Sustainable Architecture on the North Carolina Coast:
The Ocean Science Teaching Center
(Beaufort, NC)

by

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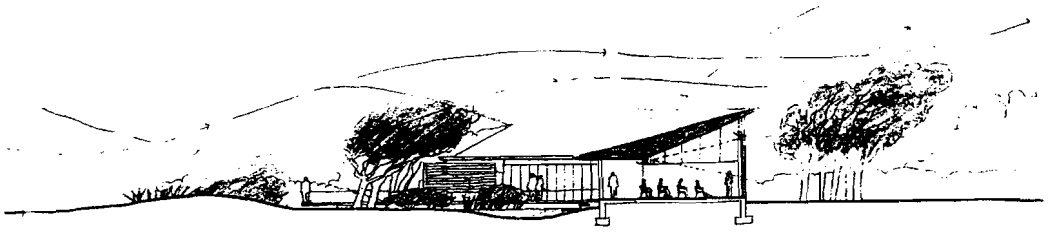

Then take me disappearin' through the smoke rings of my mind, Down the foggy ruins of time, far past the frozen leaves, The haunted, frightened trees, out to the windy beach, Far from the twisted reach of crazy sorrow. Yes, to dance beneath the diamond sky with one hand waving free, Silhouetted by the sea, circled by the circus sands, With all memory and fate driven deep beneath the waves, Let me forget about today until tomorrow.

Abstract

The Ocean Science Teaching Center (OSTC) at the Duke University Marine Laboratory (DUML) in Beaufort, NC will demonstrate the feasibility of sustainable architecture in coastal North Carolina. In the early 1990s, Dr. Joe Ramus proposed building an additional lecture hall to alleviate the stress that increased enrollment and technical demands had placed on DUML's teaching spaces. Designed according to the most recent version of the US Green Building Council's LEED rating system, this gold labeled Leadership in Energy and Environmental Design new commercial construction will serve as a benchmark for future sustainable construction at the Marine Lab.

The US Green Building Council forms a national consensus for sustainable building, design, and maintenance standards. The LEED rating systems create frameworks for measuring progress, assessing building performance, and tracking building goals. The LEED rating system for new commercial constructions and major renovations is broken down into six sections: sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental air quality, and innovation in design. While constructing LEED certified buildings requires more time and money, each new construction makes the process less expensive and less time consuming. The Ocean Science Teaching Center will serve as an example of sustainable architecture on the North Carolina coast, demonstrating water and energy saving devises. Coastal residents, architects, and contractors can look at the building's plans for sediment and pollution control as well as its regional and recycled material selections when planning future buildings along the coast.

Introduction

The Ocean Science Teaching Center, currently under construction at the Duke University Marine Laboratory in Beaufort, NC, will demonstrate the feasibility of sustainable architecture in coastal North Carolina. This state of the art facility, which will house a laboratory, a lecture hall, and a commons space, has been designed according to the most recent version of the United States Green Building Council's Leadership in Energy and Environmental Design rating system for New Commercial Constructions and Major Renovations, referred to here as LEED or LEED-NC. The rating system stimulates social and ecological thinking in the field of modern academic architecture, which is so often ruled by economics.

This preliminary documentation of the Ocean Science Teaching Center focuses on the project's development—from 1989 to present—and systems—based on the LEED-NC version 2.2 Rating System Checklist (See Appendix I for Checklist). The project development section includes a brief history of development on the Duke Marine Lab's campus, an explanation of the intent behind the Ocean Science Teaching Center, and an outline of the human ecology of the building process. The analysis of the OSTC's systems introduces a discussion of sustainable architecture in a biophysical environment subject to hurricanes, erosion, and contaminated stormwater runoff. This documentation precedes a more in depth study of the building's history and systems that will focus on the public processes that were the foundation of its development.

1 Project Development

1.1 History of Development on Pivers Island

In 1938, Dr. A.S. Pearse and his colleagues from Duke University established the Duke University Marine Laboratory (DUML) on the southern half of Pivers Island, across the channel from the historic town of Beaufort, NC (See Appendix II for map of area). The Beaufort campus "served admirably" as a haven for summertime visitors gathered to teach and learn about the natural history of coastal waters (Ramus 1993). In a statement describing the traditional summer experience at the lab, Dr. Joe Ramus, the Marine Lab's director from 1989 to 1998, wrote:

> Imagine upperclassmen and graduate students, in summer duty clothing, poring over microscopes to learn the natural history of marine biota. Sand covered the floors of the teaching labs and seawater splashed from continuous flow holding tanks (Ramus 1993).

The Marine Lab's "vision of the future of environmental education and research" spurred a shift from the traditional study of marine science (Ramus 1993). It provided the faculty and the motivation for a new paradigm in the traditional study of marine science: embracing "experiential learning" to emphasize education and stewardship in coastal and marine ecosystems (Ramus 1993).

Since its establishment nearly 70 years ago, the demands on the Marine Lab's campus have increased substantially. In its formative years, the faculty and students shared research space with the Bureau of Commercial Fisheries laboratory—located on the northern half of the island. In 1938, when DUML's summertime visitors outgrew this shared space, they moved to what is still referred to as the "quad," a cluster of nine wood frame cottages built to house all lab activities (See Appendix III for image of Pivers Island). In 1963, the Sandeen Lab, a building dedicated primarily to undergraduate

instruction, was constructed on the island to increase teaching space. The building was named after Muriel Sandeen, a Professor of Zoology and a marine biologist, who was recently deceased. In 1979, a fire broke out during a snow storm and destroyed the Sandeen Lab, which was never replaced. In the late 1960s and early 1970s, the Bookhout Research Laboratory and the I. E. Grey Library and Auditorium were constructed. The island's most recent addition is a large maintenance building.

The Beaufort campus continued to grow around these new structures and, by 1972, it was a year-round facility for research, undergraduate, and graduate programs. It currently provides teaching programs throughout the year to undergraduate, professional, and doctoral students, as well as the general public.

1.2 The Intent of the Ocean Science Teaching Center

By the early 1990s, every classroom at the Duke Marine Lab was stretched to capacity and, according to Dr. Ramus, the pressure on space and budget was intense. Overflow dormitory space was available in the town of Beaufort, but teaching space was "woefully lacking" and "oversubscribed." Because space was so limited, the administration was faced with turning away student groups. Dr. Ramus wrote, "Unless the demands are met, our students will be inadequately trained.... there is no alternative but to modernize and return to parity the teaching facilities on the Beaufort campus." (Ramus 1992)

In April 1991, Dr. Ramus presented to the Duke University Marine Laboratory Advisory Board a plan for replacing the Sandeen Building with a 3000 plus square foot building, temporarily named the Ocean Science Teaching Center (OSTC). Designed as a response to the demands of modern environmental education, the OSTC was designed to

relieve the pressure on classroom space through replacement and renovation, but not to increase the Marine Lab's student enrollment or scheduled events. In a draft plan, Dr. Ramus stated that the OSTC's mission would be to establish an outstanding facility for teaching and research in the ocean sciences. The building's rationale states:

> The field environment for Ocean Science Teaching and Research are the world's oceans, lakes, rivers, and estuaries. Our understanding of these comes in large part from detailed analyses and experiments conducted in controlled laboratory conditions. We require modern teaching and research facilities to improve our ability to address global ocean science issues that require state of the art instrumentation in the areas of geological, chemical, biochemical, and molecular biology. (Ramus 1993)

The OSTC's original objective was to exemplify our concern for the environment by modernizing the facilities for teaching the fundamental geological, cellular, and molecular aspects of the ocean sciences. At the time of its conception, no building "dedicated to the rigorous technical demands of instruction in the environmental sciences" existed on the Beaufort campus (Ramus 1993).

From the beginning, this high priority structure was proposed to complement the design of the existing buildings on Pivers Island. (See Appendix IV for original drawing). Designed with a separate lecture hall and teaching laboratory—each with its own service module—the building will accommodate a total of 50 students for simultaneous class sessions.

The laboratory was originally planned to be equipped with instruments for ecotoxicology with such analytical chemistry instruments as a liquid scintillation counter, a spectrophotometer, analytical and preparative centrifuges, and low temperature freezers. Additional equipment would include tissue culture facilities and biohazards containment facilities for radioisotopes, hazardous chemicals, viruses, and bacteria.

The service modules were originally planned to include a prep room, a meteorological data center, a computer room, a cold room, and an equipment storage room compatible with "solid state electronics instrumentation, biohazards, and toxic chemicals" (Ramus 1993). In these modules, students and researchers would have staging areas from which to prepare and analyze data collected on cruises on the newly acquired *RV Susan Hudson.*

A complete list of equipment for the lecture hall, laboratory, and service modules is still yet to be released.

1.3 Nicholas School of the Environment and Earth Sciences

The 1991 inauguration of the Nicholas School of the Environment and Earth Sciences initiated a new era of education and research in marine and terrestrial ecosystems, earth sciences, and human-environment interactions at Duke University (Ramus 1993). The Nicholas School was founded on seven core principles:

- interdisciplinary collaboration,
- objective and quantitative approaches to environmental issues,
- sustainable use of natural resources,
- environmental education,
- a systems perspective,
- a global perspective, and above all,
- excellence in endeavor.

The School's current mission is "education, research, and service to understand basic earth and environmental processes, to understand human behavior related to the environment, and to inform society about the conservation and enhancement of the environment and its natural resources for future generations" (Nicholas School).

As a world class research and teaching facility, the Marine Lab was uniquely positioned to lead the way in solving complex environmental problems in a rapidly

changing world (Ramus 1993). In 1991, however, Joe Ramus wrote that the lab must improve its facilities and increase its resources to achieve the Nicholas School's mission. He recognized a need for new training initiatives—specifically core curricula in basic ocean processes, marine environment, and human health sciences—for advanced undergraduate and beginning professional students. These new curricula would serve the proposed Arts and Sciences degree in environmental science, the professional Masters of Environmental Management degree, and the proposed graduate degree in ocean sciences.

1.4 Sustainable Architecture

In 1910, President Theodore Roosevelt stated,

> I recognize the right and duty of this generation to develop and use the natural resources of our land; but I do not recognize the right to waste them, or to rob, by wasteful use, the generations that come after us (qtd. in Gissen 185).

Almost 80 years later, the United Nations' Commission on Environment and Development echoed this notion of stewardship in a document entitled "Our Common Future." In this document, which is also known as the Brundtland Report, the UN defines sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations). The Brundtland Report responded to growing concerns over economic, social, and environmental problems resulting from the increase in global development.

Roosevelt's reasoning translates into today's field of sustainable architecture, which merges the two distinct disciplines of architecture and applied ecology. Sustainable architecture, "aimed at keeping the engines of commerce humming and people employed, while reducing resource consumption, energy use, toxic emissions, and waste" addresses social, economic, and environmental well being (Gissen 8). It

incorporates the most advanced technologies, such as wind or solar energy, into the most proven ancient building approaches to create elegant, modern architecture (Miller 35). One of the most straight forward approaches to sustainable architecture is the pursuit of the vernacular, or the local building patterns that existed in an area in the centuries before electricity—specifically air conditioning. In eastern North Carolina, for example, homes have high ceilings and porches to capture cool air and shading systems to keep out the sun during the height of summer. By combining local knowledge with modern materials and energy systems, architects are able to encourage healthy interactions with the environment and reconcile the demands of an artificial environment with a reverence for the natural materials and spaces in which humans thrive (Gissen 147).

2 Human Ecology

The Ocean Science Teaching Center's design is the result of an integrated approach—called the charrette process—that encouraged participation from the design team and the building's future occupants. The human ecology model presented below shows the connections between the different parties involved in this process.

2.1 Biophysical Environment

The geological formation of the North Carolina coast changes dramatically between the North Coastal Province and the South Coastal Province. Pivers Island is located in the Southern Coastal Province (SCP), which stretches from Cape Lookout National Seashore to the South Carolina coast. The "short, stubby" barrier islands of the SCP have older, harder rocks and narrow back barrier estuaries. They have an average

slope of 3 feet per mile and there are more than 18 inlets splitting the islands. This area is vulnerable to hurricanes, northeasters, erosion, and sun and wind exposure.

2.2 Human Constituents

Development activities along the coast do not only have an effect on the biophysical environment; they also influence the lives of the people who live and work along the coast. In the case of the Ocean Science Teaching Center, the human constituents are those stakeholders whose lives will change as either a direct or indirect result of the building's construction and operation. Its primary user groups will consist of the students, faculty, staff, and members of the public who already benefit from the island's facilities. We add to that the Nicholas School Deans and the Duke Marine Lab directors who have been working toward the building's construction for more than 15 years, and the donors, whose contributions allowed its design and construction to take place.

2.2.1 Students

The students using the Ocean Science Teaching Center will include PhD and Masters of Environmental Management candidates, undergraduates from Duke and other universities, visiting and teleconferenced classes from Duke's main campus and other universities, and middle school students participating in the Talent Identification Program (TIP). Students are present on campus year round and the number of students attending the Duke Marine Lab varies between the fall, spring, and summer sessions.

The PhD program at the Duke Marine Lab is exclusive and small—only three to four students are admitted each year. During the 2005-2006 academic year, when the building was under construction, there were 29 candidates working at the Marine Lab

toward doctoral degrees through five programs: Environment- Division of Coastal Systems Science and Policy, Biology, Cell Biology, Environment- Division of Earth and Ocean Sciences, and the University Program in Ecology.

As many as 30 students pursuing a Masters of Environmental Management with a focus on the coast spend their first year on the main Duke campus in Durham and their second year in at the Marine Lab.

The multi-disciplinary undergraduate curriculum draws, on average, 30 students in the fall semester, 25 in the spring semester, and a total of 120 students during the two summer sessions. This program focuses on "high-quality student-professor interaction and internationalization of the curriculum" (Orbach 2004). The spring semester undergraduate students either enroll in the Beaufort-2-Bermuda program—in which they spend seven weeks at the Duke Marine Lab and seven weeks at the Bermuda Biological Station for Research—or take classes in four blocks with the option to travel abroad on field trips for classes.

2.2.2 Faculty

The Duke Marine Laboratory's faculty represents the disciplines of coastal environmental management and integrated marine conservation to oceanography, marine biology, marine biomedicine and marine biotechnology (Duke Marine Laboratory).

2.2.3 Directors

Dr. Joe Ramus was Director of the Duke Marine Lab between 1989 and 1998. He originally presented the idea of building the Ocean Science Teaching Center in the early 1990s as a response to the demands that modern environmental education had placed on

the Marine Lab. He planned that the building would relieve the pressure on classroom space through replacement and renovation.

Dr. Mike Orbach replaced Dr. Ramus as director in 1998 and was reappointed in 2001 to "support [Nicholas Schools Dean Schlesinger's] basic philosophy of interdisciplinary research" (Duke Environment). Orbach continued to fundraise and coordinate the parties involved in the building's design and construction until it came to fruition, stating, "We don't want to be bigger, but we want to be better. There's a sense of scale we want to preserve here" (Duke Environment).

2.2.4 Deans

Both Dr. Norman L. Christensen and Dr. William Schlesinger have been Nicholas School Deans during the development and construction phases of the Ocean Science Teaching Center.

2.2.5 Donors

The OSTC's original construction cost was estimated to be $1.5 million. In the early 1990s, Dr. Joe Ramus raised just over $900,000.

In the late 1990s, it became clear that construction costs had risen to the point where the total cost of the center would be over $2 million. Dr. Mike Orbach, the new Marine Lab director, began to search for the remainder of the funds. To freshen donor's interests and in response to student and faculty interests, the OSTC was reconceptualized as a "green building."

The new design coordinated well with the interests of Mr. Randy Repass, a graduate of Duke University's engineering department and founder of West Marine, Inc., a boating supply company. Repass' own home in California's Monterey Bay works off

of the electric grid with photovoltaics, a battery bank, and a rarely-used generator. Although he had no history of philanthropy, Repass pledged a $1 million gift to the Ocean Science Teaching Center.

Even with a naming donor and a new "green" design in place, the OSTC's final cost escalated by approximately 30% between the time the design was completed and the project was contracted. This meant that the OSTC lost some of its sustainable elements, such as the rainwater harvesting cisterns and the green roof, but the building is designed so that these elements and others can be included once funding allows.

2.3 Scientific Community

In the case of the Ocean Science Teaching Center, the design team—including the project manager, the architect, the contractor, the LEED certified professional, and the building commissioner—is the scientific community. It is a different kind of science than we are used to here at the Marine Lab. It is critical to the success of the project that the team coordinates all exposed components of the project, including, but not limited to, structural, plumbing, mechanical, and electrical work. All trades and all professions are encouraged to interact as much as possible to complete the project successfully. Monthly team meetings make this coordination possible. With this coordination, problems can be fixed quickly and smoothly. This is a challenge, because there are so many people involved with the building, some of them coming from Raleigh.

2.3.1 Owner Contact (Project Manager)

The owner contact addresses any correspondence between the architect and building owner and between the architect and the contractor. He is also responsible for locating the utilities for the site and hiring an agency to test soils, concrete, and steel.

Duke provided soil data to the contractor and architect and Carolina Engineers distributed the results of the soil, concrete, and steel tests to the construction services. In March 2006, the owner contact identified the commissioning agent for the OSTC project. Throughout the project, the owner contact and the architect review the job for completeness.

2.3.2 Frank Harmon, Architect

Frank Harmon, an architect based out of Raleigh, NC, opened his firm in 1981, when few clients considered the environmental impacts of their buildings (Stradling). He now works green components into every one of his designs. Harmon began his education at North Carolina State University and completed it at the Architectural Association School of Architecture of London, England. He has received awards from Time Magazine; the North Carolina Chapter American Institute of Architects; the South Atlantic Region of the American Institute of Architects; Raleigh, Durham, and Chapel Hill Sections, American Institute of Architects; Triangle Architecture Awards; Architectural Record; and the North Carolina Museum of Art. His work has also been published in two books: *The New American Cottage* and *Designing the New Museum.*

Inspired by a Victorian mansion from his childhood in Greensboro, Harmon uses vernacular building techniques "to direct sunlight and shade to keep buildings cooler in the summer and naturally lit all year" (Stradling). Harmon has emerged as a leader in the growing field of sustainable building in North Carolina. He designs with local materials and his buildings blend in with or complement the surrounding landscape—or seascape in the case of the OSTC. He is also working on the DELTA SmartHouse for Duke University's Pratt School of Design. Perhaps because of his experience as an associate

professor at North Carolina State University's School of Design, he is skilled in encouraging participation of his buildings' administration and future occupants.

It is the architect's job to administer the contract documents. Under no circumstances can the building design change or deviate from contract documents without Frank Harmon's approval. If there are any questions or discrepancies, the design team will be available to clarify. The Architect and construction coordinator or project manager review the drawings once a month.

2.3.3 Joyce and Associates Construction, Inc., Contractor

Because of the higher level of skill required for sustainable buildings, Joyce and Associates has a chance to showcase its talent through the Ocean Science Teaching Center, the first "green" building that they have constructed. The contractors provide building permits, trade permits, fire permits, and a schedule of values for the architect and owner. The contractor communicates with the building's owner through the architect and keeps a record set of drawings on site for building purposes. Joyce and Associates approves all submittals before they are given to the architect. They have to prepare and keep current a schedule of submittals, providing a copy to the architect and owner on a monthly basis unless designated otherwise. It is important that the general contractor submit the LEED requirements with the normal submittals.

2.3.4 Consider Design, Engineers

Consider Design is responsible for the design of the mechanical, plumbing, and electrical work for the OSTC. The company is responsible for providing LEED calculators to Joyce and Associates. The Building Systems Engineer, Isaac Panzarella, is

also the project's LEED Consultant. He advises the team and guides its members through the process of design and certification of credits for LEED.

2.3.5 Commissioner

The commissioning agent is responsible for testing and observing the construction including mechanical systems in the building and reporting on them. (See LEED EA-R1 for more information)

2.4 Public Policy and Management Organizations

2.4.1 United States Green Building Council

The United States Green Building Council (USGBC), the United States' leading organization on environmental building matters, forms a national consensus for sustainable building, design, and maintenance standards. As a national coalition of building industry leaders, the USGBC's mission is to promote a new generation of high performance buildings that are "environmentally responsible, profitable, and healthy" inside and out (US Green Building Council). Council members represent all facets of the building industry—including contractors and builders, building product manufacturers, and building owners, managers, users, and brokers—and come from diverse backgrounds—such as financial and insurance firms, nonprofit organizations, universities, and research institutions. Its members form alliances with key industry and government members to "transform the built environment" through international conferences, policy guidance, and educational and marketing tools that support the adoption of sustainable building techniques (US Green Building Council).

To achieve its mission, the USGBC encourages buildings that work with nature, rather than against it, stating, "no longer is it acceptable to inhabit buildings and cities

that make little or no reference to environmental issues or are patently bad for our health and well-being" (Pearson 12). The newly emerging market for sustainable architecture encourages the blending of "gentle architecture" with ecosystem concepts in order to live in harmony with nature. To accomplish this, the Council promotes three broad solutions: reducing daily energy consumption, using renewable materials, and exploiting natural ventilation and illumination. It focuses its efforts on large-scale urban development, where sustainable building has the largest possible impact (Gissen 6).

The USGBC enhances the resources available for its members to make informed decisions when adopting green building practices. Its "unique perspective and collective power" culminated in the development of the Leadership in Energy and Environment Design, or LEED, rating systems (US Green Building Council).

2.4.2 Leadership in Energy and Environment Design

The LEED rating systems "adhere with USGBC policy and procedures guiding development and maintenance of building systems" (US Green Building Council). There are currently seven individual systems:

- LEED-NC: New commercial construction and major renovation projects,
- LEED-ED: Existing building operations,
- LEED-CI: Commercial interiors projects,
- LEED-CS: Core and shell projects,
- LEED-H: Homes,
- LEED-ND: Neighborhood development, and
- LEED Application Guides for Retail, Multiple Buildings/Campuses, Schools, Healthcare, Laboratories, and Lodging.

The LEED rating systems are national standards that create frameworks for measuring progress, assessing building performance, and tracking building goals—differentiating "definitely" achievable goals from "possibly" achievable goals (US Green Building Council). Created to transform the building market by establishing a standard

metric for "green building" and promoting whole-design practices, the rating systems stimulate green competition by recognizing environmental leadership in the building industry and raising consumer awareness of green building benefits (US Green Building Council). Based on a holistic, systematic analysis LEED quantifies the differences in sustainability between buildings from the initial stages of the projects through building commissioning and operation. Rating is voluntary, consensus-based, market-driven, and based on accepted energy and environmental principles that balance established practices with modern technologies (US Green Building Council). The systems are reworked every two years. The latest version of LEED for New Constructions, or LEED-NC, was published in October 2005.

In addition to the seven rating systems, LEED offers project certification, professional accreditation, training, and other practical resources.

2.4.2.1 Certification

US Green Building certification distinguishes buildings "committed to sustainability by meeting the highest performance standards" (US Green Building Council). To become certified as a green building under the USGBC guidelines, a building must register during the early phases of the project, document the achievement of all prerequisites, and satisfy a minimum of 26 points (US Green Building Council).

The first step toward LEED certification is registering the project on the LEED website. Second, the project team, with the help of a LEED accredited professional, must fulfill the documentation and calculations necessary to complete the prerequisites. The LEED accredited professional is the project's contact and the team member responsible for coordinating the LEED process. After technical reviews, USGBC decides whether or

not to award certification to the project. If a project fails to be certified, the team can appeal.

2.4.2.2 Benefits

According to the concept of "Fathership," buildings should be like ships: self-contained, independent, and able to carry their inhabitants to a better future. The self-sufficiency inherent in sustainable architecture encourages the individuality of the American frontier spirit and mimics the complexity of natural systems for the benefit of public and environmental health and of occupant productivity. (Pearson 74)

LEED certified buildings help create sustainable communities. They have reduced operation costs and contribute to the green building knowledge base. Self-sufficient buildings also communicate commitment to environmental issues, enhancing the marketability of the organizations housed within them (Gissen 8). LEED certification validates sustainable buildings through a third party review that increases market exposure.

2.4.2.3 Costs

During the development and construction phases, LEED certified buildings are more costly in terms of both time and money. Building owners must pay to register and certify their buildings and to have a LEED certified professional on the design team. Regional materials and materials used for the purposes of decreasing contamination can also be more costly than conventional, money saving materials. Although sustainable building techniques have been used for many generations, it takes time to coordinate the stages of construction for each new building and to determine how to follow each of the credits available through LEED.

2.4.2.4 LEED-NC and the Ocean Science Teaching Center

LEED for New Commercial Constructions and Major Renovations (LEED-NC) focuses on guiding and distinguishing high performance office buildings. It can apply to commercial and institutional buildings, multiple buildings (i.e., campuses), churches, and hotels that are no taller than four stories (US Green Building Council). The latest edition, version 2.2, lists intent, requirements, submittals, technologies, and strategies currently available for each credit. It also provides preformatted templates to help streamline the preparation of certificate submittal sheets (US Green Building Council). LEED-NC standards cover sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental air quality, and innovation in design.

The Ocean Science Teaching Center (OSTC) follows the Version 2.2 of LEED-NC, which was published in October 2005. LEED-NC "helps professionals across the country to improve the quality of buildings and their impact on the environment" (US Green Building Council). Because it is located on the coast, those involved in the construction and operation of the OSTC cannot simply accept nationwide building standards. They are challenged to think locally and prepare for the conditions unique to the biophysical environment.

2.4.3 The American Society of Heating and Ventilating Engineers and the American Society of Refrigerating Engineers (ASHRAE)

Under LEED-NC's standards for energy and atmosphere and indoor environmental air quality, the USGBC refers to ASHRAE—the American Society of Heating, Refrigerating, and Air-conditioning Engineers, Inc. Formed in 1959, the society's purpose is to "provide the engineer, architect, and contractor alike with useful, [practical], and reliable reference data books relating to the art of heating and ventilating"

(ASHRAE). This data comes from a collection of authoritative sources. ASHRAE is an organization of professionals responsible for the total life cycle cost of the building and it has expertise in elements related to sustainability (ASHRAE 7).

With 55,000 members, ASHRAE has a "unique opportunity to influence global [economic and environmental] sustainability" through its broadly based members and indirectly affected industries that, with an increased understanding of sustainability, can increase the sustainability of their own activities (ASHRAE 9). To reduce direct impacts of inadequate HVAC&R systems and implement mitigation measures, ASHRAE plans to create quantitative metrics similar to the LEED rating system. The accompanying document that showcases their involvement in sustainability is entitled the Sustainability Roadmap. In combination with sustainability-focused education programs and partnerships with building sustainability groups, the Roadmap provides goals and guidance for their members to "provide a safe, healthy, comfortable indoor environment while simultaneously limiting the impact on the Earth's natural resources (ASHRAE 5).

The Roadmap states that to achieve high performance through its lifetime, a sustainable building must minimize energy consumption, atmospheric emissions, discharge of harmful liquid effluents and solid wastes, and negative impacts to site ecosystems, and maximize quality of the indoor environment (ASHRAE 6).

3 LEED Project Checklist

3.1 Sustainable Sites

SS-R1: Construction Activity Pollution Prevention

Sustainable sites credits require that soil erosion, waterway sedimentation, and airborne dust generation are controlled to reduce pollution from construction activities. This requires that the OSTC has its own Erosion and Sedimentation Control Plan that conforms to either the Environmental Protection Agency's Construction General Permit or the local erosion and sedimentation control standards. The plan must address:

- Prevention of loss of soil due to stormwater runoff or wind erosion,
- Prevention of sedimentation of waterways, and
- Prevention of air pollution.

LEED suggests using temporary and permanent seeding, mulching, earth dikes, silt fencing, sediment traps, and sediment basins in the plan. (LEED 10)

SS1: Site Selection

The OSTC's design team developed an appropriate site. LEED-NC defines inappropriate, or sensitive, site elements and restrictive land types as prime farmland, previously undeveloped land whose elevation is lower than 5 feet above the elevation of the 100-year flood as defined by the Federal Emergency Management Agency (FEMA), within 100 feet of any wetlands, previously undeveloped land that is within 50 feet of a water body, and land which prior to acquisition for the project was public parkland (LEED 11). The selection of a sustainable site is important to the OSTC, because the building needed to maintain the existing view, have emergency access, and provide comfort from summer heat and humidity. It is also key that the building benefits from soft cooling breezes and resists hurricane force winds.

SS5: Site Development

The site, or the building's ground, has been designed to protect and restore habitat and promote biodiversity by conserving existing natural areas. Because the OSTC is on a previously developed site, 50% of the area will be open space restored and protected with native or adapted vegetation, such as pink muhly. LEED defines native or adapted plants as "plants indigenous to a locality or cultivars of native plants that are adapted to the local climate and are not considered invasive species or noxious weeds" (LEED 18). To minimize the OSTC's development footprint—which includes the building's footprint, access roads, and parking—and to maximize open space, there will be a vegetated open space adjacent to the OSTC the size of the building's footprint.

SS6: Stormwater Design

The OSTC limits the disruption of the island's natural water hydrology by controlling the quantity of stormwater runoff. LEED suggests reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff, and eliminating contaminants. The OSTC uses pervious paving—mulch, porous concrete, and gravel—to minimize impervious surfaces. Because its existing imperviousness is less than or equal to 50%, the OSTC's stormwater management plan prevents post-development peak discharge rate and quantity from exceeding that of pre-development. A courtyard on site is designed to promote infiltration. To reduce or eliminate contamination from stormwater runoff, the OSTC manages stormwater, limiting disruption and pollution of natural water flows and increasing on site control.

SS7: Heat Island Effect

The same techniques used to control the quality and quantity of stormwater runoff can be used to decrease the non-roof heat island effect. The heat island, according to the USGBC, is the "thermal gradient difference between developed and undeveloped areas that have an effect on the area's microclimate and on human and wildlife habitat" (LEED 23). To decrease the heat island effect from the roof, the OSTC has an Energy Star reflective membrane roof. A roof that reflects the sun's rays has a lower surface temperature, which decreases the amount of heat that is transferred to the building's interior, thus decreasing the amount of air conditioning necessary to cool the building (Energy Star). Reflective roofs also have longer life spans, because they maintain a more constant temperature and reduce thermal shock that causes stress and degrades the roof. While these roofs are designed to reflect the sun's rays, they are also designed to be water tight, durable, and long lasting (Energy Star).

SS8: Light Pollution Reduction

Reducing light pollution by minimizing light trespass from the building and site, reducing sky-glow, improving nighttime visibility through glare reduction, and reducing the development impact on nocturnal environments are important in coastal North Carolina. Populations of Loggerhead and Leatherback sea turtles nest on local beaches. When the hatching sea turtles leave the nest, they are attracted to the moon's reflection on the ocean water, but anthropogenic light sources can attract the hatchlings inland. At the OSTC, exterior lighting is designed to keep light on site. Perimeter lights are automatically controlled and do not illuminate any spaces that do not require it. Interior lights are task oriented and should not allow light to exit through the building's windows.

3.2 Water Efficiency

Water efficiency involves "decreas[ing] water pollution and enhance[ing] water's curative and life-supporting functions" (Pearson 26). Average rainfall for Beaufort, NC is 60 inches per year. Most of this rain comes in quick heavy summer storms (Luck 1).

WE1: Water Efficient Landscaping

The native and plants used for landscaping will not require as much watering as exotic plants. Although the water efficient landscaping does not eliminate the use of potable water for irrigation, it limits it.

WE2: Innovative Wastewater Technologies

The blueprints for the OSTC include a rainwater harvesting cisterns. Although they were not included in the actual building for reasons of both aesthetics and funding, the building was designed with the intention of introducing rainwater harvesting when the funds become available. In the event that such a system is included, the OSTC will earn additional credits for utilizing innovative wastewater technologies. The intent behind this credit is reducing the generation of wastewater and potable water demand, while increasing the local aquifer recharge. Other potential technologies and strategies include using high-efficiency fixtures and dry fixtures, reusing stormwater and grey water, and treating wastewater on site.

WE3: Water Use Reduction

Pivers Island ran on a septic system until 1997 when it was connected to the Town of Beaufort's water supply. In order to reduce the burden on the municipal water supply and treatment systems, the OSTC has maximized water efficiency, reducing water use by 31%. Based on the 1999 American Society of Plumbing Engineers Databook,

which estimates daily sewage flows based on size of the population using a facility, the OSTC will generate approximately eight gallons per person per day of sewage flows. This flow will not add to the current amount of sewage generated on the island, because the building will not have an effect on the Marine Lab's population. Populations can only increase with the construction of additional residences. (Isaac Panzarella, personal communication,)

The building has increased water efficiency, because it has dual flush water closets and waterless urinals. Dual flush water closets have a two button system which allows the user to determine the flush volume (Caroma Innovation). Compared to conventional 11 liter cisterns, these innovative toilets have either a 3 or a 6 liter flush volume. Waterless urinals are also known for their maintenance reduction and water conservation, because they use no water and have no flush valves. They are easy to install and are well suited for high traffic areas (Waterless).

3.3 Energy and Atmosphere

The goals of energy and atmosphere credits are to establish optimal energy efficiency and system performance, encourage renewable and alternate energy sources, and support ozone protection protocols (US Green Building Council).

EA-R1: Fundamental Commissioning of the Building Energy Systems

The project commissioner's job is to monitor the initial construction and "verify that the building's energy related systems are installed [and] calibrated [and] perform according to the owner's project requirements, basis of design, and construction documents" (LEED 31). Calibrating lighting by testing different levels of outside light as well as developing test forms for all procedures decreases building maintenance and

increase system durability. The commissioner's report includes heating, ventilating, air conditioning, and refrigeration (HVAC&R), lighting and daylight controls, domestic hot water systems, and renewable energy systems. The commissioner also ensures that all systems—right down to the wall colors—match Duke University's standards.

EA-R2: Minimize Energy Performance

The building must establish a minimum energy performance that complies with American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) standards for the building and its systems. To do this, the USGBC suggests designing the building's envelope, HVAC, lighting, and other systems to maximize energy performance. The building's engineers are concerned with three aspects of the OSTC's energy performance: the envelope, the systems, and the renewable energy.

The building's envelope includes everything that separates the interior of a building from the outdoor environment (US Department of Energy). The OSTC is insulated based on the wall thickness, using either R30 or R19 insulation, to protect wall sections from outdoor temperatures and humidity. The insulation is layered with plywood sheeting and tar paper. The OSTC's high performance windows were placed based on sunlight studies that determined the angle at which low sun angles in winter will let light in to the porch and keep light out of the porch when summer sun angles are high. This ensures daylighting in all seasons and passive heating in the winter, but protects the building from the summer's harsh sun. Sun exposure in the summertime can cause excess heat gain and increased energy use in the form of air conditioning. The OSTC's shape and orientation was inspired by the live oaks that are local to the North Carolina

coast. The building, like the trees, takes advantage of the southwest winds in the summer and avoids the harsh north wind in the winter.

EA-R3: Fundamental Refrigerant Management

The final prerequisite for Energy and Atmosphere is fundamental refrigerant management for reduced ozone depletion. This requires that no CFC-based refrigerants are used in the building. In addition, the OSTC will have a Measurement and Verification Plan for at least a year after construction to ensure that the building will have ongoing, accountable building energy consumption over time.

EA1: Optimize Energy Performance

The OSTC earns five out of ten available credits for optimizing energy performance. These credits are intended to increase the building's energy performance above that which is required for the second Energy and Atmosphere prerequisite and to reduce environmental and economic impacts associated with excessive energy use.

EA2: On-Site Renewable Energy

The USGBC encourages increasing on site non-polluting renewable self-supply energy to reduce the environmental impacts associated with fossil fuel use and to offset the building's energy costs. The OSTC uses 12.5% or more on-site renewable energy. There are abundant renewable energy resources along the Carolina coast, including solar, wind, and tidal (ocean) power.

After much consideration, the design team decided that solar power would be the most efficient use of resources for the Ocean Science Teaching Center. The solar panels selected for this project have been applied as narrow ribbons of thin film laminate bonded directly to the ridges of the building's standing seam metal roof. Sunlight falling on a

layer of semiconductor jostles electrons, creating a current that will generate more than 12% of the building's daily electricity needs (Parfit 17). The roof is made of composite nail based insulation roof sheeting sandwiched between oriented stream boards. The thin film is made of layers of silicone mounted on a stainless steel backing and laminated in stabilized polymer (Frank Harmon Architect & Consider Design, PA). This new technology allows for integration of the solar cells into the south facing roof of the lecture hall, greatly reducing roof penetrations, mounting hardware, and overall installation time and cost. It also reduces the possibility of wind damage, which is especially important on the coast. Because laminate photovoltaic technology is about 7% effective at energy conversion, the solar panels takes twice as much roof space as conventional panels. (Frank Harmon Architect & Consider Design, PA)

The OSTC has closed-loop geothermal water-only injection wells for the operation of a ground-source heat pump. The OSTC's geothermal heat pumps add to the building's energy efficient design, because the underground heat exchanges save work: instead of heating or cooling air from the building's exterior, the pumps use the air from below ground, which is 40% more efficient. The pipes go 250 feet below ground vertically and ceiling vents diffuse the air to cool areas of heat gain, keeping the building at its target temperature. Water running through the vertical system cools to 74 degrees in the summer and heats to 70 degrees in the winter. Closed loop systems require less maintenance, because they do not allow dirt and debris to enter the pipes.

EA6: Green Power

NCGreenPower is an independent, nonprofit program with the goal of supplementing the state's existing power supply with energy generated from renewable

sources. This program requires that all of the renewable energy that the building generates is sold to the power company. Because LEED-NC requires that the building must use all energy that it produces, the OSTC qualifies for neither NCGreenPower nor NC Clean Energy tax credits. If it qualified for both programs, the payback period for the renewable energy systems would be reduced by 25 years (Frank Harmon Architect & Consider Design, PA).

3.4 Materials and Resources

MR-R: Storage and Collection of Recyclables

Materials and resources credits require that the building's owners "facilitate the reduction of waste generated by building occupants that is hauled to and disposed of in landfills" (LEED 45). The Duke Marine Lab already has a conspicuous recycling program dedicated to the collection and storage of non-hazardous materials for recycling of glass and plastic that coordinates with the island's vision for sustainability.

MR1: Building Reuse

The OSTC does not qualify for building reuse credits, which are primarily intended for major renovation projects, rather than for new constructions. If either 75% or 95% of the building's structure and envelope does consist of materials reused from existing, previously occupied buildings, the USGBC suggests upgrading these components to improve energy and water efficiency.

MR2: Construction Waste Management

The contractors divert as much as 75% of construction waste from disposal. The construction management plan identifies non-hazardous debris and its disposal options.

MR3&4: Materials Reuse & Recycled Content

Although the building does not reuse any materials, it does use "material with recycled content such that the sum of post-consumer recycled content plus one-half of the pre-consumer content constitutes 20% of the total value of the materials used in the project" (LEED 54) This helps increase market demand for products with recycled content. The USGBC defines post-consumer material as "waste material generated by households or by commercial, industrial, and institutional facilities in their role as end-users of the product, which can no longer be used for its intended purposes" (LEED 54). It defines pre-consumer material as "material diverted from the waste stream during the manufacturing process" (LEED 54).

MR5: Regional Materials

Regional materials are extracted, processed, and manufactured within 500 miles of the construction site and have the intention of adding money to the local economy and reducing energy used in transport. The OSTC uses regionally harvested Southern Yellow Pine and cedar as well as locally manufactured roof trusses.

MR6&7: Rapidly Renewable Materials & Certified Wood

Because of regional constraints, the OSTC was not able to earn credits for using rapidly renewable materials or certified wood.

3.5 Indoor Environmental Air Quality

Although indoor air quality (IAQ) is value based, Arthur Dyson writes that the "resulting architecture is not only practical in terms of economy and environment, but possesses the vital spark of individual within the surging field of life" (qtd. in Pearson 25). Indoor quality has increased in popularity in recent decades, with architects who

strive to make moving through their buildings pleasurable enough to improve occupant health and state of mind. Frank Lloyd Wright's buildings are often used to describe the ability of buildings to effect people's well-being, creativity, and individuality, because "in Wright's buildings, you could walk from a closed and restricted space, to one that was light, open, and airy—as if you had emerged from a dark forest into a sunny meadow" (Pearson 50).

IAQ-R1&2: Minimum IAQ Performance & Environmental Tobacco Smoke Control

The OSTC's architect, Frank Harmon, designed the Ocean Science Teaching Center to earn all credits for indoor environmental air quality. This category requires that the building's IAQ performance adds to the comfort and well-being of its occupants and that cigarette smoking is prohibited in the building and within 25 feet of building entries, outdoor air intakes, and operable windows.

IAQ1&2: Outdoor Air Delivery Monitoring & Increased Ventilation

The ventilation system in the OSTC is monitored to "help sustain occupant comfort and well-being" (LEED 62). Ventilation in the commons area is increased.

IAQ3: Construction IAQ Management Plan

The OSTC's IAQ Management Plan helps sustain the comfort and well-being of the Marine Lab's occupants during construction and before occupancy. The USGBC suggests that this plan includes measures to protect the HVAC system during construction, control pollutant sources, and stop contamination pathways.

IAQ4&5: Low-emitting Materials &Indoor Chemical and Pollutant Source Control

Low-emitting materials include adhesives and sealants, paints and coatings, carpet systems, composite wood and agri-fiber products. Materials that are odorous, irritating, or harmful to installers and occupants must comply with the USGBC's requirements, which are based on other rules, such as those of the South Coast Air Quality Management District. Indoor chemical control standards minimize the exposure of building occupants to potentially hazardous particulates and chemical pollutants.

IAQ6: Controllability of Systems

Controllability of lighting and thermal systems gives control of lighting systems to a minimum of 90% the individual occupants and provides individual thermal controls to a minimum of 50% of the building's occupants, allowing individuals to make adjustments to suit their needs and preferences. Thermal comfort design is assessed over time to ensure that the building's thermal environment supports the productivity and well-being of building occupants.

3.6 Innovation in Design

The OSTC's design team includes a LEED Accredited Professional, who educates the other members of the community about sustainable design and the LEED rating system and facilitates the design and construction process. His input has allowed for a more streamline application and certification process.

4 Conclusion

The OSTC demonstrates the feasibility of sustainable architecture on the North Carolina coast and enhances sustainability on Pivers Island. Although the building improves the island's educational carrying capacity, it does not add to its population. The building's sustainable design also assures that it will not contribute to local erosion, pollution, contamination, or heat gain.

Perhaps one of the most challenging aspects of sustainable architecture is convincing others that it is possible to "go green." Although LEED certified buildings require extra commitments of time and money, each new construction makes the process less expensive and less time consuming. Coastal residents, architects, and contractors can learn from the OSTC's design process, looking at its plans for sediment and pollution control, energy systems, and regional and recycled material selections when planning for future buildings in eastern North Carolina.

Though you might hear laughin', spinnin', swingin' madly across the sun, It's not aimed at anyone, it's just escapin' on the run And but for the sky there are no fences facin'.

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Appendix I

LEED-NC

LEED-NC Version 2.2 Registered Project Checklist

Ocean Science Teaching Center
Beaufort, NC 28516

Yes	?	No			
10			**Sustainable Sites**		**14 Points**
Y			Prereq 1	**Construction Activity Pollution Prevention**	Required
1			Credit 1	**Site Selection**	1
			Credit 2	**Development Density & Community Connectivity**	1
		N	Credit 3	**Brownfield Redevelopment**	1
		N	Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
1			Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
		N	Credit 4.3	**Alternative Transportation**, Low-Emitting and Fuel-Efficient Vehicles	1
1			Credit 4.4	**Alternative Transportation**, Parking Capacity	1
1			Credit 5.1	**Site Development,** Protect of Restore Habitat	1
1			Credit 5.2	**Site Development,** Maximize Open Space	1
1			Credit 6.1	**Stormwater Design,** Quantity Control	1
1			Credit 6.2	**Stormwater Design,** Quality Control	1
1			Credit 7.1	**Heat Island Effect,** Non-Roof	1
1			Credit 7.2	**Heat Island Effect,** Roof	1
1			Credit 8	**Light Pollution Reduction**	1
3			**Water Efficiency**		**5 Points**
1			Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
		N	Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
		N	Credit 2	**Innovative Wastewater Technologies**	1
1			Credit 3.1	**Water Use Reduction**, 20% Reduction	1
1			Credit 3.2	**Water Use Reduction**, 30% Reduction	1

11			Energy & Atmosphere	17 Points
Y			Prereq 1 **Fundamental Commissioning of the Building Energy Systems**	Required
Y			Prereq 2 **Minimum Energy Performance**	Required
Y			Prereq 3 **Fundamental Refrigerant Management**	Required
5			Credit 1 **Optimize Energy Performance**	1 to 10
3			Credit 2 **On-Site Renewable Energy**	1 to 3
1			Credit 3 **Enhanced Commissioning**	1
1			Credit 4 **Enhanced Refrigerant Management**	1
1			Credit 5 **Measurement & Verification**	1
	?		Credit 6 **Green Power**	1

continued

Yes	?	No		
5			Materials & Resources	13 Points
Y			Prereq 1 **Storage & Collection of Recyclables**	Required
		N	Credit 1.1 **Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof	1
		N	Credit 1.2 **Building Reuse**, Maintain 100% of Existing Walls, Floors & Roof	1
		N	Credit 1.3 **Building Reuse**, Maintain 50% of Interior Non-Structural Elements	1
1			Credit 2.1 **Construction Waste Management**, Divert 50% from Disposal	1
1			Credit 2.2 **Construction Waste Management**, Divert 75% from Disposal	1
		N	Credit 3.1 **Materials Reuse**, 5%	1
		N	Credit 3.2 **Materials Reuse**,10%	1
1			Credit 4.1 **Recycled Content**, 10% (post-consumer + ½ pre-consumer)	1
	?		Credit 4.2 **Recycled Content**, 20% (post-consumer + ½ pre-consumer)	1
1			Credit 5.1 **Regional Materials**, 10% Extracted, Processed & Manufactured Regionally	1
1			Credit 5.2 **Regional Materials**, 20% Extracted, Processed & Manufactured Regionally	1
		N	Credit 6 **Rapidly Renewable Materials**	1
		N	Credit 7 **Certified Wood**	1

Yes	?	No		
14			Indoor Environmental Quality	15 Points

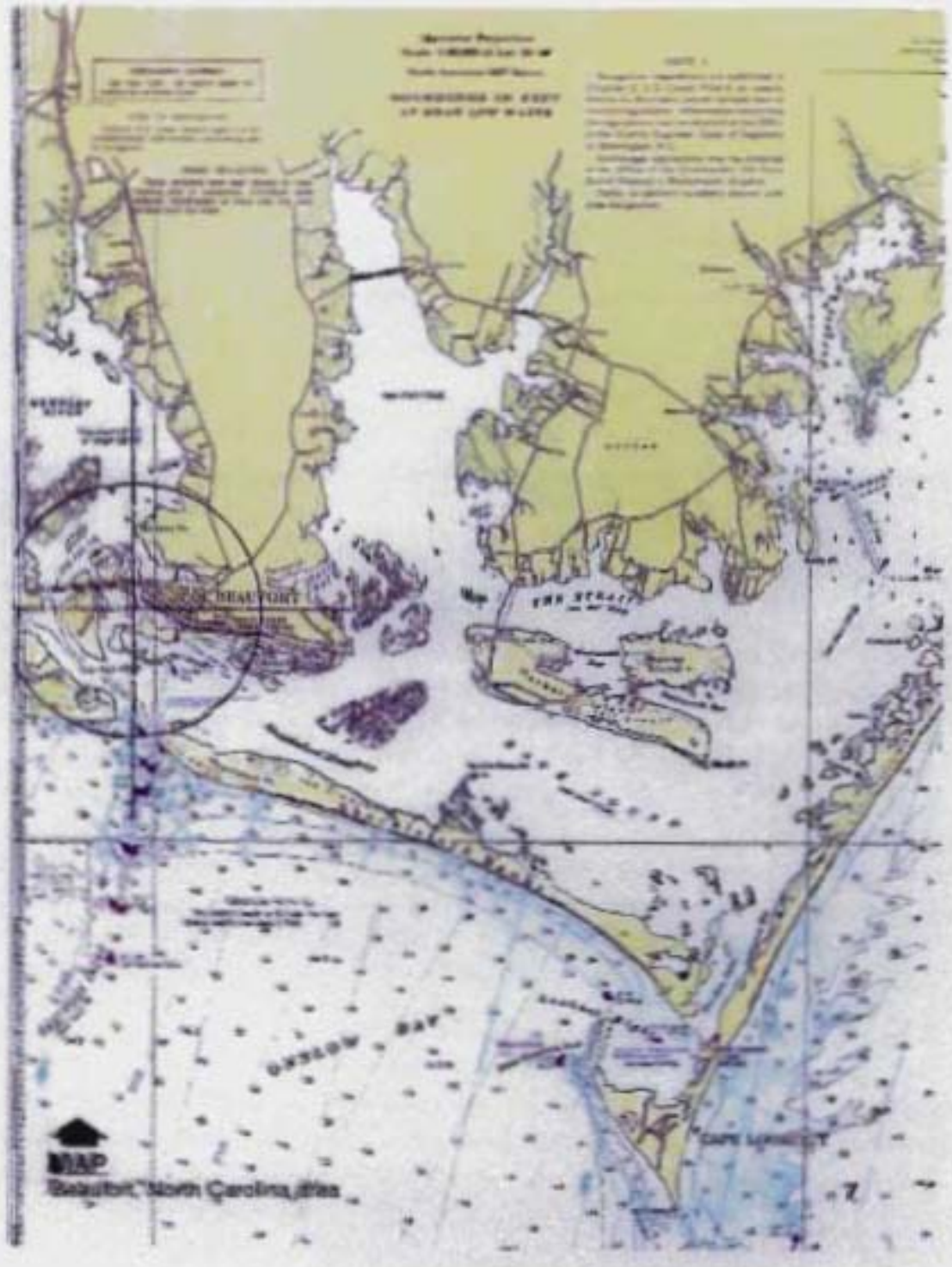
Yes	?	No			
Y			Prereq 1	**Minimum IAQ Performance**	Required
Y			Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
1			Credit 1	**Outdoor Air Delivery Monitoring**	1
1			Credit 2	**Increased Ventilation**	1
1			Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
1			Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
1			Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
1			Credit 4.2	**Low-Emitting Materials**, Paints & Coatings	1
	?		Credit 4.3	**Low-Emitting Materials**, Carpet Systems	1
1			Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products	1
1			Credit 5	**Indoor Chemical & Pollutant Source Control**	1
1			Credit 6.1	**Controllability of Systems**, Lighting	1
1			Credit 6.2	**Controllability of Systems**, Thermal Comfort	1
1			Credit 7.1	**Thermal Comfort**, Design	1
1			Credit 7.2	**Thermal Comfort**, Verification	1
1			Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
1			Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

Yes	?	No		
3			Innovation & Design Process	5 Points
1			Credit 1.1	**Innovation in Design**: Provide Specific Title 1
1			Credit 1.2	**Innovation in Design**: Provide Specific Title 1
			Credit 1.3	**Innovation in Design**: Provide Specific Title 1
			Credit 1.4	**Innovation in Design**: Provide Specific Title 1
1			Credit 2	**LEED® Accredited Professional** 1
46			Project Totals (pre-certification estimates)	69 Points

Certified 26-32 points **Silver** 33-38 points **Gold** 39-51 points **Platinum** 52-69 points

USGBC Leadership in Energy and Environment Design checklist for New Commercial Constructions (USGBC)

Appendix II



Map of area surrounding Duke University Marine Laboratory (Ramus 1993)

Appendix III

View of Duke University Marine Laboratory from above

Appendix IV

Original design drawings (Ramus 1993)