Name of the Programme: M. Sc.Marine Sciences
Course Code:MSC 531
Title of the Course: Marine Pollution
Number of Credits: 03
Effective from AY: 2022-23

Prerequisites for the course:	Core courses offered in the Semester I.	
Objective:	To provide an insight on the type of pollutants, sources and impact on marine life. Also, to learn conservative (radioactive pollutants, trace metals and pesticides) and non-conservative pollutants (oil and other organic wastes). Quantification of pollutant through suitable indicator organisms and monitoring strategies.	
Content:	**Module I** 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. 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. **Module II** Oil spills and cleanup: sources, major accidental spills, fate of spilled oil on the sea, consequences 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, Zn and Fe). The present status of coastal pollution in India and future strategies. Radioactive Pollution: Sources, Classification and effects of radiation; Protection and control from radiation: Maximum permissible dose concept, dose limits, Disposal of radioactive wastes; Beneficial aspects of radiation and food safety. **Module III** Indicator organisms: Criteria for selection of indicator organism: Quantification of pollution load, basic pre-requisites, response to	15 hrs. 15 hrs. 15 hrs.

	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. Standards in water quality: Assessment of pollution damage: The need, seriousness of damage, assessment of damage and problems of measuring impact.	
Pedagogy:	Lectures/ tutorials/ assignments/ self-study	
References/ Readings:	1.Riley J.P and Skirrow, G (1975). Chemical Oceanography(3) Riley J.P and Skirrow, G. (eds.), Academic press, New York. 2.Goldberg, E.D (1976). The health of the oceans. UNESCO Press. 3.Clark, R.B (1986). Marine Pollution. Oxford science Publications. 4.Phillips J.D.H (1980). Quantitative aquatic biological indicators Applied Science Publishers. 5.Sharma, B.K and Kaur, H. Krishna (1994). Thermal and radioactive pollution, Prakasham Mandir (pub) Meerut. 6.B. K and Kaur, H. Krishna (1994). Water Pollution, 1994 - Sharma Prakasham Mandir (pub), Meerut. 7.Chandler, K.A. (1985). Marine Offshore corrosion, Butter Worths (pub) London.	
Course Outcomes:	1. To understand the impact of various pollutants on marine ecosystems. 2. To create awareness to safeguard the marine environment through identification of factors responsible for causing marine pollution. 3. To suggest policy measures to prevent marine pollution.	

Name of the Programme: M. Sc.Marine Sciences
Course Code: MSC 532
Title of the Course: Marine Pollution Practical
Number of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Core courses offered in the Semester I.	
Objective:	To analyze the concentration of various pollutants in the seawater and their effect on marine life including BOD and COD to assess the impact of organic pollution.	
Content:	Determination of dissolved oxygen in polluted waters. (5 hours; Reference 1) Determination of biochemical oxygen demand in polluted waters. 5 hours; Reference 1) Determination of chemical oxygen demand in polluted waters. (5 hours; Reference 2) Pre-concentration of water for estimation of trace metals by AAS (5 hours; References 5, 6, 7) Estimation of Cd in polluted waters and biological sample. (5 hours; References 5, 6, 7) Estimation of Cu in polluted waters and biological samples. (5 hours; References 5, 6, 7)	30 hrs.
Pedagogy:	Demonstations/ Lab experiments.	
References/ Readings:	1.Martin, D.F (1972). Marine Chemistry (01). Academic Press, London. 2.Rice, E.W and Bridgewater L. American (2012). Standard methods for the examination of water and waste water analysis (22nd edition), Public health association, Washington DC. 3.Grasskhoff, K, M (1983). Methods of Seawater analysis. Ehrdardt and K. Krembling (eds.), Verlag Chemie, Weinneim. 4.Strickland, J.D.H, and Parsons, T.R (1972) A practical hand book of seawater analysis. Fisheries Board of Canada bulletin. (2nd edition). 5.Riley, J. P. and Skirrow, G (1975). Analytical chemistry of seawater, In Chemical Oceanography (03), Riley, J. P. and Skirrow, G (eds.). Academic Press, London. 6.Allen, S. E., Grimshaw, H. M., Parkinson, J. A., Quarmby, C. and Roberts, J. D. (1976). Chemical Analysis. In: Methods in plant Ecology, S. B. Chapman (eds.), Blackwell Scientific Publications, Oxford, Chapter 8.	
Course Outcome:	1. To apply the results of analyses of different pollutants to draw valid inferences affecting marine life.	

Name of the Programme: M. Sc. Marine Sciences
Course Code: MSC 621
Title of the Course: Remote Sensing and its Applications
Number of Credits: 03
Effective from AY: 2022-23

Prerequisites for the course:	Students who have undergone M.Sc. Part I.	
Objective:	To provide a basic understanding of remote sensing, and some applications in physical oceanography and auxiliary disciplines.	
Content:	**Module I** Principles of Electromagnetic radiation, energy and matter interactions – Rayleigh scattering – Mie scattering, Non selective scattering – radiative transfer in the atmosphere – Stefan's law and Wien's displacement law – Zenith and azimuth angles. **Module II** Optical remote sensing – bio-optical properties of sea water – inherent and apparent optical properties – scattering – absorption-attenuation - diffuse attenuation – remote sensing reflectance – Case I and Case II waters – radiative transfer in the water column.Sun photometry – Beer-Lambert's law – spectral variation of aerosol optical thickness – atmospheric correction – interpretation of ocean colour. **Module III** Thermal infrared remote sensing – Thermal infrared properties – Atmospheric windows – Thermal radiation laws – Emissivity – sea surface temperature retrieval through IR sensors – Active and passive microwave remote sensing – Satellite altimetry of sea surface topography.Sensor characteristics of AVHRR, CZCS, SeaWiFS, MODIS, MSI, OCM-2 and FLEX – fundamentals of digital image processing – image rectification – image enhancement – linear stretching – supervised and unsupervised classification.	15 hrs. 15 hrs. 15 hrs.
Pedagogy:	Lectures/ Tutorials/ Assignments	

References/ Readings:	1.Rees, W. G. (1990). *Physical Principles of Remote Sensing,* (1990). U.K.: Cambridge University Press. 2.Sabins Jr., F. F. (1987). *Remote Sensing: Principles and Interpretations (Second Edition)*. New York, U.S.A.: W. H. Freeman. 3.Robinson, I. S. (1985). *Satellite Oceanography*. Somerset, N.J., U.S.A.: John Wiley & Sons. 4.Narayan, L. R. A. (1999). *Remote Sensing and its Applications.* Hyderabad: Universities Press. 5.Mukherjee, S. (2004). *Textbook of Environmental Remote Sensing.* Delhi – Chennai – Jaipur – Mumbai – Patna – Bangalore – Bhopal – Chandigarh – Coimbatore – Cuttack – Guwahati – Hubli – Hyderabad – Lucknow – Madurai – Nagpur – Pune – Raipur – Siliguri – Thiruvananthapuram – Visakhapatnam : Macmillan India Limited. ISBN: 1403 92235 7. 6.Emery, W., & Camps, A. (2017). *Introduction to Satellite Remote Sensing: Atmosphere, Ocean, land and Cryosphere Applications.* Amsterdam – Oxford – Cambridge, Massachusetts, U.S.A.: Elsevier. ISBN: 978-0-12-809254-5. 7.Janssen, L. L. F., & Bakker, W. H. (2000). *Principles of Remote Sensing: An Introductory Textbook.* International Institute for Aerospace Survey and Earth Sciences. 8.Joseph, G. (2005). *Fundamentals of Remote Sensing (Second Edition).* Hyderabad: Universities Press.	
Course Outcomes:	1. An understanding of basics of remote sensing. 2. Applications of remote sensing to ocean science. 3. To understand basics of sensors used in remote sensing.	

Name of the Programme: M. Sc.Marine Sciences
Course Code: MSC 622
Title of the Course: Remote Sensing and its Applications Practical
Number of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Students who have undergone M.Sc. Part I.	
Objective:	Understanding of remote sensing and its applications in oceanography.	
Content:	1. Analysis of aerosol optical depth (A.O.D.) depth and estimation of atmospheric turbidity parameter and Angstrom exponent. (10 hrs, All references). 2. Chlorophyll-a concentration variability using satellite images (10 hrs, All references). 3. Application of satellite images to environmental issues. (10 hrs, All references).	30 hrs.
Pedagogy:	Practical/ tutorials/ assignments.	
References/Readings:	1.Rees, W. G. (1990). *Physical Principles of Remote Sensing,* (1990). U.K.: Cambridge University Press. 2.Sabins Jr., F. F. (1987). *Remote Sensing: Principles and Interpretations (Second Edition)*. New York, U.S.A.: W. H. Freeman. 3.Robinson, I. S. (1985). *Satellite Oceanography*. Somerset, N.J., U.S.A.: John Wiley & Sons. 4.Narayan, L. R. A. (1999). *Remote Sensing and its Applications.* Hyderabad: Universities Press. 5.Mukherjee, S. (2004). *Textbook of Environmental Remote Sensing.* Delhi – Chennai – Jaipur – Mumbai – Patna – Bangalore – Bhopal – Chandigarh – Coimbatore – Cuttack – Guwahati – Hubli – Hyderabad – Lucknow – Madurai – Nagpur – Pune – Raipur – Siliguri – Thiruvananthapuram – Visakhapatnam : Macmillan India Limited. ISBN: 1403 92235 6.Emery, W., & Camps, A. (2017). *Introduction to Satellite Remote Sensing: Atmosphere, Ocean, land and Cryosphere Applications.* Amsterdam – Oxford – Cambridge, Massachusetts, U.S.A.: Elsevier. ISBN: 978-0-12-809254-5. 7.Janssen, L. L. F., & Bakker, W. H. (2000). *Principles of Remote Sensing: An Introductory Textbook.* International Institute for Aerospace Survey and Earth Sciences. 8.Joseph, G. (2005). *Fundamentals of Remote Sensing (Second Edition).* Hyderabad: Universities Press.	
Course Outcome:	1. Understanding of basic applications of remote sensing in oceanography.	

Name of the Programme: M. Sc.Marine Sciences
Course Code: MSC 627
Title of the Course: Metal Bio-availability, Bio-accumulation and Phyto-remediation
Number of Credits: 03
Effective from AY: 2022-23

Prerequisites for the course:	Students who have undergone M.Sc. Part I.	
Objective:	To understand bioavailability, bioaccumulation and phyto-remediation.	
Content:	**Module I** Sources of metal to marine environment, factors regulating deposition. Definition and significance of speciation, bio-available and residual, driving factors for desorption from the bio-available fraction of the sediments - ionic composition – pH – Eh - organic matter degradation – metal toxicity assessment – SQUIRT – RAC. **Module II** Bioaccumulation – definition, mechanisms of accumulation in biota - Bioaccumulation factor (BAF) - concept of Bio-concentration – Bio-concentration factor (BCA) - harmful effects of bioaccumulation of metals on biota – Bio-magnification in trophic levels – risk to human health. Arsenic bioaccumulation in Sundarban Mangrove Wetland – a case study. **Module III** Metal accumulation in mangroves, phyto-remediation,techniques and applications of mangrove species (Phyto-extraction, Rhizo-filtration, phyto-volatilization, phyto-stabilization, phyto-degradation, Rhizo-degradation/Phyto-stimulation). Translocation Factor. Advantages and disadvantages of Phyto-remediation.	15 hrs. 15 hrs. 15 hrs.
Pedagogy:	Lectures / Assignments / Seminars / Discussion	
References/ Readings:	1.Sarkar, S. K. (2018). *Trace metals in a tropical mangrove wetland.* Springer. 2.Adriano, D.C. (2001). *Trace elements in terrestrial environments.* Springer. 3.Neff, J. M. (2002). *Bioaccumulation in marine organisms.* Elsevier. 4.Hogarth, P. J. (2015). *The biology of mangroves and seagrasses.* Oxford University Press. 5.Tessier, A., Campbell, P. G. C. and Bisson, M. (1979). *Sequential extraction procedure for the speciation of particulate trace metals.* Analytical Chemistry, 51, 844–851.	
Course Outcomes:	1. To understand the bioavailability of metals in sediments. 2. Understanding of accumulation of metals by biota and mangroves. 3. Knowledge of application of mangroves in remediation of metal pollution.	

Name of the Programme: M. Sc. Marine Sciences
Course Code: MSC 628
Title of the Course: Metal Bioavailability, Bioaccumulation and Phyto-remediation Practical
Number of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Students who have undergone M.Sc. Part I.	
Objective:	To determine metal concentration in sediments, macro-fauna, mangroves and remediation potential of mangroves.	
Content:	Digestion and chemical speciation of metals in sediments (Exchangeable, carbonate, Fe-Mn oxide, organic/sulphide and residual bound metals) (5 hrs.; Ref. 3, 4, 5) Estimation of Mn, Co, Ni in sediments by flame AAS method (5 hrs.; Ref. 1, 2, 3, 4, 5) Digestion and estimation of Mn, Co, Ni in tissues of biota (10 hrs.; Ref. 5, 6, 7) Digestion and estimation of Mn, Co, Ni in mangrove tissues for (10 hrs.; Ref. 5, 8, 9)	30 hrs.
Pedagogy:	Field studies/ Laboratory experiments / Interpretations	
References/ Readings:	1.Grasshoff K., Kremling K., Ehrhardt M., editors (1999). Methods of Seawater Analysis.(Third edition). Weinheim: Wiley-VCH. 2.Loring, D. H. and Rantala, R. T. (1992). *Manual for Geochemical Analysis of Marine Sediments and Suspended Particulate Matter.* Earth Science Reviews, 32, 235-283. 3.Tessier, A., Campbell, P. G. C. and Bisson, M. (1979). *Sequential extraction procedure for the speciation of particulate trace metals.* Analytical Chemistry, 51, 844-851. 4.Sarkar, S. K. (2018). *Trace metals in a tropical mangrove wetland.* Springer. 5.Ferreira, G. A., Machado, A. L. S. and Zalmin, I. R. (2004). *Temporal and spatial variation on heavy metal concentrations in the bivalve Pernaperna (Linnaeus, 1758) on the northern coast of Rio de Janeiro state, Brazil.* Brazilian Archives of Biology and Technology, 47, 319-327. 6.Yuzereroglu, T. A., Gok, G., Cogun, H. Y., Firat, O., Aslanyavrusu, S., Maruldali, O. and Kargin, F. (2010).*Heavy metals in Patella caerulea (mollusca, gastropoda) in polluted and non-polluted areas from the Iskenderun Gulf (Mediterranean Turkey).* Environmental Monitoring and Assessment, 167, 257-264. 7.Nath, B., Birch, G. and Chaudhuri, P. (2014).*Assessment of sediment quality in Avicennia marina-dominated embayments of Sydney Estuary: The potential use of pneumatophore (aerial roots) as a bio-indicator of trace metal contamination.* Science of the Total Environment, 472, 1010-1022.	

	8.MacFarlane, G. R. and Burchett, M. D. (2002). *Toxicity, growth and accumulation relationships of copper lead and zinc in the grey mangrove Avicennia marina (Forsk.) Vierh.* Marine Environmental Research, 54, 65-84.	
Course Outcome:	1. To understand bioavailability, bioaccumulation of metals and phyto-remediation process.	

Name of the Programme: M. Sc. Marine Sciences
Course Code: MSC 631
Title of the Course: Aquaculture
Number of Credits: 03
Effective from AY: 2022-23

Prerequisites for the course:	Students who have undergone M.Sc. Part I.	
Objectives:	This course focuses on the provision of basic concepts of farming of aquatic organisms, national and international status. The course educates students to learn different methods of culture, involving preparation of pond to harvesting.	
Content:	**Module I** Principles of aquaculture, history of aquaculture, global scenario, status and prospects of coastal aquaculture in India, traditional aquaculture practices, basic considerations, site selection, water quality management, species selection, feasibility and technique applied for mussel, pearl oyster, fish, lobster and seaweed culture practices. **Module II** Shrimp aquaculture, types of culture practices, traditional, modified traditional, extensive, 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. **Module III** Reproduction, induced maturation by eye stalk ablation, role of X-organ, sinus gland system, status and prospects of brood stock, domestication and genetic improvement, shrimp diseases, pathology and parasitological, prophylactic and therapeutic measures, Coastal Aquaculture Act, 2005.	15 hrs. 15 hrs. 15 hrs.
Pedagogy:	Lectures/ Tutorials/ Assignments/ Self-study	
References/Readings:	1.Bardach, J.E., Ryther J.H. and McLarney, M.O. (1972).*Aquaculture: the farming and husbandry of freshwater and marine organisms.* New York: Wiley-Interscience. 2.Black, K. D. (2000). *Environmental impacts of aquaculture.* Boca Raton, Fl., U.S.A.: CRC Press. 3.Kinne, O. (1983). *Diseases of marine animals.* Vol. 2. Introduction: Bivalvia to Scaphopoda. Hamburg:BiologischeAnstalt Helgoland. 4.Jhingran,V.G. (1991). *Fish and Fisheries of India.* Hindustan Publishing Corporation (India), New Delhi. 5.Lucas J. S., Southgate P. C., and Tucker C. S. (2019). *Aquaculture: Farming Aquatic Animals and Plants.*(Third Edition). Wiley-Blackwell. 6.McVey, J.P. (1993). *CRC handbook of mariculture*. Vol. 1. Crustacean aquaculture. (Second Edition). Boca Raton, Fl., U.S.A.: CRC Press. 7.Parker, R. (2011). *Aquaculture Science*. (Third Edition).Cengage Learning.	

	8.Paulraj, R. (1997). *Hand book on Aquafarming: Aquaculture Feed.* Manual. MPEDA, Cochin. 9.Pillay, T. V. R., Kutty, M. N. (2005). Aquaculture: Principles and Practices. (Second Edition). Blackwell Publishing Ltd. 10.Stickney, R. R. (2016). *Aquaculture: An Introductory Text.* (Third Edition).CABI Publishing.	
Course Outcomes:	1. To understand the basic principles involved in aquaculture practices. 2. To understand traditional management involved in shrimp and fish culture. 3. To understand shrimp hatchery management.	

Name of the Programme: M. Sc. Marine Sciences
Course Code: MSC 632
Title of the Course: Aquaculture Practical
Number of Credits: 01
Effective from AY: 2022-23

Prerequisites for the course:	Students who have undergone M.Sc. Part I.	
Objective:	This course aims to identify cultivable species and understand their reproductive biology.	
Content:	Methods of estimation of dissolved oxygen, BOD, suspended solids, particulate organic carbon and ammonia (15 hrs.; Ref. 1, 2, 3, 4) Identification of cultivable shrimps, mussels, oysters, fish, crabs and sea weeds (9 hrs., Ref. 5) Identification of larval stages of shrimp of commercial importance (4 hrs.; Ref. 6). Reproductive system of shrimp (2 hrs.; Ref.7).	30 hrs.
Pedagogy:	Laboratory analysis and identification	
References/ Readings:	1.Martin, D.F. (1972). *Marine Chemistry*. (Second Edition). M. Dekker (Ed.). New York. 2.Rice, E. W. and Bridgewater, L. (2012). *Standard Methods for the Examination of Water and Waste Water Analysis*. Washington DC: American Public Health Association. 3.Grasshoff K., Kremling K., Ehrhardt M., editors (1999). Methods of Seawater Analysis.(Third edition). Weinheim: Wiley-VCH. 4.Parsons, T. R., Maita, Y. and Lalli, C. M. (1984). *A Manual of Chemical and Biological Methods for Seawater Analysis*. Oxford: Pergamon Press. 5.Carpenter, K.E. & Niem, V.H. (1988). *FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific, Vol. 2.Cephalopods,crustaceans, holothurians and sharks*. (Food and Agricultural Organization, Rome), pp. 687-1396. 6.Motoh, H. (1985). *Biology and ecology of Penaeus monodon*. In: Taki Y., Primavera J. H. and Llobrera J. A. (Eds.). Proceedings of the First International Conference on the Culture of Penaeid Prawns/Shrimps, 4-7 December 1984, Iloilo City, Philippines (pp. 27-36). Iloilo City, Philippines: Aquaculture Department, Southeast Asian Fisheries Development Center. 7.McVey, J. P. (1993). *CRC handbook of mariculture.* Vol. 1. Crustacean aquaculture. (Second Edition). Boca Raton, Fl., U.S.A.: CRC Press.	
Course Outcome:	1. Understand various biological aspects of cultivable species.	