College of William and Mary

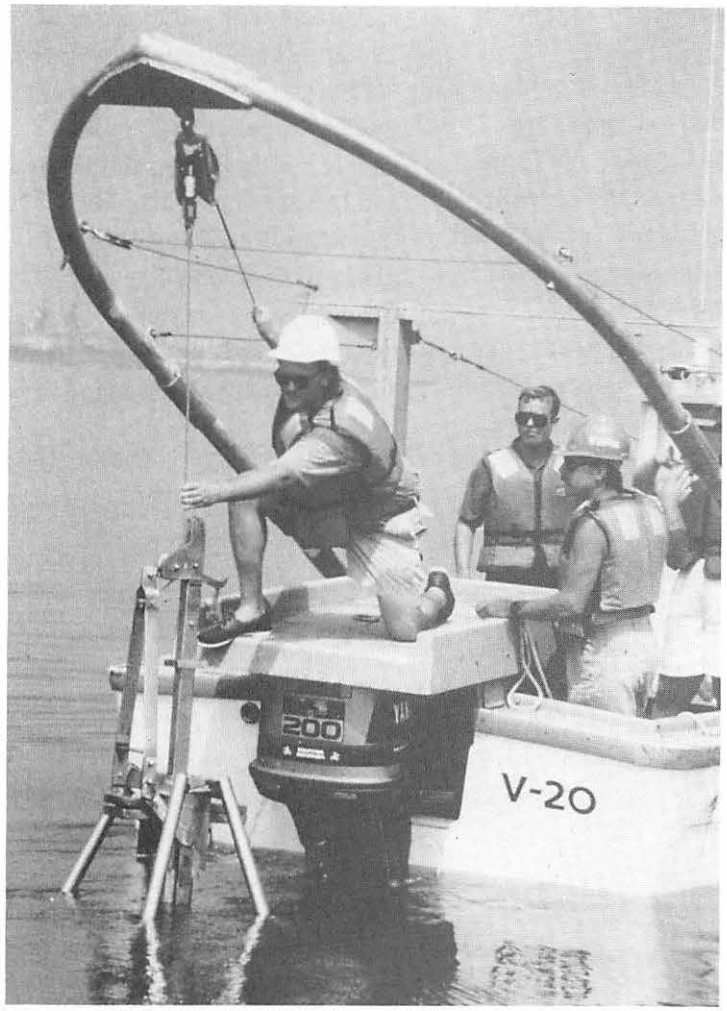
Virginia Institute of Marine Science
School of Marine Science

Programs and Services

Marine Science:

Programs for the 21st Century

The Virginia Institute of Marine Science/School of Marine Science (VIMS/SMS) of the College of William and Mary has three equally important missions: to provide cutting-edge research, education and advisory service in marine science. The Institute focuses largely, though not exclusively, on coastal and estuarine marine environments with emphasis on the Chesapeake Bay, its adjoining tributaries, and the Middle Atlantic Bight. Founded in 1940 as the Virginia Fisheries Laboratory, VIMS/SMS has evolved to become the largest marine center in the nation focused on coastal and estuarine science. The Institute is committed to generating new knowledge of coastal and marine processes; providing practical management, engineering and policy solutions to complex sets of marine-related problems and needs; and providing the highest quality, graduate marine science education available.



VIMS/SMS is structured to facilitate:

- original basic research, scholarship and graduate education in each of the traditional subdisciplines of marine science;
- the highest level of inter-disciplinary synergy with an emphasis on solving both basic and issue-driven problems; and
- translating the knowledge gained through research into practical applications and effective advisory service.

Research and education programs are based in five departments: 1) Department of Biological Sciences; 2) Department of Environmental Sciences; 3) Department of Fisheries Science; 4) Department of Physical Sciences; and 5) Department of Resource Management and Policy. Within each department, scientists from related disciplines maintain programs that support departmental objectives. Research focuses on areas such as disease in fish and shellfish, plankton and nutrient processes, ecology of various marine plants and animals, processes of pollutant transfer and fate, water quality, shoreline processes and structures, wave dynamics, and marine geology and geochemistry. This diversity reflects the varied expertise of the scientific staff.

Increasingly, scientific questions in need of solutions are interdisciplinary and require the integration of biological, chemical, physical and geological oceanography as well as ocean engineering. An overarching goal of VIMS/SMS is to achieve and maintain a national and international position as a premier coastal marine science institute with particular emphasis on the generation, application, and communication of interdisciplinary knowledge and understanding.

Interdisciplinary research focuses on increasing fundamental knowledge of the various processes affecting marine environments, and seeking practical solutions to current issues. Institute programs are funded by the Commonwealth of Virginia as well as numerous federal agencies such as National Science Foundation, Department of Interior, Department of Defense, Office Naval Research, Naval Research Lab, National Oceanic and Atmospheric Administration, and Environmental Protection Agency.

The comprehensive research plan includes Core Research Programs that are designed to evolve and change in response to emerging issues. Scientists from various disciplines provide research to support different aspects of each program. VIMS defines Core research on the basis of issues or problems rather than by department or discipline; all Core Programs are interdisciplinary.

Advisory service provides a major avenue for conveying scientific and technical information to clients and the general public. Faculty, students and staff apply their knowledge to natural resource and economic development issues through interactions with government agencies, localities, businesses, industries and the general public. Institute scientists also serve as advisors on regional, national and international marine related panels and boards.

The Sea Grant-supported Marine Advisory Program (MAP) is devoted to economic development with emphasis on maritime industries. The program actively engages VIMS scientists in the promotion of sustainable fisheries, commercial fisheries development, seafood utilization, and marine aquaculture; and provides outreach education at all levels.

National and International Partnerships

As a leader in the worldwide community of coastal marine scientists, VIMS/SMS has established formal memoranda of agreement with the Institute of Estuarine and Coastal Research of the East China Normal University; Ocean University of Qindao, China; the Korea Ocean Research and Development Institute (KORDI); New Zealand's National Institute of Water and Atmospheric Research (NIWA); and the School of Ocean Sciences University of Wales-Bangor.

Education

School of Marine Science

Problems affecting estuaries and the coastal sea are formidable and are accelerating as coastal areas become more populated, and conflicting human pressures are applied to these fragile environments increase. Our ability to cope with these problems depends in large part on the activity and involvement of appropriately trained scientists, managers and policy makers, which in turn necessitates that schools such as the School of Marine Science produce students optimally trained to study and understand the coastal environment.

Currently about 120 students are enrolled in the graduate program. They are equally divided between Master of Science and Ph.D. candidates. Students are drawn from colleges and universities nationwide. International students comprise about 12% of the student body.

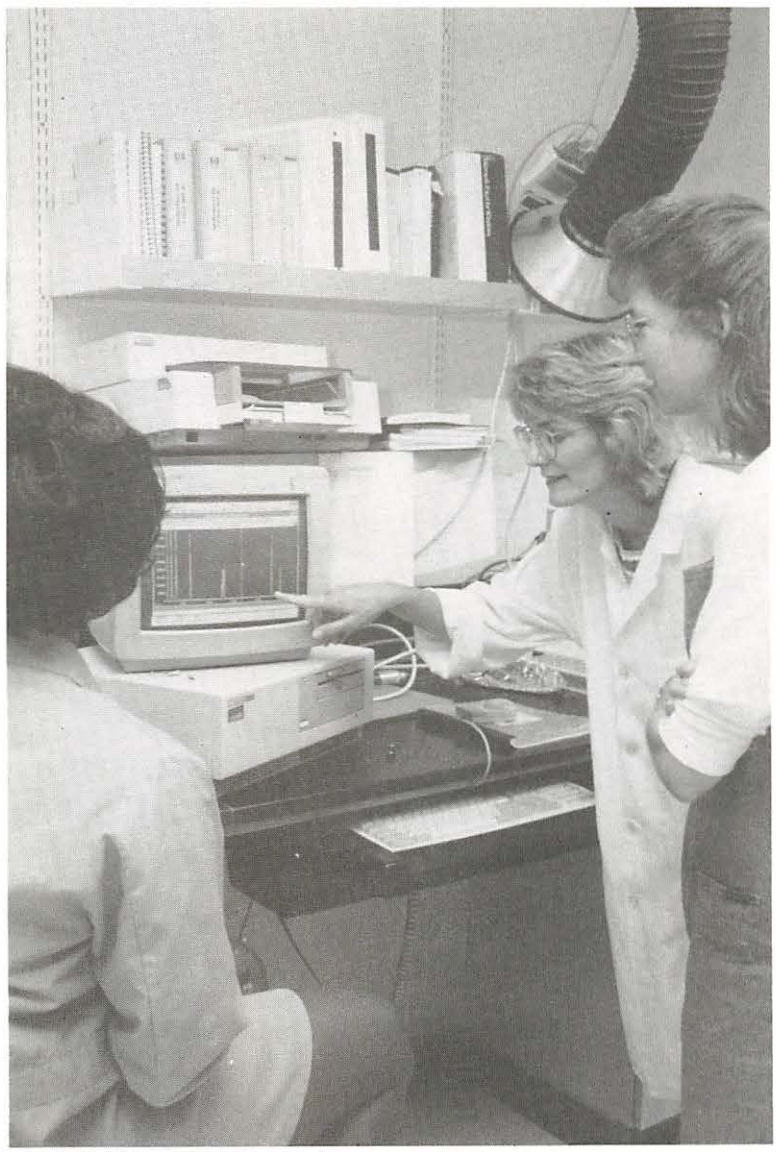
Because coastal and estuarine research requires an interdisciplinary understanding of the environment, first-year students take a series of four core courses designed to provide broad-based knowledge in marine science. Advanced students may take a wide variety of lecture, seminar, and laboratory courses, generally in their field of research interest. In addition, William and Mary programs, such as the College's Environmental Science and Policy Cluster, provide opportunities for students to work directly with faculty in the Law School, the Public Policy Institute, and other groups within the social and natural sciences.

More than 500 SMS students have received advanced degrees in marine science during the Institute's nearly sixty-year history. Graduates find work at academic and research institutes, management and regulatory agencies at the local, state and federal level, and in the corporate and private sectors.

Internships can serve as an excellent way for students to gain real-world experience as part of their interdisciplinary training at SMS/VIMS. In recent years a large number of our Resource Management and Policy students have received Knauss fellowships to intern in agency and legislative offices in Washington, and other students have had both research and teaching internships at various labs and schools around the country.

The School of Marine Science also has an active and highly competitive summer internship program for undergraduate students, funded in part by the National Science Foundation. Students spend ten weeks at VIMS working with their mentors on a variety of research projects. A number of these summer projects have resulted in published papers in peer-reviewed journals. Minorities and women are particularly encouraged to apply to this program.

Programs & Faculty



VIMS Administration and General Facilities

L. Donelson Wright
Dean and Director
Eugene M. Burreson
Director of Research and Advisory Services
John D. Milliman
Dean of Graduate Studies
David A. Evans
Associate Dean of Graduate Studies
Linda F. Caporale
Executive Assistant to the Dean and Director
Carolyn Ridgway Cook
Director of Planning and Budget
Wendell B. Goodwin
Director of Facilities Management
Page Hayhurst
Associate Director of Development
Jane A. Lopez
Director of Sponsored Research Administration
Charles A. McFadden
Director of the Library
Newton J. Munson
Director of Information Technology and Networking Services

The role of the Institute is to provide sound scientific research that contributes to new knowledge, to provide accurate, reliable data and advice upon which policy makers and regulatory agencies can base stewardship decisions, and to support and nurture the highest quality graduate marine science education available.

The VIMS thirty-five acre campus, located in Gloucester Point at the mouth of the York River, offers easy access to Virginia's estuaries, tidal and nontidal wetlands as well as the Chesapeake Bay and Atlantic Ocean. A second campus, the Eastern Shore Laboratory (ESL), located in Wachapreague, Virginia is surrounded by embayments, salt marshes, barrier beaches, and coastal waters. Facilities include wet and dry labs for visiting scientists, a seawater flume, and dormitory space for forty visitors. Widely recognized for its contributions to bivalve aquaculture, the ESL is also the primary site for oyster reef restoration research. Both campuses provide rich, living laboratories for research and teaching. Four hundred and fifty scientists, students, and support staff are engaged in activities supporting the missions of the Institute.

The Institute is well equipped with state-of-the-art field and laboratory technology to support advanced research in disciplines such as geochemistry, physical oceanography, genetics, immunology, pathobiology and toxicology. Specialized equipment is described in the following sections. Instrument fabrication equipment and calibration tanks for various sensors enable scientists to engineer, develop and maintain specialized research equipment. Facilities include six buildings with flow through salt water systems.

Chesapeake Bay Hall, a 60,000 sq. ft. research facility opened in March 1997, was designed and constructed to support advanced research, particularly in chemistry, immunology, genetics, and aquatic disease and toxicology. The building is equipped with environmental chambers, tissue storage lockers, a lead-lined lab, and a state-of-the-art air handling

Department of Biological Sciences

Hugh W. Ducklow (Chair)
Loretta and Lewis Glucksman Professor
Iris C. Anderson
Professor
Robert J. Diaz
Professor
J. Emmett Duffy
Assistant Professor
Leonard W. Haas
Associate Professor
Kenneth A. Moore
Research Assistant Professor
Robert J. Orth
Professor
Mark R. Patterson
Associate Professor
Linda C. Schaffner
Associate Professor
Walker O. Smith, Jr.
Professor
Richard L. Wetzel
Professor
Ting Dai
Assistant Research Scientist
Helen L. Quinby
Faculty Research Associate
Sylvie Mathot
Post-Doctoral Research Associate

Michael Castagna
Professor Emeritus
William J. Hargis, Jr.
Professor Emeritus
George C. Grant
Professor Emeritus
Kenneth L. Webb
Chancellor Professor Emeritus

The Department of Biological Sciences brings together biologists and ecologists from a variety of disciplines including microbiology, taxonomy, and ecosystem modeling. Faculty are engaged in research aimed at elucidating patterns and processes in benthic and planktonic systems over both space and time. Research is geared toward understanding the basic forces in these communities on the local and global scales. Results often are used to assist managers with problems of local, national, and international significance.

Benthic Ecology: Examines the major processes governing the structure and function of benthic systems. Conducts ongoing studies of processes influencing recruitment, growth and production of benthic organisms; function and role of benthic communities in the fate and transfer of organic matter and sediments.

Nutrient Cycling: Focuses on spatial and temporal control of phytoplankton production by phosphorus or nitrogen, and the impact of various processes on the food web. Sediment-related processes and exchange with overlying water studies form a portion of this program.

Macrophyte Ecology: Concentrates on submersed and emergent macrophyte species in shallow subtidal, intertidal marine, brackish, and freshwater areas. Current studies focus on plant distribution and abundance, restoration ecology, dispersal mechanisms, and plant response to environmental variability and related factors.

Physical Biology: Interdisciplinary studies investigate food capture, bioenergetics, primary and secondary production, and allometry in invertebrates and algae. Involved in ongoing collaborative work with institutes in the Chesapeake Bay, the Gulf of Maine, the Caribbean and Lake Baikal, Russia.

Ecosystem Modeling: Development of digital computer simulation models as integrative and synthetic tools for ecosystem analysis to address basic and applied management questions.

Biological Oceanography: Emphasis on examining the fundamental processes underlying primary and secondary production in marine ecosystems, primarily offshore. Studies focus on understanding the physical processes supporting primary production, plankton dynamics, biotic interactions structuring communities, vertical and horizontal distributions, foodweb structure, and the ecological role of higher and lower trophic levels and benthic-pelagic coupling.

Marine Plankton Ecology: Examines the interactions among

various plankton groups (phytoplankton, bacteria, zooplankton) and the environmental factors which influence their growth (nutrients, irradiance, trace metals). Particular emphasis is placed on the fluxes of carbon and nitrogen within the various organic and inorganic pools (both dissolved and particulate), on the biotic processes regulating these transformations, and on the ecology of harmful algal blooms.

Specialized Equipment

The department maintains state-of-the-art equipment for conducting high quality field and laboratory research. Major facilities include numerous dry laboratories, a greenhouse with running seawater, a smaller wet laboratory facility, a seawater flume laboratory (located at the Wachapreague facility), an image analysis laboratory, and a low ambient temperature and light-controlled room. A variety of instrumentation, including light meters, radiometers, transmissometers, oxygen meters, anemometers, and other types of flowmeters, CTDs and dataloggers, is available for environmental monitoring. An excellent assortment of field sample collection gear is maintained by the department. Bottom samplers include an assortment of box cores, grab samples, and piston-type cores. Sediment-profile and surface cameras, as well as a bottom sled with profiling plow, video, and still photography capabilities, allow rapid bottom mapping.

Laboratory instrumentation includes: a fluorometer, gas chromatographs fitted with thermal conductivity, flame ionization and electron capture detectors, an emission spectrometer for N-15 analyses, a UV-VIS spectrophotometer, an infrared gas analyzer, a nitrogen dioxide detector, a multispectral light analyzer, and a nutrient autoanalyzer. Dissecting, compound, and epifluorescence microscopes are maintained within the department. There is ready access to scanning and electron microscopes and complete preparation facilities. The department also has access to state-of-the-art water chemistry, geochemistry, and environmental chemistry laboratory facilities. Instrumentation and facilities are available for studies involving radioisotopes. We are obtaining a new flow cytometer with full sorting capability in the coming year.

The department maintains close contacts with the Department of Physical Sciences and has access to their equipment for use in studies of water column and benthic processes. Computer facilities range from in-lab laptop units, to work stations supporting LANs, to an institute-wide network. Computer users have ready access to external networks. Both DOS and Macintosh systems are supported by the Institute's computer center.

Department of Environmental Sciences

Morris H. Roberts, Jr. (Chair)
Professor
Mohamed Faisal Abdel-Kariem
Professor
Fu-Lin E. Chu
Professor
Robert C. Hale
Associate Professor
Stephen L. Kaattari
Professor
Howard I. Kator
Associate Professor
Michael C. Newman
Professor
Martha W. Rhodes
Instructor
Jeffrey D. Shields
Assistant Professor
Craig L. Smith
Associate Professor
Michael A. Unger
Assistant Professor
Peter Van Veld
Associate Professor
Wolfgang Vogelbein
Assistant Professor
Andrew Dacanay
Post-Doctoral
Research Assistant
Shaban L. Kotob
Post-Doctoral
Research Associate
Philippe Soudant
Post-Doctoral
Research Assistant

Henry Aceto, Jr.
Professor Emeritus
Rudolf H. Bieri
Professor Emeritus
William J. Hargis
Professor Emeritus
Robert J. Huggett
Professor Emeritus
J. Ernest Warinner
Professor Emeritus

The Department of Environmental Sciences combines the expertise of chemists and biologists to study the fate and effects of hazardous substances and pathogenic organisms in estuarine and marine systems. Within the department, faculty expertise includes environmental chemistry, biochemistry, toxicology, ecotoxicology, environmental microbiology, pathobiology, histopathology, immunology, and risk assessment. Collaboration within this multidisciplinary group provides the opportunity to obtain a more complete understanding of how toxic chemicals and pathogens move through the environment, what reactions they undergo, and how toxic chemicals and pathogens interact to affect organisms from the molecular to the population level of organization. This information can be used for ecological risk assessment and thereby made available to environmental managers in the Commonwealth, the Chesapeake Bay region, and the nation in a readily usable form.

Environmental Chemistry:
Sources, distribution, transport, fate, and bioavailability of organic and elemental pollutants are studied in marine and estuarine environments. Recent research has focused on such issues as sediment partitioning, association with dissolved organics, and photolysis of anthropogenic chemicals. Interactions of toxic chemicals with marine life are explored through collaboration of chemists and biologists within the department. New techniques are being developed to separate, purify, and identify various anthropogenic compounds and their breakdown products. Organic compounds examined include antifoulants such as tributyltin, complex mixtures of polycyclic aromatic hydrocarbons, and brominated fire retardants.

Environmental Microbiology:
This diverse program 1) focuses on the consequences of introduced indicator microorganisms (bacteria and virus) and human pathogens in waters used for recreation, aquaculture, and shellfish industries; 2) seeks to develop and validate methods for detection of allochthonous microorganisms of public health significance, and to understand their fate and autecology in aquatic environments; 3) identifies processes in watersheds that contribute to eutrophication and microbial contamination of receiving waters; 4) engages in collaborative research to understand the role of bacteria in diseases of feral and aquacultured species of fish. Ulcerative diseases attributed to *Mycobacteria* sp. and *Pfiesteria*

sp. are the focus of current collaborative studies.

Aquatic Toxicology: Toxicity effects are measured as 1) responses of individuals and populations to contaminated water and sediment; 2) uptake and elimination of pollutants by individual organisms; and 3) cellular, histological, subcellular, and molecular mechanisms of uptake, internal distribution, biotransformation, and clearance of hazardous chemicals. Through collaboration with pathobiologists, the effects of chemicals on disease resistance are being identified. The program attempts to link the responses of organisms at various levels of organization in order to develop a basis for predicting population effects from the subcellular and molecular effects that can be observed at concentrations below those at which ecological effects are identifiable.

Pathobiology: Major projects focus on infectious diseases of fish and oysters, effects of *Pfiesteria,* and noninfectious diseases of fish. A variety of immunological, cytological, histological, and biochemical techniques are being applied to determine the mechanism(s) by which pathogens (such as *Perkinsus marinus*) cause disease in the host organisms (e.g., the oyster) and to examine how the hosts attempt to deal with the invasion. Collaborative studies involving researchers from all departmental programs seek to understand the impact of toxic materials on host-parasite interactions. The pathobiology group is developing an Aquatic Animal Disease Diagnostic Laboratory using traditional histological and modern molecular techniques to identify diseases in feral animals.

Ecological Risk Assessment: Assessment tools are applied to evaluate the risk associated with exposure to hazardous chemicals, pathogens, and bacterial agents, both individually and collectively in complex mixtures. The goal is to provide a conceptual framework and quantitative tools that will improve environmental management by allowing resource agencies to focus their limited resources on those issues of greatest importance and most likely to be improved measurably by effective management. The research programs of the department are grounded in two institutional Core Programs: Risk Assessment and Hazard Evaluation, and Marine Diseases. There are also significant interactions with the Fate and Transport, Water Quality, and Aquaculture Core Programs.

Specialized Equipment

The department has a wide range of modern equipment, as well as specialized facilities for animal maintenance and toxicity testing to support faculty and students. Shared equipment use among programs is common.

The chemistry laboratories are equipped to characterize organic chemicals and elemental materials in diverse matrices.

For organic chemical analysis, Soxhlet extractors, a supercritical fluid extractor, and an accelerated solvent extractor are used to prepare organic samples. Gel permeation chromatography is used for purification. Analytical instruments include HPLCs, an infrared spectrophotometer, and gas chromatographs equipped with flame ionization, electron capture, electrolytic conductivity, flame photometric, and thermionic specific detectors. A magnetic sector and two quadrupole instruments with electron ionization and chemical ionization capabilities are available. Samples are introduced by gas chromatograph, solids probe, or fast atom bombardment.

For elemental analyses, freeze drying and microwave digestion can be used to prepare samples of various types. Elemental analyses are performed using transversely-heated graphite furnace zeeman background corrected or flame (deutrium background corrected) atomic absorption spectrometry.

The biology laboratories have light microscopes, inverted microscopes, and a fluorescence microscope. The electron microscopy laboratory has a Zeiss CEM-902 Transmission Electron Microscope and a LEO 435VP Scanning Electron Microscope fitted with an Iridium Microanalysis system (IXRF Systems, Inc.). Ancillary equipment includes an ultramicrotome, glass knife maker, critical point dryer, sputter coater, and vacuum evaporator. The histopathology laboratory can conduct routine paraffin histology, high-resolution light microscopy, plastic histology, and immunochemistry.

The immunology laboratories have laminar flow biosafety cabinets, dual chambered CO2 tissue culture incubators (37°C, 28°C and 17°C) and ultra pure water systems. Radiometric methods are supported by beta and gamma counters, and a radiomatic HPLC with radioisotope detector system. Also available are scanning densitometers, microplate readers, cell harvesters, a lipid analyzer, high speed refrigerated centrifuges, and equipment for IEF and 2-D electrophoresis and western blotting. Mouse and rabbit colonies are maintained for the production of monoclonal antibodies.

The biochemistry laboratory can analyze for various protein and enzyme systems involved in the biotransformation of toxic organic substances. Equipment for electrophoretic separation of proteins and nucleic acids, and immunoblot and radioimmune assays are included. Other equipment in this laboratory includes a dual beam UV/VIS scanning spectrophotometer, a liquid scintillation counter, and laser densitometer. Expanding molecular biology facilities are equipped with a high speed centrifuge, a thermocycler and associated equipment for performing the polymerase chain reaction, and sequencing apparatus.

The environmental microbiology laboratory is well equipped with autoclaves, incubators, and a large capacity Forma environmental room. Cells can be manipulated, recovered, and purified using a Sorval RC-5B refrigerated centrifuge with various heads, a BioSafety laminar flow cabinet, an IEC refrigerated microfuge, an Ultra-Turrax homogenizer, Amicon ultrafilter cells, a Tekmar Stomacher, and a Plas-Labs anaerobic chamber. Zeiss epifluorescence and Leitz phase-contrast microscopes are routinely used for strain characterization and direct enumeration. Microbial isolates are identified using a Biolog MicroStation system. Specialized field gear used for sample collection includes Geotech portable "GeoPump" peristaltic pumps, a small boxcore for sediment collection, and a Hydrolab H20 sonde/Surveyor 3 data logger for hydrographic data collection.

A saltwater laboratory provides filtered estuarine water in sufficient quantities for static or flow through toxicity studies with toxic substances in sediment, suspended sediment or dissolved in water with serial dilution as needed. Circular and rectangular fiberglass tanks as well as glass aquaria are available for holding animals before and during testing. Culture facilities exist for invertebrates as well as fishes. Separate laboratories house recirculating freshwater systems to hold trout for the immunology group. Another separate facility is available to maintain oysters and for producing *Perkinsus marinus*-infected oysters.

Department of Fisheries Science

John E. Graves (Chair)
Professor
Standish K. Allen, Jr.
Professor
Herbert M. Austin
Professor
Eugene M. Burreson
Professor
Mark E. Chittenden, Jr.
Professor
William D. DuPaul
Professor
John M. Hoenig
Associate Professor
Romuald N. Lipcius
Associate Professor
Mark W. Luckenbach
Associate Professor
Jon A. Lucy
Instructor
Roger L. Mann
Professor
John A. Musick
Professor
John E. Olney
Associate Professor
Jacques van Montfrans
Instructor
Kimberly S. Reece
Assistant Professor
Quanqi Zhang
Post-Doctoral
Research Assistant

Jay D. Andrews
Professor Emeritus
Dexter S. Haven
Professor Emeritus
Joseph G. Loesch
Professor Emeritus
Frank O. Perkins
Professor Emeritus
Willard A. Van Engel
Professor Emeritus
Frank J. Wojcik
Professor Emeritus

The Department of Fisheries Science supports studies in ecology, population and molecular biology, pathology, and genetics. Programs focus on stock assessment and life history of commercially valuable fish, crab and mollusk species. The fishery genetics program investigates regional and global problems, while the development of DNA probes complements established methods and provides new avenues for research on diseases that continue to decimate regional oyster populations.

Crustacean Ecology: Studies examine the behavioral ecology, population dynamics, and recruitment mechanisms of the blue crab in the Chesapeake Bay and spiny lobster in the Caribbean. Emphasis on predator-prey interactions, population and fisheries modeling, ecology of natural and artificial reef systems, and ecology of tropical fish and queen conch.

Bivalve Ecology: Studies focus on recruitment of bivalves, particularly oysters, and the effects of the environment on physiology and behavior of larval oysters and other bivalves, oyster population assessments, and the development of disease-resistant hybrids.

Fisheries Oceanography: Studies focus on the effects of environmental variables (weather and climate) on the survival, recruitment, and distribution of fishes and other marine organisms.

Fish and Shellfish Pathology: Ongoing research examines the systematics, life cycles, ecology, pathology, and control of important disease agents in the Chesapeake Bay region. Current emphasis is on protozoan parasites of oysters, blue crabs, and fishes.

Finfish Ecology: Studies of the dynamics, recruitment, stock structure, and life history of marine, estuarine and anadromous fishes, based on sampling fisheries landings, surveys and tagging studies. Data generated by this program are directly applied to stock assessment and fisheries management by state and regional agencies.

Chondrichthyan Biology: Continuing studies into the comparative morphology of sharks and their relatives; population dynamics, reproduction, feeding strategies and energetics of coastal and deep-sea sharks; and shark fishery management problems.

Sea Turtle Ecology: Long-term research conducted on the distribution, abundance, ecology and energetics of sea turtles; current behavior and migration are studied

using sonic, radio and satellite tracking as well as nesting and sex ratio studies.

Systematics: Focuses on the morphology, evolution, taxonomy and zoogeography of various finfish groups.

Fisheries Genetics: 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.

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

Marine Resource Economics: Studies focus on marine resource and environmental economics, resource management, statistics, game theory, risk and uncertainty, and operations research analysis. In addition, international trade, economic development, population dynamics, and the economics of recreational fishing are examined.

Specialized Equipment

Each research program in the Department has a fully equipped laboratory, collection and sampling equipment, and extensive computer capabilities.

The Fisheries Science Laboratory has available an Optimas image analysis system, computerized scale projectors and a Biosonics digitizing system to provide automated morphometric measurements, rapid analysis of hard structures for age determination, and automated counting procedures. Automated fish measuring boards and a variety of collections are also available.

The Crustacean Ecology Program maintains the GEM Lab with two large (1800 gallon) benthic mesocosm tanks monitored by IR-sensitive, computer controlled cameras with time-lapse image recorders.

The Bivalve 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 and Shellfish Molecular Biology Programs maintain large laboratories with walk-in cold rooms, and are equipped to perform a variety of genetic analyses. Major equipment includes an automated DNA sequencer, five thermal cyclers, refrigerated centrifuges, ultracentrifuges, a vacuum concentrator, an automated x-ray developer, and several ultracold freezers.

The Shellfish Pathology laboratory has a photomicroscope, a full histology laboratory, and is adjacent to the electron microscope facility.

Nunnally Hall contains a fish collection with over 100,000 species representing 247 families. This research and teaching collection incorporates extensive holdings from the Chesapeake Bay, the Middle Atlantic Bight, Appalachian freshwater habitats, as well as an internationally recognized collection of deep-sea fishes. The Larval Fish Laboratory houses a reference collection containing early life history stages of over 120 families of marine, estuarine and freshwater fishes. In addition, the program has considerable plankton collection equipment, an in situ silhouette plankton camera, and 1.5 m diameter mesocosms for *in vivo* experiments of larval fish trophic dynamics and mortality.

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 recirculated filtered sea water. Adjacent to the sea turtle greenhouse is a 7,560 gallon tank used for research.

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. Trailerable vessels are used to conduct field work within the Bay's tributaries.

Department of Physical Sciences

Steven A. Kuehl (Chair)
Professor
James E. Bauer
Associate Professor
John D. Boon, III
Professor
John M. Brubaker
Associate Professor
Elizabeth A. Canuel
Assistant Professor
Catherine J. Chisholm-Brause
Assistant Professor
Rebecca M. Dickhut
Associate Professor
David A. Evans
Associate Professor
Carl T. Friedrichs
Assistant Professor
Carl H. Hobbs, III
Associate Professor
Sung-Chan Kim
Visiting Assistant Professor
Albert Y. Kuo
Professor
Jerome P.-Y. Maa
Associate Professor
William G. MacIntyre
Professor
John D. Milliman
Professor
Harry Ven-chieh Wang
Assistant Professor
L. Donelson Wright
Chancellor Professor
Robert A. Gammisch
Marine Scientist Supervisor
C. Scott Hardaway
Marine Scientist Supervisor

Robert J. Byrne
Professor Emeritus
Maynard M. Nichols
Professor Emeritus
Evon P. Ruzecki
Professor Emeritus

The Department of Physical Sciences includes the subdisciplines of physical, chemical, and geological oceanography. Many of the education and application aspects of quantitative methods are incorporated here. This union facilitates a new level of interdisciplinary synergy, appropriate to rapidly evolving needs and emphases. The global objective of the department is to generate, communicate, and apply knowledge concerning physical, chemical, and geological processes that operate in the coastal ocean and estuaries.

Chemical Fate and Transport: Studies of the physical-chemical properties and the naturally-occurring transport and transformation pathways for chemical contaminants within aquatic ecosystems.

Surface Geochemistry: Studies focus on reactions of anthropogenic (e.g., traizine herbicides, organic compounds, chlorinated hydrocarbons, radioactive and toxic metal contaminants, and refined fuels) and natural products at the mineral-water, sediment-water, and suspended particle-water interfaces.

Biogeochemistry: Studies focus on interdisciplinary science and the chemistry of the Earth's surface, including interactions among the atmosphere, oceans, crustal minerals, and living organisms.

Organic Geochemistry: Examines organic matter, including factors controlling its production, transformation, and ultimate fate.

Small Scale Physical Processes: Studies focus on coastal fronts, internal waves (including internal tides), and the development and breakdown of density stratification to understand vertical and horizontal fluxes in estuaries and on the shelf.

Continental Shelf Dynamics: Emphasis is on understanding the physical mechanisms that cause across-shelf transport of particles and the formation of shelf sedimentary strata.

Estuarine Dynamics: Addresses both large-scale, long-term transport processes and smaller-scale, often localized, short-term processes, using observation as well as theoretical and computational tools.

Sediment Geochemistry and Geochronology: Studies of seabed processes that determine the ultimate fate of particulate materials and chemical species in estuarine and coastal environments.

Sediment Environments and Stratigraphy: Examines the long-term (hundreds of years) integration of the consequences of shelf, including estuarine and riverine, processes.

Shoreline Studies: Applied research aimed at developing proper responses to shoreline erosion at specific sites via beach nourishment and/or stabilization to avoid the loss of highly valued coastal property, and in some cases, living coastal resources.

Dispersal of River Sediments in Coastal Seas: Focuses on the transfer processes and the fate of river-derived sediment in coastal seas.

Sediment Erosion and Deposition Processes: Various methods are employed to quantify the erosion and deposition rates of sediment at the water-sediment interface.

Coastal and Estuarine Numerical Modeling: Emphasizes the use of numerical computational methods to simulate the current, water level, salinity, and temperature and their consequences on environmental conditions such as water quality, sediment, and larval transport.

Water Waves: Focus on transformation processes and nearshore wave climate prediction.

Bottom Boundary Layer Dynamics: Observational and theoretical studies of turbulence, mixing, stress, stratification, and sediment and velocity profiles within the lowest few meters of the water column.

Specialized Equipment

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); a seabed hydraulic flume to carry out *in situ* experiments on sediment erosion; a meteorological station with a precipitation collector for low level organic contaminants; high volume air samplers; a rotating drum surface microlayer sampler; and bottom boundary layer instrumental tetrapod systems for measuring bed stress, waves 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 sub-bottom profiling systems, directional wave gauges, turbidity sensors, acoustic doppler current profilers (ADCP), and Kasten and box corers are all 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: a microwave-assisted solvent extraction system; a large-capacity, refrigerated, programmable centrifuge; ultra-cold (-80 degrees C) freezers; a Fisons EA1108 CHNS-O analyzer; a UV/Vis spectrophotometer; gas chromatographs with flame ionization and electron capture detectors; two quadrupole mass spectrometers; an Inductively Coupled Plasma Atomic Emission Spectrophotometer (ICP/AES); an EDS system with full SEM imaging capabilities; a Powder X-ray Diffractometer; a Nitrogen Adsorption Surface Area and Porosity Analyzer; a CHNSO elemental analyzer; a high performance liquid chromatograph with UV absorbance and liquid scintillation detectors; two laboratory flumes (recirculating and annular); five intrinsic germanium gamma spectrometers; an eight-channel alpha spectroscopy system; an X-ray radiography unit; a sedigraph automatic particle analyzer; and a rapid sediment analyzer. Computer facilities range from laptop units for field use, to work stations supporting LANs to the institute-wide network. Computer users have ready access to external networks. Pentium-PC, UNIX and Macintosh systems are supported by departmental staff and by the Institute's Information Technology and Networking Services center.

Department of Resource Management and Policy

Carl H. Hershner (Chair)
Associate Professor
James L. Anderson
Visiting Professor
John E. Anderson
Research Scientist
Thomas A. Barnard, Jr.
Assistant Professor
Kevin P. Kiley
Instructor
James E. Kirkley
Associate Professor
Maurice P. Lynch
Professor
James E. Perry, III
Assistant Professor
Walter I. Priest, III
Instructor
Gene M. Silberhorn
Professor
Dennis L. Taylor
Professor
N. Bartlett Theberge, Jr.
Professor
William G. Reay
Research Assistant Professor
Arnold F. Theisen
Adjunct Professor

The Department of Resource Management and Policy's interdisciplinary research covers the spectrum of basic and applied science on coastal resources. Scientists work closely with estuarine and marine industries, the public, and state and federal agencies to integrate sound scientific principles into the management of coastal resources. Research in the department is conducted by both faculty and professional scientific staff.

Wetlands Program: This program provides basic and applied research on tidal and nontidal wetlands, with advisory support and outreach education for local, state and federal wetlands managers. Current research focuses on methods to access wetland functions, including applications of remote sensing technologies, development of targeting protocols for wetlands preservation and/or creation, and basic ecology of nontidal wetlands.

Comprehensive Coastal Inventory Program: Studies focus on inventory and monitoring of wetlands, shorelines and natural/ cultural resources in the coastal plain, as well as basic and applied research in Geographic Information Systems and remote sensing for natural resource management. Current research focuses is on development of use suitability analysis protocols, habitat restoration targeting protocols, and watershed-level land use planning/management.

Ocean and Coastal Law: Provides graduate educational and advisory support to state agencies and the General Assembly, and conducts research on resource management issues pertinent to Virginia. Current research focuses on shorezone land ownership issues.

The Coastal Ecosystems and Remote Sensing Program (CERSP): Conducts basic and applied research on detection and characterization of changes in the coastal environment. The program emphasizes development of field and remote sensing models and algorithms necessary to assess coastal ecological phenomena such as erosion/ deposition, plant community compositional changes, effects on biota, and changes in water quality. CERSP strives to provide an interface between science and policy by ensuring that sound research is followed by development of useful management and policy protocols.

Center for Coastal Management and Policy: This center is an administrative vehicle for managing interdisciplinary projects involving personnel from Resource Management and Policy, Virginia Institute of Marine Science/School of Marine Science, the College of William and Mary, and other institutions.

Specialized Equipment

The Wetlands Program maintains a supply of field sampling equipment including soil probes, meteorological instruments, vegetation surveying equipment, digital data loggers and portable computers.

The Comprehensive Coastal Inventory Program (CCI) uses Trimble global positioning system equipment and Topcon total station survey gear. CCI has developed a state-of-the-art distributed computer facility consisting of high performance workstations operating in conjunction with personal computers, digitizing stations, image scanner, and output devices to facilitate a combination of geographic information systems (GIS) and image processing techniques.

Capabilities exist for the analysis of photographic information captured from video images, scanned photographs, or digital satellite data. Tools are available for wave climate, shoreline response, and three dimensional physical process modeling. To assist in the analysis of the model data, CCI cooperates with the Department of Physical Sciences in a computer visualization laboratory equipped to provide support in areas such as flow visualization, 3-D volume rendering, and the development of presentation graphics and animated sequences. CCI currently uses the vector based GIS system ARC/INFO working in concert with the raster image processing system ERDAS as the basis for its programs.

CERSP has a variety of instruments for field and lab studies, including: an Analytical Spectral Devices, Model PS-II spectroradiometer and field spec; a digital multi-spectral video developed by SpecTerra Ltd. and the U.S. Army Corps of Engineers Topographic Engineering Center; a LI-COR LI-6400 portable synthesis system; and a Perkin-Elmer MPF-44B Fluorescence Spectrophotometer. To process data from the instruments, CERSP relies on a variety of computer equipment and programs, ranging from simple PCs to Sun Workstations. Software includes ERDAS Imagine, Hypercube, ENVI, and Adobe Photoshop.

Interdisciplinary Core Programs

Core Programs enhance the effectiveness of the total research program through the integration of Institute efforts and efficient utilization of resources. These programs are defined on the basis of issues or problems rather than by academic disciplines or departmental foci. It is through such programs, many of which interface with clients and society, that the Institute is able to make the most immediate and direct contributions to economic development, resource management, and environmental policy formulation. Other Core Programs primarily involve seeking solutions to fundamental interdisciplinary questions. These programs address crucial scientific problems of an interdisciplinary nature that are on the cutting edge of estuarine and coastal marine science.

Aquaculture

The Aquaculture Core Program focuses on the research and technology needed to facilitate the development of an economically viable commercial aquaculture industry in Virginia. In addition, the potential for wild stock enhancement of marine shellfish and finfish using aquaculture technology is being explored. The cornerstone of the Aquaculture Core Program is the recently established Aquaculture Genetics and Breeding Technology Center. Basic research on the domestication of brood stock and selective (manipulative) breeding techniques is a priority for the Center. Research into nutritional and environmental requirements for larval and juvenile stages of aquaculture species, requirements for growout in recirculating or open systems, and a realistic evaluation of candidate species for aquaculture development are all necessary.

In Virginia, the development of marine aquaculture has been led by the growth in the hard clam (*Mercenaria*) and soft-shell crab industry; accounting for over $12.8 million in sales in 1995. Total sales, including clam, scallop and oyster seed exceeded $14.4 million. Although relatively small when compared to the value of the wild fisheries for all marine species ($87 million), the potential for growth is significant and the economic impact to local communities is increasingly important.

Environmental Risk Assessment & Hazard Evaluation

The Risk Assessment and Hazard Evaluation Core Program straddles the continuum between basic research and environmental management. Risk Assessment involves assigning probabilities to events to describe the likelihood of a particular outcome, a relatively recent practice in ecotoxicology that has received much attention during the past decade. The same practice from economic or human health perspectives has a longer history and provides a statistical foundation for applications in the environmental field. Hazard Evaluation involves describing and quantifying effects resulting from a particular degree of exposure to an environmental parameter.

We are expanding our research to include the development of specific modeling capabilities to evaluate environmental risk, and thereby provide strong management-oriented advice to such regulatory agencies as the Virginia Department of Environmental Quality and the U.S. Environmental Protection Agency. As this aspect of the program is

developed, we anticipate that the models will be enlarged to include a consideration of the socioeconomic dimension, which will further strengthen the advice that we can provide. As this dimension is added, this risk assessment information can be merged with information from other Core Programs, notably Fisheries Stock Assessment, to broaden and thereby enhance the scope of the advice that we can provide to additional client agencies such as the Virginia Marine Resources Commission.

The ultimate goal or mission of this program is to provide risk managers with technical data and evaluative tools as a basis for sound management of competing uses of the estuarine and coastal environment. Within five years, a basic framework for risk analysis applicable to a range of conditions should be developed. The framework should be understandable and useful to environmental managers to yield sound management practices.

Fisheries Ecology & Stock Assessment

Fisheries Science is concerned primarily with the living resources of the Chesapeake Bay and the mid-Atlantic coastal ocean, with special emphasis on species of commercial and recreational value. Complementary investigations dealing with national and international fisheries outside of the Commonwealth's jurisdiction enhance the expertise and recognition of Fisheries Science faculty, staff and students. To accomplish the sustainable harvest of fisheries, management requires information based on a comprehensive research approach dealing with the biological, economic, and social viability of alternative fisheries management options.

In the Commonwealth, the Virginia Marine Resources Commission (VMRC) integrates biological, social and economic information in the decision-making process relating to fisheries management of commercial and recreational fisheries in its jurisdictional waters. Assessment of biological viability is dependent on information provided by the Fisheries Ecology & Stock Assessment (FESA) Core Program, which is composed of three main programmatic areas: Fisheries Ecology, Stock Assessment, and Stock Identification. The overall goal of the program is the timely provision of knowledge and advice to state, regional, and federal agencies for sound management. In addition, VIMS provides information on the economic viability of management decisions through the Fisheries Stock Assessment Core Program.

Wetlands, Shore and Harbor Processes & Management

This is an applications-oriented Core Program with a long history of involvement in state-mandated research and advisory service focusing on the management and preservation of living and nonliving resources of the Commonwealth. Living resources include the fauna and flora of wetlands and marshes, ranging from the extensive tidal salt water marshes of the Eastern Shore to the fringing marshes and tidal freshwater marshes of the Chesapeake Bay tributaries. A variety of habitats found here are of key importance to commercial fisheries. Marshes also

act as filters of waterborne contaminants and play a key role in nutrient transfer and water quality of estuarine systems. Among nonliving resources are numerous waterways essential to commercial shipping and recreational boating, and the public beaches that are one of the mainstays of Virginia's tourism industry. Adjacent to Virginia's ocean beaches is the important storm barrier buffer zone (coastal dunes). Where natural barriers are no longer present, artificial structures such as bulkheads and sea walls must provide coastal protection.

Goals of the program include 1) delineation of physical processes and sediment dynamics governing shoreline and wetlands change and systematic evolution; 2) development of improved strategies for coastal protection and shorezone management; 3) improved understanding of factors controlling (plant) species abundance and species diversity from subtidal (littoral) to supratidal regions; 4) development of improved technologies for establishing system boundaries, and quantifying areas and sediment volumes of intertidal zones, wetlands and uplands regions; 5) improved understanding of the interactions between wetlands and waterborne chemical constituents; i.e., functioning of wetlands as filters or sinks. The common thrust for all of these goals is the eventual ability to model or predict future change in shoreline and wetlands systems. With improved predictive capabilities, we hope to pursue goal 6), to establish effective management strategies for integral systems and their contained natural resources.

Ecosystem Processes & Modeling

Computer simulation models of natural systems have been important tools used by estuarine and coastal marine scientists for the past several decades. Hydrodynamic and water quality models have been developed using engineering principals (fluid dynamics) and applied to basic and applied problems, or problems that for most purposes have no direct solution and can only be addressed using a numerical modeling approach. The models are used to predict the behavior of systems for different management scenarios of interest to scientists and managers—similar to the way cost-benefit analyses have been used in economics; i.e., as a means to maximize benefit while minimizing costs (both economic and ecological). However, engineering-based modeling approaches traditionally do not portray or predict the behavior of living resources with a high degree of confidence. Thus, the models have limited use for direct impact assessment and prediction of ecological responses to either natural events or man-induced perturbations. Ecosystem process-based models directly address living resources/ecological issues, but often lack the structure or mathematical rigor to address hydrodynamics and large spatial scales.

In 1991, the Institute initiated an integrative and multidisciplinary program to address regional and larger scale scientific issues. The Ecosystem Processes and Modeling Core Program draws from the professional staff of the marine science faculties in physics, chemistry, geology, biology, and marine resources management. The comprehen-

sive goal of the program is to integrate knowledge in these disciplines concerning both management of coastal ecosystems and the acquisition of new information necessary for understanding their dynamics within a complex, large-scale framework. The overall focus of the Core Program is on Virginia's principal tributaries and their adjoining watersheds (James, York and Rappahannock Rivers), as well as the lower Chesapeake Bay and its interactions with the Upper Bay and coastal ocean.

The program's major focus reflects the application of interdisciplinary and interdepartmental research to the development of simulation models for predicting the behavior of the principal components of the estuarine environment: emergent and submerged vegetation, water column-benthic exchange processes, plankton processes, and chemical fluxes. The primary organizational and system analysis tools in the effort will be employed with the goal of developing realistic and testable ecosystem process models coupled with hydrodynamic and water quality models. Thus, one principal activity within the program is the management (use) of existing data bases and the incorporation of new information/data as they are made available.

Disease Research

For some time, aquatic diseases have been recognized as important factors affecting the natural abundance of economically and ecologically important aquatic organisms. Diseases are often the single most important factor in limiting success in aquculture. Although some disease outbreaks, in both wild and cultured populations, are caused by obligate pathogens, many, if not most, are the result of the interaction between potential pathogens, and hosts and environmental factors. When the interaction of all these factors favors the host, (even with a potential disease agent present), no disease will result. However, if the interaction favors the pathogenic agent then a disease outbreak occurs. In aquatic environments and in aquaculture, environmental factors are often responsible for triggering disease outbreaks. For example, temperature or salinity levels may influence the abundance or pathogenicity of pathogens. Environmental stressors, such as anthropogenic chemicals, diminish host defense mechanisms or provide portals of entry for pathogens through open lesions. Some chemicals may be directly deleterious and cause lethal wounds or tumors. Host factors such as immunocompetence, overcrowding, or poor nutrition can also lead to disease outbreaks, especially in aquaculture.

The overall goal of any disease research program is to understand the agent, host, and environmental factors that result in disease outbreaks, and to use this information to prevent or control diseases in aquaculture or to manage around them in wild populations. This is a daunting task because factors vary for each disease. Disease research is, by necessity, interdisciplinary. Adequate understanding of the disease process requires the involvement not only of disease specialists, but also of specialists in host biology, environmental science, water quality, immunology, biochemistry, pathology, genetics, and molecular biology.

Increasingly sophisticated research has led to an evolution in aquatic disease research from descriptive morphological and ecological studies to a growing emphasis on the dynamics of host/parasite relationships, often at the cellular and molecular levels. Current research topics include mechanisms of pathogenesis, host defense mechanisms, genetics of host and pathogen, and the role of xenobiotics. Tools and techniques originally developed for human or veterinary medicine are now commonly applied to aquatic diseases; and an emphasis on biochemistry, molecular biology, and genetics in the investigation of host/parasite dynamics is increasing rapidly.

Disease research is one of the oldest programs at VIMS, and the Institute has long been recognized as a center of excellence for research on diseases of shellfish. Disease studies at VIMS have paralleled the general evolution of research sophistication. The disease research program began in the late 1940s with the discovery of the oyster pathogen *Perkinsus marinus* (Dermo) and intensified rapidly with the appearance of *Haplosporidium nelsoni* (MSX) in the late 1950s. Most studies conducted during the 1960s and 1970s were aimed at *H. nelsoni* and attempted to describe the pathogens' morphology, life cycle, seasonal abundance, and environmental requirements. An extensive monitoring program, initiated in 1960 and continuing to this day, has provided managers with critical data on the annual distribution of oyster diseases. During the 1980s, as a result of prolonged drought conditions, research emphasis focused on increasing our understanding of climate controlling factors for both *H. nelsoni* and *P. marinus*. With the addition of expertise in pathology/immunology/genetics, progress on many fronts increased rapidly. Important new areas of emphasis were xenobiotic-induced carcinogenesis in fish, molecular diagnostics, fish immunology, cell culture, blue crab diseases, chemotherapy, virology, and molecular genetics.

Because of the negative impact of diseases on the Chesapeake Bay ecosystem and important industries, VIMS has recognized disease research as a Core research program. Current faculty expertise places VIMS in a position to enhance its leadership role in shellfish diseases; to become a leader in finfish diseases; and to provide needed disease diagnostic and control support for the emerging aquaculture industry.

Water Quality Processes & Modeling

The issue of water quality in estuarine and coastal waters is increasingly important as land use patterns in the coastal zone continue to change with population growth and development. In the broadest sense, water quality processes may be defined as any aspect of the delivery and fate of anthropogenically derived materials to a body of water and their resulting impact on the biota. The Water Quality Processes and Modeling Core Program encompasses the study of all terrestrial, surface (point and non-point), groundwater, and atmospheric inputs to coastal waters which have a deleterious effect, either directly or indirectly, on living resources.

The program includes the following components: 1) the capability for identification and quantification of deleterious materials, and the routes and mechanisms in the airsheds and watersheds by which these materials enter the receiving waters; 2) the circulation, transport and biological/chemical transformations of these materials, through both biotic and abiotic processes, in the receiving waters; 3) the study of the processes and mechanisms by which these materials impact living resources and water quality; 4) the study of the economic and societal causes, consequences and management strategies related to deteriorating water quality; and 5) development of mechanisms for effective delivery of scientific information to management agencies and other clients.

Water quality processes must be understood well enough to allow complex interactions to be resolved. The ultimate aim is to utilize our knowledge of these processes and interactions to help develop water quality management strategies. A frequently used approach is to develop water quality models for use by scientists and managers to predict how the system will change if constituents are altered. Especially important are applications that investigate the water quality conditions which would result from various proposed management scenarios in the entire watershed. For example, such models are used to estimate the system response as nutrients or toxic materials are either increased or reduced.

Material Flux & Fate

An understanding of the processes governing material flux and fate is fundamental to comprehension of marine and environmental systems ranging in scale from local estuaries to the global environment. Interactions between biological, physical, and chemical processes determine the fate of materials in aquatic systems. (In turn, the flux and fate of various materials such as nutrients, contaminants, sediments, and carbon greatly impact ecosystem health.) The relative importance of, and interactions among, biogeochemical and physical processes that determine the flux and fate of various materials in estuaries and the coastal ocean are not well understood. Moreover, both the episodic nature of many phenomena and the sharp physical, chemical, and biological gradients characteristic of environmental systems demand examination of both short- and long-term processes. Only through comprehensive understanding of material flux and fate in various environmental landscapes will quantitative modeling of anthropogenic impacts and risk assessment be possible.

Multidisciplinary studies of processes that govern the transport, cycling, and fate of biogeochemically important materials horizontally from land to the ocean, as well as vertically across the air-water and sediment-water interfaces are needed. The Material Flux and Fate Core Program conducts basic research in the areas of transport, transformation, and fate of substances via abiotic and biotic processes in estuarine and coastal environments. Biogeochemically important materials that are studied include nutrients, contaminants, sediments, and the major and minor elements. Research landscapes encompass watersheds, tributaries,

estuaries, and the ocean, as well as the linkages between these geographic regions.

The overall objectives of this highly interdisciplinary program are: 1) to compute material mass balances for various biogeochemically important materials within various landscapes; 2) to conduct long-term monitoring to establish baseline flux and fate estimates of biogeochemically important materials in the estuarine and coastal zone; 3) to examine the influence of episodic events such as hurricanes and flood rains on material flux and fate in the estuarine and coastal zone; 4) to determine the important mechanisms/processes controlling material flux and fate within various landscapes of the estuarine and coastal zone; and 5) to develop models of material flux and fate in the estuarine and coastal zone.

Biodiversity & Conservation

The diversity of organisms present in ecosystems is critically linked to the function of those systems. This includes productivity, foodweb structure, and resistance to disturbance. Yet, these linkages are only beginning to be understood in estuarine and coastal marine systems. Understanding this diversity/function linkage should be a priority for marine and estuarine ecological research for the foreseeable future.

Human activities, both direct and indirect, have led to the increasing fragmentation and in some cases, almost total destruction, of habitats. This fragmentation and loss of habitat is probably the most significant threat to the maintenance of biodiversity in aquatic ecosystems.

Restoration of altered habitats has become the focus of many federal and state agencies (e.g., rebuilding oyster reefs, marsh habitat development). This offers an opportunity to manipulate and understand processes and mechanisms governing the development of aquatic habitat. Habitat restoration plans are generally based on a knowledge of critical environmental parameters for a target organism or community. The pattern and diversity of habitat types necessary to establish and maintain a robust and desired system are increasingly important considerations. Typically, this type of analysis and planning is accomplished using geographic information systems (GIS) to manage and integrate the necessary spatially referenced data bases.

Plankton & Nutrient Dynamics

Plankton is the nutritional foundation of all aquatic ecosystems and includes viruses, bacteria (both autotrophic and heterotrophic), unicellular algae, protists (flagellates and ciliates), and an enormous diversity of invertebrate taxa (especially crustaceans). In addition, the plankton includes the temporary (or meroplanktonic) early life history stages (eggs and larvae) of both invertebrates and fishes, as well as microorganisms (viruses and bacteria) introduced into our waterways by anthropogenic activities. Phytoplankton and zooplankton play integral roles in the cycling of carbon, nitrogen and other bio-active elements, and in the transfer of photosynthetically-fixed energy through the food web.

Because of its central role in aquatic food chains, fish production, and public health, the study of plankton and nutrient dynamics is an essential element of freshwater, estuarine, and marine research. Such studies are directly relevant to issues surrounding harmful algal blooms and dinoflagellate problems such as the recent *Pfiesteria*-related fish kills and other human health concerns.

Phytoplankton populations can be strongly affected by eutrophication in coastal systems with significant negative effects on many components of estuarine and marine environments. The interrelationships between phytoplankton populations, and factors limiting their abundance and photosynthetic production can vary both spatially and temporally; the understanding of these relationships is fundamental to the study of plankton ecology. Understanding plankton ecology demands knowledge of physical (i.e., light attenuation, currents and water column properties), geochemical (i.e., nutrient dynamics, runoff and pollution) and biological processes (i.e., evolution, reproduction, photosynthesis, physiology, trophic transfers). The Core Program is directed at elucidating factors that regulate planktonic production and its fate. The program contains three primary elements: zooplankton and phytoplankton ecology, microbial ecology, and benthic-pelagic coupling.

Institute Support Resources

Eastern Shore Laboratory

The VIMS Eastern Shore Laboratory, located in the seaside village of Wachapreague, Virginia serves as a field station for research, teaching, and advisory activities. This area is uniquely suited for field research into coastal processes, and provides convenient access to the eastern portion of the Chesapeake Bay as well as the barrier island, salt marsh-lagoonal systems along Virginia's Atlantic shore.

Widely recognized for its contributions to research in bivalve aquaculture, the Lab also supports activities of scientists and students from the Gloucester Point campus and other institutions. Over the past year, 23 external groups visited the Eastern Shore Laboratory, for a total of three hundred people.

Recent research activities at the facility include investigations into nitrogen cycling in salt mashes, disease transmission between mollusks, population dynamics of finfish and shellfish, chemical induction of settlement in invertebrates, and hydrodynamic characteristics of seagrass seeds.

Extensive wet laboratory facilities include running seawater tables and large holding tanks. A hatchery for the culture of marine and estuarine organisms is especially well suited for mollusk culture. An on-site flume laboratory permits investigation of processes (hydrodynamic, sedimentological, and biological) in the benthic boundary layer.

Marine Advisory Services/Sea Grant

The role of Marine Advisory Services (MAS) is to be directly responsive to the needs of industry and the general public, and to provide information that will increase the public's awareness of the marine environment. MAS is associated with the Sea Grant Program, a state/federal program administered through NOAA. Specialists from MAS provide information and advice on a wide range of marine-related programs and activities, and work closely with the recreational and commercial fishing industries, marine trades, and other businesses, as well as with governmental agencies, educational organizations, and individuals. The direction of MAS research is dictated by industry and government needs.

Chesapeake Bay National Estuarine Research Reserve

The Chesapeake Bay National Estuarine Research Reserve (CBNERR) in Virginia, managed by the Virginia Institute of Marine Science, is one of 25 National Estuarine Research Reserves (22 designated, 3 nearing designation) established under the Coastal Zone Management Act. These Research Reserves are jointly funded and administered by the states and the National Oceanic and Atmospheric Administration. The Research Reserves form a protected area network which serves to promote informed management of the nation's estuarine and coastal habitats through the promotion of research, monitoring and education.

CBNERR in Virginia presently includes four components within the York River Basin that span a salinity range from 18-22 ppt at the mouth of the York (Goodwin Islands - 1607 acres in York County) to fresh

(brackish) water in the Pamunkey River 37 miles from the York's mouth (Sweet Hall Marsh - 1393 acres in King William County). In between are the Catlett Islands, 19 miles upriver from the mouth (910 acres in Gloucester County) and Taskinas Creek 24 miles upriver from the mouth (525 acres within York River State Park in James City County).

Approximately 25-30 research projects per year are active in CBNERR. Since September 1995 CBNERR has been participating in the National Estuarine Research Reserves system wide monitoring program. At present two data loggers (one at Taskinas Creek and one at Goodwin Islands) continuously record water quality data, and a meteorological station collects weather and climate data at Taskinas Creek. A second weather station is being established at Sweet Hall Marsh in the fall of 1998. Two graduate fellowships per year are provided by the National Estuarine Research Reserve System to CBNERR to support thesis or dissertation research in the Reserve.

A $600,000 educational facility is under construction at Taskinas Creek. The Reserve education program is also developing coastal environmental programs for a wide variety of audiences including coastal managers, decision-makers and non-science professionals in the fields of business and law.

Aquaculture Genetics and Breeding Technology Center

The Aquaculture Genetics and Breeding Center was established in 1997 to develop, adopt, and maintain an array of innovative applied technologies for genetics and breeding of aquaculture species in service to industry and science. The focus is to bring breeding technologies to aquaculture industries. To do this we have established basic infrastructure to support long-term breeding efforts. This includes support personnel; two hatcheries (one high salinity and one medium salinity), and grow out farms for oysters, clams, and scallops. In addition, we maintain a close relationship with industry users through our newly described Breeding and Demonstration Associate, a position shared with the Sea Grant Marine Advisory Services Program.

In addition to selective breeding programs for oysters and clams, we will maintain a high priority on genetic manipulation techniques such as induced polyploidy. We are actively engaged in the use of triploids as a biological control for non-native species, for example. Additionally, our molecular genetics unit focuses on aspects of shellfish and fish genomics that will aid in the practical application of our breeding programs. For example, we fully expect marker-assisted selection to assist us in developing disease resistant strains. Additional activities of the Center include studies of fish aquaculture in closed systems and the development of a research network of oyster gardeners in the Chesapeake Bay.

The Center complements the formal training available in the Department of Fisheries and is an integral component in the Aquaculture Core Program of VIMS. Research opportunities for graduate students and post-docs are available through Center programs or through research grants awarded to the Center faculty. Internships for undergraduates are

also available at hatchery or field locations during the breeding season. The Center publishes an industry update and advisory called the ABC Primer about four times a year.

VIMS Library

The Library utilizes powerful full-text indexing software, providing more than 738,000 bibliographic records to patrons at VIMS and at the William and Mary main campus. This tool, combined with the Web interface, also gives the Library a growing presence on the Internet, offering a bibliography of 30,000 items on the World Wide Web. Additionally, a large number of books are not yet represented in the database. As these and acquire other records are added, the bibliography will continue to grow. The Library's extensive journal collection has remained stable in spite of sharp increases in subscription rates.

Library Holdings

Periodical Subscriptions: 527
Monograph Titles: 22,650
Bound Volumes (books and periodicals): 51,868
Maps and Charts: 4,775

Vessels Center

Much of the Institute's field work involves locations within the Chesapeake Bay. This research is generally performed aboard one of VIMS' three larger vessels. These include the 65' R/V *BAY EAGLE* and the 44' R/V *LANGLEY,* both equipped to deploy large scientific equipment; and the 30' R/V *FISH HAWK*, specially equipped for trawl survey work. This group of vessels is operated by Coast Guard licensed crews. VIMS also maintains a fleet of trailerable vessels for estuarine work.

VIMS Dive Team

The VIMS full service dive center provides both training and equipment for diving scientists. A diving safety officer administers the program through the guidance and counsel of the Diving Control Board. VIMS has been an organizational member of the American Academy of Underwater Sciences (AAUS) since 1986, and is governed by their standards.

The facility includes classroom space, equipment sign-out and maintenance capabilities, an air fill station, and photo/video equipment. Classes for diver training are held on a regular basis, and are taught in accordance with AAUS standards.

The composition of the Dive Team is approximately half faculty/ staff and half students.

Comprehensive Coastal Inventory Program (CCI)

The Comprehensive Coastal Inventory Program (CCI) is managed by the Center for Coastal Management and Policy. Using advanced Geographic Information Systems (GIS) and Global Positioning Systems (GPS) technology, CCI develops and maps coastal resource inventories to address a broad spectrum of environmental planning needs.

CCI inventories and monitors wetlands, shorelines and natural/cultural resources within the coastal plain and upper watershed regions. The program conducts basic and applied research in natural resource management using GIS, GPS, and remote sensing techniques as its principal tools. Current research focuses on the identification of protocols for the analysis of use conflicts problems, habitat restoration targeting protocols, status and trends analysis, and watershed-level land use planning/management. The facility is equipped with 10 Unix workstations, 2 Silicon Graphics machines, and a host of personal computers all operating in a distributed network environment. The Unix version of ArcInfo, ArcView, and Erdas are the primary software packages. The facility is also equipped with high order Trimble GPS receivers and several hand-held units. A GPS base station runs 24 hours a day.

Fish Collection

The Institute maintains the Commonwealth's ichthyology collection, which includes approximately 100,000 specimens in 247 families from the Chesapeake Bay and contiguous waters, the continental slope, and the abyssal plain of the western Atlantic; as well as a number of exotic species including a 5-foot female coelacanth from the Comoros Islands in the Indian Ocean. The collection has comprehensive and historical coverage of freshwater species from Virginia and the southern Appalachians. More than 20,000 lots, of which 13,000 are computer cataloged, are stored on specially constructed shelving that provides access to the entire collection. The Institute also maintains a growing collection of marine and estuarine ichthyoplankton from the Chesapeake Bay, the Mid-Atlantic Bight, and Caribbean waters. The facility provides equipment for processing acquisitions, x-ray studies, and performing necropsies on large fishes, sea turtles and cetaceans.

Information Technology and Networking Services (ITNS)

ITNS provides the information technology infrastructure and resources to support VIMS' tripartite mission of research, education, and advisory services. All buildings on the 35-acre VIMS campus are connected to a high speed switched ethernet network. The VIMS campus network is connected to the internet via a high speed link to Network Virginia, which connects VIMS to the Wachapreague campus on the Eastern Shore, the William and Mary main campus, and the world.

Services such as electronic mail, web sites, internet news, databases, file transfer, search engines, administrative systems access, user home space, etc. are provided by a collection of Unix and Windows NT servers. This environment provides students, faculty, and staff with a robust variety of software tools and scientific data resources, facilitating activities such as analysis, visualization, GIS mapping, genetic modeling, hydrodynamic modeling, etc.

Information is made available to the VIMS community, its advisory constituency, and the world via the VIMS web site. One can get a good "view" of VIMS through information provided on the VIMS website at http://www.vims.edu.

Analytical Service Center

For more than a decade, the Analytical Service Center (ASC) has researched, developed, and refined methodologies for analysis in a wide spectrum of environmental matrices. The quality of data is a direct result of thorough statistical controls, documentation, and training. ASC instrumentation is state-of-the-art with computer control/acquisition, background correction, and optimization for saline matrix. Quality Control criteria are monitored at the instruments and overseen by the Quality Assurance Officer.

Characterization of the Chesapeake Bay and associated tributary ecosystems highlight the research efforts of the center. The team has extensive experience in monitoring research programs coordinated by state and federal agencies as well as participation in coastal and open ocean projects. Support personnel provide field services using traditional and modified sampling techniques and equipment. To meet the immediate demands of researchers, costing and processing of samples for nutrient analysis is available. The ASC provides a full cost analysis to facilitate proposal preparation, and prices remain firm for two years following submission.

Sponsored Research Center

The VIMS Office of Sponsored Programs assists the faculty and staff in soliciting, negotiating, and managing research support from a variety of funding sources. The office serves as the central point of contact for sponsored research activities, and is charged with ensuring that all awards are managed in compliance with appropriate financial and administrative regulations.

Publications Center

The Publications Center provides publishing, photographic and video support to the Institute.

Publication Graphics provides publication layout, design, and computer graphics; produces 35-mm color slides and transparencies; and provides full color copying. Center graphic designers also produce interactive, multimedia presentations, videography, and computer-based presentations. Custom photography, negative, print, color slide processing, and photographic support are provided by the photo lab.

Publications

Journal and Book Contributions

1619. **Unger**, Michael A.; **Greaves**, John; **Huggett**, Robert J. 1996. Grignard derivatization and mass spectrometry as techniques for the analysis of butyltins in environmental samples. In Champ, M.A. and P.F. Seligman, eds. Organotin: Environmental Fate and Effects. London, Chapman & Hall,1996. Chapter 6: p. 123-134.

1704. **Huggett**, Robert J.; **Evans**, David A.; **MacIntyre**, William G.; **Unger**, Michael A.; Seligman, P. F.; Hall, L. W., Jr. 1996. Tributyltin concentration in waters of the Chesapeake Bay. In Champ, M.A. and P.F. Seligman,eds. Organotin: Environmental Fate and Effects London, Chapman & Hall,1996. Chapter 24: p. 485-501.

1705. **Huggett**, Robert J.; Espourteille, Francois A.; Rice, Charles D.; **Unger**, Michael A.; Dooley, C.A.; Cola, S.Y. 1996. Analytical methods for tributyltin in sediments and tissues. In Champ, M.A. and P.F. Seligman, eds. Organotin: Environmental Fate and Effects. London, Chapman & Hall,1996. Chapter 7: p. 135-141.

1717. Carlton, James T.; **Mann**, Roger 1996. Transfers and world-wide introductions. In Kennedy, Victor S., Roger I.E. Newell and Albert F. Eble, eds. The Eastern Oyster: *Crassostrea virginica*. College Park, MD: Maryland Sea Grant College Chapter 20: p. 691-706.

1722. **Castagna**, Michael; Gibbons, Mary C.; Kurkowski, Kenneth 1996. Culture: Application. In Kennedy, Victor S., Roger I. E. Newell and Albert F. Eble, eds. The Eastern Oyster: *Crassostrea virginica*. College Park, MD: Maryland Sea Grant College. Chapter 19: p. 675-690.

1808. **Perry**, James E.; Atkinson, Robert B. 1997. Plant diversity along a salinity gradient of four marshes on the York and Pamunkey Rivers inVirginia. *Castanea* 62:112-118.

1884. **Andrews**, Jay D. 1996. History of *Perkinsus marinus*, a pathogen of oysters in Chesapeake Bay, 1950 to 1984. *Journal of Shellfish Research* 15:13-16.

1908. **Musick**, John A.; **Desfosse**, Joseph C.; Wilk, Stuart; McMillan, Donald; **Grogan**, Eileen. 1996. Historical comparison of the structure of demersal fish communities near a deep-sea disposal site in the western North Atlantic. *Journal of Marine Environmental Engineering* 3:149-171.

1922. **Park**, Kyeong; **Kuo**, Albert Y.; **Neilson**, Bruce J. 1996. A numerical model study of hypoxia in the tidal Rappahannock River of Chesapeake Bay. *Estuarine, Coastal and Shelf Science* 42:563-581.

1934. **Silberhorn**, Gene M.; **Dewing**, Sharon; **Mason**, Pamela A. 1996.Production of reproductive shoots, vegetative shoots, and seeds in populations of *Ruppia maritima* L. from the Chesapeake Bay, Virginia. *Wetlands* 16: p.232-239.

1954. **Ozkizilcik**, Sureyya; **Chu**, Fu-Lin E. 1996. Preparation and characterization of a complex microencapsulated diet for striped bass, *Morone saxatilis* larvae. *Journal of Microencapsulation* 13:331-343.

1955. **Chu**, Fu-Lin E. 1996. Laboratory investigation of susceptibility, infectivity and transmission of *Perkinsus marinus* in oysters. *Journal of Shellfish Research* 15:57-66.

1956. **Fisher**, Robert A.; **DuPaul**, William D.; Rippen, Thomas E. 1996. Nutritional, proximate, and microbial characteristics of phosphate processed sea scallops (*Placopecten magellanicus*). *Journal of Muscle Foods* 7:92.

1959. **Unger**, Michael A.; **Huggett**, Robert J.; **MacIntyre**, William G. 1996. Sorption behavior of tributyltin. Champ, M. and P.F. Seligman, eds. Organotin: Environmental Fate and Effects London, Chapman & Hall, 1996. Chapter 23:475-483.

1962. Li, Michael Z.; **Wright**, L. Donelson; Amos, Carl L. 1996. Predicting ripple roughness and sand resuspension under combined flows in a shoreface environment. *Marine Geology* 130:139-161.

1963. **Ozkizilcik**, Sureyya; **Chu**, Fu-Lin E.; Place, Allen R. 1996.Ontogenetic changes of lipolytic enzymes in striped bass (*Morone saxatilis*). *Comparative Biochemistry and Physiology* 113B:631-637.

1968. **Burreson**, Eugene M.; **Calvo**, Lisa M. Ragone 1996. Epizootiologyof *Perkinsus marinus* disease of oysters in Chesapeake Bay, with emphasis on data since 1985. *Journal of Shellfish Research* 15:17-34.

1969. **Friedrichs**, Carl T.; **Hamrick**, John M. 1996. Effects of channel geometry on cross sectional variations in along channel velocity in partially stratified estuaries. Aubrey, D.G. and C.T. **Friedrichs**, eds. Buoyancy Effects on Coastal Dynamics. Washington, D.C., American Geophysical Union, 1996. Chapter 20: p. 283-300.

1970. **Gundersen**, Jennifer L.; **MacIntyre**, William G. 1996. Dissociation constants of chloroguaiacols in water: a comparison of

measured and predicted values. *Environmental Toxicology and Chemistry* 15: p.809-813.

1971. **Chu**, Fu-Lin E.; **Burreson**, Eugene M.; Zhang, Fusui; Chew, Kenneth K. 1996. An unidentified haplosporidian parasite of bay scallops, *Argopecten irradians*, cultured in the Shandong and Liaoning provinces of China. *Diseases of Aquatic Organisms* 25:155-158.

1972. **Kuehl**, Steven A.; Nittrouer, Charles A.; Allison, M.A.; Faria, L. Ercilio C.; Dukat, D.A.; Jaeger, J.M.; Pacioni, T.D.; Figueiredo, A.G.; Underkoffler, E.C. 1996. Sediment deposition, accumulation, andseabed dynamics in an energetic fine-grained coastal environment. *Continental Shelf Research* 16:787-815.

1973. Nittrouer, Charles A.; **Kuehl**, Steven A.; Figueiredo, A.G.; Allison, M.A.; Sommerfield, C.K.; Rine,J.M.; Faria, L.E.C.; Silveira, O.M. 1996. The geological record preserved by Amazon shelf sedimentation. *Continental Shelf Research* 16:817-841.

1975. **Goodbred**, Catherine O.; **Graves**, John E. 1996. Genetic relationships among geographically isolated populations of bluefish (*Pomatomus saltatrix*). *Marine and Freshwater Research* 47:347-355.

1976. **Lowerre-Barbieri**, Susan K.; **Chittenden**, Mark E., Jr.; **Barbieri**, Luiz R. 1996. The multiple spawning pattern of weakfish in the Chesapeake Bay and Middle Atlantic Bight. *Journal of Fish Biology* 48:1139-1163.

1979. Fishman, James R.; **Orth**, Robert J. 1996. Effects of predation on *Zostera marina* L. seed abundance. *Journal of Experimental Marine Biology and Ecology* 198:11-26.

1980. **Rizzo**, William M.; **Berry**, Betty E.; **Wetzel**, Richard L.; Dailey, S.K.; Lackey, G.J.; Christian, R.R. 1996. A metabolism-based trophic index for comparing the ecological values of shallow-water sediment habitats. *Estuaries* 19(2A):247-256.

1981. **Diaz**, Robert J.; Rosenberg, Rutger 1996. The influence of sediment quality on functional aspects of marine benthic communities.. Munawar, M. and G. Dave, eds. Development and Progress in Sediment Quality Assessment: Rationale, Challenges, Techniques and Strategies. Amsterdam, SPB Academic Publishing, 1996: p. 57-68.

1982. **Hale**, Robert C.; **Gaylor**, Michael O.; Thames, Judith F.; Smith, Craig L.; **Mothershead**, Robert F., II 1996. Robustness of supercritical fluid extraction (SFE) in environmental studies: analysis of chlorinated pollutants in tissues from the osprey (*Pandion haliaetus*) and several fish species. *International Journal of Environmental Analytical Chemistry* 64: p.11-19.

1983. **Sminkey**, Thomas R.; **Musick**, John A. 1996. Demographic analysis of the sandbar shark, *Carcharhinus plumbeus*, in the western North Atlantic. *Fishery Bulletin* 94:341-347.

1984. **Pile**, Adele J.; **Lipcius**, Romuald N.; **van Montfrans**, Jacques; **Orth**, Robert J. 1996. Density-dependent settler-recruit-juvenile relationships in blue crabs. *Ecological Monographs* 66:277-300.

1986. **La Peyre**, Jerome F.; 1996. Propagation and *in vitro* studies of *Perkinsus marinus*. *Journal of Shellfish Research* 15:89-101.

1987. **Park**, Kyeong; **Kuo**, Albert Y. 1996. A multi-step computation scheme: decoupling kinetic processes from physical transport in water quality models. *Water Research* 30:2255-2264.

1988. Walton, Susan A.; **Lynch**, Maurice P. 1996. The virtual "surf" zone: environmental studies on the Internet. *Science Scope* 19:19-21.

1990. **Park**, Kyeong; **Kuo**, Albert Y. 1996. Effect of variation in vertical mixing on residual circulation in narrow, weakly nonlinear estuaries. Aubrey, D.G. and C.T. **Friedrichs**, eds. Buoyancy Effects on Coastal and Estuarine Dynamics. Washington, D.C. American Geophysical Union, 1996: Chapter 21: p.301-317.

1991. **Chu**, Fu-Lin E.; **Volety**, Aswani K. 1997. Disease processes of the parasite *Perkinsus marinus* in Eastern oyster, *Crassostrea virginica*: minimum dose for infection initiation, and interaction of temperature, salinity and infective cell dose. *Diseases of Aquatic Organisms* 28:61-68.

1992. **Chu**, Fu-Lin E.; **Volety**, Aswani K.; Constantin, Georgeta. 1996. A comparison of *Crassostrea gigas* and *Crassostrea virginica*: effects of temperature and salinity on susceptibility to the protozoan parasite, *Perkinsus marinus*. *Journal of Shellfish Research* 15:375-380.

1993. Heist, Edward J.; **Musick**, John A.; **Graves**, John E. 1996. Mitochondrial DNA diversity and divergence among sharpnose sharks, *Rhizoprionodon terraenovae*, from the Gulf of Mexico and Mid-Atlantic Bight. *Fishery Bulletin* 94:664-668.

1994. Burke, Marianne K.; Dennison, William C.; **Moore**, Kenneth A. 1996. Non-structural carbohydrate reserves of eelgrass *Zostera marina*. Marine Ecology Progress Series 137:195-201.

1995. **Lowerre-Barbieri**, Susan K.; **Chittenden**, Mark E., Jr.; **Barbieri**, Luiz R. 1996. Variable spawning activity and annual fecundity of weakfish in Chesapeake Bay. Transactions of the American Fisheries Society 125: p.532-545.

1996. **Perkins**, Frank O.; 1996. The structure of *Perkinsus marinus* (Mackin,Owen and Collier, 1950) Levine, 1978 with comments on taxonomy and phylogeny of *Perkinsus* spp. *Journal of Shellfish Research* 15:67-87.

1997. **La Peyre**, Jerome F.; **Faisal**, Mohamed 1996. Optimal culture conditions for the propagation of the oyster pathogen *Perkinsus marinus* (Apicomplexa) in protein deficient medium. *Parasite* 3:147-153.

1998. **Barber**, Bruce J.; 1996. Gametogenesis of Eastern oysters, *Crassostrea virginica* (Gmelin, 1791), and Pacific oysters, *Crassostrea gigas* (Thunberg,1793) in disease-endemic lower Chesapeake Bay. *Journal of Shellfish Research* 15:285-290.

1999. **Armstrong**, Michael P.; **Musick**, John A.; **Colvocoresses**, James A. 1996. Food and ontogenetic shifts in feeding of the goosefish, *Lophius americanus*. *Journal of Northwest Atlantic Fishery Science* 18:99-103.

2000. Hansen, John D.; **Kaattari**, Stephen L. 1996. The recombination activating gene 2 (RAG2) of the rainbow trout, *Oncorhynchus mykiss*. *Immunogenetics* 44:203-211.

2001. **Cooper**, Peter S.; **Vogelbein**, Wolfgang K.; **Van Veld**, Peter A. 1996. Immunohistochemical and immunoblot detection of P-glycoprotein in normal and neoplastic fish liver. Ostrander, Gary K., ed. Techniques in Aquatic Toxicology. Boca Raton, Lewis Publishers. CRC Press, 1996. Chapter 17: p.307-325.

2002. Shen, Jian; **Kuo**, Albert Y. 1996. Inverse estimation of parameters for an estuarine eutrophication model. *Journal of Environmental Engineering* 122:1031-1040.

2003. **Flores**, Brenda S.; **Siddall**, Mark E.; **Burreson**, Eugene M. 1996. Phylogeny of the *Haplosporidia* (Eukaryota: Alveolata) based on small subunit ribosomal RNA gene sequence. *Journal of Parasitology* 82:616-623.

2004. **Hale**, Robert C.; **Smith**, Craig L. 1996. A multiresidue approach for trace organic pollutants: application to effluents and associated aquatic sediments and biota from the southern Chesapeake Bay drainage basin 1985-1992. *International Journal of Environmental Analytical Chemistry* 64: p.21-33.

2005. Fourqurean, James W.; **Webb**, Kenneth L.; Hollibaugh, James T.; Smith, Stephen V. 1997. Contributions of the plankton community to ecosystem respiration, Tomales Bay, California. *Estuarine, Coastal and Shelf Science* 44:493-505.

2006. **Pile**, Adele J.; **Patterson**, Mark R.; Savarese, Michael; Chernykh, Valeri I.; Fialkov, Vladimir A. 1997. Trophic effects of sponge feeding within Lake Baikal's littoral zone. 2. Sponge abundance, diet, feeding efficiency, and carbon flux. *Limnology and Oceanography* 42:178-184.

VNC. **Perkins**, Frank O.; 1996. Foreword. *Journal of Shellfish Research* 15:5-7.

2007. **Austin**, Herbert M.; 1996. Observations on daylight feeding periodicities of wading birds (Ardeidae) in Sarah's Creek, York River, Virginia. *Journal of the Elisha Mitchell Scientific Society* 111:137-145.

VNC. **Siddall**, Mark E.; 1996. Stratigraphic consistency and the shape of things. *Systematic Biology* 45:111-115.

VNC. **Siddall**, Mark E.; 1996. Phylogenetic covariance probability: confidence and historical associations. *Systematic Biology* 45:48-66.

2009. **Perkins**, Frank O.; 1996. Shell disease in the gold lip pearl oyster, *Pinctada maxima* and the Eastern oyster, *Crassostrea virginica*. *Aquatic LivingResources* 9:159-168.

2010. Lund, Richard; **Grogan**, Eileen D. 1997. Relationships of the Chimaeriformes and the basal radiation of the Chondrichthyes. *Reviews in Fish Biology and Fisheries* 7:65-123.

2011. **Gustafson**, Kurt E.; **Dickhut**, Rebecca M. 1997. Particle/gas concentrations and distributions of PAHs in the atmosphere of southern Chesapeake Bay. *Environmental Science and Technology* 31:140-147.

2013. Siddall, Mark E.; **Burreson**, Eugene M. 1996. Leeches (Oligochaeta?:Euhirudinea), their phylogeny and the evolution of life–history strategies. *Hydrobiologia* 334:277-285.

VNC. Carlson, Craig A.; **Ducklow**, Hugh W. 1996. Growth of bacterioplankton and consumption of dissolved organic carbon in the Sargasso Sea. *Aquatic Microbial Ecology* 10:69-85.

2015. **Pile**, Adele J.; **Patterson**, Mark R.; Witman, Jon D. 1996. *In situ* grazing on plankton <10 mm by the boreal sponge *Mycale lingua*. *Marine Ecology Progress Series* 141:95-102.

2016. **Boon**, John D.; Green, Malcolm O.; Duck Suh, Kyung 1996. Bimodal wave spectra in lower Chesapeake Bay, sea bed energetics and sediment transport during winter storms. *Continental Shelf Research* 16:1965-1988.

VNC. **Duffy**, J. Emmett; 1996. Eusociality in a coral-reef shrimp. *Nature* 381:512-514.

2018. **La Peyre**, Jerome F.; **Yarnall**, Heather A.; **Faisal**, Mohamed 1996. Contribution of *Perkinsus marinus* extracellular products in the infection of eastern oysters (*Crassostrea virginica*). *Journal of Invertebrate Pathology* 68:312-313.

VNC. Anderson, R.S.; **Unger**, Michael A.; **Burreson**, Eugene M. 1996. Enhancement of *Perkinsus marinus* disease progression in TBT-exposed oysters (*Crassostrea virginica*). *Marine Environmental Research* 42:177-180.

2019. Gustafson, Kurt E.; **Dickhut**, Rebecca M. 1997. Distribution of polycyclic aromatic hydrocarbons in southern Chesapeake Bay surface water: evaluation of three methods for determining freely dissolved water concentrations. *Environmental Toxicology and Chemistry* 16:452-461.

2020. **Milliman**, John D.; Droxler, A. W. 1996. Neritic and pelagic carbonate sedimentation in the marine environment: ignorance is not bliss. *GeologischeRundschau* 85:496-504.

2022. **Kim**, Sung-Chan; **Wright**, L. Donelson; **Kim**, Baeck Oon 1997. The combined effects of synoptic-scale and local-scale meteorological events on bed stress and sediment transport on the inner shelf of the Middle Atlantic Bight. *Continental Shelf Research* 17:407-433.

VNC. Oguz, Temel; **Ducklow**, Hugh; Malanotte-Rizzoli, Paola; Tugrul, Suleyman; Nezlin, Nikolai P.; Unluata, Umit 1996. Simulation of annual plankton productivity cycle in the Black Sea by a one-dimensional physical-biological model. *Journal of Geophysical Research* 101(C7): p.16,585-16,599.

VNC. Flano, E.; **Kaattari**, Stephen L.; Razquin, B.; Villena, A.J. 1996. Histopathology of the thymus of coho salmon *Oncorhynchus kisutch* experimentally infected with *Renibacterium salmoninarum. Diseases of Aquatic Organisms* 26:11-18.

2023. Savarese, Michael; **Patterson**, Mark R.; Chernykh, Valeri I.; Fialkov, Vladimir A. 1997. Trophic effects of sponge feeding within Lake Baikal's littoral zone. 1. In situ pumping rates. *Limnology and Oceanography* 42:171-178.

VNC. Thompson, Raymond J.; Newell, Roger I.E.; Kennedy, Victor S.; **Mann**, Roger 1996. Repoductive processes and early development. In Kennedy,Victor S., Roger I.E. Newell and Albert F. Eble, eds. The Eastern Oyster: *Crassostrea virginica*. College Park, MD. Maryland Sea Grant College. Chapter 9: p. 335-370.

VNC. Shashar, N.; Jokiel, P.L.; **Patterson**, Mark E. 1996. Hydromechanical boundary layers over a coral reef. *Journal of Experimental Marine Biology and Ecology* 199:17-28.

VNC. Mangum, Charlotte P.; **Greaves**, John 1996. Hemocyanins of the genus Uca: structural polymorphisms and native oligomers. *Journal of Experimental Marine Biology and Ecology* 199:1-15.

VNC. **Duffy**, J. Emmett; 1996. *Synalpheus regalis*, new species, a sponge-dwelling shrimp from the Belize Barrier Reef, with comments on host specificity in *Synalpheus*. *Journal of Crustacean Biology* 16:564-573.

VNC. Molloy, Daniel P.; Roitman, Vitali A.; **Shields**, Jeffrey D. 1996. Survey of the parasites of zebra mussels (Bivalvia: Dreissenidae) in northwestern Russia, with comments on records of parasitism in Europe and North America. *Journal of the Helminthological Society of Washington* 63: p.251-256.

VNC. O'Day, Peggy A.; **Chisholm-Brause**, Catherine J.; Towle, Steven N.; Parks, George A.; Brown, Gordon E., Jr. 1996. X-ray absorption spectroscopy of Co(II) sorption complexes on quartz (-SiO2) and rutile(TiO2). *Geochimica et Cosmochimica Acta* 60:2515-2532.

VNC. Rich, James H.; **Ducklow**, Hugh W.; Kirchman, David L. 1996. Concentrations and uptake of neutral monosaccharides along 140 degrees W in the equatorial Pacific: contribution of glucose to heterotrophic bacterial activity and the DOM flux. *Limnology and Oceanography* 41:595-604.

VNC. Morris, David E.; Allen, Patrick G.; Berg, John M.; **Chisholm-Brause**, Catherine J.; Conradson, Steven D.; Donohoe, Robert J.; Hess, Nancy J.; **Musgrave**, John A.; Tait, C. Drew. 1996. Speciation of uranium in Fernald soils by molecular spectroscopic methods: characterization of untreated soils. *Environmental Science and Technology* 30:2322-2331.

VNC. Carlson, Craig A.; **Ducklow**, Hugh W.; Sleeter, Thomas D. 1996. Stock sand dynamics of bacterioplankton in the northwestern Sargasso Sea. *Deep-Sea Research* II 43:491-515.

VNC. Druffel, Ellen R.M.; **Bauer**, James E.; Williams, Peter M.; Griffin, Sheila; Wolgast, David 1996. Seasonal variability of particulate organic radiocarbon in the northeast Pacific Ocean. *Journal of Geophysical Research* 101(C9):20,543-20,552.

2024. **Moore**, Kenneth A.; Neckles, Hilary A.; **Orth**, Robert J. 1996. *Zosteramarina* (eelgrass) growth and survival along a gradient of nutrients and turbidity in the lower Chesapeake Bay. *Marine Ecology Progress Series* 142: p.247-259.

2025. Gundersen, Jennifer L.; MacIntyre, William G.; **Hale**, Robert C. 1997. pH-dependent sorption of chlorinated guaiacols on estuarine sediments: the effects of humic acids and TOC. *Environmental Science and Technology* 31: p.188-193.

2026. **Musick**, John A.; Limpus, Colin J. 1997. Habitat utilization and migration in juvenile sea turtles. Lutz, Peter L. and John A. **Musick**, eds. The Biology of Sea Turtles. Boca Raton, CRC Press: Marine Science Series, 1997. Chapter 6: p. 137-163.

2027. Chaloupka, M.Y.; **Musick**, John A. 1997. Age, growth and population dynamics. Lutz, Peter L. and John A. **Musick**, eds. The Biology of Sea Turtles. Boca Raton, CRC Press: Marine Science Series, 1997. Chapter 9: p.233-276.

2028. Lutz, Peter L., ed.; **Musick**, John A., ed. 1997. The Biology of Sea Turtles. Boca Raton, CRC Press: 1997. 432 p.

2029. **Van Veld**, Peter A.; **Vogelbein**, Wolfgang K.; Cochran, Maria K.; Goksoyr, Anders; Stegeman, John J. 1997. Route-specific cellular expression of cytochrome P4501A (CYP1A) in fish (*Fundulus heteroclitus*) following exposure to aqueous and dietary benzo[a]pyrene. *Toxicology andApplied Pharmacology* 142:348-359.

2030. Norrgard, J.W.; **Graves**, John E. 1996. Determination of the natal origin of a juvenile loggerhead turtle (*Caretta caretta*) population in Chesapeake Bay using mitochondrial DNA analysis. Bowen, B.W. and W.N. Witzell, eds. Proceedings of the International Symposium on Sea Turtle Conservation Genetics. Seattle, National Marine Fisheries Service: 1996 NOAA Technical Memorandum NMFS-SEFSC 396:129-136.

2031. **Garreis**, Kathleen A.; **La Peyre**, Jerome F.; **Faisal**, Mohamed 1996. The effects of *Perkinsus marinus* extracellular products and purified proteases on oyster defence parameters in vitro. *Fish & Shellfish Immunology* 6: p.581-597.2032.

Austin, Herbert M.; **Evans**, David; **Haven**, Dexter S. 1996. A restrospective time series analysis of oyster, *Crassostrea virginica*, recruitment (1946-1993). *Journal of Shellfish Research* 15:565-582.

2034. Sved, Daniel W.; **Roberts**, Morris H., Jr.; **Van Veld**, Peter A. 1997. Toxicity of sediments contaminated with fractions of creosote. *Water Research* 31:294-300.

2035. McGovern, John C.; **Olney**, John E. 1996. Factors affecting survival of early life stages and subsequent recruitment of striped bass on the PamunkeyRiver, Virginia. *Canadian Journal of Fisheries and Aquatic Sciences* 53: p.1713-1726.

2036. **Friedrichs**, Carl T.; **Wright**, L. Donelson 1997. Sensitivity of bottom stress and bottom roughness estimates to density stratification, Eckernforde Bay, southern Baltic Sea. *Journal of Geophysical Research: Oceans* 102C: p.5721-5732.

2037. **Grogan**, Eileen D.; Lund, Richard 1997. Soft tissue pigments of the Upper Mississippian Chondrenchelyid, *Harpagofututor volsellorhinus* (Chondrichthyes, Holocephali) from the Bear Gulch limestone, Montana, *USA. Journal of Paleontology* 71:337-342.

2039. **Maa**, Jerome P.-Y.; Sanford, L.; Halka, J. P. 1998. Sediment resuspension characteristics in the Baltimore Harbor, Maryland. *Marine Geology* 146:137-145.

2040. Leis, Jeffrey M.; **Olney**, John E.; Okiyama, Muneo 1997. Introduction to the proceedings of the symposium fish larvae and systematics: ontogeny and relationships. *Bulletin of Marine Science* 60:1-5.

2041. **Cavalluzzi**, Martin R.; 1997. Larvae of *Gillellus jacksoni*, *G. uranidea* (Dactyloscopidae), *Stathmonotus stahli tekla* and *S. hemphilli* (Chaenopsidae),with comments on the use of early life history characters for elucidating relationships within the Blennioidei. *Bulletin of Marine Science* 60:139-151.

VNC. Hamlett, William C.; **Musick**, John A.; Eulitt, Allison M.; Jarrell, Robert L.; Kelly, Matthew A. 1996. Ultrastructure of fetal alimentary organs: stomach and spiral intestine in the southern stingray, *Dasyatis americana*. *Canadian Journal of Zoology* 74:1431-1443.

VNC. Hamlett, William C.; **Musick**, John A.; Eulitt, Allison M.; Jarrell, Robert L.; Kelly, Matthew A. 1996. Ultrastructure of uterine trophonemata, accommodation for uterolactation, and gas exchange in the southern stingray, *Dasyatis americana*. *Canadian Journal of Zoology* 74: p.1417-1430.

VNC. **Mosca**, Thomas C., III; Rudershausen, Paul J.; **Lipcius**, Romuald N. 1996. Do striped bass and blue crab abundances correlate in Chesapeake Bay?. *Virginia Journal of Science* 46:249-258.

VNC. **Havens**, Kirk J.; **Priest**, Walter I., III; Jennings, Ann 1996. The use of night-vision equipment to observe wildlife in forested wetlands. *Virginia Journal of Science* 46:227-234.

2042. Moksnes, Per-Olav; **Lipcius**, Romuald N.; Pihl, Leif; **van Montfrans**, Jacques 1997. Cannibal-prey dynamics in young juveniles and postlarvae of the blue crab. *Journal of Experimental Marine Biology and Ecology* 215:157-187.

2043. Boles, Larry C.; **Lipcius**, Romuald N. 1997. Potential for population regulation of the zebra mussel by finfish and the blue crab in North American estuaries. *Journal of Shellfish Research* 16:179-186.

2045. **Reece**, Kimberly S.; **Siddall**, Mark E.; **Burreson**, Eugene M.; **Graves**, John E. 1997. Phylogenetic analysis of *Perkinsus* based on actin gene sequences. *Journal of Parasitology* 83:417-423.

VNC. Wiberg, Patricia L.; Cacchione, David A.; Sternberg, Richard W.; **Wright**, L. Donelson 1996. Linking sediment transport and stratigraphy on the continental shelf. *Oceanography* 9:153-157.

2047. **Maa**, Jerome P.-Y.; Lee, Chang-Hee 1997. Variation of the resuspension coefficients in the lower Chesapeake Bay. *Journal of Coastal Research*. Special Issue No. 25:63-74.

VNC. **Friedrichs**, Carl T.; Aubrey, D.G. 1996. Introduction. Part I. The importance of buoyancy in estuarine and coastal environments. In Aubrey, D.G.and C.T. **Friedrichs**, eds. Buoyancy Effects on Coastal and Estuarine Dynamics, Chapter 1. Washington, D.C., American Geophysical Union: 1996: p.1-6.

VNC. **Friedrichs**, Carl T.; Aubrey, D.G. 1996. Uniform bottom shear stress and equilibrium hyposometry of intertidal flats. In Pattiaratchi, Charitha, ed. Mixing in Estuaries and Coastal Seas. Washington, D.C., American Geophysical Union: 1996. Chapter 24: p. 405-429.

VNC. **Bauer**, James E.; Ruttenberg, Kathleen C.; Wolgast, David M.; Monaghan, Eileen; Schrope, Mark K. 1996. Cross-flow filtration of dissolved and colloidal nitrogen and phosphorus in seawater: results from an intercomparison study. *Marine Chemistry* 55:33-52.

2048. **Ryer**, Clifford H.; **van Montfrans**, Jacques; **Moody**, Kurt E. 1997. Cannibalism, refugia and the molting blue crab. *Marine Ecology Progress Series* 147:77-85.

2049. Blake, Sandra G.; Blake, Norman J.; **Oesterling**, Michael J.; **Graves**, John E. 1997. Genetic divergence and loss of diversity in two cultured populations of bay scallop, *Argopecten irradians* (Lamarck, 1819). *Journal of Shellfish Research* 16:55-58.

2050. **Hale**, Robert C.; Aneiro, Karen M. 1997. Determination of coal tar and creosote constituents in the aquatic environment. *Journal of Chromatography* A 774:79-95.

2051. **Havens**, Kirk J.; **Priest**, Walter I., III; **Berquist**, Harry 1997. Investigation and long-term monitoring of *Phragmites australis* within Virginia's constructed wetland sites. *Environmental Management* 21: p.599-605.

2052. **Maa**, Jerome P.-Y.; **Hobbs**, Carl H., III 1998. Physical impact of waves on adjacent coasts resulting from dredging at Sandbridge Shoal, Virginia. *Journal of Coastal Research* 14:525-536.

2053. **Austin**, Herbert M.; **Bonzek**, Christopher F. 1996. Effects of the June 1995 freshet on the main Virginia tributaries to the Chesapeake Bay. *Virginia Journal of Science* 47:251-279.

2054. **Wright**, L. Donelson; **Friedrichs**, Carl T.; Hepworth, Daniel A. 1997. Effects of benthic biology on bottom boundary layer processes, Dry Tortugas Bank, Florida Keys. *Geo-Marine Letters* 17:291-298.

2055. **Wright**, L. Donelson; Sherwood, C.R.; Sternberg, R.W. 1997. Field measurements of fairweather bottom boundary layer processes and sediment suspension on the Louisiana inner continental shelf. *Marine Geology* 140: p.329-345.

2056. Gustafson, Kurt E.; **Dickhut**, Rebecca M. 1997. Gaseous exchange of polycyclic aromatic hydrocarbons across the air-water interface of southern Chesapeake Bay. *Environmental Science & Technology* 31:1623-1629.

2057. **Barbieri**, Luiz R.; **Chittenden**, Mark E., Jr.; Jones, Cynthia M. 1997. Yield-per-recruit analysis and management strategies for Atlantic croaker, *Micropogonias undulatus*, in the Middle Atlantic Bight. *Fishery Bulletin* 95:637-645.

2058. **Moore**, Kenneth A.; **Wetzel**, Richard L.; **Orth**, Robert J. 1997. Seasonal pulses of turbidity and their relations to eelgrass (*Zostera marina L.*) survival in an estuary. *Journal of Experimental Marine Biology and Ecology* 215:115-134.

2060. **Wright**, L. Donelson; **Schaffner**, Linda C.; **Maa**, Jerome P.-Y. 1997. Biological mediation of bottom boundary layer processes and sediment suspension in the lower Chesapeake Bay. *Marine Geology* 141:27-50.

2061. **Gelsleichter**, James; Cortes, E.; Manire, C.A.; Hueter, R.E.; **Musick**, John A. 1997. Use of calcein as a fluorescent marker for elasmobranch vertebral cartilage. *Transactions of the American Fisheries Society* 126:862-865.

2064. Baker, Patrick; **Mann**, Roger 1997. The postlarval phase of bivalve mollusks: a review of functional ecology and new records of postlarval drifting of Chesapeake Bay bivalves. *Bulletin of Marine Science* 61: p.409-430.

2065. **Havens**, Kirk J.; 1997. The effect of vegetation on soil redox within a seasonally flooded forested system. *Wetlands* 17:237-242.

2066. **Reece**, Kimberly S.; Bushek, David; **Graves**, John E. 1997. Molecular markers for population genetic analysis of *Perkinsus marinus*. *Molecular Marine Biology and Biotechnology* 6:197-206.

2067. Luebke, Robert W.; Hodson, Peter V.; **Faisal**, Mohamed; Ross, Peter S.; Grasman, Keith A.; Zelikoff, Judith 1997. Aquatic pollution-induced immunotoxicity in wildlife species. *Fundamental and Applied Toxicology*: p.

2068. **Dai**, Ting; **Wetzel**, Richard L. 1998. Ecological models, ActiveX technology and the Internet. *Bulletin of the Ecological Society ofAmerica* 79:98-99.

2069. **Kuehl**, Steven A.; Levy, Beth M.; **Moore**, Willard S.; Allison, Mead A. 1997. Subaqueous delta of the Ganges-Brahmaputra river system. *Marine Geology* 144:81-96.

2070. Liu, Kewen; **Dickhut**, Rebecca M. 1997. Surface microlayer enrichment of polycyclic aromatic hydrocarbons in southern Chesapeake Bay. *Environmental Science & Technology* 31:2777-2781.

VNC. **Eggleston**, David B.; **Lipcius**, Romuald N.; Grover, Jill J. 1997. Predator and shelter-size effects on coral reef fish and spiny lobster prey. Marine Ecology Progress Series 149:43-59.

VNC. Martin, Jean-Marie; **Milliman**, John D. 1997. EROS 2000 (European River Ocean System). The western Mediterranean: an introduction. *Deep-Sea Research* II 44:521-529.

2071. Larsen, Peter F.; **Huggett**, Robert J.; **Unger**, Michael A. 1997. Assessment of organotin in waters of selected Gulf of Maine estuaries. *Marine Pollution Bulletin* 34:802-804.

2074. Williams, Susan L.; **Orth**, Robert J. 1998. Genetic diversity and structure of natural and transplanted eelgrass populations in the Chesapeake Bay and Chincoteague Bays. *Estuaries* 21:118-128.

2075. **Maa**, Jerome P.-Y.; Sun, K.-J.; He, Q. 1997. Ultrasonic characterization of marine sediments: a preliminary study. *Marine Geology* 141:183-192.

VNC. **Eggleston**, David B.; **Lipcius**, Romuald N.; Grover, Jill J. 1997. Predator and shelter-size effects on coral reef fish and spiny lobster prey. *Marine Ecology Progress Series* 149:43-59.

VNC. **Trussell**, Geoffrey C.; 1997. Phenotypic selection in an intertidal snail: effects of a catastrophic storm. *Marine Ecology ProgressSeries* 151:73-79.

VNC. **Roberts**, Morris H., Jr.; **Huggett**, Robert J.; **Bender**, Michael E.; **Slone**, H.; **De Lisle**, Peter F. 1996. Tributyltin bioconcentration

from solution and suspended sediments by oysters, with a comparison with uptake in a field experiment. In Champ, M.A. and P.F. Seligman, eds. Organotin: Environmental Fate and Effects. London, Chapman & Hall, 1996. Chapter 17: p.357-368.

2077. **Holmquist**, Richard K.; 1997. Maximum size revision and Chesapeake Bay distribution for striped burrfish, *Chilomycterus schoepfi. Virginia Journal of Science* 48:225-230.

2078. **Volety**, Aswani K.; **Chu**, Fu-Lin E. 1997. Acid phosphatase activity in *Perkinsus marinus*, the protistan parasite of the American oyster, *Crassostrea virginica. Journal of Parasitology* 83:1093-1098.

2079. **Chu**, Fu-Lin E. 1997. Trends in research on *Crassostrea virginica* and its two protozoan parasites, *Perkinsus marinus* and *Haplosporidium nelsoni. Bulletin of The European Association of Fish Pathologists* 17:184-187.

2081. **Munroe**, Thomas A.; 1998. Systematics and ecology of tonguefishes of the genus *Symphurus* (Cynoglossidae: Pleuronectiformes) from the western Atlantic Ocean. *Fishery Bulletin* 96:1-182.

2082. **Armknecht**, Susan L.; **Kaattari**, Stephen L.; **Van Veld**, Peter A. 1998. An elevated glutathione S-transferase in creosote-resistant mummichog (*Fundulus heteroclitus*). *Aquatic Toxicology* 41:1-16.

2083. **Schaffner**, Linda C.; **Dickhut**, Rebecca M.; **Mitra**, Siddhartha; Lay, Patrick W.; Brouwer-Riel, Carol 1997. Effects of physical chemistry and bioturbation by estuarine macrofauna on the transport of hydrophobic organic contaminants in the benthos. *Environmental Science & Technology* 31: p.3120-3125.

VNC. **Siddall**, Mark E.; **Reece**, Kimberly S.; **Graves**, John E.; **Burreson**, Eugene M. 1997. 'Total evidence' refutes the inclusion of *Perkinsus* species in the phylum Apicomplexa. *Parasitology* 115:165-176.

VNC. Eglinton, Timothy I.; Benitez-Nelson, Bryan C.; Pearson, Ann; McNichol, Ann P.; **Bauer**, James E.; Druffel, Ellen R.M. 1997. Variability in radiocarbon ages of individual organic compounds from marine sediments. *Science* 277:796-799.

VNC. **Baker**, Patrick; 1997. Settlement site selection by oyster larvae, *Crassostrea virginica*: evidence for geotaxis. *Journal of Shellfish Research* 16:125-128.

2086. Millar, Russell B.; **Hoenig**, John M. 1997. A generalized model for estimating intermolt periods of asynchronously molting insects and crustacea from field or laboratory data. *Journal of Agricultural, Biological, and Environmental Statistics* 2:389-402.

2094. Barimo, John F.; **Fine**, Michael L. 1998. Relationship of swim-bladder shape to the directionality pattern of underwater sound in the oyster toadfish. *Canadian Journal of Zoology* 76:134-143.

2095. **Anderson**, Iris C.; **Tobias**, Craig R.; **Neikirk**, Betty Berry; **Wetzel**, Richard L. 1997. Development of a process-based nitrogen mass balance model for a Virginia (USA) Spartina alterniflora salt marsh: implications for net DIN flux. *Marine Ecology Progress Series* 159:13-27.

2097. **Canuel**, Elizabeth A.; Freeman, Katherine H.; Wakeham, Stuart G. 1997. Isotopic compositions of lipid biomarker compounds in estuarine plants and surface sediments. *Limnology and Oceanography* 42:1570-1583.

2099. Ford, Susan E.; Smolowitz, Roxanna; **Calvo**, Lisa M. Ragone; Barber, Robert D.; Kraeuter, John N. 1997. Evidence that QPX (Quahog Parasite Unknown) is not present in hatchery-produced hard clam seed. *Journal of Shellfish Research* 16:519-521.

VNC. Roesijadi, G.; Hansen, K.M.; **Unger**, Michael E. 1997. Metallothionein mRNA accumulation in early developmental stages of *Crassostrea virginica* following pre-exposure and challenge with cadmium. *Aquatic Toxicology* 39: p.185-194.

VNC. Shiah, Fuh-Kwo; **Ducklow**, Hugh W. 1997. Bacterioplankton growth responses to temperature and chlorophyll variations in estuaries measured by thymidine: leucine incorporation ratio. *Aquatic Microbial Ecology* 13: p.151-159.

VNC. **Goldman**, Kenneth J.; 1997. Regulation of body temperature in the whiteshark, *Carcharodon carcharias*. *Journal of Comparative Physiology* B 167: p.423-429.

VNC. Anderson, Scot D.; **Goldman**, Kenneth J. 1996. Photographic evidence ofwhite shark movements in California waters. *California Fish and Game* 82: p.182-186.

VNC. **Goldman**, Kenneth J.; Anderson, Scot D.; McCosker, John E.; Klimley, A. Peter 1996. Temperature, swimming depth, and movements of a white shark at the South Farallon Islands, California. In Klimley, A. Peter and David G. Ainley, eds. Great White Sharks:

The Biology of *Carcharodon carcharias*. San Diego, Academic Press: 1996. Chapter 11: p. 111-120.

2100. Spraker, Holly; **Austin**, Herbert M. 1997. Diel feeding periodicity of Atlantic silverside, *Menidia menidia*, in the York River, Chesapeake Bay, Virginia. *Journal of the Elisha Mitchell Scientific Society* 113:171-182.

2111. **Varnell**, Lyle M.; 1998. The relationship between inundation history and bald cypress stem form in a Virginia floodplain swamp. *Wetlands* 18:176-183.

VNC. Stauffer, Thomas B.; Boggs, J. Mark; **MacIntyre**, William G. 1997. Ten years of research in groudwater transport studies at Columbus Air Force Base, Mississippi. In Sayler, Gary S., John Sanseverino and Kimberly L. Davis, eds. Biotechnology in the Sustainable Environment. New York, Plenum Press, 1997. Chapter 9: p. 85-96.

2113. **Liu**, Kewen; **Dickhut**, Rebecca M. 1998. Effects of wind speed and particulate matter source on surface microlayer characteristics and enrichment of organic matter in southern Chesapeake Bay. *Journal of Geophysical Research* 103:10,571-10,577.

2114. **Shen**, Jian; **Kuo**, Albert Y. 1998. Application of inverse method to calibrate estuarine eutrophication model. *Journal of Environmental Engineering* 124:409-418.

VNC. Squires, Dale; Campbell, Harry; Cunningham, Stephen; Dewees,Christopher; Grafton, R. Quentin; Herrick, Samuel F., Jr.; **Kirkley**, James; Pascoe, Sean; Salvanes, Kjell; Shallard, Bruce; Turris, Bruce; Vestergaard, Niels 1998. Individual transferable quotas in multispecies Fisheries. *Marine Policy* 22:135-159.

2117. **Dellapenna**, Timothy M.; **Kuehl**, Steven A.; **Schaffner**, Linda C. 1998. Sea-bed mixing and particle residence times in biologically and physically dominated estuarine systems: a comparison of lower Chesapeake Bay and the York River subestuary. *Estuarine, Coastal and Shelf Science* 46:777-795.

2118. **Calvo**, Lisa M. Ragone; **Walker**, Juanita G.; **Burreson**, Eugene M. 1998. Prevalence and distribution of QPX, Quahog Parasite Unknown, in hard clams, *Mercenaria mercenaria*, in Virginia, USA. *Diseases of Aquatic Organisms.*

VNC. **Goodbred,** Steven L.; Wright, Eric E.; Hine, Albert C. 1998. Sea-level change and storm-surge deposition in a Late Holocene Florida saltmarsh. *Journal of Sedimentary Research* 68(2):240-252.

VNC. **Greiner,** Megan; **Hershner,** Carl 1998. Analysis of wetland total phosphorus retention and watershed structure. *Wetlands* 18:142-149.

VNC. **Xu,** Jingping; **Wright,** L. Donelson 1998. Observations of wind-generated shoreface currents off Duck, North Carolina. *Journal of Coastal Research* 14:610-619.

VNC. **Bartol,** Ian K.; **Mann,** Roger 1997. Small-scale settlement patterns of the oyster *Crassostrea virginica* on a constructed intertidal reef. *Bulletin of Marine Science* 61:881-897.

VNC. **Hovel,** Kevin A.; Morgan, Steven G. 1997. Planktivory as a selective force for reproductive synchrony and larval migration. *Marine Ecology Progress Series* 157:79-95.

Data Reports

56. **Battisto,** Grace M., Carl T. **Friedrichs,** Arno de Kruif, and Daan C. Rijks. 1998. Data report: pump sampling and sediment analysis in support of the sensor insertion system, Duck, N.C., April and October 1997. 10p.

Marine Resource Advisories

64. na. 1997. Target Species and Tagging Procedures: Virginia Game Fish Tagging Program.

65. na. 1997. Fish Lesions, *Pfiesteria* and The Chesapeake Bay.

66. 1997. **Oesterling,** Michael J. Economic and Business Considerations For Small-Scale Soft Crab Production.

67. 1998. **Oesterling,** Michael J. Bay Scallop Culture.

336. **Kator**, Howard I. and Martha W. **Rhodes**. 1996. Identification of pollutant sources contributing to degraded sanitary water quality in Taskinas Creek National Estuarine Research Reserve, Virginia. 47 p.

337. **Kirkley**, James E. 1997. Virginia's commercial fishing industry: its economic performance and contributions. 77 p.

339. **Kirkley**, James E. and David **Kerstetter**. 1997. Saltwater angling and its economic importance to Virginia. 71 p.

340. **Hardaway**, C. Scott, Jr., Donna A. **Milligan**, Jerome P.-Y. **Maa** and George R. **Thomas**. 1997. Naval Amphibious Base Little Creek, Chesapeake Bay Shoreline: shoreline management plan and Officer's Beach shore protection evaluation. 60 p.

341. **Sisson**, G.M., Jian **Shen**, Sung-Chan **Kim**, John **Boon**, and Albert Y. **Kuo**. 1997. VIMS three-dimensional hydrodyamic-eutrophication model (HEM-3D): application of the hydrodynamic model to the York River system. Various pagings.

342. **Wetzel**, Richard L. and Christopher P. **Buzzelli**. 1997. Modeling the lower Chesapeake Bay littoral zone and fringing wetlands: ecosystem processes and habitat linkages. III. Model scenarios related to water quality and submersed vegetation. 27 p.

343. **Hata**, David. 1997. Comparisons of gears and vessels used the Virginia Institute of Marine Science juvenile finfish trawl survey. 244 p.

344. **Hepworth**, Daniel A., Carl T. **Friedrichs**, and L. Donelson **Wright**. 1997. Strata formation on margins (STRATAFORM) G-60 site: benthic boundary layer tripod data report, November 1996-January 1997. 98 p.

345. **Wright**, L. Donelson, Daniel A. **Hepworth**, Sung-Chan **Kim**, and Robert A. **Gammisch**. 1998. Strata formation on margins (STRATAFORM) S-60 and S-70 sites: benthic boundary layer tripod data report, December 1995-March 1996. 5 p. + figs. and disk.

Special Reports in Applied Marine Science and Ocean Engineering

124 R-1989-90. **Land**, Michael F., Patrick J. **Greer**, Christopher F. **Bonzek** and Herbert M. **Austin**. 1996. Juvenile finfish and blue crab stock assessment program York River random stratified bottom trawl survey, data summary report, volume R1989-1990. 289 p.

Special Scientific Reports

124 R-1991-94 **Land**, Michael F., Patrick J. **Greer**, Christopher F. **Bonzek** and Herbert M. **Austin**. 1996. Juvenile finfish and blue crab stock assessment program York River random stratified bottom trawl survey, data summary report, volume R1991-1994. 289 p.

135. **Maa**, Jerome P.-Y., M.-H. Maa, Changqing **Li**, and Qing **He**. 1997. Using the Gaussian elimination method for large banded matrix equations. 76 p.

136. **Maa**, Jerome P.-Y., T-W. Hsu and H.-H, Hwung. 1998. RDE model: a program for simulating water wave transformation for harbor planning. Various pagings.

Virginia Marine Resource Reports

96-6. William D. **DuPaul** and Jeffrey C. **Brust**. Landed (Ex-Vessel) Meat Counts of Sea Scallops, *Placopecten magellanicus*, in the mid-Atlantic region: 1994-1996.

97-1. James E. **Kirkley** and Michael J. **Oesterling**. The Importance of Aquaculture to Virginia's Economy: A Preliminary Assessment.

97-2. Lisa Ragone **Calvo** and Eugene M. **Burreson**. Status of the Major Oyster Diseases in Virginia - 1996.

97-3. William D. **DuPaul** and James E. **Kirkley**. Evaluation of Crew Size Limits and Dredge Ring Size Restriction in the Atlantic Sea Scallop Fishery.

97-4. William D. **DuPaul**, Michael J. **Oesterling** and Laura A. **Rose**. Marine Finfish Aquaculture in Virginia.

97-5. Reinaldo **Morales-Alamo** and Roger **Mann**. The Status of Virginia's Public Oyster Resource 1996.

97-6. Patrick J. **Geer**. Evaluation of the Potomac River American Eel Pot Fishery Based on Commercial Landings.

97-7. Claude M. Bain, III and Jon A. **Lucy**. Virginia Game Fish Tagging Program - 1996.

97-8. Jon A. **Lucy** and Tracy D. Holton. Release Mortality in Virginia's Recreational Fishery for Summer Flounder, *Paralichthys dentatus*.

98-1. Lisa Ragone **Calvo** and Eugene M. **Burreson**. Status of the Major Oyster Diseases in Virginia - 1997.

98-2. Reinaldo **Morales-Alamo** and Roger **Mann.** The Status of Virginia's Public Oyster Resource 1997.

98-3. Claude M. Bain, III, Director, VA Saltwater Fishing Tournament, Jon **Lucy** and Michael D. **Arendt.** Virginia Game Fish Tagging Program - 1997.

98-4. W. C. **Coles** and J. A. **Musick.** A Record of Sea Turtle Strandings from Virginia for May and June 1998.

Technical Reports (Wetlands Program)

96-8. Methods of Risk Analysis: Traditional and Ecological Approaches. J. **Buie.**
96-9. Tupelo/Water Tupelo. G. **Silberhorn.**
96-10. Detritus: Mother Nature's Rice Cake. P. **Mason** and L. **Varnell.**
97-1. River Birch/Red Birch. G. **Silberhorn**
97-2. Ironwood/Blue Beech/American Hornbeam/Muscle Wood. G. **Silberhorn.**
97-3. Swamp Dogwood/Silky Dogwood. G. **Silberhorn.**
97-5. Highbush Blueberry. G. **Silberhorn.**
97-6. Black Gum. G. **Silberhorn.**
97-7. The Oldest Operating Wetland Mitigation in the U.S. T. **Barnard** and C. **Hershner.**
97-8. Cattail Sledge. G. **Silberhorn.**

Virginia Wetlands Report, Vol. 11, No. 3 - Fall 1996.
Virginia Wetlands Report, Vol. 12, No. 1 - Winter 1997.
Virginia Wetlands Report, Vol. 12, No. 2 - Summer 1997.

Overview, 1994-1996. Summer 1996.

VIMS Additional Publications

Dissertations

Buzzelli, Christopher P. 1996. Integrative analysis of ecosystem processes in the littoral zone of lower Chesapeake Bay: a modeling study of the Goodwin Islands National Estuarine Research Reserve. 253 p.

Cooper, Peter S. 1996. Expression of the xenobiotic transporter P-glycoprotein in the mummichog (*Fundulus heteroclitus*). 208 p.

Dixon, Douglas Arthur. 1996. Contributions to the life history of juvenile blueback herring (*Alosa aestivalis*): phototactic behavior and population dynamics. 288 p.

Garrison, Lance Preston. 1997. The influence of physical transport and nutritional stress on the zoeae of estuarine crabs. 241 p.

Glorioso, Pablo D. 1997. On the circulation of the northern North Sea and the Patagonian shelf. 142 p.

Kim, Baeck Oon. 1996. Modeling storm-induced sediment transport on the inner shelf: effects of bed microstratigraphy. 177 p.

Lay, Patrick Winfield. 1996. Demersal predator exposure to toxic organic contaminants: direct effects of macrofauna in trophic transfer. 208 p.

Liu, Kewen. 1996. Fate and transport processes for polycyclic aromatic hydrocarbons in the surface microlayer of southern Chesapeake Bay. 162 p.

Mitra, Siddhartha. 1997. Polycyclic aromatic hydrocarbon (PAH) distributions within urban estuarine sediments. 116 p.

Mosca, Thomas C. 1997. Climatologically forced coherence between diverse juvenile populations in the Virginia tributaries to the Chesapeake Bay: 110 p.

Nelson, David A. 1996. Subadult loggerhead sea turtle (*Caretta caretta*) behavior in St Marys entrance channel, Georgia, USA. 132 p.

Pile, Adele Jean. 1996. The role of microbial food webs in benthic-pelagic coupling in freshwater and marine ecosystems. 166 p.

Rennie, Sarah E. 1998. Wind interaction with buoyant plumes on the inner continental shelf. 178 p.

Seitz, Rochelle Diane. 1996. The role of epibenthic predators in structuring marine soft-bottom communities along an estuarine gradient. 242 p.

Shen, Jian. 1996. Water quality modeling as an inverse problem. 140 p.

Yang, Zhaoqing. 1996. Variational inverse methods for transport problems. 150 p.

Theses

Armknecht, Susan Lovejoy. 1996. Altered expression of a glutathone S-transferase isoform in creosote-resistant mummichog, *Fundulus heteroclitus*. 81 p.

Brooke, Sandra Dawn. 1996. A comparison of natural and laboratory diets for the culture of marine invertebrate larvae: American oyster, *Crassostrea virginica*, queen conch, *Strombus gigas*, and milk conch, *Strombus costatus*. 155 p.

Brust, Jeffrey Clark. 1996. The effects of a regulatory gear restriction on the harvest of the recruiting year class in the offshore sea scallop, *Placopecten magellanicus*, fishery. 80 p.

Buie, John Cary. 1996. Relative risk assessment for Cape Hatteras National Seashore. 117 p.

Chasey, Michael Lawrence. 1996. Laboratory and field investigations to determine the chemical factors affecting zinc and iron transport at an industrial waste facility. 96 p.

Cooksey, Cynthia Lee. Reproductive biology of Spanish mackeral, *Scomberomorus maculatus*, in the lower Chesapeake Bay. 68 p.

Cutter, Randy G. 1997. Spatial, geostatistical, and fractal measures of seafloor microtopography across the Eel River shelf, off northern California. 53 p.

Dancy, Lynn M. 1997. Targeting wetland preservation areas for compensatory mitigation utilizing a GIS protocol. 119 p.

Farnsworth, Katherine L. 1997. Response modes of the lower Chesapeake Bay wave field. 85 p.

Gaichas, Sarah Kathleen. 1997. Age and growth of Spanish mackeral, *Scomberomorus maculatus*, in the Chesapeake Bay region.

Garreis, Kathleen A. 1996. *Perkinsus marinus* extracellular proteases: modulation of production by environmental factors and effects on the host defense parameters of the eastern oyster *Crassostrea virginica*. 106 p.

Hinchey, Elizabeth Kathleen. 1996. Autoecology of *Paraprionospio pinnata* (Polychaeta: Spionide) along an estuarine gradient. 67 p.

Horvath, Michele A. 1997. Effects of spot (*Leisostomus xanthurus*) induced bioturbation and suspension on the transport and fate of sediments and a particle-associated organic contaminant. 81 p.

Jones, William Mason, III. 1998. Physical parameters affecting incubating temperatures in loggerhead sea turtles, *Caretta caretta*, in Virginia.

Khor, Ing Wei. 1996. The development of affinity maturation in rainbow trout *Oncorhynchus mykiss*. 78 p.

Li, Tong. Lipid class composition of oysters, *Crassostrea virginica*, exposed to sediment-associated PAHs. 116 p.

Maxemchuk-Daly, Amanda. 1998. Natural variation in the vertical distribution of macrobenthic invertebrates within sandy-mud habitats. 98 p.

Mueller, Amanda McKenney. 1997. Small mammal habitat uses of two natural and created wetlands in southeastern Virginia. 105 p.

Pardieck, Renee A. 1996. The influence of location, seagrass species and water depth on the settlement and distribution of early stage blue crabs. 57 p.

Redgate, Daniel Otis. 1997. Winter/spring steady-state water balances for a palustrine forested wetland located in southeastern Virginia. 89 p.

Scanlon, Christine H. 1997. The potential for transmission of *Perkinsus marinus* by fecal matter from the eastern oyster, *Crassostrea virginica*. 108 p.

Schulman, Jessica L. Habitat complexity as a determinant of juvenile blue crab survival. 57 p.

Spencer, David Randolph. 1998. Early secondary succession in the bottomland hardwood forests of southeastern Virginia. 95 p.

Suntsov, Andrei V. 1997. New data on ichthyoplankton of the south western Pacific. 145 p.

Terwilliger, Mark Richard. 1996. Age, growth, and reproductive biology of blackcheek tonguefish, *Symphurus plagiusa* (Cynoglossidae: Pleuronetiformes) in Chesapeake Bay, Virginia. 114 p.

Wagner, C. Michael. 1997. Correspondence between environmental gradients and the assemblage structure of littoral fishes in the tidal portion of three Virginia coastal plain rivers. 163 p.

White, Geoffrey Gordon. 1996. Reproductive biology of tautog, *Tautoga onitis*, in the lower Chesapeake Bay and coastal waters of Virginia. 100 p.

Yarnall, Heather A. 1998. Development of a quantitative competitive polymerase chain reaction assay for the detection and quantitation of *Perkinsus marinus* in oyster tissues and environmental water samples.