University of Mumbai

No. AAMS_UGS/ICC/2023-24/54

CIRCULAR:-

The Principals of the Affiliated Colleges, the Head of the University Departments and Directors of the Recognized Institutions in Faculty of Science & Technology is invited to this office Circular No. AAMS_UGS/ICC/2023-24/44 dated 27th July, 2023 relating to title of the course M.Sc. (Marine Science).

They are hereby informed that the recommendations made by the **Board of Studies in Maritime Studies** at its online meeting held on 23rd August, 2022 and subsequently passed by the Board of Deans at its meeting held on 08th December, 2022 **vide** item No. 8.7 (R) have been accepted by the Academic Council at its meeting held on 06th April, 2023 **vide** item No. 8.7 (R) and that in accordance therewith, to **revise the syllabus of M.Sc. (Marine Science) – Sem I to IV (CBCS)** has been brought into force with effect from the academic year 2022-23.

(The said circular is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
08th August, 2023

(Prof. Sunil Bhirud)
I/c. REGISTRAR

To,

The Principals of the Affiliated Colleges, the Head of the University Departments and Directors of the Recognized Institutions in Faculty of Science & Technology.

A.C/8.7 (R) /06/04/2023

Copy forwarded with Compliments for information to:-

1) The Dean, Faculty of Science & Technology,
2) The Chairman, Board of Studies **Maritime Studies**,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Director, Department of Information & Communication Technology,
6) The Co-ordinator, MKCL,
7) The Deputy Registrar, Admissions, Enrolment, Eligibility & Migration Department (AEM),
8) The Deputy Registrar, Result Unit,
9) The Deputy Registrar, College Affiliations Development Department (CAD).

Copy for information and necessary action :-

1. **The Deputy Registrar, College Affiliations & Development Department (CAD),**
2. **College Teachers Approval Unit (CTA),**
3. **The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM),**
4. **The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA)**
5. **The Deputy Registrar, Research Administration & Promotion Cell (RAPC),**
6. **The Deputy Registrar, Executive Authorities Section (EA)**
   He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
7. **The Deputy Registrar, PRO, Fort, (Publication Section),**
8. **The Deputy Registrar, Special Cell,**
9. **The Deputy Registrar, Fort Administration Department (FAD) Record Section,**
10. **The Deputy Registrar, Vidyanagari Administration Department (VAD),**

Copy for information :-

1. **The Director, Dept. of Information and Communication Technology (DICT), Vidyanagari,**
   He is requested to upload the Circular University Website
2. **The Director of Department of Student Development (DSD),**
3. **The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari,**
4. **All Deputy Registrar, Examination House,**
5. **The Deputy Registrars, Finance & Accounts Section,**
6. **The Assistant Registrar, Administrative sub-Campus Thane,**
7. **The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan,**
8. **The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,**
9. **P.A to Hon'ble Vice-Chancellor,**
10. **P.A to Pro-Vice-Chancellor,**
11. **P.A to Registrar,**
12. **P.A to All Deans of all Faculties,**
13. **P.A to Finance & Account Officers, (F & A.O),**
14. **P.A to Director, Board of Examinations and Evaluation,**
15. **P.A to Director, Innovation, Incubation and Linkages,**
16. **P.A to Director, Department of Lifelong Learning and Extension (DLLE),**
17. **The Receptionist,**
18. **The Telephone Operator,**

Copy with compliments for information to :-

19. **The Secretary, MUASA**
20. **The Secretary, BUCTU.**

AC – 06/04/2023
Item No. – 8.7 (R.)

University of Mumbai

Revised Syllabus for (Marine Sciences)

Semester – (I to IV)

(Choice Based Credit System)

(With effect from the academic year 2022-23)

UNIVERSITY OF MUMBAI

Sr. No.	Heading	Particulars
1	Title of the course	M.Sc (Marine Sciences)
2	Eligibility for the admission	B.Sc degree from any UGC recognized University Physics/ Chemistry/ Mathematics/ Statistics/ any Biological Sciences OR Equivalent Qualification
3	Passing Marks	240 out of 600 every semester
4	Ordinance / Regulations (if any)	As applicable
5	No of years/semester	2 years. 4 Semester
6	Level	PG
7	Pattern	Semester
8	Status	Revised
9	To be implemented from the academic year	From Academic Year: 2022-2023

Signature
Chairman Board of Studies

Signature
Dean faculty of Interdisciplinary Studies

Preamble

Physical, chemical, and biological processes in the Marine environment are active topics of research today. A good understanding of these processes is critical to addressing several fundamental issues like weather/climate forecasting in short to seasonal scales, climate change, exploration and sustainable exploitation of both living and non-living marine resources, conservation of marine ecosystem, mitigation of natural hazards of oceanic origin ,etc. The United Nation's Decade of Oceans (Ocean Decade, 2021-2030) envisages intensive and collective efforts in oceanographic research and education to ensure that we use our marine resources to achieve the Sustainable Development Goals (SDGs) and our marine environment is protected for the future generations. The government of India has come up with the draft policy on the 'Blue Economy' to harness our enormous marine and maritime wealth to propel our growth and empower us both in social and economical fronts. Initiatives such as 'Sagarmala', 'Pradhan Mantri Matsya Sampata Yojana' etc are important steps to cater to these needs.

Considering the importance of studies in Marine Sciences and preparing our younger generations to grab the enormous job opportunities in this field, the Centre for Excellence in Marine Studies (CEMAS) of the University of Mumbai has introduced a 2-year Master's Degree program in Marine Sciences. In addition to take some core papers on Marine Sciences, the M. Sc. Marine Sciences students will have opportunity to choose elective papers to specialize either in Physical Oceanography or Biological Oceanography depending upon their eligibility and interest. Students will undertake academic project in under the guidance of reputed researchers in the 4^{th} semester.

Program : Master of Science (Marine Sciences)

1. Program Objective: Develop highly qualified manpower in the field of Marine Sciences to take up challenging opportunities in the emerging fields of Physical and Biological Oceanography, Climate Change Studies, Coastal Hazards and Mitigation; Operational Oceanography etc.
2. Eligibility for Admission:
    a. B.Sc degree from any UGC recognized University Physics/ Chemistry/ Mathematics/ Statistics/ any Biological Sciences OR
    b. Equivalent Qualification
    c. Learner must have secured minimum 50% marks at bachelor's degree examination and as per rules of University of Mumbai and Govt. of Maharashtra
    d. Foreign candidate should have equivalent degrees from foreign Universities recognized by Association of Indian Universities (AIU)
    e. Selection of Candidate can be made on the basis of merit and personal interview/ written aptitude Test
3. Intake Capacity: Maximum Intake: 20
4. Duration of the Course:

    The P.G. programs have 4 semesters. There shall be two Semesters in an academic year, the odd semester commences in July-August and on completion, the even Semester commences after a semester-break of one or two days. However, variations in this theme would be addressed with an academic calendar that would be fixed and declared by the University at the beginning of each academic year.
5. Programme Structure:

Semester I (24 Credits)

Paper	Subject	Lectures (Hrs)	Credit
MMS101	Introduction to Maritime Studies, Blue Economy & UN Sustainable Goals	60	04
MMS102	Introduction to General Oceanography (Physical/Chemical/Biological)	90	06
MMS103	Research Methodology	60	04

MMS104	Evolution of Marine Environment and Life	60	04
MMS105	Marine Geology	90	06

Semester II (24 Credits)

Paper	Subject	Lectures (Hrs)	Credit
MSCMS201	Satellite Oceanography	90	06
MSCMS202	Marine Pollution & Ecosystem	60	04
MSCMS203E	Physical Oceanography	90	06
MSCMS204E	Ocean General Circulation	60	04
MSCMS205E	Geophysical Fluid Dynamics	60	04
MSCMS206E	Biological Oceanography	90	06
MSCMS207E	Marine Microbiology & Cell Biology	60	04
MSCMS208E	Biochemistry & Molecular Biology	60	04

Semester III (24 Credits)

Paper	Subject	Lectures (Hrs)	Credit
MSCMS301	Ocean Biogeochemistry and Ocean Optics	60	04
MSCMS302E	Coastal and Estuarine Oceanography	90	06
MSCMS303E	Air-Sea interaction	60	04
MSCMS304E	Numerical Ocean Modelling	90	06
MSCMS305E	Marine Hazards and Coastal Zone Management	60	04
MSCMS306E	Fishery Resource Management and Technology	60	04
MSCMS307E	Marine Biotechnology & Bioprospecting	90	06

MSCMS308E	Marine Biological Engineering	90	06
MSCMS309E	Fish Developmental Biology & Aqua farming	60	04
MSCMS3010E	Maintenance of Marine Electrical Systems and Troubleshooting	60	04
MSCMS311E	Ship Construction	60	04

Semester IV

MSCMSDP M.Sc Dissertation Based Project Work (24 Credits)

Semester-IV of M.Sc. (Marine Sciences) consists of a full-term Dissertation Based Research Project of 24 credits. Every student will have to complete a separate project in Semester IV with twenty four credits (600 marks). Students have to prepare and submit a Master level thesis and the final evaluation will be done by an external expert and Guide on the basis of the quality of the thesis and Viva-Voce examination. Mentor/advisor should facilitate field work and laboratory experimental work related projects across domains of science and technology. Projects with interdisciplinary objectives will also be encouraged.

The candidate shall be awarded the degree of Master of Science (Marine Sciences) after completing the course and meeting all the evaluation criteria.

Scheme of Examination and Passing:

- This course will have 40% Internal Assessment (IA) and 60% end semester examination
- Written examination of 2.5 Hours duration or 3 Hours for each course paper at the end of each semester, end semester examinations (ESE) will be conducted by the University as per the existing norms, statutes and ordinances.
- Internal Assessment - IA (40%) and End Semester Examination (ESE) (60%)- shall have separate heads of passing. For Theory courses, internal assessment shall carry 40 marks and Semester-end examination shall carry 60 marks for each Theory Course.
- To pass, a student has to obtain minimum 40% marks and above, separately in the IA and end semester examination.

- The University (external) examination for Theory and term assignments shall be conducted at the end of each Semester and the evaluation of Project work at the end of the forth Semester will be by the external expert and Guide.

- The candidates shall appear for external examination of 5 theory papers out of which two papers carrying 100 marks of 3 hours duration and 3 papers carrying 60 marks of 2.5 Hours duration.

- Every student will have to complete a separate dissertation based project in Semester IV with twenty four credits (600 marks).

- Students have to prepare and submit a Master level thesis and the final evaluation will be done by external expert and Guide on the bases of the quality of the thesis and Viva-Voce examination.

6. Standard of Passing for University Examinations:

As per ordinances and regulations prescribed by the University for semester based credit and grading systems.

7. Standard point scale for grading:

Grade	Marks	Grade Points
O	80 and above	10
A+	70 to 79.99	9
A	60 to 69.99	8
B+	55 to 59.99	7
B	50 to 54.99	6
C	45 to 49.99	5
D	40 to 44.99	4
F (Fail)	39.99 and below	0

Semester -1

MMS101 Introduction to Maritime Studies, Blue Economy & UN Sustainable Goals (4 Credit)

Unit I: **Blue Economy (10 Hours)**

Background to the Blue Economy, Elements of Blue Economy: The Marine Environment, Fisheries and Aquaculture, Maritime Tourism, Ocean-based renewable sources of energy Transportation and the Blue Economy; Blue Economy Policy of India.

Unit II Sustainable Goals Linked to Marine System (30 Hours)

Overview of UN Sustainable Development Goals; SDGs linked to marine studies (GOAL 1: No Poverty; GOAL 2: Zero Hunger; GOAL 7: Affordable and Clean Energy; GOAL 12: Responsible Consumption and Production; GOAL 13: Climate Action; GOAL 14: Life Below

Water); Analysis of IPCC reports;

Unit III: India's Maritime History (15 Hours):

Indus Valley Civilization and trade links with Greeks, Egyptians and other countries. Maritime activity between Indian and Arabian Nations, West and East Asian Countries. Maritime Trade and diplomacy during Mauryan Period Expansion of Budhisim through Sea Pandiyan Navy: Sea borne trade and expeditions Chola Navy: Expeditions and relation with Sri Lanka and Southeast Asia Chera Period: Trade and Maritime Activities Gupta Navy British, Portugese, Dutch, French Naval Presence and influence in the Indian Ocean

Unit IV: National & International Maritime Laws (20 Hours):

Organisations like the UNO, OPEC, NAM, EU, League of Arab States, WARSAW Pact, NATO, SAARC, BRICS, ASEAN, SAGAR, FOIP and IPOI. UNCLOS, Coastal Security, Piracy. Leadership Challenges of Maritime Forces in 21st Century
Law of Contract, The Indian Ports Act, 1908 The Major Port Trust Act, 1963 Carriage of Good by Sea Act, 1925 Merchant Shipping Act, 1958 Customs Act, 1962 Maritime Arbitration and Alternative Dispute Resolution Modes Salvage, International Salvage Convention 1989, of 2000, SCOPIC MARPOL SOLAS and ISPS Code

Reference:

1. Maritime Labour Convention 2006 Hongkong Convention 2009
2. The Timeless Wake by Cmde Odakkal Jonson
3. A World of Nations: The International Order Since 1945 by William R Kaylor
4. Transition to Triumph: History of Indian Navy by VAdm G H Hiranandani
5. Rulers of the Indian Ocean by G A Ballard
6. A Maritime History of India Adm K Sridharan
7. Coastal Security: Maritime Dimensions of India‟s Homeland Security by Kunwar Rajendra Singh
8. Coastal Security: The Indian Experience by Pushpita Das
9. Role of Coast Guard in the Maritime Security of Indian by Prabhakaran Paleri
10. An Integrated Approach to Coastal and Offshore Defense: Leveraging the Coastal

Security by Capt Himadri Das

11. Armed Robbery in Sea in India: Trends and Imperatives by Capt Himadri Das.
12. Coastal Security, Challenges, Concerns and Way ahead by Brig Hemant Mahajan
13. The Blue Economy Policy of India, Ministry of Earth Sciences, Govt. of India.
14. The Blue Economy: 10 Years, 100 Innovations, 100 Million Jobs by Gunter Pauli
15. Rethinking the Oceans: Towards the Blue Economy by James Alix Michel
16. The Blue Economy 3.0: The Marriage of Science, Innovation and Entrepreneurship Creates a New Business Model That Transforms Society by Gunter Pauli
17. https://www.un.org/development/desa/disabilities/envision2030.html

MMS102 Introduction to General Oceanography (6 Credit)

Unit I: **Introduction to Physical Oceanography (20 Hours)**

Structure of Ocean Floor/Bed

Sea Water & its properties

Tides & Waves

Ocean Circulation

Ocean Climate

Unit II : Introduction to Biological Oceanography (20 Hours)

Ocean as Biological Medium

Biological zonation & Intertidal Ecosystem

Major Division of Marine Environments (Pelagic and benthic, their subdivision)

Benthic communities & Marine Environment

Environmental factors affecting Marine Life (Light, salinity, pH, Turbidity, DO, Temperature, Trace elements)

Classification of Marine Flora & Funa

Unit III: Introduction to Ocean Chemistry (20 Hours)

Characteristics of Sea Water

Chemical composition of Sea Water

Chlorinity & Salinity

Dissolved Gasses

Major Marine Biogeochemical cycles

Mineral Resources of the Ocean

Unit IV: Ocean Research & Case Study (30 Hours)

Major Ocean Expeditions

Introduction to research vessel

Oceanographic Instruments

Sea Water Analysis

Biodiversity of Coastal Region

References:

1. Introduction to Physical Oceanography. by Robert H. Stewart, Texas A&M University
2. Descriptive Physical Oceanography, an Introduction, 6th edition, 2011, D. Talley, George L.
Pickard, William J. Emery and James H. Swift, Elsevier Ltd.,ISBN: 978-0-7506-4552-2.
3. Atmosphere Ocean Dynamics. Adrian E. Gill, Academic Press, 1982.
4. Ocean Circulation: Prepared by an Open University Course Team (S330) by Joan Brown.
5) Seawater: its Composition, Properties and Behaviour (Second Edition),Prepared by an OpenUniversity Course Team by John M. Wright, Angela Colling and Gerry Bearman
6. Introductory Dynamical Oceanography, 2nd edition by Stephen Pond and George L Pickard.
7. Dynamics of Marine ecosystems: Biological –Physical Interactions in the Oceans,3rd Edition K.H Mann, John R.N Lazie, Wiley, 2013.
8. Lee R. Kump, James F. Kasting, Robert G. Crane, The Earth System (3rd Edition) 3rd Edition, Pearson New International Edition.
9. Essential of Oceanography, by Trujillo/ Thurman (6 January 2015)
10.Oceanography: An Invitation to Marine Science, by Tom Garrison (31 July 2012)
11. Essentials of Meteorology: An Invitation to the Atmosphere by C. Donald Ahrens
12. Meteorology Today: An Introduction to Weather, Climate, and the Environment by Robert Henson, C. Donald Ahrens

MMS103 Research Methodology (4 credits)

Unit I: Introduction/ Basics of Research Methodology: (5 Hours)

Definition of Research, The objective of Research & Types of Research, Research Process Selecting a Research Problem , Technique Involved in Defining a Research Problem Research Design, Literature Search: Reference management, Systematic literature search, literature Search techniques, Data collection: Source of Data/ Database, Primary & Secondary Data, Methods of Data collection , Data Processing

Unit II: Statistics In Research (15 Hours)

Measurement of Central tendency: Mean, Arithmetic Mean, Geometric Mean, Mode, Median Measures of dispersion: Range, Q.D., M.D., variance, standard deviation Correlation & Regression Analysis Probability Distribution & Hypothesis Testing: Binomial, poisson, normal, exponential, uniform distributions. Type I and II error, testing of mean, proportion, tests for equality of mean and variances of two populations, confidence interval, Z test, T-test and $\chi 2$ test for goodness of fit, ANOVA (one way & Two way classification) Non parametric tests: The Wilcoxon signed-Rank test for location, The Mann-Whitney Test, The Kolmogorov-Smirnov Goodness- of -Fit Test, The Kruskal-Wallis One-Way Analysis of Variance by Ranks , The Friedman Two-Way Analysis of Variance by Ranks

Unit III Interpretation, Report Writing & Decision-making Management: (5 Hours)

The technique of Interpretation, Precaution of Interpretation, Systems Thinking & Approach, Decision Making under uncertainty and Risk, Decision tables & decision Tree. Research Reports: Research Article, Review Article, Thesis, Patent, Book Chapter, Presentation, Poster, Infographics; IPR.

Unit IV: Skill Enhancement (10 Hours)

Soft Skills: Scientific/ Academic Communication, Presentation skills, Body language Computational Skill: MS Office, Adobe, Google workplace, and some other basic computer and mobile applications Web-based and mobile applications for the Literature search: Mendeley, Scopus, NCBI, Researcher, ResearchGate, web of Science, etc Software used in Reference management such as Mendeley, Zotero, Endnote; Use of thesaurus, Grammarly, typeset, etc; Introduction to Statistical and Graphical Softwares: Graph Pad, SPSS, SAS, ggplot in R language

Unit V: Analysis of Marine Field data (25 hours)

References:

1. Research Methodology Methods and Techniques by C.R.Kothari, Gaurav Garg, New Age International Publishers
2. Methodology of Research in Social Science by O.R. Krishnaswami and M.

Ranganatham, Himalaya Publishing House
3. Principles of Statistics, 2nd Ed. M Pagano & K Gauvreau (2007), Thomson Publication
4. BK Mahajan, Methods in Biostatistics (7th Edition), Published December 1st 2008 by JP Medical Ltd
5. Goode W J & Hatt P K, Methods in social research, McGraw Hill
6. Shrivastava, Shenoy & Sharma, Quantitative Techniques for Managerial Decisions, Wiley
7. Piero Mella (2021), The Magic Ring: Systems Thinking Approach to Control Systems, Springer Nature
8. Donella Meadows (2015), Thinking in Systems, Chelsea Green Publishing Co
9. Latest Research Articles & Review Articles from the Relevant Subject

MMS104 Evolution of Marine Environment and Life (4 Credit)

Unit I Earth & Atmosphere (15 Hours)

Evolution earth system; Structure of Earth, Structure of Atmosphere, World oceans, salient features of Oceans, Understanding of Map projections.

Unit II Evolution of life in earth system(15 Hours)

History, classification, theories, expeditions, hypothesis testing; Origin and evolution of life – life processes, abiogenesis, 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

Unit III Methods to Study Evolution (15 Hours)

Fossils

Carbon Dating

Molecular Evolution

Unit IV Case Study (15 Hours)

References:

1. Eugen Seibold, Wolfgang Berger. 2017. The Sea Floor: An Introduction to Marine Geology. Springer International Publishing.272 pp.
2. Crist, D.T. Scowcroft, G. and Harding Jr., J.M. 2009. World Ocean Census; a Global

Survey of Marine Life, Firefly Books, New York: 256 pp.

3. Guido di Prisco, Peter Convey (auth.), Guido di Prisco, Cinzia Verde (eds.). 2012. Adaptation and Evolution in Marine Environments, Volume 1: The Impacts of Global Change on Biodiversity. Springer-Verlag Berlin Heidelberg 236 pp.
4. Hewitt, G.M., Johnston, A. and Young, J.P.W. (Eds.) 1991. Molecular Techniques in Taxonomy, Springer-Verlag: 410 pp.
5. Mayr, E. and Ashlock, P.D. 1991. Principles of Systematic Zoology. McGraw-Hill, New York: 475 pp. Quicke, Donald L.J. 1993. Principles and Techniques of Contemporary Taxonomy, Blackie Academic & Professional, London: 331 pp.
6. Schuh, R. T. and Brower, A. V. Z. 2009. Biological Systematics: Principles and Applications (2ndedn.). Cornell University Press: 311 pp.
7. Venkataraman K & C. Sivaperuman. 2014. Marine Faunal Diversity in India: Taxonomy, Ecology and Conservation. Academic Press 546 pp.
8. Winston, Judith E. 1999. Describing Species: Practical Taxonomic Procedure for Biologists, Columbia University Press, New York

MMS105 Introduction to Marine Geology (6 Credit)

Unit I: 15 Hours

Sediment, sediment grade scale and analysis – Classification, composition, distribution and source of sediments with emphasis on nearshore 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 – Nearshore geological processes: erosion, transportation and deposition

Unit II: 15 Hours

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

Unit III 15 Hours

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.

Unit IV 15 Hours

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.

Unit V 15 Hours

Beach profile survey and sediment sample collection-Water sample collection and separation of suspended sediments- Sample collection using grab and corer and sample preservation- Beach profile plotting and volume computation- Pre-treatment of sediment- Grain size analysis (sand grade) - Grain size data computation, graphical representation and interpretation

Unit VI 15 Hours

Depositional environment studies using a data set of river, dune and beach- Techniques for heavy mineral separation - Computation of gravity data- Computation of magnetic data- Computation of Seismic data- Graphical representation and interpretation of bathymetry data set- Study of bathymetry maps - Study of seismic profiles

References:

1. Introductory oceanography (5th ed),1988 Thurman,H.V., Mercill Publ. Co, Ohio.
2. Oceanography (5th ed), 1990 –Grant Gross, M., Prentice Hall.
3. Coastal and estuarine sediment dynamics, 1986 – Dyer,K.R., John Wiley & Sons.
4. Beach processes and sedimentation, 1976 – Komar, P.D., Prentice Hall
5. Beaches and Coasts (2nd ed), 1972 – King, C.A.M.,Edward Arnold
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., McGrw-Hill
9. The mineral sources of the sea, 1965 – Mcro, J.L.,Elsevier, Amsterdam.
10. Earth resources. 1969 – Skinner, B.J., Prentice Hall
11. Structural Geology, 1972 - M.P. Billings, Third Edition
12. Marine minerals: advances in research and resource assessment, 1987 – Teleki, P.G. et al. D. Reidel Dordrechart.
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 Pakisthan 1984 – Haq. B.U. and Milliman, J.D., Van Norstrand Reinhold Co.
15. Marine Geology, 1982 – James P. Kennet. Prentice Hall INC Englewood,Cliffs, N.J.

Semester II

MMS201 Satellite Oceanography (6 Credits)

UNIT-1: Introduction to remote sensing: (10 hours) Basic concepts; electromagnetic radiation; solar and terrestrial radiation; atmospheric effects; absorption; transmission; scattering; spectral response of earth's surface features.

UNIT-2: Satellite Remote Sensing: (15 hours) Major Satellite systems for ocean remote sensing; satellite orbits- near polar geostationary and sun-synchronous satellites; swath; spatial, temporal, spectral and radiometric resolution; examples of Indian atmospheric and ocean satellites including INSAT; sensors-active and passive sensors; sensor calibration; visible, thermal and microwave sensors and their applications in oceanography

UNIT-3 Ocean Color Remote Sensing: (15 hours) Theory of ocean colour remote sensing; optical properties of pure water; natural waters and atmosphere; reflection and refraction at the surface; scattering and absorption of light underwater; reflection from sea bed; colour of the sea; phytoplankton, yellow substance, suspended particulate matter; case 1 and case 2 waters; estimating water parameters; satellite sensors for ocean colour-I and their applications

UNIT-4: Infrared Remote Sensing: (5 hours) Infrared radiometers; SST retrieval with atmospheric corrections andvalidation; application; skin and bulk SST; global SST data products

UNIT-5: Microwave remote sensing: (5 hours) Theory and principles of microwave radiometry; passive microwaveradiometers and its applications in ocean and atmosphere; active microwave sensors; principles;applications of SAR; scatterometers and altimeters for ocean and atmospheric studies.

UNIT-6: Handling Remote Sensing Data: (40 hours) Introduction to GIS; creation of point, line and polygon in form of shape file/Geo-database; geo-referencing of satellite data and digitized vector files using GIS software; geo-informatics; integration of attribute data; analysis using map algebra; map composition and finalization; web-GIS; application of ArcGIS and ERDAS.

Reference Books:

- Houghton, J. T., F.W. Taylor and C.D. Rodgers, Remote sounding of atmosphere, Cambridge University Press, 1984.
- Stewart, R. H., Methods of Satellite Oceanography, University of California, 1985.
- Robinson, I. S., Satellite Oceanography, Ellis Horwood, 1985.

- Weng,Q., Remote Sensing and GIS Integration: Theories, Methods and applications, McGaw-Hill Professional, 2009.

MMS202 Marine Ecosystem & Pollution (4 Credits)

Unit I: Marine and Coastal Ecosystems (10 Hours)

Key marine and coastal habitats (Coral reefs, Mangroves, Sea Grass, Sandy shores, Rocky Shores, Sand dunes and mudflats) Trophic structure and energy transfer at various trophic levels. Benthic ecosystem (Components, functioning and interactions) .Ecosystem functioning Population connectivity in marine systems and biogeography Carbon and nutrient cycles Biological productivity Nutrient cycles. Processes across land-ocean interface Processes in the marine boundary layer

Unit II Overview of Marine Pollution (10 Hours)

Types of pollution, Response of benthic communities to the physical disturbance, Organic and inorganic pollution, Toxic metals in marine environment, Harmful Algal Blooms Coastal pollution: Industrial; sewage; microbial pollution; eutrophication; water quality; microbial indicators; bioremediation

Unit III Marine pollution hazard management and mitigation (10 Hours)

Evaluation and monitoring of pollution, Evaluation of toxicity in marine biota, Managing Oil spills and Oil spill mitigation, Incursion management, Solid-waste discharge and management, Marine pollution bioremediation – Fungal and microbial

Unit IV Marine Noise and light pollution (5 Hours)

Sea-bed mining and oil and gas infrastructure, Impact of underwater noise on cetaceans. Impact of coastal illumination on marine fauna

Unit V Marine litter and impacts (5 Hours)

Plastic and Micro-plastic pollution and impacts; Impacts on benthic and pelagic fauna and flora

Unit VI (10 Hours) Construction of Marine Ecological Model

Marine Ecological Model construction with respect to selected marine site

Unit VII (10 Hours) Site Visit to Understand Marine Pollution

Site Visits to coastal regions to understand marine pollution (Litter Survey), sample collection (hydrocarbon and eutrophication and pollution prevention and management

References

1. Levinton, J. S. 2001. Marine Biology: Functions, biodiversity, ecology. Oxford Univ. Press. (2nd Edition)
2. Castro, P., Huber, M. E., 2003. Marine Biology. McGraw Hill Science. (4th Edition)
3. Jones, C. G., Lawton, J. H., 1995. Linking species and ecosystem. Springer.
4. Takahashi, M., Hargrave, B., Parsons, T.R., 1984. Biological oceanographic processes. Pergamon Press. (3rd Edn)
5. Gray, J. S., Elliot, M., 2009. Ecology of marine sediments. Oxford Univ. Press
6. Richard T Wright and Bernard J. Nebel : 'Environmental Science – Towards a Sustainable Future' (Eighth Edition) – Prentice-Hall of India Pvt. Ltd, New Delhi pp 213 – 237, 439 - 459
7. Savindra Singh : 'Physical Geography' – Prayag Pustak Bhavan, Allahabad pp 388 - 407
8. Asthana D K and Meera : A Textbook of Environmental Studies' – S. Chand and Company Pvt. Ltd, New Delhi pp 177 – 224
9. Savindra Singh : 'Environmental Geography' – Prayag Pustak Bhavan, New Delhi pp 414 –
10. 541
11. Karlekar Shrikant : 'Coastal Geomorphology of India' – Diamond Publication, Pune
12. Bhakhtaver Mahajan and Suma Nair : 'Health and Environment – Action Based Learning
13. (HEAL), HBCSE, TIFR, Mumbai pp 36 – 98
14. Botkin and Keller : 'Environmental Science – Earth as a Living Planet' (Fifth Edition), John Wiley and Sons pp 262 – 293, 435 – 465
15. Vivek Sharma and Deepika Singla : 'NTA, UGC – NET/JRF/SLET Geography' – Arihant Publication, New Delhi pp 202 – 204, 238 – 241
16. Doney, S. C., Lima, I., Feely, R. A., Glover, D. M., Lindsay, K., Mahowald, N., Moore, J.K. & Wanninkhof, R. (2009). Mechanisms governing internal variability in

upper-ocean inorganic carbon system and air–sea CO2 fluxes: Physical climate and atmospheric dust. Deep Sea Research Part II: Topical Studies in Oceanography, 56(8-10), 640-655

17. Valsala, V., & Maksyutov, S. (2013). Interannual variability of the air–sea CO2 flux in the north Indian Ocean. Ocean Dynamics, 63(2-3), 165-178
18. Doney, S. C., Lima, I., Feely, R. A., Glover, D. M., Lindsay, K., Mahowald, N., Moore, J.K. & Wanninkhof, R. (2009). Mechanisms governing interannual variability in upper-ocean inorganic carbon system and air–sea CO2 fluxes: Physical climate and atmospheric dust. Deep Sea Research Part II: Topical Studies in Oceanography, 56(8-10), 640-655
19. Stock, C. A., Dunne, J. P., Fan, S., Ginoux, P., John, J., Krasting, J. P., Laufkötter, C., Paulot,
20. F. & Zadeh, N. (2020). Ocean biogeochemistry in GFDL's earth system model 4.1 and its response to increasing atmospheric CO2. Journal of Advances in Modeling Earth Systems, e2019MS002043
21. Senthil Kumar : Modern Treatment Strategies for Marine Pollution (First Edition) - Elsevier

MSCMS203E Introduction to Physical Oceanography (6 credits)

UNIT-1: Introduction to Physical Oceanography: (4 hours) Historical perspective; voyages and expeditions; Dimension; Definitions; Bathymetric features;

UNIT-2: Physical properties of seawater and upper ocean vertical structure: (10 hours) Temperature, salinity, density, mixed layer, isothermal layer, barrier layer, thermal inversion. Water masses: formation and classification - T-S diagram - water masses of the world ocean with special reference to Indian Ocean; Sea level changes and associated processes.

UNIT-3: Ocean Mixing Processes: (10 hours) Mixing processes in the surface layers; wind induced mixing; convective mixing; Richardson number- Double Diffusion and Salt Fingers. Mixing in the interior ocean; Vertical structure of other properties-light, sounds, nutrients, oxygen and chlorophyll. Mixed layer heat and salt budget.

UNIT- 4: Tides and Waves: (12 hours) Theory of Ocean Surface Waves; observation techniques; Wave Spectrum; Wind forcing; Fetch; Generation, propagation and dissipation of wind waves; Swells and Sea; Tides in the Ocean; Physics of Ocean tides; observation techniques; Dissipation of tides; Tsunamis; Storm Surges.

UNIT-5: Ocean Observation: (14 hours) Principles of measurements of ocean temperature; conductivity; salinity; currents; sea level; In situ ocean observations: Moored buoys; Thermisters; Thermosalinograph; current meters; tide gauges; Bottom Pressure Recorders; Argo buoys; Drifters; Gliders; XBT-XCTDs; Wire Walker; ADCP; uCTD; Satellite Remote Sensing: Principles of measurements of SST, SSS; SLA, Surface Currents; Chlorophyll Concentration; Important satellite missions and sensors;

UNIT-6: Physical Oceanography Practice: (40 hours) Analysis of in situ ocean observation data to identify physical properties and identification of water masses; Computation of ocean mixed layer heat budget;

References

1. Introduction to Physical Oceanography. by Robert H. Stewart, Texas A&M University
2. Descriptive Physical Oceanography, an Introduction, 6th edition, 2011, D. Talley,
3. George L. Pickard, William J. Emery and James H. Swift, Elsevier Ltd.,ISBN: 978-0-7506-4552-2.
4. Seawater: its Composition, Properties and Behaviour (Second Edition),Prepared by an Open University Course Team by John M. Wright, Angela Colling and GerryBearman
5. Introductory Dynamical Oceanography, 2nd edition by Stephen Pond and George L Pickard.

MSCMS204E Ocean General Circulation (4 credit)

UNIT-1: The observed mean global ocean and atmospheric general circulation features: (10 hours) Temperature and salinity distribution in the oceans; Major ocean current systems; Ekman and Geostrophic Currents; Warm and cold currents; Ocean Circulation and distribution of heat and salt.

UNIT-2: Wind-driven ocean circulation: (10 hours) Boundary currents; theories of wind-driven circulation; Ekmann depth; Ekmann drift; Ekman Transport; Sverdrup solution; Munk theory; Stommel theory; Western boundary currents;

UNIT-3: Oceanic Gyres and Eddies: (5 hours) Ocean Gyres and their properties; Dynamics of Ocean Gyres; Characteristics of oceanic eddies; Mesoscale and submesoscale eddies; Dynamics of Oceanic Eddies; Importance of Oceanic eddies in global ocean circulation;

UNIT-4: Thermohaline circulation: (5 hours) Vertical distribution of temperature and salinity in the global oceans; Mixing processes; Thermohaline circulation; Conveyor belt mechanism and ocean climate; Abyssal circulation; Climate Change and thermohaline circulation;

UNIT-5: Indian Ocean circulation: (10 hours) Basics of Indian Monsoon Circulation; Major features of Indian Ocean circulation; Monsoon currents; Coastal currents around India and forcing mechanism; Temperature and Salinity distribution in Arabian Sea and Bay of Bengal and variability; The Indian Ocean Dipole;

UNIT-5: Analysis of Global and Indian Ocean observations: (20 hours) Preparation of maps of Indian Ocean and Global Ocean current systems and documentation of their seasonal variation using ocean reanalysis datasets; Analysis of Temperature and Salinity Distribution in the Indian Ocean using ocean reanalysis datasets and documentation of their variability.

Reference Books:

1. Pedlosky, J., Ocean Circulation Theory, Springer, 1998.
2. Marshall J., and R. A. Plumb, Atmosphere Ocean and Climate Dynamics: An Introductory Text, Elsevier Academic Press, 2008.
3. Holton J. R., and G. J. Hakim, Introduction to Dynamic Meteorology, 5th edition, Academic Press, 2012
4. Sverdrup, H. U., M. W. Johnson and R. H. Fleming, The Oceans: Their Physics, Chemistry and General Biology, Prentice Hall Inc, 1942.
5. Peixoto, J.P. and Oort, A.H. (1992) Physics of Climate. Springer-Verlag, New York, Berlin, Heidelberg.
6. Pond and Pickard (1983). Introductory Dynamic Oceanography, Elsevier;

MSCMS 205E Geophysical Fluid Dynamics (4 Credit)

Unit I (15 hours) Importance of Geophysical Fluid Dynamics, The equation of motion in a rotating coordinate frame; Coriolis and Centrifugal forces, Constant angular momentum (Inertial) oscillations, Geostrophic adjustment, geostrophic balance, thermal wind.

Unit II (15 hours) Vorticity & Circulation., Kelvin's Theorem., The Vorticity Equation., Concept of Potential Vorticity, Taylor-Proudman Theorem., Geostrophic Motion.

Unit III (15 hours) Shallow Water Model, Potential Vorticity Conservation, Small

Amplitude Motions, The Kelvin, Poincarre wave & Rossby wave, Dispersion diagram and interpretation; Steady Quasigeostrophic Motion, Inertial Boundary Currents, Quasigeostrophic Rossby waves, The beta-plane approximation.

Unit IV (15 hours) Ekman Layer, The nature of nearly frictionless flows, Boundary Layer Theory. Quasi-geostrophic dynamics in the presence of friction; Inertial Boundary Layer Theory, Inertial Currents in presence of friction.

References

1. Fluid Mechanics, Kundu, P.K., Cohen, I.M., Dowling, D.R., 6th Edition, Academic Press, Elsevier, 2015.
2. Introduction to geophysical fluid dynamics physical and numerical aspects, Benoit Cushman-Roisin, Jean-Marie Beckers, 2nd Edition, Academic press, Elsevier 2011.
3. Atmosphere-Ocean Dynamics, Gill, A. E., International Geophysics Series, Vol. 30, 1982.
4. Fluid Physics for Oceanographers and Physicists: An Introduction to Incompressible Flow, Samual A. Elder and J. Williams, 2nd Edn, Pergamon Pr, 1989.
5. An introduction to fluid dynamics, Batchelor, G. K., Cambridge University Press, 2000.
6. Geophysical Fluid Dynamics – Joseph Pedlosky

MSCMS206 E Biological Oceanography (6 credit)

Unit I (15 Hours)

Marine Habitats, Marine & Coastal Environments, Extreme Environments, 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.

Unit II (15 Hours)

Classification & Taxonomy of Marine organisms , Salient features of various Marine Phyllum, Major Marine Flora- Major Marine Funa . Classification of Major zooplankton & Phytoplankton Groups. Marine Biological distribution in Indian EEZ

Unit III (15 Hours)

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. 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.

Unit IV (15 Hours)

Marine biodiversity, Biodiversity valuation, Conservation status, Endangered marine organisms, CITES, Red data list and its categories. Regulations concerned with the conservation of marine fauna and flora. Marine sanctuaries, Marine Protected Areas (MPAs), Large Marine Ecosystems (LMEs) etc. Integrated Coastal Zone Management. International regulations related to maritime boundaries (UNCLOS, ANMJ, BBNJ etc.), EEZ and territorial waters.

Unit V (30 Hours)

Marine benthos, Sampling and quantitative analysis of marine benthos - Sieves, Grabs, Box corers, Hydraulic corers, Dredges. Estimation of standing stock and biomass of benthos. Biodiversity and community structure analysis, species richness, succession, species equitability, species diversity and species dominance. Data analysis and interpretation. Software related to biodiversity and community structure analysis. Census of marine life (CoML) – Barcoding of marine organisms, Ocean Biographic information system (OBIS), taxonomic databases (FishBase, SeaLifeBase, WORMS, CephBase, etc.).

1. Biological oceanography 1999 – Lalli, C.M.
2. Oceanography: The past, 1980 – Sears, M and Merimann D. (Eds).
3. Elements of ecology (3rd edn) 1982 – Tail, R.V.
4. An introduction to marine sciences, 1988 – Meadows, P.S. & Campbell, J.J.
5. Textbook of marine ecology, 1989 – Nair, N.B. & Thampy, D.M.
6. Marine biology, 1984 Thurman, H.V. and Webber, H.H.

7. Methods in marine zooplankton ecology, 1984 Omori, W. and Ikeda, T.

8. Methods for the study of marine benthos, 1984 – Holme, N.A. & Melntyre, A.D.

9. The ecology of rocky coasts, 1964 – Lewis, J.R.

10. The shore environment, 1980 – Irvine, J.H., Price, D.E.C. and Farnham, W.F.

11. Life between tidemark on rocky shores, 1972 – Stephenson, T.A. & Stephenson, A.

12. The invertebrates (5th Edn.), 1986 – Barnes, R.D.

13. Zooplankton Methodology Manual, 2000 - Harris, R., Wiebe, P., Lenz, J., Skjoldal, H.R., Huntley, M. (Eds), ICES Academic Press, San Diego, pp. 684.

MSCMS 207E Marine Microbiology & Cell Biology (4 credit)

Unit I Introduction to Microbiology (15 Hours)

A brief history of microbiology, An overview of the organization and cell structure of prokaryotes and archaea; Microbial nutrition; Structure & Classification; Specialized microorganisms

Unit II Marine Microbiology (15 Hours)

Introduction to Marine Microbiology. Characteristics of marine bacteria. Influence of physical and chemical factors on the distribution of marine microorganisms. Sample collection methods.

Unit III: Cell Biology (15 Hours)

Cell structure, cell organelles & their function, mitochondria and chloroplast, cell signaling , cell cycle, cell division, microtubules & microfilaments, Molecular chaperones, cell fusion techniques

Unit V Techniques in Marine Microbiology & Cell Biology (15 Hours)

Estimation of marine microorganisms. Total plate count, Epifluorescence count, ATP assay. Identification of Microorganisms

Refrences

2. David,L.Nelson.&Michael,M.Cox. (2017). *Lehninger,Principles of*
3. Fiechter, A (Ed.). (2000). *Advances in Biochemical Engineering /Biotechnology*. Berlin, Heidelberg:Springer-Verlag.
4. James, A., & Lilian, Evison. (1979).*Biological Indicators of Water Quality* in Environmental Science and Technology Textsand Monographs. NewYork: John Wiley and Sons.
5. Rodina, A.G. (1972). *Methods in Aquatic Microbiology*. University Park Press.
6. Burrows, William., Porter, R. Janvier., Moulder & J. William. (1955). *Textbook of Microbiology* (16thEdition).W. B. Saunders Company.
7. Holger, W. Jannasch. (1986). *Advances in Aquatic Microbiology*. Academic Press.
8. Irving, J. Higgins& Roger, G. Burns. (1975). *The Chemistry and Microbiology of Pollution*. Academic Press.
9. Carol, D (Ed.). (1976). *Marine Microbiology*. Stroudsburg: Dowden, Hutchinson & Ross.

10. Lynch, J.M & Hobbie, J.B (Eds.). (1988). *Micro-organisms in Action:Concepts and Applications in Microbial Ecology*. Oxford: Blackwell Scientific Publications.
11. Michael, J. Pelczar., Roger, D. Reid., & Chen. E.C.S. (1997). *Microbiology*(4thEdition). Tata MacGraw Hill.
12. Mitchell, Ralph. (1974). *Introduction to Environmental Microbiology.*Englewood Cliffs: Prentice-Hall.
13. Prescott, Harley and Klein. (2008). *Microbiology*. 8thEdition. MacGraw Hill.
14. Rheinheimer, G.(1985). *Aquatic Microbiology* (3rdEdition). Book Depart.
15. Ronald, M. Atlas. (1986). *Basic and Practical Microbiology*. New York: Macmillan Pub Co.
16. Salle, A.J.(1948). *Fundamental Principles of Bacteriology.*McGraw-Hill.
17. Skinner, F A., & Shewan, J M. (1977). *Aquatic Microbiology.*Academic Press.
18. William, C. Frazier.,& Dennis, C. Westhoff. (1988). *Food Microbiology.* McGraw-Hill.
19. https://nptel.ac.in/courses/102/103/102103015/
20. https://www.swayamprabha.gov.in/index.php/program/archive/9
21. Sabu Thomas et al. (eds). (2020). Emerging Concepts in Bacterial Biofilms: Molecular Mechanisms and Control Strategies. Cambridge Scholars Publishing, ISBN 1527545172

MSCMS208E Biochemistry & Molecular Biology (4 credit)

Unit I: Carbohydrates, Vitamins, Minerals (10 Hours)

Carbohydrate: Classification and stereochemistry, structure, properties and biological roles of storage and structural carbohydrates such as sucrose, starch, glycogen, cellulose, pectin, hemicelluloses, chitin, mucopolysaccharides. Glycoproteins, proteoglycans, glycolipids. Applications of carbohydrates (biofuel, industrial and therapeutic). Vitamins: Structure, sources and biological roles of water soluble and lipid soluble vitamins,

Unit II: Protein and Lipids (10 Hours)

Protein: Structure, classification and properties of Amino acids; Peptide bonds and Primary structure; Secondary structure eg. Keratin, Collagen; Ramachandran plot; Tertiary structure and the underlying interactions/ forces, quaternary structure and with references to haemoglobin; and quinary structure. Protein folding and denaturation; Domains and motifs; Cytoskeletal and extracellular proteins; Isolation, purification and characterization of proteins; Applications of proteins (industrial and therapeutic); Parameters of protein quality (Biological value, net protein utilization, protein efficiency rate, digestibility) Lipids: Structure, classification and properties of lipids; Lipid peroxidation;

Unit III: Enzymology (10 Hours)

Enzyme: Enzyme and enzyme substrate interactions; chemical modification and identification of active site amino acids; Enzyme kinetics (Michaelis-Menten equation and plot, Lineweaver-Burk plot, significance of Km and Vmax); Catalytic efficiency of enzymes; Mechanism of enzyme catalysis with reference to chymotrypsin/lysozymes/metalloenzymes; Role of metals in catalysis with reference to carboxypeptidase; Therapeutic and industrial applications of enzymes. Regulation: Regulation of enzyme action; Theory of allostery with reference to ATCase; Isozymes with reference to LDH; Coenzymes and their roles; Enzyme inhibitors, types and their kinetics; Enzyme inhibitors as drugs; Ribozymes and Abzymes.

Unit IV Molecular Biology (10 Hours)

Structure of RNA, DNA. Central Dogma, Replication, Repair, Translation, Transcription. Gene, Structure & function of Gene, Regulation of gene expression in prokaryotes and eukaryotes. Induced gene mutation. Transposons. Chromosome mapping.

Unit IV: Marine Biochemical Techniques (20 Hours)

pH, Buffers and colorimetry:;. Chromatography: (paper, thin layer, column (gel filtration, ion exchange, affinity, gas, HPLC,FPLC etc). Colorimetry and spectroscopy: Radioisotope methods and tracer techniques in biology: Basic principles of radioactivity, properties and handling of radioisotopes in biology and medicine, Molecular techniques in microbial community structure analysis –Denaturing Gradient Gel Electrophoresis (DGGE), Amplicon sequencing, Terminal Restriction Fragment Length Polymorphism (T-RFLP). Fluorescence *in situ* hybridization (FISH). Box PCR. Molecular methods of microbial identification -16S rRNA, Internal Transcribed Spacer (ITS), Nanopore sequencing. Microbial databases and microbial culture collections -ARB, EZtaxon, NCBI, Greengenes, MTCC, ATCC

References:

1. L. Stryer (2002): Biochemistry, W.H. Freeman and Co. 5th Edition.
2. Voet, Donald, Voet Judith, Pratt, Charlotte W. (2006): Fundamentals of Biochemistry: Life at the molecular Level 2nd Edition. Publisher: Asia, John Wiley & Sons.
3. Nelson David L., Cox Michale. Lehninger (2008.): Principles of Biochemistry 5th Edition.Publisher: New York. W. H. Freeman.
4. Text Book of Biochemistry with clinical correlation by Thomas M. Devlin, John Wiley - Liss, Hobokhen NJ publishers
5. Zubey, Biochemistry GL WCB Publishers.
6. Purich Daniel L., Allison R. Donald. (2002): The Enzyme Reference: A Comprehensive Guidebook to Enzyme Nomenclature, Reactions, and Methods. Publisher: California, Academic Press.

7. K. Wilson and I. Walker, (2000): Practical Biochemistry, 5 th edition, University press
8. David Frifelder (1982): Physical Biochemistry, W. H. Freeman; 2nd edition
9. Sheehan, D. (2009) Physical Biochemistry: Principles and Applications. John Wiley & Sons Ltd., UK.
10. Branden, C. I. and Tooze, T. (1999) Introduction to Protein Structure. Garland Publishing, USA.
11. Lesk, A. M. (2004) Introduction to Protein Science: Architecture, Function and Genomics. Oxford University Press, UK.
12. Creighton, T.E. (1983) Proteins: Structures and Molecular Properties. W.H. Freeman and Co., USA.
13. Arai, M. and Kuwajima, K. (2000) Advances in Protein Chemistry. Academic Press, USA
14. David E Metzler (2001. 2002): The Chemical Reactions of Living Cells – Vol1 and 2.
15. William J. Marshall, Stephan K. Bangert, Elizabeth S.M. Ed. S.M (ed) Marshall, Clinical Biochemistry: Metabolic And Clinical Aspects by (2008) Publisher: Elsevier Science Health Science Div

Semester III

MSCMS301 Ocean Biogeochemistry and Ocean Optics (4 credit)

UNIT-I Introduction to Ocean Biogeochemistry: (10 hours) Primary Productivity, Role of nutrients and light, Sverdrup's critical depth concept, New and Regenerated production, Export Production, Biological Pump, Solubility Pump;

UNIT-II Chemical Oceanography: (10 hours) Chemical composition of seawater, Macro and Micronutrients, Concept of proximate and ultimate limitation, importance of trace elements, Elemental stoichiometry & Redfield ratio, Carbon, Nitrogen, Silicon and Phosphorus cycles, Importance of these elements in Ocean biogeochemistry

UNIT-III Physical-Biological Interactions: (12 hours) Coupling between physical, chemical and Biological Oceanography, Upwelling and winter mixing, Physical factors controlling marine productivity; ocean food web (phytoplankton to fish and microbial loop); Growth rate of phytoplankton, nutrient limitation, light limitation, Liebig law of minimum, Michaelis-Menton representation, Redfield ratio, photosynthesis, size consideration of phytoplankton (Diazotroph, picoplankton and diatom), zooplankton grazing;

UNIT-IV Oxygen minimum Zones: (4 hours) formation, distribution and implications; Deoxygenation of ocean, Dentrification and annamox, Organic matter cycling

UNIT-V Biogeochemistry and Climate linkages: (12 hours) Ocean Carbon Cycle & Ocean Acidification, Understanding of the chemical, physical, and biological characteristics and processes influencing carbon dynamics in ecosystems, A simple carbon-cycle model, Controlling

factors of Ocean Acidification, Ocean acidification and implications for global marine ecosystems.

UNIT-VI Ocean Optics: (12 hours) Fundamentals of the light/matter; electromagnetic radiation; ocean color; measurements & uncertainties, Optics of marine particles; optically active substances (OAS); inherent optical properties (IOP); apparent optical properties (AOP); remote sensing reflectance; downwelling diffuse attenuation coefficient; effect of OAS on apparent optical properties; vertical propagation of light

References:

1. "Ocean Biogeochemical Dynamics" by J. L. Sarmiento and N. Gruber, Princeton University Press
2. "Marine Biogeochemical Cycles", 2nd Edition, by Rachael James, Open University Publication
3. "Fundamentals of Remote Sensing", 2nd Edition, by George Joseph, Universities Press.
4. "Ocean Biogeochemical Dynamics," by Jorge L. Sarmiento & Nicolas Gruber, PrincetonUniversity Press.
5. "Dynamics of Marine ecosystems: Biological –Physical Interactions in the Oceans",3rd Edition by K.H Mann, John R.N Lazie, Wiley, 2013.
6. "Phytoplankton productivity: Carbon assimilation in marine and freshwater ecosystems", by Williams, P.J. B, Thomas, D. N, Reynolds, C. SWiley,2008.

MSCMS302E Coastal and Estuarine Oceanography (6 credit)

Unit 1: Elements of coastal oceanography: (8 hours) Coasts and shorelines, coastal geomorphology, coastal processes. Beaches – classification and features, beach configuration & profiles, beach erosion & accretion, long shore bars, sand spits, atolls, mud banks- beach stability,

Unit 2: Dynamics of coastal processes: (8 hours) Wave transformation in shallow waters, effect of bottom friction, phenomena of wave reflection, refraction and diffraction, breakers, littoral currents. Sediment transport in coastal zone, wave action on sediments, alongshore and cross shore transport, characteristics of wind waves and swells.

Unit 3: Tides: (8 hours) Basics of tidal circulation; Tides-tidal constituents, Harmonic analysis of tides. Tides and tidal currents in shallow seas and estuaries. Barotropic and baroclinic tidal currents;

Unit 4 Estuaries (8 hours) Definitions; Classification and nomenclature, effect of river discharge and tides, salinity intrusion in estuaries, mixing and stratification, residual estuarine circulation, estuaries of India – monsoonal estuaries, Tidal prism, uses and issues associated with estuaries.

Unit 5: Coastal zone management: (8 hours) Oceanographic aspects in coastal zone protection, coastal uses and resources, coastal pollution, coastal zone of India, coastal hazards and mitigation measures; Sea level rise; Tsunami and Storm surge;

Unit 6: Observations of coastal ocean and estuaries: (40 hours) Field visits; collection of water and sediment samples from estuaries and coastal waters, basic analysis and classification; observation of water quality; observations of tides; harmonic analysis of tides and documentation;

References:

- Beaches and Coasts: C A M King, Edward Arnold, 1961.
- Beaches Processes and Sedimentation: P D Komar, Prentice Hall, 2nd Edn., 1997.
- Contemporary issues in estuarine physics, Arnoldo-Valle Levinson, Cambridge University Press, 2010.
- Estuaries: A Physical Introduction: K R Dyer, John Wiley, 1973.
- Sea-level science : understanding tides, surges, tsunamis and mean sea-level changes, Pugh, David, Cambridge University Press, 2015

MSCMS303E Air-Sea interaction (4 credit)

Unit 1: Introduction: (15 hours) Ocean-atmosphere boundary layer; properties; diurnal variation; Examples of oceanic influence on atmospheric boundary layer and atmospheric influence of ocean mixed layer; Scales of air-sea interaction; Important assumptions in air-sea interaction; Importance of air-sea interaction and climate; Examples of coupled ocean-atmosphere processes;

Unit 2: (15 hours) Instabilities: Buoyancy driven instability; Kelvin Helmholtz instability; Reynolds Stress; Turbulant Kinetic Enery; TKE equation; Mixing Length Theory; Similarity theory; Flux Richardson number; Tylor hypothesis;

Unit 3: (30 hours) Estimation of Air-sea fluxes: Drag coefficient, wind stress, heat and moisture exchange coefficients, bulk formula for momentum flux, sensible heat flux and latent heat flux; Eddy Viscocity;

Reference Books:

- Kraus E. B. and J. A. Businger, Atmosphere-Ocean interaction, Oxford University Press, 1995.
- Stull R. B., Introduction to Boundary Layer Meteorology, Springer, 1988.

- Kagan, B, A., Ocean atmospheric interaction and climate modeling, Cambridge University Press,1995.

MSCMS304E Numerical Ocean Modeling (6 credit)

UNIT-1: Elements of Numerical Methods (8 hours): Taylor's expansion; forward, backward and central schemes; nonlinear instability and aliasing; Arakawa grids. Time integration schemes: Explicit and implicit schemes; semi-implicit schemes; initial conditions; surface and lateral boundary conditions.

UNIT-2: Ocean Circulation Modeling (10 hours) : Primitive Equations; Approximations; Assumptions; Surface Mixed Layer Processes, Interior Ocean mixing processes, Mixing Parameterisation Schemes, Representation of radiative transfer, Atmospheric Forcing; spin-up of models;

UNIT-3: Modeling of Wind Waves (6 hours) : Fundamental Equations and concepts; Modeling of the generation, propagation and dissipation of wind waves; Assumptions and Approximations; Wave current interaction;

UNIT-4: Ocean Data Assimilation (8 hours): Elements of Ocean Data Assimilation; Data Variational methods; Adjoint Methods; Ensemble based filter methods; Assimilation of in situ data; Assimilation of satellite observations;

UNIT-5: Applications of Ocean Modeling and Data Assimilation (8 hours): Operational Oceanography; Climate Prediction and Projection; Ocean Process Studies; Ocean Analysis and Reanalysis; Observation System Evaluation and Observation System Sensitivity Experiments;

UNIT-6: Numerical Ocean Modeling Practice (40 hours): Configuration of an Indian Ocean Circulation Model- Preparation of grid, forcing fields; initial and boundary conditions; selection of constants and coefficients; selection of baroclinic and barotropic time-stepping; testing of numerical stability; selection of Physics options; selection of radiation and mixing parameterisation schemes. Experiments with numerical ocean model- impact of different Physics/parameterisation schemes options on the model simulations; impact of changes in different constants/coefficients on model simulations;

References:

- Fundamentals of Ocean Climate Models (2004) by Stephen M. Griffies,Princeton University Press, 533 pp.
- Chassignet, E.P., and J. Verron (Eds.), 1998. Ocean Modeling and Parameterization. Kluwer Academic Publishers, 451 pp.
- Kampf, J., Ocean Modeling for beginners, Springer, 2009
- Kampf, J., Advanced Ocean Modelling, Springer, 2010

MSCMS 305E Marine Hazards and Coastal Zone Management (4 credit)

Unit I: (12 hours) General introduction- classification-overview of marine and atmospheric hazards-Tsunami-cyclones-storm surges-floods-coastal vulnerability-shore line changes-land-slides-earthquakes-subsidence.

Unit II: (12 hours) Pollution - oil spills - chemical and other pollutants – toxic algal bloom - thermal pollution –radioactivity - remedial approaches – dredging – mining - sand excavation - structures and ship collision – fire on oil rigs.

Unit III: (12 hours) Winds, waves, currents as agencies bring about hazards - Hazard management -Mitigation measures- long term planning – pre hazard action plans - hazard monitoring and early warning sysems–active post hazard management plans.

Unit IV: (12 hours) Global environmental change - climate change and impacts on coastal zone – sea level changes and coastal responses – approaches to sustainable coastal zone management – adaptive management in contextual scenarios;

Unit V: (12 hours) Coastal engineering works – structures – impacts- shore protection and maintenance -dredging and impacts - ports and harbours – pre-requisites.

References:

1. Global Warming-The Complete Briefing: H. John, 4th Edn, Cambridge University Press, 2009.
2. Ocean Environmental Management: E. G. Frankel, 1st Edn, Prentice Hall, 1995.
3. Encyclopedia of Disaster Management: P. C. Sinha, Anmol, India, 2002.
4. Environmental Hazards-Assessing Risk and Reducing Disasters: K. Smith, 5th Edn, Routledge, 2009.
5. Essentials of Oceanography, Trujillo, Alan P., Pearson, 2014.
6. Sustainable Coastal Management & Climate Adaptation: R Kenchington, CRC Press, 2012.

MSCMS306E Fisheries Resource Management & Technology (4 Credits):

Unit I: Marine Fisheries resource management (15 Hours)

Important finfish and shellfish resources of India; Issues and challenges of managing multi-species fishery; Fisheries co-management; Inshore, offshore and high seas fishery; Fish stock concept and assessment; Eco path and Ecosystem models; Stock recruitment relationships

Unit II: Coastal Fishery Resource Management (15 Hours)

Biological resources (finfish, shellfish, mangroves, sea grass, sea weed); Mangrove ecosystem; Coral reef ecosystem; Coastal tourism; Coastal aquaculture; Ornamental fishery; Climate resilient coastal agriculture; Identification ecologically sensitive sites – Using Ecologically and Biologically Significant Areas tool

Unit III Fishing and allied technologies (15 Hours)

Inland & Estuarine Fishery resources of India; Commercially important fisheries in India; Hygienic Handling of fish; Traditional & Modern fish processing; Quality assurance norms and methods

Unit IV Remote sensing and GIS for fishery management (15 Hours)

Sensor platforms; Environmental satellites

References:

1. Conservation of Fish and Shellfish Resources- By J. Thorpe, Graham Gall, 2007.
2. Aquaculture, Resource Use, and the Environment- By Claude E., BoydAaron A., and McNevin. 2014.
3. Introduction to tropical fish stock assessment- By Per Sparre and Siebren C. Venema. 1998
4. Marine and Coastal Resource Management: Principles and Practice (Earthscan Oceans)- By David R. Green, and Jeffrey L. Payne. 2017.
5. Remote Sensing and GIS for Fisheries Management- By Mogalekar H S, and Johnson Canciyal. 2015
6. The book of Indian shells- by Deepak Apte (Bombay Natural History Society ; Calcutta : Oxford University Press,
7. Fisheries biology Assessment and management – by Michael King (Oxford ; Ames, Iowa : Blackwell Pub.,

MSCMS207E Marine Biotechnology & Bioprospecting (6 credit)

Unit I Cell Culture (15 Hours)

definition of primary, established, suspended and anchoragedependent cell cultures. Cell culture techniques-enzymatic disaggregation and explant culture techniques, open and closed systems, sub culturing, *in vitro* transformations and established cell lines. Preservation of established cell lines.Biomedical applications such as viral isolation and propagation. Toxicology –Cytotoxicity assay.

Unit II Bioactive Substances from Marine Environment (10 Hours)

Bioactive substances from marine organisms -alkaloids, terpenoids and steroids. Nucleosides, peptides, depsipeptides, polyketides & macrolides. Antibacterial, antifungal, antiviral, anticancerand analgesic compounds.

Unit III Biomaterials from the marine environment (15 Hours)

chitin, chitosan, oils and fats, surfactants, biopolymers and novel enzymes from marine organisms. Microbial Fermentation –bioreactors -upstream and downstream processes. Single cell proteins. Algal Biotechnology –Pharmaceutical application, antimicrobial compounds. Industrial products - fertilizers, micronutrients, alginates, agar, carrageenan, diatomaceous earth.Applications of algae in waste treatment.Photobioreactors -algae as food and feed, Bioethics, IPR and patenting issues

Unit III Marine Pharmacognosy (10 Hours)

Antimicrobial compounds, Antioxidant Compounds, Anticancer compounds Cell Assays, Drug Discovery, Targeted drug delivery, Drug isolated from the Marine organisms, Clinical trailas

Unit IV Bioreactors (10 Hours)

Design of Bioreactors, Componet of Bioreactior, Batch and Continuous bioreactors, microbial bioractors, algal bioreactors, animal cell bioreactors

Unit IV Techniques in Biotechnology (30 Hours)

Methods for screening, isolation and characterization of marine natural products.High throughput and high content screening, Bioassays for screening biomolecules -Design of assays -Brine shrimp lethality assay, Cytotoxicity assay, Antimicrobial assays, Anticancer assays, Comet assay, MTT assay, Lactate dehydrogenase (LDH), Sulforhodamine B (SRB), Neutral Red uptake, Glucose uptake, Caspase assay, Antimitotic assay. Genomics of Marine Toxins -Paralytic shellfish poisoning (PSP), Neurotoxic shellfish poisoning (NSP), Diarrhetic shellfish poisoning(DSP), Ciguatera poisoning, Amnesic shellfish poisoning (ASP). Photobioreactors

References:

1. Becker. (1994). *Microalgae –Biotechnology and Microbiology*. University of Cambridge.
2. Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten. (2010). *Molecular Biotechnology –Principles and Applications of Recombinant DNA*. 4thEdition. ASM Press.
3. Bye, V.J. (1983). *Applications of Genetics in Aquaculture*, CMFRI Special publication.

4. Cheremisinoff, N. Paul., & Ferrante, L. M. (1991). *Biotechnology-Current Progress* (Vol. 1). Lancaster, PA, USA: Technomic Publishing Company.
5. Cheremisinoff, N. Paul., & Ouellette,P. Robert (Ed.). (1985). *Applications of Biotechnology.*Lancaster, PA, USA: Technomic Publishing Company.
6. Committee on Marine Biotechnology: Biomedical Applications of Marine Natural Products, National Research Council. (2002). *Marine Biotechnology in the 21stcentury –Problems, Promise and Products.*Washington, D.C: National Academy Press.
7. Fingerman, Milton., Rachakonda, Nagabhushanam & Mary-Frances, Thompson. (1999). *Recent Advances in Marine Biotechnology* (Vol 3): *Biofilms, Bioadhesion, Corrosion, and Biofouling*. Science Publishers.
8. Freshney, R.I. (2010). *A Manual of Basic Techniques -Culture of animal cells*. John Wiley & Sons.
9. Jean, L. Marx. (1989). *A Revolution in Biotechnology.*ICSU Press, University of Cambridge.
10. John, H. Paul. (2001). *Method in Microbiology:* (Vol.13)*Marine Microbiology*, Academic Press.
11. Pillai, T.V.R. (1993). *Aquaculture-Principles and Practices*, John Wiley & Sons.
12. SambrookJ, Russell D (2001) Molecular Cloning: A Laboratory Manual, 3rd edn. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press

MSCMS 308E Marine Biological Engineering (6 Credits)

Unit I: Genetic Engineering (25 Hours)

Principles.Isolation of DNA, Restriction enzymes, Vectors. Cloning organisms.Splicing and insertion of DNA.Southern blotting.Genomic libraries.Polymerase chain reaction.Hybridoma technology –production of monoclonal antibodies and their applications.Applications of genetic engineering, Genetic engeereed organism, Selective fish breeding, GMO laws, Marine genetic library, marine cell lines.

Unit II Marine Genomics (15 Hours)

principle, protocol,l and applications. Marine modelorganisms. Differential gene expression. DNA microarray. Transcriptomics. Genesilencing techniquess.siRNA technologyy. Role of Micro RNA in gene regulation. Next-generation sequencing technology. Model organism

Unit III Marine Proteomics. (20 Hours)

Primer designing, cDNA library Proteinidentificationby MALDI-TOF-MS peptidemassfingerprinting. Proteinsequencing-Edmandegradation. Structuralproteomics: X-raycrystallography and NMR spectroscopy. Protein Docking

Unit IV Bioinformatics tools (30 Hours)

Using NCBI and Uniprot web resources. Introduction and use of various genome databases. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt. Similarity searches using tools like BLAST and interpretation of results. Multiple sequence alignment using ClustalW. Phylogenetic analysis of protein and nucleotide sequences. Use of gene prediction methods (GRAIL/Genscan,/Glimmer). Use of various primer designing and restriction site prediction tools. Use of different protein structure prediction databases (PDB, SCOP, CATH). Construction and study of protein structures using

RASMOL/Deepview/PyMol. Homology modelling of proteins. Use of tools for mutation and analysis of the energy minimization of protein structures

References

1. Becker. (1994). *Microalgae –Biotechnology and Microbiology*. University of Cambridge.
2. 2. Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten. (2010). *Molecular Biotechnology –Principles and Applications of Recombinant DNA*. 4thEdition. ASM Press.
3. 3. Bye, V.J. (1983). *Applications of Genetics in Aquaculture*, CMFRI Special publication.
4. 4. Cheremisinoff, N. Paul., & Ferrante, L. M. (1991). *Biotechnology-Current Progress* (Vol. 1). Lancaster, PA, USA: Technomic Publishing Company.
5. 5. Cheremisinoff, N. Paul., & Ouellette,P. Robert (Ed.). (1985). *Applications of Biotechnology.*Lancaster, PA, USA: Technomic Publishing Company.
6. 6. Committee on Marine Biotechnology: Biomedical Applications of Marine Natural Products, National Research Council. (2002). *Marine Biotechnology in the 21stcentury –Problems, Promise and Products.*Washington, D.C: National Academy Press.
7. 7. Fingerman, Milton., Rachakonda, Nagabhushanam & Mary-Frances, Thompson. (1999). *Recent Advances in Marine Biotechnology* (Vol 3): *Biofilms, Bioadhesion, Corrosion, and Biofouling*. Science Publishers.
8. 8. Freshney, R.I. (2010). *A Manual of Basic Techniques -Culture of animal cells*. John Wiley & Sons.
9. 9. Jean, L. Marx. (1989). *A Revolution in Biotechnology.*ICSU Press, University of Cambridge.
10. 10. John, H. Paul. (2001). *Method in Microbiology:* (Vol.13)*Marine Microbiology,* Academic Press.
11. 11. Pillai, T.V.R. (1993). *Aquaculture-Principles and Practices,* John Wiley & Sons.

MSCMS309E Fish

Physiology, Developmental Biology & Aquafarming (6 credits)

Unit I (15 Hours)

Classification of fishes with special emphasis on marine fishes. Food and feeding mechanisms, reproduction, courtship and parental care. Fish eggs and larvae. Distribution and migration of fishes. Mud banks and related fishery.

Unit II (15 Hours)

A general outline of the circulatory pattern among vertebrates and invertebrates. Respiratory System , Digestive System, Osmoregulatory system among the Fishes and Marine organisms. Electric organs

Unit III (15 Hours)

Reproductive system focusing on finfish & Shell fish. Hormonal Regulation of reproduction. Endocrine System, Neurological system

Unit IV (15 Hours)

Fisheries resources of India & their current status- Shrimps, Lobsters, Crabs, Pearl oysters and Edible Oyster, Mussels, Clams, Gastropods, Squids, Cuttlefish and Octopus. Export of marine products. Impacts of climate change on fisheries.

Unit V (10 Hours)

Aquaculture –Definition. Objectives, history and scope. Present global and national scenario. General principles of Aquaculture. Criteria for selection of species for aquaculture. Important brackish water and marine species for aquaculture in India.

Unit VI (20 Hours)

Brackish water farming practices of India – Prawn filtration system and Bhasabada fisheries. Culture of milk fish, mullets, pearl spot, Asian sea bass, shrimps, crabs, lobsters. Brackish water molluscan species for aquaculture-mussels and clamspresent status and prospects. Induced breeding in finfishes and shellfishes. Hatchery techniques of shrimp seed production. Live feed culture techniques. Coastal and open sea marine culture. Present status and future prospectus of mariculture in India. Cage culture and Pen culture. Culture of pearl oyster, edible oyster, grouper and cobia. Seaweed culture. Legal aspects of coastal aquaculture – CRZ Act and Coastal Aquaculture Authority.

References:

1. Allen, R. and Steene, R.C. 1987. Reef Fishes of Indian Ocean by Gerald TFH Publication, USA.
2. Bal D.V and Virabhadra Rao,K. 1990, Marine Fisheries of India, Tata McGrawHill, 472 p.
3. Jhingran,V.G. 1991. Fish and Fisheries of India, Hindustan Pub. Corp. (India), ISBN 9788170750178., 727 p.

4. Kurian C.V. and Sebastian, V.O. 1976.Prawn and Prawn Fisheries of India. Hindustan Pub. Corp., Delhi.
5. Modayil, M.J. and Jayaprakash, A.A. 2003. Status of Exploited Marine Fishery Resources of India, CMFRI, Kochi.
6. Morgan, R. 1956. World Sea Fisheries, Pitman Publishing Corp., New York. Pillai, K.B. 1998. Commercial Fishes and Shellfishes of India.
7. Marine Products Export Development Authority, MPEDA House. Panampilly Nagar.
8. Shanbhouge, S.L. 2000. Marine Fisheries of India, Directorate of Information and Publications of Agriculture, Indian Council of Agricultural Research, New Delhi.
9. Yadav, B.N. 2006. Fish and Fisheries 4thedn., Daya Publishing House, Delhi. ISBN: 81-7035-171-5
10. Bal, D.V. and Rao, K.V. 1990. Marine Fishes of India. 1st tevisededn. Tata McGraw Hill.
11. Beverton, R.J.H. and S.J. Holt, 1957. On the Dynamics of Exploited Fish Populations. Fish. Invest. Minist. Agric. Fish. Food G.B. (2 Sea Fish.), 19: 533p.
12. Chandra, P. 2007. Fishery Conservation Management and Development. SBS Publ. Christensen, V. and and D. Pauly (Eds.) Trophic Models of Aquatic Ecosystems. ICLARM Conference Proceedings No. 26.
13. Christensen, V. and D. Pauly, (Eds.) 1993. Trophic Models of Aquatic Ecosystems. ICLARM Conference Proceedings No. 26. ICLARM Manila, Philippines, 390 p.
14. Christensen, V. and Pauly, D. 1992a. ECOPATH II- software for balancing steady state ecosystem models and calculating network characteristics. Ecol. Modeling 61: 169-185.
15. Christensen, V. and Pauly, D. 1992b. A Guide to the ECOPATH II Programme (version 2.1). ICLARM Software 6, 72p.
16. Christensen, V. and Pauly, D. 1995. Fish production, catches and the carrying capacity of the world oceans. Naga, The ICLARM Quarterly 18 (3): 34-40. Christensen, V. and Pauly, D. 1998. Changes in models of aquatic ecosystems

approaching carrying capacity. Ecological Applications, 8 (1), (Suppl): 104-109.

17. Christensen, V., Walters, C.J. and Pauly, D. 2000. ECOPATH with ECOSIM: A User's Guide. Fisheries Centre, University of British Columbia, Vancouver, Canada and International Centre for Living Aquatic Resources Management (ICLARM), Penang, Malaysia, 125 p.
18. Gulland, J.A. (1983). Fish Stock Assessment: A Manual of Basic Methods. FAO/ Wiley, New York, 223 p. Hall, S. J and B. Mainprize, Towards ecosystem-based fisheries management, Blackwell Publishing Ltd. Fish and Fisheries, 5 (2004) 1-20.
19. Michael, R.R. 1997. Fisheries Conservation and Management. Prentice Hall. Pascoe, S. 2005. Bycatch Management and the Economics of Discarding. Daya Publ. House.
20. Pauly, D. 1983. Some Simple Methods for The Assessment of Tropical Fish Stocks. FAO Fish. Tech. Pap. 234, 52 p.
21. Pauly, D. 1999. Ecosystem consideration and the limitations of Ecosimmodels in fisheries management: insights from the Bering Sea. In: Keller, S. (Ed.) Ecosystem Approaches for Fisheries Management, University of Alaska Sea grant, Fairbanks, pp. 609-618.
22. Sparre P. and Venema, C. 1992. Introduction to Tropical Fish Stock Assessment. FAO Fish Tech. Pap. 306, 376 p.
23. Thorpe, J.E., Lannan J.E. and Nash, C.E. (Eds.) 1995. Conservation of Fish and Shellfish Resource - Managing Diversity. Academic Press Ltd, London.ISBN 0-12690685-8.

MSCMS310E: Maintenance of Marine Electrical System & Troubleshooting (04 Credits)

Unit 1: (10 hours) Essentials of Electrical Safety; Generic Guidelines for Maintenance; Maintenance of Low Voltage Equipment; Maintenance of High Voltage Equipment ;

Unit 2: 10 hours: Test Equipment and Component Testing; Earth Fault Monitors; Guidelines for Troubleshooting;

Unit 3: 10 hours: Introduction to Alarm and Monitoring Systems; MSBs, ACB, GSP; Integrated Monitoring and Control System; Main Engine Alarm and Safety System;M.E. Engine Alarms Handling and References.

Unit 4: (20 hours) Electronic Governor; Viscosity Controller; Heaters and Coolers; Air Conditioning System; Axial Flow Fan; Magnetic and Gyro Compasses; Global Positioning System ; ECDIS ; Echo Sounder and Electro Magnetic Log; Anemometer and Anemoscope; BNWAS and Master Clock ;VHF Communication Set; Weather Facsimile

Unit 5: (10 hours) Tank Radar; Gas Detection System; Fire Detection Systems; Internal Communication Systems;

References

1. Maintenance and Troubleshooting of Marine Electrical Systems Volume 1 by Harbhajan Singh,Elstan A. Fernandez and Lakshman Singh Yadav
2.Maintenance and Troubleshooting of Marine Electrical Systems Volume 2 by Harbhajan Singh,Elstan A. Fernandez and Lakshman Singh Yadav

MSCMS311E : Ship Construction (04 Credits)

Unit 1: (10 hours) Introduction to shipbuilding; Purchase and Basic Design of the Ship; Ship Dimensions and Form; Development of Ship Types.

Unit 2: (5 hours) Materials and Strength of ships:Classification societies; Steels;Aluminium Alloy; Testing of Materials; Stresses to which a Ship is Subject.

Unit 3 (5 hours): Welding and Cutting: Welding and Cutting Processes used in Shipbuilding; Welding Practice and Testing Welds.

Unit 4 (10 hours): Shipyard Practice: Shipyard layout; Computer aided Design and Manufacture; Plate and Section Preparation and Machining; Prefabrication; Launching.

Unit 5 (10 hours): Ship Structure: Bottom Structure; Shell Plating and Framing; Bulkheads

and Pillars; Decks, Hatches and Superstructures; Fore End Structure; Aft End Structure; Tanker Construction; Liquefied Gas Carriers.

Unit 5: (10 hours) Outfit: Derricks, Masts and Rigging; Cargo Access, Handling and Restraint; Pumping and Pipe Arrangements; Corrosion Control and Paint systems; Ventilation, Refrigeration and Insulation.

Unit 6: (10 hours) International Regulations:International Maritime Organization; Tonnage; Load Line Rules; Structural Fire Protection

Reference:

1. Ship Construction by D J Eyres