

COMPOSITE SKELETONS OF *ICHTHYOSAURUS* IN HISTORIC COLLECTIONS

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ABSTRACT

Many collections of Lower Jurassic ichthyosaurs from the U. K. include historic specimens collected during the 19th century, and often with poorly known origins. Here we describe nearly complete skeletons of the Lower Jurassic genus *Ichthyosaurus* that are probably composites or that, at least, require further examination to assess their authenticity. Specimens from the Thomas Hawkins and Charles Moore collections, in particular, should be examined carefully to determine if the entire specimen is a single individual. The most common elements added to skeletons of *Ichthyosaurus* are whole or partial forefins, hindfins, or posterior portions of the vertebral column. Historic and more recently collected specimens can also have reconstructed or rearranged portions, sometimes done so expertly that they are barely noticeable, if not for documentation in museum records. Composite, rearranged, and reconstructed specimens can provide valuable morphological data once the added or altered portions are recognized.

INTRODUCTION

Ichthyosaurs were among the first vertebrate fossils collected and scientifically studied in the first half of the 19th century. Mary Anning of Lyme Regis, Dorset, provided the scientific community of the time with many important specimens. Significant collections of British Lower Jurassic ichthyosaurs were amassed during the 19th century by Joseph Chaning Pearce, Thomas Hawkins, Charles Moore, Alfred Gillett, and others. Portions of those collections were acquired by museums in the U.K., especially those which were active in the 19th century and played important roles in the development of paleontology as a science, such as BRLSI, BRSMG, CAMSM, NHMUK, and OUMNH. Although Lower Jurassic specimens continue to be collected, historic specimens from Dorset and Somerset still make up most of the Lower Jurassic ichthyosaurs in museum collections, especially the fairly complete skeletons. Moreover, extensive quarrying operations in the 1800s uncovered specimens from inland locations that are not available today. Because of the active quarries, specimens were uncovered at a much faster rate than is possible today.

Historic specimens were often mounted in large wooden frames, with pieces held together by plaster or cement. All of the specimens described below are mounted in wooden frames unless otherwise noted. It was not uncommon for specimens to be ‘improved’ by reconstructing missing portions of the skeleton,

rearranging otherwise authentic elements of the specimen, or adding of pieces of other specimens. The goal was likely to produce a more complete, visually clearer specimen for educational or display purposes. Thus these specimens are not ‘frauds’ or forgeries, as are found in the commercial fossil trade today (Mateus et al., 2008). In fact, many were donated, not sold, to museums. However, researchers need to carefully examine historic specimens, especially complete or nearly complete skeletons to verify that it is a single individual (McGowan 1989, 1990; Taylor, 1989; Buttler and Howe, 2002; Massare and Lomax, 2014b).

In examining specimens for a taxonomic study of the Lower Jurassic genus *Ichthyosaurus*, we have recognized many composite specimens of that genus in museum collections (Table 1). These range from isolated forefins to seemingly complete skeletons. The focus of this work is on specimens that are considered to be partial or complete skeletons, but might include material from more than one individual. Such composite skeletons can still provide valuable information on morphology if the added components are recognized. This is not a complete account of composite skeletons of *Ichthyosaurus*, and composites of other genera are not included, although they exist (McGowan, 1990; Lomax and Massare, 2012). The purpose of this paper is to call attention to specimens of *Ichthyosaurus* that appear more complete than they actually are, and to assist researchers and museum curators in recognizing a potential composite.

Institutional abbreviations—**AGC** Alfred Gillett Collection, cared for by the Alfred Gillett Trust, C & J Clark Ltd, Street, Somerset, U.K.; **ANSP** Academy of Natural Sciences of Drexel University, Philadelphia, U.S.A.; **BGS** British Geological Survey, Keyworth, Nottingham, U.K.; **BRLSI** Bath Royal Literary and Scientific Institute, Bath, U.K.; **BRSMG** Bristol City Museum and Art Gallery, Bristol, U.K.; **CAMSM** Sedgwick Museum, Cambridge University,

Cambridge, U.K.; **DONMG** Doncaster Museum and Art Gallery, Doncaster, U.K.; **NHMUK** The Natural History Museum, London, U.K.; **NMW** National Museum of Wales, Cardiff, U.K.; **OUMNH** Oxford University Museum of Natural History, Oxford, U.K.; **RGSCU** Royal Geological Society of Cornwall, Penzance, U.K.; and **UON** University of Nottingham, Nottingham, U.K.

TABLE 1: Composite and suspicious specimens of *Ichthyosaurus* discussed herein. Note that although material from Somerset dominates the list, composites are known from other locations as well.

SPECIMEN NO.	LOCALITY	DONOR/COLLECTOR	STATUS	ADDED OR SUSPICIOUS ELEMENT
AGC 8	Street, Somerset	Alfred Gillett	composite	portion of mandible; posterior vertebral column
AGC 12	Street, Somerset	Alfred Gillett	composite	left forefin
ANSP 17429	Street, Somerset	Thomas B. Wilson	suspicious	anterior skeleton may not belong with posterior skeleton
BGS GSM 132414	Somerset	unknown	suspicious	anterior skeleton may not belong with posterior skeleton
BGS RGSCU 1091	Walton, Somerset	Joseph Channing Pearce	suspicious	possibly mandible
BRLSI M0653	unknown	Charles Moore	composite	forefins; possibly rostrum, posterior block, centra
BRLSI M3551	unknown	Charles Moore	composite	hindfins; perhaps forefin
BRLSI M3554	unknown	Charles Moore	composite	posterior vertebral column
BRLSI M3562	unknown	Charles Moore	composite	posterior vertebral column, right forefin and hindfin
BRLSI M3563	unknown	Charles Moore	composite	left forefin; probably part of posterior vertebral column
BRLSI M3569	unknown	Charles Moore	suspicious	right forefin
BRLSI M3572	unknown	Charles Moore	suspicious	posterior vertebral column and hindfins
CAMSM J35186	Barrow on Soar	J. Packe	suspicious	distal portion of right forefin
CAMSM J59575	Street, Somerset	Thomas Hawkins	composite	posterior portion of skeleton
CAMSM J59644	Street, Somerset	Thomas Hawkins	composite	forefin
CAMSM J69477	unknown	unknown	composite	posterior centra
CAMSM X50187	Lyme Regis, Dorset	Mary Anning	composite	anterior caudal vertebra
NHMUK PV R5595	Somerset	unknown	composite	left forefin, distal right forefin; possibly left hindfin
NHMUK PV R3372	Somerset	Joseph Channing Pearce	composite	portions of both forefins
NMW G1597	unknown	unknown	composite	posterior vertebral column
OUMNH J.10301	Street, Somerset	Thomas Hawkins	suspicious	blocks may not be from the same individual
OUMNH J.10310	Walton, Somerset	Thomas Hawkins	suspicious	hindfin and pelvis with different color matrix
OUMNH J.10325	Street, Somerset	Thomas Hawkins	suspicious	three separate blocks do not align well
OUMNH J.10328	Street, Somerset	Thomas Hawkins	suspicious	distal portion of tail
OUMNH J.10330	Lyme Regis, Dorset	Thomas Hawkins	suspicious	rostrum, distal portion of tail
OUMNH J.10340	Lyme Regis, Dorset	Thomas Hawkins	composite	posterior vertebral column; possibly forefin
OUMNH J.13799	Street, Somerset	Duke of Marlborough	suspicious	skull is dorsal whereas skeleton is ventral
OUMNH J.13800	?Lyme Regis, Dorset	H. L. Bowman	composite	blocks probably not from the same individual
UON VR159	unknown	unknown	suspicious	skull; posterior vertebral column

COMPOSITE SPECIMENS

AGC 8

This skeleton consists of a mandible in dorsal view, two partial forefins, and an articulated vertebral column and scattered ribs (Fig. 1A). The posterior portion of the skull and anterior portion of the skeleton are from one individual, but the posterior half of the mandible is a different color from the anterior portion, and a crack separates them. The pieces do not match up exactly across the crack, so the anterior portion of the mandible could have been added. It is completely surrounded by plaster. At the posterior end of the specimen, the last 26 articulated centra were added. They have a similar preservation and color, but they are rotated to a different orientation than the rest of the vertebral column, although this is not always an indication of a composite as it may simply be a rearrangement. However, the shape of the rib articulations indicate that the nine centra anterior to the white plaster one (which has been inserted) are oriented backwards, with the dorsal centra, those with two articulations for the rib, arranged posterior to the caudal centra, those with just a single articulation (Fig. 1B). Posterior to the plaster centrum, the transition from dorsal to caudal centra is repeated. The mount was put together so that the added portion looks like a natural break in the vertebral column, and the size and shape of the added centra are similar to those of the anterior column. Some ribs, centra, a basisphenoid and portion of a rostrum are isolated from the rest of the specimen and may or may not belong.



FIGURE 1A: AGC 8. Scale = 10 cm.

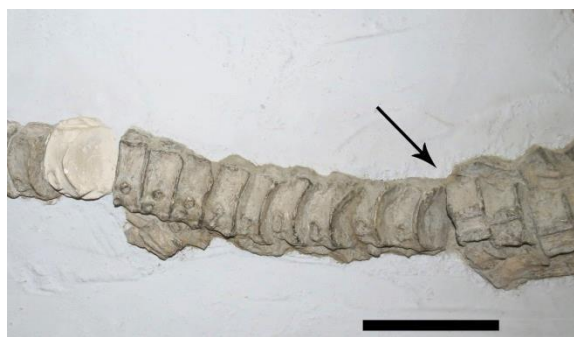


FIGURE 1B: AGC 8, posterior portion of vertebral column. Arrow indicates posterior end of the main specimen. Centra to the left have been added. Scale = 10 cm.



FIGURE 2A: AGC 12. Scale = 20 cm.

AGC 12

This specimen is a nearly complete skeleton lying on its right side, exposed in ventrolateral view (Fig. 2A). Most of the specimen is lying in a tan colored matrix, but the rest of the mount is painted plaster. The right forefin is almost completely surrounded by plaster, but the proximal portion of the humerus is in matrix, and articulates with the coracoid. Fin elements line up well despite a crack across the radiale and intermedium. The left forefin is resting on top of the vertebral column and ribs (Fig. 2B). A close examination reveals that it is propped up from below by a ledge of plaster. A dark colored material is in between many of the phalanges, which suggests that either the fin has been added or it has been put together and is not in the original position or with the original arrangement. Although we have seen specimens in which the two forefins are slightly different in morphology, the difference between these two is substantial. Thus it appears that the left forefin was added to the specimen or that the original was rearranged.



FIGURE 2B: AGC 12, left forefin. Scale = 10 cm.

BRLSI M0653

This is a very small specimen, perhaps a neonate, preserved in dorsal view (Fig. 3). Unlike most historic specimens, this one is not mounted in a wooden frame, and there is no record of it ever being in one (M. Williams, pers. comm. 2016). The posterior region of the skull and anterior vertebral column and ribs, just over half of the precaudal portion of the skeleton, are articulated across three blocks of matrix, making up the main specimen. A piece of the rostrum, showing teeth, is not connected to the rest of the skull and is much narrower than the anterior edge of the skull. If it belongs to the specimen, then a large segment of the rostrum is missing. Two partial forefins are on separate blocks of matrix. The bone color, preservation, and matrix are similar to that of the main specimen, but the humerus is larger and more robust than the scapula that is preserved near the skull; whereas the scapula is always longer than the humerus in *Ichthyosaurus*, even in small specimens (e.g. OUMNH J.13587). In addition, the second, isolated forefin, which does not have a complete humerus, has a different arrangement of the proximal elements and does not belong with the other fin. Furthermore, the elements on both fins are closely packed and would suggest a more mature individual than the main skeleton (Johnson, 1977), so the forefins were probably added to the specimen. Five articulated centra appear too large to articulate with the main specimen, although as many as ten precaudal centra are missing, so these may have come from a more posterior part of the column. On a separate block are about six articulated centra, a few disarticulated centra, ribs, and two disarticulated fins, presumably hindfins. It is possible that both of these pieces of vertebral column could belong to the main specimen, but it would have to have come from a more distal part of the skeleton than what is preserved.



FIGURE 3: BRLSI M0653, from the Charles Moore collection. Scale = 20 cm.



FIGURE 4A: BRLSI M3551, from the Charles Moore collection. Scale = 20 cm.

BRLSI M3551

BRLSI M3551 is a fairly complete skeleton in dorsolateral view, with an articulated vertebral column that is broadly curved back on itself (Fig. 4A). A diagonal crack separates the proximal and distal portions of the right forefin, and elements do not line up across the crack, but it is difficult to determine which piece was added. The hindfins might also have been added on either side of the vertebral column (Fig. 4B, C). Both femora are broken across the shaft, and the right femur (left in Fig. 4A) has an odd shape (Fig. 4B). It is unclear whether the elements of each fin are in matrix or in plaster. Moreover, both hindfins are outlined by a seam of painted plaster that is raised above the surrounding matrix, suggesting that they were placed into this position and probably do not belong with the specimen.



FIGURE 4B: BRLSI M3552, right hindfin. Scale = 10 cm.



FIGURE 4C: BRLSI M3551, left hindfin. Scale = 10 cm.



FIGURE 5: BRLSI M3554, from the Charles Moore collection. Scale = 20 cm.

BRLSI M3554

This specimen comprises an anterior skeleton and a string of articulated vertebrae and ribs, set into painted plaster (Fig. 5). The anterior skeleton is in three distinct blocks: one with the skull, another with some of the pectoral girdle, ribs, vertebrae and the left forefin, and the third with a portion of scapula and the right forefin. The bone color is similar for all three blocks, although it appears that no bones continue from one block to the next, so it is possible that the anterior skeleton is pieced together with portions of two or three individuals. Posterior to these are a few blocks with articulated vertebrae and ribs. These blocks are entirely surrounded by plaster and separated from the rest of the skeleton by a few centimeters. That, coupled with the clear difference in color between the anterior vertebral column and the posterior blocks, suggests that the posterior articulated vertebrae probably do not belong with the anterior skeleton.

**BRLSI M3562**

BRLSI M3562 is a nearly complete skeleton, preserved in dorsal view (Fig. 6). Most of the skeleton appears authentic. The right forefin and hindfin, however, are questionable. The humerus, radius and ulna of the right forefin are disarticulated near the ribs. What appears to be the distal portion of the fin is completely articulated and located a couple of centimeters away from the proximal elements. Its morphology is quite different from that of the left forefin, which suggests a composite. Moreover, it is surrounded by painted plaster. The right hindfin might also have been added as the distal elements are articulated and separated from the disarticulated proximal elements by a large crack.

FIGURE 6: BRLSI M3562, from the Charles Moore collection.
Scale = 20 cm.

**BRLSI M3563**

BRLSI M3563 is a fairly complete skeleton preserved in dorsal view. It is made up of several blocks of matrix pieced together and placed in plaster (Fig. 7). A large crack separates the large posterior block that includes the hindfin from the anterior portion of the skeleton. A broken centrum, ribs, and other bones line up fairly well across the crack, so the blocks probably belong together. The distal block with the tail bend, however, might have been added. Only 22 centra are present between the pelvis and tail bend, too few for a typical *Ichthyosaurus*, and the centrum size changes abruptly across the crack. The left forefin has certainly been added. It is set in plaster and entirely surrounded by it. Moreover, it has an entirely different morphology from the right forefin. The right forefin is surrounded by matrix and is articulated with the pectoral girdle, and so it must belong to the main specimen. Although there is a prominent crack in the right humerus, it lines up with the remaining piece of the forefin.

FIGURE 7: BRLSI M3563, from the Charles Moore collection.
Scale = 20 cm.



FIGURE 8A: CAMSM J59575, from the Thomas Hawkins collection. Scale = 20 cm.

CAMSM J59575

On first inspection, the specimen appears to be a relatively complete skeleton, however, only the anterior portion that includes the skull, pectoral girdle, forefins, and anterior torso, belongs together (Fig. 8A). The specimen has at least four distinct types of 'matrix' present, including the clear use of plasters and a patchwork style. A large band of exposed plaster with embedded nails separates the anterior torso from the posterior part of the skeleton (Fig. 8B). The portions of the skeleton posterior to this do not belong: a block with a hindfin and pelvis and another block with a string of articulated caudal vertebrae. These two blocks are completely surrounded by plaster and the color of the bone is much darker than the anterior skeleton. Furthermore, the morphology of the hindfin suggests that it does not belong to the same species as the anterior skeleton (pers. obs.). The right forefin block is also suspicious because bones do not line up with those in adjacent blocks. A piece of bone in the block adjacent to the forefin might be a piece of the humerus, so the forefin block probably belongs to the anterior skeleton (Fig. 8C).



FIGURE 8B: CAMSM J59575, close-up of the nails embedded within the plaster 'matrix'.



FIGURE 8C: CAMSM J59575, portion of the block with the right forefin. Note that the humerus is sheared off at the crack. Scale = 8 cm.

CAMSM J59644

This specimen is an anterior skeleton and mandible in dorsal view, about 20 articulated centra, and scattered ribs and other elements. The articulated forefin has a large crack running from the distal edge of the radiale, angling across the fin to bisect p3 of digit V along its diagonal (Fig.9). Two separate blocks are attached distal to the crack. Elements in the anterior block almost line up across the crack, but elements of the posterior block do not. Although the anterior portion of the forefin might be authentic, the posterior pieces are not.



FIGURE 9A: CAMSM J59644 from the Thomas Hawkins collection. Scale = 20 cm. Image courtesy of the Sedgwick Museum of Earth Sciences, University of Cambridge, U.K..

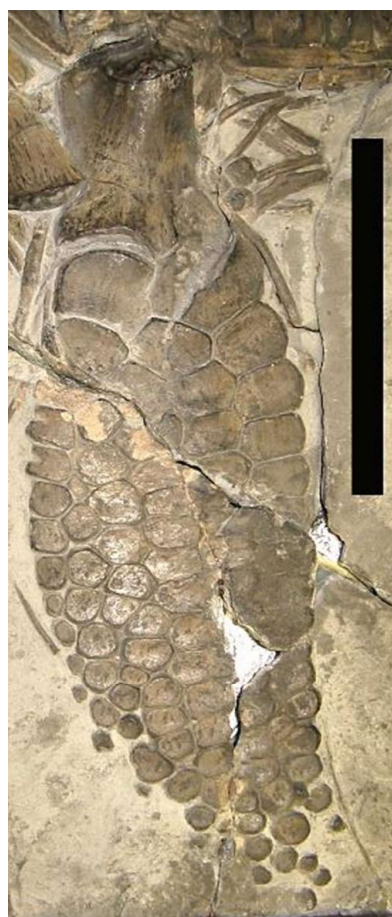


FIGURE 9B: Left forefin of CAMSM J59644. Scale = 10 cm.



FIGURE 10A: CAMSM J69477. Arrow indicates where posterior caudal centra have been added. Scale = 20 cm.

CAMSM J69477

CAMSM J69477 is a partial skeleton lying on its right side, exposed in lateral view (Fig. 10A). The specimen appears to be made up of at least three main blocks, one of which contains the skull, forefin and some of the anterior vertebrae and ribs, and the other blocks have ribs and vertebrae. There are two large cracks separating the blocks, although the bone color and size of elements appear similar on the three main blocks, so they probably belong together. However, posterior to the second large crack, the block that contains vertebrae and ribs does not line up with the rest of the vertebral column (Fig. 10B). At the end of this block there is a string of vertebrae that are abruptly smaller than the adjacent vertebrae (Fig. 10A, arrow), and the bone color is also different. The anterior portion of the skeleton has 40-45 centra up to this point, which represents approximately the transition between dorsal and caudal centra. The anterior caudals are typically as large or larger than the dorsal centra, so the centra posterior to this point (arrow on Fig 10A) are too small to belong to the rest of the skeleton. They are from a much more posterior location than they are positioned here. There is also a distinct color difference in the added centra. In addition, some ribs have also been carved.



FIGURE 10B: CAMSM J69477, closer view of the vertebral column, displaced across the crack between the second and third blocks.



FIGURE 11A: Skeleton of CAMSM X50187. The break in the vertebral column indicates where caudal centra have been added. Scale = 20 cm.

CAMSM X50187

CAMSM X50187 is a nearly complete skeleton, lying on its left side (Fig. 11A). It was purchased from Mary Anning in 1832 (Price, 1986). The precaudal portion is authentic, but the anterior caudal centra have been added (Fig. 11A, B). They are a different shape from the other centra, and oriented upside down with respect to the anterior vertebral column (Massare and Lomax, 2014a). Anning is not known for tampering with specimens. On the contrary, she was accused of falsifying a plesiosaur skeleton early in her career because the complete animal seemed so improbable (Torrens, 1995), so she must have been very sensitive to such accusations. Given that the specimen had been on display, it may be that it was made more attractive by the addition of well-preserved centra. See Massare and Lomax (2014a) for a full description of the specimen.



FIGURE 11B: Pelvic portion of CAMSM X50187. Note difference in shape of centra on either side of the break in the vertebral column. Scale = 10 cm.



FIGURE 12A: NHMUK PV R3372 from the Joseph Channing Pearce collection. Scale is approximately 20 cm, but specimen is on display behind glass and cannot be measured directly.

NHMUK PV R3372

This specimen is a nearly complete skeleton lying on its right side, exposed in ventrolateral view (Fig. 12A). It is composed of four main blocks that are all set into plaster. The left forefin (right in Fig. 12A), in ventral view, is suspicious (Fig. 12B). The accessory digit is set in filler so might have been added. Moreover, the rest of the elements distal to the radius and ulna are all set in glue, with most elements distal to the first three rows of elements largely pieced together. This suggests that the elements either do not belong to the same individual, or they have been repositioned incorrectly. Regardless, the morphology of the middle and distal portions of the forefin are incorrect. The right forefin, also in ventral view, appears to have a different morphology in the proximal elements than the other forefin. However, on closer inspection, the elements of distal carpals 2 and 3 are co-ossified, so this is probably pathological (Fig. 12C). A similar pathology was reported in OUMNH J.13799 by Motani (1999, fig. 6F). The distal half of the right forefin has possibly been added because it is offset from the proximal portion and the elements do not line up. The most posterior (fourth) block of the specimen is separated from the rest and the tail bend is in the wrong direction compared to the rest of the skeleton. It is possible that either the tail block was added, or perhaps more likely, it was prepared from the underside and mounted incorrectly.



FIGURE 12B: Left forefin of NHMUK PV R3372.



FIGURE 12C: Right forefin of NHMUK PV R3372.



FIGURE 13A: NHMUK PV R5595. Scale is approximately 20 cm, but specimen is on display behind glass and cannot be measured directly.

NHMUK PV R5595

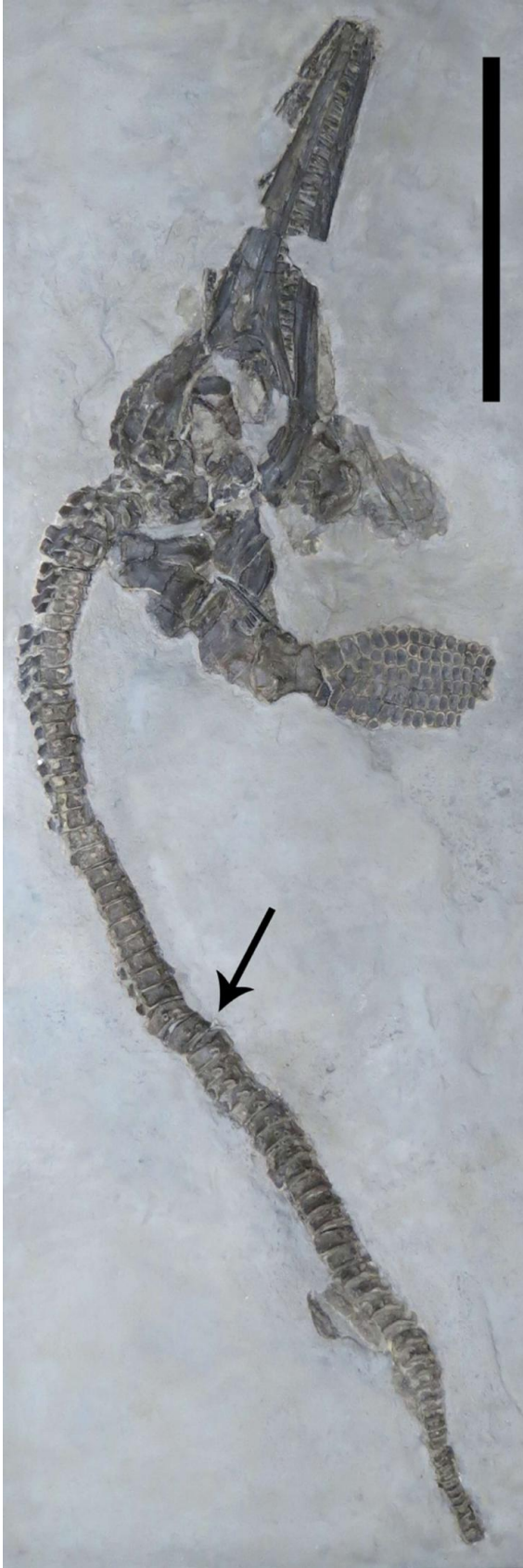
NHMUK PV R5595 is a nearly complete specimen in dorsal view (Fig. 13A). Much of the skeleton and the matrix between the bones have been coated with a dark ?varnish, which obscures some of the plaster and makes judging composite or reconstructed elements difficult. Although most of the specimen appears authentic, some of the fins are not. The left forefin (left in Fig. 13A) seems to be entirely surrounded by painted plaster and positioned higher in the matrix than the rest of the specimen, with the humerus resting partially on top of ribs and matrix. The left humerus is much longer and has a different shape than the right humerus. The humerus is also probably in ventral view whereas the rest of the fin is in dorsal view. The right forefin (right in Fig. 13A) is a composite. A large crack runs across the fin, bisecting metacarpal 5 along a diagonal, and angling across the fin to just distal to p1 of digit II (Fig. 13B). The elements distal to the crack are a darker color, do not match up with the proximal elements, and are positioned lower in the matrix. Thus the entire left forefin, and most of the right forefin have probably been added to the specimen. The left hindfin (left in Fig. 13A) has an odd arrangement of elements and digit II and III are offset anteriorly from the rest of the fin (Fig. 13C). Although this could be taphonomic, it could also indicate that the fin has been reconstructed.



FIGURE 13B: NHMUK PV R5595, portion of right forefin, proximal to the left.



FIGURE 13C: NHMUK PV R5595, left hindfin, anterior to the top.

**NMW G1597**

This specimen is a partial skeleton lying on its left side (Fig. 14). A skull, pectoral girdle, forefin and what appears to be much of the vertebral column is preserved, but no ribs are present. The lack of ribs on a partial skeleton with a vertebral column is unusual, but this does not necessarily imply a composite. The 32 anterior centra certainly belong with the skeleton, but all of the remaining centra do not. The remaining centra differ in size, shape, orientation and most importantly position. Several of the added centra includes dorsals and caudals, but they are positioned in the column in reverse order, with caudal centra anterior to dorsal centra. The specimen is described in more detail by Massare and Lomax (2014b).

FIGURE 14: NMW G 1597. Arrow indicates where posterior centra have been added. Scale = 20 cm.

OUMNH J.10340

OUMNH J.10340 is a large, disarticulated skeleton exposed in ventrolateral view (Fig. 15A, B, C). It comprises three main blocks of matrix, all set into plaster. The left forefin (anterior) appears to be genuine, but the matrix surrounding it has been cut into a rectangular-shape. It could have been collected separately and added to the specimen or perhaps repositioned closer to the rest of the skeleton. Similarly, the right forefin (posterior) might have been added. Bones from the adjacent block end abruptly at the seam along the forefin; however, some bones line up along the anterior crack. The posterior-most block contains a string of centra that are oriented differently from those on the other blocks. The distinct change in centrum size in this block and the unnatural straightness of the tail suggests that the vertebral column has been reset in plaster or that the centra have been added, or both.

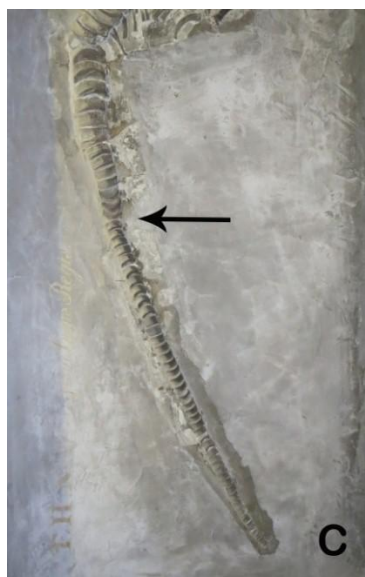


FIGURE 15: OUMNH J.10340, a large specimen from the Thomas Hawkins collection, shown in a series of images. A, anterior portion of skeleton; B, middle portion of skeleton; C, posterior portion of skeleton. Arrow indicates where size and orientation of centra change abruptly. Scales = 20 cm.



FIGURE 16: OUMNH J.13800. Scale = 10 cm.

OUMNH J.13800

OUMNH J.13800 is an amalgamation of several blocks which have been pieced together and set into plaster so as to look like a fragmentary skeleton (Fig. 16). One block has a portion of mandible, ribs and vertebrae. A second block has ribs, coracoids and a humerus, with a second humerus that is entirely in ?plaster, adjacent to the coracoid. A third block has ribs and vertebrae, with two separate fragments of vertebral column on either side of it. At the posterior end of the specimen, two additional humeri have been placed almost certainly to appear as femora. They are equal in size and shape to the other humeri associated with the pectoral block; femora are always shorter than humeri in *Ichthyosaurus*. There are also additional pieces of forefin at the end of the vertebral column.



SUSPICIOUS SPECIMENS

The specimens discussed below have elements that may not be authentic, but it is not certain that they are composites.

ANSP 17429

This specimen is made up of several blocks, but is probably authentic (Fig. 17). The bone color and size of the centra are consistent with what is expected. However, an irregular, plaster-filled crack separates the anterior block with the skull, forefin, and portion of the vertebral column from the rest of the skeleton. The bones do not line up in adjacent blocks, although this could be because of the width of the crack. The second block, containing a portion of the vertebral column and a second forefin, has ribs and other bones that are truncated at the edge of the block. The remainder of the skeleton, although comprised of at least three other blocks, appears to belong together.

FIGURE 17: ANSP 17429. Scale = 20cm.

**BGS GSM 132414**

This specimen includes a skull, anterior vertebral column, pectoral elements, and a disarticulated forefin (Fig. 18). The matrix is covered by a patterned plaster wash, going up to the edge of the bones, with little of the matrix exposed. McGowan (1989) suggested that such a feature warrants close examination of the specimen. It looks authentic, although there is a discontinuity between the anterior block and the vertebral column immediately posterior to it, so that the neural spines and centra are upside down relative to the anterior skeleton (Fig. 18). Either the block was prepared from the other side and put together with the anterior skeleton or it came from another individual. Pelvic bones and some ribs are isolated from the rest of the skeleton and may not belong.

FIGURE 18: BGS GSM 132414. Arrow marks discontinuity where the posterior block is the opposite orientation to the anterior skeleton. Scale = 20 cm.

**BGS RGSCU 1091**

This specimen comprises a mandible and partial postcranial skeleton in dorsal view (Fig. 19). The mandible is separated from the skull by a gap of approximately 10 cm and the tip is reconstructed from a darker material. The entire mandible is on a separate block of matrix, and might have been added. The specimen appears to be in several blocks of matrix, all of which are covered in a plaster wash, and the matrix bears several different patterns. A large crack runs diagonally across the dorsal region, but the ribs line up fairly well across the crack. The distal-most segment of the vertebral column lies on a separate block from the rest, but it probably belongs with the specimen. An outline of the right forefin is carved in the matrix, and some of the caudal ribs are carved and painted.

FIGURE 19: BGS RGSCU 1091, from the Joseph Channing Pearce collection. Specimen housed by BGS. Scale = 20 cm. Photograph © BGS, courtesy of S. Harris.



FIGURE 20A: BRLSI M3569, from the Charles Moore collection. Scale = 20 cm.

BRLSI M3569

BRLSI M3569 is an anterior skeleton and skull, preserved in lateral view, but sheared so that some ventral elements are visible (Fig. 20A). The right forefin (lower in Fig. 20A) is made up of several small blocks, and its authenticity is questionable because some of the elements do not match well on either side of the cracks between the blocks (Fig. 20B). Painted plaster is visible along the edge of the forefin and the fin is a much lighter color than the rest of the skeleton. The right humerus, however, appears authentic.



FIGURE 20B: Right forefin of BRLSI M3569. Scale = 10 cm



FIGURE 21 A: Skeleton of BRLSI M3572, from the Charles Moore collection. Scale = 20 cm.

BRLSI M3572

BRLSI M3572 is a partial skeleton in ventral view, made up of several blocks of matrix that are placed in plaster (Fig. 21A). Bones line up well across some of the contacts between blocks, but they do not match well at others. Both forefins are on separate blocks, but they have the same odd pathology, with an extra element between the intermedium and radiale, so at least the proximal portions probably belong with the specimen. The left humerus is placed entirely in plaster and is partially damaged. The mid-distal portion of the left forefin is on a separate block and might not be part of the specimen, although it lines up well. The posterior portion of the vertebral column, starting with the hindfin, may not belong with the anterior skeleton. There is a sharp discontinuity of the bones across that crack, although one centrum and a femur seem to line up correctly across the crack (Fig. 21B). One hindfin is along the vertebral column, whereas the other is on a separate block that is isolated a few centimeters from the vertebral column (Fig. 21B). The two hindfins are similar in size and morphology, so they might belong together.



FIGURE 21B: Closer view of posterior dorsal portion of skeleton of BRLSI M3572. Arrow indicates the crack where posterior portion of vertebral column meets anterior portion. Scale = 10 cm.

CAMSM J35186

This specimen is not in a wooden frame, although it may previously have been. It comprises a nearly complete skeleton exposed in dorsal view (Fig. 22A). The matrix has been carved around the specimen, so that the shape outlines the skeleton. The skeleton seems entirely authentic although the distal portion of the right forefin could possibly have been added (Fig. 22B). The entire distal half of the fin is separated from the rest by a crack, and the outline of the fin is carved and seems to be in plaster. The color of the distal portion of the fin is dark brown, but the rest of the skeleton is much lighter and elements do not line up well across the crack.



FIGURE 22A: CAMSM J35186. Scale = 20 cm.



FIGURE 22B: Right forefin of CAMSM J35186. Scale = 10 cm.



FIGURE 23A: Anterior portion of OUMNH J.10301, from the Thomas Hawkins collection. Scale = 20 cm. © OUMNH, image courtesy of J. Hay.



FIGURE 23B: Posterior portion of OUMNH J. 10301, isolated from the rest of the specimen. Scale = 20 cm. © OUMNH, image courtesy of J. Hay.

OUMNH J.10301

OUMNH J.10301 comprises at least three large, separate blocks of matrix that are placed together within a wooden frame (Fig. 23A, B). It includes a skull exposed in dorsal view, disarticulated fragments of the pectoral girdle and right forefin, numerous ribs, and scattered centra. A complete left forefin and clavicles are on a separate block of matrix, and articulated caudal centra, a coracoid and a disarticulated hindfin are on a third block. The ‘block’ that includes the hindfin material is itself made up of at least two blocks (Fig. 23B). It is isolated from the rest of the specimen and may not belong with the other parts of the skeleton, although the bone color and size of the elements seem to match that of the anterior blocks.



FIGURE 24: OUMNH J.10310, from the Thomas Hawkins collection. Scale = 20 cm.

OUMNH J.10310

OUMNH J.10310 comprises a fairly complete skeleton that is pieced together by four large blocks that are set in plaster (Fig. 24). The skull looks too large for the specimen. The rostrum is on a separate block from the posterior portion of the skull, but it lines up well, although the posterior portion of the mandible is reconstructed. The vertebral column is nearly straight, lacking the curvature in the dorsal portion of the column that is usually seen in lateral view. Thirteen articulated centra are associated with the skull, although a few more may be covered by ribs. A wide, filled crack separates the anterior vertebral column from the posterior portion, and the filler covers part of the vertebral column. The posterior block includes about 23-24 articulated precaudal centra. The count suggests that less than ten centra could be missing at the crack. Given that the anterior and posterior column have the same color and preservation, the pieces probably belong together but the posterior portion has been positioned too close to the anterior block, making the skeleton appear shorter and straighter than it probably was originally. There is also a small block of matrix that includes the hindfin and pelvis that does not align well with the rest of the skeleton and the color of the matrix differs from the rest. The most posterior vertebrae are also on a separate block and may have been added.

**OUMNH J.10325**

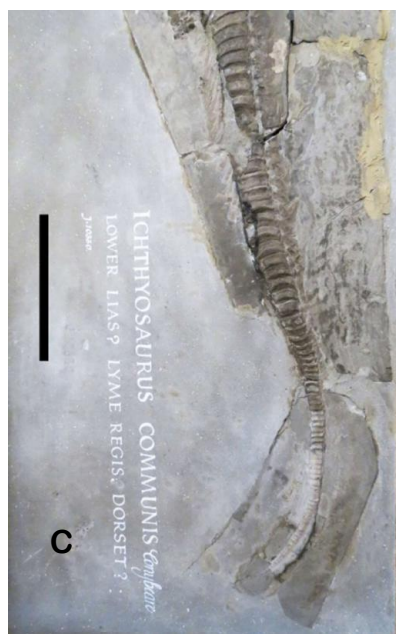
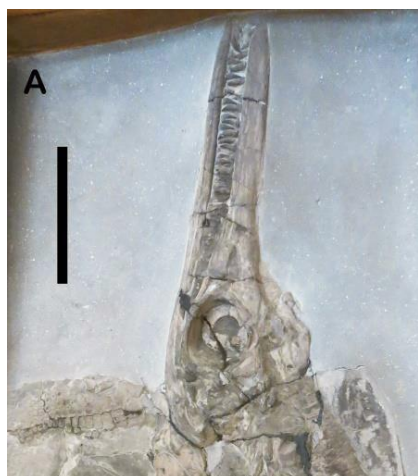
This specimen is a fragmentary skeleton comprising at least three blocks of material (Fig. 25). The anterior block, with bones of the skull and mandible, is separated from the postcranial skeleton by a filler material. The vertebral column is offset at the posterior end of the second block. The centra of the vertebral column on the posterior (third) block are substantially larger than those of the second block, with an abrupt change from one side of the crack to the other. This may be another case of fragmentary specimens being pieced together to look like a single skeleton.

FIGURE 25: OUMNH J.10325, from the Thomas Hawkins collection. Scale = 20 cm.

**OUMNH J.10328**

This specimen comprises a skull and what appears to be a nearly complete and articulated vertebral column in left lateral view (Fig. 26), although it almost completely lacks ribs, and does not preserve any fragments of limb girdles or fins. The outline of the blocks that were put together within the frame are evident, and wide seams of filler material separate the blocks. Bone and matrix color suggests that the skull and the vertebral column are from the same individual. The distal portion of the tail, however, is a different color and on a separate block from the rest of the skeleton, so it might not belong to the specimen.

FIGURE 26: OUMNH J.10328, from the Thomas Hawkins collection. Scale = 20 cm

**OUMNH J.10330**

This specimen is a large, almost complete skeleton including a skull, shown in a series of images (Fig. 27A, B, C). The skeleton is preserved in many pieces of matrix, but at least seven main blocks are pieced together and placed into plaster. The anterior portion of the snout bears a different texture and color from the rest of the skull, which suggests that this segment may have been added, or perhaps carved (Fig. 27A). The rest of the specimen appears to be genuine, although the skull and skeleton have numerous cracks throughout. The posterior matrix block comprises a portion of the distal end of the tail, which has a lighter color than the rest of the skeleton, although the bones line up across the blocks, so this may be due to preservation.

FIGURE 27: OUMNH J.10330, from the Thomas Hawkins collection. A, anterior portion of skeleton, skull and one forefin; B, middle portion of skeleton, with most of the torso; C, posterior, caudal portion of the skeleton. Scales = 20 cm

OUMNH J.13799

This specimen is a nearly complete skeleton of a very old individual (Fig. 28). The postcranial portion is in ventral view, but the skull is in dorsal view, as has been noted in the records at OUMNH. A raised outline in the 'matrix' is evident around the skull (note arrows in Fig. 28). The color of the skull is a bit lighter than the postcranial bones, but the preservation is similar. It is included here for completeness, but is probably authentic. There is also a difference in the proximal elements of the forefin, although this is due to pathology (Motani, 1999, fig. 6F).

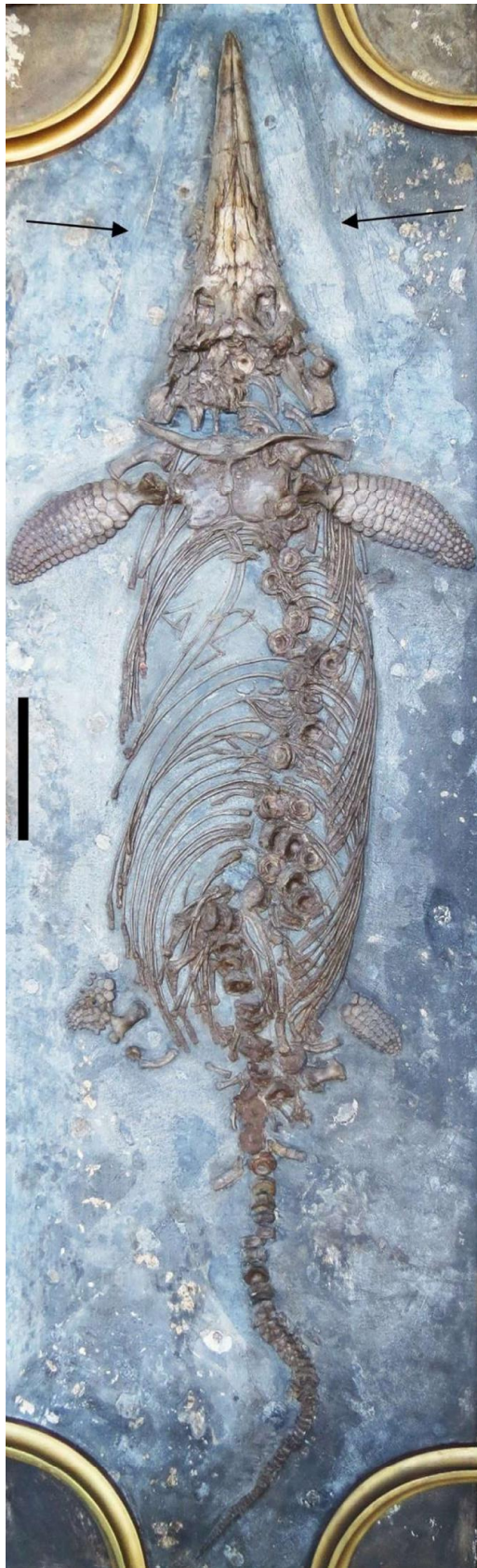


FIGURE 28: OUMNH J.13799. Arrows indicate the triangular outline in the matrix around the skull. Scale = 20cm.



FIGURE 29A: UON VR 159 (TC3199). Scale = 20 cm.

UON VR159 (TC3199)

On first inspection, this specimen appears to be a nearly complete skeleton on a single block of matrix that is placed into plaster (Fig. 29A). However, a crack at the back of the skull separates the skull from the vertebral column by approximately 4 cm, and there is also a slight difference in color between the skull and postcranium. Furthermore, a distinct line surrounds much of the specimen, but not the skull and posterior vertebrae (Fig. 29B). This appears to be a true edge of the matrix, and thus the large block containing the majority of the postcranium has been placed into plaster which has been painted the same color as the matrix. Much of the vertebral column is articulated, but the posterior portions have also been placed into a plaster filler that has been painted the same color as the genuine matrix. A kink in the posterior segment of the vertebral column bends in the opposite direction as the tail bend, although this could be taphonomic or repositioned incorrectly. The distal-most portion of the forefin has also been reconstructed. It is possible that all of the elements belong to the same specimen, but the differences here might suggest a composite.



FIGURE 29B: UON VR 159 (TC3199). Closer view of the matrix. White arrow points to outline of genuine matrix and black arrow points to painted 'matrix'. Scale = 10 cm.

DISCUSSION

This compilation has focused on fairly complete skeletons of *Ichthyosaurus* that are composites or at least suspicious (Table 1). However, less complete specimens of the genus in museum collections and on display are also composites. For example, NHMUK PV R1276 appears to be a fairly complete, articulated forefin, but the humerus has been added. This can be recognized by the different color and orientation of the humerus. Less complete, amalgamated specimens similar to OUMNH J.13800 (Fig. 16) also occur in historic collections. For example, NMW G1554 comprises three distinct pieces that were placed in plaster within a single frame: a string of 27 centra that appear to articulate, some ribs, and a single hindfin. NHMUK PV R1071 is an anterior skeleton with a coracoid, scapula, and articulated forefin in plaster adjacent to the skull. BRSMG Cc921 is a well-preserved skull and forefin; the latter is complete in three dimensions and can be removed. In the first example, NMW G1554, it is fairly clear that the pieces do not belong together, whereas in the other two, the components may well be from the same individual. Museum records can verify the authenticity, but for historic specimens, the records may not be complete, if they exist at all. Even now, amateur collectors sometimes place specimens into blocks of matrix that were not with the original specimen (pers. obs. DRL). It is therefore imperative that any changes made to the bones or matrix of a specimen be recorded.

Entirely authentic specimens can also have elements rearranged from their position *in situ*. It can involve moving pieces of a scattered skeleton closer together for a more compact display, or to reduce the size and weight of a specimen. Or a portion of a specimen could be prepared from the underside, which might result in a slightly different bone or matrix color (e.g., OUMNH J.13799, perhaps NHMUK PV R3372 as discussed above). Another rearrangement might be made if a portion of a skeleton is too poorly preserved to be recovered. Portions anterior and posterior to this region could be placed closer together, as might be the case in OUMNH J.10310 (Fig. 24). Fin elements are particularly good candidates for rearrangements. The hindfin of NHMUK PV R5595 (Fig. 13C) is a possible example of rearrangement. BRSMG Cb4997 also has hindfin elements that may have been reset in plaster; however, without complete records of the preparation, this is only speculation.

The other means of ‘enhancing’ specimens are through reconstructions. A reconstruction is often undertaken to fill gaps in broken bones or to provide a more complete looking specimen for display. For example, BRSUG 25300 has several reconstructed

elements, including a portion of digit II in the forefin and the distal portions of both hindfins. In this case, the reconstructed elements are clearly identified by a much darker color compared to the actual bone. Unfortunately, other historic specimens are not as obvious. NHMUK PV R278 comprises two forefins, where the left humerus is completely reconstructed. Reconstructions are not confined to historic specimens. For example, on NMW 93.5G.2, most of the rostrum is carved out of plaster (Massare and Lomax, 2016). Similarly, BRSMG Ce16611 has a reconstructed rostrum (Deeming et al., 1993). DONMG:1983.98 is a fairly complete anterior skeleton, but nearly all of the proximal elements in the forefin have been set in plaster (Lomax and Massare, 2015; Larkin and Lomax, 2015). All three specimens were collected in the 1980s and 1990s, and museum records clearly indicate what portions of the specimen have been reconstructed. Numerous other occurrences are in museum collections and on display.

CONCLUSIONS

Early in the development of paleontology as a science, the completeness of a specimen for display may have been more important than maintaining its authenticity. Some collectors were more diligent than others in preserving the integrity of a specimen. Thomas Hawkins was notorious for composite specimens, and many of them were put together with considerable care and skill (Taylor, 1989; McGowan, 1990). When his collections were sold in the mid-19th century, some material may have been acquired by Joseph Channing Pearce and Charles Moore, among others, who were amassing collections at the time (Taylor, 1989; McGowan, 1990). Many of the composite and ‘suspicious’ specimens described herein are from the Thomas Hawkins and the Charles Moore collections, both among the largest private collections of ichthyosaurs amassed. McGowan (1989; 1990) also found several composite specimens of *Leptonectes tenuirostris* from those collections. Specimens from those collections should initially be viewed with skepticism. In general, historic specimens, especially fairly complete ones, always require close examination, and further conservation and preparation can confirm the extent of a composite (e.g. Buttler and Howe, 2002).

Large specimens were often collected in several blocks and pieced together, as is commonly done today. Examining the seams between blocks for bones that continue from one block to another is the obvious way to recognize a composite. Matrix and bone color are also important. However, preparing the matrix to a slightly lower level in one block compared to another could also result in a difference in color. Specimens

present a challenge if the matrix is covered by a plaster wash or pattern plaster, as is common on many specimens from Somerset (McGowan, 1990; pers. obs.). If confirmation of a composite requires dismantling an historic specimen, most museums are unlikely to allow this to happen. Composites may only be obvious if the plaster infilling starts to deteriorate.

Forefins and hindfins are the elements that are most often added to a fairly complete skeleton (Table 1). Differences between the left and right forefins is a cause for concern, although it occurs, albeit infrequently, in entirely authentic specimens (e.g. AGC 11, ANSP 15766). Sometimes, however, differences are pathologic (e.g. BRSMG Ce16611, OUMNH J.13799). Comparing the shape of propodials, the position of the propodial relative to the rest of the skeleton, and finding areas of plaster surrounding bone or an entire fin can often indicate a composite. Another common ‘enhancement’ is lengthening the vertebral column (Table 1). A lack of matrix along the column or a lack of ribs, especially caudal ribs, should prompt a closer examination of the specimen. Centrum size and shape, the change in centrum shape along the column, the precaudal count, and the location of unicipital and bicipital ribs can help determine whether centra have been added (Lomax and Massare, 2012; Massare and Lomax, 2014a, b).

A composite specimen is still extremely valuable scientifically. Historic specimens, especially from inland areas of Somerset, are largely from locations that are no longer accessible. Often a large portion of the skeleton is entirely authentic, and this presents a wealth of morphological data that should not be ignored. Unusual features of a specimen, such as skeletal elements that are unusually large or small, should not be given much importance unless other specimens share the same unusual feature. Multiple criteria need to be considered in recognizing a composite. With a careful assessment of historic material, a lot of valid information can be obtained.

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