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A CATALOG OF THE LOWER LIAS ICHTHYOSAURS IN THE CHARLES MOORE COLLECTION

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ABSTRACT

Charles Moore (1815-1881) amassed a large, scientifically significant collection of fossils from southwestern England and displayed them in a public museum at the Bath Royal Literary and Scientific Institution. The collection included more than two dozen slab mounts of nearly complete or partial skeletons of Lower Lias (Lower Jurassic) ichthyosaurs, most of which are currently on loan to Amgueddfa Cymru-National Museum of Wales. Multiple specimens of *Temnodontosaurus*, *Leptonectes*, *Ichthyosaurus*, and *Protoichthyosaurus* allow comparisons of different individuals within each genus and among genera. Although research on ichthyosaurs in the collection has increased in the last decade, the potential for additional studies of intraspecific variation, taphonomy, stratigraphy, and taxonomy still remains. The specimens are readily accessible thanks to a recent investment in specialized shelving, not mounted high on a wall nor behind glass. To aid with future research, a brief description of each specimen is provided herein.

INTRODUCTION

Ichthyosaurs were fully marine reptiles that played a prominent role in marine ecosystems during much of the Mesozoic Era, from the Early Triassic (Olenekian) to the early Late Cretaceous (Cenomanian) periods. Jurassic and later ichthyosaurs, with their streamlined body, dorsal fin, and lunate tail, superficially resembled modern dolphins and fish, and filled many of the same ecological niches as toothed whales in oceans today. With their clearly reptilian head on a fish-like body, ichthyosaurs presented a puzzle for early naturalists, and they played an important role in the development of paleontology as a science, especially in the UK.

Throughout the 18th and into the early 19th century, some of the earliest scientific collections of ichthyosaur bones were being made across Europe. Most pertinent to this paper were numerous specimens from the Lower Jurassic (Lias) of southwestern England. The origins and affinities of these specimens were initially obscure, and they were often identified as crocodiles (Howe et al., 1981). For example, John Walcott of Bath figured an ichthyosaur femur and vertebrae in his book, *Descriptions and figures of petrifactions, found in the quarries, gravel-pits, &c. near Bath* (Walcott, 1779), although the correct identity of said bones remained unknown. Numerous fossils later identified as ichthyosaurs were collected in and near Bath through the early decades of the 19th century (Howe et al., 1981). During this time, there were public calls for the establishment of a learned institution of some kind in the City of Bath, motivated in part by the fossil discoveries. Indeed, a letter published in the Bath Chronicle (Thursday, October 31, 1805) calling for the inauguration of a natural history museum cites the local discovery of ‘animals resembling the crocodile or alligator’. After years of false starts and much planning, Bath Literary and Scientific Institution was founded in 1824 (Fawcett, 2008), amid the boom in ichthyosaurs being excavated in south-western England, especially from Lyme Regis (Dorset), and a little later from Street (Somerset), and sold as collectable curiosities for those with an interest in geology.

William Lonsdale (1794-1871) was appointed honorary curator soon after the Bath Literary and Scientific Institution opened to the public in 1825. Lonsdale, later a notable geologist in his own right, was responsible for persuading numerous donors to

contribute to the Institution's collections (Williams, 2008). Lonsdale was involved in the acquisition of at least eight ichthyosaur specimens, donated between 1825 and 1829 (Appendix 2). After Lonsdale departed for London in 1829 to become curator and librarian for the Geological Society of London, no other ichthyosaur specimens came to the Institution until Charles Moore deposited and displayed his own collection at the Institution's Terrace Walk building from 1854. In 1882, the Charles Moore Collection, which included thousands of invertebrate fossils as well as marine reptiles, was purchased by the Bath Royal Literary and Scientific Institution (BRLSI, Royal patronage having been granted in 1830).

Moore's collection of Lower Lias marine reptiles, mainly from Somerset, rivaled those of other contemporary collectors such as Thomas Hawkins (1810-1881), Joseph Chaning Pearce (1811-1847), and Alfred Gillett (1814-1904), who also collected in Somerset. Only the Alfred Gillett Collection of marine reptiles has remained intact, under the care of C. & J. Clark Ltd. and the Alfred Gillett Trust, Street, Somerset, UK. Only one specimen from this collection, a nearly complete *Leptonectes tenuirostris,* was donated to the Natural History Museum, London (Taylor and Berry, 2021). Hawkins dispersed his ichthyosaur collections with two sales to the British Museum [Natural History Museum, London] (1834,1840), donations to the Oxford University Museum of Natural History and the Sedgewick Museum, Cambridge University, and an auction in 1844 (Taylor, 1987). The Chaning Pierce ichthyosaurs were also dispersed through sales, mainly to the Bristol City Museum [Bristol Museum and Art Gallery], but ichthyosaurs from his collection are also at the Natural History Museum, London, the Wells and Mendip Museum, and the British Geological Survey.

The Lower Jurassic of the UK was historically divided into the Lower, Middle, and Upper Lias. Those terms have been replaced with Hettangian, Sinemurian, Pliensbachian, and Toarcian stages, although direct equivalencies are complicated (Lord, 2010). The best known specimens of ichthyosaurs in the Charles Moore Collection are from the Upper Lias (Toarcian stage) of Ilminster, from the Strawberry Bank Lagerstätte (Caine and Benton, 2011; Williams et al., 2015). The Strawberry Bank specimens, with the exception of one (see below) are housed at the Bath Royal Literary and Scientific Institution (BRLSI) in Bath.

The Lower Lias ichthyosaurs in the Charles Moore Collection are the focus of this report. The most important specimens are more than two dozen partial or nearly complete, framed skeletons and a very large three-dimensional skull (Table 1). They are on loan to Amgueddfa Cymru-National Museum of Wales (AC-NMW) in Cardiff, with the exception of BRLSI M3562, which is in Bath, and another skeleton that is in the Manchester Museum. More fragmentary material of Lower Lias ichthyosaurs from the Moore Collection are included in Appendix 1 for completeness.

The Lower Lias time interval presently includes the Hettangian, Sinemurian, and part of the Pliensbachian stages (Page, 2010). As is common in historic collections, specific location and stratigraphic information is lacking for practically all of the mounted ichthyosaurs in the Moore Collection. According to Copp et al. (2000, p. 10), the specimens "doubtlessly came from…localities in Somerset, mainly Street". The tan matrix of many specimens is typical of locations around Street, and the bone color of many specimens is typical of Somerset preservation (JAM, DRL, pers. obs.). The specimens are presumed to be from the Hettangian strata, although latest Triassic (Rhaetian) strata were also exposed in the 19th century quarries in Somerset (Lomax et al. 2018; Benson et al., 2015). Therefore it is possible that some specimens are late Rhaetian in age.

The large skeletons of Lower Lias ichthyosaurs in the Charles Moore Collection are 'slab mounts', where multiple blocks of bone and matrix are fixed in a wooden frame by plaster, as was common in 19th century collections. Because of the way they were assembled, composite skeletons are always a concern in historic collections. In the 19th century, marine reptile fossils were seen as much a work of art as scientific data. They were also used to educate the public (Taylor and Berry, 2021), so a complete specimen was probably more important than an entirely authentic one. The most frequent kind of composite included replacements for missing forefins and/or hindfins, or for missing portions of the vertebral column, to form a more complete skeleton (McGowan, 1990; Massare and Lomax, 2014, 2016). However, even if a specimen is a composite, it can still provide important morphological information from the 'authentic' portion of the specimen.

Institutional abbreviations: **AC-NMW**, Amgueddfa Cymru-National Museum of Wales, Cardiff, UK; **ANSP**, Academy of Natural Sciences of Drexel University, Philadelphia, PA, USA; **BRLSI** (formerly **BATGM**), Bath Royal Literary and Scientific Institution, Bath, UK; **MANCH**, Manchester Museum, University of Manchester, UK; **NHMUK**, Natural History Museum, London, UK.

HISTORY OF THE MOORE COLLECTION

Charles Moore (1815-1881) of Ilminster and Bath, Somerset, UK, amassed a large collection of invertebrate and vertebrate fossils mostly from southwestern England (Copp et al., 2000; Torrens and

Taylor, 2003). Moore collected many of the specimens himself, especially from Somerset (Copp et al., 2000), which at the time included the current county of Bath and North-East Somerset, but he also collected from south Wales and further afield. From the mid-1840s onward, he dedicated much of his time to geological studies of Somerset and adjacent regions and became a well-respected authority on the strata and fossils of the area (Copp et al., 2000). A complete list of his publications, a summary of the specimens in his collection, and their current location was provided in Copp et al. (2000) and will not be repeated here.

Charles Moore moved to Bath for the first time in 1837 (Winwood, 1892). Probably between then and 1844, when he temporarily returned to his hometown of Ilminster, is when he first saw ichthyosaurs at the Bath Royal Literary and Scientific Institution. In 1853, Moore returned to Bath and married Eliza Deare, the only daughter of a wealthy gentleman, which allowed him to pursue his interest in geology (Copp et al., 2000). He brought his collection with him to Bath, and the following year deposited it at BRLSI, on the condition that it be a free, public museum. The largest room at the Terrace Walk building was placed at his disposal. By1856, 23 of his large, plaster-set and framed ichthyosaurs were mounted on the walls (Copp et al., 2000; Figure 1A,B), and stratigraphically themed cases were distributed across the floor (Figure 2). His collection continued to grow. Moore's *Handbook to the Geographical Collection* described the marine reptile display: *"*On entering this Museum, visitors cannot but be struck with the beautiful series of Ichthyosauri and Plesiosauri, which occupy nearly the whole of its western wall, and which out of the British Museum are probably unequalled." (Moore, 1864, p.1).

Moore did not make, or at least did not retain, any notes of his acquisitions, and there are few archives relating to his collecting activities. Consequently, we have no information about the provenance of the ichthyosaur specimens, although locality can often be inferred. The Upper Lias specimens from Ilminster were collected by Moore himself. He probably acquired many of the other ichthyosaur specimens between 1853, when he became financially independent through his marriage, and the 1860s, the approximate date of the photograph in Figure 1. But whether he collected and prepared the specimens himself, purchased unprepared specimens and prepared them, or purchased mounted specimens from a dealer is unknown (Copp et al., 2000). As Moore's collection continued to expand, an iron gantry was constructed in the museum, completed in 1875 to increase the display space and to facilitate the viewing of specimens (Torrens et al., 1975; Copp et al., 2000).

After Moore's death in 1881, an appeal raised £1200 to purchase his collection from his widow. In 1882, with the Moore Collection now owned by BRLSI, the Rev. H. H. Winwood (1830-1920) was appointed honorary curator. Sometime later, Moore's cases of specimens were removed from the large hall and moved to a smaller room built to house them (Winwood, 1892), but many of the 'saurians' were left on the walls of what was once more a lecture hall (Figure 3A, B). Public lectures and events were held in the hall and specimens suffered damage. As reported in *Natural Science* in December 1895 "Beautiful slabs of rock with delicate projecting skeletons of reptiles are left to the tender mercies of the audiences…" (Anon. 1895).

Until the 1890s, the early acquisitions by BRLSI were kept in a separate room from the Moore Collection (Torrens et al., 1975). In 1899, the BRSLI was amalgamated with the Bath Athenaeum, and much of the collection was moved upstairs with muddling of labels, although the wall-mounted ichthyosaurs remained in the same room. After Winwood died in December, 1920, the collections fell into further disrepair.

In early 1932, the Terrace Walk building was demolished for a road widening project. The BRLSI and its collections moved to their present premises at 16-18 Queen Square. Although a new gallery was built in the rear courtyard to house the fossil specimens, this was, unfortunately, the start of a long period of disruption and neglect. At the start of WWII, honorary curator F. S. Wallis (then curator at the Bristol City Museum) was given 48-hours' notice that the Queen Square premises were about to be requisitioned by the Admiralty (then the department of the UK government that controlled and administered the Royal Navy). The large wall-mounted specimens were boarded over and remained in place, and most of the rest of the collection was hurriedly crated up and sent to the Bristol City Museum, not returning to Bath until 1959 (Torrens et al., 1975).

Despite the war ending in 1945, the Admiralty did not relinquish 16-18 Queen Square until 1959, by which time the BRLSI had ceased to function, and the premises and collections were transferred to Bath City Council. The collection was under the care of Ronald F. Pickford, who, although not hired as a curator, voluntarily took on the task of organizing and restoring the collection (Torrens, 2010). At that time there were 34 large frames containing ichthyosaur and plesiosaur skeletons at BRLSI, although some were casts (Torrens et al., 1975). A detailed account of the events that affected BRLSI and its collections in the next few decades can be found elsewhere (Torrens et al., 1975; Draper, 2008; Vincent, 2019) and will not be repeated here. Suffice to say that the Institution was eventually re-founded in the 1990s and is now a thriving intellectual hub and an accredited museum.

FIGURE 1: A, The 'Saurian Wall' of the Moore Museum at Terrace Walk, a composite of three photographic prints in the BRLSI Collection, BRLSI.L09246.09, BRLSI.L09246.10, and BRLSI.L09246.11, produced by MW. The original photographs are thought to be from the 1860s. © Bath Royal Literary and Scientific Institution, Bath, UK; B, Key for identification of the eighteen ichthyosaur specimens mounted on the wall. The three plesiosaur specimens are labelled P1-P3: P1 is BRLSI M3581, a cast of *Thalassiodracon hawkinsi*, original on display at the Natural History Museum, London, UK; P2 is a cast of *Eoplesiosaurus antiquior*, original at the Somerset County Museum, Taunton, UK (Taylor and Evans, 2016); P3 is a cast of *Plesiosaurus macrocephalus*, original on display at the Natural History Museum, London, UK.

FIGURE 2: The Moore Museum at Terrace Walk, a photograph of a painting showing Charles Moore (standing left of center) and museum visitors circa 1870s. © Bath Royal Literary and Scientific Institution, Bath, UK. The three ichthyosaurs in the top row of the 'Saurian Wall' are (from left to right): BRLSI M3554, BRLSI M3557, BRLSI M3552. In addition, at the far end of the second row is BRLSI M3553; at the far end of the third row is BRLSI M3560; and at the far end of the bottom row might be BRLSI M3551. None of these specimens are visible in Figure 1.

In 1960, Dr. Robert M. Appleby of University College, Cardiff, was working on ichthyosaurs and visited the Moore Collection in Bath. Realizing the importance of the collection, he arranged for a loan of the large, framed specimens of ichthyosaurs. They were removed from the wall and Pickford made crates and lids to enable safe transport. In 1963, 28 framed and mounted specimens of ichthyosaurs from the Lower Lias (as well as the large skull and a slab mount of a crocodylomorph) were transported from BRLSI to the AC-NMW in Cardiff (AC-NMW archives). One ichthyosaur (BRLSI M3562) was returned to Bath in 1971 (BRLSI archive notes L15405, L15046), but the remainder of the loan was not returned, which probably ensured the survival of the specimens. In 1981, AC-NMW collected three other specimens from a boiler room at the Queen Square building (BRLSI archive note L15435). Two were casts (probably BRLSI M3580 and BRLSI M3581, a plesiosaur) and one was a framed ichthyosaur skeleton (BRLSI M3579).

In 2006, the loan to AC-NMW was formalized with the BRLSI as a five-year loan, which has been continually renewed. At the time of this writing, there are no plans to recall the loan. Furthermore, a Memorandum of Understanding now defines the relationship between the two institutions regarding the care and conservation of these specimens, and the ongoing access to this remarkable collection of ichthyosaurs.

UPPER LIAS STRAWBERRY BANK ICHTHYOSAURS

In 1844 or 1845, Moore discovered what is now called the Strawberry Bank Lagerstätte in a small quarry in his home town of Ilminster, a locality from which he regularly collected for the next decade. Specimens are typically preserved in calcareous nodules, and many have been prepared in three-dimensions (Williams, et al., 2015). In addition to fish, insects, and crocodylomorphs, Moore also discovered eight nearly complete ichthyosaur skeletons: three neonates and five juveniles (Caine and Benton, 2011; Williams et al., 2015). The ichthyosaurs from

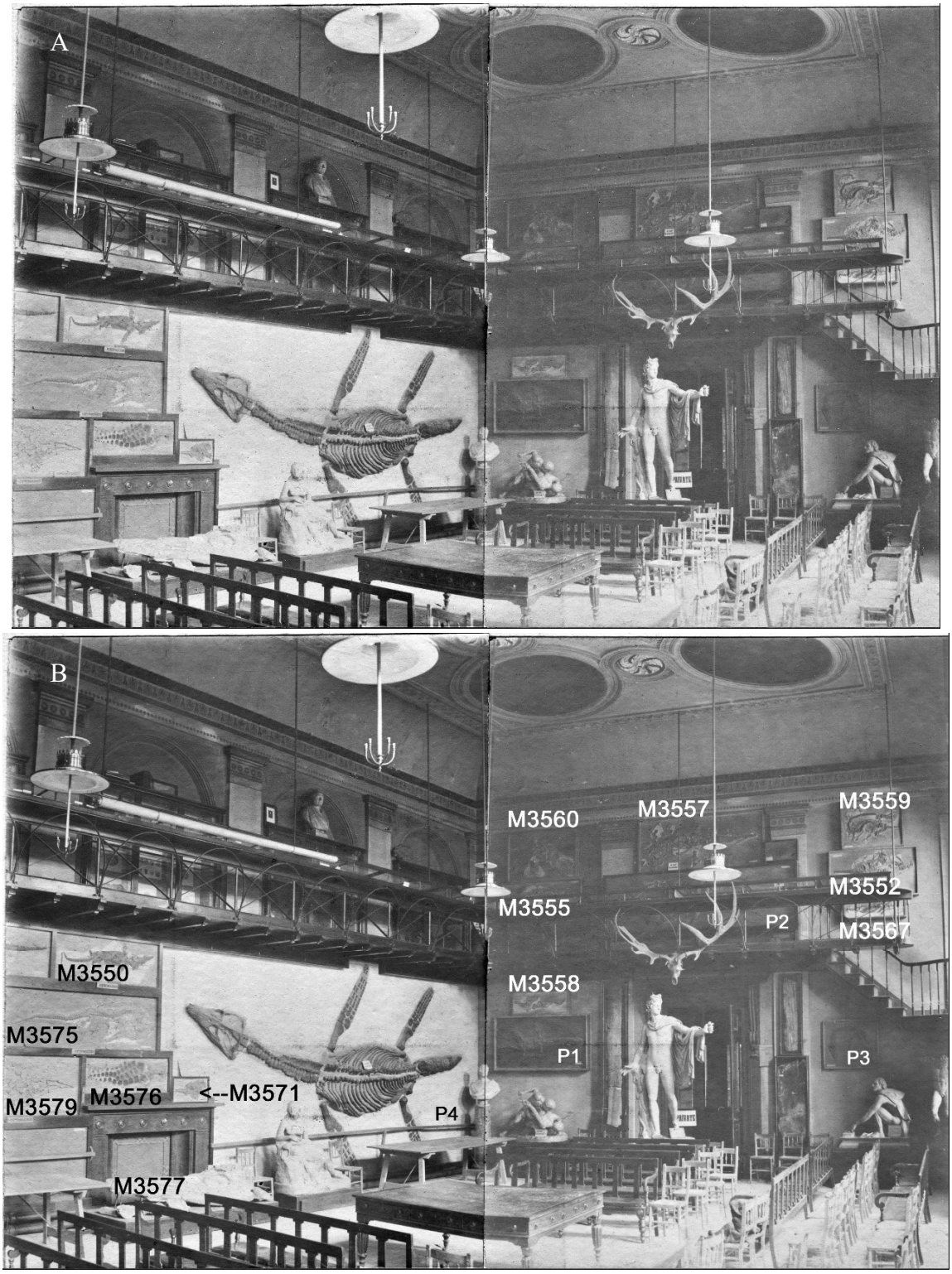

FIGURE 3: A, The lecture hall that was once the Moore Museum, showing the iron gantry built in the mid-1870s. Original photograph by George Fredrick Stone, circa late 1890s to early 1900s, reproduced here courtesy of Andrew Stone, his great grandson. B, Key for identification of the ichthyosaur specimens in Fig. 3A. The plesiosaurs are numbered as in Figure 1B. The large plesiosaur P4 is a cast of *Rhomaleosaurus cramptoni*, original at the National Museum of Ireland, Dublin (Copp et al, 1997).

FIGURE 4: BRLSI M3558, ?*Stenopterygius triscissus* from Strawberry Bank, Ilminster, UK. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

Strawberry Bank have been assigned to *Stenopterygius triscissus* and *Hauffiopteryx typicus* (Caine and Benton, 2011; but see Marek et al., 2015). The Strawberry Bank ichthyosaurs have been well documented in the literature (Caine and Benton, 2011; Williams et al 2015; Marek et al., 2015; Jamison-Todd et al., 2022) and will not be discussed further here, except for one specimen.

BRLSI M3558 ?*Stenopterygius triscissus*

(Figure 4)

BRLSI M3588 is the most complete ichthyosaur known from the Strawberry Bank Lagerstätte (Srdic et al., 2019). It was not included in recent studies of ichthyosaurs from Strawberry Bank (e.g., Caine and Benton, 2011; Williams et al. 2015) probably because the label identified it as *Ichthyosaurus intermedius* and because it was tentatively regarded as *Leptonectes tenuirostris* by McGowan (1990). Recent work, however, has recognized that the specimen is probably *Stenopterygius* (Srdic et al., 2019). It is included here because it is housed with the Lower Lias specimens at AC-NMW, probably another reason why it had been missed in previous studies. In fact, it had been displayed on the wall of the Moore Museum at BRLSI with the Lower Lias ichthyosaurs (Figure 1A, B), so it is not surprising that it was subsequently stored with them.

The small size of BRLSI M3558, ~1 m long, and its preservation in nodules is consistent with the other ichthyosaurs from Strawberry Bank (Caine and Benton, 2011; Srdic et al., 2019). Note in Figure 1 that BRLSI M3558 is resting on the mantle of the fireplace and has a label immediately below it. On the original high resolution image, the label clearly reads ‘Upper Lias’. Thus, Charles Moore himself seemingly confirms the stratigraphic inference of Srdic et al. (2019). All other such labels on the ‘saurian wall’ read ‘Lower Lias’, including for the specimen immediately to the right of BRLSI M3558 (Figure 1).

The skull and mandible are exposed in left lateral view and are almost complete, missing only the very tip of the snout (Figure 4). On the same block of matrix, a left humerus is preserved, along with scattered, proximal forefin elements and a small articulated portion of the forefin. A string of 13 articulated neural arches, disarticulated centra, and scattered pieces of ribs are also exposed. A nearly complete scapula, missing only a small portion of the distal end, is preserved on the edge of one of the blocks.

A large, fractured block of matrix, a portion of a large nodule, is immediately posterior to the skull. A humerus and articulated ulna and ulnare are exposed at the anterior end of the block. Twenty-four centra, most of them articulated with neural arches, are separated from the humerus by a series of nearly complete, parallel ribs. A third, fractured block of matrix preserves another 24 mostly articulated centra. Srdic et al. (2019) provided a more complete description of the specimen.

LOWER LIAS ICHTHYOSAURS

The Lower Lias ichthyosaurs in the Moore Collection had (and many still have) chalk numbers on the matrix, but were assigned temporary accession numbers when they were moved to the AC-NMW (Table 1; AC-NMW archives). Appleby (1979) subsequently used the temporary numbers in his

publication that erected a new genus, *Protoichthyosaurus*, but we are not aware of the temporary numbers appearing elsewhere in the paleontological literature. The BRLSI register shows a break in the numbering from M3549 to M3581, with a note in Pickford's handwriting: "use these reg numbers for the Ichthyosaurs from the Moore Coll. now (1962-81) housed at Nat. Mus. Wales, Cardiff." So most likely, the ichthyosaurs in Cardiff were renumbered in 1981 or shortly thereafter. However, one of the specimens in the sequence, BRLSI M3578, is a marine crocodyliform and has been described elsewhere (Duffin, 1979; Pierce and Benton, 2010); and another, BRLSI M3581, is a cast of a plesiosaur (P2 in Figure 1). A few specimens in the sequence (e.g., BRLSI M3549, M3570, M3574) were probably not part of the original Charles Moore Collection (see below and Appendix 2).

The Moore Collection of Lower Lias ichthyosaurs has multiple examples of the common Lower Jurassic genera *Ichthyosaurus*, *Protoichthyosaurus*, *Leptonectes*, and *Temnodontosaurus*. Taxonomic identifications were taken from the literature when the specimen was referred to a genus or species (e.g., Appleby, 1979; McGowan, 1989, 1990), and determined by JAM and DRL when they were not. We have opted to discuss the specimens by genus rather than in numerical order by accession number. The collection includes the holotype and paratypes of *Protoichthyosaurus prostaxalis* Appleby, 1979, as well as the holotype and only specimen of *Ichthyosaurus prosostealis* Appleby, 1979, a species of questionable validity (Lomax et al., 2017). Most importantly, the collection provides several skeletons, some nearly complete, of each genus, facilitating comparisons to each other and to contemporaneous taxa.

We have identified four specimens in the Moore Collection that are composites (noted as 'composite' on Table 1), most having had a forefin or hindfin added. Six other specimens warrant closer examination (noted as 'suspicious' on Table 1) to evaluate whether the main skeleton has been enhanced by the addition of elements from another individual.

The collection also includes plaster casts. BRLSI M3580 is a cast of the holotype of *Ichthyosaurus somersetensis*, the original of which is housed at the Academy of Natural Sciences, Philadelphia (ANSP 15766; Lomax and Massare, 2017). The cast can be seen mounted on the wall of the Moore Museum at Terrace Park (Figures 1, 2). Another cast of an ichthyosaur was donated by J. E. Henshawe (or 'Henshaw'; Appendix 2), but it is currently missing. In addition, four plesiosaur casts were on display in the Moore Museum (Figures 1, 3). One cast, *Rhomaleosaurus cramptoni* is housed at BRLSI (P4 on Figure 3B). A second cast, BRLSI 3581, *Thalassiodracon hawkinsi*, is housed at AC-NMW (P1 on Figure 1B, 3B). The other two casts, *Eoplesiosaurus antiquior* and *Plesiosaurus macrocephalus*, cannot be accounted for at this time.

SPECIMENS OF *TEMNODONTOSAURUS*

The Lower Jurassic specimens of *Temnodontosaurus* from the UK need re-examination and the genus as a whole requires revision. The formal diagnoses for the genus have emphasized various ratios of the skull (e.g., McGowan 1974; McGowan and Motani, 2003; Ji et al., 2016). *Temnodontosaurus* is the largest of the Lower Jurassic ichthyosaurs, reaching gigantic sizes compared to contemporaneous genera (McGowan, 1996a; Larkin et al., 2023). *Temnodontosaurus* can be most readily recognized by the humerus and forefin morphologies, although differences are more subtle than in the other genera discussed here. Species of *Temnodontosaurus* have narrow forefins with three prominent primary digits and usually a posterior accessory digit (or small digit V?; Motani, 1999; Maisch and Matzke, 2000). At least a few elements in the anterior digit are notched, although the extent of notching seems to vary between species (Motani, 1999; McGowan and Motani, 2003). The more proximal phalanges are typically rectangular, but much larger relative to the size of the radius and ulna than those of *Ichthyosaurus* and *Protoichthyosaurus*. Distal phalanges are discoidal.

The posterior mandible has a large lateral exposure of the angular compared to the surangular, which distinguishes Lower Lias species of *Temnodontosaurus* (*T. platyodon*, *T. eurycephalus*) from *Ichthyosaurus* and *Protoichthyosaurus*, whose species can have a fairly robust mandible (Maisch and Matzke, 2000; JAM, DRL pers. obs.). Furthermore, the teeth of *T. platyodon* and *T. eurycephalus* can be distinguished from those of other contemporaneous species and genera by the presence of distinct carinae on the crown (Massare, 1987; Bennion et al., 2023), although teeth are sometimes not sufficiently exposed during preparation to reveal carinae (JAM. pers. obs.)

BRLSI M3557 *Temnodontosaurus ?platyodon*

(Figure 5)

This specimen is a fragmentary anterior skeleton (Figure 5). The skull is largely missing, although a few sclerotic plates, the ?postorbital and other elements are scattered in the matrix. An almost complete right mandible (~1 m long) and a portion of the left are preserved. In right lateral view, the large exposure of the angular relative to the surangular in the posterior portion of the right mandible indicates that the specimen is *Temnodontosaurus*, probably *T. platyodon* (Maisch and Matzke, 2000; JAM, DRL pers. obs.).

Teeth are in the mandible, especially in the anterior portion, and scattered around it. They have striations in the roots that go to the base of the crown. Posterior to the mandible are portions of both coracoids and a scapula, although one coracoid is isolated from the main skeleton and set in plaster, so it might have been added. Centra, ribs, and other bone fragments are scattered in the matrix.

Posterior to the pectoral bones is the right forefin, lying on top of ribs and adjacent to a few articulated centra. Three digits, each with about five elements, are articulated, but the radius and ulna are missing. A partial left fin, in ventral view, is on the ventral edge of the specimen and is lying mostly in plaster. A fracture across the proximal portion of the shaft separates the proximal humerus from the rest of the fin, which is on a separate block of matrix, but they line up. The radius has a slight indentation. The radius and ulna are almost articulated, but the other elements are not.

On a second large block of matrix are disarticulated, scattered centra and rib pieces. There is no continuity between the two blocks, although the bone color and preservation style is similar. At the posterior end, ventral to the ribs and lying in plaster, is an articulated partial hindfin, with a complete femur, and most of the epipodials and metapodials; the tibia might be notched. Various isolated centra are lying in matrix and in the plaster.

BRLSI M3561 *Temnodontosaurus* sp.

(Figure 6)

This incomplete specimen, measuring ~ 1.5 m long, is ventrally preserved, with a partial skull, mandibles, 38 articulated centra, and ribs and other bones scattered in the matrix (Figure 6). The mandibles are ~ 62 cm long. The shapes of the coracoid and humerus indicate that the specimen is a *Temnodontosaurus* (McGowan and Motani, 2003, fig. 70). The pieces of the mandible can be removed from the mount and turned over to show the rostrum with teeth. The carinae on the teeth further support the identification (Massare, 1987; Bennion et al., 2023). The ventral portion of the quadrate, most of a hyoid, and some elements of the braincase are also preserved. On the right side of the skeleton is a forefin that is most likely reconstructed, at least in part, because a portion of a coracoid is lined up with the posterior end of the rostrum and the proximal end of the humerus, not a natural orientation. The right humerus has a fracture across the shaft, and the distal portion articulates with the radius and radiale, both of which are notched. On the other side of the vertebral column are portions of both scapulae, most of a second coracoid, a notched ?radius and ?radiale, many disarticulated, polygonal fin elements, and a ?femur, which is out of place in the anterior portion of a skeleton.

FIGURE 5: BRLSI M3557, *Temnodontosaurus* sp. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

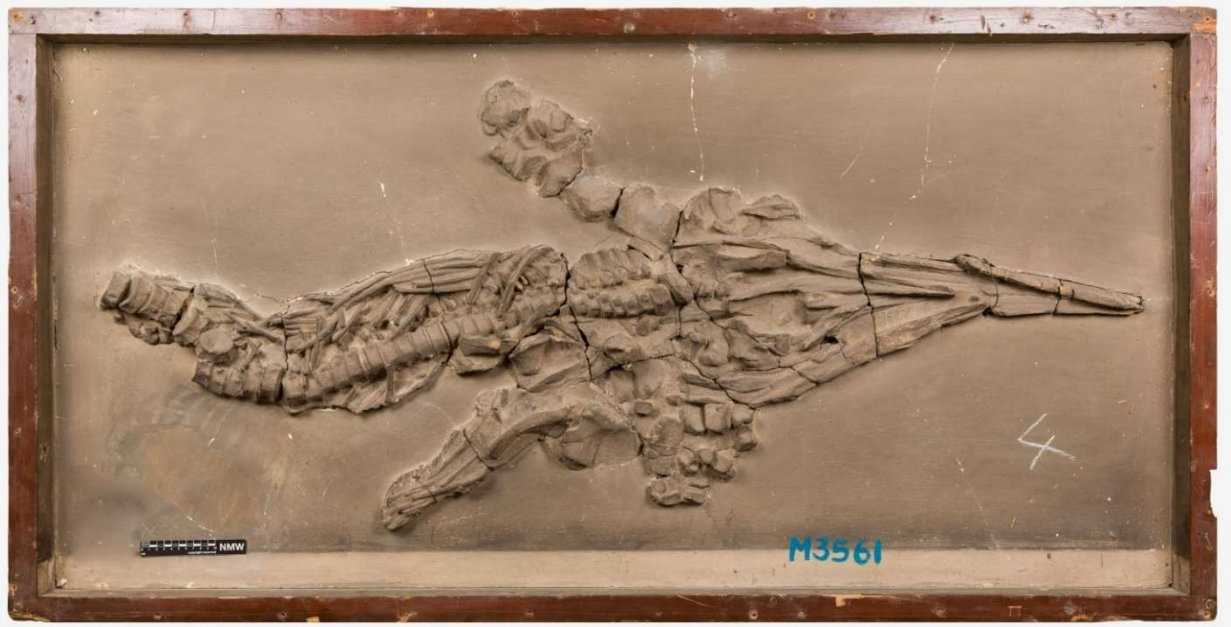

FIGURE 6: BRLSI M3561, ?*Temnodontosaurus* sp., possibly one of the smallest specimens known for the genus. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

FIGURE 7: BRLSI M3567, ?*Temnodontosaurus* sp. If the tentative identification is correct, this might be the smallest specimen known for the genus. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

BRLSI M3567 *Temnodontosaurus ?platyodon*
(Figure 7)

This specimen is a small, partial skeleton in right lateral view (Figure 7). The skull is poorly preserved, except for the temporal region of the skull roof. The preserved mandible is 22 cm long, missing about 5 cm of the anterior tip, for which only an impression in the matrix remains. The mandible is not as long, relative to the presacral skeleton, as would be expected in a very young juvenile (von Huene, 1922; McGowan, 1973), so perhaps it is not complete. The angular is high, making up almost half of the posterior mandible in lateral view, suggesting that this specimen is *Temnodontosaurus*, probably *T. platyodon* (Maisch and Matzke, 2000; pers. obs. JAM, DRL). The humerus shape is also consistent with that of *Temnodontosaurus*. The specimen might be one of the smallest individuals known, as it is less than half the size of the juvenile specimens of *T. platyodon* described by McGowan (1995).

The vertebral column is articulated and complete into the anterior caudal region, approximately 18 centra distal to the position of the right femur and pelvic bones. Most of the right ribcage is intact, and a dense

black mass of gut contents, with some obvious cephalopod hooklets, is between the ribs. Both humeri are preserved and have a distal end that is much wider than the proximal end and is distinctly flared anterodistally. The proximal end is robust, not narrow. Most of the right scapula overlies a disc-shaped coracoid, a morphology we (JAM, DRL) have seen on another juvenile *Temnodontosaurus*. The right femur and at least a partially fused ischium and pubis, are preserved ventral to the vertebral column.

BRLSI M3574 *Temnodontosaurus* sp.

(Figure 8)

BRLSI M3574 has a posterior skull preserved in ventral view, two forefins, and some articulated caudal centra (Figure 8). The robustness of the mandibles and the carina on some teeth suggest that the skull is *Temnodontosaurus* (Massare, 1987; Bennion et al., 2023). Posterior to the skull are smaller blocks of matrix with disarticulated centra and rib pieces. On either side of these blocks are forefins, which have a different bone color from the adjacent skeletal material and seem too small compared to the size of the incomplete skull, suggesting that they might have been added. The left forefin is articulated and complete to the second phalangeal row, although it appears to be set in painted plaster and may have been reconstructed. The shape of the left humerus, the notched radius, and the round phalanges are consistent with *Temnodontosaurus*. The right fin has a poorly preserved humerus, radius, ulna, and one carpal only. Posterior to the anterior skeleton are 30 articulated caudal centra that have no obvious connection to the rest of the specimen and do not seem to be in matrix. Moreover, there is a difference in size between the four posterior centra and the centra immediately anterior to them. Thus, the vertebral column might have been reconstructed.

This specimen does not appear in any of the images of the Moore Museum (Figures 1-3). It might be the mounted ichthyosaur donated by C. B. Thring in 1906 (Appendix 2). The donation was probably the ichthyosaur found in Alford in the 1850s or 1860s, which originally belonged to Rev. John G. D. Thring. The *Dorset County Chronicle* (Nov. 23, 1864) describes the Alford specimen as bones of the head, 20-30 vertebrae, bones of the paddles, and some ribs and teeth. This describes BRLSI M3574 quite well. Furthermore, the Alford ichthyosaur was identified as an *Ichthyosaurus platyodon* (=*Temnodontosaurus platyodon*) by Charles Moore, who also prepared the specimen for display by Rev. Thring (*Castle Cary Visitor*, February, 1913). BRLSI M3574 appears to be constructed from pieces of three individuals, but if this is the Alford ichthyosaur as we suspect, then these bones were all found together, although not necessarily articulated except for the skull blocks.

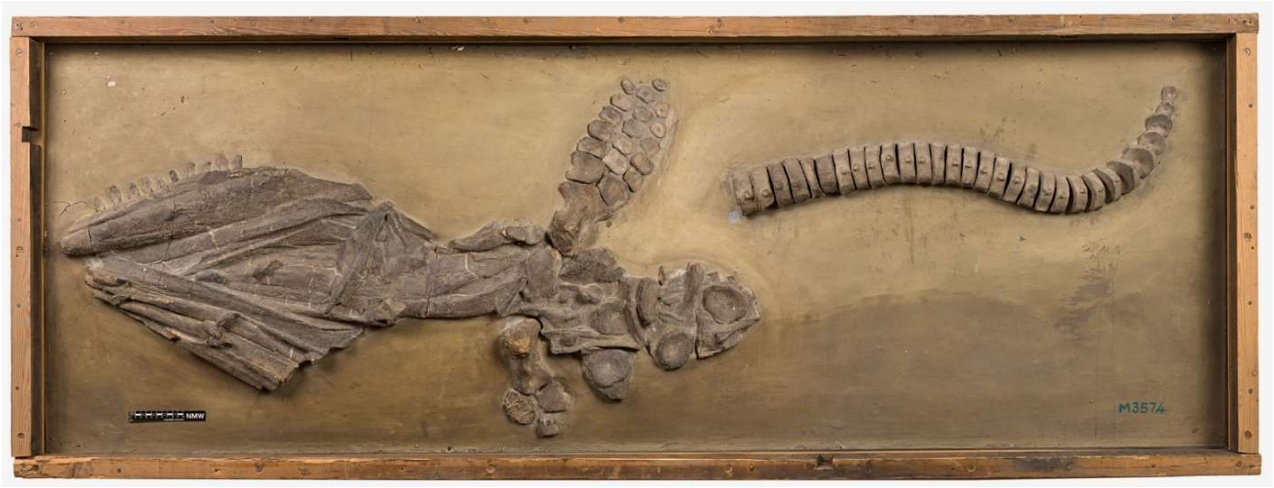

FIGURE 8: BRLSI M3574, *Temnodontosaurus* sp., possibly the Alford ichthyosaur (see text). Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

BRLSI M3576 *Temnodontosaurus platyodon*
(Figure 9)

The original label in the BRLSI records identifies this specimen as *Temnodontosaurus platyodon*, and we follow that identification here although the specimen might not be adequate for a species assignment. The specimen was collected from Lyme Regis, Dorset, according to the label. It is a left forefin, preserved in ventral view, with a total length of 109.5 cm, although it is possible that it is a hindfin (Figure 9A,B). It has been conserved, or at least painted, since coming to AC-NMW. Although the humerus and first three rows of elements seem to be set in plaster, an image of the fin from the 1960s clearly shows that the proximal elements are articulated and in matrix (Figure 9A). The distal block of matrix, with several rows of phalanges, appears to be separated from the proximal portion of the fin (Figure 9B), but that is because the matrix was painted to emphasize the separation of the elements (Compare Figure 9A to 9B). The entire fin is in matrix, and the distal and proximal portions fit together fairly well. The radius is notched, and a distal element on the posterior side of the fin appears to be notched. The latter may have been mounted incorrectly as notching only occurs in elements on the anterior edge of the fin. The specimen appears in the 1890s photo of the lecture hall that had been the Moore Museum (Figure 3), but not in earlier photos of the museum (Figures 1, 2).

BRLSI M3577 *Temnodontosaurus platyodon*
(Figure 10)

This specimen is an exceptionally large (~1.9 m long), complete, three-dimensional skull (Figure 10), referred to *T. platyodon* by McGowan (1996a). Torrens (2008, 2010) indicated that it was donated to BRLSI by William Henry Eastwick (1780-1854) in 1825. He further mentions a “later label” that identifies the skull as the Eastwick donation (Torrens, 2010). More than a

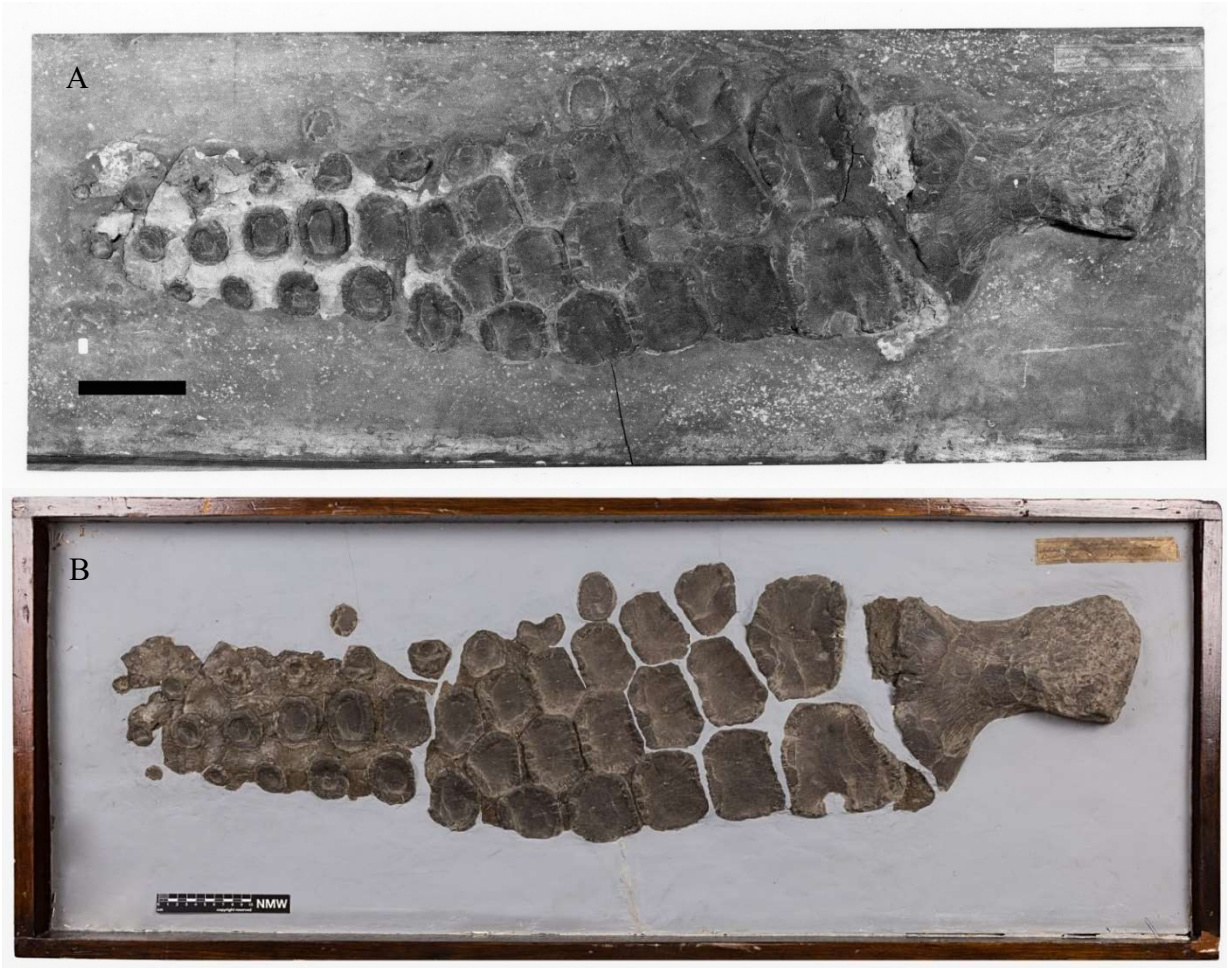

FIGURE 9: BRLSI M3576, forefin of *Temnodontosaurus platyodon* A, photo taken in the 1960s, B, photo of specimen as it is today. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK. Scale bars = 10 cm.

FIGURE 10: BRLSI M3577, three-dimensional skull of *Temnodontosaurus platyodon*, approximately 2 m in length. Figure is a composite of two images produced by DRL. Rostrum image © Dr. Benjamin C. Moon, used here with permission.

decade later, we have not been able to locate a label, but Torrens reaffirmed that the BRLSI M3577 is indeed the Eastwick specimen (H. Torrens, 2024, pers. comm., DRL). The BRLSI annual report, however, describes Eastwick's donation as "a large fragment of head" (Appendix 2), whereas BRLSI M3577 is an entire skull. If Torrens (2008, 2010) is correct, however, then it is likely that this is a Mary Anning specimen as she was actively collecting at the time of the Eastwick donation.

Another specimen in the collection, however, BRLSI GP0743, is also a possible match for the Eastwick donation because it is just the orbital portion of a skull (Appendix 2). If this is the case, then Moore would have had to purchase BRLSI M3577 in the mid-1850s or later. He could not have purchased it directly from Mary Anning, who died in 1847, although it could still be an Anning specimen. The skull does not appear in early pictures of the Moore Museum (Figures 1-2), which is odd considering that it is such an impressive specimen. However, BRLSI M3577 can be seen in Figure 3, a photo taken in the 1890s, at a time when specimens were being moved around the building and earlier donations could have been admixed with the Moore Collection (Torrens et al., 1975).

The entire rostrum of BRLSI M3577 is in a single large piece, although a fracture (~1 cm wide) is perpendicular to the length and displaces the anterior portion. McGowan (1996a) estimated that about 4 cm of the anterior tip of the mandible was missing, but it is more likely that the mandible did not extend to the tip of the premaxilla, as occurs on other specimens of the species (e.g. NHMUK VP R1158). The dorsal skull roof is relatively well-preserved and some sutures can be traced. The orbital region is in a second large piece and some of the elements that make up the orbit are identifiable. At least five smaller pieces make up the posterior skull and posterior mandible. Five centra are exposed at the back of the skull, one of which has a ventral keel that is typical of cervical centra (McGowan and Motani, 2003). More centra (including the atlas-axis) might still be buried in matrix.

SPECIMENS OF *LEPTONECTES*

Leptonectes tenuirostris is by far the most common of the three species of the genus. The skull morphology is distinctive, characterized by a very long, thin rostrum, large orbit, and very short post-orbital region (McGowan, 1989; McGowan, 1996b; McGowan and Motani, 2003). The species has high morphologic variability and a long stratigraphic range (Maisch and Reisdorf, 2006). As was the case with the common species of *Ichthyosaurus*, *I. communis* (see Lomax and Massare, 2015; Lomax and Massare, 2017), *L. tenuirostris* might represent more than one species and the genus requires revision, but that is beyond the scope of this work.

Leptonectes tenuirostris is easily distinguished from other Lower Jurassic ichthyosaurs by the humerus and forefin morphology. The humerus is much wider distally than proximally, with a narrow shaft; the radius is always notched, even in young individuals (Lomax and Massare, 2012); and the phalanges are typically round and widely spaced (McGowan, 1989). The other

two species of *Leptonectes*, *L. moorei* and *L. solei*, are known from one and three specimens, respectively (McGowan, 1993; McGowan and Milner, 1999; Lomax and Massare, 2018a). These have not been recognized in the Moore Collection.

BRLSI M3552 *Leptonectes tenuirostris*

(Figure 11)

This specimen is a disarticulated, anterior portion of a skeleton (Figure 11), assigned to *L. tenuirostris* by McGowan (1989). The skull, in left lateral view, is missing the anterior portion of the rostrum. The large eye, short post-orbital region, high-crowned skull, and slender rostrum are typical of the species. The rostrum, however, is entirely set in plaster and the anterior section is carved out of plaster. Nonetheless, the 'authentic' portion of the rostrum likely belongs to the specimen because the bones are similar in color/preservation and of an appropriate size for the rest of the skull. Excluding the two sections of plaster, the mandible is 54 cm long.

The vertebrae are scattered in the matrix posterior to the skull. More than 30 centra are preserved, nearly all of them lying on the matrix in anterior/posterior view. Partial ribs, including some with the rib heads preserved, are scattered around the skull and posterior to it.

The left scapula, left coracoid, and a portion of the left forefin are preserved in close proximity to one another, but they are not articulated. The humerus is much wider distally than proximally, as is typical of *Leptonectes*. The apparently three-fingered partial forefin has a notched radius and radiale, and round, phalanges. Although fin elements are articulated, digits III and IV are missing the metacarpal and first phalangeal rows. Digit II is preserved to the third phalangeal row, and the other two digits to the fourth and fifth row, respectively. A single femur, associated with some isolated phalanges is also preserved.

BRLSI M3556 *Leptonectes tenuirostris*

(Figure 12)

McGowan (1989) referred this specimen to *L. tenuirostris,* and suggested it was from Street, Somerset. The specimen has a disarticulated skull but a fairly complete presacral portion of the postcranium (Figure 12). The distal-most portion of the vertebral column, about a dozen mostly articulated centra, is on a separate block of matrix and placed about 12 cm away from the main skeleton, raising the possibility that it might not belong to the same individual, although McGowan (1989) concluded that the specimen was not

FIGURE 11: BRLSI M3552, *Leptonectes tenuirostris*. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

FIGURE 12: BRLSI M3556, *Leptonectes tenuirostris*. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

altered in preparation. The total length of the specimen, measured along the vertebral column is 177 cm, including the gap and the posterior centra.

The skull is preserved in right lateral view, but only the dorsal orbital region of the skull is reasonably intact. It includes the postorbital, postfrontal, and five sclerotic plates. Several other sclerotic plates and teeth are scattered in the matrix. A basisphenoid is also lying in the matrix, dorsal to the orbit. Most of the maxilla is visible. The mandible has been split apart, revealing individual long bones. A surangular, in exterior view, looks complete.

The postcranial skeleton is in dorsolateral view. The vertebral column is complete from the atlas-axis to the anterior caudal region and is mostly articulated. Most centra have complete neural spines, although some are obscured by ribs. The right ribcage is almost complete, but some of the left ribs have been displaced over the vertebral column.

The proximal half of the left scapula and the entire left coracoid are preserved adjacent to the left forefin. The left forefin, in dorsal view, is dorsal to the vertebral column and includes the humerus, although its anterior distal edge is covered by the coracoid, obscuring the radius. The forefin is articulated to about the third phalangeal row. The right forefin is less complete but the humerus is better exposed and the notched radius is clearly visible. A femur and a few associated proximal elements, including a broadly notched tibia, overlie the second femur. Adjacent to them is a fused ischium and pubis, with an associated ilium. Six articulated centra dorsal to the femur are resting on plaster, although McGowan (1989, 1990) did not question their authenticity.

BRLSI M3560 *Leptonectes tenuirostris*

(Figure 13)

McGowan (1990) identified this skeleton as *Leptonectes* tenuirostris. This specimen is unusual because of its orientation, in which segments of the vertebral column are displaced or curved back on itself (Figure 13). Notably, the segments are in matrix, not plaster. The orientation could be the result of scavengers or bottom currents disrupting the carcass or some other taphonomic scenario. The specimen was conserved in 1988 at AC-NMW (AC-NMW archives).

The skull, ~57 cm long, is in left lateral view. It is mostly intact, although bones from the right side of the skull or palate have been pushed into the orbit. The upper rostrum appears complete, although a fracture displaces the anterior portion. McGowan (1990) suggested that some of the rostrum is missing. Many premaxillary teeth are in the upper jaw. The bones around the orbit have been somewhat deformed but are identifiable. The basioccipital is exposed in ventroposterior view. The left mandible is nearly complete, but probably missing a few centimeters at the anterior end. The posterior portion of the right mandible is exposed ventral to the left mandible. A complete hyoid is exposed ventral to the left mandible and part of a second hyoid is exposed ventral to the right mandible. McGowan (1990) questioned whether

the skull belongs with the postcranium, but aside from its orientation at an angle to the vertebral column, it seems to belong because bones line up at the back of the mandible and the color and preservation of the bones and matrix match. McGowan (1990) further suggested that the skull might be *Ichthyosaurus*. We disagree; the skull is not *Ichthyosaurus*. Moreover, it seems to be within the range of variation of *Leptonectes tenuirostris*, as currently defined, although the skull orientation is somewhat puzzling.

One complete and one partial coracoid are preserved, articulated along their medial edges. The right partial forefin, in dorsal view, includes the humerus, a notched radius and articulated carpal and metacarpal elements.

Eighteen articulated dorsal centra are preserved with their neural spines. After a gap equivalent to about five centra lengths, are eight articulated sacral centra, identified by the presence of a single, elongated rib articulation on some of the centra. At almost right angles to that are two parallel segments of nine and eight articulated caudal centra. The remaining segments of the vertebral column have been displaced to the anterior end of the specimen. Thirteen centra are on either side of the coracoid, and a few might be under it. On a separate block of matrix is an articulated segment of 12 caudal and 22 fluke centra. Posterior to these, on a small block of matrix, are another 18 centra that seem to be in line with another 12 fluke centra on one of the main blocks of matrix. Fifty-two fluke centra seem to be an unusually large number, although the vertebral column of *Leptonectes tenuirostris* has not been studied in detail. McGowan (1990) questioned the authenticity of the skull, but the posterior portion of the vertebral column is more suspicious.

FIGURE 13: BRLSI M3560, *Leptonectes tenuirostris*. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

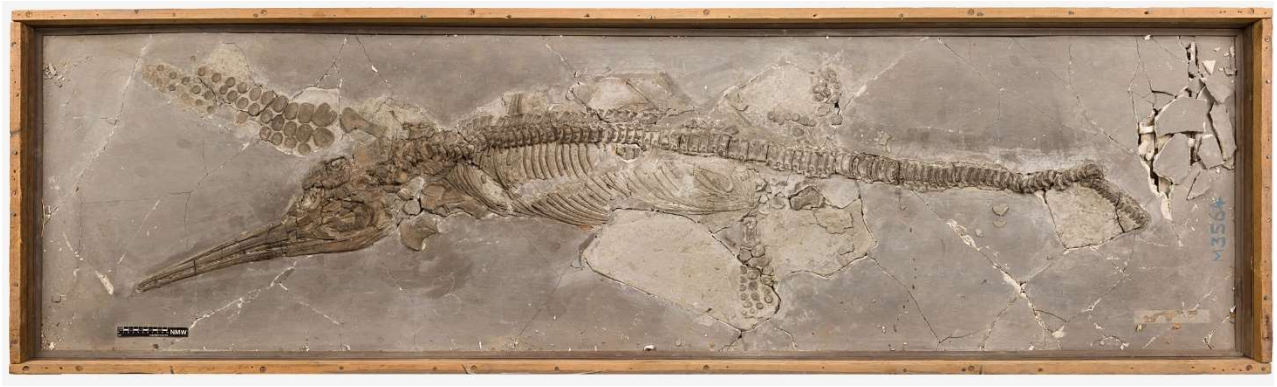

FIGURE 14: BRLSI M3564, *Leptonectes tenuirostris*. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

BRLSI M3564 *Leptonectes tenuirostris*
(Figure 14)

McGowan (1990) identified this specimen as *Leptonectes tenuirostris*, based on the skull morphology. The specimen is an almost complete skeleton, including a complete skull, in left dorsolateral lateral view (Figure 14), although McGowan (1990) concluded that it was a composite. It is ~215 cm long, measured along the vertebral column from the tip of the rostrum to the end of the fluke centra. The left side of the skull is broken into fractures perpendicular to the rostrum that become more closely spaced posteriorly, towards the orbit. The orbit is crushed but fairly intact, including a nearly complete sclerotic ring. The skull roof dorsal to the orbit, however, is completely broken up. The basioccipital is partially exposed, as are other bones of the braincase. The mandible is nearly complete, and numerous teeth are preserved in place.

The articulated vertebral column appears complete, although some anterior centra might be missing/covered and others have been arranged incorrectly in plaster. McGowan (1990) counted 86 centra anterior to what appears to be the tail bend, but did not see any wedge-shaped centra indicating the actual position of the tail bend. The distal half to two thirds of the preflexural tail is not on the same block as the hindfins and anterior caudal centra. Moreover, some of the 'caudal' centra seem to have two rib articulations, typical of dorsal rather than caudal centra. The posterior caudal centra could possibly belong to a different individual, or perhaps vertebrae may have been arranged in the wrong order by the preparator. It is likely that at least the post-flexural segment of 14 articulated centra has been added to the specimen. The authenticity of the entire vertebral column needs to be investigated in more detail.

A complete scapula is dorsal to the posterior end of the skull and looks like it has been positioned to look like the humerus of the right forefin to a casual observer. Adjacent to the anterior end of the scapula are about ten rows or partial rows of articulated fin elements, including the ulna and notched radius. The authenticity of the fin was questioned by McGowan (1990), and we agree that it was likely added or the elements were rearranged in plaster. The fin elements are on several blocks of similarly colored matrix that are separated from the main skeleton, again arousing suspicion. The two humeri are on either side of the posterior portion of the skull, the right one being partially covered and the left being partly set in plaster. They have a similar shape and are clearly part of the main skeleton. But as McGowan (1990) noted, they lack a widely flared distal end and a constriction in the shaft, both of which are characteristic of *Leptonectes*. The left humerus is associated with the left scapula and a coracoid that is partially buried. Both hindfins are also preserved, the left being the more complete one. It includes the femur, broadly notched tibia, fibula and five more rows of articulated elements. McGowan (1990) also questioned the authenticity of this hindfin, but it seems to belong with the rest of the skeleton. The right femur is preserved ventral to the vertebral column, but elements from the right fin are dorsal to the column, including another notched tibia. The distal end of both an ischium and pubis are preserved adjacent to the right femur; a second, isolated ?ischium is also present, associated with ribs, near the left hindfin.

BRLSI M3565 *Leptonectes tenuirostris*
(Figure 15)

McGowan (1989) referred this specimen to *L. tenuirostris*. The specimen is an anterior skeleton in three blocks of matrix: a small block with most of the skull, a second block with a portion of the skull and a forefin, and a large block with postcranial material (Figure 15). Three small pieces of matrix, adjacent to

each other but isolated from the main skeleton, have a few uninformative fin elements.

The skull is crushed dorsolaterally, exposing the right side of the skull, which is ~56 cm long, but the post-orbital portion of the skull is incomplete. The anterior third to half of the rostrum is separated from the rest of the skull and is largely surrounded by plaster. The anterior rostrum has the same bone color as the rest of the skull, and the morphology and size matches that of the posterior portion. McGowan (1989) concluded that they belong together, and we agree. Numerous teeth are preserved in the rostrum. The prefrontal, lacrimal, maxilla, and part of the jugal are identifiable, but the rest of the orbit margin is broken. Bones from the posterior portion of the skull have been pushed into the orbit, and most of the sclerotic plates are missing. The right mandible is preserved from the anterior tip to just below the orbit.

Fifteen articulated centra, most with neural spines and some with attached ribs, are posterior to the skull. Posterior to that are 13 articulated neural spines, but their respective centra are scattered on the matrix, along with other dorsal centra. One nearly complete coracoid is ventral to the articulated neural arches; a second coracoid is covered by ribs at the anterior end of the block. The right forefin, in dorsal view, has three digits and is articulated from the humerus to the second phalangeal row. McGowan (1989) however, thought that a couple of elements adjacent to the fin were part of a fourth digit. The radius and radiale are notched. Both femora and some fin elements are also scattered in the matrix.

BRLSI M3566 *Leptonectes tenuirostris*

(Figure 16)

This specimen is a partial skull and scattered postcranial skeleton in a single block of matrix (Figure 16). McGowan (1989) referred it to *L. tenuirostris*. The skull, ~70 cm long, is preserved in ventral view. It appears complete to the anterior tip of the rostrum, but lacks most of the mandibles. Attached to the skull is the fused atlas-axis and eight other mostly articulated centra. Numerous teeth are scattered in the matrix.

Posterior to the skull are ribs, portions of both clavicles, a complete scapula that is partially covered by ribs, most of a broken coracoid, a femur, and a ?right humerus that is articulated with a notched radius, ulna, ulnare and intermedium. A second scapula is partially covered by an articulated segment of the vertebral column, and a complete coracoid is isolated in the matrix adjacent to it. An isolated humerus, articulated with the radius and ulna, is on the edge of the matrix.

The vertebral column is taphonomically unusual: it is broken into a few articulated segments, as well as clusters of disarticulated centra. The longest segment, more than 40 centra, is more or less parallel to the long direction of the skull, and has a cluster of more than 20 disarticulated centra at its anterior (relative to the skull orientation) end. The articulated centra show the transition from double headed ribs of the dorsal region to single headed ribs of the caudal region. Only a few of the anterior articulated centra are dorsals; most of the series are caudal centra, including those that are adjacent to the forefin, and roughly perpendicular to another articulated segment of the vertebral column. A second cluster of disarticulated centra are on the posterior edge of the matrix.

FIGURE 15: BRLSI M3565, *Leptonectes tenuirostris*. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

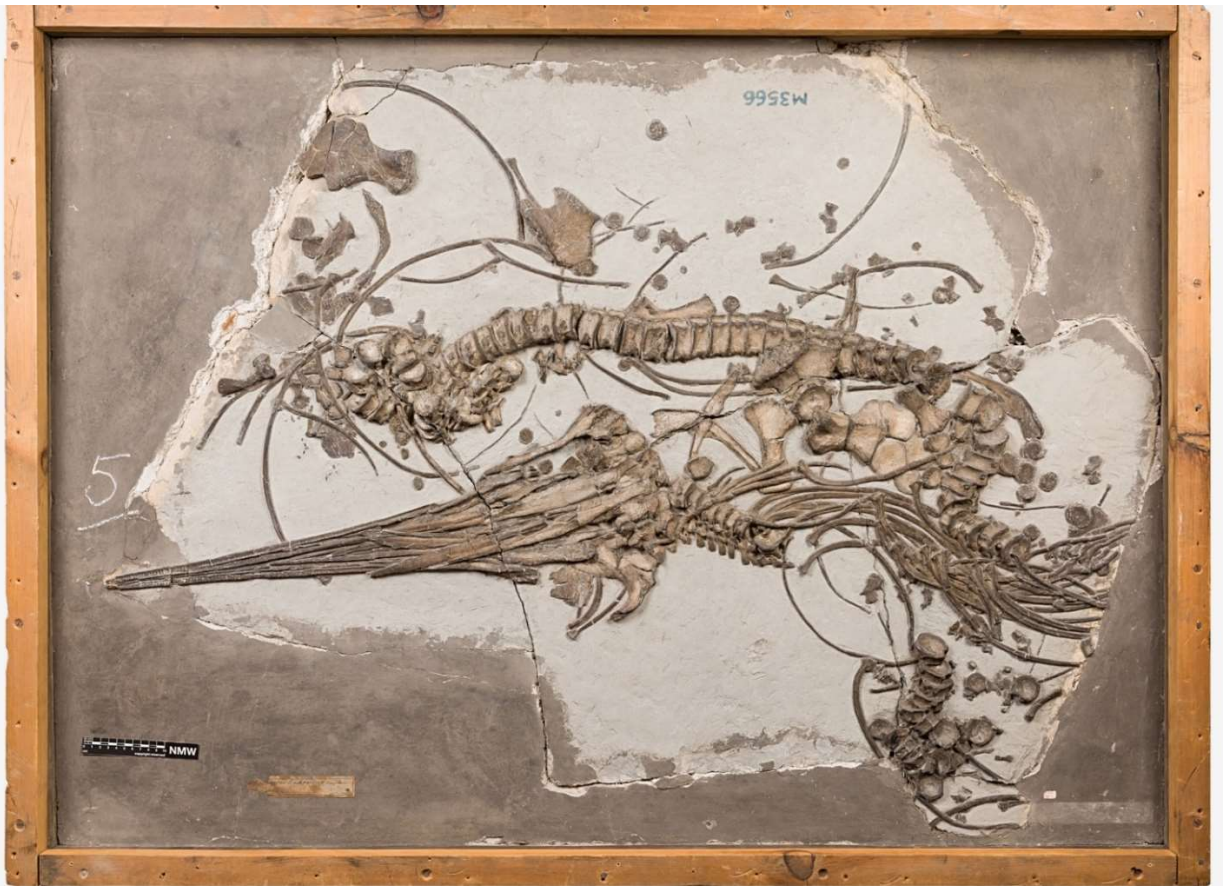

FIGURE 16: BRLSI M3566, *Leptonectes tenuirostris*. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

BRLSI M3568 *Leptonectes tenuirostris*

(Figure 17)

McGowan (1990) identified this specimen, a skull and partially articulated skeleton, as *Leptonectes tenuirostris*, (Figure 17). The skull and two forefins stand out in relief, are a slightly darker color than the rest of the specimen and are at an unnatural angle with respect to the vertebral column. Although these differences could be related to how the specimen was prepared/cleaned or mounted, it is worth additional investigation. McGowan (1990) thought that the snout was too robust to be *Leptonectes*, although the mandible was slender, as would be expected. He suggested that the skull was *Ichthyosaurus*, but we do not agree. The skull is on the same block as one of the humeri, which has all of the characteristics of *Leptonectes*. It might be that the dorsolateral crushing of the skull makes the snout seem wider than a typical *Leptonectes*. Instead, we support McGowan's (1990) alternate suggestion that this is an atypical specimen of *L. tenuirostris*. The block with the skull and forefins is separated from the postcranial skeleton by a fracture, but as McGowan (1990) noted, a few gastralia line up across the fracture.

The skull is ~44 cm long as preserved, but it is missing the anterior tip of the rostrum. It is in left lateral view. Numerous teeth are well exposed along the rostrum. The orbital region has a nearly complete sclerotic ring that fills the orbit. The jugal is complete but displaced slightly. Most of the sutures, however, are unclear.

Two forefins are adjacent to the skull and anterior to the rest of the specimen. The less complete left forefin is overlying the more complete right one. The right forefin, in ventral view, preserves the humerus, notched radius, ulna (covered), carpals, metacarpals, and two complete phalangeal rows of elements. The left fin is in dorsal view and preserves the humerus, notched radius, ulna, and some carpals.

The block immediately posterior to the forefin preserves 16 ribs and some gastralia, but no centra. Posterior to that are more than 50 articulated centra, many of which have neural spines and ribs. However,

FIGURE 17: BRLSI M3568, *Leptonectes tenuirostris*. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

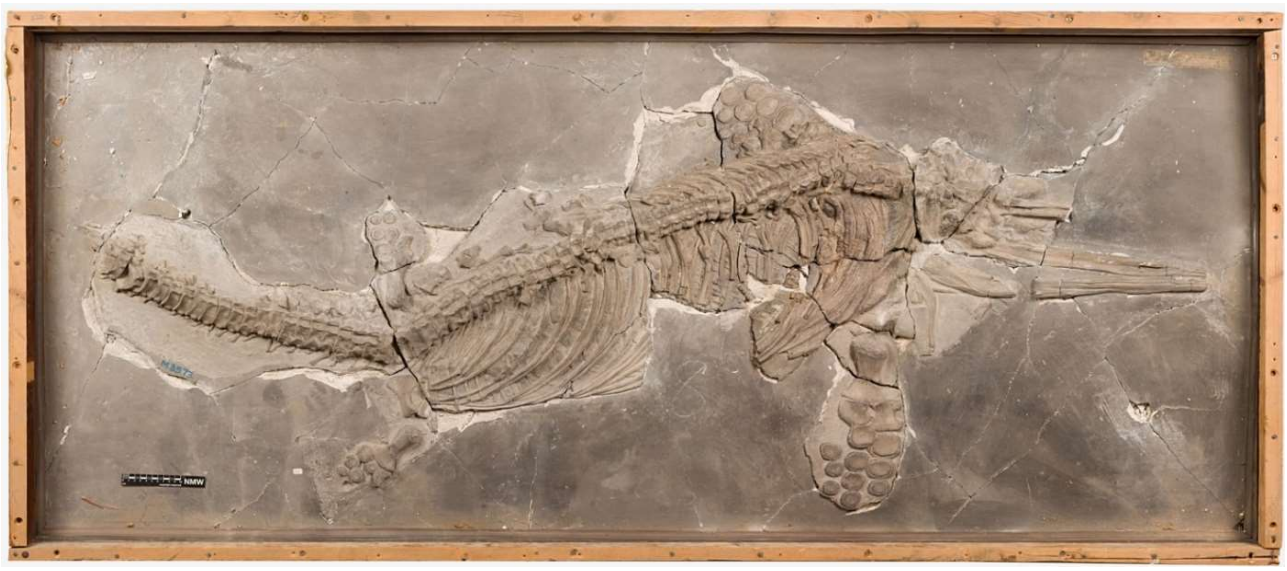

FIGURE 18: BRLSI M3573, *Leptonectes* sp. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

the last 18 articulated centra are separated from the others by a fracture and they could be on a separate, narrow block of matrix. A dark mass between the ribs might be gut contents but it requires further investigation. The tan color of the matrix surrounding the centra suggests that the specimen is from Street, Somerset.

Ventral to the vertebral column, and posterior to most of the ribs, are portions of both hindfins. The one (?right) nearest the vertebral column is more complete, but the femur is poorly preserved. The other femur is complete but articulated with only a few elements, including a broadly notched tibia. Parts of both unfused pubes and ischia are also preserved.

BRLSI M3573 *Leptonectes tenuirostris*

(Figure 18)

Although museum records identify this specimen as *Leptonectes tenuirostris*, McGowan (1989) indicated that it was too incomplete for a positive identification. However, the shape of the humerus and the two femora are consistent with the morphology of *Leptonectes*. The notched radius suggests that this is a *Leptonectes tenuirostris* (McGowan, 1989, 1996b).

This incomplete skeleton is preserved in dorsolateral view, but the skull is incomplete and partially disarticulated (Figure 18). The entire specimen, including the mandible, is ~2 m long, measured along the vertebral column. The skull and mandible are a lighter color than the postcranium and

poorly preserved. The posterior portions of both mandibles are preserved, as well as portions of the snout. No other elements in the skull are readily identifiable in the present condition of the specimen. The vertebral column is complete and articulated from behind the skull to the mid-caudal region. Most centra are associated with the proximal portion of a rib or with a neural spine, or both. The vertebral column looks authentic, even the distal segment that is at almost a right angle to the rest of the column.

All four limbs are preserved, although the right forefin and hindfin, both ventral to the vertebral column and ribs, are separated from the main skeleton and surrounded by plaster. This raises the possibility that they have been added to the specimen, although the forefin block of matrix matches up with the associated blocks and so is seemingly genuine. The right forefin includes a humerus, and preserves the notched radius, ulna, carpals and metacarpals. The proximal portion of the left forefin is presumably covered by the vertebral column, with only the ?carpals and ?metacarpals exposed.

Neither hindfin is complete, but both include the femur, broadly notched tibia, fibula, and a couple of tarsals. The right hindfin has three elements contacting the femur, a morphology that does not match the other hindfin and is not typically found in Lower Jurassic ichthyosaurs. This might simply be an oddity, similar to what has been reported in other hindfins (Massare and Lomax 2018). The right hindfin is associated with a pubis, partial ischium and a fragment of an ilium. The ischium is abruptly truncated at the fracture that separates the right hindfin block from the ribs. Neither ribs nor ischium continue across the fracture onto the adjacent block, potentially raising suspicion about whether the right hindfin has been added. The left hindfin is associated with portions of an ilium.

BRLSI M3575 *Leptonectes tenuirostris*

(Figure 19)

This specimen is a seemingly complete, articulated vertebral column with a jumble of bones, including a partial skull at its anterior end (Figure 19). It is 263 cm long, measured from the tip of the snout, across a gap posterior to the skull, and along the curved vertebral column. McGowan (1990) noted that the humerus, forefin and hindfin display the typical morphology of *Leptonectes tenuirostris*. The specimen was conserved in 1986 and 1988 at AC-NMW (AC-NMW archives).

The partial skull is mostly on a separate block of matrix, oriented ventral to the vertebral column with the right side exposed. It is missing most of the orbit and post-orbital region, but what remains is fairly well preserved. The rostrum is complete except for the anterior few cm of the mandible. McGowan (1990) suggested that the skull is that of an *Ichthyosaurus* and was added to the specimen, but we disagree with his identification. Although the partial skull is not on the same block of matrix as the rest of the skeleton, it has a long, narrow rostrum typical of *Leptonectes*. However, because it is ventrolaterally crushed, the mandible looks more robust than is typical for *L. tenuirostris*. Moreover, the matrix and bone color are similar to that of the postcranial skeleton. Numerous teeth are in the premaxilla and dentary. Distal elements from a forefin are on the same block of matrix as the skull. The posterior portion of the mandible and a portion of the sclerotic ring are on the adjacent block of matrix, although they do not seem to line up well with the skull block. Nevertheless, we conclude that the skull belongs with the rest of the skeleton.

Between the skull and vertebral column, at the anterior end of the specimen, is a dense accumulation of bones on a single block of matrix that is twisted with respect to the vertebral column. Two coracoids are preserved, although one of them is partially covered.

FIGURE 19: BRLSI M3575, *Leptonectes tenuirostris*. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

Portions of two forefins, including both humeri, are also preserved. One forefin is represented only by the humerus and the proximal elements of digit II, including a notched radius, although fin elements on the skull block might belong to this fin. The second forefin, possibly the right in ventral view, is articulated to the second phalangeal row, and includes what is either digit V or a posterior accessory digit.

The vertebral column is fractured into at least seven segments, with the posterior segment of 39 centra being unusually straight. The other segments fit together well, with bones extending across the fractures. Many centra have a portion of their neural arch preserved. Only a few ribs are preserved, mainly in the anterior portion of the column. Although more than 110 centra are preserved, the specimen is missing some anterior dorsal centra.

Associated with the vertebral column, at about the middle of the mount, is the proximal portion of an articulated hindfin; the tibia is notched and there are three elements in contact with the femur, similar to the previous specimen (BRLSI M3573). McGowan (1990) questioned whether the elements of the hindfin had been tampered with as this is a morphology not found in other *Leptonectes* specimens, but it might just be an unusual variant (see Massare and Lomax, 2018). Adjacent to the proximal end of the femur is a complete ilium and the proximal portions of the pubis and ischium.

BRLSI M3579 ?*Leptonectes* sp.

(Figure 20)

This specimen was not among those moved to AC-NMW in 1963 but was brought there at a later time. Unfortunately, as the specimen was moved out of the Queen Square building, it fell out of the frame (Howells, 2019). The specimen is now a collection of bone-bearing slabs of rock that are stored within the original frame (Figure 20A). At least a couple of photographs of the mounted specimen exist (Figure 20B,C), so it would be possible to reassemble it. The hindfin morphology suggests that this specimen probably belongs to *Leptonectes* (McGowan, 1989; DRL pers. obs.).

The skull is incomplete and the rostrum protrudes from the matrix, exposing the dorsal surface. The posterior portion of the skull is missing or buried, although the slab is not thick enough or large enough for much of the skull to be preserved. Multiple blocks expose strings of articulated vertebrae, which, based on photographs of the original mount (Figure 20B,C), suggest that the articulated vertebral column was largely intact and almost complete. Numerous ribs and neural spines are associated or articulated with the vertebrae, although several ribs and isolated vertebrae are scattered across the rest of the specimen. A well-preserved, incomplete hindfin includes a very narrow,but distally expanded femur and associated fibula and broadly notched tibia.

MANCH L.9663 *Leptonectes tenuirostris*

(Figure 21)

Unlike the other specimens described here, this one is housed at the Manchester Museum, but the label and the museum register indicates that it was once part of the Charles Moore Collection. The specimens likely reached the museum through Rev. H. H. Winwood, who is acknowledged on labels of other Moore specimens in the museum. This ichthyosaur does not appear on any of the images of the Moore Museum. The specimen has a light matrix typical of Street, Somerset, but the museum register gives the location as "?Weston" (possibly the northern suburb of Bath; see Benton & Spencer, 1995, p.104). The specimen is set in plaster-like material in which small pebbles have been imbedded, giving the mount a different appearance from the smooth, gray plaster on other mounted ichthyosaurs in the Moore Collection.

The shape of the humerus and the notched radius indicate that the specimen is *L. tenuirostris* (McGowan, 1989, 1996b). The specimen comprises the post-narial portion of a skull and skeleton in right lateral view (Figure 21). The skull is not well-preserved, and sutures are unclear, although additional preparation may reveal some details. The sclerotic ring, however, is nearly complete. The posterior portion of the skull and mandible are badly fractured, and about half of the rostrum is missing.

The vertebral column extends from the skull to the anterior caudal region, although it is poorly preserved immediately posterior to the skull. Many centra have neural arches and associated ribs. Large fractures separate portions of the post-cranial skeleton, although the bone color, orientation, and matrix color are consistent throughout the specimen, which demonstrates they all belong together.

A coracoid and parts of both forefins are preserved. The left forefin includes the humerus, notched radius, and ulna. The more complete right forefin, in dorsal view, is articulated from the humerus to the first phalangeal row. There is what might be digit V or a posterior accessory digit. Two incomplete hindfins are positioned either side of the vertebral column. The right hindfin includes the femur articulated with the tibia and fibula. A few tarsal elements are scattered in the matrix. An ilium and an unfused pubis and ischium are on either side of the femur. The left hindfin comprises the femur and associated, disarticulated elements, and an ilium is adjacent to it.

FIGURE 20: BRLSI M3579, ?*Leptonectes* sp. A, specimen presently laid out within the original frame, © Amgueddfa Cymru-National Museum Wales, Cardiff, UK. B, specimen as it appeared on the 'saurian wall' (bottom row) in Figure 1. C, old photo taken before the specimen was moved from BRLSI. Note the rostrum on the right, protruding from the matrix. Photographer unknown. Scale bar = 10 cm.

FIGURE 21: MANCH L.9663, *Leptonectes tenuirostris*. Scale bar = 10 cm.

SPECIMENS OF *ICHTHYOSAURUS*

Massare and Lomax (2017) provided a revised diagnosis of the genus *Ichthyosaurus*, but specimens of the genus can be identified most easily by their unique forefin morphology. Four elements are in the distal carpal (third) row, with two in contact with the intermedium, and the presence of at least one anterior digital bifurcation (digit II or III) results in at least five digits in the forefin, although additional distal bifurcations are common. As discussed above, forefins can be added to a specimen, so it is important to confirm their authenticity, especially if the genus assignment is based on the forefin morphology alone.

Ichthyosaurus is also unique among Lower Jurassic ichthyosaurs in that the pineal foramen is entirely within the frontals, albeit at the posterior end. Species of the genus can be distinguished by the combination of morphologies of the maxilla, prefrontal, postorbital, lacrimal, jugal, and teeth (Lomax and Massare, 2018b, table 2), the shape of the humerus (Lomax and Massare, 2017, fig. 7) and by hindfin morphology (Massare and Lomax, 2018, fig. 1, table 4).

BRLSI M3550 *Ichthyosaurus somersetensis*

(Figure 22)

This is a practically complete, articulated skeleton in ventral view, lacking only the hindfins and tip of the tail (Figure 22A). Including the skull, it is 162 cm long, measured along the vertebral column. The forefin morphology identifies the specimen as *Ichthyosaurus* (Motani, 1999; Massare and Lomax, 2017). It is herein assigned to *I. somersetensis* based on the relatively short rostrum, the shapes of the humerus and femur, and the prominent grooves in the tooth roots (Lomax and Massare, 2017). The specimen was conserved in 1986 and 1988 at AC-NMW (AC-NMW archives).

Both mandibles are preserved (left length = 36 cm), but the right one is missing a portion under the orbital region. The rostrum seems to be complete, and the preorbital length is more typical of *I. somersetensis* than the longer rostrum of *I. larkini* (Lomax and Massare, 2017). Many teeth are in the mandible and also loose, scattered in the matrix. The best-preserved teeth have roots with prominent grooves that extend to the base of the crown.

At the posterior end of the skull, braincase elements are exposed in ventral view, including parts of the parabasisphenoid. The atlas/axis are fused, and six other cervical centra are preserved anterior to the clavicle. The vertebral column is fully articulated and has what looks like a hairpin bend at about 35 centra, presumably caudal, posterior to the position of the left ilium. It is actually a break and change in the orientation of the vertebral column. It might be the actual position of the tail bend because *Ichthyosaurus* typically has 33-37 caudal centra (Buchholtz, 2001). About 26 centra are preserved in the posterior segment of the tail. The entire vertebral column appears to be from the same individual. Stomach contents, consisting of cephalopod hooklets, are preserved between the ribs, extending posterior from the pectoral girdle for about a dozen centra. Some of the vertebrae and ribs are covered by what might be soft tissue (?skin).

A nearly complete pectoral girdle is perfectly articulated, one of the best examples known for the species (Figure 22B). The two humeri articulate with the pectoral girdle. The left forefin is articulated to about the seventh phalangeal row, with more distal elements scattered in the matrix. The right forefin is less complete, articulated to about the sixth phalangeal row, but missing the anterior digits distally. Both humeri have an oval depression at the base of the deltopectoral crest, which may be pathological.

Both femora are present. Each is asymmetric, with an anterior bulge in the shaft and a more strongly concave posterior profile, as occurs in both *I. somersetensis* and *I. larkini* (Massare and Lomax, 2018, fig. 1). Two elements of digit II in the hindfin are notched, but not the tibia. The right pubis and ischium are preserved, although the ischium is missing the distal end. What is probably the left ischium is poorly preserved and overlies the vertebral column.

BRLSI M3551 *Ichthyosaurus* sp.

(Figure 23)

This specimen does not appear clearly on any of the photos of the Moore Museum (Figures 1-3), but it is probably the end specimen on the left in the bottom row of Figure 2. BRLSI M3551 is a nearly complete skeleton preserved mostly in dorsal view (Figure 23). It is ~255 cm long, measured along the vertebral column and including the skull. Although the hindfins have almost certainly been added to the specimen or are reconstructed (Massare and Lomax, 2016), the rest of the skeleton appears authentic, including the forefins, which identify the specimen as *Ichthyosaurus* (Motani, 1999; Massare and Lomax, 2017).

The skull, preserved in dorsolateral view, is largely disarticulated (length ~48 cm). Additional preparation might reveal more information on the morphology, especially for the bones in the posterior region of the skull. But in its present condition, little information can be ascertained. The skull seems to have a short snout, but this is probably an illusion of preservation. The rostrum looks robust because both dorsal and lateral aspects are preserved.

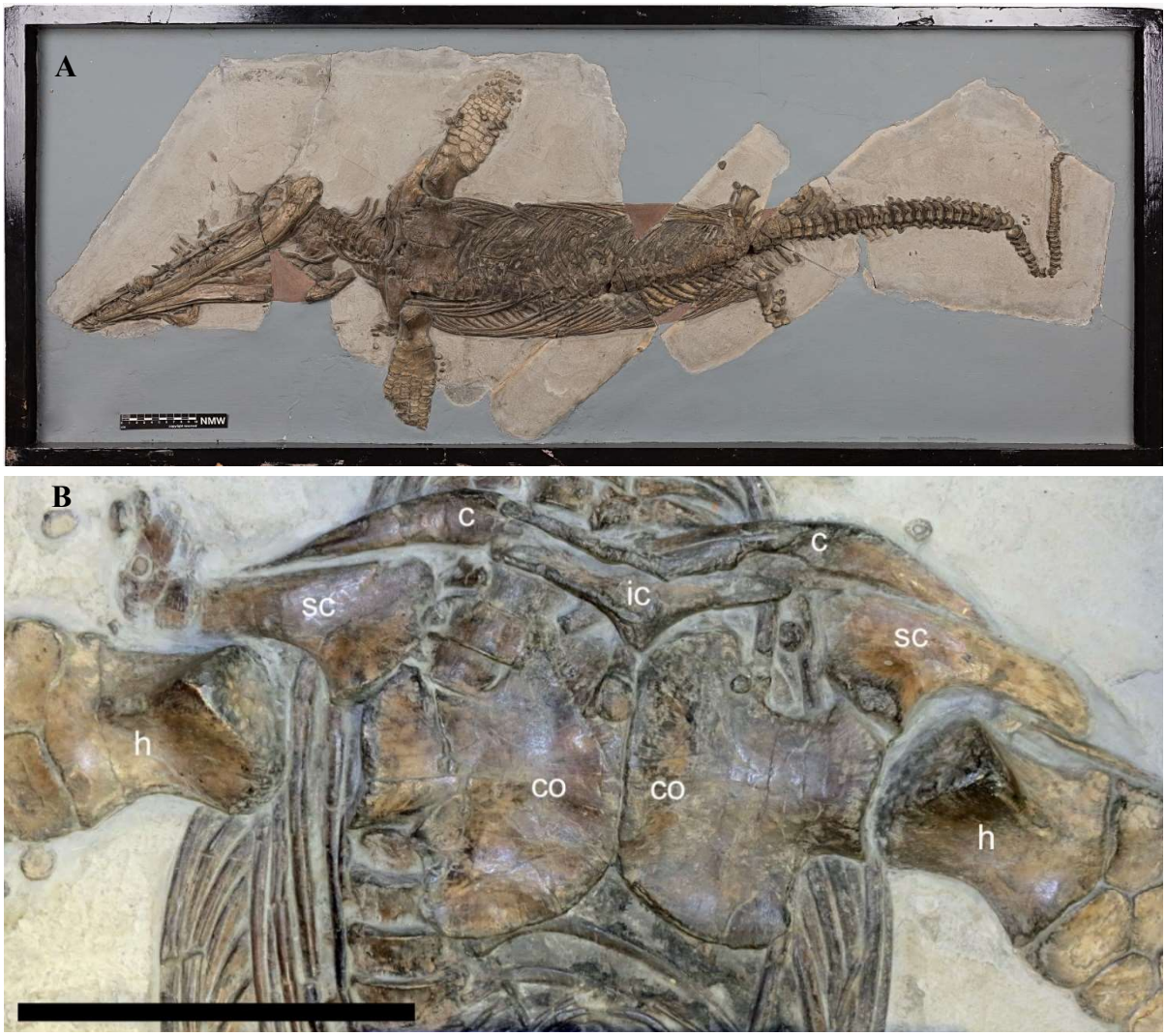

FIGURE 22: A, BRLSI M3550, *Ichthyosaurus somersetensis*. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK; B, BRLSI M3550, articulated pectoral girdle. Scale bars = 10 cm. Abbreviations: **c**, clavicle; **co**, coracoid; **h**, humerus; **i**, interclavicle; **sc**, scapula.

The vertebral column is articulated from about the mid-dorsal region to the end of the fluke, although a tail bend is not evident and some centra are lying almost entirely in plaster, so might not have been articulated when found. The column bends in an arc such that the tip of the tail is ventral to the skull, another taphonomic oddity. The transition from double headed to single headed ribs occurs at about the middle of the arc. Many partial ribs are scattered on either side of the vertebral column.

One coracoid is complete, clearly showing the anterior and posterior notches. The right forefin, in dorsal view, has a digital bifurcation in probably the first phalangeal row and a posterior accessory digit. The fin is articulated to about the eighth phalangeal row. Massare and Lomax (2016) suggested that the fin might be a composite because elements do not line up well on either side of a crack that extends diagonally across the fin, although it is also possible that some of the elements are from the other fin. The left forefin, probably in ventral view, is preserved only to the distal carpal row. One hindfin is on either side of the vertebral column, isolated from it and entirely surrounded by plaster. They are displaced posteriorly, being eight or nine centra distal to the sacral region, defined here as where the ribs change from double-headed to single-headed. A single, slightly curved ilium is preserved adjacent to the vertebral column where the dorsal vertebrae transition to caudal vertebrae.

FIGURE 23: BRLSI M3551, *Ichthyosaurus* sp. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

FIGURE 24: BRLSI M3554, *Ichthyosaurus somersetensis*. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

BRLSI M3554 *Ichthyosaurus somersetensis*
(Figure 24)

This specimen is a partial skeleton in dorsolateral view, but the posterior portion is separated from three anterior blocks of matrix that preserve the anterior skeleton and skull (Figure 24). The total length of the specimen is 150 cm, measured across the gap between the posterior and anterior portions of the skeleton. The forefin morphology identifies the specimen as *Ichthyosaurus* (Motani, 1999; Massare and Lomax, 2017). On the basis of the humerus and maxilla morphologies, the specimen can be assigned to *I. somersetensis* (Lomax and Massare, 2017).

The skull, almost 40 cm long, is dorsoventrally flattened. The rostrum, separated from the rest of the skull by a large fracture, is preserved to the anterior tip, with premaxillary teeth exposed on the right side. An internasal foramen is visible. The sclerotic plates have rotated outward due to deformation and are preserved as an articulated ring on either side of the skull roof. Sutures on the skull roof are difficult to discern because of fracturing, however, the bones around the temporal fossa are complete.

A string of about 15 articulated centra and associated ribs are on a second block, separated, but nearly articulated with the skull. The orientation of the column and the bone color is consistent with that of the skull. Part of a clavicle and coracoid can be seen under the ribs, ventral to the vertebral column. The nearly complete right scapula is ventral to the ribs on another block of the matrix that also preserves a nearly complete right forefin, in dorsal view. It is articulated from the humerus to the tenth phalangeal row. The vertebral column probably covers the left humerus, but the remainder of the left forefin, in dorsal view, is as complete as the right one. The anterior digital bifurcation, characteristic of *Ichthyosaurus,* is present in the first phalangeal row of each forefin.

The posterior portion of the vertebral column, comprising at least 30 centra, is separated from the anterior skeleton by a few centimetres of plaster. The centra do not articulate with those on the anterior block, so either centra are missing between the two portions of the vertebral column or the posterior column belongs to another individual (Massare and Lomax, 2016). The centra get larger posteriorly and have a similar orientation as on the anterior block, as would be expected, but the bone color is lighter than the anterior skeleton. Conservation and cleaning of the specimen could resolve the question of authenticity. The posterior-most centra are disarticulated.

BRLSI M3559 *Ichthyosaurus somersetensis*

(Figure 25)

The specimen is a partial skeleton, ~ 122 cm long, including the skull, measured along the vertebral column (Figure 25A). The forefin and hindfin morphologies indicate that this is a specimen of *Ichthyosaurus somersetensis* (Motani, 1999; Massare and Lomax, 2017; Massare and Lomax, 2018). The tan matrix and bone color suggests that this specimen was collected from one of the 19th century quarries around Street, Somerset. The specimen was conserved in 1988 at AC-NMW (AC-NMW archives).

The partial skull, ~34 cm long, is preserved in right lateral view. The orbital and postorbital portions of the skull are disarticulated, although some bones (e.g., postfrontal, basioccipital) are identifiable in the matrix. The premaxillary and dentary teeth are in position in the well-preserved rostrum.

The articulated vertebral column uncharacteristically curves back on itself, another example of unusual taphonomy. The vertebral column is complete to about the 60th centrum, although some centra are covered by ribs and the column is somewhat disarticulated in places. The rib articulations merge at about the 45th centrum, indicating the transition to single-headed ribs and the anterior-most caudal centrum. A more distal portion of the vertebral column, comprising 25-30 articulated centra, are preserved adjacent to the left forefin, separated from the rest of the vertebral column. Stomach contents including cephalopod hooklets are preserved below and among the ribs in the anterior portion of the vertebral column.

Both forefins, including humeri, are preserved, the right in dorsal view and the left in ventral view, positioned on either side of the partial skull. The right forefin is complete distal to the tenth phalangeal row; a bifurcation is present in either the first or second phalangeal. The left forefin is equally complete, but not as well articulated. The ?left scapula is complete and adjacent to the left forefin, associated with an incomplete coracoid.

Notably, all six bones of the pelvis and both hindfins are preserved, positioned adjacent to each other and dorsal to the vertebral column (Figure 25B). The ischia and pubes are articulated and in close proximity to their respective ilia. On the more complete hindfin, the ilium partially covers the femur so its morphology is obscured. The other hindfin is poorly preserved, and the femur is fractured. The hindfins have two different morphologies of the tarsus, a rare occurrence in *Ichthyosaurus* (Massare and Lomax, 2018). Notching is present in some elements, but not in the tibia.

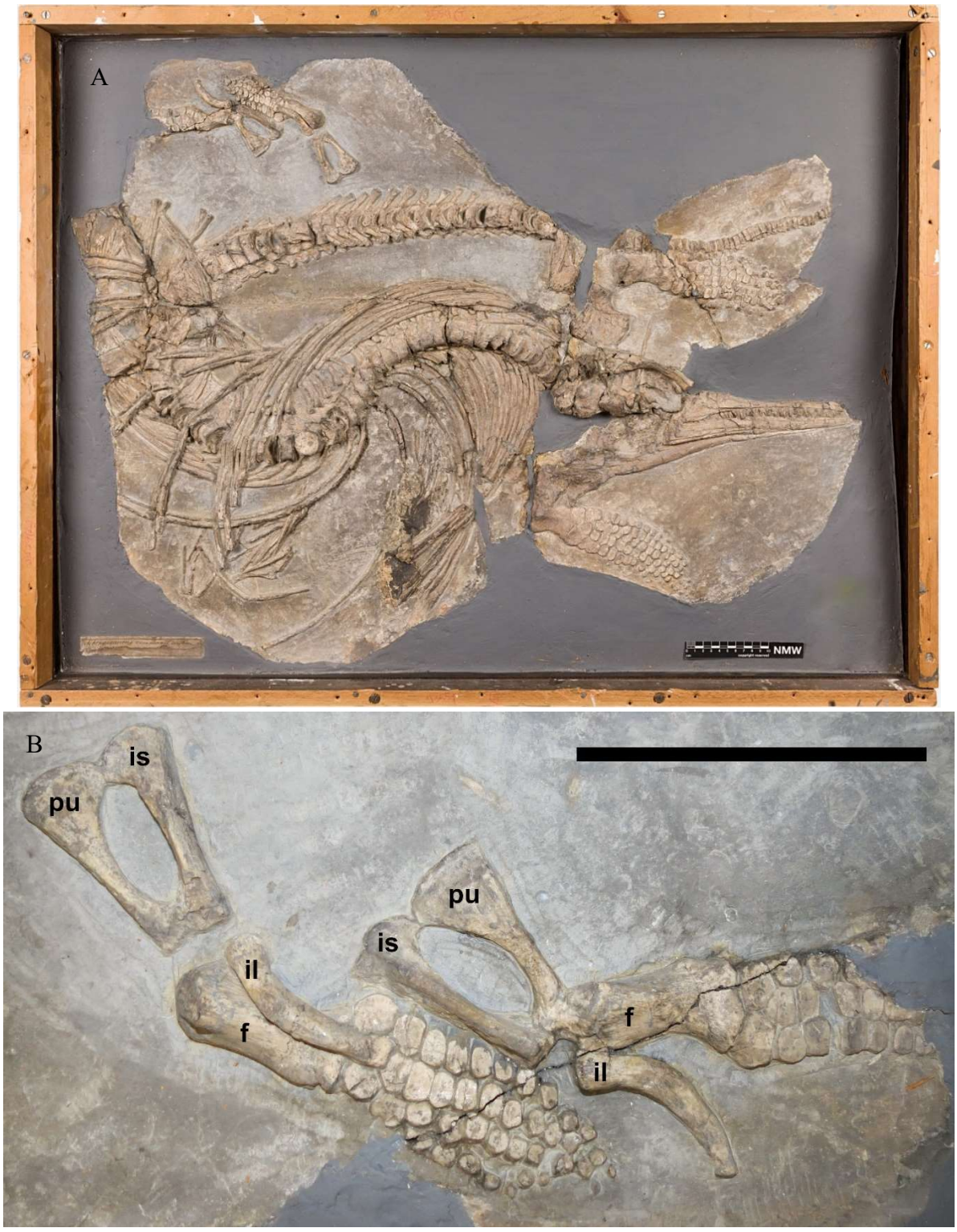

FIGURE 25: A, BRLSI M3559, *Ichthyosaurus somersetensis*. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK; B, BRLSI M3559 pelvic bones. Scale bars = 10 cm. Abbreviations: **f**, femur; **il**, ilium; **is**, ischium, **pu**, pubis.

BRLSI M3562 *Ichthyosaurus somersetensis*
(Figure 26)

Although this specimen was on loan to AC-NMW with the rest of the Moore Collection, it was returned to BRLSI in 1971, where it is presently housed (archive notes L15405, L15046 BRLSI). It was conserved at some time after its return to BRLSI, but we assume that it is in its original frame. BRLSI M3562 is a small specimen, preserved in dorsal view (Figure 26). It has a preflexural length of ~120 cm, including the apical centra, and a total preserved length of 133 cm. The specimen is a juvenile because the 36 cm long skull is quite large compared to the postcranial skeleton, with a ratio of 1:2.5 (von Huene, 1922; McGowan, 1973).

The skull is complete to the tip of the rostrum, with premaxillary, dentary and dislocated maxillary teeth exposed on the right side. A large pineal opening is entirely within the frontal, confirming that this specimen is an *Ichthyosaurus* (Massare and Lomax, 2017). The asymmetric maxilla with a very long, slender posterior process, visible on the right side, indicates that the specimen is *I. somersetensis* (Lomax and Massare, 2017).

The vertebral column is complete, from the atlas-axis into the fluke, although the fluke centra are disarticulated and separated from the main vertebral column. The atlas and axis are fused, but the individual centra are still recognizable. The complete series of neural spines, from the broad, fused atlas-axis spine to at least the pelvis, are well preserved and articulated. Ribs are preserved on both sides of the vertebral column. The first single-headed rib occurs on the 44th centrum, indicating the transition from dorsal to caudal centra. There are 74 preflexural centra, including three apical centra, and about 24 fluke centra. Portions of the clavicle and ?scapula are exposed on the right side of the specimen.

All four fins are separated from the main skeleton to some degree and are much better articulated distally than proximally. The right humerus is imbedded in matrix, and the radius and ulna are disarticulated and adjacent to it. The more distal, articulated portion of the right forefin is separated from the main skeleton and surrounded by plaster. Moreover, it has the characteristic morphology of *Protoichthyosaurus*, so it has been added to the specimen (Massare and Lomax, 2016; Lomax et al. 2017). The left forefin is articulated from the carpals to the tenth phalangeal row. However, two proximal elements in digit V (second and third row) seem too large compared to corresponding elements in the other digits, suggesting that at least some of the fin might have been altered. It is even conceivable that this fin was added to the specimen. The right femur and ilium are preserved adjacent to the vertebral column. The tibia and fibula are adjacent to the femur, but not articulated. Several scattered elements from the hindfin are probably authentic. The articulated distal portion of the hindfin is separated from the main skeleton by a large, filled fracture and almost certainly was added to the specimen. The variation in the size and shape of the elements and the arc of bone defining the distal margin of the fin strongly suggest that it has been constructed. The left hindfin is missing the femur, tibia, and fibula, and is also separated from the main skeleton. Although seemingly articulated, the size, shape, number, and orientations of the elements are problematic. Furthermore, the fins seem to have six digits, a morphology that is very rare in hindfins of *Ichthyosaurus* (Massare and Lomax, 2018).

BRLSI M3569 *Ichthyosaurus somersetensis*
(Figure 27)

This specimen is an anterior skeleton, ~94 cm long including the skull, preserved in right ventrolateral view (Figure 27). The skull is complete to the anterior end of the rostrum, but the rostrum has two large fractures roughly perpendicular to its long dimension. The mesopodium of the left forefin (anterior one in Figure 27) identifies the specimen as an *Ichthyosaurus* (Motani, 1999; Massare and Lomax, 2017). The shape of the maxilla, the long prefrontal, and the prominent grooves in the tooth roots identify this specimen as *I. somersetensis* (Lomax and Massare, 2017). The right mandible is 42 cm long. The posterior portion of the left mandible is exposed ventral to the right mandible. The sclerotic ring is complete but displaced and deformed, although does fill most of the orbit. The posterior portion of the skull is broken and disarticulated.

Almost 40 articulated centra are present, although the anterior ones are partially covered by ribs. The neural spines of the anterior centra are well-preserved. A dark mass of gut contents, including cephalopod hooklets, are preserved between the ribs. The two coracoids are articulated and partially exposed. The left forefin (anterior one in Figure 27) includes the radius, ulna, carpals, metacarpals, and a portion of the first row of phalanges, but is missing the humerus. The anterior metacarpal and first phalanx are notched. The right forefin (posterior one in Figure 27) was reconstructed at some time in the 20th century, prior to 1988, when the specimen was last conserved (AC-NMW archives). A large piece of the distal portion of the forefin is in plaster. The bones do not line up properly across the fractures, although the bone color is similar. Additionally, the distal portion of the fin is set higher above the matrix than the rest of the specimen. These features led Massare and Lomax (2016) to suggest that the right forefin might not belong with the rest of the specimen.

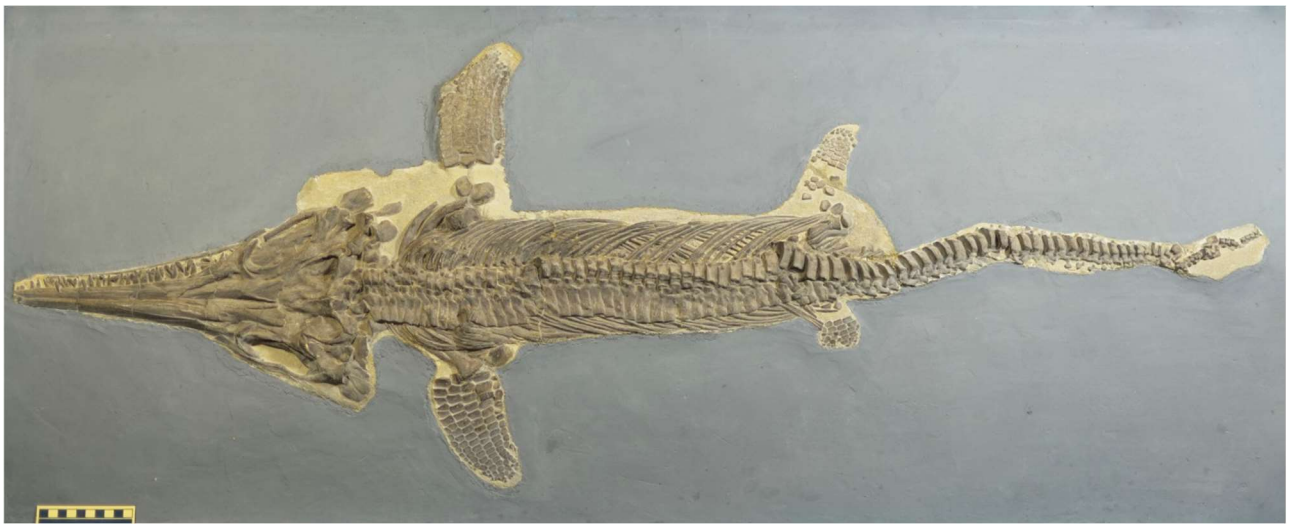

FIGURE 26: BRLSI M3562, *Ichthyosaurus somersetensis*. Scale bar = 10 cm

FIGURE 27: BRLSI M3569, *Ichthyosaurus somersetensis*. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

FIGURE 28: BRLSI M3570, *Ichthyosaurus breviceps*. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

BRLSI M3570 *Ichthyosaurus ?breviceps*

(Figure 28)

Although this specimen is presently included in the Moore Collection, the original label indicates that was donated by J. Templeman, Esq. in 1828, and that it is from Lyme Regis. Torrens (2010, p. 248, footnote 2) stated that this specimen was purchased from Mary Anning, and confirmed this with DRL (Torrens, pers. comm., 2024). The forefin morphology indicates that this is an *Ichthyosaurus* (Motani, 1999; Massare and Lomax, 2017). We tentatively identify the specimen as *Ichthyosaurus breviceps*, based on the shape of the humerus, the shape of the maxilla, and the dentition. At the time of the donation, the species had not yet been recognized as distinct from *I. communis*. The specimen is in urgent need of conservation: it has numerous fractures, some ribs and centra are lying loose on the matrix, and the underlying slats of the frame are visible in spots.

The fairly complete skeleton and partial skull is preserved in right lateral view (Figure 28). The estimated length is ~1.5m. The preorbital portion of the skull is complete and well preserved, but the orbital region and posterior skull is largely missing. The anterior portion of the rostrum appears to be 'downturned' relative to the maxilla, which is a feature found in specimens of *I. breviceps*, including the holotype (NHMUK VP OR43006). Numerous teeth are exposed in the rostrum. A fracture separates the rostrum from the postcranial material, but the posterior portion of the mandible appears to extend across the fracture, although at an angle to the rest of the mandible. The sections of the anterior vertebral column are articulated, but overall, the region is poorly preserved. A fracture separates the anterior portion from the posterior column, which includes ~30 articulated dorsal centra and ~20 articulated caudal centra. The remainder of the vertebral column is disarticulated except for the distal-most centra, which may be part of the fluke. Ribs are preserved on both sides of the vertebral column.

A scapula and partial clavicle are preserved posterior to the skull, ventral to the vertebral column. An articulated right forefin is ventral to them, preserved from the humerus distally to include most of the first two phalangeal rows. The humerus morphology is also similar to *I. breviceps*, with the shaft not being tightly constricted and in having a reduced dorsal process (Lomax and Massare, 2017, fig. 7D). A bifurcation is present in the first phalangeal row. A possible second humerus is partially buried in the matrix to the right of the forefin, but it needs to be cleaned in order to confirm the identification. Dorsal to the posterior end of the specimen, a hybodont shark spine (?*Hybodus* sp.) has been placed in the plaster.

BRLSI M3571 *Ichthyosaurus* sp.

(Figure 29)

This specimen comprises a partial skull, proximal portion of a left forefin, and scattered anterior postcranial material (Figure 29). The forefin morphology indicates that this is a specimen of *Ichthyosaurus* (Motani, 1999; Massare and Lomax, 2017). The skull, in left lateral view, is disarticulated posterior to the middle of the orbit. The rostrum is incomplete at its anterior end and has two large fractures that displace the larger anterior piece. The preserved length of the mandible is ~32 cm. Posterior to the orbit are several parallel ribs and posterior to that are almost a dozen disarticulated centra in various orientations. A nearly complete scapula is between the posterior portion of the mandible and the left forefin. The forefin includes the humerus and is preserved to the metacarpal row.

BRLSI M3572 *Ichthyosaurus* sp.

(Figure 30)

The specimen is an incomplete skeleton preserved mainly in ventral view (Figure 30A), and might be a composite (Massare and Lomax, 2016). The total length, including the skull, measured along the vertebral column is 214 cm. The specimen is the holotype of *Protoichthyosaurus prosostealis* Appleby 1979, but the species was removed from that genus and assigned to *Ichthyosaurus* by Lomax et al. (2017). We consider the species a *nomen dubium*. Although the specimen is definitely *Ichthyosaurus*, based on the forefin morphology (Motani, 1999; Massare and Lomax, 2017), it lacks features that would distinguish it from the other species of the genus or would allow it to be assigned to one of the other species.

The skull, preserved in ventral view, is missing as much as half of the anterior portion of the mandibles. Both hyoids are preserved, but only the left one is complete. They are adjacent to a few articulated centra. Immediately posterior to the mandibles is a partially articulated pectoral girdle, including the left clavicle, the interclavicle, and both coracoids, although the latter are fractured. One scapula is nearly complete, but disarticulated from the rest of the pectoral girdle. The other scapula is beneath the right forefin, with most of the shaft exposed.

FIGURE 29: BRLSI M3571, *Ichthyosaurus* sp. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

The right forefin, including the humerus, is articulated to the second phalangeal row. These elements undoubtedly belong to the same individual because bones line up perfectly across the fractures. The left forefin is complete beyond the tenth phalangeal row, with a digital bifurcation in the first phalangeal row and a second, more distal bifurcation. However, the forefin is separated from the rest of the pectoral region of the skeleton and has fractures across the humerus shaft and in the proximal portion of the fin. It is very likely, however, that it belongs to the same individual.

In both forefins, a supernumerary bone is anteroproximally adjacent to a pentagonal intermedium (Figure 30B, C). This feature prompted Appleby (1979) to consider BRLSI M3572 a new species. Two other specimens of *Ichthyosaurus*, however, display this morphology: NHMUK VP OR49204 and NHMUK VP OR39844. In the former, the right fin has the supernumerary bone, but the left fin has the usual *Ichthyosaurus* morphology, suggesting that this feature is perhaps a pathology or other oddity. NHMUK VP OR 39844 has only one forefin preserved, and it shows the unusual morphology (Lomax et al., 2017).

A large block distal to the coracoids includes ribs and about 15 more or less articulated dorsal centra. A few ribs seem to continue across the anterior fracture onto the block with the pectoral girdle. Posterior to this block is another large, fractured block of matrix with centra and ribs. Several ribs continue across these two blocks, so they appear to belong together. The bones of the two blocks seem to be truncated by plaster on the left side of the specimen. It is more likely than not that these two blocks belong to the anterior portion of the skeleton. The posterior end of the second block is mainly ribs, with more closely spaced fractures, but it also includes a pubis, ilium, and partial ischium on the right side of the specimen.

The rest of the skeleton is somewhat problematic. The next block of matrix, moving posteriorly, includes a nearly complete right hindfin and about eight centra, the posterior six in articulation. Some of the bones do not line up exactly with the anterior block across the fracture raising some suspicion (Massare and Lomax, 2016). The right hindfin is very well preserved, exposed in dorsal view and is practically complete, with an articulated femur; this does appear to match up with the previous block. Two additional blocks of matrix, one with a pubis and ischium, and another with a partial hindfin, are on the left side, separated from the main specimen by plaster. The bone color is similar, as is the morphology of the hindfins, but it is possible that these elements were added.

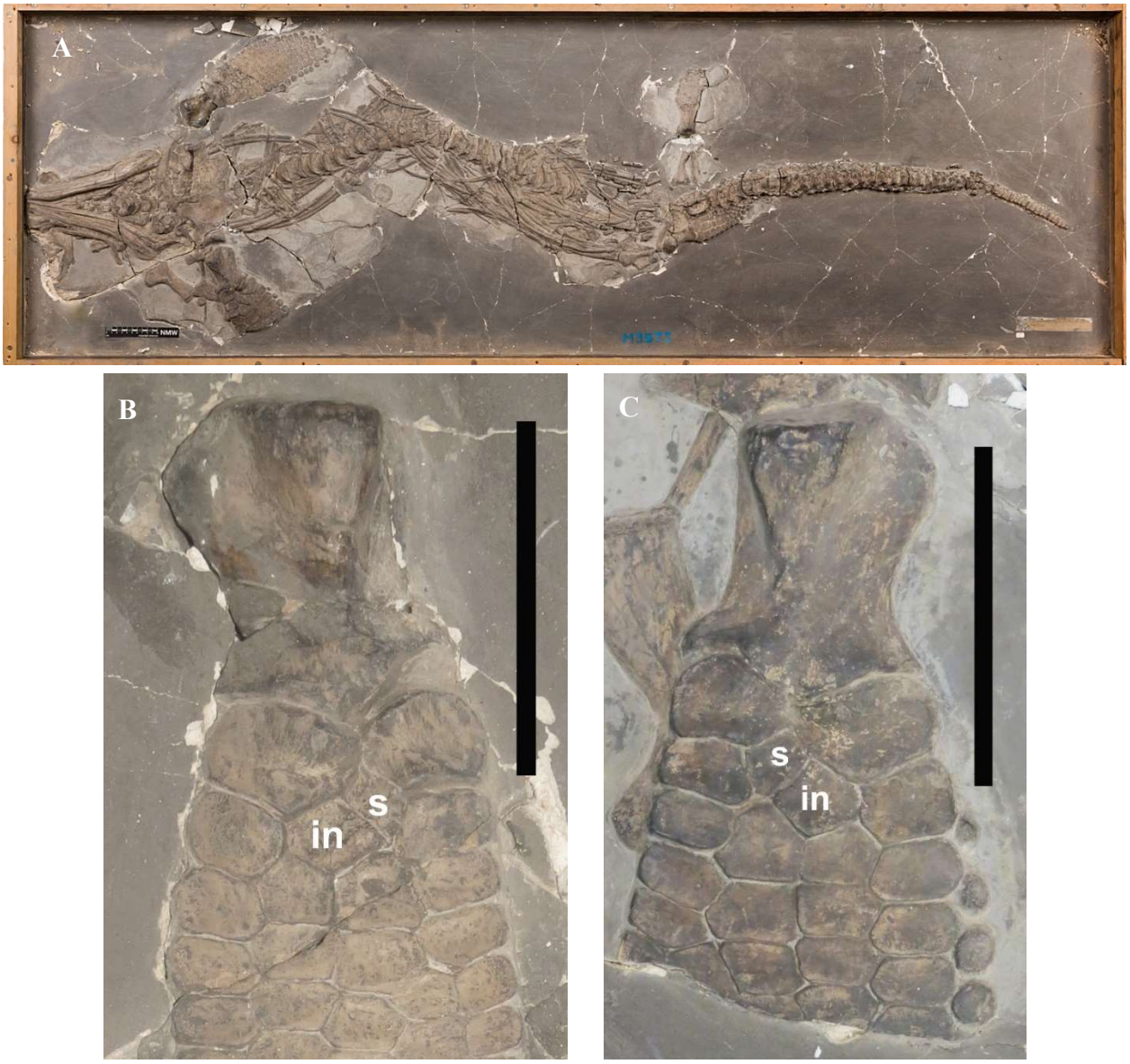

FIGURE 30: A, BRLSI M3572
, *Ichthyosaurus* sp. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK; B, BRLSI M3572 proximal portion of left forefin, ventral view; C, BRLSI M3572 right forefin, ventral view. Scale bars = 10 cm. Abbreviations: **in**, intermedium, **s**, supernumerary bone.

The remainder of the vertebral column is completely surrounded by plaster. Fifteen centra articulated centra are present before the apical centra of the tail bend, resulting in less than 25 centra in the preflexural portion of the tail, too few for *Ichthyosaurus* (Buchholtz, 2001). Thus, although the preflexural centra might belong to the main skeleton,the ~20 fluke centra immediately distal to them (i.e., the distal-most portion of the tail) have probably been added because there is a clear difference in size between the fluke centra and those immediately anterior to them.

FIGURE 31: BRLSI M3580, currently the only known cast of the holotype specimen of *Ichthyosaurus somersetensis*, original at ANSP. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

BRLSI M3580 *Ichthyosaurus somersetensis*
(Figure 31)

This specimen is the only known cast of the holotype of *Ichthyosaurus somersetensis* (ANSP 15766; Lomax and Massare, 2017), a large skeleton preserved in left lateral view, one of the most complete specimens of the genus (Figure 31). The original specimen is from near Glastonbury, near Street, Somerset, and is housed at ANSP, Philadelphia, U.S.A. Because of its size, the specimen was likely collected as separate blocks, but a patterned plaster wash on the original specimen obscures the details of how the mount was assembled. The cast is very well done: skull sutures are visible, as is the pattern on the matrix. The original molds were probably made or arranged by Samuel Stutchbury (1798-1859), curator at the Bristol Institution, who had a cast made for the Institution in return for helping Edward Wilson (1808-1888) to acquire the original specimen in ~1848 for his brother, Thomas B. Wilson (1807-1865) of Philadelphia (Taylor and Clark, 2016). Moore likely purchased a second cast from the Bristol Institution or Bristol City Museum, its successor (Taylor and Clark, 2016).

The nearly complete skull is crushed dorsolaterally, exposing some of the skull roof as well as the left side of the skull and mandible. The vertebral column (preflexural length ~2 m) is completely articulated from the back of the skull to the tip of the fluke, but the tail lacks a distinct downward bend at the start of the fluke, which might suggest that a portion of the tail was modified during preparation or mounting. Two nearly complete forefins, two partial hindfins, and portions of the pectoral girdle are also preserved. The original specimen is described in detail in Lomax and Massare (2017).

SPECIMENS OF *PROTOICHTHYOSAURUS*

Although *Protoichthyosaurus* was originally defined on the basis of a distinct forefin morphology (Appleby, 1979), the genus was not recognized by subsequent workers (e.g. Maisch and Matzke, 2000; McGowan and Motani, 2003), probably because of unrecognized composites and a misunderstanding of the range of forefin variation in *Ichthyosaurus*. The genus has recently been resurrected, and the diagnosis has been expanded to include additional features of the forefin and many features of the skull (Lomax et al. 2017; Lomax and Massare 2018b; Lomax et al., 2019). The forefin morphology, however, is still the easiest was of distinguishing *Protoichthyosaurus* from the closely related *Ichthyosaurus* and other Lower Jurassic genera. The forefin has three primary digits (II, III, IV), with only one carpal rather than two in contact with the intermedium, and three elements rather than four in the distal carpal row. Two bifurcations occur on digit II, a proximal one in the metacarpal row, and a second one in a phalangeal row, bringing the number of digits to five. *Ichthyosaurus* and *Protoichthyosaurus* are the only two ichthyosaurian genera with anterior digital bifurcations (Motani, 1999; Lomax et al., 2017).

BRLSI M3553 *Protoichthyosaurus prostaxalis*
(Figure 32)

This specimen is the holotype of *Protoichthyosaurus prostaxalis* Appleby, 1979. It is a

ventrally preserved anterior skeleton, with a portion of the right side of the skull exposed, although deformed (Figure 32A). Lomax et al. (2017) noted that this designated holotype lacked any of the features that characterized the species in their revised diagnosis. However, upon re-examination, a tall, triangular, asymmetric maxilla with a long anterior process is visible on BRLSI M3553, a diagnostic character for the species; it had not been noticed previously because of the dorsoventral crushing of the skull. The orbits, sclerotic plates, and jugals are crushed but identifiable.

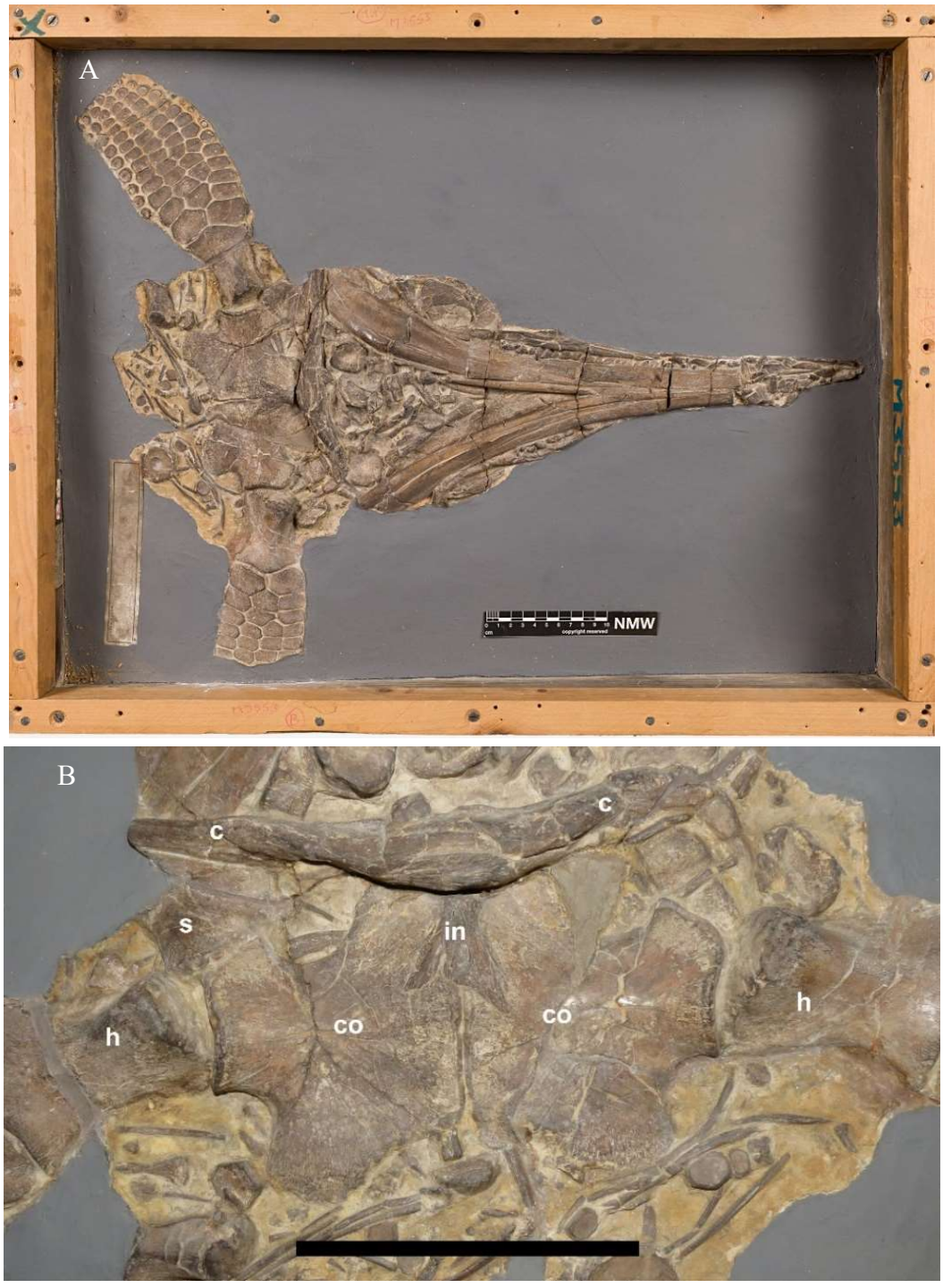

FIGURE 32: A, BRLSI M3553, *Protoichthyosaurus prostaxalis* holotype © Amgueddfa Cymru-National Museum Wales, Cardiff, UK; B, BRLSI M3553 articulated pectoral girdle in ventral view. Left side missing scapula and part of coracoid. Scale bars = 10cm

Both mandibles are preserved, but the anterior portion is missing. The premaxilla extends anterior to the broken mandibles, exposing some teeth. Taking that into account, the complete mandible was ~46 cm long. The right tooth row is also preserved. An important feature of the specimen is a nearly complete, although fractured, pectoral girdle. The coracoids, clavicles, interclavicle, and a portion of the right scapula are articulated (Figure 32B). Both humeriare preserved in ventral view, and articulate with the pectoral girdle. The right forefin is complete to the 9th phalangeal row, bearing five digits as well as a posterior accessory digit. The left forefin is articulated to only the second phalangeal row, not complete enough to preserve a second bifurcation of digit II. The specimen was conserved at AC-NMW in 1988 (AC-NMW archives).

BRLSI M3555 *Protoichthyosaurus prostaxalis*
(Figure 33)

This specimen was designated a paratype of *Protoichthyosaurus prostaxalis* by Appleby (1979). It is a nearly complete, articulated skeleton in right lateral view (Figure 33). Its preflexural length is ~155 cm, measured along the vertebral column and including the skull. It was conserved in 1988 at AC-NMW (AC-NMW archives).

The skull is ~44 cm long but is missing the anterior tip of the rostrum. A large fracture separates the rostrum from the orbital region of the skull. Many premaxillary and dentary teeth are present but poorly preserved, although a couple of teeth show that the root striations extend to the crown. The high, asymmetric maxilla with a long anterior process is well defined. The dorsal process of the lacrimal is much longer than the anterior process, and it is separated from the orbit margin by a large anterior process of the prefrontal. These are diagnostic features for the species (Lomax et al., 2017).

The articulated vertebral column is complete to just posterior to the tail bend, and neural arches are articulated on several mid-dorsal centra. The vertebral column is fractured in three places, but bones line up across the fractures, so it is clearly a single individual. The atlas and axis are fused, but the boundary between them is visible. The transition to single-headed ribs occurs on the 42nd centrum. Both femora are preserved in this region, one on either side of the vertebral column, but the one ventral to the column (right) is broken and partially buried distally. There are 33 caudal centra and as many as five apical centra, although the vertebral column is somewhat disarticulated and not well preserved at this point. Ribs are best-preserved in the anterior portion of the skeleton. Stomach contents comprising cephalopod hooklets and possibly fish remains are between some ribs, along with what might be soft tissue material covering some of the ribs.

One forefin with the humerus, presumably the right, is poorly preserved and positioned ventral to the vertebral column. The fin shows the typical *Protoichthyosaurus* morphology and includes a posterior accessory digit. Both coracoids are also preserved, along with a portion of the clavicle, but no other bones of the pectoral girdle are exposed. The block of matrix with the fin and coracoid is separated from other blocks by fractures, and not all bones line up exactly across these fractures. However, most bones line up well: e.g. the proximal portion of the humerus, although fractured, matches the distal portion on the adjacent block. In addition, the colors of the bones and matrix match on each block.

Appleby (1979) was convinced that this specimen was from Somerset, and we agree. Note that the matrix in anterior and posterior portions of the specimen is a blotchy gray color whereas the matrix in the middle portion of the specimen is tan. This often occurs in specimens from Somerset, and Street in particular, because they are preserved in laminated shales: the matrix color can vary if portions of a specimen are prepared a few mm deeper than others (M. A. Taylor, pers. comm., JAM 2016).

BRLSI M3563 *Protoichthyosaurus prostaxalis*
(Figure 34)

This specimen was designated a paratype of *Protoichthyosaurus prostaxalis* by Appleby (1979). The specimen is a fairly complete skeleton in dorsal view for most of its length (Figure 34). Massare and Lomax (2016) identified the specimen as a composite because the left forefin (from an *Ichthyosaurus*) was embedded in and entirely surrounded by plaster, and had a different morphology from the right fin (the typical *Protoichthyosaurus* morphology). The specimen is in several blocks of matrix, so it also raises the question of whether the middle and posterior portions of the specimen are from the same individual as the anterior portion.

The portion of the skeleton that almost certainly represents a single individual is the skull and the blocks immediately posterior to it, which include ribs on the right side, portions of both scapulae, and the right forefin, in dorsal view. The skull, ~48 cm long, is preserved in dorsal view, but the very tip of the rostrum is missing. The skull roof is fractured, and most sutures are difficult to discern. The right, nearly complete scapula and the distal end of the shaft of the left scapula are exposed. A portion of the right coracoid is exposed and is almost in articulation with the proximal end of the humerus and scapula. The right forefin has the typical *Protoichthyosaurus* morphology in the carpus (Appleby, 1979; Lomax et al., 2017), but it is on

a separate block from a section of the shaft and proximal end of the humerus. A minor portion of the distal end of the humerus seems to be missing as the shaft is unusually straight and the distal widening appears too abrupt. However, they almost certainly belong together because the morphology of the two pieces match, the coloration is the same and the matrix lines up.

Two large blocks comprise most of the remainder of the skeleton: sections of articulated centra, numerous ribs, partial hindfins, pelvic bones (including an associated, but incomplete pubis and ischium and an ilium), and a distal segment of the vertebral column. Although a large fracture separates the block into two pieces, a broken centrum and ribs line up fairly well across the fracture. Thus the large block belongs to a single individual, although conceivably, it might not belong to the same individual as the anterior portions of the skeleton. However, it is preserved in dorsal view. The anterior block has ribs on the right side, whereas this block has ribs on the left side. None of the ribs continue across the fracture separating the two portions of the skeleton, and this discontinuity is suspicious.

The left femur has multiple fractures, and is associated with an isolated ilium. The right femur appears to have an extra facet anterior to the facet for the tibia, an unusual feature for a Lower Jurassic

FIGURE 33: BRLSI M3555, *Protoichthyosaurus prostaxalis* paratype. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

FIGURE 34: BRLSI M3563, *Protoichthyosaurus prostaxalis* paratype. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

ichthyosaur. An anterior accessory digit might be present. The hindfin morphology is practically unknown for *Protoichthyosaurus*, but because of the aforementioned issues with the specimen, it is premature to attribute this morphology to the species or genus. The posterior portion of the vertebral column includes six articulated wedge-shaped apical centra and more than 30 articulated fluke centra. However, there are only 22 caudal centra anterior to the tail bend, suggesting that the posterior portion of the vertebral column might have been added (Massare and Lomax, 2016).

Appleby (1979) stated that this specimen was almost certainly from Street, Somerset. We agree because the anterior portion of the specimen is in a light tan matrix, which is typical of specimens from that location.

SPECIMENS OF UNCERTAIN AFFINITIES

BRLSI M0653 *Ichthyosaurus* sp. or *Protoichthyosaurus* sp.

(Figure 35)

This specimen is housed at the BRSLI and was not part of the loan to AC-NMW. If it was displayed at the Moore Museum, it would have most likely been in one of the floor cases, as the specimen is quite small and has never been mounted in a frame, although it may have been displayed at the museum. In his *Handbook to the Geographical Collection*, Moore describes the contents of case no. 37 (fossils from the Lower Lias) as including: "a single vertebra of great size [probably BRLSI M0646, see Appendix 2], belonging to an individual probably more than 30 feet long, by the side of which will be found on a tablet a very small specimen of the same genus" (Moore, 1864, p.9). The "very small specimen" was very likely BRLSI M0653 (Figure 35). We include the specimen here with the other ichthyosaurs as it is a substantial portion of a skeleton.

All of the bones are brown and imbedded in a 'blotchy' light tan and light grey matrix that is similar to the laminated shales from Street, Somerset. The main slab is the posterior portion of the skull and anterior vertebral column, preserved in dorsal view (Figure 35). The matrix block is fractured, but bones continue across fractures, indicating that it is a single individual. The skull roof is preserved from the anterior orbit margin to the posterior edge of the skull. The frontal is fragmentary, and it is not possible to discern the position of the pineal. The anterior margin of the parietals, however, suggest that the pineal was within the frontal, so the specimen is more likely an *Ichthyosaurus*, but this is far from certain (Massare and Lomax, 2017). An isolated rostrum piece is almost the same color as the skull, but there is no indication that it belongs to the same individual. It is much smaller than the broken end of the rostrum of the skull, so if it does belong to the specimen, a large portion of the rostrum is missing. The bones making up the margin of the temporal fossa are well-preserved on the right side, but are partially disarticulated on the left. The right fossa is almost square. In addition to the skull, ~20 centra are exposed, some in articulation, and ribs are preserved mainly on the left side of the vertebral column.

All other pieces of BRLSI 0653 are separate from this block, although the matrix and bone color are similar. Five isolated, articulated centra (positioned posterior to the main skeleton in Figure 35) articulate reasonably well with the centra on the posterior block of matrix. This block preserves articulated and disarticulated centra, some ribs, and two disarticulated, partial hindfins. Nothing connects this block to the main skeleton; if it belongs with it, then a substantial portion of the posterior dorsal region is missing.

The right forefin, imbedded in matrix, is from an *Ichthyosaurus,* whereas the left forefin, with little associated matrix, is from a *Protoichthyosaurus* (Lomax et al., 2017). Neither fin has a clear connection to the main skeleton aside from a similar matrix and they seem too large compared to the anterior skeleton, so it is conceivable that both forefins have been added (Massare and Lomax, 2016).

BRLSI M3549 *Ichthyosaurus* sp. or *Protoichthyosaurus* sp.

(Figure 36)

This specimen comprises disarticulated post-cranial bones imbedded in a slab of matrix (Figure 36). A complete coracoid clearly shows both an anterior and posterior notch, a morphology found in both *Ichthyosaurus* and *Protoichthyosaurus*. Vertebral centra in anterior/posterior orientation are scattered across the slab. Three vertebrae in lateral view are almost entirely within the matrix. They are larger than the others and might be articulated. A few isolated fin elements, a humerus, an incomplete scapula, and rib fragments are also preserved.

The specimen is resting in a wooden frame with material to cushion the slab of matrix. Whether it was ever mounted in the frame is unknown. It does not appear on any of the photos of the Moore Museum(Figures 1-3). It is unlike other framed specimens in the Moore Collection in that it is not an articulated skeleton. It fits the description of material donated to BRLSI by Wilkinson in 1926 (Appendix 2), so it might not be a specimen acquired by Charles Moore.

FIGURE 35: BRLSI M0653 *Ichthyosaurus* sp. or *Protoichthyosaurus* sp. juvenile. Unlike the other skeletons, this one was never mounted in a wooden frame and was likely displayed in one of the floor cases of the Moore Museum. The isolated left forefin is from a *Protoichthyosaurus* whereas the right forefin in matrix is from and *Ichthyosaurus*. It is not clear how much of the material belongs to the same individual as the skull and anterior vertebral column. Scale bar = 10 cm. © Bath Royal Literary and Scientific Institution, Bath, UK.

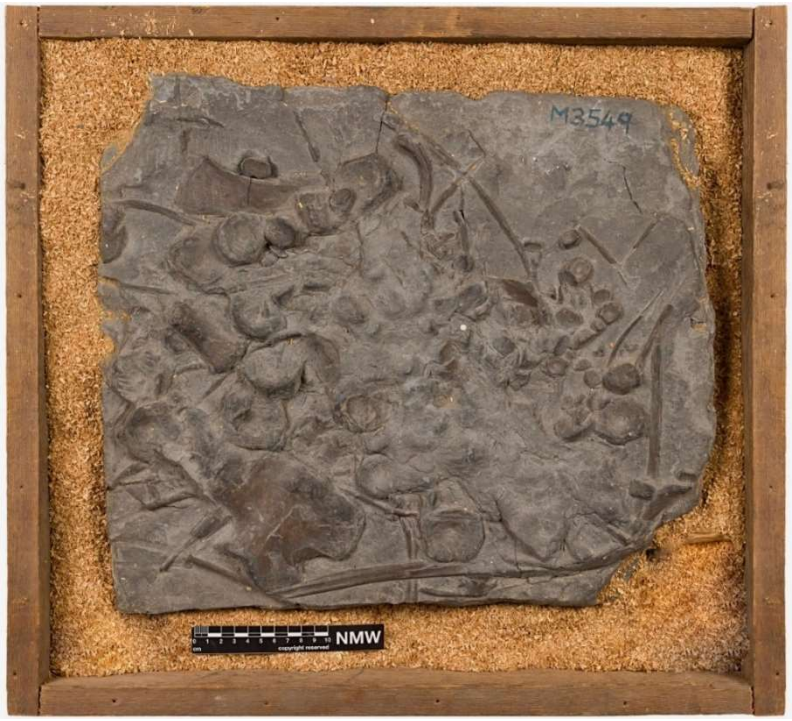

FIGURE 36: BRLSI M3549, disarticulated postcranial material of *Ichthyosaurus* or *Protoichthyosaurus*. Scale bar = 10 cm. © Amgueddfa Cymru-National Museum Wales, Cardiff, UK.

STORAGE AND CONSERVATION

When the specimens first arrived at AC-NMW, the framed ichthyosaurs were stacked flat in several piles in the Palaeontology Store. They were each protected with a thin 'lid' of hardboard screwed to the top. Lack of any mechanical lifting equipment meant that they had to be moved by hand and the lid unscrewed whenever a researcher required them for study. Although many of the sides of the original frames are fairly sturdy and well-built, they were supported underneath just with thinner slats across the width. These did not give any support to the length of the specimen, and many suffered cracking and breaks due to their many moves.

In the mid-1980s, the AC-NMW purchased a set of basic Dexion racking for the collection, to which home-made runners were added to support the frames (Howells, 2019). Along with the shelving, the museum purchased a small, battery-powered, fork-lift truck in order to assist with the moves. This greatly reduced the 'wear and tear' on both the specimens and the staff because specimens could be individually accessed rather than moving portions of a stack of specimens to access one of them.

Over the years, the runners on the Dexion slipped out of place by the weight of the specimens as they were moved. In 2017, the shelving was replaced by a customized system with rollers across the width of each shelf. Further work was carried out on the bases of a few specimens at that time to prevent flexing and maximize usability of the new racking. An electric lift cart, also with rollers, can be used to roll the specimen smoothly from the shelf to the cart. The cart can then be lowered to facilitate study of the specimen. The framed specimens are supported better and are not jarred in moving them from shelf to cart and back. Access is much easier and safer for both the researcher and the specimen (Howells, 2019).

Some conservation was done in the late 1980s, with funding from the South West Museums Service and Avon Libraries (archive note L15146, BRLSI). The project initially included strengthening most of the frames with block-board or hardboard bases as well as some conservation. The project continued into 1988, when seven of the ichthyosaur specimens were conserved by AC-NMW staff, led by Andrew Kendall: BRLSI M3550, M3553, M3555, M3559, M3560, M3569, and M3575. Gaps and cracks were filled, deteriorating plaster was repaired/replaced and painted, bones were cleaned and consolidated, etc. (AC-NMW archives).

Most of the ichthyosaurs, however, have had little conservation work carried out. Although some are fairly solid and robust, others have greatly deteriorated due to much handling over more than a century. Most specimens consist of separate blocks of matrix and bone set in plaster, which have now detached from each other as the plaster deteriorated. The current storage is designed to minimise any further damage through handling. We hope that future funding will allow additional stabilizing conservation work to be carried out on the collection.

CONCLUSION

The Charles Moore Collection, comprising vertebrates and invertebrates was amassed over about 40 years, beginning more than 150 years ago. Although portions of the original collection have been dispersed to other museums, the collection of Lower Jurassic ichthyosaurs has remained largely intact, in spite of the ups and downs of BRLSI in the decades between Moore's death and the re-founding of the Institution. Fortunately, photographs and a painting of the Moore Museum have survived (Figures 1-3), and these provide valuable information. We have been able to verify that nearly all of the mounted specimens of Lower Lias ichthyosaurs presently at BRLSI and AC-NMW were, in fact, mounted on the walls of Moore's museum at Terrace Walk. Only five framed specimens (BRLSI M3549, M3570, M3574, M3576) are not seen on the walls in the old photographs (Figures 1-3). The large skull BRLSI M3577 and a large forefin BRLSI M3576 appear on display in an 1890s photo of the lecture hall that ultimately occupied the museum room after Moore's death (Figure 3). One or both or neither could have been part of the original Moore Collection. Also, another mounted skeleton, now at the Manchester Museum, does not appear on any of the photos, although it was originally a Charles Moore specimen.

The ichthyosaurs in the Charles Moore Collection probably represent the largest number of mounted skeletons in a single museum in the UK outside of the Natural History Museum, London, at least for the Lower Lias taxa. Some specimens have already been incorporated into taxonomic research (e.g., Appleby, 1979, McGowan, 1989; Lomax et al., 2017), but more studies are needed. The accessibility of the specimens readily allows comparisons among individuals of the same species as well as comparisons with contemporaneous taxa. The collection could potentially facilitate stratigraphic studies as well: if the matrix could be sampled, it might be possible to ascertain a more exact geologic age and/or locality for at least some of the specimens. Some specimens (e.g., BRLSI M3550, BRLSI M3559) have stomach contents, which could add to the understanding of the paleoecology of these taxa. The orientation of the vertebral columns of several of the specimens (e.g., BRLSI M3559, BRLSI M3560) provide interesting taphonomic problems that future research could address. We hope that by

highlighting the important Lower Lias ichthyosaurs in the Moore Collection with this publication, it will encourage others to include the Moore specimens in their research.

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TABLE 1

Summary of framed and mounted specimens of Lower Lias ichthyosaurs in the Charles Moore Collection and others discussed in the text. 'Temp No.' are the temporary numbers assigned to the specimens when they were moved to AC-NMW in 1963. 'Chalk Numbers' were written on the specimens themselves and presumably used before the temporary numbers were assigned. They can still be seen on some specimens. Specimens listed as 'suspicious' require additional examination to determine if they are composites. Material added to 'composite' specimens is discussed in the text. Frame height and length given to the nearest 0.5 cm.

Number	Temp No.	Chalk No.	Taxon	Elements	Status	Frame Size ht x len
M3549	B.1963' 1/O.S.	29	*Ichthyosaurus/Protoichthyosaurus*	scattered postcranial		no frame
M3550	B.1963' 2/O.S.	12	*Ichthyosaurus somersetensis*	complete skeleton, ventral view		62 cm x 154.5 cm
M3551	B.1963' 3/O.S.	17	*Ichthyosaurus* sp.	complete skeleton	composite	95 cm x 185 cm
M3552	B.1963' 4/O.S.	2	*Leptonectes tenuirostris*	skull, scattered anterior skeleton		82.5 cm x 154.5 cm
M3553	B.1963' 5/O.S.	13	*Protoicthyosaurus prostaxalis*	skull, pectoral girdle, forefins; ventral view	holotype	55.5 cm x 71 cm
M3554	B.1963' 6/O.S.	25	*Ichthyosaurus somersetensis*	skull and partial skeleton	suspicious	72 cm x 146 cm
M3555	B.1963' 7/O.S.	23	*Protoicthyosaurus prostaxalis*	complete skeleton; lateral view	paratype	68.5 cm x 169 cm
M3556	B.1963' 8/O.S.	10	*Leptonectes tenuirostris*	scattered skull, most of postcranium	suspicious	96.5 cm x 200.5 cm
M3557	B.1963' 9/O.S.	1	*Temnodontosaurus ?platyodon*	mandibles and scattered anterior skeleton		98.5 cm x 237 cm
M3558	B.1963' 10/O.S.	16	?*Stenopterygius triscissus*	skull, most of postcranium		44 cm x 116.5 cm
M3559	B.1963' 11/O.S.	26	*Ichthyosaurus somersetensis*	partial skull, most of postcranial skeleton		82.5 cm x 107.5 cm
M3560	B.1963' 12/O.S.	7	*Leptonectes tenuirostris*	skull, partially disarticulated postcranium	suspicious	91.5 cm x 145 cm
M3561	B.1963' 13/O.S.	4	*Temnodontosaurus* sp.	skull and anterior skeleton, ventral view		81 cm x 160 cm
M3562	B.1963' 14/O.S.		*Ichthyosaurus somersetensis*	complete skeleton, dorsal view	composite	62 cm x 144.5 cm
M3563	B.1963' 15/O.S.	19	*Protoicthyosaurus prostaxalis*	nearly complete skeleton	composite, paratype	81.5 cm x 245.5 cm
M3564	B.1963' 16/O.S.	3	*Leptonectes tenuirostris*	complete skeleton	suspicious	71 cm x 252.5 cm
M3565	B.1963' 17/O.S.	9	*Leptonectes tenuirostris*	partially disarticulated skull & skeleton		61 cm x 158 cm
M3566	B.1963' 18/O.S.	5	*Leptonectes tenuirostris*	partially disarticulated skull & skeleton		107 cm x 144.5 cm
M3567	B.1963' 19/O.S.	22	*Temnodontosaurus ?platyodon*	partial skeleton		36 cm x 107 cm
M3568	B.1963' 20/O.S.	6	*Leptonectes tenuirostris*	skull, forefins, most of vertebral column		66.5 cm x 191 cm
M3569	B.1963' 21/O.S.		*Ichthyosaurus somersetensis*	skull & anterior skeleton	suspicious	43 cm x 107 cm
M3570	B.1963' 22/O.S.	18	*Ichthyosaurus breviceps*	rostrum & skeleton		45 cm x 156 cm
M3571	B.1963' 23/O.S.	24	*Ichthyosaurus* sp.	skull & scattered anterior skeleton		35 cm x 61 cm
M3572	B.1963' 24/O.S.	20	*Ichthyosaurus* sp.	mandibles, most of postcranium	suspicious	71 cm x 220 cm
M3573	B.1963' 25/O.S.	8	*Leptonectes tenuirostris*	partial skull, most of postcranium		91 cm x 214 cm
M3574	B.1963' 26/O.S.	27	*Temnodontosaurus* sp.	partial skull, forefin, articulated centra	see text	84 cm x 229.5 cm
M3575	B.1963' 27/O.S.	11	*Leptonectes tenuirostris*	partial skull, most of postcranium		71 cm x 140 cm
M3576	B.1963' 28/O.S.	21	*Temnodontosaurus platyodon*	articulated forefin or hindfin		49 cm x 127.5 cm
M3577	B.1963' 29/O.S.		*Temnodontosaurus platyodon*	complete 3-D skull		no frame
M3579	none		*Leptonectes* sp.	rostrum & vertebral column	loose slabs	76 cm x 244 cm
M3580	none		*Ichthyosaurus somersetensis*	complete skeleton; lateral view	cast	90 cm x 236.5 cm
M0653	none		*Ichthyosaurus*/*Protoichthyosaurus*	partial skull, vertebral column, forefin	composite	no frame
MANCH L.9663			*Leptonectes tenuirostris*	nearly complete skeleton; lateral view		61.5 x 157 cm

APPENDIX 1
Other Lower Lias Ichthyosaurs in the Charles Moore Collection

For completeness, below is a list of skeletal elements or isolated bones of ichthyosaurs from the Lower Lias that are presently considered part of the Charles Moore Collection. Some specimens can be identified to genus, whereas other material is too incomplete for an identification.

BRLSI M0202 is a very small (~1 cm) centrum from the Rhaetic fissure fill in Holwell Quarry, almost certainly collected by Charles Moore.

BRLSI M0643 is an isolated, articulated forefin of *Ichthyosaurus,* preserved in three dimensions. The brown bone color and light tan matrix is similar to specimens from the Street area of Somerset. The shape of the humerus and a fairly distal digital bifurcation (fourth phalangeal row) indicates that this specimen is most likely *I. somersetensis*.

Figure A1: BRLSI M0643, *Ichthyosaurus* left forefin with humerus. Scale bar = 10cm.

BRLSI M0644 is an isolated, articulated forefin of *Ichthyosaurus*, missing the humerus. The label indicates that it is from Lyme Regis, Dorset.

Figure A2: BRLSI M0644, *Ichthyosaurus* forefin. Scale bar = 10cm.

BRLSI M0645 is an isolated partial forefin of *Ichthyosaurus*, preserved in three dimensions. It is missing the proximal portion of the humerus. It is similar in bone color and matrix to that of M0643, and might also be *I. somersetensis*.

Figure A3: BRLSI M0645, *Ichthyosaurus* forefin. Scale bar = 10cm.

BRLSI M0646 is an isolated, very large ichthyosaurian caudal centrum (height 16 cm width 17 cm). It was probably the vertebra in Case 37 of the Moore Museum that was mentioned in Moore (1864). A photo of Charles Moore, taken in the 1860s (cover photo), shows him standing next to this large centrum.

Figure A4: BRLSI M0646, caudal centrum. Lower s[illegible]

BRLSI M0647 is an isolated tooth, complete with crown and a large, bulbous root, completely free of matrix. It is most likely a tooth of *Temnodontosaurus eurycephalus*, based on the robust shape, the lack of ornamentation, and the presence of two carinae on the crown (Massare, 1987). As such, it is most likely from the Lyme Regis area of Dorset, the only known location for the species (McGowan and Motani, 2003).

Figure A5: BRLSI M0647, *Temnodontosaurus*, large isolated tooth. Scale bar = 10cm. © Bath Royal Literary and Scientific Institution, Bath, UK.

BRLSI M0648 is an isolated, conical tooth root and crown. In Moore's time, it would probably not have been identified as *I. tenuirostris* (= *Leptonectes tenuirostris*) because the crown is not sufficiently long and narrow, nor *I. platyodon* (= *Temnodontosaurus platyodon*) because the crown lacks carinae.

Figure A6: BRLSI M0648, small isolated tooth. Scale bar = 5 cm. © Bath Royal Literary and Scientific Institution, Bath, UK.

BRLSI M1043 is a very small tooth crown (<.5 cm), very wide relative to length. It is identified as ichthyosaurian, but the tooth is hollow, which suggests that it is not ichthyosaurian.

BRLSI M1044 is a single vertebra from Ilminster, listed as 'Middle Lias'. It was most likely collected by Charles Moore.

BRLSI M4795 is an anterior jaw fragment, most likely *T. eurycephalus*, which we identify on the basis of tooth morphology: smooth crown with two carinae parallel to line of jaw. The genus and species were not recognized until the late 1800s (Lydekker, 1889). Prior to that, it would have been identified as *I. platyodon*. This could possibly be the 1826 Wilkinson donation (see Appendix 2).

Figure A7: BRLSI M4795, *Temnodontosaurus*, anterior jaw. Scale bar = 10cm. © Bath Royal Literary and Scientific Institution, Bath, UK.

Some specimens of ichthyosaurs that were originally in the Charles Moore Collection are now at the Manchester Museum. The consecutive sequence from MANCH L.9905 to L.9911 are specimens of ichthyosaurs that were donated to the museum by Rev. H. H. Winwood in 1911 (Copp et al., 2000). They are from "the Lias strata of the Bath district, Somerset" according to museum records. Winwood was a friend of Charles Moore and was appointed the honorary curator of the Moore Collection when it was purchased by BRLSI in 1882 (Torrens et al., 1975). Torrens et al. (1975) thought that some of Moore's collection might have been left with his widow, who gave it to Winwood to disperse. Although invertebrates and some vertebrates from the Charles Moore Collection have been dispersed to several museums (see list in Copp et al., 2000, appendix 1), we are not aware of any other museum that has specimens of ichthyosaurs.

MANCH L.9905 is the proximal portion of an articulated left forefin of *Ichthyosaurus ?somersetensis*, including the humerus, preserved in three dimensions.

Figure A8: MANCH L.9905, *Ichthyosaurus,* partial left forefin with humerus. Scale bar = 10cm.

MANCH L.9906 is a partial forefin of *Ichthyosaurus*, preserved in three dimensions, with a light tan matrix. The fin is articulated to the sixth phalangeal row. Only the distal portion of the humerus is preserved.

Figure A9: MANCH L.9906, *Ichthyosaurus* forefin. Scale bar = 10cm.

MANCH L.9907 is an isolated, articulated hindfin, including a damaged femur, in a grey matrix. It is broken into two pieces.

Figure A10: MANCH L.9907, hindfin with femur. Scale bar = 10cm.

MANCH L.9908 comprises light colored bones preserved in a block of dark matrix. A nearly complete sclerotic ring is preserved, along with portions of the jugal and postfrontal that are almost in life position relative to one another. Adjacent to that is a posterior portion of the mandible, a partial humerus, both clavicles in articulation, a complete scapula and both coracoids, although the more complete one is partially covered.

Figure A11: MANCH L.9908, skull and pectoral girdle elements. Scale bar = 10cm.

MANCH L.9909 is a complete, long, slender rostrum in left lateral view, probably *Leptonectes*. Numerous teeth are preserved in place. A portion of the right mandible is in the matrix and partially covered by the rostrum.

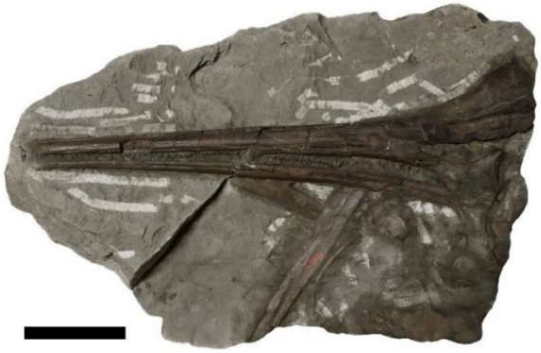

Figure A12: MANCH L.9909, rostrum and portion of mandible. Scale bar = 10cm.

MANCH L.9910 is a preserved forefin and two coracoids, identified as *Leptonectes tenuirostris*. The forefin includes the humerus and a notched radius, and is articulated as far as the second phalangeal row. In addition, a small segment of articulated centra, portions of both scapulae and parts of the mandible are preserved.

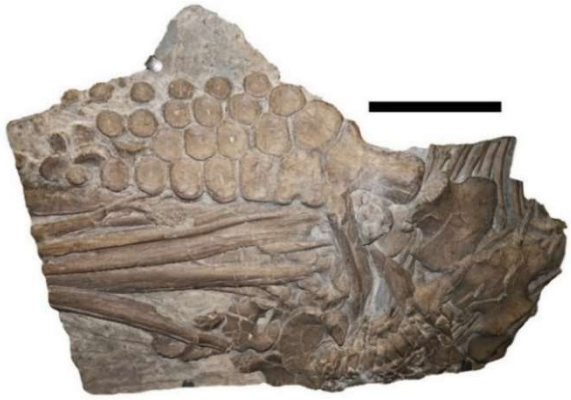

Figure A13: MANCH L.9910, *Leptonectes*, forefin, pectoral bones, and parts of mandible. Scale bar = 10cm.

MANCH L.9911 includes a string of thirteen articulated caudal vertebrae (including neural spines), a fairly complete hindfin, ischium, pubis, and the distal portion of a forefin. The fin morphologies indicate that this is an *Ichthyosaurus*; the femur shape suggests it might be *I. somersetensis* or less likely *I. larkini*.

Figure A14: MANCH L.9911, *Ichthyosaurus* distal forefin, hindfin and pelvic bones, articulated centra. Scale bar = 10cm.

In addition to the aforementioned specimens, the Manchester Museum has two drawers of fragmentary material that came from the Bath Museum in February, 1911. Most of the specimens cannot be identified taxonomically, and many are little more than bone scraps. Groups of bones have been given temporary numbers, REP153 through REP162. REP 160 (three jaw fragments and two unidentifiable bones) and REP161(four jaw fragments and a plesiosaur centrum) have old labels that identify them as Moore Collection material, but we suspect that all of the material (REP153-162) was originally associated with those labels. Copp et al. (2000) similarly concluded that this material was from the Moore Collection.

APPENDIX 2
BRLSI Acquisitions of Ichthyosaurs Prior to 1932

The BRLSI received donations of ichthyosaurian fossils prior to the display (and eventual purchase) of the Moore Collection. The following is an annotated list of the acquisitions of ichthyosaurs before the move from Terrace Walk to Queen Square. The text in bold is as the entry appears in the BRLSI Annual Reports. Note that genera and species names were not italicized at the time. Some of these specimens are included in what is presently considered the Charles Moore Collection.

1825, Mr. Woods [Henry Woods]**, 64 Vertebrae and other bones of the Ichthyosaurus and Plesiosaurus.**

1825, Dr. Davies, 10 English Fossils including Filicites from Somerset Coal Measures, and a fine vertebra of the Ichthyosaurus.

1825, Mr. Eastwick [William H. Eastwick]**, Large fragment of head of Ichthyosaurus showing the plates of the eye, from Lyme Regis; Sections of Vertebrae of Plesiosaurus from Lyme Regis, an Ammonite and Septarian nodule; Specimen of Pyrites.**

Torrens (2008, 2010) identified this donation as the large *Temnodontosaurus* skull (BRLSI M3577, Figure 10). See details in text.

Another candidate for this donation is BRLSI GP0743 a large fragment of a skull of an ichthyosaur. It shows part of the sclerotic ring, "the plates of the eye". The entire skull would have been on the order of 1 m long. The rounded edges and smooth surface of the specimen suggest that it might have been collected as a beach boulder. No location information is known for this specimen.

FIGURE A15: BRLSI GP0743, orbital portion of skull of an ichthyosaur. Scale bar = 5 cm. © Bath Royal Literary and Scientific Institution, Bath, UK.

1826, Jacob Wilkinson, esq., Valuable collection of fossil bones of Enalio-Sauri [an order proposed by Conybeare, which included ichthyosaurs]**, including the anterior part of the Cranium of the Ichthyosaurus Platyodon**

This donation might be BRLSI M4795 (Appendix 1, Figure A7), which is a fragment of a lower jaw with teeth. It would be odd, however, to describe the specimen as the anterior part of the cranium. The carinae on the teeth likely would have led to an identification as *Ichthyosaurus platyodon* at the time of the donation.

Another possibility is BRLSI GP0743, described above (Figure A15), which is, in fact, the anterior part of a cranium. The size of the skull fragment could have led to an identification as *Ichthyosaurus communis* or perhaps '*I.*' *platyodon*.

1826, H. Woods, esq. [Henry Woods]**, two cervical vertebrae of Ichthyosaurus Communis**

1826, Jacob Wilkinson, esq.,Vertebra, costae, scapula, humero-radii, paddles, coracoid bones, and other remains of I.[Ichthyosaurus] **communis, and tenuirostris**

This could be BRLSI M3549 (Figure 36), which preserves most of the bones described in the entry. It would probably be identified as *I. communis* at the time, but the reference to *I. tenuirostris* is puzzling.

1827, H. Woods, esq.2 [Henry Woods]**, 1 dorsal vertebra of the Plesiosaurus dolichodeirus, 2 teeth and a portion of the jaw of the Ichthyosaurus communis and 1 tooth of the Ichthyosaurus tenuirostris**

The jaw portion mentioned here might be BRLSI GP0650 (Figure A16). The teeth have finely striated crowns and more coarsely striated roots, so the morphology could have led to an identification of *I. communis*. Equally plausible, however, is that this donation is among the uncatalogued material that is part of the Manchester Museum's 1911 acquisition from Bath, which includes a plesiosaur vertebra and numerous jaw fragments (see Appendix 1)

FIGURE A16: GP0650, portion of a rostrum with teeth. Scale bar = 10cm.

1828, J. Templeman, esq., Specimens of Ichthyosaurus communis and Dapedium politum from Lyme

This donation is definitely BRLSI M3570, a specimen of *Ichthyosaurs breviceps*. The donation is noted on the original label (Torrens, 2010, p. 248, footnote 2) and verified by MW. At the time of the donation, *I. breviceps* was not a recognized species.

1906, Mr. C.B. Thring, Esq., Mounted remains of an Ichthyosaurus - Portions of an Ichthyosaurus, mounted, Lias, Castle Cary

This donation is probably an ichthyosaur discovered ~1860 in Alford, near Castle Cary. It could be BRLSI M3574 (Figure 8). See text for details.

1927, Late J. E. Henshawe [?]**, Cast of Ichthyosaurus from Lias (? Intermediius)**

This could possibly be a donation from the descendants of James Edward Henshaw (1864-1918). It is conceivable that this cast could have deteriorated over the years and was discarded at some point. The only cast of an ichthyosaur presently in the Moore Collection is BRLSI M3580, which is visible on images of the 'saurian wall' of the Moore Museum in Terrace Walk (Figures 1, 2).

1930, Mr. Edwards, 1 Fossil of Ichthyosaurus. Liasic

Some specimens in the BRLSI collection were undoubtedly donated before Moore's association with the Institution, although they do not appear in the Annual Reports. The original labels survive and are written in Lonsdale's distinctive handwriting. Lonsdale was curator from 1825 until 1829, and so these specimens were already part of the Institution's collection by the time Moore arrived with his extensive collection in the 1850s.

Three other specimens of Lower Lias ichthyosaurs in the BRLSI collections are not considered part of the Moore Collection and might have been donated prior to his association with the Institution, and were almost certainly donated before BRLSI moved to Queen Square. We include them here for completeness.

BRLSI GP0738 A-D is a disarticulated portion of a rostrum that has been cut and polished to reveal the cross-section. It is in four pieces: A-C fit together, D is the counterpart. The original label indicates that the specimen is from Lyme Regis, donated by Mr. Eastwick.

FIGURE A17: BRLSI GP0738, unpolished side of disarticulated rostrum. Scale bar = 10cm.

BRLSI GP0739 is a polished cross-section of six centra with neural spines. Most of the ventral portions of the centra are absent. The original label describes the specimen as "dorsal vertebrae with spinal processes of the Ichthyosaurus" from Lyme Regis, donated by Mr. Eastwick.

BRLSI GP0744 A-B comprises an articulated vertebral column of 38 centra (with impressions anteriorly for two more) and numerous ribs on two pieces of matrix that fit together. The first 18 centra are dorsals, transitioning to caudals in the next couple of centra. Soft tissue is preserved as tan or brown material on and between some ribs on the anterior block (posterior dorsal region) and it extends onto the posterior block. The original label indicates that the specimen is from Lyme Regis, but does not name the donor.

FIGURE A18: BRLSI GP0744, articulated centra and ribs. Scale bar = 10cm.

BRLSI GP1508 is a string of 18 articulated centra (probably caudal) in an old-style wooden frame. A hole at one end suggests that two or three centra may have fallen out. The dark matrix suggests that this specimen might be from Lyme Regis.

FIGURE A19: BRLSI GP1508, articulate centra. Scale bar = 10cm.

BRLSI GP1509 is a fin of *Leptonectes*, with some ribs, mounted in an old-style wooden frame. The dark matrix suggests that it might be from Lyme Regis.

BRLSI GP1870 is comprised of three blocks of matrix set in plaster in a wooden frame. The blocks have no obvious relationship to each other and are probably not from the same individual. One block has a fairly complete forefin of *Protoichthyosaurus*. A second block has distal fin elements from a larger forefin than that of the first block. It could be a fin of *Ichthyosaurus* or *Protoichthyosaurus*, based on the number of digits. The third block has an articulated vertebral column with almost 50 centra.

FIGURE A20: BRLSI GP1870, forelimbs and articulated centra, likely a composite. Scale bar = 10cm.

APPENDIX 3
Lower Jurassic Ichthyosaurs from the Charles Moore Collection
in the Scientific Literature

Below is a list of scientific publications that refer to specimens of Early Jurassic ichthyosaurs in the Charles Moore Collection. Details are provided only for the specimens from the Lower Lias discussed in this paper.

Appleby, R. M. 1979. The affinities of Liassic and later ichthyosaurs. Palaeontology 22:921-946.
Referred to *Protoichthyosaurus prostaxalis*: M3553 (holotype), M3555, M3563
Referred to *P. prosostealis*: M3572 (holotype)
Figured specimens (drawing of forefins only): M3553 (text-fig. 1b); M3555 (text-fig. 1c); M3563 (text-fig. 1d); M3572 (text-fig. 2b)

Caine H. and M. J. Benton 2011. Ichthyosauria from the Upper Lias of Strawberry Bank, England. Palaeontology 54: 1069–1093.

Deeming, D. C., Halstead, L. B., Manabe, M. and Unwin, D. M. 1993. An ichthyosaur embryo from the Lower Lias (Jurassic: Hettangian) of Somerset, England, with comments on the reproductive biology of ichthyosaurs. Modern Geology 18: 423-442.
Measurements in Appendix I: M3550, M3551, M3553, M3554, M3559, M3569

Jamison-Todd, S., B. C. Moon, A. J. Rowe, M. Williams, and M. J. Benton. 2022. Dietary niche partitioning in Early Jurassic ichthyosaurs from Strawberry Bank. Journal of Anatomy
doi:10.1111/joa.13744

Lomax, D. R. 2016. A new leptonectid ichthyosaur from the Lower Jurassic (Hettangian) of Nottinghamshire, England, UK, and the taxonomic usefulness of the ichthyosaurian coracoid. Journal of Systematic Palaeontology, 15, 387-401.
M3556, M3568 mentioned in description section

Lomax, D. R. and Massare, J. A. 2018. A second specimen of *Protoichthyosaurus applebyi* (Reptilia: Ichthyosauria) and additional information on the genus and species. Paludicola 11: 164-178.
M3553, M3555 referred to in systematics section

Lomax, D. R., Massare, J. A., and Evans, M. 2019. New information on the skull roof of *Protoichthyosaurus* (Reptilia: Ichthyosauria) and intraspecific variation in some dermal skull elements. Geological Magazine, 157, 640 - 650.
M3555 referred to in the description
Figured specimens: M3555 (Fig. 4f)

Lomax, D. R., Massare, J. A., and Mistry, R. T. 2017. The taxonomic utility of forefin morphology in Lower Jurassic ichthyosaurs: *Protoichthyosaurus* and *Ichthyosaurus*. Journal of Vertebrate Paleontology 37: e1361433 (17 pp).
Measurements in Table 1: M3553, M3555
Removed from *Protoichthyosaurus*: M3572
Figured specimens: M3553 (Fig.2A); M3555 (Fig. 2C); M3563 (Fig. 2B); M3572; (Fig. 3A-B, Fig. 5A)

Lomax, D. R., Massare, J. A., and Evans, M. 2019. New information on the skull roof of *Protoichthyosaurus* (Reptilia: Ichthyosauria) and intraspecific variation in some dermal skull elements. Geological Magazine, 157, 640 - 650.
M3555 referred to in the description
Figured specimens: M3555 (Fig. 4f)

Lomax, D. R., Porro, L. B. and Larkin, N. R. 2019. Descriptive anatomy of the largest known specimen of *Protoichthyosaurus prostaxalis* (Reptilia: Ichthyosauria) including computed tomography and digital reconstruction of a three-dimensional skull. PeerJ 7: e6112.
Mentioned in systematics, description: M3553, M3555, M3563

Massare, J. A. and Lomax, D. R. 2016a. Composite skeletons of *Ichthyosaurus* in historic collections. Paludicola 10: 270-240.
Figured specimens: M0653 (Fig. 3); M3551 (Fig. 4 A-C); M3554 (Fig. 5); M3562 (Fig. 6); M3563 (Fig. 7); M3569 (Fig. 20 A-B); M3572 (Fig. 21 A-B)
Composite: M0653, M3551, M3554, M3562, M3563
Suspicious: M3569, M3572

Massare, J. A. and Lomax, D. R. 2016b. A new specimen of *Ichthyosaurus conybeari* (Reptilia, Ichthyosauria) from Watchet, Somerset, England, U.K., and a re-examination of the species. Journal of Vertebrate Paleontology 36: e1163264.
Referred to in description: M3572

Table 2: M3563, M3559, M3550, M3562, M3569, M3572
Figured specimens (in supplemental materials): **M0653 (mentioned as M653; Fig. S6); M3562 (Fig. S7); M3551 (Fig. S8); M3563 (Fig. S9); M3569 (Fig. S10); M3572 (Fig. S11).**

Massare, J. A. and Lomax, D. R. 2018 Hindfins of *Ichthyosaurus*: Effects of large sample size on 'distinct' morphological characters. Geological Magazine 156: 725-744.
Morphotypes in Table 1: M3559, M3572
'Composite' or 'unreliable' in Table 2: M3551, M3572

Massare, J. A., Wahl, W. R. and Lomax, D. R. 2021. Narial structures in *Ichthyosaurus* and other Early Jurassic ichthyosaurs as precursors to a completely subdivided naris. Paludicola 13: 128-139.
Mentioned in description: M3562, M3552
In Table 1: M3552, M3562, M3569
Figured specimen: M3552 (Fig. 3B)

McGowan, C. 1978. Further evidence for the wide geographic distribution of ichthyosaur taxa (Reptilia: Ichthyosauria). Journal of Paleontology 52: 1155-1162.

McGowan, C. 1989a. *Leptopterygius tenuirostris* and other long-snouted ichthyosaurs from the English Lower Lias. Palaeontology 32: 409-427.
Referred to *L. tenuirostris*: M3552, M3556, M3565, M3566 (described in Appendix)
Too incomplete to identify: M3573
Forefin features described in Table 2: M3552, M3556, M3565, M3566

McGowan, C. 1989b. Computed tomography reveals further details of *Excalibosaurus*, a putative ancestor for the swordfish-like ichthyosaur *Eurhinosaurus*. Journal of Vertebrate Paleontology 9: 269-281.
"specimens studied": M3552, M3565, M3569 (no further description)
Measurements in Table 3: M3569

McGowan, C. 1990. Problematic ichthyosaurs from south-west England: A question of authenticity. Journal of Vertebrate Paleontology 10: 72-79.
Description of composites: M3558, M3560, M3564 M3568, M3575,
Figured specimens: M3560 (Fig. 2 B-D); M3564 (Fig. 3); M3568 (Fig. 2 E-F)
Measurements in Table 1: M3564

McGowan, C. 1966. Giant ichthyosaurs of the Early Jurassic. Canadian Journal of Earth Science 33: 1011-1021.
Assigned M3577 to *T. platyodon*
Measurements in Table 2: M3577
Brief description of M3577

Srdic. A., S. Beardmore, and D. R. Lomax 2019. A rediscovered Lower Jurassic ichthyosaur skeleton possibly from the Strawberry Bank Lagerstätte, Somerset, UK. Historical Biology 33: 814-822.
Referred M3558 to ?*Stenopterygius triscissus*
Figured specimens: M3558 (Fig. 1 a-e; Fig. 3 a-b); M3565 (fig. 4d)

Weedon, G. P. and S. D. Chapman. 2022. *Ichthyosaurs from the Early Jurassic of Britain*. Siri Scientific Press, Manchester, UK, 448 pp.
Figured specimens: M3555 (Fig. 15.36a, Fig. 15.37a); M3563 (Fig. 15.39a)
Specimens referred to in tables: M3553, M3555, M3565, M3566, M3577
Appendix 2: partial list of Moore framed skeletons in the BRLSI collection
Appendix 3: identifications and brief descriptions of M3552, M3553, M3555, M3556, M3558, M3559, M3563, M3565, M3566, M3569, M3577, M3580.