MASTER OF SCIENCE IN ENVIRONMENTAL AND OCEAN SCIENCES

Director
Ronald S. Kaufmann, PhD, Professor, Pelagic and Benthic Ecology

Faculty
Michel A. Boudrias, PhD, ASSOCIATE PROFESSOR, Locomotion, Benthic Ecology
Hugh I. Ellis, PhD, PROFESSOR, Avian Physiological Ecology, Waterbirds
Sarah C. Gray, PhD, PROFESSOR, Paleoclimatolgy, Sedimentology
Mary Sue Lowery, PhD, PROFESSOR, Fish Biochemistry and Muscle Development
Geoffrey Morse, PhD, ASSOCIATE PROFESSOR, Insect Evolution and Ecology
Bethany O’Shea, PhD, ASSOCIATE PROFESSOR, Environmental Geochemistry
Jennifer C. Prairie, PhD, ASSISTANT PROFESSOR, Plankton Ecology, Mathematical Biology
Nathalie B. Reynolds, PhD, ASSOCIATE PROFESSOR, Biophysical Dispersal of Larvae, Fisheries Oceanography
Steven P. Searcy, PhD, ADJUNCT ASSISTANT PROFESSOR, Early Life History of Fishes and Invertebrates
Drew M. Talley, PhD, ASSOCIATE PROFESSOR, Coastal Ecology, Habitat Connectivity
Suzanne Walther, PhD, ASSISTANT PROFESSOR, Fluvial Geomorphology
Zhi-Yong Yin, PhD, PROFESSOR, Hydroclimatolgy, GIS and Remote Sensing

Affiliated Faculty
Frederick I. Archer, PhD, Population Genetics and Delphinid Fisheries (Southwest Fisheries Science Center)
Lisa T. Ballance, PhD, Cetacean and Seabird Ecology (Southwest Fisheries Science Center)
Ann B. Bowles, PhD, Bioacoustics (Hubbs-SeaWorld Research Institute)
Jeffrey A. Crooks, PhD, Invasive Species (Tijuana Estuary National Estuarine Research Reserve)
Mark A. Drawbridge, MS, Fish Hatcheries and Aquaculture (Hubbs-SeaWorld Research Institute)
Michael G. Hinton, PhD, Pelagic Ecology, Population Ecology, Statistics (Inter-American Tropical Tuna Commission)
Thomas G. Kretzschmar, PhD, Hydrogeology (Centro de Investigacion Cientificas y de Enseñanza Superior de Ensenada)
N. Chin Lai, PhD, Physiology of Fish (Veterans Administration; UC San Diego)
Ignacio Rivera-Duarte, PhD, Marine Geochemistry (SPAWAR)
Theresa S. Talley, PhD, Coastal Ecosystems (California Sea Grant Extension Program)
Andrew R. Thompson, PhD, Larval Ecology (Southwest Fisheries Science Center)
Russell D. Vetter, PhD, Evolution and Molecular Biology of Fishes (Southwest Fisheries Science Center)

The Department of Environmental and Ocean Sciences offers graduate work leading to the degree of Master of Science in Environmental and Ocean Sciences with two tracks, Marine Science and Environmental Science. This degree is based largely on research and is intended to provide graduate students with an opportunity to design experiments or observations that test hypotheses; to contribute new information to a knowledge base; and to learn to write in a way that facilitates scientific exchange. The program, which combines coursework and research, culminates in a written thesis. The program utilizes not only the excellent facilities at the University of San Diego’s Shiley Center for Science and Technology, but those of some nearby institutions, such as the Southwest Fisheries Science Center (National Marine Fisheries, NOAA), Hubbs-SeaWorld Research Institute, the Leon R. Hubbard Hatchery, and the Tijuana National Estuarine Research Reserve. Thesis committees may be headed by USD Environmental and Ocean Sciences graduate faculty, as well as affiliated graduate faculty members. Committee members are drawn from the Environmental and Ocean Sciences faculty at USD, other science departments at USD and senior research scientists at Southwest Fisheries Science Center, Hubbs-SeaWorld Research Institute and other institutions.

Our faculty currently are involved in research in ecology, environmental geochemistry, climatology, paleoclimatology, hydrology, oceanography, marine biology, locomotion and fluid dynamics, fluvial geomorphology, physiology, and population genetics. Affiliated faculty work in the areas of bioacoustics, fisheries, aquaculture, molecular genetics, hydrogeology, ecology, marine pollution and physiology. Although there are opportunities for graduate students who are interested in biology to work with a variety of invertebrate and vertebrate animals, as well as a more limited number of plants, applicants should think carefully about the functional areas of biology they wish to work in. Whether in the life sciences or physical sciences, local research opportunities abound: from the coasts and estuaries of San Diego County to offshore and island environments. The deserts of southern California, which include inland water bodies and former ocean basins, offer additional research possibilities. In some instances, research may focus on more distant areas. More information about faculty research interests, graduate student thesis titles and facilities is available through our website.

The Master of Science in Environmental and Ocean Sciences degree can serve as a terminal graduate degree prior to entry into the work force, an enhancement of skills for an existing job in a technical area or in education, or a step toward a PhD.

Additional Requirements For Admission

Master of Science in Environmental and Ocean Sciences

See here (catalogs.sandiego.edu/graduate/admissions) for basic admission requirements.

Entrance Semesters
Full (spring, only under special circumstances)

Application Deadline
Fall: Priority application deadline Jan 15; applications received after April 1 cannot be guaranteed review
The Environmental and Ocean Sciences MS Program includes two tracks, Environmental Science and Marine Science. The selection of a track should be based on the nature of a student's thesis research.

Requirements for the Degree

### Code  Title  Hours

**Coursework**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>EOSC 500</td>
<td>Core Seminar I</td>
<td>2</td>
</tr>
<tr>
<td>EOSC 501</td>
<td>Core Seminar II</td>
<td>2</td>
</tr>
<tr>
<td>EOSC 511</td>
<td>Statistics</td>
<td>3</td>
</tr>
<tr>
<td>Graduate Science Courses (2), with lab 1</td>
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</tr>
<tr>
<td>Graduate Elective or Science course, with lab</td>
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**Graduate Science Courses (E = Environmental, M = Marine)**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
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<tbody>
<tr>
<td>EOSC 520</td>
<td>Introduction to Remote Sensing (E)</td>
<td>4</td>
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<tr>
<td>EOSC 531</td>
<td>Human Impacts on the Coastal Environment (E,M)</td>
<td>4</td>
</tr>
<tr>
<td>EOSC 532</td>
<td>Marine Community Ecology (M)</td>
<td>4</td>
</tr>
<tr>
<td>EOSC 533</td>
<td>Plankton Ecology (M)</td>
<td>4</td>
</tr>
<tr>
<td>EOSC 550</td>
<td>Geological Oceanography (E,M)</td>
<td>4</td>
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<tr>
<td>EOSC 551</td>
<td>Biological Oceanography</td>
<td>4</td>
</tr>
<tr>
<td>EOSC 552</td>
<td>Marine Geochemistry (E,M)</td>
<td>4</td>
</tr>
<tr>
<td>EOSC 574</td>
<td>History of the Earth and Climate (E,M)</td>
<td>4</td>
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<tr>
<td>&amp; 574L</td>
<td>and History of the Earth and Climate Laboratory (E,M)</td>
<td>4</td>
</tr>
<tr>
<td>EOSC 585</td>
<td>Environmental Geology (E)</td>
<td>4</td>
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<tr>
<td>EOSC 587</td>
<td>Surface Water Hydrology (E)</td>
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**Graduate Electives 2**

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<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
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<tbody>
<tr>
<td>EOSC 514</td>
<td>Introduction to Maps and Spatial Data Analysis</td>
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</table>

**Research/Thesis (minimum 11 units)**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>EOSC 596</td>
<td>Research 3</td>
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</tr>
<tr>
<td>EOSC 597</td>
<td>Thesis 3</td>
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</table>

A minimum of 1 unit of EOSC 597 must be applied toward the degree requirements.

1. Students in the Marine Science track must take two graduate science courses with an M designation. Students in the Environmental Science track must take two graduate science courses with an E designation.

2. A maximum of six undergraduate units taken at the university may be applied to the graduate program. Examples include BIOL 364, BIOL 416, BIOL 477, BIOL 478, POLS 349. This list is not exhaustive; consult the graduate program director and see the current Undergraduate Course Catalog for course descriptions. No course taken to fulfill an undergraduate deficiency may count toward the required units in the graduate program.

3. Students may take these courses for 0.5 unit only after they have completed all of the program requirements except EOSC 597. Students who are enrolled for 0.5 unit of EOSC 596 or EOSC 597 are considered half-time.

**Thesis Committee**

A thesis committee of at least three members will be established during the second semester of enrollment. It will consist of at least one full-time USD graduate faculty member and may include members from approved outside institutions. The entire thesis committee will meet with the student semi-annually to assess progress and give advice. Following approval of the thesis proposal by both the thesis chair and the graduate program director, the student will be recommended for candidacy by the thesis committee. Adequate progress will need to be made to maintain candidacy (see candidacy policy, available in the graduate handbook). Additional courses related to the student’s area may be required by the committee chair. All students must be enrolled for at least 1 unit to remain active in the program. Students who have completed all program requirements except EOSC 597, including all required courses, may enroll in 0.5 units to remain active in the program.

**Recommended Program of Study**

### First Year

#### Semester I

<table>
<thead>
<tr>
<th>Code</th>
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<tbody>
<tr>
<td>EOSC 500</td>
<td>Core Seminar I</td>
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<tr>
<td>Graduate Science Course</td>
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#### Semester II

<table>
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<th>Code</th>
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<tbody>
<tr>
<td>EOSC 501</td>
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<tr>
<td>Graduate Science Course or Elective</td>
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### Second Year

#### Semester I

<table>
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<tr>
<th>Code</th>
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<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>EOSC 596</td>
<td>Research</td>
<td>6-7</td>
</tr>
</tbody>
</table>
Master of Science in Environmental and Ocean Sciences

EOSC 596 or Graduate Elective

Semester II
EOSC 597 Thesis

Note: Students who will not finish by the end of their second summer should take 9 units in semester I of the second year and 1 unit of EOSC 596 in semester II of the second year. These students should take 0.5-1 unit of EOSC 597 each semester until they finish.

Courses

EOSC 500 | CORE SEMINAR I
Units: 2 Repeatability: No
An introduction to the infrastructure of the Environmental and Ocean Sciences graduate program and to those critical skills useful in graduate studies. Students will be exposed to a range of research areas through a series of seminars presented by the Environmental and Ocean Sciences graduate faculty, affiliated university faculty in other departments and scientists from other institutions. Students also will choose a thesis committee chair and develop a written preliminary plan for their own research in pursuit of the master’s degree.

EOSC 501 | CORE SEMINAR II
Units: 2 Repeatability: No
During this seminar, students will learn how to develop questions that can be tested scientifically, design experiments that are amenable to statistical analysis and collect data that are interpretable. Students will write a formal thesis proposal, which includes a review of pertinent literature and present it orally to the assembled Environmental and Ocean Sciences faculty. They also will form their thesis committees. Successful completion of this seminar is a prerequisite for advancement to candidacy.

EOSC 511 | STATISTICS
Units: 3 Repeatability: No
This course is intended to build on a basic understanding of statistical analysis gained at the undergraduate level. The course will review methods of hypothesis testing and the statistical tests most commonly used in environmental and ocean sciences. It will introduce multivariate techniques and modern nonparametric methods. The main emphasis will be experimental design and choosing the most appropriate methods of statistical analysis to answer specific questions. Students will learn how to use the statistical software package R and will have the opportunity to work with their own data, if applicable. Three hours per week.

EOSC 514 | INTRODUCTION TO MAPS AND SPATIAL DATA ANALYSIS
Units: 4 Repeatability: No
Use of maps as an analytical tool. Topics include: map reading; the use of maps as a medium for describing and analyzing various types of spatially-distributed data; stereoscopic interpretation and cartographic representation of landforms, vegetation, and land use. Laboratory exercises will use ArcGIS software. Two hours of lecture and one laboratory per week. Fall semester.

EOSC 515 | GEOGRAPHIC INFORMATION SYSTEMS
Units: 4 Repeatability: No
Theory and practice of Geographic Information Systems (GIS) as a tool for the display and manipulation of spatial data. Applications include: urban planning; land use classification; biomass analysis; crop monitoring; forest resource assessment and management; and disaster assessment, management, and recovery. Laboratory exercises will use ArcGIS software. Two hours of lecture and one laboratory per week. Spring semester.

EOSC 520 | INTRODUCTION TO REMOTE SENSING
Units: 4 Repeatability: No
An introduction to remote sensing technology and its applications in earth science. This course will cover principles of remote sensing, aerial photography, photogrammetry, electronic multispectral imaging, and methods of digital image processing and analysis. Applications of remote sensing in marine and terrestrial environments and integration of remote sensing and geographic information systems also will be discussed. Three hours of lecture and one laboratory per week and some field trips. Requires at least one course in physical science, or consent of the instructor.

EOSC 531 | HUMAN IMPACTS ON THE COASTAL ENVIRONMENT
Units: 4 Repeatability: No
An interdisciplinary study of physical, chemical, and biological processes in the oceans with an emphasis on coastal environments. Topics include coastal oceanography, nutrient distribution and geochemical cycles, primary productivity, food webs and fisheries, and benthic habitats. This course examines the interactions between abiotic forces in the oceans and the organisms that live in a variety of habitats. Environmental issues will be connected to major scientific themes. Three hours of lecture and one laboratory per week.

EOSC 532 | MARINE COMMUNITY ECOSYSTEM
Units: 4 Repeatability: No
This course is intended to introduce students to the fundamentals of marine community ecology, provide students with field experiences so that they may become familiar with various ecological sampling designs and methods, and expose students to the diversity of coastal marine environments in the San Diego area. Students will read and discuss classic marine ecology papers, and conduct marine ecological studies in field and laboratory settings. Students will also be required to participate in a semester-long research project. Three hours of lecture and one laboratory per week. Spring semester.

EOSC 533 | PLANKTON ECOLOGY
Units: 4 Repeatability: No
This course is a study of the fundamental processes in plankton ecology from the perspective of how individual plankton interact with each other and their environment. Throughout the course, students will gain intuition about life in the plankton by incorporating an understanding of both the biology of the organisms and their physical environment. In addition to lecture, the course includes lab activities, reading and discussing peer-reviewed scientific articles, and completing group and individual assignments.

EOSC 550 | GEOLOGICAL OCEANOGRAPHY
Units: 4 Repeatability: No
The origin and geologic history of the ocean basins, with a detailed investigation of the theory of plate tectonics, ocean sedimentation and paleoceanography. Examination of how geological processes affect physical, chemical and biological processes in the ocean will be emphasized. Students will present and discuss primary literature pertinent to the topics covered in the course. Three lectures and one laboratory per week. One cruise and one additional weekend field trip may be required. A course in introductory geology, with laboratory, is recommended.

EOSC 551 | BIOLOGICAL OCEANOGRAPHY
Units: 4 Repeatability: No
Biological oceanography is covered from an integrated, functional perspective. Unifying themes will be factors that affect marine ecosystems and the relationship between environmental characteristics and biological communities. Nearshore, open ocean and deep sea environments will be covered. Ecological, behavioral, physiological and biochemical adaptations of marine organisms also will be considered. Primary literature, scientific writing and experimental design will be emphasized. Three lectures and one laboratory per week. One cruise and additional fieldwork may be required. As well as one year of general biology, with laboratory.
EOSC 552 | MARINE GEOCHEMISTRY
Units: 4 Repeatability: No
Why are the oceans salty? This course begins by tracing the path of material sources to the ocean reservoir; from river, groundwater, atmospheric and hydrothermal vent pathways. A significant emphasis is placed on chemical processes occurring within the ocean reservoir, such as carbonate equilibrium, trace element distributions in sea water and particulate matter reactivity. The course concludes with an analysis of geochemical processes occurring within material sinks in the oceans, which are largely controlled by sediment redox and diagenetic processes. Three lectures and one laboratory per week.

EOSC 561 | INVERTEBRATE ZOOLOGY
Units: 4 Repeatability: No
A survey of the invertebrate animals with emphasis on evolutionary relationships among the groups as expressed by their morphology and physiology. Three hours of lecture and one laboratory weekly.

EOSC 562 | BIOLOGY OF FISHES
Units: 4 Repeatability: No
This course examines the various aspects of ichthyology encompassing the anatomy, physiology, ecology, evolution, ethology, and natural history of fishes. Lab includes techniques of identification and a general survey of fish systematics and zoogeography. Three hours of lecture and one laboratory per week.

EOSC 565 | MARINE MAMMALS
Units: 3 Repeatability: No
An examination of the biology of whales with emphasis on marine mammals. Topics will include general adaptations to a marine existence; systematics and biogeography; reproduction; diving physiology; communication and echolocation; feeding and migratory behavior; and marine mammal-human interactions. Some emphasis will be placed on species occurring in the North Pacific Ocean. Necropsies of a beach-stranded marine mammal may occur. Special projects will also be assigned. Three hours of lecture per week.

EOSC 573 | CLIMATOLOGY
Units: 4 Repeatability: No
A course to cover principles of climatology and methods of climatic data analysis. The fundamentals of climatology, methods and technologies used in acquiring and analyzing climatic data, and current issues such as human-induced climatic changes will be discussed. This course will cover the Earth’s energy budget and temperature, moisture in the atmosphere and precipitation, winds and the general circulation, and climates in different regions of the world. Three hours of lecture and one laboratory per week.

EOSC 574 | HISTORY OF THE EARTH AND CLIMATE
Units: 3 Repeatability: No
Corequisites: EOSC 574L
A survey of the history of the earth system focusing on ocean-atmosphere-ice sheet dynamics and their interaction on past global climate change. Topics include geologic record of past climate cycles, causal mechanisms of past climate change, and the scientific basis of global warming. Three hours of lecture per week.

EOSC 574L | HISTORY OF THE EARTH AND CLIMATE LABORATORY
Units: 1 Repeatability: No
Corequisites: EOSC 574
A laboratory course designed to introduce students to methods and techniques used in historical geology and paleoclimatology including: a) identification of depositional environments; b) identification of invertebrate fossils and modes of fossilization; correlation and sequence stratigraphy; d) radiometric dating, and e) isotopic proxies of climate. The laboratory may include field trips. Lab must be taken with concurrent registration in MARS 574.

EOSC 585 | ENVIRONMENTAL GEOLOGY
Units: 4 Repeatability: No
This course focuses on the interaction between humans and the geologic environment. We will examine geologic processes responsible for forming a variety of Earth resources, such as ore deposits (e.g., copper minerals) and energy resources (e.g., fossil and nuclear fuels). Anthropogenic extraction, processing, and disposal of these resources, and their impact on the environment, will be investigated. Two Earth resources will be the subject of detailed study: groundwater and soils. An in-depth explanation of processes relating to both (e.g., groundwater flow, water quality, soil composition) will be developed, followed by an investigation of practices used in the monitoring and assessment of anthropogenic contamination of soil and groundwater. This course will help to prepare students for working in academia, government, or as an environmental consultant. Three hours of lecture and one laboratory per week. Some weekend field trips may be required.

EOSC 587 | SURFACE WATER HYDROLOGY
Units: 4 Repeatability: No
A course to cover principles of surface water hydrology and methods to solve hydrologic problems related to urbanization, soil and water conservation, and water resources management. The components of the hydrologic cycle and the concept of water balance will be discussed in detail. This course will also cover various methods of hydrologic computation, the basics of watershed modeling, applications of GIS in hydrology, and issues especially relevant to Southern California. Three hours of lecture and one laboratory per week and some field trips.

EOSC 594 | SPECIAL TOPICS IN ENVIRONMENTAL AND OCEAN SCIENCES
Units: 2-4 Repeatability: Yes (Repeatable if topic differs)
Topics of special interest or unique opportunity. Prerequisites may be listed for these offerings.

EOSC 595 | DIRECTED READINGS
Units: 1-3 Repeatability: No
Specific sets of readings tailored to address particular needs of a student. Typically, a maximum of three units may be used toward the degree requirements without consent of the program director.

EOSC 596 | RESEARCH
Units: 0.5-7 Repeatability: Yes (Can be repeated for Credit)
Research toward the master’s thesis. This research will be under the general supervision of a thesis advisor. No more than three units may be taken prior to candidacy. Pass/Fail only. A passing grade is contingent upon participation in the annual Graduate Student Colloquium during the same academic year.

EOSC 597 | THESIS
Units: 0.5-1 Repeatability: Yes (Can be repeated for Credit)
Independent writing of the thesis with consultation of the major advisor. Master’s candidates must be enrolled in this course to turn in a thesis. It may be taken more than once, but only 1 unit will be counted toward the degree requirements.