DEPARTMENT OF MARINE SCIENCE

M.Sc., Marine Science Curriculum
2023-2024 onwards

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PROGRAMME SPECIFIC OUTCOME

1. Understand the description, physical properties and process of the ocean.
2. Analyse the chemical properties, nutrients cycles and biogeochemical interactions of the ocean.
3. Understand the organic production, floral and faunal resources of the ocean
4. Study the ocean floor, continents and paleoceanography
5. Understand the marine instrumentations and pharmaceutical and biotechnological applications of marine resources.
6. Comprehends the coastal and marine biodiversity, threats and conservation policies and conventions of marine biodiversity.
7. Realize the methods of ecosystem monitoring and management and various law of the seas.
8. Understand the techniques and applications of fisheries and aquaculture

Programme of Study: **M.Sc. MARINE SCIENCE**

SCHEME OF EXAMINATION - 2023 onwards

Course Code	Name of the Course	Credits	Teaching Hours	Maximum Marks		
				CIA	ESE	Total
Semester- I						
22MSCC01	Physical Oceanography	5	6	25	75	100
22MSCC02	Biological Oceanography	5	6	25	75	100
22MSCO01/ 22MSCO02	Marine Biotechnology / Marine Nonliving Resources	5	5	25	75	100
22MSEC01	Marine Pollution	4	5	25	75	100
22MSLC01	Practical: Physical Oceanography	3	5	40	60	100
22MSVAC1	Marine Nanotechnology	-	3	25	75	100
	Sub-Total	**22**	**30**	**140**	**360**	**500**
Semester- II						
22MSCC03	Chemical Oceanography	5	6	25	75	100
22MSCC04	Marine Biodiversity and Conservation	5	6	25	75	100
22MSCO03/ 22MSCO04	Fish Genetics/ Remote Sensing for Marine science	5	5	25	75	100
22MSEC02	Paleo- Oceanography	4	5	25	75	100
22MSLC02	Practical: Chemical Oceanography	3	5	40	60	100
22MSONCO1	MOOC or Swayam course	-	-	-	-	-
22MSNME01	Non-Major Elective – Course offered to Other Departments: Fundamentals of Oceanography	2	3	25	75	100
	Internship-I	-	-	-	-	-
	Sub-Total	**24**	**30**	**140**	**360**	**500**

Semester- III						
22MSCC05	Fisheries Science and Statistics	5	5	25	75	100
22MSCC06	Geological Oceanography	5	5	25	75	100
22MSCO05/ 22MSCO06	Deep sea exploration/ Immunology for Aquatic organisms	5	5	25	75	100
22MSEC03	Aquaculture	4	5	25	75	100
22MSLC03	Practical: Biological Oceanography and Fisheries science	3	5	40	60	100
22MSVAC2	GIS applications in Marine resources	-	3	25	75	100
22MSNME02	Non-Major Elective – Course offered to Other Departments: Marine Environmental studies	2	3	25	75	100
	Internship-II	-	-	-	-	-
22MSCP01	Project	-	2	-	-	--
	Sub-Total	**24**	**30**	**140**	**360**	**600**
Semester- IV						
22MSCC07	Integrated Coastal Zone Management	5	5	25	75	100
22MSCC08	Marine Geophysics	5	5	25	75	100
22MSEIB02	Advances in Marine Science	5	5	25	75	100
22MSCP01	Project	5	15	50	150	200
	Sub-Total	**20**	**30**	**125**	**375**	**500**
Grand Total		**90**	**120**	**545**	**1455**	**2100**

PHYSICAL OCEANOGRAPHY (Subject Code=22MSCC01)

Objectives:

1. To understand the history, ocean studies and types of research vessels
2. To know the interaction of atmospheric ocean interaction, physical properties of marine environment

Unit-I: History of Ocean Studies

Need for Ocean Studies – Definition of water bodies - Ocean as an important component of Hydrosphere – Historical account on Ocean Studies – Oceanographic exploration – International Oceanographic Organizations - Oceanographic institutions of India – Types of Vessels.

Unit-II: Ocean Description

Dimensions of the Ocean: Depth, Area and Volume – measuring the depth of the Ocean Dimensions - Principles of Echosounder – Seafloor features – mid ocean ridges – trenches – Island arcs and basins – Submarine Canyons – Bengal fan – continental shelf and slope – sea mounts – World Oceans – satellite altimetry.

Unit-III: Atmosphere – Ocean Interaction

Atmospheric boundary layer – Beaufort wind scale and state of sea – Scatterometer – windsat – Special Sensor Microwave/ Imager (SSM/I) – Anemometer – Weather buoys – windstress.

Unit-IV: Physical Properties

Oceanic Heat budget (Fluxes, insolation, infrared, and latent heat) – Temperature – Salinity - Density – Pressure – light – Eckman Spiral – Langmuir circulation – Geostrophic currents – Oceanic circulations - Vorticity – Deep circulation.

Unit-V: Oceanic Processes

Tropical Ocean stratification – E1Nino – ENSO – Global ocean models – coastal models – Ocean waves – Coastal Processes and Tides – Tsunamis – Storm surges.

Unit-VI: Advances in Physical Oceanography (Not For Examination)

Updating current developments in ocean sciences – Monitoring current Oceanographic changes- Learning new techniques to study global warming, Updating current status of AMOC cycle

Reference:

Baretta-Bekker, 1998.Encyclopaedia of Marine Science. Springer, 357pp. Brown, E., and others,2004. Ocean circulation. The Open University,286pp.

Brown, E., and others, 2006. Waves, tides and shallow water processes. The OpenUniversity, 227pp.

Diwan, A.P and Arora, D.K.,1995.Oceanographic Environment, Anmol Publication, New Delhi. Garrison, T., 1998.Oceanography. Media edition,553pp.

Gross, G., 1993. Oceanography: A view of the earth, Prentice Hall Inc, New

Hayes,S.1998. Oceanography–An illustrated guide, John Willey & Sons, New York.
Ikeda, M. and F.W. Dobson, 2005.Oceanographic applications of remote sensing. CRCPress, 492pp.
Marshall, J. and R.A. Plumb, 2008. Atmosphere, ocean and climate dynamics. NIO.Collected reprints.Vol.1 to27+.
Philander, S.G., 2004. Our affair with El NINO. Princeton, 275pp.
Pickard, G.L, 1975. Descriptive Physical Oceanography, Pergamon Press, London.Pinet, P.R.,1999. Invitation to Oceanography, Jones and Barlett Publishers,555pp.
Reddy, M.P.M.,2001. Descriptive Physical Oceanography. Oxford & IBM, 40pp.Rose, D.A.,1977. Introduction to Oceanography, Prentice Hall Inc, New Jersey.
Sverdrup, H.U., M.W. Johnson and Richard H, Fleming, 1942. The Oceans, Their Physics, Chemistry and General Biology, Asia Publishing House, New Delhi.

Course outcome

- ✓ Understanding the development of Ocean science
- ✓ Studying about the physical and geomorphological dimension of oceans
- ✓ Learning of Atmosphere- Ocean Interaction
- ✓ Understanding the Physical properties of the ocean
- ✓ Studying about the various oceanic process
- ✓ Recent developments of Ocean science
- ✓ Learning ocean bottom profiling by using instrumentation
- ✓ Field visit and onboard experience on physical process of ocean

BIOLOGICAL OCEANOGRAPHY (Subject Code=22MSCC02)

Objectives: The goal of biological oceanography is to understand the recent development of biological oceanography. Plankton and their role in ocean food web. Distribution, ecological an economic importance of marine flora and fauna. To understand the classification and zonation of marine environment and organisms.

Unit – I: Introduction to Biological Oceanography

Historical development of biological oceanography, classification of marine environment and marine organisms, properties affecting life in the sea.

Unit-II: Plankton and Organic Production

Plankton-ecological and economic importance, classification, methods of collection, primary and secondary production-methods of estimation of primary production, estimation of standing crop and biomass-numerical methods, plankton volume, adaptation of plankton, factors controlling primary production, red tide phenomenon- its causes and effects. Food chain and food webs-the microbial loop.

Unit-III: Benthic Floral Components

Seaweeds-classification, occurrence, economic importance, seagrass and saltmarshes-distribution, their role in coastal ecosystems, mangroves-distribution, ecological features, importance and uses of mangroves.

Unit-IV: Nekton and Fisheries Oceanography

Nektonic crustaceans, cephalopods, marine reptiles, seabirds, marine mammals-cetaceans, sirenians, pinnipedes, importance of marine mammals, marine fishes-classification, migration and schooling, major food species, mariculture, global fishery resources.

Unit-V: Benthic Faunal Community

Zonations-rocky shores, sandy shores, estuaries and kelp forest, marine sponges-their types and importance, Cnidarians-classification, coral reefs-structure, distribution and limiting factors, marine mollusks-classification, echinoderms-their types and importance, deep sea ecology-Brachiopoda, phoronida and pogonophora.

Unit-VI: Advances in Biological Oceanography:

Biological resource assessment and management using remote sensing and GIS. Innovative technologies i.e. algal biofuels, natural products from marine organisms, marine organisms behaviors and their interactions with the environment. Products, processes, services, technologies, or new ideas that are readily available to markets, governments and society.

References:

Carol M. Lalli and Timothy R. Parsons., 1997. Biological Oceanography-An Introduction, Elsevier pub., 314 pp.

Peter Castro and Michael E. Huber., 2003. Marine Biology, Mc Graw Hill. Pub., 468 pp.

James W. Nybakken., 2001. Marine Biology-An ecological approach, Benjamin Cummings., 516 pp.

Course outcome:

1. History and recent developments of Biological Oceanography
2. Plankton and Organic production in ocean
3. Occurrence and importance of Benthic floral components
4. Distribution and values of marine nektonic organisms
5. Status and applications of fisheries oceanography
6. Zonations of various coastal and oceanic habitat
7. Distribution and importance of oceanic benthic faunal community
8. Deep sea ecology and recent issues in ocean life

MARINE BIOTECHNOLOGY (Subject Code=22MSCO01)

Objectives:

1. To understand the bioactive compounds from marine sources
2. To learn the isolation of bioactive compounds from marine bacteria

Unit-I: Marine Bioactive Compounds

Bioactive natural products – anti-bacterial, anti-fungal, anti-viral, anti-inflammatory, anti- tumour, anti-parasitic and antihelminthic from macroalgae, marine bacteria, dinoflagellates, coelentrates (corals), bryozoans, sponges and tunicates. Extraction, isolation, purification and characterization of bioactive compounds from marine organisms.

Unit-II: Marine Pharmacology

Need and potentialities of marine drugs, importance and sources, carbohydrates and derivatives, aliphatic acids and derivatives. Antibiotic compounds from marine organisms - Toxins, chemistry and pharmacology structure, molecular mechanisms, types and functional properties. Pharmacological evaluation of drugs – routes of drug administration – absorption, distribution, metabolism and excretion of drug.

Unit-III: Enzyme Technology

Introduction to Enzymes- Terminologies, Nomenclature & Classification of enzymes. Protein, Non-protein enzymes. Ribozymes, Metallo enzymes, DNA- Enzymes. Enzyme- Lock and key Hypothesis, Kinetics Model. Regulations of enzyme. Industrial applications. Drug discovery-properties of enzymes.

Unit-IV: Molecular Biology

Bio macromolecules – structure and function. DNA- as a genetic material – Historical evidence. Bio transformation procedure- Transformation, Transduction &Transfection. Recombinant DNA-technology- Gene structure, promotor, operator.

Unit-V: Molecular Tools

PCR – principle and synthesis; its applications: Types of PCR- DNA isolation techniques-Agarose gel electrophoresis, poly acrylamide gel electrophoresis- Northern blot-Western blot-Enzyme Linked Immunosorbent Assay (ELISA).

Unit-VI: Marine Biofouling

Problems by biofouling – Antifouling, Befouling and Control technology - Biofouling organisms - paints and its environmental pollution – Biotechnological approach to biofouling control. Recent Approaches to control Fouling Organisms.

Reference

- Fundamentals of Enzymology: Nicholas Price & Lewis Stevens
- Enzymes : Biochemistry, Biotechnology and Clinical Chemistry- Trevor Palmer
- Biochemistry text book by Stryer, Voet and Lehninger (Relevant Chapters)
- Essentials of Molucular Biology (2nd edition): By Friefelder
- Proteins by Gary Walsh
- Bergey's Manual of Systematic Bacteriology - Vol 1
- Marine Biology- Lalli C.M. and T.R. Parsons., 1997. Biological Oceanograpahy - An Introduction,Elsevier, 314 pp
- Marine Pollution- Clark, R. B. 2001. Marine pollution, Fifth edition. Oxford University press, NewYork Inc., 231pp

Course outcome

1. Importance of Marine products globally
2. Some of the most pertinent applications of aquaculture/marine biotechnology
3. Transgenic, Disease Resistance, and Conservation etc
4. DNA fingerprinting to know polymorphism in fish stocks
5. Developing marker-assisted selection technologies
6. Improving technologies for cryo-preservation of gametes and embryos
7. Identifications Seaweeds and Their Products
8. Therapeutic Agents from several marine species

MARINE NON-LIVING RESOURCES (Subject Code=22MSCO02)

Unit -I:

Non-living resources- Ocean resources in coast, shelf, slope and abyssal - Distribution of various kinds particularly in India ocean- Their forms, grade and potentiality- Coastal aquifer its nature, form, migration - Integrated resource management-Preservation and conservation of non-living resources including water-Renewable & non-renewable resources. Resources originated - terrigenous, chemogenous, biogenous, allogenic and antigenic.

Unit-II:

Marine minerals - Potential in east and west coasts of India-Mineral resources – Mineral enrichment in the Black sea-Marine phosphorites-Placer minerals-Marine sulfides-Manganese nodules and crusts-Methods in the exploration of seafloor minerals deposits-Methods of exploration in manganese nodules, phosphorite and polymetallic sulfides-Sea baulk (non-living resources)

Unit-III:

Beach placers, hydrocarbon resources, manganese nodules, phosphotites, sulphur, dissolved salts, limestone deposits, evaporates - their mechanism of origin and global distribution pattern. Methods of deep-sea exploration of mineral resources - gravity, magnetic and seismic methods - principle and techniques.]

Unit-IV:

Drugs - Marine drugs – Importance – Sources-Carbohydrate and derivatives- Nitrogenous compounds-Antibiotic compound from marine animals – Bioactive compound – Sources- Natural function -Ecological and distribution in the marine environment.

Unit -V:

Toxin from marine animals - Type of toxins- Functional properties – toxin-Venoms- Venom in marine animals - sea snake, fish and mollusks -Pharmacological and toxicological properties- Marine steroids - Types- Marine cartenoids- Sterols of marine invertebrate.

Unit-VI:

Uses of various bioactive compounds from seaweeds and other algal sources.

Text Books and Reference Books:

1. Gautam, A. (1998). Conservation & Management of Aquatic Resources. Daya Publishing House.
2. Madhu, M., Jakhar, P.,& Adhikary, P. (2013). Natural Resource Conservation. Satish Serial Publishing House.
3. Singh, R. (2013). Fishery Resources. Pearl Books Publishing.
4. Teleki, P., Dobson,& M., Moore, R. (1987). Marine Minerals. Reidel Publishing Company.

MARINE POLLUTION (Subject Code=22MSEC01)

Objectives:

1. To gain the knowledge on types, sources and impact of pollution on marine resources
2. To learn the types of marine pollution monitoring methods, Ocean management and marine pollution abatement programs.

Unit-I: Introduction

Marine pollution – GESAMP definition and its role – major marine pollutants and types and impacts – classification – nature, sources and transportation pathways. Conservative and non-conservative pollutants.

Unit-II: Major Marine Pollutants

Types, sources and ecological effects on marine environment – Sewage, heavy metal, pesticide, oil, nuclear, thermal, plastic and micro-plastic pollution. Ecological impact of pollutants on marine organisms. Effect of mining and dredging operation on marine environment.

Unit-III: Marine Pollution Monitoring

Monitoring strategies of marine pollution –Physical, chemical and biological methods. Biological indicators and accumulators - bioaccumulation and biomagnification. Conservation and management of the living resources in the high sea. IUCN Categorization. Coastal issues –climate change and sea level rise.

Unit-IV: Ocean Management

National and international agencies for Ocean management – IMO, IUCN, FAO, UNEP, MoEF&CC and MOES. Principles of remote sensing and GIS for Ocean management, Coastal and ocean resource management - endangered coastal biota, marine biosphere reserves and marine parks.

Unit-V: Pollution Abatement Programs

Pollution abatement programs in developed countries – case studies. Assessing pollution damage. Law pertaining to marine pollution. State of some seas – Biodegradation and bioremediation.

Unit-VI: Recent Problems In Marine Environment (Not For Examination)

Microplastics – Micro plastics in marine environment – Sources and characterization – Bioaccumulation - Impacts on marine organisms – Marine food web –Microplastic toxicity and its effects on organisms and ecosystems.

Employability:

Students get employability skills in EIA and water quality monitoring companies and Oceanographic institutes.

Course outcome

1. Students able to understand the various marine pollutants and its impact on various resources.

2. Methods for marine pollution monitoring, assessment of pollution damage and laws pertaining to marine pollution will be known

Reference:

Carl J. Sindermann, 2005. Coastal pollution: Effects on living resources and humans (Marine Science Series). 271 pp.

Churchill, R. R and A.V. Lowe, 1983. The Law of the Sea, 3d ed. (Manchester: Manchester University Press) 494 pp

Clark, R. B. 2001. Marine pollution, Fifth edition. Oxford University press, New York Inc., 231pp.

PHYSICAL OCEANOGRAPHY PRACTICAL (Subject Code=22MSLC01)

GENERAL: Sketching, describing demonstration of marine research instruments and equipments:– Snorkel, SCUBA, moorings, floats and drifters, ADCP, CTDs, Reversing thermometer, current meters, echo sounders, wave measurers, tide gauges, Secchi disk, polarizing petrological microscope, Boomerang sediment samplers, box and piston corers, Patterson grab, sidescan sonar, marine magnetometer, ocean bottom seismometer and Tsunami Warning Systems.
PHYSICAL OCEANOGRAPHY: Problems related to Physical oceanography.GEOLOGICAL OCEANOGRAPHY: Problems related to Geological oceanography

Evaluation		Marks
Continuous Internal Assessment		40
Observation	5	
Record Note Book	10	
Test practical	25	
University Practical Examination		60
Practical's Total		100

MARINE NANOTECHNOLOGY (Subject Code=22MSVAC1)

Unit-I:

Introduction – definition of a nanosystem-Surface to volume ratio-Surface energy and surface stress- properties at nanoscale (optical, mechanical, electronic and magnetic)

Unit-II:

Classification based on dimensionality-Quantum Dots, Wells and Wires- Carbon- based nano materials (buckyballs, nanotubes, graphene)- Metal based nano materials (nanogold, nano silver and metal oxides) -Nanocomposites- Nanopolymers -Nanoglasses -Nano ceramics -Biological nanomaterials.

Unit-III:

Classification of synthesis: Top down and bottom up nanofabrication. Chemical Methods: Metal Nanocrystals by Reduction – Solvothermal Synthesis- Photochemical Synthesis – Sonochemical Routes- Chemical Vapor Deposition (CVD) -Metal Oxide – Chemical Vapor Deposition (MOCVD). Physical Methods:Ball Milling -Electrodeposition – Spray Pyrolysis – Flame Pyrolysis -DC/RF Magnetron Sputtering – Molecular Beam Epitaxy (MBE)

Unit-IV:

Nanofabrication: photolithography and its limitations- Electron -beam lithography (EBL). Characterization: Field emission scanning electron microscopy (FESEM),-Environmental Scanning electron Microscopy (ESEM), HRTEM, X-ray photoelectron spectroscopy (XPS) and STM

Unit-V:

Solar energy conversion and catalysis – Molecular electronics and printed electronics -Nanoelectronics -Polymers with aspecial architecture – Liquid crystalline systems – Linear and nonlinear optical and electro-optical properties.

Unit-VI:

Applications in displays and other devices -Nanomaterials for data storage – Photonics, Plasmonics- Chemical and biosensors -Nanomedicine and Nanobiotechnology -Nanotoxicology challenges.

Text books:

1. Bhusan, Bharat (Ed), Springer handbook of Nanotechnology, 2nd edition, 2007.
2. Hari Singh Nalwa, Nanostructured materials and Nanotechnology, Academic press, 2002
3. Pradeep T., A textbook of Nanoscience and Nanotechnology, Tata McGraw Hill Education Pvt. Ltd., 2012.

CHEMICAL OCEANOGRAPHY (Subject Code=22MSCC03)

Objective:

1. To understand the chemistry and its composition of marine water
2. To learn about the important chemical elements and nutrient cycle in marine environment

Unit-I: Introduction

General introduction of marine chemistry, chemical properties of sea water, composition of sea-water, oxidation-reduction potential of seawater constancy, concept of chlorinity and salinity, method of measurement.

Unit-II: Chemical Elements

Major and minor elements of seawater, abundance and residence time, anoxic basin. Interaction of major and minor elements with marine organisms. Trace elements concept, types of distribution, inputs and cycling of trace elements in coastal waters.

Unit-III: Nutrients Cycle

Organic matter, types, sources, seasonal variation, ecological processes and significance. Nutrients origin, Fertility of the sea, nitrogen, phosphorus, determination, seasonal variation. Nitrogen - Phosphorus ratio, Silicon: origin, distribution cycle and their significance. Gaseous relation: Dissolved oxygen, carbon dioxide origin and distribution of CO_2 -CO_3 system.

Unit-IV: Biogeochemical Interactions

Biochemical interaction of Ocean and atmosphere-phytoplankton. Biogeochemical cycles - DMS and climate, El Nino and ENSO, climate change in recent century, role of Ocean in climate change and carbonate system, global warming, green house effect, heat budget and sea levelrise.

Unit-V: Advances in Chemical Oceanography-I

Chemical Oceanography with overview of the chemical composition oceans analysed with modern technologies in Electrochemistry & other advanced techniques. Chemical composition of each ocean with reference to the physical & physiochemical characteristics and biotic environment at the molecular level using applications of recent advances *viz* Nanotechnology. Natural resources-gaseous, liquefied and solid chemical parameters. Additional resources, which were unfathomed till recent times. Exploited resources earthed using modern excavation techniques. Unexploited resources and recent & modern techniques to excavate these chemical wealth.

Unit-VI: (Advanced Biogeochemical Techniques (Not for Examination)

Multitude of advanced analytical tools used in marine sample analysis– Marine Data Analysis involve multivariate evaluation techniques in Marine Chemical research and Marine Chemical Modelling. Explain physical marine chemistry. Isotope geochemistry, Sediment chemistry and Diagenesis, Air sea exchange and control of carbondioxide and Estuarine geochemistry, chemistry of the Artic ocean, Major river flow in Arctic ocean- Chemistry of particulate matter from the south Indian and Antarctic oceans, Chemicaltracers.

Reference:

Bigg G.R.., 2003. The Oceans and Climate, Cambridge University Press, 273pp.
Fasham M.J.R., 2003. Ocean Biogeochemistry: The role of the ocean carbon cycle inglobal change.
James, R.,2005. Marine Biogeochemical cycles, 2/e. Open University, Milton Keynes,130pp.
Riley, J.P.andChester,R.,1971.Introduction to Marine Chemistry, Academic Press,465pp.
Schulz, H.D., 2000.Marine geochemistry. Springer-Verlog.
Sverdrup K.A., and Virginia Armbrust, 2008. Introduction to the World's Oceans- Science, 508

Course Outcome:

1. Sampling techniques of marine sources.
2. Preservation and storage of Marine samples
3. Understanding about the various chemical methods
4. Chemical analysis of sea water
5. Analysis of nutrients in sea water
6. Evaluation of chlorinity and salinity of sea water
7. Measurement of trace elements by using AAS
8. Demonstration of spectrophotometer

MARINE BIODIVERSITY AND CONSERVATION (Subject Code=22MSCC04)

Objectives:The objectives of this course are include: To help students develop an understanding of themajor issues in marine biodiversity research. To show students how biodiversity is measured and whatare the major patterns of diversity. To develop an understanding of the terms structural and functional biodiversity and the relationship between the two. To know the values of marine biodiversity and threats of marine biodiversity and To discuss and debate issue concerning conservation of marine biodiversity.

Unit-I: Introduction to marine biodiversity

Understanding the marine biodiversity and conservation, origin of conservation biology, divisions of biodiversity, keystone species, ecosystem functioning, world's marine biological diversity, marine hot spots-cold seeps, hydrothermal hotspots, marine biosphere reserves and their importance in India and abroad.

Unit-II: Patterns and valuing biodiversity

Species diversity, species richness, species evenness, factors affecting species diversity, values of biodiversity-ecological economic values, ethical values, socio-economic values and conservation feasibility values.

Unit-III: Threats to marine biodiversity

Biodiversity in special ecosystems with reference to mangroves and coral reefs. Species extinction, vulnerability to extinction, habitat destruction-coral reefs and mangroves, habitat degradation, habitat fragmentation, Overexploitation, alien species, diseases, global climate change-coral bleaching, ocean acidification.

Unit-IV: Conservation strategies

Importance of conservation, IUCN and their importance, various conservation strategies-germplasm banks, cryopreservation, marine protected areas, breeding and culture of food and endangered species, sea ranching, mesh size regulation, TED, fishing holidays, conservation and development at national and international level.

Unit-V: Conservation policies and legislations

Various legislations and regulations in conservation of marine biodiversity-the role of MoEn & F in conservation, NGO's involvement in conservation, various case studies related to coastal marine conservation science and policy with reference to Indian maritime states.

Unit-VI: Recent Advances in Marine Biodiversity & Conservation

Climate impacts on global hot spots of marine biodiversity, the relationship between marine biodiversity conservation and poverty alleviation in the strategies of rural development. Application of Remote Sensing and GIS in assessing marine biodiversity.

References:

1. Richard B. Primack., 2002. Essentials of conservation biology – 3rd edition, Sinauer Assoc. Inc. Pub., USA, 698 pp.

2. Singh, J.S., S. P. Singh and S. R. Gupta., 2006. Ecology, Environment and Resource conservation., Anamaya Pub., New Delhi, 688 pp.

Course outcome

1. Understanding the marine biodiversity and conservation
2. Patterns and values of marine biodiversity
3. Threats to marine biodiversity
4. Marine conservation strategies
5. Marine conservation policies and Legislations
6. Marine biosphere reserves and importance
7. Marine ecosystem functioning
8. Biodiversity in special ecosystems

FISH GENETICS (Subject Code=22MSCO03)

Unit-I:

Historical development of genetics; Cell structure, cell division and physical basis of heredity; Probability concepts; Mendelian principles: scope, limitation, Modifications to Mendelian ratios: Multiple alleles, Epistasis; Chromosome theory of inheritance; Genetic variation: Causes and measurement; Linkage and crossing over, Recombination, Interference.

Unit-II:

Modern concept of gene; DNA as genetic material, Genetic code and protein synthesis, Transfer and regulation of genetic information. Genetic bottleneck: genetic drift; Concept of Mutation: drift equilibrium; Effect on population structure, Intensity of selection.

Unit-III:

Selection: Basis of selection, Estimation of breeding values: Various sources of information, Least squares and BLUP methods. Estimation of genetic gain: Response to selection, Accuracy of selection; Aids to selection: Methods of selection; selection indices, combined selection.

Unit-IV:

Selection and mating designs for select traits: growth, disease resistance, color enhancement, fin characters; Genotype x Environment interaction and its role in fish/shellfish breeding.

Unit-V:

Effect of breeding programme on genetic diversity of farmed animals; Present status of breeding; Cross breeding in aquaculture; Broodstock management; Inbreeding depression and heterosis in various economic characters.

Unit-VI:

Conservation and preservation of aquatic species: Issues and strategies, Risk status/population viability analysis and classification; Breeding strategies of threatened species for restocking and live gene bank.

Book suggested:

1. Lutz CG. 2003. Practical Genetics for Aquaculture. Wiley-Blackwell.
2. Hartl D & Clarke AG. 2007. Principles of Population Genetics. 4th Ed. Sunderland.
3. Thomas PC, Rath SC & Mohapatra KD. 2003. Breeding and Seed Production of Finfish and Shellfish.
4. 1. Allendorf FW. 2007. Conservation and the Genetics of Populations.

REMOTE SENSING FOR MARINE SCIENCE (Subject Code=22MSCO04)

Unit – I:
Remote sensing – history & development, definition, concept and principles. Energy resources, radiation principles, EM Radiation and EM Spectrum. Black body radiation, laws of radiation. Interaction of EMR with atmosphere and earth's surface

Unit – II:
Platforms – types and their characteristics. Satellites and their characteristics – geo-stationary and sun-synchronous. Earth Resources Satellites -LANDSAT, SPOT, IRS, IKONOS satellite series. Meteorological satellites – INSAT, NOAA, GOES

Unit –III:
Sensors – types and their characteristics, across track (whiskbroom) and along track (pushbroom) scanning. Optical mechanical scanners – MSS, TM, LISS, WiFS, PAN. Concept of resolution – spatial, spectral, temporal, radiometric. Basic concept and principles of thermal, microwave and hyperspectral sensing

Unit – IV:
Basic principles, types, steps and elements of image interpretation. Techniques of visual interpretation and interpretation keys. Multidate, multispectral and multidisciplinary concepts. Instruments for visual interpretation

Unit – V:
Remote sensing data products and their procurement. Ground truth collection – spectral signatures. Commonly used ground truth equipments - use of radiometers. Display forms – computer printouts, thematic maps, dot density maps

Unit-VI:
Application in the marine environment, satellite missions in ocean studies; Indian and Global.

Books Recommended
1. Campbell, J.B.2002: Introduction to Remote Sensing. Taylor Publications
2. Jensen, J.R. 2000: Remote Sensing of the Environment: An Earth Resource Perspective. Prentice Hall.
3. Joseph George, 2003: Fundamentals of Remote Sensing. Universities Press

PALEO-OCEANOGRAPHY (Subject Code- 22MSEC02)

Unit-I: Climatology

Climatology- Definition, Weather, Climate, Monsoon, Indian climate, Natural climate change, Greenhouse gasses, Climate variability**,** Anthropogenic influence on climate change, Understanding Ocean and Climate Processes.

Unit-II: Paleoceanography

Paleoceanography, Approaches to palaeoceanographic reconstructions – various proxy indicators for palaeoceanographic interpretation - Different type of dating, Ocean Drilling programme and its major accomplishments in palaeoceanography, Late Quaternary climate change, Role of past global changes organization (PAGES)

Unit-III: Climate Change

World Oceans, Nutrient Uptake and Gas Exchange, Carbon budget, Global warming, Global climate change

Unit-IV:Impact of Climate Change

Sea Level change, Impact on the coast, Changes in Meridional overturning circulation, Changes in polar region, Marine organisms and Seawater Chemistry.

Unit-V: Management Strategy

IPCC report, Management strategy for climate change induced issues - Socioeconomic & cultural, Health, Natural disaster, etc., Government and Non-governmental organization and its role.

Unit-VI: Current Status of Climate

Current status of Atmospheric green house gas level, Global weather, climate and extreme events observation. Mechanism and climate trend analysis and discussion.

References

King, C.A.M., 1975. Introduction to Marine Geology and Geomorphology. Edward Arnold, LondonThe Ocean and Climate. Grant R. Bigg
Climatology by D.S.Lal
http://www.insaindia.org/pdf/Paleoclimate-Final_18-12-09-web.pdf
Sverdrup, Duxbury, Duxbury, An introduction to the world Ocean.Paul R. Pinet. Invitation to Oceanography.
Wefer, G. and other, 2003. Ocean Margin Systems. Springer, 495pp.Charles, A., 2005. Geological Oceanography.
King, C.A.M., 1959. Beaches and Coasts, Edward Arnold, London

CHEMICAL OCEANOGRAPHY PRACTICAL (Subject Code=22MSLC02)

Sampling techniques – seawater sampling, preservation and storage. Sample preparation prior to analysis, soluble components of seawater, filtration, solvent extraction, coprecipitation, adsorption techniques, chemical pretreatment of organics. Principles of analysis, wet chemical methods, titrimetry, spectrometry, photometry and electrometry. The determination of pH, electrical conductivity, dissolved oxygen, total dissolved solids, turbidity, total organic matter, dissolved and particulate organic matter.

Determination of major anions - Salinity, total alkalinity, chloride, bicarbonate, sulphate. Determination of major cations – calcium, magnesium, sodium and potassium. Measurement of nutrients – nitrite, nitrate, ammonia, phosphate.Determination of trace elements, classical and advanced analytical instrumentation, atomic absorption spectrophotometer.Analysis of iron, manganese, cadmium, nickel, cobalt, chromium, copper, lead, zinc. Cold vapour techniques – measurement of arsenic, mercury and selenium. Quality control tools, precision, accuracy, error in analysis, statistical methods, interpretation of datas.

References:

Crompton, T.R., 1997. Analysis of seawater, Springer, UK, 510pp Manahan, S.E., 1998.Fundamentals of Environmental Chemistry, CRC Press, NewYork,1230 pp. Beer, T., 1996. Environmental Oceanography –CRC Press, New York,367pp.

APHA,1995. Standard methods for analysis of water and wastewater, American Public Health Association, Springer, New York1600pp.

NON-MAJOR ELECTIVE – I FUNDAMENTALS OF OCEANOGRAPHY (Subject Code=22MSNME01)

M. Sc. Marine Science students will choose one course from any of the courses with a minimum of 2 credits offered by other departments of the University. Courses are commonly tutored on Thursdays' afternoons.

For courses offered by Department of Marine Science for students of other programmes of study see at the end of this book of syllabi.

FISHERIES SCIENCE AND STATISTICS (Subject Code=22MSCC05)

Objectives:

1. To learn basic ichthyotaxonomic skills and know the fisheries resources in coastal and open ocean.
2. To get knowledge on fisheries forecasting system in India and various preservation and processing techniques.

Unit-I: Introduction to Ichthyology

Systematics, Taxonomy and outline classification of fishes; Importance of taxonomy, International Code of Zoological Nomenclature, Morphology, morphometric, meristic, osteology and soft anatomical characters, Describing and naming of a new species; Cataloguing

Unit-II: Marine Fisheries Resources of India

Catch trends – pelagic, demersal, midwater, deep sea and oceanic fishery. Trawl, gill net, lines, seine, bag net fishery. Collections of data for estimation of fish catch in marine systems

Unit-III: Fisheries Forecasts

Fisheries forecasting system in India and other countries – Application of remote sensing and GIS for monitoring fish fauna; Global Positioning System (GPS). Potential fishing zones.

Unit-IV: Fish Preservation and Processing

Preservation methods – Chilling, Freezing and Irradiation. Processing methods – salting, drying, smoking and canning. Quality control and quality assurance. Marine fisheries management and conservation

Unit-V: Fisheries Statistics

Fisheries data collection and analysis. Sampling methods. Stock assessment techniques. Basic statistical tools and software for fisheries data analysis.

Unit-VI: Fisheries Extension (Not for Examination)

Sustainable management of fisheries resources. Catch per unit effort. Species level identification of major commercial fishes. Fisheries Research Institutes in India

Employability: Student will get opportunity in state fisheries departments, aquaculture industries, fish processing and preservation sector.

Outcome of the course

1. Student understands the importance of ichthyotaxonomy, morphometric and meristic features, various gears and crafts used for fishing will be known

2. They can also understand the importance of collection of data for estimation of fish catch, understands the fisheries management and conservation methods

References

Moyle, P. B. and J. R., Cech., 1996. Fishes – An Introduction to Ichthyology. Prentice Hall Inc. N. Jersey, 594p

Biradar, R.S. (2002). Course manual on Fisheries Statistics, 2 nd Edition, CIFE, Mumbai

Fischer, W. and Biachi, G., 1984. FAO-identification sheets for fishery purposes. Vol I-VI pages variable.

Jayaraman, K. C., 2002. Fundamentals of fish taxonomy. Publ.

Patel, A.N. and Surendra Singh. 1992. Remote sensing – Principles and Applications. Scientific publishers, Jodhpur. 161 p

GEOLOGICAL OCEANOGRAPHY (Subject Code=22MSCC06)

Objectives:

1. To know the ocean basins and its fracture systems, orgin and its compostion
2. To understand the marine sediments and mineral deposits and plate tectonics

Unit-I: Ocean Basins

Shape of ocean floor – Ocean floor features - Continental margins: shelf and slope - Origin of ocean basins — Oceanic ridges – East Pacific Rise – Mid Atlantic Ridge - Rift valleys – South African Rift valleys - Trenches – Marianas trench – Fracture systems – Oceanic crust: origin and composition

Unit-II: Coastal Ocean

Beaches – Beach sands - Beach zones – Longshore drift – Barrier Islands – Tidal types of Coasts - Classification of coasts – Wave action and Shoreline development – coastal features – Marine terraces - Vulnerability of coasts to natural marine disasters

Unit-III: Concepts of Plate Tectonics

Outline of plate tectonics – Plate boundaries – Geologic processes at plate boundaries – Seafloor spreading – Geomagnetic and other evidences for seafloor spreading – Subduction zones – Island arc systems.

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Unit-IV: Marine Sediments and Mineral Deposits

Terrigenous - Biogenic -Authigenic - Volcanogenic - Cosmogenous – Turbidites – Hemipelagic: shallow sediments – Sulphide chimneys – Pelagic sediments: Oozes and clays - Phosporites - Placer minerals: origin of marine placers – species and distribution - Ferromanganese oxide minerals: origin of nodules and crusts and distribution – Hydrothermal minerals:

Unit-V: Palaeooceanography

Panthalassa – Tethys Sea – Approaches to palaeooceanographic reconstructions – various proxy indicators for palaeooceanographic interpretation - Joint Global Ocean Flux Study (JGOFS) and its applications in palaeooceanography – Ocean Drilling programme and its major accomplishments in palaeooceanography – Eustary - Palaeooceanographic scenario in and around Ariyalur, Tamil Nadu.

Unit-VI: Advances in Geological Oceanography (Not for Examination)

Gas hydrates exploration, technique in Indian sub-continent world current scenario, carbon budget and Climate change issues. Future studies on Global Warming and Sea level rise. Sustainable development on Geological oceanography.

References:

Abrantes, F.and Mix, A.C.,1999. Reconstructing ocean history. Springer,4 43pp. Charles, A., 2005.GeologicalOceanography.

Cronan, D.S., 2000. Handbook of Marine Mineral Deposits.CRC press, 406pp.

Einsele, G.,2000. Sedimentary basins: evolution, facies and sediment budget. Springer,792p p. Eisma, D., Intertidal deposits, CRC Press,525pp.

King, C.A.M., 1959. Beaches and Coasts, Edward Arnold, London.

King, C.A.M., 1975. Introduction to Marine Geology and Geomorphology. Edward Arnold, Lon- don.

Radhakrishnan, V.,1997. General Geology, V.V.P. Publishers, Tuticorin,2 28pp. Seabold, E.and Berger, W.H.,1982. The Sea Floor, Springer Verlag.

Shepard, F.P., 1977. Geological oceanography: evolution of coasts, continental margins &the deep-sea floor. Crane, Russak, 214pp.

Shepard, F.P., 1978. Geological Oceanography, Heinmann, London. The Ocean, 1969. A Scientific American book, W.H. Freeman and company, San Francisco. Wefer, G. and other, 2003.Ocean Margin Systems.Springer,495pp.

Course outcome

1. Detail study about submarine futures of world ocean
2. Studying about the coastal geomorphological features and coastal ocean process
3. Understanding the plate tectonic theory
4. studying about the sea floor, sediments nature
5. understanding about past oceanographic processes
6. Studying about the sesimological study in world ocean
7. Knowing about various sea floor sediment process
8. Exploration of ocean floor living and non-living resources

DEEP SEA EXPLORATION (Subject Code= 22MSCO05)

OBJECTIVES:

To briefly introduce some important techniques needed for understanding the field of offshore marinescience. To understand important computer aided packages used for present day deep sea exploration.

Unit-I: Introduction

Introduction to oceanography: the world's oceans and seas, properties of seawater, physico-chemical factors in the marine environment such as temperature, density, nutrients, salinity, dissolved gases, waves, tides, oceanic currents,

Unit-II: Deep Sea Environment

Marine geological setting, genesis and occurrence of Metalliferous sediments, Phosphorites (including mineralogy and geochemical environments of modern deposition). Marine mineral resources: Importance, biotic and abiotic. Polymetallic nodules, Cobalt and other related crusts, Hydrothermal sulfide deposits including black and white smokers.

Unit-III: Exploration Instruments

Sampling equipment: water samplers such as Niskin sampler, Hydro-Bios sampler, Rosette samplers; sediment samplers such as van Veen grabs and corers. Principles of electrical survey at sea—Instruments— Data acquisition and interpretation: Princi-ples of gravity survey at sea—Instruments—Data acquisition, Reduction, Gravity anomalies and interpretation– Principles of radiometric survey at sea—Instruments— Data acquisition, Reduc-tion, radiometric anomalies.

.**Unit-IV: Technical Principles**

Principles, instrumentation, methodology and applications of onshore and offshore geophysical explorations - Gravity, magnetic, seismic, electrical and radioactive techniques. Well Logging Techniques: Electrical, Radioactive, Sonic and Miscellaneous. Echosounder and its uses.

Unit-V: Recent Advanced Techniques

Acoustic direction finder, Multibeam Echosounder; Bottom penetrating echosounder; seismic array (Sleeve Guns); CTD Rosetta frame with water samplers; Deep Sea Mooring with ADCP, current meter and Sediment Trap; Deep Digging Dredge (Triple-D) for sampling benthic macrofauna; Altrap Bottom Lander with larvae collector; Albex multi-purpose Bottom Lander for measurements and experiments at the sea floor; Mobile underwater vehicle (MOVE)

Unit-VI: Marine Science Data Analysis (Not for Examination)

Simple linear correlations: Karl Pearson's *r* and Spearman's Rank Correlations – Coefficient of determination - Simple Linear Regression – Multiple correlation – Coefficient of multiple deter-mination -Multiple regression - Cluster Analysis.

Reference:

Jones, E. J. W., 1999. Marine Geophysics. John Wiley, 474 p.

Kearey, P., M. Brooks, I. Hill, 2002. An Introduction to Geophysical Exploration, 3e. John Wiley, 474 p.Stein, S. and M. Wysession, 2000. An Introduction to Seismology, Earthquakes, and Earth Struc-ture Kearey, P., K. A. Klepeis and F.J. Vine, 2009. Global Tectonics, 3e. John Wiley.

Course outcome:

1. Learning about underwater design
2. Preparation of deep sea exploration prcedure.
3. Understanding structure of ocean environment
4. Sampling and Data analysis
5. Recent advancement in under water echniques
6. Statistifical significance analysis - p value, Z and t test etc.
7. Regression and Cluster analysis

IMMUNOLOGY FOR AQUATIC ORGANISMS (Subject Code= 22MSCO06)

Unit-I:
Introduction- Fish immunology and terminologies; Historical developments; Phylogeny of fish immune system. Lymphoid tissues and cellular components of the immune system

Unit-II:
Non-specific humoral and cellular defence mechanisms. Specific defence mechanisms; Memory function and immunological tolerance.

Unit-III:
The complement system, function, components, complement activation. Antigens and antigenicity; Structure of antibody. Types of antibodies, Theories of antibody formation.

Unit-IV:
Antibody-mediated immune response: General characteristics, Immunoglobulin classes, Structure and function and synthesis

Unit-V:
Phagocytic systems; Lymphoid systems; Antigen processing and major histocompatibility complex. Cell-mediated immune response and its components; Hypersensitivity reactions.

Unit-VI:
Invertebrate defense mechanisms.

Book reference:
1. Kurt Buchmann, Christopher J. Secombes. 2022. Principles of Fish Immunology from Cells and Molecules to Host Protection.
2. Fish Immunology and Biotechnology. Author, Archana Prabhakar. Publisher, Swastik Publications, 2010.
3. B. Rinkevich, W. E. G. Müller . 1996. Invertebrate Immunology. Springer

AQUACULTURE (Subject Code=22MSEC03)

Unit-I: Introduction to aquaculture

Overview-importance of aquaculture, global scenario, present status in India-prospects and scope. Commercially important cultivable finfishes, shellfishes and aquatic plants, criteria for selection of candidate species. Culture techniques-monoculture, polyculture-pond, raceway, cages, pens, raft and rope culture.

Unit-II: Aqua Hatchery

Types of hatcheries, criteria for site selection for hatchery-topography, water supply, seed production technology for edible fin fishes, crustaceans and molluscs-maturation, induced breeding and spawning, larval rearing, water quality, feeding, diseases in larvae and health management.

Unit-III: Aqua Farming

Aqua-farming systems-traditional, extensive, semi-intensive, intensive. Criteria for site selection for aqua farm-topography, soil type, water supply. Aqua farm construction, pond preparation, culture of commercial important species-Seaweeds, Fin fishes, Crustaceans and Molluscs.

Unit-IV: Aqua Feed Technology & Aquaculture Biotechnology

Types of feed, feed formulation, feed ingredients, micro diets, nutritional quality of compounded feeds, culture of live feeds-microalgae, rotifer, *Artemia*, cladoceran, copepods, amphipods and polychaetes, nutritional composition of live feeds, bioenrichment, cryopreservation of fish gametes, sex reversal, transgenic fish production, fish cell line.

Unit-V: Ornamental Aquaculture

Design and construction of aquarium and oceanarium. Aquarium accessories-Aerators, filters and lighting, water quality requirements. Setting up of aquarium, Quarantine measures. Aquarium maintenance and water quality management for marine aquariums. Breeding of marine ornamental fishes (clown fishes and Damsel fishes). Feed requirements of aquarium fishes. Common diseases of ornamental fishes and its control.

Unit-VI: Technological Innovations in Aquaculture

Recirculating Aquaculture Systems (RAS), Integrated Multitrophic Aquaculture (IMTA), Zero Water Exchange Aquaculture Production Systems (ZWEAPS), Solar power in sustainable aquaculture, Biofloc aquaculture system, Copefloc aquaculture system.

References:

1. Chiranjib Chakraborty and Arup Kumar Sadhu., 2001. Biology, hatchery and culture technology of tiger prawn and giant freshwater prawn. Daya Pub., New Delhi, 99 pp.
2. Govindan, T.K., 1992. Fish processing Technology, Oxford & IBH Pub., New Delhi., 252 pp.

3. Pillai, T.V.R., 2005. Aquaculture principals and practices, Culinary and Hospitality Industry Pub., 624 pp.
4. Santhanam, P., A. R. Thirunavukkarasu and P. Perumal., 2015. Advances in Marine and Brackishwater Aquaculture. Springer Publications (ISBN 978-81-322-2270-5). 263 pp.

Course outcome:

1. Present status of world and Indian fisheries and aquaculture
2. Marine fish hatchery and farming techniques
3. Shrimp hatchery and grow-out technology
4. Aqua feed and nutrition technology
5. Aquaculture biotechnology
6. Marine aquarium trade and health management
7. Post harvest technology
8. Fishery byproducts development

BIOLOGICAL OCEANOGRAPHY AND FISHERIES SCIENCE PRACTICAL (SUBJECT CODE=22MSLC03)

1. Phytoplankton- identification of common forms
2. Identification of common zooplankton
3. Estimation of primary production (Light and Dark bottle technique)
4. Estimation of Chlorophyll ‘a’ concentration
5. Determination of zooplankton biomass
6. Seaweeds-identification of commercially valuable groups
7. Mangroves-identification of common species
8. Fin fishes-identification of common food species
9. Identification of cultivable shrimps and prawns
10. Crabs-identification of common edible groups
11. Identification of common forms of gastropods and bivalves
12. Study on the external morphology of fishes.
13. Collection of data on fishery resources.
14. Visit to Marine and Fisheries Institutes
15. Field visit to Gulf of Mannar Marine Biosphere Reserve
16. Industrial visit to fish hatchery, grow-out farm, seafood processing plant, sea shell factory and fish landing centers

GIS APPLICATION IN MARINE RESOURCES (SUBJECT CODE=22MSVAC2)

Unit-I:
Concept and historical development. Mapping the sea has been a human pursuit for thousands of years.

Unit-II:
The advent of modern mapping technology and computing opened up many new opportunities such as the use of Global Positioning Systems (GPS) and Geographic Information Systems (GIS).

Unit-III:
Spatial information, and use software packages like QGIS, SAGA, IDRISI, GRASS, ArcGIS, Google Earth and R.

Unit-IV:
GPS and navigational equipment, as well as shapefiles, point & polygon editing, raster files, ASCII grids and ISO compliant metadata across open-source GIS platforms.

Unit- V:
Spatial analysis techniques (krigging, autocorrelation) and predictive modelling (machine learning) will also be covered, leading to training in cumulative impact assessment questions and for complex research project management applications for natural resource management, at sea and beyond.

Unit- VI:
Applications of GIS in coastal and marine environment-geological/ geomorphological mapping, soil mapping, land use/ land cover mapping in coastal zone.

Reference books:
1. Principles of Geographical Information Systems: By Peter A. Burrough, Rachael A. McDonnell, and Christopher D. Lloyd, Oxford University Press, 2015.
2. An Introduction to GIS:
http://www.paulbolstad.net/5thedition/samplechaps/Chapter1_5th_small.pdf
3. Meaden, G.J. & Aguilar-Manjarrez, J., eds. 2013. Advances in geographic information systems and remote sensing for fisheries and aquaculture. CD–ROM version. FAO Fisheries and Aquaculture Technical Paper No. 552. Rome, FAO. 425 pp.
4. Ferreira, J., João, P. and Martins, J. "GIS for Crime Analysis - Geography for Predictive Models" The Electronic Journal Information Systems Evaluation Volume 15 Issue 1 2012, (pp36 - 49) www.ejise.com/issue/download.html?idArticle=817
5. Overman, Henry G. (2010) Gis a job: what use geographical information systems in spatial economics. Journal of regional science, 50 (1). pp. 165-180. ISSN 0022-4146;
http://eprints.lse.ac.uk/30784/1/Gis_a_job_%28LSERO_version%29.pdf

NON MAJOR ELECTIVE – II; MARINE ENVIRONMENT
(Subject Code: 22MSNME02)

M. Sc. Marine Science students will choose one course from any of the courses with a minimum of 2 credits offered by other departments of the University. Courses are commonly tutored on Thursdays' afternoons.

For courses offered by Department of Marine Science for students of other programmes of study see at the end of this book of syllabi.

INTEGRATED COASTAL ZONE MANAGEMENT
(Subject Code=22MSCC07)

Objectives

1. To gain the knowledge on coastal zone and its importance, various coastal ecosystems and its vulnerability.

2. To be able to understand the Ocean laws – Law of the sea

Unit-I: Introduction
Definitions – Integration - Coastal zones and importance – Categorization of coastal zone - Coastal resources management programme - Integrated Coastal Zone Management - need, scope, potentials and constraints for ICZM.

Unit-II: Land Sea Interactions
Multiple uses of the coastal zones and conflicts. Human impacts on the coastal zones with special emphasis on artisanal fishing, coastal aquaculture and coastal tourism. Coastal vulnerability - mangroves, corals, sand dunes, sea-grasses, lagoons and enclosed seas, islands, coral reefs and other protected areas.

Unit-III: Coastal Ecosystem Monitoring
Coastal and marine ecosystem monitoring –Estuaries, mangroves, lagoons, backwater, reef etc. Effect of port activities and coastal pollution on mangroves, corals and beaches. Coastal hazards, impacts and management.

Unit-IV: Management Methods
Major principles and premises ICZM. Overview of Environmental monitoring and EIA. Ecological Economics – Economic benefits of protected areas and economic valuation. GIS and remote sensing for ICZM. Natural Hazards and mitigation.

Unit-V: Law of The Sea
United Nations Convention on the Law of the Sea (UNCLOS) I, II, III – Internal water, Territorial water, Archipelagic water, high sea, continental shelf, Exclusive Economic Zone (EEZ) and its significance, limits of territorial water and international sea bed area. International Convention for the Prevention of Pollution from Ships (MARPOL).

Unit–VI: Current Advances in ICZM (Not for Examination)
Current status of Indian coastal zone, Role of national coastal zone management authority. Case studies about integrated coastal zone management. Institute involved in Coastal zone managements.

Employability:

Students will get opportunities in multi- disciplinary sector and to use skills and techniques in ICZM. Also get opportunities in the areas like coastal hazards and vulnerability assessment, policy making etc.

Course outcome

1. Students can learn about coastal zone and its importance, multiple uses of coastal zone, and human impact on coastal zone

2. Students can also able to manage the coastal resources and maintain the stable coastal environment.

References:

Barnabe, G., 2000. Ecology and management of coastal waters. Praxis, 396pp.

Bartlett, D. and J. Smith, 2005. GIS for coastal zone management, CRC Press, 310pp.

Jean – Marina Massin, 1994. Remote sensing for the control of marine pollution. Academic Publishers, Plenus Press, 466pp.

John R. Clark. 1995. Coastal zone management handbook. Lewis publishers, Washington, D.C. 694pp.

Kay, R. and J. Aider, 2005., Coastal planning and management, 2/e. Taylor and Francis, 380pp.

Qasim, S.Z. and G.S. Roonwal, 1998. India's Exclusive Economic Zones. Omega Scientific Publishers. New Delhi.

Ray, G.C. and J. M. Ray, 2004. Coastal marine conservation science and policy. Blackwell Publishing, 327pp.

Sindermann, C.I., 2006. Coastal pollution. Taylor & Francis, 280pp.

MARINE GEOPHYSICS (Subject Code=22MSCC08)

Objectives:

1. To understand the types of rocks and its properties in sea bed
2. To learn the application and types of seismic survey, research vessels

Unit-I:Sea Bed Characteristics

Types of Rocks: Igneous, Sedimentary and Metamorphic Rocks – Oceanic Crust - Rheological Properties – Electrical Properties – Elastic Properties – Magnetic Properties - Radioactivity - Heat flow—Locating Offshore Observations—Deep-Sea Geophysics.

Unit-II: seabed exploration-Electrical, Gravity and Radio-Activity

Principles of electrical survey at sea—Instruments—Data acquisition and interpretation: Principles of gravity survey at sea—Instruments—Data acquisition, Reduction, Gravity anomalies and interpretation– Principles of radiometric survey at sea—Instruments—Dataacquisition, Reduction, radiometric anomalies.

Unit-III: Geomagnetic Survey at Sea

Geomagnetism - Paleomagnetism - Rock magnetism - Natural remanent magnetization - The past and present geomagnetic field - Polar wandering curve - Sea floor spreading andtransform faults - Marine magnetic anomalies - Geomagnetic reversals - The Vine– Matthews hypothesis – Magneto stratigraphy - Dating of the ocean floor.

Unit-IV: Seismic Survey at Sea

Seismic waves and their propagation – Seismic noise and its causes - Marine seismic data acquisition – Energy sources - Seismic reflection and refraction surveys – single and multichannel re- flection profiling, common depth point technique, sonobuoy surveys; 3Dseismics and Seismic tomography - Seismic data processing and interpretation – time- depth sections.

Unit-V: Application of Geophysical Methods

Seabed Imaging by Sonar and Lidar—Application of geophysical methods for placer deposits; oil and natural gas and other minerals of the continental margin. Survey and exploration of different types of sediments and minerals of the deep ocean floor.Geophysical Observations in Off- shore Boreholes.

Unit-VI: Advances in Instrumentation (Not for Examination)

Biosensor, solar energy capturing Tidal energy, ocean thermal energy, optically inbuilt high sensor for under water mining, Robotics techniques and Recent advancement, Nano fibre Technology for geophysical exploration.

References

Jones, E. J. W., 1999. Marine Geophysics. John Wiley, 474 p.

Kearey, P., M. Brooks, I. Hill, 2002.An Introduction to Geophysical Exploration, 3e. John Wiley, 474 p.

Stein, S. and M. Wysession, 2000. An Introduction to Seismology, Earthquakes, and Earth Struc- ture

Kearey, P., K. A. Klepeis and F.J. Vine, 2009.Global Tectonics, 3e. John Wiley.

Course outcome

1. Knowing about submarine geology
2. Learning about seabed exploration methods
3. understanding about geomagnetic survey
4. Learning fundamental 0f seismic survey
5. Basic stud about various geophysical methods for ocean studies
6. Learning about various rock types and distributed in the ocean floor
7. Studying about various of sediment distribution pattern
8. Knowing application of geophysics in ocean studies

ADVANCES IN MARINE SCIENCE (Subject Code=22MSEIB02)

Unit-I:

Fundamental research in Oceanography; biographies of the researchers that laid foundation to recent advances in the field. Basic advances with respect to the geography, physical & chemical characteristics of each ocean. Recent advances pertaining to meteorology, climatology and oceanography. Advances in Oceanography in Academics. Science & Technology. Industries.

Unit-II:

Recent knowledge of various types, faculties & branches of Oceanography. Advances in Physical, Chemical & Biological Oceanography. Need & significance of the advances in the study of each sub domain.

Unit-III:

Basic advances in Physical Oceanography. Physical conditions in oceans. Physical properties of oceans studied using recent advances in computational Sciences. Physical activities in oceans in view of the advent of science & technology. Interrelations between physical conditions, properties & activities in different oceans and the role in deciding the uniqueness of each ocean using satellite imaging. Future of Physical Oceanography in the World.

Unit-IV:

Chemical Oceanography with overview of the chemical composition oceans analysed with modern technologies in Electrochemistry & other advanced techniques. Chemical composition of each ocean with reference to the physical & physiochemical characteristics and biotic environment at the molecular level using applications of recent advances viz Nanotechnology. Natural resources-gaseous, liquefied and solid chemical parameters. Additional resources, which were unfathomed till recent times. Exploited resources earthed using modern excavation techniques. Unexploited resources and recent & modern techniques to excavate these chemical wealth.

Unit-V:

Details of attempts made to fathom the unknown natural resources in oceans. Dissolved gases and their chemical interactions leading to many geographical perturbations in oceans: modern perspectives. Dissolved liquids that make the ocean unique and its significance at physical, geographical & biological nature of an individual ocean: laboratory techniques to implement in the field for detailed study of these chemicals. Solid deposits, precipitates and suspensions in each ocean: study using modern techniques & technology like SONAR, USG *etc*. Modern & very recent Techniques deployed to unearth the chemical parameters in oceans. Account of unknown and unexploited oceanic reserves that would enrich human population in all respects.

Unit-VI:

Advanced methods to study the missing links in the phylogeny of non-chordates. Taxonomic studies using carbon dating and other modern techniques. Phylogeny, salient features, classification up to classes (wherever applicable) of the protochordate phyla found in oceans & seas.

Reference books:

1. Fundamentals of Oceanography: Keith Sverdrup et al.
2. Biological Oceanography an Introduction: Carol M. Lalli, Timothy R. Parsons
3. Chemical Oceanography: J. P Riley, R. Chester
4. Achievements in Biological Oceanography: Richard T. Barber, Anna K. Hilting

LAST SEMESTER PROJECT (Subject Code=22MSCP01)

Head of the Department of Marine Science will assign one or more of M. Sc. Marine Science stu- dents to each member of the Marine Science faculty, for the purpose of supervision of their last semester project work in the beginning of the second year itself. Project students shall be let off on duty only after the third semester examinations. However, if a candidate prefers to do his/ her project work outside the Department or with any other member of the Marine Science faculty is at liberty to do so upon the concurrence of the guide to whom he/ she is assigned previously. In case, if the student does his project work outside the Department or with any other member of the Department faculty the first guide will be his/ her previous guide and the same may be stated and the certificate from him shall be attached to his/ her dissertation.

Four copies of Dissertations shall be submitted in complete form. Having examiners affixed their signatures on dissertation, two copies will be returned to the examinee.

All examinees shall appear for viva voce with dissertations on the examination day. No requestfor change of date will be entertained.

Viva voce examination of each examinee, in the presence of respective supervising guide, will be done by two examiners (One external and one internal (Ex-officio Head of the Department) for 30 marks each. Supervising guide will evaluate the candidate's performance during the semester for 40marks.

Mode of Examination and Examiner		***Marks***
Viva Voce in the dissertation work by External Examiner		30
Viva Voce in the dissertation work by Internal Examiner		30
Continuous Evaluation by Guide		
[Item	10	
Item	20	
Item	10]	40
	Total	**100**