Do sawfish *Pristis* spp. represent South Africa’s first local extirpation of marine elasmobranchs in the modern era?§

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Largetooth sawfish *Pristis pristis* and green sawfish *P. zijsron* were not uncomon in catches made in KwaZulu-Natal (KZN) on the east coast of South Africa in the mid part of the last century but apparently have disappeared from this area. This paper traces the decline in sawfish catches from 1951 and assesses the current population status and local extinction risk, based on historical and current records up to 2012. Records were collected from research surveys, literature, media and museum specimens, and through contacting researchers and conservation managers who have worked in KZN coastal and estuarine areas. A total of 150 green sawfish, 7 largetooth sawfish and 89 unidentified sawfish records were located. Most sawfish (115) were caught during a four-year (1967–1970) gillnetting survey conducted by the Oceanographic Research Institute in the St Lucia estuarine system while 91 were caught in the bather protection nets installed and maintained along the KZN coast by the KwaZulu-Natal Sharks Board. Sawfish ranged from 63 to 533 cm total length (TL). Sawfish caught in the estuarine environments (mean TL 162 cm [SD 72], *n* = 95) were significantly smaller than those caught in the inshore marine environments (mean TL 310 cm [SD 109], *n* = 83), confirming the importance of estuaries as pupping and nursery areas. The St Lucia estuarine system, given the high abundance of sawfish, was determined to be the most important nursery area in KZN. The last sawfish encountered in KZN, which was not identified to species level, was caught in the bather protection nets in 1999 and released alive. Extinction probability analysis indicates that sawfish no longer occur in KZN waters. Anthropogenic changes to the St Lucia estuarine system, as well as to other KZN estuaries, gillnetting for bather protection, and illegal fish harvesting, coupled with a non-adaptive life-history style, may have precipitated the disappearance of sawfish from KZN waters.

Keywords: catches, length frequency, local extinction, sex ratios

Online supplementary material: The complete list of records and specimens for largetooth sawfish *Pristis pristis* and green sawfish *P. zijsron* located by consulting various data sources, primary literature, media, museums and local conservationists and scientists is available online in Supplementary Appendix S1 at http://dx.doi.org/10.2989/1814232X.2015.1027269.

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**Introduction**

Sawfish are shark-like batoids that have an elongated, flattened rostrum with an absence of rostral barbels and on each side of which is a row of large, strong, lateral teeth embedded in sockets (Wallace 1967; Compagno et al. 1989; van der Elst 1993; Compagno and Last 1999; Smith and Heemstra 2003). Sawfish comprise five species in two genera: *Pristis pristis*, *P. clavata*, *P. pectinata*, *P. zijsron* and *Anoxypristis cuspidata* (Faria et al. 2013). Sawfish taxonomy has been problematic globally (Faria et al. 2013; Kyne et al. 2013; Simpfendorfer 2013), including in South Africa (Smith and Heemstra 2003). Previously it was thought that three species occurred in South African waters: *P. microdon*, *P. pectinata* and *P. zijsron* (Compagno et al. 1989; van der Elst 1993; Smith and Heemstra 2003), but recent genetic studies have shown that only two species occur here: *P. pristis* (Linnaeus, 1758) and *P. zijsron* Bleeker, 1851 (Faria et al. 2013). Species previously identified as *P. microdon* are considered to have been *P. pristis* whereas those previously identified as *P. pectinata* and *P. pectinatus* are deemed to have been *P. zijsron*. Historical data showed that largetooth sawfish *P. pristis* originally had a circumglobal tropical/subtropical distribution whereas green sawfish *P. zijsron* were found in the Indo-West Pacific from East Africa to South-East Asia and south to Australia (Faria et al. 2013; Kyne et al. 2013; Simpfendorfer 2013). In South Africa, both species were reported to have occurred off the KwaZulu-Natal (KZN) and Eastern Cape provinces, reaching as far south as Port Alfred, although for largetooth

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sawfish this southern limit was based on a single record only (Figure 1) (von Bonde 1934; Compagno et al. 1989; van der Elst 1993; Smith and Heemstra 2003).

Largetooth sawfish occur in freshwater, estuarine and marine environments (Wallace 1967). In Australia, neonates and juveniles remain mostly in rivers and the freshwater regions of estuaries, whereas the adults are found mostly in marine and estuarine habitats (Peverell 2005; Thorburn et al. 2007; Whitty et al. 2009). Mature largetooth sawfish are believed to move into less-saline water to pup and rivers probably provide important nursery areas for juveniles of this species (Peverell 2005; Phillips et al. 2011). Stevens et al. (2005) found that green sawfish in northern Australia occur mostly in inshore areas that include river mouths with soft substrates and estuaries. They remain in the extreme nearshore environment, are tidally influenced and have a strong association with mudflats and mangroves (Peverell and Pillans 2004; Stevens et al. 2008; Phillips et al. 2011). In KZN, green sawfish reportedly entered the Mhlatuze Estuary at Richards Bay and the St Lucia estuarine system to pup (van der Elst 1993; Smith and Heemstra 2003).

Largetooth and green sawfish, like other large elasmobranchs, are characterised by slow growth, late maturity and low fecundity (Stevens et al. 2005). Both species can attain lengths of up to 7 m (Compagno and Last 1999; Simpfendorfer 2013) and their age at maturity is estimated at approximately nine years (Peverell 2008). Litter size is approximately 7 for largetooth sawfish (Thorson 1976) and 12 for green sawfish (Peverell 2008). Thorson (1976) found that largetooth sawfish in Lake Nicaragua, South America, have a biennial reproductive cycle, but in northern Australia the cycle appears to be annual (Peverell 2008). The reproductive cycle of green sawfish is unknown.

Sawfish are recognised worldwide as being one of the most endangered elasmobranchs (Simpfendorfer 2013; Dulvy et al. 2014; Harrison and Dulvy 2014). They are highly susceptible to fishing pressure because their toothed rostra easily become snagged in fishing gear such as gillnets (Simpfendorfer 2000; CITES 2007) and because they live in localised coastal and riverine habitats (Compagno and Last 1999; Robillard and Sèret 2006). During the 1930s, sawfish were reported as being one of the most common elasmobranchs found in KZN and Delagoa Bay (now Maputo Bay), Mozambique (von Bonde 1934). In KZN, sawfish are susceptible to fishing pressure from gillnets and hook and line fisheries. Anecdotal information suggested that sawfish were caught in comparatively large numbers in and around the St Lucia estuarine system in northern KZN (Mara 1986) and they had been recorded in the catches of the bather (Dudley and Cliff 1993). In this study, we have utilised all available records to document the decline of sawfish populations in KZN waters and to assess their conservation status and potential local extirpation.

Material and methods

Study area
The study area comprised the entire KZN coast of eastern South Africa, from the Mozambique border at 26°54′ S to the Eastern Cape border at 31°05′ S (Figure 1). Nearshore sea surface temperatures vary from north to south along the KZN coast with a range of 16–22 °C in the cooler months and 18–27 °C in the warmer months (Smit et al. 2013). The province experiences high average annual rainfall of over 1 000 mm (Day 1981; Schulze 1984). The KZN coastline of 570 km is broken by 73 estuaries that range in size from the 32 000 ha St Lucia estuarine system to very small estuaries of only 0.4 ha (Begg 1978). Whitfield (1998) categorised the KZN estuaries into five types: permanently open estuaries; temporarily open/closed estuaries; river mouths; estuarine lakes; and estuarine embayments. Considering the sawfish preference for estuarine and riverine habitats (Peverell and Pillans 2004; Stevens et al. 2005, 2008; Phillips et al. 2011), some of these estuaries potentially provide important habitats for the various life-history stages of sawfish. The St Lucia estuarine system consists of a large estuarine lake on the northern coast of KZN, which is connected to the mouth by a region known as ‘The Narrows’. It functions like a temporarily open/closed estuary, the implications of which are that when the mouth is open the system behaves like a typical estuary, but when the mouth is closed the physico-chemical properties of the water in the system change and the system becomes unavailable – in terms of both

Figure 1: Map of the east coast of South Africa, showing localities where green sawfish and largetooth sawfish were known to have occurred historically (see text for references)
suitability and physical access – to fish species that have estuarine-associated life histories (Whitfield 1998). The St Lucia estuary mouth has experienced long periods when it has been either closed or constricted, essentially changing the biological functioning of the system (Stretch et al. 2013).

Data used in the assessment

The following data sources were interrogated for any records of sawfish in KZN waters: KwaZulu-Natal Sharks Board (KZNSB) catch database (1964–2012); Oceanographic Research Institute (ORI) Tagging Project (1984–2012); KwaZulu-Natal Coast Anglers Union records (historical and current); ORI fish-netting projects conducted at Richards Bay (1975–1995) and St Lucia (1967–1970); KwaZulu-Natal Prawn Trawl Bycatch Observer Programme managed by the Department of Agriculture, Forestry and Fisheries (1989–2012); and the National Marine Linefish System managed by ORI (1984–2012). Sawfish catches were found in four of the datasets, which are described below. Additional records of sawfish were sought by consulting the primary literature, media, museums and local conservationists and scientists. Primary literature records were obtained by searching the library records of ORI, African Journals Online, Science Direct and Google Scholar. The historical newspaper database housed at the Court House Museum in Durban was accessed for catch records. Eight museums in South Africa were approached for museum specimens and additional rostrum specimens were found at the Fynmlands Angling Club and the Point Yacht Club in Durban. Furthermore, conservationists and scientists working in close association with the estuaries of KZN were contacted to ascertain whether they had made any sightings of sawfish in the course of their work.

Following episodes of fatal shark attacks off the KZN coastline, various municipalities installed methods of protecting bathers. These started with swimming enclosures (Davies 1963a) but gillnets were introduced in the 1950s and 1960s (Cliff and Dudley 1992). In 1964, the Natal Anti-Shark Measures Board (now KwaZulu-Natal Sharks Board) was formed and progressively assumed the responsibility of installing and maintaining bather protection nets at the most popular tourist beaches (Cliff and Dudley 1992). Prior to 1964, records of non-shark bycatch are not available. The KZNSB records date back to 1964 (catch) and 1966 (effort) but it was not until 1978 that more-organised data collection began. It is thought that the data for 1964–1977 may be incomplete and hence catch, and to a lesser extent effort, may be under-reported. The KZNSB maintains surface gillnets with a stretched mesh of 51 cm, depth of 6–7 m and length that varies between 214 and 305 m, according to location. The nets are anchored in water 10–14 m deep approximately 400 m from shore. Catches of individual animals at each location are recorded to genus or species level and, where possible, the following information is also recorded: sex, mass, length (total [TL] and precaudal [PCL]), condition and fate. Effort is expressed in kilometres of netting deployed at each locality, averaged per year.

From 1967 to 1970, ORI conducted various research surveys using gillnets in the St Lucia estuarine system. Gillnets 46 m long, with stretched mesh sizes varying from 5 to 18 cm, were set in various parts of the system (Wallace 1974; RPvdE pers. obs.) (Figure 2). Sawfish that were captured were released either with or without tags. Those tagged were also measured and sexed; this information was rarely collected for animals that were not tagged.

From 1975 to 1984, ORI conducted gillnet surveys of the fish fauna of the Mhlatuze Estuary at Richards Bay to determine the effects of the development of a deep-water port, which was commissioned in 1976. The project was aimed at monitoring the teleost fish in the system but elasmobranchs were also caught in the nets, which were of the same type as described above for the St Lucia surveys. Surveys of 3–4 days’ duration were conducted biannually from 1975 until 1978, after which they occurred annually until 1984. A further four surveys were conducted after the conclusion of the project. These took place in 1986, 1987, 1990 and 1995 (ORI 1984; ORI unpublished data).

The fourth set of sawfish catch data was obtained from the database of the ORI Cooperative Fish Tagging Project (ORI-CFTP), which commenced in 1984 and continues to operate (Dunlop et al. 2013). It is a voluntary tagging project in which recreational linefishers along the southern African coast tag and release their catches. Only a few sawfish have been caught and tagged as part of this project.
because they are easily able to cut fishing lines with their rostra (van der Elst 1993). Fishers record the catch locality and TL (Dunlop and Mann 2014).

**Data analysis**

Catches in the bather protection nets were analysed using one-way ANOVA to test for significant differences by month, season (summer = December–February, autumn = March–May, winter = June–August, spring = September–November) or locality. Chi-square tests were used to determine whether sex ratios in the catches in both the St Lucia estuarine system and in the bather protection nets differed from unity. Using length data from 48 green sawfish caught in the St Lucia estuarine system, the relationship between TL and PCL was established using regression analysis. The relationship was linear over the observed range of values (74–218 cm TL) and was used to convert 21 PCL values to TL. Given the small sample size and the fact that the species of sawfish was not reported in all cases, the same relationship was applied to both species.

Probability of local extinction was calculated using the time-series of observations collected from all the various sources as well as using data only from the longest uninterrupted time-series of catches (i.e. the KZNSB bather protection nets). Only records that had a known year of capture were used. The probability of local extinction follows a stationary Poisson process:

\[ p = 1 - \left( \frac{t_c}{T} \right)^n \]

where \( n \) is the number of time intervals in which the species was observed, \( T \) is the total number of time intervals sampled and \( t_c \) is the number of time intervals until the last specimen was observed (Burgman et al. 1995; McCarthy 1997; Grogan and Boreman 1998; Solow 2005). A probability value >0.75 indicates that a species is in danger of local extinction while a value ≥0.95 indicates that the species is locally extinct (Grogan and Boreman 1998). The timing of local extinction was estimated using the various methods evaluated by Rivadeneira et al. (2009). These methods estimate the year when the extinction probability reaches the nominal 0.95 value, and vary in their restrictiveness from Class 1 (Strauss and Sadler 1989; Solow 1993; McInerny et al. 2006) through Class 2 (Marshall 1997; McCarthy 1997) to the least restrictive Class 3 (Roberts and Solow 2003; Solow and Roberts 2003). Finally, the likelihood of extinction was evaluated using the framework provided by Butchart et al. (2006) and utilised for elasmobranchs by Luiz and Edwards (2011) and for sawfish by Fernandez-Carvalho et al. (2014). This framework considers the time since the last sighting of the species, in conjunction with the evidence for and against extinction, based on qualitative observational data.

**Results**

**Distribution of catches**

From 1951 until 2012, a total of 246 individual sawfish were caught off the KZN coastline (Figure 3), with the last confirmed capture being a 300 cm TL male that was...
caught in April 1999 in the KZNSB nets set off Richards Bay. Three rostra found at the Fynnlands Angling Club in Durban were included as specimens. All records used in the study are listed in Supplementary Appendix S1. Of these records, 150 were identified as green sawfish, 7 as largetooth sawfish and 89 as unidentified sawfish. All the sawfish caught or sighted during the netting surveys in the St Lucia estuarine system (115) and the Mhlutuze Estuary at Richards Bay (3) were identified as green sawfish. Of the KZNSB catches, only 14 sawfish were identified to species level, with 11 recorded as green sawfish and 3 as largetooth sawfish. Catch localities ranged from the St Lucia estuarine system in the north to Port Edward (Figure 4) in the south, with 19 sawfish recorded as having been caught in KZN but without specific catch-locality information.

The KZNSB nets caught 91 sawfish, with the majority at Zinkwazi (24), Richards Bay (13), Durban (11) and Umdloti Beach (10). The fate of most captures (55) was unknown but 23 were recorded as being released alive and 13 were confirmed to be dead. The ORI gillnet surveys caught 115 sawfish in The Narrows of the St Lucia estuarine system, of which 112 were released alive. Two juvenile green sawfish were caught in the ORI gillnet surveys in the Mhlutuze Estuary and were released alive, and a large female green sawfish was observed swimming in the shallow water over the sandbanks. Hook-and-line anglers participating in the ORI-CFTP caught six unidentified sawfish, two at the mouth of the St Lucia estuarine system, three just south of the mouth and one at Richards Bay. They were all tagged and released.

The KZNSB catches of sawfish peaked in 1966 (17) and they became sporadic after the early 1970s. The highest catch rate was recorded in 1966 (0.01 sawfish km-net−1 y−1) (Figure 5). The beach that had the highest catch rate was Mtunzini (0.37 sawfish km-net−1 y−1) where nets were installed intermittently and only for short periods in 1971, 1972 and 1984. Beach locality was a significant factor in

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**Figure 4:** Map of KwaZulu-Natal, South Africa, showing the capture localities of all sawfish records used in this study. Multiple captures at a particular locality are represented by a single dot; captures at Richards Bay and St Lucia were taken at a number of localities.
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... encountering sawfish in the catches (p < 0.01). For the period 1964–2012, May was the month with the highest average catch (0.35 sawfish, SD 0.78) and no sawfish were caught in July or August of any year. Whereas month was a significant factor in the occurrence of sawfish catches (p < 0.05), season was not (p > 0.05).

During the four years (1967–1970) of gillnet surveys conducted by ORI in The Narrows of the St Lucia estuarine system, most sawfish were caught in 1967 (44) and 1969 (66). Catches peaked in May and again in August. Of the 115 sawfish caught, 86 were tagged, with 24 recaptures (mean days at liberty = 186, SD 300, range 1–859). All of the recaptures were at the original tagging locality and 12 of the sawfish were recaptured more than once. Effort data are unavailable for these catches.

Sex ratios
Only 31 of the 91 sawfish caught by the KZNSB were sexed, with 61% female and 39% male, and the ratio did not deviate significantly from unity (p > 0.05). The majority (97%) of the sawfish caught in the St Lucia estuarine system by ORI were sexed, with males accounting for 49% of the total, and again there was no significant difference from unity (p > 0.05).

Length–length relationship and length frequency
Both TL and PCL were measured for 48 green sawfish, all caught in the St Lucia estuarine system, whereas 100 sawfish records included TL only and 21 included PCL only.

There was a strong linear relationship between these two length measurements: TL (cm) = 1.1381 PCL (cm) – 2.0643 (r² = 0.7271). Measured sawfish ranged in size from 63 to 533 cm TL (Figure 6). Sawfish caught in estuaries were significantly smaller (mean = 162 cm TL, SD 72, n = 95) than those caught in the nearshore marine environment.

Figure 6: Length frequencies of sawfish caught in the estuarine and inshore marine environment of KwaZulu-Natal, South Africa, 1951–1999

Figure 5: Annual catch per unit effort (CPUE) for sawfish caught in the bather protection nets from 1964 to 2012. For 1964 and 1965, CPUE is probably an overestimate due to the inaccurate recording of effort data in those years.
(mean = 310 cm TL, SD 109, n = 83) (t-test assuming unequal variances; p < 0.001).

**Probability of extinction**
The last reported catch of a sawfish (of unknown species) was in 1999 in the KZNSB bather protection nets. The probability of local extinction in KZN, using all records of sawfish, was 0.9991, whereas the value using catches from the KZNSB only was 0.9994. There was no difference in the probability of extinction between all sawfish and green sawfish. The extinction probability was not calculated for largetooth sawfish because records with actual dates of capture were available for a single year only. The upper time limits of extinction calculated for all sawfish and for green sawfish varied from 2002 to 2005 using Class 1 and Class 2 methods, whereas the range obtained using Class 3 methods was 2027–2075 (Table 1, all records). The qualitative evidence for extinction also confirmed that local extinction had taken place (Table 2).

**Discussion**
Globally, the most severe threats to sawfish are net fisheries, with the risk of rostrum entanglement very high (Stevens et al. 2008; Kyne et al. 2013; Simpfendorfer 2013). Nearshore and estuarine net fisheries began in KZN in the latter part of the 1800s (Everett 2014) and increased through the 1900s with a short-lived industrial shark-netting fishery in the 1930s (von Bonde 1934), the installation of bather protection nets in 1952 (Cliff and Dudley 1992) and the advent of illegal gill- and seine-nets in estuaries, especially in the St Lucia estuarine system, in the 1950s (Mann 1995, 2003; Kyle 1999, 2003). Catch and effort records for almost all these activities are either non-existent or incomplete, a situation exacerbated by the fact that sawfish were always bycatch species and therefore of little concern to these fisheries.

### Table 1: Comparison of upper limits of timing of extinction for sawfish, using the methods reviewed by Rivadeneira et al. (2009), for catches taken in the KwaZulu-Natal Sharks Board bather protection nets and for all sawfish records from 1951–2012

| Class | Method | Upper boundary of 95% confidence interval |
|-------|--------|------------------------------------------|
|       |        | KZNSB data | All records |
| 1     | Strauss and Sadler (1989) | 2004 | 2004 |
|       | Solow (1993) | 2003 | 2002 |
|       | McNerney et al. (2006) | 2003 | 2002 |
| 2     | Marshall (1997) | 2005 | 2005 |
|       | McCarthy (1997) | 2005 | 2005 |
| 3     | Solow and Roberts (2003) | 2132 | 2075 |
|       | Roberts and Solow (2003) | 2034 | 2027 |

### Table 2: Evaluation of the qualitative evidence for and against extirpation of sawfish using the framework developed by Butchart et al. (2006)

| Types of evidence for extinction | Evaluation |
|----------------------------------|------------|
| For species with recent last records, the decline has been well documented | Yes, catches by the KZNSB have been documented since 1964 |
| Severe threatening processes are known to have occurred | Yes, there have been many anthropogenic changes to the St Lucia estuarine system and the coastline, resulting in a highly modified environment. Also, there is gillnetting in KZN and in Mozambique to the north |
| The species possesses attributes known to predispose taxa to extinction | Yes, green and largetooth sawfish have low productivity. Also, their anatomy makes them extremely susceptible to capture by net fisheries |
| Recent surveys have apparently been adequate given the species’ ease of detection, but have failed to detect the species | Whereas no sawfish-specific surveys have been conducted, the gillnets maintained by the KZNSB that previously caught sawfish are still in place and have not caught a sawfish since 1999. Furthermore, the ORI Cooperative Fish Tagging Project is still operating and sawfish have not been recorded in the catches since 1987 |

| Types of evidence against extinction | Evaluation |
|-------------------------------------|------------|
| Recent field work has been inadequate | No, whereas no sawfish-specific surveys have been conducted, the gillnets maintained by the KZNSB that previously caught sawfish are still in place and have not caught a sawfish since 1999. The area of previous occurrence is not remote and is increasingly subjected to fishing and other human activities |
| The species is difficult to detect | No, the adults are large and they live in coastal and estuarine environments, making them easily noticeable. They are easily caught |
| There have been reasonably convincing recent local reports or unconfirmed sightings | No, there have been no reported sightings of sawfish since 1999 |
| Suitable habitat remains within the species’ known range, and/or allospecies or congeners may survive despite similar threatening processes | Whereas there are many estuaries in KZN, it appears that the St Lucia estuarine system was a preferred nursery area. This system has been unavailable to sawfish since 2002, due to the closure of the mouth. Non-nursery areas are still available to the adult population along the KZN coast. Given documented natal philopatry, it is unlikely that sawfish will return to St Lucia after their long absence from the area |
interest to fisheries managers. Nevertheless, the potential cumulative effect of all these fisheries on sawfish stocks in KZN is likely to have been high. The longest time-series of sawfish catches is that of the KZNRSB, but records have been available only since the 1960s, and, until 1978, record-keeping was not comprehensive. The largest annual catch of sawfish made by the KZNRSB was in 1966, which coincided with a period of sharp increase in the total length of netting and in the number of protected beaches (Cliff and Dudley 2010). This was followed by progressively smaller catches. Given that catches in the shark nets were highest at certain beaches, there may have been a degree of site attachment and the nets may progressively have removed site-attached individuals. Any site attachment may have been seasonal, however, because there were no catches in July and August. In an assessment of the population status of 14 species of large sharks caught in the KZN nets, Dudley and Simpfendorfer (2006) also suggested the existence of serial localised depletions.

Largetooth sawfish are generally restricted to shallow (<10 m) coastal, estuarine and fresh waters, whereas adult green sawfish may occur deeper than 70 m, where they are vulnerable to demersal trawl fisheries (Simpfendorfer 2013). In KZN, the maximum capture depth was 10–14 m in the bather protection nets. There are no known records from deeper coastal waters of KZN, despite the presence of an inshore trawl fishery that operates in depths <50 m (DAFF 2013) on the Thukela Banks (Figure 1). It is therefore highly unlikely that there is an offshore component of the KZN sawfish population from which recruitment could compensate for mortalities in the very nearshore component. The potential for recruitment from southern Mozambique, to the north of KZN, where artisanal gillnetting and demersal trawling in coastal waters is widespread (Pierce et al. 2008), is similarly very low.

Large estuarine areas on the east coast of South Africa that could constitute important nursery areas for sawfish are the Kosi Bay lakes, the St Lucia estuarine system, Richards Bay and Durban Bay. Both sawfish species are born at approximately 76 cm TL and mature at approximately 300 cm TL (largetooth) and 380 cm TL (green), respectively (Peverell 2008), so the occurrence of 42 sawfish smaller than 150 cm – the smallest being 63 cm – in the St Lucia estuarine system indicates that this estuary functioned as a nursery area. During the same period that the gillnet surveys took place in the St Lucia estuarine system, similar surveys were conducted in the large Mhlatuze Estuary at Richards Bay (Wallace 1975), some 80 km to the south of St Lucia, and no sawfish were recorded. In the later surveys, from 1975 to 1984, only three sawfish were encountered – one adult and two juveniles, as reported above. All three encounters occurred prior to the harbour development, which commenced in 1976. Although van der Elst (1993) and Smith and Heemstra (2003) mention the presence of large females at Richards Bay, only one record was found to corroborate this. There are no records of sawfish catches in Durban Bay, an estuarine embayment, (RPvDpers. obs.), which is not surprising given that this bay was transformed into Durban Harbour, one of the busiest ports in Africa, over a century ago (Brackenbury 1991). Sawfish have not been recorded in the Kosi Bay lakes, either by the conservation authorities or by local fishers (R Kyle, Ezemvelo KwaZulu-Natal Wildlife, pers. comm.), and Begg (1983) did not catch any sawfish in his extensive surveys of almost every KZN estuary. Relatively high catches of sawfish were recorded in the bather protection nets at Richards Bay, Zinkwazi and Durban; yet, given the short coastline (400 km from Kosi Bay to Durban), coupled with the fact that only the St Lucia estuarine system is known to have been an important nursery, it seems unlikely that reproductively isolated populations of sawfish, each with their own separate nursery grounds, occurred in the vicinity of those locations.

In Australia, both largetooth and green sawfish live in regional assemblages of different maternal populations with no replenishment of females from stocks in other areas, although the geographical scale is considerably greater than the distance between Kosi Bay and Durban (Phillips et al. 2011). As a result of juvenile imprinting, females drop their young only in the estuary in which they themselves were born (Phillips et al. 2011). This life-history trait has severe consequences for recovery from fishing mortalities, particularly if the natal estuary is subject to habitat degradation.

It appears that the St Lucia estuarine system was indeed the primary nursery area for KZN sawfish, but, as Perissinotto et al. (2013) have indicated, major anthropogenic changes to the estuary have greatly reduced the suitability of this habitat. Agricultural practices in the catchment and in the immediate vicinity of the estuary have led to an increase in sediment loads in the system, a decrease in the freshwater inflow and a change in the nutrient content of the water. The Mfolozi River, historically a major source of fresh water, was artificially separated from the mouth of the St Lucia estuarine system in 1952, reducing the ability of the St Lucia system to self-regulate the open/closed state of the mouth (Cyrus et al. 2011). The establishment of large timber plantations on the eastern shores also reduced freshwater levels in the system (Perissinotto et al. 2013). For over 40 years, since 1955, dredging was undertaken inside the mouth to keep it open (Perissinotto et al. 2013). The impact of these changes in the system on sawfish may account for the variability in the number of sawfish caught. In 1967 and 1969 the system was in good condition and the sawfish catches were high, but in 1968 the system became hypersaline and in 1970 the mouth closed with corresponding low numbers of sawfish caught. Although a decision was made at around the turn of the century to suspend dredging and allow the Mfolozi River to re-enter the lake, drought conditions ensured that the mouth remained closed between 2002 and 2012 (Perissinotto et al. 2013).

The data used to determine sawfish extirpation were very variable in their methods of collection and, in some cases, were inconsistent. Also, data collection did not commence until halfway through the last century so the record of catches is incomplete, with none during the time when sawfish were regarded as numerous (von Bonde 1934). Nevertheless, the data types are comparable to those of other extirpation/extinction studies (Burgman et al. 1995; McCarthy 1997; Grogan and Boreman 1998; Solow 2005; Fernandez-Carvalho et al. 2014) and the results obtained from the analysis leave little doubt that sawfish no longer occur in KZN waters. This is likely to be the consequence of the combined effects of various KZN net fisheries over many decades and
the degradation of the St Lucia estuarine system, the primary nursery ground known to have existed in KZN. In their global review of sawfish conservation, Harrison and Dulvy (2014) observed that sawfish remain abundant in only two regions in the world: Florida, in the USA, and northern Australia. Dulvy et al. (2014) and Fordham (2014) noted that in most other range states there is little or no specific protection, and that where protective legislation does exist, it tends to be inadequate and to suffer from poor enforcement. In 1997, South Africa afforded sawfish legal protection by adding them to the ‘critical list’ of species that are not permitted to be caught (RSA 1997). This protective legislation is essentially symbolic, however, given their local extirpation.

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