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Survival against predation in dolphinfish *Corypahena hippurus* (Carangiformes: Coryphaenidae) off the coast of Oaxaca, Mexico

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Abstract: A mature male dolphinfish of 140 cm furcal length was reported with an avulsive and massive wound causing the loss of the occipital crest. The wound was with mature healing of three or four months of evolution, which indicates a high regenerative capacity, which significantly reduces mortality.

Key words: Avulsive injury, *Coryphaena hippurus*, Oaxaca, predation, survivor.

Supervivencia del dorado *Corypahena hippurus* (Carangiformes: Coryphaenidae) frente a la depredación, en la costa de Oaxaca, México. Resumen: Se reporta un dorado macho maduro de 140 cm de longitud furcal que presentaba una herida avulsiva y masiva ocasionando la perdida de la cresta occipital. La herida estaba con cicatrización madura de tres o cuatro meses de evolución, lo que indica una alta capacidad regenerativa, la cual reduce de manera importante la mortalidad.

Palabras clave: Herida alvusiva, *Coryphaena hippurus*, Oaxaca, depredación, sobrevivencia.

The dolphinfish *Corypahena hippurus* Linneaus, 1758, is a species that in Mexico, its capture can only be carried out by sport fishermen in a strip that includes from the coastline to 92 km (DOF 2013, 2024), and its incidental capture by fishing fleets is permitted. Although illegal fishing is considered very important (Alejo-Plata *et al.* 2011). Their distribution is circumtropical, it is considered a major pelagic species, highly migratory and very fast-growing, reaching sexual maturity at about five months of age and senescence at five years old (Palko *et al.* 1982, Moltó *et al.* 2020); and they are voracious predators that can reach cannibalism (Manooch *et al.* 1984, Pitman & Stinchcomb 2002). The main predators of *C. hippurus* in adult stages are dolphins (Pitman & Stinchcomb 2002), billfish (Kidcochiese 2014), and sharks (Córdova-Zavaleta *et al.* 2018), including attacks by cookiecutter sharks (Menezes *et al.* 2022). Its rapid growth reflects a high metabolic rate (Moltó *et al.* 2020), which may

be responsible for the resilience and resistance of the species to non-lethal injuries and deformities. The present work is the first to document an adult male dolphin fish with a massive injury in the cephalic region with satisfactory healing, demonstraiting the high resilience of the species to physical damage.

This case is based on the observation of an adult male specimen in the bycatch of the artisanal tuna troll fishery on June 25, 2009, in the 50 m depth location (15° 39' 36" N; 96° 18' 0" W) and landed in Puerto Angel, Oaxaca (15° 40' 0" N; 96° 29' 26" W, Fig 1). The organism was allowed to be measured and photographed for only five minutes before being taken to storage. The organism was measured (furcal length FL) with a tape measure to the nearest cm and weighed (total weight W) with a WeiHeng hook scale with a capacity of 10–50,000 g (+/– 10 g). Photographs were taken with a Cannon Eos Rebeld 500D camera. Wound type was determined according to Esteva (2006), and the four degrees of healing was established according to the criteria of Sveen *et al*., (2020): 1) repitalization, 2) inflammation, 3) granulation tissue, and 4) maturation. Marks that were still visible on healthy skin surrounding the wound were analyzed according to the criteria of Ritter & Levine (2004, 2005), such as the presence of first and second bite marks (trapped and grasping cut), type of dental mark, and number of marks. The health status of the specimen was established using the allometric condition factor (Froese 2006) (K = observed weight/theoretical weight) using the theoretical weight according to the function: $W = 4x10\text{-}6FL^{3.1435}$ and compared with the values provided for the Costa Chica of Oaxaca by Solano-Fernández *et al.*, (2015).

The specimen was a male 140 cm FL (Fig. 2a) and 16,300 g with an acute avulsive wound of 16 cm with bone loss of the supra-occipital crest and separating part of the dorsal fin from its anterior pterygiophores (Fig. 2b). The wound was 90% mature. At the base of the anterior dorsal rays, the condyles of the nine rays were observed with repithelialization and vascularization in the area (Fig. 2c). At the anterior base of the supraoccipital crest (4 cm and 2 cm), two lateral openings in granulation phase were observed (Fig. 2c). Based on the mechanical characteristics of the wound, it is considered that there were two bites (Fig. 2b), the clamping bite that coincided in the part of the dorsal radii with the grip-cut bite, which must have been made with a sudden lateral head movement. In both bites, it is observed that they were made with cutting and triangular teeth (typical of a shark of the genus *Carcharhinus*) with tangential entry. There are 18 well-defined dental marks distributed in an irregular manner, with sufficient force in the pressure so that with a lateral head movement it could break the supra-occipital crest and leave shreds of skin that served as support in the healing

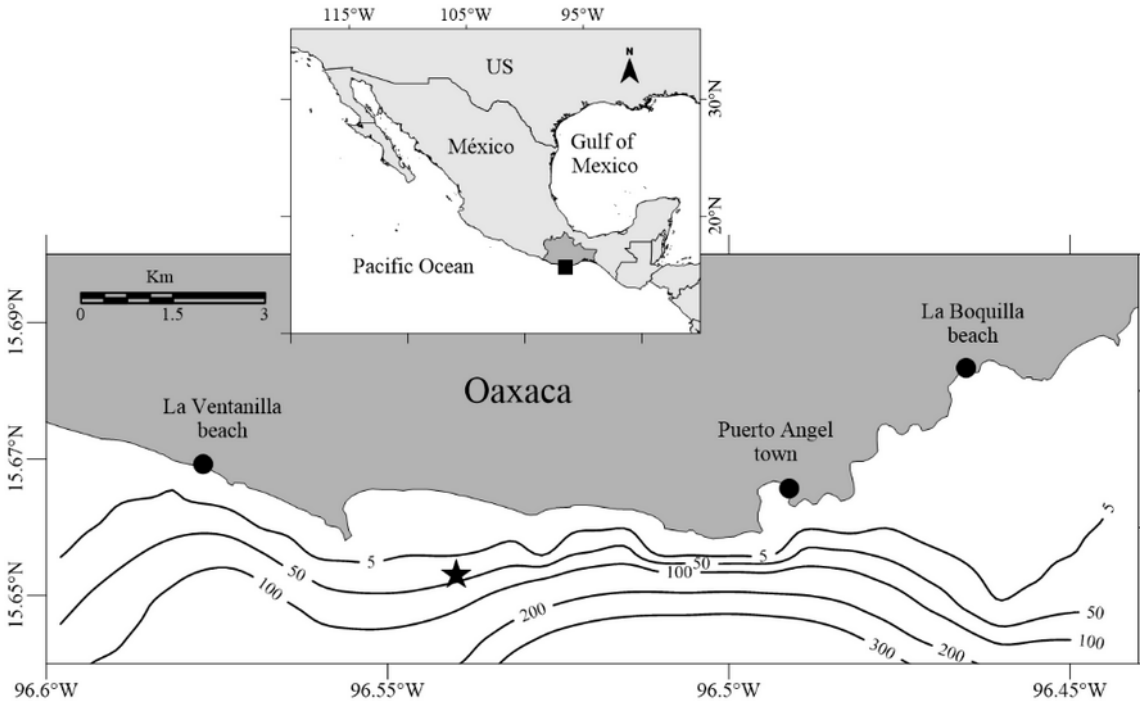

Figure 1. Map of the coast of Oaxaca, Mexico. The capture area (black star) of *Coryphaena hippurus* is shown. Figure by Vicente Anislado-Tolentino.

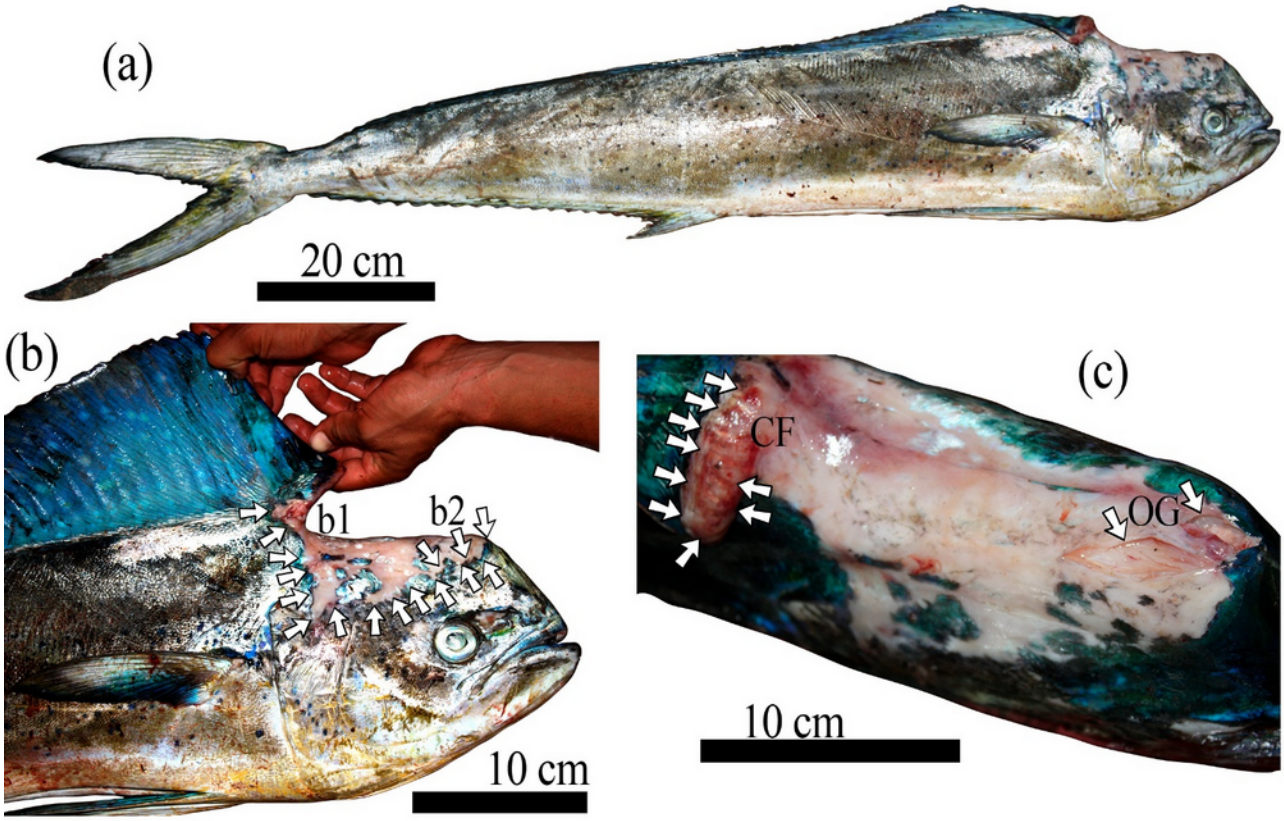

Figure 2. a, *Coryphaena hippurus* 140 cm furcal length with a wound on the dorsal cephalic part landed in Puerto Angel Oaxaca; b, Cephalic view with the dorsal fin unfolded, and maturing wound view, arrows indicate tooth marks, b1 trapped bite mark and b2 grip-cut bite mark; c, dorsal view of repithelialization at the base of the rays, left arrows indicate the condyles rays dorsal fin (CF), right arrows show a openings in granulation phases (OG); Photographs by Vicente Anislado-Tolentino.

process. Due to rapid tissue regeneration and the lack of opportunity for a detailed necropsy, it was not possible to identify the species of the attacker. Comparing the condition factor obtained for the specimen analyzed (K = 0.75) with the values reported for the Costa Chica of Oaxaca (males from K = 0.925 to 1.12) (Solano-Fernández *et al.* 2015), a severe low health condition is observed, a consequence of muscle and bone loss, and probably a degree of malnutrition because the metabolic processes were redirected to the wound healing.

Knowledge of the biology of fish species is limited to the acquisition of data in fisheries. In commercial fishing, a large amount of information is provided, while in sport fishing, data are limited to adult organisms. Other limitations are that it depends on the willingness of the fisherman, the judges, and some other instances to take the sample and biological data. When sport fish, such as dolphinfish, are caught as bycatch, they are processed immediately, and in most cases, researchers are not allowed to take samples, the best tool being the use of photography. In the analyzed case, it was possible to take photos and data from a post-predation survival event. The specimen showed a great resilience with a mature healing at almost 90%, despite the considerable loss of muscle and bone, compared to what was observed by Sveen *et al*. (2020), it is possible that this process has occurred in an interval of three to four months, considering that the dolphinfish has a high metabolism (Perrichon *et al*. 2019, Sveen *et al*. 2020), there should be some intrinsic mechanism that allows the maximum use of energy in healing and therefore the condition factor of the specimen was reduced to values that could indicate starvation (K below 0.75), according to the known values for the area whatever the time of year (Solano-Fernández *et al.* 2015), but in this particular case is due to the severe loss of biomass by the bite received and that much of the energy was focused on the healing

of the wound. This healing ability to heal a massive avulsive injury is a strategy to reduce natural mortality, and in this particular case, the survivor was a large adult male, so the population does not lose a massive spawner (high fecundity, Massutí & Morales-Nin 1997). Several pelagic species, including *C. hippurus*, must undergo this rapid healing due to attacks by various predators, including Cookiecutter sharks (genus *Isistius* sp.), which leave characteristic circular wounds (Menezes *at al.* 2022). Based on the results, it is evident that the dolphin fish is highly resilient to injuries, minimizing the effects of natural mortality due to predation. This characteristic is vital to encouraging capture and release policies for sport fishing.

Ethical statement

This study did not involve experiments on living organisms or humans. This study utilized samples obtained from commercial fisheries. No live organisms were involved or maintained for the purpose of this research.

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