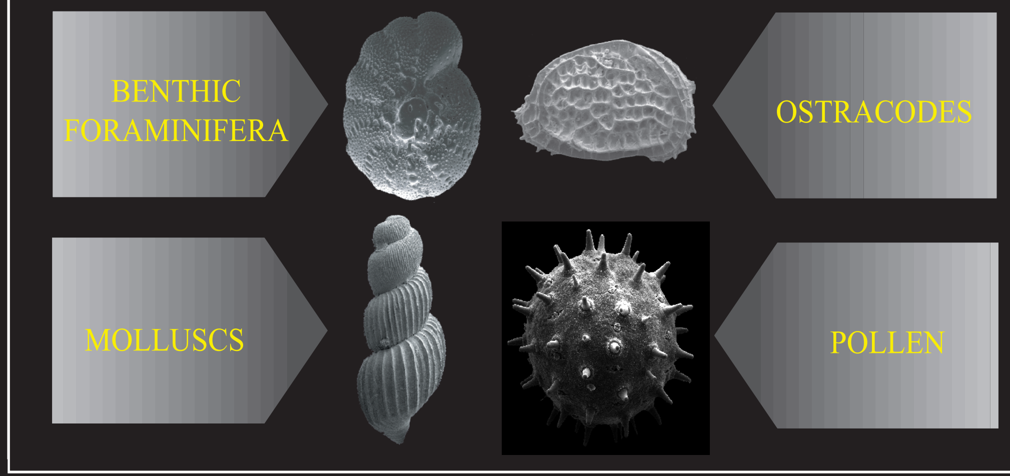
Introduction

Florida Bay and the entire south Florida ecosystem have undergone a number of dynamic changes over the last century. During the 1980's, dramatic dieoffs of large areas of seagrass, algal blooms, and diminishing numbers of shellfish and game fish focused public attention on the plight of Florida Bay. Periods of hypersalinity have been recorded since the 1950's, and these elevated salinities may be responsible for the extensive seagrass mortality during the 1980's. Changes in salinity and seagrass distribution, and the impact of these changes on the fauna, have been of primary concern in discussions of restoration of Florida Bay. To establish sustainable restoration goals for the Florida Bay ecosystem requires an accurate understanding of the natural patterns of change that exist within the physical, biological, and chemical components of the system, and the extent and timing of these changes. Paleoecologic data from cores, linked to modern analog data, provides essential historical information to those responsible for restoration.

Paleoenvironmental Proxies



Methodologies

Modern Sampling: Bay

A total of 50 surficial sediment sampling localities were established for Florida and Biscayne Bays. These sites are sampled biannually, with the Florida Bay samples collected via snorkeling and the Biscayne Bay samples collected using an Eckman grab sampler. Multiple samples are collected from some sites due to the spatial variability in substrate ranging from coarse calcareous sand to densely vegetated mud. In addition, environmental conditions such as salinity, depth, substrate type, seagrass presence, and water clarity are measured.

The upper 5 to 10 centimeters of sediment is selected from each sample because of the infaunal habitats of some benthic foraminifers. The samples are then processed using standard micropaleontologic techniques with the greater-than 63 m size fraction used for faunal analyses. Our initial studies used Rose Bengal staining to indicate specimens living at the time of collection. Observation of living versus total population data show insignificant differences between the relative abundances of the living and total populations. In addition, the use of total population data from modern samples provides closer analogs for paleoecological interpretations from core analyses due to taphonomic processes.

Faunal components, foraminifera, ostracodes, and molluscs are picked until a minimum of 300 specimens is reached. Samples not containing 300 specimens are picked of all the specimens and samples containing fewer than 100 specimens are not included in quantitative analyses of the data.

Modern Sampling: Terrestrial

Surface samples were collected from 128 sites between Water Conservation Area 1 and Florida Bay selected to maximize areal coverage and number of vegetation types sampled. At each site, standing vegetation was described, and a short push core (4 inch diameter) was collected. The top 1 cm of sediment was sampled for analysis of pollen assemblages and comparison with the standing vegetation. Sediments were processed using standard palynological processing techniques (acetolysis of all samples and HCl and HF when necessary) to produce strew slides of palynomorphs. A total of 300 grains was counted from each sample to provide percent abundance values for all taxa included in the count. The 30 samples analyzed to date were combined with a dataset generated by Riegel (1965) consisting of samples collected from the upper Shark River Slough southwest to Whitewater Bay. Addition of those sites increased the representation of several vegetation types, most notably sloughs and mangrove forests.

Downcore Sampling

Samples are collected from short (up to 2 meters) large diameter (4 inch) sediment cores at two centimeter intervals for faunal and floral analyses. For all analyses, samples are processed and quantified as described for modern samples.

Quantitative Applications

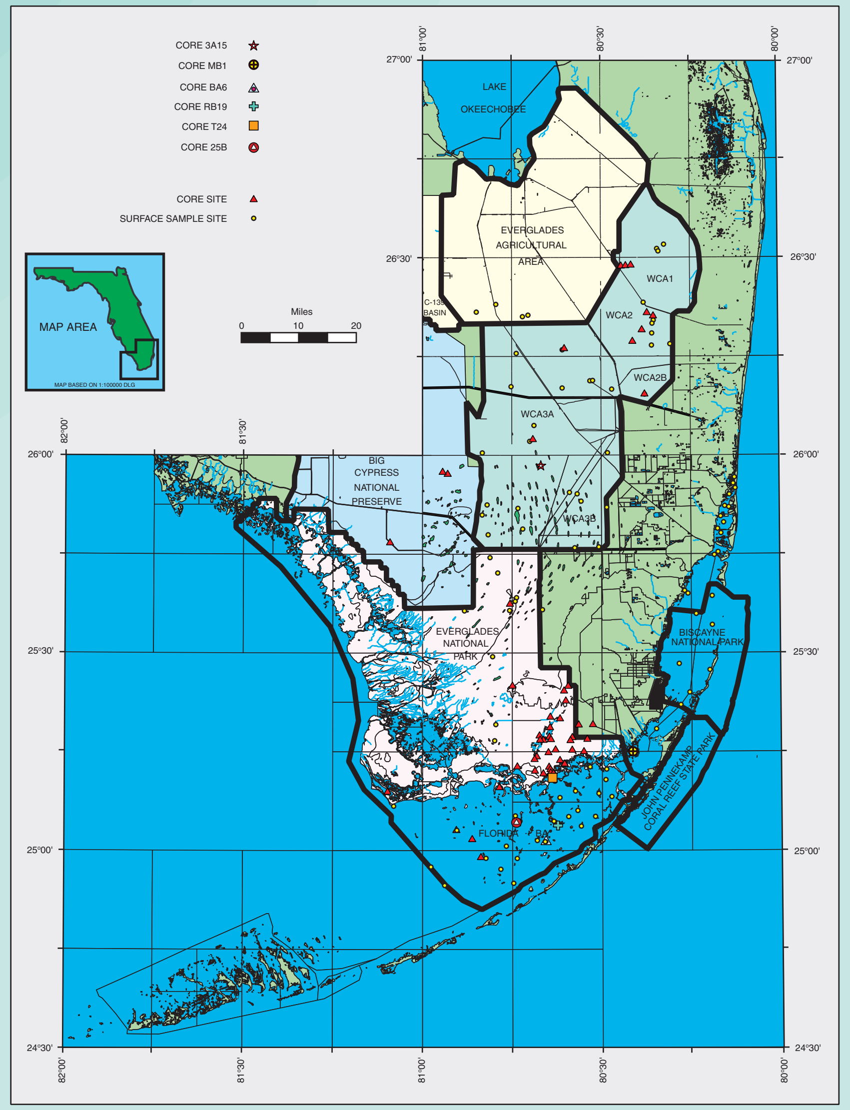
Several quantitative methods are used to evaluate the modern and geological data. The methods are used primarily to define distinct groups of species (biofacies) and groups of samples based on their species composition (biotopes), and to indicate environmental relationships controlling the faunal and floral distributions.

Cluster Analysis

Cluster analysis is applied to faunal and floral data in two forms; relative abundance of species grouped into faunal groups (R-mode), and relative abundance of species grouped into sample groups (Q-mode). The cluster analysis provides us with results that have no statistical significance, however it is used to describe groupings on which more robust quantitative applications can be tested.

Modern Analog Technique

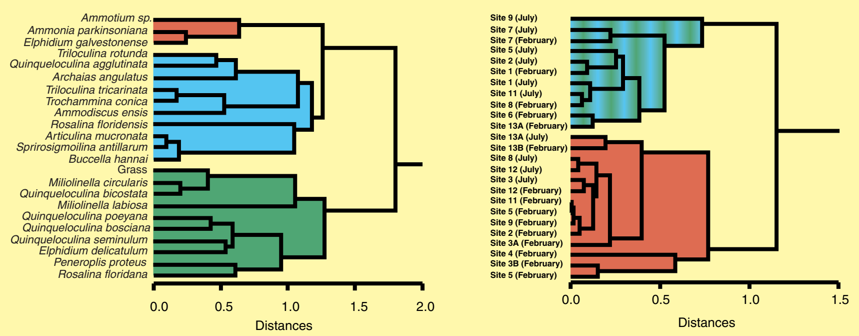
The modern analog technique (MAT) is used to identify modern analogs for down-core assemblages. The MAT is particuarly useful for interpretation of allochthonous assemblages such as pollen, which cannot be used as a direct proxy for standing vegetation at the sample site. By identifying modern analogs for fossil pollen assemblages, it is possible to estimate vegetation type and, by inference, environmental conditions at the sample site, such as hydroperiod (average annual length of inundation), disturbance regime, and nutrient status.



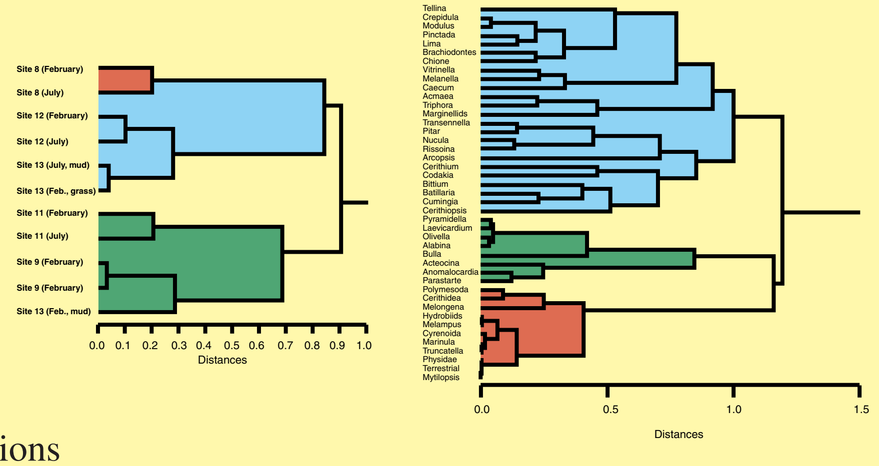
Modern Distribution

Florida Bay

Cluster Analysis of Modern Benthic Foram Data



Cluster Analysis of Modern Mollusc Data



Modern Faunal Distributions

1) Three distinct benthic foraminiferal and molluscan assemblages are identified from central and northeastern Florida Bay.
  -A low salinity, estuarine to freshwater fauna from the northern margin of the Bay.
  -A lagoonal fauna with taxa associated with seagrass substrate.
  -A marine fauna associated with low density seagrass substrate.

2) Regression analysis shows a strong correlation between the distribution of *Ammonia parkinsoniana* and salinity.

3) Some seasonal varibility exists in the relative abundance of benthic foraminifers within Florida Bay.

4) Three distinct benthic foraminiferal assemblages are recognized in Biscayne Bay that are controlled by salinity and productivity.
  -An assemblage associated with restricted regions having high variability in seasonal salinity changes.
  - An open-bay assemblage.
  - Productivity assemblage related to high organic input.

Terrestrial

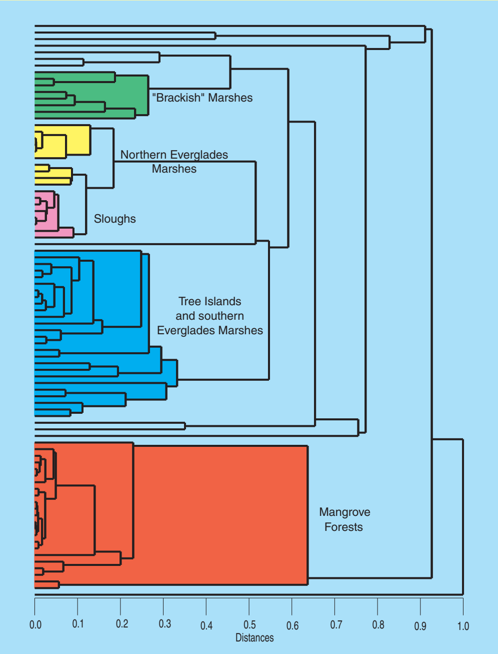
Modern Floral Distributions

1) Five distinct vegetational assemblages are identified from cluster analysis:
  -Brackish marshes
  -Northern Everglades freshwater marshes
  -Sloughs
  -Southern Everglades freshwater marshes
  -Mangrove forests

These clusters are separated by differing abundances of *Myrica, Rhizophora, Nymphaea*,and the Chenopodiaceae/Amaranthaceae.

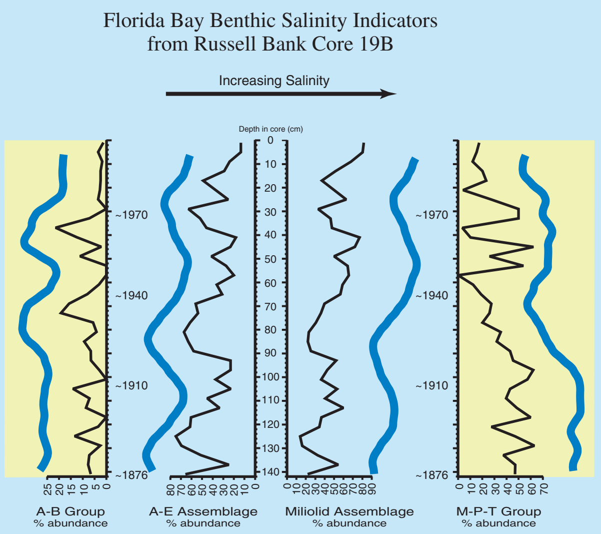
2) Outliers from the five clusters include samples strongly dominated by unusually high percentages of other taxa (such as *Sagittaria, Taxodium*, and *Ilex).*

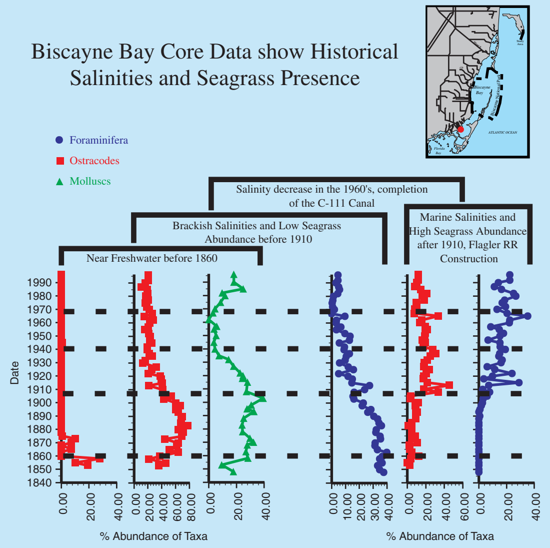
3) Freshwater marshes can be further separated into cattail marshes, flag marshes, sawgrass marshes, and "disturbed" marshes on the basis of different abundances of key taxa.



Paleoecology

Florida Bay and Biscayne Bay



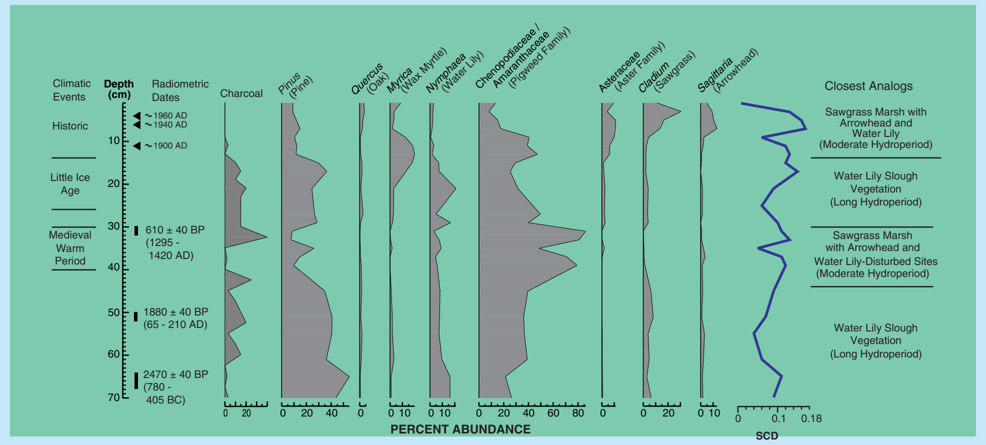


Summary of Results for Bay Cores

Salinity:
- -Natural variations have occurred in all cores and all indicators prior to 1900
- -A gradual increase in average salinity has occurred
- -Subtle changes can be seen post-1912
- -Profound changes occur post-1940
- -Amplitude and frequency of salinity change increases
- -Unstable system set up that continues to this day

Seagrass:
- -Natural variations have occurred in all cores and all indicators prior to 1900
- -Post 1940 the amplitude and frequency of seagrass distribution increases
- -There are some indications of increasing seagrass coverage and increasing presence of macro-algal mats during this century

Terrestrial



Vegetational Patterns in the Everglades

Long-Term Patterns (2,500 BP - A.D. 1900):

- Marsh and slough vegetation, characteristic of moderate to long periods of annual inundation (hydroperiod), dominated the Everglades for most of this interval. The primary changes occurred during the Medieval Warm Period (MWP) (8th to 14th centuries) and Little Ice Age (LIA) (A.D. 1550-1850). Conditions during the MWP were substantially drier and fires were more common; after a late 14th century vegetational recovery, conditions became more mesic in the latter part of the LIA, with increased abundance of tree island taxa.
- In the southernmost Everglades, salinity changes also affected vegetation. Over the last millennium, vegetation has shifted from freshwater marshes to brackish marshes to dwarf mangrove assemblages.

Short-Term Patterns (A.D. 1900 - Present):

- Vegetational changes over the last century primarily reflect local responses to specific environmental changes. These include changes in hydroperiod related to water-control practices, increased disturbance from canal and road construction, increased nutrient levels in surface waters, and, near Florida Bay, salinity increases due to reduction in freshwater flow, as well as natural sea-level rise.