Whitby Coast (East Pier–Whitestone Point)

[NZ 901 115]–[NZ 928 104]

(Potential GCR site)

Highlights

Historically, Whitby on the North Yorkshire coast is the most important Upper Lias fish-bearing locality in the country, yielding exceptionally preserved material, which includes eight type specimens. The sea cliffs along the coast are continuously eroded, enabling new material to be recovered each year.

Introduction

The Whitby coast section comprises a series of sea cliffs and ledges of Upper Lias mudstones and alum shales which rise from the east of Whitby harbour and extend to Whitestone Point (Figure 12.10). The site is of historic interest as one of the earliest localities in Britain to be exploited for its fossil fishes. It has produced many important fish specimens that form part of a distinct marine fauna including marine reptiles and an abundant macroinvertebrate assemblage. The elements of the fauna are similar to those from the famous localities of the same age at Holzmaden in Germany. The cliffs at Whitby are subject to continuing erosion (Figure 12.11), and the site has produced many good recent finds and has the potential for more.

The wave-cut platform and cliffs east of Whitby harbour have been famous for their fossil fishes since the early part of the 19th century. In 1828 Young and Bird identified 'petrified pikes' (*Lepidotes semiserratus*) in the Jet Rock succession (1828, p. 261). Five species of fossil fish from the Lias of Whitby were briefly described and several others named in the classic monographic works of Louis Agassiz (1833–1845). Simpson (1855) and Egerton (1852) both recognized additional species and in 1876 a comprehensive faunal list was provided by J.F. Blake (*in* Tate and Blake, 1876, pp. 155–60). In a series of papers between 1886 and 1899, A.S. Woodward described and figured all the Whitby fish specimens deposited in the NHM from the large collections made by Egerton and the Earl of Enniskillen (Woodward, 1886, 1896, 1897, 1898, 1899c). In what was a truly modern examination of the late Liassic fish fauna, Woodward also examined other Natural History Museum specimens and attempted a comparative study with the Upper Liassic fish assemblages from Germany and France.

Description

The Upper Lias (Toarcian, Early Jurassic) of the Yorkshire coast consists of dark shales, with intermittent limestone, siltstone and sandy bands, and has been described in local detail (Tate and Blake, 1876; Dean, 1954; Howarth, 1955, 1962, 1973; Hemingway and Wright, 1992). The general succession at Whitby, summarized by Howarth (*in* Cope *et al.,* 1980a), and with revised nomenclature from Powell (1984), is:

	Thickness (m)
————unconformity————	
Whitby Mudstone Formation	
Alum Shale Member (lower part of *Hildoceras bifrons* Zone)	
Cement Shales	5.8
Main Alum Shales	15.2
Hard Shales	6.3
Jet Rock Member (*Harpoceras falciferum* Zone)	
Ovatum Band	0.25
Bituminous Shales	23.0
Jet Rock	7.1

Grey Shales Member (upper and middle parts of *Dactylioceras tenuicostatum* Zone	13.3
Cleveland Ironstone Formation (upper part)	0.6

The beds are nearly flat-lying in the sections to the east of Whitby (Figure 12.11). The Jet Rock Member occurs in the seaward portions of the wave-cut platforms at Saltwick Nab and Black Nab just to the east of Saltwick Bay. The Main Alum Shales and Cement Shales occur mainly in the lower part of the cliff, and the upper part consists of the Middle Jurassic rocks above the unconformity. Most of the beds in the Whitby Upper Lias sequence have yielded sporadic fish remains.

The Jet Rock Member comprises well-cemented, finely laminated, grey or brown shales, locally bituminous with bands of small to large calcareous concretions known as 'doggers', up to 5 m in diameter. The unit is 1–3 m thick and the concretion-bearing horizons vary between 0.1 and 1.0 m in thickness. Fossil fishes are common in the Jet Rock Member and rarer remains also occur within the calcareous doggers (see below).

The Bituminous Shales are less well laminated than the Jet Rock and contain less bitumen. The shale units are 3–8 m thick, and there are three or four 0.15 m bands of pyrite-coated concretions. Fossils, including abundant fish remains, are often pyritized in these rocks (Woodward, 1899c; Howarth 1962; Hemingway, 1974).

The Hard Shales are a non-bituminous grey shale unit characterized by scattered calcareous concretions. Small, whole fish remains are typically found in the Hard Shales.

The Main Alum Shales are a sequence of alternating soft, grey, flaggy shales (0.25–5.00 m thick) and irregular bands containing scattered calcareous concretions and sideritic mudstone horizons. The shales typically weather to distinctive brittle flakes (Hemingway, 1974, p. 176).

Fish fossils appear to have been obtained from various horizons throughout the Jet Rock Member and Alum Shales Member, but there is much confusion over the precise provenance. This difficulty has been brought about by a combination of reasons, but principally through poor collection data; for instance, much of the material collected before 1850 was simply labelled 'Lias: Whitby', and bears contradictory statements by the early authors. For example, many of the early fish fossils were recovered from the mining of jet to the west of Whitby, on the foreshore from Sandsend Ness to the Scar. At that time, one horizon in particular, an indurated band of calcareous concretions ('doggers'), yielded so many large bones of the chondrosteid *Gyrosteus mirabilis,* in association with other fish remains, that the miners called it the 'animal dogger' (Tate and Blake, 1876). However, since Tate and Blake's description of the bed, much confusion has surrounded the exact location and position of the horizon in the series.

Recent changes in the nomenclature of ammonite zones have created further problems. Although Benton and Taylor (1984) reviewed the provenance of specimens on the basis of early collectors' reports and on a study of the matrix and ammonites associated with specimens, they focused exclusively on reptile remains. A similar study has not been attempted for the Whitby fishes. They do provide a good reference correlation of the different stratigraphical units and nomenclature used by previous authors, and this is outlined in (Figure 12.10). Most of the type specimens and the most abundant specimens of Whitby fish were labelled '*serpentinus*' Zone (Tate and Blake, 1876; Fox-Strangways, 1892). The '*serpentinus*' Zone *sensu* Tate and Blake includes the Jet Rock and the lower portion of the Bituminous Shales, which probably incorporated the fish-bearing 'animal dogger' (bed 43; Howarth 1962). However, Fox-Strangways (1892, pp. 127, 137) moved the upper boundary of the '*serpentinus*'Zone to above the *Ovatum* Bed (bed 48; Howarth, 1962), which is the position currently accepted (Figure 12.10), although the zonal nomenclature has been changed (*falciferum* Zone; Howarth, 1962).

Although it now seems that most of the early specimens were recovered from the Bituminous Shales of the Jet Rock Member, in later Victorian times fish fossils were also collected from the Alum Shale Member during excavations for the alum industry along the coast between Saltwick and Whitby (Fox-Strangways and Barrow, 1915). The Hard Shales still yield abundant *Leptolepis* and *Lepidotes* remains (C. Little, pers. comm., 1994).

In some cases there is confusion over whether some of the specimens were actually collected from the Upper Lias sequence at Whitby or were brought to Whitby from other sources, such as Lyme Regis, to fuel the flourishing fossil trade in Yorkshire in late Victorian times (Tate and Blake, 1876; Fox-Strangways, 1892). In particular the specimens labelled as *Dapedius micans* Agassiz are considered to have been recovered from a Lower Lias locality, either Lyme Regis or Barrow-on-Soar, Leicestershire (Woodward, 1899c), and similar proposals were put forward for the species of *Belonostomus* and specimens labelled *as Aspidorhynchus anglicus*'Agassiz. However, in his detailed investigation and descriptions of the Whitby fishes, Woodward (1896–1899) could find no clear evidence that this was the case (see Interpretation).

Many of the Whitby fishes, particularly those in doggers, are beautifully preserved in a state of part or complete articulation. Scavenging was presumably minimised by the prevailing anoxic conditions in the bottom sediment, as suggested by the bituminous nature of the rock. Tate and Blake (1876, p. 179) reported that many fossils in the Jet Rock were preserved in jet and these included 'ganoid' scales. Other incomplete skeletons may have been broken up prior to burial or by recent wave action before the specimens were collected from the foreshore. Much of the material of the large chondrosteid *Gyrosteus mirabilis* is disarticulated and, in some cases, fragmentary. Many of the specimens in the NHM recorded by Woodward (1899c) have suffered pyrite decay (1899c, p. 462). However, a taphonomic study of the fish remains has also been hampered by the lack of suitable collection data and in addition by the incompleteness of some specimens, the result of collection failure and artificial 'improvements' made to certain specimens.

Fauna

Large numbers of fish specimens from the Upper Lias of Whitby occur in Victorian collections in many of the provincial museums, but notable collections occur in the NHM, CAMSM, WHIMS and YORMS:

Osteichthyes: Actinopterygii: Chondrostei

Gyrosteus mirabilis A.S. Woodward, 1899

Osteichthyes: Actinopterygii: Neopterygii: Halecostomi

?Dapedium micans Agassiz, 1844

?Dapedium sp.

Lepidotes semiserratus Agassiz, 1837 (= L. *latissimus* Agassiz)

Osteichthyes: Actinopterygii: Neopterygii: Halecomorphi

?Caturus sp.

Furo (*Eugnathus*) *fasciculatus* Agassiz, 1844

Eugnathus sp. (includes specimens noted as *lepidotes pectinatus*' Egerton

'*L. rugosus*' Egerton and *Aspidorhynchus anglicus* Agassiz, 1844)

Aechmodus ovalis Agassiz, 1839

Saurorhynchus (*Belonorhynchus*) *acutus* Agassiz, 1844

S. (*B.*) *brevirostris* (Woodward, 1895)

Heterolepidotes sp. includes specimens noted as '*Lepidotes pectinatus*'Egerton,

'*L. rugosus*' Egerton and *Aspidorhynchus anglicus* Agassiz (but regarded by Woodward (1895) as indeterminable)

Ptycholepis bollensis Agassiz, 1832

Pachycormus curtus Agassiz, 1833–1844 (includes specimens labelled *P. gracilis* and *P. latus*)

P. acutirostris Agassiz, 1844 (= P *macropterus* (Blainville))

?P. latipennis Agassiz, 1844

Saurostomus esocinus Agassiz, 1833–1844 (= P *latirostris*)

Osteichthyes: Actinopterygii: Neopterygii: Teleostei

Proleptolepis saltviciensis Simpson, 1855

Pholidophorus germanicus Quenstedt, 1858

Interpretation

The Whitby coastal section is extremely important for Upper Lias bony fish remains, with eight type specimens recorded, although no chondrichthyan remains have been recovered. The bony fish type material includes the huge bones of the chondrosteid *Gyrosteus mirabilis,* recovered from the so-called 'animal dogger' in the Bituminous Shales. The fossilized remains of the sturgeon-like fish comprise mostly isolated bones, without head or trunk (Woodward, 1895–1899).

The osteology of *Gyrosteus mirabilis* was described in detail by A.S. Woodward in a series of articles on the fossil fishes of Whitby and other Lias localities (Woodward, 1889–1890, 1895–1899). The bones are usually ornamented with tubercles, ridges and striations, and many are extremely large; the hyomandibular is about 35 cm long and the clavicles measure up to 57 cm (Tate and Blake, 1876). Egerton (1858a) considered *Gyrosteus* to be be closely related to *Chondrosteus acipenseroides,* found at Lyme Regis and this was corroborated by Woodward (1889–1890, 1895a). He suggested that *Gyrosteus* could only be separated from the Lower Lias genus by the shape of its maxilla. Woodward (1895–1899) also considered that some bones of the skull and girdle were almost identical to those of the modern sturgeon, the remains differing only in possessing an extensive branchiostegal opercular apparatus, which is also present in *Chondrosteus.* Few parts of the postcranial skeleton are preserved. The fins are imperfectly known, and except for the scutes over the caudal fin, no scales or dermal plates have been found. Woodward (1895–1899) concluded that the body was probably naked, like that of *Chondrosteus.* Woodward (1895–1899) estimated that the largest individuals of *Gyrosteus mirabilis* probably reached 5–6 m.

The halecostomids are well represented in the fish collections of Whitby, with the remains of *Lepidotes semiserratus* being the most common find in the Upper Lias sections (Figure 12.12). These were first noted by Young and Bird (1822) as the remains of the 'genus *Esox* [the pike], several species of which have bony scales; and it seems most akin to the *Esox levivianus* or the *Esox chilensis*' (1822, p. 261). Later Agassiz named an incomplete specimen of this fish, *Lepidotes latissimus,* but on visiting Whitby he studied better specimens and named the species *Lepidotes semiserratus.* The species was more completely described by Woodward in 1895–1899 based upon several excellent specimens, in the NHM. *Lepidotes semiserratus* was hailed by Woodward as a robust, round-bodied species that attained lengths of up to 0.5 m.

The name *Lepidotus rugosus* was given by Agassiz (1844) for specifically indeterminate fragments, which included a portion of squama-tion referred to either of the halecomorphid genera *Heterolepidotus* or *Eugnathus* by Woodward (1895–1899). This is also the case for the imperfect jaw fragment described as *Aspidorhynchus anglicus* by Agassiz (1833–45) and the incomplete specimen named by Egerton (1843–1852), *Lepidotes pectinatus.* The latter specimen probably represented an unknown, and large species of *Heterolepidotes,* but is too poorly preserved for specific determination (Woodward, 1895–1899).

Controversy surrounds the fragmentary round-bodied halecostome *Dapedium,* recorded from Whitby. According to Woodward (1895–1899) some specimens of *Dapedium* noted by Agassiz (1844) as from Whitby, were probably from the

Lower Lias of Whitby or Barrow-on-Soar. *Dapedium micans* was the name given by Agassiz (1844) to a specimen of squamation and some specifically indeterminate scales in the Natural History Museum (NHM P. 515), but was considered by Woodward to be a *nomen dubium.*

Halecomorphids are also abundant in the Whitby fossil fish assemblages, which includes many genera also recorded from the Lower Lias of Lyme Regis (e.g. *Caturus, Eugnathus, Heterolepidotus* and *Ptycholepis*), several are strictly Upper Lias taxa, and there are five type species. The type specimen of the caturid *Eugnathus fasciculatus* was first recorded but not described from the Upper Lias of Whitby by Agassiz (1833–45). Woodward (1895–1899) noted that the material was too imperfect for specific diagnosis.

Controversy also surrounds the specimens and diagnoses of the two Whitby species of *Saurorhynchus.* The first, *S. acutus,* was described from an imperfect skull and fragment of rostrum from Whitby by Louis Agassiz in 1844. The skull had a low roof and extremely long snout lined with a powerful dentition, and he equated it with his genus *Belonostomus,* but designated the Whitby specimen a new species based on the slenderness of the snout. The genus also occurs at Lyme Regis and in the Upper Lias of Württemberg (Woodward, 1895–1899). However, in a redescription of the specimens Woodward (1895–1899) suggested that they belonged to the Triassic long-snouted genus, *Belonorhynchus.* The second species, *Belonorhynchus brevirostris,* is a typical Lyme Regis form and has also been recovered from the Upper Lias of Germany. The specimen recorded from the Alum Shales of Whitby was once thought to have been from Lyme Regis, but Woodward (1895–1899) concluded that it was probably correctly labelled.

The caturid *Ptycholepis bollensis* was first described by Agassiz (1832) from a fragmentary specimen recovered from the Upper Lias of Whitby, but was originally named by him on material from the German Upper Lias succession of Boll, in Württemberg. Woodward (1895–1899) redescribed the species based upon better preserved material from Whitby and Germany. *Ptycholepis bollensis* is the type species of the fusiform, large-headed caturid genus (Figure 12.12) and reached lengths of up to 0.35 m, of which the skull made up to one-quarter of the total length (Woodward, 1895–1899).

The teleost-like pachycormids are well represented in the Upper Lias succession at Whitby (Figure 12.12), including two type species, *Pachycormus macropterus* and *Saurostomus esocinus.* The former are common in the Whitby Lias, and four species were recognized by Agassiz (1832–1844). However, only one of these species was described at the time, and Woodward (1895–1899) undertook a complete overhaul of the genus. He concluded that only *P. curtus* and *P. acutirostris* were valid taxa. The former is a stout species, of moderate size, reaching lengths of up to 0.5 m, and differing from the type species, *P. macropterus,* in possessing a much shorter skull (Woodward, 1895–1899). *P. curtus* has also been recorded from Upper Lias deposits in France and Germany. The second species, *P. acutirostris,* is based upon an imperfect skull specimen from Whitby, which may in fact belong to *P. macropterus* (Woodward, 1895–1899). A third species, *P. latirostris,* was synonymized by Woodward (1895–1899) with *Saurostomus esocinus. Pachycormus is* an important member of the fauna also in respect of its teleost-like characters of delicate fins and an elongated rostrum and with thin scales.

The primitive tiny sprat-like teleost *Leptolepis saltviciensis is* an extremely common find throughout all the Upper Lias section exposed along the Whitby coastline. The species is typically a small, slender form with a delicate skeleton no more than about 7 cm long (Woodward, 1895–1899). A second early teleost represented in the Whitby fossil fish assemblages is the Upper Lias species *Pholidophorus germanicus,* described from material recovered from Württemberg localities in southern Germany (Woodward, 1891b, 1895a).

Comparison with other localities

Other comparable Upper Lias localities occurring along the Yorkshire coast that have yielded a similar marine fauna include Saltwick and the old alum quarries at Kettleness [NZ 83 16] and Loftus [NZ 74 20]. Further Yorkshire coast localities, including Runswick Bay, Robin Hood's Bay, Port Mulgrave, Staithes, Sandsend, Hawsker Bottoms, Boulby and Ravenscar (Old Peak–Blea Wyke Point) have also produced a comparable fauna. The Upper Lias of southern and central England is not so rich in fish fossils as the Lower Lias, but various localities in Somerset, Gloucestershire, Northamptonshire, Leicestershire, Lincolnshire and North Yorkshire have yielded a similar, but less impressive, fauna to that at Whitby. The localities at Blisworth ([SP 73 54]) and Wellingborough ([SP 98 68]) are still accessible but most of the

others are inaccessible and have little potential for future finds. The undescribed collections of Upper Lias fossil fish made by Charles Moore from the 'Fish and Saurian Bed' (*falcifer* Zone, Toarcian) around Ilminster, Somerset [ST 35 14], and now held in the Bath Geological Museum are comparable to those of Whitby, containing specimens of *Lepidotes, Dapedium, Caturus* and *Pachycormus* (Moore, 1852, 1856, 1866; Duffin, 1978). They exhibit exceptional three-dimensional preservation (Rayner, 1948), but the localities have now been infilled.

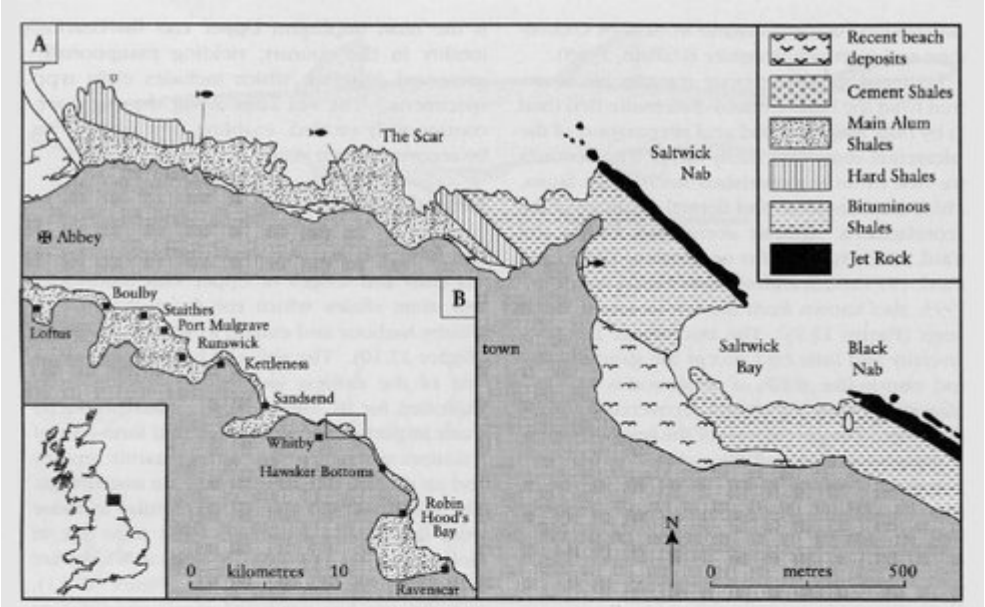
The Upper Lias caps the summits of Alderton [SP 101 345] and Dumbleton [SP 008 355] Hills in the northern Cotswolds and has yielded from the so-called 'Fish and Insect Beds' (*falcifer* Zone, Toarcian) pale limestone nodules which contain abundant fish and insect specimens. Wright recorded (1865, p. 156) *Sauropsis, Pacbycornzus, Pholidophorus, Lepidotes* and *Leptolepis.* The 'Fish Bed' at Dumbleton Hill has produced the only British specimens of the Upper Lias pachycormid which is *Euthynotus,* known from northern France and southern Germany (Woodward, 1895a, p. 377–9; Woodward, 1911). The semionotid *Tetragonolepis discus* Egerton 1853 was described from a partial fish from the Dumbleton 'Fish Beds' (Woodward, 1895a, pp. 160–1). Some of these specimens are located in GCM, NHM and other museums.

The fish faunas most similar to those from Yorkshire are from localities in the Upper Lias of south-west Germany (e.g. Holzmaden, Ohmden, Boll, Banz and Altdorf) and France (e.g. Normandy, Franche-Comte). Most of these sites cannot be compared readily with the Whitby sec tion since the recorded finds are too sparse to constitute a 'fauna'. The exception is Holzmaden, Baden-Württemberg, where the bituminous laminated shales and grey mudstones of the Posidonienschiefer, a subdivision of the Schwarzjura E (*tenuicostatum* to *bifrons* zones, Early Toarcian; Urlichs, 1977), have produced hundreds of specimens. These include *Hybodus* and *Paleospinax, Lepidotes* and *Dapedium, Ptycholepis, Tetragonolepis, Saurorhynchus,* etc. (Wild, 1990). Hauff (1921) noted that the bulk of these came from his subdivisions II 2 to II 13 (middle E, upper *tenuicostatum* Zone to *upper falciferum* Zone), thus rather older on average than the Yorkshire coast finds.

Conclusion

The Yorkshire coast sites are clearly the best for British Upper Lias fishes, hence their conservation value. The coast between Whitby and Whitestone Point has yielded more specimens, and type specimens, than any other Upper Lias marine site in Britain, and many of them are articulated.

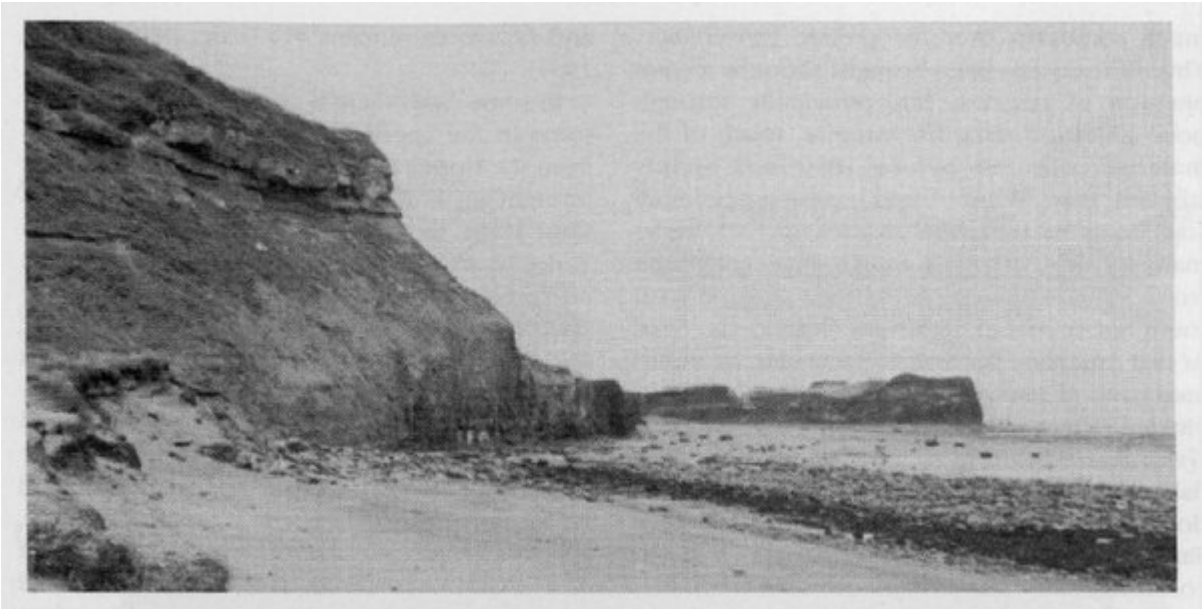
References



C

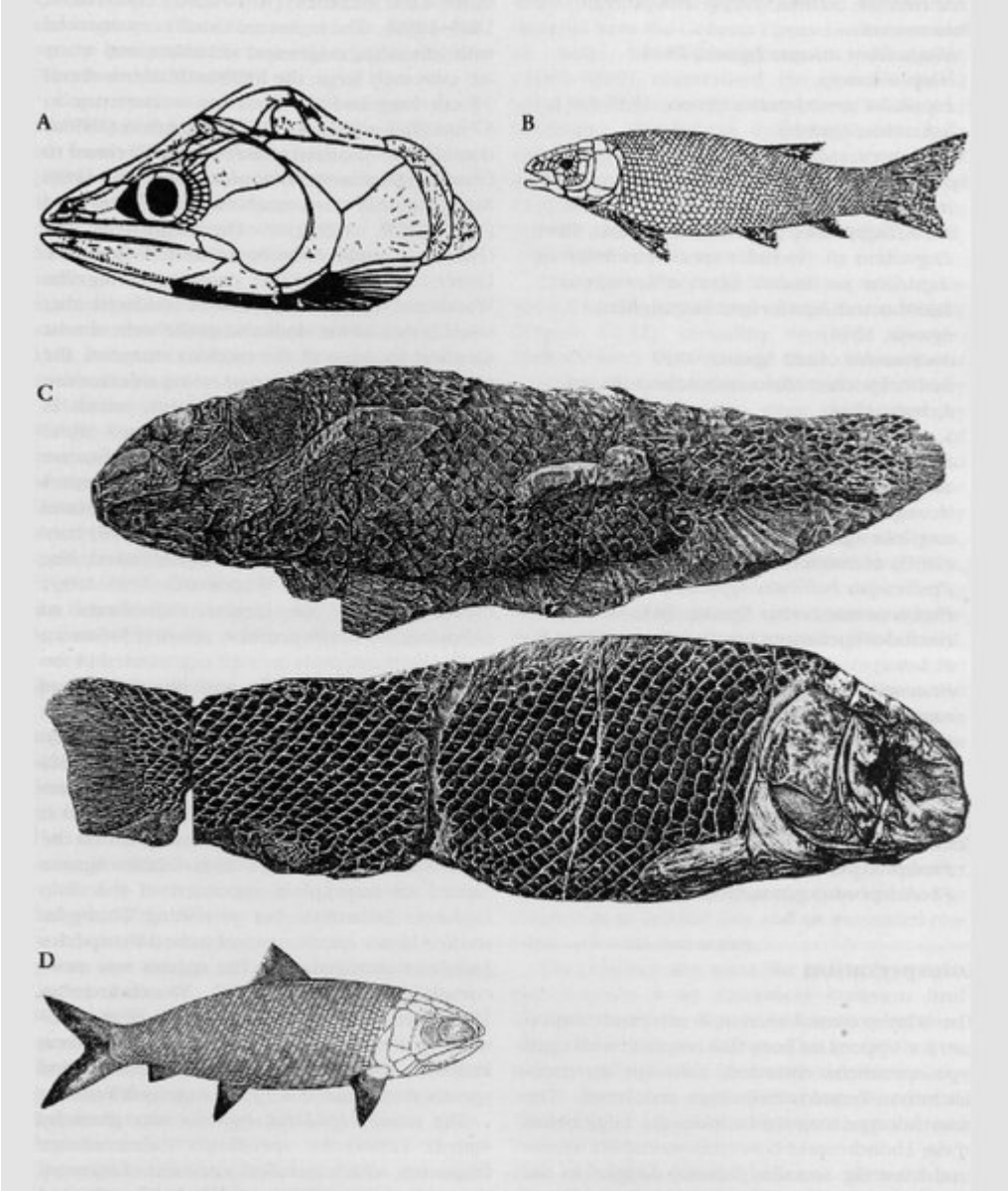
Zones	Subzones	Lithostratigraphy		Howarth's Bed Numbers	Thickness	Tate & Blake (1876)	Buckman (1910, 1915)
Hildoceras bifrons	*Catacoeloceras crassum*	Whitby Mudstone Formation / Alum Shale Member	Cement Shales	65–72	5.8 m	*communis* Zone	*braunianum* Zone
	Peronoceras fibulatum		Main Alum Shales	51–64	15.2 m		*fibulatum* Zone
	Dactylioceras commune		Hard Shales	49, 50	6.3 m		*subcarinatum* Z.
Harpoceras falciferum	*Harpoceras falciferum*	Jet Rock Member	*Ovatum* Band	48	0.25 m		*pseudovatum* Zone
			Bituminous Shales	41–47	23.0 m	*serpentinus* Zone	*exaratum* Zone
	Harpoceras exaratum		Jet Rock	33–40	7.1 m		
Dactylioceras tenuicostatum	*D. semicelatum* *D. tenuicostatum* *D. clevelandicum* *Protogrammoceras paltum*	Grey Shales Member		1–32	13.3 m	*annulatus* Zone	*tenuicostatum* Zone
Cleveland Ironstone Formation (part) 0.65 m							

(Figure 12.10) (A), (B) Sketch map of the geology near Whitby with (C), rock succession in the local Upper Liassic (after Benton and Spencer, 1995). Fish bearing localities are marked on (A).



(Figure 12.11) Saltwick Bay, Whitby: the cliff at the left is of the Alum Shale, topped by Dogger Sandstone and boulder clay. The distant Nab headland is also of Alum Shale; the Jet Shale crops out on the lower tidal area of the beach beyond

the Nab. Both formations have yielded fossil fishes. (Photo: BGS no. A5519, Crown Copyright reserved.)



(Figure 12.12) Upper Liassic osteichthyan fishes from the coast at Whitby: (A) Pachycormus curtus Agassiz, x 0.4, restoration of the head in lateral view by Lehman 1966; (B) Lepidotes semiserratus Agassiz, x 0.6, restoration by Jaekel 1929; (C) lateral views of Lepidotes semiserratus after Woodward 1895a; 1901, x 0.7; (D) Ptycholepis sp. x 0.25.