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# The chronostratigraphy of a Holocene Barrier Estuary: Lake Illawarra NSW

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**Abstract**

Valley-fill sequences, preserved in topographic lows associated with incised valley systems, potentially preserve a record of Holocene sea level fluctuations. A detailed litho- and biostratigraphy of the Holocene barrier estuary, Lake Illawarra, New South Wales has been constructed. Forty kilometres of seismic surveys, forty-one vibracores, supplemented by auger drill holes and trenches, and faunal analysis provides the data for this investigation. A detailed chronology of the infilling of the barrier estuary has been established using 115 aspartic acid derived ages and six radiocarbon ages. The results provide a detailed chronology for the deposition of marine transgressive deposits, barrier growth, and the subsequent development of the estuarine back-barrier environment. The results from Lake Illawarra indicate that the generalised evolution of the barrier estuary occurred in five geomorphologically distinct phases associated with rising sea levels following the last glacial maximum (LGM).

**Keywords**

lake, nsw, estuary, barrier, holocene, illawarra, chronostratigraphy, GeoQuest

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## The chronostratigraphy of a Holocene Barrier Estuary: Lake Illawarra, NSW

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Key words: **Barrier estuary sedimentation, Holocene sea-levels, transgressive deposits.**

Valley-fill sequences, preserved in topographic lows associated with incised valley systems, potentially preserve a record of Holocene sea level fluctuations. A detailed litho- and bio-stratigraphy of the Holocene barrier estuary, Lake Illawarra, New South Wales has been constructed. Forty kilometres of seismic surveys, forty-one vibracores, supplemented by auger drill holes and trenches, and faunal analysis provides the data for this investigation. A detailed chronology of the infilling of the barrier estuary has been established using 115 aspartic acid derived ages and six radiocarbon ages. The results provide a detailed chronology for the deposition of marine transgressive deposits, barrier growth, and the subsequent development of the estuarine back-barrier environment. The results from Lake Illawarra indicate that the generalised evolution of the barrier estuary occurred in five geomorphologically distinct phases associated with rising sea levels following the last glacial maximum (LGM).

Stage One: During the LGM sea levels on the NSW south coast were estimated to be *ca.* 120 m below present mean sea level. During the lowstand in sea level, fluvial activity extended across the continental shelf and resulted in fluvial incision on the subaerially exposed continental shelf during the Late Pleistocene. Fluvial incision resulted in the development of a dendritic drainage network, within the incised valley system, that cut through the Pleistocene barrier at the present location of Korrongulla Swamp, Lake Illawarra.

Stage Two: The second stage of the evolution of the Lake Illawarra barrier estuary is represented by the deposition of a transgressive sand sheet over the Late Pleistocene erosional surface. Inundation of the antecedent incised valley system by rising sea levels during the post-glacial marine transgression (PMT), and the subsequent Holocene sea level highstand, resulted in the deposition of a medium- to coarse-grained transgressive sand sheet between *ca.* 7.9 ka and *ca.* 5 ka (Fig. 1a). This represents a youthful stage in the development of the estuarine succession prior to barrier development, with the system operating as a drowned river estuary. The molluscs *Anadara trapezia* and *Ostrea angasi*, both species of bivalve indicative of tidal sand flats in estuarine environments, dominate the faunal assemblages within the transgressive sand sheet. Proximal to the present barrier, the transgressive sand sheet also contains a more diverse mix of low- to medium-energy estuarine molluscs that typically inhabit muddy-sand and sand flats, and molluscs that typically inhabit moderate- to high-energy nearshore environments including *Katalysia* sp. and barnacles. Landward the transgressive sand sheet becomes muddier with an increase in population of the estuarine bivalve *Notospisula trigonella*. The increase in mud content and a decrease in faunal diversity indicates that an interaction between marine and fluvial processes influenced depositional environments operating in the drowned river estuary.

Stage Three (5 ka – 3.2 ka, Fig.1b): The third stage of the evolution of Lake Illawarra is represented by the growth of the sand barrier during the Holocene sea level highstand and the deposition of cohesive estuarine mud in a low-energy back-barrier lagoon (*ca.* 5 ka to *ca.* 3.2 ka). During this stage of evolution, the northern inlet became less efficient at moving marine sediment into the lagoon, and tidal sand flats were spatially restricted proximal to the present barrier system. The restriction of open oceanic influence and the growth of the barrier facilitated the deposition of fine-grained silty estuarine mud in the back-barrier lagoon. Deflation of the southern barrier and closure of the northern inlet occurred during this stage of evolution. With the further development of Windang Barrier to the north and restriction of the northern inlet near Korrongulla Swamp, the inlet channel migrated south to its present location *ca.* 3.2 ka. The timing of the inlet migration is based on ages obtained from relict flood-tide delta deposits to the north of Windang Barrier that indicate the cessation of marine influenced deposition at *ca.* 3.2 ka, and the initiation of flood-tide deposits at the location of the present inlet at the same time. The locus of the fluvial bay-head deltas would still have been farther inland than the present western lagoon margin, as indicated by the presence of older estuarine mud facies underlying fluvial deposits farther up the palaeovalleys (Fig. 1b).

Stage Four (3.2-2.0 ka, Fig. 1c): The migration of the inlet channel to its present location at Windang and the further restriction of oceanic water circulation caused by a 1-2 m drop in sea level resulted in the extension of the central lagoonal facies from the deeper portions of the incised valley system to a more extensive basin wide depositional environment (Fig. 1c). It was also during this stage that the main fluvial deltas started prograding over the older estuarine sequence into the present lagoonal basin as sea level fell and the upper reaches of the valleys filled rapidly because of decreasing accommodation space.

Stage Five (2 ka to present, Fig. 1d): Stage five represents the infilling of the barrier estuary from *ca.* 2.0 ka to present and is represented by prograding fluvial bay-head deltas along the western lake margin, and the restriction of the Windang tidal inlet. This stage also represents relatively modern morphological changes and accelerated sedimentation associated with recent fluvial progradation induced by land clearing and urbanisation. In contrast to the fluvial-influenced depositional environment, the marine-influenced depositional environment has been relatively inactive over the last 200 years.

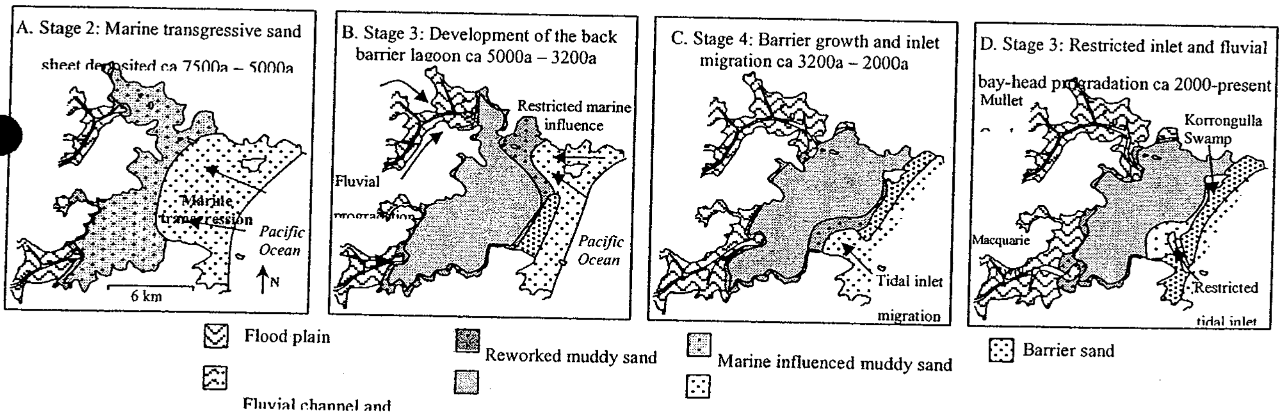


Figure 1: Schematic evolutional model of sedimentary depositional environments of the barrier estuary Lake Illawarra.

The five-stage geomorphological evolution the Lake Illawarra barrier estuary is in general agreement with previous models of Holocene barrier estuary evolution (Nichol, 1991; Roy, 1994; Roy *et al.*, 2001; Fig 2b). However, results from this study add detail to the early stages of barrier estuary development with the deposition of a basin-wide basal transgressive marine sand containing a diverse assemblage of estuarine and marine mollusc species. The deposition of this transgressive sand sheet occurred between *ca.* 7.9 – 5 ka when the barrier estuary was more open to oceanic influences, and dominated by the deposition of wash-over sands, transgressive tidal sand flats and tidal channel sands. The deposition of this basin wide transgressive sand sheet provides added detail to our understanding of the early stage of barrier estuary evolution where marine influenced facies lie unconformably over the antecedent Pleistocene land surface. This differs from previously established barrier estuary evolutionary models which where based on research conducted in deeply incised valley systems where marine influenced facies stabilise in the mouth of the incised valley and back-barrier lagoonal mud lies directly over the Pleistocene land surface (Nichol, 1991; Roy, 1994, Roy and Boyd, 1996; Roy *et al.*, 2001; Fig. 2b).

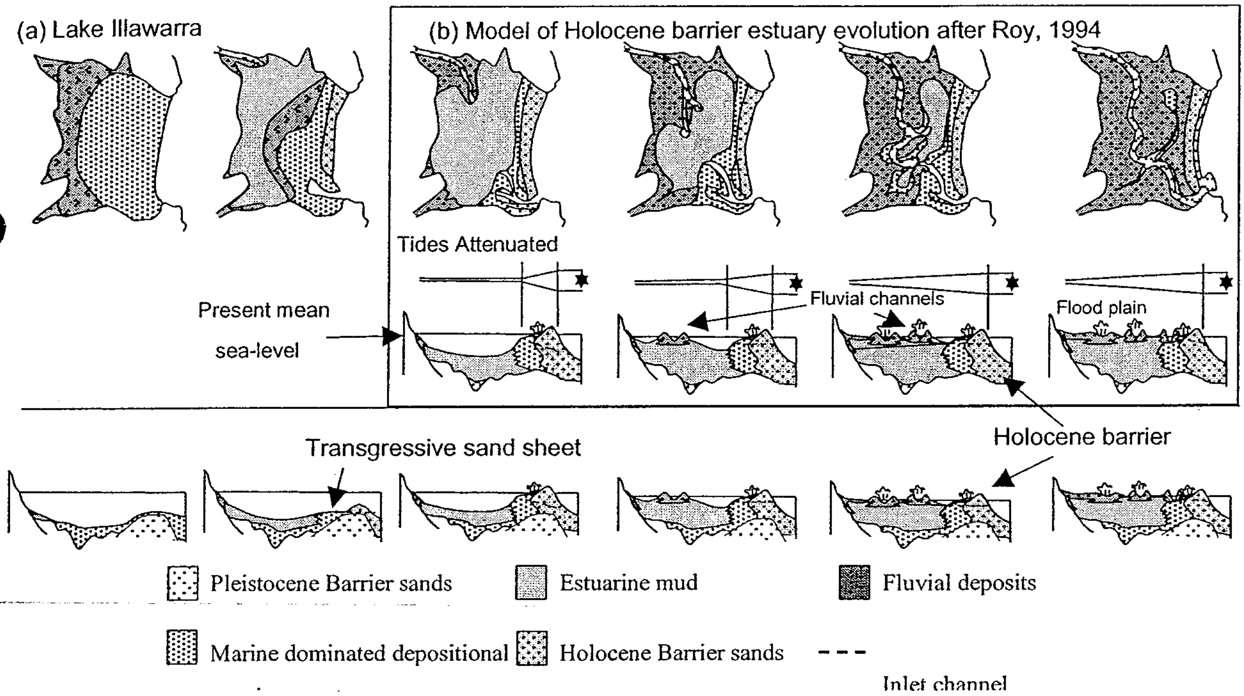


Figure 2: Schematic model of the Holocene evolution of barrier estuaries on tectonically stable coastlines. (a) Lake Illawarra showing the initial deposition of a transgressive sand sheet associated with the last PMT and subsequent Holocene sea-level still stand. B) Previous model of barrier estuary evolution (after Roy, 1994).

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