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An Overview of the Elasmobranch By-catch of the Queensland East Coast Trawl Fishery (Australia)

(Elasmobranch Fisheries – Oral)

by

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Abstract

The Queensland East Coast Trawl Fishery (ETCF) is a complex multi-species and multi-sector fishery operating along Queensland's eastern coastline, with combined annual landings of close to 10 000 tons. Elasmobranchs represent a relatively small, but potentially ecologically significant component of by-catch in this fishery. At least 94 species of elasmobranchs occur in the managed area of the ECTF and a study has been initiated to examine elasmobranch by-catch in four sectors of the fishery, as part of a larger Queensland Department of Primary Industries by-catch project. A total of 42 elasmobranch and one holocephalan species have been recorded as by-catch in the fishery. Preliminary results from fishery-independent (FI) surveys indicate that elasmobranch by-catch is highly variable between fishery sectors. Elasmobranch by-catch is extremely low in the tiger/Endeavour prawn sector, low in the eastern king prawn – deep water sector (EKP-D), and moderate in the EKP – shallow water sector (EKP-S). By-catch was dominated by one rhinobatid species (*Aptychotrema rostrata*) and two urolophids (*Trygonoptera testacea* and *Urolophus* sp. A) in the EKP-S, and by one rajid species (*Raja polyommata*) and two scyliorhinids (*Asymbolus rubiginosus* and *Galeus boardmani*) in the EKP-D sector. Results from each of the FI surveys are combined in an overview of elasmobranch by-catch across the fishery, with comments on elasmobranch conservation and continuing research directions.

Introduction

It is estimated that approximately half of the annual global catch of chondrichthyans (the cartilaginous fishes: elasmobranchs and holocephalans) is taken as by-catch (Stevens *et al*., 2000). As a consequence, some species of skates (Rajidae), sawfishes (Pristidae) and deep-water dogfishes (Centrophoridae and Squalidae) have been virtually extirpated from large areas (Stevens *et al*., 2000). In Australian waters, Graham *et al*. (2001) reported significant declines in catches of two dogfishes, *Centrophorus harrissoni* and *C. uyato*, together with skates and stingarees (Urolophidae) after 20 years of demersal fish trawling on the continental slope off New South Wales (NSW). Sharks and rays are also a regular component of the by-catch in Australia's Northern Prawn Fishery (Brewer, 1999), where Stobutzki *et al*. (2001) identified 56 species and considered the unsustainability of stingray (Dasyatidae) and sawfish capture of particular concern.

The Queensland East Coast Trawl Fishery (ETCF) is a complex multi-species and multi-sector fishery, operating from Cape York in the north (10º30'S, 142º30'E) to the Queensland/NSW border (28º00'S, 153º30'E). This fishery is comprised of otter trawlers operating in coastal waters taking prawns (Penaeidae), scallops (*Amusium* spp.) and small amounts of whiting (*Sillago robusta*); and beam trawlers targeting prawns in estuarine and inshore waters. The combined annual landings of the fishery are close to 10 000 tons, with by-catch estimated to exceed 25 000 tons (Robins and Courtney, 1999). The by-catch of elasmobranchs is known to vary considerably between fishery sectors. For example, in the Moreton Bay sector, elasmobranchs accounted for 15.4% of the by-catch by weight (Wassenberg and Hill, 1989) while in the Banana prawn sector they represented less than 0.25% of the total by-catch (Stobutzki *et al*., 2001).

The compulsory use of both by-catch reduction devices (BRDs) and turtle exclusion devices (TEDs) throughout the fishery is assisting in reducing by-catch (Queensland Government's target 40% reduction by 2005). TEDs are devices designed to prevent turtles from being retained, while BRDs are designed to allow non-target fish species to escape through modified sections of the net. Robins *et al.* (1999) and Broadhurst (2000) present overviews of BRDs and TEDs employed in Australian prawn trawl fisheries. A number of BRD designs are used in the ECTF including radial escape sections, square mesh panels, fisheyes and bigeyes, and while TED designs are also variable, bar spacings are required to be no more than 12 cm apart. Little research has focused specifically on how BRDs and TEDs influence the capture of elasmobranchs. Robins-Troeger (1994) and Brewer *et al*. (1998) both highlighted the reduced capture of larger elasmobranchs, particularly batoids, in nets fitted with TEDs. However, while it is expected that the use of TEDs should greatly reduce the capture of larger elasmobranchs, the capture of smaller species and individuals may not be altered (Brewer, 1999).

This study aims to assess the catch of elasmobranchs in various sectors of the ECTF and the impact of BRDs and TEDs on their capture. While both fishery-dependent (FD) and fishery-independent (FI) sampling has been employed in this study, this paper will largely present preliminary results on the latter. The species composition of elasmobranch by-catch in these sectors is presented and is discussed in the context of conservation and the management of biodiversity.

Materials and Methods

Four (FI) surveys were conducted in the ECTF between October 2001 and July 2002. The first was undertaken in the eastern king prawn – shallow water sector (EKP-S) off southern Queensland, the second in the tiger and Endeavour prawn sector (TE) off north Queensland, the third in Hervey Bay (HB) (part of the EKP – shallow water sector) and the fourth in the eastern king prawn – deep water sector (EKP-D) off southern Queensland. The EKP-S operates in <50 fathoms and the EKP-D in >50 fathoms, both sectors targeting *Melicertus plebejus*, with combined annual landings of approximately 1,800 t (Robins and Courtney, 1999). The TE sector operates in inshore shallow waters targeting tiger (*Penaeus esculentus*, *P. semisulcatus* and *P. monodon*) and Endeavour prawns (*Metapenaeus ensis* and *M. endeavouri*) with annual landings of around 3,200 t (Robins and Courtney, 1999). Survey details are provided in Table 1. In addition, elasmobranch species recorded from FD sampling in the scallop sector of the fishery are presented here. This sector targets *Amusium balloti* and *A. pleuronectes* with annual landings of 1,200 t (Robins and Courtney, 1999).

Surveys were conducted on commercial or ex-commercial otter trawlers using four-seam Florida Flyer nets with 24-ply polyethylene, 2 inch SMS in the net body and 48-ply polyethylene, 1.75 inch SMS in the codend. Gear configuration and net headrope length varied depending on the normal commercial configuration within the sector (Table 1). A modified Kevin Wicks type top-shooter TED constructed of 0.75 inch solid aluminium with 12 cm bar spacings was used in all surveys (Fig. 1a). BRD type varied between surveys as follows: EKP-S and TE, 48-ply polyethylene radical escape section (Fig. 1b); HB, quasi-fisheye (Fig. 1c); EKP-D, square mesh panel (Fig. 1d).

During each survey, four net treatments (codend types) were tested: Standard (no BRD or TED), TED only, BRD only, TED + BRD together. In the EKP-S, 60 2nm trawls were undertaken, sampling from 2 nets, which resulted in 120 measurements or 30 measurements per treatment. In the TE, 48 2nm trawls were undertaken, sampling from 4 nets, which resulted in 192 measurements or 48 measurements per treatment. In the HB survey, 48 1nm trawls were undertaken, sampling from 2 nets, which resulted in 96 measurements, or 24 measurements per treatment. In the EKP-D, 65 2nm trawls were undertaken, sampling from 2 nets, which resulted in 130 measurements with unequal measurements per treatment. Treatments were randomly allocated to nets with codend types removed after each trawl or night's trawling and a different treatment sewn onto a net as the sampling design for each survey dictated.

After each trawl the catch was sorted into target species, byproduct (various non-target marketable species) and by-catch. These components were weighed on the vessel. All elasmobranchs were removed from the by-catch and later examined in the laboratory. Individuals were identified, weighed, sexed and measured. Total length (TL) and disc width (DW) were used as standard measurements.

Statistical analysis

Elasmobranch by-catch composition was determined for each survey. The low catch rates in the TE, HB and EKP-D surveys restricted further analysis. Generalised linear modeling (GLM) in Genstat 5 (2000) was used to obtain predicted probabilities of capturing *A. rostrata* and urolophids in a given trawl in the EKP-S sector. Modeling used presence/absence data based on the binomial distribution with a logit link function. The model, CATCH=SHOT+BRD was used where shot was the trawl number (this considered the effect of location) and BRD was the treatment (net) type (Standard, BRD, TED, BRD+TED). The rpair procedure in GENSTAT, which performs t-tests for pairwise differences of means from a GLM, was used to test for significant differences in the probability of capture between net types.

Results

A total of 42 elasmobranch and one holocephalan species have been recorded from the by-catch of the EKP, TE and scallop sectors in the present study together with records from the banana prawn sector by Stobutzki *et al*. (2001) (Table 2). The most speciose families recorded are the whaler sharks (Carcharhinidae) with nine species and the stingrays (Dasyatidae) with eight species.

The catch rate of elasmobranchs in the TE survey was extremely low with only eight individuals from five species captured in 192 measurements. Elasmobranchs were captured in all codend types, however, the largest two individuals, a *Himantura toshi* (DW = 505 mm) and a *Rhynchobatus australiae* (DW = 420 mm) were captured in standard nets

A total of 23 individuals from eight species were captured during the 96 measurements of the HB survey. The blue-spotted maskray, *Dasyatis kuhlii* (n = 8), and the Australian butterfly ray, *Gymnura australis* (n = 5), were the most commonly recorded species. The two largest individuals (*Himantura uarnak* with DW = 52 cm and 73 cm) were captured in nets without TEDs, however a *G. australis* of 62.0 cm DW was captured in a net fitted with a TED.

Twelve species of elasmobranchs were recorded from the EKP-S survey, totaling 409 individuals over the 120 measurements. Elasmobranchs were recorded from 84 of the 120 measurements in this sector (Fig. 2a). The species composition was dominated by three species, *Aptychotrema rostrata* (Rhinobatidae), *Trygonoptera testacea* (Urolophidae) and *Urolophus* sp. A (Last and Stevens, 1994) (Urolophidae), which together, represented 91.9% of the elasmobranch catch by number, and 79.1% by mass (Table 3). *Aptychotrema rostrata* was recorded from 66 of the 120 measurements (Fig. 2b) and urolophids from 30 of the 120 measurements (Fig. 2c). The predicted probabilities of capturing an individual *A. rostrata* or urolophid in a single trawl are given in Table 4. There were no significant differences in the probabilities of obtaining either *A. rostrata* or urolophids in the different net treatments. The catch of *A. rostrata* from all net types during the survey was dominated by immature individuals in the size range 360-460 mm TL (Fig. 3a). Urolophids (*T. testacea* and *Urolophus* sp. A) were dominated by individuals in the size range 240-320 mm TL (Fig. 3b).

Nine elasmobranch and one holocephalan species were recorded from the EKP-D survey, totaling 65 individuals over the 130 measurements. Elasmobranchs were recorded from 41 of the 130 measurements (Fig. 2d). The species composition was dominated by *Raja polyommata* (Rajidae), *Asymbolus rubiginosus* (Scyliorhinidae) and *Galeus boardmani* (Scyliorhinidae), which together represented 83.5% of the catch by number and 64.6% by mass (Table 5). Individuals captured were generally small, with only five elasmobranchs weighing =500g.

Discussion

At least 94 elasmobranch and two holocephalan species occur in the managed area of the Queensland ETCF (Last and Stevens, 1994). Close to half of these species have been recorded as by-catch in the fishery during the present study and by Stobutzki *et al*. (2001). Results indicate that elasmobranch by-catch is variable between sectors, with the highest catch rates in the eastern king prawn sector. While TEDs are likely to be reducing the capture of large elasmobranchs (Brewer, 1999) preliminary results suggest that neither TEDs nor BRDs are impacting upon the retention of small individuals and species. Net type did not significantly affect the capture of *Aptychotrema rostrata* (commonly to 85 cm TL), *Trygonoptera testacea* (to 45 cm TL) or *Urolophus* sp. A (to 36 cm TL) - all relatively small species - in the EKP-S sector based on presence/absence data. Furthermore, codends fitted with TEDs actually had the highest predicted probability of *A. rostrata* capture, and standard codends (no TED or BRD) had the lowest probability of capturing urolophids. However, it needs to be noted that the differences in the probabilities of capture between nets were not substantial. The fact that urolophids were often captured in aggregations may have influenced these results.

As female *A. rostrata* are known to mature at 54-66 cm TL and males at 60-68 cm TL (Kyne and Bennett, 2002), the majority of individuals captured during the EKP-S FI survey were immature. In contrast, both urolophid species (males and females) appear to mature at between 23-27 cm TL (Kyne, unpublished data), indicating that a considerable proportion of mature individuals were captured. FD sampling has also revealed high catches of neonates at certain times of the year, resulting in high levels of trawl induced juvenile mortality. Furthermore, gravid female *T. testacea* often abort near-term embryos after capture. While *A. rostrata* appears to be a hardy species, usually capable of surviving trawling, urolophids appear to have lower survivability (unpublished information on capture mortality and survivability). Therefore, high rates of mortality at all life stages may have negative impacts on the viability of urolophid populations. Data from the South East Trawl Fishery in NSW support this suggestion, where after 20 years of fishing the capture of four urolophid species has suffered a 45-90% reduction depending on area (Graham *et al*., 2001).

One species of particular concern that has been recorded as by-catch in the ECTF is the bluegray carpetshark, *Heteroscyllium colcloughi*. This species is listed as Vulnerable on the IUCN Red List of Threatened Species and occupies a restricted range centred in Southeast Queensland, which receives high fishing effort as part of the EKP sector. Prawn trawl by-catch is considered one of the most important threatening processes acting upon this species (Pogonoski *et al*., 2002). A total of six individuals of this species have been recorded from both FI and FD sampling during the present study, including a female of 67 cm TL captured in a net fitted with a TED (the species is reported to 85 cm TL). Thus, it appears that TEDs are not effectively excluding this species from catches.

Continuing research will incorporate mortality rates to assess the survivability of various species to trawling. Further Generalised linear modeling will consider presence/absence data and actual capture rates, as well as incorporating size data into models in order to determine threshold sizes at which TEDs are effectively excluding various species. A final FI survey will be undertaken in the scallop sector of the fishery in October 2002. The results of the FI surveys will be compared with results from FD sampling. The preliminary results presented here will be expanded to provide a more detailed analysis of the elasmobranch by-catch of the East Coast Trawl Fishery.

Australia has recently released its draft National Plan of Action for the Conservation and Management of Sharks (AFFA, 2002). This plan highlights the need to reliably assess the by-catch of elasmobranchs in Australian fisheries and the need for research into by-catch reduction techniques. The current study is attempting to meets these needs in the Queensland East Coast Trawl Fishery and will provide the first information on elasmobranch by-catch in many sectors of the fishery.

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Table 1. Details of fishery-independent surveys from which data was collected for this study. Net size in gear type column refers to headrope length.

Date	Fishery sector	Latitude/ Longitude	No. trawls	Vessel length (m)	Gear type	Trawl depth (m)
Oct 2001	EKP – shallow	26º42´ - 27º59´S 153º11´ - 153º40´E	60	17.1	Triple 7 fathom nets*	19-86
May 2002	TE	13º38´ - 16º40´S 143º40´ - 145º46´E	48	18.3	Quad 4 fathom nets	17-28
June 2002	Hervey Bay	25º10´ - 25º13´S 152º38´ - 152º58´E	48	13.6	Twin 4 fathom nets	7-22
July 2002	EKP – deep	26º16´ - 27º49´S 153º33´ - 153º50´E	65	17.1	Triple 12 fathom nets*	97-166

*Although triple gear was fitted, sampling was only conducted from the port and starboard nets.

Table 2. Elasmobranch species recorded as by-catch from the East Coast Trawl Fishery during the present study and from Stobutzki *et al.* (2001) (Banana prawn sector). Fishery sectors: BP, banana prawn; EKP, eastern king prawn; HB, Hervey Bay; Sc, scallop; TE, northern tiger/Endeavour prawn.

Family	Species	Fishery Sector
Heterodontidae	*Heterodontus galeatus*	EKP
Parascylliidae	*Parascyllium collare*	EKP
Brachaeluridae	***Heteroscyllium colcloughi***	EKP
Orectolobidae	*Orectolobus maculatus*	EKP
Hemiscylliidae	*Chiloscyllium punctatum*	TE
Scyliorhinidae	*Asymbolus analis*	EKP
	Asymbolus rubiginosus	EKP
	Galeus broadmani	EKP
Triakidae	*Mustelus* sp. B#	EKP
Hemigaleidae	*Hemigaleus microstoma*	HB
Carcharhinidae	***Carcharhinus altimus***	BP
	Carcharhinus brevipinna	BP
	Carcharhinus dussumieri	BP
	Carcharhinus leucas	BP
	Carcharhinus limbatus	BP
	Carcharhinus macloti	BP
	Carcharhinus sorrah	BP
	Rhizoprionodon acutus	BP
	Rhizoprionodon taylori	BP
Sphyrnidae	*Eusphyra blochii*	BP
	Sphyrna lewini	BP
Rhinobatidae	*Aptychotrema rostrata*	EKP, HB, Sc
	Trygonnorhina sp. A#	EKP
Rhinidae	*Rhynchobatus australiae*	BP, Sc, TE
Pristidae	*Pristis zijsron*	BP
Hypnidae	*Hypnos monopterygium*	EKP
Rajidae	*Okamejei australis*	EKP
	Raja polyommata	EKP
Dasyatidae	*Dasyatis fluviorum*	BP
	Dasyatis kuhlii	EKP, HB, Sc, TE
	Dasyatis leylandi	BP, HB, Sc, TE
	Dasyatis thetidis	EKP
	Himantura sp. A#	Sc, HB
	Himantura toshi	BP, TE
	Himantura uarnak	BP, HB
	Himantura undulata	BP
Urolophidae	Trygonoptera testacea	EKP
	Urolophus sp. A#	EKP
	Urolophus sufflavus	EKP
Gymnuridae	Gymnura australis	BP, EKP, HB
Myliobatidae	*Aetomylaeus nichofii*	HB
Rhinopteridae	*Rhinoptera* spp.	BP
Chimaeridae*	*Hydrolagus lemures*	EKP

* Holocephali
# Last and Stevens (1994)

Table 3. Elasmobranch by-catch of the eastern king prawn – shallow water sector survey.

Species	Common name	Number	% Catch	Mass (kg)	% Mass
Aptychotrema rostrata	Eastern shovelnose ray	158	38.63	52.51	40.13
Trygonoptera testacea	Common stingaree	156	38.14	38.93	29.75
Urolophus sp. A[#]	Kapala stingaree	62	15.16	12.06	9.21
Dasyatis kuhlii	Blue-spotted maskray	12	2.93	7.75	5.92
Heterodontus galeatus	Crested horn shark	4	0.98	8.30	6.34
Hypnos monoterygium	Coffin ray	4	0.98	3.83	2.93
Trygonnorhina sp. A[#]	Eastern fiddler ray	3	0.73	0.75	0.57
Orectolobus maculatus	Spotted wobbegong	3	0.73	0.72	0.55
Heteroscyllium colcloughi	Bluegray carpetshark	2	0.49	4.55	3.48
Asymbolus analis	Grey spotted catshark	2	0.49	0.74	0.57
Asymblous rubiginosus	Orange spotted catshark	2	0.49	0.53	0.41
Mustelus sp. B[#]	White-spotted gummy shark	1	0.24	0.18	0.14
Total:		409		130.85	

[#] Last and Stevens (1994)

Table 4. Probabilities of capturing *Aptychotrema rostrata* and combined urolophids (*Trygonoptera testacea* and *Urolophus* sp. A) in the eastern king prawn – shallow water sector. Figures in parentheses are standard errors.

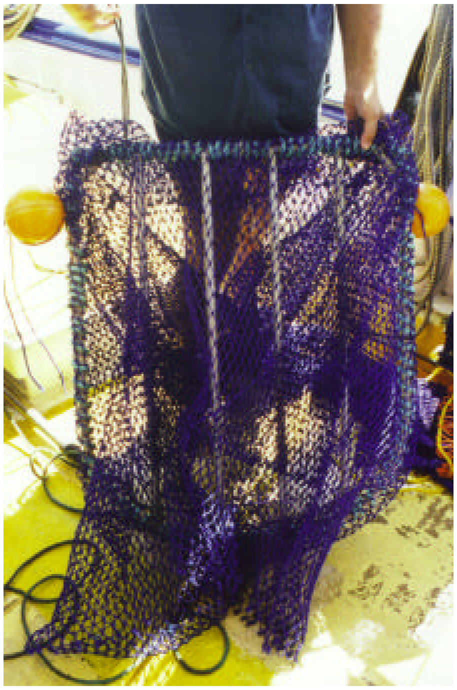
Net	Probability of capture	
	Aptychotrema rostrata	Urolophids
Standard	0.5605 (0.0796)	0.2265 (0.0401)
BRD	0.5695 (0.0915)	0.2554 (0.0509)
TED	0.6282 (0.0693)	0.2744 (0.0405)
BRD + TED	0.4744 (0.0567)	0.2456 (0.0451)

Table 5. Elasmobranch by-catch of the eastern king prawn – deep water sector survey.

Species	Common name	Number	% Catch	Mass (kg)	% Mass
Raja polyommata	Argus skate	23	35.83	4.40	21.3
Asymbolus rubiginosus	Orange spotted catshark	20	30.77	6.20	30.0
Galeus boardmani	Sawtail shark	11	16.92	2.75	13.3
Asymbolus analis	Grey spotted catshark	4	6.15	0.55	2.7
Hypnos monopterygium	Coffin ray	2	3.08	0.35	1.7
Aptychotrema rostrata	Eastern shovelnose ray	1	1.54	1.30	6.3
Dasyatis thetidis	Black stingray	1	1.54	2.50	12.1
Trygonoptera testacea	Common stingaree	1	1.54	0.30	1.5
Urolophus sufflavus	Yellowback stingaree	1	1.54	0.30	1.5
*Hydrolagus lemures**	Blackfin ghostshark	1	1.54	2.00	9.7
Total:		65		20.65	

* Holocephali

(a



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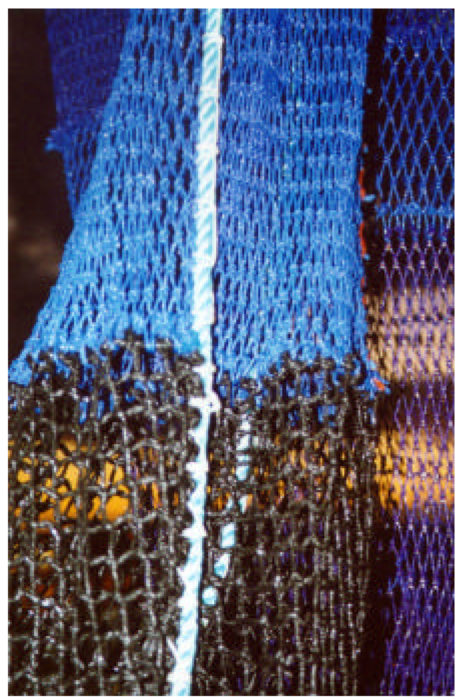

Fig. 1. Turtle excluder device (TED) and by-catch reduction devices (BRDs) used in the present study. (a) Modified Kevin Wicks type top-shooter TED; (b) Radial escape section BRD; (c) Fisheye BRD; (d) Square mesh panel BRD.

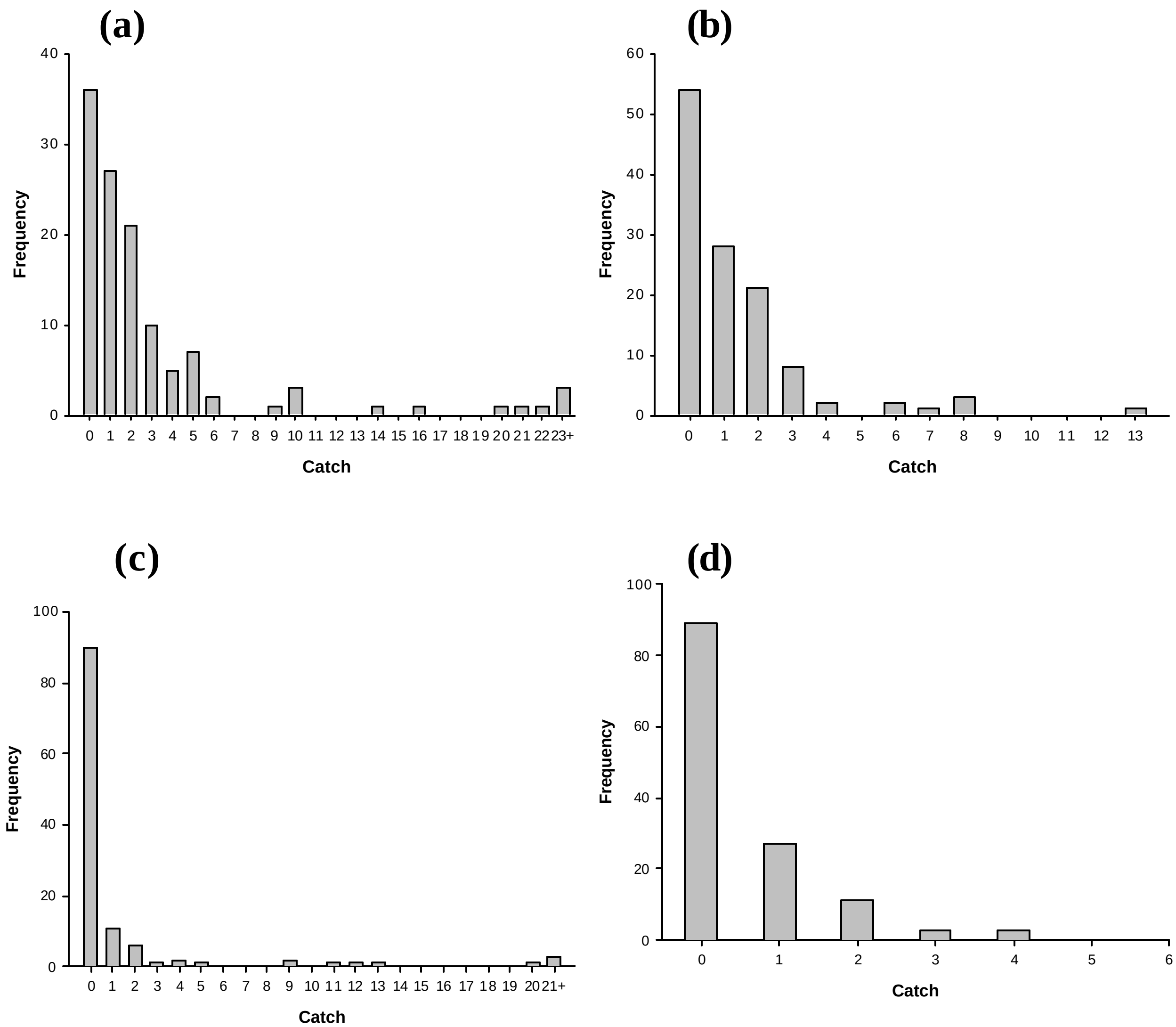

Fig. 2. Catch-frequency distributions of elasmobranchs captured in the eastern king prawn sector. (a) All species, shallow water component; (b) *Aptychotrema rostrata*, shallow water component; (c) Urolophids combined, shallow water component; (d) All species, deep water component.

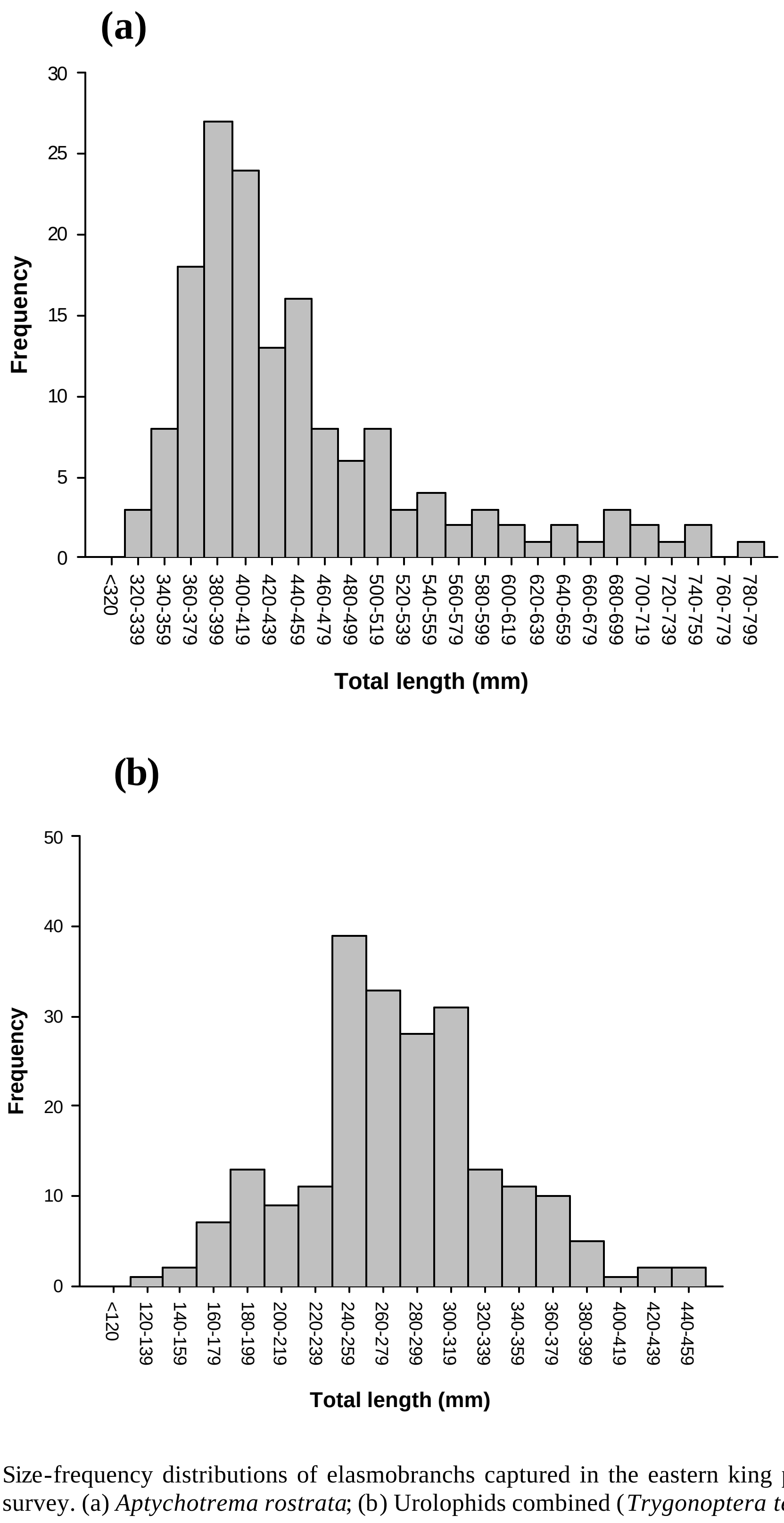

Fig. 3. Size-frequency distributions of elasmobranchs captured in the eastern king prawn – shallow water sector survey. (a) *Aptychotrema rostrata*; (b) Urolophids combined (*Trygonoptera testacea* and *Urolophus* sp. A).