Programme: M.Sc. (Marine Microbiology)
Course Code: MMO 410
Title of the Course: OCEAN OBSERVATIONS AND TECHNIQUES
Number of Credits: 3
Effective from Academic Year: 2020-21

Prerequisites	Basic understanding of the marine environments.	
Objective	Introduce the students to analytical techniques and instrumentations used for oceanographic and remote sensing studies.	
Content		
1.	**Platforms and instruments used in Oceanography**	**12 L**
1.1	Marine environment domains, observation strategies, *in situ* observation, Lagrangian and Eulerian measurements, remote sensing. Indian oceanographic research vessels and their facilities.	
1.2	Platform and Instruments: Gliders, Argo, floats, Mooring and moored profilers, buoy, Acoustic Doppler Current Profiler, XBT, Radar, Current Meters, Radars, Marine Magnetometer, Echo Sounder, SONAR, Hydrophone and Geophone, Multibeam bathymetry. Underwater robots and vehicles, Submersible Incubation Device, Camera Systems. Animal tagging, bio-telemetry, bio-logging.	
1.3	Samplers: Conductivity-Temperature-Depth (CTD) sensors, Rosette sampler. Bongo paired Zooplankton Net, BIOMAPER, Video Plankton Recorder, Zooplankton Sampler, Acoustic Recording Package, Multiple Plankton Net. Grab sampler, Gravity corer, Box corer, Piston corer, Hydraulically damped gravity corer.	
2.	**Techniques in Microbial Oceanography**	**12 L**
2.1	Traditional methods. Use of microscopy for enumeration of microbes. Microbial staining. Preservation methods. Tools to study marine microbial diversity: flow cytometry, FlowCAM. Methods to estimate primary production. Phytoplankton pigments by fluorometry, spectrophotometry, HPLC. *In vivo* fluorescence - Fluorescence induction and relaxation and Fast Repetition Rate fluorometer. Respiration measurements of planktons. Tracer technique- 13C and 15N. Isotope labelled substrate uptake. Enzymatic assays.	
2.2	Respiration measurements of plankton. Respiratory quotient to estimate carbon-flux. Community level physiological profiling (CLPP). Fluorometric assessment of enzymatic activity using 4-Methylumbelliferyl (MUF) substrate. Confocal laser scanning microscopy for study of biofilms. Changes in redox potentials using fluorescent stain.	
2.3	Carbon measurement methods: CHNS elemental analyzer. Total inorganic carbon by Coulometer. Dissolved organic carbon using high temperature combustion method. Sediment traps	

	(Moored arrays/drifting traps). ^{234}Thorium as a tracer for POC export estimates.	
2.4	Genomic and metagenomics approach. Environmental DNA. Molecular probes	
3	**Marine Bio-optics and Remote Sensing**	**12 L**
3.1	Marine bio-optics. Electromagnetic radiation. Photosynthetically active radiation. Optically active components. Photosynthetically active radiation (PAR). Optical properties. Ocean color. Chromophoric dissolved organic matter (CDOM). Bio-optical instruments. Fundamentals of remote sensing. Polar-orbiting and geosynchronous satellites. Spatial, temporal and spectral resolution. Satellite sensors.	
3.2	Applications and societal benefits: Primary productivity, sea surface temperature, salinity, wind speed and direction, Ocean currents, ocean-atmosphere heat exchange, bloom dynamics, biogeochemical cycles, assessment of carbon reservoirs and fluxes, potential fishing zones, pelagic and migratory fish, species conservation (e.g. whales, turtles), coastal eutrophication and pollution, Environmental Impact Assessment (EIA), natural and man-made hazards, ocean color and climate change.	
Pedagogy:	Lectures/tutorials/assignments/self-study/case-studies	
References/ Readings	Schiller, Andreas, Brassington, Gary B. (2011). Operational Oceanography in the 21st Century. Springer	
	Jeffrey, S.W and Vesk, M., Introduction to Marine Phytoplankton and Their Pigment Signatures. In: Phytoplankton Pigments in Oceanography. UNESCO Publishing, Paris.	
	Martin S. (2004). An Introduction to ocean remote sensing. Cambridge University Press	
	Venkatesan et al (2018). Observing the oceans in real time. Springer	
	Parsons, T. R., Maita, Y. and Lalli, C. M.; (1984). A Manual of Chemical and Biological Methods for Seawater Analysis, Pergamon Press, Oxford.	
	Strickland, J.D.H, and Parsons T.R., (1972). A practical handbook of seawater analysis, Fisheries Board of Canada bulletin. (2nd edition).	
	Colin Munn (2011). Marine Microbiology Ecology & Applications. Taylor Francis Group.	
Learning Outcomes	Knowledge on different instruments and techniques used to study oceanography and microbes in the ocean.	