

Characteristics of the Biology and Distribution of the Spinner Shark (*Carcharhinus brevipinna*) in Queensland, Australia Based on Data Collected from the Shark Control Program

WAYNE SUMPTON^{1*}, BADEN LANE² and TONY HAM²

¹Queensland Department of Primary Industries and Fisheries
Southern Fisheries Centre, PO Box 76, Deception Bay Qld 4508

²Queensland Department of Primary Industries and Fisheries
Queensland Boating and Fisheries Patrol, Primary Industries Building
Ann St, Brisbane Qld 4001

Abstract

The spinner shark *Carcharhinus brevipinna* (Müller and Henle) is among the most common sharks caught by the Queensland Shark Control Program. All sizes of sharks (from neonates to adults) are taken by the fishing gear (gillnets and drumlines), although smaller individuals are more commonly taken on drum lines. There is a strong seasonality to the catch with most sharks taken during the spring and summer months when they migrate inshore to breed. During this time the average size of sharks taken is also significantly larger ($P < 0.05$) than at other times of the year. Females outnumber males ($P < 0.05$) in the catch with the overall sex ratio being 1.4:1. The species is caught predominantly in nets in the southern part of the state (Gold Coast and Sunshine Coast) and catch rates on baited drum lines are generally low (< 0.04 per drumline/year). In this southern region there was a relatively stable trend in the catch of spinner sharks over the last 11 years but catches sometimes varied by more than 100% between consecutive years. Eighty percent of the 566 spinner shark stomachs examined were empty but teleosts were the main prey, being the most common item in over 71% of those sharks that had identifiable remains in their stomachs. The smallest pregnant female caught was 2.0m in total length. Litter size varied between 4 and 16 (mean = 9.5) and the overall sex ratio of embryos was 1:1. Thirty-six percent of sharks were meshed on the inside of the net (the side facing the shore) indicating that sharks were not just being caught as they migrated into shore.

*Corresponding author. Tel.: +61 07 38179584; Fax: +61 07 38179555
E-mail address: wayne.sumpton@deedi.qld.gov.au

Introduction

The spinner shark *Carcharhinus brevipinna* (Müller and Henle) is a common species found in the Atlantic, Mediterranean and Western Indo-Pacific Oceans where it is predominantly found in warm-temperate and tropical coastal waters (Compagno 1984, Caraguel and Iglesias 2004). In Australia, the species occurs in northern Australia from the Geographe Bay (33° 32'S 115° 14'E) in Western Australia to the Jervis Bay (35° 5'S 150° 48'E) in New South Wales where it is a minor component of northern Australian gillnet and Western Australian shark line fisheries (Last and Stevens 1994). It is also commonly caught in gill nets and baited drum lines set to catch sharks as part of bather protection strategies along the coast of Queensland and New South Wales (Reid and Krogh 1992).

There is considerable published information on the biology of *C. brevipinna* from South Africa (Bass et al 1973, Allen and Cliff 2000, Dippenaar et al. 2000, Allen and Winter 2002), east coast of the USA (Branstetter 1981, Bethea et al. 2004, Carlson and Baremore 2005, Thorpe et al. 2004), the Mediterranean (Hemida et al. 2002, Capape et al. 2003,), Taiwan (Joung et al. 2005) and Japan (Teshima et al. 2001). These studies have generally shown that the species uses coastal waters as nursery areas although there are considerable regional variations in the species general biology and fisheries characteristics. Catch statistics, age and growth and other biological data have been analyzed in South Africa (Allen and Cliff 2000, Allen and Winter 2002) based on catches from their beach meshing program (Natal Sharks Board). The South African program mainly uses large gill nets whereas Queensland uses a mixed strategy of both nets and baited drum lines (Dudley 1997).

Despite this fairly extensive international literature on the spinner shark, information in Australian waters is limited. Stevens (1984) provided some preliminary data on the species based on a small sample of 33 individuals obtained from recreational fishing catches in New South Wales. Subsequently, Stevens and McLoughlin (1991) and Stevens et al. (2000) described the general biology of some common sharks from northern Australia noting that *C. brevipinna* was not a commonly caught species and only one of the 59 spinner sharks tagged were recaptured. More recently, White and Potter (2004) noted that *C. brevipinna* used seagrass habitat in Shark Bay, Western Australia as a seasonal nursery area with juveniles (65cm – 81cm TL) of this species being taken exclusively during July.

This paper describes the general biology of the *C. brevipinna* based on samples collected as part of research into the Queensland Shark Control Program (QSCP). Comparisons are also drawn between other studies of the species from Australia and elsewhere in the species' range.

Emphasis is placed on spatial and temporal differences in catches and issues related to the differing selectivity of nets and drum lines as they pertain to the conservation and management of this species in Queensland.

Materials and Methods

Queensland Shark Control Program nets and drum lines are positioned adjacent to popular bathing locations in 10 areas along the Queensland Coast (Figure 1). Fishing strategies vary among these areas but a total of 344 drum lines and 35 nets are currently used in the program throughout Queensland (See Table 1 for gear breakdown in each area). Surface gill nets (186 m in length, 6 m drop, 50 cm stretched mesh size) and drum lines (single 14/0 baited hook) are positioned about 500 -1000 meters off the beach in approximately 8m of water. There are slight local variations to these general positioning guidelines depending on geomorphologic conditions but the nets are normally set parallel to the shoreline. Nets and drum lines are usually checked by contractors 15 days each month with the drum lines baited at that time with sea mullet (*Mugil cephalus*) or shark flesh. Fishing gear is in place continuously and is replaced every 28 days with equipment that has been cleaned and checked.

Fishing contractors complete daily log sheets and record the following information on species of sharks caught in nets and on drum lines:- species identification, length, sex (and number of pups if a pregnant female), stomach contents, prevailing weather and sea conditions at time of capture. All lengths are total lengths (TL) measured in centimeters. Assessment of reproductive structures are according to Cliff et al. (1988). Contractors also record information about the position of the shark within a net and whether the sharks were alive or dead when the gear was checked.

While the program has been in operation since 1962 (Paterson 1990), records (particularly related to species identification) within the program are considered reliable since 1992 when a program of training in species identification was initiated. Prior to 1992 many of the identifications were grouped into generic categories such as “unidentified whaler sharks” which included several *Carcharhinus* species including *C. brevipinna*. The fishing strategies in various areas have also changed since the program inception, but fishing efforts (number of nets and drum lines at each area) have remained relatively constant since 1995, apart from replacing two nets at Townsville with 12 drum lines in 1999. This analysis therefore covers the sharks caught by the program in 11 years from 1996 to 2006.

Differences in shark length were tested using students *t* tests while sex ratios and survival were analyzed for statistical significance using Chi-squared tests.

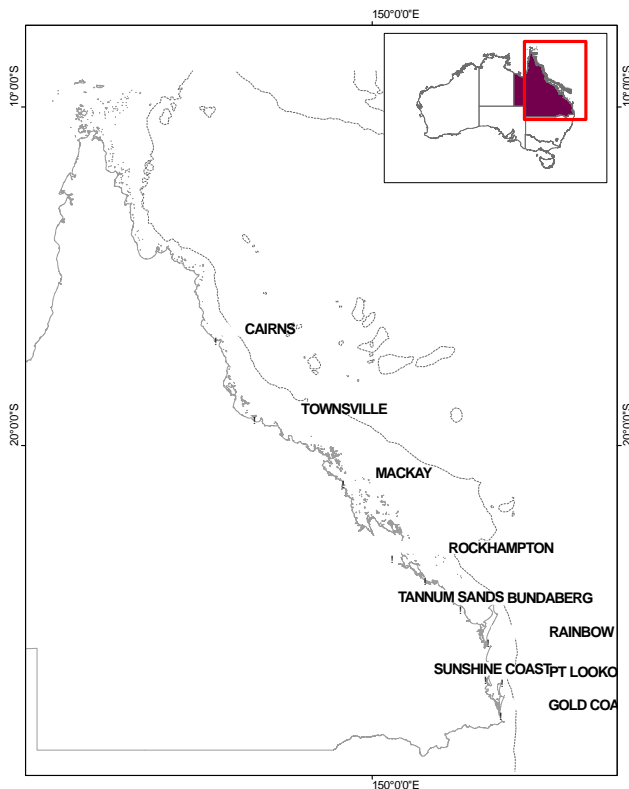


Fig. 1. Map of Queensland showing the locations of QSCP fishing gear. The 200m depth contour is shown as a broken line.

Table 1. Total catch and adjusted annual catch per unit of fishing gear of *Carcharhinus brevipinna* at various QSCP fishing locations. The quantity of fishing gear at each location is also shown.

Location	Quantity of Fishing gear		Total catch (1996 to 2006)		Adjusted catch (No./unit of gear/ year)	
	Drum lines	Nets	Drum lines	Nets	Drum lines	Nets
Cairns	24	5	9	3	0.034	0.055
Townsville	54		18		0.030	
Mackay	27	5	5	7	0.017	0.127
Rockhampton	54		0			
Tannum Sands	12		4		0.030	
Bundaberg	20		1		0.005	
Rainbow Beach	12	3	3	54	0.023	1.636
Sunshine Coast	78	11	26	321	0.030	2.653
Point Lookout	28		0			
Gold Coast	35	11	10	193	0.026	1.595

Results

There was a strong seasonality to the capture of *C. brevipinna* with most being caught from October to March (Figure 2). Peak catches were in January and February with very low catches during the winter, particularly August when sea temperatures were at their lowest. Females outnumbered males in most months and overall this pattern was statistically significant (Sex ratio = 1:1.4, $P < 0.05$).

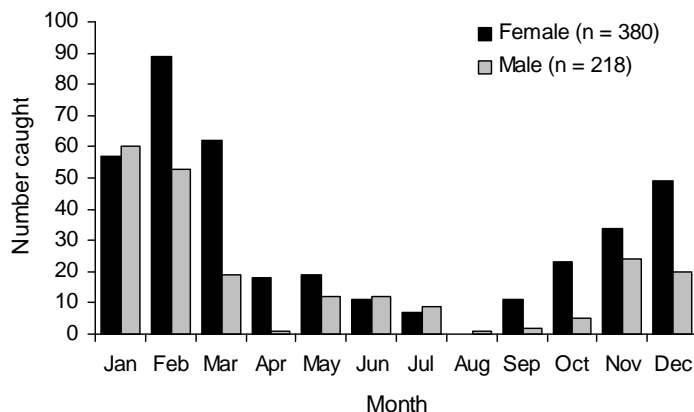
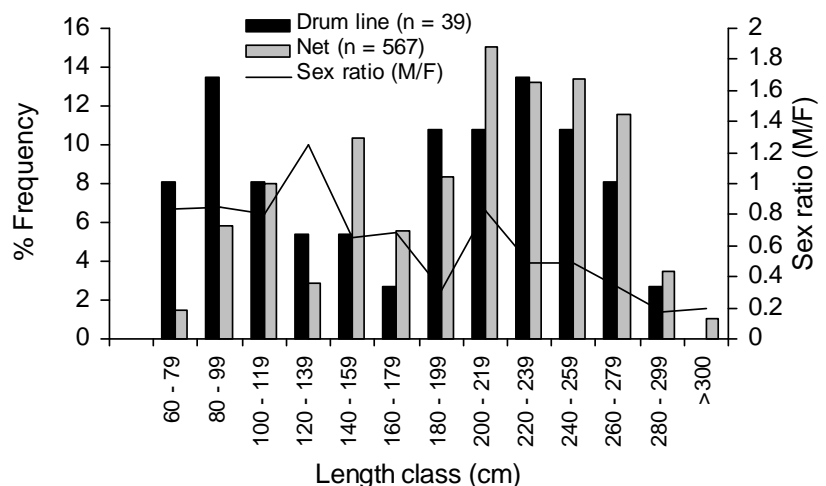


Fig. 2. Seasonal changes in the number of male and female *Carcharhinus brevipinna* caught by the QSCP throughout Queensland between 1996 and 2006.

Currently the QSCP catches the full size range of sharks in the population from neonates to large adults although the size frequency data clearly show selection for larger size classes ($>2.0\text{m}$). The largest shark caught was a

3.2 m female and the average length of females (207 cm) was significantly larger ($P < 0.01$) than males (186 cm). The average size of *C. brevipinna* was significantly larger ($P < 0.05$) in nets than on drum lines and larger individuals were selectively sampled better in nets (Figure 3).

Fig. 3. Length of *Carcharhinus brevipinna* caught in nets and on drum lines in the QSCP throughout Queensland between 1996 and 2006. Sex ratio for various size classes is also shown as a solid line.



There were statistically significant seasonal differences in the length of sharks caught, with larger adult sharks caught more commonly during summer (Figure 4). This was particularly

pronounced on the Sunshine Coast. Large confidence intervals during the autumn are partially a reflection of smaller sample size, but also the result of a greater proportion of juvenile sharks in the catch. During the period of November to January the size of sharks caught on the Sunshine Coast was significantly larger ($P < 0.05$) than those on the Gold Coast. There was no significant

difference ($P>0.05$) in the survival of spinner sharks in either nets or drum lines with a 5.0% and 5.2% survival respectively.

Table 2. Contents of the stomachs of 566 *Carcharhinus brevipinna* caught at seven locations by the QSCP 1996 to 2006. Estimates are percentages of stomachs where the particular category is the most common item.

Location	Sample size	Empty	Unknown	Bone	Cephalopods	Crabs	Rays	Sharks	Fish
Cairns	12	60.4	11.3						26.4
Townsville	14	57.1	7.1	7.1					28.6
Mackay	12	75.0							25.0
Gladstone	4	100							
Rainbow Beach	53	60.4	11.3						28.3
Sunshine Coast	282	85.8	3.2	0.4		0.4	0.4	0.4	8.9
Gold Coast	188	82.9	1.1		0.5		0.5	1.1	13.8
TOTAL	566	80.9	3.4	0.4	0.2	0.2	0.4	0.5	11.3

Table 3. Numbers of *Carcharhinus brevipinna* caught in various sections of the three panel gill nets used in the QSCP between 1996 and 2006.

Vertical position in net	Centre panel	End panels
Top	108	97
Middle	46	46
Bottom	57	65

Significantly more ($P<0.05$) *C. brevipinna* were meshed on the outside (facing the open ocean) of the nets rather than inside (adjacent to the shore) with 163 and 93 sharks respectively meshed. Most were caught in the upper third of the net and in the centre panel of the three panel nets used by the QSCP (Table 3).

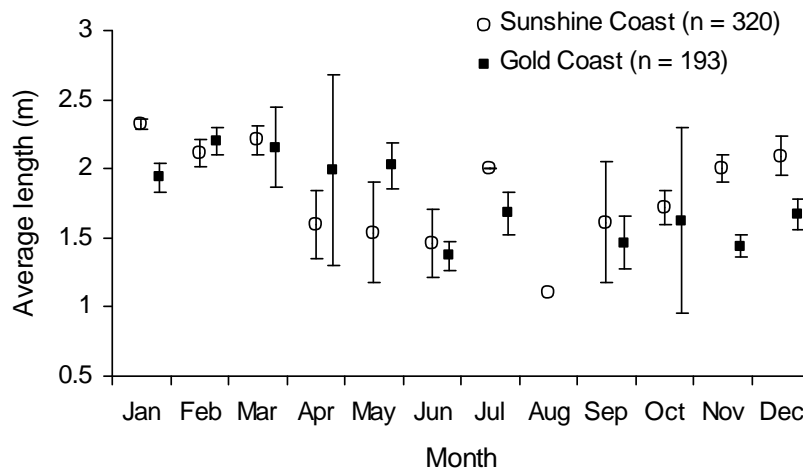


Fig. 4. Seasonal change in the average length of *Carcharhinus brevipinna* caught by the QSCP at the Gold Coast and Sunshine Coast between 1996 and 2006 (95% confidence limits are shown as vertical bars).

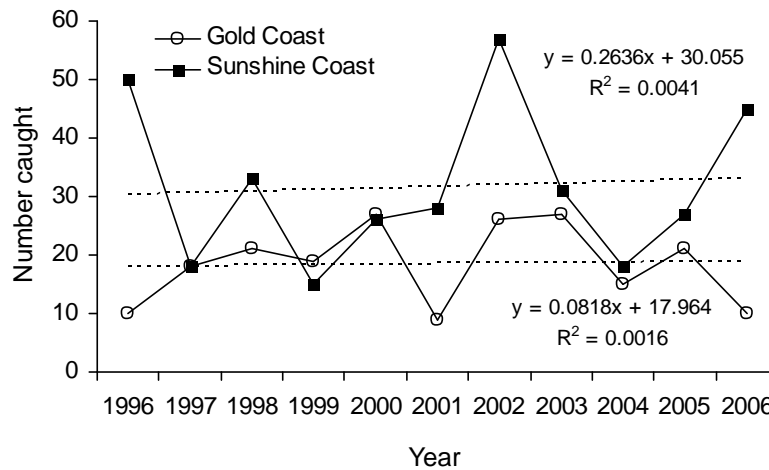


Fig. 5. Annual catch of *Carcharhinus brevipinna* recorded by the QSCP at the Gold Coast and Sunshine Coast between 1996 and 2006. Trend lines are shown as broken lines with associated R^2 and linear regression equations.

When data were adjusted and standardized for differences in fishing effort there were marked regional differences in catch rate, particularly in nets (Table 1). Catch rates were highest in areas south of the Great Barrier Reef and particularly on the Sunshine Coast where they were over 50% higher than the adjacent areas of either Rainbow Beach or the Gold Coast. No *C. brevipinna* were recorded at either Point Lookout or Rockhampton and only one individual was recorded at Bundaberg.

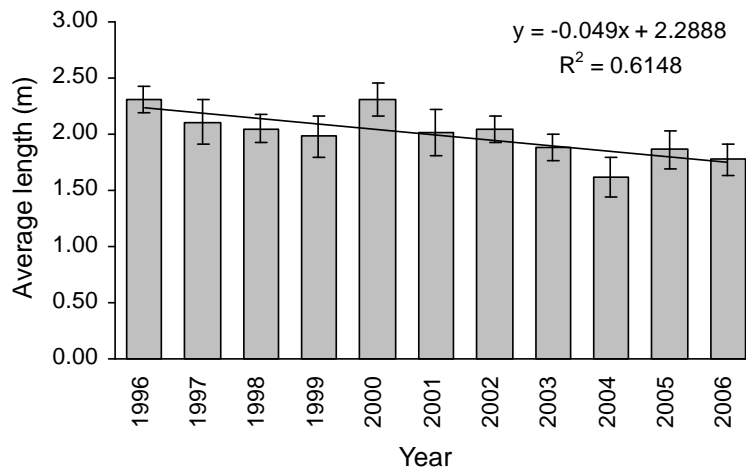


Fig. 6. The change in average length of *Carcharhinus brevipinna* recorded by the QSCP between 1996 and 2006 (95% confidence limits are shown as vertical bars). A trend line is shown with associated R^2 and regression equation.

There was no significant linear trend ($P > 0.05$) in catch over the last 11 years at either the Gold Coast or Sunshine Coast and no consistent annual pattern between these areas. Records of *C. brevipinna* were too few from other areas to enable a temporal comparison of catches but there were differences in the average length of sharks taken throughout the QSCP with larger species being taken towards the southern part of the state. Males outnumbered females and generally larger sharks were less common in the northern regions of Townsville and Cairns than in the areas outside the Great Barrier Reef Marine Park. Very few individuals were sampled in north Queensland to allow statistical comparisons. During the last 10 years there was a significant ($P < 0.05$) declining trend in the average length of this species caught by the QSCP (Figure 6).

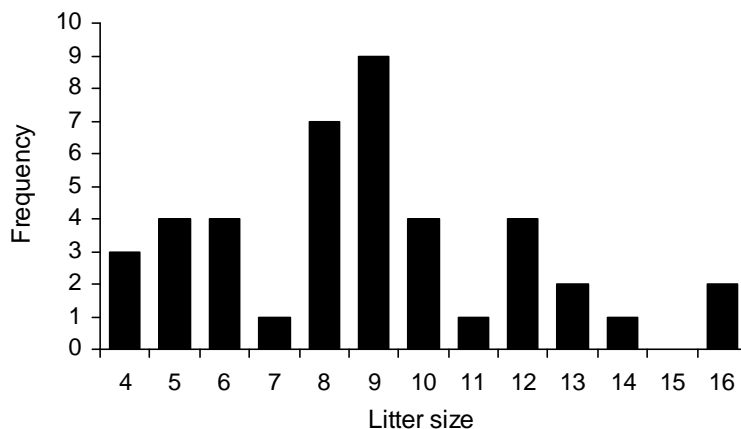


Fig. 7. Litter size of *Carcharhinus brevipinna* caught by the QSCP at the Gold Coast and Sunshine Coast between 1996 and 2006.

The majority of the 566 *C. brevipinna* stomachs examined were empty (Table 2). Teleosts were the most important prey in examined stomachs that contained prey, being present in 71% of those stomachs. Prey items of minor importance included cephalopods, crabs, other sharks and rays.

Pregnant females were caught in all months except May to September, although sample sizes were low. The smallest female that contained pups was 2.0m in length and pregnant females which were close to term were sampled during January to March. Litter sizes ranged from 4 to 16 (Mean = 8.8) (Figure 7) and the sex ratio of embryos did not differ significantly ($P > 0.05$) from equality.

Discussion

Catch rates of *C. brevipinna* were higher at the southern extreme of the species distribution in Queensland with catch rates on the Gold Coast and Sunshine Coast over 5 times the rate of any other areas where nets are currently used by the QSCP (Cairns and Mackay). The *C. brevipinna* is a warmer water species found down to about 31°S in Australia (Last and Stevens 1994) and it is more commonly caught in the southern areas of the state. This area is closer to the continental slope (See Figure 1) and also differs in habitat to northern areas. The northern areas of the QSCP from the Capricorn Coast (Rockhampton) to Cairns are within the Great Barrier Reef Marine Park (GBRMP) where the relatively shallow (generally < 50m) lagoon area bounded by the extensive coral reefs system extends many kilometers offshore. By comparison, southern areas are not bounded by any reef system, are exposed to significant wave action, are influenced more by the east Australian Current and have sediments derived from siliceous sands rather than the carbonate sediments in the GBRMP. It is likely that these differences in broad habitat and the proximity of the southern coastal areas to the continental slope are responsible for differences in catch rate of this species along the Queensland Coast.

Species misidentification of whaler sharks has been highlighted as an issue in a number of earlier studies dealing with *C. brevipinna*. The blacktip shark *C. limbatus* have been previously confused with *C. brevipinna* (D'Aubrey 1965, Branstetter 1982, Allen and Cliff 2000, Brandon et al. 2005). In addition, another morphologically similar shark, the Australian blacktip (*C. tilstoni*) is also caught by the QSCP but its range does not extend into southern Queensland where most of the spinner shark catches are reported. These misidentification issues have been highlighted in previous analyses of QSCP data which culminated in a training program in shark identification being implemented in 1992 when all contractors received instruction in the field identification of common sharks. Misidentification of *C. brevipinna* is now unlikely to be a major problem in southern Queensland given the experience of the three contractors who each have over 15 years of

experience and are highly skilled at distinguishing between the morphologically similar carcharhinids.

The strongly seasonal nature of the shark catch in Queensland is in sharp contrast to the catches recorded by the Natal Sharks Board in South Africa (Allen and Cliff 2000) where catches are distributed more evenly throughout the early part of the year with a major peak in February. It is unlikely that the slight differences in gear between South Africa and Australia (larger mesh size in South Africa) are responsible for these differences. The relatively high catches of the species during winter in South Africa is more likely a result of *C. brevipinna* feeding on the large schools of sardines (*Sardinops sagax*) that are common in KwaZulu-Natal coastal waters during this time and are consumed by a range of large pelagic predators (Van der Elst 1979). In New South Wales, Reid and Krogh (1992) also found a strong seasonal pattern in catches of large whaler sharks examined as a group with minimum catches taken in nets during winter. White and Potter (2004) noted juveniles were only sampled in July in a shallow coastal area of Western Australia although the fishing gear used in that study specifically targeted smaller sharks. The pattern in Queensland is similar to that reported in the Gulf of Mexico (Branstetter 1987) where *C. brevipinna* move inshore to breed in the summer months and then migrate into the deeper water offshore during winter.

The length of sharks recorded by the Natal Sharks Board (Allen and Cliff 2000, Allen and Winter 2002) and the QSCP are broadly comparable although there were a higher proportion of smaller sharks taken in Queensland. This possibly reflects differing gear selectivity as the drum lines used by the QSCP were more selective for smaller spinner sharks than were nets. Different whaler species appear to vary in their selectivity to nets and drumlines. Preliminary experimental comparisons of nets and drumlines in South Africa (Dudley et al. 1993) found greater selectivity of *C. brevipinna* to nets, with 39 caught in nets at one location compared with only one individual on experimental drumlines.

The litter size and other reproductive parameters are in broad agreement with the species in South Africa where there was a mean litter size of 9 and a maximum of 17 (Allen and Cliff 2000) compared with a mean of 8.8 and a litter size range of 4 to 16 observed during the present study. The species has been shown to show considerable geographic variations in biological and reproductive parameters. Litter sizes of 6 to 10 were in the Mediterranean Sea (Capape et al. 2003) and 3 to 14 (Mean 8.5) in Taiwan (Joung et al. 2005). Size at maturity of females reported here (200cm) is at the upper end of the reported range from elsewhere (170 to 210cm).

Dietary studies in northern Australia have shown that 46% of *C. brevipinna* caught in the gillnet fishery had food items in their stomachs with fish being found in 86% of these (Stevens and McLoughlin 1991). This present study found regional variation in stomach contents but the

dominance of teleost fish in the diet is in broad agreement with other studies. The primary prey of juvenile spinner sharks in Florida was clupeids (Bethea et al. 2004) and in two separate South African studies, teleosts were found in 95% (Bass et al. 1973) and 79% (Allen and Cliff 2000) of the sharks whose stomachs contained food. A consistent finding in all studies was the high proportion of empty stomachs, probably due to regurgitation of stomach contents caused by the trauma of capture.

Dudley and Simpfendorfer (2006) noted a stable catch per unit effort (CPUE) pattern and a stable/increasing size pattern for *C. brevipinna* caught by the Natal Sharks Board. Here we have likewise shown a stable CPUE pattern (albeit over a relatively short time frame) but we have also presented evidence of a possible decline in average length, although the trend was not strong. The observed seasonality in catches of *C. brevipinna* suggests that the risk of bather interaction with this species is greatest during the warmer months of the year. This is the time when this species moves inshore to pup (White and Potter 2004) and therefore the time when larger individuals are close to shore. It is also when bathing activity is greatest as beaches, particularly in the southern part of Queensland, are frequented by holiday makers during the main period of school holidays (December/January). Despite the increased probability of interaction at this time, the species is not highlighted in the literature as a significant risk to humans. However, like most large carcharhinids, it theoretically has the potential to injure bathers. Drum lines are not as effective as gill nets at catching large specimens of this species and areas where drum lines are exclusively used may not effectively target this species. This is clearly demonstrated by the absence of the species from catches at Point Lookout and the Rockhampton where only drum lines are deployed. The QSCP gear located at Point Lookout is between the two areas that had the highest catch rates (Gold Coast and Sunshine Coast) and yet this species was not caught there. However, the fishing contractor at Point Lookout regularly reports sighting *C. brevipinna* in this area (Mal Paskin pers. comm.) further indicating the greater selectivity of nets. While the differing selectivity patterns of nets and drumlines for this species may not be an issue it does demonstrate how changes in fishing strategy towards a greater use of one gear over another has the potential to alter the risk of bather interaction with this species of shark.

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