

# MSc Marine Biology – Module description (A)

## MODULE A: FUNDAMENTALS OF MARINE BIOLOGY AND ECOLOGY

Number of credit points:	15 CP (= 450 h)
Contact hours:	168 h
Self-studies:	282 h (reading text books, preparing seminar talks, exam preparation)
Module coordinator	Prof. Dr. Wilhelm Hagen

## MODULE CONTENT (OBLIGATORY COURSES)

- A1. Principles of Marine Biology and Biological Oceanography (5 CP)
- A2. Principles of Marine Ecophysiology (5 CP)
- A3. Experimental Design and Data Analysis (5 CP)

## TIMING AND DURATION OF MODULE:

each winter semester (6 weeks)

## REQUIREMENTS FOR PARTICIPATION:

no formal requirements (except for enrolment in relevant MSc programme)

## LANGUAGE

English

## LEARNING OUTCOME (COMPETENCES):

The students will acquire an overview of the role of the ocean's biota in the earth system based on the evolutionary ecology of marine organisms and their effect on past, present and future global climate via cycles of biogenic components. They will be able to apply the principles of natural selection of marine species to understand their evolution and impact on the biosphere. The students will learn the principles of physiological adaptations of marine organisms (particularly algae, invertebrates and fish) to their environment and they will understand the impact of global and local environmental changes on marine key species and the related consequences for ecosystem functioning.

The students will acquire relevant tools for experimental design and data analysis including statistical assessments, they will be able to apply various hypothesis tests and estimate model parameters.

Practical skills:

- Training of presentation skills and the ability to participate in scientific discussions
- Developing scientific questions and hypotheses

## CONTENTS OF THE MODULE:

The various topics covered include:

- Theoretical foundation of marine biological sciences

- Principal concepts and tools (statistics) in marine biology
- Life in the marine realm, its environment and how it selects for specific traits
- Physiological reactions of individual organisms and their contribution to ecosystem functioning
- Role of the biological carbon pump
- Concepts in statistics
- Introduction to current hot topics in marine biology in general and in biological oceanography in particular

#### MODES OF EXAMINATION:

This module concludes with a single written examination covering the entire module.

# MSc Marine Biology – Module description (B)

## MODULE B: MULTIDISCIPLINARY OCEANOGRAPHY

Number of credit points:	12 CP (= 360 h)
Contact hours:	140 h
Self-studies:	220 h (reading textbooks, exercises, preparation for exams)
Module coordinator	PD Dr. Holger Auel

## MODULE CONTENT (OBLIGATORY COURSES)

- B1. Marine Geosciences (2 CP)
- B2. Physical Oceanography (3 CP)
- B3. Marine Chemistry (5 CP)
- B4. Marine Biogeochemistry (2 CP)

## TIMING AND DURATION OF MODULE:

each winter semester (5 weeks)

## REQUIREMENTS FOR PARTICIPATION:

no formal requirements (except for enrolment in relevant MSc programme)

## LANGUAGE

English

## LEARNING OUTCOME (COMPETENCES):

This module provides the marine biology students with fundamental knowledge of associated disciplines, and thereby also qualifies them for multidisciplinary work. The students will acquire an understanding of the functional and evolutionary principles of the Earth system. They will assess the abiotic properties of the oceans and learn methods for measuring dynamic forces within. In marine chemistry this also includes practical experiences to analyze seawater properties. The students will recognise the ocean as a large chemical reaction system, operative on extremely variable temporal and spatial scales and mostly under non-steady-state conditions. They will be able to apply fundamental chemical principles to biogeochemical processes within the world's ocean and they will understand that simple chemical reactions form the basis of all matter transformation. The students will be able to assess the potential consequences of anthropogenic pollution for marine biota. They will acquire discipline-specific terminology and will be able to communicate and collaborate with colleagues from other disciplines.

## CONTENTS OF THE MODULE:

The module will give an introduction to the general functioning of the system Earth on various time scales as well as the transformation and exchange of elements in the marine environment. It deals with chemical, physical, geological as well as biogeochemical processes and reactions and covers climate variability and driving forces. Based on the understanding of these processes, their impact on marine biota and the evolution of key species will be highlighted.

The various topics include:

- Properties of the ocean and methodology for their measurement

- Fundamental understanding of the dynamic processes in the ocean and their climate-relevant role
- T and S distribution and water masses, density, stratification; global conveyor belt; chemical tracers
- Dynamic forces in the ocean; equatorial and coastal upwelling, subtropical gyres: Sverdrup circulation, vorticity; formation of water masses; thermohaline convection
- Thermodynamics and chemical equilibrium, chemical composition of seawater
- Marine carbonate system, alkalinity and its determinations.
- Trace elements (as micronutrients)
- Marine carbon and nitrogen cycles in space and time, including anthropogenic impact (ocean acidification, global warming, eutrophication, sea-level rising)
- Gases in seawater, redox chemistry of seawater
- POM cycle and particle flux
- Oxygen minimum zones, elemental composition of planktonic organisms
- Hydrothermal systems as sources and sinks for chemical elements
- Suspended matter and marine sediments; diagenetic sequence; role of sediments for elemental budgets
- Plate tectonics, earth history

#### MODES OF EXAMINATION:

This module concludes with a single written examination covering the entire module.

# MSc Marine Biology – Module description (C)

## MODULE C: DEVELOPMENT OF PERSONAL SKILLS AND CAPABILITIES

Number of credit points:	6 CP (= 180 h)
Contact Hours:	76 h
Self-studies	104 h (writing assignments, analysis of scientific publications)
Module coordinator	Prof. Dr. Kai Bischof

## MODULE CONTENT (OBLIGATORY COURSES)

- C1. Scientific communication (3 CP)
- C2. Marine research in Bremen (1 CP)
- C3. Ocean sciences colloquium (2 CP)

## TIMING AND DURATION OF MODULE:

each winter semester

## REQUIREMENTS FOR PARTICIPATION:

no formal requirements (except for enrolment in relevant MSc programme)

## LANGUAGE

English

## LEARNING OUTCOME (COMPETENCES):

This module aims at providing the students with an overview of the relevant topics studied in the Bremen research environment and the burning questions currently tackled by renowned experts in their field. It is meant to increase the students' skills for presenting scientific data and conclusions to the public. The students will understand the structure of a research paper and learn how to analyse the style and contents of the different sections. They will obtain a first impression on how marine research actually functions. The students will thus learn to conceptualise manuscripts to write their own research papers. They will understand the publishing process from the initial manuscript writing via the peer-reviewing to the final publication. They will understand the concept and quality control of scientific publishing. The students will realise that writing scientific papers is a vital and inspiring component of scientific research and career development. They will conduct writing exercises and practise their ability to participate in scientific discussions.

## CONTENTS OF THE MODULE:

At the beginning of this module the students will be introduced to the marine research centres in Bremen: the Alfred Wegener Institute for Polar and Marine Research, the Max Planck Institute for Marine Microbiology, the Leibniz Centre for Tropical Marine Ecology and they will get an overview on who is conducting research on which topic. For the colloquium, international and national experts are invited to present current topics in marine biology and associated disciplines. Furthermore, students will become acquainted with the principles of good scientific practise and scientific writing. The students will discuss best writing practice and analyse components of papers (title,

abstract, results, figures, discussion, etc.) with key examples for criticism chosen from submitted and published literature. Students will critically review complete manuscripts produced by scientists and generate appropriate abstracts and titles. Students will write a complete short communication or research article in a format suitable for submission and publication in a journal.

#### MODES OF EXAMINATION:

This module concludes with a writing assignment: a short communication in a journal submission format, which is evaluated by the lecturers. The assignment has to be passed, but it is not graded.

# MSc Marine Biology – Module description (D)

## MODULE D: MARINE ECOPHYSIOLOGY

Number of credit points:	15 CP (= 450 h)
Contact hours:	168 h
Self-studies:	282 h (preparation of seminar talks, writing lab report, reading textbooks, exam preparation)
Module coordinator	Prof. Dr. Kai Bischof

## MODULE CONTENT (OBLIGATORY COURSES)

- D1. Ecophysiology of marine microorganisms (5 CP)
- D2. Ecophysiology of marine algae (5 CP)
- D3. Ecophysiology of marine animals (5 CP)

## TIMING AND DURATION OF MODULE:

each summer semester (6 weeks)

## REQUIREMENTS FOR PARTICIPATION:

no formal requirements (except for enrolment in relevant MSc programme)

## LANGUAGE

English

## LEARNING OUTCOME (COMPETENCES):

This module will provide students with an understanding of the physiological principles of marine life on different organisational levels. The students will learn the fundamentals of marine microbial, algal and animal physiology and will recognise the interactions of physiology with the respective environment. The students will become familiar with the impact of metabolic pathways on marine biogeochemical cycles. They will get acquainted with analytical methods in ecophysiology and with instrumentation to monitor the abiotic environment in the context of physiological experiments. The students will be able to evaluate the impact of environmental disturbances on the individual fitness of the organisms and extrapolate this to impacts at the ecosystem level.

Theoretical knowledge:

- Students will have a solid overview of environmental biochemistry, physiology, and molecular biology
- They will have acquired a thorough understanding of the factors driving physiology, succession, zonation, and reproductive cycles
- They will develop an in depth understanding of the impacts of environmental factors on marine organisms
- They will understand the relevance of physiological studies in addressing the impacts of climate change on marine organisms

- Students will be able to conceptualise experimental studies and decide, which physiological response variables to measure under a given research question
- They will get acquainted with a variety of physiological and molecular methods

#### Practical skills:

The students will be able to

- cultivate and handle experimental organisms in cultures and how to precondition them for experimental treatments
- carry out experiments using organisms responsibly, analyse metabolic markers, and respond appropriately to problems that may occur during experimentation and measurements
- assess the relevant abiotic factors in the field, and they will know how to operate the respective instrumentation
- assess the quality of their data and suitability of the applied methods for answering the research question
- evaluate their results in the context of theoretical knowledge and to discuss their results appropriately
- present their studies to a group of peers
- write a laboratory report

#### CONTENTS OF THE MODULE:

The module will give an introduction to the vast diversity of microbial physiological phenomena in the marine environment and the role that microorganisms play in turning the marine biogeochemical cycles. The module further addresses the diversity of marine micro- and macroalgae and their physiological performance in response to the environmental framework. Under field conditions students will learn how algal physiology is shaped by the abiotic environment and vice versa. Furthermore, the module will provide an introduction to experimental studies on relevant processes in marine animal physiology with the goal to acquire a solid understanding of how organisms respond to environmental challenges such as changing temperatures, light, oxygen, salinity, pH and food supply.

The covered topics include

- Anaerobic respiration (denitrification, sulphate reduction, iron reduction), nitrogen fixation
- Chemolithotrophy, anoxygenic phototrophy, selected examples of symbiosis
- Enrichment and isolation of specific functional guilds of microorganisms
- Implications of ion- and osmoregulation for organismic functioning and performance
- Cellular energy budget and metabolite status under physiological control and stress conditions
- Molecular and physiological mechanisms underpinning climate change effects on marine organisms
- Thermal biology of marine organisms: mechanisms of thermal acclimation and evolutionary adaptation
- Ocean acidification effects on marine organisms: disturbances in acid-base regulation and functional consequences
- Hypoxia sensitivity of marine organisms in various habitats: changes in behaviour, development and energy production



#### MODES OF EXAMINATION:

This module concludes with a single written examination covering the entire module.

# MSc Marine Biology – Module description (E)

## MODULE D: MARINE ECOLOGY

Number of credit points:	15 CP (= 450 h)
Contact Hours:	168 h
Self-studies:	282 h (preparation of seminar talks, reading textbooks, exam preparation)
Module coordinator	PD Dr. Holger Auel

## MODULE CONTENT (OBLIGATORY COURSES)

- D1. Plankton Ecology (Phytoplankton, Zooplankton) (5 CP)
- D2. Benthos and Fish Ecology (5 CP)
- D3. Fisheries Biology and Aquaculture (5 CP)

## TIMING AND DURATION OF MODULE:

each summer semester (6 weeks)

## REQUIREMENTS FOR PARTICIPATION:

no formal requirements (except for enrolment in relevant MSc programme)

## LANGUAGE

English

## LEARNING OUTCOME (COMPETENCES):

This module will familiarize students with ecological principles of marine life at different organisational levels from microplankton to vertebrates. The students will learn the fundamentals of marine algal and animal ecology including taxonomic identification and they will apprehend the interactions of the respective organisms with the marine environment. The students will become familiar with the diversity and complexity of marine life, its characteristics and patterns, life history traits and trophic relationships. They will get acquainted with ecological methods to evaluate large data sets using e.g. multivariate statistics.

### Theoretical knowledge:

- Morphological characteristics and functional traits of major marine taxa (microplankton to fish)
- Conceptual models of an energy budget and its components
- Structural and functional parameters of marine populations and communities
- Role of plankton, benthos and fish in marine ecosystem functions

### Practical skills:

The students will be able to work independently on

- taxon or species identification using scientific identification keys
- the analysis of growth and reproduction (benthos)
- the statistical analysis of multivariate data sets (plankton, benthos)
- the application of empirical metabolic models to large data sets

- the calculation of common community descriptors from planktonic and benthic data sets
- the extrapolation of calculated ecosystem functions to assess local and regional ecosystem services

#### CONTENTS OF THE MODULE:

The module provides an introduction to marine ecology structure and functioning with the goal to acquire a sound understanding of the role of plankton, benthos and fish in marine ecosystems. The covered topics encompass working up plankton and benthos samples including species and trait identification, abundance, biomass, descriptive (multivariate) community statistics, biodiversity and similarity, population dynamics, community energetics and the use of empirical models to estimate community production, respiration and consumption.

#### MODES OF EXAMINATION:

This module concludes with a single written examination covering the entire module.

# MSc Marine Biology – Module description (F)

## MODULE F: ADVANCED STUDIES IN MARINE BIOLOGY

Number of credit points:	18 CP (= 560 h)
Contact hours:	200 h
Self-studies:	360 h (preparing for lab work, lab report, reading papers, seminar talk)
Module coordinator	Prof. Dr. Kai Bischof

## MODULE CONTENT (OBLIGATORY COURSES, BUT MANY OPTIONS FOR SELECTION OF TOPICS)

F1-SRP. Student Research Project (12 CP)  
F2-Ex. Marine biological field trip (3 CP)  
F3-F10 ... Advanced courses in marine biology (3 CP)

### DURATION AND TIMING OF MODULE:

flexible (offered once a year/each second semester)

### REQUIREMENTS FOR PARTICIPATION:

no formal requirements (except for enrolment in relevant MSc programme)

### LANGUAGE

English

### LEARNING OUTCOME (COMPETENCES):

During practical courses in the summer term, the students will get acquainted with various research topics and working groups at the participating institutions. In the selected research project, the students will learn how to address scientific questions. They will get involved in all phases of an experimental research project: Development of working hypotheses, experimental design, method selection, experimental work, analytics, data treatment and statistics, writing a research report and presenting the project results in a seminar.

During their field trip, the students will learn to observe and investigate ecological or physiological phenomena at field stations or on board research vessels, they will deepen their taxonomic knowledge and if performing a mini-project during a field trip, they will learn the relevant concepts and methodologies.

Advanced courses in marine biology offer the opportunity for the students to enter a preferred field of research, acquire modern (cutting-edge) methodologies and develop their individual expertise and profile (respective course descriptions provide details with regard to specific contents and to competences).

### CONTENTS OF THE MODULE:

Advanced courses in marine biology can be chosen from a wide spectrum of options (e.g. invertebrate nutrition, trophodynamic interactions, marine microbial ecology, ecological modelling, coral reef ecology, marine algae and associated animals as well as phytoplankton under global change).

Practical skills:

The students will be engaged in intense lab or fieldwork. The methodologies will depend on the selected research topic (physiology, genetics, ecological methods, statistics, NMR, etc.) and the course is usually closely related to the research activities of the involved working group.

#### MODES OF EXAMINATION:

This module is rather flexible and offers many elective options, therefore a single overall examination is not feasible. The student research project will be graded based on the lab report and the excursion will be graded based on a protocol. Several different evaluation modes are possible (seminar talk, scientific poster, etc.) for the advanced practical course, the mark is subject to decision by the supervisors. The overall grade for the module will be calculated as weighted mean of the different components.

# MSc Marine Biology – Module description (G)

## MODULE G: PROJECT DEVELOPMENT AND IMPLEMENTATION

Number of credit points:	9 CP (= 270 h)
Contact Hours:	50 h
Self-studies:	220 h (writing a research proposal, preparation of defence)
Module coordinators	Prof. Dr. Kai Bischof, Prof. Dr. Wilhelm Hagen

## MODULE CONTENT (OBLIGATORY COURSES)

G1. Research Management and Funding Opportunities (3 CP)

G2. Grant Proposal and Defence (6 CP)

### TIMING AND DURATION OF MODULE:

each winter semester

### REQUIREMENTS FOR PARTICIPATION:

no formal requirements (except for enrolment in relevant MSc programme)

### LANGUAGE

English

### LEARNING OUTCOME (COMPETENCES):

The students will gain insight into various options when applying for funding of research projects (DFG, BMBF, BfN, EU, foundations etc.). They will learn about adequate strategies for funding applications and appropriate sources to apply for research money. They will gain skills in how to write a research proposal. The students will understand, how research projects are managed.

### CONTENTS OF THE MODULE:

Theoretical knowledge:

- Presentation of the different funding institutions, explanation of funding guidelines
- Explanations and advice on proper project management

Practical skills:

- Writing of a grant proposal (in context with the planned thesis work)
- Defence (oral presentation and discussion) of the grant proposal (to supervisors and co-students)

#### MODES OF EXAMINATION:

The project proposal and the defence (oral presentation) are assessed together, and will result in one combined weighted grade.

# MSc Marine Biology – Module description (H)

## MODULE H: THESIS AND DEFENCE

Number of credit points:	30 CP (= 900 h)
Contact Hours:	ca. 100 h (individual supervision during thesis work, presentation and defence of thesis)
Self-studies:	ca. 800 h (specific to thesis project, incl. lab or field work, literature studies, data evaluation, writing the thesis, preparation of defence at colloquium)
Module coordinator	Prof. Dr. Wilhelm Hagen

## MODULE CONTENT (OBLIGATORY, TOPIC ELECTIVE)

H. Thesis and colloquium

### TIMING AND DURATION OF MODULE:

every summer semester (24 weeks)

### REQUIREMENTS FOR PARTICIPATION:

minimum of 60 CP acquired in Marine Biology MSc programme

### LANGUAGE

English

### LEARNING OUTCOME (COMPETENCES):

The graduates will have a proven level of knowledge and understanding of marine biology and related disciplines, with particular expertise in their specific field of research.

They will be able to apply their academic knowledge and understanding in a broad and multidisciplinary context and acquire new knowledge.

They will know how to approach and to conduct a largely self-directed complex scientific project (including analytical applications), solve problems and present and defend their data and conclusions to a scientific auditorium.

### CONTENTS OF THE MODULE:

As the concluding module of the MSc programme, it comprises the research-specific objectives, methodologies, data analysis and critical evaluation as well as thesis writing and defence.

Thereby, the students will investigate a specific research question.

### MODES OF EXAMINATION:

The two components of this module are graded together: the thesis contributes 75%, the colloquium 25% to the grade.