Postscript to Everhart, M.J. 2005. "Elasmosaurid remains from the Pierre Shale (Upper Cretaceous) of western Kansas. Possible missing elements of the type specimen of *Elasmosaurus platyurus* Cope 1868?" – PalArch's Journal of Vertebrate Palaeontology 4, 3: 19–32.

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2 figures, 1 table

Abstract

The holotype is the single most important specimen in zoological taxonomy, and to avoid confusion, it must be the remains of a single individual. Re–evaluation of data presented to infer that three specimens collected between 1954 and 1998 are additional material of the holotype of *Elasmosaurus platyurus*, indicate there is no evidence these two sets of remains belong to the same individual, or the genus *Elasmosaurus*. Historical documents indicate the missing skeletal elements of the *Elasmosaurus* holotype (including dorsal vertebrae and gastralia) can be explained by factors such as weathering and collection failure. The relative absence of gastroliths, if originally associated with the animal, can be explained by the collecting methods employed, or the absence in 1867–1868 of a theoretical framework to explain their presence in a plesiosaur.

Key–words: Plesiosauria, *Elasmosaurus platyurus*, holotype, Elasmosauridae

Contents:

Abbreviations:

ANSP Academy of Natural Sciences of Philadelphia, Philadelphia, Pennsylvania, USA.
CMC Cincinnati Museum Center, Vertebrate Paleontology, Cincinnati, Ohio, USA.
FHSM Sternberg Museum of Natural History, Fort Hays State University Hays, Kansas.
KUVP University of Kansas Vertebrate Paleontology Collection, Lawrence, Kansas.

1. Introduction

The type specimen is of considerable importance as the name–bearing entity in zoological taxonomy (ICZN, 1999), and to avoid nomenclatural confusion the holotype must be the remains of a single individual (Marsh, 1898). The holotype of the plesiosaur *Elasmosaurus platyurus* Cope, 1868 (in Anonymous, 1868) (ANSP 10081) is of particular importance as the type species of the genus *Elasmosaurus* and the nomotypical genus for the Family Elasmosauridae. ANSP 10081 is significant for the history of science as Edward Drinker Cope (1840–1897; Anonymous, 1897) erroneously placed the head on the end of the tail (Storrs, 1984; see also Lydekker, 1888a, b). This mistake was pointed out by Joseph Leidy (1823–1891; Geikie, 1892) in print (Leidy, 1870), and in person to Cope by Charles Othniel Marsh (1831–1899; Woodward, 1899). This latter incident apparently triggered the bitter 1870's to 1890's 'bone wars' between Cope and Marsh (Storrs, 1984), although this interpretation of events has been challenged (Jaffe, 2000).

ANSP 10081 is a fairly complete skeleton that was collected in 1867–1868 by Dr Theophilus Hunt Turner (1841–1879; Almy, 1987), an army surgeon resident at Fort Wallace, Kansas. The remains of the animal were sent to Cope in Philadelphia, and when described consisted of five tooth–bearing fragments of the skull, the occipital condyle of the basioccipital attached to the atlas–axis complex, a substantial portion of the vertebral column, the pectoral and pelvic girdles (subsequently lost; see Williston, 1906), the heads of 14 dorsal ribs with portions of a large number of rib shafts (many of which cannot be located anymore; Everhart, 2005), numerous bone fragments, and possible stomach contents of isolated fish teeth and scales (Anonymous, 1868; Cope, 1870). Thus a number of dorsal vertebrae, ribs, gastralia ('belly ribs') and the limbs of ANSP 10081 were not discovered (Almy, 1987; Everhart, 2005).

A recent synthesis of morphological, stratigraphic, lithological, geographical and historical data has been presented to infer that some of the missing elements of the *Elasmosaurus* holotype have been identified (Everhart, 2005). The recognition of this additional material, if belonging to ANSP 10081, would be of considerable importance for understanding the genus, and for the history of vertebrate palaeontology in North America. However, the data presented lacks clarity, and the conclusions that further material belonging to the same individual of *Elasmosaurus* as ANSP 10081 is erroneous. The concept that additional material belonging to the same individual as ANSP 10081 must be rejected as it strikes at the very heart of taxonomic nomenclature: the holotype.

2. New material

Three plesiosaurian specimens, FHSM VP–398, KUVP 129744 and CMC VP6865 (henceforth referred to as the 'new material'), recovered at different times and by different individuals or institutions, have been proposed as some of the missing elements of the holotype of *Elasmosaurus*. The 'new material' consists of approximately 10 dorsal vertebrae, portions of 10+ dorsal ribs, 12 gastral ribs, and 48 gastroliths (table 1):

Specimen Number	Year of collection	Material			
		D	R	G	SS
FHSM VP–398	1954	7	2 +	–	–
Uncat. *	1970's	1	–	–	–
KUVP 129744	1991	2	Several fragments	2	38
M. Everhart	1994	–	–	–	3
CMC VP6865	1998	–	8	10	7 ** (probable)
Totals:		**10**	**10+**	**12**	**48**

*Table 1. Summary table of the 'new material' (see text for further details). Abbreviations: D=dorsal vertebrae; G=gastralia; R=dorsal ribs; SS=gastroliths or stomach stones. Data collated from Everhart (2005: 20–22). *, collected by a local resident and now lost; ** cited as six by Everhart (2000).*

- FHSM VP–398 was collected and donated to George F. Sternberg in 1954 (Everhart, 2005: 20, 22) and consists of seven dorsal vertebrae, two single–headed dorsal rib heads and numerous fragments of rib shafts. There is no detailed locality data for the find and no map was made of the elements in the ground, however, the remains have been interpreted as having been found scattered and disarticulated (Everhart, 2005).

- In the 1970's a single vertebra was recovered by a private individual (Bussen in Everhart, 2005), apparently from the same locality, although the exact location was not recorded, and the specimen is now lost (Everhart, 2005).
- KUVP 129744, was recovered in 1991, and consists of two dorsal vertebrae, several single–headed rib fragments, two incomplete gastral ribs and 38 unusually large gastroliths (Everhart, 2000, 2005). No field map of the elements was made, although the gastroliths are reported as having been found with either half the stones piled together in a small area (Bussen in Everhart, 2000) or in a single large group (Bussen in Everhart, 2005); in 1994 three further gastroliths were recovered from the same site (Everhart, 2000, 2005).
- CMC VP6865, was recovered in 1998, and consists of five complete and three partial dorsal ribs, 10 substantially complete gastralia, and six (Everhart, 2000) or seven (Everhart, 2005) probable gastroliths; a map of the material was produced in the field (Everhart, 2005: figure 6).

2.1. Unity of the 'new material' and its association with ANSP 10081

The 'new material' was recovered from one or more small exposures approximately 1.5 km north–northwest of McAllaster (Everhart, 2005: 23). KUVP 129744 and CMC VP6865 were collected three years apart, but there is little doubt they originated from the same locality and they are the remains of a single individual. However, without detailed field mapping, the relationship between the two sets of elements is conjectural (Everhart, 2005: figure 6). FHSM VP–398 was found almost 40 years before KUVP 129744 and CMC VP6865, and the two sets of remains are only known to have come from "in the vicinity of" (Everhart 2005: 20), "the same general locality as" (Everhart 2005: 25), or "apparently originated from same locality" (Everhart 2005: 27) as each other, indicating there is no proven association between the KUVP 129744 and CMC VP6865 material and FHSM VP–398. Thus, the interpretation of the 'new material' as a single pile of jumbled bones and gastroliths (Everhart, 2005: 30) originally spread over an area of four square metres prior to burial (Everhart, 2005: 22), and the 'map' showing the bone scatter (Everhart, 2005: figure 6), are highly speculative and the conclusion that KUVP 129744 and FHSM VP–398 are 'most probably from the same animal' (Everhart, 2005: 27) cannot be substantiated.

However, even if the 'new material' cannot definitively be shown to belong to a single individual, can any of the elements be considered to belong to the holotype of *Elasmosaurus* ANSP 10081? The lines of argument presented (Everhart, 2005) to indicate the unity of the three specimens, can be drawn out into four threads: (i) morphological similarity (including shape, size structure, and lack of duplication of the skeletal elements); (ii) presence or absence of gastroliths and their lithology; (iii) geographical proximity; and (iv) stratigraphic and lithological similarity between the two sets of remains. Each of these lines of evidence is discussed below.

2.2. Morphology

The holotype of *Elasmosaurus* is missing most of the skull, the limbs, cervical and dorsal vertebrae, a number of dorsal ribs, and all of the gastralia (Everhart, 2005). The 'new material' consists of dorsal vertebrae, dorsal ribs and gastralia (table 1). It has been noted that there is no duplication of skeletal elements (except dorsal ribs) between the ANSP 10081 and the 'new material', and that the 'new material' represents many of the elements missing from the holotype of *Elasmosaurus* (Everhart, 2005: 27, 29, 30). In addition, the shape and size of the elements is closely similar between the two sets of remains, with slight variations explained in terms of position in the body or the effects of differential preservation (Everhart, 2005: 27, 28). The "coarse cellular texture of the spongy bone" (Cope, 1870: 49) of the vertebrae is also considered identical in both ANSP 10081 and FHSM VP–398 (Everhart, 2005: 27). However, none of the 'new material' (dorsal vertebrae, dorsal ribs, or gastralia) is diagnostic below the Superfamily level within the Plesiosauria, so neither membership of the Family Elasmosauridae, nor generic or specific identity with *Elasmosaurus platyurus* can be demonstrated based on one, or any combination, of the preserved elements of the 'new material'. The size of skeletal elements is non–diagnostic, and cannot be considered an indicator of generic or specific identity, and the open cellular structure of the bone forming the vertebrae is typical of all members of the Plesiosauria (see Wiffen *et al*., 1995; Woodward in Andrews, 1913).

2.3. Gastroliths

Gastroliths, or stomach stones, are routinely found associated with elasmosaurs and other long necked plesiosaurs (Andrews, 1910, 1913; Brown, 1904, 1907; Cicimurri & Everhart, 2001; Martill, 1992; Williston, 1893, 1904). However, the skeleton of the holotype of *Elasmosaurus* is devoid of stomach stones, other than a

single, newly recognised, pebble wedged in the neural arch of a distal caudal (Everhart, 2005: 27, 30). By contrast, the 'new material' preserves abundant gastroliths (table 1), the volume and mass of which is considered consistent with an elasmosaur the size of ANSP 10081 (Everhart, 2005: 27); the lithology of the stomach stones in the 'new material' is considered 'similar' (Everhart, 2005: 29) to the stone found in the caudal ANSP 10081. However, although gastroliths are frequently found associated with elasmosaurs, they are also known from other, non–elasmosaurian, members of the Plesiosauria (Andrews, 1913; Martill, 1992), including Western Interior Sea polycotylids (Williston, 1893, 1903). However, the presence of gastroliths or their lithology is not diagnostic of an individual, species or genus, and comparison of gastrolith lithology between the 'new material' and ANSP 10081, based on a single datum point of doubtful lithological identity (no detailed petrological study has been undertaken), is extremely tenuous, particularly as living animals are not known to select their stomach stones based on lithology, or to acquire their gastroliths from a single source.

2.4. Geography

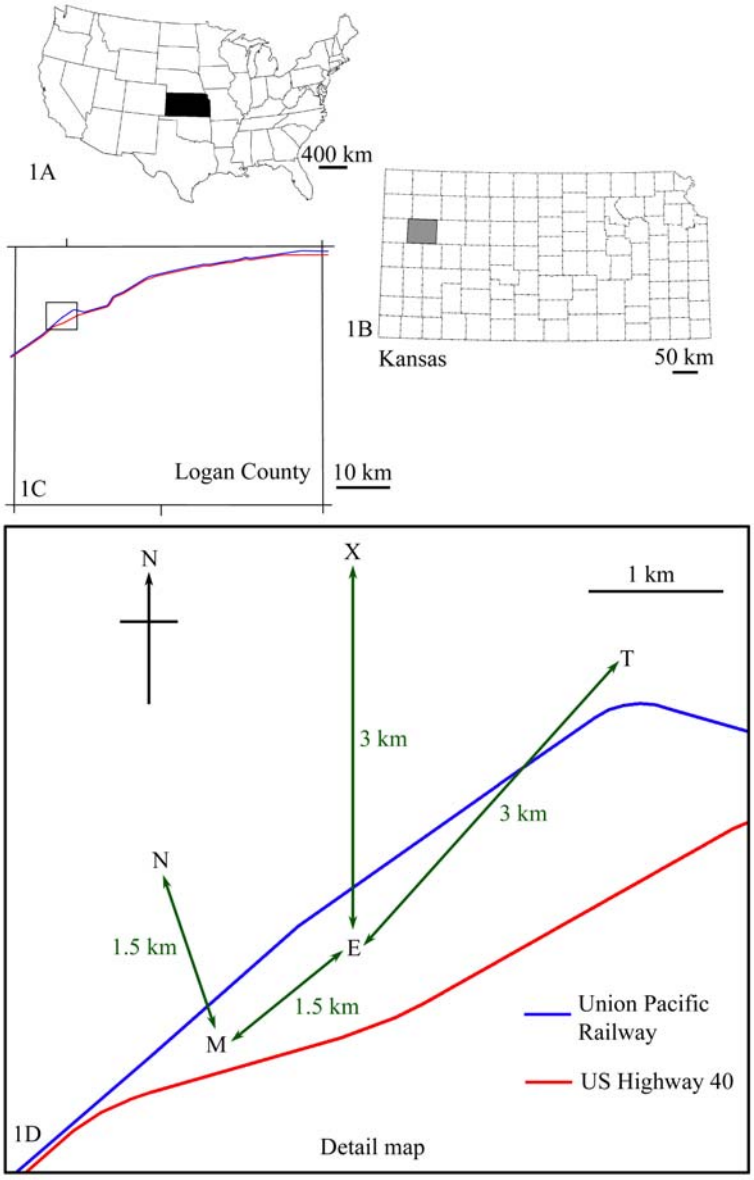
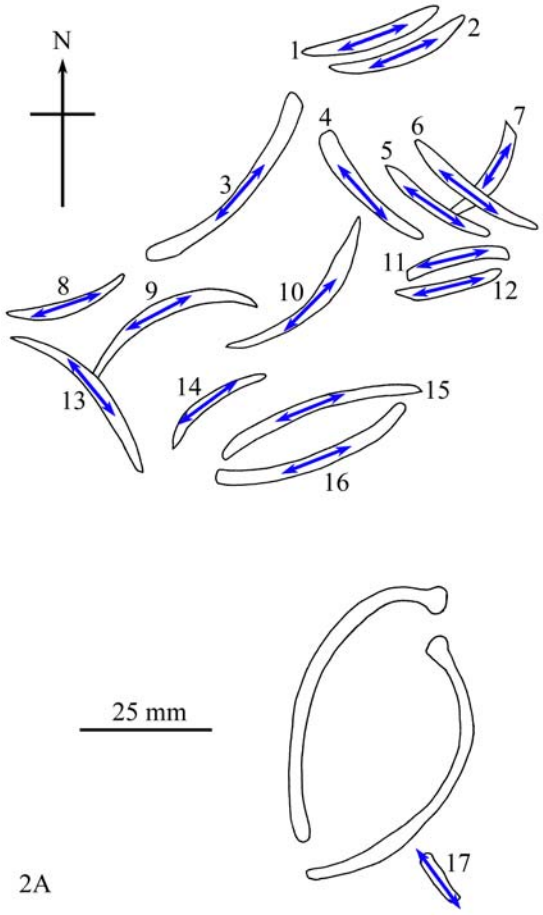
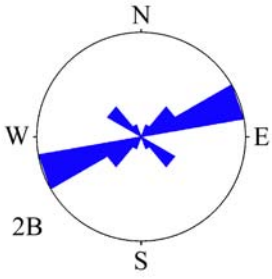


Figure 1. Maps of Logan County, Kansas showing the areas where ANSP 10081, FHSM VP–398, KUVP 129744 and CMC VP6865 were discovered. 1A: USA map highlighting Kansas; 1B: Kansas map highlighting Logan County; 1C: Logan county map highlighting area of detail map, and showing Union Pacific Railroad (blue), US highway 40 (red); 1D: detail map showing localities and distances referred to in the text, abbreviations: E=holotype of Elasmosaurus platyurus *(ANSP 10081); M=the abandoned McAllaster township; N=discovery site of the 'new material'; T=type horizon for the Sharon Springs Shale Member of the Pierre Shale; X=location of current aligned* Bacculites*. Based on information in Everhart (2005). Drawing by L.F. Noè.*

The holotype of *Elasmosaurus* was collected 14 miles (approximately 22.5 km) northeast of Fort Wallace in Logan County, Kansas (Almy, 1987; Everhart, 2005; LeConte, 1868). Most recently the find site has been interpreted as lying on the north side of McAllaster Butte, some 1.5 km to the northeast of the abandoned township of McAllaster, between the Union Pacific Railroad and US Highway 40 (Bussen in Everhart, 2005: 23; see also Storrs, 1984). By contrast, the well–localised 'new material' (KUVP 129744 and CMC VP6865) was recovered come from approximately 1.5 km north–northwest of McAllaster (Everhart, 2005: 23) (figure 1). Utilizing the relative locations of the holotype and the 'new material', and comparing them to current oriented specimens of *Baculites* (Carpenter in Everhart, 2005), a northwest–southeast current direction has been inferred for what is now the Logan County region of the former Western Interior Sea (Everhart, 2005).

However, there are contradictory accounts as to the geographical location from which the holotype of *Elasmosaurus* was collected (Everhart, 2005; LeConte, 1868; see also Storrs, 1999; Welles, 1952), and there has been much erosion and excavation in the McAllaster Butte area since 1867–1868 (Everhart, 2005), so the exact geographic location from which the ANSP 10081 was derived remains unknown (Everhart, 2005: 23). In addition, using the sites of deposition of two sets of vertebrate remains, and comparing them to a single datum point for current aligned invertebrates more than three kilometers away (figure 1) is insufficient data (Tucker, 2002) for a wide–ranging conclusion regarding former ocean currents. Also, inferring ocean surface or water body current direction(s) from sea bottom aligned invertebrates is a mismatch of information. Indeed, the bone scatter data for CMC VP6865 indicates the preferred local sea floor orientation was northeast–southwest (figure 2), not northwest–southeast. Models for large–scale circulation patterns in the Western Interior Sea are available elsewhere (Ericksen & Slingerland, 1990).





Element	Angle
1	70
2	67
3	41
4	138
5	124
6	127
7	32
8	71
9	62
10	45
11	77
12	76
13	140
14	53
15	68
16	69
17	143

2C

Figure 2. Bone scatter data for CMC VP6865. 2A: skeletal elements (redrawn from Everhart, 2005: figure 6) overlain with arrows (blue) showing relative orientations; 2B: symmetrical rose diagram with orientations plotted at 10 degree intervals; 2C: tabulated data, with angles in degrees from north. Scale in 2A is approximate and derived from the size of the largest rib. Drawing by L.F. Noè/M. Gómez–Pérez.

2.5. Stratigraphy and lithology

The holotype of *Elasmosaurus* is generally agreed to have been collected from the Lower Campanian stage, Sharon Springs Shale Member of the Pierre Shale (Everhart, 2005; Storrs, 1999; Welles, 1952; Williston, 1906) and is therefore approximately 79–83 million years old (Gradstein *et al*., 2004); however, the exact stratigraphic horizon from which the holotype was derived is not known (Everhart, 2005: 23). The well–localised elements of the 'new material' (KUVP 129744 and CMC VP6865) were recovered from the top of the Sharon Springs Shale Member, five meter below a prominent layer of septarian concretions and one meter below a yellow bentonite layer, and are interpreted as being from "the same stratigraphic level" (Everhart, 2005: 30) as ANSP 10081. The lithology of the matrix is similar in both sets of remains, and the preservation of FHSM VP–398 and KUVP 129744 are identical (Everhart, 2005: 27). However, it is not possible to correlate between the known horizon of part of the 'new material' and the unknown horizon of ANSP 10081. Preservational style, which frequently varies across a single carcass, cannot be used to link the two specimens; neither can concretionary matrix as this is not an original sedimentary structure, but of post–depositional origin, and therefore part of the remains separate diagenetic histories.

Thus, none of the evidence from ANSP 10081 or the 'new material' based on morphology, gastroliths, geographic locality, or stratigraphy and lithology supports the premise that these two sets of remains "are from the same animal" (Everhart 2005: 30). Indeed, the taphonomy indicates ANSP 10081 and the 'new material' came from different individuals (*contra* Everhart, 2005). The completeness and articulation of the holotype skeleton suggests rapid deposition, whereas the scattered remains of the 'new material' indicates they may have dropped from one or more floating carcass(es) (Brown, 1904; Everhart, 2005; Martill, 1985; Schäfer, 1972). See Schäfer (1972) and Brett (1990) for further observations on the taphonomy of vertebrate carcasses.

3. Historical notes

In late June 1867, John Lawrence LeConte (1825–1883; Almy, 1987), a surveyor for the Union Pacific Railroad, obtained three vertebrae of the future holotype of *Elasmosaurus*, although he was unable to see the remains in the ground due to war with the Native American Indians (LeConte, 1868). Two of these vertebrae were passed to Cope, and in December Cope wrote to Turner requesting that he procure all the remains of the animal. In late December Turner, together with a 'hunting party' from Fort Wallace, began excavating the remains but found the task too onerous, and had to return at a later date to complete the task (Almy, 1987). By February 1868 the bones had been collected and were boxed and ready to be transported to Philadelphia. In March, Cope produced a rapid description of the animal, in which he famously described *Elasmosaurus* with the head on the wrong end (Anonymous, 1868). In March, May and July 1868 Cope wrote to Turner requesting further remains, but the search was delayed due to the ongoing Indian war, although further material was sent to Philadelphia in September (Almy, 1987).

Although great care must be exercised not to read too much into historical documents, Cope's letters to Turner, and Turner's letters home (Almy, 1987) provide an insight into the collection history of the holotype of *Elasmosaurus*. These letters also give a valuable insight into the possible reasons for the loss of skeletal elements and the lack of gastroliths associated with ANSP 10081.

3.1. Missing skeletal elements and gastroliths

The skeleton of *Elasmosaurus* was discovered eroding from a ravine, probably during the first half of 1867. In June it was reported by William Comstock (1842–1868; Almy, 1987) that "almost the whole skeleton of this animal is exposed" (LeConte, 1868: 10–11). By that time parts of the skeleton had already been collected: at least the three vertebrae handed to LeConte. Only two of these vertebrae appear to have been received by Cope, and although it is not known which vertebrae these were, they may have been part of the dorsal series reported missing by Turner. Collection of the remains did not begin until late December 1867, following Cope's request (Almy, 1987), by which time the skeleton had remained exposed for at least six months, and possibly longer. During that time the weather, as recorded in the letters from Turner (Almy, 1987), included extreme heat, wind, rain, severe cold, and snow, with temperatures ranging from –15 to +125 Fahrenheit (–26 to 52 degrees Centigrade). With such extremes of temperature and harsh weather conditions, it would not be surprising if at least some of the skeleton had weathered out and eroded, making complete collection of the animal extremely difficult.

When recovered, the skeleton of *Elasmosaurus* was reasonably complete and at least partially articulated with thirty–five feet (approximately 10.7 metres) of the vertebral column lying in a line (Almy, 1987; Everhart, 2005). However, although Turner was scientifically and medically trained, with an interest in geology (Almy, 1987), he was an amateur collector unfamiliar with plesiosaurs and was assisted by soldiers or others at Fort

Wallace during collection of the remains. Thus it is entirely possible that some of the skeleton remained at the find site; indeed further material was collected and shipped to Philadelphia in September 1868 (Almy, 1987). Once the majority of the skeleton was received in Philadelphia, Cope requested further remains, specifically the gastralia and additional cranial material, probably recognising post–fossilisation breaks such as the one at the rear of the snout (Cope, 1870: 48). In addition, it is known that damage occurred in transit, as Cope wrote to Turner suggesting how future bones might be better packed (Almy, 1987: 189).

Thus some of the missing skeletal elements of ANSP 10081 are likely to have been lost to one, or a combination of, circumstances: weathering prior to collection due to harsh climatic conditions, collection failure due to lack of palaeontological knowledge and field work experience, damage in transit, and delay in collecting further remains due to the difficult political–military situation of the time. In addition, the absence of gastroliths may indicate that few were present in the living animal, or perhaps more likely that they were not recognised as part of the skeleton. It is likely that neither Turner nor Cope were expecting stomach stones to be present and associated with a plesiosaur skeleton. Indeed the first recorded occurrence of plesiosaur gastroliths was published ten years after the discovery of *Elasmosaurus* (Seeley, 1877; Williston, 1904). In addition, Cope explicitly stated in his letter of 3rd December 1867 that "as little of the mineral matrix, as may be convenient may accompany the bones" (Almy, 1987: 185); further loss may have occurred during preparation of the skeleton in Philadelphia.

4. Summary and conclusions

'New material' (FHSM VP–398, KUVP 129744 and CMC VP6865), referred to the same individual as the holotype of *Elasmosaurus platyurus* (ANSP 10081), cannot definitively be shown to belong to a single animal. Although CMC VP6865 and KUVP 129744 are associated, the relative positions of the two sets of skeletal elements are not known. However, FHSM VP–398 was discovered almost 40 years earlier and has no detailed collection documentation associated. In addition, no part of the 'new material' (dorsal vertebrae, dorsal ribs, gastralia and gastroliths) is diagnostic within the Plesiosauria, and does not support the contention that the material belongs to the species *Elasmosaurus platyurus*, the genus *Elasmosaurus* or the Family Elasmosauridae.

Consideration of the morphology, gastroliths, geography, sedimentology and lithology of the 'new material' and ANSP 10081 makes the suggestion that these disparate remains belong to the same individual as ANSP 10081 untenable, and must be rejected. This is of particular importance as ANSP 10081 is the holotype of *Elasmosaurus platyurus*, which must stand as a "fixed beacon light" (Marsh, 1899: 552) for current and future researchers attempting to understand the genus and species.

Published historical documents suggests that the length of time the skeleton lay in the ground subject to weathering, collection failure due to a lack of palaeontological knowledge and fieldwork experience by Turner and his 'field crew', loss and damage during transport and/or preparation, and/or the lack of a theoretical framework to explain the presence of gastroliths, can amply explain the elements missing from ANSP 10081.

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