KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI

UNIA EUROPEJSKA
EUROPEJSKI
FUNDUSZ SPOŁECZNY

Course title
Atmospheric Pollution in the coastal zone

Studies

Field of study	Type	Form	Specialization
Oceanography, Geology	BA, MA	Full-time	all

Teaching staff: prof. UG, dr hab. Anita Lewandowska

Lecture: 10 hours	**ECTS credits: 2**

Aims of education
This course aims at providing students with improved understanding of air pollution in the coastal zone of the sea. Topics will include the principles of air pollutants, their sources, formation, dispersion and removal processes. Techniques of in situ measurements of pollutants in the ambient air will be also discussed. Lectures will be incorporated into extensive discusses and videos.
Students will develop and practice skills in reading, listening, summarizing and interpreting the scientific literature and the popular daily American and English press in regards to air pollution. Students will demonstrate ability to separate facts from rhetoric or opinion. Student will practice the ability of functioning effectively in multidisciplinary teams and communicate scientific information effectively (orally, writing).

Course contents
Basic introduction to atmospheric issues, chemical composition and structure of Earth atmosphere, characteristics of selected air pollutants. History and the present study of air pollution. Characteristic of the Baltic Sea region and identification pollutants sources in the marine atmosphere. Annual, seasonal and diurnal chemical composition variation of aerosols in the urbanized coastal zone of the Baltic Sea under changeable meteorological condition. The role of the sea in decreasing the level of air pollution. Consequences of air pollution for the climate, eutrophication, human health and the life quality. The air quality monitoring and longtime trends of air pollution state in the southern Baltic Sea (concentrations levels, alerts, informing citizens about dangerous situations). Pollution emission controls and regulations. Pollution reduction techniques. Basic information about wet and dry deposition, deposition velocity for gases and selected ions in aerosols. Chemical composition, transformation and removal processes of the air pollutants in marine regions. Acidifying and neutralizing compounds of wet deposition in the coastal regions. Loads of pollutants to the Baltic Sea.

Course title
Baltic Benthic Biodiversity

Studies

Field of study	Type	Form	Specialization
Oceanography	BA	Full-time	all

Teaching staff: prof. UG, dr hab. Urszula Janas

Lecture: 15 hours
Practical exercise: 30 hours

ECTS credits: 4

Aims of education
Gaining knowledge on benthic biodiversity of the Baltic Sea, new knowledge on role of different biotopes and species, structural and functional biodiversity, human impacts on sediment systems and the benthos in management of the Baltic Sea

Course contents
A. Lectures
A.1. The uniqueness of the environment in the Baltic Sea, variability of the environment, spatial distribution of benthic habitats and species. Examples of behavioural and physiological adaptations of benthic organisms to various environmental parameters.
A.2. Keystone species, engineering species, role and value of the benthic organisms for environment and for human.
A3. Habitats and biotopes in the Baltic Sea. Coastal area and deep see sediment. Role of the Baltic benthic habitats.
A.4. Benthic communities, structural and functional diversity, functional groups, biological traits concept.
A5. Human impact on Baltic benthic systems and the benthos in management of the Baltic Sea.
B. Practical exercises
B.1. Spatial differences in structural and functional diversity of the benthic fauna. Baltic benthic assemblages in quality assessment.
B2. Non-indigenous species in Baltic benthic system.
B.3. Functioning of the benthic fauna in undisturbed and disturbed environment.

Course title

Chemical processes in and between the atmosphere, seawater and sediment of the marine environment

Studies

Field of study	Type	Form	Specialization
Oceanography Geology, Water management	BA, MA	Full-time	all

Teaching staff

prof. UG, dr hab. Anita Lewandowska, prof. UG, dr hab. Bożena Graca, dr Magdalena Bełdowska, dr Dorota Burska, dr Katarzyna Łukawska-Matuszewska

Lecture: 30 hours Workshop: 75 hours	**ECTS credits: 6**

Aims of education

The course aims to familiarize students with chemical processes occurring on the boundary layers between the atmosphere, sea and sediment. Fluxes of carbon, nitrogen, phosphorus and toxic metals (e.g. mercury, lead, cadmium) as well as the importance of relationship between the identified components of the environment will be discussed. The fundamental course issues will be associated with the present-day problems of environment pollution.

Course contents

Lecture:The introduction to atmospheric chemistry. Carbon, nitrogen and phosphorus in the air. Microlayer of the sea. The role of sea and land in creating chemical composition of aerosols in the coastal zone. Wet and dry deposition of aerosols and gases to the sea water. The influence of atmosphere on sea water and sediments quality. Aerotoxins. The exchange of aerosols and gases between sea-land and atmosphere. The introduction to bottom sediment chemistry. Tools used to collection of bottom sediment and pore water samples. The exchange of dissolved constituents and gases between sediment-water boundary layer. Preliminary information on the toxicity of mercury, lead and cadmium in the marine environment. Toxic metals in atmosphere, including gaseous, aerosols, dry and wet deposition. Toxic metals in sewater including coastal and offshore zone. Toxic metals in sediments today and in the past.

Workshop:Atmospheric field experiment. Atmospheric laboratory course/ chemical analyze of sea microlayer and air samples. Calculation of chosen aerosol species and gases fluxes between air and sea microlayer. Sampling of sediments and pore-water. Measurement of fluxes of dissolved constituents at the sediment-water interface. Calculation of fluxes of dissolved constituents at the sediment-water interface.

Sampling of pore-water. Chemical analysis of pore water and sediment. Calculation of benthic diffusive fluxes of nutrients at the sediment-water interface based on sediment and pore water analysis. Suspension field experiment. Chemical analysis of C, N, P, Si in particulate matter. Calculation of the vertical particulate C, N, P, Si flux. Preparation of environmental samples to analyze of toxic metals: mercury and lead. Analysis of mercury and lead concentration in environmental samples. Toxic metals in air, water and sediments of coastal zone.

Course title
Dynamical Systems Theory in Biology and Oceanography

Studies

Field of study	Type	Form	Specialization
Oceanography	BA, MA	Full-time studies	all

Teaching staff: prof. UG dr hab. Witold Cieślikiewicz

Lecture: 45 hours Exercise: 35 hours **ECTS credits: 7**

Aims of education

Students will learn in a clear and accessible way many concepts from contemporary dynamics that have applications in biology and oceanography, in particular in such areas as biological oceanography, ecology, geophysical fluid dynamics, coastal hydrodynamics, and marine geology. The concepts studied include stability, periodic and chaotic behaviours of nonlinear systems, fractals, cycles, and complex dynamical systems. Students will learn on how to extract information about dynamics form data and will study time-series analysis techniques that allow one to investigate chaotic behaviour of a system.

The course is meant to attract a wider range of students of oceanography, not only those interested in strict physical oceanography. I hope to demonstrate with this course the beauty and power of mathematics in general, and its practical applications in biology and oceanography as well as the excitement of dynamical systems in particular. However, the mathematical prerequisites for this course are very modest. The actual course will start with a reminder of important background mathematical material from calculus, linear algebra, and complex numbers. This mathematical background to the course will also give a gentle introduction to differential equations.

The computer is an extraordinary visual and numerical exploration tool for dynamical systems. The computer programming language used in this course is *Mathematica*, which is a very powerful high-level programming language. *Mathematica* is used for the following reasons: computations are written in a *Mathematica* program in almost exactly the same way as the user would express them; the *Mathematica* language is very simple and easy to understand; *Mathematica* allows for a symbolic programming, on one hand, and has extensive numeric capabilities, on the other hand; *Mathematica* has extensive and easy-to-use graphics capabilities which make it possible to use scientific visualisation to analyse computer computation and simulation results; *Mathematica* is actually an integrated computing environment with an extremely well designed user interface called *a notebook* that allows one to use the computing system in an interactive way. The course will start with introduction on *Mathematica* programming for writing symbolic and numerical computation and simulation programs with emphasis given to functional style of programing, i.e. (i) looping is mostly avoided, (ii) conditional branching is minimised (iii) lists being the general data structures are manipulated in their entirety rather than in a piecemeal fashion, (iv) built-in *Mathematica* functions are utilised whenever possible, and (v) *anonymous* functions and *nested* function calls are used extensively.

Course contents

I. Elements of *Mathematica* programming

1. Symbolic programming.
2. Lists.
3. *Mathematica* functions and functional programming.
4. Graphics and animations in *Mathematica*.
5. Illustrative short programs and examples.

II. Mathematical background

1. Complex numbers.
2. Mathematical sequences.
3. Functions.
4. Derivatives.
5. Indefinite and definite integrals.
6. Basics of ordinary differential equations.
7. Nonlinearity and nonlinear differential equations.
8. Matrices and elements of linear algebra.
9. Basics of vector calculus.

III. Basics and selected general problems of Dynamical Systems Theory

1. Concept of a dynamical system: state vectors, phase space, attractors, discrete time and continuous time, examples.
2. Maps and flows, Poincaré map.
3. Reconstructing the dynamics of the system: return maps, reconstructing the phase plane.
4. Linear systems in one and more dimensions: Markov chains.
5. Nonlinear systems: fixed points, stability, Lyapunov functions, periodicity in a two-dimensional dynamical system
   i. continuous time: Lorentz system and chaos
   ii. discrete time: stability of periodic points, bifurcation and computer-generated bifurcation diagrams.
6. Boolean networks and cellular automata.
7. Fractals: Cantor set, Sierpiński triangle, Koch's snowflake, fractal dimension, fractals in nature and dimension of physical fractals, examples.
8. Complex dynamical systems: Julia sets, the Mandelbrot set.
9. Strange attractors.
10. Characterising chaos.

IV. Specific topics in biology and oceanography

Biology

1. Model of fly population: nonlinear finite-difference equations, cycles and their stability, chaos and the period-doubling route to chaos; bifurcation diagram and Feigenbaum's number; Nicholson's blowflies differential equations with inputs.
2. Chaos in periodically stimulated heart cells.
3. Locomotion in salamanders: Boolean networks and cellular automata.
4. Game of "Life": cellular automata with a rule inspired by interactions of living organisms with one another.
5. Brownian motion and Lévy walks: fractals and nonlinear dynamical systems, random walks with self-similar dynamics and power-law scaling.
6. Growth in an *E.coli* colony: the Eden model for growth.
7. Predator and prey biological system: a classical model of an ecological Lotka and Volterra system.

Oceanography

1. Diffusion limited aggregation (DLA) and models of coral reef growth as an example of fractal growth.
2. Why it may be so hard to predict weather: dynamics in three dimensions; Lorentz equations, butterfly effects and chaos.
3. Lagrangian chaos: chaotic mixing of fluids, Stokes flow in a circular container.
4. Vortex movement.
5. Chaos in the North Pacific SST.

Course title
Ecological assessment of marine environments

Studies

Field of study	Type	Form	Specialization
Oceanography Water management, Marine Ichtiology	BA	Full-time	All

Teaching staff
dr Aleksandra Zgrundo, dr Katarzyna Smolarz

Lecture: 30 hours Practical class: 45 hours	**ECTS credits: 5**

Aims of education
- Outline the principles and challenges of effective biological monitoring in conservation and management of marine environments.
- Introduce and discuss different surveying and monitoring methods and technologies .
- Analyse effects of stressors across all levels of the biological organisation in order to identify efficient preventive action and restore ecosystem services and functions.
- Provide examples of biological monitoring and conservation initiatives in marine environments.
- Enable critical scrutiny of current and future programmes and monitoring data in marine waters management.

Course contents
The course commences with an introduction to the principles of biological methods used in monitoring of marine environments. The rationale and procedures behind the effective design of biological monitoring systems based on o bioindicators, biomonitors and ecotoxicology will be outlined. Techniques necessary for the interpretation of monitoring data will also be presented. Field trips and workshops covering coastal systems enable the application of these methods via a number of case studies. Emphasis will be placed on assessment of the suitability and effectiveness of existing monitoring methods. Finally the issue of sustainable marine waters management will be discussed. The following topics will be covered:
- Introduction to the subject of ecological assessment of environment and essential issues related to the monitoring of waters.
- Introduction to the fundamental definitions, concepts and problems in ecological water assessment.
- Principles behind the design of monitoring systems in marine environments.
- Introduction to surveying and monitoring methods using different type of bioindicators, biomarkers (susceptibility, exposure and effect) and ecotoxicological tests.
- Threats to marine ecosystems and assessment of their state – the Baltic Sea case study.
- Introduction to legal frameworks for ecological assessment of marine waters (the Marine Strategy and Framework Directive and other key documents for the conservation of marine waters in the EU).
- Environmental Impact Assessment (EIA).
- Introduction to marine waters management.
- Special issues: marine protected areas (MPA) and reconstructions of historical environments.

Course title
Fish Biology

Studies

Field of study	Type	Form	Specialization
Oceanography, Biology	BA	Full-time	all

Teaching staff
prof. UG dr hab. Mariusz Sapota, prof. UG dr hab. Konrad Ocalewicz, dr Anna Pawelec

Lectures: 30 hours Laboratory: 45 hours	**ECTS credits: 5**

Aims of education
This course gives a knowledge of the basic fish biology and ecology with special emphasis to marine fishes. Basic methods of ichthyological investigations will be presented and practice.

Course contents
1. Fish Biology Investigation Principles
2. Fish Anatomy
3. Fish Reproduction
4. Fish Growth
5. Fish Behaviour
6. Fish Ecology
7. Fish Genetics

Course title
Geology of the ocean and sea floor

Studies

Field of study	Type	Form	Specialization
Oceanography Geology Geography	BA, MA	Full-time	all

Teaching staff
dr Ewa Szymczak, dr Agnieszka Kubowicz-Grajewska

Exercise: 30 hours	**ECTS credits: 3**

Aims of education
This course gives a knowledge of the origin, geology and morphology of the world's seas and oceans floor and the geologic processes active in the deep oceans and in shelf seas. The course also covers the sediments, sediment sources and sedimentation patterns in oceans and seas. Modern marine geological laboratory methods and instrumentation used for analysing sediments and sedimentological data will demonstrate some of the tools used in reconstructing the past sedimentary and environmental conditions. Another important issue concerns the mineral resources, their genesis and occurrence.

Course contents
1. Morphology and genesis/origin of the oceans and inland seas (e.g. Baltic Sea)
2. Geology of the oceanic and continental crust.
3. Laboratory analysis of bottom sediment samples.
4. Core description using data sets from IODP.
5. Mineral resources of the oceans and seas.
6. Comparison of two different ocean / sea basins – case studies.

Course title
Introduction in Marine Acoustics

Studies

Field of study	Type	Form	Specialization
Oceanography Geology	BA	Full-time	all

Teaching staff
Assoc. Prof. Natalia Gorska (habilitation)

Lecture: 30 hours
Classes (problem solving): 10 hours
Practical classes: 5 hours

ECTS credits: 5

Aims of education

1. To give the knowledge of:
    - the basic phenomena concerning the sound propagation in marine conditions,
    - the acoustic wave generation and receiving,
    - the main principles governing the processes,
    - the methods used in their study,
    - the main research problems in hydroacoustics and its relation to the development streams of oceanography.
2. To demonstrate (at preliminary level) the efficiency of application of remote hydroacoustical techniques in:
    - interdisciplinary study of marine environment
    - monitoring of its state for sustainable exploitation and exploration of marine recourses
3. To provide (at preliminary level) knowledge and skills required:
    - to perform scientific research in hydroacoustics
    - to efficient and practical use the innovative hydroacoustical techniques

Course contents

1. Lectures

1.1 Acoustic wave: definition, variations in time and space and their mathematical description;
1.2 Sound propagation: sound absorption in marine water, wave spreading (spherical and cylindrical spreading);
1.3 Wave phenomena in marine environment: reflection and transmission at interfaces, wave interference (sum of sounds from two sources and interference near an interface: plane standing waves), acoustic wave scattering, sound refraction;
1.4 Hydroacoustical transducers;
1.5 Main working principles and application of sonar systems: single beam echosounder, split beam echosounder, multibeam echosounder, side scan sonar, Acoustic Doppler Current Profiler. Two lecture hours will be arranged on board of r/v “Oceanograf – 2”, where the hydroacoustical data collection using the single beam echosounder, will be demonstrated;
1.6 Basics of hydroacoustical data analysis;
1.7 Some aspects of hydroacoustical techniques application in marine environmental study and monitoring.

2. Classes (problem solving)

The simulation exercises within the entire topic range mentioned above. The first two hours are dedicated to reminding necessary mathematical basis.

3. Practical classes

Training in application of the specialized software SONAR PRO in hydroacoustical data analysis

Course title

Speciation, Ecology, Biodiversity and Biogeography of cyanobacteria and microalgae - theoretical concepts and facts

Studies

Field of study	Type	Form	Specialization
Oceanography Marine Ichtiology	BA, MA	Full-time	all

Teaching staff: prof. UG, dr hab. Katarzyna Palińska

Lecture: 12 hours Seminar: 18 hours	**ECTS credits: 2**

Aims of education **Lecture:** knowledge of specific ecology and biodiversity of cyanobacteria and microalgae. Special attention will be given to theoretical species concepts used in the past and nowadays in taxonomy of cyanobacteria.

Seminar: To give students the tools necessary to improve their oral communication & presentation skills while gaining insight into different species concepts and their application to phototrophic microorganisms

Course contents

A. Lecture:

A.1. What is biological diversity and why should we value it?

A.2. Diversity of phototrophic microorganisms and their adaptations allowing survival in different ecosystems and multiple stresses

A.3. Ecological factors that influence the pattern of life on earth.

A.4. Theoretical species concepts and their application

A.5. Taxonomy and identification of cyanobacteria: classical and modern methods

B. Seminar: Journal club: reading, presenting and discussion of original scientific papers on:

B.1. Special adaptation of phototrophs to different environments

B.2. Phenotypic vs molecular diversity

B.3. Biogeography of phototrophs; “Everything is everywhere” theory.

Course title
Use of living aquatic resources

Studies

Field of study	Type	Form	Specialization
Oceanography, Geology, Water management, Marine ichthyology	BA	Full-time	all

Teaching staff: dr Aldona Dobrzycka-Krahel

Lecture: 10 hours Project classes:15 hours	**ECTS credits: 2**

Aims of education

Achievement of a new knowledge of the use of living aquatic resources in industry and in purification processes in aquatic ecosystems.

Development of new skills of interpretation of the relationships between the energy values, biochemical composition, other properties (e.g. anticancer compounds, minerals, vitamins content) of living aquatic resources and their use by human.

Course contents

A. Lectures:

A.1. Alive marine resources.

A.2. Alive freshwater resources.

A.3. Energy values, biochemical composition and other properties (e.g. anticancer compounds, minerals, vitamins content) of aquatic organisms.

A.4. Possibilities of use of organisms in purification processes in the ecosystems and as bioindicators.

A.5. Possibilities of use of alive aquatic resources in industry. Aquatic organisms used in food processing, pharmaceutical and cosmetic industry.

B. Project classes:

C.1. How do we use living aquatic resources? Possibilities of the use of aquatic organisms in purification processes in aquatic ecosystems (case studies).

C.2. How do we use living aquatic resources? Finding the best suitable aquatic organisms to use in aquacultures and their potential applications (case studies).

C.3. How do we use living aquatic resources? Finding the best suitable aquatic organisms to use in cosmetic, pharmaceutical and food processing industry (case studies).