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# Shortfin Mako, *Isurus oxyrinchus*, Impaled by Blue Marlin, *Makaira nigricans* (Teleostei: Istiophoridae)

Harry L. Fierstine,[1] Gregor M. Cailliet,[2] and Julie A. Neer[2]

[1]*Biological Sciences Department, California Polytechnic State University San Luis Obispo, CA 93407*
[2]*Moss Landing Marine Laboratories, Moss Landing, CA 95039-0450*

Although billfish are known to drive their rostra into pelagic sharks, most accounts attribute impalement to the swordfish (*Xiphias gladius*) and not to a member of the family Istiophoridae (Gudger 1940; Smith 1961; Starck 1960). In the only record of a shark having been stabbed by an istiophorid billfish, Cliff et al. (1990) reported that a female shortfin mako (*Isurus oxyrinchus*) was caught off South Africa with the broken rostrum of a sailfish (*Istiophorus platypterus*) embedded in its left orbit. Few other details were given. We present an account of a shortfin mako caught off Baja California, Mexico that was discovered during fish processing operations to have an istiophorid rostrum embedded in its vertebral column (Fig. 1). We briefly discuss the effects of impalement on both shark and billfish.

According to David Arpia (American Sea Food Co., Inc., San Diego, CA, April 3, 1995), "the shark, a male, was caught by longline about 72 km west of Enseñada, Baja California, Mexico, and weighed approximately 28.3 kg dressed. Length was not recorded. It appeared healthy at time of capture with only a slight blemish in its skin where the rostrum entered the body. Except for a capsule of scar tissue surrounding the bone fragment, the flesh appeared normal, and was processed for sale as usual. The broken (posterior) end of the bill fragment was located about two inches (5 cm) below the skin surface." The bill entered the left side of the shark at the level of the second dorsal fin, completely penetrating a vertebral centrum without entering muscle tissue of the right side. A section of the vertebral column with the embedded bill (SIO 94-4) is housed in the Marine Vertebrates Collection, Scripps Institution of Oceanography, La Jolla, CA 92093.

We follow the methodology and terminology of Fierstine and Voigt (1996) and Fierstine and Crimmen (1996) in identifying rostral fragments. Because the bill in this study was a distal segment, measurements and ratios were compared with values from Table 1 of Fierstine and Voigt (1996) at one-fourth bill length (0.25L, or one-fourth the distance between the tip and the orbital margin of the lateral ethmoid).

The bill fragment (Table 1; Fig. 1) is from the distal end of the rostrum and is worn slightly at its tip. We estimate that it was broken slightly anterior to 0.25 L, with paired nutrient canals exposed on the posterior surface. The rostrum is from *Makaira nigricans* (blue marlin) because of the following combination of features: (1) placement of the nutrient canals (DD/D) with respect to depth of the rostrum at 0.25L (=0.65, a value outside the observed range of all istiophorids, but very close to *M. nigricans* and *Tetrapturus angustirostris*); (2) the absence of denticles on the dorsal surface (eliminates all istiophorids inhabiting the Indo-Pacific Ocean except *M. nigricans* and *T. angustirostris*); (3) no evidence of a prenasal in the fragment (eliminates *T. angustirostris*).

Fig. 1. Vertebral segment at level of second dorsal fin of *Isurus oxyrinchus* (SIO 94-4) with embedded rostral fragment of *Makaira nigricans*.

Rostrum morphology suggests the blue marlin was similar in size to Los Angeles County Museum specimen LACM 25491, i.e. slightly less than 44 kg and 173 cm lower jaw to fork length. Blue marlin of this small size would be an immature fish (Hopper 1986).

To obtain an estimate of total length (TL) of the mako shark, we used several morphometric conversion equations developed from second dorsal fin (Garrick 1967; Gubanov 1974; Applegate 1977) and centrum diameter (Cailliet et al. 1983a) measurements in the literature, and from one female shortfin mako with a similar-sized second dorsal fin collected off southern California. Both methods of estimating length resulted in ranges between 200–230 cm TL. We follow the methodology of Cailliet et al. (1983a, b) in estimating age of the shark. Two vertebrae were removed from the vertebral column directly below the second dorsal fin, one immediately anterior and another posterior to insertion of the bill. Age was estimated by counting the number of opaque bands observed in the x-

Table 1. Measurements and ratios of a rostral fragment of *Makaira nigricans* found impaled in *Isurus oxyrinchus* (SIO 94-4).

| Measurements (mm) | | | | | Ratios | | |
|---|---|---|---|---|---|---|---|
| Length of fragment | Width (W) @ 0.25L | Depth (D) @ 0.25L | Height of nutrient canals (H) @ 0.25L | Distance of nutrient canal from dorsum(DD) @ 0.25L | D/W | H/D | DD/D |
| 98 | 14.4 | 9.3 | 1.0 | 6.0 | 0.65 | 0.11 | 0.65 |

rays and by counting ridges along the anterior surface of a whole vertebra. Two different age estimates were produced, one using the assumption of one band pair per year (Cailliet et al. 1983a) and the other using two bands pairs per year (Pratt and Casey 1983a, b).

Both vertebral analysis techniques produced estimates of 7 or 8 band pairs. Thus, the age of this mako was either 3–4 years (Pratt and Casey 1983a, b) or 7–8 years (Cailliet et al. 1983a). A male shortfin mako of this size (200–230 cm TL) would be close to mature (Cailliet et al. 1983a), regardless of age. Female shortfin makos become mature at a larger size, approximately 280 cm TL (Stevens 1983).

There is no evidence to determine if the place of capture of the shortfin mako was also the site of its encounter with the blue marlin. The presence of both *I. oxyrinchus* and *M. nigricans* is more commonly found off Baja California Sur than Baja California. Both species favor a similar epipelagic, oceanic environment, have a worldwide distribution (Compagno 1984; Eschmeyer et al. 1983), and are capable of long distance migrations (Nettles et al. 1994; National Marine Fisheries Service, unpublished).

When the blue marlin broke away from the shark, we assume fracture occurred at the skin surface (the thinnest region of the exposed rostrum) and not within the muscle. Friction between the denticles and the cartilage and muscle tissue probably kept the rostrum from being withdrawn. As both fish struggled to separate, the skin surface functioned as a fulcrum about which the bill fractured in a dorso-ventral plane. Since the rostrum was found 5 cm below the skin surface, the shark grew in caudal diameter (and presumably length) after it had been speared. When compared with vertebrae from an unimpaled shortfin mako of similar size, band patterns did not indicate an alteration of growth after stabbing.

Shortfin makos are opportunistic predators often feeding on scombrids (Compagno 1984) and occasionally on istiophorids, and generally eat prey between 23–35% of their length (Cliff et al. 1990). The sailfish responsible for spearing the mako shark off South Africa (Cliff et al. 1990) was well within the size range of prey consumed by shortfin mako, thus the spearing probably was a defensive response to a predatory act. In contrast, the incident we present here may not have occurred during feeding because the blue marlin probably exceeded the preferred prey size of the shark. We do not know the exact length of either fish at time of impalement but the blue marlin (TL = ~173 cm lower jaw to fork + tip of lower jaw to tip of bill + fork to tip of caudal fin) was probably as long as or longer than the shortfin mako (TL < 200–230 cm).

Most effects of physical encounters between sharks and billfish are unknown. The shortfin mako that was captured off South Africa was impaled in its left orbit and was underweight for its length, and Cliff et al. (1990) speculated that the shark's vision had been impaired enough to affect foraging success. In the case presented here, the shark apparently remained healthy because no vital organ was pierced. In contrast, we know little of the effect on billfish after a rostral fracture. It seems reasonable that loss of a section of the bill would make a billfish more vulnerable to predation, but evidence is lacking. We do know some fish recover from their injuries because there are several records of apparently healthy billfishes with damaged, malformed, or missing rostra (Frazier et al. 1994).

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