

NATURE

Fragile shores

By Jonah Raskin

Cartographers and historians have long mapped the vast body of water inside the Golden Gate that enabled San Francisco to become a major port connecting California to the world. However, few authors have looked as closely as Matthew Morse Booker looks, in “Down by the Bay,” at the fascinating frontier where land meets sea. Moreover, no one has demonstrated as clearly as he the operation of the law of unintended consequences in our own backwaters and backyards.

For example, Booker shows that the planting of Atlantic oysters in San Francisco Bay altered the bay’s ecology. He also argues convincingly that hydraulic mining for gold in the Sierras sent millions of tons of soil and rock rushing down streams and rivers, such as the Sacramento and San Joaquin, then into the bay, where habitat never recovered.

Booker is certainly familiar with his subject. An associate professor of history at North Carolina State University, he also leads the Between the Tides project at Stanford’s Spatial History Lab.

From beginning to end, his colorful yet unsentimental history delivers a dire message: For almost every action that humans have taken in and around the bay, there have been equal and opposite reactions, usually detrimental to fish, fowl and the fecundity of the environment. “What seemed like good ideas in the nineteenth century created a cascade of consequences in the twentieth century and impossible choices in the twenty-first,” the author writes in a chapter titled “Reclaiming the Delta.”

Dredged and polluted, its shape and depths altered by the hands of men and machines, the bay has shrunk in size while streets, sidewalks and malls have spread. Commuters who cross by bridges and ferries take our greatest treasure for granted, the author suggests, and rarely realize that it’s a construct of both nature and human beings. With ocean levels rising rapidly, time may be running out, Booker warns, for communities that crowd our damaged waterways.

By focusing on the waterfront and on the tidelands, marshes and swamps, Booker gives the city a fresh face; the familiar becomes strange and wonderful. Early on, he traces the demise of sleepy Yerba Buena, a distant outpost of Mexico, and conjures up the rise of raucous San Francisco as the commercial heart of an empire within an empire. Booker allows facts and stories to speak for themselves.

In 1835, he explains, President Andrew Jackson tried to buy the port from Mexico for \$5 million. Two decades later, when California was part of the United States, the banker, William Tecumseh Sherman — who would lead Union troops through Georgia — noted of San Francisco, “Everybody seemed to be making money fast.”

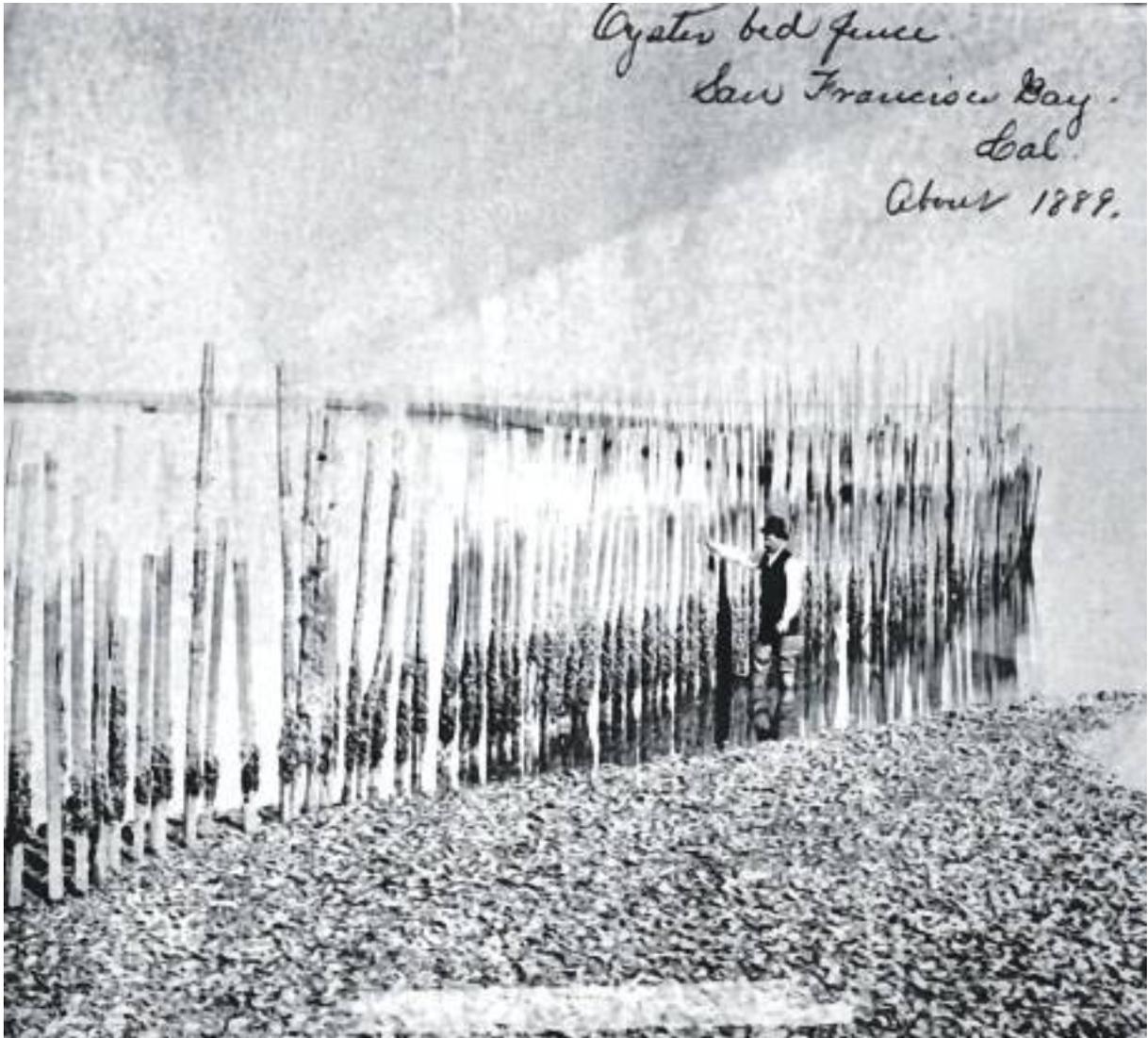
Not everyone — as Booker shows. Chinese laborers dredged rivers, constructed levees and carved farmlands from swamps. They didn’t make money fast. The land speculator George Roberts, who hired 3,000 Chinese men to build his levees, observed, “I do not think we could get the white men to do the work. It is a class of work that white men do not like.”

Perhaps because he’s an academic with an eye on learning, Booker sums up his main points as though getting students ready for finals. Then, too, prejudices occasionally interfere with his story. “The symbol of the West,” he writes, is “the pile of tin cans in front of a shanty or the extravagant imported items on the menu of a gold rush restaurant.” Surely, the West is also the majesty of the Golden Gate Bridge, Golden Gate Park, the Golden Gate itself and the San

Francisco Wildlife Refuge that Booker touts as a “precious island of waterfowl habitat in the midst of one of the world’s great urban areas.” Indeed, in the superlative and inspiring penultimate chapter, he recounts the dramatic rise of the ecology movement that helped save the bay for future generations.

For those who remember legendary Chronicle reporter Harold Gilliam and his outstanding books about San Francisco and its waters, “Down by the Bay” is a genuine pearl in the sea of contemporary environmental writing.

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Rolling Stone

Goodbye, Miami

By century's end, rising sea levels will turn the nation's urban fantasyland into an American Atlantis. But long before the city is completely underwater, chaos will begin

by JEFF GOODELL

JUNE 20, 2013

When the water receded after Hurricane Milo of 2030, there was a foot of sand covering the famous bow-tie floor in the lobby of the Fontainebleau hotel in Miami Beach. A dead manatee floated in the pool where Elvis had once swum. Most of the damage occurred not from the hurricane's 175-mph winds, but from the 24-foot storm surge that overwhelmed the low-lying city. In South Beach, the old art-deco buildings were swept off their foundations. Mansions on Star Island were flooded up to their cut-glass doorknobs. A 17-mile stretch of Highway A1A that ran along the famous beaches up to Fort Lauderdale disappeared into the Atlantic. The storm knocked out the wastewater-treatment plant on Virginia Key, forcing the city to dump hundreds of millions of gallons of raw sewage into Biscayne Bay. Tampons and condoms littered the beaches, and the stench of human excrement stoked fears of cholera. More than 800 people died, many of them swept away by the surging waters that submerged much of Miami Beach and Fort Lauderdale; 13 people were killed in traffic accidents as they scrambled to escape the city after the news spread – falsely, it turned out – that one of the nuclear reactors at Turkey Point, an aging power plant 24 miles south of Miami, had been destroyed by the surge and sent a radioactive cloud over the city.

Rising Seas: A City-by-City Forecast

The president, of course, said Miami would be back, that the hurricane did not kill the city, and that Americans did not give up. But it was clear to those not fooling themselves that this storm was the beginning of the end. With sea levels more than a foot higher than they'd been at the dawn of the century, South Florida was wet, vulnerable and bankrupt. Attempts had been made to armor the coastline, to build sea walls and elevate buildings, but it was a futile undertaking. The coastline from Miami Beach up to Jupiter had been a little more than a series of rugged limestone crags since the mid-2020s, when the state, unable to lay out \$100 million every few years to pump in fresh sand, had given up trying to save South Florida's world-famous beaches. In that past decade, tourist visits had plummeted by 40 percent, even after the Florida legislature agreed to allow casino gambling in a desperate attempt to raise revenue for storm protection. The city of Homestead, in southern Miami-Dade County, which had been flattened by Hurricane Andrew in 1992, had to be completely abandoned. Thousands of tract homes were bulldozed because they were a public health hazard. In the parts of the county that were still inhabitable, only the wealthiest could afford to insure their

homes. Mortgages were nearly impossible to get, mostly because banks didn't believe the homes would be there in 30 years. At high tide, many roads were impassable, even for the most modern semiaquatic vehicles.

Global Warming's Terrifying New Math

But Hurricane Milo was unexpectedly devastating. Because sea-level rise had already pushed the water table so high, it took weeks for the storm waters to recede. Salt water corroded underground wiring, leaving parts of the city dark for months. Drinking-water wells were ruined. Interstate 95 was clogged with cars and trucks stuffed with animals and personal belongings, as hundreds of thousands of people fled north to Orlando, the highest ground in central Florida. Developers drew up plans for new buildings on stilts, but few were built. A new flexible carbon-fiber bridge was proposed to link Miami Beach with the mainland, but the bankrupt city couldn't secure financing and the project fell apart. The skyscrapers that had gone up during the Obama years were gradually abandoned and used as staging grounds for drug runners and exotic-animal traffickers. A crocodile nested in the ruins of the Pérez Art Museum.

And still, the waters kept rising, nearly a foot each decade. By the latter end of the 21st century, Miami became something else entirely: a popular snorkeling spot where people could swim with sharks and sea turtles and explore the wreckage of a great American city.

Even more than Silicon Valley, Miami embodies the central technological myth of our time – that nature can not only be tamed but made irrelevant. Miami was a mosquito-and-crocodile-filled swampland for thousands of years, virtually uninhabited until the late 1800s. Then developers arrived, canals were dug, swamps were drained, and a city emerged that was unlike any other place on the planet, an edge-of-the-world, air-conditioned dreamland of sunshine and beaches and drugs and money; Jan Nijman, the former director of the Urban Studies Program at the University of Miami, called 20th-century Miami "a citadel of fantastical consumption." Floods would come and go and hurricanes might blow through, but the city would survive, if only because no one could imagine a force more powerful than human ingenuity. That defiance of nature – the sense that the rules don't apply here – gave the city its great energy. But it is also what will cause its demise.

You would never know it from looking at Miami today. Rivers of money are flowing in from Latin America, Europe and beyond, new upscale shopping malls are opening, and the skyline is crowded with construction cranes. But the unavoidable truth is that sea levels are rising and Miami is on its way to becoming an American Atlantis. It may be another century before the city is completely underwater (though some more-pessimistic scientists predict it could be much sooner), but life in the vibrant metropolis of 5.5 million people will begin to dissolve much quicker, most likely within a few decades. The rising waters will destroy Miami slowly, by seeping into wiring, roads, building foundations and drinking-water supplies – and quickly, by increasing the destructive power of hurricanes. "Miami, as we know it today, is doomed," says Harold Wanless, the chairman of the department of geological sciences at the University of Miami. "It's not a question of if. It's a question of when."

The 10 Dumbest Things Ever Said About Global Warming

Sea-level rise is not a hypothetical disaster. It is a physical fact of life on a warming planet, the basic dynamics of which even a child can understand: Heat melts ice. Since the 1920s, the global average sea level has risen about nine inches, mostly from the thermal expansion of the ocean water. But

thanks to our 200-year-long fossil-fuel binge, the great ice sheets in Greenland and Antarctica are starting to melt rapidly now, causing the rate of sea-level rise to grow exponentially. The latest research, including an assessment by the National Oceanic and Atmospheric Administration, suggests that sea level could rise more than six feet by the end of the century. James Hansen, the godfather of global-warming science, has argued that it could increase as high as 16 feet by then – and Wanless believes that it could continue rising a foot each decade after that. "With six feet of sea-level rise, South Florida is toast," says Tom Gustafson, a former Florida speaker of the House and a climate-change-policy advocate. Even if we cut carbon pollution overnight, it won't save us. Ohio State glaciologist Jason Box has said he believes we already have 70 feet of sea-level rise baked into the system.

Of course, South Florida is not the only place that will be devastated by sea-level rise. London, Boston, New York and Shanghai are all vulnerable, as are low-lying underdeveloped nations like Bangladesh. But South Florida is uniquely screwed, in part because about 75 percent of the 5.5 million people in South Florida live along the coast. And unlike many cities, where the wealth congregates in the hills, southern Florida's most valuable real estate is right on the water. The Organization for Economic Co-operation and Development lists Miami as the number-one most vulnerable city worldwide in terms of property damage, with more than \$416 billion in assets at risk to storm-related flooding and sea-level rise.

South Florida has two big problems. The first is its remarkably flat topography. Half the area that surrounds Miami is less than five feet above sea level. Its highest natural elevation, a limestone ridge that runs from Palm Beach to just south of the city, averages a scant 12 feet. With just three feet of sea-level rise, more than a third of southern Florida will vanish; at six feet, more than half will be gone; if the seas rise 12 feet, South Florida will be little more than an isolated archipelago surrounded by abandoned buildings and crumbling overpasses. And the waters won't just come in from the east – because the region is so flat, rising seas will come in nearly as fast from the west too, through the Everglades.

Even worse, South Florida sits above a vast and porous limestone plateau. "Imagine Swiss cheese, and you'll have a pretty good idea what the rock under southern Florida looks like," says Glenn Landers, a senior engineer at the U.S. Army Corps of Engineers. This means water moves around easily – it seeps into yards at high tide, bubbles up on golf courses, flows through underground caverns, corrodes building foundations from below. "Conventional sea walls and barriers are not effective here," says Robert Daoust, an ecologist at ARCADIS, a Dutch firm that specializes in engineering solutions to rising seas. "Protecting the city, if it is possible, will require innovative solutions."

Those solutions are not likely to be forthcoming from the political realm. The statehouse in Tallahassee is a monument to climate-change denial. "You can't even say the words 'climate change' on the House floor without being run out of the building," says Gustafson. Florida Sen. Marco Rubio, positioning himself for a run at the presidency in 2016, is another denier, still trotting out the tired old argument that "no matter how many job-killing laws we pass, our government can't control the weather." Gov. Rick Scott, a Tea Party Republican, says he's "not convinced" that global warming is caused by human beings. Since taking office in 2011, Scott has targeted environmental protections of every sort and slashed the budget of the South Florida Water Management District, the agency in charge of managing water supply in the region, as well as restoration of the Everglades. "There is no serious thinking, no serious planning, about any of this going on at the state level," says Chuck Watson, a disaster-impact analyst with longtime experience in Florida. "The view is, 'Well, if it gets

real bad, the federal government will bail us out.' It is beyond denial; it is flat-out delusional."

Local governments, including Broward and Miami-Dade counties, have tried to compensate by forging regional agreements to cut carbon pollution and upgrade infrastructure to make their cities more resilient, but without help (and money) from the state and federal governments, it's pretty ineffective. Given how much Florida has to lose from climate change, the abdication of leadership by state and federal politicians is almost suicidal – when it isn't downright comical. Watson recalls attending a meeting on natural-hazard-response planning in South Florida, funded by the Federal Emergency Management Agency and the state: "I mentioned sea-level rise, and I was treated to a 15-minute lecture on Genesis by one of the commissioners. He said, 'God destroyed the Earth with water the first time, and he promised he wouldn't do it again. So all of you who are pushing fears about sea-level rise, go back and read the Bible.'"

Rising seas will present an escalating series of challenges, most of which, on their own, will appear to be manageable. It's not hard to see how it will play out: As each new crisis arises, engineers will propose expensive solutions and people may be fooled into thinking that sea-level rise is not such a big deal. But in many cases, sea-wall extensions and elaborate pumping and drainage systems will turn out to be giant boondoggles, with money shoveled out to politically connected contractors for projects that are ineffective or overwhelmed by continually rising seas. "Engineers want to sell solutions, and often that means downplaying the seriousness of the problem in the long term," says Wanless.

One of the first consequences of rising seas will be loss of drinking water. In fact, it's already starting to happen. Nobody understands this better than Jayantha Obeysekera, the chief modeler for the South Florida Water Management District, who is known to everyone as "Obey." The water-control system in Florida is crazily complex, even to people whose business it is to understand it. One recent hot morning, Obey and I visited several dikes and canals in the Miami area.

Our first stop was a big steel gate – in water-management parlance, it's called a "salinity-control structure" – in a poor black neighborhood in North Miami. We turned off a busy four-lane road and drove through a grassy area littered with soda bottles and plastic bags, stopped at the gate and stood at the edge of a 30-foot-wide canal. Three manatees floated lazily in the stagnant water. This canal, like hundreds of others in South Florida, was dredged in the early 20th century to allow water to drain out of the Everglades. The canals worked fine for a while, lowering the water level in the swamp enough to allow developers to pave them over and make millions selling the American Dream to sun-starved suburbanites. But then by the 1950s, people started noticing their drinking water was getting salty. In South Florida, the drinking-water supply comes from a big lake just below the surface known as the Biscayne aquifer. Engineers examined the situation and determined that the combination of draining the swamps and pumping out the aquifer had changed hydrostatic pressure underground and allowed salt water to move into the aquifer. To stop this, the Army Corps of Engineers and the South Florida Water Management District built dozens of these salinity-control structures at key points on the canals. When they were closed, salty water wasn't able to flow into the canals. But if there was a big storm and intense flooding, the gates could be opened to allow drainage.

That worked pretty well for a time. The gates were engineered so that, when they were closed, the fresh water was about a foot and a half higher than the salt water. This freshwater "head" (as engineers called it) helped keep pressure in the aquifer and kept the salt water at bay.

But in the 50 years since the structures were built, much has changed. For one thing, nearly 80

percent of the fresh water flowing into the Everglades has been diverted, some of it into industrial-agriculture operations. At the same time, consumption has skyrocketed: The 5.5 million or so people who now live in South Florida consume more than 3 billion gallons of water every day (including industry and agriculture). Almost all of that is pumped out of the aquifer, drawing it down and allowing more and more salt water to move in. At the same time, the sea level is rising (about nine inches since the canals were first dredged), which also helps push more salt water into the aquifer.

"Here, you can see the problem," Obey says, pointing to the saltwater side of the gate. "The water is only 10 inches lower on this side than on the canal. When this structure was built in 1960, it was a foot and a half. We are reaching equilibrium."

Obey explains that when there is a torrential rain (a frequent occurrence) and inland Florida floods, there is nowhere for the water to go. Cities on the western edge of Miami-Dade County, such as Hialeah and Sweetwater, are now at risk of massive flooding with every big storm. To solve this, the South Florida Water District is installing pumps on the freshwater side of the control structures on the canals. The pumps, which cost about \$70 million each, can take the runoff water from storms and pump it into the ocean to alleviate flooding.

But stopping saltwater incursion is more difficult. The town of Hallandale Beach, just a few miles north of Miami, had to close six of its eight wells due to saltwater intrusion. The town now buys half its water from a well field in Broward County and is working on a deal to drill six new wells of its own, at a cost of about \$10 million. Fort Lauderdale has also faced saltwater intrusion, as has Lake Worth, a community just south of Palm Beach. "In the long run, the whole area is likely to have problems," Obey says.

The conventional solution to this was simple: Drill new drinking wells farther west, away from the salty water. The trouble is, engineers have done that already and can't move any farther west without running into the Everglades. Instead, engineers are now turning to more radical solutions, such as trying to capture storm water and store it underground, or reuse water from sewage-treatment plants. This will help, but ultimately South Florida is likely to rely more and more on desalination, a complex industrial-scale process that eliminates the salt from the sea water. Right now, South Florida has 35 desalination plants operating, with seven more under construction. They have the capacity to produce 245 million gallons of potable water per day. But desalination is expensive and requires huge amounts of energy. In 2008, the city of Tampa opened a new \$158 million desalination plant, one of the largest in the nation, which produces up to 25 million gallons of fresh water a day – about 10 percent of the region's water needs. Construction costs alone will run about \$6 billion to desalinate just one-third of the water used for southern Florida.

For many cities in South Florida, securing a reliable supply of drinking water is going to be a heavy financial burden. "South Florida is not going to run out of drinking water," says Fred Bloetscher, an associate professor of civil engineering at Florida Atlantic University. "But it will be an expensive fix." Bloetscher estimates it will cost upward of \$20 billion to \$30 billion to replumb South Florida and armor it with pumps and a stormwater-recapturing system to deal with a three-foot sea-level rise. And when the waters keep rising? "Well, you just have to believe that we will come up with some kind of a solution," Bloetscher says.

Later in the day, Obey and I visit another gate along what was once the Miami River. Today, it has been dredged and transformed into a charmless canal. Obey shows me the new pumps that were recently installed on the structure to control flooding in the area. We are standing on the east side of

the structure, where the sea bumps against the steel gates. I ask Obey if he can imagine a day when South Floridians find themselves surrounded by the water but with no clean fresh water to drink. "I do not have an answer to that question," he says modestly. "Right now, I'm focused on the next decade or two. That will be difficult enough."

I was driving with Harold Wanless through Miami Beach one day when the sun suddenly disappeared and the skies opened up. When it rains in Miami, it's spooky. Blue sky vanishes and suddenly water is everywhere, pooling in streets, flooding parking lots, turning intersections into submarine crossings. Even for a nonbeliever like me, it feels biblical, as if God were punishing the good citizens of Miami Beach for spending too much time on the dance floor. At Alton Road and 10th Street, we watched a woman in a Toyota stall at a traffic light as water rose up to the doors. A man waded out to help her, water up to his knees. This flooding has gotten worse with each passing year, happening not only after torrential rainstorms but during high tides, too, when rising sea water backs up through the city's antiquated drainage system. Wanless, 71, who drives an SUV that is littered with research equipment, notebooks and mud, shook his head with pity. "This is what global warming looks like," he explained. "If you live in South Florida and you're not building a boat, you're not facing reality."

Michael Góngora, a Miami Beach city commissioner, prides himself on his willingness to face reality. We met at a conference in April on extreme weather held downtown, where Góngora spoke eloquently about the dangers of more intense hurricanes and about his commitment to sustainability. "We want to be the greenest city in Florida," he said proudly. Góngora, 43, the state's first openly gay commissioner, is now running for mayor of Miami Beach. He was, notably, the only politician at the extreme-weather conference.

Góngora has as much green cred as any politician in Miami. As commissioner, he has pushed for the first citywide recycling program and helped create a sustainability plan that encourages developers to erect greener buildings. When it comes to sea-level rise, he is no denier: "It is a big challenge," he told me one morning in his sparsely furnished office on the fourth floor of Miami Beach City Hall. Like most South Floridians, he believes sea-level rise is something that is going to happen slowly and that engineers will figure out a way to address. "There is \$24 billion dollars of real-estate investment here," says Góngora. "The people who own that property are not going to let it just be washed away. We will figure out a solution. It's too valuable not to."

Truth be told, it's hard to live on a thin barrier island seven miles long like Miami Beach and be a climate-change denier. The ocean-facing side is protected by a man-made dune and beach, which is 10 feet high on the southern end, but the west side of the island is only a few feet above Biscayne Bay. Not so many years ago, the west side was a mangrove swamp. When the city emerged in the 1920s, nobody gave any thought to sea-level rise – they just chopped down the mangroves and started building on the low, swampy ground. As a result, the west side of Miami Beach is among the most flood-prone areas in Florida. Whenever there is a full moon and a high tide, the sea water comes up through the old storm drains and flows into the streets. In some places, it bubbles up between the street and the sidewalk. During high tide, Miami Beach can feel like it is being swallowed up by the waves. And of course, as the seas rise, this is only going to get worse.

To address this, the city of Miami Beach hired CDM Smith, a Massachusetts-based engineering firm, to come up with a \$200 million stormwater plan that, in theory, will keep the city dry for the next 20 years. Under the plan, the city will build sea walls, triple the number of stormwater-drainage pumps, reline storm-discharge pipes and install one-way valves on outlet pipes so that rising sea water cannot

flow back into the pipes and flood the city. Góngora is rightly proud of this plan. "No one else in Florida has come up with anything like this," he says. "I think it shows that we are dealing with this problem in a frank and realistic way."

Góngora's plan, as it is now, runs into some troubles: It only addresses the consequences of six inches of sea-level rise, which is on the low end of scenarios over the next 20 years. When you ask Góngora what happens to Miami Beach when the sea level rises three feet and inundates the entire west side of the city, he says, "I trust we will find a solution. I have been to Amsterdam. I have seen what the Dutch have done. If they can figure it out, so can we."

You hear this a lot in South Florida: The Dutch can do it, and so can we. The Dutch promote it, too. The Dutch Consulate in Miami hosts get-togethers to tout Dutch engineering firms, passing out beautiful coffee-table books that illustrate dike and storm barriers in the Netherlands. "It's like the Dutch East India Company all over again," Wanless says, referring to the Dutch company that dominated world trade in the 17th and 18th centuries. "They have expertise to sell, and they are pushing it hard."

The Dutch certainly have valuable experience living with water. Dutch engineers were involved in creating the massive levees that were built to protect New Orleans after Hurricane Katrina, and they are deeply involved in conversations about how to protect New York and New Jersey from another Sandy. But no Dutch engineering firm I talked to had any concrete ideas about how to save Miami. "New Orleans looks a lot like the Netherlands – it is below sea level, with a big dike around it," says Piet Dircke, program director for water management at ARCADIS in the Netherlands. "If you don't pump it out, the city drowns. It's a big bathtub. We know how to do that. Miami is different. It is also a low-lying city but far more complicated because of issues about water quality, the porousness of the limestone the city sits on, as well as water coming in from the west, through the Everglades."

Some engineers point to the coastal resort community of Scheveningen in Holland as a possible inspiration for what might be done in Miami. In Scheveningen, engineers created an elaborate dike with a road and parking within it, as well as pedestrian walks and a man-made sand dune. But Scheveningen has an altogether different geology and coastline than southern Florida. Then there is the question of scale: The dike at Scheveningen is a half-mile long and cost nearly \$100 million to design and construct. Miami Beach alone is seven miles long – the entire Florida coastline is more than 1,200 miles. Even if an elaborate dike like this were possible, you can't build a wall along the entire coast. If you just walled off Miami Beach, the water would still flow in from the bay side.

Góngora touts the virtues of sea walls as a way to protect the city, but those have problems, too. For one thing, although they can help protect from storm surges, they don't necessarily keep the water out. "The water can just seep in through the limestone," says Richard Saltrick, the Miami Beach city engineer, who notes that in some places the seepage is slow enough that it can be pumped out. Another problem: The city of Miami Beach has about 60 miles of sea walls on the island. "The vast majority of them are on private property," says Saltrick. How do you force people to raise them higher – do you pass a law requiring everyone whose property includes a sea wall to spend tens of thousands of dollars to upgrade them? Does the city pay for it? And, of course, you can have 59.5 miles of six-foot-high sea walls, but if there is one open gap that is only three feet high, the water will come rushing in.

For the next 20 years, Miami Beach hopes to escape inundation by installing a network of about 40 pumps around the city that can be cranked up after storms to pump flood water off the streets and

inject it deep underground. It's a good idea, and it may work for a while. But in the end, Saltrick believes the only long-term way to protect Miami Beach from sea-level rise is to raise the city itself: the roads, the buildings, everything. "It's a huge undertaking," Saltrick says. "But someday, it may come to that." The city is planning to raise roads when it can, but even that is an impossibly complex task in a built-up place like Miami Beach. "When you raise the road even a few inches, what happens to the water?" Saltrick asks rhetorically. "It runs off the road into the buildings and homes alongside it. So you have to raise those, as well."

Miami Beach has other infrastructure problems, too. One of them is how to dispose of the 22 million gallons of sewage the city's residents create each day. Right now, it's pumped out to one of Miami--Dade County's wastewater-treatment plant, which sits on Virginia Key in Biscayne Bay. The decrepit old facility, which has been plagued by spills and overflow for a decade, is hugely vulnerable to storm surges and rising tides. And yet instead of moving the plant to higher, safer ground, the county wants to sink \$550 million into repairs and system upgrades, leaving it where it is and risking its destruction by rising waters. "The only way to motivate people who are in denial about climate change is for the leaders to instill confidence that we'll all still be here in 2100 and that critical infrastructure – like water, roads and sewers – will be here, too," says Albert Slap, a lawyer who represents the Biscayne Bay Waterkeepers, an environmental group that is involved in the fight over the plant. "And right now, that leadership is sorely lacking."

Beyond all these fears that keep south Florida's environmentalists and urban planners up at night, rising sea levels present an even more chilling threat to life in greater Miami. Turkey Point Nuclear Plant, which sits on the edge of the Biscayne Bay just south of Miami, is completely exposed to hurricanes and rising seas. "It is impossible to imagine a stupider place to build a nuclear plant than Turkey Point," says Philip Stoddard, the mayor of South Miami and an outspoken critic of the plant.

The Turkey Point nukes began operation in the early Seventies, long before sea-level rise was an issue. But precautions were taken to protect the plant from hurricanes; most importantly, the reactor vessels are elevated 20 feet above sea level, several feet above the maximum storm surge the region has seen. According to Florida Power and Light, the electric utility that operates the plants, there is virtually no chance of a storm surge causing problems with the reactors. As evidence of this, Michael Waldron, a spokesman for the company, points to the fact that Hurricane Andrew, a Category Five hurricane, passed directly over the plant in 1992, with very little damage. "It goes without saying that safety is our number-one priority," Waldron said in an e-mail.

But Stoddard and other critics of the plant are not reassured. For one thing, although the plant did weather the hurricane, the peak storm surge, which was 17 feet high, passed 10 miles north of the plant. According to Peter W. Harlem, a research geologist at Florida International University, the plant itself only weathered a surge of about three feet – hardly a testament to the storm-readiness of the plant. How would Turkey Point fare if it were hit with a Hurricane Katrina-size storm surge of 28 feet?

Stoddard also points out that, although the reactors themselves are elevated, some of the other equipment is not. "I was given a tour of the plant in 2011," says Stoddard. "It was impressively lashed down against wind, but even I could see vulnerabilities to water." Stoddard noticed that some of the ancillary equipment was not raised high enough. He was particularly struck by the location of one of the emergency diesel generators, which are crucial for keeping cooling waters circulating in the event of a power failure (it was the failure of four layers of power supply that caused the meltdown of

reactors in Fukushima, Japan, after the plant was hit by a tsunami in 2011). Stoddard says the generator was located about 15 feet above sea level, and it was housed in a container with open louvers. "How easy would it be for water to flow into that? How well does that generator work when it is under water?"

Another problem: Turkey Point uses a system of cooling canals to dissipate heat. Those canals are cut into coastal marsh surrounding the plant, which is only about three feet above sea level.

But the biggest problem of all is that inundation maps show that with three feet of sea-level rise, Turkey Point is cut off from the mainland and accessible only by boat or aircraft. And the higher the seas go, the deeper it's submerged.

According to Dave Lochbaum, a nuclear engineer and the director of the Nuclear Safety Project for the Union of Concerned Scientists, the situation at Turkey Point underscores the backwardness of how we calculate the risks of nuclear power. The Nuclear Regulatory Committee, which oversees the safety of nukes in America, demands that operators take into account past natural hazards such as storms and earthquakes, "but they are silent about future hazards like sea-level rise and increasing storm surges," Lochbaum says. The task force that examined nuclear-safety regulations after the Fukushima tsunami recommended that the NRC begin taking future events into account, but so far, they have not acted on the recommendation.

Still, Florida Power and Light insists the plant is perfectly safe. When I asked for details about their plans to armor the plant from sea-level rise, their PR reps were elusive. They told me that the plant's current design is suitable to handle sea-level rise but would not tell me how much. (Six inches? Six feet?) They would not disclose plans to protect or redesign the cooling canals. They assured me that "all equipment and components vital to nuclear safety are flood-protected to 22 feet above sea level." But when I asked to visit the plant and see for myself, they refused.

I went out there anyway. I was denied access to the inner workings, but I got a very nice view of two aging 40-year-old reactors perched on the edge of a rising sea with millions of people living within a few miles of the plant. It was as clear a picture of the insanity of modern life as I've ever seen.

Florida Power and Light thinks Turkey Point is such a great place for nukes that they are proposing to build two more reactors out there. Given the life expectancy of a nuke plant, it means that the people of South Florida would likely live with the threat of a radioactive cloud over their heads until at least 2085. The plan, which would cost upward of \$18 billion, has not yet been approved by state or federal regulators.

Miami is the most connected city in America, a place where the entire economy is geared toward the next big banking deal, real-estate deal, drug deal. As Wayne Pathman, a land-use attorney in Miami, put it to me, "The biggest question for the future of Miami is how investors will react when they understand the risks of sea-level rise." The rivers of cash that are flowing into the city right now are pretty clear evidence that few investors are worried about that risk. Brickell, the hot new neighborhood where the \$1 billion Brickell CityCentre, one of the biggest new developments in the city, is currently under construction, is a few blocks from the water – streets are already nearly impassable during big storms. "It's partly denial and ignorance, and partly a feeling that they can beat the odds," says Tony Cho, the president of Metro1 Properties Inc., a large real-estate firm in Miami.

One thing that may change that is insurance rates. After Hurricane Andrew hit in 1992, many large

insurers stopped offering property coverage in the state, citing the high risks of hurricane insurance. That left Florida in a dangerous position, with only small regional insurers to underwrite storm coverage for homeowners. But in the event of a large storm, the small insurers don't have sufficient capital to cover the claims they would receive. To remedy the situation, the state began offering its own low-cost insurance under the name Citizens Property Insurance Corporation, which has become the largest insurer in the state. By subsidizing insurance, lawmakers hoped to keep costs down and development booming. The problem is, Florida is now on the hook for billions of dollars. "A single big storm could bankrupt the state," says Eli Lehrer, an insurance expert and president of the R Street Institute, a conservative think tank in Washington, D.C.

Flood insurance is likely to skyrocket, too. The National Flood Insurance Program is currently more than \$20 billion in debt, thanks to payouts related to Hurricane Sandy and other extreme-weather events. In 2012, Congress passed the Flood Insurance Reform Act, which jacks the price of insurance up for people living in known flood zones. More reforms of this sort are sure to come. For a place like Miami, where virtually the entire city is a flood zone, the economic costs could be in the hundreds of billions.

The financial catastrophe could play out like this: As insurance rates climb, fewer are able to afford homes. Housing prices fall, which slows development, which decreases the tax base, which makes cities and towns even less able to afford the infrastructure upgrades necessary to adapt to rising seas. The spiral continues downward. Beaches deteriorate, hotels sit empty, restaurants close. Because Miami's largest economies are development and tourism, it's a deadly tailspin. The threat of sea-level rise bankrupts the state even before it is wiped out by a killer storm.

In the not-so-distant future, rising waters will certainly drown Miami. But is that necessarily the end of the city? John Stuart, the chair of the architecture department at Florida International University, is working with students and professors on a multiyear project to imagine what South Florida's future might look like. "It's pretty clear that we are not going to be able to stop the water from coming in, so how will we live?" One of their inspirations is Stiltsville, a collection of structures built on pilings in Biscayne Bay from the Thirties by Miami residents, some looking for a place to party beyond the easy view of the law (although they are abandoned now, a few of Stiltsville's structures still survive in the bay). Stuart and his colleagues are trying to imagine what a city in the water would look like – How do you get electricity? Who provides emergency services? "It is really unlike anything humans have tried to do before," Stuart says. "How do you build a floating city in this kind of environment?"

Stuart is energized by the challenge of thinking about this. And if sea-level rise happens slowly enough and Miami doesn't get hit with a hurricane and the drinking-water supply doesn't go bad and the real-estate market doesn't crash and the beaches aren't washed away, the city of Miami may well have time to transform itself into a modern Venice.

But more likely, the ocean will seep slowly into the city, higher and higher every year, until a big storm comes along and devastates the place and people begin to question the wisdom of living in a world that is slowly drowning. The potential for chaos is self-evident as Miami becomes a place people flee from rather than flock toward. Liberty City, a black community downtown, is one of the poorest neighborhoods in Miami. It also happens to be on some of the highest ground. "Developers will target this neighborhood," Hashim Yeomans-Benford, a community organizer in Liberty City, told me. "But I'm not sure it will be a peaceful transition." As we drove around one afternoon, Yeomans-Benford talked about the history of racial violence that simmers just below the surface in

Miami. "People will not leave without a fight," he warned.

Americans will also have to face up to the fact that Everglades National Park, home to one of the most remarkable ecosystems in the world, is a goner. More than half the park will be inundated with just three feet of sea-level rise, and the rest of it will vanish shortly thereafter. "We are going to have to change the name to Everglades National Marine Sanctuary," one scientist told me. Besides the obvious tragedy of losing a unique ecosystem, it calls into question the wisdom of spending billions of federal dollars on the sentimental fantasy that the Everglades can ever be "restored."

One of the biggest uncertainties in Miami's future is how the rest of America will feel about rescuing the city. Nobody questioned the wisdom of spending \$40 billion in tax dollars to rebuild after Katrina and another \$60 billion to help rebuild after Sandy, but will they feel the same about Miami – land of millionaires and beach condos – when the time comes? Not that everyone doesn't love Miami. But at some point, Congress is going to balk at spending \$50 billion to rebuild the city every time a tropical storm passes by.

"South Florida doesn't have the power of New York," says Daniel Kreeger, the South Florida-based executive director of the Association of Climate Change Officers. "We don't have any major cultural institutions, we don't have Wall Street, we don't have any great universities. The unpleasant truth is that it will be all too easy for the rest of the nation to just let South Florida go."

That is, of course, not the American way. We don't let cities go. We don't secede territory to the ocean. But this is the direction that our failure to cut carbon pollution is taking us. The loss of Miami will be a manifestation of years of denial and apathy, of allowing Big Oil and Big Coal to divert us from understanding the real-world consequences of our dependence on fossil fuels.

In Wanless' view, the wisest course of action now is to stop subsidizing coastal development and create federal and state policies that encourage people to move out of at-risk low-lying areas. "Instead of spending a billion dollars to build a new tunnel for the Port of Miami, we should be spending that money to buy people out of their homes and relocate them to higher ground," Wanless says. "We have to accept the reality of what is about to happen to us." But that won't happen without political leadership, and on this issue, of course, the state of Florida has none. ("I have a solution for that," says former speaker Gustafson. "We need to all march up to the capital in Tallahassee and burn the fucker down. That's the only way we're gonna save South Florida.")

Stuart compares Miami with Baiae, the ancient Roman resort town in the bay of Naples that was once a playground for Nero and Julius Caesar. Today, because of volcanic activity, the ruins of Baiae are mostly under water. "This is what humans do," says Stuart. "We inhabit cities, and then when something happens, we move on. The same thing will happen with Miami. The only question is, how long can we stick it out?" But for Stuart, who lives in Miami Beach, the fact that the city is doomed doesn't diminish his love for the place. "That's the thing about Miami," he says. "You'll want to be here until the very end."

This story is from the July 4th, 2013 issue of Rolling Stone.

<http://www.rollingstone.com/politics/news/why-the-city-of-miami-is-doomed-to-drown-20130620>

