Scripps Institution of Oceanography

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Douglas H. Bartlett, Ph.D., *Marine Microbiology, and Chair of the Department*
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Paola Cessi, Ph.D., *Oceanography*
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David M. Checkley, Ph.D., *Oceanography*
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Steven C. Constable, Ph.D., *Geophysics*
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William R. Young, Ph.D., *Oceanography*

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Andrew A. Benson, Ph.D., *Biology*
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Charles S. Cox, Ph.D., *Oceanography*
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Richard L. Salmon, Ph.D., *Oceanography*
Robert Shadwick, Ph.D., *Zoology/Biomechanics*
George N. Somero, Ph.D., *Biology*
Richard C.J. Somerville, Ph.D., *Meteorology*
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Victor D. Vacquier, Ph.D., *Marine Biology*
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Kenneth M. Watson, Ph.D. *Physical Oceanography*
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A. Aristides Yayanos, Ph.D., *Biology*

ACTING ASSOCIATE PROFESSOR

Jennifer A. MacKinnon, Ph.D., *Oceanography*

ASSOCIATE PROFESSORS

Lihini I. Aluwihare, Ph.D., *Marine Chemistry*
Katherine A. Barbeau, Ph.D., *Marine Chemistry*
Helen Fricker, Ph.D., *Glaciology*
James J. Leichter, Ph.D., *Oceanography*
Joel R. Norris, Ph.D., *Climate and Atmospheric Sciences*

ASSISTANT PROFESSORS

Eric E. Allen, Ph.D., *Marine Biology*
Amro Hamdoun, Ph.D., *Physiology*
Todd R. Martz, Ph.D., *Analytical Chemistry*
Jennifer E. Smith, Ph.D., *Botany and Ecology, Evolution and Conservation Biology*
David Stegman, Ph.D., *Geophysics*

ADJUNCT PROFESSORS

Lisa T. Ballance, Ph.D., *Biological Oceanography*
Jay P. Barlow, Ph.D., *Biological Oceanography*
Exequiel Ezcurra, Ph.D., *Ecology*
Paul Falkowski, *Ph.D., Biology*
Konstantine P. Georgakakos, Sc.D., *Hydrology*
Catherine L. Johnson, Ph.D., *Geophysics*
Nancy Knowlton, Ph.D., *Marine Biology*
Stefan G. Llewellyn Smith, Ph.D., *Applied Mathematics*
Tadeusz F. Molinski, Ph.D., *Organic Chemistry*
Phillip Morin, Ph.D., *Population Genetics*
Naomi Oreskes, Ph.D., *Graduate Special Program in Geological Research and History of Science*
William F. Perrin, Ph.D., *Marine Biology*
Paul E. Smith, Ph.D., *Biological Oceanography*
Detlef Stammer, Ph.D., *Oceanography*

ASSOCIATE ADJUNCT PROFESSOR

Andrew E. Allen, Ph.D., *Ecology*

ASSISTANT ADJUNCT PROFESSOR

Shannon J. Williamson, Ph.D., *Marine Science*

SENIOR LECTURERS

Donna K. Blackman, Ph.D., *Research Geophysicist*
Yehuda Bock, Ph.D., *Research Geodesist*
George Carnevale, Ph.D., *Research Oceanographer*
Daniel R. Cayan, Ph.D., *Research Meteorologist*
Teresa K. Chereskin, Ph.D., *Research Oceanographer*
Bruce D. Cornuelle, Ph.D., *Research Oceanographer*
Grant B. Deane, Ph.D., *Research Oceanographer*
Peter Gerstoft, Ph.D., *Research Scientist*
Jeffrey B. Graham, Ph.D., *Research Biologist*
Alistair J. Harding, Ph.D., *Research Geophysicist*
Michael A.H. Hedlin, Ph.D., *Research Geophysicist*
Sam Iacobellis, Ph.D., *Specialist*
Jules S. Jaffe, Ph.D., *Research Oceanographer*
Graham M. Kent, Ph.D., *Research Geophysicist*
J. Anthony Koslow, Ph.D., *Research Oceanographer/ Director, CalCOFI*
Michael I. Latz, Ph.D., *Research Biologist*
Dan Lubin, Ph.D., *Research Physicist*
Arthur J. Miller, Ph.D., *Research Oceanographer*
B. Gregory Mitchell, Ph.D., *Research Oceanographer*
Jerome A. Smith, Ph.D., *Research Oceanographer*
Kenneth L. Smith, Jr., Ph.D., *Research Biologist*
Hubert Staudigel, Ph.D., *Research Geologist*
James H. Swift, Ph.D., *Research Oceanographer*
Frank L. Vernon, Ph.D., *Research Geophysicist*
Kraig Winters, Ph.D., *Research Oceanographer*
Peter F. Worcester, Ph.D., *Research Oceanographer*
Mark A. Zumberge, Ph.D., *Research Geophysicist*

LECTURERS

Bianca M. Brahamsha, Ph.D., *Associate Research Biotechnologist*
C. David Chadwell, Ph.D., *Associate Research Geophysicist*
Gerald L. D'Spain, Ph.D., *Associate Research Scientist*
Peter Dutton, Ph.D., *Researcher*
Falk Feddersen, Ph.D., *Assistant Research Oceanographer*
Lena Gerwick, Ph.D., *Assistant Research Scientist*
Mark Hildebrand, Ph.D., *Research Biologist*
Paul Jensen, Ph.D., *Assistant Research Scientist*
Kerry Key, Ph.D., *Assistant Research Scientist*
M. Gabriele Laske, Ph.D., *Associate Research Geophysicist*
Cheryl Peach, Ph.D., *Academic Coordinator*
Stuart Sandin, Ph.D., *Assistant Project Scientist*
Eric Simms, Ph.D., *Academic Coordinator*
Hee Chun Song, Ph.D., *Associate Research Scientist*
Janet Sprintall, Ph.D., *Associate Research Oceanographer*
Jane Teranes, Ph.D., *Associate Director, Undergraduate Program*
Eric Terrill, Ph.D., *Director, CORDC*
Aaron Thode, Ph.D., *Associate Research Scientist*

AFFILIATED FACULTY

James R. Arnold, Ph.D., *Professor Emeritus, Chemistry and Biochemistry*
Juan C. Lasheras, Ph.D., *Professor, MAE*
Paul A. Libby, Ph.D., *Professor Emeritus, MAE*
Paul F. Linden, Ph.D., *Professor, MAE*
R. Glenn Northcutt, Ph.D., *Professor, Neurosciences*
Sutanu Sarkar, Ph.D., *Professor, MAE*

UNDERGRADUATE EDUCATION OFFICE:
Galbraith Hall 188
http://sioundergrad.ucsd.edu

INTRODUCTION

Scripps Institution of Oceanography is one of the oldest, largest, and most important centers for marine science research, education, and public service in the world. Its preeminence in the marine sciences is reflective of its excellent programs, distinguished faculty and research scientists, and outstanding facilities. Scripps Institution was founded in 1903 as an independent biological research laboratory, which became an integral part of the University of California in 1912. At that time, the laboratory was given the Scripps name in recognition of donors Ellen Browning Scripps and E. W. Scripps. Research and education at Scripps encompasses physical, chemical, biological, geological, and geophysical studies of the oceans. Among the hundreds of research programs that may be under way at any one time are studies of air-sea interaction, climate prediction, earthquakes, the physiology of marine organisms, the geological history of the ocean basins, and multidisciplinary aspects of global change and the environment.

THE UNDERGRADUATE PROGRAM

The Scripps Institution of Oceanography Department offers over forty-five undergraduate courses covering a wide breadth of earth and marine sciences on several different levels. There are several introductory classes for non-majors, and upper-division courses intended for a wide range of students in natural science majors. For students interested in careers in earth sciences, the Scripps Institution of Oceanography offers a B.S. degree and a contiguous B.S./M.S. degree in earth sciences. In addition, students may follow a chemistry/earth sciences major, a physics major with a specialization in earth sciences, or an environmental systems/earth sciences major (see the "Chemistry," "Physics," or "Environmental Systems" sections of the catalog for details). The program also offers an academic minor in earth sciences.

For students interested in broadening their understanding of and opportunity in marine science and oceanography, the program offers an academic minor in marine science. The marine science minor is designed to complement the strong disciplinary training of UC San Diego basic natural science and engineering majors (i.e., chemistry, physics, biological sciences, earth sciences, engineering, mathematics, etc.) by providing a broad interdisciplinary perspective with an applied environmental focus.

EARTH SCIENCES MAJOR

Earth sciences encompass broad scientific study of the origin and evolution of the earth system and its life forms. The earth sciences major embraces a wide range of topics, including the physical and chemical evolution of the planet, the evolution of life, the causes of earthquakes and volcanic eruptions, earth-surface processes, the origin and behavior of oceans and atmosphere, and the impact of humans on the environment. Earth science investigations are increasingly quantitative and experimental, and thus most upper-division courses require a strong foundation in chemistry, physics, and mathematics.

The earth sciences curriculum takes advantage of the unique opportunities offered by Scripps Institution of Oceanography. Classes beyond introductory level are usually small, permitting personalized instruction. Field trips are an important part of the instructional program. Earth sciences students are encouraged to consult with their instructors about incorporating appropriate courses and research opportunities at the Scripps Institution of Oceanography into their undergraduate curriculum.

A degree in earth sciences is an appropriate start for a broad range of career and graduate school opportunities in various areas, including research, government, state and federal survey jobs, environmental management, the petroleum and mining industries, consulting, ocean sciences, industrial institutions, elementary or secondary education, environmental policy, or environmental law. Program advisors and faculty can provide additional information on career and graduate school opportunities.

There are three specializations, each with slightly different course requirements, in the earth sciences major: The *Earth Sciences/Geology* major, *Earth Sciences/Geochemistry* major, and *Earth Sciences/Geophysics* major.

It is strongly recommended that all earth science majors meet regularly with the earth sciences academic advising staff and a faculty advisor to discuss and update curriculum choices. The earth sciences academic staff are located in the Scripps office of Undergraduate Programs in Galbraith Hall, Room 188.

Lower-division requirements are designed to provide the foundations in mathematics, physics, chemistry, and biology that are essential in modern quantitative earth science disciplines. In addition, there are four upper-division courses introducing basic concepts, SIO 100, SIO 102, SIO 103, and SIO 104. SIO 100 and SIO 102 should be taken during the sophomore year to provide the appropriate background for other upper-division courses.

A grade-point average of 2.0 or higher in the upper-division major program is required for graduation. Students must receive a grade of C– or better in any course to be counted toward fulfillment of the major requirements. In exceptional cases, students with a grade-point average in the major of 2.5 or greater may petition to have one grade of D accepted. All courses (lower- and upper-division) required for the major must be taken for a letter grade.

Special Studies Courses

Special studies in the earth sciences are offered as the courses SIO 198 and SIO 199. These courses are subject to consent of the instructor and approval by the earth sciences faculty advisor. They are open to students who have accrued at least ninety quarter-units and have a GPA of at least 3.0. Two quarters of earth sciences special studies may be counted toward any earth sciences major.

EARTH SCIENCES/GEOLOGY

The earth sciences/geology major is designed to allow students maximum flexibility in tailoring the curriculum to their interests, within the constraints of obtaining the necessary background in physical, biological, and earth sciences. Compared to the earth sciences/geochemistry and earth sciences/geophysics tracks, it requires more earth science and fewer non-earth science courses.

Lower-Division Requirements

Math. 20A-B-C (may allow Math. 10A-B-C by petition) and Math. 20D
Phys. 2A-B-C (may allow Phys. 1A-B-C by petition)
Chem. 6A-B-C
BILD 3
SIO 50

Upper-Division Requirements

Earth Sciences Upper-Division Core Requirements

SIO 100. Introduction to Field Methods
SIO 102. Introduction to Geochemistry
SIO 103. Introduction to Geophysics
SIO 104/255. Paleobiology and History of Life

Upper-Division Earth Science Requirements

SIO 105. Sedimentology and Stratigraphy
SIO 120. Mineralogy
SIO 152. Petrology and Petrography
SIO 160. Introduction to Tectonics
SIO 162. Structural Geology
SIO 182A. Environmental and Exploration Geophysics A
SIO 182B. Environmental and Exploration Geophysics B

Upper-Division Restricted Electives, at least four courses from

Chem. 173. Atmospheric Chemistry
SIO 101. California Coastal Oceanography
SIO 110. Introduction to GIS and GPS for Scientists
SIO 111/Phys. 111. Introduction to Waves and Tides
SIO 112. Urban Landscapes
SIO 115. Ice and the Climate System
SIO 117. The Physical Basis of Global Warming
SIO 135/236. Satellite Remote Sensing
SIO 138. The Coral Reef Environment
SIO 141/Chem. 174. Chemical Principles of Marine Systems
SIO 144/252A. Introduction to Isotope Geochemistry
SIO 148/248. Evolution of Earth's Biosphere
SIO 154/254. Macroevolution
SIO 155/251. Petrology and Geochemistry of the Solid Earth
SIO 170. Introduction to Volcanology
SIO 186. Interactions Between Humans and the Natural Environment
SIO 195. Methods of Teaching Earth Sciences
SIO 197. Earth Science Internship
SIO 199. Independent Study
SIO 210. Physical Oceanography
SIO 226. Introduction to Marine Geophysics
SIO 240. Marine Geology
SIO 247. Rock Magnetism and Paleomagnetism
SIO 260. Marine Chemistry
SIO 280. Biological Oceanography

An example schedule is outlined below.

FALL	WINTER	SPRING
Freshman Year		
Math. 20A	Math. 20B	Math. 20C
Chem. 6A	Chem. 6B	Chem. 6C
SIO 50	Phys. 2A	Phys. 2B
Sophomore Year		
Math. 20D	SIO 102	SIO 105
Phys. 2C	SIO 162	
BILD 3	SIO 104	
Junior Year		
SIO 100	SIO 120	SIO 152
SIO 103	SIO 182A	SIO 182B
Senior Year		
SIO Elect.	SIO Elect.	SIO Elect.
	SIO Elect.	SIO 160

EARTH SCIENCES/GEOCHEMISTRY MAJOR

This specialization focuses on the Earth as a chemical system and on its evolution. Emphasis is placed on the fundamental observations that allow geoscientists to understand better the past history of the planet, the energetics of its evolution, and the major "cycles" (e.g., water, carbon) that characterize and control planetary-scale changes on a broad range of time scales. The major is appropriate for students interested in modern geochemistry, in "global change" studies, and in global and local environmental problems, including biochemical and anthropogenic effects.

Lower-Division Requirements

Math. 20A-B-C-D
Phys. 2A-B-C (2D recommended)
Chem. 6A-B-C and Chem. 6BL
BILD 3
SIO 50

Upper-Division Requirements

Earth Sciences Upper-Division Core Requirements

SIO 100. Introduction to Field Methods
SIO 102. Introduction to Geochemistry
SIO 103. Introduction to Geophysics
SIO 104/255. Paleobiology and History of Life

Upper-Division Earth Science Requirements

SIO 120. Mineralogy
SIO 144/252A. Introduction to Isotope Geochemistry
SIO 152. Petrology and Petrography

Upper-Division Chemistry Requirements

Chem. 120A. Inorganic Chemistry
Chem. 131. Physical Chemistry or Chem. 127
Chem. 140A. Organic Chemistry

Chemistry Restricted Electives, at least two courses from

Chem. 149A. Environmental Chemistry
Chem. 149B. Environmental Chemistry
Chem. 173. Atmospheric Chemistry

Upper-Division Restricted Electives, at least three courses from

SIO 101. California Coastal Oceanography
SIO 105. Sedimentology and Stratigraphy
SIO 110. Introduction to GIS and GPS for Scientists
SIO 111/Phys. 111. Introduction to Waves and Tides
SIO 112. Urban Landscapes
SIO 115. Ice and the Climate System
SIO 135/236. Satellite Remote Sensing
SIO 138. The Coral Reef Environment
SIO 141/Chem. 174. Chemical Principles of Marine Systems
SIO 148/248. Evolution of Earth's Biosphere
SIO 154/SIO 254. Macroevolution
SIO 155/251. Petrology and Geochemistry of the Solid Earth
SIO 160. Introduction to Tectonics
SIO 162. Structural Geology
SIO 170. Introduction to Volcanology
SIO 182A. Environmental and Exploration Geophysics A
SIO 182B. Environmental and Exploration Geophysics B
SIO 186. Interactions Between Humans and the Natural Environment
SIO 195. Methods of Teaching Earth Sciences
SIO 197. Earth Science Internship
SIO 199. Independent Study
SIO 226. Introduction to Marine Geophysics
SIO 240. Marine Geology
SIO 247. Rock Magnetism and Paleomagnetism
SIO 260. Marine Chemistry

An example schedule is outlined below.

FALL	WINTER	SPRING
Freshman Year		
Chem. 6A	Chem. 6B	Chem. 6C
Math. 20A		Math. 20C
SIO 50	Math. 20B	Chem. 6BL
Sophomore Year		
Phys. 2A	Phys. 2B	Phys. 2C
Math. 20D	SIO 102	BILD 3
SIO 100		
Junior Year		
SIO 103	SIO 120	Chem. 127 or 131
Chem. 140A	SIO 144	SIO 152
	SIO 104	
Senior Year		
Chem. 120A	SIO Elect.	SIO Elect.
Chem. Elect.	SIO Elect.	SIO Elect.

EARTH SCIENCES/GEOPHYSICS MAJOR

This specialization focuses on the mechanical, dynamical, and thermodynamical aspects of the Earth. Emphasis is placed on a solid background of fundamental physics, from mechanics and electromagnetism to continuum- and quantum mechanics, and on the necessary mathematical skills. The major introduces basic techniques used to investigate the internal structure of the Earth, from seismology to the study of potential fields, and space geodesy. Elementary geodynamics, including the physics of simple convective systems, introductory rock mechanics, and plate kinematics are among topics introduced. At the same time, a "hands-on" exposure to field problems and techniques will be accessible through an applied geophysics sequence.

Lower-Division Requirements

Math. 20A-B-C-D-E-F
Phys. 4A-B-C-D or Phys. 2A-B-C (Phys. 4 sequence recommended)
Chem. 6A-B-C
BILD 3
SIO 50

Upper-Division Requirements

Earth Sciences Upper-Division Core Requirements

SIO 100. Introduction to Field Methods
SIO 102. Introduction to Geochemistry
SIO 103. Introduction to Geophysics
SIO 104/255. Paleobiology and History of Life

Upper-Division Earth Sciences Requirements

SIO 160. Introduction to Tectonics
SIO 182A. Environmental and Exploration Geophysics A
SIO 182B. Environmental and Exploration Geophysics B

Upper-Division Physics Requirements

Phys. 100A-B-C. Electromagnetism
Phys. 110A-B. Mechanics

Physics Restricted Electives, at least one course from

Phys. 105A. Mathematical and Computational Physics
Phys. 105A. Mathematical and Computational Physics
Phys. 121. Experimental Techniques
Phys. 140A-B. Statistical and Thermal Physics
MAE 131A. Solid Mechanics I
MAE 180A. Spacecraft Guidance I

Upper-Division Restricted Electives, at least two courses from

SIO 101. California Coastal Oceanography
SIO 105. Sedimentology and Stratigraphy
SIO 110. Introduction to GIS and GPS for Scientists
SIO 111/Phys. 111. Introduction to Waves and Tides
SIO 112. Urban Landscapes
SIO 115. Ice and the Climate System
SIO 117. The Physical Basis of Global Warming
SIO 120. Introduction to Mineralogy
SIO 135/236. Satellite Remote Sensing
SIO 138. The Coral Reef Environment
SIO 141/Chem. 174. Chemical Principles of Marine Systems
SIO 144/252A. Introduction to Isotope Chemistry
SIO 148/248. Evolution of Earth's Biosphere
SIO 152. Petrology and Petrography
SIO 154/254. Macroevolution
SIO 155. Petrology and Geochemistry of the Solid Earth
SIO 160. Introduction to Tectonics
SIO 162. Structural Geology
SIO 170. Introduction to Volcanology
SIO 186. Interactions Between Humans and the Natural Environment
SIO 195. Methods of Teaching Earth Sciences
SIO 197. Earth Science Internship
SIO 199. Independent Study
SIO 223. Geophysical Data Analysis
SIO 226. Introduction to Marine Geophysics
SIO 227A. Introduction to Seismology

An example schedule is outlined below.

FALL	WINTER	SPRING
Freshman Year		
Chem. 6A	Chem. 6B	Chem. 6C
Math. 20A	Math. 20B	Math. 20C
SIO 50	Phys. 4A	Phys. 4B
Sophomore Year		
Math. 20D	Math. 20E	Math. 20F
Phys. 4C	Phys. 4D	BILD 3
SIO 100	SIO 102	
Junior Year		
Phys. 100A	Phys. 100B	Phys. 100C
Phys. 110A	SIO 104	Phys. 110B
SIO 103	SIO 182A	SIO 182B
Senior Year		
SIO 130 or 160	Phys. Elect.	SIO Elect.
	SIO Elect.	

HONORS PROGRAM

The Honors Program in Earth Sciences is offered for a limited number of students who have demonstrated excellence in the earth sciences major. Students are eligible for admission to the program when they have

Completed ninety units of courses including twelve units of earth sciences courses.

Achieved a GPA of 3.3 overall and 3.5 in earth science courses.

Submitted to the Earth Sciences Steering Committee, and had approved, an honors thesis research proposal.

Successful completion of the Honors Program requires

Maintenance of a GPA of 3.3 overall and 3.5 in earth sciences courses.

Completion, with a B grade or higher, of a minimum of eight units of SIO 196 related to the honors thesis research, distributed over at least two quarters. These units must be in addition to the ordinary major requirements. However, students who subsequently fail to complete the Honors Program may apply up to four of these 196 units to their major.

Acceptance of a written honors thesis report by a committee of not fewer than three faculty members.

Satisfactory presentation of an oral report on the thesis research, preferably at a public undergraduate research conference on campus, or at an earth sciences conference. Alternatively, the oral report may be given at a seminar involving honors students and at least three faculty members.

Students who successfully complete the Honors Program will graduate with "high distinction."

Students who are interested in the Honors Program should contact the program advisor in Galbraith Hall, Room 188, Revelle College.

(See Scripps Institution of Oceanography graduate program for information on the "Contigious Bachelor's/Master's Earth Sciences Degree Program.")

EARTH SCIENCES MINOR

A minor in earth sciences consists of twenty-eight units of earth sciences courses, at least twenty of which must be upper-division, focused on geology, geochemistry, or geophysics. Courses required by a student's major may not be applied toward a minor and neither can SIO 198 nor SIO 199. Courses for the minor may be taken on a Pass/Not Pass basis if the student's college permits. Students interested in the earth sciences minor should meet with the earth sciences academic advising staff to discuss their curriculum choices.

MARINE SCIENCE MINOR

The Scripps Institution of Oceanography offers an undergraduate minor program in marine science. The minor curriculum is designed to complement the strong disciplinary training of UCSD basic science majors by providing a broad interdisciplinary perspective with an environmental focus. Ocean-related science is relevant to many contemporary environmental issues and problems and central to understanding earth-system evolution, dynamics, climate, and sustainability. The minor consists of courses and research opportunities offered primarily through faculty and researchers at Scripps. The mix of these components can be tailored to reflect students' career interests through an "all courses" track or a "research" track. The "all courses" track offers a very flexible curriculum that serves students with a broad range of educational and career interests including environmental management and regulation, teaching, environmental law, economics and policy and a wide variety of graduate programs. The "research" track is designed for students interested in an undergraduate research experience at Scripps and serves as excellent preparation for graduate research studies.

The minor consists of twenty-eight units of course work, at least twenty of which must be upper-division. Courses required by a student's major may not be applied toward the minor. Up to two courses for the minor may be taken on a Pass/Not Pass basis (upper- or lower-division). Students must earn at least a letter grade of C– in the remaining five or more courses used for the minor. The marine science minor places a strong emphasis on a rigorous natural science foundation; thus, several of the upper-division courses related to the minor have significant prerequisites. Students planning the minor should check catalog course descriptions carefully and should meet with advising staff in the Scripps Institution of Oceanography Office of Undergraduate Programs, Galbraith Hall, Room 188.

Lower-Division Requirements

SIO 30. The Oceans

Any one of the following lower-division courses may be applied to the minor requirements

STPA 35. Society and the Sea
SIO 10. The Earth
SIO 12. History of the Earth and Evolution
SIO 20. The Atmosphere
SIO 35. Water
SIO 40. Life and Climate on Earth
SIO 50. Introduction to Earth and Environmental Sciences

Additionally, any math, chemistry, physics, or biology course that is a prerequisite for an upper-division elective for the marine science minor (ex., Math. 20 series; Chem. 6A, 6B, 6C; Phys. 2 series; BILD 1, 2, 3) may be applied, by petition, as a lower-division requirement for the minor 's major.

Upper-Division Requirements

Option 1—All Courses Track

At least five courses from the list (below) of upper-division electives

Option 2—Research Track

At least five courses from the list (below) of upper-division electives, at least three of which must be courses satisfying Option #1 and at least two of which must be Independent Study (SIO 199; eight units total) Note: The Independent Study must be designed in mutual agreement and arrangement with an SIO faculty member. Students interested in the marine science minor "Research Track" must meet with a Scripps Undergraduate Program advisor for information and policies.

Upper-Division Electives

SIO 101. California Coastal Oceanography
SIO 102. Introduction to Geochemistry
SIO 103. Introduction to Geophysics
SIO 104/255. Paleobiology and History of Life
SIO 105. Sedimentology and Stratigraphy
SIO 110. Introduction to GIS and GPS for Scientists
SIO 111/Phys. 111. Introduction to Ocean Waves and Tides
SIO 115. Ice and the Climate System
SIO 117. The Physical Basis of Global Warming
SIO 138. The Coral Reef Environment
BIMM 126. Marine Microbiology
BIMM 127/SIO 288. Marine Microbiology Lab
BIEB 132. Introduction to Marine Biology
BIBC 130/SIO 281. Marine Biochemistry
BIEB 134. Introduction to Biological Oceanography
SIO 135/236. Satellite Remote Sensing
SIO 141/ Chem. 174. Chemical Principles of Marine Systems
SIO 148/248. Evolution of Earth's Biosphere
SIO 154/254. Macroevolution
SIO 160. Introduction to Tectonics
SIO 180/292. Communicating Science to Informal Audiences
SIO 198. Directed Group Study
SIO 199. Independent Study
ECE 156/MAE 149/SIO 238. Sensor Networks
SIO 201. Geologic Record of Climate Change
SIO 210. Physical Oceanography
SIO 260. Marine Chemistry
SIO 265. Chemical Ecology of Marine Organisms

Other SIO courses may be submitted by petition.

STUDY ABROAD

Study abroad through the Education Abroad Program (http://programsabroad.ucsd.edu) or Opportunities Abroad Program can enhance a student's major, particularly as an opportunity for diverse field experiences. However, careful planning is important to meet all major requirements. Please contact the Scripps Office of Undergraduate Programs as early as possible if you are an earth sciences major and planning to study abroad.

CAREERS IN EDUCATION

Students interested in a teaching career should be aware that the earth sciences major, because of its broad course requirements in the sciences, fulfills many of the subject requirements for obtaining a California Teaching Credential through UCSD's Educational Studies Program. The projected high demand over the next decade for well-trained teachers, particularly in the sciences, makes this an attractive option for many students. Students who wish to take advantage of this opportunity may wish to complete a minor in science education. Please contact the Education Studies office directly for further details

THE GRADUATE PROGRAM

GRADUATE EDUCATION OFFICE:
Old Scripps Building 22, Scripps Institution of Oceanography
http://scrippseducation.ucsd.edu/

The Department of Scripps Institution of Oceanography offers instruction leading to Ph.D. degrees in oceanography, marine biology, and earth sciences. Although students are not admitted specifically for an M.S. degree, it is possible to obtain an M.S. on the way to completing the Ph.D. degree. The Department of Scripps Institution of Oceanography is organized into three academic programs: Climate-Ocean-Atmosphere Program (COAP), Geosciences of the Earth, Oceans, and Planets (GEO), and Ocean Biosciences Program (OBP).

Each of these programs is responsible for all graduate educational activities in its area, including teaching, advising, and examining. The academic programs are umbrellas for curricular groups as follows.

Climate-Ocean-Atmosphere Program (COAP)

Applied Ocean Science (AOS)
Climate Sciences (CS)
Physical Oceanography (PO)

Geosciences of the Earth, Oceans, and Planets (GEO)

Geophysics (GP)
Geosciences (GS)
Marine Chemistry and Geochemistry (MCG)

Ocean Biosciences Program (OBP)

Biological Oceanography (BO)
Marine Biology (MB)

Climate-Ocean-Atmosphere Program (COAP)

Applied Ocean Science is a multidisciplinary program focused on the application of advanced technology to ocean exploration and observation. AOS students perform research in marine acoustics, optics, electromagnetics, geophysics, ecology, sediment transport, coastal processes, physical oceanography, and air-sea interaction. The emphasis is on the resolution of key scientific issues through novel technological development. The science focus of the Scripps AOS program is complemented by parallel Applied Ocean Science programs in the Mechanical and Aerospace Engineering (MAE) and Electrical and Computer Engineering (ECE) departments. Students have access to professors, courses, and research facilities across all three departments.

Climate Sciences concerns the study of the climate system of the earth with emphasis on the physical, dynamical, and chemical interactions of the atmosphere, ocean, land, ice, and the terrestrial and marine biospheres. The program encompasses changes on seasonal to interannual time scales and those induced by human activities, as well as paleoclimatic changes on time scales from centuries to millions of years. Examples of current research activities include: interannual climate variability; physics and dynamics of El Niño; studies of present and future changes in the chemical composition of the atmosphere in relation to global warming and ozone depletion; effects of cloud and cloud feedbacks in the climate system; paleoclimate reconstructions from ice cores, banded corals, tree-rings, and deep-sea sediments; the origin of ice ages; air-sea interactions; climate theory; terrestrial and marine ecosystem response to global change.

Physical Oceanography is the field of study that deals with mechanisms of energy transfer through the sea and across its boundaries, and with the physical interactions of the sea with its surroundings, especially including the influence of the seas on the climate of the atmosphere. Research activities within this curricular group are both observational and theoretical and include: study of the general circulation of the oceans, including the relations of ocean currents to driving forces and constraints of the ocean basins; fluctuations of currents, and the transport of properties; the mechanisms of transport of energy, momentum, and physical substances within the sea and across its boundaries; properties of wind waves, internal waves, tsunami, and planetary waves; the thermodynamic description of the sea as a system not in equilibrium; optical and acoustic properties of the sea; and the influence of surf on near-shore currents and the transport of sediments.

Geosciences of the Earth, Oceans and Planets (GEO)

Geophysics emphasizes the application of general principles of mathematics and experimental physics to fundamental problems of the oceans, the oceanic and continental lithosphere, the cryosphere, and the crust and deep interior of the Earth. Research interests of the group include: observational and theoretical studies of electric and magnetic fields in the oceans and on the land; paleomagnetism; theoretical seismology with special emphasis on the structure of the Earth from free-oscillation and body wave studies; broadband observational seismology, including ocean bottom and multichannel seismology; earthquake source mechanisms; the measurements of slow crustal deformations using satellite and observatory methods on continents and in the oceans; marine geodynamics and tectonophysics; gravity measurements; geophysical inverse theory; observations of the ice sheets; magnetohydrodynamics of the core of the Earth; geophysical instrumentation for oceanic and

continental geophysical measurements; acoustic propagation in the oceans.

Geosciences emphasizes the application of general principles of geology, geochemistry, and geophysics to problems in the marine and terrestrial environments of the Earth. Graduate students routinely participate in expeditions at sea and on land and many doctoral theses evolve from these experiences.

Research areas in the geological sciences include: the origin and evolution of the ocean-atmosphere system and global climate; geology, geochemistry, and geophysics of oceanic crustal rocks and near-shore environments; tectonic and structural evolution of the oceans, plate margins, and back-arc basins; the role of fluids in the crust; chemistry of rare gases in active volcanoes; the use of natural nuclear processes for understanding physical and chemical processes in the Earth; paleomagnetic applications in geology and geophysics.

Marine Chemistry and Geochemistry concerns chemical and geochemical processes operating in a broad range of study areas: the oceans, the solid earth, the atmosphere, marine organisms, polar ice sheets, lakes, meteorites, and the solar system.

Areas of advanced study and research include the physical and inorganic chemistry of seawater; ocean circulation and mixing based on chemical and isotopic tracers; marine organic and natural products chemistry; marine bioinorganic chemistry; geochemical interactions of sediments with seawater and interstitial waters; geochemistries of volcanic and geothermal phenomena; chemical exchanges between the ocean and the atmosphere; geochemical cycles of carbon, oxygen, sulfur, nitrogen, and other elements; isotopic geochemistry of the solid earth and meteorites; atmospheric trace gas chemistry; paleoatmospheric composition recorded in polar ice cores, corals and sediments; and chemistry of lakes and other freshwater systems.

Studies are typically interdisciplinary and involve integration of chemical concepts with information about the physical, biological, or geological processes that influence natural systems. Students in the marine chemistry and geochemistry curricular group are encouraged to explore these links.

Ocean Biosciences Program (OBP)

Biological Oceanography is concerned with the interactions of populations of marine organisms with one another and with their physical and chemical environment. Because these interactions are frequently complex, and because the concepts and techniques used are drawn from many fields, biological oceanography is, of necessity, interdisciplinary. Therefore, studies in physical oceanography, marine chemistry, marine geology, and several biological areas are pertinent.

Research is conducted on space/time scales ranging from short-term interactions between individual organisms (mm., sec.) to interdecadal variation in widely dispersed populations. The techniques used in these investigations are diverse, and can include field observation and manipulations, experimentation in the laboratory, and mathematical modeling.

Research topics include primary and secondary productivity and nutrient regeneration, fishery biology and management, community ecology of benthic and pelagic organisms, population dynamics, habitat changes and disruptions, systematics and biogeography, population genetics and evolution, and behavior as it affects distribution. Development and testing of new tools (molecular, optical, acoustic), design of sampling programs, and statistical/mathematical analyses of data also are significant activities.

Marine Biology is the study of marine organisms. It is concerned with evolutionary, organismic, genetic, genomic, physiological, and biochemical processes in these organisms, and the relationship between them and their biotic and physical environment. Marine biology encompasses several major areas of modern biology, and is interpreted by understanding the physical and chemical dynamics of the oceans. Faculty research focuses on microbiology, photobiology, invertebrate biology, vertebrate biology, high pressure biology, deep-sea biology, developmental biology, genetics, comparative biochemistry, eco-toxicology, physiology, behavior, ecology, biogeography, taxonomy, and evolution. Processes ranging from coral larvae recruitment to the role of bacteria in marine food web dynamics are under study in over twenty independent research laboratories.

REQUIREMENTS FOR ADMISSION

Candidates for admission should have a bachelor's or master's degree in one of the physical, biological, or earth sciences; degrees in mathematics or engineering science are also accepted. A scholastic average of B or better in upper-division courses, or prior graduate study, is required. The student's preparation should include

mathematics through differential and integral calculus

physics, one year with laboratory (the course should stress the fundamentals of mechanics, electricity, magnetism, optics, and thermodynamics, and should use calculus in its exposition)

chemistry, one year with laboratory

an additional year of physics, chemistry, or mathematics

All applicants are required to submit scores from the general test of the Graduate Record Examinations (GRE) given by the Educational Testing Service of Princeton, New Jersey. Applicants to the Ocean Biosciences Program, additionally, should take one GRE subject test of their own choice.

All international applicants whose native language is not English and whose undergraduate education was conducted in a language other than English must take the TOEFL and submit their test scores to the UC San Diego Office of Graduate Admissions.

Specific additional requirements for admission to the programs are as follows.

Climate-Ocean-Atmosphere Program (COAP)

Applied Ocean Science—Students are admissible with a strong background in physical science, engineering science, or mathematics. Three years of physics or applicable engineering and three years of mathematics at college level are expected.

Climate Sciences—Students are admissible if they satisfy the requirements of the physical oceanography, geophysics, or marine chemistry and geochemistry curricular programs. Biology and geology majors may also be admissible if the Scripps faculty feel that they have a sufficiently strong background in mathematics and physical science.

Physical Oceanography—A major in a physical science, including three years of physics and mathematics, is required.

Geosciences of the Earth, Oceans, and Planets (GEO)

Geophysics—A major in physics, mathematics, earth sciences, or equivalent training, is required.

Geosciences—A major in one of the earth sciences and undergraduate physical chemistry and calculus are required. Preparation beyond the minimum requirements in mathematics, physics, and chemistry is strongly recommended.

Marine Chemistry and Geochemistry—A major in chemistry, geology, biochemistry, or related field, is required.

Ocean Biosciences Program (OBP)

Biological Oceanography—Two years of chemistry, including general and organic chemistry, and a year of general biology are required. Physical chemistry requiring calculus may be substituted for physics requiring calculus where a more elementary physics course was taken. Zoology or botany may be substituted for general biology. Preparation should also include a course in general geology and at least one course in each of the following categories: systematics (e.g., invertebrate zoology), population biology (e.g., ecology), functional biology (e.g., physiology). In special cases, other advanced courses in mathematics or natural sciences may be substituted.

Marine Biology—A major in one of the biological sciences (or equivalent), with basic course work in botany, microbiology, or zoology; two years of chemistry, including organic chemistry, is required. Training in one or more of the following areas is strongly recommended: cellular biology, molecular biology, comparative physiology, genetics, developmental biology, ecology, evolutionary biology, vertebrate and invertebrate zoology, microbiology, and/or botany. Biochemistry and physical chemistry will be expected of students in experimental biology, although the student may, if necessary, enroll in these courses at UCSD after admission.

Special consideration occasionally can be given to candidates with outstanding records who do not meet all required preadmission criteria.

PROGRAMS OF STUDY

Programs of study vary widely among the curricular groups, but generally first-year students are expected to enroll in core courses that cover physical, geological, chemical, and biological oceanography. Each first-year student is assigned a guidance committee consisting of three faculty members. The guidance committee is charged with advising the student during the first year, until the departmental exam. The intention is to provide individualized guidance to students particularly

including advice about courses of study that may reach beyond a single curricular group.

By the end of the first year, students usually select a particular area of focus and choose an advisor. As students advance beyond the first year, they begin to function effectively as research assistants or, in some cases, as teaching assistants. During their third to fifth year they are working toward writing their dissertations.

Programs of study for the first year vary between the three programs.

Climate-Ocean-Atmosphere Program

Students admitted to COAP choose a curricular group by the end of the fall quarter. This choice is aided by the student's guidance committee, which includes a Curriculum Advisor from one of the COAP curricular groups. The guidance committee will help to arrange an individually tailored set of first-year courses for the student, and to ensure that the student has taken all necessary courses to prepare for the departmental exam. During the year, students may be supported in a variety of ways, but by the end of the spring quarter students must choose a research advisor. After the first year the guidance committee is dissolved, and the research advisor and dissertation committee provide guidance.

Applied Ocean Science—The AOS academic program is designed to provide both a broad background and a core technical base to support the diverse interests and activities of the students. Early participation in an ongoing research project is encouraged. However, specialization and focus on a specific thesis topic is not required until the second or third year of the program. Required courses include SIO 214A Introduction to Fluid Mechanics, and the two-quarter Wave Physics sequence SIO 202A–B. Two of the four SIO introductory courses (SIO 210, 240, 260, 280), must be completed during the first year, with the remaining two required prior to passing the doctoral qualifying exam at the end of the third year. In addition, the applied math sequence SIO 203 A–B or MAE 294 A–B is taken in either the first or second year of study. The AOS Seminar (SIO 208) serves as a communications bridge across the program; enrollment in this seminar is required during the student's entire period of study. Beyond these core classes, the majority of each student's academic program is tailored to individual interests. The AOS departmental examination, held at the end of the first year, is based on the core technical courses SIO 214A, SIO 202A–B, and two of the four introductory courses (chosen by the student). The exam has both oral and written components.

Climate Sciences—The emphasis of this curricular group is on education through interdisciplinary research. All students are responsible for the fundamental material in the following "core" courses: SIO 210, 217A-B-C, 260. Students are also expected to supplement their backgrounds with five to seven additional courses, including, for most Climate Sciences students, at least one additional quarter of fluid dynamics. These additional course(s) will be chosen in consultation with the students' advisors. It is recommended that students participate actively in at least two quarters of seminar courses designed to complement and stimulate individual research. Though the group stresses interactions across disciplines, students will specialize in a particular subdiscipline or track that will be chosen by the student following discussions with a three-person faculty advisory committee soon after arrival. Examples of current tracks include: (1) atmospheric/ocean/climate dynamics and physics; (2) atmospheric chemistry (emphasizing climatic interactions); and (3) paleoclimate studies. Additional course requirements for these tracks will be tailored to the needs of the individual student.

Physical Oceanography—The physical oceanography curriculum combines a comprehensive program of course work with individually tailored specialization to meet student needs. Presently defined "tracks" in the curriculum are (i) Observational Physical Oceanography, (ii) Theoretical Physical Oceanography, and (iii) the Atmospheric/Ocean Climate System. All tracks are similar in the entry-year fall quarter, diverging as students become more familiar with the field and in their interests. A faculty Curriculum Advisory Committee meets with students to tailor tracks to individual needs, or to create new tracks as appropriate. Students in all subdisciplines of physical oceanography are required to take SIO 203A-B, 214A, 212A. In any track, students are required to take sixteen four-unit graduate courses, of which twelve are covered during the first year. As part of the overall requirement, tracks include a breadth component of two or more four-unit courses in other scientific disciplines. These might come from the SIO core courses in other oceanographic disciplines (SIO 240, 260, 280) or from related graduate-level courses taught at UCSD.

Any exception to the policy above requires written approval by the department chair in consultation with the curriculum advisor.

Physical oceanography students are required to take the departmental examination after completing one year of graduate work at UCSD. The examination covers the material in the four required courses and in eight additional first-year graduate courses chosen by the student in consultation with the curriculum advisor.

The Department of Scripps Institution of Oceanography offers regular seminars in several areas of current interest. After the departmental exam, students in residence are strongly encouraged to enroll for credit in at least one one-unit seminar each quarter.

Geosciences of the Earth, Oceans, and Planets

Students admitted to GEO are assigned an advisor, who is a member of the three-person guidance committee. Based on the student's interests and the major affiliation of the advisor, students are assigned to a curricular group on admission. Although students may change curricular groups in the course of the year, they must choose which departmental xxam they will take. Departmental exams have similar structures among the curricular groups within GEO (a written exam at the end of spring quarter and an oral exam before the beginning of fall quarter). The material covered is quite different so students must begin preparing for the particular exam from the start. Student support for the first year comes from a variety of sources including departmental fellowships and research grants. Students are encouraged to begin a research project from the beginning and typically do not hold teaching assistant positions during their first year. Students may change advisors during their first year, and they must find an advisor by the end of the first year.

Geophysics—There is no single course of study appropriate to the geophysics curriculum; instead, the individual interests of the student will permit, in consultation with the first-year guidance committee, a choice of course work in seismology, geomagnetism, etc. The content of certain core courses usually taken during the first year (SIO 223A,B, SIO 225, SIO 227A, SIO 229, SIO 234) forms the basis for the written departmental examination. Students are also encouraged to participate in the Special Topics seminars (SIO 239).

Geosciences—The geosciences curriculum consists of a series of core courses and a series of research focus courses. All students whether pursuing an earth sciences or an oceanography degree are responsible for material in the core courses: Marine Geology (SIO 240), Marine Chemistry (SIO 260), and Physical Oceanography (SIO 210) during their first year of study. The research courses are selected from three themes: geochemistry, paleoclimate and Earth history, and geology and geophysics. A total of four research courses are required during the first year of study, with at least one from each theme. Additional courses offered by other curricular programs (e.g., geophysics, marine chemistry, and geochemistry) can be selected and scheduled depending on the student's background and interests any time during the student's career at SIO. Each student is also encouraged to participate in the Special Topics seminars (SIO 249) every quarter during the first two years of graduate study. Students wishing to graduate with an oceanography degree are also responsible for the material in SIO 280 (Biological Oceanography).

Marine Chemistry and Geochemistry—In their first year at SIO, students in this curricular group are required to take SIO 210, 260, and either SIO 280 or SIO 240, as well as three additional elective courses. In their second year, students are required to take a further three elective courses. Although the exact choice of such courses will depend on the student's research interests, these required electives must be four-unit courses that are offered at the graduate level, and that have been approved by the curricular group as suitable electives. A list of approved courses is on file at the Department of Scripps Institution of Oceanography. If a student desires to take (as a required elective) a course that is not already on this list, he or she should consult with one of the curricular group advisors to get approval.

Ocean Biosciences Program

Students admitted to OBP are assigned an advisor, who is a member of the three-person guidance committee. Students are assigned to a curricular group based on their interests. Although students may change curricular groups near the beginning of the year, they must commit to a curricular group early on because this determines which departmental exam they will take. The BO departmental exam is an oral exam based on first year course work while the MB exam is a written report and an oral presentation based on first year research; both are

administered after or near the end of Spring Quarter. During the year, students may be supported in a variety of ways. After the first year, the guidance committee is dissolved and the research advisor, and eventually the dissertation committee, provide guidance.

Biological Oceanography—The student will be expected to be familiar with the material presented in the following courses: SIO 210, 240, 260, 270 or 270A, 275A or 277, 280, and at least one of SIO 271, 282, or 294. Other course work ordinarily will be recommended by the student's advisory committee, usually including SIO 278 (or equivalent participatory seminar) one quarter of each year, a course in introductory parametric statistics, and at least one advanced-level course in physical, chemical, or geological oceanography. Participation in an oceanographic cruise (minimum of two weeks' duration) and service as a teaching assistant (one quarter) are required.

Marine Biology—Marine Biology graduate students are expected to gain research experience in one or more laboratories during their first year. In the spring term of their first year at SIO, students will take a departmental exam consisting of a presentation of their first-year research in the form of a paper and short talk to the curricular group, followed by a meeting with their first-year advisory committee. In this exam they also will be expected to demonstrate competence in the material covered in the following courses: SIO 210, 260, 280, 290A-B as well as any other course work recommended by the advisory committee. After their first year students are expected to enroll and actively participate in at least one seminar course (SIO 278, 296, or equivalent) per year that will provide in-depth knowledge and reading in selected areas, as well as practice presenting scientific material. In addition to the seminar requirement discussed above, second-year students will present their research in a special Marine Biology mini-symposium, held in spring quarter; students in the third year and beyond are expected to participate in the research presentation class (SIO 291) each year. Marine Biology students provide annual spring quarter oral or poster presentations of their research through their fifth year.

For the Marine Biodiversity and Conservation M.A.S. program, refer to the separate *UC San Diego General Catalog* listing.

LANGUAGE REQUIREMENTS

The department has no formal language requirements. All students must be proficient in English.

QUALIFYING EXAMINATIONS

When the student has passed the departmental examination (described above under each academic program) and has completed an appropriate period of additional study, the department will recommend appointment of a doctoral committee that will supervise the student's performance and reporting of his or her research. The doctoral committee must be formed before the student may proceed to the qualifying examination

The doctoral committee will determine the student's qualifications for independent research by means of a qualifying examination, which will be administered no later than the end of the third year. The nature of the qualifying examination varies between curricular groups. In biological oceanography, marine biology, geosciences, physical oceanography, applied ocean science, and climate sciences the student will be expected to describe his or her proposed thesis research and satisfy the committee, in an oral examination, as to mastery of this and related topics. In marine chemistry and geochemistry the student, in an oral examination, is required to present and defend a single research proposition in his or her specialized area. The student also is required to provide a written summary of the research proposition, with references, prior to the examination. In geophysics, the student presents an original research problem, in the form of a written proposition, to the doctoral committee. The student's oral presentation and defense of this proposition completes the examination.

DISSERTATION

A requirement for the Ph.D. degree is the submission of a dissertation and a final examination in which the thesis is publicly defended. Students are encouraged to publish appropriate parts of their theses in the scientific literature. Individual chapters may be published as research articles prior to completion of the dissertation.

DEPARTMENTAL PH.D. TIME LIMIT POLICIES

Students must complete a qualifying examination by the end of three years, and must be advanced to candidacy for the Ph.D. Degree by the end of four years. Total university support may not exceed seven years and total registered time at UCSD may not exceed eight years.

SPECIAL FINANCIAL ASSISTANCE AND FELLOWSHIPS

In addition to teaching assistantships, and graduate student researcher positions, fellowships, traineeships, and other awards available on a campus-wide competitive basis, the department has available a certain number of fellowships and graduate student researcher positions supported from research grants and contracts, or from industrial contributions.

CONCURRENT PH.D./ M.B.A. PROGRAM

The Department of Scripps Institution of Oceanography offers a concurrent degree program allowing interested Ph.D. students to complete an M.B.A. at the Rady School of Management. Students who are admitted to Scripps may, with the consent of their academic advisor, apply to Rady, through the usual admissions process, to begin the M.B.A. program no earlier than after the completion of their departmental exam, and no later than the fall quarter following their advancement to candidacy, in line with specific plans developed with their Scripps faculty advisors. An extensive independent study, jointly supervised by Scripps and Rady faculty, enables the student to develop linkages between Scripps and Rady studies. Interested students are encouraged to consult early with Rady M.B.A. Admissions and with their Scripps academic advisors.

CONTIGUOUS BACHELOR'S/MASTER'S EARTH SCIENCES DEGREE PROGRAM

The program leading to a bachelor of science and a master of science degree in earth sciences is offered to undergraduate students who are enrolled in the earth sciences major, and to qualified students who are completing a specialization or minor in earth sciences. It is open only to UCSD undergraduates, and entails participation in research in an area of the earth sciences to be determined jointly by the student and a committee of earth sciences faculty members from the Scripps Institution of Oceanography Department. Applications will only be accepted during the final quarter of the applicant's junior year, or the first or second quarter of the senior year. A minimum undergraduate GPA of 3.0 overall and 3.3 in upper-division earth sciences courses is required for admission. Applications must include a written statement of purpose, a summary of the research proposal, and a letter of support from the potential M.S. thesis advisor. Students must complete requirements for the B.S. degree before they are enrolled in the M.S. program, and are expected to meet the requirements for the M.S. degree within three consecutive academic quarters after obtaining the B.S. Students may be dropped from the program if breaks in enrollment occur. The Scripps Institution of Oceanography Department does not have financial aid available for students enrolled in the contiguous B.S./M.S. program. Please contact the undergraduate education program office in Galbraith Hall, room 188, for information.

COURSES

For course descriptions not found in the UC San Diego General Catalog, 2010–11, please contact the department for more information.

LOWER-DIVISION

1. The Planets (4)
Space exploration has revealed an astonishing diversity among the planets and moons in our solar system. The planets and their histories will be compared to gain insight and a new perspective on planet Earth. **Prerequisite:** none. (W)

10. The Earth (4)
An introduction to structure of the Earth and the processes that form and modify it. Emphasizes material which is useful for understanding geological events as reported in the news and for making intelligent decisions regarding the future of our environment. **Prerequisite:** none. (W)

12. History of the Earth and Evolution (4)
Evolution of the Earth from its origin in the early solar system to formation of continents and ocean basins, and how the planet became habitable. It examines the geologic record of evolution, extinction, plate tectonics, and climate changes through time. **Prerequisite:** none. (S)

15. Natural Disasters (4)
Introduction to environmental perils and their impact on everyday life. Geological and meteorological processes, including earthquakes, volcanic activity, large storms, global climate change, mass extinctions throughout Earth's history, and human activity that causes and prevents natural disasters. **Prerequisite:** none. (F)

16. Geology of the National Parks (4)
An introduction to fundamental concepts of geology and environmental science through the lens of the national park system. Topics covered include the geologic time scale; plate tectonics; igneous, metamorphic, and sedimentary processes; geomorphology; climate change; and environmental degradation. **Prerequisite:** none. (S)

20. The Atmosphere (4)
Descriptive introduction to meteorology and climate studies. Topics include global and wind and precipitation patterns, weather forecasting, present climate and past climate changes (including droughts, El Niño events), "greenhouse" gas effects, ozone destruction, the "little ice age," acid rain. **Prerequisite:** none. (W)

25. Climate Change and Society (4)
Climate change is one of the most complex and critical issues affecting societies today. This course will present the scientific evidence for climate change and its impacts and consider governmental policy responses and possible adaptation strategies. **Prerequisite:** none. (W)

30. The Oceans (4)
Presents modern ideas and descriptions of the physical, chemical, biological, and geological aspects of oceanography, and considers the interactions between these aspects. Intended for students interested in the oceans, but who do not necessarily intend to become professional scientists. **Prerequisite:** none. (F)

35. Water (4)
This course will examine the properties of water that make it unique and vital to living things. Origin of water on Earth and neighboring planets will be explored. Socially relevant issues concerning water use and contamination will be covered. **Prerequisite:** none. (S)

40. Life and Climate on Earth (4)
Explores life on Earth and its relationship to the environment—past, present, and future. Topics include origins of life, earth history, elemental cycles, global climate variability and human impacts on our environment. **Prerequisite:** none. (F)

50. Introduction to Earth and Environmental Sciences (6)
This course is an introduction to how our planet works, focusing on the formation and evolution of the solid earth, and the processes affecting both its surface and interior. Laboratories and substantial field component complement and extend the lecture material. Program and/or material fee may apply. **Prerequisite:** none. (F)

87. Freshman Seminar (1)
The freshman seminar program is designed to provide the new students with the opportunity to explore and intellectual topic with a faculty member in a small setting. Topics vary from quarter to quarter. Enrollment is limited to fifteen to twenty students, with preference given to entering freshmen. (P/NP grades only). (F,W,S)

90. Undergraduate Seminar (1)
Provides an introduction to earth sciences. Faculty members from departments in natural sciences, geosciences, and marine sciences will offer perspectives in these areas. Formerly ERTH 90. (Students may earn up to three units of credit of SIO 90 and/or ERTH 90.) **Prerequisite:** none.

96. Frontiers in the Earth Sciences (2)
An introduction to current research in the earth sciences. Background in science not required, but may be useful for some topics. Areas covered vary from year to year. **Prerequisite:** none.

99. Independent Study (2 or 4)
Independent reading or research on a problem by special arrangement with a faculty member. **Prerequisite:** lower-division standing, completion of thirty units of UCSD undergraduate study, a minimum UCSD G.P.A. of 3.0, and a completed and approved Special Studies form, UCSD Application for Enrollment Special Studies Courses 97, 98, 99.

UPPER-DIVISION

100. Introduction to Field Methods (4)
Mapping and interpretation of geologic units. Field work is done locally and the data are analyzed in the laboratory. There will be one mandatory weekend field trip to Anza Borrego State Park. Program and/or material fee may apply. **Prerequisite:** SIO 50 or consent of instructor. (F)

101. California Coastal Oceanography (4)
This course emphasizes oceanographic connections between physical and climate forcing and marine ecosystem responses using examples from and activities in the California coastal environment. The approach is inquiry-based, combining classroom and experiential learning to build critical and quantitative thinking and research insights and abilities. **Prerequisite:** Chem. 6A or consent of instructor. (F)

102. Introduction to Geochemistry (4)
An introduction to the chemical composition and evolution of the Earth and solar system. Applications of chemical methods to elucidate the origin and geologic history of the Earth and the planets, evolution of oceans and atmosphere, and human environmental impacts. **Prerequisites:** SIO 50, Chem. 6A-B-C, or consent of instructor. (W)

103. Introduction to Geophysics (4)
An introduction to the structure and composition of the solid earth. Topics include seismology, the gravity and magnetic fields, high-pressure geophysics, and concepts in geodynamics. Emphasis is on global geophysics, i.e., on the structure and evolution of the planet. **Prerequisites:** Math. 20A-B-C-D and Phys. 2A-B-C, SIO 50, or consent of instructor. SIO 160 recommended. (F)

104/255. Paleobiology and History of Life (6)
An introduction to the major biological transitions in Earth history from the origins of metabolism and cells to the evolution of complex societies. The nature and limitations of the fossil record, patterns of adaptation and diversity, and the tempo and mode of biological evolution. Laboratories and substantial field component complement and extend the lecture material. Program and/or material fee may apply. **Prerequisites:** Undergraduate: BILD 3 or consent of instructor. Graduate: graduate-level standing or consent of instructor. Graduate students, additionally, will give oral presentation or research paper. (W)

105. Sedimentology and Stratigraphy (4)
This course will examine sedimentary environments from mountain tops to the deep sea across a variety of time scales. The focus is to develop the skills to interpret stratigraphy and read the history of the Earth that it records. Laboratories and substantial field component complement and extend lecture material. Program and/or course material fee may apply. **Prerequisite:** SIO 50 or consent of instructor. (S)

110. Introduction to GIS and GPS for Scientists (4)
A hands-on introduction to science applications of geographic information systems and global positioning system. Students acquire data through GPS field surveys, design and construct GIS using ESRI's ArcGIS software, analyze spatial data, and present the results in a Web-based environment. **Prerequisite:** upper-division standing or consent of instructor. (W)

111/Phys. 111. Introduction to Ocean Waves and Tides (4)
This course will cover a broad range of physical oceanography topics including: linear dynamics of surface gravity waves, dispersion relations, spectral descriptions, group velocity, shoaling waves, ray theory, edge waves, Coriolis force, the tide generating force, LaPlace's tide equations, Kelvin waves. **Prerequisites:** Math. 20A–E and Phys. 2A–C or consent of instructor. (W)

112. Urban Landscapes (4)
Introduction to scientific principles, such as conservation of mass and energy and pattern formation, that govern the development of urban centers as complex systems. Contrasts between natural and urban landscapes will be highlighted, with examples including water routing and disease transmission. **Prerequisite:** upper-division standing or consent of instructor. (S)

115. Ice and the Climate System (4)
This course examines the Earth's cryoshere, including glaciers, ice sheets, ice caps, sea ice, lake ice, river ice, snow, and permafrost. We cover the important role of the cryoshere in the climate systems and its response to climate change. **Prerequisite:** Math 20A–D and Physics 2A–C or consent of instructor. (F)

117. The Physical Basis of Global Warming (4)
Introduction to the processes behind global warming, including the physics of the greenhouse effect, controls on greenhouse gases, atmospheric and oceanic circulation, climate feedbacks, relationships to natural climate variability, and global environmental issues related to global warming. **Prerequisites:** Math. 20D and Phys. 2C or consent of instructor. (S)

120. Introduction to Mineralogy (4)
Application of mineralogical and x-ray crystallographic techniques in earth sciences. Topics include symmetry, crystal structure, chemical, and physical properties of minerals with special emphasis on the common rock-forming minerals. Laboratory component includes polarizing microscope and x-ray powder diffraction methods. **Prerequisites:** SIO 50, or consent of instructor. (W)

135/236. Satellite Remote Sensing (4)
Satellite remote sensing provides global observations of Earth to monitor environmental changes in land, oceans, and ice. Overview, physical principles of remote sensing including: orbits, electromagnetic radiation, diffraction, electro-optical, and microwave systems. Weekly labs explore remote sensing data sets. Graduate students will also be required to write a term paper and do an oral presentation. **Prerequisites:** Undergraduate: Phys. 2A–B or Phys. 4A-B-C or consent of instructor. Graduate: graduate-level standing or consent of instructor. (S)

138. The Coral Reef Environment (4)
Assessment of the physical, chemical, and biological interactions that define the coral reef system; essential geography and evolutionary history of reefs; natural and human perturbations to the coral reef ecosystem; aspects of reef management and sustainability. **Prerequisite:** BILD 3, Math. 10A, Chem. 6B, or consent of instructor.

141/Chem. 174. Chemical Principles of Marine Systems (4)
Introduction to the chemistry and distribution of the elements in seawater, emphasizing basic chemical principles such as electron structure, chemical bonding, and group and periodic properties and showing how these affect basic aqueous chemistry in marine systems. **Prerequisite:** Chem. 6C with a grade of C– or better or consent of instructor. (S)

144/252A. Introduction to Isotope Geochemistry (4)

Radioactive and stable isotope studies in geology and geochemistry, including geochronology, isotopes as tracers of magmatic processes, cosmic-ray produced isotopes as tracers in the crust and weathering cycle, isotopic evolution of the crust and mantle. **Prerequisites:** Undergraduate: SIO 50, SIO 102, and 120 or consent of instructor. Graduate: graduate-level standing or consent of instructor. Graduate level requires student presentation. (W) (Not offered 2010–11).

148/248. Evolution of Earth's Biosphere (6)
Paleoecological development of marine and terrestrial environments during Earth's evolution. Ecological and chemical evolution of the oceans, atmosphere, biogeochemical cycles, and environments with particular emphasis on the long-term history and climate of the Earth's surface. Field trips required. Program and /or course material fee may apply. Graduate level additionally requires (1) term research paper, (2) researched oral presentations during the field trips, and (3) analysis of weekly readings from the current literature. **Prerequisites:** Undergraduate: SIO 104 or consent of instructor. Graduate: graduate-level standing or consent of instructor. (W) (Not offered 2010–11.)

152. Petrology and Petrography (4)
Mineralogic, chemical, textural and structural properties of igneous, metamorphic, and sedimentary rocks; their origin and relations to evolution of the Earth's crust and mantle. Laboratory emphasizes hand specimens and microscopic

studies of rocks in thin sections. **Prerequisites:** SIO 50, SIO 102, and SIO 120 or consent of instructor. (S)

154/254. Macroevolution (4)
Tempo and mode of evolution with emphasis on the marine fossil record. Large-scale patterns and trends in diversity, speciation, and extinction. Innovation, disparity, and adaptive radiation. Evolutionary turnover and the role of the environment in macroevolution. Graduate students will also be required to write a term paper and do oral presentation. **Prerequisites:** Undergraduate: SIO 104 or BIEB 150 or consent of instructor. Graduate: graduate-level standing or consent of instructor. (S)

155/251. Petrology and Geochemistry of the Solid Earth (4)
A geochemical and petrogenetic overview of the Earth and planets. Topics include formation and differentiation of the Earth into core, mantle, crust, and atmosphere/hydrosphere, generation of magma, and isotope and trace element geochemistry of igneous and metamorphic rocks. **Prerequisites:** Undergraduate: SIO 152 or consent of instructor. Graduate: graduate-level standing or consent of instructor. Graduate students, additionally, must submit a term paper in one aspect of work discussed during the quarter to be presented orally in class. (W) (Not offered 2010–11.)

160. Introduction to Tectonics (4)
The theory of plate tectonics attempts to explain how forces within the Earth give rise to continents, ocean basins, mountain ranges, earthquake belts, and most volcanoes. In this course we will learn how plate tectonics works. **Prerequisite:** SIO 50 or consent of instructor. (S)

162. Structural Geology (4)
Principles of stratigraphy and structural geology applicable to field geologic studies. Discussion and laboratory exercises. Two to three field trips required. Program and/or material fee may apply. **Prerequisites:** SIO 50 and SIO 100, or consent of instructor. (W)

170. Introduction to Volcanology (6)
This course teaches fundamental aspects of physical and chemical volcanology with a major field study component on an active volcano on Hawaii (two weeks early September). Subjects are introduced in lectures and reinforced and expanded in field exercises. Students return to campus to attend regular lectures and to prepare final field report during fall quarter. Additional fees may be required. **Prerequisites:** SIO 50, SIO 100, and Chem. 6A, or consent of instructor. Department stamp required. (F)

180/292. Communicating Science to Informal Audiences (4)
Students develop fundamental science communication and instructional skills through the understanding and application of learning theory, interpretive techniques, and pedagogical practices, which occur in the context of communicating ocean science concepts to a diverse audience at Birch Aquarium at Scripps. Graduate science students will develop fundamental communication and instructional skills through the understanding and application of learning theory, interpretive techniques, and pedagogical practices, including the development of an education/outreach plan to support a competitive research proposal. **Prerequisites:** (graduate) graduate-level standing or consent of instructor; (undergraduate) Chem. 6A or SIO 50 or BILD 1 or consent of instructor. (F)

182A. Environmental and Exploration Geophysics A (4)
First of two-part sequence on theory and application of practical geophysics. Lectures are supplemented by the collection of gravity, magnetic, and seismic data and production of field reports. Includes an introduction to MATLAB for analysis and interpretation of data. SIO 103 recommended. **Prerequisites:** Math. 20D and Phys. 2C, or consent of instructor. (W)

182B. Environmental and Exploration Geophysics B (4)
Second of two-part sequence on theory and application of practical geophysics. Lectures are supplemented by the collection of electrical and ground penetrating radar data. Continued use of MATLAB for analysis and interpretation of geophysical data. **Prerequisite:** SIO 182A or consent of instructor. (S)

186. Interactions Between Humans and the Natural Environment (4)
As human population and resource usage have increased, the character of human interactions with nonhuman natural systems on Earth's surface has changed dramatically. This course will survey tools for characterizing this change, its nature, and projections into the future. **Prerequisites:** upper-division standing or consent of instructor. (W)

190. Special Topics in Earth Sciences (4)
A seminar course designed to treat emerging or topical subjects in the earth sciences. Involves reading from the literature and student participation in discussion. Topics vary from year to year. Enrollment by permission of instructor. (Students may enroll in SIO 190 and/or ERTH 190 no more than two times for credit.) **Prerequisite:** upper-division standing, a minimum UCSD GPA of 3.0 or consent of instructor.

192. Senior Seminar in Scripps Institution of Oceanography (1)
The Senior Seminar Program is designed to allow SIO senior undergraduates to meet with faculty members in a small group setting to explore an intellectual topic in SIO (at the upper division level). Topics will vary from quarter to quarter. Senior Seminars may be taken for credit up to four times, with a change in topic, and permission of the department. Enrollment is limited to twenty students, with preference given to seniors.

194. Research Seminar in Washington, D.C. (4)
Course attached to a six- to eight-unit internship taken by students participating in the UCDC Program. Involves weekly seminar meetings with faculty and teaching assistant and a substantial research paper. **Prerequisites:** departmental approval. Participation in the UCDC Program during quarter enrolled in seminar.

195. Methods of Teaching Earth Sciences (4)
Introduction to teaching earth sciences class section in a lower-division class, hold office hours, assist with examinations. This course counts only once towards the major. **Prerequisites:** junior or senior earth sciences major with GPA of 3.0 or an A in the course, overall GPA of 3.0 or higher, ninety units or more, and consent of instructor, plus department stamp.

196. Honors Thesis Research (4)
Independent research on a problem in earth sciences by special arrangement with a faculty member (letter grade only). Students may take ERTH 196 and/or SIO 196 two times for credit. **Prerequisites:** completed ninety units of courses including twelve units of ERTH and/or SIO courses. Achieved a GPA of 3.3 overall and 3.5 in SIO/ERTH courses. Submitted to ERTH Steering committee, and had approved, an honors thesis research proposal. Department stamp.

197. Earth Science Internship (2 or 4)
The earth science internship program is designed to complement the program's academic curriculum with practical field experience. **Prerequisites:** completion of ninety units with a GPA of 2.5, and a completed and approved Special Studies form, UCSD Application for Enrollment Special Studies Courses 197, 198, 199, and department stamp.

198. Directed Group Study (2–4)
This course covers a variety of directed group studies in areas not covered by formal SIO courses. (P/NP grades only.)

199. Independent Study for Undergraduates (4)
Independent reading or research on a problem. By special arrangement with a faculty member. (P/NP grades only.)

BS/MS COURSE

228. Research Seminar (2)
A three-quarter required sequence for B.S./M.S. earth sciences students to prepare students for thesis writing. **Prerequisites:** current earth sciences B.S./M.S. student. Department stamp required.

GRADUATE

200A. Computational Ocean Acoustics and Signal Processing I (4)
Overview of ocean acoustics. Acoustics Wave Equation with some analytic solution techniques. Ray Methods. Introduction to Spectral and Normal Modes methods. Introduction to beamforming including matched field processing. Computer programs will be constructed on all subjects covered. **Prerequisite:** graduate standing or consent of instructor. Kuperman (F)

200B. Computational Ocean Acoustics and Signal Processing II (4)
Continuation of SIO 200A. Range dependent propagation models including adiabatic and coupled mode models and parabolic equations. More advanced topics in matched field processing. **Prerequisites:** graduate standing and SIO 200A or consent of instructor. Kuperman (W)

200C. Computational Ocean Acoustics and Signal Processing III (4)
Continuation of SIO 200B. Modeling interference such as ambient noise. Time domain methods. Matched field tomography, nonlinear optimization methods, and geophysical inversion. **Prerequisites:** graduate standing and SIO 200B or consent of instructor. Kuperman (S)

201. Geological Record of Climate Change (4)
Introduction to geological archives; the tools for paleoclimate reconstruction and a sampling of important issues from the geological record, including the development of "greenhouse" and "icehouse" worlds, the origin and evolution of glacial cycles, and the origin of "millennial scale" climate variability. **Prerequisite:** chemistry and physics required for graduate admission to SIO, SIO 101 or equivalent, or consent of instructor. Charles (S)

202A–B. Fundamentals of Wave Physics (4-4)
This two-quarter sequence is designed to introduce a broad background of students to basic principles of wave physics, including generation, propagation, dispersion, refraction, diffraction, reflection, waveguides, etc. A variety of wave motions of environmental relevance, including acoustic, ocean surface and internal (SIO 202A), optical and seismic (SIO 202B) are used to illustrate these principles. In-class experiments, data collection, and analysis exercises are incorporated. **Prerequisites:** calculus and partial differential equations. Buckingham, Kuperman, Stramski, Melville, Hildebrand, Dorman (W,S)

203A. Introduction to Applied Mathematics I (4)
(Cross-listed with MAE 294A.) Review of exact methods for ordinary differential equations. Expansions about regular and irregular singular points. Introduction to asymptotic expansions. Approximate methods for nonlinear differential equations. Regular and singular perturbation theory. Additional topics depending upon the interests of the instructor. **Prerequisites:** Math. 110, Math. 120A, or consent of instructor.

203B. Introduction to Applied Mathematics II (4)
(Cross-listed with MAE 294B.) Asymptotic methods: method of steepest descent (if not covered in I) WKB, method of multiple scales, boundary layer theory. Elements of complex analysis. **Prerequisite:** MAE 294A or SIO 203A or consent of instructor.

203C. Introduction to Applied Mathematics III (4)
(Cross-listed with MAE 294C.) Partial differential equations: characteristics, similarity solutions, Green's functions, images, wave equation, diffusion equation, Laplace's equation. Applications to continuum mechanics, potential fields, and transport phenomena such as diffusion, linear and nonlinear waves, Burger's equation and shocks. Other topics according to the interests of the instructor. **Prerequisite:** MAE 294B or SIO 203B or consent of instructor.

204. Advanced Acoustics (4)
Theory of radiation, transmission, and scattering of sound with special application to ocean acoustics. Students who have taken SIO 204B for credit may not get credit for SIO 204. **Prerequisite:** graduate standing or consent of instructor. Buckingham (W)

206. Land Surface Hydrology (4)
Advanced introduction to natural processes that govern water occurrence and transport over the land surface. Principles of global hydrologic cycle and land-surface water balance, runoff and fluvial geomorphology, infiltration and subsurface water flow, evaporation and plant transpiration. **Prerequisite:** graduate standing or consent of instructor. Staff (S)

207A. Fundamentals of Digital Signal Processing (4)
Discussion of discrete-time signals and systems, Discrete-Time Fourier Transform (DFT) and window functions, Fast Fourier Transform (FFT), design of Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) digital filters and their implementations, finite word length effects, applications to data acquisition and analysis. **Prerequisite:** graduate standing or consent of instructor. Hodgkiss (F)

207B. Digital Signal Processing I (4)
Discrete random signals; conventional (FFT based) spectral estimation. Coherence and transfer function estimation; model-based spectral estimation; linear prediction and AR modeling, Levinson-Durbin algorithm and lattice filters, minimum variance spectrum estimation. Cross-listed with ECE 251A. (Recommended prerequisites: ECE 153 in addition to either ECE 161 or 161A and SIO 207A or equivalent background.) SIO 207A is intended for graduate students who have not had an undergraduate course in DSP. Prerequisite: graduate standing. Hodgkiss, Rao (W)

207C. Digital Signal Processing II (4)
Adaptive filter theory, estimation errors for recursive least squares and gradient algorithms, convergence and tracking analysis of LMS, RLS, and Kalman filtering algorithms, comparative performance of Wiener and adaptive filters, transversal and lattice filter implementations, performance analysis for equalization, noise canceling, and linear prediction applications. Cross-listed with ECE 251B. (Recommended prerequisite: ECE 251A or ECE 251AN.) **Prerequisites:** graduate standing, for ECE 251A (for ECE 251B; SIO 207B (for SIO 207C). Hodgkiss (S)

207D. Array Processing (4)
The coherent processing of data collected from sensors distributed in space for signal enhancement and noise rejection purposes or wavefield directionality estimation. Conventional and adaptive beamforming. Matched field processing. Sparse array design and processing techniques. Applications to acoustics, geophysics, and electromagnetics. Cross-listed with ECE 251D. (Recommended prerequisite: ECE 251A or ECE 251AN.) **Prerequisites:** graduate standing; ECE 251C (for ECE 251D); SIO 207C (for SIO 207D). Hodgkiss (F)

208. Seminar in Applied Ocean Sciences (1)
Topics in applied ocean sciences. One-hour seminar. (S/U grades only). Staff (F,W,S)

209. Special Topics (1–4)
Within the next few years, lectures on various special subjects will be offered by members of the staff. The emphasis will be on topics that reveal the interdependence of the biological, chemical, geological, and physical processes operating in the oceans. (S/U grades permitted.) Staff (F,W,S)

210. Physical Oceanography (4)
Physical description of the sea; physical properties of seawater, methods and measurements, boundary processes, regional oceanography. **Prerequisite:** graduate standing or consent of instructor. Hendershott, Talley (F)

211A–B. Ocean Waves (4-4)
Propagation and dynamics of waves in the ocean including the effects of stratification, rotation, topography, wind, and nonlinearity. **Prerequisite:** graduate standing or consent of instructor. Hendershott, Guza, Winant (W,S)

212A. Geophysical Fluid Dynamics I (4)
The equations of motion for rotating stratified flow and their application to the atmospheric and oceanic dynamics; Ekman layer dynamics, potential vorticity dynamics, the quasigeostrophic approximation, theories of the wind-driven oceanic circulation, theories of the atmospheric Hadley circulation, geostrophic adjustment, and baroclinic instability. **Prerequisite:** graduate standing or consent of instructor. Cessi, MacKinnon, Young (W,S)

212B. Geophysical Fluid Dynamics II (5)
The equations of motion for rotating stratified flow and their application to the atmospheric and oceanic dynamics; Ekman layer dynamics, potential vorticity dynamics, the quasigeostrophic approximation, theories of the wind-driven oceanic circulation, theories of the atmospheric Hadley circulation, geostrophic adjustment, and baroclinic instability. **Prerequisites:** graduate standing or consent of instructor. Cessi, MacKinnon, Salmon, Young (W,S)

213. Turbulence and Mixing (4)
Mixing mechanisms, their identification, description, and modeling. Introduction to turbulence, semi-empirical theories, importance of coherent structures, effects of stratification and rotation on turbulent structure, entrainment and mixing. Cross-listed with MAE 216. (S/U grades permitted.) Armi (S)

214A. Introduction to Fluid Mechanics (4)
A survey of classical problems in fluid mechanics and approximate techniques of analysis. Topics include conservation equations, straight laminar flows, low and high Reynolds number laminar flow, stability of laminar flows, turbulent flow. **Prerequisite:** graduate standing or consent of instructor. Hendershott, Winant (F)

214B. Environmental Fluid Dynamics (4)
Single-layer flows with a free surface, two-layer flows including exchange flows in harbors, estuaries, seas, and buildings. Continuously stratified flows with meteorological and oceanographic applications. Topographic effects, plumes, jets, and thermals. Planetary boundary layers. **Prerequisite:** graduate standing or consent of instructor. Armi (S)

215A. Applied Mathematics for Oceanographers I (4)
Intended for first-year graduate students who seek a quantitative way to describe how the ocean works: vector analysis, complex quantities, Fourier and Laplace transforms, ordinary differential equations, non-homogeneous ordinary differential equations, initial and boundary value problems, Heat and Laplace equations. Prerequisite: graduate standing or consent of instructor. Hendershott, Ierley, Winant (F)

215B. Applied Mathematics for Oceanographers II (4)
An introduction to the mathematical description of waves, beginning with a description of the linear oscillator, and followed by normal modes, the flexible string, membranes, water waves, ray theory, method of characteristics, and basic linear algebra. Prerequisites: graduate standing and SIO 215A or consent of instructor. Hendershott, Ierley, Winant (W)

215C. Applied Mathematics for Oceanographers III (4)
An introduction to Perturbation theory, including regular and singular expansions, Poincare's method, two-scale method, the WKB approximation and boundary layer theory. Prerequisites: graduate standing and SIO 215B or consent of instructor. Hendershott, Ierley, Winant. (S)

216. Introduction to the Physics of Complex Systems (4)
Emergent complex behavior in nonlinear, dissipative, open dynamical systems will be investigated by studying fundamental properties and their manifestation in examples drawn from the physical and biological sciences. Topics to include fractals, chaos, self-organization, artificial life, and neural networks. **Prerequisite:** graduate standing or consent of instructor. (S/U grades permitted.) Werner (W)

217A. Atmospheric and Climate Sciences I (4)
Thermodynamics and statics of dry and moist air, atmospheric composition, Earth radiation budget, vertical structure of the atmosphere, global energy balance, thermodynamic feedbacks in the climate system. **Prerequisite:** graduate standing or consent of instructor. (S/U grades permitted.) (F)

217B. Atmospheric and Climate Sciences II (4)
Structure of midlatitude synoptic systems; equations of motion, scale analysis, elementary applications and wave solutions; baroclinic instability theory; atmospheric general circulation and energetics; tropical dynamics; relationships between atmospheric dynamics, CO2 clouds, precipitation, and other weather and climate phenomena. **Prerequisites:** graduate standing and SIO 217A or equivalent background, or consent of instructor. J. Norris (W)

217C. Atmospheric and Climate Sciences III (4)
Physical and dynamical processes that determine climate and climate change; role of aerosols; water vapor; CO2 and other greenhouse gases; cloud-radiative interactions; atmospheric general circulation; role of convection; tropical climate including El Niño. **Prerequisites:** graduate standing and SIO 217A and SIO 217B or equivalent background, or consent of instructor. Ramanathan (S)

217D. Atmospheric and Climate Sciences IV (4)
Atmospheric chemistry that impacts climate change, including photochemical reactions, ozone chemistry, and aerosol evolution in the troposphere and stratosphere. Atmospheric applications of catalytic cycles, heterogeneous chemistry, and microphysical processes will include the ozone hole, urban smog, and aerosol-cloud interactions. **Prerequisites:** undergraduate general physics, chemistry, and mathematics (including differential equations). Russell (S)

219. Special Topics in Physical Oceanography (1–4)
Example topics are case histories and methods in physical oceanography, theories of the ocean circulation, numerical methods in large-scale ocean and atmospheric models, and natural electromagnetic phenomena in the earth and the oceans. (S/U grades permitted.) Staff (F,W,S)

220. Observations of Large-Scale Ocean Circulation (4)
General circulation of the oceans; tropical, subtropical, and high-latitude current systems of the Atlantic, Indian, and Pacific Oceans and marginal seas; ocean heat flux and thermohaline circulations; observational basis of large-scale dynamics. **Prerequisite:** graduate standing or consent of instructor. (S/U grades permitted.) Roemmich (S)

221A. Analysis of Physical Oceanographic Data (A) (4)
Fundamental elements of analysis of geophysical and oceanographic time series, including sampling problems, least squares techniques, spectral analysis, interpretation of series, design of experiments. **Prerequisite:** consent of instructor. Pinkel (F)

221B. Analysis of Physical Oceanographic Data (B) (4)
Techniques for analysis of physical oceanographic data involving many simultaneous processes including probability densities, sampling errors, spectral analysis, empirical orthogonal functions, correlation, linear estimation, objective mapping. **Prerequisite:** graduate standing or consent of instructor. (S/U grades permitted.) Rudnick (W)

221C. Data Analysis Laboratory (4)
This course is to give students practical experience with analysis techniques. Students complete three projects. Topics include empirical orthogonal functions, objective mapping, complex demodulation, inference of geostrophic flow, minimization of CTD salinity spiking, isolation of wind-driven currents, wavelets. **Prerequisite:** graduate standing or consent of instructor. (S/U grades only.) Rudnick, Gille (F)

222. Underwater Bioacoustics (4)
Introductory course to familiarize a broad spectrum of participants to underwater sound and its relationship to underwater animals. Basic physics of sound propagation, use of sound to study underwater animals and, the sounds made by the animals themselves for echolocation and communication will be covered. **Prerequisite:** consent of instructor. (S/U grades permitted.) J. Hildebrand, Jaffe (W)

223A. Geophysical Data Analysis I (4)
Probability and statistics and their application to make inferences from geophysical data: point processes, distributions, maximum likelihood estimation, hypothesis testing and confidence intervals, least squares, density estimation, interpolation and smoothing. **Prerequisite:** graduate standing or consent of instructor. Agnew, C. Constable (W)

223B. Geophysical Data Analysis II (4)
Analysis of geophysical measurements, especially time series, Fourier theory digital signal processing, and spectral analysis. **Prerequisites:** graduate standing and SIO 223A or consent of instructor. Agnew, C. Constable (S)

224. Internal Constitution of the Earth (4)
An examination of current knowledge about the composition and state of the earth's interior revealed by geophysical observations. Seismic velocity and mass density distributions; equations of state; phase changes; energy balance and temperatures; constraints on composition from extraterrestrial samples and exposed rocks; spherical and aspherical variations of properties. **Prerequisites:** calculus and differential equations, basic chemistry and physics, or consent of instructor. Masters (S)

225. Physics of Earth Materials (4)
Mathematics and physics of continuous media, focusing on geophysical problems. Topics include deformation, stress, conservation laws, elasticity, attenuation, viscoelasticity, fracture mechanics, and porous media. **Prerequisite:** graduate standing or consent of instructor. Agnew, Fialko (W)

226. Introduction to Marine Geophysics (4)
Methods of exploration geophysics with emphasis on those useful at sea. Magnetic and gravitational potential field methods, multi-beam echo sounding reflection and refraction seismology will be covered. Recent papers from the literature will also be read and discussed. **Prerequisites:** differential equations; at least one geology course. (S/U grades permitted.) Dorman, Hildebrand (S)

227A. Introduction to Seismology (4)
Introduction to seismometers and seismograms; stress and strain; potentials and the wave equation; geometrical ray theory and travel times in layered media; representation of seismic sources; WKBJ and synthetic seismograms; seismic hazards and other applications of seismology. **Prerequisite:** consent of instructor. (S/U grades permitted.) Shearer (F)

227B. Advanced Seismology I (4)
Introduction to low-frequency digital data; continuum mechanics and the equations of motion; free oscillation solutions; construction of Earth models; excitation of free-oscillations and source mechanism retrieval; array processing of long-period data; modelling aspherical structure; surface waves. **Prerequisite:** consent of instructor. (S/U grades permitted.) Staff (W)

227C. Advanced Seismology II (4)
High-frequency wave propagation; methods for computing synthetic seismograms including WKBJ, reflectivity and finite differences; body-wave spectra; attenuation of body waves; source physics; reflection and refraction seismology; seismic tomography. **Prerequisite:** consent of instructor. (S/U grades permitted.) Staff (S)

229. Gravity and Geomagnetism (4)
Introduction to potential theory, with applications to gravity and geomagnetism. Topics include the geoid, spherical harmonics, Laplace's equation, the Dirichlet problem on a sphere, and Fourier methods. Gravity anomalies and geomagnetic field modeling and sources are discussed; also paleomagnetic observations. **Prerequisite:** graduate standing or consent of instructor. (S/U grades permitted.) C. Constable, Parker (S)

230. Introduction to Inverse Theory (4)
Solution of linear and nonlinear inverse problems in geophysics by optimization techniques such as norm minimization and linear programming. Construction of models by regularization; inference by bounding functionals. Illustrations from gravity, geomagnetism, and seismology. **Prerequisite:** graduate standing or consent of instructor. (S/U grades permitted.) (W)

231. Introduction to EM Methods in Geophysics (4)
Introduction to electromagnetic methods for both global geophysics and applied/exploration methods. Covers history of EM induction, conduction in rocks, binary mixing laws, self potential, induced polarization, DC resistivity, magnetotellurics, geomagnetic depth sounding, elementary inverse methods, global conductivity structure, and marine EM methods. **Prerequisite:** graduate standing or consent of instructor. (S/U grades permitted.) S. Constable (F)

233. Introduction to Computing at SIO (4)
Introduction to the SIO computing environment and common software tools in geophysics and other disciplines. Topics include UNIX, Matlab, Postscript, GMT, LaTex, HTML, and a scientific programming language such as C or Fortran90. **Prerequisite:** graduate standing or consent of instructor. (S/U grades permitted.) Agnew, Shearer (F)

234. Geodynamics (4)
A general course on the dynamics and kinematics of the solid earth based on the text of Turcotte and Schubert. Topics include plate tectonics, heat flow, lithospheric cooling, flexure, viscous flow, gravity, crustal dynamics, and other related topics. **Prerequisite:** graduate standing or consent of instructor. (S/U grades permitted.) Sandwell (W)

236. Satellite Remote Sensing (4)
Satellite remote sensing provides global observations of Earth to monitor environmental changes in land, oceans, and ice. Overview physical principles of remote sensing including: orbits, electromagnetic radiation, diffraction, electro-optical, and microwave systems. Weekly labs explore remote sensing data sets. Graduate students will also be required to write a term paper and do an oral presentation. Conjoined with SIO 135. **Prerequisite:** graduate standing or consent of instructor. Sandwell (S)

237A. Introduction to Ocean Optics (4)
Overview of ocean optics. Concepts in radiometry. Inherent and apparent optical properties. Radiative transfer equation. Light absorption and scattering by seawater constituents. Optics of air-water interface. Light fields within and leaving the ocean. Optics of marine particles. Measurement methods and instrumentation. **Prerequisites:** basic physics and differential calculus, or consent of instructor. Stramski (F)

237B. Ocean Color Remote Sensing (4)
Overview of ocean color satellite missions. Concepts in radiometry. Inherent and apparent optical properties. Radiative transfer equation. Solar radiation and elements of atmospheric optics. Propagation of light across the sea surface and within the ocean. Light absorption and scattering by seawater. Water-leaving radiance and remote-sensing reflectance. Ocean color algorithms and applications. **Prerequisites:** basic physics and differential calculus, or consent of instructor. (S/U grades permitted.) Stramski (F)

237C. Optical-Biological Interactions in the Ocean (2)
A discussion class with emphasis on the interaction of light with marine plankton. Topics will include light absorption, fluorescence, and scattering by phytoplankton and effects of growth conditions on phytoplankton optical properties. Classic and contemporary papers dealing with these topics will be discussed. **Prerequisites:** basic physics and biology, or consent of instructor. (S/U grades only.) Stramski (F)

238. Sensor Networks (4)
Characteristics of chemical, biological, seismic, and other physical sensors; signal processing techniques supporting distributed detection of salient events; wireless communication and networking protocols supporting formation of robust sensor fabrics; current experience with low power, low cost sensor deployments. Conjoined with MAE 149 and ECE 156. **Prerequisite:** upper-division standing and approval of instructor, or graduate student in science or engineering. (S/U grades permitted.) Hodgkiss (S)

239. Special Topics in Geophysics (1–4)
Special course offerings by staff and visiting scientists. Example topics are seismic source theory, geophysical prospecting methods, dislocation theory and seismic mechanisms, tectonic interpretation of geodetic data, and dynamo theory. (S/U grades permitted.) Staff (F,W,S)

240. Marine Geology (4)
Introduction to the geomorphology, sedimentation, stratigraphy, vulcanism, structural geology, tectonics, and geological history of the oceans. **Prerequisites:** the physics and chemistry required for admission to the graduate curriculum in SIO, and ES 101 or equivalent, or consent of instructor. Cande, Charles, Hilton (F)

242. Marine Biotechnology (4)
The class will contain lectures discussing current topics and new technologies in the marine sciences (biology, chemistry). Faculty that are part of the marine biotechnology training grant will lecture on their own research and techniques that are being used. The students will select and present a paper that is an application of topics discussed. The areas of genomics, proteomics, expression analysts, mutagenesis, microbial diversity, etc., will be presented. Bartlett (F)

243. Marine Paleoecology (4)
Paleoecology of marine plankton, nekton, and benthos. Patterns and changes in marine communities and ecosystems over geological time in relation to changes in the physical, chemical, and geological environment and biotic interactions. The preservation filter and inference of ecological processes from fossils and biogeochemical proxies. Biotic interchanges, incumbency, escalation and trends, mass extinctions, and recovery. Lectures, seminar discussion, laboratory, and field trips. **Prerequisites:** bachelor's degree in science or consent of instructor; open to undergraduates with completion of SIO 104 and either BIEB 130 or BIEB 140, or equivalent. Jackson, Staff (S)

244. Shape and Structure of the Ocean Floor (4)
Description and explanation of the structural geomorphology of oceanic crust, and of the tectonic and volcanic processes responsible for it. Description and interpretation of deep-sea sedimentary landforms (e.g., deep-sea fans, drifts, bedforms) and of the bottom currents that shape them. Offered in alternate years. **Prerequisite:** any previous graduate/undergraduate earth science or geology course. Lonsdale (W)

245. Sedimentary Geochemistry for Chemical Paleoceanography (2)
Chemical paleoceanography will be the focus, emphasis, on seawater and/or sediment chemical and isotopic records; discussions will concentrate on some of the following istopic systems: Li, B, C, O, S, Sr, and Nd, and on select chemical tracers such as Cd and Ir; on the marine phases that most reliably record seawater chemical and isotope compositions; and on diagenetic problems, how to identify and deal with them. **Prerequisite:** SIO 260 and consent of instructor. (Offered in alternate years.) (S/U grades permitted.) Kastner (S)

246. Global Tectonics and Basin Formation (4)
Plate tectonics of the crust and upper mantle, examining a variety of environments from ridge crests to continental margins, including plate interiors, with an emphasis on basin formation in these tectonic settings. **Prerequisite:** graduate standing. Cande, Driscoll (W)

247. Rock Magnetism and Paleomagnetism (4)
Rock magnetism and acquisition of magnetic remanence in geological materials as well as laboratory procedures and data analysis (isolating remanence components and statistical approaches). The paleomagnetic literature will be used to illustrate applications in geological and geophysical problems. **Prerequisites:** one year each of college-level physics and geology; mathematics through calculus. (S/U grades permitted.) Tauxe (S)

248. Evolution of Earth's Biosphere (4)
Paleoecological development of marine and terrestrial environments during Earth's evolution. Ecological and chemical evolution of the oceans, atmosphere, biogeochemical cycles, and environments with particular emphasis on the long-term history and climate of the Earth's surface. Substantial field component (three weekend field trips in San Diego County) complement and extend the lecture material. Additionally, at graduate level oral presentation or research paper required. Conjoined with SIO 148. **Prerequisite:** graduate-level standing or consent of instructor. Jackson, R. Norris (S)

249. Special Topics in Marine Geology (1–4)
Special course offerings by staff and visiting scientists. (S/U grades only.) Staff (F,W,S)

251. Petrology and Geochemistry of the Solid Earth (4)
A geochemical and petrogenetic overview of the Earth and planets. Topics include formation and differentiation of the Earth into core, mantle, crust, and atmosphere/hydrosphere, generation of magma, and isotope and trace element geochemistry of igneous and metamorphic rocks. Graduate students, additionally, must submit a term paper in one aspect of work discussed during the quarter to be presented orally in class. Conjoined with SIO

155. **Prerequisite:** graduate-level standing or consent of instructor. Castillo (W)

252A. Introduction to Isotope Geochemistry (4)
Radioactive and stable isotope studies in geology and geochemistry, including geochronology, isotopes as tracers of magmatic processes, cosmic-ray produced isotopes as tracers in the crust and weathering cycle, isotopic evolution of the crust and mantle. Graduate level requires student presentation. Conjoined with SIO 144. **Prerequisite:** graduate-level standing or consent of instructor. Hilton, Keeling, Lal (W)

252B. Advanced Isotope Geochemistry I (4)
An advanced treatment of noble gas and stable isotope geochemistry. Offered in alternate years with SIO 252C. **Prerequisites:** SIO 252A/SIO 144. Hilton, Keeling, Lal (S)

252C. Advanced Isotope Geochemistry II (4)
An advanced treatment of radiogenic and cosmogenic isotope geochemistry. Offered in alternate years with SIO 252B. **Prerequisites:** SIO 252A/SIO 144. Lal (S)

253. Interactions of Oceanic Plates and the California Margin (4)
How the geology of Alta and Baja California has been shaped, especially in the past 30MYR, by changing patterns of ocean plates and microplates that have subducted beneath the North American Margin, slid obliquely past it, and captured continental crust. **Prerequisites:** graduate standing, or consent of instructor and any other earth science class for undergraduates. Lonsdale, Castillo (S)

254. Macroevolution (4)
Tempo and mode of evolution with emphasis on the marine fossil record. Large-scale patterns and trends in diversity, speciation, and extinction. Innovation, disparity, and adaptive radiation. Evolutionary turnover and the role of the environment in macroevolution. Additionally, oral presentation or research paper required. Conjoined with SIO 154. **Prerequisite:** graduate-level standing or consent of instructor. Jackson, R. Norris (S)

255. Paleobiology and History of Life (6)
An introduction to the major biological transitions in Earth history from the origins of metabolism and cells to the evolution of complex societies. The nature and limitations of the fossil record, patterns of adaptation and diversity, and the tempo and mode of biological evolution. Laboratories and substantial field component complement and extend lecture material. Program and/or material fee may apply. Graduate students, additionally, will give oral presentation or research paper. Conjoined with SIO 104. **Prerequisite:** graduate-level standing or consent of instructor. Jackson, R. Norris (S)

255A. Topics in Paleobiology and History of Life (3)
Lecture topics on the major transitions in the evolutionary history of life including origin of metabolisms, microbes, major eukaryote radiations, ecosystems and societies. **Prerequisite:** graduate standing or consent of instructor. Jackson, R. Norris (S)

256A. Introduction to Field Geology (4)
Principles of stratigraphy and structural geology applicable to field geologic studies. Discussion and laboratory exercises. **Prerequisites:** consent of instructor. Brown (W)

256L. Structural Geology (4)
Principles of stratigraphy and structural geology applicable to field geologic studies. Discussion and laboratory exercises. Two to three field trips required. Graduate students will complete an in-depth literature-based focused study consisting of a written report and a forty-five-minute seminar on topics related to structural geology. **Prerequisite:** graduate-level standing or consent of instructor. (W)

257. Seminar in Petrology (4)
Discussion of current research in petrology and mineralogy. (S/U grades permitted.) Castillo (W)

259. Atmospheric Geochemistry (4)
Topics in this introductory course include: structure and composition of the atmosphere; chemistry and isotopes of natural and man-made carbon-, nitrogen-, and sulfur-bearing trace gases; ozone and hydroxyl radical; halogenated gases; air-sea exchange; aerosols; climatic effects. (S/U grades permitted.) Weiss (S)

260. Marine Chemistry (4)
Chemical description of the sea; the distribution of chemical species in the world oceans, and their relationships to physical, biological, and geological processes. Aluwihare, Barbeau, R. Keeling (W)

261. Energetics and Kinetics in Marine Systems (4)
This course teaches the physical chemical principles that control chemistry in marine systems. After a basic introduction to thermodynamics and its application to an understanding of the marine environment, the emphasis will be on the study of a variety of kinetic processes. **Prerequisite:** graduate standing or consent of instructor. Dickson (S)

262. Seminar in Marine Natural Products (1)
Students will give seminars on current research topics in marine natural products chemistry. **Prerequisite:** graduate standing or consent of instructor. (S/U grades only.) Fenical, W. Gerwick, Moore (F,W,S)

263. Aqueous Chemistry (4)
This course emphasizes the chemical principles that control basic aqueous chemistry in marine systems. The focus will be to show that the geochemistry of the various elements in sea water and biological systems can be understood as a consequence of basic general chemical concepts such as electron structure, chemical bonding, and group and periodic properties. **Prerequisite:** undergraduate chemistry equivalent to UCSD Chemistry 6 sequence. Dickson (F)

264. Special Topics in Marine Natural Products Chemistry (3)
This course provides the foundation for advanced study in the field of marine natural products chemistry. Topics vary from the history of natural products to the organic chemistry of terpenes, alkaloids, acetogenins, and other natural product classes. Varying by topic quarterly, this class is given each quarter and may be repeated. **Prerequisite:** one year general organic chemistry. (S/U grades only). Fenical, W. Gerwick, Moore (F,W,S)

267. Biogeochemistry (4)
Examines quantitatively the impact of the biota on the chemistry of the atmosphere and ocean. Emphasis given to isotopes as tracers of biogeochemical processes. Attention given to paleoclimatic and paleoatmospheric data from ice cores to reveal mechanisms. **Prerequisite:** graduate standing or consent of instructor. Severinghaus, R. Keeling (S)

268. Seminar in Geochemistry and Marine Chemistry (1)
Student seminars on topics related to geochemistry and the chemistry of the marine environment. (S/U grades only.) Dickson (S)

269. Special Topics in Marine Chemistry (1–4)
Special course offerings by staff and visiting scientists. (S/U grades permitted.) Staff (F,W,S)

270. Pelagic Ecology (4)
An analysis of the concepts and theories used to explain the biological events observed in the water column. Alternate years. **Prerequisites:** SIO 210, 280, or consent of instructor. Checkley, Ohman (S)

270A. Fisheries Oceanography (4)
Aspects of marine ecology relevant to the reproduction, survival, and distribution of commercially important marine species. Alternate years only. **Prerequisite:** graduate standing or consent of instructor. Checkley (S)

271. Marine Zooplankton (5)
Lectures and laboratories treating the morphological, behavioral, and life history variations of the principal phyla of planktonic invertebrates and heterotrophic protists. Constraints of life at low Reynolds numbers; principles of allometry; growth processes of heterotrophic organisms. **Prerequisite:** graduate standing or consent of instructor. (S/U grades permitted.) Ohman (S)

272. Biogeography (3)
A lecture course concerning the origin, development, and perpetuation of distributional patterns with emphasis on benthic marine organisms. (W)

273A. Professional Ethics in Science (2)
A seminar on the historical and contemporary ethics and ethos of scientific research, based on published documents. Given in alternate years. Dayton (W)

275A. Benthic Ecology (4)
Evolution and maintenance of benthic communities from the terrestrial margins to the deep sea. Special emphasis will be placed on physical and biological scaling and processes determining patterns of distribution and abundance; interrelationships between community structure and population phenomena, including trophic relationships, reproductive and recruitment patterns, succession, and life history biology. Offered in alternate years with SIO 275B. **Prerequisite:** consent of instructor; open to undergraduates. (S/U grades permitted.) Levin, Dayton (W)

275B. Natural History of Coastal Habitats (6)
Two three-hour lecture/ laboratories per week, three weeklong field trips to coastal habitats in the Southwest and northern Mexico. Several day field trips to local habitats. Offered in alternate years with SIO 275A. **Prerequisite:** consent of instructor. (S/U grades permitted.) Dayton, R. Norris (S)

276. Quantitative Theory of Populations and Communities (4)
An introduction to the quantitative tools and conceptual issues underlying the study of the dynamics and structure of ecological systems. **Prerequisite:** calculus (three quarters) or consent of instructor. (S/U grades permitted.) Sugihara (F)

277. Deep-Sea Biology (4)
The ecology, zoogeography, taxonomy, and evolution of deep-sea organisms, with emphasis on the benthos. Course includes one day cruise to the San Diego Trough to examine deep sea organisms (700–1200 meters) (two-hour steam from Point Loma). Offered alternate years. **Prerequisite:** graduate standing or consent of instructor. Levin (W)

278. Seminar in Ocean Biosciences (2)
Presentations of reports, review of literature, and discussion of current research in the marine biological and oceanographic sciences. (S/U grades permitted.) Staff (F,W,S)

279. Special Topics in Biological Oceanography (1–4)
(S/U grades permitted.) Staff (F,W,S)

280. Biological Oceanography (4)
The biology and ecology of marine plankton, nekton, and benthos. Emphasis will be on processes regulating species, community, and ecosystem patterns and changes, including productivity, trophic relationships and species interactions with the physical, chemical, and geological environment. One or more field trips. **Prerequisite:** bachelor's degree in science or consent of instructor. Franks or Checkley, Levin (F)

281. Environmental Physiology and Biochemistry of Marine Organisms (4)
Biochemical mechanisms of adaptation of organisms to the marine environment. Special emphasis is on the effects of pressure, temperature, salinity, oxygen, and light on the physiology and biochemistry. Conjoined with BIBC 130. **Prerequisite:** BIBC 102 or consent of instructor. Felbeck (F)

282. Phytoplankton Diversity (4)
Molecular, biochemical, ecological, and evolutionary perspectives on the diversity of eukaryotic and prokaryotic phytoplankton. **Prerequisite:** consent of instructor. Palenik (W)

285. Physical-Biological Interactions (4)
Physical and biological processes affecting growth and patchiness of plankton. Concepts and equations from physical oceanography will be presented and explored in a biological context. Ideas will be treated both theoretically and with examples from the literature. **Prerequisites:** introductory calculus and SIO 210, or consent of instructor. Franks (S)

286. Marine Science, Economics and Policy (4)
This course investigates global issues in marine conservation and potential policy solutions. The approach is interdisciplinary, fast-paced, and discussion oriented. Students will become acquainted with sufficient background in

marine biology, ecology, marine and conservation economics, international law, and policy as preparation for participation in discussion on real-world issues in marine conservation. Topics and instructors change each quarter. **Prerequisite:** graduate standing or consent of instructor. (S/U grades permitted) Staff (F,W)

287A. Marine Microbial Ecology (4)
Recent developments in the study of marine bacteria. Emphasis will be on biochemical and physiological adaptations of marine bacteria to the ocean environment. Bacterial metabolism, growth, and death will also be discussed in the context of trophic interactions and flows of material and energy in marine ecosystems. Molecular biology techniques used in the study of bacterial ecology will also be discussed. **Prerequisite:** consent of instructor. (S/U grades permitted.) Azam (W)

287B. Microbial Physiology (4)
Prokaryotic microbial physiology will be discussed primarily from a biochemical standpoint with emphasis on mechanism. Topics will vary from year to year but will include the following themes: Central Metabolism. Bioenergetics, Biosynthesis, Regulation, Differentiation. Prokaryotic Structure-Function Relationships. Conjoined with BIMM 130. **Prerequisites:** BIBC 100 or BIBC 102 or equivalent. Saier (S).

288. Marine Microbiology Laboratory (4)
Advanced techniques and theory in environmental microbiology. Students will perform experiments concerning (a) enrichment of diverse microbes (b) microbial enumeration and identification (c) metabolic and physiochemical adaptations, and (d) biotechnology, along with an independent project. **Prerequisite:** consent of instructors. Brahamsha, Palenik (S)

290. Marine Biology (4)
An introduction to the field of marine biology, especially to the diversity of marine organisms at all taxonomic levels and their adaptations to the marine environment. **Prerequisite:** graduate standing. N. Holland, Palenik (W)

291. Biology Graduate Research Presentations (1)
Graduate students in the biological sciences present their research in a seminar or poster format. Class participants and instructors provide written feedback on the presentations. Required of third-year and beyond marine biology curricular group students during spring quarter. Open to all SIO graduate students. (S/U grades only.) Latz (S)

292. Communicating Science to Informal Audiences (4)
Students develop fundamental science communication and instructional skills through the understanding and application of learning theory, interpretative techniques, and pedagogical practices, which occurs in the context of communicating ocean science concepts to a diverse audience at Birch Aquarium at Scripps. Graduate science students will develop fundamental communication, and instructional skills through the understanding and application of learning theory, interpretive techniques, and pedagogical practices, including the development of an education/outreach plan to support a competitive research proposal. Conjoined with SIO 180. Prerequisite: graduate standing or consent of instructor. (F)

294. Biology of Fishes (5)
The comparative evolution, morphology, physiology, and ecology of fishes. Special emphasis on local and deep-sea and pelagic forms in laboratory. **Prerequisite:** graduate standing or consent of instructor. Hastings (S)

295S. Introduction to Marine Biodiversity and Conservation—Seminar (8)
Lectures on ecological, economic, social, and legal issues related to marine biodiversity and case studies on socioeconomic and legal issues. Students are expected to attend field trips at sea and to various sites around San Diego County as a part of the corequisite course. Students who have taken SIO 295 may not receive credit for SIO 295S. Corequisite: SIO 295LS. **Prerequisites:** MAS students only; consent of instructor. Jackson (Su)

295LS. Introduction to Marine Biodiversity and Conservation—Lab (8)
Laboratory work on major biological taxa, field trips on biodiversity in situ, computer labs for informatic tools. Students are expected to attend field trips at sea and to various sites around San Diego County as a part of the course. Students who have taken SIO 295L may not receive credit for SIO 295LS. Corequisite: SIO 295S. **Prerequisites:** MAS students only; consent of instructor. Jackson (Su)

296. Special Topics in Marine Biology (1–5)
Example topics are reproduction in marine animals, adaptation to marine environments, larval biology, marine fisheries, macromolecular evolution, physical chemical topics in physiology, philosophy of science. (S/U grades permitted.) Staff (F,W,S)

297. Marine Biology Seminar (1)
Lectures given by visiting scientists and resident staff and students. (S/U grades only.) Staff (F,W,S)

298. Special Studies in Marine Sciences (1–4)
Reading and laboratory study of special topics under the direction of a faculty member. Exact subject matter to be arranged in individual cases. **Prerequisite:** graduate standing. (S/U grades permitted.) Staff (F,W,S)

299. Research (1–12)
(S/U grades only.) Staff (F,W,S)