Chapter 14 British Cenozoic fossil fishes sites

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Introduction: palaeogeography and stratigraphy

The principal Tertiary (or Cenozoic) rocks of southern England occur in two broad basins — the Hampshire Basin and the London Basin. Elsewhere they form small isolated outcrops, e.g. basin infills at Bovey Tracy and Petrockstow, Devon. Originally a single basin, the two outcrops of the south-east are continued offshore into the Dieppe Basin and the North Sea Basin respectively. As early as 1814 the Hampshire succession and faunas were correlated to those of the Paris Basin, as described by Cuvier and Brongniart (1810) and Webster (1814). In this chapter we are concerned with the sites in the Palaeogene strata — the Palaeocene, Eocene and Oligocene (Daley, 1997). These rocks appear everywhere on land to overlie unconformably the Upper Chalk or older strata. A limited Neogene (Pliocene) sequence is present in Suffolk, and restricted Mio-Pliocene occurrences exist in Kent, Norfolk and Cornwall (Curry *et al.* 1978). Younger Cenozoic or Quaternary sediments (Pleistocene and Holocene) are more abundant, being distributed over much of the British Isles, and yielding fossil vertebrates especially in East Anglia and the southern counties of England.

At the end of Cretaceous time Britain was at about 40° north of the equator, with a tropical or subtropical climate. Its Cenozoic history is dominated by the consequences of the rifting and widening of the North Atlantic and the development of the North Sea Basin. Early Tertiary basalts in Northern Ireland and the volcanic centres of the North-West Highlands are responses to the Atlantic marginal rifting. With this came uplift and a retreat of the sea, and a tilting of the new land surface to the south-east. The Palaeogene sea spread from the North Sea Basin across south-eastern England, bounded to the west by a belt of transitional depositional facies — estuarine, deltaic, and fluviatile, and west of that a zone of freshwater deposition. To the south lay the Aquitaine Basin, linked to the Tethyan Ocean (Figure 14.1).

There is a plethora of stratigraphical rock unit and time names, and international agreement on stage and other boundaries has been slow (see Curry *et al.,* 1978; Curry, 1992; Jolley, 1996; Knox *et al.,* 1996). Early correlation on the basis of molluscan faunas has been supplemented by microfaunal and palynological schemes. Insole and Daley (1985) and Edwards and Freshney (1987) have provided syntheses of the formal stratigraphy of the Hampshire Basin (Figure 14.2). Daley and Balson (1997) have recently completed a GCR volume on Tertiary stratigraphy, and many of the Palaeogene sites overlap with fish localities reported here. Ellison *et al.* (1994) have reviewed the early Palaeogene lithostratigraphy of the London Basin.

Environments

At the end of the Cretaceous, much of Britain lay beneath the Chalk sea, but uplift was taking place linked with the initiation of rifting and ocean-floor spreading in the North Atlantic between eastern Greenland and north-west Europe. A large part of Britain became land during the Cenozoic Era, with strongest uplift in the north and west, and renewed subsidence in the southeast. During the Palaeogene, the Atlantic Ocean was already over 1000 km in width, and was connected to the subsiding North Sea marine basin by a narrow strait via the western half of the English Channel. The strait widened eastwards into an almost landlocked sea covering much of south-east England (London and Hampshire Basins), the Channel, and north-west Europe. The sediments of the London and Hampshire Basins record the interplay of marine sediments from the subsiding basins, and tongues of terrestrial sediments feeding off the lands to the north. This produces cyclic patterns recording repeated transgressions and regressions.

Palaeogene sedimentation began with a marine transgression from east to west, into the face of advancing continental deposition from rivers draining south-eastwards. It is possible that a time gap of some 20 Ma may separate the latest Mesozoic from the earliest Tertiary rocks of the London and Hampshire basins (Cope, 1955). Almost everywhere the lowest Tertiaries are glauconitic sands with rolled flint pebbles. Then followed cycles of sedimentation as the strandline migrated to and fro, influenced by climatic changes and custatic swings. The straits between the Atlantic Ocean and North Sea closed for a time in the Palaeocene and early Eocene, resulting in continental (Reading Beds) and estuarine

(Woolwich Beds) sediments in the basins to the east of the closure and probably controlling the low-energy deposition of the succeeding marine London Clay Formation (Curry *et al.,* 1978). In the late Eocene, a brief marine trangression in south-east England was followed in latest Eocene and early Oligocene times by another fall in sea level. During the Palaeogene climatic cooling continued; marine regressions appear to correlate with phases of ocean cooling and regional drought, and it seems that polar glaciation may have been responsible for the sea-level fall in the Oligocene. Deposits of this age are rare in the southern basins, but include freshwater limestones and marls, although there was continuous sedimentation in the North Sea Basin (Curry *et al.,* 1978). In south-west England the Oligocene basins of Bovey and Petrockstow contain fluvially deposited and lacustrine beds; the result of penecontempora-neous faulting and local subsidence in the Palaeozoic basement along the Sticklepath–Lustleigh fault zone. In mid- to late Oligocene times, folding and faulting associated with the Alpine orogenic movements caused basin inversion in southern Britain.

A table of the facies represented by the principal Palaeogene lithostratigraphical units of southern England shows the diversity of possible habitats (Table 14.1). Virtually all the formations are poorly consolidated. Each facies was to some extent diachronous and thus a continuous shift of habitats was in progress. This is evident in the invertebrate faunas, while the fishes are found in several marine, estuarine and brackish-water communities. Organic productivity was high virtually everywhere and teleost fishes occupied their ecological niches in much the same way as at present.

(Table 14.1) Table of Palaeogene formations and environments in southern Britain.

Formation	Depositional environment
Hamstead Beds	marine, estuarine and lacustrine clays
Bembridge Beds and Osborne Beds	marine and freshwater marls and limestones
Headon Beds	marine and freshwater clays and sands
Barton Beds	marine sands and clays
Bracklesham and Bagshot Beds	marine and fluvial sands
London Clay	marine clay with basal sand
Oldhaven and Blackheath Beds	estuarine sands
Woolwich and Reading Beds	marine and estuarine clays and sands with freshwater clays
Thanet Beds	marine sands

During Neogene time, the North Sea Basin continued to subside, and sediments accumulated during the Miocene and Pliocene. The Miocene and Pliocene are largely absent from onshore sites. The notable exceptions are the Coralline Crag and the Red Crag, a combined sequence of about 70 m which spans the Pliocene and Early Pleistocene. These are stratified cross-bedded sands containing marine invertebrate fossils which seem to have been deposited in shallow seas by tidal currents, and they indicate a cooling of the climate. During Pleistocene times, as is well known, the British Isles experienced a number of cooling and warming episodes. There were as many as six cold phases during the past 2 Ma, with associated glaciation extending, at its maximum, southwards to a line roughly from London to Bristol. Pleistocene vertebrates have been found in cave deposits, and in water-laid and glacial deposits.

Fish faunas

The great explosion of fish numbers and types during the Cenozoic Era is one of the most impressive happenings in evolution. It is, moreover, almost entirely confined to the teleost fishes. They constitute about 90% of all known extant fish species. The remainder include fishes that have retained the essential characteristics of their Mesozoic (or older) ancestors — the sharks, the coelacanth, the lungfishes, paddlefishes, sturgeons and hagfishes being excellent examples. They have adapted to particular niches where in general there may not be such intense competition for living space.

The end of the Mesozoic Era witnessed mass mortality amongst many groups of animals, but it is difficult to correlate changes in the record of the fishes with this spate of events. By the time that the Chalk was being deposited in the latter half of the Cretaceous Period the teleosts had begun to achieve their ascendancy as most of the non-teleostean neopterygians disappeared. Teleost success then gathered pace with adaptation to efficient swimming, greater speed and manoeuvrability. The homocercal tail now prevailed, freeing the paired fins from the necessity of counteracting

negative pitch induced by the earlier heterocercal tail. These basic improvements to the locomotive ability of the teleosts allowed these fishes to adopt many additional specializations, enabling them to invade every part of the oceans, seas and inland waters. Notable changes in the mechanism of the jaws and orobranchial anatomy took place. Many familiar extant teleosts in European waters first made their appearance early in the Cenozoic, others were introduced with climatic (principally cooling) changes. Chondrichthyans were plentiful early in the Cenozoic (Gluckman, 1964a, 1964b); later their numbers diminished as the shallow sea waters grew cooler. European freshwaters, too, were inhabited by many of the familiar species of today; the ancient chondrosteans (sturgeons) were, however, more widespread than at present.

Although all parts of the Cenozoic succession in southern England are locally highly fossiliferous, the fishes are perhaps most common in the lower half. The earliest Palaeogene fish remains have recently been obtained from glauconitic sands and silty clays within the Thanet Formation of Kent (Ward, 1977, 1979). Early Eocene fishes are well represented in the estuarine mud and sand communities of the pre-London Clay Tertiaries and in particular the London Clay Formation of the London Basin, where the fauna is dominated by marine forms.

The Late Eocene marine mud, shallow-marine clay and sublittoral sandy clay beds above the London Clay in the Hampshire Basin are also rich in fossil fishes (Hooker and Ward, 1980). Later communities probably existed in water not more than 50 m deep, with sea temperatures of about 16–18°C. Palaeogene brackish-water and freshwater communities are much more restricted in number and extent, as in the Osborne and Headon Beds. The latest Palaeogene fish assemblages, those of the Bembridge Marl Member and Hamstead Member of the Bouldnor Formation (Lower and Middle Oligocene respectively) on the Isle of Wight have produced a fauna dominated by freshwater forms (Daley, 1973; Hooker and Ward, 1980).

Neogene and Pleistocene fish localities are sparse and it was hard to determine particular locations that had assessable potential for future finds. Hence, none were selected for the GCR 'fishes' review.

A feature of studies of some Cenozoic fish faunas has been the work on otoliths. These fossils are the 'ear stones' of certain teleosts — small (even microscopic) ossifications from within the sacculus of the inner ear. They are extremely numerous in some deposits, even where other skeletal remains are lacking. A very large number of otoliths has now been described from the English Cenozoic formations (see Stinton, 1965–1973; Nolf, 1985), including those that have little other evidence of fossil fishes. Otoliths taxa are not listed in the following reports since their significance is obscure compared to that of the other remains.

Pre-London Clay Tertiaries of the London Basin

The earliest transgressive beds, of Late Palaeocene age (*c.* 58 Ma; Daley and Balson, 1999), occur in eastern Kent (Thanet Formation), and these marine units extended ever farther westwards through Berkshire and into Wiltshire during the Late Palaeocene (Woolwich and Reading beds) and Eocene (Thames Group: Blackheath and Oldhaven Formation, London Clay Formation). These trangressive units are bioturbated glauconitic sands, containing reworked flint pebbles derived from the underlying Chalk and tend to pass upwards into thicker regressive sand units and clays (Ellison, 1983). The Woolwich and Reading Formation (Late Palaeocene) in the west is represented by non-marine, red, mottled, kaolinitic clays and sands of fluvial, lagoonal and tidal mudflat origin that have yielded plant and insect fossils (Reading Beds), as well as a marine horizon towards the base (Ellison, 1983; Bone, 1986). In the east the Woolwich Beds comprise thick marginal marine and estuarine sand and clay units (Curry; 1965; Ellison, 1983).

A major unconformity consistently separates the Woolwich and Reading Formation from the younger strata of the Thames Group (whether they be Blackheath Beds, Oldhaven Beds or London Clay). Most current theories of the position of the Palaeocene–Eocene boundary (e.g. Knox, 1990), place it approximately at this unconformity. However, in terms of fossil fish diversity, the major faunal turnover took place with the onset of true London Clay marine deposition, and so in this report the Blackheath and Oldhaven Formation assemblages are recorded with those from the Palaeocene 'Lower London Tertiaries'. Those of the London Clay Formation are dealt with in the next section.

Fishes within the pre-London Clay Tertiaries are not uncommon, and occur within all of the early Tertiary transgressive units in southern England. Most finds are tiny fish teeth, scales and teleost otoliths, and are usually recovered by bulk sampling of the unconsolidated sediments. Hence, although some sampling was done as early as the 1920s and 1930s (Stamp and Priest, 1920; Brown, 1924; White, 1931), most of the literature has been written in the past 30 years, and includes important references by Gurr (1963), Stinton (1965a, 1965c, 1975–1980), Ward (1972, 1976, 1977, 1979), George and Vincent (1976) and Cooper (1976a).

Collections of Palaeocene and early Eocene fossil fish from the London Basin are housed in the NHM.

Fish sites

Sporadic fish material has been recovered from many localities throughout the whole outcrop of pre-London Clay Tertiaries in the London Basin. However, most of these sites have only yielded fragmentary remains of one or two fish species and thus only the more significant are listed below by county from the south-west to northeast (taken mainly from Hooker and Ward, 1980):

WILTSHIRE: Clarendon road cutting (glauconitic shelly sand 3 m above the Reading Beds, Woolwich and Reading Formation; [SU 183 284]; six species; Hooker and Ward, 1980).

KENT: Pegwell Bay sea cliffs (Thanet Formation, Base Bed Member, 'Cliffs End Greensand Bed'; [TR 354 643]; nine species, see report; Ward, 1977); Herne Bay sea cliffs and foreshore exposures (Thanet Formation, Reculver Silts Member–London Clay Division B; [TR 198 688]–[TR 217 691] 55 species, including one type specimen, see report; Ward, 1979); Swanscombe quarries (Woolwich and Reading Formation, Woolwich Shell Beds; [TQ 59 73]; four species; Stamp and Priest; 1920, Brown and Priest, 1924); Shelford disused quarry (Blackheath and Oldhaven Formation, Oldhaven Beds (Units 5–8 of Ward, 1972); [TR 160 600]; nine species; Gamble, 1968, Ward, 1972); Upnor sand pit (Woolwich and Reading Formation, Woolwich Beds; Blackheath and Oldhaven Formation, Oldhaven Beds; [TQ 757 712]; 21 species, including three type specimens, see report; White, 1931).

GREATER LONDON: Abbey Wood temporary excavation (Blackheath and Oldhaven Formation, 'Blackheath Shell Bed'; [TQ 480 786]; 23 species, including 16 type specimens, see report; White, 1931).

MIDDLESEX: Harefield quarry (Harefield Beds (Units 2–7 of Cooper, 1976a); [TQ 048 911]; two species; Cooper, 1976a).

HERTFORDSHIRE: Bignell's Corner road cutting (Harefield Beds (Unit 2 of Ward, 1976); [TL 227 007]; eight species; Ward, 1976).

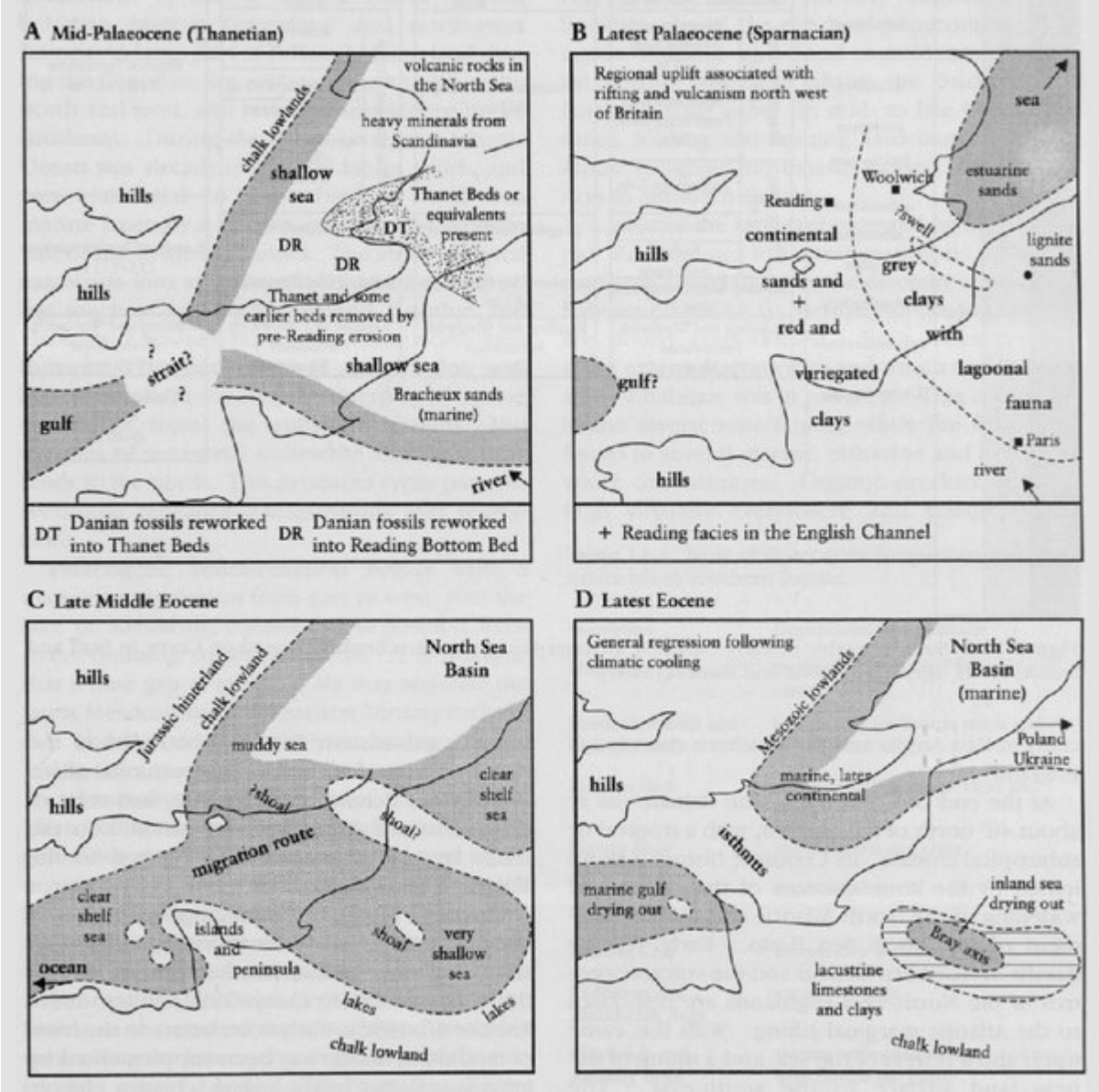
ESSEX: Harwich Harbour (Suffolk Pebble Beds; [TM 26 32]; three species; Thompson, 1911).

SUFFOLK: Ferry Cliff river exposure (Suffolk Pebble Beds; [TM 278 486]; six species of fish, one species of salamander; George and Vincent, 1976; Milner, 1986).

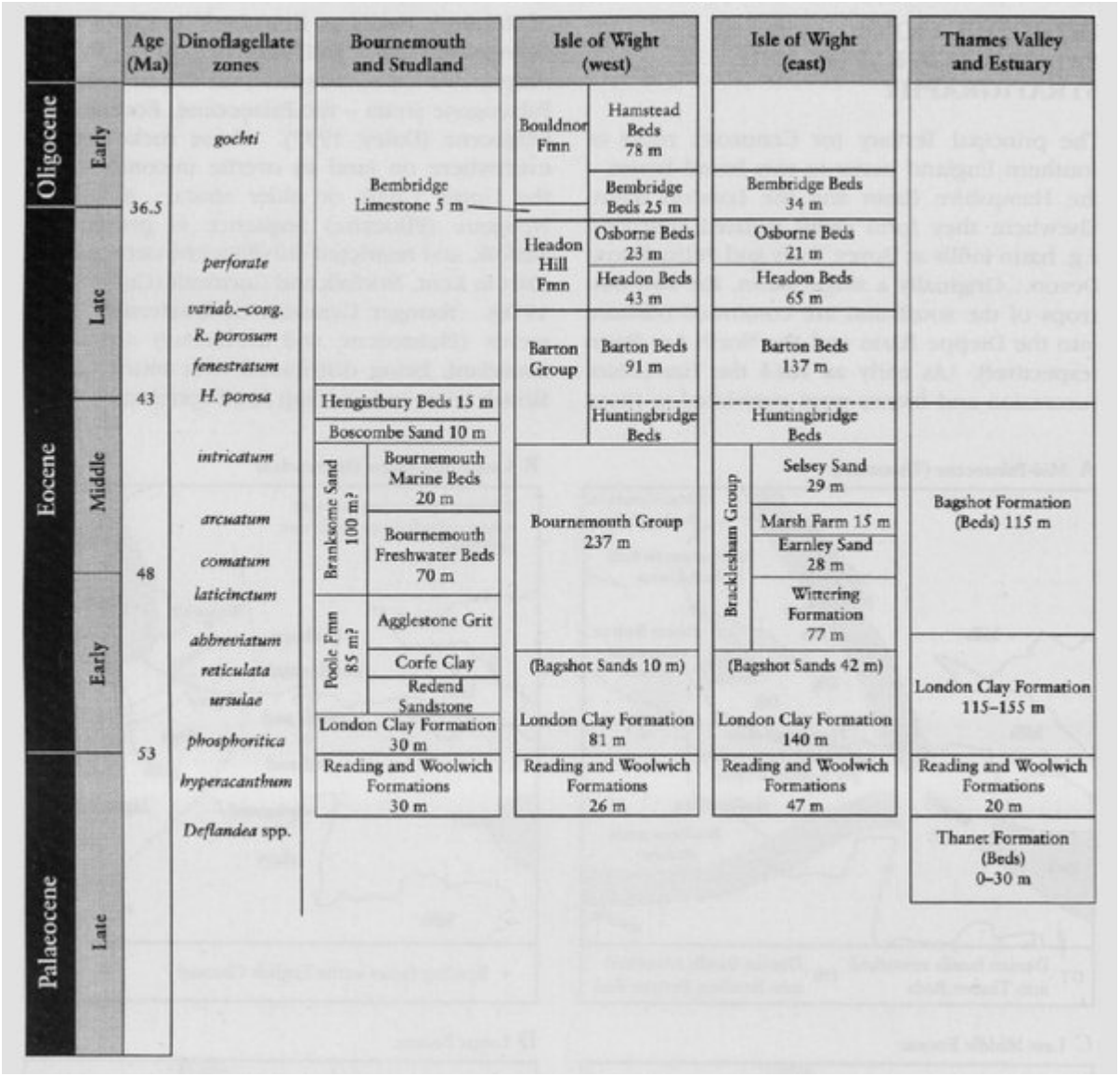
Four sites are selected as GCR sites on the basis of their important Palaeocene and Early Eocene fish faunas:

1. Pegwell Bay, Kent ([TR 348 640]–[TR 363 642]). Late Palaeocene-Early Eocene (?Upper Thanet Formation).
2. Herne Bay, Kent ([TR 217 691] — [TR 205 687]). Late Palaeocene-Early Eocene, Upper Thanet Formation (Reculver Silts Member)-London Clay Formation (Division B).
3. Upnor sand pit, Kent [TQ 757 712]. Late Palaeocene–Early Eocene, Woolwich and Reading Formation-Blackheath and Oldhaven Formation (Oldhaven Beds).
4. Abbey Wood, Greater London [TQ 480 786]. Early Eocene, Blackheath and Oldhaven Formation ('Blackheath Shell Bed').

References



(Figure 14.1) Palaeogeographical maps of southern Britain and adjacent mainland Europe during part of the Palaeogene (Early Cenozoic) (after Curry, in Duff and Smith, 1992).



(Figure 14.2) Summary table of Early Cenozoic stratigraphy in southern England (based on Curry, in Duff and Smith, 1992), ages from Cowie and Bassett (1989).