**ENVIRONMENTAL COOPERATIVE SCIENCE CENTER**
**ANNUAL REPORT 1 OCTOBER 2002 - 30 SEPTEMBER 2003**

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## A. Introduction

The Environmental Cooperative Science Center (ECSC) is led by Florida A&M University (FAMU) in collaboration with Delaware State University (DSU), Jackson State University (JSU), Morgan State University (MSU), South Carolina State University (SCSU), the University of Miami Rosenstiel School (UM-RSMAS), Creighton University (CU), and the University of Nebraska at Lincoln (UNL). The ECSC addresses ecological and management issues at five National Estuarine Research Reserves (NERR) sites and the Florida Keys National Marine Sanctuary (FKNMS). Partner NERR sites are: Grand Bay NERR (Mississippi), Apalachicola NERR (Florida), ACE Basin NERR (SC), Delaware NERR, and Chesapeake Bay NERR (MD). These sites were selected because of their proximity to ECSC member institutions and existing research, education, and outreach activities involving member institutions. The ECSC has four primary interrelated goals: 1) increase the number of underrepresented minorities in the atmospheric, environmental, and oceanic sciences by training students and expanding the capacity of faculty from member institutions to participate in NOAA related research; 2) develop tools, including conceptual models, to assess the response of coastal ecosystems and communities to perturbation and develop measurement programs to monitor critical system attributes; 3) improve the scientific basis for coastal resource management; and 4) facilitate community education and outreach relating to the function and significance of coastal ecosystems.

The present report is the second annual report for ECSC, covering the period of 1 October 2002 through 30 September 2003. This report is organized around the initial proposal for the Center, which has become the basis for the cooperative agreement between NOAA and Florida A&M University. The report discuses the individual goals and research or education tasks in the proposal, summarized in Table 1, listing the initially proposed specific tasks and deliverables for the first two years of Center activities along with the status of each milestone. Moreover, through discussions organized by the research and education tasks outlined in the initial ECSC proposal, the present report responds to specific queries detailed in a letter from the ECSC NOAA Program Manager, Ms. Jacqueline Rousseau, to the ECSC Director dated 28 August 2003. Finally, this report provides a brief discussion of a range of activities underway in ECSC that well exceed the

tasks initially proposed for Years 1 and 2. This annual report is provided as one element to be considered during the formal review of the ECSC, presently scheduled for March 2004.

## B. Progress in Years 1 and 2

The initial section in the present annual report discusses the progress made with respect to the specific goals and activities that were identified in the initial research proposal submitted to the NOAA Educational Partnership Program (EPP) Office in 2001. These goals and tasks were specified in the proposal as a table entitled, "Three-Year Program Development Plan". That table is reproduced here (Table 1), with annotation of the status of each of the individual tasks. The following section discusses each element in the initial table. Although the proposal did not number each of these activities, a number scheme has been added here to assist in clarity of the progress report.

### B.1. Management and Administration

The tasks for the Management and Administration (M&A) component of ECSC for Year 1 were to: a) hold initial planning meeting (accomplished November 2001); b) hold public information meetings at each NERR site (accomplished in Year 1 through a series of workshops at all sites); c) create the ECSC Internal Management Team (IMT) (accomplished in Year 1; note replacement of M Harwell by David Letson as lead co-PI at UM-RSMAS, and replacement of L Marshall by Tony Wilbon as lead co-PI at Morgan State University); d) establish the ECSC Technical Advisory Panel (TAP) (accomplished in Year 1); e) establish the ECSC Management Advisory Committee (MAC) (accomplished in Year 1); f) hold monthly teleconference meetings of the IMT (accomplished in Year 1 and continued through Year 2); and g) hold annual advisory board meetings (accomplished in Year 1 and Year 2 through annual meetings, plus quarterly conference call meetings of the TAP throughout Year 2).

Additional M&A tasks for Year 2 were to: a) incorporate advisory board recommendations into the work plan; and b) hold the first general information meeting open to Center participants. Progress in Year 2 for these two tasks is discussed next:

**Task M&A 2a —** The first task (incorporate advisory board recommendations into the ECSC workplan) has been accomplished through several mechanisms. Most importantly, one recommendation from the joint TAP/MAC meeting held in the Florida Keys in January 2003 was to develop a series of workplans for the specific research activities to be conducted within each partner NERR sites. These workplans were produced through joint collaborations between the lead co-PI at each partner university and the associated NERR research coordinator. These workplans were used to identify research tasks, the participating university faculty and students, the participating NERR scientists, and other collaborators, as appropriate. These plans were a basis for estimating the financial needs of each NERR site with respect to participation in the ECSC activities, including support needed for field activities (e.g., use and maintenance of boats, field equipment and supplies), NERR staff salaries in some cases, and other support needs. Each workplan was reviewed by cooperating scientists and submitted to the NERR research coordinator. The

workplans were also included as appendices to the ECSC Semiannual Report (dated 30 April 2003), submitted to the NOAA EPP Program Office, and thus not repeated here.

In part based on these workplans, ECSC submitted a request to NOAA the Educational Partnership Program in June 2003 for $87,000 funding support for four of the partner NERR sites (Apalachicola Bay NERR, ACE Basin NERR, Delaware NERR, and Grand Bay NERR). The proposal was approved and the funding mechanisms established at the sites through subcontracts from FAMU to the host agencies (e.g., Florida Department of Environmental Protection for ANERR).

Another recommendation from the TAP/MAC was to expand the remote sensing tasks from the modest program discussed in the initial proposal into a much more extensive set of remote sensing, ground-truthing, hyperspectral data analysis, and GIS activities. These activities are discussed more fully below.

Another TAP/MAC recommendation was to publish the conceptual models developed at each NERR site in the refereed literature. The initial plan was to publish as a special issue of the journal *Interdisciplinary Environmental Review*; however, based on difficulties associated with the transition of that journal to a new publisher, the decision was made to move the ECSC special edition to the journal *Urban Ecosystems.* The special issue articles are discussed more fully below.

The TAP/MAC have also been informed and engaged in discussions for the initiation of additional research tasks beyond the scope of the initial proposal; a suite of such new expansive initiatives has been developed.

**Task M&A 2b —** The second Year 2 M&A task (Center-wide meeting) was accomplished in January 2003 during a week-long meeting in the Florida Keys involving most of the ECSC co-PIs and many ECSC students. Included in this meeting were technical discussions for the research activities underway at each partner university; detailed planning for the remote sensing activities; status reports for each of the conceptual models for each NERR site, as well as the articles underway for *Urban Ecosystems*; development of specific work plans for each NERR site research activities; extensive discussions among a socioeconomic workgroup to develop the societal feedback and linkages conceptual model and framework; and other ECSC research and education activities. A report from the Florida Keys meeting was submitted to NOAA EPP in the semi-annual report in May 2003, and is included here as an appendix.

***Summary of M&A Activities*** — All of the ECSC Management and Administration activities proposed initially for Years 1 and 2 have been accomplished or exceeded.

**B.2. Goal I Professional Training — Increase the number of underrepresented minorities in the atmospheric-environment-oceanographic (AEOS) professions by training students and expanding the capacity of faculty from member institutions to participate in NOAA-related research activities.**

The specific elements of Goal I in Year 1 were to: recruit the ECSC Distinguished Scientist (accomplished April 2002); select student participants (accomplished in Year 1 and continuing throughout subsequent years); initiate curriculum review and analysis (accomplished and continuing at member HBCUs); begin faculty and student exchange (accomplished and continuing); begin distance learning activities (initiated but not completed); hold professional development workshops for faculty utilizing the Distinguished Scientist and NOAA personnel (continuing); and assign NOAA personnel to theses and dissertation committees (accomplished and continuing).

In Year 2, all items above (except recruit the Distinguished Scientist) were listed in the proposal table as continuing, with the addition of the following: transition of undergraduates to graduate programs at member institutions; and seek NOAA employment opportunities for first year graduates.

Each task will be discussed in more detail, renumbered as Goal I, Year 2, elements a-i:

**Task I.2.a — Select student participants**

A summary of the present (Fall 2003 semester) students supported by ECSC is provided in Table 2, derived from the input provided to NOAA EPP in summer 2003. Clearly, there is a large number of students working as a part of ECSC, too many to discuss individually here; however, following are some specific examples of student activities in ECSC:

At Morgan State University, a total of 22 undergraduate and graduate students received stipend, contractual, or scholarship support from the MSU/ECSC project during Year 2. The students are majors in the School of Computer, Mathematical, and Natural Sciences, School of Engineering, the Institute of Architecture and Planning, and the School of Business and Management. All students are engaged in laboratory, computer, and field training or some combination of these activities. Further, some of these supported students were involved with ECSC/NERR focused projects in addition to their own research projects. For example, we recently identified a doctoral student in environmental engineering to work with the Maryland NERR research coordinator on studies related wild rice growth and water quality at the Jug Bay NERR site.

MSU students majoring in the sciences and engineering gained exposure and knowledge in a variety of related areas including marsh ecology, habitat restoration, plankton studies, remote sensing, and Geographic Information Systems (GIS). Further, several of the students worked on research related to environmental management and economics. For instance, we have a doctoral student in the School of Business and Management gathering data on economic development in critical bay areas of the Chesapeake Bay, particularly metropolitan cities like Baltimore and Annapolis. The goal of this research is to identify

the impact of the State of Maryland's critical bay designation on residential and commercial land pricing and measure the impact of development changes to the local economies. In addition, there are several large corporations located within or near the critical bay areas that are historically known to have some impact on environment. A Master student majoring in environmental engineering in the School of Engineering is working on research to identify the changes that large companies in or near the critical bay areas have made in their operations management strategies to address their impact on the coastal environment. All students learned and participated in scientific literature searches and summarization, data collection, as well as data analysis, report preparation, and presentations. These latter activities are facilitated via student training in statistical software utilization (example: SPSS and Excel) and GIS software (e.g., ArcView using ENVI, ArcInfo, and Global Positioning Systems [GPS]). This multidisciplinary approach provides exposure, training and career development for students. We have also found that pairing undergraduates with graduate student mentors significantly enhances undergraduate student training.

At the University of Miami, ECSC funding supports three students: Cinda Scott began her PhD program in marine biology and fisheries in July 2002 and is supervised by Dr. Michael Schmale. Her research topic is "Development of bioindicators of ecosystem health in the Florida Keys National Marine Sanctuary." NOAA/EPP support enables third-year student Chad Noel to continue working toward a joint MA/JD degree in environmental law and marine affairs. He is supervised by Dr. David Letson. His research topic is legal and policy issues in marine pollution litigation. Jame McRay began work toward her MA in the UM-RSMAS Division of Marine Affairs and Policy in August 2003. She is doing research on the marine policy of large marine mammal protection and is also supervised by Dr. Letson. NOAA Superintendent Billy Causey and research coordinator Brian Keller of the Florida Keys National Marine Sanctuary (FKNMS) serve as NOAA contacts for all three students.

At FAMU, in Dr. Jennifer Cherrier's lab are three Ph.D. candidate and two undergraduate ECSC-funded students working: PhD candidates Holly Brown, April Croxton, and Donatto Surratt; undergraduate students Jarvis Brown and Erin Pinder. With the exception of Erin Pinder, who just entered ESI's undergraduate program this fall, all of these students have attended not only ECSC-related meetings but also have attended at least one national meeting of the American Society for Limnology and Oceanography. Each of these students has also participated on at least one 3-day research/training cruise in Gulf of Mexico with Dr. Cherrier, along with other FAMU undergraduate and graduate students.

Holly Brown (co-advised with NOAA scientist Steve Morton, who is based at the Charleston NOAA Research Facility) is working on a project to establish a better understanding of the mechanisms and associated interactions that impel conditions for the harmful algal bloom (HAB) species, *Karenia brevis*, in estuarine systems in the Gulf of Mexico. April Croxton (co-advised by Dr. F. Hamilton and a soon-to-be-appointed NOAA scientist from NOAA Milford CT lab) is working to evaluate the relative accuracy of traditional vs. less traditional water column indicators as a proxy for the detection of

fecal contamination in Apalachicola Bay oysters. She will monitor and compare the presence of traditional indicators (e. coli and enterococci) with less traditional but perhaps more sensitive viral (Norwalk virus) and pharmaceutical (tetracycline and triclosan) indicators in water column samples overlying selected oyster beds in Apalachicola Bay. Donatto Surratt (co-advised with Dr. Larry Robinson) is evaluating how past chronically correlated events (e.g., dredging, damming, and climactic perturbations) in the Apalachicola-Chatahoochee-Flint (ACF) river basin have impacted the historical trophic status of Apalachicola Bay and projecting how future alterations to the ACF river basin system together with local urbanization can potentially impact the trophic status of the Bay. Part of this work is being done in collaboration with NOAA scientist J. Kineman, who is based out of the NOAA Boulder CO office and FAMU ECSC co-investigator Dr. Elijah Johnson

In Dr. Mark Harwell's lab, Master's student Aaron White is working on heavy metal contamination in the loggerhead sea turtle populations of the Apalachicola NERR and Guano-Tolomato-Matanzas (GTM) NERR, on the east coast of Florida. This project involves working with county-level sea turtle patrols in collecting residues from hatched eggs as well as intact unhatched eggs of dead hatchlings. The US EPA laboratory at Gulf Breeze, FL, has made available the equipment and training for Mr. White to conduct the highly sensitive metals analyses. Another student in Dr. Harwell's lab, Angel Wynn, is researching the utility of ospreys as potential bioindicators of environmental contamination. NERR scientist Dr. Mark Woodrey is being added to her thesis committee based on his extensive experience in working on coastal birds, and the research is being conducted at both the Grand Bay and Apalachicola NERRs, using the former as a potentially contaminated site adjacent to a long-functioning petrochemical complex. Latrincy Whitehurst is also working under Dr. Harwell on a project collaborative with Creighton University co-PI Dr. John Schalles. Ms. Whitehurst is developing logarithms and ground-truthing metrics for the spectral reflectances from the AISA imagery from a series of coastal riverine and estuarine systems, including from ANERR, ACE Basin, and elsewhere. She has received considerable training in the field as a part of Dr. Schalles lab. Ms. Cassandra Barnes is working with Drs. Harwell, Robinson, and Forthman on a doctoral project addressing governance indicators under coastal zone management (CZM); we are presently exploring adding a NOAA CZM specialist to her committee.

Dr. Frederic Essien advises Joseph Amoah in work on the hydrology of the Apalachicola watershed. This includes an investigation of the characteristics of precipitation and drainage in the Apalachicola-Flint-Chattahoochee River basin, aimed at characterizing the trends in: a) water discharge by the Apalachicola River into the estuary; b) influence of river discharge on estuarine salinity and evaporation rate; c) sediment loading in the river and estuary; and d) influence of dredging activities on river and estuarine characteristics. This work also involves relating satellite sensor response (represented by the multispectral image) to the true radiance (or reflectance) of coastal water body, thereby eliminating the errors introduced by the intervening atmosphere. Further, the corrected spectral signals must be related to their physical chemical and biological sources in the water. Protocols are being developed for making reliable (and hopefully reproducible) measurements of light absorbing, scattering, and transmitting properties of Apalachicola Bay waters.

Another of Dr. Essien's students, Akia Laurant, is working on the characteristics of Apalachicola Red Tide Events. Progress is underway on the analysis of data collected by the Florida Department of Agriculture during the Apalachicola red tide events of 1995 to 2001. Correlations are being examined between *K. brevis* cell concentrations and salinity, temperature, the vertical gradients of both salinity and temperature, wind speed, and wind direction. Preparations are underway for an experimental study of the effects of salinity, temperature and lighting changes on populations of *Karenia Brevis* cultured in outdoor tanks. Ms Laurent is due to visit the University of South Florida/State of Florida's Florida Marine Research Institute to learn the techniques of culturing and handling the microorganisms.

Dr. Michael Thomas advises Master's student Carmen Lyttle N'Guessan, for whom portions of her research were funded by ECSC. During the fall of 2003, she will complete her econometric analysis of the contingent valuation survey developed to measure the economic cost of nitrates in private well water. She will document the environmental cost borne by private well owners who are exposed to high levels of groundwater nitrates, and while this is not presently thought to be a problem in the Apalachicola NERR site, it remains a potential problem throughout the coastal systems of the US. Dr. Thomas also advises a newly admitted student, LaDrier Williams, who plans to estimate the consumer surplus (value) and economic expenditures resulting from the use of vacation rental properties on St. George Island. Her research assistantship to document the economic importance of the Apalachicola Bay to the vacation rental sector of Franklin County is made possible by the ECSC.

Another FAMU student advised by Dr. Thomas, and co-advised by Carol Forthman, Ms. LaMarr Joseph, is presently working to develop a travel cost model and estimate the consumer surplus (value) and economic expenditures resulting from the recreational use of St. George Island State Park, adjacent to ANERR. In addition to documenting the economic importance of this island park, the study will also determine the importance of the Apalachicola Bay to park visitors. Ms. Joseph will cooperate with the Florida Department of Environmental Protection (DEP) in study design and in the surveying of park visitors.

Ms. Forthman also advises other FAMU students on specific topics related to the socioeconomic factors in the NERR sites. Ramona Madhosingh (M.S.) has developed a research methodology to assess the effectiveness of the Apalachicola NERR site's education and outreach programs. Towanda Anthony (M.S.) is developing a model to assess the cumulative and secondary impacts of transportation projects to allow for consideration of those impacts in the planning process.

Dr. Larry Robinson continues to advise ECSC students. Two of his doctoral students, Li Zhao and LaToya Luse, have made presentations about their thesis research at national conventions:

- *Determination of Carbon, Nitrogen, and Phosphorous in Cattail by Using Cold Neutron Prompt Gamma Activation Analysis* — Presented by Li Zhao at the American Nuclear Society International Topical Conference held in Kailua-Kona, Hawaii, on April 7 – 11, 2003.

- *The Utilization of In Mobility Spectrometry and Annular Denuder Techniques to Explore the Deposition of Ammonia in Coastal Ecosystems* — Presented by Latoya Luse at the 30th Annual Conference of the National Organization for the Professional Advancement of Black Chemist and Chemical Engineers held in Indianapolis, Indiana.

At Delaware State, Dr. Reiter advises a Master's student, Brandon Brock, who is working on the habitat preferences of the juvenile Horseshoe Crab (*Limulus polyphemus)* in relation to substrate and water parameters. This species was identified in the DNERR conceptual model as one of the important VECs for the coastal communities. Another Reiter student, Ms. Barbara Murray, is working on assessing land acquisition for biological conservation in Kent County, Delaware, and Somerset County, Maryland. Again, the DNERR conceptual model highlighted the land acquisition issue as central to societal values for the DNERR watershed. And another Master's student of Dr. Reiter's (Max Saintil) is working on the application of sensitivity analysis to integrated conceptual models, focusing on the saltmarsh habitat of the St. Jones watershed, a part of the Delaware NERR.

At Creighton University/University of Nebraska, two graduate students are participating in the project and working closely with students, faculty, and NERR staff at each site: Christine Hladik (MS thesis student in Environmental Science at Creighton University, advised by Dr. John Schalles) and Giorgio Dall 'Olmo (Ph.D. student in the School of Natural Resource Science at the University of Nebraska-Lincoln, advised by Dr. Don Rundquist). Ms. Hladik's MS thesis is investigating relationships between close-range spectroradiometer measurements at each flyover site and at the Sapelo Island NERR with measured, optically active constituents at each site in an attempt to provide site-specific algorithms for water column chlorophyll. These relationships will, in turn, be used for calibration of water reflectance data in the AISA imagery to produce chlorophyll distribution maps. Her thesis work has been a very important input to the development of the thesis research of FAMU student Ms. Whitehurst, as discussed above.

Under the leadership of ECSC co-PI Dr. Ambrose Anoruo, South Carolina State University, through the Savannah River Environmental Sciences Field Station (SRESFS), has collaborated with scientists at the South Carolina Department of Natural Resources, Marine Resource Division, and other SRESFS member institutions to recruit minority students into the environmental sciences. The Savannah River Environmental Sciences Field Station has 29 colleges and universities in its membership. Twenty-two of the member institutions are Historically Black Colleges and Universities, and students and faculty were selected from these institutions.

Two students who attended the SCSU marine research summer program have been accepted to graduate degree programs. Armah Bell has been accepted to a Ph.D. program in environmental microbiology with emphasis on wetlands microbial ecology at Tennessee

State University. Drena Howard has been accepted to the Master of Environmental Management degree at Yale University, and Arena Richardson has been short-listed for the Master of Science degree in estuarine ecology at Yale University.

Also, applications are being received from recent graduates (May 2003) who have had previous exposure in marine science for research internship positions with NERR and faculty scientists in the ACE Basin NERR of the ECSC project. Four undergraduates selected from Claflin University and South Carolina State University are involved in research at ACE Basin NERR: Nariscia Phillip, Marshall Washington, Angel Washington, and Arena Richardson. These four undergraduates were trained in ecological and environmental research methods.

At Jackson State University, a number of undergraduate and graduate students has been recruited into ECSC research activities: Joyce Williams, Ph.D. student in Environmental Science; Ana Balazero, Ph. D. student in Environmental Science; Michael McIntosh, M.S. student in Environmental Science; Kavara Dixon, M.S. Student in Biology; Joyce Belcher, Biology Junior; Curinetha Hubbard, Chemistry Junior; and Chastity Clincy, Chemistry Junior. These students were active in the field studies at the GBNERR remote sensing task.

Table 2 summarizes the students presently under ECSC support.

**Task I.2.b — Curriculum review and development**

The FAMU Environmental Sciences Institute (ESI) has undertaken a curriculum review with two main objectives: First, to strengthen the science base of the curriculum, and secondly, to broaden its scope as an interdisciplinary program in support of the ECSC goals. To accomplish these objectives, a curriculum committee was established to take a critical look at the course offerings in both the graduate and undergraduate programs. The committee was also charged with making the necessary changes that will further enhance the interdisciplinary components of the program.

The major recommendations of the ESI committee that have been implemented to date include a revamping of the M.S. and Ph.D. degree core course requirements in ESI. The net effect of this exercise is a unified set of core courses for both the MS and Ph.D. programs. These courses were carefully chosen to give the students core competencies in the environmental sciences from which they can then specialize. In addition, some courses that were deemed "unnecessary" were dropped or deleted from the program and replaced by new courses. The ripple effect of the committee's work is also felt on the admissions criteria for new graduate students in the Environmental Sciences Institute. All new applicants for admission to our graduate program must have taken undergraduate courses in chemistry up through organic chemistry, as well as a year each of biology, physics, and calculus. In this regard, the FAMU ESI undergraduate curriculum was revised to meet these minimum criteria to make our graduates competitive.

Also at FAMU, Dr. Mark Harwell is developing a new graduate-level course on Ecological Risk Assessment. This course will explore the frameworks of ecological risk assessment, ecosystem management, ecological sustainability, and conceptual model development, all themes of the ECSC. A class project involving all of the students working on a common regional environmental issue will focus training on collaborative, interdisciplinary approaches to understanding environmental management issues and bringing science to bear on environmental decision--making.

FAMU's Dr. Jennifer J. Cherrier is a co-PI on a new NSF-funded grant entitled 'Florida Center for Ocean Science Education' (FCOSEE). In addition to her efforts on the FCOSEE web portal, her primary responsibility on this project is to take the lead role in the incorporation of new science content and inclusive pedagogy into a post-secondary Ocean Science Concept-drive Interactive (OSCI) curriculum model (developed by J. Cherrier with previous NSF funding). Once modified, the intent is that this OSCI model will be made available through the FCOSEE web portal for adoption by instructors at the other ECSC partner institutions and other post-secondary institutions. Her ultimate goal is to serve as a bridge between scientists and educators and make these 'tools' (i.e., the OSCI model) available to all interested instructors at post-secondary institutions to help with a transition from a traditional approach to teaching oceanography to one that is more concept-driven, collaborative, and interactive. She is committed to adopting, developing, and implementing inclusive educational strategies that will aide in recruiting (and retaining!) diverse groups into the ocean sciences.

Moreover, Dr. Cherrier is working collaboratively with FAMU FCOSEE co-PI Bernadette Kelley, a tenured Assistant Professor in the FAMU College of Education, to develop degree progams for undergraduate- and Masters-level degrees in Education in Environmental Science, with a specialty in marine science. The purpose of this project is so that Florida K-12 teachers will be better prepared to use the highly relevent and integrative ocean sciences as a platform for teaching to national science education standards. This program will include both pre-service and in-service training components for teachers. These activities (the post-secondary teaching model, and the FAMU model for a degree program in Education and Environmental/Marine Science) will be highly applicable to the education and outreach activities at the collaborating ECSC institutions. Dr. Cherrier has now implemented the OSCI model at three post-secondary institutions, including FAMU, with very postitive results. She has developed an on-line textbook for use with this curriculum entitled "Powerweb Oceanography" that is published by Dushkin-McGrawHill (ISBN 007247979). The OSCI model has been digitized and is available on CD for distribution to interested ECSC PIs at collaborating institutions.

Finally, for the past two years Dr. Cherrier has been awarded ship time by the Florida Institute of Oceanography (FIO) for two 3-day cruises. Approximately 10 students participate on each cruise (total of 20/year). These cruises have proven to be both a valuable hands-on training tool for ECSC students as well as an effective tool recruiting some undecided students into the marine sciences. It is anticipated that she will continue to secure this ship time funding from FIO, as the research and educational objectives of her

cruises are directly in line with the mission of FIO and significantly contributes to the educational goals of ECSC.

Dr. Frederic Essien at FAMU is working to provide the background knowledge required to understand and to investigate the peculiarities of the Apalachicola Bay, including developing new courses in Meteorology, Hydrology, Physical Oceanography, and Remote Sensing for inclusion in the ESI curriculum. The series of courses being developed by Dr. Essien are:

| COURSE TITLE | LEVEL |
|---|---|
| Environmental Remote Sensing | Undergraduate |
| Introductory Earth System Science | Undergraduate |
| Environmental Climatology | Undergraduate |
| Coastal and Estuarine Remote Sensing | Graduate |
| Physical Hydrology | Graduate |
| Physical Oceanography | Graduate |
| Hyperspectral Image Analysis | Graduate |

Many other actions have been undertaken individually at the partner institutions to strengthen their education programs. For example, Creighton University has built a new science building with a new, 16-station remote sensing laboratory and ENVI site license. Last year, CU hired a new environmental geologist, Dr. Joan Ramage, who is teaching earth science and remote sensing courses, and Dr. Schalles will teach a graduate-level remote sensing course next semester for the first time (Remote Sensing Theory and Applications). These steps are strengthening the B.S. and M.S. degree programs in Environmental Science at Creighton and enhance its capabilities for training and data analysis relevant to its role with ECSC. Moreover, now that this facility has been established, ECSC will send students from partner institutions to Creighton for training in environmental remote sensing and data analysis.

At Delaware State University, the entire curricula in the DSU Natural Resources majors (Environmental Science, Fisheries Management, and Wildlife Management) have been revised to support the ECSC educational mission, and an M.S. degree in Natural Resources has been initiated. The DSU related B.S. and M.S. degrees have all been completely revised. We have updated most of the related upper-level B.S. courses, and we are officially adding new M.S. course options in GIS, Environmental Modeling, Advanced Biometrics, Environmental Policy/Law, and Ecosystem Management to our M.S. degree program. Members of the ECSC consortium, DNERR, and NOAA and related Washington DC scientists have participated in the DSU departmental Spring Seminar series over the last three years (including Dr. Robert Scarborough, Dr. Gary Matlock, Dr. John Schalles, and Dr. George Parsons). Dr. Chunlei Fan (ECSC post-doctoral research associate) taught Marine Biology last semester and is presently teaching a course in GIS and Remote Sensing this semester. Dr. Fan's demonstration M.S. course in GIS is receiving support from ECSC GIS technicians, as well as faculty from the University of Delaware who became involved in response to information on the research being performed under the ECSC grant.

The DSU department is also completing the paperwork to forward to the university a request for new and adjusted graduate courses for the M.S. programs in Natural Resources and Plant Science. Among them are graduate-level options in environmental policy/law, ecosystems management, GIS applications, and field botany. The department has also added a fisheries specialist (Dr. Dewayne Fox), a soil scientist (Dr. Maria Labreveux), and an aquaculture specialist (Dr. Dennis McIntosh, starting in January), and will soon be advertising for an economist. These faculty and curriculum additions have been done in large part leveraged by the presence of ECSC. Moreover, with Dr. Mark Harwell's assistance, Dr. Reiter is initiating a new M.S.-level Environmental Modeling course, which he will teach this coming semester (pending approval of the course by the faculty senate).

Dr. Wilbon is developing several courses to address issues of environmental management for the Morgan State University School of Business and Management. The goals of these courses are to provide students with approaches for addressing management issues related to science and technology management, public policy, and environmental strategy. The three course under development include:

1) Environmental Economics — This course will analyze environmental problems, with special focus on the relationships among the environment, natural resources, and economic development. The major concentrations in the course will include ecological versus economic approaches to the environment, sustainable development, population and development, poverty and environmental stress, and grassroots environmental action. Other important topics to be covered include: pollution and development, the economics of biodiversity and global warming, correcting measures of GNP for natural asset deterioration, intergenerational allocation of resources, green markets, and the impact of market imperfections and policy failures on environmental degradation.

2) Strategic Environmental Management and Public Policy — This course will examine the multiple approaches that businesses, governments, and non-profit organizations have designed and implemented in their interactions with their respective natural environments. It will consider the assessment of the results, with consideration of future organization-natural environment interactions. It will also take a comprehensive, in-depth exploration of global, national, and local environmental public policy processes, challenges, and outcomes, including global climate change, international trade and environmental agreements, environmental security, air and water quality, biodiversity, and land use issues.

3) Management of Science and Technology in the Environment — This course will consider the identification, investigation, and evaluation of how environment, science, and technology are interrelated, and how these interactions influence policy formulation, implementation, and evaluation at the international, regional, national, industrial, and organizational levels.

At South Carolina State University, there has been an initiative to revitalized the marine science program and now offers a minor concentration in marine science. The ECSC

project has helped SCSU to establish a functional marine science minor concentration for science majors. Old and obsolete marine science courses that were created over 10 years ago and never offered have been modified and approved by the SCSU Educational Policies Council and the Faculty Senate. Five new courses and an undergraduate summer research program are now offered at SCSU as a minor in marine science.

At Jackson State University, the curriculum of the environmental sciences Ph.D. program has been revised to include Applied Environmental Biostatistics as a required course, and Environmental Epidemiology as an elective course. In collaboration with Dr. Thomas Sturgis of the Fate and Effects Division of the US Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, MS, the content of the wetland ecology graduate course has been revised and updated. A new course on Image Interpretation has been added, emphasizing remote sensing applications such as the ECSC remote sensing flyover in GBNERR, and is scheduled to be taught next semester.

These curricula changes outlined above have been undertaken individually at the partner universities in ECSC. The next phase of additional changes will be to set up a committee made up of representatives of all the partner institutions to review their curricula (especially at the undergraduate level) and to make recommendations that will strengthen the science base to make their graduates competitive for graduate admission to ESI and other environmental sciences graduate programs. To emphasize this task, ECSC has now added Dr. Michael Abazinge, Director of ESI Graduate Studies, to the FAMU team, with responsibility to lead the cross-institutional educational development activities involving all the partner institutions in the Center.

**Task I.2.c — Faculty and student exchange**

The initial mechanism for this task is seminars and other presentations by ECSC scientists at other institutions in the partnership. For example, at Delaware State University, the department's spring-semester seminar series included two ECSC-related Speakers: Dr. Kelton Clark of the Smithsonian Institution ("The Response of Prey to Variability in Predator Guild Composition and Refuge Habitat: An Example from Chesapeake Bay"), and Dr. Gary Matlock of NOAA NOS ("Nutrient Pollution in U.S. Estuaries"). The 2004 spring seminar series is presently being developed, and will include three ECSC speakers: Dr. John Schalles (Creighton) presenting the remote sensing research of the ECSC; Dr. George Parsons (University of Delaware) presenting his work on resource valuation; and Dr. Mark Harwell (FAMU) presenting the conceptual and ecological modeling activities at Apalachicola.

Similarly, Dr. John Schalles (CU) has presented a remote sensing lecture at FAMU, and Dr. Harwell (FAMU) has lectured on ecological conceptual modeling at SCSU.

Student exchanges have begun as well. Dr. Harwell's student, Ms. Latrincy Whitehurst, has spent more than a week in the field with Dr. Schalles and his students learning field sampling techniques and spectroradiometric measurements in estuaries and coastal river systems. Three ECSC FAMU students, Angel Wynn, Latrincy Whitehurst, and April

Croxton, participated in a week-long training workshop In Puerto Rico, organized by the EPP atmospheric sciences center. Several ECSC students from one university have participated in the partner university/NERR sites ground-truthing activities during the remote sensing tasks: For example, Ms. Joyce Williams from JSU was active in the ANERR ground-truthing; FAMU students Aaron White, Angel Wynn, and Latrincy Whitehurst were part of the water quality ground-truthing team at ACE Basin and GBNERR flyovers. DSU student Barbara Murray also participated in ground-truthing at GBNERR. More such exchanges are planned for the future.

**Task I.2.d — Distance learning**

This task has not been fully developed to date. Rather, the work has been to prepare for future distance learning activities. For example, at Delaware State, the distance learning system has recently been upgraded using outside funds. At FAMU, discussions are underway with the existing distance learning center to offer graduate courses in the future, with the initial test case being discussed the new graduate-level course being developed by Dr. Harwell on ecological risk assessment and management. However, a significant concern has been the reliability and band width of the FAMU computer network. During Fall 2003, FAMU will completely replace the hardware and network software for the University, under the direction of the new FAMU Provost and ECSC Center Director, Dr. Larry Robinson, in part in response to the impacts that these issues have had on ECSC activities.

**Task I.2.e — Professional development of ECSC faculty**

The ECSC proposal indicated this task would be a responsibility of the Distinguished Scientist, but in fact many of the ECSC faculty have been very engaged in faculty development across the member institutions. For example, as the proposal suggested, Dr. Harwell does communicate research funding opportunities to all ECSC co-PIs, and has helped in the development of several proposals. He lead a team of ECSC co-PIs at FAMU in preparing a proposal to the EPA STAR program, which was accepted (discussed below), providing valuable experience for some of the junior faculty participants. But many other senior ECSC faculty, such as Drs Robinson, Schalles, Gentile, Reiter, among others, have also disseminated research opportunities and assisted in development of proposals involving more junior faculty.

Moreover, the ECSC co-PIs have evolved into a very collegial group which has continuing discussions about research activities and ideas, with each learning from the others. For example, Drs. Letson, Wilbon, Thomas, and Reiter have initiated an economics working group that has been very helpful in explaining relevant environmental economics issues and approaches to other natural scientists in the Center. Dr. Schalles and his colleagues at CALMIT have been very effective in training ECSC faculty in the theory, tools, and utility of remote sensing at the various NERR sites, which has been invaluable in expanding the perspectives of others. Thus, the professional development has not been limited to junior faculty learning from more senior faculty, but significantly, the senior faculty in ECSC have also learned from their colleagues and expanded their professional horizons. As

ECSC evolves, additional faculty participants have been brought on board (now more than 30 faculty at the member institutions are involved in ECSC research), and the exchange of research ideas, requests for assistance, analyses and results, have expanded considerably. We believe ECSC has developed into an effective community of collaborators, and, while this is an approach that requires continual renewal and expansion, we believe that already significant synergisms have been established that have contributed to the success of ECSC research to date. That feeling of shared vision and community among junior and senior faculty at the member institutions is a significant component of the faculty professional development process.

More focused mentoring programs have also been initiated. For example, Dr. Robinson has instituted a formal mentoring program at FAMU for senior faculty to assist junior female faculty members in navigating the tenure process, and ECSC faculty participate both as mentors and recipients of the mentoring. Another component of professional development for ECSC faculty is the development of manuscripts for the refereed literature, and the special issue of *Urban Ecosystems* in part is useful in getting valuable publication experience by ECSC faculty. Finally, the ECSC post-doctoral research associates have been very productive as research coordinators/contributors and as student mentors in ECSC, and they are under the active mentoring of ECSC faculty as they continue in their own career development.

In addition, at the partner institutions are various activities to advance the training and experience of partner university faculty. For example, DSU faculty members have attended several of the remote sensing flyovers in order to become familiar with the procedures before work begins on the flyover scheduled next year for DNERR. Dr. Chunlei Fan is attending GIS and remote sensing courses at the University of Delaware in order to enhance his capabilities as a scientist and for use in the ECSC work in Delaware.

*ECSC Faculty/Student Training Workshops*

During the ACE Basin flyover activities in June 2003, a two-day workshop on the use of ENVI remote sensing software was conducted by faculty of the FAMU Remote Sensing Laboratory, in cooperation with NOAA research staff at the Coastal Services Center in Charleston. ENVI is a commercial software application designed for manipulation, analysis, and interpretation of hyperspectral imagery (discussed further below). Temporary licenses of ENVI software were provided for use in the workshop by Research Systems Inc. (RSI).

During the workshop, NOAA personnel presented examples of ongoing research involving coastal applications of remote sensing technologies. This was followed by hands-on exercises in the use of ENVI software conducted by FAMU research faculty and staff. This workshop was intended to teach the principles and skills needed by faculty and students at ECSC partner institutions to work with flyover data acquired from each NERR site. In attendance were faculty from FAMU's Wetland Research program, graduate students from FAMU's Environmental Sciences Institute, and faculty from Delaware State and Jackson State.

At Delaware State, we have held modeling and GIS workshops, and will have a flow cytometry seminar/workshop this semester in conjunction with DSU researchers from the EPP Living Resources Center led by UMES. Research team faculty and students are also participating in the training sessions associated with the ECSC remote sensing flyovers.

At Jackson State, a two-day workshop was held on the applications of remote sensing to environmental studies, convened at the Trent Lott Geospatial Laboratory and Visualization Center. A similar workshop was organized by JSU on the use and applications of GIS in environmental assessments. These two workshops attracted a significant number of ECSC faculty and students for training on these techniques and applications.

At SCSU, students and faculty have been trained by the SCDNR-NERR partners in YSI data logger deployment, handling, and data mining. These students and faculty have in fact deployed two data loggers for water quality studies in the ACE Basin NERR. Additional training on the quality assurance/quality control of the data has been scheduled for November 2003. Also, a training workshop has been planned for the faculty and students by the NOS in Charleston on the use of ENVI software for the analyses of hyperspectral images.

**Task I.2.f — NOAA scientists on student committees**

The emphasis in ECSC during the first two years has been on developing collaborations with NERR scientists, including their participation on student committees. At Delaware State, Dr. Scarborough (research coordinator at DNERR) has been cleared by DSU's Graduate College for adjunct faculty status, and will serve on thesis committees for all of our NOAA graduate students. Similarly, Dr. Mark Woodrey (GBNERR research coordinator) and Dr. Lee Edmiston (ANERR research coordinator) are in the process of being approved for graduate faculty status at FAMU and will serve on several FAMU student thesis and dissertation committees. We have also begun to recruit NOAA scientists to student committees. Holly Brown, Ph.D. candidate at FAMU, has NOAA Charleston marine lab scientist Steve Morton on her committee. Dr. Ashok Deshpeande from NOAA serves on another FAMU doctoral candidate's, Shayla Williams, committee, co-advised by Dr. Elijah Johnson. At SCSU, one of Dr. Anoruo's summer research undergraduate students, Arena Richardson, worked with Dr. Alan Lewitus, who is a SCDNR employee seconded to NOAA and works out of the NOAA Hollings Marine Lab in Charleston. Ms. Richardson worked on testing the selective effects of nutrients and metals on the harmful alga, *Heterosigma akashiwo*. Dr. Lewitus also mentored Ethel Vereen, who worked on harmful algal blooms, and is now in graduate school at the University of Georgia studying environmental science (soil toxicology). Another ECSC undergraduate student worked with NOAA on a summer internship on the marine endangered species catalog; Dr. Zimmerman of the NOAA Endangered Species Lab in Galveston, TX, was her mentor. All three of these SCSU students' projects with NOAA scientists were a part of their undergraduate student theses.

ECSC will redouble efforts to add more NOAA scientists to student committees as one important component of the ongoing activities to develop specific research collaborations with NOAA labs and centers.

**Task I.2.g — Transition of undergraduates to graduate programs**

The various member institutions in ECSC have differing roles in education of students in the NOAA-related sciences. For example, FAMU, Jackson State, Morgan State, and the University of Miami Rosenstiel School have B.S., M.S., and Ph.D. degree programs in the environmental sciences, whereas the emphasis at South Carolina State and Delaware State is on undergraduate education. One successful transition from undergraduate to graduate training has involved three South Carolina State University environmental sciences students who completed their B.S. degrees under guidance of Dr. Anoruo. These students applied and were accepted into FAMU's environmental sciences program and currently are well along in their second year of graduate work under guidance of Dr. Harwell. Another set of SCSU students is expected to graduate Spring 2004 and is expected to apply for graduate study at FAMU in Fall 2004. In addition, other minority undergraduate students who have been a part of the NOAA EPP program, though not necessarily at an ECSC partner university, have been identified as potential candidates to enter the ECSC graduate studies at the Rosenstiel School at UM. However, contrary to the language in the ECSC proposal, the applicants from ECSC undergraduate programs to ECSC graduate programs have not been given "preferred admissions", as no such treatment has been necessary. Rather, the student applicants have been accepted into graduate programs at FAMU, UM, and elsewhere under the standard admissions requirements; the enhancement has been through availability of graduate research support through the Center and the personal contacts among faculty across the member institutions. This ECSC component has been successful through much greater awareness of potential graduate students of the ECSC graduate programs and through active involvement of undergraduates in research.

Another aspect of the success of this task to date has been the continued mentoring of the new graduate students by their previous major professor at the undergraduate institution. For example, Dr. Anoruo has been a very positive influence in the graduate program of his former undergraduate students, providing advice and encouragement that have made a significant contribution to the success of these students thus far in their graduate programs at FAMU. Clearly, as the ECSC continues to become even more integrated over time, additional opportunities for cross-institution contributions to the success of developing minority scientists will arise and will be encouraged. As one important example, one FAMU graduate student (Latrincy Whitehurst) was invited to participate in extensive field research activities by Dr. Schalles at Creighton University, resulting in a significant enhancement of her graduate research program, and it is anticipated that Dr. Schalles will become a member of the student's M.S. committee.

**Task I.2.h — NOAA employment for ECSC graduates**

Because ECSC has just completed its first two years, the students supported by the Center are still in the midst of their graduate programs. At FAMU, we expect to graduate the first

Ph.D. students in the next one or two years. At Delaware State, the first undergraduates will complete their degrees and begin seeking employment opportunities or graduate programs at the end of this academic year at the earliest. At University of Miami RSMAS, the J.D./M.A. student has another year to completion, and the Ph.D. student is just beginning her research. Several FAMU graduate students are participating in the EPP Graduate Fellowship program, which leads directly to NOAA employment and service commitments to repay the NOAA investment in their graduate education. We are confident that as ECSC begins to graduate more graduate and undergraduate students, there will be significant number of NOAA positions filled by ECSC students.

***Summary for Goal I Tasks*** — Almost all of the Goal I tasks have been accomplished of exceeded, including: recruitment of a large number of graduate and undergraduate in the environmental sciences into ECSC universities; extensive modifications of the curricula and development of new courses at the partner universities; initial exchanges of students and faculty among partner universities; significant professional development of faculty at both junior and senior levels in the partner universities; initial recruitment of NERR and NOAA scientists to serve on graduate student committees; and transition of ECSC undergraduates into graduate programs in the environmental sciences at partner universities. The distance learning task is still in the developmental stage, as we work to establish the institutional capabilities for distance learning.

**B.3. Goal II Research and Model Development — Develop methods, including conceptual models, to assess the response of coastal ecosystems and communities to perturbations and develop measurement programs to monitor critical system attributes.**

The specific elements of Goal II in Year 1 were to: begin data mining, including remote sensing data for each site (accomplished and continuing); implement field monitoring and data gathering (accomplished and continuing); compare data among sites (accomplished and continuing); begin economic analysis and research on socioeconomics of the community (accomplished and continuing); convene panel of experts to develop input for conceptual models (accomplished at all partner NERR sites); begin review of quantitative models (accomplished and continuing).

For Year 2 all of these tasks continued (except convene panel of experts), with the following additional tasks: initiate remote sensing using low-altitude flyovers (accomplished and continuing); begin formalization of conceptual system (accomplished and continuing); and develop and submit research proposals to extend Center activities beyond three years (accomplished and continuing). Each of these Goal II tasks are discussed in more detail below.

A summary of all ECSC research activities has been submitted to NOAA EPP, listing a total of more than 30 faculty and more than 60 students working on a total of more than 90 specific research projects. Each project is not discussed in the present report, but the summary is included here as Table 3, and selected research projects are discussed in various sections under Goals II and III.

**Task II.2.a — Data mining for each site**

The FAMU GIS facility, under direction of Dr. Katherine Milla, has the lead in data mining for spatially explicit data for the ANERR and other sites. To date, existing GIS and remote sensing data have been collected for Apalachicola Bay and Grand Bay. These include transportation, hydrography, digital raster graphics, digital elevation models, color infrared and black and white digital ortho-quarter quadrangles, and other physical and ecological attributes. As an example on the socioeconomic side, economic data inventory has been performed on the Apalachicola NERR site by FAMU's Dr. Michael Thomas, to be incorporated into Dr. Milla's data system.

A similar data gathering effort had already been done for ACE Basin NERR and the Delaware NERR as a part of their site characterizations. For example, at SCSU, data mining has been done for the following: a) Edisto-Ashepoo water quality data; b) mercury accumulation and effects in benthic invertebrates in the ACE basin; c) population genetics of ACE basin native species: phylogenic relationships and geographical variation; d) effects of heavy metals on antibiotic resistance in benthic marine bacteria; e) comparative effects of nitrate and phosphate additions on ACE Basin phytoplankton cultures; and f) ACE Basin suspended components analysis. The spatially explicit data layers will be

consolidated in future activities into a centralized GIS database that FAMU is working to implement on the ECSC website.

Many relevant environmental, resource, and environmental economic publications, reports, and data sets have been collected from both state and federal sources. Many other data gathering activities are underway in ECSC, integrated into the extensive set of research activities discussed elsewhere. These data are being assembled into data layers for the GIS coverages of each site, and will be expanded to cover all partner NERRs.

**Task II.2.b — Field monitoring and data gathering**

As mentioned previously, ECSC has more than 90 individual research projects underway, many involving field monitoring and data gathering in the field, laboratory, and modeling contexts. Each of these projects cannot be described here, but some highlights are included, in addition to what has been discussed elsewhere:

FAMU and Creighton have been responsible for overseeing all of the ground-truthing efforts associated with the ECSC's remote sensing flyovers of the Apalachicola NERR, the ACE Basin NERR, and the Grand Bay NERR, under leadership of Drs John Schalles, Mark Harwell, Jennifer Cherrier, and ECSC Post-doctoral research associate, Dr. Kevin Dillon. In collaboration with the co-PIs, we have identified the suite of parameters that would be monitored at each of the NERR sites during the ground-truthing efforts. Dr. Dillon has had particular responsibility for organizing and coordinating the research field sampling trips with students to collect ground-truthing data for each ECSC flyover missions. Thus far, flyovers and field sampling has been conducted in Apalachicola Bay, FL (October 2002) and ACE Basin, SC (June 2003)(discussed below). Dr. Dillon has also been analyzing samples collected from these sampling trips, and has trained and supervised a number of ECSC students in these chemical and biological analysis. FAMU and Creighton University ECSC graduate students assisted in collecting the ground-truthing samples collected at each site, with assistance by undergraduate and graduate students from the partner institution affiliated with the NERR. The ground-truth samples from the various NERR sites are being processed in ESI's Aquatic Sciences Laboratory, which supervised by Dr. Cherrier, at Creighton University, under supervision of Dr. Schalles, and at the Savannah River Ecology Laboratory, under supervision of Dr. Chuck Jagoe.

Dr. Dillon has also been acting as the research liaison between the ECSC graduate students and the ANERR staff to schedule and assist with student research projects associated with the ECSC grant within the ANERR boundary (some student projects are discussed in another section). He is also planning and preparing to conduct preliminary research to investigate carbon and nitrogen dynamics that occur as water flows through the vast freshwater marshes in the northern region of Apalachicola Bay. This is a research area included in the ECSC conceptual model of Apalachicola Bay of which little is known.

In addition to the ground-truthing data, we have also collected: 1) field verification data on vegetation cover in St. Marks Wildlife Refuge, including marsh and terrestrial vegetation; 2) field verification data in Grand Bay for marsh vegetation and invasive plants, including

Chinese Tallow and cogon grass; and 3) field verification data on the Mississippi Sandhill Crane Refuge for different land management areas involving fire regime studies. These data include GPS locations of different vegetation types and a growing collection of spectral signatures for different vegetation types. These data will be used in image classification to study the dynamics of marsh salt barrens, characterize the extent of invasive species distribution, and analyze the effects of different land management practices in the Sandhill Crane Refuge.

South Carolina State University has developed and initiated research programs to measure and monitor the ecology of potentially harmful algae in a brackish subdivision pond, and water quality. These research programs involved undergraduate students. Coastal pollution resulting in poor water quality or blooms of potentially harmful algae has potential detrimental effects on coastal systems.

At JSU, faculty and students began field studies in GBNERR, establishing permanent sampling station sites in Bayou Heron and Bayou Cumbest. At each site, we have conducted plankton tows, collected water quality samples, and collected sediment samples for metals analyses. In addition, JSU scientists have collected macrobenthic invertebrate samples, and measured physicochemical parameters. Sampling has begun on a quarterly basis, and collected samples are being processed for analysis.

JSU has also initiated a project assessing the dynamics of fecal coliform bacteria in GBNERR. In collaboration with Mississippi Department of Marine Resources and GBNERR, we are examining the spatial and temporal patterns in fecal coliform levels in GBNERR in relation to salinity and tidal conditions. Information from this study will be useful for managing shellfish in the area. Areas within GBNERR being studies include Bayous Cumbest and Heron, Bangs Lake, Middle Bay, and Point aux Chennes Bay. The analysis of the baseline data indicates a decreasing trend in temperature and increasing trend in salinity from Bayou Cumbest to Point aux Chennes Bay. No differences were seen among sites in Bayou Heron or Bangs Lake. But tidal condition significantly influenced the fecal coliform levels in GBNERR, with significantly higher coliform counts during low tides compared with high tides. Moreover, coliform levels were found to be higher in fall and winter, which may be related to seasonal differences in precipitation. These factors are important in designing fecal coliform monitoring programs in GBNERR. Analyses of the data are continuing in order to evaluate the influence of interannual variations in climatic factors on fecal coliform levels in the sampling areas.

At Morgan State, Dr. Kimbrough's primary responsibilities for ECSC have focused on creating GIS models to address present and historical social, demographic, and geographic CBNERR-related watershed changes. This GIS-based research focuses on the NOAA goals of predicting the response of coastal ecosystems to development, in addition to developing measurement programs to monitor critical system attributes. The overall aim is to use historical information to characterize changes in the watersheds associated with the NERR sites. By characterizing the past changes and their effect, we intend to establish relationships (models) that can be used to predict future trends and effects of land use change in NERR sites. In addition to the models, the GIS portion of this research will be

used to georeference various site parameters including water quality, vegetation, watershed demographics, land use, and organism distribution.

**Task II.2.c — Compare data among sites**

One of the outcomes of the five conceptual model development workshops is the recognition of societal drivers, environmental stressors, habitat types, and valued ecosystem components (VECs) across the NERR sites. The remote sensing activities have been very instrumental in identifying and facilitating cross-system studies. In general, cross-system studies will become an increasingly important theme of ECSC research and educational activities. Moreover, increasingly ECSC faculty and student research projects are involving more than a single NERR site; examples include the sea turtle study in ANERR and GTMNERR, the osprey bioindicator study in GBNERR and ANERR, and the spectral characterization in ANERR< GBNERR, and ACE Basin.

A central component of the cross-site comparisons is the ECSC remote sensing activities (discussed elsewhere). Remote sensing attributes being compared across NERRs sites include: water column chlorophyll, water column total suspended solids, marsh vegetation – community composition and abundance, submerged aquatic vegetation (if present, community composition and distribution), and distributions of invasive plant species. Ancillary water quality data include a consistent set of nutrient, carbon fraction, and other chemical parameters. Also, aerial AISA imagery from three sites (ACE, Grand Bay, and Delaware Bay) is being used in a NOAA/NERR assessment of the best remote sensing technologies to use for emergent salt marsh and submerged vegetation across all NERR Sites. Work is in progress, and technical workshops are planned at intervals, to assess the status of these cross-site data analyses and to provide training and other assistance to help the partner schools and reserve sites utilize the data. Similarly, the cross-site comparison task will be substantially advanced by the development of the ECSC web site with data sharing (discussed elsewhere). Until this is fully established, more traditional means of data sharing are being used; for example, the water quality data from the flyovers at ANERR, ACE, and GBNERR are being placed in a single, EXCEL file database and will be used for several student thesis (for example, Latrincy Whitehurst at FAMU, Christine Hladik at Creighton). Similarly, the AISA imagery outputs are being provided by CALMIT on DVDs and CDs for distribution to the partner universities and NERR sites. As another example of the ESC cross-site comparison activities, Drs. Schalles (CU) and Milla (FAMU) are working to ensure that all ECSC groups have installations of the ENVI software package in order to view and analyze the CALMIT AISA imagery.

Faculty from the FAMU Wetlands Research program and the FAMU Remote Sensing Laboratory are conducting ongoing analysis of salt barren features and surrounding vegetation in the marsh at several of the NERR sites. Salt pannes or barrens are hypersaline patches devoid of vegetation that form on the landward side of the marsh. Preliminary evidence suggests that these features migrate in response to changes in sea level. Salt barren locations have been delineated in the Grand Bay NERR, the ACE Basin NERR, and in the St. Marks National Wildlife Refuge near the Apalachicola Bay NERR. These sites were flown in the respective remote sensing flyovers to collect hyperspectral

data (discussed below), and the data will be compared against any available historical imagery to determine if digital image analysis techniques can reveal observable changes in position. It is intended that delineations of current positions will be used as a baseline for future sea level studies.

**Task II.2.d — Socioeconomics analyses**

Since the beginning of ECSC, two new co-PIs who are economists have joined the ECSC leadership team: Dr. Tony Wilbon at Morgan State University, who replaced Dr. Livingston Marshall as lead PI, and Dr. David Letson at the University of Miami Rosenstiel School, replacing Dr. Mark Harwell as lead PI there. In addition, ECSC has other economists, including Drs. Michael Thomas (FAMU), Dr. E.R. Osman (SCSU), and Dr. George Parsons (University of Delaware and part of the DSU team). With the influx of significant strength in economics, this research task has been emphasized, and continuing expansion of economics research is underway.

Throughout the development of conceptual models, Drs. Thomas and Letson have shown that economics should play a significant role in model design. This they explain in the second article of the forthcoming special issue of *Urban Ecosystems*, in a societal component of the paper entitled "Understanding Coupled Human-Environment Systems: Use of Conceptual Models for Environmental Decision-Making". Economics is described has providing a means of measuring the contribution of valued ecological components to humans (a monetary metric) and providing a framework to categorize the types of potential human impacts or drivers and their resulting activities on the environment (a social indicator). This theme is one of increasing important to the ECSC research and graduate education activities.

Some components of ongoing socioeconomics research in ECSC include the following:

**Morgan State University — Environmental Economics and Decision Support Systems in Environmental Management.** Dr. Wilbon is working to evaluate models related to decision-support systems in environmental management. He has assigned a doctoral student to research several computer models that will have the ability to integrate GIS, economic data, and simulation capabilities. Data from the recently completed MD CBNERR conceptual modeling workshop will be used to develop a custom decision-support system or purchase an existing package. The MSU ECSC purchased a decision-support software known as Smartplaces that will be used to develop the initial model. This package also has an ArcView extension that allows for an interface for GIS maps and provides opportunities to evaluate land use scenarios and project economic changes. Faculty and students are currently becoming familiar with the software, and initial conceptual design of a representative model for the Chesapeake Bay environment has begun on this project. Dr. Wilbon has also been communicating with Discovery Software in the United Kingdom regarding purchase of a software package called SimCoast. A new version of the software is scheduled for completion in January 2004. SimCoast is a fuzzy-logic rule-based expert system that will allow us to use our conceptual model to create and

evaluate different policy scenarios for coastal zone management and decision making. It has been used successfully in other coastal management projects around the world.

**Morgan State University — Understanding the Relationships between Landscape Change, Estuarine Habitats, and Community Sustainable Development in Harford County, MD**: Professor Yasmin Fozard and Dr. Kimani Kimbrough are conducting this research project, which includes the following elements:

*Photographic Environmental Mapping of the Visual Quality of the Coastal Zone landscape*
This research focuses on issues related to the visual environment of the NERR in Harford County, Maryland. Professor Fozard spent a major part of the summer photographically documenting various parts of Harford County. It appears that the coastal zone environment in Harford County has paid little attention to the perceptions of the physical environment. The environmental planners have virtually ignored the importance of the visual image of the community. One reason the visual quality of the coastal landscape is not a priority is because perceiving and interpreting the physical environment is a complex process involving the interaction of human physiology, development, experience, and cultural sets and values. In making sense of the visual world of Harford County, we relied on a number of physical characteristics which define objects and their relationships in three-dimensional space. Various strategies were used this summer to explore and expand our visual information database, including, but not limited to, photomapping, notation, and CADD methods used for expanding our comprehension of two local communities in the NERR's everyday visual environment.

Professor Fozard is also using the cognitive paradigm in the evaluation of this coastal landscape. The key concept of this paradigm is that the landscape has value for people because of the intellectual or social associations that they make with various settings. Rather than reacting passively to environmental stimuli, people select those aspects for which they have built up constructs, on the basis of visual experience. We then focus more on why landscapes are valued, rather than what is valued. Before preparation of any formal visual documentation, an initial visual reconnaissance will be conducted of the entire area to provide an overview of visual conditions and to collect and document information needed to evaluate visual quality including both positive and negative characteristics. Students were introduced to the concept of visual character through a group discussion and activities.

A scenic coastal landscapes model will be created to determine coastal landscapes within the Chesapeake Bay, Maryland watershed. The model will investigate levels of scenic quality and management priority. The intention of this model is to:

- formulate a sound and repeatable methodology for compiling a continuous scenic recourse inventory for the entire Chesapeake Bay Watershed, including an appropriate set of criteria for assessing scenic quality;

- assess the relative values of such resources; and

- develop recommendations regarding the relative urgency of conservation measures of scenic landscape values for particular locations.

The Harford County Joppatowne / Otter Point Creek will be divided into individual coastal landscapes and classified into one of the following coastal landscape character type: urban center; linear coastal strip; low intensity coastal plain; extensive coastal plain; coastal valley; critical bay areas; steep coastal range; and major peninsula land uses. These character types are subject to change. Dr. Kimbrough collected data from various sources for the Harford County Joppatowne / Otter Point Creek Planning District. The data collected will be used to create a visual impact assessment using the Geography Information System (GIS) model for Harford County Joppatowne / Otter Point Creek. The type of collected data will be used to create spatial objects. The spatial objects stored in the database management system will first be classified according to their significance in the Scenic Coastal Landscape. The categorical system for the features will be listed as below:

| **Categorical** | **Contents** |
|---|---|
| Natural Landscape Resources | Natural parks, community gardens, Recreation facilities, and Marinas |
| Humanities Landscapes Resources | Scenic spots |
| Public utilities | Public Office, Schools, Hospitals, Public Halls, Harbors |
| Resident Areas | Residential quarters, Apartment houses |
| Public Transportation | Main local road, National roads, Railroad tracks |
| Planning project | Draft of the constructions design, reshaped terrain |
| Critical Bay Areas | Protected areas along the waters edge |

The database for the Scenic Coastal Landscapes Model is still in development at this time.

**University of Miami Economics Analyses — Diving Survey, Florida Keys National Marine Sanctuary**

An on-going MARFIN-sponsored research effort led by Dr. David Letson in the Lower Florida Keys will help determine if there are dive-site environmental attributes that influence the choices of divers. Dr. Michael Thomas of FAMU is also participating in this study. By comparing diver preferences for sites both outside and within FKNMS marine reserves, we hope to document any contributions that the reserves make to recreational diving. Presently, divers are being interviewed as they return from their diving trip and asked a series of questions about themselves, their diving experience, and their opinion

about resource features they would find desirable at diving sites. Additionally, a stated preference format is being used to elicit a diver's willingness-to-pay for site specific environmental quality.

This survey is also designed to consider the other approach to valuation: revealed preference. By employing a random utility framework and conducting logit analysis, it will be possible to use these data to design and validate a travel cost model and estimate the compensating variation (willingness-to-accept monetary compensation) for hypothetically lost or restricted dive sites. This can be accomplished by first estimating the model with a full complement of sites, then repeat the process with selectively "removed sites" that have high levels of environmental quality.

Collecting both willingness-to-pay and willingness-to-accept estimates will permit their comparison and potentially address some interesting theoretical questions concerning their equivalence. This process, should it prove successful, may be replicated with guided sport fishing in the Apalachicola NERR site.

Another potential economics study following the FKNMS study that is presently being developed is an Apalachicola NERR Site Guided Sport Fishing Survey. Depending upon the level of success achieved with the current diver survey in the Florida Keys National Marine Sanctuary, it may be possible to conduct a similar study of the guided sport fishing industry in the Apalachicola Bay.

**Florida A&M University — Environmental Valuation**

A review of the literature on the use of contingent valuation (CV) within the field of environmental and natural resource economics reveals a degree of controversy in its application. In the early 1990s a NOAA-sponsored "blue ribbon" panel discussed the methodology in extensive detail and suggested that great care must be taken in both the design and administration of a CV survey to avoid potentially biased responses. It has been determined that willingness-to-pay (WTP) estimates are likely shaped by the construction of the survey instrument, making the format of hypothetical payment, or payment vehicle, particularly important.

In research led by Dr. Michael Thomas, we consider one part of the design controversy, the potential choice in payment vehicle; more specifically the organizational basis (i.e., payment to a private interest vs. payment to a public interest). Whether people must pay a governmental agency or private organization may significantly influence the final size and variation of their monetary response. This distinction is more relevant with the increasing devolution of government agencies into quasi-private entities. The survey we developed is designed to document this influence.

To make this comparison, a CV survey was conducted Dec 2002 through Feb 2003 to determine WTP to avoid nitrates in well water. The survey was mailed to approximately 1,000 randomly selected households across Franklin County, Florida (site of the Apalachicola NERR site). The sample was equally divided into private and public

payment vehicles and prices assigned randomly to each respondent to avoid starting point bias. After the data are coded and keyed into a database, the results will be fitted to a double-bounded, dichotomous-choice model to estimate the WTP figure and the payment vehicle hypothesis will be tested. Based on a history of rather poor relations between several state agencies and a noteworthy portion of the Franklin County population (e.g., state-wide net ban and a highly regulated shellfish industry), we expect there to be a significant difference in WTP estimates between the two types of payment vehicles. While the results will be directly applicable to the Apalachicola NERR site, a better understanding of the importance of organizational basis and payment vehicle will likely help all future practitioners of CV.

Dr. Thomas is also expanding his research program into the area of stated preference models by funding the development of a state-of-the-art contingent valuation survey and the collection of primary data. Additionally, the funding of studies into the tourism market of Franklin County may provide important capacity expansion for environmental economics. These efforts will likely open the door for further cooperation with the community and business leaders surrounding the Apalachicola NERR site, paving the way for future private-public efforts to better link the economic drivers to the environmental outcomes.

Finally, FAMU co-PI Carol Forthman is an environmental lawyer whose research is aimed at developing methods to characterize the needs of the affected human communities, and to evaluate those needs in light of coastal management considerations. As an initial phase, she has begun identifying and interviewing members of the community representative of various stakeholder segments of the community. From those interviews, she will identify issues of interest and to develop a survey that will provide more statistically based data. Once the Apalachicola methods have been developed, these methods will be applied for other ECSC NERR sites to develop a similar characterization.

**Task II.2.e — Quantitative models**

One of the most intensive efforts to develop quantitative simulation models of the coastal ecosystems is focused on the Apalachicola Bay NERR system. Using ECSC funding, Dr. Elijah Johnson has developed a Tabular User Interface for the Princeton Ocean Model, one of the standard hydrodynamic models widely used by NOAA and other oceanographic scientists. He has begun to calibrate the POM to the ECSC NERR systems, including acquiring bathymetric data for ANERR, ACE Basin NERR, and the Grand Bay NERR. In addition, the flow data and river characteristics for the Apalachicola River have been acquired in preparation for calibration of the MODBRNCH model, which will be used to study the water flows in the Apalachicola River and the associated surficial aquifer. This also has involved acquisition of the surficial aquifer characteristics data in the vicinity of the Apalachicola River. The next step will be to fully calibrate MODBRNCH to the Apalachicola River and to begin to apply it to the ACE Basin rivers. Similarly, working with Dr. Wenrui Huang of the FAMU-FSU School of Engineering, he will complete the application of the Princeton Ocean Model to Apalachicola Bay and begin to calibrate it to the Saint Helena Bay (ACE Basin).

In addition, Drs. Mark Harwell, Elijah Johnson, Katherine Milla, Wenrui Huang, and Ping Hseih at FAMU have secured a new US EPA STAR grant to develop computer simulation models of the Apalachicola Bay system. This is discussed further below, but essentially is developing coupled physical-biological models of the ANERR system, involving 3-D hydrodynamics model of the Bay, expansion of the MODBRNCH model of the River, and newly developed oyster and marsh ecosystem models, coupled in a spatially explicit framework through a GIS core. These models will be developed using data collected through the ECSC NOAA funding, as well as extensive data gathering efforts underway by Dr. Milla (discussed elsewhere).

At DSU, efforts are underway to convert the advanced societal conceptual model into a quantitative model. Dr. Parsons is beginning research on resource valuation methods as part of our efforts to quantify the DNERR conceptual model. The initial focus of this work in on valuing VECs and open spaces in the DNERR area. The plan is to integrate this type of economic analysis into the ECSC efforts to quantify the four-component coupled societal-ecological model, in particular to link it to Max Saintil's (a new M.S. student) attempts to apply basic sensitivity analysis to the initial components of the model.

**Task II.2.f — Remote sensing flyovers**

The remote sensing flyovers at the NERR sites have expanded considerably since the initial concept for the Center, and now constitute a central effort across all sites and partner universities, assisting, along with the conceptual model development, in focusing field monitoring, laboratory, and modeling studies by faculty and students in ECSC. No remote sensing was done in Year 1, but two major flyovers were accomplished in Year 2, the Apalachicola NERR flyover in October 2002 and the ACE Basin flyover in June 2003. In addition, in Year 2 we initiated the planning for the next flyover, scheduled for early October 2003 at the Grand Bay NERR site.

There has been a number of detailed planning meetings and workshops held in support of the remote sensing flyover task to: 1) explain to the ECSC scientists and students the capabilities of the remote sensing hyperspectral equipment available on the NSF-funded CALMIT aircraft at the University of Nebraska-Lincoln; b) specify the particular conditions required for taking the hyperspectral imagery (discussed below); c) identify the specific research topics for the remote sensing flyovers at each NERR site (discussed below); d) specify the ground-truthing activities needed for each site and each remote sensing research task; e) address all the logistical issues for implementing the flyover at each site; and f) develop training sessions on ENVI and other post-flyover data analysis activities.

*CALMIT hyperspectral capabilities and flight constraints*

The University of Nebraska Center for Land Management Information Technologies (CALMIT), a partner to ECSC, has an NSF-funded remote sensing aircraft, a single-engine Piper Saratoga, which is available for ECSC use at the NERR flyovers. Onboard is the AISA hyperspectral imaging system (a Pushbroom imaging spectrometer build by Specim

Ltd., Oulu, Finland), which can acquire data at spatial resolutions of 1.5 m per pixel or 3.0 m per pixel, depending on the flight altitude (5000 ft and 10,000 ft, respectively). Data are collected at selected 5 nm-wide spectral bands over the spectral range of 400-900 nm. Each line of imagery has a $20^{o}$ field of vision, which is 360 pixels wide (i.e., about 500 m or 1000 m at the resolutions flown for ECSC), and an overlap of about 30% is used for targets requiring multiple flightlines, run as a racetrack pattern. AISA is programmable from 1 to 288 spectral channels (multispectral or hyperspectral). However, because of the immense amount of data acquired (360 pixels every 1.5 or 3.0 meters for flight paths up to 10 km long) effectively 22 bands were acquired for the 1.5 m resolution data, and 30 spectral bands at the 3.0 m resolution, thus providing an enormous wealth of reflectance information along the flightlines. AISA also captures downwelling irradiance data for calibration. Overall AISA calibration has been done both by the vendor and at a second calibration done in cooperation with the NASA John C Stennis Space Center facility in Mississippi (March 2002). CALMIT has done extensive research over several years on selecting the specific spectral bands that are appropriate for different target systems (e.g., estuaries, riverine, and upland systems) and for specific analytical purposes (e.g., detecting chlorophyll concentration, total suspended solids, or vegetation composition).

Because of sun glint over wet targets (e.g., estuaries, wetlands, rivers), the aircraft is limited to flying essentially a NW-SE flight direction in the morning and NE-SW direction in the afternoon. In addition, mid-day flights are not ideal, nor are very early or late times during daylight. Once the aircraft begins a specific flightline, which may extend over 10 km or more, there may not be any cloud shadows crossing the flight path; consequently, relatively clear skies are necessary for successful data acquisition. Another constraint is the time for the aircraft to change altitudes, resulting in grouping of flightlines in a morning or afternoon session to be flown at the same resolution if possible.

The Saratoga is outfitted with differential GPS and an inertial navigation system, allowing highly precise information on the location of the target area. The AISA system makes all of the necessary adjustments for georectification of the images (e.g., correcting for the aircraft pitch, roll, and yaw, and recording the specific lat/long information for each point along the flight path). Thus, the post-processed data provided by CALMIT to the ECSC researchers have already had extensive computer processing done. The CALMIT-provided data files are ready for analysis in various hyperspectral analysis software; ECSC has selected the ENVI software package as most useful for out needs, and ECSC has negotiated a series of advantageous licensing agreements for use of that software. Moreover, ECSC has made the ENVI software available to the partner institutions involved in the analyses; for example, ECSC purchased a high-end laptop computer and installed ENVI on it, now physically loaned to the ANERR scientists so they can conduct remote sensing analyses on their own, following ECSC-provided training of ANERR scientists on ENVI usage.

***ANERR Remote Sensing Flyover***

At the beginning of October 2002, the ECSC conducted an extensive remote sensing flyover of the Apalachicola Bay NERR site using the aircraft and hyperspectral imaging equipment from the University of Nebraska CALMIT center. The airplane, three boats,

and about 40 people worked most of a week to conduct the flyover and associated ground-truthing activities. A series of specific tasks was identified for the flyover, as described below.

The events did not quite unfold as planned because of a major storm system that developed on top of the Bay at the beginning of the week. Nevertheless, the field teams continued to collect their samples and hyperspectral data all week, and the weather fortunately cleared on the final day so that the Nebraska airplane was able to fly all of the planned flight lines. Water quality samples were taken at a number of sites in the Apalachicola Bay and River systems, to analyze for Chl a, total suspended solids, nutrients, DO, and other physical parameters. In addition, two boats deployed a hyperspectral radiometer that was used to characterize the spectral reflectance just above the water at the sample locations. A towed array, provided by Dr. Robert Chen of the University of Massachusetts-Boston, was deployed on one boat to collect measurements on colored dissolved organic matter (CDOM). A third boat was used to take scientist and student observers from ECSC, as well as two colleagues from the Union of South Africa who collaborate with FAMU. On the CALMIT aircraft was deployed the AISA hyperspectral imaging system, discussed previously. The AISA instrument was flown over about 20 flight paths, collecting data over marsh, river, bay, and coastal areas. The ANERR AISA data have now been processed by CALMIT and were delivered to FAMU and ANERR scientists in late winter 2002 for detailed analysis. Initial results are extremely promising.

*ANERR Flyover Research Elements*
Each flyover has been designed around a specific set of research questions and hypotheses. For the ANERR flyover, these involved the following:

**1) Water column characterization** — The focus is on chlorophyll a, TSS, detrital particles, detrital particles, colored dissolved organic matter (CDOM), and other spectral characteristics in water column in St. Joseph's and Apalachicola Bay and Apalachicola River mouth. A comparison between deeper portions (where benthic features are not part of the signal) of Apalachicola Bay and St. Joseph Bay will extend the contrast and ability to construct and parameterize robust algorithms for prediction of algal chlorophyll and total suspended matter (seston) in estuarine waters of the Gulf Coast. Prediction of water path transparencies should also be possible. Ground-truthing involves extensive collection of water quality samples for laboratory analyses, as well as deployment of on-boat spectroradiometers to collect reflectance and downwelling spectral data at each water quality sampling site.

**2) Distribution of seagrass habitats** — The focus is on St. Joseph's Bay and Apalachicola Bay. Seagrass beds are more extensive in the less turbid water conditions of St. Joseph Bay, and occur only in limited areas in Apalachicola Bay; however, the recent 4-year drought has reduced turbid water discharges into Apalachicola Bay, and ANERR staff have noted that seagrass cover seems to be expanding in the peripheral shoreline areas of the Bay. The ability to detect seagrass cover remotely and possibly characterize attributes of these communities in the two bays with different water column transparencies is the research goal. Ground-truthing involves identifying sites that appear to have

seagrass and collecting bottom samples to confirm seagrass is present, with careful GPS of the site coordinates.

**3) Distribution of oyster bars** — Here the focus is on Apalachicola Bay; mid-October is a typically period when the water column has the greatest transparency (although in actuality, we had a tropical storm and high turbidity). The ability to detect at least the shallower beds is of considerable interest to ANERR staff and others. Ground-truthing involves identifying sites that appear to have oysters and confirming their presence, with careful GPS of the site coordinates.

**4) Distribution of emergent plant species, including invasives** — Marsh vegetation species compositions and abundances vary across gradients of salinity and other controlling variables. The ability to detect and quantitatively assess key wetland marsh vegetation is a first, basic approach that can be addressed with flight transects and good ground survey data. The focus is on Apalachicola Bay and Apalachicola River mouth; species of concern include *Spartina* (cordgrass), *Juncus* (black needlerush), *Cladium* (sawgrass), *Typha* (cattail), and *Phragmites* (giant reed grass). Ground-truthing involves identifying sites with different species present, with careful GPS of the site coordinates. In some locations (e.g., adjacent to a pure stand of Phragmites), ground tarps are placed so that the specific pixels associated with the species can be identified and ENVI algorithms used to characterize the spectral characteristics based on all 22 bands of data.

**5) Distribution of salt pannes** — The soil organic matter content and aerial distribution of salt pannes may be sensitive bioindicators of hydrologic changes and sea-level rise. These features are readily visible in aerial imagery, and hyperspectral data could provide capabilities to assess the condition and soil composition in these areas. Because of a long-time research activities by FAMU wetlands ecologist, Dr. Ping Hseih, the focus is on the mouth of the St. Mark's River, east of Apalachicola. Ground-truthing involves sampling the soil and vegetation at specific salt panne sites, with careful GPS of the site coordinates.

**6) Habitat mosaic** — Habitat alteration is one of the major stressors identified as affecting ANERR. The distribution of human development on coast, barrier island (especially St. George Island), riparian, marsh habitats will be assessed in this task.

These tasks were planned for the following sessions:

**Session 1 — St. Joseph's Bay** — Objectives to assess the water column spectral characteristics (Subproject 1); distribution of seagrasses (Subproject 2). This session focuses on approximately 5 locations within the Bay, including deeper water location. The ground-truthing will be done with a skiff and deployed multi-spectral unit from CALMIT. The session is not expected to map the entirety of seagrasses in the Bay, but specific areas need have been identified for focus. Altitude to be set for 3 m resolution.

**Sessions 2-3 — Apalachicola Bay** — Objective to assess the water column spectral characteristics (Subproject 1). Two boats will be deployed for ground-truthing, each with multi-spectral unit. The specific locations within the Bay to be sampled during the session

have been selected and identified on the chart for the field crew use. Altitude to be set for 3 m resolution.

**Session 4 — Apalachicola River mouth** — Objectives to assess the water column spectral characteristics (Subproject 1). Two boats will be deployed for ground-truthing, each with multi-spectral unit. Altitude to be set for 3 m resolution.

**Session 5 — Apalachicola Bay** — Objective to assess the distribution of seagrasses (Subproject 2); distribution of oyster beds (Subproject 3); distribution of marsh vegetation (Subprojects 4 and 6). The session is not expected to map the entirety of seagrasses or oysters in the Bay, but specific areas need to be identified for focus. Specific ground-truth locations have been identified in advance with GPS readings for known seagrass or oyster beds. Altitude to be set for 3 m resolution.

**Session 6 — Apalachicola Bay** — Objective to assess the distribution of the different species of marsh vegetation (Subproject 6). Specific ground-truth locations have been identified in advance with GPS readings for known beds of each emergent species. Altitude to be set for 1 m resolution.

**Session 7 — St. Mark's Bay** — Objective to assess the distribution of salt pannes (Subproject 5). Specific ground-truth locations have been identified in advance with GPS readings for known salt pannes. Altitude to be set for 1 m resolution.

**Session 8 —Apalachicola Bay, St. George Island**— Objective to assess the distribution of human development on coast, barrier island, riparian, marsh habitats (Subproject 6). Primary focus on development on St. George Island, with mainland shore second priority. Altitude to be set for 3 m resolution.

***ACE Basin remote sensing task***

The ACE Basin remote sensing flyover occurred in June 2002. The water quality ground-truthing was largely done by FAMU and SCSU students and scientists, but the salt marsh health ground-truthing was limited to students and post-docs form the University of South Carolina. The weather cooperated better for this flyover than at ANERR. The specific research foci were:

*ACE Basin Flyover Research Elements*

**1) Marsh Health** — This subproject focuses on the sub-watersheds of the six water quality sites monitored by ACE and/or South Carolina State University (SCSU). The focus is on differences associated with a) salinity gradients, and b) development gradients, with specific pairs of locations for each set of comparisons. Endpoints will include the marsh vegetation species and indicators of their health. Mosquito Creek and Big Bay Creek are areas of significant development. Other areas have significant changes in habitat or vegetation characteristics, perhaps associated with high salinity from the many years of drought.

**2) Marsh and Upland Vegetation Health on Morgan Island** — Morgan Island contains both maritime forest and marshes on a 2000 acre tract that also contains a feral monkey colony. This project is conducted by classic vegetation mapping using remote sensing, with the purpose of adding to the species-specific spectral library as we as characterize the health of the Morgan Island habitats in response to the population of monkeys. Close-range measures will be taken. Another similar island nearby but absent the monkey population is used as a control site.

**3) Marsh Vegetation Composition and Health Affected by Water Constrictions** — This project will focus on Edisto Island and Scott Creek areas, where restricted flow of water because of a culvert has led to changes in the habitats. Comparison of marsh tracts with impeded and unimpeded drainage conditions is the objective of this task. We look at species composition, biomass, and health indicators of marsh vegetation. Close-range measures will be taken as well, again adding to the spectral library.

**4) Water Quality Analyses** — This project is concerned with the river/estuary/bay transects and gradients and contrasts related to coastal development patterns and salinity. There will be close range spectroscopy and water analysis at this site, similar to what was done at the Apalachicola Bay flyover as a part of the cross-NERR objective of ECSC. Analyses will be done to determine the relationships among chlorophyll content, total particulates (seston), bound fractions of at least one ecotoxicological variable such as mercury, plus a suite of water variables consistent with the ECSC survey/water column work at Apalachicola NERR. It was agreed to do a comparison of the Edisto River, which has a long and extensive watershed, with the Ashepoo River, which is much shorter and smaller watershed. Flyover pathways and ground-truthing sampling stations are coordinated with the YSI monitoring station locations managed by ACE NERR and by South Carolina State University.

**5) Invasive Species** — This project will be concerned analyses of disturbed sites, particularly with respect to the invasion of *Phragmites*, again contributing to the cross-NERR analyses. This project will also add to the spectral library, supplementing the *Phragmites* work done in the fall at Apalachicola; thus, we may see phenological differences in the spectral characteristics.

**6) Salt Pannes** — Drs. Ping Hsieh and Gladys Bugna (FAMU) will conduct field and AISA/ENVI analyses on the distribution and soil characteristics of salt pannes, to use as a comparative site with the St. Marks estuary in Florida. The Florida salt marshes experience a tidal range of about 1-2 feet, whereas the ACE Basin tidal range is 6-8 feet, significantly affecting the salt panne regime.

The ACE Basin imagery processing was just completed and currently is being distributed to FAMU and South Carolina State (and then to ACE Basin NERR staff). Processing of ACE Basin imagery was delayed until elevation data for the flightlines was eventually provided by ACE Basin NERR staff. Significant difficulties were experiences in the ACE flyover ground-truthing, which will inform our future flyovers (discussed below);

nevertheless, the ACE Basin data are excellent and will significantly contribute to the ECSC cross-system analyses and to improved understanding of the ACE Basin systems.

*Planning for next remote sensing flyovers*
Many lessons were learned from the ANERR and ACE Basin flyovers that were applied to the planning for the Grand Bay NERR flyover scheduled for October 2003. There will be a significantly improved communications with the GBNERR scientists in planning the activities compared with ACE Basin, and we will have significantly increased participation by ECSC students in the flyover activities. We also are improving the development of written, detailed research and logistics plans for each research task. The GBNERR flyover will add to the water quality, salt panne, invasive species, and salt marsh health tasks done at the previous flyovers. In addition, GBNERR will have a significant upland component, including collaboration with the Sand Hill Crane National Wildlife Refuge in studying fire management effects on habitat quality, and a new look at invasive species in upland systems, especially cogon grass and Chinese tallow. Moreover, the GBNERR flyover will for the first time involve a K-12 activity, discussed later.

The ECSC co-PIs have agreed that the subsequent remote sensing activity will be in early summer at both the Delaware NERR and Chesapeake Bay (MD) NERR sites. Initial planning has begun, and a workshop for developing detailed plans is presently scheduled for February 2004. Since one objective may be the complete mapping of the DNERR watershed, requiring substantially more flight lines than previously done for ANERR, GBNERR, and ACE Basin, ECSC is exploring additional support to CALMIT. A separate proposal being prepared is the establishment of a 21-station aquatic monitoring network for the St. Jones River watershed, for use in the DNERR flyover ground-truthing, the development of a pigment-based eutrophication index, and as a backbone for future aquatic research in the DNERR watershed. The Chesapeake Bay sites are the smallest of the partner NERRs, an are sufficiently close to DNERR to allow both NERR sites to be flown at the same mission.

**Task II.2.g — Formalization of conceptual models**

A central theme of the ECSC activities is the coupling of humans and the environment, including identification of the linkages between societal activities and ecological effects, as well as the support functions and services provided by ecological systems for humans. One of the most important organizing tools has been the convening of a series of ecological/societal conceptual model development workshops led by ECSC Distinguished Professor Mark Harwell and ECSC-FAMU Adjunct Professor Jack Gentile. The ECSC activities to develop conceptual models for each of the affiliated NERR sites began in Year 1 and continued through the first half of Year 2. All of the NERR sites have had conceptual model development workshops, as follows:

- Apalachicola NERR Conceptual Model Workshop, March 2002
- ACE Basin NERR Conceptual Model Workshop, June 2002
- Delaware NERR Conceptual Model Workshop, July 2002

- Chesapeake (MD) NERR Conceptual Model Workshop, September 2002
- Grand Bay NERR Conceptual Model Workshop, November 2002

The process of developing conceptual ecological models derives from the ecological risk assessment framework implemented by the US Environmental Protection Agency and other agencies. The essence of this approach is to identify human activities, or drivers, that occur and can lead to environmental stressors, i.e., physical, chemical, or biological changes to the environment that can affect ecological systems. These stressors may also be natural, such as involving natural variability in climate, sedimentation processes, fire, etc. The ecological effects from the stressors, whether natural or anthropogenic, are characterized in terms of specific ecological endpoints, also termed valued ecological components (VECs). These VECs are selected based on either their ecological importance (e.g., the main primary producers in a community, keystone species, etc.) or their societal importance (e.g., endangered species, economically important species, aesthetic species). For each particular ecosystem or habitat type, a suite of ecological endpoints needs to be selected, with the aim of having a parsimonious set to reduce the dimensionality of the problem of characterizing the health or condition of an ecosystem. Thus, the goal is to identify those particular ecological attributes that are specific to an ecosystem type and for which the following applies: if there is a significant change in the health of the ecosystem, it would be manifested in one or more of those endpoints, and, conversely, if there is a significant change in one or more of those endpoints, that means there is a significant change in the ecosystem condition that society would care about. This understanding of human-stressor-effects linkages is essential in order to develop and implement effective management policies that can achieve sustainability of coastal ecosystems, an explicit major objective of NOAA as expressed in the NOAA strategic plan.

The ECSC conceptual model development workshops followed the same format, i.e., involving a mix of scientists from the ECSC, scientists with experience in the NERR ecosystems, other outside experts, and local stakeholders. The workshop participants in each case were asked to: 1) specify the boundaries of the NERR and associated systems of concern, including both ecological and human-influence boundaries; 2) identify the societal drivers and human activities affecting the systems of concern; 3) identify the specific environmental stressors that are relevant to the study area, including both anthropogenic stressors from the identified human activities as well as natural stressors affecting the ecosystems; 4) identify the specific habitat or ecosystem types within each case study system; 4) identify the sets of valued ecosystem components (VECs) for each habitat type; 5) specify the stress-effects relationships between each individual stressor and each individual VECs for each individual habitat in the NERR system; and 6) identify feedbacks from the ecological VECS to society, including service flows, issues of aesthetics, etc. The workshop participants also were taken on a tour of the NERR site, typically including a boat trip through the estuary and coastal ecosystems, and a vehicle trip to terrestrial habitats.

The workshop participants produced the required matrices of societal drivers and activities; activities and associated biological, chemical, and physical environmental stressors; habitats and associated VECs; and stressors with ranked effects on each VEC. These

matrices were completed at the ECSC Annual Meeting in the Keys (discussed above), and the diagrams of the graphical conceptual models were initiated, following a common template and format.

In Year 1, conceptual model development workshops were convened at ANERR, ACE Basin, DNERR, and CBNERR. The final conceptual model workshop was held in Year 2 on 13-15 November 2002 in Biloxi, MS, focused on the Grand Bay NERR system. JSU organized the workshop, in collaboration with the Mississippi Department of Marine Resources, GBNERR, and the other ECSC participating institutions. A total of 67 people participated in this workshop, with representation from the local communities and various stakeholders including the Mississippi Department of Environmental Quality, the Nature Conservancy, the U.S. Department of Wildlife and Fisheries, NASA Stennis Space Center, and several academic institutions. The workshop followed the same format as previous workshops, i.e., involving a mix of scientists from the ECSC, scientists with experience in the Grand Bay ecosystem, and local stakeholders. The experience of the previous workshops was used to identify sets of valued ecosystem components (VECs) for each habitat type, as well as sets of societal activities and environmental stressors, used as points-of-departure for identifying the habitats, VECs, activities, and stressors specific to the Grand Bay ecosystems. The workshop participants also took a tour of the GBNERR site, including a boat trip down the estuary and a land trip to terrestrial sites. The workshop participants produced the required matrices of societal drivers and activities; activities and associated biological, chemical, and physical environmental stressors; habitats and associated VECs; and stressors with ranked effects on each VEC. These matrices were completed at the ECSC Annual Meeting in the Keys (discussed elsewhere), and the diagram of the graphical conceptual model was begun, following the format of the Apalachicola Bay conceptual model.

During Year 2, progress continued on developing or refining the conceptual models of all of the NERRS sites. A series of articles has been initiated for each conceptual model, following a common outline, and these manuscripts will be submitted for publication as a special issue of the journal *Urban Ecosystems*, a peer-reviewed journal.

The Apalachicola Bay NERR conceptual model has been developed into an initial graphical representation of the drivers-stressors-VECs for each of the identified habitats of ANERR. Three graphics are needed to cover the Apalachicola Bay salt and fresh water marshes (a total of 12 stressors); three more for the Apalachicola riverine ecosystems (12 stressors); three for the riparian forests (12 stressors); three for the upland xeric and mesic forests (10 stressors); two graphics for the Bay itself (10 stressors); and two graphics for the landscape-level issues (9 stressors). The next step will be to develop more detail for the mechanisms and pathways by which individual stressors affect individual VECs. A separate workshop was held at FAMU to develop the specific stress-effect pathways and mechanisms for the freshwater and salt water marshes. These more detailed pathways will be incorporated into the *Urban Ecosystem* article for ANERR.

The other conceptual models are in various stages of completion. The ACE Basin matrices have undergone refinement and aggregation, and the graphical representations are

underway. The Chesapeake (MD) NERR matrices were incomplete at the workshop because insufficient local expertise was available at the workshop; however, a post-workshop meeting with CBNERR, Morgan State, and Delaware State scientists has advanced the matrices.

The Delaware NERR matrices and initial graphical models were completed, and increased attention is underway to develop the societal components of this conceptual model. The DNERR conceptual model has been completed for Level One ("H" links or greater only), and has been completely converted into four-component format as presented and recommended at the meeting in the Keys. The four components of this coupled model are described in the draft manuscript in preparation for the *Urban Ecosystems* special issue and include:

Component 1: Social Matrix (Drivers→Stressors)
Component 2: Ecological Matrices (Stressors→VECs)
Component 3: Service Flow Matrix and Flow-Component Matrices (VECs→Services)
Component 4: Feedback Matrices (Services→Drivers)

A meeting is scheduled at DSU on October 16th to present the model to the local community. The Mayor's office, the university President's office, and the Dover Post are involved in helping to publicize the event. The present draft of the DSU/DNERR model has been distributed to all ECSC institutions and to NOAA contacts, and is available on our outreach website at http://cars.desu.edu/faculty/mreiter/dnerr.htm.

DSU has already begun to set student projects based on conceptual model results (including the theses of our present M.S. students in this program), and have identified an M.S. student with a mathematical/statistical background to perform a sensitivity analysis of selected habitats in the existing Level One model. We will also be seeking public comment on the model thus far.

At Morgan State, we are continuing the development of the Chesapeake Bay conceptual model begun at the ECSC workshops. The completed model was presented to Ms. Carol Towle of the MD Department of Natural Resources to obtain their feedback and make adjustment where appropriate. Dr. Kimbrough, working with Dr. Marshall, will now lead the effort to complete an article on our modeling efforts for publication in *Urban Ecosystems.*

**Task II.2.h — Develop research proposals —**

The long-term goal of ECSC is to establish sustainability of its research, education, and outreach activities, in part through diversification of the funding support. ECSC co-PIs have already been active in seeking additional extramural research support for ECSC-related activities, using the Center as leverage for funding from other sources, and will enhance these initiatives in the next few years as capacity expands at the partner institutions. Examples of this include the following:

At FAMU, several research grants have been acquired, including:

- EPA STAR grant $750,000 to develop hydrodynamic and ecological models of the Apalachicola Bay and River system — M Harwell and five co-PIs. This project will build upon an initial hydrodynamical model of Apalachicola Bay to expand it into a 3-D hydrodynamical model of the Bay with expanded boundary conditions. Input to this model will include a new application of the MODBRNCH model, developed for riverine ecosystems, which will be calibrated to the Apalachicola River system. To the hydrodynamical model will be added a water quality model, by incorporating the algorithms form the latest US EPA water quality model (WASP6). We will also develop new ecological models for oyster beds and salt marsh habitats.

- EPA STAR grant $250,000 through Texas A&M University to assess global climate change science in support of decision making, with Apalachicola as case study — M Harwell and D Worthen, co-PIs. This project involves developing climate change scenarios for three case study areas (Apalachicola Bay, coastal LA, and Galveston Bay, TX) for 2010, 2050, and 2100 futures in terms of specific climate-related stressors (temperature regime, precipitation regime, tropical storm regime, and sea-level rise). The societal focus will entail extensive interviews with local stakeholders and decision-makers to evaluate their awareness of climate change issues and to assess the degree to which scientific information enters into the decision-making process about local environmental management.

- DOE grant $450,000 to study biochemistry of marine diatoms and global CO2 dynamics — J Cherrier, PI. The premise of this work is that photorespiration is an important link between phytoplankton excretion and stressful environmental conditions in coastal ecosystems. The overall goal is to better quantify organic matter excretion as a function of 'light stress' and photorespiration and to understand how this might impact global oceanic carbon and nitrogen cycling, particularly with respect to bacterioplankton remineralization processes. This research is a collaborative effort between FAMU and the University of Washington. The FAMU effort is primarily focused on the biogeochemical aspect of this work, while the UW effort primarily focuses on the molecular aspects of the work. Dr Cherrier is responsible for overseeing the identification and characterization of the compounds released as a function of 'light stress'/photorespiratory processes and determining how bacterioplankton responds to these substrates.

- NSF COSEE grant $180,000 to integrate ocean science research with K-16 education and outreach in Florida — J. Cherrier, PI. The Florida Center for Ocean Science Education Excellence (FCOSEE) was recently funded by the NSF as one of seven COSEEs distributed throughout the continental United States. FCOSEE will serve as a regional hub that integrates ocean research with education and

outreach in Florida. Our goal is to improve the ocean science competencies in a K-16 audience and to keep the policy makers, the public, and the media fully informed about ocean issues and discoveries. J. Cherrier is responsible for a) taking the lead role in the incorporation of new science content and inclusive pedagogy into a post-secondary Ocean Science Concept-drive Interactive (OSCI) curriculum model (developed by J. Cherrier with previous NSF funding) and b) serving as the Science Research Coordinator for the FCOSEE.

- NOAA EPP grant for $87,000 to support research at partner NERR sites — M Harwell and L Robinson, co-PIs. This grant provides supplemental funding from NOAA EPP to support research activities in four of the partner NERR sites for their support of ECSC. The Apalachicola NERR will receive $17,000, primarily to support the purchase of field equipment and supplies, including a boat motor for one of the ANERR craft used by ECSC scientists and students, and to support the maintenance of field equipment. The ACE Basin NERR will receive $17,000 to support the salary of an ACE Basin staff member who is working with ECSC on remote sensing analyses and other field tasks. The Delaware NERR will receive $17,000 to support the salaries of staff members who are working with DSU on conceptual model development and outreach and education activities. The Grand Bay NERR will receive $9000 to support the field studies associated with the GBNERR flyover ground-truthing activities.

- NOAA grant $250,000 to conduct environmental monitoring and modeling in the Apalachicola Bay system — L Robinson, E Johnson and five co-PIs. This grant from the NOAA EPP entrepreneurship competition will expand on ECSC outreach activities, as well as expand upon ECSC modeling activities in the ANERR system. Students will participate in assessing the potential impacts of environmental changes on the Apalachicola River Basin ecosystem by collecting ecological data, performing measurements, and by ecological modeling. The program will involve high school, undergraduate, and graduate students; high school teachers; and faculty members from FAMU. Activities with high schools in Northern Florida and Southern Georgia, two summer programs for high school students, a fall research participation program for undergraduate students, and research work by graduate students are components of the program. Graduate students at FAMU will be full participants in the research part of the program and will help provide guidance to high school and undergraduate participants. The research part of this proposal consists of coordinated studies on pollutants in the Apalachicola River ecosystem, encompassing four areas: 1) laser remote sensing; 2) spatial analysis using geographic information systems (GIS) and digital imaging technologies; 3) aquatic measurements; and 4) ecological modeling.

- Florida Institute of Oceanography grant to support instructional cruise to support marine ecosystem studies at Florida A&M University — J Cherrier, PI. This grant awards ship time for two 3-day cruises at an estimated total cost of $21,000. Approximately 10 students will participate on each cruise (total of 20/year). The overall goal for these cruises is to provide ECSC students the opportunity to gain a

greater appreciation of the complexity of marine ecosystem dynamics through the active participation in ocean science field research. This hands-on experience has served as an excellent vehicle for recruiting some undecided students into the field of ocean science. The objective of each cruise is to carry out a series of ecosystem inventories in the northeastern Gulf of Mexico continental shelf to evaluate how ecosystem dynamics change along a transect moving away from protected nearshore regions to those that are further off shore. To evaluate these potential changes, a comparison of water, plankton, nekton, sediment and dredge samples is conducted for each station in the transect.

- Pending: NSF grant $280,000 to study C dynamics in coastal marine sediments — J. Cherrier, PI. The flux of carbon from coastal marine sediments is likely to be influenced by submarine groundwater discharge (SDG), which may enhance remineralization of buried carbon and transport it to the water column. This study will use time-series measurements and monitoring of conservative tracers (conductivity, Cl⁻ concentration, $^{222}$Rn activity, and temperature) to determine the temporal and spatial scales of sedimentary advective mixing, as well as variations through time and space of discharge from the regional aquifers associated with the Indian River Lagoon System in eastern Florida. The hydrologic studies will be coupled with studies of remineralization of carbon in the sediments using carbon concentrations and natural carbon isotopes (i.e. $^{13}$C and $^{14}$C) as tracers of the sources of the carbon.

- Pending: US Department of Agriculture Economic Research Service $50,000 grant to Dr. Michael Thomas (and USDA scientist co-PI Jan Lewandrowski) entitled "Assurance Bonds as a Tool to Manage Risks Associated with Intentional Releases of Exotic Species." Invasive exotics pose a wide variety of production, price and market-related risks to farmers and the managers of natural resources throughout the United States. There is a need for information on the economic implications of alternative policy approaches to managing the economic risks these species pose to the users of natural resources. The increase in emergency program expenditures and indemnities has created an interest on the part of USDA policy makers to develop alternative approaches to managing risks associated with new invasive pest outbreaks. This research will focus on developing one such alternative – specifically producer purchases of assurance bonds when production behavior involves the potential for unintended outbreaks of invasive exotics. Assurance bonds have a couple features that appear to make them attractive to policy makes, producers and society in general as a means of managing the risks associated with at least some invasive species situations. First, they can be designed to encourage producers to monitor for pests, thereby increasing the likelihood of discovering outbreaks early. Second they can be designed to reimburse producers for bond related expenses if outbreaks do not occur, thereby reducing the potential problem with moral hazard.

At Delaware State University, the following proposal has been submitted by Drs. Michael Reiter (DSU), Chunlie Fan (DSU), and Robert Scarborough (DNERR):

- USDA, in review. 1890 Institution Capacity Building Grant, $91,748. Project: "Variations in the water quality of the St. Jones River, Delaware with respect to historic land use changes in the watershed".

Other proposals concerning the development of a watershed nutrient index using phytoplankton composition and pigmentation, and the valuation of resources, will be ready for submission from DSU shortly.

***Summary for Goal II Tasks*** — All of the GOAL II tasks have met or significantly exceeded the activities in the initial ECSC proposal. Data mining and field studies to acquire new data are well underway at all NERR sites, involving more than 90 specific research projects. Cross-site comparisons are also underway, substantially informed by the conceptual modeling and remote sensing tasks. A series of new socioeconomic studies has been initiated, led by a newly strengthened economics team of faculty in ECSC. Quantitative modeling has begun in ANERR on the physical and ecological systems, and in DNERR on societal models, The remote sensing flyovers and associated ground-truthing were done in ANERR and ACE Basin, and planning done for GBNERR, DNERR, and CBNERR flyovers in Year 3. These flyovers have already created massive databases that will have significant utility for ECSC and NERR scientists. The conceptual modeling workshops have been done for all five NERR sites, and a special issue of the peer-reviewed journal *Urban Ecosystems* is underway to present the methodology and results to the scientific community. The conceptual models have already been used as a significant basis for the individual studies by faculty and students in each NERR site. Finally, ECSC has already leveraged significant extramural research funds, making considerable progress towards long-term sustainability of the Center.

## B.4. Goal III Resource Management — Improve the scientific basis for coastal resource management

Most if not all of the ECSC activities discussed under Goal II are designed specifically to improve the scientific bases for coastal ecosystem management. In addition, however, there are other tasks under Goal III to accomplish this objective, involving interactions with managers and stakeholders.

The specific elements of Goal III in Years 1 and 2 were to: interview management and regulatory personnel from NOAA and other federal agencies, state and local agencies, and communities to determine preferred information format and platforms; involve managers in model development; test preliminary models' efficacy in the management arena; establish preliminary form of information exchange.

### Task III.2.a — Stakeholder information gathering for data bases

This task has largely involved stakeholder involvement in the conceptual model development workshops and subsequent activities. For each site, important stakeholders have been invited and invited to participate in ECSC discussions. At ANERR, a spin-off project, funded by US EPA, has significantly advanced this component through establishing a series of interviews with all relevant stakeholders in the Apalachicola Bay region to explore the environmental stressors and management options related to global climate change impacts on the regional community.

### Task III.2.b — Involvement of managers

As discussed previously, each of the conceptual model workshops involved participation by local stakeholders and decision makers/resource managers. This was most well developed at the Apalachicola NERR workshop, where the local mayor, city planner, and representatives from fishing, river management, environmental, and oyster communities, participated actively in the conceptual model development process, but each of the other NERR workshops also had local representatives of stakeholder groups, if not actual decision makers. (In all cases, decision makers or managers were invited but did not always participate.) We are reasonably confident that the interests and issues of concern by the local managers have been identified in each of the conceptual models, ensuring that the models as they become more fully developed will continue to be relevant to local management issues. As ECSC continues to develop and refine the conceptual models, and as our outreach activities gain increasing emphasis, we will expand the diversity of managers' perspectives and input to our research activities.

### Task III.2.c — Test preliminary models

Discussed elsewhere (and not repeated here) are model development activities for the conceptual model and quantitative models, as well as a number of socioeconomic studies

that test preliminary models for environmental valuation. In addition, one specific model-testing project follows:

**Morgan State University research in land-use/land cover change —** Dr. Fred Wilson is studying land-use/land-cover change (LCLUC) dynamics using remote sensing and GIS was the main research focus during this period. Several predictors were identified and selected for studying the impact of LCLUC on the environment of the NOAA NERR Sites. Otter Point Creek in Harford County being the northernmost site was chosen to be the first NERR site for this study. GIS data acquired include climate/weather (temperature and precipitation), demographics (population and occupation), biological resources (finfish and crabs), and transportation. Biological attributes such as finfish, crabs, and oysters will be used to not just determine distribution and abundance, but also be used as indicators of the health of the Bay. Students were trained in accessing multiple communication media including the Internet, for data acquisition. This approach prepares the students to not just maximize financial resources, but enable them to conduct data acquisition more effectively and independently. Efforts are also underway (through the recent purchase of a digitizer), to introduce the students to data creation/digitizing and processing.

Landsat images were processed and analyzed to determine the LCLUC change over the past ten years. Unsupervised classification of Level I categories were done . Two other Landsat TM images are currently being processed. Once completed, the LCLUC dynamic will be determined. This effort is important for adequate resource management and policy making. These land use activities have considerable negative impact on the environment. For example, a tremendous amount of natural land cover in Harford County continues to be transformed into abiotic/impervious land surfaces which support no positive biophysical processes in the environment required for coping with the increase in its population. It is therefore prudent that steps be taken now to limit these anthropogenic factors in Harford County. Preliminary results also showed an increase in county mileage during this period of study, indicating that more people are driving longer distances which will ultimately result in more atmospheric pollution in the county, exasperating respiratory ailments in the county. This study plans to investigate the cause-consequence relationships of these anthropogenic factors as they relate to environmental degradation of the Chesapeake Bay. Several field studies including groundtruthing were also carried out during this period using GPS. The data collected will be useful when constructing change dynamic matrices for the area. More field studies will be conducted to asses the accuracy of the classification methodologies. Data on other counties (starting with Baltimore and Ann Arundel Counties) will be acquired and processed. Because of the differences in scale, data fusion and integration will form a critical component of this study in the future.

**Task III.2.d — Establish information platforms**

Dr. Katherine Milla (FAMU) has responsibility for the database platforms for ECSC research and outreach activities, assisted by faculty at the partner institutions. The web-based system is currently being developed. To date, we have explored GIS and database software, as well as the network options for sharing data, password-protecting unpublished data and ideas, and presenting the ECSC frameworks, data, and results to decision-makers,

stakeholders, the general public, and the scientific community. In Year 3 ECSC will redirect funds to hire a computer network specialist to implement the ECSC website and associated database platforms at FAMU and all the partner institutions.

***Summary for Goal III Tasks*** — Goal II task accomplishments are largely embedded in the GOAL II task descriptions, extensively discussed previously. We are currently focusing efforts in developing the ECSC website and associated database platform for exchanging data and ideas among ECSC scientists and students, and with decision-makers, stakeholders, and others. Moreover, we continue to expand efforts to work with stakeholder groups in each NERR site and to make the research of ECSC relevant to managing the coastal ecosystems of the NERR sites and elsewhere along the Atlantic and Gulf Coasts of the US.

## B.5. Goal IV Education and Outreach — Improve the scientific basis for coastal resource management.

The specific elements of Goal IV in Years 1 and 2 were to: begin K-12 outreach activities (accomplished); assess environmental equity and justice issues at each NERR site (not accomplished); introduce ECSC to local stakeholders (Yr-1 only; accomplished); involve stakeholders in conceptual model development (accomplished); provide educational products and materials to general public (underway).

### Task IV.2.a — K-12 activities

ECSC has a number of K-12 activities at each partner institution:

Morgan State University has developed a cooperative and collaborative relationship with Southside Academy High School in Baltimore, MD. Because of the school's close proximity to the Chesapeake Bay area and the resources available for potential partnerships, environmental science was the perfect curriculum focus for this high school. According the school's principal, Ms. Peggy Jackson-Jobe, the mission of Southside Academy is to provide students with challenging programs in the field of environmental science and to prepare the students to enter college, the workplace, or both. Through a vigorous academic program, students pursue their individual interests in environmental science through technology, research, internships, apprenticeships, or work experience. The vision of the Environmental Science Academy Program at Southside Academy is to produce technicians who will have the understanding, knowledge, and skills to make a positive impact on environmental problems. Beginning in the ninth grade, students will be required to take Environmental Studies I, Field Biology, Environmental Studies II Project WET; and Environmental Studies III Chesapeake Bay Project.

On June 21, 2003 the MSU ECSC sponsored a student exploration of Otter Point Creek Estuary, in Harford County, Maryland. The purpose of the student exploration was to introduce inner city middle school and high school students to an estuarial world. Throughout the event, the students were able to observe the natural landscape of the estuary and its water and land ecosystems. Four students were from a select group of teenagers from the Southside Academy participated. The students conducted a water quality analysis to measure the ecological balance essential for the aquatic and land food chains. The young student scientists that participated in this analysis were able to use and apply the skills they were taught in school and apply them to an actual estuarine environment. Using laboratory materials and equipment, each student worked collaboratively with a partner to carryout specific procedures to obtain data and from the creek. The data gathered by the students were:

- pH of a water system determines the acidity and alkalinity;
- nitrogen and phosphate tests determine the amount in the water;
- turbidity tests to determine the clarity of the water; and
- dissolved oxygen tests to determine the oxygen levels of the water.

The result of the water quality analysis was that the turbidity and dissolved oxygen levels were found to be poor, which correlated with our initial observations of the greenish-brown odorless water color. Because of the fact that our region had experienced previous periodic and heavy rain fall, runoff or sedimentary disturbances may have occurred, this leading to the poor results of clarity and depleting levels of oxygen. Algae blooms may have been another reason for the depletion of oxygen and the turbid water.

In August 2003 MSU ECSC investigators, Dr. Anthony Wilbon and Professor Yazmin Fozard, participated in the Freshman Orientation Program for the Southside Academy. The title of the Freshman Orientation Program was "What's Wrong with the Bay." The purpose of the orientation was to introduce the student to high school and to the curriculum of the Southside Academy of Environmental Science. One of the main issues for the students during orientation week was an investigation into the introduction of a new species into the Chesapeake Bay. The students explored a number of issues regarding the Asian Oyster as a replacement species for the Chesapeake Bay native oyster. As part of the event we provide bus transportation for the students to the Anita C. Leight Estuary in Harford County, Maryland. The program included the following events:

- a presentation by Richard Bohn from the Department of Natural Resources on the issues associated with introducing the Asian Oyster into the Chesapeake Bay;
- an introduction to the concept of visual quality and the estuary environment in which the students conducted a visual quality analysis of the Leight Park Trail;
- a tour of the Anita Leight Center by Heather Helm, director of the center.

MSU plans to continue to develop this relationship and incorporate Southside Academy into the ECSC activities wherever possible. In addition, Professor Yazmin Fozard leads MSU efforts in the Eco Clues Camp at Otter Point Creek, which was held a second time during the summer 2003. For the first time, Morgan State will also participate in the Eco Clues Camp at Jug Bay Wetlands Sanctuary. These camps are a community Education Program for the area youth to create a positive nature experience for students in grades K-12. The camp will held in two sessions for 30 community youth participating**.**

At Delaware State, the primary K-12 and outreach effort will coincide with the development of DNERR's Coastal Training Program (CTP), which is presently under development. Until that occurs, DSU is working through its departmental recruiter (hired with USDA funds using the ECSC grant as partial leverage), through a relationship established with Polytechnic High School associated with a separate grant, and by career day and classroom visits by Dr. Reiter and his research team.

Similarly, SCSU is collaborating with the South Carolina Department of Natural Resources to conduct a CTP workshop for the public, early in Year 3.

At JSU a plan has been developed to establish a K-12 educational program. This workplan involves selecting 10-12 students along with 5-6 teachers to participate in a Saturdays, hands-on education and research training. Also, as a part of the upcoming GBNERR remote sensing flyover (October 2003), a local magnet middle school will send more than two dozen students and two teachers to assist in ground-truthing for the invasive species tasks related to cogon grass and Chinese tallow, and to assist in the characterization of the fire regime systems in the Sand Hill Crane National Wildlife Refuge. This class project will receive the AISA imagery from CALMIT as a part of a national competition for middle school environmental science projects.

At FAMU, ECSC hosted the Environmental Sciences Institute Summer Camp from June 8-24 2003, under leadership of Ms. Michelle Williams, who serves at the Coordinator for Research and Program Services for the FAMU component of ECSC. The summer camp accommodated 35 high school students from the Leon County, and Monticello County school districts. Participating high schools included Lawton Chiles High School, Godby High School, Leon High School, Lincoln High School, Rickards High School, FAMU DRS, and Florida State University High School. The overall objective of the summer camp was to challenge the participants to expand their basic knowledge of environmental science and explore new laboratory techniques.

During the two and a half week summer program, the students where introduced to environmental sciences in a variety ways. The students participated in a course called An Introduction to Environmental Science, in which they learned about current issues in marine and environmental science. The summer camp participants also attended a series of lectures that were presented by graduate students and faculty members from various departments within the University. The lecture series was designed to not only enhance the students understanding of science, but to also demonstrate the various career choices in this field of science.

The students' classroom experiences were augmented by a series of laboratory experiments designed to provide a hands-on feature to the summer camp. The highlight of the program was the laboratory experiment that was designed to teach the students about laboratory safety, and laboratory techniques such as preparing reagents and using a spectrophotometer. The project on which they worked was entitled *Determining Nutrient Limitations for Bacterial Production in Apalachicola Bay.* For this research project the students performed ammonium analysis, phosphate analysis and bacterial counts on samples of water taken from the Apalachicola Bay. At the conclusion of the experiment, the students presented the findings of their research to a panel of judges using presentation techniques that they also learned during the summer program.

The FAMU summer camp also included field trips to observe and tour unique ecosystems and other environmental sites in Florida. The students took part in an educational tour of

Apalachicola National Estuarine Research Reserve, Apalachicola Bay, and St. George Island. The summer camp participants also had the opportunity to tour the Biscayne Bay Reserve in South Florida. A tour of the Florida Everglades was scheduled for the students; however, bad weather caused the trip to be canceled.

Currently, plans are being developed for the 2004 summer camp, expanded under the supplemental NOAA funding acquired by a proposal by Dr. Elijah Johnson and others at FAMU. The Environmental Sciences Institute summer camp has become very popular among the participating schools. Therefore, the number of participants in the 2004 summer program will be increased and the length of the program will be expanded from two and a half weeks to three and a half weeks.

FAMU has also developed a partnership with Sealey Elementary School. Sealey Elementary School is a science and math magnet school for grades K through 5. The Partners for Excellence program was designed by the Leon County School District to have schools, businesses, organizations, and agencies work together for the benefit of the education and the community-at-large by enriching the curriculum, ensuring the quality of education necessary for economic growth, strengthening the future workforce, and/or increasing support for and confidence in public education throughout the community.

The Annual Environmental Sciences poster competition is a recently completed project that involved students from Sealey Elementary School and four other elementary schools in the Leon County School District. The goal of the poster competition was to promote awareness of environmental issues among children. The theme of this year's competition was "Where Does Our Water Go?" The teachers were asked to incorporate the theme into their classroom lesson. The children were then asked to develop posters that reflected domestic water use and conservation. Several hundred third, fourth, and fifth grade students participated in this poster competition by drawing and painting posters. Michelle Williams and several FAMU ECSC graduate students served as judges for the competition. The students were awarded prizes and certificates of participations. The teachers that agreed to participate were given gift certificates to a school supply store. The schools that participated were given a plaque, detailing their participation in the poster competition.

**Task I.2.b — Environmental justice and equity issues at NERR sites**

The ECSC proposal indicated that the FAMU Environmental Sciences Institute's Center for Environmental Equity and Justice would facilitate the integration of environmental justice issues and concerns, specifically the disproportionate impact of environmental stressors on low-income and minority populations, into the overall project. This has not been done through the end of Year 2. Consequently, ECSC is now initiating other activities to advance the issues of environmental justice.

Environmental justice issues are in part addressed by ECSC in each of the conceptual models for the NERR sites, in essence by highlighting those stressors that have significant societal importance, potential differential across societal groups. However, through the process of developing the conceptual models for each of the ECSC partner NERR sites, it

became clear that in two of the five NERR cases environmental justice issues are not dominant. Apalachicola NERR exists in a small county (Franklin County with less than 10,000 people) which has historically had an economy dominated by the oyster industry, and the per capita income for this county is consequently quite modest. The major stressors affecting ANERR are habitat alteration, overexploitation of resources, and alterations of freshwater flows, i.e., not stressors of chemical contamination, which has dominated environmental justice issues. The stressors at ACE Basin NERR are similar. On the other hand, the Grand Bay, Delaware, and Chesapeake NERRs do have significant contamination issues, and consequently do warrant research on potential environmental justice issues.

The initial primary focus of the environmental justice task is on the Chesapeake (MD) NERR system. This is because one of the components of this NERR site is closely situated adjacent to highly urbanized Baltimore, and because the transition of the leadership of the Morgan State University component of the ECSC has changed its emphasis from fisheries and ecological studies to economic and societal studies. We believe that the ECSC remote sensing imagery may be useful to help portray these impacts on minority populations. An explicit attempt to capture and deliver this information is planned in coordination with Morgan State for the Chesapeake Bay, MD flyover in the summer of 2004.

Now that the focus at Morgan State is shifting to more of an socioeconomics perspective, there are two students working on research related to environmental management and economics that expand into environmental justice issues. A School of Business and Management doctoral student is gathering data on economic development in critical bay areas of the Chesapeake Bay, particularly metropolitan cities like Baltimore and Annapolis, and associated low-income and minority populations. The student will identify the alternations in land development in communities located in the critical bay, both residential and commercial, and determine the changes in land pricing since Maryland made the critical bay designation in the mid 1980s. A master student majoring in environmental engineering in the School of Engineering is researching facilities of large companies in or near the critical bay areas to determine what operations management strategies they have deployed to address their impact on the coastal environment. With both of these issues, we will explore environmental justice concerns to determine if there are disproportionate risks or burdens placed upon any inner city or lower income residents in critical bay areas, particularly Baltimore City and Annapolis. Several studies have found that minorities and low-income groups are more likely to live close to hazardous facilities. The primary focus on environmental justice will be to use a "proximity-based" measure to determine whether facilities located within the proximity of people in critical bay areas pose environmental hazards. More importantly, we will explore what strategies have those facilities developed and implemented to address the risks they pose to their neighboring communities. Currently, we believe the best proposed solution to the environmental justice problem is to improve stakeholder participation in the public environmental decision-making process and improve access to environmental data and information. The Morgan State ECSC plans to address both of these solutions through our research of the issues, sharing of information with the community, and including stakeholders on all levels of the research process. Ultimately, our research will be used to

support policy developed by the Maryland Critical Bay Commission to improved enforcement of the laws and increase the sensitivity to potential environmental justice problems in the community.

**Task IV.2.c — Involvement of stakeholders in conceptual model development**

This task is essentially the same as Task III.2.b (discussed above), except the latter focuses on managers whereas the present task focuses on stakeholders. These distinction between the two for local and regional decision-making, which is the focus of the NERRs studies, is perhaps less clear than would warrant two separate tasks. Nevertheless, as discussed previously, each of the conceptual model workshops involved participation by local stakeholders. This was most well developed at the Apalachicola NERR workshop, where the local mayor, city planner, and representatives from fishing, river management, environmental, and oyster communities, participated actively in the conceptual model development process. Moreover, through a leveraged spin-off project, ECSC has acquired funding from an EPA STAR grant to explore the issue of scientific understanding by decision-makers and other stakeholders in the Apalachicola Bay region with respect to environmental decision-making and global change issues, involving extensive engagement with local stakeholders. But the other NERR conceptual model development workshops also had participation by local stakeholder representatives, providing important insights into the societal drivers, human activities, and values components of the ecosystems of concern.

Moreover, at the Delaware site, where the societal feedbacks have been a particular focus, the Dover, DE, Mayor's office helped to bring key public stakeholders to a separate ECSC public meeting, and all individuals involved in the initial model development have been kept abreast of our activities and their significance and use. The DNERR model was presented to the public for the first time during a public seminar, to which all DSU/DNERR workshop participants were invited. The presentation is available on-line at the DSU outreach website (http://www.desu.edu/faculty/mreiter/dnerr.htm). The model has since been distributed for comment both locally, nationally via the annual meeting of the Ecological Society of America, and internationally via the International Interdisciplinary Conference on the Environment in London this June. The four-component model format was also presented at the meeting of the NERR site managers on Feb. 25$^{th}$, and will be presented to the public at the Oct. 16$^{th}$ meeting at DSU. The responses to date demonstrate strong support and interest (particularly for the four-component model format), and Dr. Reiter has received several requests from site managers, NOAA personnel, and faculty researchers for related materials and manuscripts.

Thus, we are reasonably confident that the interests and issues of concern by the local stakeholders have been addressed in each conceptual models, ensuring that the models as they become more fully developed will continue to be relevant to local management issues. As ECSC continues to develop and refine the conceptual models, and as our outreach activities gain increasing emphasis, we will expand the diversity of stakeholder perspectives and input to our research activities.

**Task IV.2.d — Educational products for general public**

As discussed previously, the ECSC website presently under development will be a central component of providing ECSC products for the general public. Some additional aspects include the following:

Dr. Kimbrough has recruited a MSU student to begin development of an urban environment web page that focuses on outreach to teachers and citizens. The student secured server space and developed the preliminary Urban Environment webpage, focusing on page set up and structure. He worked on web page content, established links to other pages, determined the layout of the page, and helped develop the overall focus. The next step is to implement and put the content developed by the student on the web to facilitate a greater volunteerism and knowledge of the environment as it relates to urban citizens.

At Delaware State, a website is now functioning as our primary information exchange platform with the public (http://www.desu.edu/faculty/mreiter/dnerr.htm), including the ability to view the ECSC matrices/conceptual model as they are developed. This site is supplemented by public meetings, K-12, and outreach activities that have been discussed elsewhere. Also, Dr. Reiter has been asked by DNERR to join the community environmental education initiative they have begun. It should be a good opportunity to tie the Center's education efforts into related programs at the DNERR site. We are also including Center information in our recruiter's recruiting and career day presentations at local high schools. DNERR is also in the process of initiating a Coastal Training Program. Dr. Reiter has begun discussions with Katy Dulin, the DNERR Education Coordinator, on integrating our project's outreach efforts into their CTP. However, the CTP is not expected to move beyond the planning stage for at least a year. Other discussions with Kathy MacKaye concerning the use of the modeling process for other Delaware sites is ongoing. We are also in the exploratory phase of involving local high school students in our ongoing monitoring schedules.

Finally, Dr. David Letson (U. Miami) organized a NOAA/Office of the Chief Scientist sponsored workshop at the Orlando Expo Centre on February 28, 2003 on economics and coastal resource management. Dr. Mike Thomas (FAMU) also gave a seminar at the event titled, *Economic Analysis for Environmental Resource Management and Planning in Florida*. This workshop had two objectives: a) to help attendees understand basic tools of economic analysis including benefit-cost analysis, full cost accounting, and cost-effectiveness; and b) to demonstrate applications of these tools using case studies from important environmental management and planning problems in Florida. The workshop concluded with a roundtable discussion featuring a group of prominent economists in Florida who discussed the past and future role for economic analysis in environmental resource management in Florida. The workshop was designed for managers and staff in state and local planning offices, elected officials, and representatives from nongovernmental organizations and industry who are involved with or have an interest in management and planning for water, coastal and marine resources.

***Summary for Goal IV Tasks*** — The K-12 activities of ECSC are very well established and continuing. However, the ECSC has not advanced the environmental justice component as initially proposed, and as a result is now initiating focused research on environmental justice issues at the Chesapeake Bay NERR with its close proximity to highly urbanized areas. This new emphasis on environmental justice issues complements the new significant strengthening of the socioeconomics team in ECSC, under leadership of co-PIs Wilbon and Letson, with active participation by economists at FAMU, SCSU, and the University of Delaware. The stakeholder involvement continues to be expanded, and public outreach will be considerably advanced once the ECSC website is fully implemented in Year 3.

## III. Expansion of ECSC Activities

As the ECSC has developed and evolved during the first two years of operation, and in the spirit of the cooperative agreement with NOAA, there has been a number of research and other tasks that ECSC has undertaken that well exceed the initial proposal submitted to NOAA EPP to establish the Center. Expansions include much more involved research though the remote sensing tasks; significant expansion of the conceptual modeling and application tasks; significant expansion of the socioeconomics tasks; and considerable leveraging of ECSC to acquire research and education funds from sources beyond NOAA.

As ECSC has completed its first two years of activities, a process has been developed by NOAA EPP to conduct a formal technical and administrative review of the ECSC in order to make a determination of continuing the ECSC support by NOAA. At present, the ECSC review is scheduled for 1-3 March 2004. In preparation for that review, ECSC will develop a workplan and budget for Years 4 and 5 at its next annual meeting, scheduled for early January 2004. In addition, because of some changes in ECSC management obligations, the Center is in the process of submitting a revised budget for Year 3. These planning activities will include adjustments to some of the specific research or education activities of the Center, reflecting the program as it continues to evolve. The TAP and MAC will be involved in the development of these workplans, as will the partner scientists at the NERR sites, as well as new relation ships currently being developed with NOAA scientists in NOS and other parts of NOAA. In furtherance of the latter, ECSC is engaged in a series of discussions with NOAA scientists at various laboratories and centers to establish new activities, often building upon existing ECSC activities, but also involving new initiatives. It is the intent of the ECSC IMT to provide a summary of the new NOAA-related initiatives at the formal review in March. Further, at the encouragement of the NOAA MSI Council, ECSC is also expanding its funding sources to include other parts of NOAA and other federal and state agencies, including US EPA, US DOE, NSF, among others. These new extramural funding activities are being developed using the ECSC NOAA EPP support as leverage, with the goal of enhancing the long-term sustainability of the Center. This set of new initiatives will also be presented at the March review.

### Change in Leadership at Morgan State University

Dr. Marshall was the principle investigator for the MSU ECSC until January 2003, after which he resigned from MSU to pursue other opportunities. During his tenure, Dr. Marshall coordinated all administrative components of the grant, including budget oversight, report preparations, correspondence and conferencing with other Center PI's, student recruitment, personnel oversight, and interactions with external stakeholders and collaborators. Additionally, he served as major advisor for masters degree students supported on the grant from the School of Computer, Mathematical and Natural Sciences, and collaborated/coordinated in varying degrees all of the MSU/ECSC activities listed below. Dr. Anthony Wilbon was named PI in May 2003 for the MSU ECSC and took over the administrative responsibility previously performed by Dr. Marshall. Since Dr. Wilbon is a faculty member in the School of Business and Management, the focus of the MSU/ECSC will shift toward more environmental strategy and management, environmental economics, and societal issues. Although there was a lag in the replacement

of the PI that caused some delays in the administration of the grant, most of the research has continued and moved in a positive direction. Most of the students under Dr. Livingston's oversight were in the bio-environmental sciences and have completed their research and graduated. Current students are focusing on research in strategic management, environmental engineering, and landscape architecture. The significant expansion of socioeconomic research, discussed elsewhere, has been enhanced considerably by the addition of Dr. Wilbon to the ECSC team.

**Appendix 1**
**ECSC Annual Meeting in Florida Keys**

The first annual meeting of the ECSC was held 13-17 January 2003 at Islamorada in the Florida Keys. Participants included most of the co-PIs, graduate and undergraduate students, post-doctoral and research associates, most of the Technical Advisory Panel and Management Advisory Committee, and several representatives from NOAA HQ or NERRS programs.

At the ECSC Annual Meeting, co-PIs reported on the progress for each partner institution. The conceptual model development process was discussed, and work groups convened to develop further the individual conceptual models. Plans were made to complete the conceptual models for each site at one level of resolution, and to focus on the Apalachicola Bay model to develop in more detail the stress-effects mechanisms. A work group was also convened to develop further the societal model into a 4-tier approach, and the Delaware NERR model was selected to develop further the societal model components and linkages.

A session was convened to discuss the special issue of the journal *Urban Ecosystems.* This special issue will include the following articles:

> Article 1 Introduction to ECSC — Larry Robinson lead, with Mark Harwell, Jack Gentile, Carol Forthman, et al., and additional section on NERRS by Maurice Crawford — This will be an overview article describing the structure, goals, and approaches of the ECSC;
>
> Article 2 Conceptual Model Frameworks — Mark Harwell & Jack Gentile lead, with Mike Reiter, Mike Thomas, Dave Letson, Carol Forthman, John Schalles, et al. — This article will overview the frameworks for the conceptual models, ecological risk assessment, ecological sustainability, environmental goals and values, etc., that form the basis of the ECSC approach;
>
> Articles 3-7 will be developed for each NERR conceptual model; the outline for the conceptual model papers is shown below.
>
> Article 3 Apalachicola Conceptual Model — Mark Harwell & Lee Edmiston lead;
>
> Article 4 ACE Basin Conceptual Model — Jack Gentile, Ambrose Anoruo, and Betty Wenner lead;
>
> Article 5 Delaware NERR Conceptual Model — Mike Reiter and Bob Scarborough lead;
>
> Article 6 Chesapeake NERR Conceptual Model — Livingston Marshall and Tony Wilbon lead;

Article 7 Grand Bay NERR Conceptual Model — Mark Woodrey and Paul Tchounwou lead;

Article 8 Synthesis Article — Terry McTigue lead.

**NERRS Conceptual Model Article Outline**

**1) Abstract - summary of <100 words.**
**2) Introduction - Brief setting of stage of article**
**2.1) Ecological Site Characterization — describe the NERR site's ecological characteristics**

- Introduction: geography, demography, landuse, resources, pollution etc.
- History: primarily social and cultural
- Environmental Conditions
- Biological Resources
- Human Uses

**2.2) Socioeconomic Site Characterization — NERR site's societal characteristics**

- Socioeconomic Attributes/Issues
  - Socioeconomic Drivers for System
  - Economic, Demographic, etc. Attributes
  - Management Issues for NERR
  - Elements of NERR Management Plan

**3.0) Methods**
3.1) Brief description linking to article #2 of process.

- Definition, advantages, brief link to Overview Article
- Timing, nature of workshops

**4.0) Results**
**4.1) Conceptual Model Matrices**

- Multi-step process applied to NERR site:
  - determining boundaries for both stressors and effects
  - identifying drivers/activities (Tables from workshop)
  - identifying stressors (Tables from workshop)
  - identifying habitats/resources of value (Tables from workshop)
  - identifying valued ecological components for each habitat (VECs) (Tables from workshop)
- Matrices: establishing and ranking linkages
  - Driver (societal/natural activities)-Stressor matrices with ranking (Tables)
  - Stressor – Effects matrices with relative ranking (Tables from workshop)
  - Habitats-Service Flow matrices with relative ranking (Tables from workshop)

**4.2) Graphical Conceptual Model**

- Graphical Conceptual Model
- Text discussion of model: dominant pathways/linkages, uncertainties, etc.

**5.0) Conclusions**
**5.1) Summary of Important Issues**

- Important Drivers/Activities

- Important Habitats/VECs
- Important Stress/Effects Relationships
- Scientific Uncertainties

**5.2) Discussion of Selected Stressor(s), Pathway(s), Effects**

- Choose one or two specific stress/effects issues for detailed discussion of pathways, scientific knowledge and uncertainties, research needs, potential management issues/implications

**5.3) Other issues, conclusions**

- Important Scientific Issues Remaining
- Educational Opportunities and Other Utility of Conceptual Model

**6.0) Acknowledgements** - including funding, list of workshop participants

**7.0) References**

Another activity at the ECSC Annual Meeting was to take an initial look at the results from the Apalachicola Bay flyover. John Schalles led the workshop in exploration of the ENVI hyperspectral database management system, and sample outputs from the flyover. Following this, the workshop participants developed initial ideas for the next flyovers. It was agreed to do the next remote sensing at the ACE Basin, set for early June 2003. Initial ideas are to use this flyover to examine the health of the marshes in ACE Basin, and to do some water quality-related studies to be able to compare with the Apalachicola Bay NERR sites. Assignments were made for coordinating the logistics of the ACE flyover and further defining the specific research questions and approaches. It was also agreed that the subsequent remote sensing flyover will occur in October 2003, when Year 3 funds are available, and will focus on the Grand Bay NERR ecosystem. Since GBNERR has new management, and a new research plan is being developed at present, it was agreed to hold a mini-workshop in early summer to define better what research questions can most appropriately be addressed at the GBNERR flyover.

Another session at the ECSC Annual Meeting was to overview the ongoing or planned research activities being conducted by ECSC scientists or students in each NERRs site. The most developed set of activities was reported for Apalachicola Bay NERR, with more than a dozen active projects already underway. Other sites, such as the Chesapeake Bay NERR, are in more of a developmental stage.

The Management Advisory Committee and Technical Advisory Panel met at the Keys meeting. Issues discussed included the following: a) additional research topics within and across sites; b) improving collaborations with NERR sites; c) new research ideas for separate funding proposals; d) methods to improve communications within the Center; e) costs for NERRS support; f) interactions with NOAA; and g) expanding research activities, funding base within NOAA and outside of NOAA. It was agreed to develop individual workplans for each of the NERR sites, with each workplan a collaborative effort between the NERR manager/research coordinator and the ECSC counterpart co-PI. These workplans will help articulate the specific research topics to be addressed at each site, the expected needs for field support, and other issues that can help the NERR sites plan for the research support. It was also agreed to explore how additional funds could be provided to

at least some of the NERR sites to help compensate for costs associated with ECSC research activities.