Florida Bay Watch Report

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Acquiring a Taste for Florida Bay

Florida Bay often surprises at first. It might be the tropical setting or its brilliant turquoise waters. It might be an encounter with a mud bank lurking in its shallow waters. Whatever the cause, Florida Bay isn't what most people, even estuarine scientists, expect to find.

That's because estuaries are like beer. There are hundreds just in the U.S. And although each is unique, people form their perceptions of the whole group on the characteristics of just a familiar few. Some widely known estuaries such as Chesapeake Bay and San Francisco Bay are taken as typical of all; just as the popular brands "Budweiser" and "Miller" are for all beer. Scientists and managers now engaged in restoring coastal ecosystems all over the U.S. know the characteristics of these few estuaries from the many decades of study devoted to understanding their problems. In the same way, most of us are familiar with the taste of a few of the popular brands of beer, and think we know all there is to know.

To the uninitiated, Florida Bay challenges the palate like one's first sip of an unfamiliar beer. Scientific information about the bay is relatively recent and not yet widely known. Coordinated ecosystem research began less than ten years ago in response to alarming changes in its seagrass beds and water quality. The causes of these changes are still not fully understood. As estuarine scientists come to know the basic physical and ecological characteristics of Florida Bay they are acquiring a taste for this peculiar brew.

Basic physical ingredients

Just as all beer is made from only four basic ingredients, estuaries are defined by three characteristics, hydrology, geomorphology and hydrodynamics. Hydrology includes the input of freshwater - mostly as runoff from the land - and the resulting influence of the connected watershed. Geomorphology refers to the geometry of estuaries, which ranges from lake-like coastal lagoons to drown river valleys to river deltas. Hydrodynamics covers the nature of tide- and wind-driven mixing within the estuary and with the coastal ocean, including the effects of density stratification.

The degree to which different estuaries resemble one another largely depends on their similarity in these three basic characteristics. Knowledge of these characteristics of Florida Bay allows scientists to compare what they are finding out about its water quality and ecology with what is already known about similar, better-studied estuaries. So while some scientists are investigating changes in Florida Bay's ecology, such as seagrass die off, plankton blooms, and fluctuations in populations of fish and wading birds, other scientists are compiling basic information about the bay's hydrology, geomorphology, and hydrodynamics.

Comparison to other estuaries

The characteristics of Florida Bay set it apart from nearly all other estuaries in the continental U.S. (Table 1). The National Oceanic and Atmospheric

Table 1. Hydrology and hydrography[a] of Florida Bay compared to other estuaries in the United States. To account for differences in size, the values in Table 1 show runoff and the size of the watershed relative to the volume and area of the estuary, respectively.

Estuary	volume renewal by runoff (1/yr)[b]	area ratio; drainage basin to water surface
median value for all U.S.	3.2	29
Chesapeake Bay	1.1	18
Charlotte Harbor	2.1	16
Indian River Lagoon	0.9	4
Cape Cod Bay	0.05	1.5
Florida Bay	**0.06**[c]	**2**

Notes:

a Statistics based on data contained in "Estuaries of the United States: Vital Statistics of a National Resource Base. National Oceanic and Atmospheric Administration, Rockville, MD. October 1990, except as noted below.

b Average annual inflow of freshwater from the drainage basin divided by the volume of the estuary.

c Average annual inflow into Florida Bay estimated by Nuttle et al., *Water Resources Research* 36:1805-1822.

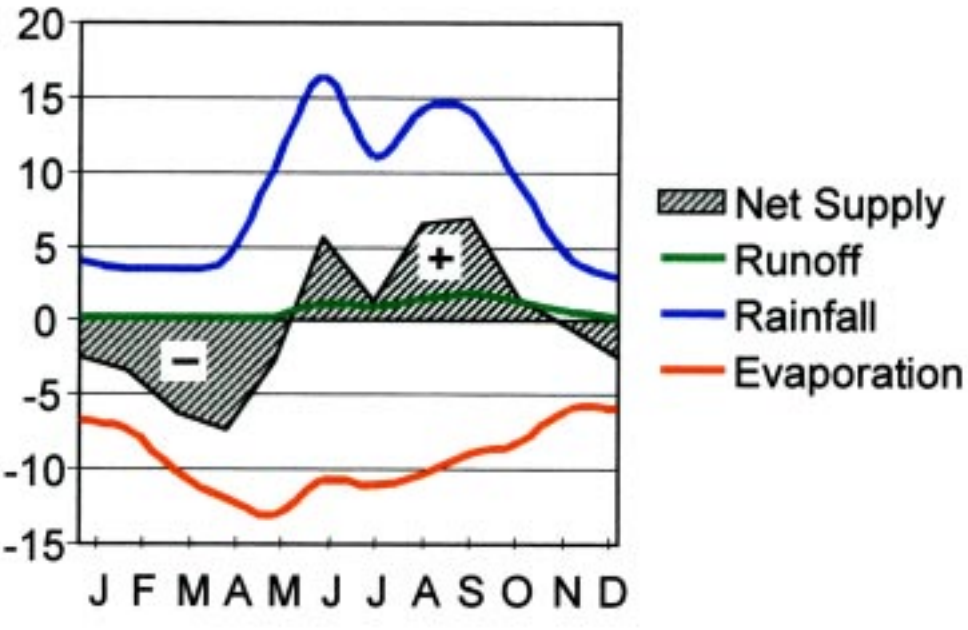

Figure 1. Average monthly fluxes of fresh water to Florida Bay (in cm) for 1970 to 1995. Net freshwater supply (filled shape) fluctuates seasonally between deficits and surpluses because peaks in seasonal patterns of rainfall and runoff lag the peak in evaporation by about 4 months. Evaporation shown here is estimated from long-term patterns of salinity variation and pan data, as described in Nuttle et al. (2000), and it is the largest freshwater flux on an annual basis (110 cm/year). Annual values for rainfall (98 cm/year) and runoff into the bay (9 cm/year) are based on measurements of these fluxes (Nuttle et al. 2000).

Administration (NOAA) has compiled information on the characteristics of estuaries in the U.S. This information can be used to explore basic similarities and differences with Florida Bay. Even compared to other estuaries in Florida, such as Charlotte Harbor and Indian River Lagoon, Florida Bay receives very little freshwater as runoff and has a small watershed compared to its size.

For example, as a consequence of the small amount of runoff into Florida Bay, the atmosphere may have more influence over conditions in the Bay than its watershed. For most estuaries, the annual volume of runoff far exceeds the amount of freshwater supplied directly by rainfall, and fresh water lost through evaporation is small. In Florida Bay this is turned around (Figure 1). Rainfall provides ten times more water than runoff and all of this is lost through evaporation. The flushing mechanism that runoff provides in other estuaries is lacking in Florida Bay. As a consequence, Florida Bay depends more on tides and wind to move water around.

This comparison alerts scientists and resource managers that differences in other aspects of the ecosystem should also be expected. To a large degree, our general knowledge of estuaries draws heavily on studies conducted in the Chesapeake Bay and a few other estuaries. This is particularly true in connection to identifying causes for loss of seagrass beds and strategies for returning them to health. But in terms of their basic characteristics, Florida Bay is about as similar to Chesapeake Bay as Guiness Stout is to Bud Light. Therefore, research into the ecology of seagrass beds in Florida Bay might be breaking entirely new ground.

The unique characteristics of Florida Bay also play a role in

the controversy over what caused the seagrass die off and plankton blooms about 10 years ago. Two opposing views quickly emerged among scientists, and the controversy has yet to be resolved. One side says that an increase in nutrients entering the Bay from runoff is the cause. This view can point to similar problems in other estuaries where nutrients supplied by runoff have been shown to be the cause. Other scientists point out that the atmosphere and exchange with the Gulf of Mexico are much larger sources of nutrients for Florida Bay, unlike other estuaries. So if nutrients are the cause, they argue, it is more likely from these other sources. Underlying this controversy is the question of how similar or different Florida Bay is compared to other estuaries.

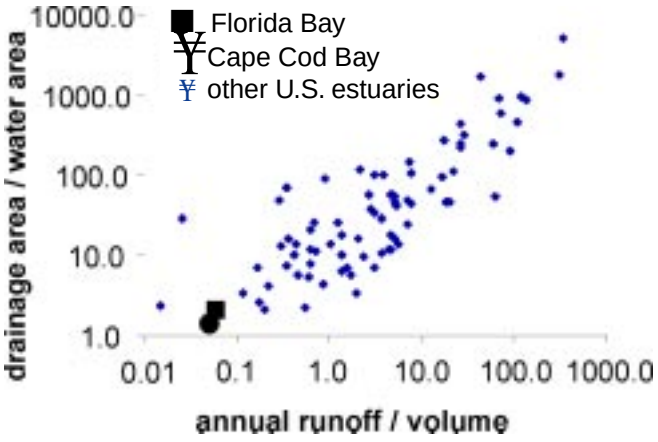

Figure 2. Of all the estuaries in the U.S., Cape Cod Bay is most like Florida Bay. These estuaries share relative magnitudes of freshwater runoff, watershed area, and tidal exchange that distinguish them from other estuaries. Note that the scales are logarithmic and encompass enormous ranges in the ratios of annual runoff to estuary volume and drainage area to estuary area.

Off the beaten track

Can we learn anything by looking for estuaries that are similar to Florida Bay? Scientists often approach a new topic by looking for similarities to other phenomena. Based on the hydrologic and hydrographic characteristics shown in Table 1, Cape Cod Bay is the U.S. estuary most similar to Florida Bay. Both have characteristics that differ greatly from those of most other estuaries in NOAA's database (Figure 2).

Cape Cod Bay, located on the coast of Massachusetts, bears a striking resemblance to Florida Bay in many aspects (Figure 3). Both estuaries are about the same size, and both are embraced between the mainland and a narrow crescent of land extending into the sea. Tourism and sport fishing are important activities in Cape Cod Bay, as they are for Florida Bay. Groundwater tainted by discharge from septic systems is a principal threat to nearshore water quality in both regions. Finally, both bays lie near a designated marine sanctuary. Florida Bay is near the Florida Keys National Marine Sanctuary, and Cape Cod Bay is near Stellwagen Bank National Marine Sanctuary.

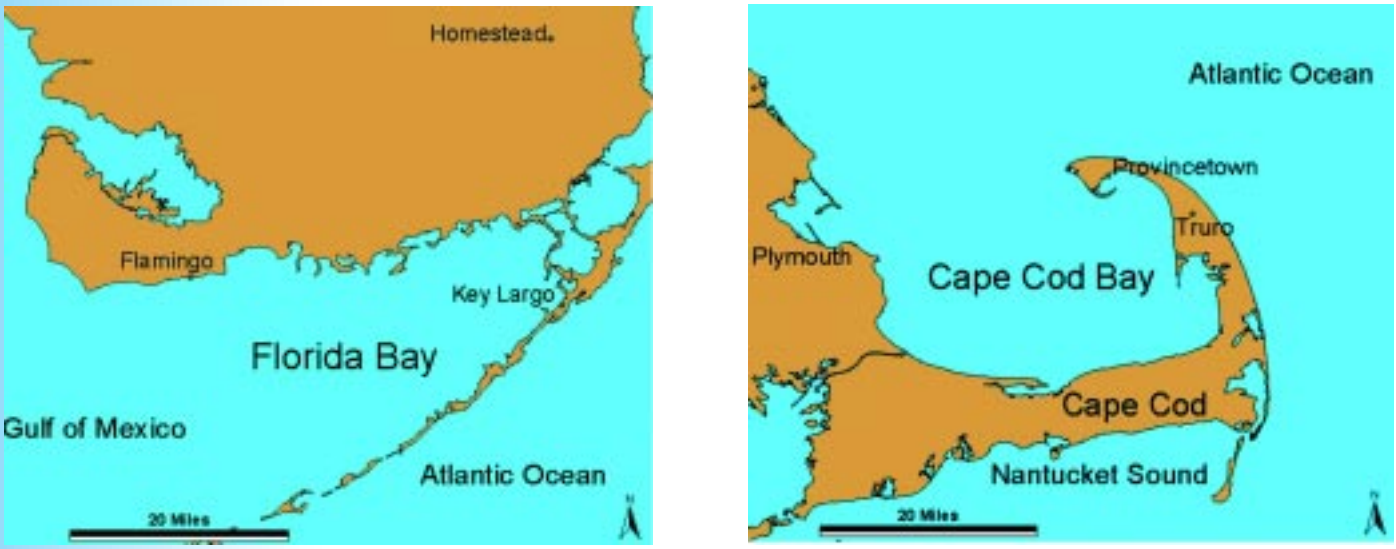

Figure 3. Despite strong similarities in their hydrology, hydrography and related characteristics, Florida Bay and Cape Cod Bay support very different ecosystems. Provided by Dan Bert, Carleton University.

Florida Bay and Cape Cod Bay share these attributes because both estuaries are off the beaten track. Historically, urban and industrial development clustered around the mouths of major rivers, but neither bay connects to a major river. Therefore, intensive development has occurred elsewhere, sparing both bays from many problems that directly affect other estuaries. So far, their hydrologic and hydrographic characteristics have isolated Florida Bay and Cape Cod Bay from these human activities, which are among the largest causes of environmental change in recent times.

Florida Bay and Cape Cod Bay share some physical characteristics, but they are quite different in other ways. It is not only the relative amounts of the ingredients that give a beer its distinctive flavor. How the ingredients are combined in the brewing process also has a lot to do with it, and biology is important, too. Different types of hops and yeasts impart subtleties to a beer's flavor. Likewise, estuaries like Florida Bay and Cape Cod Bay owe some of their unique character to geography, climate, and the organisms that inhabit them. So, what makes Florida Bay unique?

Light, and influenced by the Caribbean

Florida Bay has several traits in common with lambic beer, which is appropriately known as the rarest of all beers. These are the role of a shallow basin, organisms recruited from the surrounding environment, and a long holding time. As with all beers, water, hops and malt are first boiled to produce a sugary mixture, called the wort, in preparation for fermentation. In the brewing process for lambic beer, the wort is poured into broad, shallow pans to cool overnight. While cooling, wild yeasts carried by air from adjacent orchards and meadows settle on the wort and inoculate the brew. It is these organisms that carry out the fermentation. The mixture is then placed in wooden kegs where it is held for a long time, up to two years, to ferment.

Florida Bay occupies a broad, very shallow basin that is only about three feet deep on average. Other estuaries may be similarly shallow, on average, but these usually contain one or two deep channels that are efficiently flushed by tides. This flushing does not occur in Florida Bay. Instead, a lacework of shallow banks extends throughout

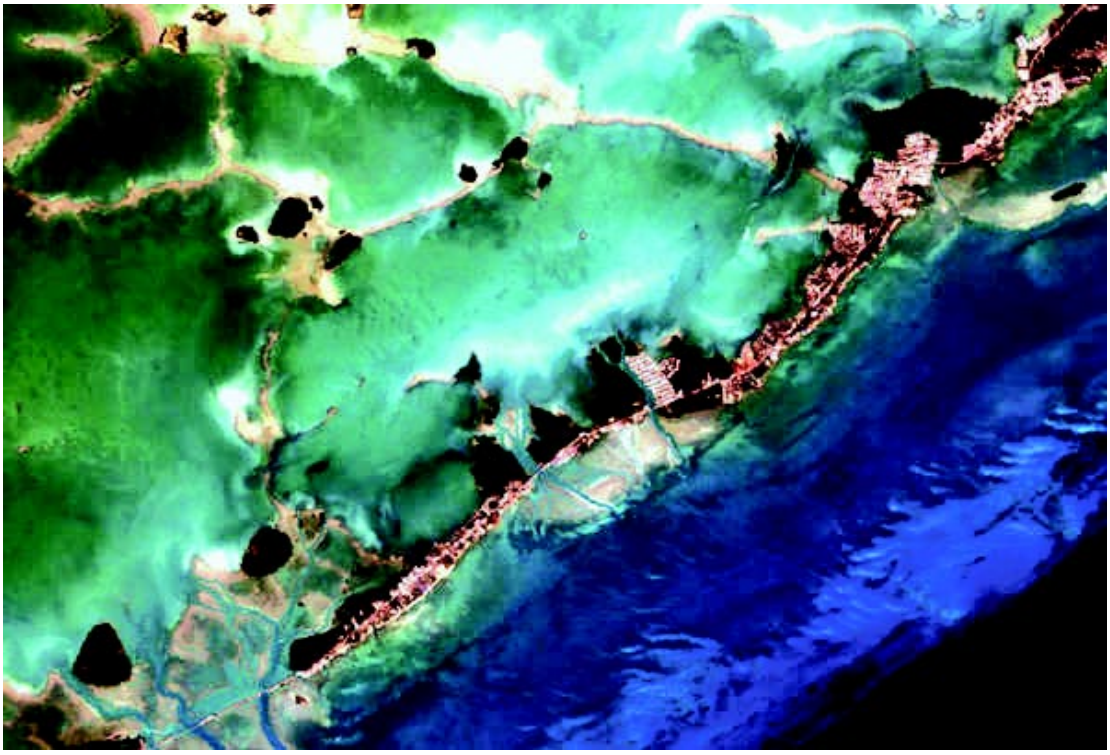

Figure 4. Algae and mollusks produce the carbonate sediments from carbon dioxide gas dissolved in the Bay's water. Organisms living in Florida Bay produce enough carbonate sediment so that the accumulation in these mudbanks can keep up with rising sea level. In this way, Florida Bay resembles more a tropical lagoon in the Bahamas than another estuary in the continental U.S. Image by Scientific Visualization Studio, NASA Goddard Space Flight Center; data courtesy Landsat Project.

and severely restricts circulation within the Bay. The banks along the western margin of Florida Bay are especially broad, several miles wide, and these effectively prevent free mixing of Bay water with the Gulf of Mexico, even though these two water bodies share an open water boundary tens of miles long.

As a consequence, water is held in Florida Bay for long periods of time. Some of the inner basins take as long as a year for water to be completely flushed by tides or wind. Even Hurricane Georges, which scored a direct hit on Florida Bay in 1998, failed to completely flush water from the Bay. This occurred even though Georges lowered water levels in the Gulf of Mexico to about three feet below the floor of Florida Bay.

The tendency for Florida Bay to trap and hold water for a long period of time leads to the phenomenon of hypersalinity. Hypersalinity occurs when the saltiness of bay water exceeds that of seawater, which is normally 35 parts salt per thousand parts water (ppt). At the end of the summer, which is the period of highest evaporation, salinity values in the central portion of the Bay frequently exceed 40 ppt. During the drought of 2001, when no fresh water reached Florida Bay from the Everglades, salinity values exceeded 50 ppt.

Because of Florida Bay's shallow depth, ample light penetrates the water column to support vigorous growth of seagrasses and algae on the bottom throughout the Bay. These seagrasses and algae form the base of the food chain in Florida Bay, a fact that affects the structure of the entire ecosystem. By comparison, Cape Cod Bay averages over 70 feet deep and cannot support such extensive growth on its bottom. The ecosystems of these estuaries are built on food chains with free-floating plankton as the main foundation. Other estuaries also contain grassed shallows and intertidal wetlands, but these features are not nearly as extensive as they are in Florida Bay.

Besides serving as the base of the food chain, the algae living on the bottom of Florida Bay is also major source of sediment. These sediments consist of solid, carbonate minerals formed by

Additional Readings and Resources

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biological processes from carbon dioxide and other dissolved minerals in the water. The shells of mollusks living in the seagrass beds are another important source of carbonate sediments. Production of carbonate sediments in Florida Bay is rapid enough so its accumulation on the banks has kept pace with rising sea level over the past several thousand years (Figure 4). Florida Bay has no other source of sediment. In this respect, Florida Bay resembles lagoons around the low-lying islands of the Bahamas, and it is unlike every other estuary in the U.S.

South Florida owes its distinctive ecological diversity to the combined influence from temperate regions to the north and the subtropical Caribbean to the south. Florida Bay, at the southern tip of this region, is perhaps more strongly influenced by the Caribbean, with which it shares its waters. Lobster and shrimp found in Florida Bay form parts of populations that range throughout the Caribbean and the eastern Gulf of Mexico. Postlarvae of these species are carried into the Bay on the tides, where they settle, metamorphose, and remain until it is time to move on as adults. Often this means being caught to supply a valuable commercial fishery. Alligator and crocodile cohabit on its shores, as nowhere else, and wading birds feed in the shallows of its banks in transit from north to south and back.

Scientists working to understand Florida Bay face a disorienting challenge. Some of the problems they see, such as loss of seagrasses, plankton blooms, and the impact of nutrient enriched groundwater, are similar to problems that have been studied in other estuaries. But their setting in Florida Bay is unfamiliar. How much of what has been learned elsewhere applies here? To answer this question, scientists must examine the Bay's basic components and how they combine to impart Florida Bay with its own particular flavor.

Acknowledgments

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