The Careless Technology

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11. IMPACT OF RIVER CONTROL SCHEMES ON THE SHORELINE OF THE NILE DELTA

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There is now an active process of coastal retreat of the Nile Delta. Comparative study of maps, review of historical documents concerning the sites of old coastal fortresses and lighthouses, and personal observations of shoreline changes show the rate of coastal erosion. The retreat is the sum of two opposite processes: (a) the natural process of building the Delta by the annual load of sediments brought to the shoreline by the river flood; (b) the erosion action of waves and a westward shoreline current that prevails throughout the main part of the year.

This coastal retreat represents a substantial departure from the history of the area. A building process had continued throughout the Pleistocene and recent time, but began to lessen during the nineteenth and twentieth centuries as a result of river control schemes, such as the Delta Barrages (1881) and the Aswan Dam (1902). The establishment of the High Dam (1967) brings the delta building process to an end.

The rate of erosion varies locally, and is associated with the distribution of bodies of coastal sand dunes (related to old channels of the Nile Delta). These dunes are mobile and proceed inlandward, burying villages on one side and exposing the shoreline on the other side.

The immediate effect of this phenomenon on the fishing villages and summer resorts is described. The future—and more alarming—effects on the agricultural lands reclaimed and cultivated as a result of drainage schemes established during the period 1925–1967 is also discussed.

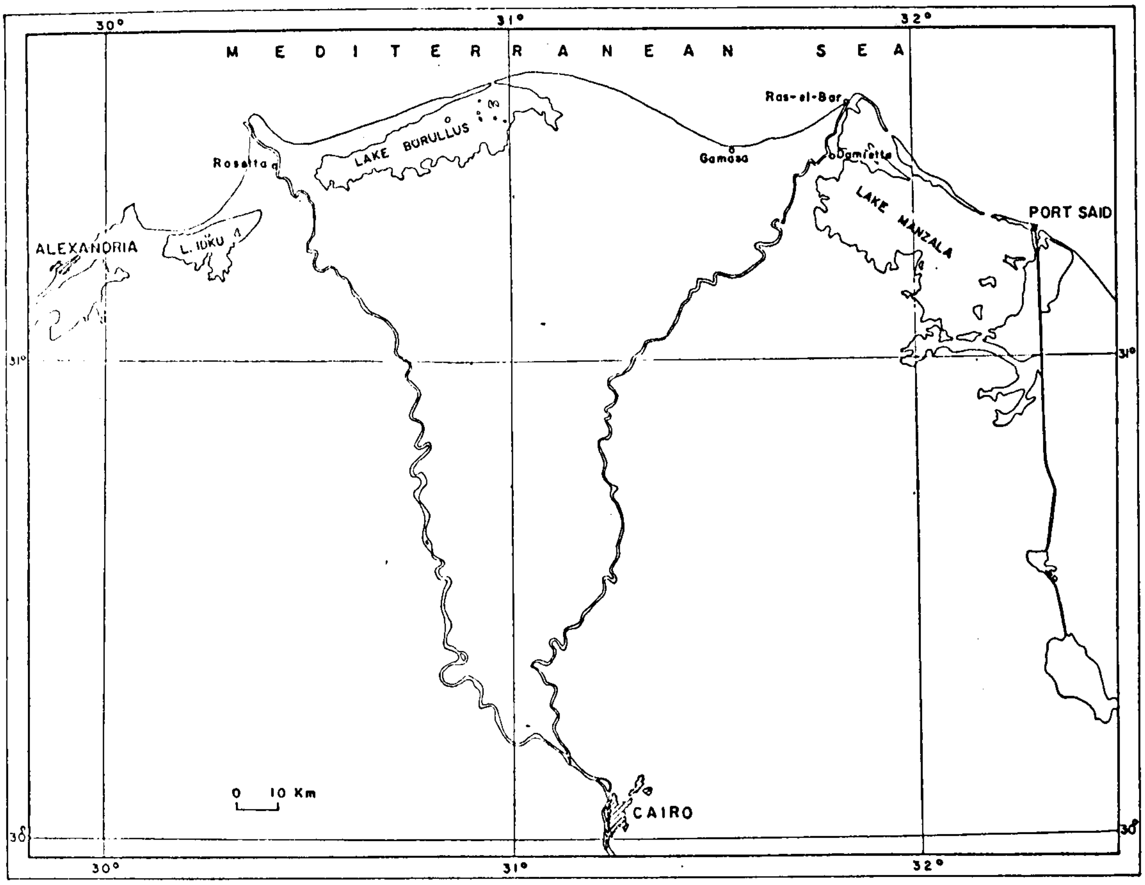

Figure 11–1 Nile Delta location map

GEOMORPHOLOGY OF THE DELTA SHORE

The Mediterranean coastline from Port Said (longitude 32 degrees 19 minutes E.) to Alexandria (longitude 29 degrees 53 minutes E.) is an undulating line that bears the features of an advancing delta (Fig. 11–1).

Three shallow lakes occupy the northern part of the Delta: Lake Manzala (east), Lake Burullus (middle), and Lake Idku (west). These lakes receive the main bulk of the drainage water collecting from the Delta; they are separated from the sea by strips of land that are very narrow in several places, and they are connected with the sea through outlets. The Delta shoreline is dotted with villages and summer resorts such as Ras-el-Bar, Gamasa, and Baltim.

Along the shore there are sand dunes seemingly associated with the eastern banks of present and past Nile branches. Two promontories are associated with the mouths of the Damietta and Rosetta branches of the Nile. The land between the two mouths extends into the sea to latitude 31 degrees 36 minutes, 12 and 5 latitudinal seconds farther than the tips of the Rosetta and Damietta promontories respectively. This middle part is the site of the mouth of an old branch of the Nile: the Sebennytic. The coastal land to the east of the Lake Burullus exit is covered by sand dunes that extend for about fifteen kilometers east of the outlet. The strip of land to the west of this outlet has no dunes comparable to those of the east side. The Lake Burullus exit is the site of the mouth of the Sebennytic branch.

This pattern is repeated at the sites of all the several branches of the Nile that emptied directly into the Mediterranean until

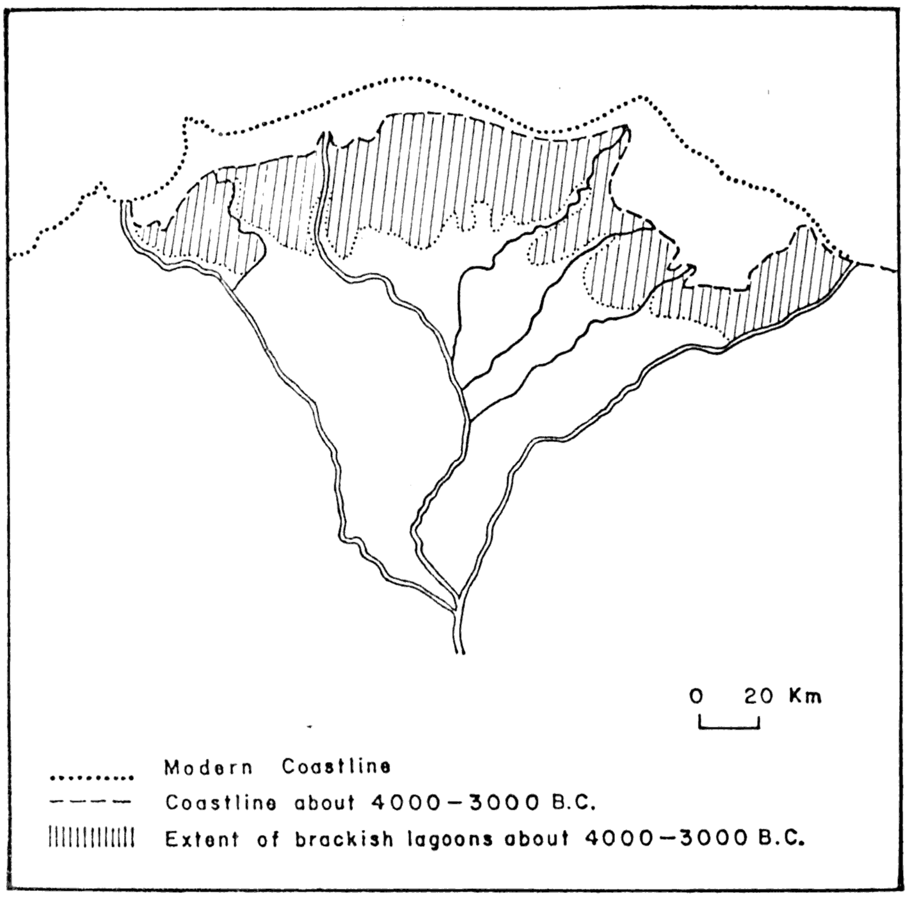

Figure 11–2 The Delta in predynastic and early historical times (After Butzer, 1959)

the ninth century.[1] The sand was obviously brought to the shoreline with the Nile sediments debouched at the mouth points. Softer silts and clays traveled further into the sea or were transported along the shoreline for long distances by littoral currents. Sand was deposited at the shoreline and pushed to the eastern sides of the mouths by the eastward current that prevails throughout the main part of the year.

That the Nile sediments travel eastward is proved by studies of Shukri and his associates. Shukri *et al.* (1956) compare the mineralogy of recent shoreline sediments with that of the Nile sediments analyzed by Shukri (1950 and 1951) and show that only little of the Nile sediments spread westward of Rosetta reaching Alexandria. Shukri and Phillip (1960) show that Nile sediments travel eastward reaching the whole of the Sinai coast and beyond. Coastal dunes of the Delta and the country to its east are formed of continental sand (siliceous) whereas dunes of the country west of the Delta are formed of maritime sand (calcareous oolitic grains).

THE PROBLEM

The Delta shoreline that had obviously been advancing throughout the history of the Delta formation is now retreating. Villages, small farms, and seaside resort establishments (notably Ras-el-Bar at the Damietta mouth and Baltim east of the Burullus exit) are gradually losing ground. The silting of the lake exits deprives fish migrations necessary to fish propagation from their natural passage. Thus silting, together with other factors, is causing gradual im-

[1] According to maps produced by O. Tosson, Egyptian Geographical Society; see also maps of Egypt in classic times reproduced by Ball (1942), and map of the Delta in predynastic times by Butzer (1959), quoted herein Fig. 11–2.

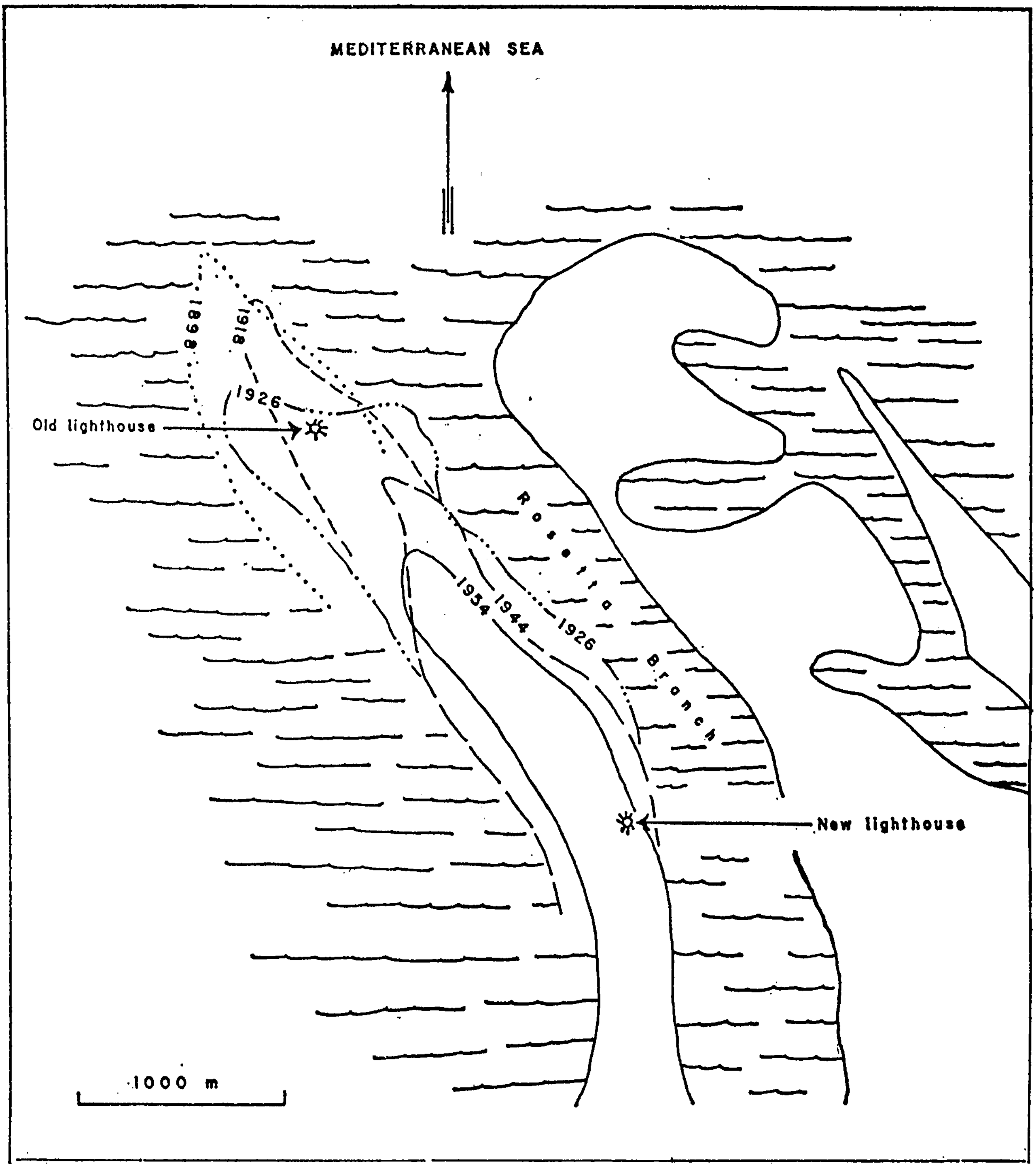

Figure 11–3 Rosetta mouth of Nile changes from 1898 to 1954 (After F. Wassing)

poverishment of the lake fisheries. The silting and instability of lake exits deprive the marine fishing industry of its natural harbors throughout the long stretch between Port Said and Alexandria.

The map in Fig. 11–3 shows the shoreline at the western side of the Rosetta mouth in 1898, 1918, 1926, 1944, and 1954. It is obvious that this promontory has lost about 1650 meters of its length in sixty-five years; the average yearly retreat is about 29 meters. Wassing (1964) produces the following figures for the rates of shoreline retreat:

Table 11–1

PERIOD	*1898–1918*	*1918–26*	*1926–44*	*1944–54*
Retreat (meters)	300	620	375	350
Average per year	15	81	21	35

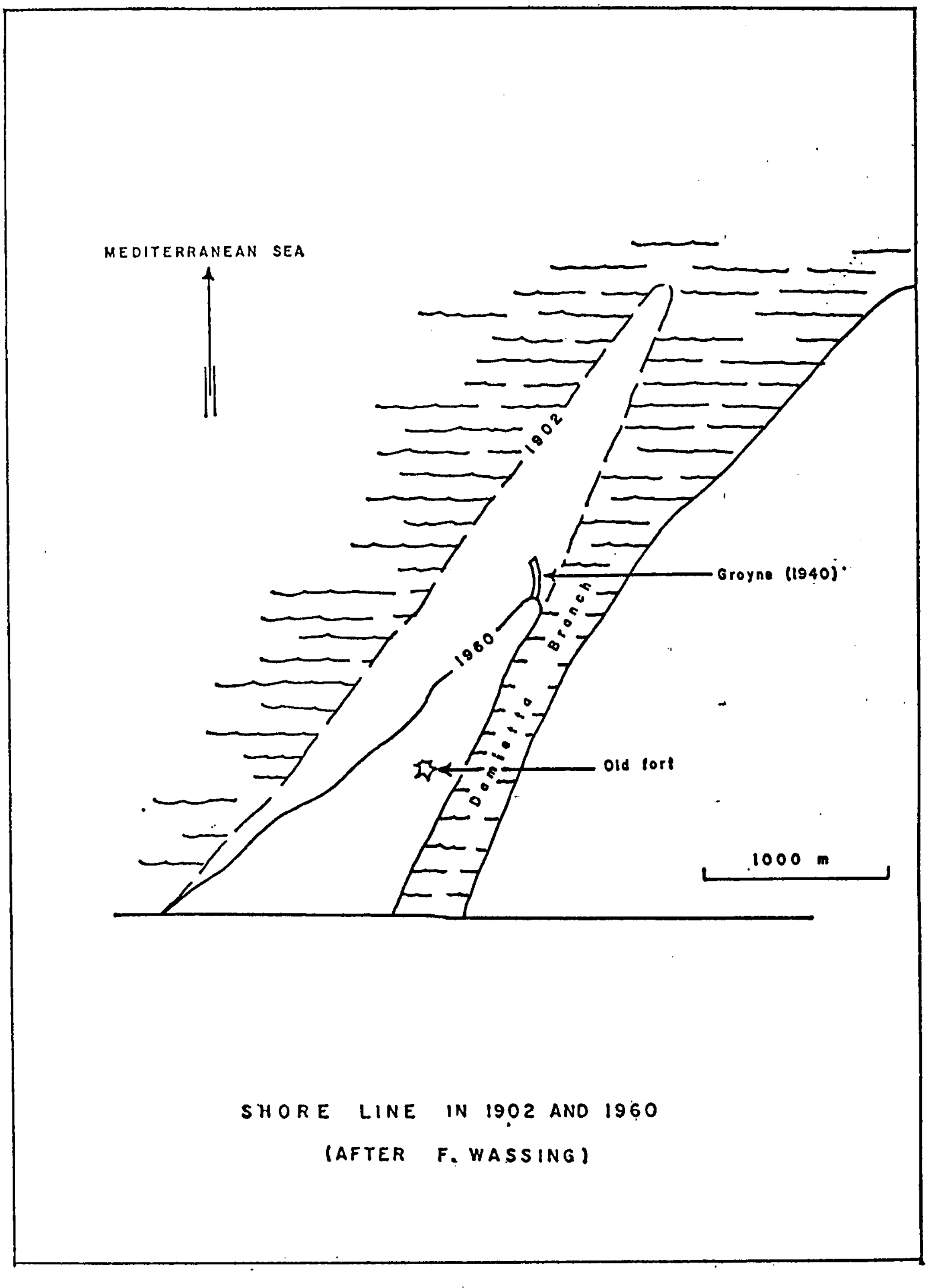

Figure 11–4 Ras el Bar on the west side of the mouth of Damietta Branch shoreline in 1902 and 1960 (After F. Wassing)

In 1898 the old lighthouse was 950 meters inland from the tip of the promontory; in 1926 it was merely a few meters from the tip. In 1942 the lighthouse became isolated from the mainland, and in 1954 a new lighthouse was built 2350 meters south of the site of the old lighthouse.

The western side of the Damietta mouth is the site of the Ras-el-Bar summer resort. From Wassing's drawing (1964), reproduced here in Fig. 11–4, it is evident that during the fifty-eight years from 1902 to 1960 the length of the Ras-el-Bar peninsula has decreased by about 1800 meters, an average of 31 meters per year.

On the western side of the Lake Burullus exit is a narrow strip of land that separates the lake from the sea. Comparing the 1919 map of the exit with the 1949 map, we note that the width of the land strip separating the sea from the lake ranged from 850 to 1000 meters in 1919 and from 200 to 350 meters in 1949. At present the eastern 10 kilometer part of this strip is about 100 meters wide, almost flat with mounds of sand that hardly reach 1 meter in height. The width of this strip increases gradually as one proceeds west toward the Rosetta mouth.

The land on the east side of the Burullus exit is a triangle increasing from about 300 meters at its tip (exit) to about 8 kilometers at Baltim, which is about 10 kilometers east of the outlet. The triangle area is covered with an immense body of sand dunes that average 10 meters above sea level, partly surveyed in Hume (1925). Villages, date-palm groves, and small farms (melons, fruits, etc.) are scattered among the dunes. These dunes seem to impede the rate of shoreline retreat by contrast to the active retreat in the western side of the exit. The dunes move slowly inland, exposing the seashore at their windward side and overwhelming the lake shore at their leeward side. The inhabitants move their villages accordingly: they travel slowly on the backs of sand dunes. On the seashore one notes submerged relicts of destroyed villages and date-palm groves. Stretches of clayey bottom of the littoral zone of the sea resemble the clayey bottom of the lake.

The village of Borg-el-Borollos, home village of the writer, was moved to its present site some eighty years ago. The old site is now about 2 kilometers out to sea, and the present site on the eastern side of the Lake Burullus exit is protected by a concrete wall supported by a number of short groynes. These constructions require yearly maintenance and repair.

A chain of coastal forts dotted the Delta coast in the late part of the nineteenth century. Archives in the Military Museum of Cairo contain inspection reports of these forts in 1880. The sites of many of these are at present under the sea. Inundated ruins of the two forts on the two sides of the Lake Burullus exit were still visible in 1930.

Each of the lakes of the northern Delta is directly connected with the sea through one or more exits. At each of these exits the material-energy relationships are rather complex: waves and longshore currents with their loads of sediments (littoral processes) react with tidal currents and seasonal currents with their loads of sediments (exit processes). The tidal current flows into the lake in flood tide and out of the lake in ebb tide. This is subject to variation in range from spring to neap and is modified by wave action. Seasonal currents in and out of the exits are due to variations in water level of the lake relative to sea level. Lake Manzala, for instance, receives an annual average of 4500 million cubic meters of water from drains and canals debouching into the lake. The monthly water discharge into the lake follows a seasonal rhythm: 100 million cubic meters in January–February and 700 million cubic meters in August–September. The water level in the lake varies accordingly due to the limited capacity of the exit.

The sum of these complex and varied processes is that the lake exits are subject to notable variation in size and position. We may quote the historical account of the Lake Manzala exit as summarized in Report No. 18 (1964) of the Research Laboratory, Suez Canal Authority. In 1887 there was one exit 100 meters wide and more than 5 meters deep. In 1890 the exit was 50 meters east of the old fort; in 1921 it was 1000 meters east of the fort: it moved eastward at an average of 30 meters per year. In 1922 the exit was 75 meters wide with a channel 3 meters deep in its eastern side. In this year an artificial exit 20 meters wide and 3 meters deep was dug immediately west of the fort. In 1926 the newly dug exit had moved eastward, causing the destruction of the fort. In 1942 this artificial exit was silted and a new exit was naturally formed further east of the original (first mentioned) exit. This new exit was deepened and a barrage was built across it to control the outflow of the lake water. In 1953 the original exit was silted; it was artificially cleared in 1955, but silted again in 1956. The instability of the Lake Manzala exit is similar to that noted of the Lake Burullus exit.

The outflow current from the lake exit may be an effective factor in lowering the rate of beach erosion through its effect on the longshore current. The silting of these exits hinders the movement of fish from lake to sea and vice versa and disturbs the migratory movements associated with fish propagation. The maintenance of these exits is part of the general problem of beach protection.

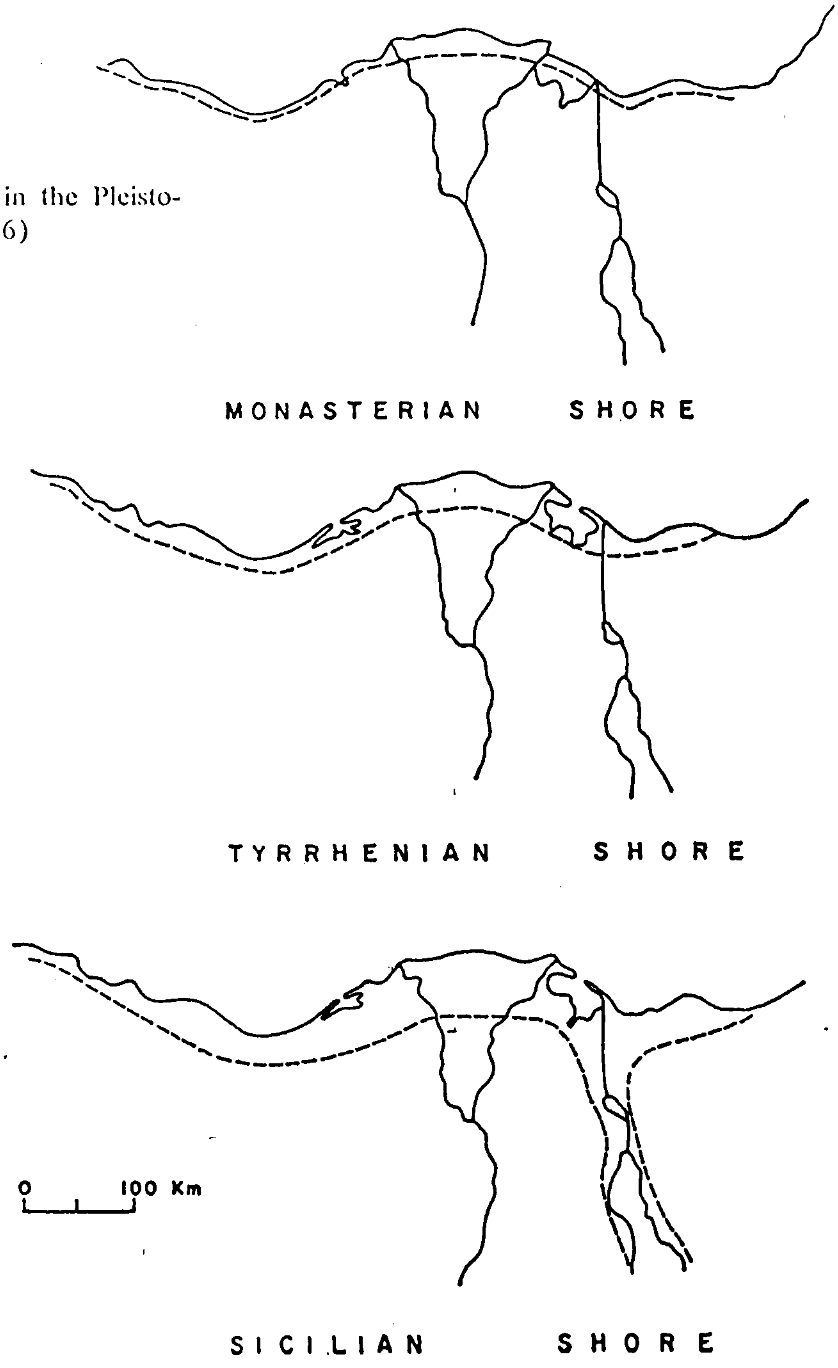

Figure 11–5 The Nile Delta in the Pleistocene (After Shukri *et al.*, 1956)

[illegible] the [illegible]cene [illegible]ies of oolitic limestone bars parallel to the shore from Alexandria to the Libyan border (Shukri *et al.*, 1956; Butzer, 1960), palynological studies on Delta deposits (Saad and Sami, 1967), radiocarbon dating of Nile sediments (Fairbridge, 1962a, 1963), historical studies on Greco-Roman sites Audebeau (1919), etc. Archaeological evidence such as the sites of ancient towns and river branches in the Delta given by Daressy (1928–1934) show that human settlements advanced gradually in a northward direction from predynastic to Hellenic times; that is, the Delta itself was advancing.

But we are here concerned with changes that have taken place during the last hundred years and with the coastal retreat that is actively taking place now at the alarming rate of several meters per year (Figs. 11–3 and 11–4). These changes are obviously due to erosive action of littoral processes: waves and currents. The eroded materials are carried eastward by the prevalent littoral current and are partly trapped by the groynes built at Port Said to protect the entrance of the Suez Canal. The area of the Port Said township has expanded on the land formed by these deposits.

The question that arises is: Why is this recent retreat occurring? The erosion processes must have been operative all the time: throughout centuries the eastward littoral current has moved Nile sediments east of [illegible] outcome of these two opposed processes was, until recently, a slow building; the Delta was gaining ground, at least at the mouths of the river where promontories were formed. A change of balance has caused the present retreat.

Earlier this century W. Willcocks, in his account of the Nile (1904), calculated that of the mean discharge of 3040 cubic meters per second which passed Aswan, 400 cubic meters per second were utilized in Upper Egypt (south of Cairo), 540 cubic meters per second were utilized in Lower Egypt (Delta), and 2100 cubic meters per second reached the sea. This means that until 1904 two-thirds of the Nile water entering Egypt was poured into the sea with its load of sediments. But by the end of the nineteenth century the Delta Barrages were completed (1861), an extensive network of canals was established; and the Aswan Reservoir and a series of barrages in Upper Egypt were in the planning stage. The purpose was to change the basin-irrigation system that was preponderant in Egypt to perennial irrigation. Reservoirs were established in the Sudan: Sennar Dam on the Blue Nile (1925), Jebel Aulia Dam on the White Nile (1937), Roseires Dam on the Blue Nile (1964), Khashm el-Girba Dam on the Atbara River (1962), etc. The establishment of the High Dam at Aswan (completed 1968) will bring the Nile in Egypt under full control and will reduce the water discharged into the sea and its load of sediments to almost nil.

Before the elaboration of these irrigation and Nile-control constructions that started on a large scale by the end of the nineteenth century, the load of sediments reaching the shoreline was much greater.

Quantities of sediments carried in suspension by the Nile water are calculated by Ball (1939). He gives these in millions of tons past Wadi Halfa (Sudano-Egyptian border) and Cairo during flood seasons of three years as follows:

Table 11–2

	WADI HALFA	CAIRO
1929	136.13	73.81
1930	75.69	41.62
1931	118.27	57.30

The suspended material diminishes in the journey from Wadi Halfa to Cairo by about half of its quantity. Part of the load is further lost through the journey from Cairo to the sea. This loss is due, in part at least, to the interception of sediments through irrigation canals and at the Aswan Reservoir.

The deposition of the full load of flood sediments was enough to compensate for the erosion and to build the Delta shores further northward at least in parts where river branches debouched into the sea. The flow of Nile water into the sea must have formed currents perpendicular to the prevalent littoral current pushing it farther from the shoreline and hence saving the beach from its erosion action. This protective influence of the river flow has gradually been diminished; it will be completely nullified by the completion of the Aswan High Dam.

DANGERS OF SHORELINE RETREAT

The narrow bars separating Lake Manzala and Lake Burullus from the sea, especially the parts west of the exits, are likely to collapse. If this is allowed to happen, the two lakes will be transformed into sea bays extending into the northern Delta. Land reclamation endeavors during the last fifty years, and recent reclamation schemes that will bear fruit during the next five years, will have gained about one million acres of land for Egyptian agriculture. But these large stretches of land are at, or only little above, sea level. The reclamation of these areas was made possible through pump-drainage into the lakes. The transformation of these lakes into marine bays will endanger the hydrology of the northern Delta drainage systems. The southern shores of the present lakes will become marine beaches, and in case of storms the high waves are likely to cause marine inundation and salt-water sprays.

The lakes are at present bodies of brackish water separating the northern Delta from the sea. The change of these bodies of brackish water (salinity 0.8–1% in Lake Manzala; Montasir, 1937) presently in contact with the Delta lands to salt water (salinity 3.5–3.9% in the Mediterranean) will increase the salinity of the near-surface underground water with obvious repercussions on the fertility of these lands.

This prospective danger is the yet-to-be-seen finale of a story. Armed by modern technology, Egyptians ceased to worship the Nile as a god and the benevolent giver of their fertile land, and started in the middle of the eighteenth century to harness the mighty river till they brought it under almost full control by the establishment of the Aswan High Dam. But the complexity an ecosystem such as this river represents is often beyond the engineer's genius. The land reclaimed by sustained effort throughout a century is being endangered by shoreline retreat; and if not alert to the repercussions we may face the finale of a story that amounts to the first man-made marine transgression.

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