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RESEARCH ARTICLE

Records of predatory, con-specific and human induced mauls on fish from the Northeast Atlantic and Black Sea

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Abstract

Present study aims to describe records of mauled and con-specific injures in various fish inhabiting different environment and to discuss possible impacts on fish behavior and ontogenesis. The fish specimens were collected from the Black Sea and Azores Islands (NE Atlantic). Individuals of European flounder, *Pleuronectes flesus*, common stingray, *Dasyatis pastinaca* and turbot, *Scophthalmus maximus* with missing dorsal and caudal fins and flesh, were found in the Black Sea. Specimens with severe mauls of the ocean sunfish, *Mola mola*, almaco jack, *Seriola rivoliana* and sargo, *Diplodus sargus* were recorded from the Azores Islands. All of them were caught alive and survived severe mauls caused by predators or by accidents with propellers, fishing nets. The NE Atlantic records, although possibly caused by natural predation, are more probably than not the result of negative interactions with human activity. Numerous records of mauled fish species from both regions show that the problem with adverse effects of fisheries is quite important. Predatory and con-specific injuries obviously are compatible with basic fish vital functions of described cases. The problem with negative anthropogenic interactions seems to be insufficiently investigated and need more attention by responsible managers and decision makers.

Keywords: Black Sea, North Atlantic, mauls, predation, human activity

Introduction

The use of fins is an important issue for understanding fish locomotors biomechanics because fish are statically unstable (Harris 1937; Webb 2002; Weihs 2002). Fish use their fins to control body posture, and the relative position of fins to the centre of mass (COM) and centre of buoyancy (COB) is important in determining the forces and torques a fish experiences and produces

during swimming (Standen and Lauder 2005). The active role of dorsal fins during propulsion and maneuvering, as well as the absence of equivalent information available on the role of anal fins were extensively discussed by Drucker and Lauder (2004) and Lauder *et al.* (2002). Dorsal fin musculature is active during steady swimming and maneuvers, which suggests the soft-rayed portion of the fin acts as a control surface independent of the body (Jayne *et al.* 1996). The strong reaction of fish to correct for roll perturbations suggests important stabilizing functions for fins having the greatest ability to influence roll in fish: the dorsal and anal median fins (Webb 2002). The paired pelvic fins in fish have been the subject of few studies. Early work on amputated pelvic fins concluded that these fins had very limited and mainly passive, stabilizing functions during locomotion (Standen 2008). It must be emphasized that the swimming movements are produced by the whole of the muscular body, and in only a few fish do the fins contribute any propulsive force. Their main function is to control the stability and direction of the fish (Lauder 2000). For juveniles and adults of many fish species, pectoral fins act as primary propulsions during rhythmic swimming (e.g.; Webb 2006; Hale *et al.* 2006), and in arrhythmic movements such as braking (e.g. Drucker and Lauder 2004) and maneuvering. The results obtained by Matthew *et al.* (2011) indicate that the functions of the fins differ markedly between larvae and adults. Larval fins are not major propulsions in forward swimming but do serve a respiratory function.

In the Black Sea, the turbot, *Scophthalmus maximus*, is one of the top predators (Ivanov and Beverton 1985; Sampson *et al.* 2014). Turbot larvae reach metamorphosis between days 30 and 36 at a length of 22 mm at temperatures between 13.2°C and 17.8°C (Kuhlmann *et al.* 1981). Predation on larvae and young-of-the-year is little studied in the wild, whereas most of the early stage malformations and prey-predator relations were reported from artificial rearing experiments in the Black Sea area (Spectorova *et al.* 1974; Spectorova and Doroshev 1976; Kohno *et al.* 2001; Rosenberg and Haugen 1982; Hara *et al.* 2002), as well as skeletal development and abnormalities of the vertebral column and fins induction of turbot triploids (Hernández-Urcera *et al.* 2011) and toxicity for turbot larvae and abnormalities (M'hadhbi and M. Boumaiza 2010).

The European flounder, *Platichthys flesus*, is a flatfish of European coastal waters from the White Sea in the north to the Mediterranean and the Black Sea in the south. The developing larvae are planktonic and drift towards the coast with juvenile flounders living in shallow waters and estuaries (Froese and Pauly 2013). The external abnormalities of captive flounders were examined by Aydin (2012); intersex abnormalities due to high concentrations of vitellogenin (Bateman *et al.* 2004).

The common stingray, *Dasyatis pastinaca*, is found in the northeastern Atlantic Ocean and the Mediterranean and Black Seas. It typically inhabits sandy or

muddy habitats in coastal waters shallower than 60 m and is also sometimes encountered near rocky reefs or in estuaries, as it is tolerant of low salinity (Lythgoe and Lythgoe 1991; Serena 2005; Karapetkova and Givkov 2006). Abnormalities in rays such as lack of part of the snout in the Bay of Biscay were reported by Forster (1967), in skates (*Raja*) from the Newfoundland area (Templeman 2011), an aberrant (rather pathetic) file fish, *Rudarius ercodes* without a tail (Honma 1994), *Dasyatis akajei* with aberrant pectoral fins from the Sea of Japan (Honma and Sugihara 1971), morphological abnormalities in embryos of *Urotrygon rogersi* in the tropical eastern Pacific (Mejía-Falla and Navia 2011).

From the literature review it is clear that the fish fins play a significant role in several of biological functions, stability and locomotion.

The objective of the present study is to describe records of mauled and con-specific injuries in various specimens inhabiting different environment and to discuss possible impacts on fish behavior and ontogenesis.

Materials and Methods

Individuals of European flounder, *Pleuronectes flesus*, were caught on board of F/V Egeo 3 (08/09/2014, N 42.98347 E 028.16805 - N 42.93098 E 028.13266) (Figure 1A). The adult individual was caught alive. The specimen of common stingray, *Dasyatis pastinaca*, was caught with missing caudal fin (Figure 1B; 09.09.2014, N 43.01350 E 027.57540 N 42.5840 E 027.58115). A specimen of turbot, *Scophthalmus maximus*, with missing of approximately $\frac{1}{4}$ of the total body length dorsal fin and flesh, was caught by F/V Egeo 3 off the Bulgarian coast in the Black Sea (on 11/09/2014, N 43.22057 E 028.21222 - N 43.25764 E 028.16161) (Figure 1C). The wound was fully healed, covered with dark pigmented skin in both turbot and flounder.

Specimens of the ocean sunfish, *Mola mola*, Almaco jack, *Seriola rivoliana*, and sargo, *Diplodus sargus*, (Figures 2A-E) were recorded from the Azores Islands (Ad libitum data collected by Prof. Bareirros (Terceira Island, Azores, NE Atlantic, 2005 to 2008). All of them were caught alive and survived severe mauls caused by predators or by accidents propellers and fishing nets.

Results

Three records of mauled specimens from the Black Sea were presented in this study (Figures 1A-C, Table 1). Total length of the turbot individual was 450 mm (TL) and missing dorsal fin was 133 mm. Width of the bite was measured as 45 mm. The record of *P.flesus* with missing dorsal fin and flesh, approximately $\frac{1}{5}$ of the total body length was 142.8 mm in total length. Third record from the Black Sea was common stingray specimen with missing caudal fin. The first

two records of mauls are probably due to predation in early life stages of the described specimens. Healed severe mauls on adult individuals obviously are not contradictory to vital functions in the ontogenesis. The adult individual of common stingray survived without caudal fin. Probably this abnormality appeared at embryonic stage.

Table 1. Length and missing body parts of three flatfish with recorded mauls

Species	Body Length	Type of Abnormalities	Dimension of Maul
<i>Scophthalmus maximus</i>	TL = 450 mm	Missing dorsal fin length 133 mm	Width of bite 45 mm
<i>Pleuronectes flesus</i>	TL = 142.8 mm	Missing dorsal fin length 27.05 mm	Width of bite 23.12 mm
<i>Dasyatis pastinaca</i>	SL = 370 mm	Missing caudal (unknown length)	

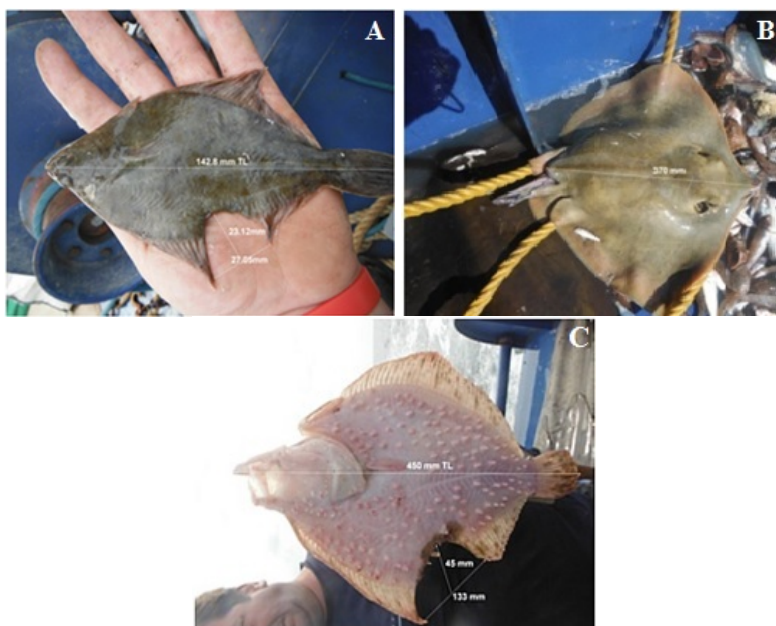


Figure 1. Mauls (A) *Pleuronectes flesus* (B) *Dasyatis pastinaca* (C) *Scophthalmus maximus* from the Black Sea

Several species of fish found in the Azores show cicatrized parts in their bodies and/or fins (Figures 2A-E). Here, we selected a possible propeller accident amputating a sunfish, *Mola mola* (Figure 2A) and a very recent one – detected just after a dorsal fin propeller amputation caused by a fishing boat – of this same species (Figure 2B). Caudal fin amputation and regeneration are seen in the specimens of Almaco jack, *Seriola rivoliana*, (Figures 2C, D) and a cicatrization process in the dorsal part of a white sea bream *Diplodus sargus* (Figure 2E).

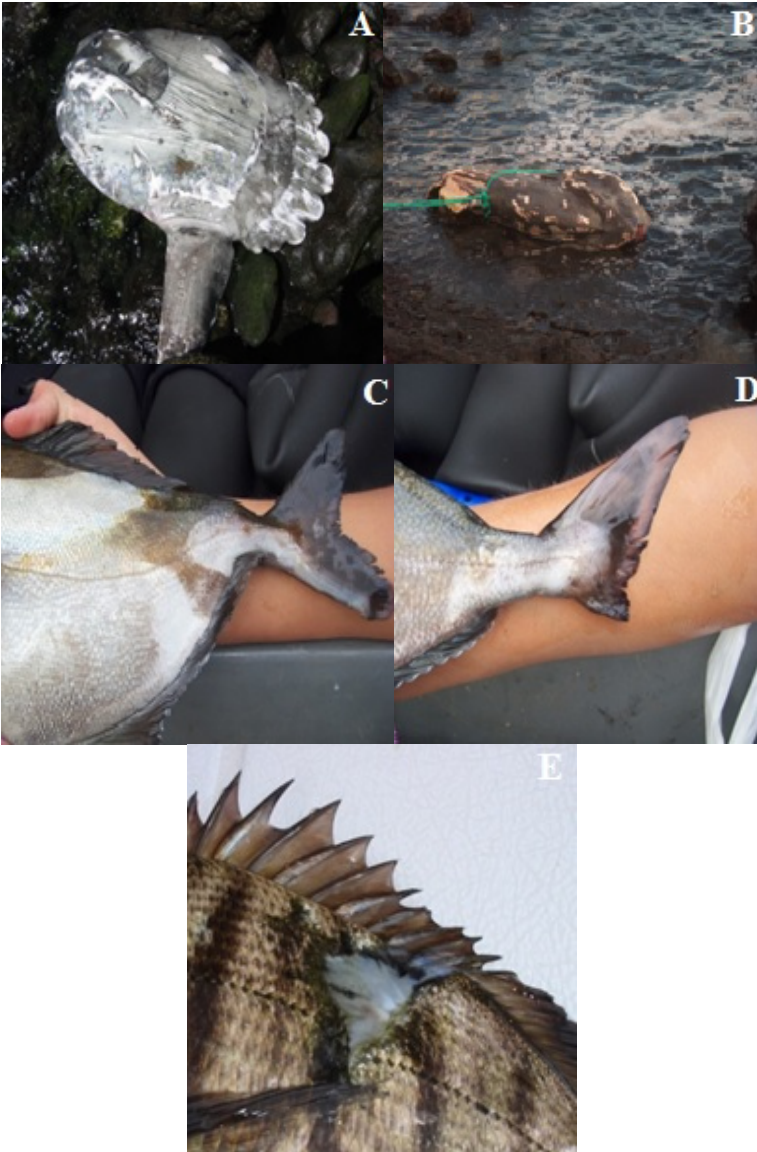


Figure 2. Records of mauled specimens from the Azores (North Atlantic); A, B - *Mola mola*; C, D - *Seriola rivoliana*, and E - *Diplodus sargus*.

Discussion

The first appearance of 0+age turbot larvae in the near coastal zone occurs in July, when the turbot larvae finalize their pelagic stage passing over to benthic way of life (Karapetkova 1980). The same author stated that in September-October the mass appearance of the turbot young-of-the-year in the near shore zone consisted of individuals between 7.8 and 14.5cm in total length. This coincides with the active migration of the bluefish, *Pomatomus saltatrix*, in the Western and North-western part of the Black Sea (Karapetkova and Givkov 2006). Adult bluefish are strong and aggressive, and live in loose groups. They are fast swimmers which prey on schools of prey fish, and continue attacking them in feeding frenzies even after they appear to have eaten their fill (Froese 2006). Buckel (1997), Buckel and Conover (1997) stated that turbot, *Scophthalmus aquosus*, from the U.S. East coast continental shelf is included in the feeding items of bluefish. Knowledge on the biology of the spiny dogfish is only fragmentary. Wilga and Motta (1998) discovered that the spiny dogfish have two separate feeding methods: they either suck their food by quickly lowering the lower jaw to produce a kind of suction, or some potential prey is rammed before being eaten. They appear to prey upon school fish as well as invertebrates such as crabs or mussels. Santos *et al.* (2007) reported the feeding items of the bottlenose dolphin, *Tursiops truncatus*, in the Galician coast (NE Atlantic) included one species from Bothidae but no species from Scopthalmidae. Feeding habits of Atlantic bonito, *Sarda sarda*, were well documented as a typical pelagic predator (Campo *et al.* 2006; Fletcher *et al.* 2013). Birkun 2002 mentioned that turbot is the primary prey in the bottlenose dolphin's diet in the Black Sea. Bowman *et al.* (2000) reported that the main food items for the Atlantic bonito is nekton - adults and juvenile forms of bony fish, squid and shrimps. The lack of tail fin in our common stingray could be due to embryonic malformation or due to predation in the early post-embryonic life stages. Nevertheless, the adult animal was caught alive, obviously able to feed and reproduce without caudal fin.

Whitfield and Becker (2014) showed that motor boats impact on the biology and ecology of fish but the effects vary according to the species and even particular size classes. The Azorean cases seem to be more connected to anthropogenic causes than those from the Black Sea. Although predatory maulings are obviously possible, the NE Atlantic examples point to human derived causes either from discarded fishing gear (also the possibility of fish having escaped fishing lines – no nets are used in the Azores) and accidents with propellers for bigger species such as *M. mola*. Visible scars from nets on the ocean sunfish are evidence for the negative effect of fishing activities. However, this aspect have been poorly documented in the literature and requires further assessment and quantification.

The amputation of various fin combinations of the living fish have been conducted in experimental conditions: (1) Amputation of the anal fin and the hypocaudal lobe of the tail: the fish swims along the bottom of the tank, unable to progress in a horizontal plane in the open water above this level. There is no longer any vertical (upward) component of the tail force, and therefore no negative pitching moment. (2) Amputation of the second dorsal fin and of the epicaudal lobe of the tail. This operation produces comparatively little effect. The area of these fin regions is small, and the increased lift at the tail end (negative pitching moment) can easily be counteracted by a slight increase in the normal angle of incidence of the pectoral fins. (3) Amputation of the first dorsal fin. There is a slight but noticeable increase in the rolling of the fish while swimming, but no other effect is visible. (4) Amputation of the pelvic fins. As would be expected from the wind-tunnel results, this operation produces no effect on the swimming. (5) Amputation of the pectoral fins: This produces the most marked effect of all such fin operations, but the actual phenomena observed require some explanation. Removal of a portion of the dorsal fin also produces an increased rolling movement while swimming, but also reduces considerably the efficiency of a turn. There is here much less flexibility of the anterior region of the body, and the contribution of the dorsal fin to the turning forces is relatively much greater (Harris 1938).

Swimming performance is important for fish because it is closely related to the ability to gain food, to avoid predators and to perform other daily activities (Fu *et al.* 2012). As an important locomotive organ for most fish species, the caudal fin plays a crucial role in propelling and guiding fish during swimming (Lauder *et al.* 2002). The shape, size and stiffness of the caudal fin are all expected to strongly affect swimming performance (Plaut 2000). In nature, the caudal fin is frequently observed to be partly lost due to aggressive behavior, predation and diseases (Winemiller 1990; Ziskowski *et al.* 2008; Sinclair *et al.* 2011; Fu *et al.* 2013). Thus, fish must physiologically and behaviorally adjust to the probable negative effects on swimming performance caused by caudal fin loss and survive. The relationship between the caudal fin and swimming performance has attracted broad attention for a long time, and caudal fin amputation has been widely used in previous studies (Webb 1973; Webb 1977; Champagne *et al.* 2008; Yang *et al.* 2013). It has been found that caudal fin amputation profoundly alters the swimming behavior and/or speed in sockeye salmon, *Oncorhynchus nerka* (Webb 1973), rainbow trout, *Salmo gairdneri* (Webb 1977) and Chinese bream, *Parabramis pekinensis* (Yang *et al.* 2013), while it showed no effect on swimming performance of brown darters, *Etheostoma edwini* (Champagne *et al.* 2008). Caudal fin damage may result in a decline in swimming performance. However, the decreased caudal fin area will also result in a decrease in drag during swimming (Webb 1973; Sinclair *et al.* 2011), making it easier for fish with damaged caudal fins to finish each tail beat. Schulz (2003) found that in fish wounds do not inflame and nothing like suppuration takes place in them after injures. The reproductive power of fish is

confined to their fins. Over the winter, food resources are limited and the fish become stressed and malnourished. The pecking combined with malnourishment makes the fish vulnerable to infection and necrosis, which ultimately overcomes them. This type of fish death is more common in ponds that are overcrowded. The same author found reports that small numbers of large breams are dying with large wounds, most likely due to cannibalism. This passes as spring starts and does not have a significant effect on the fish population (<http://www.clemson.edu>)

In addition, fin shape and size in many fish species is subject to sexual selection, either because females choose to mate with males that have larger fins or because males with larger fins gain access to more females through male-to-male competition (Warner and Schultz 1992; Wilson *et al.* 2010). Thus, for many fish species, the existing size of the caudal fin may not be best suited to sustainable swimming performance, but instead may be a response to sexual selection or a compromise with unsteady swimming performance, which come from the selective pressure of reproduction and escape, respectively (Sinclair *et al.* 2011). Swimming locomotive performance has attracted much attention for a long time because of its importance for survival (Plaut 2001; Kieffer 2010). The importance of caudal fin in locomotion has been emphasized by Romer (1966), Helfman *et al.* (1997) and Lauder (2000). During steady, fairly fast, straight locomotion, forward progression is effected entirely by lateral movements of the body and the caudal fin (Standen and Lauder 2005). In percomorph fishes, the pectoral fins are often used to generate propulsive force via oscillatory movements, and pectoral fin propulsion in this relatively derived clad has been analyzed extensively (Flammang and Lauder 2013). Fish used their pectoral fins to touch obstacles as they swam slowly past them under all conditions. This behavioral evidence suggests that it is possible for unspecialized pectoral fins to act in both a sensory and a propulsive capacity (Flammang and Lauder 2013).

Numerous records of mauled fish species from both regions show that the problem with adverse effects of fisheries is quite important. Predatory and conspecific injuries obviously are compatible with basic fish vital functions of described cases.

The problem with negative anthropogenic interactions (propellers, fishing gear, and plastic debris) seems to be insufficiently investigated and need more attention by responsible managers and decision makers.

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