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SHORT COMMUNICATION

CAPTURE OF A ONE-EYED BULL SHARK, *CARCHARHINUS LEUCAS* (VALENCIENNES 1839), FROM THE NORTHERN GULF OF MEXICO

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Key Words: Chondrichthyes, deformation, abnormality

Introduction

When we take into consideration the large number of individuals sampled as part of scientific research, reports of morphological abnormalities are relatively rare for free swimming elasmobranch fishes (Moore 2015). However, many reports of abnormalities exist. While congenital defects are fairly common in the literature where abnormalities are reported, the documentation of severe deformation due to post—natal trauma is sparse. For example, Moore (2015) documented 10 cases of physical abnormalities in free—swimming elasmobranchs from the Persian—Arabian Gulf, including fin and head deformations. While the causes of the abnormalities reported by Moore (2015) remain unclear, it is possible that many (*e.g.*, missing portions of fins and claspers) were the result of trauma. Moore (2015) also indicated that the scarcity of reports of severe deformations in the literature could be due to either a lack of reporting or that these deformations are relatively uncommon in normal populations, being elevated in areas significantly affected by various anthropogenic influences.

Fishes inhabiting the northern Gulf of Mexico (GOM) are subject to many sources of anthropogenic influence, from potential impacts associated with the oil and natural gas industries and seasonal hypoxia, to interactions with various fishing gears employed in the region. Despite these possibilities, reporting of deformations has been relatively low for this region overall, regardless of the underlying cause. However, within the past 5 years cases of abnormal embryos of both Blacktip Sharks *Carcharhinus limbatus* (Valenciennes 1839; Driggers et al. 2012) and Bull Sharks *Carcharhinus leucas* (Valenciennes 1839; Wagner et al. 2013) as well as an intersexual individual of the latter species (Hendon et al. 2013) have been reported from the GOM. The causes of these abnormalities, unfortunately, could not be assessed. The purpose of this paper is to document the capture of a one—eyed Bull Shark from the northern GOM.

Materials and Methods

On 20 September 2015, an immature male Bull Shark lacking its right eye (Figure 1) was captured off the coast of Louisiana (28.778° N, 90.041° W) using bottom longline gear and methods described in Driggers et al. (2008). To provide a record of environmental conditions at the site of capture, a Sea—Bird SBE 911plus conductivity (µOhm), temperature (°C) and depth (m) recorder (CTD) fitted with auxiliary sensors for additional parameters such as dissolved oxygen (mg/L) and transmissivity (%), was also deployed. As the shark was moribund when brought aboard, it was sacrificed and the head removed, frozen and retained for further examination.

Multiple techniques were employed to elucidate whether the missing eye was a congenital defect or whether post—natal damage occurred, and whether the situation had any effects on overall fitness. To determine the cause of the deformation, magnetic resonance imaging (MRI) and computed tomography (CT) scans were used to examine underlying soft tissue and skeletal structures. A single vertebra, removed from directly behind the cranium, was sectioned and age estimated using the methods in Driggers et al. (2004). In addition, the weight—at—length of the abnormal individual was compared to the length—weight relationship of normally formed Bull Sharks captured during the annual National Marine Fisheries Service, Mississippi Laboratories, bottom longline survey to determine if the deformation had an effect on the fitness of the animal. The head was subsequently deposited in the Biodiversity Research and Teaching Collection at Texas A&M University (TCWC 17184.01).

Results

The Bull Shark, measuring 1682 mm fork length (FL) and weighing 61.1 kg, was captured at a depth of 43.4 m. All parameters recorded by the CTD were in the normal range with the exception of bottom dissolved oxygen content (DO), which was hypoxic (1.31 mg/L). Transmissivity was also low (54.66%) at the bottom but within the normal range for the area.

External examination of the specimen revealed that there was stark asymmetry between the two sides of the head, with the eyeless (right) side appearing depressed and thinner than the eyed (left) side (Figure 1). The eyeless side was completely smooth, appearing as if the eye did not form during develop-

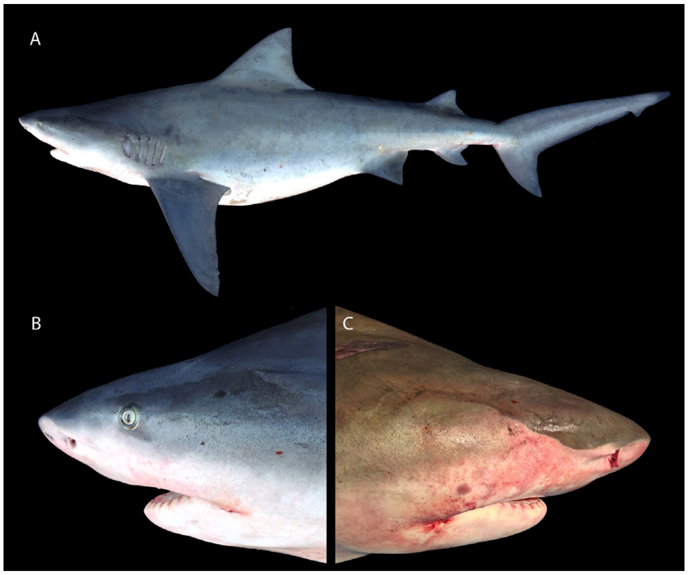

FIGURE 1. *Subject Bull Shark. A. Whole animal in left lateral view. B. Head in left lateral view. C. Head in right lateral view. Note color difference between B and C is due to lighting when picture was taken.*

ment. However, the line demarcating the countershading of the dorsal and ventral surfaces was disrupted at the location where the eye should have been (Figure 1C). Another, unrelated, more recent wound was present on the dorsal surface of the head. This wound was still healing and there did not appear to be any associated damage to underlying structures.

The images resulting from the MRI were not conclusive in determining the immediate cause of the deformation (Figure 2). The chondrified sclera was completely absent from the affected, eyeless, side. The tissues on the eyeless side of the head were thinner and showed less differentiation than those on the eyed side. The tissues associated with the electrosensory (ampullae of Lorenzini) and mechanosensory (lateral line) systems, particularly those branches anterior to and ventral of the eye, were obvious and widely distributed on the eyed side of the head while those tissues on the eyeless side appeared reduced in both size and abundance. Likewise, the length of the optic pedicle and optic nerve on the eyeless side appear reduced (Figures 2A and 2C), not penetrating to where the eye would naturally occur. The extra—ocular muscles on the eyeless side also appeared either reduced in length or absent (Figures 2B and 2D).

Three—dimensional representations of the head skeleton, rendered from CT scans, indicated adjacent structures (nasal capsule and palatoquadrate) also appeared damaged (Figure 2E and 2F). However, the pre— and post— orbital processes, as well as the Meckel's cartilage on the eyeless side appeared undamaged. This could indicate that the damage was not widely spread dorsoventrally but along a relatively narrow line extending from the nasal capsules anteriorly to the palatoquadrate posteriorly.

Examination of the vertebral section yielded an age estimate of 13.5 years old (15 total growth bands, Figure 3A). The weight—at—length of the Bull Shark specimen fell within the 95% prediction limits of the length—weight regression (weight = $-34.55 + (3.5 \times 10^{-5}) * FL^2$; $r^2 = 80.54$) generated from NMFS survey data (Figure 4B).

Discussion

Based on our examinations, as well as consultation with experts in diagnostic imaging at Louisiana State University School of Veterinary Medicine, the evidence described above appears to indicate that the right side of the head was damaged leading to the complete loss of the eye and damage to adjacent tissues and skeletal structures. We speculate that the deformation in the current case was the result of post—natal trauma. Similar instances of free swimming chondrichthyans without eyes have been reported for several ba-

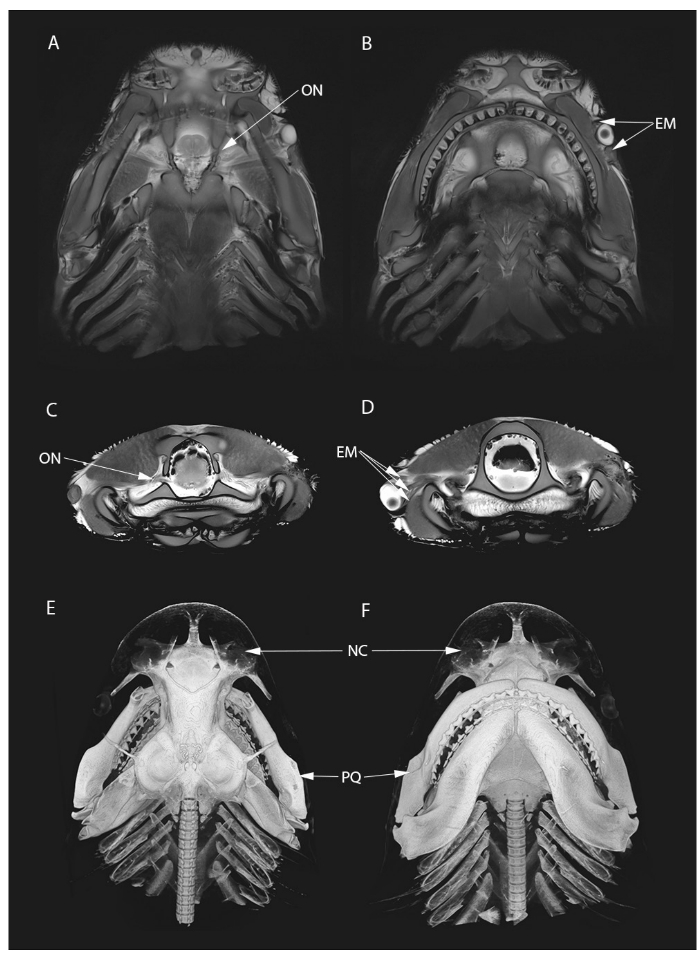

FIGURE 2. *MRI (A-D) and CT (E-F) scan images of subject Bull Shark head. A. MRI coronal section at level of optic nerve penetration in ventral view. B. MRI coronal section at mid-eye in ventral view. C. MRI transverse section at level of optic nerve penetration in caudal view. D. MRI transverse section at level of mid-eye in caudal view. E. Dorsal view of 3D reconstruction of subject bull shark cranium derived from CT scans. F. Ventral view of 3D reconstruction of subject bull shark cranium derived from CT scans. EM = extra-ocular muscles, NC = nasal capsule, ON = optic nerve, PQ = palatoquadrate.*

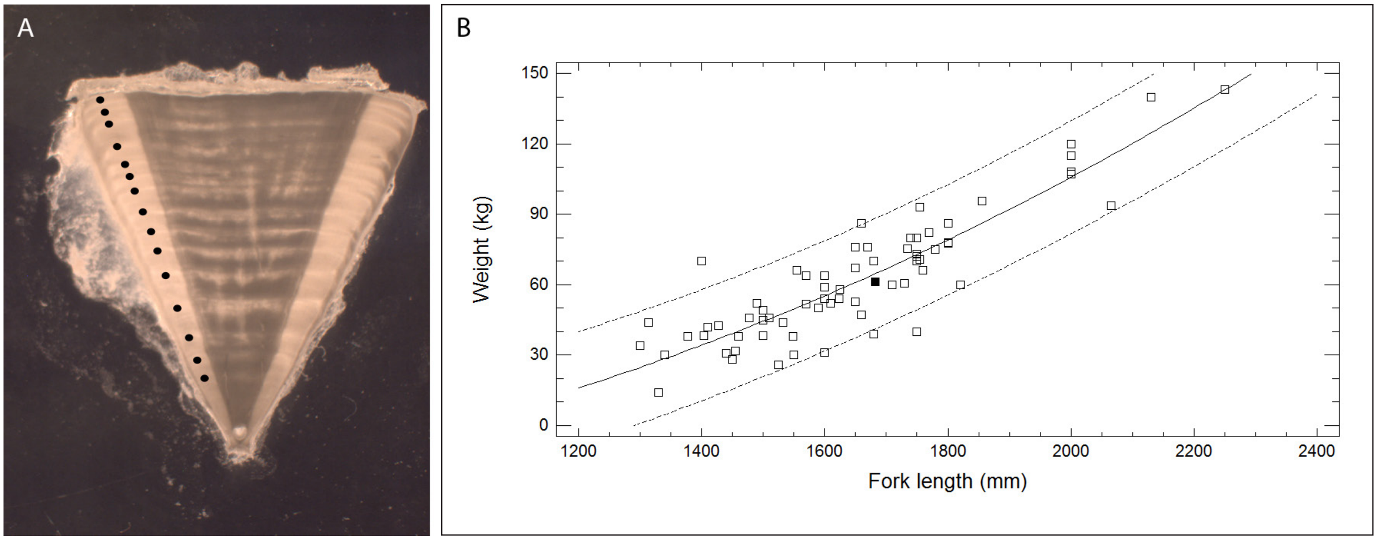

FIGURE 3. *A. Vertebral section of subject Bull Shark. Black dots marking enumerated growth features. B. Length-weight relationship for Bull Sharks captured during Southeast Fisheries Science Center (SEFSC), Mississippi Laboratories longline surveys, which are conducted from about Cape Hatteras, North Carolina on the east coast of the United States to the Texas/Mexico border in the Gulf of Mexico. Black square is the subject individual.*

toid species: *Dasyatis hypostigma* Santos and Carvalho 2004 from off Rio de Janeiro, Brazil (Gomes et al. 1991), *Zapteryx brevirostris* (Müller and Henle 1841) from Santos Bay, Brazil (Ribeiro—Prado et al. 2008), and *Hypanus americana* (Hildebrande and Schroeder 1928) from the Campeche Bank in the southern GOM (Mendoza—Carranza et al. 2016). In the former, it was determined that the abnormality was likely prenatal in origin, as scarring was not noticeable and the muscles, nerves and even the optic pedicle were in good shape on the side lacking the eye (Gomes et al. 1991). In contrast, MRI imagery appears to indicate that there are differences between the eyed and eyeless side in the current specimen with respect to musculature, sensory structures, and the optic pedicle and nerve. While not conclusive, these may indicate that the trauma causing the abnormality was post—natal. Additionally, the disruption in the line demarcating the countershading on the dorsal and ventral surface is consistent with reports of scarring related to wound healing in Blacktip Reef Sharks C. *melanopterus* (Quoy and Gaimard 1824; Chin et al. 2015). Evidence of rapid healing rates of relatively large wounds in Blacktip Reef Sharks has been recently documented from French Polynesia (Chin et al. 2015). For example, a mature male was found to have a large (~25 cm in diameter) wound on its right side. After several subsequent observations, the wound was completely healed 12 months after the initial sighting. Based on this observation, it is possible that a wound of the size necessary to result in the subject deformity would likely have taken at least a year to completely heal.

Regardless of the cause or age of the deformation, the Bull Shark appears to not only have been surviving but thriving based on weight—length relationships. Furthermore, the 13.5 year estimated age matches closely to length—at—age relationships reported in previous studies on the growth of Bull Sharks in the GOM (14.2 years for Branstetter and Stiles 1987; 11.7 or 12.7 years for Neer et al. 2005 depending on model used). The fact that the subject Bull Shark was seemingly in otherwise good health highlights the relative unimportance of vision, in comparison with other senses, to this and other species inhabiting nearshore benthic environments where visibility may be limited (Kotrschal et al. 1998, Lisney and Collin 2007, Mendoza—Carranza et al. 2016). Multivariate analyses, used in an effort to characterize Bull Shark habitat preferences, indicated that transmissivity is an important factor influencing Bull Shark distribution in the northern Gulf of Mexico (Driggers, unpublished data), with Bull Sharks caught more regularly in areas of low transmissivity and therefore, low visibility. Over their long evolutionary history, sharks have developed a suite of senses to aid in the detection of prey and avoidance of predators, including both near field (e.g., electrosensory) and far field (e.g., olfactory) senses. Coastal species like the Bull Shark may spend a substantial amount of time inhabiting turbid waters with low visibility (Lisney and Collin 2007) and must therefore rely more heavily on senses other than vision to guide prey capture and predator avoidance (Kotrschal et al. 1998).

To our knowledge, this is the first record of such a deformity in a free—swimming shark, although several reports of such deformities have been reported for batoids (i.e., Gomes et al. 1991, Ribeiro—Prado et al. 2008), including an eyeless morphotype of *Hypanus americana* from the Campeche Bank in the southern GOM (Mendoza—Carranza et al. 2016). Despite high levels of commercial and recreational fishing in the GOM, as well as many research surveys conducted in the area, records of deformations regardless of their apparent causes are rare. This is most likely due to under—reporting as the authors of this paper have personally witnessed many deformations, such as missing fins (both partial and in entirety) and completely healed bisected jaws. Most of these instances are probably the result of interactions with either fishing gear or other sharks. These unreported cases speak to the physical resilience of sharks in general and, in the case of the subject animal, specifically when it comes to deformations that would likely prove fatal to organisms that rely solely upon visually mediated predatory behaviors.

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