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FOOD AND FEEDING OF BLACK SEA BASS (CENTROPRISTIS STRIATA)

by

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ABSTRACT

The stomach contents of 395 black sea bass (*Centropristis striata*) ranging in size from 160-500 mm TL have been analyzed. Fish were caught during daylight hours on June 29, 1983 along the western boundary of Nantucket Shoals, Massachusetts. The analysis of the stomach contents showed that the black sea bass fed principally on the rock crab (*Cancer irroratus*), flat-clawed hermit crab (*Pagurus pollicaris*), long-finned squid (*Loligo pealei*), and common razor clam (*Ensis directus*), along with a variety of other benthic organisms. Only small differences were seen in the dietary composition of different size fish. However, the size of major species of prey steadily increased with an increase in predator length. Similarly, the mean stomach content weight also increased for progressively larger fish. The percentage body weight of the stomach contents was highest for the small and large fish (1.92%, 16-20 cm; 1.89%, 36-40 cm, respectively) and lowest for medium size fish (1.33%, 21-25 cm; 1.17%, 26-30 cm; and 1.30%, 31-35 cm). Predator-prey relationships are discussed in detail.

INTRODUCTION

Black sea bass (Centropristis striata, Linnaeus) is a member of the family serranidae and normally occurs in coastal as well as offshore waters (to bottom water depths of 165 m) from Cape Cod, Massachusetts to Cape Kennedy, Florida (Miller, 1959; Kendall, 1977). North of Cape Hatteras, North Carolina, they migrate inshore and northward in spring, and offshore to the south during autumn (Nichols and Breder, 1926; Nesbit and Neville, 1935; Lavenda, 1949; Frame and Pearce, 1973). Springtime brings adults into coastal spawning areas and juveniles to estuarine nurseries (Grosslein and Azarovitz, 1982). Seasonal distribution of sea bass seems to be influenced by water temperature (Kendall, 1977). South of Cape Hatteras this species may be found at the same sites throughout the year (Topp, 1963; Beaumarriage, 1969; Cupka et al., 1973).

Black sea bass are principally found in the vicinity of irregular, hard bottom areas (Hildebrand and Schroeder, 1928; Bigelow and Schroeder, 1953; Cupka et al., 1973; Kendall, 1977; Musick and Mercer, 1977; Link, 1981). Adult sea bass seem to prefer the open-shelf habitat characterized by outcroppings of rock that are heavily encrusted with sessile invertebrates (Struhsaker, 1969). However, wrecks, wharf pilings, and shellfish beds have also been identified as preferred habitat (Arve, 1960; Schwartz and Porter, 1977).

A substantial recreational and commercial fishery for black sea bass has existed along the north Atlantic coast for many years. Recently, the total annual yield has dramatically declined (from 9,980 metric tons in 1952 to 1,089 metric tons in 1971). Recreational catches usually exceed

commercial catches, especially in the southern region where charter boat and shore-related fisheries have become intense (Kendall, 1977).

Quantitative studies, in terms of percentage occurrence or volume, of the food of black sea bass have been primarily conducted on fish caught south of Chesapeake Bay (Cupka et al., 1973; Kimmel, 1973; Link, 1981; Steimle and Ogren, 1982). Aside from data provided by Maurer and Bowman (1975), who examined the stomach contents of 67 fish, only brief descriptive listings of prey are available in the literature for northern fish (e.g. Nichols and Breder, 1926; Hildebrand and Schroeder, 1928; Bigelow and Schroeder, 1953; Steimle and Ogren, 1982).

In this paper we quantitatively describe the food and feeding behavior of black sea bass caught in the northern most part of their range. This work is a component of the Marine Monitoring Assessment and Prediction Program (MARMAP) of the National Oceanic and Atmospheric Administration (NOAA).

METHODS

Collection

A total of 395 black sea bass was subsampled from the catches of the commercial fishing vessel MATTHEW MELISSA. The ship fished during the daylight hours of June 29, 1983, along the western boundary of Nantucket Shoals. An otter trawl rigged with rollers was towed at bottom water depths of approximately 18 m for seven trawl hauls, each being two hours in duration. The black sea bass portion of the catch was sorted aboard ship according to length (small, medium, and large commercial market

categories) and immediately packed in ice. Within 24 hours after the vessel returned to port the black sea bass portion of the catch was subsampled according to commercial length categories, taken to the Woods Hole Laboratory of the Northeast Fisheries Center, and stored in a freezer. One week later the fish were removed from the freezer, thawed for one day, and their stomachs excised and preserved in containers (containing a 3.7% formaldehyde solution) according to 5 cm total fish length (TL) categories.

Stomach Content Analysis

The stomachs were opened and their contents emptied onto a 0.25 mm mesh opening screen sieve to allow for rinsing with fresh water to remove the formaldehyde. After transferral to a large petri dish, the contents were sorted and identified to the lowest taxon possible, counted, and individually measured. Pieces of organisms can sometimes confuse the counting process; therefore, we used selected pieces as indicators of whole organisms (e.g. crustacean heads, gastropod opercula, pelecypod hinges, or central disks for ophiuroids) as described by Terry (1976). Prey groupings which contain pieces in addition to whole organisms are summed and noted in Table 1. Often pieces of prey were found in the stomach contents without the main body of the organism. Possible reasons for this phenomenon are mentioned in the discussion. Taxonomically distinct prey groupings were damp dried on absorbent paper and immediately weighed to the nearest 0.001 g. Prey weight, number, size, and degree of digestion were recorded on a log. A stomach was considered empty when no food items could be identified and the material found in the stomach

weighed less than 0.001 g. The number, total weight (g), and percentage weight of all identified stomach content categories are listed in Table 1. The length-weight equation [$\log_{10}W = -5.0291 + 3.1155 \log_{10}L$; where weight (W) is in grams and length (L) is in millimeters] described by Briggs (1978) was used to calculate percentage body weight (% BW) of stomach contents from mean fish lengths for each fish length category given in Table 2.

RESULTS

Overall Dietary Composition

A complete listing of all stomach contents identified for black sea bass is given in Table 1. More than 90% of the stomachs examined contained food. The mean stomach content weight (including empties) was 5.570 g. Their diet was, in terms of percentage weight, almost exclusively crustaceans (59.5%) and molluscs (27.0%). Small quantities of polychaetes (1.5%), nemerteans (1.0%), echinoderms (0.5%), and fish (0.3%) were also identified as food. Decapods (59.3%) accounted for the majority of the crustacean dietary component and included in part, *Cancer irroratus* (29.1%), *Pagurus pollicaris* (14.7%), unidentified crabs (3.0%) and *Ovalipes ocellatus* (1.6%). Molluscs were represented by cephalopods (*Loligo pealei*, 13.6%, and unidentified squid, 5.6%), bivalves (*Ensis directus*, 6.5%, and *Crepidula fornicata*, 0.1%), and gastropods (1.0%). Unidentified animal remains accounted for 9.5% of the stomach contents.

Cancer irroratus was by far the dominant food in terms of number of organisms consumed (449 identified). The number of all other single prey groupings was less than 100 each and included, only for those greater than 25, Crangon septemspinosus (98), amphipods (54), Pagurus acadianus (47), Ensis directus (47), Pagurus pollicaris (40), and Loligo pealei (38). Two other stomach content groups, nematodes (75, and likely parasites) and gastropod shells (63), were both greater than 25 but were of little dietary importance.

Dietary Variation according to Fish Length

The stomachs of the smallest black sea bass sampled (16-20 cm, and only five fish) contained large quantities of decapod crabs (Cancer irroratus, 31.5%; Panopeus sayi, 30.3%; and unidentified decapods, 6.5%, most of which were likely crabs) and polchaetes (6.2%) (Table 2). The only other stomach content group which exceeded 5% for the small sea bass was animal remains (20.6%). Fish 21-35 cm TL (three combined 5 cm length categories, and comprised of 356 fish in total) consumed large amounts (greater than 5%) of Cancer irroratus (25-36%), Pagurus pollicaris (9-21%), squid (11-23%, and mostly identified as Loligo pealei), Ensis directus (1-13%), unidentified crabs and shrimp (6-15%), and animal remains (8-12%). The major stomach content groups identified for the largest black sea bass (greater than 35 cm; and comprised of two length categories including a total of 34 fish) were Cancer irroratus (14-29%), squid (mostly Loligo pealei, 28.7%, for the 36-40 cm fish), Pagurus pollicaris (16-23%), Ovalipes ocellatus (4-13%), Ensis directus (2-14%), gastropods (13.6% for the >40 cm fish) and animal remains

(7-20%). Overall, Cancer irroratus, Pagurus pollicaris, Loligo pealei, and Ensis directus stand out as the most important prey of black sea bass. However, the diet of small fish tended to have the greatest percentage of Panopeus sayi and polychaetes. The stomachs of medium size fish contained no unique major prey; and the largest fish took only one unique major prey, namely Ovalipes occellatus.

The mean stomach content weight steadily increased from the 16-20 cm length category to the 36-40 cm TL category (range from 2.656 to 19.292 g as seen at bottom of Table 2). However, fish greater than 40 cm TL only had a mean stomach content weight of 5.957 g. Conversion of mean stomach content weight into % BW revealed the small and large (except for fish >40 cm) fish had the greatest % BW's (1.9%); and the medium size fish the least (e.g. 1.3%, 21-25 cm; 1.2%, 26-30 cm; 1.3%, 31-35 cm) Possible reasons for the above described trend in % BW's will be discussed later (see Discussion).

Predator Length versus Prey Size

The sizes of the four major prey species identified for black sea bass (Cancer irroratus, Pagurus pollicaris, Loligo pealei, and Ensis directus) were directly related to predator length (see Figures 1-4). Table 3 lists for each predator length category the species and number of individual prey measured, mean size (length or width) of prey, and size range of prey. Cancer irroratus (range 0.3-6.7 cm, carapace width) was eaten in the largest numbers and its mean size steadily increased from 1.4 cm in the small fish to 2.9 cm in the large fish (Figure 1). Pagurus pollicaris identified in the stomach contents ranged from 0.6 cm to 4.6 cm (carapace length), and its mean carapace length tended to vary between predator length categories. However, the

general trend was for the carapace length of Pagurus pollicaris to increase in size with an increase in predator length (see Figure 2). Loligo pealei ranged from 0.8 cm to 12.2 cm mantle length, and the average mantle length continually increased from 3.5 cm (for the 21-25 cm fish) to 8.9 cm (for the 36-40 cm fish) (Figure 3). The average shell length of Ensis directus (range 2.6-5.8 cm) was 3.4 cm for the small bass; 4.0 cm for 26-30 cm fish; 4.4 cm for 31-35 cm fish; 3.9 cm, and a decrease for the 36-40 cm black sea bass; and finally, 5.1 cm for fish ranging 41-45 cm (Figure 4). As with the other species, the size of E. directus consumed generally increased as predator size increased. The size of other prey organisms such as Xanthidae (Figure 5), Pagurus acadianus (Figure 6), and Pagurus longicarpus (Figure 7) ranged less than 2 cm, and the average carapace width or length only differed slightly between different fish length categories (see Discussion for an explanation of why this occurred).

DISCUSSION

Fish food studies provide some indication of the biotic environment inhabited by a species (Hickey, 1975). In addition, the morphological and behavioral adaptations of a particular predator, and its prey, are better understood when predator-prey interactions are described. We found black sea bass feeding principally on various species of crabs (e.g. Cancer irroratus and Pagurus spp.), bivalves (mostly Ensis directus), squid (Loligo pealei), and polychaetes. Items of less dietary importance included, in part,

nemerteans, echinoderms (Amphipholis abditus) and fish (Ammodytes sp. and Syngnathus sp.). Our results are consistent with data provided by Maurer and Bowman (1975), who conducted one of the few quantitative food studies of black sea bass north of Chesapeake Bay. Although their information is limited (e.g. only 67 fish, 19 of which were empty, and examined during the 1969-1972 period), Maurer and Bowman documented that the black sea bass diet includes polychaetes, Cancer sp., Pagurus sp., and small quantities of molluscs and fish (listed in decreasing order of importance according to percentage weight). In another study of limited value Steimle and Ogren (1982) examined 7 fish (4 of which were empty) caught off Monmouth Beach, New Jersey on an artifical reef. They noted squid and Cancer spp. as food of sea bass. Brief descriptive listings of the prey of black sea bass (from northern areas) may also be seen in Nichols and Breder (1926), Hildebrand and Schroeder (1928), and Bigelow and Schroeder (1953).

South of Cape Hatteras, studies by Kimmel (1973), Cupka et al. (1973), and Link (1981) identify crustaceans, molluscs, and fish, based on frequency of occurrence, as the primary food of sea bass. Steimle and Ogren (1982) conducted a volumetric analysis of the stomach contents of black sea bass caught in coastal waters off Charleston, South Carolina, and determined that amphipods, portunids, Solen sp., and fish were the principal prey. Overall, the results seen in the studies noted above are in general agreement. Black sea bass is an opportunistic carnivore which feeds on a variety of organisms such as crabs, bivalves, squid, polychaetes, fish, and an assortment of other prey.

During our study we found numerous body parts from various species in the stomach contents. For instance, the stomachs of fish within the 21-25 cm TL category contained a total of 37 polychaete heads (each including some attached anterior body segments). The heads were in excellent condition, and it didn't appear to us that the bodies had been digested away as suggested by Lipovsky (1976), who noted during a discussion that polychaetes may fall apart fairly rapidly due to the combined affects of digestive fluids and the formaldehyde used as a preservative. We found all polychaete heads to appear in fresh condition, and they uniformly measured approximately 1 cm in length. We believe that black sea bass bite off the head section of sedentary polychaetes, the only section which normally emerges from the opening of the tube or burrow (Barnes, 1974).

Morphological limitations such as mouth size seem to limit the size of prey (whole) utilized as food by black sea bass. However, if bass bite off exposed body parts (e.g. chela, legs and abdomen of crabs, or foot and opercula of gastropods) which they can swallow, it would explain why these body parts are found in their stomachs and describe another method by which they fulfill their dietary requirements.

We noted large chela of Ovalipes occellatus and egg laden abdomens of unidentified crabs without any trace of main body parts in the stomachs. Ovalipes occellatus is aggressive when cornered and usually assumes a defensive posture with chelae outstretched (Wheeler, 1980; Bowman, personal observation). Although black sea bass may sometimes regret attacking such a fiesty prey, it appears they must grasp and rip (or shake) the outstretched

chelae until it detaches from the crab. The presence of crab abdomens in the stomach contents may result from black sea bass turning over egg laden females and then biting off the distended abdomen.

Black sea bass have small, cardiform teeth not suitable for crushing thick gastropod shells (Link, 1981). Randall (1967) reported opercula and other shell-less gastropod remains in the stomachs of groupers, and suggested other predators crack open the gastropods - which are ultimately consumed by groupers. However, Link (loc. cit.) believes (and we tend to agree with him) that fish may dislodge gastropods from the substrate, and then rip off the foot when the animal attempts to right itself. Another possibility might be the dislodging of these and possibly other organisms (e.g. bivalves or crabs) by trawls or dredges, which may result in a similar feeding behavior. In addition, the majority of the large (>0.5 cm carapace length) hermit crabs we identified as prey (*Pagurus pollicaris*, *P. acadianus*, and *P. longicarpus*) were devoid of the gastropod shells they normally utilize for shelter (and from which their common name was derived). The phenomenon described above may also explain, at least in part, why they lacked shells. However, small whole gastropod shells (most less than 0.5 cm) were found in the stomachs and often contained the remains of hermit crabs (63 were identified).

To our knowledge the relationship between black sea bass length (in essence, mouth size) and prey size has not been previously documented. We observed the sizes of *C. irroratus*, *P. pollicaris*, *L. pealei*, and *E. directus* consumed to be dependent on predator length. Bowman and Michaels (1982) studied the food habits of 17 northwest Atlantic species of fish and reported that large prey organisms were selected as food more often by the largest

predators sampled. It is an energetic advantage for large predators to select and eat the largest prey possible (Yasuda, 1960b). However, in many instances the maximum size (or average size) of some organisms taken as prey is often smaller than the maximum size a predator may swallow. Our results indicate that hermit crabs (e.g. P. acadianus, P. longicarpus and P. pollicaris), and members of other taxonomic groups, such as the Xanthidae, are probably potential prey throughout much of their lives, since the average (or maximum) size of these organisms is fairly small (in most instances close to the sizes we found in the stomachs; and a maximum of about 5 cm). Other species of prey are utilized as food principally when they are juveniles (e.g. C. irroratus, L. pealei, and E. directus). The largest C. irroratus identified was 6.7 cm (carapace width); L. pealei didn't exceed 12.2 cm (mantle length); and the maximum size of E. directus was 5.8 cm (shell length).

Black sea bass weighing less than 138 g (20 cm TL) or between 789 g and 1196 g (35-40 cm TL) had proprotionately more food in their stomachs, in terms % BW, than fish weighing between 138 g and 789 g (20-35 cm TL). Fish greater than 1196 g (40 cm TL), and whose average % BW was only 0.4, didn't conform to the trend of large fish having proportionately more food in their stomachs, possibly because of sample variation. Nevertheless, the same overall trend has been noted for other species by Edwards and Bowman (1979), Bowman (1980b), and Bowman and Michaels (1982). Edwards and Bowman (loc. cit.) suggest that smaller fish, which need proportionately more food to accommodate rapid growth, likely feed many times daily; thus accounting for their greater average % BW. Medium size fish feed only

once each day, thereby resulting in smaller % BW values since digestion reduces the quantity of food in their stomachs between feedings. Large fish, which feed less than once per day, select larger prey items which take more than 24 hours to digest - and therefore their stomachs tend to always contain large quantities of food. Furthermore, Bowman (loc. cit.) documented that the stomach weight (size) of small and large fish is proportionately more than it is for medium size fish. Thus, small and large fish can consume larger quantities (proportionately) of food at one feeding than medium size fish.

The morphology of a predator usually provides some indication of its feeding strategy and ultimately the prey types consumed (Aleev, 1969). Black sea bass have a large oblique mouth with numerous pointed teeth arranged in bands on the jaws, vomer, and palatine (Hildebrand and Schroeder, 1928). The feeding habits of carnivorous fish are primarily determined by mouth structure (Yasuda, 1960). Yasuda found the width of mouth gape determines the ability of fish to trap prey, and jaw length to limit prey size.

The body of black sea bass is elongate to robust and slightly dorsoventrally compressed. The back is elevated and the head is thick. Its dorsal fin is continuous with a soft portion above the spines; the pectoral fins are long and soft, and extend beyond the tips of the ventrals (Hildebrand and Schroeder, 1928). Their monolobed caudal fin is characteristic of fish not adapted for prolonged, swift movement (Aleev, 1969). Basically, the fin structure and body shape of black sea bass favor maneuverability over speed; they are well adapted for searching over discontinuous substrate to locate prey.

Although sea bass are opportunistic feeders, their food is determined by their feeding strategy and prey availability, behavior, and abundance (Chess, 1978; Link, 1981). Feeding strategies of predatory fish are reviewed by MacArthur and Levins (1964) and Schoener (1969). Black sea bass most resemble a "searcher" as described by Schoener. They likely utilize most of their time and energy searching for prey and not in pursuit of it. In addition, black sea bass can be classified as "generalists" because of the variety of prey they consume. MacArthur and Pianka (1966) note that generalized diets are usually common in fish described as "searchers." The behavior of the prey of black sea bass provides additional evidence to support their being "generalist-searchers." C. irroratus commonly buries itself in sandy substrate or flees (possibly making them more vulnerable as prey) when provoked (Jeffries, 1966). L. pealei are usually found near (or on) bottom during daylight hours but not at night (Bowman, 1980a). This fast swimming pelagic squid is apparently available as food only between 06:00 and 18:00, unless black sea bass pursue them off bottom at night, which is doubtful. P. pollicaris, a slow moving hermit crab, is found on many types of substrate and utilizes empty gastropod shells for protection (Williams, 1965). E. directus, the common razor clam, feeds while lying on the surface of the sea bottom, but it can rapidly retreat into the sand when alarmed (by contracting muscles in its foot). Razor clams can also "swim" by expelling water from the base of their foot (Purchon, 1968). Other organisms preyed upon by black sea bass (e.g. gastropods, shrimp, amphipods, polychaetes) utilize coloration (camouflage), tubes, shells, or mobility to escape predation. The diverse array of adaptations used for defense by the prey of black sea bass provide some

indication that this predator does not travel long distances in pursuit of prey, but rather, carefully searches a restricted territory. Topp (1963) provides documentation of this in that sea bass establish and guard "homesteads" seasonally, at least for southern bass.

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Table 1. Listing of the stomach contents of black sea bass, *Centropristis striata*, collected on the western boundary of Nantucket Shoals during June 1983.

Stomach Contents	Weight (g)			Number of Organisms			Percentage Weight		
PORIFERA	0.244			1			<0.1		
COELENTERATA	6.100			---			0.3		
Anthozoa unidentified		6.100			---			0.3	
NEMERTEA	21.684			---			1.0		
NEMATODA	0.016			75			<0.1		
POLYCHAETA	33.119			---			1.5		
CRUSTACEA	1308.613			840			59.5		
Amphipoda		0.496			54			<0.1	
Gammaridea			0.494			51			<0.1
Hyperiidea			0.002			3			<0.1
Decapoda		1304.000			781			59.3	
Callianassa atlantica			3.135			---			<0.1
Cancer irroratus			640.597			449			29.1
Crangon septemspinosus			1.325*			93			<0.1
Hyas araneus			0.611			8			<0.1
Libinia dubia			5.971			12			0.3
Libinia emarginata			15.966			6			0.7
Libinia sp.			9.404*			7			0.4
Majidae unidentified			3.464			---			0.2
Pagurus acadianus			14.779*			47			0.7
Pagurus longicarpus			8.627*			23			0.4
Pagurus pollicaris			323.152*			40			14.7
Pagurus sp.			16.596			---			0.8
Heterocrypta granulata			1.766			2			0.1
Pinnixa chaetopterana			0.167			3			<0.1
Ovalipes ocellatus			36.154*			5			1.6
Hexapanopeus angustifrons			11.865			12			0.5
Panopeus herbstii			10.082			23			0.5
Panopeus sayi			12.139*			14			0.6
Xanthidae unidentified			4.458*			13			0.2
Decapod larvae			0.027			22			<0.1
Crab unidentified			65.367			---			3.0
Shrimp unidentified			0.484*			2			<0.1
Unidentified Decapoda			117.864			---			5.4
Isopoda		0.105			4			<0.1	
Idotea phosphorea			0.058			4			<0.1
Unidentified Isopoda			0.047			---			<0.1
Cirripedia		0.004			1			<0.1	
Balanus sp.			0.004			1			<0.1
Crustacea eggs		4.008			---			0.2	
MOLLUSCA	593.255			98			27.0		
Pelecypoda		145.049			53			6.6	
Ensis directus			143.564*			47			6.5
Crepidula fornicata			1.485			6			0.1
Gastropoda		22.075			7			1.0	
Gastropoda operculum			0.978			2			<0.1
Unidentified Gastropoda			21.097			5			1.0
Cephalopoda		421.953			38			19.2	
Loligo pealei			298.912			38			13.6
Unidentified Cephalopoda			123.041			---			5.6
Gastropod shells		4.178			63			0.2	
ECHINODERMATA	9.383			6			0.5		
Ophiuroidea		6.113			4			0.3	
Amphipholis abditus			6.113*			4			0.3
Holothuroidea unidentified		3.270			2			0.2	
ASCIDIACEA	3.671			2			0.2		
PISCES	6.219			8			0.3		
Syngnathus sp.			1.647			2			0.1
Ammodytes americanus			3.107			3			0.1
Fish bones			0.115			---			<0.1
Fish eggs			-----			3			<0.1
Fish scales			0.564			---			<0.1
Unidentified fish			0.786			---			<0.1
ANIMAL REMAINS	213.133			---			9.5		
PLANT REMAINS	1.695			---			0.1		
SAND	2.140			---			0.1		
ROCK	0.736			---			<0.1		
TOTAL	2200.008			1030			100.0		

Number of stomachs examined	395
Number of empty stomachs	38
Mean stomach content weight (g)	5.570
Mean fish length (cm)	28

*Weight includes pieces in addition to whole organisms.

Table 2. Stomach contents, expressed as a percentage of the total stomach contents weight, of black sea bass, *Centropristis striata*, collected on the western boundary of Nantucket Shoals during June 1983.

Stomach Contents	Length Category (cm)					
	16-20		21-25		26-30	
PORIFERA			<0.1			
COELENTERATA			1.1			
Anthozoa unidentified				1.1		
NEMERTEA			0.9		0.3	
NEMATODA	<0.1		<0.1		<0.1	
POLYCHAETA	6.2		3.8		1.0	
CRUSTACEA	72.8		55.3		58.2	
Amphipoda				0.1		<0.1
Gammaridea				0.1		<0.1
Hyperiidea				<0.1		
Decapoda		72.8		55.2		58.2
Callianassa atlantica				<0.1		0.1
Cancer irroratus		31.5		26.8		25.4
Crangon septemspinosus				0.2		<0.1
Hyas araneus				0.1		
Libinia dubia				0.6		0.3
Libinia emarginata				2.8		
Libinia sp.				0.2		0.4
Majidae unidentified				0.1		0.5
Pagurus acadianus		0.2		1.1		1.3
Pagurus longicarpus		0.6		0.8		0.4
Pagurus pollicaris		0.2		9.1		11.2
Pagurus sp.		2.8		1.0		1.7
Heterocrypta granulata				0.3		
Pinnixa chaetopterana				<0.1		<0.1
Ovalipes ocellatus						0.8
Hexapanopeus angustifrons				0.5		0.3
Panopeus herbstii				1.8		
Panopeus sayi		30.2		0.4		0.5
Xanthidae unidentified				0.6		0.2
Decapod larvae				<0.1		<0.1
Crab unidentified		0.8		3.2		7.1
Shrimp unidentified				0.1		<0.1
Unidentified Decapoda		6.5		5.5		8.0
Isopoda		<0.1		<0.1		
Idotea phosphorea		<0.1		<0.1		
Unidentified Isopoda				<0.1		
Cirripedia						
Balanus sp.				<0.1		
Crustacea eggs				<0.1		
MOLLUSCA	0.2		24.8		31.3	
Pelecypoda		0.2		1.7		12.7
Ensis directus		0.2		1.5		12.6
Crepidula fornicata				0.2		0.1
Gastropoda		<0.1				0.9
Gastropoda operculum						
Unidentified Gastropoda		<0.1				0.9
Cephalopoda				22.6		17.7
Loligo pealei				18.2		6.4
Unidentified Cephalopoda				4.4		11.3
Gastropod shells				0.5		<0.1
ECHINODERMATA			0.5		1.1	
Ophiuroidea				0.1		1.1
Amphipholis abditus				0.1		
Holothuroidea unidentified				0.4		
ASCIDIACEA			0.6			
PISCES	0.2		0.5		0.2	
Syngnathus sp.						0.2
Ammodytes americanus				0.5		
Fish bones				<0.1		
Fish eggs						
Fish scales		0.2		<0.1		<0.1
Unidentified fish						
ANIMAL REMAINS	20.6		11.9		7.6	
PLANT REMAINS			0.2		0.1	
SAND			0.4			
ROCK					0.2	
Number of stomachs examined	5		178		103	
Number of empty stomachs	0		27		9	
Mean stomach content weight (g)	2.656		3.234		4.615	
Mean fish length (cm)	20		24		28	
Mean fish body weight (g)	137.96		243.47		393.57	
% BW of stomach contents	1.92		1.33		1.17	

Table 2. (Continued)

Stomach Contents	Length Category (cm)								
	31-35			36-40			>40		
PORIFERA									
COELENTERATA									
Anthozoa unidentified									
NEMERTEA	1.4			1.3					
NEMATODA	<0.1			<0.1			<0.1		
POLYCHAETA	0.5			0.6					
CRUSTACEA	66.8			56.3			51.4		
Amphipoda		<0.1							
Gammaridea			<0.1						
Hyperiidea									
Decapoda		66.2			56.3			51.4	
Callianassa atlantica			0.4						
Cancer irroratus			35.5			29.2			13.5
Crangon septemspinosus									
Hyas araneus									
Libinia dubia			0.2						
Libinia emarginata									
Libinia sp.			0.7			0.5			
Majidae unidentified						0.2			
Pagurus acadianus			0.2			0.1			
Pagurus longicarpus			0.2			0.3			
Pagurus pollicaris			20.7			16.1			23.1
Pagurus sp.			0.3						
Heterocrypta granulata									
Pinnixa chaetopterana			<0.1						
Ovalipes ocellatus			0.9			4.2			12.5
Hexapanopeus angustifrons			0.3			1.2			
Panopeus herbstii									
Panopeus sayi			0.4			0.2			
Xanthidae unidentified									
Decapod larvae									
Crab unidentified			1.5			0.7			1.2
Shrimp unidentified						<0.1			
Unidentified Decapoda			4.9			3.6			1.1
Isopoda					<0.1				
Idotea phosphorea						<0.1			
Unidentified Isopoda									
Cirripedia									
Balanus sp.									
Crustacea eggs		0.6							
MOLLUSCA	21.7			34.2			27.2		
Pelecypoda		9.1			1.8			13.6	
Ensis directus			9.1			1.8			13.6
Crepidula fornicata			<0.1						
Gastropoda		1.3						13.6	
Gastropoda operculum			0.1						0.4
Unidentified Gastropoda			1.2						13.2
Cephalopoda		11.1			32.4				
Loligo pealei			6.6			28.7			
Unidentified Cephalopoda			4.5			3.7			
Gastropod shells		0.2							
ECHINODERMATA	0.2								
Ophiuroidea		<0.1							
Amphipholis abditus			<0.1						
Holothuroidea unidentified		0.2							
ASCIDIACEA									
PISCES	<0.1			0.2			1.2		
Syngnathus sp.						0.2			
Ammodytes americanus									
Fish bones									
Fish eggs									<0.1
Fish scales			<0.1			<0.1			0.1
Unidentified fish									1.1
ANIMAL REMAINS	9.4			7.3			20.2		
PLANT REMAINS	<0.1			0.1					
SAND									
ROCK									
Number of stomachs examined	75			22			12		
Number of empty stomachs	1			0			1		
Mean stomach content weight (g)	8.530			19.296			5.957		
Mean fish length (cm)	33			38			44		
Mean fish body weight (g)	656.64			1019.10			1609.08		
% BW of stomach contents	1.30			1.89			0.37		

Table 3. Number, size, and size range of prey of black sea bass, according to predator length.

Prey	Predator Length (TL, cm)					
	16-20	21-25	26-30	31-35	36-40	>40
Cancer irroratus						
Number	8	198	84	116	34	9
$\bar{x}$ carapace width (cm)	1.4	1.7	2.1	2.3	2.8	2.9
Size range (cm)	0.7-1.8	0.3-3.4	0.9-3.2	1.0-3.6	1.2-6.7	2.6-4.3
Pagurus pollicaris						
Number	1	10	5	12	7	4
$\bar{x}$ carapace length (cm)	0.6	1.9	2.5	2.4	2.7	1.9
Size range (cm)	0.6	0.6-3.3	1.9-3.2	1.9-2.7	1.6-4.6	1.2-3.6
Loligo pealei						
Number	-	24	7	2	5	-
$\bar{x}$ mantle length (cm)	-	3.5	4.3	6.4	8.9	-
Size range (cm)	-	0.8-5.2	3.7-5.8	5.2-7.6	4.8-12.2	-
Ensis directus						
Number	-	6	14	11	5	10
$\bar{x}$ shell length (cm)	-	3.4	4.0	4.4	3.9	5.1
Size range (cm)	-	3.2-3.6	3.4-5.6	3.2-5.4	2.6-4.9	4.6-5.8
Xanthidae						
Number	4	40	9	5	4	-
$\bar{x}$ carapace width (cm)	1.4	1.2	1.2	1.3	1.9	-
Size range (cm)	1.2-1.8	0.8-1.6	0.6-1.7	0.6-2.0	1.4-2.3	-
Pagurus acadianus						
Number	1	24	15	4	3	-
$\bar{x}$ carapace length (cm)	0.7	0.8	0.8	1.2	0.6	-
Size range (cm)	0.7	0.3-1.3	0.4-1.4	0.8-1.4	0.5-0.7	-
Pagurus longicarpus						
Number	1	14	4	2	2	-
$\bar{x}$ carapace length (cm)	0.7	1.0	0.8	1.0	1.0	-
Size range (cm)	0.7	0.6-1.3	0.4-1.2	0.9-1.1	0.6-1.4	-

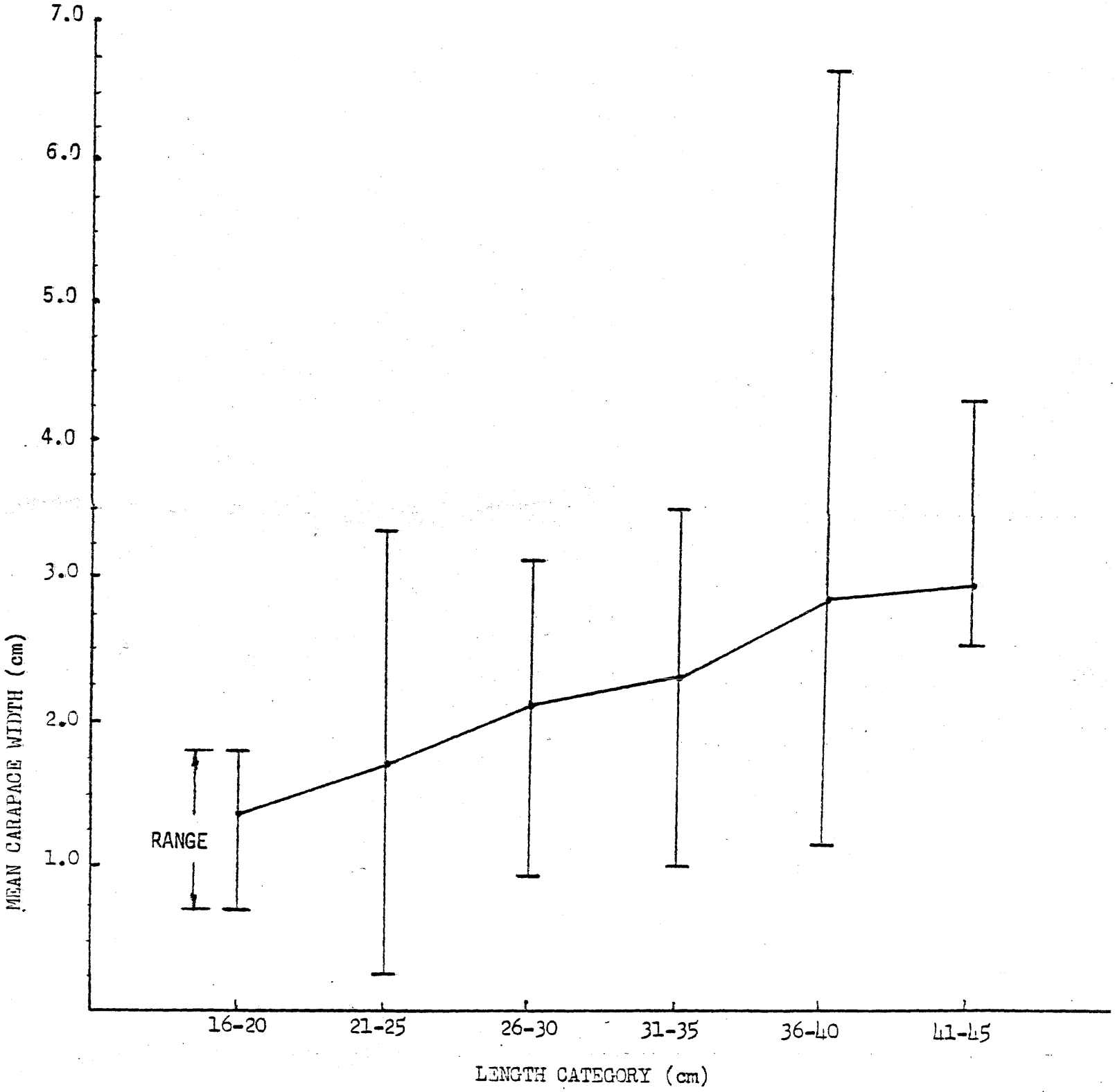

Figure 1. Plot of mean carapace width of the prey, *Cancer irroratus*, and the length of the predator *Centropristis striata*.

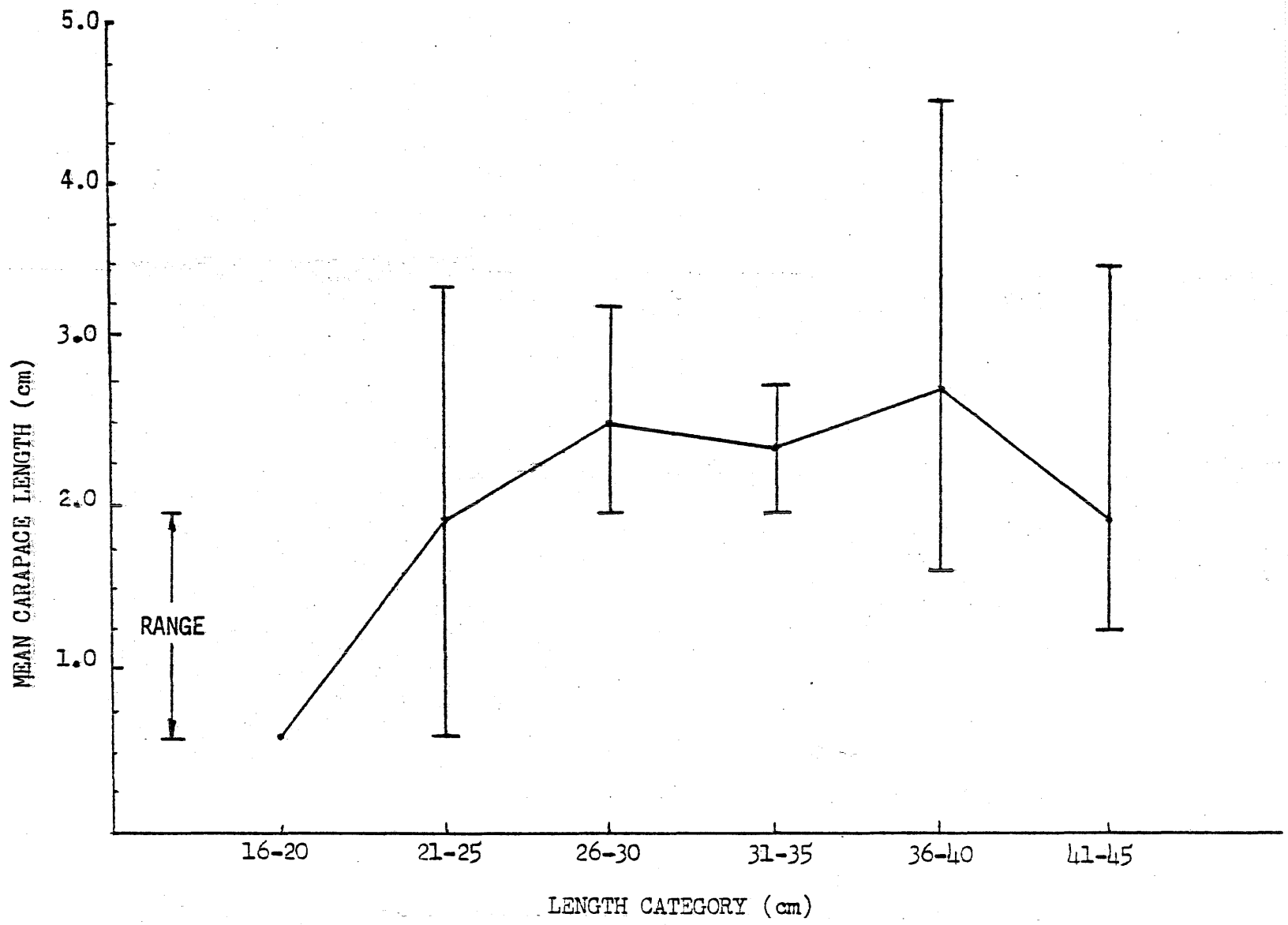

Figure 2. Plot of mean carapace length of the prey, *Pagurus pollicaris*, and the length of the *Centropristis striata*.

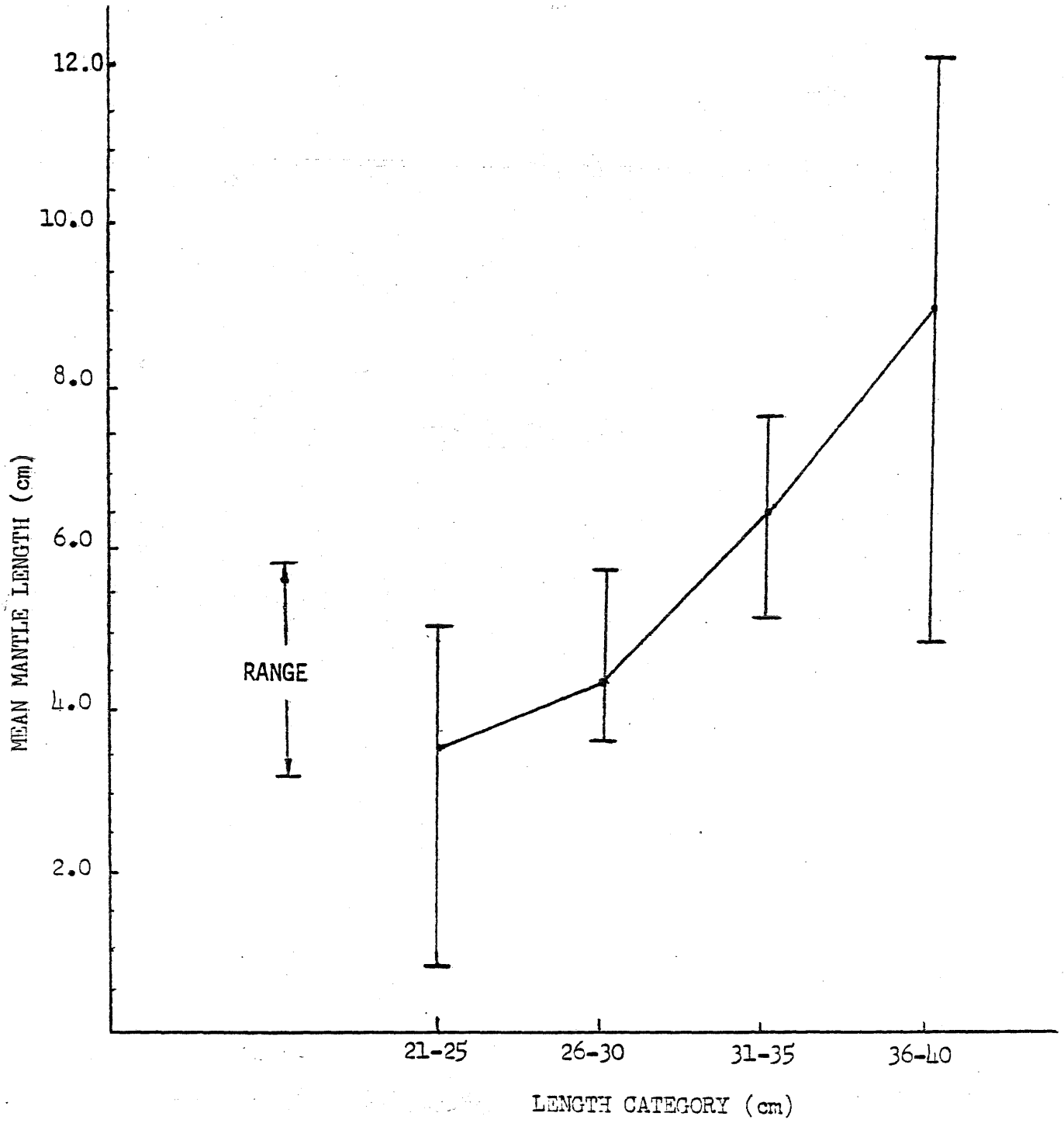

Figure 3. Plot of mean mantle length of the prey, Loligo pealei, and the length of the predator Centropristis striata.

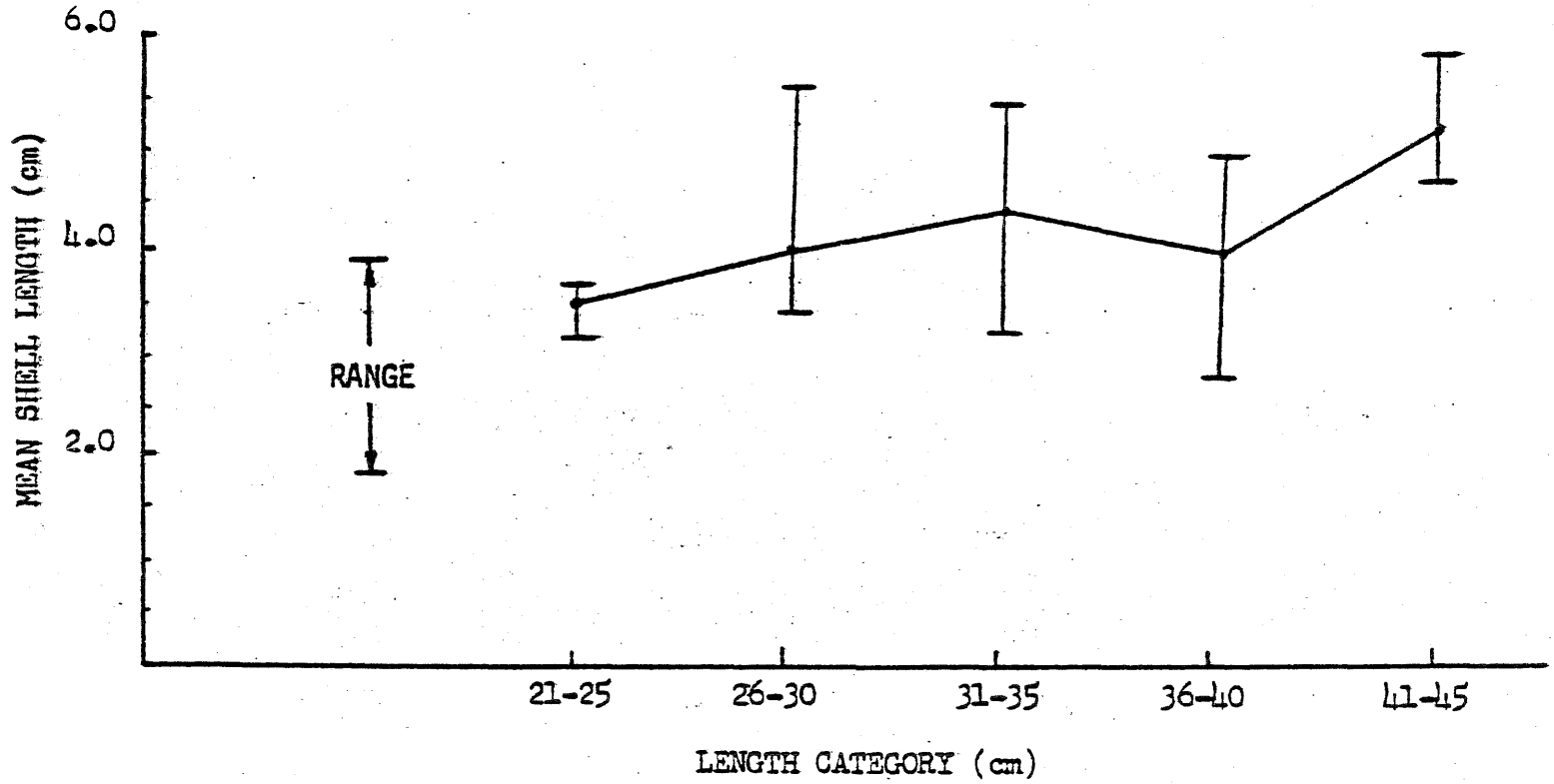

Figure 4. Plot of mean shell length of the prey, Ensis directus, and the length of the predator Centropristis striata.

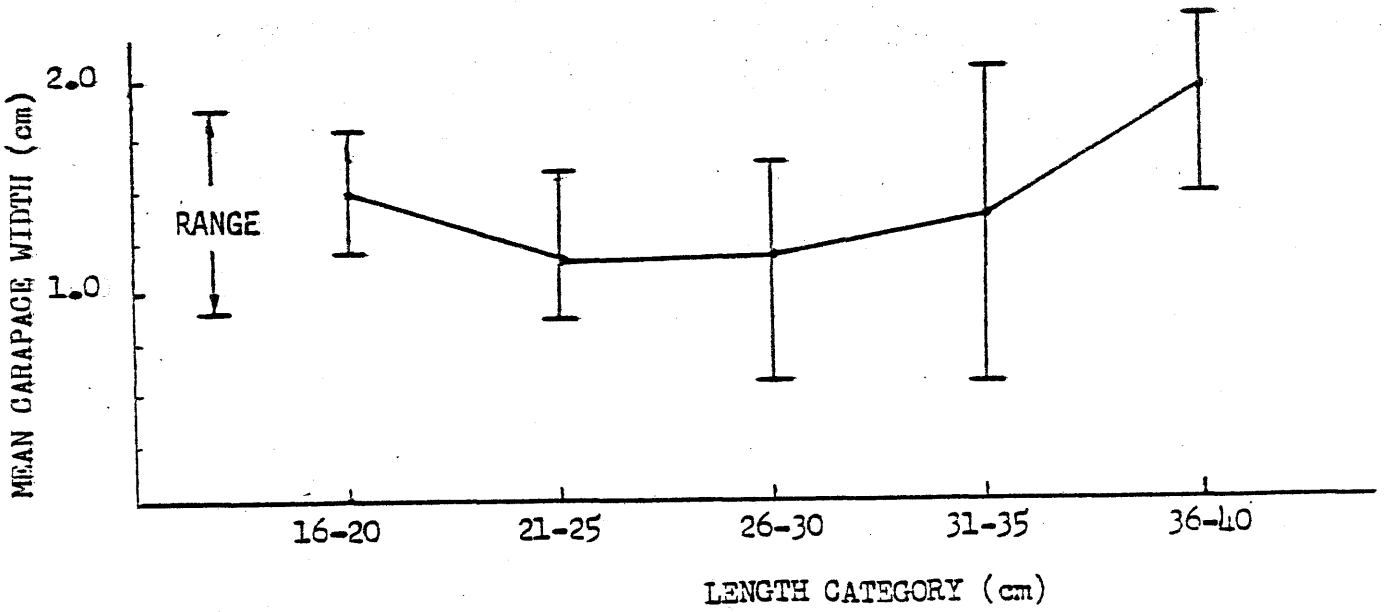

Figure 5. Plot of mean carapace width of the prey, Xanthidae, and the length of the predator Centropristis striata.

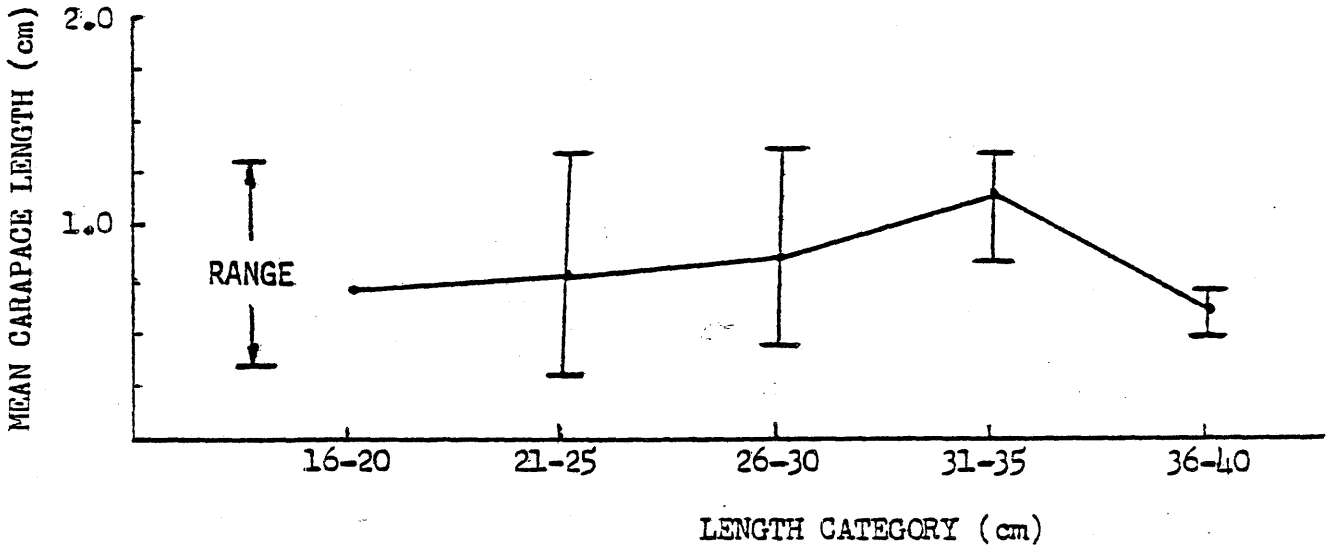

Figure 6. Plot of mean carapace length of the prey, Pagurus acadianus, and the length of the predator Centropristis striata.

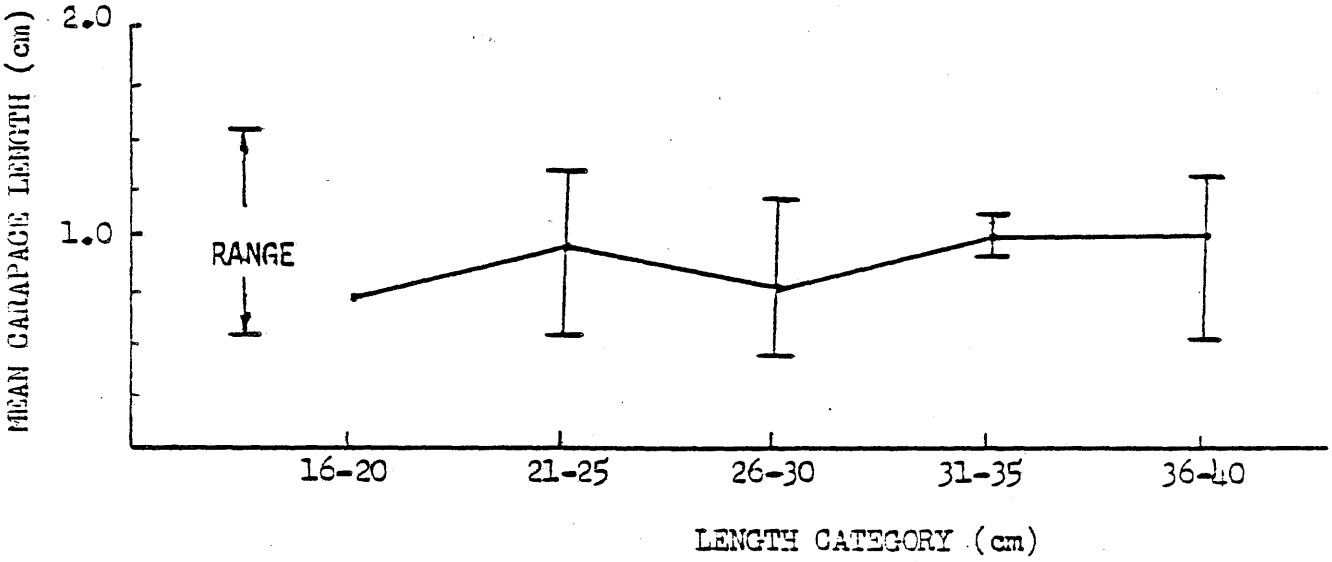

Figure 7. Plot of mean carapace length of the prey, Pagurus longicarpus, and the length of the predator Centropristis striata.