

GLOBAL CLIMATE CHANGE: WHAT DOES IT MEAN FOR SOUTH FLORIDA AND THE FLORIDA KEYS?

A REPORT ON THE MAY 24 - 28, 1999, FLORIDA COASTAL CITIES TOUR ACTIVITIES SPONSORED BY THE EPA OFFICE OF POLICY, OFFICE OF ECONOMY AND ENVIRONMENT

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SOUTH FLORIDA VULNERABLE TO CLIMATE CHANGE AND SEA LEVEL RISE

South Florida residents—hailing from the hustle and bustle of downtown Miami to the quiet and charm of Key West—gathered to learn about the potential impacts that sea level rise from global warming could have on their coastal way of life. Increased shoreline erosion, coral bleaching, saltwater inundation, and public health threats were just a few of the impacts discussed during the U.S. Environmental Protection Agency's (EPA) Coastal Cities Tour held the week of May 24, 1999.

Nearly 350 participants took part in the various activities. Anchoring the week were two half-day conferences in Miami and Marathon, Florida. Additional activities during the week included meetings involving state and local officials, community-based organizations, local business groups, and government leaders; a teacher's workshop hosted by the International Hurricane Center; and technical discussions by James Titus, sea level rise expert at EPA.

The two half-day conferences were similar in content and make-up, except that each conference looked at impacts and

solutions specific to their areas. For example, the Marathon meeting focused on impacts such as sea level rise and coral bleaching, whereas the Miami meeting emphasized public health impacts and solutions related to metropolitan areas. The Marathon meeting also took on more of an interactive format, with the audience participating in an extended question-and-answer period at the end.

The media were represented at the two events, and articles appeared in the *Fort Lauderdale Sun-Sentinel* covering the Miami conference and the Florida Keys section of the *Miami Herald* describing

the Marathon event. WLTV of Miami (Univision) recorded portions of the Miami meeting.



Top: After a session, participants in Marathon discuss their concerns about climate change with one of the speakers. *Bottom:* Conference participants in Miami chat beside a display for EPA's climate change program.

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MIAMI IN THE EYE OF THE HURRICANE

Close to 200 individuals representing a number of interests throughout South Florida—state and local government, business and industry, nongovernmental organizations, academia, and concerned citizen groups—arrived at the Wyndham Miami Biscayne Bay hotel to hear the latest information on the changing climate.

Cosponsored by nine local organizations, the May 26 Miami meeting focused on impacts specifically related to the local economy, national parks and natural resources in the region, and public health, plus sustainable solutions for the metropolitan area. Stephen Leatherman, director of the International Hurricane Center at Florida International University, kicked off the meeting by emphasizing South Florida's vulnerability to climate-related risks, including increased sea level rise and worsening storm damage.

"The International Hurricane Center views climate change as a real threat in many ways," stated Leatherman. "We are now into a more intense hurricane cycle with expectations of the number of storms increasing by 50 percent this coming year." With more than \$1.3 trillion worth of real estate vulnerable to storm damage in South Florida, the possibility of more frequent and intense weather events must be taken seriously.

Harvey Ruvin, vice-chair of the International Council for Local Environmental Initiatives (ICLEI), described positive actions taken to address climate change, including international landmarks such as the formation of ICLEI in 1990 at the

recently concluded UNFCCC meetings in Kyoto, Japan, and Buenos Aires, Argentina. "These historic events show that there is some hope and signs of people trying to make a difference," said Ruvin. He went on to discuss the role of ICLEI in the climate change negotiations and solutions undertaken by municipalities around the world.

Providing an overview of the science of climate change, Mike Farrell, director of the Center for Global Environmental Studies at Oak Ridge National Laboratory, described the communities in South Florida as an "indicator, or vulnerable area, likely to feel the effects of climate change and sea level rise first." Farrell noted the uncertainties in the science and the difficulty of knowing ahead of time the changes that a 2-degree rise in temperature may bring. "As evidence mounts that climate can change in the shorter term, say 30 to 40 years," he concluded, "we need to be aware of the possible implications now."

The morning session then shifted focus to potential impacts. Chairing a panel on impacts, Jim Titus, of the U.S. Environmental Protection Agency, said to expect a 2-foot increase in sea level rise, leading to significant effects on the local environment and economy. Loss of coastal and wetland ecosystems, flooding in the Florida Everglades, storm damage to local businesses and infrastructure, and an increase in vector-borne diseases were all potential scenarios discussed by the panel during an informative and sobering session.

Ben Starrett, Collins Center for Public Policy, followed with a discussion of Smart Growth in the greater Miami area and its role as a sustainable solution. Starrett emphasized the importance of proper land use planning and development. He noted that mixed-use policies can lead to reductions in the vehicle miles traveled (VMT) to run errands and commute to work. Considering energy use linked to transportation, he said, these practices can go a long way toward reducing greenhouse gas emissions.

David Gardiner, former assistant administrator of EPA's Office of Policy, delivered the meeting's keynote address. "When it



Stephen Leatherman, director of the International Hurricane Center at Florida International University, delivered the opening remarks at the Miami meeting.



Summit of Municipal Leaders for a Sustainable Future; the United Nations Framework Convention on Climate Change (UNFCCC) developed at the 1992 Earth Summit in Rio de Janeiro; and the

Photo right: (L-R): Doug Yoder, Harvey Ruvin, and David Gardiner all emphasized the importance of informing the public about climate change.



comes to the possible effects of global climate change," he said, "both metaphorically and literally, South Florida could be in the eye of the hurricane."

The conference closed with final thoughts from Harvey Ruvin, David Gardiner, and Doug Yoder, assistant director of the Miami-Dade Department of Environmental Resources Management. All three agreed that actions must be taken to further the dialogue so that individuals can make informed decisions about dealing with the risks of climate change. Gardiner concluded by stressing the need for additional education on the subject. "Expanding climate change education," he said, "will determine how we ultimately deal with this issue."

THE NATION RESPONDS TO CLIMATE CHANGE

Continued global warming could have serious economic, environmental, and health implications for South Florida—maybe even more so than in many other areas of the United States and the world, according to EPA's David Gardiner. Degradation of the Florida Everglades, erosion of beaches, reduced tourism, and contamination of drinking water supplies were raised as future scenarios that could threaten South Florida.

Due to the severity of the problem, Gardiner noted that the administration has created an energetic response with local, national, and international elements. He said that the administration included an international element because climate change is a global problem, and the solution will require more than just limiting U.S. emissions.

In the international arena, Gardiner referred to the Kyoto Protocol as a "monumental diplomatic achievement" that pulls together dozens of nations in an environmental cause. The agreement limits emissions of specific greenhouse gases, sets reduction targets for developed nations, establishes a deadline for reductions, and allows countries to achieve reductions through emissions trading. Gardiner pointed out that the

protocol is a work in progress as the administration seeks meaningful participation from key developing countries before sending the treaty to the Senate for ratification. He reported that this participation is beginning to happen, and he thinks that the protocol will be submitted to the Senate for ratification within the next several years.

On the domestic side, Gardiner stressed the importance of proceeding independently of the Kyoto Protocol, especially since taking action now makes economic and environmental sense. Gardiner focused on the number of successful programs being implemented today, both at the national and local levels. EPA's voluntary initiatives such as ENERGY STAR[®] Homes, Green Lights, ENERGY STAR BuildingsSM, and Climate Wise are reducing emissions, saving money, and conserving energy today. By next year, these programs are expected to reduce greenhouse gas emissions by a total of 58 million metric tons of carbon equivalent (MMTCE) and provide up to \$8 billion in energy savings for U.S. consumers and businesses using these products. In Miami-Dade County, 26 companies involved with EPA's Climate Wise program are each saving \$100,000 per year in energy costs.

Gardiner concluded by considering the next steps. On the international level, he said, the administration will continue to negotiate elements of the Kyoto Protocol and help it evolve to the point where it will be acceptable to the Senate and other countries for ratification. Domestically, the administration's budget increases spending on EPA's partnership programs, supports dissemination of innovative technologies that help reduce emissions, and provides tax incentives to consumers who purchase energy-efficient products. The administration also supports legislation that will give credit to companies that take early action to reduce emissions. Finally, Gardiner discussed the importance of hearing from conference participants about actions that should be taken on the local level and suggestions about how the federal government can support those actions.



David Gardiner: "When it comes to climate change, South Florida could be in the eye of the hurricane."



ACTING LOCALLY

What is happening to our climate, why is it happening, and what can we do about it? Harvey Ruvin, vice-chair of the International Council for Local Environmental Initiatives (ICLEI) and elected clerk of Miami-Dade County, took participants on a historical tour of climate change policy and mitigation actions over the past decade.

"In 1990 we celebrated the 20th anniversary of Earth Day," said Ruvin. During that celebration, the motto was "Think Globally, Act Locally." That sentiment was carried out in international meetings such as the Global Summit of Municipal Leaders for a Sustainable Future, which was convened in 1990 to discuss a host of issues, including climate change. One important outcome was the formation of ICLEI, which works with communities around the world to reduce greenhouse gas emissions (thinking globally, acting locally).

Another historic event was the 1992 Earth Summit meeting, held in Rio de Janeiro. Under the United Nations Framework Convention on Climate Change (UNFCCC), established during the Earth Summit, the Intergovernmental Panel on Climate Change (IPCC) was formed to bring together climate and atmospheric scientists to study the problem. In 1995, the IPCC put out its second Assessment Report concluding that there is "a discernable human influence on global climate." Ruvin noted that this human influence is "directly related to the burning of fossil fuels." As a result, we are changing our climate system so that we will continue to see an increase in extreme weather events including droughts and floods.

On a positive note, Ruvin noted that more than 400 municipalities around the world are members of ICLEI. More than 100 member cities are located in the United States, and 60 of those are implementing emission reduction strategies. Miami is undertaking an urban carbon dioxide (CO₂) reduction project and has developed a local action plan for reducing CO₂ emissions. "By making changes in areas where local governments have

direct involvement," Ruvin said, "such as transportation and electricity use, positive results are being achieved." ICLEI communities have shown the U.S. government that reductions are possible and do not disrupt local economies.

In the long-run, we need to change our basic energy paradigm by stopping our dependency on fossil fuels, said Ruvin. "As companies realize this and begin to develop business opportunities in the renewable energy sector, it could prove to be the most exciting and significant commercial opportunity the Earth has ever seen."

WILL THE EVERGLADES DISAPPEAR?

Climate change may add pressure to national parks that are already under stress from pollution, according to Paul Pritchard, president of the National Park Trust. "In 50 years, 90 percent of the parks set aside for conservation purposes may not exist as they are today," he said, "as climate is heavily affecting forests, deserts, wetlands, mountain ranges, glaciers, coral reefs, lakes, and streams."

Pritchard focused on the potential effects of climate change on the Everglades and the natural resources of South Florida, noting that it will take a great deal of effort to save the wetlands from global warming. The Everglades are already stressed by polluted runoff from agriculture and water diversions, and the impacts of climate change will only exacerbate the situation.

Historically, coastal and wetland systems were able to keep pace with sea level rise by moving inland. Because sea level rise is occurring at an accelerated rate today, these systems do not have time to adapt. Even if there were time, as development encroaches further into South Florida, there is nowhere for the Everglades to migrate inland.

Wetland loss already is taking place in the nearby state of Louisiana. "The natural delta-building cycle in Louisiana has been disrupted by the federal navigation policy, dredging, flood control levees, and oil and gas withdrawal," Pritchard



Climate change probably represents the largest single threat to our planet that we know of, including nuclear holocaust, according to Harvey Ruvin, vice-chair of ICLEI.



According to Paul Pritchard, of the National Park Trust, "Global warming is the Y2K of the 21st century."



pointed out. Wetlands in coastal Louisiana are being lost to the ocean at a rate of 50 square miles per year—a loss that South Florida could experience in the not-so-distant future.

IS PUBLIC HEALTH AT RISK?

What will the quality of life in Miami be like if the climate changes? What impacts will global warming have on human health? These questions and more were explored by Dickson Despommier, professor of environmental health at Columbia University.

From a public health standpoint, coastal and noncoastal residents alike will be affected by climate change. Safe drinking water, clean air, and an environment free of infectious diseases—the primary goals of public health programs—may all be in jeopardy as sea levels rise and temperatures warm. Along the coast, the problems would be exacerbated because of the size of the population.

The main worries are the spread of vector-borne diseases such as malaria. “We need to be prepared in case climate change causes increased outbreaks and new diseases,” Despommier said. He is involved in establishing a new branch of science called “metaphysical ecology” that will focus on the ecological principles that drive life forms on Earth and determine how disturbances in life cycles affect humans. Additional research in this area is needed, Despommier believes, and will lead to a better understanding of ozone depletion and increased CO₂ in the atmosphere. “We don’t have the science to know what is broken,” he concluded, “so how do we go about trying to fix it?”



Dickson Despommier, professor of environmental health at Columbia University, focused the conference’s attention on the significant public health threats facing Miami.

THE IMPLICATIONS OF CLIMATE CHANGE

If half of what is said about the effects of climate change is true, we will be faced with an array of expensive issues that may change our way of life, said Mike Farrell, director of the Center for Global Environmental Studies at Oak Ridge National Laboratory in Tennessee.

Farrell stressed the importance of climate change research to determine what is happening and ensure we are not hit by a surprise down the road. The United States spends about \$4.2 billion per year on climate change, including about \$2 billion for scientific research. That represents “just a smattering” of the nation’s overall budget, Farrell said, adding that an additional \$3 million should be pumped into future research on this issue.

Farrell noted that the IPCC’s conclusion about the discernible evidence of human influence on global climate is consistent with the public’s belief that something is going on with the weather. It is also consistent with the fact that 9 of the last 14 hottest years occurred during the last decade.

He pointed out that it is hard to know the precise climate changes that may occur in a particular location. Climate change does not mean that all areas will become warmer and drier. Some will be cooler and some wetter. For example, one part of Maine recently recorded its coldest temperature ever, about 55 degrees below zero. Most communities, however, will become warmer, which will mean different things to different places.

To illustrate this point, Farrell looked at a community in Tennessee near where he lives. This town of 1,200 people is located next to a reservoir that contains a large population of striped bass. Farrell estimates that global warming will cause the water temperature to warm enough to kill off the bass population. Considering the fact that 80 percent of the economic base of that community is tied to recreational fishing, loss of that fish population will have



Mike Farrell, of Oak Ridge National Laboratory: “As evidence mounts that climate can change in the shorter term—30 to 40 years—we need to be aware of the possible implications now.”



huge ramifications. The community does have options. One way to adapt and keep the town's current way of life would be to add cool water to the lake to keep water temperatures at the required level for striped bass habitat. Without that kind of change in management of the natural resource, the community would have to find a new economic base.

SMART GROWTH CAN MINIMIZE THE IMPACTS

Benjamin Starrett, a fellow with The Growth Partnership of the Collins Center for Public Policy, discussed how the Smart Growth movement and people working to curb global warming can cooperate to implement actions that will help address both issues. Starrett noted that the Smart Growth movement has gained momentum in recent years. In last year's election, more than 200 referenda linked to Smart Growth were adopted across the nation

Smart Growth, as described by Starrett, is "growth that is environmentally sound, socially conscious, and economically sustainable." It can be defined as a dividend created by successfully combating urban sprawl.

To help curb global warming, Smart Growth can provide organizational assistance because the concept brings together groups concerned with transportation, open space, and the environment. In addition, many of the actions that support Smart Growth also can help solve the global warming problem.

Starrett focused on four categories of actions that affect both issues. Beginning with transportation and land use, Starrett remarked that it takes more than twice the land area to build the same amount of residential, office, and retail space in the suburbs as it does in an urban location. Compact development can reduce vehicle miles traveled and halt the loss of agricultural land—both actions that can help reduce greenhouse gas emissions.

Reforestation, the second area for action, has a number of positive effects.

Planting trees to provide shade from the sun can reduce annual energy budgets by 30 to 40 percent. Tree-planting projects bring a community together and can get people involved in the dialogue about future Smart Growth and greenhouse gas mitigation projects.

Starrett's third action area is Smart Building practices such as the use of recycled materials and energy-efficient appliances in buildings. Such practices reduce energy use and greenhouse gas emissions, and create new jobs in the recycling industry.

Finally, Starrett called for "getting the water problem right." He stressed the importance of moving people out of floodplains so that buildings are no longer subject to flooding from the increase in precipitation from global warming expected in some regions.

"We all need to become involved," Starrett concluded. "Speak up about these issues, be committed to the solutions, take action to solve the problems, and believe that we can make a difference."

FLORIDA KEYS ALSO VULNERABLE TO CLIMATE CHANGE

On May 27, 1999, more than 100 individuals packed into the Marathon Garden Club to learn about climate change and voice their concerns about the impacts it could have on their island way of life.

Billy Causey, superintendent of the Florida Keys National Marine Sanctuary, opened the meeting by introducing Monroe County Commissioner Nora Williams. She thanked EPA and the other conference sponsors for "bringing to the table a subject of such importance and orchestrating an event that brings this global problem right down to our own backyard."

Billy Causey then provided a historical perspective of sea level change in the Keys and weather-related changes that began in 1980 and are continuing today. During that 20-year period, he witnessed a reduction in a number of marine



Ben Starrett discusses the Smart Growth movement as a potential solution to some of the impacts of climate change.



species. "In 1983 the long-spine sea urchin were dying off at an alarming rate, and the coral began to bleach," said Causey. He did not attribute these problems directly to global warming but did assert that warmer water contributed to the severity and number of disease outbreaks in the coral ecosystem.

Pamela Hallock, of the University of Florida, continued on the theme of coral reefs at risk. She noted that increased levels of CO₂ would lead to a number of damaging impacts including greater storm surges, lower levels of calcium carbonate (essential to coral reef growth), sea level rise, and increased bleaching.

The economic impacts of sea level rise were next on the agenda, with experts delivering national and local perspectives. Melinda Harris, senior economist at ICF Consulting, discussed a number of scenarios that would affect the local economies directly and indirectly. Coastal flooding, intense storm surges, and beach erosion could all intensify with a 6- to 12-inch rise in sea level. The tourist industry alone lost \$32 million when the Keys were closed for 10 days because of Hurricane Georges, said Harris.

The conference concluded with a question-and-answer session in which the audience members had an opportunity to voice their thoughts and concerns. Participants queried the panels about federal and state policies currently underway to address the issue. A discussion ensued about the actions that attendees and concerned citizens could take to be part of the solution.



Monroe County Commissioner Nora Williams welcomed conference participants to the meeting in Marathon, Florida.

"We need to figure out a way to get this message out to the other 98 percent of the population that isn't represented at this meeting," said Islamorada conservationist Karen Lee.

A BENCHMARK IN TIME FOR THE FLORIDA KEYS

Billy Causey, superintendent of the Florida Keys National Marine Sanctuary, took participants on a historical tour through geologic time to major sea level rise events in the Florida Keys. Sea level changes are an important issue because of Florida's 7,000 miles of coastline. Between 120,000 and 100,000 years ago—a time when the Keys were living coral reefs—the level of the sea dropped 600 feet, allowing the formation of the 1,700 islands that make up the Keys today.

Today, sea level is rising. At Loue Key, a spectacular reef system, land is visible only during some low tides. But back in 1744, when a British ship ran aground, the captain later described to the admiralty an island measuring 350 meters long and 75 meters wide.

In the 1960s, Causey can remember people being able to walk along the island of Sand Key, something that cannot be done today. "I'm not attributing the disappearance of that island to climate change," he cautioned. But he went on to discuss benchmark weather and ecosystem changes in South Florida that began in May 1980 and continued to the first week of July 1980—a time that Causey referred to as a "slick-calm global weather period," which is unusually calm and warm weather. The water became so hot that fish on the reefs started dying. "We started having tens of thousands of tropical fish floating to the surface and dying in 1980 ... signaling an important benchmark in time."

In 1983, the long-spine sea urchin began dying all over the Caribbean, and coral reefs started to bleach. In 1986, the number of coral disease outbreaks increased, mostly during times when the water was at its warmest. Causey witnessed the loss of 200-year-old coral at the rate of 3 millimeters per day.

"In a place where most of the population lives approximately 4 inch above sea level, nothing should be of more concern than the possibility of it rising."

— Nora Williams
County Commissioner
Monroe County



Coral bleaching was significant again in 1987, with areas affected in the Keys, the Caribbean, and various parts of the Pacific. This was another period of slick-calm weather, and Causey actually witnessed the coral changing color. These trends of increased bleaching and diseases continued in the 1990s, culminating in 1997, which marked the worst bleaching ever recorded. Causey noted that “this sequence of events coincided with El Niño years, with each [event] notably worse than the last.”

REEFS AT RISK

Is climate change contributing to the bleaching of the coral reefs that surround South Florida? Pamela Hallock, professor of marine science at the University of South Florida, noted a recent study published by the World Resources Institute that concluded that 60 percent of the coral reefs around the world are threatened, “and the reefs along the Florida Keys are at risk.”

A number of local, regional, and global stressors cause damage to coral reefs. On a local scale, coastal nutrification, alteration and removal of coastal vegetation, and overfishing contribute to increased sedimentation and other direct problems in the reef community. Regionally, deforestation along major watersheds, nutrification of waterways, desertification, and new diseases all affect coral reefs. Finally, increases in greenhouse gas emissions, depletion of stratospheric ozone, alteration of nutrient cycles, introduction of biologically active chemicals, and mixing of microbial communities can lead to warmer water temperatures and bleaching, which further exacerbate the problems experienced by these delicate ecosystems.

Hallock noted that it is a “fact that concentrations of CO₂ will double from preindustrial times sometime during the 21st century.” This elevation in CO₂ may cause more intense storm surges and storm activity, sea level rise, warming of water temperature, and alterations in ocean chemistry. Hallock’s main concern is that elevated CO₂ levels may cause a 30 percent loss in calcium carbonate, an element essential to coral growth.

Ozone depletion, another stressor brought about by human activities, contributes to coral bleaching and disease. Coral reefs actually produce a sunscreen to protect themselves against harmful ultraviolet radiation. As ocean temperatures increase, the reefs lose this defense mechanism and are prone to more bleaching. This combination of ozone depletion and global warming thus has a synergistic effect on the health of our reefs. To prove that point, Hallock noted that coral bleaching was not really noticed until the 1980s—around the time that global warming began to show up on the scientific radar screen.

“Overall there is no single smoking gun for the Florida reefs,” Hallock concluded. “The stresses are multiplicative and contribute to reduced vitality and construction.”

SEA LEVEL IS RISING

What are the implications of a 2-foot rise in sea level, both nationally and locally? James Titus, sea level rise expert at the U.S. Environmental Protection Agency, spoke to South Florida residents about potential scenarios in coastal communities if seas continue to rise.

According to Titus, scientists are predicting anywhere from a 1- to 3-foot rise in sea level over the next 100 years. Impacts could include inundation of drylands and lowlands, beach erosion, flooding, and saltwater intrusion. Titus showed a map depicting all the land below the 5-foot contour line and pointed out that most of those areas are probably within 2-3 feet of mean high water today. In addition to the large areas within a few feet of sea level, there are some relatively high areas that are also vulnerable to floods.

And as seas continue to rise, the risk of flooding is exacerbated as storm surges become more severe. Beach erosion, another implication of sea level rise, will accelerate because rising sea levels cause the offshore bottom to rise, which prevents sand from returning to the dry part of the beach when it is eroded during a storm. Titus estimates that a 2-foot rise in sea level will erode beaches by 100 to



Billy Causey discusses dangerous weather phenomena that occurred in the Florida Keys over the last 20 years.



Pamela Hallock, professor at USF, noted that there are a number of stressors causing damage to the coral reefs in Florida and around the world.



200 feet, unless efforts to nourish the beaches are expanded.

Titus noted that in the past, wetlands were able to keep pace with rising sea levels because they form peat and trap sediment. Researchers are not certain whether the wetlands in south Florida will be able to keep pace with future sea level rise. Wetlands in various parts of the country, including Maryland and Louisiana, have not been able to adapt quickly enough. In undeveloped areas, wetlands can migrate inland but this cannot occur wherever people erect structures to hold back the sea.

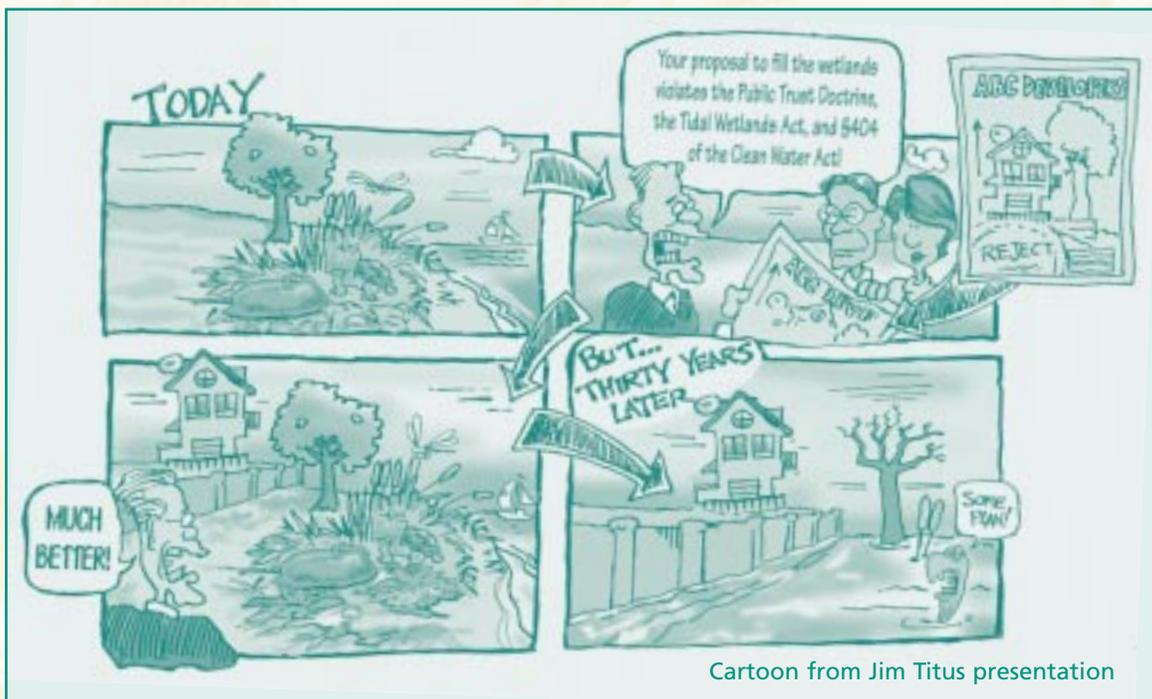
Another implication explored by Titus is saltwater intrusion into valuable freshwater supplies, including rivers and underground aquifers. Riverbeds may be altered if seas continue to rise, causing saltwater to travel farther upstream and rivers to widen and deepen. The change in riverbeds will continue unless freshwater flowing down the river increases.

Groundwater drinking supplies are also at risk as elevated seas may directly inundate aquifers, or the aquifers may become contaminated by salty recharge areas that feed them. Titus, using the 40-1 Ghyben-Herzberg model, stated that a 1-foot rise in sea level could cause the water table to thin by 40 feet. South Florida, with only a 60-foot-deep water table—Biscayne Aquifer—would narrow quite rapidly unless specific measures are taken.

Titus noted that there are really only two options: trying to hold back the sea or letting it advance. Generally speaking, property owners want to hold back the sea while environmentalists are in favor of the second option. The two main strategies for holding back the sea are the construction of dikes or bulkheads, and elevating the land. Considering the resources it would require to elevate land, roads, houses, and local infrastructure, that is probably not a feasible alternative for the entire area, although it may be feasible for barrier islands and some parts of the Florida Keys. Bulkheads and dikes, on the other hand, eliminate intertidal land, denying the public its legal entitlement to walk along and enjoy the beach.

Allowing the sea to advance gives the community an opportunity to continue enjoying the intertidal public lands as well as protecting local ecosystems. Rolling easements allow landowners to build at their own risk but forbid them from building bulkheads, dikes, or other impediments that would restrict the natural advance of the sea.

As quoted in the *Fort Lauderdale Sun-Sentinel*, Titus concluded: "The sea is going to rise. Do we deal with it today, or do we pass it on to the next generation?"



Cartoon from Jim Titus presentation



SEA LEVEL RISE—YESTERDAY AND TODAY

Through geologic times, sea level has varied to create Florida as we know it today, said Harold Wanless, chairman of the Department of Geological Sciences at the University of Miami. He took conference participants through time, providing a historical perspective on the South Florida coastline and a look at the future.

Wanless noted that 120,000 years ago, sea level was 20 feet higher than it is today. The Ice Age lowered the sea to as much as 420 feet below current levels. Since the end of the Ice Age, sea levels rose at a rate of about 23 centimeters per year, creating both the Florida and Biscayne bays. For the last 3,000 years, the rate of sea level rise has slowed to between 3 and 4 centimeters per year, allowing the coastal ecosystems to stabilize and move seaward.

Around 1930, according to Wanless, the rate of sea level rise began to increase. Since then, sea level has risen about 9 inches in South Florida—10 times the rate at which it had been rising over the past 3,000 years. “This sets the stage for dramatic changes in our coastline and shallow marine environment,” said Wanless.

These changes are increasingly evident during storms and hurricanes. Andrew, a category 4 hurricane, flattened mangroves along Biscayne Bay and the southwest coast of Florida. Storm surge created after the hurricane destroyed coastal swamps and other important ecosystems in the area. Add the stress of sea level rise, and many of these systems simply cannot recover. According to Wanless, experts agree that mangroves can withstand a sea level rise of only about 10 to 12 centimeters per century. And with seas rising now at rates of 35 to 38 centimeters per century, we may see drastic changes in mangrove swamps over the next 100 years.

The mangroves are not alone. The barrier islands, Florida Keys, reefs, and the Everglades could all look different over the next 100 years. Wanless noted that this may be a very chaotic time, with high turbidity, loss of important debris—

organic and inorganic—due to erosion, and additional stress caused by beach renourishment projects. Sea level rise may open up more gaps in reefs, continue to flood the barrier islands and mainland, and cause drainage problems for the Everglades.

Wanless concluded by stating that we need to manage natural areas for the long run since climate and sea level are evolving. “And we must decide now how far in the future to plan for so that our children may enjoy a habitable environment.”

ECONOMIC IMPACTS OF A RISING SEA

How does a change in the environment affect economic variables or resources in a particular region? Melinda Harris, senior economist at ICF Consulting, reported the results of her recently concluded study of the future economic impacts that might occur with a 6- to 12-inch rise in sea level. Specifically, Harris focused on the economic ramifications associated with more intense storm surges, including impacts on the tourist industry, beach maintenance costs, and individuals.

Tourism Industry

Harris used Hurricane Georges as an example of the impacts on the tourism industry resulting from down time and cleanup after a major storm. Hurricane Georges shut down the Florida Keys for 10 days. Regional estimates place tourist spending at roughly \$3.2 million daily. Thus, revenue losses alone amounted to around \$32 million.

Property damages included the destruction of some 4,300 homes, a significant number of which were occupied by relatively low-income families and individuals. The ensuing shortage of affordable housing contributed to additional problems for the local tourist industry. In particular, the industry, which employed many of the people who had inhabited the damaged homes, had to cope with a relatively severe labor shortage that followed when low-income workers left the region in search of housing.



Harold Wanless, of the University of Miami, believes the mangroves and other ecosystems in South Florida cannot withstand sea level rise.



Melinda Harris, senior economist at ICF Consulting, explored the economic impacts of sea level rise and storm surges.



If an event similar to Hurricane Georges were to hit Miami Beach, Harris noted that the tourism-related losses would climb at a rate of about \$4.4 million per day. A similar storm, when based on a sea level 12 inches higher than today's level, would cause 35 to 60 percent more damage (according to the Federal Emergency Management Agency), leading to more down time and lost revenue to the local tourism industry.

Beach Maintenance

Sea level rise might also affect the cost of maintaining beaches. Since the late 1970s, the U.S. Army Corps of Engineers has undertaken renourishment projects in the Miami region every 5-10 years. The cost of these projects average out to about \$650,000 per year. If erosion accelerates due to sea level rise, it might become necessary to renourish the beaches more frequently. Even assuming that the total cost per renourishment project remains constant, a one-year decrease in the interval between projects would increase the average annual cost to \$725,000.

The health of South Florida's tourism industry is strongly correlated with the health of the region's beaches. Harris stated that in the early 1970s Miami had only about 1.5 miles of beach coastline. "Between 1972 and 1978, the Corps poured some 12 million cubic yards of sand along 55,000 feet of shoreline, creating the beaches that are there today." By the early 1980s, beach attendance was up almost threefold, having positive effects on the local economy.

Impacts on Individuals

Sea level rise and increased storm surge not only cause direct impacts such as property damage and lost wages, they also might result in higher insurance rates and new building codes, thereby raising the cost of living for homeowners along the coast. If sea level rise leads to rezoning so that a house is located in an area that is designated as a flood zone, the homeowner's annual insurance rates might increase substantially. For example, the owner of a \$250,000 house in Miami that is not located in a flood zone can obtain insurance covering hurricane

wind damages for \$750 per year. However, when a home is located within a flood zone, prior to issuing a policy covering wind damages, insurers require that homeowners purchase flood insurance. Thus, to insure for both types of storm-related damages, the same home, when located within the 100-year flood zone, can cost the homeowner upwards of \$1,200 to \$1,400 per year.

Another issue for homeowners to consider is the potential for changes in building codes as a result of sea level rise. If new codes require homes to be elevated on stilts, additional construction expenses can add \$10,000 to \$40,000 to the cost of the home.

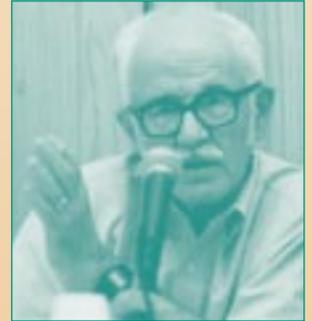
Harris concluded by stating that a lot of stakeholders in the region have cause for concern about what sea level rise could mean to them. She advised stakeholders to really "think about their vulnerability—what do they have at risk and what can they do to protect it."

FLORIDA'S BEACHES—ERODING OR ADVANCING?

What's happening to the sandy beaches along Florida's east coast? Are humans influencing the rate at which beaches are eroding or increasing? Bob Dean, professor at the University of Florida, discussed these issues as he delivered the results of his recently concluded study that looked at long- and short-term changes along Florida's beaches.

"Beaches will respond to sea level rise whether it is a human-induced or a natural change," said Dean. He provided examples of beaches in Florida that have retreated 400 feet and then rebounded 150 feet many years later. Dean said that we will not be able to detect whether humans have had a worldwide impact for another three to four decades. But he added that sea level is rising at a faster rate in Florida than it is worldwide, noting that the state has experienced an 8-inch rise over the last century, with the rest of the world experiencing a rise of 4 to 5 inches.

Dean's research examined shoreline position data dating back 120 years in



Bob Dean, of the University of Florida, answered questions at the Keys event after his talk on beach erosion.



SPEAKERS

Billy D. Causey,

Superintendent, Florida Keys National Marine Sanctuary, National Oceanic and Atmospheric Administration

Robert G. Dean, Professor, University of Florida

Dickson D. Despommier, Ph.D., Professor of Public Health in Environmental Health Sciences (and Microbiology), Columbia University

Mike P. Farrell, Director, Center for Global Environmental Studies, Oak Ridge National Laboratory

David Gardiner, former Assistant Administrator, Office of Policy, U.S. Environmental Protection Agency

Pamela Hallock, Ph.D., Professor of Marine Science, University of South Florida

Melinda Harris, Senior Economist, ICF Consulting

Stephen P. Leatherman, Ph.D., Director, International Hurricane Center, Florida International University

Paul C. Pritchard, President, National Park Trust

Harvey Ruvin, Clerk, Miami-Dade County, and Vice-Chair, International Council for Local Environmental Initiatives

L. Benjamin Starrett, Fellow, The Growth Partnership, Collins Center for Public Policy

Ty Symroski, City Planner, Key West

James G. (Jim) Titus, U.S. Environmental Protection Agency

Harold C. Wanless, Ph.D., Chairman and Professor, Department of Geological Sciences, University of Miami

Nora Williams, County Commissioner, District 4

Douglas Yoder, Ph.D., Assistant Director, Miami-Dade Department of Environmental Resources Management

Florida's sandy beach counties. Along the northern coast of eastern Florida, shoreline advanced at a substantial rate of up to 30 feet in some places. Moving down the coast, the middle counties are neutral (neither advancing or eroding), and the lower counties are experiencing erosion at a higher rate. Dean concluded that "on average, the east coast of Florida advanced at a rate of about 4 inches per year."

In places where the shoreline advanced, sediment transport from offshore and inland systems played a major role. Places like Dade County have seen benefits resulting from various beach nourishment projects, according to Dean. Beach erosion occurred mainly in areas surrounded by inlets or in areas that have suffered significant storm surges.

"While the picture looks good for the beaches, this is not a reason for complacency," Dean concluded. He advised the audience to be prudent in their building activities along the sandy beaches in Florida. "If we're prudent in these decisions," he argued, "then sea level rise shouldn't be as significant as once thought."

LOCAL GOVERNMENT'S RESPONSE TO SEA LEVEL RISE

Key West City Planner Ty Symroski reiterated the thought that we need to "think globally and act locally." Symroski focused on what local governments can do to lessen the impacts of sea level rise because, in his words, "even if we behave really well, it looks like the sea is still coming up so we better be prepared for it."



Ty Symroski, Key West city planner, examined the role of local governments in responding to the impacts of climate change.

The role of local government, according to Symroski, can be divided into three areas:

- (1) Regulatory aspects in which local governments tell citizens what they can do with their land or how they conduct their lifestyles.
- (2) Proprietary in which local governments own the land and act in a proprietary manner.
- (3) Public policy in which local governments hold public dialogue on issues important to citizens.

In the regulatory arena, local governments can mandate more stringent building codes and zoning boundaries that will allow residents to minimize the impacts of sea level rise and other climate impacts. Re-evaluating land use patterns and implementing mixed-use zoning will contribute to reductions in emissions by reducing vehicle miles traveled.

In terms of land ownership, governments can purchase open space—mangrove areas in particular—that can serve as barriers to sea level rise. Symroski supported the preservation of forests or tree stands in natural areas so that they can act as sinks for carbon. Land use and capital investments should be evaluated in terms of the long run and ability to cope with sea level rise.

In conclusion, Symroski stressed that "a couple of inches in sea level rise makes a big difference." Since Florida is flat and surrounded by water, a small rise could affect a great distance inland. "This could cause serious implications for ecosystems and the functions they perform," he said, "as these areas could be squeezed out between bulkheads and the rising sea."

