J. Mar. Biol. Ass. U.K. (2001), **81**, 1015–1018
Printed in the United Kingdom

Feeding habits and dietary overlap in spiny dogfish *Squalus acanthias* (Squalidae) and narrowmouth catshark *Schroederichthys bivius* (Scyliorhinidae)

V.V. Laptikhovsky, A.I. Arkhipkin* and A.C. Henderson

Falkland Islands Government Fisheries Department, PO Box 598, Falkland Islands.
*Corresponding author, e-mail: aarkhipkin@fisheries.gov.fk

Spiny dogfish *Squalus acanthias* and narrowmouth catshark *Schroederichthys bivius* are the only two shark species commonly inhabiting the Falkland Islands shelf. The present study was undertaken to investigate their feeding habits and possible dietary overlap between the species. The diet of the spiny dogfish was dominated by Falkland herring *Sprattus fuegensis* and squid *Loligo gahi*, though it also preyed on a wide range of other fish and invertebrates. Catsharks showed a preference for invertebrates. The diet of both species showed marked variations with season, and ontogenic shifts were also evident. Dietary overlap was minimal in winter (15.4%) and maximal in spring (61.1%), the latter being due to both species preying upon spawning aggregations of *S. fuegensis*.

INTRODUCTION

Spiny dogfish *Squalus acanthias* L., 1758 (Squalidae) and narrowmouth catshark *Schroederichthys bivius* (Müller & Henle, 1841) (Scyliorhinidae) are the only two near-bottom sharks inhabiting the Falkland Islands shelf. Both species attain similar sizes and occur at depths from 50 to 250 m. The biology of neither species has been studied in Falkland Islands waters, although the spiny dogfish is known to be a piscivorous and opportunist feeder (e.g. Ellis et al., 1996; McMillan & Morse, 1999). *Schroederichthys bivius*, however, is known to feed predominantly on invertebrate species (mainly crustaceans), although fish are also preyed upon (Cortés, 1999).

Despite the overlap in their geographical and bathymetric distributions, little is known about possible feeding competition between these two shark species. The present study was undertaken to investigate seasonal and ontogenic variations in the diets of both sharks, to compare their feeding niches, and to estimate the dietary overlap in Falkland Islands shelf waters.

MATERIALS AND METHODS

Specimens of both species were collected opportunistically onboard commercial and research vessels operating in the Falkland Islands Conservation Zone, between May 1999 and February 2001. Dogfish were found at depths ranging from 95 to 231 m (mean 148 m), while catsharks occurred from 35 to 231 m (mean 141 m). During biological analysis on board ship, the total length (LT) of each shark was measured and its stomach contents were examined.

A total of 223 spiny dogfish (L_T44–98 cm, mean 64.7 cm) and 280 catsharks (L_T20–81 cm, mean 59.3 cm) were found with stomachs containing food at different stages of digestion. Undigested food (i.e. prey that had been eaten during hauling) was not quantified. Prey items were identified to the lowest possible taxonomic level, and the percentage frequency of occurrence (%O) and percentage by number (%N) of each item calculated (Cortés, 1997). Levin's measure of niche breadth (B) was calculated following Krebs (1989) and niche overlap was estimated by Pianka's symmetrical measure (Krebs, 1989).

RESULTS

Schroederichthys bivius

Catsharks <40 cm L_T fed mostly on small crustaceans and polychaetes (Table 1). Planktonic crustaceans were less important in the diets of specimens >40 cm L_T, although euphausiids were sometimes found in sharks as large as 55 cm L_T, and amphipods in those up to 65 cm L_T. Thus, there was an ontogenic transition from planktonic crustaceans to squid *Loligo gahi* and small-sized fish, especially Falkland herring *Sprattus fuegensis*. Large decapod crustaceans represented a total of 10.5% of prey in sharks of 40–59 cm L_T and 18.2% in those larger than 60 cm. Although squid predominated the diet of the largest sharks, diet breadth was greatest in this size-class. Apart from squid, fish, and large crustaceans, catsharks consumed a wide range of benthic invertebrates (Table 1).

The diet of the catshark showed marked variations with season. In winter, the most common prey was *L. gahi* and polychaetes. In spring *S. fuegensis* and lobster-krill *Munida gregaria* became very important (Table 1), whilst polychaetes remained of the same importance. In summer, *Munida* spp., crabs and *L. gahi* dominated the diet.

Squalus acanthias

Dogfish were found to feed mostly on the Falkland herring, and to a lesser extent on *L. gahi*, though the feeding spectrum included a wide range of different fish and invertebrates (Table 2). Smaller (44–65 cm) and larger (66–98 cm) sharks had similar diets and niche

Table 1. *Diet of* Schroederichthys bivius *at different sizes and in different seasons*.

	All months						May–Aug		Sep–Nov		February	
Total length (cm)	20–38		40–59		60–81		26–81		20–79		56–72	
Number of specimens	22		118		146		144		128		6	
Occurrence	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O
Algae					0.3	0.7	0.3	0.7				
Actinaria					0.6	1.4	0.6	1.4				
Mnemiopsis leydyi			0.4	0.9			0.3	0.7				
Nemertea			0.4	0.9			0.3	0.7				
Polychaeta	20.9	27.3	25.1	33.1	13.1	17.5	18.4	25.7	19.4	24.4		
Priapula					0.3	0.7	0.3	0.7				
Themisto gaudichaudi	10.5	13.6	0.4	0.9			0.6	1.4	2.4	1.6		
Amphipoda (indet.)	14.9	22.7	0.8	1.7	0.3	0.7	2.2	3.5	1.9	2.4		
Euphausiacea	31.3	22.7	12.5	3.4			12.9	4.2	2.8	2.4		
Seriolis sp.			0.4	0.9			0.3	0.7				
Isopoda (indet.)	1.5	4.5	3.6	6.8	4.2	7.6	3.9	9.0	3.6	5.5		
Thysmops birsteini			0.4	0.9	0.6	1.4	0.8	2.1				
Campylonotus vagans					1.6	1.4	0.3	0.7	1.6	0.8		
Caridea (indet.)			0.4	0.9	0.7	1.4	0.6	1.4	0.4	0.8		
Munida spp.	3.0	9.1	4.3	7.6	8.7	9.0			13.1	14.2	54.6	62.5
Euripodius latreillei			0.4	0.9	0.7	1.4			1.2	2.4		
Peltarion spinosulum	3.0	9.1	1.9	4.3	3.2	6.5	0.3	0.7	5.9	10.2	9.1	12.5
Brachyura (indet.)	3.0	9.1	1.5	2.5	1.6	3.5	1.7	3.5	1.6	3.2	9.1	12.5
Crustacea (indet.)	3.0	9.1	1.5	3.4	1.0	2.1	1.1	2.8	2.0	3.9		
Buccinudae			0.4	0.9			0.3	0.7				
Pectinidae					0.6	1.4	0.6	1.4				
Semirossia patagonica			3.6	6.8	3.2	6.2	4.7	10.4	0.4	0.8	9.1	12.5
Loligo gahi	3.0	9.1	12.2	21.2	17.4	30.8	19.6	40.3	4.3	7.9		
Moroteuthis ingens					0.6	1.4	0.6	1.4				
Illex argentinus			0.4	0.9	1.0	2.1	1.1	2.8				
Benthoctopus/ *Enteroctopus* (adults)			0.4	0.9	1.9	3.5	1.4	2.8	0.8	1.6		
Enteroctopus (hatchlings)			1.9	3.4	0.3	0.7	0.8	2.1	1.2	1.6		
Unidentified squid			1.9	4.3	2.3	2.1	2.7	4.2	0.8	1.6		
Asteroidea					0.3	0.7					9.1	12.5
Ophiuroidea			0.4	0.9	8.7	3.5	7.5	3.5			9.1	12.5
Myxine (eggs)			1.9	3.4	1.6	3.5	2.2	4.9	0.8	1.6		
Bathyraja sp.					0.6	1.4	0.6	1.4				
Sprattus fugensis	3.0	9.1	10.6	19.5	7.7	9.7	0.6	1.4	20.2	28.4		
Agonopsis chiloensis					0.3	0.7			0.4	0.8		
Zoarcidae			0.4	0.9			0.3	0.7				
Patagonotothen ramsayi			1.5	2.5	1.9	4.2	2.5	5.6	0.4	0.8		
Patagonotothen spp.			1.5	3.4	5.4	9.7	5.6	11.8	0.4	0.8		
Fish (indet.)	3.0	9.1	7.4	16.1	8.3	17.9	3.4	8.3	13.9	27.6		
Necrophagy (scavenging)			0.4	0.9	1.0	2.1	0.9	2.1	0.4	0.8		
Niche breadth	5.51		8.53		11.80		9.42		8.02		Not calculated	

breadths (Table 2), although some ontogenic changes were observed. Large spiny dogfish consumed a significant number of octopods (*Benthoctopus* spp. and *Enteroctopus megalocyathus*) and hoki (*Macruronus magellanicus*)—large prey that would be less available to the smaller sharks.

The diet of the dogfish also showed a marked seasonality. In winter, *Sprattus fugensis* represented approximately one-third of all food items, and *L. gahi* was of secondary importance. A wide range of invertebrates was also consumed, including significant quantities of the comb jelly *Mnemiopsis leydyi*. In spring, dogfish fed almost exclusively on the dense schools of *S. fugensis*, and the diet breadth narrowed markedly. *Loligo gahi* dominated the diet in summer.

Diet overlap

Diet overlap between the two species was 15.4% in winter and 61.1% in spring (values were not calculated for summer or autumn due to limited data). The spring increase in niche overlap was most probably a result of the appearance of dense spawning schools of Falkland herring which became an important food for both sharks. Quite often only heads of Falkland herring were recovered

Table 2. *Diet of* Squalus acanthias *at different sizes and in different seasons.*

	All months				May–Jun		Sep–Nov		February	
Total length (cm)	44–65		66–98		51–98		44–79		54–79	
Number of specimens	128		134		147		104		12	
Occurrence	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O
Scyphozoa			0.6	1.5			0.9	1.9		
Actiniaria	0.3	0.8			0.2	0.7				
Beroe ovata	3.0	2.4	2.0	4.5	3.8	6.1				
Mnemiopsis leydyi	21.2	5.4	21.0	9.0	32.5	12.2	0.5	1.0		
Salpa sp.			0.9	1.5	0.5	0.7	0.5	1.0		
Polychaeta	0.7	1.6			0.5	1.4				
Themisto gaudichaudi			2.4	0.7			0.5	1.0		
Amphipoda (indet.)	0.3	0.8	0.3	0.7	0.5	1.4				
Euphausiacea			0.3	0.7	0.2	0.7				
Isopoda (indet.)			0.3	0.7	2.1	0.7				
Munida spp.	0.3	0.8			0.2	0.7				
Peltarion spinosulum			0.3	0.7	0.2	0.7				
Semirossia patagonica	0.3	0.8			0.2	0.7				
Loligo gahi	10.8	19.5	5.7	12.7	7.4	18.4	2.8	5.8	75.0	75.0
Gonatus antarcticus	0.3	0.8					0.5	1.0		
Illex argentinus			0.3	0.7	0.2	0.7				
Benthoctopus/ *Enteroctopus* (adult)	0.7	1.6	4.6	10.4	3.3	8.2	1.4	2.9	5.0	8.3
Unidentified squid			0.3	0.7			0.5	1.0		
Ophiuroidea			0.9	0.7	0.7	0.7				
Sprattus fuegensis	45.1	45.3	42.2	43.3	30.6	35.4	72.8	61.5	5.0	8.3
Macruronus magellanicus	2.3	5.4	4.0	10.4	1.7	4.8	6.5	13.5		
Patagonotothen ramsayi	2.0	4.7	1.4	3.0	1.2	3.4	2.3	3.9	10.0	16.7
Stromateus brasiliensis	0.3	0.8			0.7	0.7				
Fish (indet.)	7.4	13.3	9.7	20.9	9.7	21.1	7.4	13.5	5.0	8.3
Necrophagy (scavenging)	4.6	7.8	3.0	5.2	4.0	6.1	3.7	7.7		
Niche breadth	3.71		4.15		4.56		1.84		Not calculated	

from catsharks, and this may suggest that the bulk of herring was simply scavenged after successful predation by spiny dogfish—a feeding pattern also observed in north-east Atlantic dogfish (Henderson, 2000).

DISCUSSION

The spiny dogfish of the south-west Atlantic was found to be mostly piscivorous, though a wide range of invertebrates including low-nutritive value jellyfish and comb jellies were also consumed. A similar situation was observed for the species in the north-east (Ellis et al., 1996) and north-west Atlantic (McMillan & Morse, 1999). The remnants of hoki *Macruronus magellanicus* could be partially a result of scavenging, as they were recorded in sharks caught during intensive hoki fishery, with much discarded material. Spiny dogfish diet breadth was similar to that recorded in the north-east Atlantic (Ellis et al., 1996).

The results of the present study indicated that the catshark is a euryphagous and opportunist predator, consuming a variety of invertebrates and, to a lesser extent, fish. Its niche is wider than that of the spiny dogfish and increases with size. It is quite similar to that of the north-east Atlantic scyliorhinid shark *Scyliorhinus canicula*, which displays a similar niche breadth and feeding spectrum (e.g. Ellis et al., 1996; Henderson & Dunne, 1999). Thus, both dogfish and catshark, despite being euryphagous and co-inhabiting the same part of the Falkland shelf, had distinct dietary habits and minimal overlap. Dogfish preyed on dense schools of Falkland herring and squid *Loligo gahi*, which appear in the near-bottom layers of the shelf at different seasons, and also scavenged on fishery discards. The catshark, however, fed opportunistically on different benthic invertebrates and, seasonally, on *L. gahi*, with fish and fishery discards being of secondary importance.

Generally, the food interactions between *Squalus acanthias* and *Schroederichthys bivius* in the south-west Atlantic seem to be quite similar to those between *Squalus acanthias* and catshark *Scyliorhinus canicula* in the North Atlantic. This may reflect a similar trophic structure of the shark communities on the temperate shelves in both northern and southern hemispheres.

REFERENCES

Compagno, L.J.V., 1984. *Sharks of the world. An annotated and illustrated catalogue of shark species known to date*. Part 2. *Carchariniformes*. FAO Fishery Synopsis 125, Vol. 4, Part 2, 655 pp.

Cortés, E., 1997. A critical review of methods of studying fish feeding based on analysis of stomach contents: application to the elasmobranch fishes. *Canadian Journal of Fisheries and Aquatic Sciences*, **54**, 726–738.

Cortés, E., 1999. Standardized diet composition and trophic levels of sharks. *ICES Journal of Marine Science*, **56**, 707–717.

Ellis, J.R., Pawson, M.G. & Shakley, S.E., 1996. The comparative feeding ecology of six species of shark and four species of ray (Elasmobranchii) in the north-east Atlantic. *Journal of the Marine Biological Association of the United Kingdom*, **76**, 89–106.

Henderson, A.C., 2000. *Observations on the biology of sharks taken in Irish waters, with particular reference to the blue shark* Prionace glauca *L., the spurdog* Squalus acanthias *L., and the lesser-spotted dogfish* Scyliorhinus canicula *L.* PhD thesis, National University of Ireland, Galway, Ireland.

Henderson, A.C. & Dunne, J.J., 1999. Food of the lesser-spotted dogfish *Scyliorhinus canicula* (L.) in Galway Bay. *Irish Naturalists' Journal*, **26**, 191–194.

Krebs, C.J., 1989. *Ecological methodology*. New York: Harper Collins.

McMillan, D.G. & Morse, W.W., 1999. Spiny dogfish, *Squalus acanthias*, life history and habitat characteristics. *NOAA Tecnichal Memo. NMFS-NE*, **150**, 1–19.

Submitted 2 May 2001. Accepted 19 September 2001.