M.Sc. (Marine Biology)
Course Curriculum & Syllabi – 2023-24
Department of Marine Sciences, Berhampur University

Introduction:

The Department of Marine Sciences was established in the year 1978 at Berhampur University. This is the only University in the state which offers M.Sc., M.Phil., and Ph.D./D.Sc. degree in the subject of Marine Sciences covering both Oceanography and Marine Biology. The genesis for such a department was to produce quality human resources in the field of Marine Sciences, both through teaching and R&D activities, to meet the demand of the state as well as the country. The Department of Marine Sciences offers two degrees, M.Sc. in Oceanography and M.Sc. in Marine Biology. Candidates with B. Sc. in Physical sciences/B.E./B.Tech as are eligible to take admission in Oceanography while students with B.Sc. in Biological Sciences are eligible to take admission in Marine Biology. Admission to these degrees is through Odisha Common P.G. Entrance Test (CPET) conducted by the Student Academic Management System (SAMS), Odisha. The current Courses of Studies for master's degree (M.Sc.) in Oceanography and Marine Biology are under Choice Based Credit System (CBCS) effective from 2023-2024 Academic Sessions.

Faculty Members:

1. **Dr. Tamoghna Acharyya, Associate Professor (Oceanography)**
2. **Dr. Shesdev Patro, Assistant Professor (Marine Biology)**
3. **Dr. Suchismita Srichandan, Assistant Professor (Marine Biology)**
4. **Dr. Nibedita Behera, Assistant Professor (Oceanography)**

Facilities:

The Postgraduate Department of Marine Sciences has following facilities available for students and research scholars:

Seminar and Library:

The Department has an independent Seminar Hall with a state-of-the-art audio-visual system, where weekly student presentation seminars are conducted under the supervision of faculty-in-Charge. The Departmental library has more than 1200 books and several journals / newsletters / periodicals related to the subject of marine sciences.

Computing facility:

The department has a centralized Computer Laboratory well equipped with internet facility, PC and Servers. Software *viz*. ERDAS Imagine, Arc-view, MATLAB, Surfer, Statistical packages are preloaded with the systems and accessible to the students.

Laboratories:

The Department has six practical laboratories viz, Marine Biology, Marine Microbiology, Marine Chemistry, Marine Geology, Physical Oceanography & Meteorology and Remote Sensing.

About the Syllabus:

The syllabus is designed as per CBCS in accordance with the guidelines provided by the University Grant Commission (UGC). The Master of Science in Oceanography and Master of Science in Marine Biology are full time two years programs with four semesters each. The 1st Semester is common for both Oceanography and Marine Biology spanning the period from June to December and 2nd Semester from January to May in the first academic session. The 3rd Semester commences from June to December and similarly the 4th Semester from January to May in the subsequent academic session. The number of credits along with grade points that a student satisfactorily completed, measures the performance of the student. Overall satisfactory progress and completion of course is subject to a student's maintaining a minimum Cumulative Grade Point Average (CGPA), as well as minimum grades in different subjects as per the syllabus. The description and layout of Credit Distribution for each of the Course program is detailed below:

- Total number of Semesters is **Four.**
- Each theory paper comprises of **04 Credit points.**
- Each Practical Paper comprises of **03 Credit points.**
- Each Theory Paper comprises of **100 Marks.**
- Each Practical Paper comprises of **50 Marks.**
- Project comprises of **200 Marks.**
- Number of Core Papers (Theory) are **13 (Spread over Semester I, II and III).**
- Number of Elective Papers (Theory) are **01 (In 3rd Semester).**
- One Choice Based Credit Transfer CBCT Paper (Theory) in **3rd Semester (Mandatory).**
- Number of project/dissertations is **01** (**4th Semester**).
- Core papers (13) are **Mandatory with no choice.**
- Elective papers (01) are **Mandatory with Choice Departmentally.**
- Value added course (VAC) (02) **mandatory in 2nd and 3rd semester.**
- Add-on Course (AC) (01) is a non-credit course in **the 4th Semester excluding VAC and AC.**
- Total number of Papers is **22 including 01 Project Work in 4th Semester excluding VAC and AC.**
- Total number of Credits is **86 Credit points.**
- Total Marks for all **04 Semesters is 2000.**

Syllabus for M.Sc. (Marine Biology)

The Syllabus has been designed to cover practical/dissertations/field works/seminars etc., wherever applicable. A list of Textbooks is provided against each paper for all Semesters. However, students may also make use of authentic online sources for their benefit. A student is advised to deliver at least one seminar talk on a selected topic based on the syllabus during each semester (weekly-at least one Seminar by one of the students, to cover all students). During the course work, students are allowed to interact with the faculty to clarify their doubts, if any. They may be also assessed through weekly tests (duration: 45 minutes) of multiple-choice questions and short answers (individual or all subjects of the Semester, Combined) as appropriate.

General Course Framework & Structure

SEMESTER I- Total Credits- 26 & Core papers: 05; Elective Papers: Nil; Practical: 02

Course Code	Title of the Paper	Marks			Credit
		IA	Exam	Total Mark	
MARB C101	Introduction to Earth and Atmospheric System	20	80	100	4
MARB C102	Fundamentals of Oceanography	20	80	100	4
MARB C103	Fundamentals of Marine Biology	20	80	100	4
MARB C104	Basic Statistics and Data Analysis	20	80	100	4
MARB C105	Fish Technology and Pisciculture	20	80	100	4
MARB P106	Practical I on Paper C101 and C102	-	50	50	3
MARB P107	Practical II on Paper C103 and C105	-	50	50	3
Total Marks/Credit (C 05 + Practical 02)				**600**	**26**

**Semester I is common for both Oceanography and Marine Biology students*

SEMESTER II- Total Credits- 26 & Core papers: 05; Elective Papers: Nil; Practical: 02; Non-credit: 01

Course Code	Title of the Paper	Marks			Credit
		IA	Exam	Total Mark	
MARB C201	Plankton and Productivity in the Ocean	20	80	100	4
MARB C202	Ocean in the Anthropocene	20	80	100	4
MARB C203	Marine Biodiversity, Conservation & Management	20	80	100	4
MARB C204	Marine Invertebrate and their Biology	20	80	100	4
MARB C205	Physiology and Biochemistry	20	80	100	4
MARB P206	Practical I on Paper C201 and C202.	-	50	50	3
MARB P207	Practical II on Paper C203, C204 and C205	-	50	50	3
Total Marks/Credit (C 05 + Practical 02)				**600**	**26**
MARB VAC-I	Certificate Course on Value Addition of Marine Fishery Product	Non-credit			

SEMESTER III- Total Credits- 26 & Core papers: 03; Elective Papers: 01; CBCT: 01; Practical: 02; Non-credit: 01

Course Code	Title of the Paper	Marks			Credit
		IA	Exam	Total Mark	
MARB C301	Marine Ecology and Biogeography	20	80	100	4
MARB C302	Remote Sensing and Geographical Information System (GIS) in Marine Sciences	20	80	100	4
MARB C303	Marine Biogeochemical Processes	20	80	100	4
MARB E304	Coastal Aquaculture	20	80	100	4
MARB E305	Marine Biotechnology	20	80	100	4
MARB E306	Marine Microbiology	20	80	100	4

Course Code	Title of the Paper	Marks			Credit
		IA	Exam	Total Mark	
MARB CT300	Environmental Impact Assessment (EIA) and Management Plans	20	80	100	4
MARB P307	Practical I on papers C302, 303 and E304/305/306	-	50	50	3
MARB P308	Practical II on Marine Biological Instruments, Measurements and Data Analysis	-	50	50	3
Total Marks/Credit (C 03+ E 01+ CBCT 01+ Practical 02)				**600**	**26**
MARB VAC-II	Certificate Course on Marine Litter Monitoring and Management	Non-credit			

SEMESTER IV- Total Credits- 8 & Project: 01

Course Code	Title of the Paper	Marks			Credit
		IA	Exam	Total Mark	
MARB P401	Project Work, Dissertation & Open Viva-Voce	-	200	200	8
MARO VAC	Cultural Heritage of South Odisha				Non-credit
Total Marks/Credit (Project 01)				**200**	**8**

Details of Syllabus

Semester- I

Semester: First Semester	**Course Name:**	Introduction to Earth and Atmospheric System
Course No.: MARB C101	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the interdisciplinary overview about the domain of oceanography	*Students will be able to understand the origin, composition and tectonic of earth along with its process of formation. They will also be getting an idea of global atmospheric phenomena.*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Earth & Solar system:** Milky Way and the solar system. Modern theories on the origin of the Earth and other planetary bodies. Earths orbital parameters, Kepler‟s laws of planetary motion, Geological Time Scale; Space and time scales of processes in the solid Earth, atmosphere, and oceans. Radioactive isotopes and their applications. Meteorites Chemical composition and the Primary differentiation of the earth. Basic principles of stratigraphy. Theories about the origin of life and the nature of fossil records. Earth's gravity and magnetic fields and its thermal structure: Concept of Geoid and, spheroid; Isostasy	20
Unit 2	**Earth Materials, Surface Features and Processes:** Gross composition and physical properties of important minerals and rocks; properties and processes responsible for mineral concentrations; nature and distribution of rocks and minerals in different parts of the earth and different parts of India. Physiography of the Earth; weathering, erosion, transportation, and deposition of Earths material; formation of soil, sediments, and sedimentary rocks; physiographic features and river basins in India	20
Unit 3	**Interior of the Earth, Deformation and Tectonics** Basic concepts of seismology and internal structure of the Earth. Physico-chemical and seismic properties of Earth's interior. Concepts	20

Units	Contents	Hours/ Semester
	of stress and strain. Behavior of rocks under stress; Folds, joints, and faults. Earthquakes – their causes and measurement. Interpolate and intraplate seismicity. Paleomagnetism, sea floor spreading and plate tectonics	
Unit 4	**Meteorology:** Structure and chemical composition of the atmosphere, lapse rate and stability, scale height, Atmospheric turbulence, and boundary layer. geopotential, greenhouse gases and global warming. Cloud formation and precipitation processes, air- sea interactions on different space and time scales. Insulation and heat budget, radiation balance, general circulation of the atmosphere and ocean. Climatic and sea level changes on different time scales. Coupled ocean-atmosphere system, El Nino Southern Oscillation (ENSO). General weather systems of India, - Monsoon system, cyclone and jet stream, Western disturbances and severe local convective systems, distribution of precipitation over India	20

Suggested Text / References

1. Kent C. Condie, Earth as an Evolving Planetary System, Academic Press.
2. Naotatsu Shikazono, Introduction to Earth and Planetary System Science: New View of Earth, Planets and Humans, Springer.
3. H. Jay Melosh, Planetary Surface Processes, Cambridge University Press.
4. Pickard G.L. and W.J. Emery, Descriptive Physical Oceanography - Pergamon Press (Latestedition).
5. Lynne D. Talley, G.L. Pickard, W.J. Emery and James Swift, DescriptivePhysical Oceanography: An Introduction- Elsevier (Latest edition).
6. John A. Knauss. Introduction to Physical Oceanography, Waveland Pr. Inc.
7. Wallace and Hobbs. Atmospheric Science (Latest Edition), An Introductory Survey, Elsevier.
8. An Introduction to the General Circulation of the Atmosphere, D. A. Randall, Colorado State University Press, 2005.
9. Marshall. John, and R. Alan Plumb. Atmosphere, Ocean, and Climate Dynamics: An Introductory, Academic Press.
10. Observed Global Climate, Geophysics Series, Volume 6: Edited by M. Hantel, Springer, 2005.

Semester: First Semester	**Course Name:**	Fundamentals of Oceanography
Course No.: MARB C102	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	

To provide the basics about physical, chemical, geological, and meteorological processes of ocean	*Students will be able to understand the physical, chemical, and geological properties of the ocean and the factors affecting them.*

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Physical oceanography:** Ocean and Sea, Major Oceans of the world and their dimensions, Light in the sea, Color of the sea, Sound in the sea, Temperature, Salinity, conductivity, effect of temperature, salinity and pressure on density, Potential density, and specific volume. Specific volume anomaly. Adiabatic changes of sea water. Properties of sea water, Basic pure water characteristics, molecular, colligative, optical, and acoustical properties of sea water. Horizontal and vertical distribution of temperature, salinity, and density in the oceans. Heat budget equation.	20
	Circulations and currents: Oceanic mixed layer, barrier layer and thermal inversion. Seasonal and permanent thermocline, Halocline and Pycnocline. Heat and freshwater transport, Conservation of salt and heat, Water type and water masses, T-S diagram, Bottom-Deep-Intermediate and surface water masses. Thermohaline and Wind driven Circulation, World Ocean circulation – Major Ocean currents, Equatorial Currents, Undercurrent, Antarctic Circumpolar Current and Western and Eastern Boundary Currents, Langmuir Circulation. Currents and Circulation in the Indian Ocean, Arabian Sea, and Bay of Bengal during southwest and northeast monsoon seasons.	
	Marine Chemistry Historical perspectives, Symbols and units used in chemical oceanography, Composition of Sea Water, Major nutrients, Geochemical balance of the oceans, Residence time, 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, Chlorinity and salinity, Practical salinity scale, Residence times of elements in the sea water, Dissolved Gases (other than CO_2) in Sea Water, Solubility of gases in seawater, Air-sea gas exchange and processes affecting their distribution, Dissolved oxygen in the ocean, CO_2 equilibria in seawater, pH, Alkalinity and buffering capacity of oceans, Components of CO_2 system in seawater,	

Units	Contents	Hours/ Semester
	Percentage composition of inorganic carbon, Calcium carbonate precipitation and dissolution phenomena	
	Marine Geology: Geomorphology of ocean floor: Abyssal plain, oceanic island, sea mounts, trenches, Island Arc, Atolls and Guyots. Submarine canyons and mid oceanic ridges, hydrothermal vents. Sea floor spreading and Plate tectonics. Salient features of Indian Ocean floor: Bathymetric maps, Different methods of exploring ocean floor, Definition and classification of coast, Coastal erosion, Beach sediments and morphology, weathering of beach materials. Alongshore and cross-shore sediment transport, Beach profile, Factors controlling geomorphology of beaches.	

Suggested Text / References

1. Pickard G.L. Descriptive Physical Oceanography, Pergamon Press Oxford, 1963.
2. Open University of U.K. Sea water: its composition, properties, and behaviour. Pergammon Press.
3. LynneD.Talley, G.L. Pickard, W.J.Emery andJamesSwift(2011):DescriptivePhysicalOceanography: An Introduction- Elsevier (6th edition,2011).
4. Sverdrup H.U., Johnson M.W. and Fleming R.H (1958): The Oceans: their physics, chemistry and general biology, Prentice Hall Inc., New Jersey,1958.
5. A.S.N. Murty & V.S.N. Murty. Physical Oceanography, A.P.H. Publishing Co, New Delhi, 2010.
6. M. Tomczak. Regional Oceanography. Daya Publishing House, New Delhi
7. Open University of U.K. Ocean circulation. Pergamon Press.
8. Fairs Rhode Bridge. Encyclopedia of Atmospheric Sciences.
9. Wallace, J. M., & Hobbs, P. V., 2006. Atmospheric science: an introductory survey (Vol. 92). Academic press.
10. J.S. Fein and P.L. Stephens, Monsoons, Wiley Interscience.
11. World Meteorological Organisation, International Cloud Atlas.
12. X.Rodo and F.A. Comin, Global Climate. Springer-Verlag.
13. G.G. Tarakanov, Tropical Meteorology, MIR Publishers.
14. Bird, E.C., Coasts – An introduction to systematic geomorphology.
15. Sheppard, F.P., 1967, Submarine Geology.
16. Shepard F.P., The Earth beneath the Sea.
17. Lauff, G.H., Estuaries
18. P.D. Komar, Shore Processes and Sedimentation.
19. Ippen, A.T., Estuary and coastline hydrodynamics.
20. Johnson, D.W., Shore processes and shoreline development.

21. Open University of U.K., Sea water: its composition, properties, and behavior. Pergammon Press.
22. Martin, D.P., Marine Chemistry, Vol 1 & 2.
23. Riley J.P.& Chester, R, Introduction to Marine Chemistry.
24. Riley, J.P.& Skirrow, G, Chemical Oceanography.

Semester: First Semester	**Course Name:**	Fundamentals of Marine Biology
Course No.: MARB C103	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the basics about biological oceanography	*Students will be able to understand the different flora and fauna of the ocean, their adaptations, and the methods to study them.*	

Course Details

Units	**Contents**	**Hours/ Semester**
Unit 1	**Introduction to marine environment:** Sea as a biological medium and role of environmental factors including light, salinity, temperature, pH, turbidity, dissolved oxygen, nutrients, trace elements, Major divisions of marine environment (Pelagic and benthic), Pelagic environment (neritic and oceanic), benthic environment (supralittoral, littoral, sublittoral, bathyal, abyssal and hadal) **Life in the sea and coastal regions** Classification of marine flora and fauna (Plankton, Nekton, Pleuston, Benthos, seagrass, mangrove, salt marsh, seaweed)	20
Unit 2	**Plankton** Classification of plankton based on category, size, shape, mode of life cycle and habitat. *Phytoplankton*: Taxonomic classification of phytoplankton, Methods of phytoplankton collections, preservation, and identification. Methods for estimation of standing stock in marine environment. *Zooplankton*: Taxonomic classification of zooplankton, Methods of zooplankton collections, preservation, and identification. Methods for estimation of their biomass in marine environment.	20

Units	Contents	Hours/ Semester
Unit 3	**Benthos** Classification of benthic organisms. The intertidal region- rocky shore, sandy and muddy shore, Salient features of different shores and adaptations of organisms living in rocky, sandy, and muddy shores; deep sea benthos and their adaptations. Methods of collection, preservation and estimation of standing crop and biomass of benthos.	20
Unit 4	**Marine Flora and Associated fauna of India** Seagrass, mangrove, salt marsh and seaweed, their distribution, ecological and economical significance, and associated fauna.	20

Suggested Text / References

1. Peter Mc Roy, C., and G. Helterinch., 1977. Seagrass Ecosystems. A Scientific Perspective. Marael Dekker Inc. New York.
2. Parsons, T.R., M. Takahashi and B Hargrave (2nd Ed. s) 1977, Biological oceanography Processes Pergamon Press, Oxford.
3. Chapman, V.J. & D.J. Chapman, 1980, Seaweeds and their uses, Chapman and Hall, London Ltd.
4. Spoel S. Vander and Heyman, R.P., 1983. Comparative atlas of Zooplankton biological patterns in the oceans. Springer-Verlag, Berlin.
5. Lalli C.M., Parson, Parson, C.R., 1997, Biological oceanography: An introduction, Elsevier Butterworth-Heinemann
6. Tomas, C.R., 1997. Identifying marine phytoplankton. Acaedmic press, 858p
7. S.Z. Qasim., 1998. Glimpses of the Indian Ocean, IBH Press, New Delhi.

Semester: First Semester	**Course Name:**	Basic Statistics and Data Analysis
Course No.: MARB C104	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the basics about application of statistics in ocean studies	*Students shall be able to learn the application of statistics in ocean studies by using different software and tools.*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Basics of statistics:** Definition of statistics, Concepts of population, sample, Census and sample surveys, Classification of data, frequency,	20

Units	Contents	Hours/ Semester
	and cumulative frequency table. Diagrammatic and graphical representation of data - bar diagrams, pie-diagram, histogram, frequency polygon, frequency curve and Ogives.	
Unit 2	**Central tendency and dispersion:** Important measures of central tendency - arithmetic mean median and mode. Relative merits and demerits of these measures. Important measures of dispersion, Range, Mean Deviation, Variance and Standard Deviation. Relative merits and demerits of these measures. Coefficient of variation; Normal Curve, Concepts of Skewness and kurtosis.	20
Unit 3	**Probability distribution and hypothesis testing:** Definitions of probability, mutually exclusive and independent events, conditional probability. Random variable, concepts of theoretical distribution; Binomial, Poisson and Normal distributions and their application in fisheries. Basic concept of sampling distribution; standard error and central limit theorem. Introduction to statistical inference, general principles of testing of hypothesis, types of errors. Tests of significance based on Normal, t, and Chi-square distributions. Bivariate data, scatter diagram, simple linear correlation, measure and properties, linear regression, equation and fitting; relation between correlation and regression	20
Unit 4	**Software and Tools:** Data Processing and Plotting principles and methods using different Software and Tools. Concept of Database and Applications.	20

Suggested Text / References

1. Gupta, S.P., Statistical Methods.
2. Gupta and Kapoor (2000): Fundamentals of Mathematical Statistics.
3. Zar, J.H. (2003): Bio-statistical Analysis. 4th edition. Pearson Education.
4. Croxton F.E. and Cowden D.J. (2000): Applied General Statistics. PrenticeHall.
5. Kendall M.G. and Stuart A., The advanced theory of statistics. Vol. I &II.
6. Computer Programming in FORTRAN 90/95, (1997): V. Rajaraman, Prentice Hall of India, New Delhi.
7. Computer Oriented Numerical Methods, Fourth Edition, V. Rajaraman.

Semester: First Semester	**Course Name:**	Fish Technology & Pisciculture
Course No.: MARB C105	**Credits:** 04	**Core/Elective:** Core

Course Objective:	Student Learning Outcome
To provide knowledge on techniques used in Indian fisheries.	*Students shall learn about the technology, crafts and gears used in Indian fisheries. The paper will also help to understand the role of fisheries, aquaculture, and their management in countries economic growth*

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Basics of fishery technology** Scope and Importance of Fish Technology. Fish as food, role of fish in human nutrition, Chemical composition and nutritive value of fin fish and shellfish **Pisciculture** Present status of pisciculture in India, aquatic environment management, aquatic animal health, business management, fish nutrition and feed technology, fisheries economics, sea ranching	20
Unit 2	**Fish products and their preservation** Diversified fish products and by products dried and cured, fish meal and oil, fish oils, fish liver oil, liver rinsed fish in silage, fish maws and isinglass, fish preservation, canning mechanism, freezing of fish, spoilage of wet fish and causative factors	20
Unit 3	**Fishing crafts** Common fishing crafts with special reference to Indian coast, Indigenous crafts used along the Odisha coast, design and construction of fishing crafts and fishing boats. Traditional and modern materials are used for boat building, care, and maintenance of fishing boats. Methods of detection of fish in the sea, Fish Aggregating Device (FAD) **Fishing gears** Common gears of Indian coast, gear fabrication, net design, Seine net, trap net, drop net, cast net, gill net, fixed net, bag net, scoop net, hooks and lines, Treatment, and preservation of fishing gears	20
Unit 4	**Economics & Management** Oceans as a common heritage of mankind, Exclusive Economic Zone (EEZ) and its significance, export of fin fish and shellfish to different countries, fishing harbor and shore facilities	20

Units	Contents	Hours/ Semester
	Regulations on fishing of craft and gears – Indian Fisheries Act, OMFRA, other policy framework on fishing permission and restrictions in Odisha	

Suggested Text / References

1. Saints bury Commercial fishing methods.
2. Cornell: Control of fish quality.
3. Nedelee: FAO catalogue at small scale fishing gear.
4. Sohile: FAO catalogue of fishing gear designs.
5. Trgung: Fishing boats of the world, Vol.1, 2 & 3.
6. Kreuzer: Fishery Products, FAO Publication, 1977.
7. Kreezer: Fish inspection and qualify control, FAO Publication.
8. Govindan J.K. 1985, Fish Processing technology Oxford and IBH Publishing Company Pvt. Ltd. New Delhi.
9. Stanshy M.E. 1963. Industrial Fishery Technology, Reinhold Publishing Corporation.
10. Anon 1979. Handling Processing and Marketing of tropical fish tropical products institutes, London.

Semester: First Semester	**Course Name:** Practical I	
Course No.: MARB P106	**Credits:** 02	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the hands-on training on some of the basic instruments and tools used in physical, chemical, geological oceanography and meteorology	*Students shall be able to learn the use of basic instruments and analyzing techniques.*	

Course Details

Units	Contents	Hours/ Semester
	1. Identification of common rocks and minerals 2. Tabulate the monthly river discharges to the sea using open-source data. 3. Plotting of the bathymetric contours using digitized depth values from a published hydrographic chart or using digital data (open sources) for the Indian Ocean. 4. Estimation of grain size parameters by mechanical sieving 5. Determination of salinity of sea water, Alkalinity of seawater, dissolved oxygen, and measurement of pH of seawater.	

Units	Contents	Hours/ Semester
	6. Principles and mechanisms of different meteorological instruments and measurements of local weather parameters such as air temperature, pressure, wind, humidity, and rainfall at a given location. 7. Preparation of a atmospheric pressure contours (synoptic) during any given month (January to December) of Indian Ocean (40° to 100°E, 0° to 30°N) 8. Preparation of synoptic contour maps (spatial distribution) of sea surface temperature and salinity for a given month (January to December) in the Indian Ocean (40° to 100°E, 0° to 30°N) from open-source data. 9. Plotting of vertical profiles (monthly variability) of sea surface temperature and salinity for a given location (January to December) in the Indian Ocean (40° to 100°E, 0° to 30°N) manually using open-source data. 10. Preparation of a chart (use a printed world map showing the land boundaries) depicting World Ocean circulation: Major Ocean currents -Equatorial Currents, Antarctic Circumpolar Current and Western and Eastern Boundary Currents. 11. Plot time-series of sea surface wind speed & direction; sea surface temperature and current (speed & direction) at a given location during a selected period (January to December) in the Indian Seas (40° to 100°E, 0° to 30°N) manually using satellite data from open sources.	

Semester: First Semester	**Course Name:** Practical II	
Course No.: MARB P106	**Credits:** 02	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the hands-on training on some of the basic instruments and tools used in biological oceanography and statistics	*Students shall be able to learn the use of basic instruments and analyzing techniques.*	

Course Details

Units	Contents	Hours/ Semester
	Practical session on paper C103 and C104 1. Methods of marine Plankton collection, preservation, and analysis	

Units	Contents	Hours/ Semester
	2. Identification of phytoplankton (Diatoms and Dinoflagellates) and Zooplanktons, locally available sea weeds and sea grasses 3. Methods of benthos collection, preservation, and analysis 4. Identification of marine benthos 5. Fish identification and taxonomy, Length-Weight relationship 6. Hands on experience in MATLAB and Excel for computing simple statistical estimates such as mean, moving average and standard deviation (use a subroutine here) using time-series temperature (SST – Sea Surface Temperature), salinity, estimated standing crop & biomass, surface wind and current data. 7. Demonstrate distance between two spatially apart input data points and continue for a set of 10 such data pairs, estimate path of 10 circles having equivalent diameters (i.e., estimated distances). Compute correlation coefficient between a sample time-series wind (speed only) data from two neighboring locations in the Bay of Bengal and fit a straight line for the same data (simple linear regression). 8. Computation of mean monthly wind and current data using MATLAB Programming for the Indian Seas (400 to 1000E, 00 to 300N, choose 10 grid size) for a given month (January – December) using available Remote Sensing data from open sources. 9. Plot the above outputs (Sl. No. 5 to 8) using Grapher, excel and Surfer (Golden Software) appropriately. 10. Use MATLAB instead of FORTRAN for two selected data sets as above (Sl. No. 5 and 8) to process and plot the data.	

Semester- II

Semester: Second Semester	**Course Name:**	Plankton and Productivity in the Ocean
Course No.: MARB C201	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the details about the planktons and their relationship with environmental factors	*Students shall learn about the relation between the environmental parameters and plankton distribution. It will also help in determining productivity of the ocean*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Phytoplankton** Distribution of phytoplankton in the ocean and the environmental factors affecting their distribution, Phytoplankton patchiness, Phytoplankton bloom, red tide, Harmful algal bloom (HAB), causes and consequences of HABs, Phytoplankton succession in coastal water	20
Unit 2	**Primary Productivity** Definition of primary productivity, factors effecting primary productivity in the marine environment, methods of estimation of primary productivity- phytoplankton standing crop, analyzing the pigment, estimation of dissolved oxygen, C^{14} method, Comparison of primary productivity in Bay of Bengal and Arabian sea	20
Unit 3	**Zooplankton** Holoplankton and meroplankton, Distribution of zooplankton and the environmental factors affecting their distribution, Migration of zooplankton – Dial vertical migration and seasonal vertical migration, zooplankton as bioindicator	20
Unit 4	**Secondary Productivity** Methods of estimation of secondary production, Factors affecting secondary production, regional difference in secondary production with special reference to the Bay of Bengal and the Arabian Sea. **Plankton ecology** Interrelation between phytoplankton and zooplankton, primary and secondary productivity in different marine ecosystems	20

Suggested Text / References

1. Wimpunny, R.S. 1966. Plankton of the Sea. Feber and Feber Limited, London
2. Raymont, J.E. G, 1973. Plankton and Productivity in the Ocean (Vol.-1) Pergamon Press, London.
3. Raymont, J.E.G. 1973. Zooplankton (Vol-II) Pergamon Press, London.
4. Parsons, J.R. M. Takahasi and hargrave 9IIed), 1977, Biological oceanographic Processes. Pergaman Press, Oxford.
5. Spoel S. Vender and Heyman, R.P. 1983. Comperative atlas of Zooplankton biological patterns in the oceans, Springer, Verlag, Berlin.
6. Tomas, C.R., 1993. Marine phytoplankton: A guide to naked flagellates and coccoithophores. Academic Press
7. Mitra, A., Banerjii, K., Gangopadhyay, A., 2011, Introduction to marine plankton

Semester: Second Semester	**Course Name:**	Ocean in the Anthropocene
Course No.: MARB C202	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the insight about impact of human activities on the health ocean	*Students shall learn about the impact of anthropogenic effect on the world ocean.*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Global warming and Climate Change:** Definition and historical context, The difference between weather and climate, Atmosphere, hydrosphere, lithosphere, and biosphere, The role of oceans and their influence on climate, Understanding the greenhouse effect, Major greenhouse gases and their sources, Natural drivers of climate change (solar cycles, volcanic activity, etc.), Past climate variations from geological records, Anthropogenic greenhouse gas emissions, Deforestation and land-use changes, Historical temperature records and trends, Global warming projections and uncertainties, Ecosystem changes and biodiversity loss, Human health implications, Strategies for reducing greenhouse gas emissions, Adapting to the impacts of climate change, Overview of major international agreements (e.g., Paris Agreement), The role of governments and policymakers in addressing climate change	20
Unit 2	**Ocean Acidification:** Definition and significance of ocean acidification, Historical context and evidence of changing ocean pH, Key chemical	20

Units	Contents	Hours/ Semester
	processes and the carbon dioxide-carbonic acid system, Anthropogenic carbon dioxide emissions and the carbon cycle Ocean uptake of carbon dioxide and its impact on pH, other factors influencing ocean acidification (e.g., nutrient pollution), Effects of lower pH on carbonate chemistry, Implications for calcifying organisms (corals, mollusks, plankton). Disruption of marine food webs and trophic interactions, Species-specific vulnerabilities and potential winners and losers, Cascading effects on fisheries and economic implications, reducing carbon dioxide emissions and ocean acidification drivers, Ocean-based solutions for carbon sequestration and mitigation, Policy measures and international efforts to address acidification	
Unit 3	**Marine Pollution**: Definition and scope of marine pollution, Historical and current significance of the issue, Chemical pollutants (oil, heavy metals, pesticides), Plastic pollution and microplastics, Nutrient pollution (eutrophication), Causes and consequences of oil spills , Case studies of significant oil spill incidents, The prevalence and persistence of plastic waste, Ecological consequences of plastic waste on marine life and ecosystems, Sources and pathways of heavy metal and POP pollution, Bioaccumulation and biomagnification in marine food webs, Eutrophication: causes and effects, Harmful algal blooms and their impacts on marine organisms, Impacts of Marine Pollution on Biodiversity, Effects on marine species (corals, fish, seabirds, etc.), Loss of biodiversity and ecosystem functioning, Human health risks from contaminated seafood Economic losses in fisheries and coastal tourism, Overview of international agreements (e.g., MARPOL, UNCLOS), Role of organizations like IMO and UNEP in combating marine pollution, Mitigation strategies - Source reduction and waste management strategies, The role of technology in pollution prevention and cleanup	20
Unit 4	**Sustainable Marine Fishing**: The Importance of Marine Fisheries, The significance of fisheries in global food security, Economic and social importance of fishing communities, Causes of Overfishing : Overcapacity and technological advancements, Market demand and global trade dynamics ; Consequences of Overfishing: Decline of target fish populations, Ecosystem impacts and trophic cascades , Fishing Gear and Bycatch: Different types of fishing gear and their impacts , Bycatch, Fisheries Management, Principles of sustainable fisheries management, Regulatory frameworks and international agreements, Fishing Quotas and Total Allowable Catch (TAC), Implementing fishing quotas and TACs (Total Allowable Catch),	20

Units	Contents	Hours/ Semester
	Successes and limitations of quota-based management, Sustainable Fishing Practices, Selective fishing techniques, Eco-labeling and certification programs Role of Aquaculture, Sustainable aquaculture practices as an alternative to wild-caught fish, Challenges and environmental impacts of aquaculture, International Cooperation and IUU Fishing.	

Suggested Text / References

1. "Ocean Acidification" (2nd Edition), Authors: Jean-Pierre Gattuso and Lina Hansson
2. Title: "Ocean Acidification: A Comprehensive Overview" Editors: Debabrata Saha and Shubha Sagar Trivedi
3. Title: "Ocean Acidification: Challenges Facing Science and Society" Editors: J.-P. Gattuso and L. Hansson
4. Overfishing: Causes, Consequences, and Solutions by J. Anderson and L. Johnson.
5. Marine Pollution: Sources, Consequences, and Solutions by R. Clark and A. Smith

Semester: Second Semester	**Course Name:**	Marine Biodiversity, Conservation & Management
Course No.: MARB C203	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide the knowledge about national and regional marine biodiversity	*Students shall learn about the marine organisms of India and Odisha and understand about the existing conservation mechanisms*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Introduction** Introduction to marine biodiversity, Factors affecting marine biodiversity- environmental (salinity, temperature, and bathymetry) and biological factors (reproduction and food availability), migration of marine organisms – Birds, reptiles, fish, and mammals	20
Unit 2	**Marine and coastal Biodiversity of India**	20

Units	Contents	Hours/ Semester
	Major marine habitats – Estuary, coastal lagoons, coastal and oceanic Islands, mangrove, seagrass, salt marsh, coral reef, sand dunes**,** Marine mammals of India and their distribution, Status of Olive ridley turtles, saltwater crocodile, and horseshoe crabs with special reference to Odisha coast.	
Unit 3	**Biodiversity assessment in marine ecosystems** Mapping of marine ecosystems, Methods for biodiversity assessment in mangrove, seagrass, salt marsh, coral reef, sand dunes – quadrat method, line transect method. **Threats to marine biodiversity** Anthropogenic impact on marine biodiversity, Impact of pollution on marine biodiversity- Domestic, industrial, and agricultural, biological invasion, eutrophication, Climate change impact on marine ecosystem and biodiversity, Habitat destruction and fragmentation	20
Unit 4	**Biodiversity conservation and management** IUCN categories, Marine scheduled species of India, Conservation Laws and strategy – Wildlife Protection Act, 1972 and recent amendments, Forest Conservation Act, 1980; Biological Diversity Act, 2002 and recent amendments; Water (Prevention and Control of Pollution) Act, 1974, Coastal Regulation Zones (CRZ), Biosphere reserve, National Park, Sanctuary, Ramsar sites, Eco sensitive Zones, ICMBA (Important Coastal Marine Biodiversity Area – areas identified by WII based on biodiversity and uniqueness), Policy framework for conservation and management of coastal and marine biodiversity *viz*. UNDP, UNEP, UNCCD, UNCCC, CMS, IOSEA etc.	20

Suggested Text / References

1. Martens et al., 2006, Marine Biodiversity Patterns and Processes, Assessment, Threats, Management and Conservation, Springer, Dordrecht
2. Hiscock, K. 2014. Marine biodiversity conservation: A practical approach, Routledge
3. English, S., Wilkinson, C., Baker, V., 1997. Survey Manual for Tropical Marine Resources, Australian Institute of Marine Science, Townsville
4. Venkataraman, K., Sivaperuman, C. 2015. Marine faunal diversity in India: Taxonomy, ecology and conservation, Academic Press

Semester: Second Semester	**Course Name:** Marine Invertebrate and their Biology

Course No.: MARB C204	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide basic knowledge about the marine invertebrates	*Students can learn about the marine invertebrates and their habitat, taxonomy, and life history*	

Course Details

Units	**Contents**	**Hours/ Semester**
Unit 1	**Protozoa, Porifera, Coelenterate and Polychaete** Life History and Phylogenetic relationship of Protozoa and sponges, Coelenterate- Polymorphism-Life history, Theories on Coral reefs and their distribution. Polychaete taxonomic classification, morphology, reproduction, and adaptive radiation.	20
Unit 2	**Minor Phyla** Functional Morphology, development, and Evolution of (a) Nemertinea, (b) Entoprocta, (c) Ectoprocta, (d) Phoronida, (e) Pogonophora **Crustacea** Classification, comparative morphology, crustacean appendages, larval forms, and evolution **Chaetognath** Classification, Distribution, Morphology and Anatomy. **Brachiopoda** Classification, Distribution, Morphology and Anatomy.	20
Unit 3	**Mollusca** Classification, general characters with reference to bivalves, gastropods and cephalopods, Torsion **Echinodermata** Water vascular system, larvae-their comparative morphology and evolution. **Biofouling** Marine fouling and boring organisms: their biology and adaptations, economic importance, antifouling, and anti-boring treatments.	20
Unit 4	**Biosystematics and taxonomy** Definition and basic concepts of biosystematics taxonomy and classification. History of Classification. Trends in biosystematics:	20

Units	Contents	Hours/ Semester
	Chemotaxonomy, cytotaxonomy and molecular taxonomy, Dimensions of speciation and taxonomic characters.	

Suggested Text / References

1. Meglitsch, Paul, 1991. Invertebrate Zoology. Oxford press New York.
2. Pechenick, Jan A, 2000. Biology of Invertebrates. Tata McGraw Hill.
3. Ruppert, E.E and R.D Barnes. 1994. Invertebrates Zoology. 6th Edition. Saunders College Publishers, Philadelphia
4. Kaestner, A., 1967. Invertebrate Zoology vols. I to III. Willey Interscience Publishers. New York
5. Barnes, R.D 1980 Invertebrate Zoology. 4th edition Saunders College Publishers, Philadelphia.
6. Hyman L., 1967. The Invertebrate Zoology Vols. I to IV. McGraw Hill Books Co., New York

Semester: Second Semester	**Course Name:** Physiology and Biochemistry	
Course No.: MARB C205	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide understanding about the ocean and atmospheric dynamics in the polar region.	*Students shall learn about the unique physiological adaptations of marine organisms to survive in dynamic oceans and about their biochemical compositions.*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Physiology of digestion in marine organisms** Food types and feeding mechanisms of marine organisms, Mechanism of digestion, Digestive enzymes, and their action	20
Unit 2	**Physiology of respiration in fishes** Mechanism of respiration in cyclostome, bony fish and elasmobranch, factors affecting respiration in fishes, transport of gases **Osmoregulation and ion exchange in fishes** Physiology of osmoregulation and ion exchange, Ions in body fluids, mechanisms of ionic regulations, response to osmotic conditions and types of osmoregulatory adaptations	20

Units	Contents	Hours/ Semester
Unit 3	**Nervous system** Physiology of nervous systems, impulse generation, and conduction, Interneuronic transmission Types of sensory organs-structure, properties, and functions of sensory organs.	20
Unit 4	**Biochemistry** Structure and properties of carbohydrates, proteins and lipids, Metabolism of proteins, carbohydrates and lipids, Types of enzymes and their functions, mechanism of enzyme action and factors affecting enzyme action, Vitamins, and their role in physiology	20

Suggested Text / References

1. Prosser, C.L. (Ed) 1973, comparative animal Physiology, Saunders, Philadelphia.
2. Lehinger, A.L. Nellson. D.L. Cox., M.M. 1993 Principles of Biochemistry, CBS Publishers and Distributors, New Delhi, pp.1-36.
3. Florey, E. 1966, An introduction to general and comparative Physiology, Sounders, Philadelphia.
4. Gordon, M.S., 1971. Animal function: Principles and applications, Amerird Publicizing Co. New Delhi.
5. Baldwin, E. 1966, Dynamics aspects at Biochemistry, Cambridge, England.
6. Conn, E.E. and P.K. Stumff, 1963. Outline of Biochemistry. John Wiley and Sons Inc. New York and London.

Semester: Second Semester	**Course Name:** Practical I	
Course No.: MARB P206	**Credits:** 02	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide hands on training on primary production and secondary production in ocean	*Students shall learn about the techniques and instruments used for analyzing the marine food chain*	

Course Details

Units	Contents	Hours/ Semester
	Practical session on paper C201	

Units	Contents	Hours/ Semester
	1. Methods of pigment estimation 2. Estimation of standing crop in the ocean 3. Methods of estimation of primary productivity 4. Methods of estimation of secondary productivity	

Semester: Second Semester	**Course Name:**	Practical II
Course No.: MARB P207	**Credits:** 02	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide practical knowledge on conservation strategy of marine organisms in India	*Students can learn about the biodiversity databases and conservation strategy to protect marine organisms*	

Course Details

Units	Contents	Hours/ Semester
	Practical session on paper C203, C204 and C205 1. Use of national and international biodiversity databases 2. Preparation of the list of Marine National Parks, Sanctuaries of India 3. Preparation of list of marine scheduled species available in Odisha 4. Preparation of the list of Schedule marine mammals of India 5. Museum specimen identification (invertebrate) 6. Gut content analysis of fishes, Fecundity of fish, Proximate analysis of fishes 7. DNA Barcoding and phylogenetic tree	

Semester: Second Semester	**Course Name:**	Certificate Course on Value Addition of Marine Fishery Product
Course No.: MARB VAC-I	**Credits**: NC	**Core/Elective:** value added
Course Objective:	**Student Learning Outcome**	

To provide provides a platform for the synergy between formal and informal science and technology, institutions and knowledge system.	*Creating technology networks can help students to gain efficiency in preparing value added products from the thrown-away fishes, which in turn shall help in creating a better environment on the beach and nearby. Value addition through research and development is a key focus to train SHGs so that they become entrepreneurs and develop their socio-economic conditions and alternative livelihood options. Keeping in view the proximity of the university very near to the coast and the available expertise at the Department of Marine Sciences, the course shall help in providing inclusive solutions to the local fishermen and promotes entrepreneurship.*

Course Details

Units	**Contents**	**Hours/ Semester**
Unit 1	Status of marine fishery resources in the world, India, and Odisha. Value addition to marine resources and its reason, Nutritional value of value-added products-in the world, India, and Odisha.	NC
Unit 2	Different components of value addition of marine resources- Lime and handicrafts making from seashell, methods preservation and fish processing for value addition, methods of packaging of value-added marine products, drying and dried fish products, smoking and smoked fish products, different value-added fish products. Export and import potential of value-added marine resources.	NC
Unit 3	Working principles of fish drying machines, Smoking kiln, meat mincer, Vacuum Dryer, Meat Picking Machine, Fish de-boner, Deep Fridge, and other accessory instruments. Polymer identification through FTIR Analysis	NC

Semester- III

Semester: Third Semester	**Course Name:**	Marine Ecology and Biogeography
Course No.: MARB C301	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide knowledge on the structure and function of marine ecosystems.	*Students shall learn about the concept of population and community, species interactions, food chain and food web and biogeographical information of marine ecosystems*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Marine environment** Concept of marine ecosystem and its components – biotic and abiotic, Concept of ecological niche and ecotone	20
Unit 2	**Population ecology** Characteristic of population, Population growth and factors affecting population growth; Concept of Carrying capacity **Community concept** Structures and functions of ecological community, Diversity, and stability in community- species diversity, species richness, species evenness **Ecological succession** Types; Mechanism; Changes involved in succession; Concept of climax, Factors affecting succession	20
Unit 3	**Ecosystem Function** Energy flow in ecosystem, Food chain and food web in marine and estuarine environment; Bio-geo-chemical cycling of nutrients **Species interaction** Types of interactions- interspecific and intraspecific competition, Predation, Mutualism/Symbiosis, Commensalism, Ammensalism	20
Unit 4	**Biogeography** The major geographical provinces of the World Oceans. General attributes; the warm water shelf fauna with special reference to Indo-West Pacific, Arctic and Antarctic fauna, Biogeographical classification	20

Units	Contents	Hours/ Semester
	of India (Coast), Archipelagoes and Volcanic Islands of India, Island Biogeography-Andaman, Nicobar – Biodiversity Hotspot.	

Suggested Text / References

1. Barnes R. S. K, 1999, Introduction to Marine Ecology, Blackwell Science.
2. Jeffery S. Levinton 2000 Marine Ecology, Biodiversity and Function. Oxford University Press.
3. Bertness, M.D, S. D. Gaines and M.K. Hay 2000. Marine Community Ecology Sinauer Associates.
4. Gage. J.D. and P.A. Tyler, 1991. Deep Sea Biology, Cambridge University Press, Cambridge.
5. Balakrishna Nair, N. and D.M. Thampy, 1980. A textbook of Marine Ecology, The Macmillan Co. of India Ltd., New Delhi.
6. Crowder, 1991 William Seashore Line Between the Tides, Dover Publication

Semester: Third Semester	**Course Name:**	Remote Sensing and Geographical Information System (GIS) in Marine Sciences
Course No.: MARB C302	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide knowledge on Remote Sensing	*Students can learn about the methods used in Remote Sensing and its applications in oceanography*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Introduction to Remote Sensing:** Principles of aerial photography, Electromagnetic radiation, Solar and terrestrial radiation, Atmospheric effects, Absorption, Transmission and scattering, Spectral response of earth's surface features, Atmospheric windows– concept of signature. Infrared Remote Sensing: Thermal emission, Atmospheric absorption, IR sensors, SST retrieval, Atmospheric correction, Effect of cloud, Thermal skin layer, Skin, and bulk SST.	20
Unit 2	**Microwave Remote Sensing**: Theory of microwave radiometry, Microwave emission of sea surface, Atmospheric effects, Retrieval of	20

Units	Contents	Hours/ Semester
	salinity and wind vector, Passive microwave radiometers: SMMR, SSM/I, TRMM/TMI and AMSR, Active microwave radiometers: Microwave interaction with the sea surface, NSCAT, Sea Winds - Altimetry: principles – sea surface height anomaly – ERS, T/P, Jason-1 – observing planetary waves.	
Unit 3	**Remote Sensing Application:** Applications of AVHRR, Altimeters, SAR - Monitoring of SST, Geostrophic currents, Mesoscale variability, Eddies, Fronts, Upwelling, Sea Ice Satellite capabilities, Global scale coverage, Different types of satellite data products available SeaWiFS, MODIS, OCM-1& 2, SARAL- Altika, TOPEX-Poseidon, ERS - 1 & 2, JASON, QuikScat, etc.	20
Unit 4	**GIS:** Definition of GIS – Components of GIS, Geographical concepts, Input data for GIS, Types of output products, Application of GIS, GIS Data types – Data representation – Data sources – Data acquisition – Geo referencing of GIS data – Spatial data errors – Spatial data structures. Essential Goal of Marine GIS, Spatial Thinking and GIS Analysis in the Marine Context, Conceptual Model of a Marine GIS.	20

Suggested Text / References

1. I.S. Robinson, (1985): Satellite Oceanography- An Introduction for Oceanographers and Remote Sensing Scientists.
2. Seelye Martin (2014): An Introduction to Ocean Remote Sensing, 2nd Edition, Cambridge Press.
3. Motoyoshi Ikeda and Frederic W. Dobson (1995): Oceanographic Applications of Remote Sensing, CRC Press, USA.
4. Robert H. Stewart, (1985): Methods of Satellite Oceanography.
5. T.D. Allan, (1983): Satellite Microwave Remote Sensing.
6. G.A. Maul, (1985): Introduction to Satellite Oceanography.
7. I. S. Robinson, (2004): Measuring the Oceans from space: The principles and methods of satellite Oceanography.
8. Paul Bolstad, (2019): GIS Fundamentals – A First Text on Geographical Information System, NEW and UPDATED, Sixth Edition. ISBN-13: 978-1593995522.
9. Francis Harvey, (2015): A Primer of GIS, Fundamentals of Geographic and Cartographic Concepts. ISBN-13: 978-1462522187.
10. Karen Steede -Terry, (2000): Integrating GIS and the Global Positioning System. ISBN-13: 978-1879102811.
11. Bradley A. Shellito, (2016): Discovering GIS and ArcGIS. ISBN-13: 978-1319060473.
12. Christian Harder and Clint Brown, (2017): ArcGIS Book. ISBN-13: 978-1589484870.
13. Heather Kennedy, (2006): Introduction to 3D data – Modelling with ArcGIS 3D Analyst and Google Earth. ISBN-13: 978-0470381243.

Semester: Third Semester	**Course Name:**	Marine Biogeochemical Processes
Course No.: MARB C303	**Credits:** 04	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To understand the interdisciplinary nature of bio-geochemical processes occurred in the ocean.	*Students can learn about the concept of nutrient cycle, influence of physical and chemical factors on biogeochemical processes. The course will also help in understanding the impact of climate change on oceanic processes*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Major ocean biogeochemical cycles**: Carbon, Nitrogen, Silicon and Phosphorus cycles, Micro-nutrient dynamics and cycling, Organic matter: dissolved, particulate, and colloidal species, sources, classification, composition, distribution, seasonal variations, Ecological significance, Growth promoting and growth inhibiting effects, Biogeochemical cycles with special reference to estuaries.	15
Unit 2	**Plankton and Productivity:** Phytoplankton and primary productivity, pigments, photosynthesis, Net and gross primary productivity, Rate of primary production in inshore and offshore regions of Arabian Sea and Bay of Bengal, Latitudinal and Seasonal variations in primary productivity, Factors affecting primary production, methods of estimation, Relationship of phytoplankton productivity to light and nutrients, Role of phytoplankton in global carbon cycle, Impacts of climate change, Algal blooms – HABs and TABs- Ocean Colour Monitoring and estimation of primary productivity, Organism sediment relations, Benthic pelagic coupling, CDOM. Plankton as indicators of fisheries, SST variations and pelagic fisheries, Influence of upwelling on oil sardine fishery in Arabian Sea.	25
Unit 3	**Influence of Physical processes on primary productivity:** Hydrodynamic forcing, Upwelling, stratification, mixed layer depth, turbulent mixing, monsoon driven biogeochemical processes in the Arabian Sea and Bay of Bengal, Spatial and Temporal variations in the nutrient concentrations, Response of marine pelagic ecosystems to climatic forcing, OMZ, HNLC, Ocean currents and their impact on marine life.	20
Unit 4	**Source and sinks of particulate and organic matters in the ocean**:	15

Units	Contents	Hours/ Semester
	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. 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.	

Suggested Text / References

1. John H Simpson and Jonathan Sharples, (2012): Introduction to the Physical and Biological Oceanography of Shelf Seas; Cambridge University Press.
2. Tom Beer (1996): Environmental oceanography (CRC Marine Science), 2nd Edition, CRC Press.
3. J. P. Riley & Chester, Introduction to Marine Chemistry, Academic Press London, and New York.
4. Carol M. Lalli & Timothy R. Parsons, Biological Oceanography, and Introduction. Elsevier, Butterworth-Heinemann.
5. Peter Castro & Michel E. Huber, Marine Biology, The Mc-Grawcompanies.
6. Tom Garrison & Robert Ellis (2013), Oceanography: An invitation to Marine Science (9th Edition Cengage Learning.
7. Frank J. Millero (2013), Chemical Oceanography (4th Edition) by, CRC Press, Taylor & Francis Group.
8. Susan Libes (2009), Introduction to Marine Biogeochemistry (2nd Edition) by, Academic Press.
9. H. Elderfield (2006) The Oceans and Marine Geochemistry (1st Edition) by, Elsevier.
10. Gerry Bearman (2005), Marine biogeochemical cycles (2nd edition) by, The Open University.
11. Thomas S. Bianchi (2007), Biogeochemistry of Estuaries by, Oxford University Press.
12. Horst D. Schulz Matthias Zabel (2006), Marine Geochemistry (2nd edition) by, Springer.
13. Michael E. Q. Pilson (2005), An introduction to the Chemistry of the Sea (2nd Edition) University Press.

Semester: Third Semester	**Course Name:**	Coastal Aquaculture
Course No.: MARB E304	**Credits:** 04	**Core/Elective:** Elective
Course Objective:	**Student Learning Outcome**	
To provide knowledge on aquaculture in brackish and marine waters.	*Students can learn about the methods of finfish and shellfish farming in estuaries and ocean water*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Introduction** Fundamentals of aquaculture, Types of aquacultures, scope, and importance of coastal aquaculture	20
Unit 2	**Construction of aquaculture farm and hatchery** Design and construction of fish farm, Design and construction of shrimp hatchery, Site selection, factors of consideration and development of infrastructure	20
Unit 3	**Seed Production and transportation** Methods of seed collection- Induced breeding and wild, packing and transportation of fish seed **Culture** Monoculture and poly culture, Traditional, Extensive, semi-intensive and intensive system of culture, Cages, Pen and Raft culture, Culture of mullets, milk fish, ornamental fish, prawn, crabs, oysters, mussels and seaweeds, Culture of live feeds, culture of fishes in circulating water	20
Unit 4	**Maintenance of aquaculture farm** Common aquatic weeds in fish farm and their methods of control, Fish diseases in culture fishes and their control, Effect of pollution on aquaculture	20

Suggested Text / References

1. Inversion, E.s. 1976, Farming on the edge of the sea. Fishing News (Books) Limited, London.
2. Chen, T.P. 1976, Aquaculture Practices in Taiwan Fishing News (Books) Ltd. London.

3. Chapman V.J. 1980: Sea weeds and their uses, Chapmans Hall, London.
4. Kurien C.V. and Subastian, V.O. 1982, Prawn and Prawn fisheries of India, Hindustan Publishing Corporation (India), Delhi.
5. Pillay, T.R. ed. 1982, Coastal aquaculture in Indo-Pacific region, Fishing News (Books) Limited London.
6. Bal. D.V. and D.V. Rao, 1984. Marine Fisheries Tata, Mc. Graw. Hill Publishing Co.Ltd., New Delhi.
7. Meske, C. 1985, Fish aquaculture-technology and experiments, Pergamon Press Ltd. London.
8. Guasim, S.Z. 1998, Glimpses at the Indian Ocean, University Press (India) Hyderabad.
9. Dey, V.K. Ornamental fishes, handbook on Aquafarming, Presented by MPEDA, Kochi.
10. Nayak. L. 2001, Recent trends in aquaculture, Berhampur University.

Semester: Third Semester	**Course Name:**	Marine Biotechnology
Course No.: MARB E305	**Credits:** 04	**Core/Elective:** Elective
Course Objective:	**Student Learning Outcome**	
To provide knowledge on tools and techniques used in marine biotechnology.	*Students can learn about the tools and techniques of biotechnology used in genetic engineering, isolation of marine bioactive compounds and aquaculture industry.*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Introduction** Marine biotechnology, history, and its applications in marine biology **Basics of genetic engineering** Plasmid and bacteriophages, DNA isolation and cloning, insertion of foreign DNA into host cell, recombinant DNA technology	20
Unit 2	**Marine natural products** Bioactive marine natural products - anti tumor compounds, anti-inflammatory / analgesic compounds, anti-viral agents, Isolation of bioactive compound- liquid extraction, membrane separation, chromatography, identification of marine bioactive compounds- IR, UV, NMR and mass spectroscopy, Commercial development of marine natural products- Agar, chitin	20

Unit 3	**Application of biotechnology in aquaculture** Induced breeding in marine organisms, in-vitro fertilization, cryopreservation, Chromosome manipulation in aquaculture – hybridization; Ploidy induction; Gynogenesis, Androgenesis and sex reversal in commercially important fishes.	20
Unit 4	**Tools and techniques in marine biotechnology** RIA, ELISA, FISH, PCR Gene probes	20

Suggested Text / References

1. Italy, E (Eds). 1998, New Developments in Marine Biotechnology, Plenum Pub. Corp.
2. Milton Fingerman and Rachakonda Nagabhushanam, 1996, Molecular Genetics of Marine Organisms, Science Pub Inc.
3. Y. Le Gal and H.O. Halvorson 1998, New Developments in Marine Biotechnology. Springer.
4. David H. Attaway, 2001. Marine Biotechnology, Volume 1, Pharmaceutical and Bioactive Natural Products.
5. Rita R. Colwell 1984. Biotechnology in the Marine Sciences (Advances in Marine Science & Biotechnology) Wiley Interscience.
6. Scheupr, P.J. (Ed.), 1984. Chemistry of Marine Natural Products, Chemical and Biological Perspectives. Vol. I III, Academic Press, New York.

Semester: Third Semester	**Course Name:**	Marine Microbiology
Course No.: MARB E306	**Credits:** 04	**Core/Elective:** Elective
Course Objective: *To provide basic knowledge on marine microbial community*	**Student Learning Outcome** *Students can learn about the diversity and distribution of marine microbes, their culture methods and about required nutrition*	

Course Details

Units	**Contents**	**Hours/ Semester**
Unit 1	**Introduction to microbiology** General introduction to microbiology, marine microbiology-Definition, importance, and its significance in Oceanographic studies **Diversity and distribution of marine microbes** Ecology of coastal, shallow and deep sea microorganism - importance and their significance, Diversity of microorganism - Archaea, bacteria,	20

Units	Contents	Hours/ Semester
	cyanobacteria, algae, fungi, viruses and actinomycetes in the mangroves and coral environment	
Unit 2	**Culture method and identification** Methods of collection of water and sediment samples for microbiological studies, Methods of isolations and culture of marine bacteria, Enumeration of marine bacteria by total and viable counts, Identification of marine bacteria by total and viable counts, Identification of marine bacteria based on their morphological, physiological, and biochemical characteristics, Structure, and biology of marine bacteria	20
Unit 3	**Microbial nutrition** Common nutrient requirements of microbes, Requirement for carbon, hydrogen and oxygen, Nutritional types of microorganisms, Requirements of nitrogen, phosphorus and sulfur, uptake of nutrients by cell	20
Unit 4	**Actinomycetes** Occurrence, distribution, and morphological feature of actinomycites, Ecological and economic significance of actinomycites.	20

Suggested Text / References

1. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's microbiology. New York: McGraw-Hill.
2. John Paul 1999. Marine Microbiology, Elsevier.
3. Munn and Munn 1996. Marine Microbiology: Ecology and Applications. BIOS Scientific publisher.
4. Atlas, R.M 1988. Microbiology, Fundamentals and applications Maxwell McMillan International Editions
5. Rheinheimer, G., 1980 Aquatic Microbiology-an Ecological Approach. Blackwell Scientific Publications
6. Kirchman, L Microbial Ecology of the Oceans 2000 John Wiley and Sons.
7. The Prokaryotes: 1992 A Handbook on the biology of Bacteria. Vol. 1-4 Springer & Verlag New York

Semester: Third Semester	**Course Name:**	Environmental Impact Assessment and Management Plans

Course No.: MARB CT300	**Credits:** 04	**Core/Elective:** Elective CBCT
Course Objective: *To provide knowledge on environmental monitoring and assessment.*	**Student Learning Outcome** *Students can learn about the methods and procedures used in assessment and monitoring during EIA studies. The proper will also give a brief idea about different types of tools used in EIA studies*	

Course Details

Units	**Contents**	**Hours/ Semester**
Unit 1	Introduction to Environmental Impact Assessment. Environmental impact Statement and Environmental Management Plan. EIA notifications of Government of India from time to time. Guidelines for Environmental audit.	20
Unit-2	Environmental Impact Assessment (EIA) Methodologies. Generalized approach to impact Assessment. EIA processes, Scoping EIA methodologies, Procedure for reviewing Environmental impact analysis and statement. Environmental Management Plan and its monitoring, Evaluation of proposed actions.	20
Unit 3	Nexus between development and environment, Socio-economic impacts, Aid to decision making, Formulation of development actions, Sustainable development, categorization of projects under EIA, project planning and implementation, Impact prediction, Mitigation measures.	20
Unit 4	Introduction to. Selection of appropriate procedures, Restoration, and rehabilitation technologies. Land use policy for India. Urban planning for India. Rural planning and land use pattern. Environmental priorities in India and sustainable development. CRZ notifications and Environmental Impact Assessment in coastal zones. Coastal zone management plans of India.	20

Suggested Text / References

1. W.P. Cunningham, 2010: Principles of Environmental Science.
2. Satsangi and A. Sharma 2015: Environmental Impact Assessment and Disaster Management.
3. R.R. Barthwal 2002: Environmental Impact Assessment.
4. R. Paliwal and L. Srivastava, 2014: Policy Intervention Analysis- Environmental Impact Assessment.
5. C.H. Ecceleston, 2004: Environmental Impact Assessment.

6. J. Hou, 2015: New Urbanism: The future City is Here.
7. James R. Craig, 2010: Earth Resources and the Environment.
8. J. Glassion, 2011: Introduction to Environmental Impact Assessment.
9. Glasson J., Therivel R., Chadwick A, (2005): Introduction to environmental impact assessment Taylor & Francis Group, London and NewYork.
10. Morris P., Therivel R., (2009): Methods of Environmental Impact Assessment 2009, 3rd edition, Routledge, Taylor & Francis Group, London and NewYork.
11. Morris P., Therivel R., (2001): Methods of Environmental Impact Assessment 2001, 2nd edition, Spon Press, Taylor & Francis Group, London and NewYork.
12. Eccleston C. H., (2011): Environmental Impact Assessment 2011, CRC Press, Taylor & FrancisGroup.

Semester: Third Semester	**Course Name:**	Practical I
Course No.: MARB P307	**Credits:** 02	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide hands on training on the instruments used in marine biodiversity studies, aquaculture and remote sensing.	*Students can learn about the application of the tools and techniques used in studying marine biodiversity and coastal aquaculture.*	

Course Details

Units	Contents	Hours/ Semester
	Practical session on theory papers C302, 303, 304/305 1. Live feed culture, Culture of marine invertebrates 2. Principles and functioning of Global Positioning System (GPS) and preparation of the boundary map for a local site and identification of the major installations, buildings etc. using their co-ordinates of survey and compare results with Google Map. 3. Aerial Photo interpretation, Digital image Processing using ERDAS, Shoreline measurement using Arc Pad, Measurement of beach profile using total Station. 4. Remote sensing application for ocean resources: Ocean color and chlorophyll estimation, SST 5. SPM estimation, CDOM, DIC estimation, Carbon estimation of sediment	

Semester: Third Semester	**Course Name:**	Practical II
Course No.: MARB P308	**Credits:** 02	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To provide training on data analysis and interpretation by using oceanography instruments.	*Students can learn about the use and handling of oceanographic instruments and develop skills to interpret the generated data*	

Course Details

Units	Contents	Hours/ Semester
	Practical session on Marine Biological Instruments, Measurements and Data Analysis 1. Use of biodiversity related software 2. Use of microscopes 3. use of refractometer 4. Use of water quality probe 5. Use of pH meter 6. Use of centrifuge 7. Use of spectrophotometer 8. Use of laminar flow 9. Data analysis	

Semester: Third Semester	**Course Name:**	Certificate Course on Marine Litter Monitoring and Management
Course No.: MARB VAC-II	**Credits**: NC	**Core/Elective:** value added
Course Objective:	**Student Learning Outcome**	
To provide knowledge on marine litter pollution.	*Students can learn about the cause and management of marine litter pollution and about the techniques used in assessing the marine litter pollution*	

Course Details

Units	Contents	Hours/ Semester
Unit 1	**Fundaments on marine litters, status, impacts and transport mechanisms.** Marine litter, types of marine litters and their sources, Marine litter-a global problem and present status, marine litter around the world ocean with special reference to Indian Ocean, Impacts of marine litters-marine ecosystem, human health, and economy. Transport mechanisms of marine litters-different oceanographic and meteorological parameters, riverine transport, transport through ships and tourism and recreation activities.	NC
Unit 2	**Prevention, clean up and legislation.** Legislation for prevention of marine litters around the world including India- convention and agreements. Prevention and clean-up of marine litter. Education and awareness on marine litter with special reference to plastics (macro and micro plastics). Plastics in Indian seas and strategy for clean-up of plastic debris, Marine strategy Framework directive (MSFD)- Single use plastics and fishing gear. Methods for measurement of microplastics to reduce releases to the environment, Environmental and health risks of microplastic pollution and its prevention.	NC
Unit 3	**Monitoring of marine litters and laboratory methods for their analysis: Methods for the analysis of macro, meso, micro plastics in beach samples** • Apparatus and Materials • Beach sediment sample preparation • Segregation of beach litters and their quantification • Density Separation • Determine the mass of Total solids • Wet peroxide oxidation (WPO) • Density Separation of total solids • Use of Microscope for identification • Gravimetric Analysis • Polymer identification through FTIR Analysis	NC

Semester- IV

Semester: Fourth Semester	**Course Name:**	Project/Dissertation
Course No.: MARB P401	**Credits:** 08	**Core/Elective:** Core
Course Objective:	**Student Learning Outcome**	
To train students to carry independent research	*Students can learn about the procedure for conducting independent research by designing the study, doing field surveys, sample analysis, data generation and interpretation and to write research article and thesis*	

Course Details

Units	Contents	Hours/ Semester
	Project work is compulsory. Topics will be assigned before the end of 3rd Semester by distributing students equally among the department faculty members (internal guides). Students are free to choose any appropriate topic relating to the field of Oceanography if accepted by both internal and external guides (outside department). The students need to do the literature review and deliver a pre-Project presentation (50 mark) before the faculty members exhibiting the objective of the project work and possible outcomes for finalisation of the topic. The students shall begin their study once the topic selected. There will be a continuous internal monitoring by the guiding/supervising teacher (internal guide). After completion of the project work (within the department or in any other state/national/international level institutes/laboratories/industries engaged in similar or allied R&D work), the candidate must submit the project report/dissertation (100 marks) and defend his report by presenting about 20 technical slides in an open viva-voce (50 marks) of the department by inviting an external expert. Students should at least send one communication to any journals/periodicals/newsletters out of their project work.	Entire semester

Semester: Fourth Semester	**Course Name:**	Cultural Heritage of South Odisha
Course No.: MARO AC	**Credits**: NC	**Core/Elective:** Add-on course
Course Objective:	**Student Learning Outcome**	
To familiarizing all the P.G. Students of Berhampur University with the excellent craftsmanship exemplified by the literary	*Student Learning Outcome Students passing out from BU will have knowledge about the history and culture of south Odisha and Kabi Samrat Upendra Bhanja.*	

stalwarts including Kabi Samrat Upendra Bhanja along with the Arts, Culture and Folk Tradition of South Odisha.

Course Details

Units	**Contents**	**Hours/ Semester**
Unit 1 ୟୁନଟି ୧	Literary works of Kabi Samrat Upendra Bhanja କବିସମ୍ରାଟ ଉପେନ୍ଦ୍ର ଭଞ୍ଜଙ୍କ କୃତିଓ କୃତିତ	NC
Unit 2 ୟୁନଟି ୨	Other Litterateurs of South Odisha ଦକ୍ଷିଣ ଓଡ଼ିଶାର ଅନନ୍ୟାନନ୍ୟ ସାରସ୍ୱତ ସାଧକ	NC
Unit 3 ୟୁନଟି ୩	Cultural Heritage of South Odisha ଦକ୍ଷିଣ ଓଡ଼ିଶାର ସାସ୍କୃତିକ ବିଭବ	NC
Unit 4 ୟୁନଟି ୪	Folk and Tribal Traditions of South Odisha ଦକ୍ଷିଣ ଓଡ଼ିଶାର ଆଦିବାସୀ ଓ ଲୋକ ପରମ୍ପରା	NC

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