Information for Students in the Bachelor of Science Degree Program in Global Environmental Science

INTRODUCTION

Purpose

This manual is designed to explain procedures and requirements of the Global Environmental Sciences (GES) program (http://www.soest.hawaii.edu/oceanography/GES/), in the Department of Oceanography (http://www.soest.hawaii.edu/oceanography), School of Ocean and Earth Science and Technology (SOEST, http://www.soest.hawaii.edu/) at the University of Hawaii. General rules of the University are stated in the current version of the University of Hawaii at Manoa Catalog. This document, available for purchase at the University of Hawaii bookstore, or the university web site (http://manoa.hawaii.edu/) should be consulted for general information about the University of Hawaii at Manoa.

The Community

Hawai‘i is perceived by many visitors and residents alike as the paradise of the Pacific. Along with a subtropical climate, Hawai‘i is blessed with a multicultural population that provides a living experience that is unparalleled anywhere else in the world. Honolulu, the capital of the State of Hawai‘i, is a large, modern, cosmopolitan, metropolis, with a population approaching 1 million when satellite towns on O‘ahu are included. Many cultural and recreational opportunities revolve around the beautiful climate and abundant natural resources of Hawai‘i. These include the ocean, mountains, a large number of City & County and State Parks, and a variety of (year-round) participant and spectator sports. Additionally, the Honolulu Symphony, Honolulu Academy of Arts, the Bishop Museum and several performing theaters and musical and dance groups offer other activities to satisfy myriad interests. Largely because of its multicultural population, Hawai‘i also has an excellent selection of restaurants featuring a wide variety of ethnic cuisines. Social life in Hawai‘i is usually informal.

The University

The University of Hawai‘i was founded in 1907 as a land-grant institution. It is now also a sea-grant and space-grant institution. The main campus is located at the mouth of lush Manoa Valley, about 5 km (~3 mi) from downtown Honolulu and 3 km (~2 mi) from the tourist resort of Waikiki. The Manoa campus has approximately 20,000 students.

The School of Ocean and Earth Science and Technology http://www.soest.hawaii.edu

The School of Ocean and Earth Science and Technology (SOEST) is one of the major international research institutes in the world and enjoys an exceptional world-wide reputation for studies of the complex phenomena that drive our planet. A world class faculty with 239 Ph.D. scientists provides a broad range of experience available in only a few institutions on the planet. The faculty seek to comprehend and explain the behavior of the complex and dynamic Earth system, including the role humans play as a force in global environmental change.

SOEST was formed in 1988 combining the departments of Geology and Geophysics, Meteorology, Oceanography, and Ocean Engineering with several research institutes (Hawai‘i Institute of Geophysics and Planetology, Hawai‘i Institute of Marine Biology, Hawai‘i Natural Energy Institute) to promote and enhance educational and research opportunities in these fields. The Hawai‘i Undersea Research Laboratory (HURL), the Hawai‘i Sea Grant and Space Grant Programs, the International Pacific Research Center (IPRC), the Joint Institute for Marine and Atmospheric Research (JIMAR), and the Marine Bioproducts and Engineering Center
(MARBEC) are all units of SOEST. A wealth of educational and research tools and facilities is available within SOEST. These include several oceanographic ships and deep-sea submersibles.

The Department of Oceanography [http://www.soest.hawaii.edu/oceanography/](http://www.soest.hawaii.edu/oceanography/)

The department has a diverse faculty whose research interests span the general areas of biological, chemical, geological, and physical oceanography. Most faculty members are actively involved in teaching and research and all faculty (research and teaching categories) are expected to participate in student advising and mentoring. Most faculty employ both undergraduate and graduate students in their research endeavors. The department offers graduate programs leading to the Master of Science (M.S.) and Doctoral (Ph.D) degree in Oceanography. Additionally, the department is now home to a successful undergraduate degree granting program leading to the Bachelor of Science (B.S.) in Global Environmental Science (GES). The department has approximately 50 undergraduates and more than 70 classified graduate students in residence.

Photograph of the Hawaiian Archipelago from the space shuttle Atlantis, showing, from left to right, the eight main Hawaiian islands of Niihau, Kauai, O‘ahu, Molokai, Lanai, Maui, Kaho‘olawe and the “Big Island” (Hawaii).
Global Environmental Science (GES) Program Description

Shortly before entering the 21st century, SOEST launched a bold new undergraduate degree program to educate leaders and citizenry to become wise stewards of our planet. The degree program in GES (http://soest.hawaii.edu/oceanography/GES/) is a holistic, rigorous scientific approach to the study of Earth and its biological, chemical, geological, physical, and human systems. In the course of their scientific studies, students in the GES program are able to investigate natural as well as economic, policy, and social systems and their response and interaction with the Earth system. The ultimate objective of the program is to produce a student informed in the environmental sciences at a rigorous level, and who is able to go on to graduate or professional school. GES graduates will, through rigorous training, be prepared to enter the work force in environmental science positions in business, government, or industry; enter or return to teaching with knowledge of how the Earth system works, or simply enter the work force in another field equipped with the skills required to become wise environmental stewards of our planet.

Program Administration and Coordination

The GES program was started in 1998 by Professor Fred T. Mackenzie. Dr. Jane E. Schoonmaker is the current GES Chair and Program Coordinator. Prof. Fred T. Mackenzie and Dr. Eric H. De Carlo also participate in the day-to-day coordination and administration of the GES program, and in conjunction with Dr. Schoonmaker constitute the GES Coordination Committee. Professor Francis J. Sansone is the chair of the Department of Oceanography. Ms. Rene Tada is responsible for student admissions and records for the GES program. Ms. Leona Anthony (SOEST Education Specialist) tracks the progress of all undergraduate students enrolled in the various degree granting programs within SOEST, including the GES program. Ms. Rene Tada is the GES institutional support.

All students who enter the GES program are assigned a faculty advisor during their first semester in residence. Faculty advisors, in consultation with Ms. Leona Anthony and the Coordination Committee, track and guide GES students throughout their undergraduate residency. Regular consultation and interaction with faculty advisors ensure that students follow the most efficient track towards graduation. All GES students are required to meet with their faculty advisor at least once each semester. Students are not allowed to register for the following semester without meeting with their faculty advisor for guidance in developing their academic schedule. Faculty advisors are also available to meet with students at any time during the semester by mutual agreement, and students are strongly encouraged to meet with and seek guidance from their advisor periodically. Faculty advisors are generally assigned no more than 5 student advisees, thereby ensuring that each student will be able to obtain guidance on a regular basis and in a timely manner.

Important Contact Numbers

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<th>Name</th>
<th>Office</th>
<th>Telephone</th>
<th>email</th>
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</thead>
<tbody>
<tr>
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<td>MSB 205</td>
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CURRENT ACADEMIC AREAS OF CONCENTRATION

Although we do not have specific academic tracks of study for students within the GES program, there are optional pathways around which the student’s curriculum can be oriented during the latter phase of their studies and for the Senior Thesis. GES students are not restricted to specific pathways because each student will be expected to develop a curriculum during their last two years, that is designed to fit their various individual needs and is based upon their future career goals. A brief description of three tracks is given below. The descriptions below focus on undergraduate opportunities within the GES program. Information about the graduate programs in Oceanography is available elsewhere (http://www.soest.hawaii.edu/oceanography)

1) Policy/Economics and Environment

This track enables the student, after satisfying the GES science core, to concentrate further course work and the senior thesis in environmental economics, policy, and law, e.g. Econ. 358 (Environmental Economics), 458 (Project Evaluation and Resource Management), 491 (Marine Resource Economics), and 638 (Environmental and Resource Economics); Plan 310 (Introduction to Planning); Soc. 412 (Analysis in Population and Society) and 413 (Analysis in Peconomy and Society); with special permission from Casey Jarmen in the law school, an introductory course in environmental law. Because a number of these courses have prerequisites, students should plan ahead and ensure they meet all requirements for enrollment in advanced courses. This is probably the best route to follow for a student who is going directly into the work place or simply interested in becoming a wise environmental steward of the planet.

2) Climate and Environment

This track enables the student to concentrate academic studies and the senior thesis topic on the interactions between climate and the environment, on human impacts on climate, and the causes of climatic change. The student is encouraged to take coupled systems courses in meteorology, Geog. 300 Climatology, Geog. 402 Agricultural Climatology, Geog. 405 Water in the Environment, Soil Science 461 Soil Erosion and Conservation, for example. Additional courses in Geography are also available and students are encouraged to consult with their advisor for additional options.

3) Marine science and environment

In this track, students concentrate on studies in marine/ocean science and the application of their work to environmental problems related to the ocean. The student should be encouraged to take as many oceanography courses as practical and to have a senior thesis problem that is related to ocean studies. It is within this track that a student's program can be designed so that the student is able to apply to graduate school in oceanography.

RESEARCH FACILITIES

Computing

Students in the GES and Oceanography degree programs have 24 hr/day access to over 40 workstations distributed throughout the various departmental computer rooms. In addition to these, an equal or greater number of PC and Mac platforms are available for departmental use. Most departmental computing devices have at least 4-8 GB of storage capacity, large monitors, accelerated graphics capabilities and multimedia hardware and software. Departmental computers are interconnected through a 100 Mbps local area network, itself connected to a 80 Mbps campus-wide network and to a 1.5 Mbps link to U.S. Internet, through which various
supercomputers are accessible. SOEST also operates receiving systems for satellite images, for polar orbiting satellites (AVHRR, SeaWifs, J-ERS, ERS) and for geostationary satellites (GOES, GMS). Networked computers provide open access to the internet and a number of peripherals such as postscript laser printers (both color and black and white), large format printers, and digital scanners. The department boasts an enviable student to computer ratio near 2:1, with unlimited access to the internet, email accounts, and generous individual limits on hard disk space for network file storage. Researchers SOEST-wide also possess approximately 100 additional workstations of various types in their personal laboratories. Computing devices not specifically owned by the department are typically accessible to students through special arrangements with the directors of the various laboratories.

**Analytical and Experimental Laboratories**

SOEST operates several ocean-going research vessels from its marine operations center at Honolulu Harbor. The flagship of the University of Hawaii fleet is the R/V Kilo Moana (see photo next page). It is a SWATH vessel that is part of the UNOLS (national oceanographic vessel) and complements the maritime operations capabilities of the R/V Kai`imikai O Kanaloa, which conducts the submarine operations of the Hawai`i Undersea Research Laboratory (HURL). Smaller nearshore boats are also available for research. HURL operates two research subsessibles, the DSV Pisces IV and DSV Pisces V (depth capability of 2000 m). The School maintains machine, electronics, and engineering shops, a library, and graphics, publication, photography, and other support facilities.

![View of the PISCES V submarine operated by the Hawai`i Undersea Research Laboratory. Photograph taken at the Makai Pier, Makapu`u Point on O`ahu.](image)
A wide range of high precision instrumental analysis and experimental facilities are housed either within the Department of Oceanography or other units within SOEST. Individual instruments include stable isotope and isotope-ratio-monitoring mass spectrometers; a dual-laser analytical flow cytometer; CHN analyzers; gas and high-pressure liquid chromatographs; SEM and STEM electron microscopes with an energy dispersive X-ray fluorescence EDS-XRF micro-elemental analyzer; an electron microprobe; an X-ray diffractometer with solid state detector, a flame atomic absorption spectrometer, two inductively-coupled, plasma/optical emission spectrometers (ICP-OES); several inductively couple plasma mass spectrometer (ICP-MS) with high sensitivity laser ablation systems, liquid scintillation counters, alpha and gamma-ray counting equipment, UV-Vis spectrometers, and nutrient autoanalyzers. Class 1000 clean rooms and Class 100 laminar flow environments (hoods) are available in several laboratories for ultra trace element work. Ten and 25 m long flumes located at Coconut Island are available for experimentation on benthic communities. A variety of field equipment and instruments is also available. These include Niskin bottles, a small gravity corer and Ponar sampler for nearshore sediment work, YSI 6920 automated Multiparameter Sondes, ISCO automated samplers and water level recorders, deployable nutrient analyzers, Triton Acoustic Doppler Velocimeter (ADV) and a LISST-100 Particle Scatterometer.
Left image: A rosette of Niskin bottles with a CTD (below the bottles) is lowered into the ocean under the watchful eye of GES students aboard a cruise of the R/V Kilo Moana.

Right Image: In preparation for subsequent analysis, a GES student adds preservative to a water sample that was obtained from a Niskin bottle and is being held by Oceanography graduate student Joseph Shacat.

Faculty

J. E. Schoonmaker, PhD (Undergraduate Chair)—sedimentary geochemistry and diagenesis
J. M. Becker, PhD—geophysical fluid dynamics, nonlinear waves and stability, coastal processes, general ocean circulation
R. R. Bidigare, PhD—bio-optical oceanography, pigment biochemistry, plankton metabolism
S. Businger, PhD—mesoscale and synoptic meteorology
A. D. Clarke, PhD—physical and chemical properties of aerosol in remote troposphere, aircraft studies of aerosol in free troposphere
J. P. Cowen, PhD—microbial geochemistry, particle aggregation dynamics, hydrothermal systems
E. H. DeCarlo, PhD—aquatic geochemistry; nutrients and metals and their anthropogenic inputs, their transformations, and ocean atmosphere gas exchange
S. Dollar, PhD—biogeochemistry, nearshore processes and effects of human activity on the coastal zone
J. C. Drazen, PhD—physiological ecology of marine fishes, energetics and tropodynamics, deep-sea biology, adaptations of fishes to the deep-sea
A. El-Kadi, PhD—hydrogeology, modeling groundwater systems
R. C. Ertekin, PhD—hydrodynamics, computational methods, offshore and coastal engineering, oil-spill spreading, fishpond circulation
E. Firing, PhD—ocean circulation and currents on all scales, with emphasis on observation sand dynamics
P. J. Flament, PhD—surface ocean layer dynamics, mesoscale circulation structures of the ocean, remote sensing of the sea surface
C. H. Fletcher, PhD—quaternary and coastal marine geology, sea-level history, coastal sedimentary processes
P. Fryer, PhD—marine geology, petrology, tectonics
E. Gaidos, PhD—molecular evolution; microbiology of extreme environments; biosphere-climate feedbacks; critical intervals in Earth history; exobiology; biological networks
M. O. Garcia, PhD—volcanology, igneous petrology, geochemistry
T. W. Giambelluca, PhD—interactions between the atmosphere and the land surface, including influences of land use and land cover change on climate and surface hydrology and effects of global climate change on hydrologic processes and terrestrial ecology
C. R. Glenn, PhD—paleoceanography, marine geology, sedimentology, sediment diagenesis
E. G. Grau, PhD—environmental physiology and comparative endocrinology of fish
M. P. Hamnet, PhD—coastal zone management; fisheries economics; disaster preparedness and mitigation
B. J. Huebert, PhD—air pollution, climate change, atmospheric aerosols, global elemental cycles
M. C. Jarman, LLM—environmental law, administrative law, ocean and coastal law, legal writing; the public trust doctrine, land use, the intersection of indigenous peoples’ rights and environmental law, and community empowerment through the law

Z. Johnson, PhD—phytoplankton photosynthesis and microbial phototrophy, microbial population structure and diversity with attention to ecosystem functioning, microbial genome structure and comparative genomes

E. Konan, PhD—international trade, microeconomics, computational economics

Y. H. Li, PhD—marine geochemistry, environmental pollution

K. Lowry, PhD—design, planning and evaluation of ocean and coastal management programs. Experience in Hawai’i, Indonesia, Sri Lanka, Philippines and Thailand

R. Lukas, PhD—physical oceanography, interannual and decadal climate variability

F. T. Mackenzie, PhD—geochemistry, biogeochemical cycling, global environmental change

L. Magaard, PhD—climate and society

J. J. Mahoney, PhD—submarine volcanic processes and the geophysical monitoring of submarine volcanoes, processes of formation of ocean floor minerals

S. J. Martel, PhD—engineering and structural geology

G. M. McMurtry, PhD—geochemistry, geology and geophysics

M. A. McManus, PhD—descriptive physical oceanography, coupled physical-biological numerical models; development of ocean observing systems

C. Measures, PhD—trace element geochemistry, hydrothermal systems, elemental mass balances

P. Menon, PhD—environmental and occupational health standards

M. Merlin, PhD—biogeography, natural history of the Pacific

M. A. Merrifield, PhD—physical oceanography; coastal circulation; sea level variability; current flows and mixing in the vicinity of coral reefs, islands and seamounts

J. N. Miller, MS—marine and land environmental management, environmental assessment

T. Miura, PhD—remote sensing of terrestrial vegetation, GIS

G. F. Moore, PhD—marine geophysics, structural geology

M. J. Mottl, PhD—hydrothermal processes, geochemical cycles

P. Mougins-Mark, PhD—volcanology from space, remote sensing of natural hazards

P. K. Muller, PhD—ocean circulation, waves and turbulence

B. N. Popp, PhD—isotope biogeochemistry, organic geochemistry

J. N. Porter, PhD—atmospheric science, use of satellites to study aerosol and cloud forcing, ship measurements of aerosol and cloud optical properties

G. Ravizza, PhD—paleoceanography and environmental chemistry; geologic history of chemical weathering; geochemistry of recent and ancient metalliferous sediments; anthropogenic influences on the geochemical cycles of the platinum group elements; chemical signatures of extraterrestrial matter in marine sediments; biogeochemistry of molybdenum in the marine environment

K. J. Richards, PhD—observations and modeling of ocean processes, ocean dynamics, ocean atmosphere interaction, ecosystem dynamics

M. A. Ridgley, PhD—resource management and human-environment system analysis

J. Roumasset, PhD—environmental economics and sustainable growth

K. Rubin, PhD—isotope geochemistry, chronology

K. Ruttenberg, PhD—biogeochemistry of phosphorus and phosphorus cycling in the ocean, rivers, and lakes; nutrient limitation of aquatic primary productivity; effects of redox chemistry on nutrient cycling; early diagenesis in marine sediments with focus on authigenic mineral formation and organic matter mineralization

F. J. Sansone, PhD (Department Chair)—suboxic/anoxic diagenesis in sediments, hydrothermal geochemistry, lava-seawater interactions, trace gas geochemistry

N. Schneider, PhD—decadal climate variability, tropical air-sea interaction, coupled modeling

T. Schroeder, PhD—meso meteorology, tropical meteorology

S. K. Sharma, PhD—atmospheric instrumentation and remote sensing; Lidar, Raman, and infrared spectrometry and fiber-optic environmental sensors

C. R. Smith, PhD—seafloor ecology, deep-ocean food webs, sediment geochemistry

G. Steward, PhD—aquatic microbial ecology, molecular ecology and diversity of viruses and bacteria

M. E. Tiles, PhD—logic, history, and philosophy of mathematics, science, and technology

A. Timmermann, PhD—coral bleaching, stability of the thermohaline circulation, stochastic climate modeling, nonlinear statistics, detection of greenhouse warming

B. Wang, PhD—atmospheric and climate dynamics
G. Wang, PhD—microbial diversity, ecology and biotechnological potential of marine sponges, synthetic biology and ecological approach of marine microbes for pharmaceuticals and renewable energy, marine biosensing for environmental biotechnology and ecology
B. Wilcox, PhD—population biology; human-ecosystem interaction; ecological and human health linkages
J. C. Wiltshire, PhD—marine minerals, mine tailings and disposal, remediation and submersible engineering and operations
R. E. Zeebe, PhD—global biogeochemical cycles, carbon dioxide system in seawater and interrelations with marine plankton, paleoceanography, stable isotope geochemistry

Students and other scientific party members enjoying a rare view of the Na Pali coast, Kaua‘i, during passage of the R/V Melville near the islands. IOC 2002 Dust Cruise. For further information about this research cruise see:

ADMISSION PROCEDURES AND REQUIREMENTS

Entrance to the GES program in the Department of Oceanography is through application for admission to the University of Hawaii at Manoa. Completed application forms and all supporting documents including official transcripts, SAT scores, and in the case of foreign students who are not native English speakers, results of the Test of English as a Foreign Language (TOEFL), must be postmarked not later than February 1 for entrance in the fall semester, and not later than September 1 for entrance in the spring semester.

It is recommended that applications for admission to the University of Hawaii be submitted for the fall semester. A large number of required courses have two semester sequences
and entry during the fall semester provides greater access to these courses. A greater number of sections of the first course of a given sequence is typically offered during the fall semester. Being “in sequence” facilitates student progress through the various requirements. Additionally, there is typically a greater availability of financial aid during the fall semester. Applications for the spring semester, however, will also be considered.

Prospective students should follow instructions provided by the University of Hawaii Admissions office and explained in detail in the University of Hawai‘i at Manoa Catalog 2005-2006. The catalog can be purchased from the University of Hawaii bookstore and is available on the UH Web site at: http://www.catalog.hawaii.edu

For further general information about the University of Hawai‘i at Manoa please contact:

UH Manoa General Information
Campus Center 212
2465 Campus Road
Honolulu, HI 96822
Tel: (808)-956-7235
Web: www.hawaii.edu/

Information regarding admission to the university can also be obtained by contacting:

Admissions and Records Office
Student Services Center 001
2600 Campus Road
Honolulu, Hawai‘i 96822
Tel: (808)-956-8975
TOLL FREE: 1-800-823-9771 (In US only)
Email: ar-info@hawaii.edu
Web: www.hawaii.edu/admrec/

Financial Assistance:

Financial assistance is available to students making satisfactory progress in a degree program and includes grants, loans, student employment, and research fellowships and assistantships. For further information contact the UH Financial Aid Office, 2600 Campus Road, SSC 112, Honolulu, HI 96822 Web site: http://www.hawaii.edu/admrec/faq_faid.html.

The GES program also offers financial aid to qualified students in a variety of forms. Continuing students who have achieved grade point averages of 3.0 and above during their tenure at UH are eligible for various awards. Competition for financial aid is on an annual basis.

In addition to the above, smaller amounts of funding are available from the GES program in the form of research stipends to help GES students nearing the completion of their studies complete the required Senior Thesis project. Details regarding the availability of financial aid, eligibility, and the application process are available from the GES institutional support and from the program coordinator, Dr. Jane E. Schoonmaker.

Curriculum:

Students must complete a minimum of 38 credit hours in GES Core Basic Sciences and 11 credit hours in GES Core Derivative Sciences. In addition to the University core requirement and the GES core requirement, courses to complete the degree program will be taken from the
foundation and coupled systems courses. All students in the GES program are required, in addition to the course work outlined above, to complete a senior research project and a computer requirement. The senior research project culminates in a research report that must be reviewed, and approved by a committee consisting of the Senior Thesis advisor, and two other GES faculty.

**Waiakeaakua Watershed**

View of the Koolau range in the back of Manoa Valley, where researchers are conducting a study on the fate and transport of sediment and associated trace elements during high intensity rainstorms. The image to the right shows a stream gaging station operated by the USGS along with monitoring equipment and sample intake lines in the stream operated by UH scientists.

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**REQUIREMENTS FOR UNDERGRADUATES IN SOEST**

The core requirements of the University of Hawaii changed significantly in 2001. All students who entered the GES program in the 2001-2002 academic years and beyond are subject to the new core requirements. The **Manoa General Core and Graduation Requirements** are explained in detail in the 2006-2007 UH Manoa Catalog and are summarized here.

General Education requirements are designed to help students acquire knowledge, skills, and thought processes that provide a foundation for lifelong learning. The UHM requirements reflect the unique resources this university provides: the depth of its Hawaiian assets, and the breadth of its multiculturalism. The General Education curriculum gives students a global perspective of human diversity while at the same time paying particular attention to the richness of the individual and collective heritages of Hawaii, the Pacific and Asia.

There are two components to the General Education requirements: core requirements and graduation requirements. Core requirements include foundation courses and diversification requirements. Graduation requirements include focus requirements and a foreign (2nd) language. The General Education Core and graduation requirements are fulfilled by meeting the specifications listed in the categories below. Various options are provided in nearly all parts of
the General Education curriculum. It is possible to be exempted from certain required course work by a successful challenge through examination. In each case, the final approval rests with the Dean of the college or school to which a student belongs. Information on the procedures for satisfying requirements by examination for students in the GES program are available through the SOEST student academic services office (Leona Anthony, POST 713A, Tel: 808-956-8763, email: lanthony@soest.hawaii.edu) or the GES institutional support in the Department of Oceanography, MSB 226/230, Tel: 808-956-9937.

Students who have earned an articulated associate in arts (AA) degree from a University of Hawaii Community College will be accepted as having fulfilled the General Education Core requirements at the University of Hawaii at Manoa. Students must, however, also complete all specialized lower division, major, college/school, degree, and graduation requirements.

Students in the GES program will be assigned a faculty advisor within their first semester of declaration of major. The faculty advisor will discuss with a student his/her future goals and help the student develop the appropriate academic plan to meet the requirements of the Bachelor of Science in Global Environmental Science degree.

![Bathymetric map of Loihi Seamount, an active submarine volcano to the south east of the Big Island. Loihi will eventually become the next island in the Hawaiian Archipelago. Image courtesy of the Hawai`i Undersea Research Laboratory.](image)
COURSE REQUIREMENTS

UHM CORE REQUIREMENTS

The following represents the requirements for students entering the University of Hawaii during the Fall 2006 semester. Students who entered during the Spring of 2001 or earlier should refer specifically to the requirements listed beginning page 27 of the UH Manoa Catalog, 2002-2003.

Foundation Requirement: 12 credits

Foundation courses are intended to give students skills and perspectives that are fundamental to undertaking higher education. Foundation courses may be offered as components of learning communities that also include courses fulfilling major or Diversification requirements. However, courses taken to fulfill the foundation requirement cannot be used to fulfill Diversification or Focus requirements.

- Written Communication (FW): 3 credits
  Students will be introduced to the rhetorical, conceptual, and stylistic demands of writing at the college level; the course gives instruction in composing processes, search strategies, and composing from sources. This course also provides students with experiences in the library and on the internet and enhances their skills in accessing and using various types of primary and secondary materials.

  To enroll in a course that meets the Written Communication requirements, must first take the Manoa Writing Program examination. First year students with appropriate scores on the examination will be invited to submit a fuller writing sample that may earn course credit and thus fulfill this requirement. Contact the Manoa Writing Program for information about the examination.

  Courses Approved to Date:
  ENG100* Composition I
  ENG100A* Composition I
  ENG101* and English 101L*Composition I/Composition I lab
  English Language Institute (ELI)100* Expository Writing: A Guided Approach.

- Manoa Writing Program Writing Placement Exam required.

- Symbolic Reasoning (FS): 3 credits
  Courses that satisfy this requirement will expose students to formal systems, their beauty, power, clarity and precision. Students will understand the concept of proof as a chain of inferences and be able to apply formal rules or algorithms as well as engage in hypothetical reasoning. In addition the course aims to develop the ability of students to use appropriate symbolic techniques in the course of problem solving, and in the presentation and critical evaluation of evidence.

  Courses Approved to Date:
  BUS 250 Applied Math in Business
  ICS141 Discrete Mathematics for Computer Science I
  ICS241 Discrete Mathematics for Computer Science II
  ECON 301 Intermediate Economics: Price Theory
  MATH100 Survey of Mathematics
  MATH140* Trigonometry and Analytic Geometry
MATH 203* Calculus for Business and the Social Sciences
MATH 215* Applied Calculus I
MATH 241* Calculus I
MATH 251 Accelerated Calculus I
PHIL 110 Introduction to Deductive Logic
PHIL 111 Introduction to Inductive Logic
NREM 203 Applied Calculus for Mgmt, Life Sci. & HR

• Global and Multicultural Perspectives (FG): two courses, 6 credits

The courses in this category provide thematic treatments of global processes and cross-cultural interactions. Students will gain a sense of human development from prehistory to modern times. At least one component of these courses will involve the indigenous cultures of Hawaii, the Pacific, and Asia.

Courses Approved to Date:

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For non-UN Transfers only: HIST 155 (Students who have completed two semesters of Western Civilization must take HIST 155 instead of two courses listed above.)

Diversification Requirement: 19 credits

This requirement is intended to ensure that each student has a broad exposure to different areas of academic knowledge, while at the same time maintaining flexibility for students with different goals and interests.

Students can meet this requirement at any time over the course of their four years in the academic program. Thus, students may satisfy the requirement through enrollment in approved lower- or upper-division courses for which they meet the prerequisites. Some courses that satisfy the Diversification requirement may also satisfy simultaneously Focus or major requirements.

Diversification courses must come from different departments that the courses used to satisfy the Foundations Global Multicultural Perspective requirement.

Approved Diversification Courses

Approved courses are identified in the UH General Catalog on pages 337-498 with the following letters after the course description:

DA = Arts  DB = Biological Sciences  DH = Humanities
DL = Literatures  DP = Physical Science  DS = Social Science
DY = Laboratory

The list of approved courses is also available at: http://www.hawaii.edu/gened

• Arts, Humanities, and Literature s (DA, DH, DL): 6 credits
To satisfy this requirement, six credits: three credits each from two different groups. These are listed in the UH General Catalog on pages 33-498.

- **Natural Sciences (DB, DP, DY): 7 credits**

  To satisfy this requirement, students must take seven credits: three credits in the biological sciences (DB), three credits in the physical sciences (DP), and one credit of laboratory (DL). Because of the rigorous science requirements of the GES program, the Natural Science requirement will automatically be met by all GES students.

- **Social Sciences (DS): 6 credits**

  To meet this requirement, students must take six credits from two different departments. Approved courses are designated with the letters DS after the course description found in the UH General Catalog.

**UHM GRADUATION REQUIREMENTS**

**Focus Requirements**

The focus requirements identify important skills and discourses that can be provided through courses across the curriculum. These requirements can be met through major and diversification courses. Students should be able to plan their academic program to meet these requirements WITHOUT adding credits to the graduation requirements. The courses approved to date can be obtained from your advisor, the GES program secretary, or the SOEST student academic services office.

- **Hawaiian, Asian, and Pacific Issues (H): 1 course**

  Courses fulfilling this requirement may come from across the curriculum and focus on issues in Hawaiian, Pacific, and Asian cultures and history. Courses that satisfy this requirement are designated “H” in the *Schedule of Classes*.

- **Contemporary Ethical Issues (E): 1 course**

  Courses fulfilling this requirement may come from across the curriculum. Appropriate courses will involve significant readings of contemporary ethical issues. GES students can fulfill this requirement with OCN 310, a GES Foundation course. Courses that satisfy this requirement are designated “E” in the *Schedule of Classes*.

- **Oral Communication (O): 1 course**

  Courses fulfilling this requirement may come from across the curriculum. Appropriate courses will require students to work in groups, prepare individual and group reports, and provide training in oral delivery. Such courses are designated as “O” in the *Schedule of Classes*.

- **Writing Intensive (W): 5 courses, including two numbered 300 and above**

  Courses fulfilling this requirement may come from across the curriculum. These courses are required because writing helps students learn and communicate. Nearly all departments offer small writing-intensive classes, in which instructors work with students on writing related to the course topics. Students are encouraged to satisfy the Written Communication (FW) requirement prior to enrollment in writing-intensive courses. Students in the GES program will easily fulfill this requirement as they automatically take, OCN 310, OCN 401, and OCN/PHIL 315, all of which are W courses. GES students may also register for their senior
thesis (OCN 499) as writing-intensive. OCN 499 may be designated W during the first week of class by application to the Manoa Writing Program. Writing-intensive courses are designated as “W” in the Schedule of Classes, offering vary from semester to semester.

Students who transfer into the UH system have a pro-rated requirement, which is based on the number of non-UH credits that are accepted by the UH Manoa campus.

**Hawaiian/Second Language Requirement (HSL)**

Students in SOEST degree granting programs are NOT subject to the UH Manoa Hawaiian/Second Language requirement. The SOEST foreign language requirement can be met by successful completion of ONE year of a foreign language.

**The “Wild Card” Option**

Students may earn one wild card by participation in an extraordinary educational experience approved by the UHM General Education Committee. Examples include a Study Abroad program or a social science internship. The wild card can be used to satisfy an appropriate 3 credit diversification and/or focus requirement.

**GES COURSE REQUIREMENTS**

The following are the requirements for the Bachelor of Science in Global Environmental Science. These requirements are **IN ADDITION** to the UH General Education Core Requirements. SOEST requires that all undergraduates successfully complete 60 upper division credits. Upper division generally means 300 or 400 level courses, although many (but not all) 200 level courses with college prerequisites also qualify. A number of the courses that GES students must take as part of their other requirements are considered upper division courses and count towards the required 60 credits. A minimum grade of C- must be obtained in all GES required courses.

**Freshman Seminar:** Beginning **Fall 2003** all new GES students are required to sign up for freshman seminar during their first year or, for transfer students, during the first semester they attend UH. This course meets once a week, during which 30-minute research seminars will be presented by faculty and scientists from various departments affiliated with the GES program. The seminar presentation will be followed by a 20-minute discussion session during which students will have an opportunity to critically review the work presented and interact with the presenting scientist. This course currently does not carry any credits, but participation therein is required of all students.

**GES Basic Sciences Requirements**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology 171, 171L, 172, 172L</td>
<td>8 credits</td>
</tr>
<tr>
<td>Chemistry 161, 161L, 162, 162L</td>
<td>8 credits</td>
</tr>
<tr>
<td>Physics 170, 170L, 272, 272L</td>
<td>9 credits</td>
</tr>
<tr>
<td>Mathematics 241, 242, 243 and 244 (or G&amp;G/OCN 312 and ECON 321)</td>
<td>13 credits</td>
</tr>
</tbody>
</table>

**GES Core Derivative Sciences Requirements**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geology and Geophysics 101, 101L or GG 170</td>
<td>4 credits</td>
</tr>
<tr>
<td>Meteorology 200</td>
<td>3 credits</td>
</tr>
<tr>
<td>Oceanography 201, 201L</td>
<td>4 credits</td>
</tr>
</tbody>
</table>
GES Foundation Course Requirements

Oceanography 100 (Freshman Seminar) 1 credit
Geography 410 (Human Role in Environmental Change) or, Geography 411 (Human Dimensions of Global Environmental Change) 3 credits
Oceanography 310, 310L¹ (Global Environmental Change) 5 credits
Oceanography 320 (Aquatic Pollution) 3 credits
Oceanography 363¹ (Interpretation of Earth-system Computer Databases) 3 credits
Oceanography 401¹ (Biogeochemical Systems) 3 credits
Oceanography/Philosophy 315¹ (Modeling Natural Systems) 3 credits

GES Coupled Systems Courses (minimum of 3 courses required)

The list below provides examples. Other courses are available, please check with your advisor.
Astronomy 240 (Foundations of Astronomy) 3 credits
Biochemistry 241 (Fundamentals of Biochemistry) 3 credits
Biochemistry 265 (Ecology and Evolutionary Biology) 3 credits
Biology 360 (Island Ecosystems) 3 credits
Botany 350 (Resource Management and Conservation in Hawaii) 3 credits
Economics 358 (Environmental Economics) 3 credits
Economics 458 (Project Evaluation and Resource Management) 3 credits
Economics 638 (Environmental Resource Economics) 3 credits
Geography 300 (Climatology) 3 credits
Geography 401 (Climate Change) 3 credits
Geography 402 (Agricultural Climatology) 3 credits
Geography 405 (Water in the Environment) 3 credits
Geography 488 (Geographic Information Systems) 3 credits
Geology and Geophysics 301 (Mineralogy) 4 credits
Geology and Geophysics 309 (Sedimentology and Stratigraphy) 4 credits
Geology and Geophysics 420 (Sea Levels, Ice Ages, and Global Change) 3 credits
Geology and Geophysics 421 (Geologic Record of Climate Change) 3 credits
Geology and Geophysics 425 (Environmental Geochemistry) 3 credits
Geology and Geophysics 455 (Hydrogeology) 4 credits
Geology and Geophysics 466 (Planetary Geology) 3 credits
Meteorology 302 (Atmospheric Physics) 3 credits
Meteorology 303 (Introduction to Atmospheric Dynamics) 3 credits
Natural Resources and Environmental Management 301&Lab (Natural Resource Management) 4 credits
Natural Resources and Environmental Management 302 (Natural Resource and Environmental Policy) 3 credits
Natural Resources and Environmental Management 304 (Fundamentals of Soil Science) 3 credits
Natural Resources and Environmental Management 432 (Natural Resource Economics) 3 credits
Natural Resources and Environmental Management 461 (Soil Erosion and Conservation) 3 credits
Oceanography 330 (Mineral and Energy Resources of the Sea) 3 credits
Oceanography 331 (Living Resources of the Sea) 3 credits
Oceanography 402 (Solar Nebula to the Human Brain) 3 credits
Oceanography 620¹ (Physical Oceanography) 3 credits
Oceanography 621¹ (Biological Oceanography) 3 credits
Oceanography 622¹ (Geological Oceanography) 3 credits
Oceanography 623¹ (Chemical Oceanography) 3 credits
Oceanography 633¹ (Chemical Oceanography Laboratory Methods) 2 credits
Oceanography 638¹ (Earth System Science and Global Change) 3 credits
Planning-Urban and Regional 310 (Introduction to Planning) 3 credits
Philosophy 316 (Science, Technology and Society) 3 credits
Political Science 316 (International Relations) 3 credits
Sociology 412 (Analysis in Population and Society) 3 credits

¹ Requires approval from instructor
SENIOR RESEARCH PAPER

A senior research paper is required of all students in order to graduate from the GES program. In general, this paper will be the result of research done under the auspices of one or more of the GES faculty members in SOEST, although other faculty within the University of Hawai`i are available to mentor students. In either case, the faculty research mentor will coordinate the senior research project with the student’s academic advisor. The Department of Oceanography and SOEST have many on-going research programs, including those of a theoretical, field (observational), and/or experimental nature. The GES student will be expected to act as an apprentice in one of these programs or another of his/her choosing in consultation with the academic advisor. In some cases, the mentor and the academic advisor may be the same individual. The GES student will satisfy the senior research requirement by enrollment in Senior Thesis Research (OCN 499) for a minimum of three credits.

Concurrent with the Senior Thesis Research project, all GES students will be required to enroll in the three-credit course entitled Communication of Research Results (OCN 490). This course consists of lecture and discussion to provide instruction and experience in oral and written presentation of scientific results and material.

It is anticipated that a number of the GES students will perform their senior research in the facilities at Coconut Island to satisfy their Senior Thesis requirement. This includes research conducted within the He`eia Ahupua’a Land coastal margin ecosystem. The location of the Senior Research project is, however, not restricted to the above locations. In all cases, however, approval of a research topic/location by the research mentor and the academic advisor is required.

Students may also conduct the research component of their senior thesis by carrying out a research internship in the public or private sector (i.e., Federal, State, or City and County agencies, or private environmental companies). Students are required to seek approval from their faculty advisor and the GES program coordinator prior to initiating such an internship.

Oceanography 490: Communication of Research Results 3 credits
Oceanography 499: Senior Thesis Research (minimum) 3 credits

Students participating in the UHM Honors Program will have the opportunity of satisfying the requirements of Communication of Research Results and Senior Thesis Research through the Honors Program. Such students, however, need to discuss this option both with their academic advisor and the staff of the Honors Program.

COURSE WORK AND SEQUENCING

The course work and sequencing should be clear from the presentation of the requirements outlined above. This includes the University of Hawaii General Education Core requirements, the GES core basic science requirements, and the GES core derivative requirements in science that are necessary prior to progressing to the GES foundation courses. The foundation courses act as the cornerstone for the coupled systems courses. As previously noted, five (5) courses from the course lists must be taken as writing intensive courses, with three of those at the 300 level or above.

After completion of the various core and foundation requirements, the remaining course work is elective and can be tailored to the individual student’s needs and interests. At this stage, the student has the opportunity to take relevant courses in other departments, such as Economics, Sociology, or other sciences.
The GES core requirement courses and the foundation courses are taught each year. Many of the coupled systems courses are also taught annually. Pre-calculus is required for admission to the GES program. Satisfactory preparation in high school mathematics and science, including biology, chemistry, and physics is strongly recommended.

Aerial view of Honolulu, showing the entrances of Honolulu Harbor (left) and Kewalo small boat harbor (right) and the downtown business district. Visible on the peninsula in the foreground is Kakaako Park which hosts the land based control station for the Kilo Nalu Nearshore Reef Observatory (see [http://www.soest.hawaii.edu/OE/KiloNalu/](http://www.soest.hawaii.edu/OE/KiloNalu/)) where SOEST scientist conduct research on the physics and biogeochemistry of reefs and sandy bottoms.

Schematic of the layout of instruments at the Kilo Nalu Nearshore Reef Observatory
APPENDIX I

A Short Guide to Help GES Students Prepare for a Senior Research Project and Subsequent Writing of the Thesis

This short informational guide is designed to help students (juniors and seniors) in the Global Environmental Science B.S. degree-granting program better understand and prepare for their senior research project and the subsequent writing of a thesis. In this document, we provide some concepts/guidelines that we hope will prove useful to students in understanding the basis for the senior research project requirement and what is necessary to carry out successfully such a project.

The senior research thesis project is the culminating experience bridging classroom instruction with the research enterprise, and is typically afforded only through graduate education. Relatively few fields of study require a senior research project and thesis, but those which do provide students with a very important skill that can either be carried into the job market or utilized to advantage in any further academic undertakings (e.g., graduate education/research)

The undertaking of a senior thesis research project requires a significant level of effort on the part of the student. The thesis research is no small task and undertaking of this project should be taken very seriously. Efforts necessary for a successful project include not only carefully planning the project but also having the discipline to carry out the study in a timely fashion.

Some important steps/questions/factors that will help students determine what and how to undertake a senior thesis research project include:

- When should you begin thinking about the senior thesis research project?
- How much time should you allocate to the execution of the project?
- How to pick an appropriate mentor?
- Availability of existing projects suitable for GES senior research
- Identification of a problem of interest to you and evaluation of its relevance/importance to environmental science (pragmatically, this will also include a determination of the suitability of the proposed project with respect to what you can reasonably expect to accomplish in the course of a “senior thesis” project)
- Evaluating the risk/reward ratio of the proposed research
- Identifying sources of funding and applying for funding for the project
- Scheduling of the time needed to design and carry out the project

We cannot emphasize enough how important it is to begin to plan EARLY for this culminating experience in the GES program of study. It is strongly suggested that students begin thinking seriously about their senior thesis research project EARLY in their junior year. Because most GES students face substantial time constraints well into their senior year, we believe that the best approach to doing the senior thesis research is to plan on beginning the project during the summer between your junior and senior years. Those already in their senior year are, to some extent, already at a disadvantage in that much will need to be accomplished in a relatively short period of time.

In order to meet the objectives of the senior thesis research, i.e., learn how to develop a research project that answers specific questions and test hypotheses (derived from either preliminary observations or from a literature search on a given topic), a series of (logical) steps should be followed. These include:

- Determining who, among GES faculty, is involved in research of interest to the student and who might be willing to serve as a mentor
• Choosing a **general** area of interest that will eventually lead to a suitable project
• Actually selecting the mentor (this is very important as, ideally, this person will not only serve as a mentor, but should also become a colleague)
• Developing an original project idea (with guidance and input from the mentor)
• Making preliminary (field) observations and/or running laboratory experiments that will provide data that can be used to define/refine the problem at hand
• Preparing a short (1-2 page) prospectus describing the proposed research project (this must be approved by the mentor and the ad-hoc GES Senior Thesis Committee before undertaking the project)
• Developing a primary hypothesis statement (and possibly secondary hypotheses) based on the preliminary data available
• Developing a null hypothesis (this is the hypothesis of equality)
• Designing (laboratory, field, or theoretical) experiments that will allow testing of the hypothesis
• Conducting experiments or making field observations (i.e., acquiring data)
• Evaluation of data (including determining their reliability, reproducibility, and how representative the data are of the system/problem at hand)
• Interpreting results
• Writing the thesis
• Presenting the thesis results in a public forum (GES Senior Thesis Symposium)

Some other useful hints and possibilities that will help GES students optimize their schedules and maximize the benefits of their chosen research topic.

• Try to obtain a student research assistant position (job) in a laboratory or private company where you are interested in carrying out your senior thesis research
• Try to do an “internship” with a City and County, State or Federal agency and select a “topic” of internship that is suitable for the senior research thesis project
• Apply for financial assistance from the GES program to help defray the costs of the senior thesis research project if the research is not already funded (i.e., by grants to the mentor) and will otherwise cost you money in addition to time
• Seek the advice of students who have gone before you
• Interact closely and frequently with your mentor. Remember, he/she has been doing this for much longer than you and is experienced.

A subsequent appendix will provide additional information and guidelines for the preparation of the thesis document. This will include details on describing the research project, its results and their interpretation, as well as the significance and broader impacts of the findings of the project.

All senior thesis documents are to be prepared on bond paper as per instructions of the University of Hawaii Graduate Division for the preparation of the M.S. thesis. Margins and pagination should also follow Graduate Division approved formats.

**Timeline and Important Deadlines for the Senior Research and Thesis:**

Initiation of discussions of research project: 1\textsuperscript{st} semester of junior year
Submission of research proposal to GES office: 1\textsuperscript{st} semester of senior year
Draft copies of thesis to mentor and GES office: At least 20 days prior to last day of instruction
Oral presentation of research results: To be scheduled during final exams study period
Final copies of thesis to mentor and GES office: By the last day of final exams week
APPENDIX II

24 February 2003

A Short Guide for Faculty serving as Advisors and Mentors to GES Students
Preparing for a Senior Research Project

This document is designed to help facilitate faculty advising and mentoring of GES students preparing to undertake their “Senior Thesis Research.” Below we provide some concepts/guidelines to help understand what is expected in the senior research project and how faculty can facilitate the process and provide a nurturing learning environment for the student.

The senior research thesis project is the **culminating experience** for GES students. It bridges classroom instruction with the research enterprise, something often only afforded through graduate education. Relatively few fields of study require a senior research project and thesis, but those that do provide students with important skills they can carry into the job market or utilize to advantage in further academic undertakings (e.g., graduate education/research).

Planning and implementing a senior thesis research project requires a **significant** level of effort on the part of the student. In their efforts to identify suitable mentors and projects, GES students have been asked to follow the steps outlined in APPENDIX I of the GES “survival” manual. You, as faculty advisors and potential mentors, can facilitate this task. Many things that are second nature to seasoned researchers are not at all obvious to novice researchers. Please take a few minutes to review APPENDIX I of the GES manual. Although it is by no means a complete roadmap to research, we think it will help students get started. We welcome any comments and suggestions from the faculty to improve the document.

Students in the GES program are kept **VERY** busy owing to our rigorous curriculum. Many students wait until late in their undergraduate career before thinking about a senior research project. Thus, if at all possible, we encourage you to begin to talk to your advisees about their senior research probably as early as their sophomore year. Although some students are not prepared academically for research at that time, others are, and, by the time they reach the junior year, most students can carry out significant research. You are encouraged to inform students that work (as a lab or field assistant) during their freshman or sophomore years will give them experience that will help them later in their own endeavors. Whenever possible, we encourage you to make available opportunities for GES students to participate in research in your own program.

A good way for faculty to advertise job opportunities and existing projects, from which GES senior thesis topics might derive, is to write a short essay in the GES newsletter and/or list job opportunities there. You should describe in simple terms your research interests, list any upcoming cruises or other scheduled fieldwork and any assistance you might need. It is also important for students to know that they can be gainfully employed performing what might later become their research project. For further information on how to contribute to the GES newsletter, please contact Chris Rothschild at the GES program secretary.

As faculty, we cannot emphasize enough to students how important it is for them to begin planning **EARLY** for their senior research project. Please advise students to begin thinking seriously about their senior thesis research project **EARLY** during their junior year. Because most GES students face substantial time constraints well into their senior year, we believe that a good approach is to plan on beginning their project during the summer between the junior and senior years. Students already in their senior year are, to some extent, at a disadvantage, as much needs to be accomplished in the relatively short period of time remaining.

Although all students need to learn eventually how to develop and execute a project on their own, the first step is to help them design a study that answers specific questions and tests hypotheses. However, there are other important steps they must first take. Your assistance can greatly facilitate this potentially daunting task and improve their overall experience. Students will need to:
- Determine who is doing research of interest to them and is willing to be a mentor (Generally, but not always, GES faculty)
- Choose a **general** area of interest that can lead to a suitable project
- Meet with various faculty individually and then select a mentor
- Develop a project idea (with guidance from the mentor)
- Make preliminary observations to define the problem at hand, if necessary (this may not be necessary if the prospective mentor has some well-constrained needs of appropriate scope that are already identified)
- Prepare a short (1-2 pages) prospectus describing the proposed research. The prospectus must be approved by the mentor and the *ad-hoc* GES Senior Thesis Committee (Currently Fred, Jane, and Eric), before students begin the project.

After the initial steps have been completed, the rest of the project is no different than what you, as professional researchers, undertake in your own work. Yet, students at this stage are novices and need extra mentoring. Thus ensuring that you allow sufficient time to devote to mentor your student is often critical to their ultimate success. Keep in mind that students will also likely need assistance when they reach the writing stage of their project. This task will also require time from the mentor (discussions, reviews, etc.).

Should you need additional information or advice, please contact Fred ([fred@soest.hawaii.edu](mailto:fred@soest.hawaii.edu)), Jane ([jane@soest.hawaii.edu](mailto:jane@soest.hawaii.edu)), or Eric ([edecarlo@soest.hawaii.edu](mailto:edecarlo@soest.hawaii.edu)).