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Seasonal and Depth Distribution, Size, and Molt Cycle of the Spider Crabs, *Chionoecetes opilio, Hyas araneus,* and *Hyas coarctatus* in a Newfoundland Bay

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SEASONAL AND DEPTH DISTRIBUTION, SIZE, AND MOLT CYCLE OF THE SPIDER CRABS, CHIONOECETES OPILIO, HYAS ARANEUS, AND HYAS COARCTATUS IN A NEWFOUNDLAND BAY

by

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ABSTRACT

Miller, R. J., and P. G. O'Keefe. 1981. Seasonal and depth distribution, size, and molt cycle of the spider crabs, Chionoecetes opilio, Hyas araneus, and Hyas coarctatus in a Newfoundland bay. Can. Tech. Rep. Fish. Aquat. Sci. 1003: iv + 18 p.

Baited traps were set at 10, 30, 50, 70, 90, and 115 fathoms in Conception Bay, Newfoundland, on eight occasions over 13 months. Number of crabs/trap, crab size, and an index of shell age were noted for males of Chionoecetes opilio, Hyas araneus, and Hyas coarctatus. From trawl catches of C. opilio at 115 fathoms, taxonomic composition and weight of stomach contents were also noted.

Depth distributions were generally 10-30 fathoms for H. araneus, 30-70 fathoms for H. coarctatus, and ≥ 50 fathoms for C. opilio. Commercial catch rates of C. opilio were found as shallow as 50 fathoms, but previously presumed to occur only deeper than 80 fathoms.

Mean size of both Hyas species changed little with depth or date, whereas size of C. opilio consistently increased with depth and changed seasonally.

Soft-shelled (recently molted) Hyas coarctatus and H. araneus were found only in June through September and peaked at 23% and 26% of catches respectively. Soft-shelled C. opilio were present most of the year and peaked in June at approximately 55% of the catch. Size and shell age of C. opilio were inversely correlated.

C. opilio were smaller, less abundant, and had older shells at shallower stations. We hypothesize that crabs which reach a terminal molt below commercial size accumulate in the population, whereas fishing prevents commercial-sized crabs from developing old shells.

Dry weights of stomach contents of C. opilio were surprisingly low. Polychaetes, clams, and sea stars were the most frequently occurring prey.

RÉSUMÉ

Miller, R. J., and P. G. O'Keefe. 1981. Seasonal and depth distribution, size, and molt cycle of the spider crabs, Chionoecetes opilio, Hyas araneus, and Hyas coarctatus in a Newfoundland bay. Can. Tech. Rep. Fish. Aquat. Sci. 1003: iv + 18 p.

Des casiers appâtés ont été mouillés à 10, 30, 50, 70, 90 et 115 brasses dans la baie de la Conception (Terre-Neuve), à huit occasions réparties sur 13 mois. Le nombre de crabes par casier, la taille des crabes et un index de l'âge de la carapace ont été relevés pour les mâles Chionoecetes opilio, Hyas araneus, et Hyas coarctatus. Pour les C. opilio capturés au chalut à 115 brasses, on a noté la composition taxonomique et le poids du contenu de l'estomac.

Dans l'ensemble, les espèces se répartissaient selon la profondeur comme suit: de 10 à 30 brasses pour H. araneus, de 30 à 70 brasses pour H. coarctatus et plus de 50 brasses pour C. opilio. On a capturé des C. opilio de taille commerciale jusqu'à 50 brasses, alors qu'on supposait auparavant qu'ils vivaient à des profondeurs supérieures à 80 brasses.

La taille moyenne des deux espèces Hyas variait peu selon la profondeur ou la date, alors que la taille de C. opilio augmentait uniformément avec la profondeur et changeait selon la saison.

Des Hyas coarctatus et H. araneus à carapace molle (ayant récemment mué) ont été capturés seulement de juin à septembre, les prises les plus élevées s'établissant à 23 et 26 pour cent respectivement du total. On a capturé des C. opilio à carapace molle pendant la plus grande partie de l'année, les prises atteignant un maximum en juin avec 55 pour cent du total. La taille et l'âge de la carapace du C. opilio étaient inversement liés.

Les C. opilio étaient plus petits, moins abondants et leur carapace était plus âgée aux faibles profondeurs. Nous supposons que les crabes parvenant à la mue terminale sans avoir atteint une taille commerciale prolifèrent alors que la pêche empèche les crabes de taille commerciale d'avoir une vieille carapace.

Le poids sec du contenu de l'estomac de C. opilio était étonnamment bas. Les polychètes, les clams et les étoiles de mer étaient les proies les plus fréquentes.

INTRODUCTION

The purpose of this study was to observe depth and seasonal distribution of catch/trap, depth and seasonal distribution of stages of the molt cycle, and depth distribution of crab size for a commercial spider crab, Chionoecetes opilio, and two non-commercial spider crabs, Hyas araneus and Hyas coarctatus.

The above parameters are relevant to management of the snow crab fishery and to allocating fishing effort. They would have the same relevance to a Hyas fishery should such a fishery develop. Recently molted C. opilio are unsuitable for processing because survival from the time they are caught until they are processed is poor, their meat yield is poor, and because of high water content and frequent discoloration, the meat quality is poor (pers. comm., crab processors). Stage of the molt cycle affects catch since decapod catchability in traps decreases during premolt and markedly increases during postmolt relative to intermolt (Chittleborough 1970, 1975; Morgan 1974; Newman and Pollock 1974). Crab size is important to the snow crab fishery because of a legal minimum crab size of 95 mm carapace width (Miller 1977) and because labor costs per unit meat yield decreases with increasing crab size (pers. comm., crab processors). Seasons and depths of maximum catch per trap are of course important to fishermen who are always seeking to maximize their catch per unit effort.

The Newfoundland fishery for C. opilio began in 1968 (Watson and Simpson 1969) and by 1979 had expanded to 11,000 MT with a landed value of about $7 million. While Hyas sp. are not fished commercially they are known to occur near practically all the Newfoundland and Labrador coast (Squires 1970) and, judging from large catches in groundfish gill nets and lobster traps as reported to us by fishermen, they are abundant in many locations. Mr. Sidney Hann of the College of Fisheries, St. John's, Newfoundland, considers their meat to have a good market potential as commuted paste. In trial processing of both species with a mechanical meat/bone separator, he obtained meat yields of 35%, good color, and good texture with negligible amounts of shell.

METHODS

Area. On eight occasions from April, 1978, through May, 1979, crabs from six depths were sampled in the sheltered end of Conception Bay, Newfoundland, within a 4 km radius of 47°31'N by 53°05'W. Sampling stations were approximately on an east-west line at 10, 30, 50, 70, 90, and 115 fathoms. Station locations varied as much as 1 km among dates to avoid set fishing gear and because of inattentiveness to navigation.

The substrate at the deepest station was known from bottom photography and bottom grab samples to be uniform soft mud (Miller 1975). The substrate at other depths was not surveyed, but traps set at 90 fathoms commonly had mud on their bottom. Attempts to tow an otter trawl at shallower depths either resulted in torn trawls or catches of rocks. Bottom temperatures, taken with reversing thermometers, are given in Table 1.

Traps. Baited traps were fished at each station on each date, usually eight to a line and usually two lines per station. Traps were set 45 m apart on a line with a sand bag anchor and float on each end. The conical-shaped Japanese style traps were 1.2 m bottom diameter, 0.7 m top diameter, by 0.6 m high with a single top entrance fitted with a plastic collar to prevent crabs from escaping (Miller 1977). Traps were made of steel rods covered with polypropelene trawl netting of knotted 2 mm diameter twine of 11.5 cm mesh stretch measure. Traps were baited with approximately 1 kg of frozen squid hung from a wire on the plastic collar.

Trawl. At the 115 fathom stations only, *C. opilio* was also collected using a 3 m wide beam trawl through July, 1978, and using a #36 otter trawl on subsequent dates.

Crab measurements. Maximum carapace width of crabs caught in traps was measured with vernier calipers and classified in one of the following four categories of shell condition in order of increasing time since the last molt.

1) Claw easily bent with thumb pressure, claw irridescent on the outer edge, shell without calcarious growths and brightly colored.
2) Claw not easily bent by thumb pressure, claw irridescent on the outer edge, shell brightly colored, and shell usually with calcarious growths.
3) As in 2) but shell less brightly colored and claw edge not irridescent.
4) Shell black and soft from decay at some joints, shell colors dull.

Shell condition 1 is referred to by the crab industry as "soft shell" or "white" crab. Size and shell condition were determined for crabs from all traps on a line or part of the traps were selected using a random numbers table. Crabs not measured were counted.

Table 1. Bottom temperatures in °C.

Date	Depth (fathoms)					
	10	30	50	70	90	115
Apr. 13-19	a	a	a	a	a	a
June 5-7	+1.6	a	a	a	a	a
July 11-13	+1.7	-1.0	a	-0.9	-0.9	-0.5
Sept. 7-11	+13.0[b]	+2.4[b]	-0.3[b]	-1.1[b]	-1.1[b]	-0.6[b]
			+1.1[c]	-0.9[c]		-0.7[c]
Nov. 8-14	+6.1	+4.1	+1.1	a	a	a
Jan. 31-Feb. 5	+0.3	a	+0.1	+0.1	-0.1	-0.3
March 5-7	a	a	a	a	a	a
May 3-7	+1.3	+0.4	+0.1	-1.0	-1.0	-0.8

[a]No data
[b]Before storm-force winds
[c]After storm-force winds

Only male crabs of all three species were included in the study. Females were rarely caught in traps and are too small to be of commercial importance.

A sample of trawl-caught crabs was selected for investigation of stomach contents. Within an hour of capture stomachs were removed, wrapped in cheeze cloth, labeled, and stored in 10% buffered formalin. In the laboratory conspicuous prey types were noted and total stomach contents were dried at 60 C and weighed. Shell conditions were proportional to shell conditions in the trap sample, mostly two and three.

RESULTS

Catch per trap. A conspicuous feature of Fig. 1 is the partitioning of depths among the three species: *H. araneus* was found principally at 10 and 30 fathoms, *H. coarctatus* principally at 30 to 70 fathoms, and *C. opilio* over a wide range but mostly deeper than 50 fathoms. Crude tests of significance between mean catches can be made by noting if the two standard errors of the mean overlap.

While catches of the two *Hyas* species change from one sampling date to another, these changes suggest no obvious seasonal trend. For *C. opilio*, catches at 50 fathoms increased markedly from July to Sepetember then returned to a low level by the following March. The May, 1979, catches do not repeat those of the previous spring. Anecdotal information from fishermen and exploratory fishing carried out by other agencies in 1969-71 led us to believe that significant catches of *C. opilio* occurred only at depths greater than 80 fathoms. Thus, we were surprised to find sizable catches at 50 and 70 fathoms.

Approximate weight of catches can be determined from the mean number of crabs/trap, the mean width of crabs, and least square regressions of live weight (g) versus carapace width (mm). Regressions are as follows:

Hyas araneus: $Y = 0.000692\ X^{2.99}$ ($n = 63$, $r = 0.97$)
Hyas coarctatus: $Y = 0.00277\ X^{2.64}$ ($n = 27$, $r = 0.95$)
Chionoecetes opilio: $Y = 0.00018\ X^{3.16}$ (Miller and Watson 1976)

Hyas sp. were weighed and measured live after blotting for a few seconds.

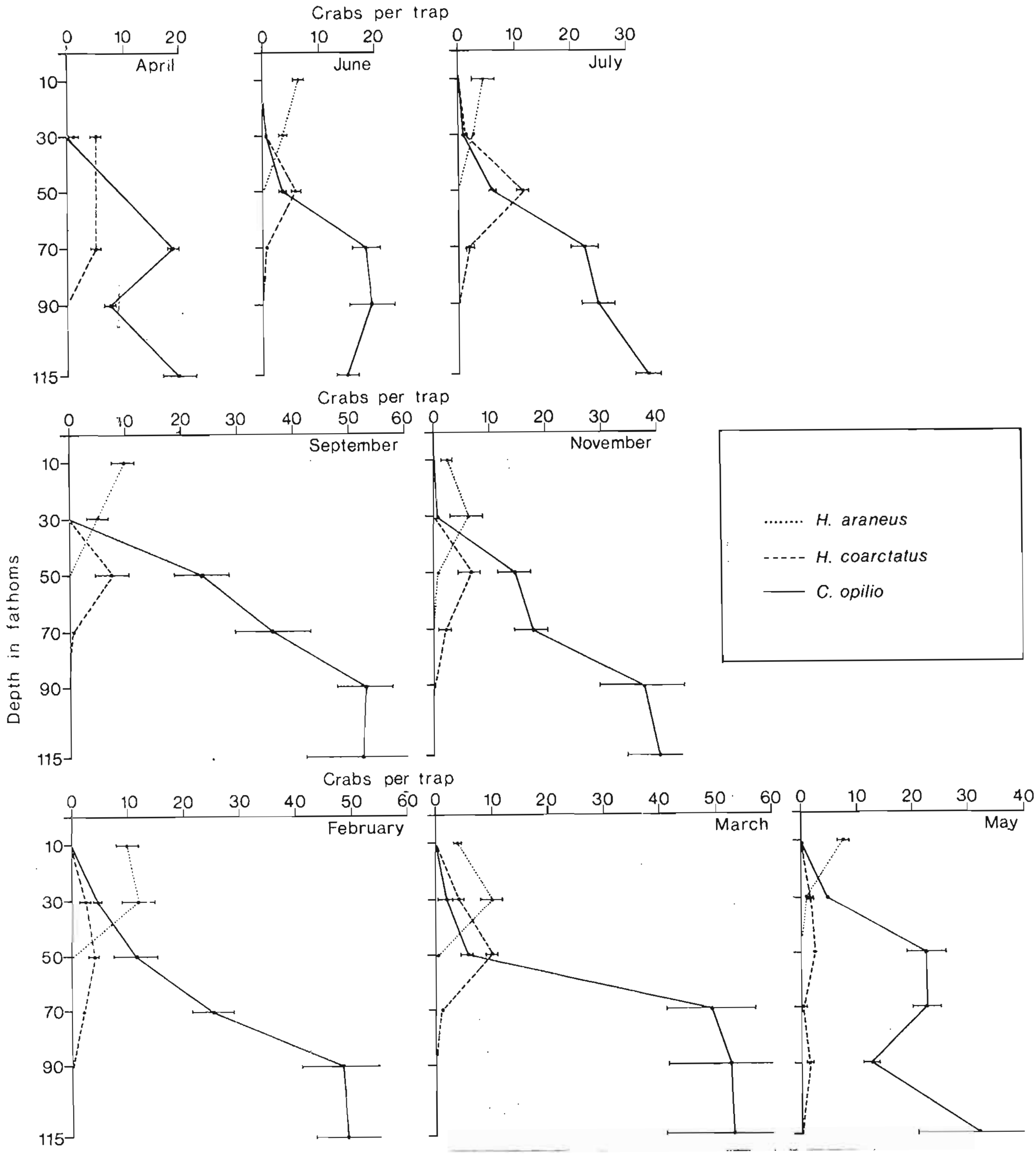

Fig. 1. Mean catch per trap at each depth on each date for all three species. Horizontal lines are ± 2 standard errors of the mean.

The maximum average catches for a given species, date, and location were:

H. araneus: 30 fathoms - February, 1979 - 3.3 kg/trap
H. coarctatus: 50 fathoms - July, 1978 - 2.2. kg/trap
C. opilio: 115 fathoms - March, 1979 - 18.1 kg/trap

These catches would not reflect relative biomass densities since the traps and bait were chosen for their effectiveness in catching C. opilio and are almost certainly less effective at catching Hyas sp.

Crab size. Mean size of H. araneus and H. coarctatus varied little (Fig. 2) among depths and dates (Table 2, Fig. 2). Of all comparisons among depths within dates for which there were enough crabs (≥ 20 of a species from a depth), in only November, 1978, for only H. araneus was there a significant difference in mean sizes, 69.3 mm at 10 fathoms versus 73.0 mm at 30 fathoms. Although mean sizes among dates were not compared statistically, the range of values were modest - 62.2 mm to 68.1 mm for H. coarctatus and 68.7 to 76.5 for H. araneus. There was no apparent seasonal trend. As indicated by the ranges in mean sizes, H. coarctatus was substantially smaller than H. araneus.

By contrast, mean size of C. opilio changed with both depth and season and spanned a larger range (Table 2; Fig. 2). Size increased with increasing depth on all dates except September, 1978. Mean sizes at 115 and 90 fathoms, depths normally fished commercially, showed a decreasing trend through November, 1978, then increased for the remainder of the sampling period. At 50 fathoms C. opilio was larger during September through February than either before or after. Mean sizes at a given depth and date ranged from 79.0 to 104.4 mm. The fact that the ranges of mean sizes for each of the three species do not overlap largely precludes mesh size selection as an explanation for crab sizes in the trap collections.

Shell condition. Hyas of either species in shell condition 1 (soft-shelled) were found in only June through September of 1978. During this period the ranges among depths and dates were 0-23% soft for H. coarctatus and 0-26% soft for H. araneus; thus, no major peak in molting was observed.

The abundance of recently molted C. opilio peaked in June, 1978, and was higher in deep water than shallow. Following the proportion of the catch in shell condition 1 in Fig. 3, we see an increase from April through June then a progressive decrease until it disappeared in February, 1979. It reappeared in March and May. Also apparent in Fig. 3 is an increase with depth of the proportion of the catch in shell

Table 2. Mean crab size (mm carapace width) by depth (fathoms). If the difference between any two means exceeds Tukey's W (Steele and Torrie 1960) the difference is considered statistically significant at the 0.05 level and the means are not connected by a horizontal line. Connected means are not significantly different. Only depths and species with sample sizes ≥ 20 crabs were included.

Date	Species	Depth 115	90	70	50	30	10
Apr. 78	*C. opilio*	104.4	93.8	80.8			
	H. coarctatus			62.2		64.3	
June 78	*C. opilio*	99.1	102.1	99.5	82.0		
	H. coarctatus				64.2		
	H. araneus					68.7	72.8
July 78	*C. opilio*	96.1	93.1	91.9	81.8	80.2	
	H. coarctatus					66.5	
	H. araneus					72.1	69.3
Sept. 78	*C. opilio*	89.9	96.1	99.5	90.9		
	H. coarctatus				68.1		
	H. araneus					75.5	
Nov. 78	*C. opilio*	91.9	92.4	92.9	87.3		
	H. coarctatus				66.8		
	H. araneus					73.0	69.3
Feb. 79	*C. opilio*	95.4	95.3	90.1	86.1		
	H. coarctatus				67.1	65.8	
	H. araneus					74.3	73.9
Mar. 79	*C. opilio*	96.8	91.0	86.7	81.1	80.2	
	H. coarctatus				65.5	66.2	
	H. araneus					73.1	70.6
May 79	*C. opilio*	100.6	93.4	92.7	84.3	79.0	
	H. coarctatus				65.1	63.0	
	H. araneus						76.5

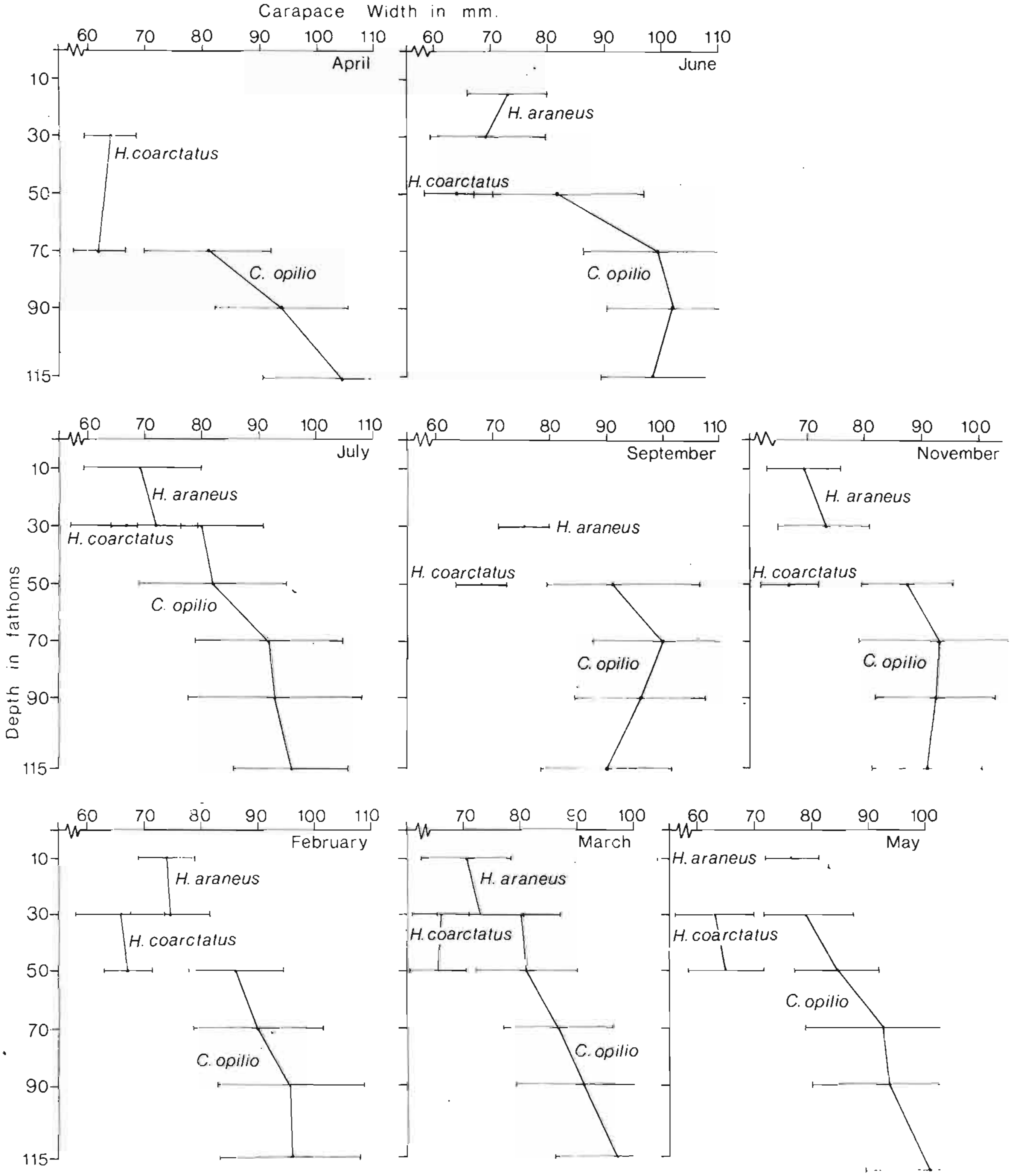

Fig. 2. Mean carapace width (± 1 sample standard deviation) at each depth on each date for three species. Minimum sample size was 20 crabs.

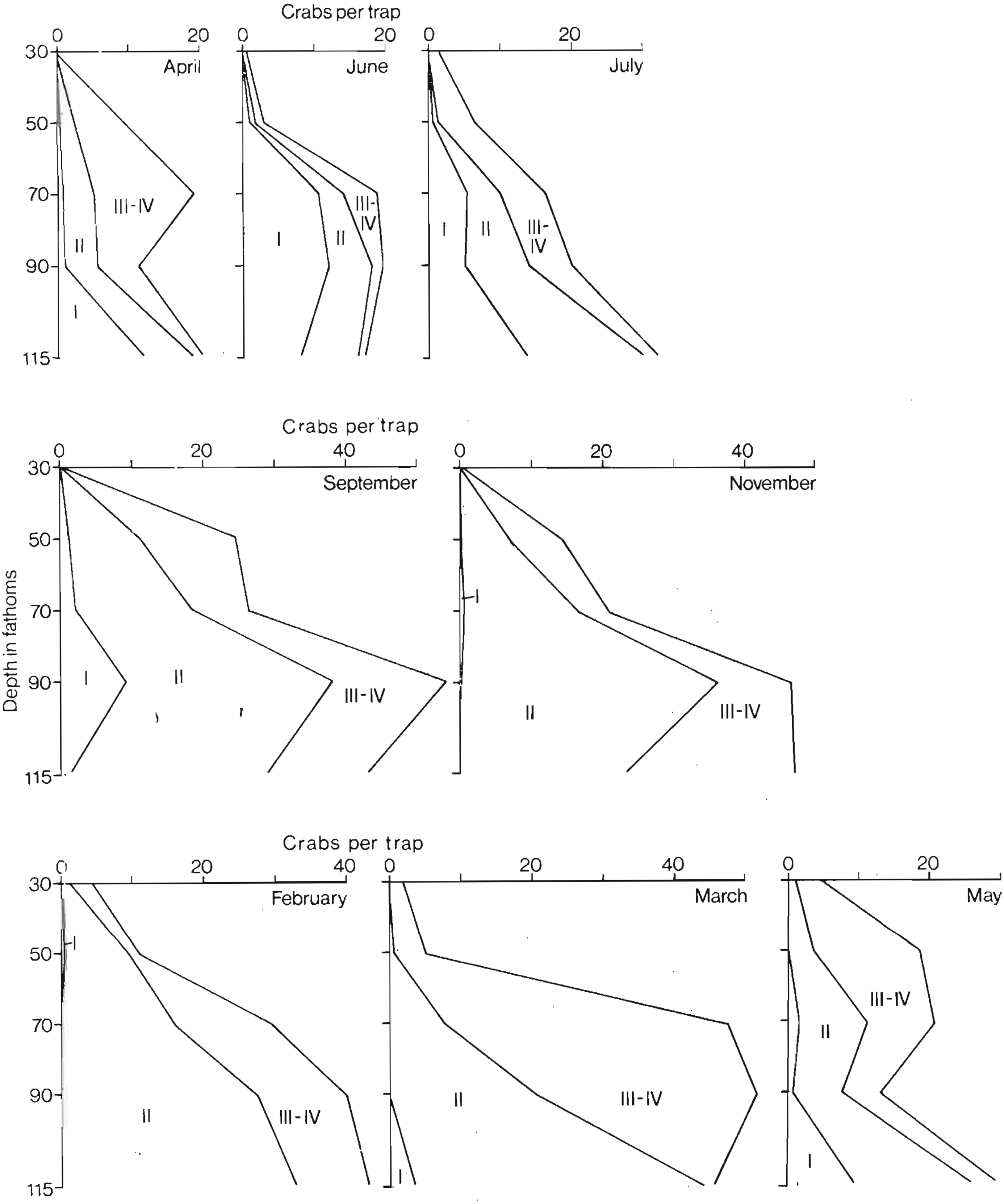

Fig. 3. Mean catch per trap of *C. opilio* for each shell condition at each depth on each date.

condition 1 and 2. Thus, proportion in shell condition 3 and 4 decreases with depth.

The data and chi-square analysis in Table 3 show a strong inverse correlation between crab size and shell age for C. opilio; i.e., a higher proportion of small crabs have old shells. This suggests that a relatively large number of crabs less than 95 mm wide, the legal minimum size for the fishery, have reached a terminal molt. Crabs of legal size probably also reach a terminal molt but are caught before their shells reach condition 3 and 4.

Reviewing the data in Fig. 2 and 3 and Table 3 we can characterize C. opilio as being less abundant, smaller, and having older shells at the shallow stations than at the deep stations. We suggest that this is because the shallow stations are marginal habitat, supporting fewer crabs which grow more slowly, and because, in the absence of fishing, these small crabs develop old shells after reaching a terminal molt.

Stomach contents of C. opilio. Dry weights of stomach contents exhibit a very wide scatter (Fig. 4). Because of this scatter least squares regressions are not very instructive. Correlation coefficients (r) between log (carapace width) and log (dry weight stomach contents + 0.1 g) were small but statistically significant for three of four dates as noted in the following text table. The 0.1 g was added to dry weights to permit log transformation of the zero values for empty stomachs. We see no conspicuous correlation between weight of stomach contents and the parameters graphed in Fig. 1, 2, and 3. Crabs had very small amounts of food in their stomachs on all four dates. Wet weight of prey would always average less than 1 g/crab compared to an average crab weight of about 300 g. It is possible that crabs regurgitated their food, but we did not test this hypothesis.

Date	Sample size	r	Mean weight (g)	Percentage empty
June '78	65	0.33 ($P < .01$	0.093	28
July '78	32	0.51 ($P < .01$)	0.175	6
Sept. '78	69	0.38 ($P < .01$)	0.109	28
Nov. '78	55	-0.13 ($P > .05$)	0.045	36

Table 3. Number of crabs in each of two size classes at each of three shell conditions. The chi-square tests the hypothesis that the ratio of crab number among the three shell conditions is the same for both size classes.

Date	Depth (fathoms)	Carapace width (mm)	Shell condition 1	2	3-4	Chi-square
Apr. '78	115	< 95	8	41	16	97**
		≥ 95	156	58	1	
	90	< 95	0	24	63	46**
		≥ 95	10	53	18	
	70	< 95	3	44	158	14**
		≥ 95	0	13	10	
June '78	115	< 95	1	34	3	48**
		≥ 95	46	15	2	
	90	< 95	8	17	5	21**
		≥ 95	65	19	4	
	70	< 95	0	16	28	93**
		≥ 95	62	7	0	
July '78	115	< 95	22	105	16	42**
		≥ 95	70	72	2	
	90	< 95	1	43	39	56**
		≥ 95	39	28	10	
	70	< 95	9	30	69	85**
		≥ 95	55	25	6	
	50	< 95	0	14	80	53**
		≥ 95	6	3	3	
Sept. '78	115	< 95	2	130	98	39**
		≥ 95	10	95	16	
	90	< 95	19	88	70	22**
		≥ 95	36	86	27	
	70	< 95	1	22	43	69**
		≥ 95	10	79	4	
	50	< 95	1	44	95	34**
		≥ 95	5	37	14	

. . . Cont'd.

Table 3 (Cont'd.)

Date	Depth (fathoms)	Carapace width (mm)	Shell condition 1	2	3-4	Chi-square
Nov. '78	115	< 95	0	84	157	58**
		≥ 95	1	101	32	
	90	< 95	0	128	44	1[ns]
		≥ 95	0	87	21	
	70	< 95	0	69	26	8**
		≥ 95	3	60	6	
	50	< 95	0	42	51	2[ns]
		≥ 95	0	14	8	
Feb. '79	115	< 95	0	111	66	40**
		≥ 95	1	152	14	
	90	< 95	0	75	59	20**
		≥ 95	1	118	28	
	70	< 95	0	91	86	4*
		≥ 95	0	39	19	
	50	< 95	1	60	94	5*
		≥ 95	3	14	8	
Mar. '79	115	< 95	20	228	45	18**
		≥ 95	26	301	18	
	90	< 95	0	87	317	169**
		≥ 95	2	159	51	
	70	< 95	0	23	235	45**
		≥ 95	1	30	42	
	50	< 95	0	3	37	a
		≥ 95	0	1	2	
	115	< 95	10	90	29	32**
		≥ 95	45	162	10	
	90	< 95	0	29	56	39**
		≥ 95	5	53	12	
	70	< 95	4	35	82	54**
		≥ 95	15	55	14	
	50	< 95	0	38	163	1[ns]
		≥ 95	0	6	16	

* statistically significant at 0.5 level
** statistically significant at 0.01 level
[a] frequency of crabs ≥ 95 mm too low
ns not significant

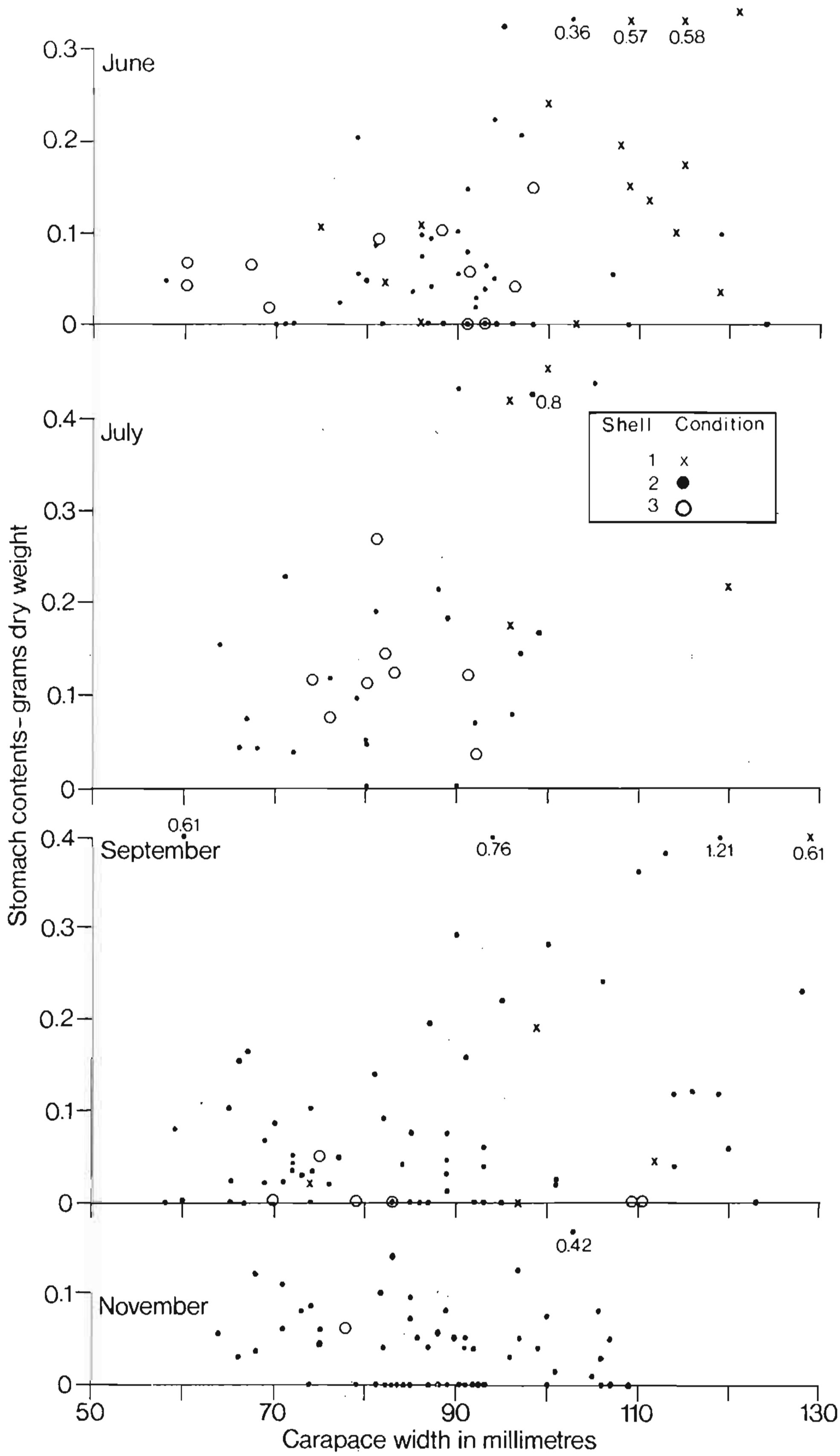

Fig. 4. Scatter plots of C. opilio stomach contents versus carapace width on four dates.

Polychaetes, clams, sea stars, and the ubiquitous "other" were the most frequently occurring prey types (Table 4). Considering the modest sample sizes, the relative importance of prey types was consistent among dates.

DISCUSSION

Ito (1970) caught soft-shelled C. opilio in the Sea of Japan all year but observed peak abundance in September. Peak abundance of soft-shelled C. opilio usually occurs in July in the southern Gulf of St. Lawrence (R. Bailey, pers. comm.). While it occurred in June in Conception Bay in 1978, in other parts of Newfoundland we have observed it most commonly in July, but as late as September.

Stasko (1975) noted for the Gulf of St. Lawrence, as we did for Conception Bay, that the percentage of C. opilio with new shells increased with crab size.

C. opilio has a considerable depth range among geographical areas. The fishery, and presumably peak abundance, is 40-60 fathoms in the Southern Gulf of St. Lawrence (Stasko 1975). In Newfoundland the fishery ranges from 80-180 fathoms and, as seen in this study, might be extended as shallow as 50 fathoms. In the Sea of Japan mature males are found mostly from 140-200 fathoms (Ito 1970) and in the Bering Sea from 33-70 fathoms (Slizkin 1974; quoted in Adams 1979). Depths of large catches of some congenetors are 100 fathoms for C. bairdi in Alaska (W.E. Donaldson 1975; unpublished report), 420-680 fathoms for C. japonicus in the Sea of Japan (Sinoda and Kobayasi 1969), and 275-350 fathoms for C. tanneri off Oregon, U.S.A. (Pereyra 1968).

Yashuda (1967) and Tarverdieva (1976), quoted in Adams (1979), listed principal prey of larger C. opilio as brittle stars, polychaetes, bivalves, and decapods. Powles (1968) found clams, polychaetes, amphipods, and brittle stars most frequently occurring in C. opilio stomachs from the Gaspê area of the Gulf of St. Lawrence. Bivalves, polychaetes, and sea stars were the most frequently occurring prey in Conception Bay. We concur with Adams' (1979) characterization of C. opilio as an omnivorous scavenger.

Biological data on Hyas sp. with which to compare our results with are scarce. Rathbun (1929) lists H. araneus distribution as shallow water to 273 fathoms and northern Labrador to Rhode Island on this coast. She lists H. coarctatus distribution as 4-906 fathoms and northern Newfoundland to North Carolina on this coast. Both Rathbun

Table 4. Number of crab stomachs in which listed prey were found.

Prey	Date				Totals
	June	July	Sept.	Nov.	
Fish	2	8	1	0	11
Sea urchins	3	0	5	1	9
Sea stars	10	5	10	2	27
Crustacea	5	1	0	7	13
Polychaetes	10	5	15	9	39
Clams	6	7	8	13	34
Algae	3	2	0	2	7
Sediment	6	2	4	1	13
Other	9	6	12	9	36

(1925) and Christiansen (1973) give H. araneus as the larger species.

The depth ranges of the three spider crabs studied makes them potentially interesting for comparative physiology studies. Ranges of light and temperature would greatly decrease over the 10 to 115 fathom depth range, substrate would change from rock to mud, and prey types would change.

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REFERENCES

Adams, A.E. 1979. The life history of the snow crab, Chionoecetes opilio: a literature review. Sea Grant Rpt. 78-13. Univ. Alaska, Fairbanks.

Chittleborough, R.G. 1970. Studies on recruitment in the western Australian rock lobster Panulirus longipes cygnus George: density and natural mortality of juveniles. Aust. J. Mar. Freshwat. Res. 21: 131-148.

_____ 1975. Environmental factors affecting growth and survival of juvenile western rock lobsters Panulirus longipes (Milne-Edwards). Aust. J. Mar. Freshwat. Res. 26: 177-196.

Christiansen, M.E. 1973. The complete larval development of Hyas araneus (Linnaeus) and Hyas coarctatus Leach (Decapoda, Branchyura, Majidae) reared in the laboratory. Norw. J. Zool. 21: 63-89.

Ito, K. 1970. Ecological studies on the edible crab Chionoecetes opilio O. Fabricius in the Japan Sea. III. Age and growth as estimated on the basis of the seasonal changes in carapace width frequencies and the carapace hardness. Bull. Jpn. Sea Reg. Fish. Res. Lab 22: 81-116 (English transl. by Fish. Res. Bd Can. Trans. Ser. No. 1512).

Miller, R.J. 1975. Density of the commercial spider crab, Chionoecetes opilio, and calibration of effective area fished per trap using bottom photography. J. Fish. Res. Bd Can. 32: 761-768.

1977. Resource underutilization in a spider crab industry. Fisheries, A Bull. Am. Fish. Soc. 2(3): 9-12.

Miller, R.J., and J. Watson. 1976. Growth per molt and limb regeneration in the spider crab Chionoecetes opilio. J. Fish. Res. Bd Can. 33(7): 1644-1649.

Morgan, G.R. 1974. Aspects of the population dynamics of the western rock lobster, Panulirus cygnus George. II. Seasonal changes in the catchability coefficient. Aust. J. Mar. Freshwat. Res. 25: 249-259.

Newman, G.G., and D.E. Pollock. 1974. Biological cycles, maturity, and availability of rock lobsters Jasus lalandei on two South African fishing grounds. Investl. Rpt. Dir. Sea Fish. S. Afr. No. 107, 16 p.

Pereyra, W.J. 1968. Distribution of juvenile tanner crabs (Chionoecetes tanneri Rathbun), life history model, and fisheries management. Proc. Nat. Shellfish. Assoc. 58: 66-70.

Powles, H. 1968. Distribution and biology of the spider crab Chionoecetes opilio in the Magdalen shallows, Gulf of St. Lawrence. Fish. Res. Bd Can. MS Rep. No. 997: 106 p.

Rathbun, M.J. 1925. The spider crabs of America. U.S. Nat. Mus. Bull. 129, 613 p + 283 plates.

1929. Canadian Atlantic fauna. Arthropoda, Decapoda. Vol. 10.

Sinoda, M., and T. Kobayasi. 1969. Studies on the fishery of zuwai crab in the Japan Sea - VI. Efficiency of the toyama kago (a kind of crab trap) in capturing the beni-zuwai crab. Bull. Jpn. Soc. Sci. Fish. 35: 948-956.

Slizkin, A.G. 1974. Characteristics of the distribution of crabs (Crustacea, Decapoda, Lithodidae, and Majidae) in the Bering Sea. Trudy Vses. Nauchno-Issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 99: 29-37.

Squires, H.J. 1970. Decapod crustaceans of Newfoundland, Labrador and the Canadian Eastern Arctic. Fish. Res. Bd Can. Ms. Rpt. No. 810, 212 p.

Stasko, A.B. 1975. Snow crab fishery in the Gulf of St. Lawrence and preliminary sampling in 1975. Fish. Res. Bd Can. Ms. Rpt. No. 1368, 22 p.

Steele, R.G.D.,and J.H. Torrie. 1960. Principals and procedures of statistics. McGraw-Hill, Toronto, 481 p.

Tarverdieva, M.I. 1976. Feeding of the Kamchatka king crab Paralithodes camtschatica and tanner crabs Chionoecetes bairdi and Chionoecetes opilio in the southeastern part of the Bering Sea. Soviet J. Mar. Biol. 21(1): 34-39.

Watson, J.,and S.L. Simpson. 1969. The queen crab industry in the Atlantic provinces. IDB Proj. Rep. No. 28: 52 p., Fisheries Canada, Ottawa.

Yashuda, T. 1967. Feeding habit of the zuwai-gani, Chionoecetes opilio elongatus, in Wakasa Bay. I. Specific composition of stomach contents. Bull. Jpn. Soc. Sci. Fish. 33: 315-319 (English transl. by Fish. Res. Bd Can. Transl. Ser. No. 1111).