Appendix D. Field guide to the beaches of Dade County

The islands of Miami Beach, Virginia Key, and Key Biscayne are the most southerly of the sand barrier islands along the east coast of the United States (fig. D-1). The material making up these islands is a mixture of quartz sand, which has traveled south by longshore drift from northern Florida and Georgia, and more locally derived calcium carbonate grains from the breakdown of mollusk shells and other marine skeletal remains. In addition, recent beach nourishment projects have added sands from various sources that were not naturally part of the beach system.

As this guide was going to press, a number of changes were taking place in Dade County. The drawbridge on Rickenbacker Causeway was being replaced by a new high bridge (designed to make storm evacuation safer). The city of Miami was in the beginning stages of developing northern Virginia Key as a recreational park facility. A large amount of new sand was scheduled to be pumped up on the beaches of central and southern Key Biscayne in 1984. And, as noted earlier, Miami Beach recently has been the site of the largest and most costly beach replenishment project in American shoreline history.

The guide begins at the entrance to Rickenbacker Causeway (reached by Interstate 95, exit 1 to Key Biscayne). The tour leads you out the causeway across Virginia Key to Key Biscayne to visit natural and developed beaches on this southernmost barrier island. This portion of the trip could best be enjoyed by bicycle, whether you pedal in from the causeway entrance or rent bicycles at some of the stops. The park areas have bicycle paths and numerous beach accesses. Once the new bridge is completed, bicycle access from the mainland will be much safer.

The tour next examines the sediment-starved shoreline of Virginia Key, after which you will then return to the mainland, drive north through Miami, and head out to the south tip of Miami Beach via the MacArthur Causeway. The massive new replenishment beach of Miami Beach is accessible at numerous points. Three stops are recommended, including one at Government Cut jetty at the south end.

The final stop on the tour is at Bakers Haulover Beach, an area that has received replenishment several times but which still has sand generally similar to that originally found on Miami Beach.

0.0 Toll booth at the entrance to the Rickenbacker Causeway (toll $0.75).

Drive out on the Rickenbacker Causeway (which becomes Crandon Boulevard on Key Biscayne) to Cape Florida State Park at the south end of Key Biscayne.

Rickenbacker Causeway was built during and just after World War II. The fill areas, including much of the roadway on Virginia Key, have restricted water circulation in Biscayne Bay. This causeway and five others to the north have divided northern Biscayne Bay into a number of sepa-
Fig. D–1. Map of the Miami area and coastal barrier islands showing locations of stops for this field trip.
rate bays. Each of these causeways serves as an evacuation route for island residents. However, all of them become impassible during the early stages of a hurricane’s approach.

On the left, Planet Ocean, created by the International Oceanographic Foundation, is an outstanding and enjoyable place to visit to learn about our oceans and also our shorelines. It is well worth your time.

The Seaquarium on the right has an exhilarating display of marine life.

On the right is the University of Miami’s Rosenstiel School of Marine and Atmospheric Science. It has tours for the public on Mondays at 1 p.m. (There also is a nice cafeteria on the water.)

On the left are the laboratories of the National Oceanic and Atmospheric Administration and the Tropical Marine Fisheries Center.

Take the bridge across Bear Cut, which separates Virginia Key and Key Biscayne. Bear Cut is a natural tidal inlet that is noted on maps from the earliest exploration of Florida waters. The tidal currents through Bear Cut have shifted much of Virginia Key’s southward-drifting beach sand seaward, forming a broad, shallow, underwater sand platform seaward of northern Key Biscayne.

Come on to Key Biscayne. The Australian pines (*Casurina*) that dominate this northern tip of Key Biscayne are exotic trees that rapidly grow on disturbed or filled land—in this case fill associated with causeway construction. These beautiful trees are a great hazard to the inhabitants of Key Biscayne. They are shallow-rooted and as a consequence are readily blown over during hurricanes. They will block passage on and off the island.

Enter the central one-third of Key Biscayne, which is residential and commercial.

Enter Bill Baggs Cape Florida State Park, which occupies the southern one-third of Key Biscayne. It is open from 8 A.M. to sundown; the entrance fee is $5.00 per person. Write to the superintendent for a waiver of fees for educational groups (Key Biscayne, FL 33149).

Turn left into the parking lot and park as soon as possible. Walk out to the beach.

*Stop 1. Natural shoreline* with sea oat stabilization, beach ridges, and controlled access walkways.

In 1959 the bulk of Cape Florida was filled by a developer to its present elevation by dredging material from the bay side (fig. D-2). Only the section of beach ridges at this stop and at an area near the lighthouse remain in their original natural state (fig. D-3). Hence, the dominance of Australian pines throughout the park. Prior to filling, this southern third of Key Biscayne was a series of southward-arching, sandy beach ridges that in some cases were separated by mangroves or small ponds (fig. D-2). Each ridge of sand was once at the tip of the island, clearly showing
that Cape Florida grew southward.

On the walk out to the beach, you will cross several beach ridges. These are quite young, having only sea oats and shrub vegetation. This is one of the few sections of beach in Dade County that has been building out during the last 50 years. By coring into these ridges we have learned that each one was formed during a major storm, and that sea oats subsequently grew on the ridges and caused some further growth as they trapped finer sand blown or washed onto the ridges during lesser storms.

Here as elsewhere sea oats and other coastal vegetation are important to assure stabilization and preservation of the beach ridges and dunes. The beach ridges in the park were severely damaged in areas where foot traffic destroyed the vegetation. In 1982 Cape Florida park began a program of restricting access to the beaches by putting up fences to define walkways. Notice the difference in the beach ridge elevations at and away from the walkways.

The shrubs of the round-leaved seagrape, the low, crawling vines of the beach peanut and the beach star, and the other grasses also are important to stabilization of the ridges.

To encourage recovery of the previously damaged beach ridges, the park planted 20,000 sea oat plants in 1982 and 1983. As you will see at the next stop, the park also is beginning to construct board walkways across beach ridges, a program they plan to expand.

Seaward of the beach is a very broad, shallow, littoral sand platform on which the seagrass *Thalassia* flourishes. Though important to the stabilization of the offshore sands, the blades wash ashore in great abundance after winter storms, detracting from the aesthetic quality of the beach to many beachgoers. The various parks have various ways of handling this problem. Wisely, park managers of Cape Florida either do not disturb this seagrass wrack or they rake it to the edge of the beach ridges as a protection to the ridge and as shore mulch. This, at the same time, deters foot traffic in from the beach. Only litter is removed from the beach. To simply gather the seagrass from the beach and carry it away also would remove precious beach sand.

The beaches of southeast Florida differ from those farther north (from Palm Beach north) in that the Bahamas to the east protect the shores from large waves coming in from the open Atlantic. In addition, certain stretches are protected by seaward reef ridges near the edge of the continental shelf. These break up larger waves generated in the Straits of Florida. Seaward of Key Biscayne, for example, is a shelf edge ridge rising from the deeper seafloor to a depth of 9 to 12 feet. In addition, north and south Key Biscayne have broad, shallow, littoral sand platforms extending about 1 mile seaward of the shore. These further dampen incoming wave energy. As a result of the relatively small waves, the beaches of Key Biscayne are composed of somewhat finer-grained sand than is present on the more
Fig. D–2. Aerial photographs from 1945, 1951, and 1972 of Cape Florida, southern Key Biscayne. Cape Florida Channel, just left of Key Biscayne. was severely modified in 1950 when dredged to provide fill for nearly the entire cape area. This fill covered the curving beach ridges that recorded
exposed beaches farther north.

From the beach here you can look north to the developed part of Key Biscayne, Crandon Park, Fisher Island, and Miami Beach (the buildings in the distance).

To the south you can see Cape Florida Lighthouse (fig. D-3), and if you look due south you may be able to see Soldier Key, the northernmost of the Florida Keys. Soldier Key is composed of coral limestone—a reef formed some 120,000 years ago during a previous interglacial stage when sea level was about 22 feet higher than it is at present.

Beach sand that is transported south past Key Biscayne is mostly carried southeastward across an elongated, shallowly submerged sand ridge that extends south about as far as the level of Soldier Key. Directly south of Key Biscayne is a carbonate mud bank cut by numerous tidal channels. Tidal ebb flow through these channels is responsible for shifting the southward-drifting beach sand seaward.

It is from this southeastward extending sandbank that sand was obtained for the Key Biscayne beach nourishment in 1984. The sand will be spread on the beach from just north of this stop northward through the park and in front of the commercial sector.

Return to your car and drive on south through the parking lot. Continue on the drive around Cape Florida unless you want to stop at the lighthouse.

As you drive through the Australian pine forest here you can see that almost nothing lives on the forest floor except
The Cape Florida Lighthouse, constructed in 1825, was active until 1878 when it was replaced by Fowey Rock light at the shelf edge reef (visible to the southeast about 3 miles distant). The old lighthouse has now been restored, and together with a replica of the lightkeeper’s home is open for tours.

When constructed, the lighthouse was apparently about 200 feet from the shoreline. Gradual erosion has left the lighthouse at the water’s edge, with only concrete seawalls protecting it from erosion. The 1984 beach nourishment program added sand and an erosion control structure near the lighthouse.

When Cape Florida was filled in 1950 (fig. D–2), the sediment was dredged from the Cape Florida channel and from the carbonate mud bars along the southwest side of Cape Florida, and a seawall was added along the entire southwest shore. The deep, broad channel produced by this dredging is a trap for beach sands carried south past the lighthouse and is a major cause of shore erosion at the south tip of Key Biscayne.

On the drive beyond the lighthouse you can see “Stiltsville” to the south. These are weekend homes built on pilings along the edge of tidal channels in the mud bar belt. This area is presently being incorporated into Biscayne National Park, and by the turn of the century these houses will be removed.

8.9 No Name Harbor. This small harbor has been a refuge
from hurricanes since early explorers first traversed these waters. In 1982, scout groups began planting red mangrove seedlings in the riprap shore margin.

9.2 Cross the main park road and park in the parking lot. (The lot is sometimes closed on weekdays; if so, park along the roadway and walk 100 yards to the beach.) Walk across the clearing to the beach.

**Stop 2. Natural beach with boardwalks.** This is a somewhat less used portion of the Cape Florida beach. In 1983, to reduce stress to the vegetation on the beach ridges, 3 boardwalks were constructed across to the beach. At least 3 more are planned. Very shortly visitors should be able to compare the influence of vegetation here with the areas to the south where boardwalks are absent.

From here north, beach fill was added in 1984. From here south, the shoreline has been stable or building out during the past 100 years, but there has been less build-up recently than at Stop 1.

Leave the parking lot and turn right (north) on the main park road toward the exit.

9.8 On the left, just beyond the park exit, is Pines Canal. This is an artificial canal constructed about 1920. It briefly separated Cape Florida from the rest of Key Biscayne, but since there were no significant jetties constructed, it quickly filled in on the beach side with sand carried in by longshore drift.

On the right, the Towers of Key Biscayne Condominium was built on a “compacted sand foundation” on the filled portion of the canal. The beach has a small bulge here (probably caused by the filling of Pines Canal) giving a false sense of beach protection. The seawall (also the front of the more seaward building) lines up with the beach shoreline to the north and south.

10.2 **Turn right** on Seaview Drive.

10.4 **Stop at the corner** of Seaview Drive and Ocean Drive. The large building in front of you, the 26-story Casa del Mar, in contrast to the Towers of Key Biscayne, is built on deep pilings and has a massive, sloping seawall whose foundation is supposed to extend 30 feet below sea level (limestone bedrock begins at about 20 feet). The purpose of deep pilings is to help the building survive a big storm if the beach erodes right out from under the foundation.

There is theoretically a public access just to the left (north) of the Casa del Mar entrance. The gate is usually locked.

10.4 **Turn left** on Ocean Drive.

10.5 **Key Biscayne Hotel and Villas** was constructed in 1952. When first built, it had more than 100 feet of beach in front of the present seawall. This beach lost more than 25 feet of shoreline in Hurricane Donna (1960), another 25 feet during Hurricane Betsy (1965), and has had minor erosion since. There has been little to no beach since 1965 (fig. D-4).
Fig. D-4. View along the seawall of the Key Biscayne Hotel during a winter storm in January, 1982. Note how the seawalls completely reflect incoming waves. This tends to move what sand is near the shore back seaward off the beach. Hence seawalls, while protecting basic structures built close to the beach, tend to destroy the beach. Of course the beach was the reason the buildings were built there to begin with.

(Note: Public beach access on the commercial section of Key Biscayne is presently poor but may improve somewhat after the 1984 nourishment project. Good public access is required because tax money will pay part of the replenishment bill. The various hotels offer good access to the shore and are, of course, open to the public for drinks and meals. This guide does not suggest that hotels offer public beach access for individuals or large groups.)

10.6 Key Biscayne Beach Club. There is another theoretical public beach access to the left of the entry drive.

By October 1983 the seawalled properties to the north and south of the Key Biscayne Beach Club had no beach even at low water. The beach at the club had eroded back to a naturally cemented layer containing mangrove roots.

10.7 Turn left on Galen Drive.

11.0 Turn right (north) on Crandon Boulevard.

11.3 Turn right on East Drive. The older homes in the development on the right are mostly low and were severely inundated during Hurricane Betsy (1965). Federal flood insurance regulations now require first-floor elevations to be 10 feet above mean sea level on the east side of Crandon Boulevard and 9 feet on the west side.

11.7 Turn right on Ocean Drive.

Stop 3. Developed shoreline of Key Biscayne. You have 2 choices here: (a) Turn left into Silver Sands and Sand Bar Restaurant. Park and walk up the stairs to the bar over-
looking the beach where there is a nice view of the beach system; (b) or park at Sonesta Beach Hotel and walk through the main entrance to the beach at the back.

The Silver Sands, built prior to Hurricane Betsy, was damaged and the seaward part of the structure undermined by both that storm and Hurricane Inez a year later (1966). Figure D-5 shows conditions along this shore during a winter storm.

The Sonesta Beach Hotel was built following these storms. The hotel is set back from the beach (as it is prior to renourishment) about the same distance that the now beachless villas of the Key Biscayne Hotel were when first constructed more than 30 years ago.

The effective beach was more than 100 feet wide at the Sonesta (prior to the 1984 renourishment). However, the beach is severely eroding at present—not laterally but vertically. The beach ridges that used to be here were stripped of vegetation as recreational use increased, and the beach ridges and back-beach area have had over 2 feet of lowering, or vertical erosion. This can be seen by the exposed roots of the palms extending about 2 feet above the sand surface. The heavily used portions of Crandon Park to the north display similar vertical erosion.

This vertical erosion means that there is less volume of sand present to act as a buffer to storm erosion. Storm waves also will more easily overtop the now lower beach. This shoreline may thus severely erode laterally during the next significant hurricane.

Fig. D-5. Seagrass wrack along the beach at the Sonesta Beach Hotel during a winter storm.
Looking north, you can see Crandon Park beyond the
condominiums. Sand pushed by the tides through Bear Cut
at the north end of Key Biscayne has formed a permanent
offshore bar. This bar is about 1 mile offshore at the north
end of Key Biscayne, and southward it angles toward the
shore.

You can see this bar just offshore by the Silver Sands and
Sonesta. It joins the shore just north of the Key Biscayne
Beach Club. If there is an onshore wind, the waves will be
breaking on it. This essentially is a permanent feature that
protects the adjacent beaches from some of the offshore
wave energy.

Disturbance of this bar by dredging off northern Key
Biscayne in 1969 caused large volumes of sand to drift
south. This drifting sand may eventually provide a “natural”
pulse of beach nourishment on the commercial sector of
Key Biscayne.

Return to Crandon Boulevard.

12.1 Turn right (north) on Crandon Boulevard.

13.1 Turn right into Crandon Park just beyond the police sta-
tion and park in the lot (entrance fee $1.00). Walk out to
the beach at the north end of parking lot #1.

Stop 4. Crandon Park Beach. To the south of the loop walk
with the curved seawall, the beach is very broad. This is
partly because the seawall is set well back from the shore
and partly because the offshore sandbar in about 1975
moved onshore here. Prior to that time the offshore bar was
separated from the beach by a trough 50 to 200 feet wide
and 10 to 12 feet deep.

The heavy recreational use, uncontrolled flow of pedes-
trian traffic, and use of heavy equipment on the shore
prevent effective vegetation from stabilizing the back-beach
area. Again, the exposed roots of palm trees are an indica-
tion of the vertical erosion, or beach lowering, that has taken
place in portions of the beach and the grassed picnic areas
behind (seen to the north of the loop).

In 1969 a small amount of sand was pumped onto the
beach from the north end of Key Biscayne south to the north
end of the parking lot. The source for this sand was a
“borrow” area 1,500 feet offshore (inside of an offshore sand
ridge) on a seagrass-stabilized portion of the nearshore
platform. Both the sand put on the beach and the sand
exposed offshore by the dredging were quite fine-grained
(having been trapped and stabilized there by the seagrasses).
Most of this nourishment is now gone, and the offshore
borrow pit became quite dynamic for about 10 years. Break-
ing waves actually eroded the inner margin of the borrow
pit, and the sand released spread both shoreward (smother-
ing other extensive areas of seagrass) and southward parallel
to the offshore ridge. The area is gradually restabilizing as
the seagrass comes back.

One of the reasons that the portion of Crandon Park
north of the loop has been eroding is that, in conjunction
with development of the park in the early 1950s, an elongated trench was dredged just offshore from the beach. Extending from just north of the loop to just north of the northernmost parking lot, this trench has an uncertain purpose. Perhaps it was to provide fill for the parking areas. Whatever, it has not only been the site of numerous unfortunate drownings over the years but also a sink for sand shifting southward along the coast. The trench is now largely filled.

The absence of vegetation-stabilized beach ridges in the developed part of Crandon Park leads to the landward loss of a great amount of sand by wind. If appropriate dune vegetation was present, this sand would be trapped and would build up the dunes.

As this park is a major beach recreation area for the county, the park managers attempt to keep it free of seagrass wrack. A large scraper-loader moves up the beach scraping the wrack (and some sand). In the past they have dug a trench along the base of the seaward-most dune (north of the parking lots) to deposit the material so it can decay. The sand was then returned to the beach. This served two purposes. It cleaned the beach without removing sand from the system, and the trench minimized the landward loss of sand from the beach zone. Unfortunately, on my last trip to the dump (which is on the west side of Crandon Boulevard) I noticed large mounds of seagrass wrack and sand there — a quite permanent loss of sand from the system.

If you feel adventurous, the walk to the north tip of the island is pleasant and normally much less peopled than near the parking lots. At the north end of the island is a rocky intertidal platform. It is actually an exposure of the 2 oldest beach ridges on Key Biscayne (formed about 3,000 years ago) that were subsequently partly inundated by later sea-level rise. As black mangroves colonized the area (about 2,000 years ago), their roots penetrated the former beach ridges. With time, the roots were fossilized and became quite hard on exposure. These cemented beach ridges are very important to the stability of northern Key Biscayne. The area appears erosional, but comparison with surveys made in 1770 indicates that there has been very little long-term erosion of this rocky platform.

Return to Crandon Boulevard. (Mileage includes a 0.5-mile circuit in Crandon Park; adjust if necessary.) Continue north.

15.0 Marina and Bear Cut Beach. If you wish to visit Bear Cut Beach, park in the Marina on the left and carefully cross the causeway. The north tip of Key Biscayne also can be reached by walking along the shore from this side. Much of the shore is an eroding forest of red and black mangroves, capped by a thin beach ridge.

Continue driving across Bear Cut Bridge. Bear Cut has been here a long time. It is shown on a 1520 map.

The beaches on both sides of Bear Cut are officially
closed to swimming. Strong tidal currents and sharp drop-offs cause numerous drownings each year.

The city of Miami has acquired much of the shoreline of Virginia Key and is developing it as a waterfront park area. Much of the area is presently closed except on weekends.

15.9 **Turn right** on “Sewer Beach Road.” This city of Miami, Virginia Key Park is presently open from 8 a.m. to 8 p.m. This, together with the name of the road, is likely to change.

The area along the left side of the road was a major county dump and landfill until the late 1970s. It is now being colonized by Australian pines.

17.4 **Turn right** (carefully) on the dirt road that leads to the beach. Stop at the shore.

**Stop 5. Virginia Key Beach.** In 1952 the raw sewage that was seriously damaging Biscayne Bay was abruptly diverted through a new sewage treatment plant on Virginia Key and then released at an outfall about 1 mile seaward. The large green structure just to the north is a pumping station. The outfall pipe has recently been extended to beyond the shelf edge and sewage is now released in the Straits of Florida.

Prior to the hurricane of 1835, the island of Virginia Key was connected to Miami Beach to the north. After formation, the inlet (Norris Cut) remained narrow and shallow through the mid-1960s.

To the north you can see Fisher Island and Miami Beach. Fisher Island was created in 1905 when the narrow southern spit of Miami Beach was severed with the dredging of Government Cut. As jetties were extended seaward of the cut to prevent it from being filled by the longshore drift of beach sand from Miami Beach, the areas to the south became sediment-starved. The granite rubble jetties are visible extending seaward from Fisher Island and Miami Beach. The northern jetty extends about 1 mile seaward of the beach.

Since about 1912 essentially no beach sand has come south past Government Cut. Prior to that time about 100,000 cubic yards of sand per year were probably drifting south. That means the beaches south of Government Cut have been deprived of about 7 million cubic yards of sand over the last 70 years. This sediment starvation has had a severe negative impact on the shorelines of Fisher Island, Virginia Key, and northern Key Biscayne (fig. D–6).

During the development boom in the 1920s Carl Fisher placed extensive fill on the back side of his Fisher Island property with the dream that it would become the deep water port of Miami. That dream died with the hurricane of 1926. The original natural beach on the seaward side is completely eroded away, and the beach is composed of Carl Fisher’s rubble fill.

Norris Cut has been almost completely flushed of sand, much of it being swept into deep-dredge channels within the bay or onto the shallow flats behind northern Virginia Key.
An area of shallow, littoral sand seaward of the beach at this stop was once extensively carpeted with seagrasses. Sediment starvation caused the loss of most of this seagrass-covered bottom, resulted in rapid deepening of the offshore area, and left the beach exposed to greater wave energy (fig. D–7).

As a result, the beach on northern Virginia Key has eroded by more than 300 feet. The granite groins visible here were installed in 1973 prior to a major renourishment program on 2.1 miles of beach. This innovative project took fossil quartz beach sand being dredged as a part of a Government Cut deepening project and placed it along the northern and central portions of Virginia Key, completely burying the groins. This was innovative because it killed two birds with one stone. The channel was dredged, and the beach was replaced, both in the same operation. At that time the shoreline along this entire portion had cut back essentially to the treeline. As you can see at the northern and southern ends, the sand is again essentially gone. Some sand remains in the central area.

As the offshore sand reservoir and protection has been largely depleted, the future of Virginia Key’s beach is not bright. Though not a developed shoreline, this is of special concern because the major sewage treatment facility lies only a few hundred yards inland.

The north end of Virginia Key, in from the shore edge, has received several episodes of fill during Government
Fig. D-7. Maps showing the loss of seagrass (black in color) on the shallow shelf seaward of the beach on Virginia Key. Percentage of cover with respect to 1945 conditions is noted. This loss is caused by the cutting off of the sand supply by jetties at Government Cut.
Cut deepening programs. Though some of this fill has been trucked to other sites, this area has the highest land elevations in Dade County.

Return to the Rickenbacker Causeway.

19.2 Turn right (west) on the Rickenbacker Causeway. Continue off the causeway. Stay in the right lane to follow the exit to I-95 North.

21.8 Exit to I-95 North.

24.2 Take right exit to I-395 to Miami Beach.

25.5 MacArthur Causeway; continue.

After crossing the drawbridge, you are on Watson Island, a fill island. Chalk's International Airline, the world's oldest commercial airline, operates seaplanes to the Bahamas from here.

To the right is Dodge Island, Miami's port and the port for a number of cruise ships.

To the left is Venetian Causeway, the oldest causeway across Biscayne Bay. During the 1926 hurricane the winds suddenly went calm, and many people drove out of the causeway to see the damage to Miami Beach. As the calm eye of the storm passed, more than 100 people were trapped and drowned on the causeway by rising water.

All of the causeways and residential and industrial islands in the Bay are artificial. Most were filled in the early 1920s. However, the eastern part of Dodge Island was filled to its present configuration in the early 1980s. The fill on some of the older islands has compacted, and because of the leeward elevations these islands are partially inundated by exceptional spring tides.

Just to the right of the roadway is Government Cut. It was recently dredged to a depth of 42 feet to accommodate the cruise ship SS Norway.

As you cross the bridge at the east end of the causeway, you can see Fisher Island to the right. The red-tile roofed buildings are the old U.S. Quarantine Station, now used as a marine geology station by the University of Miami.

28.9 Come on to Miami Beach. Continue east on 5th Street.

29.5 Turn right (south on Ocean Drive).

30.0 At the end of the road, park and walk out to the beach south of the pier.

Stop 6. South Miami Beach and Government Cut. Walk south to the jetty at the north side of Government Cut. On the way down you may see the sign:

Beach Erosion Control and Hurricane Protection Project
Protection Jetty Sand Tightening Project
Beach Erosion Control Project
U.S. Army Corps of Engineers

Though a wide, renourished beach provides protection from total beach erosion during a hurricane, it does not provide protection from flooding. A common misconcep-
tion is that beach renourishment will provide complete protection from hurricanes. As we will see, the big artificial berm (the ridge on the inner beach) may actually cause increased flooding. The “protection jetty sand tightening project” means that the spaces between the rubble making up the jetty are being filled with sand and rubble so sand cannot wash through into Government Cut.

There is a small dune near the jetty, west of the new fill, where one can see what the old, natural beach material looked like. It is a tanish sand composed of quartz and polished shell fragments, quite coarse.

Government Cut was cut in 1905 and had to be dredged repeatedly to remove sand that was filling it in. This replaced Cape Florida channel as the main access to Biscayne Bay. Government Cut was generally useless until 1912 when jetties were completed on the north and south sides of the cut. Several phases of redredging, deepening, and extending the jetties have brought Government Cut to its final form.

The cut and jetties have formed a nearly complete block to the southern drift of shore sand since 1912. Much of this southward-drifting sand backed up against the north jetty, producing a broad beach that extended north to about 13th Street (figs. D–8 and D–9). Some sand was diverted seaward, shallowing the offshore zone in this area.

From the jetty you can look south to Fisher Island. As noted earlier, the present beach on Fisher Island is rubble fill retreating at several feet per year. To the south, you can see Virginia Key and Key Biscayne. Note the erosional offset of Fisher Island and Virginia Key. Remember that Fisher Island once formed a continuous, straight-line beach with Miami Beach (fig. D–6). Beyond you can see the three

Fig. D–8. Oblique aerial view (1972) looking south across south Miami Beach, Government Cut, Fisher Island, Norris Cut, Virginia Key, Bear Cut, and a part of Key Biscayne (top left). Note the sand buildup against the jetty at Miami Beach.
sections of Key Biscayne.

This southern end of Miami Beach has received 2 phases of beach fill. The first took place as a part of the Government Cut deepening program. This sand contained an abundance of limestone and coral rubble. The contract for filling stipulated that all grains larger than 12 inches across were to be screened out!

This minor project has been overshadowed by the massive $68 million project that widened the beach some 300 feet for the entire length of Miami Beach (fig. D–10). Included in this project is an artificial berm about 11 feet in elevation along the inner portion of the beach fill. This project was begun in 1979 and completed in 1981, working from north to south. This project is, thus, only recently finished, and the waves are now "adjusting" the beach profile.

As there was no suitable volume of natural beach sand for this project, an offshore sediment was selected. In from the edge of the platform, the fossil limestone forms a series of submerged linear ridges paralleling the shore. The limestone surface dips down to more than 50 feet below sea level between these ridges, and these elongated depressions are largely filled with a calcareous sand. This sand between the ridges was dredged for the beach fill.

Though approved as a beach sand, this sediment contains very few characteristics of a natural beach sand. More than 30 percent of the sand is sufficiently fine-grained that
it tends to readily move in suspension. Many of the coarser grains that were presumed suitable for a beach environment are either very porous and have a very low effective density in water or are thin, platy grains that move much more easily than the robust shell and spherical quartz grains of the preexisting beach. Much of the larger calcareous material is delicate and highly susceptible to fracture breakage when placed in the surf zone.

If there is an onshore wind and waves, the water will probably appear quite murky, a problem rarely observed before nourishment. This fine calcareous mud in suspension was partly in the beach fill and is partly produced by the rapid breakage of the coarser grains in the surf zone.

Near the jetty you may see some large piles of coral rubble. The beach fill contained significant amounts of limestone rubble either as coral heads scattered through the sands or as limestone pieces sucked in when the dredge slipped a bit. Initial repolishing and erosion of the beach fill by natural processes concentrated these in the swash zone. A rock removal and crushing program costing more than $1 million, thus, had to be added.

The need for beach nourishment in the southern portion of Miami Beach began with the hurricane of 1926. In the early 1920s Miami and Miami Beach were rapidly developing. Resorts were built too near the water’s edge. Then the storm struck. The following description is from P. W. Harlem, Aerial Photographic Interpretation of the

The 1926 hurricane of September 14-22 advanced on South Florida at a rate of over 18 miles per hour until the 17th when it crossed the coast at Miami and slowed down to 11 miles per hour (Mitchell, 1927). The eye of the storm passed over Miami and Homestead at 6:45 on the morning of the 18th, passing just to the south of Little River. Winds, reported by the local weather bureau, were 8 miles per hour the evening before, 57 miles per hour at 1:50 a.m. on the 18th, and had peaked at about 115 miles per hour (indicated) from the northeast at 5:00 a.m. when the instrument was blown into the street. An hour and one-half later, as the eye passed, the wind was variable at 10 miles per hour. Most of the 242 deaths attributed to this storm occurred after the eye passed as people were caught unprotected on the streets and causeways. At least one hundred million dollars of property damage was incurred in a period of hours. Between Ft. Lauderdale and Miami 4,725 homes were destroyed and another 9,100 damaged. The highest storm tide along Miami and Miami Beach bayshores coincided with the second phase of the storm, after the eye passed, as the 120 miles per hour plus wind changed direction to the east and southeast. Besides inundating the city of Miami Beach, a tidal surge in the Miami River wrecked large numbers of boats put there for safe anchorage. The storm tide in the Miami Canal at Hialeah reached 3 m (10 feet). Storm tides of 2.3 m (7.5 feet) occurred north of MacArthur Causeway, 3.6 m (11.7 feet) at the Miami River mouth and 3.3 m (10.6 feet) at Miami Beach, both south of the causeway.

This marked the end of the first development boom of Miami and Miami Beach. Though there was severe damage, some of the storefront hotels survived. The beach, however, had eroded, leaving some of the hotels partly in the water and many with waves washing against their walls. Wooden groins were constructed in an attempt to bring some of the sand back to the beach.

Though Miami Beach got off to a poor start because structures were built too near the beach, there has really been very little subsequent erosion. The massive beach nourishment project just completed was, for the southern portion of Miami Beach, an attempt to solve a problem created 55 years earlier. The problem is the same one we see developing in many areas of South Florida today—construction too close to the beach.

As you walk back to your vehicle, note the old South Beach "fishing pier" now (in 1984 at least) mostly extending across the new beach fill.

Drive north on Ocean Drive. As you drive from the south to the north end of Miami Beach, you will progress from
the earliest developments to areas built up only in the late 1970s.

30.4 Public park.
At 15th Street there was no beach prior to renourishment, and for several blocks north and south the shore consisted of vertical seawalls (fig. D-11). Incoming waves reflected back offshore, creating a permanent offshore bar inhibiting shoreward movement of sand.

31.3 Jog left one block at 15th Street and continue north on Collins Avenue.
Following major hurricanes, Collins Avenue and the first floor of many hotels were commonly filled with sand. This was bulldozed back to the beach. There have been no hurricanes since 1966 (none since beach nourishment), so the response of the new beach fill has not yet been tested.

32.0 Public access and parking at 21st Street.
At 24th Street we join Indian Creek, the remnant of a tidal inlet that opened near 70th street in the mid-1800s. The inlet migrates south because of southward-drifting longshore sand transport. It was sealed off by natural processes in 1820.

32.9 Public access and parking at 34th Street.
33.0 Public access and promenade at 35th Street.
33.5 Jog left around the Fontainebleau Hotel. You are again riding along Indian Creek.

Fig. D-11. Oblique aerial photograph of Bakers Haulover Cut following the 1926 hurricane. The cut had been opened only the year before. A portion of the bridge survived; the rest of the cut and the access roadway were destroyed. In the foreground note the flattened mangrove trees at the north end of Miami Beach. Near the top of the photograph the mangrove trees are upright but defoliated. Source: Peter W. Harlem, Aerial Photographic Interpretation of the Historical Changes in Northern Biscayne Bay, Florida: 1925–1976, University of Miami Sea Grant Technical Bulletin No. 40 (1979).
Public access and parking.

As the road moves away from Indian Creek and into a canyon of condominiums, one can consider some of the alternatives for Miami Beach. This area was only recently developed. There was a significant beach here prior to beach fill.

There is presently a lot of very wide beach. If this beach is washed away in the future, is it worth renourishing for recreational or economic reasons? Who should bear the cost? Should nourishment projects be small but with good-quality sand, or large with mediocre fill (such as this one)? What would happen when an area with this extent of development is not nourished to prevent undermining? As more and more beach areas in Florida lose their beaches, where will all the money come for replenishment at $1 million to $6 million per mile?

Public access and parking.

Public access at North Shore Community Center. Parking is across the street.

Between 79th and 87th streets is a section of shoreline that was converted from private homes to a public park as a part of the recent beach nourishment program.

Stop 7. Park to the left in the lot or along the street at 81st or 82nd streets. Walk across Collins Avenue and over one of the boardwalks to the beach.

Near the foot of the boardwalk you may be able to see the brownish quartz and calcareous sand of the old natural beach. The quartz is medium to fine in grain; the grain of the rounded, calcareous shell fragments is medium to coarse.

Beyond is the new beach. Standing here shortly after the new fill had been added, I heard a proud, elderly gentleman proclaim to his out-of-town visitors, "Isn't it wonderful but my God it is hard on the feet!"

In October 1983 there was a total width of 300 feet of new beach fill here, 85 feet of which was the wave-swash zone of the beach. This section of beach is about 3 years older than that seen at the south end of Miami Beach. It has had a bit more time to reprofile and erode.

Laboratory analyses of the fill by the author suggest that only about 30 percent of the fill is suitable for beach sand. The sheer volume of sediment, however, will take time to rework.

As you walk across the new beach to the water, note the "hurricane" berm. As mentioned earlier, aspects of beach nourishment projects are commonly advertised as providing protection against hurricanes. The one protection that is provided is volumes of sand between a structure and most wave action.

The 11-foot-high berm is commonly noted as a hurricane protection element. Yes, so long as it is preserved, it will prevent moderate storms, waves, and surges from overtopping it from the seaward side. No, it will not prevent
flooding on the bay side of the berm. In fact, it may even cause worse flooding on the island. Water pushed north in Biscayne Bay by a storm will have nowhere to exit except Bakers Haulover. Water may build up in northern Biscayne Bay, seriously flooding the island. In other words, the berm may act like a dam for the storm waters trying to escape from the bay.

In the Great Labor Day Hurricane of 1935, Elliot Key, a coral limestone island forming the southern seaward boundary to Biscayne Bay, was severely flooded for more than 5 hours by waters piled up in southern Biscayne Bay. The elongated Marathon Key, in the middle Florida Keys, also is commonly flooded by hurricane surges piled up on one side of the island. In contrast, small Pigeon Key just to the west is generally not flooded by hurricanes. Water easily flows around it.

This problem may be compounded in hurricanes with strong rainfall which will increase the volume of water that must escape the bay. Along most of the U.S. East Coast, evidence that indicates that inlets are formed and maintained by water rushing back to the sea after a storm has passed. The opening of Norris Cut in 1835, for example, appears to have been from the bay side. Freshwater build-up may be important.

At this location the coarser sand you see at the surface of the fill is what has been concentrated by the action of the wind in removing the finer grains. Quartz grains, the major constituent of the original natural beach, make up only a small portion of the new beach.

This presently broad beach has only existed for a few years. You might wonder what will happen to this broad back-beach area in the future. Will it become covered with vegetation (sea oats, sand spurs)? Will rainwater acting on the surface cause the calcareous material of the broad back beach to dissolve or become cemented?

Note that the lifeguard stands are on skids so they can be moved to adjust for future erosion.

Return to your car; continue north on Collins Avenue. 96th Street, Bal Harbor Shopping Center; continue north. Bakers Haulover Bridge. Bakers Haulover prior to 1925 was a narrow zone of the beach where small fishing boats could be pulled across into and out of northern Biscayne Bay. There were no inlets for a considerable distance to the north or south. Bakers Haulover was cut through in 1925. It is unclear whether it was cut to relieve pollution in northern Biscayne Bay or to provide boat access between the bay and offshore. A bridge across the cut also was put in at this time.

As shown in the photograph (fig. D-11), the hurricane of 1926 had devastating effects on this area, leaving a portion of the bridge but washing out the roadway accesses and severely eroding the shoreline adjacent to the inlet. Much of the sand was swept into the bay.
Following the hurricane, the bridge was rebuilt and a series of groins were installed on the beach north of Bakers Haulover.

This inlet is like most of the other inlets along Florida’s east coast, which are artificially created or artificially maintained. Longshore-drifting sand sucked into the inlets by flood tides (fig. D-12) or swept seaward by ebb tides is the major cause for loss of beach sand and hence accentuated beach erosion.

Just bayward of Bakers Haulover is the Intracoastal Waterway. Repeated dredging is necessary to keep the growing flood-tidal delta (the body of sand swept into the bay by flood tide) from blocking the waterway.

39.6

Just north of the bridge, turn right to Haulover Beach and park in the lot (there may be a $1.00 fee). Walk to the beach.

Stop 8. Haulover Beach. This beach has been renourished several times since 1926. In some cases the sand has been derived from the dredging that maintains the Intracoastal Waterway; in others, more costly offshore material was used.

Nonetheless, the size and composition of the sand on the beach is similar to that which naturally occurred on both this beach and Miami Beach.

During the winter season you may see the waves breaking on an offshore bar. This bar is seasonal and forms as

**Fig. D-12.** Oblique aerial photograph of Bakers Haulover Cut in August 1935 showing the beach sand that has been swept into Biscayne Bay through the inlet to form a fan-shaped tidal delta. Active lobes of sand (light in color) are encroaching into the dredged Intracoastal Waterway. Darker areas (arrows) are areas of stallization by seagrasses and algae. Source: Peter W. Harlem, Aerial Photographic Interpretation of the Historical Changes in Northern Biscayne Bay, Florida: 1925-1976, University of Miami Sea Grant Technical Bulletin No. 40 (1979).
the stronger waves from winter storms transfer some sand from the shore seaward. This sand will move back to the beach during smaller wave conditions of the late spring and summer. This annual beach cycle including an apparent narrowing of the beach during the winter is an important, natural part of beach dynamics. Too often, development activities have ignored the natural dynamics of beaches when building in the shore zone.

If you have a mask and snorkel, the beach north of the fishing pier is usually an excellent spot to enjoy first-hand the dynamic shore zone.

End of trip. We hope it was both enjoyable and enlightening.

In summary, the beaches of Dade County vary from extremely intense development (all of Miami Beach and the central part of Key Biscayne) to undeveloped shorelines that are sites of moderate to intense recreational activity. Historical erosion rates are very minor. Had it not been for man's activities, there would be only minor shore erosion problems today. Unfortunately, man's misguided influences on the shore, such as construction of walls and groins and the dredging of channels, have increased over the years to the point that nearly the entire shore system is being adversely affected. In an attempt to counteract the resulting problems, minor to massive beach renourishment programs have been carried out. The success of the massive Miami Beach program (that is, how long will the beach stay in place, and will it help or hinder the community in a hurricane) remains to be seen. In other areas (Fisher Island, Virginia Key, northern Key Biscayne) the resultant problems along the shoreline have not really been addressed.

The next 20 years will be a time during which the citizens of Dade County will have to make some hard choices, especially if recent predictions of rising sea level are realized.
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