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 defense) 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

Modeling' (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.

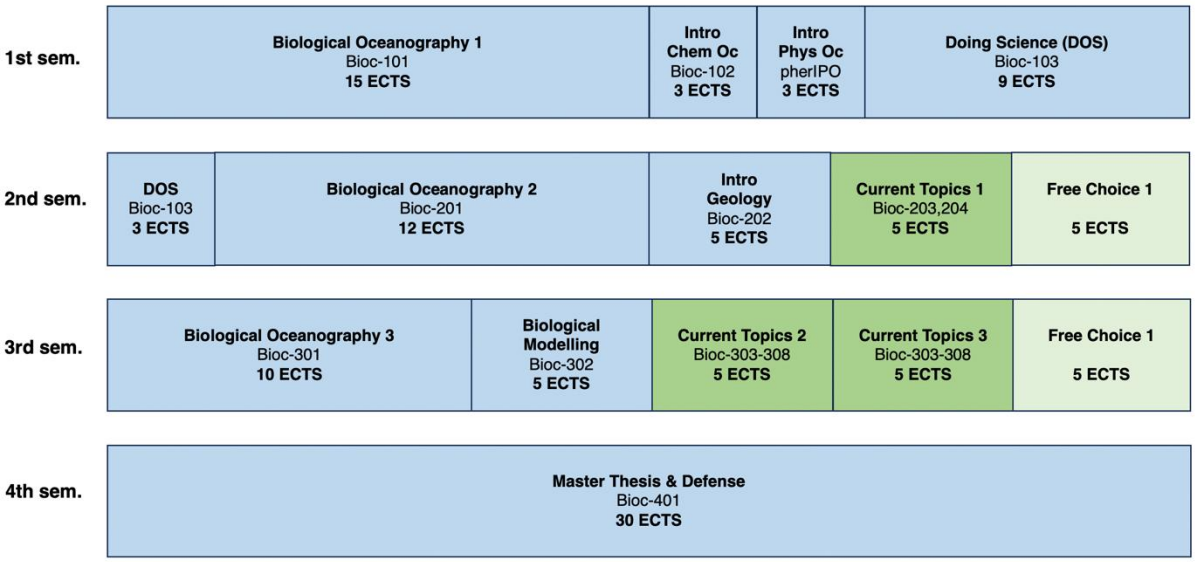

Fig. 1: the modified program structure, for the current / old structure see https://www.geomar.de/en/studying/msc-biological-oceanography/program. Courses in blue are compulsory. Dark green courses are compulsory elective, light green courses are free choice.

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).

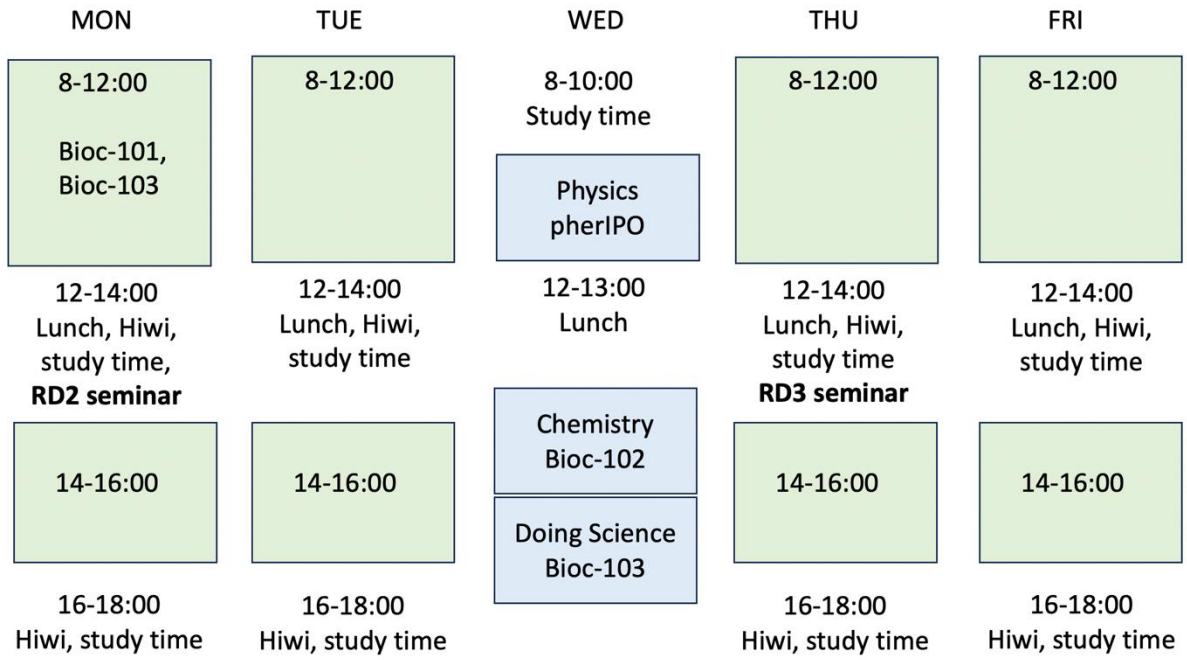

Fig 2. 1st semester time schedule. Green: block course, 24 hours per week (4 mornings, 4 afternoons) Blue: weekly recurring courses, concentrated on Wed to allow for maximum flexibility during rest of the week. RD2,3 = GEOMAR research divisions biogeochemistry, ecology.

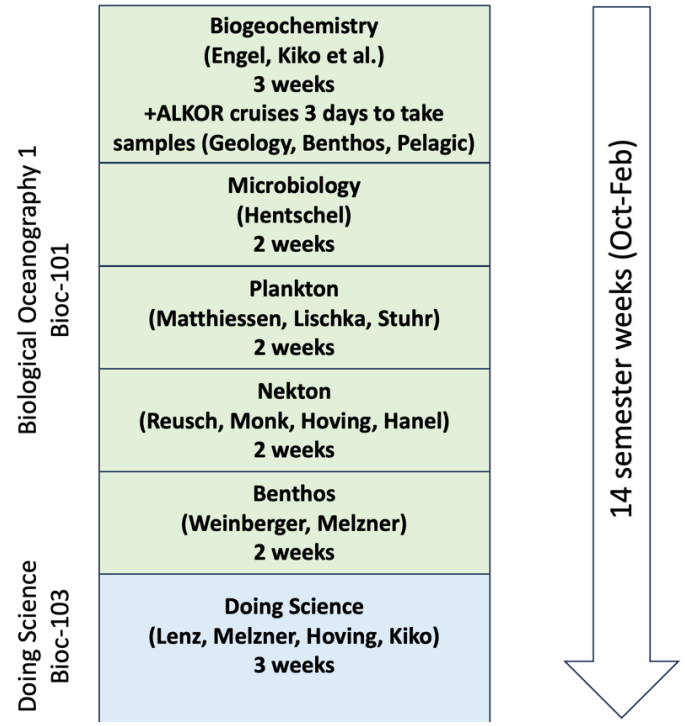

Fig 3. 1st semester. Course progression over the semester during the 24-hour time window (light green time slots in Fig. 2). The ALKOR cruise will be extended to four days.

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.

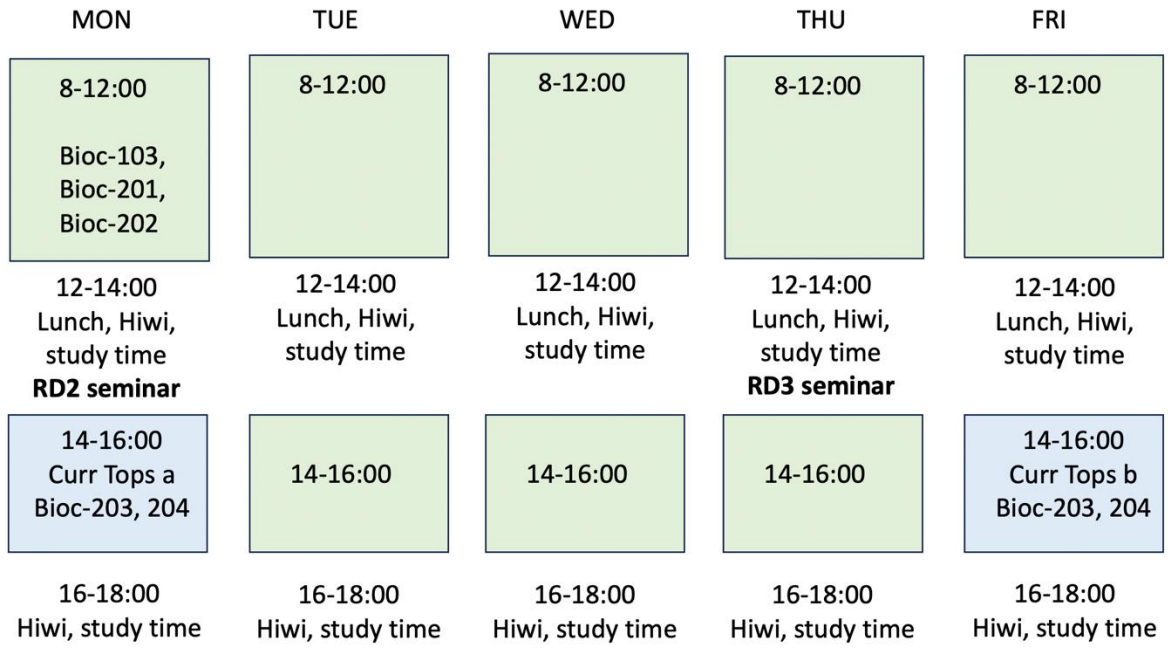

Fig 4. 2nd semester time schedule. Green: block course, 26 hours per week (4 mornings, 4 afternoons. Students have to choose one of two Current Topics options. During these classes, lectures and seminars are combined so students learn to quickly assimilate and present scientific papers.

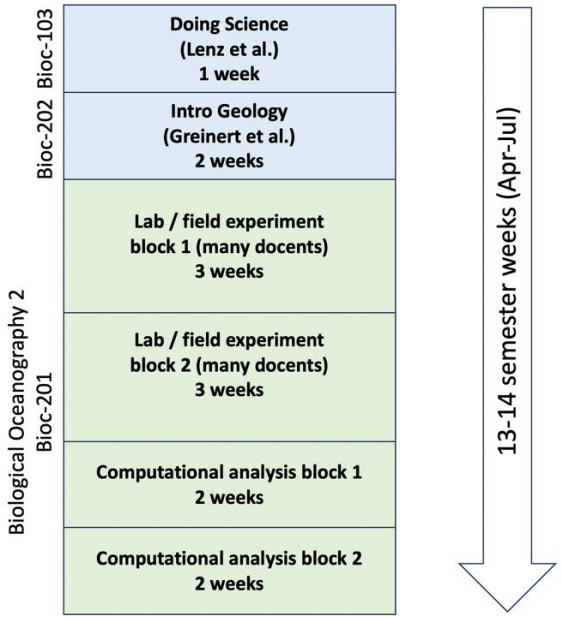

Fig 5. 2nd semester. Course progression over the semester during the 26-hour time window (light green time slots in Fig. 4).

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 Modeling).

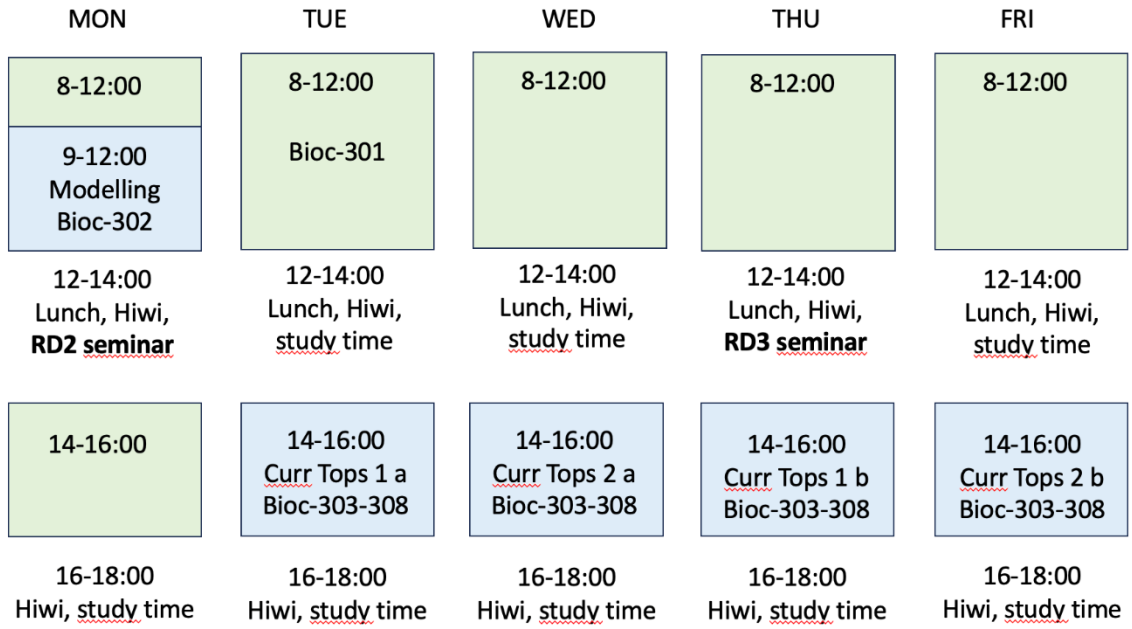

Fig 6. 3rd semester time schedule. Green: time reserved for working on thesis proposal and thesis hypotheses with future thesis advisor(s). Students have to choose two Current Topics classes. During these classes, lectures and seminars are combined so students learn to quickly assimilate and present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

The **fourth semester** is entirely reserved for preparation and, eventually, defense 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. iMSMS) 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	Prof. Dr. Thorsten Reusch Phone: +49-(0)431-600-4550, E-mail: treusch@geomar.de	
Semester / Duration	1. semester / one semester	**Status**
Regular Cycle	Annual in winter semester	Compulsory
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Biological Oceanography 1 (Lecture) Prof. Dr. Reusch, Prof. Dr. Melzner, Prof. Dr. Hentschel-Humeida, Prof. Dr. Tasdemir, Prof. Dr. Perner, Prof. Dr. Engel, Prof. Dr. Needham, Prof. Dr. Brennan, Dr. Hoving, Prof. Dr. Hanel, Prof. Dr. Kiko, PD Dr. Weinberger, PD Dr. Briski, Dr. Matthiessen, Dr. Wall, Dr. Monk, Dr. Scotti, Dr. Bergauer, Dr. Bayer et al. Biological Oceanography 1 (Practical) Prof. Dr. Reusch, Prof. Dr. Melzner, Prof. Dr. Hentschel-Humeida, Prof. Dr. Tasdemir, Prof. Dr. Perner, Prof. Dr. Engel, Prof. Dr. Needham, Prof. Dr. Brennan, Dr. Hoving, Prof. Dr. Hanel, Prof. Dr. Kiko, PD Dr. Weinberger, PD Dr. Briski, Dr. Matthiessen, Dr. Wall, Dr. Monk, Dr. Scotti, Dr. Bergauer, Dr. Bayer et al.	3 h per week / 20 students 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	Biological Oceanography 1 (Lecture) On completion of this module students should be able to discuss and link key concepts in biological oceanography. They should have an understanding of 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 able to read and critically judge current literature on the topics covered. Biological Oceanography 1 (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. Biological Oceanography 1 (Lecture) 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. Biological Oceanography 1 (Practical) 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**
Regular Cycle	Annual in winter semester	Compulsory
Study Programme	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers	Contact Time / Group Size
	Chemical Oceanography (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. CO_2) and non-greenhouse gases (incl. He, N_2) 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	pherIPOnf-01a (MNF-pher/IPO (import module Physik des Erdsystems)	
Person in Charge	PD. Dr. Joke Lübbecke Phone: +49-(0)431-600-4150, E-mail: jluebbecke@geomar.de	
Semester / Duration	1. semester / one semester	**Status** Compulsory
Regular Cycle	Annual in winter semester	
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Introduction to Physical Oceanography (Lecture) PD. Dr. Joke Lübbecke	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	Prof. Dr. Frank Melzner Phone: +49-(0)431-600-4274, E-mail: fmelzner@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 Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Doing Science (Lecture) Prof. Dr. Kiko, Dr. Hoving, Dr. Lenz Doing Science (Practical) Dr. Lenz, Prof. Dr. Melzner, Dr. Hoving	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. Doing Science (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. Doing Science (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. Frank Melzner Phone: +49-(0)431-600-4274, E-mail: fmelzner@geomar.de	
Semester / Duration	2. semester / one semester	**Status**
Regular Cycle	Annual in summer semester	Compulsory
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	A-Experimental ecology, evolution & biogeochemistry: laboratory and field approaches I and II (Practical) Prof. Dr. Reusch, Prof. Dr. Melzner, Prof. Dr. Hentschel-Humeida, Prof. Dr. Tasdemir, Prof. Dr. Perner, Prof. Dr. Engel, Prof. Dr. Needham, Prof. Dr. Brennan, Prof. Dr. Kiko, PD Dr. Weinberger, PD Dr. Briski, Dr. Matthiessen, Dr. Wall, Dr. Monk, Dr. Scotti, Dr. Bergauer, Dr. Bayer et al.	9 h per week / 20 students
	B-Experimental ecology, evolution & biogeochemistry: fundamental principles in ecology, evolution and biogeochemistry (Lecture) Prof. Dr. Reusch, Prof. Dr. Melzner, Prof. Dr. Hentschel-Humeida, Prof. Dr. Tasdemir, Prof. Dr. Perner, Prof. Dr. Engel, Prof. Dr. Needham, Prof. Dr. Brennan, Prof. Dr. Kiko, PD Dr. Weinberger, PD Dr. Briski, Dr. Matthiessen, Dr. Wall, Dr. Monk, Dr. Scotti, Dr. Bergauer, Dr. Bayer et al.	3 h per week / 20 students
	C-Experimental ecology, evolution & biogeochemistry: analysis and computing methods I and II (Practical) Prof. Dr. Reusch, Prof. Dr. Melzner, Prof. Dr. Hentschel-Humeida, Prof. Dr. Tasdemir, Prof. Dr. Perner, Prof. Dr. Engel, Prof. Dr. Needham, Prof. Dr. Brennan, Prof. Dr. Kiko, PD Dr. Weinberger, PD Dr. Briski, Dr. Matthiessen, Dr. Wall, Dr. Monk, Dr. Scotti, Dr. Bergauer, Dr. Bayer et al.	6 h per week / 20 students
Credit Points / Workload	12 ECTS / 252 h contact, 48 h self-study time	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	

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'). A-Experimental ecology, evolution & biogeochemistry: laboratory and field approaches I and II (Practical) 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. B-Experimental ecology, evolution & biogeochemistry: fundamental principles in ecology, evolution and biogeochemistry (Lecture) 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. C-Experimental ecology, evolution & biogeochemistry: analysis and computing methods I and II (Practical) 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. A-Experimental ecology, evolution & biogeochemistry: laboratory and field approaches I and II (Practical) 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). B-Experimental ecology, evolution & biogeochemistry: fundamental principles in ecology, evolution and biogeochemistry (Lecture) 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. C-Experimental ecology, evolution & biogeochemistry: analysis and computing methods I and II (Practical) 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**
Regular Cycle	Annual in summer semester	Compulsory
Study Programme	Master of Science in Biological Oceanography	
Classes	Class Title (Teaching Form) Lecturers, Seminar & Exercises	Contact Time / Group Size
	Introduction to Marine Geology (Lecture) Prof. Dr. Greinert, Prof. Dr. Nürnberg, Prof. Dr. Kutterolf, Dr. Gutjahr, Dr. Geersen, Dr. Crutchly Introduction to Marine Geology (Practical) Prof. Dr. Greinert, Prof. Dr. Nürnberg, Prof. Dr. Kutterolf, Dr. Gutjahr, Dr. Geersen, Dr. Crutchly	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	The course objective is to provide basic knowledge on Marine Geology. The course focuses on all aspects of Marine Geology and is the basis for more advanced courses in biological oceanography. A special focus will be placed on analysing samples taken during the ALKOR cruise within MNF-bioc-101. 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	Introduction to Marine Geology (Lecture) Topics of the lectures include: General introduction to marine geology, geophysics, tectonics, sedimentology 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. Introduction to Marine Geology (Practical) The topics of the hands-on parts of seminars, laboratory work and computer exercises include: Ocean technology & methodologies for ocean observations, determination of grain-size composition and organic content of sediment samples collected during ALKOR cruise,	

	morphological exploration of the seafloor, quantifying geochemical fluxes (Fick's first law, box models), modern methods in paleoclimatic research.
Examination	Graded written examination (100%).
Literature	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. Ulf Riebesell Phone: +49-(0)431-600-4444, E-mail: uriebesell@geomar.de	
Semester / Duration	3. semester / one semester	**Status**
Regular Cycle	Annual in winter semester	Compulsory
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	A-RD and RU seminars (Seminar) All heads of research units (Rus) and research divisions (RDs) involved in the M.Sc. Biological Oceanography curriculum.	1 h per week / 20 students
	B-Research cruise, field course or internship (Practical) All docents involved in the M.Sc. Biological Oceanography curriculum, external advisors.	10 days or equivalent / 20 students
	C-Thesis Proposal (Exercise) All docents involved in the M.Sc. Biological Oceanography curriculum.	2 h per week / 20 students
Credit Points / Workload	10 ECTS / 110 h contact, 140 h self-study	
Prerequisites	All the compulsory modules of the first and second semester required as stated in the Examination Regulations.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	Students will gain an insight into the ideas that drive major multidisciplinary research projects. They should be able to link applied and fundamental research. This module aims at encouraging students to think laterally between scientific disciplines and establish contacts with research groups to eventually develop ideas for their thesis. Students will interact and learn to discuss with top scientists in oceanography through participation in GEOMAR RD2 and RD3 seminars that feature invited presentations of influential publications in the various sub-disciplines in the field. Through an internship or a cruise participation, students collect additional experience in relevant fields to help them to select a suitable research topic for their thesis project. Students can reach out to NGOs, companies and internal / external academic groups to gain diverse experiences that will help them shape their thesis proposal and choice of host working group for their thesis. Students will then write their thesis proposal, in close collaboration with their primary advisor and give an oral presentation to the GEOMAR science community to further refine their thesis	

	proposal. Students will use knowledge obtained in MNF-bioc-103 ('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. A-RD and RU seminars (Seminar) Regularly 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 the GEOMAR and are held by internal as well as invited internationally leading scientists. Students participate in at least 10 seminars and document participation. B-Research cruise, field course or internship (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. C-Thesis Proposal (Exercise) Students will choose an advisor and research group to conduct their thesis with. In close collaboration with the advisor, and building on module MNF-bioc-103, 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 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**
Regular Cycle	Annual in winter semester	Compulsory
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Biological Modelling (Practical) Prof. Dr. Oschlies, Dr. Pahlow, Dr. Schartau	3 h per week / 25 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 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**
Regular Cycle	Annual in summer semester	Compulsory
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Master Thesis (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 here 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. Frank Melzner Phone: +49-(0)431-600-4274, E-mail: fmelzner@geomar.de	
Semester / Duration	2. semester / one semester	**Status**
Regular Cycle	Annual in summer semester	Compulsory elective
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Current Topics in Marine Ecology I (Lecture) Prof. Dr. Melzner, Dr. Matthiessen, PD. Dr. Florian Weinberger, Prof. Dr. Reusch, Prof. Dr. Brennan et al. Current Topics in Marine Ecology I (Seminar) Prof. Dr. Melzner, Dr. Matthiessen, PD. Dr. Florian Weinberger, Prof. Dr. Reusch, Prof. Dr. Brennan 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		
Learning Outcomes	Upon successful completion of this module, students will have improved their competence to critically evaluate on-going research in marine ecology & evolution, participate in scientific discussions, select their own research questions, formulate testable hypotheses, and select state-of-the-art methodologies. The lecture series will introduce advanced current topics in ecology & evolution that are not covered by MNF-bioc-201. Students will e.g. obtain an in depth understanding of biodiversity – ecosystem functioning relationships and how indirect effects modulate climate change impacts within complex communities. A strong focus will be placed on how climate change can alter marine food webs. Further, students will learn about genomic mechanisms driving rapid adaptation to climate change.	

Course Content	Current Topics in Marine Ecology I (Lecture) The lecture will focus on genomic mechanisms underpinning rapid adaptation to climate change (e.g. chromosomal inversions, various mutations) and methods to study these mechanisms. Students will learn how to distinguish between the influence of epigenetic vs. genetic change in adjustment to novel marine climates / environment. Physiological mechanisms underpinning phenotypic plasticity will be addressed. A special focus will be placed on rapid evolution within complex communities and the modulating role of species interactions on adaptive processes. Further topics will be biodiversity-ecosystem functioning relationships and how they might be altered due to human activities & climate change. Current Topics in Marine Ecology I (Seminar) The seminar series will mirror lectures of the respective week and students will present influential publications in small group and individual oral presentations, followed by classroom discussion with fellow students and a range of docents. A strong focus will be placed on selecting papers utilizing innovative methods (e.g. novel sequencing technology, novel mesocosm experimental infrastructure, structural equation modelling). We aim to open these seminars to PhD students and other scientists as well, to spark diverse discussions between scientists and students.
Examination	Graded oral presentation (100%).
Literature	Relevant literature will be provided during the module.
Additional Information	None.

Module Name	**Current Topics in Marine Biogeochemistry I**	
Module Number	Bioc204-01a	
Person in Charge	Prof. Dr. Ulf Riebesell Phone: +49-(0)431-600-4444, E-mail: uriebesell@geomar.de	
Semester / Duration	2. semester / one semester	**Status**
Regular Cycle	Annual in summer semester	Compulsory elective
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Current Topics in Biogeochemistry (Lecture) Prof. Dr. Riebesell, Prof. Dr. Körtzinger Current Topics in Biogeochemistry (Seminar) Prof. Dr. Riebesell, Prof. Dr. Körtzinger	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	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 series will provide students with the opportunity to improve their competence to critically evaluate on-going research, participate in scientific discussions, 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	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 series students will be exposed to current research topics, new developments and novel scientific concepts in the area of marine biogeochemistry. 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	None.

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**
Regular Cycle	Annual in winter semester	Compulsory elective
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Current Topics in Marine Ecology II (Lecture) PD Dr. Briski, Dr. Monk et al. Current Topics in Marine Ecology II (Seminar) 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, participate in scientific discussions and 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. Ulf Riebesell Phone: +49-(0)431-600-4444, E-mail: uriebesell@geomar.de	
Semester / Duration	3. semester / one semester	**Status**
Regular Cycle	Annual in winter semester	Compulsory elective
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Current Topics in Marine Biogeochemistry II (seminar) Prof. Dr. Ulf Riebesell et al.	2 h per week / 25 students
	Current Topics in Marine Biogeochemistry II (lecture) Prof. Dr. Ulf Riebesell 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 of 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, participate in scientific discussions, 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	Prof. Dr. Frank Melzner Phone: +49-(0)431-600-4274, E-mail: fmelzner@geomar.de	
Semester / Duration	3. semester / one semester	**Status**
Regular Cycle	Annual in winter semester	Compulsory elective
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Current Topics in Molecular & cellular Physiology (Lecture) Prof. Dr. Melzner, Prof. Dr. Perner & international guests	2 h per week / 25 students
	Current Topics in Molecular & cellular Physiology (Seminar) Prof. Dr. Melzner, Prof. Dr. Perner & international guests	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	Current Topics in Molecular & cellular Physiology (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. Current Topics in Molecular & cellular Physiology (Seminar) 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**
Regular Cycle	Annual in winter semester	Compulsory elective
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Current Topics in Marine Microbiology (Lecture) Prof. Dr. Ute Hentschel et al.	2 h per week / 20 students
	Current Topics in Marine Microbiology (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	Current Topics in Marine Microbiology (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. Current Topics in Marine Microbiology (Seminar) 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**
Regular Cycle	Annual in winter semester	Compulsory elective
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Current Topics in Analytical Techniques (Lecture) Prof. Dr. Tasdemir et al. Current Topics in Analytical Techniques (Seminar) Prof. Dr. Tasdemir et al.	2 h per week / 20 students 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**
Regular Cycle	Annual in winter semester	Compulsory elective
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Current Topics in BGC modelling (Seminar) Prof. Dr. Oschlies, Dr. Pahlow, Dr. Schartau Fundamentals in BGC modelling (Lecture) Prof. Dr. Oschlies,Dr. Pahlow, Dr. Schartau, Dr. Koeve, Dr. Kriest, Dr. Frenger, Dr. Dietze, Dr. Loeptien, Dr. Landolfi	2 h per week / 15 students 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	Current Topics in BGC modelling (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 modeling concepts. The assessment is based on the oral presentation in the seminar. Fundamentals in BGC modelling (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@ti.bund.de	
Semester / Duration	2. or 4. semester / 2-week block course	**Status**
Regular Cycle	Annual in summer semester	Optional
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Fish Ecology (Excursion) Prof. Dr. Reinhold Hanel Fish Ecology (Exercise) Faunistics and Ecology of the Mediterranean Sea (Seminar)	3 h per week / 8 students 3 h per week / 8 students 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 have an understanding of 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 protocol (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 will take place as a 2-weeks 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, Homepage: www.geomar.de/	
Semester / Duration	2. semester / one semester	**Status**
Regular Cycle	Annual in summer semester	optional
Study Programme	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**
Regular Cycle	Annual in summer semester	Optional
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Seabird Ecology (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 aquired an advanced knowledge of key aspects of the life history of seabirds. This includes an understanding of seabird behaviour, 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 behaviour, seabird distrubution at sea, diet and feeding ecology as well as habitat choice. Secondly, the students will learn with which methods seabird ecology may be studied, 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 will take place as an 7-days block course after first exam period (end of July / beginning of August) at the "Forschungs- und Technologie-Zentrum Westküste" in Büsum.	

Module Name	Identification and taxonomy of marine invertebrates	
Module Number	MNF-bioc-267	
Person in Charge	Prof. Dr. Frank Melzner Phone: +49-(0)431-600-4274, E-mail: fmelzner@geomar.de PD Dr. Florian Weinberger Phone: +49-(0)431-600-4516, E-mail: fweinberger@geomar.de	
Semester / Duration	2. or 4. semester / one semester	**Status**
Regular Cycle	Annual in summer semester	Optional
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Marine Phyla and Communities (Lecture) F. Melzner, F. Weinberger	1 hr per week / 20 students
	Identification of marine animal taxa (Practical) F. Melzner, F. Weinberger	3 hr per week / 20 students
	Sample collection and identification at sea F. Melzner, F. Weinberger (Excursion)	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 course will be 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: bschneider@gpi.uni-kiel.de Dr. Susan Tegtmeier Phone: +49-(0)-431-600-4160, Email: stegtmeier@geomar.de	
Semester / Duration	2. or 4. semester / 1-week block course	Status
Regular Cycle	Annual in summer semester	Optional
Study Programme	**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**
	Carbon cycling in a changing climate (Lecture/Seminar/Exercise) Prof. Dr. Birgit Schneider Dr. Susan Tegtmeier Dr. Joachim Segschneider	3 h per week / 20 students
Credit Points / Workload	5 ECTS / 42 h contact, 83 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	Upon completion of the module the students will have obtained an in-depth understanding of the role of carbon (including the greenhouse gases CO_2 and methane) in the climate-system, with a focus on the coupling of atmosphere, ocean and solid earth. Students will have obtained detailed knowledge of the earth's climate history, with an emphasis on the cycling of carbon through atmosphere, ocean, sediments and biosphere. Students will be able to discuss and disseminate findings of the current IPCC assessment with scientists and the public.	

Course Content	The seminar is divided into interactive lectures connected to a student part with presentations and exercises. The student part includes studying and presenting recent articles on modern aspects of carbon in the climate-system. Within teams the students should learn to analyze and discuss scientific papers and IPCC chapters in more detail. Finally, a synthesis paper will be developed by all participants together.
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

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**
Regular Cycle	Annual in summer semester	Optional
Study Programme	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**
Regular Cycle	Annual in summer semester	optional
Study Programme	Master of Science in Biological Oceanography, Master of Chemistry (focus on Marine Chemistry)	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Air-Sea-Exchange (Lecture) Prof. Dr. Anja Engel Prof. Dr. Christa Marandino	2 h per week / 15 students
	Air-Sea-Exchange (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 regularly every week in English.

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**
Regular Cycle	Annual in summer semester	Optional
Study Programme	Master of Science Biology / Master of Science Biological Oceanography	
Classes	**Class Title (Teaching Form)**	**Contact time / group size**
	Coastal Fish Ecology (Practical) Coastal Fish Ecology (Lectures) Coastal Fish Ecology (Seminar) PD Dr. Katja Heubel	3,5 h per week / 12 students 0,7 h per week / 12 students 0,3 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 behaviour. • 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 behaviour • 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, prepration of oral presentatins 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 tba. Examination: More details will be given at the beginning of the module.
Literature	Literature and lecture notes will be made available at online web learning and teaching platform.
Additional Note	May also serve as course for for biol201 or ocean education. Under corona regulations, group size is limited to 8 students.

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**
Regular Cycle	Annual in winter semester	Optional
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Advanced Biological Modelling (Lecture) Prof. Dr. Andreas Oschlies Dr. Markus Pahlow Dr. Markus Schartau	2 h per week / 15 students
	Advanced Biological Modelling (Exercise)	2 h per week / 15 students
Credit Points / Workload	5 ECTS / 56 h contact, 69 h self-study time	
Prerequisites	Recommended Prerequisites: MNF-bioc-220 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 analyse simple 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**
Regular Cycle	Annual in winter semester	optional
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Climate relevant trace gases in the ocean (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 gase (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**
Regular Cycle	Annual in winter semester	Optional
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	How to write and publish a scientific paper (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 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 Does 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.sfedit.net/newsletters.htm	
Additional Information	This module will be given in 2 hour-seminars every second 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**
Regular Cycle	Annual in winter semester	Optional
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	How to make and keep a habitable planet – biogeochemistry-climate feedbacks and astrobiology (Lecture) Prof. Dr. Andreas Oschlies	2 h per week / 30 students
	How to make and keep a habitable planet – biogeochemistry-climate feedbacks and astrobiology (Exercise) Dr. David Keller	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 MNF-klim-302. 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**
Regular Cycle	Annual in winter semester	Optional
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Marine biodiscovery and biotechnology (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 analyse 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**
Regular Cycle	Annual in summer semester	Optional
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Finnish-German Marine Ecological Exchange Lab (Seminar) – Florian Weinberger	1 h per week / 10 students
	Finnish-German Marine Ecological Exchange Lab (Excursion) – Florian Weinberger	3 h per week / 10 students
	Finnish-German Marine Ecological Exchange Lab (Exercise) – Florian 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 2020, 2022) and at either the Wadden Sea Station at List/Sylt or GEOMAR facilities in Kiel (in 2021, 2023). 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 pay for travel, accommodation and food.

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**
Regular Cycle	Annual in winter semester	Optional
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	New Trends in Marine Biotechnology (Seminar) 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**
Regular Cycle	Annual in winter semester	Optional
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Lecture: Microbial ecology and genomics **Exercises**: Data and genomic analyses **Seminar**: Current literature discussion in microbial ecological techniques	1 h per week / 10 students 2 h per week / 10 students 1 h per week / 10 students
Credit Points / Workload	5 ECTS / 56 h contact, 69 h self-study time	
Prerequisites	None.	
Completion Module	None.	
Following Module	None.	
Learning Outcomes	The students should leave this course with strong foundation and understanding of Microbial Ecology and Genomics, including exposure to state-of-the-art in microbial ecological methods, and practical experience with genomic analyses. Learning goals include: i. Diversity, ecology, and genomics of Microbial ecology ii. molecular ecological tools, iii. practical experience with novel sequence and genomic data from the Baltic Sea	
Course Content	The format will consist of lectures, presentation (by the students) 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. For this reason, in large degree, microbial ecology is a methods-driven field, with major insights often following advances in technology or novel applications of existing. In this course, we will discuss microbial ecology and how genomics can	

	shed light on the diversity and dynamics of the ocean microbial ecosystem. Lectures will highlight how major patterns and questions of global-scale involve microbial ecology. These questions will be considered in the context of the strongly stratified, ecological relevant, and economically meaningful system of the Baltic Sea as a model ecosystem. We will review state-of-art molecular techniques and their potential application to unraveling microbial mysteries. Example topics covered will include for example (as chosen by students), single-cell sequencing and physiological measurements, nucleic acid-isotope labelling approaches, genetic engineering of natural communities, fluorescence-based molecular microscopic analyses, Raman spectroscopy, viral tagging, chemotaxis assays. We will dive deeper into genomic techniques using powerful, interactive and intuitive visualization techniques and analyze novel molecular and genomic data from the Baltic Sea related to cycling of carbon and nitrogen.
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**
Regular Cycle	Annual in winter semester	Optional
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Geomicrobiology of sediments (Lecture) Prof. Dr. Mirjam Perner	1 h per week / 12 students
	Geomicrobiology of sediments (Seminar) Prof. Dr. Mirjam Perner	1 h per week / 12 students
	Geomicrobiology of sediments (Practical) 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 Gaschromatograhy 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	-
Examination	Graded oral presentation (100%)
Literature	Relevant literature will be given out during the module.
Additional Information	Block course: t.b.a. Dates: Lecture: 9:30-10:15 / Seminar: 10:15-11:00 / Place: East shore campus - library Geomicrobiology Geb. 12/ Room 330 Dates: Practical: 11:15-16:30 / Place: East shore campus - Geb. 12/ Labs 325 and 326

Module Name	Sustainable Ocean Food Production and Security	
Module Number	bioc380-02a	
Person in Charge	Prof. Dr. Thorsten Reusch Phone: 0431 600-4550; E-mail: treusch@geomar.de	
Semester / Duration	3. semester / one semester	**Status**
Regular Cycle	Annual in winter semester	Optional
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Introduction to sustainable ocean food production and security (Lecture) Dr. Hassan Humeida, Scientific approaches to sustainable ocean food production and security (Seminar) Dr. Hassan Humeida,	2 h per week / 25 students 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 module, students will have gained an in depth understanding of the sustainable production of seafood against the background of largely unsustainable practises present today. Students will be able to assess whether or not countries are dependent upon seafood as essential protein source. They will be able to assess whether or not fish populations are exploited / aquaculture stocks are raised in a sustainable way, and they will learn the major approaches to preserve harvested marine populations, such as quotas, gear restrictions, and spatial closures. They will have gained detailed process understanding of how climate change exerts additional pressure on exploited marine populations, how fish stocks will rapidly change distribution ranges with a warming climate, and how overexploitation drives fisheries induced selection. They will have gained insights into local aquaculture companies during site visits which will prepare them for a job in the marine food sector.	
Course Content	Hosting some of the world's most productive ecosystems, the global ocean plays an increasingly important role in providing food to an ever growing world population. However, global change, pollution, and over-exploitation put the ocean's contribution to human well-being at risk. One key question for science and society is: How can we sustain marine food production for a growing world population? Integrated approaches involving multidisciplinary science, practice, and education may promote a solution-oriented understanding and development toward a sustainable future ocean food security.	

	The interdisciplinary lecture will give an introduction to the various fields of marine food science in the context of past practices and future sustainable development goals (Agenda 2030). Topics include nutritional, environmental (including marine diseases), economic and societal aspects of marine resources for human nutrition as well as future food production and security. One focus will be placed on whether nations depending of fisheries, such as the West-African countries (i.e., Senegal or Ghana), benefit from the ocean food based value chain. Selected case studies will be presented and discussed. Students will lead the seminar's discourse. They will present ocean food related research chosen according to their individual disciplinary background and interest and will moderate the discussion.
Examination prerequisite	-
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 masters module is interdisciplinary. Students interested in nutritional, environmental, political and societal aspects of marine food science are welcome. The lecture will be given regularly every week which will be followed by student seminars. Please check UnivIS for exact dates.

Module Name	**Scientific computing: data analytics in marine research – python introduction and beyond**	
Module Number	Bioc383-01a	
Person in Charge	Prof. Dr. Rainer Kiko E-mail: rkiko@geomar.de	
Semester / Duration	1. or 3. semester / one semester	**Status**
Regular Cycle	Annual in winter semester	Optional
Study Programme	Master of Science in Biological Oceanography	
Classes	**Class Title (Teaching Form)** **Lecturers**	**Contact Time / Group Size**
	Scientific computing: data analytics in marine research – python introduction and beyond (lecture and excercises**)** 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 analyse during course.	
Examination	1 hour written examen at the end of day 3	

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**
Regular Cycle	Annual in winter semester	Optional
Study Programme	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>Case studies of marine metal contaminants</u> (Seminar) Prof. Dr. Sylvia Sander Dr. Rebecca Zitoun (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 / 42 h contact, 83 h self-study time	
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. Students will study the transport, fate, and speciation of metals, alongside bioavailability, bioaccumulation, and detoxification mechanisms. The curriculum emphasises evaluating biotic responses to metal exposure, utilising 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. By the end of the course, students will have developed an interdisciplinary knowledge and practical expertise on metals in the ocean and the skills to assess and manage metal contaminants in marine environments.
Course Content	The course format will consist of lectures, seminars illustrating case studies from ongoing activities, presentation (by students) of selected papers, and group discussions. Each student will also identify a topic of interest and 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%)
Literature	Relevant literature will be distributed within the respective courses.
Additional Information	Master students from other mnf programmes are welcome, too, but must verify with the course coordinators of the course that credits are accepted. The course will also be offered through the international SEA-EU programme.