Crossing Boundaries

A Strategy for the University of Maryland Center for Environmental Science
Beyond 2000

January 2000
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Summary

This strategic plan of the University of Maryland Center for Environmental Science (UMCES), Crossing Boundaries, sets a course for the next five years that positions the Center to address the issues of environmental science through the early 21st century. It builds on our 1995 plan, Toward 2000, and takes into account nationally recognized directions in environmental science, the needs of Maryland and the Chesapeake Bay region, and the challenges we face as educators.

The strategy is founded on first principles regarding: the responsibilities of the faculty for scholarship of multiple dimensions; our commitment to top quality, integrative science; provision of appropriate facilities; and the long-term impact of our science through education—from K-12 to graduate.

The Center will focus its research to promote discoveries regarding environmental changes across the broad coastal environment, including watersheds, estuaries and the coastal ocean. It will do this by connecting two major thrusts initiated under the previous strategic plan: Landscape Ecology of the Watershed and Regional Environmental Change at the Land-Sea Interface. We will increase our understanding of how changes in one ecosystem affect another, for example how changing land cover or ocean dynamics affect the Chesapeake Bay. We will evaluate how certain species—for example a harmful alga, a nonindigenous species, a disease-causing organism, or a commercially exploited species—can affect an ecosystem. We will advance our predictive capabilities through mathematical modeling of ecosystems, communities and populations, especially models that are made more realistic by assimilation of real observational data. And, we will bring our diverse scientific expertise to bear on designing effective restoration of ecosystems such as oyster reefs, seagrass beds, wetlands, streams and forests.

Growing out of our faculty’s needs for access to diverse data and our external partners’ desires that we assist in applying our knowledge in a more timely and effective manner, we will establish an Integration and Application Network (IAN). This will be a virtual “center,” linking our laboratories and the world through information technology. IAN will facilitate transdisciplinary integration in environmental science. It will also serve as a mechanism for efficient development of scientifically sound advice concerning environmental and natural resource management for the Chesapeake Bay region and beyond.

We will build on the successes of our collaborative programs in graduate education, and the national recognition they have enjoyed, and move them to a higher level of national eminence. We will accomplish this by aggressively attracting top students, elevating the academic rigor of the curriculum, and increasing the scientific quality and impact of theses and dissertations. We will also redouble our efforts to contribute to the continuing education of environmental professionals and an environmentally literate society.

Our Center subscribes to the notion that the reputation and effectiveness of an institution are greatly influenced by its leadership. We will strive to encourage and support the leadership roles members of our faculty play within the scientific community.
and to lead the advance of environmental science within the University System of Maryland, the State of Maryland, the Chesapeake Bay region, and the nation.

The five-year period ahead will be a period of modest growth in fiscal support from the State that will allow highly selective investment in strategic priorities, but no great expansion of programs and faculty. With the dramatic growth being experienced in sponsored research come both new resources for operational support and new demands for infrastructure and services. Because the Governor and Board of Regents are committed to applying the State’s revenues during these bright economic times to future needs, the next five years offer promising prospects for improvement of our physical plant that address serious constraints, upgrade aging facilities, and enable state-of-the-art research. With these increases in State support, however, come greater expectations for accomplishment and accountability. UMCES will develop effective means to gauge its success and account to the citizens for their investments in our mission.
Introduction

Five years ago the University of Maryland Center for Environmental Science (then the Center for Environmental and Estuarine Studies) produced a strategic plan Toward 2000: Meeting Opportunities and Challenges for Environmental Science. Toward 2000 has served the Center well, but as the benchmark year for the new millennium approached it became necessary to look “beyond 2000.” An assessment of the needs and priorities of the University System of Maryland, the state of Maryland, and the world provided the framework and guided the identification of new research priorities that are articulated in this plan.

In this new strategic plan, Crossing Boundaries, the faculty and administration of the Center have assessed progress made under the Toward 2000 plan, solicited advice from partners, reconfirmed commitments to those elements of the earlier plan which remain sound, and identified new directions where they are needed.

We took a different approach than was used in earlier planning efforts. We critically examined progress we had made under the Toward 2000 plan, solicited advice from partners, reconfirmed commitments to those elements of the earlier plan which remain sound, and identified new directions where they are needed.

We engaged partners—senior representatives of state and federal agencies and nongovernmental organizations and representative graduate students—in our deliberations. And, we were more deliberate in the planning process, which in many ways is more important than the plan itself.

This plan is intended to provide guidance for at least the next five years. Of course an effective strategic plan must have a longer view that that. Over the next several decades during which we expect many of our present faculty to continue with the Center, we will be crossing many boundaries: into a new decade, century and millennium; across the environmental media, air, land, fresh water and the ocean; within and beyond state and national limits; among the scientific disciplines; between students and teachers; and among scientists, decision-makers and the citizenry.
Progress

75 Years of Service to Maryland

During the year 2000, the University of Maryland Center for Environmental Science (UMCES) will be celebrating its 75th anniversary. While Toward 2000 noted that it had been just over twenty years since the Center for Environmental and Estuarine Studies had been formed, the Center’s true genesis was the founding of the Chesapeake Biological Laboratory by Professor Reginald Truitt in 1925. Through its various positions as a small college laboratory, a state research and education agency, and (for the past 38 years) a multi-campus institution of the university system, the Center has, at its core, served its patroness, Maryland. It has a rich tradition of excellent research, education and public outreach related to Maryland’s natural resources and environment, pursuing its statutory mission “to develop and apply a predictive ecology for Maryland.”

The Center addresses this mission at its three laboratories: the original Chesapeake Biological Laboratory (CBL), the Appalachian Laboratory (AL), established in 1962, and the Horn Point Laboratory (HPL), founded in 1973. Beginning about 1980, HPL and CBL underwent substantive growth in faculty and facilities, broadening and deepening of research strengths in the marine sciences, expanding sponsored research, and increasing involvement of its institutional leaders and faculty in national and international activities. During the 1990s a major commitment was made to expand and strengthen the faculty and facilities of the Appalachian Laboratory in order to develop a prominent program of watershed studies to balance and contribute to the estuarine and marine programs of the coastal laboratories. Furthermore, during this decade UMCES assumed an increased leadership role in strengthening and nurturing the University-wide graduate program in environmental sciences (Marine-Estuarine-Environmental Sciences or MEES).

Consequently, over the last two decades of this long history, the Center has become a nationally prominent coastal research and graduate educational institution. This is reflected in national rankings and in the success of the faculty in competing for peer-reviewed research support at the national level. As the UMCES vision statement declares, the Center has continued to evolve as a globally eminent, yet locally relevant, institution dedicated to discovery, integration, application and education concerning the environment and natural resources.

Toward 2000

As we began strategic planning in 1998, the faculty and administration alike had the impression that Toward 2000 document had been a very helpful and successful plan.
However, we decided to evaluate this by comparing the Center’s actions and outcomes related to each goal laid forth in the plan. The resulting score card is included as Appendix 1. We find it remarkable that we were able to accomplish most of the objectives indicated. This included most of the faculty hires that we identified, somewhat optimistically, for strengthened research programs and the two new research thrusts: Landscape Ecology of the Watershed and Regional Environmental Change at the Land-Ocean Interface. After a period with little addition of new blood to the faculty, the last five years have seen the most rapid development of faculty in the Center’s history.

State general fund support through the university, which had been in decline, began to grow again. Although much of this increase went to meet the growing cost of operations, we strengthened and expanded programs and—very importantly—raised faculty salaries to more competitive levels. External funding for our research also continued to grow. The value of new awards received in FY 1999 was $17.1 million, more than a 50% increase over the previous record year (1997). While this amount is greater than the goal of $15 million set in Toward 2000, because award amounts influenced by large, multi-year awards, these figures are best interpreted as indicating that we have essentially met the ambitious goal we set forth.

Among other notable accomplishments was the recognition by the National Research Council of the Graduate Program in Marine-Estuarine-Environmental Sciences at the University of Maryland College Park (heavily dependent on UMCES faculty) as being in the top ten doctoral-research programs in oceanography in the nation. Finally, the new Appalachian Laboratory was completed on schedule; we moved into this magnificent new facility in December 1998. This new research facility, together with the faculty we have been able to attract to work in it, are critical elements of the strategic thrust in the area of Landscape Ecology of the Watershed.
Environmental Science in the 21st Century

The Global Environment

There is widespread concern that based on current trajectories humankind will be reaping the bitter fruit of its profligate use of nature's resources and services and the biosphere will suffer irretrievable losses during the coming century. This had led biologists E.O. Wilson and Jane Lubchenco among others to dub the next hundred years as the Century of the Environment. What we do as a community of environmental scientists and as a society will make a big difference in the outcome. There is, then, a heightened sense of urgency and importance for environmental science. From climate change and losses of biodiversity to the collapse of fisheries and widespread eutrophication of coastal waters, the phenomena we are confronting need to be seen as global in proportion while local in significance.

The point of this brief overview, in addition to providing a background context for the UMCES strategic plan, is to illustrate that major expansion of environmental science is on the horizon and that the scientific community will be expected to contribute more to the integration and application of knowledge. Furthermore, when one matches up the specific scientific priorities identified in these reports, UMCES is on the right track and in many cases ahead of the pack. The opportunities for participation and contribution by the Center in this national effort are unprecedented.

Dr. Lubchenco (1998), in her presidential address to the American Association for the Advancement of Science, called for a new contract between science and society. This contract represents a commitment on the part of all scientists, but especially environmental scientists, to devote their energies and talents to the most pressing problems of the day, in proportion to their importance, in exchange for public funding. Meeting this challenge, she submitted, will require new fundamental research, faster and more effective transmission of new and existing knowledge to policy- and decision-makers, and better communication of this knowledge to the public.

There have been many recent reports that recommend courses of action for environmental science to address these intensified needs. Dr. Rosina Bierbaum, Associate Director of the President’s Office of Science and Technology Policy, in a speech delivered to the American Institute of Biological Sciences last year in Baltimore, summed up the critical national requirements in terms of the following issues:

- **Interlinkages**: connections among environmental media and resources and environments
- **Scales**: meaningful space and time scales of environmental processes and patterns and human intervention
- **Extremes**: importance of extreme events and changes in frequency and intensity of extremes
- **Consequences**: effects of environmental changes on ecosystems and on human society
Partnerships: cooperation among scientists, institutions, agencies, and the private sector to address large and complex issues

Assessments: combining the interpretation of environmental observations with mechanistic understanding to produce useful predictions about the future

The Ocean Studies Board (OSB) of the National Research Council also issued a report in 1998 that addressed the challenges on the horizon for ocean sciences, a major component of UMCES research activities. The OSB also stressed the need for science to protect the health and productivity of coastal and ocean waters, the sustainable use of marine resources, and consequences of climate change, as well as the new technologies needed to understand environmental changes on appropriate scales.

Opportunities in Ocean Sciences: Challenges on the Horizon
National Research Council, 1998

Improving the Health and Productivity of Coastal Oceans
- Transport and exchanges between the land, estuaries, the continental shelf and the deep sea
- Processes and effects, particularly in estuaries
- Understanding biophysical processes and governance systems

Sustaining Ocean Ecosystems for Future Generations
- Importance of food web structure to function
- Changes of ecosystem structure and production with long-term variations in climate, fishing, or inputs of materials
- Measures effective for maintaining both biodiversity and productivity

Predicting Climate Variations over a Human Lifetime
- Predictive capability of effects of climate
- Biogeochemical feedback loops
- Paleoclimatologic record
- Measurement of physical and biological measurements in context of models

Modern Observations as an Enabling Technology
- Flexible, highly capable research vessels, autonomous undersea vessels, etc.
- Combining data from sensors and satellites with communication systems and computer models
- Practical use of information in improved predictions and management of resources

Teaming with Life: Investing in Science to Understand and Use America’s Living Capital
President’s Committee of Advisors on Science and Technology, 1998

- Integrate up-to-date knowledge into management, use, and conservation of biodiversity and ecosystems
- Search out America’s biological species for their genetic properties and their interrelationships
- Explore fundamental ecological principles in order to improve monitoring of ecosystem status, better predict change, and optimize sustainable productivity
- Design new mechanisms for valuation of natural capital and create economic incentives to conserve it in order to encourage a sustainable relationship between economy and environment
Also, in 1998 the President’s Committee of Advisors on Science and Technology published a report, *Teaming with Life* that addressed the critical need to understand and use wisely the national biological resources. It emphasized the need to evaluate and conserve biodiversity, develop robust principles to monitor and predict the environment, and new mechanisms for valuing natural capital and ecosystem services.

In 1999, the National Science Board released an interim report, *Environmental Science and Engineering for the 21st Century: The Role of the National Science Foundation*. It recommends an increase of NSF investments in environmental science and engineering of an additional $1 billion (over the current base of $600 million) over the next five years. Included is expansion of disciplinary, interdisciplinary and long-term research, environmental education, and scientific assessments. Finally, in FY 2000 the federal Administration has proposed a budget initiative on Integrated Science for Sustainable Ecosystems. This initiative emphasizes four priorities: (1) invasive species, biodiversity and species declines; (2) harmful algal blooms, hypoxia and eutrophication; (3) habitat conservation and ecosystem productivity; and (4) information and integrated assessments.

**Maryland and the Chesapeake Bay Restoration**

To take our bearings and adjust our course in terms of the Center’s scientific contributions to Maryland and the Chesapeake Bay region, a Partnership Dialog was held during our first planning retreat. The participants and a summary of that dialog are provided in Appendix 2.

We asked our partners to discuss with us frankly their answers to three simple questions: what do you think we do well, what do you wish we did better, and what do you believe should be our science priorities for the first part of the 21st century?

The results were reassuring and helpful. First, the good news is that the discussion revealed enormous respect for the quality of the science performed by the Center and an appreciation that it was not only cutting-edge science but extremely useful to environmental and resource managers and conservation organizations. There was recognition that the “distant water” or research beyond Chesapeake Bay performed by the faculty is actually an asset from a regional perspective. It provides a basis for comparison and broader interpretation of regional research and adds credibility by enhancing our national reputation.

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**What the Center Does Well**

- High quality and unusually interdisciplinary scientific research, both applied and basic.
- A focus on the Chesapeake Bay and its watershed with prominent extraregional activities leading to a credible scientific basis for effective environmental and resource policies.
- The thrust in landscape ecology of the Chesapeake watershed is addressing a major need and places the Center in the unique position of integrating, within one institution, the ecological research of the watershed and the Bay.
- Timely application of science to emerging issues and responsiveness to partner requests for information and assistance.
The criticisms and suggestions of our partners are very useful to us in planning how to improve our service to the State and region. In a nutshell, these partners wish our scientists were more accessible to work with them to solve important practical problems. They would like us to help interpret the wealth of monitoring data and to refine models used by management. They hope we could be more effective brokers involving other resources of the University System of Maryland, and would like to see our knowledge and talents used more to educate the public. These are sound and reasonable suggestions.

In terms of future issues, they are very much an extension of the unsolved problems facing us today. Our partners would like us to do what we set out to do under Toward 2000, successfully integrate our science across the environmental media. They believe we should help provide information for the critical decisions facing Maryland and the region with regard to managing growth and development. They are optimistic that UMCES will lead the way to achieve management of living resources on a sustainable basis. And, they would like us to resolve the seemingly irresolvable risks that toxic substances pose to the environment. These are challenging, but appropriate goals.

### What the Center Can Do Better

- Work more closely and communicate better with its partners, including greater emphasis on synthesis and interpretation of data, sharing of data and information, personal exchanges and meetings.
- Increase its efforts to identify and develop solutions to environmental problems.
- Focus more effort on the analysis and interpretation of the wealth of monitoring data and refinements of management models.
- More effectively integrate its efforts with those of other programs and capabilities in the University System of Maryland.
- Expand its base of sponsors and partners.
- Contribute more effectively to educational outreach to Maryland citizens.

### Issues for the 21st Century

- Fully integrated science addressing multimedia (water, land, and air) questions.
- Science to inform the effective management of population growth and development and mitigation of effects of global change.
- Quantification of the cumulative and sublethal effects of toxic materials.
- Science to support the effective management of exploited living resources in an ecosystem context.

### The Education Challenge

As educators, we face tremendous opportunities and challenges as we enter The Century of the Environment. Maryland citizens will have to contend with changes in their environment and make choices regarding both public policies and personal lifestyles as our society strives to find a sustainable future. Changes and choices will come more quickly. Never has the scientific literacy about the environment among the general populace been more important. For perhaps the first time, environmental education is being recognized for its potential to contribute to that literacy.

UMCES has long been involved in environmental education and annually reaches over 12,000 students through its Horn Point Environmental Education Center, but its capacity is limited with respect to the demand. The Center also is an active contributor to
environmental education in Southern Maryland through the SEARCH partnership. The Center will bolster these programs and, in particular, expand its activities in environmental education at CBL and AL, where environmental education activities were reduced as a result of reductions in state support in the early 1990s.

The K-12 education landscape is rapidly changing as Maryland adopts Science Content Standards for K-8 school performance, assessment, and high school student graduation. These standards emphasize experiential learning through experimentation, observation, use of authentic examples, and manipulation of actual data. Professional development opportunities are urgently needed to enable today’s educators to access, understand, and teach using the wealth of information that is already or potentially available from Chesapeake Bay research and monitoring activities. In 1998 the region’s governors endorsed the Chesapeake Bay Education Initiative to make these resources available to schools across the entire watershed.

Further, Maryland alone anticipates hiring 10,000 new teachers by 2003—teachers who currently are receiving minimal preparation in environmental science as part of their undergraduate or professional development training. The K-16 Initiative, a partnership between the University System of Maryland, Maryland State Higher Education Commission, and Maryland Department of Education, seeks to link pre-University, University, and K-12 education more effectively across the entire curriculum. Improved teacher training and retraining, particularly in mathematics and the sciences, is an essential component of this linkage. A project involving 40 schools across the nation (including three in Maryland) is showing how use of the environment as a context for teaching and learning significantly improves student achievement in all subjects (Lieberman and Hoody, 1998). Beyond its traditional role in preparing a new generation of citizen stewards, environmental education has a role to play in helping the USM K-16 Initiative achieve its vitally important goals.

As mentioned under Progress, the Center has been a key contributor to the successes of the Graduate Program in Marine-Estuarine-Environmental Sciences and other USM graduate programs. The interdisciplinary breadth of these programs, coupled with the ability to develop sound disciplinary focus within this broader framework, provides UMces the unusual opportunity to prepare new kinds of environmental scientists needed to conduct research or scientific assessments on the complex issues of the future. The reputation of these graduate programs is attracting excellent students from throughout the

- Learning science is something that students do, not something that is done to them. "Hands-on" activities, while essential, are not enough. Students must have “mindson” experiences as well. National Academy of Sciences, National Science Education Standards (1996).

- We acknowledge that the Chesapeake Bay, its rivers and its watershed provide an authentic, locally-relevant source of environmental information and data that should be used to help advance student learning skills and problem solving abilities across the entire school curriculum. Chesapeake Bay Program Education Initiative (1998).

world. This generation of students we will train grew up with “internetworking” thinking. The challenge for graduate education in the Center, then, is to build on the scientific breadth and depth of the faculty, while employing new concepts and technologies that address the complexity of the world in which we live.
The Strategy

First Principles

The Center has evolved from its early beginnings as a small field laboratory to a mature academic scientific institution, and this achieved status needs to be considered in the strategy. In developing the rationale for the aspirations and goals needed for any strategic planning we need to consider our responsibilities, core values, and potentials. While we need to change and develop to discharge our responsibilities and meet our potential, we reject the goal of growth for growth’s sake.

Regarding our faculty

We, our faculty and leadership, have embraced a multifaceted concept of scholarship as the responsibility of faculty members. As defined by Ernest Boyer the work of the faculty has four functions: discovery (creating new knowledge), integration (placing this knowledge in the context of the broader body of knowledge), application (helping society use this knowledge), and teaching. Environmental scientist and former Stanford President Donald Kennedy (1997) wrote along the same lines that, along with academic freedom comes academic duty: the duty to prepare, teach, mentor, serve the University, discover, publish, tell the truth, reach beyond the walls, and change.

Because it is the basis of knowledge and essential to the mission of the Center, we expect members of our faculty to excel in discovery, but also expect that all faculty members recognize the other three dimensions of scholarship as responsibilities and contribute meaningfully to all of them. However, we recognize that some faculty members will emphasize one dimension over the others.

The UMCES community will expect, value and reward excellence in scholarship and fulfillment of academic duty. Administrators and fellow faculty members will nurture the professional development and recognize accomplishments and varied talents of the faculty. Faculty members will support, assist and expect excellence from each other. Administrators will facilitate and catalyze the scholarship of the faculty, represent the Center effectively to the outside world, and consult, explain and make wise decisions. Administrators will take the broad and long view to ensure the continuing success and well being (two different things) of both the individual and the Center. These are our shared expectations.
Regarding scientific capabilities

We will reiterate, appreciate, and always consider that quality science is the underlying basis for our reputation and effectiveness in the scientific and management communities. Quality requires relentless commitment to improvement of existing capabilities and careful selection of new directions.

As an already large and mature organization, we expect only modest increases in the size of our faculty. We have to meet the talent needs of new program development largely through replacement or addition of research faculty members.

We will actively foster integrative, collaborative research among our varied experts in ecosystem ecology, oceanography, chemistry and toxicology, and fisheries science and champion the transdisciplinary approaches needed to address regional environmental research and global-scale problems. In addition to providing key insights into the workings of nature, this transdisciplinary research will continue to address environmental management needs and provide the essential foundations for modern graduate education.

Regarding infrastructure

We will address the need for the development and long-term support of the infrastructure required to facilitate the high-quality science that is our hallmark, including:

- needed replacements for major scientific instrumentation that underlies our research capabilities which is not easily funded by external grants; and
- adequate support for basic research support such as library/information services, computer services, and research vessels.

Regarding our commitment to education

The innovation in our science and our long-term impact on science and society will depend, in part, on the quality of our students. Now that the graduate education programs of the Center have reached national recognition and attract outstanding applicants, the faculty and leadership of the Center have committed to moving these programs to the upper echelon of graduate programs in ecology and coastal oceanography worldwide. We will work to recruit the best-qualified students, improve the organization and quality of course offerings, provide broader experiences, and demand high standards in student research.

With regard to environmental education, we recognize that teaching young people is absolutely necessary but no longer sufficient. We will work to help K-16 educators to translate the results of our discoveries and integration into a resource that will truly enhance science and mathematics curricula with authentic examples and actual data. With the help of delivery over the Internet to every school in the watershed, we will contribute material that can serve as a virtual science textbook for Maryland and the Chesapeake Bay region.
Discovery: Connecting the Thrusts

A major challenge for the Center, then, is to continue to develop, improve and pursue appropriate new directions during a period when its faculty will change more slowly than during the last five years. This will depend on successful integration of the two thrusts identified in *Toward 2000: Landscape Ecology of the Watershed and Regional Environmental Change at the Land-Sea Interface*. Based on the perspectives provided by our looking forward to environmental science in the coming century and the progress we have made, these themes are still deemed to be highly appropriate. As these programs mature, we must work toward more effective integration among disciplines and laboratories to achieve the vision of becoming the only U.S. institution with the breadth and depth of expertise to comprehensively address important environmental issues across the land-sea interface from watersheds and rivers to estuaries and the coastal ocean. The four major themes discussed below provide a framework for this integration.

*Propagation of change across scales and among ecosystems*

A logical outcome of linking the two research thrusts is an increased focus on the interconnections among the atmospheric, terrestrial, freshwater and estuarine/marine components of the region. It already is widely appreciated that there are linkages between, for instance, events in the watershed of the Chesapeake basin and the quality of the water in the Bay. However, there is still much to learn to establish clear cause-effect relationships or to predict the consequences of alternative management options. In particular this will require developing improved understanding and quantitative models of how changes within a particular region or in one component of the system are propagated from smaller to larger scales to influence other components of the regional system. That these sorts of linkages exist is not the issue, rather the challenge is to discover the principles and processes that govern the propagation across scales.

There are four specific inter-related sub-themes that will be pursued:

1. **Consequences of changes in land cover and land use within the watershed.**
   The watershed of the Chesapeake is a patchwork of different land covers and uses. While much of the heterogeneity is due to variation in climate and other aspects of the physical environment, it also reflects current and past human activity as well as natural disturbances. Even extensive areas of seemingly “natural” vegetation actually are in various stages of recovery from past disturbances or clearing, which dramatically affects the properties of the current vegetation. Also, significant portions of the Bay's watershed are covered by urban and suburban systems, which are rapidly expanding, and agricultural systems, which are changing in extent and intensity. The role of these heavily human-dominated land areas must be integrated into our models. This science is critical to the Chesapeake Bay restoration as well as to making Smart Growth truly smart. The ultimate goal must be to elucidate how the spatial and temporal patterns of land use/cover influence the biogeochemistry of the watershed, especially the export of water, sediments and chemicals to aquatic, estuarine, and marine ecosystems, and in turn influence the health and functioning of downstream aquatic ecosystems. This will require integrated research in biogeochemistry, landscape and stream ecology, hydrology, ecotoxicology,
Urban ecology and related disciplines—areas in which our faculty members are leaders.

2. **Consequences of large-scale oceanic changes on estuaries and the coastal ocean.** Exchanges among estuarine, coastal marine, and oceanic ecosystems are largely affected by water movements (e.g., transport of chemicals, larval recruitment) and population migrations (e.g., by species that reside in different ecosystems during the course of their life cycle). Both of these exchanges will be influenced by global climate change and are strongly influenced by large-scale meteorological events (e.g., the North Atlantic Oscillation and El Niño-Southern Oscillation). Within estuarine and coastal marine ecosystems, variations in the ocean climate affect currents, sea level, tidal exchanges, temperature and precipitation and thereby influence biological production, the cycling of materials, recruitment and migration of animal populations, and shoreline dynamics. We must better understand these ocean influences in order to have a context for interpreting the effects of land-based human activities on estuaries and the coastal ocean.

3. **Effects of climate change and disturbance (including extreme meteorological events).** Continuing emissions of greenhouse gases to the atmosphere likely will result in significant climate change over the next 100-200 years; there is growing evidence that these changes are already taking place. Climate change will not necessarily result only in gradual changes in mean conditions, but could also cause changes in the severity or frequency of extreme events such as hurricanes, droughts or ice storms, and even in the occurrence of certain other major disturbance events such as insect defoliations. Most climate change research has focused on global-scale phenomena and relatively little effort has gone into rigorous and comprehensive analyses of effects at the local to regional level or in evaluating how climate change could alter linkages among terrestrial and marine systems. Given the known sensitivity of the Chesapeake Bay to climatic variability and land cover/use patterns in the watershed, climate changes likely over the next century will have significant effects on this ecosystem. UMCES is in an excellent position to undertake research and assessments of the effects of climate change at the local to regional level. In addition to more narrowly focused studies of effects on particular species, ecosystems or sectors (e.g., forestry, fisheries, biodiversity), there is a particular need for more comprehensive assessments that are integrated both horizontally (across sectors and ecosystems) and vertically (from specific changes in climate to ecological effects to socioeconomic effects).

4. **Responses to reversal of eutrophication.** Eutrophication is an increase in the supply of organic matter to an ecosystem and represents the most far-reaching cause of environmental degradation of the Chesapeake Bay and many other coastal ecosystems during the last half of the 20th century. A number of societies in North America and Europe have made major commitments to reduce the loadings of nutrients that stimulate the oversupply of organic matter in coastal waters. Prominent among these efforts is that for the Chesapeake Bay, where governments, industry and citizens have been striving over the last
13 years to reduce the controllable loadings of nitrogen and phosphorus by 40%. Yet we have an imprecise understanding of how the ecosystem will respond and, thus, of what to look for in monitoring progress, how to distinguish changes from those due to environmental variability, and how living resources will be affected.

**Species-specific changes: causes and consequences**

As human populations and activities increase in coastal watersheds, the combined effects of climate change and human alterations of the environment will be especially pronounced in coastal aquatic ecosystems where inputs of materials and energy from land, sea, air, and people converge. Nutrient and contaminant inputs, the exploitation of living resources, the translocation of nonindigenous species, and the destruction of coastal habitats are having profound effects on ecosystem processes, biodiversity, the sustainability of living resources, susceptibility to natural hazards, and the quality of life in general. Changes in the abundance of certain species resulting from these human-induced and natural causes may have an inordinate effect on the outcome not obvious from a strictly biophysical or geochemical perspective. Species matter! The Center will strive to unite these perspectives through interaction among its scientists who focus primarily on the organismic and population level with those who work at the community and ecosystem level. Particularly important species-specific changes include the following:

- **Harmful algal blooms**: There is growing evidence of global-scale increases in the incidence of harmful and toxic algae and protists. Impacts of harmful algal blooms (HABs) include mass mortalities of marine and estuarine organisms and farmed (aquaculture) fish and shellfish, human illness and death from contaminated shellfish and fish, and alterations of habitats and trophic structure leading to the loss of valued species. A local example is the toxic dinoflagellate *Pfiesteria piscicida*. While autecological studies have yielded valuable knowledge concerning life cycles, nutritional requirements, growth rates and the production of toxins, less is known concerning the environmental regulation of HABs. The key question remains as to what combination of environmental conditions give rise to HABs and cause their demise.

- **Changes in organism-dependent habitats**: About 50% of tidal wetlands (e.g., marshes, mangrove forests, bogs) and submersed aquatic vegetation (SAV, e.g. seagrasses) in the Chesapeake Bay have been lost or disturbed in recent decades. Extensive losses and alterations of subtidal habitats such as oyster reefs have also occurred. These habitats provide food and refuge for a high diversity of organisms (including valuable living resources) and are important in the maintenance of shoreline stability and in controlling the fluxes of nutrients, contaminants and sediments. These functions depend, however, on the success of the plants and animals that create the habitat structure. Similarly, the loss of forested riparian systems, especially around the turn of the century, has altered the flux of carbon, nutrients and sediments and also the distribution of aquatic and terrestrial species that depend on these habitats. It is also important to see the trees to understand the forest, because the species composition and
population structure greatly affect forest functions and habitat values. With intensified efforts directed at restoring or rehabilitating important habitats that are defined by the structure created by one or a few species, our discovery, integration and synthesis must be directed to quantifying the factors limiting the success of important habitat-creating organisms and the role these habitats play within the ecosystem.

- **Nonindigenous species**: The translocation of nonindigenous species was accelerated in coastal ecosystems with the advent of iron ships in the late 1800's. For the first time, whole plankton communities were being transported on a global scale between continents as ships took on and discharged their ballast water. The number of successful new invasions appears to have increased dramatically during the 1970's and 1980's, perhaps as a consequence of nutrient enrichment and over-fishing in coastal ecosystems. Furthermore, warmer coastal waters resulting from climate change may open the door to more invasions. Such invasions can profoundly alter the population and trophic dynamics of coastal ecosystems. For example, the introduction of the ctenophore *Mnemiopsis leidyi* from the Chesapeake Bay caused the collapse of the anchovy fishery in the Black Sea by preying on the anchovy’s preferred food, and the introduction of an Asian clam eliminated the summer phytoplankton bloom in San Francisco Bay. Freshwater systems are also very sensitive to invasive species, for example the round goby and the zebra mussel. The introduction of non-native trout may be causing more effects on biodiversity of other stream biota than predicted. While the successful establishment of nonindigenous species has been documented, the environmental factors responsible for their success and their ecological impacts must receive greater attention.

- **Diseases**: Disturbed ecosystems can become vulnerable to invasion and spread of pathogens. An important indicator of stress is the appearance of “new” diseases or the spread and increased virulence of “old” diseases. There is growing evidence for an increasing trend in the incidence of disease in marine and estuarine organisms in coastal waters of the Atlantic and Gulf of Mexico (e.g., MSX and Dermo in the Eastern oyster, virus epidemics among cetacean and pinniped populations, wasting disease in marine seagrasses, and coral bleaching). Diseases involving large numbers of organisms are being reported with increasing frequency. Anomalous environmental conditions and exposure to toxic chemicals may depress the immune systems of marine organisms, allowing infections to penetrate, increasing their susceptibility to epizootics (epidemics). In freshwater as well as marine systems the presence of endocrine disrupting chemicals continue to be an area of critical concern because of potential effects on immune and reproductive systems of aquatic biota. These effects are subtle but have repercussions at the population and community level.

- **Exploited populations**: Populations of exploited species, such as the fish and shellfish resources of estuaries and continental shelves, are affected by the structure as well as the production of the food webs that support them. At the same time, it has become increasingly clear that exploitation of these
populations by humans can result in significant changes in the ecosystem, either as a result of reduced predation pressure or the incidental effects of exploitation. UMCES scientists will increase focus on developing an understanding of the interrelationships of populations of exploited species with those of other species, including other exploited species. This is necessary in order to provide the underpinnings of management of multiple resource species in an ecosystem context (Houde, et al., 1998; Ecosystems Principles Advisory Panel, 1999).

An important theme of each of these examples is the need to understand the dynamics of populations and processes in an ecosystem context. Advances in our understanding and ability to predict the effects of human activities on ecosystems will occur through a more comprehensive and integrated understanding of the relationships among biogeochemical processes, biodiversity, and the population dynamics of key species. The difficulty in predicting changing patterns at the species level is the result of the lack of integration of reductionist research on species with holistic research on ecosystems. Crossing this boundary and bridging this chasm will be a major theme of the Center’s discovery, integration, application and teaching beyond 2000.

A predictive ecology

Executing the Center’s statutory mandate of useful prediction will always remain a major challenge. In the complex world in which we live, accurate ecological prediction requires: resolving trends from variability; modeling the influence of human activities, natural cycles and climate on future conditions; and understanding the ecological and socioeconomic consequences of these future conditions. This is a tall order!

The scarcity of observations on coastal and watershed ecosystems and populations of sufficient duration, spatial extent, and resolution as well as the limited knowledge (theoretical and empirical) of dynamics within and across ecosystems are major barriers to the development of a predictive ecology. One of the most basic, and generally ignored, problems in environmental science is determining the largest scale that must be observed to capture most of the variance of the properties of interest. Perhaps the greatest challenge is the development of robust theories and models that will enable the testing of hypotheses, useful predictions of future conditions and the sustainability of natural resources, and more effective management of human uses of coastal ecosystems. What is required is nothing less than the development of a predictive understanding of how local to regional-scale human activities interact with global-scale climate change and variability to alter the capacity of coastal ecosystems to support living natural resources and their human inhabitants. This advancement in scientific perspective and knowledge is essential for further developments of the modeling and monitoring tools needed for effective environmental and natural resources management of the Chesapeake Bay region and other coastal ecosystems around the world.
The time has come to expand environmental science beyond descriptions of current and past conditions to emphasize model building as an effective means of predicting changes in populations and processes. Assuming that all ecosystems, small and large, are not idiosyncratic but are regulated by functionally similar interactions and processes, there should be ways that we can take advantage of the differences in scales of variability with physical size and level of ecological organization to put individual studies in a more powerful, general context. For example, this could be accomplished by formulating mechanistic mathematical descriptions of long-term behavior and devising tests on shorter time scales. Such an approach could also take advantage of the usual assumption that the behavior of one level of ecological integration depends on characteristics at the next lower level. For example, certain long-term population behaviors may depend on individuals having specific bioenergetic characteristics that could be tested on shorter time scales. Approaches such as this are needed to develop rules for extrapolating from small-scale experiments (e.g., mesocosms) to nature, for interpolating among ecosystems, and for predicting the responses of ecosystems and exploited populations to natural forces and human influences.

In this context, the major scientific problems that must be addressed in coming decades include how:

- changes in freshwater flows and land-cover and land-use in coastal watersheds affect coastal, estuarine and marine ecosystems and modulate the effects of larger scale changes;
- changes in ecosystem processes (e.g., nutrient cycles, system metabolism and net production) are related to changes in biodiversity, living resource production, and net fluxes to atmospheric (greenhouse gasses) and deep-sea pools (C, N, and P);
- the exploitation of living resources are best managed in a sustainable manner in the face of variations in the ecosystems; and
- large-scale changes, such as global climate change and basin scale regime shifts, are propagated to and through coastal ecosystems and affect resources.

There is a clear need to resolve natural and anthropogenic effects, to understand variance across scales and through ecosystems, and to develop generic (rather than site-specific) ecosystem models. The development of such generic models will require ecosystem level research and integration that consider: (1) the time and space scales of material and energy inputs from terrestrial, atmospheric and oceanic sources; (2) controls of population dynamics by interactions between physical and biological processes, bottom-up and top-down effects in food chains, and life-history adaptations; and (3) modulation of processes governing chemical inputs, internal storage, and export to atmospheric and oceanic pools.

More comprehensive and reliable predictive models are specifically needed to guide more sustainable management of living resources. These models must assess the dynamics of exploited populations in the context of the dynamics of the ecosystems that support them. This requires that the Center be at the forefront of innovative stock assessments that take into account exploitation of multiple species in an ecosystem.
context. Moreover, it requires that these models extend to economic forces that govern human demand and behavior concerning resource exploitation.

**Restoration science**

Improving predictions about how human activities affect ecosystems across the land-ocean interface and exploitation of living resources can be sustainably managed are necessary but insufficient scientific contributions to our environmental future. Many physically degraded components of these ecosystems, and thus the natural resource base, cannot be expected to recover simply as a result of pollution abatement or managing resource exploitation. Active reconstruction of critical habitats, including wetlands, streams and riparian forests, oyster reefs and submersed vegetation beds is required. Rebuilding or enhancement of overexploited populations may also be needed. However, such restoration activities are costly and have often been misguided, either poorly designed, mislocated, or ineffective. Demand for habitat restoration is growing, particularly as related to streams, riparian zones, wetlands, oyster reefs and uses of dredged material. Many hundreds of millions of dollars are being committed. The Center must enhance and focus its diverse expertise in restoration science to improve the scientific basis for habitat rehabilitation.

The previously discussed efforts related to propagation of change, species-specific changes and predictive ecology provide broad underpinnings for our efforts in restoration science. The Center’s strengths in these areas provide an ecosystem context extending across environmental media and temporal perspectives frequently lacking in restoration science. In this sense, our enhanced research in restoration science is a critical part of connecting the landscape ecology of the watershed and regional environmental change thrusts. Specifically, we will pursue:

1. application of the Center’s expertise in hydrodynamics, geochemistry and sedimentology as well as in biological sciences in the design and functional assessment of habitats; in this sense our restoration science will be more comprehensive than “restoration ecology”;
2. landscape-scale approaches to optimizing the location of habitat restoration and rehabilitation;
3. ecological engineering and design that incorporates functional efficacy, sustainability, and biodiversity;
4. comparative assessment of the effectiveness of alternatives (e.g. in the placement of dredged sediment);
5. environmentally compatible aquaculture production to meet demand for fishery resources that cannot be met through exploitation of naturally produced resources;
6. a particular emphasis in our aquacultural research on the production of plant (e.g. wetland plants) and animal (e.g. oyster larvae and spat) materials for habitat restoration; and
7. integrated ecological and economic analyses that lead to the most effective solutions in terms of environmental benefits and social costs.
While the planned Aquaculture and Restoration Ecology Laboratory (AREL) at the Horn Point Laboratory will provide greatly enhanced facilities and a focal point for research and application, the Center’s restoration science research is and will be distributed across all three laboratories. We will improve our mechanisms for coordinating research, integration and application to address these objectives.

**An Integration and Application Network (IAN)**

In Ernest Boyer’s reconsideration, the scholarship of integration involves:

- making connections across the disciplines, placing the specialties in larger context, illuminating data in a revealing way, and often educating nonspecialists;
- serious, disciplined work that seeks to interpret, draw together, and bring new insight to bear on original research; and
- interpretation, fitting one’s own research—or the research of others—into larger intellectual patterns.

Boyer also notes that application of knowledge engages the scholar to ask, “How can knowledge be responsibly applied to consequential problems? How can it be helpful to individuals as well as institutions?” And further, “Can social problems themselves define an agenda for scholarly investigation?” Thus the scholarship of application is not a one-way street. Indeed the term application may be misleading if it suggests that knowledge is first discovered and then applied. The process is far more dynamic. New intellectual understandings can arise out of the very acts of application, whether in medicine, agriculture, education or managing our environment. Boyer suggests: “In activities such as these, theory and practice vitally interact, and one renews the other.”

UMCES has long been engaged in the integration of science across the disciplines and, from its earliest days, its application to practical matters. However, the times demand that we find more effective and powerful ways to pursue the scholarship of integration and application in a more efficacious manner. Responding to the convergent desires of the Center’s external partners that we more effectively interpret and apply our science and the faculty for more institutional support to facilitate transdisciplinary research and mindful of national calls for understanding the complex consequences of our changing environment, UMCES will establish and sustain an **Integration and Application Network (IAN)**. This initiative is called a “network” specifically to connote that it should not be in one place, but must reach out and link the faculty throughout the Center’s laboratories to resources and users beyond its boundaries. Through a fortunate convergence, the acronym IAN also honors the late Ian Morris, who as Director of the Center from 1980 to 1988 brought a dedication to scientific excellence serving sound scientific decisions.

The overall objective of the IAN will be to advance effective science and stimulate the communication of this science to managers, non-governmental organizations, educational institutions, and the public. E.O. Wilson (1998) views effective science as composed of discovery, analysis and synthesis. Discovery and analysis is the study of a
particular process or organism. Synthesis is the integration, in the same sense used by Boyer, of individual studies to generate an understanding of a system or region. Such synthesis combines the results of basic science to move a field forward or answer a fundamental question. The answers to our most important questions will be achieved through integration of such fundamental information. The results of integration are needed for effective education and public policy decisions.

Many scientists believe that while analysis activities are proceeding well, integration efforts need to be emphasized. The ecological community recognizes the need for more timely analysis and synthesis and responded by creating the National Center for Ecological Analysis and Synthesis (Association of Ecosystem Research Centers, 1989; Ecological Society of America and Association of Ecosystem Research Centers, 1993). As summarized in the 1993 report: “Synthesis is needed to advance the basic science, organize ecological information for decision makers concerned with pressing national issues, and make cost-effective use of the nation's extant and accumulating database.”

This statement also applies to pressing regional issues such as those relating human activities in the Chesapeake watershed to the ecosystems of the Bay. Because of the unusually interdisciplinary structure of UMCES and the stature of its faculty, the Center is particularly well-equipped to pursue and extend integration activities. We recognize the potential for greater integration to increase the quality, scope, relevance, and applicability of our research activities.

The fundamental notion behind the IAN is that, while integration can be and will continue to be pursued by individual scientists, much faster progress can be made on many of the more complex and relevant problems facing science and society today by transdisciplinary teams of researchers working together. To maximize the effectiveness of integration and application activities, groups of scientists with complementary disciplinary skills require physical or virtual proximity to each other in supportive surroundings together with easy access to the latest data and the technological tools to access and model them. As appropriate, these groups would also include managers, educators, students, and policy developers, as well as scientists.

**Mission and objectives**

The mission of the Integration and Application Network will be to foster the effective and timely integration and application of existing knowledge to answer relevant questions and guide further exploration, research, education, and management approaches. The IAN will enhance the Center’s environment to increase the free exchange, timely analysis, and creative synthesis of data and information gleaned from environmental research and monitoring data. This enhanced environment will be designed to foster collaboration among faculty colleagues, our students, other members of the University System of Maryland, managers, educators, and representatives of the public sector. The IAN will increase the capacity of our faculty to address new and anticipated challenges in environmental science and public policy. It will contribute to graduate and public education by providing powerful experiences that train the next generation of problem solvers and illuminate the natural world in which we live.

The Integration and Application Network will have four primary objectives:
1. Enhance the Center’s capacity for efficient problem-driven integration of scientific data and information to further our scientific understanding.

2. Support the application of scientific understanding to forecast the consequences of environmental policy options.

3. Provide a rich training ground in complex problem solving and the use of science for graduate students within the Center.

4. Facilitate the interaction of the UMCES faculty with state and federal agencies, non-governmental organizations, and other educational and research institutions.

These objectives are neither exclusive, nor separable. Rather, there are significant overlaps and interdependence among these functions. Each objective has specific elements that are described below.

**Integration**

The IAN will enhance the multi-disciplinary strengths of UMCES by enabling faculty to combine individual talents to address questions of common concern. The functions must provide flexibility so that questions over a range of disciplines can be considered; in essence, this provides a set of enabling tools for working groups to address problems covering a range of issues. Further, the IAN must conform to the way scientists interact. In particular, we recognize that: integration activities are of relatively short duration (3-6 months); informal interactions or inspirations frequently stimulate these activities; and communication must be information rich. The IAN will seek to develop the following functions:

1. It will develop and maintain the ability to access and visualize environmental data including periodic and continual observations that are made by both in situ and remote sensing systems. These functions must include intelligent data access for investigating collaborative synthesis of environmental information. This will require knowledgeable technical staff support.

2. It will support interaction among scientific colleagues at all UMCES laboratories and with outside partners and it will provide telecommunications facilities for the interaction of small to medium sized (3-30) groups of scientists. Technical assistance should be available to support larger group activities and those that involve partners from outside UMCES. Both informal, unscheduled interactions and formal, scheduled meetings must be supported.

3. It will facilitate the collaborative development of UMCES proposals for interdisciplinary research. Provide support for the collection and dissemination of relevant information to interested scientists within UMCES and external partners as directed by proposal leaders. Using the telecommunications facilities described above, support the planning and preparation of research proposals.

**Application**

The processes of scientific discovery and integration ultimately lead to a new and deeper understanding of the behavior of complex environmental systems. However, the
results of new discoveries or syntheses are often inadequately communicated to
audiences responsible for developing or influencing management policies and
procedures. Moreover, as pointed out earlier, this is very much a two-way street.
Societal needs may drive new syntheses and discoveries. An important objective of the
Integration and Application Network is to encourage and assist in evaluating the use of
scientific information and knowledge in the management of complex environmental
systems and natural resources, including understanding consequences and developing
enabling technologies.

IAN will foster a greater awareness of scientific discoveries and integration on
management policy and procedures through the following activities:

1. It will be the vehicle for organizing workshops and working groups composed of
   key personnel from the scientific, management and policy arenas.

2. It will be used to enhance communication among scientists, managers, and
   public officials by supporting public forums with the objective of developing a
   broad consensus for environmental management and policy.

3. A series of publications and websites will be established under IAN to focus on
   the scientific results of integration activities, including an assessment of these
   new findings for potential environmental management and policy change.

4. It will provide a context for active involvement with schools K-12, in which
   teachers and faculty members can communicate—face-to-face and
electronically—for the translation of data and knowledge gleaned from research
   into an effective resource for enhancing science and mathematics education to
   meet the challenges of the Maryland Content Standards for student achievement.

In the planning discussions of further steps that could be taken to enhance the culture
of application within the Center, the suggestion emerged that visible and tangible reward
for excellence in the application of science by all levels of the Center’s administration
would send a clear signal to the faculty that application is a highly valued form of
scholarship. The President will initiate an annual President’s Award for Excellence in
Application of Science to be given to a faculty member based on consultation with the
community of users of UMCES science.

Training

Because of participation of large numbers of highly capable graduate students in the
Center’s research programs, IAN will provide an outstanding opportunity for training in
integration and application that simply does not exist elsewhere in research-oriented
graduate education. Such experience is very desirable in the environmental science jobs
of today and tomorrow. If integration and application training is done effectively, it
could be a highly regarded trademark of UMCES alumni, enhancing the value of our
degrees and the reputation of the institution.

IAN will provide graduate students meaningful and practical experience in
integration and application through assistantships and short-term internships associated
with particular projects. Additionally, courses and short courses will be developed to
provide formal training in the technologies and approaches. These courses will be
offered not only to USM graduate students but also to in-career environmental professionals.

Translation

Scientific discoveries and syntheses from UMCES are of value for management and education. Too often, this value is not realized because the information is not effectively communicated to managers, advocates, and educators. Communication requires translation, connecting the scholarship of integration with the scholarship of application. For the results of basic research to be applied by managers or used most effectively by educators, this information must be translated into an appropriate and understandable form.

Translation activities will develop materials designed to communicate effectively with managers, public officials, and the general public. In particular as integration activities proceed, the IAN will provide a forum for communication with non-scientists. These activities will be conducted as part of the application function through working groups and workshops. In addition, the IAN may encourage further dissemination of this information through the publication of these syntheses and by serving as a forum for further discussion and inquiry.

Informing the public is a second translation activity. Placing particular emphasis on this activity will be required to achieve wide distribution of information generated by UMCES researchers. The news media are an important component of this activity. While the press is less ill informed than they are rushed, it is also clear that they need information they can understand (Hartz and Chappell, 1997). By developing materials for public consumption and making them available in print and on the Internet, we will contribute to a better-informed citizenry.

The third translation activity is education. The IAN can play an important role in responding to the rapidly changing K-16 education landscape, catalyzed by the Internet, which is reducing the time between discovery in field and laboratory and application and education in the classroom. National science education reform standards (National Academy of Sciences, 1995) stress experiential learning based on curricula that employ actual scientific data and "authentic" examples. A recent national study (Lieberman and Hoody, 1998), in which three Maryland schools participated, indicates that using the environment as an integrating context for learning improves scholastic performance across the curriculum.

The IAN will achieve these goals by providing an organizational framework in which interns are aided in producing informational and educational materials. For example, the IAN might host schoolteachers and students in summer internships and facilitate development of experiential environmental courses designed for K-12 teachers who transfer this experience to their numerous students in classroom curriculum. While such opportunities are not new to UMCES and have had demonstrated success, specific internships dedicated to the integration and classroom application of scientific data and information represent a significant enhancement of their purpose. UMCES will seek extramural funds to support these individuals or use existing internship programs to place interns in the IAN with the purpose of generating lesson plans or exercises that can be
applied in their school. Similarly, the IAN will host managers, authors or journalists in short-term internships or as visitors with specific objectives who work in collaboration with UMCES scientists.

**Implementation**

The Integration and Application Network will involve faculty, staff, and physical resources. The IAN can only accomplish the stated objectives with the direct involvement of the faculty. Integration must occur as a component or extension of scientific activities. Translation of research results for application, collaboration, and outreach will require faculty interaction. The faculty will probably stimulate the most successful translation activities. Thus, the core of the IAN is the recognition by the faculty that integration and application activities are important components of the Center’s mission and their own scholarship. The IAN will foster these activities by providing support services tailored to integration and application objectives.

The physical components of the initiative, including staff dedicated to the objectives of the IAN, must be distributed to maintain flexibility and responsiveness to the changing needs of the scientific and user communities. Similarly, personnel components of the IAN will need to be distributed throughout the Center. Furthermore, to be effective, staffing must be based on the needs perceived by the faculty and, in substantial part, supported from extramural funds generated by the interest and effort of the faculty.

The following components may initially comprise IAN:

1. a data librarian charged with archival of UMCES data sets and developing and maintaining access to other data sets of regional interest;
2. funds will be available to support development of large collaborative proposals especially for grants which will lead to integration activities;
3. telecommunications facilities will be dedicated to scientific collaboration among laboratories and communication with governmental agencies; and
4. projects will be generated for hosting summer internships for teachers, to develop lesson plans or classroom/field exercises, and to disseminate results through interpretive posting to the Internet.

A mature IAN may also include:

1. regular (yearly) forums to stimulate discussion of relevant scientific and management issues and to produce a proceedings of these forums;
2. a facility for hosting scientists, managers, and public officials linked via advanced telecommunications to regional, national, and international science, management, and government agencies;
3. a staff dedicated to translating research results into materials for public dissemination and use by decision-makers;
4. a resource center, virtual or otherwise, that would provide environmental information to the public, teachers, and managers; and
5. additional data librarians with specific cross-disciplinary expertise in synthesis
activities.

We foresee achieving the Integration and Application Network by developing an initial activity, which demonstrates the value of the concept and from which the Network can evolve as guided by the faculty. Some aspects of the IAN are best funded by research grants. In particular, integration activities would frequently be supported by research grants. The process of having a proposal funded and dedicating funds to the synthesis activity demonstrates that this activity is of value to the scientific community and to the particular researcher. Individual researchers benefit from this approach because they would not need to maintain a full-time data librarian or other highly skilled data synthesizer. Instead they could subscribe to IAN services to archive their data and at an appropriate time employ the services of IAN staff to aid them in integration and application activities. Funds would be required for spin-up of this activity and to provide bridging support.

Other components of the initiative will require that UMCES gain additional support. Initiating summer internships will be inexpensive as external funds are currently available. The IAN would serve as a focal point for these activities with possibilities for growth. Achieving an IAN with facilities, staff, and support for hosting forums and workshops and publishing proceedings will require considerable additional funding. As a result of the strong endorsement from the faculty and external partners, the UMCES administration has made funding of this initiative a high priority and was able to secure special appropriations of $250,000 from the Governor and 1999 General Assembly for IAN. While this provides a stable foundation on which to build IAN, additional support will be actively sought from private donors, foundations, and state and federal agencies.

Education

Rigor and excellence in graduate education

During the strategic planning process it became clear that improving the quality of the graduate education within UMCES should be one of the top priorities over the next planning horizon. We have a responsibility to maximize the competitiveness of our alumni for top positions, both in research, academic and applied science positions. Furthermore, the principal way in which UMCES can assert its intellectual and scientific leadership in the long run is by being an example for graduate education in the environmental sciences. Our national and international recognition will come not only from our own scientific achievements but also from the achievements of our graduates in the various professional activities in which they engage after they leave. Ultimately we will be known and recognized both for our research and for the cohorts of well-trained scientists and professionals that we produce. Despite the Center’s essential contribution to the relatively high ratings achieved by the Marine-Estuarine-Environmental-Sciences (MEES) Program at the University of Maryland College Park in the National Research Council’s assessment of doctoral programs, the reputation of UMCES as an institution of excellence for graduate education has considerably lagged behind its reputation as a national leader in coastal research.

In the planning retreats many faculty members and student leaders alike observed that the course work, examinations, and committee review of theses and dissertations were not as
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rigorous as at the best American universities. Bright students do not always feel challenged and faculty members feel that graduate committee expectations do not always meet high standards of excellence. All in all, it was concluded that we should, could and must be more rigorous and demanding of our graduate students and ourselves as mentors and teachers.

Any attempt to improve the current academic and scientific standard of the MEES Program or the other programs (University of Maryland Toxicology Program and Frostburg State University biology programs) must be done in concert with our USM partners that actually grant those degrees. However, it is recognized that UMCES plays a leading role in these programs, particularly in MEES. Therefore, we should show leadership in improving the excellence of these graduate programs. It must be said that the quality of our graduate education and the quality of our science are intimately linked, so that improving one will benefit the other. In particular, raising the scientific standard that is expected from our students will inevitably result in more imaginative, novel and effective research in our laboratories.

There are three specific areas where considerable improvement is clearly warranted: student recruiting, curriculum improvements, and thesis quality. Our objective will be to achieve significant improvement within the next five years in all three areas. We plan to catalyze these efforts in a series of faculty and student retreats, initially for the MEES Program (involving participants from other USM institutions) where these issues could be further discussed and then implemented. The three strategic goals are:

1. **Attract and retain top students.** MEES receives annually hundreds of applications from very promising students, and many good students are actually recruited each year. But some of the most promising candidates are lost to competing institutions. This is inevitable, since students seek the right institution, the right academic program and the right supervisor that will match their interests and needs, and these do not always coincide. But one powerful reason to choose a certain program over another equally good program is the certainty of financial support. Applicants to the MEES program must be first admitted to the program, and must then search for a suitable supervisor who both matches their interests and is willing and capable of providing adequate financial support. This process can be long and uncertain, and not surprisingly many students will opt for competing programs that offer them support up-front. The University of Maryland College Park offers fellowships that are given to top applicants to its graduate school. Some of these are offered to prospective MEES students, regardless of whether the student has found a supervisor. A higher proportion of these top students applying to MEES could be retained if there were more such scholarships. By one means or another, UMCES will secure increased funding to expand the number of fellowships that can be offered to outstanding students.

Increased publicity about the graduate studies programs at UMCES will also contribute to increased quality of applicants. This publicity will emphasize the unique academic and scientific diversity that characterized MEES and the other programs. It will include information about the success of our alumni in their subsequent professional careers. An alumni registry will be established that would allow us to follow the fate and success of different cohorts of students, with two objectives: (a) as a tool to assess the effectiveness of the program, and modifications that should be made to adapt the program to current social, economic and employment trends; and (b) attracting more outstanding students.
It is necessary to have guidelines for admission to our graduate studies program, and grades and test scores are important criteria, as well as the breadth and depth of the student’s curriculum. However, there is a need to remain flexible enough to accommodate students whose test scores may not reflect their talent and potential to excel in the right environment. We recognize that many successful scientists started off their careers with less than sterling grades and test scores but proved otherwise talented and effective in research. Nonetheless, if we are indeed serious about improving the rigor and excellence of our graduate students, we realize that exceptions to admissions guidelines must be increasingly rare and well-justified.

2. **Elevate the academic rigor of the curriculum.** In order to elevate the academic rigor of the curriculum we will:
   - improve and update course content;
   - diversify courses that are offered;
   - coordinate content among courses and strengthen prerequisite requirements;
   - reassess the curricula of the Areas of Specialization; and
   - ensure that basic pillars are covered early on in the student’s requirements and not repeated in all subsequent courses.

3. **Increase scientific quality of theses.** Student research cannot easily be separated from research being conducted by the faculty, because work done by our graduate students as part of their degree requirements is in fact a large fraction of the overall research being done at UMCES. By raising expectations of the scientific quality and relevance of student dissertations we are in fact raising our expectations of the performance of the entire institution. In many ways, the quality of our students’ theses and dissertations reflects the overall quality of the science carried out in the institution.

Graduate education in science, particularly at the Ph.D. level, should be marked by the incremental development and reinforcement of the intellectual, creative and academic talents of the students. The student’s growth and development is marked by certain milestones, including admission, fulfillment of academic requirements, comprehensive examinations, proposal development and defense, and culminates in the deposition and public defense of the dissertation. To be useful in the developmental process, these milestones should occur along a logical time frame. Too often this time frame is overlooked, as when students defend their thesis proposal when most of their research has been completed, and then the milestones lose their meaning and usefulness altogether. There must be a concerted effort within the graduate programs in which we participate, and particularly within UMCES, to enforce a logical timeframe of examinations, proposal defenses and completion of theses.

In addition, there will be a concerted effort to collectively raise the expectations of student performance across the Center. The only way to effectively raise student scientific performance is to collectively raise the expectations of the major professor and particularly of the student’s committee. Thus in demanding more of our students we are demanding more of ourselves and of each other.
Environmental professionals

Toward 2000 included a strategy for supporting continuing development of environmental professionals, but relatively little progress has been made in this area (Appendix 1). This goal remains important, perhaps more so, beyond 2000. More concerted efforts are needed.

UMCES will continue to pursue opportunities for education and development of environmental professionals through a variety of means, including state agency partnerships and the NOAA-UMCES Cooperative Institute for Coastal Science as discussed in the next section, through continued collaboration with the UMCP School of Public Affairs, and with the Maryland Sea Grant College. Approaches will include not only formal and short courses but also flexible programs that allow working professionals to pursue graduate degrees and student internships in management agencies.

Environmentally literate society

The Center will strengthen its contributions to environmental education in the following ways:

- rebuilding its environmental education programs at the Appalachian Laboratory and the Chesapeake Biological Laboratory based on the experiences at Horn Point, demonstrated needs in the service areas, scientific strengths, and appropriate partnerships (e.g. with Maryland Cooperative Extension, Maryland Sea Grant, SEARCH, and Frostburg State University);
- playing a leadership role in advancing effective collaboration among other USM programs, schools, and regional environmental education centers (e.g. Chesapeake Bay Foundation, Living Classrooms, etc.), while providing scientifically sound content;
- assisting in the implementation of the Chesapeake Bay Program environmental education initiative;
- delivering real-world data and information about the regional environment (see Integration and Application Network);
- participating in the USM K-16 initiative, particularly by expanding its efforts to provide experience and training for Maryland school teachers; and
- establishing an Environmental Education Coordinating Council to develop and facilitate the above activities on a Center-wide basis.

Leadership and Partnerships

Individual and institutional leadership

The reputation of a scientific institution such as UMCES is determined not only by the quality and impact of its publications and the capabilities and successes of its students but also by its leadership and that of its faculty in the scientific community. All of these characteristics exhibit positive feedback, with the institutional reputation affecting
success in attracting research support, highly qualified students and excellent faculty members. In addition, Maryland’s higher education charter charges the institutions of the University System of Maryland to achieve and sustain national eminence. Under legislative modifications to this charter in 1999, institutions are to be fiscally rewarded for such accomplishments. In short, the best interests of the UMCES faculty are served by the success and leadership of the institution and the institution can only attain eminence based on the reputation and leadership of its faculty members. Moreover, there are many direct benefits of leadership within the scientific community that redound to individual faculty members, including the opportunity to shape the national and regional research agenda and the resulting generation of external research support.

The faculty and administrators of the Center enjoy many positions of leadership, including election as officers of scientific societies and other organizations, service on international, national and regional committees, and journal editorships. The Center will endeavor to increase its leadership position by acknowledging and rewarding leadership service by faculty members, seeking opportunities for younger and mid-career faculty members, and organizing multi-institutional collaborative research programs, publications, and conferences. Scientific areas for which the Center’s leadership is well established or could become established include the following: integrated environmental observing systems, eutrophication research, ecotoxicology, multiple scale watershed studies, multi-species management of fisheries in an ecosystem context, ecological economics, restoration ecology, comparative ecosystem analyses, and transdisciplinary scientific assessments (e.g. IAN).

University System of Maryland

The Center is engaged in a number of important and active partnerships with other institutions of the University System of Maryland and plays a leadership role in several of these. These include partnerships in graduate education (MEES, Toxicology, FSU programs), research, and outreach. This contributes to a university system greater than the sum of its parts and greatly extends the capabilities of the Center’s programs. UMCES will strengthen its USM partnerships and more deliberately execute its leadership in five key ways:

1. Leading by example the effort to improve the rigor of the MEES program.
2. Working with the teaching campuses and the University of Maryland Biotechnology Institute to provide undergraduates research experience.
3. Developing interdisciplinary research, integration and application efforts that link UMCES natural science approaches with the social sciences and engineering.
4. Revitalizing the USM Environmental Programs Coordinating Council (EPCC) in focusing the System’s broad-based capabilities on such key issues as smart growth and sustainability.
5. Forging an effective partnership in marine resource advisory services among Maryland Cooperative Extension, Maryland Sea Grant College Program and UMCES.
Maryland Sea Grant College

As of July 1, 1999 UMCES became the Responsible Institution for the Maryland Sea Grant College Program under a new governance structure including the USM, UMCP and UMCES and with advice in the direction of the program from other participating institutions in the state. UM CES has the responsibility for sound administration of the Sea Grant Program. At the same time, the Center and Sea Grant will work to harmonize their efforts in pursuit of their missions in research, outreach and education related to marine resources while insuring that the Program is open to participation by all Maryland institutions and is accountable to the state and the National Oceanic and Atmospheric Administration. Although UM CES and Sea Grant have long had a productive relationship, this new arrangement provides more efficient, coherent and effective means to disseminate and apply knowledge for sound stewardship of marine resources.

Maryland and the Chesapeake Bay Program

The UM CES enabling legislation directs the Center to provide scientific advice to agencies of the state regarding the environment and natural resources. This partnership between the Center and state government is not optional; it is a responsibility. The Center will strengthen its partnerships with Maryland’s environment and natural resources agencies through fuller implementation of existing cooperative agreements (e.g. related to fisheries) and the development of others (e.g. related to water quality and forest conservation). UM CES will adapt and apply its capabilities to help achieve effective policies and outcomes related to the accommodation and management of population growth and development, protection of the environment and living resources, restoration of degraded habitats, and design of the green infrastructure required by future generations.

The multi-state effort to restore the Chesapeake Bay is at a critical juncture at this turn of the century. Not only must the Chesapeake Bay Program (CBP) sustain its efforts in the face of competition for resources, potentially waning public interest, and difficult technical and social challenges, but it will also have to set new goals and make new commitments based on sound scientific understanding. In particular, the CBP will have to address the evolution and restructuring of its environmental modeling and monitoring programs in response to more specific driving questions, shortcomings revealed by scientific reviews, requirements for improved efficiencies, new scientific understanding, and novel technologies for monitoring (e.g. remote sensing, continuous in situ observations, and synoptic mapping) and modeling. UM CES will encourage and support faculty contributions in this transitional period. The Integration and Application Network will play a major role in this regard.

Agency Partnerships

The Center will seek to strengthen its partnerships with state and federal agencies and develop new partnerships. Based on the last strategic plan we have developed a
cooperative agreement with the Maryland Department of Natural Resources on fisheries management, research, education and outreach. We will now seek to develop the mutually supporting relationships included under that agreement and seek to develop similar agreements with DNR in other appropriate areas.

The Center will also act upon discussions with the Maryland Department of the Environment to enter into a cooperative agreement related to science in support of water quality regulations. In particular, UMCES will work to assist MDE in estimating maximum pollutant loadings consistent with maintenance of clean waters of the state, unpaired for designated uses.

UMCES will seek to complete an agreement with the National Oceanic and Atmospheric Administration (under development over the last year or so) establishing a Cooperative Institute in Coastal Science encompassing comparative ecosystem science, fisheries science, habitat restoration, and graduate and continuing education. The Cooperative Institute will be a potent force both for implementation of NOAA’s programs within the region (e.g. the Sarbanes Cooperative Oxford Laboratory) and human resource development within NOAA.
Resources

Funding Projections

The development of a detailed budget plan for execution of this strategy is beyond the scope and purpose of this plan. Moreover, there are always substantial uncertainties concerning state funding, grant and contract awards, and private fund raising. In general terms, growth of state general fund support over the next five years is expected to be in the range of 5 to 10% per annum, based on the USM long-term budget plan and Governor Glendening’s efforts to raise the level of state support to that enjoyed by successful peer institutions in other states. Under the funding guidelines developed by the Maryland Higher Education Commission state support of the Center will be linked to that provided to the University of Maryland College Park, the flagship research university.

While the level of increases in state funding received in the past two years is generous by any comparative standard, many of these new resources will go to meet the growing costs of operations, including continuing improvements in faculty salaries. It is expected that relatively small increments of from $200,000 to $300,000 per year will be available for initiatives or program expansion.

Based on recent trends and developing capabilities, the amount of external support, principally for research, is projected to grow to $20 million by 2005. This growth will provide new resources, for example in the form of indirect cost recoveries, as well as new demands to support expanded operations. The Center must plan wisely in using these resources as well as additional state support in order to provide for capable and efficient science support, preventative maintenance and facility improvements, and appropriate rewards for staff and faculty.

All parts of the Center—each of its laboratories, its administration and faculty—must be committed to raising private funds to support a level of eminence not possible from state and research grant support alone. A Vice President for Development has been hired and an early objective will be the development of a strategy for development that is consistent with Crossing Boundaries, builds on local constituencies of the Center’s laboratories, and seeks to attract major support at the state and national levels.

Infrastructure Requirements

Major capital improvements planned or sought over the next five years include the following:

2. Addition to the Coastal Sciences Laboratory at HPL, construction during 2000, $0.6 million.
4. State-of-the-art Bay research vessel (ca. 75 ft.) to replace Aquarius and Orion, design and construction in 2001-2002, $2.5 million.
5. Information and Communication Services Building at CBL, design beginning in 2005, completion in 2008, $8 million.

On a longer time horizon (subsequent five years), UMCES will seek to renovate the HPL Coastal Sciences Laboratory, extend the CBL Truitt laboratory, renovate Mansueti and Nice Halls at CBL, and add to the Appalachian Laboratory.

Accountability

The amended Higher Education Act of 1999 provides for major commitments of public funding, freedom from limiting state regulations and institutional autonomy for institutions of the University System of Maryland. With these concessions, however, come expectations for strides toward eminence and accountability for the public support and trust provided. Toward those ends, the USM institutions, including UMCES, have developed Management for Results goals and objectives to be used by the Executive and Legislative branches of state government in assessing accountability.

<table>
<thead>
<tr>
<th>UMCES Management for Results Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal 1.</strong> Continue to develop a predictive ecology for Maryland through highly relevant and nationally eminent research programs.</td>
</tr>
<tr>
<td><strong>Objective 1.1</strong> By 2004 increase annual sponsored research funding to $20 million.</td>
</tr>
<tr>
<td><strong>Objective 1.2</strong> By 2004 raise sponsored research awards per faculty member to the 85th percentile for Carnegie Research I universities.</td>
</tr>
<tr>
<td><strong>Objective 1.3</strong> Through 2004 maintain a rate of growth of federal research support not less than the total federal R&amp;D awards to universities.</td>
</tr>
<tr>
<td><strong>Objective 1.4</strong> By 2004 improve faculty salaries to the 75th percentile for Carnegie Research I universities in order to attract and retain outstanding research scientists.</td>
</tr>
<tr>
<td><strong>Goal 2.</strong> Support university-wide graduate education and teacher education programs.</td>
</tr>
<tr>
<td><strong>Objective 2.1</strong> By 2004 increase average GRE scores for incoming graduate students to 625.</td>
</tr>
<tr>
<td><strong>Objective 2.2</strong> By 2004 maintain the ranking of the doctoral program in Marine Estuarine-Environmental Sciences in the top ten in oceanography in the decadal ratings by the National Research Council.</td>
</tr>
<tr>
<td><strong>Objective 2.3</strong> By 2004 increase number of teachers trained in environmental education programs to 50.</td>
</tr>
<tr>
<td><strong>Goal 3.</strong> Strengthen an exemplary outreach program.</td>
</tr>
<tr>
<td><strong>Objective 3.1</strong> By 2004 expand environmental education programs to all three UMCES laboratories, adapting the present model of the Horn Point Laboratory to particular geographic needs.</td>
</tr>
<tr>
<td><strong>Objective 3.2</strong> By 2004 implement a national model program for the integration and application of complex environmental knowledge.</td>
</tr>
<tr>
<td><strong>Objective 3.3</strong> By 2004 expand partnerships with minority-serving institutions and undergraduate programs to encourage recruitment in environmental sciences.</td>
</tr>
<tr>
<td><strong>Goal 4.</strong> Improve private support.</td>
</tr>
<tr>
<td><strong>Objective 4.1</strong> By 2004 improve private support to $5.0 million.</td>
</tr>
</tbody>
</table>
These MFR goals and objectives are being presented together with proposed performance indicators with the budget requests for FY 2001 and will undoubtedly be revised and refined for subsequent fiscal years. They are included here so that we may begin the process of matching these to our strategic objectives and in order to remind us of our responsibilities for accountability.

**MFR Performance Indicators**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Baseline</th>
<th>2001</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inputs:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faculty salary as percentile of AAUP</td>
<td>1999</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td><strong>Outputs:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teachers participating in teacher education program</td>
<td>1999</td>
<td>24</td>
<td>30</td>
</tr>
<tr>
<td><strong>Quality:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students participating in environmental education program</td>
<td>1999</td>
<td>12,000</td>
<td>12,000</td>
</tr>
<tr>
<td>Entering graduate student GRE scores</td>
<td>1999</td>
<td>605</td>
<td>615</td>
</tr>
<tr>
<td>National research council ranking of MEES program</td>
<td>1993</td>
<td>10</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Outcomes:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total sponsored research award dollars: two year average ($ millions)</td>
<td>1999</td>
<td>$14</td>
<td>$15</td>
</tr>
<tr>
<td>Research awarded per faculty member (percentile per Carnegie I)</td>
<td>1997</td>
<td>75</td>
<td>80</td>
</tr>
<tr>
<td>Ratio of federal grant funding growth as compared to total federal grant growth</td>
<td>1997</td>
<td>&gt;1.0</td>
<td>&gt;1.0</td>
</tr>
<tr>
<td>Total private support ($ in millions)</td>
<td>1999</td>
<td>$0.8</td>
<td>$1.5</td>
</tr>
</tbody>
</table>

We feel, however, that these goals, objectives and indicators—limited to those that can be expressed in quantitative terms—do not fully capture our contributions to the UMCES mission, the University System of Maryland, the State and nation. We will work over the next few years to develop a more comprehensive evaluation method, most probably involving an external evaluation panel of eminent individuals, which would be implemented to serve both for accountability to our sponsors in the University System and state government and as a basis of our next strategic plan, five years hence.
References


### APPENDIX 1

**Toward 2000 Score Card**

The 1994 strategic plan for the Center for Environmental and Estuarine Studies (now the University of Maryland Center for Environmental Science), *Toward 2000: Meeting Opportunities and Challenges for Environmental Science*, listed a number of specific objectives to be accomplished during the 1990s. In the following table, these objectives are listed and the present status of accomplishment (new faculty members in the cases where new hires were identified) indicated.

<table>
<thead>
<tr>
<th>Area</th>
<th>Strategic Objective</th>
<th>Present Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natural Resources Ecology (new faculty)</strong></td>
<td>Fishery scientist (CBL)</td>
<td>Dave Secor</td>
</tr>
<tr>
<td></td>
<td>Community ecologist (CBL)</td>
<td>Roberta Marinelli</td>
</tr>
<tr>
<td></td>
<td>Wetlands/SAV ecologist (HPL)</td>
<td>Eva Maria Koch</td>
</tr>
<tr>
<td><strong>Oceanography (new faculty)</strong></td>
<td>Physical oceanographer (HPL)</td>
<td>Leonard Walstad</td>
</tr>
<tr>
<td></td>
<td>Phytoplankton dynamist (HPL)</td>
<td>Paul del Giorgio</td>
</tr>
<tr>
<td></td>
<td>Fisheries oceanographer (CBL)</td>
<td>Tom Miller, New search</td>
</tr>
<tr>
<td><strong>Chemistry &amp; Toxicology (new faculty)</strong></td>
<td>Limnologist (chemistry) (AL)</td>
<td>Search underway</td>
</tr>
<tr>
<td></td>
<td>Metal/radionuclide (CBL)</td>
<td>Rob Mason, Ron Siefert</td>
</tr>
<tr>
<td></td>
<td>Toxicologist (CBL)</td>
<td>Mary Haasch; Chris Rowe</td>
</tr>
<tr>
<td><strong>Landscape Ecology of Chesapeake Watershed (new faculty)</strong></td>
<td>Landscape ecologist (AL)</td>
<td>Bob Gardner</td>
</tr>
<tr>
<td></td>
<td>Hydrologist (AL)</td>
<td>Keith Eshleman</td>
</tr>
<tr>
<td></td>
<td>Atmospheric scientist (AL)</td>
<td>Mark Castro</td>
</tr>
<tr>
<td></td>
<td>Large-scale ecol. Modeller (AL)</td>
<td>Phil Townsend</td>
</tr>
<tr>
<td></td>
<td>Soil ecologist (AL)</td>
<td>Bill Currie</td>
</tr>
<tr>
<td><strong>Regional Environmental Change at the Land-Ocean Interface</strong></td>
<td>Chesapeake Bay Observing System</td>
<td>Slow expansion</td>
</tr>
<tr>
<td></td>
<td>Remote sensing</td>
<td>Considerable program expansion</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>Remote, <em>in-situ</em> sensing, numerical modeling, GIS integrated at HPL; ScanFish, C-GOOS leadership; CISNet site</td>
</tr>
<tr>
<td></td>
<td>New faculty in:</td>
<td>Raleigh Hood</td>
</tr>
<tr>
<td></td>
<td>Optical oceanography (AL)</td>
<td>Phil Townsend</td>
</tr>
<tr>
<td></td>
<td>Landscape imagery (AL)</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Instrument engineering</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Ecosystem modeling</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Statistics</td>
<td>None</td>
</tr>
<tr>
<td><strong>Graduate Education</strong></td>
<td>Develop entry level &amp; advanced courses, flexible curricula</td>
<td>Dramatic increase in UMCES taught courses. Areas of Specialization functional</td>
</tr>
<tr>
<td></td>
<td>Achieve a fair share of tuition revenues applied to meet costs and improve training</td>
<td>&gt;$150 K/yr now received and applied to enhance MEES program</td>
</tr>
<tr>
<td></td>
<td>Open career opportunities for minorities in environmental sciences</td>
<td>Little progress</td>
</tr>
<tr>
<td><strong>Undergraduate Education</strong></td>
<td>Expand summer intern program</td>
<td>Expanded (30 students in ‘99)</td>
</tr>
<tr>
<td></td>
<td>Workshops for USM undergraduate teaching faculty</td>
<td>Not begun</td>
</tr>
<tr>
<td>Area</td>
<td>Strategic Objective</td>
<td>Present Status</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Professional Development</td>
<td>Continuing education programs for environmental science professionals</td>
<td>Modest progress: 3 School of Public Affairs courses on ecosystem management taught</td>
</tr>
<tr>
<td></td>
<td>Certificate program in ecological economics</td>
<td>Approved and in place</td>
</tr>
<tr>
<td>Service and Outreach</td>
<td>Periodic lab directors-state managers meetings</td>
<td>Not regular, but cooperation with agencies improved (e.g. DNR Fisheries Institute, Toxicology Cooperative Agreement)</td>
</tr>
<tr>
<td></td>
<td>Support and reward faculty application</td>
<td>More emphasis in annual and promotion reviews</td>
</tr>
<tr>
<td></td>
<td>Participate in CBP, MSGC and CEPP</td>
<td>CBP participation increased and more effective, Center now responsible for MSGC</td>
</tr>
<tr>
<td></td>
<td>Work with Cooperative Extension to meet advisory service needs</td>
<td>Extension Agent at CBL: broader cooperation being discussed</td>
</tr>
<tr>
<td></td>
<td>Strengthen regional educational programs</td>
<td>Modest improvements</td>
</tr>
<tr>
<td></td>
<td>Coordinate statewide environmental education programs</td>
<td>Not accomplished</td>
</tr>
<tr>
<td>Administrative Efficiency</td>
<td>Interlaboratory communications network</td>
<td>Incremental improvements</td>
</tr>
<tr>
<td></td>
<td>Participate in USM communications and administrative computing</td>
<td>Key role in UMATS, admin. computing delayed</td>
</tr>
<tr>
<td></td>
<td>Use USM Financial Management Information System</td>
<td>FMIS delayed</td>
</tr>
<tr>
<td></td>
<td>Streamline internal administrative services</td>
<td>Incremental improvements, limited by above</td>
</tr>
<tr>
<td>Maintenance and Renewal of Facilities</td>
<td>Retain maintenance staff positions</td>
<td>Retained and expanded in technical areas</td>
</tr>
<tr>
<td></td>
<td>Restore facilities renewal budget</td>
<td>Now provided through capital budget</td>
</tr>
<tr>
<td></td>
<td>Direct indirect cost recoveries to maintenance &amp; renewal</td>
<td>Matter of practicality because no state budget increases for operating</td>
</tr>
<tr>
<td></td>
<td>Request increase in state funds</td>
<td>Significant funds from USM capital appropriation</td>
</tr>
<tr>
<td>Research Support Services</td>
<td>Expand research support services as reimbursable cost centers</td>
<td>Mostly accomplished</td>
</tr>
<tr>
<td>Construction</td>
<td>Appalachian Laboratory</td>
<td>Completed Dec. '99</td>
</tr>
<tr>
<td></td>
<td>Experimental Ecology &amp; Seafood Products (HPL)</td>
<td>Now Aquaculture &amp; Restoration Ecology: FY 00 planning proposed by Regents &amp; Gov.</td>
</tr>
<tr>
<td></td>
<td>Solomons property acquisition</td>
<td>Acquired</td>
</tr>
<tr>
<td></td>
<td>Library &amp; Info. Sciences</td>
<td>Delayed into next decade</td>
</tr>
<tr>
<td></td>
<td>Upgrades: access, roads, etc.</td>
<td>Largely completed</td>
</tr>
<tr>
<td>Area</td>
<td>Strategic Objective</td>
<td>Present Status</td>
</tr>
<tr>
<td>-------------------</td>
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<tr>
<td>Vessels</td>
<td>Replace <em>Aquarius &amp; Orion</em> in cooperation with DNR &amp; MDE</td>
<td>Discussions, but no progress</td>
</tr>
<tr>
<td></td>
<td>Pursue new regional coastal oceanographic research vessel &amp; upgrade support facilities</td>
<td>New vessel on hold pending UDel upgrade of <em>Cape Henlopen</em>; new RFO building in planning</td>
</tr>
<tr>
<td>Culture</td>
<td>Expectations &amp; evaluations of faculty based on discovery, integration, application &amp; teaching</td>
<td>No formal change in ART policies; modest progress evidenced in reviews</td>
</tr>
<tr>
<td></td>
<td>Focus recruitment on younger scientists</td>
<td>14 of 17 hires at Assistant Professor level</td>
</tr>
<tr>
<td></td>
<td>Attract &amp; advance more women scientists</td>
<td>3 new female faculty, 3 promotions to Professor</td>
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<tr>
<td></td>
<td>Nurture development of minority students &amp; staff</td>
<td>Little progress</td>
</tr>
<tr>
<td></td>
<td>Training and retraining of staff &amp; faculty</td>
<td>Considerable progress with staff, less so for faculty</td>
</tr>
<tr>
<td></td>
<td>Day care &amp; liberal family leave</td>
<td>HPL day care sustained, family leave is liberal but informal</td>
</tr>
<tr>
<td></td>
<td>Improve quality of intellectual &amp; social life</td>
<td>Expanded seminars, instituted internal series at HPL, scholars in residence</td>
</tr>
<tr>
<td>Financial Resources</td>
<td>State General Funds $10 M in FY99 ($ 7.4 M in FY94)</td>
<td>$9.7 million for FY99</td>
</tr>
<tr>
<td></td>
<td>Sponsored research $15 M in FY99 ($ 8.7 M in FY94)</td>
<td>$13 million expenditures and $17 million new awards in FY99</td>
</tr>
</tbody>
</table>
APPENDIX 2

Partnership Dialog
September 1, 1998
Summary of Key Points

PARTICIPANTS

Partners: Maryland Department of Natural Resources (Sarah Taylor-Rogers, Paul Massicot, Carolyn Watson); Maryland Department of the Environment (Mike Haire); EPA Chesapeake Bay Program Office (Bill Matuszeski, Rich Batiuk); National Oceanic and Atmospheric Administration (Don Scavia); Maryland Cooperative Extension (James Wade); Maryland Sea Grant College (Jon Kramer); Chesapeake Research Consortium (Grant Gross); Alliance for the Chesapeake Bay (Fran Flanigan); and Chesapeake Bay Foundation (Mike Hirshfield)

Center Faculty, Administration, Staff: Wayne Bell, Don Boesch, Alexis Henderson, Dave Nemazie, Steve Wilson (Center Administration); Keith Eshleman, Bob Gardner, John Hoogland, Lou Pitelka (Appalachian Laboratory); Walt Boynton, Bob Costanza, Rodger Harvey, Ken Tenore, Dave Wright (Chesapeake Biological Laboratory); Paul del Giorgio, Larry Harding, Tom Malone, Diane Stoecker, Leonard Walstad (Horn Point Laboratory)

OBJECTIVES

In the course of a strategic planning retreat held at the Donaldson Brown Center, senior representatives of state and regional agencies and organizations which work closely with the University of Maryland Center for Environmental Science participated in a Partnership Dialog with Center faculty, administration and staff members. These organizations include sponsors of UMCES research, regulatory and management agencies that base decisions on scientific information produced by the Center, non-governmental organizations involved in public interest representation, education or interinstitutional science. While UMCES maintains additional partnerships at the national and international level, the organizations represented in this dialogue are those most important in terms of research and science application within Maryland and the Chesapeake Bay region.

The representatives of partner organizations attending were asked to describe what the Center does well, what they think it can do better, and what are the important questions that the Center should focus on in the 21st Century. President Boesch, who moderated the dialogue, also mentioned that consensus had already formed during the retreat on the need for both a “synthesis center” to integrate multidisciplinary scientific information and a more concerted program of public outreach and sought comments on these.
FEEDBACK FROM PARTNERS

The points of consensus, or at least common themes, articulated by the partners are summarized below for the three main questions.

What the Center Does Well

1. UMCES’ greatest strength is the high quality of its scientific research, both applied and basic, and its rare capability to conduct truly interdisciplinary science.

2. The Center’s scientific focus on the Chesapeake Bay and its watershed has produced results which have helped form effective environmental and resource policies in the region. At the same time, its extraregional activities have made important contributions to the Nation, made it a leader in coastal science and, thereby, have earned a reputation that lends credibility on a regional level.

3. The Center’s thrust in landscape ecology of the Chesapeake watershed is addressing a major need and places the Center in the unique position of integrating, within one institution, the ecology of the watershed and the ecology of the Bay.

4. In general, the Center’s faculty and administration have been responsive to partners’ needs for scientific information and advice. In this regard, the Center is seen as more engaged in Chesapeake Bay management issues than comparable institutions. The Cambridge Consensus regarding the linkage between nutrients and *Pfiesteria*, habitat requirements for submersed aquatic vegetation, and concepts of multispecies fisheries management were offered as examples of the Center’s leadership in the timely application of science to emerging issues and responsiveness to partner requests for information and assistance.

What the Center Can Do Better

1. While recognizing that good science is the fundamental key to success, the Center should work more closely and communicate better with its partners. Ways to improve these relationships beyond that of research sponsor-performer include: greater emphasis on synthesis and interpretation of data (toward that end the concept of a synthesis center was warmly received); increased access to the Center’s data and information via the Internet and the Chesapeake Information Management System; short-term assignments of faculty and graduate students to work in agencies and agency scientists to work in Center laboratories; incorporating partners in research proposals, where appropriate; and more routine strategic and tactical meetings with agency managers and science translators.

2. Increase its efforts in identification and development of solutions of environmental problems. To what degree can/should environmental scientists operate in the manner of physicians by making both diagnoses and prescriptions?

3. Focus more effort on the analysis and interpretation of the wealth of monitoring data being generated for the Chesapeake Bay and its watershed. Commit to a more active role in continued refinements of the suite of ecosystem models used in Chesapeake Bay regional management.
4. More effectively integrate its efforts with those of other programs and capabilities in the University System of Maryland, including the Maryland Sea Grant College, Maryland Cooperative Extension, and social and policy sciences.

5. Expand its base of sponsors and partners to state and federal agencies involved in agriculture, transportation, economic development and defense.

6. Contribute more effectively to educational outreach to the “next tier” of Maryland citizens, beyond those actively involved in or presently aware of issues of environmental protection and resource management. In general, play a greater role in helping citizens and decisionmakers understand the long-term context--the “natural history”--of current environmental issues.

Issues for the 21st Century

1. Fully integrated science addressing multi-media (water, land, and air) questions, using the movement of water and the consequences to the Chesapeake Bay as focusing mechanisms.

2. Science to inform the effective management of population growth and development, including landscape and land use changes, maintenance of loading “caps,” and mitigation of the effects of climate change.

3. Quantification of the cumulative and sublethal effects of toxic materials, operating in conjunction with other stresses, throughout the watershed and in coastal waters.

4. Science to support the effective management of exploited living resources in an ecosystem context, including multi-species stock assessments, and an understanding of effects of environmental quality and variability on these resources.