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ABUNDANCE, ACTIVITY, AND TROPHIC PATTERNS OF THE REDSPOTTED CATSHARK, *SCHROEDERICHTHYS CHILENSIS*, ON THE PACIFIC TEMPERATE COAST OF CHILE.—The redspotted catshark, *Schroederichthys chilensis* (Guichenot, 1848), is a common inshore shark that occurs from Ancón (central Perú) to Chiloé (southern Chile) (Chirichigno, 1974; Compagno, 1984) at depths from 1–50 m (Mann, 1954). Despite this species being reported as one of the most abundant components of the nearshore fish assemblages in central and southern Chilean waters (Bahamonde, 1952; Miranda, 1967), little quantitative information has been gathered on basic aspects of its biology and ecology. Based on a sample of 38 individuals from southern Chile (Puerto Montt), Bahamonde (1952) reported a diet consisting primarily of sipunculans. More recently, Miranda (1980) reported a sexual aggregation of this species occurring during autumn in a central Chilean locality (San Antonio). In this paper, we document information about abundance, activity, feeding, and reproductive patterns of the redspotted catshark based on a two-year study along the central Chilean coast. Particular attention is given to food habits in order to elucidate the ecological role of this species in nearshore communities and its potential impact on important commercial benthic species currently being exploited by local artisanal fisheries.

Materials and methods.—Redspotted catsharks, *S. chilensis*, were collected at two localities on the central Chilean coast, Punta de Tralca (33°35′S; 71°42′W) and Quintay (33°11′S; 71°43′W). The substrate of the subtidal zone in both sites consists of a sloping bedrock with large rocks and boulders in its shallower portion (0–6 m depth), with an increasing proportion of sand in its deeper portion (6–18 m depth). Large plants of the brown kelp, *Lessonia trabeculata*, form an extensive bed extending from 3–4 m to about 16 m depth. The catsharks were

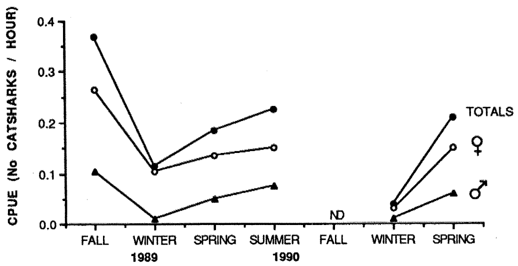

Fig. 1. Seasonal variation of the relative abundance (CPUE) of redspotted catsharks off the central Chilean coast captured during 1989–90. ND = no data.

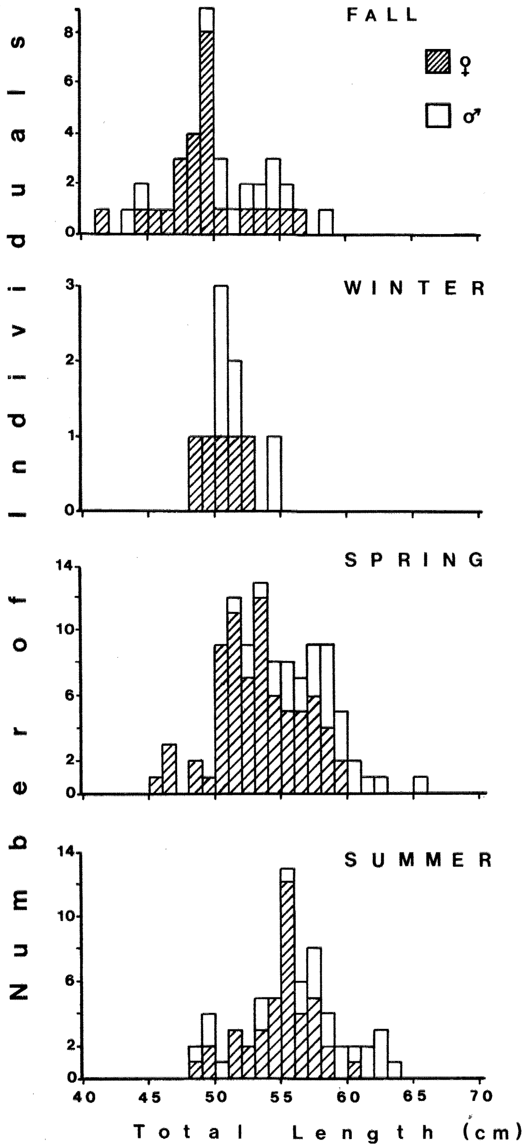

Fig. 2. Seasonal size frequency distributions of redspotted catsharks off the central Chilean coast captured during 1989–90.

seasonally sampled from May 1989 to Nov. 1990, except in fall 1990, with three 3 × 30 m experimental gillnets consisting of five panels (graded in mesh size from 10–50 mm) that were randomly set in parallel on the bottom perpendicular to the coastline at depths between 5 and 20 m. These gillnets were usually set within the first hour after sunrise and retrieved one hour before sunset. After all fish were removed, the nets were set again overnight and retrieved in the morning. All specimens captured were sexed, measured (TL) to the nearest mm, and weighed to the nearest 1.0 g. Their stomachs, intestines, and gonads were removed and fixed in a 5–10% solution of buffered formalin-seawater mixture, placed in labeled plastic bags, and transported to the laboratory for further analysis.

In the laboratory, the oviducts were internally inspected for presence or absence of encapsulated eggs. The diet was estimated from gut contents. Prey items from each stomach were identified to the finest taxonomic resolution, counted, measured and wet-weighed to the nearest g. The importance of each prey species was evaluated by calculating an index of relative importance (IRI; Pinkas et al., 1971), as follows: IRI = (n + W) FO, where n = percentage numerical composition, W = percentage gravimetric composition, and FO = percentage frequency of occurrence.

Abundance patterns of this species were determined by using a catch-per-unit-effort (CPUE) measurement. This index was calculated as the total number of specimens captured in the nets divided by the total number of sampling hours during each season.

Results.—A total of 214 specimens of *S. chilensis* ranging in size from 41–66 cm in TL was captured during this study; 157 in Punta de Tralca and 57 in Quintay. Most of these specimens were caught during the night (190 versus 24; χ^2 test for goodness of fit, $P < 0.001$) suggesting that this species is primarily crepuscular and/or nocturnal.

The abundance of this species (expressed as CPUE) showed a clear seasonal pattern (Fig. 1) with maximum values of about 0.37 individuals per hour during fall, minimum values (~0.11) during winter, and intermediate values during spring and summer. A significantly greater number of females (n = 144) than of males (n = 65) was collected throughout study ($\chi^2 = 29.9$, $P < 0.01$). Seasonal frequency distributions of body sizes showed a general increase from fall to summer (Fig. 2). This trend was mainly due to a significant increase of female size from fall to summer (One-way ANOVA; F = 17.0, $P < 0.001$). No seasonal differences in mean body size were detected among males (Fig. 2). No specimens smaller than 41 cm in TL were caught during this study (see Fig. 2).

Reproductive females (i.e., with encapsulated eggs) were observed year-round in our samples (Fig. 3). Their presence, however, was somewhat seasonal, being rare during fall of 1989 (less than 5% of total captured females), increasingly frequent from winter to spring (>45%), and reaching values of 65% during summer (Fig. 3). Most of the females had one or two eggs of about 20–30 mm in diameter.

Of the 214 catsharks captured, 13 (6.1%) had an empty stomach. The remains of about 16 prey taxa were observed in the other stomachs (Table 1). Because no significant differences in dietary composition were detected between the catsharks from Quintay and Punta de Tralca (Kendall Coefficient of Concordance, W = 0.68, $P < 0.001$; Siegel and Castellan, 1988), trophic data were pooled for analysis. Decapod crustaceans were the most important prey (IRI = 15029), being found in over 85% of the stomachs examined and representing more than 85% of the total number of prey and of total prey weight (Table 1).

Rock shrimp (*Rhynchocinetes typus*) was the most important crustacean prey (IRI = 778; Table 1). Crabs, primarily *Allopetrolisthes punctatus*, *Petrolisthes violaceus*, *Cancer edwardsi*, and *Homalaspis plana*, were also important prey items of catsharks (Table 1). Several other species of crustaceans, polychaetes, fishes, and algal material also formed part of the catshark's diet, but, in general, they were of minor importance (Table 1). No significant seasonal differences were observed in the diet of this species throughout this study (Kendall Coefficient of Concordance, W = 0.47, $P < 0.05$). Decapods (several species) represented more than 75% of total prey weight during all seasons. Other prey items such as polychaetes, fish, and gastropod mollusks were also preyed throughout the year with different intensity, most likely as a result of seasonal changes in their availability.

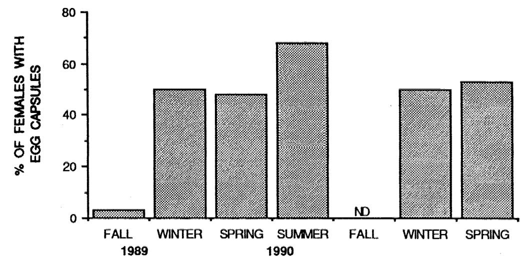

Fig. 3. Seasonal variation of the relative abundance (percentage) of ovigerous female catsharks captured off the central Chilean coast during 1989–90. ND = no data.

Discussion.—Our results suggest that the rocky sublittoral zone is utilized by redspotted catsharks for feeding and reproductive purposes. Although catsharks were present year-round, the minimum abundance observed during winter suggests an offshore migration into deeper waters probably as a consequence of the strong water movement and turbulence typical of this zone during this season.

Breeding and oviposition seem to occur throughout the year in an annual cycle. The paucity of ovigerous females during fall probably indicates that eggs were laid during summer, when massive depositions of egg-cases occurred on fronds of the subtidal brown kelp *Lessonia* (Vásquez, 1989; pers. obs.). This type of reproductive strategy has been also documented for other Scyliorhinids (Springer, 1979; Compagno, 1984; Able and Flescher, 1991), and it seems to be a common feature of bottom-dwelling sharks (Stevens and McLoughlin, 1991).

Most of the population of catsharks consisted of large-sized adult individuals (see Fig. 3). The absence of juveniles or small-sized individuals (less than 40 cm TL) documented in this study as well as by Miranda (1980) and George-Nascimento and Vergara (1982), suggests that recently hatched catsharks migrate into deeper waters. The causes of this particular migration pattern are unknown but may well represent a predator avoidance mechanism, given that the sublittoral zone is occupied by a varied suite of predatory species along this coast (Miranda, 1967; Moreno et al., 1979; pers. obs.). This phenomenon, characterized by a clear spatial segregation between juvenile and adult populations, may constitute a general pattern among Scyliorhinids (Castro et al., 1988), because it has been documented for other elasmobranchs (Garcia, 1984).

Gut content analysis and the abundance pattern of *S. chilensis* indicate that (1) this species is an important predator in the rocky subtidal zone along the central coast of Chile as previously suggested by Moreno et al. (1979); (2) this is a specialized predator on crustacean decapods; and (3) its diet is quite conservative, because no changes were detected either seasonally or spatially. Important prey items for this

TABLE 1. DIET COMPOSITION OF *Schroederichthys chilensis* EXPRESSED AS NUMBER OF INDIVIDUALS (n), PERCENTAGE OF TOTAL n (%), FREQUENCY OF OCCURRENCE (FO), PERCENTAGE OF FO (%), WEIGHT IN g (W), PERCENTAGE OF TOTAL WEIGHT (%), AND WITH THE INDEX OF RELATIVE IMPORTANCE (IRI).

Prey	n	(%)	FO	(%)	W	(%)	IRI
Mollusks							
Gastropods	3	(1.6)	3	(1.6)	7.0	(1.6)	5
Polychaetes	9	(4.8)	8	(4.2)	9.8	(2.2)	29
Crustaceans							
Decapods							
Rhynchocinetes typus	39	(20.7)	37	(19.6)	84.1	(19.0)	778
Allopetrolisthes punctatus	20	(10.6)	19	(10.1)	74.4	(16.8)	277
Cancer edwardsi	9	(4.8)	8	(4.2)	34.4	(7.8)	53
Petrolisthes violaceus	16	(8.5)	15	(7.9)	61.1	(13.8)	176
Taliepus dentatus	9	(4.8)	7	(3.7)	23.2	(5.2)	37
Homalaspis plana	7	(3.7)	7	(3.7)	38.5	(8.7)	46
Pilumnoides perlatus	3	(1.6)	3	(1.6)	4.3	(1.0)	4
Pinnixa chiloensis	2	(1.1)	2	(1.1)	0.6	(0.1)	1
Paraxanthus barbiger	3	(1.6)	3	(1.6)	5.2	(1.2)	4
Synalpheus spinifrons	1	(0.5)	1	(0.5)	0.8	(0.2)	<1
Crab remains	59	(31.4)	59	(31.2)	58.5	(13.2)	1392
Total	168	(89.3)	161	(85.2)	385.2	(87.1)	15,029
Fishes							
Remains	8	(4.3)	8	(4.2)	36.3	(8.2)	53
Algae			9	(4.8)	4.1	(0.9)	

catshark are rock shrimp and several crab species, which have been reported as common inhabitants of subtidal rocky shores dominated by large kelps (Antezana et al., 1965; Villouta and Santelices, 1984), and which are important fishery resources along the Chilean coast (Lorenzen et al., 1979; Vásquez and Castilla, 1982). The abundance of benthic invertebrates at these localities measured over the same study period (F. P. Ojeda and W. Cáceres, unpubl.), suggest that these crustacean species are preferentially consumed among a large array of potential and abundant invertebrate prey in rocky subtidal shores. The specialized diet, primarily based on crustacean decapods, is probably related to the feeding behavior of catsharks. They are mostly nocturnal predators, forming large resting aggregations in crevices and caverns during the day (pers. obs.). Crustacean prey such as crabs and rock shrimps were more active and abundant at night than during daytime, which may explain their dominance in the catshark's diet. Decapod species have been shown to contain the highest caloric contents (per gram of live mass) among a large suite of benthic invertebrates inhabiting the Chilean coast (Duarte et al., 1980; see also Ojeda and Dearborn, 1991). Accordingly, it is possible that the specialized diet observed in this catshark reflects a feeding strategy based on a maximization of energy intake.

Generally speaking, our results on the diet of the redspotted catshark in the central Chilean coast are somewhat comparable to those reported for other small-sized inshore sharks such as some dogfishes (Lyle, 1983; Compagno, 1984). Despite local variability in the composition of the associated benthic communities, Scyliorhinids seem to have developed common feeding strategies. Whether this shared consumption of crustaceans involves a maximization of caloric intake or differences in relative prey abundance is a question that needs further research.

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ESCAPE RESPONSE OF BLACK MOLLIES (*POECILIA SPHENOPS*) TO PREDATORY DIVES OF A PIED KINGFISHER (*CERYLE RUDIS*).—Fish near the water surface may be preyed upon by birds (e.g., herons, terns, gannets) which strike or plunge dive at them (Hancock and Kushlan, 1979; Lee and Reddish, 1981). Fish density, fish size range, habitat, and ambient conditions were shown to be important factors in determining prey capture success (Grubb, 1977; Migongo, 1978; Krebs and Partridge, 1973). However, direct observations of the spatial and temporal relationships between the predator and the prey during such interactions are lacking. This is in contrast with studies on predator-prey interactions among fishes or between fishes and their invertebrate prey (O'Brien, 1979; O'Brien et al., 1976). Fish-bird interactions are unique in that interactants cope with light at the air/water interface (Horvath and Varju, 1991). Fish are restricted in their ability to detect a plunge diving or a striking bird, due to light refraction, which creates "Snell's Window" underwater (Lythgoe, 1979). Birds face similar optical constraints and require a certain momentum to reach the fish at the appropriate velocity.

Prey capture success by herons and by kingfishers in the field varies yet mostly does not exceed 50% (c.f., Douthwaite, 1976; Migongo, 1978; Reyer et al., 1988). In captivity, capture