Blue Bell Hill Pits

[TQ 738 617]

Highlights

The Blue Bell Hill Pits, Burham, in Kent are one of Britain's richest Chalk (Late Cretaceous) fish sites (Figure 13.12). During active quarrying production the pits on Blue Bell Hill produced remains of over 60 species of fish from the Lower and Middle Chalk succession. Much of the fossil fish material is well preserved, frequently without significant crushing or distortion. Articulated material and delicate cranial remains have been recovered from the Burham pits and description of these specimens has formed the basis for several monographs on Chalk fishes.

Introduction

The two Culand Pits on Blue Bell Hill near Burham, the Lower Pit [TQ 737 613] and the Upper Pit ((Figure 13.12); [TQ 739 619]), have yielded some of the most important fossil fishes from the British Chalk. The material is extremely well preserved, in many cases with little distortion or disarticulation. The fauna includes 13 type specimens and several other taxa which are rare elsewhere. The type and only specimen of the gale-omorph shark *Cantioscyllium decipiens* Woodward, 1899 was recovered from Blue Bell Hill in the late 19th century. This specimen is a well-preserved, incomplete skeleton that shows not only articulated jaws and vertebral column, but also an associated braincase, which is rarely preserved in sharks. The quarries are still accessible, although no longer worked. Further finds could be made with excavation.

Lower Culand Pit is in the Lower Chalk (Cenomanian) and Upper Culand Pit is in the Middle and Upper Chalk (Turonian; (Figure 13.11)). Jukes-Browne and Hill (1903) gave a sketch section that makes this clear. Further details of the quarries are given in papers by Dibley (1900, 1904, 1907, 1918, Dibley and Spath, 1926) and by Dines *et al.* (1954). Kennedy (1969) gave a section, with details of the ammonites, for the Lower Chalk. The fish finds have been described by Dixon (1850), Woodward (1888b, 1902–1912) and Woodward and Sherborn (1890).

Description

The pit faces on Blue Bell Hill form a prominent feature in the landscape, as they are cut into the North Downs. The pits probably display one of the best and most complete inland sections of the Chalk in southern England. There are two main pits on Blue Bell Hill, known as the Culand pits, and a combined section of the Chalk in the two quarries, summarized from Jukes-Browne and Hill (1903) and Dines *et al.* (1954) is:

	Thickness (m)
Upper Culand Pit	
Soil	0.3
Upper *Chalk/planus* Zone	
Very rough, rubbly hard crystalline chalk	6.1
Rough, lumpy chalk	4.9
Layer of flints	0.2
Massively bedded chalk	1.5
Layer of flints	0.2
Rough, hard, lumpy chalk	1.1
Layer of flints	0.2
Rather rough and lumpy chalk	0.9
Rather rough, hard chalk with scattered flints	0.9
	15.8

Middle Chalk (*lata* and *labiatus* Zones)	
Firm, soft, lumpy chalk	1.2
Firm, white, smooth chalk	7.6–9.1
Massive homogeneous white chalk	35.7
	c. 46.1
Lower Culand Pit	
Middle Chalk and Melbourn Rock	9.1
Lower Chalk	
Plenus Marls (Belemnite Marls; *gracile* Zone)	
Yellowish grey laminated marl	0.3–0.4
Pale yellowish grey marly chalk	1.8
Grey Chalk and *mantelliana* Band (*naviculare* and *rhotomagense* Zones) Beds 6, 7 and 8. Firm white chalk passing gradually down into grey chalk	c. 25 m
Bed 5. Grey marly chalk	c. 5 m

The fossil fish specimens seem to have been derived from several horizons in the Chalk succession exposed at Blue Bell Hill, but the labels of many of the museum specimens do not provide detailed stratigraphical information. Some museum specimens are labelled 'Lower Chalk' (e.g. NHM P3977) or 'Middle Chalk' (e.g. NHM 1703, 4034) and some are even labelled to zonal level, such as '*H. subglobosus* Zone, Middle Chalk' (e.g. NHM 49014, 49054, 49073, P5681) or '*S. plana* Zone, Upper Chalk' (e.g. NHM P.111), but others lack horizon information. Hence it is impossible to gain an impression of the vertical distribution of fish finds through the Chalk in the Blue Bell Hill pits. It is most probable that much of the vertebrate material came from the Lower Chalk of the Lower Pit, as the Middle and Upper Chalk are much less vertebrate rich.

The fossil fishes are generally well preserved and fine detail may be seen. Individual specimens may be largely articulated or broken up. Often only isolated teeth and vertebrae of larger forms are found. The Lower Chalk (*rhotomagense* Zone) of the large southern pit shows numerous small crustacean or worm burrows (*Terebella lewesiensis*) which are commonly lined with fish scales and bones (Hancock, 1958). In the past these burrows have been mistaken for complete fish specimens (e.g. Mantell, 1822), as the elongate tube looks vaguely like the skeleton of an eel-like fish (Longbottom and Patterson, 1987). The Chalk succession of Blue Bell Hill has also yielded a rich invertebrate fauna, housed in the NHM and BGS(GSM), and documented by Dibley (1900, 1922) and Dines *et al.* (1954).

Fauna

The abundant remains from the Blue Bell Hill Pits are preserved in the NHM, CAMSM, and MAIDM. These are generally labelled 'Burham' or 'Blue Bell Hill'. The following list has been derived from Woodward (1902–1912):

Chondrichthyes: Elasmobranchii: Euselachii: Hybodontoidea

Ptychodus decurrens Agassiz, 1835–1839

P. latissimus Agassiz, 1835–1843

P. mammillaris Agassiz, 1835–1839

P. polygyrus Agassiz, 1835–1839

P. polygyrus var. *marginalis* Agassiz, 1835–1839

Chondrichthyes: Elasmobranchii: Neoselachii: Squalomorphii

Hexanchus (*Notidanus*) *microdon* (Agassiz, 1843)

Chondrichthyes: Elasmobranchii: Neoselachii: Galeomorphii

Cantiosyllium decipiens Woodward, 1889

Cretolamna (*Lamna*) *appendiculata* (Agassiz, 1843)

Cretoxyrhina (*Isurus*) *mantelli* (Agassiz, 1843)

'*Lamna*' spp.

Paranomotodon (*Oxyrhina*) *angustidens* (Reuss, 1843)

Scapanorhynchus rhapiodon (Agassiz, 1844)

S. subulatus (Agassiz, 1843)

Scyliorhinus antiquus (= *Scyllium antiquum* Agassiz, 1843)

Squalicorax (*Corax*) *falcatus* (Agassiz, 1843)

Synechodus (*Hybodus*) *dubrisiensis* (Mackie, 1863)

Chondrichthyes: Holocephali: Chimaeriformes

Edaphodon (*Ischyodus*) *agassizi* (Buckland, 1835–1836)

Edaphodon (*I.*) *mantelli* (Buckland, 1835–1836)

E. sp. (fin spines)

Elasmodectes willetti Newton, 1878

Ischyodus thurmanni Pictat and Campiche, 1858

I. incisus Newton, 1878

Osteichthyes: Actinopterygii: Neopterygii: Halecomorphi

Neorhombolepis ?punctatus Woodward, 1895

Tomognathus mordax Dixon, 1850

Osteichthyes: Actinopterygii: Neopterygii: Teleostei

Apsopelix (*Syllaemus*) *anglicus* (Dixon, 1850)

Belonostomus cinctus Agassiz, 1837–1844

Dinelops ornatus Woodward, 1901

Enchelurus anglicans Woodward, 1902–1911

Ichthyodectes (*Hypsodon*) *minor* (Egerton, 1850)

I. tenuidens Woodward, 1901

Ichthyodectes sp.

Osmeroides latifrons Woodward, 1902–11 0.

O. levis Woodward, 1895

Pachyrhizodus basalis Dixon, 1850

P. dibleyi Woodward, 1901

P. (*Acrodontosaurus*) *gardneri* (Mason, 1869) (= *P basalis* Forey, 1977)

P. (*Raphiosaurus*) *sublidens* (Owen, 1842)

Plethodus expansus Dixon, 1850

P. oblongus Dixon, 1850

P. pentagon Woodward, 1899

Protosphyraena ferox Leidy, 1857

P. (*Saurocephalus*) *minor* (Agassiz, 1837–1844)

Xiphactinus (*Portheus*) *mantelli* (Newton, 1877)

parasphenoid dentition of elopiform fish

Osteichthyes: Actinopterygii: Neopterygii: Euteleostei

Aulolepis typus Agassiz, 1837–1844

Apateodus striatus Woodward, 1901

Caproberyx (*B.*) *superbus* (Dixon, 1850)

Cimolichthys levesiensis Leidy, 1857

Ctenotbrissa (*Beryx*) *microcephala* (Agassiz, 1835–1838)

C. (*B.*) *radians* (Agassiz, 1835–1838)

Enchodus (*Esox*) *lewesiensis* (Mantel, 1822)

Eurypbolis pulchellus Woodward, 1901

Halec (*Pomognathus*) *eupterygius* (Dixon, 1850)

Hoplopteryx (*Beryx*) *lewesiensis* (Mantel, 1822)

H. simus Woodward, 1902

Homonoicthys dorsalis Dixon, 1850

H. rotundus Woodward, 1902–1911

Platycormus (*Berycopsis*) *elegans* Dixon, 1850

Sardinoides illustrans Woodward, 1902–1911

Osteichthyes: Sarcopterygii: Actinistia

Macropoma mantelli Agassiz, 1835–1844

M. praecursor Woodward, 1909

Macropoma sp. (coprolites)

Interpretation

The fishes of the Chalk at Burham were reviewed by Woodward between 1902 and 1912. As well as the fish fauna (Figure 13.13), the chalk pits at Blue Bell Hill have yielded a reptile fauna of international importance: see the GCR volume on fossil reptiles (Benton and Spencer, 1995). The reptile assemblage is of mainly marine forms including turtles, plesiosaurs and mosasaurs, but also contains three type specimens of the piscivorous pterosaur *Ornithocheirus.*

The specialized hybodont *Ptychodus* is represented in the Blue Bell Hill shark fauna by four species, all of which have been found elsewhere in the Chalk. All are based on isolated quadrate teeth or, in the case of *P. decurrens* Agassiz, 1835–1839, on partial dentition. The fauna also contains abundant advanced selachians, including a representative of the six- or seven-gilled hexanchid squalomorphs or cow-sharks. *Hexanchus* (*Notidanus*) *microdon* (Agassiz, 1843) is an extinct form, known only from the isolated occurrences of its multicuspid, comb-like, lower teeth in the English Chalk. This is a relatively small species of *Hexanchus,* with teeth only about 12 mm in width (Longbottom and Patterson, 1987).

Galeomorph sharks, well represented in the Blue Bell Hill fish assemblages, include two type specimens. The orectolobid *Cantiosyllium decipiens* Woodward, 1889 is probably the most important fossil fish to have been recovered from the Culand pits ((Figure 13.13)A), as the monospecific genus is only known from the type specimen (a crushed but partially complete skeleton) and a few scattered teeth from the Turonian of South Dakota, USA (Cappetta, 1973), and in the Cenomanian–Turonian of Northern France (Herman, 1977). The second type at Burham is that of the dogfish *Scyliorhinus antiquus* (Agassiz 1843), which is based on a skeleton that exhibits parts of the head cartilages, the jaws and some anterior vertebrae ((Figure 13.13) (B-D); Woodward, 1902–1912). Usually only the tiny (2.5 mm wide) teeth of this genus are found within acid residues (Longbottom and Patterson, 1987).

More common elements of the galeomorph shark component of the Burham fauna are the large piercing teeth of Lamniformes. These include the cretoxyrhinids, *Cretolamna appendiculata* (Agassiz) and *Cretoxyrhina mantelli* (Agassiz), the mitsukurhinids *Scapanorhynchus raphiodon* (Agassiz) and *Sc. subulatus* (Agassiz), the alopiid *Paranomotodon angustidens* (Reuss), and the anacoracid *Squalicorax falcatus* (Agassiz). The teeth of these predatory sharks are common in all Chalk facies (Longbottom and Patterson, 1987), where they probably competed with the aquatic reptiles for the top carnivore niche in the pelagic environment. Teeth of the small enigmatic palaeospinacid shark *Synechodus dubrisiensis* (Mackie) have also been recovered by acid digestion of the Lower Chalk at Burham.

Chimaeroids are well represented in the Blue Bell Hill pits, although elsewhere in the Chalk, holocephalian remains are rare and fragmentary (Newton). Those from Burham include two species of the typical Cretaceous and early Tertiary genus *Edaphodon* (based on tooth plates) and a fin spine of the same taxon, and the small, rare genus *Elasmodectes willetti* Newton, 1878 which is known from only four localities in the English Chalk (Woodward, 1902–1912, and see the Southerham (Machine Bottom Pit) report). The Jurassic genus *Ischyodus* is represented in the Burham fauna by the Gault species *I. thurmanni* Pictet and Campiche and the type and only specimen (a lower tooth plate: (Figure 13.13)E) of *I. incisus* Newton (Woodward, 1902–1912).

Bony fish remains from the Chalk at Burham include neopterygians. *Belonostomus cinctus* Agassiz is one of the last representatives of the aspidorhynchid fishes that ranged from the Upper Jurassic to the Upper Palaeocene. The genus has been found in Cretaceous formations worldwide, and is characterized by the long rostrum overhanging an equally long mandible (Woodward, 1902–1912) and by the distinctive squamation. *Neorhombolepis* was a specialized caturid halecomorph ((Figure 13.13)1), which exhibits complete vertebral centra and had no fulcra in the paired fins. Two species have been recorded from the Lower Chalk of Kent, the second, *Neorhombolepis punctatus* Woodward, 1895, being

based upon isolated but distinct ganoid scales from Burham. *N. punctatus* is also known from the '*H. subglobosus*'Zone of Dorking, Surrey and Louth, North Lincolnshire (Woodward, 1902–1912).

The large swordfish-like pachycormid *Protosphyraena* is known from fragmentary jaws and rostrum from the Lower Chalk ('*H. subglobosus* Zone') of Burham. Two species, *P. ferox* Leidy and *P. minor* (Agassiz) have been recorded from the site (Woodward, 1902–1912). The first is a common Chalk species, known from partial skulls and the characteristic sickle-shaped pectoral fins. *Protosphyraena ferox* was a large fish (the rostrum reaches 0.3 m in length) and has been noted in most Cenomanian and Turonian Chalk localities and in the underlying Cambridge Greensand (Cenomanian).

Tomognathus mordax Dixon is a halecomorph neopterygian known from only a few localities, including Blue Bell Hill and Southerham (q.v.) in the Chalk. Specimens collected from Blue Bell Hill in the 19th century by G.E. Dibley include well-preserved skulls and a partially complete skeleton, which suggest that *Tomognathus* was long-bodied, with a feebly ossified endoskeleton, large pectoral fins and a triangular caudal fin. The head was short and laterally compressed, with a very large eye and strongly curved, slender teeth. In general morphology, *Tomognathus* resembles the modern stomiiform teleosts, predators which inhabit a deep-sea niche.

Teleosts and euteleost bony fish are well represented in the Chalk fauna from Blue Bell Hill (Figure 13.13). Six type specimens of the more archiac teleosts have come from Burham, and 15 species have been recorded (Woodward, 1902–1912). These include representatives of the Elopiformes, the Ictthyodectiformes, an anguilliform and the enigmatic plethodonts.

Elopiformes are represented in the fauna by the type specimens of the crossognathid *Apsopelix anglicus* (Dixon) and *Osmeroides levis* Woodward, both fusiform elopiform fishes that resemble the modern tarpon (*Megalops*) and albuloids (*Albula*), found today in tropical seas. *Apsopelix* is a relatively large robust form with a large head, very large scales and pelvic fins which lie farther back than in any other teleost (Patterson and Rosen, 1977), whilst *Osmeroides* is a much smaller fish, which possessed a tubular, non-laterally compressed head and body (Forey, 1973a). *Dinelops* is similar to the Upper Cretaceous 'pseudotarpon' genera *Notelops* and *Protelops,* recovered from Brazil and the former Czechoslovakia respectively (Forey, 1973a, 1973b); it is known only from the Lower Chalk of Kent and Dorking, Surrey (Woodward, 1902–1912).

The pachyrhizodontids are a group of large predaceous elopiformes similar to the modern day albuloids (e.g. *Albula*), unremarkable in general body-plan, but possessing a heterodont dentition which includes robust and conical teeth, with a characteristic swollen base, which are fused to and surrounded by the bone of the jaws (Woodward, 1902–1911; Longbottom and Patterson, 1987). Two type specimens of *Pachyrhizodus* are recorded from Burham, the type species *P. basalis* Dixon and the more robust species *P. dibleyi* Woodward ((Figure 13.13)H).

Closely related to the elopiform fishes described above, are the eels or Anguilliformes, and the two orders are united within the teleost Superorder Elopomorpha (Greenwood *et al.,* 1966; Forey, 1973a, 1973b). *Enchelurus anglicans* Woodward is a typical Upper Cretaceous anguilliform that differs from modern and Tertiary eels in possessing distinct tail and pelvic fins.

The Ichthyodectiformes arc an extinct order of Mesozic teleost fishes, a sister group of the extant osteoglossomorphs (Greenwood *et al.,* 1966, 1973; Patterson and Rosen, 1977), and similar in general appearence to the living clupeiform *Cheirocentrus* (Woodward, 1902–1912; Bardack, 1965). The icthyodectids possess a large triangular supraoccipital crest, fused parietals, and were large (up to 2 m long) teleosts, which tended to swallow their prey head first and whole (Patterson and Rosen, 1977). This Family is well represented in the English Chalk and two genera, *Ichthyodectes* and *Xiphactinus,* are known from Burham, including the type specimen of *I. tenuidens* Woodward (Figure 13.13)L, M. Both had long fusiform bodies and large heads with an upward-pointing lower jaw and slightly protruding upper jaw, both lined with sharp hollow teeth set in deep sockets (Woodward, 1902–1912; Bardack, 1965; Nelson, 1973).

The plethodonts are an enigmatic Cretaceous teleost group probably related to the crossognathids and pachyrhizodontids (Patterson, 1967; Greenwood, 1973), which ranged from the Gault to the Upper Chalk, and of which *Plethodus* is the only genus recorded from the Chalk (Longbottom and Patterson, 1987). The plethodonts had a crushing

dentition consisting of two opposing plates with smooth grinding surfaces formed from the fusion of small teeth. The species of *Plethodus* are characterized by their differently shaped tooth plates.

Representatives of the higher teleosts or euteleosts are found in the Chalk at Blue Bell Hill. The Euteleostei are fishes that primitively have an adipose dorsal fin, and are also characterized by features of the caudal skeleton. All those forms represented in the Burham fauna are highly advanced eutelosts or 'neoteleostean' fishes as defined by Rosen and Patterson (1969) and Rosen (1973). The neoteleosts are the largest group of living bony fishes (Rosen, 1973), and hence those of the Chalk succession are extremely important in defining basal characteristics of the group.

Among the neoteleosts, the extinct Cretaceous ctenothrissiform fishes *Aulolepis* and *Ctenothrissa* of Patterson (1964, 1968) are allied to the two major neoteleost groups, the acanthopterygians and paracanthopterygians, but seem to form their sister-group (Rosen, 1973).

The Chalk euteleosts also include several taxa referrable to the aulopiforms (Rosen, 1973). The Chalk aulopiforms are commonly referred to the informal grouping 'enchodonts' by many authors (Woodward, 1902–1912; Goody, 1969; Longbottom and Patterson, 1987) and were predatory fishes with characteristic fangs, probably with a lifestyle similar to that of extant deep-sea predators like the lancet-fish, *Alepocephalus* (Longbottom and Patterson, 1987). 'Enchodonts' at Burham include representatives of three extinct aulopiform groups, enchodontids *Enchodus lewesiensis* (Mantel) and the type specimen of *E. pulchellus* Woodward ((Figure 13.13)J), the cimolichthyid *Apateodus striatus* Woodward, and *Cimolichthys lewesiensis* Leidy, and the halecoid *Halec eupterygius* (Dixon). The general morphology of the 'enchodonts' is displayed in the type specimen of *Eurypholis pulchellus,* an imperfect head recovered from Burham and described by Woodward (1901). *Enchodus* shows some advanced aulopiform characteristics in the snout and scales (Rosen, 1973). The isolated fangs of 'enchodonts' are the more easily recognizable teleost teeth to be recovered from all Chalk facies (see also Southerham (Machine Bottom Pit) report).

The sardinoidid myctophiform *Sardinoides illustrans* Woodward is known from the type specimen (an almost complete fish: (Figure 13.13)K) and a skull from the ?Lower Chalk of Burham (Woodward, 1902–1911; Patterson, 1964).

The Burham neoteleost fauna also includes several acanthopterygian taxa (see (Figure 13.19)). The Acanthopterygii is the largest of all teleost groups, containing about 15 000 living species, including the perch and mackerel. In the Chalk seas the only acanthopterygians belonged to the most primitive living group, the Polymixiiformes and the Beryciformes. Extant beryciformes are marine fishes and include the holocentroids or soldier-fishes, which commonly inhabit coral reefs, and the trachithyoids, which are deep-water oceanic fishes. The latter group is represented in the Blue Bell Hill fauna by two species of *Hoplopteryx,* including the type of *H. simus* Woodward, and two of *Homonoticthys,* a polymixiid. However, *Homonoticthys is* a less perfectly known genus, being represented only by the two species *H. dorsalis* Dixon and *H. rotundus* Woodward. The genus possessed a deepened and laterally compressed body, with a much extended dorsal fin and consipicuous lateral line of ridged scales (Woodward, 1902,1912). Both species are known from the Lower Chalk of Kent and *H. dorsalis* ranges well into the highest zones (*quadrata* and *mucronata* Zones) of the Upper Chalk (Woodward, 1902–1912).

The second beryciform group represented in the Burham fish collections are the polymixiids, by the species *Berycopsis elegans* (Dixon). Several good specimens of *Berycopsis elegans* have been found in the Cenomanian and Turonian Chalk sequence of Sussex and Kent. *B. elegans* possessed a deepened and laterally compressed trunk, small mouth with minute teeth and a large eye. The dorsal and anal fins are much extended and oppose one another upon the ventral and dorsal surfaces (Woodward, 1902–1912).

Two species of the Cretaceous coelacanth *Macropoma* complete the fish fauna from the Blue Bell Hill. *Macropoma mantelli* (Agassiz) is known from several complete specimens from the Thronian of Southerham (q.v.) and several horizons in the Middle and Upper Chalk succession of Kent, Sussex and Surrey (Woodward, 1902–1911). *Macropoma praecursor* Woodward is a much smaller species named from isolated bones from the '*S. varians*' Zone of Folkestone, Kent and the '*H. subglobosus*'Zone of Burham. Coprolites found in the Chalk are traditionally assigned to the coelacanth genus, although Woodward (1902–1911) pointed out that they might equally be from sharks or chimaeroids. Some spiral coprolites might not be fossil faeces but petrified intestinal contents, known as enterospirae. Longbottom and Patterson

(1987) remarked that all primitive fishes, selachians, chimaeroids and non-teleost bony fishes, possess a spiral valve, and hence, the Chalk coprolites or enterospirae could have been derived from any of these fossil groups. However, no enterospirae have ever been found preserved *in situ* within more complete specimens of *Macropoma,* so it is likely that these may have been derived from sharks (Longbottom and Patterson, 1987).

Comparison with other localities

Most of the genera from the Blue Bell Hill pits have also been found in other Chalk quarries in southern England, with only the pits of the Lewes area, namely Southerham (Machine Bottom Pit; q.v.) and Southerham Grey Pit (q.v.), attaining a similar diversity. Similar Late Cretaceous marine faunas are known from the Chalk of Belgium, France, Sweden and from North America (Texas, Mississippi, Alabama, New Jersey, Kansas, etc.).

Conclusion

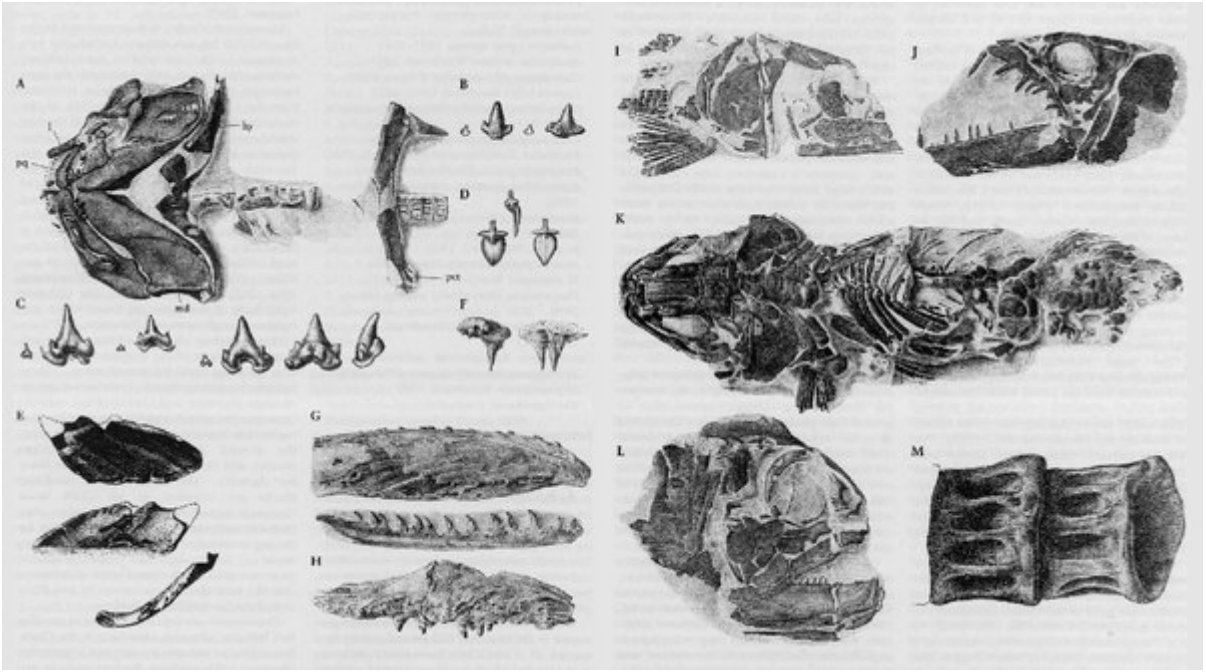
The Blue Bell Hill pits at Burham have yielded the most extensive fauna of Chalk fishes in Britain. This is the best British Chalk fish site with potential for new finds and is a key Late Cretaceous site of international importance, hence its conservation value.

References

(Figure 13.12) Photograph of Blue Bell Hill upper chalk pit: north-east face (photo: S.J. Metcalf).

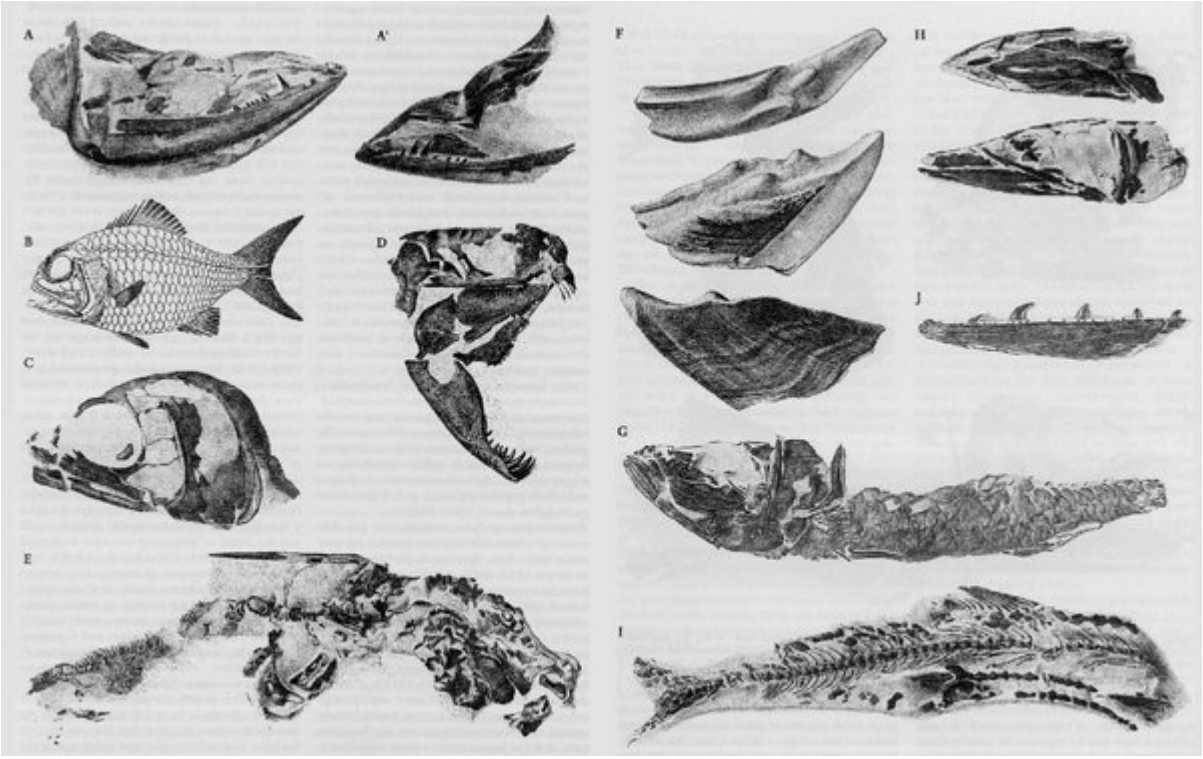
Northern Province		Stage	Southern Province	
Lithological unit	Zone		Zone	Lithological unit
	higher zones beneath drift	Maastrichtian		Sussex White Chalk Formation: Portsdown Member 30 m
Flamborough Chalk Formation 300 m+		Campanian	*mucronata*[a]	
			quadrata[a]	Culver Member 115 m+
	lingua[b]		*pilula*[c]	Newhaven Member 75 m
	testudinarius[e]	Santonian	*testudinarius*[e]	
	socialis[e]		*socialis*[e]	
Burnham Chalk Formation 150 m	*rostrata*[d]		*coranguinum*[d]	Seaford Member 90 m
	cortestudinarium[d]	Coniacian	*cortestudinarium*[d]	Lewes Member 90 m
	planus[d]	Turonian	*planus*[d]	
Welton Chalk Formation 53 m	*lata*[f]		*lata*[f]	
	labiatus[b]		*labiatus*[b]	Ranscombe Member 85 m
	geslinianum[c]	Upper Cenomanian	*geslinianum*[c]	*Plenus* Marls Formation
Ferriby Chalk Formation 28 m	*trecensis*[d]		*naviculare*[c]	Abbotts Cliff Chalk Formation 22 m
	subglobosus[d]	Middle Cenomanian	*rhotomangense*[c]	East Wear Bay Formation 58 m
		Lower Cenomanian	*mantelli*[a]	

(Figure 13.11) The Upper Cretaceous Chalk Group succession, northern and southern provinces (Wood and Smith, 1978; Owen, 1975). Correlation is provisional because of uncertainties in the biostratigraphical scales: a, belemnite; b, bivalve, c, ammonite; d, echinoid; e, crinoid; f, brachiopod.



(Figure 13.13) Fossil fishes from Burham Blue Bell Hill Pits (all from Woodwood, 1895a): (A) Cantioscyllium decipiens Woodward, anterior part of the skeleton; hy, hyoid arch; md, mandible; pct, pectoral arch; pq, pala-to-quadrate, x 0.75; (B), (C) Scyliorhinus antiquus (= Scyllium antiquum) Agassiz, teeth in labial and lingual views, x 4.0 and x 0.5 respectively; (D) Scylliorhinus antiquus (= Scyllium antiquum) Agassiz, dermal den-tides, c. x 10; (E) Ischyodus incisus Newton, left mandibular dental plate; outer, inner and upper views, x 1.5; (F), (G) Pachyrbizodus basalis Dixon; (F) part of the right premaxilla with teeth, x 1; (G) right dentary in lower and inner aspects, x 0.25; (H) Pachyrbizodus dibleyi Woodward, left maxilla in outer view, x 0.3.Fossil fishes from Burham Blue Bell Hill Pits (all from Woodwood, 1895a): (I) Neorhombolepis excelsus Woodward (from Kent), imperfect head and anterior abdominal region (N. punctatus) Woodward, (known from scales in Burnham area), X 0.6; (J) Enchodus pulchellus Woodward, holotype (NHM P1703)

left-hand side of the head and opercular area„ x 0.9; (K) Sardinioides illustrans Woodward, holotype (NHM P3977) imperfect crushed specimen in ventral view, x 0.6; (L) Ichthyodectes tenuidens Woodward, right side of head and jaw, x 1; (M) Ichthyodectes sp., two vertebral centra, x 1.



(Figure 13.19) Fossil fishes from the Chalk of the Lewes area (after Woodward, 1895b). All distorted head and jaw parts; (A), (A') Apateodus striatus Woodward, distorted head, right and left lateral views, both are c. x 1.0; (B) Hoplopteryx lewesiensis Woodward, restoration x 0.5; (C) Thrissopater megalops Woodward, head with left pectoral arch, x 0.6; (D) Tomognathus mordax Dixon, imperfect skull and left mandible, x 1; (E) Elasmodectes willetti Newton, right side of head and part of trunk, x 0.8.(F) Edaphodon agassizi (Buckland), left mandibular dental plate in labial, lingual and upper views, x 1; (G) Aulolepis typus Agassiz, incomplete head and trunk in left lateral view, x 3; (H)–(j) Cimolichthys lewesiensis Leidy: (H) head and opercular region in dorsal and left lateral views x 0.35, (I) damaged trunk and tail parts x 0.35, (J) labial aspect of left dentary x 0.9.(K) Macropoma mantelli Agassiz, crushed skull in right lateral view, x 0.6; (L) Enchodus lewisiensis Mantell, head and anterior part of trunk in lateral view, x 0.9; (M), (N) Halec eupterginus (Dixon): (M) head and abdominal region in lateral view, x 0.9, (N) head in lateral view, x 1.