



Tracing the occurrence of the Critically Endangered smalltooth sawfish *Pristis pectinata* at its southernmost distribution in the Southwest Atlantic Ocean

Juan Martín Cuevas^{1,2,*}, Mirta García^{2,3}, Natalia Hozbor⁴, Vicente V. Faria⁵,
Laura Paesch⁶

¹Wildlife Conservation Society de Argentina, Amenabar 1595, C1426AKC, Ciudad Autónoma de Buenos Aires, Argentina

²División Zoología Vertebrados, Museo de la Plata, Universidad Nacional de la Plata, Paseo del Bosque s/n, 1900, La Plata, Argentina

³Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Godoy Cruz 2290, C1425FQB, Ciudad Autónoma de Buenos Aires, Argentina

⁴Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP), Paseo Victoria Ocampo N° 1, Escollera Norte, B7602HSA, Mar del Plata, Argentina

⁵Departamento de Biología, Centro de Ciências, Universidade Federal do Ceará – UFC, Campus do Pici, Bl. 906, Av. Mister Hull, s/n, 60440-900, Fortaleza, Brazil

⁶Dirección Nacional de Recursos Acuáticos (DINARA), Calle Constituyente N° 1476, 11.200, Montevideo, Uruguay

ABSTRACT: Sawfishes are the most globally threatened group of sharks, rays, and chimaeras. One of the 5 sawfish species is the Critically Endangered smalltooth sawfish *Pristis pectinata*. Although it is currently found in only a small portion of its historical range, this species was once distributed along tropical and subtropical coasts on both sides of the Atlantic Ocean. Its historical distribution included the Southwest Atlantic in Brazil and Argentina, with its presence in Uruguay assumed from its occurrence in neighboring countries. However, occurrence records in this region have only been compiled for Brazil. The aim of this study was to characterize the occurrence of *P. pectinata* in the Argentinean–Uruguayan Common Fishing Zone (AUCFZ). Quantitative sampling data revealed no sawfish specimens during 150 bottom trawl cruises and 8490 hauls (1905 in winter; 1647 in fall; 3141 in spring; 1797 in summer months) in the AUCFZ between 1981 and 2015. Nevertheless, qualitative data based on interviews (N = 275; researchers, fishing companies, fishermen, and recreational anglers) supports the occasional presence of sawfish in the AUCFZ. Five new oral reports were obtained and, although these records lack reference material, they have an associated capture year: 2 records from the 1950s, 1 record from the 1990s, and 2 records from the 2010s. Two of these records are the first for Uruguay and were reported by experienced fishermen. We conclude that the species was always a vagrant to the region, and suggest that the view of *P. pectinata* as extirpated from Uruguay and northern Argentina should be revisited.

KEY WORDS: Pristidae · Elasmobranchs · Bottom trawling · Southwest Atlantic · Oral reports

1. INTRODUCTION

Sawfishes (family Pristidae) are among the largest marine and euryhaline fishes. Collectively, the 5 extant sawfish species were formerly globally distributed in tropical and subtropical coastal, estuarine,

and in some instances, freshwater habitats (Faria et al. 2013, Dulvy et al. 2016). However, with the local extinction and severe depletion of most populations, global sawfish distribution has been vastly reduced; sawfishes are extirpated from 20 countries, and 43 countries have at least one species classified as Possi-

*Corresponding author: jcuevas@wcs.org

bly Extinct (Dulvy et al. 2016). These population depletions have made sawfishes the most threatened group of chondrichthyans (Dulvy et al. 2014, Fernandez-Carvalho et al. 2014). According to the International Union for the Conservation of Nature's (IUCN) Red List of Threatened Species, 3 sawfish species (*Pristis pristis*, *P. pectinata*, and *P. zijsron*) are currently classified as Critically Endangered (Carlson et al. 2013, Kyne et al. 2013a, Simpfendorfer 2013). The remaining two (*Anoxypristis cuspidata* and *P. clavata*) are Endangered (D'Anastasi et al. 2013, Kyne et al. 2013b). All 5 species are also listed in Appendix I of the Convention on International Trade of Endangered Species (CITES) (Carlson et al. 2013). In addition, the smalltooth sawfish *P. pectinata* has been listed under the US Endangered Species Act since 2003 by the US National Marine Fisheries Service (NMFS 2003).

The historical distribution of *P. pectinata* includes tropical and subtropical coasts on both sides of the Atlantic Ocean (Faria et al. 2013). However, *P. pectinata* population reduction is inferred at 95% over a period of 3 generations (Carlson et al. 2013). In addition, this species has suffered an 81% geographical reduction of its original range (Dulvy et al. 2016). As a consequence, the distribution of *P. pectinata* is now patchy, and it is possible that only remote parts of the Caribbean Sea could host any viable populations outside US waters (NOAA 2013).

Even though this perception of large-scale depletion outside the USA is undisputed, regional and local information about the contemporary occurrence of *P. pectinata* is mostly scarce outside of Florida. For example, *P. pectinata* is considered no longer present in the eastern south American countries of Brazil, Uruguay, and Argentina (Charvet & Faria 2014), yet Brazil is the only country in the region for which historical *P. pectinata* records have recently been reviewed. Historical records are distributed along the Brazilian coast (Faria & Charvet-Almeida 2008), thus suggesting a once large range there. The last known record of *P. pectinata* for Brazil, however, refers to Thorson's (1974) report for saws traded in northern Brazil in the 1960s and 1970s (Faria & Charvet-Almeida 2008, Charvet & Faria 2014, Manir Feitosa et al. 2017). Unlike *P. pectinata* records in Brazil, information from the other eastern South American countries, Uruguay and Argentina, is limited.

P. pectinata has never been recorded in Uruguay (Charvet & Faria 2014); its presence in the country (Nion et al. 2002, Meneses & Paesch 2003) has only been inferred from Argentine records (Lahille 1906, 1921). These records refer to specimens 180 and

205 cm in total length (TL), both from Mar del Plata (Lahille 1921). In the same area (38° 52' S, 56° 16' W), 5 decades later in 1971, an unidentified sawfish (most likely *P. pectinata*) measuring 300–400 cm TL was encountered (Menni et al. 2010).

Besides the aforementioned records for Argentina, no effort has been directed towards investigating other potential sources of sawfish records for Argentina and Uruguay. Such records could clarify its occurrence in these countries. Given this lack of knowledge and the Critically Endangered status of *P. pectinata*, the aim of this study was to characterize the occurrence of this irregularly occurring species in the Argentinean–Uruguayan Common Fishing Zone (AUCFZ) using quantitative and qualitative data.

2. MATERIALS AND METHODS

2.1. Study area

The Southwest Atlantic Ocean (SWA) is a global hotspot of threatened chondrichthyans; 50% of endemic species in this region are threatened with extinction (Dulvy et al. 2014). At the same time, these areas of high chondrichthyan diversity in the SWA are associated with marine front areas of high biological activity (Lucifora et al. 2012). These areas, formed by the confluence of different water masses, have enormous biological productivity as a result of the input of nutrients (Acha et al. 2004). Our study area is located within the SWA and covers the AUCFZ (Fig. 1). It includes the outer region of the La Plata River and its adjacent inner continental shelf, the Argentine and Uruguayan coast (depth <50 m) and the outer continental shelf (50 to 420 m) in the SWA (34° 30' to 39° 30' S, 52° 00' to 59° 00' W), covering 35.848 square nautical miles (nmi²). This area is the meeting point of 3 different water masses: freshwater flow from the La Plata River; the Brazil Current; and the Malvinas/Falkland Current. It is characterized by high spatio-temporal variability in hydrographic parameters and primary productivity (Acha et al. 2004).

2.2. Data collection

2.2.1. Historical records and interviews

First, an exhaustive literature review was carried out to search for old records in local fish catalogues, published journals, theses, and technical reports as

well as local newspapers and fishing magazines. Then, the ichthyological collections of museums (Table 1), research institutions, and universities in Argentina and Uruguay were examined in 2015 for historical records of *Pristis pectinata*, and each individual sawfish was identified according to Lahille (1906), Bigelow & Schroeder (1953), and Faria et al. (2013).

Survey interviews (N = 275) were then conducted with ichthyologists (Argentina, n = 42; Uruguay, n = 9), recreational anglers (Argentina, n = 138; Uruguay, n = 5), artisanal fishermen (Argentina, n = 28; Uruguay, n = 51), and the 2 oldest and largest frozen seafood companies in the AUCFZ. These interviews were conducted from September 2015 to December 2016. A simple questionnaire was used for interviews (see Text S1 in the Supplement at www.int-res.com/articles/suppl/n038p001_supp.pdf). Each interview was conducted in person, by telephone, or through social media (Facebook). In Uruguay, interviews were conducted with artisanal fishermen at La Paloma. In Argentina, interviews with recreational anglers and artisanal fishermen were focused on the Buenos Aires coast to cover areas close to the AUCFZ (communities 2–6 in Fig. 1). Interviews for the 2 frozen seafood companies were conducted at their headquarters in Mar del Plata (Fig. 1). Currently, 14 frozen seafood companies operate in Uruguay and are responsible for fisheries landing records for the ports of Montevideo and La Paloma.

Finally, all fishery landing records belonging to the Dirección Nacional de Recursos Acuáticos (DINARA; The National Directory for Aquatic Resources) from 1977 to 2017 were checked for any sawfish landings. Additional consultations were conducted with regional experts (n = 54), including authors of published chondrichthyan species catalogues for Argentina and Uruguay that include *P. pectinata*.

2.2.2. Research surveys

In Argentina, data collected from 73 bottom trawl research cruises in the AUCFZ between 1981 and 2015 by research vessels (RV) operated by Argentina's Instituto Nacional de Investigación y Desarrollo

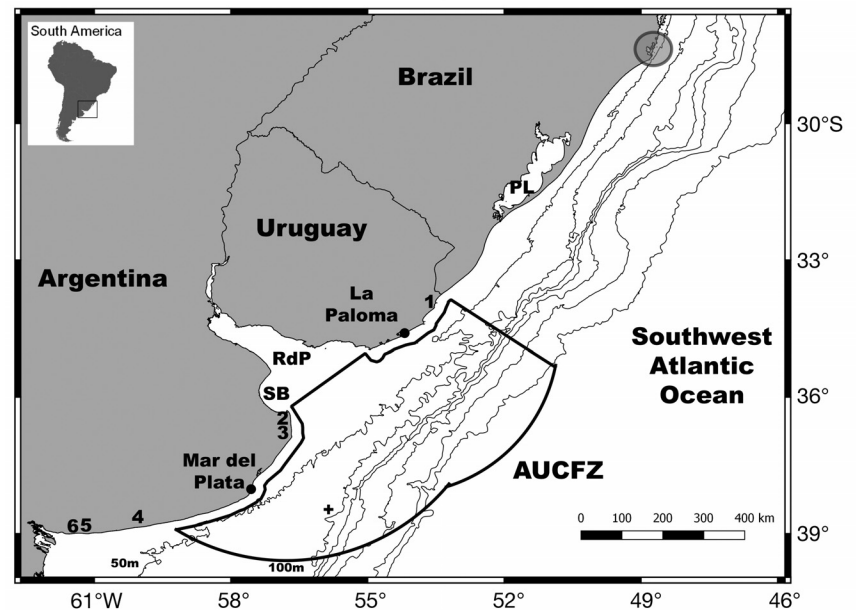


Fig. 1. Study area. PL: Patos Lagoon; RdP: La Plata River; SB: Samborombón Bay; AUCFZ: Argentine–Uruguayan Common Fishing Zone. (+) indicates the location of the last confirmed sawfish record in the study area in 1971, probably *Pristis pectinata*. Grey circle: southern limit of the red mangrove *Rhizophora mangle* in the Southwest Atlantic. Artisanal fishermen communities 1: Punta del Diablo; 2: San Clemente del Tuyú; 3: Mar de Ajó; 4: Claromecó; 5: Monte Hermoso; 6: Pehuencó

Pesquero (INIDEP; National Institute for Fisheries Research and Development) were analyzed for records of sawfishes. Of these cruises, 33 were conducted in coastal waters (depths <50 m), and the remaining 40 were in the outer continental shelf (depths between 50 and 250 m). Each coastal trawl station (haul) consisted of a 15 min tow during daylight at a speed of 3–4 knots. The outer stations used 30 min tows at the same speed. During both hauls, a high-opening 'Engel' type bottom trawl was used with a stretched mesh of 100 mm, cod-end, and horizontal mouth opening of 19–22 m.

In Uruguay, data from 79 bottom trawl research cruises collected in the AUCFZ between 1984 and 2015 were examined and analyzed. Fifteen of these research cruises were conducted by the RV 'Cruz del Sur' (1984–1989), while the remaining 64 were conducted by the RV 'Aldebarán' (1991–2015) operated by DINARA. Of these 79 cruises, 32 were coastal and 47 were conducted on the outer continental shelf. Hauls were selected using a stratified random sample design, and each trawl consisted of a 30 min tow during daylight at a speed of 3–4 knots. A high-opening 'Engel' type bottom trawl with a stretched mesh of 80–100 mm, cod-end, and 55–60 m horizontal mouth was used.

Table 1. Rostral records of sawfishes from ichthyological collections in Argentina and Uruguay. MLP: Museo de la Plata. (–) No data

Code	No. rostral teeth side ⁻¹	Total rostral length (cm)	Species	Original ocean basin	Date (dd/mm/yyyy)	Sample source	Name	Country
MLP 10899	31	98	<i>P. zijsron</i>	–	–	Museum	Museo de La Plata	Argentina
MLP 10900	27	68	<i>A. cuspidata</i>	Indian Ocean	–			
MLP 10912	25	46	<i>A. cuspidata</i>	–	–			
MLP 10913	26	69	<i>A. cuspidata</i>	–	–			
MLP 10914	23	72	<i>P. pectinata</i>	–	–			
General catalogue	27	124	<i>Pristis zijsron</i>	Indian Ocean	02/03/1906	Museum	Museo Argentino de Historia Natural 'Bernardino Rivadavia' (MACN)	Argentina
General catalogue	24	138	<i>P. zijsron</i>		02/03/1906			
General catalogue	16	88	<i>P. pristis</i>		02/03/1906			
–	–	–	–	–	–	Museum	Museo de Historia Natural y Antropología de Montevideo	Uruguay
–	22	108	<i>P. zijsron</i>	–	–	University	Cátedras de Zoología III Vertebrados. Facultad de Ciencias Naturales y Museo (FCNyM)	Argentina
–	27	73	<i>A. cuspidata</i>	–	–	University	Cátedra de Ictiología. Facultad de Ciencias Naturales y Museo (FCNyM)	Argentina
–	–	–	–	–	–	University	Facultad de Ciencias de la Universidad de la República	Uruguay
–	–	–	–	–	–	Research institute	Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP)	Argentina
–	–	–	–	–	–	Frozen seafood company	Moscuzza	Argentina
–	–	–	–	–	–	Frozen seafood company	Frigorífico del Sudeste	Argentina

We assume here that the trawling speed and duration (15 and 30 min) used during the hauls carried out in each country could potentially capture sawfishes. This is based on the fact that these trawls captured other benthic batoids with similar size ranges as *P. pectinata*. On the other hand, we considered that the likelihood of these surveys capturing sawfish was low. This is because sawfish global declines were already in place by the time these surveys started in the 1980s.

3. RESULTS

3.1. Interviews

Interviews conducted with fishermen did reveal new evidence of the presence of sawfish in the region.

However, these new instances lacked associated reference material such as photos or dried rostra and are therefore currently considered anecdotal.

Interviews with Uruguayan artisanal fishermen resulted in 3 oral reports of *Pristis pectinata* (Table 2); their fishing experience ranged from 25 to 45 yr (mean \pm SD = 25.6 \pm 3.1 yr). The 3 records were as follows: (1) 1 specimen of about 150 cm TL landed at La Paloma port in 1954; (2) 1 specimen (unknown TL) caught by commercial fishing vessels near Pozo del Fango between 1997 and 1998; and (3) 1 specimen (~80 cm TL) caught by commercial fishing vessels in the Papamoscas fishing zone between Uruguay and Argentina in 2010. Interviews with Argentinian artisanal fishermen yielded no records of *P. pectinata*; these fishermen's fishing experience ranged from 7 to 73 yr (23.8 \pm 15.7 yr).

Table 2. Interviews with fishermen with sightings of sawfishes in the Argentinean–Uruguayan Common Fishing Zone. Oral reports lacked reference material (i.e. no rostra, photo or video). (–) No data available

Type	Fisherman		Date of sighting	n	Estimated total length (cm)	Locality	Coordinates	Comments
	Age (yr)	Experience (yr)						
Artisanal	65	45	1954	1	150	La Paloma, Uruguay	34°39'31"S, 54°8'50"W	Captured, landed at La Paloma Port
Angler	74	17	1997–1998	1	–	Pozo del Fango, Uruguay	34°47'S, 53°45'W	Captured, fate unknown
			1958	1	<100	Punta Iglesias, Mar del Plata, Argentina	37°59'59.74"S, 57°32'18.30"W	Captured, fate unknown
Artisanal	50	35	2010	1	70–80	Papamoscas, 80 nmi south of La Paloma, Uruguay	–	Captured, fate unknown
Angler	24	15	2012	1	–	Mar Chiquita Lagoon, 2 km east, Argentina	–	Captured, released alive

Table 3. Confirmed records of sawfishes in the Argentinean–Uruguayan Common Fishing Zone

Date	Season	Species	n	Size (cm)	Site	Country	Source
1906 ^a	?	<i>Pristis pectinata</i>	?	?	Mar del Plata	Argentina	Lahille (1906)
1921 ^a	?	<i>Pristis pectinata</i>	2	180, 205	Mar del Plata	Argentina	Lahille (1921)
1971	Summer	<i>Pristis</i> sp. ^b	1	300–400	Station No. 346: 38°52'S, 56°16'W	Argentina	Menni et al. (2010)

^aSampling date could be earlier; only date of citation was available. ^bCatalogued as *Pristis* spp.; probably *P. pectinata*

The presence of sawfish in the area was also reported by anglers, who described reported 2 sawfish encounters in Argentina: (1) 1 specimen of less than 100 cm TL from the Mar del Plata port in 1958 and (2) 1 specimen (unknown TL) ~2 km east of the mouth of Mar Chiquita Lagoon in 2012. Angler fishing experience ranged from 2 to 57 yr in Argentina (23.4 ± 12.6 yr) and from 13 to 30 yr in Uruguay (16.4 ± 7.6 yr) (Table 2).

The remaining sources of information did not produce any new sawfish records. These were: (1) interviews with Uruguayan and Argentinian ichthyologists—their research experience ranged from 15 to 50 yr in both countries (Argentina, 24.1 ± 12.3 yr; Uruguay, 27.2 ± 11.5 yr); (2) historical records from seafood companies—the 2 oldest frozen seafood companies in Argentina: Moscuza (96 yr) and Frigorífico del Sud Este (73 yr); and (3) Uruguayan fishery statistics—based on all declared captures from Uruguay landed in the ports of Montevideo and La Paloma since 1977.

3.2. Historical records

No additional sightings of *P. pectinata* were recorded in the region after Lahille (1906, 1921) for

Argentina (Table 3). This species was only listed nominally in several marine fish lists for Argentina (Pozzi & Bordalé 1935, Ringuélet & Arámburu 1961, Menni et al. 1984, Menni & Stehmann 2000, Chebez & Athor 2009, 2013, Figueroa 2011) and for Uruguay (Nion et al. 2002, Meneses & Paesch 2003). But at the same time, other authors did not include *P. pectinata* for either Argentina or Uruguay (De Buen 1950, Abella et al. 1979, Cousseau 1985, Boschi 1988, Carlson et al. 2013, CMS 2014).

No sawfish specimens with locality data associated with Argentina or Uruguay were found in the regional ichthyological collections visited. Therefore, the only *P. pectinata* dried rostrum found (10914; Table 1) without a locality or collection date cannot be assumed to have been removed from a specimen collected in the region. Sawfish rostra deposited in ichthyological collections of Argentina were mostly acquired from European private collectors in the early 1900s.

3.3. Research surveys

No sawfish specimens were recorded during research surveys. Data from 152 bottom trawl cruises and 8490 hauls (winter: 1905; autumn: 1647; spring:

3274; summer: 1797; Tables 4 & S1–S4) with a total covered area of 185.78 nmi² yielded no sawfish records in Argentina or Uruguay between 1981 and 2015 (Fig. 2).

4. DISCUSSION

The present study suggests that the view of sawfishes as extirpated from Uruguayan and Argentinean waters should be revisited. This is based on anecdotal evidence of the relatively recent presence of sawfish in the AUCFZ.

Pristis pectinata is currently still considered possibly extinct along the coast of 15 countries in the east Atlantic and 16 countries in the west Atlantic (Carlson et al. 2013). The absence of any sawfish records in ichthyological collections, bibliographies, fisheries records, and the last 35 yr of research cruise data from the AUCFZ may match an extinction scenario. However, interviews conducted in the present study with fishermen have now challenged this regionally extinct status.

The new reports obtained from fishermen interviews rely on the testimony of 2 professional fishermen and 2 recreational fishermen. Due to the absence of any specimens, photos, or other documented evidence, these records can not be regarded as conclusive evidence of the present-day occurrence of *P. pectinata* in the AUCFZ. Nevertheless, it is valuable that these fishermen knew what a sawfish looks like. In addition, no other similar species (i.e. sawsharks or swordfish) occur in the study area. Therefore, a misidentification of a sawfish in the region is highly unlikely.

At least 2 of the newly obtained oral records for relatively recent occurrences of sawfish in the AUCFZ appear to be reliable. These were obtained from 2 experienced fishermen from Uruguay. Colleagues from DINARA conducted the interviews (DINARA is an institution that has historically collaborated closely with local fishermen). In the 1997–1998 Pozo del Fango case, the fisherman was fishing and witnessed the capture of the specimen. In the 2010 record, the fisherman was fishing in the sea between the Uruguayan–Argentinean border. The specimen was killed and brought on board, but it was lost (either thrown away or stolen). The experience of the fishermen and the detailed accounts provided for the fishing capture event, such as site locality, bottom and vegetation type, and gillnet mesh size of 18 cm (Table 2), make this report credible.

It is likely that *P. pectinata* has always been a vagrant in the region. Vagrancy is defined as those individuals that are/were 'recorded once or sporadically, but [...] known not to be native to the area' (IUCN 2013, p. 64). In this sense, the largetooth *P. pristis* and smalltooth sawfishes have been recorded as vagrant in the Mediterranean Sea (Ferretti 2014) and in southwest Australia (Last & Stevens 2009). Since the first sighting of *P. pectinata* in 1906 in Argentina, only a few historical confirmed and sporadic records have been documented in the area (Tables 3 & 4). In addition, fishermen are mostly unaware of the existence and/or decline of this species in the region.

Table 4. Research cruise information by season conducted in Argentina and Uruguay without records of *Pristis pectinata* in the study area between 1981 and 2015. S: Spring; Su: Summer; A: Autumn; W: Winter. Sources: Dirección Nacional de Recursos Acuáticos (DINARA) (Uruguay) and Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP) (Argentina)

Year	Season	Country	Sampling effort (no. of hauls)
1981	S	Argentina and Uruguay	47
1983	Su, A	Argentina and Uruguay	101
1984	S, Su, A, W	Argentina and Uruguay	356
1985	S, Su, A, W	Argentina and Uruguay	320
1986	Su	Argentina and Uruguay	80
1987	S, W	Argentina and Uruguay	139
1988	Su, A, W	Argentina and Uruguay	304
1989	W	Argentina and Uruguay	80
1991	Su, A, W	Argentina and Uruguay	247
1992	S	Argentina and Uruguay	95
1993	S	Argentina and Uruguay	258
1994	Su, A, W	Argentina and Uruguay	523
1995	S, Su, A, W	Argentina and Uruguay	567
1996	S, Su	Argentina and Uruguay	425
1997	S, Su	Argentina and Uruguay	326
1998	A, Su	Argentina and Uruguay	359
1999	A	Argentina and Uruguay	407
2000	A, S	Argentina and Uruguay	307
2001	S, Su, A	Argentina and Uruguay	406
2002	S, A	Argentina and Uruguay	144
2003	S	Argentina and Uruguay	259
2004	S, W	Argentina	154
2005	S, W	Argentina and Uruguay	351
2006	Su, A, W	Argentina and Uruguay	460
2007	S, Su, A	Argentina and Uruguay	344
2008	S, A	Argentina and Uruguay	304
2009	S, Su, A	Argentina and Uruguay	209
2010	Su, A	Argentina and Uruguay	136
2011	S, A, W	Argentina and Uruguay	399
2012	S, W	Argentina and Uruguay	228
2013	S, W	Argentina and Uruguay	155
2015	S	Uruguay	133

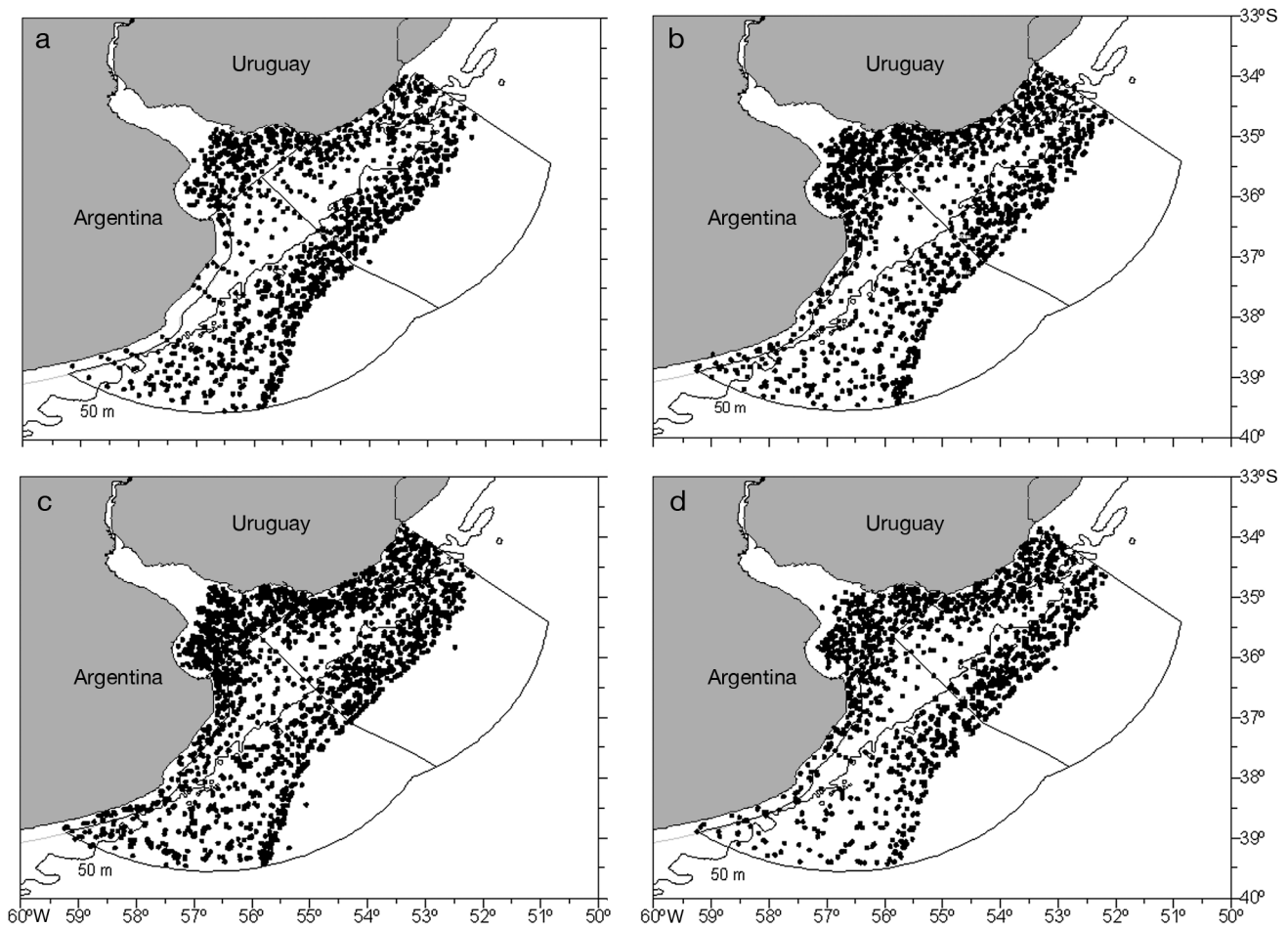


Fig. 2. Spatial distribution of the 8490 hauls from 152 research cruises by season conducted by Argentina and Uruguay in the study area between 1981 and 2015 during (a) autumn, (b) winter, (c) spring, and (d) summer

Overall, this suggests that a population was never established in Argentina and Uruguay. Thus, old records could refer to vagrant individuals from northern habitats (possibly the red mangroves from southern Brazil; Fig. 1), juveniles searching for new suitable estuarine habitats, or adults following prey as other demersal elasmobranchs do during the summer southward arrival of the Brazilian current into the AUCFZ (several elasmobranch species in the region display this seasonal behavior; Vooren 1997).

The fact that this species has not been recorded in Brazil for so long weakens a hypothesis of present-day migrants coming from Brazil. Nevertheless, the northwestern Atlantic population of *P. pectinata* in Florida and the Bahamas has been a successful example of sawfish conservation and recovery (Wiley & Simpfendorfer 2010, Guttridge et al. 2015). Therefore, it is possible that this effort will gradually result

in the presence of sawfish in areas where they have long been gone. This may help to enable the return of *P. pectinata* to the eastern coast of South America.

In conclusion, *P. pectinata* was always a vagrant to the region, and we suggest that the view of this species as extirpated from Uruguay and northern Argentina should be revisited. The present study is the first to focus on reviewing the occurrence of sawfishes within their distribution in the SWA. Despite the limitations of the evidence obtained, these records may serve as a call for further research in the region, leading towards collection of more rigorous evidence. For instance, one potentially useful technique is environmental DNA (eDNA). This technique investigates the presence of a species using samples collected in the environment. It has already been successfully applied to sawfishes (Simpfendorfer et al. 2016), as well as other elasmobranchs (Boussarie et al. 2018).

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Editorial responsibility: Dean Grubbs (Guest Editor),
St. Teresa, Florida, USA

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