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Distribution of sawfishes (Pristidae) in the Queensland Gulf of Carpentaria, Australia, with notes on sawfish ecology

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Synopsis

Pristis microdon, *P. zijsron*, *P. clavata* and *Anoxypristis cuspidata* are distributed throughout the Queensland section of the Gulf of Carpentaria, Australia. In a survey of the four species, *Anoxypristis cuspidata* was the most abundant and was recorded in both the inshore and offshore set net fisheries. The size distribution and catch locations of *A. cuspidata* suggest that the inshore area to a depth of 10 m may be the preferred habitat for juveniles of this species, while adults primarily occur offshore. *Pristis microdon*, *P. zijsron* and *P. clavata* were recorded only in the inshore fishery with catches dominated by immature animals. *Pristis microdon* was caught in the inshore fishery late in the monsoonal wet season (February to April) and inhabited both freshwater and estuarine environments. *Pristis zijsron* occurred only on the sand and mud flats outside river mouths whilst *P. clavata* inhabited both the sand and mud flats and upstream estuarine habitats. Observations on reproductive staging and the capture of neonate specimens suggest that in all four pristids, pupping occurred through the wet season until the beginning of the dry season in May. A seasonal set net closure for the barramundi, *Lates calcarifer* and shark fisheries, which has been in place since 1980 in Queensland Gulf waters, therefore offers a measure of protection to breeding female sawfish and their offspring.

Introduction

Sawfish (Pristidae) are distinctive members of the Superorder Rajomorphii characterised by an elongate rostrum with lateral tooth like denticles (Bigelow & Schroeder 1953, Hamlett 1999). Sawfish occur worldwide occupying tropical and subtropical marine, hypersaline and freshwater habitats and can attain large sizes, often in excess of 2 m total length (Last & Stevens 1994). Taxonomic uncertainties exist for Pristidae and around the world sawfish systematics are unsettled (Compagno & Cook 1995). It is known that the family is comprised of two genera *Pristis* and *Anoxypristis* Currently, between four and seven species are known from Australia (Last & Stevens 1994).

There is a lack of information on the life history, biology and demography of pristids, however it is assumed that like most elasmobranches they are long lived, produce few offspring and mature late in life (Walker 1998). This life history strategy would make them especially vulnerable to overexploitation (Stobutzki et al. 2002). This creates difficulties for resource managers who are then faced with making management policies in the face of uncertainty and after the animals have been fully exploited. These concerns have been expressed by a number of authors (Thorson 1982a, b, Tanaka 1991, Compagno & Cook 1995, Zorzi 1995, Simpfendorfer 2000).

Sawfish populations have been declining worldwide (Stevens et al. 2000, Cavanagh et al.

2003). The International Union on the Conservation of Nature (IUCN) shark specialist group categorised the species of sawfish that inhabit the Gulf of Carpentaria (GoC) as endangered on the basis of their rapid decline in range throughout the southern hemisphere (Cavanagh et al. 2003). The extent of population decline is difficult to quantify due to a lack of reliable historical data on sawfish. Thorson (1982b) documented the decline of the Lake Nicaragua sawfish population, and anecdotal reports suggest declines of sawfish species throughout the Indo-West Pacific (Compagno & Cook 1995). Demographic analysis of the available biological data (Bigelow & Schroeder 1953, Thorson 1976, 1982b) on *Pristis perotteti* and *P. pectinata* by Simpfendorfer (2000) suggest that Western Atlantic populations have been significantly depleted. The status of sawfish populations in Australia are currently unknown.

Simpfendorfer (2000) identified commercial net fishing as one of the key threatening activities to sawfish survival in the Western Atlantic. A combination of their shallow water coastal distribution and their toothed rostrum make all size classes of sawfish vulnerable to capture by net fisheries. The capture of sawfishes within Australian commercial net fisheries has been poorly reported but it is known that they are taken as bycatch in set net operations along the Queensland (QLD) GoC and east coasts (Gribble 2004).

Other threats to the survival of pristids are aquarium and museum specimen collectors (Cook et al. 1995) and recreational line fishers. Recreational fishing has been identified by Seitz and Poulakis (2002) as being a process threatening the survival of pristid populations in Florida (United States of America). In Australia, sawfish are known as a target sport fish within GoC rivers and estuaries (Nelson 1994) and landings of sawfish have been recorded in recreational fishing competitions in the GoC.[1] The Australian indigenous harvest of sawfish is currently unknown, however it has been suggested that sawfish play a significant cultural and spiritual relevance to indigenous Australians around the entire GoC.[2]

Habitat loss is another significant factor influencing the global decline of sawfish populations throughout their ranges (Zorzi 1995, Camhi et al. 1998, Simpfendorfer 2000). Because of limited human impact, and based on anecdotal information and specimen collections, northern Australia has been identified as one of the only remaining geographical regions in the world where viable populations of pristids remain (Pogonoski 2002).

The distribution of pristids in the Northern Territory section of the GoC is largely unknown with only a limited number of specimen records held at the Museum and Art Gallery of the Northern Territory (H. Larson Curator of Fishes Northern Territory Museum pers com. 2003). The limited distribution records for the four GoC pristid species indicate that their distribution extends along the NT coastline of the GoC, however there are incomplete details.

Last & Stevens (1994) identified the occurrence of *P. microdon*, *P. zijsron*, *P. clavata*, *P. pectinata* and *Anoxypristis cuspidata* within the GoC. *Pristis zijsron* and *A. cuspidata* are known incidental bycatch species in the Northern Prawn Fishery (NPF), which operates throughout the GoC (Stobutzki et al. 2002). These two species have also been recorded in Arthurs Creek, a coastal estuarine system in the western GoC (QLD Museum records, pers com. Geoff Johnson, 2003). *Pristis microdon* has been recorded from the Gilbert River (Tanaka 1991) and the Norman River (QLD Museum records, pers com. Geoff Johnson, 2003). A QLD based commercial aquarium collector (L. Squires Jnr Director Cairns Marine pers com. 2003) reported capturing *P. microdon* in the Wenlock, Flinders, Bynoe, Norman and Gilbert Rivers and *P. clavata* and *P. zijsron* in the Pine River. Thorburn et al. (2003) also reported the capture of *P. microdon* in the Wenlock, Gilbert and Mitchell Rivers.

The primary objectives of this study were to: (1) collate available sawfish catch data from the QLD

[1] Helmke (1999). Survey results of the 1998 Normanton and Burketown Fishing Competitions. Project report to Queensland Fisheries Management Authority. The State of Queensland, Department of Primary Industries and Fisheries, QO99004. 18 pp.

[2] McDavitt (2001). Abstract: Sharks inland. The symbolism of freshwater sharks and sawfishes in north Australian Aboriginal societies. American Elasmobranch Society 2001 Annual Meeting State College, Pennsylvania. [on line] Available from the URL http://www.flmnh.ufl.edu/fish/Organizations/aes/abst2001c.htm <<.

GoC set net fisheries; (2) map the spatial distribution and frequency of occurrence of sawfish species in the QLD GoC based on the net fisheries catch data and government fishery monitoring program data; and (3) summarise the maturity and size class data associated with the catch data. This paper provides additional information to the limited data currently available on pristids and complements studies being undertaken in the northern hemisphere on pristid biology and ecology.

Methods

Study area

The GoC is located in northern Australia and is a very extensive, relatively shallow embayment of approximately 320 000 km^2. The GoC is influenced by a warm, moist northwest monsoonal circulation from December to March (i.e. wet season) each year and a cooler, drier southeast trade wind period from May to October (i.e. dry season).[3] Sawfish distribution and abundance estimates are discussed in reference to three GoC regions (Figure 1): northern region (12°–14° S, 140°–142°30′ E), southern region (14°–18°30′ S, 142°–140° E) and western region (14°–18°30′ S, 138°–140° E).

The southern and western regions of the GoC are shallow (consistently less than 18 m) and have extensive mudflats. Combined with large tidal fluctuations and wind induced wave action this causes high water turbidity in these regions. In contrast, the inshore and offshore waters of the northern region have a steeper shoreline gradient than the south and as such are characteristically clearer.

The southern region has an extensive mangrove fringed coastline and silty undulating mud and sand bars. The western region is commonly shallow with wide, firm mud bars extending well offshore. The substratum offshore is predominantly mud and sand with rubble beds and isolated emergent reefs to a depth of 40 m (J. Stapley Shark Fishery Observer QLD Fisheries Service pers com. 2002). The river watersheds of the southern and western regions of the GoC are larger than those from the rivers in the northern region.

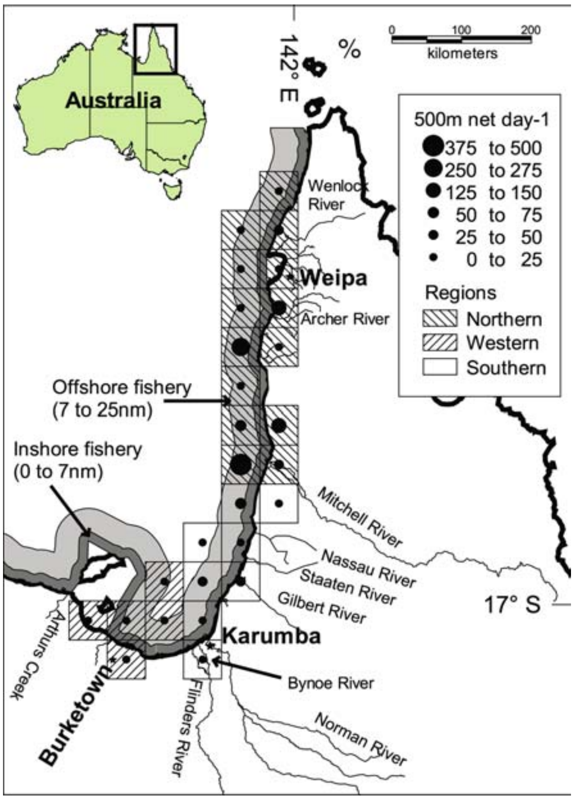

Figure 1. Area of fishing operation for inshore (N3) and offshore (N9) set net fisheries of the Queensland Gulf of Carpentaria; and distribution of fishing effort (days observed) for each 30 min commercial logbook grid reference, pooled for the years 2000–2002.

Data description

The QLD sector of the GoC covers 270 000 km^2 and supports a diverse commercial fishing industry worth approximately AU$67 million annually (L. Williams Economist QLD Fisheries Service pers com. 2001). Within the QLD managed sector of the GoC, ninety-two inshore commercial set net fishing licences (N3 fishery symbol) and six offshore commercial set net fishing licences (N9 fishery symbol) are currently operational (M. Doohan Fisheries Manager QLD Fisheries Service pers com. 2003). Both the inshore and

[3] Staples (1983). Environmental Monitoring: Climate of Karumba and Hydrology of the Norman River Estuary. Southeast Gulf of Carpentaria. CSIRO Marine Laboratories Report 156.

offshore commercial set net fisheries have a closed season (October to January) corresponding to the lunar cycle for spawning barramundi (Garrett 1987). The data presented in this paper examines data recorded only within the boundaries of the commercial fishing season and area of operation.

The inshore set net fishery is a multispecies finfish fishery that targets barramundi and threadfin salmon (Polynemidae sp.) from the shoreline seaward to 7 nm (QFMA 1999). A number of area closures, mainly governing the freshwater reaches of rivers and cultural areas of significance to indigenous owners have been established. The offshore commercial set net fishery is predominantly for shark (mainly *Carcharhinus tilstoni* and *C. sorrah*) and grey mackerel (*Scomberomorus semifasciatus*) and extend from 7 nm offshore out to 25 nm (Figure 1).

Information on sawfish was obtained from three sources: researcher surveys of catches made by commercial fishing vessels; voluntary reporting of commercial catch; and fishery independent set net sampling. Observations were made throughout the fishing season (February to September) for 2000–2002. Unfortunately the data were insufficient to infer seasonality trends for wet and dry seasons for all pristid species. Information on *P. microdon* seasonality was acquired through an intensive tagging program undertaken by two commercial fishers and fisheries observers within the Mitchell River.

Captures of sawfish in the GoC are often sporadic and seasonal, unlike traditional catch sampling of finfish where large densities of animals are encountered year round (QLD Fisheries Observer unpublished data). As such, researchers aimed to obtain as much biological information as possible from every sawfish specimen encountered. The collection of this information in a systematic way was restricted by field conditions and the logistics involved in dealing with large and potentially dangerous animals.

The inshore set net fishery uses monofilament gillnets of between 162.5 and 245 mm stretched mesh with an approximate mesh drop (depth of net) of between 3 and 6 m. The offshore fishery used 162.5 mm stretched mesh nets consistently with an approximate mesh drop of 13 m. The gear in both fisheries is predominantly anchored off the head rope and is surface set. These nets will reach the bottom during all periods of the tide, hence sample from the full water column. The use of hydraulic net hauling devices is permitted in both fisheries, and is used principally by the offshore fishery where longer and deeper nets are fished.

Researcher surveys of commercial catch

Research surveys on commercial vessels were undertaken on an opportunistic basis as time and space on board vessels became available. The mandate of the research observer was to record total catch statistics focusing primarily on target species. Sawfish captures were recorded as part of the bycatch species composition, and were identified with appropriate taxonomic keys published in Last and Stevens (1994).

Voluntary reporting of commercial catch

The 15 inshore commercial fishers that assisted in the research observer program also provided information about their catches of sawfish when research observers were not on board. These commercial fishers fished in all three study regions, and were trained in sawfish identification and biological sampling procedures when the author was on board their vessels during researcher surveys. In addition, a formal training workshop with sawfish specimens was held in 2001 with the fishers to further improve their identification and reporting skills. A sawfish identification guide[4] with photographs that highlight key morphological features was distributed to all inshore and offshore set net fishers. Researchers used photographs taken by fishers of sawfish that were released alive and of recently deceased specimens to validate commercial fisher sawfish identifications.

Fishery independent samples

The QLD Fisheries Service undertakes an ongoing multi-finfish species long term monitoring program that obtains in part fisheries independent

[4] Peverell (2002). Queensland sawfish identification guide. The State of Queensland, Department of Primary Industries and Fisheries, QIO3038. 2 pp.

data on the status of barramundi stocks in the GoC. The Flinders, Staaten, Mitchell, and Archer Rivers (Figure 1) were all surveyed during March and April each year. Fishing apparatus for the research surveys includes the use of 50, 100 and 150 mm monofilament nets of 33 mesh drop and up to 200 m in length (R. Garrett Principal Fisheries Biologist QLD Fisheries Service pers com. 2004). Data from sawfish catches in this fishery were recorded as part of the monitoring program.

Biological parameters recorded

In light of the conservation concerns for pristids, all animals examined were tagged and released alive when possible. Morphological measurements taken (nearest 5 mm) included total length (T_L), lower jaw to total length (LJT_L), and lower jaw to fork length (LJF_L) and gender was determined by examining the presence or absence of claspers. Where specimens were dead or deemed not to be in condition for release, approximately 8 vertebrae were extracted from below the first dorsal fin for an age and growth study and the gonads were dissected out to determine reproductive staging. Reproductive stage was recorded using the technique described in Stevens & McLoughlin (1991). Tissue samples of either muscle or fin were taken from all sawfish captured in the researcher and fishery independent sampling surveys and preserved in dimethyl sulfoxide (DMS) for future genetic analysis.

Data analysis

Sawfish records were collated in an Access® database. Preliminary analysis was conducted in Excel®. Analysis of size distribution data between the inshore and offshore set net fishery for *A. cuspidata* was conducted in Genstat® using a Kruskal–Wallis non-parametric one way analysis of variance. Regression analysis was used to determine if a significant relationship existed between the morphometric measurements of LJT_L and T_L, for the four sawfish species examined (Table 1). This relationship was used to provide an estimate of the total length of recaptured sawfish, which had had their rostrums removed for ease of release from commercial fishing nets.

For each species catch per unit of effort (CPUE) was recorded as number of sawfish caught 500 m net day-1 (24 h) for all three data types. These data were assigned to a 30 min of latitude commercial grid reference (a 30 by 30 nautical mile grid) for mapping purposes. This scale of data presentation is necessary to comply with confidentiality provisions of QLD commercial fishing logbook reporting. The data was pooled for the 3 years from 2000 to 2002 and for the two QLD GoC set net fisheries for ease of reporting. It was assumed that the gear employed by the three sources of data collection had the same "catchability" and represented an equal chance of capturing sawfish.

Results

Fishing effort observed

From 2000 to 2002, commercial fishing effort was observed over approximately 70% of the available fishing area for the inshore set net fishery and 66% for the offshore set net fishery. This coverage was widely spread geographically (Figure 1). In this study, the combined fishing effort observed by researcher surveys and voluntary reporting of commercial catch accounted for 3.3% and 12.6% of the total 2000–2002 fisher days reported in the inshore and offshore commercial fisheries respectively. All licensed

Table 1. Parameters of the regression relationships between lower jaw total length (LJT_L) and total length (T_L) in the form of $T_L = a * LJT_L + b$ for pristid species of the Queensland Gulf of Carpentaria.

Species	a	(s.e)	b	(s.e)	R^2	n
Pristis microdon	1.47	0.044	−5.71	6.550	0.99	12
Pristis clavate	1.2	0.009	8.75	0.993	0.99	14
Pristis zijsron	1.56	0.040	−12.63	5.818	0.99	17
Anoxypristis cuspidata	1.41	1.638	2.98	0.018	0.99	10

operators in the offshore set net fishery and approximately 7% of inshore operators were included. In total, 582.72 km and 256.8 km of net in the inshore and offshore fisheries respectively were observed over 1428 effort days.

Geographic distribution and relative abundance

Sawfish distribution and relative abundance varied considerably between and within the three GoC regions and also among commercial logbook grids

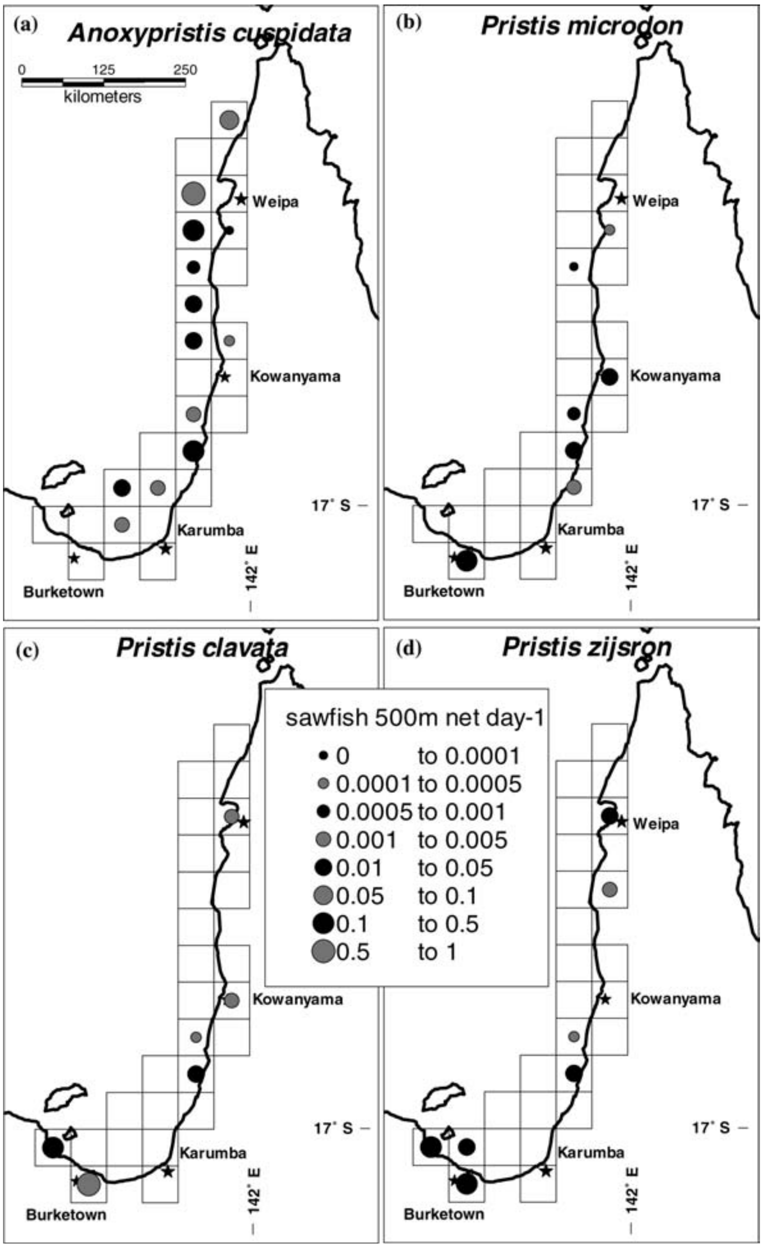

Figure 2. Sawfish CPUE (number of sawfish 500 m net day-1) pooled for the inshore and offshore set net fishing seasons for the Queensland Gulf of Carpentaria from 2000 to 2002 for (a) *Anoxypristis cuspidata*, (b) *Pristis microdon*, (c) *Pristis clavata*, and (d) *Pritis zijsron*.

(Figure 2). *Pristis microdon*, *P. clavata* and *P. zijsron* were recorded only in the inshore fishery. *Anoxypristis cuspidata* was recorded in both fisheries.

Pristis microdon, *P. clavata*, and *P. zijsron* were each recorded in the northern, southern and western regions of the GoC although *P. microdon* and *P. clavata* was rarely found north of Kowanyama (Figure 2). *Anoxypristis cuspidata* was recorded in the northern and southern regions of the GoC and was rarely found west of Burketown. During the months of February to April *P. microdon* was taken more frequently in the creeks and estuaries and *P. clavata*, *P. zijsron* and *A. cuspidata* along the coastal flats and bays.

Anoxypristis cuspidata and *P. clavata* had the highest CPUE at 0.83 sawfish 500 m net day-1. *Anoxypristis cuspidata* was recorded in many more commercial logbook grids than the other sawfish species. The highest catch rate of *A. cuspidata* was recorded in the northern region of the GoC. *Pristis zijsron* had a maximum CPUE of 0.21 sawfish 500m net day-1, which was the lowest catch rate of all of the sawfish species. Despite this, *P. zijsron* was recorded in more commercial logbook grids than either *P. clavata* or *P. microdon* (Figure 2).

Pristis clavata and *P. zijsron* were both patchy in their distribution (Figure 2) and were recorded in all three GoC regions. The abundance of *P. clavata* appears to be stronger in the western region of the GoC although its distribution is very patchy (Figure 2). *Pristis zijsron* appears to be more abundant in the northern and western regions of the GoC than in the southern GoC.

Pristis microdon was widely distributed along the northern side of the GoC, and the maximum catch rate recorded was 0.02 sawfish 500 m net day-1. It was recorded at the mouths of the major rivers; the Mitchell, Gilbert, Archer, Nassau and Staaten Rivers (Figures 1 and 2). Analysis of the catch dates for *P. microdon* from records from the intensive tagging program in the Mitchell River showed that 95% of the catch was recorded in the wet season months through February to April.

Size distribution, sex ratio, and maturity

The size distributions of *P. microdon*, *P. clavata*, *P. zijsron* and *A. cuspidata* included both juveniles and adults (Figure 3) and all appear to have a peak from 700 to 1200 mm T_L. These peaks represent immature stages in all four species. The size distributions for *P. microdon* and *A. cuspidata* were multi-modal, with the former having another peak between 2000 and 2600 mm T_L, and *A. cuspidata* a peak from 2700 to 3300 mm T_L. This second peak for *A. cuspidata* represents adult individuals caught in the offshore fishery. *Pristis microdon* has a more complex size distribution pattern.

The size classes of *A. cuspidata* in the offshore fishery were significantly larger than those recorded in the inshore fishery (Kruskal-Wallis one-way test, $H = 62.61$, $p < 0.001$). The largest *A. cuspidata* recorded in the offshore set net fishery was 3300 mm T_L and the smallest in the inshore set net fishery at 750 mm T_L.

The sex ratio of male to female was nearly 1:1 among all four sawfish species caught in the inshore fishery (Table 2). The sex ratio of *A. cuspidata* in the offshore fishery however, was dominated by female animals at a ratio 2.1 females to 1 male (Table 2). Of the 74 *A. cuspidata* recorded in the offshore fishery, 16 male and 15 female specimens were reproductively staged and were identified as being sexually mature. All female *A. cuspidata* examined were found to possess large yolky oocytes with an average egg diameter of 25 mm. These animals were all caught during the month of August, in both 2000 and 2001.

Pristis species taken in the inshore set net fishery were predominantly immature except for four individuals: a female *P. zijsron* caught just after the wet season at 3800 mm T_L (post partum); a male *P. clavata* of 3060 mm T_L (long rigid claspers); and two female *P. microdon*, the first of 6000 mm (with full term embryos and large yolky oocytes with an average egg diameter of 125 mm) and the second at 3030 mm T_L (full term embryos, pupping when caught). These mature *P. microdon* were taken in the months of March and April 2002 coinciding with large freshwater flows at the mouths of the Leichardt and Mitchell Rivers during the 2001 and 2002 wet season.

We captured 13 neonate (new born) *P. microdon* in commercial gill nets between January to early April in 2001 and 2002. Umbilical scaring was identified on the underside of these individuals which ranged in size from 720 to 930 mm T_L. *Pristis microdon* of these size classes were not recorded

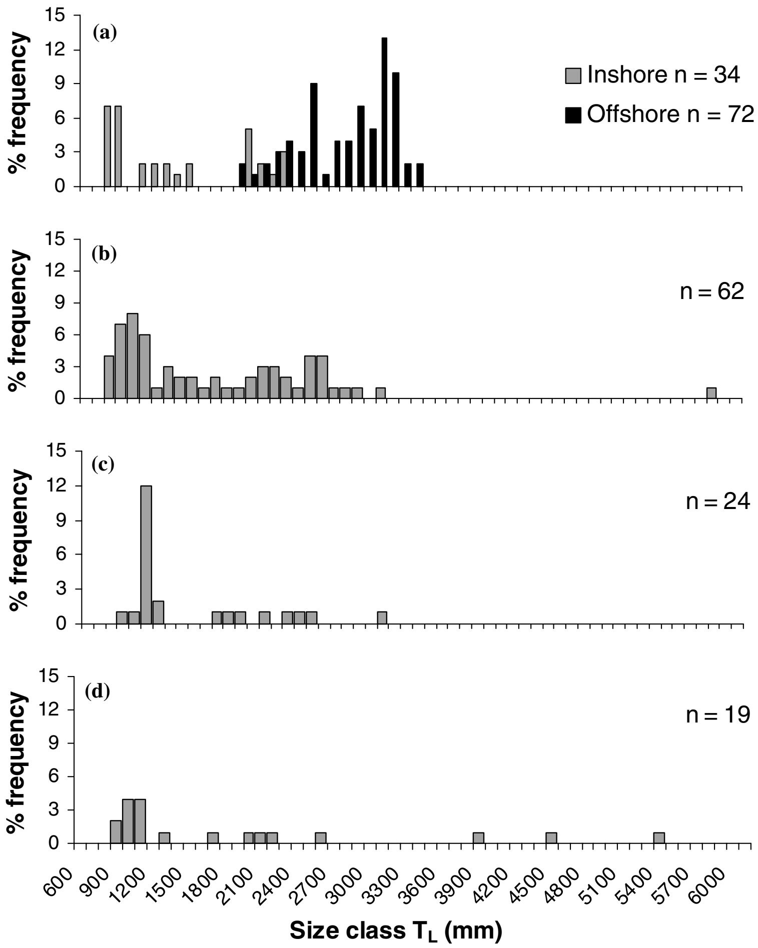

Figure 3. Size frequency (T_L mm) records for the inshore (grey) and offshore (black) set net fisheries between 2000 and 2002 from the Queensland Gulf of Carpentaria for (a) *Anoxypristis cuspidata*, (b) *Pristis microdon*, (c) *Pristis clavata* and (d) *Pristis zijsron.*

outside these wet season months. Four full term embryos of between 875 and 900 mm T_L were collected from a female *P. microdon* of 6000 mm T_L.

Discussion

Very little is known of the distribution and abundance of Australian sawfishes. Last & Stevens (1994) coarsely mapped the distributional range of Australian pristids using data from museum records and historical photographs. This paper has further refined the spatial resolution of pristid distribution within the Queensland GoC. It is evident that the inshore net fishery of the QLD GoC interacts with *P. microdon*, *P. clavata*, *P. zijsron* and *A. cuspidata*. In this study, the only sawfish species recorded in the offshore fishery was *A. cuspidata*. However, anecdotal information (chiefly preserved *Pristis* sp. rostrums and historic specimen photographs) from offshore set net fishers suggests that the fishery has limited interactions with large specimens of several *Pristis* sp. throughout the fishing season. This conclusion is further supported by Stobutzki et al. (2002), where *Pristis* sp. were recorded in the Northern Prawn Fishery trawl bycatch. If these QLD GoC *Pristis* sp. possess similar life history traits to that of *P. pectinata*, a northern hemisphere sawfish species, it maybe reasonable to suggest that mature animals are highly migratory and inhabit waters in excess of 50 m (Simpfendorfer 2002).

Table 2. Sex ratios (M – male, F – female) and frequency of occurrence of mature specimens recorded in the inshore and offshore set net fisheries of the Queensland Gulf of Carpentaria, 2000–2002. Total lengths T_L – $\overline{X}$ (range) mm are provided for mature animals.

	Ratio		Male			Female		
	n	M:F	n	$\overline{X}$ (range)	% Mat	n	$\overline{X}$ (range)	% Mat
Inshore fishery								
Pristis microdon	66	1:1.05	38		0	28	(3030–6000)	7
Pristis clavata	22	1:0.91	12	(3060)	8	10		0
Pristis clavata	17	1:1.33	8	1740 (870–4490)	7	9	(3800)	7
Anoxypristis cuspidata	37	1:1.15	7		0	11		0
Offshore fishery								
Anoxypristis cuspidata	74	1:2.1	16	2300 (2030–3150)	77	15	2930 (2250–3290)	100

Pristis microdon

Little is known of the biology or life cycle of *P. microdon*, the freshwater sawfish. Last & Stevens (1994) documented the range of this species as extending to all GoC river systems, and provided a brief description of the species biology based on a small number of juvenile specimens. *Pritis perotteti*, a freshwater species from Lake Nicaragua, Rio San Juan system, is considered a sister species to *P. microdon* (Simpfendorfer 2000). Although *P. perotteti* has been extensively studied (Thorson 1976, 1982a, b), *P. microdon*, a tropical "partially" marine species has little information documented. In the current study *P. microdon* appears to pup in freshwater but can move into estuarine and coastal marine habitats. In contrast Thorson (1982b) reports that *P. perotteti* spends much if not all of their lives in freshwater and that recruitment from downstream seems to be minimal. Reproduction of the population occurs in freshwater primarily in the lake. However, not enough is known about *P.microdon* to adequately compare the two species at this stage.

In this study *P. microdon* was recorded in all three regions of the GoC and the CPUE was highly variable with the highest catch rates restricted predominantly to the wet season months. Catches of *P. microdon* were concentrated in the commercial fishing grids that include the river mouths of the Archer, Nassau, Staaten, Mitchell, and Gilbert Rivers (Figure 1). This finding is possibly the result of the species preference for freshwater habitats during this time of the year for breeding purposes or to exploit the abundance of prey items such as the freshwater prawns (*Macrobrachium australiense*, *M. rosenbergi* and *M. handschii*).

The peak catch rates for *P. microdon* correspond with the monsoonal wet season, when the salinity levels at the river mouths and along the coastal shoreline are very low. However, *P. microdon* are known to inhabit tidal waters and will tolerate salinity levels of a marine environment (L. Squires Director Cairns Marine, pers com 2003).

There is growing evidence, both documented (Ryan et al. 2002, Stobutzki et al. 2002, Thorburn et al. 2003) and anecdotally from commercial, recreational and traditional fishing sources, to support the hypothesis that mature *P. microdon* inhabit marine waters during the post wet season months and enter less saline waters inshore during the wet season months to pup. In June 2003 a mature female *P. microdon* (in pup) was captured by a commercial long line fisher operating off the Wessel Islands, Northern Territory (G. Lawrence Commercial Shark Fisher pers com. 2003). Research fisheries observers identified the specimen from photographs and the retained rostrum. In the QLD GoC study reported here no *P. microdon* were captured upstream of river mouths in post west season months and two mature *P. microdon* were taken at river mouths in March and April. Further studies are required to validate this hypothesis.

Anecdotal information obtained from commercial and traditional fishers from the GoC suggest that freshwater flows associated with monsoonal weather patterns maybe the environmental cue responsible for triggering pupping in all GoC sawfish species. In this study, pupping in a *P. microdon* of 3030 mm T_L was observed on one occasion, a female (6000 mm T_L) carrying full term embryos was examined on another occasion and a number of neonate *P. microdon* were captured in the inshore fishery during the wet season. These results suggest pupping in *P. microdon* occurs late in the wet season and therefore *P. microdon* has been at least partially protected during breeding by the seasonal closure of the inshore and offshore commercial set net fisheries in the QLD GoC from October to January.

Pristis clavata

The dwarf sawfish is a small robust animal reported to attain a maximum length of 1400 mm T_L (Last & Stevens 1994). However in this study, two specimens larger than this size were recorded; a mature male specimen of 3060 mm T_L; and a immature female of 2100 mm T_L. These findings suggest this species attains a much larger maximum size in GoC waters than previously suspected. This study also shows that the distribution of *P. clavata* extends into all regions of the QLD GoC, but its abundance is low everywhere and highly variable. Catches of *P. clavata* were made during the post wet season months, however only along the coastal shoreline where the waters are predominantly marine at this time of the year.

Pristis zijsron

In this study, the green sawfish was not recorded during the first three months of the commercial fishing season (February to April), however this species is known to inhabit freshwater environments (Compagno & Cook 1995). The catch records show that *P. zijsron* inhabits all regions of the QLD GoC with a pattern of relative abundance similar to that of *P. clavata*, that is, in low numbers and with a highly variable frequency of occurrence. *Pristis zijsron* was caught only along the coastal shoreline. A post partum female specimen measuring 3800 mm T_L was recorded in May 2001. A collaborative study of the sustainability of Australian sharks and rays by Commonwealth Scientific Industrial Research Organisation, and the Fisheries agencies in Western Australia, Northern Territory and QLD has recorded instances of *P. zijsron* pupping in January (R. McAuley Fisheries Biologist Western Australian Fisheries pers com. 2003). This very scant dataset suggests pupping for this species may occur during the wet season, as has been suggested earlier for *P. microdon*.

Anoxypristis cuspidata

The narrow sawfish was the most abundant of all sawfish species recorded in this study. This species is regarded as being a marine sawfish (Gleorfelt-Tarp & Kailola 1984, Taniuchi & Shimizu 1991, Stobutzki et al. 2002), and was recorded both in the inshore and offshore fisheries of the QLD GoC. The CPUE of *A. cuspidata* varied considerably with observed catch rates greatest in the northern region of the QLD GoC.

Anoxypristis cuspidata is also the most commonly caught sawfish within the NPF (Stobutzki et al. 2002) and it is most likely trawled from the sea bottom as opposed to being captured during setting and retrieving the fishing gear. By comparison, the offshore set net fishery sets surface nets and *A. cuspidata* forms part of the incidental bycatch. These results suggest that this species not only inhabits the sea floor but also the mid water column. As such *A. cuspidata* can be best referred to as a benthopelagic animal.

No mature *A. cuspidata* were recorded in the inshore fishery out of the total of 34 specimens recorded between 2000 and 2002. This suggests that the inshore set net fishery area in the GoC may be an important juvenile habitat for this species. The size classes of *A. cuspidata* were significantly different in the inshore and offshore set net fisheries, with the offshore set net fishery predominantly catching large mature animals (Table 2; Figure 3). Female *A. cuspidata* were found to be vitellogenic (yolky oocytes present) in August (the dry season). If this species has a gestation period of five months, as suggested for *P. microdon* (Compagno & Last 1999), then pupping in *A. cuspidata* could also occur over the monsoonal months.

Given the rarity of Pristids, it can be challenging to obtain life history information necessary to model sawfish population dynamics such as stock structure and age and growth. However, the Queensland GoC pristids may represent one of the best-conserved sawfish populations internationally, and this circumstance provides an opportunity to undertake such biological studies, given the cooperation of all sectors of the fishing industry.

Sawfish populations have been conserved in the Queensland GoC due to a number of factors including relatively minor coastal development, low levels of habitat degradation, and a multitude of fishing spatial and temporal closures, which help reduce levels of commercial set net fishing effort. It seems that management initiatives, introduced in the 1980s to protect the other GoC fisheries resources have fortuitously provided some protection for sawfish populations over the reproductively critical monsoonal wet season. Whether this level of protection is sufficient to sustain GoC sawfish populations is not known, and additional fishery management measures maybe required.

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