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MARINE REPTILES FROM THE UPPER LIAS (LOWER TOARCIAN, LOWER JURASSIC) OF THE YORKSHIRE COAST

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(Read at Leeds, 19th March, 1983)

CONTENTS

I. INTRODUCTION ........................................... 399
II. COLLECTIONS OF YORKSHIRE REPTILES .......... 400
III. THE YORKSHIRE LIAS ............................. 401
IV. THE REPTILES ..................................... 404
V. DISCUSSION: THE REPTILE FAUNAS ............... 419
VI. REFERENCES ........................................ 423

SUMMARY

Fossil marine reptiles have been collected in some abundance from several sites along the Yorkshire coast over the last 225 years. Much of this material has remained unstudied and there is confusion over the provenance of most specimens. A detailed study of early collectors' reports has revealed the sources of some specimens, and others have been dated by means of associated ammonites and matrix. A complete list of all specimens known to us is given, and these include 55 crocodiles, 69 ichthyosaurs, 33 plesiosaurs and one pterosaur. Reptiles are rare in the Lower and Middle Liass of Yorkshire. The richest horizons are within the Upper Lias (Lower Toarcian, Whithian), with 14 specimens from the Jet Rock Formation and 144 from the Alum Shales Formation (predominantly the Main Alum Shales). The best localities have been the Whitby – Saltwick section (137 specimens) and the old alum quarries at Kettleness (5 specimens) and Loftus (4 specimens). The faunas from these sites are unrivalled in the Upper Liassic of Britain, and they show significant differences from the Upper Liassic faunas of SW Germany (e.g. Holzmaden) and France.

I. INTRODUCTION

The Upper Lias (Toarcian, Lower Jurassic) of the Yorkshire coast has produced many important specimens of plesiosaurs, ichthyosaurs, and marine crocodiles. Specimens have been collected from the cliffs and alum quarries for over 200 years, and they are well known for their completeness and excellent preservation. Occasional remains have also been found in the Lower Lias. However, in revisions of the plesiosaurs (Watson 1909, 1910; White 1940; Persson 1963), crocodiles (Westphal 1961, 1962; Duffin 1979), and ichthyosaurs (McGowan 1974), the authors have had difficulty in assigning specimens to their correct localities and zones. This difficulty has arisen because of the general lack of collection data, contradictory statements by early authors, and changes in the nomenclature of the ammonite zones.

In this paper, we review the major reptile finds, and give evidence for their localities and ages as far as possible, on the basis of published and unpublished data, and an examination of the matrix and ammonites

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associated with the specimens, where possible. Most museum specimens, however, have little or no associated matrix. We hope that this information will be of value in establishing the age and provenance of particular Yorkshire reptiles and in comparisons with similar forms elsewhere. In the course of the review, a summary of known specimens is given and the complete faunas are assessed.

This paper stems from work by M.J.B. on documenting British fossil reptile localities for conservation, as part of the Geological Conservation Review of the Nature Conservancy Council, and work by M.A.T. on the functional biology of Lias plesiosaurs.

II. COLLECTIONS OF YORKSHIRE REPTILES

The first fossil reptile recorded from near Whitby was a crocodile collected in 1758. Further crocodiles were collected in 1791 and 1824. The first recorded Yorkshire ichthyosaur was collected in 1819, and another one in 1821. The first Yorkshire plesiosaurs were reported in 1822. In a review of the Lias reptiles from the Yorkshire coast, Young and Bird (1828) mentioned seven crocodiles, forty or more ichthyosaurs and four fragments of plesiosaurs, and further information was given in some of their letters (Melmore 1942-3). Localities included The Scar and Saltwick, east of Whitby, the section between Staithes and Runswick, and Loftus (Fig. 1). Many of the skeletons were discovered and excavated by Mr. Brown Marshall, a carpenter in Whitby who sold them to collectors (Brown 1946, p. 15). Very few of these early finds can be identified with certainty now. Further reptile localities include Runswick Bay, Kettleness Alum Quarry, Sandsend, Hawsker Bottoms, Ravenscar (Old Peak – Blea Wyke Point) (all Upper Lias) and the Lower Lias of Robin Hood’s Bay (Fig. 1).

Some of the earliest fossil bone discoveries on the Yorkshire coast were not fully described and the true identity of the finds is not clear. Kendall (1816, pp. 285-307) reviewed the finds of fossil bones and included some interesting unconfirmed examples. The earliest record is that “about the year 1743, the Rev. Mr Borwick, found in the Alum-rock, the complete skeleton, or petrified bones of a man; but though the utmost caution was used it was broken into many pieces, and greatly mutilated before it could be taken out.” Later, “about the year 1762, the skeleton, or petrified bones of a horse, were found in the alum-works at Saltwick, at the depth of about thirty yards underground, which were taken up with much care, though not without being considerably broken; they were afterwards sent to the University of Aberdeen”. There is no trace of such a specimen there now. Kendall (1816, p. 236) also mentions that “a gentleman who was bathing” just east of Whitby found “a complete ossification” of “part of a human skeleton”. Flesh and skin were still present and “after being kept some years, it entirely mouldered away into dust”. Young (1817, pp. 779-780) mentioned two other fossils just discovered whose identity is uncertain – a 22 inch cranium from Boulby and a jawbone on the beach near Sandsend.
GOOD COLLECTIONS OF YORKSHIRE LIAS REPTILES ARE PRESERVED IN THE BRITISH MUSEUM (NATURAL HISTORY) (SPECIMENS LARGELY PURCHASED OR DONATED BETWEEN 1840 AND 1880, WITH SOME RECENT ACCESSIONS), THE SEDGWICK MUSEUM, CAMBRIDGE (SPECIMENS LARGELY PURCHASED BY A. SEDGWICK IN THE 1840S), WHITBY MUSEUM (SPECIMENS DONATED AND PURCHASED BETWEEN 1824 AND 1867, WITH SOME RECENT ACCESSIONS: BROWNE 1946), AND THE YORKSHIRE MUSEUM, YORK (FORMERLY YORK MUSEUM; SPECIMENS DONATED AND PURCHASED LARGELY IN THE MID-19TH CENTURY, WITH ESPECIALLY LARGE COLLECTIONS FROM W. REED WHO BOUGHT OTHER PEOPLE'S COLLECTIONS; MUCH OF THIS MATERIAL LACKS DATA, BUT IT MAY INCLUDE SOME OF THE VERY EARLY SPECIMENS, MELMORE 1942-3). THESE, AND OTHER MUSEUM COLLECTIONS ARE SUMMARISED IN THE APPENDIX.

REPOSITORY ABBREVIATIONS REFERRED TO IN THE TEXT: BMNH, BRITISH MUSEUM (NATURAL HISTORY); GSM, GEOLOGICAL SURVEY MUSEUM, LONDON; HM, HULL MUSEUM; MCZ, MUSEUM OF COMPARATIVE ZOOLOGY, HARVARD; MM, MANCHESTER MUSEUM; MU, MANCHESTER UNIVERSITY, DEPARTMENT OF GEOLOGY; NMI, NATIONAL MUSEUM OF IRELAND, DUBLIN; SM, SCARBOROUGH MUSEUM; SMC, SEDGWICK MUSEUM, CAMBRIDGE; WM, WHITBY MUSEUM; YM, YORKSHIRE MUSEUM, YORK.

III. THE YORKSHIRE LIAS

succession at Whitby has been summarised by Cope et al. (1980, p. 57) (Fig. 2). Since the current ammonite zonal scheme has come into use only in the last twenty years (Dean et al. 1961), older descriptions of the reptiles used different zonal terminologies, such as those of Oppel (1856), Tate and Blake (1876), Wright (1878–1886), Buckman (1910, 1915), Arkell (1933) and Spath (1942). Important synonymies for Yorkshire are given here (Fig. 2).

The three zonal terms, annulatus, serpenitus and commum were used to describe the Lower Toarcian (Whitbrian) of Whitby until 1910. The annulatus Zone is directed equivalent to the teuicostatum Zone. The serpenitus Zone of Tate and Blake (1876) included the Jet Rock and the lower portion of the Bituminous Shales (beds 33-41 (lower half) of Howarth 1962), while Fox-Strangways (1892, pp. 127, 137) moved the upper boundary of the Jet Rock Series to lie above the Ovatum Band (bed 48 of Howarth 1962), the position currently accepted. Buckman (1915, p. 75) made the Ovatum Band the base of the Alum Shale Series, and united it with the Hard Shales as the pseudovatum Zone (Buckman 1910).

The commum Zone of Tate and Blake (1876) comprised beds 41 (upper half) to 72 of Howarth (1962), thus all but the basal 3m of the Bituminous Shales, the Ovatum Band, the Hard Shales, the Main Alum Shales, and the Cement Shales. Thus, the designation “alum shales” in older works may refer to any of the shale horizons, except the Grey Shales. Alum has been obtained from the Hard Shales and the Cement Shales, as well as the Main Alum Shales themselves.

The Grey Shales are pale grey and silty with some fine sandstones. Shale units are 0.2–2.1m thick and interbedded with 0.05–0.25m bands of round or flattened calcareous nodules. In the lower parts, the nodules are sideritic and weather to a deep red colour. Most beds contain

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**TABLE 1**

<table>
<thead>
<tr>
<th>ZONE</th>
<th>HOUGHTON, 1956</th>
<th>BED VOL.</th>
<th>THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Hildoceras</em></td>
<td></td>
<td>11</td>
<td>4.5</td>
</tr>
<tr>
<td><em>Pseudopluma</em></td>
<td></td>
<td>12</td>
<td>3.5</td>
</tr>
</tbody>
</table>

**FIG. 2.** The Upper Lias (Lower Toarcian) at Whitby, showing ammonite zones and subzones, formations, bed numbers from Howarth (1962), and thicknesses for sections near Whitby (after Cope et al. 1980). The terminology used by earlier authors is also indicated.
fine-ribbed ammonites of the genus *Dactylioceras* (Howarth 1973; Hemingway 1974).

The Jet Rock is a sequence of hard finely laminated dark grey or brown shales, often bituminous, with bands of small to large calcareous concretions ("doggers") up to 5m in diameter. The shales are 1-3m thick and the concretion units 0.1 – 1.0m thick. Pyrite is abundant and fossil molluscs are often pyritised. Typical ammonites belong to the genera *Harpoceras*, *Hildaites* and *Eleganticeras* in the lower five metres of the Jet Rock and *Inoceramus dubius* occurs above (Howarth 1962; Hemingway 1974). "Hard" jet was formerly mined in the upper three metres of the Jet Rock, and particularly during the latter half of the 19th century. It was mined on the coast, by quarrying the cliff face or by driving adits into it, and particularly at Boulby, between Staithes and Kettleness, around Saltwick Bay, Hawsker Bottoms and Ravenscar. There was also much casual beachcombing for jet, and presumably also for fossils (Hemingway 1974).

The Bituminous Shales are similar to the Jet Rock, but contain only a little soft jet and there are few calcareous concretions. The shales are less well laminated than the Jet Rock, and they smell less of bitumen. Shale units are 3-8m thick, and there are three or four 15cm bands of pyrite-skinned concretions. Typical ammonites belong to the genus *Harpoceras*, and the bivalve *Inoceramus* occurs. Fossils are often pyritised (Howarth 1962; Hemingway 1974).

The Ovatum Band is a 25cm thick double row of large sideritic doggers which weather dark red. The typical ammonite is *Ovaticeras ovatum*, and aggregations of belemnites occur.

The Hard Shales consist of a non-bituminous grey shale unit with sporadic calcareous concretions, and a thin bed of siderite mudstones. The typical ammonite is *Dactylioceras commune*.

The Main Alum Shales are a sequence of soft grey micaceous shales (0.25 – 5.00m thick) interspersed with irregular bands of scattered calcareous concretions and siderite mudstones. The Alum Shales weather to crisp flakes. Typical ammonites are *Dactylioceras commune* in the lower 12m and *Peronoceras fibulatum* in the upper 3m, with other species of *Hildoceras*, *Phylloceras*, *Dactylioceras*, *Zugodactylites*, *Pseudodioceras* and *Peronoceras* (Howarth 1962; Hemingway 1974). At Kettleness and Loftus alum quarries, the Main Alum Shales become very fissile, and in places the flakes form hexagonal patterns rimmed by ridges of iron-rich material.

The Cement Shales consist of grey shales rather like the Main Alum Shales (0.25 – 4.00m thick) interbedded with rows of cementstone doggers (0.10 – 0.25m thick). Ammonites include *Hildoceras bifrons* and species of *Porporoceras*, *Catacoeloceras* and *Phylloceras*. The bivalves *Nuculana* and *Gresslya*, and belemnites are abundant (Howarth 1962, 1978). At Whithby the Cement Shales are unconformably overlain by the Dogger Formation (Aalenian, Middle Jurassic).

The Main Alum Shales and the Cement Shales were formerly quarried extensively for the manufacture of alum. According to Hunton
(1836), only the shales that yielded the bivalve *Nuculana* were suitable, thus only the upper part of the Main Alum Shales and all of the Cement Shales (Hemingway 1974, p. 176). The Cement Shales were also formerly calcined for the production of hydraulic cement, particularly at Sandsend. The alum industry may have begun in Yorkshire with the Romans, and it was a major source of revenue from the 17th century until about 1860 when cheaper methods were discovered for the manufacture of alum from Coal Measure shales. Fossil reptiles were obtained from several of the large coastal alum works, and the main ones in operation during the 19th century were (Fox-Strangways 1892, pp. 452-5; Rutter 1961, 1971):

<table>
<thead>
<tr>
<th>Location</th>
<th>Dates</th>
<th>Coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lofus (Lofhouse)</td>
<td>c.1650 - 1863</td>
<td>(NZ 746200)</td>
</tr>
<tr>
<td>Boulby</td>
<td>16 - 1861</td>
<td>(NZ 753196)</td>
</tr>
<tr>
<td>Kettleness</td>
<td>1728 - 1861</td>
<td>(NZ 833160)</td>
</tr>
<tr>
<td>Sandsend Ness</td>
<td>c.1615 - 1880</td>
<td>(NZ 859138)</td>
</tr>
<tr>
<td>Peak</td>
<td>16 - 1862</td>
<td>(NZ 969016)</td>
</tr>
</tbody>
</table>

IV. THE REPTILES

(a) Crocodiles

The first fossil reptile to be reported from the Yorkshire coast was a marine crocodile. William Chapman (1758) described it as the “fossil bones of an alligator... discovered in the sea-shore, about half a mile from this place [Whitby]... The ground they laid in is what we call alum-rock; a kind of black slate, that may be taken up in flakes... The bones were covered five or six feet with the water every full sea, and were about nine or ten yards from the cliff, which is nearly perpendicular, and about sixty yards high...”. Later in the same year, Wooller (1758) described the same specimen, and indicated that it had lain on the beach for some time, “the vertebrae now wanting having been either dug up by curious persons, or washed away by the violence of the waves at high water.” He confirmed that “this skeleton lay about six yards from the foot of the cliff, which is about sixty yards in perpendicular height” and that by examining the strata in the cliff, the skeleton lay “10 or 12 feet deep ... in the black slate or alum rock.” This specimen (BMNH R1088) was later named *Teleosaurus chapmani* König (in Buckland 1836).

This information is sufficient to localise the find to a small promontory called The Scar, half a mile east of Whitby harbour mouth (NZ 909115). At this point, the cliff is indeed sixty yards (55m) high, and the wave-cut platform is easily accessible from Whitby. The Scar is composed completely of beds of the Alum Shale Formation (Howarth 1962, pl. 28; Hemingway *et al.* 1968, p. 12). At a distance of six to ten yards (c. 5-10m) from the base of the cliff, beds 53-72 of Howarth (1962) are currently exposed (Main Alum Shales – Cement Shales). Erosion over 200 years will have removed younger beds and moved the cliff-line back, so that in 1758, The Scar was probably composed of upper parts of the Main Alum Shales and the Cement Shales. This locality is confirmed by Young & Bird (1828, p. 291) as “The Scar”, and “near the east pier”.

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The description of the rock as “black slate” is confusing since this description does not really fit any of the sediments. If we assume that “slate” means any well-laminated fine-grained sediment, we must consider all of the shale units of the Jet Rock and Alum Shales Formations. The Grey Shales (pale grey in colour) may be ruled out. The Jet Rock is described as “dark brown” (Hemingway 1974, p. 174) and the Bituminous Shales are similar. The Alum Shale formation shales are all grey or dark grey in colour (Howarth 1962). The Main Alum Shales weather to crisp flakes (Hemingway 1974, p. 176), a feature clearly described by Chapman (1758: “a kind of black slate, that may be taken up in flakes”). The matrix associated with this specimen (BMNH R1088) also points to the Alum Shale Formation.

Wooler (1758) indicated that the specimen lay 10 or 12 feet (i.e. 3-4m) deep in the alum rock, but this information is of doubtful value unless we can identify which bed he measured from. If he chose the marked unconformity between the Upper Lias and the Middle Jurassic Dogger Formation, the specimen would have come from near the base of the Cement Shales. Other unit boundaries are not particularly strongly marked in the outcrop.

The best evidence as to the zone comes from associated ammonites. The slab of BMNH R1088 contains uncrushed specimens of *Dactylioceras commune* (Westphal 1962, p. 106), and Tate and Blake (1876) assigned it to the “zone of *A. communis*”. This clearly indicates the *commune* Subzone of the *bifrons* Zone (beds 49-54 of Howarth 1962), and probably the upper part, within the Main Alum Shales.

Westphal (1962, p. 106) attempted to assign this specimen to a zone, and he accepted the determination by Simpson (1884, p.xi) who placed it 40-60 feet (12-18m) above the Jet Rock Series in the zone of *A. serpentinus* (i.e. Bituminous Shales, *falciferum* Zone). It is uncertain where Simpson obtained his information and the weight of the evidence suggests that he was mistaken. Simpson (1884, p.6) also noted that the skeleton was collected “at the mouth of Whitby harbour”, an inaccurate location repeated by Westphal (1962, p.86).

A second crocodile was found in 1791 between Staithes and Runswick (Young 1825, p. 79; Young and Bird 1822, p. 263; 1828, p. 291; Simpson 1884, p. 6: “seven or eight miles to the north of Whitby”), but it was apparently not collected complete, and the specimen cannot now be traced. There is no information concerning the exact locality or zone of this animal. It could have been found in the Main Alum Shales, blocks of which fall from the cliffs west of Port Mulgrave (NZ 799179), mid-way between Staithes and Runswick.

The third fossil crocodile from Whitby was collected in 1824. Young (1825) characterised the locality as “in the face of a steep cliff, not far from the town” [Whitby] and the rock was named as “alum-shale”. Young and Bird (1828, p.287) added that it was found “in the face of the steep alum cliff beyond Saltwick”. The collector Brown Marshall, a carpenter in Whitby, spotted the snout sticking out of the cliff and
excavated the skull and the bulk of the skeleton by hanging from the top of the cliff on ropes. Part of the tail was taken out three years later. The locality description of a “steep alum cliff beyond Saltwick” could refer to the cliff beyond Saltwick Nab (NZ 915110) or that beyond Saltwick Bay (NZ 919107). The former is more likely since the second locality would probably have been named Black Nab. In both cases, the cliff section shows the Upper Bituminous Shales and the entire Alum Shales Formation. The figure given by Young (1825) shows an ammonite associated with the specimen (WM 7705; the type of *Teleosaurus chapmani* König in Buckland 1836) and it appears to be a crushed *Dactylioceras commune*. This again suggests the *commune* Subzone, and the Main Alum Shales, an assignment indicated by Tate and Blake (1876, p. 244).

Westphal (1962, p. 86) gave the locality of this specimen as between “Staiths” and Runswick, and indicated (pp. 85, 106) that it came from an alum pit. This information appears to refer to the untraced 1791 specimen.

Three or four further crocodile heads from the Yorkshire coast are mentioned by Young and Bird (1828), Young (1829) and Charlesworth (1837), but no locality information is given. Owen (1842, pp. 73-81) redescribed the crocodiles from Whitby and mentioned nine specimens in various collections, but offered no further locality information. In addition, Owen (1842, p. 90) mentioned a crocodile dorsal vertebra, identified as *Streptospondylus* Meyer 1830, from the “jet-rock (lithos shale) near Whitby”. Charlesworth (1855) briefly described a crocodile skull from Whitby as *Teleosaurus ischnodon*, but he did not adequately establish the species, so that it is a *nomen nudum* (Steel 1973, p. 35). The position of *Teleosaurus brevirostris* Owen 1861 (p. 299), based on a vertebra from the Upper Lias of Whitby (not “Lower Lias”, Steel 1973, p. 35) is uncertain. The specimens are not known.

Seeley (1869, p. 122) noted various teleosaur remains “from the Lias of Whitby” in the Cambridge collections. One specimen (SMC J35177), described (Seeley 1869, p. 121) as the “cranial region of a large and undescribed Teleosaur from the Lias of Whitby” was named *Teleosaurus eucephalus* by Seeley (1880a). He offered no further locality information.

Tate and Blake (1876, pp. 244-5) described a further teleosaur species from the “Zone of A. *serpentinus*, Whitby” as *Steneosaurus brevior*. They stated that the specimens (BMNH 14781, R756) contained examples of *Ammonites mulgravei* and *Inoceramus dubius* in the matrix which gave the horizon as within the Jet Rock Series, an assignment accepted by Westphal (1962, pp. 106-7). According to Howarth (1962, p. 411), *Ammonites mulgravei* Young and Bird 1822 is a synonym of *Harpoceras falciferum* (J. Sowerby 1820), and its presence restricts the

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**FIG. 3.** A Yorkshire crocodile. *Steneosaurus gracilisirostris* Westphal 1961, type specimen (BMNH 14792). Collected before 1840 near Whitby. A long-snouted marine form in dorsal view with incomplete limbs and tail, x 0.11. Photograph by the British Museum (Natural History) Photo Unit.
horizon of *Steneosaurus brevior* to beds 41-44 or 45 of the *falciferum* Subzone, and thus the Bituminous Shales.

These two specimens may have come from the extensive exposures of beds 41 and 43 east of Whitby on the foreshore at Saltwick Nab (NZ 915114) or between Black Nab (NZ 921108) and Whitestone Point (NZ 928103). Simpson (1884, p. 7) noted a further large specimen of *S. brevior* (BMNH 20691) that “was dug out of the alum pit at Kettleness”. The specimen is rust-stained, but there is no matrix. It most probably comes from the Main Alum Shales which display much iron-staining at certain levels at Kettleness.

In his catalogue of fossil reptiles in the British Museum, Lydekker (1888, pp. 106-113) mentioned many crocodiles "from the Upper Lias of Whitby", including a partial skull of *Pelagosaurus typus* Bronn 1841 (BMNH 14437), various specimens of *Pelagosaurus brunniarti* (Kaup 1843) (including BMNH 14792 (Fig. 3), figured Owen (1884, pl. 15, fig. 1) as *Teleosaurus chapmani*), a partial skull of *Steneosaurus bollensis* (Jäger 1828) (BMNH 14436), partial skeletons and skulls of *Steneosaurus chapmani* (Köning in Buckland 1836) and partial skulls of *Steneosaurus brevior* Blake 1876.

The taxonomy of the Upper Lias crocodiles from Whitby and Germany was reviewed by Westphal (1961, 1962). He described a new species, *Steneosaurus gracilirostris* Westphal 1961 (pp. 211-2; 1962; pp. 75-78) on the basis of BMNH 14792 (Fig. 3), 15500, R757, and WM (unnumb.), specimens previously ascribed to *Pelagosaurus brunniarti* (Kaup 1843). He synonymised *Teleosaurus chapmani* König in Buckland 1836 (WM 770S, BMNH R1088) with *Steneosaurus bollensis* (Jäger 1828), and recognised the validity of *Steneosaurus brevior* Blake 1876 (BMNH 14781, R756, 20691). Steel (1973, pp. 28-29) synonymised all of the Whitby species: *Teleosaurus chapmani*, *Pelagosaurus brunniarti*, *Steneosaurus brevior*, *Teleosaurus eucranius*, and *Steneosaurus gracilirostris* with *S. bollensis*. The specimen (BMNH 14437) ascribed to *Pelagosaurus typus* Bronn 1841 by Lydekker (1888, p. 106) is probably correctly identified (Duffin 1979, p. 484).

The majority of the Yorkshire coast crocodiles appear to have come from the Alum Shale Formation of the Whitby – Saltwick section, with isolated finds from Sandsend, Runswick Bay and Kettleness. BMNH R5703 from Runswick Bay bears several ammonites, including *Dactylioceras* c.l. *commune*, *Hildoceras sublevisoni* and *Harpoceras falciferum*, which suggest the commune Subzone (Howarth, pers. comm. 1982). Some specimens of *Steneosaurus brevior* came from the Bituminous Shales at Saltwick, and at least three unnumbered teleosaur skulls in the Yorkshire Museum which bear *Harpoceras* also came from the Jet Rock Formation. Another YM specimen from Ravenscar may also have come from this formation. BMNH 14436 probably comes from the Jet Rock (*falciferum* Zone) on the basis of the ammonite *Dactylioceras* and the presence of a patch of jet and associated calcite (Howarth, pers. comm. 1982).
(b) Ichthyosaurs

The third fossil reptile to be recorded from the Yorkshire coast was an ichthyosaur skull and partial skeleton collected in 1819. Young (1820) noted that “the skeleton was imbedded in the alum rock, where it is washed by the tide, and covered at high water, about half a mile east from the entrance of Whitby harbour, and ten yards from the face of the steep cliff, which... is about sixty yards in height. The skeleton lay in the upper part of the great aluminous bed, which here descends below high water mark”. A second, more complete, ichthyosaur skeleton was “found in the Alum Shale in October, 1821... on the cliffs at Whitby... Bird 1828, p. 282). The illustration of this 2.7m long skeleton (Young and Bird 1828, Pl. 16, Fig. 5) shows that the tail has been straightened out, a practice common among early collectors before it was realised that ichthyosaurs had a bend in the vertebral column to accommodate a large tail fin.

These two specimens apparently came from The Scar (NZ 909115), the source of the first crocodiles, and possibly also from the Main Alum Shales there. The specimens have not been traced, but the figures indicate that they may be examples of *Leptopterygius acutirostris* (Owen 1840).

Young and Bird (1828, pp. 283-286) mentioned a further 40 or so specimens of ichthyosaurs from the Whitby area that had been collected since 1820, but most of these were bought by private collectors and cannot now be traced. The bulk of these “were found at or near Saltwick, in the main bed of the alum shale”. The Scar is mentioned again for some of these, but others may have come from excavations in the alum shale cliff at Saltwick Nab (NZ 914112). This was quarried commercially for the manufacture of alum between 1649 and 1708, and 1755 and 1791 (Fox-Strangways 1892, vol. 1, p.453). All of these specimens then are probably to be ascribed to the Main Alum Shales or Cement Shales.

In a review of British ichthyosaurs, Owen (1840) described skeletons of *Ichthyosaurus intermedius* Conybeare 1822 “in the lias near Whitby and Scarborough” and “in the lias of different parts of Yorkshire” (p. 112), remains of *Ichthyosaurus platyodon* Conybeare 1822 from the lias “of Scarborough and Whitby” (p. 116), and remains of *Ichthyosaurus acutirostris* Owen 1840 “common in the lias formations of the neighbourhood of Whitby” (p. 121). The references to Scarborough as a locality probably indicate where Owen examined specimens in collections, since the rocks there belong to the Middle and Upper Jurassic.

Carte and Baily (1863a, p. 162) mention two ichthyosaurs from Kettleness Alum Works (NZ 833160). These works were operated until 1861 by the Marquis of Normanby, and they expose sections in the Jet Rock Formation and Alum Shale Formation. One of these specimens was collected in 1847, and it was sold to Mr James Heywood. This may refer to a large skeleton presented to Manchester Museum by James Heywood and George Hadn in 1847. This 6m skeleton has been figured as “Ichthyosaurus crassimanus Owen. Upper Lias, Whitby” by
Eagar and Preece (1977, p. 15, Fig. 1). The other ichthyosaur "which is now in the Yorkshire Museum, was found a few yards distant [from the type specimen of the plesiosaur Rhomaleosaurus cramptoni in Kettleness alum quarry], and 15 or 16 feet higher in the alum shale" (Carte and Bailey 1863a, p. 162), thus Main Alum Shales. This is probably YM 497, which was donated to the Yorkshire Museum by the Rev. D.R. Roundell in 1857. Owen (1859, p. 9) mentioned this specimen, and it was described as Ichthyosaurus crassimanus by Tate and Blake (1876, pp. 253-4) who gave its provenance as "Zone of A. communis, Lofthouse" (thus, bifrons Zone, ?Main Alum Shales). This specimen was stated to come from "the alum pit at Kettleness" by Simpson (1884, p. 12), and later authors (Melmore 1930; Pyrah 1979) were non-committal ("north of Whitby", "near Whitby").

A large specimen of *I. crassimanus* (8m long) was excavated from the Hawsker cliff in the 1860s, when jet working was in progress. It was bought by Whitby Museum for £105 (Browne 1946, p.170). The label on this specimen (WM 2546S) reads "from the bed above the Jet Rock, Hawsker, i.e. No. 6 Simpson's division of the Upper Lias". The matrix is poorly laminated and specimens of *Dactyloceras* occur. WM 2546S probably came from the Bituminous Shale near the Jet Rock workings at Hawsker Bottoms (NZ 945081). When the new Whitby Museum building was erected, it was found that this specimen was too long to be mounted on the wall as had been planned. The problem had two solutions (Browne 1946, p. 210): "should a foot or so be cut off the end of his tail, or should he be placed diagonally instead of horizontally". Fortunately, the latter course was adopted.

Seeley (1869, pp. 124, 129, 130) mentioned four specimens of *Ichthyosaurus* "from Whitby" in the Sedgwick Museum, one of which (SMC 35176) he later (Seeley 1880b) described as *I. zealandicus*. This specimen was presented by Earl Zetland who operated the Loftus Alum Quarries until 1863 and it was probably collected there.

Tate and Blake (1876, p. 254) mentioned a poor skeleton of *Ichthyosaurus intermedius* Conybeare 1822 whose provenance was "probably the zone of *A. oxynotus*", Robin Hood's Bay (? BMNH R653). The *oxynotus* Zone lies in the middle of the Upper Sinemurian (Dean et al. 1961) and this is one of the few Lower Lias reptiles reported from the Yorkshire coast.

The other ichthyosaurs from the Yorkshire coast that Tate and Blake (1876, pp. 253-4) mention are *Ichthyosaurus acutirostris* Owen 1840 from the "Zone of *A. communis*" (i.e. bifrons Zone), *I. tenuirostris* Conybeare 1822 ("their horizon is unknown"), and *I. longirostris* Mantell 1851 ("probably zone of *A. communis*, Whitby (not serpentinus)"). Simpson (1884, pp. 12-13) offered a similar list, and noted that *I. acutirostris* "is by far the most common in our Lias". He noted a specimen of the large *I. platyodon* Conybeare 1822 (WM "5") "extracted by Mr Louis Hunton, from the Lofthouse alum excavations", thus probably bifrons Zone (? Main Alum Shales). This 16 ft 8 in. (5.05m) long specimen was donated by R. M. Hunton to Whitby Museum in 1867 (Browne
1946, p. 170; 1949, pp. 32, 136). Another ichthyosaur from the Loftus Alum Quarry, 14ft (4.3m) in length, was donated to Whitby Museum by the brothers Richard and John Ripley in 1847 (Browne 1946, pp. 58, 130, 308; 1949, pp. 14, 24, 134). Owen (1881), in his review of British Lias ichthyosaurs, added no further locality details.

Lydekker (1889, pp. 73-112) listed the ichthyosaurs from the Yorkshire coast in the British Museum, and noted several skeletons and partial skeletons from the “Upper Lias of Whitby”. The specimen of I. trigonodon (BMNH 47153) quoted (pp. 105-106) as “from the Upper Lias of Kingsthorpe, Yorkshire: almost certainly came from Kingsthorpe, Northamptonshire, formerly the site of several quarries in the Upper Lias (Woodward 1893, pp. 278, 298-299).

Huen (1922) reviewed some of the Yorkshire ichthyosaur material, and recorded the species present as Leptopterygius acutirostris (Owen 1840), Eurhinosaurus longirostris (Jaeger 1851), Stenopterygius zeelandicus (Seeley 1880) and S. hauffianus Huen 1922. McGowan (1974) considered that only two valid species were present: Temnodontosaurus longirostris (Mantell 1851) and Stenopterygius acutirostris (Owen 1840). He later (McGowan 1976, p. 675, footnote; 1979, pp.120-1) provisionally returned S. acutirostris to Leptopterygius. McGowan (1978, p. 1156; 1979, p. 116) further outlined the confusion between Ichthyosaurus longirostris Jaeger 1851 and I. longirostris Mantell 1851, the latter of which only occurs in Yorkshire. The specimen identified by Huen (1922, p. 54) as S. hauffianus is now lost (McGowan 1978, p. 1155; 1979, p. 105). Further, a neural arch and spine from Whitby ascribed by Fraas (1891) to S. quadriscissus (Quenstedt 1858) are indeterminate (McGowan 1978, p. 1155). In view of the confusing views that have been expressed on ichthyosaur taxonomy, it is important that all the Yorkshire Lias material be revised together in detail.

The type specimen of Temnodontosaurus longirostris (BMNH 14566; Fig. 4a) is ascribed (McGowan 1974, p. 24) tentatively to the Lower Toarcian of Whitby (bifrons or falciiferum Zones). Other specimens referred to this species come from the Lower Lias (Lower Hettangian) and McGowan states that “the Lower Lias does outcrop in Whitby”, but the nearest exposures are west of Staithes and in Robin Hood’s Bay, 12km and 7km from Whitby respectively. Ichthyosaur remains are rare in the Lower Lias of Yorkshire, and it seems likely that this species has a long range in time.

McGowan (1974, pp. 27-33) gave the locality and horizon of Leptopterygius acutirostris as “in the vicinity of Whitby...from the Alum Shales, and also from the Hard Shales and Bituminous Shales...” (i.e. falciiferum and bifrons Zones).

The majority of ichthyosaurs appear to have come from the Alum Shale Formation of the Whitby-Saltwick section. Four specimens came from the Bituminous Shales. BMNH R8309 is labelled “Bituminous Shales. Bed 43 [of Howarth 1962] Black Nab nr. Whitby”, thus lower Bituminous Shales, lower falciiferum Subzone. BMNH R8661 comes from Black Nab also and the matrix suggests a similar age assignment.
WM 880a.1 comes from “Saltwick” (?beds 41–47 on the foreshore: Bituminous Shale) and WM (unnumb.) is a partial snout from below High Lights lighthouse (NZ 929102), thus ?bed 41 or 43, Lower Bituminous Shales, lower falciferum Subzone. A few specimens have been recorded from the Alum Shale Formation of Kettleness and Loftus, and one possibly from the Jet Rock Formation of Ravenscar. Ichthyosaurs apparently also occur rarely in the Lower Lias of Robin Hood’s bay.

(c) Plesiosaurs

Plesiosaurs were first described from the Jurassic of southern England by De la Beche and Conybeare (1821). However, large isolated bones had previously been recorded from the “alum shales” of the Yorkshire coast and these were immediately recognised as plesosaurian (e.g. Young and Bird 1822, pp. 267–268, 328). There was at first some confusion with crocodile remains, but this was soon cleared up by discoveries of more complete skeletons of both reptiles, plesiosaurs from southern England (Conybeare 1822, 1824) and crocodiles from Whitby (Young 1825, pp. 76, 80, and in Melmore 1942, pp. 326-327). Young and Bird (1822, p. 328, pl. 16, figs. 4–6; 1828, pp. 286–287, pl. 16, figs. 7, 7A, 8, 15) described and figured various isolated plesiosaur postcranial elements that were apparently in Whitby Museum. The only precise locality mentioned was Loftus, presumably the alum quarry, for one vertebra (Young and Bird 1828, p. 287). At least one of their specimens is still in Whitby Museum, a set of four vertebrae figured in Young and Bird (1822, pl. 16, fig. 5; 1828, pl. 16, fig. 8). Further plesiosaur specimens figured and described by Young and Bird (1822, 1828) and later authors are doubtless present in Whitby Museum, but many of the specimens have lost their numbers and cannot be related directly to Watson’s (1910, pp. 12-13) catalogue.

The first important plesiosaur was found “by Mr Marshall of Whitby, imbedded in a hard rock belonging to the upper lias beds, situate between Scarborough and Whitby, near the place where that gentlemen had formerly discovered the remains of a crocodile ”(Dunn 1831). If the crocodile is WM 7705, this plesiosaur came from the vicinity of Saltwick Bay, and probably from a nodule in the Alum Shale Formation. It was a partial skeleton, lacking the head and neck, apparently of a large pliosauroid about 3m long over the body. It was

FIG. 4. A Yorkshire ichthyosaur and plesiosaur.

a. Temnodontosaurus longirostris (Mantell 1851), type specimen (BMNH 14566). A long-snouted fish-eater from Whitby. Dorsal and partial side view of damaged skull and skeleton. The specimen is so long that the photograph is split into two halves, x 0.093. Photograph by the British Museum (Natural History) Photo Unit.

b. Rhomaleosaurus cramptoni (Carte & Baily 1863), type specimen (NMI F8785). Collected about 1848 at Kettleness. A large-skulled pliosauroid; nearly complete skull and skeleton in dorsal view, x 0.015; and 19th century model of its supposed appearance in life. Photograph by the National Museum of Ireland.
then in the Rotunda Museum of the Scarborough Philosophical Society (Dunn 1831), and it may be the one mentioned by Young and Bird (1828, p. 286) and Williamson (1837, p. 227). It was purchased by Mr Stickney, the Hon. Curator of Geology, but cannot now be traced in the present museum (D. J. Waterman, pers. comm., 1982). Indeed, Owen (1840) did not mention this skeleton, which may have left the museum before his visit.

Williamson (1837, pp. 226-227) mentioned plesiosaur remains from these “lower portions” of the section of the Upper Lias “from which alun is procured” in “the museums of Scarborough, Whitby and Mr Witham of Lartington”, this last collection is now in the BMNH (Sherborn 1940, p. 145). Hunton (1836, p. 217) said that remains of plesiosaurs were “pretty equally distributed through the upper shale” of the Lias of the Loftus and Boulby area, but later (p. 221) contradicted most accounts by apparently referring plesiosaurs only to the Jet Rock and the immediately overlying shales.

Owen (1840, p. 71) mentioned type vertebrae of *Plesiosaurus brachycephalus* Owen 1840 “in the Lias of Whitby”, without giving a repository. He also mentioned (pp. 82-83) vertebrae of *P. rugosus* Owen 1840 from the Upper and Lower Lias of England, including the “neighbourhood of Whitby”: some of these types were in the York Museum, but have not yet been identified. Tate and Blake (1876, p. 252) and Simpson (1884, p. 11) also mentioned vertebrae of *P. brachycephalus* in the York Museum, which have not yet been traced.

The next major plesiosaur find was SMC J35182, a virtually complete skeleton of a plesiosaurid about 4.5m long and with a head about 0.2m long. It was referred to the Lower Liassic species *Plesiosaurus dolichodeirus*, or to the Owen MS species *P. grandipennis* (Phillips 1853a, p. 8) until Seeley (1865a, b) described it as the type of *P. macropterus*. Watson (1911) redescribed and partly figured it as *Microcleidus macropterus* (Seeley 1865). It was briefly mentioned and first figured in Reed’s *Illustrated Guide to Whitby* (Reed 1854, pp. 83-84). This figure was reprinted by Simpson (1855, pp. 15-17) with brief comments. The circumstances of its discovery and acquisition are not as Seeley (1865a) stated; it was not found in 1842, but in the early summer of 1841 by Matthew Green and two other jet collectors of Whitby. They offered it for £500 to the BMNH, who declined the offer. It was then sold to Cambridge University for £230 in competition with other bidders, including Whitby Museum (Sedgwick, in Clark and Hughes 1890, vol 2, pp. 37-38; Browne 1946, p. 57; Sedgwick MS correspondence, Cambridge Univ. Library, ref Add. 7652/ID,1E). Indeed, a handbill dated 7 August 1841 is preserved in copy in the Sedgwick Museum, advertising the display of the plesiosaur in Green’s shop in Whitby. The reptile was taken by steamboat to Kings Lynn and thence by barge to Cambridge (Sedgwick MS correspondence, Add. 7652/ID/111.d). It was found in “the Lias of the cliffs at Saltwick” (Browne 1946, p. 57), and thus in the Bituminous Shales or Alum Shale Formation, and possibly the Main Alum Shales. Tate and Blake (1876, p. 246) stated apparently
wrongly that it came from the “Zone of A. communis, Lofthouse”, an assignment followed by Watson (1909, p. 1) and Persson (1963, p. 25). Charlesworth (1845) briefly described a large-headed plesiosaurid exhibited to the 1844 meeting of the British Association at York. It had been “found a short time previously in the Lias shale, quarried for the manufacture of alum in the Kettleness cliff”. He referred it, with reservations, to the Lower Liassic species Plesiosaurus macrocephalus. The records of the Yorkshire Philosophical Society (B.J. Pyrah, pers. comm., 1981) state that it was given to the York Museum by the quarry lessees, and that when the owner of the quarry, the Marquis of Normanby, learnt of this he demanded and got the specimen back. It was then sent to Mulgrave Castle, the seat of the Marquis, and sold to Whitby Museum for £200 in 1847 (Browne 1946, pp. 57-58, 308). WM 8515 fits the rough dimensions given by Charlesworth (1845) and is labelled as having come from Kettleness. It is an incomplete skeleton about 4.5m long with a head about 0.6m long. It is presumably the skeleton mentioned by Phillips (1853a) as Plesiosaurus brachyspondylus in Whitby Museum. Carte and Baily (1863a, b) mentioned it as *P. macrocephalus*, giving some dimensions. Tate and Blake (1876, pp. 247-249, pl. 2, fig.1) described and figured it as the type of Rhomaleosaurus proginquus (Blake), listing it also as *P. simpsoni* (p. i). Watson (1909, p. 2) noted that the specimen was rearranged and included material from other individuals, and he described and figured it (Watson 1910). Tate and Blake (1876, p. 249) refer WM 8515 to “Zone of A. serpentinus, Whitby”, from which Lydekker (1899, p. 170) presumably stated “base of the Upper Lias”, and Persson (1963, p. 26) “*falcifer* Zone”. However, WM 8515 came from Kettleness Alum Quarry (also Simpson 1884, p. 10) and therefore probably from the Cement Shales or the upper part of the Main Alum Shales.

Moberley (1849) reported the discovery of a large plesiosaurid “in Lias at the alum-works of Lord Mulgrave [the Marquis of Normanby’s earlier title] at Kettleness”, giving dimensions about right for the type of specimen, *Rhomaleosaurus cramptoni* (Carte and Baily 1863). This is presumably the skeleton described by Phillips (1853a, p. 8) as “the most perfect of all remains at Mulgrave Castle”, in a report published on 1st February 1853. The skeleton is next recorded in Dublin, having been given to Sir Philip Crampton, Bart., who put it on exhibition in May 1853 (Carte and Baily 1863a, pp. 160-161; 1863b, p. 68). Carte and Baily (1863a, b) described and figured this magnificent skeleton (NMI F8785) (Fig. 4b) which is about 7m long with a large and robust head about 1m long, and noted that the limb elements had been mounted in incorrect positions; Lydekker (1889, p. 162) and Watson (1909, p. 2) also noted this rearrangement. Carte and Baily (1863a, b) confirmed that it had been found at Kettleness Alum Quarry on 27th July 1848, and they gave the horizon as about 59 feet (18m) from the top of the Cement Shales, thus well down within the Main Alum Shales. Tate and Blake (1876, p. 247) noted that the “Zone of A. communis, Kettleness”, and Persson (1963, p. 26) that it came from the upper part of the *falcifer* Zone, Kettleness.
The type specimen of *Rhomaieosaurus zelandicus* (Phillips 1853) (YM 503) was donated by the Earl of Zetland to York Museum in the first half of 1852 (Phillips 1853a, pp. 19-20) and named and very briefly described by Phillips (1853a, pp. 7, 8; 1854a, p. 7; 1854b). It is a large and incomplete skeleton, about 6m long, comprising the head, about 1m long, and the vertebral column with parts of the ribs, limb girdles and limbs. It is a robust-snouted form very like *R. cramptonii*. Tate and Blake (1876, pp. 249-250, pl. 1, fig. 5) described and, partly figured it. It came from Loftus (Phillips 1853a, pp. 7, 20; 1853b, p. 142; 1854b; 1875, p. 272; Tate and Blake 1876, p. 250; and the museum label) and not from Kettleness, to which Carte and Baily (1863a, p. 168) appear to refer it, as “the same locality” as the type of *R. cramptonii*. It came from Loftus Alum Quarry (Phillips 1854b), which was operated by the Earl of Zetland, and therefore probably from the Cement Shales or the upper part of the Main Alum Shales. This is confirmed by the matrix on the specimen, which is a flaky grey pyritous shale surrounding concretions around the bone. Tate and Blake (1876, p. 250) referred it to the “Zone of *A. communis*, Lothhouse”, an assignment repeated by Lydekker (1889, p. 167) and Persson (1963, p. 26).

Owen (1865, p. 12) briefly described the type of *Plesiosaurus coelospondylus* Owen, a set of sixteen consecutive cervical vertebrae, from “a heap of rubbish from the old alum works carried out in the upper alum shale – a part of the Liassic series on the coast, characterised by the *Ammonites heterophyllus*, Sow.” and therefore probably from the Cement Shales or the upper Main Alum Shales. He examined them in Whitby Museum in 1842. Watson (1910, pp. 12-13) thought that he could identify these with a set of 15 cervicals referred to *Stenarosaurus dawkinsi* which was grouped with a single caudal of *Microcleidus homalospondylus*; he gave their number as WM 854, and their label as “15 caudal vertebrae of *Plesiosaurus homalospondylus* Owen. Upper Liassic, Saltwick.” However, Simpson (1884, p. 9) listed separately the 16 vertebrae of *P. coelospondylus* and 15 “caudals” of *M. homalospondylus*, both groups being from the rubbish of the Saltwick alum works, so that Watson may perhaps have confused the type material of *P. coelospondylus* with the material of *P. homalospondylus*.

Owen (1865, pp. 12-13) mentioned a second group of vertebrae amongst those examined by him in Whitby Museum in 1842 and referred them, together with some others, to *P. homalospondylus*. The vertebrae in Whitby Museum may be the “15 caudals” mentioned by Simpson (1884, p. 9). This new species was founded on these vertebrae, all from the “Alum Shale of Whitby”, and also on two almost complete skeletons from “that locality”, YM 502 and BMNH 36184. YM 502 is about 5m long. It is a head 0.3m long, represented only by the dentary. It was found in “the Lia Cliffs, south of Whitby, by Mr Brown Marshall, and liberally presented by Col. Cholmley” to York Museum in 1853 (Phillips 1845a; Owen 1859). Presumably this is the specimen described in an extract from the *New Whitby Treasury* for January 1854 (in Browne 1946, p. 74) as having been found by Brown Marshall “in March last [i.e.
March 1853), in the lias or alum shale, a little south of the harbour mouth”. Owen (1865, pp. 12-20, pl. 5-8) described and figured YM 502 and BMNH 36184 and Seeley (1865a, p. 52; 1865b) also briefly described YM 502. It was presumably found in the cliffs of the Whitby–Saltwick section and is thus probably to be ascribed to the bifrons Zone. BMNH 36184 was purchased in 1861 and came from “the upper lias of Whitby”, and thus probably from the same section. Tate and Blake (1876) refer *P. homalospondylus* to the “Zone of A. communis, Whitby”, and thus probably the Main Alum Shales (*commune* Subzone).

Watson (1909) made *M. homalospondylus* (Owen 1865) the type species of *Microcleides*. He described and partly figured YM 502 and MM L7077, a head and incomplete skeleton, although he omitted to mention the head of MM L7077 (Watson 1909, 1911). Watson (1909, p. 4) referred MM L7077 to the “D. commune zone...from Whitby”. It was collected by W.H. Sutcliffe who also found MM L8023, a partial postcranial skeleton “from the D. commune zone of the Upper Lias of Saltwick, some 10 feet above and 100 yards” from the locality of MM L7077 (Watson 1909, p. 13). Both specimens can therefore be referred to the Hard Shales or Main Alum Shales of the cliffs in Saltwick Bay. Watson (1909) described MM L8023 as the type of the new genus and species *Silenosaurus dawkinsi*. He thought it very similar to the pliosaurid *Rhomaleosaurus longirostris* but Brown (1981, p. 339) now regards *S. dawkinsi* as a pliosaurid. Both MM L7077 and MM L8023 were donated by W. H. Sutcliffe to Manchester Museum in 1906 and 1908 respectively (R. M. C. Eagar, pers. comm., 1982).

Tate and Blake (1876, p. 246, pl. 1, fig. 7, 8) briefly described and figured the type of *Plesiosaurus dubius* Blake, a fairly complete skeleton about 1.9m long with a head about 0.25m long, and very similar to *Microcleides maxopectoris*. It was then owned by Brown Marshall but was lost, presumably sold, by 1909 (Watson 1909, p. 2) and has not since reappeared (Persson 1963, p. 26).

Tate and Blake (1876, pp. 250-252, pl. 1, fig. 6, pl. 3, fig. 2) also figured and described another skeleton then owned by Brown Marshall as the type of *Rhomaleosaurus longirostris* (Blake). Watson (1909, p. 3) reported it as lost but it ended up in the Museum of Comparative Zoology, Harvard University (MCZ 1033), where it was described and figured by White (1940). It is about 5m long with a head about 0.7m long. Its head has a remarkably slender and elongate rostrum which is rare in pliosaurids. Tate and Blake (1876, p. 252) referred it to the “Zone of A. serpentinus, Whitby”, thus the *falciferum* Zone, which White (1940, pp. 451-452) wrongly thought equivalent to the lower part of the *bifrons* Zone. This contrasts with the only other record of a skeleton of *R. longirostris* which was found in 1960 in the *bifrons Zone “between Old Peak and Blea Wyke Point, south-east of Robin Hood’s Bay*” (Broadhurst and Duffy 1970). This magnificent specimen (MU unnumb.), about 4m long and with a head about 0.45m long, is superbly displayed in the Department of Geology, University of Manchester. It was figured by Broadhurst and Duffy (1970).
Plesiosaurs are apparently most abundant in the Cement Shales and Main Alum Shales of the Whitby-Saltwick section and the Kettleness Alum Quarry, an observation also made by Simpson (1884, p. 9). Rarer remains come from the same horizon at Loftus and Ravenscar. Tate and Blake (1876, pp. 252-3) also mentioned some plesiosaur remains from the Lower and Middle Lias, but their present whereabouts is unknown. These include a vertebra from the *jamesoni* Zone of Huntcliff and one from the *davoei* Zone of Saltburn (both Lower Lias), as well as a skeleton from the ironstone mines at Eaton, which was broken up, and two coracoids from the ironstone at Skinningrove (Middle Lias).

(d) Pterosaur

A single specimen of the partial skull of a pterosaur was collected by the Rev. D. W. Purdon “from the Alum Shale at Lofthouse”, and named *Scaphognathus purdoni* by Newton (1888). This specimen (GSM 3166) shows middle and posterior parts of the skull, as well as a fine brain cast. It is now named *Parapsicephalus purdoni* (Newton 1888), and is regarded as ancestral to the Late Jurassic *Scaphognathus* (Wellnhofer 1978, p.39), but no further data as to its provenance can be given than Lower Toarcian (?Hifrons Zone, ?Main Alum Shales), Loftus Alum Quarries. Newton (1888, p.503) states that the specimen was “much obscured by the surrounding hard matrix” and the remaining rock suggests that the skeleton was contained in a carbonate concretion, possibly from the Main Alum Shales (H. Ivimey Cook, pers. comm. 1982).

(e) ?Dinosaur (Theropod)

Huene (1926, pp. 36, 71; also Wild 1978, p. 2) mentioned an undescribed specimen in WM of a “middle sized femur” of a carnivorous theropod dinosaur from Whitby. Huene noted that he had not himself seen the specimen, and cited a personal letter from “Dr. [D. M. S.?] Watson”. The specimen had the fourth trochanter placed above the midpoint of the femur.

This specimen has not been traced. If it is found, and its identity confirmed, it will be of great interest as the only find of a theropod dinosaur from the Upper Liassic of any locality. Indeed, only one other specimen of any dinosaur is known from the Upper Liassic: the hindlimb of the sauropod *Ohmdenosaurus* from Ohmden, near Holzmaden, SW Germany (Wild 1978).

(f) ‘Eggs’ and ‘Embryos’

Melmore (1931) described a possible teleosaur egg (YM 505) from Whitby. This object is egg-shaped and consists of mudstone and calcite surrounded by a pyrite skin. According to the description, there is no evidence of shell structure, and the specimen is probably a concretion.

Seeley (1887, 1888a, b, 1896) described a pyritic concretion (BMNH R3585) obtained through a dealer from the “Lias of Whitby” which purported to show at least four embryo or juvenile plesiosaurs. Thulborn
UPPER LIAS MARINE REPTILES FROM YORKSHIRE

(1982) redescribed and figured the specimen, ruling out any plesiosaurian origin, and noted that it had been improved artificially to bring out the superficial likenesses of the plesiosaurs. He interpreted it as inflated *Thalassinoidea* burrows around a concretion, although this interpretation is not wholly convincing. The main body of each "embryo" varies greatly in diameter and shows narrow pointed outgrowths. In typical burrows, the girth generally remains constant, and matches that of the producer. The sharp "spine" along the centre of each "embryo" is hard to explain by the burrow interpretation, and the "burrows" are not clearly separate from the central nodule. The specimen is probably of wholly inorganic origin, and could be the core of a large septarian concretion, the sharp-backed "embryos" being no more than the infill of fissures. Such calcareous and pyritic mudstone "doggers" occur abundantly in the Jet Rock Formation in particular (Howarth 1962).

V. DISCUSSION: THE REPTILE FAUNAS

We have been able to discuss certain of the reptiles from the Upper Lias of the Yorkshire coast in some detail and to determine their provenance. However, the bulk of the existing museum material has never been described, and very few specimens now carry any useful collecting data. A second problem in attempting an overview of the faunas is the absence of current detailed taxonomic reviews. Westphal (1961, 1962) and Duffin (1979) studied some of the crocodiles, McGowan (1974) evaluated some of the ichthyosaurs, and Watson (1909, 1910), White (1940), and Perrson (1963) examined some of the plesiosaurs. Thus, it is difficult to give a well-balanced list of the reptiles that are present in the Upper Lias of the Yorkshire coast.

Nevertheless, we may summarise the important elements of the faunas in a provisional way. There are two genera of marine crocodiles, *Steneosaurus* and *Pelagosaurus*, both teleosaurs, but differing in overall size (*Steneosaurus*, 2.5 – 5.0m long, *Pelagosaurus*, <1.75m) and in certain features of the skull and skeleton. *S. brevior* has a shorter snout (64% of skull length) than *S. bolliensis* (72%) or *S. gracilirostris* (77%) (Westphal 1961, 1962). However, Steel (1973) synonymised all three species as *S. bolliensis*. In *P. typus*, the snout is not sharply set off from the skull. The two ichthyosaur species recognised as valid by McGowan (1974), *Temnodontosaurus longirostris* and *Leptopterygius acutirostris*, are distinguished largely by the relative proportions of parts of the skull. For example, *L. acutirostris* has a larger eye-socket and nasal opening than *T. longirostris* in relation to overall skull length. *L. acutirostris* is generally larger than *T. longirostris* with skull lengths from 60–150cm compared to skull lengths of less than 100cm. There are at least four or five plesiosaurs. Of these, there are at least two pliosauroids (plesiosaurs with short necks and large skulls), namely *Rhomaleosaurus longirostris* which has a gracile snout, and the *R. cramptoni – zetlandicus – propinquus* group with robust snouts. There are also two or three pliosauroids (plesiosaurs with long necks and small heads), namely *Microcleidus*...
macropterus, *M. homalospondylus* and *Sthenarosaurus dawkinsi*. There is one flying reptile, *Parapsiccephalus purdonii*.

We list all known Yorkshire coast material in the Appendix by general locality. When the horizon has been determined, this is also indicated. We may summarise the distribution of the different reptile groups at each locality (Table 1, p. 429). The total number of recorded specimens is given for each group, as well as the number of skulls or partial skulls. This last figure is an estimate of the minimum number of individuals since several separately numbered postcranial pieces may have belonged to the same animal.

Remains of teleosaurs and ichthyosaurs appear to be about equally common (Fig. 5), but many of the ichthyosaur specimens are odd vertebrae and limb bones. Most of the teleosaurs, on the other hand, are represented by skulls or skull fragments, occasionally with associated skeletons. Plesiosaurs are less abundant, and only about one-third of all specimens have skull remains. Only one pterosaur is known. Turtles are not present in the Yorkshire Lias, but nor are they known from Lower Jurassic strata elsewhere.

The Whitby-Saltwick section has yielded most specimens, and their relative abundances are similar to the total figure. Plesiosaurs are more abundant at Kettleness and Loftus, but the total numbers of specimens from these sites are small.

When the known Lias reptile specimens are plotted against a stratigraphic column, the overwhelming abundance in the Alum Shale Formation is obvious (Fig. 5) as noted also by Phillips (1875, p. 272) and Simpson (1884). Specimens whose age has been determined independently by associated ammonites, matrix, or collecting information are distinguished from those whose age has been determined from the literature. The Middle Lias specimen is a plesiosaur or ichthyosaur limb bone from Staithes (YM box 13, unnumb.) which is in a red
medium-grained sandstone. Reddened Middle Lias sandstones are exposed on the wavecut platform just east of Staithes.

Upper Lias reptiles are rare elsewhere in England. Several skulls and skeletons of *Pelagosaurus typus* are known from the “Fish and Saurian Bed” (exaratum Subzone, falciferum Zone) of Strawberry Bank, north of Ilminster, Somerset (ST 361148)(Duffin 1979) and the ichthyosaur *Stenopterygius hauffianus* is also recorded from Ilminster (McGowan 1978). Several sites in the Upper Lias of Northamptonshire have also yielded isolated reptiles. These include Kingsthorpe (SP 7562): ichthyosaurs (BMNH 47153, 47409), plesiosaur (BMNH 47154), type
specimen of *Rhomaleosaurus thorontoni* Andrews 1922 (BMNH R4853); Greens Norton (SP 6649); *Steneosaurus bollensis* (BMNH 47151); Blishworth (SP 7354); ichthyosaur (BMNH 16052); and Wellingborough (SP 8968); *Microraxicodraco homalospondylus* from the *bifrons* Zone (Watson 1909, p. 4). Some specimens of crocodiles (BMNH R6625, R6636), ichthyosaurs (BMNH umb.) and plesiosaurs (BMNH R6623) are recorded from the *bifrons* Zone of Stibbington, Northants (probably the old quarry at TL 092991). Most of these sites are now inaccessible and have little potential for future finds. The Yorkshire coast sites are clearly the best for British Upper Lias reptiles and two of them have been selected as Sites of Special Scientific Interest in the Geological Conservation Review by the Nature Conservancy Council: Whitby Coast (East Pier to Whitestone Point) (NZ 901115 to NZ 928104) and Loftus – Boulby Alum Quarries (NZ 736200 to NZ 757193).

The reptile faunas most similar to those from Yorkshire are those recorded from various localities in the Upper Lias of SW Germany (e.g. Holzmaden, Ohmden, Boll, Banz, Altdorf) and France (e.g. Calvados, Normandy). The bituminous laminated shales and grey marlstones of Holzmaden, Baden-Württemberg, are commonly called the Posidonienschiefer, and they belong to the Schwarzer Jura (tennicostatum to bifrons Zonal of the Lower Toarcian, Urlichs 1977). Haufl (1921) gave an excellent detailed account of the provenances of all fossil reptiles known to him from the Holzmaden area, and the bulk of them came from his subdivisions II 2 to II 13 (middle , upper tenuicostatum Zone to upper falciferum Zone). The German reptiles are clearly rather older on average than those from the Yorkshire coast. Haufl (1921) records ten specimens of plesiosaurs, including four nearly complete skeletons, about 350 specimens of ichthyosaurs, many of which are relatively complete, about 70 specimens of crocodiles, many of which are also complete, and about 10 skeletons and bones of pterosaurs. Thus, plesiosaurs and crocodiles are relatively less abundant, and ichthyosaurs are much more common at Holzmaden than around Whitby.

Several species of reptile are shared between Whitby and Germany. Among the crocodiles, *Steneosaurus bollensis*, *Pelagosaurus hongnaii* and *P. typus* occur in both areas. Among plesiosaurs, the only Holzmaden pliosaaurid is specifically different from the Yorkshire forms, but it is not clear whether any of the plesiosaurids are shared. Huene (1931) described 12 species of ichthyosaurs from Holzmaden and these include *L. acutirostris*, but McGowan (1979) ascribes German “*L. acutirostris*” to *L. burgundiae* (Gaudry 1892).

A great deal has been written about the taphonomy of the Holzmaden reptiles (e.g. Haufl 1921; Brenner 1976; Brenner and Seilacher 1978; Kauffman 1978; Urlichs *et al*. 1979). The exact stratigraphic assignments of several hundred specimens are known, the facies associations and modes of preservation have been studied, and the environments represented by each fossiliferous unit have been reconstructed.
By contrast, so little collecting data have been retained with the Yorkshire coast specimens that very little of substance can be said. An examination of published accounts and the museum specimens has indicated the general stratigraphic assignments of some. We may also say that the museum material shows that a large number of the Yorkshire Lias reptile skeletons were well preserved in an articulated state with evidence of only slight scavenging. The bottom conditions were probably rather anoxic which prevented scavenging. Other partial specimens may have been broken up before burial, by recent wave action or by poor collecting techniques. In some cases, parts of the skeleton were enclosed in a nodule, and other parts may have been damaged or lost during extraction. Further problems arise since early collectors often mounted the bones of a skeleton wrongly, sometimes introducing parts from other animals.

We urge future collectors to record both locality (8-figure National Grid Reference) and horizon (ammonite zone and the exact bed, using a published account, when available), as well as taphonomic data (e.g. completeness of skeleton, orientation and position of burial, state of articulation, relationships of bones to sediment, condition of bones). This is the responsibility of every informed collector and of museum curators who are given specimens by amateur collectors. An important fund of data has been lost because collecting details have rarely been recorded, and we must not continue to behave in this destructive way.

We have listed only those specimens of Upper Lias reptiles from the Yorkshire coast that we have seen. Since writing this paper, we have been informed of several recent finds by private collectors, and a teleosaur skull roof has turned up in Scarborough Museum. There are also several specimens in Scarborough Museum that we have not seen, including a skull that may be the original of Young & Bird (1822, pl. 16, 2).

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APPENDIX

List of known museum specimens of fossil reptiles from the Liass of the Yorkshire coast by locality. Specimens labelled ‘Whitby’ are placed in the Whitby-Saltwick section, although it must be noted that some of them may come from elsewhere along the coast. Taxonomy according to the latest revisions, where available (see text). Repository abbreviations given at the end of the section on “Collections of Yorkshire reptiles”. Where the age of a specimen has been determined from associated ammonites, matrix or collecting information, this is indicated by a superscript: b Binuminous Shales, c Cement Shales, h Hard Shales, j Jet Rock, m Main Alum Shales. The Lower and Middle Liass specimens are noted. Specimens with no repository numbers are given as “unnumb.”.

(a) CROCODILIA

*Steneosaurus bollensis* (Jäger 1828) BMNH 14436 b, 14438-9, 33095, 33105, 33107, 39154, R108b, R5325, SMC J47097, J47099-100, WM 7705a (Type specimen of *Telamosaurus chapmani* König in Buckland 1836), unnumb.

*Steneosaurus brevior* Blake 1876 BMNH 14781b (type specimen), 20691, a R63, a R282a, R405, R7506.

*Steneosaurus gracilis* Westphal 1962 BMNH 14792 (type specimen), 15500, R757, WM unnumb.

*Pelagosaurus bronniarii* (Raupl 1835) BMNH 11589, R4; SMC J35177 (type specimen of...
Telesaurus eucaphalus Seeley 1880.

Pleistosaurus typus Brown 1841 BMNH 14437.

teleosaur indet. BMNH 33995-7, R324, R1091; SMJ 34984-5; YM box 6, 21, 23, 25, 56, and 10 unnumb. specimens without data (one, one).

(b) ICHTHYOSAURIA
Leptopterygius acutirostris (Owen 1840) BMNH 14553 (type specimen), 15500a, 36876, 39454; SMJ 35176 (type specimen of Ichthyosaurus zelandicus Seeley 1880); WM 8775, 8785.

Temnodontosaurus longirostris (Mantell 1851) BMNH 14566 (type specimen). ichthyosaurus indet. BMNH 1229, 2415, 3419, R792, R865, R889; Cambridge Zoology Dept. T1191-2; SMJ 34985-7, J46987, J46994, J47009-9, J47036, J47059, J47062, J47899-1, WM 880, 881, unnumb.; YM boxes, 3, 3a, 4, 7, 11, 12, 14, 18, 21, 22, 326A, and 9 unnumb. specimens without data; HM 85 56.2, 3, 3, 2, 38, 284, 289, 302.

(c) PLEOSAURIA
Microlepidus homalopsis Seeley 1865 BMNH 3618 (type specimen); 40118, R1334, R1367-7; MM J1077 (type), WM 854; BMNH 502 (type specimen).

Microlepidus macrurus (Seeley 1865) SMJ 35182 (type specimen).

Rhomaleosaurus cramptoni (Carte Baily 1863) BMNH 40123, R1008, R1365.

Rhomaleosaurus longirostris (Blake 1876) MCM 1053 (type specimen).

Rhomaleosaurus propinquus (Blake 1876) BMNH 33086; 33115.

Stenaraosaurus dawinsi Watson 1909 MM L8023 (type specimen); WM 856.

pleiosaur indet. BMNH 33101, 33106, 33110; YM boxes 5, 20, 21, and 3 unnumb. specimens without data; SM pleosauroid.

RAVENSCAR

(a) crocodylia
teleosaur indet. YM box 8

(b) ICHTHYOSAURIA
ichthyosaurus indet. YM box 13

(c) PLEOSAURIA
Rhomaleosaurus longirostris (Blake 1876) MU unnumb., (type specimen)

pleiosaurus indet. YM box 16

HAWKESER BOTTOMS

(b) ICHTHYOSAURIA
Leptopterygius acutirostris (Owen 1840) WM 2546S

SANDESEND

(a) crocodylia
"Telesaurus chapmani König in Buckland 1836" YM boxes 329A, B, 331A (one specimen)

KETTLENES

(a) crocodylia
Stenoaouras brevior Blake 1876 BMNH 20691

(b) ICHTHYOSAURIA
Leptopterygius acutirostris (Owen 1840) BMNH unnumb., WM 8765

(c) PLEOSAURIA
Rhoamaleosaurus cramptoni (Carte & Baily 1863) NMI F1878S (type specimen)

Rhomaleosaurus propinquus (Blake 1876) WM 851S (type specimen)

RUNSWICK

(a) crocodylia
teleosaur indet. BMNH R5703

 Staithes - Port Mulgrave

(b) ICHTHYOSAURIA
Leptopterygius acutirostris (Owen 1840) BMNH R5791

ichthyosaurus indet. YM box 13 (M. lias)
UPPER LIAS MARINE REPTILES FROM YORKSHIRE

(c) Plesiosauria
- pleiosaur indet. YM box 13th

(b) Ichthyosauria
- *Leptopteryx staitensis* (Owen 1840) WM 5th; YM 487th (type specimen of *Ichthyosaurus crassimanus* Blake 1876)

(c) Plesiosauria
- *Rhomaleosaurus zetlandicus* (Phillips 1853) YM 503th (type specimen)

(d) Pterosauria
- *Parapsicephalus purdoni* (Newton 1888) GSM 3166th (type specimen)

(b) Ichthyosauria
- ichthyosau indet. BMNH R653 (Lower Lias); HM 2.38.300.

| TABLE 1 |

Reptiles from the Lias of the Yorkshire coast listed by general locality. Totals and percentage totals are given. For all localities, the number of skulls is also indicated as a minimum estimate of the number of individuals present.

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