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Temporal variations in the abundance, activity, and trophic patterns of the rockfish, *Sebastes capensis*, off the central Chilean coast

Variación temporal en los patrones de abundancia, actividad y tróficos de la cabrilla, *Sebastes capensis*, de la costa de Chile central

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ABSTRACT

We studied seasonal abundance, activity, and feeding patterns of the rockfish, *Sebastes capensis* (Gmelin 1788), in two localities off the central Chilean coast. Rockfishes were seasonally sampled from May 1989 to February 1990 using experimental gillnets at depths between 5 and 20 m. The results showed that most of the nearshore population of *S. capensis* consisted of large-sized adult individuals (> 16 cm total length), which were mainly active during the night. The abundance of this species (expressed as nightime CPUE) showed a clear seasonal pattern with maximum values during winter and spring, minimum values during fall, and intermediate values during summer. A variety of decapod crustaceans, including rock shrimps and crabs, were the most common prey. The patterns described for *S. capensis* are discussed in relation to other fish species present in the area, and in terms of the recent fishing pressure exerted on this species.

Key words: *Sebastes*, seasonal abundance, activity pattern, dietary composition, rockfishes.

RESUMEN

Se estudiaron los patrones estacionales de abundancia, actividad y dieta de *Sebastes capensis* ("cabrilla") en dos localidades de la costa de Chile central. Los peces fueron capturados estacionalmente desde mayo de 1989 a febrero de 1990 usando redes agalleras experimentales a profundidades entre 5 y 20 m. Los resultados muestran que, en esta área, la mayor parte de la población costera de *S. capensis* está representada por individuos adultos (> 16 cm de longitud total), los cuales son activos preferentemente durante la noche. La abundancia de esta especie (expresada como la CPUE nocturna) muestra un claro patrón estacional con valores máximos durante invierno y primavera, valores máximos durante otoño, y valores intermedios durante el verano. Su dieta la componen una gran variedad de crustaceos decápodos, siendo los camarones y las jaibas las presas más comunes. Los patrones descritos para *S. capensis* son discutidos en relación con otras especies de peces presentes en el área, y en términos de la presión de pesca desarrollada sobre esta especie en los últimos años.

Palabras clave: *Sebastes*, abundancia estacional, patrón de actividad, composición dietaria, cabrilla

INTRODUCTION

Rockfishes of the genus *Sebastes* are a diverse group with over 100 species reported from intertidal to deep water zones (Nelson 1984, Haldorson & Love 1991). Most of these species, however, are restricted to the North Pacific coasts where they constitute an abundant component of the fish fauna of these regions.

Sebastes capensis, is the only known species of this genus in the southern hemisphere off South America and South Africa (Chen 1971). This species has been reported as a common carnivorous fish inhabiting rocky subtidal habitats along the Chilean coast (Mann 1954, Miranda 1967, Kong 1985). Despite reports as one of the most abundant components of nearshore Chilean fish assemblages (Miranda 1967, Moreno et al. 1979), little quantitative information exists on its basic biology and ecology. Along the Chilean coast, this species is also an important economic

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resource that is primarily exploited by artisanal fisheries on shallow waters. Annual commercial landings of rockfish in 1994 reached nearly 26 tons (SERNAP 1994: p. 76).

Most prior studies of this species have emphasized taxonomy (Mann 1954, Kong 1985). Miranda (1967), studying the littoral fish assemblage in a central Chilean locality (San Antonio), characterized this species as an abundant nocturnal predator. Moreno et al. (1979) reported geographical variations in its diet; in central Chile its diet was comprised of mainly crustaceans, and in the south included both fish and crustaceans. Alveal & Quintana (1985) reported copulation of *S. capensis* occurring annually from February to April in the southern port of San Vicente Bay. These authors also reported internal fertilization, with females giving birth to free swimming larvae from October to February.

In this paper we provide information on seasonal abundance, activity, and feeding patterns of *Sebastes capensis* off the central Chilean coast. Particular attention is given to its predatory habit for elucidating the ecological role of this species in nearshore communities and its potential impact on important commercial benthic species currently exploited by local artisanal fisheries.

MATERIAL AND METHODS

A total of 88 specimens of *Sebastes capensis* were collected at two localities off the central Chilean coast: Punta de Tralca (33° 35' S; 71° 42' W) and Quintay (33°11'S; 71°43'W). The subtidal substrata at both sites consist of sloping bedrock with large rocks and boulders in their shallower portion (0-6 m depth), and an increasing proportion of sand in their deeper fringe (6-18 m depth). Large plants of the brown kelp *Lessonia trabeculata,* Villouta & Santelices 1986 form extensive beds from 3-4 m to about 16 m depth (Camus & Ojeda 1992).

The rockfishes were seasonally (quarterly) sampled from May 1989 to February 1990, with three 3 x 30 m experimental gillnets consisting of five panels (graded in mesh size from 10 to 50 mm) that were randomly set parallel on the bottom, perpendicular to the coastline at depths between 5 and 20 m, over the kelp area. The nets 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 measured for total length (TL) to the nearest mm, and weighed to the nearest g. Stomachs, intestines, and gonads were removed and fixed in a 5-10% solution of buffered formalin-seawater, placed in labeled plastic bags, and transported to the laboratory for further analysis.

In the laboratory, gonads were sexed (through macroscopic analysis) and weighed to the nearest 0.1 g. The reproductive status of each fish specimen was calculated by means of the Gonadosomatic index (GSI) as GSI = [gonad weight / (total weight - gonad weight)] x 100. Size at sexual maturity was calculated by using the linear regression equation reported by Haldorson & Love (1991) for the genus *Sebastes,* as follows: LM = 1.49 + 0.54 MRL, where LM = length at maturity (cm), and MRL = maximum reported length (cm). Diet was described using 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 characterized by 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 were determined by a catch-per-unit-effort (CPUE) statistic. This index was calculated as the total number of specimens caught in the nets divided by the total number of sampling hours during each season.

Statistical differences were tested using the Kruskal-Wallis non-parametric test followed by a K-W multiple comparison test, Kendall coefficient of concordance (Siegel & Castellan 1988), and one-way analysis of variance (Zar 1974).

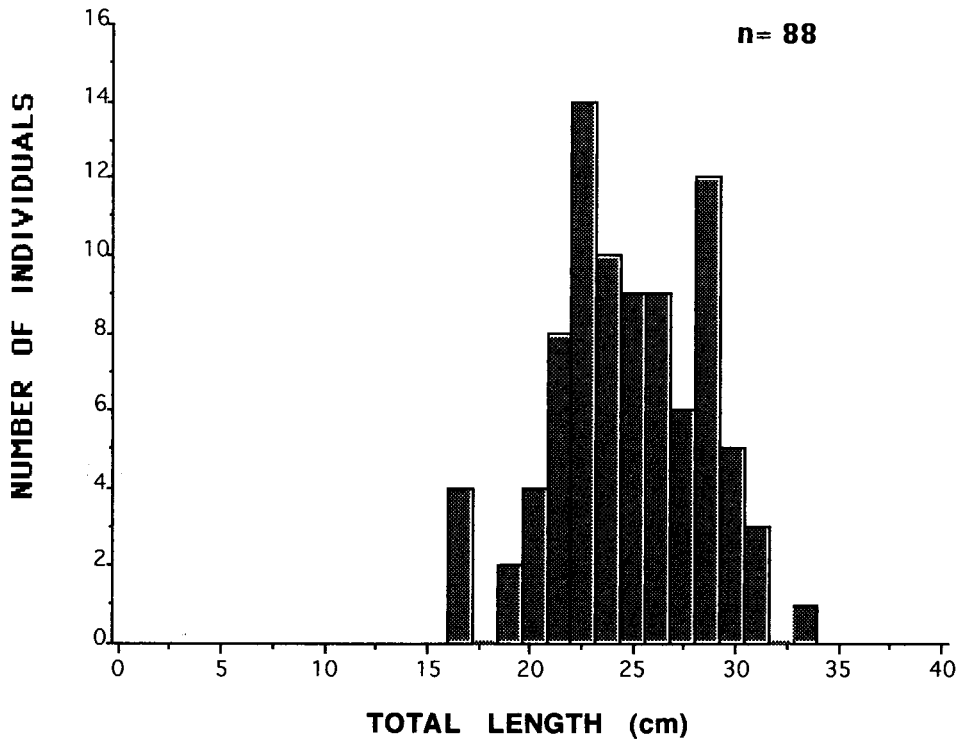

Fig. 1: Size frecuency distributions of all specimens of *Sebastes capensis* captured during 1989-1990 off the central Chilean coast.

Distribución de la frecuencia de tamaños de todos los especímenes de *S. capensis* capturados durante 1989-1990 en la costa de Chile central.

RESULTS

A total of 88 specimens of *S. capensis* (40 males, 40 females, and 8 undetermined) ranging in size from 16 to 34 cm TL was captured (Fig. 1). Mean body size was 24.7 cm, and did not differ between the two study sites (one-way ANOVA; $F = 0.84$, df= 1; $P = 0.65$). Most specimens were caught during the night (80 versus 8; χ^2 test for goodness of fit, $\chi^2 = 648.5$; df= 11; $P < 0.001$) suggesting that this species is primarily crepuscular and/or nocturnal.

The abundance of this species (expressed as nighttime CPUE) showed a clear seasonal pattern with maximum values of 0.28 and 0.30 individuals per hour during winter and spring, respectively, minimum values during fall (0.10), and intermediate values during summer (Fig. 2).

All specimens collected throughout this study had mature gonads with varying levels of gonadal development. No seasonal differences in the GSI values were observed among both females and males (Kruskal-Wallis $H = 3.8$ for females, $H= 5.2$ for males $P > 0.10$; df = 3; N= 40 for either). However, GSI values measured in females were significantly greater than those of males ($H = 37.2$; df = 1; $P < 0.01$). Size at sexual maturity for the genus, theorically calculated according to Haldorson & Love (1991), was 18 cm for females and 19 cm for males. These values agree with results obtained for the population of *Sebastes capensis* analyzed in this study (16 and 17 cm TL for females and males, respectively).

Stomach contents were examined for 88 rockfish. Of these, 31 individuals (36 %) had empty stomachs. A total of 16 prey taxa were present in stomachs of the remaining 57 individuals (Table 1). No differences in prey composition were detectable between rockfishes from Quintay and Punta de Tralca (Kendall coefficient of concordance, $W= 0.07$, df = 1; $P < 0.001$). Stomach samples were therefore pooled for analysis. A variety of decapod crustaceans was the most

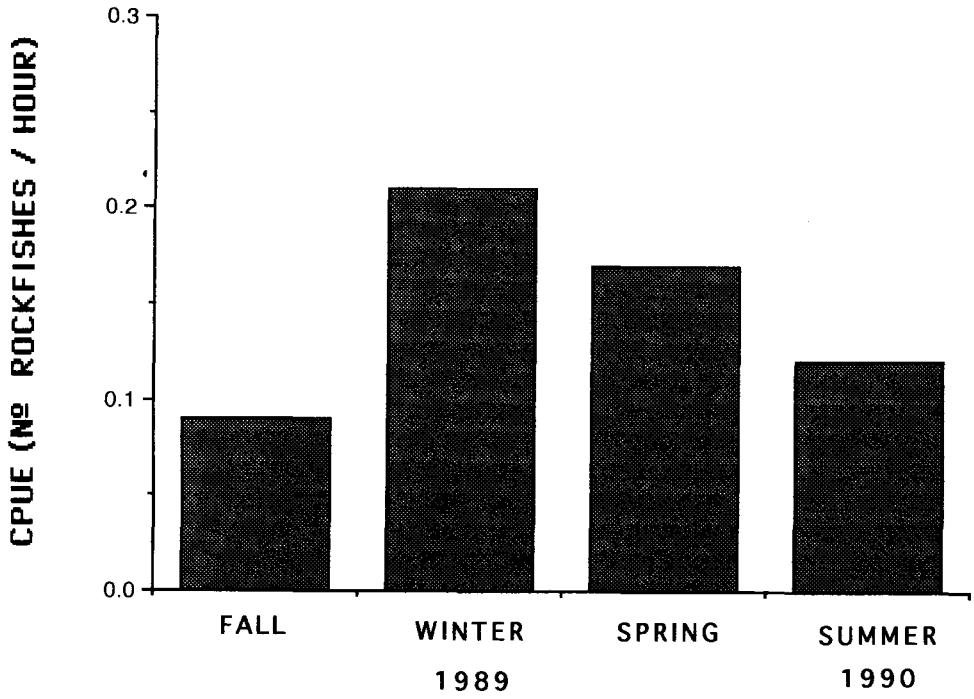

Fig. 2 : Seasonal variation in the relative abundance (CPUE) of *Sebastes capensis* off the central Chilean coast captured during 1989-1990.

Variación estacional de la abundancia relativa (CPUE) de *S. capensis* en la costa de Chile central durante 1989-1990.

important prey (IRI = 15082), occurring in > 87% of the stomachs examined and representing > 80 % of the total number and total weight of prey (Table 1). Rock shrimps (*Rhynchocinetes typus* Milne Edwards 1837) were the most heavily utilized crustaceans (IRI = 3599; Table 1). Crabs, primarily *Pilumnoides perlatus* (Poeppig 1836) and *Petrolisthes tuberculatus* (Guérin 1835) also were important prey items (Table 1). Several other species of crustaceans decapod, mollusks, sea urchins, and fishes also were present in the diet, but in general prey were of relatively minor importance (Table 1). Seasonal differences in prey composition, for the total of rockfishes captured during the study, were only detectable during fall (Kruskall-Wallis H = 10.63; df = 3; $P < 0.05$). The main dietary differences observed during fall, however, were related to the total number of prey items, which decreased from about 9 during spring, summer and winter to 4 during fall. Nonetheless, rock shrimps were the most important prey (in terms of the IRI) during all seasons.

DISCUSSION

Rockfishes represented about 9 % of the total number of fishes captured during this study (1001 specimens of 22 species), which confirms the importance of this species in the nearshore assemblages of the Chilean central coast. Mean CPUE of *S. capensis* found in this study was 0.09 individuals per hour, which is markedly lower than the figure documented by Miranda (1967) for San Antonio (33° 34' S; 71° 01' W) (0.25 individuals/ hour), a locality 20 km south of Punta de Tralca, and who also used gill nets. Although these differences might be ascribed to local geographic variability among sites, they most likely reflect long-term changes due to the intensive exploitation of this species during the last decade by local artisanal fisheries (SERNAP 1994).

Our results show that the rocky sublittoral zone is utilized by rockfishes mainly for feeding purposes. Although rockfishes were present year-round, their abundance changed on a seasonal basis characterized by a sharp decline during fall. A very similar seasonal

TABLE 1

Diet composition of *Sebastes capensis* expresed as number of individuals (n), percentaje 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).

Composición dietaria de *S. capensis* expresada como número de individuos (n), porcentaje del n total (%), frecuencia de ocurrencia (FO), porcentaje de FO (%), peso en g (W), porcentaje del peso total (%), e índice de importancia relativa (IRI)

Prey items	n	(%)	FO	(%)	W	(%)	IRI
Mollusks							
Tegula sp.	1	(1,1)	1	(1,6)	1,6	(1,2)	3,6
Nassarius sp.	1	(1,1)	1	(1,6)	0,1	(0,1)	1,9
Total	2	(2,3)	2	(3,1)	1,7	(1,3)	11,0
Echinoderms							
Tetrapygus niger	1	(1,1)	1	(1,6)	0,1	(0,1)	1,8
Crustaceans							
Decapods							
Rhynchocinetes typus	45	(50,6)	26	(40,6)	51,5	(38,0)	3.589,9
Allopetrolisthes punctatus	5	(5,6)	3	(4,7)	59	(4,4)	46,7
Pilumnoides perlatus	8	(8,9)	7	(10,9)	172	(12,7)	237,0
Synalpheus spinifrons	2	(2,3)	2	(3,1)	5,1	(3,8)	18,9
Gaudichaudia gaudichaudii	3	(3,4)	3	(4,7)	9,1	(6,7)	47,3
Petrolisthes tuberculatus	5	(5,6)	5	(7,8)	9,2	(6,8)	97,2
Petrolisthes tuberculosus	4	(4,5)	3	(4,7)	2,8	(2,1)	30,8
Petrolisthes violaceus	4	(4,5)	3	(4,7)	4,5	(3,4)	36,8
Petrolisthes desmaresti	4	(4,5)	3	(4,7)	1,9	(1,4)	27,5
Pagurus sp.	1	(1,1)	1	(1,6)	2,9	(2,2)	5,1
Total	81	(91,0)	56	(87,5)	110,1	(81,4)	15.082,2
Fishes							
Sicyases sanguineus	2	(2,3)	2	(3,1)	3,5	(2,6)	15,0
Chromis crusma	2	(2,6)	2	(3,7)	19,7	(15,7)	67,7
Blenniidae	1	(1,1)	1	(1,6)	0,3	(0,2)	2,1
Total	5	(5,6)	5	(7,8)	23,5	(17,3)	179,4

abundance pattern was observed by Miranda (1967) for this species at San Antonio, which suggests that at the end of summer and during fall there is an offshore migration into deeper waters, likely for reproductive purposes. Alveal & Quintana (1985) showed that copulation in *S. capensis* occurs from February to April (mid-summer to mid-fall in the southern hemisphere), supporting our claim that the fall migration into deeper waters is for reproductive activities.

Many rockfish species occurring in the northern hemisphere recruit to shallow waters with shallow-dwelling macrophytes such as large brown algae (Love et al. 1991). It has also been reported that, in general, rockfishes tend to recruit to shallower portion of the bathymetric range occupied by conspecific adults (Boehlert 1977, Love et al. 1991). Most of the subtidal population of *S. capensis* consists of large-sized adult individuals. Recruitment of *S. capensis* has never been reported or observed in rocky sublittoral environments off the Chilean coast (Miranda 1967, Moreno et al. 1979, personal observations). The absence of juvenile rockfishes (smaller than 16 cm TL) documented in this study suggests that recruitment most likely occurs in deep-water habitats. This contrasting pattern has also been documented in a few species of *Sebastes* whose adults (like *S. capensis*) inhabit shallow waters (Love et al. 1990, 1991). The absence of recruits and young juveniles in shallow subtidal waters seems to be the rule rather than the exception in most of the components of the littoral fish assemblages of the central Chilean coast

(Miranda 1967, Moreno et al. 1979, Fariña & Ojeda 1993, Cáceres et al. 1993, personal observations). Along this coast, intertidal rock pools represent important nursery areas for a minority of species such as *Graus nigra* Philippi 1887 and *Girella laevifrons* (Tschudi 1845) (Varas & Ojeda 1990), which suggests that most of the littoral fishes should recruit in deeper waters. The causes of this particular pattern are unknown but may represent: (1) a predator avoidance mechanism, given that the subtidal zone is occupied by a diversity of predators (Miranda 1967, Moreno et al. 1979, Fariña & Ojeda 1993); or (2) a common strategy to avoid the strong turbulence and heavy surge typical of this zone along the central Chilean coast, fully exposed to prevailing winds and waves (Santelices 1990).

Gut content analysis and the abundance pattern of *S. capensis* indicates: (1) that it might be an important predator of the rocky subtidal zone along the central Chilean coast as previously suggested by Moreno et al. (1979); and (2) that it is a bottom-dwelling predator that feeds selectively on decapod crustaceans. Important prey items for this rockfish are rock shrimp (*Rhyncocinetes typus*) and several crab species (particularly *Pilumnoides perlatus*), which have been reported as common inhabitants of subtidal rocky shores dominated by large kelps (Antezana et al. 1965, Villouta & Santelices 1984), as well as important fishery resources along the Chilean coast (Vásquez & Castilla 1982). The abundance of benthic invertebrates in these localities measured over the same study period (Cáceres & Ojeda 1991)[1], suggests that these crustacean species are preferentially consumed among a large array of potential and abundant invertebrate prey found in subtidal rocky shores. This specialized diet is likely related to the nocturnal feeding behavior of this species. Crustacean prey, such as crabs and rock shrimps, are more active and abundant at night than during daytime, which may explain their large consumption by rockfishes. Decapod species also have been shown to have 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 & Dearborn 1991). Accordingly, it is possible that the specialized diet of this rockfish reflects a feeding strategy based on the maximization of energy intake rather than prey availability as developed by other predator fishes in the area (Moreno et al. 1979).

1 Macroinvertebrados bentónicos asociados a praderas de *Lessonia trabeculata* del submareal rocoso de las zonas norte y centro de Chile. Resumen XI Jornadas de Ciencias del Mar, Viña del Mar.

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