SEA LEVEL CHANGE AND SHORELINE DEVELOPMENT IN SOUTH-EASTERN TASMANIA

By

J. L. DAVIES

Department of Geography,
University of Tasmania

(With 5 Text Figures)

ABSTRACT

The existence of shore features associated with two older, higher sea levels has been an important factor in the development of the present coast of south-eastern Tasmania. The Llanherne level lies between 12 and 15 feet above present sea level and is probably related to the last interglacial or an interstadial time. The Milford level is two to three feet above present sea level and is almost certainly post-glacial in date. The nature and effect of marine action at the two levels is discussed in relation to Seven Mile Beach spit, Ralph Bay Neck and Marion Bay spit.

INTRODUCTION

The major outline of the coast of south-eastern Tasmania results directly from the world-wide, post-glacial rise of sea level, which drowned the Derwent and Pittwater valleys and flooded the lowlands of Ralph, Frederick Henry, Norfolk, and Blackman Bays. That such a submergence took place is generally accepted, although its exact extent has yet to be determined. Sections across the Derwent near Hobart, published by Lewis (1935), show a mud-filled channel cut in bedrock to about 150 feet below present sea level, thus implying a strandline at least about 200 feet lower than that which exists today. A clearly-defined, submerged, mud-filled and apparently river-cut channel runs from east to west from Norfolk into Frederick Henry Bay, reaching a maximum depth of 132 feet immediately to the north of Slopen Island. Since it contains an unknown amount of mud, its original depth can be assumed to be something in excess of this (Admiralty Chart No. 809, Frederick Henry and Norfolk Bays).

Such evidence for previous low sea levels probably relates in the main to a general average Pleistocene low sea level, which approximately may have been attained during each glacial. Detailed stratigraphic investigation in suitable localities will be necessary before the full sequence can be worked out and this has not yet been attempted. However, for the purpose of interpreting the present shoreline, it is sufficient to appreciate that the last major shift of sea level was an upward one, that the main coastal outline results from the drowning of a former sub-aerial landscape and that it was this event which initiated the present cycle of marine erosion. Since that time the sea has modified the initial coastline by the cutting back of headlands and the building of spits and tidal marshes, and, simultaneously, smaller changes of sea level have occurred. It is with the interrelationship between these marine processes and these later and smaller sea level changes that the present account is concerned.

THE LLANHERNE AND MILFORD SEA LEVELS

Two recent higher sea levels have played a large part in determining the morphology of the present coast. Features resulting from these two levels are well developed in the vicinity of Hobart airport and this provides a convenient "type locality". At the higher level, high-water mark stood at between 12 and 15 feet above that at present and it is proposed to designate this the Llanherne level, since the small hill of that name, on which the airport control tower now stands, then formed an island. To the east of here, at Milford, the lower level is represented along the shores of Pittwater by old vegetated cliffs fronted by narrow raised beaches. A part of these can be seen from the old road on the Bluff at the western end of the Sorell causeways. It is proposed to call this the Milford level and high-water mark at this time was between two and three feet higher than at present. These two old shorelines can be detected throughout south-eastern Tasmania. Where they occur their height has been checked using a level and staff and relating present and past high-water marks. Tidal range along these coasts is about three to four feet, ecept in Norfolk Bay where it rises to six feet.

Lewis (1935) discussed Tasmanian raised beaches and river terraces and attempted correlations of each with his scheme of Tasmanian glacial stages. His lowest raised beach at 5 to 15 feet above high-water mark was thought to date from the last interglacial. Later (Lewis, 1946) he named this the Ralph's Bay stage and referred the next level at 50 to 60 feet to his Cambridge stage. Lewis's Ralph's Bay stage terraces seem to correlate generally with the Llanherne level and he does not seem to have recognised the lower level as distinct, although he does appear to have noticed its

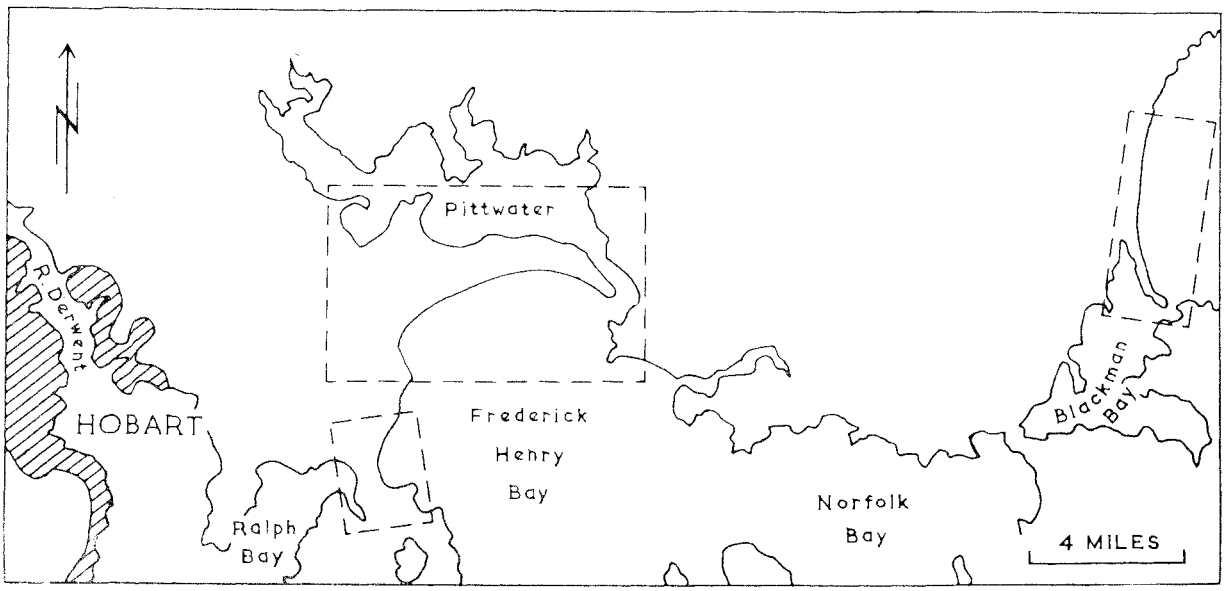

FIG. 1.—Location of the three areas discussed.

existence. For instance, in referring to the South Arm peninsula, he mentions (1946, p. 154) that " a raised beach generally five feet high skirts the whole coast, but at Maria Point this is 15 feet above sea level." On the other hand, he later (p. 209) referred to his Cambridge stage the raised beaches tying Llanherne island. In view of this confusion and uncertainty, Lewis's nomenclature is not used here.

The general nature of the features associated with the Llanherne and Milford levels and their influence upon the development of the present shoreline can best be discussed by reference to three major structures, Seven Mile Beach spit, Ralph Bay Neck and Marion Bay spit, the location of which is shown in Figure 1.

SEVEN MILE BEACH SPIT

The large spit of Seven Mile Beach is a mid-bay bar lying at the head of Frederick Henry Bay and almost closing the Pittwater ria. The Llanherne shoreline ran from the eastern end of the old Cambridge airfield to the eastern foot of Single Hill (Figure 2A). The Bluff and Llanherne formed two islands, probably tied to this shoreline by a complex tombolo on which low frontal dunes developed. At the eastern, less sheltered end of the tombolo, blow-outs occurred and parabolic dunes moved over the southern slopes of the Bluff. The platform now extending seaward from the Llanherne shoreline, and on which the new Hobart airport has been built, appears in the main to be a depositional one of sand and shell. Both marine and aeolian sands belonging to this level have been well podzolised and Loveday (1957) in a soil survey of the region, classified them as " podzols on cover sands ".

At the time of the Milford shoreline, the former islands of Llanherne and the Bluff were incorporated into a peninsula, along both northern and southern sides of which the sea cut low cliffs (Figure 2B). On the southern shore, frontal dunes were built up, although subsequently these have been much eroded by the small creek which now runs through from south-west to north-east. This creek, in addition to carrying tidal flood and ebb, drains a large, shallow pool, which forms on the Llanherne surface south-west of the airport at times of heavy rain.

Between the Milford shoreline and the present-day shoreline has grown up the Seven Mile Beach spit and factors influencing its alignment have been discussed elsewhere (Davies, in press). That the spit appears to have grown from west to east seems to be due to three main factors: the presence of the initial peninsula on the western shore of Pittwater, the prevalence of beach drifting from west to east under the influence of local waves generated by south-westerly winds, and the decrease in wave height and consequently berm height from west to east caused by refraction of the dominant swell. This last effect, which may be demonstrated by the construction of refraction diagrams and by inspection of berm heights and beach cusp dimensions on the present beach, is probably the most important, for beach drifting appears to be negligible and the western peninsula is only there because the Llanherne tombolo also grew from the west, presumably under the influence of the other two factors. Bascom (1954) has discussed the control of stream outlets by wave refraction.

The present spit is composed of a series of between 40 and 50 sand beach ridges, lying generally parallel with the present shore. A statistical analysis of a cross profile of these (Davies, 1958) suggests that, while they were being formed,

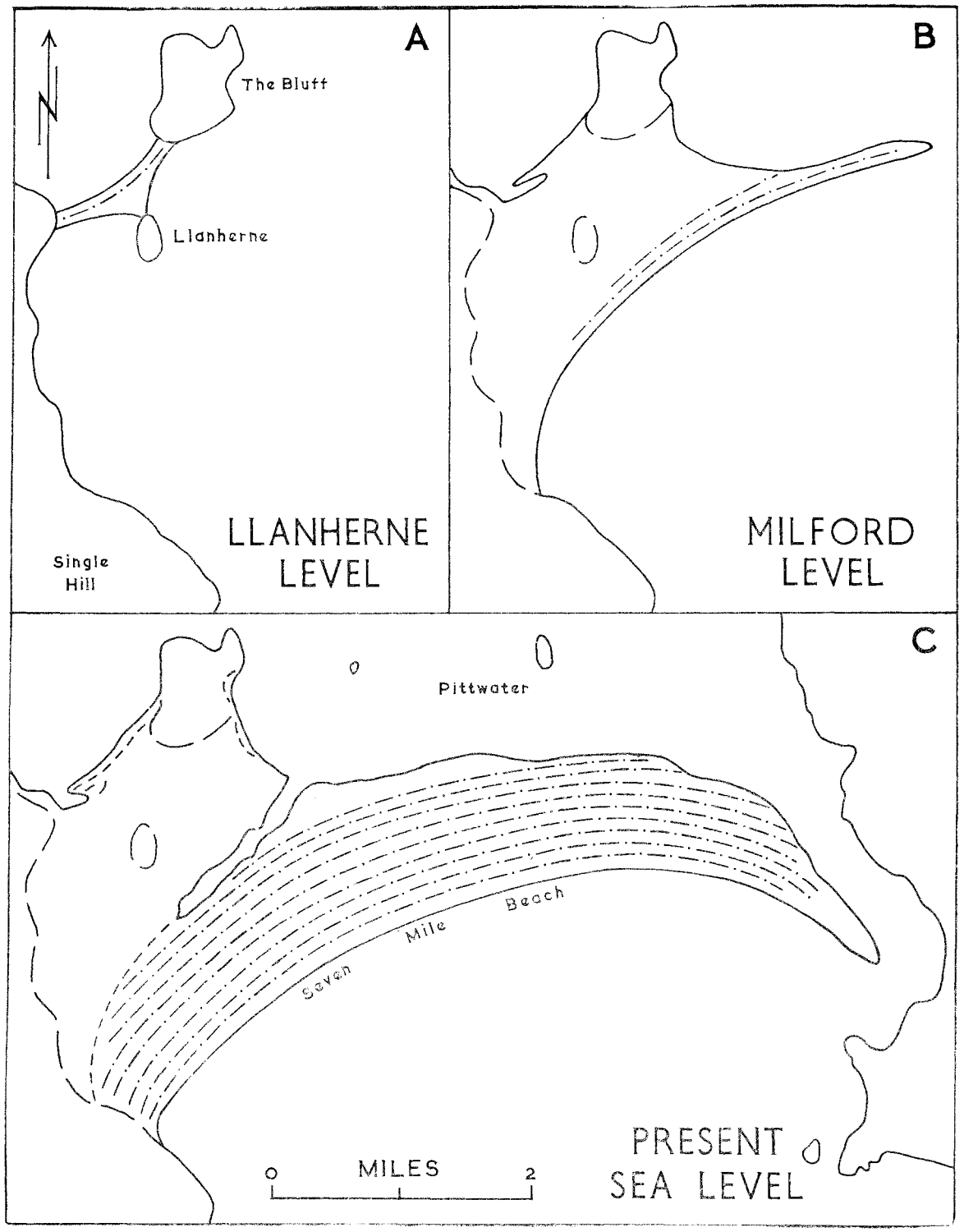

FIG. 2.—Evolution of Seven Mile Beach Peninsula. The "dash-dot" lines indicate the position of foredunes and beach ridges, but on the present-day spit only every fifth ridge is shown.

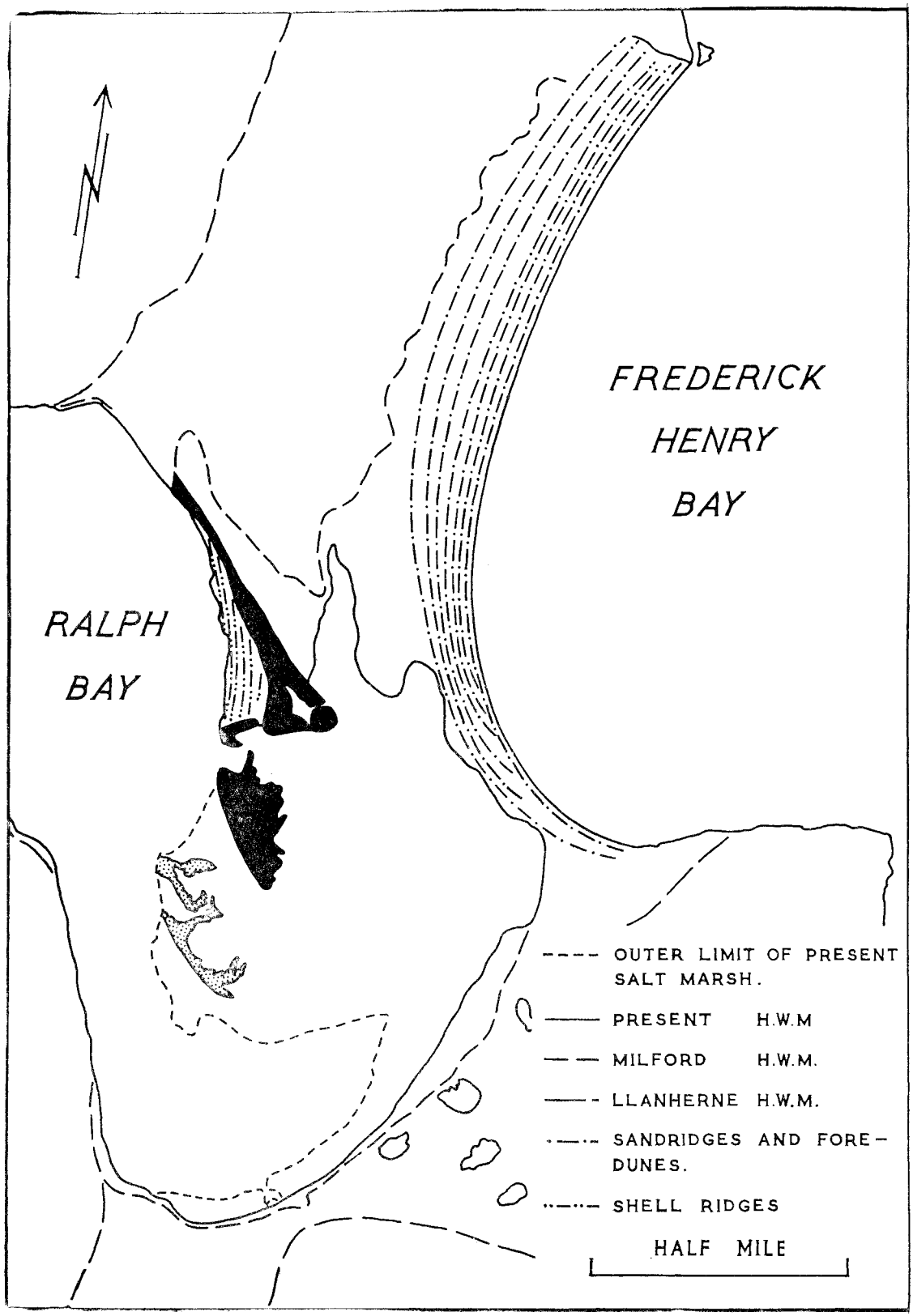

FIG. 3.--Evolution of Ralph Bay Neck. Shingle structures are shown in black; shell structures stippled.

sea level, or at least high-water mark, fell by about three feet. It seems clear that they were formed as the sea fell from the Milford level approximately to where it lies today and the field evidence is consistent with this conclusion. Loveday (1957) grouped Milford dunes, beach ridges and present-day dunes under the heading of "recent sands," although he noted that podzolisation is proceeding in those sections furthest inland which "it can be assumed . . . will eventually lead to formation of a profile similar to that described for the podzols on cover sands" (under which heading the Llanherne dunes and beaches are grouped).

A similar sequence of features can be seen on the north from the Hobart-Sorell road near the boundary of the Llanherne airport. South of the road is the line of Llanherne dunes, recently cut through in the laying down of the new airport runway. To the north of the road is the Llanherne beach, which is succeeded by the Milford shoreline crowned with a narrow strip of low dunes and succeeded in turn by the raised Milford beach and present-day salt marsh.

RALPH BAY NECK

The South Arm peninsula consists of a series of former isiands tied by marine deposition at several former high sea levels. Ralph Bay Neck provides a good example of the influence of the two most recent of these high sea levels on the development of the present coast (Figure 3).

The Llanherne shoreline can easily be traced from the southern foot of Single Hill to a point just west of the Hobart-South Arm road, although in two places it is somewhat obscured by alluvial fans which have been built across it. On the southern side of the Neck this shoreline is less distinct, but runs from Richardson's Hill to Mount Mather. At the Llanherne sea level then the Neck did not exist and a strait separated South Arm from the main part of Tasmania. Such a strait was also in existence in the early stages of the Milford sea level, although now more constricted. The Milford shoreline runs from the northern end of Roches Beach to Ralph Bay and forms generally indistinct low cliffs, a foot or two high, cut into the partly erosional and partly depositional platform left by the recession of the Llanherne sea. As in the case of the Llanherne shore, the Milford shore is not so distinct at the southern end of the Neck and there is no extensive platform intervening between the two levels as there is in the north. This is clearly to be correlated with the significantly greater exposure to wave attack in the north.

After some initial corrasion, the Miford sea began to build two spits across the strait, which must have been shallow at this time. One, on the Frederick Henry Bay side, was composed of sand and eventually grew so as to close the strait completely. At this stage it must have resembled on a small scale the bars tying the two halves of Maria and Bruni Islands today. Its establishment was helped by the formation of the second spit. This grew from a small promontary in the north-eastern corner of Ralph Bay and was composed of small shingle and shell. It reached only part way across the strait and its distal end became recurved and complex. The two spits must have grown up simultaneously and afforded each other mutual protection. Wave action in the sheltered north-eastern corner of Ralph Bay is very limited and the shingle spit rose very little above the Milford high-water mark. On the Frederick Henry Bay side, wave action is much greater and the sand spit grew to about six feet above the Milford high-water mark by dune accumulation on the wave-built bar. In between the two spits, salt marsh started to develop and to the south of the shingle spit is a group of banks of shingle and shell also related to the Milford level. They are now above high-water mark, although they lay just below the high-water mark of the Milford sea. One of them, to the east of the main road, has been quarried for its shingle content. These structures resemble mid-channel tidal banks, but it seems unlikely that weak tidal currents, such as those operating today, could move shingle and it is more probable that the banks are associated with a time just before the sand spit closed the strait, when stronger current action prevailed in the narrow opening.

Finally the sea dropped from the Milford level to approximately that of the present day. In doing so, it built a series of sand beach ridges along Frederick Henry Bay in front of the sand spit and a series of shell ridges on Ralph Bay in front of the shingle spit. These shell ridges have been obliterated to some extent by the building of the road across the Neck, but they can still be seen immediately north of the canal. Statistical analysis of the sand ridges indicated a drop in sea level of about two or three feet while they were being formed (Davies, 1958). At the same time the Milford salt marsh and mid-channel banks were uplifted and surrounded by new salt marsh developed at the present sea level.

MARION BAY SPIT

The spit at Marion Bay is about five miles long and almost closes off Blackman Bay from the open ocean (Figure 4). A narrow and changeable channel at its southern tip is kept open by tidal scour. Behind the spit, to the west, the Llanherne shoreline is plainly visible as a line of high cliffs cut into basalt and sandstone. In front of these cliffs is a platform comparable to that at the northern end of Ralph Bay Neck and to that on which the Llanherne airport stands. This terminates at its seaward end in low cliffs a few feet high cut by the sea at the Milford level.

It was at the Milford level that the modern spit first appeared. Initially it grew southward from an old headland of dolerite immediately south of the point where Bream Creek originally reached the coast. This first spit extended the full length of the present spit and salt marshes developed behind it at its northern end and in front of the low cliffs at the foot of the Llanherne platform. Later, as the sea fell from the Milford level, a raised sand beach and shell ridges broadened the old spit to the west (Figure 5) and new foredunes were added to seaward. In part the new dunes rest on a second spit emanating from a headland to the north of Bream Creek. The result has been that

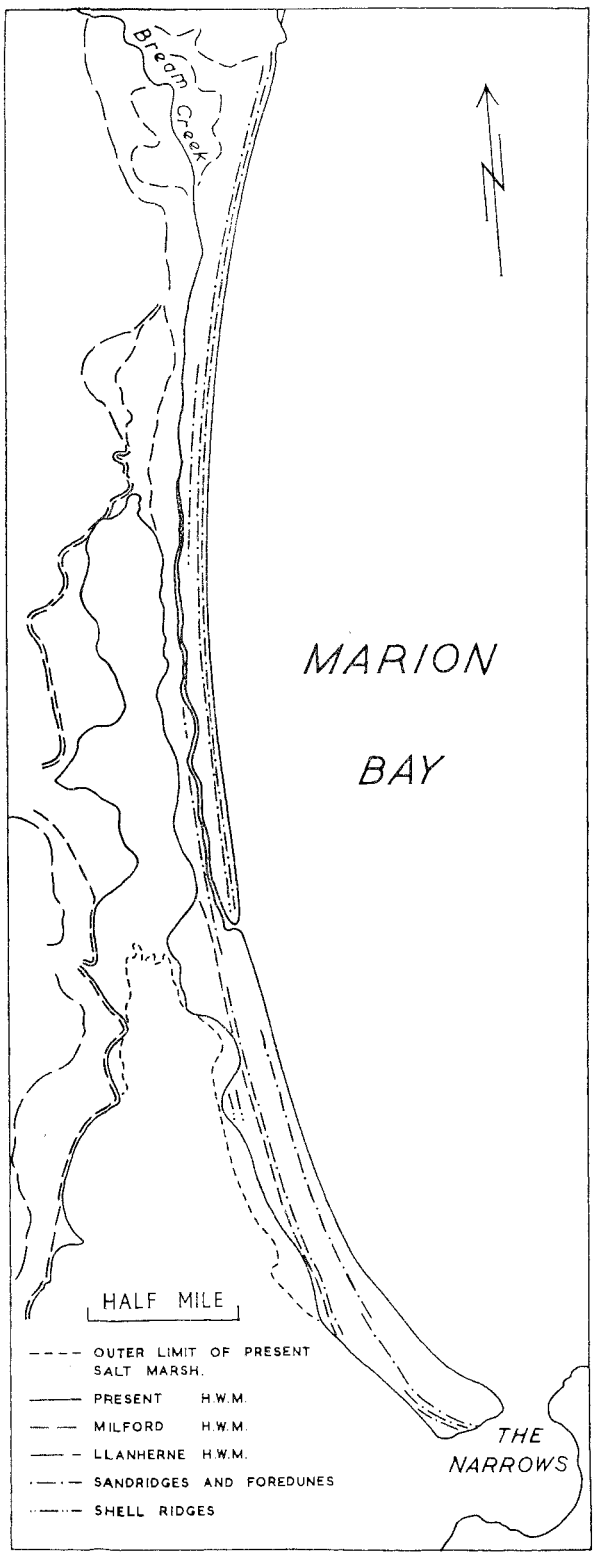

FIG. 4.—Evolution of Marion Bay Spit.

the creek has been sandwiched between the two spits and enters the sea in the middle of Marion Bay. The mouth of Bream Creek oscillates within about 600 yards along the shore, but, apart from this minor wandering, it has probably been stable throughout the life of the spit at present sea level. There is no evidence of an older mouth elsewhere and the present mouth is marked by blow-out dunes of varying ages, indicating a fair degree of permanence.

Convenient partial sections of the uplifted portion of the spit are now visible in the south-west where small storm waves, generated in Blackman Bay have eroded the inner tip of the spit into a straight line perpendicular to the direction of greatest fetch. Semi-concretionary sand with bedded shells, lying at and slightly above present high-water mark here, is representative of the spit at the Milford level.

Since the sea reached approximately its present level, extensive new salt marshes have been built and a short account of these is given by Curtis and Somerville (1947).

DISCUSSION

The Llanherne level is marked by strong cliffing and by relatively wide platforms, in part wave-cut. This is especially true of the Marion Bay site, which faces the open ocean. Depositional features at this level are limited. In any case, they are no longer in contact with the present shore and are not related to the present cycle of erosion. The importance of the Llanherne level lies in its effect on the landscape of the coastal zone rather than in its influence on the shoreline proper. Marine and aeolian sands associated with this level are well podzolised.

The Milford level is marked by weak cliffing and this mostly in unconsolidated materials at the foot of the Llanherne platforms. Associated wave-cut or wave-built platforms are virtually non-existent. Apparently, there was only a short period of corrasion at the Milford level before the building of spits and tidal marshes began. It is important to note that spit building began before the emergence from the Milford level. Some authors (for instance, Loveday, 1957) have taken such features as the Marion Bay spit as characteristic of an emerged shoreline, but in fact this spit had attained its present length (though not breadth) before the slight emergence took place. Similarly, at Ralph Bay Neck, the two spits which initiated the present isthmus formed before emergence and many other similar structures around the south-east coast, such as Eaglehawk Neck and the spit closing the southern end of Ralph Bay, are Milford features raised two or three feet to their present position. Seven Mile Beach spit is an exception in that, although an embryo spit was formed at the Milford level, the great bulk of the present structure accumulated during the emergence from that level. The building of spits to close re-entrants and of tidal marshes behind the spits is part of the cycle of erosion consequent upon submergence of a coastline. The slight emergence has only accentuated these features and to some extent speeded their construction.

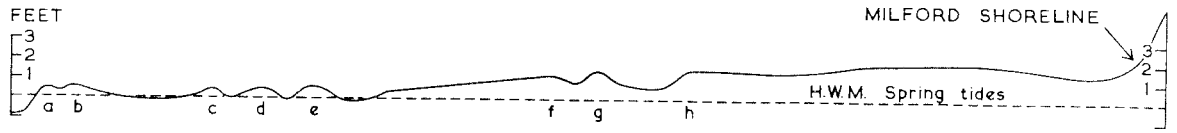

FIG. 5.—Cross profile of inner edge of Marion Bay Spit.
The letters indicate ridges, all composed primarily of the shells of *Eubittium lawleyanum* (Crosse) and *Assiminia brazieri* (Tenison-Woods).

It would be very difficult to interpret the succession of events between the initiation of the Milford sea level and the present as other than essentially continuous. In particular, the beach ridges and frontal dunes show a gradual transition in soil profile from the raw, calcareous sands of the present-day to the incipient podzols of the Milford level. There is no break other than possibly a recent one, indicated perhaps by the present erosion of ridges and dunes. But this break, if it has existed, represents only a very small interval of time and may be due to a slight contemporary submergence, or as suggested elsewhere (Davies, 1957), to an increase in storminess. In short, the present cycle of erosion started at the Milford sea level and has hardly been interrupted by a small emergence and possibly an even smaller and most recent submergence. If this conclusion is correct, then the Milford level must represent the limit of post-glacial submergence in southern Tasmania, which, by world-wide analogy, would date from about 7,000 to 6,000 years before the present. The relative freshness of features associated with the Milford level and the small amount of podzolisation which has taken place in the Milford sands are in sympathy with this.

In contrast to the relationship between the Milford level and the present, there is an evident break between marine processes at the Milford level and those at the Llanherne. No process initiated at the Llanherne level carried through into the Milford. In keeping with this, there is a pronounced gap between the degree of podzolisation of Milford sands and that of Llanherne sands. Loveday (1957) noted this and remarked upon it. The tentative inference is that the Llanherne level dates from the last interglacial or an interstadial of the last glacial age.

REFERENCES.

BASCOM, W. N., 1954.—The Control of Stream Outlets by Wave Refraction. *J. Geol.*, 62: 600.

CURTIS, W. M., AND SOMERVILLE, J., 1947.—Boomer Marsh—A Preliminary Botanical and Historical Survey. *Pap. Proc. Roy. Soc. Tas.*, 1946: 151.

DAVIES, J. L., 1957.—The Importance of Cut and Fill in the Development of Sand Beach Ridges. *Aust. J. Sci.*, 20: 105.

———, 1958.—Analysis of Height Variation in Sand Beach Ridges. *Aust. J. Sci.*, 21: 51.

———(in Press).—Wave Refraction and the Evolution of Shoreline Curves. *Geog. Studies.*

LEWIS, A. N., 1935.—Correlation of the Tasmanian Pleistocene Raised Beaches and River Terraces in Unglaciated Areas. *Pap. Proc. Roy. Soc. Tas.*, 1934: 75.

———, 1946.—Geology of the Hobart District. Hobart.

LOVEDAY, J., 1957.—Soils of the Sorell-Carlton-Copping Area, Tasmania. C.S.I.R.O. Soil Publ. No. 8.

PLATE 1.

FIG. 1.—The Milford shoreline at the north-western corner of Ralph Bay Neck: a low, vegetated, raised beach of semi-concretionary shell and small shingle is being eroded at present sea level where wave action is now extremely small.

FIG. 2.—The Llanherne shoreline at Marion Bay: abandoned cliffs and raised marine platform.