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INCIDENTAL CAPTURE OF ELASMOBRANCHS BY COMMERCIAL PRAWN TRAWLERS ON THE TUGELA BANK, NATAL, SOUTH AFRICA

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Species composition, sizes, trends in occurrence and catch rates of elasmobranchs caught by prawn trawlers on the Tugela Bank of Natal, South Africa, were examined from May 1989 to June 1992. Seven endemic species were recorded, the remainder having Indo-West Pacific or western Indian Ocean distributions. Most sharks were between 0,5 and 1 m long and most of the Myliobatiformes were 0,5 m in disc width. The small sizes of trawl-caught elasmobranchs indicates that the Tugela Bank functions as a nursery area for several species. None of the species examined exhibited diel patterns in frequency of occurrence, but *Gymnura natalensis*, *Himantura gerrardi*, *Dasyatis chrysonota chrysonota*, *Sphyrna lewini* and the rhinobatids occurred more frequently in warmer months. One species, *Halaelurus lineatus*, was more frequently taken during cooler months. *Himantura gerrardi*, *Sphyrna lewini*, *Mustelus mosis* and *Rhizoprionodon acutus* were recorded more frequently in shallower trawls (20–33 m) and *G. natalensis* and *D. c. chrysonota* more frequently in deeper trawls (33–45 m). Trawl-induced mortality was shown to be species specific, *S. lewini* having the highest mortality (98%). Based on catch rates recorded and trawl fleet effort, it is calculated that 44 600 elasmobranchs were caught by Tugela Bank trawlers from 1989 to 1992. About 57% of these were returned to the water alive. These figures are compared to catches made by recreational anglers and the Natal Sharks Board during the same period.

Spesiesamestelling, grootte, voorkomstendense en vangkoerse van kraakbeniges gevang deur garnaaltreilers op die Tugelabank van Natal, Suid-Afrika, is van Mei 1989 tot Junie 1992 ondersoek. Sewe endemiese spesies is aangeteken en die res het verspreidings in die Indo-Wes-Pasifiese en westelike Indiese Oseaan gehad. Die meeste haaie was 0,5–1m lank en die meeste van die Myliobatiformes se skyfwydte was 0,5 mm. Die klein groottes van die getreilde kraakbeniges dui daarop dat die Tugelabank as 'n grootwordgebied vir etlike spesies dien. Geeneen van die ondersoekte spesies het gedurende 'n etmaal patrone in voorkomsfrekwensie vertoon nie, maar *Gymnura natalensis*, *Himantura gerrardi*, *Dasyatis chrysonota chrysonota*, *Sphyrna lewini* en die rinobatides was volopper in die warmer maande. Een spesie, *Halaelurus lineatus*, is meer dikwels in die koeler maande gevang. *Himantura gerrardi*, *Sphyrna lewini*, *Mustelus mosis* en *Rhizoprionodon acutus* is meer dikwels in vlakker treilslepe (20–33 m) aangeteken en *G. natalensis* en *D. c. chrysonota* meer dikwels in dieper treilslepe (33–45 m). Sterftes deur die treil veroorsaak het na gelang van die spesie gewissel en *S. lewini* het die hoogste mortaliteit gehad (98%). Gegrond op die aangetekende vangkoerse en die vangpoging van die treilvloot word bereken dat 44 600 kraakbeniges deur treilers van die Tugelabank gevang is van 1989 tot 1992. Sowat 57% daarvan is lewend in die see terugbesorg. Hierdie syfers word met vangste deur ontspanningshengelaars en die Natalse Haaieraad oor dieselfde tydperk vergelyk.

Most elasmobranchs (sharks and rays) recorded from southern Africa occur in shelf waters (Compagno *et al.* 1989) and are therefore vulnerable to recreational and commercial fishing operations. There are very few commercial fisheries which target elasmobranchs in South Africa, primarily because there are no well developed local markets. However, large quantities of these fish are thought to be taken as a by-catch by demersal trawlers (Compagno *et al.* 1989) and by recreational linefishermen (Guastella and Nellmapius 1993). Elasmobranchs are vulnerable to overexploitation by virtue of their slow growth rate, late reproduction and low fecundity (Compagno 1990, Pratt and Casey 1990). Despite this, and the limited knowledge regarding their role in the marine environment (Smale 1992), there are few estimates of catch rates by local fisheries in the literature. Two examples are the fishery for St Joseph *Callorhinchus capensis* off the South-Western Cape (Freer and Griffiths 1993) and the catches made by the Natal Sharks Board (Cliff *et al.* 1988, Dudley and Cliff 1993a).

Much of the current knowledge of the elasmobranchs off Natal is based on this latter fishery, as well as on earlier work done at the Oceanographic Research Institute, Durban, by Wallace (1967a, b, c) and Bass *et al.* (1973, 1975a, b). More recently, however, data collected from recreational angling competitions have been analysed by Van der Elst (1979) and Guastella (1993). Since the mid 1970s, a small trawling fleet has operated on the Tugela Bank on the inshore shelf off

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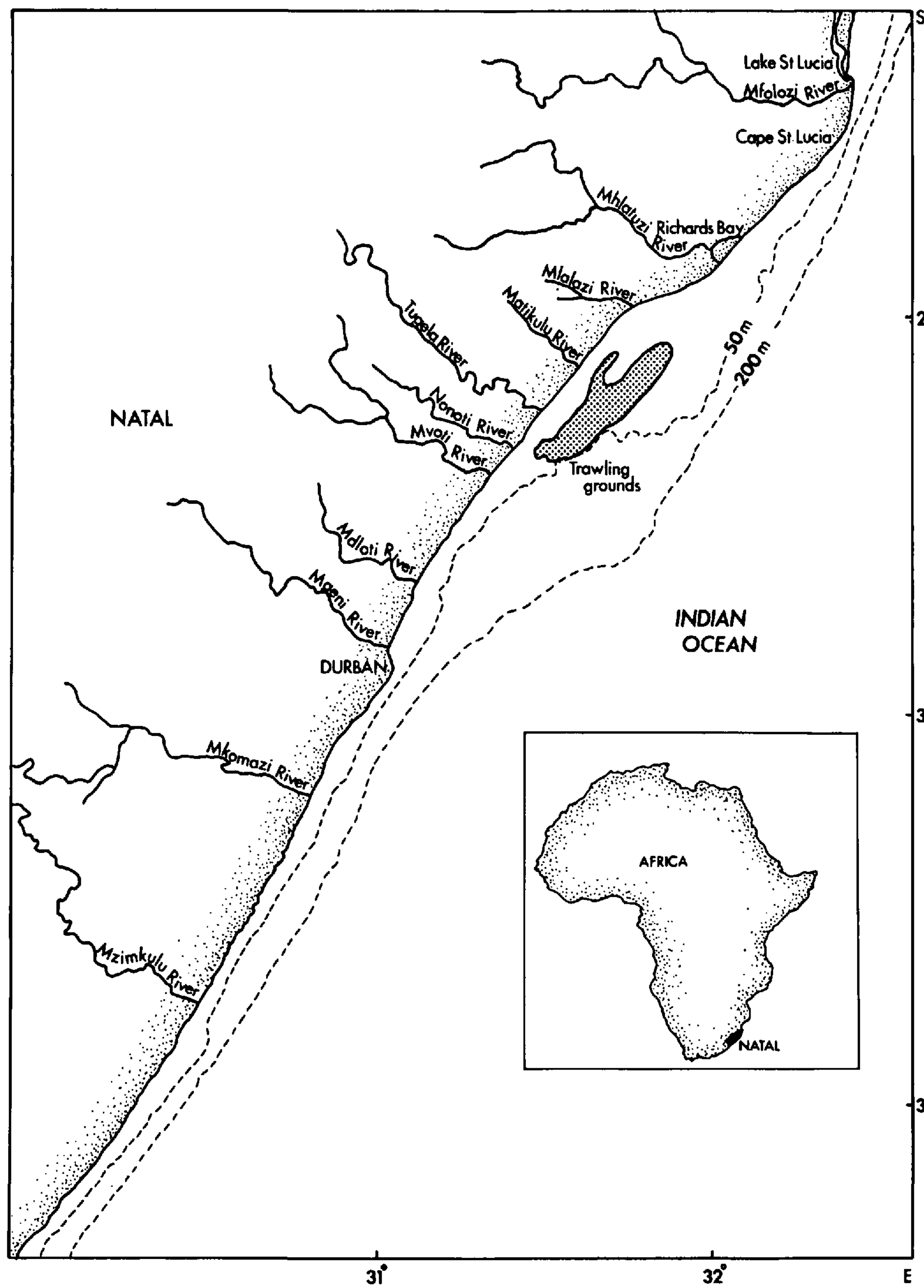

Fig. 1: Location of the Tugela Bank trawling grounds for prawns

Table I: Overall abundance of by-catch elasmobranchs from 169 Tugela Bank commercial prawn trawls, May 1989–June 1992

Taxon	Common name	Number	Percentage by number	Percentage of positive trawls
DASYATIDAE	Stingrays	299	32,8	65,1
*Gymnura natalensis**	Butterfly ray	118	12,9	34,9
Himantura gerrardi	Sharpnose stingray	75	8,2	25,4
*Dasyatis chrysonota chrysonota**	Blue stingray	74	8,1	22,5
Himantura uarnak	Honeycomb stingray	20	2,2	10,1
Dasyatis thetidis	Thorntail stingray	12	1,3	5,3
SPHYRNIDAE	Hammerhead sharks			
Sphyrna lewini	Scalloped hammerhead	192	21,0	32,5
CARCHARHINIDAE	Requiem sharks	184	20,2	41,4
Mustelus mosis	Hardnosed smooth-hound	79	8,7	16,6
Rhizoprionodon acutus	Milkshark	34	3,7	11,2
Carcharhinus brevipinna	Spinner shark	30	3,3	10,7
Unidentified carcharhinids		20	2,2	8,0
Carcharhinus obscurus	Dusky shark	10	1,1	5,3
Carcharhinus plumbeus	Sandbar shark	6	0,7	3,6
Carcharhinus sealei	Blackspot shark	3	0,3	1,2
Carcharhinus amboinensis	Java shark	1	0,1	0,6
*Scylliogaleus quecketti**	Flapnose houndshark	1	0,1	0,6
SCYLIORHINIDAE	Catsharks			
*Halaelurus lineatus**	Banded catshark	139	15,2	18,3
RHINOBATIDAE	Guitarfish	49	5,4	18,9
*Rhinobatos leucospilus**	Greyspot guitarfish	23	2,5	8,3
Rhynchobatus djiddensis	Giant guitarfish	15	1,6	8,3
*Rhinobatos annulatus**	Lesser guitarfish	9	1,0	2,4
Rhina ancyclostoma	Bowmouth guitarfish	2	0,2	1,2
RAJIDAE	Skates			
Raja miraletus	Twineye skate	15	1,6	3,0
MYLIOBATIDAE	Eaglerays	14	1,5	8,3
Pteromylaeus bovinus	Bullray	6	0,7	3,6
Myliobatis aquila	Eagleray	4	0,4	2,4
Aetobatus narinari	Spotted eagleray	4	0,4	2,4
SQUATINIDAE	Angelsharks			
*Squatina africana**	African angelshark	11	1,2	5,9
TORPEDINIDAE	Electric rays			
Torpedo sinuspersici	Marbled electric ray	9	1,0	4,7
ORECTOLOBIDAE	Carpet sharks			
Stegostoma fasciatum	Zebra shark	1	0,1	0,6

* Endemic species

northern Natal, predominantly targetting the white prawn *Penaeus indicus*. While investigating the teleost component of trawler by-catch in this area (Fennessy 1993), the opportunity arose to record the identities and numbers of elasmobranchs occurring in trawl catches. This information is presented here in order to supplement those data obtained from the sources described above.

MATERIAL AND METHODS

The Tugela Bank prawn trawling grounds off the Natal coast (Fig. 1) coincide closely with a depocentre of mud originating from the fluvial discharges of the numerous rivers in the area (McCormick *et al.* 1992) and, as a result, the water is permanently turbid. Samples

Table II: Sizes of elasmobranchs recorded from Tugela Bank prawn trawls from May 1989 to June 1992. Sizes are disc widths for Myliobatiformes and *T. sinuspersici*; all others are total lengths

Taxon	Number caught	Maximum size (m)	Minimum size (m)	Mean size (m)	Size at first maturity ♂	Size at first maturity ♀	Size at first maturity Both sexes	Source of maturity data
DASYATIDAE								
G. natalensis	110	1,7	0,3	0,5	1,0	1,5	–	Van der Elst 1988
H. gerrardi	64	0,8	0,2	0,3	–	–	0,6–0,7	Van der Elst 1988
D. chrysonota chrysonota	73	0,7	0,2	0,5	0,4	0,5	–	Cowley 1990a
H. uarnak	21	0,8	0,3	0,5	–	–	1,0	Van der Elst 1988
D. thetidis	11	1,5	0,8	1,4	–	–	–	
SPHYRNIDAE								
S. lewini	174	1,5	0,4	0,6	~1,5	–	–	Bass *et al.* 1975b
CARCHARHINIDAE								
M. mosis	77	1,2	0,3	0,5	0,9	0,8	–	Smith and Heemstra 1986
C. brevipinna	29	1,6	0,6	0,9	1,8	2,1	–	Van der Elst 1988
R. acutus	33	1,0	0,3	0,5	0,7	0,7	–	Bass *et al.* 1975a
C. obscurus	10	1,3	0,7	1,0	2,8	2,8	–	Bass *et al.* 1973
C. plumbeus	7	1,4	1,0	1,1	1,7	1,7	–	Cliff *et al.* 1988
C. sealei	3	1,2	1,0	1,1	0,7	0,7	–	Bass *et al.* 1973
C. amboinensis	1	1,3	–	–	2,1	2,2	–	Bass *et al.* 1973
S. quecketti	1	1,1	–	–	–	–	–	
SCYLIORHINIDAE								
H. lineatus	91	0,6	0,2	0,4	0,3	0,4	–	Bass *et al.* 1975b
RHINOBATIDAE								
R. leucospilus	23	0,5	0,2	0,4	–	–	~0,5	Van der Elst 1988
R. djiddensis	14	2,0	0,5	0,9	–	–	1,5	Van der Elst 1988
R. annulatus	9	0,6	0,3	0,4	0,6	–	–	Rossouw 1983
R. ancyclostoma	2	1,2	0,7	1,0	–	–	–	
MYLIOBATIDAE								
M. aquila	4	0,8	0,2	0,5	0,5	0,7	–	Van der Elst and Adkin 1991
P. bovinus	6	1,2	0,4	0,7	0,9	–	–	Wallace 1967b
A. narinari	4	0,8	0,4	0,5	–	–	1,2	Van der Elst 1988
RAJIDAE								
R. miraletus	33	0,3	0,1	0,2	–	–	>0,3	Wallace 1967c
SQUATINIDAE								
S. africana	14	0,5	0,2	0,3	0,7	0,9	–	Van der Elst 1988
TORPEDINIDAE								
T. sinuspersici	10	0,4	0,1	0,3	–	–	0,4	Van der Elst 1988
ORECTOLOBIDAE								
S. fasciatum	1	1,3	–	–	1,5	1,7	–	Van der Elst 1988

– No data

were collected from trawlers at irregular intervals between May 1989 and June 1992. During this period, trawlers ranged from 24 to 33 m long and used otter trawls with footropes of length 30–37 m. Codend mesh size was 38 mm (stretched) and trawling speeds were from two to three knots. Time, duration and depth were recorded for each trawl. Once the catch was released on deck, the identities and numbers of the elasmobranch component were recorded. Taxa were identified by reference to Smith and Heemstra (1986). Total lengths (sharks) or disc widths (batoids) were measured or estimated to the nearest 10 cm; estimates were used when animals were alive or large numbers were encountered. Total lengths were the maximum possible length, i.e. with the caudal fin rotated until it was parallel to the body. From August 1990 the proportion of dead : alive individuals (per species) was recorded for each trawl.

Species occurred too infrequently for regression analyses of diel, seasonal or depth patterns, so the effects of these on frequency of occurrence were tested by a one-way χ^2 test. Expected values were the overall frequency of occurrence for all trawls combined (for each species) and the observed values were the obtained frequency of occurrence for each treatment (season, depth, day/night — S. J. M. Blaber, CSIRO Marine Laboratories, Cleveland, Australia, pers. comm.). Two seasons were defined: a warm season (December–May) and a cool season (June–November). These were based on sea surface temperatures recorded in close proximity to the trawl grounds (Natal Sharks Board unpublished data) and were considered to be representative of the sampled area. Trawls made in 20–33 m of water were classified as shallow and those in 33–45 m as deep. The analyses were only carried out for species or families that were found in 10% or more of the trawls.

One-way χ^2 tests were also used to test the effects of trawl depth, duration, catch size and size of individual on trawl-induced mortality of *Gymnura natalensis*. Trawls were categorized as follows:

Trawl depth (m)	Trawl duration (h)	Trawl catch size (kg)	Disc width of individual (m)
Shallow 20–33	Short 0–2	Small 0–150	Small <0,5
Deep 33–45	Medium 2–5	Medium 150–300	Medium >0,5 < 1m
	Long >5	Large >300	Large >1

Catch size was estimated from the numbers of crates of by-catch (average mass 20 kg) and the mass of the retained catch for each trawl. Percentage mortalities in each category (observed) were compared to the overall percentage mortality (expected) for all trawls from August 1990. Only *G. natalensis* was sufficiently well represented in each trawl category to utilize this approach.

Catch rates were standardized to numbers of individuals per trawl hour. Because the data were extremely skewed (many zero values), transformations of the form log $(x+1)$ were attempted, but these did not reduce asymmetry. The numerous zero values also precluded the use of medians. A jack-knife procedure (Neter *et al.* 1988) produced estimates of the mean that were more than double those of the arithmetic mean, and the latter was eventually used. Total fleet effort (in hours) was obtained from drag sheets completed by skippers and was used to obtain annual estimates of

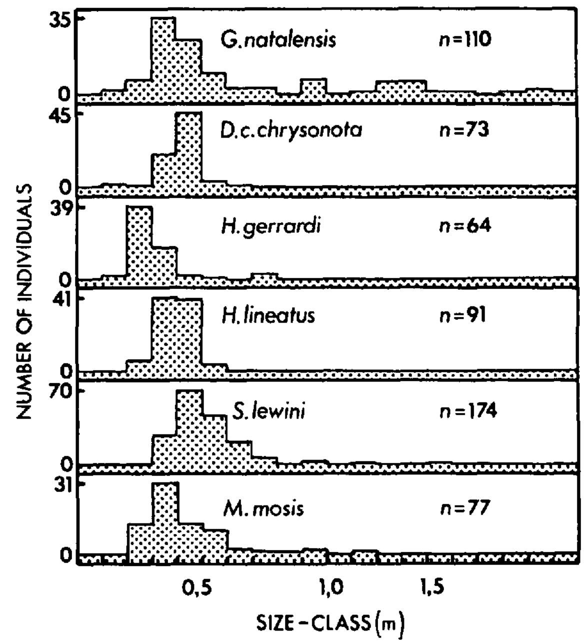

Fig. 2: Size frequency distributions of six commonly occurring elasmobranchs from Tugela Bank commercial catches of prawns (disc widths for *G. natalensis, H. gerrardi* and *D. chrysonota chrysonota*; total lengths for *S. lewini, H. lineatus* and *M. mosis*

the numbers of elasmobranchs trawled.

RESULTS

From May 1989 to June 1992, a total of 169 trawls was observed, representing approximately 2% of all commercial trawls on the Bank during the 38-month sampling period. Of the 26 species (10 families) of elasmobranchs identified, the most abundant was the scalloped hammerhead shark *Sphyrna lewini* (Table I). Dasyatids as a group, but particularly the butterfly ray *Gymnura natalensis*, were numerically the most common (Table I). With the exception of the thorntail stingray *Dasyatis thetidis*, the Myliobatiformes (dasyatids and myliobatids) were relatively small, averaging about 0,5 m disc width (Table II). The banded catshark *Halaelurus lineatus* and *S. lewini* were also generally about 0,5 m long, as were two carcharhinids, *Mustelus mosis* and *Rhizoprionodon acutus*. The other carcharhinids were generally larger, averaging about 1 m long. Size frequency distributions of the six commonest

Table III: Patterns in frequency of occurrence (based on one-way χ^2 analyses) of elasmobranchs occurring commonly in commercial Tugela Bank prawn trawl catches

Taxon	Significance level		
	Diel (day/night)	Season (warm/cool)	Depth (shallow/deep)
DASYATIDAE	NS	NS	NS
G. natalensis	NS	Warm $p<0,5$	Deep $p<0,05$
H. gerrardi	NS	Warm $p<0,5$	Shallow $p<0,05$
D. chrysonota chrysonota	NS	Warm $p<0,5$	Deep $p<0,05$
H. uarnak	NS	NS	NS
SPHYRNIDAE			
S. lewini	NS	Warm $p<0,5$	Shallow $p<0,05$
CARCHARHINIDAE	NS	NS	NS
M. mosis	NS	NS	Shallow $p<0,05$
C. brevipinna	NS	NS	NS
R. acutus	NS	NS	Shallow $p<0,05$
SCYLLIORHINIDAE			
H. lineatus	NS	Cool $p<0,5$	NS
RHINOBATIDAE	NS	Warm $p<0,5$	NS

NS = no significant difference ($p > 0,05$) between overall frequency of occurrence and frequency of occurrence per trawl category

Table IV: Numbers of mortalities and survivors of elasmobranchs recorded from 100 Tugela Bank commercial prawn trawls, August 1990–June 1992

Taxon	Number dead	Number alive	% Mortality
DASYATIDAE	66	115	36,5
G. natalensis	39	45	46,4
H. gerrardi	20	27	42,6
D. chrysonota chrysonota	6	28	17,7
H. uarnak	4	12	25,0
D. thetidis	7	3	70,0
SPHYRNIDAE			
S. lewini	165	4	97,6
CARCHARHINIDAE	38	50	35,9
M. mosis	4	10	28,6
C. brevipinna	14	11	56,0
R. acutus	7	17	29,2
C. obscurus	1	7	12,5
C. plumbeus	2	4	33,3
C. amboinensis	0	1	0
SCYLIORHINIDAE			
H. lineatus	9	38	19,2
RHINOBATIDAE	13	27	32,5
R. leucospilus	10	9	52,6
R. djiddensis	2	9	18,2
R. annulatus	1	8	11,1
R. ancyclostoma	0	1	0
MYLIOBATIDAE	3	8	27,3
M. aquila	2	2	50,0
P. bovinus	1	3	25,0
A. narinari	0	3	0
RAJIDAE			
R. miraletus	0	2	0
SQUATINIDAE			
S. africana	6	4	60,0
TORPEDINIDAE			
T. sinuspersici	2	3	40,0
ORECTOLOBIDAE			
S. fasciatum	0	1	0

elasmobranchs are presented in Figure 2.

Diel, seasonal and depth patterns in frequency of occurrence of the elasmobranchs occurring more commonly are presented in Table III. All the species examined were as frequent by day as by night. *G. natalensis*, *Himantura gerrardi*, *Dasyatis chrysonota chrysonota*, *S. lewini* and the Rhinobatidae occurred more frequently in trawls from December to May, whereas *H. lineatus* was more frequent from June to November. *H. gerrardi*, *S. lewini*, *M. mosis* and *R. acutus* were recorded more frequently in shallower trawls (20–33 m), and *G. natalensis* and *D. c chrysonota* more frequently in deeper ones (33–45 m).

Mortality data were only collected from August 1990 (for a total of 100 trawls). Trawl-induced mortality varied considerably between and within families. Almost 98% of the *S. lewini* caught were killed by trawling, whereas other families had trawl mortalities of 60% or less (Table IV). χ^2 tests showed that trawls of short duration (<2 h) resulted in reduced mortality of *G. natalensis*, whereas larger catches (>300 kg) increased mortality (Table V). Fish of medium size (0,5–1 m disc width) tended to suffer greater mortality, whereas trawl depth had no effect on trawl mortality of this species.

Mean catch rates (number·h^{-1}) and derived estimates of annual catches of elasmobranchs are presented in Table VI. Based on catch per unit effort and total trawling effort, it is estimated that 44 600 elasmobranchs would have been caught by Tugela Bank prawn trawlers from 1989 to 1992. Catches were highest in 1989 when effort was greatest. Fleet effort declined from 1989 to 1992, and catches decreased concomitantly.

DISCUSSION

Most of the elasmobranchs found commonly over soft substrata in shallow Natal shelf waters were re-

Table V: One-way χ^2 analyses comparing overall mortality of *G. natalensis* to mortalities by depth, duration, trawl catch size and size of individual

Trawl category		Significance level
DEPTH		
Shallow	(20–33m)	NS
Deep	(33–45m)	NS
DURATION		
Short	(0–2 h)	$p < 0,05$ (reduced mortality)
Medium	(2–5 h)	NS
Long	(>5 h)	NS
CATCH SIZE		
Small	(0–150 kg)	NS
Medium	(150–300 kg)	NS
Large	(>300 kg)	$p < 0,05$ (increased mortality)
SIZE OF INDIVIDUAL		
Small	(<0,5m)	NS
Medium	(>0,5<1m)	$p < 0,05$ (increased mortality)
Large	(>1m)	NS

NS = no significant difference ($p > 0,05$) between overall mortality and mortality in that category

corded in Tugela Bank prawn trawl catches. However, there were exceptions, including several of the carcharhinid sharks (e.g. the blacktip shark *Carcharhinus limbatus* and the Zambezi shark *C. leucas*), which were probably not caught owing to their pelagic habit. The bluntnose spiny dogfish *Squalus megalops*, which is very common in shelf waters of the Agulhas Bank (Compagno *et al.* 1989), was not recorded either. It is possible that the Tugela Bank trawl grounds border on the preferred depth range of the species (N. Kistnasamy, Oceanographic Research Institute, pers. comm.). Seven endemic species were recorded (Table I), but most of the other species have tropical Indo-West Pacific or western Indian Ocean distributions (Smith and Heemstra 1986).

With the exception of the carcharhinids, the elasmobranchs caught in prawn trawl catches tended to be demersal in habit (apart from *S. lewini*) and generally slow-swimming, which probably accounted for their vulnerability to trawlers. At least two species, *S. lewini* and *G. natalensis*, form shoals (Van der Elst 1988, Compagno *et al.* 1989), which may have increased their vulnerability to trawlers. Also, the Tugela Bank is a source of a variety of demersal fish, crustaceans and molluscs (Fennessy 1994, Fennessy *et al.* 1994), which constitute a large part of the diet of many elasmobranchs (Bass *et al.* 1973, 1975a, b, Smith and Heemstra 1986, Compagno *et al.* 1989). Packs of such shark species as *Carcharhinus brevipinna* and *C. plumbeus* were often observed feeding on discarded "trash" fish, so the trawlers may even attract these elasmobranchs, which often appeared as trawls were being hauled. Bass *et al.* (1973) also reported that *C. obscurus* attacked prawn trawl nets in deep water off Natal. It is possible that shoals of *S. lewini* feeding in pelagic waters were caught as the trawls were being shot or hauled. From their size, these sharks are newly born (Stevens and Lyle 1989) and may not be able to avoid trawls as efficiently as other (older) juvenile pelagic sharks, so accounting for the high number of this species in trawl catches. It is likely that the presence of suitable food items, either as prey or scavenged, contributed to the occurrence in the area of several of the elasmobranchs recorded in the by-catch.

The mean sizes and, in many cases, the maximum recorded sizes, of trawled elasmobranchs were below the documented sizes at first maturity (Table II, Fig. 2). Exceptions were *H. lineatus* and *D. chrysonota chrysonota*. The occurrence of large numbers of juveniles suggests that the Tugela Bank functions as a primary and/or secondary nursery area (as defined by Bass 1978) for many of the elasmobranch species recorded in this study. Several teleost species also utilize the area as a nursery (Fennessy 1994), because the turbid conditions and the presence of suitable prey make it suitable for this purpose. The co-occurrence of juveniles of several shark species may also reduce the potential level of predation by larger sharks (Simpfendorfer and Milward 1993). Bass *et al.* (1973, 1975a) found that newborn *C. brevipinna* and juvenile *S. lewini* and *R. acutus* were common on the Natal coast, and studies in Australia have also shown that these three species utilize coastal waters as nurseries (Stevens and McLoughlin 1991, Salini *et al.* 1992, Simpfendorfer and Milward 1993). The relatively infrequent or non-occurrence in trawl catches of juveniles of three other sharks commonly found in Natal waters, i.e. *C. obscurus*, *C. limbatus* and *C. plumbeus*, might indicate their ability to avoid trawls, or perhaps alternative habitat preferences. The primary nursery grounds for those sharks are southern Natal for *C. obscurus* (Bass *et al.* 1973) and southern Moçambique for the last two species (Bass *et al.* 1973, Dudley and Cliff 1993b). Such species may utilize the Tugela Bank as part of their secondary nursery area but, having attained a larger size, they may be less vulnerable to trawls.

The small sizes of some of the trawled batoids also points to the nursery function of the region for several species, particularly *G. natalensis*, *H. gerrardi*, *H. uarnak* and *Rhinobatos leucospilus*. Based on observed sizes of trawled *D. c. chrysonota*, most of that species caught were bordering on maturity, although this contrasts with the observation of Cowley (1990a) that immature individuals are more common offshore (7–50 m). Most of the other batoids were immature. Gear selectivity is not likely to have skewed the size

Table VI: Catch rates and derived estimates of catches of elasmobranchs from Tugela Bank commercial prawn trawlers, 1989–1992. Standard errors are not given for catch rates based on single individuals. Total fleet hours — 1989 = 12 457, 1990 = 8 016, 1991 = 7 841, 1992 = 6 601

Taxon	Mean catch rate in number·h^{-1} and (*SE*)	Derived estimates of trawled elasmobranch numbers			
		1989	1990	1991	1992
DASYATIDAE	0,42022 (0,04873)	5 235	3 368	3 295	2 774
G. natalensis	0,15059 (0,02096)	1 876	1 207	1 181	994
H. gerrardi	0,11567 (0,02097)	1 441	927	907	764
D. chrysonota chrysonota	0,10276 (0,02994)	1 280	824	806	678
H. uarnak	0,0339 (0,00958)	422	272	266	224
D. thetidis	0,01317 (0,00523)	164	106	103	87
SPHYRNIDAE					
S. lewini	0,26397 (0,05516)	3 288	2 116	2 070	1 742
CARCHARHINIDAE	0,30063 (0,04348)	3 745	2 410	2 357	1 984
M. mosis	0,11007 (0,02826)	1 371	882	863	727
C. brevipinna	0,05055 (0,01390)	630	405	396	334
R. acutus	0,0580 (0,01498)	723	465	455	383
C. obscurus	0,02565 (0,01326)	320	206	201	169
C. plumbeus	0,01011 (0,00415)	126	81	79	67
C. sealei	0,01524 (0,01096)	190	122	119	101
C. amboinensis	0,00111	14	9	9	7
S. quecketti	0,00641	80	51	50	42
SCYLLIORHINIDAE					
H. lineatus	0,16227 (0,03914)	2 021	1 301	1 272	1 071
RHINOBATIDAE	0,06479 (0,01382)	807	519	508	428
R. leucospilus	0,03087 (0,01032)	385	247	242	204
R. djiddensis	0,01858 (0,00549)	231	149	146	123
R. annulatus	0,01238 (0,00695)	154	99	97	82
R. ancyclostoma	0,00182 (0,00128)	23	15	14	12
MYLIOBATIDAE	0,02219 (0,00633)	276	178	174	146
M. aquila	0,00569 (0,00283)	71	46	45	38
P. bovinus	0,01201 (0,00538)	150	96	94	79
A. narinari	0,00513 (0,00268)	64	41	40	34
RAJIDAE					
R. miraletus	0,01570 (0,01037)	196	126	123	104
SQUATINIDAE					
S. africana	0,01379 (0,00495)	172	111	108	91
TORPEDINIDAE					
T. sinuspersici	0,01249 (0,00442)	156	100	98	82
ORECTOLOBIDAE					
S. fasciatum	0,0014	17	11	11	9

distributions of batoid catches, because large *G. natalensis* and *Dasyatis thetidis* were caught frequently (Table II, Fig. 2).

None of the taxa analysed showed diel patterns of frequency of occurrence. The high turbidity of the water probably reduced the incidence of net avoidance during daylight. Most dasyatids and rhinobatids forage only on the sea bed and, unlike many demersal teleosts, do not migrate vertically. They are therefore equally vulnerable to trawls by day or night. Reduced trawl catches of sharks at night might be expected as they move inshore at night to feed (Wallett 1973). However, the possibility exists that discarding of fish may continue to attract sharks at night. Of the species which showed seasonal abundance, most were more frequent in trawls made during the warmer months. This agrees with reported increases in abundance of these species in summer (Bass *et al.* 1973, 1975a, Bass 1978, Van der Elst 1988). Cowley (1990a), however, found that *D. c. chrysonota* were more common in anglers' catches in cooler months along the Natal coast. The seasonal abundances described by these authors were ascribed to patterns of reproduction and hence pulses of recruitment.

Although the trawlable area of the Tugela Bank has a relatively narrow depth range (20–45 m), six species exhibited depth preferences. Depth is often an important factor in determining demersal fish distribution (Blaber *et al.* 1990) and may play a role in niche separation of species with potentially overlapping diets. This could be established for Tugela Bank elasmobranchs by means of analysis of stomach contents.

Counts of fatalities and survivors showed that trawl-induced mortality in elasmobranchs is species-specific. The scalloped hammerhead *S. lewini* appeared to be particularly vulnerable. No quantifiable estimates of this type of mortality could be found in the literature, but a few studies have been made on teleosts (Van Beek *et al.* 1989, Wassenberg and Hill 1989). Many of the teleosts observed during the current study were barotraumatised and the majority were dead by the time the catch was released on deck. Elasmobranchs lack swim bladders and are therefore less susceptible to pressure changes as the trawl is hauled. However, they are still exposed to crushing effects as the trawl is lifted out of the water. Analyses for *G. natalensis* showed that catch size, trawl duration and size of individual all affected survival. This may have implications in trawl fisheries where catches are often large, for instance that for the Cape hakes off western and south-western South Africa. Elasmobranch mortalities may be considerably higher in that fishery than those recorded in this study (Compagno *et al.* 1989).

Of the estimated 44 600 elasmobranchs caught by trawlers from 1989 to 1992, about 57% (25 600 fish) were returned to the water alive (based on mortality rates recorded on board). Mortality subsequent to this study was not estimated. During the same period, the Natal Sharks Board caught 9 276 elasmobranchs, of which 3 350 (36%) were released alive (Natal Sharks Board unpublished data). Catches at Natal angling competitions, from skiboats and by shore-anglers, amounted to 37 566 sharks and rays (National Marine Linefish System feedback analyses 1989–1992). Increasing numbers of elasmobranchs are being released by competition anglers, some estimates being as high as 90% (R. Roux, Natal Coastal Anglers Union, pers. comm.). Estimates of recreational catches of elasmobranchs are imprecise, because they rely on the voluntary completion of catch cards by anglers. Total catches recorded by recreational skiboat- and shore-anglers for the period 1989–1992 amounted to 5 590 fish (National Marine Linefish System feedback analyses 1989–1992), a figure which could be underestimated by as much as 90%. However, an increasing proportion of these are also released (Cowley 1990b).

The contribution by Tugela Bank prawn trawlers to elasmobranch catches in Natal waters is clearly substantial. The ecological implications of the removal of these quantities of predators are unknown. Inshore trawling in Natal waters is a relatively recent development (*c.* 1976) and, although fleet effort declined during the study period, the fishery is likely to persist. Long-term monitoring of trawl composition may give further insight into the impact of trawlers on elasmobranch populations on the Natal coast and provide valuable information on the biology and ecology of this often-overlooked group of fish.

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