DEPARTMENT OF EARTH, MARINE, AND ENVIRONMENTAL SCIENCES

Contact Information
Department of Earth, Marine, and Environmental Sciences
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Introduction
The Department of Earth, Marine, and Environmental Sciences (EMES) launched in 2021–2022, combining the departments of Geological Sciences (GEOL) and Marine Sciences (MASC) with the Institute for Marine Sciences (IMS). The new department provides instruction and conducts research into the physical, chemical, and biologic processes that operate within the Earth and its oceans. Research seeks to understand how the dynamic interplay among these processes shape the Earth’s surface, govern environmental change, generate natural hazards, supply energy and resources, and sustain life. The department has a strong tradition of undergraduate students conducting independent and guided research as part of their training.

Students interested in the geological sciences have the option of pursuing a B.S. or B.A. degree. The former provides training and skills necessary for a satisfying career as a professional geologist or as a foundation for graduate training, while the latter affords flexibility for students interested in pursuing associated careers in environmental studies, education, or law. Students interested in the marine sciences may pursue a minor designed to allow students to develop a specialization aligned with their major course of study that can provide a foundation for postgraduate study.

Advising
All majors and minors have a primary academic advisor in Steele Building. Students are strongly encouraged to meet regularly with their advisor and review their Tar Heel Tracker each semester. The department’s directors of undergraduate studies work with current and prospective majors by appointment. Departmental academic advising is particularly important for those majors who are considering continuing graduate education. Further information on courses, undergraduate research opportunities, the honors program, career opportunities, and graduate schools may be obtained from the department’s website. Prospective students in the department are encouraged to meet with one of the directors of undergraduate studies.

Facilities
The department maintains laboratory facilities, many of which are available for undergraduate students to use in research and classroom learning. These include several mass spectrometers for isotopic, geochronology, and geochemical research, a scanning electron microscope, x-ray fluorescence and diffractometers, geophysical and seismic imaging facilities, and a paleoclimate laboratory. Research laboratories are equipped for studies in all aspects of marine sciences — physical, chemical, and biologic. In addition, the Institute for Marine Sciences, located in Morehead City, N.C., houses laboratory buildings with dock and ocean access. The institute operates a modern 48-foot coastal vessel, the R.V. Capricorn, as well as a fleet of outboard-powered boats.

Graduate School and Career Opportunities
In the earth sciences, geologists are employed in the commercial/industrial, educational, and governmental sectors. Graduates may find employment in private industry and consulting firms, including hydrology, environmental geology, engineering geology, the energy industry, and/or resource extraction. Job opportunities exist within both state and federal geologic and environmental agencies. Many positions prefer some graduate training at the master’s level, and a doctoral degree is typically required for employment in higher education.

In the marine sciences, graduates often seek postgraduate training to develop expertise in a field of particular interest.

Majors

Minors
• Geological Sciences Minor (http://catalog.unc.edu/undergraduate/programs-study/geological-sciences-minor/)
• Marine Sciences Minor (http://catalog.unc.edu/undergraduate/programs-study/marine-sciences-minor/)

Graduate Programs
• M.S. in Geological Sciences (http://catalog.unc.edu/graduate/schools-departments/geological-sciences/)
• M.S. in Marine Sciences (http://catalog.unc.edu/graduate/schools-departments/marine-sciences/)
• Ph.D. in Geological Sciences (http://catalog.unc.edu/graduate/schools-departments/geological-sciences/)
• Ph.D. in Marine Sciences (http://catalog.unc.edu/graduate/schools-departments/marine-sciences/) (http://catalog.unc.edu/graduate/schools-departments/geological-sciences/)

Distinguished Professors
Christopher S. Martens, Brent A. McKee, Rachel Noble, Hans Pearl.
Professors
Carol Arnosti, John M. Bane Jr., Jaye E. Cable, Drew S. Coleman, Eric Kirby, Jonathan Lees, Niels Lindquist, Richard A. Luetich, Laura Moore, Rachel Noble, Tamlin M. Pavelsky, Michael Piegler, Antonio Rodriguez, Alberto Scotti, Harvey Seim, Donna Surge, Andreas Teske.

Associate Professors
Marc J. Alperin, Karl Castillo, F. Joel Fodrie, Scott Gifford, Adrian Marchetti, Johanna Rosman, Alicia Septer, Kevin G. Stewart, Brian L. White.

Assistant Professors
Emily Eidam, Xiaoming Liu, Wei Mei, Antonia Sebastian.

Adjunct Professors
Frederick Bingham (UNC–Wilmington), Alan Boudreau, Carolyn Currin (National Oceanic and Atmospheric Administration Lab, Beaufort, N.C.), Stephen Fegley (UNC Institute of Marine Sciences), Jeffrey Hanson (Waveforce), Mandy Joyce (University of Georgia), R. Wayne Litaker (National Oceanic and Atmospheric Administration Lab, Beaufort, N.C.), Kenneth J. Lohmann (Biology), Stephen A. Skrabal (UNC–Wilmington), Jill Stewart (Environmental Sciences and Engineering), William Sunda (National Oceanic and Atmospheric Administration Lab, Beaufort, NC, retired), Patricia Tester (National Oceanic and Atmospheric Administration Lab, Beaufort, N.C.).

Adjunct Assistant Professor
Julia Barzyk.

Research Professor
Michael Shore.

Research Assistant Professors
Nathan Hall, Ryan D. Mills.

Teaching Assistant Professors
Michelle Haskin, Joel Hudley, Megan Plenge.

Professors Emeriti

Courses
GEOL—Geological Sciences

Undergraduate-level Courses

GEOL 70. First-Year Seminar: One Billion Years of Change: The Geologic Story of North Carolina. 3 Credits.
A field-based course focused on the geologic story of North Carolina. Includes local field trips and weekend trips to the coast and mountains
Gen Ed: PL.
Grading status: Letter grade.

GEOL 71. First-Year Seminar: Bones Back to Life. 3 Credits.
Get hands-on experience with the reconstruction of vertebrate fossils. Learn the paleontology of the Carolinas and beyond.
Gen Ed: PL.
Grading status: Letter grade.

GEOL 72H. First-Year Seminar: Field Geology of Eastern California. 3 Credits.
This seminar provides a hands-on introduction to active geologic and environmental processes in eastern California, including active volcanoes, earthquake-producing faults, and extreme climate change.
Gen Ed: PL, EE- Field Work, EE- Mentored Research.
Grading status: Letter grade.

GEOL 73. First-Year Seminar: Global Warming and the Future of the Planet. 3 Credits.
Global warming is the most important environmental problem of the 21st century. This seminar explores geologic history of global warming, its physical principles, and prospects for future societies.
Gen Ed: PL.
Grading status: Letter grade.

GEOL 74. First-Year Seminar: Geology of Climate Change. 3 Credits.
Examination of the problem of natural versus human-induced climate change from the perspective of the geologic record of earth history. Field trips to coast, Piedmont, and Blue Ridge.
Gen Ed: PL.
Grading status: Letter grade.

GEOL 75. First-Year Seminar: Waste in the Environment. 3 Credits.
Origins and effects of waste in the environment. Introduces natural wastes and ecosystem recycling, but focuses on case studies of generation, environmental impacts, and remediation of anthropogenic wastes.
Gen Ed: PL.
Grading status: Letter grade.

GEOL 76. First-Year Seminar: Energy Resources for a Hungry Planet. 3 Credits.
Discussions are centered on the most pressing issues of our time: environmental deterioration and construction of a sustainable (livable) world during and after the depletion of traditional energy resources.
Gen Ed: PL.
Grading status: Letter grade.

GEOL 77. First-Year Seminar: Volcanoes and Civilization: An Uneasy Coexistence. 3 Credits.
Volcanoes provide a breathable atmosphere, a habitable climate, and precious ores, but they have the potential to destroy civilization. This seminar will explore the uneasy coexistence of volcanoes and civilization.
Gen Ed: PL.
Grading status: Letter grade.

GEOL 79. First-Year Seminar: Coasts in Crisis. 3 Credits.
An investigation of the geologic evolution and function of coastal environments, the recent effects of coastal development and engineering, and an examination of existing coastal management strategies and the tensions between coastal development and the desire to preserve natural environments.
Gen Ed: PL.
Grading status: Letter grade.

GEOL 89. First-Year Seminar: Special Topics. 3 Credits.
Special topics course. Content will vary each semester.
Repeat rules: May be repeated for credit; may be repeated in the same term for different topics; 6 total credits. 2 total completions.
Grading status: Letter grade.
GEOL 101. Planet Earth. 3 Credits.
Major geologic events: earthquakes, volcanic activity, mountain formation, plate tectonics, and erosion. Landscape development by glaciers, streams and groundwater, ocean currents and waves, wind. Not open to students with credit in GEOL 105, 109, or 110. Optional laboratory. GEOL 101L. PX credit for GEOL 101+101L.
Gen Ed: PX.
Grading status: Letter grade.

GEOL 101L. Planet Earth Laboratory. 1 Credit.
Study of common minerals and rocks. Use of topographic and geologic maps to illustrate geologic processes. Two laboratory hours a week.
Requisites: Pre- or corequisite, GEOL 101, 159, 200, or 201.
Grading status: Letter grade.

GEOL 103. The Marine Environment. 3 Credits.
Introduction to marine sciences emphasizing physical, chemical, biological, and geological phenomenon in oceanic and coastal environments. Human use of, and impact on, marine resources. Science majors should take MASC 401. Students may not receive credit for both MASC 101 and MASC 401.
Gen Ed: PL.
Grading status: Letter grade.
Same as: MASC 101.

GEOL 108. Climate and Energy Transitions: Understanding the Forecasts. 4 Credits.
This course examines uncertainties in projecting future fossil fuel consumption and impact on global climate by quantifying how effectively alternative power-generation and energy-storage technologies can scale to meet needs in developing and developed nations, and by understanding past and present climates.
Gen Ed: PX, GL.
Grading status: Letter grade.
Same as: MASC 108, PHYS 108.

GEOL 159. Prehistoric Life. 3 Credits.
Fossils and the origin and evolution of life, including micro- and macroevolution, mass extinctions, the evolution of dinosaurs and humans, and scientific perspectives on multicultural creationism.
Gen Ed: PL.
Grading status: Letter grade.
Same as: BIOL 159.

GEOL 190. Special Topics in Geological Sciences at an Introductory Level. 3 Credits.
An undergraduate seminar course that is designed to be a participatory intellectual adventure on an advanced, emergent, and stimulating topic within a selected discipline in geological sciences. This course does not count as a credit towards geological sciences majors.
Repeat rules: May be repeated for credit; may be repeated in the same term for different topics; 6 total credits. 2 total completions.
Grading status: Letter grade.

GEOL 200. The Solid Earth. 3 Credits.
An introduction to the solid earth, and with GEOL 201 is an overview of earth systems for students continuing in geological, environmental, and other sciences. Topics include synthesis of the elements, formation of the solar system and earth, plate tectonics, earth materials, internal energy, magnetism, geochemical cycles, and earth resources.
Gen Ed: PL.
Grading status: Letter grade.

GEOL 201. Earth’s Surface: Processes, Landforms, and History. 3 Credits.
This course focuses on the biological, chemical, and physical processes that shape the surface of the earth. Major points of emphasis will include earth’s climate, the global water cycle, geomorphic processes and the landforms they create, sedimentology and depositional environments, and elements of earth history recorded by earth surface processes.
Gen Ed: PL.
Grading status: Letter grade.

GEOL 202. Earth Systems History. 3 Credits.
Required preparation, one introductory geology course numbered below GEOL 202, except first-year seminar. History of the earth (including its oceans, atmosphere, and life forms) as deciphered from the geologic record. Birth of continents/oceans; evolution and extinction of life forms; the changing global environment.
Gen Ed: EE- Field Work.
Grading status: Letter grade.

GEOL 221. Geology of North America. 3 Credits.
Required preparation, one geology course numbered below GEOL 202. General introduction to the geologic evolution of North America through intensive study of a particular region. Includes mandatory Spring Break field trip.
Gen Ed: EE- Field Work.
Grading status: Letter grade.

GEOL 233. Geology of Beaches and Coasts. 3 Credits.
Required preparation, one introductory geology course numbered below GEOL 202, except first-year seminar. Introduction to coastal processes, including waves, tidal currents, tectonics, climate, and human activity, and their influence on barrier islands, beaches, dunes, marshes, and estuaries. Involves a field trip to the Outer Banks of North Carolina.
Grading status: Letter grade.
Same as: MASC 223.

GEOL 234. Marine Carbonate Environments. 2 Credits.
Permission of the instructor. Chemical and biological origins of calcium carbonate, skeletal structure, and chemo-mineralogy, preservation, sedimentation, and early diagenesis are studied in deep and shallow environmental settings to understand skeletal genesis, limestone origin, and carbonate facies variability. Field trip to Florida, Bahamas, or Bermuda. Laboratory exercises; research report. Previously offered as GEOL 434.
Gen Ed: PL, EE- Field Work.
Repeat rules: May be repeated for credit; may be repeated in the same term for different topics; 4 total credits. 2 total completions.
Grading status: Letter grade.

GEOL 235. Marine Sedimentary Environments. 3 Credits.
An introduction to marine sediments and their origin, physical and chemical properties, occurrence and stratigraphy. Emphasis on sedimentary environments; their classification, occurrence, and uses. Methods of identifying and interpreting sedimentary environments using field and laboratory techniques. Three lecture and three laboratory hours a week.
Requisites: Prerequisite, GEOL 200; pre- or corequisite, CHEM 101; permission of the instructor for students lacking the prerequisite.
Grading status: Letter grade.

GEOL 301. Earth Materials: Minerals. 4 Credits.
Minerals in sedimentary, igneous, and metamorphic environments: their properties, occurrence, and uses. Methods of identifying minerals, including use of optical properties. Three lecture and three laboratory hours a week.
Requisites: Prerequisite, GEOL 200; pre- or corequisite, CHEM 101; permission of the instructor for students lacking the prerequisite.
Grading status: Letter grade.

GEOL 302. Structural Geology. 4 Credits.
Introduction to the mechanical behavior and dynamic evolution of the earth's crust through the study of deformed rocks. Previously offered as GEOL 401.
Requisites: Prerequisite, GEOL 101 or 200.
Grading status: Letter grade.
GEOL 303. Sedimentology and Stratigraphy. 4 Credits.
Introduction of principles involved in description and classification of sedimentary rocks and stratigraphic units as well as stratigraphic correlation. Students will be introduced to relationships of processes, depositional environments, and sedimentary facies. Previously offered as GEOL 402.
Requisites: Prerequisites, GEOL 200 and 201; permission of the instructor for students lacking the prerequisites.
Grading status: Letter grade.

GEOL 304. Petrology and Plate Tectonics. 4 Credits.
Studies of the origin and evolution of igneous and metamorphic rocks, including microscopic, X-ray, and field methods; volcanology; plate-tectonic interpretation of rock sequences. Three lecture and three laboratory hours a week. Previously offered as GEOL 404.
Requisites: Prerequisite, GEOL 200 and 301; permission of the instructor for students lacking the prerequisite.
Grading status: Letter grade.

GEOL 305. Planetary Geology: Meteorites and Asteroids. 3 Credits.
Required preparation, one introductory geology course numbered below GEOL 202, except first-year seminar. Effects and probable effects of meteorite and asteroid impacts on earth and other planets: craters, new meteorites, and tektites; giant sea waves; reduction of species and extinction of organisms.
Requisites: Pre- or corequisite, CHEM 101.
Gen Ed: PL.
Grading status: Letter grade.

GEOL 310. Coastal Environmental Change. 3 Credits.
An exploration of the large-scale evolution of coastal environments, including relevance of geologic setting, wave and sediment transport processes, the evolution of beach and barrier island morphology, and issues of coastal environmental management.
Requisites: Prerequisite, GEOL 101 or MASC 101 or MASC 401; permission of the instructor for students lacking the prerequisite.
Grading status: Letter grade
Same as: ENEC 310, MASC 316.

GEOL 315. Energy Resources. 3 Credits.
Required preparation, one geology course numbered below GEOL 202 or ENEC below 203, except first-year seminar. Considers the distribution, extraction, economics, and demand for mineral resources. Treats the impact of the mineral industry on industrial and preindustrial economies, economic factors, maldistribution and depletion of resources, and the environmental impact of the mineral extraction industry. Previously offered as GEOL 215.
Gen Ed: PL.
Grading status: Letter grade.

GEOL 324. Water in Our World: Introduction to Hydrologic Science and Environmental Problems. 3 Credits.
This introductory course will cover two broad themes: the physical processes of the hydrologic cycle and how human use (and abuse) of freshwater resources can lead to major environmental problems. PX credit for ENEC/GEOL 324 + 324L. PL credit for ENEC/GEOL 324.
Gen Ed: PX.
Grading status: Letter grade
Same as: ENEC 324.

GEOL 324L. Water in Our World Laboratory. 1 Credit.
Students will conduct laboratory and field experiments to reinforce the topics covered in ENEC/GEOL 324. PX credit for ENEC/GEOL 324 + 324L.
Requisites: Pre- or corequisite, ENEC/GEOL 324.
Grading status: Letter grade
Same as: ENEC 324L.

GEOL 390. Special Topics in Geology. 1-4 Credits.
Permission of the department. Topics and instructors vary from semester to semester. Course may be repeated. Honors version available
Repeat rules: May be repeated for credit; may be repeated in the same term for different topics; 12 total credits. 4 total completions.
Grading status: Letter grade.

GEOL 390H. Special Topics in Geology. 1-4 Credits.
Permission of the department. Topics and instructors vary from semester to semester. Course may be repeated.
Repeat rules: May be repeated for credit; may be repeated in the same term for different topics; 12 total credits. 4 total completions.
Grading status: Letter grade.

GEOL 395. Undergraduate Research in Geology. 1-4 Credits.
Permission of the instructor. Research in geology under the supervision of a selected instructor. Approved learning contract required. May be repeated up to four times for a maximum of 12 credits.
Repeat rules: May be repeated for credit. 12 total credits. 4 total completions.
Grading status: Letter grade.

GEOL 396. Independent Study in Geology. 1-4 Credits.
Permission of the instructor. Independent study under the supervision of a selected instructor. Learning contract required. May be repeated up to four times for a maximum of 12 credits.
Repeat rules: May be repeated for credit. 12 total credits. 4 total completions.
Grading status: Letter grade.

Advanced Undergraduate and Graduate-level Courses

GEOL 403. Oceanography. 3 Credits.
Required preparation, major in a natural science or two courses in natural sciences. Studies origin of ocean basins, seawater chemistry and dynamics, biological communities, sedimentary record, and oceanographic history. Term paper. Students lacking science background should see MASC 101. Students may not receive credit for both MASC 101 and MASC 401.
Grading status: Letter grade
Same as: MASC 401, BIOL 350, ENVR 417.

GEOL 405. Geochemistry. 3 Credits.
Required preparation, one introductory geology course. Introduction to the application of chemical principles to geological problems. Topics include thermodynamics, kinetics, and isotope geochemistry. Previously offered as GEOL 512/MASC 553.
Requisites: Prerequisites, CHEM 102 and MATH 231; permission of the instructor for students lacking the prerequisites.
Gen Ed: QI.
Grading status: Letter grade
Same as: MASC 455.
GEOL 406. Introduction to Geophysics. 3 Credits.
Introduction to the fundamentals of global geophysics: gravity, seismology, magnetism, heat, and plate tectonics. Both shallow and deep processes are considered. Emphasis is aimed at problem solving by applying concepts. Previously offered as GEOL 515.
Requisites: Prerequisites, PHYS 114, 116, or 118, and 115, 117, or 119.
Grading status: Letter grade.

GEOL 410. Earth Processes in Environmental Systems. 4 Credits.
Principles of geological and related Earth systems sciences are applied to analyses of environmental phenomena. The link between the lithosphere and other environmental compartments is explored through case studies of environmental issues. Three lecture hours and one laboratory hour a week.
Requisites: Prerequisites, CHEM 102, GEOL 200, MATH 231, and PHYS 115 or 119; permission of the instructor for students lacking the prerequisites.
Grading status: Letter grade
Same as: ENEC 410, MASC 410.

GEOL 411. Oceanic Processes in Environmental Systems. 4 Credits.
Principles of analysis of the ocean, coast, and estuarine environments and the processes that control these environments are applied to the analysis of environmental phenomena. Case studies of environmental issues. Three lecture hours and one laboratory hour a week.
Requisites: Prerequisites, BIOL 101, CHEM 102, ENEC 222, MATH 231, PHYS 115 or 119; permission of the instructor for students lacking the prerequisites.
Grading status: Letter grade
Same as: ENEC 411, MASC 411.

GEOL 412. Principles and Methods of Teaching Earth Science. 4 Credits.
Required preparation, any introductory geology course. This course develops the knowledge and skills teachers need to implement inquiry-based earth science instruction: conceptual knowledge of earth sciences and mastery of inquiry instructional methods. Students study inquiry in cognitive science and learning theory. This course is a requirement for the UNC-BEST program in geological sciences.
Gen Ed: EE- Service Learning.
Grading status: Letter grade
Same as: ENEC 412.

GEOL 415. Environmental Systems Modeling. 3 Credits.
This course explores principles and strategies for studying environmental phenomena, and presents methods for developing explanatory and predictive models of environmental systems, e.g., predator-prey, estuaries, greenhouse gases, and ecosystem material cycles.
Requisites: Prerequisite, MATH 383; pre- or corequisite, PHYS 115 or 118, and COMP 116.
Grading status: Letter grade
Same as: ENEC 415, MASC 415.

GEOL 417. Geomorphology. 3 Credits.
Introduction to process geomorphology with emphasis on quantitative interpretation of weathering, hill slope, fluvial, glacial, and eolian processes from topography and landscapes.
Requisites: Prerequisites, GEOL 201 and MATH 231; permission of the instructor for students lacking the prerequisites.
Grading status: Letter grade
Same as: ENEC 417.

GEOL 417L. Geomorphology Laboratory. 1 Credit.
Two laboratory hours per week.
Requisites: Pre- or corequisite, GEOL 417.
Grading status: Letter grade.

GEOL 421. Archaeological Geology. 3 Credits.
Permission of the instructor. The application of geological principles and techniques to the solution of archaeological problems. Studies geological processes and deposits pertinent to archaeological sites, geologic framework of archaeology in the southeastern United States, and techniques of archaeological geology. Field trips to three or more sites; written reports required.
Repeat rules: May be repeated for credit; may be repeated in the same term for different topics; 6 total credits. 2 total completions.
Grading status: Letter grade
Same as: ANTH 421.

GEOL 422. Physics of the Earth’s Interior. 3 Credits.
Requisites: Prerequisites, MATH 383, and either PHYS 201 and 211 or 311 and 401.
Grading status: Letter grade
Same as: PHYS 422.

GEOL 425. Introduction to Field Geology. 3 Credits.
Introduction to geologic field methods. Includes making observations, mapping, identification of structures and features, and interpretation to solve basic geologic problems. Many field trips. Previously offered as GEOL 225.
Requisites: Prerequisites, GEOL 302, 303, and 304; permission of the instructor for students lacking the prerequisites.
Gen Ed: EE- Field Work.
Grading status: Letter grade.

GEOL 432. Paleoclimatology. 3 Credits.
Introduction to mechanisms that drive climate. Examination of past climate reconstructions using ecological and geochemical proxies. Utility of computer models to reconstruct past climates and predict future climate change. Emphasis placed on late Quaternary.
Requisites: Prerequisite, GEOL 202 or 303; permission of the instructor for students lacking the prerequisite.
Grading status: Letter grade.

GEOL 433. Paleoceanography. 3 Credits.
Origin and distribution of pelagic sediments. Review of the major Mesozoic and Cenozoic events in the world oceans. Glacial/interglacial changes in the ocean/atmosphere system.
Requisites: Prerequisite, GEOL 303 or 503; permission of the instructor for students lacking the prerequisite.
Grading status: Letter grade.

GEOL 435. Groundwater. 3 Credits.
Required preparation, one introductory geology course. Introduction to physics, chemistry, and geology of groundwater. Previously offered as GEOL 509.
Requisites: Prerequisite, GEOL 201; CHEM 102; MATH 231; PHYS 104 or 114 or 116 or 118; permission of the instructor for students lacking the prerequisites.
Gen Ed: QI.
Grading status: Letter grade
Same as: ENEC 435.
GEOL 436. Geochemistry of Natural Waters. 3 Credits.
Required preparation, one introductory geology course. Survey of processes affecting the compositions of streams, lakes, the ocean, and shallow ground waters. Previously offered as GEOL 510.
Requisites: Prerequisites, CHEM 102 and MATH 231; permission of the instructor for students lacking the prerequisites.
Gen Ed: QI.
Grading status: Letter grade.

GEOL 440. Principles of Seismology. 3 Credits.
Descriptive account of global seismology, earthquake distribution, and focal mechanics. Principles of geometrical optics and applications to imaging the earth’s interior. Principles of seismic prospecting of hydrocarbon and geothermal reservoirs.
Requisites: Prerequisites, GEOL 200, 302; MATH 231; permission of the instructor for students lacking the prerequisites.
Grading status: Letter grade.

GEOL 450. Biogeochemical Processes. 4 Credits.
Principles of chemistry, biology, and geology are applied to analysis of the fate and transport of materials in environmental systems, with an emphasis on those materials that form the most significant cycles. Three lecture hours and one laboratory hour a week.
Requisites: Prerequisites, MATH 231, and PHYS 114 or 118; permission of the instructor for students lacking the prerequisites.
Gen Ed: PL.
Grading status: Letter grade
Same as: ENEC 450, MASC 450.

GEOL 460. Fluid Dynamics of the Environment. 3 Credits.
Principles and applications of fluid dynamics to flows of air and water in the natural environment. Conservation of momentum, mass, and energy applied to lakes, rivers, estuaries, and the coastal ocean. Dimensional analysis and scaling emphasized to promote problem-solving skills.
Requisites: Prerequisite, MATH 232; permission of the instructor for students lacking the prerequisite.
Gen Ed: QI.
Grading status: Letter grade.

GEOL 480. Modeling of Marine and Earth Systems. 1-3 Credits.
Mathematical modeling of dynamic systems, linear and nonlinear. The fundamental budget equation. Case studies in modeling transport, biogeochemical processes, population dynamics. Analytical and numerical techniques; chaos theory; fractal geometry.
Requisites: Prerequisite, MATH 232; permission of the instructor for students lacking the prerequisite.
Grading status: Letter grade
Same as: MASC 480, ENVR 480.

GEOL 483. Geologic and Oceanographic Applications of Geographical Information Systems. 4 Credits.
Required preparation, four GEOL courses or permission of the instructor. Focus is on applying GIS concepts and techniques to mining and petroleum geology, resource assessment, hydrogeology, coastal and marine geology, physical oceanography, engineering geology, and a geologic perspective on land use. Three lecture and two laboratory hours a week.
Grading status: Letter grade
Same as: MASC 483.

GEOL 485. Summer Field Course in Geology. 3 Credits.
Three-week field camp conducted in the western United States (Arizona, California, Colorado, Nevada, New Mexico, and/or Utah). Learn proper use of geology field tools and how to make a geologic map. Field interpretation of rocks and their deformation. Previously offered as GEOL 601.
Requisites: Prerequisites, GEOL 302, 303, and 304; permission of the instructor for students lacking the prerequisites.
Gen Ed: EE- Field Work.
Grading status: Letter grade.

GEOL 486. Summer Field Course in Geology. 3 Credits.
Three-week field camp conducted in the western United States (Arizona, California, Colorado, Nevada, New Mexico, and/or Utah). Learn advanced mapping skills necessary to interpret geologic history of complexly deformed rocks. Previously offered as GEOL 602.
Requisites: Prerequisites, GEOL 302, 303, and 304; permission of the instructor for students lacking the prerequisites.
Gen Ed: EE- Field Work.
Grading status: Letter grade.

GEOL 490. Topics in Earth and Environmental Sciences. 3 Credits.
Key topics and resources for high school teachers preparing to teach earth and environmental sciences. Includes lithosphere, tectonic processes, hydrosphere, atmosphere, origin of solar system and life, and environmental stewardship.
Grading status: Letter grade.

GEOL 501. Geological Research Techniques. 3 Credits.
Permission of the instructor. Theory and practice of analytical methods in geochemistry including X-ray diffraction, X-ray fluorescence, and scanning electron microscopy; introduction to electronics.
Grading status: Letter grade.

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)
Requisites: Prerequisite, GEOL 110.
Gen Ed: PL.
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, glacial-marine 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.
Gen Ed: PL.
Grading status: Letter grade
Same as: MASC 503.

GEOL 504. Advanced Petrology. 3 Credits.
Origin of magmas and evolution of igneous and metamorphic rocks, combined with petrographic study of selected sites.
Requisites: Prerequisite, GEOL 304.
Grading status: Letter grade.
GEOL 505. Chemical Oceanography. 4 Credits.
Graduate students only; undergraduates must have permission of the instructor. Overview of chemical processes in the ocean. Topics include physical chemistry of seawater, major element cycles, hydrothermal vents, geochemical tracers, air-sea gas exchange, particle transport, sedimentary processes, and marine organic geochemistry. Three lecture and two recitation hours per week.
Gen Ed: PL.
Grading status: Letter grade
Same as: MASC 505, ENVR 505.

GEOL 506. Physical Oceanography. 4 Credits.
For graduate students; undergraduates need permission of the instructor. Descriptive oceanography, large-scale wind-driven and thermohaline circulations, ocean dynamics, regional and nearshore/estuarine physical processes, waves, tides. Three lecture and one recitation hour per week.
Gen Ed: PL.
Grading status: Letter grade
Same as: MASC 506.

GEOL 508. Global Hydrology. 3 Credits.
An introduction to methodologies and instrumentation for quantifying the movement of water in the earth system focusing on components of the hydrologic cycle.
Requisites: Prerequisites, GEOL/ENEC 324 and MATH 231; permission of the instructor for students lacking the prerequisites.
Grading status: Letter grade.

GEOL 511. Stable Isotopes in the Environment. 3 Credits.
Introduction to the theory, methods, and applications of stable isotopes to environmental problems. Primary focus will be on the origin, natural abundance, and fractionation of carbon, hydrogen, oxygen, and nitrogen isotopes.
Requisites: Prerequisite, CHEM 102.
Grading status: Letter grade
Same as: ENEC 511.

GEOL 514. Rivers and Floods. 3 Credits.
River floods are critically important in the global hydrologic cycle. While seasonal floods can be environmentally restorative, they can also have devastating socio-economic and public health consequences. Beginning with the hydrologic cycle, this course will cover concepts related to rainfall runoff and hydrologic response, flood frequency analysis, the mechanics of open channel flow, and overland and channel routing. Students will also gain experience working with real-world data and engineering software.
Requisites: Prerequisites, GEOL 201 and MATH 231; or permission of instructor.
Grading status: Letter grade
Same as: ENEC 514.

GEOL 517. Sequence and Seismic Stratigraphy. 3 Credits.
Examination of lithostratigraphic principles and the sequence stratigraphic paradigm. Students will study use of variation of well log signature reflection attributes and reflection termination patterns to identify and correlate sequences and systems and to interpret the lithology and depositional history of subsurface stratigraphic units.
Requisites: Prerequisite, GEOL 303.
Grading status: Letter grade.

GEOL 518. Geodynamics. 3 Credits.
Required preparation, one introductory geology course. Interior of the earth deduced from seismology, gravity, heat flow, magnetism; geophysics of continents and ocean basins; age of earth.
Requisites: Prerequisites, CHEM 102; MATH 232; and PHYS 104 and 105, or 114 and 115.
Grading status: Letter grade.

GEOL 520. Data Analysis in the Earth Sciences. 3 Credits.
Required preparation, an introductory geology course numbered below 202, except first-year seminar, or permission of the instructor. Introduction to quantitative analysis in earth sciences: solid earth, atmospheres, oceans, geochemistry, and paleontology. Topics covered: univariate and multivariate statistics, testing, nonparametric methods, time series, spatial and cluster analysis, shapes.
Requisites: Prerequisites, MATH 231 and 232.
Grading status: Letter grade.

GEOL 521. Clastic Depositional Systems: Processes and Products. 3 Credits.
Examination of the use of lateral and vertical changes in sedimentary facies to identify depositional processes and environments of deposition within the terrestrial, marginal marine, shelf, and deep sea clastic depositional systems. These systems will be examined in a sequence stratigraphic framework.
Requisites: Prerequisite, GEOL 303.

GEOL 522. Physical Volcanology. 3 Credits.
Required preparation, introductory courses in geology and physics. Course is aimed at understanding the physical properties and processes controlling volcanism and magma transport. Topics covered include volcanic processes from the formation of magma in the upper mantle to violent eruption at the surface. Emphasizes dynamic processes and underlying mechanisms.
Grading status: Letter grade.

GEOL 523. Petroleum Geoscience. 4 Credits.
Students study the origin, migration, and entrapment of hydrocarbons in sedimentary basins and learn how several areas of the geosciences are integrated to locate and produce hydrocarbons. Students learn about these topics while analyzing a real subsurface data set.
Requisites: Prerequisites, GEOL 302 and 303; permission of the instructor for students lacking the prerequisites.
Grading status: Letter grade.

GEOL 525. Inverse Theory: Advanced Data Analysis and Geophysical Modeling. 3 Credits.
The course deals with earth science problems related to extracting model parameters from data and field observations. Details of mathematical concepts, real world examples, and practical applications associated with noisy or incomplete data are covered. Key concepts include multivariate regression, model discretization, Tikhonov regularization, and Bayesian methods.
Grading status: Letter grade.

GEOL 550. Biogeochemical Cycling. 3 Credits.
Biogeochemical cycling explores interfaces of marine, aquatic, atmospheric, and geological sciences emphasizing processes controlling chemical distributions in sediments, fresh and salt water, the atmosphere, and fluxes among these reservoirs.
Requisites: Prerequisites, ENV 421; GEOL 405, 436, 655; MASC 440, 505; or permission of the instructor.
Gen Ed: PL, CI.
Grading status: Letter grade
Same as: MASC 550.
GEOL 552. Organic Geochemistry. 3 Credits.
Recommended preparation, CHEM 261 or MASC 505, and one additional ENVR, GEOL, or MASC course above 400. Sources, transformations, and fate of natural organic matter in marine environments. Emphasis on interplay of chemical, biological, and physical processes that affect organic matter composition, distribution, and turnover.
Gen Ed: PL.
Grading status: Letter grade
Same as: MASC 552, ENVR 552.

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.
Requisites: Prerequisites, BIOL 202, and one other BIOL course above 200; corequisite, BIOL 555L; permission of the instructor for students lacking the prerequisites.
Gen Ed: EE- Field Work.
Grading status: Letter grade
Same as: BIOL 555.

GEOL 560. Fluid Dynamics. 3 Credits.
The physical properties of fluids, kinematics, governing equations, viscous incompressible flow, vorticity dynamics, boundary layers, irrotational incompressible flow.
Requisites: Prerequisite, PHYS 401; permission of the instructor for students lacking the prerequisite.
Grading status: Letter grade
Same as: MASC 560, ENVR 452, PHYS 660.

GEOL 563. Descriptive Physical Oceanography. 3 Credits.
Observed structure of the large-scale and mesoscale ocean circulation and its variability, based on modern observations. In-situ and remote sensing techniques, hydrographic structure, circulation patterns, ocean-atmosphere interactions.
Requisites: Prerequisite, MASC 506; permission of the instructor for students lacking the prerequisite.
Gen Ed: PL.
Grading status: Letter grade
Same as: MASC 563.

GEOL 567. Application of Plasma Mass Spectrometry in Earth and Environmental Sciences. 3 Credits.
This class is an introduction to one of the state-of-the-art analytical techniques in geological and environmental research - the ICP-MS (Inductively Coupled Plasma - Mass Spectrometry). Students will have hands-on experiences with ICP-MS sample preparation and analysis, and they will design their own hypothesis-driven research projects to analyze major and trace elements in geological and environmental samples including water, rock, and soil.
Requisites: Prerequisite, GEOL 101, 200, or 201.
Gen Ed: EE- Mentored Research.
Grading status: Letter grade.

GEOL 580. Evolution of Earth’s Surface Environment. 3 Credits.
The course combines geology, climatology, hydrology, and soil science to explore the evolution of the surface environment of the earth from the Archean to the present, including the great oxidation event and modern ocean anoxia. Students will read research papers and will be encouraged to question and debate course topics.
Grading status: Letter grade.

GEOL 590. Special Topics in Earth Sciences. 1-4 Credits.
Discussion or lab-based consideration of topical issues in earth sciences.
Repeat rules: May be repeated for credit; may be repeated in the same term for different topics; 8 total credits. 2 total completions.
Grading status: Letter grade.

GEOL 595. Advanced Field Seminar in Geology. 1-4 Credits.
A field course that emphasizes advanced field methods. Emphasis is placed on large-scale, detailed field work in complex structural terrains and on independent mapping that will lead to thesis/dissertation and/or publication. Previously offered as GEOL 695.
Requisites: Prerequisites, GEOL 485 and 486.
Grading status: Letter grade.

GEOL 608. Continuum Mechanics in the Earth Sciences. 3 Credits.
Applications of continuum mechanics in the earth sciences, including stress, strain, elasticity, and viscous flow. Numerical solutions to problems in heterogeneous finite strain including finite element analysis.
Requisites: Prerequisites, GEOL 302, and PHYS 114, 116, or 118.
Grading status: Letter grade
Same as: ENEC 608.

GEOL 655. Recent Advances in Non-Traditional Stable Isotope Geochemistry. 3 Credits.
This seminar will introduce students to state of the art analytical techniques, current theories, and their applications in various geological processes regarding the non-traditional stable isotopes (e.g., Li, Mg, Fe, Mo, and Cr). After introducing some basic principles and analytical techniques of these so called "non-traditional" stable isotopes, students will present and discuss recent literature in this arena.
Gen Ed: QI.
Grading status: Letter grade.

GEOL 691H. Honors. 3 Credits.
By permission of the department. For details, see geology degree requirements.
Gen Ed: EE- Mentored Research.
Grading status: Letter grade.

GEOL 692H. Honors. 3 Credits.
For details, see geology degree requirements.
Requisites: Prerequisite, GEOL 691H.
Gen Ed: EE- Mentored Research.
Grading status: Letter grade.

MASC–Marine Science
Undergraduate-level Courses
MASC 51. First Year Seminar: Global Warming: Science, Social Impacts, Solutions. 3 Credits.
Students will examine evidence that human activity has caused global warming, investigate scientists’ ability to predict climate change, and discuss the political and social dimensions of global climate change.
Gen Ed: PL, QI.
Grading status: Letter grade.

MASC 52. First-Year Seminar: Living with Our Oceans and Atmosphere. 3 Credits.
Modern theories of changing weather, severe weather events, oceanic hazards, interactions between the oceans and atmosphere, and changes that are linked to human activity.
Gen Ed: PL.
Grading status: Letter grade.
MASC 53. First-Year Seminar: The Ends of the Earth: Polar Oceanography and Exploration. 3 Credits.
What explains the "pull of the poles"? This seminar combines a modern survey of polar oceanography with historical views of early polar explorations, as reported by the explorers themselves.
Gen Ed: PL.
Grading status: Letter grade.
MASC 55. First-Year Seminar: Change in the Coastal Ocean. 3 Credits.
This course provides an opportunity to explore changes in marine and closely linked terrestrial environments caused by the interactions of fascinating oceanographic processes. Introductory presentations and discussions will focus on published works of active marine scientists who combine disciplinary training with knowledge and skills from other fields.
Gen Ed: PL.
Grading status: Letter grade.
Repeat rules: May be repeated for credit; may be repeated in the same term for different topics; 6 total credits. 2 total completions.
MASC 57. First-Year Seminar: From "The Sound of Music" to "The Perfect Storm". 3 Credits.
Students will develop the conceptual framework necessary to understand waves of any kind, starting from laboratory observations. Honors version available
Gen Ed: PL, QI.
Grading status: Letter grade
Same as: MATH 63.
MASC 57H. First-Year Seminar: From "The Sound of Music" to "The Perfect Storm". 3 Credits.
Students will develop the conceptual framework necessary to understand waves of any kind, starting from laboratory observations.
Gen Ed: PL, QI.
Grading status: Letter grade
Same as: MATH 63H.
MASC 58. First-Year Seminar: Connections to the Sea: The Challenges Faced by Using and Living near Coastal In. 3 Credits.
This course explores the natural history of several inlets, impact of human intervention, and political/policy challenges faced; includes several group projects/presentations and a field trip to a coastal inlet.
Gen Ed: PL.
Grading status: Letter grade
Same as: GEOL 108, PHYS 108.
MASC 59. First-Year Seminar: Extreme Microorganisms: Pushing the Limits of Life on Earth and Beyond. 3 Credits.
This seminar focuses on some of the most extreme microorganisms on the planet, microorganisms that thrive without oxygen, under high temperatures (e.g., in pressurized water above the boiling point), and under chemical stress factors (high sulfide and heavy metal concentrations) that were once thought to be incompatible with life.
Gen Ed: PL.
Grading status: Letter grade.
Repeat rules: May be repeated for credit; may be repeated in the same term for different topics; 6 total credits. 2 total completions.
Grading status: Letter grade.
MASC 101. The Marine Environment. 3 Credits.
Introduction to marine sciences emphasizing physical, chemical, biological, and geological phenomenon in oceanic and coastal environments. Human use of, and impact on, marine resources. Science majors should take MASC 401. Students may not receive credit for both MASC 101 and MASC 401.
Gen Ed: PL.
Grading status: Letter grade
Same as: GEOL 103.
MASC 101L. The Marine Environment Laboratory. 1 Credit.
In this CURE course, students will research historical physical conditions and plankton abundance on a temperate reef on the NC coast and use the information to design a common garden experiment to test the effects of projected ocean warming and decrease food availability for heterotrophy on the calcification response of temperate corals. Students must also enroll in the MASC 101 lecture.
Requisites: Corequisite, MASC 101.
Gen Ed: PX.
Grading status: Letter grade.
MASC 108. Climate and Energy Transitions: Understanding the Forecasts. 4 Credits.
This course examines uncertainties in projecting future fossil fuel consumption and impact on global climate by quantifying how effectively alternative power-generation and energy-storage technologies can scale to meet needs in developing and developed nations, and by understanding past and present climates.
Gen Ed: PX, GL.
Grading status: Letter grade
Same as: GEOL 108, PHYS 108.
MASC 190. Special Topics in Marine Sciences. 3 Credits.
An undergraduate seminar course that is designed to be a participatory intellectual adventure on an advanced, emergent, and stimulating topic within a selected discipline in marine sciences.
Grading status: Letter grade.
MASC 220. North Carolina Estuaries: Environmental Processes and Problems. 3 Credits.
Natural processes and human impacts on estuarine systems using the Neuse River estuary as a case study. Course includes one week of intensive field work based at the Institute of Marine Sciences. A student may not receive credit for this course after receiving credit for ENEC 222.
Gen Ed: PX, EE- Field Work.
Grading status: Letter grade
Same as: ENEC 220.
MASC 223. Geology of Beaches and Coasts. 3 Credits.
Required preparation, one introductory geology course numbered below GEOL 202, except first-year seminar. Introduction to coastal processes, including waves, tidal currents, tectonics, climate, and human activity, and their influence on barrier islands, beaches, dunes, marshes, and estuaries. Involves a field trip to the Outer Banks of North Carolina.
Grading status: Letter grade
Same as: GEOL 223.
MASC 310. Our Changing Planet: Science, Social Impacts, Solutions. 3 Credits.
An overview of the scientific basis for global warming, current and future impacts on society, options for mitigation and adaptation, and the role of politics and the media.
Gen Ed: PL.
Grading status: Letter grade.
MASC 312. From the Equator to the Poles: Case Studies in Global Environmental Change. 3 Credits.
Case studies in environmental change, highlighting human and environmental dynamics in terrestrial and marine ecosystems on multiple spatial and temporal scales. Includes active-learning modules, group presentations, writing assignments.
*Gen Ed:* SS, GL.
*Grading status:* Letter grade.

MASC 314. Earth Systems in a Changing World. 3 Credits.
This course presents an integrated view of our planet, how it evolved during the past, why it has changed (and continues to change), and what makes Earth a habitable planet.
*Grading status:* Letter grade.

MASC 316. Coastal Environmental Change. 3 Credits.
An exploration of the large-scale evolution of coastal environments, including relevance of geologic setting, wave and sediment transport processes, the evolution of beach and barrier island morphology, and issues of coastal environmental management.
*Requisites:* Prerequisite, GEOL 101 or MASC 101 or MASC 401; permission of the instructor for students lacking the prerequisite.
*Grading status:* Letter grade
*Same as:* GEOL 310, ENEC 310.

MASC 352. Marine Fisheries Ecology. 3 Credits.
Gives students a foundation in population biology and the ecological processes that influence populations of economically important fish and shellfish. Students will gain practical quantitative skills including statistical analyses, model development, and data visualization. Familiarity with introductory statistics concepts is preferred but not necessary.
*Requisites:* Prerequisite, MASC 101, 401, or ENEC 202.
*Grading status:* Letter grade
*Same as:* ENEC 352.

MASC 390. Special Topics in Marine Sciences (for Undergraduates). 1-4 Credits.
Special topics in marine sciences for undergraduate students.
*Repeat rules:* May be repeated for credit; may be repeated in the same term for different topics; 12 total credits. 3 total completions.
*Grading status:* Letter grade.

MASC 395. Undergraduate Research in Marine Sciences. 1-3 Credits.
Permission of a faculty research director. Directed readings with laboratory study on a selected topic.
*Gen Ed:* EE: Mentored Research.
*Repeat rules:* May be repeated for credit. 8 total credits. 8 total completions.
*Grading status:* Letter grade.

MASC 396. Independent Study in Marine Sciences. 3 Credits.
Permission of the instructor. Directed readings on a selected topic.
*Repeat rules:* May be repeated for credit; may be repeated in the same term for different topics; 6 total credits. 2 total completions.
*Grading status:* Letter grade.

Advanced Undergraduate and Graduate-level Courses

MASC 401. Oceanography. 3 Credits.
Required preparation, major in a natural science or two courses in natural sciences. Studies origin of ocean basins, seawater chemistry and dynamics, biological communities, sedimentary record, and oceanographic history. Term paper. Students lacking science background should see MASC 101. Students may not receive credit for both MASC 101 and MASC 401.
*Grading status:* Letter grade
*Same as:* BIOL 350, ENVR 417, GEOL 403.

MASC 410. Earth Processes in Environmental Systems. 4 Credits.
Principles of geological and related Earth systems sciences are applied to analyses of environmental phenomena. The link between the lithosphere and other environmental compartments is explored through case studies of environmental issues. Three lecture hours and one laboratory hour a week.
*Requisites:* Prerequisites, CHEM 102, GEOL 200, MATH 231, and PHYS 115 or 119; permission of the instructor for students lacking the prerequisites.
*Grading status:* Letter grade
*Same as:* ENEC 410, GEOL 410.

MASC 411. Oceanic Processes in Environmental Systems. 4 Credits.
Principles of analysis of the ocean, coast, and estuarine environments and the processes that control these environments are applied to the analysis of environmental phenomena. Case studies of environmental issues. Three lecture hours and one laboratory hour a week.
*Requisites:* Prerequisites, BIOL 101, CHEM 102, ENEC 222, MATH 231, PHYS 115 or 119; permission of the instructor for students lacking the prerequisites.
*Grading status:* Letter grade
*Same as:* ENEC 411, GEOL 411.

MASC 415. Environmental Systems Modeling. 3 Credits.
This course explores principles and strategies for studying environmental phenomena, and presents methods for developing exploratory and predictive models of environmental systems, e.g., predator-prey, estuaries, greenhouse gases, and ecosystem material cycles.
*Requisites:* Prerequisite, MATH 383; pre- or corequisite, PHYS 115 or 118, and COMP 116.
*Grading status:* Letter grade
*Same as:* ENEC 415, GEOL 415.

MASC 432. Major World Rivers and Global Change: From Mountains to the Sea. 3 Credits.
What are the linkages between rivers and global change? This course examines the hydrological, geological and biogeochemical processes that control material flux from land to the oceans via rivers.
*Grading status:* Letter grade.

MASC 433. Wetland Hydrology. 3 Credits.
Study of wetland ecosystems with particular emphasis on hydrological functioning, the transition from terrestrial to aquatic systems, wetlands as filtration systems, and exchange between wetlands and other environments.
*Grading status:* Letter grade
*Same as:* ENEC 433.

MASC 434. Blue Carbon and Coastal Environments. 3 Credits.
Permission of the instructor is required. Readings and discussions about processes in traditional “Blue Carbon” environments (marshes, seagrass beds, and mangroves) and an exploration of carbon burial in other coastal ecosystems such as floodplains and oyster reefs.
*Grading status:* Letter grade.
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.
Requisites: Prerequisite, BIOL 201 or 475.
Gen Ed: PL.
Grading status: Letter grade
Same as: BIOL 462.

MASC 441. Marine Physiological Ecology. 3 Credits.
This course introduces students to the physiological, morphological, and behavioral factors employed by marine organisms to cope with their physical environment. Emphasis will be placed on the response of marine organisms to environmental factors such as seawater temperature, light, water salinity, ocean acidification, etc.
Grading status: Letter grade
Same as: BIOL 457.

MASC 442. Marine Biology. 3 Credits.
Recommended preparation, BIOL 201 or 475. A survey of plants and animals that live in the sea: characteristics of marine habitats, organisms, and the ecosystems will be emphasized. Marine environment, the organisms involved, and the ecological systems that sustain them.
Grading status: Letter grade
Same as: ENEC 441.

MASC 443. Marine Microbiology. 3 Credits.
Restricted to junior or senior science majors or graduate students, with permission of the instructor. Seminar class focuses on the primary research literature. Physiology of marine microorganisms, microbial diversity and ecology of the marine environment, biogeochemical processes catalyzed by marine microorganisms.
Gen Ed: PL.
Grading status: Letter grade
Same as: BIOL 457.

MASC 444. Marine Phytoplankton. 3 Credits.
Permission of the instructor. For junior and senior science majors or graduate students. Biology of marine photosynthetic protists and cyanobacteria. Phytoplankton evolution, biodiversity, structure, function, biogeochemical cycles and genomics. Harmful algal blooms, commercial products, and climate change. Three lecture/practical session hours per week.
Grading status: Letter grade
Same as: ENEC 444, BIOL 456.

MASC 445. Marine Invertebrate Biology. 4 Credits.
See BIOL 475 for description.
Grading status: Letter grade

MASC 446. Marine Microbial Symbioses: Exploring How Microbial Interactions Affect Ecosystems and Human Health. 3 Credits.
Course material covers host-microbe and microbe-microbe interactions found in marine ecosystems, including beneficial and parasitic relationships among viruses, microbes, marine animals, and humans. Limited to upper-level undergraduate science majors and graduate students.
Gen Ed: PL.
Grading status: Letter grade
Same as: BIOL 452.

MASC 447. Microbial Ecological Genomics. 3 Credits.
Permission of the instructor. For junior and senior science majors and graduate students. Active learning class focused on sequencing and bioinformatic analysis of microbial genomes to identify their ecological function. Topics include sequencing technologies, genome assembly and analysis, command line, bioinformatic tools, and genes mediating microbial physiology and metabolism in natural ecosystems.
Gen Ed: PL.
Grading status: Letter grade.

MASC 448. Coastal and Estuarine Ecology. 4 Credits.
A field-intensive study of the ecology of marine organisms and their interactions with their environment, including commercially important organisms. Laboratory/recitation/field work is included and contributes two credit hours to the course.
Requisites: Prerequisites, CHEM 102 and MATH 231.
Grading status: Letter grade
Same as: ENEC 448.

MASC 450. Biogeochemical Processes. 4 Credits.
Principles of chemistry, biology, and geology are applied to analysis of the fate and transport of materials in environmental systems, with an emphasis on those materials that form the most significant cycles. Three lecture hours and one laboratory hour a week.
Requisites: Prerequisites, MATH 231, and PHYS 114 or 118; permission of the instructor for students lacking the prerequisites.
Gen Ed: PL.
Grading status: Letter grade
Same as: ENEC 450, GEOL 450.

MASC 455. Geochemistry. 3 Credits.
Required preparation, one introductory geology course. Introduction to the application of chemical principles to geological problems. Topics include thermodynamics, kinetics, and isotope geochemistry. Previously offered as GEOL 512/MASC 553.
Requisites: Prerequisites, CHEM 102 and MATH 231; permission of the instructor for students lacking the prerequisites.
Gen Ed: QI.
Grading status: Letter grade
Same as: GEOL 405.

MASC 460. Fluid Dynamics of the Environment. 3 Credits.
Principles and applications of fluid dynamics to flows of air and water in the natural environment. Conservation of momentum, mass, and energy applied to lakes, rivers, estuaries, and the coastal ocean. Dimensional analysis and scaling emphasized to promote problem-solving skills.
Requisites: Prerequisite, MATH 232; permission of the instructor for students lacking the prerequisite.
Gen Ed: QI.
Grading status: Letter grade.

MASC 470. Estuarine and Coastal Marine Science. 4 Credits.
For graduate students; undergraduate students should take ENEC 222 or have permission of the instructor. Introduction to estuarine environments: geomorphology, physical circulation, nutrient loading, primary and secondary production, carbon and nitrogen cycling, benthic processes and sedimentation. Considers human impacts on coastal systems, emphasizing North Carolina estuaries.
Gen Ed: PL, QI.
Grading status: Letter grade.
MASC 471. Human Impacts on Estuarine Ecosystems. 4 Credits.
A cohesive examination of the human impacts on biological processes in estuarine ecosystems. Laboratory/recitation/field work is included and contributes two credit hours to the course. Taught at off-campus field station.
Requisites: Prerequisites, CHEM 102 and MATH 231.
Gen Ed: EE- Field Work.
Grading status: Letter grade
Same as: ENEC 471.

MASC 472. Barrier Island Ecology and Geology. 6 Credits.
Recommended preparation, one introductory geology course. An integration of barrier island plant and animal ecology within the context of physical processes and geomorphological change. Emphasis on management and impact of human interference with natural processes.
Gen Ed: PL, EE- Field Work.
Grading status: Letter grade

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

MASC 480. Modeling of Marine and Earth Systems. 1-3 Credits.
Mathematical modeling of dynamic systems, linear and nonlinear. The fundamental budget equation. Case studies in modeling transport, biogeochemical processes, population dynamics. Analytical and numerical techniques; chaos theory; fractal geometry.
Requisites: Prerequisite, MATH 232; permission of the instructor for students lacking the prerequisite.
Grading status: Letter grade
Same as: GEOL 480, ENVR 480.

MASC 483. Geologic and Oceanographic Applications of Geographical Information Systems. 4 Credits.
Required preparation, four GEOL courses or permission of the instructor. Focus is on applying GIS concepts and techniques to mining and petroleum geology, resource assessment, hydrogeology, coastal and marine geology, physical oceanography, engineering geology, and a geologic perspective on land use. Three lecture and two laboratory hours a week.
Grading status: Letter grade
Same as: GEOL 483.

MASC 490. Special Topics in Marine Sciences for Undergraduates and Graduates. 1-3 Credits.
Directed readings, laboratory, and/or field study of marine science topics not covered in scheduled courses.
Repeat rules: May be repeated for credit. 12 total credits. 4 total completions.
Grading status: Letter grade.

MASC 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, glacial-marine 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.
Gen Ed: PL.
Grading status: Letter grade
Same as: GEOL 503.

MASC 504. Biological Oceanography. 4 Credits.
For graduate students; undergraduates need permission of the instructor. Marine ecosystem processes pertaining to the structure, function, and ecological interactions of biological communities; management of biological resources; taxonomy and natural history of pelagic and benthic marine organisms. Three lecture and one recitation hours per week. Two mandatory weekend field trips.
Gen Ed: PL.
Grading status: Letter grade
Same as: BIOL 657, ENVR 520.

MASC 505. Chemical Oceanography. 4 Credits.
Graduate students only; undergraduates must have permission of the instructor. Overview of chemical processes in the ocean. Topics include physical chemistry of seawater, major element cycles, hydrothermal vents, geochemical tracers, air-sea gas exchange, particle transport, sedimentary processes, and marine organic geochemistry. Three lecture and two recitation hours per week.
Gen Ed: PL.
Grading status: Letter grade
Same as: ENVR 505, GEOL 505.

MASC 506. Physical Oceanography. 4 Credits.
For graduate students; undergraduates need permission of the instructor. Descriptive oceanography, large-scale wind-driven and thermohaline circulations, ocean dynamics, regional and nearshore/estuarine physical processes, waves, tides. Three lecture and one recitation hour per week.
Gen Ed: PL.
Grading status: Letter grade
Same as: ENVR 505, GEOL 505.

MASC 550. Biogeochemical Cycling. 3 Credits.
Biogeochemical cycling explores interfaces of marine, aquatic, atmospheric, and geological sciences emphasizing processes controlling chemical distributions in sediments, fresh and salt water, the atmosphere, and fluxes among these reservoirs.
Requisites: Prerequisites, ENVR 421; GEOL 405, 436, 655; MASC 440, 505; or permission of the instructor.
Gen Ed: PL, CI.
Grading status: Letter grade
Same as: GEOL 550.

MASC 552. Organic Geochemistry. 3 Credits.
Recommended preparation, CHEM 261 or MASC 505, and one additional ENVR, GEOL, or MASC course above 400. Sources, transformations, and fate of natural organic matter in marine environments. Emphasis on interplay of chemical, biological, and physical processes that affect organic matter composition, distribution, and turnover.
Gen Ed: PL.
Grading status: Letter grade
Same as: GEOL 552, ENVR 552.
MASC 560. Fluid Dynamics. 3 Credits.
The physical properties of fluids, kinematics, governing equations, viscous incompressible flow, vorticity dynamics, boundary layers, irrotational incompressible flow.
**Requisites:** Prerequisite, PHYS 401; permission of the instructor for students lacking the prerequisite.
**Grading status:** Letter grade
**Same as:** ENVR 452, GEOL 560, PHYS 660.

MASC 561. Time Series and Spatial Data Analysis. 3 Credits.
Three components: statistics and probability, time series analysis, and spatial data analysis. Harmonic analysis, nonparametric spectral estimation, filtering, objective analysis, empirical orthogonal functions.
**Requisites:** Prerequisite, MATH 233; permission of the instructor for students lacking the prerequisite.
**Gen Ed:** PL, QI.
**Grading status:** Letter grade.

MASC 562. Turbulent Boundary Layers. 3 Credits.
**Requisites:** Prerequisite, MASC 506 or 560; permission of the instructor for students lacking the prerequisite.
**Gen Ed:** PL, QI.
**Grading status:** Letter grade.

MASC 563. Descriptive Physical Oceanography. 3 Credits.
Observed structure of the large-scale and mesoscale ocean circulation and its variability, based on modern observations. In-situ and remote sensing techniques, hydrographic structure, circulation patterns, ocean-atmosphere interactions.
**Requisites:** Prerequisite, MASC 506; permission of the instructor for students lacking the prerequisite.
**Gen Ed:** PL.
**Grading status:** Letter grade
**Same as:** GEOL 563.