC50 and EC50 for suitable pollutant using Daphnia/ Chironomus larvae/ Mosquito 28 Larvae:* To understand and analyze the toxicity of suitable pollutants prevalent in marine environment. *5) Histo-pathological examination of diseased fish specimen.* To use Histo-pathological examinations to compare and contrast between the healthy and diseased fish specimen.	*U, An, Ap, E*	*PO2, PO6, PO7* *PSO1, PSO2, PSO3*

Oceanography and Fishery Science
Semester III – Theory

Core Course 1 (Paper 1): Principles and Disciplines of Oceanography
Course Code: SIPZOOCC611

Learning Objectives:

- *To give a brief introduction to acclimate students with the different aspects of Oceanography.*
- *To learn about the general features of the earth's surface under water with reference to the ocean waters of the Indian subcontinent.*
- *To gain knowledge of the tools used for oceanographic studies and research.*
- *To analyze the physical attributes of sea water and comprehend their influence on aquatic life;to throw light on ocean circulation – a key regulator of climatic changes.*
- *To study inorganic constituents – the chemicals that make up the ocean and their role in nurturing oceanic life.*
- *To appreciate the vast array of life forms found in the ocean from bacteria to large nektons and their adaptations to best suit the niche in which they thrive, and to study the influence of the fluctuations they encounter in their habitats.*

Unit 1: General Oceanography — **15 Lectures**

1.1: Geological time scale and major Physico-chemical and biological events in Earth's History
1.2: History of Oceanography
1.3: Milestones in the history of Ocean exploration: Challenger Expedition, *****METEOR and DISCOVERY Expeditions, International Geophysical Year (IGY), International Indian Ocean Expedition (IIOE), Tropical Ocean Global Atmosphere (TOGA), World Ocean Circulation Experiment (WOCE), Joint Global Ocean Flux Studies (JGOFS).
1.4: Satellite oceanography and remote sensing technology
1.5: Ocean bottom topography:
- 1.5.1: Continental Shelf
- 1.5.2: Continental Slope
- 1.5.3: Submarine Canyons
- 1.5.4: Submarine Mountain Ranges
- 1.5.5: Sea Mounts and Guyots
- 1.5.6: Oceanic Trenches
- 1.5.7: Oceanic Ridges and Rises
- 1.5.8: Abyssal Floor

Unit 2: Physical Oceanography — **15 Lectures**

2.1: Physical Properties of Sea water:
- 2.1.1: Salinity and Chlorinity
- 2.1.2: Light and Temperature
- 2.1.3: Density and Pressure
- 2.1.4: Salinity-Temperature-Density (STD) Relationship

2.2: Oceanographic circulation:
- 2.2.1: Wind Induced circulation, Thermohaline circulation and Upwelling of water
- 2.2.2: Coriolis Effect, Ekman Spiral, Langmuir circulation
- 2.2.3: Geostrophic current, Westward Intensification
- 2.2.4: ENSO Cycle, Indian Monsoon- Indian Ocean Basin Mode (IOBM), Indian Ocean Dipole (IOD)
- 2.2.5: Ocean warming and Climate change

2.3: Waves:
- 2.3.1: Characteristics of waves
- 2.3.2: Deep water and Shallow water waves
- 2.3.3: Transitional waves, Wind generated waves, Internal waves, and Tsunami

2.4: Tides:
- *****2.4.1: Tide generating forces, their causes, variation, and types
- 2.4.2: Tidal currents, Tidal and wave energy
- 2.4.3: Importance of tide tables

Unit 3: Chemical Oceanography — **15 Lectures**

3.1: Chemical composition of Sea water:
- 3.1.1: Constancy of its composition and factors affecting the composition
- 3.1.2: Major and minor constituents
- 3.1.3: Trace elements and their biological role

3.2: Dissolved gases in sea water and their role in the environment:
- 3.2.1: Carbon dioxide system
- *3.2.2: Dissolved oxygen and Oxygen Profile
- 3.2.3: Hydrogen Sulphide

3.3: Nutrients in the ocean, their cycles and factors influencing their distribution: Nitrogen, Phosphorous, Silicon

3.4: Mineral resources from the sea:
- 3.4.1: Deep Sea mud oozes and Manganese nodules
- 3.4.2: Oil, Gas and Sulphur deposits
- 3.4.3: Resources along the Continental margin

Unit 4: Biological Oceanography — **15 Lectures**

*4.1: Divisions of Marine environment

*4.2: Intertidal organisms and their zonation

4.3: Marine biotic diversity: Plankton, Nekton and Benthos

4.4: Effect of Physical factors on marine life:
- 4.4.1: Light- Photosynthesis, Coloration, Structural adaptations, and Bioluminescence
- 4.4.2: Temperature- Tolerance, Geographical distribution, Size, Calcium Precipitation, Metabolism, Bipolarity, Tropical submergence, and Periodicity
- 4.4.3: Salinity: Tolerance and distribution, Size, Buoyancy and Osmoregulation
- 4.4.4: Currents: Role in Nutrition, Transportation and Propagation

4.5: Animal associations in marine environment: Endemism, Inquilinism, Phoresis, Epizoism, Mutualism, Parasitism

4.6: Effects of Pollution on marine life

- *Student's activity:* Shore walks to observe and appreciate the parallel universe which emerges when the tide recedes. Also, to combine experiential learning in laboratory with actual observations on field.
- *Visit to institutes involved in Marine Biology or Oceanography Research:* To gain knowledge about potential areas in oceanographic research, research trends, methodology, instrumentation, facilities in order to inculcate a research-based attitude.

Topics marked with '*' are to be prepared and presented by the students as a part of internal assessment

Core Course 2 (Paper 2): Aquaculture- Methods and Practices
Course Code: SIPZOOCC612

Learning Objectives:
- *To introduce aquaculture to know its immense potential for generating employment; to acquire knowledge for wise management of aquatic resources to minimize production costs and gain profit.Also, to consider aquaculture as a subsidiary in the income of someone having a taste for it.*
- *To attain a clear perception of the present status of sea farming in India.*
- *To impart essential knowledge and skills regarding advanced technologies of different aquaculture production systems.*
- *To familiarize the learners about breeding, raising, and harvesting of shellfish, finfish, and aquatic plants.*
- *To inculcate an entrepreneurial culture by acquainting students to marketing and finance sector in aquaculture*

Unit 1: Introduction to Aquaculture — **15 Lectures**

*1.1: History, Scope, and Importance of Aquaculture

1.2: Cultivable organisms for aquaculture and criteria for their selection

1.3: Different farming systems: Extensive, semi-intensive, intensive, composite/poly culture, integrated fish farming, raceway culture.

*1.4: Aquaculture practices and their current status in India

1.5: Impact of aquaculture on the environment

1.6: World and Indian aquaculture production and trends

Unit 2: Shell Fish Cultures	**15 Lectures**
2.1: Crab Culture: 2.1.1: Cultivable species of crabs in India 2.1.2: Pond Design 2.1.3: Principles of crab hatchery, brood stock, larval and post-larval management *2.1.4: Prospect, problems, and development of crab culture in India 2.2: Prawn/Shrimp Culture: 2.2.1: Introduction, History and Present status of Shrimp culture 2.2.2: Cultivable species of shrimps in India 2.2.3: Hatchery and grow out practices for the culture of Brackish water prawn- *Penaeus monodon* 2.2.4: Hatchery and grow out practices for the culture of Fresh water prawn- *Macrobrachium rosenbergii* 2.3: Pearl Oyster culture: Techniques of Pearl Oyster culture (Freshwater and Marine water) for artificial production of pearls	
Unit 3: Fin Fish and other cultures	**15 Lectures**
3.1: Hatchery and Grow out practices for the culture of Fresh water fishes: Indian Major Carps (Rohu, Catla, Mrigal, Pangasionodon) 3.2: Hatchery and Grow out practices for the culture of Brackish water fishes: 3.2.1: *Chanos chanos* (Breeding techniques, Hatchery and Nursery management, Rearing practices) 3.2.2: *Lates calcarifer* (Breeding techniques, Hatchery and Nursery management, Rearing practices) *3.3: Seaweed Culture 3.4: Sewage-fed Fishery	
Unit 4: Marketing and Finance	**15 Lectures**
4.1: Traditional marketing vis-à-vis role of fishery co-operatives with reference to operations at Satpati, Sasoon dock and Karanja 4.2: Global marketing and Export-Import procedures. *Role of Marine Products Export Development Authority (MPEDA) 4.3: Fund raising: Financial institutions, Schemes and Subsidies, Basic Accounting, Costing and Feasibility report 4.4: Role of NABARD (National Bank for Agriculture and Rural Development) for finance and NFDB (National Fishery Development Board) for funding through the state government.	
Students' activity: Visit to fresh water hatchery/aquaculture farm and submit a report	
Topics marked with '*' are to be prepared and presented by the students as a part of internal assessment	

Department Specific Elective (Paper 3): Marine Biodiversity, Conservation and Management
Course Code: SIPZOOEL611

Learning Objectives:

- *To make students mindful of the Marine biodiversity and its conservation.*
- *To inculcate the awareness about rich faunal diversity, its distribution, adaptations and conservativemeasures in marine ecosystems.*
- *To get acquainted to the conservation and management of significant marine habitats.*
- *To get the information about the legislative measures and the norms designed by the government toencourage biodiversity conservation.*
- *To gain in depth knowledge about the Ocean Policies and their management*

Unit 1: Marine Biodiversity and Conservation	**15 Lectures**
1.1: Introduction to marine biodiversity, Importance, Levels of biodiversity, Causes of extinction of marine bio-resources, Rate of extinction 1.2: Marine vertebrates of India: 1.2.1: Marine Reptiles: 1.2.1 a) Sea Turtles: Diversity and distribution, Migration, Threats, Endangered species, Conservation 1.2.1 b) Saltwater Crocodiles: Distribution, Adaptations, Conservation 1.2.1 c) Sea snakes: Diversity and distribution, Adaptations, Conservation	

1.2.2: Marine Birds: Diversity and Distribution, Migration, Conservation
1.2.3: Marine Mammals
1.2.2 a) Sirenians: Diversity and Distribution, Conservation
1.2.2 b) Cetaceans: Diversity and Distribution, Conservation
1.3: Conservation and Management of:
1.3.1: Mangroves
1.3.2: Corals
1.3.3: Estuaries and Lagoons
1.3.4: Intertidal regions

Unit 2: Biodiversity Conservation laws and Marine protected areas of India	**15 Lectures**

2.1: National Laws and their current advancement: Convention of Biological diversity 1992, National Biodiversity Act 2002, National Environmental Policy, 2006, National Biodiversity Act 2002, Wildlife (Protection) Amendment Act 2022, National Wildlife Action Plan 2017-2031.
2.2: The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
2.3: Law of the Sea: Geneva Conventions, UNCLOS, Exclusive Economic Zone (EEZ) and its significance
2.4: Anthropology and Conservation:
2.4.1: Introduction to Anthropology
2.4.2: International approaches to conservation and sustainable development.
2.4.3: Marine Protected Areas, designing of protected areas, managing protected areas, restoration ecology & Marine Protected Areas (MPAs) of India
2.4.4: Organizations working towards marine biodiversity research and conservation
2.4.5: Role of Conservation Biologists and Citizens in marine biodiversity conservation

Unit 3: Environmental Impact Assessment and Coastal Regulatory Zone	**15 Lectures**

3.1: Environment Impact Assessment (EIA): Introduction and Types
3.2: Environmental Clearance Process
3.3: Structure of EIA: Description of Project, Analysis of alternative site and technology, description of environment- land, water, marine, air, noise, and Socio-economic occupational health impact, Form I and II.
3.4: Coastal Zone Management Plan (CZMP 2019): Coastal Regulation Zones (CRZ), Changes due to development, Comparison between temperate and tropical countries, Integrated coastal zone management.
3.5: Scientific, Economic, Geo-political aspects of Seabed exploration and mining. Seabed Treaty.
3.6: Ocean Policy of India

Students activity: Visit to coastal areas and Study of Molluscan shells, Marine Algae and Method of Preparation of Herbaria
Students activity: Visit to Mangrove area (Coastal and Marine Biodiversity Research Centre, Airoli)

Oceanography and Fishery Science
Semester III – Practical

Practical I based on Core Course 1 SIPZOOCC611
Course Code: SIPZOOCCP611

1) Identification of Oceanographic Instruments:
   a. Nansen reversing bottle
   b. Deep sea reversing thermometer
   c. Bathythermometer
   d. Ekman's current meter
   e. Secchi's disc
   f. Plankton nets: Standard net, Hensen's net and Clarke Bumpus net
   g. Stempel pipette and counting slide
   h. Nekton sampling device: Trawls
   i. Benthic sampling devices: Dredges (Ekman, Sanders deep-sea anchor dredge), grabs (Petersen, VanVeen, Smith-McIntyre), and corers
2) Determination of Physico-chemical parameters:
   a. Salinity (Argentometric and conductivity method)
   b. Dissolved oxygen

c. Carbon dioxide
d. Nitrates-nitrites
e. Silicates
f. Phosphate-phosphorus

3) Estimation of Primary productivity by Light and Dark Bottle
4) Identification of Intertidal Organisms:
   a. Rocky shore: *Patella, Chiton, Mytilus, Perna viridis, Balanus, Onchidium, Nudibranchs (Goniobranchus bombayanus, Bornella stylifera, Doriopsilla miniata), Zoanthids (Green Button Polyp)*
   b. Sandy shore: *Nereis, Fiddler crab, Star fish, Molluscan shells*
   c. Muddy shore: *Lingula, Arenicola, Tubiculus worm, Mud skipper and Shore Birds*

Practical II based on Core Course 2 SIPZOOCC612
Course Code: SIPZOOCCP612

1) Identification of commercially important fishes in aquaculture:
   Labio rohita (Rohu), Catla catla (Katla), Clarius magur (Catfish), Pangasionodon hypophthalmus (Pangasius), Oreochromis mozambicus (Mozambique Tilapia), Piaractus brachypomus (Roopchand), Lates calcarifer (Asian Seabass), Chanos chanos (Milkfish)
2) Identification of commercially important crustaceans in aquaculture:
   Macrobrachium rosenbergii (Giant Freshwater Prawn), Penaeus monodon (Tiger Prawn)
3) Identification of various farm equipment used in aquaculture practices:
   Feeding cups, trays, paddle wheels, aerators, fountains, Sluice gate models, elbow pipe outlets
4) Identification of various culture models implemented in aquaculture practices:
   Pen culture, Cage culture, Raft culture and Rope culture
5) Fecundity, Maturation studies in fish and plotting frequency polygon by Ova diameter measurement.
6) Estimation of physico-chemical properties of pond water:
   a) Turbidity
   b) Hardness
   c) Estimation of Chlorophyll
   d) COD/BOD
   e) Ammonia
7) Identification of Aquaculture feed:
   Green algae, blue-green algae, spirulina, diatoms, infusoria, rotifers, Cladocerons, Tubifex, Brine shrimp, Chironomids
8) Study of various components of fish hatchery and design/layout of an aquaculture farm.

Practical III based on Department Specific Elective SIPZOOEL611
Course Code: SIPZOOELP611

1) Identification of Foraminiferan shells
2) Identification of marine organisms: a) Marine Birds b) Marine Reptiles c) Marine Mammals
3) Case studies based on EIA and CRZ notifications
4) Identification of Common Mangrove species and Mangrove Associates
5) Identification of Common Coral species
6) Identification of Zooplankton:
   Noctiluca, Obelia, Zoea, Copepods, Mysids, Echinoderm larvae, Nauplius, Sagitta, Doliolum, Salpa, Fish eggs and larvae, Jelly fish, Physalia, Porpita
7) Permanent preparation of Zooplankton mountings
8) Laboratory procedure for Quantitative estimation of plankton
9) Use of QGIS software in Marine Biodiversity Conservation (Hands on practice)

Practical IV based on Research Project
Course Code: SIPZOORP611

Research Project Component based on Oceanography/Fishery Science/Interdisciplinary topic:

Details of Research project component for Semester III are as follows:

1) The students will prepare a Research proposal based on Oceanography/Fishery Science/Interdisciplinary topic under Zoology in Semester III.
2) A teacher from the department will act as a project mentor to the student.
3) It will be the duty of the mentor to assign to the group a topic related to a particular theme covered in the syllabus/interdisciplinary topic.
4) The mentor will prepare, guide, and supervise the group by giving orientation/instructions about writing the project proposal.
5) The Outline/Scheme of the project proposal will include Literature review/search, introduction, objectives, purpose and rationale, materials, and methods, expected outcomes/results, relevance of the project and bibliography (Note that the students have been taught Research Methodology in the revised syllabus of M.Sc. Part 1 in the subject of Zoology).

Evaluation of the Research Project Proposal during the practical examination for Semester III will be as follows:

1) The examiner will evaluate the **'Research Proposal'** for the research project by taking into the account of the evaluation criteria given below:

Title
Literature review/search
Introduction
Objectives, Purpose, and Rationale
Materials and Methods
Expected outcomes/results
Relevance of work
Bibliography

2) The examiner will evaluate the **'PowerPoint Presentation'** for the research proposal by taking into the account of the evaluation criteria given below:

Title
Content of the presentation
Quality of the presentation
Presentation skills
Viva/ Question- Answer session

Oceanography and Fishery Science
Semester IV – Theory

Core Course 1 (Paper 1): Marine Fisheries
Course Code: SIPZOOCC621

Learning Objectives:

- *To gain knowledge of Fishery Science that opens an avenue for bioeconomics.*
- *To gain in depth knowledge of marine finfish and shellfish resources in pelagic and demersal systems.*
- *To offer an insight in the field of trophodynamics in aquatic ecosystems.*
- *To impart the knowledge of Economics and Conservation in order to develop a sustainable approach.*
- *To know about the current trends in global as well as national capture fishery.*
- *To get acquainted to the significance of Fishermen communities in fishery, agencies which focus ondevelopment of fish farmers and Fishery Extension Programs.*

Unit 1: Marine Finfish resources	**15 Lectures**

1.1: Oil Sardine Fishery:
1.1.1: Fluctuations in landings of Oil Sardine Fishery from year to year
1.1.2: Utilization of the catch
1.2: Mackerel Fishery
1.3: Bombay Duck Fishery
1.4: Tuna Fishery
*1.5: Sole fish and Ribbon fish Fishery
1.6: Shark and Ray Fishery

Unit 2: Marine Shellfish resources	**15 Lectures**

2.1: Crustacean fisheries
2.1.1: Prawn and Shrimp Capture Fishery
*2.1.2: Crab Capture Fisheries
2.2: Molluscan Fisheries
2.2.1: Commercial and Edible species of Oysters, Mussels, Clams, Gastropods, Cephalopods
2.2.2: Lime yielding Molluscan shells

Unit 3: Trophodynamics in aquatic systems	**15 Lectures**

3.1: Concept of Trophodynamics
3.2: Methods of food and feeding analysis, Gut content analysis, Index of Relative Importance (IRI), Forage Ratio
3.3: Food digestion and energetics
*3.4: Fishing effect on prey and predator species and their interaction
3.5: Morphological and Anatomical feeding adaptations in fishes.
3.6: Self-regulation of fish stock density in the event of change in food supply.

Unit 4: Marine fishery- Economics and Conservation	**15 Lectures**

4.1: Major fishing nations of the world. Present trend of marine capture fisheries. Statistics on world fish catches.
*4.2: Growth in marine fisheries and current status of India in marine fish production and export.
4.3: Concept of management and conservation of wild stock, conservation of genetic and ecological diversity, IUCN red list categories, measures for fish conservation.
4.4: Fisheries economics and extension, Russel's equation, production and yield, overfishing, ranching.
4.5: Satellite/Aircraft Remote Sensing of fish stocks
4.6: Factors influencing fish production along the West and East Coast of India
4.7: Fish Farmer's development agencies (FEDAs), Fisheries Extension Programme.

- *Student's activity: Visit to Fish landing centers to combine experiential learning in laboratory with actual observations on field.*

Topics marked with '*' are to be prepared and presented by the students as a part of internal assessment

Core Course (Paper 2): Fish Processing Technology
Course Code: SIPZOOCC622

Learning Objectives:

- *To impart knowledge of the vast array of opportunities offered by Fish processing industry by acquainting them to various methods of fish processing.*
- *To familiarize the learners about logistics and skill of handling of fish in hygienic conditions at variouslevels. Also, to assess freshness of fish.*
- *To get acquainted with different methods and materials required in traditional and recent methods infish processing.*
- *To give in depth knowledge of recent methods in quality control and their norms.*

Unit 1: Logistics in fish processing	**15 Lectures**

1.1: Physical, Chemical and Biological Characteristics of fish significant in fish processing
1.2: Wet fish handling and preparation
1.2: Hygienic conditions required on board, landing centers and processing industry
1.3: Temperature modeling and relationships in fish transportation
*1.3.1: Transportation of Fish
1.3.2: Containers and Cooling Gels

1.3.3: Safety, quality and spoilage of fish during transportation
1.3.4: Types of predictive modelling in fish transportation
1.3.5: Food Micromodel
1.4: Post mortem changes in Fish and Safety Hazards

Unit 2: Traditional Fish Processing	**15 Lectures**

*1.1: Indigenous methods of preservation (Drying, Salting, Smoking)
1.2: Simple Vapor Compression System (Refrigerator):
1.3.1: Ideal refrigerant
1.3.2: Types of refrigerants
1.3: Types of freezers, freezing of fin fishes and shell fishes.
1.4: Canning of fin fishes
1.5: Additives in fish processing
1.6: Major equipment used in fish processing industry

Unit 3: Modern Fish Processing	**15 Lectures**

*2.1: Surimi Technology and Surimi based analogue products.
2.2: Thermal Processing of fishery products:
2.2.1: Infra-red (IR) Processing Technology
2.2.2: Radio Frequency Processing Technology
2.2.3: Ohmic Heating Processing Technology
2.3: Non-thermal processing of fishery products:
2.3.1: Pulsed Light Processing Technology
2.3.2: High Pressure Processing Technology
2.3.3: Vacuum cooling
2.3.4: Irradiation
2.4: Modified Atmosphere Packaging

Unit 4: Quality Assurance Norms and methods	**15 Lectures**

3.1: Introduction to Quality Assurance
3.2: Microbiological testing: Standard norms, Biogenic Amines, Rapid Detection Kits
*3.3: Hazard Analysis Critical Control Point (HACCP)
3.4: Checklist for ensuring seafood safety
3.5: Changes that occur during freezing and frozen storage: Microbiological, Physical and Chemical changes, Protein denaturation, Fat oxidation, Dehydration, Drip
3.6: Protective treatments: Polyphosphate, Glazing, Antioxidants, Packaging
*3.7: National and International food laws. Integrated food law (FSSAI, CODEX GMP)

- *Student's activity: Visit to fish processing industry, cold storages, and ice factory to combine experiential learning in laboratory with actual observations on field.*
- *Visit to institutes involved in fish processing: To gain knowledge about potential areas in research, research trends, methodology, instrumentation, facilities in order to inculcate a research-based attitude.*

Topics marked with '*' are to be prepared and presented by the students as a part of internal assessment

Department Specific Elective (Paper 3): Marine Biotechnology, Toxicology and Pathology
Course Code: SIPZOOEL622

Learning Objectives:

- *To keep abreast with the current trends in the fields of Biotechnology, Toxicology and Fish Pathology.*
- *To consider the history, application and, advances in the techniques of Biotechnology in improving fishstock for better yields.*
- *To get acquainted to the principles of toxicology, various toxicants, their movement, and their effects with reference to marine environment.*
- *To familiarize learners with promising Marine Bioactive compounds and their immense potential in variousfields of oceanography in order to encourage a multidisciplinary approach.*
- *To gain in depth knowledge about various finfish diseases and the diagnostic techniques for their detection.*

Unit 1: Marine Biotechnology	**15 Lectures**

1.1: Introduction and History of Marine Biotechnology.
1.2: Applications of Biotechnology in the fields of Aquaculture, Pharmaceutics, Nutraceutics, Bioremediation.
1.3: Cryopreservation of fish gametes and its advances.
1.4: Gene transfer technology in fish: General steps for developing a transgenic fish (e.g., Gene transfer in Common Carp), Identification of transgenic fish and Expression of transgenes.
1.6: Seaweed Biotechnology: Mass production of seaweeds, Tissue culture, Protoplast production in seaweed cells, Cell fusion, Gene Manipulation, and Industrial applications of seaweeds.
1.7: Drugs and Leads from the Ocean through Biotechnology: Marine Environment, a Unique and Prolific Source of Bioactive Natural Products, Approved Marine Drugs as Pharmaceuticals, Marine Natural Products in Advanced Clinical Trials

Unit 2: Marine Toxicology	**15 Lectures**

2.1: Introduction to Toxicology:
- 2.1.1: Brief history, scope, relationship to other sciences
- 2.1.2: Different areas of Toxicology
- 2.1.3: Types of toxicity tests
- 2.1.4: Dose-response relationship

2.2: Introduction to Toxicokinetics - Absorption, Distribution, Excretion of Toxicants
2.3: Sources and movements of toxicants in marine environment.
2.4: Heavy metal toxicity in fishes:
- 2.4.1: Heavy metal bioavailability and bioaccumulation
- 2.4.2: Toxicity of Hg, Cd and Pb
- 2.4.3: Neurotoxic effects of heavy metals
- 2.4.4: Endocrine disruption due to heavy metals toxicity
- 2.4.5: Effects on Locomotory and Respiratory behavior
- 2.4.6: Effects on Reproduction, Fish-larval deformities

2.5: Toxicity caused by Agrochemicals

Unit 3: Fish Pathology	**15 Lectures**

3.1: Introduction to fish pathology
- 4.1.1: Pollutants in the aquatic environment
- 4.1.2: Adverse biological factors for fish health

3.2: Parasitology of the fish: Parasites of the Integument, Eye, Vascular system, Central nervous system, Skeletalsystem, Alimentary canal
3.3: Bacteriology of the fish:
Fish pathogenic bacteria belonging to families: Flavobacteriaceae, Enterobacteriaceae, Vibrionaceae, Aeromonadaceae, Pseudomonadaceae, Streptococcaceae (Isolation, Habitat, Morphology, Culture, Epizootiology, Clinical Pathology,Treatment)
3.4: Mycology of the fish:
Oomycetes (*Saprolegnia sps*., *Aphanomyces sps*., *Brachiomyces sps.*, Chytridiomycetes (Chytridiales) Zygomycetes (Entomophthorales) Deuteromycotina (Aspergillomycosis)

Oceanography and Fishery Science
Semester IV – Practical

Practical I based on Core Course 1 SIPZOOCC621
Course Code: SIPZOOCCP621

1) Study of food and feeding habits in fish
2) Identification of common crafts and gears operated along the Indian shoreline
3) Identification and practicing of various Knots and Hitches used in fisheries.
4) Biometric studies of fish/prawn:
   a) Study of relationship between Total Length and Standard Length/Head Length/Body Depth/Body Weight
   b) Calculate Correlation (Total Length and Standard Length/Head Length/Body Depth/Body Weight)
5) Crustacean fishery:
   a) Shrimps/Prawns: *Penaeus indicus, Metapenaeus monoceros, Parapenaeopsis stylifera, Solenocera indica, Acetes indicus*

b) Lobsters: *Panulirus polyphagus*
c) Crabs: *Scylla serrata, Portunus pelagicus, Portunus sanguinolentus*

6) Molluscan fishery:
   a) Bivalves: *Clams (Meretrix casta, Paphia malabarica), Mussels (Perna viridis, Perna indica), Oysters (Crassostrea madrasensis, Pinctada fucata)*
   b) Gastropods: *Turbinella pyrum (Sacred Chank), Turritella sp., Tibia curta*
   c) Cephalopods: *Loligo duvauceli (Indian Squid), Sepia aculeata (Needle Cuttlefish), Cistopus indicus (Old-Woman Octopus)*
7) Identification and Classification of Marine fish: As per Francis Day's Volume and FAO Identification sheets (Fishing Area 51):

Sr. No.	Fish Nomenclature (As per Francis Day's Volume)	Family (As per Day's Volume)	Fish Nomenclature (As per FAO Fishing area 51)	Family (As per FAO)
A) ELASMOBRANCHS (CARTILAGENOUS FISHES)				
1.	*Carcharias sps*	Carcharidae	*Carcharhinus altimus*	Carcharhinidae
2.	*Zygaena malleus*	Carcharidae	*Sphyrna zygaena*	Sphyrnidae
3.	*Rhynchobatus djeddensis*	Rhinobatidae	*Rhynchobatus djeddensis*	Rhinobatidae
4.	*Trygon uarnak*	Trygonidae	*Himantura uarnak*	Dasyatidae
B) TELEOSTS (BONY FISHES)				
1.	*Lutianus johnii*	Percidae	*Lutjanus johnii*	Lutjanidae
2.	*Therapon theraps*	Percidae	*Terapon theraps*	Teraponidae
3.	*Synagris japonicus*	Percidae	*Nemipterus japonicus*	Nemipteridae
4.	*Gerres filamentosus*	Percidae	*Gerres filamentosus*	Gerreidae
5.	*Scatophagus argus*	Squamipinnes	*Scatophagus argus*	Scatophagidae
6.	*Upenoides vittatus*	Mullidae	*Upeneus vittatus*	Mullidae
7.	*Polynemus tetradactylus*	Polynemidae	*Polynemus tetradactylus*	Polynemidae
8.	*Trichiurus savala*	Trichiuridae	*Lepturacanthus savala*	Trichiuridae
9.	*Clupea longiceps*	Clupeidae	*Sardinella longiceps*	Clupeidae
10.	*Chirocentrus dorab*	Carangidae	*Chirocentrus dorab*	Chirocentridae
11.	*Rastrelliger kanagurta*	Scombridae	*Rastrelliger kanagurta*	Scombridae
12.	*Cybium guttatum*	Scombridae	*Scomberomorus guttatus*	Scombridae
13.	*Harpodon nehereus*	Scopelidae	*Harpodon nehereus*	Harpadontidae
14.	*Saurida tumbil*	Scopelidae	*Saurida tumbil*	Synodontidae
15.	*Cynoglossus elongatus*	Pleuronectidae	Cynoglossidae	*Cynoglossus arel*
16.	*Psettodus erumei*	Pleuronectidae	*Psettodus erumei*	Psettodidae
17.	*Belone stongylurus*	Sombresocidae	*Strongylura strongylura*	Belonidae
18.	*Pampus argenteus*	Stromatidae	*Pampus argenteus*	Stromatidae
19.	*Pampus chinensis*	Stromatidae	*Pampus chinensis*	Stromatidae
20.	*Sphyraena acutipinnis*	Sphyraenidae	*Sphyraena acutipinnis*	Sphyraenidae

Practical II based on Core Course 2 SIPZOOCC622
Course Code: SIPZOOCCP622

1) Organoleptic tests of freshness of fish and fishery products
2) Dressing (Beheading, Peeling and Deveining) of shrimps
3) Fish dressing and filleting
4) Determination of Histamine content from the given fish specimen using Thin Layer Chromatography Technique
5) Identification of various equipment used in fish processing industry
6) Students activity: Preparation of prawn pickle, Preparation of fish burger, Preparation of surimi

Practical III based on Department Specific Elective SIPZOOEL621
Course Code: SIPZOOELP621

1) Detection of Heavy metals: a) Zinc b) Lead c) Copper
2) Identification of Gene transfer techniques in marine biotechnology: Gene transfer by Microinjection, Gene transfer by Electroporation, Gene transfer using Retroviruses, Fish Antifreeze-Protein gene transfer
3) Identification of Fish pathogens
4) Isolation of Bioluminescent Bacteria from the given fish/prawn specimen
5) Determination of LC_{50} and EC_{50} for suitable pollutant using Daphnia/ Chironomus larvae/ Mosquito Larvae
6) Histo-pathological examination of diseased fish specimen.

Practical IV based on Research Project
Course Code: SIPZOORP621

Research Project Component based on Oceanography/Fishery Science/Interdisciplinary topic:

Details of Research project component for Semester IV are as follows:

1) Actual execution/practical work of this project is to be done in Semester IV, inclusive of Diwali vacation/Winter vacation and on weekends/holidays of semester IV.
2) Actual execution may involve laboratory/ table work and or field work and or survey (the approach for the project work can be *in vitro* / *in vivo* / *in silico*, among others) as per the specifications mentioned in their project proposal.
3) The mentor for the respective group will keep a track of the actual execution of the project.
4) After completion of the practical work the student will prepare a '**Dissertation**' which will have copy of the outline/scheme of the proposal, abstract/ synopsis of the research work, introduction, materials and methods, observations, interpretation of results, conclusion and discussion, future plan/extension of work.
5) The student will also give a '**PowerPoint presentation**' for the research project.

Evaluation of the Research Project Proposal during the practical examination for Semester III will be as follows:

1) The examiner will evaluate the **'Dissertation'** for the research project by taking into the account of the evaluation criteria given below:

Title
Abstract/ synopsis
Materials and Methods
Observations
Interpretation of results
Conclusion and Discussion
Relevance of work
Abstract/ synopsis

2) The examiner will evaluate the **'PowerPoint Presentation'** for the research project by taking into the account of the evaluation criteria given below:

Title
Content of the presentation
Quality of the presentation
Presentation skills
Viva/ Question- Answer session

References

Semester III

Course Code: SIPZOOCC611 Principles and Disciplines of Oceanography

1) Sverdrup, H.U., Johnson, M.W. and Fleming, R.H., 1958. The Oceans- their Physics, Chemistryand General Biology, Prentice- Hall Inc. New Jersey.
2) Thurman, H., 2001. Introduction to Oceanography, Prentice Hall Inc. New Jersey.
3) Nair N.B. and Thampi D.H. (1980). A textbook of marine ecology. Macmillan.
4) Siddhartha, K. (2001). Oceanography: A Brief Introduction. Kisalaya Publications.
5) Paul. R. Pinet, 2006. Invitation to Oceanography, 4th Edition. Jones and Bartlett, Sudbury, Massachusetts.
6) Garrison, Tom. Oceanography: An invitation to Marine science. 7th Edition
7) Russel and Young. Seas
8) King, C.A.M. Introduction to Physical and Biological oceanography
9) Sumich, J.L., 1999. Introduction to the Biology of Marine life. Seventh Edition. The Mc Graw Hill Companies Inc.
10) Grasshoff, K., 1999. Methods of Sea water Analysis. Wiley VCH, New York.
11) Michael, P. (1984). Ecological methods for field and laboratory investigations. Tata McGraw-Hill.
12) Tait, R.V. and DeSanto (1972). Elements of Marine Ecology: An Introductory Course. Spinger Veelag.
13) Newell and Newell. Marine plankton
14) Newell, G. E., & Newell, R. C. (1963). Marine plankton: a practical guide (No. 592 NEW).
15) Pillai N. Krishna (1986). Introduction to Planktology. Himalaya Publication house Bombay.
16) Karleskint, George. Introduction to Marine Biology
17) McConnaughey, Bayard H. Introduction to Marine Biology
18) MacDougall and Doug. Endless Novelties of Extraordinary Interest: The Voyage of H.M.S. Challenger and the Birth of Modern Oceanography. Yale University Press 2019
19) Natural History Museum. The Science of the Ocean: The secrets of the seas revealed.

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2) https://www.nio.res.in/
3) https://niot.res.in/
4) https://oceandecade.org/
5) https://www.marinelifeofmumbai.in/
6) https://tos.org/oceanography/

Course Code: SIPZOOCC612 Aquaculture- Methods and Practices

1) Bardach, et. Al. Aquaculture – The Farming and Husbandry of Freshwater and Marine Organisms. John Wiley & Sons, NY, 1972.
2) Bardach, John E. 1997. Sustainable Aquaculture. John Wiley and Sons.
3) Pillay TVR & Kutty M N. 2005. Aquaculture- Principles and Practices. Blackwell.
4) Pillay, T.V.R. & M.A. Dill. Advances in Aquaculture. Fishing News (Books) Ltd. England 1979.
5) Stickney, 2009. Aquaculture: An Introductory Text. CABI.
6) Robert. R. Stickney. Encyclopaedia of Aquaculture. A Wiley-Interscience Publication. John Wiley & Sons, Inc.
7) Jhingran, V.G. Fish and Fisheries of India. Hindustan Publishing Corporation India, 1982.
8) Ayyappan, S., J. K. Jana, A. Gopalakrishnan and A. K. Pandey 2006. Handbook of fisheries and aquaculture. Indian Council of Agricultural Research.
9) Felix, S. Advances in Shrimp aquaculture management. 2013 Daya publishing house® A Divisionof Astral International Pvt. Ltd.
10) Central Institute of Brackish water Aquaculture, Chennai. Indian Council of Agricultural Research. Training manual on Mud crab breeding and culture
11) Food and Agricultural Organization. Mud Crab Culture- A Practical Manual
12) Kurian, C.V. & V.O. Sabastian. Prawn and Prawn Fisheries of India. Hindustan Publ. Corp. India, 1982.
13) Ramakrishna, Anirudha Dey. Handbook on Indian Freshwater Molluscs
14) K.A. Narasimham, V. Kripa. Textbook of Oyster Biology and Culture in India. Indian Council of Agricultural Research, Delhi
15) S.D. Tripathi, W.S. Lakra, N.K. Chadha. Aquaculture in India. Narendra Publishing House
16) R.A. Dunham. Aquaculture and fisheries biotechnology-Genetic approaches. CABI publishing
17) Craig S. Tucker, John A. Hargreaves. Environmental Best Management Practices for Aquaculture. 2008 Blackwell Publishing
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6) https://sciencejournals.stmjournals.in/index.php/RRJoE/article/view/3263
7) https://www.globalseafood.org/advocate/the-fish-farming-industry-of-india/

Course Code: SIPZOOEL611 Marine Biodiversity, Conservation and Management

1) Young J.Z. 1981. The Life of Vertebrates. Oxford University Press, New Delhi, 645pp.
2) Karleskint G., Turner R. and Janes W. Small, Jr. 2013. Introduction to Marine Biology. Brooks/Cole, Cengage Learning, Canada. 563pp.
3) Perrin W., Würsig B. and Thewissen J.G.M. (Eds.) 2017. Encyclopedia of Marine Mammals. Academic Press Imprint.1352 pp.
4) Berta A., Sumich J.L. and Kovacs K.M. 2015. Marine Mammals Evolutionary Biology. ElsevierInc. 726 pp.
5) Ghosh, A.K., Alfred, JRB and Jonathan, J.K. 1999. Manual Environmental Impact Assessment. Zoological Survey of India, Calcutta. 335pp.
6) Environmental guidelines for Ports and Harbour Projects - 1998. Ministry of Environment and Forest, Govt. India
7) Primack, R.B., 2004. A Primer of Conservation Biology, Sinaur Asso. Inc. Publ.
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9) Norse, E.A., 1993. Global Marine Biological Diversity; Island Press.
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14) Venkataraman, K., Satyanarayana, Ch., Alfred, J.R.B. and Wolstenholme, J. 2003. Handbook on Hard Corals of India. Zoological Survey of India, Kolkata, India.
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16) Roonwal, G.D. (Ed.) 1986. The Indian Ocean exploited mineral and petroleum resources, Springer Verlag, Berlin.
17) Juda, L., 1998. International Law and Ocean Use Management: The Evolution of Ocean Governance. Routl

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5) https://ntca.gov.in/assets/uploads/Reports/Others/Wildlife_Action_Plan_2017_31.pdf
6) https://cmlre.gov.in/research-programs/marine-biodiversity-and-ecology-0
7) https://www.iucnredlist.org/en

Course Code: SIPZOORP611 & SIPZOORP621 Research Project

1) Creswell, John W. Research Design: Qualitative, Quantitative, and mixed methods approach
2) Hammond, Michael. Writing a postgraduate thesis or dissertation: Tools for success
3) Booth, Wayne C. & others. The Craft of Research
4) Turabian, Kate L. A manual for Writers of Research papers, Theses and Dissertations: Chicago style for Students and Researchers
5) Passer, Michael W. Research Methods: Concepts and Connections
6) Tan, Willie. Research Methods: A Practical Guide for Students and Researchers
7) Waliman, Nicholas. Research Methods: The Basics

Semester IV

Course Code: SIPZOOCC621 Marine Fisheries

1) Jhingran, V.G. Fish and Fisheries of India. Hindustan Publishing Co., 1975.
2) A Textbook of Fishery Science and Indian fisheries, Srivastava C.B.L.
3) Khanna, S.S. & H.R. Singh 2006. A Textbook of Fish Biology and Fisheries. Narendra Publ. Hse.,India
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Course Code: SIPZOOCC622 Fish Processing Technology

1) Govindan, T. K. Fish Processing Technology
2) Food and Agricultural Organization. Fish handling, Quality, and processing: training and community trainers manual
3) G.M. Hall. Fish Processing Technology. Blackie Academic and Professional, London
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8) H. Allan Bremner. Safety and quality issues in fish processing. © 2002, Woodhead Publishing Limited
9) J.B. Luten, C. Jacobsen, K. Bekaert. Seafood research from fish to dish. © Wageningen Academic Publishers The Netherlands, 2006
Fishes by M Chandy, National Book Trust India.
10) Codex Alimentarius. Organically Produced Foods, Third edition. World Health Organization. Food and Agricultural Organization of United Nations.

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1) https://www.foodprocessingindia.gov.in/sectors/Fisheries
2) https://fssai.gov.in/

Course Code: SIPZOOEL621 Marine Biotechnology, Toxicology and Pathology

1) Clark, R.B 1992. Marine pollution. Third edition Clavendron, Press Oxford.
2) Williams, 1996. Introduction to Marine Pollution Control. John Wiley.
3) Johnston, R., (Ed.), 1976. Marine Pollution, Academic Press, London.
4) Kennish, M.J., 1994. Practical handbook on estuarine and marine pollution. Elsevier.
5) Y. Le Gal and H. O. Halvorson (Eds). 1997. New Developments in Marine Biotechnology, PlenumPub. Corp.
6) Steven M. Colegate and Russel J. Molyneux. 2008. Bioactive Natural Products (II Ed.). CRCPress.
7) Scheper T. (Ed.). 2005. Marine Biotechnology (Vol. I), Springer (Germany).
8) Scheper T. (Ed.). 2005. Marine Biotechnology (Vol. II), Springer (Germany)

Scheme of Examination

The performance of learners will be evaluated in two parts for the Theory component of the Course:

1. Internal Assessment
2. Semester End Examination (written)

The Practical component of the Course will be evaluated by conducting Semester End Practical Examination.

Internal Assessment

It is the assessment of learners on the basis of continuous evaluation as envisaged in the Choice Based Credit System (CBCS) by way of participation of learners in various academic and correlated activities in the given semester of the program.

For Core Course (CC) 1 and 2:
Total marks: 40
Seminar Marks: 20
Evaluation will be conducted on the basis of Seminar/ Presentation given by the student on a topic chosen from the syllabus for each paper. The marking scheme shall be:

- Content of Presentation: **05 marks**
- Quality of Presentation: **05 marks**
- Presentation skills: **05 marks**
- Question-Answer discussion: **05 marks**

Assignment Marks: 20
Evaluation will be conducted on the basis of Research paper review / Book review / Poster presentation / Abstract writing / Preparation of Standard Operating Procedure or Calibration of Instruments / Role play or Skit on topic relevant to the paper / Report on Industry or Field Visit or Writing an article relevant to the paper etc.

For Department Specific Elective (DSE):
Total marks: 25
Assignment marks: 25
Evaluation will be conducted on the basis of Research paper review / Book review / Poster presentation / Abstract writing / Preparation of Standard Operating Procedure or Calibration of Instruments / Role play or Skit on topic relevant to the paper / Report on Industry or Field Visit or Writing an article relevant to the paper etc.

For Research Project (RP):
Total marks: 50
A continuous evaluation based on the performance will be conducted throughout the semester which will consist of punctuality, regular reporting to the concerned faculty about the progress, literature review for drafting the research proposal etc. (Semester III)
A continuous evaluation based on the performance will be conducted throughout the semester which will consist of punctuality, regular reporting to the concerned faculty about the progress, literature review and all the other activities related to the research project. (Semester IV)

Semester End Assessment Theory

For Core Course 1 and 2:
Marks: 60
Duration: 2.5 hours
Theory question paper pattern:

- There shall be five questions of 12 marks each. On each unit there will be one question and the 5th question will be based on the entire paper.

OR

- There shall be four questions of 15 marks each, each question based on one unit.

- All questions are compulsory with internal choice within the questions.
- Questions may be subdivided and the allocation of marks depends on the weight age of the topic and by considering the Blooms Taxonomy for evaluation.

For Department Specific Elective (DSE):
Marks: 50
Duration: 2 hours
Theory question paper pattern:

- There shall be three questions of 12 marks each, each question on one unit.
- All questions are compulsory with internal choice within the questions.
- The 4^{th} question will be based on the entire paper with internal choice within the questions.

For Research Project (RP): NO THEORY EXAM