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Food and Feeding of the Short-finned Squid, *Illex illecebrosus*, on the Scotian Shelf in 1978

by

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INTRODUCTION

The objectives of the joint Canada-Japan research cruise were to examine mesh-selectivity aspects of otter trawls and biology and distribution of short-finned squid (Illex illecebrosus). A special aspect in this program was to collect sufficient biological samples and background data to prepare a report on the food and feeding of the short-finned squid. Biologist John Neilson was assigned this aspect of the project during the October/November cruise (2) and biologists from MacLaren Marex Inc. analysed all the samples and prepared most of the report for Cruise 2.

The feeding biology of the short-finned squid is poorly understood, particularly its interactions with other commercially important species (Ennis and Collins, 1978). Such information is difficult to obtain, as several investigators (Ennis and Collins, 1978; Mercer and Paulmier, 1974; and Squires, 1957) have noted the problem in identifying squid gut contents. MacLaren Marex Inc. investigators found similar difficulties in prey identification. Prey have been observed to be macerated before ingestion (O'Dor et al., 1977). However, often hard tissues such as otoliths, squid beaks, vertebrae, lenses, and scales remained as clues as to what the squid were eating. Often, the process of digestion compounded identification problems. However, identification was usually possible to at least the family level with a majority of the material. In this report, aspects of the food and feeding of short-finned squid, including diet, and the effects of location, depth, time of day, and size of squid are examined.

METHODS

Material used in this study was collected on a joint Canada-Japan fisheries research cruise conducted aboard the Japanese stern trawler Shirane Maru on the Scotian Shelf and slope, over the periods June 3 to July 4 (Cruise I) and October 16 to November 14 (Cruise II), 1978. Sampling was depth stratified over the 100-1000 meter range. While only routine gut content observations were made during Cruise 1, samples were collected for laboratory analyses in Cruise 2 from stations defined as Emerald Bank, Sable Island Bank, and Banquereau Bank (Figure 1). Details of the cruises are reported in Amaratunga and Roberge (1979).

In Cruise 1, all trawls except one were bottom trawls of one-half hour duration. An otter trawl was used during the survey. In Cruise 2, all trawls, with the exception of two mid-water sets, were bottom trawls. All trawls, with the exception of the first (which was one-half hour in duration), were of one hour duration.

Once the catch was dropped into the factory sorting area, one hundred short-finned squid from the codend and cover nets were randomly selected for morphometric measurements. Most important of these measurements from this study's perspective was a visual description of the degree of stomach and caecum fullness. This code (from Amaratunga and Durward, 1978) is given below:

Code	Stomach or Caecum
0	empty
1	½ full
2	full
3	distended

Other measurements routinely recorded were mantle length, weight, sexual maturation indices, and the presence of parasites. Set data recorded concurrently included: time (GMT), water depth (m), location, surface, and bottom water (C^{O}) at start and end of trawl, and catch (kg) by species and sex.

In Cruise 2, approximately three hundred samples of male and female squid were weighed after stomach and caecum removal to examine variability due to the degree of gut fullness. From the 100 animals collected for morphometrics, a subsample of 10 squid was taken for laboratory gut content analyses. The

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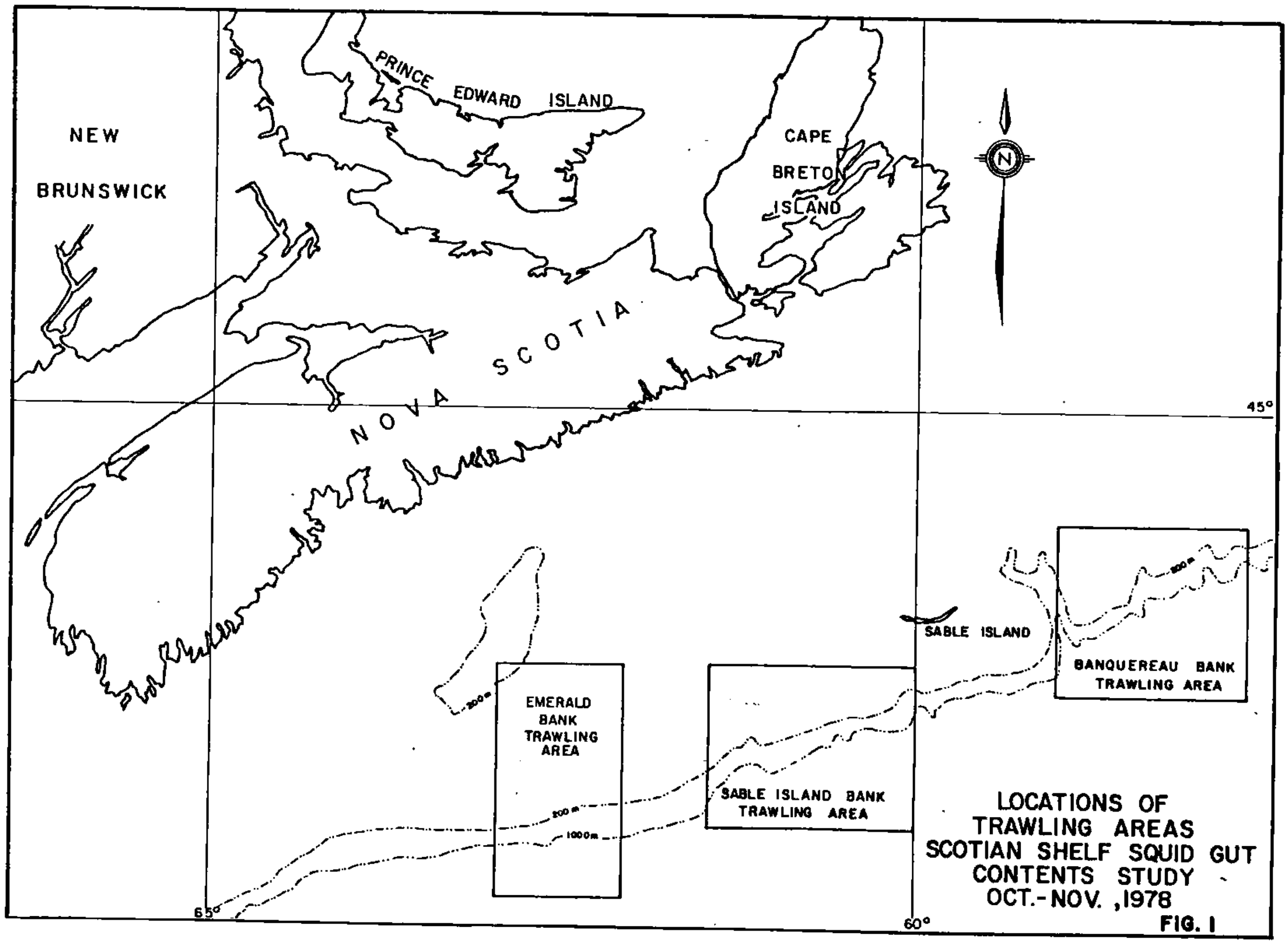

Fig. 1. Location of trawling areas, squid gut contents study, Scotian Shelf, October-November 1978.

digestive tracts, consisting of stomach and caecum, were removed and frozen individually in "whirlpaks". A number corresponding to the morphometric data recorded for the whole animal was assigned to every sample.

In the laboratory, after thawing, stomach and caecum contents were separated from their respective sacs. Stomach and caecum content volumes were determined by volumetric displacement of water in graduated cylinders. Sorting and identification of the prey was aided by the use of binocular dissecting microscopes. A list of references used in identification of biological material is included in the REFERENCES section of the report.

RESULTS AND DISCUSSION

Cruise 1

Gut fullness in relation to season.

A total of 232 sets were carried out in Cruise 1, during the period June 3 to July 4. Morphometric data from these sets carrying the gut fullness indices were analysed for seasonal changes and size-related patterns of feeding. 21,245 squid were studied by pooling index codes 0 and 1 as one unit of "not recently fed" animals and all other codes as "recently fed". Only 20% of squid had recently fed. Text table below shows that number of squid feeding progressively decreased with time.

Percentages by week

Week #:	23	24	25	26	27	Total # squid
Not recently fed	73.7	78.9	87.0	93.0	95.0	17,711
recently fed	26.3	21.1	13.0	7.0	4.3	3,534

This information is difficult to interpret; however, it is possible to propose a hypothesis. In the abundance estimations during this survey, Amaratunga and McQuinn (1979) indicated early June represented the period of immigration, with abundance increasing during the first leg of Cruise 1. Thus, the relative decrease in feeding animals may represent a density dependence. In support of this hypothesis, we may consider the prey and digestive period. It was noted that over 90% of squid showing gut contents fed on crustacea, especially Euphausiids. These guts are characterized by the deep red colouration in the contents, often with identifyable fragments such as eyes and carapace. These contents apparently were digested very rapidly (Boucher-Rodion, 1975), making encounters with gut codes of 0 more common. A large percentage of guts coded 0 often carried fluid of the same characteristic colour. If these animals were feeding high up in the water column, the bottom trawls were less likely to encounter "recently fed" animals, and result in the above observed conditions.

Gut fullness in relation to size of squid.

Gut fullness codes 0 and 1 were once again pooled and compared to the rest of the codes (text table below).

Percentages at each mantle length size class

Mantle length (mm):	115	120	125	130	% range
Not recently fed	86.3	90.2	87.4	87.9	86.3-90.2
Recently fed	13.7	9.8	12.6	12.1	9.8-13.7

135	140	145	150	155	160	165	170	175	180	% range
82.8	83.7	82.4	80.9	82.1	82.5	85.5	85.6	82.7	82.8	80.8-85.6
17.2	16.3	17.6	19.1	17.9	17.5	14.5	14.4	17.3	17.2	14.4-19.1

185	190	195	200	205	210	215	220	% range
79.8	79.0	82.6	84.4	79.8	82.3	82.0	67.9	82.6-67.9
20.2	21.0	17.4	15.6	20.2	17.7	18.0	32.1	17.4-32.1

Squid up to 130 mm in size show "recently fed" percentages ranging from 9.8 to 13.7. This percentage increased to ranges from 14.4% to 19.1% in the larger animals of mantle lengths 135 to 180 mm. Squid larger than 180 mm had an even higher percentage of "recently fed" animals (17.4% to 32.1%). These results concur with O'Dor's et.al. (1977, 1979) laboratory observations of feeding heirarchy, where larger animals were observed to feed first. However, since the prey speces were mainly planktonic crustacea, these figures also reflect squid density dependence on a limited food supply.

Gut fullness in relation to time of day.

Text table below shows percentage recently fed animals were mostly encountered between 12:00 hrs and 18:00 hrs. and 06:00 hrs. and 12:00 hrs. Cruise 2 data which showed similar observations are discussed later.

Percentage at time of day

	00:01-06:00	06:01-12:00	12:01-18:00	18:01-24:00
Not recently fed	95.4	79.8	77.3	85.6
Recently fed	4.6	20.2	22.7	14.4

Cruise 2

A total of 538 digestive tracts (consisting of stomach and caecum) were analysed for prey items taken. Of the total, 235 were collected from the Emerald Bank area, 212 from Sable Island Bank, and 91 from Banquereau Bank.

Data from the three areas were treated as one collective group in the analyses dealing with depth, time, and size-related aspects of feeding. Only stomach contents are considered in the aspects of feeding related to time and depth. The stomach contents are most relevant for these aspects as they represent the most recent ingestions of food. For aspects of the study not critically dependent on time, geographic area, and size-related aspects, stomach and caecum contents are combined.

Tables showing primary data derived from the gut content analyses can be found in the Appendix to this report.

Quantifications of Stomach and Caecum Fullness Indices

It is first useful to determine the meaning and reliability of the visual observations on the degree of stomach and caecum fullness. Mean displacement volumes of stomach and caecum contents (exclusive of fluid) within each fullness category are shown in Table 1, together with standard deviation and range. The mean values increased with each fullness index as expected; however, standard deviations within each fullness category are large, reflecting the wide range of volumetric measurements. There were many occasions when guts were distended by fluid, resulting in a bias toward greater fullness. In a few cases, there appeared to be an error in recording or transcription of data as caecums noted as Code 0 or 1 contained up to 12 cc of food. Stomach volumes in Code 2 and 3 categories are shown to exceed caecum volumes in corresponding fullness categories by a factor of more than two.

Contents of the digestive tract constitute a highly variable fraction of squid total weight. As indicated in O'Dor et al. (1979), where squid were observed to feed up to 23 % of their body weight, length-weight relationships were likely to show variability associated with different degrees of gut fullness. To test this, length-weight data for gut-out and gut-in animals were logged and equations describing these relationships were generated by linear regression. There was no significant difference observed between the correlation coefficients of the gut-in and gut-out samples for either sex, which suggests that there was little variability due to degrees of gut fullness. However, the sets from which these data originated were all completed during the period of higher percentage of empty stomachs (Figure 2). Of the squid examined during these sets, 85.6% of stomachs varied considerably during the diel cycle; therefore, comparison of gut-in and gut-out, length-weight relationships becomes specific for time of day.

Table 1. Relation of observed gut fullness indices to gut content volume of short-finned squid, Scotian Shelf, October-November 1978.

Fullness Index [1]	No. of Squid	VOLUME (c.c.)		
		Mean Vol.	One Standard Deviation	Range
Stomach Code				
0	296	0.3	0.6	0 - 4.5
1	110	1.5	1.9	0 - 9.0
2	61	6.4	7.6	0.5 - 40.0
3	30	15.8	9.9	0.5 - 40.0
TOTAL	497			
Caecum Code				
0	305	0.3	1.2	0 - 12.0
1	140	1.6	2.1	0 - 12.5
2	43	2.8	2.3	0 - 10.1
3	9	5.6	5.6	0.2 - 25.0
TOTAL	497			

[1] Codes: 0 = empty; 1 = half full; 2 = full; 3 - distended.

The Diel Cycle of Feeding Activity

The diel cycle of feeding activity is shown in Figure 2. This figure is derived from data taken from 21 trawl sets, all of which were in the 201-300 meter depth stratum. The mean number of animals in each of the sets was 95. The curve represents observations on a total of 1,995 squid.

The percentage of squid with empty stomachs (stomach code 0) is generally higher during the period 0001-1200 Solar Time than in the period 1201-2400 Solar Time. The data shown in Figure 2 suggests a 24-hour feeding cycle. This is supported by Boucher-Rodoni's (1975) work which demonstrated a very fast rate of digestion, with prey passing through the digestive tract in 12 hours.

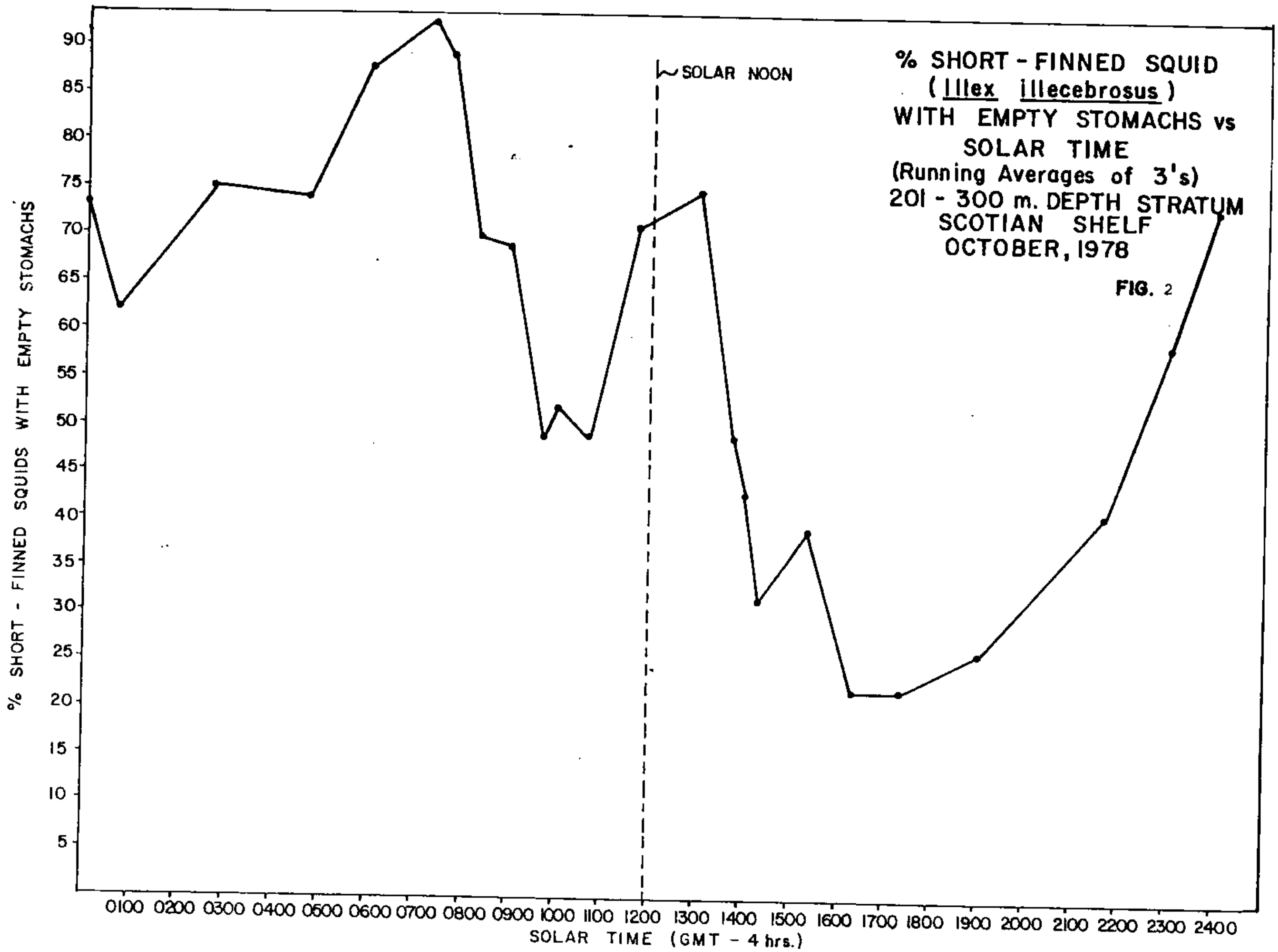

Fig. 2. Percent short-finned squid (*Illex illecebrosus*) with empty stomachs in relation to time of capture, Scotian Shelf, October 1978.

It is quite likely that this represents smaller meals and the pattern may change with larger meals.

It is known that squid migrate on a diel basis under laboratory conditions, showing a preference for surface waters during dark periods (O'Dor et al., 1977). In the field, while there were squid catches made at bottom around the clock, evidence of a diel migration was seen from the relative abundance (Amaratunga and McQuinn, 1979). It is possible that only part of the short-finned squid population vertically migrates on a diel basis.

If Figure 2 is considered in light of this, the downward trend in the percentage of empty stomachs exhibited by squid taken in bottom trawls between 0701 and 1600 Solar Time may signify the return of squid which have fed higher in the water column to the balance of the population which have remained on or near the bottom, possibly feeding at a relatively lower rate.

The Relationship of Mantle Length to Feeding Patterns

In squid larger than 210-220 mm, an upward trend (albeit fluctuating) was found in the proportion of fish in the squid diet (Table 2). The myctophids Ceratoscopelus maderensis and Myctophum punctatum were present, as were barracudinas (Notolepis rissoi), several gadid (cod) species, and at least one representative of the Macrouridae (grenadiers). Squires (1957) examined short-finned squid gut contents from the outer Grand Banks area, and was able to demonstrate a similar increasing proportion of fish in the diet with increasing size. Capelin, redfish, and gadids were the fish identified.

Squires (1957) further noted a general decrease in the proportion of invertebrates with increasing size. Unidentified squid was the most frequently found invertebrate prey item in Squires' largest size categories for short-finned squid. In the present study it was found that a portion of squid taken as prey was Illex illecebrosus. Moreover, there were enough similarities to assume that the species in the "unidentified squid" category were largely Illex, although sufficient evidence was not present for positive identification. As can be seen in Table 2, the proportion of squid taken as prey generally increases with increasing mantle size.

Euphausiids (Thysanoessa sp. and/or Meganyctiphanes sp.[1]) comprised the most frequently found prey item in all size classes up to the 250-260 m size. Squires' (1957) Grand Bank sample had a lesser occurrence of euphausiids in

[1]Most distinguishing characteristics of crustaceans were lost to maceration and rapid digestion. Mandibular structure indicated that many of the euphausiids taken were of the genus Thysanoessa and/or Meganyctiphanes; however, individual specific identification on this basis could not be assured.

size classes greater than 210 m, with a correspondingly greater frequency of fish remains. However, a note of caution with regard to the interpretation of squid gut contents. Under laboratory conditions, squid feeding on live Fundulus sp. tend to "dissect" their prey and very few bony parts appear to be ingested. (O'Dor et al., 1979). Since the occurrence of fish in the preceding analyses was based on the presence of hard parts such as otoliths, vertebrae and scales, it is conceivable that the importance of fish in the diet of squids may be underestimated.

Table 2. Percent occurrence of prey item among all prey items relative to mantle length of predator (*Illex illecebrosus*), Scotian Shelf, October-November 1978.

PREY ITEM	MANTLE LENGTH (mm)							
	< 190	190-200	210-220	230-240	250-260	270-280	290-300	> 300
Fish								
Myctophum punctatum				1.2	2.2	4.0		
Ceratoscopelus maderensis				2.5	2.2	1.0		
Notolepis rissoi				0.6	2.8	1.0	2.9	
Urophycis chesteri					0.6	1.0		
Merluccius sp.						1.0		
Gadidae		33.3	8.2	2.2	1.1	2.0	5.9	
Macrouridae				0.9	1.7	1.0	2.9	
Unidentified fish	33.3	33.3	18.4	26.9	19.0	26.7	20.6	46.2
TOTAL FISH	33.3	66.7	26.6	34.3	29.6	37.7	32.3	46.2
Crustacea								
Euphausiids (Meganyctiphanes sp. and/or Thysanoessa sp.)		33.3	36.8	29.9	24.5	15.8	20.6	30.8
Unidentified Euphausiids			2.0	0.9	0.6			
Candacia armata				0.3				
Euchaeta norvegica			2.0	1.5	1.7			
Unidentified Copepods				0.3				
Parathemisto sp.				0.3	0.6			
Unidentified Crustacea			6.1	4.0	5.0	2.0		
TOTAL CRUSTACEANS		33.3	46.9	37.2	32.4	17.8	20.6	30.8
Cephalopods								
Illex illecebrosus	33.3		2.0	2.5	0.6	11.9		7.7
Gonatus fabricii						1.0		
Histioteuthidae					0.6			
Unidentified squid	33.3		8.2	11.4	18.4	21.8	35.3	15.3
TOTAL CEPHALOPODS	66.7		10.2	13.9	19.6	34.7	35.3	23.0
Misc.								
Pteropods			6.2	4.3	7.8	3.0		
Chaetognaths			2.0					
Unidentified Prey Items			8.1	10.3	10.6	6.8	11.8	
TOTAL MISC.			16.3	14.6	18.4	9.8	11.8	
TOTAL ITEMS (%)	100	100	100	100	100	100	100	100
TOTAL ITEMS (No.)	3	3	49	324	179	101	34	13

Depth-Related Aspects of Feeding

Two aspects of squid feeding are examined in relation to depth. Firstly, the problem of whether or not squid feed at all depths sampled is explored. Secondly, what squid feed on at different depths is discussed.

On the basis that different levels of feeding activity occur at different times, it was possible to split a day into two 12-hour segments. This reduces variance that would be introduced due to time-specific levels of feeding activity.

Tables 3 and 4 show degrees of stomach fullness cross tabulated with depth and time. In general, degree of stomach fullness was less during the period 0001-1200 Solar Time, compared to the period 1201-2400. This was also apparent in Figure 2. Of further interest is the relatively high proportion of animals in 701-1000 m depth stratum which have empty stomachs. Lu (1973) and O'Dor et al. (1977), suggested that squid moving offshore may show ontogenetic descent with maturation and that animals stop feeding at maturity. This hypothesis is supported by data gathered on this cruise, in that larger squid were more common in deep water, and usually were in a more advanced state of maturity than those encountered in shallower water. This condition was most apparent in females.

Table 3. Degree of stomach fullness for short-finned squid taken at different depths during time period 0001-1200 solar time (GMT), Scotian Shelf, October-November 1978. (Number in brackets represents percent of all squid stomachs in depth stratum with the particular stomach fullness code.)

DEPTH (m)	STOMACH FULLNESS CODE [No. (%)]			
	0	1	2	3
<100	8 (73)	1 (9)	2 (18)	0
100-200	62 (60)	25 (24)	11 (10)	6 (6)
201-300	52 (63)	22 (26)	0	9 (11)
301-400	7 (27)	9 (35)	7 (27)	3 (11)
401-500	6 (43)	0	6 (43)	2 (14)
501-700	7 (70)	0	2 (20)	1 (10)
701-1000	11 (73)	3 (20)	1 (7)	0
TOTALS	153	60	29	21

Table 4. Degree of stomach fullness for short-finned squid taken at different depths during time period 1201-2400 solar time (GMT), Scotian Shelf, October-November 1978. (Number in brackets represents percent of all squid stomachs in depth stratum with the particular stomach fullness code.)

DEPTH (m)	STOMACH FULLNESS CODE [No. (%)]			
	0	1	2	3
<100	4 (40)	6 (60)	0	0
100-200	31 (49)	15 (24)	9 (14)	8 (13)
201-300	36 (44)	17 (21)	14 (17)	15 (18)
301-400	15 (54)	8 (29)	3 (11)	2 (7)
401-500	24 (62)	4 (10)	9 (23)	2 (5)
501-700	12 (46)	6 (23)	5 (22)	3 (12)
701-1000	18 (78)	4 (17)	0	1 (4)
TOTALS	140	61	42	34

Table 5 shows prey selection at varying depths. Fish dominated the gut contents in the < 100, 101-300 and 701-1000 m strata. The majority of gadids (cod) identified were found in the 101-200 m statum, and four of five macrourid (grenadier) occurrences were in the 701-1000 m depth stratum. Crustacea, mainly the euphausiids Meganyctiphanes sp. and/or Thysanoessa sp., dominated the other depth strata. Cephalopods occurred in approximately the same proportion in all depth strata. This concurs with cannibalism observed in the laboratory (O'Dor et al., 1977). However, the possibility that squid could feed while in the net (through cannibalism and defense) cannot be overlooked. Most pteropods found in the guts were taken from shallow waters. The occurrence of pteropods in the squid stomachs is somewhat puzzling, as pteropods are small prey items. It is possible that they may have been taken incidentally along with other prey. The possibility that pteropods were from stomachs of other prey was rejected because the fragile pteropod shells were in very good condition.

Geographic Variation in the Prey Species

The squid taken in the Emerald Bank area had preyed mostly on fish (Table 6). Fish totalled 39.5% of their diet. Squid from Banquereau Bank showed a 32.3% occurrence of fish, and Sable Island Bank had the lowest with 27.2% fish occurrence. Of the identifiable fish species, the gadids were most frequent in the squid taken from the Sable Island and Emerald Banks. Notolepis rissoi (Short barracudina) showed the highest occurrence in the Banquereau Bank squid.

The greatest occurrence of crustaceans was found in squid from the Sable Island Bank. Euphausiids (Meganyctiphanes sp. and/or Thysanoessa sp.) comprised 34.1% of the squid diet, with the total crustacean occurrence for this region being 40.2%. Crustaceans occurred in 35.3% and 29.5% of the squid taken from Emerald and Banquereau Banks, respectively. The prey item of greatest abundance in these areas was also the Meganyctiphanes sp. and/or Thysanoessa sp.

Table 5. Prey found in short-finned squid stomachs at different depths, Scotian Shelf, October-November 1978. (Figure in bracket represents the percent of all prey items in depth stratum that indicated prey item comprises.)

PREY ITEM	DEPTH STRATUM (m)													
	< 100		100-200		201-300		301-400		401-500		501-700		701-1000	
Fish														
Myctophum punctatum			6	(3)	2	(1)	3	(5)	1	(3)	1	(6)		
Ceratoscopelus maderensis			5	(2)	2	(1)	3	(5)			1	(6)	3	(18)
Notolepis rissoi			3	(2)	7	(4)								
Urophycis chesteri			2	(1)										
Merluccius sp.			1	(1)										
Gadidae			17	(8)	1	(1)	1	(1)					2	(12)
Macrouridae			1	(1)									4	(24)
Unidentified fish	15	(45)	56	(26)	51	(27)	17	(26)	10	(35)				
TOTAL FISH	15	(45)	91	(44)	61	(34)	24	(37)	11	(38)	2	(12)	9	(54)
Crustacea														
Euphausiids (Meganyctiphanes sp. and/or Thysanoessa sp.)	4	(13)	64	(30)	66	(35)	25	(38)	9	(31)	11	(64)		
Unidentified Euphausiids									2	(7)				
Candacia armata							1	(1)						
Euchaeta norvegica			2	(1)	5	(2)								
Unidentified Copepods			1	(1)										
Parathemisto sp.					1	(1)								
Unidentified Crustacea	1	(3)	7	(3)	7	(3)	1	(1)	1	(3)			5	(28)
TOTAL CRUSTACEANS	5	(16)	74	(35)	79	(41)	27	(40)	12	(41)	11	(64)	5	(28)
Cephalopods														
Illex illecebrosus	1	(3)	5	(2)	9	(5)	4	(6)	1	(3)	2	(12)		
Gonatus fabricii			1	(1)										
Unidentified Histioteuthid					1	(1)								
Unidentified squid	6	(18)	31	(14)	29	(15)	9	(14)	5	(18)	2	(12)	3	(18)
TOTAL CEPHALOPODS	7	(21)	37	(17)	39	(21)	13	(20)	6	(21)	4	(24)	3	(18)
Miscellaneous														
Pteropods	6	(18)	10	(4)	8	(4)	2	(3)						
TOTAL %	100%		100%		100%		100%		100%		100%		100%	
TOTAL PREY ITEMS IN DEPTH STRATUM	33		212		189		66		29		17		17	

Of the identifiable cephalopods, Illex illecebrosus was the most common species in the analysed squid digestive tracts. Sable Island Bank and Emerald Bank showed a similar percent occurrence of cephalopods in squid stomachs with Bankquereau Bank having the lowest occurrence.

Miscellaneous prey species occurred in guts from all three areas. Pteropods were found in both Sable Island Bank and Banquereau Bank squid. Chaetognath remains were found in one stomach from Banquereau Bank.

Table 6. Comparison of prey species found in the digestive tracts of the short-finned squid in the Sable Island, Emerald Island and Banquereau Banks areas, October-November 1978. (The number in brackets indicates the percent of all prey occurrences that item represents.)

PREY SPECIES	SABLE ISLAND BANK	EMERALD BANK	BANQUEREAU BANK
Fish			
Myctophum punctatum	5 (1.4)	5 (1.9)	2 (1.4)
Ceratoscopelus maderensis	4 (1.2)	7 (2.8)	2 (1.4)
Notolepis rissoi	4 (1.2)	1 (0.4)	5 (3.6)
Urophycis chesteri		1 (0.4)	1 (0.7)
Merluccius sp.		1 (0.4)	
Gadidae	8 (2.3)	9 (3.5)	1 (0.7)
Macrouridae		8 (3.1)	
Unidentified fish	73 (21.1)	69 (27.0)	34 (24.5)
TOTAL FISH	94 (27.2)	101 (39.5)	45 (32.3)
Crustacea			
Euphausiid (Meganyctiphanes sp. and/or Thysanoessa sp.)	118 (34.1)	74 (29.0)	28 (20.2)
Unidentified Euphausiids	3 (0.9)	3 (1.2)	
Candacia armata		1 (0.4)	
Euchaeta norvegica	3 (0.9)		6 (4.3)
Unidentified copepods			1 (0.7)
Parathemisto sp.		1 (0.4)	
Unidentified Crustacea	15 (4.3)	11 (4.3)	6 (4.3)
TOTAL CRUSTACEA	139 (40.2)	90 (35.3)	41 (29.5)
Cephalopods			
Illex illecebrosus	7 (2.0)	12 (4.7)	5 (3.6)
Gonatus fabricii		1 (0.4)	
Histioteuthidae			1 (0.7)
Unidentified Cephalopod	59 (17.1)	36 (14.2)	16 (11.5)
TOTAL CEPHALOPODS	66 (19.1)	49 (19.3)	22 (15.8)

Table 6. (cont'd)

PREY SPECIES	SABLE ISLAND BANK	EMERALD BANK	BANQUEREAU BANK
Miscellaneous			
Pteropods	22 (6.3)		7 (5.1)
Chaetognaths			1 (0.7)
Unidentified Prey Items	25 (7.2)	15 (5.9)	23 (16.6)
TOTAL MISCELLANEOUS	47 (13.5)	15 (5.9)	31 (22.4)
TOTAL PREY ITEM OCCURRENCE	346 (100.0)	255 (100.0)	139 (100.0)
NUMBER OF SQUID ANALYZED	212	235	91

SUMMARY

Cruise 1

1. 20% of 21,245 squid studied had gut contents greater than Code 0 and 1. Fewer squid had "recently fed" as the season progressed, probably relating to density dependence.
2. Diet during this season consisted mostly of crustacea.
3. Larger squid had higher percentage of "recently fed" conditions.

Cruise 2

1. Gut fullness indices are found to be useful descriptive units with mean volume showing increments with each index. However, variance of each mean is large.
2. Feeding activity varies with time of day. Peak feeding activity may occur in the period 0001-0800 Solar Time. Time of capture is important in comparisons of gut-in and gut-out length-weight relationships.
3. Larger squid tend to have a lesser proportion of crustaceans in their diet, relative to other prey items. A trend towards a greater cephalopod component in the squid diet is also seen with increasing size.
4. Squid appear to feed at all depths, with the possible exception of the 701-1000 m depth stratum. Cessation of active feeding with the onset of

sexual maturity is postulated. Fish were the predominant prey in the extreme depth strata, with crustacea most commonly found in all others.

5. Squid from the Banquereau Bank had more fish in their diets than those from Emerald Bank and Sable Island Bank. Fish and crustacean components were roughly equal in Emerald Bank, while in Sable Island Bank, crustaceans was the major component.

6. With the qualification that fish remains may not be as recognizable in squid gut contents as are crustacean remains, euphausiids were the most commonly found prey item.

   Illex preying on commercially important species is also worthy of note. In addition to the occurrence of Illex remains in stomachs, several gadid species including silver hade and longfin hake, along with grenadiers (at greater depths) were found.

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APPENDIX

Table 1. Prey identified from digestive tracts of *Illex illecebrosus* taken on Emerald Bank, October-November 1978.

SET No. (# of guts analyzed)		STOMACH PREY ITEMS	CAECUM PREY ITEMS
251	(9)	Urophycis chesteri, Merluccius sp., unidentified fish	Unidentified fish
252	(10)	Ceratoscopelus maderensis, Illex illecebrosus, unidentified fish, unidentified prey items	Illex illecebrosus, unidentified fish, unidentified prey items
253	(5)	Unidentified cephalapods	Illex illecebrosus
254	(8)	Myctophum punctatum	Myctophum punctatum
255	(10)	Illex illecebrosus, unidentified fish	Illex illecebrosus, unidentified prey items
256	(11)	Gadid, Macrourid, unidentified fish, unidentified crustacea, unidentified cephalopods	Macrourid, unidentified fish, unidentified crustaceans, unidentified cephalopods
257	(5)	Ceratoscopelus maderensis, Macrourid, unidentified cephalopods	Ceratoscopelus maderensis, Macrourid, unidentified cephalopods
258	(5)	Gadid, unidentified fish, euphausiids[1], unidentified cephalopods, unidentified prey items	Unidentified fish material, euphausiids[1], Illex illecebrosus, unidentified cephalopods
259	(5)	Gadid	-
260	(4)	Euphausiids[1]	Euphausiids[1]
261	(5)	Notolepis rissoi, Ceratoscopelus maderensis, gadid, unidentified fish material, euphausiids[1]	Notolepis rissoi, Ceratoscopelus maderensis, euphausiids[1], unidentified fish
262	(5)	Gadid, Ceratoscopelus maderensis, unidentified fish, Gonatus fabricii	Ceratoscopelus maderensis, Gonatus fabricii, unidentified fish
263	(5)	Unidentified crustacea	Unidentified crustacea
264	(5)	Unidentified fish, euphausiids[1]	Unidentified fish, euphausiids[1]
265	(6)	Myctophum punctatum, unidentified fish, euphausiids[1]	Myctophum punctatum, unidentified fish
267	(5)	Euphausiids[1], Illex illecebrosus, unidentified cephalopods	Euphausiids[1], Illex illecebrosus, unidentified cephalopods
268	(5)	Euphausiids[1], Illex illecebrosus, unidentified cephalopods	Euphausiids[1], Illex illecebrosus, unidentified cephalopods
269	(16)	Unidentified fish, unidentified crustacea, euphausiids[1], Illex illecebrosus, unidentified prey items	Unidentified fish, euphausiids[1], unidentified crustacea, Illex illecebrosus, unidentified prey items
270	(4)	Macrourid, unidentified crustacea, unidentified prey items	Euphausiids[1], unidentified crustacea

SET No.	(# of guts analyzed)	STOMACH PREY ITEMS	CAECUM PREY ITEMS
337	(5)	Myctophum punctatum, unidentified fish, unidentified cephalopods	Myctophum punctatum, unidentified cephalopods
338	(5)	Unidentified fish, unidentified cephalopod	Unidentified cephalopod
339	(5)	Ceratoscopelus maderensis, unidentified cephalopod	Unidentified fish, unidentified cephalopod
340	(4)	Unidentified prey items	Macrourid, unidentified prey items
341	(5)	Macrourid, Ceratoscopelus maderensis, Myctophum punctatum, unidentified fish, euphausiids[1], unidentified cephalopods	Unidentified fish, Ceratoscopelus maderensis, Myctophum punctatum
342	(5)	Gadid, Illex illecebrosus	Illex illecebrosus
343	(5)	Unidentified crustacea, unidentified cephalopods, unidentified prey items	Unidentified crustacea, unidentified cephalopods, unidentified prey items
344	(5)	Myctophum punctatum, unidentified fish, unidentified cephalopods	Illex illecebrosus, unidentified fish, unidentified cephalopods, unidentified prey items
345	(10)	Unidentified fish, euphausiids[1], Illex illecebrosus, unidentified cephalopods	Unidentified fish, euphausiids[1], unidentified cephalopod
346	(5)	Unidentified fish, euphausiids[1], Illex illecebrosus, unidentified cephalopods	Unidentified fish, euphausiids[1], Illex illecebrosus, unidentified cephalopods, unidentified prey items
348	(5)	Unidentified fish, Candacia armata, euphausiids[1], unidentified cephalopods	Unidentified fish, euphausiids[1], unidentified cephalopod
349	(5)	Euphausiids[1], unidentified crustacea, Illex illecebrosus, unidentified cephalopods	Euphausiids[1], unidentified crustacea, unidentified cephalopods
351	(5)	Unidentified fish, euphausiids[1], unidentified cephalopods	Euphausiids[1], unidentified cephalopods, unidentified prey items
352	(5)	Unidentified fish, euphausiids[1]	Euphausiids[1]
353	(3)	Unidentified fish, euphausiids[1], unidentified cephalopods, unidentified prey items	Unidentified fish, unidentified euphausiids, unidentified cephalopods
355	(5)	Unidentified fish, euphausiids[1]	Unidentified fish, euphausiids[1], Illex illecebrosus
358	(5)	Parathemisto sp., unidentified cephalopods	-
359	(5)	Unidentified fish, euphausiids[1],	Unidentified fish, euphausiids[1], unidentified cephalopods
360	(5)	Unidentified fish, euphausiids[1], Illex illecebrosus	Unidentified fish, euphausiids[1], unidentified cephalopods

SET No. (# of guts analyzed)	STOMACH PREY ITEMS	CAECUM PREY ITEMS
361 (5)	Unidentified fish, euphausiids[1], unidentified cephalopods	Unidentified fish, euphausiids[1], unidentified cephalopods
363 (5)	Unidentified cephalopods	-

[1] Most distinguishing characteristics of crustaceans were lost to maceration and rapid digestion. Mandibular structure indicated that many of the euphausiids taken were of the genus Thysanoessa and/or Meganyctiphanes; however, individual specific identification on this basis could not be assured.

Table 2. Prey identified from digestive tracts of *Illex illecebrosus* taken on Sable Island Bank, October-November 1978.

SET No. (# of guts analyzed)	STOMACH PREY ITEMS	CAECUM PREY ITEMS
274 (5)	Gadid	Gadid, unidentified cephalopods
275 (5)	Unidentified fish, euphausiids[1], unidentified crustacea, unidentified cephalopods, unidentified prey items	Euphausiids[1], unidentified prey items
276 (5)	Notolepis rissoi, unidentified fish, euphausiids[1], unidentified crustacea, Illex illecebrosus	Unidentified fish, euphausiids[1], unidentified crustacea
277 (5)	Ceratoscopelus maderensis, unidentified fish, euphausiids[1], unidentified prey items	Unidentified fish, euphausiids[1], unidentified prey items
278 (5)	Gadid, unidentified fish, euphausiids[1], unidentified crustacea	Unidentified fish, euphausiids[1], unidentified crustacea, unidentified prey items
279 (4)	Unidentified fish, euphausiids[1], unidentified crustacea, unidentified cephalopods	Unidentified fish, unidentified prey items
280 (4)	Unidentified fish	Unidentified fish
281 (5)	Euphausiids[1], unidentified prey items	Euphausiids[1], unidentified prey items
282 (5)	Unidentified fish, euphausiids[1], Illex illecebrosus	Unidentified fish, euphausiids[1], unidentified crustacea
283 (5)	Gadid, euphausiids[1]	Gadid, euphausiids[1]
286 (5)	Unidentified fish, euphausiids[1], Illex illecebrosus	Unidentified fish, euphausiids[1]
287 (5)	Unidentified fish, euphausiids[1]	Unidentified fish, euphausiids[1]
288 (5)	Notolepis rissoi, unidentified fish, euphausiids[1]	Notolepis rissoi, unidentified fish, euphausiids[1], unidentified prey items

SET No. (# of guts analyzed)	STOMACH PREY ITEMS	CAECUM PREY ITEMS
289 (5)	Gadid, euphausiids[1], unidentified prey items	Euphausiids[1], unidentified prey items
290 (5)	Myctophum punctatum, unidentified fish, euphausiids[1], Limacina sp.	Myctophum punctatum, unidentified fish, euphausiids[1], Limacina sp.
291 (5)	Myctophum punctatum, unidentified fish, euphausiids[1]	Myctophum punctatum, unidentified fish, euphausiids[1], unidentified prey items
292 (5)	Myctophum punctatum, unidentified fish, euphausiids[1]	Myctophum punctatum, unidentified fish, euphausiids[1], unidentified prey items
293 (5)	Notolepis rissoi, euphausiids[1], unidentified cephalopods	Euphausiids[1], unidentified cephalopods
294 (5)	Unidentified fish, euphausiids[1], unidentified cephalopods	Euphausiids[1], unidentified material
295 (5)	Unidentified fish, euphausiids[1], unidentified cephalopods	Unidentified fish, euphausiids[1], unidentified cephalopods
296 (5)	Unidentified fish, euphausiids[1], unidentified cephalopods, Limacina sp., unidentified prey items	Unidentified fish, euphausiids[1], unidentified cephalopods
297 (4)	Unidentified fish, euphausiids[1], unidentified crustacea	Unidentified fish, euphausiids[1], unidentified crustacea
298 (5)	Unidentified fish, euphausiids[1]	Euphausiids[1], unidentified cephalopod, unidentified prey material
299 (5)	Unidentified fish, euphausiids[1], pteropods	Unidentified fish, euphausiids[1], unidentified cephalopods, unidentified prey material
364 (5)	Unidentified fish, euphausiids[1], unidentified cephalopods	Unidentified fish, unidentified crustacea, unidentified cephalopods, unidentified prey items
365 (5)	Euphausiids[1], unidentified cephalopods, Limacina sp.	Euphausiids[1], unidentified cephalopods
366 (5)	Unidentified fish, euphausiids[1], unidentified cephalopods	Unidentified fish, euphausiids[1], unidentified cephalopods
367 (5)	Unidentified prey material	-
368 (5)	Unidentified fish, euphausiids[1], unidentified cephalopods	Euphausiids[1], unidentified cephalopods, Limacina sp.
369 (5)	Unidentified fish, unidentified euphausiids[1], unidentified cephalopods, unidentified crustacea	Unidentified fish, euphausiids[1], unidentified crustacea
372 (5)	Euphausiids[1], unidentified cephalopods	Euphausiids[1], unidentified cephalopods
373 (5)	Unidentified fish, euphausiids[1], unidentified crustacea, unidentified cephalopod, unidentified pteropod	Unidentified fish, euphausiids[1], unidentified crustacea, unidentified cephalopods, unidentified pteropod
374 (5)	Euphausiids[1], unidentified crustacea, Illex illecebrosus, unidentified cephalopods	Illex illecebrosus, unidentified cephalopods, unidentified crustacea

SET No. (# of guts analyzed)		STOMACH PREY ITEMS	CAECUM PREY ITEMS
376	(5)	Ceratoscopelus maderensis, unidentified fish, euphausiids[1], pteropods	Euphausiids[1], unidentified crustacea, unidentified cephalopods, unidentified prey items
377	(5)	Unidentified fish, Illex illecebrosus, unidentified cephalopods, unidentified prey items	Unidentified fish, Illex illecebrosus, unidentified cephalopods
378	(5)	Unidentified fish, unidentified cephalopod, unidentified pteropods	Unidentified fish, unidentified cephalopod
379	(5)	Unidentified fish, unidentified cephalopod	Unidentified fish, unidentified cephalopods
381	(5)	Notolepis rissoi, Myctophum punctatum, unidentified fish, euphausiids[1], unidentified cephalopods	Notolepis rissoi, Myctophum punctatum, unidentified fish, euphausiids[1], unidentified cephalopods, unidentified prey items
383	(5)	Unidentified fish, euphausiids[1], Euchaeta norvegica, unidentified cephalopods, Limacina sp.	Euphausiids[1], Euchaeta norvegica, unidentified cephalopods
384	(5)	Myctophum punctatum, gadid, unidentified fish, unidentified crustacea, pteropods	Unidentified fish, unidentified cephalopod, unidentified prey items
385	(5)	Unidentified fish, unidentified crustacea, unidentified cephalopod, Limacina sp., unidentified pteropods	Unidentified fish, euphausiids[1], unidentified cephalopods
389	(5)	Unidentified fish, euphausiids[1], unidentified cephalopods, Limacina sp.	Unidentified fish, euphausiids[1], unidentified cephalopods
391	(5)	Euphausiids[1], unidentified cephalopods, Limacina sp.	Euphausiids[1], unidentified cephalopods, Limacina sp.

[1] Most distinguishing characteristics of crustaceans were lost to maceration and rapid digestion. Mandibular structure indicated that many of the euphausiids taken were of the genus Thysanoessa and/or Meganyctiphanes; however, individual specific identification on this basis could not be assured.

Table 3. Prey identified from digestive tracts of *Illex illecebrosus* taken on Banquereau Bank, October-November 1978.

SET No. (# of guts analyzed)		STOMACH PREY ITEMS	CAECUM PREY ITEMS
304	(5)	Unidentified fish, euphausiids[1], Illex illecebrosus, unidentified cephalopods, unidentified prey items	Unidentified fish, unidentified crustacea, Illex illecebrosus, unidentified cephalopods
305	(5)	Unidentified fish, euphausiids[1], Illex illecebrosus, pteropods, unidentified prey items	Unidentified fish, Illex illecebrosus

SET No. (# of guts analyzed)		STOMACH PREY ITEMS	CAECUM PREY ITEMS
306	(5)	Euphausiid[1], Illex illecebrosus, unidentified cephalopod, Limacina sp., unidentified pteropod	Unidentified cephalopod, Illex illecebrosus, Limacina sp., unidentified prey items
307	(5)	Unidentified fish, euphausiids[1], unidentified copepods, unidentified prey items	Unidentified fish, euphausiids[1], unidentified copepods
308	(5)	Unidentified fish	Unidentified fish, unidentified prey items
309	(5)	Unidentified fish, euphausiids[1], pteropods	Unidentified crustacea, pteropods, unidentified prey items
310	(5)	Unidentified fish, euphausiids[1], Euchaeta norvegica, unidentified cephalopods	Unidentified cephalopods, euphausiids[1], Euchaeta norvegica, unidentified crustacea, unidentified chaetognaths, Limacina sp.
311	(5)	Unidentified fish, Illex illecebrosus, unidentified cephalopods, unidentified prey items	Unidentified fishes, unidentified cephalopods, unidentified prey material
312	(5)	Notolepis rissoi, Ceratoscopelus maderensis, euphausiids[1], Limacina sp.	Unidentified fish, euphausiids[1], unidentified prey material
313	(5)	Myctophum punctatum, euphausiids[1], unidentified cephalopods, unidentified prey items	Myctophum punctatum, euphausiids[1], unidentified cephalopods, unidentified prey items
315	(5)	Euphausiids[1]	Unidentified fish, euphausiids[1], unidentified cephalopod, unidentified prey item
316	(5)	Unidentified fish, euphausiids[1], unidentified prey items	Unidentified fish, euphausiids[1], unidentified prey items
317	(5)	Urophycis chesteri, unidentified fish	Urophycis chesteri, unidentified fish, unidentified prey material
319	(5)	Notolepis rissoi, euphausiids[1], Histioteuthidae	Notolepis rissoi, euphausiids[1]
321	(5)	Unidentified fish, unidentified cephalopod	Unidentified fish, unidentified prey items
322	(6)	Unidentified fish, Illex illecebrosus	Unidentified fish, unidentified prey items
325	(5)	Gadid, unidentified cephalopod	Unidentified fish
405	(5)	Ceratoscopelus maderensis, Myctophum punctatum, unidentified fish, Euchaeta norvegica, euphausiids[1]	Myctophum punctatum, unidentified fish, euphausiids[1], unidentified cephalopods

[1] Most distinguishing characteristics of crustaceans were lost to maceration and rapid digestion. Mandibular structure indicated that many of the euphausiids taken were of the genus Thysanoessa and/or Meganyctiphanes; however, individual specific identification on this basis could not be assured.