Ballast and the Tay Eider Duck Populations

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SUMMARY

Deposits of coarse gravels which line the southern margin of the Tay Estuary entrance channel east of Tayport support a thriving population of mussels. Large numbers of Eider ducks, dependent on mussels for food, overwinter in this part of the estuary. The mussels depend on the gravels to provide a firm base on which to grow. The accidental grounding of an oil tanker on the gravel beds led to analysis of the component pebbles, demonstrating that they were unlike gravels from glacial deposits nearby, but closely resembled gravels in the River Tay at Perth, 40km to landward. It is suggested that the gravels which originated at Perth were transported seawards as ballast in lighters seeking to trans-ship cargoes from larger vessels anchored at Tayport which were unable to penetrate the upper estuary due to lack of water. Gravel ballast, required by the empty sailing ships, was unloaded to ballast barges and discharged at the edge of the tidal flats, forming the island of Lucky Scalp. It was spread by salmon fishermen to improve footholds for net hauling. With the improvement of navigation waters to Perth the trans-shipment trade at Tayport ceased. With the demise of the salmon netting industry the gravel banks were abandoned and the mussel beds grew more freely, so that the shell beds increased in area. The presence of the extensive winter Eider duck population in the Tay is at least partly dependent upon the 'waste'products of a human activity that ceased more than a century ago.

INTRODUCTION

The seaward reaches of the 50km long Tay estuary, one of the principal embayments of the east coast of central Scotland, host a large over-wintering population of Eider ducks, said to reach over 20,000 individuals in a favourable year (Smout 1986). Although between 1000 and 2000 pairs of these birds breed locally, most migrate into the area from their breeding grounds on the Ythan estuary 120km to the north. They are attracted to the Tay by extensive beds of the edible mussel, *Mytilus edulis,* which border the southern margin of the

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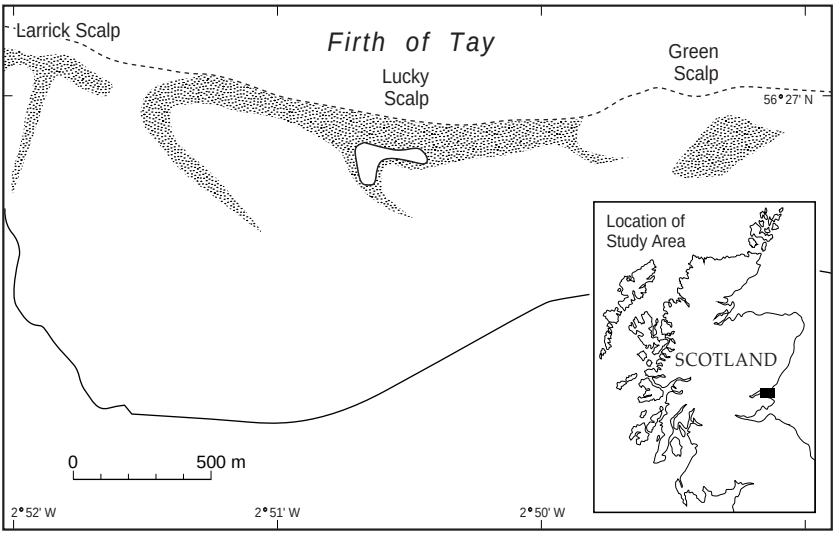

FIGURE 1. Map of the Tayport Tidal Flats, based on Admiralty Chart 1481 (River Tay). Broken line indicates the position of Low Water Mark of Spring Tides. Gravel deposits indicated by stippled ornament.

navigation channel. The thriving mussel beds are dependent upon the presence of extensive boulder and pebble beds which line the outer margin of the tidal flats east of Tayport (fig. 1).

In early December, 1995 a 40,000 ton double-hulled oil tanker calling at the port of Dundee to discharge part of its cargo of crude oil touched bottom on a gravel bank and cobble sized pebbles were trapped in the split plates. The hull design of the vessel ensured that no oil spillage occurred. When it was subsequently dry-docked the pebbles were recovered and returned for confirmation of derivation. Geological analysis, using thin sections demonstrated that the pebbles were principally from the Grampian Highlands and that the ship had most likely taken bottom near the entrance to the Tay.

ORIGIN OF THE PEBBLES

Analysis of the identities of the well rounded pebbles present in the gravel banks of the Tayport tidal flats revealed that the particles were of strikingly different compositions from those which were already well known from the locally

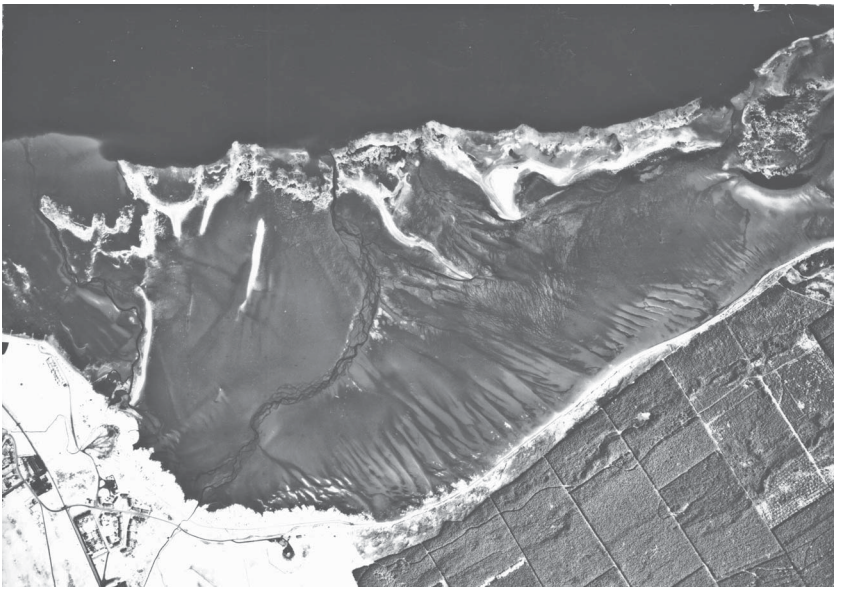

FIGURE 2. Air photograph of the Tayport end of the tidal flats, showing the gravel ridges as pale toned curvi-linear features, Larrick Scalp (left), the island of Lucky Scalp (centre) and Green Scalp (right).

worked gravel quarries in Fife and Angus (fig. 3). The tidal flat gravels had far greater proportions of highland quartzites and much less of the volcanic rocks which typify the Sidlaws and Ochils, to north and south of the estuary respectively. Likewise there was an unusually small proportion of sandstone among the pebbles.

Reference to the work of Al-Ansari (1976) and Al-Jabbari (1978) who examined the sediments in transport along the two main rivers entering the estuary, the Rivers Earn and Tay, respectively, shows that the pebble content evolves seawards along both waterways. In both cases the pebble assemblages are dominated by metamorphic rocks derived from the Grampian highlands, with additions of sandstones, lavas and intrusive rocks carried in by tributary streams. The Earn pebbles (fig. 3) have large proportions of slate in the upper reaches, but these readily break down to small fragments during transport seawards. As a result quartzites become dominant as the vein quartz, lavas, sandstones and felsites all increase until each forms between 10% and 20% of the population. The Tay pebbles are strongly dominated by quartzite, with much smaller proportions of lava and sandstone present in the gravels in the river off Perth.

In terms of composition it is the well rounded gravels at Perth which most closely resemble those found resting on the outer parts of the tidal flats east of Tayport. Although the source of the pebbles is clear, the means whereby the gravels came to be in their present position was far from certain.

NATURAL SEDIMENTS OF THE ESTUARY

The sediments which form the bed of the Tay estuary have been studied for many years. Into a river valley floor, which became deeply incised during the periods of glaciation, were deposited successions, firstly of glacial tills, later (about 13,000 years ago) of silty clays with ice-melt boulders dropped into them, and above these are the upward fining sediment successions of two ancient estuaries, complete with sub-fossil marsh peats, above which the deposits of the present Tay estuary are encountered (McManus, 1970). The present estuary is floored mainly by sands, coarse along the channels, but becoming finer across the tidal flats (Buller and McManus, 1975, McManus et al 1980). Locally thin layers of fine gravels with shell fragments line the channel floors. Only in the uppermost reaches between Perth and Newburgh and in the outer reaches are coarse gravels present. While the former may be of active, occasionally mobile river-derived material, the latter are residual lags created from erosion of glacial deposits by the migrating estuary channel.

In the easternmost reaches of the Tay estuary the tidal flats between Tentsmuir Point and Tayport are mainly of rippled sands supporting a fauna dominated by *Arenicola*, the annelid worm, and including a range of bivalve molluscs such as *Cerastoderma*, *Mactra* and *Mytilus*. (Green, 1975). The outer margin of the tidal flat is covered by an uneven layer of cobble gravels, sometimes arranged in continuous curving ridges, sometimes as a spread covering the entire tidal flat margin and running into the main navigation channel.

With average pebble diameter between 10cm and 20cm the gravel particles are too coarse to be carried by present day tidal currents, and there is no evidence that major floods in the Tay system would be capable of carrying such coarse deposits seaward. During the 200 year floods which were experienced on the Tay in 1992 (Anderson and Black, 1993) there was no sign of significant movement of the gravels anywhere within the estuary.

TRANSPORT BY SAILING SHIP

Some other means of transporting the materials was required, and human intervention was suspected. It was not until Duncan (1996) provided an analysis of the shipping movements in the Tay estuary during the period 1750 to 1850 that

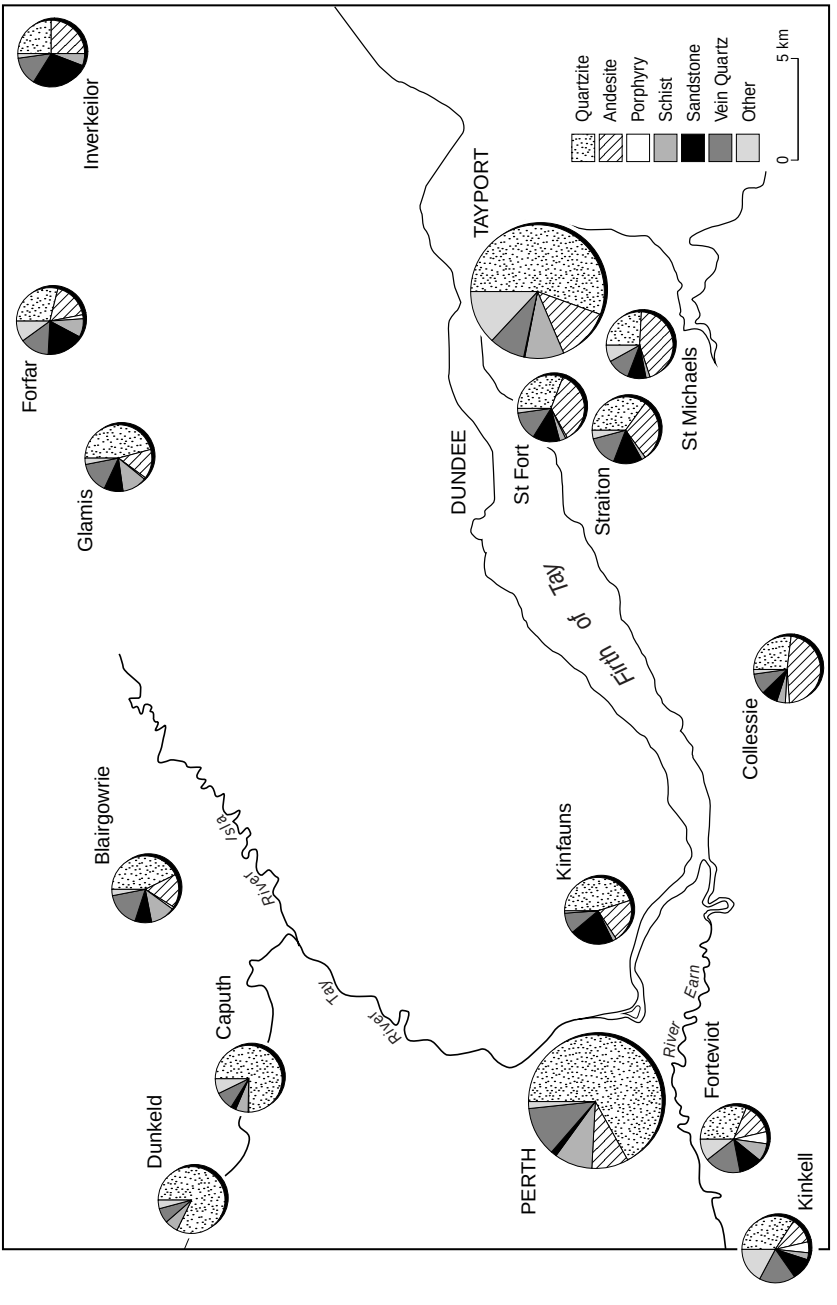

FIGURE 3. Compositional variations in fluvial and fluvio-glaci al gravels in Fife and Tayside.

a means of transport became apparent. Until about 1840 the reach between Perth and Newburgh was shallow, with its main shipping channel providing water depths of less than 3 metres. This was a major constraint upon the trade of the City of Perth.

Large vessels, which were unable to penetrate the estuary as far as Perth, entered the lower reaches with their cargoes and trans-shipped them to smaller vessels capable of reaching the city. These smaller sloops or brigs were commonly up to 100 ton vessels which, for the purposes of stability, required to carry ballast on their outward journey to Dundee or Tayport, the principal ports of trans-shipment. According to the size and design of craft the lighters would have needed to carry 20-25 tons of ballast on each seaward journey. The ballast would have been off-loaded on to ballast barges prior to taking on cargo from the brigs or barques in the lower estuary. At Dundee there was a charge for ballast, and materials off-loaded were reused for other vessels as required. However, at Ferry Port on Craig (now Tayport) the Scotscraig Quarry was used to provide any necessary ballast for outward bound vessels at no cost to the ship's Master (Duncan op.cit). It is suggested, therefore, that the ballast off-loaded on to ballast barges at Tayport was taken east to be discharged on the edge of the tidal flats, seaward of the harbour. More may have been discharged by ballast barges from Dundee, possibly generating the small anomalous boulder beds on the tidal flat margins off Broughty Ferry and Monifieth.

It is estimated that between 100,000 and 200,000 tons of gravels are present along the tidal flat margin between Tayport and Tentsmuir Point. If only one vessel per week discharged 20 tons of ballast that would have yielded 1000 tons in a year. Over a period of a century this would generate 100,000 tons, and it is known from the records that there was more than one sailing most weeks. Not all of the vessels would have been in ballast to Tayport, for there was outward bound cargo to carry from Perth. Nevertheless, the quantities of gravel carried could have accounted readily for the quantities now to be found off Tayport. Could such quantities have been taken from the Tay at Perth? The greatest volume required amounts to no more than 100,000 cubic metres and would have allowed considerable improvement to the harbour and its approaches.

DISPERSION OF THE GRAVELS

A major employment of the inhabitants of Tayport during the period 1750-1850 was in the salmon fishing industry. During the development of the salmon fishery today one of the first steps taken is to release coarse gravels over the area across which the nets will be hauled to improve footholds for the fishermen recovering the nets. It is suggested that the ballast gravels were redeployed for

the salmon fishings along the outer margin of the tidal flats, so that the gravels which were originally taken from Perth are now to be found in the lower estuary.

Once the concept is recognised that the gravels east of Tayport may have been manipulated by man it is possible to speculate that the 200m long island of Lucky Scalp may have been constructed to provide a refuge for personnel during the period of high water. Until the 1980s the island carried a structure which served not only as a valuable navigation marker, but also provided storage space for equipment such as nets. Inspection of modern air photographs of the tidal flat margin, where the estuary bed exposed at low tide falls sharply by 3-4m into the water-filled navigation channel (fig. 2), reveals that the western gravel masses are arranged into curvi-linear ridges, and that these run back towards the coast some way east of the present harbour. Near Lucky Scalp itself the ridges partly enclose shallow pools, formerly used to cultivate mussels in a manner similar to that followed today in the *mariscos* basins in the Spanish rias. At such sites bivalve molluscs are provided with sheltered living space in corrals which flood during high water on each tide, but retain shallow water at low tide. The cultivation of such areas provides delicacies for the table.

Several other concentrations of gravels remain on the tidal flat margin today, each having a known name, e.g. Larrick Scalp, and Green Scalp. These may have marked separate sites of deposition of the ballast materials, possibly for different proprietors of the fishings, as it is otherwise unlikely that gravels would have been transported for long distances from the point of discharge.

Once the gravels had been emplaced they would have served as a highly suitable substrate for the growth of the mussels, whose numbers may have been partly controlled by the trampling feet of the fishermen. However, with the decline of fishing, the mussels would have established themselves in what is an ideal location. It was a matter of time until the eiders adopted the area for over-wintering.

CONCLUSIONS

The occurrence of a modern industrial accident in the form of the grounding of an oil tanker drew attention to the anomalous series of gravel beds along the southern margin of the entrance to the Tay estuary. Analysis of the compositions of the pebble assemblages enabled the source of the gravels to be pinpointed to the Perth harbour area. There is no physical evidence anywhere in the Tay estuary area of a major natural event which could have carried the gravels 40km from Perth to the tidal flat margin off Tayport. Likewise there is no record of such an event in local legends, or in the written historical records of the area. In consequence some form of human intervention was suspected. The analysis of

the shipping activities in the Tay between 1750 and 1850 undertaken by Duncan (1996) provided the final indication that transport as ballast could have been a causal factor.

Thus without the use of sailing vessels requiring ballast to enable trade with Perth the gravels would not have become emplaced on the tidal flat margin off Tayport, the salmon fishers would not have spread the cobbles and pebbles, the mussels would not have developed so strongly and it is most unlikely that the eiders, if they visited the Tay at all, would have come in such large numbers as they do today. Put in more extreme environmental terms, the outer margin of the Tayport tidal flat is an old industrial waste dump which, since abandonment a century or more ago, has become an ecological asset.

It is almost certain that similar gravel deposits owing their origin to human rather than natural agencies will be recognised in the lower reaches of estuaries elsewhere. For example, did the gravels beside the Forvie sands on the Ythan estuary similarly originate through disposal of ballast gravels from shipping to Ellon?

NOTE

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