# DEPARTMENT OF EARTH, MARINE, AND ENVIRONMENTAL SCIENCES (GRAD)

The Department of Earth, Marine and Environmental Sciences (EMES) advances understanding of the earth and ocean processes that govern our planet, shape diverse ecosystems, sustain life, and drive environmental change. We promote exploration and discovery of the natural world by engaging students in research-based learning at all levels. Our graduates are equipped with the strong science foundation, critical thinking skills, and interdisciplinary perspectives required to tackle current and future environmental and resource challenges. We encourage engaged service that translates knowledge for the public good. We support a welcoming and inclusive environment, foster diverse identities and perspectives, and encourage collaboration with all segments of society.

# **Facilities**

The primary location of our department in Chapel Hill fosters interactions with faculty, students, and staff from other UNC–Chapel Hill departments, nearby research institutions and companies; places scientists within easy reach of RDU International Airport, allowing for the convenient transport of equipment and personnel to distant ports and field locations; and provides ready access to advanced computational resources through RENCI (Renaissance Computing Institute). The department's marine laboratory, the Institute of Marine Sciences (https://emes.unc.edu/ institute-of-marine-sciences/) in Morehead City, provides coastal access for field studies and instruction. Shared, flexible laboratory space is also now available at the Institute since the addition of a new wing.

The department maintains research facilities and office space in both Murray-Venable Hall and Elisha Mitchell Hall. Specialized analytical equipment and facilities supporting marine science include low background alpha, beta, and gamma detectors, a dedicated GC/MS system, a state-of-the-art isotope ratio monitoring mass spectrometry facility for compound specific carbon analyses, high capacity lightand temperature-controlled incubators, and a full range of specialized chromatographic and spectroscopic gear. Observational instrumentation for field use includes a suite of current meters and temperature/pressure sensors, near-bottom and sub-bottom water samplers and profilers, and a specially built a sensor and data system for aircraft sampling of the coastal ocean and atmosphere.

Geological instrumentation includes two thermal ionization mass spectrometers with associated Class 100 clean labs; quadrupole ICPMS; a sediment analysis laboratory including refrigerated core storage; a laser-size particle analyzer; X-ray fluorescence spectrometer; X-ray diffractometer; scanning electron microscope with X-ray analysis and cathodoluminescence; counting laboratory (alpha-, beta-, and gammaemitting radionuclides); experimental petrology laboratory. Access to a field-emission electron microprobe is also available through a remotely operated system at Fayetteville State University.

# **Geological Sciences**

The department offers programs leading to the M.S. and Ph.D. degrees in geological sciences. A broad background is offered in most major areas

of geoscience, with particular emphasis on global hydrology, flooding and fluvial hydrology, coastal processes and geomorphology, isotope geochemistry and geochronology, seismology, volcanology, igneous and metamorphic petrology, low-temperature geochemistry, paleoclimatology and paleoecology, structural geology and tectonics, surface processes, and tectonic geomorphology.

# **Admission and General Degree Requirements**

Students admitted to pursue a graduate degree in the department are typically expected to have an undergraduate degree in traditional geology, geochemistry, geophysics, biology, chemistry, mathematics, physics, or other related interdisciplinary fields. Please note that the Graduate Record Examination (GRE) is no longer required of applicants. All foreign students whose native language is not English also must take the Test of English as a Foreign Language (TOEFL) examination.

Course requirements for incoming students will be determined by individual graduate committees, often in consultation with the director of graduate studies. Specific requirements are varied to meet the needs and career objectives of the individual.

# **Financial Aid**

The department typically supports 10-12 graduate students in geological sciences with teaching assistantships during the 9-month academic year with stipends of ~\$18000. In addition, all graduate students are eligible to apply for departmental summer fellowships (\$7,000), research funds, and conference funds from a departmental endowment.

The department also nominates up to three students for consideration by The Graduate School for graduate fellowships; no additional application is necessary. Faculty research grants support some research assistantships. Out-of-state students are recommended for remission of out-of-state tuition costs; all students are recommended for an instate tuition award. Most students are eligible for both and therefore are responsible only for the payment of student fees. Further information may be found on the department's website (http://marine.unc.edu/).

# **Master of Science**

Requirements for the master of science degree are 30 semester hours (including a minimum of three hours, but no more than six hours of GEOL 993), a thesis, and a final oral examination in defense of the thesis.

# **Doctor of Philosophy**

Many students have completed a master's degree before being admitted to the doctoral program, but some students enter the Ph.D. program having completed only an undergraduate degree. Students admitted to the M.S. program who elect to pursue a Ph.D. instead may be permitted to bypass the master's degree after one semester of residence upon demonstration of superior scholastic performance and research potential. Recommendation by the student's graduate committee and approval by the geological sciences faculty is required in this case.

Admission to the Ph.D. program after completing the M.S. degree in the Department of Geological Sciences requires faculty approval.

Requirements for the Ph.D. degree are a minimum of 48 semester hours of graduate credit (which may include 30 hours from the M.S. degree) and a minimum of six hours and preferably no more than 12 hours of GEOL 994, a written comprehensive examination and an oral comprehensive examination, a dissertation, and a final oral examination in defense of the dissertation.

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# **Marine Sciences**

The department provides teaching and research in estuarine, coastal, and oceanographic sciences leading to M.S. and Ph.D. degrees in marine sciences. Research programs in physical oceanography, marine biology and ecology, marine geochemistry, marine geology, and coastal meteorology are conducted in North Carolina and throughout the world by faculty from the department.

Courses and facilities at other coastal laboratories are also available to UNC-Chapel Hill marine sciences students through cooperative agreements. Courses at North Carolina State University, UNC-Charlotte, UNC-Greensboro, North Carolina Central University, and Duke University may be taken for credit through an interinstitutional registration program.

# **Admission Requirements**

For admission to the department, an undergraduate degree is required in a basic science such as physics, mathematics, chemistry, biology, bacteriology, botany, zoology, geology, or in computer science or engineering. Students are advised to develop a broad undergraduate science major with as many as possible of the following courses: mathematics through calculus, computer science, physics, general and organic chemistry, environmental science, physical chemistry, invertebrate zoology or paleontology, botany, zoology, ecology, physiology, geology, and statistics.

Each graduate student must gain a broad background in the marine sciences as well as an in-depth understanding of his or her own subdiscipline (e.g., chemical oceanography). This is accomplished by taking at least three of the four core courses (listed below) and advanced courses determined by each student's advisory committee, and by participating in research that ultimately results in an M.S. thesis or a Ph.D. dissertation. By the end of the 24-month period that begins when a student first enrolls in the department, the student is expected to have completed the four core courses, How to Give a Seminar (MASC 705), and Student Interdisciplinary Seminar (MASC 706), and to have taken a written comprehensive exam (M.S. students) in his or her subdiscipline. Further information on degree requirements may be found at the department's website (http://marine.unc.edu/).

# **Master of Science**

The M.S. degree program is similar to the Ph.D. program except for the following: the advisory committee will be composed of three faculty members, the comprehensive examination is a written exam only, and scientific research will result in a written thesis, to be defended by the student. At least 30 hours of course credit must be earned prior to completing the M.S. degree program. Additional details on the comprehensive examination, admission to candidacy, semesters of residence credit, the thesis, and final oral examination (the thesis defense) are provided in the *Marine Sciences Graduate Student Handbook* and in *The Graduate School Handbook*, both available on the department's website (http://marine.unc.edu/).

# **Doctor of Philosophy**

The academic program for a Ph.D. student will be supervised by a faculty advisory committee of at least five members drawn from the UNC-Chapel Hill graduate faculty. Course requirements normally include at least three of the four core courses, additional advanced courses determined by the student's advisory committee, one hour of MASC 705 and one hour of MASC 706. A waiver for one or more of the core courses can be arranged with the approval of the student's advisory committee and the department's Performance Committee. Additional

requirements include passing a comprehensive examination containing both written (research proposal) and oral (proposal defense seminar) parts, a period of study or research at a marine station or participation on an oceanographic cruise, teaching experience sufficient to develop and demonstrate competence, and scientific research resulting in a written dissertation, which is defended by the student. More details on the Ph.D. comprehensive examination, admission to candidacy, semesters of residence credit, the dissertation, and final oral examination (the dissertation defense) are provided in the *Marine Sciences Graduate Student Handbook* and in *The Graduate School Handbook*, both available on the department's website (http://marine.unc.edu/).

# **Marine Sciences Core Courses**

Code	Title	Hours
EMES 503	Marine Geology	4
EMES 505	Chemical Oceanography	4
EMES 506	Physical Oceanography	4
EMES 507	Biological Oceanography	4
Total Hours		16

# **Professors**

**Carol Arnosti,** Marine Organic Geochemistry, Microbial Biogeochemistry **John M. Bane,** Physical Oceanography and Meteorology, Gulf Stream and Upwelling Dynamics

Jaye Cable, Groundwater Dynamics at the Land-Sea Interface, Biogeochemical Cycling, Wetland and Coastal Hydrology Drew S. Coleman, Isotope Geochemistry, Geochronology Joel Fodrie, Fisheries Oceanography and Ecology, Restoration Ecology Eric Kirby, Active Tectonics, Landscape Evolution, Tectonic Geomorphology

Jonathan M. Lees, Seismology, Volcanology

Niels Lindquist, Chemical Ecology, Natural Products

Richard Luettich, Coastal Physical Oceanography, Modeling, Coastal Hazards

Christopher S. Martens, Marine Geochemistry

Brent A. McKee, Geochemistry/Geology of River-Ocean Environments, Sedimentary Geochemistry/Radiochemistry

Laura J. Moore, Coastal Geology

Rachel Noble, Dynamics of Marine Microbial Food Webs

Janet Nye, Quantitatie Fisheries Ecology

Hans W. Paerl, Microbial Ecology

Tamlin M. Pavelsky, Global Hydrology

Mike Piehler, Coastal Ecosystems and Estuarine Ecology Antonio B. Rodriguez, Sedimentology, Marine and Coastal Geology Harvey E. Seim, Observational Physical Oceanography, Coastal and Estuarine Dynamics

Donna M. Surge, Paleoclimate, Paleoecology, Low-Temperature Geochemistry

Andreas Teske, Microbial Systematics and Evolution, Microbial Ecology, Microbiology of Hydrothermal Vents and the Marine Subsurface

# **Associate Professors**

Marc J. Alperin, Chemical Oceanography, Biogeochemistry Karl D. Castillo, Marine Physiological Ecology, Climate Change and Coral Reefs

Scott Gifford, Microbial Ecology and Biogeochemistry Xiaoming Liu, Geochemistry

Adrian Marchetti, Ecophysiology and Molecular Biology of Marine Phytoplankton

Johanna Rosman, Coastal and Estuarine Fluid Dynamics Alecia N. Septer, Microbiology Kevin G. Stewart, Structural Geology Brian L. White, Fluid Dynamics of Coastal Marine Systems, Hydrodynamics of Aquatic Vegetation, Gravity Currents, Shear Flows and Internal Waves

# **Assistant Professors**

Kennet E. Flores, Petrologic and Tectonic Processes Wei Mei, Tropical Cyclones and Climate Dynamics Antonia Sebastian, Applied Hydrology and Water Resources

# **Research Professor**

Michael J. Shore, Geophysics and Seismology

# **Research Assistant Professors**

Nathan Hall Ryan Mills, Geochemistry Xiao Yang, Global Hydrology, Remote Sensing, Big Data Analytics

# **Professors Emeriti**

Dan Albert, Larry K. Benninger, Joseph G. Carter, Paul Fullagar, Allen F. Glazner, Jan J. Kohlmeyer, A. Conrad Neumann, Daniel A. Textoris.

# **Assistant Teaching Professors**

Michelle Haskin, Geoscience Education Megan F. Plenge, Geoscience Education

# **GEOL**

# Advanced Undergraduate and Graduate-level Courses

GEOL 502. Earth Surface Processes. 3 Credits.

This course will focus on the processes of soil formation, erosion, and landform evolution with an emphasis on the interaction of geomorphic processes with surface hydrology and ecosystems. (EES)

# **Rules & Requirements**

Making Connections Gen Ed: PL. Requisites: Prerequisite, GEOG 110. Grading Status: Letter grade. Same as: GEOG 440.

# GEOL 503. Marine Geology. 4 Credits.

For graduate students; undergraduates need permission of the instructor. Investigates formation of the oceans, plate tectonics, carbonate reefs and platforms, sediment transport from the land to deep-sea fans, glacialmarine geology, marine records of changes in sea level and climate, and the evolution of barrier islands, estuaries, and deltas. Mandatory weekend field trip to the Southern Outer Banks. Course previously offered as MASC 503.

Rules & Requirements Making Connections Gen Ed: PL. Grading Status: Letter grade. Same as: EMES 503.

# GEOL 555. Paleobotany: An Introduction to the Past History of Plants. 3 Credits.

An introduction to the fossil record of plants, investigating how plants originated and changed through geological time to produce the modern flora. Both macrofossils and microfossils will be considered. Three lecture hours a week.

## **Rules & Requirements**

Making Connections Gen Ed: EE- Field Work.

**Requisites:** Prerequisites, BIOL 103, BIOL 104, and either BIOL 250 or BIOL 271; or permission of the instructor for students lacking the prerequisites; Corequisite, BIOL 555L; permission of the instructor for students lacking the requisites. **Grading Status:** Letter grade.

Same as: BIOL 555.

# Graduate-level Courses

## GEOL 700. Research Seminar. 1 Credits.

Required of all entering graduate students or permission of the department. A topical seminar in current research topics in the earth sciences. Presentations by selected faculty with an emphasis on indepth, critical analysis of current research literature. Two hours a week.

## **Rules & Requirements**

Grading Status: Letter grade.

GEOL 701. Graduate Seminar. 0.5-21 Credits. Rules & Requirements

Grading Status: Letter grade.

# GEOL 703. Sedimentary Geology I. 3 Credits.

Stratigraphic, sedimentologic, geochemical, petrologic, and paleontologic principles will be summarized. Emphasis is placed on both the techniques used in sedimentary geology and on the characteristics and processes that distinguish sedimentary environments.

# **Rules & Requirements**

**Requisites:** Prerequisite, GEOL 402. **Grading Status:** Letter grade.

Grading Status: Letter grade.

**GEOL 704.** Sedimentary Geology II. 3 Credits. Continuation of GEOL 703.

### **Rules & Requirements**

**Requisites:** Prerequisite, GEOL 703. **Grading Status:** Letter grade.

# GEOL 705. Advanced Petrology I. 3 Credits.

Application of thermodynamics, phase equilibria, thermobarometry, radiogenic and stable isotope geology, and geochemical modeling to the study of igneous and metamorphic rocks and crustal evolution.

### **Rules & Requirements**

**Requisites:** Prerequisites, CHEM 102, GEOL 304, MATH 233, and PHYS 105.

Grading Status: Letter grade.

**GEOL 706.** Advanced Petrology II. 3 Credits. Continuation of GEOL 705.

## **Rules & Requirements**

**Requisites:** Prerequisite, GEOL 705. **Grading Status:** Letter grade.

GEOL 707. Stratigraphic Micropaleontology: Mesozoic Calcareous Nannofossils. 4 Credits. Rules & Requirements Grading Status: Letter grade.

GEOL 708. Stratigraphic Paleontology: Cenozoic Calcareous Nannofossils. 4 Credits. Rules & Requirements Grading Status: Letter grade.

**GEOL 709. Proposal Writing and Scientific Communication. 3 Credits.** This course provides a broad view of cutting-edge research across the geo- and marine sciences and develops proposal-writing and scientific communication skills. Proposals follow the NSF Earth Sciences Postdoctoral Fellowships program guidelines and involve peer review and oral presentations. Students will hone their critical thinking and scientific writing skills. They will learn how to craft project objectives and working hypotheses, explain the significance of the problem, outline broader implications, and effectively design a research plan.

#### **Rules & Requirements**

Grading Status: Letter grade.

GEOL 711. Advanced Mineralogy. 3 Credits. Rules & Requirements Grading Status: Letter grade.

#### GEOL 712. Isotope Geochemistry. 3 Credits.

Survey of isotopic studies in geology; geochronology, crustal evolution, heat flow, paleotemperatures, origin of ore deposits.

#### **Rules & Requirements**

Requisites: Prerequisites, CHEM 102, GEOL 301, 303, and 304. Grading Status: Letter grade.

# GEOL 804. Advanced Igneous Petrology. 4 Credits.

Rules & Requirements Grading Status: Letter grade.

GEOL 805. Igneous Geochemistry. 4 Credits. Rules & Requirements Grading Status: Letter grade.

GEOL 806. Metamorphic Petrology. 4 Credits. Rules & Requirements Grading Status: Letter grade.

#### GEOL 809. Tectonophysics. 3 Credits.

Fundamental physical processes necessary for an understanding of plate tectonics; stress and strain in solids; elasticity and flexure; heat transfer; gravity; mantle rheology and convection.

**Rules & Requirements** 

**Requisites:** Prerequisites, MATH 383, PHYS 201, and 211; Permission of the instructor for students lacking the prerequisites. **Grading Status:** Letter grade.

GEOL 851. Seminar in Stratigraphy. 1-15 Credits. Rules & Requirements Grading Status: Letter grade.

GEOL 852. Seminar in Paleoclimatology. 1-15 Credits. Rules & Requirements Grading Status: Letter grade.

GEOL 853. Seminar in Paleontology. 1-15 Credits. Rules & Requirements Grading Status: Letter grade. GEOL 854. Seminar in Continental Margins. 0.5-21 Credits. Rules & Requirements Grading Status: Letter grade.

GEOL 855. Seminar in Sedimentology. 1-15 Credits. Rules & Requirements Grading Status: Letter grade.

## GEOL 856. Seminar in Isotope Geology. 3 Credits.

Introduction to the theory, methods and applications of stable isotopes to low- and high-temperature problems. Primary focus will be on the origin, natural abundance, and fractionation of carbon, hydrogen, and oxygen isotopes.

#### **Rules & Requirements**

Grading Status: Letter grade.

GEOL 857. Seminar in Geochemistry. 1-15 Credits. Rules & Requirements Grading Status: Letter grade.

GEOL 858. Seminar in Petrology. 1-15 Credits. Rules & Requirements Grading Status: Letter grade.

GEOL 859. Seminar in Economic Geology. 1-15 Credits. Rules & Requirements Grading Status: Letter grade.

#### GEOL 860. Seminar in Volcanology. 3 Credits.

All aspects of volcanism will be covered including seismology, geochemistry, deep structure, volcanic products and hazards. Readings of original papers will be stressed.

#### **Rules & Requirements**

Grading Status: Letter grade.

#### GEOL 861. Seminar in Geophysics. 0.5-21 Credits.

Develop explanatory and predictive models of the earth's climate. Introductory level and focused on modeling past climate with the hope of understanding its future. A thorough discussion of current global warming/climate change issues, including the science, history, and controversy, are the main topics of the last third of the course.

#### **Rules & Requirements**

Grading Status: Letter grade.

GEOL 862. Seminar in Seismology. 3 Credits. Rules & Requirements Grading Status: Letter grade.

GEOL 863. Seminar in Structural Geology. 1-15 Credits. Rules & Requirements Grading Status: Letter grade.

#### GEOL 864. Seminar in Tectonics. 3 Credits.

The goal of this seminar is to examine the Cretaceous to Eocene tectonics of the western United States to evaluate the putative flat slab processes responsible. Geologic research on the Laramide Orogeny predates plate tectonic theory, and the explosion of subsequent research warrants a reevaulation of existing theory.

Rules & Requirements Grading Status: Letter grade.

GEOL 900. Research in Geology. 1-9 Credits. Rules & Requirements Grading Status: Letter grade.

# GEOL 993. Master's Research and Thesis. 3 Credits. Rules & Requirements

Repeat Rules: May be repeated for credit.

GEOL 994. Doctoral Research and Dissertation. 3 Credits. Rules & Requirements

Repeat Rules: May be repeated for credit.

# MASC

# Advanced Undergraduate and Graduate-level Courses

## MASC 440. Marine Ecology. 3 Credits.

Survey of the ecological processes that structure marine communities in a range of coastal habitats. Course emphasizes experimental approaches to addressing basic and applied problems in marine systems.

## **Rules & Requirements**

Requisites: Prerequisites, BIOL 201; or BIOL 475; or BIOL 103, BIOL 104, and BIOL 260.

Grading Status: Letter grade. Same as: BIOL 462.

## MASC 473. The Changing Coasts of Carolina. 3 Credits.

A rigorous combination of field work, lab work, and colorful, original contemporary writing on the natural world will help tell the story of our many, evolving North Carolina coasts. Combining marine science and the creative literary arts, this immersive course will explore issues of change over many eras. This combination of social, cultural, and scientific observation will lead to imaginatively constructed, well-written non-fiction reportage about one of North America's most productive, compelling, and challenging regions.

### **Rules & Requirements**

Making Connections Gen Ed: CI, EE- Field Work. Grading Status: Letter grade. Same as: ENGL 473.

# **Graduate-level Courses**

# MASC 705. How to Give a Seminar. 1 Credits.

Discussion of methods and strategies for giving effective technical presentations. Topics will include seminar structure, use of visual aids, personal and professional presentation, and responding to questions.

### **Rules & Requirements**

Grading Status: Letter grade.

# MASC 706. Student Interdisciplinary Seminar. 1 Credits.

Marine Sciences graduate students will prepare and present a seminar on an interdisciplinary topic from contemporary research in marine systems.

### **Rules & Requirements**

Requisites: Prerequisite, MASC 705. Grading Status: Letter grade.

# MASC 741. Seminar in Marine Biology. 2 Credits.

Discussion of selected literature in the field of marine biology, ecology, and evolution.

# **Rules & Requirements**

Grading Status: Letter grade.

### MASC 742. Molecular Population Biology. 4 Credits.

Hands-on training, experience, and discussion of the application of molecular genetic tools to questions of ecology, evolution, systematics, and conservation.

### **Rules & Requirements**

Requisites: Prerequisite, BIOL 471; Permission of the instructor for students lacking the prerequisites. Grading Status: Letter grade. Same as: BIOL 758.

## MASC 750. Modeling Diagenetic Processes. 3 Credits.

An introduction to the theory and application of modeling biogeochemical processes in sediments. Diagenetic theory, numerical techniques, and examples of recently developed sediment models. Three lecture hours a week.

### **Rules & Requirements**

**Requisites:** Prerequisite, MASC 480; Permission of the instructor for students lacking the prerequisite. **Grading Status:** Letter grade.

## MASC 761. Geophysical Fluid Dynamics. 3 Credits.

Momentum equations in a rotating reference frame, vorticity, potential vorticity, circulation, the shallow water model, Rossby and Kelvin waves, the Ekman layer. Three lecture hours a week.

### **Rules & Requirements**

**Requisites:** Prerequisite, MASC 560 or MATH 528; permission of the instructor for students lacking the prerequisite. **Grading Status:** Letter grade.

### MASC 762. Ocean Circulation Theory. 3 Credits.

Theories, models of large-scale dynamics of ocean circulation. Potential vorticity, quasi-geostrophy, instabilities.

### **Rules & Requirements**

**Requisites:** Prerequisite, MASC 506 or 560, or MATH 529; permission of the instructor for students lacking the prerequisite. **Grading Status:** Letter grade.

# MASC 763. Coastal Oceanography. 3 Credits.

Multi-disciplinary survey of circulation, sediment and biological processes operative in estuaries, on the shelf and at the shelf break.

### **Rules & Requirements**

**Requisites:** Prerequisites, MASC 503 and 506; permission of the instructor for students lacking the prerequisites. **Grading Status:** Letter grade.

### MASC 764. Ocean Circulation Modeling. 3 Credits.

Computational methods used in modeling oceanic circulation. Numerical solution of equations governing mass, momentum, and energy equations.

### **Rules & Requirements**

**Requisites:** Prerequisite, MASC 506 or MATH 529; permission of the instructor for students lacking the prerequisite. **Grading Status:** Letter grade.

## MASC 765. Small-Scale Physics of the Ocean. 3 Credits.

Physics of sub-mesoscale processes in the ocean. Nonequilibrium thermodynamics. Air-sea interaction. Mixing in the ocean boundary layer, convection, double diffusion. Near-inertial and high frequency internal waves. Three lecture hours a week.

### **Rules & Requirements**

**Requisites:** Prerequisites, MASC 506 and 560. **Grading Status:** Letter grade.

## MASC 781. Numerical ODE/PDE, I. 3 Credits.

Single, multistep methods for ODEs: stability regions, the root condition; stiff systems, backward difference formulas; two-point BVPs; stability theory; finite difference methods for linear advection diffusion equations.

#### **Rules & Requirements**

Requisites: Prerequisites, MATH 661 and 662. Grading Status: Letter grade. Same as: MATH 761, ENVR 761.

### MASC 782. Numerical ODE/PDE, II. 3 Credits.

Elliptic equation methods (finite differences, elements, integral equations); hyperbolic conservation law methods (Lax-Fiedrich, characteristics, entropy condition, shock tracking/capturing); spectral, pseudo-spectral methods; particle methods, fast summation, fast multipole/vortex methods.

#### **Rules & Requirements**

Requisites: Prerequisite, MATH 761. Grading Status: Letter grade. Same as: MATH 762, ENVR 762.

## MASC 783. Mathematical Modeling I. 3 Credits.

Nondimensionalization and identification of leading order physical effects with respect to relevant scales and phenomena; derivation of classical models of fluid mechanics (lubrication, slender filament, thin films, Stokes flow); derivation of weakly nonlinear envelope equations. Fall.

### **Rules & Requirements**

Requisites: Prerequisites, MATH 661, 662, 668, and 669. Grading Status: Letter grade. Same as: MATH 768, ENVR 763.

### MASC 784. Mathematical Modeling II. 3 Credits.

Current models in science and technology: topics ranging from material science applications (e.g., flow of polymers and LCPs); geophysical applications (e.g., ocean circulation, quasi-geostrophic models, atmospheric vortices).

#### **Rules & Requirements**

Requisites: Prerequisites, MATH 661, 662, 668, and 669. Grading Status: Letter grade. Same as: MATH 769, ENVR 764.

MASC 799. Experimental Graduate. 1-9 Credits. Experimental graduate level courses as offered by the Department.

### **Rules & Requirements**

**Repeat Rules:** May be repeated for credit; may be repeated in the same term for different topics; 9 total credits. 1 total completions. **Grading Status:** Letter grade.

#### MASC 893. Special Topics in Marine Geology. 1-9 Credits.

Special topics courses in Marine Geology as offered by Department.

#### **Rules & Requirements**

**Repeat Rules:** May be repeated for credit; may be repeated in the same term for different topics; 9 total credits. 1 total completions. **Grading Status:** Letter grade.

MASC 894. Special Topics in Biological Oceanography. 1-9 Credits. Special topics courses in Biological Oceanography as offered by Department.

### **Rules & Requirements**

**Repeat Rules:** May be repeated for credit; may be repeated in the same term for different topics; 9 total credits. 1 total completions. **Grading Status:** Letter grade.

MASC 895. Special Topics in Physical Oceanography. 1-9 Credits. Special topics courses in Physical Oceanography as offered by Department.

### **Rules & Requirements**

**Repeat Rules:** May be repeated for credit; may be repeated in the same term for different topics; 9 total credits. 1 total completions. **Grading Status:** Letter grade.

MASC 896. Special Topics in Chemical Oceanography. 1-9 Credits. Special topics courses in Chemical Oceanography as offered by Department.

#### **Rules & Requirements**

**Repeat Rules:** May be repeated for credit; may be repeated in the same term for different topics; 9 total credits. 1 total completions. **Grading Status:** Letter grade.

MASC 897. Special Topics in Marine Sciences. 1-9 Credits. Special topics courses in Marine Sciences as offered by Department.

### **Rules & Requirements**

**Repeat Rules:** May be repeated for credit; may be repeated in the same term for different topics; 9 total credits. 1 total completions. **Grading Status:** Letter grade.

MASC 940. Research in Marine Sciences. 2-21 Credits. Rules & Requirements Grading Status: Letter grade. Same as: BIOL 953.

MASC 993. Master's Research and Thesis. 3 Credits. Rules & Requirements Repeat Rules: May be repeated for credit.

MASC 994. Doctoral Research and Dissertation. 3 Credits. Rules & Requirements Repeat Rules: May be repeated for credit.

# **Contact Information**

Chair Eric Kirby ekirby@unc.edu

Director of Graduate Studies Adrian Marchetti amarchet@email.unc.edu

Director of Graduate Admissions (GEOL) Xiaoming Liu xiaomliu@email.unc.edu

Director of Graduate Admissions (MASC) Johanna Rosman jrosman@unc.edu

Student Services Manager Violet Anderson vmanders@email.unc.edu