The Florida Bay Education Project

Florida Bay Watch Report

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Mangroves in Florida Bay Dying-Back (Again)?

In the late 1980s, the most severe drought in several decades caused water shortages in south Florida, driving salinities in coastal waters up to levels well above normal seawater concentrations.Scientists working in Florida Bay in 1990 and 1991 reported that mangrove trees were “dying-back” on islands, especially in the north-central region of the bay.The term “die-back,” when referring to trees, means progressive death of certain plant parts rather than sudden death of an entire tree.There was a heightened sense of alarm about these reports because extensive areas of seagrass beds had been dying at the same time.Many observers wondered whether the two events shared a common origin, perhaps related to the management of the hydrologic system of south Florida during the drought.Although the question of a common cause for the mangrove die-backs and seagrass die-offs remains unanswered, evidence indicates that mangrove die-back can be tied to natural cycles, with a probable secondary influence by water management.

Mangrove Die-Back in Florida Bay

In subtropical south Florida, coastal areas like those bordering the Gulf of Mexico and Florida Bay support forests of salt-tolerant trees comprised of three species: red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), and white mangrove (*Lagunculariaracemosa*). All mangroves share the ability to grow in salty soil-water, but differ in their potential to survive in this kind of environment.

The first reports of mangrove die-back came from Pelican Key and the Dump Keys in 1989.Coastal areas along the north shore of Florida Bay, largely out of the view of boaters, also exhibited die-back. In 1992, an aerial survey found leafless and apparently dying mangroves on more than 30 islands from the Boggy Keys and Deer Key west to the Dump Keys.The affected trees, principally red and black mangroves, exhibited symptoms ranging from leaf fall and discoloration to dead branches and defoliation of entire trees. Die-back may affect only foliage or it may extend to twigs and branches.If severe enough, die-back can eventually cause death of the tree.In other cases, individual trees or entire stands suffering die-back may recover if the source of stress is ameliorated.Die-back is a generalized response of trees to physiological stress that may be caused by various factors such as pests, severe climatic conditions, or nutrient deficiency.

Figure 1. Aerial view of Russell Key, a low island in central Florida Bay. Most of the island is bare of vegetation and ponded for much of the year with brackish or more saline water. Roots of mangrove trees anchor the perimeter berm.

Although the more than 200 islands in Florida Bay differ in elevation, sediment conditions, and vegetation cover, the great majority are covered by mangrove forest over much of the island, or at the least, on the island perimeter (Fig. 1).Many of the mangrove-lined islands have interior basins where rainwater and seawater overwash accumulate and mix.Here, mangroves often are no more than 3-10 feet tall, with sparse, partly leafless crowns without a central stem.These “trees” often have multiple stems, several of which are leafless or dead, reflecting stressed growing conditions.North Nest, Eagle, and Pass Key are just three of the many keys where stunted trees can be seen.In the dry season, when evaporation rates are high, soil salinity on the islands may reach more than twice normal seawater concentrations.The term “salina” is used to describe these areas (Fig. 2).The perimeters of the islands typically feature a raised berm of sediment, which is deposited when storms, especially hurricanes, push mud from Florida Bay’s bottom onto the islands.These berms, usually anchored by mangrove roots, are resistant to wind and tides.Although berms act as barriers to most of Florida Bay’s modest tides, storm tides may breach all islands.

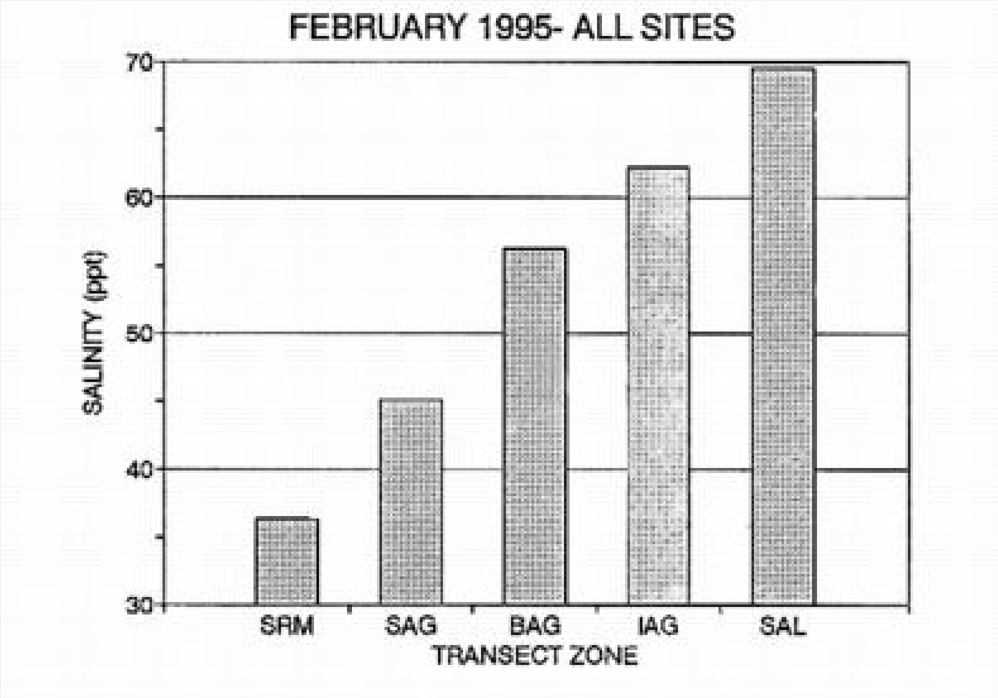

Figure 2. Pattern of porewater salinity averaged across nine Florida Bay keys in the 1995 dry season. Salinities increased from the red mangrove perimeter (SRM) to the interior basins that support black mangroves (BAG and IAG) to the barren salina (SAL). Data from Carlson (1997).

The high salt concentrations that occur in island interiors during droughts can exceed the physiological tolerances of even the most salt-tolerant mangroves.In fact, mangroves grow more slowly when salinities reach 10-20% above normal seawater concentrations.Even black mangrove, the most salt-tolerant mangrove species, is stressed when salinities exceed twice-seawater levels.Yet on some islands, salinities can be nearly three-times normal seawater. Also, the marl soil can be saturated with water for extended periods, causing poor aeration and accumulation of chemicals such as sulfides that can reach levels that kill roots or interrupt growth. The temperature of shallow salina waters also can rise to over 100ºF, further stressing the plants.Consequently, salinas often are devoid of plants except for algal mats (Fig. 3).

Figure 3. The interior of Butternut Key showing apparently dead black mangroves established around a central barren salina. In wet years, re-sprouting of some of these trees occurs while others die.

During rainy intervals such as 1994-96, plants are able to colonize some of the interior areas and the surviving trees “green-up.”However, typical of south Florida’s climate cycles, drought inevitably returns, driving soil salinities on many islands up to stressful levels again, thus initiating a new die-back episode.Paul Carlson (Florida Fish and Wildlife Conservation Commission), using wells in the interior of several islands, showed that salinity within the soil was markedly higher on islands exhibiting severe die-back than on islands where die-back was relatively light (Fig. 4).Similar conditions occur along the Florida Bay coast where raised sediment berms impound water.

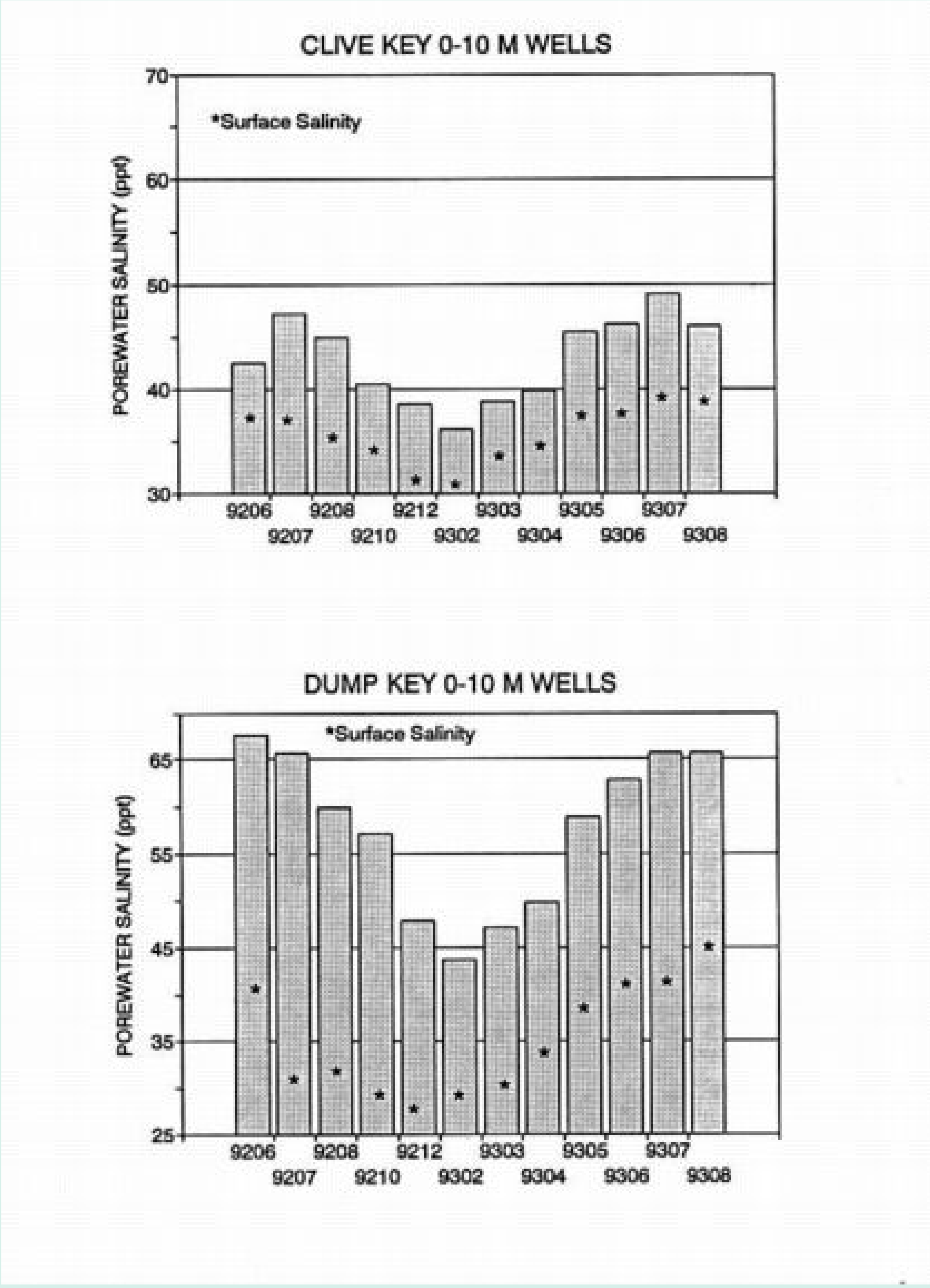

Figure 4. Porewater salinity (bars) over the period of June 1992 through August 1993 in the interior of Clive Key, where mangrove die-back was minor, and on one of the Dump Keys where die-back was conspicuous. Note that surface water salinity (asterisks) was relatively low on both islands, contrasting with the high porewater salinity on Dump Key. Data from Carlson (1977). 9206= June 1992, 9207=July 1992, etc.

The Role of Sea Level Fluctuations and Tides

What could explain the differences in soil salinity among islands?Factors other than rainfall amounts probably are involved because mangrove die-back can be much greater on certain islands than others nearby. Typically, islands in central Florida Bay experience tidal overflow that floods the island interiors with saltwater up to several times per month in the winter.If there is sufficient rainfall, the salt may be diluted to levels tolerable to resident plants.However, the more the inundation and the less the rain, the more likely it is that damaging levels of salinity will develop.Carlson observed a relatively high frequency of tidal inundation in the winters of 1991 and 1992 on some islands such as the Dump Keys in central Florida Bay. In December 1990 through February 1991 and again in the 1991/1992 dry season, bay water reached the interior of study islands several times more often than normal.A good correlation exists between the frequency of tidal inundation during this period and subsequent high soil salinity in the island interiors.This trend appears to coincide with a cyclic increase in sea level that occurs roughly every decade in the southern Florida-Gulf of Mexico region.With three months of dry season left after the winter saltwater inundation, there was ample time for evaporation and transpiration to drive up salinity in island interiors above the levels on islands not subject to high inundation frequencies.

Additional evidence supporting the conclusion that natural factors predominate in explaining mangrove die-back comes from other environments.A stunted red mangrove scrub with common die-back symptoms extends as a band more than a mile wide on the inland side of the mangrove forests of Florida Bay and the lower Gulf Coast.The stunting appears to result from infertile and drought-prone marl soils and periodic severe freezes such as the one that occurred in 1989 when interior mangroves were killed or damaged over thousands of acres (Fig. 5).Similar environments support stunted mangroves elsewhere in the tropics such as in the Lower Florida Keys, Belize, West Africa, and Australia.

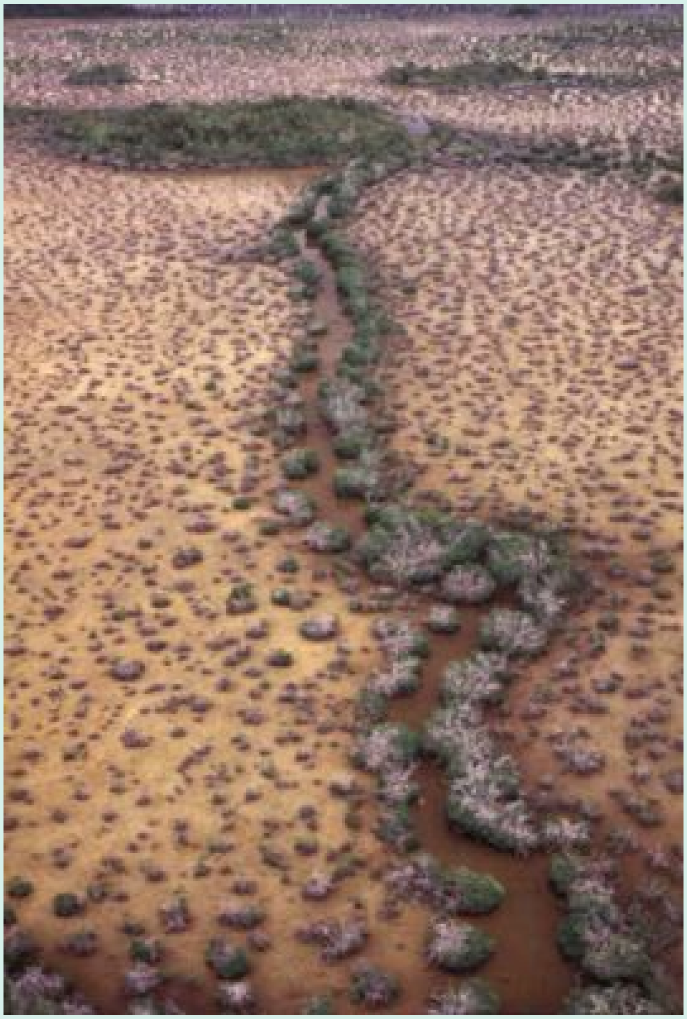

Figure 5. Stunted red mangroves north of Joe Bay where winter freezes and nutrient limitations are important factors limiting growth and causing die-back.

In areas of Puerto Rico, a repeating cycle occurs involving mangroveestablishment, growth, and maturation followed by die-back and sometimes mass mortality.The affected forests are found, as in Florida Bay, where tidal exchange is reduced and evaporation drives up soil salinity.In Puerto Rico, this cycle has a periodicity of about 25 years, the approximate return interval of hurricanes, which destroy forests, setting the stage for a new cycle.Hurricanes play a similar role in Florida, although the periodicity is less obvious.In addition, on Florida Bay's islands powerful hurricanes redistribute sediments and debris, which alters the pooling of water and hence the location where damaging hypersalinity develops.

A Connection between Mangrove Die-Back and Seagrass Die-Off?

Are the episodes of mangrove die-back and seagrass die-off connected in any way?To the extent that overwash water flooding islands was saltier because of freshwater diversions from the Everglades, water management probably added to the salinity stress on islands and on seagrass beds.Figure 6 conceptualizes how this could occur on islands. Although die-back connected to droughts and cyclic sea level rise occurs naturally, the wider variability in salinity and the higher peak salinities in the modern era would increase the frequency and perhaps the intensity of die-back episodes.In other words, the likelihood of the 10-year cycle of sea level fluctuations in Florida Bay coinciding with a high-salinity drought period has increased in the modern era of reduced freshwater flow into the bay. However, this effect has not been verified.Carlson's work on Florida Bay islands also reveals an indirect connection: masses of dead seagrass rafted across the Bay by winds and tides sometimes ended up as large deposits in island interiors.Also, seagrass die-off in areas such as Whipray Basin acted as a source of mud that formerly was stabilized by seagrass beds.Much of this material wound up in the interiors of islands, where it impounded water and created new sites where salts and sulfides accumulated, causing stressful growing conditions for mangroves.In this way, seagrass die-off may have exacerbated mangrove die-back and contributed to tree mortality.However, mangrove die-back in Florida Bay most likely would have developed anyway, in response to high soil salinities resulting from natural drought conditions and cyclic tidal inundation.

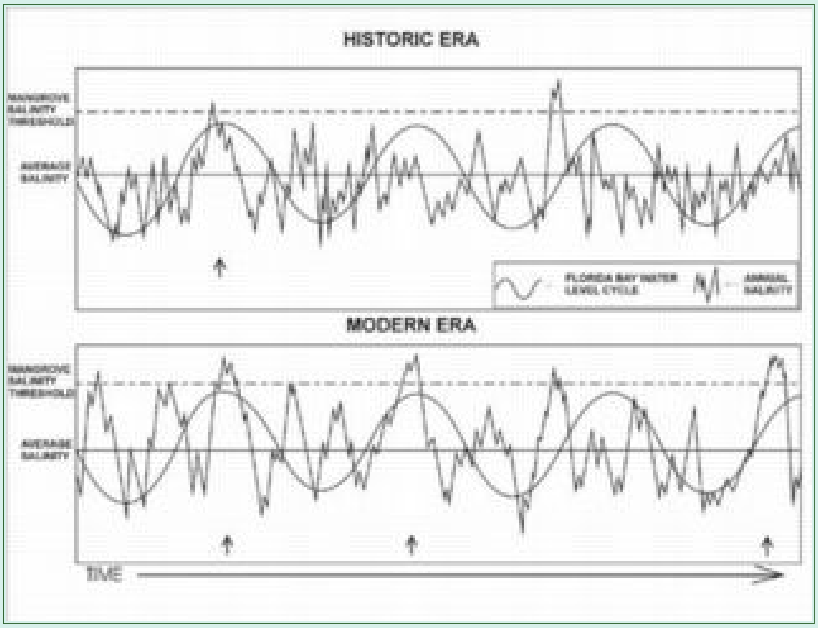

Figure 6. Conceptual model suggesting how mangrove die-back may have increased in the modern era as a result of reduced freshwater flow associated with water management. Florida Bay salinities have been higher on average and fluctuations have been wider since 1940. Consequently, episodes of hypersalinity may coincide more frequently with the cyclic sea level highs that lead to increased inundation of island interiors. The "mangrove salinity

threshold" represents the salt concentration at which mangrove die-back begins. Arrows indicate times when the 10-year cycle of sea level coincides with high salinity in the bay.
(click on the above image for a larger view)

Additional Reading

Armentano, T.V.1995.Analysis of pattern and possible causes of die-back of Florida Bay keys mangroves.Report to the U. S. Army Corps of Engineers.National Park Service, Everglades National Park.20 pp.

Armentano, T.V., R.F. Doren, W.J. Platt, and T. Mullins.1995.Effects of Hurricane Andre on coastal and interior forests of southern Florida: overview and synthesis.*J. Coast. Res.* **21**: 11-144.

Brewster-Wingard, L., T. Cronin, B. Wardlaw, J. Stone, S. Schwede, S. Ishman, C. Holmes, R. Halley, M. Marot, G. Dwyer, and J. Huvane.1999.Long-term Florida Bay salinity history: a synthesis of multi-proxy evidence from sediment cores.Pages 182-183 *in* Program and abstracts, 1999 Florida Bay and Adjacent Marine Systems Science Conference.

Carlson, P.R., Jr.1997.Sediment porewater chemistry of mangrove die-off sites in Florida Bay. Florida Department of Environmental Protection Report to Everglades National Park.

Carlson, P.R., Jr., S. Brinton, T. Armentano, D. Smith, and J. Absten.1995.Mangrove mortality in Florida Bay.Page 227 *in* Florida Bay Science Conference: a report by principal investigators - abstracts and program.

Cintron, G., A.E. Lugo, D.J. Pool, and G. Morris.1985.Mangroves and arid environments in Puerto Rico and adjacent islands.*Biotropica* **10**: 110-121.

Dewar, H. 1992.Dying mangrove trees killing off bay islands. Page 1, *The Miami Herald*, April 19, 1992.

Enos, P.1989.Islands in the bay - a key habitat of Florida Bay.*Bull. Mar. Sci.* **44**: 365-386.

Lugo, A.E.1997.Old-growth mangrove forests in the United States.*Conserv. Biol.* **11**: 11-20.

Smith, T.J, III.1992.Forest structure.Pages 101-136 in A. I. Robertson and D. M. Alongi, eds.Tropical mangrove ecosystems.American Geophysical Union, Washington, DC.

Acknowledgments

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National Park) and edited by Brian D. Keller and Cluny Madison (The Nature Conservancy), John Hunt (Florida Marine Research Institute [FMRI] and Florida Bay and Adjacent Marine Systems Program Management Committee), and Laura Engleby (Florida Sea Grant College Program).Figure 6 was prepared by Dave Eaken and Rod Bertelsen (FMRI).

Produced by The Nature Conservancy, Program Management Committee of the Florida Bay and Adjacent Marine Systems Science Program , University of Florida and Monroe County Cooperative Extension, Florida Sea Grant College Program, and the Florida Fish and Wildlife Conservation Commission.

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