Determining the Ages of Sub-Fossil *Cetacean* Remains, Found in the Carse of Stirling, Scotland.

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Submitted in fulfilment of the requirements for the degree of Masters by Research.

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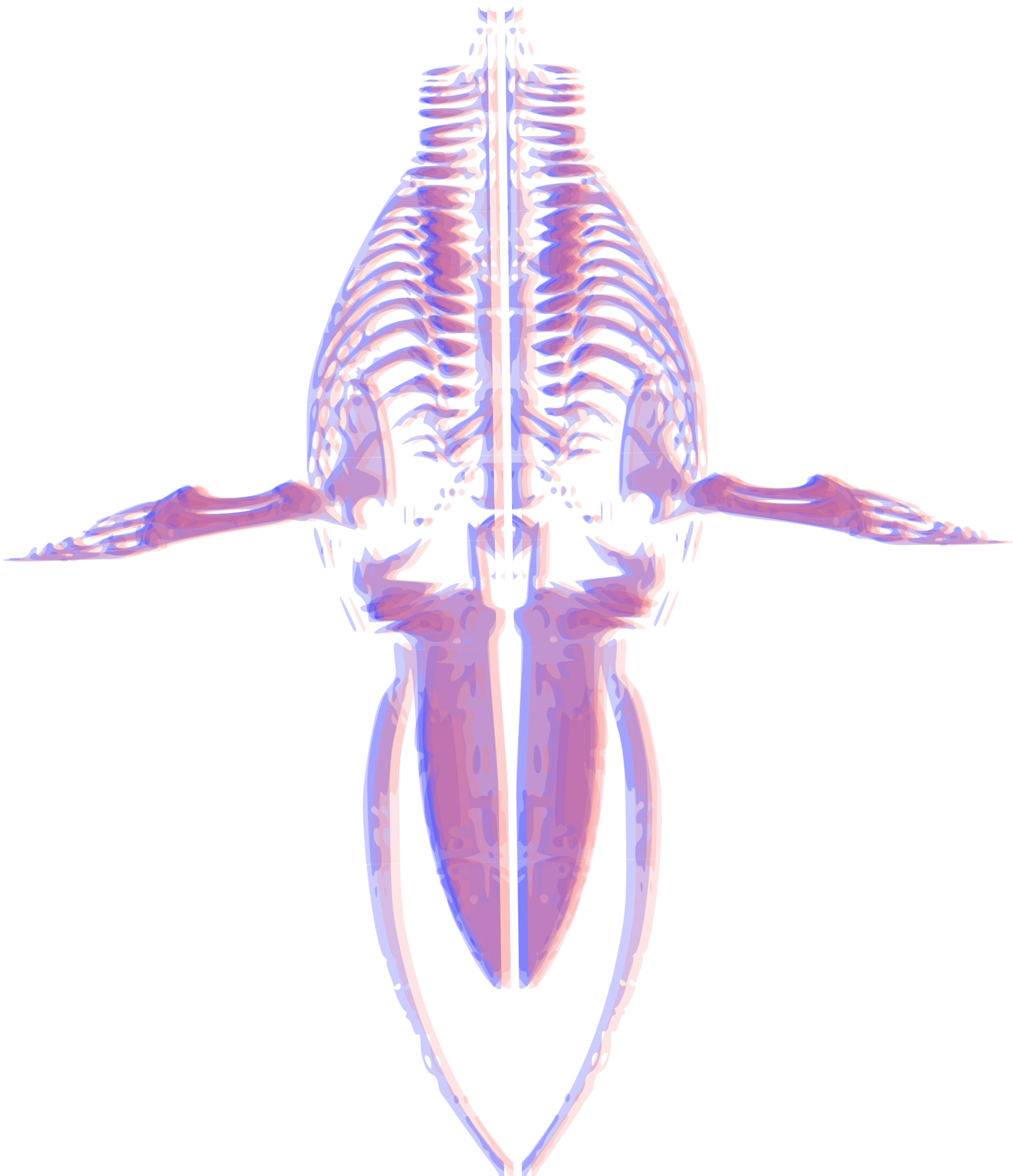

December 2023

Acknowledgements

With thanks to my supervisors, Dr Richard Staff, Dr Amanda Owen and Dr Cristina Persano, to my family and to Valerie McCaig, Dr Mark Wildman, Dr Richard Tipping, Kenny Roberts, Maggie Reilly, Charlotte Slaymark and Charlotte Rex.

With especial thanks to Dr Murray Cook and to Ruth Pollitt, Malcolm MacCallum and Professor Tom Gillingwater of the Anatomical Museum (University of Edinburgh), Dr Jerry Herman of the National Museum of Scotland (Edinburgh), and Nicola Wilson and Caroline Mathers of the Stirling Smith Art Gallery and Museum (Stirling).

The National Environmental Isotope Facility (NEIF) provided funding for five radiocarbon dates, presented in this thesis (No. 2371.0321).

Abstract

During the 19th and early 20th centuries, sub-fossil *cetacean* remains were often discovered in the Firth of Forth, Central Scotland. These bones and skeletons of *"Whales"* were excavated from a recent, estuarine deposit (named "carse clay") and, within the biological and geological sciences, were not judged to be important. That palaeontological evidence is re-evaluated in this thesis. These *cetacean* remains have been preserved in an unusual marine environment and form an exceptional fossil assemblage, with almost no geological precedents. Why is it there?

Whatever caused exceptional preservation in the Firth of Forth in the early Holocene (c. 9.5 – 2.5ka cal BP) can be best identified with chronological data. The ages of six sets of *cetacean* remains are determined in this thesis, by radiocarbon dating and stratigraphic inference. To reconstruct where a bone or skeleton had been found in the "carse" and then to identify any surviving elements in modern museum collections, archaic textual sources had to be thoroughly investigated. Radiocarbon dates from marine organisms require *correction* for *"reservoir effects"* and those applicable to *mysticete cetaceans* require careful consideration.

The absolute dating evidence shows that no two *"Whales"* are the same age and that each died, and was then preserved, over the period 9.5 – 7.0ka cal BP. Therefore, a "disaster" (e.g. tsunami) or mass mortality is unlikely to have caused these remains to accumulate. A combination of physical processes and stable environmental conditions are more likely responsible, and might still permit exceptional preservation in the modern Firth of Forth. Actualistic experiment (observing if, and how, a *cetacean* carcass is preserved or dispersed on a modern tidal foreshore) would allow further insights into this cryptic palaeontological assemblage.

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Declaration

I declare that this thesis is a product of my own work, except where the contributions of others are credited. I submitted a dissertation on the same subject in April 2020, entitled *“Cetacean Bone and Skeleton Disproportions”,* for completion of a BSc undergraduate degree in Archaeology and Earth Sciences at the University of Glasgow. Some of the data collected for that dissertation (e.g. historic documents) are used in this Masters by Research thesis (Appendices A and B).

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1. INTRODUCTION.

1.1. Overview: Phylogeny, Taxonomy and Palaeontology of the *Cetacea.*

In the Eocene (55 – 36 Mya), *cetaceans* evolved from semi-aquatic mammalian quadrupeds into obligate marine predators, completely adapted to life and movement in water (Thewissen & Hussain 1993; Uhen 2007 517; 2010 207). The *Neoceti* – the clade, containing all extant *cetaceans* – appeared at the Eocene-Oligocene boundary (36 – 28 Mya; Uhen 2010 191) and are divided into two orders, characterised by novel feeding mechanisms (Uhen 1998 53, 2010 210). *Odontoceti* rely on echolocation to locate prey whereas *Mysticeti* specialise in bulk-feeding, facilitated by broadened, flattened skulls ("telescoping", Uhen 2010 209; DeMuizon et al. 2019), elongated mandibles and, in place of solid teeth, keratinous baleen filters.

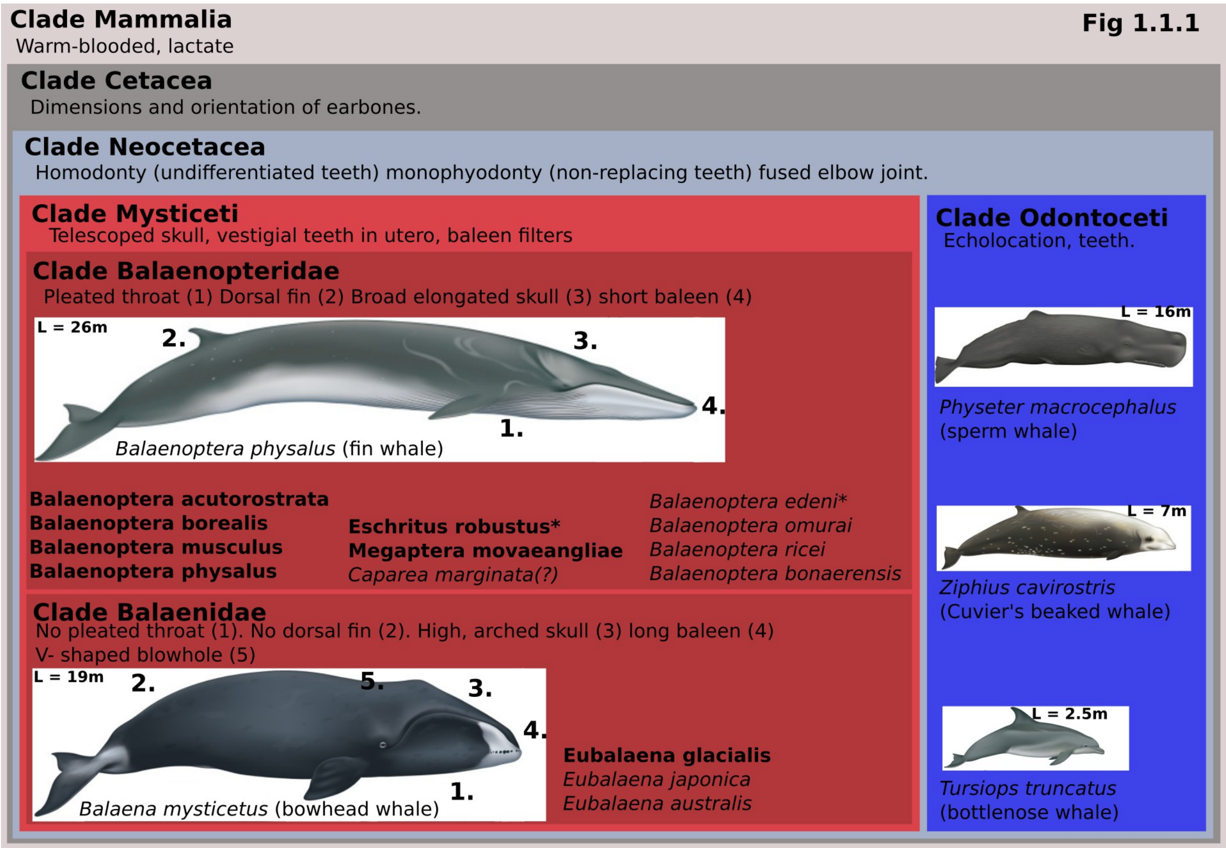


Fig. 1.1.1 Simplified cladogram for extant cetacean genera and species, describing traits for membership to each clade. *Mysticete* species in bold inhabit Northern and Southern Atlantic. *Eschritus robustus* is now only found in the Pacific, but an Atlantic population may have recently gone extinct. Number of species represented by "*Balaenoptera edeni*" and the status of *C marginata* are both disputed. After: Fordyce (2018), Fig. 1. Wells & Scott (2018); Whitehead (2018); Baird (2018); George et al. (2018); Aguilar & Garcia-Vernet (2018).

Mysticetes were most diverse in the late Oligocene to the mid Miocene (25 - 10 Mya; 100+ species, Uhen 2010; Fordyce de Muizon, 2001) but are, at present, at the lowest known point of their diversity. Sixteen species are recognised across two families and six genera, whose distinct cranial physiologies correspond to different feeding styles. Bowhead *(B. mysticetus*) and right whales (*Eubalaenae* complex) belong to the ram-feeding *Balaenidae*, which dive 150 – 200 metres and slowly cruise through dense copepod layers (planktonic crustacea; Baumgartner & Mate 2003).

Lunge-feeding *Balaenoptera* (e.g. humpback whale, *M. novaengliae*, blue whale *B. musculus*) feed at similar depths but in shorter and demanding bursts, by accelerating and then engulfing large volumes of prey in a distending throat sac (Goldbogen et al. 2017). All *mysticetes* are migratory, and almost all are gigantic (Fig. 1.1.1.)

Compared to other mammal taxa, the *Cetacea* have been on Earth in a recognisable form for a much greater period of the Cenozoic. However, the evolutionary history of these animals is difficult to reconstruct because palaeontological evidence for them is uneven. Entire *cetacean* skeletons are rarely found as fossils and, in some geological periods, almost no *mysticete* or *odontocete* remains have been preserved. In particular, *mysticete* whales have almost no fossil representation in the Pleistocene (2.5 Mya – 11.7 ka) and Holocene (11.7 – 0 ka): the origins of extant *Balaenidae* and *Balaenopteridae* species are unclear (Fordyce 2018).

In the Firth of Forth, Central Scotland, many fossil *Balaenoptera* skeletons are said to have been found in a shallow and recent (c. 9.5 – 2.5ka BP) marine deposit, termed "carse clay." More *cetaceans* seem to be preserved here (and preserved, to a much higher standard) than in any other comparable deposit, from any other location in the British Isles (Fig. 1.1.2a) or Northern Europe (Fig. 1.1.2b). However, these fossils have been studied in an arbitrary manner. No ancient *cetacean* remains have been discovered in the "carse" since the early 20th century. The literature concerning them is from the 19th century. Into the 21st century, curation of these bones and skeletons has been irregular. This documentary record, and the unique palaeontological assemblage of Holocene fossil *Balaenoptera* that it relates to, are the subject of this thesis.

1.2. Aims and Objectives.

Why so many *cetacean* skeletons are preserved in the Firth of Forth has not been fully explained. The aim of this thesis is to determine the ages of some of these sets of remains, through indirect stratigraphic inference and direct ^{14}C dating of *cetacean* bone. With this information, it will be clearer if these animals were killed (and their remains, preserved) in a mass-mortality event, or if these bones and skeletons accumulated steadily over time. To fulfil these aims, the following objectives have been achieved:

1. Collection of documentary evidence (scientific papers, newspaper articles, eye-witness testimony) for eleven sets of *cetacean* remains, said to have been discovered in the Carse of Stirling in the 19th and early 20th centuries. Inconsistencies between different accounts are examined, and the attribution of certain bones to particular individuals is assessed.

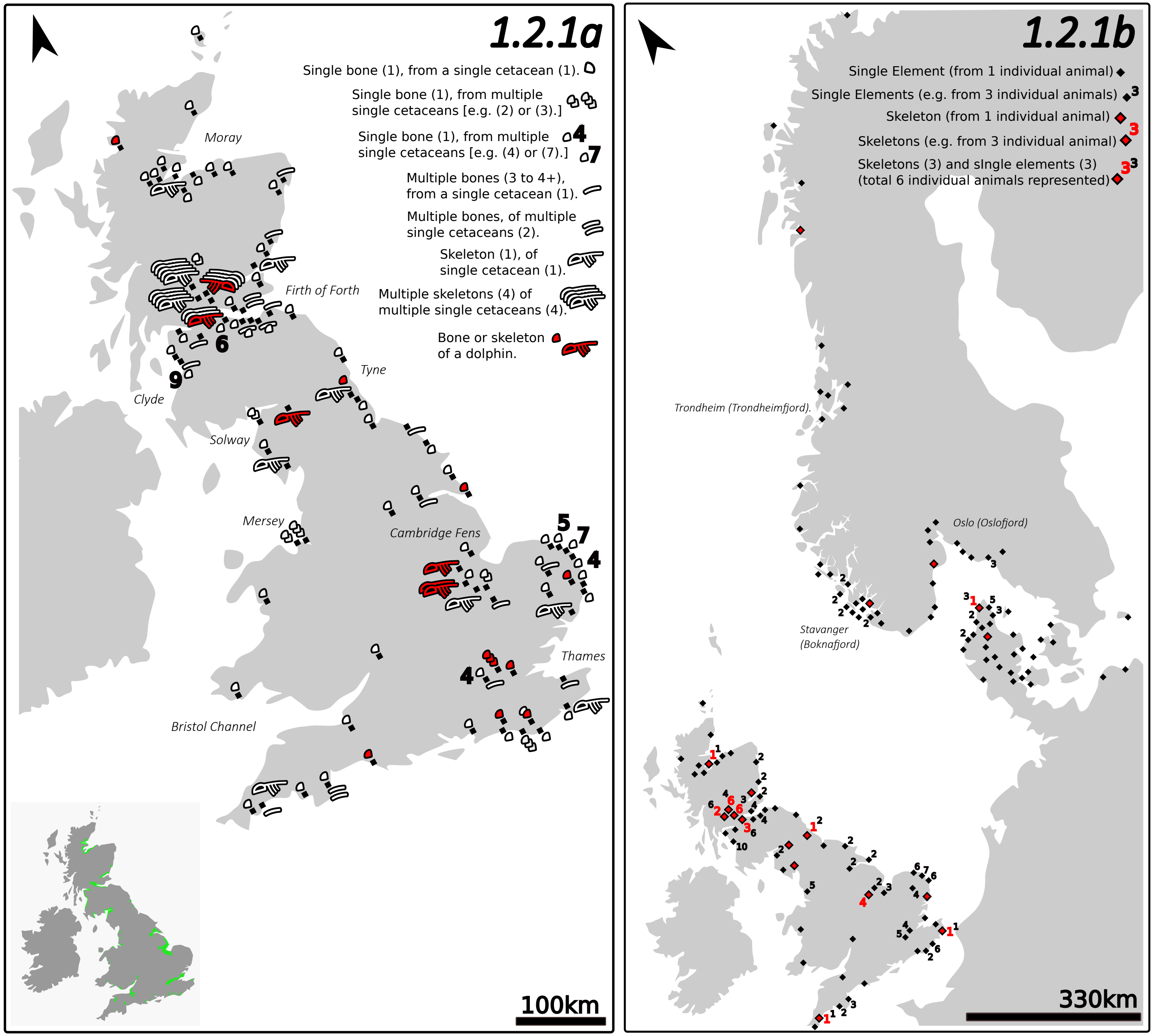


Fig. 1.2.1 *Cetacean* Remains in Northern Europe, found in Pleistocene-Holocene Deposits. **(a:)** British Isles (Inset: Distribution of Holocene raised marine deposits on Great Britain (green). After Geological Survey of Great Britain (Edina Digimap). **(b:)** British Isles and Scandinavia. Mapping data after Google Earth Pro. Palaeontological data from Scandinavia after Wiig et al. (2019), Aaron-Sorenson et al. (2010) For palaeontological data from England and Scotland, Appendix A. For palaeontological data for Firth of Forth, Appendix B.

2. Reconstruction of the original stratigraphic positions, for six sets of *cetacean* remains. This information either lacks in the other five cases, or or one skeleton is suspected to have been split into multiple assemblages and then mistaken for multiple, individual animals. With this stratigraphic information, simple predictions about the ages of the bones and skeletons are made, in respect to potential taphonomic complications.

3. Identification, sampling and radiocarbon-dating of bones, supposed to belong to five of these *cetacean*s. The scientific literature concerning *mysticete* whales is reviewed and, based on their habitats and habits, the necessity of applying local marine reservoir corrections (or $\Delta R\ ^{14}C$) is evaluated.

4. Testing of the radiocarbon dates from those bones against the reconstructed stratigraphic positions, of the *cetacean* skeletons they are supposed to have been part of. Larger patterns in the distribution of these remains in time, or in the marine palaeoenvironments of the Firth of Forth, are discussed. A possible agent of preservation is identified.

1.3. Thesis Structure and Summary of Chapters.

In Chapter Two, the geomorphology and recent geological history of the Estuary of the Forth is outlined. The historical and archaeological contexts that apply to this palaeontological assemblage of *Balaenoptera* skeletons are discussed. The importance of chronological data, to understanding why and how these *cetacean* skeletons accumulated, is emphasised.

In Chapter Three, stratigraphic inference and ^{14}C absolute dating technique are identified, as the means to get that information. Their limitations, as applied to recent Scottish marine deposits and to *mysticete* tissue, are discussed. Archaic recording and conservation practices may introduce complex problems to each case, and could complicate interpretation.

In Chapter Four, these 19th century documentary sources are evaluated for eleven sets of *cetacean* remains. The purpose is to reconstruct where (and if) they were found in the Forth Valley, their stratigraphic position, state of preservation, and whether any of those bones are still extant and identifiable. Based on their stratigraphic position, simple predictions are made about the possible ages of nine sets of *cetacean* remains.

In Chapter Five, the principles of the ^{14}C dating are described and the application of that technique to *mysticete* whale tissue is discussed. An apparent contradiction between their feeding behaviours and observed ΔR ^{14}C local marine reservoir values is identified. Whether radiocarbon dates from such materials require *correction* is an outstanding problem.

In Chapter Six, ^{14}C dates are produced for five bones, supposed to belong to the *cetaceans* described in Chapter Four. Their predicted and absolute ages largely correspond, and the overall temporal distribution of these remains is then discussed. This information broadly indicates that these *cetacean* remains could not have accumulated simultaneously, through infrequent and high-magnitude disasters. Sedimentation and burial are discussed, as possible agents of preservation.

In Chapter Seven, the thesis is concluded and areas of future research are identified.

2. BACKGROUND AND CONTEXT.

2.1. Geomorphology of The Firth of Forth and Valley of the River Forth.

"... The plain through which the River Forth follows its winding course is known as the "Carse of Stirling." The word "carse" is a very old one, and of somewhat obscure derivation. Though now applied to a stretch of fertile land, [it] seems to have originally indicated a wet or marshy place – a meaning quite appropriate. The plain is an old ocean floor: standing on the edge of the carse, no great effort is required to imagine a time, when the blue waves of an ancient firth covered all that flat expense.

The surface of the carse consists of clay. When it is pierced, unmistakeable evidence of its marine origin is disclosed. There have been found continuous beds of whelks, mussels, and oysters in great abundance. No fewer than twenty instances of the discovery of the remains of whales have occurred. In most of these instances, the skeletons of the whales were complete, the bones being well preserved in the clay. Their lengths varied from 40' to 85'. ..."

David Buchan Morris, *The Whale Remains of the Carse of Stirling* (1925 137 – 138).

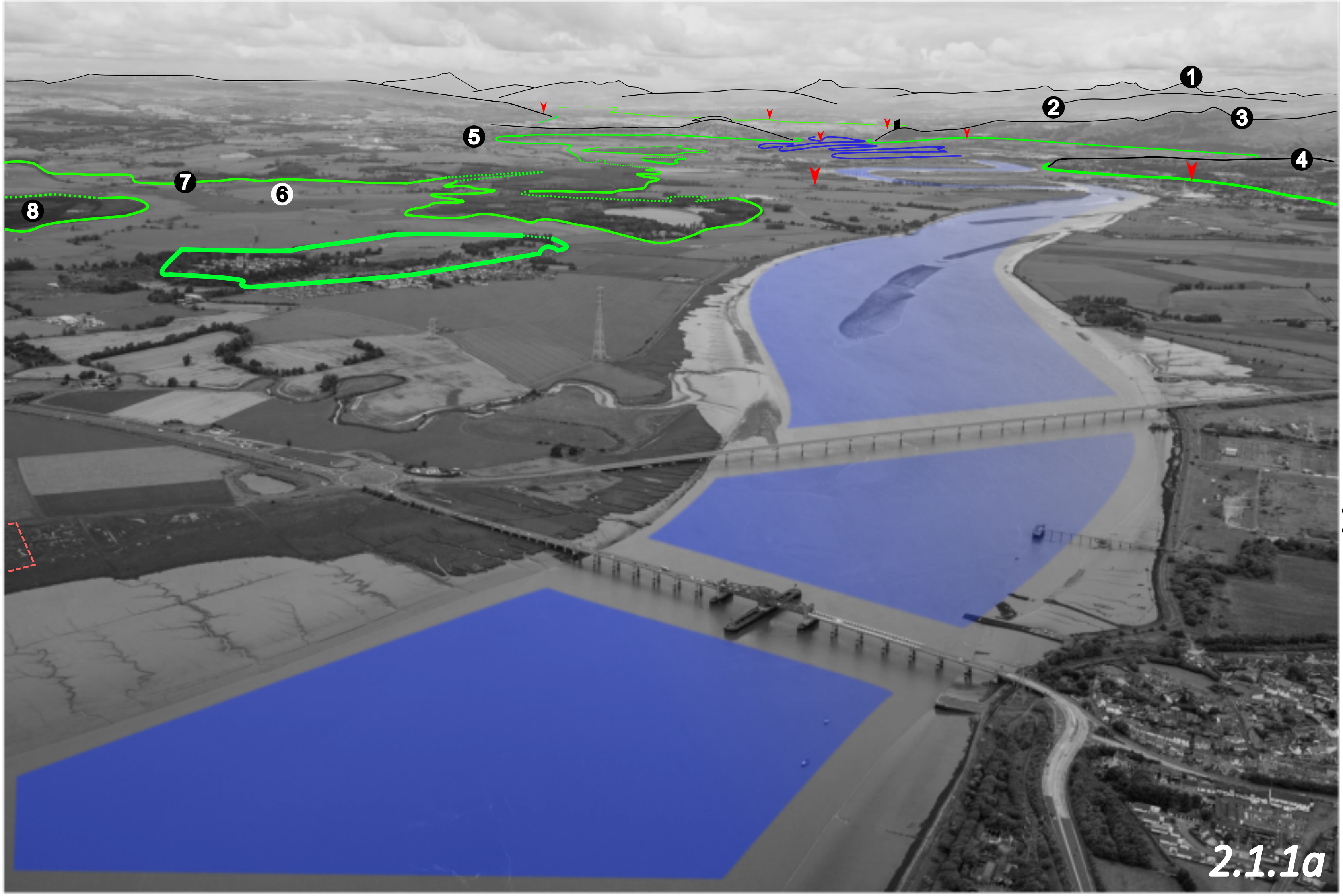
2.1.1. Geographical Overview.

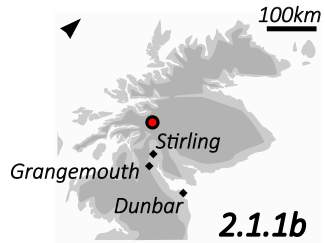
The Firth of Forth is a c.80km long marine sound that divides central Scotland in two, narrowing from its outermost point at Dunbar (c.25km wide) to Grangemouth (c.2km wide; Figure 2.1.1b). From there, the macrotidal estuary of the Forth meanders another 30km to its current tidal limit at the Cruives of Craigforth, slightly beyond Stirling. The river Forth can then be followed inland over 20km of carse, to within 2km of its source at Loch Ard (Fig. 2.1.1a and c.) The idiomatic Scots term *"carse"* refers both to a lithological material (blue clay-silts containing temperate marine organisms, supposed to have been deposited in very shallow estuarine environments, Holloway 2002; Barras & Paul 1999, 2000) and to the landforms which that material composes (level plains and terraces, adjacent to firths and estuaries (Fig. 2.1.1a.)

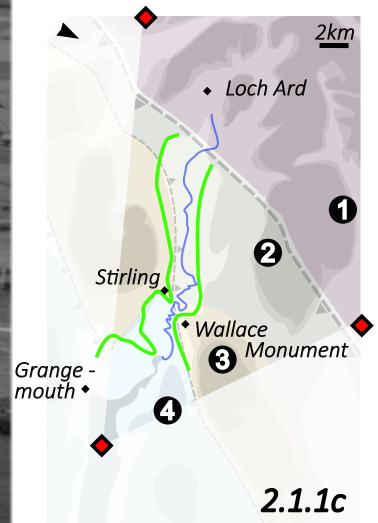
2.1.2. Glaciation and Isostasy-Eustasy.

The river has been a minor morphological agent in this landscape. During the Pleistocene, the inner valley and outer Firth were eroded into Central Scotland's heterogenous bedrock (Fig. 2.1.1c) by ice-sheets, centred in the Western Highlands (Fig. 2.1.1b; Gordon and Ballantyne 2021.) Many of the unconsolidated deposits that fill it (e.g. till, sand, gravel, clay) are direct products of glaciogenic processes (basal- or terminal moraines, drumlins, sub-glacial rivers, aerial weathering, Fig. 2.1.1a.)

By indirect means, the carse also formed because of glaciation (Sissons 1962). The volume of water in the ocean increases and decreases as glaciers grow and waste, causing corresponding (and instantaneous) changes in global sea-level (*eustasy*). In themselves, continental ice-sheets are







(c:) Cambrian-Ordovician Metamorphic Rocks (lilac, '1'). Devonian Sandstone (green, '2'). Carboniferous-Permian Igneous (yellow, '3'). Carboniferous Sandstone and Limestone (cyan, '4'). Faults (dashed lines): Highland Boundary (top, SW - NE) Ochil (middle, E - W.) Edge of carse (green line). "1" - "4" in Fig. 2.1.1c correspond to "1" - "4" in Fig. 2.1.1a. Limits of viewshed in Fig. 2.2.1a indicated by red diamonds.

Fig. 2.1.1. **(a:)** Morphology and Landscape Units of the Forth Estuary and Carse of Stirling; view faces east "1" Metamorphic Rock (Highlands). "2" Sandstones (Low Relief). "3" Basalts (High Relief). "4" Glacial Deposits. "5" Pleistocene Raised Marine Deposits. "6" Loch Lomond Stadial Raised Marine Deposits. "7" Holocene Raised Marine Deposits (green line, landward edge of same.) Modern estuary and course of river Forth (blue area and line). Wallace Monument (black oblong). Places where *cetacean* remains, supposed to have been found (red arrows). **(b:)** inset, Scotland and Firth of Forth. Centre of glaciation (red circle); after Bradwell et al. 2008). **(c:)** inset, Geology of the Upper Firth of Forth. **(1.) Palaeozoic metasedimentary rocks** at high elevation. Site of ice-sheet formation in the Pleistocene and source of micaeous sediments, deposited to form the Carse of Stirling (Bradwell et al. 2008.). **(2.)** Soft **Devonian sandstones** and **(3.)** Hard **Carboniferous-Permian basalts**. Greater erosion of the former relative to the latter by Pleistocene glaciers has formed the valley, and left "peninsulae" (Abbey Craig, site of Wallace Monument [black oblong].) **(4)** Till (or boulder clay), sands, gravels and other **direct glaciogenic deposits** overlie the solid rock in most locations and crop out as low hills and ridges. **(5.) Pleistocene raised marine deposits**. A continuous terrace of laminated red clay, deposited in Arctic conditions as the Last British Ice Sheet retreated. **(6). Lomond Stadial raised marine deposits, or "Buried Beaches".** Formed as sea-levels rose and fell, this landscape unit is now buried beneath the Carse of Stirling. **(7.) Holocene raised marine deposits, or "Carse".** Marine sediments deposited as sea-level rose in the Early Holocene Inundation, in which *cetacean* skeletons are preserved. See Fig. 2.1.2a -b for more detail. At the Bothkennar Research Site [red dashed, foreground] Barras (2000) analysed the chemistry and mineralogy of the carse clays. **(8.)** Raised Bogs. Peat, mostly formed on the carse as sea-level fell. Aerial photo (taken 5.7.2016) from Historic Environment Scotland (HES), Cat. No. (DP 237354.) Insets after Google Earth Pro. Solid geology after Geological Survey of Scotland Sheet 39 (Stirling) (Dunham 1969).

massive enough to displace the brittle crust, causing small-scale (10 – 200m) subsidence over large regions (500 – 100km) during prolonged periods (100,000yr +) of accumulation. When the glaciers melt, the local equilibrium of the crust gradually restores itself (e.g. in Scandinavia, between 1 and 7mm of *isostatic* uplift/year in modernity, changing over space and decreasing with time, Fjeldskaar et al. 2000.) Areas that had been under a lesser volume of ice recover a smaller distance in the same time, relative to central regions (Sissons 1963). In the Firth of Forth, isostatic uplift has been greater in the west (e.g. Stirling, closest to the Highlands) than in the east (e.g. Dunbar, Fig. 2.1.1b.)

2.1.2.1. *"Raised Marine Deposits"* and Geomorphological "*Shorelines*".

Scotland has undergone continuous (if diminishing) *isostatic* uplift since the last regional ice-sheet retreated (from c. 17.5ka BP, Ballantyne & Small 2019). However, relative sea-level has not fallen incessantly during that time. Collapsing ice-sheets in North America and Scandinavia have, at intervals, increased the global volume of sea-water at a faster rate than Scotland's local *isostatic* uplift could compensate for (Harrison et al. 2019). Relative sea-level has briefly risen, multiple times in recent geological history. Marine deposits then accumulated, in parts of Scotland that are now 20km distant from the modern coast (Fig. 2.1.2a). Relative sea-level has since fallen and those marine deposits have been elevated, by as much as 30m (Sissons & Smith 1965a) above modern ***mean average sea-level*** (as represented by Ordnance Datum Newlyn [ODN]; Fig. 2.1.2b, "G".)

These so-called "raised marine deposits" are sometimes distinguished, and placed into a simple chronological order, by their sedimentology or biotic contents (e.g. arctic, boreal or temperate *mollusca*; Fig. 2.1.1a). Nevertheless, relative sea-level in Scotland has not risen and fallen in perfect correspondence with local changes in climate. Multiple fluctuations could even have occurred, under unchanging climatic conditions. To reconstruct Scotland's recent history of relative sea-level change, isostasy-eustasy researchers now organise "raised marine deposits" by their morphology, geometry and elevation, into landscape units termed "*Shorelines*" or "*Beaches*" (Sissons 1963).

The use of the latter term is unavoidable, but discouraged: "*Beach*" has strong connotations for a certain class of sediment (coarse clastic) and a specific type of physical environment (energetic, wave-washed foreshore.) A geomorphological *"Shoreline"* might be represented by sedimentary units from multiple depositional environments, like tidal foreshores (silts and muds) or storm beaches (coarse gravel.) Erosive landforms (cliffs, planation surfaces) may also be included. Fine-grained sediments from low-energy tidal flats predominate in three of Scotland's four major *"Shorelines"* (Main Glacial Shoreline, Buried "Beaches" and Main Post-Glacial Shoreline; respectively "A", "C" – "E" and "F" on Figs. 2.1.2a and b.)

In the Firth of Forth, a "*Shoreline"* is recognised as a set of marine landforms which must all have formed and been uplifted at the same time, because their surfaces slope by the same, unique gradient from west to east (Fig. 2.1.2a, b, "A" – "F".) As the rate of *isostatic* uplift diminishes in time and is uneven in space, a steeply-sloping *"Shoreline"* must be older than a gentler one (Fig. 2.1.2b. "A" and "F".) Critically, successively gentler (and younger) "*Shorelines*" are not found at sequentially lower elevations (Fig. 2.1.2b. "A", "B", "C", "F".) Some *"Shorelines"* formed when relative sea-level was low but were engulfed by later, and more extreme increases (Fig. 2.1.2b; "C" – "E" and "F"). As such, the "raised marine deposits" in the Firth of Forth are not found in an intuitive chronostratigraphic succession. The nested "Shorelines" they form, represent a complex interaction between global *eustatic* change and local *isostatic* recovery.

2.1.3. History of Recent Relative Sea-Level Change in the Firth of Forth.

The "*Main Glacial Shoreline*" (archaic "100' Beach") is the oldest raised marine deposit in the Firth of Forth (Sissons & Smith 1965a). It formed when isostatic uplift was most rapid (c. 14.5 – 11.1ka BP), and is both the most inclined and most elevated (30m – 25m; Fig. 2.1.1b, "A"). During the Loch Lomond Interstadial (c.10.9 – 9.5 ka BP) these deposits (and many solid rock exposures along the Firth of Forth) were planated, forming an erosion-dominated *"Late Glacial Shoreline"* as the sea stood close to modern **mean average sea-level** (0m ODN; Fig. 2.1.2b, "B".)

Towards the end of this period (c.10.9 – 9.5 ka BP), Sissons (1966, 1969, 1971) and others (Sutherland 1984; Firth 1986) argue that relative sea-level rose again to inundate the Firth of Forth, before the Loch Lomond montane glacier had abandoned the Mentieth Moraine (Fig. 2.1.3 & 2.1.4, "1".) The "*High Buried Beach*" (Fig. 2.1.2b "A", 2.1.3 "1") forms on the north and south sides of the Forth Valley and fine-grained marine sediments are deposited on erosional *"Late Glacial Shoreline"* landforms (e.g. Bothkennar Gravel; Peacock 1998). None accumulate within the Moraine (Sissons & Brooks 1971; Smith et al. 2010) or on the Teith Outwash Fan (Kemo 1971).

Scotland fully deglaciates by c. 9.5ka BP (Bradwell et al. 2008). As the *"High Buried Beach"* is isostatically raised from the active marine environment, relative sea-level falls to form the *"Main Buried Beach."* (Fig. 2..1.2b "D", Fig. 2.1.4 "2"). Marine sedimentation associated with this land-form occurs within the Mentieth Moraine (Fig. 2.1.3, "3"). Peat-bogs establish themselves on the abandoned mudflat surfaces of the *"High Buried Beach"* and then *"Main Buried Beach"* (Sissons 1969, Smith & Sissons 1965b) as sea-level continues to fall to the *"Low Buried Beach."* (Fig. 2.1.2b "E", Fig. 2.1.3 "3".)

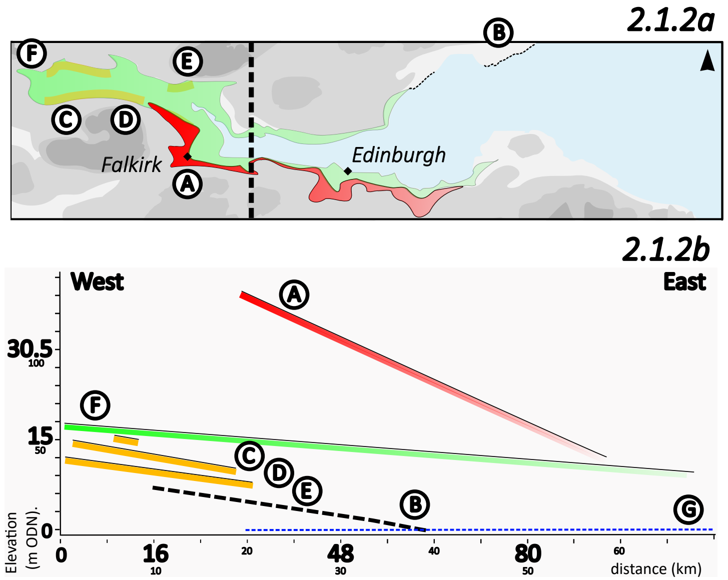


Fig. 2.2.1. a:) Raised Marine Deposits / "Shorelines" in the Firth of Forth, Scotland. Red ("A") Pleistocene raised marine deposits. Extreme landward edge of same used to determine "Main Glacial Shoreline". Black Dashed ("B") Erosive landforms of "Main Late Glacial Shoreline." Yellow ("C", "D", "E") Loch Lomond Stadial Raised Marine Deposits, or High, Main and Low Buried Beaches. Green (F) Holocene Raised Marine Deposits (carse). extreme landward edge of same used to determine "Main Post Glacial Shoreline." Area of Fig. 2.1.3 (Black Dashed Line.) After Geological Mapping (Edina).

b:) "Shoreline Diagram" for Firth of Forth (after Sissons, Smith & Cullingford 1966) showing elevation and inclination of: Red ("A") "Main Glacial Shoreline". Black Dashed ("B") "Main Late Glacial Shoreline." Yellow ("C", "D", "E") High, Main and Low Buried Beaches. Green (F) "Main Post Glacial Shoreline." Blue Dashed ("G") modern mean average sea level (ODN).

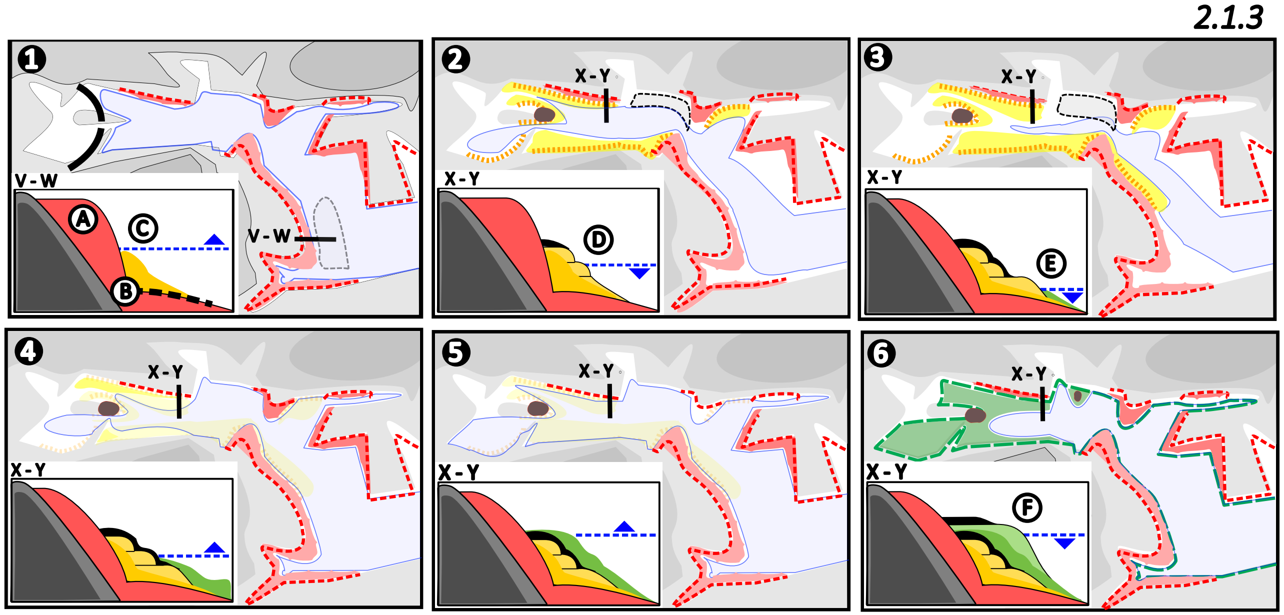


Fig. 2.1.3. "1" - "6".Western Forth Valley. Relative Sea-Level Change over the period c. 11.0ka BP - 4.5ka BP and accumulation of "raised marine deposits", illlustrated schematically. Panels "1" - "6" correspond to No's "1" - "6" on Fig. 2.1.4. Letters "A" - "F" correspond to "A" - "F" on Fig. 2.2.1a & b.

(**insets**: Schematic section diagrams of "Raised Marine Deposits" at Grangemouth (V - W) & Burnbank, c. Blair Drummond (X - Y): Position of high water water mark (blue dashed). Net falling or rising sea-levels, indicated by blue arrow (pointed down or up). Pleistocene raised marine deposits (red). Landward edge of same (red dashed). Loch Lomond Interstadial raised marine deposits, or "Buried Raised Beaches" (yellow - High (i), Main (ii), and Low (iii). Landward edge of same (yellow dashed). Holocene marine deposits, or "carse" (green). Peat (thick black). Basemap after Google Earth Pro (2022).

Extent of raised marine deposits, after (Sissons & Smith 1965; Sissons 1966; Sissons 1969; Sissons 1972; Kemp 1971; Peacock 1999; Smith et al. 2010).

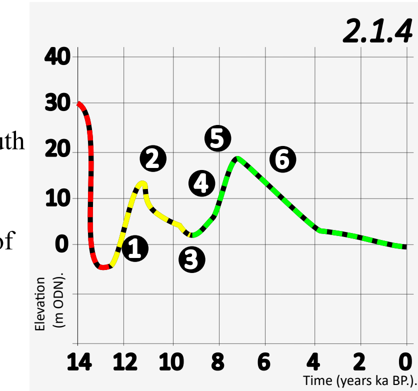


Fig. 2.1.4. Composite Sea-Level Change Curve (Western Forth Valley). "1" - "6" correspond to panels "1" - "6" in Fig. 2.1.3. Section from 12.5 - 10.9 ka BP approximate - after Sissons (1966, 1969.) Sections 10.5 - 4.5 ka BP after Smith et al. (2010). Sections 14 ka BP - 12ka BP and 4.5ka BP - 0 ka BP after Shennan et al. (2018).

Large eustatic increases lead to rapid rise in relative sea-level (the "Early Holocene Transgression".) (Smith et al. 2010). Homogenous, blue "carse clay" is deposited on the Teith Outwash Fan (Kemp 1976), and accumulates on the peat that had formed on the *"Buried Beaches"* (Fig. 2.1.3 and 2.1.4, "4") which are eventually engulfed (Fig. 2.1.3 and Fig. 2.1.4, "5".) As relative sea-level approaches its high-stand in the Forth Valley to form the *Main Post-Glacial Shoreline* (or *50' / 25' Beach*), the Storegga Tsunami strikes Scotland (Smith et al. 2010).

Isostasy elevates the western end of the Valley and peat begins to accumulate over the exposed mudflats, or "carse". (Fig. 2.1.4 and Fig. 2.1.3, "6".) The *Main Post-Glacial Shoreline* is abandoned and the coast moves eastward, and inward, to briefly stabilise at the *"Blair Drummond Shoreline"* (by 4.8 ka BP.) Relative sea-level falls to its present level by c. 0BP (0m ODN; Fig. 2.1.4), which it has maintained since. During this final cycle of rising and falling sea-levels (c. 9.5 – 2.5ka BP) the bones and skeletons of *cetaceans* accumulate in the "carse clay".

2.1.4. Mineralogy and Lithological Provenance of the Carse Clay.

The mineralogy of the carse clay (or "Claret Formation") has been analysed only at Bothkennar (Fig 2.1.1, "7") in support of geotechnical research. Paul et al. (1991, summarised in Hight et al. 1992 309, 312 -13) initially reported that, during the accumulation of these sediments, the silicate-dominated assemblage (quartz, feldspar, kaolinite, illite/mica) remained practically invariable. While noting that, within the carse, the silt (predominantly quartz, feldspar, ferromagnetic minerals) and clay (quartz, illite, chlorite, kaolinite, feldspar) had dissimilar concentrations of some minerals, the relative proportions of each fraction were consistent throughout the coring (Paul et al. 1991; Hight et al. 1992 309, 313, 334.)

X-ray diffraction data published by Paul et al. (1992 188 -189) and Barras (2000; Barras & Paul 1999 134), in which several Bothkennar cores were sampled at multiple intervals, (Figs. 2.1.5a – d, 2.1.6a - c) corroborate those findings. Other than querying the presence of kaolinite and confirming chlorite, muscovite and biotite as important constituents via optical microscopy and X-ray spectroscopy, all agree on the remarkably uniform mineralogy of the carse clay (ibid. 1992 189; ibid. 2000 86, 87 – 88; Fig. 2.1.5d, 2.1.6b and c.) Barras (2000) attributes the different mineral concentrations within the silt and clay fractions (Fig 2.1.6a - c) to natural contrasts in mineral hardness, cleavage and fracture, also identifiying probable parent lithologies from within 20 – 30km of the Forth Valley (ibid. 2000 11; Table 2.1.4). However, as many quartz grains in the carse clays were angular and conchoidally fracured, Barras (2000 92) argues that re-worked glacial deposits are the immediate sedimentary source, rather than the natural rock.

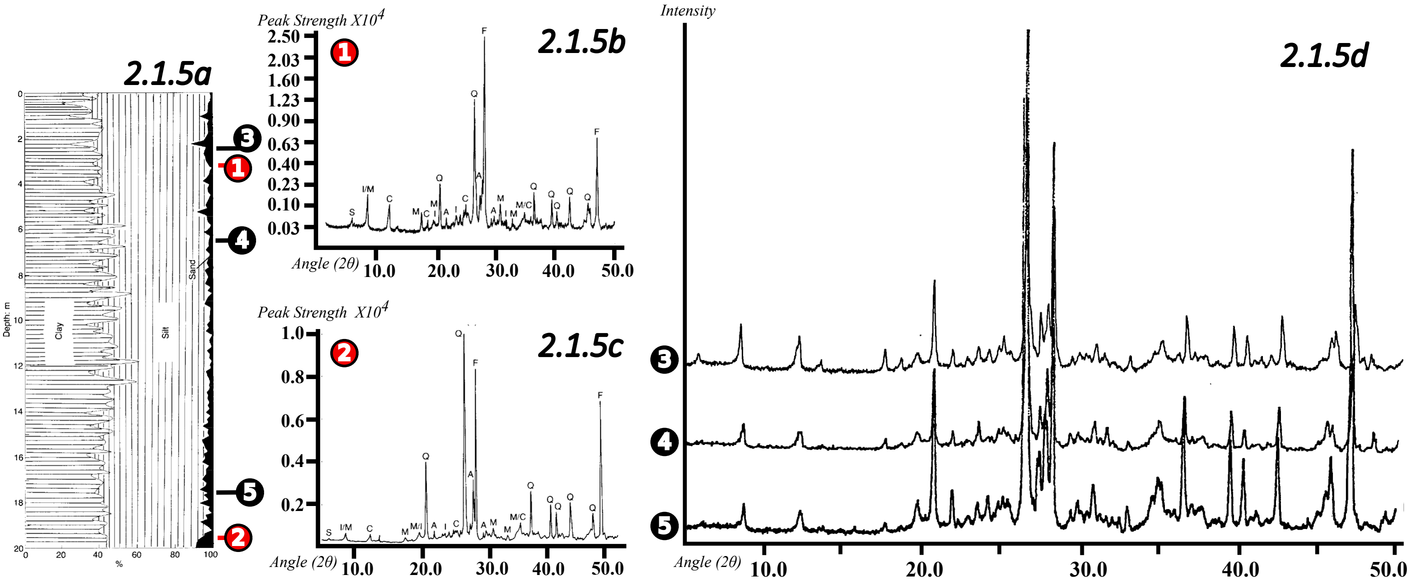
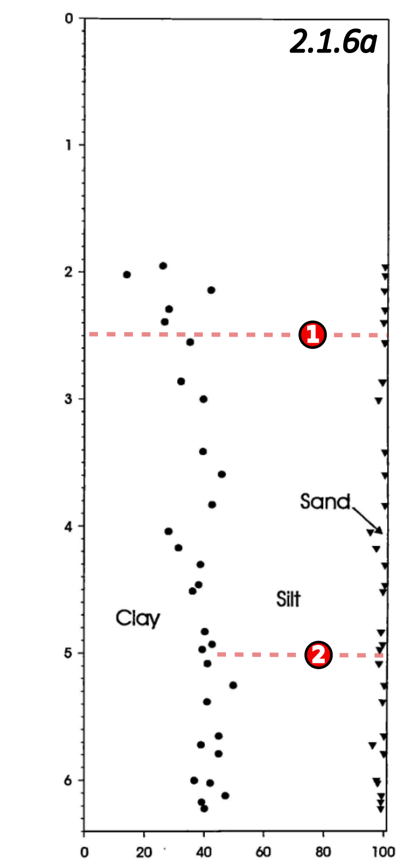


Fig. 2.1.5. **(a:)** Profile of particle size distribution in Bothkennar core HW3, after (Paul et al. 1992), Fig. 8. "1" (3.15m) "2" (19.52m) "3" (2.32m) "4" (6.30m) and "5" (17.72m) correspond to "1" - "5" in Figs. 2.1.4b and 2.1.4c. **(b:)** X-Ray Diffractogram for Bothkennar core HW3 (3.15m). "S": Smectite. "F" : Flourite (standard). "I" : Illite. "M" : Mica. "C" : Chlorite". "A" Albite (Feldspar). "Q" : Quartz. After (Paul et al. 1992) Fig. 9a. **(c:)** X-Ray Diffractogram for Bothkennar core HW3 (19.52m) - mineral key as in Fig. 2.1.4b. After (Paul et al. 1992) ,Fig. 9b. **(d:)** X-Ray Diffractograms for Bothkennar core HW, at 2.32m ("3"), 6.30m ("4") and 17.72m ("5") After Barras (2000), Fig. 6.1.



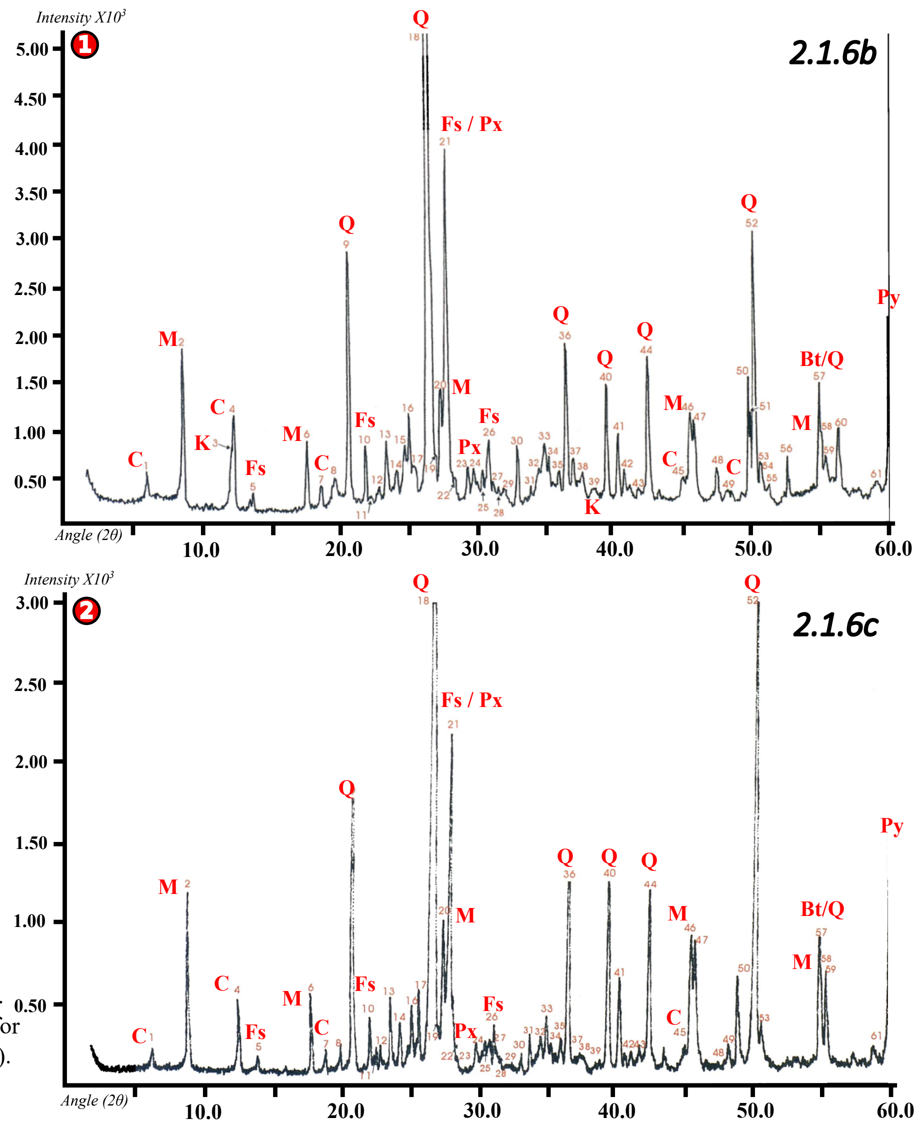


Fig. 2.1.6. **(a:)** Profile of particle size distribution in Bothkennar core HW7/8, after (Barras 2000), Fig. 6.12b. "1" (2.43m) and "2" (5.06m) correspond to "1" and "2" in Figs. 2.1.5b and 2.1.5c. **(b:)** X-Ray Diffractogram for Bothkennar core HW7, entire fraction (2.43m). "K": Kaolinite. "I" : Illite. "M" : Mica. "C" : Chlorite". "Fs" Feldspar. "Q" : Quartz. "Px" : Pyroxene. "Bt" : Biotite. "Py" : Pyrite. After (Barras 2000) Fig. 6.2.

(c:) X-Ray Diffractogram for Bothkennar core HW8, silt fraction (5.06m). Partial mineral key as in Fig. 2.1.5b. After (Barras 2000) Fig. 6.9. For complete table of minerals in diffractograms 2.1.5a & b, see Table 2.1.4.

Table 2.1.4. Mineralogy of the Carse Clay, Determined by XRD Analysis. (Bothkennar Core HW 7, 2.43m). After Barras (2000), Table 6.1.

No.	Angle (2θ)	Relative Intensity	Mineral Family	Provenance	No.	Angle (2θ)	Relative Intensity	Mineral Family	Provenance
1	6.36	1.86 w	Chlorite	AFS / DP	**32**	34.6	2.05 m	Chlorite	AFS / DP
2	8.99	9.23 s	Mica	BLG / BBS	**33**	35.09	3.8 m	Mica / Kaolinite	N.A.
3	12.46	3.59 m	Kaolinite	Authigenic	**34**	35.39	2.78 m	Olivine / Pyroxene	PZB
4	12.64	5.26 s	Chlorite	AFS / DP	**35**	36.13	2.14 vs	Kaolinite / Olivine	N.A.
5	13.98	1.02 w	Feldspar	BBS (“GB”)	**36**	36.65	10.11 m	Quartz / Mica	Var.
6	17.92	4.31 m	Mica	BLG / BBS	**37**	37.15	2.94 w	Pyrite	Authigenic
7	18.94	1.63 w	Chlorite	AFS / DP	**38**	27.84	1.84 vw	Chlorite / Mica / Kaolinite	N.A.
8	19.91	2.05 m	Mica / Chlorite	AFS / DP	**39**	38.62	0.9 s	Kaolinite	Authigenic
9	20.97	15.64 vs	Quartz	Var.	**40**	39.56	7.43 m	Quartz	Var.
10	22.15	3.89 m	Feldspar	BBS (“GB”)	**41**	40.38	7.43 m	Quartz	Var.
11	22.55	0.83 m	Mica	BLG / BBS	**42**	40.82	2.05 vw	Pyrite	Authigenic
12	23.11	1.38 w	Feldspar	BBS (“GB”)	**43**	41.82	0.81 s	Mica	BLG / BBS
13	23.66	4.18 m	Feldspar	BBS (“GB”)	**44**	42.55	8.85 w	Quartz	Var.
14	24.42	2.48m	Mica	BLG / BBS	**45**	45.01	1.31 s	Chlorite	AFS / DP
15	24.97	3,93 m	Kaolinite	Authigenic	**46**	45.58	5.52 m	Mica	BLG / BBS
16	25.3	6.05 s	Chlorite/ Mica	AFS / DP	**47**	45.88	4.95 w	Quartz	Var.
17	25.74	2.55 m	N.A.	N.A.	**48**	47.5	1.92 vw	Pyrite	Authigenic
18	26.74	100	Quartz	Var.	**49**	48.21	0.57 s	Chlorite	AFS / DP
19	26.98	14.54	Feldspar	BBS (“GB”)	**50**	39.79	7.01 m	N.A.	N.A.
20	27.57	7.68 s	Mica	BLG / BBS	**51**	49.95	4.6 vs	N.A.	N.A.
21	28.04	21.71 vs	Feldspar / Pyroxene	PZB	**52**	50.22	16.45 m	Quartz	Var.
22	28.6	1.96 w	Feldspar	BBS (“GB”)	**53**	50.65	2.4 m	N.A.	N.A.
23	29.51	2.48 m	Feldspar / Pyroxene	PZB	**54**	50.75	2.01 vw	N.A.	N.A.
24	29.94	2.26 m	Pyroxene	PZB	**55**	51.25	0.64 m	N.A.	N.A.
25	30.57	2.28 m	Feldspar	BBS (“GB”)	**56**	52.62	2.45 s	N.A.	N.A.
26	31.05	4.08 m	Feldspar	BBS (“GB”)	**57**	54.94	7.05 m	Biotite / Quartz	BLG / BBS
27	31.35	1.51 w	Mica / Pyroxene	N.A.	**58**	55.1	3.99 m	Mica	BLG / BBS
28	31.74	1.17 w	Chlorite	AFS / DP	**59**	55.4	2.6 m	Quartz	Var.
29	32.15	1.1 w	Olivine	PZB	**60**	56.3	4.24 m	Pyrite	Authigenic
30	33.13	3.77 m	Amphibole / Pyrite	PZB	**61**	59.07	0.83 vw	Pyrite	Authigenic
31	34.07	1.04 w	Pyroxene	PZB					

Abbreviations:
AFS / DP – Aberfoyle Slate / Dunoon Phyllite.
BBS (“GB”) - Ben Bheula Schist (“Green Beds”).
BLG / BBS – Ben Ledi Grit / Ben Bheula Schist
PBZ – Palaeozoic Basalts
Var. - Any excepting “Palaeozoic Basalts.”

2.1.5. Summary and Terminology.

The Carse of Stirling was, as David Buchan Morris (1925 137 - 138) once imagined, "*[covered by] the blue waves of an ancient firth."* It is tempting but misleading to think of this landform (or any other one like it in Scotland) as *"an old ocean floor". Isostasy* does not act equally in space and time, and each "raised marine deposit" that it produced can be sub-divided, by subtle variations in gradient and elevation. These are "*Shorelines",* which represent the extreme landward limit of the sea at given points in geological time.

The *"Main Post-Glacial Shoreline"* strictly refers to one such feature, that formed at the culmination of the Early Holocene Transgression (c.6.5ka BP.) All the unstructured, blue clay that accumulated over the period 9.5 – 2.5ka BP, and which has since been elevated from the active marine environment by isostatic uplift, is referred to as "carse clay" or "carse". This is irrespective of the several Mid- to Late Holocene *"Shorelines"* which formed below the *Main Post-Glacial Shoreline*, and into which the Carse of Stirling can be sub-divided. The term "*Raised Beach*" is used only to refer to the "*Buried Raised Beaches*", as these landforms have no appropriate pseudonym.

2.2. The "*Whales*" in the Carse of Stirling.

2.2.1. Overview.

Over the last two centuries, David Buchan Morris (quoted above) is one among hundreds to have claimed that many bones and skeletons of *"Whales"* are preserved in the carse (Fig. 2.2.1a - d). This palaeontological assemblage has attracted members of many academic disciplines, but never been systematically studied by any one of them. In conventional scientific literature, references to the "*Whales*" appear in anatomical (Turner 1883), archaeological (Wilson 1851; Clark 1947), historical (Ferguson 1905), agricultural (Carmichael 1835), zoological (Brady et al. 1874) and geological (Bald 1819; Milne Home 1871) publications. Beyond a few radiocarbon dates (Smith et al. 2010), McIntosh (1923) was the last to publish original research on these *cetacean* remains.

That many *"Whales*" have been discovered in the carse, at such high standards of preservation, is considered unremarkable. Academics (e.g. Turner 1912; Redman 2004; Warren 2005; Smith et al. 2010) assume that the Firth of Forth is a normal place to find a palaeontological assemblage of this class and quality. Several (e.g. Clark 1947, Smith et al. 2010, Turner 1890) have even ventured explanations for it, after only a cursory examination of the evidence. Perhaps the only thing elevating these *cetacean* skeletons from local curiosities, is the fact that prehistoric tools are said to have been found alongside some of them (Bald 1819, Home Drummond 1826, Turner 1890).

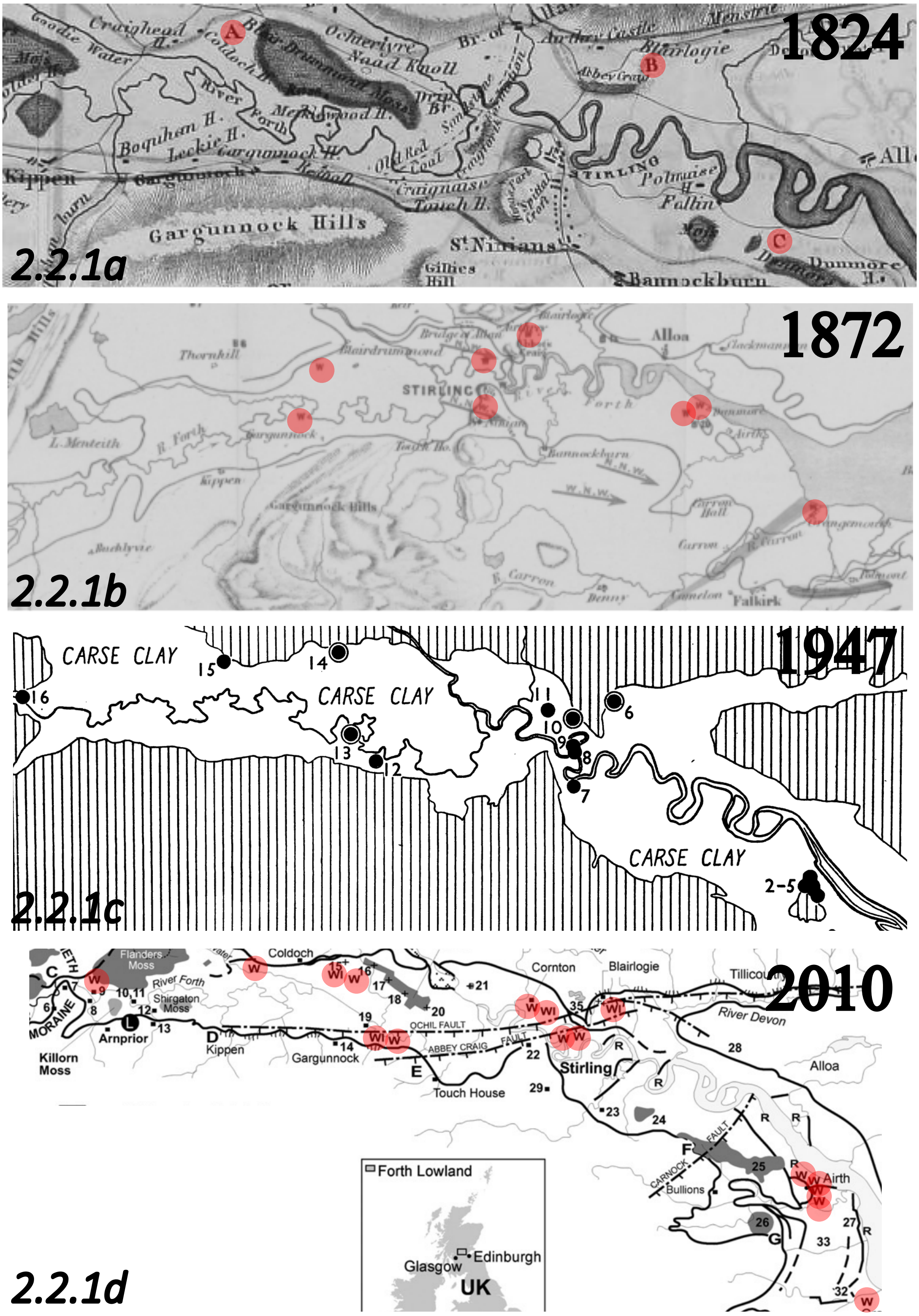


Fig. 2.2.1 a - d. Maps showing places, where the bones and skeletons of "Whales" are supposed to have been found in the carse clay (Holocene shallow estuarine sediments, deposited c. 9.5ka - 2.0 ka BP.) After **(a:)** Blackadder (1826); "A", "B", "C" corresponding to discoveries of "Whales". **(b:)** Milne Home (1871); "W" corresponding to "Whale Skeletons." **(c:)** Clark (1947), based on Morris (1893,1925); Turner (1912). Circles for "Remains of Whales", circles with rings for "Remains of Whales Accompanied by Implements." **(d:)** Smith et al. (2010). "W" for "Whale Skeleton", "WI" for "Whale Skeleton with Implement."

2.2.2. The Archaeological Aspect.

The physical evidence for human inter-activity with these animal remains is slight. Amongst Morris' (1925) *"twenty whales",* only three are recorded to have been found with *"antler implements",* of which two are lost and only poorly-described (Bald 1819, Home Drummond 1826). Furthermore, interpretation of the tools and their functions has changed with time. In *absentia*, many judged them to have been harpoon-points, or parts of lethal hunting implements (e.g. Chambers 1847, Wilson 1851). Since the discovery and conservation of the only extant example, the tools have been re-interpreted as mattock-heads, or butchery equipment (Turner 1890, Clark 1947, Elliot 2015.)

Even the earliest archaeological authorities have then had to consider, if members of Scottish prehistoric societies had caused these animal remains to accumulate (e.g. Wilson 1851; Turner 1890, 1912; Munro 1899; Clark 1947; Lacaille 1954; Warren 2005.) In principle, humans could have intervened, in only one of two ways:

1. Killing more *cetaceans* than would have died naturally in the Firth of Forth, and modifying their mortality (i.e. hunting.)

2. Expediting the preservation of *cetaceans* that had died here by natural causes, and whose carcasses would otherwise have dispersed rapidly (i.e. butchery, or gathering).

What is known of these prehistoric societies, and the activities of their members, is based on a wider body of archaeological and ethnographic data. Clark (1947) argued that Mesolithic hunter-gatherers (who inhabited Scotland in the early Holocene) lacked the technology to pursue, capture, and lethally injure such large animals. Although ethnographic research shows that analogous tribal societies have successfully hunted *mysticete* whales (e.g. Makah Native Americans, Beck 1996; Thule and Inuit cultures, MacCartney & Savelle, 1985, 1993; Savelle 2005), British archaeologists largely remain in line with Clark (MacKie 1972; Mulville 2002; Warren 2005; Conneler 2021).

The alternative explanation - that Mesolithic humans selectively butchered the largest *mysticetes*, that stranded in one specific location (the Forth Valley) – is not much discussed. This activity has often been dismissed with the pejorative terms, "scavenging" or "scavengers" (e.g. Turner 1890; Clark 1947). These authorities may have under-estimated the amount of manpower, equipment and organisation that is required, to butcher ("flense") a *mysticete* (e.g. a blue whale (*b. musculus)* c. 20m long, and weighing c. 150 tons). Stranded *cetacean* carcasses decay rapidly and may already have begun to decompose before grounding on land (Moore et al. 2020). This permits little time to gather labour, materials and tools, before organising and equipping work-parties. The collected meat would then have to be cached in some way (e.g. in pits, requiring another set of tools and work-details; e.g. Darwin 1968 213 – 4, on the Fuegans). All this suggests that "flensing" whales for food is an organised activity, requiring leadership, planning, and a large labour-force.

With the current archaeological evidence, it does not seem probable that Mesolithic humans in Scotland were equal to this task – for purely practical reasons. At this time, people are supposed to have lived in dispersed, low-population and mobile familial groups (Lacaille 1954; Finlay et al. 2002). Their tools were not prepared in advance but manufactured on-demand (e.g. Pannett & Baines 2006; Wickham-Jones et al. 2020) to exploit anticipated and predictable food resources (Mellars et al. 1980; Mithen et al. 2001; Mithen & Finlayson 1991; Mithen et al. 2020). These items were composites of other materials (e.g. flints, cervid antlers, adhesives) which required "gathering" themselves. Given that *cetacean* stranding in time and space is random (and that a carcass is "fresh" for such a short period of time), it is hard to see how Mesolithic hunter-gatherers in Scotland could have assembled enough equipment and labour in time to exploit that resource. As such, humans cannot be argued to have hunted these *"Whales"*, nor to have efficiently and entirely flensed them.

2.2.3. Death and Preservation of *Cetaceans*, Explained by Natural Causes.

These tools overshadow the *cetacean* skeletons themselves (e.g. Chambers 1847, Wilson 1851, Turner 1890; Fig. 2.2.1c), and draw attention from their inherent significance as palaeontological specimens. If the presence of these "*Whales*" in the carse clay cannot be validly explained by prehistoric human intervention, then the bones and skeletons of these animals must have accumulated in the Firth of Forth though natural causes. While this palaeontological assemblage has been investigated in an arbitrary manner, the factors that might have caused *cetacean* remains to be present in the carse clay, have always been speculated on. Consensus is longstanding, about what could have happened here:

> *"There seems little doubt that the animal was stranded where it now lies. ... I am more convinced of my original idea, that a number of [whales] must have been stranded coming up the Forth at the same time, and that many more of the flock remain to be discovered."* (Reddoch 1824 417).

> *"It is not uncommon for the larger* cetacea*, which can float only in a considerable depth of water, to be carried during storms into estuaries. Upon the retiring of high water, they are stranded. To some accident of this kind, we may refer the position of the skeleton of a whale was found imbedded in clay, on the [River] Forth, [at Airthrey].* (Lyell 1837 163).

> *"The [whale] skeletons have all been found in carse clay. They must have been entire, or only partially decayed, when they were swept along to the place where they were found. If they were*

cast ashore, and left exposed to the influence of the atmosphere and action of the waves, the skeleton would very soon have been separated into pieces. The circumstance of their having been found so entire, can only be explained on the supposition that they were covered with mud while the skin and ligaments were undecayed." (Brodie 1867 49).

" The skeletons of seven or eight whales found in Stirlingshire, about 25' to 35' above the high-water mark, imply (if the animals ran themselves aground) that the sea must have stood at least 50' or 60' above its present level. (Milne Home 1881 137)

"The Firth of Forth must have been a veritable death-trap for whales at the time of the deposition of the carse clays. Even in modern times, whales are stranded in the Firth. When able to swim many miles further up the estuary, whales ran a commensurately greater risk of being caught by the falling tide." (Clark 1947 91).

*"The diggings unearthed 8,000 year-old whale bones, presumably washed there by a tidal wave." (*Durie 2014).

"Clark (1947) *suggested that the whales had become stranded by the tide, before being buried in accumulations of fine sediment. The presence of whale skeletons, at apparently several levels, indicates that they were deposited during a period of relative sea-level rise."* (Smith et al. 2010.)

Some suggest that an extraordinary lethal mechanism in the Firth of Forth (extreme tidal range, phenomenal tidal wave) has caused *cetacean* skeletons to accumulate here, but the problem seems almost self-explanatory. These creatures sometimes strand in shallow water and, wherever they die in great numbers, their remains should accumulate.

This argument does not require a detailed knowledge of *cetaceans* to be persuasive, but fails to address the extraordinary aspects of this case. Whales and dolphins are expected to strand in estuaries and shallow marine environments. Are *remains* of dead whales and dolphins expected to be *preserved* in these environments (very shallow marine) and in geological deposits from this time-period (the Pleistocene-Holocene?) As *cetaceans* have inhabited marine environments for the last 40my years (section 1.1.1), it should be clear from the geological record if the *"Whales"* in the carse are unusual or not.

2.3. *Cetaceans* in the Geological Record.

2.3.1. *Cetacean* Palaeontological Assemblages and Typical Preservational Environments.

Cetaceans committed themselves to marine habitats in the early Eocene (Uhen 2008; Lambert et al. 2019) and in consequence, the rocks which are known to contain their remains are well-dispersed (e.g. South Pacific, Lambert et al. 2019; Egypt, Gingeritch et al. 2019; Atlantic North America, Uhen 1999; India, Gingeritch et al. 2009; Antarctica, Fordyce & Marx 2018). Marine strata from the entire Cenozoic are present at some of these locations (e.g. Australia, Fitzgerald 2004; Pacific North America, Barnes 1976; Chile, DeMuizon et al. 2019; Japan, Oishi & Hasegawa 1994). However, no single location has a complete record of high-quality *cetacean* fossils spanning the Eocene, Oligocene, Miocene and Pliocene. Certain periods are represented by solitary high-quality fossils, from all continental landmasses (e.g. basal *mysticetes* in the Oligocene New Zealand (Tsai & Fordyce 2015), Australia (Fitzgerald 2006) North West America (Marx et al. 2015; Peredo & Pyenson 2018) and Antarctica (Fordyce & Marx 2018).

The chronostratigraphic fragmentation of the *cetacean* palaeontological record reflects the fact that a small number of depositional environments account for a disproportionate number of the fossils. Most *cetacean* remains have been found in coastal shelf sequences and basinal fills, often deposited during large-scale (200m) marine transgressions along tectonically-active coastlines (e.g. Pacific North (Ray 1976) and South America (Bosio et al. 2021; Italy, Danise & Dominici 2014.) In some cases, complete profiles of sedimentary units from the shallowest (tidal flats and beaches) to the deepest (shelf-edge) parts of the neritic zone have been uplifted intact and can be traced laterally and vertically in the stratigraphic column (e.g. Pliocene Italy, Dominici et al. 2018; Oligocene-Miocene Austria; Filek et al. 2021, Voss et al. 2016; Micoene Pisco Formation, Peru; Bosio et al. 2021). In geological time, the deeper-shore face (i.e. below wave-base, 50 - 200m) has proven most amenable to pristine preservation of dead *cetaceans*.

Here, a complex interaction of physical (type and rate of sedimentation; Brand et al. 2004; Gariboldi et al. 2017), ecological (role of *osedax* osteophages and carnivorous scavengers; Kiel et al. 2010, Cicimurri & Knight 2009), chemical (local or episodic anoxia, Gioncada et al. 2018) and physiological factors (length of time carcass has floated; degree of decay preventing or permitting re-floating; Danise & Dominici 2014) can prevent the destruction even of baleen (Marx et al. 2017). Deposits from progressively shallower environments contain fewer remains at exponentially greater states of fragmentation: conditions here promote, rather than arrest, the dispersal of a *cetacean* carcass (e.g. Boessnecker et al. 2014). In the geological record, skeletons in sediments from beaches or tidal flats are known (Stewart et al. 2011; Pyenson et al. 2014; Collareta et al. 2020; Bosio et al. 2021 8, 12, 42) as the rarest type of palaeontological assemblage: *"Stranded* [cetacean] *carcasses are dispersed rapidly. Sporadic broken bones from shallow water, inner shelf facies suggest that strandings are a minor potential source of fossils."* (Ford & DeMuzion 2001 209).

Poorly-understood phases of *cetacean* evolution correspond to those periods of geological time, in which rocks from deeper marine environments are scarce. Due to extreme sea-level fluctuations (Uhen & Pyenson 2007; Pyenson & Lindberg 2011), the Pliocene-Pleistocene is largely represented by very shallow marine deposits that contain few *cetacean* fossils (e.g. Pacific North America, Barnes 1973; Europe, Deméré et al. 2005; Japan, Kimura 2009). Beyond dispersed and isolated bones, extant *Balaenopteridae* and *Balaenidae* species have almost no presence in the palaeontological record (Fordyce 2018, Deméré et al. 2005.) This is a major absence, at a critical time in *mysticete* evolution: small-bodied species became almost entirely extinct in the Pliocene as the survivors were selected for giganticism, migrancy, and an anti-tropical distribution (Marx & Fordyce 2015; Fordyce 2018; Fordyce & Marx 2018). The causes of these physiological, behavioural and ecological changes are under debate (Pyenson & Lindberg 2011; Slater et al. 2017; Bisconti et al. 2021) and new palaeontological specimens for this period are badly wanted.

2.3.2. The *"Whales"* in the Carse of Stirling, as a Palaeontological Assemblage of *Cetacean* Skeletons from the Early Holocene.

As fossil *cetaceans* had not been much studied by the early 20th century (e.g. Owen 1846; Van Beneden 1882; Kellogg 1928) Morris (1893, 1925) and his predecessors (Milne Home 1872, 1881; Turner 1912) are blameless in their oversight. Nevertheless, the bones and skeletons of "*Whales"* in Scotland's Firth of Forth could have major implications for the palaeontology of *cetaceans*.

Primarily, these remains evidence species of *mysticete*, and a period *cetacean* evolution, otherwise devoid of palaeontological representation. Moreover, the remains of dead whales and dolphins are not expected to be preserved in deposits from estuaries and beaches. It may be self-evident that *cetaceans* strand in shallow water but that, by itself, cannot explain why the *skeletons* of dead *cetaceans* have been found in the Firth of Forth. The number of *cetaceans* that die and the number, whose remains are preserved in geological deposits, are not in a simple, proportionate relationship.

The Firth of Forth may have been a "death trap" (Clark 1947) for *cetaceans,* and some extraordinary lethal mechanism could be a factor (e.g. toxic blooms). However, high mortality without exceptional preservation (e.g. rapid sedimentation, extreme cold) would leave no trace in the geological record. A physical, chemical or biological agent must have acted in the Forth estuary during the early Holocene Inundation to promote preservation of dead *cetaceans*, and cause their skeletons to accumulate. If that agent is general to all very shallow marine environments then other, major reserves of *cetacean* fossils from this period may have been overlooked. Can that agent be identified? Again, the wider palaeontological record for *cetaceans* may help here.

2.3.3 Taphonomic Interpretation and *Cetacean* Palaentology.

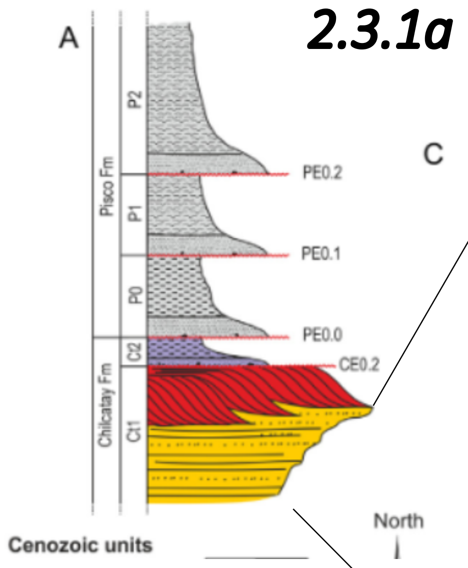
Palaeontologists rely on qualitative observations to reconstruct what might have happened to a *cetacean* carcass, after the animal's death but before the preservation of its remains. These include the disposition of any bones and their state of articulation (e.g. lying "belly up", re-orientation of long bones; Moore et al. 2020; Collareta et al. 2015), study of the enclosing sediments and depositional structures (e.g. soft deformation structures, hummocky-cross bedding; Bosio et al. 2021; Fleming 2014) and microscopic observation on bone tissue (micro-abrasion, Pyenson et al. 2009; osteophage colonisation, Pyenson et al. 2014, Boessnecker 2011; diagenesis, Malinverno et al. 2023.) (Fig. 2.3.1a - d.) These might substantiate certain mechanisms (e.g. long exposure on a sediment-starved surface or submersion into a soupy anoxic substrate, Bosio et al. 2021) and, in the case of assemblages of many *cetacean* skeletons, permit generalisations about the causes of preservation in the greater palaeoenvironment.

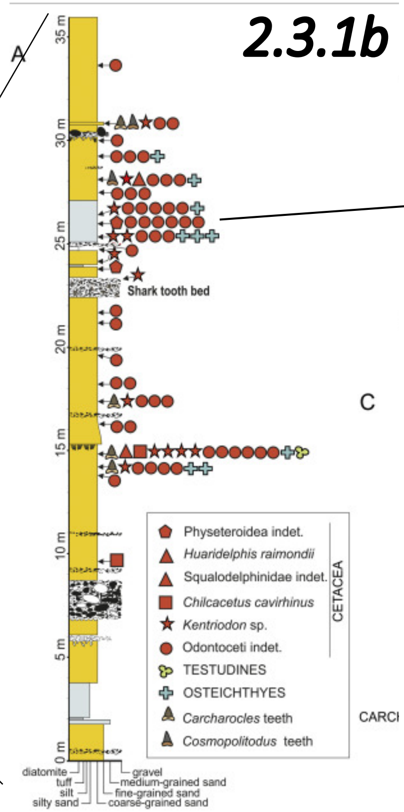
Therefore, explaining how and why the remains of animals accumulate in a geological deposit is an exercise in conjectural reasoning (e.g. Fig. 2.3.1 d; also Pyenson et al. 2014 4 – 6; Walsh & Martill 2006, for assemblages in discrete members of the Bahia Ingesa Formation, Le Roux et al. 2016). As taphonomic observations were rarely made for the assemblage of *cetacean* bones and skeletons in the carse clay, it is almost too easy to conjecture about the agents of preservation in the Forth estuary. For example, repeated storm events might have caused simultaneous burial of multiple animal carcasses. On the other hand, a steady rate of sedimentation could have gradually preserved many individuals, over a much longer time-period.

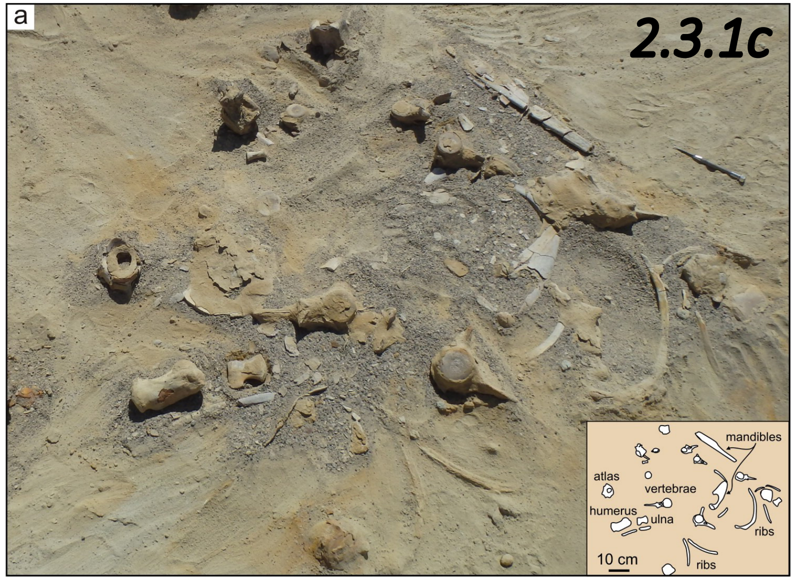
2.4. Importance of Chronological Data to Palaeontological Interpretation.

Mass mortality events and steady accumulation can be argued for equivocally because none of the ages of these fossil *cetaceans* in the carse are known for certain. With this information, one of these two, mutually incompatible theories could be eliminated. For example, if bones are evenly distributed throughout a rock unit (and are therefore all of different ages) then the chronology would not permit an instantaneous and simultaneous catastrophe. The remains have accumulated rapidly or gradually, but ultimately continuously, under the action of a consistent environmental agents (e.g. Early Miocene Chilcatay Formation, Biannuchi et al. 2016; Fig 2.3.1a-d).

Steady processes over long time-periods can still cause bones and skeletons of *cetaceans* to accumulate on single stratigraphic levels. Sediment starvation or winnowing of fine deposits can condense thousands of years of animal remains into dense "bonebeds" (e.g. Pliocene Purissima Formation, Boessnecker et al. 2014; Sharktooth Hill, Pyenson et al. 2009). As such, contextual clues (e.g. if bones have been abraded or shifted by currents, indicating prolonged exposure) also provide important chronological information.







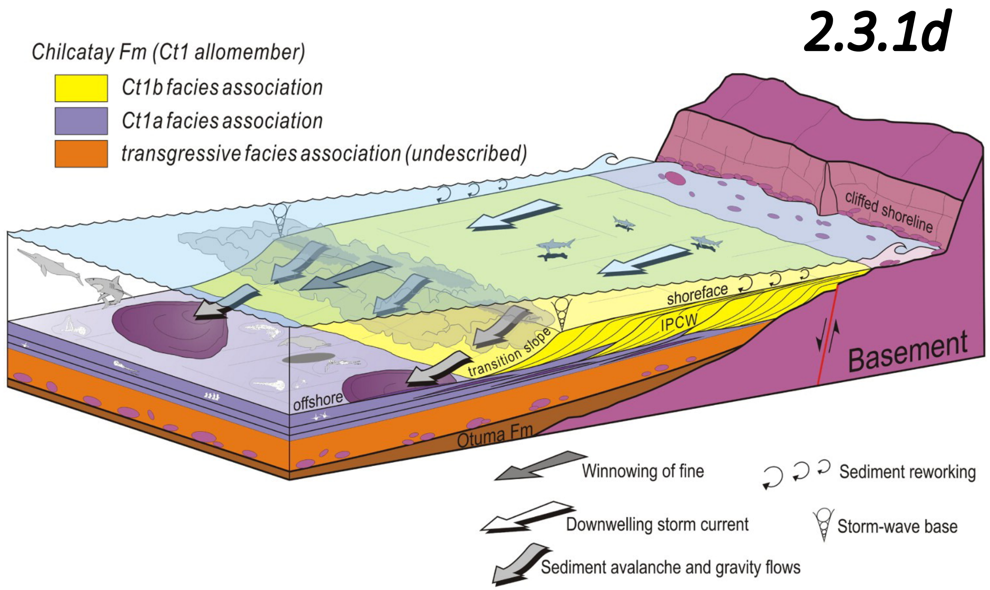


Fig. 2.3.1 Chilcatay Formation and *Cetacean* Palaeontological Assemblage. **(a:)** Stratigraphic column, Pisco Basin, Peru (Eocene-Pliocene): Chilcatay Formation (early Miocene) consisting of two allomembers [CT1b, red, coarse cross-bedded gravity-flow deposits; CT1a, fine-grained suspension deposits]. **(b:)** Concentration of *cetacean* remains (stars, triangles, squares) to lower allomember; even chronostratigraphic distribution of *cetacean* remains, within lower allomember. **(c:)** Taphonomic evidence, e.g. state of dispersal, lack or presence of micro-wear abrasion, absence or presence of uniform orientation of long bones. **(d:)** Synthesis, to explain why *cetacean* skeletons accumulated in this specific offshore marine environment in the Early Miocene. *Cetaceans* die (e.g. disease, injury) and carcasses float and decay for a prolonged period [evidenced by skulls missing bodies, bodies missing skulls; bite-marks on bones] before sinking to the seabed in a moderately deep, shelf-edge marine environment [facies architecture resembles a prograding carbonate wedge]. Deposition on a compact substrate [evidenced by lack of soft deformation structures around skeletons] in oxygen-deficient bottom conditions, inhibiting the action of benthic macro-scavengers [iron oxide framboids and absence of shelled benthic organisms in CT1a.] Sedimentation is very slow. After Biannuchi et al. (2016.)

Without these observations, it may never be possible to identify the agents which caused *cetacean* skeletons to accumulate in the Firth of Forth, during the early Holocene. A provisional chronology would limit the number of potential explanations and direct the conjecture. To advance with this problem, stratigraphic data and absolute dating evidence (C^{14}) can be used.

2.5. Summary.

Academics were well-aware that many *cetacean* skeletons had been preserved in the carse clay: a shallow marine, estuarine deposit, that accumulated during the early Holocene in the Firth of Forth. Such palaeontological assemblages are rare for this geological period, and almost unprecedented for such depositional environments. Ruling out prehistoric human intervention, the most simple and intuitive explanation - that *cetaceans* strand in shallow water - relies on superficial and anecdotal knowledge of exotic marine animals, rather than on palaeontological data. For *cetacean* skeletons to have accumulated in the Firth of Forth, an exceptional agent, or mechanism of preservation, must have been in operation. It may therefore have operated in other, similar environments. To help identify that agent, the ages of some of these *cetacean* bones and skeletons must be determined. The means do this are by stratigraphic inference and absolute dating evidence.

3. METHODOLOGICAL APPROACH.

3.1. Introduction.

To establish how and why *cetacean* remains accumulated in the Firth of Forth, the ages of some of those bones and skeletons must be determined. In principle, stratigraphic inference and absolute dating techniques (e.g. ^{14}C, or radiocarbon dating) can provide this information. In practice, the carse is an unconventional chronostratigraphic unit and *cetacean* tissue can be challenging to radiocarbon date. In addition to these technical obstacles, the documentary record of *cetacean* remains in Scotland is archaic, and likely defective. Bones in museum curation have been subject to anarchic conservation practices. Mix-ups, false attributions or missing specimens are all possible.

3.2. Determining the Age of *Cetacean* Remains.

3.2.1. Determine the Age of *Cetacean* Remains by Position Relative to the Stratigraphy.

The ages of most *cetacean* fossils in the palaeontological record are not, themselves, known. It is often clear, from stratigraphic context, if the animal's remains are older or younger than something else. In relative terms, those lower in the sedimentary column pre-date those that are higher, and those at the same level are roughly contemporaneous. The ages of geological units are determined by qualitative and quantitative chronometric devices (e.g. type-fossils, isotope ratios, tephra.) Widespread units are correlated to each other with this information, and then fitted into a global chronostratigraphic framework. Textures, structures, trace and body fossils etc. evidence the environment, in which these sediments and remains accumulated.

The *cetacean* remains in the Forth Valley are preserved in a sedimentary unit with a cryptic depositional history: the carse (Chapter Two, 2.1.2.3.) Relative sea-level change in Quaternary Scotland has been conditioned by isostatic uplift, which is spatially variable. The western and eastern extremities of the Forth Valley uplifted at different rates (Sissons 1963). Relative sea-level rose over older "*Shorelines*" that were abandoned progressively, and asynchronously (Cullingford et al. 1991). The carse, itself, is inclined. Over the short period of its accumulation (9.5 – 2.0 ka BP), periods of relative stability and shoreline formation have never been prolonged (Smith et al. 2010).

Rapid alternation between regression and transgression in the Firth of Forth complicates any inference, about the relative ages of the *cetacean* remains in the carse (Chapter Two, Fig, 2.1.4.) The *cetacean* skeletons at the greatest elevations (15m ODN) are not the most recent, but those subjected to the greatest uplift. Remains at the lowest elevations are not the most ancient, and those at the equal elevations may not be the same age. This particularly applies to any between 0m and 5m ODN, which could have accumulated at the start (9 ka BP) or end (2 ka BP) of the inundation in shallow water, or at the time of highest sea-levels (6 ka BP) in the deepest parts of the estuary.

Compounding these problems, the carse clays are homogenous and do not form well-defined facies that extend laterally throughout the Forth Valley (Browne et al. 1984; Dalrymple et al. 1992; compare 2.3.1a, "Chilcatay Formation.") Whilst Barras & Paul (1999 130) describe three facies witin the carse clays ("Claret Formation") at Bothkennar, these were principally distinguished by microfabric and X-ray densinometry signatures. Per Paul et al. (1992 188), *"the vertical transition of the facies is not always easily seen from visual inspection."* Given that these facies require time-intensive and sophisticated analytical techniques to identify – and may not be so well-expressed in the Upper Forth Valley, where the carse clays are only 5 - 6m thick – Barras & Paul's framework (1999) cannot be applied in this thesis. Even though numerous depositional environments exist in the Forth estuary (and must have been in constant motion as relative sea-level rose and fell) the sediments, themselves, do not appreciably reflect these changes in water depth and energy.

3.2.2. Determine the Age of *Cetacean* Remains by Radiocarbon Dating Bones.

If the stratigraphic context allows only very simple chronological inferences then the ages of the *cetacean* bones themselves can be derived directly, using the radiocarbon dating technique. These specimens are well-preserved but unpetrified: notionally, the amount of unstable ^{14}C atoms (half-life 5730 years) that remain in the bones should indicate the year in which the animal, itself, died. Whilst radioactive decay is inherently unpredictable and instrumental inaccuracy is unavoidable, the margin of error for a radiocarbon date is within 300 – 500 years.

With caveats, this technique can provide precise chronological data for the *cetacean* remains in the carse. To ensure their accuracy, all radiocarbon dates undergo adjustment to account for the variable concentration of ^{14}C in time and space (adding or subtracting 200 – 300 years; *calibration*). Determining how much adjustment a radiocarbon date requires is especially important for marine organisms: some have proven to require additional, and sizeable *corrections* (adding up to 1000 - 1,500 years; ΔR ^{14}C) to compensate for local *marine reservoir effects*. It is then necessary to make assumptions about the amount of ^{14}C that an ancient marine organism took up prior to its death.

For a gigantic, intelligent and mobile *mysticete* whale, it may not be easy to say where it went, what it ate, and how much ^{14}C it assimilated over its lifetime. These animals' behaviours are complex and adaptive to local circumstances. In the last fifty years, *mysticetes* have been observed to abandon or adopt new feeding grounds (e.g. blue whales [*B. musculus*] near California; Fielder et al. 1998) or to have settled into non-oceanic bodies of water (e.g. Mediterranean fin whale [*B. physalus*] population; Geijer et al. 2016). It may be unsafe to assume that modern and ancient *mysticetes* behaved in the same ways (e.g. *E. robustus* and habitat loss, Pyenson & Lindberg 2011), but some researchers argue that it may not matter. Mangerud et al. (2006) reason that, because of these same behaviours, radiocarbon dates from *cetacean* tissue do not require local reservoir *corrections*.

3.2.3. Cross-Checking the Stratigraphic Position of a *Cetacean* Skeleton, with the Radiocarbon Date from a Bone, with the Empirical Timeline of Sea-Level Change in the Forth Valley.

In the Firth of Forth, the relative ages of different *"Shorelines"* are clear from their geometry (e.g. decreasing gradients; Chapter Two, Fig.2.2.1b). Based on their relative situations (e.g. one *"Shoreline"* is eroded into another) or stratigraphic succession (the deposits of one *"Shoreline"* are emplaced on another) the order in which they formed can be established (Chapter Two, 2.1.2.3). Since peat formed on the *"Buried Beaches"* as sea-level fell, and was then "buried" under carse clay during the Early Holocene Transgression (c. 9.5ka BP – 4.5ka BP), the timing of sea-level rise in this period has been confined by radiocarbon-dating (Smith et al. 2010, 2012.) Peat also grew on the carse as sea-level fell from the *"Main Postglacial Shoreline",* allowing the rate of regression to be determined by the same methodology.

The bones and skeletons of *cetaceans* in the Forth Valley are all preserved in that carse clay. As such, radiocarbon dates from their bones should conform with the radiocarbon dates on the buried peat, supporting this part of the inundation timeline. Whales and dolphins only live in the sea: at certain times, it will have been physically impossible for these animals to have reached certain parts of the Firth of Forth. For example, a skeleton found at 14m ODN (which sea-level had only risen to, by c. 7.5 ka BP) should not produce a radiocarbon date of 10.5 ka cal BP. At that time, sea-level stood at c. 5m ODN. Contradictions like this are already apparent. Smith et al. (2010) radiocarbon-dated a bone, said to be from the *Balaenoptera* skeleton found at Cornton (c. 8m ODN), to 500 – 0 cal BP. By 1700 AD, sea- level had long since fallen to its present level.

Therefore, chronostratigraphic inference and direct ^{14}C dates from *cetacean* bone can mutually validate one another, and any remains found in contact with an underlying terrestrial deposit could be dated by stratigraphic association. However, many of these remains are "suspended" in homogenous carse clay: it is not safe to assume that these remains are from animals that stranded, and were then preserved, at high-water mark. At the time of highest sea-level levels (c. 15m ODN, 7.5ka BP) bones and skeletons could even have accumulated at deeper parts of the shoreface and now occupy a lower station (e.g. 7m ODN) – misleadingly suggesting, that they are very old.

For this to work at all, the original position of the *cetacean* remains must be reconstructed and a bone, certain to belong to that assemblage, located and sampled. If the original documentation is at fault, then neither task can be done. Since all these *"Whales"* were recorded, recovered and conserved in the 19th century, there is good reason to handle these materials carefully.

3.3. The Documentary Record.

3.3.1. Overview.

Geology matured rapidly as a scientific discipline in the 19th century. In that time, many individuals (e.g. Conybeare 1822, 1824; DeLaBeche & Conybeare 1824; Mantell & Mantell 1822, Owen 1846) studied palaeontology and published cohesive papers on this subject. Their research is archaic, but also methodical, organised, and professional. Even if the conclusions have been superseded, the primary information in these papers (location, stratigraphic position, dimensions of bones and descriptions of anatomical structures) should have been faithfully recorded.

Every reported discovery of *cetacean* bones and skeletons in the Forth Valley resulted unexpectedly from another activity (construction, Morris 1893; drainage, Home Drummond 1826; excavation, Lothian 1864 etc.) The recording itself has been reactive and many accounts are retrospective, second-hand, anecdotal, or incidentally embedded in documents on other topics. It has not been the responsibility of experts, but amateurs, who relate different and contradictory details about the same objects and events. No single account of a *"Whale's"* discovery is, in this sense, authoritative (although having numerous unauthoritative voices does allow cross-examination).

Furthermore, many of the *"Whales"* that appear in scientific papers were first recorded in informal sources (e.g. newspapers, Statistical Accounts of Scotland, *marginalia* in museum catalogues, maps, local government proceedings). In some cases, references have been handed down over centuries (e.g. Morris 1893, citing MacGregor Stirling 1815, citing Graham 1723, [appendix, op cit.]). As these bones and skeletons have been discovered in an arbitrary manner and documented by a succession of casual parties, it would be unwise to take this literature at face value.

Many of the "*Whales"* have then spent a long time in museum conservation, and been passed through several successor institutions. None of the skeletons are still in the high state of completion in which they were found, and several have been broken up between two or more collections. Lost bones are unfortunate. The association of bones lacking provenance with specific *cetacean* skeletons could undermine this investigation entirely. A radiocarbon date might validly indicate the age of a dubious specimen - but not that, of the "*Whale"* that it allegedly belongs to. As such, these factors may compromise any chronological data for this palaeontological assemblage, whether gotten by stratigraphic reconstruction or by radiocarbon dating.

3.3.2. Strategy for Analysis and Organisation of Historic Scientific Literature.

3.3.2.1. Selection Criteria.

Morris (1893 1924) asserted that as many as *"twenty Whales"* had been discovered in the Carse of Stirling. The most secure chronological inferences can be made in those cases, where:

- The place where the *cetacean* bone or skeleton was found, can be identified (e.g. maps, toponymy, verbal or textual descriptions, quantitative distances from known landmarks.)
- The original position of the *cetacean* bone or skeleton in the stratigraphic column can be reconstructed (e.g. depth below land surface, above a sea-surface datum, at a stratigraphic contact).
- A bone or other element, known without doubt to have belonged to that skeleton or to have been excavated at that place and time, can be identified in a museum collection (e.g. by a documented measurement, illustration, or species identification.)

3.3.2.2. Cases Selected.

Most *"Whales"* fail to meet these criteria (Appendix B). The following sets of *cetacean* remains are the best candidates, and as much evidence as possible has been compiled for them. The documents (e.g. eye-witness testimony, maps, museum records) in which allusions to that set of *cetacean* remains are thought to have been made, will be presented and evaluated ("Chain of References"):

- The skeleton of a *mysticete*, kept at Coldoch (c. Doune) and first documented by Morris (1893.) [TR]
- The skeleton of a *cetacean,* discovered at Blair Drummond (c. Doune) in 1824 (Home Drummond 1826.) [BF]
- The skeleton of a *Balaenoptera*, discovered at Meiklewood (c. Gargunnock) in 1877. (Stewart 1879). [USG]
- The skeleton of a *Balaenoptera*, discovered at Christie's Brickworks (Stirling) in 1858 (Milne Home 1871). [AJ]
- The skeleton of a *Balaenoptera*, discovered at Christie's Brickworks (Cornton, c. Bridge of Allan) in 1864. [JB]
- The disarticulated bones of a *mysticete*, discovered at Causewayhead (c. Stirling) in 1897

and 1901. (Morris 1903). [JB]

– The skeleton of a *Balaenoptera*, discovered at Airthrey (c. Bridge of Allan) in 1819 (Bald 1819). [ZT]

In connection with the *cetacean* skeletons discovered at Christie's Brickworks (Cornton) [JB] and Blair Drummond (c. Doune) [BF], reports of *cetacean* bones at Forthbank (Stirling) [AS] [JQA] and at a "Wood Lane" (c. Doune) [JM] are also discussed (Morris 1893, 1925).

3.3.2.3. , *"Whales", "Places"* and Misleading Nomenclature.

Information about these *"Whales"* has been structured around an informal naming tradition. For example, Home Drummond (1826 440) Milne Home (1847 53) Rogers (1852 207), Page (1865 102), Turner (1890 790) and Morris (1925 138) use the tag, *"Airthrey Whale",* when referring to the *cetacean* skeleton found at Airthrey. The same formula is also used to identify any bones in museum collections, thought to belong to that individual animal (e.g. catalgoue of the then-Smith Institute, in Redman 2004 365; label on *B. musculus* occipital NMSZ 1991.86 1, Fig.6.2.4b).

This convention is intuitive and enduring, but may prove to have been misleading. At different times, more than one set of animals' remains may have been found in a given locale (e.g. Dunmore). The tag, *"Dunmore Whale"*, might not sufficiently distinguish them and accounts, relating to entirely seperate skeletons, could have been mixed-up. More realistically, during the 18th and 19th centuries, a single set of remains could have been discovered, sampled or documented several times, by unrelated parties. Even those skeletons, said to have been excavated in their entirety upon discovery, were rarely catalogued at that time and have since been broken up. Bones in conservation might be thought to represent discrete and individual animals (e.g. *"Cowpark Whale 1"* and *"2"*) but could, hypothetically, be alienated parts of one single specimen.

Continuing to identify *"Whales"* only by *"Places"* is easy, but risks compromising this study. Accounts of different and discrete *cetaceans* could have been conflated, whereas single sets of fossil remains might have multiplied into several bogus*"Whales."* To better distinguish "*how many* discrete sets of remains, have been found in unique locations" from "*how many times* one single set of remains has been discovered", and examine *"how many pieces,* has a single skeleton been broken into", a new naming system is used here. Each case, in which a discrete and unique set of ancient *cetacean* remains is alleged to have been found, has been associated with an arbitrary alphabetic code (e.g. *"Airthrey Whale",* [ZT], *"Blair Drummond Whale",* [BF].) Whenever a *"Whale"* or whalebone from the Forth Valley is discussed in this thesis, the unique identifying code is also cited.

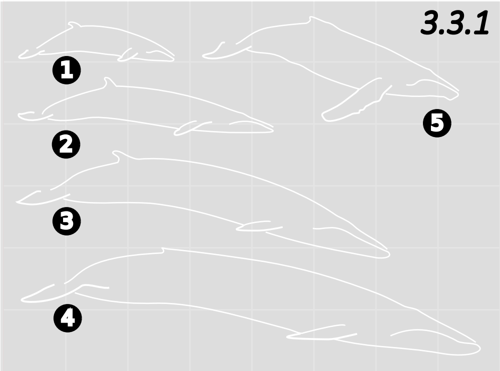
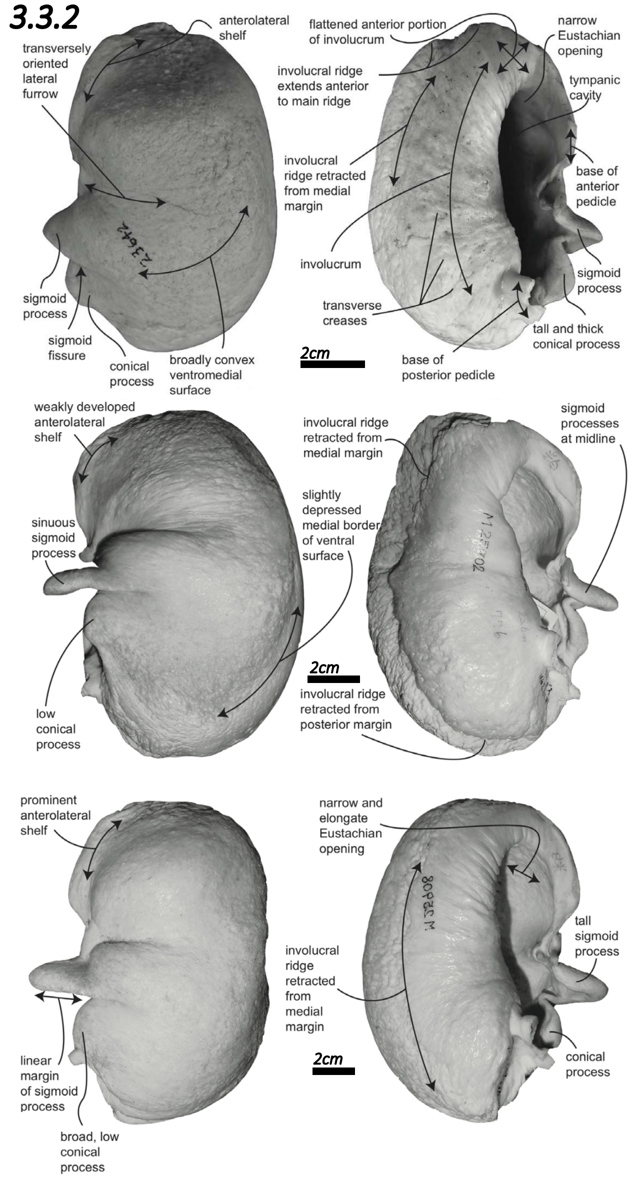


Fig. 3.3.1. (L). *Balaenopteridae* in profile: 1. Minke whale (*Balaenoptera acutorostrata*), c. 5m long. 2. Sei whale (B. borealis), c.15m long. 3. Fin whale (*B. physalus*), c. 20m long. 4. Blue whale (*B. musculus*) c. 25m long. 5. Humpback whale (*Megaptera novaeangliae*) c. 15m long.

Fig. 3.3.2. (R). ventral (left) and dorsal (right) views of *Balaenopteridae* tympanic bullae, annotated to show morphology and diagnostic structures. *B. acutorostrata* (top), *B. musculus* (middle) and *B. borealis* (bottom). After Berta et al (2008.)



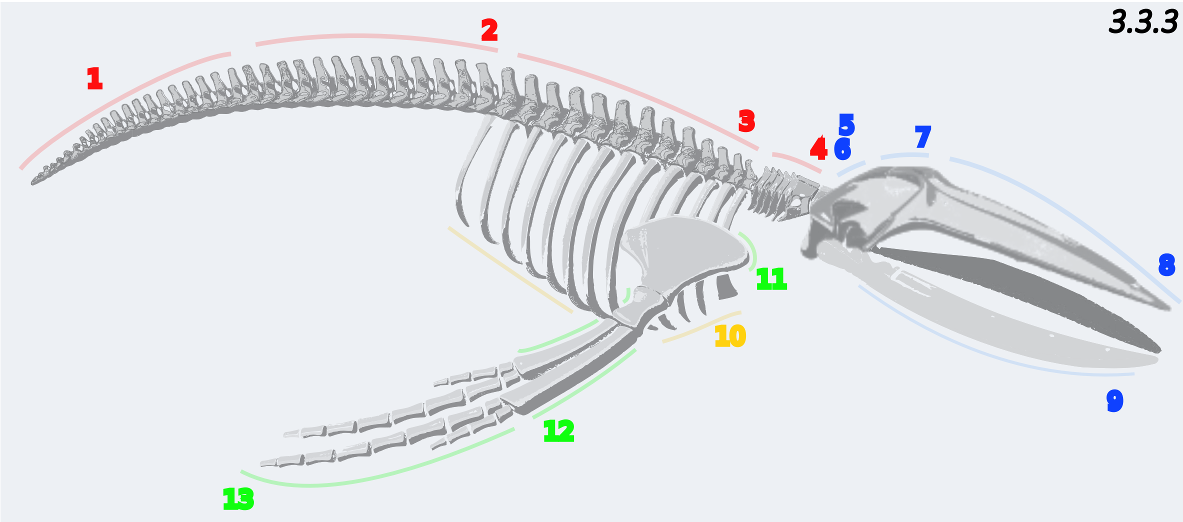


Fig. 3.3.3. Simplified Skeletal Anatomy of a *Balaenopteridae* mysticete, *Megaptera novaeangliae*. **Vertebrae [52]. 1.** Caudal (chevrons omitted) [21]. **2.** Lumbar [10]. **3.** Thoracic, or dorsal [14]. **4.** Cervicals, including axis vertebra (articulating with the skull) [7]. **Skull. 5.** occipital and **6.** tympanic bones **7.** frontal and paretial. **8.** maxillae. **9.** mandible [hyoid omitted]. **Ribs (15) 10.** from 1st (closest to the skull) to 15th [sternum omitted]. **Forelimbs. 11.** Scapula. **12.** Humerus, ulna and radius (fused). **13.** phalanges. [vestigial pelvis omitted] *M. novaeangliae's* disproportionate spine (number of caudal versus lumbar vertebrae), broad, equilateral scapulae and elongated forelimbs are unique to this species, and atypical among the *Balaenopteridae*. Anatomical data after Struthers (1889).

3.3.3.4 "*Whales*" , "*Balaenopteridae*", *Cetacean* Skeletal Anatomy and Informal Terminology.

Fossil *cetacean* remains from the Forth Valley are, in most original textual sources, simply described as "*bones*" or "*remains"* of "*Whales*" (e.g. Bald 1819; Home Drummond 1826). It is assumed that these are all the remains of baleen-bearing *mysticete* whales – and more specifically, of *Balaenopteridae* (e.g. Clark 1947 91, "*rorquals*".) That assumption seems valid: in all but one case, the "*Whales*" selected for this study (3.3.2.2) have been referred to that clade through competent anatomical diagnosis (Turner 1912).

Nevertheless, *"mysticete"* and "*Whale*" are not synonyms. The term applies to an entire family of animals, whose members differ markedly in size and physiology (e.g. Cuvier's beaked whales (*Ziphius cavirostris*), blue whales (*Balaenoptera musculus*), killer whales *(Orcinus orca.*). Amongst themselves, the *Balaenopteridae* are distinguished by gross differences in overall skeletal anatomy (e.g. adult body size; Fig 3.3.1) and by subtle differences between certain diagnostic bones. The crania, scapulae, tympanics and mandibles of *mysticete* whales can all allow for species-level identifications, due to those elements' unique morphologies or characteristic structures (Fig. 3.3.2).

If the species of a given *cetacean* skeleton is known from a creditable historic source, certifying which bones did and did not belong to it then becomes an easier task. Diagnostic elements have particular value here, because they can matched to (or alienated from) a given *"Whale"* with greater conclusivity. Formal taxonomic nomenclature is therefore maintained throughout this thesis. The term "*whale*" is avoided when discussing a set of fossil *cetacean* remains, except where the animal's species has been proven by professional diagnosis. Whenever appropriate, specific anatomical terms for given bones (e.g. axis vertebra) or structures (e.g. glenoid cavity) are used (Fig 3.3.3).

Only a bone, with the greatest amount of proof for it belonging to a given fossil *cetacean*, will be selected for radiocarbon-dating. By way of justification, the curatorial history of each set of remains is recounted, as far as it possible to do so. Bones surviving in modern collections, thought to belong to a specific *"Whale"*, are identified. In several cases, bones without any provenance have been associated with certain *"Whales".* The evidence for these associations is evaluated. Whenever a bone in a museum collection is referred to, its accession or catalogue number is also cited.

3.3.2.5. *"Whales"*, "*Skeletons*", Defining and Interpreting Articulation in Palaeontology.

An exhaustive vocabulary exists, by which the soft and bony organs belonging to a *mysticete* whale can be identified precisely (Fig. 3.3.3). When *cetacean* bones have been excavated from the carse, authors usually rely on general terms with looser meanings to describe what was found. "*Remains*"

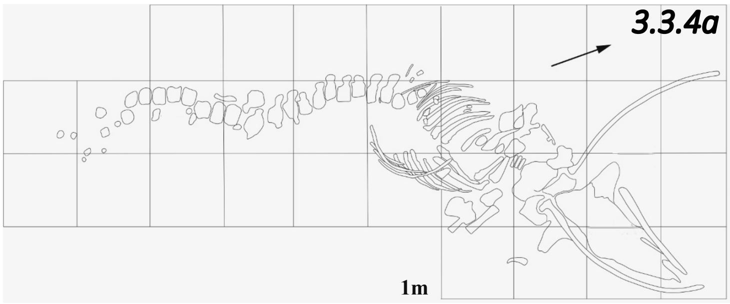
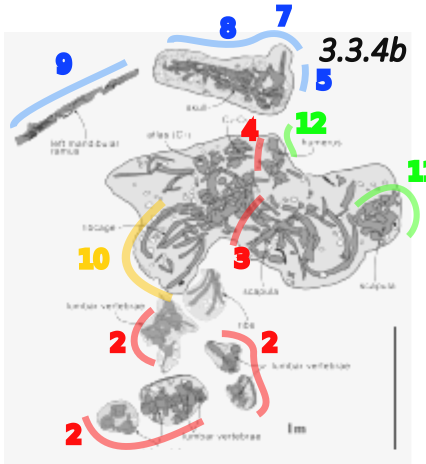
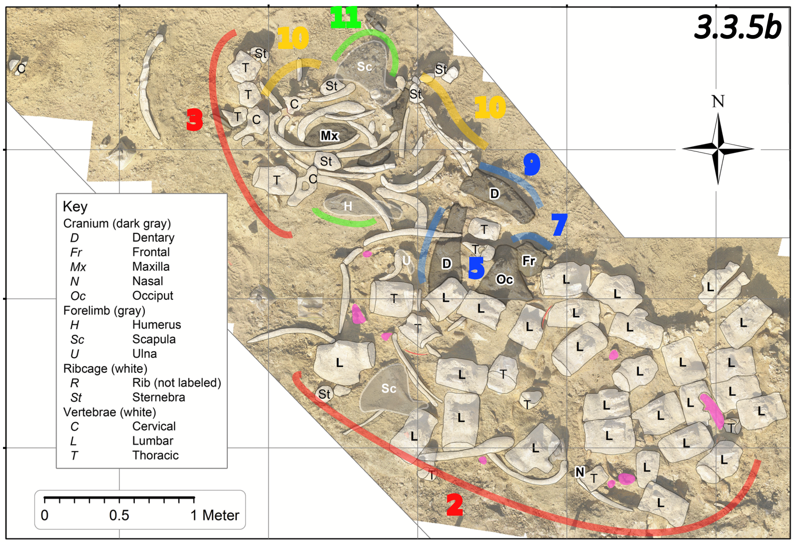


Fig 3.3.4a. *Mysticete* skeleton [WH1] from Orciano Pisano, Italy, Fine Basin (Gelasian 3.19 - 2.82 mya). In fine-grained sandstones with a "whale-fall" mollusc assemblage (Dominici et al. 2009). After Danise (2010.)

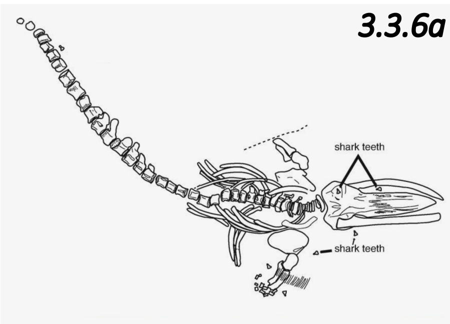


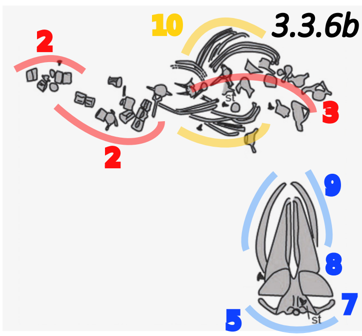
Fig, 3.3.4b. *Mysticete* skeleton "*Brunella*" from Poggio alle Mura, Italy, Ombrone Basin (E. Zanclean, 5.1 - 4,4mya). In clayey sand with wood nodules: (2) - (12) as in Fig, 3.3.3. After Bisconti et al. (2023).

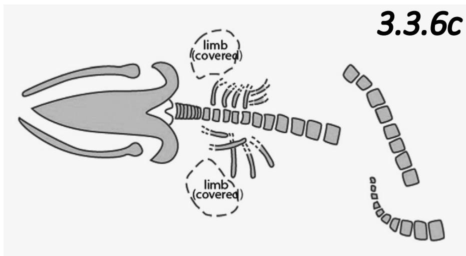
Fig 3.3.5a. *Basilosaurus isis* skeleton from Wadi etl Hitan, Egypt, Birket Qarun Formation (E. Late Eocene, 37 - 45mya.) After Peters et al. (2009).



Fig, 3.3.5b. *Basilosaurus isis* skeleton [WH10001] from Wadi etl Hitan, Egypt, Gehannam Formation (Mid Eocene, 41 - 37mya). (2) - (12) as in Fig, 3.3.3. Fragmented and bite-marked bones of other animals, interpreted as stomach contents, in purple. After Voss et al. (2019).







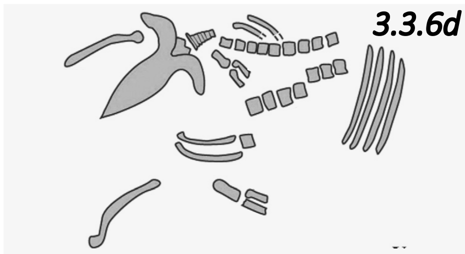
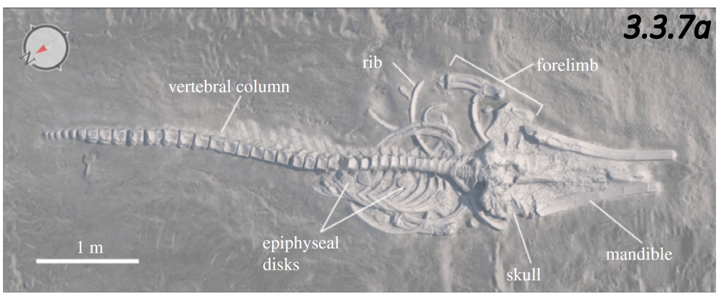


Fig 3.3.6a. *Mysticete* skeleton (WCBa-20) from Pisco Formation, Peru, Cerro Blanco Norte. Found in diatomaceous siltstone. After (Esperante et al. 2008).
Fig 3.3.6b. *Mysticete* skeleton (CB11-03) from Pisco Formation, Peru, Cerro Blanco Norte. Found in diatomaceous siltstone. After (Esperante et al. 2015).
Fig 3.3.6c. *Mysticete* skeleton (CBal5) from Pisco Formation, Peru, Cerro Blanco Norte. Found in diatomaceous siltstone. After (Esperante et al. 2015). (2) - (10) as in Fig. 3.3.3.
Fig 3.3.6c. *Mysticete* skeleton (CBal14) from Pisco Formation, Peru, Cerro Blanco Norte. Found in diatomaceous siltstone. After (Esperante et al. 2015).



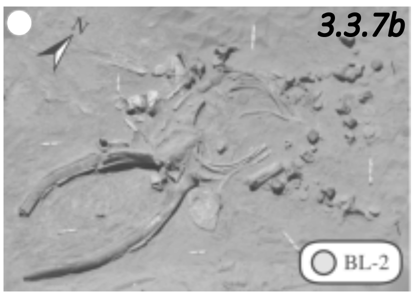
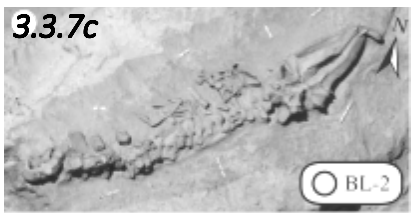


Fig 3.3.7a. *Mysticete* skeleton from Cerro Ballena, Chile, at stratigraphic level "BL-3". After Pyenson et al. (2014).
Fig 3.3.6b. *Mysticete* skeleton from Cerro Ballena, Chile, at stratigraphic level "BL-2". After Pyenson et al. (2014).
Fig 3.3.6b. *Mysticete* skeleton from Cerro Ballena, Chile. at stratigraphic level "BL-2". After Pyenson et al. (2014



(Home Drummond 1826; Stewart 1882; Geikie J 1881 399), *"bones"* (Owen 1845 542; Milne Home 1847 30, 51; Jamieson 1865 190), "*fossils*" (Wilson 1851 33 – 4; Lyell 1863 53) or simply, "*whales*" (Morris 1893, 1925; Clark 1947) are also found throughout this thesis but, if used too freely, give false impressions of the palaeontology. Reading of Morris' (1925 139 - 140) *"Broomhall Whale, found in Lord Elgin's garden"* [JEC] and *"Grangemouth Whale, found 9' below the surface*" [JFK], the discovery of an entire *"whale"* (i.e. Fig. 3.3.3) at those locations might be inferred. In each case, only a single *mysticete* vertebra was excavated (Dundee Telegraph 22.2.1912; Burns 1869 367).

19th century eye-witnesses describe numerous bones *in-situ* (e.g. Lothian 1865; Milne Home 1871), account for them qualitatively (e.g. Stewart 1882) and rarely, catalogue them systematically (e.g. Bald, in Cal. Merc. 31.7.1819; Home Drummond 1826; Turner 1912 8). The most unusual thing about the fossil *cetacean* remains, found in the carse, does have a basis in fact: many individual animals are well-preserved here, wherein a large proportion of their bones survive. Few *"whales"* are represented by only solitary vertebrae, wherein all the other parts have been destroyed. Unsurprisingly, the terms "*skeleton"* or *"skeletons"* have been been applied consistently to this palaeontological assemblage (e.g. Bald 1819; Rogers 1853 342; Haswell 1865; Geikie J & Etheridge 1874 288; Munro 1899 58 – 9; Clark 1947 91; Smith et al. 2010).

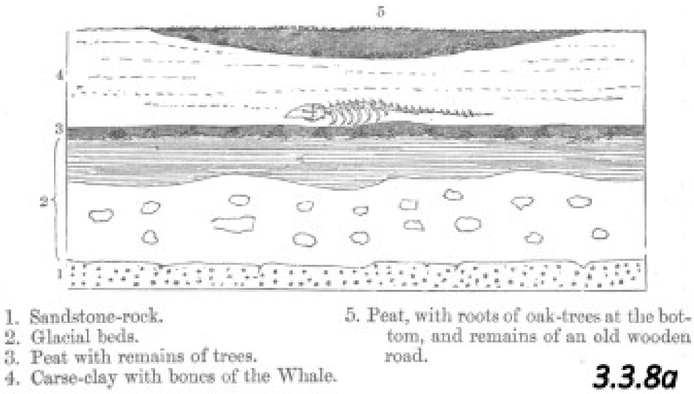
The high standard of preservation in the Forth Valley, and its unknown cause, are the subject of this thesis. Using unambiguous language to define different states of preservation is therefore a priority but the word, *"skeleton"*, is nuanced. As a familiar anatomical term, it has an explicit quantitative meaning (entire, i.e. every single bone represented) and an implicit qualitative sense (articulated, i.e. those bones occupy the positions, as if the organism were living; Fig. 3.3.3). When applied to palaeontological specimens, *cetacean* "*skeletons*" must also satisfy the first condition and be largely complete (e.g. 3.3.4a – 3.3.7b), even if conspicuous absence of certain bones indicate particular taphonomic pathways (e.g. 2.3.1c – d, for acephalous *"skeletons"* in the Chilcatay Formation).

Respecting the second condition, the term *"skeleton"* is not exclusive to those fully-articulated *cetacean* fossils (e.g. Fig. 3.3.4a , 3.3.6a, 3.3.7a) which most closely resemble an anatomical preparation (Fig. 3.3.3). Sets of remains from palaeontological contexts present a continuous spectrum of states (e.g. Fig 3.3.4b, 3.3.5a-b, 3.3.6b-d, 3.3.7a - c) and those which are profoundly disarticulated (e.g. 3.3.4b, 3.3.5b, 3.3.6b) can still be validly described as *"skeletons."* Even in these extreme examples, the elements are still correctly arranged from the anterior to the posterior (or, head to tail; Fig. 3.3.4b, 3.3.5b, 3.3.6b). The "*skeleton*" is undispersed even if all the constituent bones have themselves been moved (Voss et al. 2019).

Anlaysing those movements (or, degree of a *cetacean* skeleton's disarticulation) allows insights into the agents of preservation in a palaeoenvironment (Wuttke & Reisendorf 2012). The *Basilosaurs* from Wadi el Hitan (Fig. 3.3.5a – b) belong to the same species and were preserved at a similar part of the shoreface (neritic zone) at different stages of the same marine transgression (Peters et al 2009; Anan & Shahat 2014; Voss et al. 2019). Peters et al. (2009) argue that high-energy storm deposits buried the denser bones of the better-articulated specimen (3.3.5a), whilst dispersing its ribs. The disarticulated (but undispersed) skeleton (3.3.5b) is attributed to prolonged exposure on a sediment-starved seafloor, under the continuous action of a gentle, north-easterly current (rotation of long bones to perpendicular, stomach contents "downstream" from the thorax; Voss et al. 2019).

However, *cetacean* skeletons preserved in analogous environments and under similar conditions are not guaranteed to be in comparable states of articulation. The remains in Figs. 3.3.4a and 3.3.5b are both thought to represent whale-falls to the neritic zone after brief floatation (found "belly-down", i.e. not bloated by decompositional gases) to an area of slow sedimentation (Dominici et al. 2009; Danise 2010; Voss et al. 2019).Within assemblages from the same sites and rock units (e.g. Pisco Formation, Cerro Blanco Norte 3.3.6a – d) the same agents of preservation manifest themselves in a variety of semi-articulated and partly-dispersed "*skeletons."* Even animals at the same stratigraphic levels, and which died simultaneously (Cerro Ballena, 3.3.7b – c), are not at uniform states of articulation. Patterns can then emerge when an assemblage is analysed altogether: many Cerro Ballena skeletons are oriented north-south and found "belly-up" which, to Pyenson et al. (2014) was proof that these animals had died at sea and floated in, during repeat mass-mortality episodes.

When an eye-witness calls a *"whale"* from the carse a "*skeleton*", the remains could have been at any point on the spectrum of articulation (Fig. 3.3.4a – 7c). In one environment, the same agents of preservation do not express themselves uniformly. This data can reveal the causes of preservation for a given fossil or for an entire assemblage but, for the *cetacean* skeletons in the Forth Valley, it is not yet possible to investigate this. Articulation is essentially visual information (Fig. 3.3.4a etc.) and, so far as it has been explored, the 19th documentary record is purely textual. Although Bald (1819) and Turner (1912) allude briefly to articulation, other sources leave too much to the imagination. For example, Jamieson (1863) and Smith (1966a) both depict the *"Blair Drummond Whale"* [BF] as a complete and articulated skeleton (Fig. 3.3.8a – b), like Fig. 3.3.3. The original eye-witness accounts (Home Drummond 1826) do not describe the articulation, do not use the word *"skeleton"* and, in a catalogue, suggest that many bones were missing.



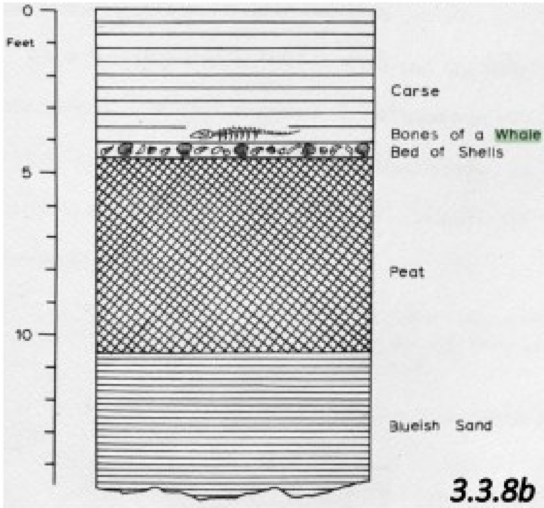


Fig. 3.3.8a. *"The Relations of the Superficial Deposits at Blair Drummond".* After Jamieson (1865).
Fig. 3.3.8b. *"The Carse Section near Blairdrummond.".* After Smith (1966).

Therefore, the term "*skeleton*" can give a false impression of the palaeontology if used too freely - just as much as "*whale*", "*remains*" and "*fossils*". Here, a set of *cetacean* remains is described as a "*skeleton*" if the sources suggest that a large number of indeterminate bones from one single individual animal survive, or if part of the cranium and a few post-cranial elements were present. The term "*skeleton*" implies nothing about the disposition of the remains and their state of articulation, as originally discovered. If few bones were preserved and there is no evidence of the survival of the skull, the term "*disarticulated remains*" is used. A symbol of an articulated *mysticete* skeleton, used in maps and diagrams (e.g. Fig. 1.2.1a), is illustrative only.

3.3.2.6. Stratigraphic Reconstruction.

No single method has been used consistently to record the positions of these *cetacean* remains. There are two common types: subtractive measures (e.g. a bone or skeleton's depth below ground or situation, relative to geological units of known thicknesses) and additive measures (e.g. a bone or skeleton's height above a marine datum).

The land surface elevation at the place of discovery must therefore be known, although this information is rarely found in the original reports. As the carse is sloped, a *cetacean* skeleton 1m deep at Dunmore (8m above ODN) and 1m deep at Gartmore (15m above ODN) stand at different elevations, relative to ***mean average sea-level*** (0m ODN). Many additive measures are not taken from ***mean average sea level*** (0m ODN) but from a local marine datum (e.g. highest high tide of the Forth, a prominent weathering line) at a higher elevation. In itself, ***mean average sea-level*** – expressed as the Ordnance Datum – has also changed since the 19^{th} century. Elevations are now taken against Ordnance Datum Newlyn (0m ODN) but, prior to 1920, were indexed to Ordnance Datum Liverpool (0m ODL). On old and new OS maps, there are discrepancies of up to 30cm +-

between elevations at the same locations.

Whether calculated by addition (e.g. 0m ODN + 14m) or subtraction (e.g. 15m ODN – 1m) the same result should be reached for the position of a set of *cetacean* remains. By adding the thickness of the overlying sediments (e.g. 1m of clay) to the elevation of the bone or skeleton (e.g. 0m ODN + 14m + 1m) the land-surface height at the location can also be determined (e.g. 15m ODN). All these values should equate. Mutually contradictory results (e.g. 15m ODN – 2m; 0m ODN + 12m) might indicate that one of the two data surfaces has been misidentified, or ultimately, that a primary source has made an incorrect measurement. Therefore, all available stratigraphic data are plotted and cross-examined ("Datum Diagrams.")

OS spot-heights may not have been taken recently in some locations and, in others, the land-surface may have been altered by construction, extraction, subsidence or compaction. Old Ordnance Survey elevations (ODL) must be used and, as far as possible, corroborated by modern surveying data from other sources (levelling for geotechnical cores, isostasy-eustasy research, building plans, Google Earth Pro, etc.) In this way, disparities between measures taken relative to ODL and ODN should be revealed. When required to estimate a land surface elevation, other isostasy-eustasy scholars (e.g. Sissons 1964, 1969) permitted a c. 30cm margin of error. If the margin of error between a measure ODL and ODN falls in that range, then the measure ODL will be acknowledged, but not adjusted. All maps, used for all figures in Chapter Four, are compiled in Appendix C.

3.4. Summary and Aims.

Every *cetacean* bone will provide a radiocarbon date. If that bone belonged to a certain skeleton, found at a known location and in a determined stratigraphic position, then that date should not contradict the empirical inundation timeline for the Forth Valley, c. 9.5 – 2.5ka BP. Determining the age of these *cetacean* bones and skeletons will allow some insight, into the processes that caused them to accumulate in the carse. However, archaic documentary sources must be relied on, most of which do not qualify as formal scientific literature. The information they contain is not inherently false, but will require careful reading and thorough evaluation to be useful. If this methodology succeeds, the following aims should be fulfilled:

1. Review literature (scientific or informal), relevant to the discovery of sets of *cetacean* remains in the carse. Evaluate information concerning the location, circumstances of discovery, stratigraphic position and degree of preservation of the *cetacean* bone or skeleton. Acknowledge discrepancies between accounts and if possible, resolve them.

2. Predict the age of a set of *cetacean* remains, based on the most plausible stratigraphic reconstruction (location, elevation, thickness of overlying deposits, at a stratigraphic contact.) Consider the taphonomic circumstances that result from the peculiar physiology of *mysticete* whales, and which might apply to each case.

3. Learn the fate of the bones, after their excavation and establish if any elements are still extant in modern museum collections. Identify bones that can, with the greatest confidence, be said to belong to specific *cetacean* skeletons, excavated at known places and times. Examine bones that are stated to belong specific *cetacean* skeletons, and whether there is sound proof for those attributions. Prioritise bones with provenance for radiocarbon-dating.

4. EVALUATION AND ANALYSIS OF HISTORICAL SOURCES.

4.1. Introduction.

4.1.1. Introduction of Cases.

Each time a *cetacean* bone or skeleton was discovered in the Forth Valley during the 19th century, a different set of individuals, in different circumstances, recorded information about those remains in a different manner. Once excavated, each assemblage had a chaotic curatorial history. While a few people (introduced below) are involved in several cases, each discrete set of *cetacean* remains is associated with a unique set of palaeontological, stratigraphical and historical problems. These are approached case-by-case, from east to west (Fig. 4.1.1a and b):

- The skeleton of a *mysticete*, kept at Coldoch (c. Doune) [TR]. An entire *mysticete* skeleton, of unknown origin. Several authors have tried to account for its provenance. The primary documentary evidence concerning it is reviewed.

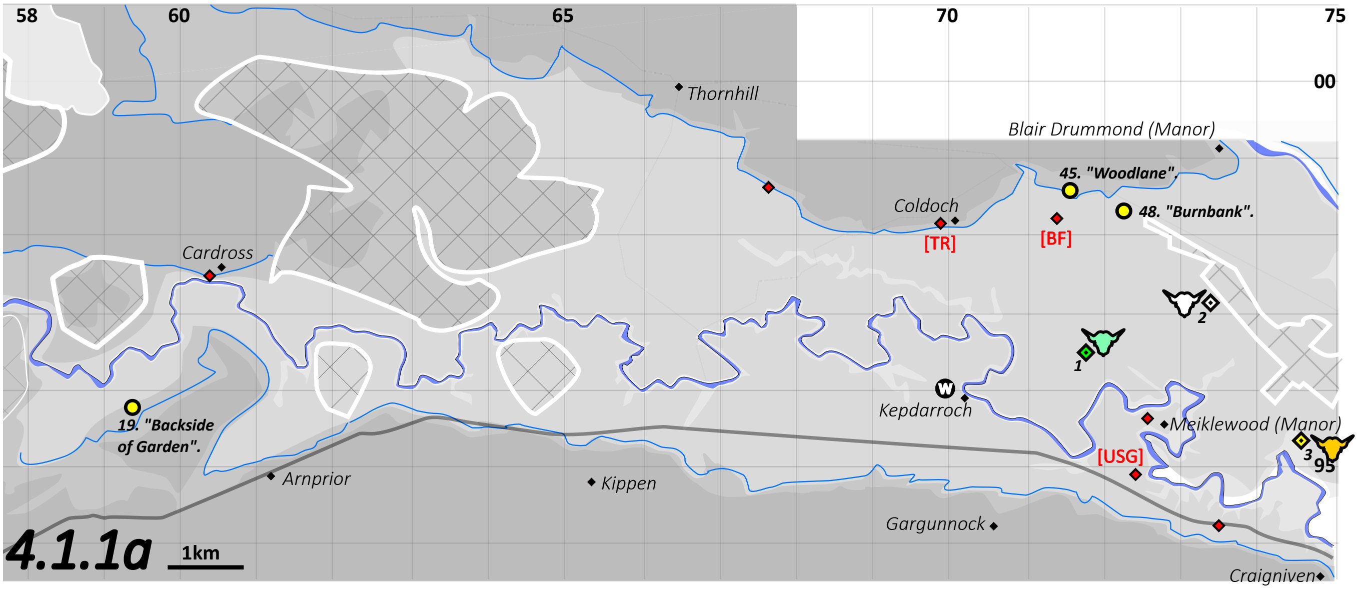
- The skeleton of a *cetacean,* discovered in a geological context at Blair Drummond (c. Doune) [BF]. Its stratigraphic situation can be reconstructed and accords with modern sea-level change research. Its species, and the survival of any bones in modern collections, are unresolved problems.

- The vertebra of a *cetacean*, kept at Blair Drummond Manor (c. Doune). Believed by Morris (1893) to have been part of a discrete, unique, and otherwise unreported animal discovered on that estate, denoted *"Wood Lane Whale"* [JM]. The primary documentary evidence for this (cartography and toponymy) is reviewed.

- The skeleton of a *Balaenoptera*, discovered at Meiklewood (c. Gargunnock) in 1877 [USG]. Outstanding problems concern its location, stratigraphic position, geological contacts, provenance of bones assigned to it, and derived C^{14} dating evidence.

- The skeleton of a *Balaenoptera*, discovered at Christie's Brickworks (Stirling) in 1858 [AJ]. Introduction and discussion on unorthodox marine datum-points.

- Modern and foreign bones, brought to decorate the manor of Forthbank (Stirling) [AS] by its proprietor, the brickmaker John Christie. Morris (1893) suspected that some of these bones had been mistaken for parts on an ancient skeleton [JB] which radiocarbon-dating proves.



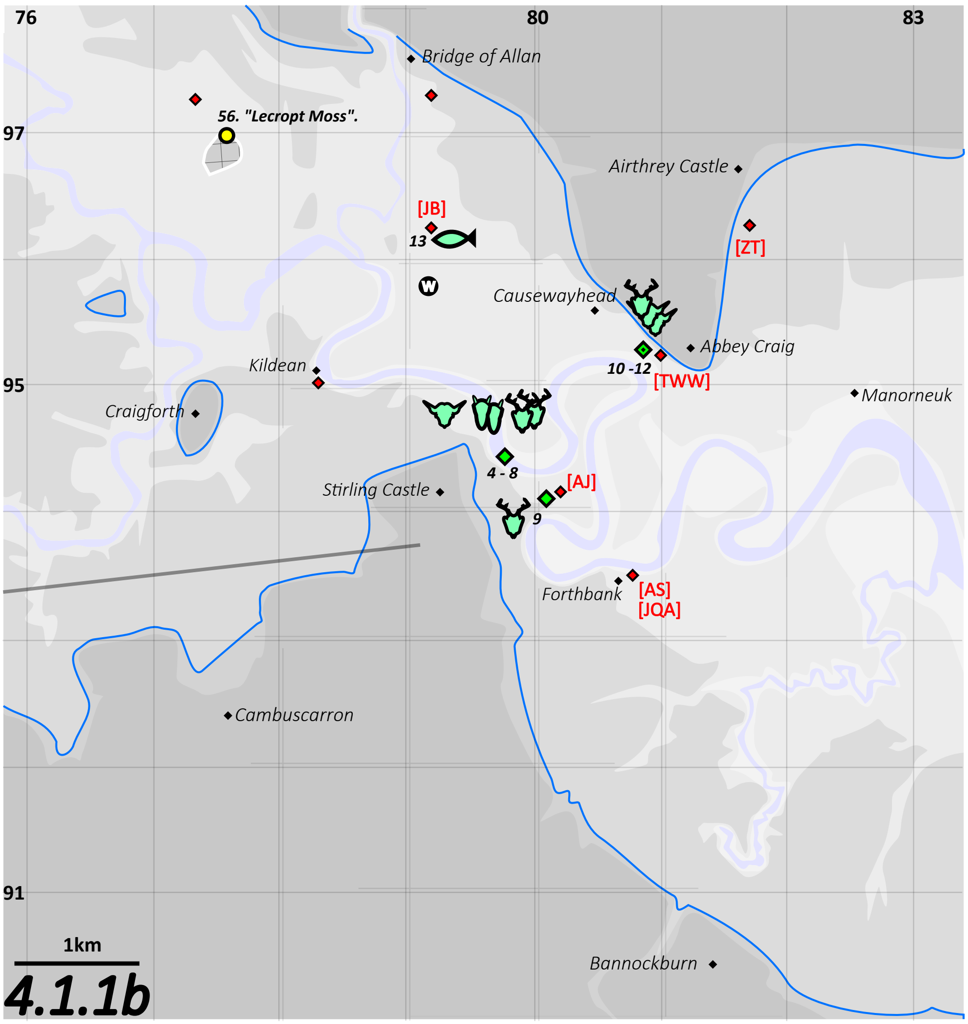


Fig. 4.1.1. a:) Mentieth and Gargunnock. **b:)** Stirling and Bridge of Allan. Edge of the carse clay (thin blue line). Peat or raised bog (white border, grey check.) Urban Area (Double-Ruled Line). 1 - 12. Other faunal remains (bovines, cervids, horses) from carse clay (green) peat (yellow) no provenance (white) [see Appendix C].). Road (thick grey line). Location where Milne Home marked a "*Whale*" in the map to *Estuary of the Forth* ("W"). Locations where *cetacean* bones and skeletons are alleged to have been found (red diamonds; Appendix B). Radiocarbon data from an isostasy-research paper (yellow circle). All numbers refer to compilation table ("2") in (Smith et al. 2010). Basemap and contour data after Modern OS Mapping (2022). All Eastings and Northings apply to Grid Square "NS".

- The skeleton of an ancient *cetacean,* which may have been legitimately discovered at the manor of Forthbank (Stirling). The primary documentary evidence for this (cartography and toponymy) is reviewed.

- The skeleton of a *Balaenoptera*, discovered at Christie's Brickworks (Cornton, c. Bridge of Allan) in 1864 [JB]. Conflicting stratigraphic reconstructions and doubt, on whether Smith et al. (2010) have radiocarbon-dated an element, that legitimately came from this animal.

- The disarticulated bones of a *mysticete*, discovered at Causewayhead (c. Stirling) in 1897 and 1901. Possibility that two discrete set of *cetacean* remains have been discovered, and conflated into one. Uncertainty on stratigraphic reconstruction, and position of bones in relation to a deer antler.

- [JB] The skeleton of a *Balaenoptera*, discovered at Airthrey (c. Bridge of Allan) in 1819 (Bald 1819) [ZT]. Use and interpretation of an unorthodox marine datum.

<u>4.1.2. Introduction of Main Sources.</u>

- David Milne Home (1805 – 1890). An aristocrat, whose interests included seismology (Milne Home 1841), astronomy (Milne Home 1828), geology (Milne Home 1835, 1839) and archaeology (Milne Home 1871). His two books on relative sea-level change in Scotland (*Estuary of the Forth*, Milne Home 1871 and *Water-Lines,* Milne Home 1882) are important sources of information on *cetacean* remains in the carse. Before the death of his father-in-law in 1852, "David Milne Home" was known as "David Milne". He is cited throughout as "Milne Home".

- David Buchan Morris (1867 – 1943). Town Clerk of Stirling (1903 – 1938) and amateur historian. He is responsible for compiling a list of "*Whales*" , supposed to have been found in the Carse of Stirling (*Raised Beaches*, Morris 1893), amended as more were discovered in his lifetime (Morris 1897, 1901) and earlier cases came to his attention (Morris 1923, 1935 *Whale Remains in the Carse of Stirling*.) These documents are widely cited and appear in several scientific papers (e.g. Smith et al. 2010).

- Prof. William Turner (1832 – 1916) Professor of Anatomy at the University of Edinburgh (1867 - 1903) and later, Principal of the same institution. Under his care, the University's Anatomical Museum came to house an extensive collection of cetacean bones, skeletons, and soft-tissue preparations, latterly catalogued in *Marine Mammals of the Anatomical Museum* (Turner 1912). Scotland's fossil *cetaceans* also engaged him, and Turner is responsible for performing identifications on several "*Carse Whales*".

- Prof. Grahame Clark (1907 – 1995) An archaeologist, revered for the earliest systematic studies of the Mesolithic hunter-gatherer societies in Great Britain. In his paper, *Whales as an Economic Factor in Prehistoric Europe*, Clark (1947) presented Morris' (1893, 1925) lists as a map ("Figure 5", reproduced here as Fig. 2.2.1c) which has circulated widely (e.g. Lacaille 1954).

- David Smith et al. (2010) The most recent paper on relative sea-level change in the Forth Valley, and the latest to produce a map or figure showing the distribution of "*Whales*" in the Carse ("Figure 1", reproduced here as Fig. 2.2.1d). All relevant radiocarbon-dates, collected over fifty years of research into isostasy-eustasy in the Forth Valley, are collated into a single table in this paper (Table Two; Godwin & Willis 1961; Sissons 1969; Sissons & Brooks 1971; MacKie 1972; Browne et al. 1984; Hedges et al. 1988, 1993; Bonsall & Smith 1990; Sloan 1993; Robinson 1993; Ashmore & Hall 1997; Ellis 2000, 2001; Ellis et al. 2002; Saville 2001). For clearness and brevity, Smith et al. (2010) are cited whenever making a chronostratigraphic interpretation for a *cetacean* bone or skeleton.

- David Redman's (2004) *Whale Bones of the British Isles*, in which the author documented every single extant *mysticete* bone in England, Scotland and Ireland. Several primary sources and papers that were otherwise inaccessible at the time of writing (e.g. Morris 1923) are partially quoted within it.

4.2. The Skeleton of a *Mysticete*, Kept at Coldoch (c. Doune) [TR].

"These are all the whale remains found in the Carse of Stirling which I can distinctly trace ... It is perhaps right to mention that, at Coldoch House, there is a great quantity of bones of a whale, about which nothing is known beyond the local tradition that they were brought there, whence no-one knows. They may be the remains of a skeleton found in the Carse, but it is quite possible that they are not fossil and have been brought from foreign parts."

David Buchan Morris (Town Clerk of Stirling) *The Raised Beaches of the Forth Valley* (1893 35.)

4.2.1. Chain of References and Documentary Sources.

Morris (1893 30 – 36; 1924) compiled a list of fossil *cetacean* remains in the Forth Valley, amending it as more were discovered in his lifetime and earlier cases came to his attention. These included some bones and skeletons, which he doubted had been excavated from the carse (Fig. 4.1.1a.) Among these were the "*great quantity of bones of a whale"* at Coldoch (Fig. 4.4.1a), a mansion built c. 1500 and demolished c. 1965. In personal correspondence with Morris (1923), John George Graham (the late owner of Coldoch) had also been unable to explain their origins[1]. David Milne Home, who attended the excavation of the broch at Coldoch in 1870[2], does not refer to whalebones at this location in *Estuary of the Forth* (1872) or in *Water-Lines* (1883). Neither Clark (*Whales as an Economic Factor,* 1947) nor Smith et al. (2010) list a "*Whale*" at Coldoch. Smith (1965 48) reported seeing *mysticete* bones at Coldoch during fieldwork but doubted their antiquity.

Others speculated that the *mysticete* skeleton at Coldoch [TR] had been found nearby, and was ancient. George Graham (quoted in Morris 1923) seemed inclined to think this and the authors of 3rd Statistical Account for Kinkardine (Dundas & Hutcheson 1979 653)[3] state that *"the vertebrae of a whale found on Coldoch are today in the broch."* In the old palaeontological ledger of the Hunterian Museum, two whale vertebrae found *"on top of Broch, Coldoch"* and donated in 1964 are listed as *"from 25' Beach Clays"* (i.e. the carse). MacKie (2007 1311) suspected a more elaborate set of circumstances: the *mysticete* skeleton at Coldoch had been found locally, but not recently. The bones had been dug up from the carse in the Iron Age, put in Coldoch Broch, and re-discovered when archaeologists excavated the site. As substantiation, MacKie wrote that he*" clearly remembers reading many years ago [that fragments of whalebones are reported to have been found inside the broch], but has been unable to track down the source."*[4]

1 As quoted in Redman (2004). Graham's father, Robert Graham (founder of Glasgow Botanical Gardens) had acquired Coldoch c. 1828 (Fleming 1902 111; Ransford 1846 37.)

2 *Notes About Coldoch Broch, Collections Soc. Antiq. Scot. DP 172407, DP 172485* "*Further [excavations] took place on 5th August 1870, in the presence of Mr Milne Home."* Brochs - low circular towers formed of concentric drystone walls – are almost all found in Atlantic Scotland, and were almost all built in the earlier Iron Age. Coldoch Broch, and the other brochs in the Forth Valley, are peculiar in these and in other respects.

3 The 3rd Statistical Account took over 40 years to compile. The Account for Kinkardine was published in 1979 but had been revised at least once in 1962, and originally written in 1952.

4 Canmore I.D. 45356, *"Coldoch Broch."* (Accessed 10.10.22).

4.2.2. Documentary Provenance.

MacKie's mystery source could establish limited provenance for the *mysticete* bones at Coldoch [TR]. Worked and unworked *cetacean* bones are common finds in brochs but brochs are, themselves, almost all found on the Atlantic coast: they came from animals that stranded at the time. No remains of this kind are recorded in Scotland's other lowland brochs (MacKie 2007). He is correct that *"fragments of whalebone ... were found inside the broch",* a century after the Victorian archaeological investigation at Coldoch had concluded. No known source supports the claim (ibid. 2007 1311) that *cetacean* bones were excavated from the broch itself, by archaeologists.

The intramural passage at Coldoch had been accessed by 1845 (OS Namebook for Kilmadock, Perth 37; 1862 101) but was considered to be a natural structure until 1870, when Christian MacLagan (1872) proposed that it was part of a broch. John Stuart, who had read her paper to the Society of Antiquaries[5], led the excavation at Coldoch and was credited with the discovery (Anderson 1891). While never formally reported in an archaeological journal, Stuart wrote to the *Scotsman*[6] that *the excavations did not bring to light many evidences of occupation, beyond fragments of bones, apparently of the ox, sheep, and pig."* None of the subsequent allusions to Coldoch Broch (Milne Home 1873; Anderson 1873, 1877, 1883, 1890; MacLagan 1875, 1883; Chrystal 1903) by contemporaries mention the discovery of *cetacean* remains there.

4.2.3. State of Preservation, Identification, Fate of the Bones.

Morris (1893 35 – 6) notes a *"great quantity of bones"* but specifies only the *"jawbones, erected to form an arch"* and *"vertebrae."* Dundas & Hutcheson (1979 653) are no more detailed *("the vertebra are in the broch ... other parts of the whale are stored in the vicinity")* but, in 1960, the Smith Museum received a *"rib, shoulder bone"* and three vertebra *"of a whale"* from the last owner of Coldoch, Lady MacNair Snadden (Redman 2004 218.) As aforestated, two vertebrae from *"Coldoch Broch"* were donated to the Hunterian and another *"weathered* [cetacean] *vertebra",* found *"in about 1940 while tree felling work was taking place on Coldoch Estate"* lay "*in the garden of Clan House, Doune"* (Redman 2004). These all likely belonged to the one *mysticete* skeleton [TR].

Given the presence of bones from the cranium and evidence for a large number of post-cranial elements, the remains at Coldoch [TR] can be classed as a "skeleton". Only one set of unique diagnostic bones is identified (the mandibles) so these bones all likely belonged to one single

5 Christian MacLagan (1811 - 1901) one of the first Scottish archaeologists. Women were only permitted to join this society as "Lady Associates", without the right to read papers.

6 Scotsman (1.8.1870) [7] *Discovery of a Broch.* Scotsman (2.8.1870) [7] *The Broch at Caldoch [sic].*

animal. Based on the size of the bones in the Smith Museum (Stirling) (and the presence of a mandible large enough to form an archway, which precludes *M. physeter*) the animal can be inferentially classed as a *mysticete.* The scapula (6310) is too greatly decayed to identify the species, based on morphology.

4.2.4. Discussion: Approximate Age of *Mysticete* Skeleton at Coldoch [TR].

It is still impossible to say if the *mysticete* skeleton at Coldoch is ancient and local, or modern and foreign. However, MacKie's (2007) notion that the bones were "re-discovered" in the Coldoch broch by Victorian archaeologists has no substantiation. Having exhausted the available documentary resources, the only remaining way to determine the origin of this *cetacean* skeleton [TR] is by establishing its age, through radiocarbon-dating.

4.3. The Skeleton of a *Cetacean*, Discovered at Burnbank (c. Blair Drummond). [BF]

"... the remains of a whale were found in the barony of Burnbank, which forms part of the estate of Blair-Drummond, nearly a mile from the present course of the River Forth. ... it was on a second and lower stratum of moss, below the clay, that the bones were found. They were embedded in the clay, and did not penetrate at all into the moss below."

Henry Home Drummond (then M.P. for Stirlingshire) *Notice regarding Fossil Bones of a Whale discovered in the District of Mentieth*. Memorials of the Wernerian Natural History Society, Vol. 5, Pt. 2 (1826 440 – 441.)[1]

4.3.1. Chain of References and Documentary Sources.

In Autumn 1824, the discovery of *cetacean* bones in a drainage ditch on the estate of Blair Drummond (Fig. 4.4.1a) was noticed in the national press[2]. The *"Blair Drummond Whale"* [BF] (or sometimes *"Burnbank Whale";* e.g. Turner 1912 5; Munro 1899 61) was the last to be reported to the Wernerian Natural History Society by Henry Home Drummond (cited above) and Alexander Blackadder (appendix to his paper and geological map, on the *Superficial Strata of the Firth of Forth* (1826a,b). Home Drummond (1826 441) also related *"a very singular circumstance ... that along with these bones, there should have been found a fragment of stag's horn similar to that found along with the Airthrey Whale* [ZT], *with a round hole bored through it."*

David Milne Home[3] later corresponded with Home Drummond on this *"Whale"* (1847 30, 51 – 53; 1871 25 – 6) and with the factor of the estate, a Mr Ballingall[4], (Milne Home 1882 34,153) who had been present in 1824. "Ballingall" is also credited beside the entry for *"Skeleton of a Whale"* in the Ordnance Survey Namebook for Kinkardine (Parish, Perth) (1859-62, 11). The location plotted for this *cetacean* skeleton on the corresponding maps is likely on his authority (Fig. 4.3.1a). Milne Home (1871, 1882) and Home Drummond (1826) are cited by Morris (1893) in support of the *"Blair Drummond Whale"* [BF] which subsequently appears on Clark's (1947 92) Fig. 5 ("No. 14. Blair Drummond") and Smith et al.'s (2010) Fig. 1 ("WI", *'Whale skeleton with implement'*, c. "15.")

4.3.2. Location.

Each source describes the site of discovery in a different way, but all corroborate closely. Home

1 Often cited to 1824, when the discovery occurred. Mem. Wern. Soc. 5, pt. 2 was not published until 1826. Henry Home Drummond's name is also mis-printed as "E E Drummond".

2 e.g. Perthshire Courier (12.11.1824) [2]; New Times (London) (10.11.1824) [3]; Enniskillen Chronicle (18.11.1824) [4].

3 Distant relation by marriage to Henry Home Drummond.

4 A Mr Ballingall, *"factor at Blair Drummond"* also *"gave valuable council"* during the excavation of Coldoch Broch in 1870 (Scotsman (1.8.1870) [5]), which Milne Home attended [TR].

Drummond's (1826 440) 3/4 mi (1.2 km) from Kinkardine parish church (56.164973° -4.064006°) and 1mi (1.6km) from the closest point of the river (taken as the confluence of the Goodie with the Forth, 56.147795° -4.090487°) forms a small ellipse, which Ballingall's *"Skeleton of a Whale Found Here"* (NS 7123 9820) falls within (Fig. 4.3.1b). This location is slightly over 400yd (0.39 km) from the edge of the carse (i.e. the A873; Fig. 4.3.1a, Blackadder 1826b 437).

4.3.3. Stratigraphic Reconstruction.

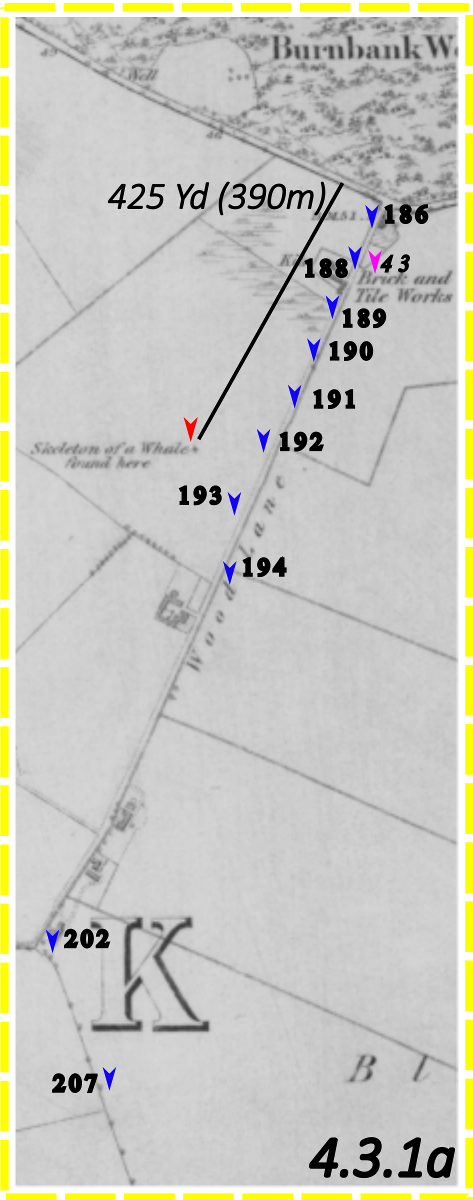
These *cetacean* remains [BF] were found lying on peat, and all were overlain by carse clay (Milne Home 1871 21; Home Drummond 1826 440). Blackadder (1826b 437) details the thickness of each bed (4' [1. 2m] of clay and 6' [1.8 m] of peat) for a cumulative 3m of sediments over a "*bluish sandy clay*" (Milne Home 1871 21), later recognised as "*The Main Buried Beach*" (Fig. 4.3.2a and Fig 4.3.3, "1".) To determine the extent and morphology of the "*Buried Beaches*", Kemp (1971 53) undertook a 1.5km transect of bores along Wood Lane (BH 181 – 207, ibid. 270 – 272), which passed 100m east of the site of the *cetacean* skeleton's [BF] discovery. (Fig. 4.3.1a, Fig. 4.3.2 a - b). In this section, < 1.2m of carse clay overlaid a thicker (1. 3 – 1.5m) bed of peat, up to c. 0.29km from the edge of the carse (Borehole 191.) Beyond that point on the transect, the clay rapidly thickened relative to the peat (Fig 4.3.2b).

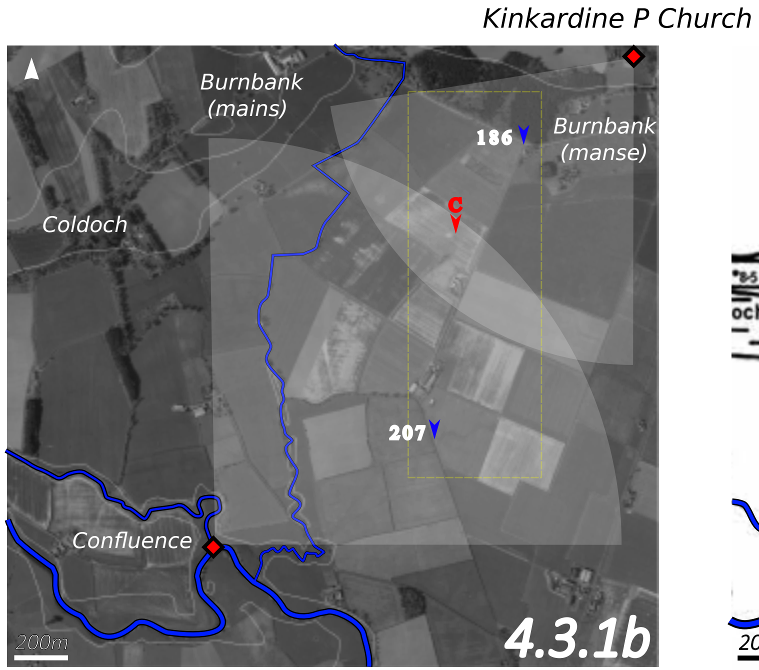
Blackadder's (1826b 437) description of the stratigraphy (1. 2m of clay overlying 1.8 m of peat) is apparently at odds with the location reported for this discovery, c. 390m from the edge of the carse. More than 2m of clay are recorded in Kemp's (1971 270 – 1) corresponding boreholes ['191' – '193', Fig. 4.3.3] and, in his transect, peat only attained a maximum thickness of c.1.4 – 1.6m (Fig. 4.3.2b.) However, the Main Buried Beach slants sightly to the south and the cumulative thickness of sediments overlying it constantly increases with distance (Fig 4.3.2b). 3m of overburden is comparable with the corresponding borehole in Kemp (1971) (Fig. 4.3.3, '1' and '193'.)

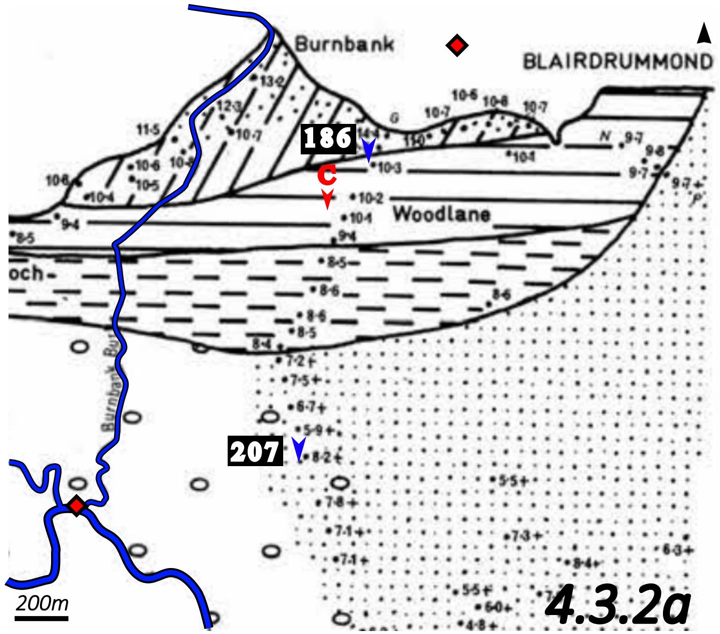
The skeleton may have been discovered at a position slightly further to the north than Ballingall recollected, 40 years later. Nonetheless, all available evidence indicates that the position marked on the OS is accurate (Fig. 4.3.1a.) Kemp's (1971) boreholes '192' and '193' bracket that point (56.159080° -4.074740°), each providing the same value for land-surface elevation (12.6m ODN; Fig. 4.3.3). If the skeleton [BF] lay 1.2m below the ground here, its approximate height relative to modern ***mean average sea-level*** was 11.4m ODN. (Fig. Fig. 4.3.3. '1').

4.3.4. State of Preservation, Identification, and Fate of the Bones.

4.3.4.1. the Scapula (NMSZ 1824.40).







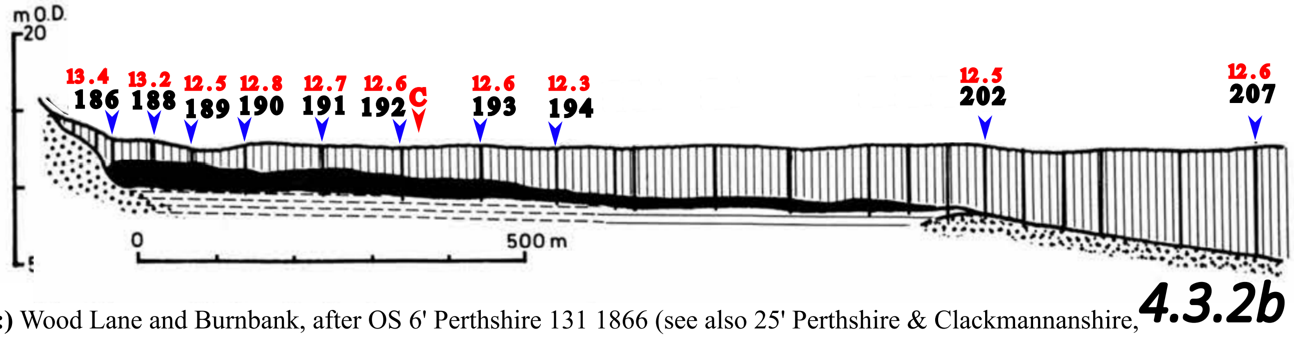


Fig. 4.3.1. a:) Wood Lane and Burnbank, after OS 6' Perthshire 131 1866 (see also 25' Perthshire & Clackmannanshire, 132.5 1864). '186' - '207' are cores from Kemp (1972) see also Fig. 4.3.2a and 4.3.2b. **b:)** Satellite Imagery (Google Earth) Burnbank and Goodie Water. 'C' corresponds to '*Skeleton of a Whale Found Here*', Fig. 4.3.1a. In correspondence with Home Drummond (1826) 1.2km and 1.6km arcs have been drawn from the '*closest point of the river*' and Kinkardine Parish Church (red diamonds, white arcs). '186' and '207' correspond to cores from Kemp (1971) Figure 4.3.2a and 4.3.2b.

Fig. 4.3.2. a:) Cores along Wood Lane, after Kemp (1971). **b:)** Cross-section of Wood Lane based on cores: after Kemp (1971). In both figures: Teith Outwash Gravel (Dots.) Low Buried Beach (Broken Dashes.) Main Buried Beach (Continuous Horizontal). High Buried Beach (Continuous Diagonal). 4.3.2b only: Carse (Vertical Lines). 'C' corresponds approximately to Fig. 4.3a, *'Skeleton of a Whale Found Here.'*

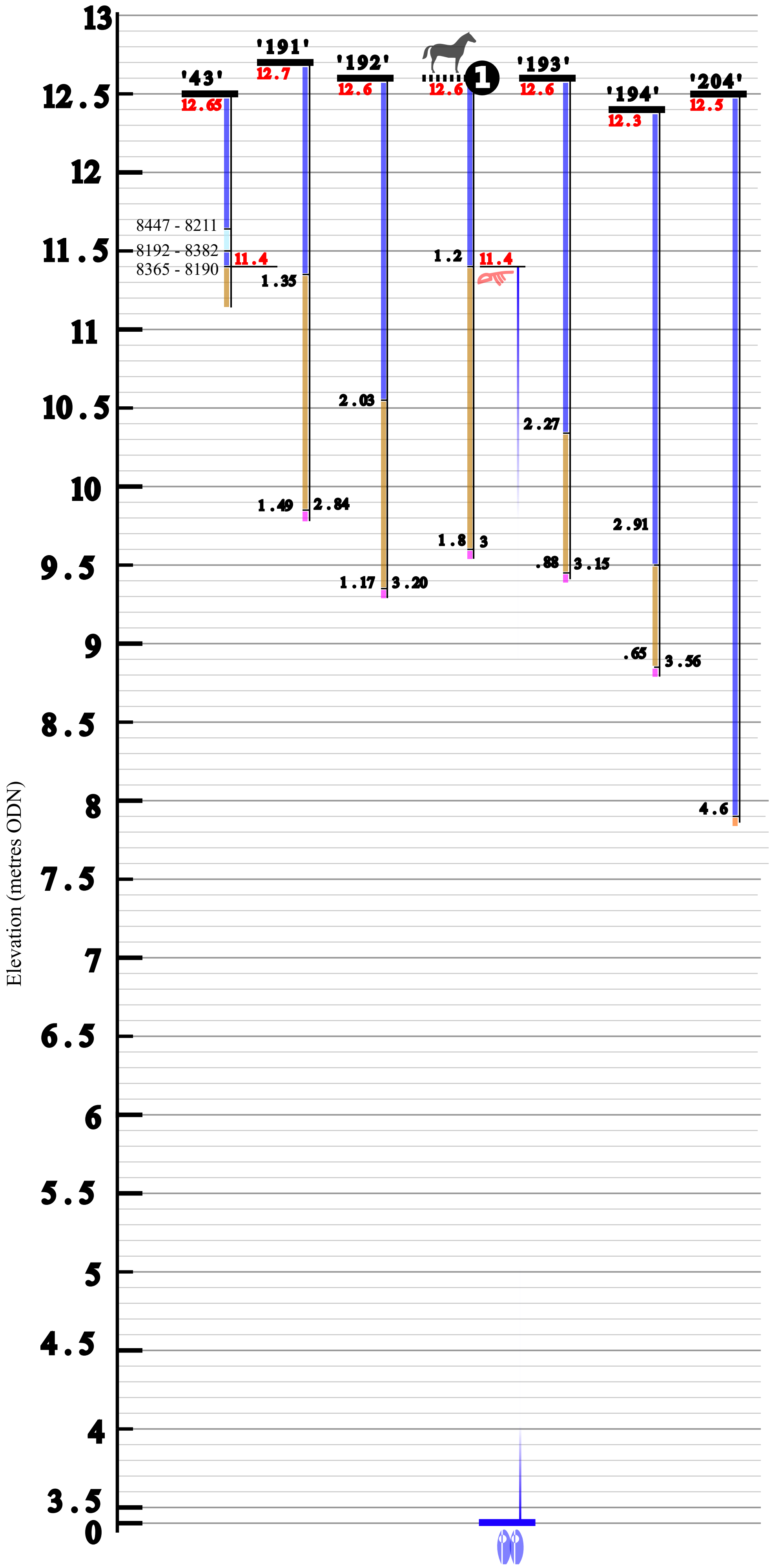


Fig. 4.3.3. *Burnbank Datum Diagram.*

'191' - '204' - Boreholes along Wood Lane (Fig. 4.3.1a and 4.3.2a and b). Stratigraphy after Kemp (1971).
'43' - Borehole (Fig. 4.3.1a). Stratigraphy and radiocarbon dates on peat, after Smith et al. (2010).
'1' (Horse) - stratigraphy at Burnbank (Fig. 4.3.1a) and situation of *cetacean* remains, as reconstructed from Blackadder (1826b). [12.6m ODN - 1.2m = 11.4m ODN].

Stratigraphic Data:
Blue (Carse Clay).
Cyan (Silty Peat).
Brown (Peat).
Pink (Surface of Main Buried Beach).

Elevation Data (Land):
Thick Black Horizontal - land surface, with measured elevation (m above modern sea-level).
Dashed Black Horizontal - land surface, with reconstructed or inferred elevation (m, above modern sea-level).

Elevation Data (Sea):
Thick Blue Horizontal - a marine datum surface.

Two Blue Shells - modern mean average sea level (0m ODN.)

Numbers:
Number in Red - elevation, as measured, reconstructed, or inferred (m, above modern sea-level).
Number in Black, and Thin Black Vertical Line - distance, or thickness of a sedimentary unit (m).
Number in Blue - Elevation of a marine datum (m above modern sea-level)
Number in Blue, and Thin Blue Vertical Line - distance (m) above a marine datum.

Only Home Drummond (1826 441) describes the bones: *"A large portion of the cranium,* [occipital and foramen, frontal, partial superior maxillary] *a scapula, several vertebra."* [5] This qualifies as a "skeleton" because of the presence of the head and of some post-cranial bones. However, it may not have been a fully-articulated *mysticete* skeleton, as depicted in Jamieson's (1865 1865) much-reproduced section diagram of the strata at Blair Drummond (e.g. Smith 1865; Lacaille 1947).

Blackadder (1826b 437) and Home Drummond (1826 441) state that the remains [BF] were donated to Prof. Robert Jameson (Chair of Natural History, and founder of the Wernerian Natural History Society) for preservation in the Edinburgh College Museum (or Natural History Museum, University of Edinburgh). There is no textual confirmation of their receipt, and no explicit reference to their presence in that collection. Morris (1893 32)[6] and Turner (1912 8) assert that at least one of those bones survived through various successor institutions and can still be found in the National Museum of Scotland (NMS). This specimen, now designated (NMSZ 1824.40) (Herman 1992 48), is a large right scapula on an adult humpback whale (*Megaptera novaengliae*). It has no identifying marks and no documentary provenance, but is still thought to belong to the *"Blair Drummond Whale"* [BF].

Home Drummond (1826) used impressive anatomical vocabulary to identify the bones found at Blair Drummond, in 1824. However, he also failed to describe their dimensions in qualitative or quantitative terms. Due to this lapse, *cetacean* bones with no provenance can, all too easily, be linked to the "*Blair Drummond Whale"* [BF]. In correspondence with Morris (1893 32), Ramsay Traquair suggested that *"a portion of a large skull, a scapula and a few vertebrae in the Museum of Science and Art*[7] *belong to* [The Blair Drummond Whale] [BF]. *[They] correspond with the bones found at Blair Drummond as recorded in the paper by Mr Home Drummond* (1826). *The species is* B. sibbaldi." (blue whale, now *B. Musculus.*) The *"portion of a large skull"* of a fossil blue whale is one of a kind, comes from Airthrey, and is labelled to that effect [ZT]. The association of the scapula (NMSZ 1824.40) to the one documented by Home Drummond (1826) is equally tenuous.

The species of *cetacean* found at Blair Drummond was never formally identified and none of the information in Home Drummond's (1826) list permits retrospective diagnosis. However, some evidence suggests that it was not even a *mysticete.* A note in the "History" of the Wernerian Society

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5 Blackadder (1826b 437) states that *"the bones will be presented to the [Edinburgh College] museum when fully traced."* This is taken to mean *"after the search for the bones has been extended as far as possible"* and not *"after illustrations of the bones have been made."*

6 Citing Ramsay Traquair, then Keeper of Natural History Collections, in the-then Royal Scottish Museum.

7 Successor to Prof. Jameson's Edinburgh College Museum – then, "Royal Scottish Museum", now "National Museum of Scotland."

refers to Home Drummond's (1826) and Blackadder's (1826b) papers as *"communications relative to the discovery of the Bones of a Grampus or Small Whale."*[8]

Scientific descriptions of *cetaceans* from this period were unreliable and few depended on skeletal anatomy (e.g. Neill 1806 222 – 228.) However, *"Grampus"* and "*Small Whale"* both had taxonomic usages. The former served as a familiar name for a killer whale (*Orcinus orca*) (e.g. in taxonomies by Shaw 1801 513, Pennant 1812 96, Cuvier 1827 436) and, to this day, is still associated with *odontocetes (grampus grisseus,* or Risso's dolphin.) "*Small Whale"* may simply have been descriptive. Nonetheless, the term is listed in Shaw's *Zoology* (1801 496) as a pseudonym for *"Balaena rostrata: the smallest of all the* Mysticetes*, being rarely known to attain the length of 25'."* (i.e. *Balaenoptera acutorostrata*, or minke whale.) This strongly implies that the *cetacean* bones found at Blair Drummond in 1824 belonged either to a juvenile animal, or an adult member of a (relatively) smaller species (Fig. 4.3.4). Both count against the scapula (NMSZ 1824.40) as part of this assemblage [BF], as it has clearly come from a mature, and very large, *cetacean*.

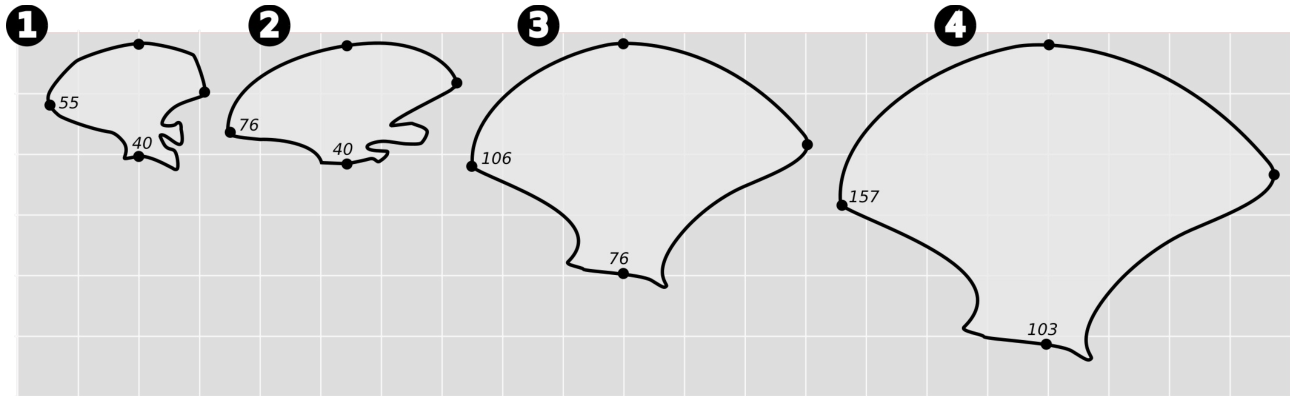

Fig. 4.3.4. Comparative anatomy and dimensions of (1) killer whale (O. orca), (2) minke whale (B. acutorostrata) and (3) (4) humpback whale (M. novaengliae) scapulae.

(1) Dimensions (cm) of scapula, of an orca (after Eschricht 1866 180 - 185).
(2) Dimensions (cm) of scapula, of minke whale stranded at Granton, c. 8.5m long (after Turner 1892 50, 69.)
(3) Dimensions (cm) of left scapula, of the 'Tay Whale', c. 12m long, after Struthers (1889, Fig. 7).
(4) Dimensions (cm) of (NMSZ 1824.40), allegedly part of the 'Blair Drummond Whale [BF], after (Turner 1912).

4.3.4.2. Vertebra of the *"Woodlane Whale".*

Morris (1893) reported that the vertebra of a *cetacean*, "*found at Woodlane on the Blair Drummond Estate"* was kept at the manor of Blair Drummond. He considered this to have been part of a unique and discrete set of remains, denoted *"Woodlane Whale"* [JM]. It is more probable that this vertebra had, in fact been part of the *cetacean* skeleton [BF], discovered in 1824 (see [JM].) However, the

8 Mem Wern. Soc 5 (2) Appendix: History of the Society 4.12.1824 (Anon. 1826 572). Reported contemporaneously in the Lon. Jour. Arts & Sci. 9 (Newton 1825 100), "*Scientific Intelligence: Wernerian Society, 5.12.1824 [sic],"* with an addendum: *"R. K. Greville requested Dr. [Robert?] Knox to ascertain as far as the specimens admitted, to what species of* cetacea *the bones now presented to the Society belonged; and to give notice at a future meeting."* Knox's notice does not, explicitly, appear in Mem. Wern. Soc. 5 (2) (1826), 6 (1832) or 7 – 8 (1838).

manor passed from the Home Drummonds in 1913 and then burned to the ground in 1923[9]. The vertebra referred to by Morris (1893) and Caddell (1913) is likely destroyed.

4.3.5. Discussion: Approximate Age of the *Cetacean* Skeleton, found at Burnbank (1824) [BF].

None of the extant *cetacean* bones, said to have been found at Burnbank on the Blair Drummond estate in 1824, can be proven to have come from there. If any were radiocarbon-dated, their ages would not be valid indicators of the age of the *"Blair Drummond Whale."* [BF]. However, this *cetacean* skeleton was discovered at a conformable stratigraphic contact between peat (a terrestrial deposit) and the carse clay (a marine deposit). Its age can be determined indirectly.

The timeline of sea-level change in the Forth Valley has been built on a few assumptions: as sea-levels rose over the Buried Beaches, carse clay was deposited immediately on the peat and the peat, itself, ceased to accumulate. If correct, a radiocarbon-date from the top c.2cm of peat on a Buried Beach can be interpreted as the time, at which sea-level had risen to that elevation (*transgressive overlap;* Fig. 4.3.5, "4".). Correspondingly, a radiocarbon-date from the basal 2cm of the peat (either on the carse, or on a Buried Beach) represents the time when sea-level had fallen far enough, for terrestrial plants to colonise the exposed sediment surfaces (*regressive overlap*; Fig. 4.3.5, *"1."*) While no delay is likely to have occurred between rising sea-levels and mineralogenic sedimentation (e.g. of carse clay) peat formation is slow and a lapse in time may have already occurred, between sea-level fall and permanent plant colonisation. Therefore, regressive overlaps do not confine the time of falling sea-levels as closely as transgressive overlaps confine the time of rising sea-levels.

The *cetacean* remains at Blair Drummond [BF] were found at a transgressive overlap. Therefore, the *"Blair Drummond Whale"* [BF] must date to the period, when sea-level was rising in the Forth Valley but before it had advanced enough, to entirely engulf the Main Buried Beach or High Buried Beach (Fig. 4.3.5, "2" and "3".) More specifically, the peat on which the skeleton rested must have stopped forming and been buried, almost simultaneous with the *cetacean's* death. A radiocarbon date of from the top of the peat at this location (56.147795° -4.090487°) would therefore be a valid indicator, of the skeleton's [BF] age. Although this has not been performed, Smith et al. (2010) dated this contact (11.4m ODN) at top of Wood Lane, c. 500m north-east of the *cetacean* remains' approximate position (Fig. 4.3.3, "43"; Fig. 4.3.5, "4".) Therefore, the *"Blair Drummmond Whale"* [BF] can be no younger than 8365 – 8190 cal BP.

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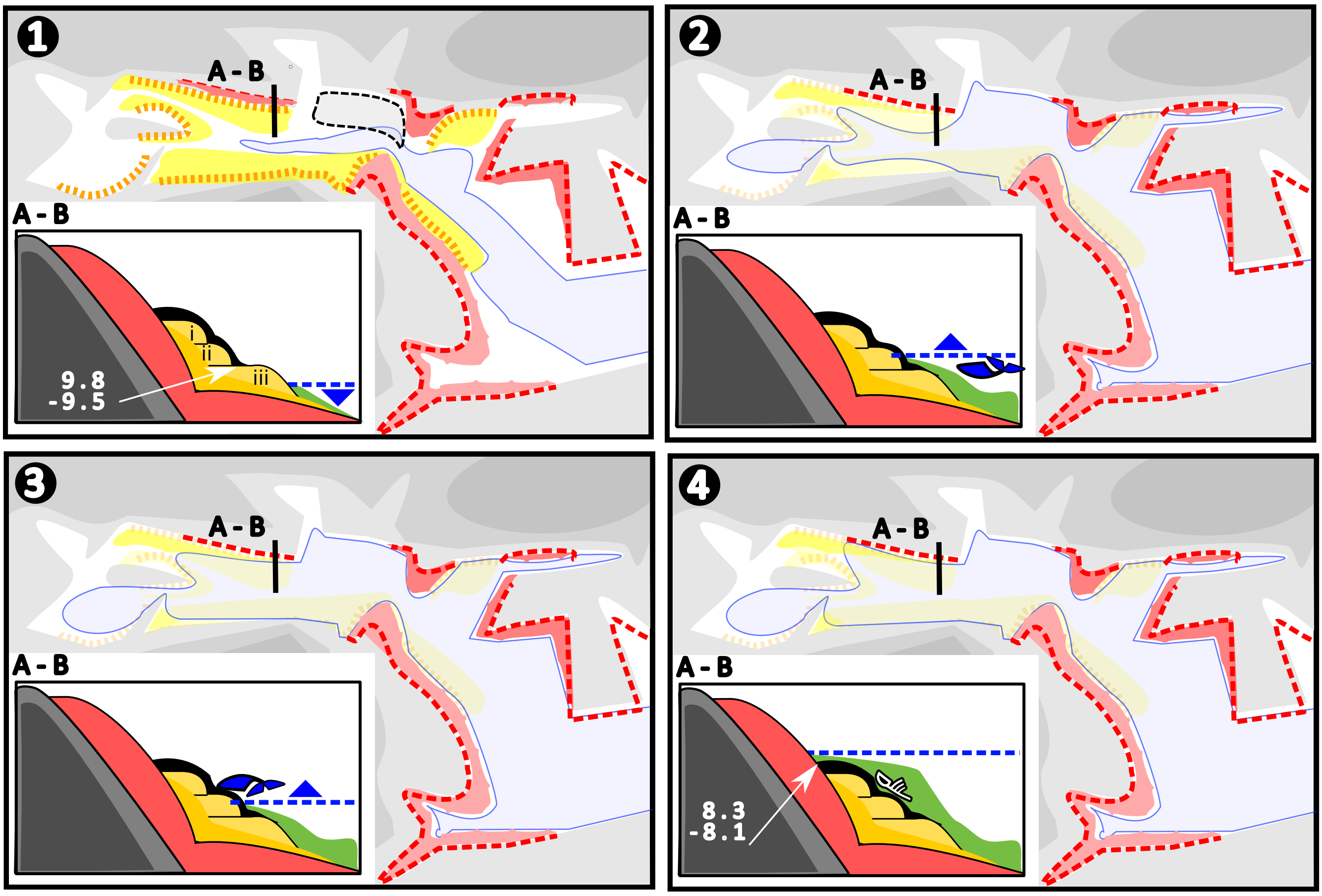
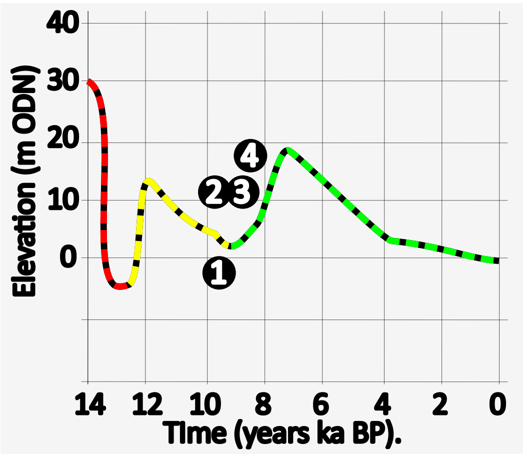
9 Scotsman 16.5.1921 [6]. *Blair Drummond Mansion Destroyed by Fire.*



4.3.5a



4.3.5b

Fig. 4.3.5. a:) "1" - "4". Sea-level increase in Western Forth Valley during the early Holocene Transgression, illlustrated schematically. Panels "1" - "4" correspond to No's "1" - "4" on Fig. 4.3.5b. (**insets**: Schematic section diagrams of raised marine deposits and landforms at Burnbank, c. Blair Drummond (A - B) and sequence of deposition.) Position of high water water mark (blue solid, or blue dashed). Net falling or rising sea-levels, indicated by blue arrow (pointed down or up). Pleistocene raised marine deposits (red). Landward edge of same (red dashed). Loch Lomond Interstadial raised marine deposits, or "Buried Raised Beaches" (yellow - High (i), Main (ii), and Low (iii).). Landward edge of same (yellow dashed). Holocene marine deposits, or "carse" (green). Peat (thick black). Basemap after Google Earth Pro (2022). Extent of raised marine landforms, after (Sissons & Smith 1965; Sissons 1966; Sissons 1969; Sissons 1972; Kemp 1971; Peaccok 1999; Smith et al. 2010). Radiocarbon dates from Smith et al. (2010; pooled mean for No's 37 and 39m and No. 43.)

b:) Composite Sea-Level Change Curve (Western Forth Valley). "1" - "4" correspond to panels "1" - "4" in Fig. 4.3.5a. Section from 12 ka BP - 5ka BP after Smith et al. (2010). Section from 12.5 - 10.9 ka BP approximate, after suggestions in Sissons (1966, 1968.) Sections 14 ka BP - 12ka BP and 4.5ka BP - 0 ka BP after Shennan et al. (2018). No empirical sea-level curve has been constructed for these time-periods, due to the lack of transgressive and regressive overlaps for the associated deposits.

4.4. The Vertebra of a *Cetacean*, kept at Blair Drummond Manor and Discovered at "Wood Lane". [JM]

> *"The remains of a whale were found at Woodlane on the Blair Drummond Estate. My informant is Colonel Home Drummond, who has one of the vertebrae in his possession at Blair Drummond Castle."*

David Buchan Morris (Town Clerk of Stirling.) *The Raised Beaches of the Forth Valley* (1893 32).

4.4.1 Chain of References and Documentary Sources.

Morris (1893, 1925) asserted that, in addition to the discovery of a *cetacean* skeleton on the Blair Drummond estate in 1824 [BF], a second set of remains had been found at a location nearby, but at an unknown time (quoted above). He designated the two cases as:

1. The *"Blair Drummond Whale"*, or in other sources, *"Burnbank Whale"* (e.g. Turner 1912 5; Munro 1899 61), discovered in 1824 [BF]. These bones are supposed to have all been donated to the College Museum, University of Edinburgh. If any of these elements survive today in a modern collection, none can be firmly identified.

2. The *"Woodlane Whale"* (quoted above), concerning a vertebra kept at the mansion of Blair Drummond. Col. Henry Edward Home Drummond[1] testified to its origin at a "*Woodlane*" on his estate, Blair Drummond. [JM]

Clark's (1947) "Fig. 5" follows Morris' (1925) list closely but omits *"Woodlane Whale"* without explanation, and plots only "No. 14 *[discovery at] Blair Drummond with a tool"]* [BF] (Fig. 2.2.1c). However, Smith et al. (2010) allude on "Fig 1" (Fig.2.2.1b) to both:

1. A "WI" for "whale skeleton with implement" at c. "No. 15, Woodlane". (56.161151° -4.071144°). This is otherwise termed the "*Blair Drummond*" or "*Burnbank*" Whale [BF].
2. A "W" for "whale skeleton" at c. "No. 16, Burnbank" (56.160921° -4.056879°). This is otherwise termed the "*Woodlane Whale*." [JM].

Contemporary accounts do corroborate the claim, that *cetacean* bones were kept at the mansion of Blair Drummond in the late 19th century. Col. Drummond loaned *"part of vertebrae of whale found at Blairdrummond*" to an exhibition at Doune in 1898[2] and in 1903, Caddell (1913 277) stated that *"the bones of a large whale found [lying beside traces of human weapons] are still to be seen in the*

1 Col. Henry Edward Stirling-Home-Drummond-Moray (1846 – 1911), great-grandson of Henry Home Drummond.
2 Dundee Courier (1.8.1898) [3] *Doune Industrial Exhibition. In the Loan Section ...*

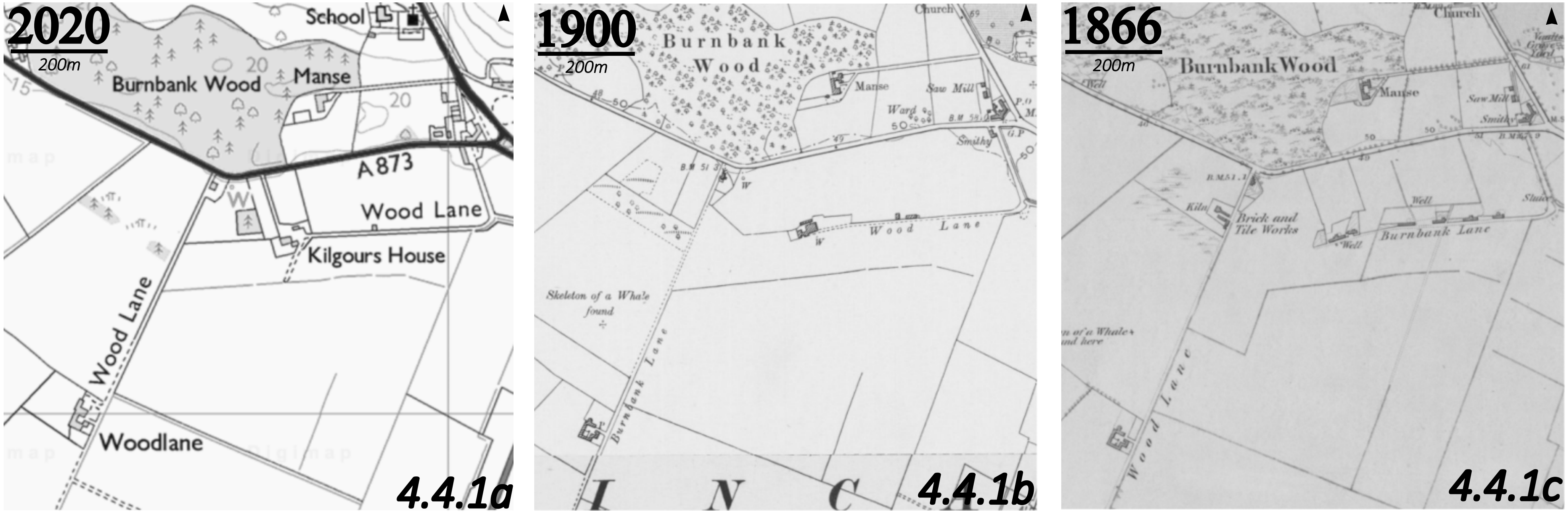


Fig. 4.4.1. **a:)** Burnbank in 2020 (after 2020 modern OS mapping.) **b:)** Burnbank in 1900 (after OS 25' Perth & Clackmannanshire 132 1900) **c:)** Burnbank in 1863 (after OS 6' Perthshire 132 1866) . Originally, (1863) the name 'Wood Lane' applied only the road running (N - S). It now (2020) also refers to a nearby cul-de-sac, oriented (E-W). At Morris' (1893) time (1900) 'Wood Lane' referred to the cul-de-sac (E-W). 'Burnbank Lane' referred to the original "Wood Lane" (1863) oriented (N - S).

museum at Blairdrummond." No other discoveries of *cetacean* remains on the estate of Blair Drummond have ever been reported, apart from the skeleton in 1824 [BF].

4.4.2. Location.

What place does "Wood Lane" refer to and did a discrete instance of discovery, of a unique set of *cetacean* remains, really occur there? Clark (1947) stepped around this question and Smith et al. (2010) have complicated it, plotting *"Burnbank Whale"* [BF] at "Woodlane" and *"Woodlane Whale"* [JM] apparently, at "Burnbank."

At present, there are two "Wood Lanes" at Burnburnk, near Blair Drummond, within 200m of each other. While the toponymy in this part of Scotland is generally stable, both "Wood Lanes" have been known by different names in the recent past. Modern "Wood Lane" (N-S) becomes "Burnbank Lane" and then, on the oldest surveys, returns to "Wood Lane"(Fig. 4.4.1a - c). "Wood Lane" (E-W, a small cul-de-sac) was originally called "Burnbank Lane." (Fig. 4.4.1c.) The Ordnance Survey Namebook for Kinkardine (Parish, Perth) (1859-62 19, 23)[3] confirms that "Wood Lane" (N – S) and "Burnbank Lane" (E – W) are the proper and intended names for these roads (Fig. 4.4.1c.)

Given this uncertainty, only one set of *cetacean* remains can be safely stated, to have been found near "Wood Lane" (N – S). This is the *"Blair Drummond Whale"* [BF], in 1824 (Fig. 4.4.1c.) The authors of the original reports (Blackadder 1826b, Home Drummond 1826) related the location of its [BF] discovery to distant landmarks (e.g. a parish church) rather than local ones (e.g. the road). The only toponymic term in either of those accounts - "*Barony of Burnbank*" (Home Drummond 1826 440) - refers to an ancient feudal land unit which became absorbed into the estates of the Drummonds. It survives in many nearby place-names, e.g. "Burnbank Woods", "Burnbank Burn", "Mains of Burnbank", including a coring (No. 16) taken by Smith et al. (2010) at the top of Kirk Lane. That location is distant from the other "Burnbanks". No *cetacean* remains are known to have been discovered there.

4.4.3. Fate and Origin of the Bone.

The manor passed from the Home Drummonds in 1913 and then burned to the ground in 1923[4]. The vertebra referred to by Morris (1893) and Caddell (1913) is likely destroyed. However, Morris (1893) was mistaken in thinking that this bone belonged to a discrete set of remains from a unique animal (*"Woodlane Whale"* [JM)].) Henry Home Drummond and his descendent, Henry Edward Home Drummond, are taken to have used different terms of reference to describe the same location,

3 On the authority of "Mr Ballingall", factor of Blair Drummond estate. See [BF].
4 Scotsman 16.5.1921 [6]. *Blair Drummond Mansion Destroyed by Fire.*

and parts of the same *cetacean* skeleton *("Blair Drummond Whale",* [BF].) One term (*"Burnbank"*) is unspecific, and the other (*"Wood Lane"*) has not been applied consistently.

When Morris (1893) undertook his research, *"Wood Lane"* referred to another place (Fig. 4.4.1b.). His assumption that two sets of *cetacean* remains had been discovered on the Blair Drummond estate was quite reasonable. However, there is unlikely to be both a *"Woodlane Whale"* [JM] and *"Blair Drummond Whale"* [BF]. It is more probable that the "Blair Drummond Whale" [BF], excavated in 1824, was then divided into at least two assemblages (one vertebra minimum kept at Blair Drummond Manor, and the rest to the Edinburgh College Museum). None of this material likely survives today.

4.5. The Skeleton of a *Balaenoptera*, Discovered at Woodyett on the Meiklewood Estate (c. Gargunnock) [USG].

" ... The field whence the brick clay was excavated [at Woodyett] exhibits depressions where the water lodged to the injury of the crops. To remedy this state of things, a main drain was led from the river bank and the workmen came upon the joints of the vertebrae of a whale. They were found lying in a line inclined upwards, and in the direction of north-west to south-east. One would almost imagine that the animal had been stranded in shallow water and was making for the sea when its progress was arrested for ever ..."

James F Stewart to the Geological Society of Glasgow (read by John Young 1.11.1877). *On the Discovery of Whale Remains in the Clays of the Carse of Stirling.* (1879 50.)

4.5.1. Chain of References and Documentary Sources.

Drainage around a derelict tileworks at Woodyett, a farm on the estate of Meiklewood (Fig. 4.4.1a), occurred throughout 1877[1]. In result, elements of a *mysticete* skeleton were uncovered during April and September (Turner 1912 8 – 9) but only publicised in the winter, when Stewart's (1879) account (quoted above) was reported in several newspapers.[2] Other contemporaries disclosed more information over the next fourty years. Andrew Hutcheson (1882), rector of the Stirling High School, wrote an account of the discovery in his newspaper column and, as a member of the Stirling Natural History Society, may have later provided Morris (1893 33) with his recollections of the "*Meiklewood Whale*"[3] [USG].

Sir William Turner, Professor of Anatomy at the University of Edinburgh, first became involved in *cetacean* palaeontology with this discovery (Stewart 1879 51). However, it is one of the last he himself provided information on (Turner 1912 8 – 9), showing more concern for an antler tool found *"resting on the front of the [mysticete's] skull* [USG]*, lying vertically in the blue clay"* (Turner 1890 790). Although this fact was alluded to in earlier sources (e.g. Milne Home 1882 34; Hutcheson 1882) and had clearly become common knowledge[4], no specific reference to this tool appeared in scientific literature until Turner's (1890) paper to the 59th British Association. The tools found beside the "*Blair Drummond Whale*" [BF] (Home Drummond 1826) and "*Airthrey Whale*" [ZT] (Bald 1819) had vanished by this time but become mythologised, in a large number of texts, as harpoon points (e.g. Wilson 1851). Based on the evidence from Woodyett, Turner (1890) argued

1 Lit. "Gate to the forest" and "the big forest" respectively. Also rendered as "Micklewood", "Mucklewood", "Meicklewood."

2 E.g. Falkirk Herald (9.11.1877) [7]. There is one trivial discrepancy between the paper as reported in 1877 and as formally published in 1879, regarding the distance from the riverbank to site of discovery.

3 *Historic Scenes in Stirlingshire,* Dundee Courier (3.1.1882). D.B. Morris studied at the Stirling High School and had almost certainly been Hutcheson's student.

4 E.g. Ordnance Gazetteer 2, (Groome [ed.] 1884 472): *"The brain of [the whale at Meiklewood], in all probability, had been extracted for food, the skull having been broken open at the thinnest part. Hard by was found the implement which had evidently been used for this purpose. A comparison of the marks on the face of the implement with those on the skull showed that they perfectly agreed."* Also paraphrased by J B Peach to Sir John Murray, in (Nansen 1904 129.)

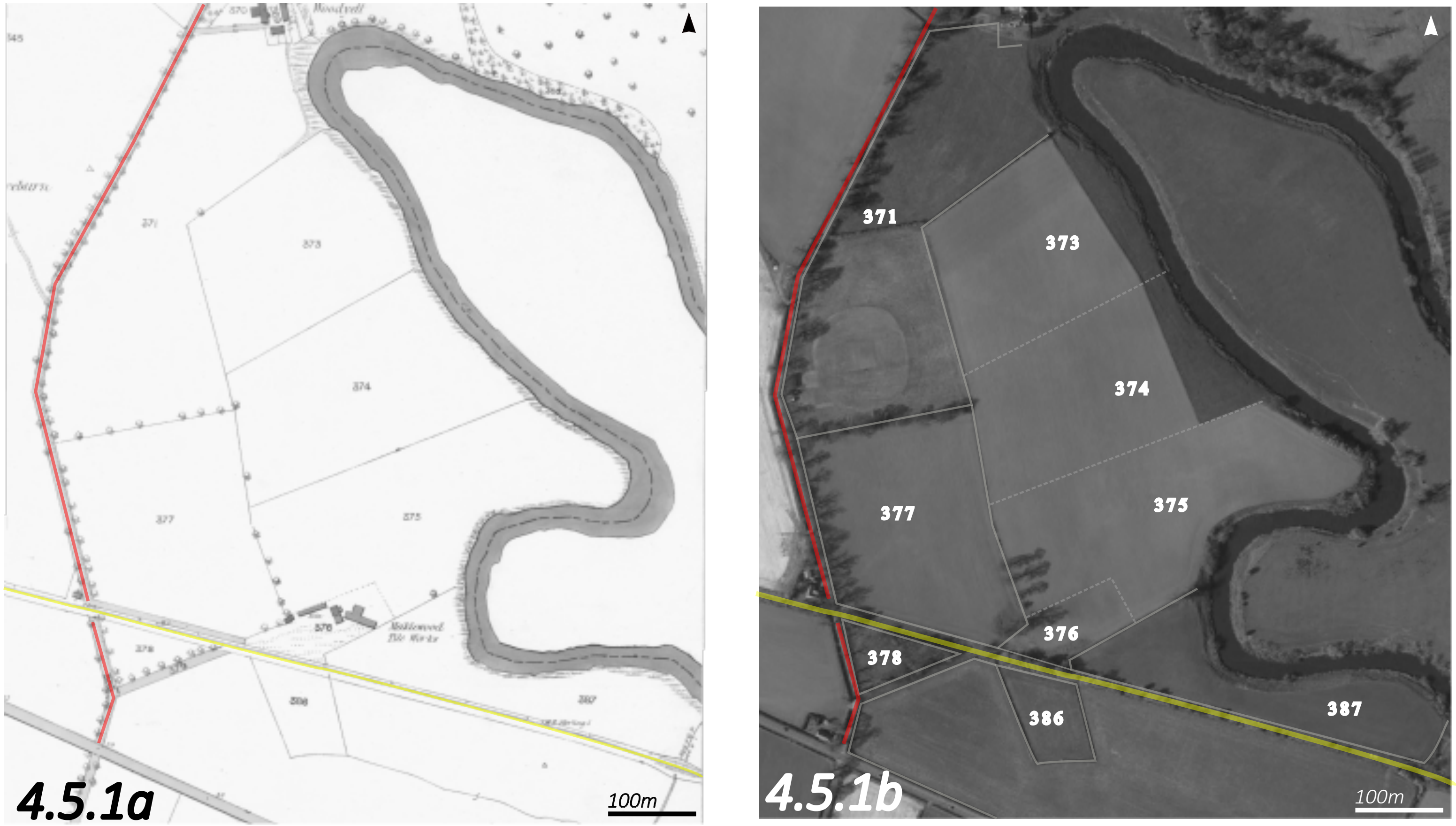


Fig. 4.5.1 Woodyett, c. Meiklewood. **(a:)** in 1862. after 25' Stirlingshire 9.1. 1862. (See also 6' Stirlingshire 9 1865). (**b:**) in 2022. annotated satellite image (Google Earth). *"Road leading to Meiklewood House."* (red line). *"The railway."* (yellow dashed). No's '371' to '387' correspond to fields, marked on the 25' OS. Field boundaries, extant (solid white). Field boundaries, erased (dashed white.)

Fig. 4.5.2. Satellite Imagery Timelapse of Woodyett (Google Earth). **(a:)** 2022, **(b:)** 2018. **(c:)** 2017. Cropmarks, possibly of the drains, extend SWW and NNE from the bottom right corner of Field '375'. 10m contour (Modern OS mapping) plotted on 4.5.2a. (Solid White Line). Approximate location of *cetacean* remains "C". Points 91m West of River Forth (Red Lines and Red Numbers.) Suggested limits for site of drain outlet, cut in 1877 ("A - B.") Suggested site of drain outlet, cut in 1877 ("E").

that all three tools had been the heads of chopping tools[5].

Milne Home (1882 32) briefly mentions this discovery at Meiklewood [USG] as an aside, while referring to a *cetacean* skeleton supposed to have been found *"near Gargunnock."* Morris (1893 45) thought that to be an allusion to the "*West Carse Whale*", when citing Milne Home (1882) and Turner (1890) in *Raised Beaches.* However, his account of the "*Meiklewood Whale*" [USG] seems to come from another party. Only ten years old in 1877, Morris' sources are likely the *"gentlemen present"* on the evening he read this paper to the Stirling Archaeological Society. Clark (1947) and Smith et al. (2010) cite Morris (1893) and Turner (1890), omitting Stewart (1879.)

4.5.2. Location.

"Meiklewood Tile Works" is marked only on the 1st edition Ordnance Survey but the pattern of roads and field-boundaries in the area has remained intact to this day (Fig. 4.5.1a - b).*"The field, whence the brick-clay was excavated"* (Stewart 1879 50) and in which, the *mysticete* skeleton [USG] was ultimately discovered, most likely adjoined its former site (Fig. 4.5.1a, Field "376"). Unlike larger brick-works in the area (see [AJ]) the clay-pit at Meiklewood was not plotted on the survey. Based on Morris' description (1893) of *"the second field, east of the road leading to Meiklewood House, on the north side of the railway"* the *cetacean* skeleton was most likely found in "Field 375" (Fig. 4.5.1a - b). The co-ordinates given in Smith et al. (2010) and on Canmore[6] are not close estimates.

Within that field, the site of discovery is supposed to lie 100yd (91m) (Stewart 1879 50; Turner 1912 8 – 9) to 150yd (137m) west, of its eastern boundary: the river Forth (Morris 1893 33). Even so, none of the sources state the exact point along the bank from which to measure back (Fig. 4.5.2a, "A – B".) Hutcheson (1882) does mention that the drain-track, in which the *cetacean* bones [USG] were found, passed through old workings associated with the tileworks *("the upper portion of the soil had been removed as material for a brick-work .")* Assuming that the distance between the clay-pit and workshop was as small as possible, the old workings, drain (and *mysticete* skeleton) are unlikely to have been located on the peninsula, between points "A" and "C" (Fig. 4.5.2a).

Between points "C" and "B" (Fig. 4.5.2a) persistent linear parch-marks appear to extend c. 100m N and W from the riverbank (Fig. 4.5.2b – c). As these may indicate the positions of the drains, Point E (Fig 4.5.2a; 56.129838° -4.050926°) is taken to be the outlet for the drain. Following Turner (1912) and Stewart's (1879) independent observation that the skeleton was discovered 100yd (91m) "inland" from that point, in a westerly direction (Morris 1893), the co-ordinates (56.129601°

5 Hutcheson (1882) and Christian MacLagan (1875 55) had already made similar points.
6 Entry for Mattock (Antler) Canmore ID 46079. Last checked 8//8/2022.

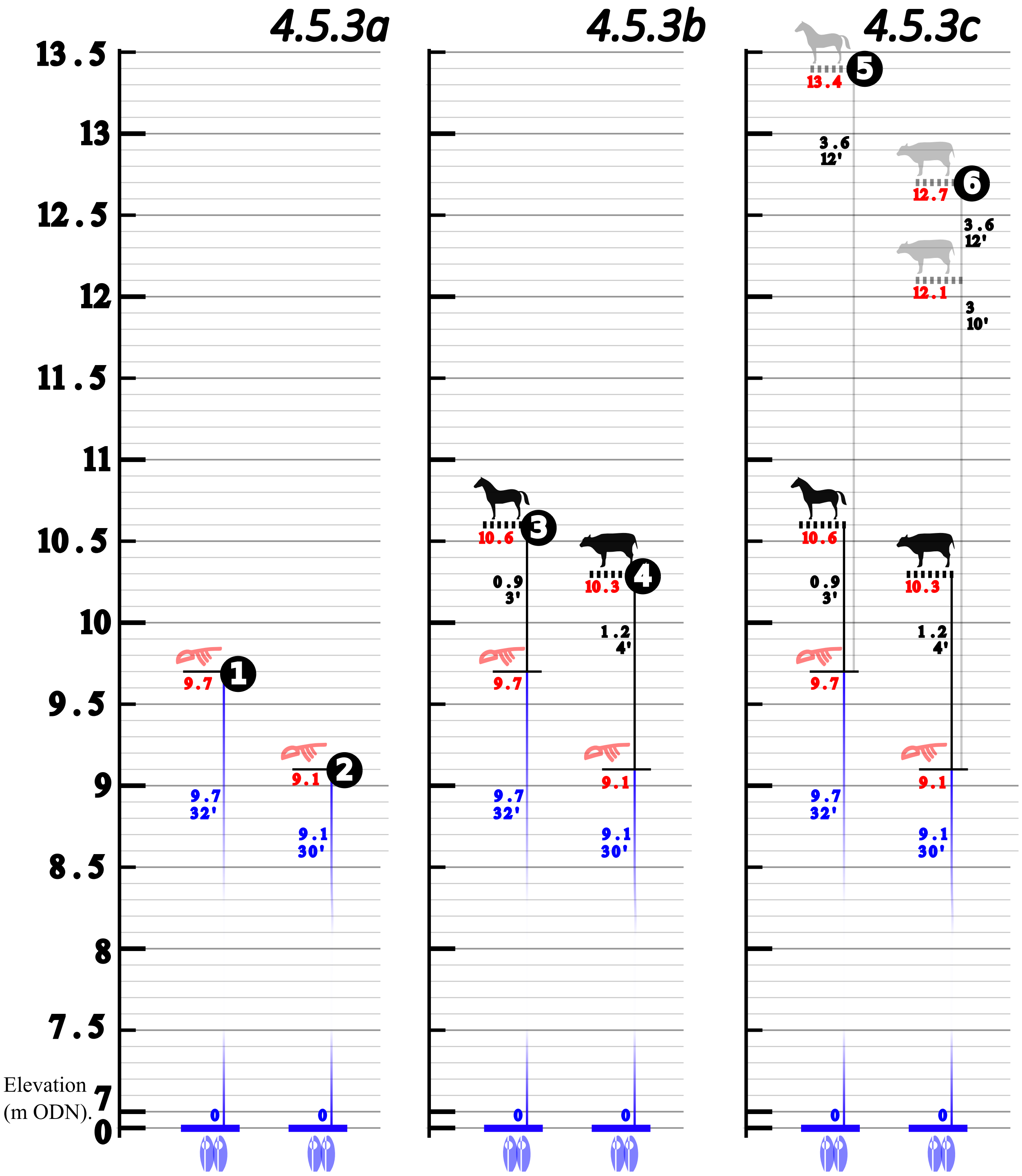


Fig. 4.5.3 - *Woodyett Datum Diagram.*

a:) ("1") - position of *cetacean* remains, reconstructed from Stewart (1879). [0m ODN + 9.7m = 9.7m ODN].
("2") - position of *cetacean* remains, reconstructed from Hutcheson (1882). [0m ODN + 9.1m = 9.1m ODN].

b:) ("3") (Black Horse) - land surface elevation of "Field 375" in 1877, reconstructed from Stewart (1879). [0m ODN + 9.7m + 0.9m = 10.6m ODN].
("4") (Black Cow) - land surface elevation of "Field 375" in 1877, reconstructed from Hutcheson (1882). [0m ODN + 9.1m + 1.2m = 10.3m ODN].

c:) ("5") (Grey Horse) - land surface elevation of "Field 375" before 1877, reconstructed from Stewart (1879). [0m ODN + 9.7m + 3.6m = 13.4m ODN].
("6") (Grey Cow) - land surface elevation of Field "375" before 1877, reconstructed from Hutcheson (1882). [0m ODN + 9.1m + 3.6m = 12.7m ODN].

Elevation Data (Land):
Dashed Black Horizontal - land surface, with reconstructed or inferred elevation (m, above modern sea-level).
Dashed Grey Horizontal - past land surface, with reconstructed or inferred elevation (m, above modern sea-level).

Elevation Data (Sea):
Thick Blue Horizontal - a marine datum surface.
Two Blue Shells - modern mean average sea level (0m ODN.)

Numbers:
in Red - elevation, as measured, reconstructed, or inferred (m, above modern mean sea-level).
in Black - distance (m).
in Blue - Elevation of a marine datum (m above modern mean sea-level)
Number in Blue, and Thin Blue Vertical Line - distance (m) above a marine datum.

-4.052318°) represent the approximate location, at which the *"Meiklewood* Whale"[USG] was discovered ("C", Fig. 4.5.2a).

4.5.3. Stratigraphic Reconstruction

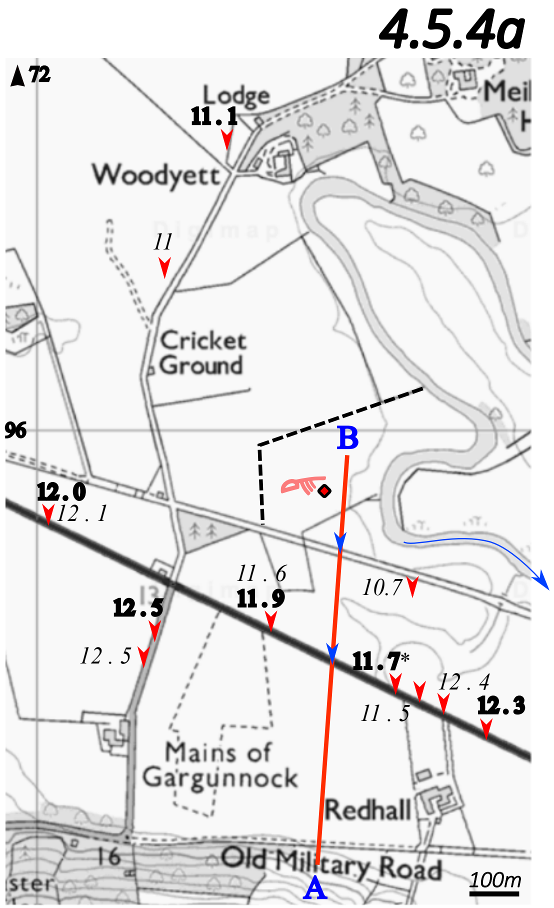
4.5.3.1 Stratigraphic Reconstruction (Elevation).

Unlike the *"Blair Drummond Whale"* [BF], the elevation of the remains at Woodyett [USG] cannot be calculated by simple deduction. No levels or spot-heights have ever been taken at this location (56.129601° -4.052318°), or in "Field 375". Furthermore, Morris' (1893) *"6'* (2m) *below ground"* has a major omission, when compared to Stewart's (1879 50) and Hutcheson's (1882) descriptions of the stratigraphy at Woodyett. Both state that, in or around the place where the bones [USG] were discovered, the ground surface of the carse had been altered by extraction of clay for the tileworks.

Therefore, Stewart (1879 50) and Hutcheson (1882) relate the stratigraphic position of this *mysticete* skeleton [USG] by an unusual formula. The height of the remains *"above the present **mean level of the sea"*** (Hutcheson 1882) is stated first (9.7m, 9.1m ODL; Fig. 4.5.3a, '1' & '2'). A depth below ground level, as it stood in 1877, is then given (0.9m, 1.2m; Fig. 4.5.3b, '3' and '4'). Finally, a depth beneath a hypothetical "original" ground level (3.6m, 3m), before any clay had been removed from the site, is then estimated (Fig. 4.5.3c, '5' and '6'.)

By these values, the surface elevation of "Field 376" in 1877 (beneath which point, the skeleton [USG] was discovered) should have equalled c. 10.6m – 10.3m ODL (Fig. 4.5.3b). This fits, when compared to the available modern elevation data (Fig. 4.5.4a). The point (56.129838° -4.050926°) falls just within the 10m (ODN) contour on the modern OS map. Google Earth satellite data gives a similar figure (10m ODN). Therefore, Stewart (1879 50) and Hutcheson (1882) appear to have calculated the position of the skeleton [USG] correctly, relative to a marine datum.

Since 1877, the level of "Field 375" cannot have changed again. Stewart (1879 50) and Hutcheson (1882) also try to account for the thickness of clay, which had been removed from the surface to make tiles with. If the skeleton [USG] lay 10' – 12' (3m) under the "original level", the land surface elevation at Woodyett (56.129601° -4.052318°) would, at one time, have been about c. 13m ODL (Fig. 4.5.3c, '5' and '6'.) This correction seems excessive. Within the local area (c. 1 – 2km^2) most spot-heights are below 12m ODN. Between locations (e.g. E – W, along the road) elevations change gently. In a S – N section over unmodified ground (Fig. 4.5.4b), the surface would have to have changed very abruptly at "Field 375", in order for it to have once stood at 13m ODN.



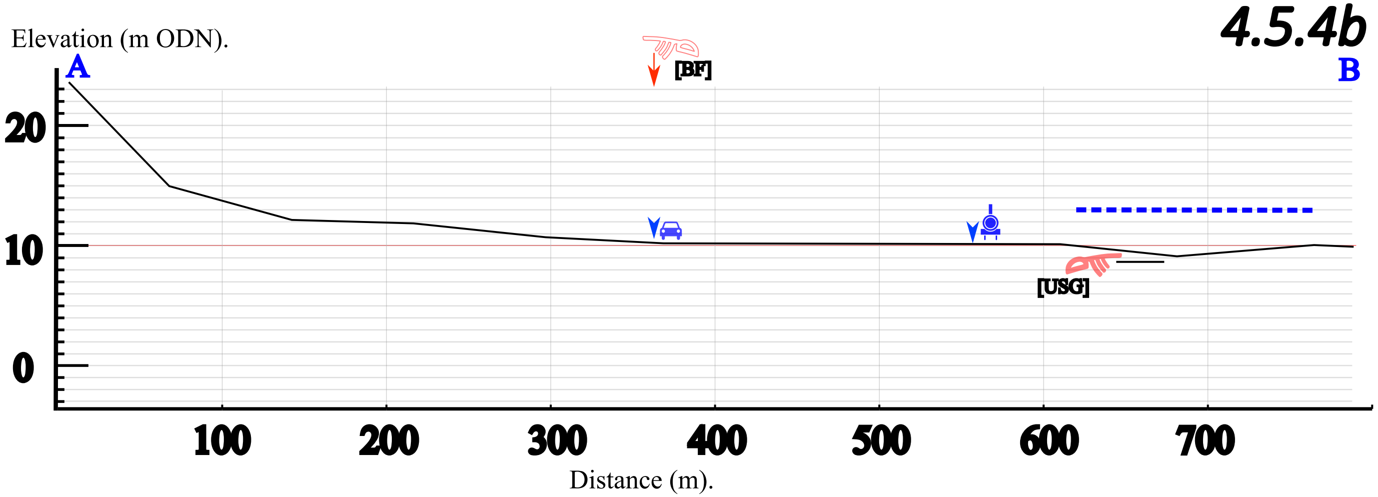


Fig. 4.5.4. Woodyett, Elevation and Topography. v **a:)** After modern Ordnance Survey (2020). Disparities between OS spot-heights (ODN; bold) and OS spot-heights (ODL); italics). Area of "Field 375" (Black Dashed). River Forth, flowing east (blue arrow horizontal). **b:)** Elevation Profile (After Google Earth) A - B on Fig. 4.5.4a. Position of road and railway marked (blue arrow vertical). Original ground surface of "Field 375" if Hutcheson and Stewart's reconstruction is valid (blue dashed). Distance of *cetacean* remains from landward (S) edge of carse at Woodyett, Meiklewood [USG], and the distance of *cetacean* remains from landward (N) edge of carse at Wood Lane, Blair Dummond [BF] marked.

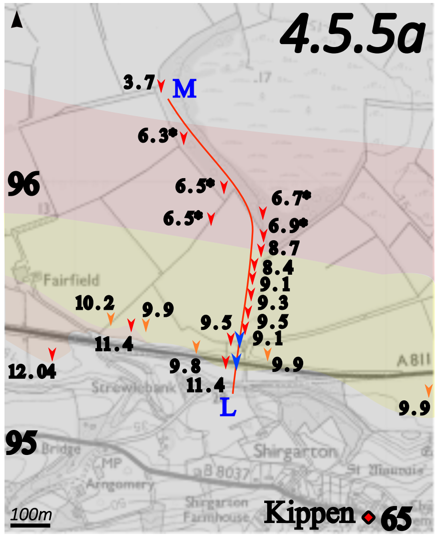
Stewart (1879 50) and Hutcheson's (1882) reconstructions fail here. Morris' (1893 33) claim that the "*Meiklewood Whale*" [USG] was *"found 6'* (1.8m) *from the surface"* should also be read carefully. It is unclear if the deduction is from the actual ground surface elevation in 1877, or from an estimated, past ground surface elevation. If so: that "original level" was likely misjudged.

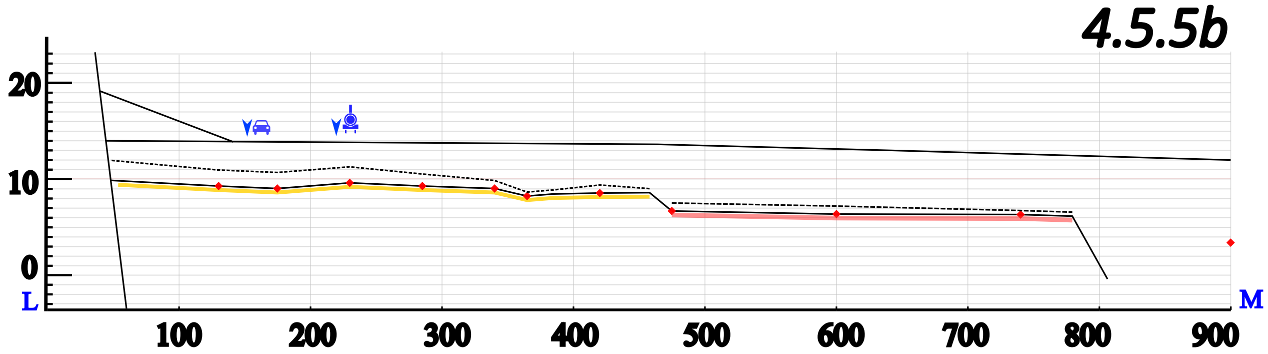
4.5.3.2. Stratigraphic Reconstruction (Geological Deposits and Contacts.)

Morris (1893 33) not only makes a problematic omission, but a problematic addition: he claims that the *mysticete* skeleton [USG] *"lay on a layer of moss".* This is suspect, since none of the eye-witnesses mention peat, or beds of peat, during the excavation at Meiklewood in 1877. All are unanimous about the geological materials around the skeleton [USG]:

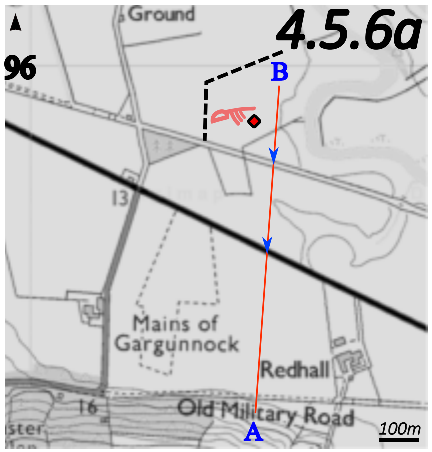
1. *"Resting upon the front of the [mysticete] skull, and* ***lying vertically in the blue silt*** *..."* (Turner 1890 790.)
2. "*Some vertebrae of a whale were* ***seen in the clay subsoil****. ... I visited [Meiklewood] when the excavations were in progress;* ***the vertebrae were lying irregularly in the clay****."* (Turner 1912 12).
3. *"In a field in the farm of Woodyet, belonging to the Carse estate of Meiklewood, some drain-cutters came upon* ***the skeleton of a whale embedded in the soft blue clay****. Both [the Airthrey whale,* [ZT] *and the Meiklewood Whale,* [USG] *were found* ***in the soft dark-blue clay which underlies the harder surface-clay****."* (Hutcheson 1882).
4. "*To a depth of about 4' the clay was fit for use [in a tileworks], but below it became so soft as to be unworkable. ...* ***the position in the dark-blue unctuous clay, in which the bones were found****, may be put down as 32' above mean sea-level, or perhaps a little lower."* (Stewart 1879 49 – 50).
5. *"I was requested to send a specimen of* ***the clay, in which the bones were embedded****, to Mr David Robertson. ... Mr Robertson has since favoured me with the following report ..."* (Stewart 1879 50).
6. *"I have examined* ***the clay, taken from under the whale bones****, found at Meiklewood. It contained numerous species of* Ostracoda *and* Foraminifera, *all belonging to those of our present seas."* David Robertson, quoted in (Stewart 1879 50 – 51.)

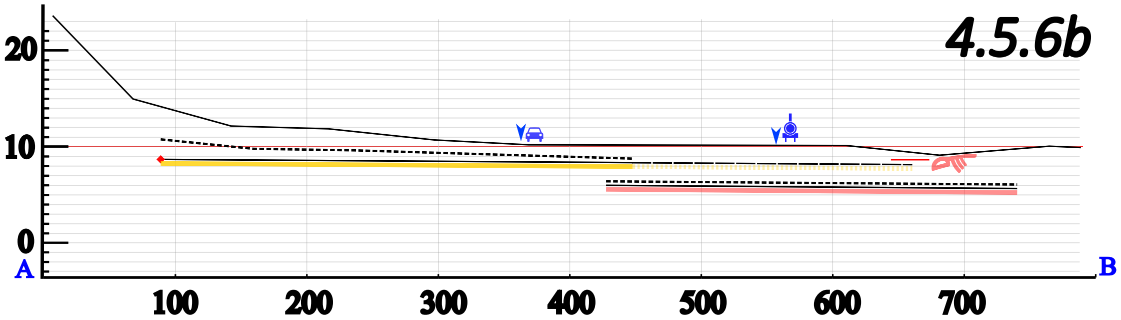
Peat might have been discovered during the excavations at Meiklewood in 1877 if the surface of a *"Buried Raised Beach"* had been reached. There is a precedent, since the "*Blair Drummond Whale*" [BF] was discovered in this situation and at similar depth below ground (c. 1.2m). Nonetheless, the "*Meiklewood Whale*" [USG] lay at greater distance from the landward edge of the carse (600m vs 380m) than the "*Blair Drummond Whale*" [BF] (Fig. 4.5.4b). Each *"Buried Beach"* inclines from east to west along its length but also, south to north (or north to south) across its breadth. The thickness of carse clay overlying a *"Buried Beach"* must therefore increase, with distance from the landward edge of the carse to the centre of the valley. To reach the peat on the *"Main Buried*





Figs. 4.5.5. (**a:**) Kippen, after Modern OS Mapping. Spot-heights (m ODN) and section L - M after Sissons (1966,1972.) Red Arrows (Sissons 1966). Orange Arrows (Sissons 1972) (**b:**) Kippen, Section L - M, after Sissons (1966). Points where surface of Buried Raised Beach reached (red diamonds). Approximate thickness of peat, on Buried Raised Beaches (black dashed). Main Buried Beach (yellow). Low Buried Beach (pink).





Figs. 4.5.6 (**a:**) Woodyett, after Modern OS Mapping. (**b:**) B. Woodyett Section, A-B (elevation profile after Google Earth). Inferential elevation profiles of Main and Low Buried Beaches, after Sissons (1966). Approximate thickness of peat, on Buried Raised Beaches (black dotted). Main Buried Beach (yellow). Low Buried Beach (pink). Neccessary extent of Main Buried Beach at Woodyett, to reach position of *cetacean* skeleton [USG] (black dashed, yellow dashed.)

Beach" beneath "Field 375" at Woodyett, the excavation would then have to deeper than at Woodlane. The reconstructed position of *"Meiklewood Whale"* (56.129601° -4.052318°) is so far distant, that it might be at a point over the *"Low Buried Beach."* In this case, 3 - 4m of carse clay might have to be removed, before reaching the peat.

The extent and altitudes of these landforms at Woodyett is inferential: Sissons' (1972) study of the "*Buried Beaches"* on the south side of the Valley was less exhaustive than Kemp's (1971) for north. At Kippen, Sissons (1966) established that the "*Main Buried Beach* "slanted (N-S) from 9.47m to 8.75m ODN over its breadth (365m; Fig. 4.5.5a - b). From Kippen to Woodyett, this landform inclined (E-W) from 9.4m to 8.83m ODN (loss of 0.7m; Fig. 4.5.7; Sissons 1972.) If the "*Main Buried Beach"* slants (N-S) to the same degree at both locations then, at Woodyett, its surface would falls from 8.83m to at least 8m ODN before it has begun to extend under "Field 375" (Fig. 4.5.6a - b.) Taking the co-ordinates (56.129601° -4.052318°) for the position of the "*Meiklewood Whale*" [USG], the lowest land surface elevation (ODN) possible for the location is 10m ODN. Deducting the greatest valid value for "depth below ground" (4', or 1.2m), the elevation of the *Balaenoptera* skeleton [USG] relative to ***mean average sea level*** would equal 8.8m ODN.

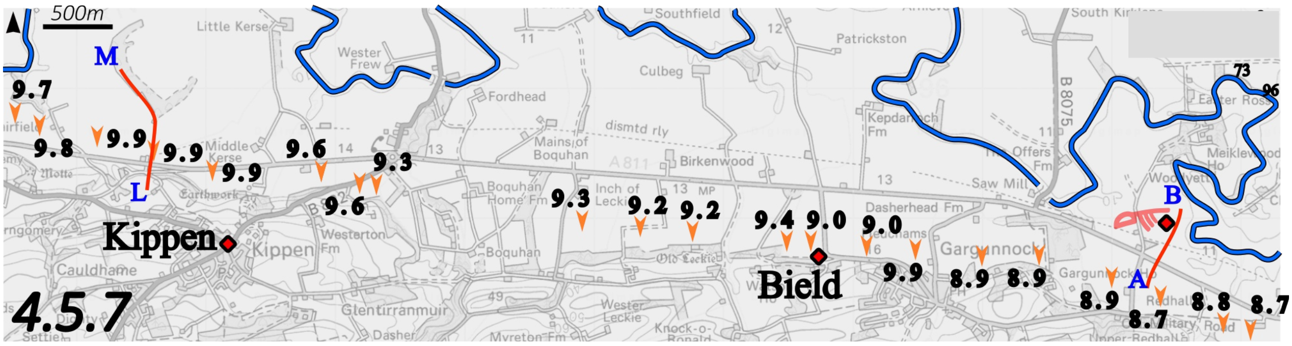


Fig. 4.5.7. W – E inclination of '*Main Buried Beach'*, between Kippen and Gargunnock. Elevation values (m ODN) are for the landward (S) edge of the '*Main Buried Beach'*, either at the break of slope with the '*High Buried Beach'* (beyond Kippen) or to alluvial fans, glacial deposits (Gargunnock to Kippen.) After Sissons (1966, 1972.)

If the "*Main Buried Beach"* extends outwards to this point at Woodyett (56.129601° -4.052318°), then the peat on its surface would also need to be at least 0.8m thick, in order to make up the difference between its elevation (8.0m ODN) and that of the *mysticete* skeleton [USG] (8.8m ODN). Sissons (1966, 1972) does not provide detailed logs but, at the same distance (c. 0.6km) from the edge of the carse at Wood Lane, Kemp (1971 59 – 60, 271) recorded only 0.5m of peat in Borehole 196. At the landward edge of the "*Main Buried Beach"* at Bield, c. 3km west of Meiklewood (Fig. 37) Brooks (1976 103) found that the peat had only attained 0.4m before being buried by carse clay. From this point, the peat typically thins over the breadth of the "*Buried Beach"*

(Fig. 4.5.5b). If the co-ordinates (56.129601° -4.052318°) are at a point over the "*Low Buried Beach"* (Fig. 4.5.6b) then an extraordinary thickness of peat would be necessary (4 – 5m) to make up the difference (apx. c. 4.5m ODN; Fig. 4.5.6b).

Morris' (1893) report of peat at Woodyett might be valid, if tested in the field. It requires the *"Main Buried Beach*" to extend an unusually great distance from the valleyside, to reach "Field 375". In addition, the peat on its surface would have to be exceptionally thick. Finally, the eye-witnesses (of which Morris is not one) who independently reported clay, would all have to be mistaken. As such. the notion that the *mysticete* skeleton [USG] was discovered on a *'layer of moss'* is not creditable.

4.5.4. State of Preservation, Identification and Fate of the Bones.

The excavation seems to have been intermittent and Stewart (1879 51) suggests that, when it finally ended, some portion of the remains were yet to be found. As the skull and post-cranial elements were present, the *"Meiklewood Whale"* [USG] can be described as a "skeleton." Turner (1912 8) measured a selection of the recovered bones : shortly after their discovery in 1877 and again, in 1911, when he re-encountered them in the Smith Institute (now Smith Museum, Stirling).[7] Both lists appear in *Marine Mammals* (ibid. 1912 8, 9, 69) where he also revealed that, in addition to the antler tool, he had left Meiklewood with a lumbar vertebra, cervical vertebra, and tympanic bones. With this evidence, he identified the "*Meiklewood Whale*" [USG] as a juvenile fin whale (*B. physalus*) (Turner 1912 69).[8] The tympanics (NMSZ 1981.57.537) and tool (X.HLA 3) survive in the collections of the National Museum of Scotland (Edinburgh) and were received there in 1963. No further record of the vertebrae are known and these are assumed to have been destroyed.

The two catalogues of bones in *Marine Mammals of the Anatomical Museum* (Turner 1912 9; ultimately, concerning the collections of an entirely different museum) broadly correspond:

- **1877.** *"On the lawn at [Meiklewood House]*. Two dorsal vertebra, seven lumbar vertebra, one cervical vertebra, pair of 1st ribs, part of another rib, "hinder part of the skull."
- **1911**. *"In the collections of the Smith Institute."* one dorsal, 1st left rib, the skull; "some broken vertebrae, [intravertebral] plates, and portions of ribs."

There is one exception. In 1911, Turner (1912 9) also notes an *"Atlas vertebra, the anterior*

7 The SI opened in 1878 but the "Meiklewood Whale" [USG] did not arrive there until 1893, when the Stirling Archaeological Society received it: *"The Council have to acknowledge their thanks to Mrs Dalrymple Duncan of Meiklewood for the better preserved remains of the Meiklewood whale which were still in her possession."*

8 In Turner (1912 69) as *"B Musculus." B. musculus* is now the scientific name for a blue whale. In Turner's time, blue whale was known as "*B. sibbaldi*."

articular surface of which measures 14' (35cm) *by 7'* (17.78cm) commenting that it *"may also have belonged to this animal."* [USG]. Presumably, the cervical vertebra which he recorded *"on the lawn"* in 1877 was not this atlas vertebra (19651.07), in the Smith Museum (Stirling), but the one taken to the Anatomical Museum (Edinburgh). No other specific reference to this atlas (19651.07) is known (e.g. Morris 1893) and its provenance depends on Turner's (1912 9) judgement.

4.5.5. Absolute Dating Evidence.

Smith et al. (2010) radiocarbon-dated a vertebra held in the Smith Museum, Stirling, which is thought to have been part of the *B. physalus* skeleton found at Meiklewood in 1877 [USG]. No accession number is quoted in that paper but the lumbar(?) vertebra (19651.03) is, most probably, the specimen in question.[9] The bone produced a radiocarbon date of 8400 BP, calibrated-corrected to 9140 – 9540 cal BP. The antler tool (X.HLA 3), found in context with the *mysticete* skull (Turner 1890), had been radiocarbon-dated by Bonsall & Smith (1989) to 5020 BP, and then re-calibrated in several subsequent studies (e.g. Tolan-Smith & Bonsall 1999). Smith et al. (2010) determined its age to 6540 – 6850 cal BP.

4.5.6. Discussion: Approximate Age of the *Balaenoptera* Skeleton, Found at Woodyett [USG].

This *mysticete* skeleton [USG] is supposed to be among the oldest evidences for the early Holocene Transgression in the Forth Valley. If the vertebra (19651.03) dates to 9540 – 9140 cal BP and did belong to the *"Meiklewood Whale"* [USG] then, as Smith et al.'s (2010) empirical sea-level curve for the area suggests (Fig. 4.5.8c), the animal must have died here when the Low Buried Beach had just become submerged, and carse clay had only just begun to accumulate over it. (Fig. 4.5.8a "1" - "3".) Morris' (1893) account of this skeleton's situation – *"on a layer of moss"* – provided Smith et al. (2010) with stratigraphic corroboration (at a transgressive overlap) for such an old radiocarbon date. Even so, they (ibid. 2010) did not establish where the skeleton [USG] had been found, and therefore, did not know which of the *"Buried Beaches"* it was supposed to have been found on.

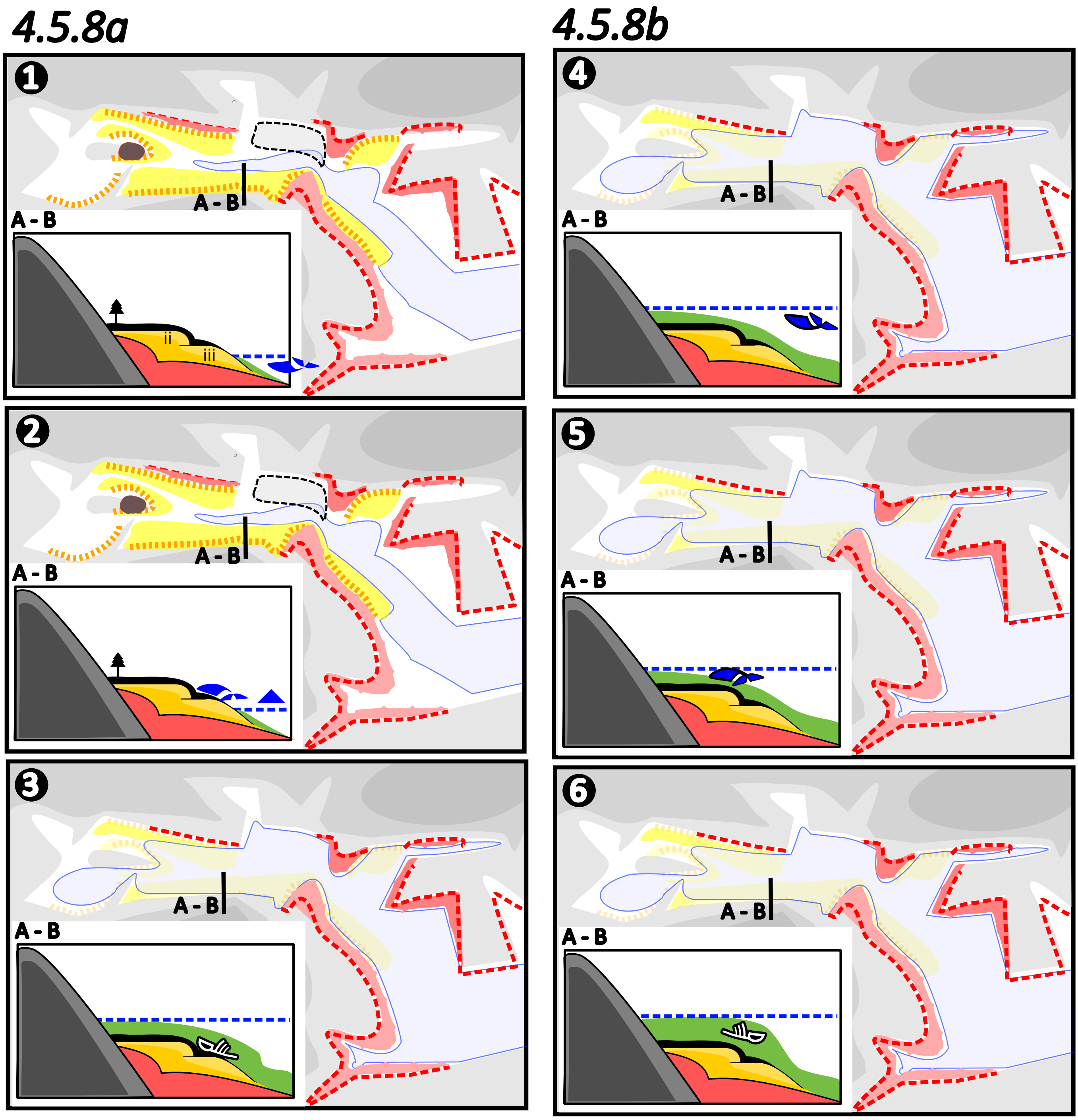
After reviewing all available witness testimony, Morris' (1893) account of the stratigraphy at Woodyett is not supported and the remains of this *mysticete* [USG] are unlikely to have been found on any of the three "*Buried Raised Beaches*." However, sea-level was rising very rapidly at this time, burying peat at 9.5m (ODN) (Newburn No. 28; Smith et al. 2010) by 9,270 – 8,500 cal BP and at 11.3m (ODN) by 8,990 – 8,480 cal BP (Mentieth Moraine, Backside of Garden No. 19; Smith et al. 2010) in the Forth Valley (Fig 4.5.8c). A living *cetacean* could, therefore, have reached Woodyett

9 Formerly "17599". A c. 4cm diameter hole is drilled through one process.

(c.9m ODN) by c. 9.5 BP, but would needed to have done so just as it became inundated (and as the carse began to accumulate). By the time of the death and preservation of the *"Meiklewood Whale*" [USG] at Woodyett, some thickness of marine sediments already covered the Buried Beaches here. As such, the remains of this animal do not seem to have been deposited here at the earliest possible opportunity, and an age of 9140 – 9540cal BP does not correspond so well with the revised stratigraphic position (Fig. 4.5.8b, "4" - "6").

This is the lesser of the two radiocarbon discrepancies associated with the "*Meiklewood Whale*" [USG]. To account for a three-thousand year difference in radiocarbon dates between the vertebra and the *"antler implement"*, Smith et al. (2010) suggest that provenance is the problem – for the tool. Given that Turner (1890 790; 1917 173) provided exhaustive measurements of this item, qualitative descriptions, a photograph (Turner 1912 70) and also permission to Robert Munro (1899 58) to make and publish his own illustration, it is unlikely that the tool (X.HLA 3) is an impostor. Smith et al.'s (2010) point about a contaminant distorting its radiocarbon date may be valid. However, within Elliott's (2014 17) archaeological typology of Mesolithic "T-axe" antler mattocks, an age of 6850 - 6540 cal BP is broadly correct for these implements.

If a provenance problem is relevant to this case, it is more likely to concern the *cetacean* bones. Twenty years elapsed before the remains from Meiklewood were taken into conservation, and *mysticetes* have many vertebrae. By 1890, the Smith Institute had already acquired a large number of uncatalogued *cetacean* bones (Morris 1893; [AJ] [ZT].) Other ancient vertebrae in the collections, which have no provenance, might have been mistakenly associated with this skeleton [USG].



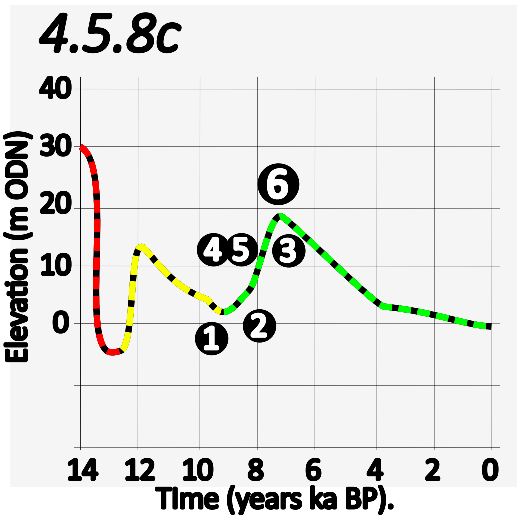


Fig. 4.4.8. a:) "1" - "3". Sea-level increase in Western Forth Valley during the early Holocene Transgression, illlustrated schematically. Panels "1" - "3" correspond to No's "1" - "3" on Fig. 4.5.8c. Death and preservation of *mysticete* [USG] if Morris' (1893) stratigraphic reconstruction is followed. **b:)** Death and preservation of *mysticete* [USG] if eye-witness stratigraphic reconstructions (Turner 1912 etc.) are followed. Panels "4" - "6" correspond to No's "4" - "6" on Fig. 4.5.8c.

(**insets**: Schematic section diagrams of raised marine deposits and landforms at Woodyett, c. Meiklewood (A - B) and sequence of deposition.) Position of high water water mark (blue solid, or blue dashed). Net falling or rising sea-levels, indicated by blue arrow (pointed down or up). Pleistocene RMDs (red). Landward edge of same (red dashed). Loch Lomond Interstadial RMDs, or "Buried Raised Beaches" (yellow - Main (ii), and Low (iii).). Landward edge of same (yellow dashed). Holocene RMDs, or "carse" (green). Peat (thick black). Basemap after Google Earth Pro (2022). Extent of raised marine landforms, after (Sissons & Smith 1965; Sissons 1966; Sissons 1969; Sissons 1972; Kemp 1971; Peacock 1999; Smith et al. 2010).

c:) Composite Sea-Level Change Curve (Western Forth Valley). "1" - "6" correspond to panels "1" - "6" in Fig. 4.3.5a - b. Section from 12 ka BP - 5ka BP after Smith et al. (2010). Section from 12.5 - 10.9 ka BP approximate, after suggestions in Sissons (1966, 1968.) Sections 14 ka BP - 12ka BP and 4.5ka BP - 0 ka BP after Shennan et al. (2018). No empirical sea-level curve has been constructed for these time-periods, due to the lack of transgressive and regressive overlaps for the associated deposits.

4.6. The Skeleton of a *Balaenoptera*, Found at Christie's Brickyard (Stirling Shore) in 1858. [AJ].

...Mr Thompson stated his attention had been called to the remains of the whale lying in the old Burgh Buildings [Stirling.] Professor Turner of Edinburgh was desirous of examining the remains, and asked if the Council would be willing to allow the bones to be transferred to the Anatomical Museum. [The skeleton] was got in the brick-work belonging to ex-Provost Christie's father, and was of extraordinary antiquity. It had been lying up in the attics for fifteen or sixteen years, and was then removed to one of the cells of the old guardroom. It was just fortunate it was preserved. [But] if the Committee found it was worth retaining it in the Smith Institute, he had no doubt they would put it there. ..."

Minutes of *the Monthly Meeting of Stirling Town Council: The Whale's Skeleton in the Butter Market*. (Stirling Observer 19.2.1880) [3 – 5].

4.6.1. Chain of References and Documentary Sources.

The medieval harbour of Stirling was situated on the Shiphaugh peninsula (or "Shore"), where the Forth Valley narrows between the Abbey Craig and Castle Rock (Fig. 4.1.1b). It became home to several industrial developments in the 19th century, among the first of which was a brickworks: leased for most of that century by members of the Christie family (Rogers 1878). Excavation here led to the discovery of a *Balaenoptera* skeleton in the clay-pit, during the winter of 1857-1858 (Lothian 1864). Milne Home (1871), Haswell (1865) and Rogers (1860, 1874) also refer to it.

Reported exclusively in local newspapers as *"most complete specimen of the fossil whale which has been discovered in North Britain"*[1], Prof. George Allman recommended *"that the bones should be united by a qualified articulator, and preserved in a Museum"*[2]. The burghers of Stirling, to whom the skeleton had been entrusted by George Christie (Sr), neglected this advice (quoted above). By the time of Turner's intervention in 1880, *"many bones were awanting, and many of those remaining [were] broken"*[3]. Despite some resistance, he was permitted to take the skull, mandible, and a deformed rib to the Anatomical Museum to join the bones from Meiklewood[4] [USG].

Morris (1893) and Turner (1883a, b; 1912 8) both asserted that the skull, mandible and rib which

1 For initial discovery: Stirling Observer (7.1.1858) [3] and Alloa Advertiser (9.1.1858) [3]; also in Commonwealth (Glasgow) 9.1.1858 [2] and Witness (Edinburgh) 13.1.1858 [3]. Quotation from Stirling Observer (20.5.1858) [3]

2 Robert Jameson's de-facto successor to the Chair of Natural History, Edinburgh (1855 – 1870). Allman is quoted in Stirling Observer (20.5.1858) [3] and is not known to have prepared or published a formal notice on this *"Whale"*.

3 Mr Croall, Curator of the Smith Institute, quoted in Stirling Observer (18.3.1880) [5]. How Turner found out that Stirling Council kept a fossil *mysticete* skeleton in their offices at the Burgh Buildings, *alias* Tollbooth, is a mystery. Allman retired from Edinburgh in 1870 and Turner's first contact with *cetacean* palaeontology was in 1877, at Meiklewood [USG]. This skeleton [AJ] had been left on the pavement among other *"relics of old Stirling"* after *"the guardroom"* was cleared to accommodate the homeless. Only the Stirling Observer (5.2.1880) reported on this event.

4 For the Town Council's deliberations: Stirling Observer (19.2.1880); (18.3.1880); (20.5.1880); (24.6.1880).

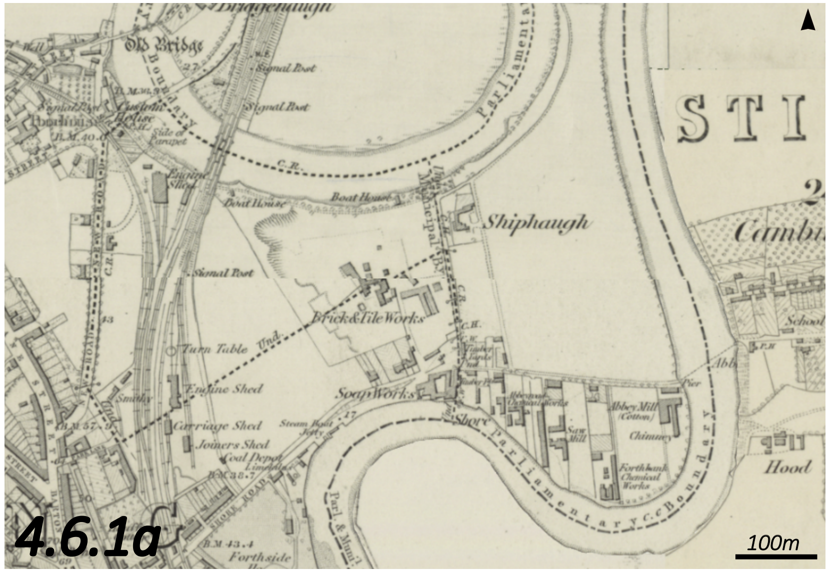


Fig. 4.6.1 (**a:**) Shiphaugh in 1860 (6' Stirlingshire Sheet 17 1865). (**b:**) Shiphuagh in 2020 (after Modern OS mapping). 10m contour after Modern OS (thick grey line). Elevation data after OS spot-heights (m ODN) and Google Earth (value with an asterisk). Area and position of clay-pit as calculated in Fig. 4.6.2.

Fig. 4.6.2. Christie's Brickworks (Stirling) in 1858 (after Stirling 1:500 1858 17.3.5).

Turner took from Stirling in 1880 had been discovered in 1863, and belonged to the second set of *cetacean* remains found at Christie's Brickwork (Stirling). This information has been widely reproduced (e.g. Herman 1992 51) but is not correct. This problem, and the muddled evidence for two discoveries in this one location, and if that ever happened, is discussed in Appendix D.

<u>4.6.2. Location</u>.

This discovery [AJ] has been referred to several locations, including *"at Christie's Brickwork, Stirling"* (Lothian 1864; Milne Home 1871 26; 1882 32) *"at Stirling Bridge"* (Haswell 1872 59; Turner 1912 8), "*in the neighbourhood of the Shore road and quay"* (Rogers 1860 37 – 8) and even *"in the vicinity of Cambuskenneth Tower, fourteen years ago."* (Rogers 1876 115 - 6, speaking in 1873). The term *"Cow Park Whale"*, introduced by Morris (1893) then adopted by Turner (1912 8, 68) and Clark (1947) was unnecessarily archaic. It referred to the traditional use of Shiphaugh by its owners, Cowane's Hospital, as pasturage to supply medicinal milk. The "Cow Park" was itself a vaguely-defined area that had become entirely urbanised by the 1920s[5]: Clark (1947; Fig. 2.2.1c, "8 – 9") and Smith et al. (2010; Fig. 2.2.1d) struggled to locate it.

Christie's brickworks (Stirling) appeared on many maps until its abandonment c. 1890 (Fig. 4.6.1a). Among these, the 1:500 OS Town Plan (Fig. 4.6.2) records the position of the clay-pit in the same year that the *Balaenoptera* skeleton [AJ] was recovered from it. Lothian (1864) and Turner (1912 9) try to relate the position of the skeleton [AJ] to other landmarks (e.g. distance from the Forth), but are both unintelligible. The remains were certainly located within 100m^2 of the co-ordinates (56.124508° -3.932551°) (Fig. 4.6.1b; school playground at the top of Argyll Avenue.)

<u>4.6.3. Stratigraphic Reconstruction.</u>

The position of the *Balaenoptera* skeleton [AJ] can be worked out from one of several formulae:

1. Depth below ground surface in 1858:
   - *"14'* (4.25m) ***below the surface****."* Stirling Observer (7.1.1858) [3]
   - *"In a bed of clay some 12'* (3.65m) ***below the surface****."* Alloa Advertiser (9.1. 1858) [3]

2. Distance above the water surface of the River Forth, at certain states of the tide:
   - *"In a thick stratum of clay, 5'* (1.50m) *above the* ***pitch of the stream tide in the river****."* Rogers (1860 37 – 8); or in Miller (1865 29 – 30) *"... about 5'* (1.50m) *higher than the* ***rise***

5 *"The Cow Park extended from behind Cowane Street down to the river. Since then it has been so cut up and altered by railways and roads that its very name has fallen into abeyance. I suppose most of the present generation would be puzzled, if asked to say where the Cow Park is."* (Galbraith 1894 125 – 6).

***of the spring tides**."*[6]

3. Distance above *"high water"*:
   - *"In the sleech below the brick clay, about 15'* (4.57m) ***above high water**."* Milne Home (1871 26, 1882 34)

4. A combination:
   - *"I was told by Provost Christie that the bones were imbedded in the blue clay, 13' – 14'* (3.96 – 4.26m) ***below the surface of the ground** and from 3' to 4'* (0.90m – 1.20m) ***above the level of high water**."* Turner (1883b 398 - 9; 1912).

Using this information to reconstruct the position of the skeleton [AJ] may be challenging. The Shiphaugh peninsula has become a suburb and the topography may have been altered (Fig. 4.6.1a - b). Although neither form of sea-level datum should have changed since 1858, the elevation of the skeleton [AJ] relative to them may not have been estimated accurately. Heights ***"the pitch of the stream tide in the river"*** and ***"high water"*** require careful interpretation.

<u>4.6.3.1 Height (m) above *"High Water"*.</u>

Milne Home (1882 4 - 5) identifies the instruments which he used to measured elevation ("*Adie's sympsometer*[7]*, a pocket spirit level ... an aneroid barometer")* and the datum, which he chose to measure from (*"high-water (spring) tides.")* This was a pragmatic decision ("*The medium between high and low as adopted in the Ordnance Survey would have been better, but a geologist cannot, in a hasty survey, discover this level"*), made in full understanding that *"the line of high-water round any coast does not form a line absolutely horizontal."* He (ibid. 1882 5) also emphasised that, in narrow sounds like the Bristol Channel and Firth of Forth, *"the line of water slopes [inland] so that at the head of the estuary, [high-water] is higher than at the mouth."*

These observations are important. Whilst Milne Home (1882) did use optical surveying instruments to measure the difference in level between raised terraces and tide-marks, some elevations will have been determined by proxy of declining atmospheric pressure. The latter measures are, in effect and however imprecisely, taken relative to *"mean average sea-level"* (0m ODN.) The former are all indexed to higher datum-points (e.g. 2.5m ODN). Critically, the height of a normal spring tide (and

6 Rogers fled Stirling in disgrace c. 1865: Miller, his publisher, acquired the copyright to the *Bridge of Allan* series These two are, fundamentally, the same source, but Miller uses clearer terms to identify the marine datum.

7 Alexander Adie (1775 – 1858) Edinburgh instrument maker and inventor of the *sympsometer* – an atmospheric barometer that did not use mercury.

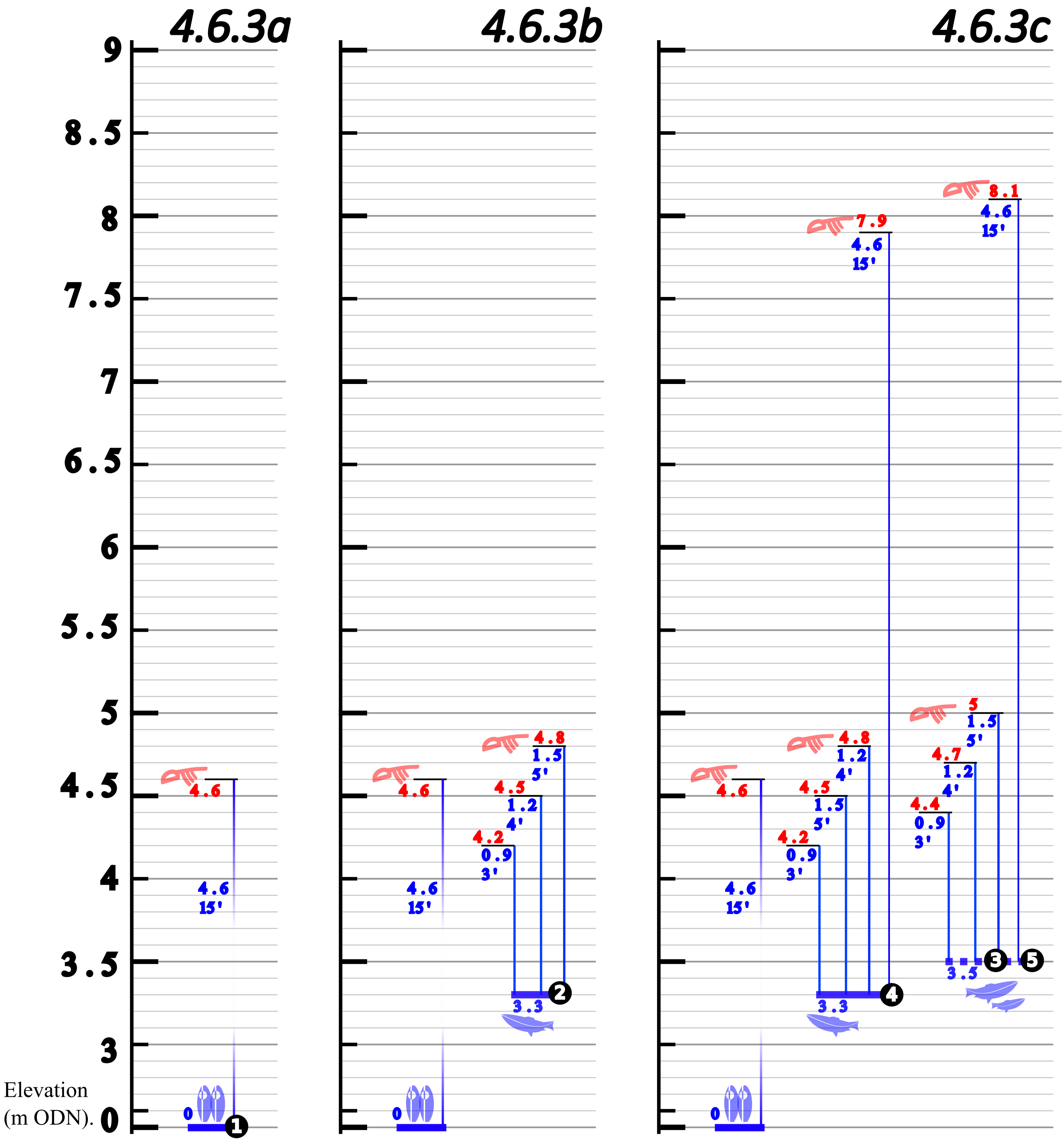


Fig. 4.6.3 - *Shiphaugh Datum Diagram (1).*

a:) ("1") - Position of *cetacean* remains [AJ]. Reconstructed from Milne Home (1871,1883): [0m ODN + 4.6m = 4.6m ODN].
b:) ("2") - Position of *cetacean* remains [AJ]. Reconstructed from Turner (1883, 1912): [3.3m ODN + 0.9m = 4.2m ODN] & [3.3m + 1.2m = 4.5m]. From Rogers: (1860) [3.3m ODN + 1.5m = 4.8m ODN.]
c:) ("3") - Position of *cetacean* remains [AJ]. Reconstructed from Turner (1883, 1912): [3.5m ODN + 0.9m = 4.4m ODN] & [3.5m + 1.2m = 4.7m]. From Rogers (1860) [3.5m ODN + 1.5m = 5m ODN.]
("4" , "5") - Position of *cetacean* remains [AJ]. Reconstructed from Milne Home (1871,1883): [3.3m ODN + 4.6m = 7.9m ODN] & [3.5m ODN + 4.6m = 8.1m ODN].

Elevation Data (Sea):
Thick Blue Horizontal. A marine datum surface. **Dashed Blue Horizontal**. a reconstructed marine datum surface. **Two Blue Shells.** modern mean average sea level (0m ODN.) **One Blue Fish**. mean high water springs, Stirling (3.3m ODN). **Two Blue Fish**. Steamboat Jetty (Shore) Datum (3.5m ODN).

Numbers:
in Red - elevation, as measured, reconstructed, or inferred (m, above modern sea-level). **in Black** - distance (m). **in Blue** - Elevation of a marine datum (m above modern sea-level) **Number in Blue, and Thin Blue Vertical Line -** distance (m) above a marine datum.

therefore, a "high-water mark" datum) declines with distance along the estuary of the Forth (3.3m ODN at Craigforth to 2.9m ODN at Grangemouth, ***mean*** *high water spring tides*.) To make sense of levels taken against *"high water mark"*, the location of that physical datum must be determined.

Milne Home (1871, 1883) states the same value in both books (c. 15', 4.6m), but not if this measure was taken with a barometric or a geometric instrument. Both possibilities must be admitted: adding Milne Home's (1871) value (4.6m) to ***mean average sea-level*** (0m ODN) produces an elevation for the *Balaenoptera* skeleton [AJ] of 4.6m ODN (4.6.3a. "1".)

<u>4.6.3.2. Height (m) Above the Water-Surface of the River Forth, at Shiphaugh</u>.

Rogers (1860) and Turner (1912) also used a marine datum to record the position of the skeleton [AJ]. Both provide a much smaller value (1.5m, 0.9 – 1.2m) than Milne Home (1871; 4.6m), and it might appear that one of these sources are in error. However, Rogers (1860) and Turner (1912) have not measured relative to ***mean average sea-level*** (0m ODN), but relative to a "higher" datum-point. More precisely, the values (1.5m, 0.9 – 1.2m) were made in respect to "*the pitch of the stream tide in the river [Forth]"* (Rogers 1860), also expressed as "*... higher than the rise of the spring tides"* (Miller 1865). Shiphaugh stands at the upper reaches of the estuary of the Forth and, at any state of the tide, the surface of the river would stand at an elevation greater than ***mean average sea-level*** (0m ODN.) Milne Home (1871) Rogers (1860) and Turner (1912) may all have calculated the same total elevation for the *cetacean* remains [AJ], but by adding up different sums.

Readings from tidal gauges, taken over many lunar cycles, have always been used to calculate spring and neap tides as *high* and *low* ***mean averages***. Modern Admiralty tidal charts provide the *mean averages* themselves (e.g. Stirling, 3.3m ODN) and the measures (1.5m, 0.9 – 1.2m) provided by Turner (1912) and Rogers (1860) could then be added straight to that datum. The range of elevations that result for the *Balaenoptera* skeleton [AJ] (4.2 – 4.8m ODN) bracket the value, calculated from Milne Home's data (1871, 1882) (Fig. 4.6.3b, "2"). However, the actual elevation (m ODN, ODL) of ***mean*** *high water springs*, at given locations, was not readily available information in 1800s. In archaic Admiralty Tidal Charts, only the *range*, or *rise*, from a *mean* low to a *mean* high tide was published[8]. Turner (1912) and Rogers (1860) may have taken the measures (1.5m, 0.9 – 1.2m) from a physical benchmark (I.e. a weathering line) on the riverbank near the brickworks. This could be higher, than the conceptual ***mean high water springs*** at Stirling (3.3m ODN).

8 Compare *Admiralty Tide Tables 1* (Admiralty Hydrographic Department, 1972) to *Tide Tables for British and Irish Ports for the Year* 1863 (Burdwood 1862.)

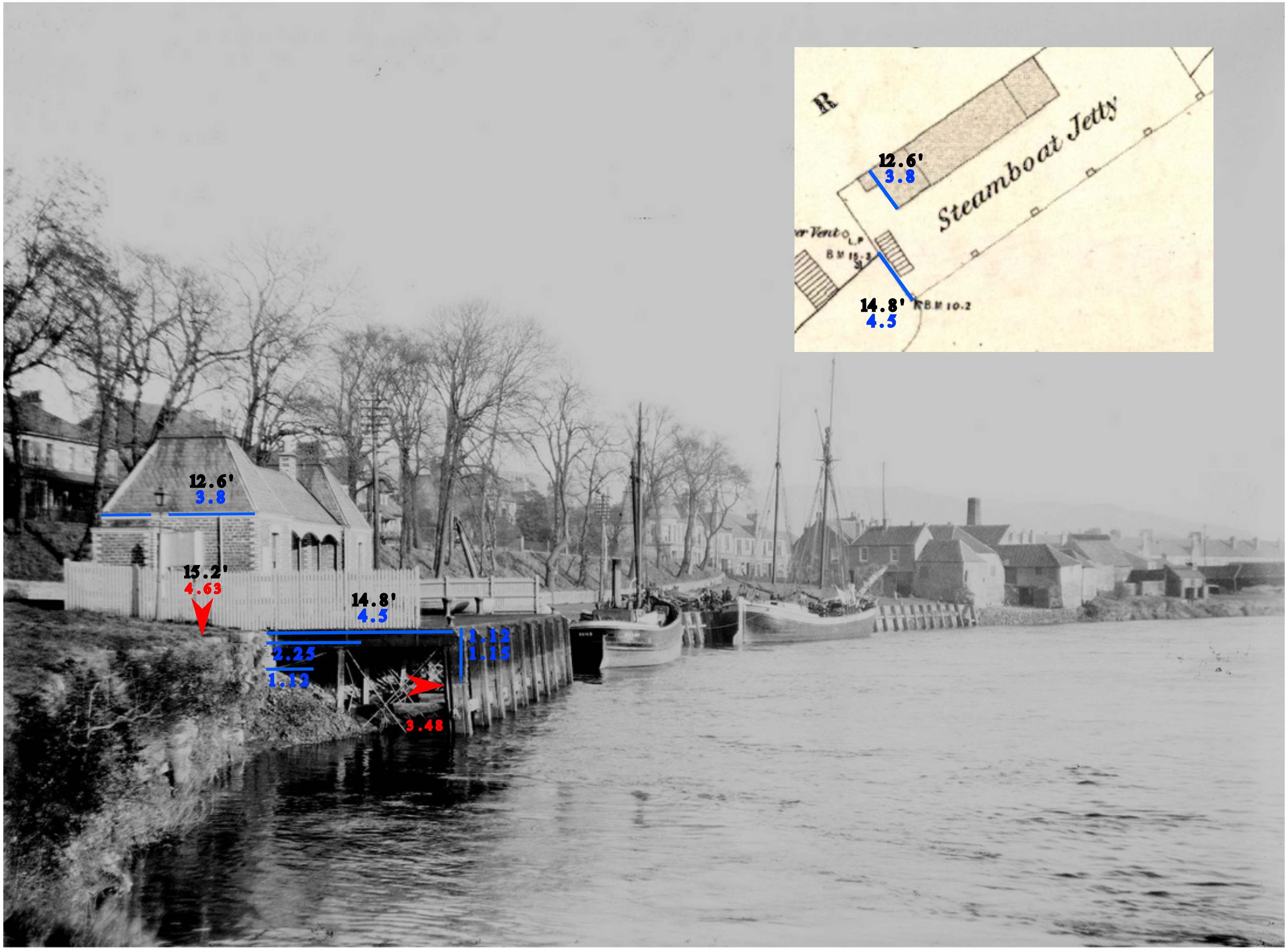


Fig. 4.6.4. (**a:**) Historic Photo **of Stirling Shore and Steam Jetty c. 1890,** annotated with reference to (**b:**) [inset] Coresponding location, as recorded on Stirling Town Plan 1:500 (1858 17.3.5). Distances (blue lines; feet and inches [black] metres [blue].) Elevation (m ODL red arrows; feet and inches [black] metres [red].) The bank by the lamp-post (4.6m ODN) and deck of the Steam Jetty are clearly on one level. Photo from Stirling Council Archives.

Rogers (1860 37) and Miller (1865 30) both relate the discovery of the *Balaenoptera* skeleton [AJ] to the jetty at Stirling Shore, rather than to Christie's Brickworks (Stirling). The wharves no longer exist (Fig. 4.6.1b) but, in a photograph of the Shore from the later 19th century (Fig. 4.6.4a), a prominent weathering-line is evident on the piles of the jetty. By extrapolating elevation data from OS benchmarks on the 1:500 Town Plan (Fig. 4.6.4b), the height of this weathering line is inferred to have been 3.5m (ODL). In this instance, little distinguishes *mean average springs* (3.3m ODN) from the outlier high tides within that data-set (3.5m ODL). Working out Turner's (1912) and Rogers' (1860) data (1.5m, 0.9 – 1.2m) from this this datum produces a similar elevation for the skeleton [AJ], as when using the ***mean high water springs*** statistic (Fig. Fig. 4.6.3c, "4".) However, taking Milne Home's value (4.6m) and (as he intended the reader to) measuring from local *high water (springs)* (3.3m, or 3.5m ODN) results in anomalously high elevations for the skeleton [AJ] (Fig. 4.6.3b "4" and "5".) Not least, because the thickness of overlying clay must then be added too.

<u>4.6.3.3. Depth (m) below the Land-Surface of Shiphaugh in 1858</u>.

No spot-heights were ever taken in the-then "Cow Park" and the land-surface may then have been altered by construction (Fig. 4.6.1a - b). Since Turner (1883b, 1912) provides paired data, the elevation of Shiphaugh in 1858, at the co-ordinates (56.124508° -3.932551°), can be worked out in reverse and compared to modern measures. If it is 3.5m from *mean average sea-level* (0m ODN) to the Jetty tide-mark, 3 - 4' (0.9 - 1.20m) from the tidemark datum to the position of the skeleton [AJ] and 12' – 14' (3.96 - 4.26m) to the surface of the Cow Park, then the cumulative land-surface elevation in 1858 was c. 8.35m – 8.95m (ODN) (Fig. 4.6.5a "6").

Elevation data for this area are little better now, and there are disparities between the available geospatial datasets (Fig. 4.6.1b). For the same co-ordinates, Google Earth satellite elevations are greater than OS Survey measures by as much as 3m. The satellite data value of 11m ODN for the co-ordinates (56.124508° -3.932551°) is not a trustworthy datum to deduct from (Fig. 4.6.5b "7".) No levels have been taken near to the school playground built on the site of the clay-pit, but it falls outwith the 10m contour on the most modern Ordnance Survey (Fig. 4.6.1b). The spot-height at the foot of Argyll Avenue (Fig. 4.6.1b) is broadly corroborative (8.5m ODN), setting a minimum possible elevation: the road rises gently from that point, to the west and over the former site of the pit (Fig. 4.6.5b, "8") .

<u>4.6.4. State of Preservation, Identification, and Fate of the Bones</u>.

This skeleton [AJ] was found in a high state of preservation, e.g. *"about 40' in length ... the most complete specimen of the fossil whale which has been discovered in North Britain."* (Stirling

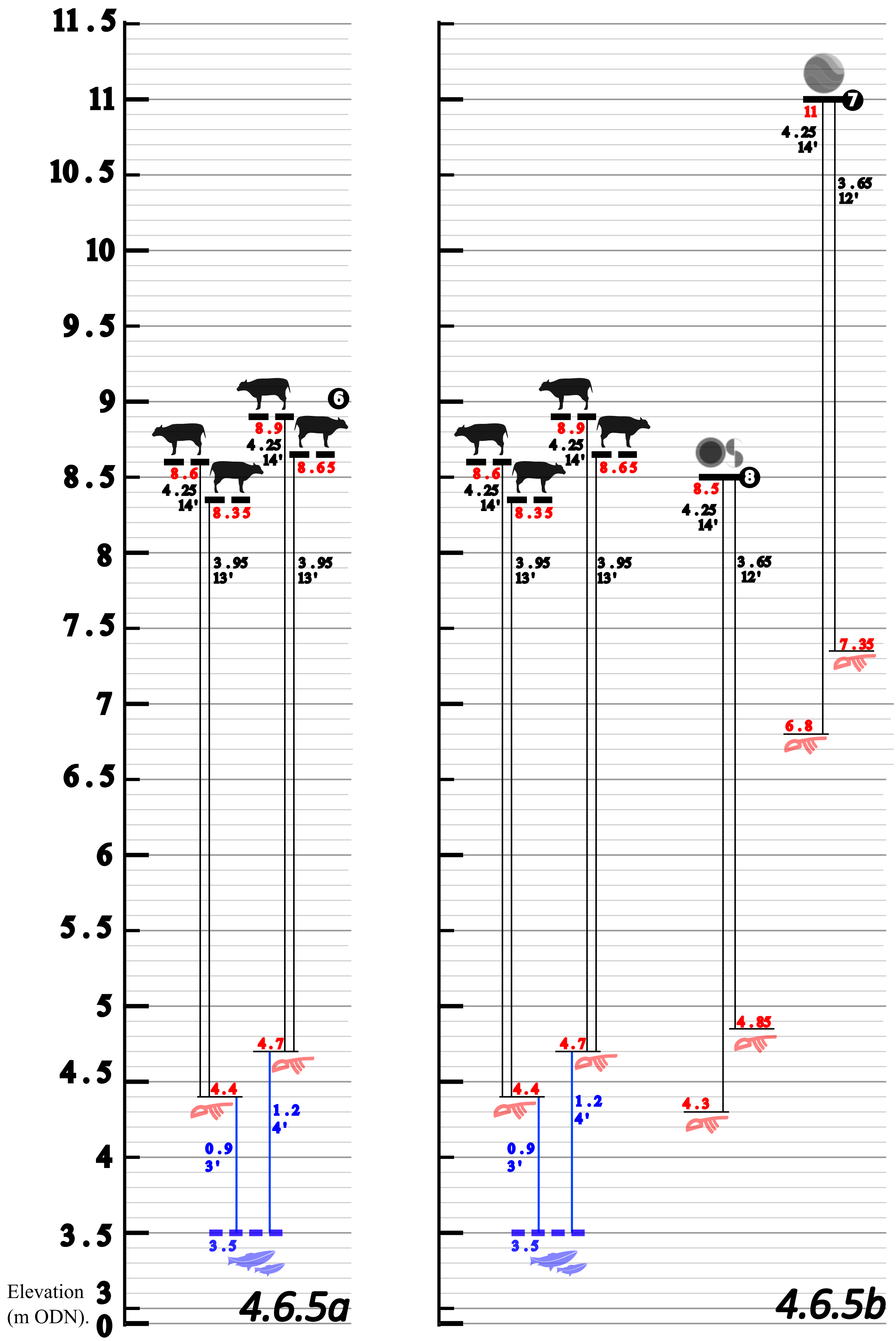


Fig. 4.6.5 - *Shiphaugh Datum Diagram (2).*
a:) ("6", Black Cow) - Position of *cetacean* remains [AJ] and land surface elevation of the "Cow Park" in 1858. Reconstructed from Turner (1883, 1912): [3.5m ODN + 0.9m + 3.95m = 8.35m ODN]. [3.5m ODN + 0.9m + 4.25m = 8.6m ODN]. [3.5m ODN + 1.2m + 4.25m = 8.9m ODN]. [3.5m ODN + 1.2m + 3.95m = 8.65m ODN].
b:) ("7", Black Planet) - Position of *cetacean* remains [AJ]. Reconstructed from (Stirling Observer 7.1.1858) and (Alloa Advertiser 9.1.1858) using Google Earth Pro (2022) elevation for Shiphaugh. [11m ODN - 3.65m = 7.35m ODN]. [11m ODN - 4.25m = 6.8m ODN].
("8", Black OS Logo.) - Position of *cetacean* remains [AJ]. Reconstructed from (Stirling Observer 7.1.1858) and (Alloa Advertiser 9.1.1858) using OS Survey (x) elevation for Shiphaugh. [8.5m ODN - 3.65m = 4.85m ODN]. [8.5m ODN - 4.25m = 4.3m ODN].

Elevation Data (Land): **Black Horizontal -** land surface, with measured elevation (m above modern sea-level.) **Dashed Black Horizontal** - land surface, with reconstructed or inferred elevation (m, above modern sea-level). *Elevation Data (Sea):* **Dashed Blue Horizontal**. a reconstructed marine datum surface. **Two Blue Fish**. Steamboat Jetty (Shore) Datum (3.5m ODN). *Numbers:* **in Red** - elevation, as measured, reconstructed, or inferred (m, above modern sea-level). **in Black** - distance (m). **in Blue** - Elevation of a marine datum (m above modern sea-level). **Number in Blue, and Blue Vertical Line -** distance (m) above a marine datum.

Observer 20.5.1858). No detailed catalogue of the bones is known to have been made in 1858, nor by any of the witnesses who saw them as they lay in the Burgh Buildings (Rogers 1860 37 - 8; Lothian 1864; Miller 1865; Harvey 1874). In 1880, Turner (1883b, 1912) removed the only surviving diagnostic elements, and any remaining ribs and vertebrae were received by the Smith Institute (Stirling), uncatalogued. The mandible remains on display in the Anatomical Museum of the University of Edinburgh. The bicipital rib was taken, in the 1960s, to the National Museum of Scotland (NMS). No record of the skull survives in either museum and is assumed to have been destroyed, although photographs may survive (Stirling Observer 24.5.1880).

Roger Allman performed an identification when the skeleton was most complete, and came to a surprising judgment: *"the whale [AJ] belonged to a species now almost extinct."* (Stirling Observer 20.5.1858). Allman's diagnosis is related in more detail in other sources, where he is said to *"[Have pronounced] the skeleton [AJ] to be a species of* Balaenoptera, *one of the true whalebone whales."* (Rogers 1860 37 – 8.) Almost all *Balaenopteridae* species are now close to extinction but, in the early 1850s, only *Balaenidae* whales had been systematically and exhaustively hunted.

Although a marine zoologist, Allman (1856) specialised in tunicates rather than vertebrates. Turner had become familiar with these animals and their anatomy, but his abilities were tested by the remnants of this skeleton [AJ] in 1880. He was also able to identify the animal as a *Balaenoptera* and, based on the dimensions of the cranium, judged it to have been a 40' - 50' long individual (Turner 1912 68, 33). However, with only the mandible, bicipital rib and skull, he could not conclude if the species had been a sei whale *(B. borealis)* or a fin whale *(B. physalus)* (Turner 1883b). McIntosh (1923 88) also reserved judgement.

4.6.5. Archaeology.

Rogers (1860 38) comments that *"a portion of oak was found among the remains [of the skeleton* [AJ]. *It had, doubtless, formed part of the harpoon of an aboriginal whaler."* When the skeleton of another *mysticete* was discovered at Cornton Brickworks in 1864 [JB], Milne Home (1871 26) also reported finding *"a stick about 1' in length, which had the appearance of being the handle of an implement"* from *"amongst, or rather from under [the bones]."* However, sticks and branches are often reported in the carse clay (e.g. Milne Home 1881), Roger's (1860 38) claim is uncorroborated, and he (ibid. 1860 38) does not specify why *"the portion of oak"* appeared to be a manufactured item.

<u>4.6.6. Approximate Age of the Skeleton of a *Balaenoptera*, found in Christie's Brickwork (Stirling) in 1858 [AJ].</u>

The western extremes of the Forth Valley have been uplifted at a faster rate than the eastern. Therefore, the area around Stirling remained a marine environment for a longer period of the early Holocene, than the area near Meiklewood and Blair Drummond. However, there are fewer regressive overlaps in the Forth Valley (raised bogs have been cleared off the carse) and inherent uncertainty on whether the peat formed on the carse as soon as it had been isostatically lifted from the marine environment. The timeline for falling sea-levels is less well-established although, at c. 5,260 – 4,590 cal BP, it may still have been as high as 11m ODN (Lecropt Moss, no 56; Smith et al. 2010.) Qualitatively, Smith et al. (2010, "Fig. 19") suggest that the gap between Abbey Craig and Castle Rock remained a full marine environment until c. 3.9 ka BP (Fig. 4.6.6a.)

In principle, a living *cetacean* could have reached Christie's Brickworks (Stirling) over a much longer period of the Holocene than for almost any other place in the Forth Valley. Given that remains of the *Balaenoptera* [AJ] were found at a low elevation (c. 5m ODN) they may therefore be quite recent: the animal's carcass reaching this location just as the sea was about to retreat from this location (Fig. 4.6.6a - b). However, the skeleton must also have lain there for enough time, for at least 4m of carse clay to accumulate over it before marine sedimentation ceased at this location (elevation of Cow Park, c. 9m ODN.)

Although more carse clay has been deposited over this *mysticete* skeleton [AJ] than any other known example from the Firth of Forth. this does not, necessarily, indicate that it has been lying there for more time than any of the other *cetacean* remains. The gap between Abbey Craig and Castle Rock is likely to have been a deep part of the palaeoestuary, even when relative sea-levels were no longer at their highest (c. 15 m ODN, 7.5ka BP.) Based on palaeontological precedent, good preservation is most likely at these parts of the shoreface. As such, the *cetacean* carcasses [AJ] may have sunk to the bed of the river Forth at a more recent date and still had time to be buried under this volume of sediments (Fig. 4.6.6b). In the Canadian Arctic, Dyke and Morris (1990) suggest that as many as 50% of their sample of fossil Bowhead Whale skeletons (*B. mysticetus*) were "sinkers". It is still plausible that the skeleton dates from the start of the inundation, and was preserved in a shallow inter-tidal environment as sea-level began to rise over the Low Buried Beach (Fig. 4.6.6c '5' - '6').

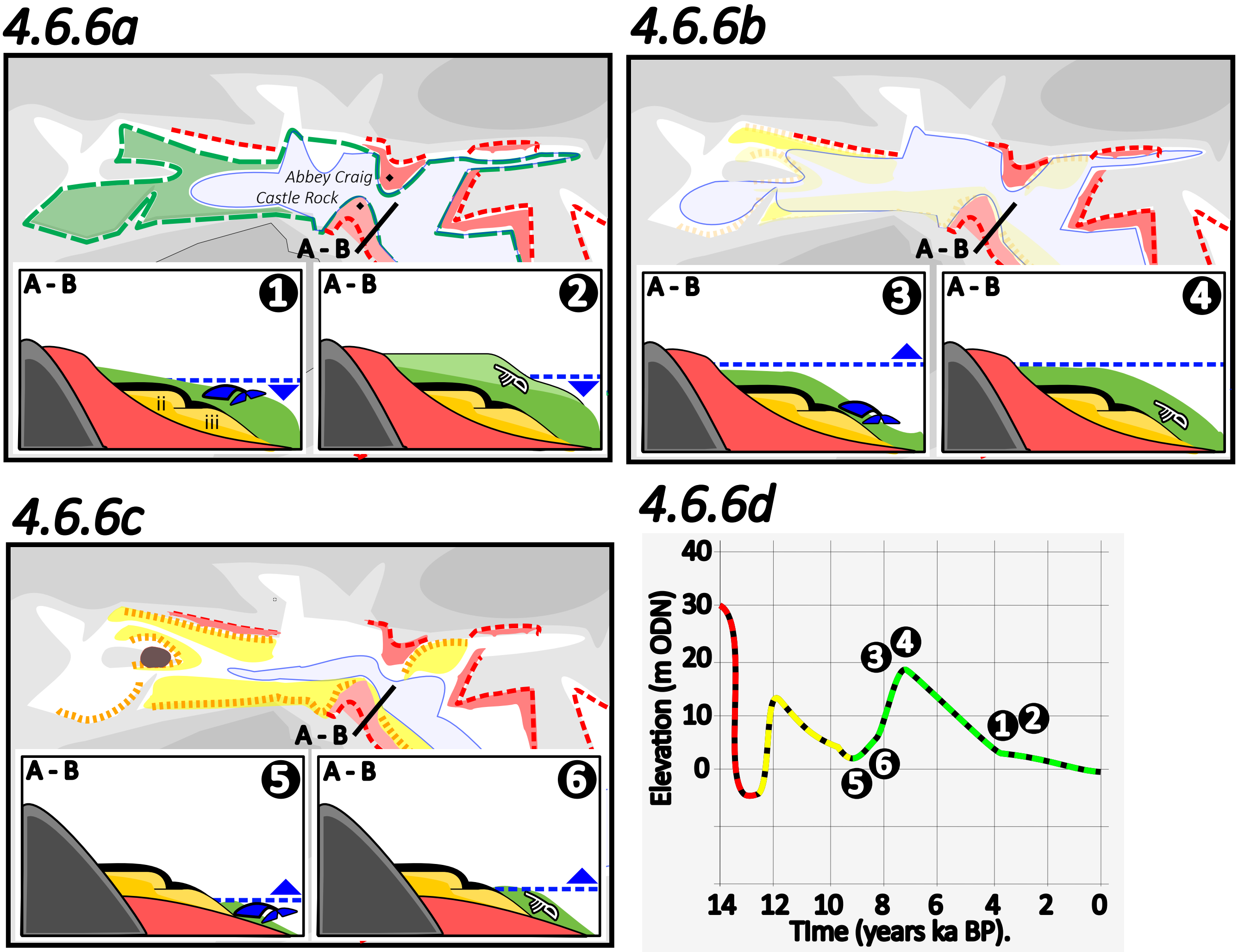


Fig. 4.6.6. Schematic Illustrations of sea-level change in the Western Forth Valley during the early Holocene Transgression and (insets): schematic section diagrams of raised marine deposits and landforms at Shiphaugh, c. Stirling (A - B) and sequence of deposition.

a:) Death and preservation of *mysticete* [AJ] in the later transgression, in shallow water. Panels "1" - "2" correspond to No's "1" - "2" on Fig. 4.6.6d.
b:) Death and preservation of *mysticete* [AJ] in the mid-transgression, in deeper water. Panels "3" - "4" correspond to No's "3" - "4" on Fig. 4.6.6d.
c:) Death and preservation of *mysticete* [AJ] in the early transgression, in shallow water. Panels "5" - "6" correspond to No's "5" - "6" on Fig. 4.6.6d.

Position of high water water mark (blue solid, or blue dashed). Net falling or rising sea-levels, indicated by blue arrow (pointed down or up). Pleistocene RMDs (red). Landward edge of same (red dashed). Loch Lomond Interstadial RMDs, or "Buried Raised Beaches" (yellow - Main (ii), and Low (iii).). Landward edge of same (yellow dashed). Holocene RMDs, or "carse" (green). Peat (thick black). Basemap after Google Earth Pro (2022). Extent of raised marine landforms, after (Sissons & Smith 1965; Sissons 1966; Sissons 1969; Sissons 1972; Kemp 1972; Peacock 1999; Smith et al. 2010).

d:) Composite Sea-Level Change Curve (Western Forth Valley). "1" - "6" correspond to panels "1" - "6" in Fig. 4.6.6a - c. Section from 12 ka BP - 5ka BP after Smith et al. (2010). Section from 12.5 - 10.9 ka BP approximate, after suggestions in Sissons (1966, 1968.) Sections 14 ka BP - 12ka BP and 4.5ka BP - 0 ka BP after Shennan et al. (2018). No empirical sea-level curve has been constructed for these time-periods, due to the lack of transgressive and regressive overlaps for the associated deposits.

4.7. The *Cetacean* Bones, Brought to Forthbank (Stirling) from Leith, c. 1870s [AS].

"I think it right to clear up a matter about which there seems to be some apprehension. I have been repeatedly told of the finding of the skeleton of a whale at Forthbank, Stirling. I can find no information of any remains ever having been found in that locality. ...The late Mr [John] Christie of Forthbank brought from Leith a number of large whale bones for the purpose of making gate-posts. Some of them may be seen to this day. Stories of whale skeletons having been found being current, these, without investigation, have been set down as fossil relics. One has had rather a curious history ..."

David Buchan Morris (Town Clerk of Stirling) *The Raised Beaches of the Forth Valley* (1893 36).

4.7.1. Chain of References and Documentary Sources.

Morris (1893) investigated genuine discoveries of *cetacean* remains in the carse as well as cases that he considered valid, but which additional evidence now show to be illegitimate. With the evidence that was available to him at the time, he (ibid. 1893, quoted above) judged that fossil *cetacean* bones had never been excavated from the carse at Forthbank, then on the eastern outskirts of Stirling. Later, Morris (1925) conceded that this could have occurred, on the basis of new primary documents which he had found (see [JQA].)

The fact remains that John Christie – elder son of brickmaker George Christie (Sr) and elder brother of George Christie (Jr), later Provost of Stirling – did bring modern *cetacean* bones to use on his property at Forthbank (Fig. 4.1.1b), sometime between 1865 and 1876[1] (quoted above) [AS]. (John) Christie died in that year (Rogers 1878 52 - 3) and his estates gradually dissipated, one of the developments being a football stadium, "Forthbank", home-ground of King's Park F. C.[2]. Redman (2004) recounts that, as late as the 1930s, gateways to the stadium had been built out of *cetacean* ribs, and conjectured that these were among the bones which John Christie had *"brought from Leith"* (Morris 1893 36) in the previous century [AS]. By 1945, a military depot had replaced the manor at Forthbank; "Forthbank" stadium had, itself, been destroyed by the *Luftwaffe*[3]. It is doubtful that any of the modern *cetacean* bones which Morris (1893) had identified at this location are still extant in the field [AS].

4.7.2. Identification and Fate of the Bones.

A modern cetacean bone from Forthbank [AS] is suspected to have been preserved. Under the

1 *"Day's Darg. The neighbours and friends of the new proprietor of Forthbank, Mr Christie, turned out to give then gentleman a day's ploughing on his entering the lands of said farm ...."* (Stirling Observer 16.11.1865) [4]

2 Archaically named *"Goosecroft"*, per Ronald (1899 138) *"Now part of Forthbank lands but held of the town."* The modern football stadium in Stirling, of the successor team to King's Park, is also called "Forthbank."

3 Stirling Journal (25.7.1940). *Why Do German Bombers Pick on Our Football Grounds?*

impression they were saving part of the *Balaenoptera* skeleton discovered in the carse at Cornton, near the Bridge of Allan [JB], one of Morris' predecessors at the Stirling Archaeological Society had rescued a whalebone being used as *"a straining post."* Morris (1893) found this item in the Smith Institute collections, and disputed its origins. Working back through a series of thefts, he believed that this bone had been among those brought by John Christie to Forthbank, from Leith [AS]. No elements from the *mysticete* skeleton found at Cornton in 1864 [JB] were in the Institute (Morris 1893 32 – 33.)

This imposter is, presumably, still in the-now Smith Museum (Stirling). No reference to that bone - in its identity as from Leith via Forthbank [AS], or as from Cornton [JB] - appears in the 1934 catalogue[4]. Morris (1893 36) does not describe the element itself but, from contextual clues in his account, it is overwhelmingly likely that the bone is a rib or a mandible:

1. *"Used for the purpose of making gateposts..."*
2. *"Erected and used as a straining post ..."*
3. *"Converted into a garden seat ..."*
4. *"Reposing outside the Smith Institute ..."*

4.7.3. Absolute Dating Evidence.

Smith et al. (2010) radiocarbon-dated a *"rib of whale"* from the Smith Museum collections, the find-site for which is given as "Cornton"[5]. Although no accession number is cited, it is presumably the c. 150cm long rib (1774, now 19654.03) with a c. 3cm-diameter hole drilled through the tip.[6] It produced a radiocarbon date of 330 +- 80, calibrated-corrected to 0 - 500 cal BP.

As such, Morris' (1893 36) anecdotal evidence has been validated by scientific analysis. A bone in the Smith Museum (Stirling) collections, said to be part of the *cetacean* skeleton found at Cornton [JB] is a modern impostor (probably from Forthbank [AS].) Nevertheless, Smith et al. (2010) insist that the rib (19654.03) really is from "*Cornton"* and that, within the last 500 years, a *Balaenoptera* whale really could have gotten to that location naturally. This proposal is tested later (see [JB].)

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4 *"Palaeontology, Animal Remains. Bones of whales, found at: Cowpark [AJ], Woodyett [USG], Causewayhead [TWW].* (Anon. 1934 179)

5 The co-ordinates (NS787973) are c. 1km to the NE of where the "W", for "Cornton Whale", is plotted on Fig. 1.

6 In the Ascessions Book of the Smith Museum, the rib (19654.03) is noted as *"found at Christie's brickworks"*, with co-ordinates for Cornton (NS 793 963). Smaller, c. 1mm diameter holes have also been drilled through the body of the rib at some time. A *mysticete* mandible found near Montrose in 1955, was also assumed to be ancient but then revealed to be modern, because *"two holes were bored [through it] to allow wires to go through, because it was used as a straining post in a fence." (*Montrose Standard, 31.3.1955) [5].

4.8. The *Cetacean* Remains, Supposedly Found in the Carse at Forthbank (Stirling),1780s (?) [JQA].

*"A Farm to Let. Upon Monday the 21st day of August, at two o'clock in the afternoon, there is to be set by public roup, for the space of nine years, after Martinmas, the farm of **Thirty Acres**, now called **Whalefield**. Consisting of about 50 acres of rich carse ground, lying on the River Forth, hard by the town of Stirling ..."*

Caledonian Mercury, Small Ads (29.8.1775) [3/4]

4.8.1 Chain of References and Documentary Sources.

In 1893, Morris had heard reports of the discovery of "*the skeleton of a whale"* in the carse, at Forthbank. He did not credit this (See [AS]) until, in 1925, he claimed to have found corroborating toponymic evidence that *"... the former name of [Forthbank] was* "**Whalefield.**" " (Morris 1923, 1925). Correspondingly, Clark (1947) plotted a *"Whale"* at "*Forthbank"* on "Fig. 1."

4.8.2. Toponomy.

Nearly a century after the discovery of the *"Airthrey Whale"* [ZT], the place where it had been found was still sometimes called "Whale Field" (Milne Home 1882 33; Shearer 1897 37) or "Whale Park"[1]. The fact that a vague public awareness of this name had developed is, in itself, a surprise. While individual "parks" did have names, these were typically only recorded on estate plans which landowners commissioned in the 18th and 19th centuries. "Parks", and their admininistration, were a private concern between the proprietors and their tenants – and above that, perhaps relevant in local government proceedings or within legal arbitration.

It is plausible that, in addition to the one at Airthrey [ZT], "Whale Fields" and "Whale Parks" have existed elsewhere the Forth Valley. Although this grade of toponymical information is hard to access, Morris would have had extensive contact with the county archives in his professional capacity as Town Clerk. He certainly exploited this resource when researching other parts of Stirling's local history (e.g. on John Cowane, Morris 1919). In this instance, he (ibid. 1923, 1925) fails to identify the text which told him that "**Forthbank**" had once been called "**Whalefield**". This is not a minor oversight because, for this part of Scotland, documents relating to conveyancing and local government go back to the 1100s (Renwick 1884). The property, latterly known as "**Forthbank**", may even have been among the lands adjacent to Stirling which Robert the Bruce awarded to the Bissets, in the early 1300s (Cook 1893 169).

1 "Park" I.e. An enclosed field. Also: British Medical Journal 2 (Anon. 1888 497), *Excursion to Stirling. "All dismounted and preceded to climb [Abbey Craig.] Drs Haldane and Galbraith pointed out Airthrey, Bridge of Allan, Bannockburn, the Whale Park, and Dumyat ... "*

Nevertheless, the estate is first mentioned in 1520, under the name "**Thirty Acres**." (Renwick 1887 4.)[2] It is consistently called "**Thirty Acres**", or a close formulation (e.g. "Easter Thretty Akeris"; Cook 1893 172 – 3) until c. 1800. The place is then named "**Forthbank**" from that time, until military warehouses supplanted it in the 1940s. Many maps testify to these facts (Fig. 4.8.1a - f).

Morris' (1923, 1925) claim can be independently corroborated by adverts of lease from 1775 (quoted above) and from 1785: *"To be let, the lands of* ***Whalefield****, lying to the east and within half a mile of the town of Stirling, agreeably situated along the banks of the River Forth."* (Caledonian Mercury, 1.8.1785) [3]. Despite that, the former name of "**Thirty Acres**" is used on almost every other document from this period. For instance, *"The House of Thirtie Acres"* is marked on Sconce's 1788 plan of the Burghmuirs (reproduced in Ronald 1899 113) which, when put up for sale themselves in 1804 (Caledonian Mercury, 22.10.1804) [3] were advertised as *"The Park next Thirty Acres House."* Furthermore, the land tax rolls for both 1771 and 1802[3] employ that name, rather than "**Whalefield**" or "**Forthbank**." The earliest known use of "**Forthbank**" is in 1805[4], after which time "**Thirty Acres**" is defunct (Rogers 1878 29.)

The toponymy in this part of Scotland is quite stable and some names from the 1300s are still used today (Reid 2019). "**Thirty Acres**" had been well-established by 1800 and not only changed, but changed twice in rapid succession. Why the old name had become inappropriate is inexplicable; why "**Whalefield**" had no traction but "**Forthbank**" did is also a mystery. However, the only other "whalefield" on record was associated with the discovery of fossil *cetacean* remains in the carse [ZT]. Given that this abrupt and botched baptism occurred in the late 1700s, more substantial documentary corroboration for a discovery at this location might be expected, if it ever occurred. Possibly, Campbell's (1796 320) "*it is not long since fish bones of a considerable size have been met with in the neighbourhood of Stirling"* was another allusion to this discovery [JQA].

The only certain reports are unattributed rumours, heard by Morris during his initial investigation (1893 36): *" I have been repeatedly told of the finding of the skeleton of a whale at Forthbank, Stirling".* No bones or skeletons of *cetaceans* have since been found here. However, "Forthbank" really was once called "Whalefield" - if not in the distant past, then for a very brief period of time in the late 1700s. Morris (1925) felt that this fact substantiated a story which he (ibid. 1893) had dismissed: that the remains of a *cetacean* had been discovered here, before John Christie's birth.

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2 *Extracts from the Records of the Burgh of Stirling 1591-1752.* Rendered "*xxx Aikiris*" in *"Alexander Besat of the Quarell"* and *"Jonet Crechtouns' "* marriage contract.
3 The previous land tax roll, 1771, p. 15. "Thirty Aikers." £133.
4 *A Collection of Public Statutes, Passed in the 45th Year of the Reign of King George III.* (Anon. 1805 765).

Fig. 4.8.1. '30 Acres', as marked on (**a:**) Adair's *Mape of the Counties about Stirling* (c.1680); (**b:**) Edgar's *Map of Stirling Shire* (c.1745); (**c:**) Ross' *Map of Stiring Shire* (c. 1780); (**d:**) Cooper's *River and Frith of Forth* (c. 1730); (**e:**) Roy's *Lowland Survey* (c.1755); (**f:**) Grassom's *Actual Survey* (c. 1817), the first appearance of 'Forthbank.'

4.9. The Skeleton of a *Balaenoptera*, Found at Christie's Brickworks (Cornton) [JB].

> *"On Tuesday* (29.3.1864) *the workmen employed on the brick and tile works at Cornton came upon the bones of some large animal embedded in the blue clay. They prove to be the bones of a whale ... . A number of marine shells were found hard by, and I am told two horse-shoes have been dug out by the work-men, about 20'* (6m) *from the whale. As yet, the skeleton has not been disturbed. Mr [John] Christie, the proprietor of the land, offers it to anyone who will disentomb it. Can not some facts be gathered for Sir Charles Lyell? Is not this worthy of the attention of the Geological Society?"*

(Sir) John Murray, then Keeper of the MacFarlane Museum of Natural History, Bridge of Allan, to the editor of the *Scotsman* (1.4.1864). *Discovery of the Remains of a Whale at Bridge of Allan.*

4.9.1. Chain of References and Documentary Sources.

In the last decade of his life, John Christie acquired a wife, seven children, a manor named Forthbank and, in field outside the Bridge of Allan, a fossil *Balaenoptera* skeleton [JB] (Rettie et al. 1872 622; Ferguson 1905 228.) He was ignorant of this possession at Cornton until 1864, when building contractors uncovered the bones whilst laying the foundations of a new brickworks there Fig. 4.1.1b; Fig. 4.9.1a). *"[The* Balaenoptera *skeleton,* [JB] *having been offered [by J. Christie] to John MacFarlane for his Museum, at £5, and not being accepted by him"* (Glasgow Morning Journal 2.4.1864), John Murray then pleaded publicly for somebody to rescue the *'whale'* from his grandfather's intransigence (quoted above.)

The "*Cornton Whale*" [JB] reached readers in all corners of the British Isles[1], and attracted so many spectators that [John] Christie *"thinks that, could he have exhibited [the skeleton] somewhere at a small charge, [it] would have proved more lucrative than brick-making"* (Lothian 1864). However, nobody was found to buy it whole and, apart from a few elements, the *mysticete* skeleton remained "*entombed* " under John Christie's brickworks (Cornton; Fig. 4.9.1a). These events are related in:

1. (Glasgow Morning Journal 2.4.1864); (Alloa Avertiser 2.4.1864); (Stirling Observer 7.4.1864).
2. Johnston's *Skeleton of a Whale near Stirling* (1864) to the Philosophical Society, Glasgow.[2]
3. Lothian's *Whale Found at Cornton* (1864) to the Alloa Society of Natural Science.[3]
4. Scouler's *Exhibition* (1869) read in 1864 to the Glasgow Natural History Society.[4]
5. Catalogue of the Andersonian Museum (Anon. 1865).
6. Miller's *Handbook to Central Scotland* (1865 47).

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1 e.g. (Shields Daily Gazette 2.4.1865); (Nottingham Journal 8.4.1864) (Sheffield Independent 12.4.1864); Croydon Observer (15.4.1864); Birmingham Journal (16.4.1864); Stamford Mercury (22.4.1864) Dublin Weekly Nation (30.4.1864); Ballyshannon Herald (6.5.1864).

2 Unpublished - known only by the title.

3 As in (Alloa Advertiser 16.4.1864) not the proceedings of the Alloa Society of Natural Science.

4 Precis associated with a "Specimen Exhibited" / oral presentation, rather than a formally written publication.

7. Haswell's *Post-Glacial Clay* and *Old Estuarine Beds* (1865[5]; 1872) to the Edinburgh Geological Society.
8. Milne Home's *Estuary* and *Water-Lines* (1871 15, 26; 1882 34).

Morris (1893) quotes from Milne Home (1871 15, 26; 1882 34) but, in this instance, his information comes from *"a labourer who helped dig out the bones."* Turner (1912) cites Haswell (1872) but also provides some anatomical data not known in any published text. He is assumed to have corresponded with an as-yet unidentified source at the Andersonian Museum (Glasgow) where bones certain to have come from Cornton [JB] were preserved. Smith et al. (2010) radiocarbon-dated a rib in the Smith Museum (1774, now 19654.03), and insist that it too was part of this *Balaenoptera* skeleton [JB]. That bone is, in no way, proven to have been among those dug out at Cornton in 1864 and its provenance had already been disputed by Morris (1893) (see [AS].)

<u>4.9.2. Location.</u>

This skeleton's [JB] location must be within the footprint of Christie's Brickworks (Cornton) (Fig. 4.9.1a – b) given that *"part of the cranium [was exposed in] the foundation base for a wall. ... A portion of the vertebrae were exposed by the workmen, when opening the foundation of a parallel wall ... [the skeleton has] been ascertained to lie across a space of 26'* (7m) (Stirling Observer 7.4.1864). While the 1st edition Ordnance Survey (Stirlingshire 25' 10.11, surv. 1860 pub. 1865) was completed shortly before that brickwork's construction, and the 2nd (Fig. 4.9.1a), shortly before its demolition c. 1905 (Ferguson 1905 248, 271) its fabric seems to stay the same in the intervening time. The three radiating wings of building in 1898 are all practically 26' (7m) in width (Fig. 4.9.1a) so one of these likely intersected with the remains of the *Balaenoptera* [JB].

Morris' source (1893 32) does suggest some change of plan had happened since 1864, as *"this skeleton [JB] was found ... just under or adjoining the present large square chimney stack [of Christie's Brickworks (Cornton).]"* The whale's *(B. physalus)* [JB] position could be narrowed to a few square metres with this information, but the chimney is not plotted on the 2nd edition OS and no adequate photographs of Christie's Brickworks (Cornton) have been identified. The location of the "*Cornton Whale"* is, however, inaccurately marked on the 1' (Stirlingshire 39 1882) and 6' (Stirlingshire 1899 10.SE) geological maps, in fields c. 400 - 600m south of the brickworks.[6] Smith et al. (2010) correctly place a "W" at "Cornton" on "Fig 1", but provide arbitrary co-ordinates (NS 787 973) for *"rib of whale"* from *"Cornton"* (Table 2, No. 58).

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5 Known only in an extended abstract, in the Geological Magazine. slightly different version reported in (Scotsman 3.2.1865).

6 The 1' survey used a pre-1864 basemap, on which "Cornton Brickworks" is not plotted. The location may have been taken from a map in Milne Home (1871) where a striation marked across Cornton displaces the "W" for "Whale" (Fig. 2.2.1b).

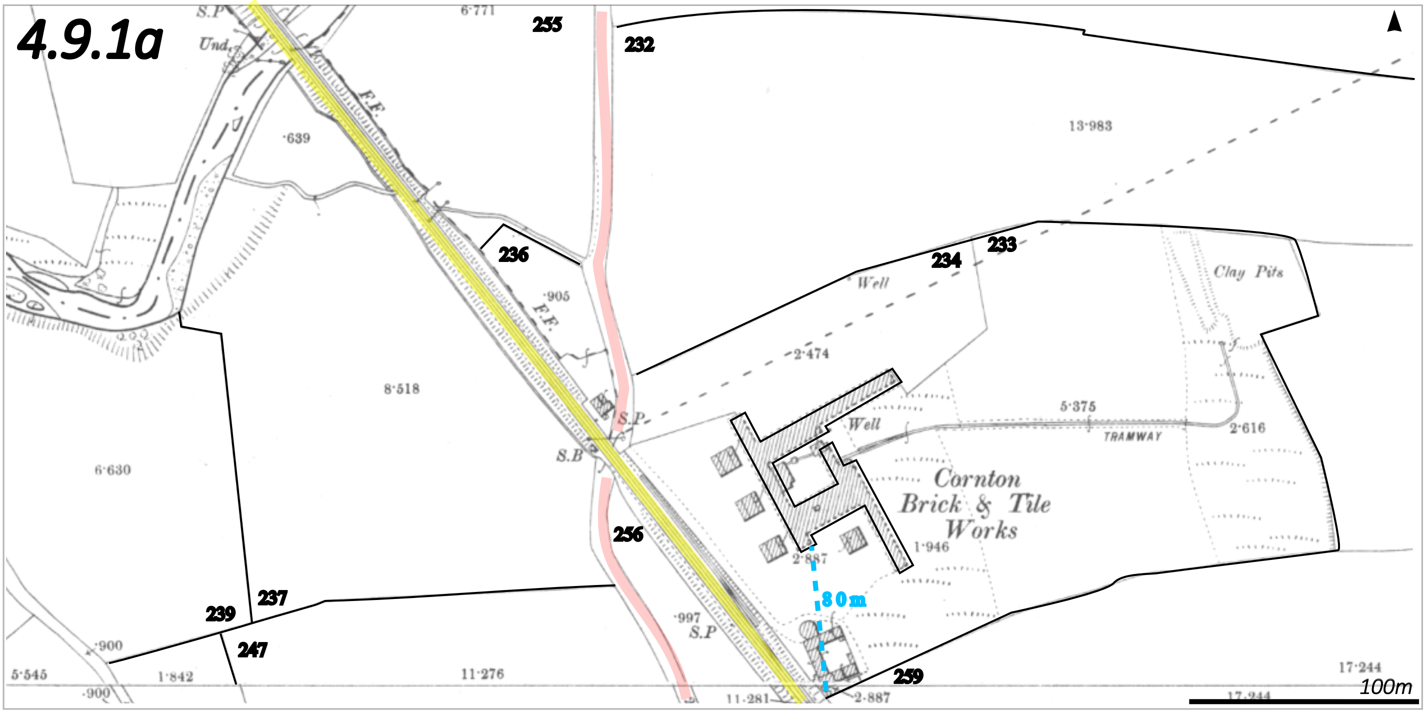

Fig. 4.9.1 Cornton, c. Bridge of Allan. (**a:**) Cornton Brickworks and Railway Siding c. 1898 (Stirlingshire 25' 10.11, surv. 1896 pub. 1898) and (**b:**) annotated satellite imagery of the same site in 2020 (from Google Earth.) Field Boundaries (black and white solid lines) and numbers (white numbers) are taken from (Stirlingshire 25' 10.11, surv. 1860 pub. 1865) at the time of Haswell's (1765, 1872) research. Field Boundary present in 1865 but absent in 1898 (white dashed). Road from Stirling to Bridge of Allan (red line). Railway between same (yellow line). Footprint of brickworks (as in 1898) (orange) and dimensions (blue numbers).

4.9.3. Stratigraphic Reconstruction

4.9.3.1 Stratigraphic Reconstruction (Sources).

The *mysticete* [JB] lies inside a 25m^2 radius of the co-ordinates (56.143390° -3.945605°) (Fig. 4.9.1b). No levels are known to have been taken here at any time but the skeleton's [AJ] location is well-confined. Within that small area, the ground surface is not expected to have varied. From this point, its stratigraphic position has been expressed as:

1. A depth below ground surface in 1864:

   - "*The bones were found about 5'* (1.52m) *below the surface*." Glasgow Morning Journal (2.4.1864).

   - *"The remains lie embedded at a depth of betwixt 5'* (1.52m) *and 6',* (1.82m) *in the blue alluvial deposit."* Alloa Advertiser (2.4.1864).

   - *"The remains lie imbedded in clay, at a depth from the surface of between 5'* (1.52m) *and 6'* (1.82m) *being the common red carse clay."* (Lothian 1864).

   - *"The cranial and jaw bones were removed for preservation, but the vertebrae were allowed to remain where discovered. They lie at a depth of about 6"* (1.82m) *embedded in blue alluvial clay."* (Miller 1865 47).

   - *at a depth of about 6"* (1.82m) *below the surface.* (Morris 1893 32).

2. A depth below ground surface in 1864, paired with a height above **mean average sea-level**. This is not gotten from self-contained accounts, but from three textual compounds:

i. John Scouler/Robert Garner. John Scouler (1804 – 1871), former professor at Anderson's University (now Strathclyde) and later, superintendent of the Andersonian Museum (Nelson 2014). He bought the skull of the *"Cornton Whale"* [JB] from John Christie for this collection but, in an associated publication (Scouler 1869), only the skeleton's [JB] depth below ground is stated. Robert Garner (1867) saw this skull on exhibition and records the elevation relative to sea-level at which it was discovered, either transcribing a label or quoting the Andersonian Catalogue.[7] This is likely to be the data, omitted from the published version of (Scouler 1869; read 1864).

1. *" [The remains of the whale found at Cornton] occurred in brick-clay, at about 8'* (2.4m) *below the surface. From the elevation at which it was found, the whale in this instance was probably of older date than the canoes found in the river deposits of the Clyde near*

7 Printed as a small pamphlet, for sale to visitors: *"The student, by the aid of his book alone, may become his own teacher. ... Under the table behind the Elephant, fragments of the cranium of a whale* (Balaenoptera Boops) *found near Stirling, about 2mi distant from the forth and 20'* (6.09m) *above the level of the sea."* (Anon. 1865 1.)

Broomielaw.[8] *"* (Scouler 1869 89).

2. *"In the Museum of the Andersonian Institution ... There are the cranial fragments of a whale (*Balaenoptera boops*), found near Stirling, 20' (6.09m) above sea-level, and two miles from the Forth.*" (Garner 1867 208.)

ii. Milne Home. Milne Home (1872) does not explicitly state the depth of the skeleton [JB] below ground surface. This value must be extrapolated from his description of the stratigraphy at Cornton:

1. *"At Cornton brickwork, a whale was found, partly in brick clay, partly in the blue soft mud beneath [the clay], at a height of about 16'* (4.87m) *above high-water mark.* (Milne Home 1872 26.)
2. [Section at Cornton Brickwork]: "*Surface soil*, *1'* (.3m). *Brick clay (light brown), 6"* (1.82m). *Mud or sleech (dark blue), 3'* (0.91m). *Mud or sleech (light blue), 3'* (0.91m). *Sand, of unknown depth."* (Milne Home 1872 15 - 16.) He comments: *"In the sleech a great number of extraneous objects have been found, viz. Portions of trunks and branches of oaks, leaves and nuts of hazel – also the skeleton of a whale."*

iii. Haswell. James Haswell wrote two papers on the carse, entitled *Old Estuarine Beds* (1865) and *Post-Glacial Clay near Cornton* (1872). The "*Cornton Whale*" [JB] featured in Haswell (1865), where he stated its depth below ground but not a land-surface elevation. Later, he (Haswell 1872) stated a land-surface elevation for the brickworks, but not the skeleton's [JB] depth below ground.

1. *The [post-glacial clay near Cornton] in which during the spring of last year the skeleton of a whale was found, at a depth of 9'* (2.7m) *from the surface.* (Haswell 1865 182.)
2. *"The top of the bank [of the River Allan] is on a level here, with Cornton Brick-Work: about 25" (7.6m) or 26" (7.9m) above the sea* [Field "237".] *The whale which was found at Cornton in 1864 [JB] could easily have got up here when the Carse stood at a lower level."* Haswell (1872 62 – 3).

4.9.3.2. Stratigraphic Reconstruction (Analysis.)

Scouler-Garner have the greatest estimated height (20' / 6.1m) above *sea-level* (0m ODN) for the skeleton [JB] and suggest a relatively great thickness of overlying clay (8' / 2.4m). If these values are correct, Christie's Brickworks (Cornton) stood at c. 8.5m ODN (Fig. 4.9.2a "1".) In contrast, Milne Home (1872) describes a similar volume of sediments (c. 2.3m) but a much greater or lesser elevation for the *mysticete* remains [JB] (4.9m ODN / 8.2m ODN), depending on the interpretation of the "*high-water"* datum (0m ODN or 3.3m ODN.) (Fig. 4.9.2b, "2" and "3"). Taking "high water

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8 One of which was in the Andersonian Museum, so not an arbitrary reference. Five canoes were found 1847-1849 at Springfield Quay /*"opposite the lower portion of the Broomielaw"* on the Clyde – *"the average depth was 19'."* (Buchanan, in Smith 1862, 163 – 5). The land-surface elevation here was c. 22' – 18.6' (Springfield Lane to Springfield Quay by Windmillcroft, Lanarkshire 6.10 25' (1860).

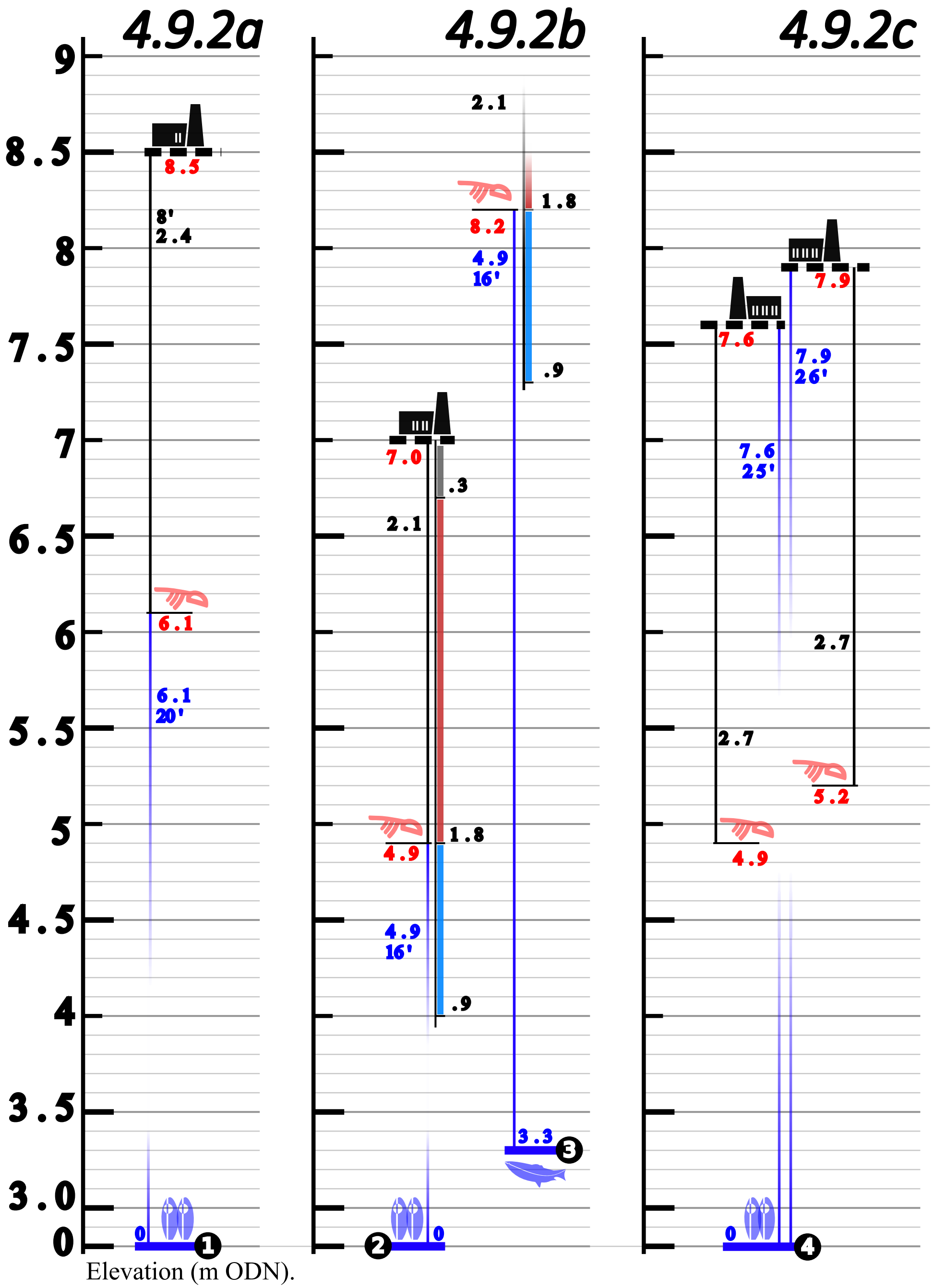


Fig. 4.9.2 - *Cornton Datum Diagram (2).*

a:) ("1", Black Factory, Two Windows.) Position of *cetacean* remains [JB] and land surface elevation of Christie's Brickworks (Cornton) in 1864. Reconstructed from Scouler (1869) and Garner (1867): [0m ODN + 6.1m + 2.4m = 8.5m ODN.]

b:) ("2" and "3", Black Factory, Four Windows.) position of *cetacean* remains [JB] and land surface elevation of Christie's Brickworks (Cornton) in 1864. Reconstructed from Milne Home (1872, 15 - 16 & 22): [0m ODN + 4.9m + 2.1m = 7.0m ODN]. [3.3m + 4.9m + 2.1m = 10.3m ODN.]

Stratigraphic Data: Surface Soil (Grey). Light Brown Brick Clay (Brown). Mud or Sleech (Blue). after Milne Home (1872 15).

c:) ("4", Black Factory, Six Windows.) Position of *cetacean* remains [JB] and land surface elevation of Christie's Brickworks (Cornton) in 1864. Reconstructed from Haswell (1865, 1872): [0m ODN + 7.6m = 7.6m ODN. 7.6m ODN - 2.7m = 4.9m ODN.] [0m ODN + 7.9m ODN = 7.9m ODN. 7.9m ODN - 2.7m = 5.2m ODN.]

Elevation Data (Land): **Black Horizontal -** land surface, with measured elevation (m above modern sea-level.) **Dashed Black Horizontal** - land surface, with reconstructed or inferred elevation (m, above modern sea-level).

Elevation Data (Sea): **Blue Horizontal**. a marine datum surface. **Two Blue Shells**. modern mean average sea-level (0m ODN). **One Blue Fish.** mean high water springs (Stirling) (3.3m ODN.)

Numbers: **in Red** - elevation, as measured, reconstructed, or inferred (m, above modern sea-level). **in Black** - distance (m). **in Blue** - Elevation of a marine datum (m above modern sea-level). **Number in Blue, and Blue Vertical Line -** distance (m) above a marine datum.

mark" as read (3.3m ODN, ***mean high water springs*** at Stirling) produces an anomalously high result, even before adding the volume of overlying materials (10.3m ODN total, Fig. 4.9.2b "3".)

Two plausible and incompatible elevation values for the skeleton [JB] and land surface at Cornton have been calculated: Scouler's 6.1m and 8.5m ODN, and Milne Home's 4.9m and 7.0m ODN (Fig. 4.9.2a - b). Of all known sources, Haswell (1865) recorded the greatest depth below ground for the *"Cornton Whale"* [JB]. (9' / 2.7m). At a later date, he (ibid. 1872 63) also estimated that the field in which Christie's Brickworks (Cornton) stood ("234"), and the field adjacent to the Allan Water ("237", Fig. 4.9.1a), were both 25' – 26' (7.6m - 7.9m) above *sea-level* (0m ODL.)[9] Working from that assumption, the elevation value (4.9m – 5.2m ODL; Fig. 4.9.2c, "4") deduced for the skeleton [JB] is closer to Milne Home's 4.9m ODN (Fig. 4.9.2b) than to Scouler-Garner's 6.1m ODN; Fig. 4.9.2a.)

In 1872, it may have been clear by eye that the two fields ("237, 234") were on a level. No historic or contemporary spot-heights are known to have been in the area, and an estate has since been built on Field "237" (Fig. 4.9.1b). Furthermore, that area is plotted within the 10m (ODN) contour on the most modern Ordnance Survey, whereas the site of Christie's Brickworks (Cornton) is excluded (4.9.3a). However, the extent of this contour at Cornton seems to be misjudged. A number of spot-heights that were determined in earlier surveys to be at lower elevations (e.g. 7.3m ODN) are encompassed by it. Although antiquated, the 25' contour (i.e. 7.5m ODN) on the 1957 OS may have better captured the topography. Both fields ("237, 234") are within that contour (Fig. 4.9.3b).

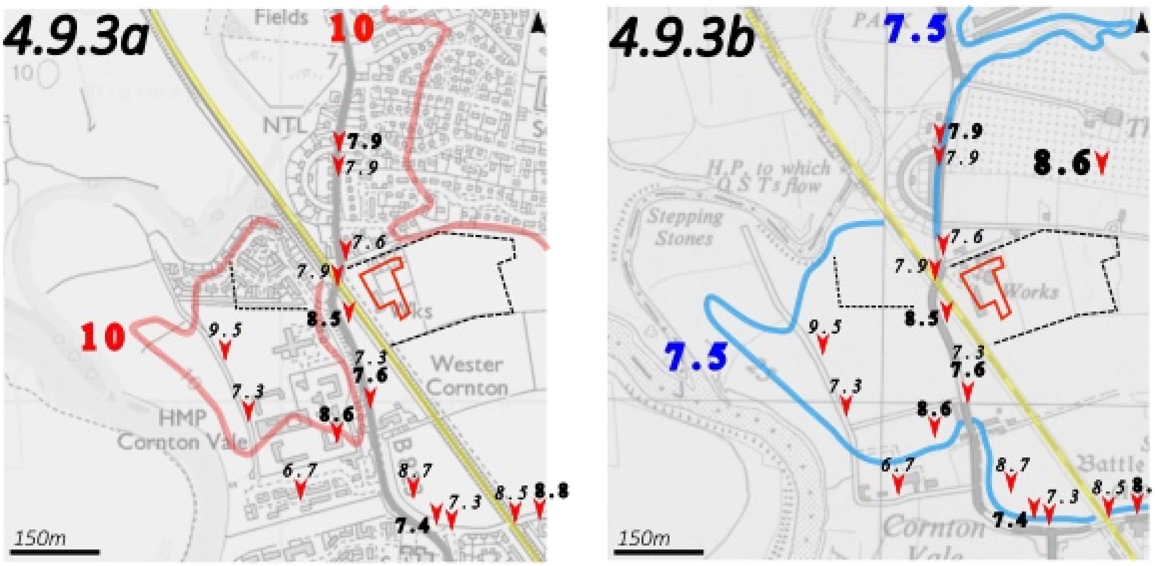


Fig. 4.9.3. (**a:**) Cornton, after Modern OS Mapping Data. Contour (red, m ODN) vs. spot-heights, m ODL (italics) and m ODN (bold). (**b:**) Cornton, after OS 1:25,000 NS79-B (Stirlingshire). Contour (blue, m ODN) vs spot-heights, m ODL (italics) and m ODN (bold). Areas of field "237" , "234" (black dashed) and footprint of brickworks (red).

9 Haswell (1872 62) makes explicit references to 1st ed. Ordnance Survey in this paper.

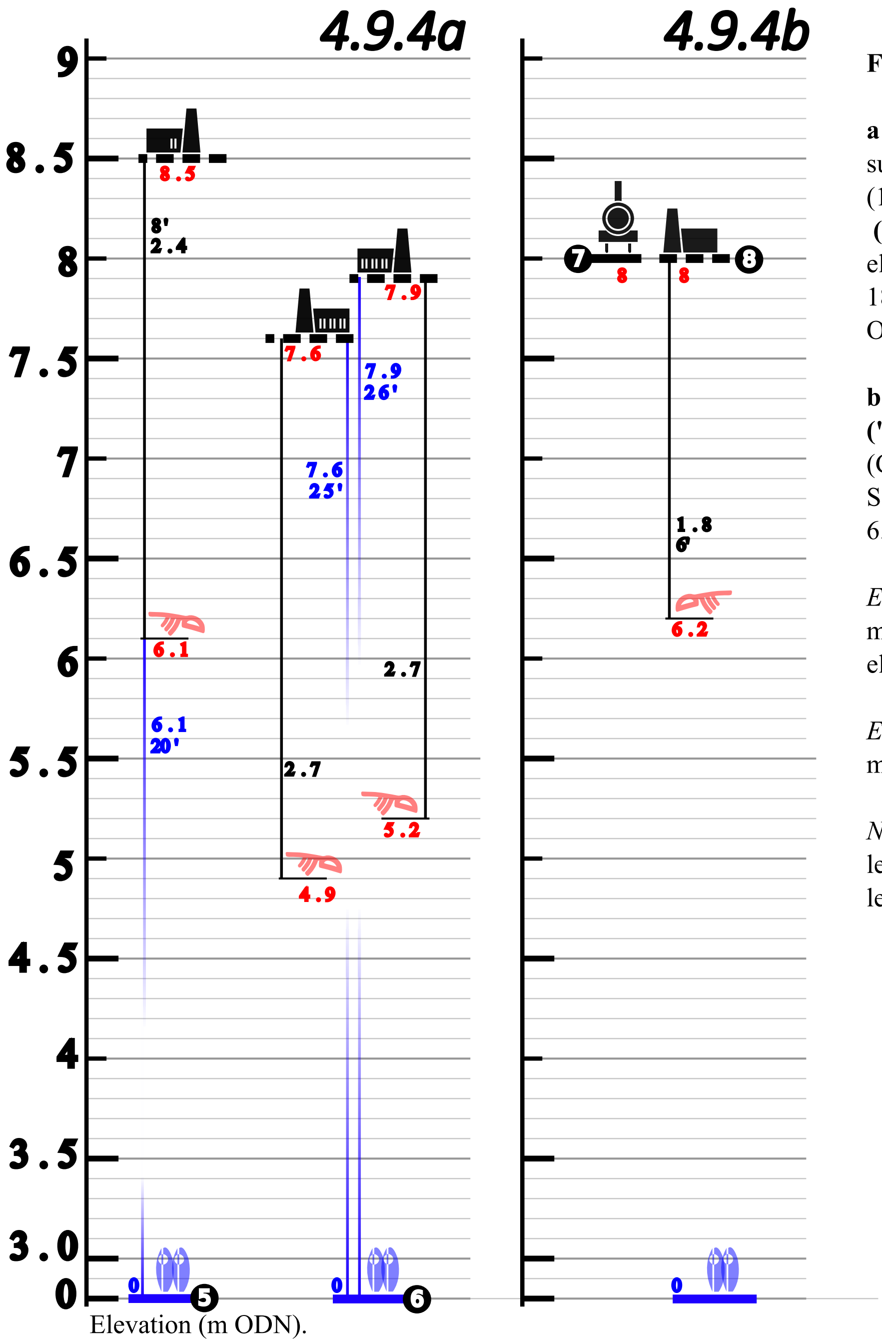


Fig. 4.9.4 - *Cornton Datum Diagram (2).*

a:) ("5", Black Factory, Two Windows.) Position of *cetacean* remains [JB] and land surface elevation of Christie's Brickworks (Cornton) in 1864. Reconstructed from Scouler (1869) and Garner (1867): [0m ODN + 6.1m + 2.4m = 8.5m ODN.]
("6", Black Factory, Six Windows.) Position of *cetacean* remains [JB] and land surface elevation of Christie's Brickworks (Cornton) in 1864. Reconstructed from Haswell (1865, 1872): [0m ODN + 7.6m = 7.6m ODN. 7.6m ODN - 2.7m = 4.9m ODN.] [0m ODN + 7.9m ODN = 7.9m ODN. 7.9m ODN - 2.7m = 5.2m ODN.]

b:) ("7", Black Train). Land surface elevation of Cornton Siding, 1896.
("8" Black Factory, No Windows). Land surface elevation of Christie's Brickworks (Cornton) in 1864 and position of *cetacean* remains [JB]. Reconstructed from "Cornton Siding Datum" (8m ODN, "7") and (Morris 1893, Lothian 1864 etc.) [8m ODN - 1.8m = 6.2m ODN.]

Elevation Data (Land): **Black Horizontal -** land surface, with measured elevation (m above modern sea-level.) **Dashed Black Horizontal** - land surface, with reconstructed or inferred elevation (m, above modern sea-level).

Elevation Data (Sea): **Blue Horizontal**. a marine datum surface. **Two Blue Shells**. modern mean average sea-level (0m ODN).

Numbers: **in Red** - elevation, as measured, reconstructed, or inferred (m, above modern sea-level). **in Black** - distance (m). **in Blue** - Elevation of a marine datum (m above modern sea-level). **Number in Blue, and Blue Vertical Line -** distance (m) above a marine datum.

The 1957 OS map does not confine the maximum elevation of Field "273" but limits the land-surface at Christie's Brickworks (Conrton), at a minimum, to 7.5m ODN (Fig. 4.9.3b). Milne Home's (1871) data must then be seen as suspect, since the land-surface elevation (7m ODN) worked out from his measurements falls below that value (Fig. 4.9.2b.) Both Scouler-Garner's (8.5m ODN) and Haswell's (7.9m – 7.6m ODN) can still be admitted but are, again, mutually incompatible (Fig. 4.9.4a).

Several levels have been taken, very close to the site of Christie's Brickworks (Cornton) (Fig. 9.3.3b). However, this evidence is conflicting. The level crossing (7.9m ODL) and corner to the cul-de-sac (7.6m ODL) stand at elevations suggesting a lower height ODN for the brickworks (Cornton) is appropriate (Fig. 4.9.3b). In contrast, greater levels were taken on the other side of the tracks at Wester Cornton (8.5m ODN) and in a contemporary measure for the railway siding at the brickworks (8m ODL)[10].

The original ground surface is almost always adjusted when building a railway. Here, the siding was not on an embankment, but in a cutting (Fig. 4.9.5). Therefore, the neighbouring brickworks must have been at equal to, but no at no less height then, that elevation (8m ODL).On the premise that the minimum elevation of the site is 8m ODL (Fig 4.9.4b, "7"), only Scouler-Garner's elevation data for the land-surface (8.5m ODN) and skeleton (6.1m ODN) can be admitted - although the thickness of the deposits may have been exaggerated (Fig. 4.9.4a). Many contemporary sources state that the remains lay only 5'- 6' (1.5m – 1.8m) below the land surface. By deducting that value from the (minimum) land-surface elevation for this location (8.0m ODL; Fig. 4.8.4b, "8") a corresponding elevation for the skeleton [JB] (6.2m ODL) results (Fig. 4.9.4b).

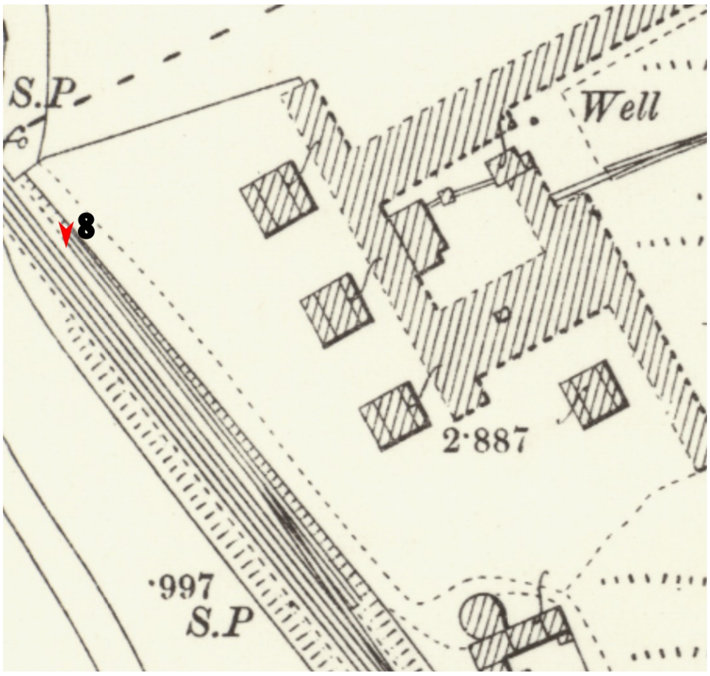


Fig. 4.9.5 Cornton Siding (after Stirlingshire 25' 10.11, surv. 1896 pub. 1898).

10 (Anon. 1896), No 2. Caledonian Rail Plan & Section. *"Cornton Siding."*

4.9.4. State of Preservation and Fate of the Bones.

The *cetacean* remains at Cornton [JB] were exposed for a short and chaotic time, and the records concerning them are contradictory. Several parties expressed an interest in acquiring the skeleton in its entirety,[11] but John Christie had no problem selling it piecemeal. Lothian (1864) inquired after *"some small portion for preservation in [our museum], at nominal charge"* and confirmed that *"[Christie] had allowed the head, jaw bones, and a few of the vertebrae of the whale, to be removed to the Andersonian Museum in Glasgow, for £5."* Although *"people were carrying away pieces [of bone] with them, [so it was resolved to cover all up again]"* (Glasgow Morning Journal 2.4.1864), the elements acquired by Scouler are the only bones, of certain provenance, known to belong to this *mysticete* skeleton [JB]. Later sources confirm that the rest of the bones remained *in situ* (Miller 1865; Harvey 1872; Morris 1893).

Almost every source reports that the skeleton was complete, although not, as sometimes reported, 60' long (e.g. Lothian 1864; Miller 1865; Gibson 1883). Scouler's (1869) own description of the discovery at Cornton [JB] is inexplicable and internally illogical: *"No part was found except the cranium: after being stranded and decomposed, the bones of the skeleton had been scattered by the tides. The head had not been transported ... for one of the small bones of the internal ear was found within the tympanic cavity of the temporal bone."* Given that he had violated the integrity of an otherwise pristine palaeontological specimen, Scouler's (1869) elaborate cover-story is, perhaps, unsurprising. He does provide the only quantitative measures of the skull (7' long, 2.1m).

This source also implies that the tympanic bones were acquired for the Andersonian Museum and not, as Morris' labourer claimed (ibid. 1893 32), *"taken by a gentleman from Alloa."* Turner (1912 8) also states that *"the skull [from Cornton], along with the earbones, was given to a museum in Glasgow"* and provides a detailed quantitative description of the tympanics. However, neither a paper nor an informant is cited and, by the time *Marine Mammals* was written, the Andersonian Museum had been closed for a decade (Reilly and Sutcliffe 2014). No other publication, informal or formal, is known to contain this information: Turner is assumed to have received it in private correspondence, at an unknown date.

The Andersonian's zoological specimens were acquired by the Hunterian Museum (University of Glasgow) in 1888 and the geological collections by the City of Glasgow in 1902 (ibid. 2014). While

11 Glasgow Morning Journal (2.4.1864), *"The Glasgow Senatus Academicus should endeavour to secure this [specimen]"*; Stirling Observer (7.4.1864) *"Negotiations are at present to have [the remains] moved to Edinburgh. We hope to see it placed in a local museum."* Glasgow Morning Journal (6.4.1864) *"the skeleton remains* in situ. *We learn that it was visited by an Edinburgh Professor on Saturday."*

this assemblage of *cetacean* bones might class as either, no records of these specimens appear in the Hunterian Ledger. Other Quaternary palaeontological specimens, known to have been in the Andersonian collections, were taken by Glasgow Museums (Now, "Glasgow Live." ibid. 2014). If any parts of "*Cornton Whale"* [JB] survive today, they most likely belong to the city of Glasgow.

4.9.5. Identification.

Named in some initial reports as a *Balaena*, or Greenland Whale (Glasgow Morning Journal 2.4.1864), Scouler (1869) initially referred it to *Balaenoptera rostrata* or minke whale *(B acutorostrata).* In the Andersonian Catalogue and in Garner's transcription (1876), it is referred to *Balaenoptera boops*. This is an archaic and deprecated taxonomic grouping (Fleming 1828; Bell 1837) which made no distinction between fin whales *(B physalus)* and minke whales *(B acutorostrata)* - similar physiologically, apart from their adult sizes. However, in Bell et al. (1872) and Alston (1880) (a co-author on the previous work) the skull is again referred to *B rostrata*, *alias* lesser rorqual, or Minke whale (*B acutorostrata*.) Turner (1912) reverted again, identifying the remains as those of a "*young* B. musculus[12].", i.e. a fin whale (now *B. physalus*.) Given the apparent size of the (fragmentary?) skull and minimum length of the entire skeleton, a juvenile fin whale seems to be the more plausible of the two identifications (Fig. 4.9.6, "2" and "4".)

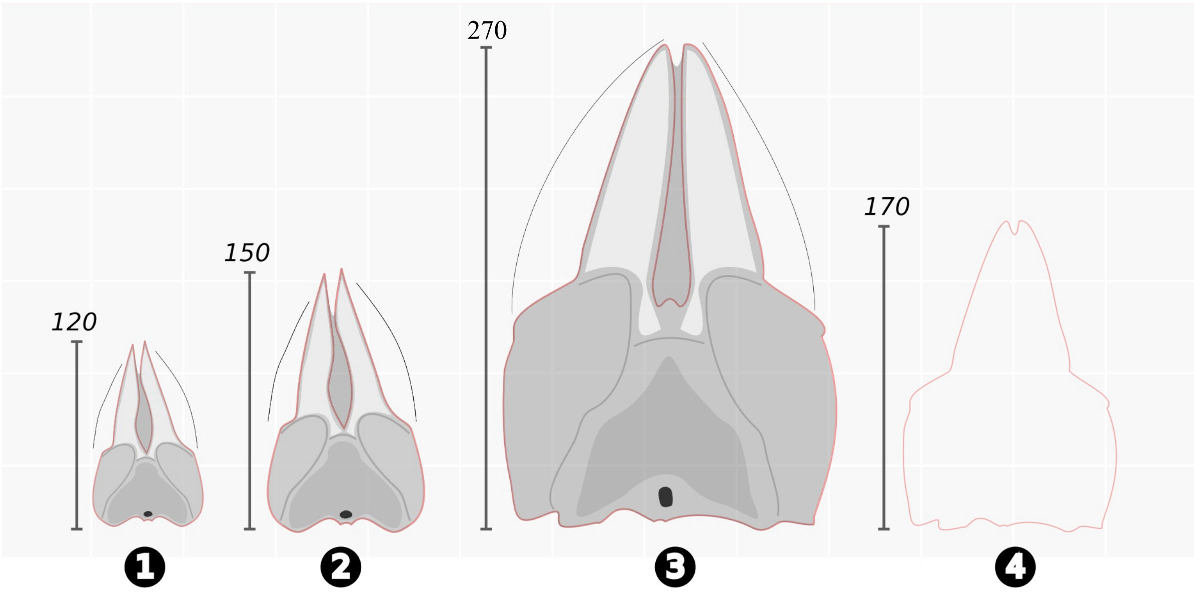


Fig. 4.9.6. Comparative anatomy and dimensions of *mysticete* crania

(1) Dimensions (cm) of cranium, juvenile *B. acutorostrata* (6m long; Elie.). After Turner (1912 61)
(2) Dimensions (cm) of cranium, adult *B. acutorostrata* (9m long; Dunbar). '*One of the largest examples of this species in any museum.'* (Turner 1892 39.) After Turner (1892 39, 1912 61.)
(3) Dimensions (cm) of cranium, adult *B. physalus* (15m long ; Aberdeen.). After Turner (1912 33.)
(4) Dimensions (cm) of fossil cranium, *mysticete* (Cornton) After Scouler (1869). Even if incomplete, the skull is larger than even the largest examples, from *B. acutorostrata.*

12 "B musculus" now refers to a blue whale, formerly "B sibbaldi."

4.9.6. Absolute Dating Evidence.

In 1893, Morris (1893) investigated the origins of a rib in the collections of the-then Smith Institute, which had been thought to belong to the *mysticete* skeleton from Cornton [JB]. He (ibid. 1893 46) concluded that it was a modern bone that enjoyed *"a reputation for antiquity which is not warranted".* Co-incidentally, it had also once belonged to John Christie, who had bought a number of whalebones to make fences around his mansion at Forthbank [AS]. This is entirely apart from the fact that another fossil *cetacean* skeleton may have been found at that same location in the preceding century, although the only proof for this is toponymy [JQA].

In 2010, Smith et al. (2010) radiocarbon-dated a rib in the Smith Museum (Stirling). This is presumed to be the specimen (19654.03) which produced an age of 330 +- 80, calibrated-corrected to 0 – 520 cal BP. It provides the strongest possible confirmation of Morris' (1893) anecdotal evidence [AS]. However, Smith et al (2010) re-iterate that this rib belonged to *"the Cornton Whale"* [JB]. Furthermore, they (ibid. 2010) suggest "*that whale was stranded [between 1500 - 2000], perhaps as the Allan Water channel migrated. The site of [Christie's Brickyard (Cornton)] is relatively close to the western limit of the estuary, near the confluence of the Allan and Forth."*

4.9.7 Discussion: Approximate Age of the *Balaenoptera* Skeleton, Discovered at Cornton [JB].

Christie's Brickyard (Cornton) stood at least 0.5km distant from the confluence of the Forth and Allan (Fig. 4.1.1b). The *mysticete* skeletons found at Meiklewood [USG] and Christie's (Stirling) [AJ] are both within 100m of the Forth, while bones from Causewayhead [TWW] are within 200m (Fig. 4.10.X). It has never occurred to anyone before, to think that those *cetaceans* were preserved in near-contemporary and *"as the [river] channel migrated".* No bones or skeletons of *cetaceans* have been discovered in the bedded sands and gravels of the modern Allan Water (Fig. 4.9.7). All have been found in the carse clay (an unstructured, blue clay-silt, containing marine organisms).

Most eye-witnesses confirm that the skeleton [JB] had been discovered in "blue clay", "blue silt", "sleech", "carse clay" etc. Others note the presence of marine (and not freshwater) *mollusca* in that same material, at this location (Murray 1864; Haswell 1865, 1872; Milne Home 1871.) Based on geotechnical bores (Fig. 4.9.7) the fluvial deposits are unlikely to extend inland to the site, where Christie's brickworks (Cornton) used to be. No corings can be done at the site itself to confirm the 19^{th} century descriptions of the stratigraphy, but one was made during this study at the closest point possible (Fig. 4.9.7, "7"). Carse clay demonstrably surrounded the site of the brickworks on its eastern, northern and southern sides. It is hard to credit that it was built on modern fluvial deposits –

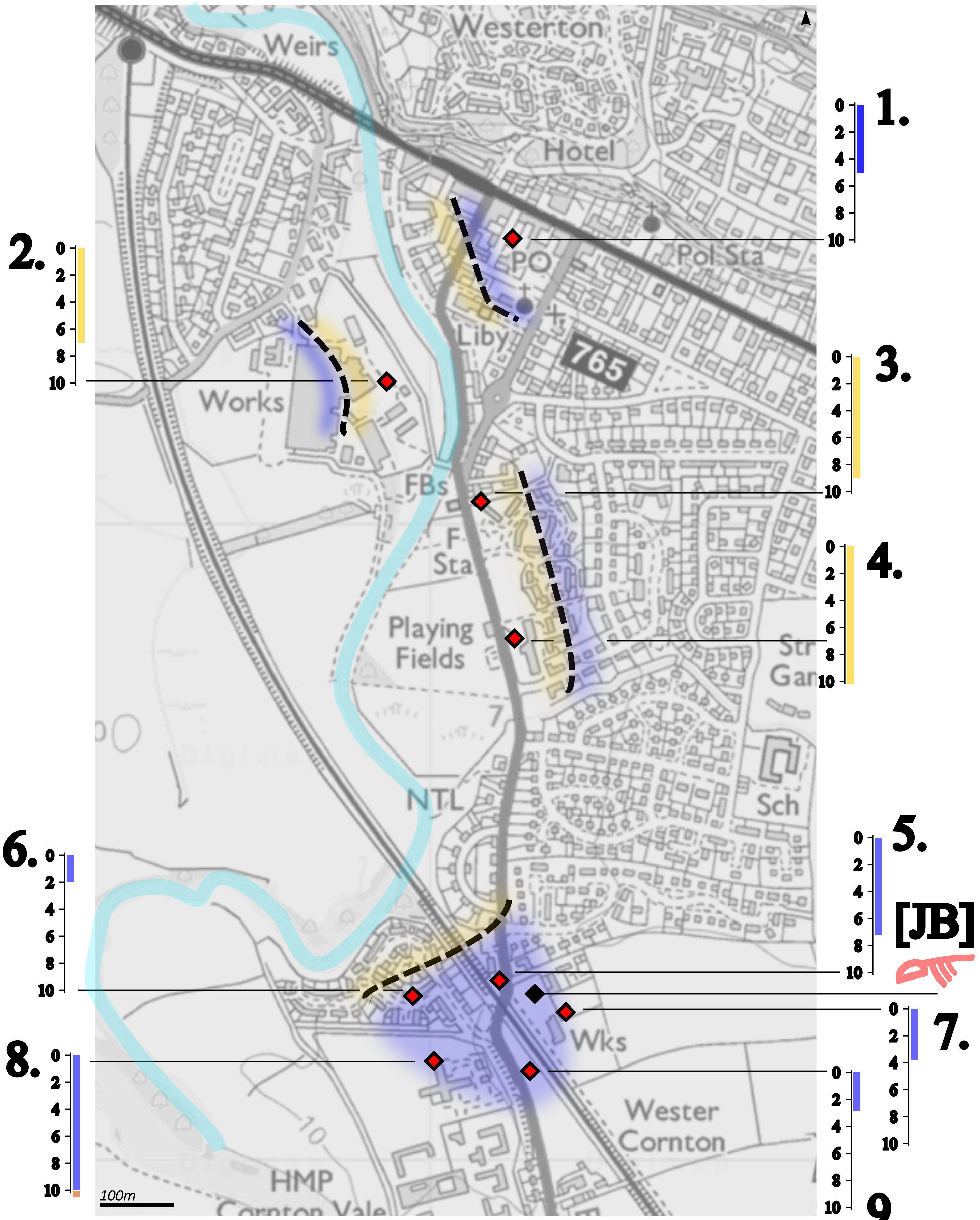
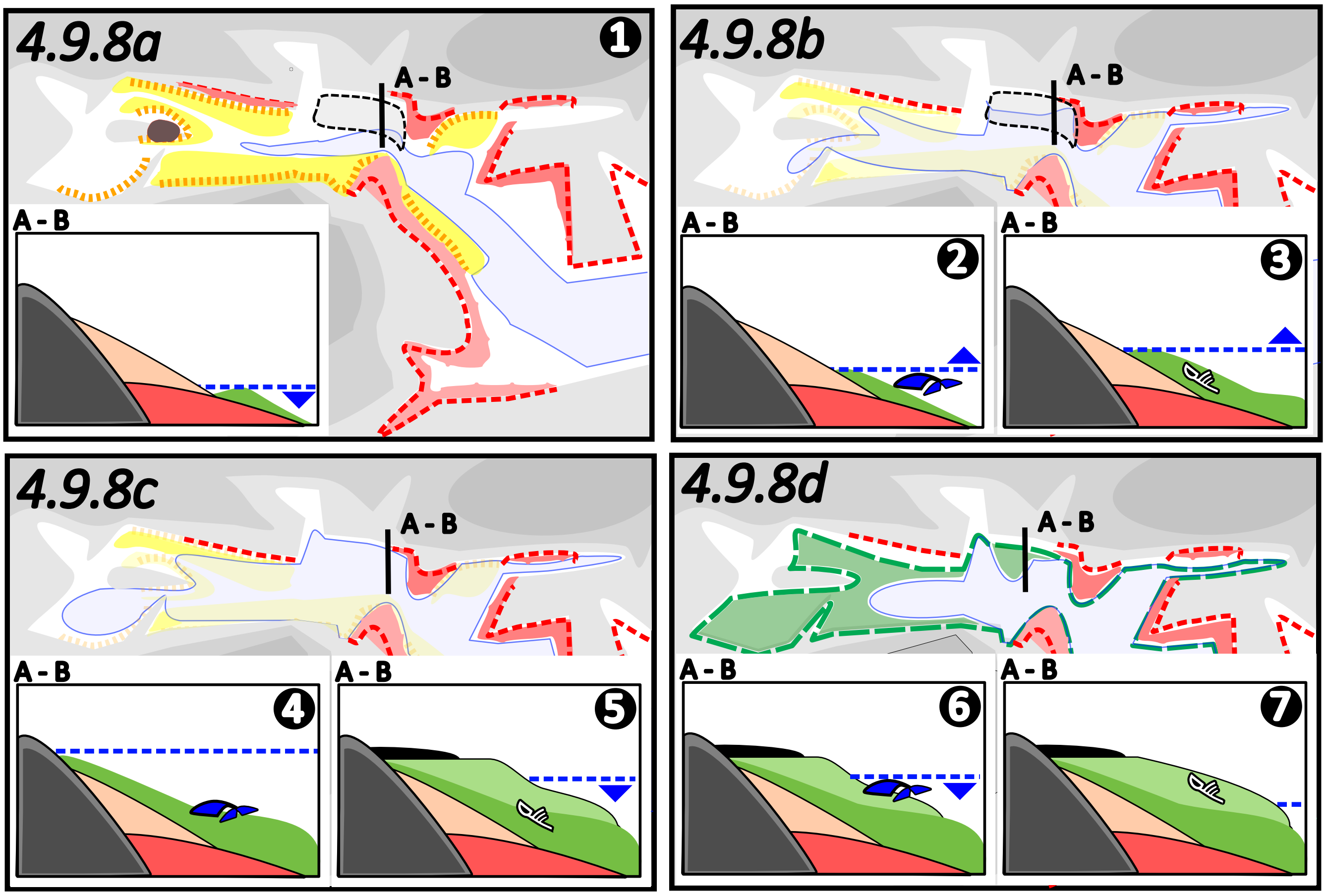


Fig. 4.9.7. Superficial Deposits, **Bridge of Allan and Cornton.** Extent of early Holocene carse clay (blue) and of modern alluvium (yellow), deposited by the River Allan (light blue). Site of coring (red diamond). Site of *cetacean* skeleton (black diamond). Logs describe thicknesses of deposits below ground (m), not their elevations (m ODN). The sand at 10m depth in log 8 belongs to the Teith Outwash Fan. Stratigraphic data from geotechnical cores (Appendix C).

nor, that so many eye-witnesses could have failed to describe the stratigraphy correctly.

Therefore, the *mysticete* skeleton [JB] can only have been excavated from the carse clay. This material accumulated between 9.5 ka BP – 2.0 ka BP (Smith et al. 2010). Anything preserved within it - and legitimately recovered from it - must also date to this period. The rib (19654.03) aged 500 cal BP cannot have belonged to the skeleton [JB], and its provenance is otherwise accounted for satisfactorily (Morris 1893) [AS].

It is hard to make a more precise inference about the age of this *cetacean* skeleton [JB]. There are no Buried Beaches in this part of the Forth Valley and the carse clay is deposited directly on an outwash fan (Fig. 4.9.8a). The remains [JB] are not, in any case, on that transgressive surface and are at least 1km distant from the inland margin of the carse clay. A living *cetacean,* or floating *cetacean* carcass, could have reached this location and elevation (c. 6.1m ODN) at practically any point in time during the Early Holocene Inundation (Fig. 4.9.8b, "2" – "3", Fig. 4.9.8d "6" – "7"). However, if it were preserved here just as sea-levels were falling from this location (c. Brickworks, c. 8m ODN; after approx. 3.0 ka BP) it would lie under only a shallow covering of clay. The remains were well-buried (c 2m) but this is not enough to confirm if the animal stranded in shallow water (in the early inundation) or sank in deep water (at the highstand; Fig. 4.9.8c, "4" – "5".)



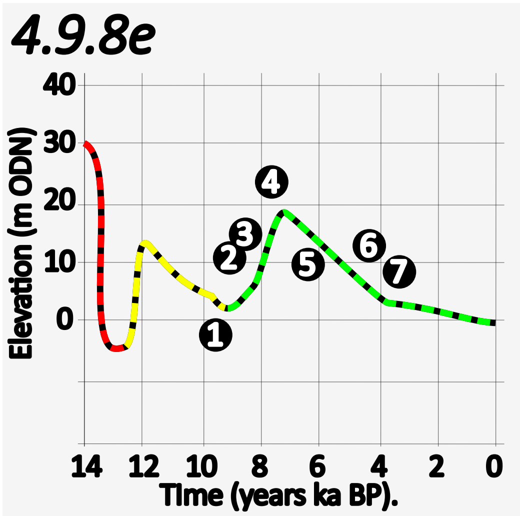


Fig. 4.9.8. Schematic Illustrations of sea-level change in the Western Forth Valley during the early Holocene Transgression and (insets): schematic section diagrams of "Raised Beach" landforms at Cornton, c. Bridge of Allan (A - B) and sequence of deposition.

a:) Deposition of carse clay on Teith Outwash sand. Panel "1" corresponds to No. "1"on Fig. 4.9.8e.
b:) Death and preservation of *mysticete* [JB] in the early transgression, in dhslloe water. Panels "2" - "3" correspond to No's "2" - "3" on Fig. 4.9.8e.
c:) Death and preservation of *mysticete* [JB] in the mid-transgression, in deeper water. Panels "4" - "5" correspond to No's "4" - "5" on Fig. 4.9.8e.
d:) Death and preservation of *mysticete* [JB] in the late transgression, in shallow water. Panels "6" - "7" correspond to No's "6" - "7" on Fig. 4.9.8e.

e:) Composite Sea-Level Change Curve (Western Forth Valley). "1" - "7" correspond to panels "1" - "7" in Fig. 4.9.8a - d. Section from 12 ka BP - 5ka BP after Smith et al. (2010).Section from 12.5 - 10.9 ka BP approximate, after suggestions in Sissons (1966, 1968.) Sections 14 ka BP - 12ka BP and 4.5ka BP - 0 ka BP after Shennan et al. (2018). No empirical sea-level curve has been constructed for these time-periods, due to the lack of transgressive and regressive overlaps for the associated deposits.

Position of high water water mark (blue solid, or blue dashed). Net falling or rising sea-levels, indicated by blue arrow (pointed down or up). Pleistocene RMDs (red). Landward edge of same (red dashed). Loch Lomond Interstadial RMDs, or "Buried Raised Beaches" (yellow). Landward edge of same (yellow dashed). Teith Outwash (beige). Holocene RMDs, or "carse" (green). Peat (thick black). Basemap after Google Earth Pro (2022). Extent of raised marine landforms, after (Sissons & Smith 1965; Sissons 1966; Sissons 1969; Sissons 1972; Kemp 1971; Peaccok 1999; Smith et al. 2010).

4.10. The Disarticulated *Mysticete* Remains, found at Causewayhead (c. Stirling) in 1897 and 1906. [TWW].

"14. Causewayhead Whale. Found in May and June 1897, and August 1906 at Causewayhead, near Stirling, from 5' to 10' below the surface. A fragment of rib showed traces of human workmanship. There was also found a boring implement made of deer's horn."

David Buchan Morris (1925 139.) *The Whale Remains of the Carse of Stirling.*

4.10.1. Chain of References and Documentary Sources.

When sewage pipes were laid in Causewayhead, opposite Stirling (Fig. 4.1.1b) *cetacean* bones were found on at least two discrete instances. In November 1897, Morris (1898) related the discovery of a number of ribs earlier that year to the Stirling Archaeological Society although, at the time, no newspapers seem to have reported it[1]. Correspondence with Prof. Turner is paraphrased in that paper (ibid. 1898) but he is not named as an author: *"Turner states that the ribs are of the size of* B. musculus [fin whale, now *B. physalus*] or B. sibbaldi [blue whale, now *B. musculus*] *which had not reached full growth."* The *cetacean* bones recovered in 1897 are assumed to have all belonged to one single *mysticete* [TWW]. Morris' report on events at Causewayhead, in 1897, has at least six iterations:

1. In the Proceedings of the Stirling Archaeological Society (Morris 1898).
2. Read to the Alloa Natural History Society in 1899 (Alloa Advertiser 11.3.1899).
3. Quoted extensively in Munro's (1899) *Prehistoric Scotland.*[2]
4. Slotted into the re-print of *Raised* B*eaches* (Morris 1901) - the only significant revision.
5. In *Whale Remains*, as read to the Stirling Archaeological Society (Morris 1923).
6. In *Whale Remains*, as published by the Scottish Naturalist. (Morris 1925).

Turner's diagnosis is not found within any of his own publications and, on his return to the Smith Institute while writing *Marine Mammals* (1912), he did not re-examine the bones from Causewayhead which were conserved there. Instead, Turner wrote at much greater length (e.g. Turner 1912 10, 1917 173) on the evidence for prehistoric human activity, supposedly associated with this assemblage. This evidence consisted of a fragment of red deer *(C. elaphus)* antler: perceived to have been artificially smoothed but not otherwise cut, sawn, shaped, scraped, filed, engraved, perforated, decorated, etc. *"The tine was so sharp at its point that it could have been*

1 But also Falkirk Herald (5.5.1897) [5]: *"Antiquarian Find Near Stirling. During recent excavations under [Abbey] Craig at Airthrey Castle, the workmen came upon fragments of a vessel and a number of bones, which have ... been sent to Dr Paterson, Bridge of Allan, as additions to his collection.n[They] were deeply embedded under boulders."*

2 Also Munro (1898 271 – 2); itself later badly paraphrased by Johnson (1908 44).

employed as a borer for skins, or even as a pick which much force did not require for it to be employed. ..." (Turner, quoted in Morris 1901 26 – 7.) In addition, one fragment of one rib was *"cleft into the chancellated tissue. ... the condition was not natural*." (Turner 1912 10.)

At least one more *"part of the backbone or rib of a whale"* was excavated during August 1906 *"in the [drain track] at present being dug in the public road between Causewayhead and Bridge of Allan",* as reported in several contemporary newspapers[3]. These articles refer to Morris and his research, but he himself appears to have been unaware of this discovery. Alluding to it later, Morris (1923) quotes the newspaper text *verbatim: "In digging another drain track in 1906, the workmen came upon what was described as* "part of the backbone or rib" *of a whale."* He adds that *"I have no doubt that this bone was part of the whale, of which fragments were found in 1897."* Lastly, Andrew Kerr (1910) exhibited *"the vertebra of a whale from Causewayhead, Stirling"* to the Geological Society of Glasgow in 1909. However, it is unknown if this bone was among those found in 1897, in 1906, or even in a third instance of discovery.

Clark (1947), Smith et al. (2010) and others count this as "*whale, discovered with a tool*" (e.g. Fig. 2.2.1 c – d.) Whether the antler discovered at Causewayhead had undergone any manufacture, or been usefully employed by *"the whale-hunters of [prehistoric Scotland]"* (Munro 1899 65) is speculative. Even if their function remained subject to interpretation, the antlers discovered at Meiklewood (Turner 1890), Blair Drummond (Home Drummond 1826; Milne Home 1841) and Airthrey (Bald 1819) had evidently been modified by humans. Moreover, the stratigraphic relationship between the antlers and the *cetacean* remains [USG] [BF] [ZT] was unambiguous in those other cases. At Causewayhead, it is not proven that any of the *mysticete* bones [TWW] shared the same stratigraphic position with the antler.

4.10.2. Locations.

The sewer discharges into the Forth at Ladysneuk (56.134631° -3.920321°) and follows the main road between Alloa and Bridge of Allan, around the base of the Abbey Craig (i.e. *"along the old coast line of the 50' Raised Beach.";* Scotsman 13.8.1906; Fig. 4.10.1). The discoveries in 1896 and 1906 occurred at different stages of the project and at different points along the pipeline. In 1896, *"the whale remains were found not all found together* [sic] *but scattered over a distance of 100yd"* (91m) (Munro 1899 64) at a distance 300yd (275m) – 400yd (365m) east from the inn at the

3 E.g. (Scotsman 13.8.1906); (Strathearn Herald 18.8.1906); (Edinburgh Evening News 13.8.1906). Also (Alloa Journal 18.8.1906): *"A fragment of a whale's skeleton has been found near Causewayhead. In some far distant epoch, the valley of the Forth was a bounding ocean where marine monsters of the largest type had ample room to gambol. Perhaps Stirling was a seaside resort in these days."*

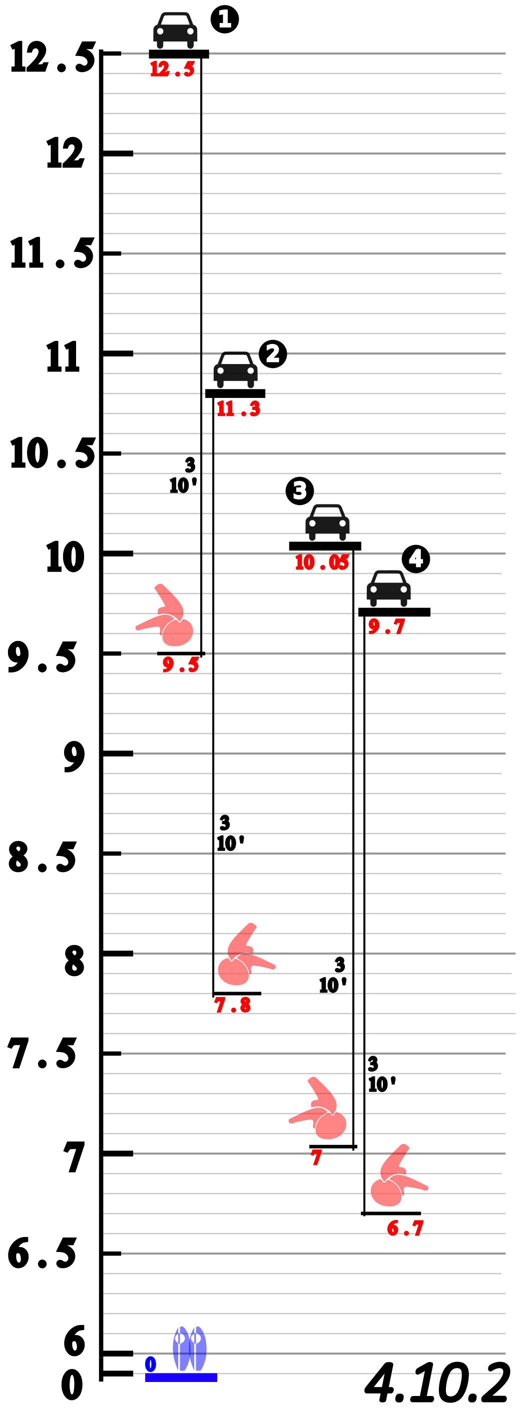


Fig. 4.10.2 - *Causewayhead Datum Diagram (1).* **("1" - "4", Black Cars.)** Position of *cetacean* remains [TWW] found in 1906 (red vertebra). Reconstructed from (Scotsman 13.8.1906 etc.), using several OS spot-heights on the "Airthrey Road" (Fig. 4.10.1). [12.5m ODN - 3m = 9.5m ODN.] [11.3m ODN - 3m = 7.8m ODN.] [10.05m ODN - 3m = 7m ODN.] [9.7m ODN - 3m = 6.7m ODN.]

Elevation Data (Land): **Black Horizontal -** land surface, with measured elevation (m above modern sea-level.)

Elevation Data (Sea): **Blue Horizontal**. a marine datum surface. **Two Blue Shells**. modern mean average sea-level (0m ODN).

Numbers: **in Red** - elevation, as measured, reconstructed, or inferred (m, above modern sea-level). **in Black** - distance (m). **in Blue** - Elevation of a marine datum (m above modern sea-level).

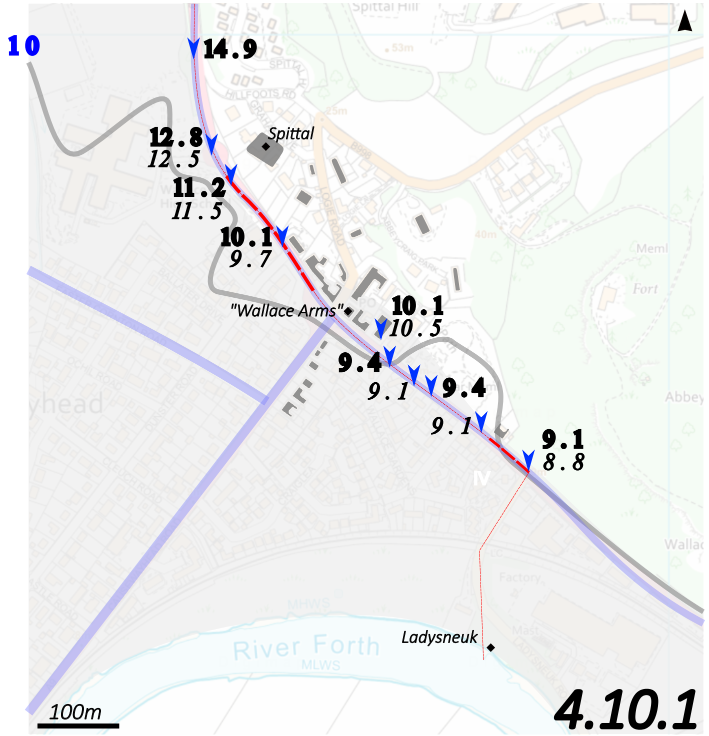


Fig. 4.10.1. Causewayhead. Details from OS 25' Stirlingshire 10.2 (Surv. 1896 pub. 1898) Superimposed on Modern OS mapping (2020.) 10m contour (grey line.) Elevation in m ODL (italics) and m ODN (bold). Buildings extant in 1896 (grey blocks.) Roads extant in 1896 (blue lines). Course of sewer (fine red dashed). Sections of sewer excavation, over which *cetacean* bones proposed to have been found (thick red dashed).

crossroads (now, the *"Wallace* Arms"; Fig. 4.10.1).[4] In 1906, *"the workman came upon the [bone] at a point about 100yd* (91m) *west of the former village [of Causewayhead], in the public road."*

Therefore, the 1896 and 1906 discoveries were at least 600m apart. This stretch of road has been surveyed exhaustively and, over this distance, the carse is not level. The ground-surface climbs relatively steeply from the east of the inn (9.1m ODN) to the western extremities of Causewayhead (14.9m ODN; Fig. 4.10.1). Given that difference of elevation, it may not be as certain as Morris (1923) supposed, that the bones found in 1896 and 1906 really all came from one animal [TWW].

4.10.3. Stratigraphic Reconstructions

4.10.3.1. Stratigraphic Reconstruction (West, 1907.)

The position of the "*backbone*" discovered in 1907 must be calculated by deduction (10' underground, or 3m.) However, the place of discovery cannot be closely confined with the available locational information: *"at a point about 100yd* (91m) ***west*** *of the former village [Causewayhead], in the public road."* Causewayhead does not have a clear "edge" but, given that the road to Bridge of Allan runs due north beyond Spittal, the bone was likely discovered between there and the pub (Fig. 4.10.1). This admits too great a range of possible ground surface elevations (10.05m, 11.27m, 12.5m ODN) from which to deduct 3m (Fig. 4.10.2, '1' – '4'.)

4.10.3.2. Stratigraphic Reconstruction (East, 1897.)

Less information is available for these *cetacean* bones and Morris (1901) did not, initially, state the position of any of the ribs [TWW] as a depth below ground, height above a marine datum, or in relation to the deposits. Only the position of the deer antler is recorded clearly, lying *"within a short distance of the fragments of whale's ribs, at the junction of the blue clay and the subjacent sand"* (Morris 1901). The antler and the *mysticete* bones are all, simply, inferred to have been found at that same contact. Latterly, Morris (ibid. 1925) clarified that *"[the bones* [TWW] *were found] from 5'* (1.5m) *to 10'* (3.04m) *below the surface"*. Turner (1912 10) also records that *"[portions of the ribs]* [WHH] *were found lying in the clay."* (not in the sand.)

Based on Morris' (1901) 15' (4.2m) section, "*300m east of the inn*" (Fig. 4.10.3, "IV") 4.2m of material overlaid the antler. Taking 9.1m ODN as land-surface elevation, the antler was found at 4.9m ODN (Fig. 4.10.4b, "5".) Taking either 5' (1.5m) or 10' (3m) for the depth of the *cetacean* ribs [TWW] below ground surface results in elevation values of 7.6m or 6.1m (ODN) - well within the

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4 (Paterson 1966 155) (written 1954) 3rd SA. *"[Discovered at] no great distance from the Causewayhead roundabout on the Alloa Road."* Rev. William Paterson is no relationship to the Dr Alexander Wilkie Paterson, an eccentric who acquired a rib from Causewayhead in 1897.

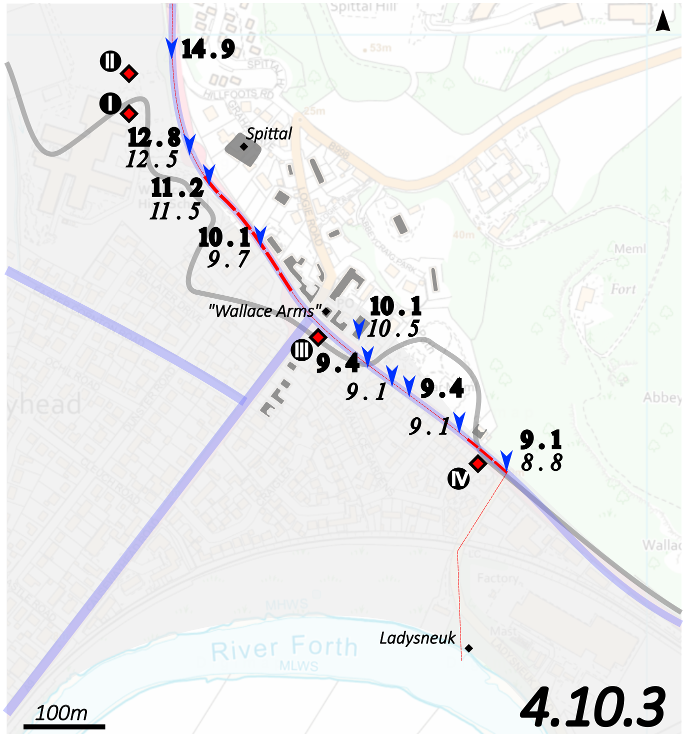

Fig. 4.10.3. Causewayhead. Details from OS 25' Stirlingshire 10.2 (Surv. 1896 pub. 1898) Superimposed on Modern OS mapping (2020.) 10m contour (grey line.) Elevation in m ODL (italics) and m ODN (bold). Buildings extant in 1896 (grey blocks.) Roads extant in 1896 (blue lines). Course of sewer (fine red dashed). Sections of sewer excavation, over which *cetacean* bones proposed to have been found (thick red dashed). Sites of corings or sections (red diamonds) i - ii, Smith (1965), iii - iv. Morris (1901).

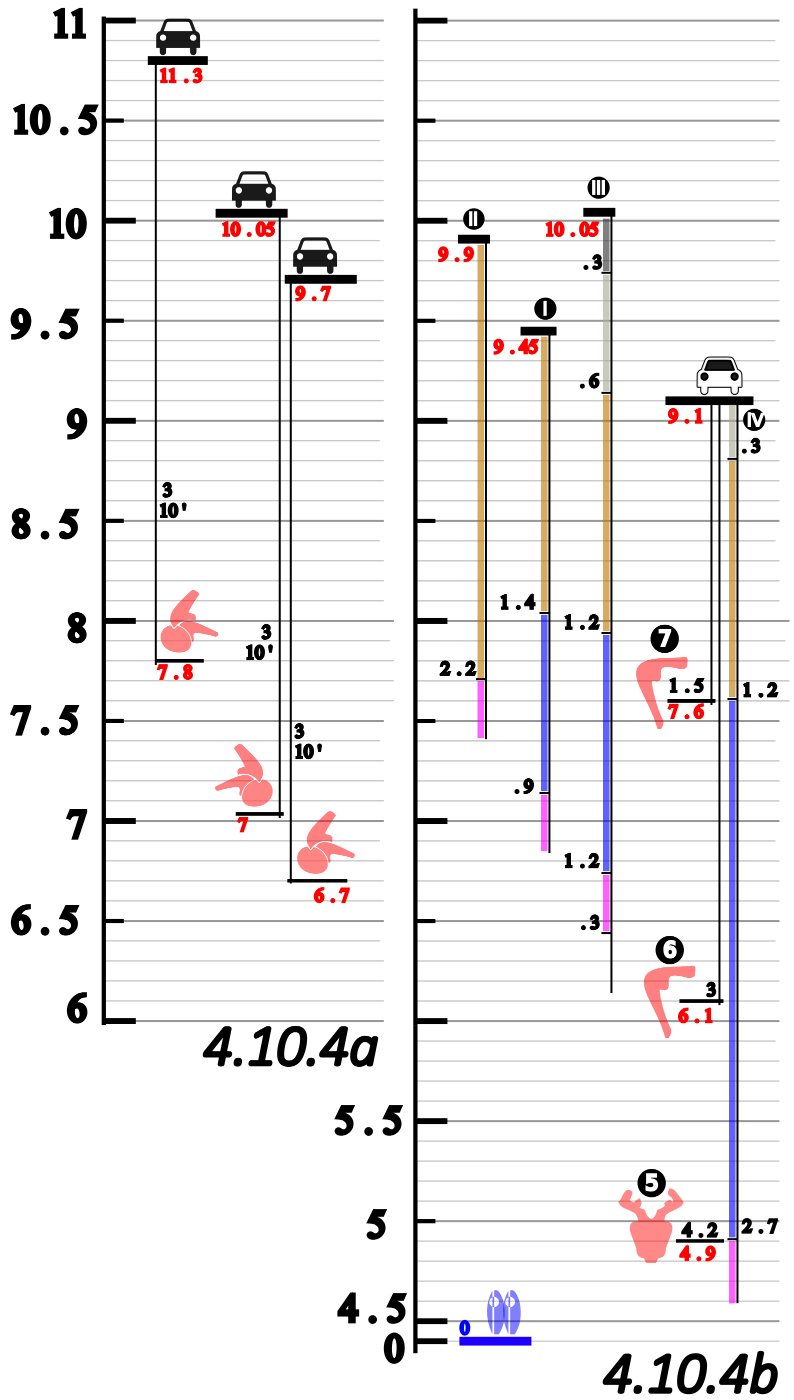

Fig. 4.10.4 - *Causewayhead Datum Diagram (2).*

a:) ("1" - "4", Black Cars.) Position of *cetacean* remains [TWW] found in 1906 (red vertebra). Reconstructed from (Scotsman 13.8.1906 etc.), using several OS spot-heights on the "Airthrey Road" (Fig. 4.10.1). [11.3m ODN - 3m = 7.8m ODN.] [10.05m ODN - 3m = 7m ODN.] [9.7m ODN - 3m = 6.7m ODN.]

b:) ("5" - "7" White Car.) Position of *cetacean* remains [TWW] (red rib) and deer antler, found in 1897. Reconstructed from Morris (1901), using OS spot-height 9.1m ODN on the "Alloa Road" (Fig. 4.10.3)

("5"). Elevation of clay-sand contact: [0.3m + 1.2m + 2.7m = 4.2m of sediment.] [9.1m ODN - 4.8m = 4.9m ODN.]

("6") Possible elevation of *cetacean* remains, following (Morris 1925): [9.1m ODN - 3m - 6.1m ODN.]
("7") Possible elevation of *cetacean* remains, following (Morris 1925): [9.1m - 1.5m = 7.6m ODN.]

Stratigraphic Data: Surface Soil or Road Metal (Black and Grey.) Brown Clay (Yellow). Mud, Sleech, Carse Clay (Blue) Sand (Teith Outwash Fan) (Pink). After (Morris 1903, Smith 1965).

Elevation Data (Land): **Black Horizontal -** land surface, with measured elevation (m above modern sea-level.)

Elevation Data (Sea): **Blue Horizontal**. a marine datum surface. **Two Blue Shells**. modern mean average sea-level (0m ODN).

Numbers: **in Red** - elevation, as measured, reconstructed, or inferred (m, above modern sea-level). **in Black** - distance (m). **in Blue** - Elevation of a marine datum (m above modern sea-level).

carse clay, and some distance from the contact with the sand (Fig. 4.10.4b, "6" and "7".) Given that such a volume of carse clay had accumulated between the deposition of the antler and the deposition of the ribs to the east of Causewayhead (even at the most generous assessment), it is doubtful that one could have been contemporaneous with the other.

4.10.4. State of Preservation, Identity, Fate of the Bones.

Neither the *"backbone"* found in 1906 nor the vertebra exhibited by Kerr in 1910 can be traced. Several bones found in 1897 "*that have not been identified, but are probably bones of a whale"* passed to a "*Mr Morries Stirling"* and are also presumed lost (Munro 1899 62.) Lastly, the fate of the *"rib, 3' long, broken into three pieces"* acquired by Dr Alexander Wilkie Paterson (Morris 1901) is unknown. However, it is likely to have informed Turner's diagnosis, that the assemblage had all belonged to a single juvenile *mysticete* [TWW]. Morris (1901 22 - 3) describes two ribs which, along with the antler, remain in the collections of the Smith Museum. It cannot be shown that remains from two discrete animals, at two different elevations, were found at the two different locations in 1897 and 1906 (Fig. 4.10.4a - b). Morris' (1925) assertion that all these bones [TWW] came from individual is respected.

4.10.5. Discussion: Approximate Age of the *Cetacean* Remains found at Causewayhead [TWW]

From the Loch Lomond Stadial, sand and gravel washed out of glaciers at the head of the river Teith and were deposited at its confluence with the River Forth. Termed "Teith outwash", this material continued to accumulate during the cycle of increasing sea-levels, in which the Buried Beaches formed in almost all other locations of the Forth Valley. Between the Bridge of Allan and Abbey Craig, carse clay was deposited directly on these coarser sediments in the Holocene Transgression.

Therefore, the red deer antler at Causewayhead was found at a transgressive contact, between carse clay and the Teith outwash (Fig. 4.10.5a, "1" – "2".) If the marine clay was deposited on the alluvial sand, simultaneous with rising sea-levels, then the antler must date to a very early part of the transgression (Fig. 4.10.5a, "1" – "2".) given its low elevation (c. 4.5m ODN; c. 9.5 ka.) All available positional data suggest that the *cetacean* ribs were not discovered on that contact and were at a higher point in the stratigraphic column and so must be younger in age. If one of the bones known to been part of the assemblage found at Causewayhead were radiocarbon-dated, and did produce an early age (c. 9.5 ka BP), then the stratigraphic re-construction (Fig. 4.10.4b) would be incorrect.

In the preceding instances [BF] [AJ] [JB], the *cetacean* remains were fully-articulated. It is possible that some of these skeletons represent carcasses that sank in deep water to the bed of the estuary [AJ] [JB] rather than animals which stranded in the shallows, as sea-levels rose or fell. Their stratigraphic position might suggest that they date to an earlier part of the inundation, and seem older than they really are. However, as these were all intact skeletons, it is safe to assume that the bones are very close to the place and position, in which the *cetacean* carcass itself originally came to rest.

The *cetacean* remains at Causewayhead (East) [TWW] are at a low elevation (c. 6.1m ODN) but are disarticulated and fragmented. Therefore, it is probable that these bones have been moved – and likely, that the place and elevation where the ribs were found is not the place and elevation where the animal's carcass initially came to rest (Fig. 4.10.5b, "3" – "4".) Forman et al. (1987) point out that weathered *cetacean* bone is not buoyant and sinks rapidly. If these bones have migrated down the shoreface and settled into clay, accumulating in deeper water, then animal's skeleton may have broken up in shallow water, when sea-levels were higher (Fig. 4.10.5c). A disparity between the radiocarbon ages of the ribs and their stratigraphic positions should therefore be expected, but the size of that disparity is hard to predict. Not least, because two elevations have been calculated for them (6.1m ODN and 7.6m ODN; Fig. 4.10.4b) and it is uncertain, which is correct.

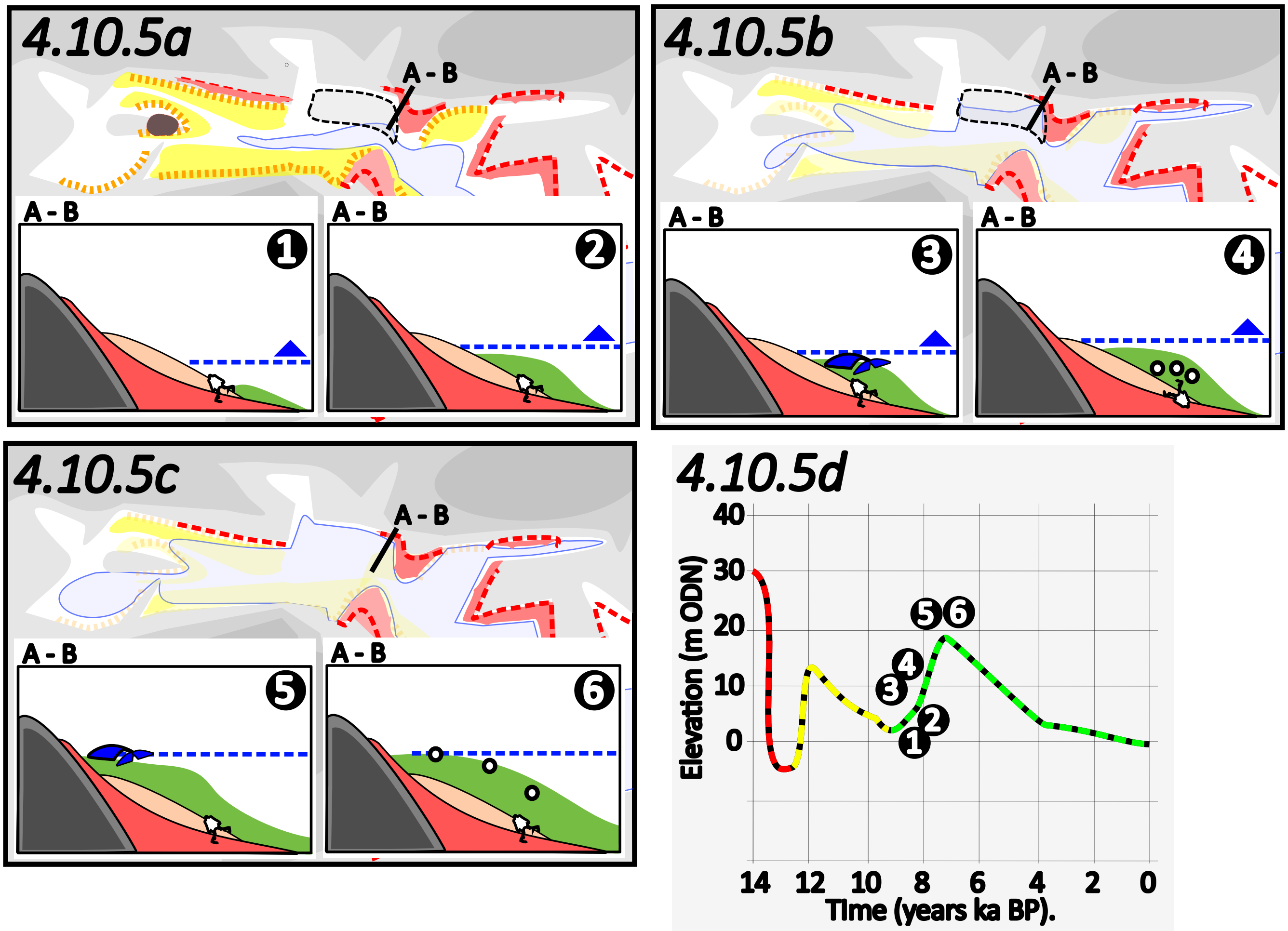

Fig. 4.10.5. Schematic Illustrations of sea-level change in the Western Forth Valley during the early Holocene Transgression and (insets): schematic section diagrams of raised marine deposits and associated landforms at Causewayhead, c. Stirling (A - B) and sequence of deposition.

a:) Deposition of carse clay on Teith Outwash sand, and preservation of red deer antler. Panels "1" - "2" correspond to No's "1" and "2" on Fig. 4.10.5d.
b:) Death and preservation of *mysticete* [TWW] in the early transgression, in shallow water. Panels "3" - "4" correspond to No's "3" - "4" on Fig. 4.10.5d.
c:) Death and dispersal of *mysticete* [TWW] in the later transgression, with remains sinking into deeper water. Panels "5" - "6" correspond to No's "5" - "6" on Fig. Fig. 4.10.5d.

e:) Composite Sea-Level Change Curve (Western Forth Valley). "1" - "7" correspond to panels "1" - "7" in Fig. 4.9.8a - d. Section from 12 ka BP - 5ka BP after Smith et al. (2010). Section from 12.5 - 10.9 ka BP approximate, after suggestions in Sissons (1966, 1968.) Sections 14 ka BP - 12ka BP and 4.5ka BP - 0 ka BP after Shennan et al. (2018). No empirical sea-level curve has been constructed for these time-periods, due to the lack of transgressive and regressive overlaps for the associated deposits.

Position of high water water mark (blue solid, or blue dashed). Net falling or rising sea-levels, indicated by blue arrow (pointed down or up). Pleistocene RMDs (red). Landward edge of same (red dashed). Loch Lomond Interstadial RMDs, or "Buried Raised Beaches" (yellow). Landward edge of same (yellow dashed). Teith Outwash (beige). Holocene RMDs, or "carse" (green). Peat (thick black). Basemap after Google Earth Pro (2022). Extent of raised marine landforms, after (Sissons & Smith 1965; Sissons 1966; Sissons 1969; Sissons 1972; Kemp 1971; Peaccock 1999; Smith et al. 2010).

4.11. The Skeleton of a *Balaenoptera*, Discovered at Airthrey (c. Bridge of Allan) [ZT].

> *"Several years ago, Sir Robert Abercromby began to drain [a considerable piece of flat ground, adjoining the east gate to Airthrey Castle]. In the course of this operation, the workmen, in deepening the east ditch, came upon a substance which they conceived to be the trunk of a tree. ... In the month of July [1819], the ditch was still farther deepened when the workmen were again obstructed. They began to cut with hatchets before they discovered that the substance was bone, not wood. They soon ascertained that the bones belonged to some animal of very great magnitude. The skeleton is evidently that of a whale: the animal appears to have been about 71' in length. ..."*

Robert Bald, Civil Engineer and Member of the Wernerian Natural History Society. *Notice Respecting the Discovery of the Skeleton of a Whale, on the Estate of Airthrey.* (1819 893 – 394.)

4.11.1. Chain of References and Documentary Sources.

Bald's *Notice* (1819; quoted above) was largely redundant, by the time of its publication in Robert Jameson's *Edinburgh Philosophical Journal*: the *"Airthrey Whale"* [ZT] had already been taken notice of in hundreds of newspapers and magazines. It [ZT] was the first fossil whale from the carse to be found with a tool, among the first to come to the attention of the Wernerians, and certainly the first to come into the possession of that Society's founder, Robert Jameson. To this day, no other skeleton of a blue whale *(B musculus)* has been found in a geological deposit (Deméré et al. 2005).

These may all have contributed to the (relative) celebrity of the "*Airthrey Whale"* [ZT]. However, almost all of the available information from the time of its discovery derives from one of Robert Bald's accounts: the *Notice* (Bald 1819) and the section on "Geology" in Robertson's (1845 221 – 222) *Statistical Account for Logie (Stirlingshire)*. As the excavations at Airthrey (Fig. 4.1.1b) continued, the Caledonian Mercury received periodic updates from the site which circulated in other newspapers - Bald likely being the author. After that time, original textual sources concern the species of the "*Airthrey Whale*" [ZT], or of its passage through different museums.

4.11.2. Location.

The "Whale Park" at Airthrey is easily identifiable (Fig. 2.2.1a-d), lying east of the Castle (now, Stirling University; Fig. 4.11.1a-c.) This corroborates Bald's (1819) textual descriptions of the location, alongside others (e.g. Rogers 1853 176 – 177; Farie 1856 32; Gibson 1883 28; Johnstone 1835 180, 192; Haswell 1972 59; Miller 1865 66 – 67; Milne Home 1882 33.) The exact point at which the *Balaenoptera* skeleton [ZT] was discovered there is harder to judge. The Caledonian Mercury (31.7.1819) provides the only quantitative clue, *"about 300yd* (275m) *south from the East porter's lodge, which leads to Airthrey Castle."* Neither Geological Map fits with that value and the distances and are, in both cases, shorter (c. 150m, 200m respectively; Fig. 4..11.1a – c, d "A".)[1]

1 Sheet 39 (Geikie et al. 1879) has no explanation paper. It is unclear what, if anything, the authors have cited.

Fig. 4.11.1. **Whale Parks, Airthrey**. (**a:**) Shearer's (1869) *Illustrated Tourists' Guide to Stirling.* (**b:**) 1' Stirlingshire 39 Geological Map (1882) (**c:**) 6' Stirlingshire Geological Map (1899 10.SE). **(d:)** after Modern OS Mapping (2022). Elevation in m ODN (bold). proposed 'Line of March' between estates of Powis and Airthrey (fine red dashed). Distances from "East Lodge" (blue dashed, blue numbers.) Three possible locations of *Balaenoptera* skeleton [ZT] (A - C.) Sites of corings or borings (red diamonds) "i" and "ii" (Smith et al. 2010.) "iii" Kemp (1972.)

Bald (1819) records that "*... the head was lying across the march-ditch. ... the jaw-bones projecting into the estate of* Powis (east of Airthrey). *The tail was in a westerly direction from the head."* [2] While this admits two possibilities, i.e. the ditch going E -W (southern boundary of "Whale Field"; Fig. 4.11.1, "C") or the ditch going N-S (eastern boundary; or Logie Burn; Fig 37, "B"), the evidence largely confines the site of discovery to the southern end of the "Whale Park", within a c. 100m^2 radius of (56.144265° -3.905784°) (Fig. 4.11.1d.)

4.11.3. Stratigraphic Reconstruction.

4.11.3.1. Stratigraphic Reconstruction (Deduction).

A precise location may not be critical. Surveys by isostasy-eustasy researchers have shown that the "Whale Field" is quite level (c.12m ODN; Fig. 37)[3]. The skeleton's [ZT] depth below ground is also reported consistently:

1. *"The greater part of the bones were found at a depth of about 4' 1/2* (1.37m) *but some were nearer to the surface."* (Bald 1819 394)
2. Caledonian Mercury (31.7.1819) *"All these bones* [the skull and thirteen ribs] *were found at a depth of from between 18"* (0.45m) *to 3'* (0.9m) *below the surface.*
3. Caledonian Mercury (12.8.1819) *"[The spot] has been accurately levelled by a scientific gentleman of Edinburgh. The bones were exactly 5'* (1.5m) *under the surface of the ground."*

Therefore, Bald's (1819) value for the depth (1.4m) can be deducted from a surface-elevation of 12m ODN for the "Whale Field", producing an approximate height above **mean average sea-level** of 10.6m (ODN), or c. 35', for the *Balaenoptera* skeleton [ZT] (Fig. 4.11.2a, "1").

4.11.3.2. Stratigraphic Reconstruction (Addition).

Despite that, many sources state this set of remains was discovered 6m, or (20'), above a "**sea-level**" datum. This has been identified in the following terms:

- Duncan (1823 47) *"At Airthrey, near Stirling, in 1819 the bones of a whale were found ... 20'* ***higher than the water of the Forth****."*

- Brady et al. (1874) *"Entire skeletons of whale were found at Airthrey and Dunmore, 20'* ***above tide-mark****, imbedded in the clay."*

Dinham and Haldane (1932 213), *Economic Geology*, a *de facto* explanation sheet, refer to this discovery [ZT] but do not cite a paper.

2 Cal. Merc (31.7.1819) initially suggest the opposite – head was in Airthrey and the "torso" in Powis. Later (Cal. Merc 5.8.1819) amended to correspond with Bald (1819) – only the jaws found in Powis.

3 Also commented on at the time. (Cal. Merc. 9.8. 1819) "*The deposition of so large a body would have led us to expect some slight protuberance would have marked the spot where it was laid. This was not the case, however, and a uniform flat surface extended all around. If ever its grave was marked by an undulation, at all, time, that almighty leveller, has completely worn it out."*

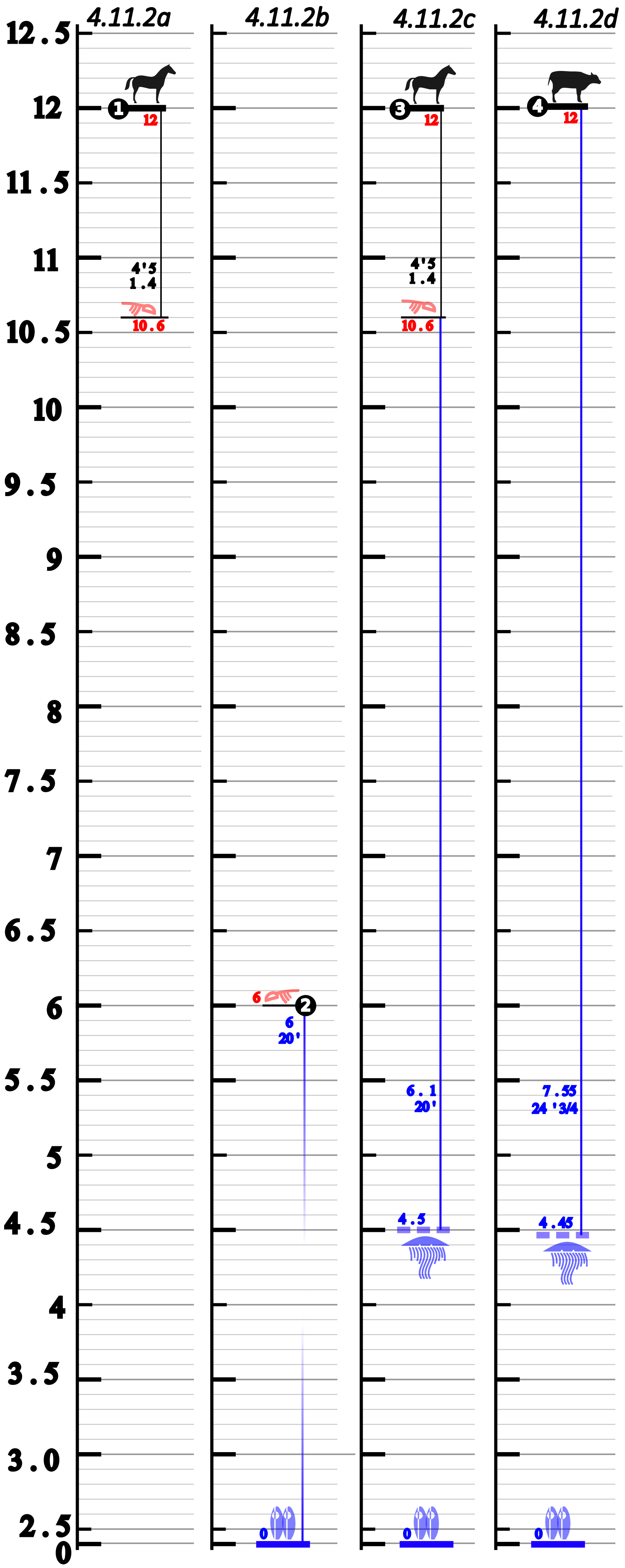

Fig. 4.11.2 - *Airthrey Whale Park Datum Diagram (1).*

a:) ("1", Black Horse.) Position of *cetacean* remains [ZT] found in 1819. Reconstructed from (Bald 1819), using 12m ODN as the land-surface datum: [12m - 1.4m = 10.6m ODN.]

b:) ("2"). Position of *cetacean* remains [ZT] found in 1819. Reconstructed from (Bald 1819) using 0m ODN as the sea-surface datum [0m + 6m = 6m ODN.]

c:) ("3", Black Horse). Position of *cetacean* remains [ZT] found in 1819, and elevation of postulative "extreme high tide" at Manorneuk. Reconstructed from (Bald 1819, Robertson 1845) using 12m ODN as the land-surface datum: [12m - 1.4m = 10.6m ODN.] [10.6m ODN - 6.1m = 4.5m ODN.]

d:) ("4", Black Cow.) Elevation of postulative "extreme high tide" at Manorneuk, relative to the "Whale Park." Reconstructed from (Stevenson 1821) using 12m ODN as the land-surface datum [12m ODN - 7.55m = 4.45m ODN.]

Elevation Data (Land): **Black Horizontal -** land surface, with measured elevation (m above modern sea-level.)

Elevation Data (Sea): **Blue Horizontal**. a marine datum surface. **Blue Horizontal Dashed**. a hypothetical marine datum surface. **Two Blue Shells**. modern mean average sea-level (0m ODN). **One Blue Jellyfish**. extreme high tide at Manorneuk (4.5m ODN.)

Numbers: **in Red** - elevation, as measured, reconstructed, or inferred (m, above modern sea-level). **in Black** - distance (m). **in Blue** - Elevation of a marine datum (m above modern sea-level). **Blue with Horizontal Blue Line** - distance to or from a marine datum (m).

- Reddoch (1824 416) *"It has been ascertained that the place where the remains [of the Dunmore Whale [WM] lie, is 23 '- 24'* ***higher than the highest tide of the Frith*** *[sic] at present. ... nearly the like height above high-water as the fossil remains at Airthrey.*

- Owen (1846 524) *"More than 20'* ***above the reach of the highest tide****."*

- Jamieson (1865 189) *"[the whale skeletons] at Airthrey and Dunmore were imbedded in the clay at a height of fully 20' above the* ***present reach of the tide****."*

- Sutherland (1869 128) *"Skeletons of whales have been found at Blaid Drummond and other places [in the upper reaches of the Forth], generally 20' above the reach of the tide. At Airthrey. ..."*

- Bell (1885 32 – 33) *"Bones of whales have also been found at Airthrey, Blair Drummond etc. at from 20' to 30' above the present* ***highest level of the spring-tides****."*

- Encyclopaedia Brittanica (Anon. 1842 729) *"The skeleton of a whale, now in the Museum of the University of Edinburgh, was found in a field, the surface of which is 18' above the* ***present average level of the Forth****, from which it was a mile distant."*

Some confusion has developed. The *"Airthrey Whale"* [ZT] cannot be both 6m above "sea-level" (0m ODN), and 1.5m beneath the "Whale Park" (12m ODN; Fig. 4.11.2a – b.) In fact, the foregoing quotes are all corrupted or distorted versions of Bald's (1819) actual measurement, which was taken relative to the surface of the river Forth:

- *"Mr [James] Jardine has ascertained that the place where the skeleton was found is 20'* (6.09m) *higher* ***than the surface of the highest tide of the Forth*** *at the present day."* (Bald 1819 395)

- *It was found, from very accurate levels, that this skeleton lay 22'* (6.7m) ***higher than the pitch of the present stream-tides*** *of the River Forth,* ***immediately opposite."*** (Bald, in Roberson 1845 222)

The measurement was not only taken at a specific location, i.e. *"[at] the River Forth, immediately opposite [Whale Park]"* but relative to the tide as it stood on a specific date:

- "*The spot on which the skeleton of a whale was lately found on the Airthrey estate ... has been accurately levelled by a scientific gentleman of Edinburgh. The bones were exactly* 5' (1.5m) *below the surface of the ground and 22' 1/2* (6.85m) ***above the tide on Thursday (5.8.1819). Though a spring-tide****, [it]* ***was not so high*** *by* 2' 1/2 (0.76m) ***as it has been occasionally known to rise****."* (Caledonian Mercury 12.8.1819).

Therefore, the value (20' , or 6.09m) is the difference in elevation between the *Balaenoptera* skeleton [ZT] and an above-average tide, that has then been corrected to resemble an extreme high tide (Fig. 4.11.2c, "3".) At a slightly later date, Robert Stevenson (1821 327) produced a similar value (24' 3/4), when determining the land-surface elevation of the "Whale Park" itself:

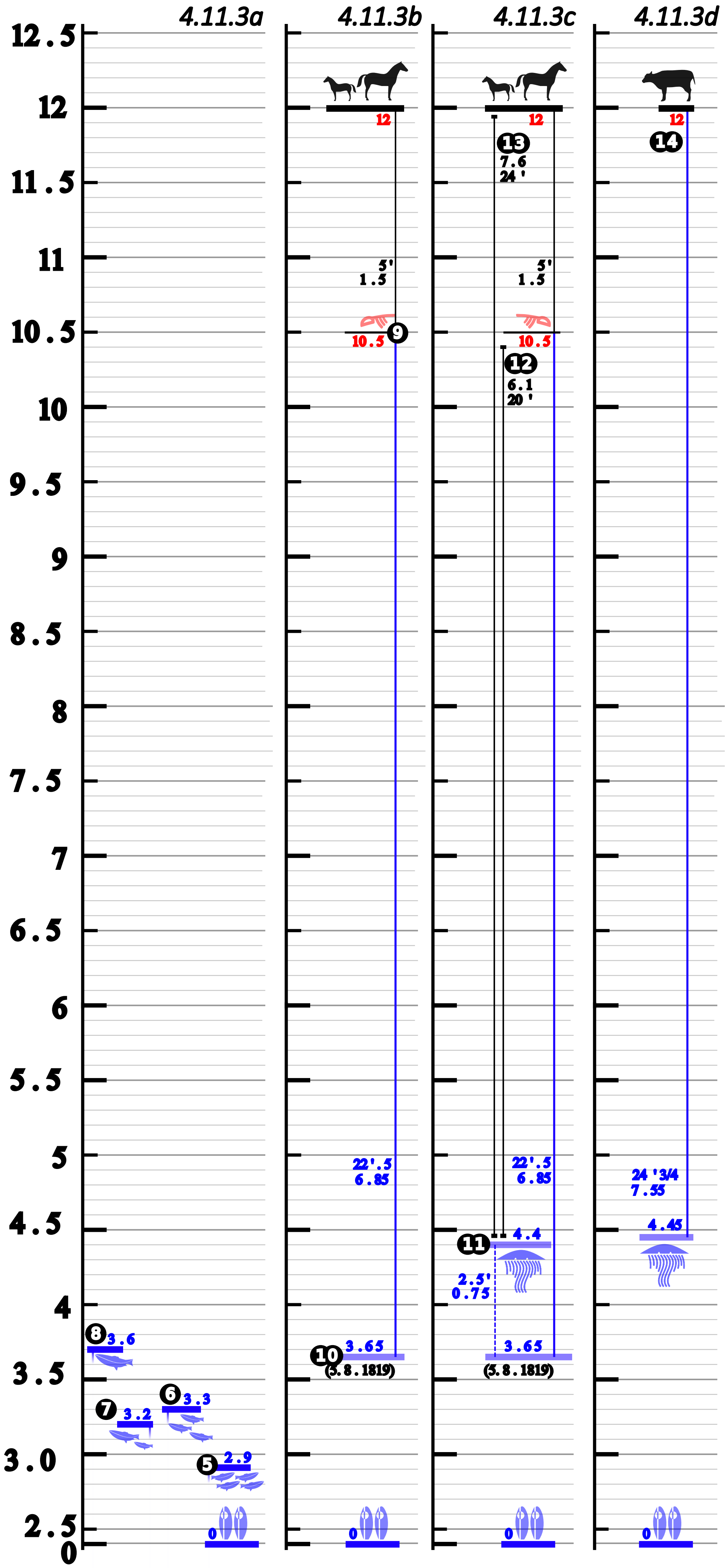

Fig. 4.11.3 - *Airthrey Whale Park Datum Diagram (2).* **a:) ("5", Four Fish.:** MHWS, Grangemouth. **("6", Three Fish):** MHWS Alloa. **("7", Two Fish):** MHWS Stirling. **("8" One Fish):** Surface of Forth, Cruives of Craigforth.

b:) (Two Black Horses). ("9"): Position of *cetacean* remains [ZT] found in 1819. Reconstructed from Bald (writing in Caledonian Mercury 12.8.1819) and using 12m ODN as the land-surface datum. [12m ODN - 1.5m = 10.5m ODN.] **("10"):** elevation of high-tide on (5.8.1819), relative to *cetacean* remains [ZT]. [10.5m ODN - 6.85m = 3.65m ODN.]

c:) (Blue Jellyfish). ("11"): elevation of a (putative) extreme high tide at Manorneuk. Reconstructed from Bald (writing in Caledonian Mercury 12.8.1819). [3.65m ODN + 0.75m = 4.4m ODN.] **("12"):** Difference in elevation between a (putative) extreme high tide at Manorneuk and *cetacean* remains [ZT]. [4.4m ODN + 6.1m = 10.5m ODN.]. **("13"):** Difference in elevation between a (putative) extreme high tide at Manorneuk and surface of the "Whale Park" [4.4m ODN + 7.6m = 12m ODN.]

d:) ("14", Black Cow.) Elevation of (putative) extreme high tide at Manorneuk, relative to the "Whale Park." Reconstructed from (Stevenson 1821) using 12m ODN as the land-surface datum [12m ODN - 7.55m = 4.45m ODN.]

Elevation Data (Land): **Black Horizontal -** land surface, with measured elevation (m above modern sea-level.)

Elevation Data (Sea): **Blue Horizontal**. a marine datum surface. **Two Blue Shells**. modern mean average sea-level (0m ODN). **One Blue Jellyfish**. extreme high tide at Manorneuk (4.5m ODN.)

Numbers: **in Red:** elevation, as measured, reconstructed, or inferred (m, above modern sea-level). **in Black:** distance (m). **in Blue:** Elevation of a marine datum (m above modern sea-level). **Blue with Horizontal Blue Line:** distance to or from a marine datum (m).

- *"The present surface of the ground where the remains of this huge animal [ZT] were deposited having been ascertained by my assistants, when lately in that neighbourhood, to be no less than 24' 9"* (7.55m) ***above the present level of the Firth of Forth at high water of Spring Tides****."* Stevenson (1821 327; Fig. 4.11.2d, "4".)

Stevenson and Jardine were two of Scotland's most eminent civil engineers and the latter is even credited for first calculating *mean average sea level* (Stevenson 1886 75 -76.) While their surveying skills cannot be doubted, the line of *high water*, or maximum vertical extent of a spring tide, declines in altitude with distance from the head of an estuary to the mouth. These elevations were likely taken relative to the tidemark at Manorneuk[4] a point on the River Forth between those two extremes. Although the *mean average spring tides* calculated for Alloa and Stirling (and presumably, in-between) are similar (Fig. 4.11.3a, '5' – '8'), neither figure confines the *highest astronomical tide* at any intervening location.

On the premise that the land-surface of the "Whale Park" is 12m ODN, the respective elevations of the *Balaenoptera* skeleton [ZT] and high tide at Manorneuk on Thursday (5.8.1819) can be determined by deduction: 10.6m ODN and 3.65m ODN, respectively (Fig. 4.11.3b, '9' – '10'.) The height of the putative extreme high tide, *"to which [the level of the Forth] has been occasionally known to rise"*, would then stand at 4.4m (ODN) (Fig. 4.11.3c, '11'.) The difference in height between its surface and that of the *cetacean* skeleton is 20' or 6.1m (Fig. 4.11.3c, '12') and between it and the level of the 'Whale Park' is 24', or c. 7.6m (4.11.3c, '13".) Stevenson (1823) produced a similar value (7.5m; Fig. 4.11.3d, '14') when he measured that same difference in elevation between the Park and the extreme high-tide. So long as the land surface datum has been identified correctly at 12m (ODN), the *"Airthrey Whale"* lay 20' (6.1m) above an extreme high-tide at Manorneuk, 6.8m above *mean average spring tides* at Stirling, and 35' (10.6m ODN) above ***mean average sea-level.***

4.11.4. State of Preservation, Identification, and Fate of the Bones.

4.11.4.1 Edinburgh College Museum (Former Natural History Museum, University of Edinburgh.)

Bald wrote a catalogue of the bones [ZT] for the Caledonian Mercury (31.7.1819) and Turner (1912 4 - 5) later published correspondence between Bald and Baird, then Principal of Edinburgh University, in which the bones were enumerated again. Both list more than fourty vertebra, thirteen ribs, one set of elements from the forelimb, a partial occipital and the mandible. It [ZT] is often claimed to have been 72' (22m) long (e.g. Bald 1819; Gibson 1883 28). In fact, *"the excavation made in digging out the skeleton is 74'* (22.55m) *long. As the tail of the animal bent round a little, it may be assumed that the fish* [ZT] *was some feet longer."* (Caledonian Mercury 5.8.1819).

4 Or "Manor Ford." The "Roman Causeway" and "Castellum", which Bald (1819 295) used to illustrate the fact that *"the stranding of the whale [occurred in] a period much more remote than the Christian era,"* once stood there.

Abercromby committed the "*Airthrey Whale"* [ZT] to Prof. Jameson's care, and was one among 74,000 geological, palaeontological and zoological specimens that he is estimated to have collected by the end of his tenure (and death) in 1854 (Jameson 1854 43.) The museum was in a state of such notorious chaos by this time (e.g. Wilson & Geikie 1861 112) that its collections were expropriated to found Edinburgh's Museum of Science and Art (later, "Royal Scottish Museum" and then "National Museum of Scotland" [NMS]).The occipital and some ribs of the "*Airthrey Whale*" [ZT] survive in the collections of the NMS, designated (NMSZ 1991.86 1- 10.) In a letter to Morris (1893) Ramsay Traquair correctly referred the occipital to the blue whale (*B. musculus*) but incorrectly associated with *"Blair Drummond Whale"* [BF]. Both Turner (1912) and MacIntosh (1923) came to the same diagnosis, based on the morphology of the fragmentary skull and *"the simple magnitude of the bones."* (Turner 1912 5.)

4.11.4.2. Parts of the *"Airthrey Whale"* [ZT], Supposed to be in the Smith Museum (Stirling).
Most of the bones found in 1819 are now unaccounted for. The *"Airthrey Whale"* [ZT] is, nonetheless, more intact than any of the other *cetacean* skeletons from the carse. Other museums claim to have recieved pieces of this animal but, in most cases, their provenance is hard to establish. Glasgow University's Hunterian Museum is supposed to have acquired a fragment of a vertebra with the Lanfine Collection[5], while, in 1904, The Stirling Natural History Society was presented *"with a piece of the* "Airthrey Whale", *from the family of Captain Forrester. It is a bit of bone, labelled with the date 1822."* (Kidston and Morris 1906 7.) No other record of this *"bit of bone"* is known, but the Stirling Natural History Society (and Smith Institute) is also supposed to have inherited some parts of this *cetacean* skeleton [ZT] in 1883, from the collections of MacFarlane's Museum (Stirling). Both Morris (1893) and Turner (1912) found references to them in MacFarlane's Catalogue, whereas Milne Home (1883) claimed to have seen them on display in 1863.

In this case, some compelling, if circumstantial evidence suggests that a transfer occurred. Jameson's successor to the Chair of Natural History at the University of Edinburgh, Robert Allman, oversaw the closure of the Edinburgh College Museum, and the movement of the collections to new premises. In 1858, Allman had been invited to Stirling to examine another fossil *mysticete,* just discovered in Christie's brickyard (Stirling) [AJ]. When there, he is recorded to have said that *"In the event of [a museum] being established at Stirling, [Allman] offered to present to it many valuable specimens of natural history,"* (Stirling Observer 20.5.1858). MacFarlane's Museum (Stirling) opened, and advertised for donations, at that time (Stirling Observer 25.2.1857).

5 Palaeontological Ledger of the Hunterian Museum (5438).

4.11.4.3. Scapula (N1777) or (19653.02)

It is not possible to determine which parts of the "*Airthrey Whale"* [ZT] might have been returned to Stirling from the University of Edinburgh, or if they still survive in the collections of the Smith Museum (Stirling). Neither the Catalogue (Morris 1893) nor Milne Home (1882) describe the bones at MacFarlane's (Stirling) and, on receipt at the Smith in 1883, this material was not documented.

However, a sub-fossil *mysticete* scapula has been held in the Smith Museum, Stirling, since at least 1912. Turner (1912) distinguished it from the other uncatalogued bones in the collection because it had belonged to a humpback whale (*Megaptera novaengliae*)[6]. He did not speculate on its origins because it *"bears no mark of locality"* (Turner 1912 9 – 10). Whilst Turner (1912 9 – 10) provides no accession number for this specimen, the measurements and identification in *Marine Mammals* indicate that the scapula (N1777) (now denoted 19653.02) was the item in question (Fig 4.11.4, '3').

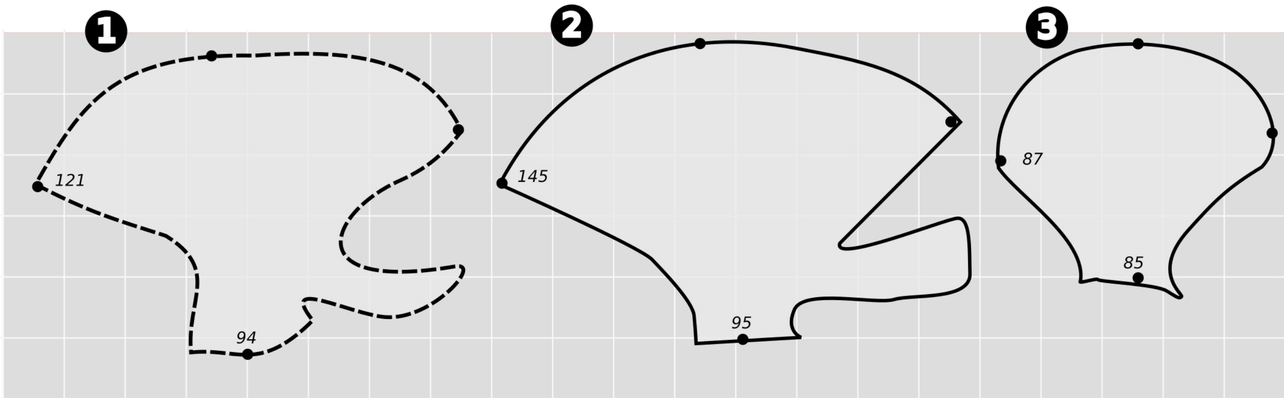

Fig. 4.11.4. Comparative anatomy and dimensions (cm) of *myticete* scapulae. (1) ancient blue whale (*B. musculus*) from Airthrey. (2) modern blue whale *(B. musculus*) from S. Atlantic. (3) Ancient humpback whale (*M. novaengliae*), unknown provenance (Smith Museum, Stirling 19653.02). Humpback scapulae are equilateral and lack the jutting acromion process. (1) Dimensions after Robert Bald, as reported in (Caledonian Mercury 31.7.1819.) (2) Dimensions after Miller (1924) (3) Dimensions after Turner (1912.)

No known documentation is associated with this bone and it is not catalogued in the Smith Institute's public catalogue[7]. Morris (1893, 1925) never made a specific allusion to this scapula (19653.02) himself, perhaps under the impression that it belonged to one of the other *mysticete* skeletons in the Smith Institute's (Stirling) collections. This would be incorrect, as the remains found at Meiklewood [USG] *(B. physalus) and* Christie's Brickyard (Stirling) *(B. physalus)* [AJ] belonged to species of *Balaenoptera* (respectively Turner 1912 68, 69, 5 – 6.) The scapula (19653.02) has since been alleged to belong to the "*Airthrey Whale*" [ZT]. An unknown interpolator, writing in the Accessions Register of the then-Smith Institute, is responsible:

6 In Turner (1912) as *"Megaptera boops."*

7 (Anon. 1934), *Catalogue of Collections in the Picture Galleries and Museum of the Smith Institute of Stirling*.

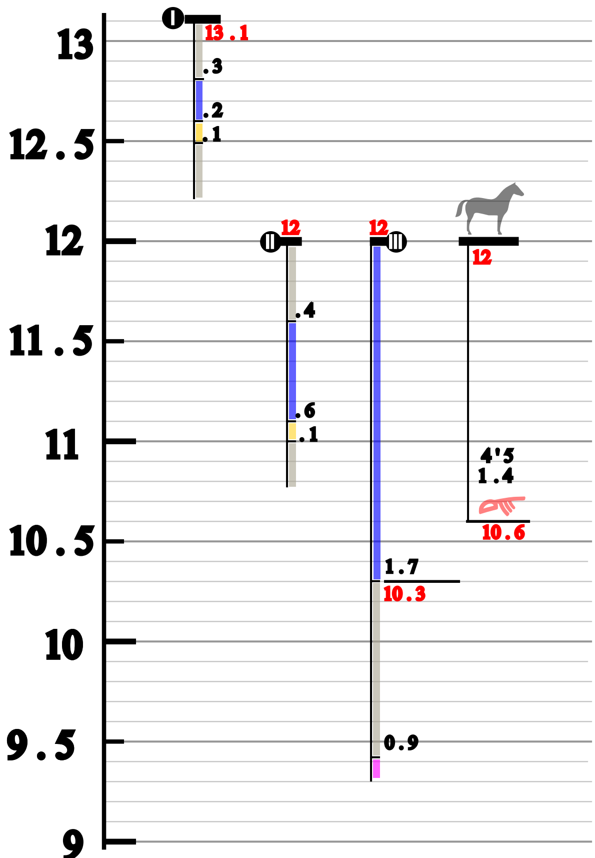

Fig. 4.11.5 a:) *Airthrey Whale Park Datum Diagram (3)*

Stratigraphic Data: Peat (Grey.) Carse Clay (Blue.) Storegga Tsunami Deposit (Yellow.)

"i" and "ii" After Smith et al. (2010.) "iii" after Kemp (1971 302) (BH 529).

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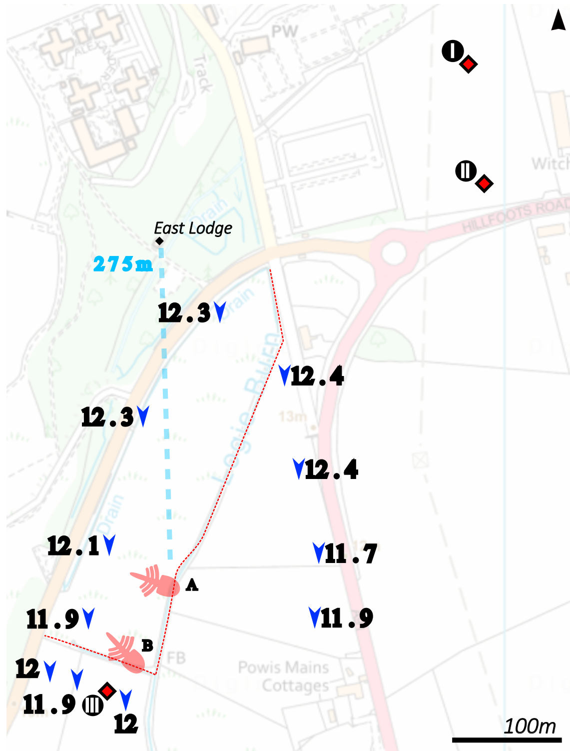


Fig. 4.11.5 b:) Whale Park (Powis Loan) after Modern OS Mapping (2022). Elevation in m ODN (bold). proposed 'Line of March' between estates of Powis and Airthrey (fine red dashed). Distances from "East Lodge" (blue dashed, blue numbers.) Three possible locations of Balaenoptera skeleton [ZT] (A - C.) Sites of corings or borings (red diamonds) "i" and "ii" (Smith et al. 2010.) "iii" Kemp (1972.)

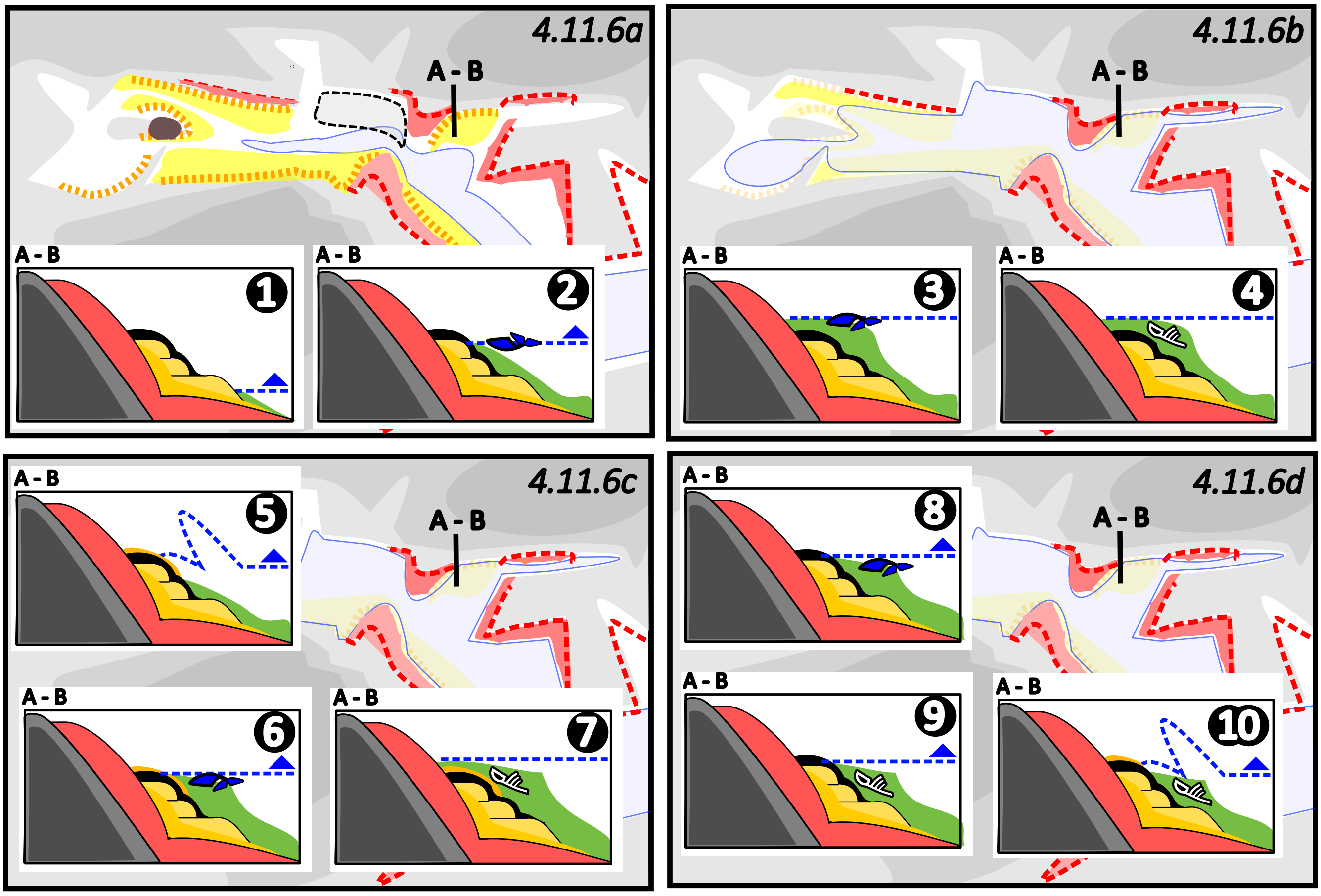
1. *"William Turner examined all the specimens of whale bones in the collection of the Smith Institute (28.12.1911.) He would pronounce no opinions on the specimens 1777-1779. It is most probable that these are portions of the Airthrey Whale."* (quoted in Redman 2004 314).

To reiterate, Turner (1912) assigned the scapula (1777, or 19653.02) to a humpback whale (*M. novaengliae*). These *mysticetes* are placed in a discrete genus, partly because the anatomy of their forelimbs is so distinctive. Their scapulae have several characteristic traits (shape, proportions, absence of *acromion* process) to identify it by (Fig. 4.11.4, '2' and '3'.) In contrast, the *cetacean* skeleton found at Airthrey in 1819 belonged to a blue whale *(B. musculus)* [ZT]. A scapula formed part of that palaeontological assemblage but its dimensions do not match those, of the one held in the-now Smith Museum (Stirling) (Fig. 4.11.4, '1' and '3'). Therefore, the scapula (19653.02) did not belong to a blue whale *(B. musculus)* and was not discovered, at Airthrey, in 1819 [ZT].

4.11.5. Discussion: Approximate Age of the *Balaenoptera* Skeleton found at Airthrey [ZT].

The earliest possible time that a living *cetacean,* or floating *cetacean* carcass, could have been deposited at the elevation (10.6m ODN) is c. 8.5 – 8.0 ka BP (No. 19, Mentieth Moraine/Backside of Garden, 11.36m; Smith et al. 2010). Although discovered in carse clay, Kemp's (1971) core "529" (III, Fig. 4.11.5a) indicates that, at the depth and location which this skeleton [ZT] is supposed to have been found at, it may have lain about 30cm above the transgressive overlap (Fig. 4.11.5a). However, it is not safe to assume that the *Balaenoptera* carcass came to rest here, almost as soon the peat was buried by the clay (Fig. 4.11.6, "1" - "2") Bosio et al. (2021) note that, in coastal settings, the carcasses of large *cetaceans* can bury themselves due to their sheer mass, especially if the substrate is unconsolidated. If the blue whale (*B musculus*) carcass [ZT] has worked itself to a deeper stratigraphic position then it may prove to be younger than the reconstruction suggests - and date to any point during the period, in which sea-level stood above or equal to this elevation (c. 8.5 – 5.0 cal BP; Fig. 4.11.6, "3" – "4".)

A unique stratigraphic marker applies to this case. Smith et al. (2010) suggest that a 1cm layer of sand on the buried peat, c. 500m to the north-east of the location of this *cetacean* skeleton [ZT], had been deposited by the Storegga tsunami (Fig. 4.11.5b). This event dated to c. 7.9 ka cal BP, around the time that sea-level in the Forth Valley stopped rising. Had Kemp (1971) found the same sand-layer on the buried peat when coring in the "Whale Park", then the death and preservation of the *"Airthrey Whale"* [ZT] could only have happened after the Tsunami (Fig. 4.11.6, "5" – "7"). The fact that the skeleton is close to the transgressive overlap suggests that it should belong to the period of rising sea-levels, and may therefore predate the Tsunami (Fig. 4.11.6 "8" - "10"). As the carse clay lies conformably on the peat here, it is not possible to say which of the two events occurred first.



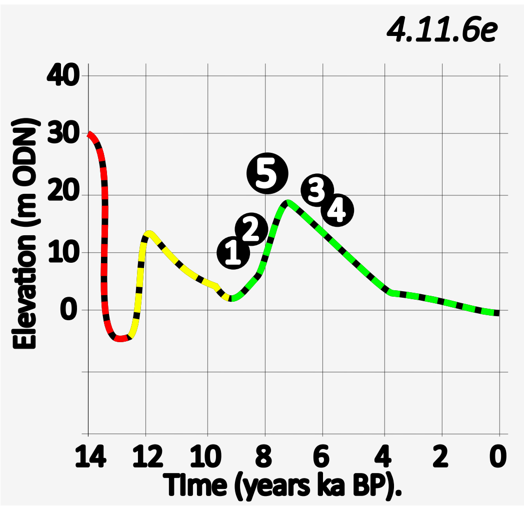


Fig. 4.11.6. Schematic Illustrations of sea-level change in the Western Forth Valley during the early Holocene Transgression and (insets): schematic section diagrams of raised marine deposits and associated landforms at Airthrey, c. Stirling (A - B) and sequence of deposition.

a:) Death and preservation of *mysticete* [ZT] in the early transgression, at the earliest possible opportunity. Panels "1" - "2" correspond to No's "1" and "2" on Fig. 4.11.6e.
b:) Death and preservation of *mysticete* [ZT] in the later transgression, working itself deeper into stratigraphic column. Panels "3" - "4" correspond to No's "3" - "4" on Fig. 4.11.6e.
c:) Death and preservation of *mysticete* [ZT], after the Storegga Tsunami. Panel "5" corresponds to No. "5" on Fig. 4.11.6e.
d:) Death and preservation of *mysticete* [ZT], before the Storegga Tsunami.

e:) Composite Sea-Level Change Curve (Western Forth Valley). "1" - "5" correspond to panels "1" - "5" in Fig. 4.9.8a - c. Section from 12 ka BP - 5ka BP after Smith et al. (2010). Section from 12.5 - 10.9 ka BP approximate, after suggestions in Sissons (1966, 1968.) Sections 14 ka BP - 12ka BP and 4.5ka BP - 0 ka BP after Shennan et al. (2018). No empirical sea-level curve has been constructed for these time-periods, due to the lack of transgressive and regressive overlaps for the associated deposits.

Position of high water water mark (blue solid, or blue dashed). Net falling or rising sea-levels, indicated by blue arrow (pointed down or up). Pleistocene RMDs (red). Landward edge of same (red dashed). Loch Lomond Interstadial RMDs, or "Buried Raised Beaches" (yellow). Landward edge of same (yellow dashed). Stoegga Sand (gold). Holocene RMDs, or "carse" (green). Peat (thick black). Basemap after Google Earth Pro (2022). Extent of raised marine landforms, after (Sissons & Smith 1965; Sissons 1966; Sissons 1969; Sissons 1972; Kemp 1972; Peacock 1999; Smith et al. 2010).

4.12. Summary.

Cetaceans inhabit the Firth of Forth now, and may have lived here throughout the most recent cycle of sea-level change (c. 9.5 – 2.5ka BP). During the 19th century, the remains of these animals were certainly found in the carse at many locations. Intelligible positional data for these "*Whales*" can be extracted from archaic scientific literature (Table 4.12.1a – b), if some assumptions about past land- and sea datum-points are accepted and the technical limitations of the time are understood.

These materials must still be read carefully: using placenames to identify and distinguish *"Whales"* leads to misunderstanding (e.g.*"Woodlane Whale",* [JM]; the modern [AS] and ancient [JQA] *cetacean* remains at Forthbank - Whalepark - Thirty Acres.) The same names can apply to many places, many places have multiple names, and old names can be used by modern authors in unexpected ways. Toponomy is a poor way to organise complex palaeontological information.

Reconstructing the original position of *cetacean* bones and skeletons, legitimately found in the carse, is not easy. Most cases [USG] [AJ] [JB] [TWW] [ZT] have inter-related problems, on the location, the measure, or the datum. Ultimately, that stratigraphic information cannot support precise predictions, about the ages of the *cetacean* remains themselves. As sea-level in the Early Holocene increased very rapidly and then declined gradually, there is a broad window of time in which the bones and skeletons of these animals could have accumulated in the Forth Valley.

Nevertheless, several of these dead *cetaceans* seem to have accumulated in the short period of abruptly rising sea-levels, rather than in the prolonged period of gradually falling sea-levels. The skeleton at Blair Drummond [BF] rested on a dated, transgressive contact, and the *Balaenoptera* at Airthrey [ZT] may have been in close proximity to another. The same has been claimed for *mysticete* skeleton at Meiklewood [USG]. While it does not seem to have been found on buried peat, it could still just have reached its resting-place by the date (9.5 – 9.0 ka cal BP) suggested by Smith et al.(2010.) The skeletons at Christie's Brickworks (Stirling and Cornton) [AJ] [JB] have the potential to date to the earliest phases of the Inundation, which cannot be said for the remains at the greatest elevations. Since unique taphonomic factors (e.g. floatation, subsidence) apply to *mysticete* whale carcasses, the cases [TWW] [JB] [AJ] could be younger than their low elevations suggest.

With only stratigraphic information, it is impossible to say if these sets of *cetaceans* remains are all the same age, cluster in time, or have a range of ages. Absolute dating evidence on bones, certain to belong to those *cetaceans*, may provide more detailed information. That chronological data could then help to explain why the remains of these animals are preserved in the Firth of Forth.

Table 4.12.1. Locations or Origins of *Cetacean* Remains from the Carse of Stirling, as Reconstructed from Historic Literature.					
Code:	Pseudonyms:	Suggested Origin, or Place of Discovery:	Upheld?	Lat.:	Long.:
[TR]	*"Whale at Coldoch Broch."*	Coldoch Estate (c. Doune, Parish of Kinkardine, formerly Perthshire.).	No judgement.	N.A.	N.A.
[BF]	*"Blair Drummond Whale", "Burnbank Whale."*	Wood Lane, c. Burnbank, Blair Drummond Estate (c. Doune, Parish of Kinkardine, formerly Perthshire.).	Yes.	56.159080°	-4.074740°
[JM]	*"Woodlane Whale."*	Wood Lane, c. Burnbank, Blair Drummond Estate (c. Doune, Parish of Kinkardine, formerly Perthshire.).	No: The "Blair Drummond Whale" [BF] by a pseudonym.		
[USG]	*"Meiklewood Whale", "Woodyett Whale."*	Woodyett Farm, Meiklewood Estate (c. Gargunnock, parish of Gargunnock, Stirling).	Yes.	56.129601°	-4.052318°
[AJ]	*"Cow Park Whale." "Whale at Stirling Shore." "Whale at Christie's".*	Christie's Brickyard (Stirling), Shiphaugh, Stirling (parish and town).	Yes.	56.124508°	-3.932551°
[AL]	*"Bones brought to Forthank."*	N.A. (introduced material.)	Yes.	N.A.	N.A.
[MVB]	*"Forthbank Whale."*	Forthbank Estate (c. Stirling town; parish of St Ninians.)	Yes.	56.117790°	-3.926535°
[JB]	*"Cornton Whale." "Whale at Christie's".*	Christie's Brickyard (Cornton.) Parish of Logie; formerly Stirlingshire, Perthshire, Clackmannanshire.).	Yes.	56.143561°	-3.945309°
[TWW]	*"Causrwayhead Whale."*	East of Causewayhead ("Alloa Rd." Parish of Logie; formerly Stirlingshire, Perthshire, Clackmannanshire.)	Yes.	56.140160°	-3.925944°
		North of Causewayhead ("Airthrey Rd.". Parish of Logie; formerly Stirlingshire, Perthshire, Clackmannanshire.)		56.137060°	-3.919983°
[ZT]	*"Airthrey Whale".*	Whale Park (or Powis Loan, Blairlogie). Airthrey. Parish of Logie; formerly Stirlingshire, Perthshire, Clackmannanshire.)	Yes.	56.144265°	-3.905784°

Table 4.12.2. Stratigraphic Positions of *Cetacean* Remains from the Carse of Stirling, as Reconstructed from Historic Literature.

Code:	Pseudonyms:	Lat.:	Long.:	Land Surface Elevation (m ODN):	Elevation of remains (m ODN)	Calculated by:	Position of Remains, in Relation to other Stratigraphic Markers:
[TR]	*"Whale at Coldoch Broch."*	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
[BF]	*"Blair Drummond Whale", "Burnbank Whale."*	56.159080°	-4.074740°	12.6	11.4	Deduction from land surface. Stratigraphic marker.	Remains found on peat (Main Buried Beach.)
[JM]	*"Woodlane Whale."*						
[USG]	*"Meiklewood Whale", "Woodyett Whale."*	56.129601°	-4.052318°	10	8.8	Deduction from land surface. (Addition to marine datum.)	Remains alleged to have been found on peat (?)
[AJ]	*"Cow Park Whale." "Whale at Stirling Shore." "Whale at Christie's".*	56.124508°	-3.932551°	9	4.6	Addition to marine datum. (Deduction from land surface.)	N.A.
[AL]	*"Bones brought to Forthank."*	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
[MVB]	*"Forthbank Whale."*	56.117790°	-3.926535°	N.A.	N.A.	N.A.	N.A.
[JB]	*"Cornton Whale." "Whale at Christie's".*	56.143561°	-3.945309°	8	6.1	Addition to marine datum. Deduction from land surface.	N.A.
[TWW]	*"Causrwayhead Whale."*	56.140160°	-3.925944°	N.A.	N.A.	N.A.	N.A.
		56.137060°	-3.919983°	9.1	7.6	Deduction from land surface. Stratigraphic marker.	Remains alleged to have been found on Teith Outwash sand (?)
					6.1		
[ZT]	*"Airthrey Whale".*	56.144265°	-3.905784°	12	10.6	Addition to marine datum. Deduction from land surface.	Remains found near peat (?) and near Storegga tsunami deposit (?)

5. RADIOCARBON DATING.

5.1. Introduction.

Radiocarbon dating is well-established (Libby et al. 1949) and has been used more than any other technique to determine the ages of organic materials. It is a complex analytical tool but can provide secure chronological data, so long as some assumptions about solar activity, the terrestrial carbon cycle, and plant and animal physiology are accepted. To understand how the radiocarbon dating is generally applied to organisms from marine environments, the technique is reviewed (Chapter Five, 5.2). To decide on the best methodological practice when radiocarbon dating the *cetacean* remains from the Carse of Stirling, this technique's use on other Atlantic *mysticete* whales is then evaluated (Chapter Five, 5.3).

5.2. Radiocarbon Dating Technique

5.2.1 Introduction

The isotopes of carbon (C) are introduced and their use to calculate the age of organic materials, based on their relative proportions, is described. Several mechanisms can distort these ratios: their causes, and methods to account for fractionation, ^{14}C flux and reservoir effects, are discussed.

5.2.2 Radiocarbon Dating in Theory.

There are 3 naturally-occurring isotopes of the element carbon (C):

Carbon-12 (^{12}C) (98.93% terrestrial bulk abundance of C; stable isotope.)
Carbon-13 (^{13}C) (1.1% terrestrial bulk abundance of C; stable isotope.)
Carbon-14 (^{14}C) (0.0001% terrestrial bulk abundance of C; unstable isotope.)

On Earth, ^{14}C is produced in specific circumstances (interaction of galactic cosmic rays with atmospheric nitrogen (N), at high latitudes and altitudes). Due to its radioactive instability (decaying into ^{14}N, half-life 5,730 years) very ^{14}C little accumulates on Earth (Gillespie 1984). All three C isotopes oxidise into CO_2 gas and mix thoroughly in the atmosphere. The molecules ($^{12}CO_2$, $^{13}CO_2$, $^{14}CO_2$) would be found in the same ratio, in any atmospheric sample.

In theory, all locally co-existing organisms are also in equilibrium with the ^{12}C : ^{14}C ratio of the atmosphere (Gillespie 1984). Photosynthetic organisms metabolise CO_2 to form biomass. This is consumed by herbivores who are then eaten by their predators. Each organism in the food chain inherits the same ^{12}C : ^{14}C ratio and maintains it, until their deaths. From that time, the atoms of ^{14}C which compose their tissues undergo radioactive decay, without being replenished. Rigid organic compounds (e.g. collagen, lignin, apatite) resist biological decay (Libby 1952) but the amount of ^{14}C within them depletes appreciably and predictably, halving every 5,730 years. A "radiocarbon date" is a measure of the remnant ^{14}C atoms relative to ^{12}C atoms, in a piece of bone, wood etc. The sample with less ^{14}C has theoretically undergone more radioactive decay, and is therefore older.

If the production of ^{14}C had never varied in time and its distribution had always been even in space, then all organisms would have had a similar ratio of ^{14}C : ^{12}C atoms at the moment of their deaths. A radiocarbon date might easily be calculated for most organic materials, regardless of where, when or what it came from (Fig. 5.2.1). In fact, different plants and animals, in marine and terrestrial habitats, at various points in geological history, died with dissimilar ratios of ^{14}C : ^{12}C in their tissues. To turn a radiocarbon date into accurate chronological data, it must be *calibrated* to account for the flux of ^{14}C in time and *corrected,* to account for the irregular distribution of ^{14}C in space.

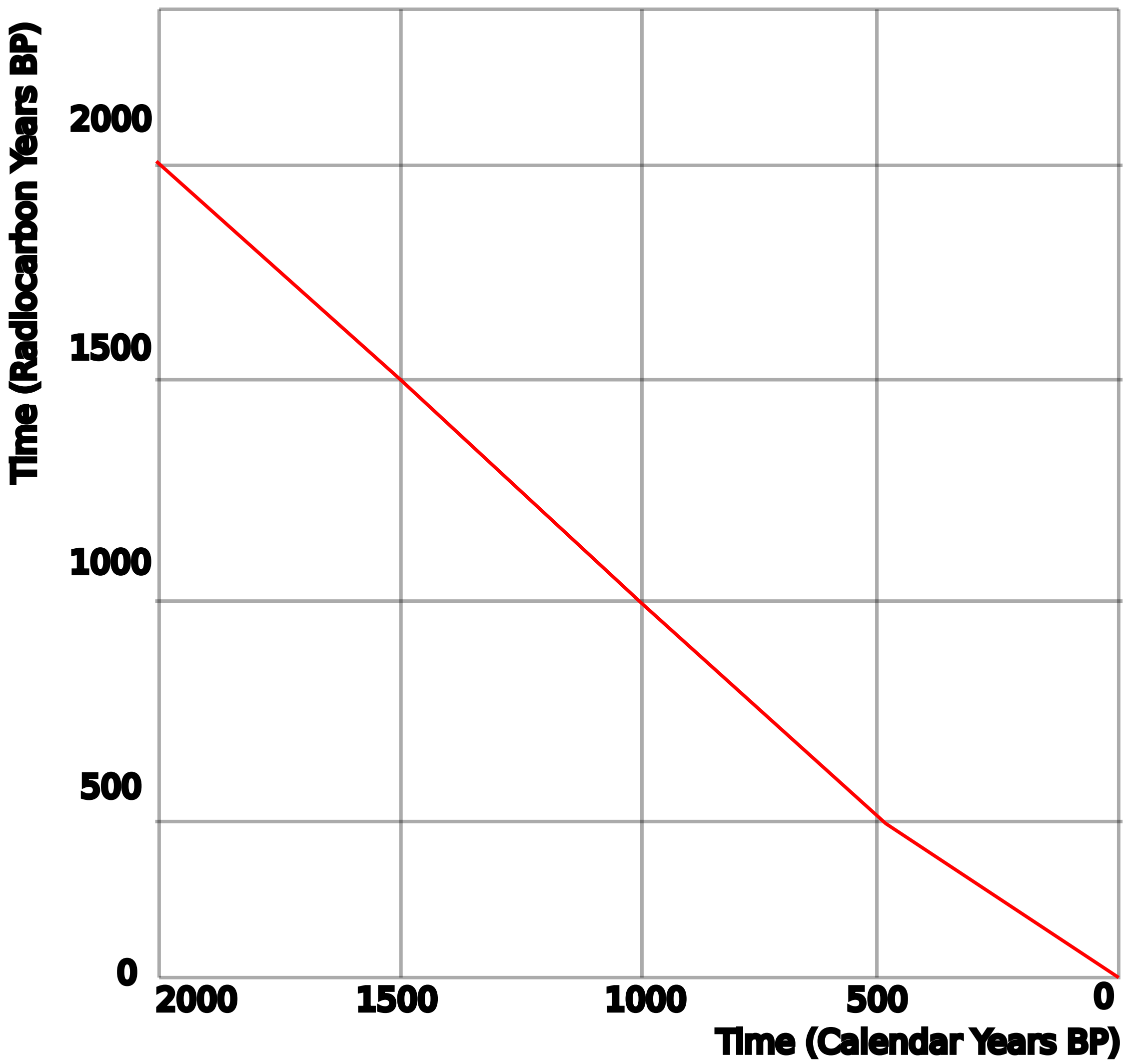


Fig. 5.2.1. Idealised Radiocarbon Curve. Relationship between calendar years (BP) and radiocarbon years (^{14}C : ^{12}C ratio). After (Reimer et al. 2020).

5.2.3. Radiocarbon Dating in Practice: Correction and Calibration.

5.2.3.1 *Correcting* for Fractionation.

Primary producers integrate atoms of all three C isotopes into their biomolecules (Craig 1954) but take up $^{12}CO_2$, in preference to $^{13}CO_2$ and $^{14}CO_2$ (Farquhar et al. 1989). Due to this species-specific "fractionation", the ratio of ^{12}C : ^{14}C that propagates to higher organisms is lower than the ratio in the atmosphere. Craig's (1954 133) solution is elegant:*" the enrichment* [or dilution] *of ^{14}C in any simple fractionation process* [is] *almost exactly twice* [or half] *that of ^{13}C*." A radiocarbon date (ratio of ^{14}C : ^{12}C in a sample) can then be simply adjusted to correct for fractionation, by referring to the ratio of stable ^{12}C : ^{13}C isotopes and multiplying by two (then normalising that value, with reference to a ^{13}C : ^{12}C standard, Stenström et al. 2011).

5.2.3.2 Radiocarbon Dating in Practice: ^{14}C Flux and *Calibration*.

Atmospheric concentrations of ^{14}C are now lower, than at any other time in the last 30,000 years (Bard et al. 1990). The decline has been so great (per Mazaud et al. 1991, 300‰) that a change in rate of the production must be a factor. Climate-forced changes in ocean-atmosphere C exchange (Sigman & Boyle 2000; Broecker et al. 2004) and glacial-interglacial ocean circulation modes are hypothesised to be of equal (or greater) importance (Skinner et al. 2017).

The Earth's magnetosphere has strengthened over the period 0 – 30,000 cal BP (Bucha & Neustupný 1967; Usoskin 2017), which has reduced the amount cosmic radiation reaching the Earth's upper atmosphere (Suess 1980) and suppressed production of cosmogenic nuclides (e.g. ^{14}C). The Sun's electromagnetic activity frequently (c. 11-year Schwabe cycle, Stefani et al. 2020) cycles between so-called *minima* and *maxima.* During solar *minima*, the velocity and density of the solar wind decreases (Zirker 1977; McComas et al. 2003) and the number of galactic cosmic rays that can reach the Earth increases (Potgieter 2013.) When successive sunspot cycles are weak (Usoskin et al. 2007) relatively more ^{14}C can accumulate on Earth (Lockwood & Owens 2011).

In recent geological history, atmospheric ^{14}C concentrations have declined steadily and oscillated constantly. This has large implications for the radiocarbon dating technique. ^{14}C decays at known rate but, at death, each organism "started" with unpredictable proportions of ^{14}C, ^{13}C and ^{12}C in its tissues. A radiocarbon date (^{14}C : ^{12}C ratio) can still be turned into useful chronological data, by c*alibration*. Trees at high latitudes grow annually, each ring preserving that year's ^{14}C : ^{12}C ratio (Suess 1980.) A record of ^{14}C flux, indexed to calendar years, is the inadvertent result (Neftel et al. 1981). The lifespans of individual trees overlap, so growth-rings and calendar dates can be correlated into the past (up to 14,000 years; Leavitt et al. 2022). A *calibrated* radiocarbon date is

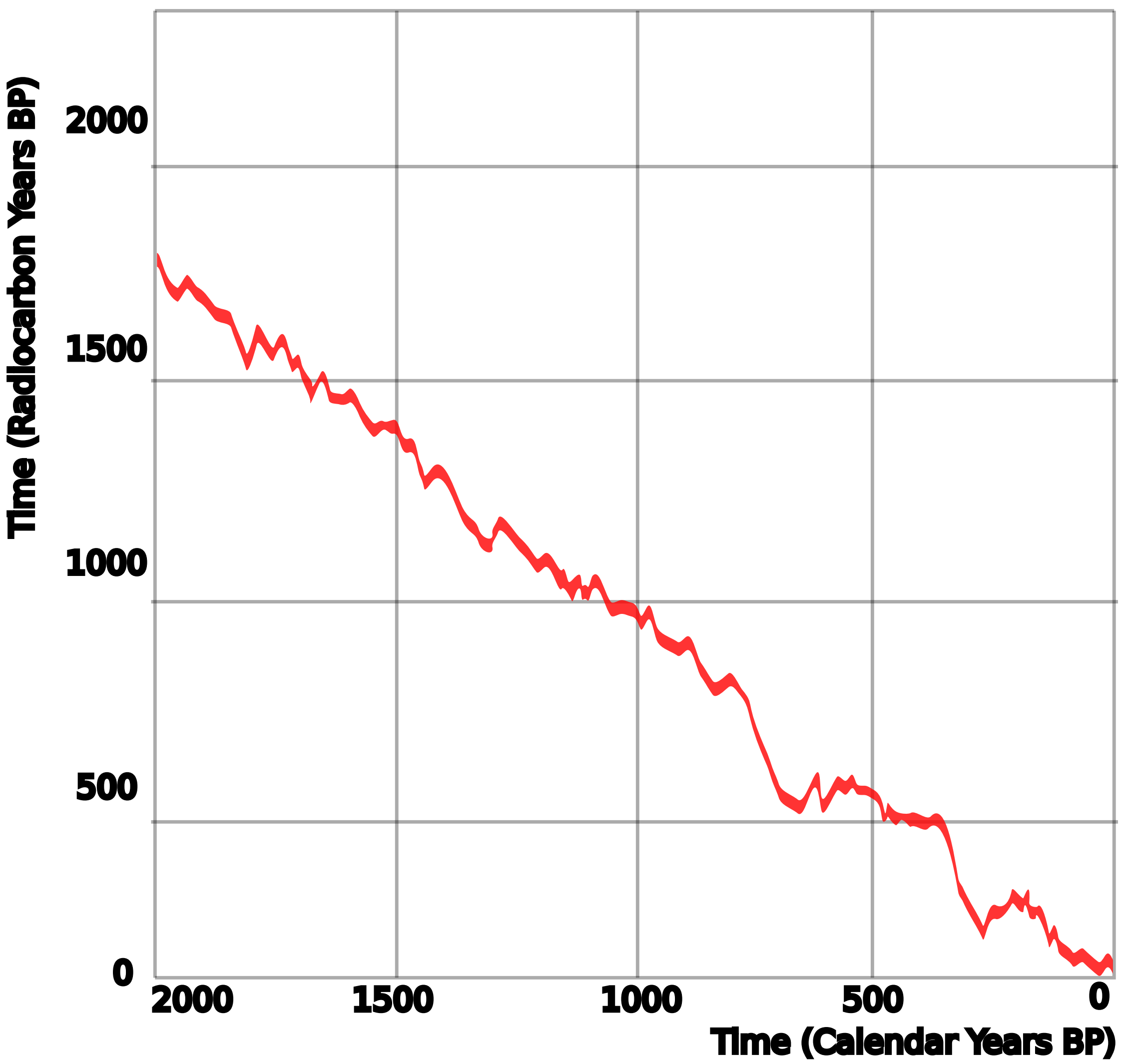


Fig. 5.2.2. Actual Radiocarbon Calibration Curve (Atmosphere of the Northern Hemisphere). Relationship between calendar years (BP) and radiocarbon years (^{14}C : ^{12}C ratio), IntCal 2020. After (Reimer et al. 2020).

one that has been compared to this record, and whose remnant ^{14}C has been matched to that of a given tree-ring (and so to a calendar year; presented as a "calibration curve": Fig. 5.2.2).

5.2.3.4 Radiocarbon Dating in Practice – Reservoir Effects and *Correction*.

The concentration of ^{14}C in contemporaneous terrestrial environments is uneven. Making up for the deficit of ^{14}C, between organisms that lived at the same time but in different places, is *correction.* These deficits are also termed *reservoir effects*, after the conceptual terrestrial "carbon reservoirs" (e.g. atmospshere, biosphere, lithosphere, marine) which this element is sequestered in and transferred between (Stuiver et al. 1986; Bashkin 2018). Plants and animals from marine environments are subject to a major *reservoir effect* and are very impoverished in ^{14}C relative to co-extant terrestrial organisms (Stuiver et al. 1986). Their radiocarbon dates appear "older."

Each *reservoir* conserves different quantities of C, and exchanges with other reservoirs at different rates and by different mechanisms (Fig. 5.2.3). The terrestrial carbon not held in the lithospheric *reservoir* (e.g. fossil fuels; residence time 10my+) is constantly exchanged between the atmospheric (e.g. CO_2, CH_4 gases) biospheric (organic biomass) and marine (H_2C0_3, HCO_3, CO_3^{-2}) *reservoirs* (Carlson et al. 2001.) After the lithosphere, the oceans (m*arine reservoir*) have the greatest capacity for C (Carlson et al. 2001; Baskin 2019). Surface ocean waters (up to 10m deep) mix readily with the atmosphere and freely exchange C, so the two bodies remain in equilibrium (Mangerud 1972).

Less than 1% of the capacity of the marine *reservoir* is accounted for here. Low-temperature, high-salinity and high-density water masses of the deep ocean retain 99% of marine carbon (therefore 98% of all C, "actively" moving between *reservoirs*, Carlson et al. 2001.) Average residence times in the marine *reservoir* are high because circulation of these water masses is slow. Atoms of ^{14}C are held in the deep ocean for so long that an appreciable quantity are able to decay (into ^{14}N, Broecker et al. 2004). The "new" ^{14}C entering at the surface cannot compensate for the volume of recycled and ^{14}C-depleted seawater (Mangerud 1972). Mean concentrations of ^{14}C in the ocean (or the conceptual *oceanic mean*) are c.10% lower than in the atmosphere of the Northern Hemisphere, depending on latitudinal range (an offset termed "global R" or rT, Craig 1956; Heaton et al. 2020.)

For the reasons explained above, marine organisms are deficient in ^{14}C, relative to their contemporary terrestrial counterparts. Radiocarbon dates from the former always appear to be older than those from the latter by an average of 400 - 600 years (Alves et al. 2018), and are also conditioned by the flux of ^{14}C in time (see Section 5.2.3). Rapid ^{14}C oscillations in the atmosphere (e.g. by sunspot cycles) are not transposed into the ocean due to its internal mixing. As the 30,000-

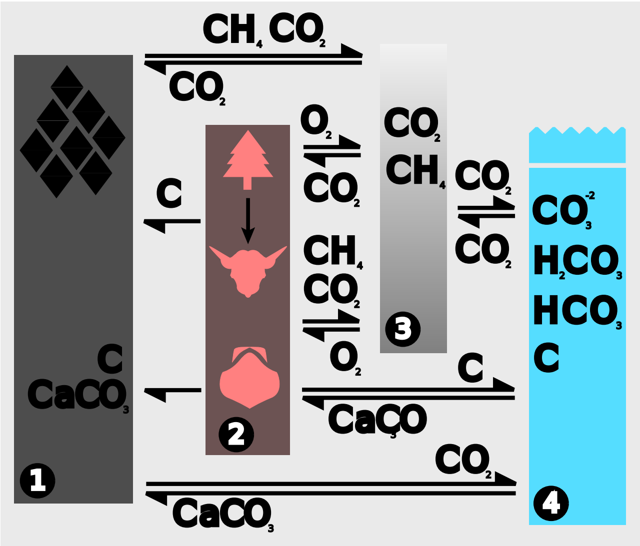


Fig. 5.2.3. Carbon Reservoirs and Chemical Interchanges. (1) Lithospheric (2) Biospheric (3) Atmospheric (4) Marine. After Baskin (2019).

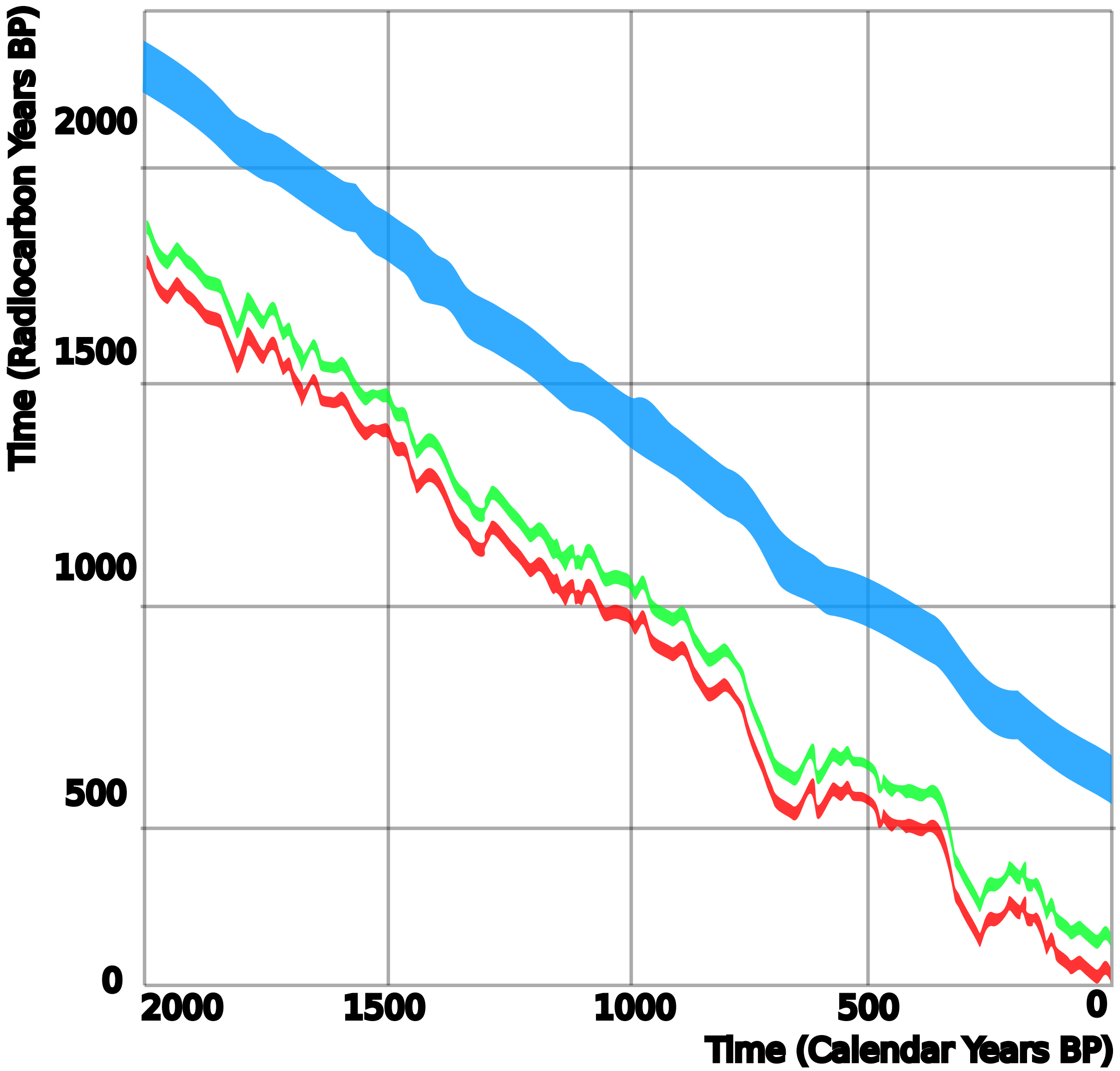


Fig. 5.2.4. Actual Radiocarbon Calibration Curves. Red: (Atmosphere of the Northern Hemisphere; IntCal 2020). Green: (Atmosphere of the Southern Hemisphere; SHCal20). Blue (the conceptual mean concentration of ^{14}C in ocean surface waters, at low- to mid-latitudes; Marine20). Relationship between calendar years (BP) and radiocarbon years (^{14}C : ^{12}C ratio). After (Reimer et al. 2020, Heaton et al. 2020; Hogg et al. 2020).

year trend of declining ^{14}C is therefore not perfectly parallel in both bodies, the atmosphere and ocean require discrete calibration curves that are regularly updated: Marine20 (Heaton et al. 2020) and IntCal20 (Reimer et al. 2020; Fig. 5.2.4) are the latest iterations.

Calibrating a marine radiocarbon date to the Marine20 curve (Heaton et al. 2020) *corrects* for the "baseline" *marine reservoir* effect (i.e. the conceptual mean concentration of ^{14}C in ocean surface waters, at low- to mid-latitudes.) In reality, the oceans are physically heterogenous. Discrete marine basins sustain ^{14}C concentrations ranging above, or below, the *oceanic mean*. The difference between ^{14}C concentrations in a local marine environment, and the conceptual mean average for ocean surface waters, is termed ΔR ^{14}C (or *local reservoir correction*, Stuiver et al. 1986; Alves et al. 2018).

For example, the Weddell Sea (Southern Ocean) is isolated within the thermohaline system by the Circumpolar Current, and insulated from the atmosphere by perennial ice cover (Weiss et al. 1979). Its surface waters contain 80 – 90% less ^{14}C than the Atlantic (and 99% less than in the atmosphere of the Northern hemisphere; Gordon & Harkness 1992.) Emperor penguins acquire so little ^{14}C from this environment that their radiocarbon age and "real age" are dislocated by c. 1,500 years. It is necessary to apply a large *local reservoir correction* to dates from their tissues (ΔR ~1,110 ^{14}C; Gordon & Harkness 1992), in addition to *calibration* to Marine20 (Heaton et al. 2020; Fig 5.2.5).

Typically, *local reservoirs* deviate from the *oceanic mean* by much smaller degrees (e.g. Norwegian Sea, -0.5% to -1%, ΔR ^{14}C of 50 to 100 years; Mangerud 1972). Nevertheless, oceanic circulation is not perfectly stable and the supply of ^{14}C-depleted seawater to marine sub-environments fluctuates in time (Broecker et al. 2004; Fig. 5.2.5). As the difference in ^{14}C concentrations between a local *marine reservoir* and the cumulative *oceanic mean* can grow and shrink (Stuiver et al. 1986) a *local reservoir correction* is both specific to a place and only valid for c. 200 – 300 year periods (e.g. Ascough et al. 2005; Butler et al. 2009). the magnitude of a local marine *reservoir* effect can only be determined from samples found in specific contexts (e.g. seashells in archaeological deposits; Deewar 2010).

5.2.3.5. Local *Marine Reservoirs* Effects Modified by Animal Behaviour.

Sedentary organisms (e.g. *mollusca)* are subject to one local *reservoir* effect and inherit a matching ^{14}C : ^{12}C ratio (Mangerud 1972; but see Bulter et al. 2009). Most marine vertebrates are not confined to single habitats, and mammals like *cetacea, sirenians* and *pinnipeds* have complex migratory behaviours. The impact of local *marine reservoir* effects on radiocarbon dates from these animals is

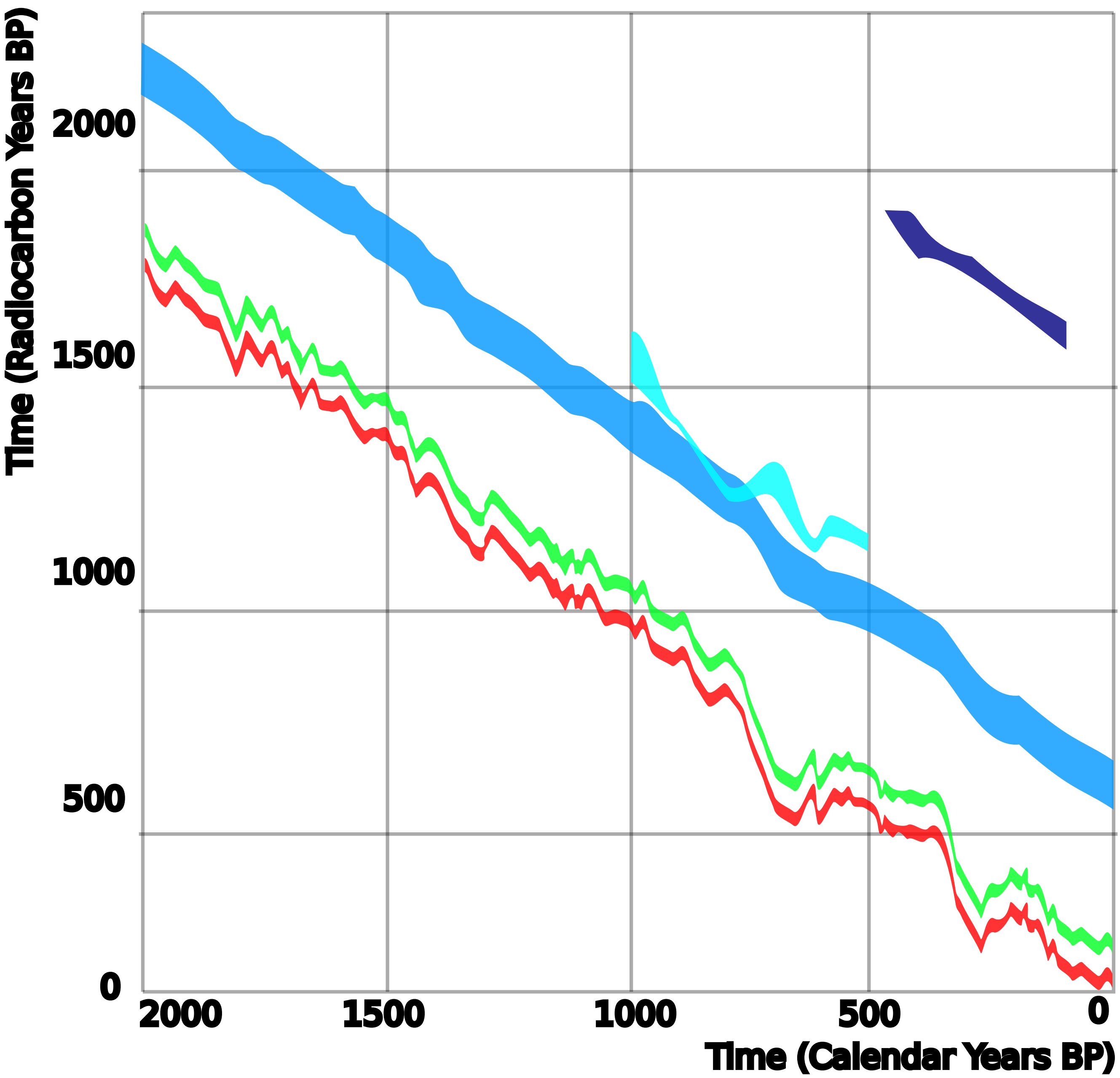


Fig. 5.2.5. Actual Radiocarbon Calibration Curves. Red: (Atmosphere of the Northern Hemisphere; IntCal 2020). Green: (Atmosphere of the Southern Hemisphere; SHCal20). Blue (the conceptual mean concentration of ^{14}C in ocean surface waters, at low- to mid-latitudes; Marine20). Dark Blue (Weddell Sea; illustrative.) Cyan (Norwegian Sea; illustrative.) Relationship between calendar years (BP) and radiocarbon years (^{14}C : ^{12}C ratio). After (Reimer et al. 2020, Heaton et al. 2020; Hogg et al. 2020).

much less predictable. The ^{14}C : ^{12}C ratios in their tissues may amount to averages between several local *marine reservoirs*, rather than conforming to any one of them (e.g. Mangerud et al. 2005). The size and necessity of the *correction* depends on observations of extant species - and an assumption, that their ancestors behaved similarly.

5.2.3.6. Ontogenic Physiological Fractionation of ^{14}C, or "Bone Reservoir Age."

As already alluded to, different structures within the body of a single organism sustain different ratios of ^{14}C : ^{12}C. While many vertebrates never stop growing, their tissues undergo constant turnover. In bones (e.g. cortical) that are renewed at a slow rate (e.g. Calcagnile et al. 2013), the ^{14}C : ^{12}C content with them nearly amounts to a lifetime average (e.g. Nelson & Mohl 2003).

Some structures (e.g. tooth dentine, the petrous bones, lens crystals) cease to exchange with the rest of the body at early stages in life (in humans, 12, 2, and 1 year of age, respectively; Cook et al. 2006, Jørkov et al. 2009; Lynnerup et al. 2008) preserving the ^{14}C : ^{12}C ratio of the years in which they formed. Radiocarbon dates from such samples indicate the time elapsed since the infancy, rather than the death, of the organism. Therefore, the correction is equal to the lifespan of the species (maximum of 90 years in humans; e.g. Ubelaker et al. 2005, Cook et al. 2015).

5.2.3. Summary.

The ratio of ^{14}C : ^{12}C in an organic sample can be measured, but turning that information into valid chronological data is complicated. *Calibration* is obligatory for all radiocarbon dates whereas *corrections* are applied in a more situational and discretionary manner. The marine ^{14}C reservoir and additional local reservoir corrections (ΔR ^{14}C) create particular difficulties, when trying to calculate accurate radiocarbon dates. However, even a very large ΔR ^{14}C correction is not a problem, if the relevant marine organism behaves in a predictable way and the size of the ^{14}C deficit in its immediate habitat is known.

<u>5.3. Radiocarbon Dating Technique, Applied to *Mysticete* Whale Tissue.</u>

<u>5.3.1. Introduction.</u>

Vertebrates acquire ^{14}C from their diets and most feed in a local area for their entire lives. Due to their gigantic body-sizes, *mysticete* whales have extreme nutritional demands and migrate very long distances for sustenance. Where, how and when these animals acquire their food is conditioned by the species, habits, habitat, gender and age of the *"whale"* in question. Therefore, it is important to be detailed if trying to determine the age of *cetacean* tissue by radiocarbon-dating – and whether a specimen does, or does not, require **Δ**R ^{14}C correction.

Radiocarbon research on *mysticete* whale tissue is reviewed, after an overview of these animals and their habitats. The bowhead whale *(Balaena mysticetus)* - a *Balaenidae mysticete,* with an Arctic habitat - has been particularly extensively studied in radiocarbon science and this literature is discussed (5.3.2). The *cetacean* remains in the Carse of Stirling have not been referred to members of that genera, but belonged to cosmopolitan *Balaenopteridae mysticetes.* The habits, habitats and feeding behaviours of those animals are described in more detail (5.3.3). From those observations, *Balaenopteridae* whales should be subject to local ^{14}C reservoir effects. This conflicts with past research, which suggests that radiocarbon dates from *cetacean* tissue do not require local ^{14}C reservoir (**Δ**R ^{14}C) corrections – at least, for species endemic to the North Atlantic. For specific parts of the *mysticete* anatomy, potential ontogenic ("bone reservoir age") factors are identified.

<u>5.3.2. Review and Overview.</u>

Cetaceans only live in the oceans. All species must be subject to the baseline ^{14}C marine reservoir (or conceptual *oceanic mean* for surface waters, at a given period of geological time; Heaton et al. 2020.) Even so, the same *Balaenoptera* species inhibit the oceans of both hemispheres (anti-tropical). As Northern and Southern Hemisphere fin whales (*B physalus)* inhabit completely different water-masses, and interact with different local C^{14} marine reservoirs, a "blanket" species-level **Δ**R ^{14}C correction would be inappropriate. If one population of *cetaceans* are found to require (or not require) a local reservoir correction, it is unwise to assume that that applies universally.

There is no unifying methodology for radiocarbon-dating *cetacean* tissue. Compared to other kinds of organic material (e.g. peat), c*etacean* bone has been radiocarbon-dated infrequently: the ages of the "*whales*", themselves, are rarely even the object of the study. *Cetacean* remains from Quaternary deposits are uncommon (Section 2.3.1) and have often proven to be older than the than < 60,000 year radiocarbon limit (Noakes et al. 2013; Deviėse et al. 2018). Bones from archaeological contexts (e.g. McGhee & Tuck 1976; Nydal 1989; Anderson & Sinoto 2002) have sometimes been radiocarbon-dated, although the authors can be inexplicit about their methodology. Wiig et al. (2019) and Dyke & Savelle (2001) dated large samples of *cetacean* bone but in service of overarching hypotheses (e.g. timing of retreat and advance of polar sea-ice). When the relevant scientific literature is diffused across many different disciplines, it is important to read it carefully.

5.3.3. *Balaena mysticetus*, or the Bowhead Whale.

5.3.3.1 Habitat and Habits of (*B. mysticetus*).

Although physiologically similar to the *Balaenidae mysticetes*, *B*owhead whales (*B. mysticeus)* are exceptional in other respects. They have maximum observed lifespans of any mammal (c. 200 years; Keane et al. 2015) and, in modernity, have the most confined range of any *mysticete*. These *cetaceans* are segregated in Pacific and Atlantic populations, neither of which leave the Arctic circle (Moore et al. 2010). Both groups migrate seasonally, but in correspondence with a specific physical marker (sea-ice retreat and advance; Moore & Laidre 2006) and over a comparatively short distance (c. 3000km). Based on stomach content analysis (Lowry et al. 2004), ^{13}C and ^{15}N stable isotope ratios and Hg concentrations in their baleen (Pomerleau et al. 2018), both stocks of Bowhead whale are thought to feed year-round, rather than only in the summer (Fig. 5.3.1a - b)

5.3.2.2. Habit, Habitat, Radiocarbon Dating.

What is true for Bowhead whales *(B. mysticetus)* and their radiocarbon dates is unlikely to apply for *mysticetes* in general. On the other hand, no other large *cetacean* has been subject to systematic radiocarbon-dating programmes (e.g. Dyke et al. 1996; Dyke & Savelle 2001; Sørenson et al. 2010; Wiig et al. 2019) which have undergone subsequent review (Furze et al. 2014; Pieńkowski et al. 2022). Due to their ice-margin habitat, the presence or absence of their bones is a reliable proxy for the extent of sea-ice in the Pleistocene and Holocene Atlantic. In Denmark, Sørenson et al. (2010) found that *B. mysticetus* bones dated to only c. 14. ka cal BP, whereas Wiig et al. (2019) found that younger bones were found at successively higher latitudes, along the coast of Norway.

B. mysticetus only inhabits one part of the ocean in modernity and, within that region, ice cover and marine circulation are likely to sustain local marine reservoir effects (e.g. Dyke et al. 1996). These were suggested to amount to 400 years, in addition to the existing marine average (Stuiver et al. 1986; 800 years total). Organisms in that environment should be expected to inherit a corresponding deficit of ^{14}C and offset radiocarbon age. McGhee & Tuck (1976) were the first to identify and examine this disparity. The ages of Palaeo-Inuit artefacts made of *cetacean* bone were known from style but produced radiocarbon-ages that, even when adjusted by 400 years, failed to correspond. The **Δ**R ^{14}C correction for *B. mysticetus* has since been revised. Dyke et al. (1996) suggested that

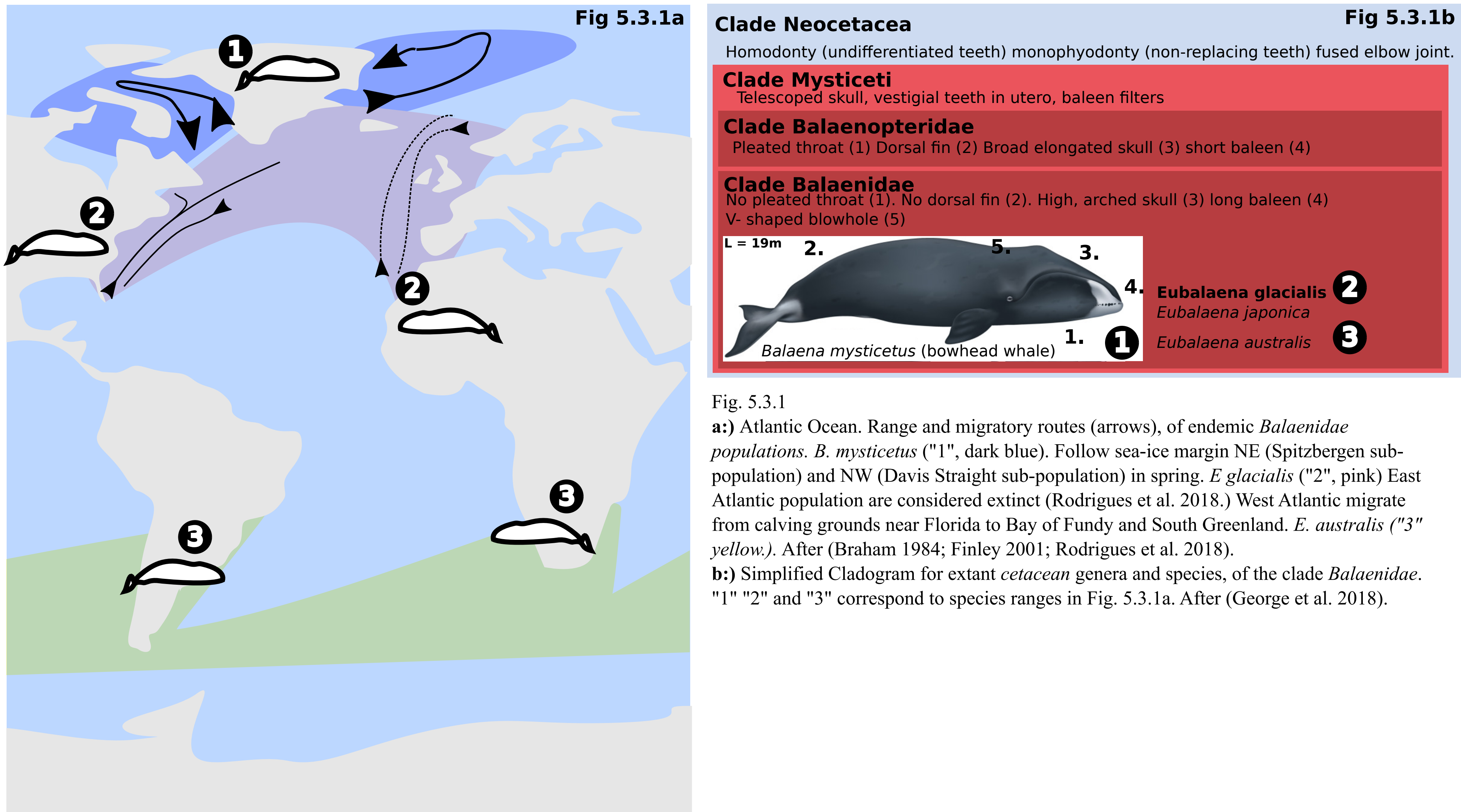


Fig. 5.3.1
a:) Atlantic Ocean. Range and migratory routes (arrows), of endemic *Balaenidae populations. B. mysticetus* ("1", dark blue). Follow sea-ice margin NE (Spitzbergen sub-population) and NW (Davis Straight sub-population) in spring. *E glacialis* ("2", pink) East Atlantic population are considered extinct (Rodrigues et al. 2018.) West Atlantic migrate from calving grounds near Florida to Bay of Fundy and South Greenland. *E. australis ("3" yellow.).* After (Braham 1984; Finley 2001; Rodrigues et al. 2018).
b:) Simplified Cladogram for extant *cetacean* genera and species, of the clade *Balaenidae*. "1" "2" and "3" correspond to species ranges in Fig. 5.3.1a. After (George et al. 2018).

only a 200yr “total” correction for *B. mysticetus* bone was necessary, in contrast to the 400 "total" adjustment for Arctic molluscs. Recently, **Δ**R ^{14}C corrections of 50 years (Dyke et al. 2011), 180 years (Furze et al. 2014) and 24 years (Peińkowski et al. 2022) have all been posited for *B. mysticetus*, as well as a 107-year **Δ**R ^{14}C correction for beluga (*D. Leucas,* an *odontocete*.)

5.3.2.3. Implications: *Cetaceans,* Local Marine ^{14}C Reservoirs, and **Δ**R^{14}C Corrections.

There is broad agreement that *cetaceans* are subject to local marine reservoirs effects. Even for inhabitants of the same local environment, different *cetacean* species require bespoke corrections (Peińkowski et al. 2022.) Even in the best-studied *mysticete* (which also happens to have the smallest spatial range) the magnitude of the correction has been uncertain. The most recent and drastic revision (Furze et al. 2014; Peińkowski et al. 2022) was not prompted by new data from the Arctic, but by an update to the MarineCal Curve (Heaton et al. 2020). In this iteration, the marine and atmospheric reservoirs are calculated to have differed, on average, by 500 years (Fig. 5.2.4.)

In consequence, Peińkowski et al. (2022) argue that all previous local marine corrections are invalid. Even so, in all published the studies (Dyke et al. 1996; Furze et al. 2014; Peińkowski et al. 2022), the local reservoir effect in the Arctic is suppressed in *cetaceans*, relative to mollusca inhabiting the same environments. If this is also true in principle for *Balaenopteridae mysticetes*, which inhabit much larger marine environments, then the ages of the *cetacean* remains from the carse of Stirling might not too distorted by local marine reservoir effects.

5.3.4. *Balaenopteridae Mysticetes.*

5.3.4.1 *Balaenopteridae Mysticetes:* Habitats, Habits.

This comprises a greater number of species, several of which are represented in the Forth Valley (e.g. fin whale, *B. physalus;* blue whale, *B. musculus*, humpback whale, *M. novaengliae*). Members of the same species inhabit both hemispheres but maintain discrete populations, and are rarely known to cross the equator (anti-tropical, or bipolar distribution; Davies 1962). All are highly mobile and undertake annual, 6000 - 8000km migrations from low to high latitude, in the respective boreal and austral summers (Baumgartner et al. 2003, Mate et al. 2011; Kennedy et al. 2014). (Fig. 3.5.2a – b.)

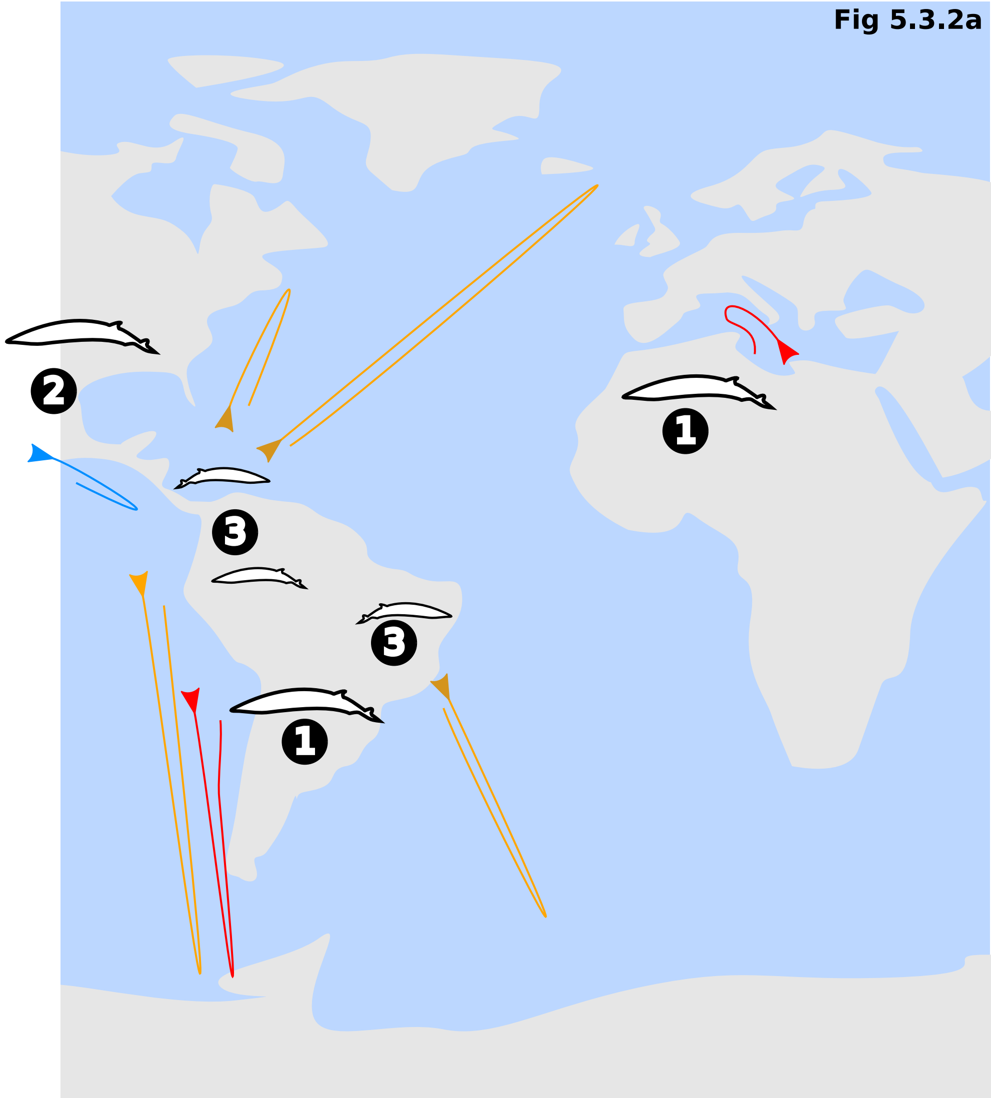
Geijer et al. (2016) emphasise that "migration" is a reductive term, which fails to capture the sophisticated activities which *mysticetes* undertake on these journeys. It is not a herd behaviour in *Balaenopteridae*, but strongly conditioned by an individual's species (Baumgartner et al. 2003), gender (Lockyer 1981, 1984 Lockyer & Brown 1981), maturity (Soule & Wilock 2013), and even culture (Kennedy et al. 2014; Geijer et al. 2016). To generalise, *mysticetes* migrate polewards for physiological reasons. In summer, marine productivity in these regions is greatest and, as enormous bulk-feeders, baleen whales can only survive by exploiting these ephemeral and dense food resources (Acevedo Gutierrez & Croll 2002; Baumgartner & Mate 2003; Goldbogen et al. 2017).

5.3.4.2 *Balaenopteridae Mysticetes*: Habitats, Habits and Presumed ^{13}C Reservoir Effects.

Balaenopteridae migrate to eat and, while migrating, eat nothing. The mechanism by which they feed (diving to great depth, lunging to engulf prey, and then expelling the sea-water) is energy-intensive: the metabolic investment is not rewarded, unless their prey is concentrated (Goldbogen et al. 2012; Friedlander et al. 2015.) These animals feed for a few months in the summer, and then spend the rest of the year at the equator, living off that reserve. Lockyer (1984) estimates that 90% of *Balaenopteridae* feeding is done at high-latitude, and that, in the case of humpback whales *(M. novaeangliae)* as much as 50% of their body-mass is lost while at low latitude, or travelling to or from high latitude (Lockyer 1981.) Female *mysticetes* can spend up to nine months fasting, while nursing infants at the tropics (Oftedal 1993). The one exception is *Eschritus robustus*, the only extant suction-feeding *mysticete* (and only now found in the Northern Pacific; Tyuneva et al. 2010.)

There is a simple chain of consequences. *Balaenoptera* require high prey densities and congregate, seasonally, at areas of high marine productivity (Slater et al. 2017). These areas are, typically, where deeper ocean waters upwell and bring nutrients to the surface, increasing productivity locally. This association is not hypothetical. In the Southern Hemisphere, most *Balaenopteridae* species migrate to Antarctica to feed off upwelling driven by the Circumpolar Current (Tynan 1998). In the Pacific Northern Hemisphere, blue and fin whales migrate to Conception Point, California (Fiedler et al. 1998; Mate et al. 1999,) where wind drives upwelling between June and October. In the Northern Hemisphere, North Atlantic Right whales *(E. glacialis)* and fin whales (*B. physalus*) migrate to the Bay of Fundy, Nova Scotia in the boreal autumn (Baumgartner et al. 2002, 2003; Woodley & Gaskin 1996) where upwelling is intense and when productivity is high (Fig. 5.3.2a).

Co-incidentally, marine upwelling is the mechanism which brings ^{14}C-depleted seawater to the surface of the ocean (Eglinton et al. 1997.) Since *Balaenopteridae* mysticetes feed exclusively at areas of upwelling, and as diet is the means by which vertebrates receive their radiocarbon allocation, these *mysticetes* should be subject to local marine reservoir effects. Radiocarbon dates from *Balaenoptera*, like the ones preserved in the Carse of Stirling, may then require **Δ**R ^{14}C corrections in order to be accurate.



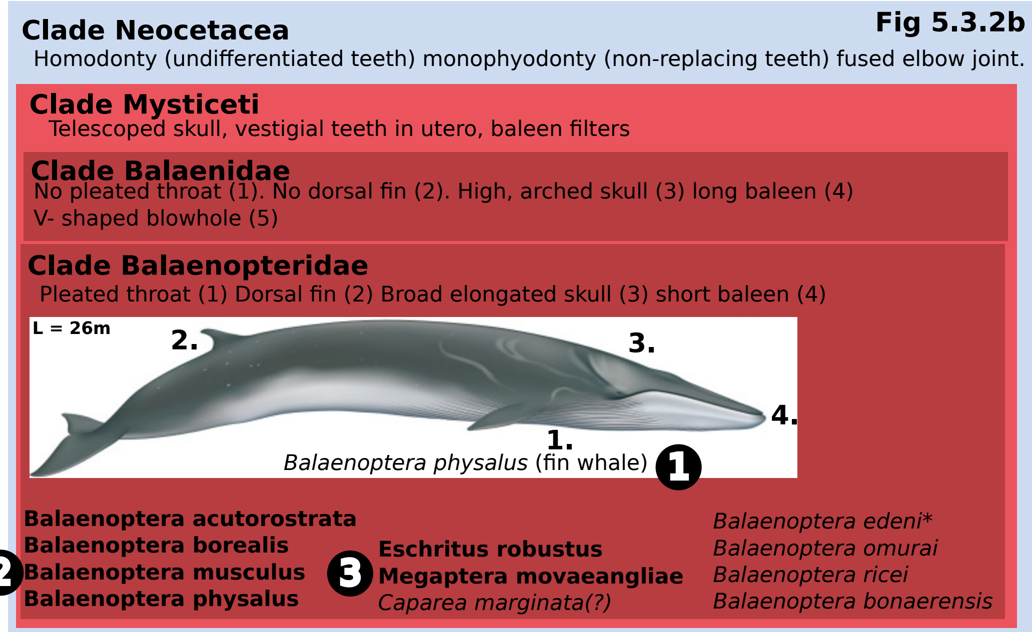


Fig. 5.3.2 **a:)** Atlantic, Southern, South-East Pacific Ocean. Range and migratory routes, of endemic *Balaenopteridae* populations. *B. physalus ("1",* red arrows). endemic Mediterranean population congregate in Ligurian Sea during summer and leave in autumn. Winter habitats are unknown. South-East Pacific population migrate to Antarctic (austral summer) and are now believed to calve near Chile. *B. musculus ("2", blue).* North-East Pacific populations migrate between Central America and Western North America (off figure). *M. novaeaengliae ("3" orange arrows.).* South Atlantic and South West Pacific populations both migrate to Antarctica in the austral summer, but exploit entirely discrete feeding grounds. North Atlantic sub-populations are also known to return to particular areas (e.g. Guadelope Group to Iceland) but individuals have been observed to visit "foreign" feeding grounds (see Kennedy et al. 2014). After (Fiedler et al. 1998; Notarbartolo et al. 2003; Alcevedo et al. 2012; Geijer et al. 2016; Johnson et al. 2022).
b:) Simplified Cladogram for extant *cetacean* genera and species, of the clade *Balaenidae*. "1" "2" and "3" correspond to species ranges in Fig. 5.3.2a. (After Aguiler & García-Vernet, 2018).

5.3.4.3 *Balaenopteridae Mysticetes*: Habitats, Habits, Observed Local Marine Reservoir Effects.

Balaenopteridae mysticetes in the Southern Hemisphere are certainly ^{14}C-depleted. Humpback (Nichols et al. 2022) Antarctic minke (*B. bonaerensis*; Viquerat & Herr 2017) and blue whales (*B. musculus*; Shannon et al. 2005) are all observed to feed around Antarctica during the austral summer. These water-masses are highly ^{14}C-depleted (Weiss et al. 1979). In correspondence, radiocarbon-dated *cetacean* bone from Antarctica, South Georgia and the South Shetlands all required 1000 – 1500 **Δ**R ^{14}C corrections (e.g. Clapperton & Sudgen 1988; Clapperton et al. 1989; Gordon & Harkness; 1992; Hall 2010). ^{14}C has even been used as a tracer isotope in baleen from extant Southern Hemisphere humpback whales (Eisenmann et al. 2017). While these *mysticetes* do sometimes feed at lower latitudes (signified by relatively higher ^{14}C concentrations in sections of baleen) this did not compensate for extreme negative ΔR ^{14}C signal acquired in the Antarctic.

No part of the North Atlantic is as deficient in ^{14}C as the Southern Ocean (Alves et al. 2018) and local water-masses within the North Atlantic (e.g. Norweigan Sea; Mangerud et al. 2006) sustain moderately divergent local reservoirs (e.g. ΔR ^{14}C of 50 to 100 years). Members of the same *Balaenopteridae* species migrate to feed in different areas in single years, e.g. humpbacks to Iceland, Jan Mayen Island, Newfoundland (Kennedy et al. 2014; Fig. 5.3.2a). Relative to the conceptual *oceanic mean*, these areas are all depleted in ^{14}C. Therefore, Northern Atlantic *Balaenoptera* should be subject to local marine reservoir effects and require ΔR ^{14}C corrections.

However, Mangerud et al. (2006) determined – from a small (22) and heterogenous sample, of single *Balaenoptera* and *odontocete* specimens – that 19th century North Atlantic *cetaceans* did not exhibit any ^{14}C deficit. Their radiocarbon ages were identical to the *oceanic mean* for the period: Mangerud et al. (2006) conclude that *cetacean* tissue does not require ΔR ^{14}C corrections. The observation (ibid. 2006) is valid: local reservoir effects were, seemingly, entirely suppressed in 19th century North Atlantic *cetaceans.* The reasoning used to explain that observation is suspect: *"the tissue of whales should have a reservoir age, representative for the sea-water in which the whales live. Whales travel far: the ^{14}C reservoir age are a "mean", for the water along their routes."* (Mangerud et al. 2006 3231). Insofar as most *cetaceans* migrate long distances, this is correct. Nevertheless, *Balaenoptera* and *Megaptera* whales do not feed while they travel. For large parts of the year, *"the sea-water in which the whales live"* is not being sampled because these animals fast at low latitude.

Smith et al. (2010) and Wiig et al. (2019) both apply Mangerud et al.'s (2006) conclusions, to radiocarbon-dates from *mysticete* tissue. They did not report any results, which they thought to be inexplicable. Yet the problem has not been revisited, since IntCal04 and Marine04 (Riemer 2004; Hughen et al. 2004) was valid. If Marine20 (Heaton et al. 2020) has invalidated all pre-existing local reservoir corrections (Peińkowski et al. 2022), applying Mangerud et al.'s (2006) conclusions may no longer be best practice.

5.3.5. Ontogeny, Bone Reservoir Age, and ^{14}C in *Balaenopteridae* and *Balaenidae*.

The problem has not been systematically researched in *cetaceans.* Mangerud et al. (2006) postulate that the residence time of ^{14}C in "whalebone" was compensated for, by the fact that these animals grew continuously over their lifetimes. They suggest that a 20yr deduction is sufficient, regardless of the element or species (but not age) of the *cetacean* in question. One of the animals they identify is very long-lived (200yr lifespan of bowhead whales, *B. mysticetus*) and one of the elements they sampled (the periotic) is – at least in humans – ontogenically "locked" from C exchange with the rest of the body, at a young age (c1yr, Jørkov et al. 2009). If the periotic (or tympanic) bones of *mysticete cetaceans* are "locked" at a similar developmental stage as in humans, a bone reservoir correction of up to c. 180yr might be necessary to correct radiocarbon dates on these elements.

In context, only the tympanic bones survive for some of the *cetacean* skeletons from the carse of Stirling. Most *Balaenopteridae* do have shorter lifespans than bowhead whales *(B. mysticetus).* If the animal in question is a juvenile, then the (hypothetical) reservoir age of the tympanics would still be very small (10 – 20yr.) Lastly, Dyke et al. (1996) Dyke & Savelle (2001) preferentially dated the tympanic bones of bowhead whales but also sampled from post-cranial elements. They do not apply bone reservoir corrections, and elements of each type produced mutually corroborative radiocarbon dates. Therefore – and in the species, where the effect would be most pronounced – bone reservoir ages in *cetacean* tympanic bones do not significantly distort radiocarbon dates.

5.3.6. Do Radiocarbon Dates from the *Balaenoptera* Bones, found in the Carse of Stirling, Require Local Reservoir Corrections (ΔR ^{14}C) to Provide Accurate Chronological Data?

There are few studies to draw on. In most, the authors have generalised, were imprecise or, in some cases, were entirely mistaken about the dietary and migratory behaviours of the animals they were researching. As this literature largely pre-dates Marine20 (Heaton et al. 2020), their conclusions may need reviewing. With these uncertainties, it is hard to judge what to do about the *cetacean* remains in the Forth Valley. In principle, *mysticete* whales should not be exempt from local marine reservoirs. As far as Southern Hemisphere *cetaceans* are concerned, radiocarbon dates for their tissues are clearly inaccurate, if very large ΔR ^{14}C corrections are not applied. They feed exclusively at Antarctica, and acquire corresponding ^{14}C deficits, relative to other marine and terrestrial animals.

In contrast, Northern Hemisphere *Balaenopteridae* might have visited a wider range of feeding grounds over their lifetimes. The divergence of local marine reservoirs from the conceptual *oceanic mean* is also smaller in the Northern Atlantic than the in Southern Ocean (Fig. 5.3.3). This has likely been so, for most of the Holocene (e.g. Ascough et al. 2004, 2007, 2009). *Mysticetes* feeding in these environments, now and in the past, might have been subject to much smaller local reservoir effects. Radiocarbon dates from these animals might not then require large **Δ**R ^{14}C corrections.

Furthermore, *B. mysticetus* feeds exclusively in the Arctic Circle and should be more ^{14}C-depleted, than any other Northern Hemisphere *mysticete.* It requires only a c. 200 year ΔR ^{14}C correction (at the most extreme estimate.) Even bones from the beluga *odontocete (D. leucas)*, which samples with much less discrimination from the same Arctic food web as the bowhead whale *(B mysticetus),* require larger local ^{14}C reservoir corrections. In both cases, the magnitude of the *correction* is still within the margin of statistical error, inherent to all radiocarbon dates from marine samples. A *correction* might then be dispensed with, and not compromise the chronological data. However, Arctic animals represent a specific and unusual marine environment: they are unlike the *Balaenoptera* preserved in the Carse of Stirling, which are the object of this study.

Fig 5.3.3

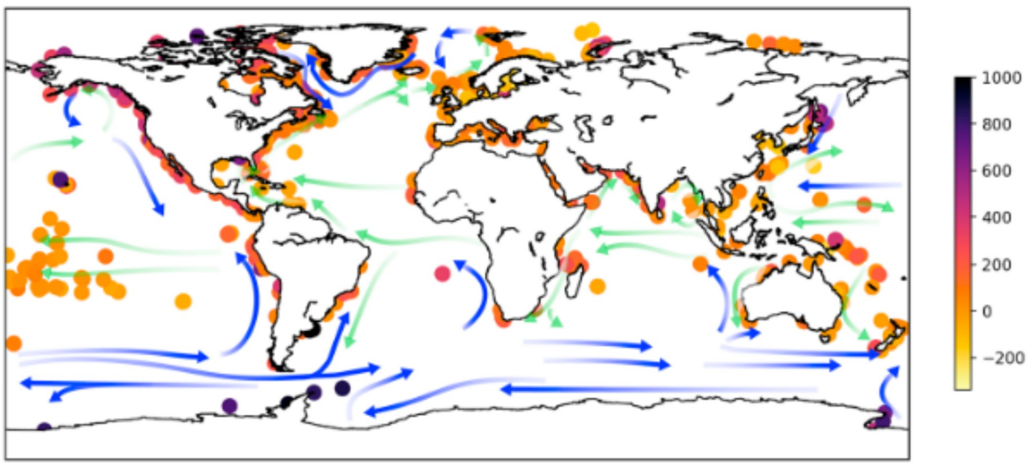


Fig. 5.3.3. Δ ^{14}C marine reservoir values. Magnitude of deviation from global marine average indicated by colour (e.g. purple, 1000yr Δr correction; pre-Marine20.) Cool currents (blue) warm currents (green). After (Alves et al. 2018).

In this respect, Mangerud et al.'s (2006) sample of 19^{th} century North Atlantic *cetaceans* are more akin to the assemblage from the Forth Valley. This study has a fundamentally unsound premise: that "whales" feed and assimilate ^{14}C at all the latitudes they visit. This does not reflect any observed *Balaenoptera* feeding behaviour (and could only apply to *Eschritus robustus.*) Despite this misconception, Mangerud et al. (2006) might still have identified a significant pattern. In their study, the radiocarbon dates from the sedentary *mollusca* were subject to a local reservoir effect, and required a ΔR ^{14}C correction. In comparison, the sampled *cetaceans* seemed to have no offset at all from the conceptual *oceanic mean*, as calculated in Marine04 (Hughen et al. 2004).

This result was irrespective of their greater *(odontocete* and *mysticete)* and smaller (*B acutorostrata*, *B. physalus)* differences in species, or element sampled (tympanic, or post-cranial element). Factors that cannot be reconstructed (e.g. gender, general migratory habits of the species) also, presumably, had no major impact on the ^{14}C content of the animals' tissues. However, Mangerud et al.'s (2006) almost exclusively sampled adult *cetaceans.* Whether juvenile and mature individuals are both equilibrated to the conceptual *oceanic mean* is unknown.

5.3.7. Summary and Conclusion.

On the basis of this evidence, it may not be necessary to apply additional ΔR ^{14}C marine reservoir corrections, or bone reservoir corrections, to *cetacean* remains from the carse clay. This rests on the safe assumption, that the *Balaenoptera* preserved there spent their lives in the Northern Hemisphere. It is then necessary to assume that, 200 and 10,000 years ago, *mysticetes* were visiting the same feeding grounds and furthermore, that local ^{14}C reservoirs and the North Atlantic marine mean diverged to the same, small degree as in the 19th century. If these are valid, then *calibrated* radiocarbon dates for the *cetacean* remains in the Forth Valley will accurately indicate the times since their deaths, so providing accurate chronological information.

The existing scientific literature is diffuse, problematic and superannuated: radiocarbon reservoir corrections, and which *cetaceans* they should be applied to, remains a problem. With the research available, a calibrated ^{14}C date from a North Atlantic *mysticete* whale should be accurate enough, to meet the goals of this project. As far as the *cetacean* remains from the Carse of Stirling are concerned, sample provenance is likely to be an equally great problem. As recounted earlier (Chapter 4), the *mysticete* skeletons found in the carse have had prolonged and chaotic curatorial histories. A highly accurate radiocarbon date is no use, if the bone being sampled does not belong to *"Whale",* that it is supposed to belong to.

6. RADIOCARBON DATING *MYSTICETE* BONES FROM THE FORTH VALLEY, SCOTLAND.

6.1.1 Introduction.

Outstanding problems relating to six sets of *cetacean* remains, said to have been excavated from the carse clay in the Forth Valley, are reviewed. Five *cetacean* bones, said to have been parts of those skeletons or assemblages, are selected for radiocarbon-dating. The absolute ages of these bones, and whether they correspond to or contradict with the reconstructed stratigraphic position of the skeleton or assemblage they are said to have been part of, are discussed. The data are examined for an overall pattern (e.g. all the same age, or not). Some scenarios, which could hypothetically have caused these *mysticete* bones and skeletons to accumulate (e.g. mass mortality and simultaneous preservation of multiple animals), are eliminated. Sedimentation and rapid burial are discussed, as factors that might have preserved these *cetacean* remains.

6.1.2. Sets of *Cetacean* Remains, and What Chronological Data May Prove in Each Case.

New absolute dating evidence is supposed to address an overall aim (insight into the agents, which preserved these *cetacean* bones and skeletons) but also addresses several smaller, self-contained problems. Some problems are general (e.g. whether *mysticete* carcasses reached their resting-places by beaching in shallow water or sinking in deeper water). More are specific to a given case (e.g. contradictory stratigraphic reconstructions, unresolved stratigraphic inferences, attribution and provenance of bones.) These are reviewed:

6.1.2.1 A *Mysticete* Skeleton, Kept at Coldoch (c. Doune) [TR].)

An issue of provenance that does not apply to a single bone, but to an entire *mysticete* skeleton. All available textual sources have been exhausted and the origins of the *cetacean* remains at Coldoch [TR] are no clearer than in 1893 (Chapter Four, 4.2). An absolute date will resolve if this skeleton is ancient and therefore, most likely to have been preserved locally in carse clay. If it is modern, then human agents most likely brought the skeleton to Coldoch in the recent past.

6.1.2.2 A *Balaenoptera* Skeleton, found at Woodyett (c. Meiklewood) [USG].

An issue of contradictory stratigraphic reconstruction, combined with an issue of conflicting radiocarbon dates, and possible provenance problems (Chapter Four, 4.5). An age of 9.5 – 9.0 ka cal BP for the vertebra (19651.03) might just make sense for a *mysticete* skeleton found c.8.8m ODN at Meiklewood. It is in conflict with the age of (6.8 – 6.5 ka cal BP) for the tool (X.HLA 3) discovered in context with that same set of remains [USG].

<u>6.1.2.3 A *Balaenoptera* Skeleton, found at Christie's Brickyard (Stirling Shore, 1858) [AJ].</u>

An issue of unresolved stratigraphic inference, with a corresponding taphonomic problem (Chapter Four, 4.6). It is unclear if this skeleton belonged to a *mysticete* carcass that beached in shallow water, at the start of the inundation (c.9.5ka) or sank in deeper water, at the height of the inundation (c. 7.5 – 5.5ka BP.) A radiocarbon date for one of the bones, certain to have been discovered at Christie's Brickyard (Stirling) in 1858, may eliminate one of the two possibilities.

<u>6.1.2.4. A *Balaenoptera* Skeleton, found at Christie' Brickyard (Cornton, 1864) [JB].</u>

An issue of unresolved stratigraphic inference, with an associated taphonomic problem and certain provenance problem (Chapter Four, 4.9). It is unclear if this skeleton belonged to a *mysticete* carcass that beached in shallow water at the start of the inundation (c.9.5ka) or sank in deeper water, at the height of the inundation (c. 7.5 – 5.5ka BP.) A radiocarbon date from a bone, certain to have been discovered at Christie's Brickyard (Cornton) in 1864, may eliminate one of the two possibilities. It will also confirm that these remains are old, and that the rib (19654.03) dated (500 cal BP) must belong to another *cetacean*.

<u>6.1.2.5. Disarticulated *Mysticete* bones, found at Causewayhead (c. Stirling, 1906) [TWW].</u>

An issue of contradictory stratigraphic reconstructions, with an associated taphonomic problem (Chapter Four, 4.10) The remains may have occupied one of two stratigraphic positions, as described by Morris (1901, 1925). A third – found on the Teith Outwash sand, with a red deer antler – appears invalid. As the remains are disarticulated, it is also probable that they have sunk to a deeper part of the shoreface during a later stage of the inundation. A radiocarbon date from a bone, discovered at Causewayhead (Stirling) in 1897, may eliminate one of these possibilities.

<u>6.1.2.6. A *Balaenoptera* Skeleton, found at Airthrey (c. Bridge of Allan, 1819) [ZT].</u>

An issue of unresolved stratigraphic inference, with an associated taphonomic problem (Chapter Four, 4.11). The skeleton may have been found near to a transgressive overlap. The animal in question was an adult blue whale *(B. musculus)* and may have displaced the soft silty substrate, sinking deeper into the stratigraphic column and so appearing older than it might really be. A radiocarbon date from a bone, certain to have been discovered at Airthrey (Stirling) in 1819 may show that it dates to the phase of rising sea-levels and eliminate this possibility. The Storegga Tsunami layer (7.9 ka cal BP) was discovered near to where the skeleton [ZT] was preserved, but the order of events is unclear.

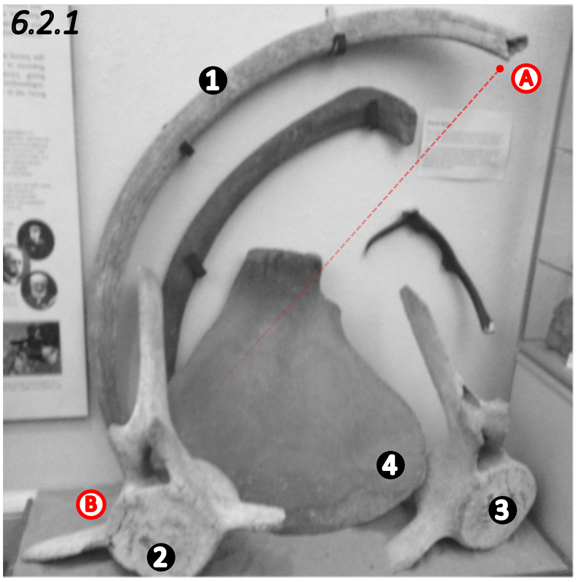


Fig. 6.2.1. *Mysticete* bones at the Smith Museum (Stirling). The rib (6390) [**"1"**] and vertebrae [**"2" , "3"**] donated by Lady MacNair Snadden in 1965: assumed to be among those, seen by Morris in 1893 at Coldoch. Sampled from inside broken head of rib. The scapula [**"4"**] is specimen (19653.02) mistakenly assigned to the *"Airthrey Whale"* [ZT]. Author's own photo (10.2021.) Dimensions:
per this study: **[A - B]** 177m in the chord. (extreme point of broken head (interior) to tip of rib [concealed].)

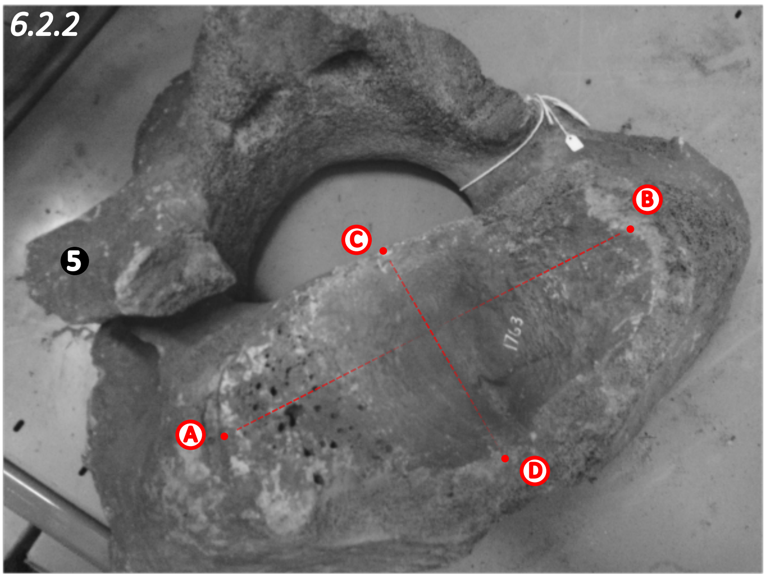


Fig. 6.2.2. "5". Atlas vertebra (19651.07) in the Smith Museum (Stirling). Thought by Turner (1912) to have been among the bones excavated at Woodyett in 1877, and still assigned to the *"Meiklewood Whale"* [USG]. Sampled from base. Author's own photo (10.2021.) Dimensions:

Per Turner (1912 8 - 9): *'14" by 7" 3/4 on the anterior articular surface.'* (35.5cm by 19.7cm).
[A - B]: 35.5cm. **[C - D]** 19.7cm.
Per this study: **[A - B]** 33cm **[C - D]** 20cm.

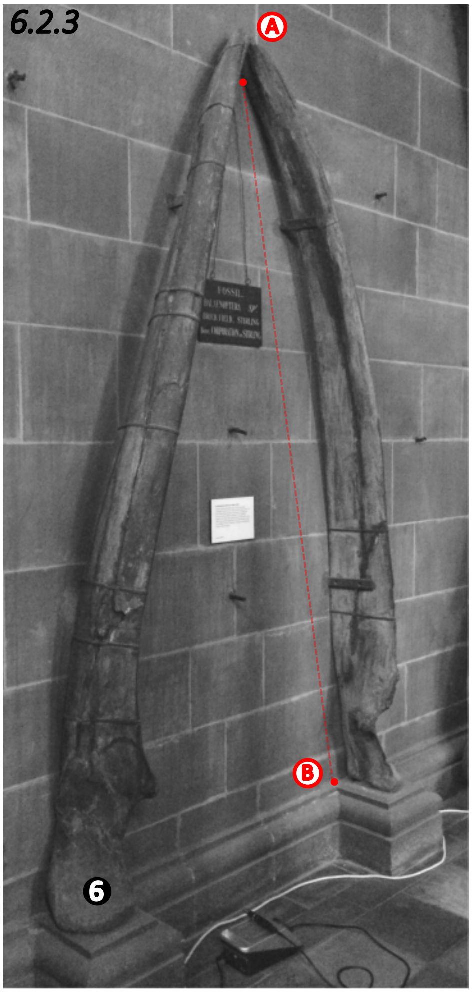
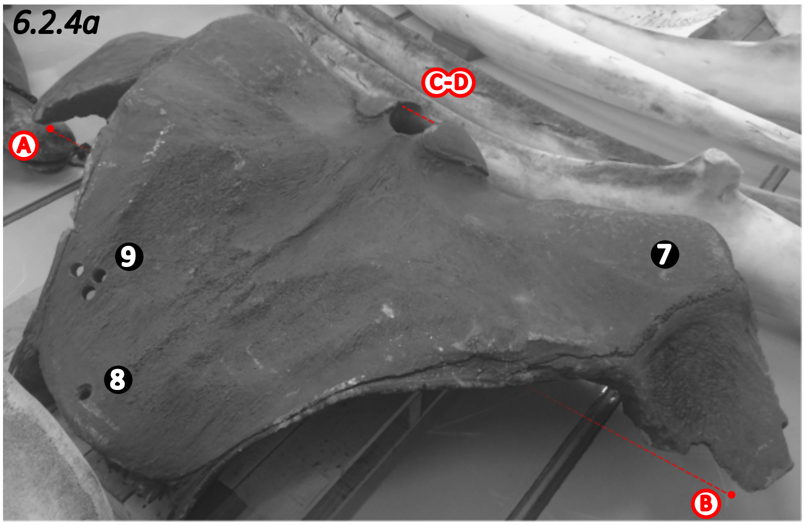


Fig. 6.2.3. "6". *Balaenoptera* mandible (AN 2626) in the Anatomical Museum (University of Edinburgh.) Donated in 1880 by the Burgh of Stirling, who recieved in from John Christie (Sr) following the skeleton's [AJ] excavation in 1858. Sampled from inside foramen, of left mandible. Author's own photo (11.2021) Dimensions:

Per Turner (1912 68): *Length of chord: 9' 1" 1/4* (276cm).
[A - B] 276 cm.
Per this study: **[A - B]** 269cm.



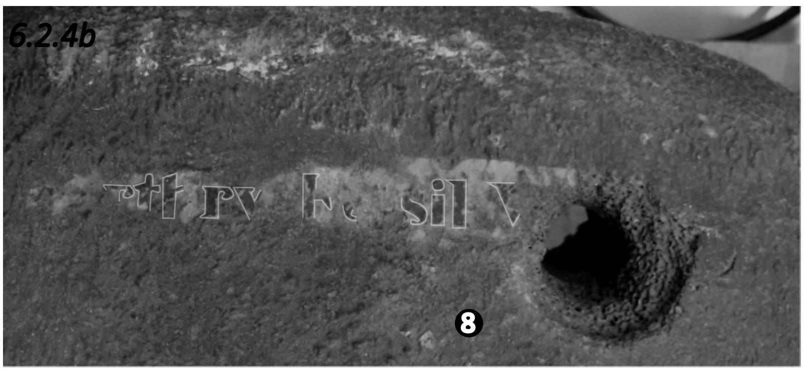


Fig. 6.2.4a:) "7" *B. musculus* occipital (NMSZ 1991.86 1) and **"8"** label (see Fig. 6.2.4b.) Excavated and then donated, with the rest of the skeleton [ZT], to the Edinburgh College Museum in 1819. This element had been sampled for radiocarbon-dating in the 1960s (three large holes, (**"9"**) which was apparently never done (Herman 2021, pers. comm.) Sample in this study taken from inside one of the older sampling holes. Author's own photos (11.2021). Dimensions:

Per Bald (Cal. Merc. 31.7.1819). *'Breadth of crown bone: 8' 5". diameter of blow-hole [sic]: 5" 1/2.'* (255cm & 14cm.) **[A - B]** 255cm **[C - D]** (*foramen magnum*) 14cm.
Per Turner (1912 5). *'Temporo-occipital breadth: 9' 6".'* (289cm) **[A - B]** 289cm.
Per McIntosh (1923 77) *"Breadth of occipital, point-to-point (inc. damaged temporal arches): 8'. This measure differs from [that] of William Turner, who states that it is 9' 2" long* [sic].*"* **[A - B]** 244cm.
Per this study: **[A - B]** 237cm **[C - D]** 14cm.
Fig. 6.2.4b:) Close-up of occipital. ("8", Fig. 6.2.4a). Remains of label: *" r t h r y F o s i l W "*, or "*Airthry Fossil Whale*". Origin unknown. Origin and purpose of hole, also unknown.

6.2. Specimen Selection, Sampling Practice and Radiocarbon Dating Protocol.

To ensure that the correct elements were being sampled, *cetacean* bones in museum collections were measured and these values compared against those recorded in historic sources (Fig. 6.2.1 – 4). To sample undegraded collagen protein and avoid contamination from 19th century glues or varnishes (Smith et al. 2010), a small (<0.5cm) incision was made at a discrete location on each *cetacean* bone with an electric drill, away from areas that had been visibly treated. By drilling from within that cavity, c. 1g of bone powder was obtained from each specimen and collected in sterile tinfoil. The samples underwent chemical pre-treatment at the Oxford Radiocarbon Accelerator Unit (ORAU), following the bone collagen protocol (AF) (Brock et al. 2010.) The ^{14}C content in each treated sample was then determined by accelerator mass spectronomy (AMS) at the same facility.

6.3. Results.

Six radiocarbon measurements were produced from five samples, listed in Table 6.3.1. As part of the Oxford Radiocarbon Accelerator Unit's quality-control procedures, the sample from the occipital (National Museum of Scotand, NMSZ 1991.86 1) was analysed twice. The age of this specimen is also reported as a combined radiocarbon date, produced using OxCal software (ver. 4.4; Bronk Ramsey 2009.) Using this tool, all radiocarbon dates in this study, and the one produced by Smith et al. (2010) for the vertebra (Smith Museum, Stirling, 19651.03), were calibrated to the Marine20 calibration curve (Heaton et al. 2020). All calibrated radiocarbon dates are reported as 95.4% highest probability density [hpd] ranges before present (cal BP). "Present" refers to "AD 1950. No local reservoir corrections ($\Delta R^{14}C$) or bone reservoir corrections have been applied.

Table 6.3.1. Radiocarbon Dates.										
"Whale" (alleged):	*Cetacean* Spc:	Element:	Museum & Accession No:	Lab Code:	$\delta^{13}C$ (‰):	^{14}C Determination (uncalibrated): ^{14}C years BP± (1σ)	^{14}C Age (Calibrated to Marine20) (68% probability):	^{14}C Age (Calibrated to Marine20) (95% probability):	^{14}C Age (Calibrated to Marine20) combined. (95% probability):	References:
"Whale at Coldoch" [TR]	*Mysticete* spc.	Rib.	Smith Museum (Stirling): [6309].	OxA-41942	-13.64	632 ± 19 BP	127 – 0 BP	231 – 0 BP	N.A.	
"Meiklewood Whale." [USG]	*B. physalus*.	Vertebra (atlas)	Smith Museum (Stirling): [19651.07].	OxA-41940	-12.96	3142 ± 22 BP	2838 – 2719 BP	2924 - 2660 BP	N.A.	
"Meiklewood Whale." [USG]	*B. physalus*.	Vertebra (lumbar?)	Smith Museum (Stirling): [19651.03].	Beta-158485	-15.5	7623 ± 30 BP	7968 – 7831 BP	8025 - 7748 BP	N.A.	Smith et al. (2010) No. 50.
"Cow Park Whale." [TWW]	*Balaenoptera* spc.	Mandible (left)	Anatomical Museum (University of Edinburgh): [AN2626]	OxA-41939	-15.39	8675 ± 33 BP	9240 – 9059 BP	9313 – 8983 BP	N.A.	
"Airthrey Whale." [ZT]	*B. musculus.*	Cranium (occipital)	National Museum of Scotland (Edinburgh): [NMSZ 1991.86 1].	OxA-41937	-14	7353 ± 30 BP	7695 – 7564 BP	7776 – 7497 BP	7754 – 7486 BP	
				OxA-41938	-14.37	7324 ± 30 BP	7675 – 7542 BP	7744 – 7467 BP		
"Causewayhead Whale." [TWW]	*Mysticete* spc.	Rib (fragment).	Smith Museum (Stirling): [19656.01].	OxA-41941	-14.54	7623 ± 30 BP	7968 – 7831 BP	8025 - 7748 BP	N.A.	

Table 6.3.1. Percentages (95% and 65%) represent the probability (as determined by the High-Probability Density Range Method, [HPD],) that the radiocarbon date from the sample lies within that range of ages (e.g. 8025 – 7746 cal BP). 'Combined Age' is a weighted average, calculated from two radiocarbon dates on single sample.

6.4. Discussion.

6.4.1. Origins of the *mysticete* Skeleton kept at Coldoch [TR] in 1893 - The Rib (6309)[1]

There are no quantitative (e.g. measurements) or qualitative (e.g. photo, illustration or label) means to match the *cetacean* bones seen at Coldoch [TR] by Morris (1893) with those still preserved in the Smith Museum (Stirling) and Hunterian (Glasgow). The assemblage in the Smith Museum (Stirling) is directly linked with a former owner of the Coldoch estate, Lady MacNair Snadden, who acts as guarantor for their provenance. It is hard to credit that the *cetacean* bones she donated in 1960 belong to anything other than the "*whale*", which many people witnessed on her property.

Whilst these bones are all in a uniform state of decay (weathered, flaky, crumbling; Fig. 6.2.1) the rib (6309) is the least degraded element and so selected for sampling. It has been radiocarbon-dated to 231 – 0 cal BP. The animal to which this bone belonged died very recently. Therefore, it cannot have been excavated locally, from the carse clay (deposited c. 9.5 - 2.5ka cal BP; Smith et al. 2010). Assuming that the rib and other bones from Coldoch were all from one single *cetacean* and all, similarly, modern, then human agents likely brought the skeleton [TR] here in the recent past, from a foreign location (as Morris 1893 always suspected.)

MacKie's (2007) suggestion - that Victorian archaeologists had excavated these bones from Coldoch Broch (Iron Age; c. 2.0 – 2.5 cal BP) - can be categorically dismissed. Why an entire *mysticete* skeleton [TR] was brought to a manor in rural Perthshire, how recently this was done, and whoever was responsible, are all still mysteries. Certainly: it [TR] was not excavated locally.

6.4.2. The Skeleton of a *Balaenoptera*, Discovered at Woodyett on the Meiklewood Estate (c. Gargunnock) [USG] - The Atlas Vertebra (19651.07), Lumbar(?) Vertebra (19651.03), and Tool (X.HLA 3).

The disparity in ages between the tool (X.HLA 3, certain to have been found at Meiklewood in 1877) and lumbar vertebra (19651.03, supposed to belong to the *"Meiklewood Whale"* [USG]) is an outstanding problem. Given that the tool (X.HLA 3) was found "*resting on the front of the [mysticete's] skull* [USG], *lying vertically in the blue clay"* (Turner 1889 790), it should be the same age as the cranium (19651.02) or tympanic bones (NMSZ 1981.57.537) of the *cetacean*. On the other hand, if either of the bones proves to be the same age as the vertebra (19651.03), it would confirm that a great difference in these radiocarbon dates does exist.

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1 The *cetacean* bones from Coldoch (6309 – 6313) in the Smith Museum (Stirling) had not yet received updated accession numbers at the time of visiting. The older identifying numbers are used here.

The bones of the skull are unique skeletal elements with known dimensions, which could not easily be supplanted by impostors. The cranium (19651.02) could not be found within the collections of the Smith Museum (Stirling). Permission to sample the tympanic bones (NMSZ 1981.57.537) in the collections of NMS (Edinburgh) could not be granted within the time-frame of this project. The remaining elements in the Smith Museum (Stirling), attributed to the *"Meiklewood Whale"* [USG] are ribs and several classes of vertebra. None of these are diagnostic, distinctive or unique bones.

From this assemblage, Smith et al. (2010) sampled and radiocarbon-dated a (lumbar?) vertebra (19651.03). Turner (1912) only records the dimensions of a 1st dorsal vertebra, a 1st rib, and an atlas vertebra. These measures could only be matched to a corresponding bone, which was also listed in the modern SM Accessions Register as being part of the "*Meiklewood Whale*" [USG], for the atlas vertebra (19651.07; Fig. 6.2.2). Even so, Turner's (1912) attribution of the atlas (19651.07) to the *Balaenoptera* skeleton discovered at Woodyett in 1877 [USG] was not firm. Of all the parts of the *"Meiklewood Whale"* [USG] in Smith Museum (Stirling) collections, it is the only bone that he (ibid. 1912) did not see, measure, or refer to, when he attended the skeleton's excavation in 1877.

In this case, the smaller certainty (a unique and identifiable bone, with corresponding dimensions and cataloguing) is balanced against the greater uncertainty (whether the bone (19651.07) really is part of the *Balaenoptera* skeleton from Woodyett [USG].) Turner's judgement is respected, based on his expertise with these animals' anatomy and familiarity, with the *cetacean* remains found in the carse clay. Trusting that he is correct, and that the atlas vertebrae (19651.07) does belong to the *"Meiklewood Whale"* [USG] this element was selected for sampling and radiocarbon-dating.

The atlas vertebra (19651.07), thought by Turner (1912) to be part of the *Balaenoptera* skeleton found at Woodyett [USG] has been radiocarbon-dated to 2924 – 2660 cal BP. The age of the lumbar vertebra (19651.03) also supposed to belong to this *cetacean* [USG] and first radiocarbon-dated by Smith et al. (2010) to 9540 – 9140 cal BP (IntCal09; Reimer et al. 2009) has been re-calibrated to 9022 – 8511 cal BP (Marine20; Heaton et al. 2020). The antler tool (X.HLA 3) found in context with the cranium of the same animal, produced a radiocarbon-date of 6850 – 6540 cal BP (Smith et al.'s 2010 calibration, to IntCal09; Reimer et al. 2009.)

6.4.2.1 The Atlas Vertebra (19651.07).

By c. 2.9 – 2.6 cal BP, relative sea-level in the Forth Valley had fallen near to its present level (0 m ODN). A bone aged 2924 – 2660 cal BP cannot plausibly have formed part of a *mysticete* skeleton, found in carse clay at c. 8.8m ODN. A living *cetacean* could only have reached this elevation, between c. 9.3 – 4.0 ka cal BP (Chapter Four, Fig. 4.5.8a – c). Therefore, Turner's (1912) attribution of the atlas vertebra (19651.07) to the *"Meiklewood Whale"* [USG] was mistaken. Although it likely belonged to a similarly-sized *mysticete*, the circumstances in which this bone was found are unknown (apart from the fact, that it must have occurred before 1912.) As the atlas vertebra is now recognised to belong to a discrete and unique set of *cetacean* remains, it receives its own arbitrary alphabetic code [AER].

Unlike the *mysticete* skeleton at Coldoch [TR], the atlas vertebra (19651.07) is, apparently, an ancient *cetacean* bone. Since it is such a large and heavy element, it might be reasonable to think that it was found in carse clay, and belonged to a *mysticete* [AER] that died locally. Fundamentally, the provenance of the bone (19651.07), before it became part of the Smith Institute (Stirling) collections, is unknown. *Cetacean* vertebrae were used as ballast on 19th c. ships (Wiig et al. 2019): in principle, bones from modern Southern Hemisphere *mysticetes* - which are ^{14}C deficient - could easily have been transported to Northern Europe. Unless its history can be established, no safe inferences can be drawn from the atlas (19651.07).

6.4.2.2 The Lumbar(?) Vertebra (19651.03) and Tool (X.HLA 3)

The atlas vertebra (19651.07) may not be the only undiagnostic, post-cranial element, incorrectly attributed to the skeleton from Woodyett [USG]. The age of the lumbar(?) vertebra (19651.03) does not categorically prevent it from being part of that animal but, even after re-calibration (changing the radiocarbon date by 500yr, from Smith et a. 2010), the disparity between it and the tool (X.HLA 3) is still great (c. 2000 years). The simplest explanation is that the lumbar(?) vertebra (19651.03) is another impostor. In this case, the *"Meiklewood Whale"* [USG] may date neither to 9022 – 8511 cal BP, nor to 2924 – 2660 cal BP.

Giving the benefit of the doubt, and assuming that both the vertebra (19651.03) and tool (X.HLA 3) were excavated at Woodyett in 1877, then something must explain why the ages of these two objects fail to correspond. Two thousand years cannot simply have elapsed between the death of the animal and the deposition of the antler tool, since the two were found in direct contact. Given that only one set of diagnostic bones were recovered at Woodyett (cranium and tympanics) it is also improbable that two sets of *mysticete* whale remains were preserved at the same location (two thousand years apart) and then mixed indiscriminately during the excavation. Given the tool's (X.HLA 3) strong textual provenance (Chapter Four, 4.5.6), it is unlikely to be an impostor.

6.4.2.2.1 The Tool (X.HLA 3) and Mesolithic Mattock Typologies.

Smith et al. (2010) suggest that the radiocarbon date of the tool has been distorted by a 19th c. organic varnish, adding ^{14}C and making it seem "younger". As aforestated (Chapter 4, 4.5.6) an age of 6850 - 6540 cal BP is supposedly appropriate for a Mesolithic antler (beam) mattock tool, like the one found at Meiklewood (X.HLA 3). (Bonsall & Smith, 1990, Tolan-Smith & Bonsall 1998, Elliott 2014 17[2]). This might indicate that (X.HLA 3) is correctly dated. By elimination, the age-discrepancy between the "*Whale*" [USG] and the tool could then only concern the *"Whale."*

This reasoning rests on a subjective archaeological typology. Antler can be radiocarbon-dated but such chronologies depend on an object's style evolving over time, as perceived by a particular researcher (e.g. Smith 1989 vs Elliot 2014.) Many (13 of 16) of the antler mattocks from Scottish Mesolithic contexts have proven impossible to classify, typologically (Smith 1989). The one found at Meiklewood (X.HLA 3) is a unique "C type" beam mattock, whereas most Mesolithic tools of this class are "D type" (and English; Smith 1989, Fig. 1). Those antler tools had a conservative design, which did not change over the period 9000 – 6000 cal BP (Tolan-Smith & Bonsall 1998).

Even within Elliot's (2014; Fig. 9) refined and radiocarbon-supported typology of Mesolithic mattocks (in which [X.HLA 3] is now classed as a "T-Axe") the tool from Meiklewood is still two-of-a-kind. The only other Mesolithic "T-Axe" is also Scottish (Risga) and of a similar age (7200 – 6700 cal BP). Were "T-Axes" (or "C-Type" mattocks) very common, and had many been radiocarbon-dated to this same narrow time-period, then it would be safer to state that the age 6850 - 6540 cal BP for the tool (X.HLA 3) was correct (and 9022 – 8511 cal BP, for the *"Meiklewood Whale",* incorrect.) The sample is too small and the "mattock" typology is clearly developmental. Even if it were more robust, it is questionable whether functional tools would evidence incremental changes in style over long time-periods.

<u>6.4.2.3. ΔR ^{14}C Correction on the Vertebra (19651.03).</u>

Finally, ancient North Atlantic *cetacean* remains might require local marine reservoir corrections. If the *mysticete* that died at Meiklewood [USG] and the antler found beside it really did belong to animals that lived at the same time, then the *cetacean* would have been very ^{14}C deficient and require a ΔR ^{14}C correction of c. 2,200 years. Even in the Antarctic (where the local marine reservoir effect is most extreme, Sections 5.2.3 and 5.3.3.3), ΔR ^{14}C corrections are typically 1000 – 1500 years. No local marine environment, in the Holocene North Atlantic, is known to have

2 Elliot (2014) reported radiocarbon dates as Cal BC, not Cal BP. These are "corrected" here by adding 2000 years.

deviated so greatly from the marine mean during this period (Chapter Five, Fig. 5.3.3).
In addition, the *"Meiklewood Whale*" [USG] is unlikely to have been the only early Holocene North Atlantic *mysticete,* to exhibit such a severe ^{14}C deficiency. Although studies on *cetacean* tissue from this period are limited (Section 5.3.2) none have produced a discrepancy of this size between an expected radiocarbon age (e.g. as estimated by the stratigraphy) and actual radiocarbon age. A very large ΔR ^{14}C correction on the vertebra (19651.03) is therefore not a valid solution, for the apparent age discrepancy between the "*Whale*" [USG] and the tool.

6.4.2.3 "*Meiklewood Whale*" [USG] Summary.

The disparity in age between the lumbar vertebra (19651.03) and tool (X.HLA 3) is unresolved. A radiocarbon-date for the skull or tympanics (which are certain to have been excavated at Woodyett in 1877, and were in direct contact with the tool (X.HLA 3) may advance this problem. The lumbar vertebra (19651.03) is still considered part of the *"Meiklewood Whale"* [USG]. The re-calibrated date 9022 – 8511 cal BP, as first derived by Smith et al. (2010) for that bone, is taken as accurate indicator of that *cetacean's* age. The axis vertebra (19651.07) does not belong to the *Balaenoptera* skeleton excavated at Woodyett in 1877 [USG], but to a different *cetacean* [AER]. Based on that skeleton's [USG] location and stratigraphic position (at Woodyett, close to the landward edge of the carse) the animal must have been preserved in the shallowest, inter-tidal part of the palaeoestuary – irrespective of the time this actually occurred.

6.4.3. The Skeleton of a *Balaenoptera*, Discovered at Christie's Brickyard (Stirling Shore) in 1858 [AJ] - the Mandible (AN 2626).

On their discovery in 1858, the bones constituting the *mysticete* skeleton [AJ] were not catalogued. Contemporary qualitative descriptions ("*the most complete fossil whale yet found*") suggest that it was in a very high state of preservation, which must have included the cranial bones. Without them, Allman (cited in Rogers 1860) could not have identified the skeleton [AJ] as that of a *Balaenoptera* whale. Several eye-witnesses independently record the same, quantitative clue: the skeleton [AJ] was c. 40' (12m) long (Milne Home 1871; Lothian 1864).

Far fewer elements survived in 1880. Based only on the proportions of the skull (now lost) and mandible (AN 2626, 276cm; Fig. 6.2.3), Turner (1883, 1912) estimated that these had had belonged to a 40' (12m) long *Balaenoptera*. Therefore, the mandible (AN 2626), still fixed to vestibule walls of the Anatomical Museum (University of Edinburgh) and acquired from the Stirling Butter Market in 1880, can be positively linked to the *Balaenoptera* skeleton, discovered at Christie's Brickyard in 1858 [AJ]. It has been sampled and radiocarbon-dated to 9313 – 8983 cal BP.

The stratigraphic reconstruction for this *Balaenoptera* skeleton [AJ] supported two predictions, about the manner and time at which the carcass came to its place of rest. It was either an old floater in shallow water that dated to the start of the Holocene inundation (c. 9.5ka BP) or a young sinker in deep water, dating to the culmination or period of falling sea-levels (c. 7.5 – 4.0 ka BP; Chapter Four, Fig. 4.6.6a-d.) Palaeontological precedent, and recent observations on other sub-fossil *mysticetes* in the Arctic, suggested that the latter was more plausible: very shallow water being the worst kind type of preservational environment for *cetacean* remains (Section 2.3.1).

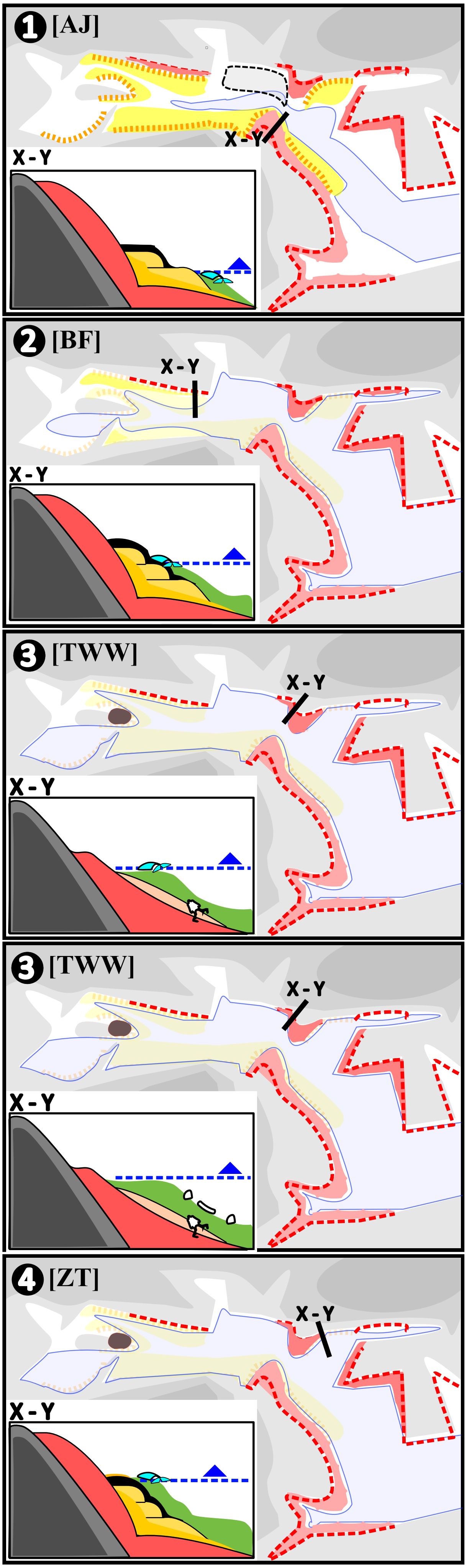
This radiocarbon date (9313 – 8983 cal BP) indicates that the *Balaenoptera* skeleton [AJ], discovered at Christie's Brickworks (Stirling), was preserved at the onset of the early Holocene inundation (9.5 – 2.5ka BP). It is plausible that this carcass grounded in a marginal marine environment, when sea-levels were low. Nevertheless, relative sea-level in the Forth Valley rose very rapidly in this period and by 9,270 – 8,500 cal BP, had already attained c. 9.5m ODN (Newburn no. 28; Smith et al. 2010.) As such, if the younger age estimate for the mandible (AN 2626) is more accurate than the older, the *Balaenoptera* carcass [AJ] may still have sunk in deeper water. This would still not have occurred during the long period, when sea-level at the Stirling Gap was highest (and water-depth, greatest; Chapter, Fig. 4.6.6a-d).

This same uncertainty applied to the other *Balaenoptera* skeleton, found in a similar stratigraphic situation at Christie's other Brickworks (Cornton) in 1864 [JB] (Chapter Four, 4.9). No bones, certain to belong to that *cetacean* skeleton, have ever been radiocarbon-dated [AS]. Due to the public health regulations that applied in Scotland c. 2020 - 2022, it was not possible to access any of the bones of this *"Whale"*, thought to have been taken by Scouler for the Andersonian Museum. The fact that the skeleton at Christie's (Stirling) [AJ] trended older might indicate that the one found at Christie's (Cornton) [JB] could also date to the onset of the Inundation.

6.4.4. The Skeleton of a *Balaenoptera*, Discovered at Airthrey (c. Bridge of Allan) [ZT] – The Occipital (NMSZ 1991.86 1).

Bald (1819; and as recorded in the Caledonian Mercury, 31.7.1819) made a partial quantitative catalogue of the bones excavated at Airthrey. Almost a century later, Turner (1912) and McIntosh (1923) measured the surviving elements, in the-then Royal Museum of Scotland (also publishing photographs of the occipital). Bald (1819), Turner (1912) and McIntosh (1923) measured this element in the greatest detail (also identifying a label, which still partially survives, Fig. 6.2.4a - b). The occipital (NMSZ 1991.86 1) was sampled, and radiocarbon-dated to 7754 – 7486 cal BP (combined date).

6.5.1a



6.5.1b

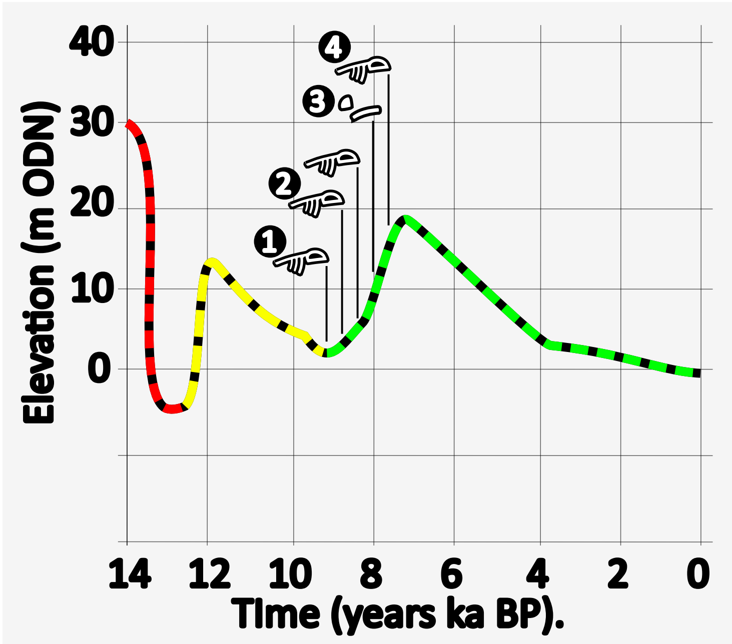


Fig. 6.5.1. a:) "1" - "4". Sea-level increase in Western Forth Valley during the early Holocene Transgression, illlustrated schematically. Panels "1" - "4" correspond to No's "1" - "4" on Fig. 6.4.1b. Succesive death and preservation of *mysticetes* [AJ] , [BF] , [TWW] and [ZT] during period of relative sea-level increase, indicated by absolute dating evidence and stratigraphic reconstruction.

(**insets**: Schematic section diagrams at "1" Stirling Gap, "2" Burnbank, (Blair Drummond), "3" Causewayhead, "4" Airthrey (Whale Park.) Position of high water water mark (blue solid, or blue dashed). Net falling or rising sea-levels, indicated by blue arrow (pointed down or up). Pleistocene RMDs (red). Landward edge of same (red dashed). Loch Lomond Interstadial RMDs, or "Buried Raised Beaches" Landward edge of same (yellow dashed). Holocene RMDs, or "carse" (green). Peat (thick black). Basemap after Google Earth Pro (2022). Extent of raised marine landforms, after (Sissons & Smith 1965; Sissons 1966; Sissons 1969; Sissons 1972; Kemp 1971; Peacock 1999; Smith et al. 2010).

b:) Composite Sea-Level Change Curve (Western Forth Valley), with absolute ages for *cetaceans* plotted. "1" - "4" correspond to panels "1" - "4" in Fig. 6.5.1a. from 12 ka BP - 5ka BP after Smith et al. (2010). Sections 14 ka BP - 12ka BP and 5.5ka BP - 0 ka BP are approximate and illustrative. No empirical sea-level curve has been constructed for these time-periods, due to the lack of transgressive and regressive overlaps for the associated deposits.

The stratigraphic reconstruction for this *Balaenoptera* skeleton [ZT] indicated that it had discovered at a relatively greater elevation (c. 10.6m ODN). It could not therefore have dated to the earliest phases of the Inundation. It remained unclear if the remains had come to their place of rest at the earliest possible opportunity (i.e. as sea-levels were still rising) or following the high-stand (Chapter Four, Fig. 4.11.6a-e). While the skeleton [ZT] may have been close to a transgressive overlap, it belonged to one of the largest individuals, of the largest species of *mysticete*. The carcasses of much smaller *cetaceans* have been observed to subside into unconsolidated substrates (Bosio et al. 2021). If this also occurred in the silts and clays that form the carse, chronostratigraphic inferences about the *"Whales"* found within it would be even more uncertain. If this problem were to apply to any of the *mysticete* skeletons found in the Forth Valley, it applies to the *"Airthrey Whale"* [ZT].

The cranium of this animal dates to 7754 – 7486 cal BP, i.e. to the period in which sea-levels were still rising, or had come close to stabilising (Smith et al. 2010; Fig. 4.11.6a.) This radiocarbon age does not support the notion, that the carcass [ZT] beached 1000 - 2000 years after the High Buried Beach was inundated and then worked itself down through the accumulated clays. the skeleton was likely preserved here, shortly after sea-levels rose to this location (Fig. 4.11.6b).

The Storegga Tsunami, which occurred at c. 7900 cal BP, is another factor. If the uncorrected radiocarbon date 7754 – 7486 cal BP accurately represents the age of the *"Airthrey Whale"* [ZT], then its death and preservation occurred very close to, but ultimately after, that event. A sand layer (which is the recognised stratigraphic marker for the Tsunami) overlaid buried peat, within 500m of the Whale Park at Airthrey. No sand is known to have been found at the transgressive overlap, at the skeleton's [ZT] approximate location. This suggested that the death and preservation of the *Balaenoptera* [ZT] pre-dated the Tsunami (Fig. 4.11.6d). However, the sand layer is not usually found within the carse clay, itself: only on peat, that was subsequently buried by carse (e.g. Robinson 1993). The Whale Park may therefore have already been inundated when the Tsunami struck, but relative sea-level had still not reached its high-stand.

6.4.5. The Disarticulated *Mysticete* Remains, found at Causewayhead (c. Stirling) in 1897 [TWW] - The Fragment of Rib (19656.01)

Turner's (1912, and as cited in Morris 1906) measures could only be matched to a corresponding bone, which was also listed in the modern Smith Museum (Stirling) Accessions Register as being part of the "*Causewayhead Whale*" [TWW], for the fragment of rib (19656.01). This is the element that Turner (1912 10) believed "*had been artificially shaped by the hand of man*."

The rib fragment (19656.01), found at Causewayhead and then brought to the Smith Museum (Stirling), has been radiocarbon-dated to 8025 – 7748 cal BP. The stratigraphic reconstruction for these fragmented *Balaenoptera* bones [TWW] indicated that they had been discovered at one of three potential elevations, all of which were relatively low (c. 7.6m, 6.1m , 4.9m ODN). Despite that, it is not safe to think that they [TWW] therefore dated to the earliest phases of their Inundation. Taphonomy suggested that the ribs might date to a period of higher or highest sea-levels, and have migrated down to a lower station of the shoreface (Fig. 4.12.5). The date 8025 – 7748 cal BP supports that interpretation. It confirms that these remains are too young to have been found at the c. 4.9m ODN Teith Sand transgressive overlap, with the red deer antler.

6.5. General Implications.

It has been easy to hypothesise about the environmental, climatic and biological mechanisms which might have caused the skeletons of *Balaenoptera* to accumulate here. With such a limited and archaic textual record, substantiating those hypotheses with evidence and elevating them into credible explanations is harder. This proposed that the ages of these *cetacean* remains could still be determined, from their reconstructed (and contextualised) stratigraphic positions and from absolute dating of bones, certain to have belonged to those same animals. If established, chronological data was supposed to provide an insight into the unknown agents, whose action led to the preservation of *cetacean* skeletons of the Firth of Forth. At least, some possible explanations were expected to be eliminated. Is this now possible?

Respectively, the *Balaenoptera* skeletons at Christie's Brickyard (Stirling) [AJ] and at Airthrey [ZT] date to the phases of lowest (c. 9.5ka BP) and highest (c.7.5ka BP) relative sea-levels in the Forth Valley. All the other sets of *cetacean* remains, with an associated absolute date [BF] (8.3 – 8.1 ka BP) [TWW] (8.0 – 7.7 ka BP) [USG] (9.0 – 8.5 ka BP) are not clustered within that period, but scattered throughout (Fig. 6.5.1a - b, "1" – "4".). A singular catastrophe (e.g. tidal wave and simultaneous burial of many individuals) can be ruled out. Although the sample is small, infrequent or cyclical disasters (e.g. once in a thousand year storms) also seem less plausible. These events are random, and so very unlikely to have coincided with both the low-stand and high-stand (I.e., the oldest [AJ] and youngest [ZT] sets of *cetacean* remains. Fig. 6.5.1b).

The comparative lack of *cetacean* bones and skeletons from the period of stable and falling sea-levels (7.5 – 2.5ka BP) may not be significant (i.e. evidence of a process that only acted, as sea-levels rose; Fig. 6.5.1b). Sets of remains with the best documentary records (and surviving elements, of certain provenance) were prioritised for radiocarbon-dating [ZT] [AJ] [TWW] [USG]

[TR]. These all, also, happened to have been found in the western extremes of the Forth Valley, which were the first to be raised from the marine environment. The landforms from the last phases of falling sea-levels (c. 4.5 – 2.1ka BP) are mostly found near Grangemouth and Alloa, to the east of Stirling Gap. *Cetacean* remains have certainly been recovered from raised marine deposits in these locations (Morris 1893, 1925; Appendix B). Some may date to the period of falling sea-levels, but many of the bones found at these places have been disposed of, or were never preserved.

Nevertheless, the regions to the West of Stirling Gap also have deposits that accumulated as sea-levels fell (c. 7.5 – 4.5ka BP), and an associated *"Shoreline"* (Blair Drummond Shoreline; Smith et al. 2010). If *cetacean* remains were preserved in sediments from this period, nothing has prevented their discovery. If carcasses had grounded in shallow water, these might even be closer to the surface and more readily found. Similarly, the remains of *cetaceans* were free to accumulate in deeper water of the palaeoestuary, throughout the entire period of relatively higher sea-levels. Deposits from both environments, from across the entire period of rising and falling sea-levels, have been sampled. The remains of many dead *cetaceans* have been found, and so far, all date exclusively to the period of rising sea-levels (Fig. 6.5.1b). This is assumed to reflect limited sampling, rather than a significant temporal pattern. If continuous physical processes are responsible, these are unlikely to have ceased acting just as sea-levels reached their high-stand.

As a final point, several of these *mysticete* skeletons must have been preserved in the most marginal and shallow marine environments in the palaeoestuary – and perhaps, almost simultaneous with those places, becoming marine environments (Fig. 6.5.1a). This is certainly the case for the *"Blair Drummond Whale"* [BF] and likely also applies to the *"Airthrey Whale"* [ZT] both at or near a transgressive overlap. Even at Stirling Gap - where the water was deepest, for longest - the only *mysticete* skeleton to have been preserved here [AJ] dates to the period of lowest sea-levels. The age of the *"Meiklewood Whale"* [USG] is unresolved but it must also have been preserved in the inter-tidal or foreshore zone, given how close it lay to the margin of the carse. This is, again, in defiance of observed palaeontological precedent (Section 2.3.1).

6.6 Identifying the Agents of Preservation in the Firth of Forth, c. 9.5 – 4.5ka BP.

A large number of complete *cetacean* skeletons are preserved in the carse clay. With the available chronological data, it is most probable that continually-acting processes, or a continuous period of stable environmental conditions, are responsible for the accumulation of those animal remains. Some may now be led to conjecture on the type of process (or processes) that operated in the Firth of Forth during the early Holocene, or to even nominate a specific agent of preservation.

Sedimentation (and rapid burial of the remains) suggests itself. Conditions for supply are ideal: by c. 9.5ka cal BP, Scotland had just deglaciated (Bradwell et al. 2008). Large areas of unconsolidated, uncemented and unvegetated glacial detritus were exposed (Galloway 1961), in addition to deeply-weathered micaceous metamorphic rocks at elevation (Fitzpatrick 1963; Wilson 2020). In the prevailing climate (Atlantic; humid, cool, rainy), erosion and transportation of those materials into marine depositional environments was likely expedited (Ballantyne 2008). Given the rapid rate of relative sea-level increase in the Early Holocene Inundation (c. 9.5 – 6.0ka cal BP; Smith et al. 2010) accommodation space for those sediments would have been generous in the Forth Valley. Hight et al. (2003 555) estimate that rates of sedimentation could have been as great as 11mm/yr in some parts of that palaeoestuary, even during the Inundation's latter stages (c. 5000 – 4000 BP).

As a broad palaeontological principle, high rates of sedimentation can cause rapid burial and has led to exceptional preservation of plants and animals, from most periods of geological history (e.g. Hall et al. 2013; Qi et al. 2007; Thomka & Brett 2015). It is an effective agent of preservation, and it likely operated in the Firth of Forth during the Early Holocene. However, it hardly operated here, exclusively. The Firths of Clyde, Tay, Solway and Moray were all inundated in the early Holocene (e.g. Jardine 1986; Smith et al. 1999), and would all have benefited from enhanced sediment supply. In other de-glaciating land-masses like Scandinavia and Eastern Canada, the same processes were at work as in Scotland (and may have been even more pronounced, the ice-sheets being more enduring and extensive there; Fjeldskaar et al. 2000; Simon et al. 2015). While some *cetacean* remains are preserved in deposits from all these places (Fig. 1.2.1a – b; Harington 1977, for the "Champain Sea", Canada) none of them have a large number of entire skeletons, concentrated in a small area (and apparently, short time-period) – like the Forth Valley.

Furthermore, high rates of sedimentation (and rapid burial) act, indiscriminately: not only preserving arthropods, vertebrates and in-situ plants, but ensuring that the remains of birds, fish, terrestrial animals and marine reptiles are all represented (e.g. "Grey Fossil Site", Tennessee; Clark et al. 2005; Shunk et al 2006). This is highly typical of *cetacean* assemblages from the geological record (even where sedimentation and burial has not been a factor; e.g. Walsh & Martill 2006; Biannuchi et al. 2016). In the Firth of Forth, the bias in preservation to (and near-total representation by) the largest *mysticete* whales is peculiar. In palaeontological assemblages featuring *cetaceans,* smaller and larger species are usually both present (e.g. Pyenson et al. 2014; Dominici et al. 2018). If sedimentation (and burial) is a factor in the Forth Valley then it could not apply, exclusively, to the remains of the very largest animals.

When trying to work out what actually happened in the Firth of Forth, during the early Holocene, the palaeontological record for *cetaceans* is only so instructive. As aforestated (Section 2.3.2) most assemblages formed in deeper, shelf-edge waters. Even here, high rates of sedimentation rarely seem to have been a critical control, on the preservation (or destruction) of these animals' remains (e.g. Wadi et Hitan; Peters et al. 2009; although King et al. 2014 argue for *rapid burial*, caused by intense energy flows. See also Chilcatay Formation, Peru, Chapter Two, Fig. 2.3.1). Researchers of the Pisco Formation, Peru, no longer believe that sedimentation was exceptionally quick here, nor contributed meaningfully to the formation of this rich *cetacean* lagerstätte (Brand et al. 2004; Gariboldi et al. 2017). Bosio et al. (2021) believe that *rapid burial* in sediments is a factor, but by an alternate mechanism (e.g. sinking in soft substrates).

Assemblages of skeletons from shallow shoreface deposits are rare, geologically. At Cerro Ballena (the only other assemblage of *mysticete* skeletons and other animal remains, preserved in inter-tidal deposits) the rate of sedimentation is estimated to have been c. 1mm/yr (Pyenson et al. 2014, Supplement) and *rapid burial*, by any mechanism, is not considered relevant. The key factors are thought to have been the absence of large scavengers in the Mio-Pliocene Atacama (and possibly the temperature, aridity and salinity of this extreme environment). However, as this study has shown, *cetacean* remains have been found in recent deposits from shallow coastal environments (Fig. 1.2.1a – b) and many ancient bowhead whale (*B. mysticetus*) skeletons are preserved in the Arctic circle (Section 5.3.3) Sedimentation also cannot be a factor here, since some of those remains were not buried at all: their preservation is likely due to extreme cold (Savelle et al. 2000).

In the short-term, factors other than sedimentation and burial clearly preserve *cetacean* skeletons in coastal marine environments. In modernity, the decay (or preservation) of stranded *cetaceans* have been observed in Tierra del Fuego, Argentina (Goodall 1976). Those preserved in the highest state, and for the longest for the longest periods of time were found *"mummified by salt-water, about 1km from shore on the mud. The skin and meat have gradually decayed away, leaving the skeleton. ... Along the outer edge of vegetation bordering the salt flats, nearly 15 complete orca* (O. orca) *skeletons are spread over a distance of about eight kilometres".* (Goodall 1976 215.) These observations are valuable, but rare. Goodall (1976) is one among few to make *actuotaphonomic* observations of *cetaceans* on beaches or tidal flats (also Shafer 1972) and these accounts are, with some exceptions (Gol'din et al. 2013), quite anecdotal.

When the real-time decay of *cetacean* carcasses in a modern marine environment is observed in an experimental manner (e.g. Esperante 2005), it is usually to make inferences about palaeontological assemblages in analogous, deep-water geological units. As ancient and modern environments are never perfect cognates, this approach can still be limited. Nevertheless, the estuary of the Forth has, largely, not changed as a physical environment in the early Holocene. The processes, now acting on dead *cetaceans,* should also have acted on dead *cetaceans* ten-thousand years ago. Actuotaphonomy could lead to the most valuable insights, and explanations, for the *"Whales*" in the carse.

To summarise, it is improbable that any palaeontological assemblage formed through the action of one single process. Sedimentation is a necessary element but should be distinguished from *rapid burial*, which can have multiple causes. It is especially important to make this distinction with *cetaceans*, and not least, *mysticetes* whales: due to their exceptional physiologies, principles that apply to them may not apply to trilobites, and *vice versa*. The best insights into the decay or preservation of *cetacean* carcasses come from watching it happen, in real time. The uncertainty in applying those insights is much reduced for the bones and skeletons of whales in the Firth of Forth, when compared to most other palaeontological assemblages.

6.7. Summary.

Absolute dating evidence on *cetacean* bone broadly corroborates the inferences made from stratigraphic reconstruction. Whilst 19th century recording and researching practices were informal and unconventional, the information itself is sound. The *cetacean* remains in the Forth Valley, Scotland, evidence a spread of ages through the first phases of the early Holocene Inundation (c. 9.5 – 7.0 ka BP). Catastrophes and sudden disasters, in which many individuals were preserved simultaneously, cannot then explain why the bones and skeletons of *mysticete* whales have accumulated here. A spread of ages provides better supports the action of a continuous process or combination of processes. However, the sample is small. For this reason, an apparent absence of bones and skeletons from the period of falling sea-levels is not seen as significant. Unprovenanced *cetacean* bones, associated with "*Whales"* to which they never belonged, remain the most significant obstacles within this data-set.

7. CONCLUSION AND FUTURE WORK.

7.1 Review of Aims and Objectives.

The aim of this thesis was to determine the ages of the *cetacean* remains, preserved during the early Holocene (c. 9.5 – 4.5ka BP) as carse clay accumulated in the Forth of Forth, Scotland. With that information, some possible explanations for their presence could be eliminated. It is now hard to argue that these *mysticete* remains accumulated in high-quantity, random-frequency episodes (e.g. a tsunami; simultaneous death and burial in a storm.) By deduction, dead animals were preserved in a gradual manner in the Firth of Forth, at least during the first stages of the early Holocene Inundation (c. 9.5ka – 7.5ka cal BP). The following objectives had to be fulfilled:

7.2. Collection, Organisation and Evaluation of Historic Documents – Future Work.

The objectives of this thesis (stratigraphic reconstruction, provenance of bones) which serve the aim directly (determining the age of a *"Whale"*) ultimately depend on records and recollections, which accumulated informally throughout the 19th century. Past research relied on the same few sources and did not deeply scrutinise their authors' testimony. Factual inaccuracies about the locations, species, preservation and fates of the *cetacean* remains in the carse had propagated, while discrepancies between different historic texts or with modern research were left outstanding.

Credible scientific research into any palaeontological assemblage is not possible, without sound information on what had been discovered and where it had been found. By methodically searching 19th century publications, many unknown sources about Scotland's *cetacean* palaeontology were revealed and, for the first time, consulted in this thesis. To resolve the problems unique to each set of *cetacean* remains, the information within these historic documents was collated within discrete cases and organised into formulaic sub-sections. The records for eleven *"Whales",* each believed to represent a discrete and individual fossil animal, were tested by cross-examination, comparison, contextualisation and original geological fieldwork. Appropriate taxonomical, anatomical and palaeontological language was also maintained throughout.

The convoluted, intertwined and incomplete histories of these *"Whales"* have been made plain by these measures, to a reader from any academic background. Each self-contained case provides an adaptive structure to address specific problems, even when the documentary materials under examination are heterogenous. Using standardised scientific terms like *"mysticete"* to complement loosely-defined words like *"whale"* eases technical discussions on important topics: not least, the (mis)attribution of certain bones to given sets of remains. The risks in reading historic sources, without also critiquing them, should now be clear.

This template accommodates future archival research into this palaeontological assemblage, wherein other cases can be developed (Appendix B) - and existing ones, adapted (Chapter Four) - as new documents are uncovered. Due to public health restrictions in Scotland between 2020 and 2022, only digitised print media on public-access platforms were searched. These resources are, still, far from exhausted and undigitised archival materials (e.g. physical paper manuscripts without electronic copies and personal correspondence) have yet to be exploited. Whilst this thesis drew on a greater quantity of sources than any previous study, it is likely just a fraction of all the potential historical material. New texts may relate to an otherwise-unrecognised discovery, permit another of Morris' (1925) *"twenty Whales"* to be analysed, or challenge the conclusions reached here.

Of the *"Whales"* studied in detail, one was considered a duplicate [JM], another a modern impostor [AS] and a third to have circumstantial corroboration for its antiquity [JQA]. Judgement was withheld pending further research in one case [TR] and, in another [TWW] accounts relating to two discrete sets of remains may have been conflated. Bones lacking provenance have, on dubious grounds, been assigned to some *cetacean* skeletons [ZT] [JB] [AJ] [USG] [BF] whereas the fates of legitimate elements were traced to their loss, destruction, or survival in a modern collection. The locations at Blair Drummond (56.159080° -4.074740°), Meiklewood (56.129601° -4.052318°), Stirling Shore (56.124508° -3.932551°), Cornton (56.143561° -3.945309°), Causewayhead (56.140160° -3.925944°; 56.137060° -3.919983°) and Airthrey (56.144265° -3.905784°), where *cetacean* remains are supposed to have been discovered [BF] [USG] [AJ] [JB] [TWW] [ZT], have also been established more accurately.

7.3. Testing Scientific Data from Historic Sources and Using the Sea-Level Curve to Make Retrospective Chronostratigraphic Inferences – Future Work.

A modicum of spatial, stratigraphic and elevation data can be extracted from 19th century literature, if the scientific conventions of that period are understood. In modern times, instrumental levelling of the carse and systematic coring of the "Buried Beaches" corroborate these older observations. This thesis derived stratigraphic reconstructions for six *"Whales"* from those archaic accounts [TWW] [BF] [USG] [JB] [AJ] [ZT] but also heavily adapted existing isostasy-eustasy research [BF] [ZT] [TWW] [USG]. Only one reconstruction could be tested in reality [JB] and the elevation of the carse and of the buried landscapes at Meiklewood, Blair Drummond, Airthrey and Causewayhead remain hypothetical. Validating those predictions through original geological fieldwork would be essential in any future research.

The veracity of these reconstructions matters. By relating them to the empirical timeline of sea-level change in the Forth Valley, 9.5 – 4.5ka cal BP (Smith et al. 2010), broad temporal limits can be imposed on the ages of some fossil *cetaceans* [TWW] [BF] [USG] [JB] [AJ] [ZT]. This was a novel use for a sea-level curve built on transgressive and regressive overlaps although, as expected, these retrospective chronostratigraphic inferences were imprecise. Many more *"Whales"* have associated stratigraphic data but no surviving bones to radiocarbon-date [JCC] [GRF] [HST] [HCH] [FDR] [BP] [LBJ] [JT] [MF] [WM] [MVB] and this methodology could not, by itself, determine their ages with certainty (unless the remains were revealed to be close to an overlap surface; [BF].) These sets of remains also lie progressively further eastwards in the Firth of Forth, where the empirical sea-level curve does not even extend. There are clear limits to this technique but, if only for its value in revealing and eliminating impostor bones [JB] [AS] [USG] [AER], stratigraphic reconstruction should not be dispensed with in future research.

7.4. Determining the Ages of *Cetacean* Bone by Radiocarbon Dating – Future Work.

This thesis reviewed, and expanded upon, the absolute dating evidence for the fossil *"Whales"* in the Forth Valley. The ages of seven *mysticete* bones, all allegedly found in the carse, have now been determined: here, five original bones were identified in museum collections and sampled for radiocarbon-dating (the rib 6309, atlas vertebra 19651.07, mandible AN2626, occipital NMSZ 1991.86 1, and rib fragment 19656.01). Smith et al.'s (2010) date for the lumbar vertebra (19651.03) was recalibrated in accordance with Riemer et al. (2020) and attribution of the rib (19654.03) to the *"Cornton Whale"* [JB] queried. Additionally, radiocarbon dates for the antler implement (X.HLA.3) and peat on the "Buried Beach" at Wood Lane (Smith et al. 2010) bear heavily when discussing the ages of the "*Meiklewood Whale*" [USG] and "*Blair Drummond Whale*" [BF].

Modern bones were suspected to have been mistaken for parts of ancient skeletons and elements from discrete assemblages could possibly have been mixed together. Unfortunately, these suspicions have now been substantiated. Any researcher in future must beware of remains from modern *cetaceans* which have brought into the Forth Valley in recent history (rib 6309 and [TR]; rib 19654.03 and [AS].) Additionally, neither that latter element nor the atlas vertebra (19651.07) belonged, as alleged, to the fossil *mysticetes* found at Cornton [JB] and Meiklewood [USG]: the absolute ages of the bones and stratigraphic reconstructions of those skeletons do not correspond. In mitigation, an element's provenance should be thoroughly investigated before future radiocarbon-dating. Contrasting that age against chronostratigraphy also insures against this palaeontological assemblage's defective textual record. This thesis did still fail to resolve all the issues it raised with the dating evidence of the *"Meiklewood Whale"* [USG], even in spite of these measures.

Nevertheless, four of these *cetacean* bones are ancient. Beyond having adequate documentary provenance, their ages fit the stratigraphic positions reconstructed for the *"Whales",* to which they allegedly belonged (mandible AN2626 and [AJ]; occipital NMSZ 1991.65 1 and [ZT]; rib fragment 19656.01 and [TWW]; lumbar vertebra 19651.03 and [USG].) The age of another fossil *cetacean* skeleton could be inferred indirectly [BF]: the absolute dating evidence from this sample shows no two *"Whales"* found in the carse are the same age, and that two thousand years separates the oldest from the youngest [AJ] [ZT]. Further radiocarbon dating could confirm that pattern. However, amongst all the remaining *cetacean* fossils reported during the 19th and early 20th centuries, relatively few are represented by bones in current museum collections [GRF] [JB] [DDE] [JEC]. This line of enquiry might not progress any further, unless provenance is established for stray bones (e.g. scapula 19654.02; [MVB]?) or new samples are recovered from the carse in modernity.

Within radiocarbon dating, *cetacean* (and namely *mysticete*) tissue presents unique methodological problems which make this palaeontological data even harder to interpret. These animals have not received attention recently in the radiocarbon community and, even then, their habitats, ecological roles and complex dietary behaviours were not appreciated fully. Major uncertainty could be sidestepped entirely if modern and ancient *mysticete* whales, native to the North Atlantic, could be proven as not subject to local marine reservoir effects. This problem awaits future research and robust data: until then, it compounds on all the existing contextual uncertainties. Did the bone belong to the *"Whale"* it is said to? Was that "*Whale*" really found, at the place and elevation that the reconstruction indicates? Is that stratigraphic position tightly or broadly delimited by the empirical sea-level curve? Do radiocarbon dates from bones of ancient North Atlantic *mysticete* whales require ΔR ^{14}C corrections, in any circumstances?

7.5 *Cetacean* Palaeontology and Preservation in Very Shallow Marine Environments - Future Work.

Anything could have explained why *mysticete* whale skeletons were preserved in the carse clay because, for this palaeontological assemblage, no chronological data existed. This thesis proposed to get that information by retrospective chronostratigraphic inference, radiocarbon-dating *cetacean* bones and, as validation, comparing both against the empirical sea-level curve for the Forth Valley (Smith et al. 2010). Now, the *"Whales"* fall into a temporal pattern which is inconsistent with a single episode of preservation and mass-mortality, or mass-mortality at random intervals. Some hypothetical agents of preservation (e.g. single deadly tidal wave) can be dismissed categorically.

A combination of continuous physical processes and consistent environmental factors most likely caused these *cetacean* remains to accumulate in the Firth of Forth, ten thousand years ago. Future research might identify what, exactly, those processes and factors were. Conditions for preservation may still be optimal in the modern Firth of Forth, and this thesis recommends actuotaphonomy (observing the decay or preservation of *cetacean* and *mysticete* remains in real time) as the least-speculative way, to understand the agents of preservation in the shallowest, inter-tidal environments. Further research on the microstratigraphy and geochemistry of the carse, especially on corings taken in the vicinity of undisturbed *cetacean* skeletons, may also provide new insights.

The *"Whales"* in the Forth Valley are now better integrated into *cetacean* palaeontology, and the implications of this are worth considering. In assessments of other assemblages, stratigraphic chronology has been an important if implicit element, serving as background to sedimentological or environmental interpretations. Although determined by necessity, this thesis put temporal data foremost and relied on it exclusively to analyse the *mysticete* remains in the carse. Palaeontological assemblages which have been compromised by defective recording or curatorial practices can still be studied, by taking this approach.

The Quaternary is neglected within *cetacean* palaeontology but, as this thesis shows (Fig. 1.1.2a - b), the quantity and the quality of remains is richer than supposed. Scotland's *"Whales"* are important representatives for this period and, particularly, for these shallowest marine environments. Other reserves of fossil *cetaceans* may have formed in estuaries during the Holocene, Pleistocene and preceding geological epochs. If these exist, and are better studied, then the assemblage of *mysticete* skeletons in the Firth of Forth will be easier to understand.

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8. APPENDICES

8.1. Appendix A: *Cetacean* Remains in Recent Geological Deposits (Great Britain).

8.1.1. Preamble.

The author of this thesis has compiled a record of the discovery of *cetacean* remains in British and Scottish geological deposits, during the 18th, 19th and 20th centuries. This was to provide context, for the record of discoveries of *cetacean* remains in the Firth of Forth and Valley of the Forth over the same period (Appendix B). The criteria for inclusion are generous: any bone or skeleton from any species of *cetacean,* found in an unlithified geological deposit from any epoch of the Quaternary, counts. Recent and unfossilised *cetacean* bones that have been cast ashore are taken as evidence for active and ongoing taphonomic processes, governing the preservation of *cetacean* remains. These cases also count. The aim is to determine the minimum possible number of individual *cetacans*, with the exception of "Irvine." (8.1.2.6.1 – 6.6). Here, the aim is to determine the minimum possible number of times, that *cetacean* remains have been discovered out of an eroding riverbank section.

The main criterion for disqualification (or non-inclusion) is evidence that human activity is solely responsible, for presevation of the *cetacean* remains. Any material from an unambiguous archaeological context (e.g. from a midden, from inside a house, worked *cetacean* bone) is omitted. Ambiguous cases are, generally, given the benefit of the doubt (e.g. the number of *E. glacialis* cervical vertebrae in the River Thames; or where a source has speculated, that bones have been thrown overboard etc). In some cases, human intervention is unambiguous (e.g. *mysticete* skeletons at Dungeness and an *odontocete* skeleton in the Tyne, evidencing butchery marks) but a physical process also proved critical to preservation of the animal remains (rapid movement of shingle, or siltation). These are rare, but are also counted. In Fig. 8.1.1, different colours and icons correspond to different tables. The number in the figure corresponds to the number on the table.

<u>8.1.2 Tables (Scotland).</u>

8.1.2.1 Highlands & Islands [1- 2] (2)
8.1.2.2 Moray Firth [3 – 15] (12)
8.1.2.3 Angus [1 – 4] (4)
8.1.2.4 Firth of Tay [1 – 5] (5)
8.1.2.5 Solway Firth [1 – 3] (3)
8.1.2.6 Clyde [1 – 4] (4)
8.1.2.7 Irvine Water [1 – 10] (10)

<u>8.1.3 Tables (England).</u>

8.1.3.1 Solway Firth to Land's End [1- 11] (11)
8.1.3.2 Lands End to Brighton [1 - 20] (20)
8.1.3.3 Kent & Thames [1 - 13] (13)
8.1.3.4 Norfolk and Suffolk [1 - 24] (24)
8.1.3.5 Cambridge Fens[1 - 11] (11)
8.1.3.6 Humber & Tyne[1 - 13] (13)

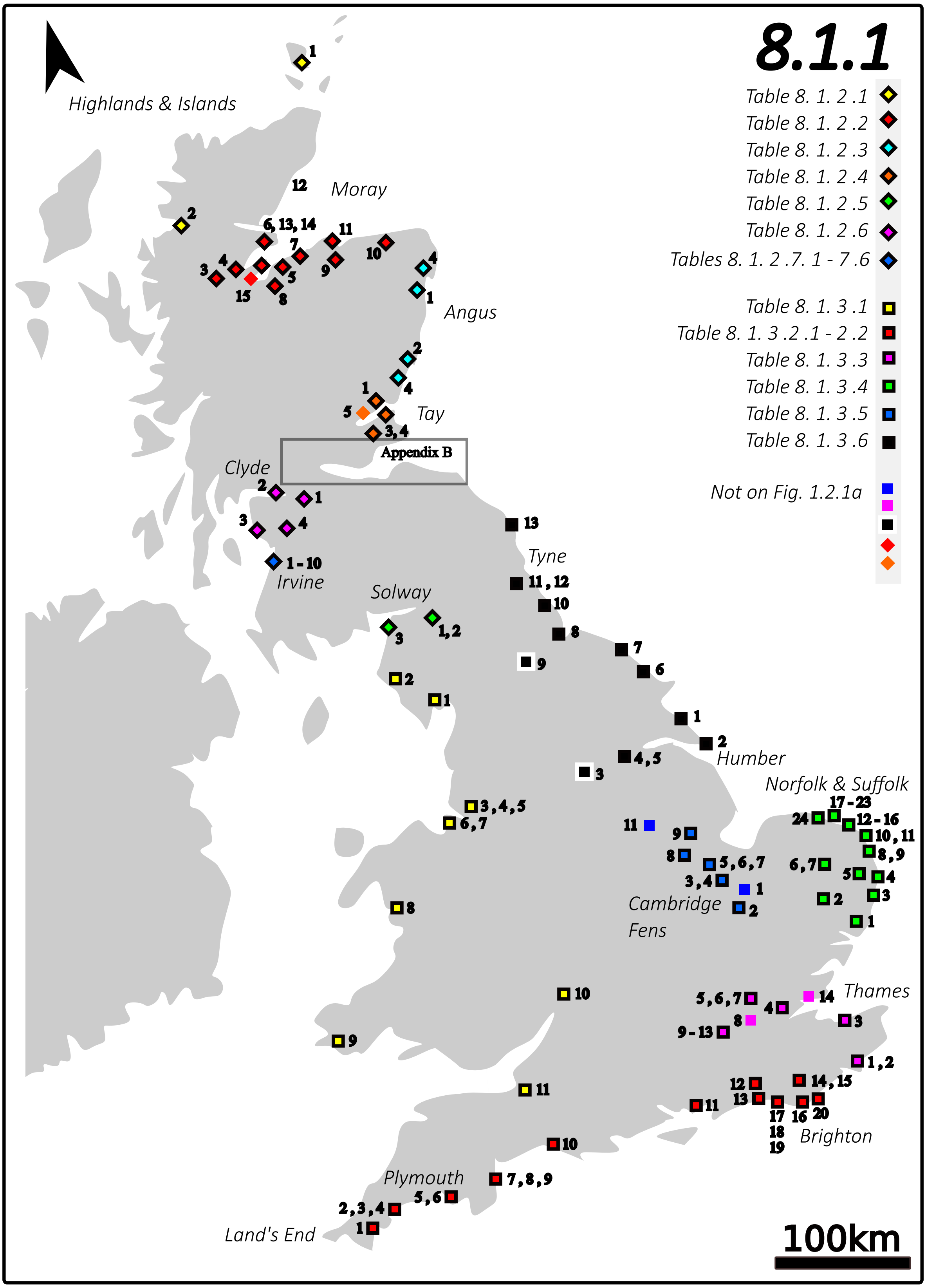

Fig. 8.1.8. British Isles: places where the bones and the skeletons of cetaceans have been disocvered in Pleistocene and Holocene geological deposits in the 19th, 19th and 20th centuries. Colours and icons correspond to tables, numbers to the entry in that table.

Table 8.1.2.1

Highlands & Islands (Scotland)

I.D.:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
1	Herman (1992 54)	1929	Achtilbuie, Ross and Cromarty.	58.00	-5.36	"From a porpoise which had recently been buried."	Skull (adult)	Phocoena phocoena (Linn).	NMS.	8.5.1929. Presented: G Callander.
2	John o' Groat Journal 17.2.1859 [¾]	N.A.	"In cutting a large ditch or out-fall through the valley of Binscarth ... [Orkney]."	59.76	-3.13	"I found [under 9' of recent moss and marl] in a gravel bed [of rounded and blackened boulders] the crown part of whale's head."	Skull or occipital ("crown part of whale's head.")	"Whale" (mysticete?)	*"you can see [the skull] still lying where taken up."*	*"Having received from Mr Cleghorn, of Wick, a series of questions as to the character of the so-called submerged forests in Orkney, I forwarded them to one of our country gentlemen, who has kindly furnished me we the following particulars of this interesting subject."*

Table 8.1.2.2

Moray (Scotland):

I.D.:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
3	Caledonian Mercury. 23.11.1818 [¾]	1818	"The Vale of Strathpeffer. … Some workmen, while digging lately in a piece of waste ground since brought into culture."	57.59	-4.53	[Found when digging.]	"One of the spinal vertebrae of an unknown animal, which measures no less than 10' (25cm) in diameter and 20' (50cm) in circumf."	Cetacean. (mysticete?)	N.A.	*"It has long been a favourite opinion among out northern geologists, that the vale of Strathpeffer, ... was at no very distant period, under the ocean. Its local situation, proximity to the sea, the nature of its soil, and the strata of oyster and cockle shells, seem to strengthen the conjecture, and a recent discovery renders it still less problematical …"*
4	MacKenzie (1826 105)	1821	On the property of Mr Mackenzie of Hilton, in Strathpeffer At a distance from HWL of about 3 m.	57.6	-4.48	"Found in a bed of blue clay [that] extends several miles up the valley. The height above the sea [at Dingwall] of the spot from which [the vertebra] was dug, is c. 12'. The bone was found in clearing out a drain."	"A vertebra … of some cetaceous animal. "It is probable more of the skeleton might have been found, had a search been made for it."	Cetacean. ("some cetacous animal.")	Sent to D Brewster.	*"MacKenzie of Hilton, Strathpeffer."* "Hilton" refers to the branch of the family and where it originated (the Barony of Hilton, c. Loch Fannich, Strathconon, Highlands), not to a location in Strathpfeffer (MacKenzie 1894 478). (See also MacKenzie 1810 81). The distance inland from Dingwall (3mi) is somewhere near Fodderty (57.60 -4.48°). There are Holocene RMDs there, but their height ASL is c. 40" (GE), not 12". Poss. Referring to same as Cal. Merc.

										(23.11.1818), Moray "3"?
5	The Scotsman. (4.3.1826) [3/8]	1825	Found last year, on the glebe of the Minister of Nairn.	57.58	-3.87	Found lying on a bed of gravel about 15' above the present **HWM**, and 6' beneath a bed of moss.	A vertebrae bone [sic] of a whale.	*Cetacean*. (mysticete?)	N.A.	6' OS Nairnshire 1 1871: "Glebe", c. "Kingillie Hou." Also OS Namebook Nairnshire 7 (1869 24). The location is c. 50" above ***mean average sea-level*** (GE.)
6	Aberdeen People's Journal. (15.3.1884) [⅝]	1884	Recenty, on the farm of Cubsie [sic] Easter Ross.	N.A.	N.A.	Found embedded in blue clay, about 3' from the surface. The discovery was made while drains were being cut.	The vertebra of a whale (weighing about 20lb.)	Cetacean. (mysticete?)	N.A.	"Cubsie" is unidentifiable. "Culisse", or "Cullisse", is a farm near the Cromarty Firth,(57.750913° -3.970837°).
	Invergordon Times & General Advertiser (12.3.1884) [¾]	1883	Recently, on the farm of Culisse [sic] Easter Ross.	57.75	-3.97	[As above.]	[As above.]			
7	Inverness Courier (1.5.1903) [6/8]	1903	Fished up in the Moray Firth, near the Old Bar.	57.65	-3.73	"Fished up" [i.e. on seabed.]	A large bone. The lumbar vertebrae, or what is commonly called the joint of the backbone, of a whale. From the size of the bone it is conjectured that the whale … was over 50" in length.	Cetacean (mysticete.)	N.A.	"Identified by Mr Taylor, Lhanbryde." (See Taylor 1910 244-5; 1913 211); Moray "9" and "10".
8	Taylor (1910 244 - 5)	1910	About ¼ of a mile from the present sea-shore, on a farm near Fort George. [Found] while a drain was being cut.	57.58	-4.04	Under 1-2' of moss, and 3' of firm blue clay.	A large block of bone. I went to see it, but owing to its rolled and worn condition I could not, at first, make it out. compared it with the united cervical bones of some *cetaceans*, and proved it to be the united 7 cervicals of a whale. All the neural spines and arches, and the transverse processes [are] entirely worn away.	It is the neck-bone of a *Balaena*, showing articulations for the condyles of the skull distinctly … the neck-bone of *Balaena mysticetus* is much broader across the articulating surface. … I have no doubt now the Fort George bone belongs to *Balaena biscayensis.* [I.e. N Atlantic Right Whale. Now, *Eubalaena glacialis.*]	N.A.	"*Taylor*." See Moray "8" and Moray "10".

							It measures 12' (30cm) across the articulating surface now, but may have been an inch or two more before it was worn. The length of the cervicals is only 7' (15cm) long.			
9	Taylor (1913 211)	1913	Found in the river Lossie, at Old Mills, Elgin.	57.64	-3.33	Found in the river Lossie, at Old Mills, Elgin. As Elgin is about 5mi from the sea, and the River Lossie at this point 50' ASL, the bone must be very old. It was probably washed out of the post-glacial sand which covers the valley at Old Mills.	A bone [vertebra]. imperfect, water-worn, and slightly mineralised. The greatest height of the bones was about 9' (22cm) and the greatest breadth, at the transverse process, about 14' (35cm.)	A thin, broken process on the lower edge projected backwards nearly ½' … this process has been observed by Flower and Turner in the Atlas of Rudolphi's Rorqual (*Balaenoptera borealis*, or Sei Whale.)	N.A.	Found by James Farquhar, when working in the river Lossie. "The only species of Rorqual common on our Moray Firth shores at present are the Common Rorqual (Fin Whale? B. physalus) and the Lesser Rorqual (Minke Whale? B acutorostrata.) *"[Identified], with the help of Sir William Turner's books..."* "*Taylor*." See Moray "8" and Moray "9".
10	Smiles (1877 365 – 372.)	1822	(366) When a mill-dam was being enlarged at Inverichny, near Banff …	57.63	-2.51	(366) When a mill-dam was being enlarged at Inverichny, near Banff, one of the workmen came upon a dark-looking object embedded in the bank amongst the clay and shingle, 6" from the surface.	(365) "One of the most interesting [fragments of antiquity] collected in the museum [Banff Institution] was the joint-bone of some extinct animal." [Edward Smiles] took a photograph of the bone, and sent it to a scientific correspondent in London. He had the pleasure of being informed there was no doubt whatever that bone was one of the femurs [sic] of the fore-paddle of the Plesiosaurus.	One of the femurs [sic] of the fore-paddle of the Plesiosaurus. (Smiles 1877 369) for photograph. It is very unlikely that a phalange bone of Mesozoic dinosaur would be preserved in a Scottish Quaternary the deposit. It is more likely to have belonged to a *mysticete* cetacean.	In the collections of the Banff Instutition (now defunct.)	Thomas Edwards (1814 – 1886), self-taught naturalist and keeper of museum at the Banff Institution. Per Smiles (1877 365 – 372) Edwards spent his entire life trying to identify this bone.
	Cramond (1891 377.)	1822	Found in digging a mill-dam at Inverichnie in 1822 (Cramond 1891 377)			N.A.	The bone of one of the forepaddles of the Plesiosaurus dolichodeirus, found in digging a mill-dam at Inverichnie in 1822 (Cramond 1891 377)	The bone of one of the forepaddles of the *Plesiosaurus dolichodeirus.*	In the collections of the Banff Instutition (now defunct.)	

11	Elgin Courant & Morayshire Advertiser (8.2.1856) [5/8]	1856	The following donations to the Museum [Elgin] were announced: vertebra of a whale, brought up with a fishing line at Lossiemouth	57.72	-3.28	brought up with a fishing line [on the seabed.]	Vertebra of a whale.	*Cetacean* (mysticete?)	In the collections of the Elgin Museum (1856).	Presented by Provost Grant, Elgin.
12	Redman (2004 282)	N.A.	There is part of a skull outside the door of Latheronwheel Mains.	58.27	-3.4	It [the skull] was found in a field on the farm.	Part of a skull … It is 4' 6" long.	*Cetacean* (mysticete?)	At Latheronwheel Mains (2004).	There are no raised marine deposits and few alluvial deposits near Latheron.
13	*Ledger of the Hunterian Museum, University of Glasgow: 5794.*	1945	Farm of Bindal, Easter Ross. Less than 50' from farm-house. Under an alder tree: Found when erecting a steading. [NH 930 848]	57.85	-3.79	10" - 15" UGL. Sandy soil.	[Not described.]	*B acutorostrata.*	In the Hunterian collections (2021).	Collected 1965.
	Redman (2004 280)	1945	At Bindal.			100' raised beach.	occipital region of a whale's skull, 52.6cm in length 41.2cm breadth. Very greatly abraded, especially on the marginal and protruding regions of the skull.	N.A.	In the Hunterian collections (2021).	" 100' Raised Beach". Archaic term, referring to Pleistocene raised marine deposits in Scotland.

14	Anon. (1845 23.)	N.A.	At Fearn, hich is 2mi distant from the present shores of either frith [sic; Dornoch and Cromarty]	55.93	-4.61	The parish [Nigg] must at one time have been an island. Throughout the whole extent of the neck of land betwixt the Cromarty bay to the W, and the village of Shandwick to the E, the substratum contains a layer of shells and shingle.	At Fearn, which is 2mi distant from the present shores of either frith, The skeleton of a cetaceous animal has been found.	Cetacean.	N.A.	New Statistical Account for the Parish of Nigg: Geology.
15	The Scotsman (2.1.1934) [11/14]	1934	In the Museum at Inverness there is a desiccated skull. It was handed in by someone who found it in a bog or moss locality.	57.58	-4.25	The curator says it was handed in by someone who found it in a bog or moss.	A desiccated skull. It is definitely reptilian. It resembles else the skull of a saurian of the Nile species, but it is certainly not of an existing species.	N.A.	In the museum at Inverness.	*"It may prove to have nothing to do with the Loch Ness inhabitant, but if it did, it would be of real scientific interest."* Scottish media were preoccupied by the Loch Ness Monster in the 1930s and stories involving sightings were front-page articles.
	The Scotsman (4.1.1934) [11/14]	N.A.	The skull had been taken to the Museum by a lady from the Black Isle, Ross-shire, for identification.			N.A.	The skull had been submitted to experts, and was declared to be that of a whale.	Cetacean (mysicete?)	N.A.	[Moray 16] is not counted. It is unlikely to have entered its stated stratigraphic context ("peat") without a human agent.

Table 8.1.2.3

Angus (Scotland).

I.D.:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
1	Aberdeen Herald and General	1854	It was found amongst some new	57.12	-2.17	N.A.	It is round in shape, measures about 1yd (90cm) in circumf.,	Cetacean (mysticete?)	N.A.	Presently there is on our table an article about which we know not well what to say. It was brought to out office … the

	Advertiser . (12.8.1854) [⅝]		trenched land at Cults.				and approaches 1' (30cm) in diameter. About a dozen individuals .. tell us the thing is part of the vertebra of an enormous whale.			owner describes it as being a petrified cheese, and holds that certain openings or punctures in it are mouse holes …
2	Montrose, Arbroath & Brechin Review; Forfar and Kincardineshire Advertiser. (29.9. 1916)	1916	At Lunan Bay.	56.64	-2.50	From its fossilised condition it is thought to have been embedded in the sand for many hundreds of years.	The vertebra of a whale or other mammal. … [it] weighs about 10lbs, is 9' (22cm) in length, 1" 9' (50cm) in circumf., and 6' by 8' (15cm - 20cm) in diameter.	Cetacean (mysticete?)	N.A.	
3	Dundee Courier 22.2.1936 [8/12]	1936	At the rear of the premises of Carnegie, Soutar & Sons Ltd, bakers, High Street, Arbroath.	56.55	-2.58	The bones were found at a depth of 7', on the surface of what appeared to be traces of an old sea-beach.	A portion of a skeleton of a whale. The bones are parts of the vertebrae. It is not considered, however, that the bones are fossilised remains. There are no evidences of other parts of the skeleton.	*Cetacean.*	N.A.	"The theory has been advanced that the bones are parts of the vertebrae brought home by an old time whaler as curios, and later disposed of by being buried in the garden."
4	Redman (2004 239)	1992	At Ardiffery Croft, near Hatton. … They were found on Ardiffery Lands.	57.41	-1.90	found on Ardiffery Lands.	Ribs. One measured 7' long, the other was shorter.	*Cetacean.*	N.A.	Source is a "Peter Tarves." There are some areas of alluvium/RMD near to Mains of Ardiffery / Ardiffery Croft.

Table 8.1.2.4										
Tay (Scotland).										
I.D.:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
1	Headrick (1813); Apx. Don (1813 39.)	1813	I observed to the east of Dundee ...	56.46	-2.89	N.A.	Of the order Cete, we occasionally find the following [in the County of Forfar:] A skeleton of this species [*Balaena physalus*; the fin-fish.]	*Balaena physalus*; the fin-fish. (mysticete).	N.A.	Don (1813) distinguishes *"Balaena mysticetus"*, the "common whale" from *Balaena physalus"*, the fin-fish. In Harvie-Brown (1906 31) *Balaenoptera musculus* (L). Common Rorqual. "*Don records, under the synonym* Balaena physalus, *having found the skeleton of one of this species* "to the E of Dundee" *about 2 years prior to the date of his writing (say 1811).*
2	Kettle (1796)	1796	Sheughy-dyke [sic] or Tentsmuirs, is a very large flat area of the district.	56.40	-2.84	When these moors have been opened by digging, there has been found a great variety of shells and fish-bones [sic] . It seems that the aged and storm-struck inhabitants of the ocean being washed ashore, obtained a grave by the next tide covering them with sand.	"Fish bones ..."	Cetacean.	N.A.	*"Fish"*. Common and archaic way to describe *cetaceans*, in this period (e.g. Milne Home 1847.) OSA for Leuchars.
3	Page (1859 103 - 104)	N.A	There are ancient sea-margins in the valley of the Eden. ... at 20', 40', 60', 90', 150', and 200'.	56.29	-3.05	The lowest (20') yields shells of the existing shores and overlies a well-marked submerged forest. The second (40') contains bones of the whales, and several shells of boreal species.	Bones of the whales.	Cetacean (mysticete?)	N.A.	In the Howe of Fife, Devensian RMDs are found as far inland as Ladybank, c. 150' (45m) ASL. The majority are around Cupar, c. 80-90' (25m – 27.5m ASL.) The lowest terraces (20', 40') are the Holocene.The 200' terrace (60m ASL) is not a legitimate marine landform.. Page (1859) generalises. No event, in which *cetacean* remains were discovered in the Howe of Fife, is known.
4	Page (1859 103 - 104)	N.A.	There are ancient sea-margins in the valley of the Eden. ... at 20', 40',	56.29	-3.05	The third and forth (60' and 90') rarely contain remains, and the forth [sic; 90'] bones of whales and the [skeleton of a seal now in question.]	Bones of the whales.	Cetacean (mysticete?)	N.A.	In the Howe of Fife, Devensian RMDs are found as far inland as Ladybank, c. 150' (45m) ASL. The majority are around Cupar, c. 80-90' (25m – 27.5m ASL.) The lowest terraces (20', 40') are the Holocene.The 200' terrace (60m

			60', 90', 150', and 200'.							ASL) is not a legitimate marine landform.. Page (1859) generalises. No event, in which *cetacean* remains were discovered in the Howe of Fife, is known.
5	Graham (1812 35)	N.A.	In the Carse of Gowrie.	56.39	-3.2	A stratum of peat moss is found 19' below the surface, full of the roots of large trees, deer's horns, and large bones (all probably antediluvian.)	large bones (all probably antediluvian.)	N.A.	N.A.	Graham (1812 35) is not specific enough about the type of bones, and the animals to which they may have belonged.

Table 8.1.2.5

Solway (Scotland & England).

I.D:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
1	Turner (1885 333 – 8)	1883	Silloth, Cumbria: site of the new dock (Miller 1885 342.)	54.86	-3.39	On shingle w/seashells overlying boulder clay. 28' UGL, 16' BHW 450yd inland.	1 caudal vertebra. “The spine and transverse processes were so broken that the full dimensions could not be taken. [body – c. 5' (12cm) diam.]	Finner whale – B musculus (now Fin Whale, B physalus.)	N.A.	
2	Turner (1885 333 – 8)	1885	Silloth, Cumbria: site of the new dock (Miller 1885 342.)	54.86	-3.39	On shingle w/seashells overlying boulder clay. 28' UGL, 16' BHW 450yd inland.	1 lumbar vertebra. The ends of the processes were broken off and the been had the appearance of having been rolled. [body – height c. 10' (25cm), between processes 11' (27cm.)]	From one of the toothed whales: probably a *globiocephalus* [archaic; long-finned pilot whale, *Globicephalus melas.*]	N.A.	
3	McPherson & Ferguson (1892 xlix 49)	1990	In the summer of 1889, in a back yard in Caldewgate, Carlisle...	54.89	-2.94	Unexpectedly disinterred in a back-yard.	An entire skeleton of this animal [*Globicephalus melas]* was discovered. When I hurreid to the spot, I found the skeleton	*Globicephalus melas.* [long-finned pilot whale.]	N.A.	"*There can be no reasonable doubt that this animal must have been taken in the waters of the English Solway, but at what period, no man can decide..*" Caldewgate is built on alluvium. It is possible this animal died, and was

							broken up. The cranium was not much injured …			preserved naturally there.

Table 8.1.2.6

Clyde (Scotland)

I.D.:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
1	Caledonian Mercury (24.5.1855) ¾	1866	Dredged from the bed of the river Clyde by one of the machines ... On the south side of the River Clyde, a short distance above Erskine.	55.90	-4.44	In the bed [of the river Clyde]	The bone is manifestly the vertebra of a whale. It appears to be one of the dorsal vertebrae from near the middle of the back. From the size of the bone, as compared with those of skeletons I have seen, I am inclined to think that it has belonged to a whale of from 35' to 40' in length.	From the worn state of the bone I could not determine whether it has belonged to the Greenland whale or the Finner or Rorqual.	N.A.	“The bone evidently belonged to an animal much exceeding in size any of those which have frequented the shore or stream during this era … the occurrence of this bone so far up the Clyde is interesting.” Referred to in Appendix to Smith J (1862 176) *Researches in Post-Tertiary Geology...* : Buchanan J *Ancient Canoes found at Glasgow.*
2	Bishop (1879 12 2 - 133)	1879	Dredged from the Clyde in the deepening operations. ... below Bowling, Finlayston Bank.	55.93	-4.61	14' below low water.	Portions of the vertebrae and caudal bones of a whale.	Portions of the vertebrae and caudal bones of a whale.	N.A.	“Bones of the whale … being only the second or third example from the West Coast.”
3	Redman N (2004 254)	1988	Dug up during major sewage works [at] Ardeer, near Stevenson	55.63	-4.74	N.A.	slightly damaged vertebra.	Cetacean.	N.A.	
4	Anon. (1831 535)	1819 (?)	Found in sinking a coal pit in Ayrshire.	55.44	-4.62	The scapula of a whale.	Scapula	Whale (mysticete?)	Royal Society of Edinburgh(?)	*"List of presents [to the Roy. Soc. Ed.]"* Donor: Thomas Allan Esq. Presum. Thomas Allan 1777-1833? Per Caddell (1820 (2) 419) *“The scapula of a whale was found, in 1819, in Ayrshire, in sinking a coal pit.”* Howev. Information about the Airthey whale in the same source: *“The skeleton of a whale 40' in length was found, in 1819, near Stirling, 20' above the level of the sea.”* is inaccurate on several points. Co-ordinates are arbitrary.

Table 8.1.2.7.1

Clyde – River Irvine [1, 2 - 3] (Scotland)

I.D:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
1	Irvine Herald (15.1.1877)	1781.	*part of the skeleton of [the whale] which was first found at Warrix about 1781 ..."*	55.6	-4.65	N.A.	Part of the skeleton of [a whale.	A whale [mysticete?]	N.A.	N.A.
	Kilmarnock Standard 10.12.1892 [Landsborough, Pt 3]	1769 [R. Irvine changes course.] 1790 [Currie]	After a great fall of rain [in 1869] the Irvine Water cut a new channel through the sand-hills. Previously, its course had been a tortuous one, having the farms of Warrix and New Mill on the outside, and that of Tanyholm on the other. about this time [1790', Mr Andrew Currie discovered some very large bones on the banks of the river at the new channel.			[In] the banks of the river at the new channel [R. Ivine].	Some very large bones.	[the bones] were seen and examined by many scientific persons, and were pronounced by them to be the bones of a whale. [mysticete?]	[Currie] took the bones to his ropework, where they hung for half-a-century. Here they were seen and examined by many scientific persons, and were pronounced by them to be the bones of a whale. I [ex-Provost] was acquainted with Andrew Currie, a grandson of the discoverer, and have often seen them. About 50 years ago the Curries went to Glasgow. One of the family wrote to my father offering to sell to him the remains. My father did not purchase, and what became of [the bones] I never learned.	Kilmarnock Standard (26.11.1892.) [5/8] Kilmarnock Standard (3.12.1892.) [6/8] Kilmarnock Standard (10.12.1892.) [6/8] *Discovery of Whale Remains on Irvine River Bank.* [Parts 1 – 3]. *"I [Landsborough] am still receiving additional information regarding the Irvine whale. My class-fellow at Irvine Academy, the ex-Provost of that town, writes …"* *"Previously, its [R. Irvine] course had been a tortuous one, having the farms of Warrix and New Mill on the outside, and that of Tanyholm on the other."* [Compare Roy Lowlands (1755) w/ 6' OS 1860, Ayrshire Sheet 17. The boundary between Dreghorn and Dundonald parishes is still on this alignment (c. 55.609129° -4.652683° to 55.600843° -4.653814°.)
	Smith (1895 356.)	1790	At the great bend in the River at Shewalton Moor, a mile above Irvine Town Bridge, is the finest of all sections. … on the south and west side of the river, about 400yd in length, and undergoing rapid denudation. Every flood in the river exposes a fresh face.			Irvine Whale Bed, 24' UGL.	Whale remains ... Discovered by Andrew Currie, rope-spinner, in 1790; [According to a former Provost of Irvine; who told this to Rev. David Landsborough; who wrote it in Kimarnock Standard 11.1892]	Whale remains ... [mysticete?]	N.A.	Smith (1895) includes a section of Irvine-Shewalton. The "Whale Bed" is a c. 3' thick deposit of "dark sand." *Cited in Turner (1912 3)*
2	Daily Review (Edin.) 17.3.1863 3/10	1863	1 mile from the present sea margin.	55.6	-4.65	Beneath blown sand. ... Several feet above the level of high water.	An enormous bone. ... the posterior portion of the skull of a whale. *Ex pede Herculem,* it is certain that the whale was probably 70' long. For many years, bones of an unknown animal, more gigantic than any land animal have been	Whale (mysticete.)	N.A.	"Hugh Miller supposes that the upheaval that took place was sudden, so that this huge animal may have been only one of many that were left stranded by the rapidly receding tide. The whale tribe seems markedly deficient in sagacity, and is the most likely of marine animals to have suffered in such a catastrophe." [The paper of book by Hugh Miller is not known.]

2							found in the same locality. It is probable much of the skeleton is lost.			
	Crosskey 1863 243 - 246	1863	Following the Irvine Water about 2 mi from the sea, we reach a fine section of clay and sand cut out by a curve of the stream.			[VI.] The fine sand [V] is broken by a 2nd shell bed, nearly 2' in depth. [V.] Fine sand "of the district." (to the surface). [IVb]. "1st Great shell bed" (20' from surface) [IVa.] 2 -3' Peat. [III.] "A vast gap" [CK expects the "Clyde Beds", containing boreal marine shells.] [II.] A few feet of ferruginous gravel (occas.) [I.] Base of the section – boulder clay. ____________ In the "fine sand", 14' from the surface, and about 4' above the level of the stream, Mr Hugh Jack observed a large bone.	Photographs of the [large bone, measuring 6' across] have been kindly examined by Professor Allen Thomson, and declared to be a considerable portion of the occipital bone … of a cetacean. Upon visiting the section, I was fortunate enough to extract another specimen of apparently the same animal, and now exhibit the bone from its left ear.	Whale (mysticete.)	N.A.	*"I [Crosskey] now exhibit the bone from its left ear."* See Hunterian Catalogue 5674: R Tympanic bulla. *"Shortly after its [the occipital, V560] being discovered, Rev Mr C* [Crosskey] *visited the spot and found a pair of earbones."*
	Sutherland 1869 127	N.A.	1 mile inland, at a place called the Water Meetings, where the River Irvine exposes a considerable part of the raised beach, no fewer than four beds of shells may be seen. Bones of a huge whale were dug up in this spot.			N.A.	Bones of a huge whale (*Balaeus mysticetus*) [sic], which must have measured, judging from the size of the occiput, c. 70" in length.	Mysticete (*Balaena mysticetus?)*	N.A.	
	Kilmarnock Standard (26.11.1892) [5/8] [Landsborough, Pt 1].	1863	Found in the bank of the Irvine River, in Lord Glasgow's property.			Found in the bank of the Irvine River.	Part of the bones of the head of a whale.	Whale.	Mr Hogg, late of Riccarton, now of Irvine Academy, made enquiries lately. He had been told [the head[was to be seen at the gamekeeper's. He learned that, before the departure of	Kilmarnock Standard (26.11.1892.) [5/8] Kilmarnock Standard (3.12.1892.) [6/8] Kilmarnock Standard (10.12.1892.) [6/8] *Discovery of Whale Remains on Irvine River Bank,* by D Landsborough. [Parts 1 – 3].

2									Lord Glasgow for the Governorship of New Zealand, he had presented the remains to the Glasgow University Museum [Hunterian.]	
	Kilmarnock Standard (3.12.1892.) [6/8] Landsborou gh, Pt. 2.]	c. 1863 (“nearly 30 years since the bones were found.”) c. 1878 (Menzies' Rib.) c 1885 (“About 7 years ago the bones were present d to the Museum.)	Dr Alexander: [The bones] were on the S side [of the R. Irvine] about 1mi above the bridge which connects Irvine with the “Half Way.”			N.A.	I [Dr Alexander] saw the bones after they were moved to Mr Jack's, at Old Hall. They consisted of part of the post-occipital bones of the head of a whale. ___________________ Menzies: The bones of the whale were found by Hugh Jack Oldhall. By order of the late Patrick Boyle, Esq., these were sent to Shewalton, and were about 7 years ago presented to the Museum of Glasgow University. It was these bones that were seen by Mr Borland at Oldhall in 1863. In addition them I [Menzies] myself found, about the year 1878, and near the same spot, a rib 10' ½ long and 5" in diameter. It was sent to the University along with the others.	Whale.		Kilmarnock Standard (26.11.1892.) [5/8] Kilmarnock Standard (3.12.1892.) [6/8] Kilmarnock Standard (10.12.1892.) [6/8] *Discovery of Whale Remains on Irvine River Bank,* by D Landsborough. [Parts 1 – 3]. “Regarding these finds [of whale bones] I [Landsborough[have received the following information. Dr Alexander, Dundonald writes … [and] referred me to Mr Menzies, formerly gardener at Shewalton, now at Kelburn. He writes … Who is Borland?
	Smith (1895 356)	1863	At the head of the “Great Bend" [R. Irvine.]			“Irvine Whale Bed.” 24' UGL	Part of a whale's skull.	Whale.	I remember going with a number of other lads to see it. It is now in the Hunterian Museum, Glasgow.	
	Boyd Watt (1902 193)	1889	A Post-Tertiary deposit near the mouth of the River Irvine, bears the name of the Irvine Whale Bed, Cetacean remains have been found here …			“Irvine Whale Bed."	A skull, obtained in 1863, and another one and some ribs and vertebrae, obtained in 1889, are in the Hunterian Museum.	Whale	In the Hunterian Museum.	“A Post Tertiary deposit near the mouth of the River Irvine bear the name of the Irvine Whale Beds. A skull, obtained in 1863, and another one and some ribs and vertebrae, obtained in 1889, are in the Hunterian Museum.” _____________________ There is no toher reference to a discovery at Irvine in 1889, nor to remains discovered in 1889 in the Hunterian Ledger / Gregory & Currie (1928). 1889 is the year, that Capt. Boyle of Shewalton donated his collections of

2										cetacean bones from c. River Irvine to the Hunterian. The skull, found in 1863, was part of this collection, as was a rib. Boyd Watt is assumed to be mistaken – there were not discrete discoveries in 1863 and 1889. Material, discovered between 1863 and 1889, were donated to the Hunterian in 1889.
	Gregory & Currie (1928 13)	N.A.	From 40' Raised Beach on banks of the Irvine Water, Ayrshire.			From 40' Raised Beach on banks of the Irvine Water, Ayrshire.	13. Balaena Biscayensis. From 40" raised beach on banks of the Irvine Water, Ayrshire. V. 5670. Occipital Bone, max breadth 4" 10'. Presented by Capt. Boyle, 1889. V. 5671. A rib. 9' 3" in the curve, length of chord of are 6' 9". Presented by Capt. Boyle, 1889.	Balaena Biscayensis. (now. E glacialis.)	In the Hunterian Museum.	"40' Raised Beach." Archaic: but usually refers to the Pleistocene marine beds in the Clyde ("Or Clyde Beds"), that accumulated in the Windermere Interstadial. Based on Crosskey's (1863) description of the stratigraphy, the occipital was not found in a higher (and younger) deposit.
	Ledger Hunterian Museum 5670 - 5683	N.A.	On the banks of the Irvine Water.			On the banks of the Irvine Water.	5670. Occipital bone. *Balaena Biscayensis. Pres. By the Hon. Captain Boyle 1889.* 5673. R Tymp. Bulla. *Coll. H W Crosskey.* 1 rib.	Balaena Biscayensis. (now. E glacialis.)	In the Hunterian Museum.	Whether the skull found by Hugh Jack in 1863, tympanic bone discovered by Crosskey in 1863, and rib discovered by Menzies in 1878 really all belonged to one single *mysticete,* is not certain
3	Gregory & Currie (1928 13)	N.A.	From 40' Raised Beach on banks of the Irvine Water, Ayrshire.	55.6	-4.65	From 40' Raised Beach on banks of the Irvine Water, Ayrshire.	V. 5772. L humerus. Max length 2" 3'. Presented by Capt. Boyle, 1889.	N.A.	N.A.	
	Ledger Hunterian Museum 5670 - 5683	N.A.	From 40' Raised Beach on banks of the Irvine Water, Ayrshire.			From 40' Raised Beach on banks of the Irvine Water, Ayrshire.	Left humerus.	N.A.	N.A.	Whether the skull found by Hugh Jack in 1863, tympanic bone discovered by Crosskey in 1863, and rib discovered by Menzies in 1878 really all belonged to one single *mysticete,* is not certain There is no record of when/where this humeras was discovered (although presum. It was also at Shewalton.)

Table 8.1.2.7.2

Clyde – River Irvine [4 – 5] (Scotland)

I.D:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
4	*Irvine Times* (24.12.1886) [4/8]	1868 (“18 years ago”)	About 1mi above Irvine. [In the same place as Irvine Cetacean "5".]	55.6	-4.65	Embedded in mud, by the side of the river [irvine].	The illium, or hip bone.	There is a suggestion by Mr Kirsop of Glasgow, that the remains are those of a whale.	Now in the possession of Captain Boyle of Shewalton.	[The discovery of a *cetacean* vertebra in 1886 (see Irvine "5") prompted this retrospective report, of the discovery of an "ilium." Some *mysticete* species have a vestigial pelvis.] [Not among the bones donated by Boyle, to the Hunterian, in 1889.]
5	*Irvine Times* (24.12.1886) [4/8]	1886 ("A few days ago.)	About 1mi above Irvine.	55.6	-4.65	Embedded in mud, by the side of the river [irvine].	a vertebra, about 28lb in weight, with one and two transverse processes, the latter measuring 28" (2' .3") from tip to tip.	Mr William Mitchell, Schoolmaster, Irvine, has pronounced the find to be a section of the vertebrae of a plesiosaurus, one of the largest animal of the Lias subdivision, Jurassic period. There is a suggestion by Mr Kirsop of Glasgow, that the remains are those of a whale.	N.A.	"Mr William Mitchell, Schoolmaster, Irvine, has pronounced the find to be a section of the vertebrae of a plesiosaurus … [he] has been in communication with Mr Cochran-Patrick, Secretary of the Ayrshire Archaeological Society, and that gentleman intends to write to Capt. Boyle for leave to recover the remainder of the skeleton."
	Kilmarnock Standard (3.12.1892.) [6/8] Landsborough, Pt. 2.]	c. 1882 - 5 (Menzies: “About 10 years ago,”) Found in the Winter of 1858 (Hogg, talking of Mitchell, talking of the “Old Man.”)	[The vertebra] was found in the winter of 1858, by an old man, at the same place as the other [vertebrae]. [sic. Presum: at Irvine Bend?]			[The vertebra] was found in the winter of 1858, by an old man, at the same place as the other [vertebra]. [sic. Presum: at Irvine Bend, in the "Whale Bed"?]	[The vertebra] was found in the winter of 1858, by an old man, at the same place as the others. [sic. Presum: at Irvine Bend?]	About 10 years ago, some joints of a backbone were found. I did not see them, but I [Menzies] know that Mr Mitchell, teacher, Irvine, got one of them. I [Hogg] called on Mr Mitchell, who showed me the vertebra in his possession. Including the processes, the bones is 2” 8' in breadth by 2” 4' in length... 8' in thickness.	[Hogg]: The appearance of the bone stuck [the old man]. He took it home and deposited it in his hen house, where Mr Mitchell found it. Mr Mitchell informed Lord Glasgow, who intimated his intention of having a thorough examination of the ground within his property, but [was] never executed. t I [Menzies] know that Mr Mitchell, teacher, Irvine, got one of them.	Kilmarnock Standard (26.11.1892.) [5/8] Kilmarnock Standard (3.12.1892.) [6/8] Kilmarnock Standard (10.12.1892.) [6/8] *Discovery of Whale Remains on Irvine River Bank,* by D Landsborough. [Parts 1 – 3]. “Regarding these finds [of whale bones] I have received the following information. Dr Alexander, Dundonald writes … [and] referred me to Mr Menzies, formerly gardener at Shewalton, now at Kelburn. He writes … [and] Mr Hogg, teacher, Irvine Academy, has also favoured me with a note. He writes … The “old man” discovers [a] vertebra in 1858. Mitchell's finds that bone in the old man's henhouse, c. 1882; and goes to the place where it was found, collecting another and issuing a notice in 1886.In 1892, this story is told, again, to Landsborough (via Hogg.)

Table 8.1.2.7.3										
Clyde – River Irvine [6] (Scotland)										
I.D:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
6	Kilmarnock Standard 26.11.1892. [5/8] [Landsborough Pt. 1.]	1892	"Mr Joseph Downs, taking a turn along the banks of the River [Irvine] after a flood... "	55.6	-4.65	*Surroundings*: The remains of the Whale rested on a bed of shingle stones and gravel, amongst which was an abundance of shells. These were all such as is found on the beach at the present time. Immediately beneath the remains was a layer of dark-brown, peaty-looking matter, from ½' to 2' in thickness. Among it are a few hazel nuts, hazel twigs, impressions of sedges … This peaty stratum is of some extent. It is about 3' above the average height of the surface of the river.	[Joseph Downs] discovered, partially laid bare, an enormous bone. … It was all right, save that a passing cow had trodden upon it, sending its hoof through part of the bone. … *A Description.* The remains consist of a great bone: 3" 8' across, 2" 8' in length, and more than 2" in thickness. Towards the lower extremity there is a rounded aperture 5' in width. This was for the spinal cord. until the cow, the upper part of it was unbroken. Both jaw bones are present. These are of enormous strength, being 18' in girth (45cm) and 32' in length (81cm.) One of them is entire, the other nearly so.	We believe it may be safely concluded from the appearance of the head and jaws that the whale was of the "Baleen" Order.	This wonderful example ought undoubtedly to be deposited in the Kilmarnock Museum.	Kilmarnock Standard (26.11.1892.) [5/8] Kilmarnock Standard (3.12.1892.) [6/8] Kilmarnock Standard (10.12.1892.) [6/8] *Discovery of Whale Remains on Irvine River Bank,* by D Landsborough. [Parts 1 – 3]. Mr Smith, Kilwinning, visited the spot and was so fortunate as to find near to it a large thin circular plate of bone. [Irvine "7".]
	Kilmarnock Standard 3.12.1892. [6/8] [Landsborough Pt 2.]	1892	The bed of the river, at the spot where [the whale bones] were discovered (a mile as the crow flies, from the main street [from Irvine to the Railway Station], and the same distance from the sea), is about 25' above sea-level. .			N.A.	N.A.	N.A.	*Request for the Whale Remains.* Sir William Turner has written a very courteous letter, and makes the request that those [cetacean] remains recently got at Irvine should be deposited in the museum at Edinburgh – at least until provision has been made for them at Kilmarnock by the erection of a museum.	Kilmarnock Standard (26.11.1892.) [5/8] Kilmarnock Standard (3.12.1892.) [6/8] Kilmarnock Standard (10.12.1892.) [6/8] *Discovery of Whale Remains on Irvine River Bank,* by D Landsborough. [Parts 1 – 3].
	Anon. (1896 117)	1892	In the sand-hills near Irvine.			Beds of marine shells extend to the banks of the River Irvine … Mr Downs, Irvine, discovered the remains of a whale in the neighbourhood of these beds.	Remains of a whale.			About a hundred species have been gathered [from the shell beds by Mr Smith and by Mr Downs, Irvine.] (Anon 1896 117.) Report on an excursion to Troon on 5.9.189, by Gla. Nat. Hist. Soc. Publication in 1896, but the excursion is in 1893.
	Smith (1895 356)	1892	Near the middle of the Great Bend … 250 paces from			"Irvine Whale Bed." 24' UGL	A portion of another whale's skull. Mr Joseph Downs, carpenter, Irvine, found [it].		We saw the specimen *in situ*. This specimen is now in the Edinburgh College	

			where the specimen found in 1863 [See Irvine "2"] was discovered.			"It [the skull] was lying in darkish sand, about 3' above the level of the river, and perhaps 10' above high tide level.	He immediately wrote to me on the subject.		Museum [Presum. Anatomical Museum, Edinburgh Uni], but Sir William Turner has not yet been able to say to what species it belongs.	
	Turner (1912 3)	1892	N.A.			N.A.	"From its size and character, the skull was probably that of a *Balaenoptera.*	N.A.	N.A.	No record of this element in *Marine Mammals* (Turner 1912 3.)

Table 8.1.2.7.4

Clyde – River Irvine [7] (Scotland)

I.D:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
7	Kilmarnock Standard 26.11.1892. [5/8] [Landsborough Pt. 1.]	1892	Mr Joseph Downs, taking a turn along the banks of the River [Irvine] after a flood... Mr Smith, Kilwinning, [also] visited the spot.	55.6	-4.65	N.A.	Mr Smith, Kilwinning, visited the spot and was so fortunate as to find near to it a large thin circular plate of bone.	Cetacean.	N.A.	Kilmarnock Standard (26.11.1892.) [5/8] Kilmarnock Standard (3.12.1892.) [6/8] Kilmarnock Standard (10.12.1892.) [6/8] *Discovery of Whale Remains on Irvine River Bank,* by D Landsborough. [Parts 1 – 3].
	Smith (1895 356)	1892	Near the middle of the Great Bend … 250 paces from where the specimen found in 1863 [See Irvine "2"] was discovered.			"In a bed 5' higher up from the "Irvine Whale Bed." [19" UGL. "Grey Sand?"]	"the epiphysial plate of a whale's vertebra."	Whale. (mysticete?)	N.A.	

Table 8.1.2.7.5

Clyde – River Irvine [8, 9] (Scotland)

I.D:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
8	*Sunday Post. (11.7.1920) 3/16*	1920	At the bend of the River Irvine, near Shewalton.	55.6	-4.65	N.A. [Presum. "Whale Bed."?]	"The vertebral column of a fossil whale, measuring 4' ½ by 4', and weighing nearly one-hundred weight. ..." (50kg)	Cetacean.	N.A.	"Found by Mr Henry Donnes ..." [Downs, or Downes?]
9	Kilmarnock Standard 3.12.1892. [6/8] [Landsborough Pt 2.]	1892	Hogg: I learn that there used to be plenty of vertebrae in Irvine. They were brought down by the river …	55.59	-4.65	"brought down by the river …" [The "Great Bend", or "Water Keetings", is upstream of Irvine (town).]	Vertebrae (plenty)	Cetacean.	N.A.	Kilmarnock Standard (26.11.1892.) [5/8] Kilmarnock Standard (3.12.1892.) [6/8] Kilmarnock Standard (10.12.1892.) [6/8] *Discovery of Whale Remains on Irvine River Bank,* by D Landsborough. [Parts 1 – 3]. "Regarding these finds [of whale bones] I have received the following information. Dr

										Alexander, Dundonald writes … [and] referred me to Mr Menzies, formerly gardener at Shewalton, now at Kelburn. He writes … [and] Mr Hogg, teacher, Irvine Academy, has also favoured me with a note. He writes …
	Irvine Herald. In and Around Irvine. 26.8.1966	Mid 1800s?	Mr Charles Ross has told here of an old man who, as a boy, herded cattle around Shewalton. [He] said that there were hundreds of bones lying around.			N.A.	Bones ("hundreds").	Cetacean.	The bones were appropriated by weavers for loom weights..	Neither Charles Ross nor the original article, presum. In the Irvine Herald, is known.

Table 8.1.2.7.6

Clyde – River Irvine [10] (Scotland)

I.D:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
10	*Irvine Herald. 18.10. 1968 5/8*	1968	At Shewalton Sand Pit, behind Dundonald Cemetery, 1 mile from Irvine, on the Ayr Road. … Kenneth's Building Servics.	55.5 9	-4.65	Over the years, some 20' of sand have have been removed from the area in which the discoveries were made, at which level there is a thin layer of stones with another foot of sand below. This is considered to be the "raised beach."	the finds … are thought to be 2 ribs and 1 vertibrae [sic] of a very large creature, probably a whale. There is also a smaller piece of bone, which may be a broken rib.	Cetacean.	Foreman William Kerr remembered that many years ago, another skeleton of a whale had been found in the vicinity, and is now in the Art Galleries in Glasgow. … He has in his home a pair of reindeer antlers and an old-fashioned pistol, which were discovered in the sand-pit 28 years ago.	The present discoveries bring to mind the excavations of the late Bailie Joseph Downes of Irvine, who was responsible for the excavations of the skull of a whale in 1892. Our picture shows Mr William Kerr exhibiting a piece of bone while Mr James Floyd [of Kerr Drive, Irvine, a final year student sent by Glasgow University]holds up two ribs. The vertibrae [sic] lies on the ground in front of the ribs. "Another skeleton of a whale had been found in the vicinity, and is now in the Art Galleries in Glasgow. …" otherwise, completely unknown.
	Ledger of the Hunterian Museum 6004 – 6006.	1968	Shewalton Sand Pit, Ayrshire. [NS 329 367]. 600 – 700yd SE of Gt Bend, R Irvine.			"At c. road level." 8' - 10' post-glacial sand. Peat. [Bones found below peat.] Peat dated – 9620 – 9530 BP (Jardine 1964.)	*Balaena.* 1 – 3 ribs. 1 vertebra. 1 rib.	*Balaena.* (sp.?)	In the Hunterian.	Coll. Mr Campbell (Assist. Gen. Manager.) Mr Kerr (Foreman.) Coll. Student J D Floyd.

Table 8.1.3.1.

England (Solway – Land's End)

I.D.:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
1	Macpherson (1892 xlivii [47].)	N.A.	in Morcambe Bay. After a heavy gale, which caused some change in the sands, a local fisherman discovered … in a thick deposit of clay near Ulverston.	54.18	-3.05	In [the Morcambe Estuary] in a thick deposit of clay near Ulverston.	The remains of a large animal. Having with great labour extracted these bones, the fisherman carted them home and showed them to a doctor of divinity.	A doctor of divinity pronounced the bones to be those of a mammoth. Some time afters a vertebra fell to Mr W Duckworth, who sent me [MacPherson] a sketch. The Mammoth resolved itself into a whale of the [*Balaenoptera]* family.	[The bones] were exhibited at Ulverston some time later.	*"[found] some years ago."*
2	Macpherson (1892 xlivii - i [47 - 48.]	1850	Found about the year 1850 at Cockermouth [Castle.]	54.66	-3.37	[Discovered during improvements at Cockermouth Castle.]	Old jaw of the thick-toothed grampus (*Pseudorca crassidens.)* …	(*Pseudorca crassidens.)*	N.A.	.[MacPherson is citing correspondence between a Mr T C Heysham and Mr R Bell.] The provenance of the mandible was never established. Heysham felt that: *"this jaw has been met with at some remote period on the coast, and conveyed to the castle [Cockermouth] for some reason or other."* Macpherson was more circumspect: *“The evidence leaves us in doubt as to weather it was recent or in a fossil state … we shall be tempted to surmise that the animal was sent to Cockermouth Castle as an addition to the larder. … it may easily have been exhumed in excavations on the coast.”*
3	Reade (1872 118)	N.A.	The North Docks, Liverpool.	53.34	-2.90	The last movement of the land was down. Beds of tidal silt were intercalated with growing peat. That [silt], in which the vertebra of a whale was discovered in the North Docks, I confine to the term “Recent.”	1 vertebra	"Whale." (mysticete?)	In Brown's Museum.	*"The most frequent mammalian remains found in these beds, but which are also common to the overlying peat-bed and recent silts, are those of the … red deer. There have also been found in both the skulls of Bos longifrons, Bos primigenius, and bones of a small variety of Equus, and of the dog or wolf. Bones of Cetaceans occur, as far as I have been able to ascertain, only in the recent silts."*
4	Reade (1872 118)	N.A.	[in excavating] the Liverpool Docks.	53.39	-2.98	“Recent Deposits” … the land has gradually subsided to its present level … in this silt, bones of cetaceans have been found.	bones of cetaceans.	*Cetacean.*	N.A.	Arbitrarily plotted on “Queen's Dock.”]
5	Reade (1872 118)	N.A.	[in excavating] the Birkenhead	53.39	-3.01	“Recent Deposits” … the land has gradually	bones of cetaceans.	*Cetacean.*	N.A.	[Old Wallesey Pool, now occupied with by the Birkenhead Docks.]

			Docks, Liverpool.			subsided to its present level … in this silt, bones of cetaceans have been found.				
6	Collingwood (1864 164 - 5)	N.A.	From excavations at Wallesey Pool, Liverpool.	53.41	-3.05	N.A.	Cetacean rib.	*Cetacean.*	N.A.	
7	Collingwood (1864 164 - 5)	n.a.	From peat of a submarine forest, opposite Leasowe Castle.	53.41	-3.10	From peat.	Humerus of a cetacean.	*Cetacean.*	N.A.	
8	Forrest (1919 18)	1919	In September 1918, I [Forrest] noted in the shop of Mr Davies, Fishmonger, Barmouth...	52.72	-4.05	Cast up by the sea [at Barmouth.]	A single lumbar vertebra. It measured 14" across the disc, and 9" along the upper process. From its size, it can only have belonged to the largest of all existing animals (B musculus).	*B musculus.*	At the fishmongers.	
9	Anon. (1912 89 - 90)	1912	At Freshwater West, Pembrokeshire.	51.64	-4.86	A considerable area of “submerged forest” has been laid bare. Stumps of trees rooted in place are frequent … in some overlying beach-sand of the same general age, part of the skull of a whale has been found.	Part of the skull of a whale, probably the common rorqual (Fin Whale, B physalus.)	*B physalus.*	N.A.	Anon. (1912 89 – 90): Nature 89, *"Notes."* The area has been examined by Liet. Colonel F. Lambton.
10	Symonds (1857 93)	1867	At Tewkesbury Ham, in the alluvial drift of the Severm.	51.98	-2.16	The excavations are nearly 40' deep, and the river bed has been dredged to 7'. Several feet below the gravel [while dredging], were discovered the remains of Roman pottery, the vertebra of a whale, and many round-shaped glass bottles.	The vertebra of a whale.	Whale (*mysticete*?)	Presented to Worcester Museum (Symonds 1864 40.)	*"The alluvial drift is a mass of clay and brick-earth 39” thick, resting upon an ancient river-bed of gravel and shingle. 37' ½ from the surface, we find the fossilised antler of a large stag. "* ______________________ Hugh Miller's *Popular Geology* (1865 59), footnote by “W. S. S.”, AKA William Samuel Symonds: “*Bones of the whale have been found in the clay of the Avon and Severn Drifts.”* Symond's *Old Bones* (1864 40): *“A fossil-bone of a whale was found at Tewkesbury in the alluvium of the Severn.”*
11	Owen (1846 543)	N.A.	Dug out of a sandbank at Huntshill, near Bridgewater.	51.12	-2.99	Dug out of a sandbank.	The tympanic bone of a *Balaenoptera*.	N.A.	Mr Baker of Bridgewater possesses...	

Table 8.1.3.2.1

England (Land's End – Thames Estuary) [Cornwall & Plymouth]

I.D.:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
1	Hamilton (1881)	1880	On the beach at Port Holland, about 20 fathoms below high water mark.	50.24	-4.86	[On the day preceding discovery], a violent disturbance of the sea had occurred … during the night, several hundred tons of cliff fell, and the spot where this bone was picked up was just beyond the debris of this fallen cliff, and the-then receding waves which were supposed to have washed it. There can be little doubt, however, but that this commotion in the waters of the previous day distrubed from the ocean bed, in the submerged forest, known to exist off that coast.	The humerus the great rorqual, or razor-back whale. It weighed 53lb, is 20" in length, 39" in circumference at its broadest part, and probably was originally longer.	great rorqual, or razor-back whale (*Balaenoptera).*	The man who picked it up being of an inquiring disposition, attempted to saw it, in which attempt his saw had the worst of the encounter.	Mr Matthias Dunn has submitted the photograph of it to Francis Day, who has shown it to Professor Flower. They confirm this opinion
2	Colenso (1832 33 – 37).	N.A.	[At the tin-works] in the harbour of Pentuan, in the parish of St Austell...	50.28	-4.78	[above the tin deposit] a stratum of dark silt, about 12" thick. [Above the dark silt,] a layer of moss, 6" – 12" thick. [above the moss] a layer of sludge or silt, 10' thick. Sprinkled with recent shells, bones and horns of deer, oxen. [above this the sludge] a layer of sea-sand, 4' in thickness. [above this,] 2' of silt. [above this,] **a layer of sea-sand, 20' in thickness.** In all parts are timber trees, parts of the red deer, heads of oxen [above this], a bed of rough river-sand and gravel, 20' in depth.	I beg to present to the [Geological Society of Cornwall] [some] animal remains. **These lay near the bottom [of the 20' of sea-sand].** 1-2. Humerus and scapula of an ox. 3. Jaw of a hog. 4. A(?) human skull 5. Radius of a whale (imperfect.) 6. Humerus of a whale. 7-8. Phalanges of a whale. 9-10. Large bones, supposed of a whale. 11-12. Stag's horns.	N.A.	In the Museum of the Royal Geological Society of Cornwall.	The tin ore at Pentuan (or Pentewen) was a placer deposit, that had itself been buried. *"At the place of working, the alluvial deposit [drift] attains the depth of 60' resting on bedrock. The stratum in which the stream tin is found lies on solid rock, and is generally 3' - 6' -10' in thickness."* (Colenso 1832 33 – 37)
	Flower (1872 440 - 442)	N.A.	At Pentuan, in the parish of St Austell.			It appears that the bones were found about 1/2mi away from the present sea-shore, at a depth of more 20' from	The bones mentioned by Colenso are now in the Museum at Penzance, and are:	It is perfectly evident that these bones belong to no species of whale known to inhabit British seas … I was able to identify them, with those of a specimen	In the Museum of the Royal Geological Society of Cornwall.	*"At the time [the bones] were discovered, they were identified as having belonged to* "a large whale." … *found 20" below the surface."* Flower has made a mistake. Colenso (1832) refers to two discrete discoveries: the *"bones*

						the surface, embedded in a stratum of sea-sand.	1. right ramus of the mandible. 2. a lumbar vertebra. 3. a humerus. 4. a radius. 5-6. two metacarpals. There is every reason to suppose that they belonged to the same individual, and to an animal which had attained its full size, though the disk-like terminal epiphyses had not yet coalesced with the body.	found in the Swedish island of Graso .., of the Genus *Eschrichtus*. (E. robustus?)		*of a large whale"* [LE – T "3") referred to a discovery in the upper part of the sea-sand, so 20' UGL. The bones listed by Colenso (1832) in a footnote, and examined by Flower, referred to a discovery near the bottom of the sea-sand: so 40' UGL. Also in Owen (1846 543) Also in Pengelly (1878 633)
3	Colenso (1832 33 – 37).	N.A.	[At the tin-works] in the harbour of Pentuan, in the parish of St Austell...	50.29	-4.78	[above the tin deposit] a stratum of dark silt, about 12" thick. [Above the dark silt,] a layer of moss, 6" – 12" thick. [above the moss] a layer of sludge or silt, 10' thick. Sprinkled with recent shells, bones and horns of deer, oxen. [above this the sludge] a layer of sea-sand, 4' in thickness. [above this,] 2' of silt. [above this,] **a layer of sea-sand, 20' in thickness.** In all parts are timber trees, parts of the red deer, heads of oxen [above this], a bed of rough river-sand and gravel, 20' in depth.	[In the upper part of the 20' of sea- sand], and about 200 fathoms (365m) nearer the mouth of the harbour, the bones of a large whale were found.	bones of a large whale were found.	N.A.	
	Winn (1839 45 – 46.)	N.A.	In the Pentuan Valley, during the working of the Happy Union Tin Mine.			Found in the alluvial deposit …. in a stratum of sea-sand, at a depth of about 25' from the surface.	[bones of a whale.] The smaller bone of the two is a lumbar vertebra. It measures 3' from the tip of one transverse process to the other – its spinous process is 1' 5"' ½ in length. The other bone formed one of the ribs on the right side of the chest. Part of it has been worn away. In its present state, it is about 7' long. In its original condition it	*Balaena mysticetus.*		Winn (1839 47) for a section diagram at Pentuan.. Also in Redman (2004 16-17.) where he speculates that this was another N Atlantic Grey Whale *(E robustus).* Winn (1839) is potentially describing a fourth discovery of cetacean bones at Pentuan. Based on similarity in depth UGL, Colenso (1832) and Winn (1839) are assumed to be describing the same set of remains.

							was probably 1' longer.			
4	Smith (1817 408.)	N.A.	At Pentuan [tin mine]:	50.29	-4.77	Section of the Pentuan Stream Work in 1807. Micacous sandy clay – 9”. Peat – 7” Sand – 8” Finer Sand – 12” (vertebra found) Coarse Gravel – 2” Sand mixed with clay – 12” Loose stones – 1” Tin Ground	A joint of the vertebra of a whale … now in the possession of Rev. John Rogers, of Mawnan.			*“In the possession of Rev. John Rogers.”* Rogers had donated the vertebra to the Geological Society (London) 3 years before Smith's paper was read.
	Anon. (1816 408).	1816	4.7.1814. Specimens from Cornwall and the Vertebra of a Whale, found in the stream work of Pentowan.			Found in the stream work of Pentuan.	Vertebra of a Whale.	"Whale." (mysticete?)	In the Museum of the Geological Society.	*Anon 1816 208): Donations to the Cabinet of Minerals [of the Geological Society, London.]* *Donor: Rev. John Rogers.*
5	Moore (1841 62 - 63)	1841	The raised beach discovered under the Hoe [occupies] a depression in the face of the limestone cliff, 100' wide and 40' deep.	50.36	-4.14	[The raised beach] is covered by 10' of gravel, thus making its entire elevation 65' above the present sea-level. Recently, in its upper part, 10' below the surface of the present soil, were discovered bones and teeth …	Caudal vertebrae of the whale … [they] appeared much worn, as if by long-continued friction in the water.	"Whale". (mysticete?)	N.A.	*"The raised beach has been lately, by extension of the quarry [at Plymouth Hoe] near which it was situated, been entirely removed."*
	Moore (1842 540 - 1)	N.A.	[As above]			[As above]	The vertebrae of a whale, much rounded, with undeterminable portions of ribs.	"Whale". (mysticete?)	N.A.	
6	Clark (1866 81 – 2.)	1866	At Plymouth.	50.36	-4.14	N.A.	Some cervical vertebrae.	Some cervical vertebrae. … probably belong to	N.A.	[The paper is concerned with a fossil *cetacean* rib, found near Cromer. The

								Balaena biscayensis. (E glacialis.)		remains at Plymouth are one of two asides, the other is about Landbeach.

Table 8.1.3.2.2										
England (Land's End – Thames Estuary) [Plymouth - Brighton.]										
I.D.:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
7	Pengelly (1878a 631)	1870	Taken up in a trawl off Berry Head.	50.4	-3.47	Taken up in a trawl [i.e. On the seabed.]	2 bones of a whale. 1 dorsal vertebra. 1 humerus … greatly worn.	Whale (*mysticete?*)	Part of the collection of the Torquay Natural History Society.	
8	Pengelly (1870)	1863 - 1869	On a beach near Babbcombe.	50.48	-3.51	Cast up by the waves on the beach.	3 cervical vertebrae, which had been cast up at intervals over the last 6 years.	The vertebrae belonged to a whale new to the British fauna (*Eschrichtus robustus*, or Grey Whale.)	N.A.	Also in: Grey J, *Whale From the Coast of Devonshire* (1865 492-5), Annals & Magazine of Natural History, vol. 15.
	Pengelly (1878a 631)	1865	[My second specimen] was found on Peitor Beach, ½mi east of Babbacombe.			on the beach.	No other specimen was met with until 1867 … [636] I purchased a third cervical vertebra. The person who sold it stated, it had been found that day, on Peitor Beach.	*Eschrichtus robustus*, or Grey Whale.	N.A.	Pengelly found one of the three vertebra himself, and purchased the other two. Remains of Whales Found in Devonshire Pt. . 2 Pt 1 is unknown. May not be real? Per Hester Pengelly's *A Memoir of William Pengelly* (1897 328), this may also be: *"109. Remains of whales found on the coast of Devonshire. Devon. Assoc. Trans. 10. pt. 2), 1878, pp. 630-63"*]
9	Pengelly (1878b 392)	N,A,	At Torbay.	50.4	-3.55	N.A.	*Cetacean* remains.			
	Pengelly (1878a 631)	1878	Drawn up on the beach in Elbury Cove, Torbay.			Taken up in a seine in about 20' of water.	The vertebrae of the neck of a whale. … the vertebrae are anchylosed. Their exposed surfaces are very concave. The dimensions betoken a much larger animal. This specimen has undergone considerable abrasion, but the neural arch is well-preserved.	*Mysticete.*	N,A,	(Pengelly 1878b). Nature is reporting: 17th Meeting, Devonshire Association for the Advancement of Science, Literature, and Art. This volume is not digitised (4.2021). Pengelly is presumed to talking about the same "remains", from Torbay, in both papers.
10	Grey (1866 319 323)	1853	Dredged up at Bridport, on the coast of Doresetshire.	50.71	-2.76	Dredged up at Bridport	The skull of a *cetacean*... a large animal, being nearly as large as that of the common pilot-whale.	I believe a species that has not before been noticed: *Globicephalus incrassatus.* [*Globicephalus melas,* long-finned pilot whale.]	N.A.	
11	Prestwich (1895 272)	N.A.	At Bracklesham.			N.A. [From context: in the "Rubble Drift/Head" (271.).]	An earbone of a whale.	N.A.	N.A.	
12	Owen (1846 272)	N.A.	In the "Beeding Levels."	50.87	-0.30	N.A.	Remains of *Delphinidae.*	*Delphinidae*	N.A.	Location is imprecise – may refer to somewhere lower on the River Adur than the village of Beeding.

13	Anon. (1827 456)	1827	In the mud near Shoreham Bridge.	50.84	-0.28	In the mud.	The rib of a whale.	Whale (*mysticete?)*	N.A.	
14	Mantell (1857 61 - 63)	N.A.	Lewes Levels. ... in the valley of the Ouse, near Lewes.	50.82	0.026	Lewes Levels. The deposits are as follows: Bog Earth and Peat (5'). Blue Clay (freshwater shells) (N.A.). Clay (freshwater and marine shells) (N.A.). Blue clay (marine shells). In this deposit …	A skull of the narwhal, or sea-unicorn (*monodon monceros.)*	narwhal, or sea-unicorn (*monodon monceros.)*	N.A.	Lyell's *Principes of Geology* vol. 2. (1832 283.) where Mantell is credited. Presum. *Wonders of Geology* (1) ? (Mantell 1857 63) [7th ed.)
	Owen (1846 522)	N.A.	In the marshy plain called Lewes Levels.			N.A.	A portion of a skull	A portion of a skull.	N.A.	
15	Lydekker (1887 20)	1858	From the silt at Lewes, Sussex.	50.83	0.026	From the silt at Lewes, Sussex.	A dorsal vertebra.	*Balaena biscayensis. [E. glacialis].*	In the British Museum.	
16	Sussex Advertiser (31.10.1825) [¾]	1825	As some labourers were at their work embanking a sewer nigh to the Tide Mill, at Bishopstone.			Nigh to the Tide Mill, at Bishopstone … the [animal] to which it belonged had not sported with the billows since the waves of the ocean washed the shores of the port of Lewes.	A fossil skull. Due to its size, some fancied was the remains of an elephant's head. From comparative anatomy, it appears distinctly to be the skull of an enormous porpoise. It measures from the spinal orifice to the extremity of the nasal bone, 2' 2" ½, and transversely, 1' ½.	"Enormous porpoise" (*Delphinidae).*	N.A.	*"Porpoises anciently were, in point of size, little whales, compared with the porpoises of today."*
	Mantell (1857 61 – 3).	N.A.	Lewes Levels. ... in the valley of the Ouse, near Lewes.			Lewes Levels. The deposits are as follows: Bog Earth and Peat (5'). Blue Clay (freshwater shells) (N.A.). Clay (freshwater and marine shells) (N.A.). Blue clay (marine shells). In this deposit	A skull of the porpoise.	Porpoise. *(Phocoeana phocoeana.)*	N.A.	
17	Lydekker (1887 38)	1882	From the Pleistocene [Elephant Bed] of Brighton, Sussex.	50.82	-0.15	From the Pleistocene [Elephant Bed] of Brighton, Sussex.	The centrum of a cervical vertebra.	*Balaenoptera borealis.*	In the British Museum.	
18	Lydekker (1887 39)	1882	From the Pleistocene [Elephant Bed] of Brighton, Sussex.	50.82	-0.13	From the Pleistocene [Elephant Bed] of Brighton, Sussex.	Fragment of a rib.	*Balaenoptera borealis.*	In the British Museum.	
19	Mantell (1831 164)	1829	between Kemp Town and Rottingdean (Brighton.) In the cliff, Mr Mantell discovered …	50.81	-0.12	[The mandible] was lying embedded in the shingle of the cliff, in which the teeth and bones of elephants are also found.	Part of the jaw of a whale, 9' long.	*Mysticete.*		

	Lydekker (1887 38 - 9)	1836	From the Pleistocene [Elephant Bed] of Brighton, Sussex.			From the Pleistocene [Elephant Bed] of Brighton.	Part of a mandibular ramus.	*Balaenoptera borealis.*	In the British Museum.	
	Prestwich (1895 269)	N.A.	At Brighton, we have the typical “Head” of the South Coast, overlying a well-marked Raised Beach.			At Brighton, we have the typical “Head” of the South Coast, overlying a well-marked Raised Beach. The overlying mass of rubble, or the “Elephant Bed”, attains a thickness of 60'. Mantell describes the “Head” as a confused heap of alluvial materials, having a layer of broken sea-shells at its junction with the underlying raised beach. (267-8) The old beach consists of a well-worn and rounded flint-shingle. At the base of the shingle there is, in places, a bed of sand 2' thick. (269) [Mantell] found a jawbone of a whale here.	[Mantell] found a jawbone of a whale here.	*Balaena mysticetus.*		
20	Anon. (1827 456)	1827	In the silt, near the mouth of the Cuckmere.	50.76	0.14	In the silt.	The skull of a large porpoise.	Porpoise *(Phocoeana phocoeana.).*	N.A.	Gentleman's Magazine 172 (1827 456). *Domestic Intelligence.* Article concerns a cervid skeleton discovered in the River Ouse, and notes this "porpoise" among other recent, similar discoveries.
	Owen (1846 520)	N.A.	At the mouth of Cuckmere.			N.A.	Remains of *Delphinidae*	*Delphinidae.*	N.A.	

Table 8.1.3.3.										
England (Kent – Thames)										
I.D.:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
1	Gardiner et al. (1999 97 – 98, 101)	1994	Dengemarsh, Lydd, Dungeness	50.94	0.94	On black sandy silt (inter-tidal flat) overlain by clast-supported beach gravels.	Fragmented skull ... five cut-marks [on supraorbital process] are consistent with the use of a heavy metal implement and were likely caused in antiquity.	*Balaenidae.*		"Not exposed for a long period before being buried by shingle." "First unequivocal archaeological evidence for the exploitation of whale meat in Anglo-Saxon England."
2	Gardiner et al. (1999 97 , 99 – 101)	1995	Dengemarsh, Lydd, Dungeness	50.94	0.93	On black sandy silt (inter-tidal flat) overlain by clast-supported beach gravels.	Eight vertebrae, portion of the occipital, rib fragments. Five of the ribs and three of the vertebrae show [ancient] cut-marks, consistent with systematic de-fleshing along the back-bone.	*Balaenidae.*		"Not exposed for a long period before being buried by shingle." "First unequivocal archaeological evidence for the exploitation of whale meat in Anglo-Saxon England."
3	Richard (1839 98 - 99)	1837	At Herne Bay, Kent	51.35	1.137	In the yellow marle, or brick earth. … The spot from whence they were taken is not more than 10' from the high-water mark, and certainly not more than 10' above the occasional reach of the sea.	I obtained 12 vertebrae of a whale, some caudal and others dorsal. … They were the bones of a young animal, since their *epiphyses* were still unconnected with their bodies, and the bony structure was not fully developed.	A whale. (*mysticete?)*	N.A.	*"No other animal remains were discoverable in the clay."*
	Owen (1842 72)	N.A.	At Herne Bay, Kent			[As above.]	The vertebrae of a whale.	A whale. (*mysticete?)*	N.A.	Owen (1843 72) names *"Mr Richardson"* as the discoverer but does not properly reference the paper (Richard 1839.)
4	Lydekker (1887 84)	1864	From the Pleistocene of Greys, Essex.	51.47	0.32	N.A.	Vertebra: the centrum, and portions of the neural arch and transverse processes.	Tursiops tursio. (Now *Tursiops truncatus.)*	In the British Museum.	*"Provisionally referred to this species. The specimen is indistinguishable from the 9th lumbar of the existing form."*
5	Lydekker (1887 81)	1865	From the marshes near Barking, Essex.	51.53	0.08	N.A.	An imperfect cranium.	*Globicephalus melas.*	In the British Museum.	[Lydekker (1887 81) does not seem to think these two specimens (T – N "5", "6") donated by the same man and discovered in the same location, referred to the same species, to be from one individual animal.]
6	Lydekker (1887 81)	1865	From near Barking.	51.53	0.08	N.A.	The anchylosed series of cervical vertebrae.	*Globicephalus melas.*	In the British Museum.	[Lydekker (1887 81) does not seem to think these two specimens (T – N "5", "6") donated by the same man and discovered in the same location, referred to the same species, to be from one individual animal.]
7	Lydekker (1887 63)	1864	East Ham Marshes, Essex. ... in digging the main sewer.	51.53	0.07	N.A.	A considerable part of the left ramus of the mandible.	*Hyperoodon rostratus.* (Now *Hyperoodon ampullatus.)*	In the British Museum.	

8	Lydekker (1887 17)	1864	At Deptford.	51.47	-0.02	8' below the surface.	2 imperfect scapula.	*Balaena mysticetus.*	In the British Museum.	*"[The scapulae] are in a comparatively fresh condition. It is highly probable that they were brought to the locality by human agency."*
9	Lydekker (1887 81)	1867	From the banks of the Thames, at Limehouse.	51.51	-0.04	N.A. (riverbank.)	The conjoint cervical vertebrae.	*Balaena mysticetus.*	In the British Museum.	
10	Lydekker (1887 19)	1861	From the bed of the Thames, at Wapping.	51.5	-0.05	N.A. (the riverbed).	The conjoint cervical vertebrae, in a slightly imperfect condition.	*Balaena biscayensis. (E. glacialis).*	In the British Museum.	
11	Anon (1835 27)	1830	5.2.1830 Neck of a whale found in making St Katherine's Dock.	51.5	-0.07	N.A. (alluvial deposit?)	Neck of a whale.	*N.A.*	In the Museum of the Geological Society (London).	
12	Owen (1842 72)	N.A.	At New Temple Church, London.	51.51	-0.1	In gravel, 15' below the surface.	A large vertebra of a whale.	*Balaena mysticetus.*	N.A.	
13	Lydekker (1887 20)	1865	Dredged from Thames at Wandsworth.	51.45	-0.19	N.A. (the riverbed).	An early caudal vertebrae.	*Balaena biscayensis. (E. glacialis).*	In the British Museum.	
14	Owen (1842 72)	N.A.	In the Essex diluvium.	51.95	1.34	Diluvium.	The teeth of a Cachalot.	*Physeter.*	[Discovered by Mr Brown.]	
	Charlesworth. (1845 40 - 41)	N.A.	Some years since ... I whilst looking over [Mr Brown's fossils], I was struck by a cylindtical nodule from the Red Crag of Felixstowe.			the Red Crag of Felixstowe. ... Owen (1842 72) through mistake, has assigned [the tooth] to the "Diluvium of Essex." Mr Brown procued the specimen fro a man at Felixstowe, who picked it up off the beach.	Tooth of a Cachalot.	*Physeter.*	In the collection of Mr Brown of Stanway.	*"Picked up off the beach. ... several of the rarest Crag fossils having been found at this spot under similar circumstances, there is no room to doubt it being a genuine fossil from the Crag."* Red Crag, a Pliocene deposit.

Table 8.1.3.4.

England (Suffolk and Norfolk)

I.D.:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
1	Crisp (1869 61)	1869	On the Eastern coast of Suffolk.	52.11	1.48	Found in Chillesford clay, about 10' below the surface.	The first perfect skeleton found in England. … It was 31” in length. Many of the bones, the vertebrae especially, were so soft that they fell to pieces on removal.	*Mysticete*	N.A.	
	Prestwich (1871 336 - 8)	N.A.	Chillesford Stack-pit, between Chillesford and Aldborough. Chillesford sand (resting on Red Crag) is seen at Chillesford Church Pit, but is better developed at Chillesford brick-pit. (337) Fig 19. Section in Chillesford Brick Pit.			At a depth of 8' from the surface, in Chillesford clay, lying at right angles to the face of the section … (Fig. 19 Chillesford Brick Pit.)	I was shown the vertebral column of a great whale … exactly in the position in which they might have been left at the depth of the animal – each vertebra lying a few inches apart from its neighbours	*Mysticete*	N.A.	
2	Anon (1818 150.)	1818	In Roydon gravel pit, near Diss.	52.37	1.08	In gravel.	Part of the jaw-bone of a whale. It measured 20" in girth, but was not above 9' long. The outside was penetrated by lapideous matter, but the inside was similar in every thing to recent bone.	*Mysticete.*	N.A.	*"[The mandible's] present form and appearance are attributed to attrition it is supposed to have suffered at former times. The ends are so worn that they seem rather artificial than natural."* Also: (Woodward and Sherbourn 1890 339).
3	Redman (2004 135)	1963	Kessingland Beach, Suffolk.	52.4	1.72	N.A.	Vertebra, 12' across centrum.	*Mysticete.*	N.A.	Thought to be from a whale washed ashore and buried in 1897.
4	Newton (1891 76)	N.A.	Obtained from the “Forest Bed” of Pakefield.	52.45	1.73	“Forest Bed” [Pleistocene.]	A tooth. … agrees precisely with one of the smaller teeth of the Killer [Whale.]	*Orcinus orca.*	N.A.	
5	Newton (1882 110 – 111)	N.A.	From the fluvio-marine crag of Aldeby.	52.47	1.59	From the fluvio-marine crag.	N.A. This species [*Delphinus delphis]* has also been determined by Professor Flower from the fuvio-marine crag.	*Delphinus delphis*	N.A.	*“Determined by Professor Flower.”* In Newton E T (1882 110 – 11). Per (Woodward and Sherbourn 1890 339), the original source is Crowfoot and Downson (1878 27), *Proc. Norwich Geol. Soc. 1.* This

										publication is not digitised.
6	Redman (2004 137)	1914	from Norwich Crag deposits at Whitlingham.	52.62	1.34	Norwich Crag.	3 vertebrae bones (whale?)	*Mysticete (?)*	the Hunterian Museum {London? Nos. 5655, 5656.}	
7	Redman (2004 135, 137)	1952	In Postwick Marshes.	52.6	1.39	4' UGL in peat.	Vertebra, 15' across centrum, 24' across processe	*Mysticete (?)*	In Norwich Museum.	
8	Woodward (1891 45 – 6)	1860	obtained from [The Forest Bed] at Bacton.	52.85	1.47	45.) The Forest Bed Series. 1. The estuarine soil of the Forest Bed. The Forest Bed has been an object of attention for the Elephantine, Cervine, and other Mammalian remains it has yielded. It was regarded as one uniform formation, but an occurrence took place in 1860 …	The vertebra of a whale.	*Mysticete (?)*	In Norwich Museum.	Obtained by Mr John Henry Gurney, M.P. Lyell (1867 216-7). *“Mr Gunn informs me that two large whales were found in the fluvio-marine beds at Bacton.”* Also in Redman (2004 123-4.)
	Newton (1882)	N.A.	Obtained from [The Forest Bed] at Mundesley and Bacton.			N.A.	In 1863, Lyell *(Antiquity of Man)* included *Balaenoptera* among the “Forest Bed” Mammals. The specimens upon which this determination rested were those in Mr Gunn's collection, to which the latter gentleman referred in 1864. [Gunn, *Geology,* (in White 1864 124).] The specimens alluded to are some very large vertebrae, measuring 14' – 15' across the ends of the centra.	*Balaenoptera.*	In Norwich Museum.	Gunn, *Geology,* (in White 1864 107 – 131) *History, Gazetteer and Directory of Norfolk.* (122.) *“The forest bed... is evidently fluvio-marine, as is proved by the admixture of cetacean with terrestrial mammalian remains. … * (123.) two species of whales.* Newton (1886 322) a large *Cetacean* vertebra In Mr Gunn's collection in the Norwich Museum … nearly 15' in diameter.
9	Woodward (1891 47)	1860	I [Gunn] went at once to the spot [where N – S "24" was found.].	52.85	1.47	(47.) The Forest Bed Series. 1. The estuarine soil of the Forest Bed. ... The spot pointed out to me proved to be the Elephant Bed. Soon after, I obtained a second vertebra from the blue clay of the same age, and part of the same deposit, as the Elephant Bed. (48.) for section diagram.	A vertebrae [sic] of a whale … An occipital bone, and several other *cetacean* remains.	N.A.	In Mr Savin's Collection.	Gunn, *Geology,* (in White 1864 107 – 131) History, gazetteer and directory of Norfolk. (122.) *“The forest bed... is evidently fluivo-marine, as is proved by the admixture of cetacean with terrestrial mammalian remains. … * (123.) two species of whales.* Also in Redman (2004 123-4.)

	Newton (1882 108 – 9)	N.A.	Obtained at Mundesley and Bacton.			The Forest Bed.	In 1863, Lyell *(Antiquity of Man)* included *Balaenoptera* among the "Forest Bed" Mammals. The specimens upon which this determination rested were those in Mr Gunn's collection, to which the latter gentleman referred in 1864. [Gunn, *Geology,* (in White 1864 124).] Other smaller vertebrae have been supposed to represent a second species, on account of their smaller size.	*Balaenoptera.*		No mention of the occipital. [Assuming the bones found by Gunn in 1860 are the same as those he wrote about in 1864, and were in his collection when Newton presum. Examined them himself?] Not in: Newton (1886)
10	Redman (2004 134, 214)	1957	collected from the Mundesley "Forest Bed" on 28.12.1957.	52.87	1.43	The Forest Bed.	a fossil vertebra … It measures 12' 1/2 across the centrum, and stands 7' high.	*Mysticete.*	in the store of the Natural History Department at Birmingham Museum.	donated by Mr P R Bordewick.
11	Woodward (1891 77)	N.A.	From the Forest Bed of Mundesley.	52.87	1.43	The Forest Bed.	An imperfect atlas vertebra, to which the small 2nd cervical is firmly ankylosed. …	On comparison with recent skeletons it seems to come nearly to *Pseudoorca crassidens.*		
12	Newton (1882 110 - 111)	N.A.	Obtained from the "Forest Bed" at Overstrand, Cromer.	52.91	1.34	The Forest Bed.	4 small cetacean vertebrae. 2 of them are much too rolled for determination.	2 agree so closely with corresponding vertebrae in the genus *Delphinus* that I have referred them to that genus.	Preserved in Mr A Savin's Collection.	
13	Newton (1886 316 - 18)	1886	Washed out of the "Forest Bed" at Sidestrand. Found on the shore just after a storm, it has, cemented to it by iron pyrites, the peculiar white sandy matrix of "The Forest Bed" at Sidestrand.	52.9	1.36	The Forest Bed.	This tooth is in a very perfect condition, only the thin edge of the pulp cavity being broken away.	(318.) I see no difference worth mentioning between this fossil and the tooth of a recent Sperm Whale (*P macrocephalus.)*	N.A.	Acquired by Mr Clement Reid, who purchased from a fisherman.
14	Newton (1889 149)	N.A.	From the Forest Bed of Sidestrand.	52.9	1.36	The Forest Bed.	A caudal vertebra of a small *cetacean*. … the neural arch and transverse processes are broken away.	The proportion of length to width is quite unlike what is found in a dolphin, but agrees with that seen in a porpoise. (*Phocea phocea.)*	N.A.	
15	Newton (1882 111)	N.A.	Obtained from the "Forest Bed" at Overstrand, Cromer.	52.91	1.34	The Forest Bed.	1 small *cetacean* vertebra, from the caudal region … a younger animal, as showing by the want of epihpyses. It has been	*Delphinus.* The close agreement, except in size, between this vertebra and corresponding ones in Dolphins leads me to refer it to the same genus, but no specific	Preserved in Mr A Savin's Collection.	

							much rolled.	determination can be made.		
16	Newton (1886 321)	N.A.	this mass of vertebrae came from a low ledge of rocks (Forest Bed) opposite Overstrand, which is only exposed at very low spring tides.	52.91	1.34	The Forest Bed.	the right half of the 7 cervical vertebrae of a Whale, so ankylosed that only the slightest trace of their original distinctness is now discernible.	(321.) Mr Backhouse's specimen is certainly a *Balaena.*	In the possession of Mr Jas Backhouse, of York.	Also in Redman (2004 138).
17	Newton (1889 148)	N.A.	From the Forest bed at Overstrand.	52.91	1.34	The Forest Bed.	*Monodon monoceros.* A portion of the right side of a Narwhal's skull.	*Monodon monoceros.*	Preserved in Mr A Savin's Colleciton.	
18	Netwon (1889 148)	N.A.	From the Forest bed at Overstrand.	52.91	1.34	The Forest Bed.	A vertebra, which, although much damaged, is evidently from the lumbar region.	referred to *(Delphinapterus leucas),* or Beluga.	Preserved in Mr A Savin's Collection.	
19	Newton (1882 108)	N.A.	Dug out of the "Forest Bed" on the foreshore near Cromer.	52.93	1.3	The Forest Bed.	The largest *cetacean* vertebrae with which I am acquainted … The diameter of the centrum without processes in 16'.	*Mysticete.*	Dug out by Mr W Barker, of Birmingham.	Mr W Barker, of Birmingham, who has kindly sent me a sketch with measurements. Also in Newton (1886 322) Also in Redman (2004 66, 125, 182.)
20	Newton (1882 109)	N.A.	N.A.	52.93	1.3	The peculiar grey sandy matrix still adhering to [the tusk], as well as its mineral condition, leaves no doubt as to its being from "The Forest Bed."	The earliest notice of the "Narwhal" being found in the "Forest Bed" is Lyell (1863), *Antiquity of Man* 1st ed., where he says that a specimen was found by Mr King near Cromer. The King collection contains no specimen which could be referred to the Narwhal. The only portion which can now be traced being a portion of a tusk in the Norwich Museum, labelled in the Gurney collection.	Narwha; *(Monodon monoceros.)*	In Norwich Museum.	Lyell (1867 216-7). *"A narwhal's tusk was discovered by Mr King, near Cromer."* *Gunn, Geology, (in White 1864 107 – 131) History, gazetteer and directory of Norfolk. (123-4.) "The Laminated Beds. Rev. S W King has obtained from them remains of the narwhal."*
21	Newton (1889 148)	N.A.	From the Forest Bed at East Runton.	52.93	1.27	The Forest Bed.	A 5th or 6th caudal vertebra from the "Forest Bed" of East Runton, more nearly perfect than most of the *Cetacean* vertebrae from these beds. The terminal epihpyses are wanting and the ends of the transverse processes are somewhat broken.	It agrees in size and shape with the 5th or 6th caudal vertebra of the White Whale *(Delphinapterus leucas),* or Beluga.	Preserved in Mr A Savin's Colleciton.	

22	Newton (1891 58)	N.A.	From the Forest Bed at East Runton.	52.93	1.27	The Forest Bed.	A large *Cetacean* tympanic bone … provisionally placed in [*Balana biscayensis.*]	[*Balana biscayensis.*] *[E. glacialis.]*	Preserved in Mr A Savin's Colleciton.	
23	Newton (1891 76)	N.A.	Obtained from the "Forest Bed" … from East Runton.	52.93	1.27	The Forest Bed.	*Orca gladiator*. The centrum of a dorsal vertebra, with the bases of the transverse processes preserved. … the terminal faces are nearly flat and the epiphyses are firmly ankylosed.	*Orca gladiator*.	Preserved in Mr A Savin's Colleciton.	
24	Clark (1886 81 – 2)	1866	Near Sherringham, NW of Cromer.	52.94	1.2	It was discovered after a high tide, which caused a fall of the cliff; it was reported to have been imbedded in drift gravel. [Professor Sedgwick had great doubt, from its general appearance, whether it could have come out of the gravel.]	It was probably the fourth or fifth rib, on the left side. [Professor Sedgwick remarked that this was the largest rib that he had ever seen.]	Mr Clark has compared it with the rib of *Physalus*, with which it does not agree. It resembled *Balaenoptera* more nearly, and still more closely *Balaena mysicetus*. *(mysticete.)*	N.A.	

Table 8.1.3.5

England (Cambridge Fens)

I.D.:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
1	Owen (1846 520)	N.A.	Found near Ely.	52.39	0.26	It was found in the brown clay (alias till). I have no doubt that it washed out of the Kimmeridge (alias Oxford) clay. In condition, it is exactly like the bones of those clays.	An anchyloid mass of cervical vertibrae … the most completely petrified specimen known.	*"Palaeocetus sedgwickii."*	N.A.	Apx. Location. Kimmmeridge Clay is Jurassic. If the vertebra came from there, it cannot have belonged to a *cetaean*.
	Seeley (1855 54 – 57)	1825 (?)	Near Ely … Found at the Roswell Pit in the boulder-clay			in the boulder-clay.	*Cervical vertebrae.*	*"Palaeocetus sedgwickii."*	N.A.	*"The specimen is mineralised with phosphate of lime, and so could have been derived from no deposit newer than the Crag … It is partly coated with stalagmite …"*
2	Clark (1865 81 – 82)	1866	found at Landbeach, near Cambridgeshire.	52.27	0.17	N.A.	Some large *cetacean* vertebrae had been found.			[The paper is concerned with a rib, found at Sherringham, near Cromer. This is one of two asides: the other is about Plymouth.] [Sedgwick claims this. There is no other account to verify it.]
3	Redman (2004 9)	1994	found near Chatteris.	52.45	0.05	part of a jaw-bone of a whale from sub-fossil levels, presumably carried in by flooding.	A piece of bone, about 2' long, … part of a jaw-bone of a whale.	*Whale (mysticete?)*	The bone was removed to the Wisbech and Fenland Museum.	David Devenish, Curator and Librarian, Wishbech and Fenland Museum, 1994
4	Redman (2004 9)	1994	found in Fen clay near Ramsey Hollows.	52.46	0.05	Found in Fen Clay … It is believed to be late Neolithic or Bronze Age.	A whale's skeleton. The skull, jawbones and cervical vertebrae were removed.	*Mysticete.*	The skull, jawbones and cervical vertebrae were removed to Cambridge University and Peterborough Museum.	(Pers. Comm. Gordon Chancellor Nat Hist. Curator Peterborough Museum.) [“Ramsay Hollow” is named on OS 6' Huntingdonshire 11 (SW) 1901].
5	Miller & Skertchley (1878 353, 345)	N.A.	The following [faunal remains] all occur in the older parts of the [Cambridge] Fen deposits.	52.61	-0.06	The Silt, a marine formation, has entombed for us a few specimens of the denizens of the sea. At 3', in Thorney Fen. ...	"Grampus." (Orca gladiator) *[orcinus orca.]*	*Orcinus orca.*	N.A.	One Clark's (1947) two references to *cetacean* palaeontology in WEF. No further information in: (Miller 1880; Bennett et al. 1891; Whitaker et al. 1893; Jukes-Brown 1876.) (Bonney 1875?)
	Skertchley (1877 174)	N.A.	[Found in] [Cambridge] Fen Silt			Fen Silt can be readily described under two facies: clay and warp.	The organic remains [in clay and warp] consist entirely of *Scrobicularia piperata* … here and there, a few bones of grampus are exhumed, but very sparingly.		N.A.	
6	The Sphere 10.12.1921 [8/44]	1921	A remarkable discovery has been made on Bassenhally Moor	52.61	-0.09	Lying under the peat, and just embedded in the clay …	The find at Thorney consists of 2 animals, one slightly larger than the other. They were	The teeth were all of the same conical shape, while the shape of the skull fragments and small relative size of the fore limbs	Dr Garrood [sic] in whose possession the bones are now.	

			Farm, Thorney, 7mi from Peterborough. Found whilst the employees were engaged in celery-lifting.				lying side by side … their heads were found to be pointing to Peterborough and the their tails towards the sea. On the whole, the bones are in very good condition, and those that have been got out carefully are scarcely damaged at all. The skulls are very much damaged.	made it clear that the remains were those of one of the toothed whales. … it was determined that the species was *Pseudorca crassidens.* (+ photo of 1 skeleton.)		
	Sheppard (1922 19)	1921	At a farm at Thorney.			N.A.	The remains of two whale-like animals. …	It is evident that a pair of False Killer Whales, a male and a female, had been stranded.	Now in the museum of the Stamford Institution.	
7	The Sphere 10.12.1921 [8/44]	1921	A remarkable discovery has been made on Bassenhally Moor Farm, Thorney, 7mi from Peterborough. Found whilst the employees were engaged in celery-lifting.	52.58	-0.09	Lying under the peat, and just embedded in the clay …	The find at Thorney consists of 2 animals, one slightly larger than the other. They were lying side by side … their heads were found to be pointing to Peterborough and the their tails towards the sea. On the whole, the bones are in very good condition, and those that have been got out carefully are scarcely damaged at all. The skulls are very much damaged.	The teeth were all of the same conical shape, while the shape of the skull fragments and small relative size of the fore limbs made it clear that the remains were those of one of the toothed whales. … it was determined that the species was *Pseudorca crassidens.* (+ photo of 1 skeleton.)	Dr GarrOd of Alconbury Hill, Huntingdonshire, secured all the remains.	
	Sheppard (1922 19)	1921	At a farm at Thorney.			N.A.	The remains of two whale-like animals. …	It is evident that a pair of False Killer Whales, a male and a female, had been stranded.	Dr Garrood [sic] in whose possession the bones are now.	
8	Owen (1846 516 - 517)	1843	Discovered in the great fen of Lincolnshire, beneath the turf, in the neighbourhood of the ancient town of Stamford.	52.69	-0.31	"Beneath the turf."	The most complete example of a skeleton of a *cetacean*, which, by alteration of the osseous texture and by the peculiar configuration of the bones, can rank with the "British Fossil Mammalia."	*Phoceana crassidens [now, Pseudorca crassidens] – the false killer whale.*	Now in the museum of the Stamford Institution.	One of two books on cetacean palaeontology referenced by Clarke (1947). ______________________ *Phoceana crassidens.* Presum. Skertchley means *Pseudorca crassidens* (Owen 1846), AKA false killer whale. The holotype was a sub-fossil skull, discovered in the Cambridgeshire Fens (Owen 1846), so the species was believed extinct.
	Miller & Skertchley (1878 345)	N.A.	The Silt, a marine formation [of the Cambridge Fens] has entombed for us a few specimens of the denizens of the sea.			N.A.	As yet, we have only obtained [A few specimens]: *Phoceana crassidens*. - a rare or extinct species. (porpoise) [sic.] *(Pseudorca crassidens.)*	As yet, we have only obtained [A few specimens]: *Phoceana crassidens*. - a rare or extinct species. (porpoise) [sic.] *(Pseudorca crassidens.)*	N.A.	

	Skertchley (1877 174)	N.A.	[Found in] [Cambridge] Fen Silt.			[Fen Silt] can be readily described under two facies: clay and warp.	The organic remains consist of *Scrobicularia piperata* … here and there, a few bones of whales are exhumed, but very sparingly.	*N.A.*	N.A.	
9	Miller & Skertchley (1878 353, 345)	N.A.	The following [faunal remains] all occur in the older parts of the [Cambridge] Fen deposits.	52.93	-0.16	At 30', Swineshead.	Greenland whale. *[B. mysticetus]*	*B mysticetus.*	N.A.	One of two books on *cetacean* palaeontology referenced by Clark (1947) in WEF. *"*The South Forty Foot Drain runs through the northern part of the parish [Swineshead] in an easterly direction to Boston." (Miller 1890 137)
	Skertchley (1877 174)	N.A.	[Found in] [Cambridge] Fen Silt			[Fen Silt] can be readily described under two facies: clay and warp.	The organic remains consist of *Scrobicularia piperata* … here and there, a few bones of whales are exhumed, but very sparingly.	*B mysticetus.*	In the possession of Mr W Little of Heckington.	
10	Skertchley (1877 174)	N.A.	[Found in] [Cambridge] Fen Silt	52.68	0.09	[Fen Silt] can be readily described under two facies: clay and warp.	The organic remains consist almost entirely of *Scrobicularia piperata* … here and there, a few bones of *Bos, Sus,* whale, seal and grampus are exhumed, but very sparingly.	N.A.	**N.A.**	
	Miller & Skertchley (1878 353, 345)	N.A.	The Silt, a marine formation [of the Cambridge Fens] has entombed for us a few specimens of the denizens of the sea.			The Silt, a marine formation.	As yet, we have only obtained [A few specimens]: Delphinus tursio. (dolphin) [*Tursiops truncatus]* Bottlenose dolphin.	[*Tursiops truncatus]* Bottlenose dolphin.	N.A.	One of two books on *cetacean* palaeontology referenced by Clark (1947) in WEF. ________________________ Skertchley (1878) does not substantiate this claim with an example from a specific location. No further information in: (Miller 1880; Bennett et al. 1891; Whitaker et al. 1893; Jukes-Brown 1876.) (Bonney 1875?)
11	Sheppard (1898 304)	1898	The discovery of some huge bones at Farndon Field, near Newark … at a distance of c. 1 ¼ mi S of Newark Station.	53.05	-0.84	The bones were found in the alluvium, not far below the surface, on the banks of the water-way.	Two large pieces are now in the yard of Horace Mill's Bask Works, whilst a third portion was thrown into the water and lost. There were two pieces: one long and narrow, measuring 7' 6' by 1" 5', and the other, a broken piece, was 3' long and measured 4' 6" in circumference. Both had been joined together, and would have	Specimens of this description are common enough in the vicinity of Hull. … It is quite possible that these merely represent a specimen brought from the Humber, though it is hardly like that the specimens would have been buried.	N.A.	*Locaton apx.*

							represented one side of the lower half of a whale.			
	Sheppard (1931 62)	1898	I [Sheppard] paid a visit to Newark nearly 30 years ago.			Some discarded whales jaws used as gate-posts, which had rotted at the ground-level, had been thrown on the river side and grassed over.	Some bones of a “Megatherium” which a certain London daily recorded, only to find some discarded whale jaws.	*N.A.*	N.A.	

Table 8.1.3.6.										
England (Humber - Tyne)										
I.D.:	Source:	Yr:	Location & Co-Ordinates:			Situation:	Osteology:	Species:	After Discovery:	Context:
1	Anon. (1924 321 – 2.)	N.A.	Picked up on the beach at Withnersea.	53.73	0.03	"Mr Turner, painter, sat down on what appeared to be a big stone, partly covered with sand. … Councillor Turner [Mr Turner's father] expressed the opinion that the head has been buried in the cliff and has been released by the action of the sea." (As reported in "A Hull paper.")	The "fossilised head" turned out to be part of the skull of a young, and quite modern whale. … "The shape [of the skull] is much like that of one side of the head of a hippopotamus" (As reported in "A Hull paper.")	*Mysticete.*	N.A.	
2	Hincks et al. (1954 78)	N.A.	Found in creek in salt marsh.	53.58	0.11	Found in creek in salt marsh.	Skull [of a porpoise.]	*Phocaea phocea*	N.A.	[*Entomogy* series ran across multiple editions, 1951 – 4.]
3	Hardy (1866 32 – 3)	N.A.	Found in the valley of the Don, about 2mi from Tinsley and 4mi from Rotherham, on a line of a railway now in the course of construction.	53.37	-1.35	Met with in excavating, at a depth of 14' UGL, in a bed of gravel overlaid by alluvium.	A large *cetacean* vertebra … one of the lumbar vertebrae of a species of whale, probably identical in genus with the *Balaena*. The bone measured on its largest diameter a little over 10", in thickness 7", in circumference 3'. It presented every appearance of having lain in the earth for a very considerable length of time.	*Balaena*	N.A.	"Mr Hardy" is not otherwise known. ________________ The location is c. 50km from the sea. Definitely a *cetacean*?
4	Waite (1892 167 - 169)	**N.A.**	A large quantity of bones had been found in the Ouse.	53.7	-0.86	A large quantity of bones had been found in the Ouse.	Part of a whale's jaw was found.	Whale *(mysticete,)*	N.A.	Other bones inc,: jaws and skulls of the horse, ox and dog; also a few ribs, vertebrae, and leg-bones. *"The explanation is simple: the dredger was at work on a spot where bones were formerly landed from vessels on their way to Sheffield."*
5	Anon. (1897 50)	1898	In the vicinity of Goole	53.7	-0.87	Dug up in the vicinity of Goole.	Some huge bones … on comparing these with the large whale's skeleton in the Hull Museum, they proved to be part of the bones belonging to the fin of a young whale. They had several grooves and impressions on them,	*Mysticete.*	N.A.	*"No doubt a relic of the old whaling days. … In the neighbourhood of the Humber, and especially around Hull, the lower jawbones of the whale are frequently used a gate-posts, or as ornaments in gardens."*

							evidently made by a plough-share passing over them.			
6	Howes et al. (1954 78)	N.A.	South Bay, Scarborough.	54.28	-0.39	[Washed ashore.]	Part of skull [*B acutorostrata.]*	*B acutorostrata.*	N.A.	
7	Howes et al. (1954 78)	N.A.	Hayburn Wyke.	54.35	-0.44	[Washed ashore.]	8 vertebrae.	*B acutorostrata.*	N.A.	
8	Lofthouse (1887 4)	N.A.	The dredges of the Tees Conservancy Commissioners have at various times brought to the surface semi-fossil remains.	54.63	-1.15	In the Tees.	A single vertebra (of some animal) fully 1' in diameter.	*Mysticete (?)*	N.A.	*Other bones: “a fairly perfect skull of Bos primigenius … part of a very large skull, probably a Mastodon, two very large and perfect deer's horns ...”*
9	Anon. (1907 195)	N.A.	The discovery, at Darlington …	54.51	-1.56	At a depth of 6', immediately below a bed of glacial clay and above the gravel.	A bone 2' in diameter and about 3' long. ... What the verdict may be is impossible to say. Mr Edward Wooler kindly favoured us with a photograph of the “discovery”, and as it was suspected, it turns out to part of the lower jaw of a whale.	Mysticete	N.A.	*"[The bone] will be produced at a meeting of the Farlington Naturalists' Field Club …. [it was] probably part of a gate-post, as 50 years ago hundreds of these were sold for this purpose and distributed over the country."*
10	Embleton (1858 50 - 54)	N.A.	Brought up from time to time by the dredger … at the entrance of Hylton Dene.	54.92	-1.42	From a depth of from 15' to 20'.	A vertebra of a large whale.	*Mysticete (?)*	To be deposited in the Sunderland Museum.	There were in all 25 specimens … 4 imperfect crania of the red deer, several horns of the red deer, 3 imperfect crania of young *Bos longifrons,* 1 fragment adult *Bos longifrons.*
11	Embleton (1858 50 - 54)	N.A.	50.) Certain Marine Store Dealers of Gateshead had got “a great haul of old bones” out of the river [Tyne.]	54.96	-1.6	51.) The bones had been, only a day or two before [my] visit, fished out from the mud of the river bed opposite to the upper part of the site of the great explosion of 1854, having been discovered at very low ebb tide, the lofty cranium appearing above the surface of the water.	50 -1.) I found … the skull, (the lower and some part of the upper maxillary bones were wanting) some caudal vertebrae entire, and some fragments of ribs. In another shop I discovered 6 of the 7 cervical vertebrae, broad, thin and ankylosed into one mass, and a scapula, with perfect and imperfect vertebrae of the back and tail. Some of the bones showed the non-consolidation of their epiphyses to the central part.	The bones appeared to be those of an adult *Hyperoodon (Butzkoff).*	52.) The “haul of old bones” were being rapidly dispersed or broken up … they would soon be converted into “superphosphate”.	*“Opposite to the upper part of the site of the great explosion of 1854.”* This was Bertram's Warehouse, and Wilson & Sons' worsted mill, both c. the older Tyne-Gateshead Bridge, itself close to Stephenson's extant bridge. (Wikipedia, “Great Fire of Newcastle”).

							From so many bones having been found together it may be inferred that the whole skeleton was there. How the skeleton came to the above spot gives room for conjecture. … there were strong traces of vigorous choppings of old date on the right upper maxilla.			
12	Embleton (1858 50 - 54)	N.A.	Extracted from the bed of the river [Tyne], close to the chemical works of Messrs Gray & Crow at Friars Goose.	54.96	-1.56	From the bed of the river. …	The right half of the skull … It corresponds closely in profile and in the relative arrangements of the cranial bones, with the plate of the skull of *Delphinus orca* in Cuvier's *"Ossemens Fossiles"* Vol 2., 223, Fig. 4.	*Orcinus orca.*	Presented to the College of Practical Science … transferred to the Newcastle College of Medicine in 1857.	53.) There can be little doubt that this half skull had been in some previous year brought by a whale ship, and thrown overboard, since it was found opposite to the ordinary berths that were used by whalers. *"Ossemens Fossiles"* is (Baron) Georges Cuvier's *Recherches sur les ossemens fossiles de quadrupèdes* (1812), AKA *Fossil Bones and Geological Catastrophes* (trams. Rudwick 1997).
13	Anon. (1888 274)	N.A.	Found on the rocks at Alnmouth, near Locke's Leap.	55.39	-1.59	Found on the rocks.	Portion of the skull of a whale.	*Mysticete?*	Presented to the Natural History Society. [Newcastle]?	Presented by G H Smart. Locke's Leap is unidentifiable. Presum.: the "rocks" refer to Marden Rocks, C. 1.5km NE of Alnmouth.

8.2. Appendix B. *Cetacean* remains in Firth of Forth.

8.2.1. Preamble.

Through his research, Morris (1925) determined that *"Twenty Whales"* had been discovered in the Carse of Stirling in the 18th , 19th and early 20tth centuries. The author of this thesis has built on that work. The number of *cetacean* bones and skeletons which have been recovered from geological deposits in this part of Scotland is greater than twenty (Fig. 8.2.1). Determining an exact number is not possible: not of all Morris' (1893, 1925) *"Whales"* are what they seem. Skeletons have been split up between museums [WHH] and different names have been used to refer to discoveries at the same locations [AJ] [JQA] [AS]. The same skeletons may have been discovered at discrete instances by unrelated parties [CAA][WM](?), and bones from modern sources [AS][SAS] other animals [JAG] or without provenance [EJK] [DTP] could have been mistaken for ancient *cetacean* remains. All of these inflate the number of *"Whales",* relative to the quantity of actual *cetacean* bones and skeletons. Given the scale of the problem and limited aims of this thesis, only those *"Whales"* directly linked to the aims [BF] [AJ] [TR] [USG] [AJ] [JQA] [AS] [JB] [TWW] [ZT] were evaluated at length.

<u>9.2.2 Tables (Firth of Forth).</u>

9.2.2.1 From Beyond Grangemouth.
9.2.2.2 Grangemouth & Falkirk.
9.2.2.3 Clackmananshire & Beyond.
9.2.2.4 Dunmore.
9.2.2.5 Bridge of Allan.
9.2.2.6 Stirling.
9.2.2.7 Gargunnock & Beyond.
9.2.2.8 Mentieth.

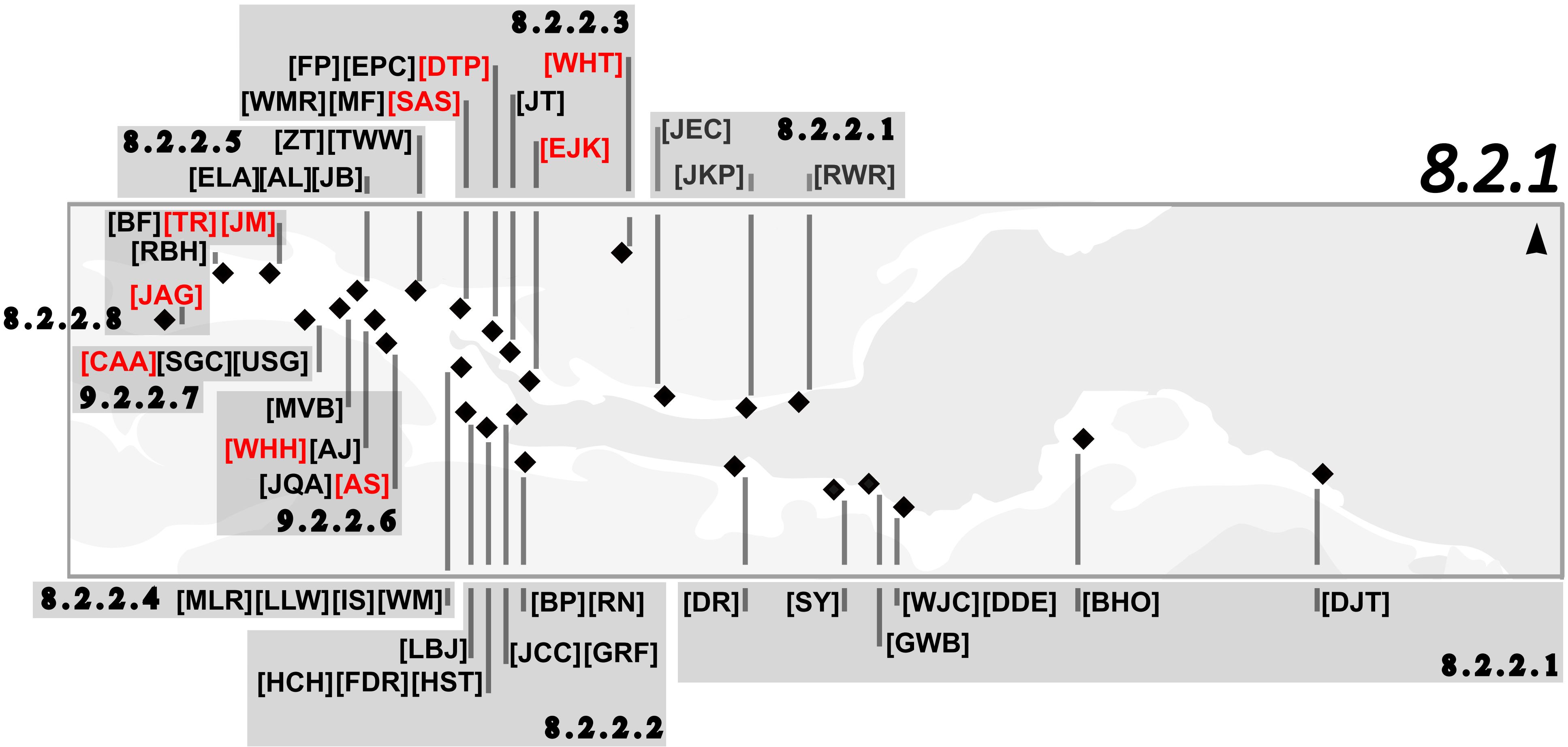

Fig. 8.2.1 Firth of Forth, Scotland. Places, where the remains of *cetaceans* are supposed to have been found. Name in red: bones did not belong to a *cetacean*; bones belong to *cetacean* (modern and introduced); bones belong to a *cetacean* (moved to that location by a human agent); bones belong to a *cetacean* (ancient, but duplicated - bones conserved in multiple places, misunderstanding of a primary source.) Name in black: remains of a *cetacean*, found in a geological deposit (no outstanding problems.)

Table 8.2.2.1

Firth of Forth (From Beyond Grangemouth)

Code:	Psuedonym:	Reference(s)	Sources cited:	Time:	Location & Co:Ordinates:			Posit. Data:	Osteology:	Species:	Fate:	Context:
[DJT]	N.A.	Platt (1936)	N.A.	N.A.	In the Old Pier at Dunbar.	56	-2.51	[The old pier] was damaged during a storm. The skull of a *mystcete* was exposed, 20' above the beach.	Skull of a *mysticete*. It measures 6' (180cm) in width and probably extends at least 10' (304cm) in the pier.	*Mysticete.*	[Still in the Old Pier, Dunar.]	*"One of the fragments of bone found among the fallen debris shows a sawn surface."* *"[the skull] had been incorporated ... and utilised as building material, when the pier was made {c.1650}."*
[BHO]	N.A.	Milne Home (1871 27) Redman (2004)	[Personal obsevation by source.]	N.A.	In the shrubbery or garden, behind Luffness House.	56.01	-2.84	Not above 10 or 12' above **high water.**	Bones of a whale.	"Whale."	N.A.	Redman (2004) inquired at Luffness and got no additional information.
[WJC]	N.A.	Milne Home (1839 66 - 7)	Morton, proprietor of brickworks.	N.A.	Portobello, Morton's Brickyard.	55.95	-3.11	Marine clay, Portobello.	Bones, nearly as thick as a man's thigh, as excited the surprise of the workmen.	That such bones were found, is not unlikely, when it is remembered it was in the Carse clay that whale bones were found at Airthrey etc.	N.A.	Not referred to in any of Milne Home's later books or paprs.
[DDE]	N.A.	Ritchie (1926 96) Herman (1992 39)	Brought by Adam Stoddard.	1925	Found on the Beach at Portobello.	55.95	-3.12	Near the Marine Gardens, where excavations have been ongoing. ... the tooth shows signs of having been imbedded in one of the [distturbed beds.]	A tooth of an aged sperm whale. Its cavity is filled with clayey sand, and the mass, on drying, has become penetrated by deep radial cracks.	*P. macocephalus.*	NMS (NMSZ 1926.67)	
[GWB]	N.A.	Scotsman (8.8.1891) Craig (1893)	[Personal obsevation by source.]	N.A.	Leith Links, in an excavation made during the extension of the new drain.	55.97	-3.16	Under 12' of blown sand. On the thin red clay, overlying the boulder clay.	A vertebra (1) supposed to belong to a whale: water-worn and smooth. (35cm X 30cm X by 13cm)	"Whale." *(mysticete)*	Exhibited by Craig to Ed. Geol. Soc.	Craig's (1893) presentation to Ed. Geol. Soc. Is not fully reported in their own transactions.
[SY]	N.A.	Fleming (1859 76, 79)	"Mr Howkins."	N.A.	Near Granton Harbour.	55.98	-3.22	[in a raised beach.]	Vertebrae and ribs of a whale.	"Whale."	N.A.	John Fleming was hostile to all evidence of recent sea-level change in Scotland, and

												interpreted all raised beaches as deposits from storms.
[DR]	N.A.	West Lothian Courier (7.12.1928) [3] , [8]	N.A.	1928	South Queensferry, near the Reid Memorial Fountain.	55.99	-3.39	Geologically, the site is the section of an ancient raised beach.	The vertebra of whale, [carrying] the remains of a rib. (17.8cm in length, 15.2cm in diameter.)	"Whale." (dimensions presum. Across centrum, not including processes.)	N.A.	Two articles on this discovery ran in the same edition of the newspaper.
[RWR]	N.A.	Aberdeen Press & Journal (3.4.1891) Sprague (1898 43)	John Struthers (not formally published).	1981	In Whitesands Bay, Aberdour.	56.06	-3.28	At no great depth. The sand, which had covered the bones, shifted by backwash caused by the construction of a railway embankment.	15 vetebrae of an immense whale. ... comparatively recent and not fossilised.	Struthers states that the vertebra is that of a razor-back. *(B. physalus.)*	Exhibited to the Ed. Field Naturalist's & Microscopic al Club (Sprague 1898)	John Struthers, Prof. Anatomy at University of Aberdeen.
[JKP]	N.A.	Cunningham (1899 79)	[Personal obsevation by source.]	N.A.	Dug up in the centre of North Queenssferry when making a drain.	56	-3.39	Its [sic] presence there points to the recent elevation of the land.	Large vertebra (1) of a whale.	"Whale."	N.A.	*"Not long ago, I [Cunnigham] was shown the large vertebrae [sic] of a whale, dug up in North Queensferry."*
[JEC]	*"Broomhall Whale"*	Morris (1925) Redman (2004)	Dundee Telegraph (22.2.21912)	1912	In Broomhall Gardens (min. 1/4mi inland).	56.03	-3.48	In an ancient sand bed.	Vertebra (1). (15cm across centrum, 35cm across transverse processes.)	"Whale." (*mysticete?)*	At Broomhall (2004).	Apx. Co-ordinates.

Table 8.2.2.2

Firth of Forth (Falkirk & Grangemouth)

Code:	Psuedonym:	Reference(s)	Sources cited:	Time:	Location & Co:Ordinates:			Posit. Data:	Osteology:	Species:	Fate:	Context:
[JCC]	*"Grangemouth Whale".*	Cal. Merc. (28.3.1840). Falk. Herald (13.7.1840) Begg (1845 12) Milne Home (1847 30) (?) Morris (1925)	N.A.	1840	Found in the new dock at Grangemouth. ... in the course of excavations, at Grangemouth.	56.02	-3.72	20' under the present surface.	Dorsal vertebrae (2). 6' long (15cm) 11' greatest diameter (27cm) 12' side-processes (30cm) 18' top process (45cm).	*Mysticete*.	(1) of which [vertebrae] Mr Grosart presented to the College of Surgeons, Edinburgh.	The sea harbour at Grangemouth expanded has four times (1843, 1859, 1882 amd 1906). The "New Dock" is now the oldest.
[GRF]	N.A.	Turner (1912 10 - 11)	Donald Arbruthnott, Engineer.	1903	[Found] at the new dock at Grangemouth. ... at the point where the R. Carron debouches on the estuary of the Forth.	56.03	-3.69	30' below the surface .... [the bones lay on] a bed gravel 2' - 3' thick, composed of roundish boulders, dipping into the Forth.	Numerous bones (horrse, sheep, dog.(see Cossar Ewart 1913 168.) ... Left mandible of a whale with sockets for teeth.	*Orca gladiator.*	Smith Museum (Stirling): madinble (19656.01) and rib (19656.02)	D. B. Morris brought the *cetacean* bones to the Smith Museum but does not list this case among the *"Twenty Whales."* (Morris 1925). Arbruthnott describes Bothkennar Gravel? (Peacock 1998)
[HST]	*"Falkirk Whale."*	Monmouthshire Beacon (22.2.1840) Cal. Merc. (28.3.1840). Begg (1845 12) Morris (1925)	N.A.	1840	Workmen [at Mr Smith's brickfield] near Grangemouth, dug up a large fossil bone. At the Earl of Zetland's brickfield, 3mi from the sea, at Lock No. 3.	56.01	-3.75	2' 1/2 below the surface ...The stratum [of clay] is 8' – 9' above **high water mark.** 18" below the surface.	A large fossil bone. The vertebra (1) of a wahle [in a very dry state, and a third of it decayed.] The bone is 9' long and 9' at its greatest diameter (23cm X 23cm).	"Whale".	N.A.	"John Smith" is named as the manager of the "Kerse Tile Works (Pigots Comercial Directory; Anon. 1837 771.) Per the NSA for Falkirk (Begg 1845) *"Kerse"* is the name given to the estates of the Earls of Zetland. "Smith's Brickfield" and the "Zetland Brickfield" are the same.
[HCH]	N.A.	Carmichael (1835 12) Cal. Merc. (28.3.1840). Falkirk Herald (13.7.1848)	N.A.	"some years ago."	At Smith's Brickfield [Grangemouth.]	56.01	-3.75	About 5' below the surface.	There was discovered a "full skeleton" [of a *cetacean*] some 9' long, supposed to be of the porpoise species.	"Porpoise" (*odontocete?*)	N.A.	For "Smith's Brickfield", see [HST]
[FDR]	N.A.	Falkirk Herald (13.7.1848)	N.A.	"some years ago."	At Smith's Brickfield [Grangemouth.]	56.01	-3.75	About 5' below the surface. At a different place to the "skeleton of the porpoise" [HCH]	Skeleton of a whale.	"Whale."	N.A.	For "Smith's Brickfield", see [HST]
[BP]	N.A.	Collections of Falkirk Council	Cleddan & Keppie	N.A.	"Fire Trench Excavation, BP	56	-3.67	Found c. 8' below the ground, in	Vertebra of whale (1).	"Whale."	Falkirk Collections	Apx. Co-Ordinates. Cleddan & Keppie (1981).

		Area (Online Catalogue).	(1981).		Chemical Works."			carse clay.			(AN 1981-027-001.)	concerned Roman forts and did not mention this vertebra.
[RN]	N.A.	Falkirk Herald (21.3.1956)	N.A.	1955	Last year about this time, the [sewer laying operations] at Beancross [2mi inland] were more successful.	55.99	-3.72	N.A.	The vertebra (1) from the spinal column of a whale was found, two miles inland.	"Whale"	N.A.	Apx. Co-Ordinates. Falkirk Herald (21.3.1956) concerned the excavation of a horse's skeleton in that year, mistaken to be ancient. The reference to the *cetacean* vertebra [RN] was retrospective. No notice of discovery from 1955 is known.
[LBJ]	N.A.	Cal. Merc. (3.1.1824), (28.3.1840).	N.A.	C.1790	Coble Brae [a farmhouse] to the east of Carron Bridge, is built upon a whale's back. There was found, w[when clearing the foundation of a building].	56.02	-3.79	3' underground.	Immense bones, found to be the vertebra of the spine. ... The skeleton of the great animal yet remains. *Ex pede Herculuem* [it] was 30' – 35' long.	"Whale".	Except the bones it was neccessary to take up, the skeleton yet remains [at Coble Brae.]	
[JFK]	*"Grangemouth Whale"* (erroneous).	Burns (1869 367) Milne Home (1871 26) (?) Morris (1893)	N.A.	N.A.	[Burns exhibited] part of a vertebra, found in a bed of clay [in the Carse of Falkirk.]	-	-	9' from the surface, 12' above present **high water mark.**	A vertebra (1) of a whale.	"Whale."		Not plotted. Morris (1893) believed that Burns (1869) and Begg (1845) were describing the same set of *cetacean* remains. Burns is describing a discovery, where the land surface elevation is min. 9.4m ODN (0m ODN + 3m [HWM] + 3.65m [vtbr] + 2.7m). Begg described a discovery at Grangemouth Harbour (3m ODN.)

Table 8.2.2.3

Firth of Forth (Clackmannan & Beyond)

Code:	Psuedonym:	Reference(s)	Sources cited:	Time:	Location & Co:Ordinates:			Posit. Data:	Osteology:	Species:	Fate:	Context:
[JT]	N.A.	(Bald 1821 125 – 6). Dunferm. Sat. Press (5.3.1864)	[Personal obsevation by source.]	c. 1816	At the foot of Clackmannan Hill.	56.1	-3.76	[Found] upon the rock head, in a bed of sand and oyster-shells, under a cover of clay.	Some very large bones. From the size, the animal must hav ebeen min. 30' in length. Adjoining these [bones] two teeth, above 5' in length.	These bones are supposed to belong to the "Whale", or "Grampus" tribe. *(odontocete).*	Exhibited to Wernerian Society. Bald's fossil collection acquired by the Alloa Nat. Hist. Soc. In	Bald's (1821) paper read on (1.5.1819). Four months later, the same man excavatess and publishes notices, on the discovery of the *"Airthrey Whale"* [ZT] without once mentioning this earlier discovery, at "*Clackmannan Hill"* [King's Seat Hill]?

											1864.	Alloa Nat. Hist. Soc. Museum dissolved in 1930.
[MF]	N.A.	Alloa Adv. (13.3.1869). Alloa Adv. (29.5.1889)	[Personal obsevation by source.]	1869	The low ground along the river side [between Blackgrange point and Cambus.] were flooded by the late high tide. As the water receded [at the farm of Blackgrange].	56.11	-3.85	The skeleton must have been buried under 10' of alluvial soil. [This is reclaimed ground. A retaining wall on the tidal forsehore trapped sediment at high tide. It was incrementally raised in height. The skeleton [MF] was deep enough, to be at the base of the artificial seds.]	"[The bones] had been thrown aside by the workmen, as worthless. The skull (2' long, 60cm) 3' 8" in circuference [sic] (110cm) 1 of the bones of the lower jaw, in which the cavities for teeth are well marked, 2 vertebra, 1 scapula, some of the ribs..	The skeleton appears to remeble the grampus. *(Odontocete.)*	Presented to the Alloa Nat. Hist. Soc. In 1869.	Alloa Adv. (13.3.1869) reports on the discovery of the bones at Blackgrange. Alloa Adv. (29.5.1889) reports on Duncanson's presentation and donation of those bones, to the Alloa Nat. Hist. Soc. The two sources give conflicting accounts on the circumstances of discovery. The former: the "flood" eroded a channel and the bones were in the bottom. The latter: workmen cut a channel to release impoounded floodwaters, findng the bones. Alloa Nat. Hist. Soc. Museum dissolved in 1930.
[SAS]	N/A.	Turner (1912 110 – 111) Herman (1992 24)	[Personal obsevation by source.]	1880	In a field at Orchard Farm, near Tullibody House … 20yd from the embankment.	56.11	-3.82	about 20' (50cm) from the surface.	No. (3) skull (52cm broad) and (No 6.) block of cervical vertebrae.	Killer Whale *(O. Orca.)*	Anatomical Museum, then NMS: (NMSZ 1990.84.)	*"Probably stranded and buried in the field."* Turner (1912 110) is probably correct: at this location, the land has been reclaimed.
[EPC]	N.A.	Alloa Adv. (27.7.1889) Edin. Ev. News (27.71889) Gla. Ev. Post (6.8.1889) Alloa Circ. (31.7.1889)	James Ferguson Lyon.	1889	Excavating on the site of the "old mill" (Messrs J Paton, Sons & Co.). ... In preparing the foundations for a new building. ... in the vicinity of the "old bridge burn."	56.11	-3.78	[the workmen found] covered in rubbish [sic] in the cavity of a rock adjacent to the bed of the old Town Burn ...	Parts of a huge skeelton of some animal. The upper part of the head, 2' across (60cm). The rib 3' 10" in length (115cm).	The remains of a marine reptile, known as the icthyosaurus. The skull closely resembled [one of *Icthyosaurus communis*] in the museum of the Earl of Enniskillen. [Identification by J F Lyon.]	Added to Lyon's *"already very important museum"*, later presented to the Alloa Nat. Hist. Soc. Museum Alloa Nat. Hist. Soc. Museum dissolved in 1930.	Many problems. Paton's Mill, or Kilncraigs Mill (Alloa): grew reapidly in the 19th century into a complex of warehouses, mills, sheds etc. the "Old Mill" is a specific building by "the old town burn [now under a culvert]. Per Sproat et al (2004), no construction done there in 1889. Foundations for these buildings were blasted from the bedrock: the "rubbish" may have been "rubble." This rock is Carboniferous (350mya) – the largest vertebrates in these units are c. 10cm long (Clack et al. 2022.) I*cthyosaurus* lived from the Jurassic (c. 200 mya.) The remains poss. Belonged to an *odontocete?*

[FP]	N.A.	Alloa Adv. (6.6.1908)	James Ferguson Lyon.	N.A.	[...Next I (Alex. Wilson) show:] Whale bone, from Forbes St. Drains, similar to the many whale remains found in alluvial deposits of our valley.	56.11	-3.8	[alluvial deposit.]	"Whale bone."	"Whale."	In J F Lyon's collections. Presented to the Alloa Nat. Hist. Soc. Museum	J F Lyon donated his personal collection of geological specimens to the Alloa Nat. Hist. Soc. In 1908. In appreciation, the secretary (Alex Wilson) presented the best parts. [no reference here, to the *"Ichthyosaur"* found at Kilncraigs in 1889 [EPC].) Alloa Nat. Hist. Soc. Museum dissolved in 1930.
[WMR]	*"Cambus Whale."*	Morris (1893) Morris (1923) Morris (1925)	Wilson (1851 33) Wilson (1863 49)	1819 – 1824 (erroneous)	I [Morris] have been informed of the finding of [whale remains] at Cambus, but can get no definite information (1893). Mr John Robertson, Dunblane, tells me [Morris] that his maternal grandfather , who lived at Menstrie, used to tell him that he was at digging out of a whale's skeleton, somewhere, according to Mr Robertson's recollection, in the Cambus district. [not the *Airthrey Whale*, being well-known.] (1923) In a locality now forgotten. Somewhere between Airthrey and Cambus. (1925).	56.12	-3.84	*I* [Morris, 1923] *have found the following reference* (in Wilson 1851 33)*:* "In the carse lands, there was discovered in the year 1819 the skeleton of a whale with a perforated lance or harpoon beside it. [ZT] ... A few years later another whale was found, and in 1824 a third was discovered on the Blair Drummond estate [BF]." *I* [Morris] *have failed to trace the second whale referred to. I suggest this may be the one at Cambus [WMR]."*	"Whale skeleton."	"Whale."	N.A.	John Robertson (1851 – 1931), caretaker an librarian of the Dunblane Institute. (obit. In Dundee Courier 18.2.1928). Wilson (1851 33) and Wilson (1863 49) are the 1st and 2nd editions of *"Prehistoric Annals":* the first book to systematically organise Scottish archaeological material into the Stone, Bronze, Iron Ages. In the second edition, Wilson (1863 49) is clearer about the *"Whales"* , that he was really alluding to: 1. *"Discovered in 1819 with a lance*" cited to Bald (1819) [Airthrey Whale, [ZT].] 2. *"Another whale, disclosed a few years later"* cited to Reddoch (1824). [Dunmore Whale, [WM].] 3. *"The 3rd skeleton, found in 1824"* cited to Home Drummond (1826) [Blair Drummond Whale, [BF].] Therefore: Wilson (1851, 1863) is not referring to *"Cambus Whale."* [WMR]. Robertson's grandfather likely "dug out" this skeleton, before 1819.
[DTP]	"*Longcarse Whale."*	Alloa Adv. (11.3.1899)	James Ferguson Lyon.	N.A.	'Mr Lyon stated that the [Alloa Nat. Hist.] Society had in its museum … a whale found at Longcarse (not mentioned by Morris (1893.).	56.11	-3.82	N.A. [found at Longcarse].	The skull of a "whale."	*Whale*	In the Alloa Nat. Hist. Soc. Museum	Morris read "Raised Beaches (ibid. 1893) to the Alloa Soc. In 1899. Lyon brought some *cetacean* bones to his attention ([DTP]. [EJK]. but not the "grampus" found at Blackgrange, [MF].) Morris (1923, 1925) never alludes to these bones

												himself. Were not fossil? Alloa Nat. Hist. Soc. Museum dissolved in 1930.
[EJK]	*"Kinkardine Whale."*	Alloa Adv. (11.3.1899)	James Ferguson Lyon.	N.A.	'Mr Lyon stated that the [Alloa Nat. Hist.] Society had in its museum … a whale found at Kinkardine (not mentioned by Morris (1893.).	56.06	-3.71	N.A. [found at Kinkardine].	The scapula of a "whale."	*Whale*	In the Alloa Nat. Hist. Soc. Museum.	Morris read "Raised Beaches (ibid. 1893) to the Alloa Soc. In 1899. Lyon brought some *cetacean* bones to his attention ([DTP]. [EJK]. but not the "grampus" found at Blackgrange, [MF].) Morris (1923, 1925) never alludes to these bones himself. Were not fossil? Alloa Nat. Hist. Soc. Museum dissolved in 1930.
[WHT]	N.A.	Murdoch (1886 200)	N.A.	1886	In the neighbourhood of Rumbling Bridge (150m ODN.)	56.18	-3.54	Dug up from under a bed of peat, at a depth of 10'. ... Higher above the sea, that whale remains had previously been discovered at.	The caudal vertebral bones of a *cetacean*.	*Cetacean.*	N.A.	Relative sea-level never rose to this altitude (c. 150m ODN). The remains of this *cetacean* cannot have reached Rumbling Bridge naturally.

Table 8.2.2.4

Firth of Forth (Dunmore)

Code:	Psuedonym:	Reference(s)	Sources cited:	Time:	Location & Co:Ordinates:			Posit. Data:	Osteology:	Species:	Fate:	Context:
[IS]	No. 9. "Dunmore Whale 1."	Morris (1893, 1925)	MacGachen (1845)	1817	Dunmore	56.08	-3.78	N.A.	Skeleton	Whale	N.A.	Apx. Co-Ordinates.
[LLW]	No. 10. "Dunmore Whale 2."	Morris (1893, 1925)	Milne Home (1871 26) Milne Home (1872 32) Richard (1839)	1846	Dunmore	56.08	-3.78	N.A.	Skeleton	Whale	N.A.	Apx. Co-Ordinates. Morris cites (Wilson 1851). [*Prehistoric Annals.*] Wilson (1851) was actually citing (Owen 1846). Owen was actually citing Richard (1839).
[MLR]	No. 11. "Dunmore Whale 3."	Morris (1893, 1925)	Milne Home (1871 26) Milne Home (1872 32)	1857	Dunmore	56.08	-3.78	N.A.	Skeleton	Whale	N.A.	Apx. Co-Ordinates.
[WM]	No. 18. "Dunmore Whale 4."	Morris (1925)	Reddoch (1824)	1824	Dunmore	56.08	-3.78	N.A.	Skeleton	Whale	N.A.	Apx. Co-Ordinates.

N.B. Dunmore: With the evidence available to him, Morris (1925) believed that four discrete sets of *cetacean* remains had been discovered at four discrete locations in and around Dunmore Park (now, in Falkirk District.) His case for this is based, primarily, on the four different dates of discovery (1817, 1846, 1857, 1824). Therefore, he may be mistaken: some of his cited sources (Milne Home 1871, 1882; Reddoch 1824; MacGachen 1845) could have been referring to different instances of discovery, of the same *cetacean* skeletons. There is a critical inconsistency in the dates reported by Milne Home in *Estuary* (1871) and *Water-Lines* (1882) and, furthermore, many documents that Morris (1893) did not have available to him report different details, about Dunmore: (Blackadder 1826ab, Blackadder's *Geognostical Map* (1826), Blackadder & Murray 1824, Morning Avertiser 29.4.1824; Falkirk Herald 13.7.1848; Cal. Merc. 23.3.1840; Alloa Advertiser 27.6.1863; Alloa Advertiser 5.3.1864). Working out who is referring to what, discovered where, and at what time, is beyond the scope of this project. Morris' (1925) conclusion - that there are four discrete "*Dunmore Whales"* - is respected.

Table 8.2.2.5

Firth of Forth (Bridge of Allan)

Code:	Psuedonym:	Reference(s)	Sources cited:	Time:	Location & Co:Ordinates:			Posit. Data:	Osteology:	Species:	Fate:	Context:
[ZT]	[redacted]											
[TWW]	[redacted]											
[JB]	[redacted]											
[AL]	N.A.	Bryce (1873 194 - 7)	Inhabitants of Bridge of Allan, also a “Dr Cambell”; Rev, James Muir.	N.A.	The lower part of the village of Bridge of Allan is situated upon the alluvium of the Forth Valley, n which, as far up from the present channel of the river [Forth?] as the streets of the lower part of the village, skeletons of whales have been found.	56.15	-3.94	Alluvium of the Forth Valley [i.e. Carse.]	Skeletons of Whales.	*Whale*	N.A.	Bryce (1873) possibly only alluding to the *B. physalus* skeleton, discovered at Christie's Brickyard (Cornton.) However, the "lower part of Bridge of Allan" was about 2km distant from there, and also built on the carse.

Table 8.2.2.6

Firth of Forth (Stirling)

Code:	Psuedonym:	Reference(s)	Sources cited:	Time:	Location & Co:Ordinates:			Posit. Data:	Osteology:	Species:	Fate:	Context:
[AJ]	[redacted]											
[WHH]	[redacted]											
[AS]	[redacted]											
[JQA]	[redacted]											
[MVB]	N.A.	Stirling Journal (8.6.1854) Alloa Adv. (14.2.1883)	N.A.	1854	The farm of Kildean, Craigforth. ... At Craigforth, near Stirling.	56.13	-3.96	Ehumed by labourers engaged in draining. ... some 6' below the surface, on blue	A large bone, which appears to the scapula of a *cetaceous* animal. ... the scapula of a	*Whale.*	"in the hands of Hugh McColl, gardener at Craigforth.	Apx. Co-Ordinates. Tempting to match the scapula (19653.02) in the Smith Museum, with the one described

								silt.	small whale.		His well-known affability will place it in the power of any visitor to examine it.	here. However, there are no means to link the two (e.g. dimensions, proof that McColl's bone went to the MacFarlane (Stirling) or Smith Instute collections. the fate of McColl's scapula (d. 1860; Alloa Adv. 23.4.1860) is still unknown. The origins of the scapula (19653.02) are still uncelar.

Table 8.2.2.7

Firth of Forth (Gargunnock & Beyond)

Code:	Psuedonym:	Reference(s)	Sources cited:	Time:	Location & Co:Ordinates:			Posit. Data:	Osteology:	Species:	Fate:	Context:
[USG]	[redacted]											
[CAA]	N.A.	Jamieson (1865 188-9)	N.A.	1866 or before	These Carse-lands are plains of fine silty clay, identical with the sediments now forming along the shallows of present estuaries. ... Three or four instances have occurred of remains of the Whale in this Carse-clay of the Forth, namely at Dunmore [WM], Airthrey [ZT], Blair Drummond [BF], and Micklewood.	56.13	-4.04	In the carse clay.	Remains of the "Whale."	Whale.	N.A.	Apx. Co-Ordinates. A *B. phyaslus* skeleton was discovered at Woodyett, on the Meiklewood estate in 1877 [USG]. Jamieson's (1865) allusion to *"the remains of the Whale ... at Micklewood* [sic]*"* occurred more than a decade before that. Plausibly: more than one set of *cetacean* remains have been discovered on the estate of Meiklewood. Conservatively: part of the skeleton [USG] may have been found, on more than occasion.
[ATS]	N.A.	MacLagan (1875 55)	[Personal observation.]	c. 1875	... Both the [*cetacean*] skeletons [ZT] and [BF], and one now partly laid bare, lie only 4' below the surface.	-	-	only 4' below the surface [of the carse]. Found in close neighbourhood to the skeleton of of a quadruped, which turned out	Skeleton of a whale.	whale	N.A.	Not plotted. A *B. phyaslus* skeleton was discovered at Woodyett, on the Meiklewood estate in 1877, 4' under the surface. MacLagan's allusion to a *"skeleton, now partly laid bare"* occurred two years before that.

								to be only a dead calf buried by the owner."				No other reference to a discovery in the period 1870 – 1875 (i.e. while MacLagan was writing) is known.
[SGC]	*"West Carse Whale."*	Morris (1893, 1925) Milne Home (1871, 1882)	Postmaster Forsyth. James Johnston (via his grandfather.)	1787 1817	On the farm of West Carse, on the Touch Estate. ... partly under the road and partly under the field to the south, [where] there is a slight hollow: a field's breadth to the east of West Carse Farm Steading. (Morris 1893) 4mi west of Stirling, viz. Near Gargunnock.	56.12	-4.03	The skeleton lay NW and SE, at a considerable angle to the road ... found when the turnpike [road] from Stirling to Gargunnock was being formed.	The skeleton of a whale ... 50' long.	*Whale (mysticete.)*	N.A.	Morris (1893) assumes that his informant (James Johnston) and Milne Home's (1871) (Postmaster Forsyth) are describing the same set of remains. There are inconsistencies. Milne Home describes the same place [4mi west] in *Estuary* (1871) and *Water-Lines* (1882) but gives a different date of discovery (1878, 1817). On the map to *Estuary,* the only "W" plotted near to Gargunnock is at Kepdarroch, c. 6 -7mi W of Stirling.

Table 8.2.2.8

Firth of Forth (Mentieth)

Code:	Psuedonym:	Reference(s)	Sources cited:	Time:	Location & Co:Ordinates:			Posit. Data:	Osteology:	Species:	Fate:	Context:
[BF]	[redacted]											
[JM]	[redacted]											
[TR]	[redacted]											
[ELA]	N.A.	Hately Waddell (1876 199)	N.A.	"Many years ago."	At Lecopt.	56.15	-4.12	N.A.	The skeleton of a whale.	*A whale.*	N.A.	Unconventional source. Hately-Waddell (1876) is presenting evidence for recent sea-level change in Scotland, to support his argument that Fingal was a actual historical figure and that the poems of *Ossian*, widely regarded to be 18th c. fabrications, were legitimate ancient Celtic poems.
[RBH]	*"Ballinton Whale."*	Morris (1925)	MacGregor Stirling (1815)	N.A.	[181] "The tradition is, that all that country where this	56.15	-4.12	N.A.	*"some prodigious big bones, which by their bigness,*	*A Whale.*	*"In my Lord Napier's House of*	Morris (1925 139) attributes the report to MacGregor Stirling

			Graham (1724 181). apx. In MacGregor Stirling 1815.)		moss [Flanders] lyes, was once under water, up to the hill of Gartmore. *In some places, in the casting of peats, there have been found some prodigious big bones...*				*cannot be supposed to be any thing else but bones of whales."* *"There is one [bone], ... supposed to be the joint of a whale's back."*		*Ballanton."*	(1815) rather than to Alexander Graham (1724).
[JAG]	*"Cardross Whale."*	Morris (1925)	MacGregor Stirling (1815) Graham (1724 182 -3). apx. In MacGregor Stirling 1815.)	1660, 1724.	the river Forth, near the house of Cardross, in summer 1723, there was a big bone found, being by appearance, the ark-bone of aquadrupede. ... This bone I lately saw, and took dimensions of (Graham 1724). Cardross Whale. Stated to have been found at various times, 1660 - 1723. Possibly there was more than one whale. (Morris 1925).	56.15	-4.24	In the river Forth.	In 1723, an ark bone. Before 1660, a shank-bone. Before 1689, a thigh bone of such bigness, a man could have put his leg in it. all these bones were of one beast, and it was a four-footed horned beast. What kind of beast it was, I leave the curious to judge. (Graham 1724) A whale. (Morris 1924.)	*N.A.*	N.A.	Morris (1925 139) attributes the report to MacGregor Stirling (1815) rather than to Alexander Graham (1724). It is unlikely that Graham (1724) has described, measured, or handled any *cetacean* bones here. *"Whales"* do not have legs.

8.3 Appendix C: Mapping Data.

Table 8.3.1.

Figure:	Additional References	
(4.1.1a - b)	"1"	*Bos taurus* horn (1). Smith (1872 629)
	"2"	*Bos taurus* horn (1). Smith (1872 629)
	"3"	*Bos taurus* horn (1). Smith (1872 629)
	"4"	Cervid *(Dama dama)* antler (1). (Haswell 1865 182; Scotsman 3.2.1865).
	"5"	Cervid *(Cervus elaphus)* antler (1). (Haswell 1865 182; Scotsman 3.2.1865).
	"6"	*Bos taurus* skull (1). Smith (Haswell 1865 182; Scotsman 3.2.1865).
	"7"	*Equus caballus* mandible (1) (Haswell 1865 182; Scotsman 3.2.1865).
	"8"	*Equus caballus* pelvis (1) (Haswell 1865 182)
	"9"	Cervid *(Cervus elaphus)* skull & antlers (1) (The Scotsman 15.7.1837; Milne Home 1839 308; Caledonian Mercury 19.8.1840; Beith et al. 1845 308; Stirling Observer 7.1.1858).
	"10"	*Bos taurus* horn (1). (Munro 1899 62 - 3)
	"11"	*Bos taurus* horn (1). (Munro (1899 62 - 3)
	"12"	Cervid *(Cervus elaphus)* antler (1). (Munro 1899 62 – 3; Turner 1912).
	"13"	Fish (N.A.) skeleton (1). Lothian (1864).
(4.3.1.)	N.A.	
(4.3.2.)	N.A.	
(4.3.3.)	N.A.	
(4.3.4.)	N.A.	
(4.3.5)	N.A.	
(4.4.1.)	N.A.	
(4.5.1.)	N.A.	
(4.5.2.)	N.A.	
(4.5.3.)	N.A.	
(4.5.4.)	OS 6' Stirlingshire Sheet 9 (1865). OS 6' Stirlingshire Sheet 9 (1899) OS 25 Perth & Clackmannanshire' Sheet 132.9 (1900)	
(4.5.5.)	N.A.	
(4.5.6.)	N.A.	
(4.5.7.)	N.A.	
(4.5.8.)	N.A.	

(4.6.1.)	Stirlingshire 25' Sheet 17.3 (1863) Stirlingshire 6' Sheet 17.NE (1899) OS Plan 1:1250 NS 8094 SW (1952) OS Plan 1:1250 NS 7994 – A (1953) OS Plan 1:1250 NS 7894 & Plan NS 7994 – BB (1869)	
(4.6.2.)	N.A.	
(4.6.3.)	N.A.	
(4.6.4.)	N.A.	
(4.6.5.)	N.A.	
(4.6.6.)	N.A.	
(4.8.1.)	N.A.	
(4.9.1.)	N.A.	
(4.9.2.)	N.A.	
(4.9.3.)	OS Stirlingshire 6' Sheet 10 (inset 11) (1865) OS Stirlingshire 25' Sheet 10.11 (1898) OS Stirlingshire 25' Sheet 10.15 (1898) OS Stirlingshire 25' n11.11 (1918) OS Stirlingshire 25' n11.15 (1947) BSG Borehole. I.D: 19536564	
(4.9.4.)	N.A.	
(4.9.5.)	N.A.	
(4.9.6.)	N.A.	
(4.9.7.)	"1."	BGS ID: 18665788
	"2."	BGS ID: 780839
	"3."	BGS ID: 780940
	"4."	BGS ID: 780944
	"5."	BGS ID: 780792
	"6."	BGS ID: 17751962
	"7"	(Milne Home 1871 15)
	"8"	BGS ID: 20950278
	"9"	This study. Co-Ordinates: (56.142893° -3.946670°). Land Surface Elevation: (8.65m ODN)
(4.9.8.)	N.A.	
(4.10.1.) (4.10.3.)	OS Stirlingshire 25' Sheet 10.12. (1864) OS Stirlingshire 25' Sheet 10.16. (1864) OS Perth & Clackmannanshire (det.) 25' Sheet 133 (1864) OS Perth & Clackmannanshire (det.) 25' Sheet 139 (inset. 132.16) (1864) OS Stirlingshire 25' n11.15 (1918)	

	OS Plan 1:1250 NS 8095 8195 - AA (1960) OS Plan 1:1250 NS 8095 SE (1959) OS Plan 1:1250 NS 8095 SE (1952) OS Plan 1:1250 NE B (1959) OS Plan 1:1250 NS 8095NE (1952) (Smith 1965 48)
(4.10.2.)	N.A.
(4.10.4.)	N.A.
(4.10.5.)	N.A.
(4.11..1.)	Kemp (1972): Boreholes 529, 526, 524, 378, 379, 380, 382. Smith (1965) Levels S.237, S. 238, S. 240, S. 241.
(4.11..2.)	N.A.
(4.11..3.)	N.A.
(4.11..4.)	N.A.
(4.11..5.)	N.A.
(4.11..6.)	N.A.

9.4. Appendix D – "Skeleton of a *Balaenoptera*, Supposed to Have Been Found in Christie's Brickworks (Stirling Shore) in 1863.

[WHH] – *"Mr Milne Home stated in his work,* The Estuary of the Forth, *that in **1859** bones of a whale were found in Christie's brickfield, Stirling but no details were given. In **1863**, in the same field, called Cow Park, a large part of a skeleton was exposed. [The bones] were given to the Corportation of Stirling, who some years afterwards presented them to the Anatomical Museum of the University [of Edinburgh]. They were much broken, but I have succeeded in piecing together fragments of the skull and of the mandible ...*

Sir William Turner, Professor of Anatomy (later Principal of the University of Edinburgh.) (1912 8 - 9) *The Marine Mammals in the Anatomical Museum of the University of Edinburgh.*

9.4.1. Chain of References.

Two discrete and complete *mysticete* skeletons are alleged to have been found, in very short succession, at Christie's Brickyard (Stirling) (Milne Home 1871, 1882; Turner 1912; Morris 1893) [AJ] [WHH]. Clark (1947) and Smith et al. (2010) accept this without query, despite clear confusion over what is supposed to have been discovered, and in which years.

At least one *Balaenoptera* skeleton was found at that location. It then underwent partition on two known occasions (1880, 1960) into three separate assemblages, now held in three discrete museums: The Smith Museum, The Anatomical Museum of Edinburgh University, and the National Museum of Scotland (NMS). All three institutions assert that the remains of the *cetacean*, now shared between them, had been discovered in 1863. Working in reverse:

10. (1991) *1st left rib (bicipital). Presented [to the National Museum of Scotland] by the University of Edinburgh. Presented to [University of Edinburgh] by the Corporation of Stirling. Excavated in Cow Park, Stirling, Scotland, **1863**.* (Herman 1991 51, *Catalogue of Cetacean Specimens in the NMS.*)

9. (1912) "*Mr Milne Home stated in his work,* The Estuary of the Forth (1872), *that in **1859** bones of a whale were found in Christie' Brickfield, Stirling,* **but no details were given**. *In **1863**, in the same field, called Cow Park, a large part of a skeleton was exposed. **[The bones] were given to the Corportation of Stirling, who afterwards presented them to the Anatomical Museum** of the University [of Edinburgh]. I [pieced together] the skull, the mandible, and [the 1st left rib (bicipital).]* (Turner 1912 8, 68 - 9 *Marine Mammals.*)

8. (3.1880). *"The Committee met in the Buttermarket, Stirling and inspected the* [cetacean] *skeleton. ... **Mr Croall thought there was nothing to prevent them complying with Professor Turner's request*** **[for the diagnostic elements.]** *He would be glad to take a few of the* [remaining] *bones for preservation in the Smith Institute."* (Stirling Observer 18.3.1880. *Stirling Town Council, Works Committee: Skeleton of Whale.*)

7. (2.1880) *"Mr Thompson ...stated his attention had been called to **the remains of the whale lying in the old Burgh Buildings*** [by Professor Turner. He asked if the Council would be willing to allow the bones to be transferred to the Amatomical Museum of the Edinburgh University.] *Thompson*

instructed Mr Ronald to remove them into the Butter Market [opposite the Burgh Buildings] *for examination.*

[the skeleton of the whale] *was got in the brick-work belonging to ex-Provost Christie's father.* ***It had been lying up in the attics of the old Burgh Buildings for fifteen or sixteen years****, and was then removed to one of the cells of the old guardroom. It was 50' long ...* (Stirling Observer 19.2.1880. *Stirling Town Council, Skeleton of Whale.*)

6. (1874) *"I was not a little interested in seeing a* ***cart-load or more of the bones of [a] whale*** *carefully preserved, and* ***piled up on the floor*** *of an attic room entered from* ***Broad Street Steeple*** **[I.e. Burgh Buildings, Stirling**.] (William Harvey to the editor of the Stirling Obsever, *The Cornton Whale*. Stirling Observer 7.8.1874.)

5. (1872) *"At Stirling, in the year* ***1859****, a whale about 40' was found in a field now occupied by Mr Christie's brickwork."* (Milne Home, *Estuary of the Forth* 1872 26).

4. (1864) *"It is worthy of notice that in* ***December 1857****, while the men employed in Mr Christie's other brick and tile work near the Shore were excavating clay, they came upon the vertebrae of a whale. The remains of this whale are* ***now deposited in the Town-House*** **[Burgh Buildings**]*, where they can be seen. The skeleton is upwards of 38' in length."* (Lothian 1864, *Cornton Whale*).

3. (1860). *"The skeleton of a whale was lately dug up [in the vicinity of the boat pier.] It was examined by* ***Dr Allman, Professor of Natural History*** *in the University of Edinburgh. The bones have been carefully* ***deposited in an apartment of the Town-House*** [Burgh Buildings]. (Rogers 1860 37 – 8, *Day at the Bridge of Allan.*)

2. (5.1858) *"At the request of Dr Rogers,* ***Dr Allman visited Stirling*** *to inspect the cetaceous remains excavated in the clay field adjoining Mr Christie's brick-work at the Shore. He found the whale to have been about 40' in length. ... the most complete specimen of the fossil whale in North Britain."* (Stirling Observer **20.5.1858**. *Local News: The Fossil Whale.*)

1. (1.1858) *"Some days ago, the men in the employment of Mr Christie (Sr), Shore, came upon the vertebrae of some large animal – in all probability, a whale. Mr Christie (Sr) has already intimated his intention of* ***presenting [the bones] to the town of Stirling****."* (Stirling Observer **7.1.1858**. *Local News: Skeleton of a Whale Discovered.*)

Therefore: the remnants of the 40' - 50' *Balaenoptera* whale, split between the NMS and the Anatomical Museum in 1960 and between Anatomical Museum and Smith Institute in 1880, can be traced via Stirling's Butter Market to the Burgh Buildings. Until that time, the skeleton had lain in one or another part of that building since at least the year 1860 (Rogers 1860 38). Ultimately, it had been excavated and examined by George Allman, Professor of Natural History at the University of Edinburgh, in 1858 [AJ].

Once that mix-up is resolved, a major issue remains [WHH]. What happened in 1863? What evidence exists that another unique and discrete *cetacean* skeleton was ever discovered in exactly the same location? A fourth museum - MacFarlane's Museum (Stirling) - is no longer extant and at the heart of the problem. The Smith Institute and Edinburgh University's Anatomical Museum are, themselves, unusual places to find the bones of fossil *cetaceans*.

9.4.2. Anatomical Museum of the University of Edinburgh.

Scotland's world-renowned medical tuition produced an extraordinary number of influential scientists in the 18th and 19th centuries (Geison 1972). Many private parties and public establishments accumulated large collections of anatomical specimens, supposed to help illustrate human pathology (Alberti 2016). Almost all included some faunal remains to instruct comparative anatomy which, over the same period, became integral to biological classification: initially, to distinguish species and latterly, to establish their relatedness and evolutionary descent (Consans & Frampton 2015). Edinburgh produced many scholars who practiced both and, among those who abandoned medicine for natural history, Richard Owen and Charles Darwin are most prominent.

Those who remained in that city and whose vocation was, notionally, medicine, also made major contributions to the study of natural history: beginning with Robert Sibbald (1641 - 1722), founder of the Royal College of Physicians and Edinburgh University's first Professor of Medicine. John Barclay (1758 - 1826) failed to establish a discrete Chair of Comparative Anatomy at the same institution[1] (MacDonald & Warwick 2014), but his collections were preserved by his infamous protégé, Robert Knox (1791 – 1862) in a museum at the Royal College of Surgeons (Kaufman 2006; Donaldson 2022.). Knox's own student, John Goodsir (1814 – 1867) served as William Turner's (1832 – 1916) tutor and immediate predecessor at the University of Edinburgh, as Professor of Anatomy.

Coincidence or not, all these men made major contributions to the study of *cetaceans.* In an early taxonomy, Sibbald wrote the first scientific description of the blue whale, which bore his name into the 20th century *(B sibbaldi,* now *B musculus,* Barker & Bouchier 1976.) Knox and Turner both peformed spectacular public dissections on stranded blue whales *(B. musculus),* the latter publishing a landmark paper on its soft and bony tissues (Turner 1872.) For their part, Barclay (1815) and Goodsir were the first to anatomise a beluga and a beaked whale, respectively. Turner's interest in *cetaceans* therefore fell within his professional mandate, as a member of a medical faculty at a 19th century Scottish university. Goodsir (et al. 1868) had begun to build up the University's collection of comparative anatomy, but Turner's ambitions went further. In particular, the number of specimens from marine mammals grew from fewer than 10 in 1829 (Whyte 1829)[2] to over 500 soft tissue preparations, single bones and fully-articulated skeletons by 1912 (Turner 1912.)

These came from Turner's own numerous dissections and local acquisitions, as well as from more

1 Sabotaged by Robert Jameson, and Robert Munro, Prof. Of Anatomy: subject of a famous caricature, involving these men, an elephant skeleton and a walrus.

2 p. 9, 117 118, 119; p. 104 35; p. 172 54; p. 161 13; p. 171 32, 37;

exotic sources like the Challenger Expedition (on which, Sir John Murray served as oceanographer.) Few were palaeontological and, as anatomical specimens, the sub-fossil *mysticete* bones from the carse had no outstanding value. *B. physalus* was not rare in the North Atlantic and Turner (1912 32 - 39) collected many samples from modern members of this species. In fact, Turner wrote more extensively on fossil pinnipeds (1872, 1879) and bovines (1863) from Scotland, than on *cetaceans*. Only the bicipital rib[3], acquired in 1880 from Stirling Town Council but ultimately discovered at Christie's Brickyard (Shore), ever featured in a physiological publication (Turner 1883). He made the following comment:

1. *"[the bicipital rib] formed a part of a skeleton of a* Balaenoptera*, some of the bones of which were found in **1859**, others in **1863**, embedded in the clay at Christie's brickfield."*

If true, only one set of *cetacean* remains has ever been discovered in Christie's Brickyard (Stirling). Although, in **1858**, enough of the bones [AJ] had been discovered to warrant the description, *"the most complete specimen of the fossil whale in North Britain"*, some could have remained to be discovered a few years later, **1863**. However, [WHH] cannot yet be retired as a case of multiple reportage, because Turner's (1912) story changes:

2. *"Mr Milne Home stated that in **1859** bones of a whale were found in Christie's brickfield, Stirling but no details were given. In **1863**, in the same field, called Cow Park, a large part of a skeleton was exposed. [The bones] were given to the Corportation of Stirling, who some years afterwards presented them to the Anatomical Museum of the University [of Edinburgh].*

9.4.3. MacFarlane's Free Library and Museum (Stirling).

John MacFarlane (1785 - 1868) extracted a fortune from Manchester in the early industrial revolution and invested as much of it as possible in his hometown, Stirling. This legacy is now, largely, imperceptible: MacFarlane was unable to revive plans for a canal between the Forth and Loch Lomond, failed to establish an annual competitive regatta and could not persuade the burghers of Stirling to found an art school (Malcolm Allan 2006). He recieves little credit for the Wallace Monument and Old Town Cemetery, despite providing seed capital for both projects.[4]

MacFarlane's greatest achievements were largely inadvertent. He had a lifelong intention to open a

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3 I.e. Two-headed. As Turner argued, a misnomer: the space between two ribs had filled with bone, rather than that the rib had developed another head.

4 e.g. Witness (11.3.1846); Elgin Courier (13.3.1846); Leamington Spa Courier (14.3.1846).

museum of natural history which would equal Prof. Robert Jameson's at the University of Edinburgh, and in 1864, finally instituted it at the Bridge of Allan (Malcolm Allan 2006). His grandson, Sir John Murray, trained here. MacFarlane had already founded a museum by that time, as an annexe to his "MacFarlane Free Library": the first in Stirling dedicated to *"articles of vertu."* (Stirling Observer 25.2.1857). The local antiquities, which began to accumulate there from 1858, came to include:

1. A cast of the skull of King James 3rd (Rogers 1865 24.)
2. A piece of roof tree [sic] of Beaton's Cottage [Mill], where King James 3rd is alleged to have been murdered (Shearer 1880 48).
3. A piece of cornice from the incinerated Douglas Room, where King James 2nd is alleged to have murdered William Douglas, 8th Earl of Douglas (Hogg 1893 78)
4. An original portrait of James Guthrie, murdered Presbyterian martyr; also his library and chair (Rogers 1865 24, 27; Shearer 1880, 15 25.)
5. Armaments from Bannockburn battlefield. (Rogers 1865 24, 27; Shearer 1909 72.)
6. Bronze spearheads, stone hatchets, and medieval curling stones. (Shearer 1880 48 Milne Home 1871 116, Paton 1903 232)

The *Megaptera* scapula (19653.02) is assumed to have been conserved here, although its ultimate origins are speculative [MVB]. Sub-fossil *cetacean* remains were certaintly part of the MacFarlane Museum (Stirling) collections, although that fact was almost never alluded to. Milne Home (1882 63) reports seeing *"some bones of [a] whale"* here in 1862 and, while he does not describe the skeletal elements, transcribed a label which identified them as from the "*Airthrey Whale*" [ZT]. He (ibid. 1871 26; 1882 33) does not mention any other remains in that collection but, independent of this observation, is the first to state that two discrete *"whales"* had been discovered at Shiphaugh:

1. A 40' long individual in **1859** [sic] *"in a field now occupied by Mr Christie's brickwork".*
2. *"another [whale] found in the same field"* in **1863**.

<u>The Smith Institute, later Smith Museum</u>. An illegitimate son from a minor gentry family in Dublane, Thomas Stuart Smith cultivated his talents as a fine artist in Europe until, in 1849, his uncle died intestate (Jamieson and Paton 1991 100 – 105.) Having won title to the familial estates in 1857 after an arduous legal battle, Smith then sold up in 1863 and, by November 1869, chose to settle his inheritance in a *"museum or institute"* in Stirling (ibid. 110). Smith died on New Year's Eve in Avignon and his extensive collection of artwork unexpectedly devolved to the Trustees of the

Smith Institute, who fulfilled his last wishes. In 1874, George Christie (Jr), then Provost, formally opened the Smith Institute: *"three rooms, a Museum, a Picture Gallery, and a Library and Reading Room adapted for the benefit of the Working Classes.*" (ibid. 112).

Smith's paintings formed the core of the collections and the other functions of the Institute were neglected. For this reason, Turner's request of the *mysticete* skeleton [AJ] for the Anatomical Museum in 1880 caused local disquiet:*"If the [whale] skeleton is an antiquity for Edinburgh it is an antiquity for Stirling. ... There is plenty of room [in the deserted-looking museum in the Smith Institute] unfortunately, to accomodate not only 50', but 500' of skeletons if they could be got."* (Stirling Observer 4.3.1880.) Splitting the skeleton [AJ] placated both parties, but the contents of MacFarlane's Free Library and Museum were recieved at the Smith on more amicable terms.

Although the books were transferred in 1880 as there was no longer room for them all in their orginal premises, the artefacts arrived by a more convoluted route. The Stirling Field Club began to meet at the Smith Institute in 1878 and, in 1883, were asked to take custody of the MacFarlane Museum's (Stirling) collections by John Murray. This was on the condition that the Field Club expanded its remit and furnished the display cases: the renamed "Stirling Natural History and Archaeological Society" agreed, and successfully negotiated with the Trustees of the Smith Institute to accomodate this material.*"The museum would be cleared of its contents ... to make way for the cases of the new collection [from MacFarlane's.]"* (Croall & Hutcheson; 1885 34; 1885 113 – 116.)

In 1893, Morris read *Raised Beaches* at the Smith Institute. In preparing that paper, he examined what by then had, through various channels, accumulated in that musum. He found:

1. A *"heap of whale bones – ribs, vertebrae and plates. Every one of these I examined, but on only one of them is a label." ...* (Morris 1893 32).
2. A rib, labelled: *"Part of the skeleton of a whale found at the Shore Brick Work, Stirling, in **1863**. - 10' – 12' below the surface of the ground, and 5' – 6' above the present high water level."* (Morris 1893 33).
3. An entry in the catalogue of MacFarlane's Museum (Stirling), confirming that bones of the "Airthrey Whale" [ZT] had been part of the collection.
4. An entry in the catalogue of MacFarlane's Museum (Stirling), concerning: *"The vertebrae of a whale found in the brickwork of Messrs Christie, in the Cow Park. It must have been 70' long. The reason of there being only a small portion shown, is because the room is not big enough to exhibit the whole skeleton."* (Morris 1893 33).

9.4.4. Evaluation.

Instead of a chain of references, the three most important sources for information on *cetacean* remains in the carse have all independently identified the same years (**1858, 1863**) and the same location (Cow Park / Christie's Brickwork, Stirling.) Turner (1883, 1912) got these dates from Provost George Christie (Jr), a man directly related to these discoveries and who was, perhaps, a witness to both events. In the Smith Institute, Morris (1893) found physical evidence for a discovery in that year (rib labelled **1863**) and textual evidence, for *cetacean* bones from "Cow Park" in the collections of MacFarlane's. Milne Home (1871, 1883) who first named these two years (**1858, 1863**) and identified them as two discoveries of discrete *cetacean* remains, had visited MacFarlane's (Stirling) but does not name it as his source.

On the other hand, no allusions to the year (**1863**) are made by any other author. Lothian (1864), Haswell (1872) and Rogers (1865, 1876) all mention the *mysticete* skeleton found at Christie's (Stirling) in **1858** [AJ] but none refer any subsequent discoveries at that place. Similarly, no newspaper is known to report on any discovery of *cetacean* remains, at any location in Stirlingshire, in 1863. In 1864, another *Balaenoptera* skeleton was discovered at another Christie brickworks near Cornton, Bridge of Allan, to national acclaim [JB]. It is difficult to credit that a *cetacean* skeleton had been found just the year before [WHH] and nobody knew of it or talked about it.

It is incumbent on Morris (1893, 1925), Mile Home (1871 1882) and Turner (1883, 1912) to provide convincing evidence for a second set of *cetacean* remains from Christie's Brickyard (Shore) [WHH]. They fail: Turner (1883) originally stated that only one *mysticete* skeleton [AJ] had been discovered in two separate instances. His story changed in light of Milne Home's (1871) *Estuary* – or more probably, Morris' (1893) adaptation of it. However, Morris (1893) can only demonstrate that *cetacean* bones from Christie's (Stirling) were kept at MacFarlane's Museum (Stirling).Whether these constituted a completely different set of remains from an entirely discete animal is not proven.

"Whale" bones from "Cow Park" could certainty have been kept at the Burgh Buildings and at MacFarlane's (Stirling) at the same time, even if the catalogue entry for the "*vertebrae ... found in the brickwork of Messrs Christie"* is not associated with a date of discovery or of acquisition. However, only the simultaneous presence of two skulls or mandibles at these two locations could prove, conclusively, that two sets of remains from two individual *cetaceans* had ever been found at Christie's Brickworks (Stirling). Only one set of unique and identifying bones has been identified: those kept in the Burgh Buildings, acquired by Turner in 1880 [AJ]. Similarly, the rib is labelled **(1863)** is not diagnostic in this way.

Sufficient evidence exists to state, that large parts of a *mysticete* skeleton was discovered at Christie's Brickworks in 1858 [AJ]. There is a possibility that bones from this animal were discovered on more than one occasion (Turner 1883). Furthermore, the conservation of those remains between 1858 and 1880 was markedly negligent. The skeleton in the Burgh Buildings [AJ] could have been subject to an unacknowledged partition during those years, where some vertebrae were removed to MacFarlane's (Stirling) before an unrecognised "reunion" in the Smith Institute, c. 1885. Either way suggests that only one single skeleton, had ever been discovered at the Shore.