AC –07/07/2023
Item No. – 6.25 (N)

As Per NEP 2020

University of Mumbai

Title of the program

A- P.G. Diploma in Oceanography and Fishery Technology)
B- M.Sc. (Zoology- Oceanography and Fishery Technology) } 2023-24
C- M.Sc. (Zoology- Oceanography and Fishery Technology) **2027-28**

Syllabus for

Semester – Sem I & II

Ref: GR dated 16th May 2023 for Credit Structure of PG

PREAMBLE

1) Introduction:

- The existing syllabus is re-constructed following the intent and objectives of the National Education Policy (NEP) 2020 and the National Credit Framework (NCrF).
- The syllabus has total of 44 credits (22 credits in semester I) and (22 credits in semester II) covering classroom teaching, practicum and field study.
- Each semester, the courses (PSZO105M1 & PSZO105M2 for Semester I and PSZO202M1 & PSZO205M2 for Semester II) have been designated as Mandatory Courses which are subject-specific, for the students of zoology department only with specialization of Oceanography.
- PSZO105M1 and PSZO205M1 are generic and hence will be chosen by postgraduate students of other unrelated discipline/subject departments while PSZO105M2 and PSZO205M2 are generic and will be opted by postgraduate students ofother unrelated discipline/subject departments.

- In addition to core courses (Major & Minor), Research Methodology (RM) course (PSZO106) and On Job Training (OJT)/FieldProjects (FP) (PSZO206) have been included in Semester I and Semester II respectively
- OJT/FP has been kept open and will be decided by the institutions/colleges in their capacity and infrastructures/resources available. For internship/apprenticeship/fieldwork, the credit weightage for equivalent hours will be 50% of that for lectures/tutorials.

2) Aims and Objectives:

- The primary aim of present syllabus is to equip the learners with recent advances in the field of Zoology and allied branches.
- To encourage and empower the learners to understand the challenges of the society and the country that falls into the realms of Zoology, such as Non-Chordates, Chordates, Developmental Biology, Genetics andEvolution, Biochemistry and Biotechnology, Research Methodology, etc.
- The courses incorporated in present syllabus are appropriate to inculcate the research aptitude and skills in the learners that are required to carry out research projects in the field of Zoology.
- On-Job Training/Field Project kept in second semester will bridge the gap between academia and industry. Besides, the present syllabus will also ignite the inquisitive minds of the learners.

3) Learning Outcomes:

The learners will be able to -

i) incorporate critical thinking into their study to carry out scientific investigation objectively.
ii) differentiate anatomy and physiology of different systems/organs of animals.
iii) understand genetic analysis, gene, and genome, complex networking of genes in biological systems, altruism, racial distribution, and application of evolutionary principles.
iv) comprehend the concept of environmental impact assessment.
v) understand processes and techniques used in development of biotechnology products.
vi) again the knowledge about the special techniques developed for studying animal models.
vii) equip with skillsto analyze problems, formulate a hypothesis, evaluate and validate results, and draw reasonable conclusions thereof.
viii) prepare for pursuing research or careers in industry inarea of animal sciences.
ix) prepare themselves for teaching in Schools, Colleges and Universities.
x) continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of issues in animal sciences.
xi)become an enlightened citizen with commitment to deliver one's responsibilities to the society and the country at large.

4) Credit Structure of the Program (Sem I, II, III & IV) (Table as per Parishisht 1 with signature of HOD and Dean)

R:_____

Post Graduate Programs in University **Parishisht: 1**

Year	Level	Semester			Hours
1st Year	6.0	**Semester I (Mandatory)**			
		Course Code	**Title**	**Credits**	
		PSZO101	Basics of Oceanography	4	60
		PSZO102	Fish Processing Technology	4	60
		PSZOPM1	Lab Exercises based on PSZO101	4	60
		PSZOPM1	Lab Exercises based on PSZO102	2	60
		Semester I (Elective)			
		PSZO103	Non-Chordates	4	45
		PSZOPE1	Lab Exercises based on PSZO103		15
		PSZO106RM	Research Methodology	4	60
		Total Credits		**22**	**360**
		Semester II (Mandatory)			
		PSZO201	Freshwater Aquaculture	4	60
		PSZO202	Fin Fish and Shell Fish Biology	4	60
		PSZOPM2	Lab Exercises based on PSZO201	4	60
		PSZOPM2	Lab Exercises based on PSZO202	2	60
		Semester II (Elective)			
		PSZO203	Chordates	4	45
		PSZOPE2	Lab Exercises based on PSZO203		15
		PSZO206 OJT/FP	Open	4	60
		Total Credits		**22**	**360**
Total Credits (Both Semesters)				**44**	**720**

OJT/FP has been kept open and will be decided by the institutions/colleges in theircapacity and infrastructures/resources available.

SEMESTER I

PAPER 1: PSZO101 BASICS OF OCEANOGRAPHY (4 CREDITS)

(15 Hr)

Objectives & Course outcomes:

To familiarize learners to the background of Oceanography and the recent developments in the field of Oceanography.

To impart the knowledge about the fundamental terminologies and the instrumentation in the Oceanography.

The learner will be able to understand the fundamentals of Oceanography and the current trends in the field.

The learner will gain the knowledge about various sampling devices and techniques in the Oceanography.

To acquaint the learners to the physical properties of Ocean water, ocean dynamics and the Ocean- Atmospheric coupled processes.

The learner will be able to comprehend the physical processes occurring in the ocean, their dynamics and their effects at local and global scenario.

To acquaint the learners about the elemental composition of the sea water and fundamentals of Ocean chemistry.

To educate the learners about the marine flora and fauna, their ecology, their significance and sustainable conservation.

To introduce the concept of marine pollution and its impact on marine environment.

The learner will gain the knowledge about the life under the sea and their interactions with marine environment.

The learner will acquire the knowledge about the marine pollution and related aspects

Unit 1: General Oceanography

History of Oceanography, Oceanographic Expeditions in Indian Ocean Region: IIOE, MONEX, JGOFS, WOCE, Ocean Climatology: ENSO, Impact of climate change on marine life Oceanographic Research Vessel, laboratories and equipment, Satellite Oceanography: Remote Sensing and their applications

Ocean bottom features ,Continental shelf ,Continental slope ,Submarine canyons ,Submarine mountain ranges ,Sea mounts and Guyots,Oceanic ridges ,Oceanic trenches ,Abyssal floor, Oceanographic Instruments ,Grabs (Peterson's and Van Veen) for benthos collection ,Naturalist's dredge ,Trawl – Beam trawl, Otter trawl ,Plankton nets and Continuous plankton sampling system ,Niskin Sampler , CTD Profiler, Stempel's pipette and Dilution jar , Underwater photography equipment,SCUBA apparatus, Secchi disk.

Unit 2: Physical Oceanography (15 Hr)

Sea water , Physical properties of Sea Water – Temperature, Salinity, Density and their distribution, Acoustical and Optical characteristics of Sea water , Waves and Tides,General aspects of Ocean waves, wave characteristics, sea swells, deep and shallow water waves, storm, surges and Tsunami,Tides and tide generating forces, their causes, variation and types, Tidal currents , Ocean Circulation ,Ekman spiral, Geotropic current, Westward intensification with dynamic topography ,Wind induced circulation, Thermohaline circulation and upwelling of water ,Types of currents, major currents of the world, Coriolis effect .

Unit 3: Chemical Oceanography (15 Hr)

Major and minor elements in seawater ,Chlorinity and Salinity: definition and significance, practical salinity scale ,Radioactive nuclides in the sea,Major Nutrients and their role in marine environment (Nitrates, Phosphates and Silicates) ,Dissolved Oxygen in seawater – Basic concepts: solubility of oxygen in seawater and Oxygen Minimum Zone (OMZ) ,Air – sea gaseous exchange and processes affecting their distribution ,Dissolved Inorganic and Organic Carbon in seawater and Ocean Acidification,Carbon dioxide equilibria in seawater, pH, alkalinity and buffering capacity of ocean,Calcium carbonate precipitation and dissolution phenomena ,Lysocline and carbonate compensation depth , Mineral resources from the sea, Deep sea mud oozes and Manganese Nodules, Oil, gases and sulphur deposits

Unit 4: Biological Oceanography (15 Hr)

. Division of marine environment,4.1.1 Intertidal organisms and their zonation,4.1.2 Marine biotic diversity: Plankton ;Nekton ;Benthos,4.1.3 Indices of species richness, measuring diversity, models explaining diversity gradient ,4.1.4 Benthic communities(Kelp forests ,Estuaries) Formation and Growth of Coral Reefs , Ecological Features of Mangrove Swamps

Deep Sea Ecology ,Faunal composition, Species diversity, Food sources, Rates of Biological Processes, Whale Fall Ecosystem ,Hydrothermal Vents and Cold seeps(Chemosynthetic production ,Vent Fauna ,Shallow Vents and Cold seeps ,Unique Environmental Features of Sulphide communities , Human impact on marine Biota ,Fisheries Impact ,Marine Pollutants(Petroleum Hydrocarbons ,Plastics ,Heavy Metals ,Sewage,Radioactive Waste ,Thermal Effluents ,Noise; Impact on marine environments(Estuaries ,Mangrove Swamps & Coral Reefs)

PAPER II: PSZO102 FISH PROCESSING TECHNOLOGY (4 CREDITS)

(15 Hr)

Objectives & Desired Outcome:

To impart knowledge and skill of handling of fish in hygienic conditions at various levels as well as personnel hygiene.
To assess the freshness of fish.
To gain knowledge of site selection, building construction and layout of different processing units.
The learner will be able to handle the fish hygienically after sorting the fresh fish.
To gain knowledge of site selection, building construction and layout of different processing units.
To get acquainted with different methods and materials required in traditional fish processing.
The learner will understand packaging materials, compression system, refrigerants, freezers, freezing, canning of fish with additional knowledge of additives and instrumentation used in fish processing industry.

To give in depth knowledge of recent methods in fish processing
The learner will gain insight of recent methods in fish processing industry
To give in depth knowledge of recent methods in quality control and their norms.
The learner will gain insight of recent methods in quality control and their norms.

Unit 1: Hygienic Handling of Fish

Methods of handling of fish ,Hygienic conditions required on board, landing centres and processing industry ,Methods of transportation (conventional and recent) of fish to processing industry,Organoleptic tests , Temperature modelling and relationships in fish transportation 1.6 Typical layout for freezing industry, ice factory and canning industry , Site Selection, Location ,Site Level ,Communications ,Site size , Building specifications,General introduction ,Doors and windows ,Lighting ;Ventilation ,Drains ,Power supply ,Water supply ,Factory yards

Unit 2: Traditional Fish Processing (15 Hr)

Indigenous methods of preservation, Simple Vapour Compression System (Refrigerator), Ideal refrigerant, Types of refrigerants ,Types of freezers, freezing of fin fishes and shell fishes ,Accessory industry for canning, canning of fin fishes, shell fishes and cephalopods, Additives in fish processing , Major equipment used in fish processing industry and its maintenance

Unit 3: Modern Fish Processing (15 Hr)

Surimi technology and surimi based analogue products (only technology aspect) ,Thermal processing of fishery products ,Thermal processing ,Pulsed light technology,Infra-red (IR) and Radio frequency (RF) processing technology and its applications ,Ohmic or Joule heating ,Non-thermal processing of fishery products, High pressure processing ,Vacuum cooling ,Irradiation

Unit 4: Quality Assurance Norms and Methods (15 Hr)

Introduction to Quality Assurance ,Microbiological testing,Standard norms ,Biogenic amines ,Rapid detection kits ,Hazard Analysis Critical Control Point (HACCP) ,Check list for ensuing sea food safety ,Changes that occur during freezing and frozen storage, and Protective treatments, Changes(Microbiological ,Physical and chemical changes ,Protein denaturation ,Fat oxidation ,Dehydration , Drip), Protective treatments(Polyphosphate ,Glazing ,Antioxidants ,Packaging ,ISO-9000 series certification of the International Standard Organization ,National and International food laws, integrated food law (FSSAI, CODEX GMP) ,Harbour management ,Fish Toxins – Intrinsic and extrinsic factors for toxicity of fish

PRACTICAL
BASICS OF OCEANOGRAPHY (2 CREDITS)

1. Study of Oceanographic Instruments.

a) Niskin sampler
b) CTD Profiler
c) Bucket Thermometer
d) Ekman's Current Meter
e) Secchi disc
f) Plankton nets:
i. Standard net ii. Hensen net iii. Clarke Bumpus net
g) Stemple pipette and counting slides
h) Nekton sampling device:
i. Beam trawl
ii. Otter trawl
i) Benthic sampling devices:
i. Naturalist dredge ii. Scallop dredge iii. Petersen's grab
iv. Van Veen grab
v. Ekman grab and Corers

2. Physical and chemical oceanography: Determination of physico-chemical parameters: a) Salinity (Argentometric method)

b) Silicates

3. Estimation of primary productivity by light and dark bottle.
4. Identification of Zooplankton permanent slides: *Noctiluca*, *Obelia* medusa, Jelly fish, *Physalia*, *Porpita*, Zoea, Copepods, Mysids, Megalopa, Bipinnaria, Nauplius, Pteropods, *Sagitta, Doliolum, Oikopleura*, Fish eggs and larvae
5. Laboratory procedure for quantitative estimation of plankton settling method, wet weight method,weight displacement method, counting method.
6. Identification of intertidal organisms:

a) Rocky shore: *Patella*, *Chiton*, *Perna viridis*, *Cardium*, *Balanus*, Gorgonids, *Littorina* and Corals (*Acropora*, *Meandrina*, *Astraea* / Star coral)
b) Sandy shore: *Solen, Umbonium, Oliva,* Fiddler crab, Star fish, *Balanoglossus*
c) Muddy shore: *Lingula, Chaetopterus, Arenicola,* Mud skipper

7. Preparation of marine algae herbarium.
8. Students Activity: Observation of Molluscan shells and Marine algae during field visit and submission of a report.
9. Visit to Institutes involved in Marine Biology or Oceanography Research.

PRACTICAL
FISH PROCESSING TECHNOLOGY (2 CREDITS)

1. Organoleptic tests: freshness of fish and fishery products.
2. Organoleptic tests: freshness of prawn.
3. Dressing (Beheading, Peeling and Deveining) and grading of shrimps.
4. Preparation of Prawn pickle
5. Fish dressing and filleting.
6. Preparation of Fish fingers.
7. Estimation of moisture content in fish and shrimp muscle.
8. Sketching of layout of ice factory, cold storage, freezing and canning industry.
9. Identification of various equipment (Photographs)

a) Thermal processing
b) Pulsed light technology
c) Infra-red (IR) and Radio frequency (RF) processing
d) Ohmic or Joule heating
e) High pressure processing
f) Vacuum cooling
g) Irradiation

10. Preparation of proposal for fish processing industry.
11. Visit to fish processing industry, fish landing centres, cold storages and ice plants etc.

M. Sc. PART I SEMESTER I (ELECTIVE) PSZO103: NON-CHORDATES (3 CREDITS)	
Unit 1: Digestion and Excretion	**(15 Hr)**
Objectives:	*To understand functional anatomy, differences and similarities ofdigestive and excretory systems of non-chordates.*
Desired Outcome:	*The learner will be able to differentiate anatomical and physiological modifications of digestive and excretory systems of non-chordates like Protostomes and Deuterostomes.*
1.1 General organization of digestive systems of Protostomes (Annelids, Arthropods and Molluscs) and Deuterostomes (Echinoderms and Hemichordates)	
1.2 Digestive Systems with Special emphasis on the organs or glands of:	
1.2.1 Annelids	Clamworm – Denticles or Paragnaths, Jaws
1.2.2 Arthropods	Prawn: Buccal cavity, Cardiac and Pyloric stomach,Hepatopancreas
1.2.3 Molluscs	*Pila*: Odontophore, Sub-radular organ, Radula, Oesophageal pouches, Cardiac and Pyloric chambers, Salivary gland, Hepatopancreas
1.2.4 Echinoderms	Sea Star: Cardiac and Pyloric stomach, Intestinal Caeca, Digestive glands
1.2.5 Hemichordates	*Balanoglossus*: Buccal Diverticulum, Digestive Pharynx, Post-branchial canal, Hepatic and post-hepatic regions
1.3 General organization of excretory systems of Protostomes (Annelids, Arthropods and Molluscs) and Deuterostomes (Echinoderms and Hemichordates)	
1.4 Excretory Systems with Special emphasis on the organs/structures or glands of:	
1.4.1 Annelids	Clamworm: Coiled Nephridia
1.4.2 Arthropods	Prawn: Antennal glands or Green glands or Maxillary glands,Bladder, Renal sac
1.4.3 Molluscs	*Pila*: Organ of Bojanus, anterior Renal chamber, posterior Renal chamber
1.4.4 Echinoderms	Sea Star: Water Vascular System, Coelomocytes, Intestinalcaeca
1.4.5 Hemichordates	*Balanoglossus*: Glomerulus or Proboscis gland
Unit 2: Respiration and Circulation	**(15 Hr)**
Objectives:	● *To understand anatomical differences and similarities of respiratory and circulatory systems in non-chordates.* ● *To understand physiological processes in non-chordates.*
Desired Outcome:	*The learner will be able to differentiate anatomical and physiological modification in respiratory and circulatory systems of non-chordateslike Protostomes and Deuterostomes.*
2.1 General organization of respiratory systems of Protostomes (Annelids, Arthropods and Molluscs) and Deuterostomes (Echinoderms and Hemichordates)	
2.2 Respiratory Systems with Special emphasis on the organs/structures or glands of:	
2.2.1 Annelids	Clamworm: Parapodia, Body wall
2.2.2 Arthropods	Prawn: Branchiostegites, Branchiae, Epipodite
2.2.3 Molluscs	*Pila*: Ctenidium, Pulmonary sac
2.2.4 Echinoderms	Sea Star: Dermal papulae, Tube Feet
2.2.5 Hemichordates	*Balanoglossus*: Gill slits, Branchial sac, Gill pores
2.3 General organization of circulatory systems of Protostomes (Annelids, Arthropods and Molluscs) and Deuterostomes (Echinoderms and Hemichordates)	
2.4 Circulatory systems with special emphasis on the organs/ structures or glands of:	
2.4.1 Annelids	Clamworm: Dorsal blood vessel, Ventral blood vessel,Transverse vessels
2.4.2 Arthropods	Prawn: Heart and Blood lacunae

PSZOP104: LAB EXERCISES BASED ON PSZO101, PSZO102 AND PSZO 103 (60 Hr)

1. Study of digestive, excretory and reproductive systems of Clamworm, Prawn, *Pila,* Sea Star, *Balanoglossus*.

2. Study of Fossils of *Serpula* sp., *Glomerula* sp, Trilobites, Insects trapped in amber,*Palmerella kutchensis, Cimomia forbesi*, Lamellidens, *Gongrochanus spp., Goniocidaris,* Graptolite fossils

3. Construction of phylogenetic tree based on:

a) Nucleotide sequences.
b) Morphological characters based phylogenetic tree.

4. To culture and observe: *Drosophila* to study its life cycle.

5. To culture and observe: *Tribolium or Sitophilus* to study its life cycle.

6. To study the imaginal discs of *Drosophila* through temporary mounting.

7. To study germ layers using permanent slides:
- T.S. of body wall of Sponge and Cnidaria (Coelenterata)
- T.S. of body wall of Platyhelminthes
- T.S. of body wall of *Ascaris*
- T. S. of body wall of Earthworm

8. To study larvae of non-chordates:
- Porifera – Amhiblastula
- Cnidaria (Coelenterata) – Planula
- Annelida and Molluscs– Trochophore
- Mollusca – Glochidium
  - Crustacea -
  - Nauplius
  - Zoea
  - Mysis
  - Megalopa
- Echinodermata -
  - Auricularia
  - Echiopluteus
- Hemichordata– Tornaria

PSZO106RM: RESEARCH METHODOLOGY (4 CREDITS)

Unit 1: Principles of Scientific Research (15 Hr)

Objectives:	• *To acquaint learners with the principles of scientific research andmethods of conducting scientific enquiry.* • *To inculcate scientific temperament and research aptitude amongthe learners.*
Desired Outcomes:	• *Learner will be able to formulate research problem and conceptresearch design.* • *Learner will be able to execute the research problem.*

1.1 Basic Concepts in Research

1.1.1 Definition

1.1.2 Characteristics of research (controlled, rigorous, systematic, valid and verifiable,

empirical and critical)

1.1.3 Objectives of research

1.1.4 Types of research:

a) Pure and applied	
b) Structured and unstructured	
c) Descriptive, correlational, explanatory, exploratory, historical, comparative and experimental	
1.2 Formulating a Research Problem	
1.2.1 Reviewing literature: Using library, computerized searches, evaluating literature	
1.2.2 Developing a research problem: Importance, sources, considerations, steps,	
defining a problem, formulate objectives	
1.2.3 Identifying variables: Introduction, types of variables, measurement scales	
1.2.4 Hypothesis: Definition, function, characteristics, types (H0, HA), Principles of hypothesis, framing hypothesis, errors in hypothesis, research question versus research hypothesis,hypothesis versus non-hypothesis research	
1.3 Research Design	
1.3.1 Definition and purpose	
1.3.2 Characteristics of good research design	
1.3.3 Sampling strategy and sampling size determination, eliminating extraneous variables	
1.3.4 Types of study design: study designs in quantitative research (cross-sectional, before and after, longitudinal, retrospective, prospective, retrospective-prospective, experimental, non-experimental, quasi-experimental)	
Unit 2: Data Management and Analysis (15 Hr)	
Objectives:	• *To introduce learners to various statistical tools for analysis ofresearch data.* • *To familiarize learners with the in-silico approach for datamanagement.*
Desired Outcome:	• *The learner will be able to develop skill set for organization andeffective presentation of data.* • *The learner will be able to choose correct statistical test.* • *The learner will be able to perform statistical analysis indifferent fields of research using various computer programs.*
2.1 Methods of Data Collection	
2.1.1 Primary sources	
2.1.2 Secondary sources	
2.2 Data Classification and Presentation	
2.2.1 Classification of data (Geographical, Chronological, Qualitative, Quantitative)	
2.2.2 Tabulation of data (one-way table, two-way table, complex table)	
2.2.3 Type of charts (Line, Column, Scatter plot, Box plot, Heat Map)	
2.3 Concepts of Measurements	
2.3.1 Univariate (standard deviation, variance, quartiles)	
2.3.2 Bivariate (correlation and regression)	
2.3.3 Multivariate (ANOVA: one-way, two-way)	
2.3.4 Level of significance and p-value	
2.3.5 Normal distribution, Skewness, Kurtosis, Outliers	
2.4 Testing of Hypothesis	
2.4.1 Null hypothesis, Alternative hypothesis	
2.4.2 Type 1 and Type 2 Errors	
2.4.3 Testing of Hypothesis (single population mean, two population means)	
2.4.4 One-tailed and Two-tailed tests	
2.5 Parametric and Non-parametric Tests	
2.5.1 Parametric tests: t test, z test, F test	
2.5.2 Non-parametric tests: Chi-square test, Mann-Whitney test, Kruskal-Wallis test, FriedmanTest, Wilcoxon signed-rank test	

Unit 3: Scientific Communication	**(15 Hr)**
Objectives:	● *To enable learners to develop skills for effective research communication.* ● *To enable learners to publish research paper in journals withgood impact factors.*
Desired Outcome:	*The learner will be able to get an insight of scientific communication documentation and will become familiar with good scientific journals.*
3.1 Research Planning	
3.1.1 Project Proposal and research funding agencies – Research grants, scholarships and funding (CSIR, DBT, DST, DST- INSPIRE Fellowship, ICMR, INSA, BRNS, MoEFCC, UGC- RFSMS, Fulbright Fellowships for Indian students, Lady Tata Memorial Trust, EPA, Bill and Melinda Gates Foundation, Wellcome Trust, Erasmus Mundus)	
3.1.2 Use of reference management software (MS Word / Zotero / Mendeley)	
3.1.3 Scientific writing –Thesis and Dissertation	
3.2 Documentation for approval from Institutional Animal Ethics Committee (IAEC) and Institutional Biosafety Committee (IBSC):	
3.2.1 Documents for registration, renewal and reconstitution of IAEC as per CPCSEA	
guidelines	
3.2.2 Proposal layout for permission from IAEC for use of animals in research	
3.2.3 Proposal layout based on recombinant DNA safety guidelines from IBSC	
3.2.4 Proposal layout for use of transgenic animals in research	
3.3 Publications and Research Journals	
3.3.1 Types of research journals	
3.3.2 Impact factors of Journals	
3.3.3 Predatory Journals	
3.3.4 Review process - benefits and drawbacks of single blind, double blind and open peerreview process	
3.3.5 Understanding "h – index" and "i10 – index"	
3.3.6 SCOPUS, Google Scholar, Web of Science	
3.3.7 Process to obtain ISSN and ISBN	
Unit 4: Model Organisms and their Applications	**(15 Hr)**
Objectives:	● *To introduce to learners the key species which are used as modelorganisms in research.* ● *To acquaint the learners with special techniques developed forstudying these model organisms.*
	● *To make them aware of the contributions of model organisms to basic biology, genetics, development and diseases.*
Desired Outcome:	● *The learners will be able to understand the special features of different animals that have made them useful as a model system.* ● *The learners will become familiar with the specific applications of model organisms for various biological processes.* ● *The learners will be able to appreciate how experimentation withthese organisms has enhanced the understanding of the basis ofhuman diseases.*
4.1 Introduction: Concept, key features and importance of model organisms	
4.2 Earthworm	
4.2.1 Biology and genome	
4.2.2 Model for studies on regeneration	
4.3 *Caenorhabditis elegans*	

4.3.1 Body plan of the worm, genetics, genome, cultivation, advantages and limitations
4.3.2 Techniques used for genetic modification, Mutant characterization, discovery of RNAi
4.4 *Daphnia* sp.
4.4.1 Genome, epigenetics, phenotypic variation
4.4.2 Advantages and limitations
4.4.3 Model for studies in toxicology
4.5 *Drosophila melanogaster*
4.5.1 Genome, advantages and limitations
4.5.2 Model for cytogenetics, development, neuroscience, human diseases and
therapeutic drug discovery
4.6 *Danio rerio* (Zebra fish)
4.6.1 Genome, advantages and limitations
4.6.2 Insights on embryology, ageing and toxicology
4.7 *Mus musculus* (Mouse)
4.7.1 Genomics, advantages and limitations
4.7.2 Model for studies on physiology, development, ageing, human diseases (Cancer andDiabetes) and behavior research
4.7.3 Transgenic and germ line transgenic mouse models, genetically engineered mouse
models (GEMMs): Knock-In and Knock-out mouse models

SEMESTER II

PAPER I: PSZOO201 FRESHWATERAQUACULTURE (4 CREDITS)

Unit 1: Principles of Aquaculture (15 Hr)

Objectives& Course outcome

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

To focus on provision of basic concepts of farming of aquatic organisms.

To educates students to learn different methods of culture.

The learner will acquire knowledge regarding advanced technologies in aquaculture.

Basics of aquaculture – definition and scope,Systems of aquaculture,Pond culture,Pen culture,Cage culture,Rope culture,Running water culture,Zero water exchange system,Re-circulatory aquaculture system (RAS),Biofloc Technology,Physical, chemical and biological factors affecting productivity of ponds,Criteria for selection of candidate species for aquaculture,Major fin fish candidate species for fresh water aquaculture such as(Indian major carps – Rohu, Catla, Mrigal,Exotic carps – Grass carp, Common carp, Silver carp, Catfishes – Basa, Mangur), Monoculture, polyculture, composite culture and integrated culture systems,Rearing Practices and its feasibility/economics,Traditional,Extensive,Semi intensive,Intensive methods,Sustainable Aquaculture

Unit 2: Aquarium Fishes and Management (15 Hr)

Identification, breeding and maintenance of important ornamental fishes (Angel,Danio,Discus,Flower horn,Gourami,Siamese fighter,Sword tail,Gold fish,Koi),Setting and design of freshwater aquarium, aeration devices, aeration accessories,various types of filters,Aquatic plants and other structures for beautification and utility,Amazon sword,Cork screw, Ludwigia,Aqua rose,Cobamba,Pistia,Formulated feed, its composition and its production.

Unit 3: Brooder and Sexual dimorphism in Major carps (15 Hr)

Induced Breeding

History of induced breeding of fishes
Methods of pituitary extract preparation
Dosage determination and injection to the brood fishes
Spawning and hatching
Use of different synthetic hormones and analogues for induced spawning.
Induced breeding in Indian Carps – Catla, Labeo, Mrigal
Induced breeding in Exotic Carps – Common Carp, Silver Carp, Grass Carps

Hatchery design and operation

Criteria for site selection of hatchery
Design and function of incubators
Essential components of hatchery, Role of hatchery
Management of hatchery
Traditional double-walled hapa, Floating hapa

Types of hatchery

a. Vertical hatchery – Glass jar hatchery,
b. Plastic Bucket hatchery
c. Chinese hatchery
d. Circular hatchery – CIEF D 80 Model and CIEF 81 Model

Mahaseer and Trout hatchery

Nursery Pond Management

Pre-stocking pond management

Stocking pond management

Post stocking management

Packaging and Transport.

Quality of container used in packaging and transporting the fish seed

Transport containers for fish and fingerlings

Packing and transportation of fish seed

Use of anaesthetics and disinfectants in fish breeding and transport

Unit 4: Giant Freshwater Prawn: *Macrobrachium rosenbergii* (15 Hr)

Identification, sexual dimorphism, selection of brooder

Breeding and hatchery management

Life cycle

Rearing of Fresh water Giant Prawn

PAPER 2: 202 FIN FISH AND SHELL FISH BIOLOGY (4 CREDITS)

Unit 1: Morphology of Fin Fish and Shell Fish (15 Hr)

Fin fish morphology: skin, colour, eyes, mouth structure, jaws and teeth, fins, fin rays, spine, scales, operculum, gills and gill rakers, claspers;
Shell fish morphology: eyes, hectocotylus arm, foot, shells, tentacles, pleopods, uropods, cehalo-thoraxic appendages, antennae, antennules, spines ;
Morphometric measurement, Significance of morphometric measurement ;
Taxonomic importance of morphological characters .

Unit 2: Basic Fish Anatomy (15 Hr)

Digestive system of a teleost and its associated glands
Respiratory system (Gill - Structure and Types, Mechanism of respiration ,Air bladder – Structure and Types, functions ,Accessory Respiratory Organs ,Respiratory pigment)
Nervous system of Teleost ,Sense organs and Endocrine organs in fishes ,Weberian ossicle – Structure and functions,Heart and aortic arches of a teleost
Excretion and Osmoregulation: (Structure and function of the excretory organs ,Major excretory products of fishes, Patterns of nitrogen excretion ,Osmotic and ionic regulation – Acid-base balance)

Unit 3: Locomotion and Light Producing Organs in Fishes (15 Hr)

Locomotion in fish
- Types of locomotion
- Special mode of locomotion
- Locomotion due to the movement of appendages

Migration in fish
- General account of migration
- Types of migration
- Advantages of migration
- Factors influencing migration
- Symbiosis

Light producing organs
- Location
- Nature of light producing organs
- Structure of light producing organs
- Significance of luminescence in fishes

Unit IV: Mud Crab: *Scylla serrata* (15 Hr)
- Distribution, Habit and Habitat
- External characters
- Life history
- Migration and movement
- Heart and circulatory system
- Respiratory system
- Economic importance

PRACTICAL (2 CREDITS)

Freshwater Aquaculture

1. Estimation of Turbidity, DO, pH, Hardness CO_2 and BOD of pond water.
2. Identification

a) Major candidate species of fishes – *Labeo rohita, Catla catla, Cirrhina mrigala, Cyprinu scarpio, Ctenopharyngo donidellus, Hypophthalmichthys molitrix*)

b) Crustacean – *Macrobrachium rosenbergii*.

3. Identification of important ornamental fishes (Angel, Danio, Discus, Flower horn, Gourami, Siamese fighter, Sword tail, Gold fish, Koi).

4. Identification of important aquatic plants used in aquarium. (Amazon sword, Cork screw, *Ludwigia,* Aqua rose, *Cobamba, Pistia*).
5. Setting up of aquarium and maintenance of aquarium fishes.
6. Study of developmental stages in fish – Eggs, hatchings and fingerlings.
7. Study of various components of fish hatchery.
8. Study of sexual dimorphism in *Macrobrachium rosenbergii*
9. Study of various stages in the life cycle of *Macrobrachium rosenbergii* (Eggs, larva, Juvenile)
10. Visit to fresh water hatchery/aquaculture farm and submit a report.

P2: Fin fish and Shell Fish Biology (2 Credits)

1. Identification of Shell fishery
   1) *Matuta* sp.
   2) *Scylla serrata*
   3) *Neptunus sanguinolentus*
   4) *Neptunus pelagicus*
   5) *Charybdis* sp.
   6) *Sepia* sp.
   7) *Loligo* sp.
2. Dissection of bony fish so as to expose its digestive system.
3. Dissection of bony fish so as to expose its nervous system.
4. Dissection of bony fish so as to expose its aortic arches.
5. Dissection of bony fish so as to expose Weberian ossicles.
6. Mountings of Fish -Fins, Scales, Gills and rakers, air bladder.
7. Mountings of Prawn - rostrum, chelate leg, pleopod, uropod, antenna, antennule, walking leg.
8. Determination of ammonia from the tank water
9. Identification of Air Breathing Fishes – *Anabas testudineus*, *Clarius batrachus*, *Boleophthalmus* sp.
10. Study of Larval stages of crab.
11. To identify and locate the shoals of fish from the data/photographs captured by remote sensing devices/techniques/GPS (Demonstration only).
12. Visit to local fish market to identify commercially important shellfishes and prepare a report.

M. Sc. PART I SEMESTER II ELECTIVE PAPER 1 PSZO201: CHORDATES	
Unit 1: Protochordates and Agnatha	**(15 Hr)**
Objectives:	• *To equip learners with the knowledge of evolutionary progressionof Protochordates.* • *To familiarize learner with the origin, morphology and phylogenyof the Protochordates.*
Desired Outcome:	*Learners would be equipped with the understanding of morphologyand phylogeny of Protochordates.*
1.1 Protochordates	
1.1.1 Origin and ancestry of Protochordates, similarities and differences with Invertebratesand Chordates	
1.1.2 Comparison of characteristics between subphyla Urochordates and Cephalochordates	
1.2 Urochordates	
1.2.1 Life history of *Herdmania* and its phylogenetic affinities	
1.3 Cephalochordates	
1.3.1 General features and phylogenetic affinities	
1.3.2 Life history of *Branchiostoma*	
1.4 Ostracoderm	
1.4.1 Salient features and biological significance	
1.4.2 Interrelationship and affinities with fish	
1.5 Cyclostomes	
1.5.1 Resemblance with Cephalochordates, Vertebrates and differences from Fishes	
1.5.2 Life history of *Petromyzon*	
Unit 2: Phylogeny of Chordates	**(15 Hr)**
Objectives:	• *To provide learners with the knowledge of evolutionaryprogression of Protochordates.* • *To familiarize learner with the origin, morphology and phylogenyof the Protochordates.*
Desired Outcome:	*Learners would be equipped with the understanding of morphologyand phylogeny of Protochordates.*
2.1 Ancestry of Chordates	
2.2 Pisces	
2.2.1 General characters of Dipnoi and affinities with Fishes, Elasmobranchs and Amphibia	
2.2.2 Origin of air bladder and its relationship with tetrapod lungs	
2.2.3 Deep sea adaptations of fishes	
2.2.4 Origin of fins	
2.3 Amphibia	
2.3.1 Origin of Tetrapods	
2.3.2 Pedomorphosis	
2.3.3 Adaptive radiation in amphibians Lepospondyli and Lissamphibia	
2.4 Reptilia	
2.4.1 Origin of Reptiles and affinities with Amphibia	
2.4.2 Terrestrial adaptations in Reptiles	
2.5 Aves	
2.5.1 Origin of Birds and affinities with Reptiles	
2.5.2 Adaptive radiation in Birds – Ratitae (Flightless Birds) and Carinatae (Flying Birds)	
2.5.3 Origin of Flight – Theory of Cursorial and Arboreal origin	
2.6 Mammalia	
2.6.1 Origin of Mammals	

2.6.2 Phylogeny of terrestrial and aquatic mammals	
Unit 3: Functional and Comparative Anatomy of Chordates (15 Hr)	
Objectives:	● *To equip learners with the knowledge of evolutionary progressionof chordates.* ● *To familiarize learner with the origin, morphology and phylogenyof the chordates.*
Desired Outcome:	*Learners would understand evolution, morphology and phylogeny ofchordates.*
3.1 Comparative Anatomy of:	
3.1.1 Chondrocranium	
3.1.2 Splanchnocranium	
3.1.3 Skull in different Vertebrates	
3.2 Evolution and Comparative Anatomy of Excretory System of Chordates	
3.2.1 Evolutionary development of Kidney	
● Archinephros	
● Pronephros	
● Mesonephros	
● Metanephros	
3.3 Comparative Anatomy of Nervous System in Vertebrates	
3.3.1 Brain	
3.3.2 Sense organs – Eyes and Ears	
3.4 Comparative Anatomy of Respiration	
3.4.1 Gills, Skin and Lungs	
3.5 Circulation: Heart and Aortic Arches	
3.6 Male and female reproductive and urinary ducts of Vertebrates (Cyclostomes, Teleost,	
Elasmobranchs, Amphibia, Reptilia, Aves and Mammalia)	

PRACTICAL BASED ON ELECTIVE

PSZOP 204: LAB EXERCISES BASED ON PSZO201, PSZO202 AND PSZO203(60 Hr)
1. Museum specimens / Photographs / Pictures / Slides: *i.* Protochordates: Study of *Doliolum, Herdmania, Ascidia, Botryllus* ii. Adaptive radiation in Reptiles-Turtles, Crocodile, Tuatara, Snakes and Lizards iii. Adaptive radiation in Mammals – Talpa (mole), Tarsius, Armadillo, Camel and Spermwhale
2. Types of jaw suspension in vertebrates- Autodiastylic, Holostylic, Amphistylic andAutostylic.
3. Types of vertebrae – Acoelous, Procoelus, Opisthocoelus, Amphicoelus, Amphiplatins,Heterocoelus, Axis and atlas vertebrae.
4. Pigeon – Study / Virtual dissection of i. Flight muscles ii. Digestive system iii. Respiratory system iv. Circulatory system v. Excretory system vi. Reproductive system – male and female
5. Measurement of fish ova diameter using oculometer.

6. Histology of male and female accessory reproductive glands – Human Prostate gland,Bulbourethral gland and placenta [Permanent slides].
7. Preparation of histological slides for histomorphology and histochemistry (PAS staining) study of fish ovary/testis.

Modality of Assessment:

A) Internal Assessment- 50%

Sr. No.	Evaluation type	Total Marks
	One Assignments/Case study/Project	30
	Active participation in routine class instructional deliveries	10
	Attendance – (0-25%=0 marks, 25-50%=1mark,50-75%=3 marks and 75-100%= 5 marks)	05
	Overall conduct as a responsible student, manners, skill in articulation, leadership qualities demonstrated through organizing co- curricular, etc.	05

B) External examination- 50%

a) Semester End Theory Assessment- 50% 50 Marks

i. Duration – These examinations shall be of two hours duration for each paper.

ii. Theory Question Paper Pattern:

- There shall be five questions each of 10 marks. On each unit there will be one question and the first one will be based on entire syllabus.
- All questions shall be compulsory with internal choice within the questions. Each question will be of 15 to 20 marks with options.
- Question may be subdivided into sub- questions a, b, c… and the allocation of marks depend on the weightage of the topic.

b) Practicals 100 Marks

University of Mumbai

M.Sc. (Zoology - Oceanography and Fishery Technology)

Semester I / Semester II EXAMINATION

Course PSZO

Maximum Marks: 50 Duration: 2.0 Hours Marks Option: 80

Question 1: Based on Unit I to IV (Mixed Questions)
Question 2: Based on Unit I
Question 3: Based on Unit II
Question 4: Based on Unit III
Question 5: Based on Unit IV
Instructions:

i. All questions are compulsory.
ii. All questions carry equal marks.
iii. Draw neat and labelled diagrams wherever necessary.

1. Answer any four questions from the following (Based on all 4 units). (10 Marks)
   A)
   B)
   C)
   D)
   E)
   F)
   G)
   H)
2. Answer any two questions from the following. (Based on Unit1). (10 Marks)
   A)
   B)
   C)
3. Answer any two questions from the following. (Based on Unit 2). (10 Marks)
   A)
   B)
   C)
4. Answer any two questions from the following. (Based on Unit 3). (10 Marks)
   A)
   B)
   C)
5. Answer any two questions from the following. (Based on Unit 4). (10 Marks)
   A)
   B)
   C)

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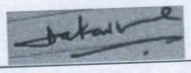
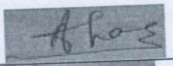
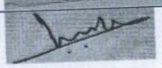
Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result
9.00 - 10.00	90.0 - 100	O (Outstanding)
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)
5.00 - < 5.50	50.0 - < 55.0	C (Average)
4.00 - < 5.00	40.0 - < 50.0	P (Pass)
Below 4.00	Below 40.0	F (Fail)
Ab (Absent)	-	Absent

SYLLABUS COMMITTEE

NAME	COLLEGE NAME	SIGNATURE
Dr. Dilip Kakvipure	B.N.N. College, Bhiwandi, Thane	
Dr. Surekha Gupta	G. N. Khalsa College, Mumbai	
Dr. Aamod Thakkar	Veer Vajekar College, Phunde, Raigad	
Mr. Nitin Wasnik	D. G. Ruparel College, Mumbai	
Ms. Mrunmayi Rane	SSS, CEMAS, University of Mumbai, Mumbai	

Director, Prof. Adwait M. Vaidya
Thane Sub-Campus, Kalyan Centre
School of Engineering & Applied Sciences,

Prof. Shivram S. Garje
Dean, Science and Technology
University of Mumbai

Appendix B

Justification for M.Sc. (Zoology - Oceanography and Fishery Technology)

	Necessity for starting the course:	This program of PG diploma in. "(Zoology - oceanography and fishery technology)" has infusion of study of zoology, oceanography and fishery technology used for up gradation of manpower is imperative in contemporary Times to keep Pace with exponential increase in the coastal area in view of Sagarmala project and changing its investigations. PG diploma program of school is well structured and design by seeking guidance and inputs from various academic experts in the field of Oceanography. The subject is incorporated in the degree area chosen from major domain of zoology and Oceanography.
	Whether the UGC has recommended the course:	**Yes**
	Whether all the courses have commenced from the academic year 2023-24	The PG Diploma In Oceanography And Fishery Technology" Courses Already Comments From The Academic Year 2020 and academic year 2023-24 it is restructured as per NEP 2020.
	The courses started by the Universityare self-financed? whether adequate number of eligible permanent faculties are available?	At present this course is started in Sindhu swadhya and School of Engineering and technology khadakpada Kalyan
	To give details regarding the duration of the Course and is it possible to compress the course?	The duration of the program is 1 year (2 Semesters). It is not possible to compress this course
	The intake capacity of each course and no. of admissions given in the current academic year:	The intake capacity of the program is 30. Number of admission for academic 2021-22 were 24.
	Opportunities of Employability/ Employment available after undertaking these courses:	the PG diploma in "(Zoology - oceanography and fishery technology)" has wide range of employment opportunities across various sectors.

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