

Syllabus of M. Sc. (Marine Sciences) Programme

Approved by the Board of Studies on 21.04.2016

A brief description of the course

EFFECTIVE
2016-17, 17-18

Purpose: To provide trained manpower in different branches of Marine Sciences.
Prerequisites: Degree of Bachelor of Science of this University or an examination of any other University recognized as equivalent therein, with at least seven units of 100 marks in the first, second and third years taken together. Eligibility is B.Sc. Physics, Mathematics, Electronics, Computer Science, IT, Chemistry, Industrial Chemistry, Analytical Chemistry, Pharmaceutical Chemistry, Botany, Zoology, Microbiology, Biotechnology, Biosciences, Fisheries, Aquatic Sciences, Earth Sciences, Geology.

Credits (theory, tutorials, practical): 1 credit (theory) shall be equivalent to 15 clock hours of contact teaching. 15 clock hours are inclusive of lectures/group discussion/seminars/problem solving/tutorials/assessment, etc. 1 credit (practical) shall be equivalent to 30 clock hours of contact teaching, i.e. 15 practical of 2 clock hours duration each. The assessment of the courses shall be fully internal. The evaluation of the courses shall be by continuous assessment. The weightage of marks for intra and semester-end examinations in both theory and practical courses shall be 40:60. Each ISA shall be evaluated for 20% of the total marks of the course. Total number of ISA for each Course shall be two irrespective of the number of credits. An additional assessment irrespective of number of credits of course carries, will be provided on the request of students to improve the grade, in which case the assessment with the least score shall not be considered for ISA. However, for 1 credit course, a single ISA shall be conducted and evaluated for 40% of total marks of the course. The duration of all comprehensive written Semester End Assessment (SEA) examinations carrying 25 marks or less, shall be of one hour; SEA carrying above 25 marks up to 50 marks shall be two hours; SEA carrying above 50 marks shall be of three hours. The pattern of questions for SEA theory and practical courses in Marine Sciences is as follows:

Theory Course

Credits	Question Number	Number of questions to be answered	Marks per question	Total Marks
1	1 Compulsory	2 short notes out of 4	2.5 per short note	5
	2 and 3	1 out of 2 - descriptive	10	10
2	1 Compulsory	4 short notes out of 7	2.5 per short note	10
	2 to 5	2 out of 4 - descriptive	10	20
4	1 Compulsory	6 short notes out of 9	2.5 per short note	15
	2 to 6	3 out of 5 - descriptive	15	45

Practical Course

Credits	Marks for Experiment	Marks for Journal/Records	Marks for Viva	Total Marks	Time Duration
1	10	3	2	15	4 hours
2	20	6	4	30	4 hours

Number of semesters and how the courses are distributed: The students will be eligible for the Master's degree on the successful completion of courses equivalent to 80 credits. Student shall not be allowed to register for less than 10 credits and more than 25 credits in a semester. A student must obtain 60 credits from the parent Department remaining 20 credits may be earned by the student by opting for courses (optional) either from the parent Department or from any other Department of the University.

Dissertation: Dissertation is optional. Topics will be assigned at the end of 2nd semester and the study will begin from starting of 3rd semester. There will be a continuous internal monitoring by the guiding/supervising teacher.

Field Studies: M.Sc. Marine Sciences involves regular onboard training on research vessel / boat.

M. Sc. (Marine Sciences) List of Courses

In the following tables, L refers to lectures, T to tutorials and P to practical. Description of a course appears on the page number listed in the tables.

Core courses

Course Code and Name	L-T-P (hours/week)	Credits
MSC 131 Physical Oceanography	4-0-0	4
MSC 132 Marine Chemistry	4-0-0	4
MSC 133 Marine Biology Practical	0-0-4	2
MSC 231 Marine Geology	4-0-0	4
MSC 232 Computational Methods in Oceanography	4-0-0	4
MSC 233 Computational Methods in Oceanography Practical	0-0-4	2
MSC 331 Geophysical Fluid Dynamics	4-0-0	4
MSC 332 Ocean - Atmosphere coupling and Climate I	2-0-0	2
MSC 333 Geophysical Fluid Dynamics Practical	0-0-4	2
MSC 334 Ocean -Atmosphere coupling and Climate Practical	0-0-4	2
MSC 335 Marine Pollution Practical	0-0-4	2
MSC 337 Marine Pollution I	2-0-0	2
MSC 338 Marine Pollution II	2-0-0	2
MSC 341 Marine Geochemistry Practical I	0-0-2	1
MSC 342 Marine Geochemistry Practical II	0-0-2	1
MSC 346 Marine Ecology	4-0-0	4
MSC 347 Marine Ecology Practical	0-0-4	2
MSC 350 Sedimentology	4-0-0	4
MSC 351 Sedimentology Practical	0-0-4	2
MSC 431 Estuarine and Coastal Physical Oceanography	2-0-0	2
MSC 432 Estuarine Chemistry	2-0-0	2
MSC 433 Estuarine Biology	2-0-0	2
MSC 434 Estuarine and Coastal Geology	2-0-0	2

Optional courses

Course Code and Name	L-T-P (hours/ week)	Credits
MSO 134 Marine Biology	4-0-0	4
MSO 135 Geomorphology and Tectonics	2-0-0	2
MSO 136 Physical Oceanography Practical	0-0-4	2
MSO 137 Marine Chemistry Practical I	0-0-4	2
MSO 234 Marine Geology Practical	0-0-4	2
MSO 235 Remote Sensing and its application	4-0-0	4
MSO 236 Remote Sensing and its application Practical	0-0-4	2
MSO 237 Analytical Chemistry of Sea water and Instrumental Techniques	4-0-0	4

MSO 334 Analytical & Instrumental Techniques		
Practical	0-0-4	2
MSO 335 Aquaculture	4-0-0	4
MSO 340 Aquaculture Practical	0-0-4	2
MSO 341 Marine Chemistry Practical II	0-0-4	2
MSO 342 GIS Applications in Marine Science Practical	0-0-4	2
MSO 336 Ocean Atmosphere coupling and climate II	2-0-0	2
MSO 337 Marine Pollution I	2-0-0	2
MSO 338 Marine Pollution II	2-0-0	2
MSO 339 Aerosol and Atmospheric Optics	2-0-0	2
MSO 340 Aerosol Chemistry Practical	0-0-4	2
MSO 343 Marine Geochemistry I	2-0-0	2
MSO 344 Marine Geochemistry II	1-0-0	1
MSO 345 Marine Geochemistry III	1-0-0	1
MSO 348 Marine Microbial Ecology	4-0-0	4
MSO 349 Marine Microbial Ecology Practical	0-0-4	2
MSO 433 Dynamic Oceanography I	2-0-0	2
MSO 434 Dynamic Oceanography II	2-0-0	2
MSO 437 Physical and Inorganic Chemistry of Sea water	4-0-0	4
MSO 438 Marine Biodiversity, Conservation and Practices	4-0-0	4
MSO 439 Marine Geo-physics	4-0-0	4
MSO 440 Dissertation	0-0-2	8

Goa University
Department of Marine Sciences
Syllabus of M. Sc. Marine Sciences
Effective from 2016-2017

Course Structure

Semester I

Course code	Course Title	L-T-P hrs/week	Credits	Contact hours/week	Page number
MSC 131 (Core)	Physical Oceanography	4-0-0	4	4	8
MSC 132 (Core)	Marine Chemistry	4-0-0	4	4	8
MSC 133 (Core)	Marine Biology Practical I	0-0-4	2	4	9
MSO 134 (Optional)	Marine Biology	4-0-0	4	4	10
MSO 135 (Optional)	Geomorphology and Tectonics	2-0-0	2	2	11
MSO 136 (Optional)	Physical Oceanography Practical	0-0-4	2	4	11
MSO 137 (Optional)	Marine Chemistry Practical I	0-0-4	2	4	12

Semester II

Course code	Course Title	L-T-P hrs/week	Credits	Contact hours/week	Page number
MSC 231 (Core)	Marine Geology	4-0-0	4	4	12
MSC 232 (Core)	Computational Methods in Oceanography	4-0-0	4	4	13
MSC 233 (Core)	Computational Methods in Oceanography Practical	0-0-4	2	4	14
MSO 234 (Optional)	Marine Geology Practical	0-0-4	2	4	15
MSO 235 (Optional)	Remote sensing and its applications	4-0-0	4	4	15
MSO 236 (Optional)	Remote sensing and its application Practical	0-0-4	2	4	16
MSO 237 (Optional)	Analytical Chemistry of Sea water and Instrumental Techniques	4-0-0	4	4	17
MSO 238 (Optional)	Analytical chemistry of sea water and Instrumental Techniques Practical	0-0-4	2	4	17
MSO 239 (Optional)	Aquaculture	4-0-0	4	4	18
MSO 240 (Optional)	Aquaculture Practical	0-0-4	2	4	19
MSO 241 (Optional)	Marine Chemistry Practical II	0-0-4	2	4	19
MSO 242 (Optional)	GIS Applications in Marine Science Practical	0-0-4	2	4	20

Semester III

Course code	Course Title	L-T-P hrs/week	Credits	Contact hours/week	Page number
Physical Oceanography Specialization					
MSC 331 (Core)	Geophysical Fluid Dynamics	4-0-0	4	4	20
MSC 332 (Core)	Ocean -Atmosphere coupling and climate I	2-0-0	2	2	21
MSC 333 (Core)	Geophysical Fluid Mechanics Practical	0-0-4	2	4	22
MSC 334 (Core)	Ocean Atmosphere coupling and climate Practical	0-0-4	2	4	22
MSC 335 (Core)	Marine Pollution Practical	0-0-4	2	4	23
MSO 336 (Optional)	Ocean -Atmosphere coupling and climate II	2-0-0	2	2	23
MSO 337 (Optional)	Marine Pollution I	2-0-0	2	2	24
MSO 338 (Optional)	Marine Pollution II	2-0-0	2	2	24
MSO 339 (Optional)	Aerosol and Atmospheric Optics	2-0-0	2	2	25
MSO 340 (Optional)	Aerosol Chemistry Practical	0-0-4	2	4	25
Marine Chemistry Specialization					
MSC 332 (Core)	Ocean -Atmosphere coupling and climate I	2-0-0	2	2	21
MSC 334 (Core)	Ocean Atmosphere coupling and climate Practical	0-0-2	2	4	22
MSC 335 (Core)	Marine Pollution Practical	0-0-2	2	4	23
MSC 337 (Core)	Marine Pollution I	2-0-0	2	2	24
MSC 338 (Core)	Marine Pollution II	2-0-0	2	2	24
MSC 341 (Core)	Marine Geochemistry Practical I	0-0-2	1	2	25
MSC 342 (Core)	Marine Geochemistry Practical II	0-0-2	1	2	26
MSO 336 (Optional)	Ocean -Atmosphere coupling and climate II	2-0-0	2	2	23
MSO 339 (Optional)	Aerosol and Atmospheric Optics	2-0-0	2	2	25
MSO 340 (Optional)	Aerosol Chemistry Practical	0-0-2	2	4	25
MSO 343 (Optional)	Marine Geochemistry I	2-0-0	2	2	26
MSO 344 (Optional)	Marine Geochemistry II	1-0-0	1	1	27
MSO 345 (Optional)	Marine Geochemistry III	1-0-0	1	1	27
Marine Biology Specialization					
MSC 334 (Core)	Ocean Atmosphere coupling and climate Practical	0-0-2	2	4	23
MSC 335 (Core)	Marine Pollution Practical	0-0-2	2	4	23
MSC 337 (Core)	Marine Pollution I	2-0-0	2	2	24
MSC 346 (Core)	Marine Ecology	4-0-0	4	4	27
MSC 347 (Core)	Marine Ecology Practical	0-0-4	2	4	28
MSO 332 (Optional)	Ocean -Atmosphere coupling and climate I	2-0-0	2	2	21
MSO 336 (Optional)	Ocean -Atmosphere coupling and climate II	2-0-0	2	2	23

MSO 338 (Optional)	Marine Pollution II	2-0-0	2	2	24
MSO 339 (Optional)	Aerosol and Atmospheric Optics	2-0-0	2	2	25
MSO 340 (Optional)	Aerosol Chemistry Practical	0-0-2	2	4	25
MSO 348 (Optional)	Marine Microbial Ecology	4-0-0	4	4	29
MSO 349 (Optional)	Marine Microbial Ecology Practical	0-0-4	2	4	30
Marine Geology Specialization					
MSC 335 (Core)	Marine Pollution Practical	0-0-2	2	4	23
MSC 337 (Core)	Marine Pollution I	2-0-0	2	2	24
MSC 341 (Core)	Marine Geochemistry Practical I	0-0-2	1	2	25
MSC 342 (Core)	Marine Geochemistry Practical II	0-0-2	1	2	26
MSC 350 (Core)	Sedimentology	4-0-0	4	4	30
MSC 351 (Core)	Sedimentology Practical	0-0-4	2	4	31
MSO 338 (Optional)	Marine Pollution II	2-0-0	2	2	24
MSO 339 (Optional)	Aerosol and Atmospheric Optics	2-0-0	2	2	25
MSO 340 (Optional)	Aerosol Chemistry Practical	0-0-2	2	4	25
MSO 343 (Optional)	Marine Geochemistry I	2-0-0	2	2	26
MSO 344 (Optional)	Marine Geochemistry II	1-0-0	1	1	27
MSO 345 (Optional)	Marine Geochemistry III	1-0-0	1	1	27

Semester IV

Course code	Course Title	L-T-P hrs/week	Credits	Contact hours/week	Page number
Physical Oceanography Specialization					
MSC 431 (Core)	Estuarine and Coastal Physical Oceanography	2-0-0	2	2	31
MSC 432 (Core)	Estuarine Chemistry	2-0-0	2	2	32
MSC 433 (Core)	Estuarine Biology	2-0-0	2	2	32
MSC 434 (Core)	Estuarine and Coastal Geology	2-0-0	2	2	33
MSO 435 (Optional)	Dynamic Oceanography I	2-0-0	2	2	33
MSO 436 (Optional)	Dynamic Oceanography II	2-0-0	2	2	33
MSD 440 (Optional)	Dissertation	0-0-2	8	16	36
Marine Chemistry Specialization					
MSC 431 (Core)	Estuarine and Coastal Physical Oceanography	2-0-0	2	2	31
MSC 432 (Core)	Estuarine Chemistry	2-0-0	2	2	32
MSC 433 (Core)	Estuarine Biology	2-0-0	2	2	32
MSC 434 (Core)	Estuarine and Coastal Geology	2-0-0	2	2	33
MSO 437 (Optional)	Physical and Inorganic Chemistry of Sea Water	4-0-0	4	4	34
MSD 440 (Optional)	Dissertation	0-0-2	8	16	36
Marine Biology Specialization					
MSC 431 (Core)	Estuarine and Coastal Physical Oceanography	2-0-0	2	2	31
MSC 432 (Core)	Estuarine Chemistry	2-0-0	2	2	32
MSC 433 (Core)	Estuarine Biology	2-0-0	2	2	32
MSC 434 (Core)	Estuarine and Coastal Geology	2-0-0	2	2	33
MSO 438 (Optional)	Marine Biodiversity Conservation and Practices	4-0-0	4	4	35
MSD 440 (Optional)	Dissertation	0-0-2	8	16	36
Marine Geology Specialization					
MSC 431 (Core)	Estuarine and Coastal Physical Oceanography	2-0-0	2	2	31
MSC 432 (Core)	Estuarine Chemistry	2-0-0	2	2	32
MSC 433 (Core)	Estuarine Biology	2-0-0	2	2	32
MSC 434 (Core)	Estuarine and Coastal Geology	2-0-0	2	2	33
MSO 439 (Optional)	Marine Geo-physics	4-0-0	4	4	35
MSD 440 (Optional)	Dissertation	0-0-2	8	16	36

Semester I

MSC 131: Physical Oceanography (4 credits)

Module – I

Oceanographic explorations - Evolution of theoretical ideas – Units used in Oceanography- The role of observations in Oceanography –Ocean and seas - Dimensions of the ocean- Physical properties of water- Influence of dissolved salts- Physical properties of seawater-Salinity – Temperature-Density- Distribution of temperature - salinity and density in space and time- Oceanic mixed layer and thermo-cline – Measurement of temperature and salinity - Sound in the sea. Propagation of sound in the sea- Light in the sea – The Oceanic heat budget.

Module – II

The earth in space – Atmospheric wind systems – Composition of atmosphere - Vertical extent of atmosphere -Planetary boundary layer – Measurement of wind – Calculations of wind stress - Coriolis force- General circulation of atmosphere-Atmospheric temperature -Temperature system and scales - Atmospheric humidity - Vapour pressure - Circulation – Wind- driven and thermo-haline circulations – Importance of deep circulation – Theory for deep circulation

Module – III

Equatorial processes - El Nino – El Nino tele-connection - Southern Oscillation and Indian Ocean Dipole (IOD) - Indian Ocean Circulation, T.S.V. diagram- T.S. diagram - Oceanic fronts -Upwelling - Water masses in the ocean - Bottom water - Deep water - Antarctic intermediate water - Central water - Lagrangian and Eulerian methods for measuring currents .

Module – IV

Equipment used for physical oceanographic studies: Mechanical bathythermograph, Expendable bathythermograph, Reversing thermometers, CTD, Current meter, Acoustic Doppler Current Profiler (ADCP), Autosol. Equipment used for atmospheric studies: Psycho meter, anemometer, radio sonde, sun-photometer, Radiation meter, Automatic Weather Station - Research vessels: O.R.V. Sagar Kanya, R.V. Sagar Sampada.

References

1. The Ocean: Their Physics, Chemistry and Biology, 1962 - Sverdrup, H.U., Johnson, M.W. and Flemming, R.H., Asia Publ. House, New Delhi.
2. Descriptive Physical Oceanography: An Introduction, 1989 - Pickard, G.B. and Emery, W.J., Pergamon press, U.K.
3. Principles of physical oceanography, 1966 - Pierson, W.J. and Newmann, G.S., Prentice Hall, Inc., New Jersey, U.S.A.
4. Meteorology Today: An Introduction to weather, climatic and the environment (2nd edn), 1985 - Ahrens, St. Paul, West Publ. House, U.K.
5. Meteorology: Forecasting the weather, 1973 - Wachter, H., Collins Publ., U.K.
6. The Atmosphere and Ocean: A physical Introduction, 1986 - Wells, N., Taylor and Francis Ltd., U.K.
7. General Climatology, 1960 - Critchfield, H.J., Prentice Hall Inc., New Jersey, U.S.A.
8. Introduction to Micrometeorology, 2nd edition, 2001 - S. Pal Arya, Vol 79 in International geophysics Series, Academic press.

MSC 132: Marine Chemistry (4 credits)

Module – I

Symbols and units used in chemical oceanography – Major and minor elements in seawater – Geochemical balance of the oceans, residence times, chemical speciation.

Module – II

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.

Module – III

Dissolved gases (other than CO_2) 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_2) in seawater – Carbon dioxide equilibria in seawater; pH, alkalinity and buffering capacity of oceans; components of CO_2 system in seawater – Percentage composition of inorganic carbon; calcium carbonate precipitation and dissolution phenomena – Lyso-cline and carbonate compensation depth.

Module – IV

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.

References

1. Introduction to Marine Chemistry, 1971 – Riley, J.P. and Chester, R., Academic Press.
2. Chemical Oceanography (Vol.1, 2, 3 & 8), 1975 – Riley, J.P. & Skirrow, G., Academic Press.
3. Marine Chemistry, 1969 – Horne, R.A., Wiley-Interscience
4. Seawater: Its composition, properties & behaviour, 1989, 1995, 2004 – The Open University.
5. Marine Chemistry (Vol.2), 1970 – Martin, D.F., Marcel Dekker, NY.
6. Tracers in the Sea, 1982 – Broecker and Peng., Lamont-Doherty Geological Observatory, NY.
7. Marine Geochemistry, 1990, 2000 – Chester, R., Blackwell Science.
8. Chemical Oceanography, 1992 – Millero, F. J. and Sohn, M.L., CRC Press.
9. Dynamic processes in the chemistry of the upper ocean, 1986 – Burton et al., Plenum Press.
10. The chemistry of the Atmosphere and Oceans, 1978 – Holland, H.D., Wiley.
11. An Introduction to Environmental Chemistry, 1996 – Andrews et al., Blackwell science.
12. Environmental Chemistry, 1994 – De, A.K., Wiley – Eastern Ltd.
13. Geosphere – Biosphere Interactions and Climate, 2001 – L.O.Bengtsson and C.U.Hammer., Cambridge University Press.
14. Oceanography of the Indian Ocean, 1992 – B. N. Dossai (Ed.), AA Balkema.
15. Chemical Oceanography of the Indian Ocean, North of Equator, 1984, Sengupta and Naqvi, Deep Sea Res. 31A, 671-706.
16. Chemical Oceanography, 1996, 2006 – F. J. Millero, CRC Press.
17. The Sea Surface and Global Change, 1997, 2005 – P.S. Liss and R. Duce., Cambridge University Press.
18. Ocean Biogeochemistry: The role of the ocean carbon cycle in Global change, 2003 – M.J.R. Fasham, Springer.
19. An Introduction to Marine Biogeochemistry, 2nd edition, 2009 – S.B.Libes, Wiley.
20. Marine Chemistry and Geochemistry, 2010 – K. K. Turekian, Academic Press.
21. An Introduction to the Chemistry of the Sea, 2nd edition, 2013 – M.E.Q. Pilson, Cambridge University Press.

MISC 133: Marine Biology Practical (2 credits)

Module – I

1. Introduction to standard sampling devices / instruments employed for collection and analysis of biological parameters in water and sediments used in oceanographic studies (6 hrs; Ref 21)
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 (6 hrs; Ref 16)
3. Identification of marine phytoplankton, their life cycle and role in food chain (6 hrs; Ref 1, 19, 20)
4. Identification of marine zooplankton, their life cycle and role in food chain (6 hrs; Ref 10, 12)
5. Identification of mangroves, their life cycle and few biological characteristics (6 hrs; Ref 15, 18)
6. Morph metric measurements and meristic counts of the Indian Mackerel, *Rastrelliger kanagurta* (2 hrs; Ref 17)

Module – II

1. Morph metric and meristic parameters in identification of elasmobranchs and teleost (6 hrs; Ref 13, 14)
2. Identification of few commonly occurring teleosts (ray-finned fishes) and their biological characteristics (6 hrs; Ref 5, 7, 11)
3. Identification of brachyuran crabs using morphology and gonopod characteristics, sex determination and their biological importance (9 hrs; Ref 4)

4. Identification of prawns and shrimps using external characteristics, sex determination and biological aspects (9 hrs; Ref 4)

References

1. Phytoplankton Identification Catalogue - Sakhuja Day, South Allen, April 2001, 2011 - Bates, E. (2003) , Globalast Monograph Series No. 7, IMO London.
2. Drawing Techniques for Publication, 2013 - Bowstead D. & Eccles T. M. Museum of Natural History, Oxford University, 23 pp. Available at: <http://www.ox.ac.uk/collect/Drawing%20Techniques.pdf>
3. FAO species identification guide for fishery purposes, The living marine resources of the Western Central Pacific, 1988a - Carpenter K.E. & Niem V.H., *Volume 1. Seaweeds, corals, bivalves and gastropods* (Food and Agricultural Organization, Rome), pp. 1-686.
4. FAO species identification guide for fishery purposes, The living marine resources of the Western Central Pacific, 1988b - Carpenter K.E. & Niem V.H., *Volume 2. Cephalopods, crustaceans, holothurians and sharks* (Food and Agricultural Organization, Rome), pp. 687-1396.
5. FAO species identification guide for fishery purposes, The living marine resources of the Western Central Pacific, 1999a - Carpenter K.E. & Niem V.H., *Volume 3. Batoid fishes, Chimaerids and bony fishes Part 1 (Eleotidae to Linophrynidae)* (Food and Agricultural Organization, Rome), pp. 1397-2068.
6. FAO species identification guide for fishery purposes, The living marine resources of the Western Central Pacific, 1999b - Carpenter K.E. & Niem V. H., *Volume 4. Bony Fishes Part 2 (Mugilidae to Carangidae)* (Food and Agricultural Organization, Rome), pp. 2069-2790.
7. FAO species identification guide for fishery purposes, The living marine resources of the Western Central Pacific, 2001a - Carpenter K.E. & Niem V.H., *Volume 5. Bony Fishes Part 3 (Atherinidae to Pomacentridae)* (Food and Agricultural Organization, Rome), pp. 2791-3380.
8. FAO species identification guide for fishery purposes, The living marine resources of the Western Central Pacific, 2001b - Carpenter K.E. & Niem V.H., *Volume 6. Bony Fishes Part 4 (Labridae to Latimeriidae), estuarine crocodiles, sea turtles, sea snakes and marine mammals* (Food and Agricultural Organization, Rome), pp. 3381-4218.
9. Monograph of Shallow-Water Indo-West Pacific Echinoderms., 1971 - Clark A. M. & Rowe F. E. W, Trustees of the British Museum of Natural History, London, 238 pp.

MISO 134: Marine Biology (4 credits)

Module – I

Introduction to marine biology – history, classification, theories, expeditions, hypothesis testing; Origin and evolution of life – life processes, abio-genesis, theories of natural selection, organic evolution, primordial soup hypothesis, organic molecules, chemical evolution, iron sulfide and black smoker's theory, RNA world hypothesis, theory of evolution and panspermia.

Module – II

Marine and coastal environment – biological zonation, inter-tidal ecosystem (rocky - zonation pattern - physical and biological factors, sandy shores and protected sand flats – physical and biological factors, faunal composition and adaptations), sea as a biological environment – physiological changes, regulators and conformers, scope for growth, temperature and metabolic rates, comparison among marine and terrestrial environment.

Module - III

Primary productivity – mechanism, light and dark reaction, intermediate products, factor affecting primary productivity, role of pigments, methods of assessment, biological pump and transformation of organic matter, vertical profile of primary productivity and SCM, turbulence and MLD.

Module – IV

Secondary productivity - heterotrophic processes and pathways, herbivores and grazing, zooplankton sampling and constraints, biomass estimation, ontogenic and vertical migrations, mud bank formation, processes and fisheries.

References

1. Marine Biology, 8th Edition – 2009 Castro, P. and Huber, M. McGraw Hill Education, 461 pp.
2. Introduction to Marine Biology, 4th Edition. – 2012, Krleskint, G., Turner, R., Small, J., Cengage Learning, 576 pp

3. Biological oceanography 1999 – Lalli, C.M., Elsevier Ltd.
4. Oceanography: The past, 1980 – Sears, M and Merimann D. (Eds.), Springer-Verlag
5. Elements of Marine ecology (4th edn) 1982 – Tait, R.V. and Dipper, F. Butterworth - Heinemann
6. An introduction to Marine Sciences, 1988 – Meadows, P.S. & Campbell, J.J., Springer Science & Business Media
7. Textbook of Marine Ecology, 1980 – Nair, N.B. & Thampy, D.M., Macmillan, 352 pp.
8. Marine Biology, 1984, Thurman, H.V. and Webber, H.H., Harper Collins Publishers
9. Methods in Marine Zooplankton Ecology, 1984 Omori, W. and Ikeda, T. Wiley
10. Methods for the study of Marine Benthos, 1984 – Holme, N.A. & McIntyre, A.D. Blackwell Scientific Publications
11. The Ecology of Rocky Coasts, 1964 – Lewis, J.R. English Universities Press
12. The shore environment, 1980 – Irvine, J.H., Price, D.E.C. and Farnham, W.F. Systematics Association
13. Life between tidemark on rocky shores, 1972 – Stephenson, T.A. & Stephenson, A. W. H. Freeman
14. The invertebrates (3rd Edn.), 1986 – Barnes, R.S. K. Blackwell Science
15. Zooplankton Methodology Manual, 2000 - Harris, R., Wiebe, P., Lenz, J., Skjoldal, H.R., Huntley, M. (Eds), ICES Academic Press, San Diego, pp. 68

MSO 135: Geomorphology and Tectonics (2 credits)

Module – I

The earth and the solar system-Size, shape, structure, origin and age of the earth-Geological time scale – Size and shape of the ocean basins: Pacific, Atlantic and Indian – Morphology and structure of continental margins, mid oceanic ridges and deep sea floor – Origin of ocean basins – Continental drift sea floor spreading and plate tectonics – Evolution of the Indian ocean

Module - II

Earth Quakes - classification, magnitude, epi-centre, recoding - seismographs, shadow zone, important earth quakes, causes. Volcanoes - magma, lava, volcanic land forms, famous eruptions. Mountains and mountain chains

References

1. Introductory oceanography (5th ed), 1988 Thurman, H.V. Columbus Mercill Publ. Co, Ohio.
2. Oceanography (5th ed), 1990 Grant Gross, M., Englewood Cliffs, N.J. Prentice Hall.
3. Coastal and estuarine sediment dynamics, 1986 Dyer, K. R., John Wiley & Sons, Wiley, Chichester.
4. Earth resources, 1969 Skinner, B. J., Englewood Cliffs, N.J., Prentice Hall.
5. Marine Geology and Oceanography of the Arabian Sea and coastal Pakistan, 1984 Haq, B. U. and Milliman, J. D., Van Nostrand Reinhold Co.
6. Marine Geology, 1982 James P. Kennet, Prentice Hall INC Englewood, Cliffs, N. J. 07632.
7. Earth Science, 1985- Mamowitz and Spaulding, Heath and Company, Heath.

MSO 136: Physical Oceanography Practical (2 credits)

Module – I

1. Analysis of vertical profiles of temperature, salinity and density to understand the physical processes in different regions at low, mid and high latitude of the world ocean (6hrs; Ref 1)
2. Analysis of vertical profiles of a) temperature, b) salinity and c) density in upwelling and non-upwelling regions of the world ocean (3hrs; Ref 1)
3. Generating vertical section of temperature to study the physical processes along a transect (6hrs; Ref 1, 2)
4. Generating vertical section of salinity to study the physical processes along a transect (6hrs; Ref 1, 2)
5. Generating vertical section of density to study the physical processes along a transect (6hrs; Ref 1, 2)
6. Estimation and analysis of heat content in different parts of World Ocean (3hrs; Ref 3, 4)

Module – II

1. Identification of water masses determination of stability of water column using T-S diagram (6hrs; 1-4)
2. Estimation of sound speed and determination of SOFAR channel in different parts of the world ocean (6hrs; Ref 1, 4)
3. Analysis of physical oceanographic processes from Horizontal sections using in-situ data (3hrs) (Ref 2)
4. Computation and Analysis of dynamic topography (6hrs; Ref 2, 5)
5. Measurements of atmospheric pressure, humidity, minimum and maximum temperature, computation of absolute

humidity, specific humidity – Mixing ratio (3hrs; Ref 7)

6. Field observations of physical oceanographic parameters-use of meteorological instruments - two batches (6hrs; Ref 7, 8)

References

1. Seawater: Its Composition, Properties and Behaviour, 1995 - Second Edition, Open University Press.
2. Ocean Circulation, 2001 - Second Edition, Open University Press, Walton Hall, Milton Keynes, MK76AA, UK
3. Algorithms for computation of fundamental properties of seawater, 1983, UNESCO TECHNICAL PAPERS IN MARINE SCIENCE, Endorsed by UNESCO/SCOR/ICES/IAPSO/ Joint Panel on Oceanographic Tables and Standards and SCOR Working Group 51, Unesco, Place de Fontenoy, 75700, Paris, France
4. Principles of physical oceanography, 1996 – Pierson, W.J. and Newmann, G.S., Prentice Hall Inc., New Jersey, U.S.A.
5. Introduction to Dynamic Oceanography, 1983 - Pond, S. and Pickard, G.H., Pergamon Press, U.K.
6. Tropical Pacific near-surface currents estimated from altimeter, wind, and drifter data. 1999 - Gary S. E. Lagerloef, Gary T. Mitchum, Roger B. Lukas, Pearn P. Niller., *Journal of Geophysical Research*, Volume 104, Issue C10, pages 23313–23326.
7. Meteorology Today: An introduction to weather, climate and the environment (2nd edition), 1985 - Ahrens, St. Paul, West Publ. House.
8. Meteorology - Understanding the atmosphere, 2012 - Steven A.A

MSO 137: Marine Chemistry Practical I (2 credits)

Module – I

1. Introduction to good laboratory practices in Chemical Lab and introduction to sampling, sub-sampling, storage and analysis of dissolved trace constituents of seawater (6 hrs; Ref 1)
2. Estimation of salinity of seawater by the Mohr- Knudsen chlorinity titration method (6 hrs; Ref 1)
3. Determination of dissolved O₂ of seawater by Winkler's iodometric titration method (6 hrs; Ref 1)
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 (6 hrs; Ref 1)
5. Spectrophotometry: Verification of Beer's law (6 hrs; Ref 2)

Module – II

1. Spectrophotometric determination of dissolved inorganic phosphate in seawater by ammonium molybdate – ascorbic acid method (6 hrs; Ref 1)
2. Spectrophotometric determination of nitrite in seawater by sulphanilamide – diamine method (6 hrs; Ref 1)
3. Spectrophotometric determination of nitrate in seawater by reduction to nitrite using copper – coated cadmium reduction column (6 hrs; Ref 1)
4. Spectrophotometric determination of ammonia in seawater by indophenol blue method (6 hrs; Ref 1)
5. Spectrophotometric determination of dissolved inorganic silicate in seawater by ammonium molybdate – ascorbic acid – oxalic acid method (6 hrs; Ref 1)

References

1. Methods of Seawater Analysis, 1983, 1999 – Grasshoff, K., Ehrhardt, M. and Kremling, K.; Verlag Chemie, Weinheim.
2. Instrumental Methods of Chemical Analysis, 1981 – Ewing, G. W.; McGraw-Hill, New York.
3. A Manual of Chemical and Biological Methods for Seawater Analysis, 1984 – Parsons, T. R., Maita, Y. and Lalli, C. M.; Pergamon Press, Oxford.

Semester II

MSC 231: Marine Geology (4 credits)

Module – I

Sediment, sediment grade scale and analysis – Classification, composition, distribution and source of sediments with emphasis on near shore areas – Surveying, sampling and laboratory techniques for the study of coastal and estuarine sediments – Analysis of sedimentological data and interpretation – Instruments used in marine geology, Beach and

beach profile, variations in beach morphology and its significance – Near shore geological processes: erosion, transportation and deposition

Module – II

Sea bed minerals with emphasis on Indian ocean – Polymetallic nodules, phosphorites, carbonates, placer deposits and petroleum resources, gas hydrates – Fossilization process – Types of microfossils and classification, technique for paleoclimate reconstruction with respect to oxygen isotope studies, role of microfossils in paleo – oceanography, paleoclimate, marine archaeology petroleum exploration and monitoring marine pollution

Module – III

Structural Geology - Folds - parts of fold, nomenclature, types, causes; Faults - nomenclature, types; Joints, Minerals and their physical properties, Rocks - classification and properties, Ground water and saline water intrusion on the coastal plain and ground water.

Module – IV

Principles of geophysical methods: Gravity, magnetic and seismic – Elucidation of the structure of the earth using seismic model – Instruments used in marine geophysics. Hydrography – position fixing, depth measurement and sea bed mapping technique, side scan sonar, hydrographic chart.

References

1. Introductory oceanography (5th ed), 1988 Thurman, H. V., Columbus Mercill Publ. Co, Ohio.
2. Oceanography (5th ed), 1990 Grant Gross, M., Englewood Cliffs, N.J, Prentice Hall.
3. Coastal and estuarine sediment dynamics, 1986 Dyer, K. R., John Wiley & Sons, Wiley, Chichester.
4. Beach processes and sedimentation, 1976 Komar, P. D., Englewood Cliffs, NJ Prentice Hall.
5. Beaches and Coasts (2nd ed), 1972 King, C. A. M., Edward Arnold, London.
6. Introduction to marine micropaleontology, 1978 Haq, B.U. and Boersma, A. (Eds.), Elsevier Publ.
7. Introduction to geophysical prospecting, 1976 Dobrin, M. B., McGraw-Hill.
8. Gravity and magnetics in oil prospecting, 1976 Nettleton, L. L., McGraw-Hill.
9. The mineral resources of the sea, 1965 Mero, J. L., Elsevier, Amsterdam.
10. Earth resources, 1969 Skinner, B. J., Prentice Hall.
11. Structural Geology, 1972 M.P. Billings, Third Edition, Prentice Hall College Div.
12. Marine minerals: advances in research and resource assessment, 1987 Teleki, P.G., et al., D. Reidel Dordrecht.
13. The micropaleontology of oceans, 1971 Funnell, B. M. and Reidel, W. R., Cambridge Univ. Press, U.K.
14. Marine geology and oceanography of the Arabian Sea and coastal Pakistan, 1984 Haq, B.U. and Milliman, J. D., Van Nostrand Reinhold Co.
15. Marine Geology, 1982 James P. Kennet., Prentice Hall INC Englewood, Cliffs, N. J. 07632.

MSC 232: Computational Methods in Oceanography (4 credits)

Module – I

Programming FORTRAN (90/95): constants, variables, arithmetic operations, arithmetic expressions – assignment statements – input – output statement - library functions – Hierarchy of operation – mixmode operations- relational operators, precedence of operators. IF-THEN - ELSE statement – ELSEIF structures – NESTED IF blocks – DO LOOP – NESTED DO LOOP – Intrinsic DO LOOP.

Module – II

Applications of basic Mathematics to oceanography : Indices, Logarithms, linear and parabolic functions – Permutation and combinations – Arithmetic and geometric progression – Differentiation, application of differentiation – Velocity, acceleration, related rates. Application of integration to growth and decay problems - Matrices: addition, subtraction, multiplication, inverse by adjoint method.

Module – III

Descriptive statistics: population sample – measures of central tendency - measures of dispersion – skewness kurtosis – simple correlation, Karl Pearson's coefficient of correlation, concurrent deviation method, method of least squares (regression) – regression equation – introductory probability.

Module – IV

Normal and binomial distribution – Inferential statistics: standard error – significance level – hypothesis testing: students t-test: test of significance for attributes, large samples and small samples, Z test, χ^2 (chi square) test, F test, analysis of variance

References

1. A biologist's basic mathematics, 1983 – Causton, D.R., Edward Arnold, London, Edward Arnold Publishers Ltd.
2. Statistical Methods in Atmospheric Sciences, 2nd edition, 2011 - Daniel S. Wilks, Academic Press
3. Introduction to mathematics for life scientists, 1971 – Batchelet, E., Springer
4. Mathematics for biological sciences, 1980 – Newby J.C., Oxford University Press, U.K.
5. College algebra, 1966 - Bardell, R.H. and Spitzbart, A., Addison-Wesley, Massachusetts, U.S.A.
6. Introduction to algebra, 1966 – Perlis S., Blaisdell Publ. Co., London.
7. Differential equations, 1985 - Wylie, C.R., McGraw Hill Publ., Singapore.
8. Statistics: Theory methods and applications, 1988 – Samchev, D.C. and Kapoor, V.K., Sultan Chand and Sons, New Delhi.
9. Biometry, 1981 – Sokal, R.R. and Rohlf, F.J. Freeman & Co. San Francisco.
10. Statistical methods, 1967 – Snedecore, G.W. and Cochran, W.G., Allied Pacific Pvt. Ltd., Mumbai.
11. Multivariate statistical methods, 1990 – Morrison, D.F., McGraw, Hill Publ., Singapore.
12. Fundamental computer concepts, 1986 - Davis, W.S. McGraw Hill Publ., Singapore.
13. Theory and problems of data processing, 1982 – Lipschutz, M.M. and Lipschutz, S., McGraw Hill Book Co., Singapore.
14. Fortran 77 and numerical methods, 1994 Xavier, C., Wiley-Eastern Ltd., New Age International Ltd., New Delhi.
15. Computer Programming in FORTRAN 90/95, 1997, V. Rajaraman, Prentice Hall of India, New Delhi.
16. FORTRAN 90/95 for Scientists & Engineers, 1998 - S.J. Chapman, Mc-Graw Hill.

MSC 233: Computational Methods in Oceanography Practical (2 credits)

Module – I

1. Programs illustrating use of Numeric constants & variables, Arithmetic operators & expressions, simple input and output statements, hierarchy of operations. (6hrs; Ref 1,2,3,4)
2. Programs illustrating use of logical expressions, integer, real & mix mode operations & library functions (6hrs; Ref 1, 2, 3, 4)
3. Programs illustrating use of IF-ENDIF, IF-ELSE-ENDIF and IF-ELSEIF-ELSE-ENDIF (4hrs; Ref 1,2,3,4)
4. Programs illustrating use of DO loops, nested DO loops (4hrs; Ref 1, 2, 3, 4)
5. Programs illustrating use of one and two dimensional arrays (6hrs; Ref 1, 2, 3, 4)
6. Programs illustrating use of different types of FORMATS (4 hrs; Ref 1, 2, 3, 4)

Module – II

1. Programs illustrating subroutines and reading/writing data from files - hard disk. (6hrs; Ref 1, 2, 3, 4)
2. Programs for computation of statistical parameters for analysis of oceanographic data. (6hrs; Ref 1 2, 3, 4, 5)
3. Writing programs for sample data extraction and validating (6hrs; Ref 1, 2, 3, 4)
4. Use of statistical software for estimation of statistics /parameter of sample/population (2hrs; Ref 5)
5. Writing programs for data extraction, validating & generating horizontal sections of oceanographic property using software with different gridding method to ascertain the most suitable gridding method. (6hrs; Ref 1, 2, 3, 4 & Surfer software manual)
6. Writing programs for data extraction, validating & generating contour map for analysis of vertical & surface properties (4hrs; Ref 1, 2, 3, 4 & Surfer software manual).

References

1. Computer Programming in FORTRAN 90/95, 1997. V. Rajaraman, Prentice Hall of India, New Delhi.
2. Fundamental algorithms, 1985 – Knuth, D.E., Narosa Publ. House, New Delhi.
3. Theory and practice of programming, with FORTRAN, 1986 – Lipschutz, S & Poe, A., McGraw Hill Book Co., Singapore.
4. FORTRAN 90/95 for Scientists & Engineers, 1998 - S.J. Chapman, Mc-Graw Hill.
5. Statistical Methods, 2009 - S C Gupta, Sixth edition, Himalaya publishing House

MSO 234: Marine Geology Practical (2 credits)

Module – I

1. Field survey (Beach) - locating a station using compass and GPS; Beach profile measurement and sediment sample collection from different parts of the beach (4 hrs; Ref 2)
2. Plotting station locations on the base map and beach profile; volume computation from the given data (4 hrs; Ref 2)
3. Coning and quartering, pretreatment of sediment sample to remove calcium carbonate, organic matter and ferruginous material (4 hrs; Ref 1, 6)
4. Grain size analysis (sand) using Ro-tap sieve shaker – batch I (8 hrs; Ref 1, 6)
5. Computation of weight and cumulative percentages, plotting frequency and probability graphs, computation of modes of transport and grain size parameters and interpretation (4 hrs; Ref 1, 6)
6. Field Survey (Estuary) – locating stations using GPS, Measurement of Secchi depth, total depth; collection of water samples using Niskin sampler at near surface and near bottom and measurement of temperature at different locations along the estuary. Collection of sediment sample using a grab sampler (8 hrs; Ref 3, 4)
7. Separating total suspended matter from water, plotting suspended matter, interpretation with respect to locations and considering tide (4 hrs; Ref 5)

Module – II

1. Heavy mineral separation from different fractions of sand and interpretation (4 hrs; Ref 1, 9)
2. Plot bathymetry lines and interpret geomorphology (4 hrs; Ref 4)
3. Study bathymetry maps (4 hrs; Ref 4)
4. Study seismic profiles and draw sections and interpret features (4 hrs; Ref 8)
5. Compute gravity data, plot and study variations. Plot and compute depth of a ore body using half anomaly method. Compute gravity corrections (8 hrs; Ref 7, 8)
6. Compute magnetic data, plot and study variations. Plot and compute depth of a single pole using half anomaly and peter's slope methods (8 hrs; Ref 7, 8)
8. Compute seismic data – compute depth of horizontal sedimentary bed using both reflection and refraction methods (4 hrs; Ref 7, 8)

References

1. Exercises in sedimentology, 1982 Freidman, G. M. and Johnson K. G., John wiley and sons.
2. Beach processes and sedimentation, 1976 Komar, P. D., Prentice Hall
3. Estuaries – a physical introduction, 2nd edition, Hoboken, N J., John Wiley.
4. Flume studies on the transport of sediments in estuarine shoaling processes-A report, 1962 Hydraulic Engineering Laboratories, University of Berkeley, C A.
5. A practical handbook of seawater analysis, 1972 Strickland, J.D.H and Parsons, T. R., FISHERIES RESEARCH BOARD OF CANADA, Ottawa.
6. Practical manual of sedimentary petrology, 1987 Babu, S. K. and Sinha, D. K., CBS, Publishers and Distributors, Delhi.
7. Introduction to geophysical prospecting, 1976 Dobrin, M. B., McGraw-Hill.
8. Gravity and magnetics in oil prospecting , 1976 Nettleton, L. L., McGraw-Hill.
9. The mineral sources of the sea, 1965 Mcro, J. L., Elsevier, Amsterdam.

MSO 235: Remote sensing and its applications (4 credits)

Module – I

Principles of Electromagnetic radiation– Energy matter interactions – Rayleigh scattering – Mie scattering – Non selective scattering - Radiative transfer in the atmosphere – Stefan's and Wien's displacement laws –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.

Module – III

Sun photometry - Beer-lambert's law - spectral variation of aerosol optical thickness - atmospheric correction - interpretation of ocean colour - spectral response of water as a function of organic and inorganic constituents - Analysis

of suspended minerals, chlorophyll *a* and dissolved organic matter through OCM/MODIS data.

Module – IV

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 – MSS, GOES, AVHRR, CZCS, SeaWiFS, IKONOS, MODIS, OCM I and OCM-II, LISS -I, LISS-II, WIFS and PAN – Fundamentals of digital image processing – Image rectification – Image enhancement – linear stretching – supervised and unsupervised classification - Introduction to Geographic Information system.

References

1. Physical principles of remote sensing, 1990 – Rees, W.G., Cambridge Univ. Press, U.K.
2. Remote sensing optics and optical systems, 1980 – Slater, P.N., Addison Wesley Publ. Co.
3. Remote sensing and image interpretation (2nd edn), 1987 – Lillesand, T.M. and Kiefer, R.W., John Wiley and sons.
4. Remote sensing: Principles and interpretations (2nd edn), 1987 – Floyd and F. Sabnis Jr. W.H. Freeman and Co., New York.
5. Theory and application of optical remote sensing, 1989 – Asrar G., John Wiley & Sons.
6. Introduction to satellite oceanography, 1985 – Maul, G.A., Martinus Nijhoff Publ.
7. Advanced remote sensing from theory to applications (vol.1, 2 & 3), 1981 – Chlamys, F.T., Addison wisley Publ. Co. Inc., Canada.
8. Oceanography from space, 1987- Gover, J.A.R., Plenum Press, New York.
9. Remote sensing of atmospheres and oceans, 1980 - Deepak A., Academic press.
10. Satellite oceanography, 1985 - Robinson, I.S., John Wiley & Sons

MSO 236: Remote Sensing and its applications Practical (2 credits)

Module - I

1. Field survey and laboratory analysis to generate apparent optical properties from case II waters using in-water radiometer, and profiles of salinity and temperature using conductivity, temperature and Depth (CTD) sensor, (16 hrs; Ref 1)
2. Generation of Inherent Optical properties (IOP) of optically active substances (OAS), namely absorption of chlorophyll-*a* (chl-*a*), Chromophoric dissolved organic matter (CDOM) and total Suspended Inorganic Matter (TSM) from water samples collected during the field survey of case II waters (10 hrs; Ref 1)
3. Simulation of remote sensing reflectance and water leaving radiance from case II waters (4 hrs; Ref 2)

Module – II

1. Simulation of remote sensing reflectance for each optically active substance and delineation of range of wavelengths susceptible to each OAS and development of empirical algorithms (10 hrs; Ref 3)
2. Generation of aerosol optical depth using sun-photometer and analysis of aerosol optical depth to estimate atmospheric turbidity parameter and Angstrom exponent (8 hrs; Ref 4,5,8)
3. Satellite data processing to map chlorophyll *a*, using ERDAS IMAGINE SeaDAS(12 hrs; Ref 6, 7 and 8)

References

1. Regional validation of MERIS CHLOROPHYLL products in North coastal waters (REVAMP) Protocol, based on NASA and colors protocols, 2002 - Tilstone, G.H, Moore, G.F, Sorensen, K, Doerffer, R, Rottgers, K.G, Ruddick, R, Psterkamp, P.V and Jorgensen, ENVISAT – 1
2. Physical principles of remote sensing, 1990 – Rees, W.G., Cambridge Univ. press, U.K. 25
3. Remote sensing: Principles and interpretations (2nd edn), 1987 – Floyd and F. Sabnis Jr, W.H. Freeman & Co., New York.
4. Theory and applications of optical remote sensing, 1989 – Asrar, G., John Wiley & Sons.
5. Introduction to satellite oceanography, 1985 – Maul, G.A., Martinus Nijhoff Publ.
6. Advanced remote sensing from theory to applications (Vol.1, 2 & 3), 1981, Chlamys, F.T., Addison – Wesley Publ. Co. Inc., Canada.
7. Oceanography from space, 1987 – Grover, J.A.R., Plenum Press, New York.
8. Remote sensing of atmospheres and oceans, 1980 – Deepak, A., Academic Press.
9. SBE plus CTD, User's manual www.seabird.com/pdf_documents/manuals/9_plus_017.pdf
10. Regional Oceanography, an Introduction, 2nd edition, 2003 - Tomczak, Mattias and Stuart Godfrey J., Daya Publishing house, Delhi.

MSO 237: Analytical Chemistry of Sea water and Instrumental Techniques (4 credits)

Module - I

Sampling – Collection and preservation of water, sediment and biological samples. General Errors, Accuracy and Precision.

Filtration and Storage - Criteria of an ideal filtering medium- Glass fiber, membrane and Nucleopore filters. Storage for analysis of water for major elements, nutrients, dissolved phosphate, total phosphorous, nitrogen compounds silicates, and trace metals.

Chemical separation methods: Matrix effects, Interference effects. Pre-concentration methods: Co-precipitation, Co-crystallization, ion exchange and solvent extraction methods, their principles and applications.

Module - II

Fresh water recovery by various methods of desalination, Low temperature thermal desalination, Distillation, solar evaporation, Membrane process, scale formation and its prevention.

Chemical recovery process- Chemistry of salt manufacture, Different grades of salt, washing of sea salt, salt for industries, up-gradation of sea salt, solar evaporation, forced evaporation of brine, Grainer process, Alberger process, Open pan evaporation and vacuum pan evaporation methods.

Recovery of bromine from salt bittern, Dow process, Steaming out process for the manufacture of bromine.

Recovery of magnesium, magnesium metal from sea water, Dow process and IG-MEL process for the production of magnesium.

Recovery of potassium from sea water, Balard and Niccoli Processes for the production of potassium from sea water.

Module - III

Extraction of Agar, Alginates and Carrageenan from seaweeds - their structures, production, uses and toxicology.

Extraction of marine drugs: Chemical and Pharmacological Aspects- Prostaglandins, Steroids, Terpenes and Nitrogenous compounds, Antibiotic compounds from sponges, Cephalosporins and Fish and Shellfish toxins.

Module - IV

Electro-analytical methods: Polarography: Basic principles and application in chemical speciation studies.

Chromatographic methods: Paper thin layer gas liquid and high performance liquid chromatograph Basic principles and application to marine samples.

Spectroanalytical methods: Photometry and Spectrophotometry, Fluorimetry, Flame photometry, Atomic absorption spectrophotometry, Flameless AAS and Inductively coupled plasma emission spectrometry (ES and MS) - Basic principles, instrumentation and applications in the analyses of marine samples.

References

1. A text book of qualitative Inorganic Analysis including Elementary Instrumental analysis, Vogel - 1978. The English Language book society.
2. Standard methods for the examination of water and waste water analysis (22nd edition), 2012. Rice, E.W and Bridgewater L. American Public health association, Washington DC.
3. Methods of seawater analysis, 1983 - Grosshoff, Verlag Chemie, Weinheim.
4. Manual for geochemical analysis of marine sediments and suspended particulate matter, 1992 - Loring and Rantala, Earth Science Review.
5. Chemical Oceanography, 1975 - Riley, J.P and Skirrow, G (eds.), Vol. 3, 1975. Academic Press, London.
6. Environmental Chemistry, 1995 - Anil Kumar De, Wiley Eastern Limited and New age international limited, New Delhi.
7. Marine drugs: chemical and Pharmaceutical aspects. In Chemical Oceanography - H.W. Young Y. Shimizu. In Chemical Oceanography, volume 4, Riley, J.P, and Chester, G (eds.).
8. Marine natural products, 1983 - Scheuer, P.J (ed), Chemical and Biological prospective, Academic Press, London.
9. Marine natural products, 1973 - Scheuer, P.J. Academic Press, London.
10. Quantitative analysis, 2001 - Day, R.A, and Underwood, A.L. Prentice-Hall of India, New Delhi.
11. Instrumental methods of Chemical analysis, 4th edition, 1981 - Ewing, G.W., Mc Graw Hill.

MSO 238: Analytical Chemistry of Sea water and Instrumental Techniques Practical (2 credits)

Module - I

1. Pre concentration of sea water for estimation of dissolved trace metals by AAS technique. (8 hrs; Ref 1, 2, 3, 4)
2. Digestion of particulate matter for estimation of trace metals (6 hrs; Ref 5)

1. Estimation of dissolved and particulate Mn in seawater by Flame AAS method. (6 hrs; Ref 2, 3)
4. Estimation of dissolved and Particulate Co in seawater by Flame AAS method (5 hrs; Ref 2, 3)
5. Estimation of dissolved and particulate Fe in seawater by Flame AAS method (5 hrs; Ref 2, 3)

Module II

1. Sediment digestion. (10 hrs; Ref 5)
2. Estimation of Mn in sediments by Flame AAS method. (5 hrs; Ref 2, 3, 4, 5)
3. Estimation of Co in sediments by Flame AAS method. (5 hrs; Ref 2, 3, 4, 5)
4. Estimation of Fe in sediments by Flame AAS method. (5 hrs; Ref 2, 3, 4, 5)
5. Speciation of metals in sediments (Sequential extraction procedure) (5 hrs; Ref 5)

References

1. Standard methods for the examination of water and waste water analysis (22nd edition), 2012, Rice, E.W and Bridgewater L. American Public health association, Washington DC.
2. Analytical chemistry of seawater, 1975 – Riley J. P. In Chemical Oceanography, J.P. Riley and G. Skirrow (eds.), Vol. 3, Academic Press, London.
3. Methods of Seawater analysis, 1983 – Grasshoff K. K, Grasshoff, M, Ehrhardt and K. Krembling (eds.), Verlag Chemie, Weinheim, 419.
4. Manual for geochemical analysis of marine sediments and suspended particulate matter, 1977 – Loring, D. H. and Rantala, R. T. T., Fish, Mar. Serv. Dev. Technical Report 700.

MSO 239: Aquaculture (4 credits)

Module - I

Principles of aquaculture, global scenario, status and prospects of coastal aquaculture in India, traditional aquaculture practices.

Module – II

Basic considerations, site selection, water quality management, species selection, feasibility and technique applied for mussel, pearl oyster, fish, lobster and seaweed culture practices.

Module – III

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 and lessons learned from Global and local scenario.

Module – IV

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, shrimp health management, need and advantages of integrated aquaculture practices, Brackish water aquaculture, environmental issues and management strategies, Coastal aquaculture Act, 2005.

References

1. Stickney, R. R. 2009. Aquaculture: An Introductory Text. 2nd edition. CABI. 304 pages
2. Parker, R. 2011. Aquaculture Science. 3rd Edition, Cengage Learning. 672 pages
3. Aquaculture, 1989 – Pillai, T.V.R.
4. Fish and fisheries of India, 1982 – Jhingran, V.G., Hindustan Publ. Corp. India Ltd. New Delhi
5. Diseases of Marine animals – Marine Ecology (Vol 4). 1983 – Kinne, O., Wiley
6. Crustacean aquaculture, 1983 McKey, J.P. CRC series.
7. Aquaculture, 1972 – Bardach J. E. Wiley-Inter-science
8. Prawn and prawn fisheries of India, 1976 – Kurian, C.V. & Sebastian, V.O. Hindustan Pub. Corp
9. Environmental management for aquaculture, 1998 – Midlen, A., Springer, Netherlands
10. Nutrition and feeding of fish, 1999 – Lovell, T. Springer Science & Business Media

MSO 240: Aquaculture Practical (2 credits)

Module – I

Identification of cultivable fishes of shrimps, mussels, oysters, fish, crabs and sea weeds (12 hrs; Ref 1), Reproductive system of shrimp (2 hrs; Ref 5), Identification of larval stages of shrimp of commercial importance (4 hrs; Ref 3), Methods of estimation of dissolved oxygen, BOD, suspended solids, dissolved and particulate organic carbon and ammonia (12 hrs; Ref 2)

Module – II

Visit to shrimp hatchery for demonstrations (12 hrs), Visit to NIO laboratory for demonstration of biological filter and air lift aeration system (12 hrs), Fabrication of raft, transplantation of spat for mussel culture (6 hrs).

References

1. Crustacean aquaculture, 1983 – Mekey, J.P., C.R.C. series.
2. Training manual on recent advances in management of water quality parameters in for aquaculture, 1997 – C.I.F.E. Publication, Mumbai.
3. Training manual on advances in keeping and breeding ornamental fishes, 1997 – C.I.F.E. Publication, Mumbai.
4. Training manual on culture of live food organisms for aqua hatcheries, 1998 – C.I.F.E. Publication, Mumbai.
5. Training manual on culture of live fish for aquaculture, 1998 – C.I.F.E. Publication, Mumbai.

MSO 241: Marine Chemistry Practical II (2 credits)

Module – I

1. Determination of sulphate in seawater gravimetrically by precipitation of BaSO_4 using BaCl_2 in the presence of picric acid (6 hrs; Ref 1)
2. Determination of thiosulphate in seawater by iodometric titration with the removal of sulphide using zinc acetate (6 hrs; Ref 1)
3. Determination of bromide in seawater by oxidizing to bromate using hypochlorite followed by iodometric titration (6 hrs; Ref 1)
4. Spectrophotometric determination of urea in seawater by diacetyl monoxime – semicarbazide method (6 hrs; Ref 1)
5. Spectrophotometric determination of carbohydrates in seawater by 3- methyl-2-benzothiazoline hydrazone (MBTH) method (6 hrs; Ref 1)

Module – II

1. Spectrophotometric determination of nitrate in seawater by resorcinol method (6 hrs; Ref 2, 7)
2. Spectrophotometric determination of ammonia in seawater by oxidation method (6 hrs; Ref 3)
3. Laboratory experiments to study variation of pH on river water-seawater interactions (mixing experiments followed by pH measurements by pH meter) (6 hrs; Ref 1, 6, 11)
4. Determination of dissolved Al spectrophotometrically by pyrocatechol violet method (6 hrs; Ref 1)
5. Reactivity of dissolved Al with particulate material: laboratory simulations (mixing experiments followed by determination of dissolved Al spectrophotometrically by pyrocatechol violet method) (6 hrs; Ref 1, 5, 12)

References

1. Methods of Seawater Analysis, 1983, 1999 – Grasshoff, K., Ehrhardt, M. and Kremling, K.; Verlag Chemie, Weinheim.
2. Organic Reaction Mechanisms, 1997 - Knipe, A. C. and Watts, W. E., John Wiley and Sons, New York.
3. A Manual of Chemical and Biological Methods for Seawater Analysis, 1984 – Parsons, T. R., Maita, Y. and Lalli, C. M.; Pergamon Press, Oxford.
4. Aquatic Chemistry, 1981, 1996 – Stumm, W. and Morgan, J. J., John Wiley and Sons, New York.
5. Aquatic Surface Chemistry, 1987 – Stumm W., John Wiley and Sons, New York.
6. Practical Estuarine Chemistry, 1985 - Head, P.C., Cambridge University Press, Cambridge.
7. A simplified resorcinol method for direct spectrophotometric determination of nitrate in seawater, 2006 - Zhang, J. Z. and Fischer, C. J. Marine Chemistry, 99, 220 – 226.
8. Phosphorus release from lake sediments: effects of pH, temperature and dissolved oxygen, 2014 - Wu, Y., Wen, Y.,

Zhou, J. and Wu, Y., KSCF Journal of Civil Engineering, 18, 323 – 329.

9. The effect of pH on the release of phosphorus from Potomac estuary sediments: Implications for blue-green algal blooms, 1991 - Seitzinger, S. P., Estuarine, Coastal and Shelf Science, 33, 409-418.
10. Emission of carbon dioxide from a tropical estuarine system, Goa, India, 2001 - Sarma, V.V.S.S., Dileep Kumar, M. and Manerikar, M., Geophysical Research Letters, 28, 1239-1242.
11. Chemistry of dissolved inorganic carbon in estuarine and coastal brackish waters, 1975 - Mook, W.G. and Koene, B.K.S., Estuarine, Coastal and Marine Science 3, 325-336.
12. Sorption model for dissolved and leachable particulate Al in the Great Ouse estuary, England, 2012 - Upadhyay, S., Aquatic Geochemistry, 18, 243-262.

MSO 242: GIS Applications in Marine Science Practical (2 credits)

Module – I

1. GIS, GIS software familiarization and image properties (8 hrs; Ref 1&2)
2. Data acquisition and integration in GIS software (6 hrs; Ref 1&3)
3. Image edge detection, Transects, spectra and time series images (6 hrs; Ref 3)
4. Contrast stretching, Colour palettes, smoothing satellite images (4 hrs; Ref 3 & 4)
5. Digitizing Vector maps (6 hrs; Ref 6)

Module – II

1. The Importance of Acquiring satellite Images of the Appropriate resolution (4 hrs; Ref 3 & 5)
2. CRZ mapping (6 hrs; Ref 2,3 & 4)
3. Estimating coral bleaching potential from SST (6 hrs; Ref 1 & 3)
4. Mangrove Leaf-Area Index (LAI) using imageries (6 hrs; Ref 1&3)
5. Geospatial Analysis of Vector data (8 hrs; Ref 6)

References

1. Practical Handbook of Digital Mapping: Terms and Concepts Arlinghaus, 1994 Sandra L., - CRC Press. 0-8493-0131-9
2. Coastal and marine geospatial technologies, 2010. Ed. David R Green, Springer, ISBN 978-1-4020-9719-5
3. Remote Sensing Handbook for Tropical Coastal Management. Coastal Management Source books 3, 2004. Edmund P. Green, Peter J. Mumby, Alasdair J. Edwards and Christopher D. Clark, UNESCO, Paris.
4. Principles of Geographic information systems- An introductory text book, 2009 - Eds Jottohuisman and Roft A. de By (ed.) International Institute for Geo-Information and Earth Observation, Netherlands.
5. Essentials of Geographic Information Systems, 2011 - Jonathan Campbell, Michael Shin Publisher: Flat World Knowledge
6. GRASS GIS: a multi-purpose Open Source GIS. Environmental Modelling & Software, 2012 - Neteler, M., Bowman, M.H., Landa, M. and Metz, M.

Semester III

MSC 331: Geophysical Fluid Dynamics (4 credits)

Module – I

Basic concepts: fluid continuum; fluid properties, ideal fluid, actual fluids, types of flow; D'Alembert's Paradox; statics: pressure surface and body forces on a fluid element; fundamental equation of fluid statics; application to compressible and incompressible fluids, perfect gas equation, hydrostatic equation along the vertical, application to the atmosphere, Laplace's equation. Units of measurement – Newtonian and non – Newtonian fluids – Kinematics –

Module – II

Kinematics: Lagrangian and Eulerian methods of description of fluid flow-Lagrangian and Eulerian method- stream

lines, streak lines and trajectories, Biot's equation, steady and non-steady flow, decomposition of the field of motion in the vicinity of a point, translation, rotation, divergence and deformation, Principles of Prandtl's mixing length theory, Taylor's statistical theory and Kolomogoroff's similarity theory physical interpretation, application to plane motion, typical flow patterns, stream function, divergence and vorticity in different co-ordinate systems, material, local and convective derivatives.

Module – III

Dynamics -I: equation of continuity and its applications, non-viscous incompressible flow, Eulerian equations of motion, inertial and rotational frames of reference, Coriolis force, irrotational flow, velocity potential, integration of the equations of motion, Bernoulli's theorem and its applications.

Module – IV

Dynamics – II: Circulation and vorticity, Stoke's theorem, Kelvin's theorem, Helmholtz theorem, barotropic and baroclinic fluids, absolute and relative circulation; V. Bjerknes circulation theorem and its interpretation, potential vorticity-conservation, application to air flow over mountain barriers, Navier-Stoke's equations of motion for a viscous Newtonian fluid; laminar flow of viscous incompressible fluids, Poiseuille flow, Couette flow, steady flow around a sphere, Stoke's formula, Reynold's number and dynamic similarity of flows, physical significance of Reynold's number, low and high Reynold's number.

References

1. Hydraulics and fluid mechanics, 1985 – Modi, P.N. and Seth., Standard Book House, Delhi.
2. Foundation of fluid mechanics, 1969 – Yuan, S. W., Prentice Hall, New Delhi.
3. An introduction to fluid mechanics, 1967 – Batchelor, G.K., Cambridge Univ. Press, UK.
4. Hydrodynamics, 1975 – Lamb, H., Cambridge Univ. Press, U.K.
5. Introduction to fluid mechanics, 1976 – Rathy, R.K., Oxford and IBH Publ. Co., New Delhi.
6. The physics of marine atmosphere, 1965 – Roll, H.U., Academic Press, London.
7. Atmosphere – Ocean Dynamics, 1982 – Gill, Adrian E, International Geophysics, 30 Academic press, New York.

MSC 332 / MSO 332: Ocean-Atmosphere coupling and Climate I (2 credits)

Module – I

Wind generation, forces acting on wind, Geostrophic winds, thermal winds. Wind wave generation, scale of interaction, General character of sea surface as a lower boundary of air flow – Geometry of the sea surface – The wind field in the maritime frictional layer. Drag coefficient.

Module – II

General consideration of air sea interaction – Planetary boundary layer - Laminar boundary layer, surface layer and spiral layer. Variation of air sea fluxes with special reference to upwelling – Transfer of heat and water vapour – Determination of air – sea fluxes – Fronts and water masses interaction -Profile method and non profile methods.

References

1. Monitoring & prediction of tropical cyclones in Indian Ocean & climate change, 2014 - U. C. Mohanty, M. Mohaptra, O.P Singh, B. K Bandhopadhyay & L. S. Rathore.
2. Hot Spots in the climate system, 2016 - Nakamura H., Isobe A., Minobe S., Mitsudera, H. Nonaka M., Suga, T. (Eds.), Springer.
3. Air Sea exchange of heat and moisture during storms, 1987 - R.S Bortkovskii, Revised English edition by Edward C. Monahan, Springer.
4. The physics of marine atmosphere, 1965 - Roll, H.U., Academic Press, London.
5. The sea: Ideas and observations (Vol.1), 1962 – Hill, M.N.(Ed.), John Wiley & sons, New York.
6. Oceanography for meteorologists, 1945 – Sverdrup, H.U., George Allen &Unwin, London.
7. Principles of physical oceanography, 1996 – Pierson, W.J. and Newman, G., Prentice Hall Inc., New Jersey, U.S.A.
8. Introduction to theoretical meteorology 1959 – Hess, H.L., Holt, Rinehart & Winston, New York.
9. Tropical meteorology (Vol. 1 & 2), 1993 – Asnani, G.C., Asnani Publ., Pune, India.
10. The physics of monsoons, 1992 – Keshavmurthy and Rao, Allied Publ., New Delhi.
11. Climate change, 1995 – Houghton, J.T., Cambridge Univ. Press, U.K.
12. Climate of South Asia, 1997 – Pant and Kumar, John wiley.

13. Global environmental issues: Climatological approach, 1994 – *Global environmental issues: A climatological approach* (2nd edn), 1994, David D. Kemp, Routledge, (London).

MSC 333: Geophysical Fluid Dynamics Practical (2 credits)

Module – I

1. Kinematics analysis of wind and ocean current – Isotach and isogen analysis and construction of streamline patterns (10 hrs; Ref 1)
2. Construction of trajectories of air parcels from successive synoptic charts (8 hrs; Ref 1)
3. Computation of divergence and vorticity in horizontal flow (12 hrs; Ref 2)

Module – II

1. Construction of stream lines for simple types of flow (7 hrs; Ref 2)
2. Field observations and analysis of Physical Oceanographic parameters of estuarine waters using conductivity temperature and depth (CTD) instrument (15 hrs; Ref 1,3)
3. Analysis of aerosol trajectory using HYSPLIT (HYbrid Single – Particle Lagrangian Integrated Trajectory) model. (8 hrs; Ref 4)

References

1. Introduction to Physical Oceanography, 2008 – Robert H. Stewart, Department of Oceanography Texas A&M University, [oceanworld.tamu.edu/resources/ocng_textbook/PDF files/book.pdf](http://oceanworld.tamu.edu/resources/ocng_textbook/PDF%20files/book.pdf)
2. Guide to wave analysis and forecasting (2nd edition), 1998 - World Meteorological Organization (WMO- no 702) ISBN-92-63-12702-6, www.wmo.int/pages/prog/amp/mmop/documents/WMO%20No%20702/WMO702.pdf
3. Ocean Circulation and Climate (2nd Ed), 2013 - A 21st Century perspective eds. Siedler, G, Griffies, S, Gould J, and Church, J, ISBN- 978-0-12-391851-2, Academic press.
4. HYSPLIT- Hybrid Single Particle Lagrangian integrated Trajectory Model, Air Resources Laboratory, <http://www.arl.noaa.gov/>, NOAA technical memorandum ERL, ARL-224, Roland R. Draxler and Hess, G.D
5. The physics of marine atmosphere, 1965 – Roll, H.U., Academic Press, London.
6. Atmosphere – Ocean Dynamics, 1982 -- Gill, Adrian E, International Geophysics, 30 Academic press, New York.

MSC 334: Ocean Atmosphere Coupling and Climate Practical (2 credits)

Module – I

1. Data extraction from global data sets of Short Wave Radiation and analysis of its distribution (6hrs; Ref 1, 2, 3, 4)
2. Data extraction from global data sets of Long Wave Radiation and analysis of its distribution (6hrs; Ref 1, 2, 3, 4)
3. Data extraction from global data sets of Sensible Heat flux and analysis of its distribution (6hrs; Ref 1, 2, 3, 4)
4. Data extraction from global data sets of Latent Heat Flux and analysis of its distribution (6hrs; Ref 1, 2, 3, 4)
5. Estimation of Net heat flux from above extracted data sets and analysis of its distribution (6hrs; Ref 1, 2, 3, 4)
6. Analysis of fluxes over Central Pacific during Normal, El-Nino and La Nina events (6hrs; Ref 5)

Module – II

1. Arabian Sea SST and Indian Summer rainfall correlation (6hrs; Ref 6)
2. Central Pacific SST and Indian Summer rainfall correlation (6hrs; Ref 6)
3. Cyclone intensity estimation using Dvorak technique for satellite images (8hrs; Ref 6, 7)
4. Determination and analysis of cyclone tracks in Arabian Sea and Bay of Bengal (6hrs; Ref 6)
5. Analysis of annual variations of N and S hemispheric air temperature (4hrs; Ref 3)

References

1. The Physics of marine atmosphere, 1965 – Roll, H.U., Academic Press, London.
2. Oceanography for meteorologists, 1945 – Sverdrup, H.U., George Allen & Unwin, London, U.K.
3. Climate change, 1995 – Houghton, J.T., Cambridge Univ. Press, U.K.
4. Atlas of Surface Marine Data 1994, Volume I: Algorithms and Procedures, 1994 - A. da Silva, A. C. Young, S. Levitus, No. 6, Department of Commerce, NOAA, NESDIS.
5. Air - sea fluxes from ICOADS: the construction of a new gridded dataset with uncertainty estimate, 2011 - Berry, D. L. and E. C. Kent, International Journal of Climatology, 31, 987 - 1001; DOI: 10.1002/joc.2059.
6. Tropical Meteorology, 2005 - Asnani G C.

7. The Dvorak Tropical Cyclone Intensity Estimation Technique: A Satellite-Based Method that Has Endured for over 30 Years, 2006 - Velden, Christopher, and Co-authors, *Bull. Amer. Meteor. Soc.*, 87, 1195-1210.

MSC 335: Marine Pollution Practical (2 credits)

Module - I

1. Determination of dissolved oxygen in polluted waters. (6 hrs; Ref 1)
2. Determination of biochemical oxygen demand in polluted waters. (6 hrs; Ref 1)
3. Determination of chemical oxygen demand in polluted waters. (6 hrs; Ref 2)
4. Determination of fluoride. (6 hrs; Ref 3)
5. Determination of hydrogen sulphide. (6 hrs; Ref 3)

Module - II

1. Pre-concentration of water by solvent extraction method (6 hrs; Ref 5, 6,7)
2. Digestion of biological samples for estimation of toxic metals. (6 hrs; Ref 8)
3. Estimation of Cd in polluted waters and biological sample. (6 hrs; Ref 5, 6,7)
4. Estimation of Cu in polluted waters and biological samples. (6 hrs; Ref 5, 6,7)
5. Estimation of Pb in polluted waters and biological samples. (6 hrs; Ref 5, 6,7)

References

1. Marine chemistry Vol. 1, 1972 - Martin, D.F., Academic Press, London.
2. Standard methods for the examination of water and waste water analysis (22nd edition). 2012. Rice, E.W and Bridgewater L. American Public health association, Washington DC.
3. Methods of Seawater analysis, 1983 - Grasshoff, K., M. Ehrhardt and K. Kremling (eds.), Verlag Chemie, Weinheim.
4. A practical hand book of seawater analysis, 1972 - Strickland, J.D.H. and Parsons, T.R., Fisheries Board of Canada bulletin. (2nd edition).
5. Analytical chemistry of seawater, In Chemical Oceanography, 1975 - Riley, J.P. and Skirrow, G. (eds.), Vol. 3. Academic Press, London.
6. Methods of Seawater analysis, 1983 - Grasshoff, K., M. Ehrhardt and K. Kremling (eds.), Verlag Chemie, Weinheim.
7. Chemical Analysis. In: Methods in plant Ecology, 1976 - Allen, S. E., Grimshaw, H. M., Parkinson, J. A., Quarmby, C. and Roberts, J.D. 1976, S. B. Chapman (eds.), Blackwell Scientific Publications, Oxford, Chapter 8.

MSO 336: Ocean-Atmosphere coupling and Climate II (2 credits)

Module - I

Energy exchange and global climate - Radiation and its role on tropical circulation - Monsoons: cause, inter-seasonal and intra-seasonal variability. El-nino & La - nina - Indian summer monsoon.

Module - II

Tropical cyclones: Cyclone structure, Generation, growth and decay. Temperature, pressure field and wind speed and direction. Cyclones in North Indian Ocean. - Instruments used in marine meteorology - Concepts in climatology, fundamental oceanic processes influencing climate - climate change.

References

1. The physics of marine atmosphere, 1965 - Roll, H.U., Academic Press, London.
2. The sea: Ideas and observations (Vol.1) 1962 - Hill, M.N. (Ed.), John Wiley & sons, New York.
3. Oceanography for meteorologists, 1945 - Sverdrup, H.U., George Allen & Unwin, London.
4. Principles of physical oceanography, 1996 - Pierson, W.J. and Newman, G., Prentice Hall Inc., New Jersey, U.S.A.
5. Introduction to theoretical meteorology, 1959 - Hess, H.L., Holt, Rinehart & Winston, New York.
6. Tropical meteorology (Vol. 1 & 2), 1993 - Asnani, G.C., Asnani Publ., Pune, India.
7. The physics of monsoons, 1992 - Keshavmurthy and Rao, Allied Publ., New Delhi.
8. Climate change, 1995 - Houghton, J.T., Cambridge Univ. Press, U.K.

9. Climate of South Asia, 1997 – Pant and Kumar, John Wiley.
10. Global environmental issues: Climatological approach, 1994 – Kemp, D., Routledge, D.

MSC 337 / MSO 337: Marine Pollution I (2 credits)

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.

Module – II

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.

References

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.

MSC 338 / MSO 338: Marine Pollution II (2 credits)

Module – I

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 – II

Indicator organisms: Criteria for selection of indicator organism; Quantitation 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. Standards in water quality; Assessment of pollution damage: The degree, seriousness of damage, assessment of damage and problems of measuring impact.

References

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 - Chundler, K.A. Butter Worths, London.

MSO 339: Aerosol and Atmospheric Optics (2 Credits)

Introduction to aerosols - Aerosol motion - Stoke's law and settling velocity - Sun photometry - Multi-wavelength radiometer - estimation of aerosol optical depth (AOD)- Brownian motion and diffusion deposition-Brownian coagulation- Angstrom turbidity formula - Particle sizes and functions used to fit aerosol size distribution - The lognormal- gamma and power law functions- aerosol measurement network - ARFI and AERONET- Aerosol water uptake-Solubility and hygroscopicity - Hygroscopicity and cloud condensation nuclei (CCN) activity - Aerosol optical properties and Mie theory for spherical particles.

Light absorbing black Carbon (BC) aerosol- Aerosol light scattering-absorption and extinction- Aethalometer - Quartz crystal microbalance (QCM) for size analysis - Identification of planetary boundary layer - In-situ production of aerosol -Shear and turbulence- estimation of Richardson number (Ri) - estimation of heat flux - sensible and latent-maritime and continental aerosol- land and sea breeze - Long range transport of aerosol. Retrieval of aerosol optical depth from satellite data. Estimation of aerosol radiative forcing and atmospheric heating rate- implications to climate - present status of aerosol research in India and in the world.

References

1. Atmospheric Chemistry and Physics, 2006 - From air pollution to Climate change. Seinfeld, John H; Pandis, Spyros N, John Wiley.
2. Radiation and cloud processes in the atmosphere, 2006 - Theory, Observation and modeling, Kuo-Nan Liou, Oxford University Press.
3. Atmospheric aerosol properties, 2006 - Kondratyev, K.Y, Ivlev L.S, Kravtsov, V.F, Varostov C.A, Springer Praxis Book.
4. An Introduction to Boundary Layer Meteorology, 1999 - Roland B. Stull, Kluwer, Academic Publishers.

MSO 340: Aerosol Chemistry Practical (2 Credits)

Module - I

1. RDS sampler - principle and instrumentation (6 hrs; Ref: 1, 2, 3)
2. Method to collect dry deposited material by using PM 10 and PM 2.5 (6 hrs; Ref: 1, 2, 3)
3. Estimation of mass loadings of PM 10 and PM 2.5 (06 hrs; Ref: 1, 2, 3)
4. Estimation of water soluble metals (Fe, Zn, Cu and Pb) in dry deposited material (06 hrs; Ref: 4, 5, 6, 7)
5. Estimation of total metals (Fe, Zn, Cu and Pb) in dry deposited material (06 hrs; Ref: 4, 5, 6, 7)

Module - II

1. Collection of wet deposited atmospheric samples (6 hrs; Ref: 1, 2, 3)
2. Processing of the sample for analyses of anions and cations (4 hrs; Ref: 1, 2, 3)
3. Estimation of cations (NH_4^+ , Ca^{2+} and Mg^{2+}) in wet deposited material (10 hrs; Ref: 5, 6, 7)
4. Estimation of anions (NO_3^- , PO_4^{3-}) in wet deposited material (10; Ref: 5, 6, 7)

References

1. Methods for air sampling and analysis (2nd edition), 1977 - Katz M, APHA Press Inc.
2. Methods of air sampling and analysis (3rd edition), 1989 - Lodge Jr., Lewis Publishers: Michigan.
3. Guidelines for the measurement of ambient air pollutant (Vol. 1), 2012 - NAAQMS series/36/2012-13.
4. Manual for geochemical analysis of marine sediments and suspended particulate matter, 1977 - Loring, D. H. and Rantala, R. T. T, Fish. Mar. Serv. Dev. Technical Report, 700.
5. Methods of Seawater analysis, 1983 - K. Grasshoff, M. Ehrhardt and K. Kremling (eds.), Verlag Chemie, Weinheim.
6. Analytical chemistry of seawater, 1975 - Riley, J.P., In Chemical Oceanography J.P. Riley and G. Skirrow (eds.), Vol. 3, Academic Press, London.
7. Standard methods for the examination of water and wastewater (20th edition), 1998 - APHA, Washington, D. C.

MSC 341: Marine Geochemistry Practical I (1 credit)

Module - I

1. Determination of dissolved organic N in seawater by alkaline - persulphate oxidation followed by spectrophotometric technique (6 hrs; Ref 1)
2. Determination of dissolved and particulate organic P in seawater by acid - persulphate oxidation followed by spectrophotometric technique (6 hrs; Ref 1)

1. Spectrophotometric determination of dissolved Fe in seawater by TPTZ – ascorbic acid method (6 hrs; Ref 1)
4. Spectrophotometric determination of dissolved Mn in seawater by formaldoxime method (6 hrs; Ref 1)
5. Spectrophotometric determination of dissolved B in seawater by curcumin method (6 hrs; Ref 1)

References

1. Methods of Seawater Analysis, 1983, 1999 – Grasshoff, K., Ehrhardt, M. and Kremling, K.; Verlag Chemie, Weinheim, 419.
2. A Manual of Chemical and Biological Methods for Seawater Analysis, 1984 – Parsons, T. R., Maita, Y. and Lalli, C. M., Pergamon Press, Oxford.

MSC 342: Marine Geochemistry Practical II (1 credit)

Module – I

1. Determination of Organic carbon in sediment. (6 hrs; Ref 1)
2. Determination of phosphorus in sediment. (6 hrs; Ref 1, 2, 3)
3. Sediment digestion procedure (8 hrs; Ref 1)
4. Estimation of Cr in sediment (5 hrs; Ref 4, 5)
5. Estimation of Zn in sediment (5 hrs; Ref 4, 5)

References

1. Manual for geochemical analysis of marine sediments and suspended particulate matter, 1992 - Loring, D. H. and Rantala, R. T. T., *Earth Science Rev.* 32: 235-283.
2. Chemical Analysis. In: Methods in plant Ecology, 1976 - Allen, S. E., Grimshaw, H. M., Parkinson, J. A., Quarmby, C. and Roberts, J.D., 1976., S. B. Chapman (eds.), Blackwell Scientific Publications, Oxford, Chapter 8, 411-466.
3. Methods of Seawater analysis, 1983 - Grasshoff, K.K. Grasshoff, M. Ehrhardt and K. Kremling (eds.), Verlag Chemie, Weinheim, 419.
4. Analytical chemistry of seawater, 1975 - In Chemical Oceanography J.P. Riley and G. Skirrow (eds.), Vol. 3, Academic Press, London.
5. Standard methods for the examination of water and waste water analysis (22nd edition), 2012, Rice, E.W and Bridgewater L. American Public health association, Washington DC.

MSC 343: Marine Geochemistry I (2 credits)

Module – I

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.

Module – II

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.

References

1. Introduction to geochemistry, 1967 Krauskopf, K. B., Mc.Graw-hill.
2. Geochemistry, 1962 Goldschmidt, V. M., Clarendon press.
3. Principles of geochemistry, 1956 Mason, B. and Moore, B., John Wiley & Sons, Inc.
4. Chemical oceanography (Vol. 1 & 3), 1975 Riley, J. P. and Skirrow, G., Academic Press, New York
5. Introduction to geochemistry, 1995 Krauskopf, K. B. and Bird, Mc-Graw Hill.
6. The geochemistry of natural waters, 1982 Drever, J. L., Prentice-Hall, Inc., Englewood Cliffs, N.J.
7. Estuarine chemistry, 1976 Burton, J.D. and Liss, P. S., Academic Press.
8. Ocean chemistry and deep sea sediments, 1989 Open University Course Material.

9. Aquatic chemistry, 1996 Stumm, W. and Morgan, J.J., Wiley Interscience, New York.
10. Aquatic surface chemistry, 1987 Stumm, W., Wiley Interscience, New York.
11. Marine Chemistry, 1969 Horne, R. A., Reinhold Publishing Corporation, New York.

MSO 344: Marine Geochemistry II (1 credit)

Module – I

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; 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.

References

1. Introduction to geochemistry, 1967 - Krauskopf, K.B., Mc.Graw-hill, Kogasuksha Ltd, International student edition.
2. Geochemistry, 1962 - Goldschmidt, V.M., Clarendon press.
3. Principles of geochemistry 1966 - Mason, B. 3rd edition published by John Wiley and Sons, Inc, New York.
4. Chemical oceanography (Vol. 1 & 3), 1975 - Riley, J.P. and Skirrow, G.(eds), Academic Press, New York.
5. Introduction to geochemistry, 1995 - Krauskopf, K.B. and Bird, Mc-Graw Hill, Kogasuksha Ltd, International student edition.
7. The geochemistry of natural waters, 1982 - Drever, J.I. 3rd Edition, Prentice Hall.
8. Estuarine chemistry, 1976 - Burton, J.D. and Liss, P.S., Academic Press, New York.
9. Ocean chemistry and deep sea sediments, 1989 - Open University Course Material.
9. Aquatic chemistry, 1996 - Stumm, W. and Morgan, J.J., Wiley- Interscience, New York.
12. Aquatic surface chemistry, 1987 - Stumm, W., Wiley - Interscience, New York.
13. Marine Chemistry, 1969 - Horne, R.A. Wiley-Interscience.

MSO 345: Marine Geochemistry III (1 credit)

Module – I

The solid-solution interface – Electro-kinetic phenomena, The electrical double layer, the structure of water at the solid solution interface, surface chemistry of oxides, hydroxides and oxide minerals; the colloidal state, origin of surface charge, aggregation of colloids, the role of coagulation in natural waters – Surface phenomena

-Langmuir and Freundlich Adsorption isotherms, trace metal partitioning on solid-solution phases, particle concentration effects.

References

1. Introduction to Geochemistry, 1967 - Krauskopf, K.B., Mc.Graw-hill.
2. Geochemistry, 1962 - Goldschmidt, V.M., Clarendon Press.
3. Principles of Geochemistry 1956 - Mason, B. and Moore, B., John Wiley.
4. Chemical Oceanography (Vol. 1 & 3), 1975 - Riley, J.P. and Skirrow, G., Academic Press.
5. Introduction to Geochemistry, 1995 - Krauskopf, K.B. and Bird, Mc-Graw Hill.
6. The Geochemistry of Natural Waters, 1982, 2002 - Drever, J.I., Prentice Hall.
7. Estuarine Chemistry, 1976 - Burton, J.D. and Liss, P.S., Academic Press.
8. Ocean Chemistry and Deep Sea Sediments, 1989, 1991 - Open University Course Material.
9. Aquatic Chemistry, 1996 - Stumm, W. and Morgan, J.J., Wiley- Interscience, New York.
10. Aquatic Surface Chemistry, 1987 - Stumm, W., Wiley - Interscience, New York.
11. Marine Chemistry, 1969 - Horne, R.A., Wiley Interscience.
12. Text Book of Physical Chemistry, 1981, Glasstone, S., Macmillan India Press.
13. Marine Chemistry and Geochemistry, 2010 - K.K.Turekian, Academic press.

MSC 346: Marine Ecology (4 credits)

Module – I

Marine ecosystems (pelagic and benthic ecosystem), coral reef, deep sea, polar seas and hydrothermal vents and its ecology, concept of food chain, food web, niche, trophic structure and ecological efficiency, community structure

diversity and ecosystem function, factor regulating community structure. Symbiosis, plant - animal and animal - animal associations in the marine environment.

Module – II

Phytoplankton ecology – diatoms, dinoflagellates, coccolithophores, foraminifers, harmful algal blooms – foraminifers – causative species, bloom formation, propagation, decomposition and its impact on ecosystem function, cyst and dormant stages, shellfish poisoning and effect on fish.

Module – III

Zooplankton ecology – copepods, euphasids, chaetognaths and other major groups and their role in food chain and food web, microbial loop and its role in tertiary production, secondary production and fisheries, fouling communities and introduced species.

Module – IV

Macro, meio and micro benthic fauna and their ecology, aerobic and anaerobic environments, benthic autotrophic production, chemical composition of sediments, animal - sediment relations, benthic metabolism

References

1. Marine Ecology: Processes, systems and impacts (2nd edition), 2011 - Kaiser, J.M., OUP Oxford, 501 pages.
2. Trait, R.V., 2013. Elements of Marine Ecology (3rd Edition), 2013 – Trait R. V., Elsevier, 366 pages
3. Marine biology: An ecological approach (6th ed), 1988 – Nybakken, J.W. and Bertness, M. D. Pearson/Benjamin Cummings
4. Marine ecology, 1982 – Levinton, J.S. Prentice-Hall
5. Biological Oceanographic Processes, 1984 – Parsons, T.R., Pergamon Press.
6. Marine Biological Processes(2nd ed), 1995 - Valiela, I., Springer Verlag Press.
7. Plankton and productivity in the oceans (Vol. I & 2), 1983 – Raymont, J.E.G., Pergamon Press.
8. Introduction to Marine Ecology, 1982 - Barnes, R.S.K. and Hughes, R.N. Blackwell Science Ltd
9. Population ecology: An unified study of plants & animals, 1986 - Begon, M. & Mortimer, M., Blackwell Science Ltd, 247 pp
10. Ecology: the experimental analysis of distribution and abundance, 1985 – Krebs, C.J.
11. Biological oceanography (2nd edn.), 1999 – Lalli, C.M. Elsevier Ltd.
12. Deep sea demersal fish and fisheries, 1997 – Merrett, N.R. Chapman and Hall, Springer
13. Reef fisheries, 1996 – Polunin, R.S.V. Springer Science & Business Media
14. Marine Ecological Processes, 1995 – Valiela Evans, Springer Verlag, New York, 686.

MSC 347: Marine Ecology Practical (2 Credits)

Module – I

1. Estimation of primary production by using light and dark bottle method (6hrs; Ref 15)
2. Estimation of chlorophyll and phaeo-pigments in seawater sample using a spectro-photometric method (6hrs; Ref 14)
3. Quantitative estimation of phytoplankton using stereoscopic microscope and an analysis of sea water sample for phytoplankton cell count (9hrs; Ref 19)
4. Quantitative estimation of zooplankton using volume displacement, wet weight and dry weight method (3hrs; Ref 6)
5. Qualitative estimation of zooplankton using stereoscopic microscope and an analysis of sea water sample for zooplankton count (9hrs; Ref 6)

Module – II

1. Preparation of permanent slides of few phytoplankton and zooplankton using DPX (6hrs)
2. Mounting of mouth parts and appendages of prawn and crab and radula of molluscs: Pedicellaria and Aristotle lantern of sea urchin (6hrs; Ref 2, 7, 10)
3. Designing of an experimental set-up to study uptake of oxygen by fish (under stressed conditions) in the laboratory (9hrs; Ref 18)
4. Computation of species diversity (H' , J and D) indices using the data of phytoplankton and zooplankton analysis and their implications in ecological studies (6hrs; Ref. 11, 16, 17)

References

1. Population ecology. A unified study of plants and animals. (3rd Edition), 1996 - Begon M., Mortimer M. & Thompson D.J., Blackwell Science Ltd, 247 pp.

2. FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Volume 2., 1998b - Carpenter K.E. & Niem V.H., Cephalopods, crustaceans, holothurians and sharks. (Food and Agricultural Organization, Rome), pp. 687-1396.
3. A Method of Population Estimation: Mark & Recapture, 2013 - Fall, *Biology 103*
4. Investigations on the biology of Indian Mackerel *Rastrelliger kanagurta* (Cuvier) along the Central Kerala coast with special reference to maturation, feeding and lipid dynamics, 2010 - Gunga U., Unpublished Ph. D. thesis submitted to Cochin University of Science and Technology, 159 pp.
5. Tilapia Fish Farming: Practical Manual: Volume 1, 2012 - Rosagast M., Create Space Independent Publishing Platform, 58 pp.
6. Zooplankton Methodology, collection and identification - A field manual, 2004 - Goswami S.C., National Institute of Oceanography, 16 pp.
7. A new record of *Temnopleurus declivens* (de Meijere, 1904) (Echinoidea, Temnopleuroidea, Temnopleuridae) from Indian waters, 2013 - Hegde M.R. & Rivonker C.U., *Zoosystema* 35(1): 97 - 111.
8. Estimating Population Size: Mark-Recapture (Exercise 3B), 2013 - Heyer B., Bio6C: Ecology & Evolution, 67-72 pp.
9. Stomach content analyses - A review of methods and their application, 1980 - Hyslop E.J. (1980), *Journal of Fish Biology*, 17:411 - 429.
10. A New Record of *Morula anaxares* with a Description of the Radula of Three Other Species from Goa, Central West Coast of India (Gastropoda: Muricidae), 2012 - Hyslop E.J., *Turkish Journal of Fisheries and Aquatic Sciences*, 12: 189-197.
11. Perspectives in Ecological Theory, 1968 - Margalef R. Chicago: University of Chicago Press, 111 p.
12. Ecological Methodology (2nd ed.), 1999 - Krebs C.J., Benjamin Cummings, 624 pp.
13. Procedures to estimate fecundity of marine fish species in relation to their reproductive strategy, 2003 - Murua H., Kraus G., Saborido-Rey F., Withames P.R., Thorsen A. & Junquera S., *Journal of Northwest Atlantic Fishery Science*, 33: 33-54.
14. A Manual of Chemical and Biological Methods for Seawater Analysis, 1984 - Parsons T.R., Maita T. & Lalli C.M., Oxford and New York: Pergamon Press, 184pp.

MSO 348: Marine Microbial Ecology (4 credits)

Module - I

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.

Module - II

Characteristics of marine microbes; Distribution and abundance and their adaptations to pressure, depth, salt, temperature; Integrated effects of nutrient dynamics; Chemosynthesis and microbial heterotrophic metabolism; Effect of ions of major and trace elements; Toxicity and mechanism of tolerance in marine microbes; Biochemical characterization of marine prokaryotes.

Module - III

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.

Module - IV

Sampling strategies for molecular biological analysis; Meta-genomic analysis; Principles and applications of TFF for microbial molecular analysis; DNA/RNA extraction, principles and methods; Principles and applications of PCR; GEL electrophoresis, DNA purification and visualization techniques; Bioinformatics for marine molecular analysis - principles of phylogenetic tree, BLAST analysis, search tools; sequence data base; Application of different statistical test (Shannon weaver's index, simpson index, species richness, Chao, ACE indices and Leibshuff technique) for microbial biodiversity analysis.

References

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 Earth's habitability, 2005 - Hunter - Cevera, J. Karl, D. and Buckley, M., American Academy of Microbiology.
4. Microbial ecology of the Oceans (2nd edition), 2008 - Mitchell, R. and Kirchman, D. L., Wiley - Blackwell

Publishers

5. Ocean and Health: Pathogens in the marine Environment, 2005 - Belkin S. and Colwell, R. R., Springer – Verlag, New York.
6. Biological Oceanography, 2012 - Meller, C. B. and Wheeler P.A., Wiley – Blackwell Publishers.
7. Marine Microbiology: Ecology and Applications (2nd edition), 2011 - Munn, C. Garland Science, Taylor and Francis group, NY.
8. Taxonomic scheme for the identification of marine bacteria, 1982 - Oliver, J. D., Deep Sea Research Part A., Oceanographic Research Papers, 29 (6); 795 – 798.
9. Marine Ecological Processes (2nd edition), 1995 - Valiella L., Springer – Verlag, New York.

MSO 349: Marine Microbial Ecology Practical (2 credits)

Module – I

Sterilization techniques, preparation of bacterial media, nutrient, broth & agar preparation of slants (8 hrs; Ref 1); Method of sample collection (water) from marine environment (4 hrs; Ref 2). Estimation of bacterial, fungal population and isolation (8 hrs; Ref 4) Preservation of cultures, isolation of pure cultures microscopy; wet mounts (4 hrs; Ref 4). Isolation of pathogenic organisms from water and sediments (6 hrs; Ref 5)

Module – II

Identification of marine bacteria (4 hrs; Ref 3). Separation of mixed culture, isolation, maintenance and preservation of pure culture (6 hrs; Ref 3). Characterization, biochemical tests (4 hrs; Ref 1). Staining of bacteria and cell morphology (6 hrs; Ref 1). Marine microbes from different ecological niches (water column and sediments) with reference to physico-chemical conditions (10 hrs; Ref 5)

References

1. Bergeys manual of systematic bacteriology (Vol. I), 1984 - (William & Willcens, Baltimore, MD, 518 pg
2. Marine and estuarine microbiology laboratory manual, 1975 – Rita R. Colwell – University Park Press, 1975, 96 pgs.
3. Marine microbiology, a monograph & hydro-bacteriology, 1946 - C.E. Zobell, – Chronica botarica Compare, 240 pgs.
4. Laboratory methods in microbiology, 1966 - W.F. Harigan, M.E. Mc Cance, Academic press 1966, 362 pgs.
5. Manual of environmental microbiology, 1997 - G. J. Hurst, G. R. Knudsen, AsM Press, 894 pgs.

MSC 350: Sedimentology (4 credits)

Module – I

Distribution and genesis of terrigenous, biogenous, chemogenous, volcanogenic, authigenic and extra terrestrial (cosmogenous) sediments in the world ocean – Rate of sedimentation in the oceans.

Module – II

Concepts of sedimentary facies, facies construction and interpretation, factors controlling the nature and distribution of facies – Provenance – Heavy minerals, rock particles and clay minerals – Mineral stability – Goldich stability series, sediment maturity, heavy mineral zones - X ray diffraction technique and its use in mineral and sediment study.

Module - III

Sedimentary depositional environments – Aeolian, lacustrine, glacial desert, fluvial, coastal shallow marine and deep sea – Sedimentary and faunal markers of paleoenvironmental conditions

Module - IV

Sedimentary rocks – Classification, properties, origin and importance – Sandstone, limestone, mudstones and evaporites – Sedimentary structures formed by unidirectional water flows, water waves, airflows, liquefaction and current drag, diapirism and differential loading, desiccation and shrinkage structure – Diagenesis: general considerations, terrigenous clastic sediments, carbonate sediments, evaporates and hydrocarbons, Diagenesis of silica, iron and Manganese .

References

1. Sedimentation in the world ocean, 1972 lisitzin, A. P., Soc. Of E. C. Paleontologists.
2. Sedimentology, 1982 Leeder, M. R., George Allen & Unwin.
3. Sedimentary rocks (3rd edn.), 1984 Pettijohn, E. J., C.B.S. Publ. and Distrib.
4. Stratigraphy and sedimentation, 1963 Krumbein, W. C. and Sloss, L. L., W. H. Freeman & Co.

5. Sedimentary environments and facies (2nd edn), 1986 Reading, H.G., Blackwell Sci Publ.
6. Depositional sedimentary environments, 1986 Reineck, H.E. and Singh, I.B., Springer Verlag.
7. Origin of sedimentary rocks, 1972 Blatt, H., Middleton, G. and Englewood, M.R., Cliff, New Jersey.
8. Principles of sedimentology, 1978 Friedman, G.M. and Sanders, J. F., John Wiley & Sons.
9. Procedures in sedimentary petrology, 1971 Carver, R.F., Wiley Interscience.
10. Sedimentary structures: their character and physical basis (Vol.1 & 2), 1982 Allen, J.R.L., Elsevier.
11. Physical processes of sedimentation: An introduction, 1970 Allen, J.R., George Allen & Unwin.
12. Ancient sedimentary environments: A brief survey, 1970 Selley, R. C., Chapman & Hall.
13. Atlas and glossary of primary sedimentary structures, 1964 Pettijohn, F. J. and Potter, P. E., Springer verlag.
14. Sand and sandstone, 1972 Pettijohn, F. J., Potter, P.E. and Siever, R., Springer Verlag.

MSC 351: Sedimentology Practical (2 Credits)

Module – I

1. Grain size analysis – sand, silt, clay using pipette method – estimation and interpretation – at least ten samples from a sediment core (12 hrs; Ref 1, 5)
2. Determination of organic carbon – at least ten samples from a sediment core (4 hrs; Ref 1, 4, 6)
3. Heavy mineral identification (4 hrs; Ref 1, 2)
4. Study of stratigraphic correlation (4 hrs; Ref 5)
5. Study of paleo-current analysis (8 hrs; Ref 4)

Module – II

1. Measurement of sphericity and roundness of sediment grains - at least 30 grains (8 hrs; Ref 1, 2)
2. Identification of sedimentary rocks (4 hrs; Ref 3, 7)
3. Identification of sedimentary structures (4 hrs; Ref 3, 4)
4. Study of sedimentary facies (4 hrs; Ref 4, 5)
5. Preparation of samples for X-ray diffraction analysis (4 hrs; Ref 4, 6)
6. XRD analysis for clay minerals (4 hrs; Ref 4, 6)
7. Clay mineral identification and estimation of Semiquantitative percentages and interpretation (4 hrs; Ref 4, 6)

References

1. Exercises in sedimentology, 1982 Friedman, G. M. and Johnson K. G., John wiley & sons.
2. A practical approach to sedimentology, 1987 Londholm, R., CBS Publication and Distributors.
3. Practical manual of sedimentary petrology, 1987 Babu S. K. and Sinha, D. K., CBS Publication and Distributors.
4. Procedures in sedimentary petrology, 1971 Carver, R. F., Wiley Interscience.
5. Text book of sedimentary petrology, 1981 Varma, V. K. and Prasad, C., Intl. Book Distribution.
6. Scientific method of analysis of sediments, 1987 Griffiths, J. C., McGraw – Hill.
7. The study of rocks in thin sections, 1985 Moorhouse, W. W., CBS Publication and Distributors.
8. Rutley's elements of mineralogy, 1984 Read, H. H., CBS Publication and Distributors.

Semester IV

MSC 431: Estuarine and Coastal Physical Oceanography (2 credits)

Module – I

Sea level set up and buoyancy driven flows. Definition of estuaries, Physical characteristics of estuaries – Classification on the basis of fluid dynamics principles – Tides and tidal currents in estuaries – Tide producing forces – tidal theorem, tidal analysis and prediction – salinity intrusion – gravity driven freshwater flow – estuarine circulation and mixing – stratification and entrainment – Salt – balance technique , Conservative pollutants, non - conservative pollutants, coupled non-conservative pollutants, Fronts in estuaries.

Module – II

Breakers and surf – Littoral currents – Rip currents – Factors influencing coastal processes – River – estuary-near shore system – Generation of waves by wind – their growth – propagation and decay-wave reflection- refraction and diffraction – Theories of wave generation – general characteristic of waves – boundary conditions – small amplitude waves – phase speed – particle velocity and displacement – group velocity – wave energy – internal waves.

References

1. Physical processes in Estuaries, 1988 – John Dronkers and Wim Van Leussen., Springer Verlag.
2. Physical Oceanography, Vol 2, 1960 – A. Defant., Pergamon press.
3. Waves, Tidal and Shallow water processes, 1989 – The Open University, Walton Hill, Pergamon press.
4. Coastal oceanography, 1982 – H. G. Clade, A Edward and H. Svendsen, plenum press.
5. Estuaries – a physical introduction (2nd edition), 1997 – K. R. Dyer, John Wiley and sons.
6. Regional Oceanography – an Introduction (2nd edition), 2003 – Daya publishing house – New Delhi.

MSC 432: Estuarine Chemistry (2 credits)

Module – I

Salinity distribution in estuaries – a chemical perspective, flushing time, mixing and diffusion dispersal of pollutants in estuaries and near shore areas – Conservative and non – conservative properties of dissolved constituents during estuarine mixing – Behaviour of dissolved oxygen, pH and major elements in estuarine water.

Module – II

Biogeochemistry of P, N, Si, minor and trace metals and dissolved organic matter in estuaries – Sources, sinks and general biogeochemistry; Simple flux calculations.

References

1. Estuarine Chemistry, 1976 – Burton, J.D. and Liss, P.S., Academic Press.
2. Practical Estuarine Chemistry, 1985 – Head, P.C., Cambridge University Press.
3. Chemistry and Biogeochemistry of Estuaries, 1980 – Olausson, E. and Cato, I., John Wiley & Sons.
4. Chemical Oceanography (Vol.7), 1978, Riley, J.P. and Chester, R., Academic Press.
5. Waves, Tides and Shallow-Water Processes, 1991, 2005 – The Open University.
6. Coastal and Estuarine Sediment Dynamics, 1986 – Dyer, K.R., Wiley.
7. Estuarine Hydrography and Sedimentation, 1980 – Dyer, K.R., Cambridge University Press.
8. Biogeochemistry of Marine Dissolved Organic Matter, 2002 – D.A. Hansell and C. A. Carlson., Academic Press.
9. Biogeochemistry of Estuaries, 2007 – Thomas S. Bianchi, Oxford University Press.
10. Treatise on Estuarine and Coastal Science - Vol. 4: Geochemistry of Estuaries and Coasts, Vol. 5: Biogeochemistry, 2012, E. Wolanski and D. McClusky, Elsevier Inc.

MSC 433: Estuarine Biology (2 credits)

Module I

Primary productivity – mechanism and processes, Productivity in coastal and estuarine waters, Dissolved Organic Matter – sources, aerobic and anaerobic environments, losses of organic carbon, processes, decomposers, anoxic environments – Fermentation, sulfate reduction, Methano-genesis, Release of DOM by phytoplankton.

Module II

Salt marsh ecosystem – species composition, distribution, nutrient dynamics, primary productivity and ecological processes and fate of salt marsh plant; Mangrove ecosystem species composition, distribution, adaptations, primary productivity, heterotrophic production, secondary communities and energy flow. Plankton, nekton and benthic communities, adaptations (buoyancy, locomotion and defense) in coastal and estuarine plankton and nekton population, major pelagic and demersal fish resources, Horse-shoe crab, Fish migrations and spawning.

References

1. Estuarine Ecology, 2nd Edition, – K. R. Dyer, John Wiley and Sons, 568 pages.
2. The Biology of Estuarine Management, Wilson, J. 2012, Springer science and business media, 204 pages
3. Elements of Marine ecology (4th edition), 1982 – Tait, R.V. and Dipper, F. Butterworth-Heinemann.
4. An introduction to Marine Sciences, 1988 – Meadows, P.S. and Campbell, J.J. John Wiley and Sons.
5. Textbook of Marine Ecology, 1989 – Nair, N.B. and Thampy, D.M. Macmillan
6. Advances in marine biology, Vol. 20, 1982 – Academic Press Ltd, New York.
7. Advances in marine biology, Vol. 36, 1999 – Press, New York
8. Marine Biology – An ecological approach 6th ed), 2005 – Nybakken, J. W and Bertness, M. D. Pearson/Benjamin Cummings

MSC 434: Estuarine and Coastal Geology (2 credits)

Module - I

Estuaries: Classification based on tide - geological classification and evolution - sub-environments in estuaries: mudflats, salt marsh, mangrove, salt pans - sediment source, transportation and deposition - bed and suspended sediment sampling and analysis - mineralogy and geochemistry of estuarine sediments - seasonal variation in geochemistry - metal variation with time in the sub-environments and their application in paleoenvironment, sea level changes and paleoenvironment, bioavailability of metals from sediments in estuaries.

Module - II

Coasts: classification, types of coast with reference to Indian coast line - evolution of the Indian coast - global sea level changes: eustatic, tectonic and isostatic. Coastal signature of sea level changes, coastal resources and coastal zone management, CRZ regulations and ICZM, Impact of floods, tsunamis and anthropogenic interferences in coastal processes, coastal erosion, preparedness and precaution measures.

References

1. Estuarine chemistry, 1976 Burton, J. D. and Liss, P. S., Academic Press, New York and London.
2. Practical estuarine chemistry, 1985 Head, P. C., Cambridge: Cambridge University Press Wiley Chichester.
3. Chemical oceanography (Vol.7), 1978 Riley, J. P. and Chester, R., Academic Press, London.
4. Waves, tides and shallow-water processes, 1991 The Open University.
5. Coastal and estuarine sediment dynamics, 1986 Dyer, K. R., John Wiley & Sons.
6. Estuarine hydrography and sedimentation, 1986 Dyer, K. R., John Wiley & Sons.
7. Beach processes and sedimentation, 1976 Komar, P. D., Prentice Hall.
9. Sea-level rise and coastal subsidence: causes, consequences and strategies, 1966 Milliman, J.D. and Haq, B. U., Kluwer Academic.
10. Introduction to geochemistry, 1967 Krauskopf, K. B., McGraw-Hill.
11. Elements of ecology (3rd edition), 1982 Tait, R. V., Springer.
12. An Introduction to Marine Sciences, 1988 Meadows, P. S. and Campbell, J. J., Campbell BSc, FRES.
13. Textbook of Marine Ecology, 1989 Nair, N. B. and Thampy, D. M., The Open University Butterworth.

MSO 435: Dynamic Oceanography - I (2 credits)

Module - I

Basic physical laws used in oceanography - Classification of forces and motion - Equation of continuity - static stability - double diffusion - Equation for the mean or average motion - Non-linear terms in the equation of motion - Eddy viscosity

Module - II

Currents without friction - Vorticity: relative vorticity, planetary vorticity, absolute vorticity, potential vorticity - Geostrophic flow - Hydrostatic equilibrium - Geopotential - Geopotential surfaces and isobaric surfaces - Geostrophic methods for calculating relative velocity - Thermal wind equation - Relation between isobaric and isopycnal surfaces

References

1. Introductory Dynamical Oceanography, 1983 - Pond, S and Pickard, G.H., Pergamon Press, U.K.
2. Principles of Physical Oceanography, 1966 - Newman, G. and Pierson, W.J., PrenticeHall, Inc., New Jersey, U.S.A.
3. Physical Oceanography (Vol.1) 1961 - Defant, A., Oxford pergamon press, U.K.
4. The dynamics of the upper ocean (2nd edition) 1977 - Phillips, O.M., Cambridge Univ. Press, U.K.
5. Modeling and prediction of the upper layers of the ocean, 1977 - Krous, E.B. (Ed.).
6. Modeling of marine systems, 1986 - Nihoul, J.C.J., Elsevier Scientific Publ. Co., Oxford, U.K.
7. Atmosphere - ocean Dynamics, 1982 - Gill, Adrian E, International Geophysics, 30 Academic press, New York.

MSO 436: Dynamic Oceanography - II (2 credits)

Module - I

Currents with friction - The equation of motion with friction: Transport and upwelling - Bottom friction and shallow water effects - Ekman's solution to the equations of motion with friction - Limitation to Ekman's theory - Sverdrup's solution for the wind driven circulation - Stommel's contribution - The planetary wind field, upwelling and sinking with special reference to the Indian ocean - Westward intensification - equatorial current system - Munk's equation -

Module – II

Co-ordinate system – Governing equations – Boundary conditions layer averaged equations – Staggered grid systems – Finite difference method- Model spin up time-Model stability condition.

References

1. Introductory Dynamical Oceanography, 1983 – Pond, S and Pickard, G.H., Pergamon Press, U.K.
2. Principles of Physical Oceanography, 1966 – Newman, G. and Pierson, W.J., Prentice Hall, Inc., New Jersey, U.S.A.
3. Physical oceanography (Vol.I) 1961 – Defant, A., Oxford Pergamon press, U.K.
4. The dynamics of the upper ocean (2nd edition) 1977 – Phillips, O.M., Cambridge Univ. Press, U.K.
5. Modeling and prediction of the upper layers of the ocean, 1977 – Krouse, E.B. (Ed.), Pergamon press
6. Modeling of marine systems, 1986 – Nihoul, J.C.J., Elsevier Scientific Publ.Co., Oxford, U.K.
7. Atmosphere – Ocean Dynamics, 1982 – Gill, Adrian E., International Geophysics, 30 Academic press, New York.

MSO 437: Physical and Inorganic Chemistry of Seawater (4 credits)

Module – I

The structure of liquid water – Theories of water structure, colligative properties of seawater with the thermodynamic derivations of expressions for boiling point elevation and freezing point depression, electrostriction – The Thermodynamics of seawater – Ideal and real solutions.

Module – II

Equation of state for pure water and seawater, thermodynamics of PVT changes in seawater, activities, activity coefficients; Debye - Huckel theory and the Debye - Huckel limiting law; heats of solution, dilution, and mixing.

Module – III

Acids and bases – basic concepts, proton condition and the electroneutrality of solutions; pH as a master variable – log C – pH diagram for monoprotic and diprotic acid – base system; buffer pH, buffer intensity – Oxidation and Reduction Reactions – Redox equilibria, electron activity and pE – Peters-Nernst equation; pE-pH diagram for the aqueous chlorine system, pE – pc diagram for Fe (II) - Fe (III) system, Kinetics of redox processes (Oxidation of Fe (II) and Mn (II) only).

Module – IV

Metal Ions in Aqueous solutions – hydrolysis of metal ions, formulation of stability constants, the stability of hydrolysis species, chelates and the chelate effect; Precipitation and dissolution – Heterogeneous equilibria, solubility product and saturation; the solubility of oxides and hydroxides – carbonate system closed to atmosphere and in equilibrium with CO₂(g); the stability of hydroxides and carbonates; crystal formation – The initiation and production of the solid phase – Solubility of silicates, gibbsite and iron (oxy) hydroxides.

References

1. Marine Chemistry, 1969 – Horne, R.A., Wiley – Interscience, London.
2. Aquatic Chemistry, 1981, 1996 – Stumm, W. and Morgan, J.J., Wiley-Interscience, New York.
3. Water Chemistry, 1980 – Snoeyink, V.L. and Jenkins, D., John Wiley & Sons, New York.
4. Principles of Aquatic Chemistry, 1983 – Morel, E.M.M., Wiley Interscience
5. Chemical Kinetics and Process Dynamics in Aquatic Systems, 1994 – Brezonik, P.L., Lewis Publ., London.
6. Aquatic Chemistry, 1995 – Huang, C.P., O'Melia, C.R. and Morgan, J.J. American Chemical Society, Washington, DC.
7. Aquatic Surface Chemistry, 1987 – Stumm, W., Wiley Interscience, New York.
8. Chemical Oceanography (vol. 1), 1975 – Riley, J.P. and Chester R., Academic Press.
9. Text Book of Physical Chemistry, 1981 – Glasstone, S., Macmillan Indian Press.
10. The Geochemistry of Natural Waters, 1982, 2002 – Drever, J.I., Prentice Hall.
11. Introduction to Geochemistry, 1995 – Krauskopf, K.B. and Bird, Mc.Graw Hill.
12. Water Chemistry – An Introduction to the Chemistry of Natural and Engineered Aquatic Systems, 2011 – P. L. Brezonik and W. A. Arnold, Oxford University Press.

MSO 438: Marine Biodiversity, Conservation and practices (4 credits)

Module - I

Biodiversity, definitions, taxic, phylo-genetic and molecular measurements, Intellectual property rights and bio-piracy, life patenting, impact of GATT on farmer's right, Indigenous and traditional knowledge.

Module - II

Coastal biodiversity, wild and domesticated, Indian fisheries & status, ecosystem based management traditional and mechanized crafts and gears, fishing fleets, fishing through food webs.

Module - III

Semi-intensive shrimp culture and mangroves, environmental costs, problems associated with conservation of mangroves and shrimp culture, reef related fisheries and banned fishing practices, Coastal tourism, implications and management.

Module - IV

Biodiversity conservation - corals, turtles, dugong, holothurians and shark, environmental laws and protection of coastal ecosystems, marine parks and protected areas, sanctuaries and marine biosphere reserves of India - Bhitarkanika wildlife sanctuary, Gulf of Kachch Marine National Park and Sanctuary, Gulf of Mannar biosphere reserve, Wandoor Marine National Park.

References

1. Marine Biodiversity Conservation: A practical approach, 2014 - Hiscock, K., Routledge. 318 pages
2. Marine Biodiversity: Patterns, processes, assessment, threats, management conservation, 2007 - Queiroga, H., Cunha, M.R., Cunha, A., Moreira, Q. V., Rodrigues, A. M., Serodio, J., Warwick, R. M., Springer science and business media. 353 pages.
3. Marine Biodiversity - Pattern and Processes, 1997 - Rapert F.G. Ormond, John.D.Gage and Martin.V. Angel (eds.), Cambridge University press: 449pp.
4. Biodiversity and Environment, 2004 - Arvind Kumar, S.B.Nangia, A.P.H. Publication Corporation, New Delhi, 659 pp.
5. Biodiversity Conservation, 1994 - Vandana Shiva (eds.), Publication of Indian National Trust for Art and Cultural Heritage, New Delhi, 315 pp.

MSO 439: Marine Geophysics (4 credits)

Module - I

Fundamentals of Geophysical prospecting, sound transmission in water and sediments, Acoustic properties of water and sediments – Marine instrumentation – Techniques of echosounding, side scan sonar, sparker and pneumatic pulser profiling.

Module - II

Marine geophysical instrumentation and various methods employed in oceans – Single channel and multi-channel seismic reflection source – Airguns, sleeve guns, water guns – Array configuration and advantages. Seismic reflection receivers – Geophones – hydrophones; streamers, wide angle reflection – Seismic reflection – sonobuoys, ocean bottom seismometers OBS – Data acquisition and quality control.

Module - III

Seismic data processing, signal processing – Spectral analysis in geophysics – Analysis of geophysical signals – frequency and spectral analysis, spectra vs time domain analysis – Fourier series and Fourier transforms – Theoretical development and Fourier series and applications – Identification of reflectors, their correlation and interpretation.

Module - IV

Gravity and magnetic surveys over the ocean – Reduction of observations, identification of anomalies and interpretation of the data set – integrated interpretation of geophysical data – Continental margin studies of India – Application of geophysical methods in offshore exploration for oil natural gas and other minerals.

References

1. Principles of Geophysical Prospecting, 1976 Dobrin, M. B., Mc.Graw Hill.
2. Geophysical Prospecting for Oil, 1976 Nettleton, L. L., Mc.Graw Hill.
3. Exploration Seismology (Vol. 1 and 2) 1982, 1983 Sheriff, R. E. and Geldant, L. P., Cambridge Univ. Press, U.K.

1. Developments in Solid Earth Geophysics (Vol. 5) Spectral analysis in geophysics, 1974 Bath Markens.
5. Seismic Prospecting Instruments (Vol. 1) 1977 Evenden, R. N., Stone, D. R. and Amstey, Gebrudev.
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MSD 440 Dissertation (8 credits)