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A rapid assessment of the status of sawfishes in the Philippines

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ABSTRACT: Globally, sawfishes are amongst the most threatened of all sharks and rays, but a paucity of current data on their presence and status has limited conservation action in many countries. Whilst 2 sawfish species, *Pristis pristis* and *P. zijsron*, were historically present in the Philippines, a lack of recent reports suggests that they may have become extremely rare. To determine the current status of sawfishes in the Philippines, interviews were conducted with 106 fishers, fish brokers and fisheries officers at 31 sites in 2016. Interviewees confirmed that sawfishes had inhabited Laguna de Bay and the Agusan and Cagayan Rivers in the past, but the majority of interviewees had last seen a sawfish several decades ago. The most recent observations of a sawfish reported during interviews were in 2014, at the estuary of the Tamontaka River, Mindanao, and at Mercedes fish port, Bicol. After the study, photographic evidence of the landing in 2015 of a largetooth sawfish in Zamboanga Peninsula was published on social media. The considerable degradation and modification of freshwater ecosystems, mangrove loss, coastal degradation, fishing pressure and widespread bottom trawling since the 1940s have all likely contributed to sawfish declines. This study confirms that sawfishes, previously abundant in the Philippines, are now extremely rare or locally extinct. Bottlenose wedgefish *Rhynchobatus australiae* were observed at Mercedes port during the study and interviewees stated that they are landed regularly. Given the Critically Endangered status of this species, this fishery likely needs immediate management.

KEY WORDS: Endangered species · Fishers' ecological knowledge · Largetooth sawfish · Green sawfish · Bottom trawling · Laguna de Bay · *Rhynchobatus australiae*

1. INTRODUCTION

The 5 extant species of sawfish (Family Pristidae) comprise one of the world's most threatened families of marine fishes (Harrison & Dulvy 2014, Dulvy et al. 2016). Only after substantial declines and local extinctions had occurred was the critical conservation status of many populations understood (e.g. Everett et al. 2015, Leeney 2017). In the absence of time series datasets for many marine species, local extinctions may be overlooked if species are lost from a part of their range before monitoring begins. This results in shifting baseline syndrome, whereby once species cease to be encountered on a regular basis, they are

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rapidly forgotten by local communities (Turvey et al. 2010). If such species have not previously been scientifically documented, it can then be difficult to assess their historical range and potential for recovery (Sadovy & Cheung 2003, Webb & Mindel 2015).

Largetooth sawfish *Pristis pristis* and green sawfish *P. zijsron* are thought to have inhabited the waters around the Philippines in the past (Compagno et al. 2005, Kyne & Simpfendorfer 2014). Across Southeast Asia, published data are limited, but localised depletions and local extinctions of sawfishes have been reported or inferred from across the region (Kyne et al. 2019a). A study of the tangle net fishery for shark-like rays in Indonesia, which analysed port survey data from 2001 to 2005 (1551 elasmobranchs in total), recorded only 2 largetooth sawfish, possibly caught in the Arafura or Banda Sea region, in August 2002 (D'Alberto et al. 2022). More recently, the Indonesian Ministry of Fisheries and Marine Affairs published information online about the capture, in May 2018, of a narrow sawfish around Merauke, Papua (https://www.conservationleadershipprogramme.org/media/2020/06/CLP-Final-Report_03143220_Final.pdf). No other known recent catches of sawfishes have been documented from Indonesian waters, but demersal elasmobranchs are intensively targeted by fishers in Indonesia (Blaber et al. 2009), and the lack of recent reports is probably indicative of severely depleted populations. In Sabah (Malaysian Borneo), fishers and villagers reported sawfishes as abundant in the 1970s but declining from the 1980s onwards, with very limited catches since that time (Manjaji 2002), whilst the last confirmed record of a sawfish capture in the Kinabatangan River was in 1996 (Manjaji-Matsumoto et al. 2016). In Thailand, historic accounts indicated that sawfishes were 'common' and frequently caught (Smith 1945), but data from as early as 1963–1972 showed the considerable decline in batoids in the Gulf of Thailand (Pauly 1979), including the virtual disappearance of sawfishes (Pauly 1988).

The knowledge of local resource users can be a valuable source of information on the historical and current distribution and relative abundance of threatened species, the local threats they face and observed changes in encounters with these species over time. Collecting this information can be especially valuable for conservation and management in remote areas that lack historical time-series data (e.g. Dulvy & Polunin, 2004). Interview techniques have been used in recent years to generate baseline data on sawfishes in data-poor areas (e.g. Leeney & Poncelet 2015, Jabado et al. 2017, Leeney et al. 2018, Grant et al. 2021). Interviews with individuals who are actively engaged in fisheries in some way, in particular the fishers themselves, have proven a cost-effective way to collect data from large geographic areas and to allow researchers to describe the historical distribution and current status of rare and cryptic species, as directly experienced by those who have encountered those species.

Data on the current distribution and abundance of sawfishes, and the threats they face, are lacking for much of Southeast Asia, making it impossible to develop meaningful conservation strategies or to know where such strategies should be implemented. This study was implemented to assess whether sawfishes are still present in the Philippines and, if so, in which habitats they occur and the primary threats to sawfishes in those areas. Published records of sawfishes, and of sawfish specimens in museums, were collated to provide an overview of their historical distribution. Interviews were conducted throughout the Philippines to collect information on people's recent and past interactions with sawfishes. Such baseline studies are essential in order to direct funding and species-specific management efforts where they are most needed. They can also serve to raise awareness amongst relevant national and local authorities of the need for data on landings of sawfishes and other threatened elasmobranchs. The findings contribute to an understanding of the status and current distribution of sawfishes globally and to prioritising sawfish conservation efforts to areas where viable sawfish populations still exist.

2. MATERIALS AND METHODS

The Philippines is geographically complex, and the limited funding available for this study constrained the number of sites at which interview data could be collected. The selection of study sites was thus primarily based on historical records of sawfish distribution (Fig. 1) but also included the Cagayan River, the longest river and the largest river by discharge volume of water in the Philippines, and other accessible coastal sites where collaborators were available to assist with interviews.

2.1. Historical records

A comprehensive literature review was conducted, based on published scientific papers, unpublished reports and surveys, to find as many records as possible of sawfishes in the waters around the Philip-

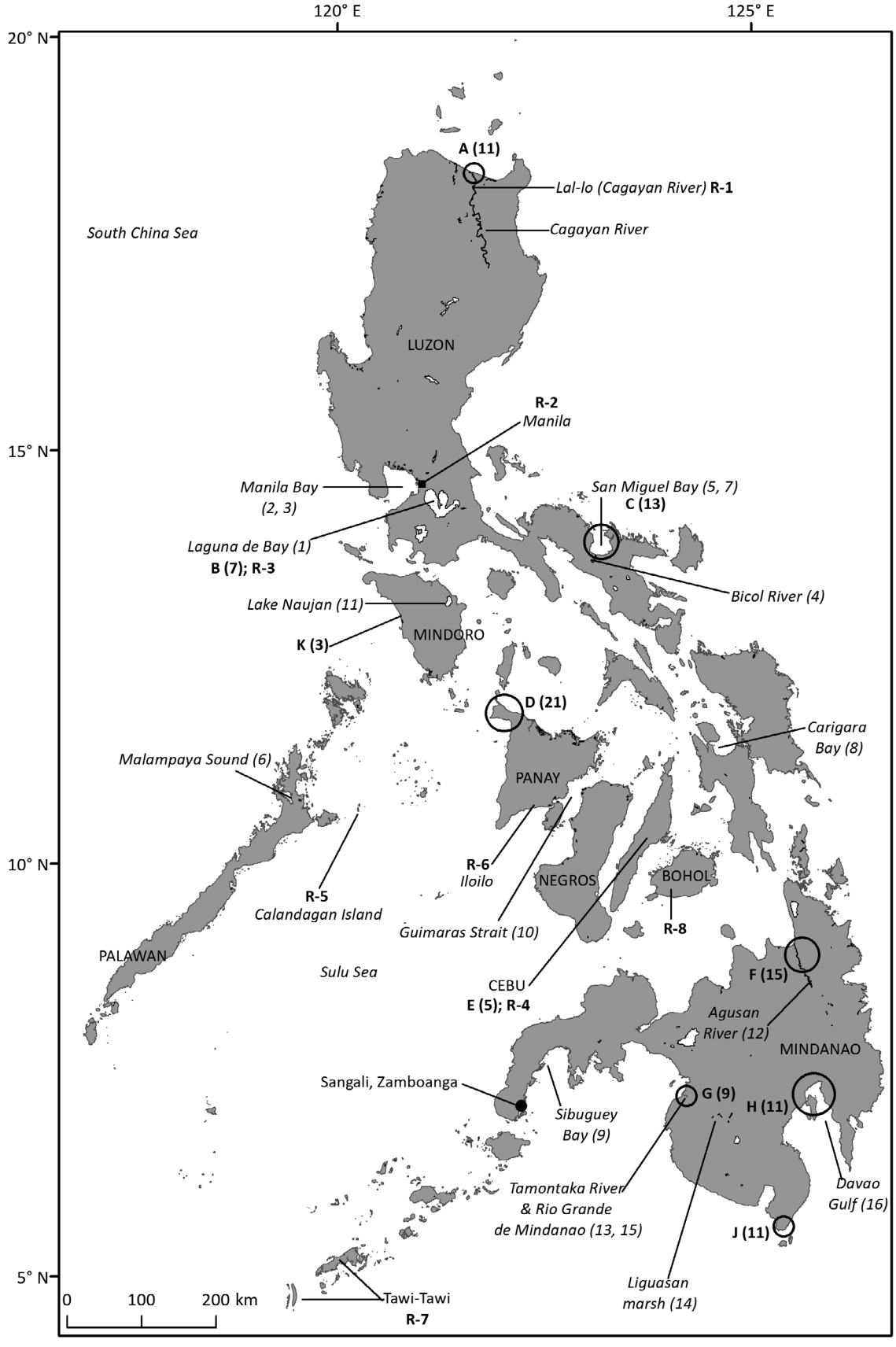

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Fig. 1. Locations of historical records of sawfishes in the Philippines (numbered; see Table 1 for sources) and capture location (or where it was located at the time of the study, if no origin data were available) for sawfish rostra (see Table S2). Interview regions are indicated by bold letters **A–K** (omitting '**I**' for clarity), with the number of interviews, also in bold, in parentheses. Rostrum locations are indicated in bold by the letter R and a number. The interview sites corresponding to each region are listed below. A black point indicates the location of the landing of a largetooth sawfish in 2015, recorded by Marine Wildlife Watch of the Philippines. (A) Cagayan River: Bisagu, Macanaya, Sapping, Aparri barangays. (B) Laguna de Bay: Aplaya, Bayside Clios, San Pablo Norte, Los Baños barangays. (C) San Miguel Bay: Mercedes fish port, Quinapaguian Island, Caringo Island, Sabang. (D) Western Panay: Santa Fe, Dionela, Baybay, Magaba, Botbot, Bachaw Sur, Old Buswang, New Buswang, Camanci Norte barangays. (E) Cebu: Bangbang barangay. (F) Agusan River: Lumbocan, Talacogon, San Nicolas, Esperanza. (G) Cotabato City: Mother Kalanganan, Kalanganan II, Buaya-Buaya barangays. (H) Davao province & Davao Gulf: Lebugano; Purocacao, Talikud Island. (J) Glan, Sarangani: Poblacion, Kalanasan, Tapun, Padidu. (K) Mindoro: Balokbalok, Sablayan, Buenavista

pines. A search was conducted in Google Books and Google Scholar, using the keywords Philippines, sawfish, *Pristis* and *Anoxypristis* (in English only). Because sawfish presence in the Philippines had not previously been summarised and neither historical nor recent occurrence was documented, no cut-off date was set for historical records. The literature resulting from the search was examined for additional references to past reports of sawfishes. All of the resulting literature that included a reference to encounters with sawfishes in the Philippines is summarised in Table 1. In many cases, the identity of the species could not be accurately determined based on the information available.

2.2. Museum records

A list of sawfish specimens collected from the Philippines and deposited in museum collections around the world was established, and is summarised in Table S1 in the Supplement at www.int-res.com/articles/suppl/n053p097_supp.pdf. In addition to the comprehensive list of museum specimens in Faria et al. (2013), museums throughout the Philippines were contacted by the authors, and the online catalogues of museums in Spain (due to the colonial history of the Philippines) were also searched for sawfish specimens. Where possible, images and measurements were obtained from the specimens (whole or rostrum) to verify their identity.

2.3. Local ecological knowledge

A standard semi-structured questionnaire, containing both open and closed questions, was developed during previous baseline studies on sawfishes in other countries (e.g. Leeney et al. 2018, Leeney 2017). This questionnaire was slightly modified for the present study (Text S1) and was used to collect basic background information from fishers, details of past and recent sightings and captures of sawfishes, and any socio-economic or cultural importance of sawfishes. Interviews were carried out with fishers and fish brokers (middlemen) at landing sites, ports and fishers' homes, and with several fisheries officers at the Filipino Bureau of Fisheries and Aquatic Resources (BFAR) offices or landing sites. The interviewer (R. H. Leeney, A. Bagarinao-Regalado or D. Verdote) was accompanied in each area by a local contact from BFAR, the Municipal Agriculture Office or an organisation already conducting conservation or fisheries work in the area, who could advise on where to find interviewees or introduce the research team to potential interviewees, and act as a translator. In some cases, interviews were conducted in English and in others, local field assistants translated the questions from English into Tagalog or another locally spoken language (such as Cebuano, Hiligaynon, Ibanag or Maguindanaon) and translated the interviewees' responses back into English, to be noted down.

Interviewees were selected based on availability of individuals when the interview team arrived at each site. Each interviewee was informed that the purpose of the interview was to collect information on rare aquatic species, and that interviews were being conducted with the permission of BFAR. They were informed that the interview was anonymous, that they did not have to respond to any question they did not feel comfortable responding to, and that they could stop the interview at any time. They were then asked for their permission to conduct the interview.

All sawfish rostra encountered during the study were photographed, rostral teeth were counted and a series of standard measurements including standard rostral length and standard rostral width were taken to verify the species each rostrum came from (Whitty et al. 2014). Any available information on where and when the sawfish had been caught or landed was also recorded.

Saw sharks (Pristiophoriformes) have been recorded from some parts of the Philippines (Ebert & Wilms 2013), and a previous study suggests that, when presented with photographs of both taxa, fishers who

Table 1. Historical records of sawfishes in the Philippines. The numbered locations of each record refer to the numbers in Fig. 1. Where non-metric units were used in the original source, metric equivalents have been noted in square brackets

Date	Species	Location (Fig. 1 reference no.)	Reference to sawfish/ location	Source
1870	*Pristis pristis*	Laguna de Bay (1)	Presence of sawfish (most likely *P. pristis*, despite the name used in the quote below) in Laguna de Bay, the large lake south of Manila, connected to the sea by the Pasig River: 'The largest fish entering Philippine fresh waters is the tagan or sawfish, *Pristis cuspidatus*. In 1870, Dr. A.B. Meyer, a celebrated German Naturalist, spent a month at Santa Cruz, Laguna Province. He reported that every day several large sawfish, up to a length of 20 feet, [~6.1 m] were brought to the Santa Cruz market. Later, in Rizal's time, he told in his noted novel, 'The Social Cancer' of huge sawfish being caught in fish corrals near Calamba, Nowadays the Pasig River and Laguna de Bay are too full of ships and motor launches for any but very small sawfish to enter, During the last 25 years I have seen no sawfish from Laguna de Bay more than a meter in total length, and even those were quite rare.'	Herre (1958)
1894	Unknown	Mindanao	'Pez sierra y Raya — De gran tamaño, del que se sacan bastones muy apreciados, y á los que el indio atribuye extrañas virtudes.'	Aguilar (1894)
Prior to 1900	Unknown	Manila Bay (2)	'The vast Bay of Manila holds fish and mammals of all sorts and sizes... Sharks of all sorts, enormous saw-fish... abound, so that the fisherman does not have everything his own way.'	Sawyer (1900)
Prior to 1923	Unknown	The Philippines	'Sawfish never attack man intentionally, but due to their size, strength, and terrific weapon they are greatly and justly dreaded when entangled in nets or caught in traps.'	Herre (1923)
Prior to 1936	Unknown	Manila (3)	'Although sometimes caught in the beam trawls, the sawfish is rarely met with in the local markets. Only one or two individuals were seen during the entire period of investigation. The sawfish is usually caught by hook and line and is brought to the market with the 'saw' already severed from the body. It is sold in fresh unfrozen strips at a price similar to that paid for sharks. The very limited and unsteady supply prevents this fish from playing a definite role in the fresh-fish stalls.'	Umali (1936)
1947??	Probably *P. pristis*	Bicol River (4)	Bicol River, which drains into San Miguel Bay.	Herre (1953)
1947	Unknown	San Miguel Bay (5)	Caught in July 1947; weighed 480 lb [~218 kg]	Warfel & Manacop (1950)
1948	Unknown	Malampaya Sound (Palawan) (6)	Gill netting conducted between 30 Oct and 24 Nov 1948 resulted in a capture of a '*Pristis cuspidatus*' weighing 305 pounds [~138 kg]. The weight of this sawfish is probably included under the 'Pounds of sharks' field heading in their Table 11 of sampling localities, thus the specimen must have been caught at Alligator Bay, Malampaya Sound.	Warfel & Clague (1950)
July 1948	*Pristis microdon*[a]	San Miguel Bay (7)	'One 480-pound [~218 kg] sawfish (*Pristis microdon*)...'	Warfel & Manacop (1950)
August 1949	*Pristis microdon*[a]	Carigara Bay (8)	'The second drag, between the 19- and 20-fathom [~34.7—36.6 m] contours,took about 390 pounds [~177 kg] of marketable fish per hour; but this consisted of one 300-pound [~136 kg] sawfish...'	Warfel & Manacop (1950)
October 1949	*Pristis microdon*[a]	Sibuguey Bay (9)	'110 pounds [~50 kg] of marketable fish, including sawfish, sting ray, slipmouths... The major items of these hauls, however, were one 350-pound [~159 kg] sawfish (*Pristis microdon*).'	Warfel & Manacop (1950)
1949	*Pristis microdon*[a]	Guimaras Strait (10)	'Sawfish (Pristidae)... 6 at 11—15 fathoms [~20.1—27.4 m].'	Warfel & Manacop (1950)
Prior to 1950	*Pristis microdon*[a]	Lake Naujan (11)	'Localities: Lake Naujan, Mindoro; Laguna de Bay; Bikol River; Camarines Sur Province; Rio Grande and Liguasan Swamp, Cotabato Province; Agusan River, Davao Province.'	Umali (1950)

(*Table 1 continued on next page*)

Table 1. (continued)

Date	Species	Location (Fig. 1 reference no.)	Reference to sawfish/ location	Source
Prior to 1950	*Pristis cuspidatus*[b]	Throughout the Philippines	'Localities: Throughout the Philippines in marine waters, especially in bays, gulfs, and straits.'	Umali (1950)
Prior to 1955	Probably *P. pristis*	Agusan River (12)	'In the Philippines, the Ganges shark and the sawfish mentioned previously occur in all rivers of any size and in all fresh-water lakes where there is a good-sized outlet, unimpeded by a dam or waterfall, leading to the sea. They pass through the rapids to reach the upper Agusan at least 150 mi [~240 km] from the sea by the winding river.'	Herre (1955)
Prior to 1958	Probably *P. pristis*	Rio Grande de Mindanao (13) & Liguasan Marsh (14)	'The Rio Grande de Mindanao or Pulangi, and the vast Liguasan swamp were still frequented by sawfish four to five meters long when I used to visit those regions. But no doubt the great increase in population and water traffic now prevent large sawfish from frequenting those waters.'	Herre (1958)
Prior to 1958	'Rivers' implies *P. pristis*	Cotabato (15) & Davao (16) provinces, Mindanao	'I found the Ganges shark and the sawfish well known along all the rivers of Cotobato and Davao provinces. The Monobos and Mandayas along the upper Agusan had the curious belief that the sawfish was the male, the [Ganges] shark the female of the same species... At Moncayo, on the upper Agusan River, the people reported to me that they caught rays... and sawfish.'	Herre (1958)

[a]*Pristis microdon* has been synonymised with *P. pristis*. However, sawfish taxonomy was not resolved until 2012 (Faria et al. 2013) and thus at the time of many of these historical reports, multiple sawfish species may have been identified as *P. microdon*.
[b]It is unknown whether '*Pristis cuspidatus*' refers to *P. zijsron* or *Anoxypristis cuspidatus*.

have encountered either sawfish or saw sharks may be unable to connect their observation of an elasmobranch with a rostrum to the appropriate image (Leeney 2017). The presence of a rostrum in the image of an animal appears to be a dominant feature that many fishers identify, and may lead them to mistakenly provide information about sawfishes when they have in fact encountered only saw sharks. Such a situation was identified in the first week of this study, when an interviewee in western Panay identified the image of a sawfish as an animal he had caught several times. He was able to produce a cell phone photograph of his most recent catch, which proved to be a saw shark. The animal was identified as such from the photograph by its more triangular-shaped rostrum, small size (<2 m), narrow body and smaller pectoral fins than those of sawfishes. The distribution of saw sharks around the Philippines is not well understood. All interviewees who fished in marine waters were therefore shown images of both sawfishes and saw sharks, and asked whether they had encountered either taxon. Those who fished solely in freshwater habitats were not asked about saw sharks.

2.4. Data analysis

To avoid potentially including data on fishers' encounters with saw sharks in this study, the information provided by the initial 10 interviewees in western Panay and from other interviewees who stated that they had observed saw sharks (n = 7) or both sawfishes and saw sharks (n = 9) was excluded from the final dataset. This cleaned dataset was then filtered to include only responses of interviewees who had encountered sawfishes at least once during their lifetime. Descriptions of the data were expressed as proportions of these individuals (or as many of those that provided a response to a given question). Due to the small number of responses, no statistical analyses were conducted, but descriptive analyses were performed to provide insight into the decades in which interviewees had most recently seen a sawfish, distribution, local uses and value of and perceived threats to sawfishes. To investigate whether any perceived changes in sawfish abundance had been observed and what the perceived causes of such changes might have been, responses only from interviewees who had seen a sawfish at least 2 times during their lifetime were assessed.

The research team worked closely with BFAR, thereby ensuring that local fisheries staff were educated about the status of sawfishes and the importance of collecting data on any sawfish landed by local fishers. All BFAR regional teams that provided support for this study were given data sheets and sawfish identification guides, to assist them in the collection of data from sawfishes in the future.

3. RESULTS

3.1. Historical records

There are historical records of sawfishes in the Philippines from numerous locations, from 1870 until the 1960s (Fig. 1, Table 1). In 1900, Sawyer reported a diversity of sharks and sawfishes in Manila Bay. Herre (1955, p. 417) reported that in the Philippines, sawfish occurred in 'rivers of any size and in all fresh-water lakes... leading to the sea'. Umali (1950) listed 2 species of sawfish as present in the Philippines. *Pristis microdon* (now synonymised with *P. pristis*) was stated to be present in Lake Naujan, Mindoro; Laguna del Bay; the Bikol River, Camarines Sur Province; Rio Grande and Liguasan Swamp, Cotabato Province (Mindanao); and the Agusan River, Davao Province (Mindanao). *Pristis cuspidatus* (which may refer to *P. zijsron*, the other species this study documented as historically present in the Philippines) was stated to be found throughout the Philippines 'in marine waters, especially in bays, gulfs and straits' (Umali 1950, p. 3). Herre, who collected fish specimens extensively in the Philippines from 1920 to 1948, recorded the presence of sawfishes (most likely *P. pristis*) in the Bicol River (Herre 1953) and in Laguna de Bay, the large lake south of Manila, connected to the sea by the Pasig River. Herre (1958) also recorded the presence of sawfish, again most probably *P. pristis*, in several rivers in northern Cotabato and Davao provinces (Mindanao), including the Agusan River.

In a description of the fishes observed at landing centres in Manila, Umali (1936) commented that sawfishes were occasionally caught in beam trawls, but that he had seen only 2 during his (unspecified) period of investigation. He noted that even then, the supply of sawfishes was limited and not continuous. In a review of marine fishes in Philippine rivers and lakes, Herre (1958) noted the decline of sawfish in certain freshwater localities over a 25 yr period.

3.2. Museum records

In addition to the historical records, a number of sawfish rostra that were collected in the Philippines are held by museums, including rostra from the islands of Luzon and Mindanao (no specific locations recorded) and from Laguna de Bay, the largest lake in the Philippines (Table S1). Whole specimens of largetooth sawfish and rostra from both largetooth and green sawfish confirm the presence of both these species around the Philippines. A single narrow sawfish specimen (a complete, taxidermied animal) suggests that this species may also have been present around the archipelago, but if so, was likely encountered far less often.

3.3. Local ecological knowledge

A total of 106 interviews were carried out between 6 February and 15 August 2016 at 34 sites across the Philippines (Fig. 1). In western Panay, saw sharks appeared to be commonly encountered by fishers, and it was not possible to verify whether interviewees were talking about sawfishes or saw sharks. For this reason, the initial 10 interviews conducted in western Panay were excluded from further analysis. An additional 16 individuals at other study sites stated that they had encountered saw sharks, and of those 16, 9 stated that they had also seen sawfishes. Efforts were made to establish whether each interviewee could discern between the 2 taxa, to be certain that the information collected during the interview pertained solely to sawfishes, but this was not always clear from the interviewee's responses, and thus, for precautionary reasons, the responses from those 16 interviewees were also removed from the final dataset. The cleaned dataset consisted of 80 interviewees, of whom 35 could not recognise the image of a sawfish, whilst 6 individuals recognised the image but had never seen one themselves, were unsure or had only seen a rostrum. Thus, 39 individuals (49% of the cleaned dataset) had encountered sawfishes at least once in their lifetime.

The broader descriptions of the dataset relate to the 106 interviews conducted for this study, but for all descriptive statistics relating to encounters with sawfishes, only information provided by the individuals who had encountered a sawfish at least once and who had not encountered saw sharks was used (n = 39). These simple analyses provide some insight, albeit from a small dataset, on observations of sawfishes by small-scale fishers in the Philippines.

Interviewees ranged in age between 32 and 85 yr, with the majority of interviewees aged between 40 and 69 yr (Fig. 2). Although interviewees in their 70s and 80s accounted for a small proportion of all the interviewees, they made up a relatively higher proportion of interviewees who had encountered sawfishes (Fig. 2). For the majority of interviewees, fishing was either their sole livelihood or one of their jobs (81% of 106 individuals). An additional 11% were retired or former fishers and 6% were fish brokers or

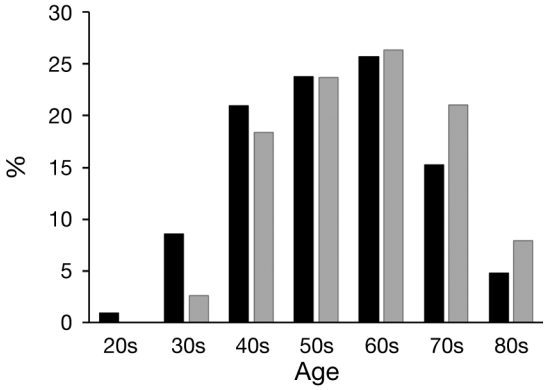

Fig. 2. Age distribution of all interviewees (black bars; n = 105; one individual did not know his age) and of interviewees who had seen a sawfish at least once (grey bars; n = 38)

both fishers and brokers. A fisheries officer and an individual who did not fish but was very familiar with the local river were also interviewed. Those interviewees who fished (or had in the past) used a wide range of gears and techniques, including surface and bottom gill nets, gill nets for crabs, hook and line, traditional longlines ('palangre'), beach seines, fish and crab traps, fyke nets, spearguns, trawl nets and gleaning. Only one woman — a gleaner — was interviewed as part of this study, as female fishers were rarely encountered.

Various local names for sawfish are used throughout the Philippines; Table 2 lists the names documented during this study and the region(s) in which each name was used. Of 37 individuals who provided an estimated decade for their most recent sawfish observation (Fig. 3), most individuals had last seen a sawfish either in the 1970s (24%), 1980s or 1990s (19% each). Only 12% (4 interviewees) of those who provided a response stated that they had observed a sawfish since 2010. Gill nets (21% of 34 interviewees who provided a response) and other net types (ring nets, purse seines and unspecified; 18%) were the primary form of fishing gear responsible for sawfish catch, but hook and line (18%) and longlines (18%) were also stated to have been used to catch sawfishes.

3.3.1. Distribution

The most recent observations of sawfishes reported by interviewees occurred in Mercedes port in 2014 (a landing reported separately by 2 interviewees) and in 2011 (1 interviewee). Prior to these, there were observations in the 2000s 'at sea near the Tamontaka River' (the river running into Illana Bay in western Mindanao) and off the Island Garden City of Samal (Davao Gulf).

Historical records confirm that amongst other sites, Laguna de Bay (Luzon) and the Agusan River (Mindanao) were once sawfish habitats. Examining the recollections of interviewees at these sites of their last sawfish encounters can provide insight into when sawfishes may have disappeared from these habitats. In Laguna de Bay, 7 fishers with between 38 and 62 yr of fishing experience were interviewed. Only one of the 7 (whose ages ranged from 54 to 78 yr; mean age of 70 yr) had ever seen a sawfish; he estimated his last

Table 2. Local names for sawfish recorded from the areas visited during this study and number of interviewees who mentioned each name. The table includes the name of the dialect in which the local name is used, and where this was recorded

Local name	Region (sites where local name was recorded)	Dialect/notes
Warawak/warawag/ warawog/barawag (n = 8)	Bisagu barangay, at mouth of Cagayan River; Macanaya barangay; Sapping, Aparri	Ibanag dialect
Tagan (n = 1)	San Pablo Norte (Sta Cruz)	
Tagahan (n = 11)	Talacogon; St Nicholas barangay; Esperanza; Lumbucan	
Sorodan/surudan (n = 5)	Mercedes; Quinapaguian Island; Caringo Island	This name was also reported by Pauly (1982)[a]
Barabad (n = 3)	Mindoro	
Tiwan tiwan (n = 3)	Buaya-Buaya, Kalanganan Dos; Brgy Kalanganan Dos, Cotabato	Maguindanaon
Bagisan/salday na bagisan (n = 4)	Cotabato	Maguindanaoan; means shark (bagisan) with comb (salday)
Taglungan (n = 2)	Talikud Island; Purocacao	

[a]Other names noted in Pauly (1982) are barasan and pakangan.

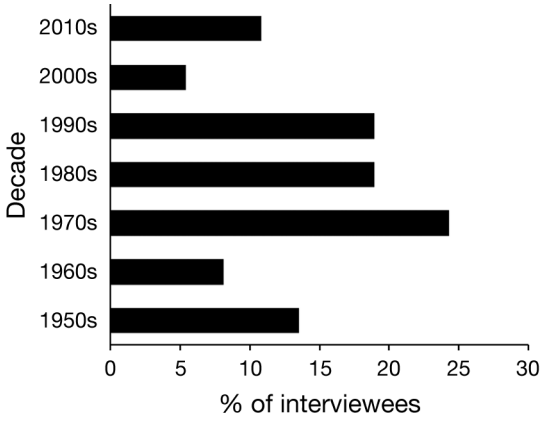

Fig. 3. Decade in which interviewees last observed a sawfish (n = 37; 2 individuals did not provide a response)

observation to have been in 1959. Another 2 individuals recognised the image; one had only seen a rostrum, and the other knew about sawfish through stories he had heard from elders, of 'tagan' that were as long as their boats (>4 m). This suggests that by 1978 (38 yr prior to these interviews) and possibly much earlier, sawfishes were already rare in Laguna de Bay.

Interviews were conducted at 4 sites along the Agusan River, with 15 interviewees (age range: 44 to 76 yr), of whom 10 had seen sawfish between one and more than 20 times. All had observed sawfish in the Agusan River or its estuary. Two individuals stated they had last seen a sawfish in the 1980s, whilst the others cited the 1970s or 1960s as the decade of their last observation. No sawfish rostra could be located in this region, despite considerable effort. Several households were located where rostra had previously been on display, but all the owners stated that when they had moved house or renovated their home, they had misplaced or thrown away the rostra.

Along the Cagayan River (northern Luzon), 11 interviews with fishers and retired fishers (aged 34 to 82 yr) were conducted at 4 sites all within several kilometres of the river mouth. Eight of these interviewees had encountered sawfishes between one and more than 20 times, and always in the river or the river mouth. The most recent sawfish observation was reported to have been in the 1990s.

An interviewee in Lebugano barangay, close to the mouth of the Libuganon River (Davao Gulf; Fig. 1), remembered his uncle catching a sawfish at the river mouth, 38 yr before. Another (aged 84 yr) had caught a sawfish once, close to Lebugano, and had seen other fishers catch them several additional times, but only when he was in his 20s.

3.3.2. Uses for sawfish

Of 39 interviewees who had seen a sawfish at least once, 30 individuals provided responses regarding the uses to which sawfishes were put. The most common uses mentioned were consumption (50% of 30 respondents) and selling the flesh or the whole fish (50%), keeping the rostrum at home for decorative purposes, as a 'lucky charm' or for other reasons (50%). Just 2 individuals mentioned selling the fins; 2 individuals mentioned using the liver oil medicinally and 1 individual mentioned that sawfish skin could be used to make a belt. Very few individuals could or were willing to give sale prices for any sawfish parts, possibly because they had not witnessed the landing or sale of a sawfish for a long time. A fisher interviewed on Quinapaguian Island who had caught a sawfish with a gill net in San Miguel Bay in the 1970s sold the whole fish (estimated to have been 4 m in length) for 700 PhP (approximately 95 USD; based on an exchange rate of 1 USD = 7.37 PhP, generated as the mean of the end-of-year exchange rates between 1974 and 1979; https://www.in-philippines.com/fx-rates-historic-from-1965-usd-php/). An 84-yr-old fisher on Caringo Island who had caught a 3 m sawfish using a gill net in San Miguel Bay in 1999 said he sold the rostrum for 500 PhP (approximately 12.80 USD; based on a mean exchange rate for 1999 of 1 USD = 39.089 PhP, calculated from monthly mean exchange rates; https://www.ceicdata.com/en/indicator/philippines/exchange-rate-against-usd).

The only mention of traditional beliefs associated with sawfishes was by 2 interviewees in Cotabato, who mentioned that a sawfish rostrum could be kept above a doorway or gate, to keep out evil spirits; one also mentioned that it could protect people from lightning.

3.3.3. Perceived changes in sawfish abundance and causes

Of 20 interviewees who had encountered sawfishes at least twice, 4 did not provide a response and 2 interviewees stated that there had been no change in sawfish abundance; one of them believed this was because bottom-set longlines were no longer used and thus sawfish were just caught less often now than in the past. The other 14 interviewees noted that sawfishes were less common than in the past, and perceived causes for this decline included pollution in freshwater environments, climate change, high levels of sawfish catches and changes in the fishing gears used.

Amongst interviewees around the Cagayan River, reasons for the perceived decline in sawfishes included high levels of sawfish catch:

'People would catch sawfish accidentally but then keep them to sell. Before the 1970s there were no nylon gillnets' — 65-yr-old fisher, Bisagu barangay.

'Too many people caught sawfish in the past' — 82-yr-old retired fisher, Macanaya barangay.

Interviewees also mentioned more general changes in the Cagayan River. A 65-yr-old fisher in Sapping barangay noted that he had seen changes in the Cagayan River over his 30 yr of fishing experience. He noted that catches were more 'scarce' now than in the past, and mentioned 'pollution, climate change and more people fishing' as possible reasons. A 43-yr-old fisher in Aparri who had encountered a sawfish once noted, 'Over 29 years fishing in Cagayan River, catch levels have decreased, maybe because of destructive fishing gear like the buli-buli' (a fine-mesh net used on the coast).

In the Agusan River, several interviewees mentioned pollution of the river as a possible factor in sawfish declines. A 61-yr-old fisher in Lumbocan (at the mouth of the Agusan River) stated that sawfishes had declined 'maybe because of mining and the mercury going into the river. There are 2 barangays with many fish ponds that use pesticides, and this causes pollution'. Another fisher (age 55 yr) in Talacogon noted that there had been sedimentation of the river, and that 'in the 1990s the river was clear and there was no mining. Mining for gold started 1990s, and the water depth decreased by about 10 feet' [~3 m].

Other interviewees in Talacogon mentioned the use of electrofishing and cyanide to catch fish.

Around Laguna de Bay, only one of the 7 interviewees had ever encountered a sawfish, and believed that they were not commonly caught because the saw is dangerous. This interviewee, a 72-yr-old fisher from Los Baños, noted that over his 60 yr of fishing experience, some fish species had disappeared from the lake and some new 'introduced' species had appeared. He noted that he caught more fish in the past, but also that there were more fishers in the past, and suggested that pollution might have caused declining catches. A 77-yr-old fisher in Aplaya who had seen a sawfish rostrum but never the whole animal, remarked that 'seawater used to come into the lake from Manila Bay'. He remembered that a dam was built (he could not recall the year) to control flooding in metropolitan Manila, and suggested that this may have prevented sawfishes from entering Laguna de Bay.

3.4. Recent sawfish landing

After this study had been completed, a Filipino NGO, the Marine Wildlife Watch of the Philippines, received an anonymous report and images of the landing of a largetooth sawfish at Sangali, Zamboanga Peninsula on 24 December 2015 (Fig. 4).

3.5. Sawfish rostra

Data were collected from 7 sawfish rostra during the study, and information on another rostrum, observed in Tawi-Tawi, was shared by a researcher from the

Fig. 4. Largetooth sawfish landed at Sangali, Zamboanga Peninsula, on 24 December 2015. Photograph submitted anonymously to the Marine Wildlife Watch of the Philippines and reproduced here with their permission

Manta Trust (Table S2). Two of these rostra were from green sawfish and the remainder were from largetooth sawfish. The owner of the green sawfish rostrum encountered in a house on Malapascua Island provided details on its origin. The sawfish had been caught in 1978 at Calandagan Island, Palawan, by the owner's father. The sawfish was reportedly caught in a net geared towards catching large elasmobranchs. It thrashed around as they lifted the net and its teeth made indentations into the boat, so they cut the rostrum off quickly. The liver oil was extracted, the rostrum was kept by the fisher and brought to Malapascua, and the rest was discarded.

3.6. Saw sharks

In western Panay, a 51-yr-old interviewee who had been fishing for 38 yr stated that he had encountered sawfishes but, based on the image he was shown, was not familiar with saw sharks. However, through additional questioning, it appeared more likely that he might be mistakenly identifying his catches as sawfishes. He recalled catching a 'sawfish' in Pandan Bay in 2015 and posting a photograph of it on social media, and when we (R. H. Leeney and A. Bagarinao-Regalado) were later sent this photograph, it was clear that he had caught a saw shark, most likely *Pristiophorus lanae*, which has been recorded from the Philippines (Ebert & Wilms 2013). He estimated having caught 10 of these animals during his lifetime. Another fisher, who stated he was familiar with both sawfishes and saw sharks, told the authors that he caught more than 20 animals per year. This suggested to the authors that the interviewee was not encountering sawfishes. Upon further questioning, the interviewee affirmed that the animals he had encountered had barbels on their rostra ('like a moustache'), implying that he was encountering saw sharks. He caught these saw sharks at depths of 200 fathoms (~366 m; unverifiable) and stated that he could catch up to 4 individuals in one net deployment. He sold the liver oil from these sharks as a treatment for skin rashes, or to oil bicycle chains, at 300 PhP per litre (approximately 6.30 USD; based on an exchange rate of 1 USD = 47.4925 PhP, the mean exchange rate for 2016; https://www.in-philippines.com/fx-rates-historic-from-1965-usd-php/). He stated that there was no use for saw shark rostra.

A saw shark was caught on 10 March 2016 in the waters off Culasi, Antique. The shark was sent to the University of the Philippines Visayas in Iloilo, where it was photographed and skin samples were taken for genetic analysis (Fig. 5). Genetic sequencing confirmed it as *P. lanae* (G. Naylor pers. comm., May 2022).

3.7. Other observations

Several bottlenose wedgefish *Rhynchobatus australiae* were landed at Mercedes port during the single day the research team spent at that site. A broker interviewed there stated that this species is landed almost every day and estimated that between 5 and 7 individuals were landed daily, each weighing approximately 3–7 kg. He stated that they are caught with a buli-buli trawl net, bottom gill nets and drift gill nets. Another fisher interviewed at the same site, who used hook and line and bottom-set gill nets, stated that March to May was the peak season for wedgefish

Fig. 5. Saw shark *Pristiophorus lanae* caught in the waters off Culasi, Antique province, in March 2016. Photo credit: Alexanra Bagarinao-Regalado

landings. He said he could catch 2 or 3 wedgefish per month during the peak season, each weighing from 20 to 30 kg.

4. DISCUSSION

Historical data combined with evidence collected during this study suggest that in the past, largetooth sawfish and green sawfish were present in numerous habitats throughout the Philippines, including the Cagayan River, Laguna de Bay, San Miguel Bay and the Bicol River, Lake Naujan, the Agusan River and several other rivers in Mindanao. Interview data suggest that sawfishes may have been extirpated from some freshwater habitats (e.g. Laguna de Bay) as early as the 1970s, but may have persisted in other habitats such as the Cagayan River until the 1990s. The prevalence of rostra from largetooth and green sawfishes, both in museum collections and all of those encountered in the Philippines during this study, and the documentation of only one narrow sawfish rostrum (in Villa Escudero Museum, Tiaong, Quezon) supports previous sawfish range assessments that suggest that narrow sawfish were likely not present historically in the waters of the Philippines (e.g. D'Anastasi et al. 2013). The decline of sawfish in some freshwater habitats over a 25 yr period, reported by Herre (1958), was one of the first reports of declines of freshwater elasmobranch populations under pressure from human activities, but it was ignored, along with reports of severe declines in marine shark fisheries, until the early 1990s (Compagno & Cook 1995).

Just over half of interviewees in the filtered dataset either did not recognise the image of a sawfish, or were familiar with it but had never encountered one. This is a greater proportion than documented in countries such as Mozambique (25% of interviewees; Leeney 2017) and Guinea-Bissau (15%; Leeney & Poncelet 2015). Combined with the dearth of recent sawfish observations amongst the interviewees, this suggests that sawfishes are now extremely rare or, more likely, have become locally extinct in the waters around the Philippines. The largetooth sawfish landed in Mindanao in December 2015 may have been caught by fishers operating outside of the Philippines' territorial waters or may have been a vagrant animal encountered in Filipino waters.

Historically, Herre (1923, p. 69) noted:

> In the Philippines, several species of sharks and rays are commonly seen in the markets and are esteemed as food. In some parts of the Islands, especially in the Sulu Archipelago, large numbers of sharks are caught for the fins alone [...] The dried fins are exported to China, where they are in great demand as the basis for a delicious soup.

In the present study, interviewees primarily suggested that sawfishes, when caught, were used as a source of food by the fishers or sold for the same purpose. The value of the fins was rarely mentioned by interviewees, and rostra appear to have been used mostly as a decorative item rather than seen as a saleable commodity. In contrast, studies in Papua New Guinea (Leeney et al. 2018), the Arabian Gulf (Jabado et al. 2017) and Bangladesh (Hossain et al. 2014), amongst others, have highlighted the high prices that sawfish fins can fetch, which may motivate fishers to land sawfishes even if they are aware that doing so is illegal. However, most interviewees in the Philippines had not encountered sawfishes for several decades and thus they may not have recalled all the ways in which sawfishes had been used in the past.

Globally, the largest threat to sawfishes currently is incidental capture, particularly in net fisheries (Simpfendorfer 2014). Unsustainable levels of incidental capture are likely to have been a major cause of the decline of sawfishes in the Philippines. Sawfishes were being landed and marketed alongside shark meat in Manila in the 1930s, although they were not abundant (Umali 1936). Whether this is because numbers were already depleted, because this was not an area of sawfish abundance, or because they were mainly landed and sold at other sites is unknown, but records of 'several large sawfish, up to a length of 20 feet [~6.1 m]' (Herre 1958, p. 87) being brought to the market in Santa Cruz (a town on the shore of Laguna de Bay) every day in the 1860s suggests that they were common at least in the lake. The largetooth sawfish that inhabited Lake Nicaragua were thought to spend their entire lives in freshwater, within the lake (Thorson 1982). It is possible that the largetooth sawfish in Laguna de Bay may also have spent most or all of their lives in the lake, making encounters with sawfish along the adjacent coast near Manila rare. Unfortunately, there is no detailed description of the ecology of sawfish in Laguna de Bay to confirm or refute this suggestion.

It is unclear whether sawfishes were ever targeted in the Philippines, but it is likely they were caught, at unsustainable rates, either as part of broader shark fisheries or accidentally in trawl and various net fisheries. In San Miguel Bay, elasmobranchs represented 22% of the trawlable biomass in 1947 (Warfel & Manacop 1950), whilst 4 decades later, they comprised 0.6%, indicating that the exploitable part of the

elasmobranch stock in the bay had been reduced to 1/177 of its previous extent (Pauly 1982).

Pauly (1982, p. 109–110) noted:

> Most of the present elasmobranch catch consists of small sharks, whereas in 1947 rays were the main group taken. This indicates that [...] as also reported from various parts of the world, including the Gulf of Thailand [...] large rays (and sawfish) dwindle rapidly upon exploitation.

Between the late 1940s and the 1980s, bottom trawling was the most common fishery for demersal fishes in the Philippines (Armada 2004). Demersal trawl surveys between 1947 (with several sawfishes recorded from trawls between 1947 and 1949; Table 1; Warfel & Manacop 1950) and 1995 revealed a clear decline in trawlable biomass (Armada 2004). Sawfishes are commonly bycaught in trawl fisheries (e.g. Brewer et al. 2006), and thus it seems likely that the extensive trawling around the Philippines contributed to reducing local sawfish populations. Species composition has also changed significantly as a result of trawling. Throughout Southeast Asia, the species composition of demersal fish communities has shifted towards lower-sized species (Butcher 2004, Garces et al. 2006, Stobutzki et al. 2006b, Siar et al. 2017), indicating that intensive trawling has had a detrimental effect on fisheries resources and marine ecosystems in the region (Butcher 2004, Pomeroy et al. 2016). In the Philippines, shifts in catch composition in Manila Bay (Silvestre et al. 1987), San Miguel Bay (Pauly 1982) and the Lingayen Gulf (Silvestre et al. 1991) indicate that fishing down food webs was occurring (Pauly et al. 1998, Palomares & Pauly 2014). Any impacts on prey species may have had indirect impacts on sawfish populations, in addition to the direct impacts of bycatch. In the Philippines and elsewhere in the region, coastal fisheries have also been impacted by issues including overfishing, other destructive fishing practices (e.g. dynamite fishing) and insufficient law enforcement to prevent such practices, siltation and sedimentation, mangrove conversion and various types of pollution (Silvestre & Pauly 1997).

River and mangrove ecosystems are important habitats for sawfishes. Research in western Australia has revealed that juvenile green sawfish have high site fidelity near the mouth of the Ashburton River and in the adjacent tidal mangrove creeks, highlighting these habitats as an important focus for conservation efforts (Morgan et al. 2017). Likewise, largetooth sawfish use rivers and their estuaries as nursery habitats (Whitty et al. 2017). The loss and degradation of such habitats in the Philippines has thus likely contributed to declines of local sawfish populations (Kyne & Moore 2014) There has been an estimated 30% reduction in mangrove area since 1980 in the Indo-Malay Philippine Archipelago — one of the highest rates of mangrove area loss globally (FAO 2007). Approximately half of the 279 000 ha of mangroves in the Philippines lost between 1951 and 1988 was developed into aquaculture ponds for fish or shrimp (Primavera 2000, Polidoro et al. 2010). This conversion of vast areas of the Philippines' coastlines has likely had direct impacts on sawfishes. In addition, sawfishes in these habitats may be exposed to elevated pressures from anthropogenic-induced stresses including fishing (e.g. bycatch or direct capture) and in-stream habitat modification and degradation such as water extraction and mining. Changes in water quality due to the use of antibiotics and chemicals in shrimp farming, and the dumping of pond effluent in neighbouring waters (Primavera 1991), may have impacted sawfishes directly or may have affected the health and abundance of prey species. Gold mining has resulted in mercury contamination of the Agusan River system (e.g. Appleton et al. 1999), and black sand mining has been conducted both legally and illegally on the banks of the Cagayan River since at least 2008 (Chaussard & Kerosky 2016; https://ejatlas.org/conflict/cagayan-black-sand-mining-in-shore-area), causing land subsidence, sediment redistribution and permanent flooding of some coastal areas. These negative impacts on river and marsh ecosystems previously inhabited by sawfishes may have contributed to their decline, especially largetooth sawfish, which spend the early years of their lives in such habitats.

During this study, only one of the 7 interviewees in Laguna de Bay had ever seen a sawfish, and estimated his most recent observation of a sawfish to have been in the 1950s. Fishery productivity in Laguna de Bay declined dramatically over several decades, whilst deforestation in the watershed heightened soil erosion rates, leading to siltation. Fishing in the Pasig River (which feeds the lake) was prohibited in the 1980s, and by the 1990s, the river was considered biologically dead (Hartmann 2019). It appears very unlikely that any sawfish have inhabited this lake, which has been described as 'an extremely stressed ecosystem needing rehabilitation' (Tamayo-Zafaralla et al. 2002, p. 127), for perhaps half a century. Even several decades ago, high nutrient levels and temperature and seasonally low dissolved oxygen values suggested that the lake was in an advanced state of eutrophication (Barril 1993).

4.1. Caveats

As has been noted in a previous baseline study for sawfishes (Leeney 2017), saw sharks may occasionally

be confused with sawfishes by interviewees who have only seen one or other group of these saw-bearing elasmobranchs. Given that the distribution of saw sharks in the Philippines is not well understood, baseline studies of sawfishes such as this one, where the data collected are not based on observations by the researchers or reports verified using photographs, should establish whether saw sharks occur in or near the study area and use specific interview questions that can help to establish which taxon an individual has encountered. In this study, interviewers used information on the size and capture locations of the animals encountered, and whether interviewees had noted barbels on the rostrum, to assess whether interviewees fishing in marine waters had encountered saw sharks or sawfishes, but at times this was challenging to determine.

The small sample size from which information about sawfishes was taken (39 interviews) means that the results presented here may not present a comprehensive picture of encounters between coastal communities and sawfishes in the Philippines. However, given the relatively low proportion, even within this small dataset, of interviewees who had encountered sawfishes at all during their lifetime (39 of 80 interviewees), the additional cost and effort of collecting more data may not have resulted in considerably more information. Likewise, the geographic scope of this study was not comprehensive due to the small budget available for this work, and the considerable time and cost involved in travelling through the archipelago. Nonetheless, interviews were conducted in the majority of areas for which there were historical reports of sawfishes, with only Palawan, Samar and Leyte not covered by this study.

4.2. Conservation and management

The Bureau of Fisheries and Aquatic Resources (BFAR) within the Department of Agriculture is responsible for the implementation of the development, improvement, law enforcement, management and conservation of the Philippines' fisheries and aquatic resources and, thereby, the Philippines Fisheries Code of 1998 (Republic Act No. 8550 as amended by Republic Act No. 10654). The Philippines Fisheries Code specifies that the capture, sale, purchase, possession, transport and export of species listed on CITES Appendix I or categorised as threatened by the IUCN Red List of Endangered Species — as all sawfishes species are — is prohibited.

The landing in 2015 of a largetooth sawfish in Mindanao may indicate that sawfishes may be present in extremely low numbers, but the lack of recent encounters documented in this study, and the well-documented degradation of a number of key sawfish habitats, suggests that sawfishes are extremely rare or, more likely, are now locally extinct around the Philippines archipelago. Targeted efforts to manage catches or to sensitise fishers regarding legislation are thus not likely to be a wise use of resources, unless these efforts include other protected elasmobranch species.

However, the reportedly frequent landings of bottlenose wedgefish at Mercedes port are notable as this species is listed as Critically Endangered on the IUCN Red List (Kyne et al. 2019b) and is one of several wedgefish and giant guitarfish species now listed in Appendix II of CITES. The fins of these species are highly valued in the Asian shark fin trade (Jabado 2019), which likely drives fisheries for this species. A recent study of imports and landings of elasmobranch products in Singapore found that *R. australiae* was the most commonly encountered wedgefish species, and traders there noted declines in the supply of wedgefishes in recent years (Choy et al. 2022). CITES Appendix II requires trade to be carefully controlled and not detrimental to the survival of the species in the wild. This points to an urgent need for better monitoring of landings of *R. australiae*, research to develop quotas to ensure sustainable catches, and enforcement of those quotas.

4.3. Conclusions

This study has confirmed that at least 2 species of sawfish were once present in the waters of the Philippines and may have been regularly encountered in several habitats, including the Philippines' largest river, the Agusan River, and largest lake, Laguna de Bay. The results also suggest that these 2 species, largetooth sawfish and green sawfish, are now extremely rare in the waters of the Philippines, and probably have been for several decades. Both species are classified as Critically Endangered on the IUCN Red List (Espinoza et al. 2022, Harry et al. 2022). Intensive fishing throughout the Philippines' EEZ and severe degradation of several possible nursery habitats for sawfishes probably contributed to this depletion. Largetooth sawfish exhibit maternal philopatry, returning to the same river system where they were born to give birth themselves (Feutry et al. 2015), and thus this species may not be able to repopulate areas from which they have been driven to local extinction. The recovery of sawfish populations in the Philip-

pines seems unlikely, and resources for monitoring and management of threatened elasmobranchs should thus be directed towards species — such as the wedgefishes — for which recovery is still possible. It will be essential to document landings and manage fisheries for these species carefully in the Philippines, to ensure that they do not meet the same fate as sawfishes.

Data availability. All interview and rostrum measurement data collected for this study have been submitted to the International Sawfish Encounter Database, Florida Museum of Natural History, USA.

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