

M.Sc. Biological Oceanography: introduction to the program & module descriptions

1-INTRODUCTION TO THE PROGRAM

The unique Master of Science (M.Sc.) program “Biological Oceanography” is arranged in 4 semesters providing knowledge and skills in a number of disciplines that address the global ocean as a complex system. The curriculum is focused on biological oceanography, but teaches students essential knowledge in chemistry, geology and physics of the ocean, so that they become interdisciplinary oceanographers once they complete the program (current program structure, see <https://www.geomar.de/en/studying/msc-biological-oceanography/program>). This is essential, as only such a system understanding can help us understand vital ocean processes such as food web dynamics, ecosystem health and the role of the ocean in carbon cycling and climate change.

A strength of the program is the high fraction of practical courses (modules), the small class sizes and direct interaction with numerous docents and scientists every day, as well as the integration of ongoing science projects into the curriculum. This strength will be further expanded with the current re-accreditation process (see Fig.1). 'Discipline based education research' (DBER, Wieman 2019, Daedalus, DOI:10.1162/daed_a_01760) has convincingly demonstrated that the simulation of the entire scientific process within classes (including feedback-loops, i.e. experimental failures and improvement of strategies), are fundamental for modern science teaching and enhance the learning success of students in natural sciences. We thus believe that increasing the fraction of modules that follow DBER principles will strengthen our program even further. Changes made to that end are the expanded ‘Doing Science’ class (Bioc103-01a), which teaches students the entire scientific workflow in the first and second semester (hypothesis generation, data collection & handling, statistical methods, project development, proposal writing, proposal defence) and the practical courses Bioc101-01a and 201-01a which will receive more time and flexibility, so that more complex experiments and sampling campaigns can be run in small groups. Finally, we plan to increase the number of ‘Current Topics’ modules (Bioc203-01a, 204-01a, Bioc-303-308-01a), which expose students in small groups to the scientific literature, oral presentations and classroom discussion with scientists of all sub-disciplines.

Further changes to the program reflect the rapid and dramatic changes that we have encountered in the last years: the genomic revolution and advances in computer and analytical techniques enable us to collect vast amounts of data. This requires modern biological oceanographers to become excellent computer users. Here, we will allocate more time to computing and bioinformatic approaches. Students will learn about best practices in data handling and storage and how to efficiently use their computers using command line scripts in weekly sessions within Bioc101-01a and -103-01a in the first semester, are then introduced to statistical approaches and data visualization using R and python (Bioc103-01a). In the second semester, four-week blocks of time within Bioc201-01a are allocated to computing intensive experimental analysis of bioinformatic and open ocean large datasets. In the third semester, the ‘Biological

Modelling' (Bioc302-01a) module will introduce students to biogeochemical modelling and individual based bioenergetic models using R. In addition, elective classes will give opportunities to further improve skills in this vital area.

1st sem.	Biological Oceanography 1 Bioc-101 15 ECTS		Intro Chem Oc Bioc-102 3 ECTS	Intro Phys Oc pherIPO 3 ECTS	Doing Science (DOS) Bioc-103 9 ECTS
2nd sem.	DOS Bioc-103 3 ECTS	Biological Oceanography 2 Bioc-201 12 ECTS	Intro Geology Bioc-202 5 ECTS	Current Topics 1 Bioc-203,204 5 ECTS	Free Choice 1 5 ECTS
3rd sem.	Biological Oceanography 3 Bioc-301 10 ECTS	Biological Modelling Bioc-302 5 ECTS	Current Topics 2 Bioc-303-308 5 ECTS	Current Topics 3 Bioc-303-308 5 ECTS	Free Choice 1 5 ECTS
4th sem.	Master Thesis & Defense Bioc-401 30 ECTS				

Fig. 1: the modified program structure, for the current / old structure see <https://www.geomar.de/en/studying/msc-biological-oceanography/program>. Courses in blue are compulsory. Dark green courses are compulsory elective, light green courses are free choice.

Especially during the first two semester, weekly lectures and practicals are arranged in a manner to have a maximum degree of flexibility. This is crucial, as many experimental techniques and analytical methods have different time demands. Class times (contact times) are ca. 30 semester week hours in the first and second semester core period. The class hours of compulsory and compulsory elective modules are arranged in the family-friendly time window 8:00-16:00, with a long lunch break that also encompasses time for students to join the departmental seminar series (GEOMAR research division 2 and 3 seminars, Mon. and Thur. 13:00-14:00), which bring students in direct contact with the most innovative scientists in the various oceanographic and biological fields. The GEOMAR library has working spaces for all students, so that students can also use the time to work on assignments or study.

We aim to leave the time window 16:00-18:00 open for students to work as HiWis. HiWi jobs (student helper jobs) are crucial for most students to support themselves financially and can be seen as a vital addition to our curriculum as well, as they bring students in close contact with working groups, thus enabling them to further develop their interests and identify working groups they want to associate with for their master thesis. We thus aim to have most elective classes as blocks in between semesters (spring and summer breaks), so that there is enough time for self-study and HiWi / other jobs within the lecturing period.

In the **first semester** (see Fig. 2), all courses are compulsory. We have moved the geology module from the first semester to the second semester in order to move physics to the first semester, as an understanding of ocean circulation patterns is crucial in the first semester already to efficiently teach water column biogeochemical processes. Four days have an open structure, so that experiments during the practical

course (Bioc101-01a) can run for longer time periods. The practical introduces students to basic methods in biological oceanography. The 24-hour green block in Fig. 2 is then filled with subsequent Bioc-101 blocks that analyze samples taken during a 4-day ship cruise at the beginning of the semester, followed by a block of ‘Doing Science’ Bioc103-01a (Fig. 3).

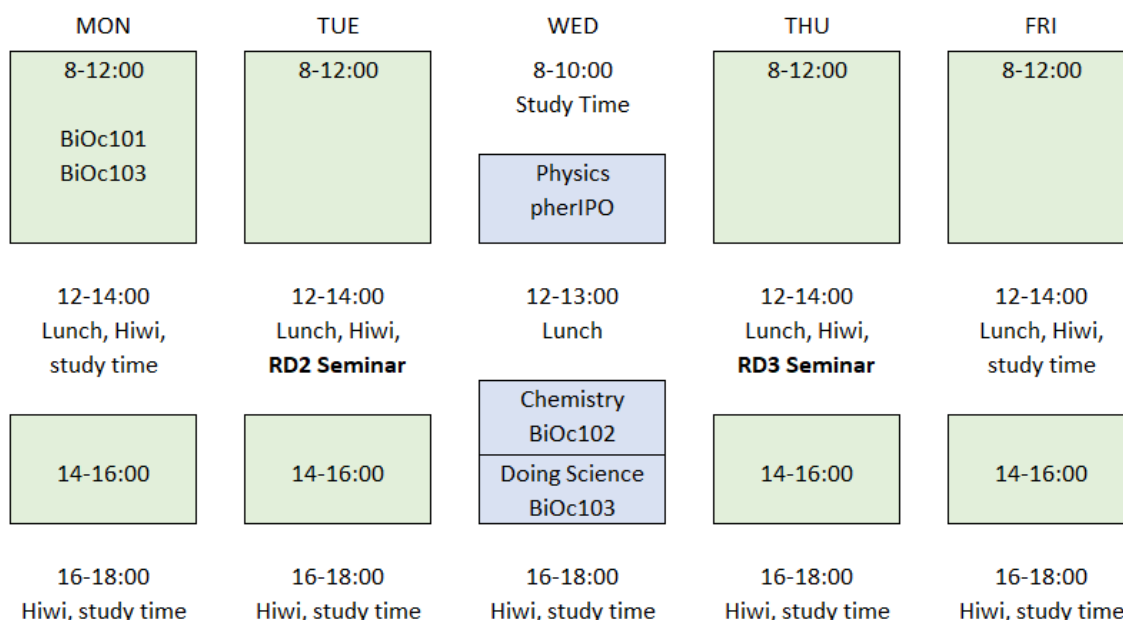


Fig 2. 1st semester time schedule. Green: block course, 24 hours per week (4 mornings, 4 afternoons) Blue: weekly recurring courses, concentrated on Wed to allow for maximum flexibility during rest of the week. RD2,3 = GEOMAR research divisions biogeochemistry, ecology.

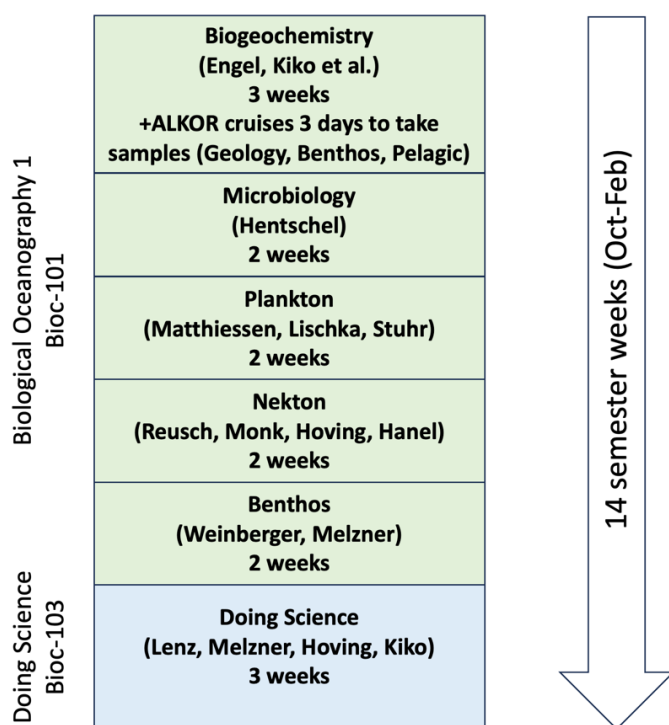


Fig 3. 1st semester. Course progression over the semester during the 24-hour time window (light green time slots in Fig. 2). The ALKOR cruise will be extended to four days.

In the second semester, we devote even more time to practicals within Bioc201-01a and only have one weekly recurrent module ('Current Topics' Bioc203-01a or -204-01a). During the large practical block (light green in Fig. 4), we first have one week to complete the 'Doing Science' Bioc103-01a module that started in the first semester. This is followed by a 'Geology' block Bioc202-01a and the main practical Bioc201-01a, which will expose students in very small groups to advanced innovative experiments and computing exercises. Lectures are integrated in a flexible manner.

MON	TUE	WED	THU	FRI
8-12:00 BiOc103 BiOc201 BiOc202	8-12:00	8-12:00	8-12:00	8-12:00
12-14:00 Lunch, Hiwi, study time	12-14:00 Lunch, Hiwi, RD2 Seminar	12-14:00 Lunch, Hiwi, study time	12-14:00 Lunch, Hiwi, RD3 Seminar	12-14:00 Lunch, Hiwi, study time
14-16:00 Curr Tops I BiOc203 + 204	14-16:00	14-16:00	14-16:00	14-16:00 Curr Tops I BiOc203 + 204
16-18:00 Hiwi, study time	16-18:00 Hiwi, study time	16-18:00 Hiwi, study time	16-18:00 Hiwi, study time	16-18:00 Hiwi, study time

Fig 4. 2nd semester time schedule. Green: block course, 26 hours per week (5 mornings, 3 afternoons). Blue: Students have to choose one of two Current Topics options. During these classes, lectures and seminars are combined so students learn to quickly assimilate and present scientific papers.

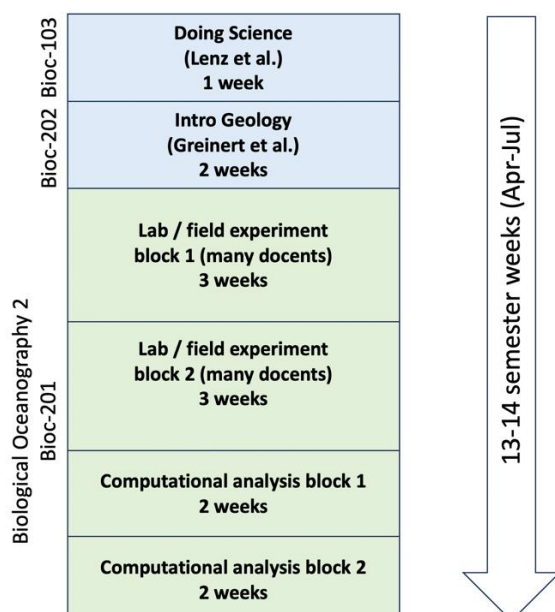


Fig 5. 2nd semester. Course progression over the semester during the 26-hour time window (light green time slots in Fig. 4).

In the **third semester**, a focus is placed on three recurring modules and the remainder of the time (light green in Fig. 6) is allocated to the module Bioc301-01a, which includes developing a thesis topic in collaboration with the future thesis advisor and the preparation of the thesis proposal. Students will defend their thesis proposal prior to starting their work in the fourth semester. Students have to choose two ‘Current Topics’ modules with two weekly sessions each and we will establish a range of new options so that students have several choices (CTs in Ecology & Evolution, Biogeochemistry, Microbiology, Analytical Methods, Molecular & Cellular Physiology, Biogeochemical Modelling).

MON	TUE	WED	THU	FRI
8-9:00	8-12:00	8-12:00	8-12:00	8-12:00
9-12:00 Modelling BiOc302	BiOc301	BiOc301	BiOc301	BiOc301
12-14:00 Lunch, Hiwi, study time	12-14:00 Lunch, Hiwi, RD2 Seminar	12-14:00 Lunch, Hiwi, study time	12-14:00 Lunch, Hiwi, RD3 Seminar	12-14:00 Lunch, Hiwi, study time
14-16:00	14-16:00 Curr Tops II BiOc303-308	14-16:00 Curr Tops II BiOc303-308	14-16:00 Curr Tops II BiOc303-308	14-16:00 Curr Tops II BiOc303-308
16-18:00 Hiwi, study time	16-18:00 Hiwi, study time	16-18:00 Hiwi, study time	16-18:00 Hiwi, study time	16-18:00 Hiwi, study time

Fig 6. 3rd semester time schedule. Green: time reserved for working on thesis proposal and thesis hypotheses with future thesis advisor(s). Blue: Students have to choose two Current Topics classes. During these classes, lectures and seminars are combined so students learn to quickly assimilate and present scientific papers.

The **fourth semester** is entirely reserved for preparation and, eventually, defence of the thesis.

Students have to take two free-choice classes each worth 5 ECTS in the second and third semester. We offer a range of courses within our program that students can choose from, but also accept courses taught within other programs at CAU (see e.g. iSMS) or at other universities, depending on the specific interests of our students. Students can complete these elective classes in the time periods between semesters, or outside of the core-time windows of semesters two and three.

2-MODULE DESCRIPTIONS

Module descriptions are given in the categories compulsory (A), compulsory elective (B) and elective (C).

A-COMPULSORY MODULES

Module Name	Biological Oceanography 1	
Module Number	BiOc101-01a	
Person in Charge	Dr. Mark Lenz Phone: +49-(0)431-600- 4576, E-mail: mlenz@geomar.de	
Semester / Duration	1. semester / one semester	Status
Regular Cycle	Annual in winter semester	Compulsory
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Biological Oceanography 1</u> (Lecture) Professors and lecturers of research departments 2 and 3	3 h per week / 20 students
	<u>Biological Oceanography 1</u> (Practical) Professors and lecturers of research departments 2 and 3	16 h per week / 20 students
Credit Points / Workload	15 ECTS / 266 h contact, 109 h self-study time	
Prerequisites	Recommended prerequisites: A bachelor's degree in a biological discipline.	
Completion Module	None.	
Following Module	Bioc201-01a	
Learning Outcomes	<u>Biological Oceanography 1</u> (Lecture) On completion of this module students should be able to discuss and link key concepts in biological oceanography. They should understand the importance of functional groups of uni- and multicellular auto-, mixo- and heterotrophic organisms both in shaping food webs as well as in elemental fluxes, as well as of distinct oceanic habitats and eco-regions (from coasts to the deep-sea) with their specific abiotic challenges. Students should acquire enough knowledge to be able to read and critically judge current literature on the topics covered. <u>Biological Oceanography 1</u> (Practical)	

	Students should leave this module with skills that enable them to take measurements of key variables and parameters of marine ecosystems (e.g. nutrients, particulate and dissolved material, pigments, microorganisms, phytoplankton, zooplankton, nekton, benthos etc.) as well as be able to interpret the results they obtain. They will gain experience in taking samples during a 4-day research ship trip using standard oceanographic equipment, as well as additional excursions. Further, students will learn to use various laboratory techniques to analyse oceanographic samples taken during the cruise and during excursions. Students should acquire knowledge to discuss complex oceanographic data sets during this module.
Course Content	This module consists of a lecture that introduces basic concepts in biological oceanography and blocks of practical work. The lecture series will run through the entire semester and will be woven around the practical work, depending on the specific time requirements within the practical blocks. Lectures will also be recorded and stored on the e-learning platform OLAT, so that students can repeatedly interact with the content. In certain cases, students will watch the lecture first and class time will be used for discussion of the presented concepts. <u>Biological Oceanography 1 (Lecture)</u> This module will provide a broad overview of the functioning of marine ecosystems and the interactions between organismal groups that determine the cycling of bio-reactive elements in the ocean. Topics to be covered include: Physicochemical conditions in the ocean, introduction to ocean circulation, functional groups & taxonomy (microorganisms to megafauna), ecophysiology of pro- and eukaryotes, biogeochemical cycles and organismal feedbacks, biogeochemical models of the ocean, oceanic habitats and eco-regions, biodiversity, climate & ocean change impacts on organisms. <u>Biological Oceanography 1 (Practical)</u> The practical work will be organised in 5 two to three week-long thematic blocks (biogeochemistry + cruise, microbiology, plankton, nekton, benthos) that introduce the main methods used in biological oceanography research. Students will work in small groups on experimental and methodological aspects of research and will gain experience in field research on board the research vessel 'FS ALKOR'. During the first of four subsequent day cruises with the ship in the beginning of the semester, students will take water and plankton samples, as well as CTD casts for determination of abiotic, chemical & biogeochemical parameters, as well as microbial, phyto- and zooplankton community composition in close cooperation with module Bioc103-01a. During day two, students will be introduced to standard methods in physical oceanography (e.g. ADCP) in cooperation with module pherlPO docents. During ship days three and four, students will sample macrobenthic communities using standard invasive gears (e.g. Van Veen grab), as well as optical (non-invasive) techniques to quantitatively image the water column and seafloor. In addition, a suite of geological methods (e.g. multi corers, multibeam echosounders) will be introduced and used and sediment samples will be taken for analysis during BiOc101-01a and during module Bioc202-01a in the second semester. Samples taken during the cruise and during 1-2 land-based excursions will be analysed in all blocks of this module to enable the students to obtain a comprehensive snap-shot of the biological oceanography of Kiel Bay in October / November. Briefly, the

	following techniques will be covered in the respective blocks, precise length of blocks may change depending on time requirements: 1-Biogeochemistry (3 weeks): Pelagic sampling methods and CTD casts, documentation of samples, dissolved and particulate nutrient determination, dissolved and particulate organic matter determination, oxygen and carbonate system determination, particle imaging and analysis techniques. 2-Microbiology (2 weeks): Sample filtration & fractionation via FACS, microbial quantification using cell staining and microscopy, microbial cultivation techniques, DNA extraction, amplicon sequencing & analysis techniques, fluorescence in situ hybridization (FISH) techniques. 3-Plankton (2 weeks): Microscopic identification of the most important phyto- and zooplankton species using taxonomic guides, quantification of phytoplankton using fixation and sedimentation chambers & inverted microscopy. Use of optical techniques (UVP, Zooscan, Planktoscope) and automated routines to quantitatively analyse plankton samples. 4-Nekton (2 weeks): Anatomy and taxonomy of key nekton taxa (teleosts, cephalopods), DNA extraction and barcoding methods to identify species, stable isotope measurements and pelagic food web construction. 5-Benthos (2 weeks): Macro- and microscopic identification of benthic invertebrates and algae, anatomy and functional morphology of invertebrates and algae, quantitative analysis of sediment fauna & analysis of differences in community structure between sampling stations and in relation to sediment type.
Examination	Graded written exam (100%).
Literature	Morrissey, Sumich, Pinkard-Meier 2016, Introduction to the Biology of Marine Life, Jones & Bartlett Publishers, 448 pp. Additional current literature and lecture notes will be distributed during the semester.
Additional Information	None.

Module Name	Introduction to Chemical Oceanography	
Module Number	BiOc102-01a	
Person in Charge	Prof. Dr. Eric Achterberg Phone: +49-(0)431-600-1290, E-Mail: eachterberg@geomar.de	
Semester / Duration	1. semester / one semester	Status Compulsory
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Chemical Oceanography</u> (Lecture) Prof. Dr. Eric Achterberg	2 h per week / 30 students
Credit Points / Workload	3 ECTS / 28 h contact, 47 h self-study	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	Students will gain demonstrable abilities to evaluate the role of ocean chemistry in major elemental cycles and be able to use these to understand interdisciplinary concepts and principles associated with them. The students will gain understanding of the principles of ocean salinity, density and elemental cycles (including sources and sinks) and ocean productivity from a geochemical perspective. The interplay between geochemical, and physical and biological processes on shaping global ocean biogeochemistry in an ocean under pressure by climate change and further anthropogenic pressures forms a key educational objective.	
Course Content	Topics to be covered are: Basic concepts and principles in marine chemistry with respect major ions and salinity. The global elemental cycles of the major ions are covered, as well as N, P, Si, C and trace elements (including bio-essential elements of Fe, Co, Mn, Zn). The presentation of the elemental cycles includes their sources, sinks and ocean budgets. The elemental ocean budget presentation includes river-ocean fluxes, sediment-ocean fluxes and atmosphere-ocean exchange, the role of ocean circulation and microbial processes in shaping the elemental cycles is covered. The chemical speciation of nutrients and trace elements is covered, including their availability and potential toxicity to organisms. The role in the N cycle of N2 fixation, di nitrogen fixation and anammox is covered, and the role of the Si cycle in carbon export is discussed. The behaviour of greenhouse gases (e.g. CO2) and non-greenhouse gases (incl. He, N2) in the ocean is covered, including air-sea gas exchange. Models and observational methods to study elemental cycles form part of the presentation. The ocean processes are placed in the context of on-going ocean pollution and climate change.	
Examination prerequisite	None.	

Examination	Graded written exam (100%).
Literature	Millero, F.J.: Chemical Oceanography, CRC Press, 4th Edition, 2013 https://doi.org/10.1201/b14753. Berner, E & Berner, R: Global Environment: Water, Air and Geochemical Cycles. Princeton University Press, 2nd Edition. 2012, ISBN 9780691136783. Sarmiento, J & Gruber, N: Ocean Biogeochemical Cycles. Princeton University Press, 2006. ISBN. 9780691017075 Further recommendations for textbooks and relevant literature will be made during the course.
Additional Information	None.

Module Name	Introduction to Physical Oceanography	
Module Number	pherIPO (MNF-pher/IPO (import module B.Sc. Physik des Erdsystems))	
Person in Charge	Dr. rer. nat. Marcus Dengler Phone: +49-(0)431-600-4107, E-Mail: mdengler@geomar.de	
Semester / Duration	1. semester / one semester	Status Compulsory
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Introduction to Physical Oceanography</u> (Lecture) Dr. rer. nat. Marcus Dengler	2 h per week / 80 students
Credit Points / Workload	3 ECTS / 28 h contact, 47 h self-study	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	The students will develop a basic knowledge of the structure and dynamics of the ocean. They will be able to understand the most important physical mechanisms in the ocean and to apply this knowledge in the study of processes in biological oceanography.	
Course Content	Topography of the sea bed, composition and physical properties of sea water and sea ice, sound, heat budget, mean sea salt stratification, characteristic water masses, wind induced ocean currents, geostrophic currents, thermohaline circulation, regional oceanography, tides, ocean currents	
Examination	Graded written exam (100%)	
Literature	Talley, L.D., G.L. Pickard, W.J. Emery, J.H. Swift, 2011: Descriptive Physical Oceanography - An Introduction. Pergamon Press, 6 th edition, 555 pp. Bearman, G. (Ed.), 1989: Waves, tides and shallow-water processes. Pergamon Press, Oxford (Open Univ.), reprinted with corrections 1991,1995, 1997, 187 pp. Bearman, G. (Ed.), 1989: Ocean circulation. Pergamon Press, Oxford (Open Univ.), reprinted with corrections 1998, 238 pp. Bearman, G. (Ed.), 1998: The ocean basins: their structure and evolution. Pergamon Press, Oxford (Open Univ.), 2nd edition, 185 pp. Tomczak, M. and J.S. Godfrey, 1994: Regional Oceanography: An Introduction. Pergamon Press, 422 pp.	
Additional Information	None.	

Module Name	Doing Science	
Module Number	BiOc103-01a	
Person in Charge	Dr. Mark Lenz Phone: +49-(0)431-600-4576, E-mail: mlenz@geomar.de,	
Semester / Duration	1. + 2. semester / two semesters (9 ECTS first semester, 3 ECTS second semester)	Status Compulsory
Regular Cycle	Annual in winter & summer semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Doing Science</u> (Lecture) Dr. Lenz, Prof. Dr. Kiko <u>Doing Science</u> (Practical) Dr. Lenz, Prof. Dr. Kiko	2 h per week / 25 students 7 h per week / 25 students
Credit Points / Workload	12 ECTS / 126 h contact, 174 h self-study time	
Prerequisites	Recommended prerequisites: A bachelor's degree.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	This module will equip students to pursue independent scientific research, be able to critically read and judge scientific literature, conduct statistical analyses and visualize data using R, develop a scientific research proposal and communicate and defend their proposals in oral and verbal form.	
Course Content	This module aims at teaching and practicing specific skills necessary for participating in scientific research. It prepares students for the experiments conducted in BiOc201-01a and the thesis proposal within BiOc301-01a. <u>Doing Science</u> (Lecture) First, weekly sessions aim at teaching basic data handling and visualization skills to students in parallel to the module BiOc101-01a, so that students can process and visualize scientific data generated during the cruise and in the laboratory practical approaches. Here, students will learn to use text editors, related expressions, running scripts using command line tools and visualization of data using R or python. Students will be introduced to best computing practices. <u>Doing Science</u> (Practical) Weekly lectures are followed by a three-week long block-course in the first semester that covers the scientific process from hypothesis development to project planning, data gathering, data management, open science principles, statistical analysis and visualization using R	

	(uni- and multivariate statistics, from regression techniques to ANOVA, ANCOVA, GLM), scientific writing and research proposal preparation. Towards the end of this block, small groups of students (2-3) will be paired with GEOMAR scientists from various disciplines ('coaches') that help them develop a scientific question for a short research proposal. This research proposal will then be written by the student groups in the semester break between semesters 1 and 2, with occasionally scheduled meetings with coaches and docents to clarify problems and questions that arise during the writing process. Students will then defend their written proposals in oral presentations during a two-week block-course towards the beginning of the second semester, followed by critical discussion within the student group, docents, coaches and guests. The remainder of the second semester block will be filled with teaching of advanced statistical techniques (GLMM & GAM, as well as PCA / nMDS techniques using R) students need to be able to analyse experimental findings in MNF-bioc-201.
Examination	Composed exam: graded oral presentation (25%), graded written research proposal (75%).
Literature	Doing Science - Design, Analysis and Communication of Scientific Research von Ivan Valiela, Oxford, University Press, 2001. Quinn, G.P. and Keough, M.J. Experimental design and data analysis for biologists, Cambridge University Press.
Additional Information	None.

Module Name	Biological Oceanography 2	
Module Number	Bioc201-01a	
Person in Charge	Prof. Dr. Thorsten Reusch Phone: +49-(0)431-600-4550, E-Mail: treusch@geomar.de	
Semester / Duration	2. semester / one semester	Status Compulsory
Regular Cycle	Annual in summer semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>A-Experimental ecology, evolution & biogeochemistry: laboratory and field approaches I and II</u> (Practical) Prof. Dr. Reusch, Prof. Dr. Hentschel-Humeida, Prof. Dr. Tasdemir, Prof. Dr. Perner, Prof. Dr. Engel, Prof. Dr. Needham, Prof. Dr. Kiko, Prof. Dr. Han, PD Dr. Weinberger, PD Dr. Briski, Dr. Alzubaidy, Dr. Matthiessen, Dr. Monk, Dr. Scotti, Dr. Bergauer, Dr. Bayer et al. <u>B-Experimental ecology, evolution & biogeochemistry: fundamental principles in ecology, evolution and biogeochemistry</u> (Lecture) Prof. Dr. Reusch, Prof. Dr. Hentschel-Humeida, Prof. Dr. Tasdemir, Prof. Dr. Perner, Prof. Dr. Engel, Prof. Dr. Needham, Prof. Dr. Kiko, Prof. Dr. Han, PD Dr. Weinberger, PD Dr. Briski, Dr. Alzubaidy, Dr. Matthiessen, Dr. Monk, Dr. Scotti, Dr. Bergauer, Dr. Bayer et al. <u>C-Experimental ecology, evolution & biogeochemistry: analysis and computing methods I and II</u> (Practical) Prof. Dr. Reusch, Prof. Dr. Hentschel-Humeida, Prof. Dr. Tasdemir, Prof. Dr. Perner, Prof. Dr. Engel, Prof. Dr. Needham, Prof. Dr. Kiko, Prof. Dr. Han, PD Dr. Weinberger, PD Dr. Briski, Dr. Alzubaidy, Dr. Matthiessen, Dr. Monk, Dr. Scotti, Dr. Bergauer, Dr. Bayer et al.	9 h per week / 20 students

Learning Outcomes	On completion of this course, the students should have an in-depth understanding of stress reactions, ecological, biogeochemical and evolutionary processes in marine ecosystems. They should be able to understand the design of experiments / sampling schemes, and various analytical techniques (physiological, molecular & biochemical approaches). They will learn to conduct experiments, retrieve and evaluate data, conduct extensive bioinformatic analysis, utilize computing pipelines to analyse large oceanographic datasets and put their findings into the context of the scientific literature. They will also present their findings in oral presentations and poster session formats. The design of this course will follow discipline-based teaching approaches (DBER), which aim at simulating the entire scientific process within courses to enhance learning success of students (Wiedemann 2011). Students will practice and further develop skills they have learned in MNF-bioc-103 ('Doing Science'). <u>A-Experimental ecology, evolution & biogeochemistry: laboratory and field approaches I and II (Practical)</u> Here students will use and further develop skills obtained in the 'doing science' module to plan and conduct field or laboratory experiments in close collaboration with scientists from all biological sub-disciplines in two three-week long blocks. Projects will be aligned with current research questions of the advising scientists in ecology and biogeochemistry such as that the students realize that they are part of the 'real' scientific process. Basic results obtained during these lab or field experiments & sampling campaigns will be analysed and presented. Additional samples taken from these experiments can be analysed externally (e.g. genomic, transcriptomic sequencing data, stable isotope data, fatty acid data etc.) so that the resulting large data sets can be analyzed in part C of this course. <u>B-Experimental ecology, evolution & biogeochemistry: fundamental principles in ecology, evolution and biogeochemistry (Lecture)</u> On completion of this lecture series, students will have an in depth understanding of fundamental principles in marine community ecology, evolutionary ecology, ecophysiology and biogeochemistry. Students will be able to discuss principles covered in lectures with docents. <u>C-Experimental ecology, evolution & biogeochemistry: analysis and computing methods I and II (Practical)</u> On completion of this course part, students will be able to utilize command-line based pipelines to analyse complex bioinformatic, ecological and oceanographic data sets. Students will have obtained good R, MySQL and Python skills and will be able to statistically analyse large data sets and to visualize them.
---------------------------------	---

Course Content	This module consists of 2 three-week experimental and 2 subsequent two-week blocks of computation-intensive approaches (practicals) and a lecture series that is integrated into these blocks. <u>A-Experimental ecology, evolution & biogeochemistry: laboratory and field approaches I and II (Practical)</u> The student cohort will be divided into small groups of 2-4 students and assigned an advisor that will develop an innovative research project with the student group that can be executed within a three-week time block. Projects will be aligned with current research questions of the advising scientists in ecology and biogeochemistry such as that the students realize that they are part of the 'real' scientific process. Each student can choose and needs to complete experiments within 2 subsequent three-week time blocks. Each year, different topic will be offered that reflect current cutting-edge research questions investigated by scientists contributing to the master's program. While these three-week experiments should be stand-alone, ideally samples are generated that can be further processed (e.g. sequencing data, stable isotope data, image data sets etc.) by external service providers or the GEOMAR central chemical laboratory, such as that they can be analysed during the subsequent bioinformatic & computing focused two-week blocks described below (see C). <u>B-Experimental ecology, evolution & biogeochemistry: fundamental principles in ecology, evolution and biogeochemistry (Lecture)</u> The lecture series will be flexibly integrated into the block structure depending on the specific time demands of the respective experiments & sampling campaigns happening at the time. Many lectures will be recorded ('inverted classroom') so that students can watch lectures during non-contact times & experimental breaks and contact time can be used for longer discussion of presented concepts with the respective docents. Lectures will cover fundamental principles in marine community and stress ecology, physiology and evolution, as well as biogeochemistry, all with strong relation to ongoing ocean change. Contents will be adapted slightly each year to optimally fit to the chosen experimental approaches and new developments in the field. <u>C-Experimental ecology, evolution & biogeochemistry: analysis and computing methods I and II (Practical)</u> Here, small groups of students will analyse large data sets generated during experimental blocks 1 and 2, ideally such as that experimental block 1 and computing block 1, and experimental block 2 and computing block 2 are directly related. Sequencing data, stable isotope datasets or large oceanographic datasets (e.g. underwater vision profiler UVP datasets) will be analysed using state of the art bioinformatic and computing methods. Students will become proficient users of bioinformatic pipelines to assemble (meta)genomes and transcriptomes and to study gene expression patterns. Students will learn how to generate data bases and how to build pipelines to analyse large oceanographic datasets using MySQL, Python and R or how to use stable isotope data to constrain food web models using e.g. Ecopath with Ecosim. Students will use R and Python to statistically analyse and visualize their findings. The aim is to have one computing block with a bioinformatic focus, one block with a food web or large oceanographic dataset focus.
Examination	Composed exam: three graded oral or poster presentations (3 x 33,3%)
Literature	Stearns, Hoekstra 2005, Evolution, Oxford University Press, 575 pp. Hartl 2020, A Primer of Population Genetics and Genomics, Oxford University Press, 272 pp.

	Morrissey, Sumich, Pinkard-Meier 2016, Introduction to the Biology of Marine Life, Jones& Bartlett Publishers, 448 pp. Further literature recommendations will be communicated in the course.
Additional Information	None.

Module Name	Introduction to Marine Geology	
Module Number	BiOc202-01a	
Person in Charge	Prof. Dr. Jens Greinert Phone: +49-(0)431-600-600-2590, E-Mail: jgreinert@geomar.de	
Semester / Duration	2. semester / one semester	Status Compulsory
Regular Cycle	Annual in summer semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers, Seminar & Exercises	Contact Time / Group Size
	<u>Introduction to Marine Geology</u> (Lecture with practical) Prof. Dr. Greinert, PD Dr. Kutterolf, Dr. Gutjahr, Dr. Crutchley, Dr. Beck, PD Dr. Raddatz	2 h per week / 25 students The module is taught as a block course of two weeks
Credit Points / Workload	5 ECTS / 56 h contact, 69 h self-study time	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	The course objective is to provide basic knowledge on Marine Geology and how this is connected to other Biological Oceanography content. The course focuses on all aspects of Marine Geology from the movement of earth plates, earthquakes, volcanos, sediment deposition, or the deciphering paleo climate. We also introduce fluid flow and how this changes the ocean chemistry and explain the ins and outs of deep-sea mining. Special focus will be on biogeochemical processes in the sediment layer and here we link closely to other courses in the master. Many of the methods that we describe have been introduced during the ALKOR cruise within BiOc101-01a. Upon completion of this course, students will be able to understand major geological processes shaping our planet, as well as be able to utilize modern geological methods to characterize sea floor structure and sediment composition.	
Course Content	<u>Introduction to Marine Geology</u> (Lecture) Topics of the lectures include: General introduction to marine geology, geophysics, tectonics, sedimentology, mineralogy and ocean morphology; geological resources; oceanic sediments and microfossils in relationship to the modern ocean system; degradation of organic matter; dissolution and precipitation of carbonate minerals; evolution of marine biogeochemical cycles; global change recorded within oceanic sediments.	

	<u>Introduction to Marine Geology</u> (Practical) The topics of the practical part include lab-visits, computer exercises with regards to biogeochemical fluxes, geophysical examples and an introduction to GIS.
Examination	Graded written examination (100%).
Literature	Physical Geology First University of Saskatchewan Edition (v1, January 2019). Adapted by Karla Panchuk from Physical Geology, 1st Edition by Steven Earle. (https://www.saskoer.ca/physicalgeology/) The Seafloor, an introduction to Marine Geology, Seibold & Berger (2017), Springer Marine Geology, Kennet (1982), Prentice-Hall Marine Geochemistry, 3rd Edition, Chester & Jickells (2012), Wiley-Blackwell Scientific papers as fit.
Additional Information	None.

Module Name	Biological Oceanography 3	
Module Number	BiOc301-01a	
Person in Charge	Prof. Dr. Rainer Kiko Phone: +49-(0)431-600-1751, E-mail: rkiko@geomar.de	
Semester / Duration	3. semester / one semester	Status Compulsory
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>A-RD and RU seminars</u> (Seminar) All heads of research units (RUs) and research divisions (RDs) involved in the M.Sc. Biological Oceanography curriculum. <u>B-Research cruise, field course or internship</u> (Practical) All docents involved in the M.Sc. Biological Oceanography curriculum, external advisors. <u>C-Thesis Proposal</u> (Exercise) All docents involved in the M.Sc. Biological Oceanography curriculum.	1 h per week / 20 students

	proposal. Students will use knowledge obtained in BiOc103-01a ('Doing Science') to write their thesis proposal using appropriate experimental design and statistical approaches.
Course Content	This module will offer an overview into multidisciplinary oceanographic research from a wide range of topics. These will cover all aspects of biological oceanography. <u>A-RD and RU seminars</u> (Seminar) Regular colloquia of the Research Divisions (RDs) 2 and 3 and Research Units (RUs) at GEOMAR will give an overview on the current research. These cover topics of interest to all disciplines at GEOMAR and are held by internal as well as invited internationally leading scientists. Students participate in at least 10 seminars and document participation. <u>B-Research cruise, field course or internship</u> (Practical) Students can choose to either participate in an oceanographic cruise, a field course or an internship (2 weeks minimum duration). Internships can be conducted within GEOMAR working groups, or in external academic working groups, NGOs, or companies – depending on student interests. Students compile a 5-page report describing their experiences. <u>C-Thesis Proposal</u> (Exercise) Students will choose an advisor and research group to conduct their thesis with. In close collaboration with the advisor, and building on module BiOc103-01a, students will write a ca. 10-15-page research proposal with an introduction section (state-of-the-art) that leads to testable hypotheses and description of experiments / sampling procedures that can be used to test them. Students then present their thesis proposal ideas at the end of the third semester to their colleagues and the GEOMAR scientific community, use feedback to improve their proposal and submit it for evaluation by the advisor.
Examination prerequisite	Oral presentation of thesis proposal and internship or cruise report
Examination	Graded written thesis proposal (100%)
Literature	Literature will be provided during the course.
Additional Information	None.

Module Name	Biological Modelling	
Module Number	BiOc302-01a	
Person in Charge	Prof. Dr. Andreas Oschlies Phone: +49-(0)431-600-1936, E-mail: aoschlies@geomar.de	
Semester / Duration	3. semester / one semester	Status Compulsory
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Biological Modelling</u> (Practical) Prof. Dr. Oschlies, Dr. Pahlow, Dr. Schartau	3 h per week / 25 students
Credit Points / Workload	5 ECTS / 65 h contact, 60 h self-study time	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	The class will educate the students in quantitative environmental and Earth system science, strengthen the students' quantitative and computational skills, provide understanding of a variety of forward and inverse modelling approaches, and develop an understanding of the creation and application of numerical models in biological oceanography.	
Course Content	The unit consists of a combination of lectures and accompanying hands-on exercises carried out by the students on their computers using R. The course teaches relatively simple mathematical approaches for the quantitative description of organism growth and interactions in marine plankton ecosystems. We introduce basic modelling concepts and apply them for constructing simple models of marine ecosystems. Students will learn the basics of solving ordinary differential equations using numerical methods. Essential parts of the exercises are model validation (comparing model results with observational data) and sensitivity analyses (how model solutions change when we vary the values of the model parameters). We cover generic aspects of plankton dynamics and how to use them for model-based analyses of data from experimental studies. At the end of the course, students will be able to create, apply and analyse simple numerical ecosystem models.	
Examination	Graded written protocol (100%)	
Literature	The course is based on two manuscripts, one covers the theory, the other R applications; both will be issued as handouts to the students on a chapter-by-chapter basis.	

Additional Information	None.
-------------------------------	-------

Module Name	Master Thesis	
Module Number	MNF-bioc-401	
Person in Charge	Prof. Dr. Thorsten Reusch Phone: +49-(0)431-600-4550, E-mail: treusch@geomar.de	
Semester / Duration	4. semester / one semester	Status Compulsory
Regular Cycle	Annual in summer semester	
Study Programme	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Master Thesis</u> (Project) all GEOMAR professors	25 students
Credit Points / Workload	30 ECTS / 750 hours (variable contact vs. self-study times)	
Prerequisites	BiOc301-01a as stated in the Examination Regulations.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	Students will need to demonstrate their ability to conduct scientific research in an independent manner, apply their theoretical knowledge to a practical or conceptual scientific question and be able to communicate their results in a lucid manner.	
Course Content	Students are required to submit a master thesis consisting of original, independent scientific work. The thesis will be accompanied by an oral presentation and defence.	
Examination	Composed exam: graded written thesis (75%) and graded oral thesis defence (25%)	
Literature	None.	
Additional Information	None.	

B-COMPULSORY ELECTIVE MODULES:

Module Name	Current Topics in Marine Ecology & Evolution I	
Module Number	BiOc203-01a	
Person in Charge	Prof. Dr. Ute Hentschel Humeida Phone: +49-(0)431-600-4480, E-mail: uhentschel@geomar.de	
Semester / Duration	2. semester / one semester	Status Compulsory elective
Regular Cycle	Annual in summer semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Current Topics in Marine Ecology I</u> (Lecture) Prof. Dr. Hentschel Humeida, Prof. D. Needham, Dr. Kwi Young Han, Dr. Elizabeta Briski, Dr. David Ngugi, Dr. Daniel Liesner, Dr. Marco Scotti, Prof. Dr. Reusch	2 h per week / 25 students
	<u>Current Topics in Marine Ecology I</u> (Seminar) Prof. Dr. Hentschel Humeida, Prof. D. Needham, Dr. Kwi Young Han, Dr. Elizabeta Briski, Dr. David Ngugi, Dr. Daniel Liesner, Dr. Marco Scotti, Prof. Dr. Reusch	2 h per week / 25 students
Credit Points / Workload	5 ECTS / 56 h contact, 69 h self-study time	
Prerequisites	None.	
Completion Module	None.	
Following Module		
Learning Outcomes	Upon completion of the course, students will have (i) improved their skills in scientific reading and synthesis, (ii) will have obtained insights into academic publishing (iii) given oral presentations and obtained peer feedback, and (iv) learned about AI-based approaches in scientific literature.	
Course Content	<u>Current Topics in Marine Ecology I</u> (Lecture) Our focus will be the study of marine organisms ranging in size from viruses to whales. We will read contemporary literature on adaptation processes at the gene and population level to address evolutionary modulation of interactions at the ecosystem level. We will discuss publications on marine holobionts and learn that a finely	

	tuned balance is essential to maintain relevant functions and productivity in support of hospitable marine ecosystems. We will learn about the stressors and pressures to marine life, explore the diversity of marine pathogens and parasites, and understand how they impact important health and disease processes in the ocean. Exciting, cutting-edge research is presented by experts in the field both from GEOMAR and by invited guest researchers. Besides, several instructors will showcase their favourite AI-tools for literature work and beyond. Following an introduction of the AI-tools on Monday, we will test them on Friday. Therefore, bring your notebooks along! <u>Current Topics in Marine Ecology I (Seminar)</u> The seminars will mirror lectures of the respective week. Students will present selected publications in individual graded oral presentations. The seminar will be 30 min + discussion. Students are expected to read more literature than the chosen paper, to present pros and cons, and to form their own opinion. We further expect students to lead the discussion with the peers and we count on everyone to contribute to the discussion.
Examination	Graded oral presentation (100%).
Literature	Course contents and further reading will be specified for each course. The course material will be uploaded on OLAT.
Additional Information	The course explicitly invites Erasmus students. Please check UnivIS for exact dates.

Module Name	Current Topics in Marine Biogeochemistry I	
Module Number	BiOc204-01a	
Person in Charge	Prof. Dr. Rainer Kiko Phone: +49-(0)431-600-1751, E-mail: rkiko@geomar.de	
Semester / Duration	2. semester / one semester	Status Compulsory elective
Regular Cycle	Annual in summer semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Current Topics in Biogeochemistry</u> (Lecture) Prof. Dr. Kiko, Prof. Dr. Körtzinger	2 h per week / 25 students
	<u>Current Topics in Biogeochemistry</u> (Seminar) Prof. Dr. Kiko, Prof. Dr. Körtzinger	2 h per week / 25 students
Credit Points / Workload	5 ECTS / 56 h contact, 69 h self-study time	
Prerequisites	None	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	This module serves two purposes: In the lectures students will be taught the basics of marine biogeochemical cycling, with particular focus on the carbon, nitrogen and iron cycles. In the seminar students will be tasked to conduct literature research and to write an essay about a current research topic in marine biogeochemistry. The essay will be graded and the students will discuss their work with the lecturers and among each other in a World Café format at the end of the semester. On successful completion of this module, students will be familiar with biogeochemical processes involving the ocean's major bioactive elements. They will have a basic understanding of the physical, chemical, and biological processes driving fluxes between the different marine carbon pools, between land, ocean and atmosphere. Students will learn about the dynamics of the marine carbon, nitrogen and iron cycle on time scales from seconds (seawater carbonate system), to months (seasonal cycles), to years (inter-annual variability), to tens of thousands of years (glacial/interglacial periods) and will be able to identify feedback mechanisms in the climate system. They will be aware of the present and projected future impacts of human activities on marine ecosystems and biogeochemistry. The seminar, including the essay writing and World Café discussion will provide students with the opportunity to improve their competence to critically evaluate on-going research, to conduct literature research, to write an essay about a current topic, to present their work in a World Café format and to participate in scientific discussions. By	

	experiencing the interdisciplinary nature of marine sciences, students will develop the ability to place results in a specific area into the larger context of understanding the role of the ocean in the earth system
Course Content	On-going research in marine biogeochemistry will be presented and critically discussed. Current topics will be from a broad area of marine sciences with relevance to marine biogeochemistry, including molecular biology and genetics, physiology, ecology, to marine chemistry, isotope geochemistry, atmospheric chemistry, to ecosystem and biogeochemical modelling.
Examination	Graded written exam (100%).
Literature	Relevant literature will be provided during the module.
Additional Information	The course consists of a lecture and a seminar, during which a mini review on a current topic in Marine Biogeochemistry should be prepared. During three seminar dates at the beginning of the semester topics will be distributed and relevant information regarding the essay writing will be provided. The essays are due towards the end of the semester. Students will get the chance to discuss the topics of their work in a podium discussion format during a block course in the last two weeks of the semester

Module Name	Current Topics in Marine Ecology & Evolution II	
Module Number	BiOc303-01a	
Person in Charge	Dr. Elizabeta Briski Phone: +49-(0)431-600-1589, E-mail: ebriski@geomar.de	
Semester / Duration	3. semester / one semester	Status Compulsory elective
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Current Topics in Marine Ecology II (Lecture)</u> PD Dr. Briski, Dr. Monk et al. <u>Current Topics in Marine Ecology II (Seminar)</u> PD Dr. Briski, Dr. Monk et al.	2 h per week / 25 students 2 h per week / 25 students
Credit Points / Workload	5 ECTS / 56 h contact, 69 h self-study time	
Prerequisites	None	
Completion Module	None	
Following Module	None.	
Learning Outcomes	Upon successful completion of this module, students will have improved their competence to critically evaluate on-going research in marine ecology & evolution conducted in GEOMAR working groups, to participate in scientific discussions and to select state-of-the-art methodologies. During the module, students will give brief oral presentations on a weekly basis, thus training them to speak confidently in scientific settings.	
Course Content	The lecture series will feature research conducted by working group leaders, Postdoctoral scientists and PhD students. These invited guests will present their ongoing research and discuss it with students, then suggest publications that will be presented by the students during the seminar. Here, small groups of students will present these publications, followed by classroom discussions. Each student will select one publication for a more detailed oral presentation.	
Examination	Graded oral presentation (100%).	
Literature	None.	
Additional Information	None.	

Module Name	Current Topics in Marine Biogeochemistry II	
Module Number	BiOc304-01a	
Person in Charge	Prof. Dr. Rainer Kiko Phone: +49-(0)431-600-1751, E-mail: rkiko@geomar.de	
Semester / Duration	3. semester / one semester	Status Compulsory elective
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Current Topics in Marine Biogeochemistry II</u> (seminar) Prof. Dr. Kiko et al.	2 h per week / 25 students
	<u>Current Topics in Marine Biogeochemistry II</u> (lecture) Prof. Dr. Kiko et al.	2 h per week / 25 students
Credit Points / Workload	5 ECTS / 56 h contact, 69 h self-study time	
Prerequisites	None	
Completion Module	None	
Following Module	None.	
Learning Outcomes	Students will obtain a broad overview over current research topics, new methodologies, novel scientific concepts, and latest developments in the area of marine biogeochemistry. Upon successful completion of this module, students will have improved their competence to critically evaluate on-going research, to participate in scientific discussions, to select their own research questions, formulate testable hypotheses, and select state-of-the-art methodologies. By experiencing the interdisciplinary nature of marine sciences, students will develop the ability to place results in a specific area into the larger context of understanding the role of the ocean in the earth system.	
Course Content	On-going research in marine biogeochemistry will be presented and critically discussed. Current topics will be from a broad area of marine sciences with relevance to marine biogeochemistry, including molecular biology and genetics, physiology, ecology, to marine chemistry, isotope geochemistry, atmospheric chemistry, to ecosystem and biogeochemical modelling.	
Examination	Graded oral presentation (100%).	
Literature	Relevant literature will be given out during the module.	
Additional Information	None.	

Module Name	Current Topics in Molecular & Cellular Physiology	
Module Number	BiOc305-01a	
Person in Charge	NN Phone: NN, E-mail: NN	
Semester / Duration	3. semester / one semester	Status Compulsory elective
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Current Topics in Molecular & cellular Physiology</u> (Lecture) NN	2 h per week / 25 students
	<u>Current Topics in Molecular & cellular Physiology</u> (Seminar) NN	2 h per week / 25 students
Credit Points / Workload	5 ECTS / 56 h contact, 69 h self-study time	
Prerequisites	None	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	With the genomic revolution, transcriptomic and genomic data rapidly becomes available to biological oceanographers. This wealth of data can be overwhelming, and a very good working knowledge of cellular molecular processes is necessary to interpret sequencing data. This course provides a solid understanding of the most important cellular processes and pathways in archaea, bacteria and eukaryotes, both autotrophic and heterotrophic. The seminar series will provide students with the opportunity to improve their competence to critically evaluate on-going research in marine molecular & cellular biology, participate in scientific discussions, select their own research questions, formulate testable hypotheses, and learn more about state-of-the-art methodologies.	
Course Content	<u>Current Topics in Molecular & cellular Physiology</u> (Lecture) The lecture series will focus on discussing the most important cellular pathways underlying proteins and networks relevant for energy metabolism, photosynthesis and nutrient uptake, ion regulation, osmoregulation, immune system processes, sensing, excretion, cell division, reproduction and others and also discuss how these might be impacted by climate change & abiotic stressors in general. In addition, cellular organelle function and anatomy, as well as cellular thermodynamics will be discussed across the full taxonomic diversity of organisms that inhabit our oceans. Guest lecturers will attend in person or via video conference so the students can meet some of the	

	best international researchers in this field and discuss novel research findings with them. <u>Current Topics in Molecular & cellular Physiology (Seminar)</u> The seminar series will focus on discussing recent exciting publications (selected by guests, lecturers and students) that identified novel cellular pathways and gene functions in all marine organisms or genes that are targets of selection in response to climate change stressors. Students will give group and individual presentations of publications each week, followed by class discussion of research findings, paper quality & plausibility of conclusions and utilized methods.
Examination	Graded oral presentation (100%).
Literature	Somero, Lockwood, Tomanek (2017) Biochemical Adaptation, Sinauer Associates, 571 pp. Pollard, Earnshaw (2022) Cell Biology, Spektrum, 917 pp. Relevant specific literature will be provided during the module.
Additional Information	None.

Module Name	Current Topics in Marine Microbiology	
Module Number	BiOc306-01a	
Person in Charge	Prof. Dr. Ute Hentschel Phone: +49-(0)431-600-4480, E-mail: uhentschel@geomar.de	
Semester / Duration	3. semester / one semester	Status Compulsory elective
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Current Topics in Marine Microbiology</u> (Lecture) Prof. Dr. Ute Hentschel et al.	2 h per week / 20 students
	<u>Current Topics in Marine Microbiology</u> (Seminar) Prof. Dr. Ute Hentschel et al.	2 h per week / 20 students
Credit Points / Workload	5 ECTS / 56 h contact, 69 h self-study time	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	With the genomic revolution and advances in flow cytometry, a vast diversity of ocean microorganisms has been discovered in the last decades, fundamentally changing our understanding of the tree of life. This course provide student with a solid understanding of the microbial tree of life and the multitude of adaptations these diverse groups of organisms possess. The seminar series will provide students with the opportunity to improve their competence to critically evaluate on-going research in marine microbiology, participate in scientific discussions, select their own research questions, formulate testable hypotheses, and learn more about state-of-the-art methodologies.	
Course Content	<u>Current Topics in Marine Microbiology</u> (Lecture) Within the lecture series, taxonomy, biological adaptations and contribution to biogeochemical cycles of the various microbial groups will be introduced and discussed. Invited guests will give lectures on recent developments in this rapidly growing field, especially how microbial organisms can make use of resources in fundamentally different ocean habitats ranging from the surface ocean to the deep sea. A special focus will be placed on symbiotic relationships between microbial species. In addition, increased prevalence of diseases in the oceans caused by climate change and dispersal of pathogens via ship transport and aquaculture will be discussed in depth. Guest lecturers will attend in person or via video conference so the students can meet	

	some of the best international researchers in this field and discuss novel research findings with them. <u>Current Topics in Marine Microbiology (Seminar)</u> The seminar series will focus on discussing recent exciting publications (selected by guests, lecturers and students). Students will give group and individual presentations of publications each week, followed by class discussion of research findings, paper quality & plausibility of conclusions and utilized methods.
Examination	Graded oral presentation (100%).
Literature	Relevant specific literature will be provided during the module.
Additional Information	None.

Module Name	Current Topics in Analytical Methods	
Module Number	BiOc307-01a	
Person in Charge	Prof. Dr. Deniz Tasdemir Phone: +49-(0)431-600-4430, E-mail: dtasdemir@geomar.de	
Semester / Duration	3. semester / one semester	Status Compulsory elective
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Current Topics in Analytical Techniques</u> (Lecture) Prof. Dr. Tasdemir et al.	2 h per week / 20 students
	<u>Current Topics in Analytical Techniques</u> (Seminar) Prof. Dr. Tasdemir et al.	2 h per week / 20 students
Credit Points / Workload	5 ECTS / 56 h contact, 69 h self-study time	
Prerequisites	None	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	Biological Oceanographers have an overwhelming amount of analytical methods at their disposal. In order to design their future thesis work, students need to acquire knowledge of analytical techniques and methods to be able to address research hypotheses in the best possible way, which often involves interdisciplinary approaches. This module will give students a foundation in theory and practical approaches of various key analytical methods that are frequently used by biological oceanographers to be able to conduct innovative research projects and make use of the infrastructure available at GEOMAR and at CAU Kiel.	
Course Content	The lecture series will focus on discussing important analytical methods, especially measurement principles, resolution, strengths & weaknesses of the respective methods including ranging from mass spectrometry & metabolomics, long and short-read sequencing, bisulfite sequencing, stable isotope analysis, infrared spectroscopy, NMR, proteomics, enzyme assays to whole-organism phenotyping approaches. The seminar series will focus on discussing exciting new interdisciplinary publications that make use of methods that were discussed in the lecture in the same week. Students will give group and individual presentations of publications each week, followed by class discussion of research findings, paper quality & plausibility of conclusions and utilized methods.	

Examination	Graded oral presentation (100%).
Literature	Relevant specific literature will be provided during the module.
Additional Information	None

Module Name	Current Topics in Biogeochemical Modelling	
Module Number	BiOc308-01a	
Person in Charge	Prof. Dr. Andreas Oschlies Phone: +49-(0)431-600-1936, E-mail: aoschlies@geomar.de	
Semester / Duration	3. semester / one semester	Status Compulsory elective
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Current Topics in BGC modelling</u> (Seminar) Prof. Dr. Oschlies, Dr. Pahlow, Dr. Schartau	2 h per week / 15 students
	<u>Current Topics in BGC modelling – Fundamentals in BGC Modelling</u> (Lecture) Prof. Dr. Oschlies, Dr. Pahlow, Dr. Schartau, et al.	2 h per week / 15 students
Credit Points / Workload	5 ECTS / 56h contact, 69h self-study time	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	The students will become acquainted with the fundamentals of global biogeochemical modelling as well as current concepts used in state-of-the-art biogeochemical and ecological models, their specific advantages and disadvantages and potential pitfalls in working with these models and their output.	
Course Content	<u>Current Topics in BGC modelling</u> (Seminar) The students will develop a seminar presentation on a current topic of marine biological modelling. Preparation of the presentation involves the study of recent literature and some understanding of new modelling concepts. The assessment is based on the oral presentation in the seminar. <u>Fundamentals in BGC modelling</u> (Lecture) The lecture series covers the fundamentals in marine biogeochemical modelling, with focus on regional to global three-dimensional models: models of ocean circulation, air-sea gas exchange, organic matter production in the surface ocean, transport and remineralisation of organic matter; practical applications; use of logical arguments; resolution matters; time scales; model assessment.	
Examination	Graded oral presentation (100%).	

Literature	Literature references will be provided in the individual lectures.
Additional Information	None.

C-ELECTIVE COURSES:

Due to the proposed changes for compulsory and elective compulsory (Current Topics) modules, some elective courses will likely be terminated and their contents integrated into compulsory formats, especially courses related to genomics and microbiology.

Module Name	Fish Ecology and Aquaculture	
Module Number	Bioc252-01a	
Person in Charge	Prof. Dr. Reinhold Hanel Phone: +49-(0)431-600-4556, E-mail: reinhold.hanel@thuenen.de	
Semester / Duration	2. or 4. semester / 2-week block course	Status Optional
Regular Cycle	Every other year in summer semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Fish Ecology</u> (Excursion) Prof. Dr. Reinhold Hanel	3 h per week / 8 students
	<u>Fish Ecology</u> (Exercise)	3 h per week / 8 students
	<u>Faunistics and Ecology of the Mediterranean Sea</u> (Seminar)	1 h per week / 8 students
Credit Points / Workload	5 ECTS / 98 h contact, 27 h self-study time	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	On completion of this module, students will have gained a basic knowledge on biodiversity and ecology of the littoral zone of the Mediterranean Sea, with special focus on fish, macrophytes and macrozoobenthos. They will understand different functional groups of organisms, their interactions and the principal abiotic factors shaping their environment.	
Course Content	This module will give insight into the flora and fauna of the Mediterranean Sea, the role of environmental parameters and different methods to explore the littoral zone. Topics to be covered include: Taxonomy and ecology of key species of different marine littoral habitats. Ecology and behaviour of Mediterranean fish species. Mediterranean benthos: Taxonomy, habitats and life forms.	
Examination	Graded written exam (100%).	

Literature	Among others: Hofrichter, R. 2002. Das Mittelmeer – Fauna, Flora, Ökologie. Teile 1-3. Spektrum Verlag. Riedl, R. 1984. Fauna und Flora des Mittelmeers. Verlag Paul Parey, Hamburg – Berlin.
Additional Information	This module takes place as a 2-week block course in Calvi, Corsica.

Module Name	Element cycles in the ocean (500040)	
Module Number	MNF-bioc-250	
Person in Charge	Prof. Dr. Hermann W. Bange Phone: +49-(0)431-600-4204, E-mail: hbange@geomar.de	
Semester / Duration	2. semester / one semester	Status optional
Regular Cycle	Annual in summer semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	Element cycles in the ocean (Biogeochemical cycles) (Lecture) Prof. Dr. Hermann W. Bange	2 h per week / 20 students
Credit Points / Workload	3 ECTS / 28 h contact, 47 h self-study time	
Prerequisites	Recommended prerequisites: Basic knowledge in chemistry, physics, and biology	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	The goal of this lecture is to gain a deeper understanding of the marine biogeochemical cycles in the water column and their interactions with the atmosphere: Students will gain an in-depth expertise (i) to critically evaluate the effects of ongoing environmental changes on element cycles in the ocean and (ii) to develop concepts and guidelines to mitigate these effects.	
Course Content	(i) Evolution of biogeochemical cycles (ii) Basic principles and concepts (iii) Nitrogen cycle (iv) Phosphorus cycle (v) Sulphur cycle (vi) Silicon cycle (vii) Coupling of biogeochemical cycles: Time-series measurements at Boknis Eck (Eckernförde Bay, SW Baltic Sea)	
Examination	A graded oral exam.	
Literature	• “Biogeochemistry – An Analysis of Global Change”, 3rd edition, W.H. Schlesinger & E.S. Bernhard, Academic Press, 2013. • “An introduction to the Chemistry of the Sea”, 2nd edition, M.E.Q. Pilson, Cambridge University Press, 2013. • “Introduction to Marine Biogeochemistry”, 2nd edition, S.M. Libes, Academic Press, 2009 • “Ocean Biogeochemical Dynamics”,J.L. Sarmiento and N. Gruber, Princeton University Press, 2006.	
Additional Information	This lecture is interdisciplinary. Students interested in chemical oceanography, biological oceanography, marine microbiology and	

	Earth system science are welcome. The lecture will be given regularly every week. Please check UnivIS for exact dates.
--	--

Module Name	Seabird Ecology	
Module Number	MNF-bioc-264	
Person in Charge	Prof. Dr. Stefan Garthe Phone: +49-(0)4834-604-116, E-mail: garthe@ftz-west.uni-kiel.de	
Semester / Duration	2. semester / 7-day block course	Status Optional
Regular Cycle	Annual in summer semester and winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Seabird Ecology</u> (Practical) Prof. Dr. Stefan Garthe	4 h per week / 12 students
Credit Points / Workload	5 ECTS / 56 h contact, 69 h self-study time	
Prerequisites	Recommended prerequisites: A bachelor's degree in a biological discipline.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	On completion of this course students should have acquired an advanced knowledge of key aspects of the life history of seabirds. This includes an understanding of seabird behavior, distribution, diet and habitat choice. Also, students should have understood the use of seabirds to indicate changes in the marine environment.	
Course Content	This course will have two main goals. One is to provide an overview of key aspects of the life history of seabirds, with practical elements studying seabird behavior, seabird distribution at sea, diet and feeding ecology as well as habitat choice. Secondly, the students will learn which methods seabird ecology may be studied with, including observations and experiments in the field and in the lab. Also, data collected during the course will be analysed and written up in a protocol.	
Examination prerequisite	Written protocol.	
Examination	Written and graded examination (100%)	
Literature	Literature and lecture notes will be distributed before and during the course.	
Additional Information	This module takes place as a 7-day block course after the first exam period (WS: mid-March SoSe: end of July / beginning of August) at the “Forschungs- und Technologie-Zentrum Westküste” in Büsum.	

Module Name	Taxonomy, Biodiversity, Physiology of Macroalgae Habitats	
Module Number	Bioc267-01a	
Person in Charge	N.N. Phone: N.N., E-mail: N.N.	
Semester / Duration	2. or 4. semester / one semester	Status Optional
Regular Cycle	Annual in summer semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Marine Phyla and Communities</u> (Lecture) N.N.	1 hr per week / 20 students
	<u>Identification of marine animal taxa</u> (Practical) N.N.	3 hr per week / 20 students
	<u>Sample collection and identification at sea</u> (Excursion) N.N.	1 hr per week / 20 students
Credit Points / Workload	5 ECTS / 70 h contact, 55 h self-study time	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	The objective of this course is to enable students to identify marine animals, to provide thorough knowledge of the local flora and fauna, and to gather practical experience of sample collection at sea.	
Course Content	This course will provide knowledge of the morphology of marine animals and algae communities from the Baltic Sea and develop the capacity of correct and scientific identification of marine invertebrate and some selected vertebrate taxa. A further important aspect is to gain an understanding of the variety of life histories that are possible and realized in the marine environment.	
Examination	Graded written protocol (100%).	
Literature	None.	
Additional Information	The module is held as block course after the first exam period (end of July / beginning of August). The course is held bilingually. A major portion of the identification keys is in German since no English translations are available yet.	

Module Name	New aspects of meteorology and oceanography: Carbon cycling in a changing climate	
Module Number	MNF-bioc-271	
Person in Charge	Prof. Dr. Birgit Schneider Phone: +49-(0)431-880-3254, Email: birgit.schneider@ifg.uni-kiel.de	
Semester / Duration	2. or 4. semester / 1-week block course	Status Optional
Regular Cycle	Annual in summer semester	
Study Program	Master of Climate Physics, Master of Science in Biological Oceanography, Master of Science in Marine Geoscience	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Carbon cycling in a changing climate</u> (Lecture / Seminar / Exercise) Prof. Dr. Birgit Schneider	3 h per week / 20 students
Credit Points / Workload	5 ECTS / 56 h contact, 94 h self-study time	
Prerequisites	Recommended prerequisites: A bachelor's degree in a biological, geological, physical or chemical discipline.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	The students can present and discuss research articles on modern aspects of carbon in the climate system. They are able to analyze and discuss scientific papers and chapters of the most recent IPCC assessment report within the context of anthropogenic climate change. Finally, students are able to familiarize themselves with the topic of anthropogenic climate change in greater detail and to assess current literature under scientific and socio-economic aspects.	
Course Content	This interdisciplinary seminar gives an introduction into the role of carbon (including the greenhouse gases CO2 and CH4) in the climate system, with a focus on the coupling of atmosphere, ocean and solid earth. The seminar includes the basics of the earth's climate history, with an emphasis on the cycling of carbon through atmosphere, ocean, sediments and biosphere. Climate change issues are discussed interactively with the students based on the current Intergovernmental Panel on Climate Change (IPCC) assessment report, accompanied by hands-on practical exercises. The seminar is divided into interactive lectures that are connected with student presentations and practical exercises.	
Examination	Graded oral presentation (100%).	

Literature	John Houghton, Global Warming: The Complete Briefing, Cambridge University Press Additional literature and lecture notes will be distributed.
Additional Information	Formal subscription to this course via OLAT and participation in a planning meeting is mandatory; please check UnivIS for more information. The module is held as a block course.

Module Name	New Trends in Marine Biodiscovery	
Module Number	MNF-bioc-274	
Person in Charge	Prof. Dr. Deniz Tasdemir Phone: +49-(0)431-600-4430, E-mail: dtasdemir@geomar.de	
Semester / Duration	2. semester / one semester	Status Optional
Regular Cycle	Annual in summer semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	New Trends in Marine Biodiscovery (Seminar) Prof. Dr. Deniz Tasdemir	2 h per week / 30 students
Credit Points / Workload	2 ECTS / 28 h contact, 22 h self-study	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	• Students will be able to mine, select and summarize information on marine biodiscovery from scientific papers and to cite it according to scientific standards • Students will be able to identify the most promising marine environments and biological sources for marine biodiscovery and discuss the main challenges • Students will be able to comprehend main contemporary methodologies in marine biodiscovery and demonstrate an understanding of their scope and limits • Students will be able to develop skills in scientific visualization, presentation and communication of information	
Course Content	The course is comprised of weekly seminars given by internal and external, international scientists working on the topic. The presentations deal with all aspects of marine biodiscovery; organisms, application areas, established and emerging methodology, innovative approaches and trends, strategies to overcome bottlenecks, future directions. The students are encouraged to participate into discussions with the speaker to grasp the topic and develop deep understanding and curiosity to the topic.	
Examination	Graded oral presentation (100%)	
Literature	Is provided at the first Introduction lecture	
Additional Information	None.	

Module Name	Air-Sea-Exchange	
Module Number	MNF-bioc-277	
Person in Charge	Prof. Dr. Anja Engel Phone: +49 (0)431 600-1510, Email: aengel@geomar.de Prof. Dr. Christa Marandino Phone: +49-(0)431-600- 4219, E-mail: cmarandino@geomar.de	
Semester / Duration	2. or 4. semester / one semester	Status optional
Regular Cycle	Annual in summer semester	
Study Program	Master of Science in Biological Oceanography, Master of Chemistry (focus on Marine Chemistry)	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Air-Sea-Exchange</u> (Lecture) Prof. Dr. Anja Engel, Prof. Dr. Christa Marandino	2 h per week / 15 students
	<u>Air-Sea-Exchange</u> (Seminar) Prof. Dr. Anja Engel, Prof. Dr. Christa Marandino	1 h per week / 15 students
Credit Points / Workload	5 ECTS / 42 h contact, 83 h self-study time	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	In this module students will learn the basics of air-sea gas exchange and biological production of the sea surface microlayer. The influence of the sea surface microlayer on gas exchange and primary aerosol formation will be discussed. Furthermore, the module offers an interdisciplinary basis to understand biogeochemical processes at the surface of the ocean and in the lower atmosphere. There will be a secondary, but major, focus on the critical reading and discussing of international scientific publications.	
Course Content	This module provides a comprehensive overview of biogeochemical processes at the interface between the ocean and the atmosphere. Topics will include models/theory of gas transfer, physical and chemical influences on gas exchange, quantification of gas exchange and methods of research, microbial control on the sea surface microlayer, microbial trace gas cycling, and the role of air-sea exchange processes in climate change. The subject will be taught through lectures and student led discussions of relevant scientific literature.	
Examination	Oral presentations (pass/fail, ungraded)	

Literature	Nightingale, P. D. (2009) Air-Sea Gas Exchange in Surface Ocean-Lower Atmosphere Processes, Le Quere and Saltzman eds., AGU, Washington, USA, pp 69. Liss, P. S. and Duce, R. A. (2005). The sea surface and global change. Cambridge University Press
Additional Information	This lecture is interdisciplinary and addresses students from the fields of biological oceanography and chemistry. The lecture will be given in English on a weekly basis.

Module Name	Coastal Fish Ecology	
Module Number	Bioc280-01a	
Person in Charge	PD Dr. Katja Heubel Phone: +49-(0)4834-604-203 email: heubel@ftz-west.uni-kiel.de	
Semester /Duration	2. or 4. semester / 10-day block course	Status Optional
Regular Cycle	Annual in summer semester	
Study Program	Master of Science Biology / Master of Science Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact time / group size
	<u>Coastal Fish Ecology</u> (Practical)	3 h per week / 12 students
	<u>Coastal Fish Ecology</u> (Lecture)	1 h per week / 12 students
	<u>Coastal Fish Ecology</u> (Seminar) PD Dr. Katja Heubel	1 h per week / 12 students
Credit Points / Workload	6 ECTS / 63 h contact, 87 h self-study time	
Prerequisites	Recommended prerequisites: A bachelor's degree in a biological discipline (or at least proven similar level of experience and knowledge in the relevant fields)	
Completion Module	None	
Following Module	None	
Learning Outcomes	Students who successfully completed this course ... • have acquired detailed knowledge regarding the ecology of coastal marine and estuarine fish with a special emphasis on integrating eco-evolutionary concepts and gaining insights in related key aspects of conservation and biodiversity of fish and its community and environment. • have acquired first experiences on conducting and analyzing experiments on fish behavior. • are able to use a variety of different fishing, sampling, and laboratory methods that are needed as a tool for projecting different kind of studies in the field of fish ecology. • can independently carry out small scientific projects related to the topic of the module. • have learned how to present research results in oral and written form and to critically discuss scientific publications related to the topic of the module on a professional level. • have acquired detailed knowledge on the coastal biodiversity and on the functioning of littoral and estuarine ecosystems (incl. tidal flats, salt marsh, shores). • are able to transfer skills acquired in this module to other fields of biology.	
Course Content	• Current topics in Ecology of marine and estuarine fish (esp. life history, spatial and temporal aspects of ecology, adaptations to	

	abiotic and biotic environments, effects due to anthropogenic stressors). The role of fish in the ecosystem • Methods and design for field experiments • Fish diversity, ecology, and behavior • Trophic interactions, diet and feeding ecology • Variety of fishing and sampling methods • Methods for field experiments • Ecological laboratory methods • Collection, handling, analysis, presentation, and interpretation of data • Typical life forms and communities of tidal mud flats and estuaries
Teaching / Learning methods	This module will be taught in a blended learning setting with a block course at Research and Technology Centre (FTZ), Kiel University, Hafentörn 1, 25761 Büsum, Germany embedded in online units taught before and after the course. Interactive lectures; Practical/Lab (Project work); Seminar; Excursions; Guidance to independent research; Training on presentation techniques in oral and written form. Stimulation for critical thinking, open discussion, deep learning, peer-feedback.
Examination	Composed exam: graded oral presentation (30%), graded written protocol (70%)
Additional information	General time schedule: Prior to the actual course taking place at FTZ Büsum, there will be an online meeting and a preparatory online seminar task. During the course time in Büsum: Morning meeting with interactive lectures, field work and practical lab times, discussion and seminar sessions, time for data handling and analysis, preparation of oral presentations of results. Written protocol. Note: The module contains hands-on laboratory work conducted by small groups of students and is mainly taught in the field (even under bad weather conditions) and in research laboratories. Introduction to the module: there will be an introductory opening of the module via Zoom with invitation by email. Date and time to be announced. Examination: More details will be given at the beginning of the module.
Literature	Literature and lecture notes will be made available at the online web learning and teaching platform.
Additional Note	May also count as iSMS course or towards "Zertifikat Angewandte Meereswissenschaften"

Module Name	Advanced Biological Modelling	
Module Number	Bioc341-01a	
Person in Charge	Prof. Dr. Andreas Oschlies Phone: +49-(0)431-600-1936, E-mail: aoschlies@geomar.de	
Semester / Duration	3. semester / one semester	Status Optional
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Advanced Biological Modelling</u> (Lecture) Prof. Dr. Andreas Oschlies, Dr. Markus Pahlow, Dr. Markus Schartau	2 h per week / 15 students
	<u>Advanced Biological Modelling</u> (Exercise) Prof. Dr. Andreas Oschlies, Dr. Markus Pahlow, Dr. Markus Schartau	2 h per week / 15 students
Credit Points / Workload	5 ECTS / 56 h contact, 69 h self-study time	
Prerequisites	Recommended Prerequisites: Bioc302-01a or equivalent. Basic knowledge of MATLAB.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	The class shall • educate in different modelling approaches in environmental and Earth system science, • strengthen the students' quantitative and computational skills, and • the students are supposed to learn how to develop, set up, run and analyze simply numerical models	
Course Content	The unit will be delivered through a combination of lectures and computer-based accompanying assignments. Students will use higher-level programming languages to manipulate numerical models provided by the organizers. We will discuss typical model errors and provide strategies for error minimization. At the end of the course, students will develop their own simple models to address a scientific problem of their choice.	
Examination	Graded written protocol (100%)	
Literature	Literature references will be provided in the individual lectures.	
Additional Information	None.	

Module Name	Climate-relevant trace gases in the ocean	
Module Number	MNF-bioc-350	
Person in Charge	Prof. Dr. Hermann W. Bange Phone: +49-(0)431-600-4204, E-mail: hbange@geomar.de	
Semester / Duration	3. semester / one semester	Status optional
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Climate relevant trace gases in the ocean</u> (Lecture) Prof. Dr. Hermann W. Bange	2 h per week / 20 students
Credit Points / Workload	3 ECTS / 28 h contact, 47 h self-study time	
Prerequisites	Recommended prerequisites: Basic knowledge in chemistry, physics, and biology.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	The goal of this lecture is to gain a deeper understanding of the distribution and biogeochemical pathways of climate relevant trace gases in the ocean. Additionally, the students will gain insights into the mechanisms of air-sea gas exchange as well as the role of the ocean as source or sink of atmospheric trace gases and the implications for the atmosphere (greenhouse effect, ozone hole).	
Course Content	(i) significance of oceanic trace gases for greenhouse effect and ozone hole (ii) chemical and physical properties of dissolved gases (iii) models of air-sea gas exchange (iv) methods to measure dissolved trace gas (incl. guided lab tour) (v) marine biogeochemistry of selected trace gases (N2O, CH4, DMS, COS, CO, halocarbons, H2, NH3, OVOCs)	
Examination	A graded oral exam (100%).	
Literature	1) "Biogeochemistry – An analysis of global change", 2) 3rd edition, W.H. Schlesinger and E.S. Bernhardt, Academic Press, 2013. 3) "An introduction to the chemistry of the sea", 2nd Edition, M.E.Q. Pilson, Cambridge University Press, 2013. 4) „Physik unserer Umwelt: Die Atmosphäre“, W. Roedel und T. Wagner, 4. Auflage, Springer Verlag, 2010. 5) "Surface Ocean – Lower Atmosphere Processes", C. Le Quéré and E. Saltzman (eds.), AGU, 2009. 6) "Ocean-Atmosphere Interactions of Gases and Particles", P.S. Liss and M.T. Johnson (eds.), Springer Verlag, 2014.	

	7) Open Access: www.springer.com/earth+sciences+and+geography/earth+system+sciences/book/978-3-642-25642-4
Additional Information	This lecture is interdisciplinary. Students interested in chemical oceanography, biological oceanography, marine microbiology and Earth system science are welcome. The lecture will be given regularly every week. Please check UnivIS for exact dates.

Module Name	Scientific Writing - How to Write and Publish a Scientific Paper	
Module Number	bioc353-01a	
Person in Charge	PD. Dr. Avan Antia Phone: +49-(0)431- 8802685, E-mail: aantia@uv.uni-kiel.de	
Semester / Duration	3. semester / one semester	Status Optional
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>How to write and publish a scientific paper</u> (Seminar) PD. Dr. Avan Antia	1 h per week / 20 students
Credit Points / Workload	2 ECTS / 14 h contact, 36 h self-study time	
Prerequisites	Recommended prerequisites: A bachelor's degree in a natural science discipline.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	In this module students will be introduced into the process of manuscript publishing in peer-reviewed scientific journals. The goal of the module is to provide insights into the fun and frustration of paper writing, important rules on manuscript structuring and scientific language as well as how to deal with the reviewing process. After completion of the module students should be familiar with the general principles of a successful publishing process.	
Course Content	This module will address different stages of manuscript writing and publishing by answering basic questions such as: When are my data ready for publishing? Where should I publish? How do I structure the manuscript? How to present the data? What is my message? What are the Do's and Don'ts of scientific writing? How to deal with the reviewers and editors? How to manage my coauthors? The module will be an interactive seminar.	
Examination	Homework (pass/fail, ungraded).	
Literature	R. A. Day, B. Gastel: "How to Write and Publish a Scientific Paper" Cambridge University Press - ISBN: 1107670748, 9781107670747 Day: "How to write and publish a scientific paper", Oryx Press, ISBN: 1-57356-165-7; Day: "Scientific English", Oryx Press, ISBN: 0-89774-989-8; San Francisco Edit: http://www.sfed.it.net/newsletters.htm	
Additional Information	This module will be given in 2-hour seminars every other week. The module will start mid of October. Please check the dates online or contact Avan Antia.	

Module Name	How to make and keep a habitable planet - biogeochemistry-climate feedbacks and astrobiology	
Module Number	MNF-bioc-357	
Person in Charge	Prof. Dr. Andreas Oschlies Phone: +49-(0)431-600-1936, E-mail: aoschlies@geomar.de	
Semester / Duration	3. semester / one semester	Status Optional
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>How to make and keep a habitable planet – biogeochemistry-climate feedbacks and astrobiology</u> (Lecture) Prof. Dr. Andreas Oschlies <u>How to make and keep a habitable planet – biogeochemistry-climate feedbacks and astrobiology</u> (Exercise) Dr. David Keller	2 h per week / 30 students 1 h per week / 30 students
Credit Points / Workload	5 ECTS / 42 h contact, 83 h self-study time	
Prerequisites	None.	
Completion Module	None.	
Following Module	None	
Learning Outcomes	The main goal of this seminar is to discuss recent hypotheses on how life and biogeochemical cycles developed on Earth or could develop on other planets, and how Earth has remained habitable for a very long time. Students will learn about biogeochemical-climate feedbacks operating on Earth and other planets, and gain practice in interpreting controversially discussed hypotheses about planetary evolution.	
Course Content	Evolution of Earth, “young faint sun” paradox, role of physical and biogeochemical feedbacks, evolution of life and its impact on Earth’s atmosphere and climate. Climate variability, snowball Earth events, glacial cycles, and the Anthropocene. Discussion of where and how to look for life on other planets.	
Examination	Written graded examination (100%).	

Literature	Ruddiman, W., "Earth's Climate: Past and Future", Freeman, NY, 465 pp; Schlesinger et al: "Biogeochemistry", Elsevier; Kump, Kasting & Crane "The Earth System" Pearson Education; Gilmour & Sephton: "Astrobiology", Cambridge Open University.
Additional Information	This course is identical with <i>climAPCFEED-01a: Feedbacks in the Climate System</i> . It is interdisciplinary and addresses students from the fields of physical oceanography and meteorology, biological oceanography, geology, and microbiology.

Module Name	Marine biodiscovery and biotechnology	
Module Number	Bioc360-01a	
Person in Charge	Prof. Dr. Deniz Tasdemir Phone: +49-(0)431-600-4430, E-mail: dtasdemir@geomar.de	
Semester / Duration	3. semester / 2-week block course	Status Optional
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Marine biodiscovery and biotechnology</u> (practical course) Prof. Dr. Deniz Tasdemir	6 h per week / 6 students
Credit Points / Workload	5 ECTS / 84 h contact, 41 h self-study time	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	• Students will be able to design and perform field work/sampling strategy for marine micro- and macroorganisms • Students will be able to achieve hands-on competence in basic marine microbiological techniques (sterile work, enrichment, morphological/molecular biological identification, cultivation) • Students will gain practical experience in techniques used in chemical investigation of marine organisms (extraction, chemical profiling, metabolomics) • Students will be able to assess biological/pharmacological activities of marine extracts prepared • Students will be able to analyze microbial interactions and its outcome(s) • Students will develop competency in analysis, documentation, scientific presentation of methodology & results	
Course Content	This block practical course is composed of field sampling followed by hands-on training on crucial methodology in marine microbiology (enrichment, isolation and identification of marine microorganisms), marine natural product chemistry (extraction, also macroorganism, dereplication) and pharmacological analyses relevant for marine biodiscovery and biotechnology	
Examination	Graded oral presentation (100%)	
Literature	Is provided at the first introductory meeting	

Module Name	Marine Ecological Exchange Lab	
Module Number	Bioc368-01a	
Person in Charge	PD Dr. Florian Weinberger Phone: +49 431 600-4516, E-mail: fweinberger@geomar.de	
Semester / Duration	3. semester / 2-week block course	Status Optional
Regular Cycle	Annual in summer semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Finnish-German Marine Ecological Exchange Lab</u> (Seminar) PD Dr. Weinberger	1 h per week / 10 students
	<u>Finnish-German Marine Ecological Exchange Lab</u> (Excursion) PD Dr. Weinberger	3 h per week / 10 students
	<u>Finnish-German Marine Ecological Exchange Lab</u> (Exercise) PD Dr. Weinberger	3 h per week / 10 students
Credit Points / Workload	5 ECTS / 98 h contact, 27 h self-study time	
Prerequisites	Recommended Prerequisites: Participation in a master study programme in a scientific discipline	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	This course will address most current questions in marine ecology. Transferable skills that can be acquired in the course are analytical, systematic and theoretical thinking skills, information retrieval skills, problem-solving skills, laboratory skills, presentation skills, and teamwork ability.	
Course Content	Topics will vary between years, but most likely link investigations on species interactions with climate change related research questions. We will combine field observations with aquarium to mesocosm experiments and modern laboratory analyses. This will be a hands-on practical course, supported by short lectures and short student presentations. A prior literature review will form the basis of successful participation. The participants will elaborate on a specific research topic (to be dedicated each year) and will plan, conduct and evaluate an ecological experiment, run for two weeks, alternatingly at the Husö Biological Station at the Åland Islands, Finland (in 2026) and at either the	

	Wadden Sea Station at List/Sylt or GEOMAR facilities in Kiel (2023, 2025). Specific content (also dependent on the focus of the annual project): - Planning ecological experiments with focus on appropriate experimental designs - Handling of marine species, from macrophytes and their associated invertebrate grazers to filter feeders and their predators - Setting up experiments in aquarium containers to smaller mesocosm facilities - Common laboratory procedures and specific eco-physiological, chemical-ecological or molecular biological methodology - Using bioassays to answer ecological questions For passing the course, the participants are expected to: - Execute a literature review on a suggested topic in marine ecology. - Present one chosen paper as seminar contribution to the course participants enabling an overview of the research topic. - Work in an international team of researchers and actively bring in thoughts and suggestions to the project. - Actively participate in sampling, running experiments and in laboratory assays and analyses during the course. - Evaluating the findings from the course in groups, graphically and statistically (support will be provided). Deliver a written home assignment, i.e. a protocol of the conducted experiments, including a short summary, an introduction to the research topic, the main methods that were applied during the course, a short presentation of the main findings, and a discussion of the key outcomes from the course.
Examination	Composed exam: graded home work (50%), graded oral presentation (50%).
Literature	Independent literature review, laboratory protocols, additional literature for the written home assignment will be suggested at the end of the course
Additional Information	This course will be jointly conducted with Åbo Akademi University at Turku/Finland, and will be open to participants from Germany and Finland. The course will be taught in English. Participants need to cover their expenses for travel, accommodation and meals.

Module Name	New Trends in Marine Biotechnology	
Module Number	MNF-bioc-374	
Person in Charge	Prof. Dr. Deniz Tasdemir Phone: +49-(0)431-600-4430, E-mail: dtasdemir@geomar.de	
Semester / Duration	3. semester / one semester	Status Optional
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>New Trends in Marine Biotechnology (Seminar)</u> Prof. Dr. Deniz Tasdemir	2 h per week / 30 students
Credit Points / Workload	2 ECTS / 28 h contact, 22 h self-study time	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	• Students will be able to mine scientific literature, select and summarize information on marine biotechnology from scientific papers • Students will be able to define the most promising biological sources and marine environments for marine biotechnology and discuss the main challenges and opportunities in the field • Students will be able to distinguish main contemporary (and emerging) methodologies in marine biotechnology and demonstrate an understanding of their scope and limits • Students will be able to acquire skills in scientific visualization, presentation and communication of information	
Course Content	This seminar course comprises oral presentations given weekly by internal and external, often international scientists working on the topic. The presentations deliver different aspects of marine biotechnology; organisms, application areas, trends, established and emerging innovative technology, strategies to overcome bottlenecks, future potential. The students participate into discussions with the speaker to develop in-depth knowledge and curiosity to the topic.	
Examination	Graded oral presentation (100%)	
Literature	Is provided at the first Introduction lecture/meeting	

Module Name	Microbial ecology and genomics	
Module Number	bioc378-01a	
Person in Charge	Prof. Dr. David M. Needham Phone: +49 431 600-4411, E-mail: dneedham@geomar.de	
Semester / Duration	3. semester / one semester	Status Optional
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Microbial ecology and genomics (Lecture)</u> Prof. Dr. David Needham	1 h per week / 10 students
	<u>Data and genomic analyses (Exercise)</u> Prof. Dr. David Needham	2 h per week / 10 students
	<u>Current literature discussion in microbial ecological techniques (Seminar)</u> Prof. Dr. David Needham	1 h per week / 10 students
Credit Points / Workload	5 ECTS / 45 h contact, 80 h self-study time	
Prerequisites	None	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	The students should leave this course with an overview of how machine learning and IT can be used in microbial genomics and practical applications on real data using Kiel University's high-performance computing cluster.	
Course Content	This course builds upon bioinformatics learned in Bioc-201. Thus Bioc-201 or another class on genomic analysis via the command is a pre-requisite. The format will consist of lectures, presentations by the students and instructor of selected papers with discussions, and hands on exercises in microbial genomics. Synopsis: Marine microbial systems are challenging to study because they are composed of organisms that are extremely diverse, tiny, and mostly uncultivated. Studying the genomes of these organisms is critical to understand their functions. In this course, we examine the state of the art in how microbial genomics is being transformed by machine learning and artificial intelligence.	
Examination	Graded homework (100%)	
Literature	Relevant literature will be distributed within the respective courses.	

Additional Information	None.
-------------------------------	-------

Module Name	Geomicrobiology: from sediments to bacteria: turnover rates, enzyme activities and genetics	
Module Number	MNF-bioc-379-01b	
Person in Charge	Prof. Dr. Mirjam Perner Phone: +49-(0)431-600-2837, E-mail: mperner@geomar.de	
Semester / Duration	3. semester / 3-week block course	Status Optional
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Geomicrobiology of sediments (Lecture)</u> Prof. Dr. Mirjam Perner	1 h per week / 12 students
	<u>Geomicrobiology of sediments (Seminar)</u> Prof. Dr. Mirjam Perner	1 h per week / 12 students
	<u>Geomicrobiology of sediments (Practical)</u> Prof. Dr. Mirjam Perner	2 h per week / 12 students
Credit Points / Workload	5 ECTS / 56 h contact, 69 h self-study time	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	Seminar: In this seminar, students will study basic principles of benthic bio-geo-coupling processes in an interactive fashion. The seminar aims at developing an understanding of the important role microorganisms play for cycling distinct chemical compounds, e.g. carbon, hydrogen, iron nitrogen, sulfur on the seafloor. Students will learn how to gather information on element cycling from the primary literature and to prepare oral presentations. Lecture: In the lecture, basic principles of microbially mediated element cycling e.g. carbon, hydrogen, iron nitrogen, sulfur on the seafloor will be taught in an interactive fashion. We will address microbial turnover rates, enzyme activities and genes relevant for element cycling in benthic habitats. Students will acquire an integrative view of bio-geo-coupling processes. Practical: Within the practical, students will be trained in modern techniques relevant for experimental approaches in Geomicrobiology. Students will be distributed in small groups to conduct experiments. Focus will lay on hydrogen and sulfur cycling	
Course Content	Lecture topics include: microbially mediated hydrogen-, carbon-, iron-, sulfur-cycling. The role and relevance of these processes for the	

	local benthic habitat and the global Ocean will be discussed. Enzymes associated with these processes will be discussed. Practical experiments will be related to determining turnover rates of specific compounds and measuring activities of enzymes from incubation experiments. Spectrophotometry and Gaschromatograhpy will be used. Additionally, PCR will be conducted to prove the presence of genes encoding respective enzyme activities. Research projects will be closely aligned with ongoing research in the working group Geomicrobiology.
Examination prerequisite	none
Examination	Graded oral presentation (100%)
Literature	Relevant literature will be given out during the module.
Additional Information	none

Module Name	Ocean Health, Ocean Food and Sustainability	
Module Number	bioc380-03b	
Person in Charge	Prof. Dr. Ute Hentschel Humeida Phone: 0431 600-4480; E-mail: uhentschel@geomar.de	
Semester / Duration	3. semester / one semester	Status Optional
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form)	Contact Time / Group Size
	Lecturers	
	<u>Ocean Health, Ocean Food and Sustainability</u> (Lecture) Dr. Hassan Humeida (hhumeida@geomar.de)	2 h per week / 25 students
	<u>Ocean Health, Ocean Food and Sustainability</u> (Seminar) Dr. Hassan Humeida (hhumeida@geomar.de)	2 h per week / 25 students
Credit Points / Workload	6 ECTS / 56 h contact, 94 h self-study time	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	Upon completion of the course, students will have (i) improved their reading skills in interdisciplinary scientific literature, (ii) given oral presentations and obtained peer feedback, (iii) obtained an in-depth understanding the area of ocean health and sustainable marine food production, its role in global food security and beyond, (iv) learned about the UN Decade of Ocean Science for Sustainable Development and practical actions for implementation, and (iv) increased their international perspectives and networks.	
Course Content	A healthy ocean and a sustainable food supply are deeply interconnected. The seemingly contradictory needs to balance human food security on the one hand and to preserve marine ecosystems on the other, urgently call for a sustainable and coordinated ocean management. This lecture series will introduce the various fields of ocean health and food science in the context of past practices and future sustainable development goals (Agenda 2030). The term ocean health is here used in the literal sense to explore the causes of health and disease of marine organisms and how such processes affect ecosystem functioning and services along with their consequences for human health. Topics include nutritional, environmental, economic and societal aspects of marine resources for human nutrition as well as food production and security. One regional focus will be placed on selected West-African countries (i.e., Cabo Verde Islands, Ghana, Gambia, Senegal). Integrated approaches (co-design, best practice examples) involving multidisciplinary science, practice, and education	

	will be assessed with the aim to promote a solution-oriented understanding and development toward a sustainable future ocean food security. Guiding questions are as follows: • What are the impacts of climate change on the functioning of marine ecosystems? • Are marine diseases increasing through global change? • How can we protect marine biodiversity across time, space and international borders? • How can we sustain marine food production for a growing world population? • Which types of ethical, economic, and political decisions can improve human-environment relationships?
Examination prerequisite	none
Examination	Composed exam: graded oral presentation (50%), graded written exam (50%)
Literature	Course contents and further reading will be specified for each course. The course material will be uploaded on OLAT.
Additional Information	This master's module is interdisciplinary in nature. The weekly lectures and student seminars will be held in hybrid format and are open to students interested in ecological, biological, nutritional, environmental, political, and societal aspects of the marine sciences are welcome. The course explicitly invites Erasmus students. Please check UnivIS for exact dates.

Module Name	Scientific computing: Data analytics in marine research – Python and beyond	
Module Number	Bioc383-02b	
Person in Charge	Prof. Dr. Rainer Kiko Phone: +49 431 600 1751; E-mail: rkiko@geomar.de	
Semester / Duration	1. or 3. semester / one semester	Status Optional
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Scientific computing: data analytics in marine research – python introduction and beyond (lecture and practical)</u> Prof. Dr. Rainer Kiko	2 h per week / 15 students
Credit Points / Workload	2 ECTS / 28 h contact, 22 h self-study	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	On completion of this introductory module, students will be able to program different scientific analyses using python. They will also be able to run scripts using command line tools and will be familiar with the subversion tool GIT to backup and distribute the scientific analysis pipelines to be developed. The overall objective of the course is the development of a sustainable work attitude and computing environment that aims to code all steps of a scientific data analyses. Such tools are needed to handle marine big data problems such as the processing of satellite image data or the merging of data from different provenances (e.g. CTD, Satellite and image data). No previous computing experience is needed, as this course aims to provide the initial tools to develop own big data analytics skills, which are also in high demand in the non-academic labor market.	
Course Content	Students will learn python language basics and programming basics and will be able to develop scripts to read in diverse file formats (*.txt", *.xlsx", *.nc", *.hdf"), to combine and manipulate data from different sources (CTD, UVP, Experimental data, Satellites, ...) and to create various plots (scatter, timeseries, contour, maps...) using python. The course will include basics in geospatial data analysis (e.g. gridding, distance calculation, timezone handling) and simple statistics approaches. It will be a hands-on course that will include short introductions into the relevant programming techniques alternated with practical tasks. Students are encouraged to, in advance, hand-in data that they would like to analyze during course.	
Examination	Composed exam: Homework (50%) and Oral Presentation (50%)	

Literature	Among others: McKinney, W. (2017) Python for Data Analysis, 2nd edition. O'Reilly Media Inc., Ernesti J. & Kaiser P. (2020) Python 3. Rheinwerk Verlag GmbH
Additional Information	This module will take place as a 3-day block course at GEOMAR. Students need to bring their own laptops and software needs to be installed prior to the course, please therefore register with rkiko@geomar.de for the course.

Module Name	Metal Contaminants – Metals in the Ocean	
Module Number	bioc385-01a	
Person in Charge	Prof. Dr. Sylvia Sander Phone: +49-(0)431-600-1420, E-mail: ssander@geomar.de	
Semester / Duration	3. semester / one semester	Status Optional
Regular Cycle	Annual in winter semester	
Study Program	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	<u>Metal Contaminants - Metals in the Ocean</u> (Lecture) Prof. Dr. Sylvia Sander, Dr. Rebecca Zitoun (some topics may be taught by other internal or external scientists to provide the best expertise)	2 hr per week / 20 students
	<u>Metal Contaminants – Metals in the Ocean</u> (Seminar) Prof. Dr. Sylvia Sander (some topics may be taught by other internal or external scientists to provide the best expertise)	1 hr per week / 20 students
Credit Points / Workload	5 ECTS / 150h: 35 contact hours, 115 h independent study	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	This course provides students with a comprehensive understanding of marine metal contaminants, encompassing their chemistry, environmental toxicology, risk assessments, management, and analytical skills. By the end of the course, students will have developed an interdisciplinary understanding and practical expertise on metals in the ocean and the skills to assess and evaluate potential impacts of metal contaminants in marine environments.	
Course Content	Students will study the transport, fate, and speciation of metals, alongside bioavailability, bioaccumulation, and detoxification mechanisms. The curriculum emphasizes evaluating biotic responses to metal exposure, utilizing biomarkers, and conducting risk assessments through environmental toxicology principles. A key focus is on the impact of current and future ocean activities, such as deep- sea mining and ocean alkalinity enhancement, on metal contamination. Students will analyze these activities' environmental implications and explore potential solutions.	

	The course also covers the scientific, technological, societal, and economic aspects of ocean interventions, integrating natural sciences with economics, biotechnology, ethics, policy, and ocean governance. Case studies will provide practical insights into contemporary marine ecotoxicology applications. The blended course format will consist of on-site / hybrid, as well as self-study online lectures, on-site / hybrid Q&A sessions and applied learning exercises. While the hybrid / online lectures will be accompanied by online self-tests, the exercises will deepen the theoretical knowledge by examples of practical application. Students will read and discuss selected papers and engage in group discussions. Each student will also identify a topic of interest and produce an essay, as well as present it to the group. The topic of the presentation may be any area of metal contaminants, a case study or a question (e.g. impact of climate change, efficacy of ocean solutions / interventions) with an explicit link to marine metal contaminants.
Examination	Graded oral presentation (100%) Prerequisite to delivering the oral presentation is an active participation during the seminars and exercises.
Literature	Relevant literature will be distributed over the course of the module.
Additional Information	Master students from other mnf programs are welcome, too, but must verify with the course coordinators of their study program that credits are accepted. The course will also be offered through the international SEA-EU program.