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Note

Anthropogenic effects on the smalltooth sawfish (*Pristis pectinata*) in the United States

Jason C. Seitz [a,*], Gregg R. Poulakis [b,c]

[a] *Florida Program for Shark Research, Florida Museum of Natural History, University of Florida, Dickinson Hall, Museum Road, Gainesville, FL 32611-7800, United States*

[b] *Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Charlotte Harbor Field Laboratory, 1481 Market Circle, Unit 1, Port Charlotte, FL 33953-3815, United States*

[c] *Department of Biological Sciences, Florida Institute of Technology, 150 West University Boulevard, Melbourne, FL 32901-6975, United States*

Abstract

Bycatch mortality in net fisheries was the major reason for the decline of the endangered smalltooth sawfish, *Pristis pectinata*, in the United States. These fisheries have been reduced or eliminated in some states including Florida—where most smalltooth sawfish are currently found in the United States. To determine whether other factors are still affecting this species, we obtained non-net fishery entanglement, injury, and mortality data by soliciting information from anyone who may have encountered this species. Smalltooth sawfish were damaged by marine pollution (e.g., polyvinyl chloride pipe, monofilament line, non-monofilament line) and injured by humans. Examples of injuries caused directly by humans include removal of rostra, shooting an individual with a powerhead, and shooting another with arrows. Many people are aware that the smalltooth sawfish is protected by state and federal laws, but some are still not aware of (or willing to accept) this status. The impacts of marine pollution and injuries directly caused by humans on this endangered species can be ameliorated by incorporating fisher education into the conservation and management processes.

Keywords: Bycatch; Endangered species; Florida; Marine debris; Monofilament; *Pristis pectinata*

1. Introduction

The smalltooth sawfish, *Pristis pectinata* Latham 1794, declined in the United States because it was overfished *unintentionally* (i.e., bycatch) during the nineteenth and twentieth centuries. This happened because sawfishes have an elongate, blade-like, toothed snout that made them susceptible to entanglement in nets that targeted bony fishes. In addition, sawfishes, like other rays and sharks, have evolved a K-selected life history strategy which includes production of small numbers of large young, slow growth, and late maturity. These factors caused fished populations to be reduced faster and replaced slower than many exploited bony fishes that produce thousands of pelagic larvae (Stevens et al., 2000). Further, because sawfish were caught as bycatch, they did not appear in official fishery statistics and the reduction of the smalltooth sawfish population in the United States went largely unnoticed (or unaddressed) by fisheries managers for many years. Other sawfish species elsewhere in the world have likely been affected similarly.

The smalltooth sawfish historically ranged from New York (rarely) to Texas in the United States, but occurs today primarily in only south Florida—where it is sometimes encountered by various fishers, especially recreational hook and line fishers that target other species (Poulakis and Seitz, 2004). Although legal net fisheries have essentially been eliminated from Florida waters and the species is protected by both state and federal laws

* Corresponding author. Present address: Creative Environmental Solutions, Inc., 1425 NW 6th Street, Gainesville, FL 32601, United States. Tel.: +1 352 373 7704; fax: +1 352 371 0020.

E-mail address: floridasawfish@yahoo.com (J.C. Seitz).

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(Florida Fish and Wildlife Conservation Commission, 1999; United States National Marine Fisheries Service, 2003), the smalltooth sawfish is still being negatively affected by humans in the United States. The purpose of this study is to (1) document anthropogenic factors, other than nets, that are still affecting the smalltooth sawfish in Florida and (2) summarize literature accounts of these effects on sawfishes worldwide.

2. Materials and methods

Because of their unusual appearance and relatively large size, sawfishes are easily recognized and remain a memorable experience for those who encounter them. Encounters with the smalltooth sawfish were documented by soliciting information from anyone who could encounter these fish (e.g., recreational and commercial fishers, fishing guides; Seitz and Poulakis, 2002; Poulakis and Seitz, 2004). In addition, our study appeared on local media outlets, we circulated posters asking for anyone with information on these fish to contact us (by telephone, mail, or e-mail), and we created a web site (www.floridasawfish.com). Posters were distributed beginning in January 1999, and covered most of south and southwest Florida by April 2001. Some posters were also distributed elsewhere in Florida. The posters were displayed where anglers and boaters would likely encounter them (e.g., bait and tackle shops, boat ramps). Participants were asked the same series of questions about their encounter(s) to determine information such as the date and location of each encounter, the estimated total length (ETL) of each sawfish, and the general health of each animal, noting any injuries and entanglements. Photographic or video documentation was obtained when available. All lengths are reported as estimated total lengths unless otherwise noted. It is important to note that our data collection efforts are ongoing.

3. Results

Through November 2005, a total of 989 interviews were conducted that document 3289 smalltooth sawfish encounters in United States waters—the majority occurring in south Florida since 1998 (Poulakis and Seitz, 2004). Of these encounters, 50 reported entangled, injured, or dead sawfish including 18 with photographic or video documentation. Anthropogenic effects were most commonly reported (82%). Other effects on sawfish included interactions with sharks.

3.1. Pollution-related injuries

Participants reported entanglement of sawfish in various forms of marine pollution, including a polyvinyl chloride (PVC) pipe, an elastic band, and monofilament, non-monofilament, and braided fishing lines (Table 1). In most cases, the pollution was removed prior to release of the animals. We do not know if fishing line entanglements occurred while the lines were being actively fished, or if these animals contacted the pollution after the gear was discarded or lost.

A 1.7 m smalltooth sawfish with an elastic band encircling its body was captured on hook and line in July 1996 at the mouth of the Caloosahatchee River (Fig. 1). Upon removal of the band, an irritated indentation was observed. The band was similar to the o-ring used in 19 l (5 gallon) bucket lids (ca. 30 cm diameter). It was removed before the sawfish was released.

A 2.4 m smalltooth sawfish that had a PVC pipe encircling its rostral base was inadvertently captured by cast net in December 2001 in Florida Bay off Flamingo (Fig. 2). The head had been chaffed by the edge of the pipe. Measuring ca. 10 cm long by 10 cm diameter, the pipe was similar to the type used as the opening of the traps used in the local stone crab, *Menippe mercenaria*, fishery. Barnacles

Table 1
Human-induced, pollution-related interactions with *Pristis pectinata* in Florida identified by this study

Date	Location	Length (m)	Description
Late 1980's	Peace River	1.2	Monofilament line around rostrum
Winter, 1990	Bear Lake, north of Flamingo	1.5	Monofilament line around rostrum
Ca. 1995	Caloosahatchee River	1.5	Monofilament line around rostrum
July, 1996	Caloosahatchee River	1.7	Flexible elastic band encircled body (Fig. 1)
June, 1997	Caloosahatchee River	1.7	Monofilament net around rostrum
November, 1997	Gulf of Mexico, off Key West	3.7	Rope around rostrum
April, 2001	Atlantic Ocean, L. Matecumbe Key	4.4	Monofilament line around rostrum
December, 2001	Florida Bay, off Flamingo	2.4	PVC pipe encircled rostrum (Fig. 2)
2001	Atlantic Ocean, Big Pine Key	4.5	Entangled in lobster trap line
January, 2002	Florida Bay, Big Pine Key	4.6	Entangled in lobster trap line
June, 2003	Charlotte Harbor, Cayo Costa	2.1	Coffee can encircled rostrum
May, 2004	Atlantic Ocean, Cape Canaveral	3.5	Multi-braid line encircled rostral base, partially imbedded in skin
March, 2005	Caloosahatchee River	1.550[a]	Various fishing lines around rostrum (Fig. 3)
May, 2005	Atlantic Ocean, St. Lucie Inlet	2.9	Entangled in crab trap line
June, 2005	Caloosahatchee River	1.070[a]	Fishing line encircled head anterior to spiracles

Lengths are estimated total lengths unless otherwise noted. Interactions are listed chronologically.
[a] Length measured.

Fig. 1. A 1.7 m estimated total length *Pristis pectinata* with an elastic band encircling its body at the origin of the pectoral fins that was caught with hook and line in July 1996 in the Caloosahatchee River (near Fort Myers). The band was used to hang the sawfish for the photo, then it was removed before the fish was released. Photo courtesy of John and Lisa Gallagher.

covered all surfaces of the PVC pipe; however, it is unknown whether they attached to it before or after the sawfish encountered it. The pipe was removed before the sawfish was released.

A 1.550 m total length smalltooth sawfish that had a variety of marine pollution entangled around the entire length of its rostrum was captured in a large research haul seine in March 2005 at the mouth of the Caloosahatchee River (Fig. 3). The pollution consisted of three types of monofilament fishing line (4.5–9.1 kg/10–20 lb test) including one bead (“bobber stop”), braided fishing line (ca. 36.2 kg/80 lb test), and part of a cotton trot line which included a 14.2 g (0.5 oz) lead egg sinker. During removal, two previously damaged entire rostral teeth fell out of their sockets and several irritated and bleeding areas were revealed. An additional three rostral teeth were already missing as a direct result of damage caused by the pollution. Except for a small amount of braided line that had become incorporated into the rostrum as a result of healing, all of the material was removed before the sawfish was released.

3.2. Injuries caused by humans

Reports of injuries to smalltooth sawfish by humans included some that were intentionally caused, such as rostrum-removal and shooting an individual, but also included an accidental injury to a sawfish during capture on hook and line near a bridge piling (Table 2). A total of 12 smalltooth sawfish were reported completely lacking a rostrum. In four of these cases, the missing rostrum caused the anglers to question whether they had caught a sawfish until we confirmed this for them.

3.3. Examples from the literature

Sawfish populations around the world have been affected by humans in a variety of ways beyond net fishery

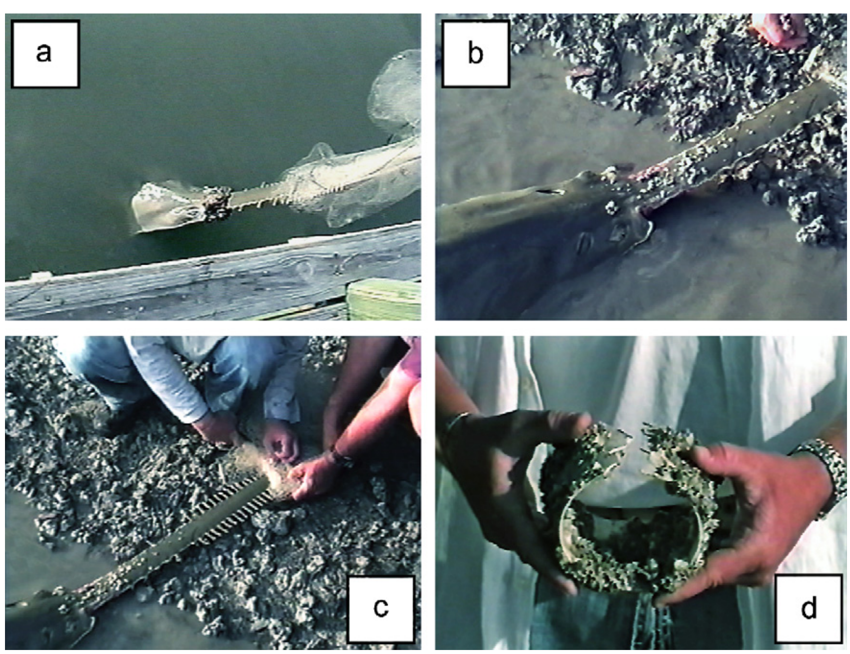

Fig. 2. A 2.4 m estimated total length *Pristis pectinata* that had a polyvinyl chloride (PVC) pipe encircling its rostral base was inadvertently caught in a cast net in December 2001 in Florida Bay (near Flamingo). *Note*: (a) the broken rostral teeth caused by the presence of the pipe, (b) damage to the head caused by the edge of the pipe, revealed after pipe removal, (c) the exceptionally long, unbroken rostral teeth toward the anterior end of the rostrum, and (d) the presence of barnacles on both surfaces of the pipe. The exceptionally long rostral teeth and the overall emaciated appearance of this sawfish suggest that it was not feeding normally. It is important to note that as long as the bases of the broken rostral teeth were not damaged, they will eventually regenerate. Video courtesy of Bryant Roberts, Jason Soronan, and Rick Hayman.

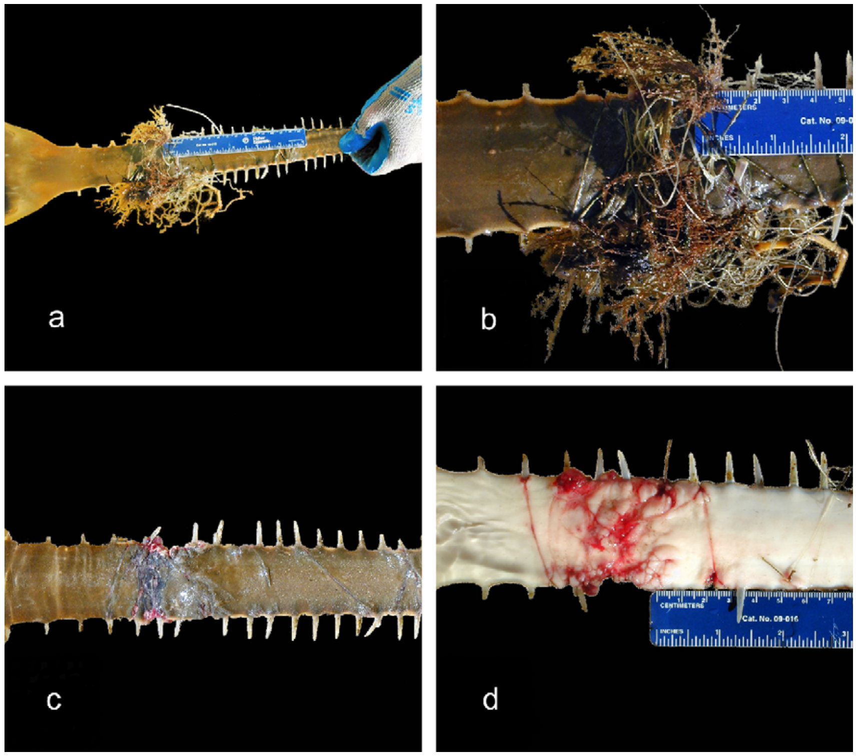

Fig. 3. A 1.550 m total length *Pristis pectinata* that had a variety of pollution including several types of fishing line and part of a cotton trot line entangled around its rostrum was captured in a research haul seine in March 2005 at the mouth of the Caloosahatchee River (near Fort Myers). *Note*: (a) the presence of pollution along the entire length of the rostrum as well as the broken and missing rostral teeth caused by its presence, (b) the displaced rostral tooth near the 0.5 in. mark on the ruler, and (c, dorsal view; d, ventral view) the damaged areas that were revealed after removal of the pollution from the section of the rostrum shown in (b). Photos by Gregg R. Poulakis.

bycatch and include human consumption, leather production, and use in traditional medicine or religious offerings (Table 3).

4. Discussion

4.1. Pollution-related injuries

Examples of how the smalltooth sawfish has been affected by marine pollution include the elastic band, PVC, and fishing gear interactions reported here (see Table 1). Physical damage from the pollution, including loss of rostral teeth due to its presence, probably affected the ability of some of these animals to feed normally. Since sawfish use their rostra to acquire food, lost rostral teeth are significant because sawfish do not replace them if they are completely lost (Slaughter and Springer, 1968). The extent of these types of pollution-related interactions and their long-term effects on the recovery of the smalltooth sawfish population (and other sawfish populations worldwide) is unknown; however, because sawfishes often use coastal habitats near human populations, the probability of negative effects from many types of marine pollution is high and should be monitored.

Although there are few well-documented accounts of how pollution affects sawfishes, well-documented accounts do exist for other elasmobranchs. Documented shark entanglements include a carcharhinid shark encircled by an automobile tire (Gudger and Hoffman, 1931), two species (*Squalus acanthias* and *Triakis semifasciata*) encircled by rubber bands (Gudger, 1937; Herald, 1953), and various species encircled by straps (e.g., Bird, 1978; Sazima et al., 2002). Data on batoid entanglements are exiguous and includes a giant manta, *Manta birostris*, and a freshwater sawfish, *Pristis microdon*, entangled in lost monofilament line (Wallace, 1985; Thorburn et al., 2004a). Clearly, marine pollution affects a variety of elasmobranchs, but because of their unique morphology, sawfishes may be exceptionally susceptible. Proper disposal of refuse and use of more environmentally friendly fishing gear by fishers would be helpful. For example, plastic fishing gear can be substituted with biodegradable materials (e.g., natural hemp rope can substitute for plastic crab trap line), or the plastics could be designed to photo-degrade over a short period of time.

4.2. Injuries caused by humans

We received reports of people killing or damaging sawfish for a variety of reasons including confirmation of identification, personal consumption, or to display to friends or family members. Gudger (1912) first documented the practice of rostrum removal followed by live release of a sawfish, and since then, sawfishes have been captured with

Table 2
Injuries caused to *Pristis pectinata* by humans in Florida identified by this study

Date	Location	Length	Description
1950's	Gulf of Mexico, off Naples	"large specimens"	Landed and sold for crab bait, and to feed zoo animals
Ca. 1975	Charlotte Harbor	1.7 m[a] (2.3 m)	Rostrum previously removed, bleeding from wound
Late 1970's	Lakes Passage, off Key West	3.0 m	Observed swimming with arrow protruding from dorsal surface
Ca. 1990	Gullivan Bay, Ten Thousand Islands	3.0 m[a] (3.8 m)	Only ca. 13 cm of rostrum remaining, previously removed
1990–2003	Florida Bay	No lengths given	Angler occasionally removes a rostral tooth before release of over 100 sawfish
1993	Atlantic Ocean, off Ft. Lauderdale	No length given	Rostrum previously removed, wound healed
1996	Atlantic Ocean, off Key West	6.1 m	Shot with a powerhead, killed
1998	Dry Tortugas	2.4 m[a] (3.3 m)	Rostrum previously removed, wound healed
June, 1998	Gulf of Mexico, off Naples	6.3 m	Tip of rostrum missing
Summer, 1998	Gulf of Mexico, off Naples	2.7 m[a] (3.7 m)	Rostrum previously removed, wound healed
Summer, 1999	Big Carlos Pass	3.5 m	Damaged rostrum caused by impact against bridge piling[b]
June, 2000	San Carlos Bay	3.0 m[a] (4.0 m)	Rostrum previously removed, wound healed
Winter, 2000	Atlantic Ocean, off Key Largo	2.4 m[a] (3.2 m)	Rostrum previously removed, wound healed
2001	Dry Tortugas	2.4 m	Rostrum removed, released live
Spring, 2001	Caloosahatchee River	2.1 m[a] (2.8 m)	Rostrum previously removed, wound healed
February, 2003	Atlantic Ocean, off Apollo Beach	2.6 m	Landed for human consumption
June, 2003	Atlantic Ocean, off Daytona Beach	3.7 m[a] (4.6 m)	75% of rostrum missing
September, 2003	Gulf of Mexico, Content Keys	3.0 m[a] (3.8 m)	ca. 85% of rostrum missing, wound healed
February, 2004	Gulf of Mexico, off Naples	3.2 m[a] (4.3 m)	Rostrum previously removed
April, 2004	Gullivan Bay, Ten Thousand Islands	4.0 m	Rostrum previously removed, wound fresh
June, 2004	Gulf of Mexico, off Marco Island	3.4 m[a] (4.5 m)	Rostrum previously removed, wound fresh
June, 2004	Gulf of Mexico, off Naples	3.2 m[a] (4.3 m)	Rostrum previously removed, wound healed
April, 2005	Florida Bay, Little Madeira Bay	3.7 m[a] (4.3 m)	50% of rostrum previously removed
April, 2005	Gulf of Mexico, off Fort Myers	4.6 m[a] (5.3 m)	50% of rostrum previously removed, wound fresh[c]
April, 2005	San Carlos Bay, off Sanibel	2.7 m[a] (3.7 m)	Rostrum previously removed, wound fresh
July, 2005	Atlantic Ocean, off Vaca Key	2.4 m[a] (2.7 m)	50% of rostrum previously removed, all rostral teeth damaged or removed, damaged rostrum healing

Sawfish captured on hook and line were included. Sawfish bycatch in actively fished commercial net gear (e.g., entanglement nets, trawls) was not included. All lengths are estimated total lengths. Lengths in parentheses are total lengths of sawfish if they had healthy rostra (following Bigelow and Schroeder, 1953). Interactions are listed chronologically.

[a] Length estimated without rostrum, or with only a portion of the rostrum remaining.

[b] This sawfish was recaptured at least six times over a two month period at this location and was identified by its damaged rostrum (Seitz and Poulakis, 2002).

[c] The wound on this sawfish was observed healed during a subsequent recapture 71 days later on 26 June 2005, as evidenced by white scar tissue. On the basis of its uniquely damaged rostrum, this animal was probably caught at least four times at this location between April and August 2005.

Table 3
Examples of previously reported anthropogenic causes of injury, mortality, and use of sawfishes worldwide

Description	References
Directed fisheries	
Taken in directed fisheries (Lake Nicaragua, worldwide)	Thorson (1982a) and Camhi et al. (1998)
Harpooned or impaled with a spear (Florida Bay & Keys, Mexico)	Dimock and Dimock (1908), Endicott (1925) and Verrill (1948)
Sold for research purposes and to public aquaria (Florida panhandle, Australia)	Gulf Specimen Company, Inc. (no date), Rudloe (1988) and Peverell (2005)
Habitat modification and pollution	
Affected by pollution (e.g., herbicides, heavy metals; United States, Panama)	Montoya and Thorson (1982), Adams and Wilson (1995) and Compagno and Cook (1995)
Affected by impoundments, oil spills, and other habitat modifications (India, Australia, worldwide)	Camhi et al. (1998), Compagno and Last (1999) and Thorburn et al. (2004b)
Use of sawfish parts	
Carcasses used as shark bait (Panama Bay, Lake Nicaragua)	Hedges (1925) and Tuma (1976)
Rostra used as religious offerings, traditional medicine, and sold as curios (United States, India, Thailand, Mexico, worldwide)	McCormick et al. (1963), Shipp (1986) and McDavitt (2002)
Rostral teeth used in cockfights, hand-crafted into tools, clothing pins (Brazil, Florida, India)	McDavitt (1996) and Charvet-Almeida (2002)
Fins sold into Asian 'shark fin' market (India, Lake Nicaragua, worldwide)	Norman and Fraser (1938), Thorson (1982a) and Fowler (1998)
Meat consumed by humans (western central Atlantic, Indo-Pacific, United States)	Breder (1929), Last and Stevens (1994) and Guste (1997)
Skins made into leather (Lake Nicaragua, worldwide)	Thorson (1976), McDavitt (1996) and Musick et al. (2000)
Livers processed for oil (Lake Nicaragua, Australia, North America)	Thorson (1982a), Last and Stevens (1994) and McDavitt (1996)
Other	
Killed by boat-strike (Nicaragua)	Thorson (1982b)

Known incidental captures (i.e., bycatch) in commercial and sportfishing activities were not included.

healed wounds where only the rostrum was removed (e.g., Baughman, 1943, see Table 2). Rostrum removal may kill some individuals or at least cause these animals to change their feeding habits because the rostrum does not regenerate. In addition, rostrum removal renders the affected animals defenseless.

4.3. Examples from the literature

To our knowledge, large scale directed fisheries for sawfishes have not developed (the well-documented collapse of the sawfish fishery in Lake Nicaragua is the exception; see Thorson, 1982a). However, the synergistic effects of their K-selected life history traits, the small-scale (or poorly documented) use of sawfish products, and other human-induced factors (see Table 3) has probably contributed to worldwide population reductions of all species. Opportunistic encounters with sawfishes may have resulted in their harvest rather than their release because fishers knew that the carcasses (or parts of them) had value. For example, sawfish fins are considered high quality in the 'shark fin' market and sawfish rostra are popular curios that can command high prices. Habitat modification and loss as well as non-point source pollution have likely affected sawfishes, but the extent of these effects will not be known until we learn more about the habitat requirements of these animals. Collectively, these negative effects on sawfishes will likely contribute to declining worldwide populations until international protections (with enforcement) are in place and the markets for sawfish products can be eliminated.

Many people are aware that the smalltooth sawfish is protected by state and federal laws in the United States, but some are still not aware of (or willing to accept) this status. The same is probably true for other sawfish species elsewhere in the world. The impacts of marine pollution and injuries directly caused by humans on endangered sawfishes can be ameliorated by incorporating fisher education into the conservation and management processes. Similarly, fostering information sharing between scientists and fishers is vital because to date, much of what we know about *P. pectinata* has come from this collaboration. We still have much to learn about the biology and ecology of sawfishes worldwide.

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