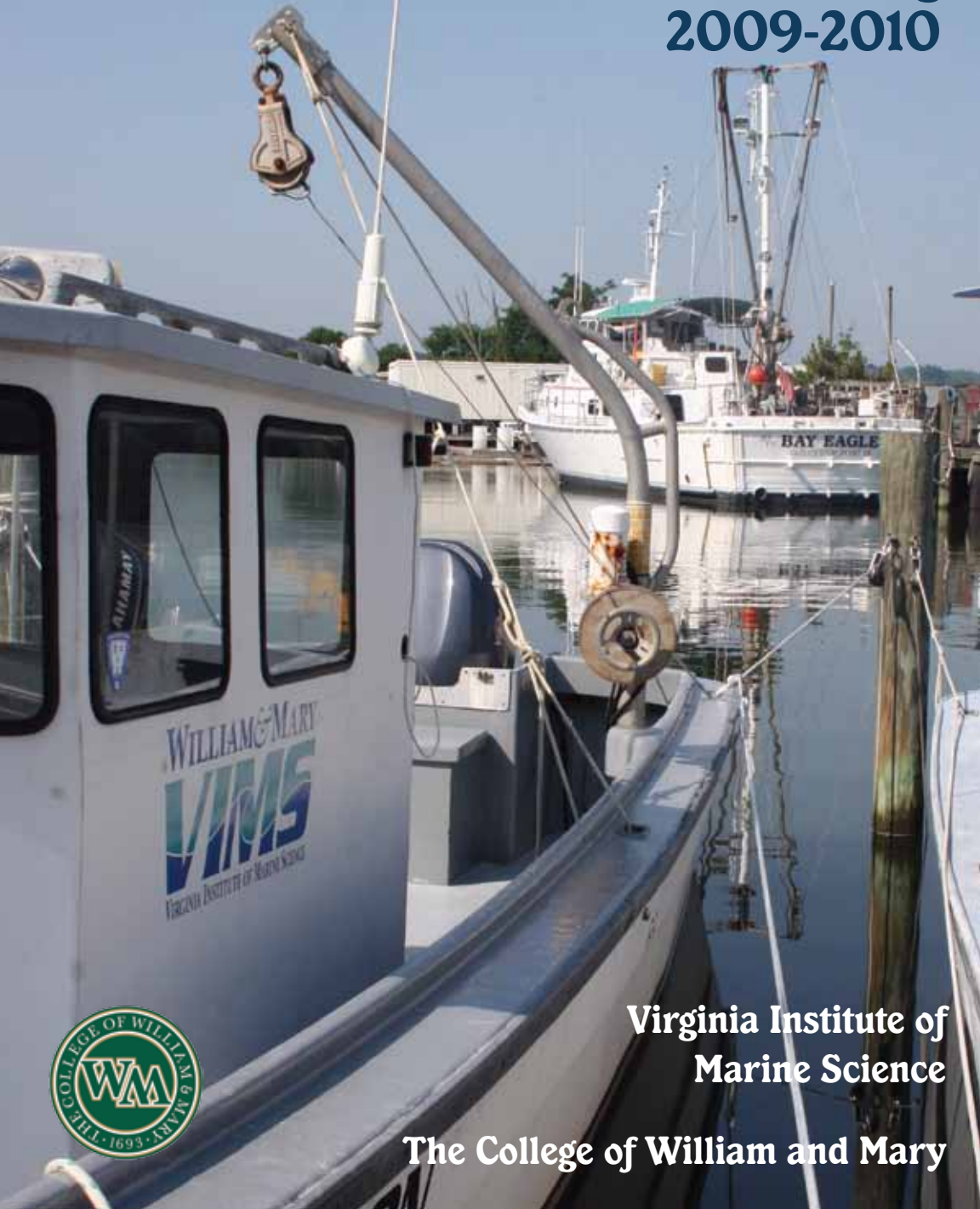


School of Marine Science

Graduate Catalog
2009-2010



Virginia Institute of
Marine Science

The College of William and Mary

August 2009

NOTE: This catalog provides announcements for the 2009-2010 academic year. It is current until August 2010. The College reserves the right to make changes in the regulations, charges, and curricula listed herein at any time.

Catalogs are issued for College programs as follows:

Undergraduate
School of Business Administration
School of Education
Graduate Studies in Arts and Sciences
School of Marine Science
Marshall-Wythe School of Law
Summer Sessions
Special Programs

The College of William and Mary does not discriminate on the basis of race, color, religion, national origin, sex, sexual orientation, disability or age in its programs and activities. All inquiries regarding non-discrimination policies should be addressed to:

Director of EO/AA
The College of William and Mary
Hornsby House
P.O. Box 8795
Williamsburg, Virginia 23187-8795
(757) 221-2615

The policies in this catalog apply to students who matriculate into the School of Marine Science graduate program in the academic year 2009-2010.

School of Marine Science

**Graduate Catalog
2009 - 2010**



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Calendar

Fall Semester 2009

August

24	Mon.	Tuition and Fees due for 2009 Fall Semester
24-25	Mon.-Tues.	Orientation for New Students
24-25	Mon.-Tues.	Final Fall Registration period for all SMS Students
26	Wed.	FIRST DAY OF CLASSES: 8:00 am
26	Wed.	Beginning of Add/Drop Period for 2008 Fall Semester
26	Wed.	Non-degree seeking Student Registration

September

4	Fri.	Last Day to Add/Drop a Class for Fall 2009 Semester
5	Sat.	Withdrawal Period Begins - See Graduate Registrar for more information
7	Mon.	Labor Day (classes meet)

October

2	Fri.	DEADLINE TO FILE FOR GRADUATION IN MAY or AUGUST 2010 (Notice of Candidacy Forms due to SMS Registrar)
10-13	Sat.-Tues.	Fall Break

November

2-8	Mon.-Sun.	Advanced Registration for Spring 2010
9	Mon.	Begin Registration for Spring 2010
25	Wed.	Begin Thanksgiving Holiday: 8:00 am
30	Mon.	End Thanksgiving Holiday: 8:00 am

December

4	Fri.	Last Day to Withdraw (see catalog for complete withdrawal policy)
4	Fri.	END OF FALL CLASSES: 5:00 pm
4	Fri.	End Make-up of Spring 2009 course work ("I's" change to "F" after this date)
5-6	Sat.-Sun.	Reading Period
7-8	Mon.-Tues.	Examinations
9	Wed.	Reading Period
10-11	Thurs.-Fri.	Examinations
12-13	Sat.-Sun.	Reading Period
14-15	Mon.-Thurs.	Examinations

NOTE: Calendar dates may be subject to change. Check additional dates with the SMS Graduate Registrar, or refer to the William and Mary Combined Calendar: <http://www.wm.edu/registrar/acad-calendars.php>

Spring Semester 2010

January

4	Mon.	LAST DAY TO SUBMIT THESES AND DISSERTATIONS FOR JANUARY 2010 CONFERRAL OF DEGREES
4	Mon.	Fall 2009 Semester Grades Due (by 9:00 am)
7	Thurs	Begin registration for new spring degree-seeking students
15	Fri.	WINTER DEGREE CONFERRAL (Formerly a December date)*
15	Fri.	End of Advanced Registration for continuing SMS students for Spring 2010
19	Tues.	End Registration Adjustment Period for Spring 2010
19	Tues.	End Registration for new spring degree-seeking students
20	Wed.	FIRST DAY OF CLASSES: 8 a.m.
20	Wed.	Beginning of Add/Drop Period for 2010 Spring Semester
29	Fri.	Last day of Add/Drop Period for 2010 Spring Semester
30	Sat.	Withdrawal Period Begins - See Graduate Registrar for more information

March

6-14	Sat.-Sun.	Spring Break
15	Mon.	Begin Registration for Continuing Students for Summer Sessions 2010
16	Mon.	Classes Resume
23	Tues.	Begin Advanced Registration Period For Fall 2010

April

30	Fri.	Last Day to Withdraw from Course - See Graduate Registrar for more information
1	Fri.	LAST DAY OF SPRING CLASSES: 5:00 pm*
30	Fri.	DEADLINE TO FILE FOR GRADUATION IN JAN. 2011 (Notice of Candidacy for Graduation Forms due to SMS Registrar)

May

1-2	Sat.-Sun.	Reading Period
3	Mon.	LAST DAY TO SUBMIT THESES AND DISSERTATIONS FOR MAY 2010 CONFERRAL OF DEGREES
3-7	Mon.-Fri.	Examinations
8-9	Sat.-Sun.	Reading Period
10-12	Mon.-Wed.	Examinations
12	Wed.	Make-up of Fall 2009 "I's" (change to "F" after this date) end
14	Fri	Spring 2010 Semester grades due for graduating students
15	Sat.	Deadline for students to complete work for Spring 2009 classes with "I" grades
16	Sun.	COMMENCEMENT/SPRING CONFERRAL date
19	Wed.	Remaining SPRING Grades Due
28	Fri	End Registration for Continuing Students for Summer Sessions 2010
31	Mon	Memorial Day - NO CLASSES

Summer Sessions 2010

SESSION I:	June 1 - July 2
SESSION II:	July 6 - August 6

The College of William and Mary

The College of William and Mary in Virginia, founded in 1693, is the nation's second oldest institution of higher education. During its long history, the College has built an eminent reputation for excellence in education. The College's commitment to a thorough, well rounded education through exploration, innovation and involvement is the source of institutional coherence. Today the College is national and international in its character and contributions. Students and faculty from diverse backgrounds are attracted to both the undergraduate programs and the various schools offering graduate studies.

The College of William and Mary is a small, residential university currently enrolling approximately 5,400 undergraduate and 2,300 graduate students. The School of Arts and Science offers Masters and Doctorate degrees in several departments. Graduate degrees may also be pursued in four professional schools: Marshall-Wythe School of Law, the School of Business Administration, the School of Education and the School of Marine Science.

The College is accredited by the Southern Association of Colleges and Schools. In keeping with the College's mission as a state institution, a wide range of courses, seminars and programs both for credit and noncredit are offered on all campuses.

School of Marine Science/ Virginia Institute of Marine Science

Since its founding in 1940, the Virginia Institute of Marine Science has functioned under a tripartite mission: to conduct independent research, to provide advisory services to the state and nation, and to provide education in Marine Science. The School of Marine Science is the academic program within the Virginia Institute of Marine Science. It is one of four graduate and professional schools of the College of William and Mary. The School of Marine Science awarded its first Masters degree in 1943 and inaugurated a Doctoral program in 1964. More than 800 marine scientists have earned graduate degrees from the School of Marine Science. At present the School of Marine Science has over 110 graduate students; about half are working toward a Masters of Science (M.S.) degree and half toward a Doctoral (Ph.D) degree.

Mission of the School of Marine Science

The mission of the School of Marine Science is to provide graduate students with education and training that will allow them to achieve their full intellectual potential and successfully pursue careers in marine science.

To accomplish this we:

- provide instruction in the fundamentals of marine science so that students gain a general understanding of oceanic, coastal and estuarine systems,
- offer advanced courses tailored to each student's area of research specialization, and
- encourage students to develop a specialization that is informed by basic and applied principles of marine science and facilitates the development of independent, as well as collaborative and interdisciplinary research perspectives.

Placed within the Virginia Institute of Marine Science's tripartite mission of research, education and advisory service, the SMS offers exposure to a variety of career options while providing students with the education and research skills necessary to meet present and future societal needs. In addition, SMS graduate students perform or assist with research and teaching activities that directly benefit the Commonwealth of Virginia and the nation.

Facilities

School of Marine Science students participate in graduate studies at an active, year round research facility with approximately 450 scientists, support technicians and staff. The 35-acre main campus of the School of Marine Science/Virginia Institute of Marine Science (SMS/VIMS) is located in Gloucester Point at the mouth of the York River, a major tributary and natural passageway to the Chesapeake Bay and Atlantic Ocean. Various service centers and special programs complement and enhance the student's experience.

Eastern Shore Field Laboratory (ESL): ESL offers access to coastal lagoons, salt marshes, barrier islands and coastal waters. Located in Wachapreague, about 2 hours from Gloucester Point, this facility supports research on a wide variety of coastal issues with special emphasis on bivalve aquaculture. The facility houses a hatchery, nursery, seawater flume, nearby bivalve grow-out sites and has a well-equipped laboratory, small boat facility, and dormitory.

William J. Hargis, Jr. Library: The collections of the Hargis Library are focused on the spectrum of literature, which supports the major programs of studies of the School of Marine Science as well as the research and advisory service programs of the Institute. These specialized collections are a blend of books, technical reports, online and print journals as well as topographic maps and nautical charts. Many of the VIMS scientific reports have been digitized and are available for viewing by connecting to the library's website at www.vims.edu/library.

Current research literature can be identified by using the major scientific research databases such as the Web of Science, Science Direct, ASFA, CSA Biological Sciences, Environmental Sciences and Pollution Management, GeoRef, and Oceanic Abstracts. These and other electronic resources are accessible both on and off campus. Students, faculty and staff can connect to over 200 databases available through connection to the Main Campus and VIVA, the Virtual Library of Virginia, as well as materials in the collections of the other William and Mary Libraries. In addition to the College collections,



research materials from other institutions can be acquired through Hargis Library's Inter-Library Loan Service. Librarians are available to provide help in locating information and identifying the best tools for research projects. More information on the Hargis Library can be viewed at www.vims.edu/library.

Vessels: SMS/VIMS maintain and operate a fleet of 40 vessels for research and educational purposes. Larger

vessels are equipped with flow-through seawater, sample collection-analysis labs and electronics labs. In addition to the 65-foot R/V *Bay Eagle*, 29-foot *Elis Olsson*, 29-foot R/V *Fish Hawk* and 75-foot *Pelican*, there is a sizable trailerable fleet. State-of-the-art electronic systems can be transferred among the smaller boats. The diving facility includes a diver training room and classroom to support the 40-member dive team.

Information Technology and Networking Services Unit: ITNS provides technical support for Information Technology resources used on campus. Supported desktop and laptop systems are primarily Windows and Macintosh- based. ITNS maintains a campus-wide backbone network, which has a high-speed link to the Internet (and Internet II) via NetWork Virginia. ITNS provides a plethora of IT services such as file, print, E-mail, web, database, data storage, high performance computing, and video conferencing. Students have access to up-to-date hardware and software in computing labs, the library and via mobile laptop systems that can be used in any classroom. ITNS assists students in configuring and using personally owned computer systems that meet or exceed minimum requirements.

Analytical Service Center: The Analytical Service Center (ASC) provides water and sediment analyses to students, scientists and governmental agencies. The ASC has researched, refined and developed methodologies for analysis in a wide spectrum of environmental matrices. The quality of data is the result of thorough statistical controls, documentation, and training. ASC instrumentation is state-of-the-art, with computer control interfacing, background correction and optimization for saline samples.

Nunnally Hall: Completed in 1992, Nunnally Hall houses modern laboratories, dissection facilities for large vertebrates, and an extensive fish collection that includes approximately 122,000 specimens representing approximately 300 families of marine and freshwater fishes.

Chesapeake Bay Hall: Completed in spring 1997, this facility provides 60,000 sq. feet of research facilities, including labs for advanced research in chemistry, biogeochemistry, toxicology, pathobiology, microbiology, genetics, physiology, plankton ecology, nutrient cycling and parasitology.

Andrews Hall: This facility, completed in 2007, consolidates some of the research programs from Biological, Physical, and Fisheries Sciences. It provides 71,000 square feet of space for 39 research laboratories, 25 faculty offices and space for nearly 100 students, technicians, and visiting scientists.

Seawater Research Laboratory: The 47,000 square foot Seawater Research Laboratory (SRL) allows scientists from VIMS and other institutions to conduct research on living marine and estuarine organisms under controlled conditions, allowing for great diversity with respect to the type(s) of organisms which may be studied and the conditions of exposure. The SRL consists of six primary contained wet lab areas. Most of these areas are highly specialized to allow the safe containment and treatment of aquatic pathogens and toxins. Special care is taken to protect the laboratory personnel who work within these areas. State-of-the-art filtration and effluent treatment technologies are utilized to protect the receiving waters of the York River estuary from exposure to these compounds as well.

Programs & Centers

Marine Advisory Service/Virginia Sea Grant Program: Virginia Sea Grant provides expert science-based information and assistance to marine industry sectors to maximize efficiency, economy and safety in the judicious utilization of marine resources. In addition, VA Sea Grant supports programs to educate the public, K-12 students and private industry as to the importance of sustaining the marine environment and its resources.

Chesapeake Bay National Estuarine Research Reserve in Virginia (CBNERRVA): VIMS, in partnership with the Estuarine Reserves Division of the National Oceanic and Atmospheric Administration (NOAA), is responsible for the operation and management of CBNERRVA, whose mission is to preserve a network of reserves that represent the diversity of coastal ecosystems found within the York River estuary. CBNERRVA manages these reserves to support informed management of coastal resources through research, education, stewardship and advisory service. Focus areas of current Reserve programs include ecology of coastal shallow water environments, watershed and atmospheric processes and material flux, episodic storm events and climate change, shoreline management, environmental monitoring and integrated coastal and ocean observing systems.

Center for Coastal Resources Management (CCRM): CCRM provides support to the state and nation to enable informed management of coastal resources in Virginia and the mid-Atlantic region. To accomplish its mission the Center is organized into three programs with broadly integrated activities. The Wetlands Advisory Program provides scientific and technical advice on management of tidal and nontidal wetland resources, tidal shorelines, and subaqueous lands. The Comprehensive Coastal Inventory Program collects data, conducts inventories, and develops analytical tools in support of coastal resource management. The Coastal Watersheds Program conducts basic and applied research on the ecological services provided by coastal resources.

Aquaculture Genetics and Breeding Technology Center (ABC): ABC operates an experimental shellfish hatchery for genetics and breeding studies of oysters and hard clams. The Gloucester Point Hatchery maintains varieties and stocks of native and non-native oysters. ABC's field operations include experimental farms at Gloucester Point, and four other locations throughout the Virginia portion of the Bay. The Kauffman Aquaculture Center is a state-of-the-art quarantine facility for brood stock isolation and conditioning.



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Fu-Lin Chu, Professor of Marine Science. B.S., The Chinese University of Hong Kong; M.S., University of Rochester; Ph.D., College of William and Mary.

William D. DuPaul, Professor of Marine Science. B.S., Bridgewater State College; M.A., Ph.D., College of William and Mary.

David A. Evans, Associate Professor Emeritus of Marine Science. B.A., M.A., Cambridge University; D.Phil., Oxford University.

Leonard W. Haas, Associate Professor of Marine Science. A.B., Dartmouth College; M.S., University of Rhode Island; Ph.D., College of William and Mary. Biological Sciences.

Dexter S. Haven, Professor Emeritus of Marine Science. B.S., M.S., Rhode Island State College.

Robert J. Huggett, Professor Emeritus of Marine Science. M.S., Scripps Institution of Oceanography; Ph.D., College of William and Mary.

Albert Y. Kuo, Professor Emeritus of Marine Science. B.S., National Taiwan University; M.S., University of Iowa; Ph.D., Johns Hopkins University.

Maurice P. Lynch, Professor Emeritus of Marine Science. A.B., Harvard University; M.A., Ph.D., College of William and Mary.

William G. MacIntyre, Professor Emeritus of Marine Science. B.S., M.S., Ph.D., Dalhousie University.

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Frank O. Perkins, Professor Emeritus of Marine Science. B.A., University of Virginia; M.S., Ph.D., Florida State University.

Morris H. Roberts, Jr., Professor Emeritus of Marine Science. B.A., Kenyon College; M.A., Ph.D., College of William and Mary.

Evon P. Ruzecki, Associate Professor Emeritus of Marine Science. A.B., Knox College; M.S., University of Wisconsin; Ph.D., University of Virginia.

Gene M. Silberhorn, Professor Emeritus of Marine Science. B.S., Eastern Michigan University; M.S., West Virginia University; Ph.D., Kent State University.

N. Bartlett Theberge, Jr., Professor Emeritus of Marine Science. B.S., J.D., College of William and Mary; LL.M., University of Miami.

Willard A. Van Engel, Professor Emeritus of Marine Science. Ph.B., Ph.M., University of Wisconsin, D.S (honorary) College of William and Mary.

J. Ernest Warinner, III, Assistant Professor Emeritus of Marine Science. B.S., M.A., College of William and Mary.

Kenneth L. Webb, Chancellor Professor Emeritus of Marine Science. A.B., Antioch College; M.S., Ph.D., Ohio State University.

Richard L. Wetzel, Professor Emeritus of Marine Science. B.S., M.S., University of West Florida; Ph.D., University of Georgia.

Frank J. Wojcik, Assistant Professor Emeritus of Marine Science. B.S., University of Massachusetts; M.S., University of Alaska.

L. Donelson Wright, Chancellor Professor of Marine Science. B.A., University of Miami; M.A., University of Sydney; Ph.D., Louisiana State University. Physical Sciences.



Graduate Study Programs

Research at SMS/VIMS emphasizes the study of marine environments from estuaries to the open ocean, with special emphasis on coastal systems. Interdisciplinary programs are encouraged. In addition to teaching and conducting basic research, many faculty members are engaged in applied research of concern to industry and management agencies. Students often find that their assistantship duties and/or research activities offer opportunities that bring them in close contact with other departments at SMS and William and Mary, marine related industries, and state, regional, and federal management agencies.

Based on the primary academic and research disciplines represented at SMS/VIMS, graduate studies are offered in four major areas.

Biological Sciences

(www.vims.edu/bio)

The Department of Biological Sciences includes a diverse group of biologists working in a range of research areas from biogeochemical cycling to physiological, population, and community ecology to whole ecosystem modeling using state-of-the-art approaches. Scientists in the department study benthic nektonic and planktonic organisms and the temporal and spatial patterns and processes that control their distribution and ecological functioning in estuarine, coastal and open ocean regimes.

Major Programs

Benthic Ecology and Biodiversity: Studies focus on the processes governing structure and functioning of benthic communities, and ecosystems. Current research includes: experimental and observational studies of recruitment, growth, and production; role of benthic organisms and communities in the fate and transfer of nutrients, organic matter, energy and sediments; effects of natural and anthropogenic disturbances on benthic community structure and functioning; consumer-prey relationships and benthic support of higher trophic levels; systematics and biodiversity of benthic animals and evolutionary ecology. Scientists in the department employs diverse research approaches including molecular genetics field experimentation biogeochemical analyses, remote sensing and a range of modeling techniques. Most research focuses on benthic systems of the land-sea margins, including tidal freshwater, estuarine and coastal regions, and coral reefs.

Ecosystem Modeling: The ecosystem modeling program develops and employs numerical simulation models as integrative and synthetic tools for ecosystem analysis to address basic science and applied management questions. Current efforts include modeling studies of coastal and watershed carbon and nutrient cycling, estuarine eutrophication, submerged aquatic vegetation, multispecies trophic interactions, regional ocean ecosystem models and climate-related ecosystem changes. Studies involving optimal methods for combining in situ and satellite-based biological data with numerical models are also ongoing. Working with hydrodynamic, fisheries, and water quality modelers, an over-arching goal of the program is to develop cross-disciplinary models that address both basic and applied ecological research questions.

Macrophyte Ecology: Studies in this program concentrate on submerged and emergent macrophyte species that dominate shallow subtidal and intertidal marine, brackish, and freshwater areas. Current research includes studies on plant distribution and abundance, restoration ecology, plant dispersal mechanisms, plant responses to environmental variability, plant growth and productivity, carbon and nitrogen cycling, plant-herbivore interactions and ecosystem simulation modeling. The program encourages multi-investigator and multi-institutional collaborative efforts.

Nutrient Cycling: Studies focus on the fate of nutrients in benthic and pelagic ecosystems and on the role they play in regulating primary and secondary production. Nutrient cycling is studied in habitats ranging from intertidal marshes and mudflats to shallow subtidal, littoral zone systems, coastal embayments, riverine systems, large estuaries such as Chesapeake Bay, and to the coastal ocean including that adjacent to Antarctica.

Biological Oceanography/Plankton Processes: Research is focused on biological populations and processes as integral components of the dynamic, interconnected marine biosphere that provides half the food and absorbs half the anthropogenic carbon dioxide on the planet. Our research emphasis is on lower trophic levels in estuarine, coastal and oceanic foodwebs, including bacteria, phytoplankton, micro-, meso- and gelatinous zooplankton, harmful algal blooms and marine snow. Processes studied in all ecological provinces of the global ocean include fluxes of carbon and nitrogen between the various organic and inorganic pools, nutrient limitation, organic matter (dissolved and particulate) cycling, and biogenic trace gas production and consumption. The biotic processes regulating these transformations, the physical mixing and circulation mechanisms affecting their transport and redistribution, and the linkages and feed backs between the water column and all its boundaries (benthos, atmosphere, land margins) are emphasized. Collaborative research aimed at understanding the links between plankton dynamics and recruitment of economically important fisheries populations is also pursued.

Antarctic Oceanography: The Antarctic continent and the Southern Ocean together regulate the Earth's weather, and the Southern Ocean, a major component of the planetary carbon cycle, is a key engine of global climate change, a source of rich fisheries, and haven for marine birds and mammals. VIMS/SMS programs provide an opportunity for graduate and undergraduate students to live and work in the Antarctic and on icebreakers; and to carry out research on production, nutrient cycling, organic matter diagenesis and ecosystem change. VIMS researchers work primarily in the Ross Sea (McMurdo Station) and the West Antarctic Peninsula (Palmer, Antarctica Long Term Ecological Research site). These programs also emphasize public education and outreach as important components of our work.

Research Facilities

The department is well equipped with state-of-the-art equipment for conducting field and laboratory research, including laboratories in the recently completed Andrews Hall. Major facilities include several light-, temperature- and humidity-controlled environmental chambers, a greenhouse with running seawater and temperature controlled tanks for aquatic macrophyte photosynthesis-related studies and plant restoration work, an expansive wet laboratory facility completed in Fall 2007, and a large array of flow-through seawater mesocosm tanks. Laboratory instrumentation includes gas chromatographs fitted with various detectors, high performance liquid chromatograph, infrared gas analyzer,

elemental analyzer, scintillation counter, a Lachat auto-analyzer for nutrient analyses, computer-assisted image analysis hardware and software, biosafety hoods, fluorometers, spectrophotometers, various microscopes including access to electron microscope facilities, a Coulter Altra flow cytometer, a FLOWCAM imaging cytometer, Total Organic Carbon and Total Nitrogen analyzer, Elzone particle counter/sizer, and microelectrode microprofiler.

An excellent assortment of field sampling gear is maintained by the department. Bottom samplers include an assortment of box corers; grab samplers, and piston-type corers. Sediment-profile and surface cameras as well as a bottom sled with profiling plow, video, and still photography capabilities allow rapid bottom mapping. A variety of nets are available for plankton sampling. A Fetch-class Autonomous Underwater Vehicle (equipped



with CTD, 600 kHz sidescan sonar, underwater video, fluorometer/turbidity sensor, and fast response dissolved oxygen sensor), a vertical profiler and towed sensor packages including a towed undulating vehicle along with a variety of data sondes, fluorometers, dissolved oxygen sensors allow continuous, under-way and fixed station monitoring of riverine and estuarine water quality. The department also has access to state-of-the-art facilities for molecular genetic analyses, including automated DNA sequencers and environmental chemistry laboratory facilities.

The Department of Biological Sciences maintains close contacts and shares instrumentation with the other departments at VIMS. Also available are computer facilities with support of both Windows and Macintosh platforms ranging from in-lab laptop units, to work stations supporting LANs, to an institute-wide network.

Preparatory Studies

A strong background in modern biology and basic science is required. This should include mathematics (ideally through calculus), chemistry (through organic chemistry) and basic statistics. Students should have strong writing and verbal communication skills. Past research experience and training are highly desirable. Students are strongly encouraged to contact and discuss plans with prospective advisor(s) before applying to the graduate program.

Typical Course of Study

In addition to the core courses required of all SMS graduate students, Biological Sciences students are required to take MSCI 526 and MSCI 515 unless exemption is granted by the Dean of Graduate Studies. Students are strongly encouraged to take MSCI 501D unless they can demonstrate to their graduate committee that they have successfully taken a similar course as part of earlier graduate studies. Additionally, appropriate courses related to the student's area of specialization will be included, in consultation with the student's graduate committee. These might include Plankton and Microbial Ecology for students specializing in plankton biology; Marine Benthos, Seagrass Ecology, or Secondary Production for those specializing in benthic systems. Theoretical Ecology, Ecological Modeling and computer applications are recommended for students whose research will rely on modeling or theoretical mathematical formulations.

Environmental and Aquatic Animal Health

(www.vims.edu/env)

The dominant mission of the Department of Environmental and Aquatic Animal Health is to identify and detect toxicological, pathobiological and biochemical agents in the Chesapeake Bay and its watershed that affect the health of important aquatic organisms and surrounding human populations. Our research emphasizes understanding the fates of contaminants and pathogens in estuarine and marine environments and their effects on important species and man. A diverse faculty consisting of environmental chemists, toxicologists, ecotoxicologists, biochemists, immunologists, microbiologists, and pathobiologists collaborate to achieve these goals. Research questions are pursued at all levels of biological organization from the molecular and cellular to the organismal and population levels. Our activities reflect a strong commitment to provide technical support to those who regulate and protect the waters and natural resources of the Commonwealth regional and federal management agencies, and marine-related industries.

Some current projects exemplify these themes:

- Effects of carcinogenic contaminants in sediments on population genetics and adaptation
- The interactions of contaminants and pathogens in the disease process
- The role of mycobacteria and other emerging pathogens on animal and human health
- The role of emerging chemicals in endocrine disruption and reproduction
- Development of molecular probes and other techniques to study immune defense mechanisms
- Use of molecular methods to identify and characterize pathogens, populations and disease resistance elements in bivalve molluscs
- Use of molecular methods to detect and quantify fecal indicators, human pathogens and harmful algal bloom organisms in recreational and shellfish growing waters
- Generation of trophic transfer-based models of mercury movement in aquatic and terrestrial environments

Major Programs

Environmental Chemistry: Research addresses the sources, transport, fate, bioavailability and impacts of contaminants in marine and estuarine systems. Some recent efforts include the behavior of anti-foulants, use of geographic information systems (GIS) for modeling spatial distributions of environmental data and development of environmentally friendly analytical procedures. Emerging contaminants are a particular interest. The faculty collaborates with international researchers, federal and state agencies (e.g. EPA, NOAA, DOE, and VA Dept of Environmental Quality VA Dept. of Health) and private industry. Recent student research has examined the binding of pesticides to natural organic matter and subsequent impact on bioavailability and toxicity; bioremediation of tributyltin-contaminated sediment in a created wetland; factors influencing the degradation rate of crop protectants in natural waters; the utility of supercritical fluid extraction for the determination of flame retardants in fish.

Environmental Microbiology: This program studies indicator or pathogenic microorganisms in waters used for recreation, aquaculture, and shellfish industries. Research includes development and validation of new methods for detection of microorganisms of human health significance in marine environments, and studies to understand processes that contribute to eutrophication and microbial contamination of receiving waters. A particular strength of this program is multidisciplinary research on microorganisms that are pathogenic to fish.

Toxicology: Effects of toxic chemicals in water and sediment are measured at the molecular to population levels. Endpoints include 1) uptake and elimination of pollutants by individual organisms, 2) vital processes (mortality, growth, reproduction), and 3) mechanisms of internal distribution, biotransformation, and clearance of hazardous chemicals. Molecular, cellular, and whole organism responses are being evaluated as a basis for predicting population effects at sublethal concentrations.

Diseases of Marine Animals: Research in this field 1) focuses on infectious and noninfectious diseases of fish and shellfish, 2) determines the mechanism(s) by which pathogens cause disease in the host organisms, 3) examines pathological consequences of exposures of estuarine animals to contaminants, 4) studies etiology and epidemiology of pathogens in estuarine and marine organisms, 5) investigates host defense mechanisms in order to develop diagnostics, therapeutics and vaccines for use in aquaculture, and 6) seeks to understand the impact of toxic materials on disease processes. The pathology group has developed an Aquatic Animal Disease Diagnostic Laboratory using modern histological, microbiological, immunological, and molecular techniques to study diseases in shellfish and fish. Additional studies focus on marine genomics and disease mechanisms, molecular phylogenetics, population genetics and the development of molecular diagnostics for pathogens.

Environmental Risk Assessment: Risk assessment tools are applied to evaluate the risk associated with exposure to hazardous chemicals, pathogens, bacterial agents, both individually and collectively in complex mixtures. The goal is to provide a conceptual framework that will improve environmental management by allowing resource agencies to focus their limited resources on those issues of greatest importance.

Research Facilities

Laboratories of the Department of Environmental and Aquatic Animal Health are located in Chesapeake Bay Hall and in new facilities in Andrews Hall. The Department laboratories in Chesapeake Bay Hall are equipped with state-of-the-art instrumentation for studies on environmental chemistry, toxicology, immunology, electron microscopy, pathobiology, and microbiology.

Analytical instrumentation is available to identify and quantify a wide range of organic and inorganic contaminants in water, sediment and biota. This allows faculty and students to develop new analytical methodologies, detect emerging contaminants and track



pollutants in the environment at trace levels. For example, an atomic absorption spectrophotometer is available for measuring heavy metals at low ambient concentrations. Gas chromatographs, high performance liquid chromatographs, mass spectrometers and enhanced solvent extractors are maintained for the determination of organic pollutants.

Genetic and molecular analyses of pathogenic organisms are performed using DNA sequencers, PCR thermal cyclers, a real-time PCR system and associated electrophoretic and imaging equipment. State-of-the-art electron microscopes allow identification of microorganisms (e.g. harmful algae) and ultrastructural analysis of diseased organisms, supplementing traditional light microscopy.

Instrumentation is available for sophisticated research on enzyme systems that play a role in detoxification of chemicals and lipids that are involved in accumulation of hydrophobic chemicals and in resistance to some disease organisms. The immunology laboratory has the capability to produce monoclonal antibodies for a variety of antigens.

A large marine research flowing seawater exposure facility is now operational and provides increased space and substantially expanded opportunities for toxicant and pathogen challenge studies and includes a Level 3 biosafety facility

The present facilities and equipment available in the department are described in more detail on the departmental website.

Preparatory Studies

Students entering the Environmental and Aquatic Animal Health program should possess a degree in an applicable natural science (e.g. biology, chemistry, or a related sub discipline). Courses in advanced biology (e.g. biochemistry, molecular biology, and genetics), chemistry (inorganic and organic), physics, calculus and probability/statistics are strongly encouraged. Students should have strong written and oral communication skills. Students applying to the Department should discuss academic background, research experience and career objectives with prospective mentors before applying.

Typical Course of Study

The educational program prepares students for careers as environmental scientists, educators and managers. Since departmental research and educational programs are interdisciplinary, incoming students are expected to have strong backgrounds in biology and chemistry. Following satisfactory completion of the institutional core curriculum, students may pursue courses and research in any of the major program areas (environmental chemistry, toxicology, environmental risk assessment, environmental microbiology or pathobiology). The department offers a number of relevant courses including Protein Biochemistry in Marine Organisms (MSCI 558), Parasitology (MSCI 559), Fundamentals of Ecotoxicology (MSCI 560), Water Pollution (MSCI 562), Environmental Chemistry (MSCI 563), Aquatic Toxicology (MSCI 564), Principles of Pathobiology (MSCI 565), Diseases of Marine Organisms (MSCI 566), Comparative Immunology (MSCI 567), Environmental Microbiology (MSCI 573), Molecular Genetic Data Analysis, Bioinformatics (MSCI 583), Fish Histology and Histopathology (MSCI 638), Quantitative Ecotoxicology (MSCI 640) and Environmental Risk Assessment (MSCI 641). Students are expected to select at least two departmental offerings and typically complement their curriculum with additional courses offered by this and other departments.

Fisheries Science

(www.fisheries.vims.edu)

Research within the Department of Fisheries Science is focused on understanding the population dynamics and biology of fish, crab and mollusc species of commercial, recreational and ecological importance. Also included within the research framework of the department is the Aquaculture Genetics and Breeding Technology Center. Collaborative research and teaching efforts are common among department faculty. In addition to furthering knowledge through peer-reviewed publications, members of the department advise local, regional and national resource management agencies and involve students directly in fisheries management. The department also maintains an internationally recognized collection of alcohol-preserved and skeletal specimens of fishes that are available for student research. Also available to students are highly equipped laboratories and many opportunities for fieldwork in estuarine and marine environments, especially the Chesapeake Bay.

Major Programs

Anadromous Fishes Program: Research and monitoring of the abundance, reproductive ecology, life history and exploitation of highly migratory marine species such as striped bass, Atlantic sturgeon, river herrings and American shad that spawns in fresh water. Studies include monitoring commercial and recreational landings, monitoring stock status with fishery-independent surveys, developing novel approaches to stock assessment, conducting surveys of juvenile abundance, mark/recapture and telemetry methods for estimation of fishing rates and description of migratory behavior.

Aquaculture Genetics and Breeding Technology Center: Research includes development of brood stocks in shellfish species of interest to Virginia and the region, including selective breeding (especially for disease resistance), chromosome set manipulation, and evaluation of non-native species.

Molluscan Ecology: Studies focus on ecology and stock assessment of estuarine and continental shelf molluscs. Broad program interests include ecology and behavior of molluscan larvae, life history and population dynamics, restoration culture for commercial purposes, and molluscs as indicators of climate and environmental change.

Invasive Species Biology: Research focuses on history and pathways of invasions, the characteristics of invasive species ecosystem impacts, and mechanisms of control, national and international policy relating to introductions, and evaluation and implementation of intentional introductions for ecological and economic purposes.

Commercial Fisheries Development: Research is focused on gear selectivity and bycatch as well as management and regulatory strategies for seafood production, processing and utilization.

Crustacean Ecology: Investigations address the ecology, population dynamics, and conservation of the blue crab in Chesapeake Bay and spiny lobster in the Caribbean.

Fisheries Ecosystem Modeling and Assessment Program: Areas of interest in this program include monitoring of the abundance, predator-prey, and competitive interac-

tions among fish populations within Chesapeake Bay. Primary objectives of the program are the development of multispecies stock assessments for the purpose of understanding the joint impact of harvesting and biological interactions on these populations. Information derived from these assessments is designed to yield advice for ecosystem-based approaches to fisheries management.

Fisheries Genetics: This program examines the application of molecular genetic techniques to address problems in fisheries science. Studies focus on analysis of stock structure, use of molecular characters to identify early life history stages of marine organisms, and the evaluation of taxonomic and biogeographic hypotheses with molecular genetic information.

Marine Conservation Biology: Areas of interest include the ecology and conservation of the blue crab, sea turtles (loggerhead and Kemp's Ridley), Caribbean spiny lobster, queen conch, Nassau grouper, and marine bivalves. Emphasis is placed on metapopulation and source-sink dynamics, marine reserves and dispersal corridors, habitat fragmentation, degradation and loss effects on marine invertebrates, recruitment processes, and predator-prey interactions.

Marine Finfish Dynamics: Investigations focus on the recruitment dynamics of finfish in coastal ecosystems based on data from long-term bottom-trawl and beach seine surveys in Chesapeake Bay. A primary goal of these studies is to calculate recruitment indices to gauge the strength of the current year class and permit informed management of coastal fisheries. Another goal is to integrate observations from the surveys with field and laboratory research to understand large-scale patterns in the distribution and habitat use of coastal fishes. Such research may include individual-based behaviors as evidenced by acoustic tagging studies or physiological responses to habitat change.

Marine Resource Policy and Fisheries Management: Research is performed to support determination of socially optimal rates of exploitation and optimum allocation of marine resources among competing user groups. Studies emphasize assessment and estimation of net social benefits to society and the economic impacts of proposed management and regulatory options. Additional research focuses on numerous international aspects of marine resource management, including, but not limited to, reducing the capture of sea turtles and other undesirable outputs, enhancing technical and economic efficiency of fishing gear, designing capacity reduction programs, and promoting ecosystem-based management.

Marine Vertebrate Ecology: Research areas of interest include the comparative morphology, reproduction, and population dynamics of sharks; long term changes in the distribution, migration, abundance, ecology and energetics of sea turtles; and investigations of the life history and community structure of finfish taxa.

Stock Assessment Methodology: This program involves the systematic evaluation of stock assessment procedures and the development of new mathematical models and statistical methods for studying populations and their responses to exploitation. Tagging, survey, and landings data are used to estimate population size, mortality rates, components of mortality, yield, spawning potential, and effects of changes in fishery regulations. Applications include invertebrates and vertebrates in temperate and tropical sport and commercial fisheries.

Deep-Sea Ecology: Research focuses on oceanic ecosystems with emphasis on community structure, trophic dynamics, biophysical coupling and ecosystem functioning with emphasis on deep-sea fishes and their prey. Current projects include studies of the deep Atlantic, Pacific and Southern Oceans.

Systematics and Taxonomy: Taxonomically diverse studies focus on the taxonomy, morphology, phylogenetic systematics, zoogeography and evolutionary biology of various vertebrate and invertebrate groups. The program promotes a total evidence approach to phylogenetic research, including molecular techniques and morphological studies of larval, juvenile and adult forms.

Research Facilities

The Department of Fisheries Science comprises several programs, each with a fully equipped laboratory, a variety of collection and sampling equipment, and extensive computer facilities.

The Fisheries Science Laboratory has a dedicated age and growth laboratory equipped with multiple high quality optical microscopes linked to an image analysis system. The facility



supports rapid analysis of hard structures for age determination and automated morphometric measurements. Also available are otolith sectioning and grinding equipment, hydraulic scale presses, and digital scale projectors. The fish-processing laboratory is a large, multi-user facility designed for the work-up of field samples and storage of field equipment. The lab is equipped with automated fish measuring boards and electronic balances that are linked to the departmental computer network.

The Crustacean Ecology Program maintains two large (1800 gal) benthic mesocosm tanks monitored by IR-sensitive, computer-controlled cameras with time-lapse image recorders to be housed in the new seawater laboratory.

The Molluscan Ecology Program's laboratory is well equipped for physiological and ecological studies with a UV-VIS spectrophotometer, centrifuges, a fluorescence microscope, compound and dissecting microscopes, and an image analysis system.

The Fisheries Genetics Program maintains a large laboratory that is fully equipped to undertake a variety of genetic analyses. Major equipment includes automated DNA sequencers, a bank of thermal cyclers, refrigerated centrifuges, ultracentrifuges, a vacuum concentrator, a digital imaging system, several ultra cold freezers and a walk-in cold room.

The Fisheries Ecosystem Modeling and Assessment Program maintains a laboratory with a full complement of the equipment needed for finfish diet and analysis and age determination, including several compound and dissecting microscopes, balances, low-speed isomet saws, and hot plates

Nunnally Hall contains a fish collection with approximately 85,000 specimens representing 295 families. This research and teaching collection incorporates extensive holdings from Chesapeake Bay, the Middle Atlantic Bight, Appalachian freshwater habitats, and an internationally recognized collection of deep-sea fishes.

Two wet lab facilities are available to department faculty and students. The general wet lab contains a flow-through system with several wet tables and tanks. In addition, a special greenhouse/wet lab houses the large sea turtle holding tanks, which are supplied with re-circulated filtered seawater. Adjacent to the sea turtle greenhouse is a 7,560-gallon tank used for research.

Physiology laboratories are available on the VIMS main campus and at the Eastern Shore Laboratory containing equipment for measuring metabolic rates, as well as conducting a broad range of advanced procedures relevant to environmental physiology, including cardio-respiratory physiology and sensory biology.

Monthly surveys of juvenile fishes and crabs are conducted throughout the Bay and on three major rivers. Plankton studies, larval fish research, and reproductive studies of recreational fishes are conducted in the Bay as well as offshore.

The present facilities and equipment available in the department are described in more detail on the departmental website.

Preparatory Studies

Students interested in graduate study in Fisheries Science should have substantial undergraduate coursework in biology including: physiology, biochemistry, comparative morphology or developmental biology, genetics, ecology and related topics, and evolutionary biology. College physics, chemistry (through organic) and math through calculus are required. Courses in statistics, marine biology and fishery biology may be helpful but are not prerequisites.

Typical Course of Study

In addition to the core courses required of all SMS graduate students, Fisheries students are required to take Marine Fisheries Science (MSCI 528) as the advanced (3 credit) course in their core course curriculum. Fisheries students are required to take an additional quantitative course, chosen from the following menu: Multivariate Analysis and Time Series (MSCI 625), Experimental and Quantitative Ecology (MSCI 667), Stock Assessment Methods (MSCI 670), Statistical Analysis of Fisheries Data (MSCI 669), or Applied Regression and Forecasting (MSCI 672). Fisheries students are also expected to enroll in the departmental noon seminar (MSCI 515) each spring semester. Other courses offered by the Fisheries faculty include Modeling Biological and Ecological Systems (MSCI 530), Quantitative Methods for Coastal and Ocean Policy Analysis (MSCI 549), Early Life History of Marine Fishes (MSCI 657), Larval Ecology (MSCI 658), Deep Sea Biology (MSCI 663), Marine Conservation Biology (MSCI 664), Ichthyology (MSCI 666), Malacology (MSCI 668), Statistical Analysis of Fisheries Data (MSCI 669), Fisheries Population Dynamics (MSCI 671), Marine Molecular Genetics (MSCI 673), Marine Molecular Genetics Laboratory (MSCI 674) and Fish Physiology (MSCI 698).

Physical Sciences

(www.vims.edu/physical)

The objectives of the Department of Physical Sciences are to generate, communicate and apply knowledge concerning the physical, chemical and geological processes that operate in the coastal ocean and estuaries. The physical oceanography group studies and models water properties and water movement in estuarine, coastal and continental shelf environments. Geological oceanography includes the study of the processes of sediment erosion, transport and accumulation as well as the resulting stratigraphy. Marine chemistry emphasizes the study of marine biogeochemical processes, and environmental fate and transport of natural and anthropogenic substances. Interdisciplinary studies are strongly emphasized in the Department of Physical Sciences.

Major Programs

Chemical Oceanography/Marine Geochemistry: This program includes a diverse faculty with numerous cross-disciplinary interests. Work is conducted across riverine, estuarine, continental margin and open ocean environments on a variety of projects intended to help better understand the cycling of organic and inorganic species from both natural and anthropogenic sources. Individual faculty and students in this program collaborate actively not only with other programs in Physical Sciences, but also with the departments of Biological and Fisheries Science. Examples of current and on-going projects within the Chemical Oceanography/Geochemistry group include: cycling and diagenesis of dissolved and particulate organic matter in estuaries and open ocean settings; carbon and nitrogen transport and cycling in rivers, estuaries, and the coastal ocean, environmental exchanges and transport of contaminants and use of natural and anthropogenic substances as tracers of ecological processes.

Geological Oceanography: Encompasses local and international research on a variety of disciplinary and interdisciplinary topics. Research sites span the full range of marine/near-shore environments from coastal plain and river floodplains, through estuaries and across the margin to the base of the continental rise. Although much of our effort addresses questions in Chesapeake Bay and surrounding areas, federal funding supports research in many other areas in the U.S. and around the world (including New Zealand, China, Bangladesh, and New Guinea) that generates knowledge about geological phenomena in the coastal ocean. Some of the major focal areas include: sediment transport and boundary layer processes; sediment flux and fate; seabed dynamics; shoreline erosion/sand resource issues; and Quaternary stratigraphic development. Interdisciplinary research efforts involve faculty from the departments of Biological Sciences and Environmental and Aquatic Animal Health, as well as colleagues from other institutions worldwide.

Physical Oceanography: Focuses on water motion in estuaries and on the continental shelf along with the associated transport of buoyancy, suspended particles, nutrients and pollutants. Physical Oceanography at VIMS is extremely interdisciplinary, with ongoing collaborations with chemists and geologists within our department, biologists and resource managers elsewhere at VIMS, and scientists from various disciplines throughout the country and around the world. We have ongoing field projects in the Chesapeake Bay and its tributaries as well as on the shelves of the east and west coasts of

the U.S., and we are applying three-dimensional numerical models to study circulation and associated dissolved and particulate transport in estuarine and shelf environments. Cooperative research projects are underway with scientists from countries including Korea, The Netherlands, Taiwan, and the U.K. Some of the major focal areas of scientists in our group include: wind- and buoyancy driven circulation on the inner shelf; effects of stratification on the bottom boundary layer; the dynamics of estuarine fronts; three-dimensional modeling of estuarine sediment transport and water quality; the association of characteristic density- and tidally-driven estuarine circulation patterns with the fate and transport of pollutants; wind wave evolution in estuaries and on shelves; and the physics governing sediment transport on shelves and in the surf zone.

Research Facilities

The department maintains state-of-the-art equipment for conducting high-quality field and laboratory research. Major field equipment includes: Laser In-Situ Scattering and Transmissiometry (LISST); sea-bed hydraulic flume; and bottom boundary layer instrumental tetrapod systems for measuring bed stress, wave and currents, sediment resuspension, and bed-level changes. A variety of instrumentation including tide gauges, current meters, conductivity- temperature-depth (CTD) profilers, fluorometers, dissolved oxygen (DO) meters, fathometers, dual-frequency side-scan sonars, variable frequency seismic profiling systems, directional wave gauges, turbidity sensors, acoustic Doppler current profilers (ADCP), and Kasten and box corers are available for field studies. Microwave and GPS navigation systems are maintained by the department for accurate positioning of research vessels.

The department houses extensive laboratory instrumentation, including: an elemental analyzer; UV/Vis spectrophotometer; gas chromatographs with flame ionization and electron capture detectors; quadrupole mass spectrometers; EDS system with full SEM imaging capabilities; nitrogen adsorption surface area and porosity analyzer; high performance liquid chromatograph with UV absorbance and liquid scintillation detectors; two laboratory flumes (recirculating and annular); five intrinsic germanium gamma spectrometers; eight channel alpha spectroscopy system; X-ray radiography unit; sedi-graph automatic particle analyzer; rapid sediment analyzer. Computer facilities range from laptop units for field use to work stations supporting LANs (local area networks) to the institute-wide network. Computer users have ready access to external networks. For numerical modeling, department personnel also use a multi-processor UNIX machine maintained by VIMS, and the College of William & Mary's zoo-processor SCI-CLONE supercomputer cluster.

Preparatory Studies

In all aspects of the Department of Physical Sciences' education and research programs, there is a heavy reliance on quantitative skills. Our incoming students are expected to have a strong background in one or more areas of physical sciences and mathematics. Undergraduate majors providing preparation for graduate study in Physical Sciences include physics, applied mathematics, engineering, chemistry and geology. Biological Sciences majors interested in pursuing graduate work in Physical Sciences are encouraged to include introductory physics and calculus through ordinary differential equations in their backgrounds.

The present facilities and equipment available in the department are described in more detail on the departmental website.

Typical Course of Study

Graduate students in chemical oceanography/marine geochemistry may specialize in any of the various aspects of marine and environmental chemistry. Required courses include Principles of Chemical Oceanography (MSCI 524), and Advanced Aquatic Chemistry (MSCI 630) is recommended. Specialized course work in other aspects of marine and environmental chemistry can be selected through recommendation of the student's thesis committee.

Students interested in geological oceanography may pursue tracks emphasizing sedimentary environments and stratigraphy, sediment geochemistry, or physical transport/morphodynamic processes. Courses include marine sedimentation, coastal morphodynamics, benthic boundary layers, multivariate and time-series analysis, and isotope geochronology. Geological Oceanography students are required to take Geological Oceanography (MSCI 522). In addition, depending on a student's particular emphasis, geological students may be required to take advanced courses in physical, chemical or biological oceanography.

For students majoring in physical oceanography, required courses include Principles of Coastal and Estuarine Physical Oceanography (MSCI 520). Advanced courses address estuarine hydrodynamics and water quality, providing an in-depth focus on estuarine physics and its influence on biogeochemical processes. Additional courses address other advanced topics in ocean dynamics and apply three-dimensional numerical modeling to estuarine and coastal issues.



Marine and Environmental Policy Tracks

The School of Marine Science recognizes the critical need to improve communication between marine scientists and resource managers, policy makers, and the public. This requires literacy in the language of policy. Students enrolled in the M.S. and Ph.D. programs in Marine Science who wish exposure to Marine and Environmental Policy can elect one of the following options:

- A combined marine science and public policy program is available in which students may obtain both a Masters of Science (M.S.) degree in Marine Science and Public Policy (MPP) in three years, instead of the four years that would be required if each degree were pursued separately. Candidates interested in this concurrent degree program must apply to and gain acceptance by both the School of Marine Science and The Thomas Jefferson Program in Public Policy at the main campus.
- A joint program between the SMS and the Thomas Jefferson Program in Public Policy (TJPPP) at the main campus enables students to complete additional course work for a sub-concentration in marine policy. Students exercising this option will receive a notation of “Sub-concentration in Marine Policy” on their transcript. In addition to the course work required for the M.S. or Ph.D. degrees in Marine Science, the following criteria must be met by students pursuing the marine policy track:
 1. Completion of 10 credits of course work to include the following courses:
 - a. MSCI 689, Public Policy for Science and Professions. 3 credits. (main campus)
 - b. MSCI 687, Environmental Policy. 3 credits. (main campus)
 - c. Sea Grant Policy Seminar Series. 1 credit.
 - d. Elective course (3 credits) from the following menu:
 - MSCI 684 Coastal & Marine Policy and Management (VIMS campus)
 - MSCI 693 (Law 424) Environmental Law (main campus)
 - MSCI 694 (Law 425) Land Use Control (main campus)
 2. All grades for coursework in the Marine Policy sub-concentration must be B- or above.
 3. A student must receive the approval of his/her advisor prior to starting the joint program.
 4. Once the student is approved for the sub-concentration, notification must be made to the SMS Graduate Registrar.
- Within the SMS, students can access a wide range of cross-departmental policy and resource management-oriented courses that are designed to provide a more complete understanding of marine and environmental policy and its application to marine problems. In addition, courses related to environmental law are available through the Marshall-Wythe School of Law at the main campus.

Course Descriptions

Graduate Courses

These descriptions provide basic information about the courses. Actual course content and format are updated regularly and may also be modified to meet students' specific needs. MSCI 691 to MSCI 696 are cross-listed courses taught by staff of the College of William and Mary's School of Law on the Williamsburg campus. Students wishing to take any of these courses must contact the School of Law instructor to gain permission.

MSCI 501A - Fundamentals of Marine Science, Physical Oceanography. Fall (2) Brubaker

This course provides an introduction to the various types and scales of motion in the ocean, the global heat budget, major water masses, and processes controlling distributions of temperature and salinity. Discussions on phenomena associated with water motion will include global circulation, wind-driven circulation in ocean basins, tides, coastal upwelling, storm surge, waves, turbulence, and circulation in estuaries. Underlying dynamics governing water motion will be presented, elucidating the role of the rotation of the earth. The El Nino/La Nina oscillation will be examined as a key example of large-scale ocean-atmosphere interactions.

MSCI 501B - Fundamentals of Marine Science, Chemical Oceanography. Fall (2) Dickhut

This course presents an overview of the chemistry of estuaries and the ocean including chemical processes that occur in marine sediments and at the air/sea interface. Discussion topics will include the chemical properties of seawater, chemical equilibrium and kinetics, the seawater carbonate system and ocean acidification, the global and oceanic carbon and nitrogen cycles, ion speciation, trace metals, and nutrients, sediment diagenesis, and fundamentals of radioisotope and stable isotope biogeochemistry. Interdisciplinary applications are emphasized.

MSCI 501C - Fundamentals of Marine Geology. Fall (2) Hobbs

This course provides an introduction to the major topics of marine geology without expecting the student to have a background in geology. The course addresses the age and internal structure of the earth, the processes of plate tectonics including the formation of oceanic crust, seamounts, hydrothermal vents, the characteristics and classification of sediments and the distribution of sediments in the deep sea. Also addressed is the interrelationships among and importance of paleoceanography, climate change, and sea-level change, and the processes and characteristics of various marine, estuarine, and coastal sedimentary environments. The course includes discussion of various types of field equipment and logistics and of some economic and societal implications.

MSCI 501D - Fundamentals of Marine Science, Biological Oceanography. Fall (2) Steinberg

This course examines the biology and ecology of marine organisms and how they interact with their environment. Topics include the organisms and their behavior, distribution, and underlying physiology; effects of biology on elemental and nutrient cycles and visa versa; and ecosystem structure and ecological interactions. An interdisciplinary

approach will be taken, as biology both depends on and influences ocean chemistry, physics, geology, and climate. The course will emphasize open ocean, pelagic systems, but will include many examples from coastal and estuarine systems, as well as shallow and deep-sea benthic ecosystems.

MSCI 501E - Fundamentals of Environmental Chemistry, Toxicology and Pathobiology. Fall (2) Van Veld, Vogelbein

This course emphasizes ongoing and emerging environmental concerns in the Chesapeake Bay and world ocean. Lectures will address basic concepts and mechanisms of contaminant chemistry and toxicology, infectious and noninfectious diseases in aquatic organisms. Case histories will be used to illustrate sources, fate and effects of anthropogenic chemical contaminants, and the important role of environmental change on disease in marine and estuarine ecosystems.

MSCI 501F - Fundamentals of Marine Fisheries Science. Spring (2) Fabrizio, Graves

This lecture course is intended for SMS students outside of the Department of Fisheries Science and will introduce the principles and techniques of fishery science. Lecture topics will include the theory and impacts of fishing, description and status of international, North American and regional fisheries, fisheries oceanography, recruitment processes, single-species and ecosystem-based approaches to stock assessment, and fisheries management, and the goals and problems of sustaining an open-access common pool resource.

MSCI 503 - Interdisciplinary Research in Estuarine and Coastal Systems. Spring (2) Brush

This is an interdisciplinary, field-based laboratory course applying concepts from MSCI 501 to a semester-long study of the estuarine and coastal environments of the lower Chesapeake Bay and Virginia's Eastern Shore. The course is designed to expose students to today's typical interdisciplinary research process from project conception through presentation of results. Students will organize into cross-disciplinary groups around a particular study site and research topic, and develop and implement a scientifically sound, hypothesis-driven research plan through a series of group cruises and instrument deployments. Particular emphasis will be placed on spatial and temporal patterns of biotic and abiotic processes and their interactions, along with sample design, collection, analysis, and interpretation of data. Students will also be exposed to utilizing historical and ongoing databases as well as synthesizing data from each group member to create an interdisciplinary story. The course culminates with oral presentations and a group poster.

MSCI 504 - Fundamentals of Statistical Methods and Data Analysis. Spring (4) Latour

In this course, students are introduced to the fundamental statistical methods commonly used for analysis of biological and ecological data. Topics include describing data, probability distributions, statistical inference, hypothesis testing, elementary experimental design, analysis of variance, and regression and correlation. The introductory aspects of categorical data analysis and multivariate techniques will also be covered. Course content will be integrated with a weekly laboratory session using the statistical computing language R.

MSCI 506 - Scientific Communication Skills. Spring (2) Milliman

The important elements of oral and written presentation skills for communicating scientific research will be reviewed in this course. The course addresses topics such as

the critical evaluation of literature, development of scientific questions and rationale for research, and formulation of conceptual models for developing high-quality scientific research projects. Oral and written presentation skills are emphasized through written exercises and class presentations, with peer review.

MSCI 515A-D - Marine Science Seminar. Fall and Spring (1) Staff

The departmental seminar course offers a multidisciplinary review of significant areas of marine science. Guest speakers will present a variety of views, and course participants will organize and present talks related to the seminar theme. Students may repeat seminar registration as required by their respective departments; however, only two (2) credits will be applicable to an SMS degree.

MSCI 520 - Principles of Coastal and Estuarine Physical Oceanography. Spring (3) Brubaker, Friedrichs

Following a review of the governing equations, the lectures and discussions of this course will focus on dynamics of currents and waves on continental shelves and in estuaries. Topics to be covered include fundamentals of wind and density-drive flow, and aspects of fronts, mixing and secondary circulation. Time-dependent motion such as surface gravity waves, internal waves, and coastally trapped waves and tides also will be discussed.

MSCI 522 - Principles of Geological Oceanography. Fall, even years (3) Kuehl

A brief review of the tectonic history of the oceans will be presented in this course, followed by detailed study of the ocean margins, including sea-level history and near shore geological processes in the coastal zone and continental shelf regions. The geological effects of bottom currents on ocean sediments will be examined along with ocean basin sediment history and approaches to pale oceanography.

MSCI 524 - Principles of Chemical Oceanography. Spring (3) Bauer, Beck, Canuel. Prerequisite: Instructor's consent

This course covers in a comprehensive and integrated manner the important factors controlling the chemical composition of seawater. Basic principles of chemical thermodynamics will be applied to the seawater medium and will serve to introduce contemporary, global-scale chemical processes such as the role of the oceans in global climate change. Selected topics include distributions of the bio limiting elements; chemistry of marine sediments; trace metal chemistry; marine organic chemistry; and ocean-atmosphere interactions.

MSCI 526 - Principles of Marine Ecology. Spring, odd years (3) Duffy, Tang

Students will study the fundamental processes underlying structure and functioning of marine ecosystems. Lectures, readings and discussion will emphasize physical processes supporting primary production, planktonic and benthic dynamics, distribution and functional importance of marine biodiversity, biotic interactions structuring communities, vertical and horizontal distributions, and food web structure. Also addressed will be the ecological role of higher and lower trophic levels, and response of marine ecosystems to anthropogenic pressures and global change. The course concludes with an exercise in proposal writing and reviewing.

MSCI 527 - Coastal Botany. Fall (3) Perry

A botanical and ecological survey of vascular plant communities of the mid-Atlantic coastal plain is presented in this course. Discussion topics include the common and

important terrestrial, emergent and aquatic vascular plant species of the coastal plain tidal marshes, swamps, beaches, dunes, maritime forests and submerged aquatic communities of the mid-Atlantic coastal regions as well as their strategies for survival in these coastal habitats. The course consists of field trips as well as both laboratory and lectures sessions.

MSCI 528 - Marine Fisheries Science. Spring (3) Fabrizio, Graves

This course focuses on the principles and techniques of marine fisheries science, including the theory of fishing, age and growth, definition of stocks, catch statistics, description of world fisheries, and goals and problems in managing a common property resource. Students will participate in lectures, laboratory exercises, and field trips.

MSCI 543 - Law and Resource Management. Fall (3) Taylor

This course is designed to introduce scientists, resource managers and environmentalists to the legal principles and tools used to address the causes of environmental degradation and resource depletion. The argument is not for more or less environmental law, but better environmental law. The approach reflects the view that law governs activities not



the environment. Rather than using a traditional approach to teaching the law, environmental and resource law is explained as it relates to human and societal activities from the time resources are allocated to their manufacture and disposal. Activities are examined from resources to recovery within three major domains: harvesting, energy and feedstocks. Geographic scope and history, the laws governing the activity and an evaluation of goals and effectiveness are provided in case studies. Attention is given to the role of law in altering human and societal behaviors in favor of a better environment and resource conservation. (Cross-listed with PUBP 626 and LAW 341).

MSCI 545 - Marine Sedimentation. Spring, even years (3) Milliman, Staff

This course provides an introduction to continental margin sedimentary environments with emphasis on physical, biological and chemical controls on the development of sedimentary strata over a range of spatial and temporal scales. Case studies from modern settings will be used to illustrate concepts of strata formation. Laboratory exercises include petrographic, textural and mineralogical analysis.

MSCI 548 - Technical and Continuing Education in Marine Science. Fall, Spring and Summer (1-3) Staff. Prerequisite: Instructor's consent

This course provides graduate-level instruction to public school teachers and other professionals who require postgraduate certification or special training. Courses are offered on an occasional basis as demand warrants. Instructors or faculty team members identify a client group and formulate a course description that serves individual professional needs. Courses may include lecture and laboratory components, field trips and demonstrations. An example of a course offered recently is experimental design in the marine science laboratory, a lecture and laboratory course for science teachers that addressed standards of learning in Virginia.

MSCI 550 - Rivers: Processes and Problems. Spring, odd years (3) Milliman

Rivers form the main link between land and the ocean, discharging more than 35 thousand km³ of water and more than 20 billion tons of suspended and dissolved solids annually to the global ocean. Three central themes are stressed: 1) How do rivers work: the hydrologic cycle and water budget, basin character, physical and chemical erosion; 2) Temporal and spatial variations, ranging from seasonal to millennial, with particular emphasis on catastrophic events; 3) Human interactions: land degradation, river management, future impact of climatic change and anthropogenic activities. Includes a one-week field trip.

MSCI 552 - Coastal Sedimentary Environments. Fall (3) Staff

This course examines the depositional systems of coastal sedimentary environments such as sand-dominated (barrier islands), mixed (modern deltas), and mud-dominated (wetlands, tidal flats). Modern and ancient examples will be explored in field trips and lectures. Controlling physical and sedimentary processes will be emphasized. Depositional environmental parameters, particularly hydrodynamics, will be interpreted from geomorphology and sedimentary structures. Observational techniques, such as satellite imagery, near-bottom current measurements, seismic profiles, and vibracores will be discussed in lecture and utilized during field trip exercises.

MSCI 553 - Introduction to Benthic Boundary Layers and Sediment Transport. Fall, even years (3) Harris

This course addresses the physical and geological aspects of coastal and estuarine benthic boundary layers, their dynamic forcing and the associated suspension and transport of sediments. Principles of waves, tides and currents are introduced with emphasis on shall-water processes. Boundary layer structure and shear stress on the seabed, wave boundary layers and turbulence are considered in relation to the coastal environment. Forces on sediment particles, initiation of sediment movement and principles of sediment transport are treated at an intermediate level.

MSCI 554 - Principles of Numerical Computing. Spring, odd years (3) Harris, Wang

This course provides students in the marine sciences with the tools needed to pursue study and research using numerical methods. It will enable them to write programs to solve fairly complex problems, to explore and understand the current literature in which numerical methods are used. Topics include principles of floating-point computation, interpolation, linear and non-linear systems of equations, numerical integration, ordinary and partial differential equations, and optimization. Emphasis is placed on finite difference solutions to conservation of mass and momentum equations. The course consists of three lecture hours per week, assigned problems using MATLAB, and a term project in a topic chosen by the student.

MSCI 556 - Biogeochemical Modeling. Spring (3) Dickhut

This course will focus on developing mathematical descriptions for biogeochemical processes, as well as on using mathematical models to design experiments to verify specific biogeochemical mechanisms in a system. Equations describing biogeochemical processes will be derived. Discussion will include descriptions of the conditions and assumptions of the models, as well as situations where specific models apply. The course will emphasize mathematical derivations, graphical visualization and use of model fitting software.

MSCI 558 - Protein Biochemistry in Marine Organisms. Spring (3) Van Veld, Staff
Synthesis, structure and function of proteins with an emphasis on proteins and enzymes involved in health and disease of marine organisms are covered in this course. The course also will examine unique protein adaptations in response to environmental stress. Methods of detection, purification and characterization of proteins including new proteomic approaches will be evaluated.

MSCI 559 - Parasitology. Spring, odd years (3) Shields. Recommended: Invertebrate Zoology or comparable course

This course covers the biology and ecology of protozoan, helminth and crustacean parasites. Focus is on parasites of medical and veterinary importance. Emphasis is placed on life cycles, pathology, control methods and ecological impacts of parasitic infections. Three lecture and three laboratory hours. (Cross-listed with Bio 404 and Bio 504)

MSCI 560 - Fundamentals of Ecotoxicology. Spring (3) Newman. Prerequisite: Basic Ecology

This course is an introduction to ecotoxicology, the science of contaminants in the biosphere and their effects on constituents of the biosphere, including humans. The course provides a general survey of environmental toxicology and risk assessment from an ecological vantage.

MSCI 562 - Water Pollution. Fall (2) Hale

This course will introduce students to processes impacting aquatic environments. Emphasis will be on pollution by man-made chemicals and metals. Additional topics include consequences of excessive nutrients, habitat modification and introduction of exotic or elimination of native species.

MSCI 563 - Environmental Chemistry. Spring (3) Unger

The fundamental physical, chemical and biological processes controlling the fate of major classes of aquatic contaminants are covered in this course. Topics such as photolysis, biodegradation, sorption and redox chemistry are examined to elucidate the mechanisms controlling chemical degradation and transport. Case studies are used to show how these basic research principals can be integrated and applied to solve real word environmental problems.

MSCI 564 - Aquatic Toxicology. Spring (3) Van Veld

This course will present factors influencing the fate and behavior of major environmental toxicants in aquatic organisms and mechanisms involved in their uptake, distribution, biotransformation and clearance. Topics of discussion will include the effects of toxicants on aquatic organisms ranging from effects at the biochemical and cellular level, to effects on individuals, populations and communities. Current methods of laboratory and field toxicity testing will be addressed

MSCI 565 - Principles of Pathobiology. Spring (3) Kaattari, Shields

This course focuses on the molecular and cellular mechanisms of pathogenesis in important emerging diseases in the medical, veterinary, and aquacultural fields. Students will learn how current molecular and cellular techniques are being applied to the resolution of a variety of infectious and non-infectious diseases. Mammalian models provide a foundation for application to the diseases of fish and shellfish.

MSCI 566 - Diseases of Marine Organisms. Fall, odd years (4) Burreson

This course includes identification, life histories, pathology, and control of important infectious disease agents of fish and shellfish including viruses, bacteria, protists, helminths and arthropods. Also covered will be general principles of disease in the marine and estuarine environment. Three lecture and three laboratory hours.



MSCI 567 - Comparative Immunology. Fall, odd years (3) Kaattari. Recommended: Some familiarity with biochemistry and genetics.

This lecture course focuses on the immunology of teleost and elasmobranch fish. Topics include the biochemistry of antibody function, the molecular and cellular basis of the immune response, the role of innate and adaptive immunity in disease resistance, aquacultural vaccine design, development, and application, immunopathology, immunodeficiencies, and immunotoxicology.

MSCI 572 - Estuarine Benthic Processes. Fall, odd years (3) Moore, Schaffner

This course examines current concepts in estuarine benthic processes, especially the major factors governing productivity and biodiversity. It is organized around the theme of major habitats from the upper to lower estuary and open bay, and the coastal bay mouth region. Lectures and readings will draw on examples from the Chesapeake Bay and other estuarine systems. The format consists of lectures and discussions of the primary literature.

MSCI 573 - Environmental Microbiology. Fall, even years (3) Anderson, Kator

This course examines the role of autotrophic and heterotrophic microorganisms in response to anthropogenic and natural perturbations of importance in aquatic environments. Specific topics may include responses to nutrient enrichment and changes in sea level, temperature, and light quality/quantity. The effect of global climate change on microbial biodiversity, factors leading to the development of harmful algal blooms, and the occurrence and transmission of water-borne pathogens will also be considered. Attention will also be focused on the role of microorganisms in biodegradation and bioremediation in both surface and subsurface habitats. Methodologies for detecting microorganisms and measuring processes in a variety of environments will be addressed as well as regulatory approaches designed to address environmental microbiological concerns.

MSCI 575 - Aquatic Microbial Ecology. Fall, odd years (3) Anderson, Kator. Recommended: Organic chemistry or biochemistry

This course provides an introduction to the role that microorganisms play in the biogeochemical cycling and production of dissolved and particulate inorganic and organic matter in freshwater and marine ecosystems. The approach will be ecological, relating environmental physiochemical properties to regulation of microbial processes, distributions, and biodiversity. Topics will include state of the art methods for detecting

distributions, biomass, and activities of microorganisms in the natural environment, the energetics regulating microbial processes, microbial biochemical pathways, biodegradation, microbial interactions, and the role that microorganisms play in the food webs of various ecosystems. Although emphasis will be placed on marine systems, processes in lacustrine, riverine, and groundwater ecosystems will also be discussed. Readings will draw heavily on the primary literature.

MSCI 576 - Evolutionary Ecology. Fall, even years (3) Duffy

This course presents a conceptual and empirical exploration of interactions between environment and evolution of organismal structure, function, and behavior in deep time through contemporary ecological time scales. Topics include natural selection and adaptation, sexual selection and mate choice, evolution of life histories, speciation, coevolution, human evolutionary ecology, and evolutionary responses to human-induced environmental change. Reading, discussions and writing projects draw from the primary literature, concentrating on examples involving marine organisms.

MSCI 577 - Biomechanics of Marine Organisms. Spring, odd years (3) Patterson

This course introduces principles from the physical sciences (fluid and solid mechanics, mass and heat transfer theory) applied to the analysis of form, function, ecology, and evolution of marine organisms. Topics covered include suspension and deposit feeding in invertebrates, allometry of metabolic processes, locomotion of fishes and plankton, thermal transactions in intertidal organisms, the biology of the benthic boundary layer, and the properties of biomaterials and biological structures. Engineering methods and measurement techniques applicable to biomechanical investigations will be presented.

MSCI 578 - Ocean Observing Systems: Technology and Applications. Fall, odd years (3) Patterson

Ocean Observing Systems (OOSs) are oceanography's newest tools, and this course aims to make graduate students expert in ocean observing system technology and applications. The course includes weekly "hands-on" experience with Autonomous Underwater Vehicles (Fetch 1 AUV), sensor platforms like the VIMS buoys in the York River, and other online resources at other OOSs planet-wide. Topics include but are not limited to hardware components of OOS platforms (buoys, AUVs, gliders, shore-based radars), sensors, navigation techniques and georeferencing, integration of OOSs with models, OOS data management issues, and science and dual use (homeland defense, search and rescue, shipping commerce) aspects. Students from all disciplines are qualified to take this course. Student presentation of original work with an OOS is required.

MSCI 579 - Wetlands Ecology. Fall (4) Chambers, Perry. Prerequisite: Instructor's consent

Structural and functional attributes of tidal and non-tidal wetlands are examined in this course, with emphasis on analysis of wetland systems at the landscape and community level. The course provides an introduction and practical experience in common research techniques, including wetland classification, vegetation mapping, functional assessment models, and field sampling techniques. Individual research projects and/or a paper will be expected. The course includes lectures and field trips. (Cross-listed with BIOL 427, BIOL 627)

MSCI 580 - Asian Environmental Issues of the 21st Century, Spring, (3) Perry, Smith

This purpose of this course is to provide students with a working knowledge of past, current, and future environmental issues in East Asia in relation to societal, economic, and regulatory structures. Emphasis will be placed on large-scale environmental issues that impact ecological, social, and economic processes. Students will be expected to assimilate the course material into hypothetical development of future East Asian and global environmental policies. Grading will be based on a presentation, written mid-term prospectus, and final term paper on an individual environmental topic. (Cross-listed with ENST 440-02).

MSCI 581 - Estuaries Management. Spring (3) Taylor

This course is designed to introduce students to the concepts and ideas related to estuarine ecosystems, their management and preservation. The place and purpose of humans in the ecology and evolution of estuarine ecosystems will be examined.

MSCI 583 - Molecular Genetic Data Analysis, Bioinformatics. Spring, odd years (3) Reece

This is a lecture and largely computer-based laboratory course covering the principles and practice of analyzing and interpreting population genetic, phylogenetic and genetic mapping datasets. Molecular data sets including sequences and genotypic profiles will be generated on agarose gels or the automated sequencers/gel scanners. Data will be exported and processed for analysis by the appropriate suite of computer software programs. Software to be utilized include DNA sequence analysis, genotyping, population genetic, sequence alignment, phylogenetic, and mapping programs. Phylogenetic programs will include those based on genetic distance, maximum parsimony, maximum likelihood and Bayesian analyses. Population genetics programs include those such as GenePop to perform standard population genetic statistical analyses, Arlequin for doing AMOVAs, and STRUCTURE for doing assignment testing.

MSCI 599 - Thesis. Fall, Spring and Summer (hours to be arranged)

This is the avenue for original research in biological, chemical, geological and physical oceanography, environmental science, marine fisheries science and marine resource management. The master's project is chosen in consultation with the student's major professor and the Dean of Graduate Studies.

MSCI 610 - Effects of Global Change on Modern Marine Systems. Fall (2-3) Bauer, Canuel, Smith

The course will explore the recent literature highlighting effects of climate and global change on various aspects of marine systems including (but not limited to) biogeochemical cycling, ecosystem structure and function, alterations in ocean chemistry, and physical processes such as polar and glacial ice melting, ocean circulation and sea level rise. The course is designed as a 2-credit course. Students will be evaluated primarily on the basis of the quality and organization of the class discussion they lead (including a short introductory background presentation), as well as participation in all other class discussions. In addition, a short (5 pages) critical writing assignment assessing the effectiveness of one or more recently published papers on impacts of global change in marine systems will be required. A 3-credit option may be made available to students who wish to undertake more detailed independent study of a particular topic in the form of additional readings and a research term paper.

MSCI 611 - Estuarine Hydrodynamics I. Spring, even years (3) Wang. Prerequisite: MSCI 520

This course examines classification of estuaries, time scales of motions, tidal dynamics in estuaries, non-tidal circulation, mechanism of arrested salt wedge, gravitational circulation, diffusion induced circulation and turbulence in stably stratified flows.

MSCI 612 - Estuarine Hydrodynamics II. Fall, even years (3) Wang. Prerequisite: MSCI 611

The contents of the course includes zero-, one- and two-dimensional descriptions of estuaries, salt intrusion, and pollutant flushing sediment transport through estuaries, field experience in estuaries and model laws for estuarine models.

MSCI 613 - Ocean Dynamics. Fall (3) Brubaker, Friedrichs. Prerequisite: MSCI 520 or Instructor's consent.

In this course, conceptual and analytical models are used to elucidate the effects of the rotation of the earth, stratification, and friction on the dynamics of ocean motion at various scales. Topics include wind-driven gyre circulation, coastal upwelling, turbulence in stratified flows, large-scale waves, internal waves, and climate dynamics.

MSCI 615 - Hydrodynamic Modeling of Estuarine and Coastal Waters. Spring (3) Wang. Prerequisite: MSCI 613 or Instructor's consent

This course will survey numerical methods for the solution of partial differential equations describing the estuarine and coastal water motion and transport. Topics include stability, accuracy, consistency and convergence analysis of numerical scheme, formulation of primitive and scalar transport equations, and the pre- and post-processing for numerical computational models. The course will involve classroom lectures, seminar readings, application of models for operational environmental prediction.

MSCI 617 - Estuarine Water Quality Models. Fall, odd years (3) Staff. Prerequisite: MSCI 611

This course examines the principles of mass balance, physical transport processes, diffusion and dispersion in estuarine environments. Water quality processes, representation of biochemical transformations, dissolved oxygen modeling and survey of available models are other topics of discussion.

MSCI 621 - Morphodynamics of Deltaic Coasts and Shelves. Fall, odd years (3) Friedrichs

This course focuses specifically on morphodynamic processes operating on coasts and shelves that receive large inputs of mud from rivers. The term morphodynamics implies the coupled suite of mutually interdependent hydrodynamic processes, coastal and seafloor morphologies, and sequences of change. As in the case of non-deltaic coastal morphodynamic systems, mutual adjustments among coastal physical oceanographic flows, depositional morphologies and sediment transport processes are fundamental and current understandings and data on these phenomena will be presented.

MSCI 623 - Isotope Geochronology. Fall, odd years (3) Kuehl

The focus of the course is on the principles of radioisotope dating techniques with emphasis on those applicable to marine settings. Equations of radioisotope decay and in growth will be detailed along with the geochemical systematics of each technique.

MSCI 624 - Ocean Waves: Theory, Measurement and Analysis. Fall, even years (3) Maa. Prerequisite: Instructor's consent

In this course, students are introduced to linear water wave theory and its applications. Course topics include mechanisms of wave generation (wind waves and tides), the governing equations, wave properties, wave transformation, special cases for tidal wave propagation (e.g., Kelvin waves), wave bottom boundary layer, nonlinear properties (i.e., radiation stress). Practical applications of numerical models for wind wave generation, wave transformation, the spectrum analysis for wave measurements, and harmonic analysis for tides will be introduced and demonstrated.

MSCI 625 - Multivariate Analysis and Time Series. Spring, odd years (3) Forrest

This course will address the topics of regression and modeling, analysis of residuals; Multivariate regression, eigenvector methods, principal component analysis and factor analysis. Fourier and stochastic models applied to geophysical and other time series data sets will be included.

MSCI 626 - Advanced Quantitative Methods for Marine Scientists. Spring (3) Staff

Topics in this course include an introduction to matrices, multiple regression, sensitivity analysis, non-linear function-fitting techniques. Additional areas of focus include empirical eigen function methods with applications, complex notation as applied to the description of sinusoidal variations, and fourier transforms spectra and filtering.

MSCI 627 - Marine Organic Geochemistry. Spring, even years (3) Bauer, Canuel. Prerequisite: Organic Chemistry

This course focuses on the characterization of organic carbon, nitrogen, phosphorus and sulfur in the marine environment. Modern methods of organic analysis that enhance our understanding of how organic materials cycle through the oceans will be discussed. Topics include the role of organic matter in the C, N, S and P cycles; chemical composition of marine organic matter; biogeochemistry; diagenetic transformations of organic materials; organic matter decomposition and preservation; and petroleum geochemistry.

MSCI 627L - Marine Organic Geochemistry Lab. Spring, even years (1) Bauer, Canuel. Prerequisite: Organic Chemistry

In this 1-credit lab module students will conduct an independent lab project that complements the lecture portion of MSCI 627.

MSCI 629 - Environmental Organic Chemistry. Fall, odd years (3) Dickhut

This course presents an overview of the partitioning, transport, and transformation processes controlling the environmental fate of organic contaminants. The fundamentals of thermodynamics and chemical kinetics relevant to organic chemical fate and transport, elementary mass transfer equations and their application to chemical transport in the environment is discussed.

MSCI 630 - Advanced Aquatic Chemistry. Fall, even years (3) Staff

This course describes of the principles of chemistry focusing on the chemistry of natural waters. Topics include chemical kinetics and thermodynamics, structure and properties of liquid water, electrolyte solution chemistry; carbonate equilibria, precipitation-dissolution reactions, basic coordination chemistry, and redox reactions with reference to the physical chemistry of biochemical and aquatic systems.

MSCI 638 - Fish Histology and Histopathology. Spring, even years (4) Vogelbein
The course is a detailed examination of the normal microscopic structure and function of tissues and organs in fishes and the morphological and functional changes that occur in tissues during disease. Infectious and non-infectious diseases, including pathological changes elicited by chemical toxicants and environmental factors will be evaluated. Lab will consist of in-depth training in routine methods of paraffin histology and histochemistry. (Three lecture and 3 laboratory hours. Restricted to 6 students.)

MSCI 640 - Quantitative Ecotoxicology. Spring (4) Newman
This course covers essential ecotoxicology principles and quantitative methods for the analysis of ecotoxicological data. Laboratory exercises will include method applications with PC-based software. Emphasis will be placed on the scientific and statistical soundness of techniques.

MSCI 641- Identifying, Quantifying and Communicating Environmental Risk. Fall (3) Newman
Methods for identifying harmful agents, quantifying any associated risk, and communicating that risk will be covered in this course, with an emphasis on practical, quantitative techniques. The basic NRC framework and methods for environmental risk assessment are presented for comparative, retrospective, and predictive assessments. The course explores logical and quantitative methods for identifying hazards in the presence of high uncertainty, working in teams to effectively assess risk, and communicating risk to stakeholders. Bayesian inference and estimation will be emphasized with additional theory and quantitative methods drawn from cognitive psychology, epidemiology, innovation diffusion theory and group decision theory.

MSCI 642 - Practical Environmental Statistics. Spring, even years (3) Newman.
Prerequisite: Instructor's consent
This course explores practical statistics for sampling, measuring, and making sound inferences from environmental data. The course is intentionally a broad survey of methods applicable to physical, chemical and biological studies, drawing examples from each of these areas. It will blend lectures, student-directed exploration of concepts, and computer-based examples. Exercises will be done with the SAS statistical software package and other more specialized shareware. Eight general themes will be addressed: quantitative measurement, basic measurement quality control/outlier detection, variance structure, applications of regression analysis, sample size estimation, establishing field sampling or laboratory experiment designs, quantifying belief, and Monte Carlo/Bootstrap methods.

MSCI 648 - An Introduction to Mathematical Biology. Fall (3) Staff
In this course, students are given an introduction to developing, simulating, and analyzing models to answer biological questions. Mathematical topics may include matrix models, non-linear difference and differential equations, and stochastic models. Biological topics may include ecology, epidemiology, evolution, molecular biology, and physiology. (Cross-listed with MATH 345).

MSCI 649 - Modeling Biological and Ecological Systems. Spring, even years (3) Brush, Latour
This course provides an introduction to quantitative modeling in marine science, with an emphasis on the process of constructing mechanistic models of biological, ecologi-

cal, and biogeochemical processes. General topics include determination of modeling objectives and assumptions, model formulation and parameter estimation, determination of model accuracy through calibration, validation, and sensitivity analysis, and use of models to address scientific questions through simulation analysis. Types of models covered include compartmental ecosystem models, age/size-structured population models, and food web network analysis, with consideration of deterministic, stochastic, and spatially explicit approaches. Lectures are supplemented with readings from the primary literature and students receive hands-on experience building and using models through in-class lab exercises.

MSCI 652 - Marine Plankton Ecology. Fall, odd years (3) Smith, Steinberg, Tang.
Prerequisite: MSCI 524 or 526 or consent of the instructors

This course will cover contemporary topics in cellular, population, community and ecosystem level dynamics of plankton systems, including nutrients and organic matter, viruses, bacteria, phytoplankton, protists and zooplankton. Course format will be primarily discussions, student presentations, literature evaluation, and writing exercises.

MSCI 653 - Marine Benthos. As required (3) Diaz, Schaffner. Prerequisite: Permission of instructor

Ecology of marine and estuarine benthos is the focus of this course. Emphasis is placed on determining how ecological processes affect function and structure of benthic communities. Consideration is given to interactions among autotrophs, micro-heterotrophs and larger metazoans and interactions between these organisms and their physical-chemical environments.



MSCI 655 - Stable Isotope Biogeochemistry. Fall, even years (2) Anderson, Bronk
This course is a survey of applications that use stable isotopes of carbon, nitrogen, oxygen, and sulfur to define elemental flow through experimental and natural systems. Topics include stable isotope theory; tracer versus natural abundance techniques; quantifying processes of elemental uptake, regeneration, and respiration; and defining trophic relationships using multiple tracers.

MSCI 656 - Seagrass Ecosystems. Spring, odd years (1-2) Moore, Orth

This lecture-seminar course covers topics related to seagrass ecosystems. Emphasis will be on the structure and function of seagrass communities, submerged angiosperm physiology, primary and secondary production, and integration of seagrass communities to the marine environment. Students will be assigned projects to complete. Course credit will depend upon difficulty of the assignments and must be arranged prior to registration.

MSCI 657 - The Early Life History of Marine Fishes. Fall, odd years (3) Staff.
Prerequisite: MSCI 666 or consent of instructor

This lecture and laboratory course offers a comprehensive view of the biology and taxonomy of early life stages of fishes. These stages (pelagic eggs, larvae and newly-transformed juveniles) are abundant and diverse components of aquatic ecosystems.

Their small size, dynamic growth and mortality rates, and dependence on ambient environmental factors make these stages vulnerable to variability in climate and to stresses of anthropogenic origin. Level of reproductive success in teleosts, termed recruitment, is highly variable and largely dependent on variability in survival of these early life stages. Knowledge of their morphological development contributes to studies of phylogenetic relationships. In the laboratory, larvae of 180 families of teleostean fishes are examined and characters useful in identification are presented. (Two lecture and two laboratory hours) See <http://www.vims.edu/adv/657/>.

MSCI 658 - Larval Ecology. Spring, odd years (3) Mann

The course is based on a broad discussion of the following topics within the marine invertebrates: the concept of the larval form, spawning and developmental patterns, limitations on the fertilization process and embryology, the Reynolds number environment at typical larval size, feeding and nutrition in the larval size range, larval size and parental investment, larval dispersal and supply in maintaining community structure, roles of physical versus biological processes in inducing metamorphosis, early post-metamorphic survival, and larval ecology in extreme environments.

MSCI 659 - Phytoplankton Ecology. Fall, odd years (3) Smith. Prerequisites: MSCI 501 (may be taken concurrently with Instructor's consent.)

This course will examine the factors, which influence the growth, losses and distributions of phytoplankton in marine systems. Topics include photosynthesis, pigmentation, productivity, biochemical fractionation, grazing, and nutrient uptake and interactions. A laboratory will introduce students to modern methods used in the study of phytoplankton such as isotopic measurements, HPLC analysis of pigments, fluorometry, and image analysis. Samples from the local estuaries will be used in the laboratories to illustrate the principles discussed in class.

MSCI 660 - Zooplankton Ecology. Spring (4) Steinberg, Tang

This course will examine the ecology, natural history, basic cell or body design features, physiology, and life histories of all the major groups of zooplankton. Food webs, specialized habitats, physical-biological coupling, and behavior are also discussed. Laboratories will concentrate on the groups or topics that are being discussed that week in lecture. The laboratories will be devoted to studying freshly collected (live local net tows), laboratory cultured, and occasionally museum specimens of the various taxa, and to introducing students to methods of study of zooplankton ecology (microscopy, biomass measurement, grazing experiments). There will also be field trips.

MSCI 663 - Deep-Sea Biology. Spring (2) Vecchione. Prerequisite: Instructor's consent

Students will receive an introduction to the animals of the deep sea and characteristics of deep-sea and polar ecosystems. Lectures will survey the major metazoan groups found in deep-sea habitats, as well as physical characteristics of the environments and adaptations to life in these cold, dark, hyperbaric regions. An opportunity to participate in a deep-sea trawling cruise may be coordinated with the course.

MSCI 664 - Marine Conservation Biology. Spring, even years (3) Lipcius

This course focuses on the application of multidisciplinary scientific principles to the protection, enhancement and restoration of marine biodiversity (genetic, species, com-

munity and ecosystem). Ecological emphasis will be on the conservation of biodiversity threatened by habitat degradation and loss, overexploitation, invasive species, and global change. Social, legal, economic and political influences will be discussed. Also included will be practical application through case studies and training in population viability analysis. (Lecture and laboratory)

MSCI 666 - Ichthyology. Fall (4) Hilton

Fishes comprise a large, diverse group of vertebrates that are culturally, economically, and scientifically important, and they offer much for the study of evolutionary biology. This course provides an intensive overview of all aspects of the evolution of fishes, with an emphasis on their morphology and systematic relationships; other topics include the biogeography, functional anatomy, and physiology of fishes. The lectures will describe the diversity and evolutionary history of fossil and living fishes, and discuss the evidence for different hypotheses of their phylogenetic relationships. The mandatory lab section emphasizes dissection-based anatomical study and the global diversity of fishes, and includes some field sampling.

MSCI 667 - Experimental and Quantitative Ecology. Spring, odd years (3) Lipcius

The course addresses the design, conduct, analysis and interpretation of field and laboratory experiments in ecology. The lectures, discussion and supervised field and laboratory projects are designed to illustrate the diversity of experimental and quantitative approaches in use by ecologists. Topics include the scientific method, experimental design, the use and abuse of statistical techniques, modeling and manuscript preparation, with emphasis on topical ecological issues such as those dealing with predatory-prey interactions, recruitment phenomena, environmental science (e.g., dose-response assays) and metapopulation dynamics. (Lecture and laboratory)

MSCI 668 - Malacology, Spring, even years (3) Mann

The course begins with a discussion of the ancestral mollusc form and the fossil record, proceeds through examination of the structure and function of the molluscan shell. It concludes with reviews of molluscan taxonomy, reproductive biology, physiology, ecology, and feeding mechanisms.

MSCI 669 - Statistical Analysis of Fisheries Data. Fall (3) Fabrizio. Prerequisite: MSCI 528 or consent of instructor, and MSCI 698-SAS and Data Management (or ability to program in SAS or R).

This course emphasizes the design and analysis of field data (e.g., retrospective studies, experimental manipulations in the field), rather than design and analysis of controlled laboratory experiments. Students will gain a working knowledge of statistical methods useful in the analysis of fisheries data. Both theoretical development and application of statistical methods will be presented, including General Linear Models, Generalized Linear Models, and Multivariate Analyses such as principal component analysis, discriminant analysis, and clustering.

MSCI 670 - Stock Assessment Methods. Spring (4) Hoenig

This course will survey methods for assessing the status of exploited populations given various combinations of data types. Emphasis will be placed on deriving statistical methods using maximum likelihood and other analytical techniques, and on computing estimates for a variety of datasets. Population models will be used to integrate information

on stock status in order to determine appropriate management measures. Additional topics include analysis of uncertainty in the assessment of results and implications of uncertainty for management, analysis of research surveys, commercial catch, fishing effort, and tagging data.

MSCI 671 - Fisheries Population Dynamics. Fall (3) Latour

This course provides an introduction to the fundamental processes governing fish population dynamics, with an emphasis on the theory and practical application of models used to characterize the factors influencing population abundance. Topics include the theory of mortality, growth, stock-recruitment (compensation, depensation), surplus production, VPA, statistical catch-at-age, tagging, and the introductory aspects of multispecies and fisheries ecosystem models. Lectures are supplemented with readings from the primary literature and students receive hands-on experience with nonlinear parameter estimation through computer laboratory sessions using the statistical software package R.

MSCI 672 - Ecology of Fishes. Spring, (3) Sutton

This course will provide students with an understanding of fish ecology as related to vertebrate evolution and diversity, systematics, feeding and reproductive biology, early life history ecology, and fish community structure and biotic interactions.

MSCI 673 - Marine Molecular Genetics. Spring, (3) Graves, McDowell, Reece. Prerequisite: Undergraduate Genetics or permission of instructor

Students will study the evolutionary processes responsible for the intra- and interspecific genetic relationships of marine organisms, with an emphasis on the application of current molecular methodologies. 3 hrs. lecture.

MSCI 674 - Marine Molecular Genetics Laboratory. Spring (2) Graves, McDowell, Reece. Prerequisite: Undergraduate Genetics or permission of instructor

Students will elucidate intra- and interspecific genetic relationships by employing a variety of molecular techniques for the analysis of proteins and nucleic acids (5 hrs. of laboratory).

MSCI 685 - Practical Application of Marine Resource Management Techniques. Hershner, Staff. As required (1-3)

In this course, students participate in real world management activities under the guidance of involved faculty members and in association and consultation with members of various levels of government. Topics may include issue identification and resolution, committee involvement at local, regional, state, interstate, and federal levels of government, development of management plans, drafting position papers, developing draft legislation and exposure to policy making mechanisms. Requirements will vary depending on the issue(s) addressed. Students will be evaluated on participation, written work (memoranda, position papers, etc.) and knowledge gained as evidenced by interaction with staff and by other means. The course may be repeated provided the instructor determines there is no duplication of material. Credit, which must be arranged in advance of registration, will depend upon difficulty of the assignment.

MSCI 686A or 686B - The Public Commons Project I or II. Fall or Spring (3) Taylor. Prerequisite: Permission of the instructor

The Public Commons Project is offered to upper level undergraduate, graduate and

professional students in Education, Law, Marine Science and Public Policy, who have been nominated by their School or Department, or who have applied with a letter of faculty recommendation. The Public Commons Project seeks to develop a culture of service learning and life-long civic engagement among participating students through interdisciplinary work to develop a multi-year inventory and assessment of historic, cultural, and natural resources held in the Commons that are protected under the Public Trust Doctrine. Emphasis in the early years will be on the environmental commons. Students enrolled in the The Public Commons Project will be introduced to the concepts and the importance of service learning and civic engagement as an essential part of professional development and citizenship. They will then be introduced to the legal and environmental construct of the Public Trust, the requirements of comprehensive planning in local government and the planning documents, an overview of data and the recognition of ecological scaling, the identification and assessment of ecological services, the economic valuation of ecological services, and the legal and regulatory environment of the Public Trust. As students progress, they will begin to work as interdisciplinary teams to build a comprehensive inventory of the public commons, determining hierarchies of value and importance, and identifying the scientific, social, economic and legal issues surrounding elements contained within the inventory.

MSCI 687 - Environmental Policy, Fall, (3) Hicks

This course will explore policy making for environmental problems and will focus on issues that are local, national, and international. The course will primarily focus on national environmental policy, and the procedures by which policy is implemented at both local and regional levels. Issues explored will include water pollution policy and land-use in the Chesapeake Bay, U.S. Marine Mammal Policy, and U.S. water and air quality regulations. For each of these issues, U.S. laws and regulations as well as federal agencies' approaches for quantitatively assessing the benefits and costs of environmental policy will be examined. (Cross-listed with PUBP 622)

MSCI 688 - Climate Change: Science, Policy, and Law. Spring (3) Ivanova

This seminar will examine climate change as one of the most critical environmental and economic challenges facing humanity. The course will review the interplay among science and policy regarding each discipline's understanding of the sources and impacts of climate change. It will also focus on the history and future of the legal negotiations and examine the ethical implications of climate change. Topics will include humans as a geophysical force, the science of climate change, measuring the impacts, international legal perspectives and negotiations, market forces, and political constraints. The course will also analyze the energy economies and the rationale for climate change policies in key actors, including the European Union, the United States, Russia, and major developing countries such as India, China, and Brazil. Weekly sessions will include lectures and discussions led by the instructor, invited speakers, and students. Assignments will comprise discussion facilitation, presentations, and written work. Students will participate in small groups that explore in detail a particular aspect of climate change and produce a substantial term paper. (Cross-listed with PUBP 629)

MSCI 689 - Public Policy for Science & Professions. Fall (3) Gilmour, Rossiter

This course is intended to provide graduate students in disciplines outside of the social sciences with an introduction to the basic tools of economics, political science, and

statistics upon which public policy analysis rests. No prior exposure to any of these subject areas is required. The course will consist of a mixture of lecture, discussion, an application, and will make frequent use of computers in class. The goal is to make students intelligent consumers of, and contributors to, policy analyses related to their areas of expertise.

MSCI 690 - Progress and Process - The Relationships of Science and Law in Determining Public Policy on the Environment. Spring (3) Taylor

This course is given from the perspective of the working scientist, and it is intended to provide an understanding of the relationships between the disparate cultures of science and law in the arena of public policy. The professional cultures of science and law will be examined, their historic and ethical foundations, their place within the constitutional framework of the United States, and their origins in the Age of Reason. The dynamic tension of their respective roles in determining the outcome of environmental policy in the contemporary American context also will be examined along with alternatives to the status quo. (Readings, lectures and discussion)

MSCI 693 - (LAW 424). Environmental Law. As required (3) Law School Staff. Prerequisite: Consent of instructor

Students will study the nature and causes of environmental pollution and of the main legal techniques for its control. The course will consider the common law, the environmental impact assessment process (e.g., the National Environmental Policy Act), and the basic regulatory framework for air, water and solid and hazardous waste control (the Federal Clean Air Act, Clean Water Act and Resource Conservation and Recovery Act), with attention given under each statute to the basic regulatory framework and the main policy issues presented by it. Other topics will include the role of the federal courts in reviewing agency action, new developments in federal administrative law (including current efforts at administrative law reform), natural resource management and allocation issues involved in the division of scarce resources (e.g., air and water) among competing users, toxic and hazardous substance regulation, and enforcement of environmental laws.

MSCI 694 - (LAW 425). Land Use Control. As required (3) Law School Staff, Butler. Prerequisite: Consent of instructor

This course presents an analysis of the legal principles governing the use and management of land and the fundamental values underlying those principles. While focusing primarily on government regulation of land use, the course also will examine common law rules, which affect the way that land is used. Topics that might be considered include judicial control of land use, zoning and the rights of landowners, zoning and the rights of neighbors, land use planning, public regulation of land development, aesthetic regulation, and the preservation of natural and historic resources.

MSCI 695 - (LAW 453). Administrative Law. As required (3) Law School Staff. Prerequisite: Consent of instructor

This course is a study of practice in the administrative process, examining the procedures for administrative adjudication and rule making; legislative and judicial control of administrative action; and public access to governmental processes and information.

MSCI 697 - Problems in Marine Science. Fall, Spring and Summer (1-4) Staff

This is the avenue through which supervised projects may be selected to suit the needs of the graduate student, including those wishing to perform an internship as part of the Curricular Practical Training Program. Projects are chosen in consultation with the student's major professor and the instructor. Acceptable research outlines and project reports are required, and the amount of credit depends upon difficulty of course. Examples of projects offered in recent years include management issues in shellfish sanitation; groundwater nutrient processes; bacterioplankton methods and techniques; pesticide analysis in environmental samples; marine molecular population genetics; and law and policy relating to the introduction of non-indigenous plants. Subjects will be announced prior to registration and after approval by the Educational Policy Committee (EPC).

MSCI 698 - Special Topics in Marine Science. Fall, Spring and Summer (1-3) Staff

This is the avenue through which subjects not covered in other formal courses are offered. These courses are offered on an occasional basis as demand warrants. Examples of courses offered in recent years include: continental margin sedimentation; biomineralization in marine organisms; molecular markers and evolution; oligochaete biology; quantitative methods of image analysis; and organism-sediment interactions in coastal systems. Subjects will be announced prior to registration and after approval by the EPC.

MSCI 699 - Dissertation. Fall, Spring and Summer (hours to be arranged).

This is the avenue for original research in biological, chemical, geological and physical oceanography, environmental science, marine fisheries science and marine resource management. The doctoral project is chosen in consultation with the student's major professor and the Dean of Graduate Studies.

Undergraduate Courses

Undergraduates can take 500- level courses with the permission of instructor

MSCI 330 - Introduction to Oceanography. Spring, even years (3) Bronk, Patterson

In this course the physical, chemical, biological and geological processes operating in the world's oceans will be described. The interdisciplinary nature of oceanography is emphasized, providing an integrated view of factors, which control ocean history, circulation, chemistry and biological productivity. (Cross-listed with BIOL 330 and GEOL 330)

MSCI 497 - Problems in Marine Science. Fall, Spring and Summer (1-4) Staff

This is the avenue through which supervised projects are selected to suit the need of the upper level undergraduate student. Projects are chosen in consultation with the student's supervising professor and the instructor. Credit hours depend upon the difficulty of the project and must be arranged with the instructor in advance of registration.

MSCI 498 - Special Topics in Marine Science. Fall, Spring and Summer (1-3) Staff

This is the avenue through which subjects not covered in other formal courses are offered. These courses are offered on an occasional basis as demand warrants. Subjects will be announced prior to registration. Hours to be arranged.

Academic Program

General Program Description

The academic program of the School of Marine Science is intended primarily for the student who wishes to specialize in marine science at the graduate level. Degrees offered are the Master of Science and Doctor of Philosophy in Marine Science. The school offers research opportunities and instruction at the graduate level in four general areas: Biological Sciences, Environmental and Aquatic Animal Health, Fisheries Science and Physical Sciences. For students interested in resource management and policy an educational track in Marine and Environmental Policy offers courses both at SMS and in conjunction with the Thomas Jefferson Program in Public Policy at the Williamsburg campus.

Though the courses offered by the School are primarily for graduate students, advanced undergraduates (juniors and seniors), who have received permission of the instructor, may participate. For instance, biology, chemistry, and physics majors can enroll in suitable 500-level marine science courses for credit toward the Bachelor's degree provided certain conditions are met (see College of William and Mary Undergraduate Program Catalog). Undergraduates also may enroll for research credit to work on problems in marine science. The student is responsible for making the necessary arrangements with an individual School of Marine Science faculty member, and the consent of the chairperson of the student's major department is also required.

General Preparatory Requirements

Students who are interested in pursuing marine science as a profession should consult with their academic advisor or the Dean of Graduate Studies, School of Marine Science, early in their college careers to identify an academic program that will prepare them for graduate study in marine science. Students interested in Biological Sciences, Environmental and Aquatic Animal Health,

or Fisheries Science should have a strong background in basic science, including a suite of contemporary biology courses, physics and chemistry (through organic), and mathematics through calculus and differential equations. The prospective Chemical, Geological or Physical Oceanography student should have an undergraduate degree with appropriate course work in chemistry, geology or related geophysical science, physics, meteorology, mathematics or engineering, and a solid quantitative background. Course work in statistics and competence with computers are particularly important.



Degree Requirements

General

Students generally are bound by the requirements stated in the catalog that is in effect when they enter the School. The department in which a student specializes and individual advisory committees may prescribe additional requirements for their students.

Residency

To fulfill the full-time academic residency requirement of the School of Marine Science, students must:

1. Successfully complete the core course requirements
2. Be a full-time student in good standing for two consecutive semesters

Satisfactory Progress

To continue in a degree program, a student must make satisfactory progress towards the degree. If the faculty of a department in which a student is enrolled determines that satisfactory progress is not being made, a student may be required to withdraw because of academic deficiency. The Academic Status and Degrees Committee reviews the progress of all students to ensure that they have completed milestones toward completion of degrees in a timely fashion.

Registration Requirements

All active students (i.e., those working toward completion of a degree program who have not been granted leave) must register for a minimum of nine hours each semester, and one hour for each term of the summer session. Students must be registered in the semester during which they graduate. Once they have achieved Candidacy, students may be eligible for a semester of Research Graduate Status.

Changes in Registration

All changes in students' schedules after the close of registration require approval of the instructors involved and the Dean of Graduate Studies. Students may not add courses after the last day for changes in registration as indicated in the calendar. If a student drops a course or courses before mid-semester but remains registered for other academic work, the course or courses dropped will be removed from the student's record. If the student drops a course or courses after mid-semester through the last day of classes but remains registered for other academic work, the grade of "W" or "F" will be awarded by the instructor in the course depending upon whether or not the student was passing at the time the course was dropped.

A student wishing to withdraw from a course (or courses) after mid-semester may apply to the Dean of Graduate Studies for approval. With the approval of the request, a grade (or grades) of "W" will appear on the transcript.

Students may not drop a course after the last day of classes. If a student does not complete a course, "W" with appropriate notation will be entered on the record upon approval of the Dean of Graduate Studies and the appropriate authorities at the College.

System of Grading and Quality Points

The grades A (excellent), B (good), C (satisfactory), P (pass), in certain courses, D (unsatisfactory), and F (failure) are used to indicate the quality of work in a course. “W” indicates that a student withdrew from the College before mid-semester or dropped a course between mid-semester and the last day of class and was passing at the time that the course was dropped.

For each semester credit in a course in which a student is graded A, 4 quality points are awarded; A-, 3.7; B+, 3.3; B, 3; B-, 2.7; C+, 2.3; C, 2; C-, 1.7. P carries credit but is not included in a student’s quality point average; D and F carry no credit, but the hours attempted are included in the student’s average.

In addition to the grades A, B, C, P, D, F, and W, the symbols “G” and “I” are used on grade reports and in the College records. “G” is given to work in progress towards Masters (MSCI 599) or Ph.D. (MSCI 699) research, since there is insufficient evidence upon which to base a grade. “I” indicates that because of illness or other major extenuating circumstances, the student has postponed, with the explicit consent of the instructor, the completion of certain required work. “I” automatically becomes “F” at the end of the next semester if the postponed work has not been completed.

Required Courses

Students must pass all required core courses with a grade of B- or better by the end of their second year in the School of Marine Science. Alternatively, students may petition for exemption from core courses upon application to the Academic Status and Review Committee (see below).

The SMS Core Curriculum

Our goal for the core courses is to ensure that students achieve a broad understanding of the essential processes that define oceanic, coastal, and estuarine environments. Students are expected to build upon this foundation by pursuing specialized and advanced courses tailored to the needs of their individual research projects.

Relative to this goal, our specific objectives for the SMS core course curriculum are:

- To educate students in the fundamentals of marine science in a way that fosters interdisciplinary and synthetic understanding of oceanic, coastal and estuarine systems
- To provide our students with an appreciation for the integration of marine science and its application to complex environmental problems
- To ensure that our students have the methodological, quantitative and communication skills needed to pursue successful careers in marine science.

Students are required to choose courses in each of the following four groups, I-IV, as follows:

- I. **Fundamentals Courses - MSCI 501A, 501B, 501C, 501D, 501E, or 501F**
A Ph.D. student must choose four (4) of the fundamentals courses outside of the student’s specialty.

A M.S. student must choose three (3) of the fundamental courses outside of the student's specialty. (For example, a student in the Department of Biological Sciences cannot choose Fundamentals of Biological Oceanography.)

II. Advanced Principles Core Courses

Students in either degree program must choose one (1) of the advanced principles courses in the student's department of specialty (For example, a student in the Department of Biological Sciences must take MSCI 526):

Biological Sciences: MSCI 526

Environmental & Aquatic Animal Health: MSCI 563, MSCI 564 or MSCI 565

Fisheries Science: MSCI 528

Physical Sciences, discipline specific: MSCI 520 (*physical oceanography*); MSCI 522 (*geological oceanography*); MSCI 524 (*marine chemistry*)

III. Quantitative Core Courses:

Students in either degree program must choose one (1) of the following quantitative courses: MSCI 504, MSCI 554, MSCI 583, MSCI 625, or MSCI 642

IV. Interdisciplinary Core Requirement

Students in either degree program must take the following interdisciplinary course: MSCI 503

Departmental Core Courses

Students in Biological Science: Students must take MSCI 515A (Spring Semester).

Students in Environmental and Aquatic Animal Health: Students must take MSCI 515B (Fall and Spring Semesters) and at least one additional departmental offering.

Students in Fisheries Science: Students must take MSCI 515C (Spring Semester) and one of the following: MSCI 625, MSCI 667, MSCI 669, MSCI 670, MSCI 671 or MSCI 672.

Students in Physical Sciences: Students must take MSCI 515D (Fall and Spring semesters) and at least one advanced course (550-level or higher) appropriate to the student's specialty

Language Requirement

Proficiency in a foreign language is not required; however, a student's advisory committee may require demonstration of foreign language skills. All graduate students who submit TOEFL scores are also required to take the SPEAK test (upon admission). Unlike TOEFL, the SPEAK test can only be taken on the William & Mary campus. Its purpose is to determine whether ESL (English as a Second Language) courses would be appropriate for the student. If appropriate, students will be encouraged to take ESL courses available on the William & Mary campus.

Retaking a Course

In order for a core course to satisfy the core course requirements, a grade of B- or above must be earned in the course. A deficiency in a core course may be made up only by

successful completion of another course from the core group. In the case of non-core coursework, degree credit is granted only for the course in which a student earns a grade of “C” or above. A graduate student may repeat one non-core course in which a grade of “C” or lower is received. When a course is repeated, the initial grade earned remains a part of the student’s record and is included in computations of quality point requirements. Any student receiving more than one “D” or “F” in a program of study will not be permitted to continue in the School of Marine Science.

Core Course Exemption

Students who have had comparable course work elsewhere may petition for exemption from any of the SMS core courses. The application for core course exemption must be approved by the core instructor(s) of the SMS course for which exemption is sought. Prior to consulting the core instructor, the student must attach the following to the application for exemption: (1) a syllabus of the student’s applicable prior course work and (2) a transcript showing the grade/credits of the student’s prior course work. The SMS instructor must indicate on the application that he/she has reviewed the student’s previous studies and is satisfied that those studies are sufficient to permit exemption from the applicable core course. The application and attachments then must be submitted in entirety to the Academic Status & Degrees Committee, in care of the SMS Graduate Registrar. **Credits for exempted courses will not be transferred automatically to a student’s record unless the student petitions the AS&DC for credit transfer.**

Transfer of Academic Credit

On the recommendation of the Academic Status and Degrees Committee and the approval of the Dean of Graduate Studies, a regular student may apply up to 15 hours of graduate credit for courses equivalent to the SMS core courses earned at another accredited institution. However, credit may be transferred only for courses in which the student received a grade of “B” or better and will not be counted in compiling his/her quality point average at William and Mary.

To petition for acceptance of transfer credits, the approved application must be submitted to the Academic Status and Degrees Committee c/o the Graduate Registrar, Watermen’s Hall 233. The application must include documentation for the course(s) proposed to supplant the core course(s), and a statement from each School of Marine Science faculty teaching the course for which transfer credits are sought. The faculty member’s statement must indicate that he/she has reviewed the student’s previous studies and is satisfied that those studies are sufficient to permit acceptance of the applicable transfer credits.

Students can petition for up to six hours of other graduate work not already applied toward another degree, but the total transfer credits cannot exceed 15 hours. The credits must have been earned in courses appropriate to the student’s program in the SMS and must fall within the time specified by the general college requirements for degrees.

Comprehensive Examination

All students in the Ph.D program will be required to pass a written Comprehensive Exam, designed to demonstrate the student’s comprehension and integration of material

from the various disciplines of marine science that are relevant to the student's area of specialization. Successful completion of a rigorous Comprehensive Exam signals that a student is ready to pursue advanced training and original scientific research.

The objective of the written comprehensive exam is to ensure that the student has an appropriate general understanding of the field as well as the specific knowledge needed to undertake their research project. The Comprehensive Exam will be created, administered, and graded by the student's Advisory Committee. The major advisor is responsible for scheduling the exam before the end of the student's second academic year, and should notify the Dean of Graduate Studies of the exam date. The student's advisor will notify the Dean of Graduate Studies of the outcome of the pass/fail exam and if any remedial action is needed. A copy of the graded exam with the student's responses will be included in the student's file.

If more than one section is not passed, the student receives a "no pass" for the entire exam. The student is allowed one exam retake for any sections that were not passed. The exam retake must be completed within 3-6 months of the original exam date. If a Ph.D. student does not pass the retake, he or she will be given an option to enroll in the M.S. degree program. Master's bypass candidates who do not pass cannot advance to the Ph.D. program.

Qualifying Exam

The qualifying examination is an oral examination designed to test a student's scientific competence and ability to pursue her/his graduate research project. The exam consists of two components: (1) questions that address knowledge specific to the proposed research project and (2) questions concerning the general knowledge in the student's field of study.

The qualifying examination will be administered by the student's Advisory Committee and chaired by a Moderator who is not a member of the student's Advisory Committee. The Moderator must be identified at least two weeks prior to the examination. Students must file appropriate paperwork for the scheduling and announcement of the qualifying examination with the office of the Dean of Graduate Studies. Consistent with SMS procedures, the examination will be advertised and open to all faculty members. The examination should be taken by the end of the third semester (M.S. students) or end of the fifth semester (Ph.D. students), and should in every case occur well before the final defense consistent with SMS Milestones. The minimum elapsed time between successful completion of the qualifying examination and the final defense must be no less than six months for M.S. students and no less than one year for Ph.D. students.

If the student does not pass the Qualifying Examination he/she must retake the examination within six months. A no-pass on the second examination is grounds for dismissal from the graduate program.

Leave of Absence

The Dean of Graduate Studies may grant a leave of absence upon the recommendation of the student's advisor. A leave of absence is limited to a maximum of one year during the duration of the student's degree program, and relieves the student of the obligation of paying tuition during the approved absence. It is understood that a student on leave of absence is not present on campus and drawing upon campus resources. A student must

terminate the leave of absence and be a registered student in the semester in which his or her degree requirements are completed or in which he or she graduates.

Students approved for a leave of absence will have their time limit for degree completion requirement stopped for the duration of the approved period. Upon return from approved leave, the student's time limit to degree completion will resume.



Probation

Students will be placed on probation if their cumulative average is less than B (< 3.0). In the case of a grade deficiency in a core course, the student must make up the deficiency by taking another course from the core group. Probation will last until a student's cumulative average is raised to at least a B (3.0), and will in no circumstances last longer than one calendar year. Failure to raise the cumulative grade average to B within one calendar year will result in dismissal from the School of Marine Science. Reinstatement is possible only after successful appeal to the Academic Status and Degrees Committee.

Withdrawal from the Program

Withdrawal from the program constitutes termination of the student's program of study in the School of Marine Science. Withdrawal may be voluntary on the part of the student or be imposed by the School of Marine Science for reasons of academic deficiency. A student, who fails to register for a regular semester (Fall or Spring) once the student has begun his/her graduate study and who has not requested a leave of absence or permission to withdraw, will be placed on a leave of absence for one semester by the Dean of Graduate Studies. If the student has not applied for a leave of absence prior to the end of registration for the next regular semester, or if the Dean of Graduate Studies is not able to justify continuing the leave of absence, the student's record will be marked "withdrawn unofficially."

If the student withdraws from the College before mid-semester, a grade of "W" will appear on the record for each course in progress at the time of withdrawal. After mid-semester through the last day of classes, students who withdraw from the College will be awarded a "W" or "F" by the faculty member teaching each course in progress at the time of withdrawal.

Reinstatement after Withdrawal

A student wishing reinstatement after withdrawal must reapply to the School of Marine Science under the procedures in effect at the time of reapplication.

Extension of Time Limit

Classified (regular) students who have exceeded the time limit for degree completion and who have not been granted a time extension by the Dean of Graduate Studies will not be permitted to register in the School of Marine Science.

Notice of Candidacy for Graduation

Candidates for graduation must submit a Notice of Candidacy for Graduation to the SMS Graduate Registrar by the date listed in the calendar in this catalog. If the student determines that he or she is unable to complete requirements by the specified graduation date, cancellation must be made with the SMS Graduate Registrar; and a new form must be submitted for another graduation date.

Submission of Theses and Dissertations

Degree candidates must submit the appropriate number of copies of their thesis or dissertation, ready for binding, to the Swem and Hargis Libraries no later than 5:00 p.m. on the deadline date listed in the calendar in this catalog. An SMS Cashier's receipt of payment of binding fees also must be presented to the respective libraries. Specific details about the required number of copies and current binding fees are available from the SMS Graduate Registrar.

Conferral of Degrees

The College confers degrees in August, January and May of each year. The commencement ceremony is in May. Degree recipients of the previous August and January are recognized and invited to attend the May ceremony. Student who will complete requirements in August rather than May must obtain permission of the Dean of Graduate Studies and the Vice President for Student Affairs to participate in the spring commencement.

Degree of Master of Science

The milestones to be accomplished and requirements for the degree are:

1. The student must select a suitable major professor, who must be a faculty member of SMS/VIMS, as soon as possible following admission. The student and the major professor will choose an Advisory Committee, which must be approved by the Dean of Graduate Studies. The major professor and Advisory Committee direct the student's program. Should a student's major advisor retire or leave the SMS/VIMS before the student completes his or her degree, the student is required to select an appropriate on-campus co-advisor.
2. The Advisory Committee, chosen by the student and approved by the Dean of Graduate Studies, must consist of at least four members. A majority of the Committee's members must be from the faculty of SMS/VIMS, although persons with appropriate qualifications from outside SMS/VIMS may serve on the committee. The committee must include at least one member who is both outside of the student's research discipline and outside of the student's home department.

3. At least one academic year of each student's program must be spent as a full-time resident student as defined in the general degree requirements.
4. At least 36 credit hours of advanced work, of which at least nine (9) credit hours have been earned in courses numbered 550 or above with a cumulative grade point average of 3.0 or better, are required for the M.S. degree. In addition, a student must have registered for thesis (MSCI 599) for at least one semester. No more than six (6) thesis credits may be counted toward the minimum 36 credits required for the M.S. Students also will be expected to register for seminar as required by their respective departments; however, only two (2) credits will be applicable to the degree.

Credits more than seven (7) years old and earned in the program in which the student is currently enrolled will be deleted from the accumulation of credits required for a degree. Credits acquired while enrolled in previous programs here or elsewhere must fall within the time specified by the general college requirements for degrees.

5. Upon a favorable recommendation of the student's Advisory Committee and the Academic Status and Degrees Committee, followed by a majority vote of the Academic Council and the approval of the Dean of Graduate Studies, a student may be admitted to candidacy after completion of the following requirements:
 - a. The student must have achieved a grade point average of B (3.0) or better, averaged over all courses taken for credit at the time of application for admission to candidacy.
 - b. Each core course required by the School of Marine Science must be passed with a grade of B- or better. Alternatively, students may be exempted from core courses upon application to the Academic Status and Review Committee (see above).
 - c. The qualifying examination and prospectus must be completed.
6. The student must present a seminar to the marine science faculty, staff and students on a thesis topic approved by the major professor, the Advisory Committee and the Dean of Graduate Studies, and must defend this thesis before his/her major professor and committee. The defense of the thesis will be separate from any other examination. A six-month period must elapse between successful completion of the qualifying exam and defense of the M.S thesis. Full details of this requirement can be obtained from the Office of the Dean of Graduate Studies. We encourage all students to deposit an electronic (PDF) copy of their thesis with the School of Marine Science library. Authors will retain all ownership rights to the copyright of their work.
7. All requirements for the degree must be completed within three calendar years after commencing graduate study. In exceptional cases, if recommended by the Academic Status and Degrees Committee, the Dean of Graduate Studies may approve time extensions.

Degree of Doctor of Philosophy

The milestones to be accomplished and the requirements are:

1. The student must select a suitable major professor, who must be a faculty member of SMS/VIMS, as soon as possible following admission. The student and the major professor will choose an Advisory Committee, which must be approved by the Dean of Graduate Studies. The major professor and Advisory Committee direct the student's program. Should a student's major advisor retire or leave the SMS/VIMS before the student completes his or her degree, the student is required to select an appropriate on-campus co-advisor.
2. The Advisory Committee, chosen by the student and approved by the Dean of Graduate Studies, must consist of at least five members, at least one of whom must be from outside the College of William and Mary. A majority of the Committee's members must be from the faculty of SMS/VIMS, although persons with appropriate qualifications from outside SMS/VIMS may serve on the committee. The committee must include at least one member who is both outside of the student's research discipline and outside of the student's home department
3. A minimum of three years of graduate study beyond the baccalaureate is required. At least one academic year must be spent in residence at SMS/VIMS as defined in the general degree requirements.
4. At least 42 credit hours of advanced work, of which at least 15 credit hours have been earned in courses numbered 550 or above with a grade point average of 3.0 or better, are required for the Ph.D. degree. In addition, a student must have registered for dissertation (MSCI 699) for a least one semester. At least nine (9) but no more than 12 dissertation credits may be counted toward the minimum 42 credits required for the Ph.D. degree. Students also will be expected to register for seminar as required by their respective departments; however, only two (2) credits will be applicable to the degree.

Credits more than seven (7) years old and earned in the program in which the student is currently enrolled will be deleted from the accumulation of credits required for a degree. Credits acquired while enrolled in previous programs here or elsewhere generally are not subject to this limitation.

5. Upon a favorable recommendation of the student's Advisory Committee and the Academic Status and Degrees Committee, followed by a majority vote of the Academic Council and the approval of the Dean of Graduate Studies, a student may be admitted to candidacy after completion of the following requirements:
 - a. The student must have achieved a grade point average of B (3.0) or better, averaged over all courses taken for credit at the time of application for admission to candidacy.
 - b. Each core course required by the School of Marine Science must be passed with a grade of B- or better. Alternatively, students may be exempted from core courses upon application to the Academic Status and Review Committee (see above).
 - c. A written comprehensive examination must be passed.

- d. The qualifying examination and prospectus must be completed.
6. The student must present a seminar to the marine science faculty; staff and students on a dissertation topic approved by the major professor, the Advisory Committee and the Dean of Graduate Studies and must defend this dissertation before his/her major professor and committee. The defense of the dissertation will be separate from any other examination. A one-year period must elapse between successful completion of the qualifying exam and defense of the Ph.D dissertation. Full details of this requirement can be obtained from the Office of the Dean of Graduate Studies.
7. All requirements for the degree must be completed within the following time frame:
 - 4 years with a Master's Degree from the School of Marine Science
 - 5 years with a Master's Degree from another Institution
 - 6 years with direct admittance (bypass Master's Degree)

In exceptional cases, if recommended by the Academic Status and Degrees Committee, the Dean of Graduate Studies may approve time extensions.

8. Graduating students are required to submit copies of their theses or dissertation for the College archives as follows: one copy to Swem Library and two copies for Hargis Library. Additional copies will be required for advisors and personal use.

In addition, Ph.D. students must submit two copies of their abstracts to Swem Library – the one that is included in the dissertation manuscript and a second one for submission with ProQuest's Agreement Form. The Agreement Form and second abstract will be submitted to ProQuest's UMI Dissertation Publishing for production of an archival microform copy and inclusion in the ProQuest dissertation database.

Each graduating student is encouraged to deposit an electronic (PDF) copy of his/her thesis or dissertation with the School of Marine Science library. Authors will retain all ownership rights to the copyright of their work.



General Statement of Policy

The School of Marine Science and the College of William and Mary have an Affirmative Action Policy and are committed to attracting underrepresented students into marine science. The School's Admissions Committee considers applicants without regard to sex, race, color, religion, national origin, sexual orientation, or disability. Admissions criteria are based on past and potential academic and research performance.

The facilities and services of the College are open to all enrolled students on the same basis, and all standards and policies of the institution, including those governing employment, are applied accordingly.

Senior citizens of Virginia who wish to take advantage of fee waiver privileges in order to attend courses at William and Mary are invited to contact the Dean of Graduate Studies for full details.

The College reserves the right to make changes in the regulations, charges and curricula listed herein at any time.

Honor Code

The Honor Code, first established at William and Mary in 1779, remains one of the College's most cherished traditions. It assumes that principles of honorable conduct are familiar and dear to all students, and hence dishonorable acts will not be tolerated. Students found guilty of cheating, stealing or lying are subject to dismissal. The principles of the Honor Code and the method of administration are described in the Student Handbook (www.wm.edu).

Graduate Regulations

Application for Admission

Application forms are available electronically at: <http://www.vims.edu/sms/admissions>.

If applicants do not have access to a computer, requests for application forms and completed application materials should be sent to:

Dean of Graduate Studies
School of Marine Science
College of William and Mary
P.O. Box 1346
Gloucester Point, Virginia 23062

Students are encouraged to apply for admission during the winter of each calendar year, with a closing date of January 15. Applicants will be notified after April 15. Admission will be valid for matriculation for the following summer, Fall and Winter semesters. Most students should anticipate a Fall matriculation. The Dean of Graduate Studies should be contacted prior to submitting applications at any other time or regarding any special circumstances the student's application or matriculation might present.

Students applying to SMS should make contact with faculty members, with whom they share similar research interests. Generally only students with an identified faculty mentor are admitted to SMS.

The following are required of applicants to the School of Marine Science:

1. One (1) copy of the completed application form.
2. A non-refundable processing fee of \$50. This fee is not credited to the student's account. There is no fee for application for admission as an unclassified (post-baccalaureate) student.
3. Three (3) letters of recommendation.
4. Official transcripts of all college work. (Final degree transcripts are required of admitted students before they matriculate).
5. Official Scores of the Verbal and Quantitative sections of the Graduate Record Examination (GRE).

Scores in an advanced section of the Graduate Record Examination in the applicant's undergraduate major field or an area appropriate to the applicant's proposed concentration in marine science are informative but are not required. GRE scores more than 5 years old are not acceptable. Applicants are encouraged to take the Graduate Record Examination at scheduled dates that will allow for receipt of scores by the aforementioned closing date. The School will not evaluate applications lacking GRE scores or other critical materials after the closing date.

SMS Applicant Statistics	Fall 2004	Fall 2005	Fall 2006	Fall 2007	Fall 2008	Fall 2009
# of Applicants	152	112	103	93	114	133
# Admitted	48	34	37	32	35	31
# Enrolled	34	27	20	22	23	27
Mean GPA	3.39	3.48	3.50	3.51	3.40	3.47
Mean GRE	1221	1220	1194	1233	1243	1273

In general, minimum requirements for acceptance to the School of Marine Science are a GPA of 3.0 or higher; GRE score (Verbal plus Quantitative) of 1100 or higher.

International Students

In addition to the verbal and quantitative sections of the Graduate Record Examination (GRE), international applicants whose primary language is not English must submit the results of the Test of English as a Foreign Language (TOEFL).

In general, the minimum acceptable TOEFL scores are: 500/4.5 (paper version) or 250 (computer version). The TOEFL requirement may be waived if the applicant has completed an undergraduate or graduate degree at an accredited U.S. institution or other appropriate institution in which the language of instruction is English. Students with marginal proficiency in English will be required to attend an appropriate English course offered at the Williamsburg campus. A reduced load of graduate courses is suggested for these students.

Non-English academic transcripts, certificates of degrees and similar documents submitted by international applicants must be accompanied by an English translation.

International students admitted to the School must present proof that they have available funds sufficient to meet all costs they will incur while studying at the School of Marine Science. The form I-20 will not be mailed until this proof of financial support is received. For those students offered financial aid by the School of Marine Science, such aid may be included as a source of funds.

For additional information on the process of obtaining a student visa, please contact the Global Education Office (globe@wm.edu) or (757) 221-3594. Their website: www.wm.edu/revescenter/iss also contains valuable information for international applicants as well as current international students.

Admission Information

Applicants are encouraged to visit the campus and to contact faculty members about specific research interests, funding opportunities, and program information.

Admission to the School of Marine Science is highly competitive; there were 133 applicants for the entering class of 2009, of which 31 were accepted and 27 matriculated. The Faculty carefully evaluates criteria of performance, which include GRE scores, overall GPA and GPA in area of concentration, the applicant's statement of purpose, letters of recommendation, and prior experience. Although it is neither possible nor desirable to provide absolute values of criteria that will ensure admission, see the figure on the previous page for GPA and GRE scores of students offered admission in 2004 – 2009.

Degree-Seeking Students

Students are admitted as regular or provisional graduate students in either the M.S. or Ph.D. program. For matriculation as a regular graduate student, an applicant must have completed the requirements for a bachelor's degree at an accredited college, with a record of high performance, and must have the recommendations of the faculty and officials of the School of Marine Science.

Students may be admitted to either the Master of Science or Doctor of Philosophy programs. Students without a Master's degree must enter the program as a Master's student; however, students wishing to continue directly to the Ph.D. degree can apply to by-pass the M.S. degree, provided the student meets the criteria for the bypass (see Masters of Science bypass option). Bypass requires approval of the student's advisory committee, the Academic Status and Degrees Committee, and the Dean of Graduate Studies.

Applicants judged deficient in preparatory studies or other areas may be admitted as provisional students. A provisional student may petition for regular student status after successful completion of those requirements stipulated in his/her notification of admission. Petition for change in status shall be reviewed by the Academic Status and Degrees Committee, using as criteria overall academic performance and performance standards previously specified on the student's notification of admission. Graduate credit earned by a provisional student will be applied toward the graduate degree upon conversion to regular student status.

Master of Science Bypass Option

A superior student originally accepted to the master's program and who has demonstrated potential to conduct Ph.D level research may petition to bypass the M.S degree and proceed directly toward the doctorate. Students interested in the bypass option should file an Intent to Bypass M.S Degree Form prior to taking the Comprehensive Examination at the end of their second year in their degree program. Once approved and by the start of their third year the student may submit an Application to Bypass the M.S Degree to the Academic Status and Degrees Committee (AS&DC), with the following elements:

1. Approval of the Notification of Intent to Bypass M.S. Degree Form.
2. Completion of the SMS core course requirements for the M.S. degree
3. A student must be in good academic standing (cumulative GPA of B or better with no core course grade lower than B-).
4. Submission of a CV and 1-2 page statement by the student describing the student's achievements and demonstrated potential to conduct independent research.
5. Submission of a 1-2 page statement by the student's advisor describing the student's achievements and demonstrated potential to conduct independent research.
6. Recommendation by the student's Advisory Committee to bypass the Master's degree.
7. Successful completion of the written Comprehensive Examination at the Ph.D. level.
8. Formal acceptance of a Ph.D. prospectus by the student's committee.
9. Successful completion of the Qualifying Exam at the Ph.D. level.

Evidence of scholarly potential in the form of independent research, professional presentations, submitted or accepted manuscripts and research proposals will strengthen a student's petition for the bypass. The AS&DC will recommend to the Dean of Graduate Studies whether or not permission to bypass should be granted. Appeals of an adverse decision of the Academic Status and Degrees Committee may be made to the Dean of Graduate Studies. It is important that a student submit the bypass form in a timely fashion; typically, no later than the start of the third year. In order to apply the doctoral program milestones equitably, the AS&DC will determine an "effective completion date" of the doctoral program, which normally will be designated as 72 months from date of matriculating at SMS/VIMS.

Non Degree-Seeking Students

Students who have received a Bachelor's degree from an accredited college or university and who wish to take courses in the School of Marine Science but who are not entering an advanced degree program may apply for unclassified student status (post-baccalaureate). Graduate credit earned as an unclassified student may be applied toward the graduate degree upon matriculation as a regular graduate student.

Financial Information

Tuition and Fees

The College reserves the right to make changes in its charges for any and all programs at any time, after approval by the Board of Visitors.

Starting Fall 2009, the tuition and general fee for full-time students in the School of Marine Science is \$5,257 per semester for residents of Virginia and \$12,102 per semester for non-residents.

Special Note: All incoming students registered for nine hours or more in 500-level courses or above, or for twelve hours or more at any level, are considered full-time students and charged the full-time rates unless qualified for Research Graduate Student Status.

Tuition for part-time students, at both the undergraduate and graduate levels, is as follows:

\$315 per semester hour for Virginia residents.

\$840 per semester hour for out-of-state students.

Regularly enrolled degree-seeking students of the College will be charged these rates during the regular session for part-time work, based on their established domiciliary status.

In addition to tuition, there is a \$25.00 registration fee and a \$50 comprehensive fee.

Part-time students who are not regularly enrolled at the College of William and Mary, and for whom, therefore, no domiciliary status previously has been determined, will be charged on the basis of their satisfactorily established domiciliary status. (See statement regarding Eligibility for In-state Tuition Rate).

Auditing fees are the same as those specified for part-time students, unless the auditor is a full-time student. Permission to audit must be obtained from the instructor.

Graduate Assistantships

Graduate research and graduate teaching assistants work an equivalent of twenty hours per week. For graduate research assistants, every effort will be made to ensure that assistantship duties are relevant to the student's course of study and research program. Graduate assistants must satisfactorily carry out the duties assigned by the School of Marine Science, must make satisfactory progress on their programs as defined by the College degree requirements and the regulations of the School of Marine Science, and may not hold any other employment or appointment of a remunerative nature during the term of their assistantships without approval of the Dean of Graduate Studies. Failure to comply with these conditions will lead to revocation of appointments.

Graduate Fellowships

A limited number of outstanding applicants are awarded fellowships that consist of "tuition remission" in addition to a graduate assistantship. These fellowships are awarded via a priority ranking system and are renewable annually for up to 24 months (M.S students)

or 36 months (Ph.D or by-pass students), contingent upon satisfactory performance. All fellowship students are expected to participate (equivalent to twenty-hours a week) in their advisor's group activities and in a research project or program as determined jointly with their faculty advisor.

Research Graduate Student Status

Upon the recommendation of a student's major professor, a student who has achieved Candidacy may apply to the Dean of Graduate Studies for a single semester of Research Graduate Status. During this period the student will be charged reduced tuition (3 credits).

The following conditions must be met:

1. The student has completed all SMS and departmental required coursework.
2. The student has passed the qualifying examination and the prospectus has been approved.
3. The student is not employed significantly in any activity other than research and writing in fulfillment of degree requirements.
4. The student is present on campus or is engaged in approved fieldwork related to his/her thesis or dissertation.

Research Graduate Status enables a student to register for a maximum of 12 credit hours of Thesis or Dissertation credit per regular semester upon payment of the part-time rate (3 credit hours). The student may elect to utilize up to two (2) of the three paid credit hours for formal coursework.

A student with Research Graduate Status may register for additional course credit only upon payment of the generally applicable additional part-time tuition.

A student with Research Graduate status is eligible for services (e.g. student health and athletic events) only if required fees are paid.

Eligibility for In-State Tuition for Research and Teaching Assistants

Students awarded research or teaching assistantships that pay at least \$4000 per annum may qualify for in-state tuition. Eligibility will be determined by the Dean of Graduate Studies and submitted to the Provost for final approval.

Eligibility for In-State Tuition for Students with Permanent Domicile

To be eligible for the lower tuition rate available to in-state students, a student must meet the statutory test for domicile set forth in Section 23-7.4 of the Code of Virginia. Detailed information may be obtained from the State Council of Higher Education for Virginia at <http://www.schev.edu/students/vadomicile.asp?from=students> and also from the Office of the University Registrar's web site at: <http://www.wm.edu/offices/registrar/domicile/index.php>.

Domicile is a technical legal concept, and a student's status is determined objectively through the impartial application of established rules. A student who claims Virginia residency must support that claim by clear and convincing evidence. In general, to establish domicile students must be able to show (1) that for at least one year immediately preceding the first official day of classes their permanent home was in Virginia and (2) that they intend to stay in Virginia indefinitely after graduation. Residence in Virginia primarily to attend college does not establish eligibility for the in-state tuition rate. On admission to the College an entering student who claims domiciliary status is sent an application form. The Office of the University Registrar evaluates the application and notifies the student of adverse decisions only. A student re-enrolling in the College after an absence of one or more semesters must re-apply for domiciliary status and is subject to the same requirements as an entering student.

A matriculating student whose domicile has changed may request reclassification from out-of-state to in-state; however, the application must be submitted before the beginning of the academic semester. Any student may ask for written review of an adverse decision, but a change in classification will be made only when justified by clear and convincing evidence. All questions about eligibility for domiciliary status should be addressed to the Office of the University Registrar, (757) 221-2808.

Payment of Accounts

Charges for tuition and general fees are payable by each semester's due date as established by the Office of the Bursar. Any unpaid balance remaining on an individual's account after the end of the add/drop period may result in cancellation of registration. In most cases tuition and fees for SMS students are paid by the student's advisor.

Payment may be made in U.S. dollars by cash, check, money order or cashiers check made payable to the College of William and Mary. Checks returned by the bank for any reason will constitute nonpayment of fees and may result in cancellation of registration. The option of paying in full by credit card or electronic check is offered through our payment plan provider, TMS (Tuition Management Systems); however, TMS does charge a convenience fee for these services. Additional information may be obtained from the Bursar's Office website at www.wm.edu/financialoperations/sa/ab.php

Any past due debt owed the College (telecommunications, emergency loans, parking, health services, library fines, etc) may result in cancellation of registration and/or transcripts being withheld. In the event a past-due account is referred for collection, the student is required to pay all costs associated with the collection and/or litigation, as well as the College's late payment fee.

Students Who Withdraw from the College

Subject to the following regulations and exceptions, all charges made by the College are considered to be fully earned upon completion of registration by the student.

Full-time Graduate Students Who Withdraw From College

Full-time students who withdraw from the College are charged a percentage of the tuition and fees based on the school week within which the withdrawal occurs. A school week

is defined as the period beginning on Monday and ending on the succeeding Sunday. The first school week of a semester is defined as that week within which classes begin. Full-time students who withdraw from the College within the first school week of the semester are eligible for a refund of all payments for tuition and fees less the required enrollment deposit for entering students or a \$50.00 administrative fee for continuing students. After week 1 of the semester, the amount of the tuition and fees charged / refunded will be determined based on the following schedule:

Week	Percentage Charged	Percentage Refunded
1	0%	100%
2	20%	80%
3	30%	70%
4	40%	60%
5	50%	50%
6	60%	40%
After week 6	100%	0%

Students will not be eligible for any refund of tuition and general fees if required to withdraw by the College.

It is College policy to hold the enrolled student liable for charges incurred; therefore, in the case of refunding any overpayment, refund checks will be issued in the name of the student.

Part-time Graduate Students Who Withdraw From College

Part-time students who withdraw from the College within the first school week of the semester are eligible for a full refund of tuition and fees less a \$50.00 administrative fee. After the first week, the amount of the tuition and fees to be charged will follow the full-time withdrawal schedule.

Students will not be eligible for any refund of tuition if required to withdraw from the College.

Graduate Students Who Withdraw From a Course

A part-time student who withdraws from a course(s) after the add/drop period and remains registered for other academic work will not be eligible for a refund.

Withdrawal Schedule-Summer Sessions

Please contact student accounts at bursar@wm.edu or 757-221-1220 for withdrawal refund information for your summer session(s).

Withholding of Transcripts and Diplomas in Cases of Unpaid Accounts

Transcripts or any other information concerning scholastic records will not be released until College accounts are paid in full. Diplomas will not be awarded to persons whose College accounts are not paid in full.