UNIVERSITY OF ZAGREB

FACULTY OF SCIENCE

Department of Geology

in cooperation with

Ruđer Bošković Institute, ZAGREB, ROVINJ

Institute for Oceanography and Fisheries, SPLIT

Institute for Marine and Coastal Research of University in Dubrovnik

INTERDISCIPLINARY DOCTORAL STUDY IN OCEANOLOGY

PLAN nd CURRICULA

Area of Natural Sciences

Field of Geosciences

Branch of Oceanology

Zagreb, December 2008

The list of compulsory and optional courses with the number of teaching hours required for their fulfillment and the respective ECTS credit points.

(i) obligatory courses for all attenders (180 teaching hours need to be registered, i.e. 24 ECTS credits need to be collected):

Code	Lecturer	Course	Hours of teaching	ECTS credit
8700	M. Orlić	Physics of the Sea	30	4
8300	M. Plavšić	Marine Chemistry	30	4
8400	D.Viličić	Marine Biology	30	4
8500	M. Juračić	Marine Geology	30	4
8800	F. Kršinić	History of Marine Research	15	2
8801	T.Legović, M.Juračić, M.Orlić	Science in Society and Ethics	15	2
8802		Seminar I	30	4
8803		Seminar II	40	10
8804		Seminar III (public defence of thesis)	40	10

(ii) Selection of courses within the course group for particular branch (physics, chemistry, biology, geology);

Selected courses for the marine physics group (minimum 60 teaching hours need to be registered, i.e. 10 ECTS credits need to be collected):

Code	Lecturer	Course	Hours of teaching	ECTS credit
8701	V. Dadić	Measurement in physical oceanography	20	4
8702	M. Kuzmić	Satelite oceanography	15	3
8703	Z. Pasarić	Time series analysis in oceanography	20	4
8704	N. Supić	Interaction at the air-sea interface	15	3
8705	B. Grbec	Natural and anthropogenic climate changes	15	3

8706	M. Gačić	Selected Topics in Physical Oceanography	15	3
8707	M. Kuzmić, I. Janeković	Numerical modelling in physical oceanography	15	3
8708	M. Morović, D, Risović	Ocean optics	15	3
8709	P. Vukadin	Ocean acoustics	15	3

Selected courses for the marine chemistry group (minimum 60 teaching hours need to be registered, i.e. 10 ECTS credits need to be collected):

Code	**Lecturer**	**Course**	**Hours of teaching**	**ECTS credit**
8301	B.Ćosović	Organic matter in the sea	20	4
8302	N.Mikac, V. Cuculić	Trace elements in seawater, marine organisms and sediments	20	4
8303	V. Žutić, V.Svetličić, A.Hozić	Marine organic matter organization and function	20	4
8304	R. Precali, D. Fuks	Primary and secondary production in shallow seas	15	3
8305	D. Hršak	Biotransformation of organic pollutants in marine environment	15	3
8306	B. Raspor T. Smital	Biological effects of metals and organic pollutants on marine organisms	15	3
8307	S. Terzić	Analytical chemistry of organic contaminants in the marine environment	15	3
8308	M. Ahel M.Najdek-Dragić	Biomarker organic compounds in the marine science	20	4
8309	H. Bilinski	Precipitation and adsorption processes in the sea	15	3
8310	I.Ciglenečki Jušić	Anoxia and hypoxia in marine environment	15	3
8311	V. Žutić	Oxidation-reduction processes in the sea	15	3
8312	G. Kniewald	Geochemical equilibria and processes in seawater	15	3
8313	S.Lulić	Radioecology	15	3

8314	B.Ćosović	Physical chemistry of the sea and seawater	15	3
8315	M. Mlakar, D. Omanović, N. Mikac	Analysis of trace elements in marine environment	15	3

Selected courses for the marine biology group (minimum 60 teaching hours need to be registered, i.e. 10 ECTS credits need to be collected):

Code	Lecturer	Course	Hours of teaching	ECTS credit
8401	B. Antolić	Marine Phytobenthos	15	3
8402	T. Bakran Petricioli, I. Grubelić	Biodiversity and ecology of sponges	15	3
8403	A. Benović, M. Batistić	Planctonic cnidaria	15	3
8404	N. Bihari	Marine Molecular Toxicology	15	3
8405	R. Batel	Programmed Biosynthesis and Genotoxic Risk	15	3
8406	J. Dulčić	Reproduction and embryology of fishes	15	3
8407	I. Katavić , L. Grubišić	Aquaculture	20	4
8408	N. Krstulović	Marine Bacteriology	15	3
8409	F. Kršinić	Marine Zooplankton	15	3
8410	T. Legović	Modelling in ecology	20	4
8411	I. Marasović	Marine phytoplankton	15	3
8412	M. Peharda Uljević	Bivalve biology	15	3
8413	A. Požar-Domac	Marine Zoobenthos	15	3
8414	G. Sinovčić	Biology of pelagic fish	15	3
8415	M. Šolić	Marine Ecology	15	3
8416	E.Teskeredžić	Diseases of fish, shellfish and crustaceans	15	3
8417	Z. Teskeredžić	Nutrition requirements of fish, shellfish and crustaceans	15	3
8418	A. Travisi	The meiofauna of marine sediments	15	3
8419	N. Vrgoč, I.	Fisheries	20	4

	Jardas			
8420	A. Požar-Domac	Marine biodiversity preservation and protection	15	3

Selected courses for the marine geology group (minimum 60 teaching hours need to be registered, i.e. 10 ECTS credits need to be collected):

Code	Lecturer	Course	Hours of teaching	ECTS credit
8501	M. Juračić	Selected topics in marine geology	20	4
8502	M. Juračić	Recent sedimentation in the sea	15	3
8503	V. Ćosović	Environmental micropaleontology	20	4
8504	N. Horvatinčić, L. Palinkaš	Isotope Oceanography	20	4
8505	I. Sondi	Biomineralization	15	3
8506	E. Prohić	Geochemistry of marine environment	15	3
8507	I. Sondi	Mineral Particles and Pollution Processes	15	3

(iii) optional courses for all attenders (120 teaching hours need to be registered, i.e. 24 ECTS credits need to be collected):

- All optional courses from course groups on this doctoral study
- courses from doctoral studies in physics, chemistry, biology, geology, geography, veterinary medicine, and biotechnology at University of Zagreb,
- Courses from the following list:

Code	Lecturer	Course	Hours of teaching	ECTS credit
8805	Pečar-Ilić, Ružić	GIS in Oceanography	15	3
8806	T.Legović	Data analysis in oceanography	20	4
8807	L.Klasinc, T.Cvitaš	Atmosphere and the sea	20	4
8808	A.Jaklin,	Methods and Techniques in	15	3

	E.Teskeredži ć, I.Sondi	Oceanlogy		
8809	B. Jergović	Science communication	15	3
8810	B.Vukas	Legal Aspects of the Protection and Uses of the Sea	15	3

In the first year of the study, student has to register courses with minimum of 60 ECTS credit points.

CURRICULA

(Description of each course and/or module)

Notice: Below mentioned courses contents are standard course contents that can be adapted to the students' interests and research topics as needed.
Order of courses is accordin the above list.

A) Obligatory courses

Interdisciplinary Doctoral Study in Oceanology
COURSE: Physics of the Sea
AUTHOR OF COURSE PROGRAMME: Prof. Mirko Orlić, Faculty of Science, University of Zagreb
TEACHING TECHNIQUES: lectures + exercises (18 + 12 hours)
ECTS: 4
COURSE ACHIEVEMENTS: Familiarity with the way various physical oceanographic parameters are measured and processed, understanding of the physical properties and processes in the sea, and appreciation of relevance of the knowledge thus gained for the solution of some important present-day problems (floods, pollution, climate changes).
COURSE PROGRAMME: Lectures: Students acquire basic knowledge of physical oceanography by attending a series of lectures on descriptive and dynamical oceanography: (1) subject of the investigation and methodology; (2) measuring instruments, 'in situ' and remote sensing; (3) elementary equations; (4) salinity, temperature, pressure, density, water masses, with a review of forcing and internal processes: surface fluxes of heat and water, mixing, advection/convection; (5) circulation of the oceans and seas: geostrophic and hydrostatic approximation, wind and wind-driven currents (Ekman spiral), thermohaline currents; (6) wind waves, tsunamis, seiches, inertial oscillations, Rossby waves; (7) tides (generating force, description of the phenomenon, basic dynamics), storm surges (influence of the air pressure and wind on coastal sea), seasonal variability. Exercises: Students get familiar with the basic instrumentation, participate in one-day cruise aboard a research vessel, and process and analyze the data collected during the cruise.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Attending the classes, participating in the one-day cruise, analyzing the data collected.
OBLIGATORY LITERATURE: Open University Course Team: Seawater – Its Composition, Properties and Behaviour. Butterworth-Heinemann, Oxford, 1999, 168 pp. Open University Course Team: Ocean Circulation. Butterworth- Heinemann, Oxford, 2002, 286 pp. Open University Course Team: Waves, Tides and Shallow Water Processes. Butterworth-Heinemann, Oxford, 2002, 227 pp. Pickard G. L., Emery W. J.: Descriptive Physical Oceanography. Butterworth-Heinemann, Oxford, 1996, 320 pp. Pond S., Pickard G. L.: Introductory Dynamic Oceanography. Butterworth-Heinemann, Oxford, 1997, 329 pp.
SUPPLEMENTARY LITERATURE: Mala internet škola oceanografije (http://skola.gfz.hr).
EXAMINATION PROCEDURE: Oral.

Interdisciplinary Doctoral Study in Oceanology
COURSE: Marine Chemistry
AUTHOR(S) OF COURSE PROGRAMME: Dr. sc. Marta Plavšić, Institut R. Bošković
TEACHING TECHNIQUES: lectures + exercise (20 + 10 hours)
ECTS: 4
COURSE ACHIEVEMENTS : Introduction to the knowledge about the chemical composition of seawater and chemical processes occurring in the seawater
COURSE PROGRAMME: Shorter presentation of the history of the investigation of the sea regarding the marine chemistry, distribution and surface areas of the oceans and seas, chemical composition of the seawater , the constancy of the composition of the seas and seawater, micro and macroconstituents, salinity, density, temperatures, pH, pE, redox state, dissolved gasses, nutrients, organic matter and complexation of trace constituents, determination of chemical elements and their distribution between different compartments(sediment, seawater, surface microlayer atmosphere and biota), chemical speciation, residence time, use of seawater as a source of raw materials and minerals (NaCl, Mg, Br, ferromanganese nodules) and pollution of the sea by man made activities(e.g. eutrofication , influence of mariculture).
STUDENTS' ACTIVITIES AND THEIR EVALUATION: attendance of the lectures, writing of the seminar as a part for the preparation for the exam.
OBLIGATORY LITERATURE: 1.Riley,J.P., Chester, R. (1971),Introduction to Marine Chemistry, Academic Press, London,New-York 2.Riley, J.P., Skirrow, G.(1975),Chemical Oceanography,Vol.I,II, Academic Press, London,New-York 3. Morgan ,J.J., Stumm W.(1993) Aquatic Chemistry, Wiley &Sons,New-York,Chichester 4. Open University Course Team,(1991), Seawater:Its Composition, Properties and Behaviou, Pergamon Press(Oxford,New-York) in association with The Open University, Walton Hall, Milton Keynes MK6AA, England.
SUPPLEMENTARY LITERATURE: Buffle, J., 1988. Complexation reactions in aquatic systems. Ellis Horwood, Chichester . Dursma, E.K., Dawson, R. (Eds)., 1981. Marine Organic Chemistry, Elsevier Oceanography Series, 31, Amsterdam. Millero, F.,Solin M.L.(1992) Chemical Oceanography,CRC-Press,B.R., Ann Arbor,London.
EXAMINATION PROCEDURE: oral exam

Interdisciplinary Doctoral Study in Oceanology

COURSE: Marine Biology

AUTHOR(S) OF COURSE PROGRAMME: Prof. dr. sc. Damir Viličić, University of Zagreb, Faculty of Science, Division of Biology

TEACHING TECHNIQUES: lectures + seminar (20 + 10 hours)

ECTS: 4

COURSE ACHIEVEMENTS: Introducing students into the marine life, general structure, functions and interactions in the marine ecosystem

COURSE PROGRAMME:

1. Link between cell biology and ecosystem function
2. Species, genetic information, speciation, evolution
3. Taxonomic classification of marine life; prokaryotes, eukaryotes and taxonomic categories
4. Size structure
5. Development cycles
6. Metabolism and feeding
7. Organisation of marine biological system: producers, consumers, detritivors, decomposers
8. Food webs, trophic and energetic pyramids, flux of organic matter and energy
9. Role of marine organisms in bio-geochemical cycles
10. Microbial regeneration: molecular-biological mechanisms
11. Abiotic and biotic ecological factors, development of populations, production and respiration
12. Colonization in the sea:

a) Pelagic organisms
b) Organisms on continental edges; shelf, continental slope, abyssal
c) Life in hydrothermal vents; extremophiles
d) Life in coral reefs
e) Life in estuaries
f) Life of mangroves

STUDENTS' ACTIVITIES AND THEIR EVALUATION: Attendance to lectures, solving problems, discussion, exam.

OBLIGATORY LITERATURE:

Castro, P., Huber, M.E., 2005: Marine Biology. McGraw-Hill, New York. ISBN: 0-07-111100-X

SUPPLEMENTARY LITERATURE:

Margulis, L., Schwartz, K.V., 1999: Five kingdoms. An illustrated guide to the phyla of life on Earth. W.H.Freeman and Comp., New York. 520 pp. ISBN: 0 7167 3027 8

Schultze, E-D., Heimann, M., Harrison, S., Holland, E., Lloyd, J., Prentice, I.C., Schimel, D., 2001: Global biogeochemical cycles in the climate system. Academic Press, San Diego. ISBN 0 12 631260 3

Viličić, D., 2003: Fitoplankton u ekološkom sustavu mora. Školska knjiga, Zagreb. ISBN: 953-0-31130-3

EXAMINATION PROCEDURE: Written and oral exam

Interdisciplinary Doctoral Study in Oceanology
COURSE: Marine geology
AUTHOR OF COURSE PROGRAMME: Professor Mladen Juračić, Faculty of Science, University of Zagreb
TEACHING TECHNIQUES: lectures + exercise (25 + 5 hours)
ECTS: 4
COURSE ACHIEVEMENTS: Recognition and understanding of the sea bottom, the important part of the marine environment, its composition, structure and interaction with marine water. Understanding of marine sedimentation and of the role of biotic processes in it.
COURSE PROGRAMME: History of marine research. Morphology and genesis of the oceans. Sources and composition of marine sediments. Lithogenous, hydrogenous and biogenous sediments. Physical oceanography relevant for genesis and sea sediment disposition (wave, current, tide). Sea water and hydrogenous sediments. Coast, sea level processes and effects of sea level change. Climates and sediments. Estuarine and anti-estuarine water exchange currents and their influence to the sea bottom. Organisms and sea bottom. Residence time. Sedimentation rates. Paleocanography. Deep-sea sediments. Mediterranean and Adriatic Sea. Marine geological cartography. Sea-bottom sampling and data acquisition.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Lectures and practical work (optional: field work - sediment sampling , work with sub-bottom profiler)
OBLIGATORY LITERATURE: 1. Juračić, M.: Geologija mora (http://geol.gfz.hr/Juracic/predavanja/index.html) 2. Selbold E. & Berger W.H.: The Sea Floor. An introduction to Marine geology. Springer Verlag, Berlin, 1996
SUPPLEMENTARY LITERATURE: Open University Course Team, Butterworth-Heinemann, Oxford, 1997: • The Ocean Basins: Their Structure and Evolution • Seawater: Its Composition, Properties and Behaviour • Waves, Tides and Shallow Water Processes • Ocean Chemistry and Deep Sea Sediments
EXAMINATION PROCEDURE: Verbal exam and/or written seminar

Interdisciplinary Doctoral Study in Oceanology
COURSE: History of Marine Research
AUTHOR OF COURSE PROGRAMME: Prof.dr.sc. Frano Kršinić, Senior Advisor Institute of Oceanography and Fisheries, Split and honorary professor at PMF University of Zagreb
TEACHING TECHNIQUES: lectures + seminar (12 + 3 hours)
ECTS: 2
COURSE ACHIEVEMENTS: Introduction of students with important knowledge of the seas and oceans from the Ancient World to the modern Marine Science.
COURSE PROGRAMME: I period; knowledge of the sea during the Ancient World and the Middle Ages. II period; from the Renaissance to Nineteenth Century. III period; the Early Nineteenth Century, a period of Growth. IV. Period; between two World Wars; V period; modern knowledge of the seas, experiments in laboratory and in field. Historical contributions to knowledge of the Adriatic Sea.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance
OBLIGATORY LITERATURE: Schlee, S. (1973) The edge of an unfamilar world. A Histora of Oceanography. Dutton & Co. New York, 398 pp. Stephens W. M (1966) Science beneath the Sea. The story of oceanography. Putnam, Sons. New York, 224 pp.
SUPPLEMENTARY LITERATURE: Kršinić, F. (2000/1): Kratka povijest biologije mora. *More*,67, 100-102; 68, 104-106; 69, 108-110.
EXAMINATION PROCEDURE: final oral exam

Interdisciplinary Doctoral Study in Oceanology
COURSE: Science in Society and Ethics
AUTHOR(S) OF COURSE PROGRAMME: Prof. dr.sc. Tarzan Legović, R. Bošković Institute, Zagreb; Prof. dr. sc. Mladen Juračić and Prof. dr. sc. Mirko Orlić, Faculty of Science, University of Zagreb
TEACHING TECHNIQUES: lectures + practice + seminar (8 + 3 + 4 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Develop competence for scientific writing and preparation of project proposals. Acquaint students with ethics of scientific work.
COURSE PROGRAMME: Social role and functioning of scientists in the modern society. Value of science. Ethics standard in science. Formulation of scientific project proposal: preliminary work, partner's role, role of the coordinator, proposal writing, project management, role of reviewers. Principles of project defence. Writing a scientific paper. Experimental techniques and data elaboration. Conflict of interest. Publications and open literature. Authorship and acknowledgements. Reply to reviewer comments. Often made mistakes. Carelessness and unallowable mistakes in science. Responses to breach of ethical standards. Formulating and writing a proposal for a doctoral thesis. Writing rules of a doctoral thesis.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Attendance to lectures, active participation in practical work, public presentation of seminar.
OBLIGATORY LITERATURE: Silobrčić V., Kako sastaviti, objaviti i ocijeniti znanstveno djelo. Medicinska naklada, Zagreb, 1998, 159 str. NAS, On being a scientist: Responsible Conduct In Research, National Academy Press, 1995 http://www.nap.edu/readingroom/books/obas/ Professional Ethics Report Archives, 2005 (students have to choose at least one publication and using other literature have to write a seminar and express an opinion about particular problem) http://www.aaas.org/spp/sfrl/per/archives.htm Codes of Ethics in Science, Illinois Institute of Technology, 2006. http://ethics.iit.edu/codes/science.html Proposal Writing for EU, University of Bristol, 2006 http://www.bris.ac.uk/research/support/funding/european
SUPPLEMENTARY LITERATURE: Harvey, B.: Business Ethics A European Approach, Prentice Hall, 1994. Hoffmann, W. Moore, M.: Business Ethics, McGraw Hill, 1996. Ecological Society of America. Code of Ethics http://www.esa.org/certification/codeofEthics.php Business Ethics Resources on WWW. http://www.ethics.ubc.ca/resources/business/
EXAMINATION PROCEDURE: In writing and oral.

B) Selected courses

Interdisciplinary Doctoral Study in Oceanology
COURSE: Measurement in physical oceanography
AUTHOR(S) OF COURSE PROGRAMME: Vlado Dadić, Ph.D., scientist/assistant professor, Institut za oceanografiju i ribartstvo, Split
TEACHING TECHNIQUES: lecturers + practical execises + seminars (10 + 5 + 5 hours)
ECTS: 4
COURSE ACHIEVEMENTS: Advanced knowledge about oceanographic measurements, measuring methods and instruments, and problems related oceanographic data collection, processing and analyzing
COURSE PROGRAMME: History of oceanographic measurements. Problems with measurements in oceanography. Measuring methods. Hind cast, repeated and continued measurements. Measurement in single point, profiles and tree-dimensional marine space. Measurements of classical oceanographic parameters by vessel. Measurements by stationary instruments. Measurements by drifters and floating objects. Automatic measuring systems with data transmission in real time. Remote sensing measuring methods. Specific problems with measurements of various oceanographic parameters. Review of oceanographic parameters and measuring methods and instruments. Application of multiparameter probes and water samplers in oceanography. Maintenance of oceanographic instrumentation. Errors within oceanographic measurements; sources and solutions. Influences of measuring methods and instruments on data quality. Precision, resolution, time response, stability and operability of instruments as measure of measuring instruments quality. Absolute, relative and total error. Methods and procedures for errors reduction. Calibration and intercalibration of measuring instruments and logs. Planning cruise and measuring stations in the research polygon. Importance of registering of data relating research cruise (SCR form) and meta data. Oceanographic data management. Processing, validation, storing and exchange of oceanographic data. Methods and procedures for data quality control. Usage of geostatistical methods and GIS tools in data harmonization. Operational oceanography. Planning of oceanographic research and selection of measuring methods. World, regional and local research oceanographic programs.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Class attendance, homework, seminars, filed exercises
OBLIGATORY LITERATURE: - William J. Emery and Richard E. Thomson, 2001. Data Analysis Methods in Physical Oceanography. Elsevier Science Ltd: 634. - IOC (UNESCO), 1993. Manual of Quality Control Procedures for validation of Oceanographic Data, prepared by CEC:DG: XII, MAST and IODE. Manuals and Guides NO. 26: 436 pp.
SUPPLEMENTARY LITERATURE: - Boyer T. and S. Levitus. QC and processing of historical oceanographic temperature, salinity and oxigen data. U.S. Department of Commerce. NOAA technical

report NESDIS 81, 1994: 64 pp.

- Dadić V., 1999. Razvitak i primjena sustava na plutačama uz daljinsko odašiljanje podataka (AMOS), Institut za oceanografiju, Split, Studije i elaborati 216: 64 pp.
- Deutch C.V. and A.G. Journel, 1992. GSLIB – Geostatistical software; library and user's guide. Oxford University Press. 369 pp.
- http://ioc.unesco.org/oceanteacher/oceanteacher2/TOC.htm;
- http://www.ndbc.noaa.gov/;
- www.izor.hr/on-line.html

EXAMINATION PROCEDURE: Seminars and oral examine

Interdisciplinary Doctoral Study in Oceanology
COURSE: Satellite Oceanography
AUTHOR(S) OF COURSE PROGRAMME: Dr. Milivoj Kuzmić, research associate, Ruđer Bošković Institute
TEACHING TECHNIQUES: lectures + seminar (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: The objective of this course is to introduce students to the contemporary capabilities of ocean remote sensing, i.e. to overview the principles and procedures of satellite remote sensing of oceanographic variables (ocean color, sea surface temperature, sea state, and sea surface topography).
COURSE PROGRAMME: The course offers basic knowledge of the principles and procedures of satellite remote sensing and develops skills to apply it in different fields of oceanography. Introduction: importance of remote sensing in oceanography, development of the field. Fundamentals of satellite remote sensing: basic physical characteristics of the atmosphere and ocean, air-sea boundary, radiation, interaction of radiation and matter, radiometry, mechanics of satellite motion, satellite sensors and platforms. Procedures of satellite remote sensing: sensor calibration, atmospheric correction, geometric correction, geophysical calibration. The basic techniques of remote sensing: infrared and passive microwave radiometry (sea surface temperature), visible radiometry (ocean color), altimetry (sea surface topography), scatterometry and active microwave radiometry (sea surface state). Processing of remotely sensed data, oceanographic interpretations, and examples.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: assignments on course topics, term paper
OBLIGATORY LITERATURE: Oluić M.: Snimanje i istraživanje Zemlje iz Svemira.: sateliti, senzori, primjena. HAZU i Geosat, 2001, 516 pp.
SUPPLEMENTARY LITERATURE: Martin S.: An introduction to ocean remote sensing. Cambridge University Press. 2004, 454 pp. Robinson I.S.: Satellite oceanography. Ellis Horwood, 1985, 455 pp. Stewart R.W.: Methods of satellite oceanography, 1985, 360 pp.
EXAMINATION PROCEDURE: written report plus final oral examination

Interdisciplinary Doctoral Study in Oceanology
COURSE: Time series analysis in oceanography
AUTHOR(S) OF COURSE PROGRAMME: Zoran Pasarić, Ph. D., research associate, Faculty of Science, University of Zagreb
TEACHING TECHNIQUES: Lectures + computer exercises (15 + 5 hours)
ECTS: 4
COURSE ACHIEVEMENTS: To become familiar with ideas and problems related to the time series. To develop the skill for the time domain vs. frequency domain reasoning. To become able to apply various methods of time series analysis in practice and interpret obtained results.
COURSE PROGRAMME: Deterministic theory: Linear systems, Fourier transform, discrete sampling, aliasing, digital filters. Stochastic theory in time domain: Stationary stochastic processes, ergodicity, autocorrelation and crosscorrelation functions. Stochastic theory in frequency domain: Linear systems with stochastic input, power spectra and cross-spectra of stationary stochastic processes, linear model with noise. Exercises comprise of writing or modifying computer programs (Matlab) for various time series analysis methods and applying them to real or sintethic data.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Attendance of lectures and exercises.
OBLIGATORY LITERATURE: Bendat, S. J., Piersol, G. A. 2000: Random Data Analysis and Measurement Procedures. John Wiley & Sons, Inc., New York, 594 pp.
SUPPLEMENTARY LITERATURE: Emery, W. J., Thomson, E. R. 1998: Data Analysis Methods in Physical Oceanography. Pergamon, Elsevier Science Ltd., Oxford, 634 pp. Hamming, R. W. 1977: Digital Filters. Prentice-Hall, Englewood Cliffs, N.J. 284 pp. Koopmans, H. L. 1995: The Spectral Analysis of Time Series. Academic Press, San Diego, 366 pp. Papoulis, A. 1977: Signal Analysis. McGraw-Hill, Auckland, 431 pp. Papoulis, A. 1984: Probability, Random Variables, and Stochastic Processes. McGrew-Hill, Auckland, 576 pp. Press, H. W., Teukolsky, A. S., Vetterling, T. W., Flannery, P. B. 2001: Numerical Recipes in Fortran 77, Cambridge University Press, Cambridge, 974 pp. Priestly, M. B. 1981: Spectral Analysis of Time Series, Academic Press, London, 653 pp.
EXAMINATION PROCEDURE: The exam consists of a) writing a computer program and applying it to some real data and b) oral part.

Interdisciplinary Doctoral Study in Oceanology
COURSE: Interaction at the air-sea interface
AUTHOR(S) OF COURSE PROGRAMME: dr. sc. Nastjenjka Supić, assistant, Center for Marine Research, Rovinj, Institute "Ruđer Bošković"
TEACHING TECHNIQUES: lectures/consultations (15 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Students should understand of basic mechanism of interaction between sea and atmosphere. They should learn how to estimate surface fluxes and what is the role of surface fluxes in changes of hydrographic and dynamic characteristics of the sea.
COURSE PROGRAMME: 1.Surface heat, water and buoyancy fluxes. 2. Influence of surface fluxes on hydrographic conditions and sea circulation. 2.1. Surface fluxes in the ocean. Thermohaline circulation. El Nino and long-term prognosis of this phenomena. 2.3. Surface fluxes in the Adriatic Sea. Geostrophic currents in the northern Adriatic and their relation to atmospheric forcing.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance
OBLIGATORY LITERATURE: Gill, A.E., 1982. Atmosphere Ocean Dynamics. Academic Press, Orlando, 662 pp. Kraus, F. B., Businger, J. A., 1994. Atmosphere-Ocean Interaction. Oxford University Press, New York, 362 pp. Csanady, G. T., 2001. Air-Sea Interaction: Laws and Mechanisms. Cambridge University Press, Cambridge, 290 pp. Cushman-Roisin, B., Gačić, M., Poulain, P.-M., Artegiani, A., 2001. Physical Oceanography of the Adriatic Sea. Kluwer Academic Publishers, Dordrecht, 320 pp. Penzar, B., Penzar, I., Orlić, M., 2001. Vrijeme i klima hrvatskog Jadrana. Nakladnička kuća "Dr. Feletar", Zagreb, 258 pp.
SUPPLEMENTARY LITERATURE: Supić, N., Orlić, M., Degobbis, D., 2000. Istrian Coastal Countercurrent and its year-to-year variability. Estuarine, Coastal and Shelf Science, 50, 385-397. Supić, N., Ivančić, I., 2002. Hydrographic conditions in the northern Adriatic in relation to surface fluxes and Po river discharge rates (1966-1992). Periodicum Biologorum, 104, 203-209. Supić, N., Orlić, M., Degobbis, D., 2003. Istrian Coastal Countercurrent in the year 1997. Il Nuovo Cimento, 26, 117-131. Krajcar, V., 2003. Climatology of geostrophic currents in the Northern Adriatic. Geofizika, 20, 105-114. Krajcar, V., 2004. A new method of estimating climatological temperature and salinity fields in the northern Adriatic from historic data. Acta Adriatica, 45 (2), 131-143.
EXAMINATION PROCEDURE: oral exam

Interdisciplinary Doctoral Study in Oceanology
COURSE: Natural and anthropogenic climate changes
AUTHOR OF COURSE PROGRAMME: Branka Grbec,Ph.D, senior scientist, Institute of Oceanography and Fisheries
TEACHING TECHNIQUES: lectures + seminar (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: The lectures are intended to help student to understand the global and regional climatic changes in the atmosphere-land-ocean system due to natural and anthropogenic causes, and the consequences of these changes to marine ecosystem, with main topic to Jadran.
COURSE PROGRAMME: Introduction in climate system and climate changes. Climate differences amongst Earth, Mars and Venus. Climatic processes: Solar radiation and radiation budget. The Hydrological cycle. Greenhouse gases, aerosols. Ocean and atmosphere. Synchronized oscillations of the atmosphere and the sea. Teleconnections: ENSO, NAO, MOI. Climatic changes: Causes of climate changes. External and Terrestrial factors. Natural variability and human effects on climate. Abrupt climate changes. Debate on global warming. The Gaia Hypothesis. Impacts: Sea level, sea temperature and salinity changes. Great salinity anomaly. Influence of climatic changes on oceanographic properties of the Adriatic Sea. Changes in phytoplankton community and fish stocks. Marine ecosystem adaptations to climate changes.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: During semester the students work on solving of problems related to the course themes. Participation in one project task or elaboration of seminar report with given theme is obligatory. Students earn credits, which are valuated on the final exam.
OBLIGATORY LITERATURE: W.J. Burroughts. Climate Change: A Multidisciplinary Approach, Cambridge University Press. 2001. E. Bryant. Climate Process and Change, Cambridge University Press. 1977.
SUPPLEMENTARY LITERATURE: The First National Report of Climate Changes, 2002, MZOPU. www.mzopu.hr; IPCC Climate Changes 2001: IPCC Third Assessment Report. www.grida.no/climate J. Lovelock. Taj živi planet GEA. Izvori, Zagreb 1999.
EXAMINATION PROCEDURE: Seminar work (or project task), final exam.

Interdisciplinary Doctoral Study in Oceanology
COURSE: Selected Topics in Physical Oceanography
AUTHOR OF COURSE PROGRAMME: Dr. Miroslav Gacic, Senior Researcher, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, 34010 Sgonico (TS), Italy
TEACHING TECHNIQUES: Lectures (including homeworks) (15 hours)
ECTS: 3
COURSE ACHIEVEMENTS: The aim of the course is to offer to students a detailed presentation of selected topics in the physical oceanography relevant to their specific interest. More specifically, in function of the students' interest, one of the following topics can be addressed: dense water formation, coastal upwelling, strait exchange, conveyor belt, wind-driven circulation, semi-enclosed bays and lagoons.
COURSE PROGRAMME: Dense water formation: open-ocean deep convection, air-sea buoyancy fluxes, conditions and phases of the open-ocean deep convection, deep convection and ecosystem functioning; Coastal upwelling: world ocean coastal upwelling, methods of studies, influence on the ecosystem; Strait exchange: estuarine and anti-estuarine circulation, case studies; Conveyor belt: definition, components, conveyor belt and climate; Wind-driven circulation: Ekman layer, world ocean wind-driven circulation; Semi-enclosed bays and lagoons: water exchange through inlets, tidal forcing, wind-driven circulation.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: within the chosen topic homework and small projects will be requested.
OBLIGATORY LITERATURE: Pijush Kundu: Fluid Dynamics, Academic Press, 638 pp., 1990. Benoit Cushman-Roisin: Introduction to Geophysical Fluid Dynamics, Prentice Hall, 320 pp. 1994.
SUPPLEMENTARY LITERATURE: Scientific papers to be selected in function of the topic addressed.
EXAMINATION PROCEDURE: Oral

Interdisciplinary Doctoral Study in Oceanology
COURSE: Numerical modelling in physical oceanography
AUTHOR(S) OF COURSE PROGRAMME: Milivoj Kuzmić,DSc. research associate, RBI, Ivica Janeković, BSc, researcher, RBI
TEACHING TECHNIQUES: lectures + exercise (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: The aim of the course is to introduce students to numerical modelling in physical oceanography using basic dynamics and publicly available numerical hydrodynamic models. Demonstrate importance and applicability of physical-oceanographic models in other fields of oceanography (particle transport, reactions).
COURSE PROGRAMME: Fundamentals of numerical modelling and simulation, taxonomy of models, approaches, and procedures. Short presentation of numerical algorithms, approximations, convergence of solutions, and stability of calculations. Examples of coastal ocean dynamics simulations (tidal, wind, residual currents) base on three-dimensional models (ADCIRC, QUODDY, ROMS). Finite difference and finite element formulations; importance of boundary conditions. Examples of modelling studies in other fields of oceanography. Use of passive and active tracers (spreading in precomputed velocity fields, inclusion of biologically and/or chemically controlled changes in space and time.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: assignments on course topics, exercises
OBLIGATORY LITERATURE: Crean P.B., Murty T.S., and Stronach J.A., Mathematical modelling of tides and estuarine circulation. Lecture Notes on Coastal and Estuarine Studies 30, Springer Verlag, 1988, 471pp. Murty T.S., Kowalik Z. Numerical modeling of ocean dynamics, World Scientific, 1993, 481pp. Gochenbach M.S. Partial Differential Equations, Analytical and numerical methods, SIAM, 2002, 614 pp.
SUPPLEMENTARY LITERATURE: Pond S. and Pickard G.L. : Introductory Dynamical Oceanography, Pergamon press, Oxford, 1983. von Schwind J.J. Geophysical fluid dynamics for oceanographers, Prentice-Hall, 1980, 307pp.
EXAMINATION PROCEDURE: written report plus final oral examination

Interdisciplinary Doctoral Study in Oceanology

COURSE: Ocean optics

AUTHOR(S) OF COURSE PROGRAMME: Dr. sc. Dubravko Risović, Research Associate, "Rudjer Boskovic" Institute, Zagreb, Dr. sc. Mira Morovć, Research Associate, Institute of Oceanography and Fisheries, Split

TEACHING TECHNIQUES: Lectures + seminar + in-field and laboratory practice (5 + 5 + 5 hours)

ECTS: 3

COURSE ACHIEVEMENTS: Mastering of basics in optical oceanography, including optical properties of sea water and constituents, basic theoretical assumptions needed for understanding of optical processes in sea water, and application of laser/optical methods in detection, quantification and characterization of dissolved and dispersed material and bulk properties. Acquirement of basic skills in experimental optical oceanography and instrumental use through laboratory and in-field/on ship training.

COURSE PROGRAMME:

Introduction to ocean optics, historical overview, terminology, definitions of physical quantities, importance of light in the sea, reflection, refraction, scattering and absorption of Solar radiation at the interface. Apparent and inherent optical properties. Basic interaction mechanisms: absorption, scattering and fluorescence. Radiation transfer equations. Influence of dissolved and dispersed matter and phytoplankton on optical properties of sea water. Underwater visibility. Color of the sea and light-related processes: bioluminiscence, fluorescence and photosynthesis. Principles of bio-optical models, sea color and algorithms for chlorophyll. Inverse problem and remote sensing – role of backscattering. Instruments and methods. Laser based methods for detection, quantification and characterization of dissolved and dispersed material and phytoplankton. Laser based in-situ methods for measurement of inherent optical properties and particle size distribution. Light scattering and suspended particles. Laser induced fluorescence in characterization of dissolved organic matter.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: Attendance to lectures and practical work at the oceanographic vessel BIOS and in labs.

OBLIGATORY LITERATURE:

R.W. Spinard, K.L. Carder, M. Perry: "Ocean Optics", Oxford University Press, New York, (1994). 283pp.

N.G. Jerlov and E.S. Nielsen, Eds. "Optical Aspects of Oceanography", Academic Press, New York, (1974), 194 pp

N.G. Jerlov: "Optical Oceanography", Elsevier, Amsterdam (1968), 194pp.

Kirk, J.T.O. "Light & Photosynthesis in Aquatic Ecosystems" (second edition). Cambridge University Press, Cambridge, Great Britain, (1994.) 509p.

SUPPLEMENTARY LITERATURE:

Williams, J. 1970. Optical properties of the sea. Annapolis, Md., U. S. Naval Institute.

Hojerslev, N. K. 1990, Daylight in the sea, Landolt-Borstein, New Series V3a.

Robinson I.S., 1995. Satellite Oceanography, Wiley-Praxis Series in

Remote Sensing

Sullivan JM. Twardowski MS. Donaghay PL. Freeman SA. "Use of optical scattering to discriminate particle types in coastal waters". Applied Optics. 44(9):1667-1680, (2005)

D. Risović: *"Two component model of sea particle size distribution"*, Deep-Sea Research, Part I-Oceanographic research Papers, 40, 1459-1473 (1993)

D. Risović, *"Effect of suspended particulate-size distribution on the backscattering ratio in remote sensing of seawater"*, Applied Optics (LPEO) 41 (33),7092-7101, (2002)

A. Morel, S. Maritorena, *"Bio-optical properties of oceanic waters: A reapprisal"*, J. Geophys. Res. 106, 7163-7180, (2001)

A. Bricaud, C.Roesler and J.R.V. Zaneveld, *"In situ methods for mesuring the inherent optical properties of ocean waters"*, Limnol. Oceanogr. 40, 393-410,(1995)

Twardowski MS. Boss E. Macdonald JB. Pegau WS. Barnard AH. Zaneveld JRV. "*A model for estimating bulk refractive index from the optical backscattering ratio and the implications for understanding particle composition in case I and case II waters". Journal of Geophysical Research-Oceans. 106(C7):14129-14142, (2001)*

H. Loisel and A.Morel, "Light scattering and chlorophyll concentration in case 1 waters: reexamination", Limnol. Oceanogr. 43, , 847-858, (1998)

EXAMINATION PROCEDURE: Tests during the lectures. Final oral exam and presentation of a seminar.

Interdisciplinary Doctoral Study in Oceanology
COURSE: Ocean acoustics
AUTHOR(S) OF COURSE PROGRAMME: Predrag Vukadin, Ph.D., Brodarski institut Zagreb
TEACHING TECHNIQUES: lectures + seminar (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Acquiring basic knowledge on underwater sound generation, propagation and detection. Specific competitions are the possibility of understanding ocean sound physics and possibilities of its application in oceanology.
COURSE PROGRAMME: Sound field theory basics (the concept of sound, wave equation, units, reflection, refraction, difraction, attenuation, sound velocity in the ocean (dependencies, basic equations, profiles), underwater sound propagation models (refraction influence, wave theory, propagation ways, sound channels), underwater noise and sea noise (sources, spectra, levels), underwater propagation prediction, hydroacoustic measurements, hydroacoustic devices and systems and its application in oceanology and oceanography.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Class attendance, seminar
OBLIGATORY LITERATURE: Ž. Lazarević: Tehnička hidroakustika, SSNO, Split 1987
SUPPLEMENTARY LITERATURE: Urick, R.J: Principles of the underwater sound, McGraw-Hill, 1983 Vukadin, P.: Povećanje točnosti mjerenja profila brzine zvuka u moru, doktorska disertacija, 2001
EXAMINATION PROCEDURE: Oral

Interdisciplinary Doctoral Study in Oceanology
COURSE: Organic matter in the sea
AUTHOR(S) OF COURSE PROGRAMME: Dr. Božena Ćosović, senior scientist, Ruđer Bošković Institute
TEACHING TECHNIQUE: lectures + practice (15 + 5 hours)
ECTS: 4
COURSE ACHIEVEMENT: Students will gain knowledge and skills about sources, chemical composition and distribution of organic matter in the sea and the role of organic matter in the biogeochemical processes in the sea.
COURSE PROGRAMME: Origin of organic matter in the sea: primary production and input of allochtonous organic substances. Dissolved, colloidal and particulate organic matter: content, concentration and chemical composition, residence time. Organic matter in sediments and diagenetic processes. Processes that control distribution of biogenic organic matter in seawater: biological processes of production and degradation; eutrophication; transport by physical processes. Physico-chemical processes at natural phase boundaries. Adsorption, aggregation processes. Photochemical processes. Interaction of organic matter with trace metals: organic ligands and complexation, acid-base properties. Methods of organic matter analysis: dissolved (DOC) and particulate organic carbon (POC), physico-chemical speciation, specific organic compounds, biomarkers, radioisotopes, complexing capacity. Organic matter in the estuary: input and transformation processes.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance, practical work, seminar
OBLIGATORY LITERATURE: W. Stumm, J.J. Morgan: Aquatic Chemistry, Wiley, 3rd Ed., New York,1996. D.A. Hansell, C.A. Carlson (Eds.): Biogeochemistry of Marine Dissolved Organic Matter. Academic Press, London, 2002. S.E.G. Findlay, R.L. Sinsabaugh (Eds.): Aquatic Ecosystems: Interactivity of Dissolved Organic Matter, Academic Press, London,2003. J.I. Hedges, C. Lee(Eds.): Measurement of Dissolved Organic Carbon and Nitrogen in Natural Waters, Mar Chem 41 (1993) Nos. 1-3.
SUPPLEMENTARY LITERATURE: C. Lee, S.G. Wakeham: Organic Matter in Seawater: Biogeochemical Processes, u Chemical Oceanography (Ed. J.P. Riley, G. Skirrow), Vol 9, Academic Press, New York, 1988, str. 1-51. J.W. Farrington (Ed.): Marine Geochemistry: Review and challenges for the future, Marine Chemistry 39 (1992) 242 p.
EXAMINATION PROCEDURE: oral exam, seminar

Interdisciplinary Doctoral Study in Oceanology
COURSE: Trace elements in seawater, marine organisms and sediments
AUTHOR(S) OF COURSE PROGRAMME: Dr. Nevenka Mikac, senior research associate, «Rudjer Bošković» Institute, Dr. Vlado Cuculić, research associate, Institute for Oceanography and Fishery, Split
TEACHING TECHNIQUES: lectures + seminar (15 + 5 hours)
ECTS: 4
COURSE ACHIEVEMENTS: Getting knowledge on the behavior and distribution of trace elements in various types of samples from the marine environment (sweater, marine organisms, sediments) and the biogeochemical cycles and toxicity for the most important metals and metalloids in the marine environment (cadmium, copper, lead, zinc, mercury, tin, arsenic).
COURSE PROGRAMME: Trace element in the environment - definition and significance; Distribution and typical behavior of individual trace metals or groups of metals with similar chemical behavior in seawater, marine organisms and sediment; Biogeochemical cycles for more important metals and metaloids in marine environment; Bioaccumulation, biomagnification and toxicity of some ecotoxic metals for marine organisms and humans.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Lectures or consultations + writing seminar, depending on the number of students.
OBLIGATORY LITERATURE: Elements and their Compounds in the Environment (Occurence, Analysis and Biological Relevance), Eds: E. Merian, M. Anke, M. Inhat and M. Stoeppler, Wiley_VHC, 2004. An introduction to Marine Biogeochemistry, S.M. Libes, John Wiley & Sons, 1992.
SUPPLEMENTARY LITERATURE: Organometallic compounds in the environment, Ed: Craig, P.J, John Wiley & Sons, 2003.
EXAMINATION PROCEDURE: Verbal exam or written seminar (depending on the number of students).

Interdisciplinary Doctoral Study in Oceanology

COURSE: Marine organic matter organization and function

AUTHOR(S) OF COURSE PROGRAMME: Dr. Vesna Svetličić, research professor, Ruđer Bošković Institute, Zagreb, Croatia**,** Dr. Vera Žutić, research professor, , Ruđer Bošković Institute, Zagreb, Croatia
with participation of research assistents:, Amela Hozić Zimmermann, B.Sc.,Ruđer Bošković Institute, Zagreb, Croatia, Tea Mišić, dipl.inž., B.Sc., Ruđer Bošković Institute, Zagreb, Croatia

TEACHING TECHNIQUES: lectures+exercise + seminar (10 + 5 + 5 hours)

ECTS: 4

COURSE ACHIEVEMENTS: This course goes beyond the traditional disciplines in oceanography to emphasize the relation between the structure, organization and function of organic matter in the sea and to explore the link between the abiotic and biotic processes in the ocean. Students will get familiar with the state of art techniques recently applied in studies of structure and organization of organic matter in the sea.

COURSE PROGRAMME:

- interfacial processes: adsorption, adhesion, aggregation
- EPS (extracellular polymer substance) production in the sea
- supramolecular organization of biopolymers in the sea
- marine particles: from nano particles to macroscopis structures
- marine gel phase with special reference to the northern Adriatic Sea
- molecular organization of marine organic matte rstudied by modern imaging techniques: Atomic Force Microscopy (AFM) and electrochemical imaging

STUDENTS' ACTIVITIES AND THEIR EVALUATION:
lectures, laboratory courses in AFM and electrochemical imaging, prelab exam, consultations and written seminar

OBLIGATORY LITERATURE:
V. Žutić and V. Svetličić (2000) Interfacial processes, The Handbook of Environmental Chemistry, Vol. 5 Part D, Marine Chemistry. *Springer-Verlag*, , pp. 149-165.
J. Israelachvili: Intermolecular and Surface Forces, *Academic Press*, 1992.
N. Smodlaka, D. Degobbis, V. Svetličić (2004) Effect of Phosphorus on Particle Dynamics during Phytoplankton Blooms. Northern Adriatic Mesocosm Experiment Rovinj 2003. *Periodicum Biologorum,*106 1-79.
V J Morris, A R Kirby, A P Gunning (1999) Atomic Force Microscopy for Biologists, *Imperial College Press*
Santos, N.C. & M.A. Castanho (2004). An overview of the biophysical applications of atomic force microscopy. *Biophys Chem* 107(2), 133-149.
Underwood, G.J.C. & D.M. Paterson (2003). The importance of extracellular carbohydrate production by marine epipelic diatoms. *Advances in Botanical Research* 40, 184-240.

SUPPLEMENTARY LITERATURE: selected in interaction with the student depending on the seminar topic

EXAMINATION PROCEDURE: written seminar, pre-laboratory exam, satisfactory performance in the laboratory

Interdisciplinary Doctoral Study in Oceanology
COURSE: Primary and secondary production in shallow seas
AUTHOR(S) OF COURSE PROGRAMME: Dr. Robert Precali, Senior research associate Dr. Dragica Fuks, Research associate, „Ruđer Bošković“ Institute, Center for Marine Research, Rovinj
TEACHING TECHNIQUES: lectures + seminar (12 + 3 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Introduction of attendants to the understanding of carbon cycling through primary and secondary production in shallow seas.
COURSE PROGRAMME: 1. Mechanisms of dissolved organic matter production in the sea. 2. New phytoplankton production in the sea. 3. Carbon cycling in the marine food webs. Microbial food webs in the sea. Heterotrophic bacteria and the dynamics of DOM. Control of bacterial growth and biomass. Trophic consequences: link, sink of DOM and functionality of ecosystems. 4. Carbon flux in shallow seas. Estuary and delta areas. Coastal and offshore waters of the Adriatic Sea. Trophic gradients in the northern Adriatic.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Active participation to the lectures and seminar preparation.
OBLIGATORY LITERATURE: **1.** Primary Productivity and Biogeochemical Cycles in the Sea, (Environmental Science Research: Volume 43), Paul G. Falkowski, Avril D. Woodhead, Plenum Press, 1992 ISBN: 0306441926M **2.** Microbial Ecology of the Ocean, ed. David L. Kirchman, Wiley-Liss Inc. 2000 ISBN: 0-471-29993-6
SUPPLEMENTARY LITERATURE: 1. Viličić D. Phytoplankton in the marine ecosystem. Školska knjiga, Zagreb 2003 (in Croatian) ISBN: 953-0-31130-3 2. Review and original research papers**.**
EXAMINATION PROCEDURE: Accepted seminar and oral exam.

Interdisciplinary Doctoral Study in Oceanology
COURSE: Biotransformation of organic pollutants in marine environment
AUTHOR(S) OF COURSE PROGRAMME: Dubravka Hršak, Senior Scientist, Ruđer Bošković Institute, Zagreb, Croatia
TEACHING TECHNIQUES: lectures + seminars (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Introducing the students about natural habitats of microorganisms and the specificity of biotransformation processes in marine environment; pointing to the role of marine microorganisms in biogeochemical cycling, particularly to their biocatalytic activities in the transformation of environmentally hazardous organic compounds, which is a prerequisite for taking measures against pollution and alleviation of contamination.
COURSE PROGRAMME: Introduction to Environmental Microbiology. Microorganisms and their natural habitats. Microorganisms in marine environments. Microorganisms in extreme environments. The nature of microbial communities. Microbial interactions. Physicochemical factors affecting the environmental fate of microorganisms. Role of microorganisms in biogeochemical cycling. Microorganisms and organic pollutants. Biotransformation of main pollutants (oil, halogenated aliphatic and aromatic compounds, pesticides). Most frequent marine pollutions – control and prevention.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance and seminars
OBLIGATORY LITERATURE: 1. Maier, R. M., Gerba, C. P. and Pepper, I. L. (eds.): Environmental Microbiology. Academic Press, Inc. 1999. 2. Clark, R.B., Frid, C. and Atrill, M.: Marine Pollution. Oxford Univ Pr. 2001. 3. Alexander, M.: Biodegradation and Bioremediation, 2nd ed. Academic Press, Inc. 1999.
SUPPLEMENTARY LITERATURE: Rittmann, B.E. and McCarty P.L.: Environmental Biotechnology – Principles and Applications. The McGraw-Hill Companies, Inc. 2001
EXAMINATION PROCEDURE: seminar or oral examination

Interdisciplinary Doctoral Study in Oceanology
COURSE: Biological effects of metals and organic pollutants on marine organisms
AUTHOR(S) OF COURSE PROGRAMME: Dr. Biserka Raspor and Dr. Tvrtko Smital, Ruđer Bošković Institute, Division for marine and environmental research
TEACHING TECHNIQUES: lectures (15 hours)
ECTS: 3
COURSE ACHIEVEMENTS: The students will get acquainted with the distribution of metals and organic pollutants in seawater and the biologically available components, the pathways of their uptake and excretion from the marine organisms, and their subtoxic effects measurable at the cellular level.
COURSE PROGRAMME: Cycling and the fate of metals and organic pollutants in the marine ecosystem. Physico-chemical parameters that control the fate of metals and/or organic pollutants (chemical forms and their abundance, hydrophilic/hydrophobic characteristics, decomposition). Bioavailability and the uptake routes of pollutants into the organisms, their bioconcentration and biomagnification. Elimination of pollutants in the organisms (biotransformation, detoxification). The effects of metals and organic pollutants on marine organisms. Subtoxic (genomic, molecular, cellular) effects. Biomarkers- definition, subdivision. Some examples of the selected biomarkers (induction of metallothioneins, inhibition of acetilholinesterase, induction of detoxification system of mixed function oxydase and MDR system, DNA damage). Distinction between natural variability of biomarkers and the effects caused by pollutants. Statistical data treatment.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance
OBLIGATORY LITERATURE: 1. W.J.Langston, M.J.Bebianno (editors), Metal Metabolism in Aquatic Environments, Chapman&Hall Ltd, London, 1998. 2. C.H. Walker, S.P. Hopkin, R.M. Sibly, D.B. Peakall, Principles of Ecotoxicology, Second edition, Taxlor and Francis, London, 2001. 3. Proceedings of the Bivalve Biomarker Workshop, A.H. Ringwood (guest editor), Biomarkers, 4 (1999) 391-553.
SUPPLEMENTARY LITERATURE: 1. B. Raspor, Elements and Elemental Compounds in Waters and the Aquatic Food Chain, Chapter 7 in: Elements and their Compounds in the Environment, vol. 1, E. Merian, M. Anke, M. Ihnat, M. Stoeppler (editors), Wiley-VCH Verlag, Weinheim, 2004, pp. 127-147. 2. U. Varanasi, Metabolism of Polycyclic Aromatic Hidrocarbons in the Aquatic Environment. CRC Press Inc., 1989, Boca Raton, Florida 3. J.F. McCarthy, L.R. Shugart, Biological Markers of Environmental Contamination. Lewis Publishers, 1990, Boca Raton, Florida
EXAMINATION PROCEDURE: final oral exam

Interdisciplinary Doctoral Study in Oceanology
COURSE: Analytical chemistry of organic contaminants in the marine environment
AUTHOR(S) OF COURSE PROGRAMME: Dr. Senka Terzić, Higher Research Associate, Rudjer Boskovic Institute, p.p. 180, Bijenička 54, 10 002 Zagreb
TEACHING TECHNIQUES: lectures+ exercise (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Introduction of basic principles of analytical chemistry of organic compounds in the marine environment and familiarisation with the main groups of environmental organic contaminants. Acquisition of the most important techniques for sample enrichment and fractionation and subsequent analyses by applying the highly specific analytical techniques.
COURSE PROGRAMME: Introduction to analytical chemistry • priority pollutants • EU Water Framework Directive • physico-chemical properties of contaminants • sampling and sample preservation • sample enrichment and fractionation• chromatographic techniques• hyphenated techniques (GC/MS, LC/MS) • development and validation of analytical methods • qualitative and quantitative analysis • spectroscopic techniques • specific determination of classical (polycyclic aromatic hydrocarbons, surfactants, polychlorinated biphenyls, herbicides, pesticides) and novel types of contaminants (alkylphenols, xenoestrogens, pharmaceutical compounds)
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Lectures, laboratory practice, seminar
OBLIGATORY LITERATURE: 1. Perez-Benedito D. and Rubio S. *Environmental Analytical Chemistry*, Elsevier, Amsterdam, 1999. 2. CIESM, 2004. *Novel contaminants and pathogens in coastal waters*. CIESM Workshop Monograph n°26, 116 pages, Monaco < www. Ciesm.org/publications/Neuchatel104.pdf>. 3. Loconto, P. R. Trace Environmental Quantitative Analyses Principles: Techniques and Applications, Taylor and Francis Group, Boca Raton, 2006, 731 pp.
SUPPLEMENTARY LITERATURE: 1. Schwarzhenbach R.P., Gschwend P.M, Imboden D.M. Environmental Organic Chemistry, John Wiley and Sons, Inc., Hoboken, New Jersey, 2nd edition, 2003, 1313 pp. 2. Barcelo, D. (Ed.) *Sample Handling and Trace Analysis of Pollutants. Techniques, Applications and Quality Assurance*, Elsevier Science, Amsterdam, 2000, 1116 pp. 3. Simpson, N.J.K. (Ed.). *Solid Phase Extraction. Principles, Techniques, and Applications*, Marcel Dekker, Inc., New York, 2000, 514 pp.
EXAMINATION PROCEDURE: Seminar and oral exam.

Interdisciplinary Doctoral Study in Oceanology
COURSE: Biomarker organic compounds in the marine science
AUTHORS OF COURSE PROGRAMME: Prof. Dr. Marijan Ahel, hon. full professor and senior scientist at the Ruđer Bošković Institute **,** Dr. Mirjana Najdek-Dragić, research associate, Ruđer Bošković Institute
TEACHING TECHNIQUES: lectures + exercise (15 + 5 hours)
ECTS: 4
COURSE ACHIEVEMENTS: Acquaintance with the main classes of biogeomarker compounds (hydrocarbons, fatty acids, pigments, long-chain alkenones, sterols, amino acids, carbohydrates, lignin compounds) with a special emphasis on their possible importance in the investigation of the origin, preservation and transformations of organic matter in the marine environment.
COURSE PROGRAMME: Source of the organic matter in the sea ● relative importance of allochtonous and autochtonous sources the organic matter ● origin of the sedimentary organic matter ● stratigraphic analysis of organic matter in the sediments – geochronology ● main classes of biomarker compounds ● characterisation of phytoplankton using biomarkers ● biomarker lipids from zooplankton ● photosynthetic pigments and their transformation● fatty acids as biomarkers of the sources of organic matter and biogeochemical processes in the sea ● long-chain alkenones and investigation of paleoclimate ● biomarkers of the processes involved in mucous aggregates ● lignin compounds as biomarkers of allochtonous inputs
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Lectures, laboratory practice, seminar, final exam
OBLIGATORY LITERATURE: 1. Killops S.D., Killops V. J. An introduction to organic geochemistry. Wiley & Sons Inc., New York, 1993, 265 pp. 2. Prahl F. G., Muehlhausen L. A. Lipid biomarkers as geochemical tools for paleooceanographic study. In: Productivity of the Ocean: Present and Past. W.H. Berger, V.S. Smetacek, G. Wefer, J.Wiley & Sons, 1989. 3. Jeffrey S.W., Mantoura R.F.C., Wright S. W. (Eds.) Phytoplankton pigments in oceanography, UNESCO Publishing, Paris, 1997, 661 pp
SUPPLEMENTARY LITERATURE: 1. Dalsgaard J., StJohn M., Kattner G., Muller-Navarra D., Hagen W. Fatty acids trophic markers in the pelagic marine environment (Review) Advances in Marine Biology, 46, 225-340 (2003). 2. Mayzaud P., Chanut J.P., Ackman R.G. Seasonal changes of the biochemical composition of marine particulate matter with special reference to fatty acids and sterols. Marine Ecology Progress Series 56, 189-204 (1989).
EXAMINATION PROCEDURE: seminar and oral exam

Interdisciplinary Doctoral Study in Oceanology
COURSE: Precipitation and adsorption processes in the sea
AUTHOR(S) OF COURSE PROGRAMME: Scientific advisor Ph.D. Halka Bilinski, Institute "Ruđer Bošković", Zagreb
TEACHING TECHNIQUES: lecture + exercise + seminar (5 + 5 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Introduce students to physico-chemical processes (precipitation, dissolution, adsorption, desorption), which control composition of natural waters; especially with the development of experimental methods and recent investigations of estuaries, seas and oceans.
COURSE PROGRAMME: Processes of precipitation and dissolution. Processes of adsorption and desorption. Infulence of temperature, pH, ionic strenght and complex formation on mentioned processes. As the most important adsorbens carbonates of calcite, aragonite, dolomite gruops, quartz, some aluminosilicates, hydroxides and oxides of aluminium and iron, mangan oxides and ferromanganese minerals will be described. The examples of adsorption of trace elements will be presented with special emphasis on Hg, Mn, Cr, Co, Ni, Cu, Zn, Cd, Pb and As. Examples of different tecniques suitable for mentioned processes will be presented. Relative importance of inorganic in relation to organic adsorbence in estuaries, seas and oceans will be discussed.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Attendance of classes, writing seminar work.
OBLIGATORY LITERATURE: 1. Chemical Oceanography Vol. 1, ed. J.P. Riley and G. Skirrow, Academic Press, London, 1975. 2. Brown, G.E. & Parks, G.A.: Sorption of trace elements on mineral surfaces: Modern perspectives from spectroscopic studies, and comments on sorption in the marine environment (Review). International Geology Review, 43(11), 963-1073, 2001 Nov. 3. Turner, A., Millward, G.E. & Le Roux, S.M.: Significance of oxides and particulate organic matter in controlling trace metal partitioning in a contaminated estuary. Marine Chemistry, 88(3-4), 179-192, 2004 Sep.
SUPPLEMENTARY LITERATURE: 1. Criscenti, L.J., Sverjensky, D.A.: The role of electrolyte anions (ClO_4^-, NO_3^-, and Cl^-) in divalent metal (M^{2-}) adsorption on oxide and hydroxide surfaces in salt solutions (Review). American Journal of Science, 299(10), 828-899, 1999 Dec. 2. Turner, A., Millward, G.E., Le Roux, S.M.: Sediment-water partitioning of inorganic mercury in estuaries. Environmental Science & Technology, 35(23), 4648-4654, 2001 Dec. 3. Hintelmann, H., Harris, R.: Application of multiple stable mercury isotopes to determine the adsorption and desorption dynamics of Hg (II) and MeHg to sediments. Marine Chemistry, 90(1-4), 165-173, 2004 Nov.
EXAMINATION PROCEDURE: Seminar work as written pre-exam, final exam oral

Interdisciplinary Doctoral Study in Oceanology

COURSE: Anoxia and hypoxia in marine environment

AUTHOR(S) OF COURSE PROGRAMME: Irena Ciglenečki-Jušić, senior research associate, Rudjer Bošković Institute**,** With participation of Stefanija Šestanović, PhD in Biology, research assistant at IOR Split

TEACHING TECHNIQUES: seminars + practice (5 + 10 hours)

ECTS: 3

COURSE ACHIEVEMENTS:
To provide the student with a basic understanding and knowledge on hypoxic-anoxic environment as well as biogeochemical processes, roles of bacteria and metabolic pathways which characterized such environment. Special emphasize will be paid on the influence and cause of hypoxia-anoxia conditions on eutrophication processes and their mutual influence on living environment. As "case studies" will be illustrated Rogoznica Lake, peloid muds and appearance of mucus aggregates in the Adriatic Sea. The Rogoznica Lake will be also example for providing students with basic knowledge on lakes. This interdisciplinary course is recommended for chemists, biologists and physicists.

COURSE PROGRAMME:
Basic definitions, examples and physico-chemical characteristics of hypoxic-anoxic environment (stratification,halocline,termocline,chemocline,mixing processes). Biogeochemical processes, the roles of bacteria and metabolic pathways which are typical for hypoxic-anoxic environment (demineralization processes; redox cycles of major redox-sensitive elements. Fe,Mn,Mo,reduced sulfur species; transport and distribution at the different redox-transition zones: oxic-anoxic conditions, sediment-water column, porewater-sediment; pyritization). Mixing of water layers and classification of hypoxic-anoxic environments regarding on type and frequency of mixing. Sampling and preserving of anoxic samples (field and laboratory work). Development of new sampling in- and ex-situ techniques, needed for better investigation of anoxic environment. Eutrophication processes (natural-anthropogenic). Influence and cause of hypoxia-anoxia conditions on eutrophication processes and their mutual influence on the living environment (flora and fauna in the conditions of redox changes). "Case studies" Rogoznica Lake, peloid muds and appearance of mucus aggregates in the Adriatic Sea.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: seminars, projects, exams

OBLIGATORY LITERATURE:
W.G. Deuser, Reducing Environment, u: Chemical Oceanography, (J.P. Rilley, G. Skirrow, ur.), Vol. III 2nd edition, London 1975, 1.
W.Stumm, J.J. Morgan: Oxidation and Reduction, u: Aquatic Chemistry, (W. Stumm, J.J. Morgan, ur.), Wiley, New York, 1996, 300.
J.W. Murray (ur.), Black Sea Oceanography, Deep-Sea Research 38 (2A), 1991 (Special Issue)
W.Stumm (ur.), Chemical Processes in Lakes, Wiley &Sons, 1985.
A.J.B. Zehnder, Microbiology and Ecology of Sulfate- and Sulfur Reducing Bacteria, u: Biology of Anaerobic Microorganisms, (A.J.B. Zehnder, ur.) Wiley, New York, 1988,

469.
R.E. Riding, S M. Awarmik: Microbial sediments. 2000. Springer-verlag Berlin, Heidelberg, New York. p.331.

SUPPLEMENTARY LITERATURE:

J.Z. Zhang, F.J. Millero, The chemistry of anoxic waters in the Chariaco Trench, Deep-Sea Res. 40 (5), 1993, 1023.
N.N. Rabalais, S.W. Nixon (ur.), Nutrient Over-enrichment in Coastal Waters:Global Patterns of Cause and Effect (Special Issue). Estuaries 25. 2002.
R.S.S.Wu, Hypoxia: from molecular responses to ecosystem responses. Marine Pollution Bulletin 45, 2002, 35.
I. Ciglenečki, Z. Kodba, D. Viličić, B. Ćosović, Seasonal variation of anoxic conditions in the Rogoznica Lake, Croat. Chim. Acta, 71/2 (1998) 217.
I. Ciglenečki, M. Carić, F. Kršinić, D. Viličić, B. Ćosović, The extinction by sulfide – turnover and recovery of a naturally eutrophic, meromictic seawater lake, J. Marine Systems, 2005.

EXAMINATION PROCEDURE: Seminar+oral examination

Interdisciplinary Doctoral Study in Oceanology
COURSE: Oxidation-reduction processes in the sea
AUTHOR(S) OF COURSE PROGRAMME: Dr. Vera Žutić, research professor, , Ruđer Bošković Institute, Zagreb, Croatia **,** Dr. Vesna Svetličić, research professor, Ruđer Bošković Institute, Zagreb, Croatia
TEACHING TECHNIQUES: lectures + exercise + seminar (5 + 5 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: This course is aimed at introducing modern approach to : the major electron transfer processes in the ocean resulting in the oxygen production and consumption photosynthesis and respiration, both at a single cell and the aquatic ecosystem level. The course goes beyond the traditional divisions in oceanography and is recommended to chemists, biologicts and physicists who are interested in biophysical approach to marine processes.
COURSE PROGRAMME: Introduction to oxidation-reduction reactions Oxygen in the sea, origin and reactivity Oxygen production and consumption processes in the aquatic ecosystem Photosynthesis, at a cellular and aquatic ecosystem level Respiration in the marine ecosystem: aerobic and anaerobic respiration Human activity and global environmental change Oxidation-reduction aspects of eutrophication
STUDENTS' ACTIVITIES AND THEIR EVALUATION: lectures, laboratory courses in electrochemical imaging, prelab exam, consultations and written seminar
OBLIGATORY LITERATURE: P.G. Falkowski, J.A. Raven, Aquatic Photosynthesis (1997) Blackwell Science P.A. del Giorgio, P.J. le B. Williams (editori), Respiration in Aquatic Systems (2005), Oxford University Press F. M. Harold (2001)The Way of the Cell: Molecules, Organisms and the order of Life, Oxford University Press
SUPPLEMENTARY LITERATURE : selected in interaction with the student depending on the seminar topic
EXAMINATION PROCEDURE: written seminar, pre-laboratory exam, satisfactory performance in the laboratory

Interdisciplinary Doctoral Study in Oceanology
COURSE: Geochemical equilibria and processes in seawater
AUTHOR(S) OF COURSE PROGRAMME: Dr. Goran Kniewald, senior scientist and full professor, Rudjer Boskovic Institute, Zagreb
TEACHING TECHNIQUES: lectures + exercise (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Development of fundamental and special skills in understanding of basic theoretical concepts and reaction mechanisms controlling the attainment of geochemical equilibria in the sea, and the implementation of computer codes for geochemical modelling and analysis of environmental equilibrium systems.
COURSE PROGRAMME: (1) Basic concepts and definitions (2) Thermodynamic data – measaurement, estimation techniques, compilation of datasets and revisions (3) The laws of thermodynamics, entropy (4) Standard states and equilibrium constants (5) Homogeneous and heterogeneous systems (6) Solid and aqueous solutions (7) Redox equilibria (8) Hydrothermal solution equilibria (9) Equilibria of mineral reactions (10) Geochemical processes at phase boundaries (11) The oceans and atmosphere (12) Role of microorganisms in the mediation of geochemical processes (13) Speciation and geochemical modelling (14) Computer codes and their use – MINEQL, PHREEQ, EQ 3/6 (15) Presentation of term assignements
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Active participation in class, preparation and presentation of term assignement (seminar paper). Numerical problems and computer lab.
OBLIGATORY LITERATURE: Stumm, W. and Morgan, J.J. (1996) Aquatic Chemistry, 3rd edition, John Wiley & Sons, New York.
SUPPLEMENTARY LITERATURE: 1. Anderson, G.M. and Crerar, D.A. (1993) Thermodynamics in Geochemistry – the equilibrium model. Oxford University Press, Oxford. 2. Albarede, F. (1996) Introduction to geochemical modelling. Cambridge University Press, Cambridge. 3. Zhu, C. and Anderson, G. (2003) Environmental applications of geochemical modelling. Cambridge University Press, Cambridge.
EXAMINATION PROCEDURE: Written and oral examination

Interdisciplinary Doctoral Study in Oceanology
COURSE: Radioecology
AUTHOR(S) OF COURSE PROGRAMME: Dr.sc Stipe Lulić
TEACHING TECHNIQUES: lectures + seminar (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Qualify the student for the understanding of impact of radioactivities on the environment, her expansion and impact on the man.
COURSE PROGRAMME: Radioactivity natural and artificial. Nuclear processes and detection of radioactivities. Sources of radioactive contamination. Radioactivity of the environment. Methods research contaminations. Capacity of organisms that concentrate the radionuclide. Concentration relations, concentration factors and contamination factors. Indicatory organisms. Legality of entry and accumulations of radionuclide in water organisms. Kinetic and physical chemical aspects of accumulation of radionuclide. Deposits of organisms and distributions natural and artificial radioactivities. (somatic and genetic) the radiocontamination on organisms and ecosystems must.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Attending and participating in the lesson, making of seminar and prepares for the taking an exam.
OBLIGATORY LITERATURE: R.J. Garner: Transfer of Radioactive Materials from the Terrestrial Environment to Animals and Man, CRC Press, 1972 International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, IAEA, 1996. Dursma, E.K., Carell, J.: Environmental Compartments, Spinger, Berlin, 1996. D.Feretić i suradnici: Elektrane i okoliš (sveučilišni udžbenik), Zagreb 2000.
SUPPLEMENTARY LITERATURE: Edward W. Finucane, Definitions, Conversions and Calculations for Occupational Safety and Health Professionals, Second Edition, Lewis Publishers, 1998. Scott S. Olson, International Environmental Standards Handbook, Lewis Publishers, 1999. Science & Technology, McGraw-Hill, 2005.
EXAMINATION PROCEDURE: Orally and seminar

Interdisciplinary Doctoral Study in Oceanology
COURSE: Physical chemistry of the sea and seawater
AUTHOR(S) OF COURSE PROGRAMME: Dr.sc. Božena Ćosović, senior scientist, Ruđer Bošković Institute
TEACHING TECHNIQUE: lectures (15 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Introduction to chemical equilibrium and kinetics of processes in the sea and in the seawater, which regulate chemical composition of seawater and interactions of matter with sediment and biota.
COURSE PROGRAMME: Chemical thermodynamics of natural waters (chemical equilibrium and changes, influence of temperature and pressure, limitations of thermodynamic information in natural systems, equilibrium and stationary state). Seawater – electrolytic solution (chemical composition, pH, salinity, ionic pairs, complexes, chelates, hydrolysis, determination of actual and apparent ionic states, dissolved gases). Oxido-reduction processes and equilibrium (redox pairs and potentials, the role of oxygen, photochemical reactions). Dissolution and precipitation processes (solubility of hydroxides, carbonates, aluminosilicates, stability of hydrolyzed species, crystal growth, adsorption-desorption processes and equilibrium at conditions of natural waters). Regulation of chemical composition of seawater (evaporation, precipitation, atmospheric and river inputs, dissolution, influence of biological processes and life cycles). Model systems of the sea and seawater.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance and seminar
OBLIGATORY LITERATURE: W. Stumm, J.J. Morgan: Aquatic Chemistry, Wiley, 3rd Ed., New York,1996. F. Millero: The Physical Chemistry of Natural Waters, Wiley, New York,2001. P. Liss, R.A. Duce: The Sea Surface and Global Change, Univerity Press, Cambridge, 1997.
SUPPLEMENTARY LITERATURE: P.J. Wangersky (Ed): Marine Chemistry, The Hanbook of Environmental Chemistry, Vol 5 Part D, Springer, Berlin Heidelberg, 2000. A. Saliot (Ed): The Mediterranean Sea, The Handbook of Environmental Chemistry, Vol 5 Part K, Springer, Berlin Heidelberg, 2005.
EXAMINATION PROCEDURE: Oral exam and seminar

Interdisciplinary Doctoral Study in Oceanology
COURSE: Analysis of trace elements in marine environment
AUTHOR(S) OF COURSE PROGRAMME:, Marina Mlakar, PhD, senior research associate, «Rudjer Bošković» Institute, Zagreb, Nevenka Mikac, PhD, senior research associate, «Rudjer Bošković» Institute, Zagreb, Dario Omanovic, PhD, research associate, «Rudjer Bošković» Institute, Zagreb
TEACHING TECHNIQUES: lectures + practice (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Getting knowledge on the analytical methods for trace elements determination in seawater, marine sediments and organisms; Getting knowledge on methods for trace elements speciation in various types of samples; More detailed insight on determination and speciation of some important elements (cadmium, copper, lead, zinc, mercury, arsenic, nickel, chromium, iodine)
COURSE PROGRAMME: Methods for sampling and sample storage; Methods for preparation and treatment of seawater, sediments and biota samples for speciation and determination of total element concentration; Basic instrumental techniques for elements determination in marine samples (electrochemistry, ICP-MS, AAS, spectrophotometry); Quality control of measurement.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Lectures or consultations + writing seminar, depending on the number of students.
OBLIGATORY LITERATURE: 1Analytical Electrochemistry, J. Wang, John Wiley & Sons, New York, 2000. Spectrochemical Trace Analysis for Metals and Metalloids, R. Lobinski and Z. Marczenko, Comprehensive Analytical Chemistry (Ed. S. G. Weber), Volume XXX, Wilson & Wilson's, 1997.
SUPPLEMENTARY LITERATURE: Sample Preparation for Trace Metal Analysis, Z. Mester and R. Strugeron, Comprehensive Analytical Chemistry (Ed. D. Barcelo), Volume XLI, Wilson & Wilson's, 2003.
EXAMINATION PROCEDURE: Verbal exam or written seminar (depending on the number of students).

Interdisciplinary Doctoral Study in Oceanology

COURSE: Marine Phytobenthos

AUTHOR(S) OF COURSE PROGRAMME: Ph. dr. Boris Antolić, IOR, Split

TEACHING TECHNIQUES: lectures (15 hours)

ECTS: 3

COURSE ACHIEVEMENTS:
During the lectures students will be introduced to basic systematic, biology and ecology of seaweeds and seagrasses. The most important representatives of benthic marine flora from the Adriatic and Meidterrannean. Phytobenthic communities and their distribution together with changes in their composition as result of pollution or introduction of the new species will be presented.

COURSE PROGRAMME:
History, metodology and important of phytobenthic investigations. Systematical, biological and ecological characteristics of blu-green (Cyanophyta) green (Chlorophyta), brown (Phaeophyta) and red (Rhodophyta) algae, and segrasses (Spermatophyta). Benthic vegetation in the Adriathic Sea and Meidterrann. Seasonal, deep and horizontal distribution of benthic flora and vegetation in the relathsionship of ecological factors. Changes in composition and distribution of the benthic flora and vegetation as result of pollution or introduction of the new species.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: seminar

OBLIGATORY LITERATURE:
1. Ercegović,A. 1960. Značajne crte vegetacije alga Jadranskog mora. Acta Bot.Croat., 28/29:17-36.
2. Ercegović,A. 1964. Dubinska i horizontalna raščlanjenost jadranske vegetacije alga i njezini faktori. Acta Adriat., 11 (9): 75-84.
3. Ercegović,A. 1966. Pogled na floru i ekologiju plitkovodne vegetacije alga u srednjem Jadranu. Ekologija, 1 (1-2): 55-75.
4. Péres,J.M.i H.Gamulin-Brida, 1973. Biološka oceanografija. Bentos. Bentoska bionomija Jadranskog mora. Školska knjiga, Zagreb, 493 pp.

SUPPLEMENTARY LITERATURE:
1. Lobban,C.S., Harrison,P.J. and M.J.Duncan, 1985. The physiologycal of seaweeds. Cambridge University Press, Cambirdge, 242 pp.
2. Lüning,K. 1990. Seaweeds. Their environment, biogegraphy and ecophysiology. John Wiley and Sons, Inc., New York, Chichester, Brisbane, Toronto, Singapore, 527 pp.
3. Hoek,C.van den, Mann,D.G. and H.M.Jahns 1995. Algae. An introduction to phycology. Cambridge University Press, Cambridge, 623 pp.

EXAMINATION PROCEDURE: oral

Interdisciplinary Doctoral Study in Oceanology
COURSE: Biodiversity and ecology of sponges
AUTHOR(S) OF COURSE PROGRAMME: Tatjana Bakran-Petricioli, PhD, Assistant Professor, Division of Biology, Faculty of Science, University of Zagreb, Doc.dr.sc. Ivana Grubelić, Institute of Oceanography and Fisheries Split
TEACHING TECHNIQUES: lecture + exercise + seminar (5 + 5 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: The students will become familiar with different aspects of sponge biodiversity as well as with their ecology. After successfully passing the exam they will have insight into the newest knowledge of biology, ecology and chemistry of sponges. They will be able to evaluate when and where the sponges are suitable model organisms in research and explain why. Also, they will be able to suggest and plan a research project on sponges from their point of view (*i. e.* considering their own field of work or/and problem they have been working on).
COURSE PROGRAMME: Introduction to phylum Porifera. Bauplan organization of sponges, aquiferous system, skeleton. Sponge physiology, endosymbionts in sponges, nutrition (case of carnivorous sponge). Reproduction of sponges (gametogenesis, embryogenesis, types of larvae, metamorphosis; asexual reproduction and regeneration). Embryology and taxonomy. Ecology of the larvae and population structure. Classification - basis of taxonomy: Demospongiae, Hexactinellida, Calcispongiae, the special case of Homoscleromorpha. Phylogeny of Porifera: Monophyly or paraphyly of Porifera? Molecular phylogeny of Calcisponges and Demospongiae. Dynamics of sponge populations and population genetics. Are there true cosmopolitan sponge species? Allozymes, microsatellites and DNA sequences in sponge population genetics. Ecology of Porifera; bathymetric repartition; sponges in various habitats. Chemical ecology of sponges. Sponges as bioindicators and bioremediators. Fossil sponges and hypercalcified sponges. Paleoecology of Porifera: sponges in the ecosystem of the Paleozoic. Observation, photography and collection of sponges in the field. Methods for inventory of sponges. Fixed quadrates for long term observations. Databases. Use of sponges by man. Commercial sponges. Bioactive molecules (antibacterial activity, cytotoxicity, etc.). Case studies: *Crambe crambe.* Some examples of pharmacological activities. Bioactive molecules and chemotaxonomy.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: - regular attendance of classes, active participation during classes, writing homework and seminar paper, oral presentation of seminar paper in front of the colleagues
OBLIGATORY LITERATURE: - printed course materials, lecture presentations, selected reviews, professional and scientific articles, selected parts of the book: Hooper, J. N. A. & Van Soest, R. W. M. (editors) 2002: Systema Porifera, vol. 1 i vol. 2, Kluwer Academic/Plenum Publishers, New York, Boston
SUPPLEMENTARY LITERATURE: - selected reviews and scientific articles according to student interest and main field of

study
EXAMINATION PROCEDURE: - in the final grade all of the following will be counted: active participation in lectures, seminar paper grade, oral presentation of seminar paper, short written tests in the course of lectures, final oral exam

Interdisciplinary Doctoral Study in Oceanology
COURSE: Planktonic cnidaria
AUTHOR(S) OF COURSE PROGRAMME: Dr.sc. Benović Adam i Dr.sc. Mirna Batistić, IMP-UNIDU
TEACHING TECHNIQUES: lecture + exercise (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Introduce students into marine cnidaria, their role in the ecosystem in coastal and pelagic environments, metagenetic generations of cnidaria and links of benthic and planktonic communities.
COURSE PROGRAMME: Systematics and evolution of Cnidaria, food chain, vertical distribution in the water column, metagenetic organisms, cnidome and cnydocystes, species and population ecology, role in communities, zoocurrents and indicator species, practical knowledges on threats for human health, protection against intoxication, sampling in the field, laboratory practices in recognition of species.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Class attendance and active lecturing, seminars, (optional: field work, sampling at the sea, in situ video, laboratory analyses of specimens)
OBLIGATORY LITERATURE: Buillon, J, Medel, M.D., Pages, F., Gili, J.M., Boero, F. and C. Gravili: Fauna of the Mediterranean Hydrozoa, Scientia Marina, suppl. 2, 2004. Kramp, P.L. The hydromedusae of the Atlantic Ocean and adjacent waters, Dana-Report, 46, 1959. Benović, A., D. Lučić, V. Onofri, M. Batistić, and J. Njire: Bathymetric distribution of medusae in the open waters of the middle and south Adriatic Sea during spring 2002. J.Plankt.Res, 27, 1, 79-89, 2005 The hydrozoa directory: http://www.ville-ge.ch/musinfo/mhng/hydrozoa-directory.htm Gamulin, T. & Kršinić, F., 2000. Calycophores (Siphonophora, Calycophorae) of the Adriatic and Mediterranean Seas. *Natura Croatica*, 9 (Suppl. 2), 1-198.
SUPPLEMENTARY LITERATURE: to be selected in consultation with the lecturer
EXAMINATION PROCEDURE: Oral exam, presentation of seminar paper.

Interdisciplinary Doctoral Study in Oceanology
COURSE: Marine Molecular Toxicology
AUTHOR(S) OF COURSE PROGRAMME: Dr. sc. Nevenka Bihari, senior scientist**,** Institute "Ruđer Bošković" Center for Marine Research
TEACHING TECHNIQUES: lectures (15 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Students will get acquainted with natural and anthropogenic effects on marine organisms and environment as an inescapable fact of life. Integration of molecular biology response with physical and chemical processes involved in origination of toxic and genotoxic effects as well as diagnosis and prognosis, will be emphasized. Students will be introduced with different biochemical and molecular biology techniques, flow cytofluorimetry, field work and sampling. Special attention will be paid on data processing (statistic) and presentation.
COURSE PROGRAMME: Input and fate of toxins and genotoxins in marine environment. Effect of toxins and genotoxins on marine organisms with special accent on macromolecular level. Methodology necessary for determination of toxins and genotoxins in water column and sediment as well as for monitoring of alteration on macromolecular (proteins, DNA) level in marine organisms belonging to different phyla. Statistical processing and interpretation of the results. Risk assessment of environmental conditions on individual and population level in order to prognoses consequences on biological resources, ecosystem and human health.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Class attendance, seminars and acquaintance with research methodology
OBLIGATORY LITERATURE: Due to interdisciplinary and relatively new molecular biology approach to investigations of presence and effect of toxins and genotoxins in the marine environment students will follow primary publications and reviews that are available for academic society of Croatia.
SUPPLEMENTARY LITERATURE: Hoffman, D.J., Rattner, B.A., Burton, G.A., Jr., Cairns, J. Jr..: Handbook of Ecotoxicology, 1995
EXAMINATION PROCEDURE: Seminar paper and final oral exam

Interdisciplinary Doctoral Study in Oceanology
COURSE: Programmed Biosynthesis and Genotoxic Risk
AUTHOR(S) OF COURSE PROGRAMME: Renato Batel, DSc., Research Associate, Ruđer Bošković Institute
TEACHING TECHNIQUES: lectures (15 hours)
ECTS: 3
COURSE ACHIEVEMENTS: The primary goal is to present the general knowledge about DNA mutagenesis and repair, with special emphasis on aquatic organisms.
COURSE PROGRAMME: DNA damage (spontaneous, stress induced, the impact of chromatin structure, measurement methods). The mechanisms of DNA repair: damage reversion (photoreactivation, repair of alkylated bases and phosphotriesters, repair of single strand break), excision repair of bases (glycosylases, AP lyases and endonucleases, oxidative damage). Nucleotide excision repair in eukaryotes: (lower eukaryotes and mammals, genes and proteins). Error prone repair (SOS system in prokaryotes and eukaryotes). Mutagenesis and tolerance of DNA damage in eukaryotes (DNA double strand break and recombination). The response mechanisms of eukaryotes to DNA damaging contaminants (gene activation upon genotoxic stress, perturbation of the cell cycle, programmed cell death, signal transduction).
STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance, seminars
OBLIGATORY LITERATURE: Friedberg,, Walker, Siede. «DNA repair and Mutagenesis» (ISBN 1-55581-088-8), ASM Press, Washington DC, 1997.
SUPPLEMENTARY LITERATURE: JHJ Hoeijmakers. Genome maintenance mechanisms for preventing cancer. Nature 411: 366-374,2001. S Broomfield, T Hryciw & W Xiao. DNA postreplication repair and mutagenesis in Saccharomyces cerevisiae. Mutation Res. 486: 167-184, 2001. PMJ Burgers et al. Eukaryotic DNA polymerases: proposal for a revised nomenclature. J. Biol. Chem. 276:43487-43490, 2001. MF Goodman. Error-prone repair DNA polymerases in prokaryotes and eukaryotes. Annu. Rev. Biochem. 71:17-50, 2002. JQ Svejstrup. Mechanisms of transcription-coupled DNA repair. Nature Revs. Mol. Cell Biol. 3:21-29, 2002. P McGlynn, RG Lloyd. Recombinational repair and restart of damaged replication forks. Nature Revs. Mol. Cell Biol. 3:859-870, 2002. TJ Begley, LD Samson. AlkB mystery solved: oxidative demethylation of N1-methyladenine and N3-methylcytosine adducts by a direct reversal mechanism. TIBS 28: 2-5, 2003. EC Friedberg. DNA damage and repair. Nature 421: 436-440, 2003. J Jiricny, G Marra. DNA repair defects in colon cancer. Curr. Opin. Genet. Devel. 13: 61-69, 2003. JR Mitchell, JHJ Hoeijmakers, LJ Niedernhofer. Divide and conquer: nucleotide excision repair battles cancer and ageing. Curr. Opin. Cell Biol. 15: 232-240, 2003.

SD Cline, PC Hanawalt. Who's on first in the cellular response to DNA damage? Nature Revs. Mol. Cell Biol. 4: 361-372, 2003.
MR Lieber, Y Ma, U Pannicke, K Schwarz. Mechanism and regulation of human non-homologous DNA end-joining. Nature Revs. Mol. Cell Biol. 4: 712-720, 2003.
Sancar A, Lindsey-Boltz LA, Unsal-Kacmaz K, Linn S. Molecular mechanisms of mammalian DNA repair and the DNA damage checkpoints. Annu Rev Biochem 73: 39-85, 2004.
Shiloh Y, editor. BRIDGE OVER BROKEN ENDS - The Cellular Response to DNA Breaks in Health and Disease. Special issue of DNA Repair Volume 3, Issues 8-9, Pages 779-1251 (August - September 2004)
Bartek J, Lukas C, Lukas J. Checking on DNA damage in S phase. Nat Rev Mol Cell Biol 5: 792-804, 200

EXAMINATION PROCEDURE: Written and verbal exam + written semianr

Interdisciplinary Doctoral Study in Oceanology
COURSE: Reproduction and embryology of fishes
AUTHOR(S) OF COURSE PROGRAMME: prof.dr.sc. Jakov Dulčić, scientific advisor, Institute of Oceanography and Fisheries-Split, University of Split
TEACHING TECHNIQUES: lectures + exercise (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: To introduce students with life cycle of fishes, reproduction and embryology of fishes.
COURSE PROGRAMME: Introduction. Reproductive organs and cells in fishes. Reproductive cycle. Fecundity. Fertilization. Embryonic development. The basic embryonic terms. Biological factors in reproduction. Early life history stages. Food and feeding of early life history stages. Growth. Mortality and survival. Reproduction in captivity. The influence on reproduction by manipulation of ecological factors and by genetic modifications. Sampling of early life history stages. The calculation of biomass on the basis of early life history stages.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance, exercises
OBLIGATORY LITERATURE: Mellinger, J. 2002. Sexualite et Reproduction des Poissons. CNRS Editions, Paris, France, 349 pp. Regner, S. 1989. Reproduction of fishes and ecology of their early stages. Institute of Oceanography and Fisheries. Centre for the training of fishing personnel from developing countries. 107 p. Depeche, J. et R. Billard. 1994. Embryology in fish. A review. Editions speciales de la Societe francaise d'ichthyologie, 123 pp
SUPPLEMENTARY LITERATURE: Ćurćić, B. 1984. Razviće životinja. Naučna knjiga, Beograd. Gilbert, S.F. 2003. Developmental Biology. Seventh Edition, Sinauer Associates, 838 pp. Bond, C.E. 1997. Biology of Fishes. Saunders College Pub. 576 pp.
EXAMINATION PROCEDURE: exercises, final oral exam

Interdisciplinary Doctoral Study in Oceanology
COURSE: Aquaculture
AUTHOR(S) OF COURSE PROGRAMME: Prof.PhD. Ivan Katavić, University of Split**,** PhD. Leon Grubišić, University of Split
TEACHING TECHNIQUES: lectures + practice + seminar (10 + 5 + 5 hours)
ECTS: 4
COURSE ACHIEVEMENTS: Objective of this course is introduction of students to basic of aquaculture, methods and technologies of rearing aquatic species and environmental aspects of aquaculture.
COURSE PROGRAMME: Historical background of Croatian and World aquaculture. Definition, goals, directions and global trends of fish, mollusk and crustaceans culture. Bio-ecological features of culture species. Selecting criteria for new rearing species. Broodstock management, induce reproduction, methods and produce techniques. Culture of phytoplankton and zooplankton. Extensive, semi-intensive, intensive and super-intensive aquaculture. Land based (ponds and raceway systems) and cage farming. Sea restocking – ranching. Mono and poli-culture. Suitability criteria of marine habitats for mariculture. Impacts of aquaculture on environment. Disturbances in aquaculture processes.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Lectures, seminar, laboratory exercises, fieldwork exercises
OBLIGATORY LITERATURE: Stickney, E. R. 2000. ENCYCLOPEDIA OF AQUACULTURE. John Wiley & Sons, Inc. 1063 p. Beveridge, M.C.M. 1996. Cage aquaculture. Fishing News Books, Blackwell, Oxford, 351p. Ivan Bogut, Ivan Katavić, Zdenek Adamek, Laszlo Horvath RIBOGOJSTVO
SUPPLEMENTARY LITERATURE: Moretti, A i dr. 1999. Manual on hatchery production of seabass and gilthead seabream. Volume1. FAO Ottolenghi, F., Silvestri, C., Giordano, P., Lovatelli, A., New, M.B., 2004. Capture-based aquaculture. The fattening of eels, groupers, tunas and yellowtails. Rome, FAO, 385p. Spencer, B.E. 2002. Moluscaan shellfish farming. Blackwell Science, UK.325p. Black, K.D. and Pickering, A.D. (eds). 1998. Broodstock management and egg and larvae quality. Blackwell Science Ltd. 424p.
EXAMINATION PROCEDURE: Written and oral exam

Interdisciplinary Doctoral Study in Oceanology

COURSE: Marine bacteriology

AUTHOR(S) OF COURSE PROGRAMME: Nada Krstulović, professor, Institute of Oceanography and Fisheries, Split

TEACHING TECHNIQUES: lectures + seminars + exercise (10 + 5 + 5 hours)

ECTS: 3

COURSE ACHIEVEMENTS:

This subject should provide students answers to the questions: What are the standing stock and production rates of various microbial groups in marine environment? What is the flux of DOM through bacteria to higher trophic levels? What is contribution of heterotrophic bacteria to mineralization of C and N, especially as sources of nutrients like ammonium for primary production? In short, this subject should provide the students understanding the role of microbes in food web dynamics and biogeochemical cycles in the marine environment. How microbes impact oceanographic and ecological processes ?

COURSE PROGRAMME:

An introduction to marine microbiology. Marine microbes – an overview. Habitats for marine bacteria. Abundance, biomass, productivity and distribution of microorganisms, especially of bacteria in marine environment. Factors influencing the density and dynamics of bacteria. The role of bacteria in marine ecosystem. Microbial food web. Heterotrophic processes and the Microbial Loop. Interaction between bacteria and their Grazers. Impact of Viruses on Bacterial processes. Dynamics and activity of bacteria in sediments. Dynamics and activity of bacteria in deep-sea environment. Relationship of bacteria and macroorganisms in marine environment. Alochtonous microorganisms in marine environment.

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

Class attendance, seminars, activities in some projects

OBLIGATORY LITERATURE:

1. Krstulović, N. i M. Šolić, 2006 (in press). Mikrobiologija mora. Sveučilišni udžbenik, IOR-Split, 350p.
2. Šolić, M. i N. Krstulović, 2000. Ekologija morskog bakterioplanktona, Sveučilišni priručnik, IOR-Split, 472p.

SUPPLEMENTARY LITERATURE:

1. Austin, B. 1993. Marine Microbiology, Cambridge University Press,218 p
2. Kirchman, D.L. 2000. Microbial Ecology of the Oceans, Wiley Series in Ecological and Applied Microbiology, 542p

EXAMINATION PROCEDURE:

Assessments during lectures.
Exam: written after main chapter and oral at the end of teaching process.

Interdisciplinary Doctoral Study in Oceanology
COURSE: Marine Zooplankton
AUTHOR OF COURSE PROGRAMME: Prof.dr.sc. Frano Kršinić, Senior Advisor Institute of Oceanography and Fisheries, Split and honorary professor at PMF University of Zagreb
TEACHING TECHNIQUE: lectures + practice (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Introduction with important knowledge of the seas and oceans zooplankton biology and ecology.
COURSE PROGRAMME: Expeditions, methodology of collecting, spatial and seasenal distributions, migration of dominant assemblages of zooplankton. Distributional pattern of copepods. Zooplanktonic communities in the deep-sea, coastal water and estuaries. Succession of species, generation time and physiological activity. Variability of population in conection to environment, and biotic conditions. Rare organisms and growth rates. Mass occurrences of gelatinous and other assemblages. Cysts and resting eggs and their ecologycal importance. Contribution of zooplankton in proceses remineralisation of organic matter. The frontal zons and the upwelling. Laboratory growth of zooplankton.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance and seminars.
OBLIGATORY LITERATURE: Raymont, J.E.G. (1983) Plankton and productivity in oceans. Zooplankton, 2, Pergamon Press, Oxford, 824 pp.
SUPPLEMENTARY LITERATURE: Hure, J. & F. Kršinić (1998) Planktonic copepods of the Adriatic Sea. Spatial and temporal distribution. Natura Croatica, 7, suppl. 2, 135 pp.
EXAMINATION PROCEDURE: Final oral exam

Interdisciplinary Doctoral Study in Oceanology
COURSE: Modelling in ecology
AUTHOR(S) OF COURSE PROGRAMME: Dr. sc. Tarzan Legović, entitled full prof., R. Bošković Institute
TEACHING TECHNIQUES: lectures + exercises (10 + 5 hours)
ECTS: 4
COURSE ACHIEVEMENTS: Enable students to understand reasons why mathematical models of ecosystems are being built, how they are build and analyzed and how they are applied.
COURSE PROGRAMME: Dynamics of populations in peaceful, periodic and random environments. Continuous and discrete dynamics. Malthus and Verhulst laws. Proportional fishery and quota. Maximum sustainable yield. Consequence for persistence of species. Chaotic dynamics and control. Prey-predator systems. The principle of Volterra. Fishery and conditions for the existence of the MSY. Food chains. Consequences of fishery and eutrophication. Competition models and principle of competitive exclusion. Models of cooperation. Models of cycling of matter. Invasion of a population into space. Theory of epidemics and the threshold theorem. Further elements of population control. Applications to marine ecosystems
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Attendance to lectures, solving problems, presentation of solutions, exam.
OBLIGATORY LITERATURE: Sharov A., Quantitative Population Ecology, Virginia Tech., 1996 http://www.gypsymoth.ento.vt.edu/~sharov/PopEcol/popecol.html Edelstein-Keshet, L., Mathematical Models in Biology, SIAM, 2005.
SUPPLEMENTARY LITERATURE: Murray J. D., Mathematical Biology, Springer, 2004. Kott, M., Elements of Mathematical Ecology, Cambridge Univ. Press, 2001. Neumann T, Fennel W. Introduction to the Modelling of Marine Ecosystems, Elsevier, 2004
EXAMINATION PROCEDURE: Written and oral exam.

Interdisciplinary Doctoral Study in Oceanology
COURSE: Marine phytoplankton
AUTHOR(S) OF COURSE PROGRAMME: Ivona Marasović**,** University proffesor, Director of Institute of Oceanography and Fisheries
TEACHING TECHNIQUES: Lectures + exercises + seminar (5 + 5 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS*:* Students are introduced to biological and ecological characteristics of phytoplankton and its role in marine ecosystem.
COURSE PROGRAMME: General characteristics of plankton. General characteristics and systematic of phytoplankton. Primary production in the sea. Relationship between primary production and biomass. Regional distribution of of biomass. Seasonal fluctuations of biomass. Diversity and succession of species. Phytoplankton role in food web. Relationship between different size fractions of phytoplankton. Zooplankton grazing – control of phytoplankton biomass. Ecological analysis of phytoplankton bloom. Toxic phytoplankton species. Indicator species.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance, seminars, laboratory practicum, field work on research vessel
OBLIGATORY LITERATURE: Raymont, J.E.G.: Plankton and productivity in the oceans. Pergamon Press. New York, 1980. Steidinger, K.A. and Walker, L.M. Marine Plankton Life Cycle Strategies, CRC Press Inc. Boca Raton, Florida, 1986. Okaichi, T., D.M. Anderson and T. Nehoto, 1989. Red tides: Biology, Environmental Science and Toxicology, Elsevier, Amsterdam, 489 p. Viličić, D. Fitoplankton u ekološkom sustavu mora, Školska knjiga, Zagreb 2003.
SUPPLEMENTARY LITERATURE: UNESCO, 2003. Manual on Harmful Marine Microalgae. Ed. G.M.Hallegraeff, D.M.Anderson, A.D.Cembella, UNESCO publ., Paris, France. ISBN: 92-3-103871-0 Review papers and Scientific papers
EXAMINATION PROCEDURE: Term exam related to practical exercises, final oral exam

Interdisciplinary Doctoral Study in Oceanology
COURSE: Bivalve biology
AUTHOR OF COURSE PROGRAMME: Dr. Melita Peharda Uljević, Institut of Oceanography and Fisheries
TEACHING TECHNIQUES: lectures + exercises + seminar (5 + 5 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Students will gain knowledge on biology and ecology of bivalves, with special reference to bivalve species living in the Adriatic Sea.
COURSE PROGRAMME: Bivalve morphology. Biodiversity of bivalves. Bivalves of the Adriatic Sea. Feeding of bivalves. Reproduction and settlement. Bivalve growth. Circulation, respiration, excretion and osmoregulation. Fisheries management of wild populations of bivalves. Sampling and methods for bivalve research.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Class participation, literature review, critical analysis of scientific papers, laboratory exercises, term paper, final oral exam
OBLIGATORY LITERATURE: - Gosling, E. Bivalve molluscs: Biology, Ecology and Culture. Blackwell Publishing, 2003 - Dame, R.F. Ecology of marine bivalves – an ecosystem approach. CRC Press, 1996
SUPPLEMENTARY LITERATURE: - Poppe, G.T. & Y. Goto Y. European Seashells. Volume II. (Scaphopoda, Bivalvia, Cephalopoda). 2nd edn. ConchBooks, Hackenheim, Germany, 2000 - Scientific papers about bivalves
EXAMINATION PROCEDURE: Completion of all obligations during the term, term paper and final oral exam

Interdisciplinary Doctoral Study in Oceanology
COURSE: Marine Zoobenthos
AUTHOR(S) OF COURSE PROGRAMME: Professor (permanent position), Antonieta Požar-Domac, PhD, Faculty of Science University of Zagreb
TEACHING TECHNIQUES: Lectures + seminar (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Getting to know life on the sea bottom and developing awareness of the meaning of sustainmnet and protection of the marine ecosystem.
COURSE PROGRAMME: Historical overview of the sea bottom life exploration. Main processes and factors that influence sea bottom living world. Biogeochemical cycles, material cycles and energy flow, food chains. Influence of abiotic factors on the distribution and endangerment of the seabottom populations and habitats. Littoral and deep sea area. Interspecies and intraspecies relations. Biostocks, mariculture, specially protected areas.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Obligatory class attendance and seminar.
OBLIGATORY LITERATURE: Levinton, J. S: Marine Biology (Function, Diversity, Ecology), Oxford University Press, Oxford, UK, 2001. Pérès, J.M., Gamulin-Brida, H: Biološka oceanografija. Bentos. Bentoska bionomija Jadranskog mora. Školska knjiga, Zagreb, 493 pp., 1973. Bellan-Santini, D. et al: Les biocénose marine set littorales de Méditerranée, synthese, menaces et perspectives. Muséum Nationale d'histoire naturelle Paris, 245 p., 1994.
SUPPLEMENTARY LITERATURE: Miller, C. B: Biological Oceanography. Blackwell Publising, Oxford UK, 2004. Gubbay, S: Marine Protected Areas. Chapman & Hall London, 1995.
EXAMINATION PROCEDURE: Written and oral examination

Interdisciplinary Doctoral Study in Oceanology
COURSE: Biology of pelagic fish
AUTHOR(S) OF COURSE PROGRAMME: Gorenka (Gorana) Sinovčić, Ph. D., Scientific adviser
TEACHING TECHNIQUES: lecture (15 hours)
ECTS: 3
COURSE ACHIEVEMENTS: To inform students of pelagic community, especially small pelagic fish species which in ecological pyramid or in trophic chain follow the phytoplankton and zooplankton populations. Together with informing biological characteristics of pelagic fish species, their intra species relationships and correlations with environmental factors will be pointed out. Stock assessments, as well as the causes of population size, will be discussed.
COURSE PROGRAMME: The function and importance of pelagic fish in marine ecosystem. Identification. Biometry. Nursery, feeding and spawning grounds. Spatial and temporal distribution. Migrations. Factors that determine population dynamics and population biomass fluctuations of pelagic fish species. Early development stages. Survival. Condition. Reproduction. Growth. Mortalities. Fisheries stock assessments and sustainable exploitation of pelagic fish species.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Attending lectures, taking written exams on particular units, practicum, seminars.
OBLIGATORY LITERATURE: 1. Bone, Q., Marshall, N.B. & Blaxter, J.H.S. 1999. Biology of fishes. Stanley Thornes Ltd, 324 p. 2. Sinovčić, G. 2000. Anchovy, *Engraulis encrasicolus* (LINNAEUS, 1758) : biology, population dynamics and fisheries case study. Acta Adriat., 41 (1): 53 p. 3. Hart, J.B. &J.D. Raynolds. 2002. Handbook of fish biology and fisheries. Blackwell Science Ltd, 410 p.
SUPPLEMENTARY LITERATURE: 1. Iversen, E.S. 1996. Living marine resources. Chapman & Hall, 403 p. 2. Campbell, N. A. 1996. Biology, Cummings publishing company, 1206 p.
EXAMINATION PROCEDURE: Attending lectures and practicum regularly. Writing seminars will influence significantly the forming of the final mark.

Interdisciplinary Doctoral Study in Oceanology
COURSE: Marine Ecology
AUTHOR OF COURSE PROGRAMME: Prof. Mladen Šolić, Institute of Oceanography and Fisheries, Split
TEACHING TECHNIQUES: lecture (15 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Understanding the relationship between marine organisms and their environment is essential for understanding the all life processes in marine environment, evolution of life and their diversity on the spatial and temporal scale. Moreover, knowing the ecological principles is necessary for sustainable exploitation of the marine living resources
COURSE PROGRAMME: Basic ecological terms. Characteristics of marine environment. Marine habitats. Marine life forms: Pelagic organisms, Benthic organisms. Feeding of marine organisms. Ecological factors in marine environment. Energy flow and nutrients cycling in seawater. Marine populations ecology. Marine communities. Biodiversity in the oceans. Human impact on marine ecosystems.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Class attendance, homework, seminar papers and presentations, exercises, class discussions, group projects, written quizzes
OBLIGATORY LITERATURE: 1. Šolić, M. 2006. Ekologija mora - CD (include scripta, power point presentation, examples of exam questions and written quizzes)
SUPPLEMENTARY LITERATURE: 1. Levinton, J.S. 1995. Marine Biologi, Function, Biodiversity, Ecology. Oxford Univ. Press. 420 p. 2. Castro, P. And M.C. Huber 2005. Marine Biology (5th ed.) McGraw-Hill. 452 p. 3. Tait, R.V. and F.A. Dipper. 1998. Elements of Marine Ecology. Butterworth-Heinemann, Oxford. 462 p. 4. Scientific papers
EXAMINATION PROCEDURE: Regular check-ups of knowledge during the course through exercises and homework assignments. Written quizzes during the term and final oral exam.

Interdisciplinary Doctoral Study in Oceanology
COURSE: Diseases of fish, shellfish and crustaceans
AUTHOR(S) OF COURSE PROGRAMME: Dr Sc Emin Teskeredžić, senior scientist, Ruđer Bošković Institute
TEACHING TECHNIQUES: lestures + exercise + seminar (5 + 5 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: To qualify students for understanding the problems of fish, shellfish and crustaceans diseases (viral, bacterial, parasitic and unknown ethiology) in cultured and wild populations.
COURSE PROGRAMME: Pathoanatomic/pathophysiological (diseased) status of fish, shellfish and crustaceans. Biology and physiology of agents and their determination. Diagnosis of contagious (viral, bacterial, fungal and unknown ethiology), parasitic (endo and ecto), uncontagious diseases (poisoning, trauma, asphyxia, neoplasia) and zoonoses and toxins dangerous to human. Preventive and curative therapy. Influence of diseases on environment and physico, chemical and/or biological parameters v.v. Stresses and outbreak of diseases. Diseases and toxins dangerous for human, their determination and protection of humans.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Lectures, practical work and seminars
OBLIGATORY LITERATURE: Austin, B. and Austin, D.A. 1999. Bacterial Fish Pathogens, Disease of Farmed and Wild Fish. Praxis Publishing Ltd. Chichester. 457 p. Woo P.T.K. and Bruno, D.W. 2003. Fish Diseases and Disorders, Viral, Bacterial and Fungal Infections. CABI Publishing, 874 p. Teskeredžić, E. i Kurtović, B. 2004. Bolesti riba, školjkaša i rakova. Manuskript. Institut Ruđer Bošković, 145 str. Teskeredžić, E. i Teskeredžić, Z. 2005. Bolesti organizama iz vode i ljudsko zdravlje. U štampi, 150 str.
SUPPLEMENTARY LITERATURE: Brown, L. 1993. Aquaculture for veterinarians: fish husbandry and medicine. Pergamon press.
EXAMINATION PROCEDURE: Oral and written

Interdisciplinary Doctoral Study in Oceanology
COURSE: Nutrition requirements of fish, shellfish and crustaceans
AUTHOR(S) OF COURSE PROGRAMME: Dr Sc Zlatica Teskeredžić, senior scientist, Ruđer Bošković Institute
TEACHING TECHNIQUES: lecture + exercise (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: To qualify students for understanding the problems caused by using an inadequate and wrong balanced feed.
COURSE PROGRAMME: Nutritional requirements of fish, shellfish and crustaceans, preparing and composition of feed, choosing of components, feeding method, and problems caused by using an inadequate and wrong balanced feed.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: lectures and practical work
OBLIGATORY LITERATURE: Webster, C. D. and Lim, C. E. (2002): Nutrient Requirements and Feeding of Finfish for Aquaculture. WAS. Villamar, D. (2002): Scientific Advances in animal Nutrition: Ch. 10. International Aquaculture Market and Global Needs. Nat. Acad. Press. Teskeredžić, Z. (2005): Prehrana pastrva. Ribarstvo, 63, (2), 47-60.
SUPPLEMENTARY LITERATURE: Teskeredžić, Z., Higgs, D., Dosanjh, B., Teskeredžić, E.:(1994): Hrana i načini hranjenja salmonida kao preduvjet za uzgoj zdrave riba. Ribarstvo, 52, (1), 33-46.
EXAMINATION PROCEDURE: Oral and written

Interdisciplinary Doctoral Study in Oceanology

COURSE: The meiofauna of marine sediments

AUTHOR OF COURSE PROGRAMME: Dr.sc. Ana Travizi, research associate, Ruđer Bošković Institute, Center for Marine Research - Rovinj

TEACHING TECHNIQUES: lectures + practice (10 + 5 hours)

ECTS: 3

COURSE:

Objectives: 1) to understand the concept and importance of marine meiofauna, 2) to get insight into different aspects of meiofauna structure and functioning, 3) to understand how biotic and abiotic factors influence the meiofauna communities structure and dynamics, 4) to gain experience in processing of meiofauna samples, 5) to gain basic skills in meiofauna identification, 6)to learn how to use meiofauna in environmental quality assessment.

COURSE PROGRAMME:

Introduction to the study of meiofauna. ● Meiofauna in basic and applied marine researchs. ● Methodology of meiofauna sampling and processing: collection, extraction, sorting, microscopy. ● Taxonomic composition of meiofauna (identification of constitutive taxa) ● Spatial and temporal dynamics of meiofauna; environmental impacts (biotic and abiotic factors) ● Free-living marine nematodes as a dominant taxon of meiobenthos ● Structural analysis of soft-bottom nematofauna: density, dominance, constancy, spatial distribution, sexual and age structure, trophic structure ... ● Free-living marine nematodes from the Adriatic Sea: status and importance within benthic communities, and its contribution to biodiversity ● Meiofauna and nematofauna as a tools in the environmental quality assessment ● Biodiversity indices. Environmental quality indices based on meiofauna ● Statistical analyses and interpretation of data in meiobenthology (univariate, multivariate, graphical and distributional methods).

STUDENTS' ACTIVITIES AND THEIR EVALUATION: Class attendance, qualification in basic laboratory techniques (including identification of constitutive meiobenthic taxa), seminar or project task (by arrangement), written examination, viva voce.

OBLIGATORY LITERATURE:

Higgins, R & Thiel, T. (1988). Introduction to the study of meiofauna. Smithsonian Institution Press Washington, D.C. London. 376 pp. (selected chapters)

Danovaro, R., Gambi, C. Mirto, S., Sandulli, R., Ceccherelli, V.U. (2004). Chapter III: Meiofauna (pp 55-97). In: Gambi, M.C., Dappiano (eds) Mediterranean marine Benthos: a manual of methods for its sampling and study. S.I.B.M., Genova. 604 pp.

*Note: Selected chapters will be obtainable as PDF files on a CD R, if necessary.

SUPPLEMENTARY LITERATURE:

Clarke, K.R. & Warwick, R.M. (1990). Lecture notes prepared for the training on the statistical treatment and interpretation of marine community data. FAO/IOC/UNEP, Split 87 pp.

Coull, B. C. & G. T. Chandler (2001). Benthos (Meiobenthos). In: Encyclopedia of Ocean Sciences, (J. H. Steele, K, K. Turekian and S. A. Thorpe, Editors), Academic Press, London, pp. 705-711

Gray, J.S. (1974). Animal-sediment relationship. Mar.Biol.Ann.Rev., 12: 223-262. Heip, C., Vincx M. & Vranken, G. (1985). The ecology of marine nematodes. Ocean.Mar.Biol.Ann.Rev, 23: 399-489. McIntyre, A.D. (1969). Ecology of marine meiobenthos. Biol. Rev., 44:245-290. * Selected chapters and/or papers (by arrangement).
EXAMINATION PROCEDURE: Oral presentation of the seminar or project task results (by arrangement)●Written examination ●Viva voce

Interdisciplinary Doctoral Study in Oceanology
COURSE: Fisheries
AUTHOR(S) OF COURSE PROGRAMME: Dr. Ivan Jardas, Full Prof., Institute of Oceanography and fisheries, Split**,** Dr. Nedo Vrgoč, Doc., Institute of Oceanography and Fisheries, Split
TEACHING TECHNIQUES: lecture + seminar (15 + 5 hours)
ECTS: 4
COURSE ACHIEVEMENTS: Specific education related to sustainable management and protection of biological resources.
COURSE PROGRAMME: The primary objective of stock assessment and management. Analytical and Holistic models. Russel's axiom. Population dynamic. Estimation of growth parameters. Estimation of mortality rates. Sampling methodology. Biomass estimation. Direct methods. Indirect methods. Recruitment. The concept of responsible and sustainable exploitation. Prediction models and estimation of maximum sustainable yield. Multispecies and multifleet stock assessment and management. Fishery regulation measures and responsible fisheries. Objects of commercial sea fishery.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Regular attend of lectures, seminar paper, field work (research or fisheries vessel)
OBLIGATORY LITERATURE: Sparre, P., Venema, S.C., 1998. Introduction to tropical stock assessment. Part 1. Manual. FAO Fish. Techn. Paper, No. 306.1, Rev. 2.: 407 pp. Pauly, D., 1984. Fish population dynamics in tropical waters: a manual for use with programmable calculators. ICLARM, Stud. And Rev., 8: 325 pp. Bond, C.E., 1996. Biology of Fishes. Saunders Coll. Publ., Orlando, Florida, 750 pp.
SUPPLEMENTARY LITERATURE: Krebs, C.J., 1989. Ecological methodology. Harper and Row Publ., NY, 550 pp.
EXAMINATION PROCEDURE: Written and oral examination.

Interdisciplinary Doctoral Study in Oceanology
COURSE: Marine biodiversity preservation and protection
AUTHOR(S) OF COURSE PROGRAMME: Professor (permanent position), Antonieta Požar-Domac, PhD, Faculty of Science University of Zagreb
TEACHING TECHNIQUES: lectures + seminar (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Getting to know marine biodiversity importance and developing awareness for marine ecosystem preservation and protection.
COURSE PROGRAMME: Biodiversity in ocean environment. Importance of the marine and coastal biodiversity. Human impact on marine biodiversity. Implementation of integrated marine and coastal area management. Marine living resources. Marine protected areas. Mariculture. Invasive alien species. State and pressures of the marine and coastal Adriatic and Mediterranean environment.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Obligatory class attendance and seminar.
OBLIGATORY LITERATURE: 1. BARBER, C. V. et al 2004: Securing protected areas in the face of global change. WCPA, IUCN. 1-269. 2. WWF/IUCN 2004: The Mediterranean deep-sea ecosystems: an overview of their diversity structure, functioning and anthropogenic impacts, with proposal for conservation. IUCN Malaga and WWF Rome. 1-64. 3. GUBBAY S. 1995: Marine protected areas. Principles and techniques for managements. Chapman & Hall, London. 1-232.
SUPPLEMENTARY LITERATURE: 1. Millennium Ecosystem Assessment 2003: Ecosystems and Human Well-Being: A Framework for Assessment. Island Press, 212 p. 2. Levinton, JS (2001) Marine Biology (Function, Diversity, Ecology), Oxford University Press, Oxford, UK
EXAMINATION PROCEDURE: Oral examination.

Interdisciplinary Doctoral Study in Oceanology
COURSE: Selected topics in marine geology
AUTHOR OF COURSE PROGRAMME: Professor Mladen Juračić, Faculty of Science, University of Zagreb
TEACHING TECHNIQUES: lectures + exercises (15 + 5 hours)
ECTS: 4
COURSE ACHIEVEMENTS: A detailed work on some selected topics in the marine geology. Emphasis on interdisciplinary approach in marine research and especially marine sediments.
COURSE PROGRAMME: Methods in marine research, shelf environments, land ocean interactions (river mouths, coastal processes), diagenetic processes in marine sediments. Sea level changes - causes and consequences. Morphology and genesis of the oceans. Sources and composition of marine sediments. Wave base (determination and importance). Role of organisms in deposition and diagenesis of sediments.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Lectures, seminars and practical work (field work - optional)
OBLIGATORY LITERATURE: Juračić, M.: Geologija mora (http://geol.gfz.hr/Juracic/predavanja/index.html) Kennett J.: Marine geology. Prentice-Hall International, London, 1982.
SUPPLEMENTARY LITERATURE: Open University Course Team, Butterworth-Heinemann, Oxford, 1997: • The Ocean Basins: Their Structure and Evolution • Seawater: Its Composition, Properties and Behaviour • Waves, Tides and Shallow Water Processes • Ocean Chemistry and Deep Sea Sediments Selected review and original scientific papers
EXAMINATION PROCEDURE: Verbal exam and/or written seminar

Interdisciplinary Doctoral Study in Oceanology
COURSE: Recent sedimentation in the sea
AUTHOR OF COURSE PROGRAMME: Professor Mladen Juračić, Faculty of Science, University of Zagreb
TEACHING TECHNIQUES:lectures + exercises (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Familiarization of students with formation of sediment in marine environments. Sampling and determination of recent sediments. Recognition of sediment constituents.
COURSE PROGRAMME: Sources and composition of marine sediments. Lithogenous, hydrogenous and biogenous sediments. Importance of physical, chemical and biological processes in origin of sediments. Effects of waves, currents and tides on sediment deposition and distribution. River input and river mouths Estuarine and antiestuarine water circulation and sediments. Life, organisms and sediments. Shelf sediments. Sedimentation rates.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Lectures, seminars, practical work and home work (field work - optional)
OBLIGATORY LITERATURE: Kennett J.: Marine geology. Prentice-Hall, International, London, 1982. Open University Course Team, Butterworth-Heinemann, Oxford, 1997: • Seawater: Its Composition, Properties and Behaviour • Waves, Tides and Shallow Water Processes • Ocean Chemistry and Deep Sea Sediments
SUPPLEMENTARY LITERATURE: Reading, H.G..: Sedimentary environments: Processes, Facies and Stratigraphy. Blackwell Science, Oxford, 1996 Selected review and original scientific papers
EXAMINATION PROCEDURE: Verbal exam and/or written seminar

Interdisciplinary Doctoral Study in Oceanology
COURSE: Environmental micropaleontology
AUTHOR(S) OF COURSE PROGRAMME: Associate Professor Vlasta Čosović, Faculty of Science, University of Zagreb
TEACHING TECHNIQUES: Lectures + practice + seminars (10 + 5 + 5 hours)
ECTS: 4
COURSE ACHIEVEMENTS: Students will get an overview of how to use different kinds of microfossils in environmental studies and of their unique potential to document changes in marine and fresh water environments through time. The course emphasis the multidisciplinary approach to evaluate the role of microorganisms in recent and past marginal marine to marine environments.
COURSE PROGRAMME: Environmental Micropalaeontology deals with the use of microfossils to interpret environmental changes, whether naturally or human induced. Examples from marine and paralic systems are presented, focusing on how the different microfossil groups provide information about different aspects of the environment. The fact that this information is highly complementary broadens our understanding of environmental changes in aquatic environments (e.g., pollution, eutrophication, climatic change). (1) Basic considerations about Foraminifers; morphologies, growth patterns and reproduction, anomalies in test morphologies, sampling techniques and biological role in ecosystem. (2) Foraminifers as indicators of natural and anthropogenic induced changes. (3) Distribution of foraminifers in the Northern Adriatic Sea (lagoons, estuaries, coastal region and offshore), anthropogenic (industrialization in last 150 years) and natural changes (diatoms and dinoflagelattes bloom) in environments. The causes of deformations of foraminiferal tests. (4) Ostracods: morphologies, growth patterns, aberrations in carapace morphologies, sampling and biological impact on ecosystem. (5) Changes in composition of ostracod assemblages in brackish, lagoonal and coastal environments due to human (heavy metal contamination, industrialization, sewage pollution and agriculture processing) induced changes, and to marine regime changes in estuaries and lagoons (physiographic and weather conditions). Exercise: Collecting material (techniques, laboratory treatments). Systematic of the most common foraminiferal and ostracod species from the Adriatic Sea (eventually Mediterranean Sea). Biodiversity indexes, calculation and interpretation. Monitoring of changes in composition of foraminiferal and ostracod assemblages, finding the causes and interpretation of the consequences. Seminars: A complete ecological interpretation of the selected sample or analysis of problematic events that can occur in the Adriatic Sea.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Exercise: analysis and interpretation of samples collected for the particular settings in the Northern part of the Adriatic Sea (Piran bay; Plomin bay, Tar Gulf, Lago di Garda, Trieeste Gulf). Seminars that treat particular case study related to changes in composition of foraminiferal or ostracod assemblages from the Adriatic Sea or Mediterranean Sea. Written tests related to each topic, homework includes writing an essay on the Case study select from the most recent literature.

OBLIGATORY LITERATURE: Tyszka, J., Oliwkiewicz-Miklasinska, M., Gedl, P. & Kaminski, M. (eds), 2005, Methods and applications in micropaleontology. Polska Akademia nauk. //Haslett, S.K., 2002, Quaternary Environmental Micropaleontology. Arnold, oxford University Press Inc., London, New York.//Martin, R. (ed), 2000, Environmentl Micropaleontology, the application of Microfossils to Environmental geology, Kluwer Acad. Publ.//Scott, B.D., Medioli, F.S. & Schafer, C.T., 2001, Monitoring in coastal environment using Foraminifera and Thecamoebian Indicators. Cambridge Univ. Press.//Sen Gupta, B.K. (ed), 1998, Modern Foraminifera. Kluwer Acad. Publ.
SUPPLEMENTARY LITERATURE: Haslett, S.K., 2003, Coastal Systems. Routledge, London.//Samir, A.M., 2000, The response of benthic foraminifera and ostracods to various pollution sources. Journal of Foraminiferal Research, 30: 83-98.//Barnes, R.S.K. & Hughes, R.N., 1999, An Introduction to Marine Ecology. Blackwell Science.
EXAMINATION PROCEDURE: Homeworks make 30% of exam and final oral exam 70%.

Interdisciplinary Doctoral Study in Oceanology

COURSE: Isotope Oceanology

AUTHOR(S) OF COURSE PROGRAMME: Nada Horvatinčić,DSc., senior scientist, Ruđer Bošković Institute, Zagreb**,** Ladislav Palinkaš, DSC., Professor, Faculty of Science, Mineralogical Department

TEACHING TECHNIQUES: Lectures + practice + seminar (10 + 5 + 5 hours)

ECTS: 4

COURSE:

Application of stable and radioactive isotopes in oceanography and related disciplines (hydrogeology, climatology, geochemistry of sediment, karst geology, geochronology).The ocean water as a part of hydrogeochemical system is in permanent interaction with atmosphere, hydrosphere, lithosphere and biosphere. Isotopic geochemical methods are the important tools in studying of these processes, e.g. determination of residence time of some elements in sea water (^{226}Ra, ^{210}Pb), paleotemperature, evaporation (δ^{18}O, δ^{13}C, δH), isotope variations in geological time ((δ^{34}S, δ^{18}O, ^{87}Sr/ ^{86}Sr) , sedimentation rate (^{210}Pb, ^{230}Th/^{234}U, ^{14}C) dating of groundwater (^{3}H, ^{14}C), process of contamination in atmosphere-water-sediment interaction, etc

COURSE PROGRAMME:

- Introduction- Isotopes in the nature (stable and radioactive), application in geology/hydrology. Radioactive decay, nuclear technique, measurement, mass spectrometry.
- ^{14}C dating: Principe of method, measurement techniques, dating method, application in archaeology, hydrology, palaeoclimatology, ecology, geology.
- ^{10}Be: in atmosphere, soil profile, ocean, geological system
^{36}Cl, ^{129}J, ^{26}Al
- Uranium disequilibrium: ^{230}Th/^{234}U, method princip, measurement technique, application in geochronology, palaeoclimatology; ^{234}U disequilibrium, ^{234}U/^{238}U geochronometry;
- ^{210}Pb dating, chronology of ice, lake and marine sediments.
- Rb-Sr dating method, K/Ar and Ar/Ar dating method; U-Th-Pb dating method;
- Oxygen and hydrogen in hydrosphere and atmosphere – isotopes O and H in water, water vapor, stratigraphy of snow and ice, isotopic composition of ocean, paleotemperature, geothermal waters, ^{3}H in hydrogeology.
- Carbon – fractionation of carbon isotopes in the environment (atmosphere, water, biosphere, marine and terrestrial sediments)
- Sulphur – biogenic fractionation, S-isotopes in recent sediments, fosil fuel, marine sulphate etc.
- Application of radioactive and stable isotopes in Dinaric karst investigation (lake and marine sediments, speleothems, surface and groundwater)

STUDENTS' ACTIVITIES AND THEIR EVALUATION

Seminars, practice examines, final examine

OBLIGATORY LITERATURE:

Faure, G. (1989): Principles of isotope geology. Smith-Wyllie, str.463. Dickin, A.P. (2002): Radiogenic isotope geology. Cambridge university press, str.490.
SUPPLEMENTARY LITERATURE: Prasada Rao (1996): Moder carbonates (tropical, temporate, polar). Univ.Tasmania, str.206. Pearson, F.J. (1991): Applied isotope hydrogeology. Elsevier, str. 439. Pezdić, J. (1999): Izotopi in geokemijski procesi. Littera picta, Ljubljana, str. 269. Heaman, L. i Ludden, N.J. (1991): Short course handbook on application of radiogenic isotope systems to problems in geology. Min.ass.Canada, str. 498. Fritz, P. I Fontes, J.Ch. (1980): Handbook of environmental isotope geochemistry. Elsevier, vol.1, str 545, vol.2, str.557. Ivanovich, M. I Harmon, R.S. (1992): Uranium series disequilibrium: Applications to environmental problems. Clarendon Precc, Oxford, str.571.
EXAMINATION PROCEDURE: Practice examine, final examine

Interdisciplinary Doctoral Study in Oceanology

COURSE: Biomineralization

AUTHOR(S) OF COURSE PROGRAMME: Dr. sc. Ivan Sondi, Senior Research Associate , Center for Marine and Environmental Research "Rudjer Bošković" Institute, Zagreb

TEACHING TECHNIQUES: lectures + seminar (10 + 5 hours)

ECTS: 3

COURSE ACHIEVEMENTS:
Introduction to basics of biological mineralization, its importance for the geosphere, for the global geochemical cycle, and for the characterization of the state of the environment. Introduction to biomimetically inspired preparation of inorganic materials.

COURSE PROGRAMME:
Introduction to biomineralization. Links between biota and the nonliving geosphere. Biominerals – the inorganic structure of biota. Biomineralization processes and the marine biogeochemical cycles. Basic processes of formation and the morphogenesis of organic-mineral architecture of biominerals. Structure and dynamics of organic and inorganic interfaces and the role of organic macromolecules in the genesis of biominerals. The characteristics of supramolecular structures and of self organizing inorganic structures. Understanding of relations between structure and function of biominerals. Biominerals as indicators of the state of the environment. Biomineralization of nanoparticles, and nano-composite biomaterials in marine environments. Biomimetically inspired synthesis of inorganic materials.

STUDENTS' ACTIVITIES AND THEIR EVALUATION:
Lectures or consultations + writing seminar, depending on the number of students.

OBLIGATORY LITERATURE:
Simkiss, K., Wilbur, K.M. (1989): Biomineralization. Cell biology and mineral deposition. Academic Press, 337 p.
Lowenstam, H.A., Weiner, S. (1989): On biomineralization. Oxford University Press. 336 p.
Mann S. (2001): Biomineralization. Principles and concepts in bioinorganic materials chemistry. Oxford Press, 216 p.

SUPPLEMENTARY LITERATURE:
Baeuerlein, E. (ed) (2002): Biomineralization. From Biology to biotechnology and medical applications. Wiley, 316 p.
Muller, W.E.G. (ed) (2003): Silicon biomineralization: Biology, biochemistry, molecular biology and biotechnology. Springer Verlag, 340 p.
Sondi, I., Salopek-Sondi, B. (2005): The influence of the primary structures of urease enzyme on the formation of $CaCO_3$ polymorphs: A comparison of plant (*Canavlia ensiformis*) and bacterial (*Bacillus pasteurii*) ureases. *Langmuir* 21, 8876-8882.

EXAMINATION PROCEDURE: Verbal exam or written seminar (depending on the number of students).

Interdisciplinary Doctoral Study in Oceanology
COURSE: Geochemistry of marine environment
AUTHOR(S) OF COURSE PROGRAMME: Esad Prohić, DSc., professor, Faculty of Science, University of Zagreb
TEACHING TECHNIQUES. lectures + seminar (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: To introduce students to the fundamentals of the geochemistry of marine environment and basics of physico-chemical processes in sea water.
COURSE PROGRAMME: ▪ Marine bioinorganic chemistry : the role of trace metals in the oceanic cycles of major nutrients; ▪ Chemical composition of marine sediments : major and trace element geochemistry ▪ Trace metals in marine microorganisms; ▪ Effects of trace metals on marine biogeochemical cycles; ▪ Chemical tracers of particle transport : transfer from solution to particles (scavenging); ▪ Lateral redistribution of sediments; ▪ Geochemical concept of marine sediment diagenesis; ▪ The oceanic $CaCO_3$ system ▪ Mechanisms controlling $CaCO_3$ system : precipitation – dissolution – kinetics ▪ Geochronometrty of marine sediments
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Class attendance or consultation (depends upon the number of enrolled students), seminars and homeworks
OBLIGATORY LITERATURE: Prohic, E. (1998) : Geokemija, Targa, 554 str, Zagreb Elderfield, H, ed, (2003) : The oceans and marine geochemistry, in : Holand, H.D. & K. K. Turekian, eds, „Treatise on Geochemistry“, Elsevier, 625.p
SUPPLEMENTARY LITERATURE: Morse, W.J., Mackenzie, F.T.(1990): Geochemistry of Sedimentary Carbonates. Developments in Sedimentology 48, Elsevier
EXAMINATION PROCEDURE: oral and written exams, seminar

Interdisciplinary Doctoral Study in Oceanology
COURSE: Mineral Particles and Pollution Processes
AUTHOR(S) OF COURSE PROGRAMME: Dr. sc. Ivan Sondi, Research Associate , Center for Marine and Environmental Research "Rudjer Bošković" Institute, Zagreb
TEACHING TECHNIQUES: lectures + seminar (10 + 5)
ECTS: 3
COURSE ACHIEVEMENTS: Introduction to physico-chemical processes at the solid/liquid (surfaces of mineral particles – aquatic system) interfaces. Understanding their role in binding, transport, and deposition of contaminants and pollutants in natural aquatic environments.
COURSE PROGRAMME: Mechanical and chemical disintegration of rocks and minerals. Genesis of small particles and their active interfaces. Classification and the methods of characterization of micro- and nanosize particles in natural aquatic media. Suspended materials and sediments. Basic properties, structural and interfacial physico-chemical characteristics of clay minerals, carbonates, oxides, and oxyhydrates. Surface charge and the electrochemical double layer. Electrokinetics and the zeta-potential. Colloidal stability and the processes of aggregation of micro- and nanosize particles in natural aquatic environments. Basic physico-chemical processes of interaction of solid surfaces with organic and inorganic compounds. Surface complexes at the solid/liquid interface. Contaminants and pollutants in natural waters. Micro- and nanosize particles in processes of binding, transport, and deposition of pollutants in nature. Sediments as depositories of pollutants.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Lectures or consultations + writing seminar, depending on the number of students.
OBLIGATORY LITERATURE: Stum, W., 1992. Chemistry of the solid-water interface. John Wiley. New York. 428 p. Buffle, J., van Leeuwen, H.P., 1992. Environmental particles. Lewis Publishers. 554 p.
SUPPLEMENTARY LITERATURE: Hunter, R. J., 2001. Foundations of colloid science. Oxford University Press. 806 p. Sondi, I., 2002. Electrokinetic of clay particles. In: *Interfacial Electrokinetics and Electrophoresis,* (ur. Delgado, A. V.). Marcel Dekker, Inc., New York, Chapter 27, p 773-797. Sondi, I., Pravdić, V. (2002): Electrokinetic of clay mineral surfaces. In: *Encyclopedia of Surface and Colloid Science*, (ur. Hubard, A. T.). Marcel Dekker, Inc., New York, p 1887-1893.
EXAMINATION PROCEDURE: Verbal exam or written seminar (depending on the number of students).

C) Optional courses

Interdisciplinary Doctoral Study in Oceanology
COURSE: GIS in Oceanography
AUTHOR(S) OF COURSE PROGRAMME: Dr.sc. Jadranka Pečar-Ilić, research associate, Ruđer Bošković Institute**,** Prof.dr.sc. Ivica Ružić, scientific advisor, Ruđer Bošković Institute
TEACHING TECHNIQUES: lectures + seminar (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Enable students to understand geographic information systems (GIS) and their application in Oceanography.
COURSE PROGRAMME: General information on databases and information systems; Basis of cartography, cartographic projections and georeferencing; Geographic information systems and corresponding software packages; Temporal-spatial presentation of information on Web; The application of GIS in different fields of Oceanography; Oceanographic data sources and GIS databases; Application of GIS in marine and fresh water fisheries and aquaculture; Data sources in Fisheries and GIS databases.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Attendance to lectures, preparing a seminar and passing exam.
OBLIGATORY LITERATURE: 1. Vasilis D. Valavanis: "Geographic Information Systems in Oceanography and Fisheries", Taylor & Francis, London-New York, 2002. 2. Tor Bernhardsen: "Geographic Information Systems – An Introduction", John Wiley & Sons Inc., 3rd Editon, 2002.
SUPPLEMENTARY LITERATURE: 3. J. Breman: "Marine Geography - GIS for the Oceans and Seas", ESRI press, Readlands CA, 2002. 4. D. J. Write: "Undersea with GIS", ESRI Press, Redlands Ca, 2002. 5. D. J. Write, D.J. Bartlett: "Marine and Coastal Geographic Information Systems", Research Monographs in GIS Series, Taylor & Francis, London-Philadelphia, 2000.
EXAMINATION PROCEDURE: Oral exam.

Interdisciplinary Doctoral Study in Oceanology
COURSE: Data analysis in oceanography
AUTHOR(S) OF COURSE PROGRAMME: Prof. dr. sc. Tarzan Legović, R. Bošković Institute, Doc. dr. sc. Branimir Hackenberger, University of Osijek
TEACHING TECHNIQUES: Lectures + exercises (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Enable students to analyze and interpret qualitative and quantitative data using basic and advanced statistical methods. Students will also get an overview of advanced methods and adequate software tools.
COURSE PROGRAMME: Notebook in the laboratory and in the field. Measurements. Scales. Properties of variables. Standardizations. Errors. Estimation of errors in derived variables. Frequency diagrams. Probability distributions. Sampling. Estimators. Comparisons. Parametric tests. Multidimensional data and multivariate methods. Nonparametric tests. Indices or species richness, biodiversity and evenness. Time, space and space-time series. Objective estimation methods. GIS and statistics. Statistics and modelling. Review and use of existing software packages.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Regular class attendance, participation at exercises, timely submission of homework.
OBLIGATORY LITERATURE: Petz B. Osnovne statističke metode za nematematičare, Slap, 1997. Hopkins, W.G. A new view of statistics, 2004. http://www.sportsci.org/resource/stats/ B. Hackengerger i T. Legović, Alexandrina Statistica, Natura Aeterna, Osijek 2003. Zar, J. H.: Biostatistical Analysis, Prentice Hall, 1999. Krebs, C. J.: Ecological Methodology, Addison-Wesley, 1999.
SUPPLEMENTARY LITERATURE: NIST, Engineering Statistics, http://www.itl.nist.gov/div898/handbook/ Legendre J., Legendre P. Numerical Ecology, Elsevier, 2001.
EXAMINATION PROCEDURE: Written and oral exam

Interdisciplinary Doctoral Study in Oceanology
COURSE: Atmosphere and the sea
AUTHOR(S) OF COURSE PROGRAMME: Dr. Leo Klasinc, professor, , Ruđer Bošković Institute, Zagreb, Croatia **,** Dr. Tomislav Cvitas, professor, Faculty of Science and Mathematics, Zagreb, Croatia**,** Dr. Nenad Kezele, research associate, Ruđer Bošković Institute, Zagreb, Croatia
TEACHING TECHNIQUES: lectures + seminar (15 + 5 hours)
ECTS: 4
COURSE ACHIEVEMENTS: This course is aimed at introducing to the processes between the atmosphere and the hydrosphere. The course goes beyond the traditional divisions in oceanography and is recommended to chemists, biologists and physicists who are interested in biophysical approach to marine processes.
COURSE PROGRAMME: Air, weather and climate: composition, properties and division of atmosphere, energy considerations (bilance, albedo, greenhouse effect, evaporation, clouds, precipitation), physical and dynamic processes (air circulation patterns and ocean currents), seasonal winds and monsoons, cyclonic storms, hurricanes(typhoons), tornadoes climatic variation and catastrophes, driving forces and patterns in climatic change, human activity and global climate change
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Lectures, consultations and written seminar
OBLIGATORY LITERATURE: W.P.Cunningham, M.A.Cunningham.B.Saigo, **Environmental Science. A Global Concern (2005)** McGraw Hill Higher Education S.E.Manahan,**Fundamentals of Environmental Chemistry (2000)** Lewis
SUPPLEMENTARY LITERATURE: B.J.Finlayson-Pitts, J.N.Pitts,Jr.,Chemistry of the Upper and Lower Atmosphere (2000), Academic A.C.Duxbury,A.B.Duxbury , An Introduction to the World's Oceans(2001) Brown Publishers T.M.Oberlander,R.A.Muller, Essentials of Physical Geography Today (1987) Random House also selected in interaction with the student depending on the seminar topic
EXAMINATION PROCEDURE: written seminar

Interdisciplinary Doctoral Study in Oceanology
COURSE: Methods and Techniques in Oceanlogy
AUTHOR(S) OF COURSE PROGRAMME: Dr.sc. Emin Teskeredžić, Senior Scientist, Institut Ruđer Bošković, Zagreb., Dr.sc. Ivan Sondi, Research Associate, Ruđer Bošković Institute, Zagreb., Dr.sc. Andrej Jaklin, Research Assistant, Ruđer Bošković Institute, Rovinj.
TEACHING TECHNIQUES: lectures + seminar (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Introduction to basic research methods and techniques in the Oceanology. The course consists of three independent units, which comprehend: (i) optimal use of diving technique in sampling and underwater observation (ii) sampling and characterization of waters, suspended matter and sediments; (iii) *in situ* observations and indirect sampling and determination of benthos.
COURSE PROGRAMME: (i) Introduction of diving techniques; underwater photo- and video-documentation, and other research methods in diving (ii) methods and techniques used in sampling of waters, suspended mater and sediments, determination and characterization of physico-chemical parameters of water systems and sediments; (iii) methods and techniques of benthos sampling; basics of aut- and sin- ecology; introduction to the biocenology with determination of benthic communities.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Lectures or consultations + writing seminar, depending on the number of students.
OBLIGATORY LITERATURE: Buffle, J. and van Leeuwen, H.P., 1992. Environmental particles. Lewis Publishers. 554 p. Tucker, M., 1988. Techniques in Sedimentology. Blackwell Scientific. 394 p. Gambi. M.C. and Dappiano, M. (eds) 2004. Mediterranean marine benthos: A manual for its sampling and study. Biol.Mar.Medit., 11 (Suppl.1), 604 pp, Flemming, N.C. and Max, M.D. (eds) 1996. Scientific diving: A general code of practice. UNESCO, 278 pp. ., U.S. Navy Diving Manual, Revision 4, 1999, Gošović, S. Ronjenje u sigurnosti – podvodna medicina i osnovne tehnike ronjanja, 4 izd. , Jumena Zagreb, 1986
SUPPLEMENTARY LITERATURE: Jaklin, A. And Travizi, A. 1991. Naša istraživanja zajednica morskog dna. Priroda, 80: 21-24.
EXAMINATION PROCEDURE: Verbal exam or written seminar (depending on the number of students).

Interdisciplinary Doctoral Study in Oceanology
COURSE: Science communication
AUTHOR(S) OF COURSE PROGRAMME: Dr.sc. Blanka Jergović, in the process of election for the reader at the University of Zagreb
TEACHING TECHNIQUES: Lectures + seminar (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Gives knowledge about the basis and models of science communication, offers the overview of Public Understanding of Science (PUS in the UK), scientific literacy (in the USA) and *culture scientifique* (France). Offers the overview of long term studies of media coverage of science, focusing on the common elements and on differences between the media, which can be used as the starting point for scientists and scientific institutions to communicate to the public via mass media. Shows to the students how the media work (media logics), the structures, values and routines of the media. Studying the typical cases, students learn the theoretical basis and practical possibilities of the media coverage of science.
COURSE PROGRAMME: Science communication and its models. The social organization of science, science as culture, science as ideology. Science and the public; media and media corporations, science and policy. Fiction and science: the CSI effect. How science becomes the news. Practical skills of communicating science.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance, seminars, projects
OBLIGATORY LITERATURE: Bucchi, M. (2004), Science in Society: An Introduction to Social Studies of Science, Routledge. De Semir, V. «Scientific Journalism: Problems and perspectives», u Internati. Microbiol.3:125-128. Jergović, B. (ur.),(2002.) Znanost i javnost, Izvori, Zagreb. Gregory, J., Miller, S., (2000), Science in Public, Perseus Publishing, Cambridge, Massachusetts. Lewenstien, B. (2003), Models of public communication of science and technology, http://communityrisks.cornell.edu/BackgroundMaterials/Lewenstien2003.pdf
SUPPLEMENTARY LITERATURE: Chosen articles from the scientific magazines Public Understanding of Science and Science Communication. Lewenstein, B., «Cold fusion and hot history», Osiris, second series, 7:135-163. Durant, J., Bauer, M., Gaskell, G., Midden, C., Liakopulos, M., Sholten, L., (2000), Two Cultures of Public Understanding of Science and Technology in Europe“, Dierkes, M., von Glotz, C. Between Understanding and Trust, The Public, Science and Technology, Amsterdam, Harword academic publishers. Friedman, S.F., Dunwoody,S., Rogers, C.J. (eds)(1986): Scientists and Journalists. Reporting Science as News, New York, Free Press.
EXAMINATION PROCEDURE: Written examinations

Interdisciplinary Doctoral Study in Oceanology
COURSE: Legal Aspects of the Protection and Uses of the Sea
AUTHOR(S) OF COURSE PROGRAMME: Dr. sc. Budislav Vukas, full professor, University of Zagreb Faculty of Law
TEACHING TECHNIQUES: Possibility of participating in the course on the law of the sea at the Zagreb Faculty of Law - lectures + seminars (10 + 5 hours)
ECTS: 3
COURSE ACHIEVEMENTS: Understanding of the basic notions of international law; distinction between various international regimes at sea; basic problems of the protection of the marine environment.
COURSE PROGRAMME: Sources of international law; sea areas under the sovereignty of the coastal state; competences of the coastal state beyond the limits of its territory; international instruments on the protection of the living resources in the sea and on the protection of the marine environment in general.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Besides the possibility of participating in the course on the law of the sea at the Zagreb Faculty of Law, any other specific activity is impossible to organize because of the small number of students.
OBLIGATORY LITERATURE: J. ANDRASSY, B. BAKOTIĆ, B. VUKAS: Međunarodno pravo 1, Zagreb 1995. ili 1998., str. 172-230; M. SERŠIĆ: Međunarodnopravna zaštita morskog okoliša, Zagreb, 2003. str. 13-40.
SUPPLEMENTARY LITERATURE: B. VUKAS: The Law od the Sea: Selected Writings, Leiden/Boston, 2004, str. 3-9, 113-124, 207-259.
EXAMINATION PROCEDURE: Oral examination.