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Scientific Note

Putative extinction of two sawfish species in Mexico and the United States

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All species of sawfish are listed by the International Union for the Conservation of Nature (IUCN) as endangered or critically endangered. In fact, the smalltooth sawfish *Pristis pectinata*, and the largetooth sawfish *Pristis pristis*, have been declared to be regionally and locally extinct from the US Atlantic coast and the Gulf of California, Mexico, respectively, likely due to overfishing. However, here we dispute these claims by illustrating how lack of existence of a given species within a region can be misconstrued as evidence for extinction.

Todas as espécies de peixe-serra são qualificadas pela União Internacional para a Conservação da Natureza como ameaçadas ou criticamente ameaçadas de extinção. De fato, o peixe-serra-de-dentes-pequenos, *Pristis pectinata*, bem como o peixe-serra-de-dentes-grandes, *Pristis pristis*, têm sido declarados como regionalmente e localmente extintos da costa atlântica dos EUA e do Golfo da Califórnia e México, respectivamente, provavelmente devido ao excesso da pesca. No entanto, aqui pretendemos questionar estas extinções ilustrando como a falta de evidências da existência de uma espécie em uma região pode ser mal interpretada como evidência de extinção.

Key words: Elasmobranch, Batoid, *Pristis*, Local extinction, Conservation.

The smalltooth sawfish, *Pristis pectinata* Latham, 1794 and the large tooth sawfish, *P. pristis* (Linnaeus, 1758) are tropical and subtropical euryhaline elasmobranchs that live in sandy or muddy shallow waters, often close to the shore including bays, estuaries and fresh water habitats with salt water connections (Bigelow & Schroeder, 1953; Last & Stevens, 1994).

The smalltooth sawfish is widely distributed in the Eastern Pacific. It ranges from Mazatlan, Mexico, to Ecuador (Castro-Aguirre *et al.*, 1999) and is also represented in the correspondent latitudinal belt of the Western Pacific and Indian Oceans. In the Atlantic Ocean, it ranges from central Brazil to northern Florida (the northwestern terminus of its Atlantic range) and from equatorial West Africa to the Mediterranean Sea. The largetooth sawfish has been recorded from Southern Florida, throughout the Gulf of Mexico, the Caribbean coast of Central America and the northern coast of South America to Brazilian State of São Paulo. There are also reports from the tropical Eastern Pacific and Eastern Atlantic (NMFS, 2009).

All species of sawfish are listed by the International Union for the Conservation of Nature (IUCN) as endangered or critically endangered (www.iucnredlist.org). In particular, the smalltooth and the largetooth sawfish are sought for their fins, liver and for the ornamental value of their rostrum (Froese & Pauly, 2009); they are considered as severely threatened by overfishing and are becoming increasingly rare (McEachran & Carvalho, 2002). In fact, Dulvy *et al.* (2003) declared 133 cases of marine extinctions worldwide, including these two species to be locally extinct from the Gulf of California (Mexico) and regionally extinct from the Atlantic coast of the United States.

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However, here we dispute the claims of extinctions of *P. pectinata* and *P. pristis* by illustrating how lack of existence of a given species within a region can be misconstrued as evidence for extinction. These two reported regional and local extinctions (henceforth "extirpations") of species of *Pristis* are rather interesting and illustrative of the problems inherent in defining and verifying partial losses for marine organisms.

Dulvy *et al*. (2003) declare *P. pristis* to be extirpated from the Gulf of California, implying that there are no individuals left alive within the basin, due likely to overexploitation. This extirpation report is supported by a personal communication from L. Findley to J. Musick (Musick *et al*., 2000).

The original description for *P. pristis* is based on a sawfish probably caught in Indochina and described in 1758 by Linnaeus, and in 1895 from one specimen sampled in fresh water from Senegal (Castro-Aguirre & Espinosa-Pérez, 1996). The description for Mexico is based on a skin (not even an entire specimen) recovered around 1895 in Mazatlán (outside the southeastern edge of the Gulf of California) by Jordan & Starks (1895), early *P. pristis* is mentioned in the taxonomic list of fishes collected at Mazatlan, Mexico (Jordan & Gilbert, 1882). Moreover, Jordan himself recognized that "The identification may be questioned especially as there are several details in which the description of *P. perotteti* [currently known as *P. pristis*] differs from our fish".

Although there are no other references concerning the occurrence of this species inside the gulf, Castro-Aguirre *et al*. (1999) nevertheless reported *P. pristis* as ranging from Peru to the Southern Gulf of California, based on Minckley *et al*. (1986). However, Minckley *et al*. (1986) never actually collected a live specimen within the Gulf of California, but only "assumed occurrence because of geographic range".

Dulvy *et al*. (2003) also reported *P. pectinata* as extirpated from Bermuda, with the likely cause again being overexploitation. They cite Smith-Vaniz *et al*. (2000) as the original source. Yet almost all literature on this species mentions that *P. pectinata* commonly inhabits the marine environments within the immediate vicinity of land and to waters (Bigelow & Schroeder, 1953) such as bays, estuaries and fresh water habitats connected to the sea (McEachran & Fechhelm, 1998). Such habitats are unlikely to be found in an oceanic island like Bermuda. Second, in order to reach this island from the nearest continental shore (North Carolina), as a few individuals may do on rare occasions; sawfish must cross at least 600 miles of open ocean. Bermuda is therefore unlikely to support a persistent locally maintained stock (Bigelow & Schroeder, 1953). Moreover, there are just three reports for the species in the heavily trafficked waters of Bermuda. The first is a small sawfish found in the stomach of a dolphin, a second was taken near St. David's island in Bermuda, and the third was reported as a sighting (Bigelow & Schroeder, 1953). In fact, Smith-Vaniz *et al*. (2000) clearly mention that the Bermuda occurrence of *P. pectinata* is based entirely on sparse historical records, and they classify the species as vagrant and rare. Does this also qualify as extinction? We argue not. In total and to the extent of our knowledge, *P. pristis* and *P. pectinata* have never been formally reported in the Gulf of California or Bermuda, respectively. How can these species be extirpated by exploitation in those regions if the very existences of resident populations have never been verified?

Although we argue against declaring local extinctions of these sawfish in the Gulf of California and Bermuda, evidence certainly supports the view that these species are now severely threatened in many parts of their range. Currently, smalltooth sawfish population level in US waters is less than 5% of its size at the time of European settlement (NMFS, 2009). *Pristis pectinata* is most common within the boundaries of the Everglades and Florida Keys and becomes rarer with increasing distance from this area (Simpfendorfer, 2002). It is considered a summer visitor to North Carolina; less often to Chesapeake Bay and is only occasionally found northwards of this point (Schwartz, 2003). The northern most limit of *P. pectinata* in the western Atlantic has been reported to be New Jersey and New York (Bigelow & Schroeder, 1953). However, this is based in two records, one for each site, documented 130 and 227 years ago, respectively (Adams *et al*., 2000). On the other hand, *P. pristis* has not been recorded for any locality in the Atlantic west coast north of Florida (Bigelow & Schroeder, 1953), except for a single specimen caught in the Indian River in 1979 (Snelson & Williams, 1981). As such, the available information for this species is even scarcer than that for *P. pectinata*.

The smalltooth sawfish population of US waters includes a migratory segment that follows the outer east coast for the major part of their journey (Bigelow & Schroeder, 1953). Lower sea temperature and availability of appropriate coastal habitat act as the major environmental constraints to this migration (Simpfendorfer, 2002). Since the smalltooth sawfish moves northward during summer and may occur in waters in excess of 50 m depth, it is possible that the entire potential habitat for this species has not been properly sampled. Moreover, the alteration of its brackish and fresh water habitats does not necessarily imply a population decline, because movement into rivers and lakes may be unrelated to the species' life cycle requirements (Thorson, 1976). If such stressors as fishing and habitat modification are mitigated in the historically highly impacted habitats of its former range, dispersion may be sufficient to re-colonize those areas in the future.

Both *P. pectinata* and *P. pristis* were once common and even plentiful in Florida waters (Bigelow & Schroeder, 1953), but are now considered threatened. The official position of the US Government is that despite an absence of strong quantitative information, the obvious rarity of these species and the consistency of anecdotal evidence of population declines are clear indicators of their vulnerability to any form of use, including international trade (NMFS, 1999). In other parts of the world, the status of these species is similar. For instance, populations of sawfish from Colombia and Panama have also been substantially reduced by fishing, although there is no indication of extinction (Vásquez-Montoya &

Thorson, 1982; Mejía & Acero, 2002).

In order to derive improve estimates of extirpation risks for these species, Simpfendorfer (2000) suggests the prudent use of what information is available from the historical literature. In this attitude, we applied the optimal linear estimation method (Roberts & Solow, 2003) based on the sighting record of *P. pectinata* taken from Adams *et al*. (2000) to determine a time interval when this species may go extinct. We divided the sighting records in three different domains of its former distribution range, based on the geographic locations where the species is presumed extinct and on the divisions proposed by Adams *et al*. (2000): (1) US Gulf of Mexico, from Texas to Florida; (2) US Atlantic coast, from the north of Florida to North Carolina; and (3) the northern limit of its distribution, from Virginia to New York.

The model of Roberts & Solow (2003), based on a Weibull distribution for the interval between successive sighting dates, is rather simple and does not take into account the relative abundance as a function of sighting effort nor consider natural spatial distribution of the species. Thus, the conclusions that can be drawn from this method are limited, but useful in the absence of more detailed information required to develop a population viability model.

Their model is described as:

$$\upsilon = \frac{1}{k-1}\sum_{i-1}^{k-2}\log\frac{T_1 - T_k}{T_1 - T_{i+1}}$$

which is an estimate of the shape parameter of the Weibull distribution, where T1>T2>…Tk are the k most recent sighting times of a species, ordered from most recent to least recent. The confidence interval is given by

$$T_1 + \frac{T_1 - T_k}{S_L - 1}, T_1 + \frac{T_1 - T_k}{S_U - 1}$$

where the lower limit is calculated as

$$S_L = \left(-\log\frac{1-\frac{\alpha}{2}}{k} \right)^{-\nu}$$

and the upper limit as

$$S_U = \left(-\log\frac{\frac{\alpha}{2}}{k} \right)^{-\nu}$$

Confidence intervals ($\alpha = 0.05$) for extirpation in domain (1) are 1984 and 2013; for domain (2) they are 1999 and 2061; and for domain (3) are 1929 and 1956. These results suggest that, statistically, the species could only be confidently declared as absent from Virginia to New York, where it has historically been only an exceptional visitor.

We are aware that the current available information on the genus *Pristis* in US waters clearly indicates that population numbers of *P. pectinata* and *P. pristis* are likely to be dangerously below viable levels in almost all of their former range, and that conservation measures to assist both species to recover to "safe" population levels are urgently needed. However, we believe that our analysis of such information, and the results presented herein, are sufficient to cast doubt on the "regional extinction" (no individuals have been left alive) of those species outside the Florida Keys and the Everglades National Park in US waters. It would be unfortunate if conservation efforts were misdirected away from protecting former stronghold habitats in the US, in a vain attempt to 're-establish' these species in other regions where they may never have maintained viable populations.

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