The Food of Hecate Strait Crabs August 1977

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ABSTRACT

Bernard, F. R. 1979. The food of Hecate Strait crabs, August 1977. Fish. Mar. Serv. MS Rep. 1464: 23 p.

The stomach contents from 202 commercial crabs (Cancer magister) taken in Hecate Strait by trawling was analysed by weight and species composition. 116 prey species were present; 74 identified to species and 42 to genus.

Small clams and crustaceans were the major food items, except for large individuals where carrion was important. Juvenile razor clams (Siliqua patula) and the shrimp Crangon alaskensis were the major component, but the wide spectrum of prey organisms showed commercial crabs to be opportunistic feeders on the most available species. Large individuals posses an advantage for the exploitation of carrion.

There was a difference between morning and afternoon fulness of stomach, determined by proportional weight, that showed a diurnal feeding pattern was operational.

To determine whether there was interspecific competition with other species of crabs of the region, 48 Cancer gracilis and 27 C. productus stomachs were sampled. Results suggested that the former species was a competitor with equal-size commercial crabs, but the latter fed largely on epibenthos not taken by C. magister.

Key words: Benthos, crab, cancer, food, ecology, crustacea.

RÉSUMÉ

Bernard, F. R. 1979. The food of Hecate Strait crabs, August 1977. Fish. Mar. Serv. MS Rep. 1464: 23 p.

L'analyse portant sur le poids et l'identification des matières gastriques de 202 crabes (Cancer magister), de catégorie commerciale pêchés au chalut dans le détroit d'Hecate, a révélé la présence de 116 proies différentes dont 74 identifiées selon l'espèce et 42 selon le genre.

Les petits clams et crustacés constituaient la principale denrée, mais les plus gros individus avaient consommé beaucoup de charogne. Les couteaux juvéniles (Siliqua patula) et crevettes (Crangon alaskensis)étaient les plus souvent remarqués, toutefois, le large éventail de proies indique que le crabe commercial se nourrit des espèces disponibles. Les gros crabes peuvent accaparer une plus grande part de charogne.

L'analyse gastrique a aussi révélé un écart de poids entre le matin et l'après-midi, écart selon lequel le crabe est un animal à alimentation diurne.

Afin de déterminer la possibilité d'une concurrence avec les autres espèces de crabes de la région, on a prélevé des échantillons stomacaux de 48 Cancer gracilis et de 27 Cancer productus. Les résultats ont indiqué que les premiers s'attaquaient aux mêmes proies que le crabe commercial de taille égale, mais que les seconds s'alimentaient surtout de l'épibenthos, délaissé par le Cancer magister.

Mots-clés: Benthos, crabe, Cancer, aliments, écologie, crustacés.

INTRODUCTION

A survey of the invertebrate benthic fauna, substrate particle size, and the stomach contents of commercial crabs (Cancer magister Dana) from Hecate Strait, Queen Charlotte Islands, was undertaken in August 1977. Smaller samples of the purple crab (C. gracilis Dana), and the rock crab (C. productus Randall) were also obtained to determine if there is competition for the food resource.

METHODS

The Smith-McIntyre 0.1 m^2 grab was used to obtain quantitative samples of biota and substrate. Large organisms were picked from the grab bucket and preserved. A representative sample for particle analysis was frozen, and the balance of the bucket contents preserved with 5% formaldehyde. Particles were sized in the laboratory using the sieve method of Buchanan and Kain (1971). Organisms were sorted from the preserved sample, identified, and the dry weight was recorded.

Crabs were obtained by trawling, the sex and carapace width recorded, and the stomach removed from 202 C. magister, 48 C. gracilis, and 27 C. productus. The entire stomachs, including the gastric mill, were preserved with 10% formaldehyde and stored in individual containers. The stomachs were opened in the laboratory by vertical incision through the dorsal wall. A pipette was introduced and a small amount of contents transferred to a pre-weighed 5μ pore-size filter to include any minute components. The stomach contents were then washed through a 250μ mesh screen and the retained material washed to the filter. Filters were placed in numbered petri dishes, the contents identified under the microscope, and the volume percentages of major categories estimated by eye. The filters and contents were dried and the constant weights recorded. To eliminate variations due to body size, a common index of fullness was obtained by dividing weight of stomach contents by the carapace width and multiplying to whole numbers.

RESULTS

Locations and depths of the Smith-McIntyre grab stations are listed in Table 1 and plotted in Fig. 1. The results of the sieve analyses, expressed as percentage weight on screens, are given in Table 2. Organisms present in the samples are identified in Table 4 by an asterisk. Locations of the trawl lines are listed in Table 3 and plotted in Fig. 2.

The following paragraphs deal exclusively with the commercial crab. The interaction with the other two species of crabs is covered in the discussion.

There is a statistically valid ($p = >0.05$) difference between the morning and afternoon index of fullness (Fig. 3). Paradoxically, the highest index recorded (Station 36 at 1845) also had the largest proportion (58%) of larger than 120 mm carapace width. The fullness index, when collated by size, shows no sexual bias, but small crabs (<80 mm) consistently have lower indexes and small standard deviations, while large crabs (>120 mm) have higher indexes and much increased standard deviations. When amalgamated into two groups, the <80 mm average is 5.7 (SD 7.5) and the >120 mm average is 22.1 (SD 175.1). The very large standard deviation of the latter group renders the t. test unreliable.

There is a significant statistical difference ($p = >0.05$) between the average number of species (diversity index) present in the stomachs of small crabs compared with older individuals (Fig. 4).

The cumulative percentages, estimated by volume, for the various food species, considered by phylum groups, is presented in Fig. 5. There is a trend in larger crabs to greater proportional utilization of crustaceans, with corresponding decreases of polychaetes and molluscs. Fish, mostly post-larval Pleuronectiformes (possibly the Pacific sand dab Citharichthys stimaeus exclusively to the dogfish (Squalus acanthias) carcasses, introduced to the study area by the activity of a concimitant dogfish program. Carrion is used only by large crabs (>120 mm).

The crab stomachs contain a catholic assemblage, representing almost the total spectrum of the smaller benthic community. 116 different organisms are present, 74 identified to species and 42 to genus (Table 4). The total is undoubtedly greater, as many stomachs contain an unidentifiable mass of semi-digested material, mixed with recognizable fragments, mostly crustacean integument and dactyls, bivalve mollusc shell fragments, and polychaete setae. While a wide array of organisms is represented, the nutritionally important items, estimated by volume, consist of bivalve molluscs, polychaetes, and crustaceans.

The small clam Tellina carpenteri is an important food, particularly for small crabs, and is also the most frequent organism present in the grab samples. The razor clam, Siliqua patula, also figured prominently, but only juveniles were taken, particularly those in their first season after settlement (percentages by size found in stomachs: 4-10 mm = 80%; 10-30 mm = 15%; 30-60 mm = 5%). The basket cockle (Clinocardium muttallii) represented by mantle edges and adductor muscles from large individuals (estimated shell length 80-100 mm), is frequently eaten by the larger crabs.

Polychaetes, represented by little soft remains, but numerous setae and jaws, include both the errant and sedentary groups, with the latter predominating. The size and structure of the setae, and the few undigested soft parts, are mainly from juvenile individuals, with a maximum average length of 20 mm, though the occasional large specimen to 55 mm is present in the stomachs of the largest crabs.

Fragments of crustacean integuments are present in many stomachs, and undigested fragments of the soft parts are abundant. The minor crustacean components include cumaceans, amphipods and various decapods. The freshwater cladoceran Bosmina is represented by several individuals in three, and porcellanid crab zoae were found in four crabs. No cannibalism is detectable, but juvenile (<10 mm carapace width) Cancer branneri occur frequently. The shrimp Crangon alaskensis is the most utilized crustacean, and is present in many stomachs.

DISCUSSION

There is a marked relationship between the infauna and the particle size spectrum of the quantitative grabs, however statistical correlation of the quantitative samples with stomach contents of trawled crabs is not possible. A single grab sample, taken at the termination of the trawl tow, is not representative of the region trawled, particularly in an area with marked heterogenity of sediments. In every case, with a single exception, the biomass calculated from the quantitative data is less diverse and too meagre to account for the observed stomach contents of crabs. Accepting an overestimate of 10% per diem cropping of the standing stock of fauna, each gram (dry weight) of the estimated commercial crab population, requires 82 m^2 foraging area. The richest grab results in an estimate of 50 m^2. Both estimates are doubtless far too large; crabs either actively forage over unlikely extended areas, or the food species are markedly clustered. The last probably is the correct interpretation, but requires an extensive quantitative survey of a limited area for confirmation.

The fullness index increases throughout the day from a low morning value. While definite conclusions cannot be drawn, except with an adequate diel sample schedule, a diurnal pattern is established statistically. The periodicity is not, as expected, correlated to the nocturnal emergence and increased activity of the small infauna, but appears dependent on ambient illumination. Vision may be an important factor in prey location, and must be considered in relation to the observations (MacKay 1942) that commercial crabs capture food organisms by dredging the chelae through the superficial deposits. A factor that is not included is the effect of the tidal cycle on activity, but it is probable the illumination may be critical, as there has been demonstrated a marked correlation between oxygen consumption and photoperiod in the shore crab (Dehnel 1958).

There is no difference in the fullness index between male and female crabs. Small crabs (<80 mm carapace width) demonstrate consistently smaller indexes, with small standard deviations, while larger crabs (>120 mm) are characterized by large indexes, with greatly increased standard deviations. These observations are explainable by small crabs drawing on the small infauna that is more evely distributed both spatially and quantitatively, than the larger prey organisms and carrion utilized by the larger crabs.

Small crabs feed more evenly on small fauna, while large crabs are opportunistic sporadic feeders. The use of carrion is an important underlying reason for the variable indexes, and may be due to the large individuals' advantage of rapid locomotion to quickly exploit new carrion, and the active exclusion of small individuals from such food.

There is no detectable difference between the food items taken by male and female crabs, a conclusion in agreement with Butler (1974), but there is a shift in prey type with increasing size. Molluscs are the major food item of small crabs, however crustaceans gradually assume greater importance with a corresponding decrease in the utilization of polychaetes. The shift in emphasis is attributable to the fact that larval and juvenile stages of all benthos are more vulnerable than the adults, as increasing shell thickness or depth of burial decreases the risks of capture, while crustaceans remain active epifaunal forms and increasing size may not be an effective protection from large predators.

Due to the difficulty of identifying organisms fragmented by the jaws and further triturated by the large ossicles of the gastric mill, little work has appeared on the diets of crabs. MacKay (1942) briefly noted stomach contents of a few individuals, but Butler (1954) was the first to publish a comprehensive list of stomach contents taken from 170 crabs. Mayer (1973), working off Washington, also examined stomachs and concluded that amphipods, ostracods and tanaids were important prey. The sole remaining comprehensive publication is by Gotshall (1977) who identified 40 food organisms in crabs from Northern California, with bivalve mulluscs, followed by crustaceans and fish, the principal prey.

Analysis of the species identified for this study (Table 4) shows that all organisms are grist to the commercial crab, and make their appearance in direct proportion to availability. For instance, the high use of the small clams Tellina carpenteri and Psephidia lordi is directly related to their high abundance and wide distribution in the quantitative samples. It is probable that all crabs of the genus Cancer exploit the benthic fauna in a 'coarse-grained' manner (MacArthur and Levins 1964; Porter 1972), that is, they feed on the more abundant species, rather than selectively. This browsing behaviour may be a potent factor in increasing community diversity.

The majority of organisms occurring in the stomachs are recently settled larvae and juveniles in their first year of life. The conclusion is unavoidable that a marked seasonality of diet must occur, conforming to the recruitment patterns of the benthic fauna.

The razor clam (Siliqua patula) is a major food item, particularly for larger crabs (>90 mm), several contain more than one gram (dry weight) of this clam. Predation is limited entirely to juvenile stock and no adult clams are taken. The absence of large razor clams, or their siphon tips, is attributable to their scarcity in the study area.

It is difficult to speculate on the presence of mantly margins and adductor muscle from large (80-110 mm shell length) basket cockles (Clinocardium nuttallii), though Gotshall (1977) reported observing commercial crabs digging and clutching large basket cockles in southeastern Alaska. It is doubtful that even large crabs can open the robust shell as entire cockles, presented to hungry aquarium-held crabs, were not attacked (Bernard MS). Trawl nets contained numerous articulated undamaged valves from recently dead cockles and several were found in the grasp of the large sunstar (Pycnopodia helianthoides Brandt), an active clam predator. It is possible that crabs obtain large cockles from sunstars.

The high proportion of polychaetes listed in the systematic table (Table 4) does not reflect the true importance of marine worms in the diet. Identifications are based on setae and jaws that are highly resistant to degradation in the digestive juices and may remain lodged in the stomach for long periods. Undigested soft parts of worms comprise only a small part of the stomach contents, so setae may be retained many days after the prey is consumed.

Crustaceans are utilized by all sizes of crabs, with the prey size in relation to the predator. No cannibalism is observable, probably due to the absence of juvenile commercial crabs, rather than avoidance, as numberous small Cancer branneri are taken. Butler (1954) reported frequent remains of small commercial crabs in the stomachs of adults taken from Naden Harbour, and Gotshall (1977) also noted cannibalism in Northern California. Doubtless if sampling is conducted when juveniles are available they will appear in the diet list.

Occurrence of food items in the other two species of crabs (Table 4) suggests that the purple crab (C. gracilis) is a competitor for food with equal-sized commercial crabs, but the rock crab (C. productus) exploits epibenthos with little overlap of resource species.

The three species examined are non-specific feeders, utilizing readily available foods. The presence in the stomachs of the commercial crab of the pelagic organisms Oikpleura and crab zoae, and freshwater forms such as Bosmina, settled on bottom by a localized catastrophy in the planktonic environment, is evidence for the rapid exploitation of feeding opportunities.

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Table 1. Position and depth of Smith-McIntyre grab stations.

Station	Position		Depth (m)	Date
1	54°3.1'N	131°7.0'W	29	Aug. 11, 1977
2	54°5.8'N	131°10.5'W	34	
9	54°0.3'N	131°32.9'W	18	12
12	54°2.8'N	131°22.0'W	27	
14	54°9.2'N	131°31.1'W	19	13
15	54°7.8'N	131°26.0'W	24	
16	54°8.9'N	131°21.3'W	24	
18	54°9.5'N	131°7.5'W	33	
19	54°8.2'N	131°37.3'W	13	14
20	54°8.4'N	131°35.5'W	17	
24	54°2.2'N	131°37.6'W	19	
27	54°2.6'N	131°39.8'W	12	
28	54°0.2'N	131°37.5'W	13	
31	53°57.7'N	131°39.7'W	16	15
38	53°58.8'N	131°33.3'W	11	16
39	54°0.9'N	131°29.2'W	15	
41	54°0.8'N	131°19.1'W	28	
42	53°59.2'N	131°13.6'W	37	
43	54°3.7'N	131°7.0'W	27	
44	54°4.1'N	131°33.5'W	18	17
47	54°3.4'N	131°27.8'W	10	
48	54°6.3'N	131°30.2'W	16	
50	54°3.8'N	131°26.6'W	24	
51	54°2.9'N	131°27.2'W	15	
52	54°1.5'N	131°34.4'W	17	
60	54°8.2'N	131°38.6'W	11	18
61	54°10.8'N	131°37.6'W	11	

Table 2. Substate particles -- sieve analysis.

Station	Pebbles	% weight on screen							Silt/clay
		5 mm	4-2 mm	2-1 mm	1-500µ	500-250µ	250-125µ	125-62µ	<62µ
1		10	8	2	50	18	5	5	2
2			18	10	60	2	6	4	
9				6	21	47	8	7	11
12	20	4	8	11	32	18	9	3	15
14	12	14	23	19	10	3	2	5	15
15		4	9	14	23	31	2	1	16
16			12	9	19	36	6	3	15
18		21	18	10	22	19	6	4	
19	3	12	21	27	15	8	5	3	6
20	50	30	10	2	1	1	2	3	1
24	4	6	10	11	14	25	26	4	
27	63	12	10	8	5	2			
28	10	12	7	6	12	23	14	10	6
31	45	18	14	12	8	3			
38	4	6	9	14	21	29	12	3	2
39	6	7	11	23	14	9	14	9	7
41		3	21	24	30	12	3	4	3
42		6	9	12	23	27	14	2	7
43	5	12	18	21	17	8	6	5	8
44	20	22	17	21	3	4	5	7	1
47			5	14	18	34	23	4	2
48			6	39	25	12	8	6	4
50			2	11	19	23	29	10	6
51				8	19	37	26	8	2
52	10	8	3	12	23	21	11	4	8
60				8	19	34	29	8	2
61			10	8	12	20	31	10	9

Table 3. Position at depth of trawl drags.

Haul no.	Position		Depth (m)	Number of crabs sampled		
				C. magister	C. gracilis	C. productus
3	54°06.1'	131°16.4'	31-29	2		
4	54°05.8'	131°22.1'	29-22	26	22	13
5	54°06.7'	131°24.3'	22	37		
10	54°01.4'	131°37.1'	14-16	5	4	1
11	54°03.7'	131°26.0'	24-23	22		
14	54°08.7'	131°31.8'	18-11	12	11	12
28	54°00.8'	131°37.4'	15-13	26	11	
35	54°02.4'	131°39.2'	12-11	15		
36	54°01.0'	131°39.6'	13-12	21		1
38	53°59.9'	131°33.3'	12-11	2		
46	54°03.9'	131°30.2'	13	4		
47	54°02.4'	131°28.6'	11	9		
56	54°01.5'	131°39.6'	10-9	9		
58	54°04.1'	131°39.1'	6	2		
59	54°07.5'	131°38.8'	6-11	9		
60	54°10.1	131°38.2	7-11	1		

Table 4. Summary of occurrence of various organisms present in crab stomachs.

	Number of stomachs		
	C. magister	*C. productus*	*C. gracilis*
PROTOZOA			
Foraminifera spp.	3		1
PORIFERA			
Leucosolenia sp.	1	1	
CNIDARIA			
Hydroid spp.	1		
Obelia sp.	2	3	1
Sertularia spp.	1	1	1
PLATYHELMINTHES			
Notoplana sp.			1
NEMERTEA			
Amphiphorus sp.	2		
GASTROTRICHA			
Musellifer sp.			2
KINORHYNCHA			
Echinoderes (?) sp.	1		1
ANNELIDA			
Polychaeta errantia			
*Eunice valens (Chamberlin)	2		1
Gattyana cf. cirrosa (Pallas)	3		
**Glycera capitata* Oersted	5		1
Glycinde armigera Moore	6		2
Halosydna brevisetosa Kinberg	3	2	
**Harmothoe extenuata* (Grübe)	3	1	
Harmothoe imbricata (Linné)	4	1	
**Lumbrinereis luti* Berkeley & Berkeley	1		2
Lumbrinereis sp.	1		4
Micronereis nanaimoensis Berkeley & Berkeley			3
Nephtys spp.	2		2
Nereis procera Ehlers	3		1
Odontosyllis phosphorea Moore	3		
Phyllodoce sp.	1		1
**Syllis elongata* (Johnson)	2		
Syllis sp.	3		1

Table 4 (Cont'd)

	Number of stomachs		
	C. magister	C. productus	C. gracilis
Polychaeta sedentaria			
Amphitrite cirrata (Müller)	1	1	1
Armandia brevis (Moore)	3		
Artacama conifera Moore	2		1
Chaetozone cf. setosa Malmgren	3		1
Laonice cirrata (Sars)	1	1	
*Maldane glebifex Grübe	1		1
Nicomache personata Johnson	2	1	1
Pectinaria sp.	6		
Pista cf. fasciata (Grübe)	2		1
Spiochaetopterus sp.			2
Spirorbis cf. validus Verrill		3	
*Sternaspis fossor Stimpson	10		2
Terebellides cf. stroemi Sars	1	1	
*Travisia brevis Moore	4		
ECHIURA			
Arhynchite sp.	2		
MOLLUSCA			
Amphineura			
Tonicella lineata (Wood)		1	
Gastropoda			
*Amphissa columbiana Dall		1	
Caecum crebricinctum (Carpenter)			2
Crepidula adunca (Sowerby)			
Homalopoma luridum (Dall)		1	
Mitrella gausapata Gould		2	
Natica clausa Broderip & Sowerby	2		
*Olivella boetica Carpenter		1	
Tachyrhynchus lacteolus (Carpenter)			1
Velutina sp.			1
Bivalvia			
*Axinopsida serricata (Carpenter)			1
Chlamys rubida (Hinds)	1	2	
*Clinocardium californiense (Deshayes)	16	5	
Clinocardium nuttallii (Conrad)	23	1	1
Glycymeris subobsoleta (Carpenter)	1	1	

Table 4 (Cont'd)

	Number of stomachs		
	C. magister	C. productus	C. gracilis
Hiatella arctica Linné	6	2	1
Lyonsia californica Conrad			1
*Macoma alaskana Dall	17		3
Macoma carlottensis Whiteaves	2		1
Macoma elimata Dunnill & Coan	2		
Musculus sp.	1	1	
Mya truncata Linné		1	
Mytilus edulis Linne		1	
Nemocardium centifilosum (Carpenter)	1		
*Psephidia lordi (Baird)	13	1	1
Siliqua patula (Dixon)	45		
Tellina bodegensis Hinds	1		
*Tellina carpenteri Dall	40	2	2
Tellina nuculoides (Reeve)	1		1
Transenella tantilla (Gould)	3		
Cephalopoda			
Rossia pacifica Berry	1 (Beak)		
ARTHROPODA			
Amphipoda			
Amphipod spp.	1	1	1
Melita sp.		1	1
Photis spp.			1
Cirripedia			
Balanus cariosus (Pallas)		5	
Cladocera			
Bosmina sp.	3		
Cumacea			
*Cumacea sp.			2
Diastylis spp.	1		3
Eudorella spp.		1	
Leucon sp.			1

Table 4 (cont'd)

	Number of stomachs		
	C. magister	*C. productus*	*C. gracilis*
Decapoda			
Betaeus harrimani Rathbun			2
**Cancer branneri* Rathbun	12		
**Cancer gracilis* Dana	2		
Cancer oregonensis (Dana)		1	
**Crangon* cf. *alaskensis* Lockington	48	1	6
Eualus sp.		1	
Pagurus aleuticus (Benedict)	2	1	
Pachycheles cf. *rudis* Stimpson	1		
Petrolisthes cinctipes (Randall)	1	2	
Petrolisthes sp.	8		
Pinnixa littoralis Holmes	3		
Porcellanid crab zoae	4		1
Spirontocaris sp.		1	
Harpacticoida			
**Harpacticoid* sp.	3		1
Diosaccus sp.		1	
Harpacticus sp.		1	
Ostracoda			
Cylindrolebris cf. *mariae* (Baird)	1		1
Euphilomedes sp.	2	1	1
ECHINODERMATA			
Echninoidea			
Strongylocentrotus droebachiensis (Müller)		1	
Holothuroidea			
Leptosynapta clarki Heding	3		
Parastichopus californicus (Stimpson)	2		
Ophiuroidea			
**Amphipholis squamata* (Delle Chiaje)		1	

Table 4 (Cont'd)

	Number of stomachs		
	C. magister	*C. productus*	*C. gracilis*
CHORDATA			
Larvacea			
Oikopleura sp.			1
Ascidiacea			
Ascidia cf. paratropa (Huntsman)		1	
Fish			
Bony fish vertebrae	9	2	1
Squalus acanthias Linné	10		
ALGAE			
Ulva	3		1

*Also present in grab samples.

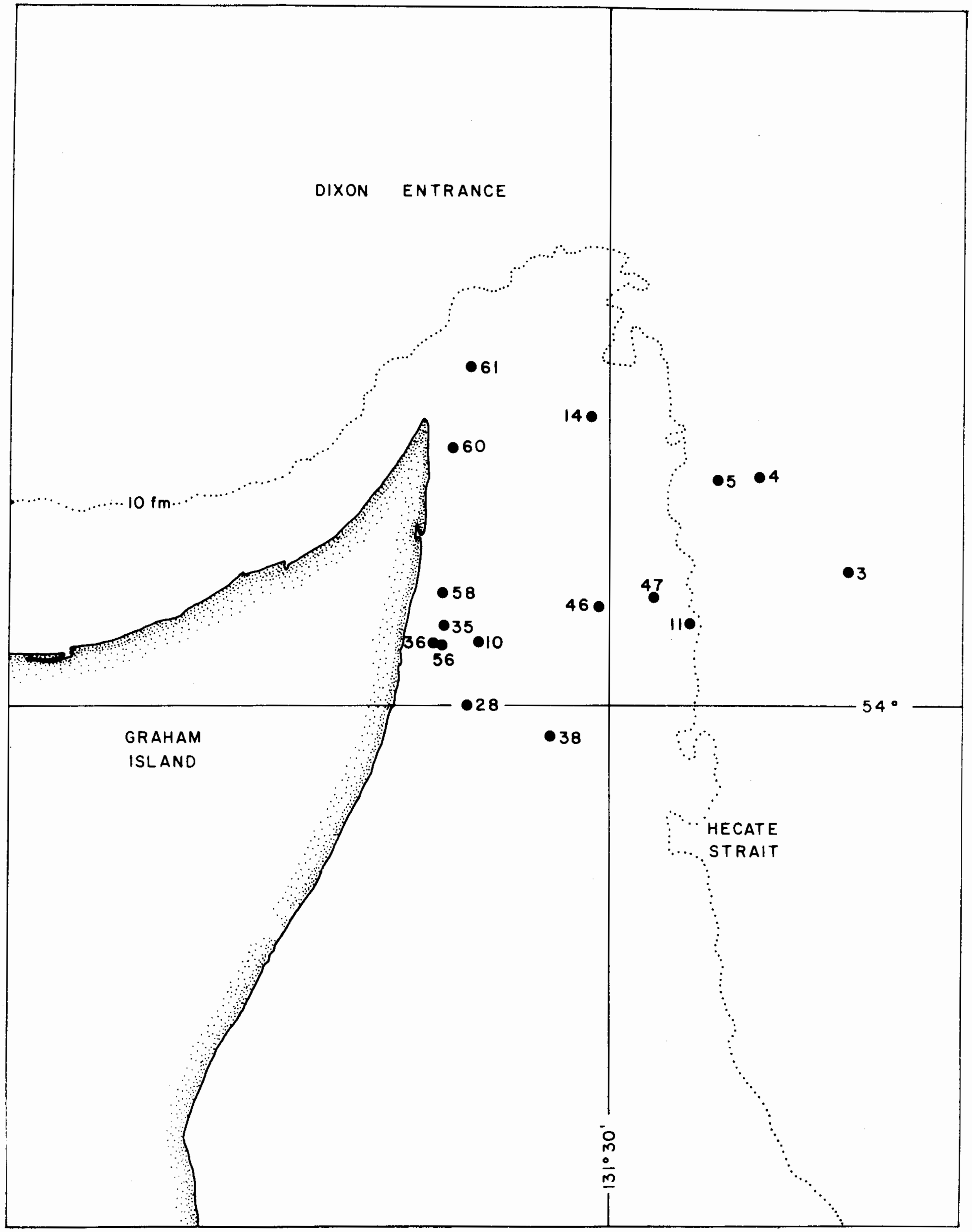

Fig. 1. Map showing positions of Smith-McIntyre grab stations.

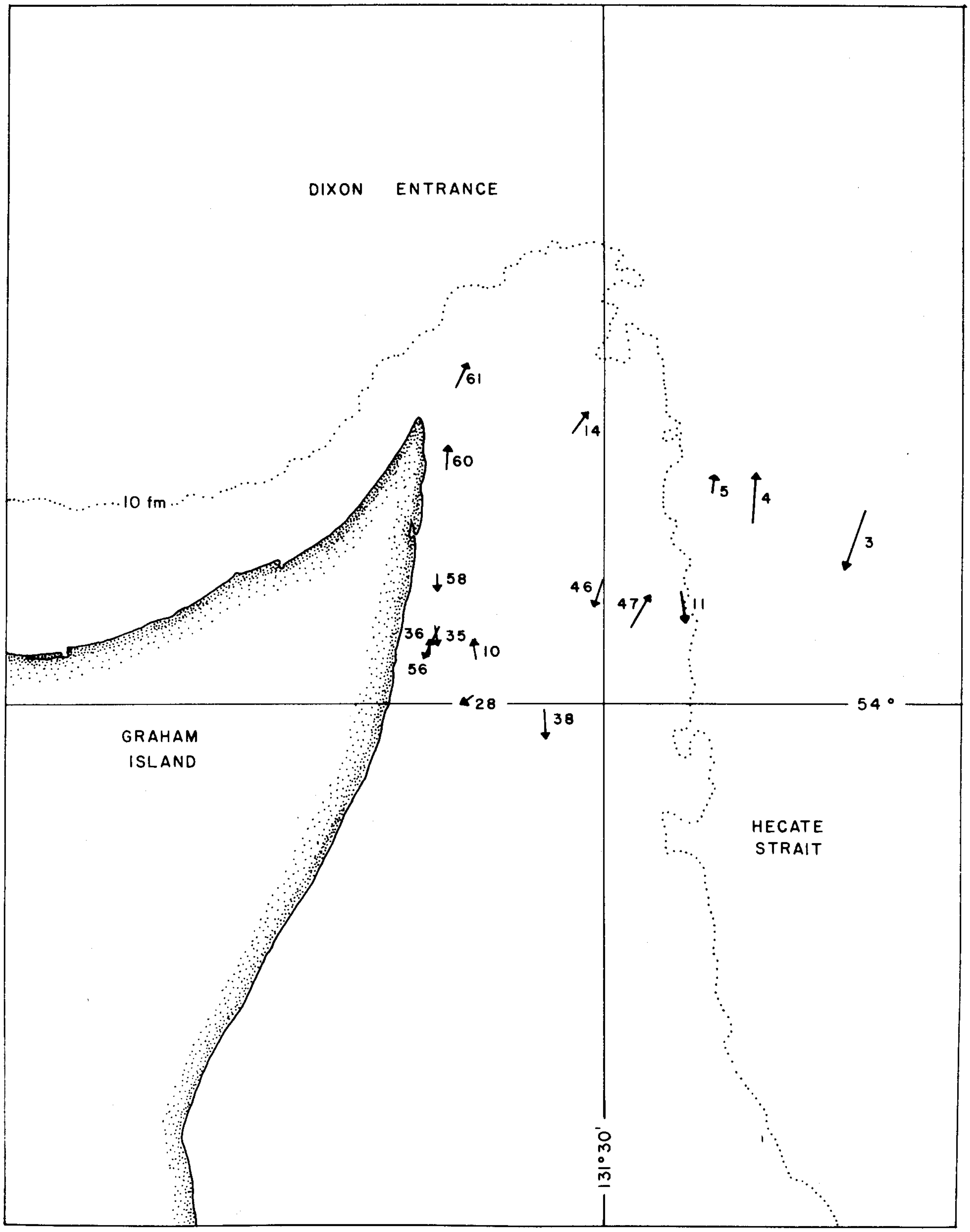

Fig. 2. Map showing positions of trawl drags.

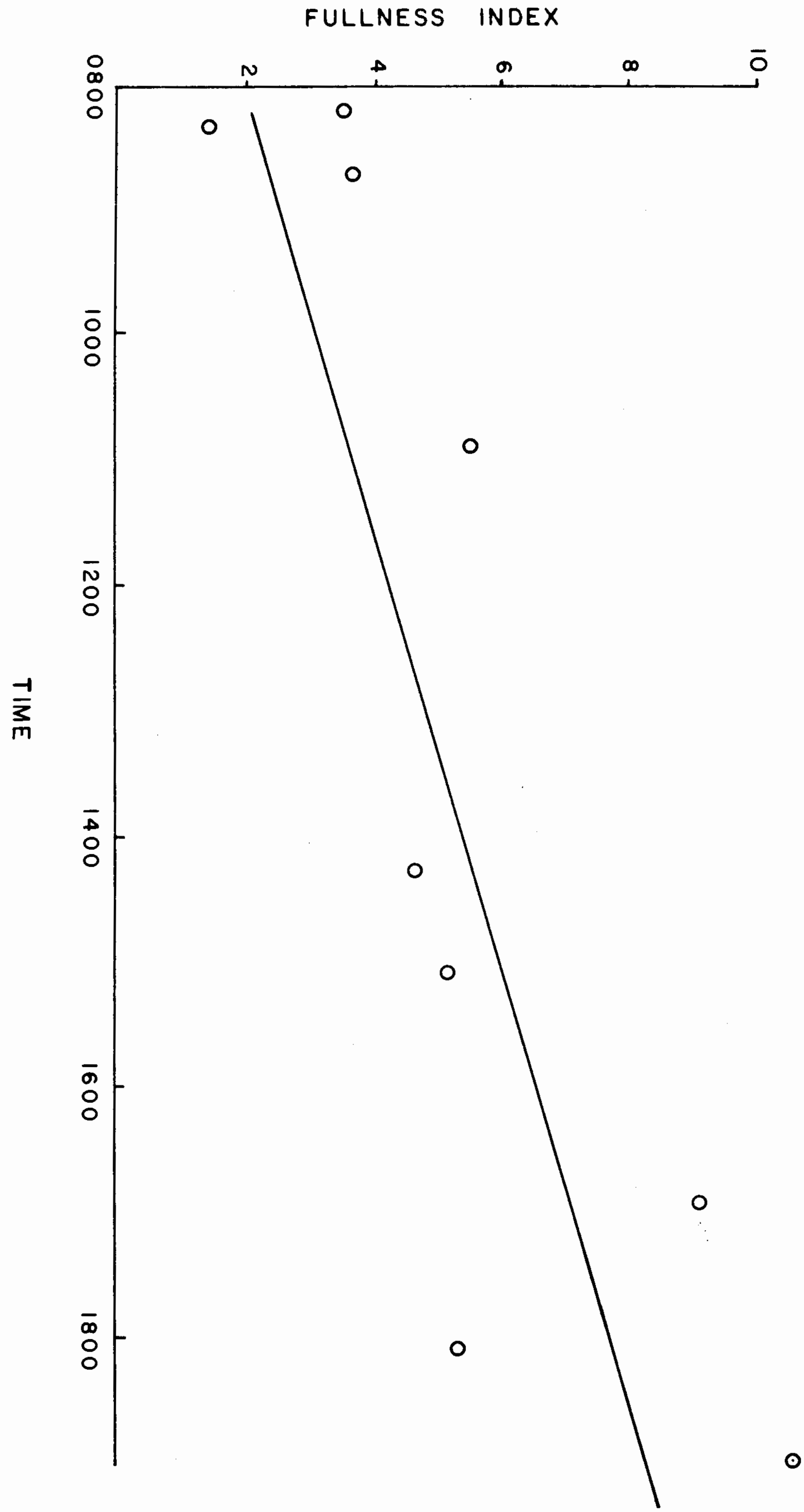

Fig. 3. Fullness index and time of day for Cancer magister.

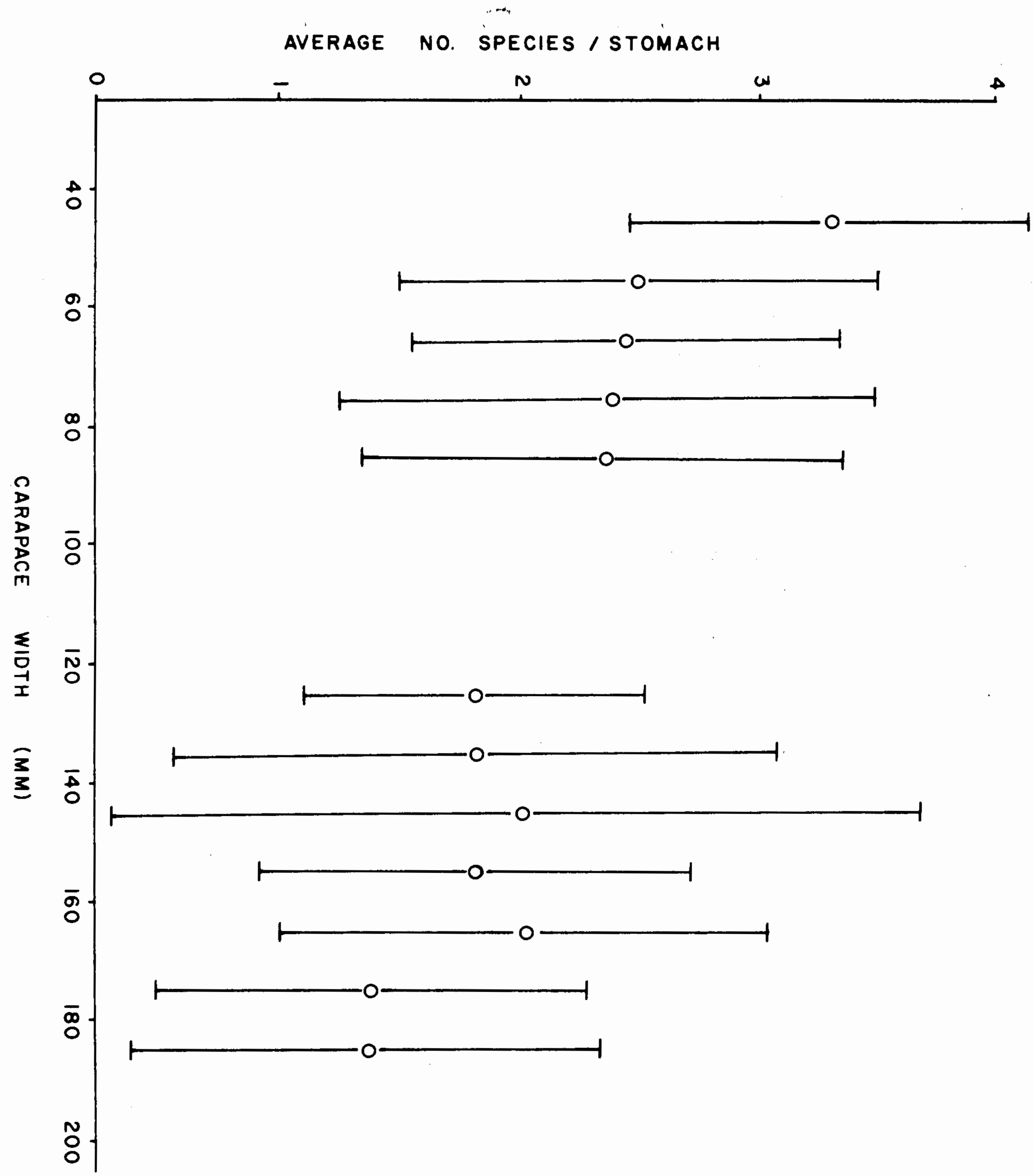

Fig. 4. Average number of species and standard deviation for <u>Cancer magister</u> as a function of carapace width.

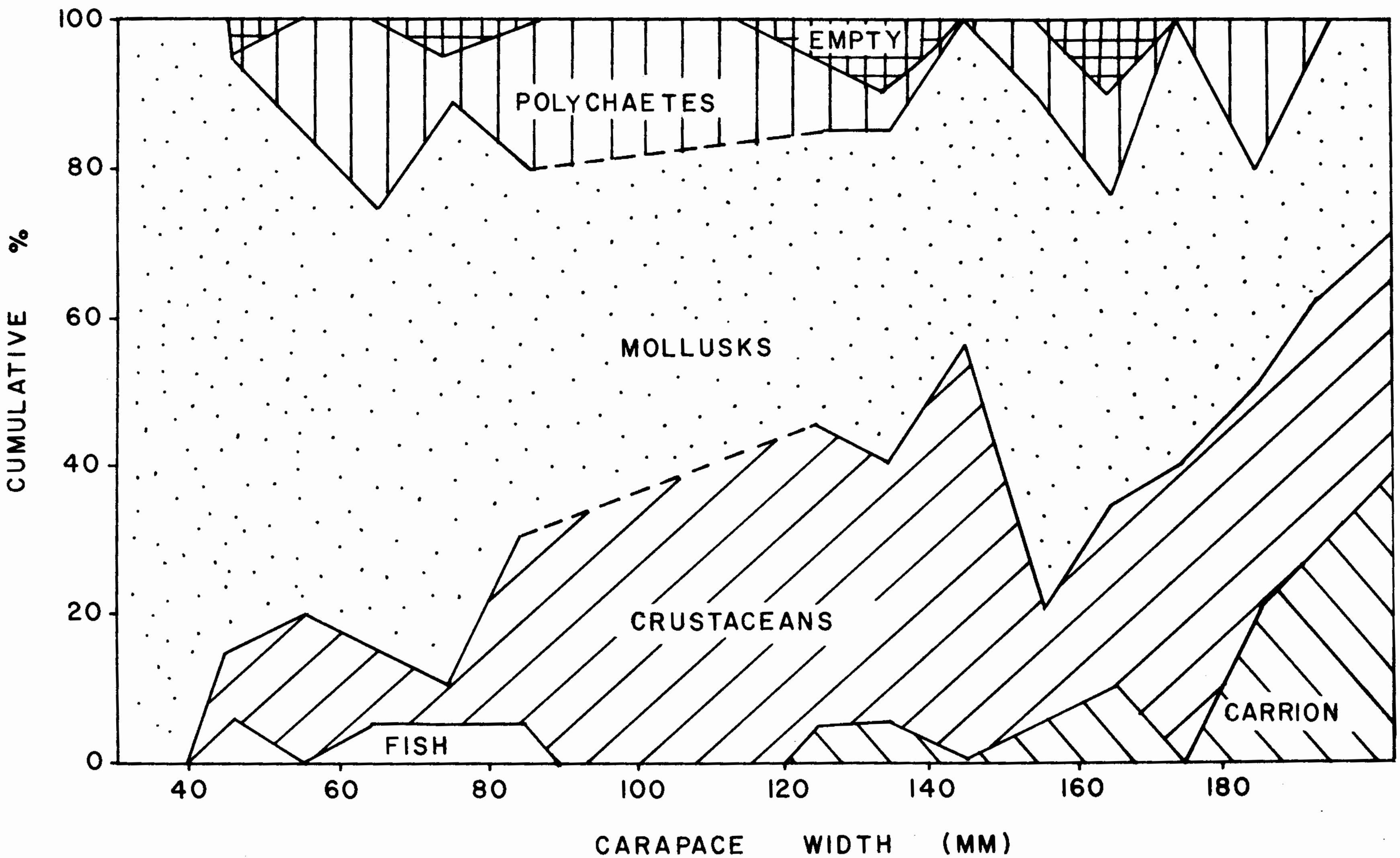

Fig. 5. Estimated cumulative percentage use of major benthic categories as food by *Cancer magister*.