Trip B-3

MONITORING COASTAL CHANGE: EASTERN LAKE ONTARIO

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INTRODUCTION

This field trip will examine the sandy beach-dune barrier system that extends for nearly 17 miles north of the Salmon River mouth along the eastern Lake Ontario coast (Fig. 1). Barrier bars separate ponds and wetlands from open waters of Lake Ontario and are cut by inlets that connect ponds to Lake Ontario. The sandy beaches and dunes on the barrier system, together with adjacent wetlands, ponds and lake waters, provides habitat for a number of rare plant and animal species and also for fish, waterfowl and migratory birds. The beaches also afford recreational opportunities for residents and tourists, and inlets provide access to Lake Ontario for recreational craft from marinas and boat launches around ponds and tributary streams. The sand dunes here are the largest in the state, and they protect residences landward of the dunes from wind and wave erosion and flooding due to storm surge. The shoreline is a mix of public and privately-owned land, with public lands designated as state parks and wildlife management areas. The private land that amounts to roughly half the barrier system has been developed for cottages, homes, RV parks and campgrounds that are built on or just behind the dunes. Governmental and non-governmental conservation agencies have been working for decades to protect this fragile system.

A program of beach profiling has been ongoing since 2002 at 5 locations in the barrier system (Fig. 2). The goal is to identify patterns of seasonal and longer-term erosion and deposition on these beaches. This field trip will visit several locations where beach monitoring has been conducted. Since 2003, Sandy Pond Inlet has been studied by detailed mapping. This inlet is a very important access point to the lake from the numerous marinas and private residences around North Pond. The inlet becomes shallow in late summer, and larger craft have difficulty navigating the shallow channel. We will visit Sandy Pond Inlet at the end of this field trip.

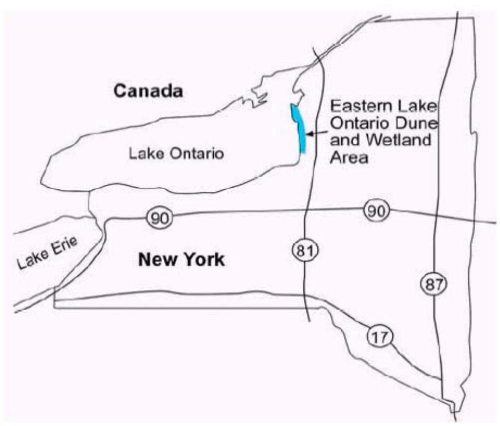


Fig. 1 - Location of the sandy barrier system.

Background

The eastern Lake Ontario barrier system formed during a period of significantly lower lake level that allowed wave action to transport sand from a shallow submerged sand body shoreward (Sutton, et al., 1974). Winds and wave action had established the beach-dune system by at least 1290 years ago (Woodrow, et al., 2002). Present-day, higher lake levels, have submerged the sand source to a depth where wave action can not reach and transport additional sand to the barrier system. Other sources (rivers, erosion of coastal lands) contribute little sand to the system today (Steadman, 1997). Therefore, when waves and wind erode sediment from the beaches and dunes, there is no significant replacement. Especially toward the southern end of the system, increasing areas of beach are becoming covered with cobbles.

Previous studies of coastal change in the barrier system utilized analyses of historical maps and aerial photographs (Weir, 1977), and focused on the barrier between Lake Ontario and North Pond. DelPrete

(1997) supervised SUNY Oswego students in mapping changes in Sandy Pond Inlet during the 1980s and early 1990s. More recently, McClennen, et al. (2000) used Geographic Information Systems (GIS) and air photo analysis to document changes along the entire barrier system. Steadman (1997) reviewed previous studies of the barrier system and identified research needed to improve conservation efforts for beach-dune ecosystems. His report identified geomorphic studies, including beach profiling, as one of 4 major research areas needed to improve understanding of coastal processes and conservation plans.

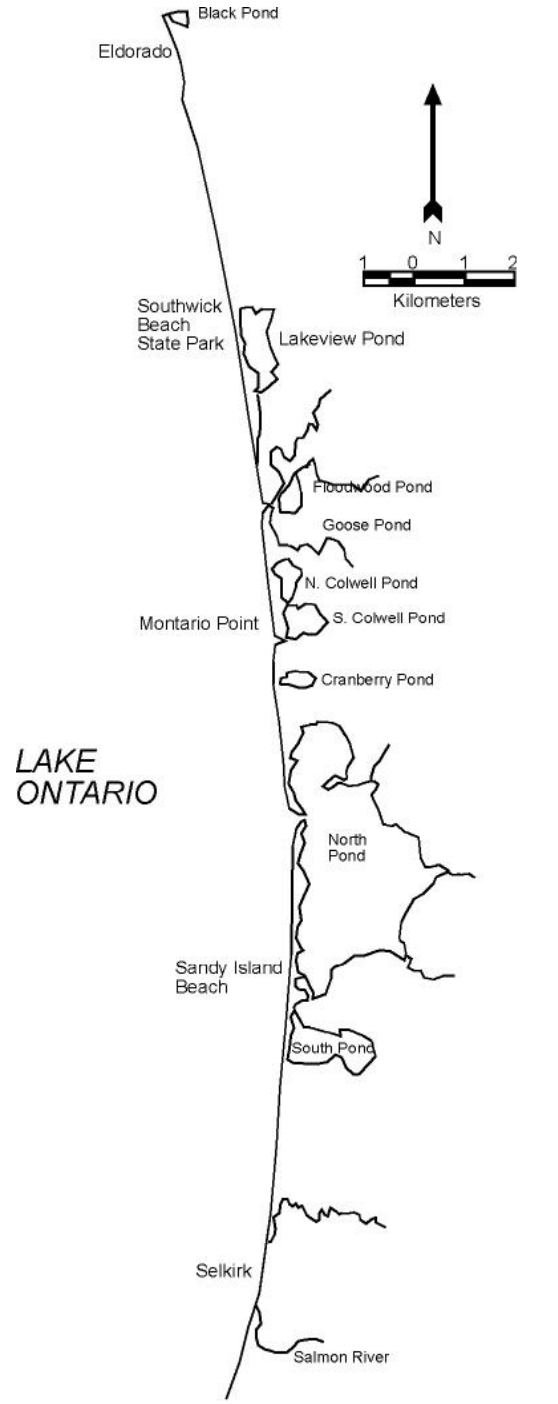


Figure 2 - Beach profiling was conducted at Selkirk,Sandy island Beach, Montario Point, Southwick Beach State Park, and Eldorado Beach.

Long-term trends in beach erosion and deposition can be understood in terms of a beach budget. If sources of sand supplied to a beach and processes that erode sand from a beach can be identified and quantified, a simple mass balance can be performed. If rate of sediment supply and rate of sediment erosion are equal, an equilibrium beach morphology will be maintained. If rates of sediment supply and erosion are not equal, the beach will either shrink or grow. The amounts and rates of sediment supply and sediment erosion on this coast have not been quantified (Steadman, 1997; Woodrow, et al., 2002), but as noted above, sediment supply is thought to be limited. Sediment is removed from beaches by wind, wave action transports the majority of sediment offshore or parallel to shore. Repeated beach profiling can detect onshore and offshore movements of sediment over time (Komar, 1998). By comparing beach profiles made over the course of several years, changes in the amount of sediment gained or lost on individual beaches can be assessed.

Lake levels vary on long-term, seasonal, and shorter time scales. During extended periods of higher than average lake levels, coastal erosion intensifies. This is a great concern for coastal property owners as well as conservation groups and land managers. Lake Ontario levels vary seasonally by 0.6m to more than a meter between high summer and low winter lake levels (Fig. 3). During the study period, wind storms caused lake level to rise by .25-.30m over time scales of hours. Beach profiles are affected by lake level variations at all these scales.

Bruun (1962) developed a simple model to predict changes in an equilibrium beach profile due to sea (or lake) level rise. The equilibrium profile is of the form

$$d(\mathrm{x}) = A\mathrm{x}^{\mathrm{b}}$$

where d(x) is water depth at a distance x from the shoreline, the exponent b is typically near 2/3 and the coefficient A is related to grain size. The "Bruun Rule" states that an increase in sea level results in erosion of a volume of sediment from landward portions of the profile. An equal volume of sediment is deposited in the nearshore zone, raising the sea floor such that the shape of the equilibrium profile is maintained, but shifted upward and landward (Schwartz, 1968). For the case of falling sea level, Bruun (1983) noted that lowered water levels would result in erosion in the nearshore zone and deposition onshore, resulting in the formation of beach ridges on steep shores and offshore bars on gently sloping shores, and thus the profile may change. Wood, et al. (1994) studied beach profile changes on Lake Michigan. They found systematic changes in beach profiles due to lake level variations, due to time lags between the rate of lake level change and profile changes, it was not clear that an equilibrium profile was maintained.

BEACH PROFILING LOCATIONS AND METHODS

Beach profiles were measured monthly during snow-free months (April or May through November) at 5 locations along the sandy eastern Lake Ontario shoreline (Fig. 2; Table 1) using the Emery method (Morisawa and King, 1973; Fig. 4). The Selkirk profiles were measured on private land just north of the mouth of the Salmon River, at the southern end of sandy barrier system. This portion of the shoreline has been extensively developed, with closely-spaced cottages built atop vegetated aeolian dunes (Fig. 5a). The beach at Selkirk is coarser-grained than the other beaches, with gravel-sized sediments dominating on the swash face. At other localities, mean grain size of beach sediments is fine sand. The Sandy Island Beach locality is now a state park, and the profile was measured on the public beach (Fig. 5b). This area lies at the south end of a zone of very tall dunes vegetated by dune grasses, bushes and mature trees. Some residences were built atop some of these dunes. At Montario Point, beach profiles were measured just north of a small inlet that connects South Colwell Pond to Lake Ontario. This beach is undeveloped, and the dunes at this location are not as tall as at Sandy Island (Fig. 5c). The profiles at Southwick Beach State Park were measured just south of the park boundary in the Lakeview Wildlife Management Area (Fig. 5d). The Eldorado site (Fig. 5e) lies just north of an area of closely-spaced cottages, but within the undeveloped Black Pond Wildlife Management Area. The profile locations at Southwick Beach and Eldorado begin on low dunes vegetated by shrubs and mature trees. At all 5 profiling locations, a datum was installed and its location and elevation relative to mean sea level was surveyed. Profiles were made from the datum along transects oriented perpendicular to shore. Profiles extended into the water until water depths became to great for wading. During cold months, the profiles ended at the water edge. In 2004, a program of surveying profiles to greater water depths was begun. Water depths were measured from a boat and the boat location was measured using an electronic distance meter. The plan is to measure profiles twice per year, at higher and lower lake levels.

BEACH PROFILING RESULTS

Monthly beach profiles were plotted for each of the 5 locations. There was good agreement among profiles taken at each location (Fig. 6), showing that the Emery technique generally yielded satisfactory results. The Selkirk (Fig. 6a) profiling locality showed the least variation in profile shape during the study period. This is to be expected, as Selkirk Beach is the coarsest-grained. The profiles at Montario Point showed the greatest variability (Fig. 6b), as this locality was affected more strongly by storm surge and perhaps due to its proximity to an inlet. All locations show seasonal changes in profile shape. Storms caused changes in profile shape at some locations. Longer-term changes in beach profiles are subtle. All of these changes are described below.

Seasonal variations in beach profiles

At all locations, the beach face shifts position as lake level rises and falls. During the study period, highest lake levels, about 75.1-75.3m during the study period, occurred in late spring/early summer. Lake levels dropped through the fall season, reaching levels of roughly 74.3-74.6m by early to mid-December. Profiles measuring during late spring, rising lake levels, showed that nearshore portions of the profiles had been eroded, and the subaerial portion of the beach was narrower compared to its position the previous fall. As lake level fell in late summer and into the fall season, the beach widened, and deposition occurred in the nearshore zone as the beach face prograded lakeward. These patterns are similar to those observed by Weishar and Wood (1983) on the Lake Michigan coast in Indiana.

Table 1. Dates and lake levels during beach profiling

Date	Lake Level (msl)	Selkirk	Sandy Island	Montario	Southwick	Eldorado
Jun 26, 00*	75.305			X	X	X
Nov. 25, 00+	74.414				X	X
Sep. 22, 02	74.596	X	X			
Sep. 29, 02	74.552			X		
Oct. 25, 02	74.413	X	X	X	X	X
Nov. 30, 02	74.364		X	X	X	
Apr. 13, 03	74.716		X			X
May 3, 03	74.845		X			
May 30, 03	75.066	X	X		X	
Jul. 9, 03	75.067				X	X
Jul. 10, 03	75.037	X	X	X		
Aug. 11, 03	75.022	X	X	X	X	X
Sep. 14, 03	74.697		X	X	X	X
Oct. 12, 03	74.624	X	X	X		
Oct. 18, 03	74.633				X	X
Nov. 14, 03	74.694		X	X		X
May 1, 04	74.955					X
May 2, 04	74.975		X		X	
Jun. 6, 04	75.151	X	X			X
Jun. 8, 04	75.151			X		
Jul. 8, 04	75.107	X	X		X	X
Jul. 11, 04	75.101			X		
Aug. 17, 04	75.009		X	X	X	X
Sep. 6, 04	75.097	X				
Sep. 25, 04	74.930		X	X	X	X
Oct. 26, 04	74.596					X
Nov. 6, 04	74.561		X	X	X	X
May 5, 05	75.151	X	X	X	X	X

* measured by J. Gibbs, SUNY ESF + measured by F. Florence, Jefferson Community College

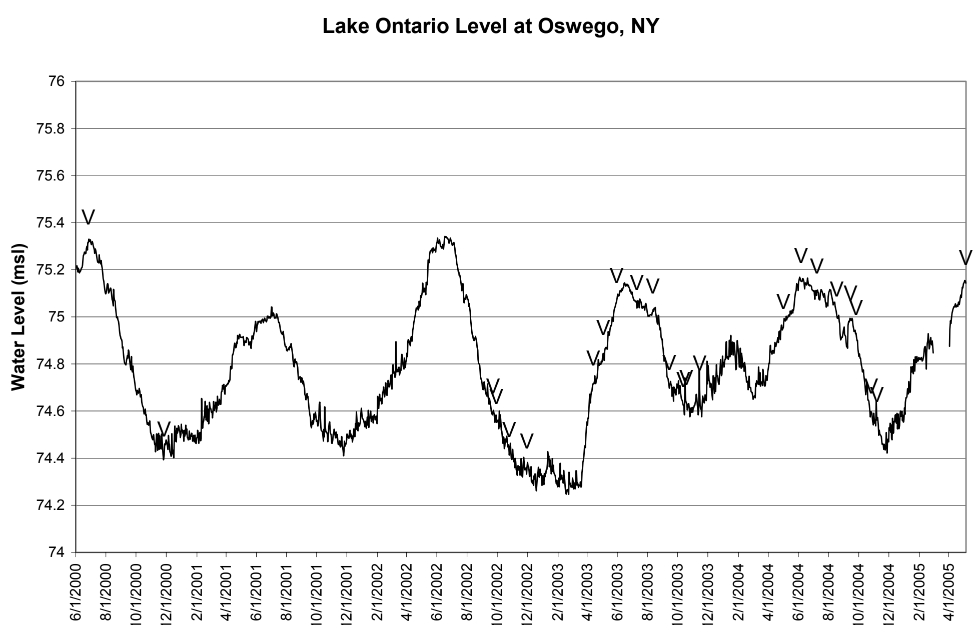


Figure 3 - Lake Ontario levels, June 1, 2001 to May 31, 2005. Arrows indicate dates beach profiles were measured.

Figure 4 - Emery technique used to measure beach profiles.

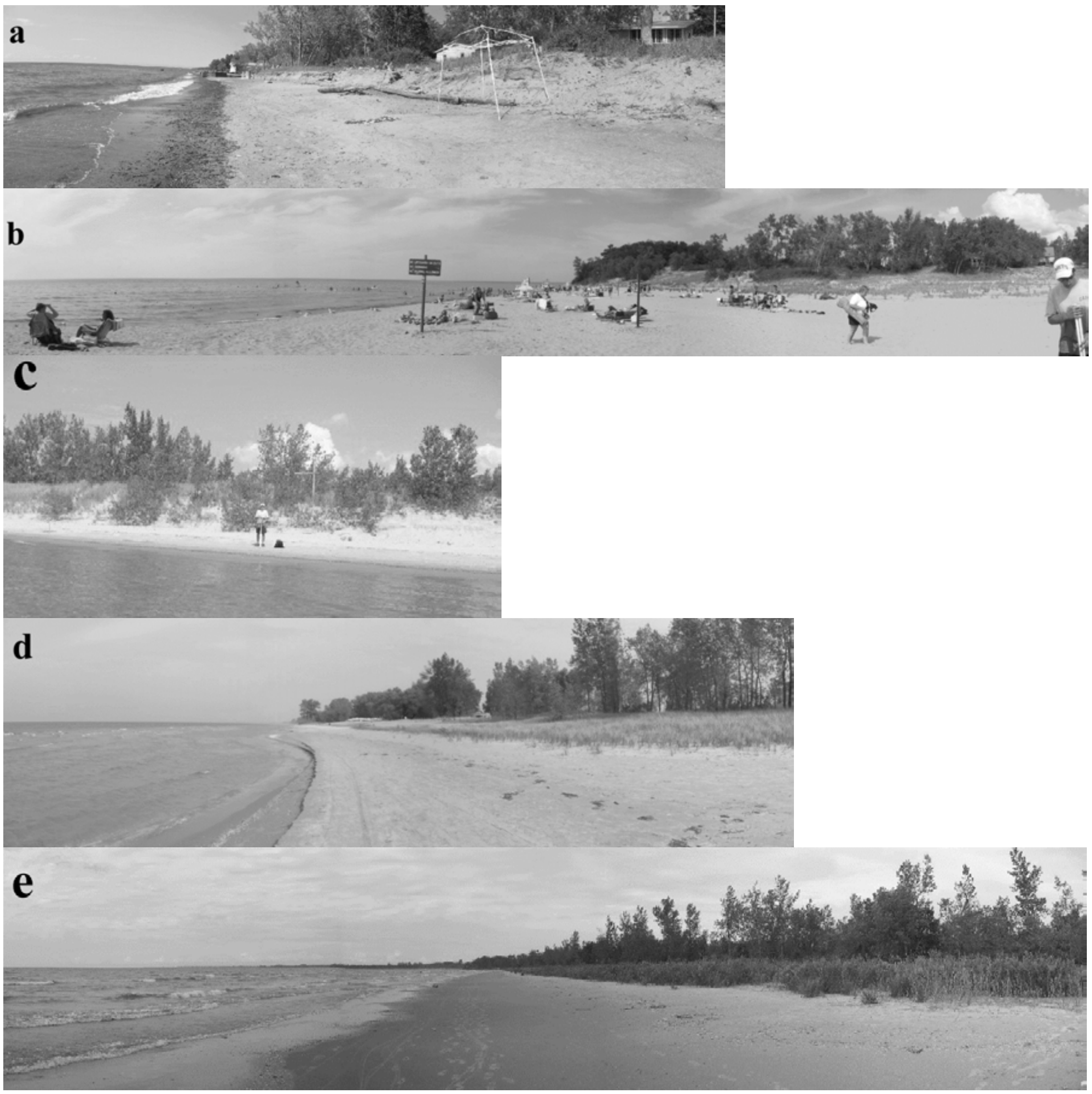
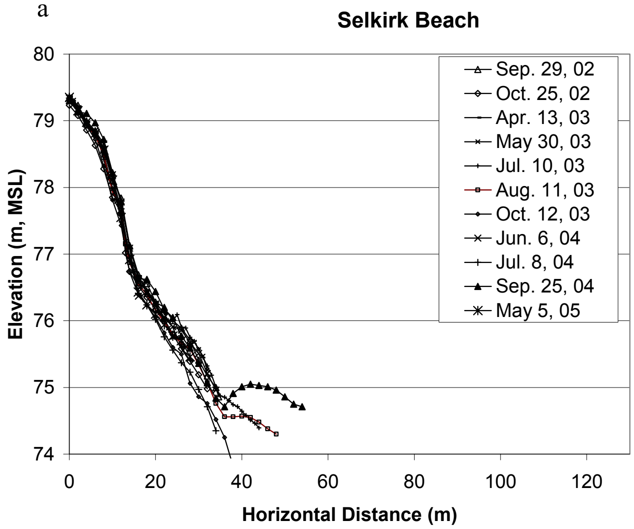


Figure 5 - Beach profiling locations: a) Selkirk; b) Sandy Island Beach State Park; c) Montario Point; d) Southwick Beach State Park; e) Eldorado Beach.

At some locations, nearshore bars developed during the summer and decreased in size with time as the beach face prograded lakeward. For example, at Montario Point, beach width was approximately 10m on July 11, 2004, but by November the beach had widened to about 36m (Fig. 7a). The 2004 Montario profiles also show that one or more nearshore bars were present in June and July and decreased in size during the summer and into fall. The 2004 profiles from Eldorado (Fig. 7b) also show the progradation of the beach face from May through November, and the August and September profiles show a nearshore bar. The landward margin of that bar was eroded between the August and September profiles.

The Eldorado profiles also show changes in the back berm portion of the beach, which at this location is vegetated by dune willow. The vegetated area increased in elevation during 2004, presumably due to the accumulation of wind-blown The subaerial portion of the beach lakeward of the vegetated area also increased in elevation during the May-September period, but was eroded before the November 6 profile was measured. This could have been the result of wave action during fall wind storms.

a



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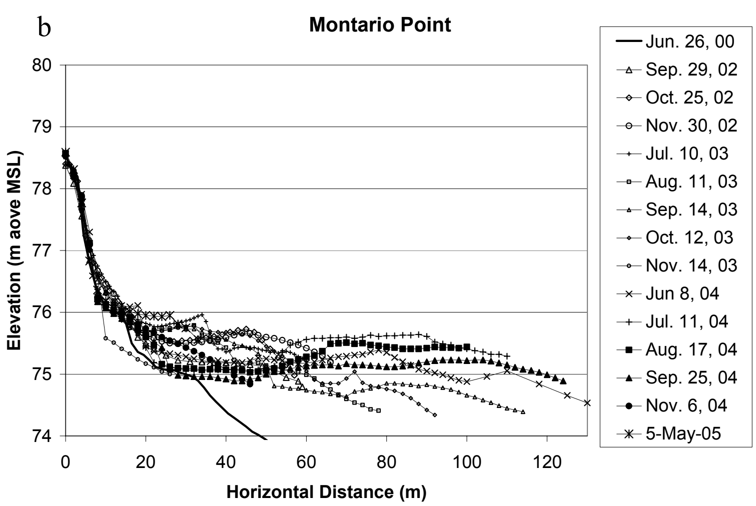


Figure 6 - Examples of graphs comparing all beach profiles measured at a particular location. a) The gravelly beach at Selkirk show very little variation in profile shape over time. b) The beach at Montario Point showed the greatest variability in profile shape during the study period.

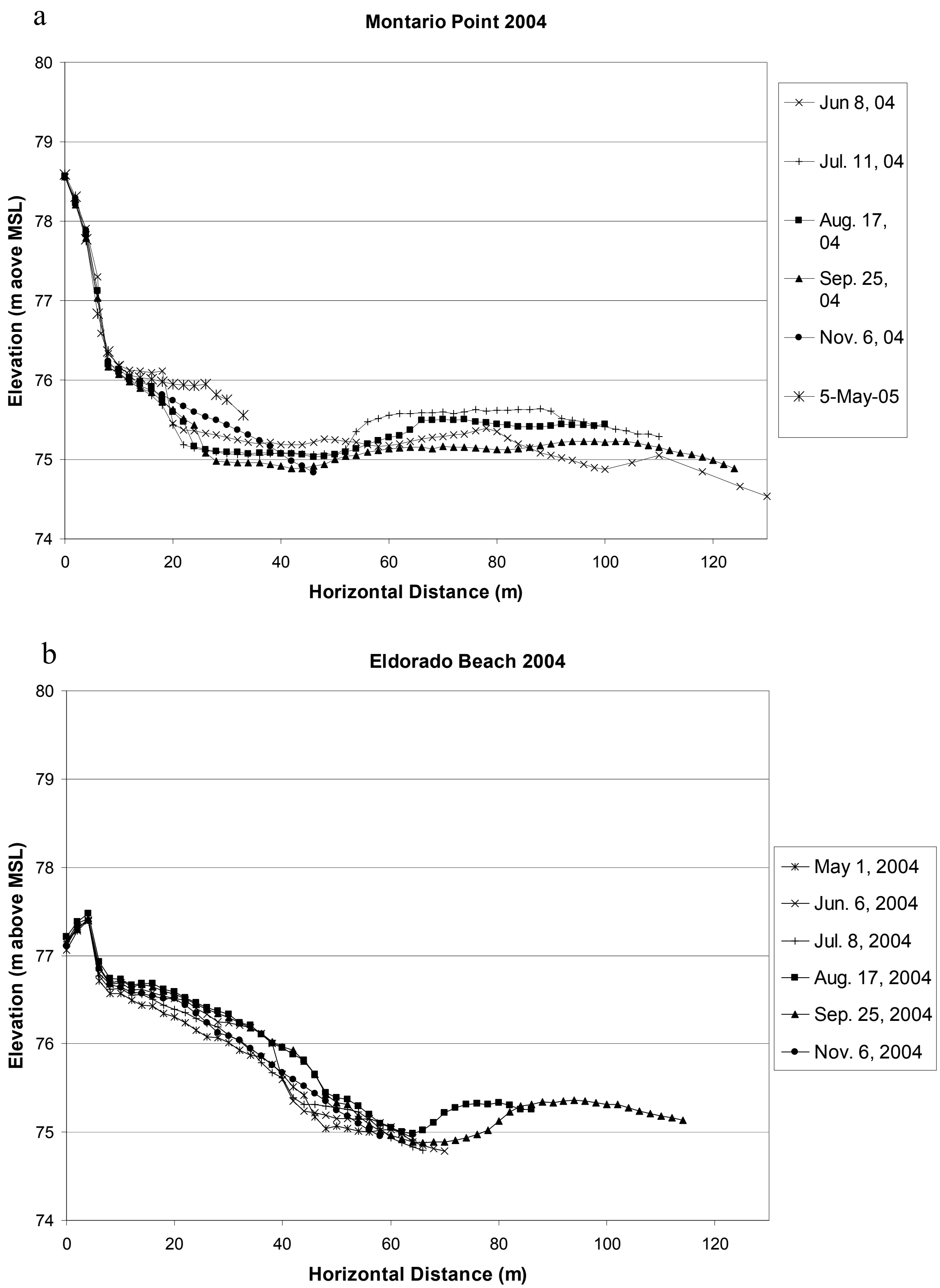


Figure 7 - a) 2004 Montario profiles showing nearshore bar from meters 60-100. b) Eldorado profiles from the same year show build-up in the vegetated area (0-10m) and a nearshore bar in late summer.

Short-term changes in beach profiles due to storms

Several wind storms occurred during the study period. Wind data retrieved from the NOAA Data Buoy on Lake Ontario north of Rochester (National Data Buoy Center, n.d.) showed that wind speeds (8 minute averages) over 40mph occurred for much of the afternoon and evening of October 15, 2003. Winds were dominantly westerly, and gusts up to 61mph were recorded. During the storm, lake levels measured at the Oswego and Cape Vincent, NY gages increased by about 0.25m. On November 13, 2003, winds increased to over 30mph during the early morning hours, and from 10am to 10pm, average wind speeds were over 40mph with gusts of 66mph (70-81mph gusts were recorded at SUNY Oswego). Winds were initially west-southwesterly, and became westerly by evening. Winds in e_cess of 30mph persisted until about noon the ne_t day, and eventually became northwesterly. During the height of the storm, lake level increased by 0.3m at Oswego and 0.45m at Cape Vincent. Beach profiles were measured at Eldorado and Southwick Beach a few days after the October storm, and profiles were measured at all locations except Selkirk on November 14, 2003.

The October, 2003 wind storm had little effect on Southwick Beach, but on Eldorado Beach, a large accumulation of zebra mussel shells was deposited as a result of the storm (Fig. 7). In places, the mussel shells formed accumulations more than 0.2m thick. Zebra mussels flourish on the bedrock at the lake bottom just a few hundred meters offshore as well as in shallow water along the rocky coast to the north. Therefore, it is fairly common to find smaller accumulations of mussel shells at Eldorado in the springtime, probably due to deposition from melting ice. Zebra mussel shells are found on all beaches, but in much smaller numbers.

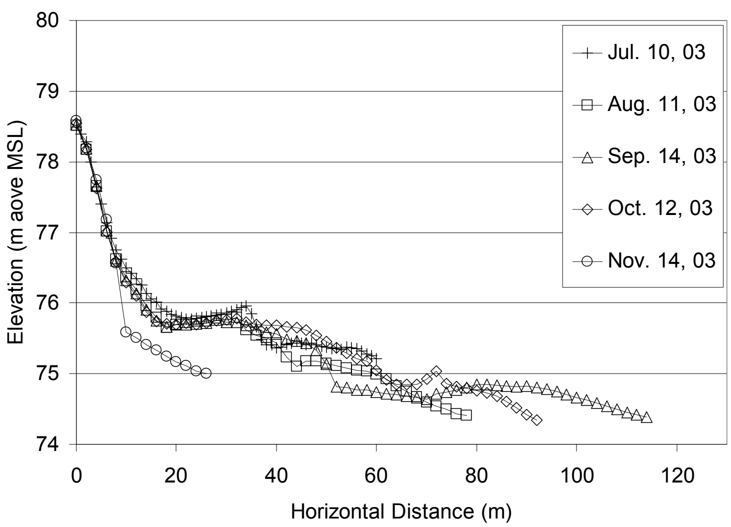
The larger, November, 2003 windstorm also affected some beaches more dramatically than others. The greatest impact of the November storm occurred at Montario Point where waves eroded the beach and the base of the dune (Fig. 8a, b). Wave ripples were observed on the beach at Eldorado (Fig. 8c) and Southwick (Fig. 8e) beaches, indicating that water had covered much of beach to some depth, but beach elevations were only slightly altered (Fig. 8c,h). Storm surge also inundated Sandy Island Beach (Fig. 8f), and cobbles were observed over much of the beach following the storm (Fig. 8g). However, the November profile at Sandy Island Beach was similar to the October profile, except that the beach face increased in elevation in November relative to October (Fig. 8i).

On November 5, 2004 there was a windstorm that produced westerly winds with speeds greater than 30 mph persisted from about 1am until midnight, with gusts up to 53 mph. Hourly lake levels rose by about 0.25m and 0.30m at the Oswego and Cape Vincent gages, respectively. Beach profiles were measured at Eldorado, Southwick, Montario Point, and Sandy Island beaches the next day, but none of the profiles showed any significant changes.

Figure 8 - Zebra mussel shells deposited during the windstorm of Oct. 15, 2003. Photo was taken on Oct. 18, 2003.

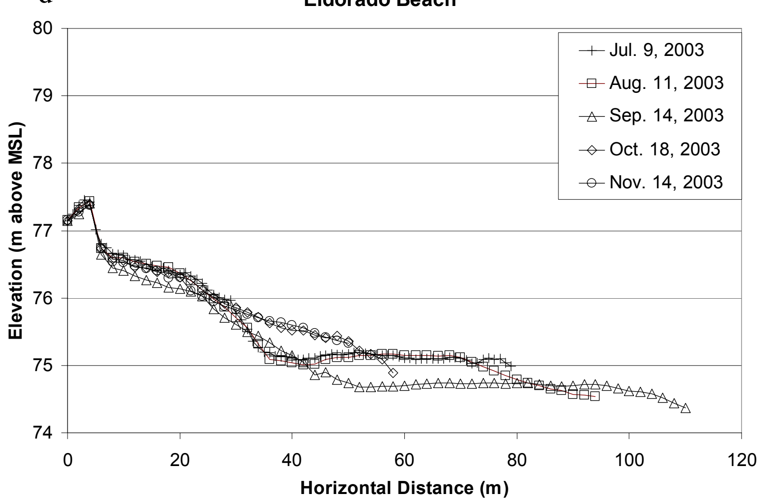
b

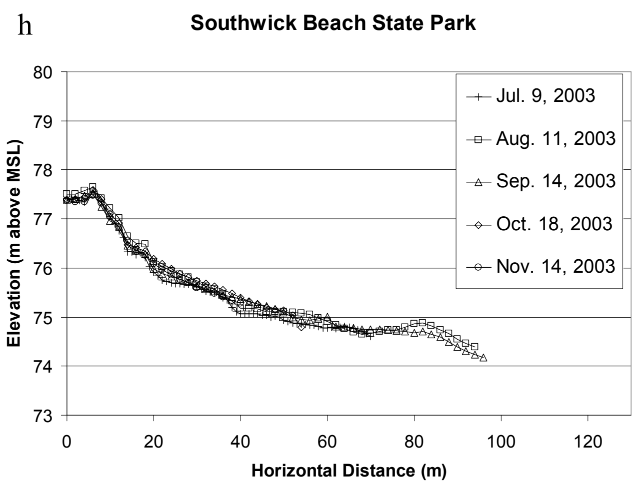
Montario Point



d

Eldorado Beach





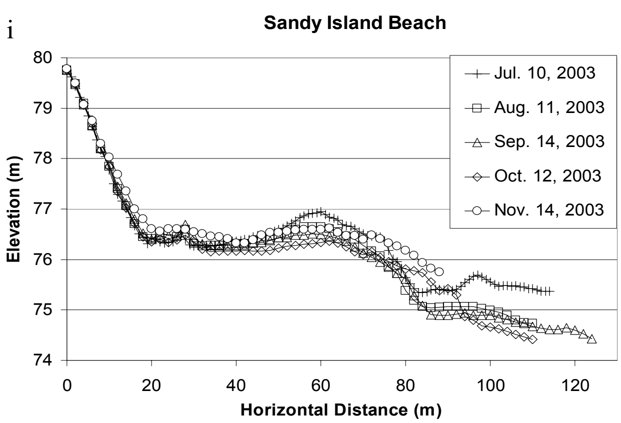


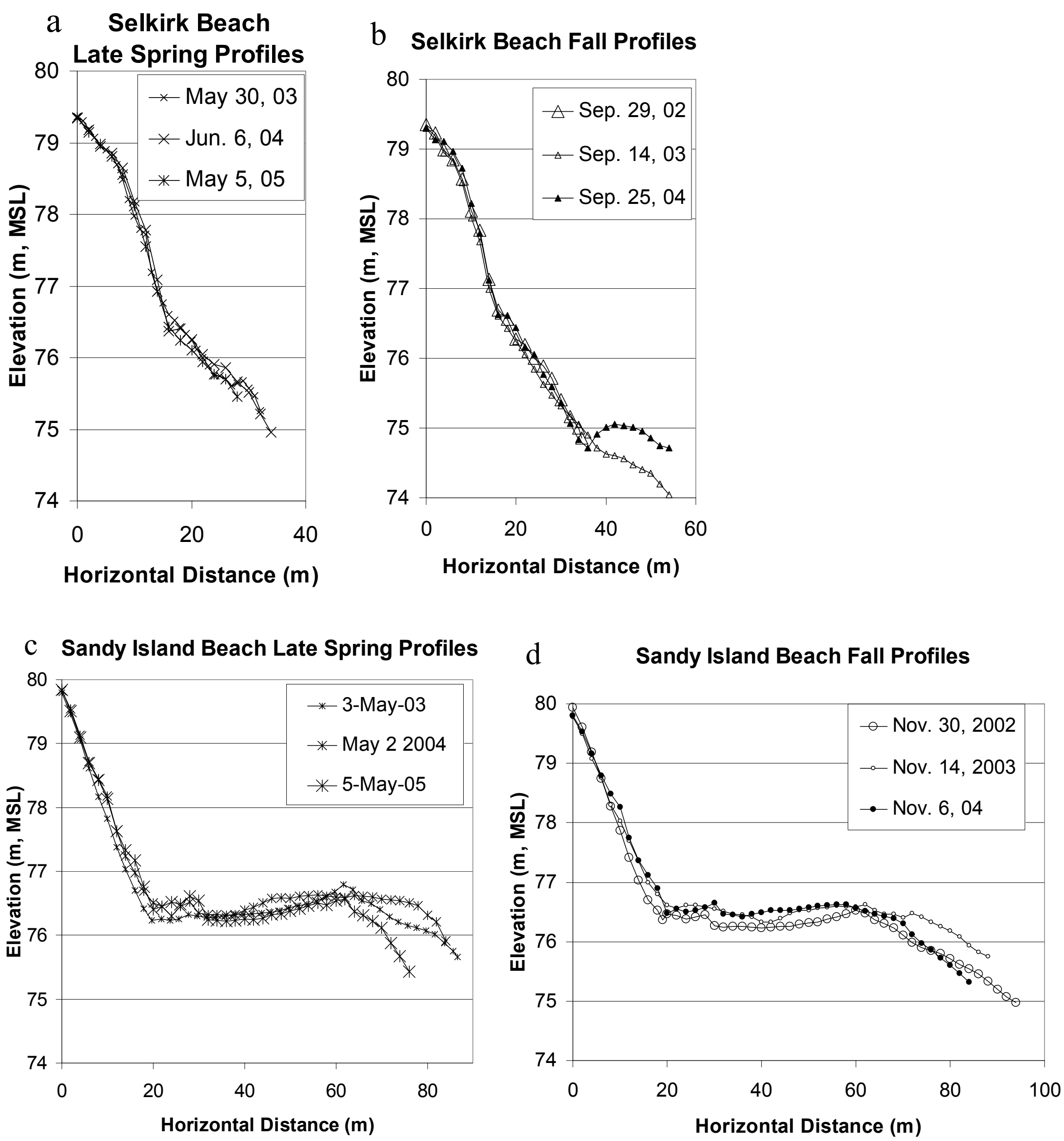
Figure 9 - Effects of windstorms on eastern Lake Ontario beaches. a) Montario Point beach, on Nov. 14, 2003. Note scarp at base of dune. b) Montario Point profile measured on November 14, 2003 shows erosion on the beach and lower dune slope. c) Wave ripples on Eldorado beach, November 14, 2003. d) Eldorado beach profile for November 14, 2003 is similar to the one measured in October. e) Southwick Beach State Park on Nov. 14, 2003. f) Sandy Island Beach at the height of the wind storm on Nov. 13, 2003 (photo courtesy S. Bonanno), and g) the following day. h, i) Comparisons of beach profiles measured on Nov. 14, 2003 with previous profiles measured at Southwick and Sandy Island Beaches, respectively.

Long-term changes in beach profiles

In order look for longer-term changes in beach profiles, comparisons were made between profiles measured in successive years at the same time of year for each beach profiling location. Fig. 10 shows profiles that were measured during late spring/early summer (higher lake levels) and fall (lower lake levels) at each location.

The Selkirk profiles (Fig. 10a,b) show the least change of all the profiling localities. The coarser grain sizes on this beach has precluded any significant modification of the beach during the study period. The increase in elevation on the Sept. 2004 file (Fig. 10b) resulted from formation of a sand bar as lake level dropped and that is not likely to have survived into the next season.

Comparisons of late spring/early summer and fall profiles measured at Sandy Island Beach (Fig. 10c,d) show that elevations on the swash face, beach berm and back-berm portions of the beach fluctuated over the 3-year period. Only on the vegetated dune slope was an increase in elevation from 2002/2003 sustained into 2004/2005. This net accretion indicates that the efforts of the conservation groups that planted the beach grasses there were effective in stabilizing the slope.



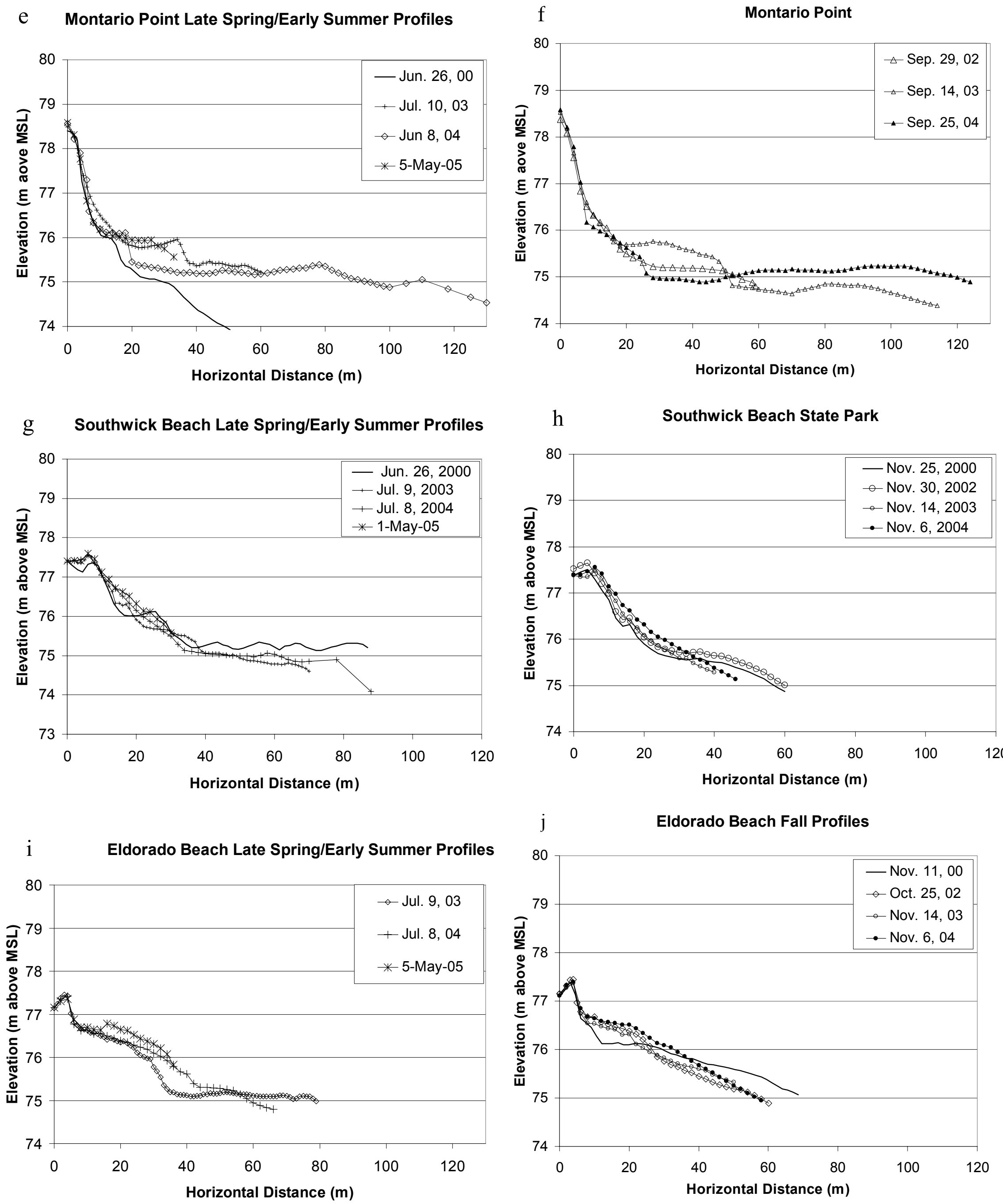


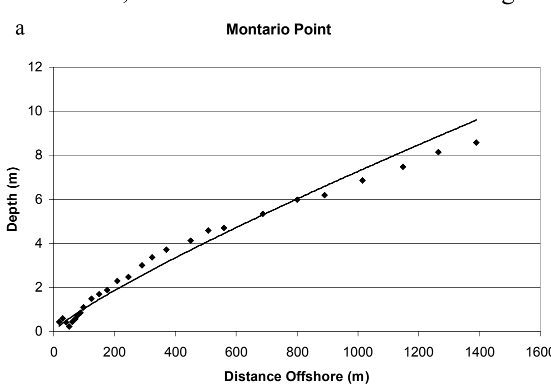
Figure 10 - Comparisons of beach profiles made in successive late spring/early summer surveys at each beach profiling location.

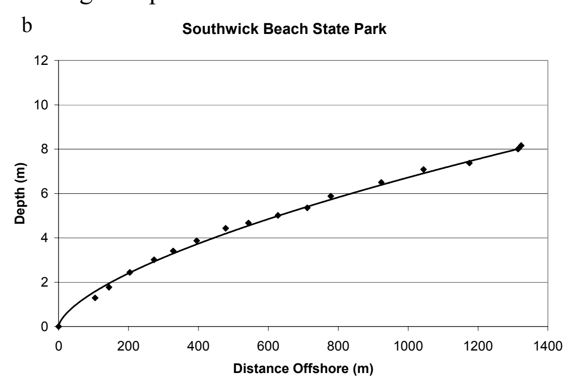
At Montario Point a beach profile measured in June, 2000 during an earlier study is available for comparison. Figure 10c shows that the landward portions of the beach and the beach face had been prograding lakeward from 2000-2003, but erosion during the November, 2003 windstorm scoured the beach and base of the dunes below the June, 2003 levels (Fig. 10d). The July, 2004 and May, 2005 profiles show that the beach has largely recovered from the storm, as the May, 2005 profile elevations are near or above those measured in July, 2003. Comparisons of the July and November, 2004 profiles with earlier ones indicates that the beach had not recovered fully by those dates.

Southwick Beach profiles show only minor changes during the 2002-2005 study period (Fig. 10g,h). One consistent trend is deposition in the area vegetated by beach grass just lakeward of the dune. The vegetation appears to be effective at trapping windblown sand, and the simple string fencing is helping to protect this area from damage by foot traffic. In the nearshore zone at Southwick Beach, elevations on late spring/early summer profiles from 2003 and 2004 show a decrease of about 0.2m relative to those measured by other workers in 2000. The profile measured in Fall, 2000 indicates that the beach was wider and higher at that time, compared to the 2002-2004 period. Seasonal changes in beach profiles seem to have been greater during 2000 than during the 2002-2005 study period.

Eldorado profiles (Fig. 10i,j) show that sediment has accumulated in the area vegetated by dune willow just lakeward of the dunes during the 2002-2005 study period. A profile measured in November, 2000 by other workers shows that accumulation of more than half a meter occurred in this vegetated zone between 2000 and 2002. The May, 2005 profile shows an increase in elevation of 0.1 to 0.25m due to the accumulation of sand and zebra mussel shells in the vegetated area and on the beach berm. When the November, 2000 profile is compared with more recent ones it appears that, like at Southwick, the 2000 profile was lower in the vegetated part of the beach but higher near the water edge.

Figure 11 shows beach profiles measured from a boat at 3 of the 5 profiling localities. The profiles from Montario Point and Southwick Beach State Park generally have the shape predicted for equilibrium beach profiles, $d = Ax^b$ (Bruun, 1962). The Eldorado profile does not have this form because the sand sheet thins rapidly offshore exposing bedrock on the lake bed. Power functions fit to the Montario Point and Southwick profiles yielded values for the exponent b of 0.8458 and 0.6403, respectively. These values are in the range found by Wood, et al. (1994) for Lake Michigan profiles, and the Southwick exponent is quite close to the predicted value for equilibrium profiles of 0.67. The values obtained for A were 0.0211 and 0.0806 for Montario and Southwick, respectively. The R^2 parameter for the curve fits was 0.935 for Montario and 0.999 for Southwick. These preliminary results from profiling into deeper water are encouraging, and we hope to continue repeating these profiles at least twice per year, in early summer and late summer, in order to assess seasonal and longer-term changes in profiles.





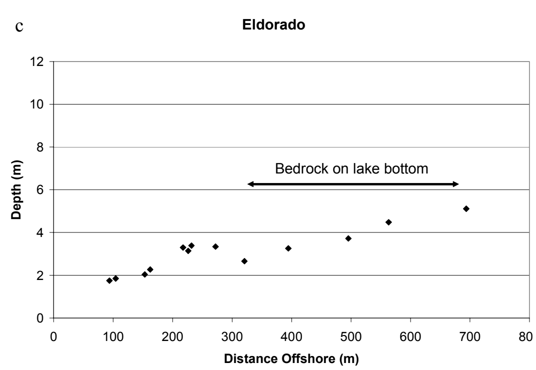


Figure 11 - Beach profiles measured from boat, August 14, 2004. a) Montario Point b) Southwick Beach State Park; c) Eldorado. Trendlines on the Montario Point and Southwick profiles are of the form $d = Ax^b$.

Sandy Pond Inlet

Sandy Pond Inlet connects North Pond to Lake Ontario (Fig. 12). Boaters use the sandy beach on the north side of the inlet for sunbathing and picnicking. The vegetated area and low dunes just south of the inlet channel is a bird sanctuary, and access is restricted. Farther south, there is a washover channel and fan just south of the line of low dunes closest to the inlet. This area is used for boaters to walk from the pond side to the lake side for swimming and sunbathing (Fig. 13). During late summer, declining lake level and deposition in the inlet channel make it increasingly difficult for larger boats to navigate through the channel as the season progresses. The area between the inlet and Carl Island becomes shallow and difficult to navigate as well. In 2004, a group of private citizens obtained permits to dredge the inlet in order to maintain channel navigability.

In order to study changes in bed topography, the inlet was mapped using an electronic distance meter (EDM or "total station"; Fig. 14) in July 2003 during high early-summer lake level, and at lower lake levels in September, 2003 and September 2004. A limited amount of dredging was done in late summer, 2004, before the September, 2004 map was made (E. Bernstein, pers. comm.). Survey data were loaded into Gocad ™ drafting software and contoured. Figure 15 shows topographic maps made from the EDM surveys of the channel in July 2003, September 2003, and September 2004. It should be noted that few areas on land were surveyed, so the topography depicted in land areas is poorly constrained.

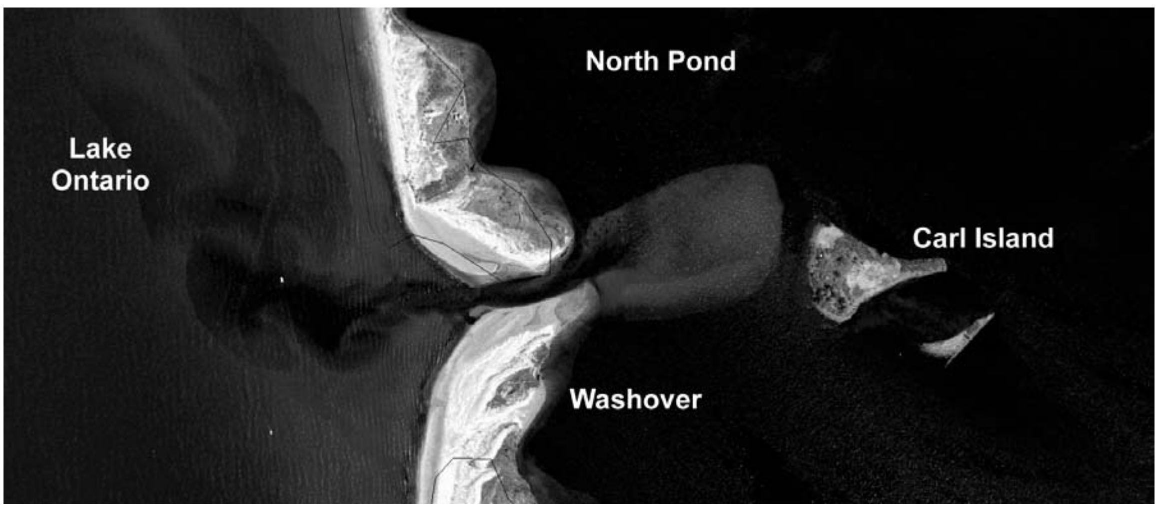


Figure 12 - Aerial photograph of Sandy Pond Inlet, April 2003, north to top of photo. Note sand shoal on pond side of inlet. Source: NY GIS Clearinghouse (n.d.).

Figure 13 - Photomosaic of washover channel just south of Sandy Pond Inlet, view toward North Pond.

Comparing the July and September, 2003 maps, one can see that the shoreline shifted lakeward and pondward as lake level dropped. Using Gocad ™, elevations from the July map were compared with September map elevations to identify areas of erosion and deposition (Fig. 16a). Bed elevations increased on the lake side and pond side of the inlet channel between July and September. Deposition on the pond side of the channel occurred on the north and south sides of the channel, but occurred over a slightly larger area on the south side. Water depths measured in the inlet channel exceeded 8 ft. in July, 2003, but the greatest depths measured in September were less than 6 ft.

Figure 14 - EDM used to survey Sandy Pond Inlet

Dramatic changes occurred in the inlet between the September 2003 and September 2004 surveys (Fig. 16b). The transition zone, where the shoreline angles toward the inlet channel, became widened and shifted landward. The south shore of the transition zone retreated to the edge of the low sand dunes, and on the north side the water edge shifted eastward by nearly 100m. Erosion lowered lakebed elevations on north and south portions of the transition zone that had been exposed in September 2003 by more than a 0.3m on the south side and by more than half a meter in many places on the north side. The inlet channel in 2004 was reduced to less than one-half its length the previous year. Deposition occurred where the lakeward end of the inlet channel had been in 2003. Greater buildups of sediment occurred on the sides of the inlet channel. Deposits up to 1m thick helped to build up the channel margin on the north side of the inlet channel. On the south side of the channel, an elongate deposit more than a meter thick extends lakeward of the inlet mouth, and deposition increased the beach area on the pond side of the inlet south of the inlet channel. Erosion lowered the bed in the inlet channel by more than half a meter, but depths in the channel were similar in 2003 and 2004.

The fall, 2003 wind storms caused many of the changes observed between September 2003 and September 2004. Photographs taken a day after the November 13-14, 2003 wind storm show that the inlet mouth had widened compared to earlier in the year (Fig 18). Photographs taken from approximately the same location on the south shore of the inlet channel in July, 2003 and November, 2003 show that widening of the transition zone and shortening of the inlet channel occurred during Fall, 2003 (Fig. 17). Modifications of the channel shoreline did occur between November, 2003 and September 2003, and it is not possible from photographs to determine the extent of deposition and erosion due to the storms. A local resident indicated that there was significant storm surge on North Pond during the October, 2003 wind storm (T. Jones, pers. comm.). Wave ripples were observed in the washover channel the day after the November, 2003 windstorm, indicating that water levels had been quite high during that storm as well.

Weir (1977) mapped two inlets that were open between North Pond and Lake Ontario at that time, one at the location of the present-day inlet and the other roughly 300m to the south. The inlet to the south had closed by 1978 (DelPrete, 1995). Weir's map shows sheet piling located on the eastern side of the barrier north of the north (i.e. present-day) inlet channel. The southern edge of the sheet piling is now located on the western side of the barrier approximately 180m north of the inlet channel. This indicates that the barrier has shifted landward at a rate of at least 0.93 m/y. The rate is likely higher as Weir's study indicated recession rates of about 1.3 m/y since the late 1800s.

Since 1829, the inlet between North Pond and Lake Ontario occupied at least 5 different locations along the barrier south of the present day inlet (Weir, 1977). Weir stated that inlets do not shift gradually along the shore in the direction of longshore drift. Instead they are stable for a period of time, and progressively lengthen. This decreases channel efficiency due to increased friction and favors inlet abandonment. When a new inlet is established during a large storm, for example, the older less efficient inlet is abandoned. Presumably then, the shortening of the inlet that occurred between the 2003 and 2004 surveys would increase the likelihood that the inlet will remain in its current location. However, if storms similar to the Fall, 2003 wind storms were to occur at times of higher lake levels, erosion may well create a new inlet. Candidate locations for a new inlet would be areas where the barrier is narrow, large dunes are absent, and vegetation is sparse. One such candidate is the washover area just south of the inlet, and another is an older washover to the north of the present inlet location.

Sediment transported by longshore drift and onshore transport during storm surge into Sandy Pond Inlet and other inlets in the eastern Lake Ontario barrier system may be stored in the inlet or pond for long periods of time. Although some sediment may return to the lake during spring snowmelt or other large runoff events, much of this sediment is essentially lost from the barrier system. The direction of longshore drift on the Lake Ontario coast is not precisely known at most locations, but recent work has indicated that Sandy Pond Inlet may receive sediment from both southward and northward longshore drift (Woodrow, et al., 2002). Additional study is needed to determine the quantities of sediment that are transported from adjacent beaches via longshore drift and deposited in pond and wetland areas.

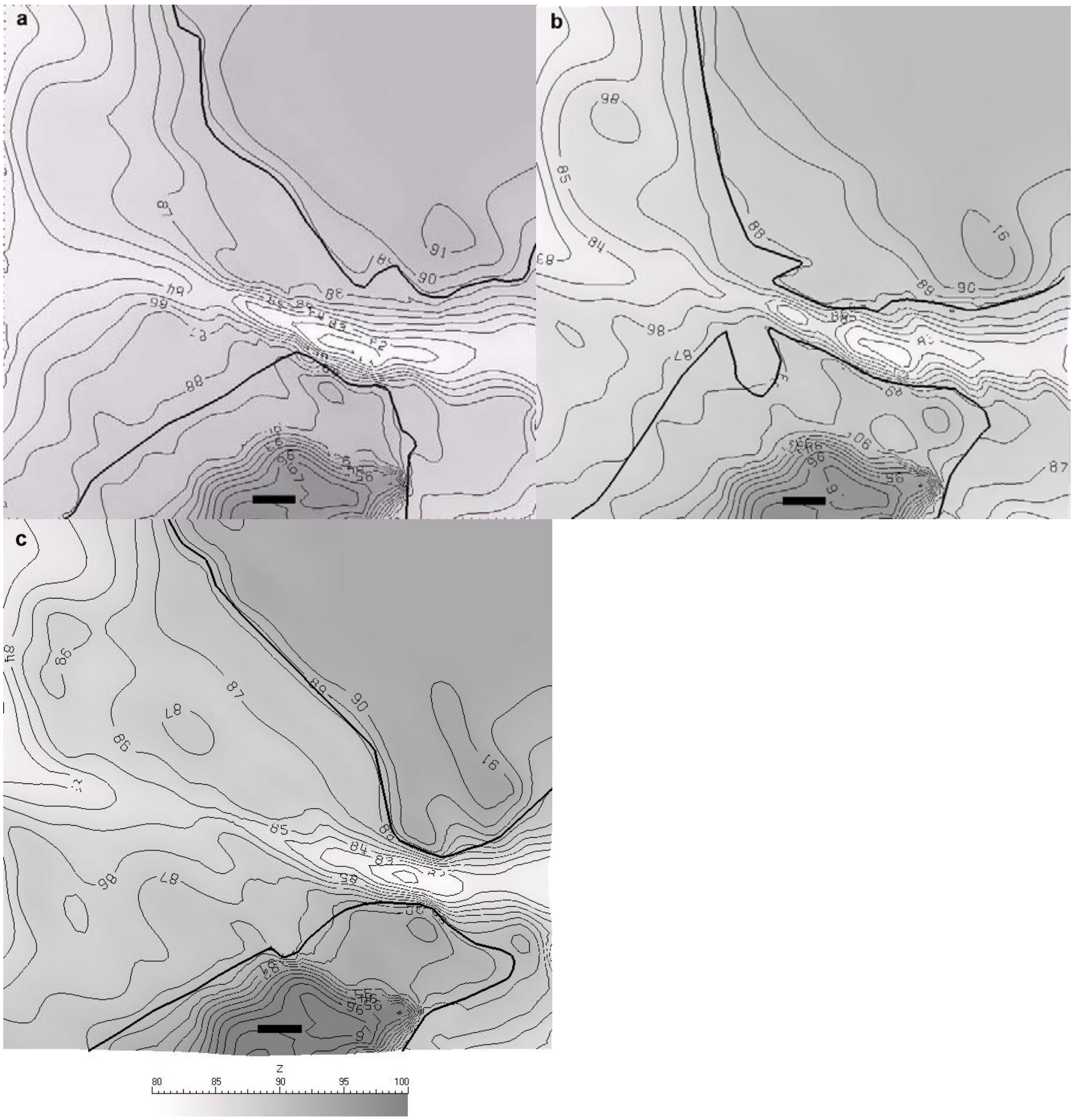


Figure 15 - Topographic maps of Sandy Pond Inlet on a) July 21, 2003, b) September 12, 2003, and c) September 21, 2004. Contour interval is 1 ft. Scale bar in each map
represents 100 ft.

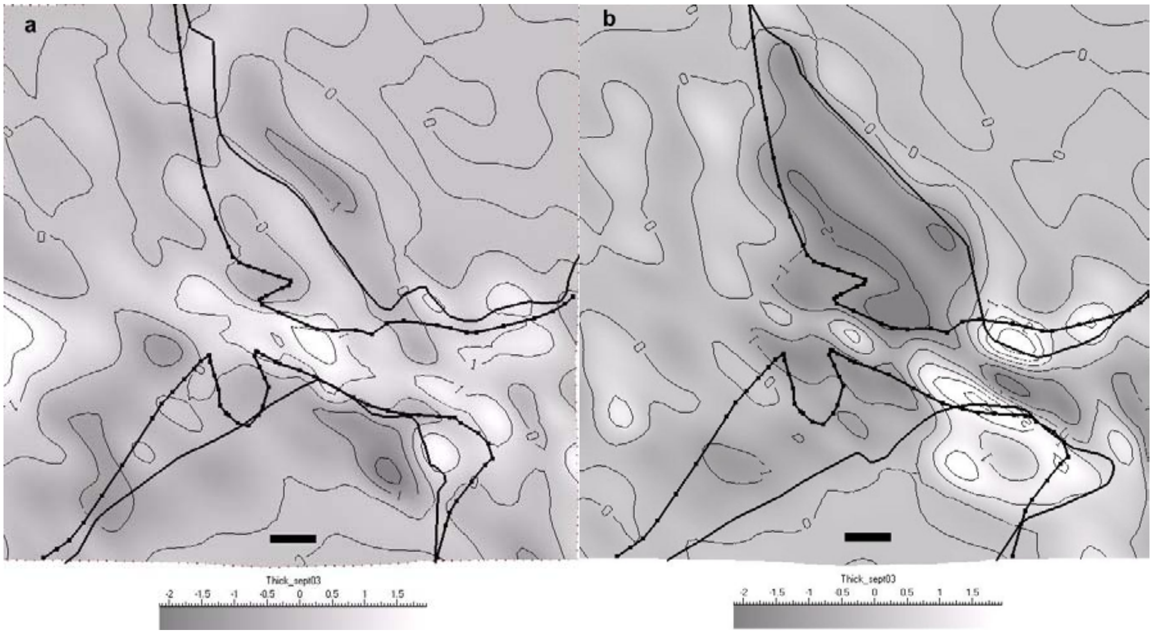


Figure 16 - Shaded relief map showing change in topography and position of water edge a) from July, 2003 (plain solid line) to September, 2003 (solid line with dots) and b) from September 2003 (solid line with dots) to September 2004 (plain solid line). Contours represent change in elevation in feet. Scale bar in each map represents 100 ft.

Figure 17 - Views of the transition zone of Sandy Pond Inlet in a) September, 2003, b) the day after the wind storm in November, 2003, and c) September, 2004. View to north.

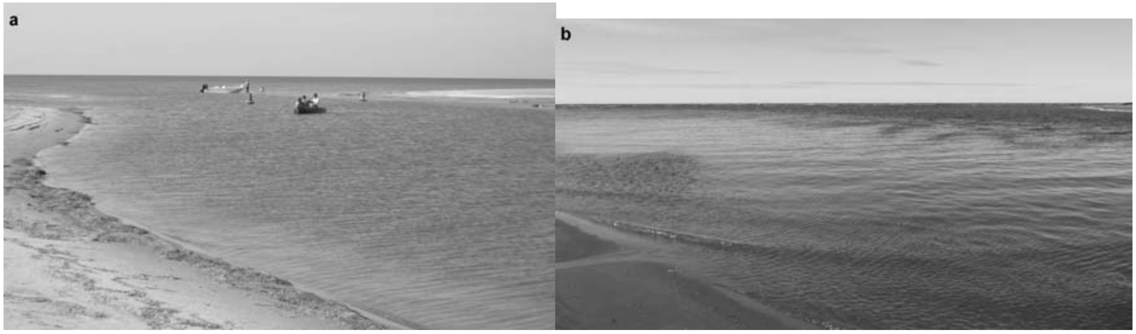


Figure 18 - View of inlet channel, looking lakeward in a) September, 2003 and b) the day after the windstorm of November, 2003.

SUMMARY

Monthly beach profiling revealed short-term, seasonal and longer-term variations in beach profiles along the eastern Lake Ontario coast. Profiles are eroded in the shallow nearshore zone up to the beach berm as lake level rises in the spring. As lake level drops during the summer and into autumn, the beach widens as the beach face progrades lakeward. The elevation of the beach face declines as the beach face progrades. In most locations nearshore bars were observed during the summer during at least some years, and in some cases profiles revealed that bars were eroded as the beach face prograded. This supports Bruun's (1983) contention lake level drops may lead to bar formation as sediment in the nearshore zone is mobilized, and that deposition of that sediment would occur in landward areas.

Storms had a significant impact on some beaches and little to no impact on others. Erosion of the beach and base of the dune at Montario Point during the November, 2003 wind storm was the most significant alteration observed. It took nearly a year and a half for the beach to recover.

Only minor longer-term changes in beach profiles were observed during the Fall, 2002-Spring, 2005 study period. Some beaches (Montario Point and Eldorado) showed larger fluctuations in profile shape than others, but these fluctuations showed no overall trend. The only consistent trend observed was accumulation of sediment in vegetated portions of the beach profiling transects at Sandy Island, Southwick and Eldorado. This shows that efforts to maintain vegetative cover by planting beach grasses and/or erecting fencing to keep people off vegetated areas are having a positive effect.

Beach profiles measured from a boat extend into deeper water show that the profiles at Montario Point and Southwick have the shape expected for equilibrium profiles. Best fit power functions to the profiles measured at these two locations yielded results similar to other studies on Great Lakes coasts. The exponent in the power function at Southwick was close to the value predicted for equilibrium profiles, but the Montario Point profile was steeper than the equilibrium profile. This may be due to modification of the profile due to the Fall, 2003 windstorms. More profiling in deeper water is needed to fully understand the nature of erosion and deposition on the eastern Lake Ontario shore and whether equilibrium profiles are maintained in this area.

Sandy Pond Inlet provides a vital navigational link between North Pond and Lake Ontario. Reduced water depth in the inlet channel between the inlet and Carl Island hinders navigation. Detailed mapping revealed that as lake level drops, channel depths are reduced by deposition on the lake side of the channel as well as lowered water level. Sediment deposited in the channel is derived from erosion of the shallow water transition zone on the lake side of the inlet during falling water levels. Wind storms during Fall, 2003 enlarged the transition zone and shortened the inlet channel to less than one-half its previous length as the transition zone shifted nearly 100m landward. Contributions of sediment from longshore drift from areas of the coast north and south of the transition zone could not be determined from the present study. Such information is needed to determine the role that sedimentation in inlets and ponds plays in the beach budget for eastern Lake Ontario.

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0.0	Parking lot near Hewitt Union and Culkin Hall, SUNY Oswego. Proceed south out of lot, turn right onto West End Ave. then left onto Sweet Road.
0.2	Turn left (east) onto State Rt. 104
1.1	Bear right at 5-way intersection (traffic light) to stay on Rt. 104 (AKA Bridge Street)
10.1	Turn left onto Rt. 104B
15.6	Rt. 104B becomes State Rt. 3
36.3	Turn left onto Eldorado Road
36.5	Stop sign; go straight. Road becomes gravel road.
37.5	Yield sign; turn left.
37.8	Bear left
38.2	STOP 1 Black Pond Wildlife Management Area (gravel parking lot)

We will walk from the parking lot along the boardwalk that takes us through the wetland adjacent to Black Pond onto the barrier. Note the tall dunes at this location. The boardwalk takes us over the dunes to the beach. At this location we will examine the wetland and pond environments of the barrier system as well as the beach and dunes. Zebra mussel and quagga mussel shells are abundant here, particularly in the spring or after storms. A short hike on the beach to the north will take us to the inlet that connects Black Pond with Lake Ontario.

40.1	Turn right (south) onto State Rt. 3
42.0	Intersection with Rt. 197 and Southwick Beach State Park access road. Turn right onto Southwick Beach State Park access road.
42.9	STOP 2 Southwick Beach State Park picnic area adjacent to beach.

We will walk along the beach to our beach profiling locality. Here we can observe some of the efforts that have been made to reduce human impacts on the beach and dunes. This will also be our lunch stop.

43.8	Turn right (south) onto State Rt. 3
55.7	Turn right (west) onto Rainbow Shores road.
57.4	Turn left (south) onto dirt road that parallels the shoreline.
58.4	STOP 3 Deer Creek Marsh (grass parking lot)

A short trail will lead us to an viewing platform overlooking Deer Creek Marsh where we can discuss some of the human impacts on coastal wetlands. We will then proceed to the cobble beach.

61.6	Turn left (north) onto State Rt. 3
63.5	Turn left (west) onto Oswego County Rt. 15.
65.8	STOP 4 Sandy Island Beach State Park

Sandy Island Beach is the location of another beach profiling transect. We will discuss the many changes in management this beach has undergone over the decades. Tremendous efforts have been made by government agencies and conservation groups to improve conditions at this beach. One such effort involved moving a vast quantity of sand that had blown from the tall aeolian dune on the eastern margin of the park into North Pond. The sand was trucked to the lakeward side of the dune. Beach grasses were planted by conservation groups to help stabilize the dune. Cars are no longer permitted on the beach, except for access to residences on the barrier. Fencing was erected to help stabilize sand and keep people off the dunes. Our beach profiling indicates that these efforts have helped protect the dunes.

STOP 5 (Optional) We will walk along the beach approximately 2 miles north to Sandy Pond Inlet. There we will examine the beach, inlet, pond and washover.

68.1	Turn right (south) onto State Rt. 3
83.5	Turn right (west) onto State Rt. 104
93.4	Sweet Road (main entrance to SUNY Oswego campus)
93.6	Hewitt Union, SUNY Oswego

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