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The study of feeding of short-finned, *Illex illecebrosus*, and long-finned, *Loligo pealei*, squids at Nova Scotia and New England in 1974 and 1975

by

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I. Introduction

Shortfinned squid is an abundant species in the Northwest Atlantic. Great numbers of this species can be observed annually at the end of the spring and at the beginning of the summer on the shelf, from the southern New England to Newfoundland, where they intensively feed, rapidly grow and then migrate from the shelf to the spawning grounds in the fall. The abundance of the species is very high, though subject to fluctuations. In the summer of 1976, for instance, its biomass on Georges Bank was similar to that of all the fish species, as is evident from the data of the trawling survey conducted by the RV BELOGORSK.

Large aggregations of longfinned squid are found southward of Georges Bank.

Due to high abundance, the squids considerably support the fishery, as well as the ichthyocenosis structure and production. The studies on feeding of the species, therefore, are vital for understanding of the processes taking place in the community of fishes and squids, and for developing of the program of rational fishery.

II. Material and Methods

The data for the feeding studies were collected during the trawling surveys conducted by research vessels KHROMETER and BELOGORSK in August-November 1974 and in August 1975, at Nova Scotia and New England (Fig. 1).

In order to study the daily feeding pattern of the short-finned squid, the sampling was made at the multy-day station on 1-4 August 1975, on the northwest slopes of Georges Bank. On 18-19 September 1975, the samples for the longfinned squid feeding studies were gathered to the south of Nantucket Island.

The following size groups were sampled: 10-18 and 19-25 cm of shortfinned squid; 8-15 and 16-30 cm of longfinned squid. The first size group of longfinned squid includes the immatures, while the second group - the mature specimens (Vovk, 1972). In the catches from the shelf the shortfinned squids are represented by the immature specimens. Maturing squids are very seldom and occur mainly in the fall during the migration from the shelf to the spawning grounds. For this reason the size groups of short-finned squid were selected with regard for predominance of food organisms: the crustaceans for smaller individuals (10-18 cm) and the fishes for larger individuals (19-25 cm). Each sample was represented by 20 specimens or less, if the required number could not be obtained. The majority of samples was frosted and the stomach contents was examined in the laboratory after defrostation. A part of the samples was fixed at the sea in 10% formalin. These samples were soaked off during the day prior to analyses. The contents of dissected stomachs of the same size group is placed in the cup. The number of empty stomachs is recorded. The food mass was preliminarily examined by components with regard for the digestion degree. Since the food is reduced to small fragments by the beak and redula of squids, the identification could be made only from the fragments. Less digested food components were divided into taxonomic groups, if possible (in most cases to order or to species from the otolith structure of some fishes).

The feeding intensity was estimated from the total indices of the squid stomach filling (the ratio of the food mass to the squid body mass in ‰, "Methodical guide to ..., 1974").

III. Results

1. Food composition and feeding intensity of shortfinned squid

The euphausiids, fishes, squids, as well as decapods, mysids etc., though in smaller numbers were the taxonomic groups of organisms found in the food of shortfinned squid (table 1). As is evident from table 1, the euphausiids (25.4%), fishes (25.4%) were on the average major food organisms in mass. The crustaceans totalled 50.6% and the fishes and squids - 49.4%. The Canadian scientists M.Mercer and G.Paulmier (1974) found 10 species of food organisms in the squid feeding on the Nova Scotia shelf in May-June and suggested that the selectivity may be present in the feeding of this species. Our studies have not indicated the presence of any selectivity. Significant differences were observed between the food composition of small and large squids. So, on Georges Bank the proportion of squids and fishes in the smaller individuals of 10-18 cm amounted to 55% in August 1955; in larger individuals of 19-25 cm it was 94% in mass (table 2).

Similar food composition was recorded in the Nantucket Shoals area. In September, to the south of Long Island, the bulk of the food of smaller *I. illecebrosus* was represented by squids, and of the larger individuals - by the fishes. The predominance of the longfinned squid juveniles in the food of smaller squids may be explained by the fact that the juveniles of *L. pealei* of 3 to 10 cm in length are abundant in the given area in that period (Vinogradov, 1970). The Browns Bank area, where the crustaceans served as the main food of larger squids in August 1975 (100% in mass), may be regarded as an exception, though the absence of suitable fishfood and the availability of high concentrations of euphausiids and other crustaceans accessible to squids in this time may be considered as a telling argument. Such a phenomenon was also observed by G.Ennis and P.Collins (1978) in the Newfoundland area.

The importance of crustaceans in the smaller squid diet is reduced with the increase of the depth ^{from} 42 to 365 m. At greater depths the crustaceans are replaced by the fishes and squids

(table 3). The importance of crustaceans in the feeding of larger squids is increased, on the contrary, from 10 to 83% in mass.

The indices of the squid feeding intensity by areas varied on the average from 4‰ in the Emerald Bank area in August 1975 to 294 ‰ on Browns Bank in 1974. The number ^{of} empty stomachs was also the highest on Emerald Bank (74) and the lowest on Browns Bank (0). The lower indices of stomach filling (40‰) and higher per cent of empty stomachs had smaller squids of less than 18 cm in length, while larger individuals had higher indices of filling (88‰) and lower per cent of empty stomachs (table 2).

The feeding intensity both of small and large squids is markedly increased, especially of the latter, with depth, and the number of empty stomachs is decreased (table 3). Though there is no considerable difference between the indices of stomach filling of the squids and silver hake (Vinogradov, 1975), the daily food consumption by squids is higher due to preliminary reduction of food organisms to fragments and more rapid digestion in the course of 6-8 hours. This results in high monthly growth rate in the feeding period from June to October, which amounts to 2 cm on the average (Konstantinov and Noskov, 1973, Tibbetts, 1975) and may be even higher.

2. Daily feeding pattern of the shortfinned squid

The analyses of the daily feeding pattern of the shortfinned squid from the data of three-days station showed that the stomach filling indices are highest in the nighttime and lowest in the afternoon (fig. 2). Therefore, it may be concluded that the squids feed most intensively in the dusk and at night. The observations of feeding of the squids in captivity showed that they feed before daybreak (H. Bradbury and F. Aldrich, 1969).

As is evident from the analyses of the daily feeding pattern, the fish-food predominates in the dark, and crustaceans - in the light hours of the day, which indicates that the nighttime is more favourable for predation by the shortfinned squid.

Based on the daily feeding pattern and the indices of the stomach filling the daily ration of the shortfinned squid was

determined. In August 1975, on the north-west slopes of Georges Bank, this was 5.8% of the body mass of the shortfinned squid of 19-25 cm.

3. Food composition and feeding intensity of longfinned squids

The major food for longfinned squids was the fish, the squids and crustaceans being of less importance. However, the food composition of this species varied by season, year and area. Thus, in August and October 1974, on Georges Bank, smaller squids of 8-15 cm body length fed mainly on crustaceans - respectively 100 and 58% in mass (table 4). In November, the silver hake juveniles were major food of squids of same size groups. The importance of the fish and squids as food organisms for larger squids of 16-30 cm in length increased from August to November 1974 from 35 to 100% in mass, and the number of empty stomachs decreased.

In August, on the Nantucket Shoals, small squids fed mainly on the crustaceans (55%), while in October the fish comprised 58% in mass. In feeding of larger squids the fish prevailed (93%).

In September, southward of Long Island, both large and small squids fed mainly on the fish and squids.

With the increase of the depth from 27 to 600 m the amount of consumed fish and squids in feeding of the longfinned squid juveniles (8-15 cm) is increased from 56 to 77% in mass, and the amount of the crustaceans is accordingly decreased (table 3), as well as the number of empty stomachs. Larger individuals of 16-30 cm fed mainly on the fish. Neither the stomach filling index, nor the number of empty stomachs changed with depth and were respectively about 20‰ and 30‰.

A sharp fluctuation of the feeding intensity of small squids of 8-15 cm from 18 to 186‰ was observed on Georges Bank, increasing gradually from August to November (table 4).

No considerable difference was recorded between the feeding intensity of smaller and larger individuals: it was 27‰ and 23‰ respectively for smaller and larger squids. The only diff-

erence is that larger specimens feed almost exclusively on the fish.

4. Daily feeding pattern of longfinned squid

No clear correlation between the stomach filling index and time of the day was revealed from our data due to lacking observations on the daily feeding intensity. It should be noted, however, that most intensive consumption of the food by longfinned squid of 16-30 cm falls on the evening hours (18-20 p.m.). According to A.N.Vovk (1972), in the fall longfinned squids feed most intensively in the period from 16 to 20 p.m. Monthly increment of longfinned squids according to W.Summers (1971) makes up 1.0-1.5 cm.

From the available data on the daily feeding pattern and feeding intensity of longfinned squids an approximate estimate of their daily ration is given, which is 3.8% of the body mass of the specimens with mantle length of 8-15 cm, and 3.2% for the specimens with mantle length of 16-30 cm (September 1975, Nantucket Shoals).

Conclusions

1. Shortfinned squids are predators feeding mainly on the crustaceans (at mantle length of 10-18 cm) or on the fish and squids (at mantle length of 19-25 cm).

2. Longfinned squids also feed chiefly on the fish; in the diet of the specimens with 8-15 cm mantle length the crustaceans, fish and squids constituted respectively 40, 40 and 20% of the food mass; in larger specimens diet (16-30 cm mantle length) these organisms made up accordingly 18, 61 and 21%.

3. Due to high intensity the monthly length increment ^{of} shortfinned squids is 2 cm; of longfinned squids - 1-1.5 cm or still higher in the period from June to October (feeding period).

4. The daily ration of shortfinned squid with mantle length of 19-25 cm made up 5.8% of the body mass on Georges Bank; in the Nantucket Shoals area the daily rations of longfinned squids

with 8-15 cm and 16-30 cm mantle lengths were respectively 3.8 and 3.2% of the body mass.

5. Squids play an important role in the ichthyocenosis of the Nova Scotia shelf area, of Georges Bank and southern New England due to high abundance and predatoriness, which is especially true for shortfinned squids. This should be taken into consideration in studying the dynamics of the commercial fish abundance and organization of rational fisheries.

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Table 1.

Food composition of shortfinned and longfinned squids in the Northwest Atlantic

Food objects	: Numbers in % and in mass	
	:shortfinned squids	:longfinned squids
Mysids	0.5	-
Gammarids	0.1	1.8
Meganyctiphanes	0.5	-
Euphausiids	25.4	0.3
<i>Pandalus montagui</i>	0.1	-
Crabs	0.2	0.1
Decapods	5.1	9.8
Not identified crustaceans	18.7	8.4
Total crustaceans	50.6	20.4
Squids	24.0	26.2
Myctophids	2.9	-
Silver hake	7.1	4.2
Not identified fishes	15.4	49.2
Total fish and squids	49.4	79.6
Number of examined sp.	980	1323

Table 3. Food composition (% in mass) and feeding intensity (‰) of the long-finned and short-finned squids by depths (‰).

Food objects	Shortfinned squids						Longfinned squids					
	Depth, m											
	42-70		71-150		151-365		27-70		71-150		210-600	
	1	2	1	2	1	2	1	2	1	2	1	2
Mysids	19	-	-	-	-	-	-	-	-	-	-	-
Gammarids	3	+	-	-	-	-	10	1	-	-	-	-
M. norvegica	-	-	-	-	-	1	-	-	-	-	-	-
Euphausiids	-	-	-	29	1	38	-	-	-	-	13	-
Pandalus borealis	-	-	-	+	-	-	-	-	-	-	-	-
Crabs	-	-	-	-	14	-	-	-	-	-	-	-
Decapods	25	-	42	1	-	-	24	9	16	7	10	-
Not identified crustaceans	-	10	6	6	-	43	10	2	17	6	-	-
Total crustaceans	47	10	48	36	15	83	44	12	33	13	23	-
Squids	24	2	51	36	26	12	26	20	15	39	40	11
Myctophids	-	9	-	4	-	2	-	-	-	-	-	-
Silver hake	-	-	-	16	-	-	-	17	27	-	-	-
Not identified fish	29	79	1	8	59	3	30	51	25	48	37	89
Total fish and squids	53	90	52	64	85	17	56	88	67	87	77	100
Number of examined specimens	133	92	299	212	61	183	354	266	325	328	40	10
empty stomachs, %	43	32	32	24	39	27	41	35	28	34	5	30
Stomach filling index, ‰	21.8	44.7	49.2	91.9	37.7	105.0	25.8	24.1	28.0	20.2	48.5	28.2

Note: shortfinned squid: 1 - mantle length - 10-18 cm
 2 - mantle length - 19-25 cm
 longfinned squid: 1 - mantle length - 8-15 cm
 2 - mantle length - 16-30 cm

Table 4. Food composition (% in mass) and feeding intensity (‰) of immature and mature long-finned squids by areas.

Food objects	Georges Bank						Nantucket Shoals						Area southward of Long Island (72°W - 75°W) Mean	
	Area													
	1974		1974		1974		1974		1974		1974			
	August	October	November	August	October	September	August	October	September	August	October	September		
1	2	1	2	1	2	1	2	1	2	1	2	1	2	
Gammarids	-	11	-	-	-	-	30	-	-	-	-	-	5	2
Euphausiids	-	-	-	-	-	-	8	-	-	-	-	-	1	-
Crabs	-	-	-	1	-	-	-	-	-	-	-	-	-	+
Decapods	100	54	-	2	-	-	16	-	-	14	10	21	14	
Not identified crustaceans	-	-	58	3	-	-	1	-	-	19	7	13	2	
Total crustaceans	100	65	58	6	-	-	55	-	-	33	17	40	18	
Squids	-	3	8	41	10	20	32	-	42	7	28	36	20	21
Silver hake	-	-	-	-	90	-	-	-	-	-	-	-	15	-
Not identified fish	-	32	34	53	-	80	13	-	58	93	39	47	25	61
Total fish and squids	-	35	42	94	100	100	45	-	100	100	67	83	60	82
Number of examined sp.	40	99	140	167	20	16	135	-	40	40	324	302	-	-
empty stomachs, %	26	42	39	30	25	6	54	-	38	5	27	36	35	17
Stomach filling index, %	18	19	23	21	186	17	17	-	30	74	25	17	27	23

Note: 1 - immature squids with mantle length of 8-15 cm
 2 - immature squids with mantle length of 16-30 cm

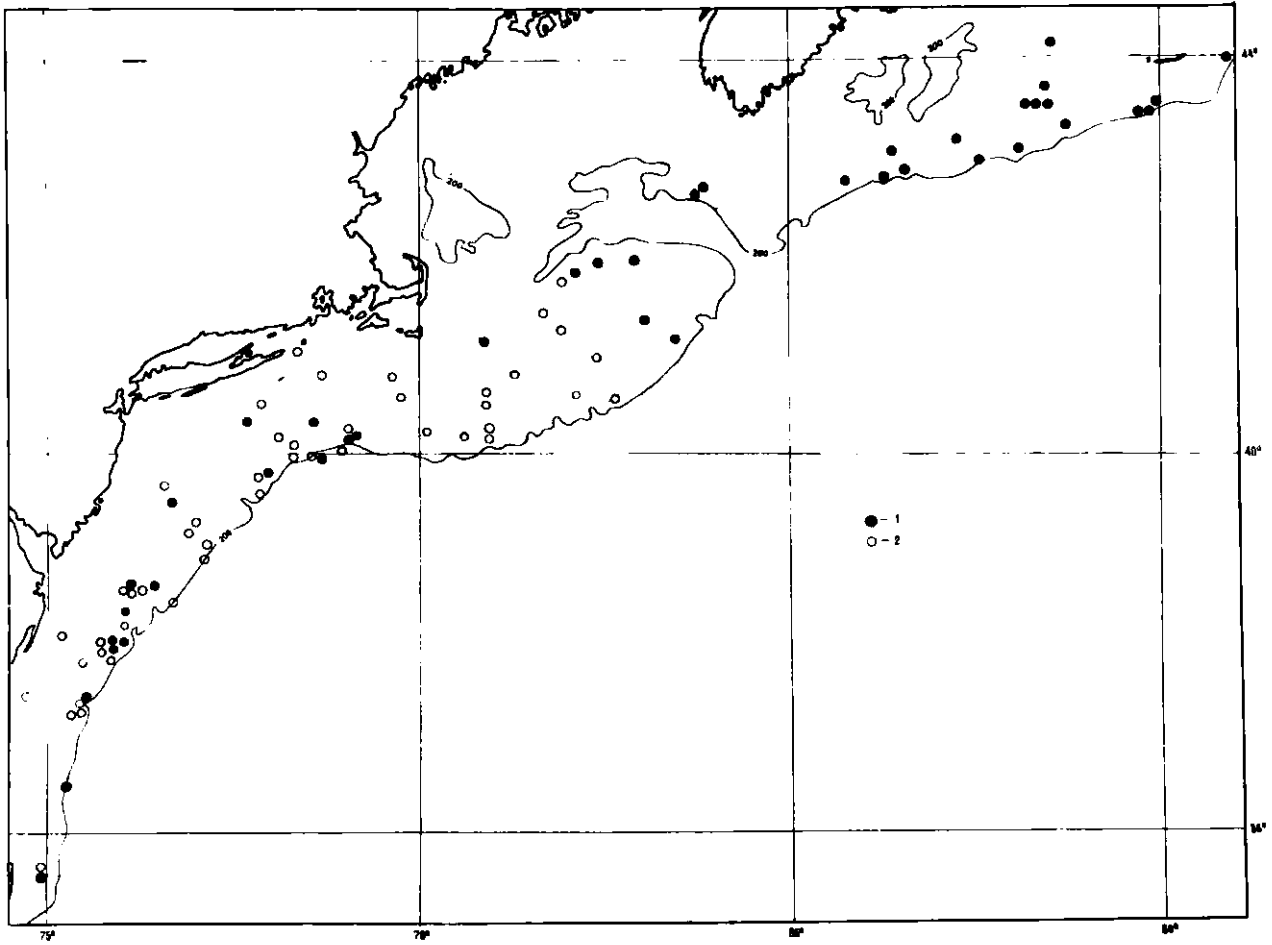


Fig. 1. Sampling areas for the squid feeding studies. 1 - short-finned squid; 2 - long-finned squid.

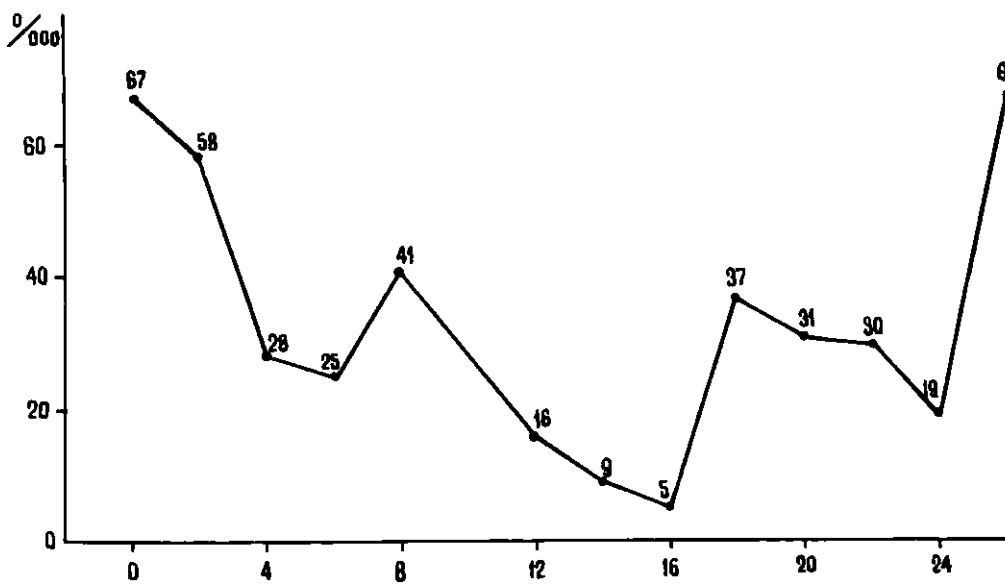


Fig. 2. The change of the short-finned squid feeding intensity during the day (from the data of 3-day station).

