

**Post Graduate Diploma in Marine Science  
(PGDMS)**



**Effective from Academic Year (2020-2021)**

**Shri Govind Guru University  
Godhra**

❖ **Course Title:** Post Graduate Diploma in Marine Science (PGDMS)

❖ **Objectives:**

- To make the students familiar with respect to the subject and its practicable applicability.
- To promote the students towards understand basic and advanced concepts in Marine Sciences including Marine life, Marine ecosystem, geology, oceanography, chemistry and its bioactive compounds.
- To expose the students to enhance the skill in fish farming, aquaculture and its harvesting and preservation technology.
- To develop skills required in various industries, academic institutes and research centers.
- To prepare the students to accept the challenges in industrial and marine sectors

❖ **Duration:**

❖ Total duration of the PGDMS Course shall be of 1 year.

❖ **Course Tenure:**

June to November & December to May.

❖ **Admission Criteria:**

The minimum eligibility for admission shall be clear 12+3 examination in any subject of Life Sciences/Biological Sciences

❖ **Documents Require:**

- School Leaving Certificate
- Mark sheet of SSC, HSC Board and Bachelor of Science (Graduation)
- 2 Passport size photos
- Caste Certificate (If applicable)

❖ **Medium of Instruction:** English

❖ **Maximum Intake:** 30

# Post Graduate Diploma in Marine Science

## Course Structure SEMESTER – I

Subject Code	Paper No.	Paper	Internal Marks	External Marks	Total Marks	Credits
PGDMS 01	101	Marine chemistry	30	70	100	04
PGDMS 02	102	Marine pollution	30	70	100	04
PGDMS 03	103	Marine Microbial Ecology	30	70	100	04
PGDMS 04	104	Basics of Marine Sciences	30	70	100	04
PGDMS 05	105	Practical		100	100	04

## Course Structure SEMESTER – II

Subject Code	Paper No.	Paper	Internal Marks	External Marks	Total Marks	Credits
PGDMS 01	201	Marine geochemistry	30	70	100	04
PGDMS 02	202	Basics of Aquaculture	30	70	100	04
PGDMS 03	203	Freezing technology	30	70	100	04
PGDMS 04	204	Process & Product Development	30	70	100	04
PGDMS 05	205	Practical		100	100	04

## P. G. Diploma in Marine Science

### Paper 101 Marine chemistry

**Teaching Hours: 48**

**Total Marks: 70**

**Credit:04**

<b>Unit: 1</b> <u>Basic of Marine Chemistry</u>	Symbols and units used in chemical oceanography – Major and minor elements in seawater – Geochemical balance of the oceans, residence times, chemical speciation.	<u>12 hrs</u>
<b>Unit:2</b> <u>Marine Chemistry-I</u>	Constancy of relative ionic composition of seawater, conditions under which major elements may not be conservative, factors affecting the distribution of trace elements in the sea, interaction of trace elements with marine organisms, enrichment factor, Chlorinity and salinity: definition and significance, practical salinity scale, Radioactive nuclides in the sea.	<u>12 hrs</u>
<b>Unit:3</b> <u>Marine Chemistry-II</u>	Dissolved gases (other than CO <sub>2</sub> ) in seawater – Basic concepts : solubility of gases in seawater, air – sea gas exchange, processes affecting their distribution, dissolved oxygen in the ocean – Dissolved gases (CO <sub>2</sub> ) in seawater – Carbon dioxide equilibria in seawater; pH, alkalinity and buffering capacity of oceans: components of CO <sub>2</sub> system in seawater – Percentage composition of inorganic carbon; calcium carbonate precipitation and dissolution phenomena – Lyso-cline and carbonate compensation depth.	<u>12 hrs</u>
<b>Unit:4</b> <u>Micronutrients</u>	Micro-nutrient elements (P, N and Si) in seawater – Forms in seawater, distribution and cycle, N:P ratios – Stoichiometry of the uptake and regeneration of the nutrient elements and of oxygen – Chemical oceanography of the seas around India – Instruments used in chemical oceanography. Atmospheric chemistry and air-sea interactions – Composition of the atmosphere, steady state or equilibrium, sources of gases in the atmosphere, reactivity of trace gases in the atmosphere, acid rain, ozone hole; chemistry of sea surface microlayer – Origin, thickness and collection of surface material, properties of the sea surface micro-layer.	<u>12 hrs</u>
<b><u>Suggested practical</u></b>		
	<ol style="list-style-type: none"> <li>1. Introduction to good laboratory practices in Chemical Lab and introduction to sampling, subsampling, storage and analysis of dissolved trace constituents of seawater.</li> <li>2. Estimation of salinity of seawater by the Mohr- Knudsen chlorinity titration method.</li> <li>3. Determination of dissolved O<sub>2</sub> of seawater by Winkler's iodometric titration method.</li> <li>4. Determination of pH of seawater by potentiometric method using pH meter and determination of total alkalinity of seawater by potentiometric titration using pH meter.</li> <li>5. Spectrophotometry: Verification of Beer's law.</li> <li>6. Spectrophotometric determination of dissolved inorganic phosphate in seawater by ammonium molybdate – ascorbic acid method.</li> <li>7. Spectrophotometric determination of nitrite in seawater by sulphanilamide – diamine method.</li> <li>8. Spectrophotometric determination of nitrate in seawater by reduction to nitrite using copper – coated cadmium reduction column.</li> <li>9. Spectrophotometric determination of ammonia in seawater by indophenol blue method.</li> <li>10. Spectrophotometric determination of dissolved inorganic silicate in seawater by ammonium molybdate – ascorbic acid – oxalic acid method.</li> </ol>	
<b><u>Refence book</u></b>		
	1. Introduction to Marine Chemistry, 1971 – Riley, J.P. and Chester, R., Academic Press.	

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|  | <ol style="list-style-type: none"> <li>2. Chemical Oceanography (Vol.1, 2, 3 &amp; 8), 1975 – Riley, J.P. &amp;Skirrow, G., Academic Press.</li> <li>3. Marine Chemistry, 1969 – Horne, R.A., Wiley-Interscience</li> <li>4. Seawater: Its composition, properties &amp;behaviour, 1989, 1995, 2004 – The Open University.</li> <li>5. Marine Chemistry (Vol.2), 1970 – Martin, D.F., Marcel Dekker, NY.</li> <li>6. Tracers in the Sea, 1982 – Broecker and Peng., Lamont-Doherty Geological Observatory, NY.</li> <li>7. Marine Geochemistry, 1990, 2000 – Chester, R., Blackwell Science.</li> <li>8. Chemical Oceanography, 1992 – Millero, F. J. and Sohn, M.L., CRC Press.</li> <li>9. Dynamic processes in the chemistry of the upper ocean, 1986 - Burton et al., Plenum Press.</li> <li>10. The chemistry of the Atmosphere and Oceans, 1978 – Holland, H.D., Wiley.</li> <li>11. An Introduction to Environmental Chemistry, 1996 – Andrews et al., Blackwell science.</li> <li>12. Environmental Chemistry, 1994 - De, A.K., Wiley – Eastern Ltd.</li> <li>13. Geosphere – Biosphere Interactions and Climate, 2001 – L.O.Bengtsson and C.U.Hammer., Cambridge University Press.</li> <li>14. Oceanography of the Indian Ocean, 1992 – B. N. Dessai (Ed.), AA Balkema.</li> <li>15. Chemical Oceanography of the Indian Ocean, North of Equator. 1984, Sengupta and Naqvi, Deep Sea Res. 31A, 671-706.</li> <li>16. Chemical Oceanography, 1996, 2006 – F. J. Millero, CRC Press.</li> <li>17. The Sea Surface and Global Change, 1997, 2005 – P.S. Liss and R. Duce., Cambridge University Press.</li> <li>18. Ocean Biogeochemistry: The role of the ocean carbon cycle in Global change, 2003 – M.J.R. Fasham, Springer.</li> <li>19. An Introduction to Marine Biogeochemistry, 2 nd edition, 2009 – S.B.Libes, Wiley.</li> <li>20. Marine Chemistry and Geochemistry, 2010 – K. K. Turekian, Academic Press.</li> <li>21. An Introduction to the Chemistry of the Sea, 2 nd edition, 2013 – M.E.Q. Pilson, Cambridge University Press.</li> </ol> |  |
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**P. G. Diploma in Marine Science**  
**Paper 102 Marine pollution**

**Teaching Hours: 48**

**Total Marks: 70**

**Credit:04**

<u>Unit: 1</u> <u>Marine</u> <u>Pollution-I</u>	Marine Pollution: Definition, categories of additions, Pollutant and its classification. Organic wastes: BOD, COD, dilution factor, Fluctuations in DO, Consequences of organic discharges to estuaries with examples; Thames and Mersey estuary; Consequences of sludge dumping at sea with reference to Thames and Firth of Clyde. Sewage treatment: Primary, Secondary and Tertiary treatment processes. Solid waste pollution: Classification and disposal of solid wastes.	<u>12 hrs</u>
<u>Unit:2</u> <u>Marine</u> <u>Pollution-II</u>	Industrial pollution: sources, nature and their treatment processes with reference to wastes from paper and pulp and soap manufacturing industries. Marine corrosion: Definition, corrosion reactions, classification of corrosion, factors affecting corrosion of metals in sea water and prevention of marine corrosion. The state of some seas in the world (pollution aspect); The North sea, The Mediterranean sea and the Baltic sea.	<u>12 hrs</u>
<u>Unit:3</u> <u>Toxic</u> <u>Environments</u>	Oil spills and cleanup: sources, major accidental spills, fate of spilled oil on the sea, consequences 12 hours 12 hours 33 of oil spills and treatment of oil spills. Pesticide pollution: inputs, fate in the sea, factors affecting the bioaccumulation of pesticides, DDT-the most wide spread molecule, Impact of pesticides on the Environment, Mode of poisoning of pesticides, Methods to minimize pesticide pollution. Conservative pollutants: Measures of contamination, toxicity, measurement of toxicity, acute and chronic exposure, Detoxification. Metal pollution in coastal waters (Hg, Pb, Cd, Cu, and Fe).The present status of coastal pollution in India and future strategies.	<u>12 hrs</u>
<u>Unit:4</u> <u>Monitoring</u>	Indicator organisms: Criteria for selection of indicator organism: Quantification of pollution load, basic pre-requisites, response to different pollution load and time integration capacity, Macro algae, crustaceans and mollusks as indicator organisms for monitoring of trace metal pollution; Red tides : distribution, types of poisoning, effects and methods to minimize red tides in the sea. Monitoring strategies of marine pollution: Critical pathway approach and Mass balance approach.	<u>12 hrs</u>
	<b><u>Suggested practical</u></b>	
	1. Determination of dissolved oxygen in polluted waters. 2. Determination of biochemical oxygen demand in polluted waters. 3. Determination of chemical oxygen demand in polluted waters. 4. Determination of fluoride. 5. Determination of hydrogen sulphide. 6. Pre-concentration of water by solvent extraction method. 7. Digestion of biological samples for estimation of toxic metals. 8. Estimation of Cu in polluted waters and biological samples.	
	<b><u>Refence book</u></b>	
	1. Chemical Oceanography (Vol: 3), 1975 - Riley J.P and Skirrow, G. (eds.), Academic press, New York. 2. The health of the oceans, 1976 - Goldberg, E.D. UNESCO Press. 3. Marine Pollution, 1986 - Clark, R.B. Oxford science Publications. 4. Quantitative aquatic biological indicators, 1980 - Phillips J.D.H. Applied Science Publishers. 5. Thermal and radioactive pollution, 1994 - Sharma, B.K and Kaur, H. Krishna Prakasham Mandir, Meerut. 6. Water Pollution, 1994 - Sharma, B. K and Kaur, H. Krishna Prakasham Mandir, Meerut. 7. Marine and offshore corrosion, 1985 - Chandler, K.A. Butter Worths, London.	

**P. G. Diploma in Marine Science**  
**Paper 103 Marine Microbial Ecology**

**Teaching Hours: 48**

**Total Marks: 70**

**Credit:04**

<b><u>Unit: 1</u></b> <b><u>Basics of</u></b> <b><u>Microbial</u></b> <b><u>Ecology</u></b>	Marine Microbiology its importance, existence and need; History of marine microbiology; Instruments and sampling methods; Modern methods; Microbial habitats and major types (producers, consumers, symbionts, probionts, etc.) in relation to their habitats; Evolution of sampling strategies and methods for assessment of microbial biodiversity .	<u>12 hrs</u>
<b><u>Unit-2</u></b> <b><u>Microbial</u></b> <b><u>Ecology-I</u></b>	Characteristics of marine microbes; Distribution and abundance and their adaptations to pressure, depth, salt, temperature; Integrated effects of nutrient dynamics;	<u>12 hrs</u>
<b><u>Unit:3</u></b> <b><u>Microbial</u></b> <b><u>Ecology-II</u></b>	Chemosynthesis and microbial heterotrophic metabolis ; Effect of ions of major and trace elements; Toxicity and mechanism of tolerance in marine microbes; Biochemical characterization of marine prokaryotes.	<u>12 hrs</u>
<b><u>Unit:4</u></b> <b><u>Ecological</u></b> <b><u>cycles</u></b>	Microbial role in cycling of N, P, S, and C; Concept of microbial loop in relation to marine food web dynamics ; Role of micro-organisms in DOM production and consumption; Microbial mineralization and oxidation of organic matter; Role of marine microbes in production of RDOC and sequestering of carbon dioxide; Pollution indicator and pathogenic marine microbes.	<u>12 hrs</u>
<b><u>Suggested practical</u></b>		
	1. Sterilization techniques, preparation of bacterial media, nutrient, broth & agar preparation of slants. 2. Method of sample collection (water) from marine environment. 3. Estimation of bacterial, fungal population and isolation. 4. Preservation of cultures, isolation of pure cultures microscopy: wet mounts. 5. Isolation of pathogenic organisms from water and sediments.	
<b><u>Refence book</u></b>		
	1. Microbial Ecology of the oceans (2nd Edition), 2010 - Kirchman, D. L., John Wiley & Sons. 616 pages 2. Marine Microbiology (2nd Edition), 2011 - Munn, C. Garland Science. 320 pages 3. Marine Microbial Diversity: the key to Earths habitability, 2005 - Hunter – Cevera, J. Karl, D. and Buckley, M., American Academy of Microbiology. 4. Biological Oceanography, 2012 - Meller, C. B. and Wheeler P.A.. Wiley – Blackwell Publishers. 5. Marine Microbiology: Ecology and Applications (2nd edition), 2011 - Munn, C. Garland Science, Taylor and Francis group, NY. 6. Taxonomic scheme for the identification of marine bacteria, 1982 - Oliver, J. D., Deep Sea Research Part A., Oceanographic Research Papers, 29 (6); 795 – 798. 7. Marine Ecological Processes (2nd edition), 1995 - Valiella I., Springer – Verlag, New York	

**P. G. Diploma in Marine Science**  
**Paper 104 Basics of Marine Biology**

**Teaching Hours: 48**

**Total Marks: 70**

**Credit:04**

<b>Unit: 1</b> <u>Basic</u> of <u>Marine</u> <u>Biology</u>	Introduction to marine biology, history, classification, theories, hypothesis testing; life and non life, Origin and evolution of life, life processes, abiogenesis, theories of natural selection, models and hypothesis of organic evolution, primordial soup hypothesis, organic molecules, chemical evolution, iron sulfide and black smoker's theory, RNA world hypothesis, theory of evolution and panspermia.	<u>12 hrs</u>
<u>Unit:2</u> <u>Marine</u> <u>Ecosystem</u>	Biotic structure, Invertebrate larvae and their biology, larval types and strategies, theories of biphased life history, Marine and coastal environment, biological zonation, inter-tidal ecosystem, rocky, sandy and protected sand flats, zonation pattern, physical and biological factors and processes affecting biotic communities and their adaptations.	<u>12 hrs</u>
<u>Unit:3</u> <u>Marine</u> <u>Environments</u>	Sea as a biological environment, physiological changes, regulators and conformers, scope for growth, temperature and metabolic rates, comparison among marine and terrestrial environment, Organic matter production, Marine primary productivity, photo-autotrophic production, mechanism, light and dark reaction, intermediate products, role of pigments, methods of assessment, factor and processes affecting primary productivity, transformation of organic matter, vertical profile of primary productivity and SCM, turbulence and MLD	<u>12 hrs</u>
<u>Unit:4</u> <u>Marine</u> <u>Productivity</u>	Marine productivity - heterotrophic processes and pathways, herbivory and grazing, zooplankton sampling, constraints, methods of biomass estimation, ontogeny and vertical migrations, mud bank formation, processes and fisheries.	<u>12 hrs</u>
	<b><u>Suggested practical</u></b>	
	<ol style="list-style-type: none"> <li>1. Introduction to standard sampling devices / instruments employed for collection and analysis of biological parameters in water and sediments used in oceanographic studies.</li> <li>2. Design and execution of field / sampling surveys for collection and analysis of biological communities (water and sediment), their preservation and storage techniques using standard methods.</li> <li>3. Identification of marine phytoplankton, their life cycle and role in food chain.</li> <li>4. Identification of marine zooplankton, their life cycle and role in food chain.</li> <li>5. Identification of mangroves, their life cycle and few biological characteristics.</li> <li>6. Morphometric measurements and meristic counts of the Indian Mackerel, <i>Rastrelligerkanagurta</i> and elasmobranchs.</li> <li>7. Identification of few commonly occurring teleosts (ray-finned fishes) and their biological characteristics.</li> <li>8. Identification of brachyuran crabs using morphology and gonopod characteristics, sex determination and their biological importance.</li> <li>9. Identification of prawns and shrimps using external characteristics, sex determination and biological aspects.</li> </ol>	
	<b><u>Refence book</u></b>	
	<ol style="list-style-type: none"> <li>1. Marine Biology. 8 th Edition – 2009 Castro, P. and Huber, M. McGraw Hill Education. 461 pp.</li> <li>2. Introduction to Marine Biology. 4 th Edition. – 2012, Krleskint, G., Turner, R., Small, J., Cengage Learning. 576 pp</li> <li>3. Biological oceanography 1999 – Lalli, C.M., Elsevier Ltd.</li> <li>4. Oceanography: The past, 1980 – Sears, M and Merimann D. (Eds)., Springer-Verlag</li> <li>5. Elements of Marine ecology (4th edn) 1982 – Tait, R.V. and Dipper, F. Butterworth - Heinemann</li> <li>6. An introduction to Marine Sciences, 1988 – Meadows, P.S. &amp; Campbell, J.J.,</li> </ol>	



	<p style="text-align: center;">Springer Science &amp; Business Media</p> <ol style="list-style-type: none"> <li>7. Textbook of Marine Ecology, 1980 – Nair, N.B. &amp;Thampy, D.M., Macmillan, 352 pp.</li> <li>8. Marine Biology, 1984, Thurman, H.V. and Webber, H.H., Harper Collins Publishers</li> <li>9. Methods in Marine Zooplankton Ecology, 1984 Omori, W. and Ikeda, T. Wiley</li> <li>10. Methods for the study of Marine Benthos, 1984 – Holme, N.A. &amp;Melntyre, A.D. Blackwell Scientific Publications</li> <li>11. The Ecology of Rocky Coasts, 1964 – Lewis, J.R. English Universities Press</li> <li>12. The shore environment, 1980 – Irvine, J.H., Price, D.E.C. and Farnham, W.F. Systematics Association</li> <li>13. Life between tidemark on rocky shores, 1972 – Stephenson, T.A. &amp; Stephenson, A. W. H. Freeman</li> <li>14. The invertebrates (3<sup>rd</sup>Edn.), 1986 – Barnes, R.S. K. Blackwell Science</li> </ol> <p style="text-align: center;">15. Zooplankton Methodology Manual, 2000 - Harris, R., Wiebe, P., Lenz, J., Skjoldal, H.R., Huntley, M. (Eds), ICES Academic Press, San Diego, pp. 68</p>	
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**P. G. Diploma in Marine Science**  
**Semester-II**  
**Paper 201 Marine Geochemistry**

Teaching Hours: 48

Total Marks: 70

Credit:04

<b><u>Unit: 1</u></b> <b><u>Marine</u></b> <b><u>Geochemistry</u></b>	Geochemical classification of elements - distribution and abundance of elements in lithosphere – Principle geochemical cycle, Chemical weathering. Suspended matter – Methods of collection and analysis, spatial and temporal variation of total suspended particulate matter in the ocean – Component composition and settling rates of suspended matter – Particle flux in the ocean and various techniques of measurement, Particulate organic matter in the sea: its origin, nature, composition and methods of measurements.	<u>12 hrs</u>
<u>Unit:2</u> <u>Marine</u> Sedimentation	Sedimentation – physicochemical factors in sedimentation – ionic potential, hydrogen ion concentration, redox potential and colloids – Behaviour of major and trace elements during sedimentation – Significance of organic content in sedimentation – Component composition and geochemistry of deep sea sediments – Application of major and minor elements in the reconstruction of marine paleo-environment.	<u>12 hrs</u>
<u>Unit:3</u> <u>Radionuclides-</u> <u>I</u>	Chemical and biological aspects of dissolved organic matter in the sea – Sources of supply and processes of removal of dissolved organic matter. Radioactivity – Classification – Primary, cosmogenic and artificial radio nuclides.	<u>12 hrs</u>
<u>Unit:4</u> <u>Radionuclides-</u> <u>II</u>	Distribution and occurrence of radionuclides, their properties in the marine environment and their decay series – Sampling and storage of radionuclides, radio chemical separation- Applications of radionuclides to the geochronology of marine sediments and rocks – Carbon dating methods in marine sediments, oceanic mixing and residence time	<u>12 hrs</u>
<b><u>Suggested practical</u></b>		
<ol style="list-style-type: none"> <li>1. Determination of dissolved organic N in seawater by alkaline - persulphate oxidation followed by spectrophotometric technique.</li> <li>2. Determination of dissolved and particulate organic P in seawater by acid - persulphate oxidation followed by spectrophotometric technique.</li> <li>3. Spectrophotometric determination of dissolved Fe in seawater by TPTZ – ascorbic acid method.</li> <li>4. Spectrophotometric determination of dissolved Mn in seawater by formaldoxime method</li> <li>5. Determination of Organic carbon in sediment.</li> <li>6. Determination of phosphorus in sediment.</li> </ol>		
<b><u>Refence book</u></b>		
<ol style="list-style-type: none"> <li>1. Introduction to geochemistry, 1967 Krauskopf, K. B., Mc.Graw-hill.</li> <li>2. Geochemistry, 1962 Goldschmidt, V. M., Clarendon press.</li> <li>3. Principles of geochemistry, 1956 Mason, B. and Moore, B., John Wiley &amp; Sons, Inc.</li> <li>4. Chemical oceanography (Vol. 1 &amp; 3), 1975 Riley, J. P. and</li> </ol>		

	<p>Skirrow, G., Academic Press, New York</p> <ol style="list-style-type: none"><li>5. Introduction to geochemistry, 1995 Krauskopf, K. B. and Bird, Mc-Graw Hill.</li><li>6. The geochemistry of natural waters, 1982 Drever, J. I., Prentice-Hall, Inc., Englewood Cliffs, N.J.</li><li>7. Estuarine chemistry, 1976 Burton, J.D. and Liss, P. S., Academic Press.</li><li>8. Ocean chemistry and deep sea sediments, 1989 Open University Course Material.</li><li>9. Aquatic chemistry, 1996 Stumm, W. and Morgan, J.J., Wiley Interscience, New York.</li><li>10. Aquatic surface chemistry, 1987 Stumm, W., Wiley Interscience, New York.</li><li>11. Marine Chemistry, 1969 Home, R. A., Reinhold Publishing Corporation, New York.</li></ol>	
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**P. G. Diploma in Marine Science**  
**Paper 202 Basics of Aquaculture**

Teaching Hours: 48

Total Marks: 70

Credit:04

<b><u>Unit: 1</u></b> <b><u>Marine chemistry</u></b>	Principles of aquaculture, global scenario, status and prospects of coastal aquaculture in India, traditional aquaculture practices.	<u>12 hrs</u>
<b><u>Unit:2</u></b> Aquaculture techniques	Basic considerations, site selection, water quality management, species selection, feasibility and technique applied for mussel, pearl oyster, fish, lobster and seaweed culture practices.	<u>12 hrs</u>
<b><u>Unit:3</u></b> Hatchery management	Shrimp aquaculture, types of culture practices, traditional, modified traditional, extensive, modified extensive, semi intensive and intensive, critical requirements, site selection and pond preparation, selection of candidate species, brood stock procurement, hatchery production and management, nutrition, live feed culture and formulated feed preparation, water quality management in hatchery.	<u>12 hrs</u>
<b><u>Unit:4</u></b> <b><u>Breeding techniques &amp; disease</u></b>	Reproduction, techniques of inducing breeding, induced ovulation, treatment of eggs during incubation. status and prospects of brood stock, domestication and genetic improvement, shrimp diseases, pathology and parasitological, prophylactic and therapeutic measures, Coastal aquaculture Act, 2005.	<u>12 hrs</u>
<b><u>Suggested practical</u></b>		
	<ol style="list-style-type: none"> <li>1. Methods of estimation of dissolved oxygen, BOD, suspended solids, dissolved and particulate organic carbon.</li> <li>2. Identification of cultivable fishes of shrimps, mussels, oysters, fish, crabs and sea weeds.</li> <li>3. Reproductive system of shrimp.</li> <li>4. Identification of larval stages of shrimp of commercial importance</li> <li>5. Visit to shrimp hatchery and grow out farms for demonstrations.</li> <li>6. Fabrication of biological filter in aquarium tank.</li> <li>7. Fabrication of raft, transplantation of spat for mussel culture.</li> </ol>	
<b><u>Reference book</u></b>		
	<ol style="list-style-type: none"> <li>1. Stickney, R. R. 2009. Aquaculture: An Introductory Text. 2 nd edition. CABI. 304 pages</li> <li>2. Parker, R. 2011. Aquaculture Science. 3 rd Edition. Cengage Learning. 672 pages</li> <li>3. Aquaculture, 1989 – Pillai, T.V.R.</li> <li>4. Fish and fisheries of India, 1982 – Jhingran, V.G., Hindustan Publ. Corp. India Ltd. New Delhi</li> <li>5. Diseases of Marine animals – Marine Ecology (Vol 4), 1983 – Kinne, O., Wiley</li> <li>6. Crustacean aquaculture, 1983 Mckey, J.P. CRC series.</li> <li>7. Aquaculture, 1972 – Bardach, J. E, Wiley-Inter-science</li> <li>8. Prawn and prawn fisheries of India, 1976 – Kurian, C.V. &amp; Sebastian, V.O. Hindustan Pub. Corp.</li> <li>9. Environmental management for aquaculture, 1998 – Midlen, A., Springer, Netherlands</li> <li>10. Nutrition and feeding of fish, 1999 – Lovell, T. Springer Science &amp; Business Media</li> <li>11. An Introduction to Marine Chemistry, 1971 – Riley, J.P. and Chester, R., Academic Press.</li> </ol>	

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|  | <ol style="list-style-type: none"> <li>12. Chemical Oceanography (Vol.1, 2, 3 &amp; 8), 1975 – Riley, J.P. &amp; Skirrow, G., Academic Press.</li> <li>13. Marine Chemistry, 1969 – Horne, R.A., Wiley-Interscience</li> <li>14. Seawater: Its composition, properties &amp; behaviour, 1989, 1995, 2004 – The Open University.</li> <li>15. Marine Chemistry (Vol.2), 1970 – Martin, D.F., Marcel Dekker, NY.</li> <li>16. Tracers in the Sea, 1982 – Broecker and Peng., Lamont-Doherty Geological Observatory, NY.</li> <li>17. Marine Geochemistry, 1990, 2000 – Chester, R., Blackwell Science.</li> <li>18. Chemical Oceanography, 1992 – Millero, F. J. and Sohn, M.L., CRC Press.</li> <li>19. Dynamic processes in the chemistry of the upper ocean, 1986 - Burton et al., Plenum Press.</li> <li>20. The chemistry of the Atmosphere and Oceans, 1978 – Holland, H.D., Wiley.</li> <li>21. An Introduction to Environmental Chemistry, 1996 – Andrews et al., Blackwell science.</li> <li>22. Environmental Chemistry, 1994 - De, A.K., Wiley – Eastern Ltd.</li> <li>23. Geosphere – Biosphere Interactions and Climate, 2001 – L.O.Bengtsson and C.U.Hammer., Cambridge University Press.</li> <li>24. Oceanography of the Indian Ocean, 1992 – B. N. Dessai (Ed.), AA Balkema.</li> <li>25. Chemical Oceanography of the Indian Ocean, North of Equator. 1984, Sengupta and Naqvi, Deep Sea Res. 31A, 671-706.</li> <li>26. Chemical Oceanography, 1996, 2006 – F. J. Millero, CRC Press.</li> <li>27. The Sea Surface and Global Change, 1997, 2005 – P.S. Liss and R. Duce., Cambridge University Press.</li> <li>28. Ocean Biogeochemistry: The role of the ocean carbon cycle in Global change, 2003 – M.J.R. Fasham, Springer.</li> <li>29. An Introduction to Marine Biogeochemistry, 2 nd edition, 2009 – S.B.Libes, Wiley.</li> </ol> |  |
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**P. G. Diploma in Marine Science**  
**Paper 203 Marine freezing technology**

**Teaching Hours: 48**

**Total Marks: 70**

**Credit:04**

<b><u>Unit: 1</u></b> Introduction of freezing	Introduction to freezing technology; characteristics of fish and shellfish; changes in fish after death, spoilage of fish, spoilage and pathogenic microorganisms; handling of fresh fish; sanitation in processing plants; principles of low temperature preservation.	<u>12 hrs</u>
<b><u>Unit:2</u></b> Chilling Techniques	Chilling of fish – methods and equipment for chilling; icing – quality of ice, ice-making; refrigerated or chilled sea water, chilling rate; spoilage of fish during chilled storage; use of antibiotics and chemicals.	<u>12 hrs</u>
<b><u>Unit:3</u></b> Basics of Preservation	Freezing of fish – fundamental aspects; heat units; freezing point depression, eutectic point; freezing rate; methods of freezing; cryogenic, immersion freezing, physico-chemical changes that occur during freezing – mechanism of ice-crystal formation; preparation of fish for freezing.	<u>12 hrs</u>
<b><u>Unit:4</u></b> Storage properties	Changes that occur during frozen storage – microbiological, physical and chemical changes; protein denaturation, fat oxidation, dehydration, drip; protective treatments – polyphosphate, glazing, antioxidants, packaging; thawing of frozen fish – methods of thawing.	<u>12 hrs</u>
	<b><u>Suggested practical</u></b>	
	<ol style="list-style-type: none"> <li>1. chilling and freezing equipment, instruments;</li> <li>2. packages and product styles;</li> <li>3. methods of icing fish; cooling rate;</li> <li>4. preservation by chilled sea water; freezing and thawing curves;</li> <li>5. freezing of different varieties of fish and shellfish;</li> <li>6. estimation of drip;</li> <li>7. determination of quality changes during frozen storage;</li> <li>8. inspection of frozen fishery products;</li> <li>9. visits to freezing plants.</li> </ol>	
	<b><u>Refence book</u></b>	
	<ol style="list-style-type: none"> <li>1. Frozen Food Science and Technology by Judith A. Evans – 2009</li> <li>2. Seafood Chilling, Refrigeration and Freezing: Science and Technology by NalanGokoglu, Pinar Yerlikaya – 2015</li> <li>3. Handbook of Frozen Foods by Y. H. Hui, Isabel Guerrero Legarretta, MiangHoong Lim – 2004</li> <li>4. Frozen Food Technology by Patricia Alexandra Batista - 2018</li> </ol>	

## P. G. Diploma in Marine Science

### Paper 204 Process & Product Development

**Teaching Hours: 48**

**Total Marks: 70**

**Credit:04**

Unit: 1 Canning	Steps in canning – raw materials, preparatory treatments, precooking, packing, exhausting, seaming, thermal processing, cooling and storage. Thermal processing – heat resistance of microorganisms, heat penetration, graphical method of formulation. Fo-value. Canning of commercially important fishes, shellfishes and other food products – salient features.	12 hrs
Unit:2 Process	Traditional methods – sun drying, curing, wet curing and smoking. Colombo curing, artificial drying, solar drier, tunnel dryer, freeze dryer. Water activity and its relation to fish preservation. Marinated fishery products. Fish pickles. Fish silage – methods of production. Fish meal and oil. Dry reduction and wet reduction methods.	12 hrs
Unit:3 Product Development	Fish protein concentrate (FPC). Historical. FPC incorporated products. Paste fishery products – Sausage. Fish Ham, fish cakes, surimi. Kamaboko. Chitin – chitosan and glucosamine hydrochloride industrial production and applications. Fishery Products – fish maws, fish glue, fish peptone, Ising glass, pearl essence, shark fin rays, beche-de-mer, fish analog, squaline, ambergris products from krill.	12 hrs
Unit:4 Value-added products	Utilization of sea weeds – agar – agar, alginic acid, carrageenan diversified fish products –Battered and breaded products, fish finger, fish cutlets, fish burger, fish water, fish soup powder. Fermented fishery products – fish sauce, method of production.	12 hrs
<b><u>Suggested practical</u></b>		
	<ol style="list-style-type: none"> <li>1. Canning of different varieties of fish and shellfish.</li> <li>2. Heat resistance of bacteria.</li> <li>3. Heat penetration in canned food.</li> <li>4. Drying – curing smoking. Fish meal and oil – fish silage – fish pickles – fish sauce – FPC, fish maws, agar-agar, fish soup powder fish fingers, fish cutlets.</li> </ol>	
<b><u>Reference book</u></b>		
	<ol style="list-style-type: none"> <li>1. Fish Drying and Smoking: Production and Quality by Peter E. Doe</li> <li>2. Seafood Processing: Adding Value Through Quick Freezing, Retortable Packaging and Cook-Chilling by Vazhiyil Venugopal</li> <li>3. Post Harvest Technology of Fish and Fish by K. K. Balachandran</li> <li>4. The Canning of Fish and Meat by R. J. Footitt</li> <li>5. Fish Processing Technology by George M. Hall – 2012</li> <li>6. Innovative Technologies in Seafood Processing by Yesim Ozogul – 2019</li> <li>7. Fish Canning Handbook by Les Bratt - 2010</li> </ol>	

## **List of Instrument**

1. Light Microscopy
2. Spectrophotometer
3. Refrigerator
4. Colorimeter
5. Autoclave
6. pH Meter
7. EC Meter
8. COD digester
9. Sampling material: Phytoplankton and Zooplankton net
10. Grab sampler (Optional)
11. Flame photometer (Optional)
12. Incubator
13. Oven
14. Other course related equipments