THE ECOLOGY OF LAGOS LAGOON
I. THE LAGOONS OF THE GUINEA COAST

By J. E. WEBB
Department of Zoology, University College, Ibadan, Nigeria

(*Communicated by G. P. Wells, F.R.S.—Received* 20 *September* 1957)

(Plates 11 to 13)

In this account of the lagoon systems of the Guinea Coast of West Africa, the distribution of lagoons is discussed in relation to the direction of the coast-line and the quarter of the dominant wind. Two types of lagoon are recognized according to the presence or absence of large rivers in the different regions.

An aerial survey of the Dahomey and Western Nigerian lagoon systems has been made, and three types of beach accretion responsible for the seaward advance of the shore are described.

It has been shown that the pattern of vegetation on lagoon deposits, being governed by the nature of the soil, can be used to indicate the position of the past beaches, sand ridges, spits and lagoons. An area to the west of Lagos has been studied by this method and a map prepared to show the successive advances of the shore.

Introduction

This paper is the first of a series on the ecology of the marginal lagoons of Western Nigeria and, in particular, the brackish lagoons surrounding the island of Lagos. The West African lagoons are of interest to the ecologist in view of the fluctuations in salinity, which occur wherever there is an opening to the sea, and the effect which these changes have on the distribution of the fauna and flora. Except for Rougerie's (1951) account of the geography and geology of the lagoon at Abidjan in the Ivory Coast, little has been written on either the lagoons themselves or the life to be found in them. Reference to the geomorphology of marginal lagoons in general is made by Johnson (1919) and Twenhofel (1939), but without specific mention of the West African coast, while, as Pugh (1954) has pointed out, standard geographical texts, such as Fitzgerald (1934), Bernard (1939) and Stamp (1953), covering West Africa, deal only very briefly with the coastal belt. Among works on tropical marine or brackish water ecology, Galtsoff (1954) surveys the mangrove coastal lagoons and the great mangrove barrier ridge of the coasts of southern Florida and the Yucatan peninsular, but these formations are not similar to the West African lagoons and, in spite of the fact that the species of mangrove present are common to both areas, the ecological conditions in the two regions are different in many respects. On the other hand, many of the general principles outlined by Day (1952) in his review of estuarine conditions in South Africa, and by Scott, Harrison & MacNae (1952) and Day, Millard & Harrison (1952), in their more detailed surveys of certain South African estuaries, are also relevant to the tidal reaches of the West African lagoons, although South Africa is not tropical, and lagoons of the same type as those in West Africa are not found along the South African coast. A study, therefore, of the Western Nigerian lagoons and their fauna and flora will provide data on the ecology of a type of environment common in West Africa which has not previously received attention except in the most general terms. It is appropriate first, however, to outline the topography of the area, and to consider the origin and probable history of the lagoons.

The origin, age and distribution of the Guinea Coast lagoons

The shores of the Guinea Coast of West Africa are chiefly wave-beaten sandy beaches with occasionally an outcrop of rock. In two main regions, one in the Ivory Coast and the second extending from the Volta River to the Niger Delta, the beach is a barrier beach backed by a lagoon system. Part of the West African coastline is shown in figure 1 with

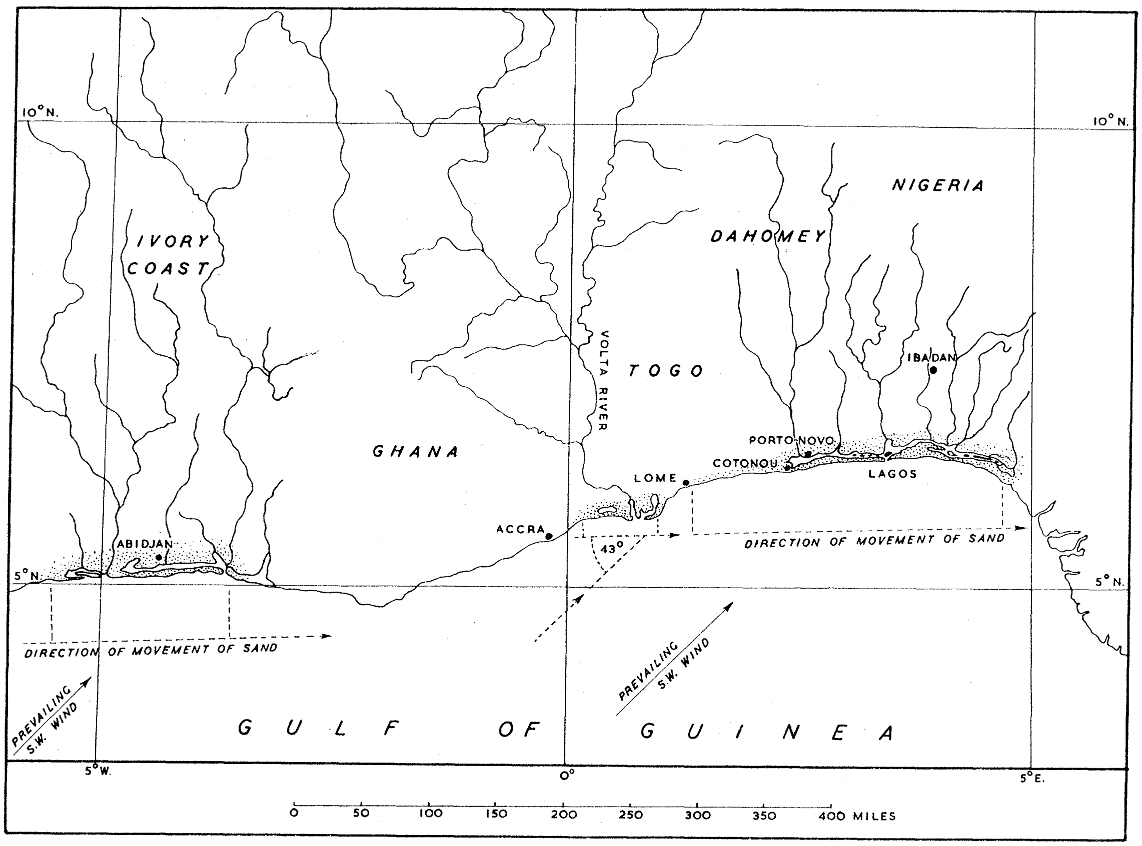


Figure 1. The distribution of marginal lagoons on the Guinea Coast.

the regions where marginal lagoons occur stippled. It can be seen from this map that lines drawn through each of these lagoon systems are parallel and at an angle of about 45 degrees to the dominant and prevailing south-west wind. Thus the extent of the lagoons appears to be limited by the direction of the coast-line in so far as the barrier beach backed by lagoons is present in all cases where the coast is at the appropriate angle to the dominant wind and terminates when the coast turns away to the north or south.

The formation of these lagoons is evidently dependent on the movement of sand along the coast in a west–east direction. Kouriatchy (1934) comments on the deposition of sand on these coasts from sea currents to form a prograding barrier beach with lagoons to the landward side, while Bernard (1939), agreeing with this suggestion, further considers that the lagoon systems with their deposits have been formed within recent times along a previously notched coast. He suggests that deposits of sand at suitable points on the original coastline have filled in these notches, thus shortening the coast-line and giving rise to a straight, ever lengthening barrier beach. This beach, therefore, is backed by lagoon deposits, the inland extent of which may be many miles, but varies from place to place according to the position of the original shore.

The rate of movement of sand along the coast seems to vary from place to place but, according to Guilcher (1954*a*) and Clason, Tellegen, Frijlink, Thijsse, Jansen & Schijf (1954), is of the order of 1 000 000 to 1 500 000 tons per annum. It is doubtful, however, how far the movement of sand is due entirely to the west–east coastal Guinea Current flowing from the Senegal to the Cameroons as Kouriatchy and Bernard suggest, particularly as the littoral currents of the Guinea Coast are by no means constant. Clason *et al.* (1954) have shown that, at Lagos, where observations over the five-year period 1949–54 have been made, reverse currents occur and that the reverse flow occupies as much as 40 % of the time in May, although only 5 % in August. It is now more generally held that much of the west–east transport of sand is due to longshore drift in this region and is caused by the angle at which the waves of the Atlantic swell strike the beach (Jessen 1951; Clason *et al.* 1954; Guilcher 1954*a*, 1954*b*; Pugh 1954), the movement of sand grains due to wave action being similar to that described by Steers (1946) and Newell (1954). Longshore drift would certainly account for the occurrence of the barrier beaches at a more or less fixed angle of 45 degrees to the dominant south-west wind which, raising the waves of greatest fetch, would determine the movement of sand and hence the line of the beach. However, the steady seaward progradation of the barrier beach must involve a supply of sand to the beach as distinct from longshore movement, and must take place in the band fringing the coast which is affected by wave action, for it is only here that, first, sand is found, the deposits seaward of this region consisting of mud and clay (Clason *et al.* 1954), and, second, that the water movement is sufficient to disturb the bottom deposits. In the Lagos area, the presence of marine deposits containing some sand indicates that turbulent water extends up to about 1 mile from the shore. Under conditions of turbulence there is likely to be an irregular but predominantly west–east drift of sand parallel to the coast, due to the set of the inshore components of the Guinea Current and quite independent of longshore drift. This current, therefore, may well be responsible for the main supply of sand to the coast and should operate irrespective of the direction of the coast-line or the location of barrier beaches. Wave action will be responsible for the transport of sand from the offshore turbulent zone to the beach and give rise to graded deposits according to the degree of water movement. At the shore the extent and direction of the movement of sand will depend on the direction of the coast-line relative to the dominant wind and the presence or absence of longshore drift. Thus, in the region under discussion, longshore drift is from west to east, but, where the coast turns through an angle of 90 degrees and runs approximately north–south, as in parts of the Niger Delta and in Sierra Leone, the drift is in a northerly direction as shown by the growth of sand spits in those regions. It is possible, therefore, for the movements of sand by the sea current and by longshore drift to be in opposite directions, although this is not usually the case on the Guinea Coast. The origin of this sand is not known with certainty, but the rounded form of the grains, both from the beaches and from lagoon deposits in comparison with the sharp sand of the riverine deposits of the region, suggests that the sand is wind blown. If this is correct then it seems probable that the sand may originate in the Sahara, possibly being blown into the sea in the region of the Senegal to be carried south by the Guinea Current.

The Guinea Coast lagoons appear to be of comparatively recent origin. Junner (1940) has shown that changes in sea-level relative to the land mass have taken place on the West African coast presumably due to the withdrawal of water during periods of glaciation followed by a rise in the post-glacial period. Apart from the presence of marine terraces, plains and wave benches at various elevations up to 120 ft. above sea-level, borings show that the beds of the Volta and other rivers 40 miles inland from the present coast-line are

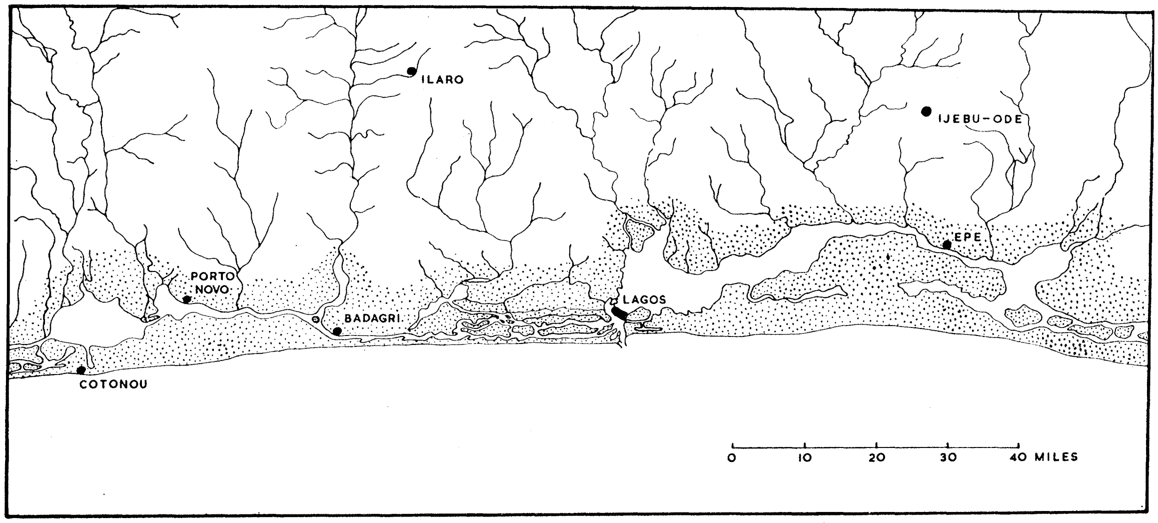


FIGURE 2. The marginal lagoon of Dahomey and Western Nigeria.

as much as 40 to 60 ft. below sea-level. In view of these changes in sea-level, it is evident that the most distant from the sea and therefore the oldest of the present series of lagoon deposits are post-glacial in origin and probably not more than 25000 years old at the most, and, as these deposits are being added to at the present time, they become progressively younger as they approach the coast-line.

Four lagoon systems can be recognized, each a separate entity. In the west there is an extensive lagoon in the Ivory Coast with Abidjan at its centre. This lagoon is fed by a number of large rivers. A much smaller lagoon is present in the neighbourhood of the mouth of the Volta River. Here the lagoon is wide and shallow and fluctuates in extent according to the flow of the river. Thirdly, there is a lagoon traversing the 'Dahomey Gap'. The Dahomey Gap is a region where the coastal forest belt is interrupted by savannah country with few rivers of any size. The fourth and largest of the systems stretches for 160 miles from Cotonou to the western edge of the Niger Delta. This lagoon is shown in detail in figure 2 where again the approximate area of lagoon deposits is represented by stipple. The lagoon borders the forest belt and receives a number of large rivers draining rather more than 40000 square miles of country. The lagoon is in communication with the sea at Cotonou and at Lagos, the Lagos opening being by far the larger and forming an extensive harbour which serves as the major outlet of fresh water from the lagoon system during the season of the rains. Bernard (1939) and de Rouville (1946) recognize two types of lagoon, the first, forming in regions where there are few rivers draining the mainland, is a greatly elongated, narrow, uninterrupted waterway immediately behind the beach and communicating with the sea by widely separated shallow inlets. This type of lagoon, of which the Dahomey lagoon is an example, is necessarily brackish and is shown in figures 4 and 5, plate 11. Lagoons of the second type form where the lagoon is fed by large rivers. In a lagoon of this kind wide sheets of shallow water covering ancient river-beds and creeks often occur and extend deeply inland. The water is practically fresh except in the tidal reaches surrounding an inlet from the sea. The lagoons of the Ivory Coast and coast of Western Nigeria are of this second type. A view of the latter is shown in figure 6, plate 11.

The mode of formation of the Western Nigerian lagoons

One of the characteristic features of the Western Nigerian lagoon deposits is the presence of sandy ridges parallel to the coast. These ridges evidently mark the lines of advance of the shore and are of two kinds. The first is a series of broad bands, each a mile or more wide, extending inland in places the full width of the deposits. The second is a series of numerous, much narrower, subparallel ridges which are usually most obvious immediately behind the barrier beach in certain regions. The broad bands or ridges can be recognized through differences in the vegetation, the sandy ridges supporting in many cases rather sparse vegetation as compared with the muddy hollows with which they alternate (see figure 7, plate 11). In cultivated areas, however, this is not obvious except at certain times of the year. For instance, the area to the north-west of Lagos shows no banding except at the beginning of April, early in the rainy season. At this time the vegetation on the muddy soil breaks into new leaf before that on the well-drained sand, so that, from the air, the mile-wide bands of green vegetation alternating with brown can be seen stretching into the distance in a series parallel to the coast. Later in the year, when the sandy soil, too, is saturated, this colour difference in the vegetation disappears and the ground is covered with a uniform green. The narrow ridges of the second type are quite different from the broad bands and again show most clearly in uncultivated areas. An example of these is given in figure 8, plate 11, from the western end of the region mapped by Pugh, (1953, 1954) at Badagri. The presence of two types of ridging suggests that there are at least two ways in which the seaward advance of the shore is taking place.

The formation of broad ridging

One of the methods whereby ridging of the broad type may be formed is through the growth of great sand spits at intervals along the beach. The spit lengthens and runs parallel to the shore as a barrier beach, enclosing between itself and the old shore a shallow lagoon of calm water. In the lagoon, sedimentation takes place where streams enter and also at the point where the lagoon is in communication with the sea. As a result of this and also, perhaps, as Pugh (1954) has suggested, through the turning of the extremity of the spit by winds from the non-dominant quarter, the lagoon may become sealed off from the sea. The growth of one spit follows another, extending the barrier beach further and further seaward and leaving behind an area of lagoon deposits of increasing width in which successive parallel ridges of sand are interspersed by muddy swamp or water channels. A spit of this type with a lagoon still open to the sea and the base of an adjacent spit to the right with its lagoon almost occluded is seen in the aerial photograph of the coast between Opobo and Bonny in the Niger Delta in figure 14, plate 13. Back from the coast, the lines of previous lagoons and beaches now covered with vegetation are clearly visible. The spit, of which part only is shown in this photograph, is more than 2 miles in length.

Not all the coastal deposits, however, have been formed from long spits. Near Lomé in Togoland, at the extreme western end of the Dahomey Gap lagoon, a series of short crochet-shaped spits have been observed built out into the sea with the ends of the spits directed toward the east. Guilcher (1954*a*, 1954*c*) and Guilcher & Nicolas (1954) report the existence of similar crochet-shaped sand spits on the Barbary Tongue, Saint Louis, Senegal where the waves also strike the coast obliquely.

The formation of narrow sand ridging

The narrower ridging of the second type seems to occur commonly, although not everywhere, irrespective of whether progradation is taking place by means of great spits or in other ways. This ridging is seen in figure 8, plate 11, on a shore which was evidently not formed by such a spit and also in figure 14, plate 13, at the base of the eastern spit. Pugh (1953, 1954) also maintains that ridging of this kind cannot have been formed by the growth of great offshore sand bars or spits parallel to the coast and backed by open lagoons for, although lagoons exist throughout this coast, in some regions they are separated from the sea by as much as 5 miles of alternating sand ridges and muddy hollows. Clason *et al.* (1954), reporting on similar deposits to the west of the Niger Delta, conclude that, since the beach ridge is 5 to 10 ft. above mean sea-level and the accreting new ridge is built in front of the old ridge, if the supply of sand were constant, a coastal plain at the level of the ridge would be formed without undulations. Thus the formation of visible parallel ridges indicates variations in the supply of sand, new ridges being formed at some distance from the old. If, as has been suggested, the supply of sand is dependent upon littoral currents in the turbulent zone immediately off shore, then variations in those currents, such as have been demonstrated at Lagos, could affect the quantity of sand reaching the beach and hence contribute to ridge formation. Where ridges are not parallel to the existing coast, they indicate a past period when conditions were different, as the direction of the ridge is a result of littoral drift, the quantity of which is a function of the angle between the wave front and the coast.

A survey of the Iyagbe lagoon deposits

About 12 miles to the west of Lagos, the shape of the lagoon and the form of the deposits behind it illustrate the ways in which coastal advance has taken place in the past. Differences in the nature of the deposits can be inferred from the pattern of the vegetation indicating the position of old sand bars backed by filled in lagoons and clearly seen in aerial photographs. This region, centred about the lagoon town of Iyagbe, has been mapped (see figure 3) and shows at least three main ways in which the deposition of sand has taken place and caused the advance of the coast-line seaward. Oblique aerial photographs of the area are given in figures 10 to 13, plate 12.

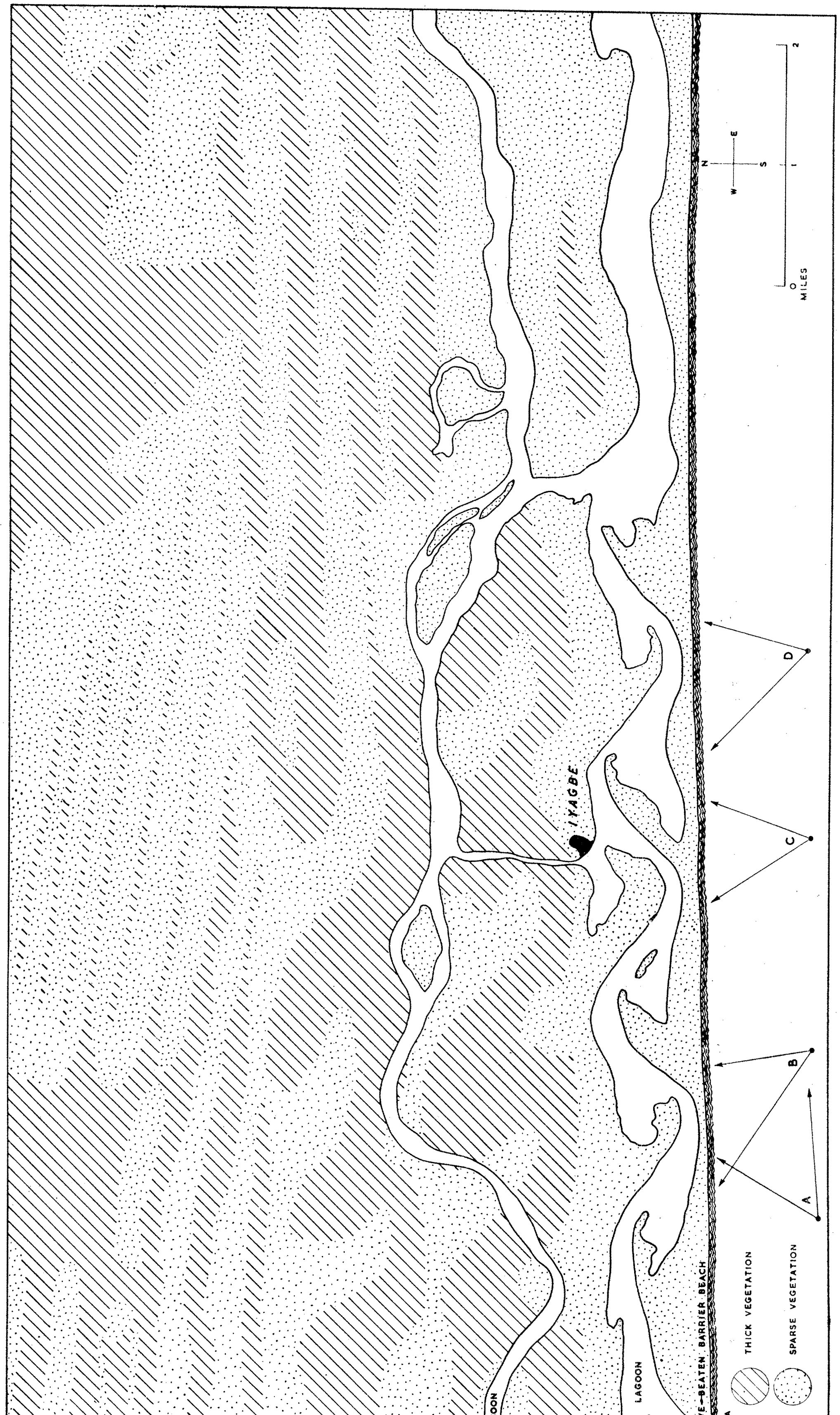


FIGURE 3. The lagoon deposits of Iyagbe.

The map in figure 3 covers an area of coast from 5 miles west to 7 miles east of Iyagbe and extending nearly 6 miles inland. The present barrier beach is quite straight, but is backed by a lagoon which, for the westerly 8 miles, shows a regular repetition of sand spits extending into the lagoon alternately from the seaward and landward banks and pointing toward the east. About 3 miles east of Iyagbe these spits cease and the lagoon becomes a broad, more or less straight channel. It seems evident that the western two-thirds of the Iyagbe lagoon was formed by the growth of successive short, crochet-shaped sand spits seaward from the line of the previous barrier beach. A new barrier beach (now the present beach) was then thrown up beyond the ends of the spits enclosing the lagoon into which these spits project. From the air it can be seen that a new series of spits or sand bars are at present forming underwater and extend outward from the beach at intervals corresponding to those between the spits now in the lagoon. Indications of these underwater spits can be seen on figure 10, plate 12. The spits arising from the seaward side of the lagoon may have been formed later, perhaps by the west–east flow of water along the lagoon itself, and do not seem to be part of the original marine formation. This is shown by the fact that there is evidence of a filled in water-way across the base of some of the spits (see figure 9, plate 11), and that the spits are still in process of extension. From the differences in vegetation shown on the map in figure 3, it is clear that a seaward advance of the coast has already taken place three times by this method, for the outline of the sandy crochet-shaped spits is delimited by the areas of denser vegetation growing in the muddy hollows between the spits. Each series of deposits is a little over a mile in width and a fourth advance of the same type and dimensions, as shown by the underwater spits, is in progress at the moment. It may be significant that the width of each of these formations is approximately equivalent to the width of the offshore turbulent zone, suggesting that their growth may be a function of the water movements within that zone as a whole. It would seem to be clear that the underwater crochet-shaped spits would not survive on this coast once they reached the water surface as they do not lie at the appropriate angle of 45 degrees to the dominant wind and would thus be destroyed if exposed to wave action. If, however, the spits are formed by the deposition of current-borne sand and there is a progressive reduction in water depth as the thickness of the deposit increases, it seems feasible that an offshore bar might be formed which would preserve them from wave action. Such a bar would be parallel to the shore enclosing behind it a lagoon into which the spits would project. In support of this hypothesis is the fact that the height of the spits in the lagoon is less than that of either the barrier beach or the ridge from which they arise (see figures 10 to 13, plate 12). On other parts of the coast offshore bars forming underwater at the seaward limit of the turbulent zone can be seen from the air.

In contrast to the western end of the Iyagbe lagoon system, the eastern third appears to have been formed by the growth of a long spit in the manner shown in figure 14, plate 13. The lagoon enclosed by that spit is long and straight and has subsequently joined to that formed by the crochet-shaped spits. As in the case of this latter type, there is evidence from the pattern of vegetation shown in figure 3 that a similar spit has been formed three times in continuation of the respective series of crochet spits, but that the point of origin of the long spit has in each case moved slightly to the east. The lagoons enclosed by the long spits also appear to have had a median sand bank running down their length. The existence of this median sand bank is of interest. Where a temporary break in the barrier beach occurs, as shown in figure 5, plate 11, it seems that a median sand bank forms in the lagoon in continuation with the beach east of the break. It is likely, therefore, that, were such a break in the beach to move progressively in the eastward direction, a median sand bank would be laid down along the length of the lagoon. The median sand banks in the filled in lagoons enclosed by long spits in the Iyagbe area may have had such an origin and indicate a past temporary break in the beach which moved down the length of the spit.

To the north of these three belts of lagoon deposits and above Iyagbe there is a series of subparallel sand ridges separated by narrow banks of dense vegetation which probably represent muddy hollows rather than past lagoons. On either side of this area there is an extensive patch of dense vegetation which suggests the presence at one time of a wide shallow lagoon opening to the sea (see figure 3) and similar to that now forming the harbour at Lagos. Across the mouth of each of these openings there was a sand bar comparable to that present at Lagos today (see Pugh 1954). It seems possible that the existence of ridges at this point may have been determined by the inlets from the sea on either side, since, on the closure of the inlets, coastal advance by ridging was succeeded by spit formation across the entire width of the area.

As the coast advances further seaward and new lagoons behind successive barrier beaches are formed, the old lagoons tend to change their course and meander among the ridges, inundating some with a wide expanse of shallow water or forming an anastomosis of tortuous creeks with here and there blind backwaters. Many of the lagoons become silted up and overgrown with vegetation while new waterways may be cut across the spits obscuring the sequence of deposits. In the Iyagbe area there is a double line of lagoons joined at two points by connecting waterways. The course of the more southerly lagoon still shows its origin from a series of spits, but the north lagoon has changed its course. It is probably derived from two previous lagoons and, apart from running more or less parallel to the coast, does not follow the original channel of either.

The Iyagbe area has been chosen as a particularly good example demonstrating the various methods of coastal advance and lagoon formation along the western Nigerian coast and showing the type and arrangement of deposits to be found throughout the region. The lagoon deposits vary in breadth according to the distance of the original coastline from the sea and, in some places, notably at Lagos, may be up to 20 miles broad.

It is possible from the breadth of the lagoon deposits to reach a tentative conclusion on the rate of seaward advance of the coast. These deposits must be post-glacial and have been laid down within the last 25 000 years. The formation of each of the mile-wide broad bands representing an arrangement of spits backed by a lagoon, therefore, should occupy a time period of the order of 1000 years. Certainly on charts of the coast drawn 100 years ago the lagoons in the Iyagbe area are recognizably similar in outline, which indicates that no major change has taken place at least within the period for which records are available.

As the lagoons pass through successive phases of sedimentation in which the open lagoon tends to become first a swamp and later, by the accumulation of further deposits and through drainage, an area of dry land, it is evident that the lagoon deposits are varied in type. These include at one end of the range coarse sands relatively free from silt and at the other fine muds and clays rich in organic matter, with various types of mixed sands, muddy sand and sandy mud occurring where conditions for deposition have been changeable. As has been mentioned, the greater part of the western Nigerian lagoon is fresh water which has drained from the land bringing mud and silt with it, but the area around Lagos is tidal and the entry of salt water from the sea gives rise to a region of brackish water of an extent which fluctuates with the seasons. Here much of the lagoon area is mangrove swamp. The mangroves colonize the edges of the waterways wherever the conditions at some time during the year are brackish, and thus promote the deposition of silt by reducing the rate of water flow with their prop-root systems. It is this brackish region around Lagos which is of particular interest to the ecologist, and is the main topic of the succeeding papers in this series.

Summary

1. The four main lagoon systems of the Guinea Coast situated respectively in the Ivory Coast, at the mouth of the Volta River, in Dahomey and in Nigeria west of the Niger, are orientated at an angle of about 45 degrees to the dominant and prevailing south-west wind. Their formation is evidently a result of the movement of sand from west to east along a previously notched coast and has taken place since the last glacial period. The sands of the beach and the lagoon deposits show signs of wind etching, and it is suggested that they may be derived from the Sahara, being blown into the sea perhaps off the Senegal coast.

2. Two distinct types of lagoon have been recognized. The first is a narrow brackish lagoon situated immediately behind a barrier beach which breaks down in widely separated places forming temporary inlets. Lagoons of this type are characteristic of areas where there are few large rivers, and a West African example is the Dahomey Lagoon. The second type occurs where the lagoons are fed by large rivers. In these lagoons, of which the Ivory Coast, Volta and Western Nigerian lagoons are examples, the water is fresh, except where there is an inlet from the sea, and large sheets of shallow water are formed extending deeply inland.

3. The arrangement of the various lagoon deposits can be recognized from the differences in the vegetation they carry. The lagoon area is a complex of sandy ridges interspersed with muddy hollows and, although the differences in altitude between the crest of the ridge and the trough of the hollow is rarely sufficient to enable them to be recognized from the ground, aerial photographs show their position and sequence clearly because of the denser vegetation on the muddy soil as compared with the sandy ridges.

4. Two kinds of ridging have been found to be characteristic of the Guinea Coast lagoon deposits and evidently mark the seaward lines of advance of the coast. The more obvious from the air is a series of broad bands each about 1 mile in width running parallel to the coast. The second is a large number of much narrower subparallel ridges usually present immediately behind the barrier beach.

5. The formation of the broad ridges appears to take place in one of two ways. Either a long spit is built seaward from the coast and runs parallel to the shore enclosing a lagoon, or a series of short crochet-shaped spits are formed extending out to sea under water and an offshore bar is thrown up at a point beyond their tips. In both cases a new barrier beach is formed about a mile in front of the old and a lagoon is enclosed between them.

6. The narrower ridging does not appear to take part in the formation of lagoons and probably represents periodic variations in the rate of supply of sand to the beach.

7. A survey of the Iyagbe area of the Western Nigerian lagoon has shown that the three methods of coastal advance have occurred in succession in the past, and that the formation of crochet-shaped spits beneath the sea is proceeding at the moment. There is some evidence to show that comparatively narrow sand ridges backed by muddy hollows are formed near major, semi-permanent, inlets into a large lagoon. Such a lagoon with two inlets existed at one time to the north of Iyagbe but has since filled in.

8. The rate of seaward advance of the coast has been estimated to be of the order of 1 mile in a thousand years.

The author is grateful to Dr J. C. Pugh and Mr R. A. G. Savigear for discussions on the mode of formation of lagoons and comments on the draft of the paper, to the West African Airways Corporation for the use of one of their aircraft in making a survey of the Western Nigerian and Dahomey lagoons, and also to the Shell-BP Petroleum Development Company of Nigeria Ltd for permission to reproduce the aerial photograph figure 14 on plate 13.

References

Bernard, A. 1939 *Géographie Universelle. XI. Afrique Septentrionale et Occidentale. II.* Paris: Armand Colin

Clason, E. W. H., Tellegen, B. D. H., Frijlink, H. C., Thijsse, J. Th., Jansen, P. Ph. & Schijf, J. B. 1954 *Report on the Western Niger Delta by the Netherlands Engineering Consultants to the Government of Nigeria. Lagos:* The Hague: NEDECO.

Day, J. H. 1952 *Trans. Roy. Soc. S. Afr.* **33**, 53.

Day, J. H., Millard, N. A. H. & Harrison, A. D. 1952 *Trans. Roy. Soc. S. Afr.* **33**, 367.

de Rouville, M. A. 1946 *Le régime des côtes.* Paris: Dunod.

Fitzgerald, W. 1934 *Africa.* London: Methuen.

Galtsoff, P. S. 1954 *Fishery Bulletin of the Fish and Wildlife Service*, **55**. Washington.

Guilcher, A. 1954*a* *L'information Géographique, I Afrique*, p. 57.

Guilcher, A. 1954*b* *Revue Norois, Poitiers*, **1**, 83.

Guilcher, A. 1954*c* *C.R. Soc. Géol. Fr.* **10**, 201.

Guilcher, A. & Nicolas, J. P. 1954 *Bulletin d'Information du Comité Central d'Océanographie et d'Étude des Côtes*, **6**, 227.

Jessen, O. 1951 *Petermanns geogr. Mitt.* **95**, 7.

Johnson, D. W. 1919 *Shore processes and shoreline development.* New York: Wiley.

Junner, N. R. 1940 *Gold Coast Geol. Survey*, Bull. **11**.

Kouriatchy, N. 1934 *Bull. Com. A.O.F.* **16**, 4.

Newell, G. E. 1954 *S. East. Nat.* **70**, 34.

Pugh, J. C. 1953 *Research Notes, Univ. Coll. Ibadan, Dep. Geogr.*, **3**, 3.

Pugh, J. C. 1954 *J. W. African. Sci. Ass.* **1**, 3.

Rougerie, G. 1951 *Études Éburnéennes. II.* Institut Français d'Afrique Noire.

Scott, K. M. F., Harrison, A. D. & MacNae, W. 1952 *Trans. Roy. Soc. S. Afr.* **33**, 283.

Stamp, L. D. 1953 *Africa.* London: Wiley.

Steers, J. A. 1946 *The coastline of England and Wales.* Cambridge University Press.

Twenhofel, W. H. 1939 *Principles of sedimentation.* New York: McGraw-Hill.

Description of plates 11 and 12

Plate 11

Figure 4. The lagoon of the Dahomey Gap typical of riverless country, and with comparatively narrow lagoon deposits behind.

Figure 5. A temporary breakdown of the barrier beach forming an inlet to the Dahomey lagoon east of Granpopo.

Figure 6. The lagoon at Porto Novo. This lagoon shows the typical wide expanse of shallow water associated with regions where there is excessive land drainage.

Figure 7. The lagoon to the east of Badagri. The lagoon deposits behind show a characteristic broad banding parallel to the coast, each band being about one mile in width.

Figure 8. The lagoon east of the Dahomey–Nigerian border. Note the narrow, subparallel, ridges between the sea and the lagoon.

Figure 9. The lagoon to the west of Lagos showing a spit with a filled-in channel across its base.

Plate 12

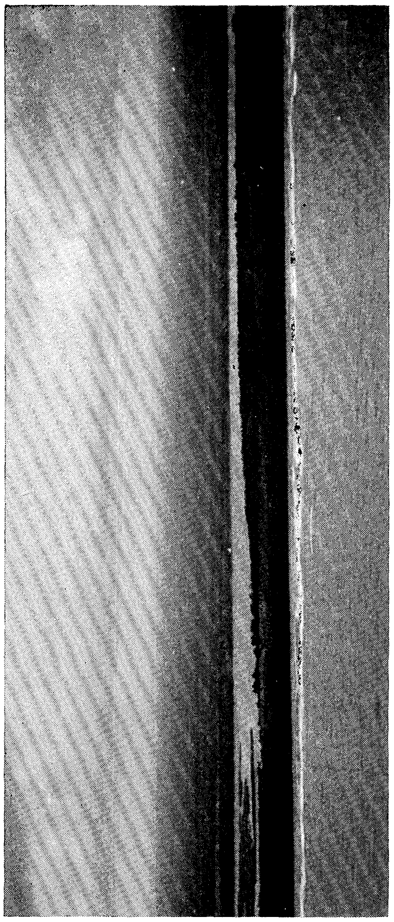
Figure 10. The lagoon at Iyagbe taken from point '*A*' in figure 3. Note the regular alternation of spits in the lagoon and the formation of underwater spits out to sea.

Figure 11. The lagoon at Iyagbe taken from point '*B*' in figure 3.

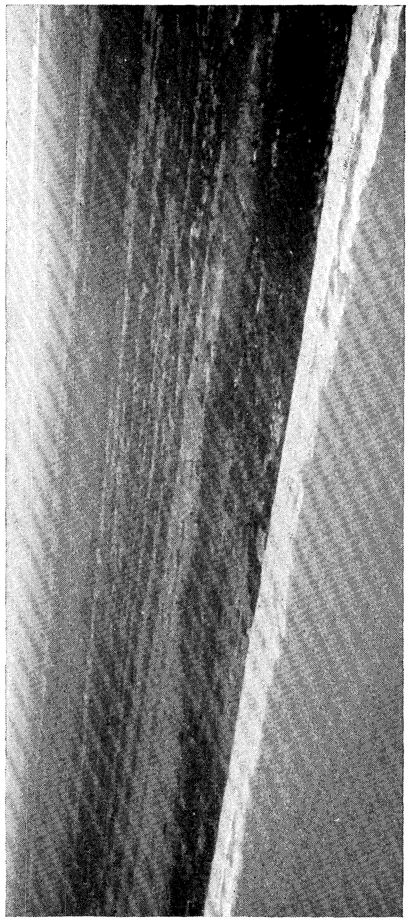
Figure 12. The lagoon at Iyagbe taken from point '*C*' in figure 3. Note the town of Iyagbe on the landward bank of the lagoon.

Figure 13. The lagoon at Iyagbe taken from point '*D*' in figure 3.

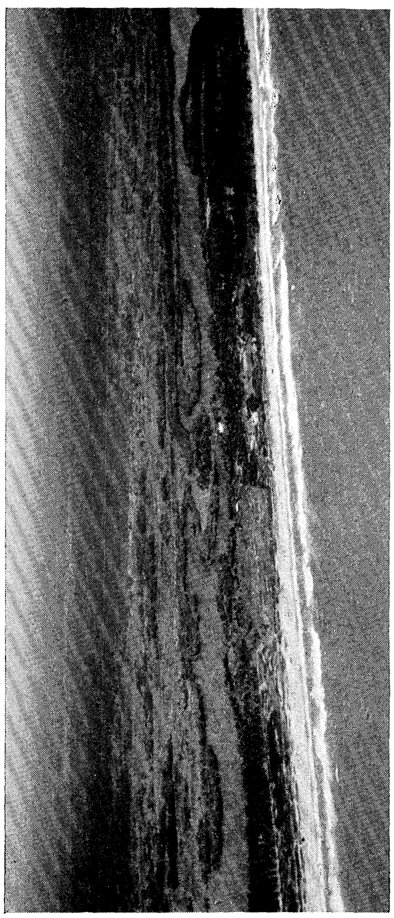
7



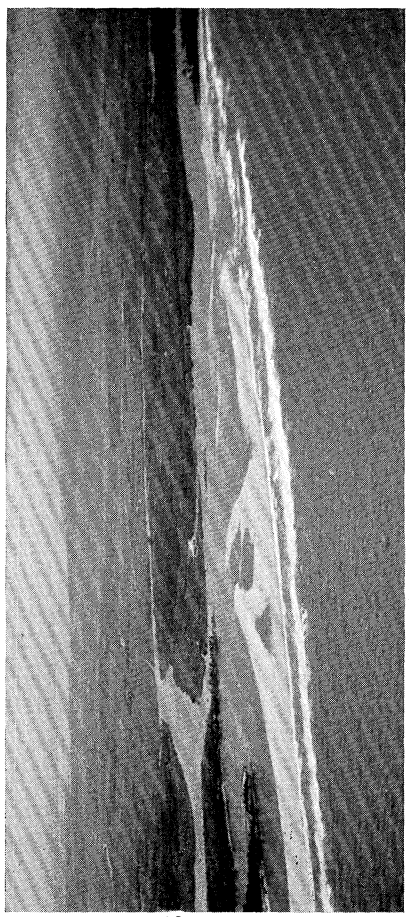
8



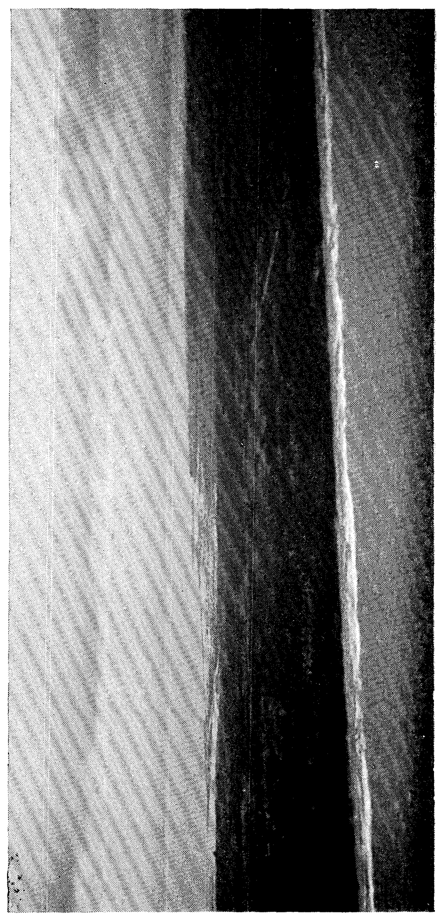
9



4

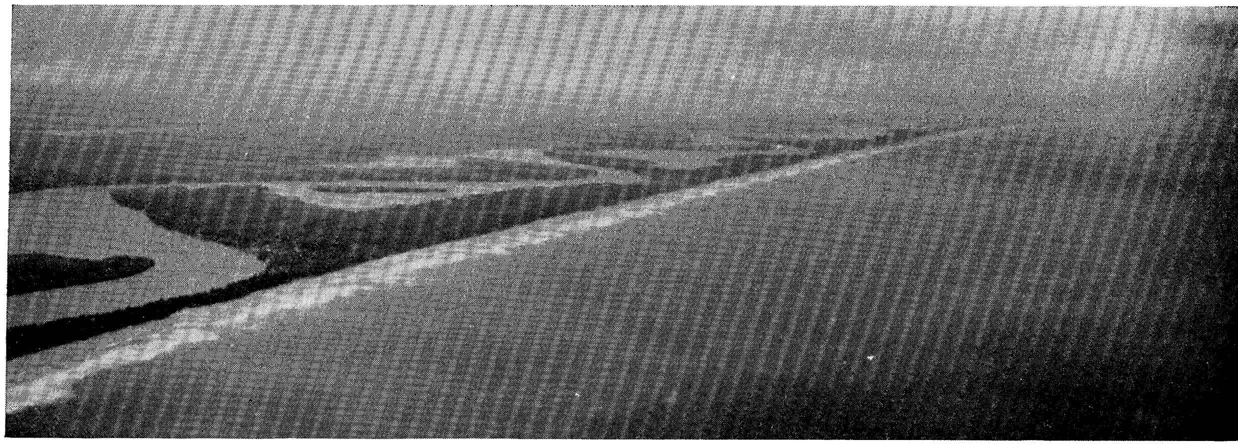


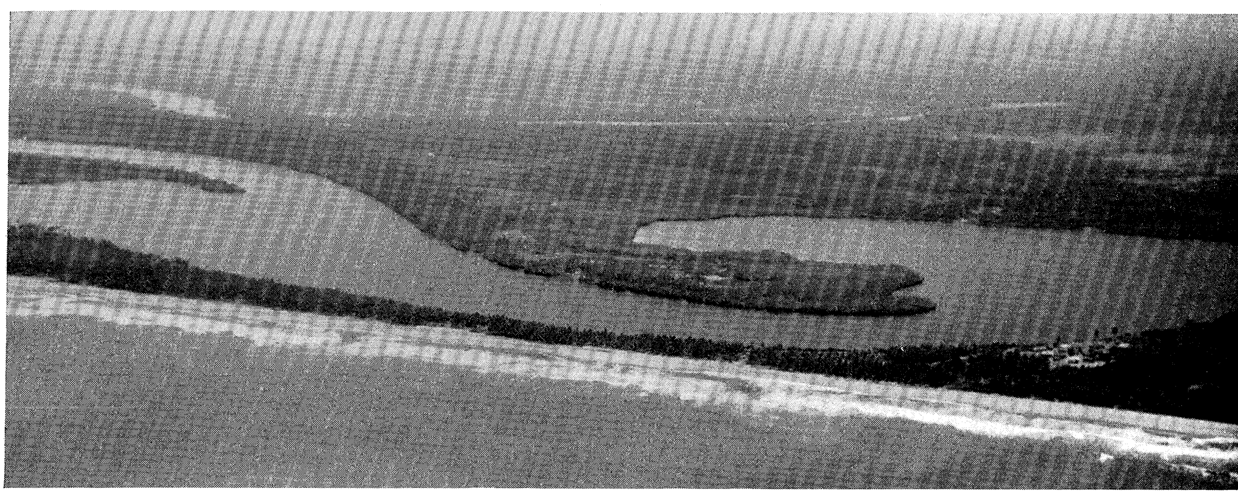
5

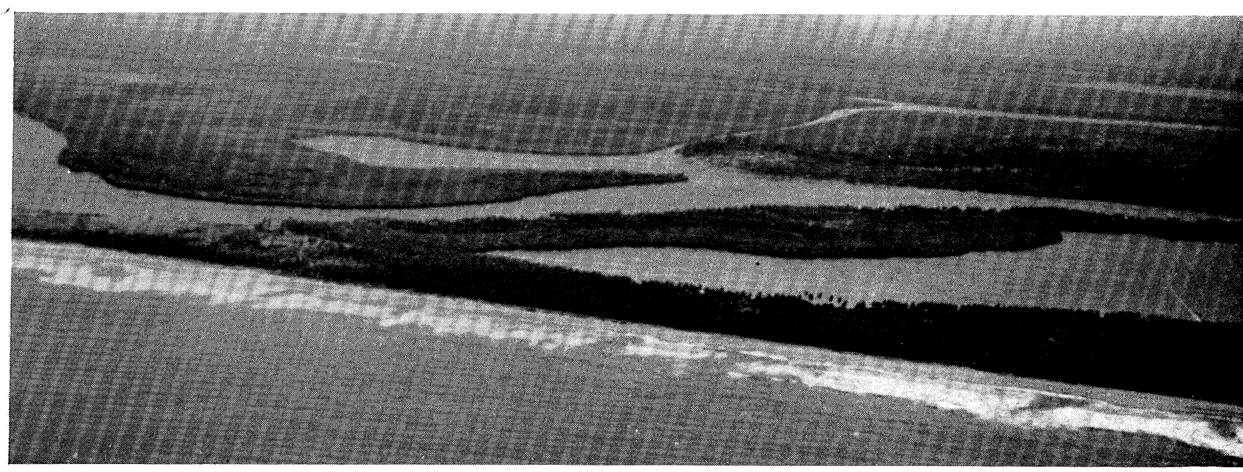


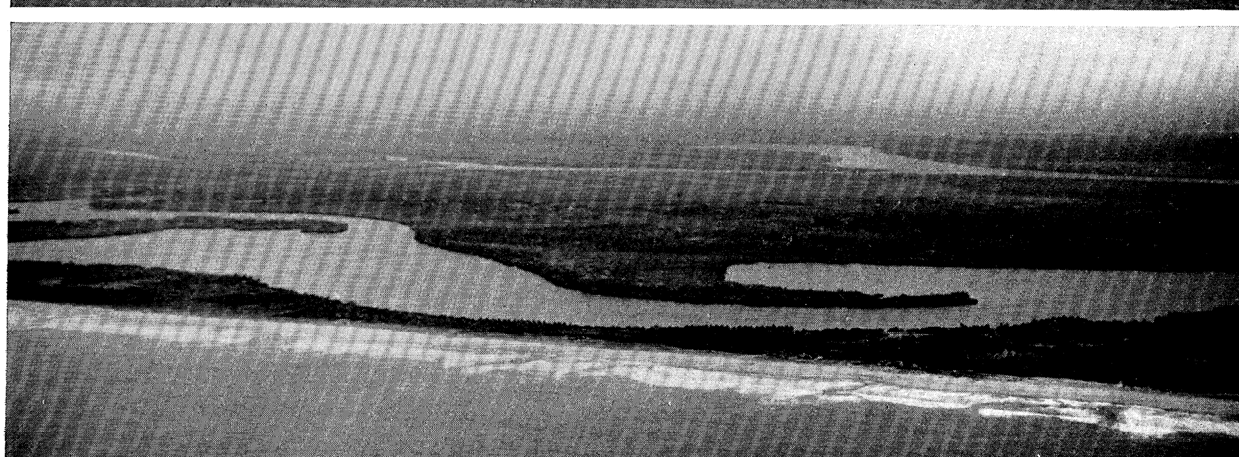
6

(*Facing p.* 318)


10


11


12


13

For description see p. 318.

Figure 14. The coast between Opobo and Bonny in the Niger Delta showing the tip of one great sandspit enclosing a narrow lagoon parallel to the coast but still open to the sea. The base of a second spit to the east also enclosing a lagoon is seen on the right. Aerial photograph taken from an altitude of 9000 ft. by the Shell-BP Petroleum Development Company of Nigeria Ltd. The circles on the photograph are of no significance.

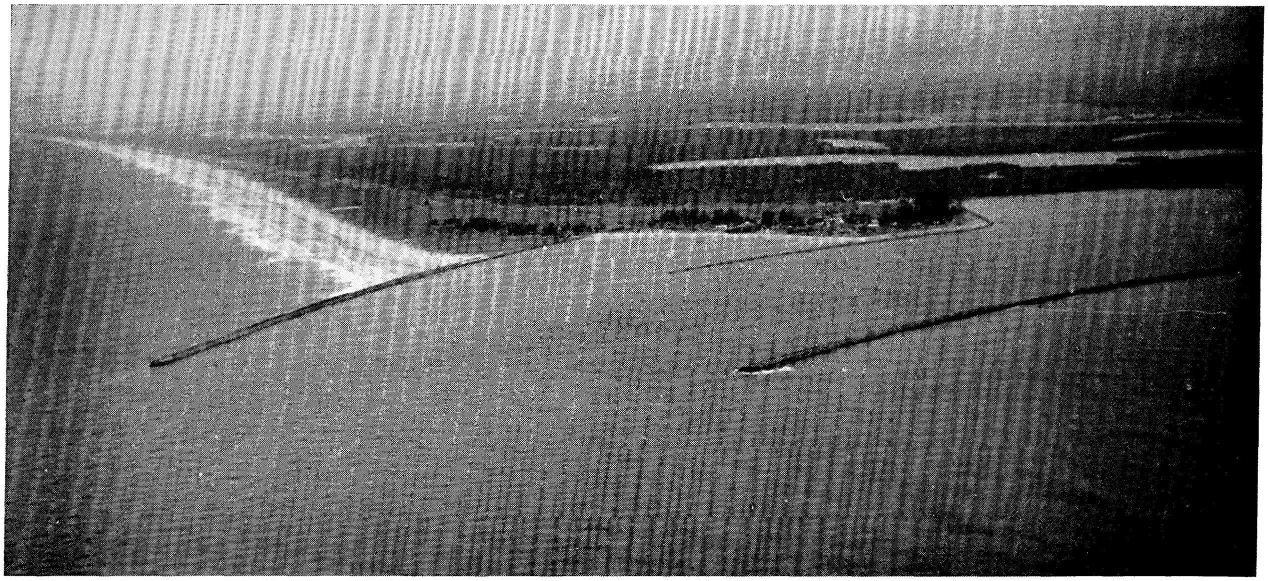


FIGURE 7. The entrance to Lagos Harbour viewed from the south-east. Lighthouse Beach is to the west. The photograph shows the position of the original coastline and the extent to which this beach has advanced seaward since construction of the West Mole began in 1901.

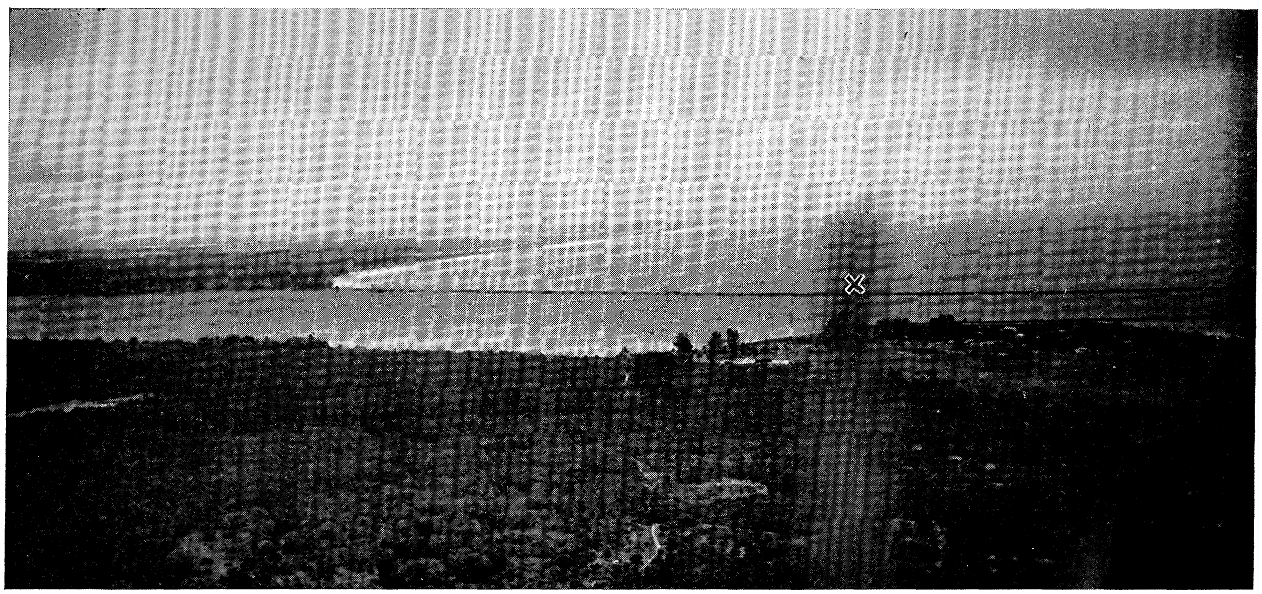
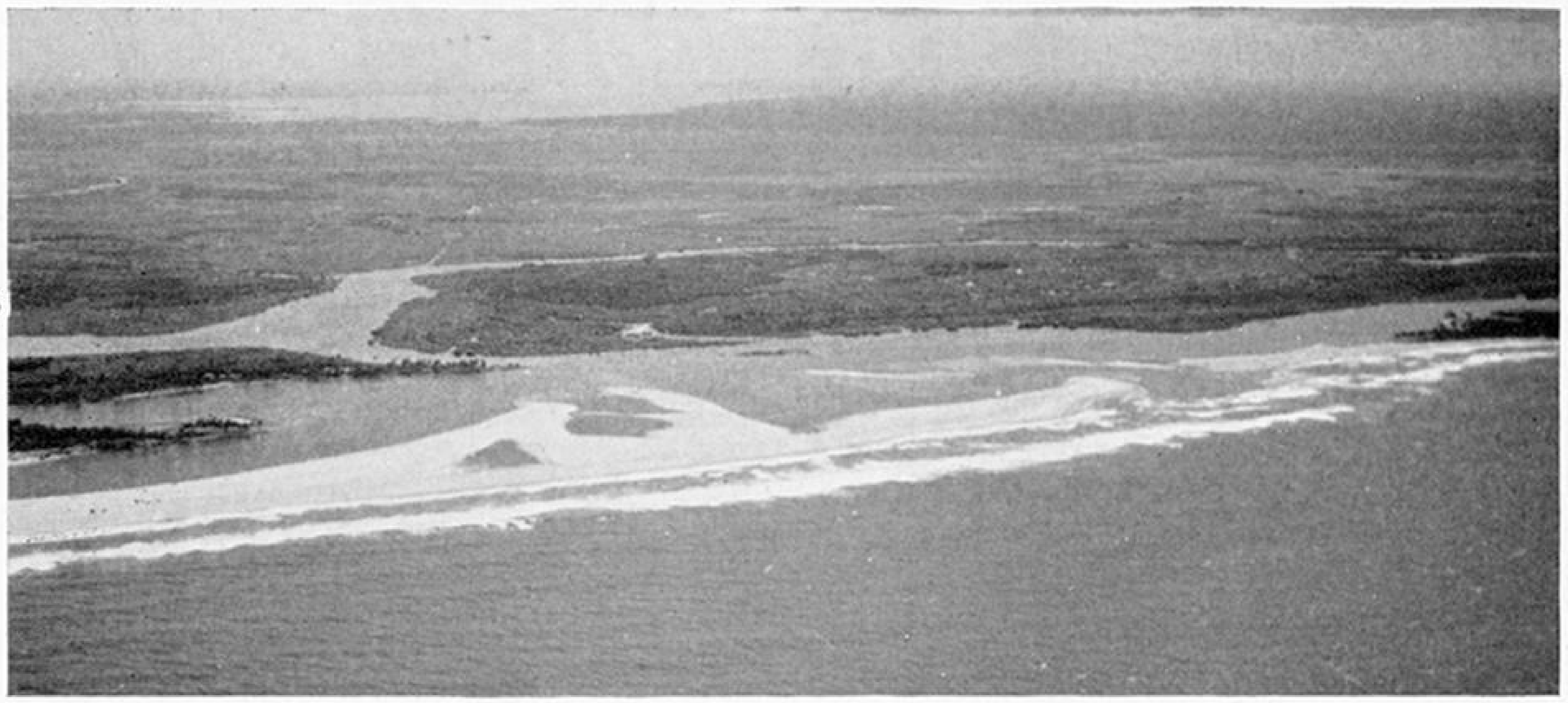
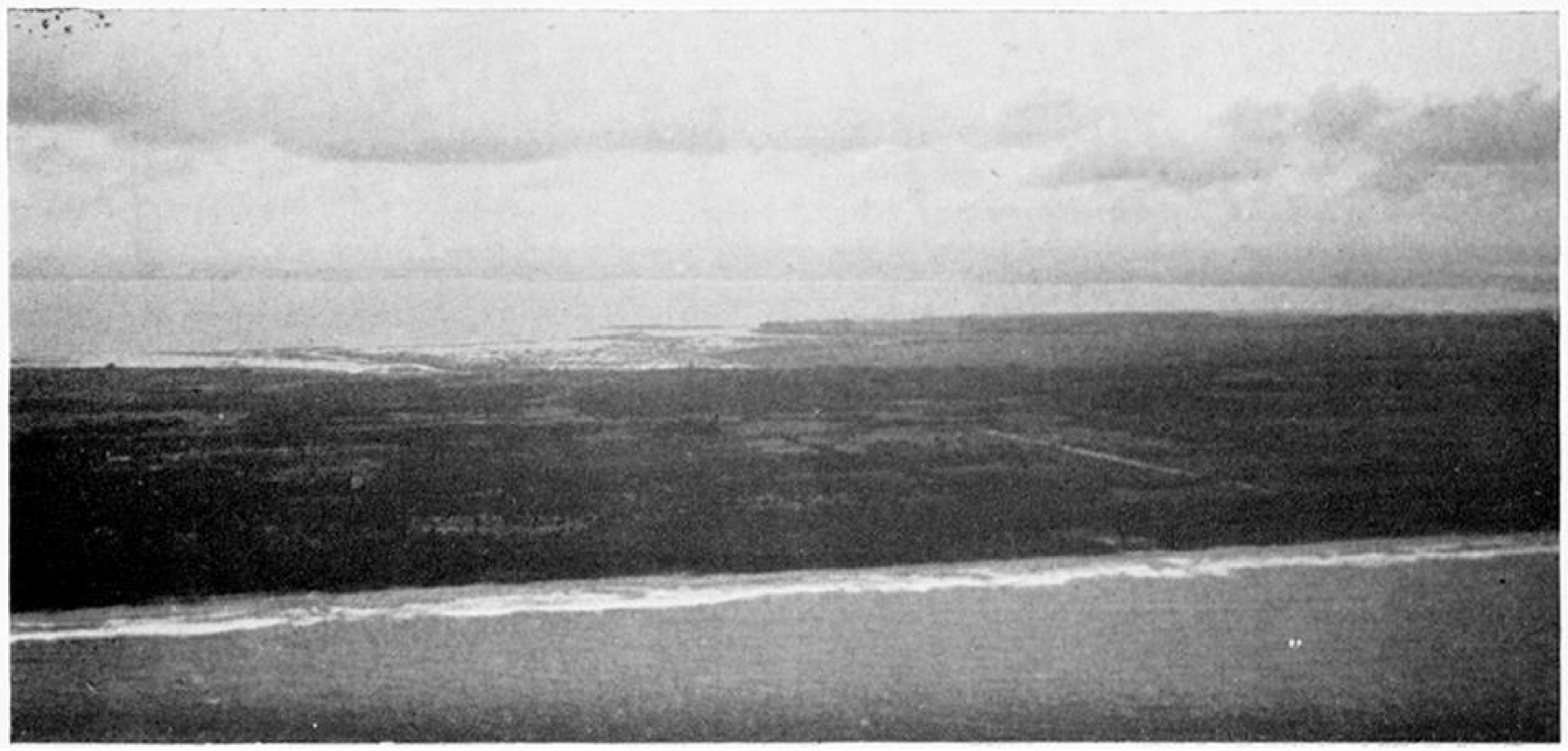
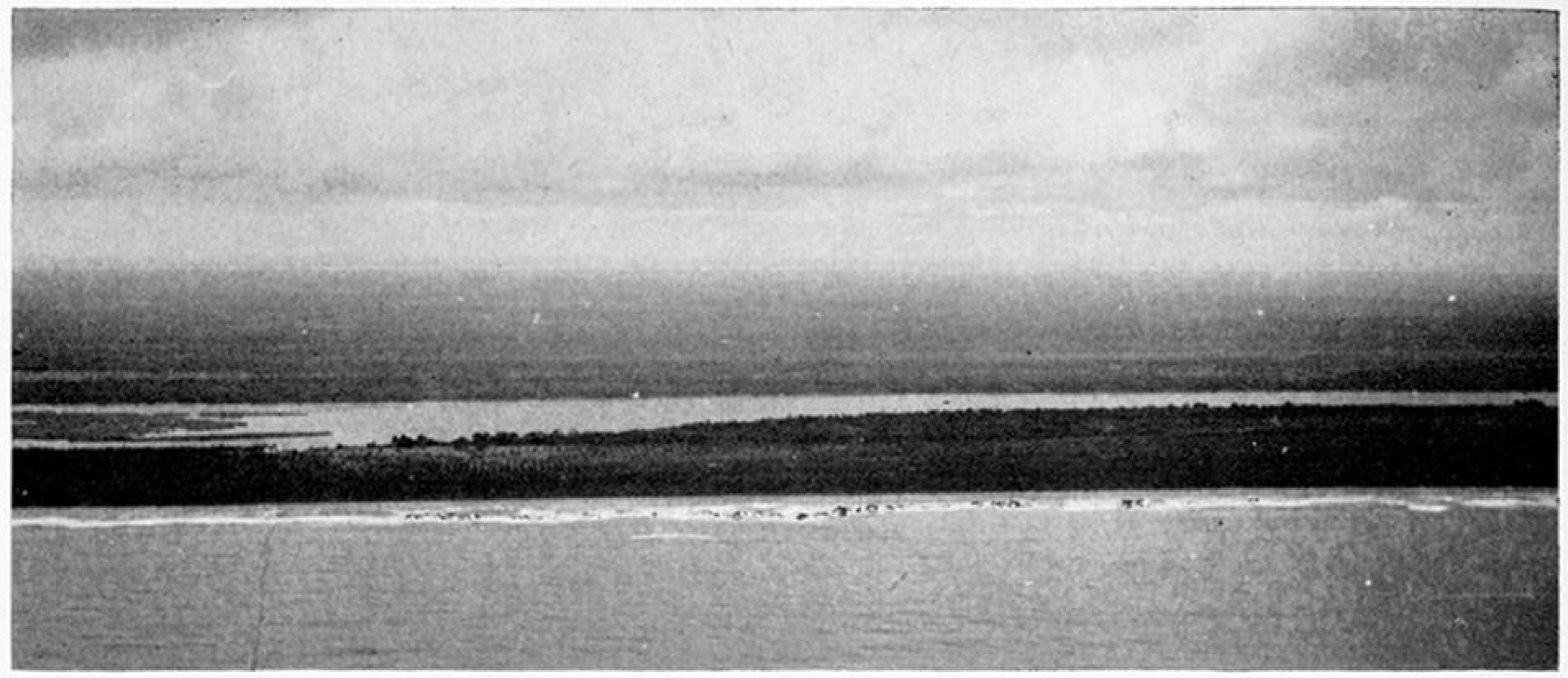


FIGURE 8. A view from the west across Lagos Harbour. Victoria Beach is to the east. This beach has been eroded from the point X since construction of the East Mole began in 1907.

4


5


6


7


8

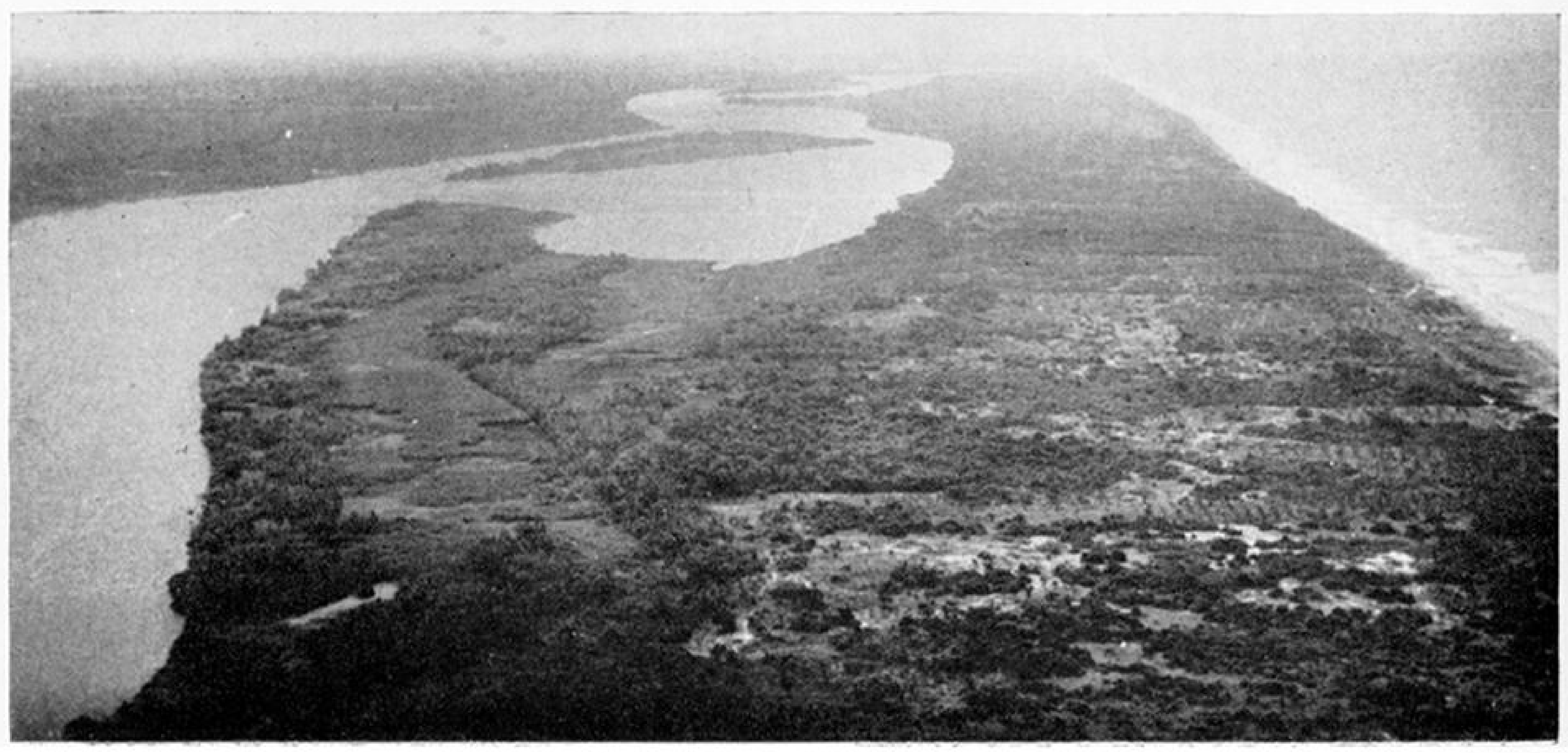

9


PLATE 11

FIGURE 4. The lagoon of the Dahomey Gap typical of riverless country, and with comparatively narrow lagoon deposits behind.

FIGURE 5. A temporary breakdown of the barrier beach forming an inlet to the Dahomey lagoon east of Granpopo.

FIGURE 6. The lagoon at Porto Novo. This lagoon shows the typical wide expanse of shallow water associated with regions where there is excessive land drainage.

FIGURE 7. The lagoon to the east of Badagri. The lagoon deposits behind show a characteristic broad banding parallel to the coast, each band being about one mile in width.

FIGURE 8. The lagoon east of the Dahomey–Nigerian border. Note the narrow, subparallel, ridges between the sea and the lagoon.

FIGURE 9. The lagoon to the west of Lagos showing a spit with a filled-in channel across its base.

10

11

12

13

For description see p. 318.

FIGURE 14. The coast between Opobo and Bonny in the Niger Delta showing the tip of one great sandspit enclosing a narrow lagoon parallel to the coast but still open to the sea. The base of a second spit to the east also enclosing a lagoon is seen on the right. Aerial photograph taken from an altitude of 9000 ft. by the Shell-BP Petroleum Development Company of Nigeria Ltd. The circles on the photograph are of no significance.

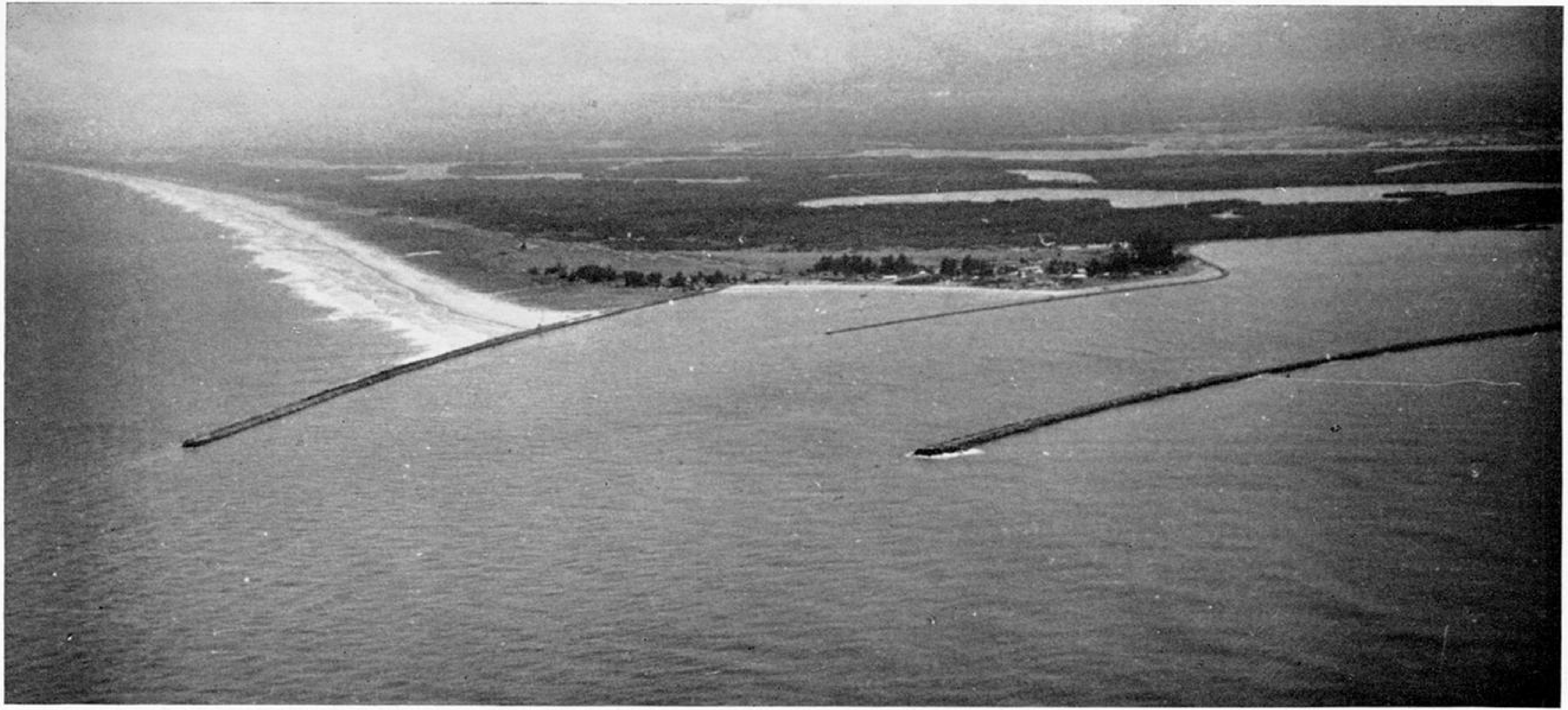


FIGURE 7. The entrance to Lagos Harbour viewed from the south-east. Lighthouse Beach is to the west. The photograph shows the position of the original coastline and the extent to which this beach has advanced seaward since construction of the West Mole began in 1901.

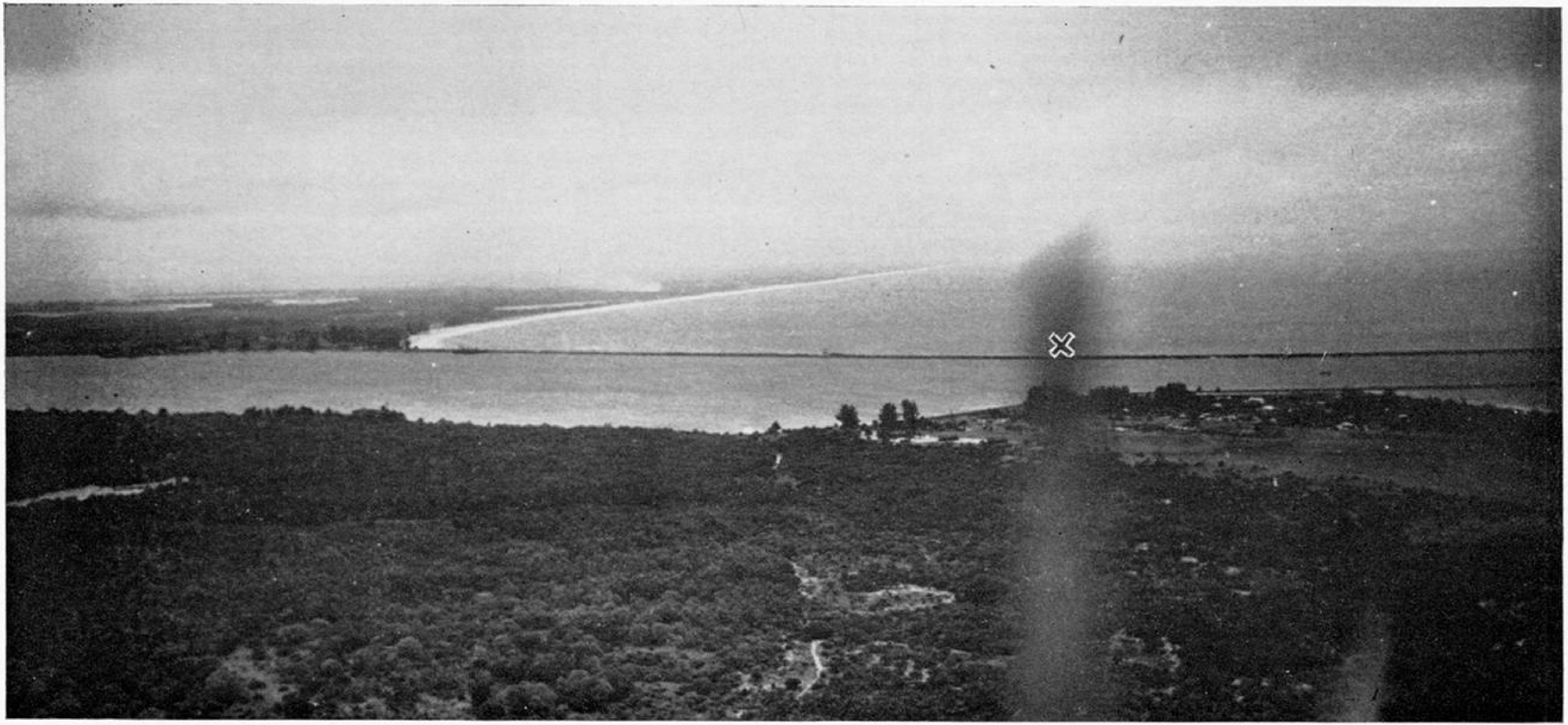


Figure 8. A view from the west across Lagos Harbour. Victoria Beach is to the east. This beach has been eroded from the point X since construction of the East Mole began in 1907.