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Diurnal Periodicity in the Feeding and Catchability of Some Marine Fish and Squid

by

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INTRODUCTION

Periodicity in the feeding and catchability of many marine fish and squid is well documented (Fritz 1962; Beamish 1966; Brunel 1972; Sissenwine and Bowman 1978; Edwards and Bowman 1979; Lane et al., 1979; Vinogradov and Noskov 1979; Wallace and O'Dor 1980). Investigations on the feeding chronology of *Pleuronectes platessa* by Hempel (1964), and deGroot (1964), show that plaice feed during daylight hours. Edwards and Bowman (1979) identified ocean pout and longhorn sculpin as night feeders. The longfinned squid, *Loligo pealei*, is known to feed in the daytime (Vovk 1972). However, the feeding times of most offshore species have not been described. Silver hake, for example, is a species both ecologically and commercially important in the Northwest Atlantic, yet the only published data describing their feeding periodicity is by Bowman and Bowman (1980). The availability of some Northwest Atlantic fish and squid to bottom trawls has been evaluated by Sissenwine and Bowman (1978). They noted diel variations in catch for most of the species examined during their study.

Knowledge of when fish feed and why more fish are caught during certain times of the day when bottom trawling is useful information for fishery biologists as well as fishermen. The feeding cycles of fish have been used by Elliott and Persson (1978) to estimate daily rates of food consumption. Accurate estimates of food consumption are needed for multispecies models such as the one developed by Anderson and Ursin (1977), and the model presently evolving at the NEFC. Finally, fish catches may be significantly increased if more is known about when and why fish are most vulnerable to bottom trawls.

METHODS

A feeding chronology study was conducted in September of 1978 by American and Soviet scientists aboard the Soviet research vessel BELOGORSK, operated by the Atlantic Research Institute of Marine Fisheries and Oceanography (Atlant-NIRO), Kaliningrad, USSR. The ship fished the Soviet Hake 815 bottom trawl for 30 min once every 3-h for two days, on the southern part of Georges Bank. The study area covered approximately 250 km^2 (10 miles by 10 miles) and was selected on the basis of results of survey data obtained during the first part of the cruise. Variables such as bottom temperature, water depth, bottom type, and fish abundance were examined, and the area chosen was one where the least variation in these parameters was anticipated (Figure 1). The date, time, depth, latitude and longitude, and cloud cover at the beginning of each tow is given in Table 1.

Feeding periodicity and/or catchability data were gathered on a total of 18 species of fish or squid. However, most effort was concentrated on obtaining information about silver hake and shortfinned squid, the two target species of the study. The silver hake data in this report represents a subset of a more complete data set which is presented in a paper by Bowman and Bowman 1980. The feeding data on species other than shortfinned squid and silver hake are incomplete because the remaining species were not caught during all time periods. Nevertheless, the information obtained does give some indication, in many instances, of when a particular species is most available to a bottom trawl and/or when they feed. At the very least the information serves as a guide for future studies. The species making up the catch in each time period are given in Table 2. Species selected from the catches for food and feeding periodicity studies are presented in Table 3.

The stomach and intestine (or caecum of squid) of each specimen was excised aboard ship, wrapped in gauze, labeled, and preserved in 3.7 percent formaldehyde. At the Northeast Fisheries Center's laboratory in Woods Hole, Massachusetts, the digestive tracts were removed from the preservative and individually opened over a 0.25 mm mesh opening screen sieve. The contents of the stomach and intestine were kept separate, except for the squids whose caecum contents were combined with those of the stomach because of difficulty in keeping the contents separate. After flushing with seawater to remove the odor of formaldehyde the stomach and intestine contents were damp dried on absorbent paper and immediately weighed to the nearest 0.001 gram. Once weighed the intestine contents were discarded and the stomach contents were transfered to a dish. Prey organisms were then sorted, counted, identified, weighed, and recorded.

No intestine content data is given in the results although the usefulness of this type of data has been shown by Bowman and Bowman (1980). Examination of the intestine content data for fish other than silver hake revealed that insufficient data was gathered to be of use in this study.

Feeding periodicity data are presented as the mean stomach content weight of fish caught within each time period. Species were divided into length groups whenever a modal length frequency was observed, or if large length differences were noted, to reduce the effect of fish length (quantity of food) on the mean stomach content weights. The number of stomachs examined, and mean fish length, of each length group is given in the figures showing stomach fullness. Catchability was calculated as the mean catch per tow in kilograms, and these calculated values may be found alongside the stomach fullness data. Individual catches were processed according to routine ground-

fish survey procedures established by the NEFC.

The food of each species is presented as the percentage weight each prey group comprised of the total stomach contents weight over all time periods (Table 4). Subtotals of the major taxa are offset to aid in making comparisons. Important prey species making up the broader groupings listed in the table are discussed in the text.

RESULTS

Data on the 18 most abundant species caught in the study area were analyzed. Because the feeding periodicity data is incomplete for most single species, the species have been combined into general biologically similar groups. The groups are as follows: (1) skates, (2) hakes, (3) pelagics, (4) flatfishes, (5) squids, and (6) miscellaneous fishes. Consideration of species groups rather than individual species helped in the analysis of the data because the same trends are often noted for several species of fish. For example, the species within a group may all have the fullest stomachs or be caught within a particular time period, which tends to offer some credence to the data. The diet of each species is discussed following the section entitled "Feeding Periodicity and Catchability."

Feeding Periodicity and Catchability

SKATES - Data were gathered for little skate (*Raja erinacea*), winter skate (*Raja ocellata*), and thorny skate (*Raja radiata*). The stomachs of little skate and winter skate contained the most food between 24:00 and 03:00 (Figure 2). No thorny skate stomachs were examined. This group of

fishes probably begin feeding near dusk and continue feeding until midnight.

The largest quantities of little skate, winter skate, and thorny skate were caught at night between 18:00 and 06:00. Generally, the catches steadily increased from a minimum at dusk to a maximum slightly before or after midnight.

HAKES - Haddock (*Melanogrammus aeglefinus*), silver hake (*Merluccius bilinearis*), red hake (*Urophycis chuss*), and white hake (*Urophycis tenuis*) were caught in the study area (Figure 3). The stomach contents of haddock (all juveniles) collected from two time periods were examined. The quantity of food found in the stomachs of haddock collected close to noon (09:00 to 12:00) was greater than the quantity found in fish caught near dawn (06:00 to 09:00). Juvenile haddock catches were larger during the day than at night. The largest catch was obtained between 12:00 and 15:00 (0.5 kg).

The quantities of food found in silver hake stomachs showed that just after dusk (18:00 to 21:00) the stomachs begin to fill, and steadily increase to peak fullness from 21:00 to 06:00. The feeding data for silver hake establishes that this species begins feeding at dusk and continues feeding during hours of darkness. Red hake and white hake stomachs contained the most food from 21:00 to 24:00. It appears that most adult hakes are probably night feeders.

Silver hake, red hake, and white hake were caught mostly during hours of darkness (18:00-06:00). They were more available to the trawl between 24:00 and 03:00 then during any other time period.

PELAGICS - The pelagics include bluefish (*Pomatomus saltatrix*), Atlantic herring (*Clupea harengus*), Atlantic mackerel (*Scomber scombrus*), and butterfish (*Peprilus triacanthus*). The feeding periodicity of bluefish, Atlantic

herring and Atlantic makerel cannot be determined because of the limited data gathered (Figure 4). The single butterfish stomach examined from the fish caught between 03:00 and 06:00 contained more food (1.463g) than any other stomach examined. However, the average quantity of material found in the 28 stomachs examined from the 12:00 to 15:00 time period was more than that found for any other time period for which more than one fish stomach was examined (from 12:00 to 24:00). Based on the samples consisting of more than one stomach it appears that butterfish feed mainly during hours of daylight.

Overall, the pelagics were caught predominantly during periods of daylight. The largest quantities of bluefish and Atlantic herring were caught between 12:00 and 15:00. Mackerel catches were greatest (2.3 kg) between 06:00 and 09:00, but fairly large amounts (1.1 to 1.5 kg) were also obtained during the remainder of the daylight periods (09:00-18:00). Night tows for Atlantic mackerel (18:00-06:00) only yielded from 0.0 to 0.2 kg. Butterfish were most vulnerable to bottom trawling between 12:00 and 18:00. A substantial quantity (131.8 kg) of butterfish was caught in the 15:00 to 18:00 time period.

FLATFISH - Fourspot flounder (*Paralichthys oblongus*) and yellowtail flounder (*Limanda ferruginea*) are the only flatfish represented (Figure 5). The stomachs of both species were fullest between 18:00 and 21:00. The smaller yellowtail flounder collected (average TL of approximately 23 cm) surprisingly had greater quantities of food in their stomachs than the larger fish (average TL of about 36 cm). Also of interest is that the same trend of stomach emptying occurs in the small and large yellowtail. The quantity of food steadily decreased from 18:00 to 03:00. The data suggests that both

fourspot and yellowtail flounder feed during hours of daylight.

Fairly large catches of fourspot and yellowtail flounder occurred in all time periods between 18:00 and 06:00. However, the greatest quantities of both species were caught from 21:00 to 24:00 (fourspot, 28.4 kg and yellowtail, 7.4 kg).

SQUIDS - Shortfinned squid (*Illex illecebrosus*) and longfinned squid (*Loligo pealei*) were obtained at the study site (Figure 6). The shortfinned squid stomach content data analysis (large specimens) reveals that the stomachs were fullest near dusk. This indicates that the larger individuals in the shortfinned squid population feed mostly just before and after dusk (15:00 to 21:00). Slightly more food was also noted in the stomachs collected between 06:00 and 09:00, indicating a less intense feeding may occur near dawn. Although the data is incomplete for the smaller shortfinned squid a somewhat similar pattern was observed. The most food was found in their stomachs just before dusk (15:00 to 18:00) and before dawn (03:00 to 06:00). All the longfinned squid caught were juveniles. The stomachs of the longfinned squid collected were fullest between 15:00 and 18:00.

The largest quantities of shortfinned squid were caught between 24:00 and 03:00 (40.0 kg) and from 15:00 to 18:00 (21.0 kg). Longfinned squid were caught mainly during hours of daylight (06:00-18:00), with the largest quantity being obtained between 06:00 and 09:00 (0.9 kg).

MISCELLANEOUS FISHES - Sea raven (*Hemitripterus americanus*), American goosefish (*Lophius americanus*), and longhorn sculpin (*Myoxocephalus octodecemspinosus*) comprise this group (Figure 7). Only one sea raven and four American goosefish stomachs were examined, therefore nothing can be determined about the feeding periodicity of these two species. The stomach fullness data gathered on longhorn sculpins (both large and small) suggests they feed at night. The single stomach of a longhorn sculpin (large) caught between 06:00 and 09:00 con-

tained a large quantity of food (6.557 g). The remaining three time periods shown for large longhorn sculpin, for which the sample size was 15 or more fish in each, indicate that large longhorn sculpins probably begin feeding near dusk and continue to feed during the night. Smaller longhorn sculpins had the fullest stomachs between 21:00 and 24:00, suggesting they may cease feeding near midnight.

All three species in this group were caught predominantly during hours of darkness (18:00 to 06:00). The largest quantities of sea raven and American goosefish (0.9 kg and 17.8 kg, respectively) were caught from 24:00 to 03:00; longhorn sculpin catches were greatest between 21:00 and 24:00.

Food

The diets of 14 species of fish and two species of squid have been examined (Table 4). Overall, the predators caught in the study area fed primarily on either crustaceans, or fish and squid, or some combination thereof. However, the diet of two species, namely the yellowtail flounder and Atlantic mackerel, was unique. Yellowtail flounder fed principally on polychaete worms (78.1% of their diet by weight) and Atlantic mackerel prey was almost exclusively chaetognaths (98.8%). The only other predators which ate a fair quantity of polychaetes were winter skate, little skate, and red hake (20.5, 14.4, and 2.8%, consecutively), but their diets were comprised chiefly of a variety of crustaceans. The amounts of chaetognaths found in the stomachs of species other than Atlantic mackerel were of little dietary importance (i.e., 0.1% in silver hake and butterfish).

Crustaceans, the single most important major prey group, made up almost 50% or more of the diet of seven predator species (refer to Table 4). Within

the crustacean category decapod shrimp and/or crabs comprised at least 30% of the food of little skate, winter skate, silver hake, red hake, white hake, sea raven, longhorn sculpin, and fourspot flounder. The two species of shrimp most commonly found in the stomachs were identified as *Dichelopandalus leptocerus* and *Crangon septemspinosus*. Crabs taken as prey consisted mainly of *Cancer irroratus* and *Cancer borealis*. The only other crustacean category important as prey was the Amphipoda (mostly of the genera *Monoculodes*), which made up a substantial part (24.5%) of the silver hake diet.

Fish and/or squid are the primary food of bluefish (99.4%), American goosefish (98.3%), and shortfinned squid (91.7%). Only the cephalopods found in the American goosefish stomachs were identified to species, and they were identified as *Loligo pealei*. Several families, or genera, of fish were identified as prey, but none was quantitatively important to more than three predators. Fairly large quantities of herring were identified in the stomach contents of bluefish (20.3%), shortfinned squid (8.7%), and American goosefish (7.1%). A small amount of herring (1.9%) was also identified in the stomach contents of winter skate. Hake of the genus *Merluccius* was identified as prey of shortfinned squid (26.5%), American goosefish (21.1%), and silver hake (0.9%). Skates (Rajidae) were taken as prey by longhorn sculpin (4.8%) and shortfinned squid (3.4%). Fish broken down by the digestive processes could not be identified and are included in the "other fish" category. These unidentified fish made up a substantial portion of the stomach contents of bluefish (74.6%), fourspot flounder (43.0%), white hake (41.8%), shortfinned squid (29.2%), and red hake (28.2%).

DISCUSSION

The feeding periodicity and catchability of silver hake and shortfinned squid have been described. The results show silver hake begin feeding at dusk and continue to feed during hours of darkness. Large catches of silver hake are obtained between dusk and dawn when fishing a Soviet Hake 815 bottom trawl. Apparently, the reason few silver hake are caught during daylight hours is because bottom trawls with rollers pass over the fish which settle into depressions on the bottom during periods of daylight (Bowman and Bowman 1980).

Shortfinned squid fed predominantly near dusk, although some feeding also occurred near dawn. The diet of the shortfinned squid examined for this study was almost exclusively fish (67.8%). These results differ from those of Vinogradov and Noskov (1979) who noted that shortfinned squid feed mainly on fish near midnight and on crustaceans during the daytime. However, Vinogradov's and Noskov's work also indicates that the feeding intensity of shortfinned squid increases near dawn and dusk, the same results obtained here. The major difference between the two studies was that no midnight peak in stomach fullness was noted during the present research. Observations on feeding of shortfinned squid in captivity by Bradbury and Aldrich (1969) revealed that this squid feeds most often in the early morning, even when food is available throughout daylight and darkness periods. Overall, it seems *Illex illecebrosus* in the wild feed mostly at night, with the period of highest feeding intensity probably dependent on the availability of prey.

The diurnal vertical migrations of *Illex illecebrosus* effects their availability to bottom trawls. Because this squid moves up in the water column by night and is near bottom during daylight, they are caught more

often during periods of daylight when bottom trawling (Arnold 1979). An unusally large catch of shortfinned squid was obtained during one nighttime tow (69.7 kg at 01:15) during the present study. The reason such a large quantity of squid was caught during this particular tow is unknown. Since only two tows were made within each time period, the catch noted immediately above strongly influenced the catchability data. It's interesting to note the catchability data would fall more in line with day/night catches reported by other investigators (Sissenwine and Bowman 1978; Arnold 1979) if the tow was omitted (see time period 24:00 to 03:00 in Figure 6). A recent study conducted aboard the USSR EVRIKA (see cruise results at the NEFC from USSR EVRIKA 80-05) establishes that *Illex illecebrosus* is caught in larger quantities at dusk and dawn than at any other time of day when fishing a Soviet Hake 815 bottom trawl. Since there will be no further discussion of the group "squids", I will note here that the feeding intensity and catchability of *Loligo pealei* (longfinned squid) is reported to be similar to that of *Illex illecebrosus* (refer to review of squids by Arnold 1979).

Generally, all groundfish species (excluding juvenile haddock) caught in the study area appeared to feed, and were most vulnerable to the Soviet Hake 815 trawl during hours of darkness. The only exception among the groundfish was the group "flatfish", which are discussed separately below. It seems that nightime activity, possibly associated with feeding, of such groups as the skates, hakes, and miscellaneous fishes, increases their availability to bottom trawls. Diurnal variation in feeding intensity and catchability noted for most of the species reported on here confirms the results of prior investigations (Parrish et al. 1964; Beamish 1966; Sissenwine and Bowman 1978).

Fish comprising the group "pelagics" were caught mainly during daylight hours. The pelagics tend to concentrate close to the bottom in daylight and are well off bottom at night. These diurnal movements cause them to be expecially vulnerable to bottom trawls during periods of daylight. Fish such as herring are known to actively feed near dusk, the time they presumably leave bottom (Blaxter and Holliday, 1958). The feeding data presented here gives some indication that butterfish may begin feeding in the morning (possibly near sunrise), since their stomachs were fullest at noontime. It seems pelagics feed mostly near dawn or dusk, the transition periods of their diurnal vertical migrations.

A study by deGroot (1971) describes the feeding activity and catchability of several "flatfishes". The feeding habits of Pleuronectiformes have been divided into three general categories by deGroot: (1) Visual feeders which search for food in the daytime by sight, (2) Visual feeders which find their food mainly by sight, but also use olfaction, and, (3) Non-visual feeders which find their food mainly in darkness by olfactory clues. Pitt (1976) included yellowtail flounder in the non-visual night feeder category. However, the data presented here suggests that yellowtail flounder may feed in the early afternoon. If this is the case yellowtail may belong in the second category, and should be classified as visual feeders which also use olfaction and feed mainly in daylight. Fourspot flounder appeared somewhat similar to yellowtail in their feeding activity.

This study confirms the results of earlier studies which have shown that most flatfish species are more available to bottom trawls towed at night (Parrish et al. 1964; Beamish 1966; Sissenwine and Bowman 1978). However, as pointed out by deGroot (1971), many aspects of the diurnal variation in trawl catches of flatfish are far from clear, and at certain times of the year

daylight catches are greater than those obtained at night. Apparently there is still much to be learned about the diurnal behavior of Northwest Atlantic flatfishes.

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Table 1. Station data for the feeding chronology study conducted by American and Soviet scientists aboard the USSR R/V BELOGORSK in September of 1978. All station data are the conditions at the beginning of each tow.

Station	Date	Time (DST)	Depth (M)	Latitude	Longitude	Cloud cover (%)
90	28/09/78	1245	72	40°41.3'	68°13.0'	Fog
91	28/09/78	1545	75	40°41.0'	68°14.0'	100
92	28/09/78	1845	74	40°40.2'	68°15.6'	20
93	28/09/78	2215	71	40°41.0'	68°14.0'	0
94	29/09/78	0120	73	40°40.0'	68°14.0'	20
95	29/09/78	0420	68	40°42.6'	68°13.9'	20
96	29/09/78	0720	62	40°44.2'	68°14.9'	20
97	29/09/78	1015	68	40°41.5'	68°15.2'	60
98	29/09/78	1315	62	40°42.5'	68°14.8'	20
99	29/09/78	1615	64	40°41.8'	68°16.4'	20
100	29/09/78	1915	80	40°40.0'	68°12.5'	0
101	29/09/78	2215	71	40°41.2'	68°14.7'	0
102	30/09/78	0115	86	40°37.5'	68°13.4'	0
103	30/09/78	0415	86	40°37.6'	68°14.0'	0
104	30/09/78	0715	68	40°41.5'	68°17.0'	10
105	30/09/78	1020	67	40°41.7'	68°16.3'	30

Table 2. Species composition of catches (kg/tow) made in each time period during the feeding chronology study conducted on the southern part of Georges Bank.

	TIME PERIOD								
	12-15	15-18	18-21	21-24	00-03	03-06	06-09	09-12	Total catch
Little skate	0.2	-	10.0	8.5	14.1	19.0	6.0	-	57.8
Winter skate	0.8	-	8.9	15.5	14.6	0.2	3.6	-	43.6
Thorny skate	<0.1	-	0.8	1.0	1.8	-	-	-	3.6
Haddock[1]	0.5	0.3	0.2	0.1	0.1	0.1	0.4	0.3	2.0
Silver hake	11.0	13.9	95.8	70.5	202.1	153.0	5.9	2.8	555.0
Red hake	-	-	1.5	1.9	2.3	2.1	-	-	7.8
White hake	-	-	0.8	0.4	1.4	1.8	-	-	3.9
Bluefish	16.0	2.7	6.8	-	-	-	4.7	6.3	36.5
Atlantic herring	1.4	1.2	-	0.3	0.6	0.6	0.2	-	4.3
Atlantic mackerel	1.5	1.1	0.2	0.1	-	-	2.3	1.5	6.7
Butterfish	27.3	131.8	2.3	0.4	0.1	0.1	0.2	0.2	162.4
Fourspot flounder	-	-	11.5	28.4	7.0	10.1	-	-	57.0
Yellowtail flounder	0.2	-	4.4	7.4	1.8	4.4	0.5	-	18.7
Shortfinned squid	16.7	21.0	14.5	9.8	40.0	19.0	6.9	11.5	139.4
Longfinned squid[1]	0.4	0.4	<0.1	-	-	-	0.9	0.7	2.4
Sea raven	-	-	0.5	0.7	0.9	0.2	-	0.2	2.5
American goosefish	0.7	-	8.4	5.4	17.8	9.9	-	5.8	48.0
Longhorn sculpin	-	-	6.4	8.8	8.1	6.7	0.7	-	30.7

[1]All juveniles.

Table 3. Number of digestive tracts excised from each species of fish and squid caught at different times of the day in September of 1978.

	TIME PERIOD								
	12-15	15-18	18-21	21-24	00-03	03-06	06-09	09-12	Total
Little skate	-	-	8	10	6	-	15	-	39
Winter skate	2	-	5	10	9	-	6	-	32
Thorny skate	-	-	-	-	-	-	-	-	0
Haddock[1]	-	-	-	-	-	-	6	7	13
Silver hake	54	51	97	72	76	77	48	23	498
Red hake	-	-	12	9	2	3	-	-	26
White hake	-	-	5	3	4	-	-	-	12
Bluefish	4	-	-	-	-	-	1	3	8
Atlantic herring	-	-	-	-	-	-	-	-	0
Atlantic mackerel	-	3	-	-	-	-	-	-	3
Butterfish	28	27	26	4	1	1	-	7	94
Fourspot flounder	-	-	20	12	13	-	-	-	45
Yellowtail flounder	-	-	17	11	5	-	1	-	34
Shortfinned squid	52	60	35	24	27	46	47	32	323
Longfinned squid[1]	-	19	-	-	-	-	49	52	120
Sea raven	-	-	-	-	-	-	-	1	1
American goosefish	-	-	-	-	-	4	-	1	5
							GRAND TOTAL =		1350

[1]All juveniles.

Table 4. Food of 16 species of fish and squid caught at the site of the feeding chronology study. Data is presented in terms of a percentage weight.

	Little skate	Winter skate	Had-dock	Silver hake	Red hake	White hake	Blue-fish	Atl-antic mack-erel	Butter-fish	Fourspot flounder	Yellow-tail flounder	Short-finned squid	Long-finned squid	Sea raven	American goose-fish	Long-horn sculpin
POLYCHAETA	14.4	20.5	-	+	2.8	-	-	-	-	0.5	78.1	-	-	-	-	0.5
Aphroditidae	3.5	5.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Polychaeta	10.9	14.7	-	+	2.8	-	-	-	-	0.5	78.1	-	-	-	-	0.5
CRUSTACEA	60.5	37.8	42.1	88.3	38.7	57.9	+	0.3	1.2	49.5	10.0	4.4	88.8	100.0	-	85.5
Amphipoda	6.6	3.0	3.9	24.5	0.8	0.1	-	-	0.2	1.3	4.6	0.1	-	-	-	1.0
Pandalidae	4.6	2.0	-	10.8	9.3	20.0	-	-	-	9.2	-	-	-	-	-	1.7
Crangonidae	2.7	2.1	-	25.6	7.4	0.8	-	-	-	4.5	-	-	-	-	-	2.1
Cancridae	7.0	-	-	-	3.9	-	-	-	-	1.6	-	-	-	-	-	65.7
Other shrimp	4.3	9.2	1.7	25.0	5.3	3.4	-	-	0.1	19.5	0.2	-	-	100.0	-	1.3
Other crabs	27.1	16.7	4.4	-	4.9	23.5	-	+	-	5.0	2.2	-	-	-	-	9.6
Other Crustacea	8.2	4.8	32.1	2.4	7.1	10.1	+	0.3	0.9	8.4	3.0	4.3	88.8	-	-	4.1
MOLLUSCA	-	26.7	-	0.4	-	+	4.5	-	-	-	-	23.9	2.9	-	50.8	0.3
Cephalopoda	-	26.7	-	0.4	-	-	4.5	-	-	-	-	23.9	2.9	-	50.8	-
Other Mollusca	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	0.3
CHAETOGNATHA	-	-	-	0.1	-	-	-	98.8	0.1	-	-	-	-	-	-	-
PISCES	8.3	10.3	15.8	2.6	28.2	41.8	94.9	+	-	45.5	-	67.8	+	-	47.5	7.3
Rajidae	-	-	-	-	-	-	-	-	-	-	-	3.4	-	-	-	4.8
Clupeidae	1.9	1.9	-	-	-	-	20.3	-	-	-	-	8.7	-	-	7.1	-
Merluccius	-	-	-	0.9	-	-	-	-	-	-	-	26.5	-	-	21.1	-
Limanda	-	-	-	0.1	-	-	-	-	-	2.5	-	-	-	-	-	-
Other Pisces	8.3	8.4	15.8	1.6	28.2	41.8	74.6	+	-	43.0	-	29.2	+	-	19.3	2.5
Other groups	0.4	0.6	4.7	+	1.1	+	0.1	0.1	1.5	0.1	4.2	0.9	-	-	1.7	3.2
Animal remains	16.4	4.1	37.4	8.6	29.2	0.3	0.5	0.8	97.2	4.4	7.7	3.0	8.3	-	+	3.2
Number examined	39	32	13	498	26	12	8	3	94	45	34	323	120	1	5	97
Number empty	2	1	0	75	0	0	3	0	7	1	10	2	68	0	1	19
$\bar{x}$ stom. content wt (g)	1.70	1.47	0.12	0.21	1.02	1.25	51.18	6.73	0.20	0.73	0.82	0.78	0.01	0.07	106.95	1.40
Length range(cm)	11-51	13-50	13-20	21-40	21-45	26-40	70-76	29-42	11-22	25-34	18-42	12-30	4-9	20	46-86	13-34

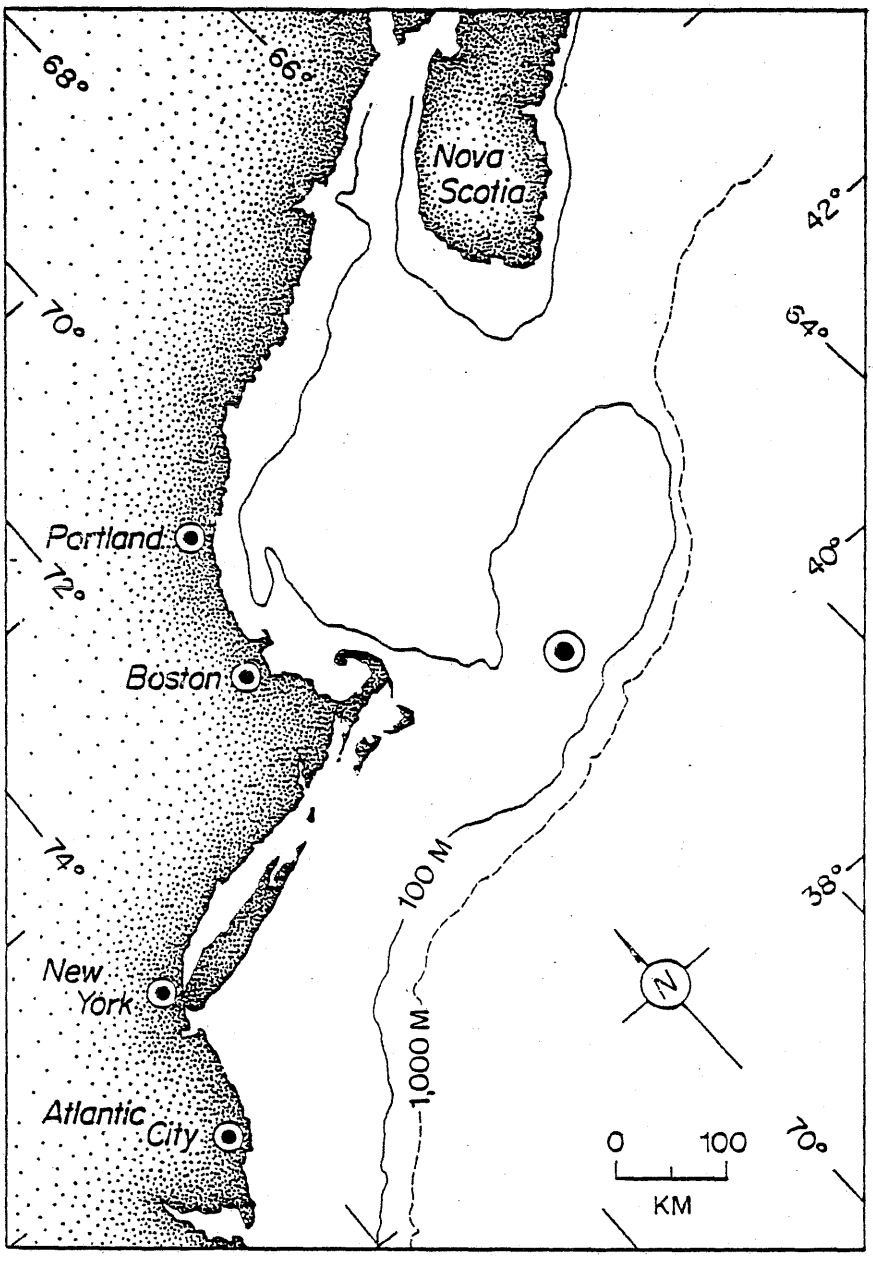

Figure 1. Location of feeding chronology study conducted in September of 1978. The approximate center of the study area is $40^{o}41'$; $68^{o}14'$.

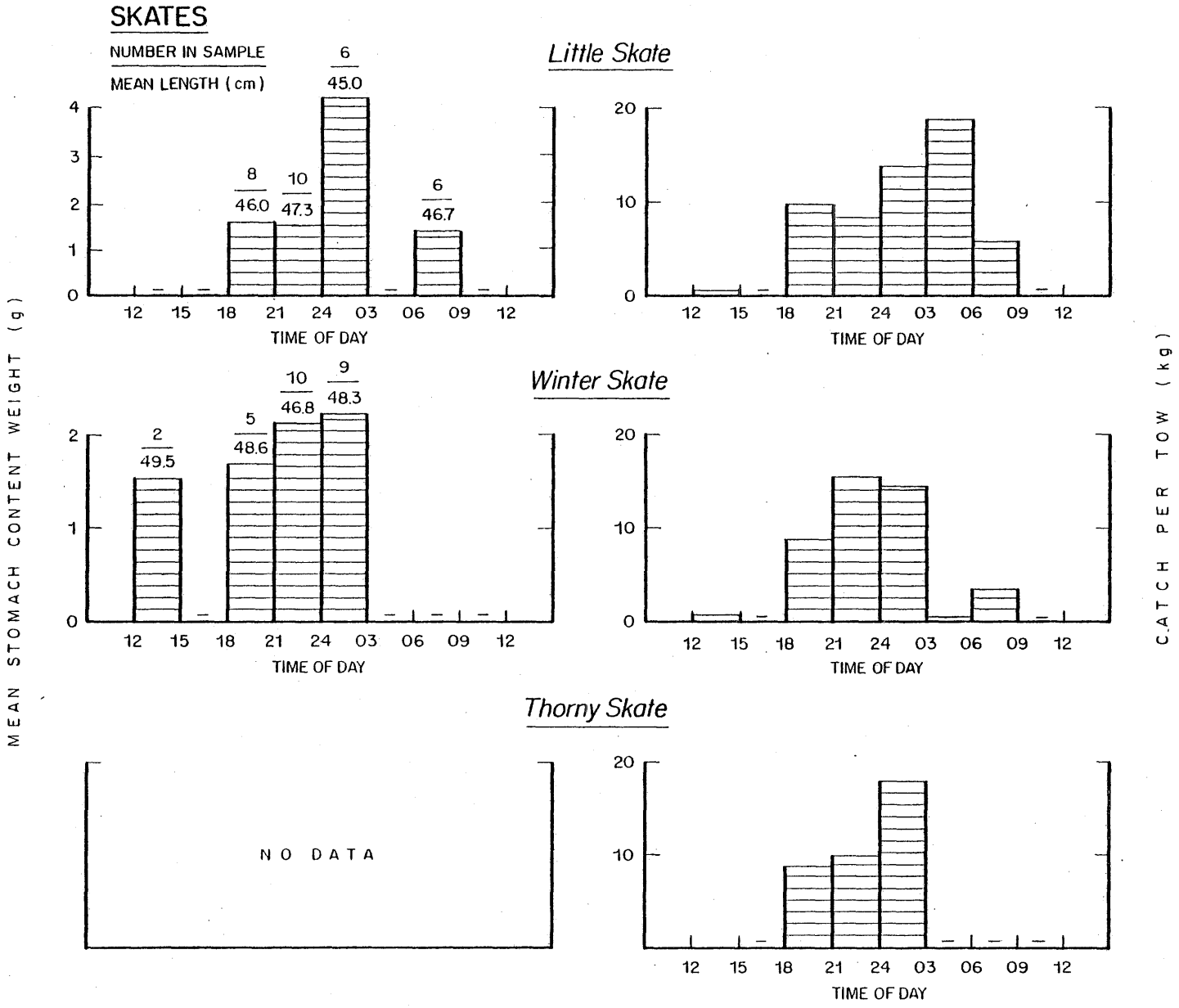

Figure 2. Feeding and catchability data by time of day for the "skates" caught during a USSR BELOGORSK cruise in September of 1978 on the Southern part of Georges Bank.

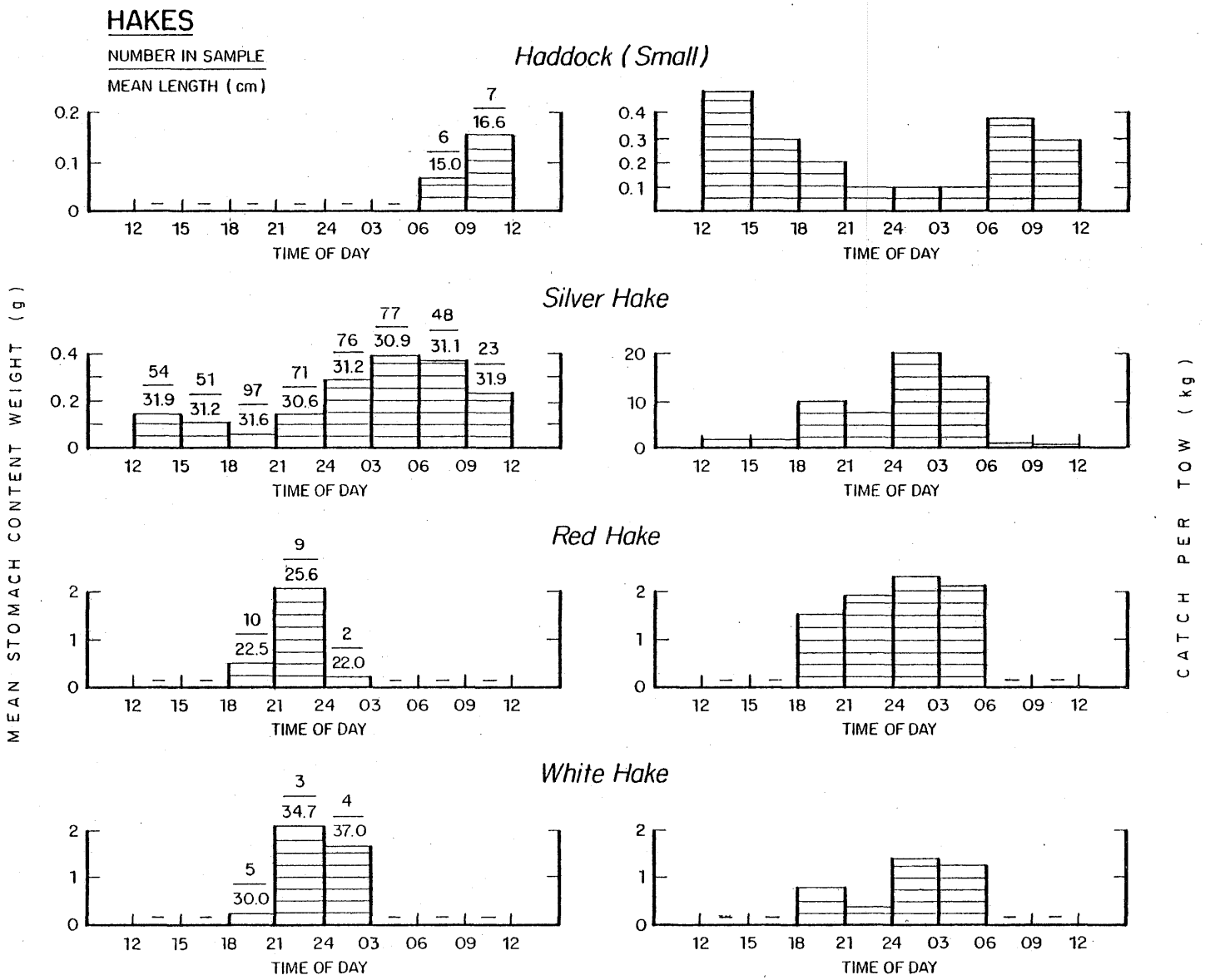

Figure 3. Feeding and catchability data by time of day for the "hakes" caught during a USSR BELOGORSK cruise in September of 1978 on the Southern part of Georges Bank.

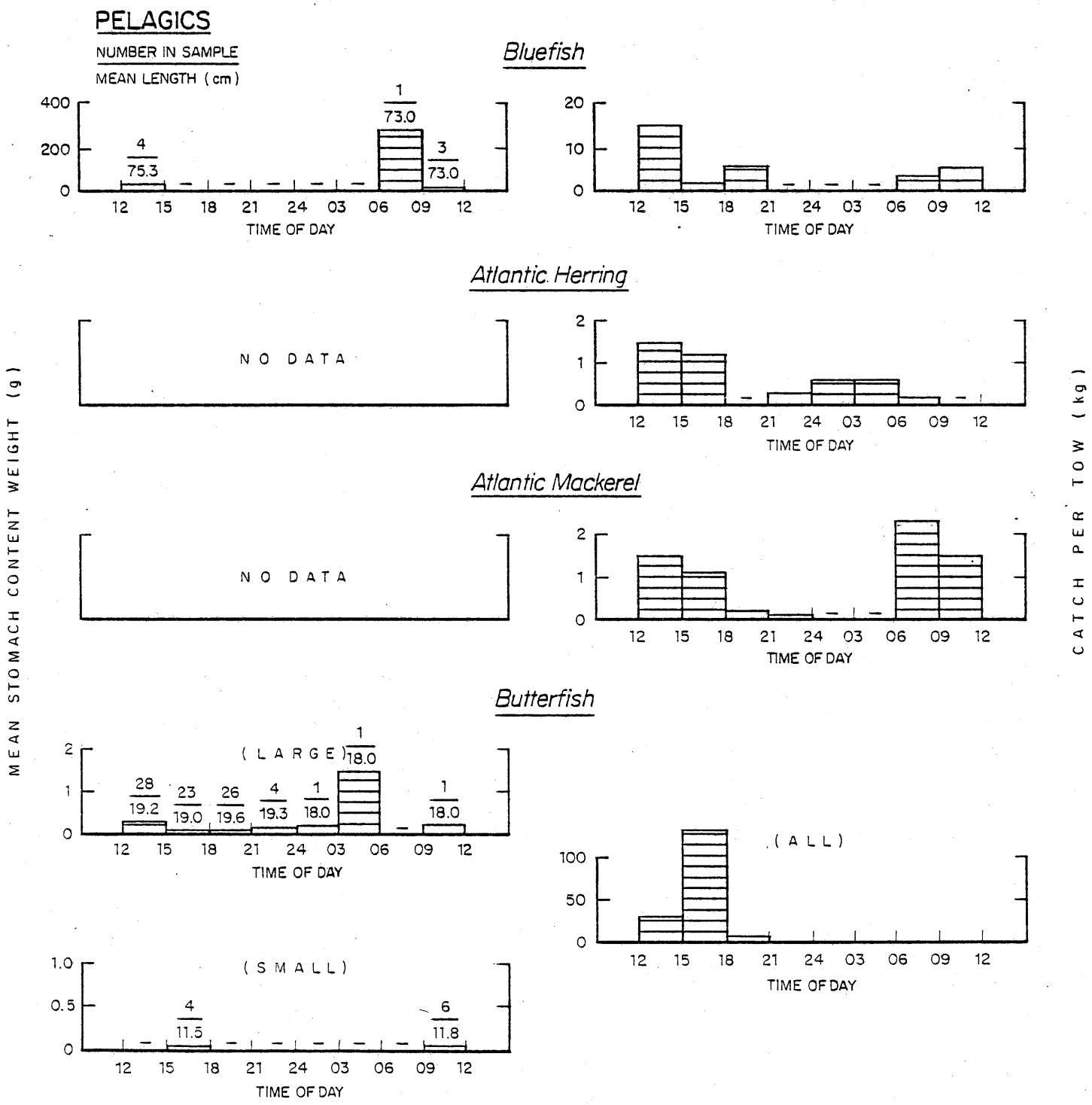

Figure 4. Feeding and catchability data by time of day for the "pelagics" caught during a USSR BELOGORSK cruise in September of 1978 on the Southern part of Georges Bank.

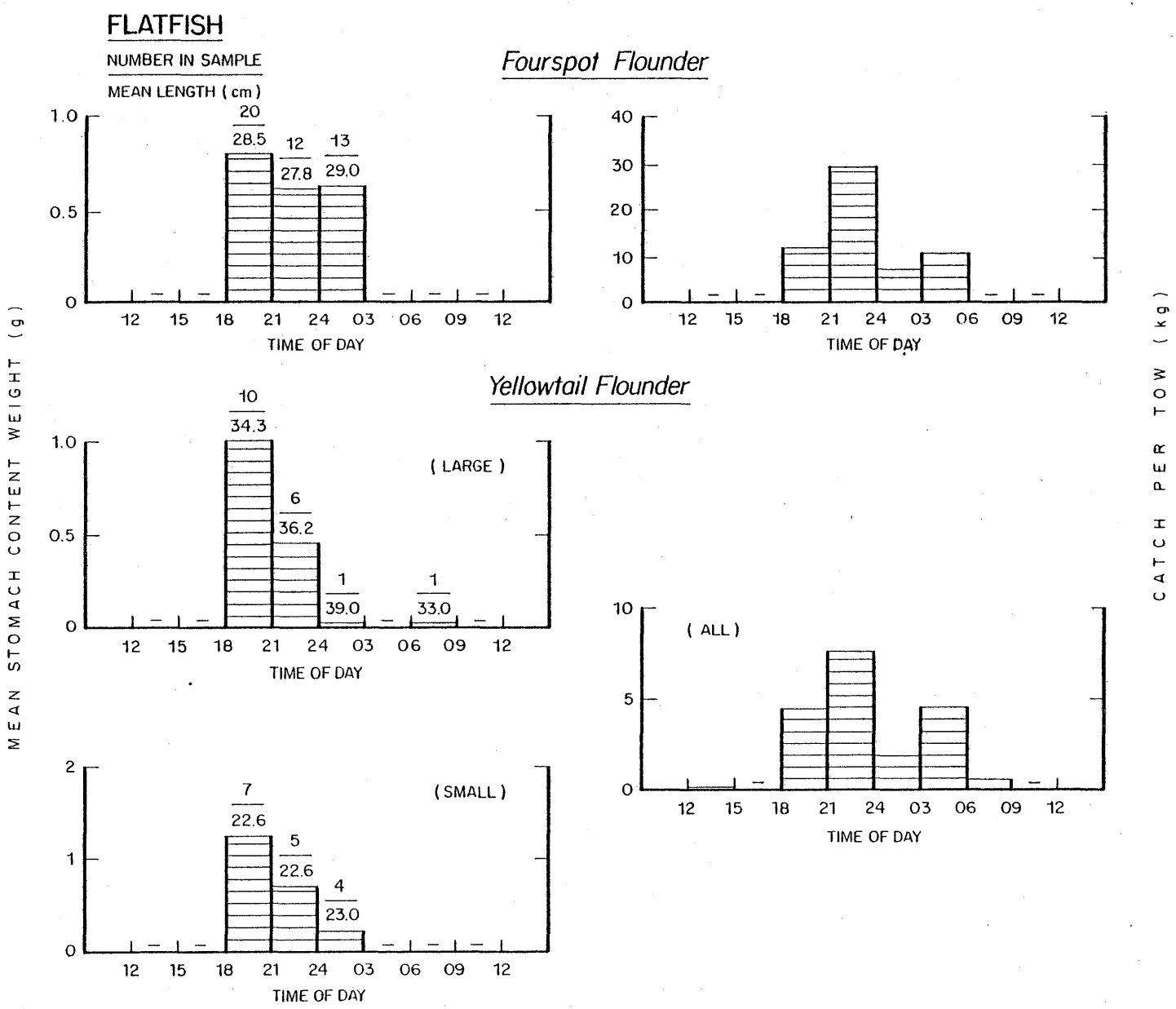

Figure 5. Feeding and catchability data by time of day for the "flatfish" caught during USSR BELOGORSK cruise in September of 1978 on the Southern part of Georges Bank.

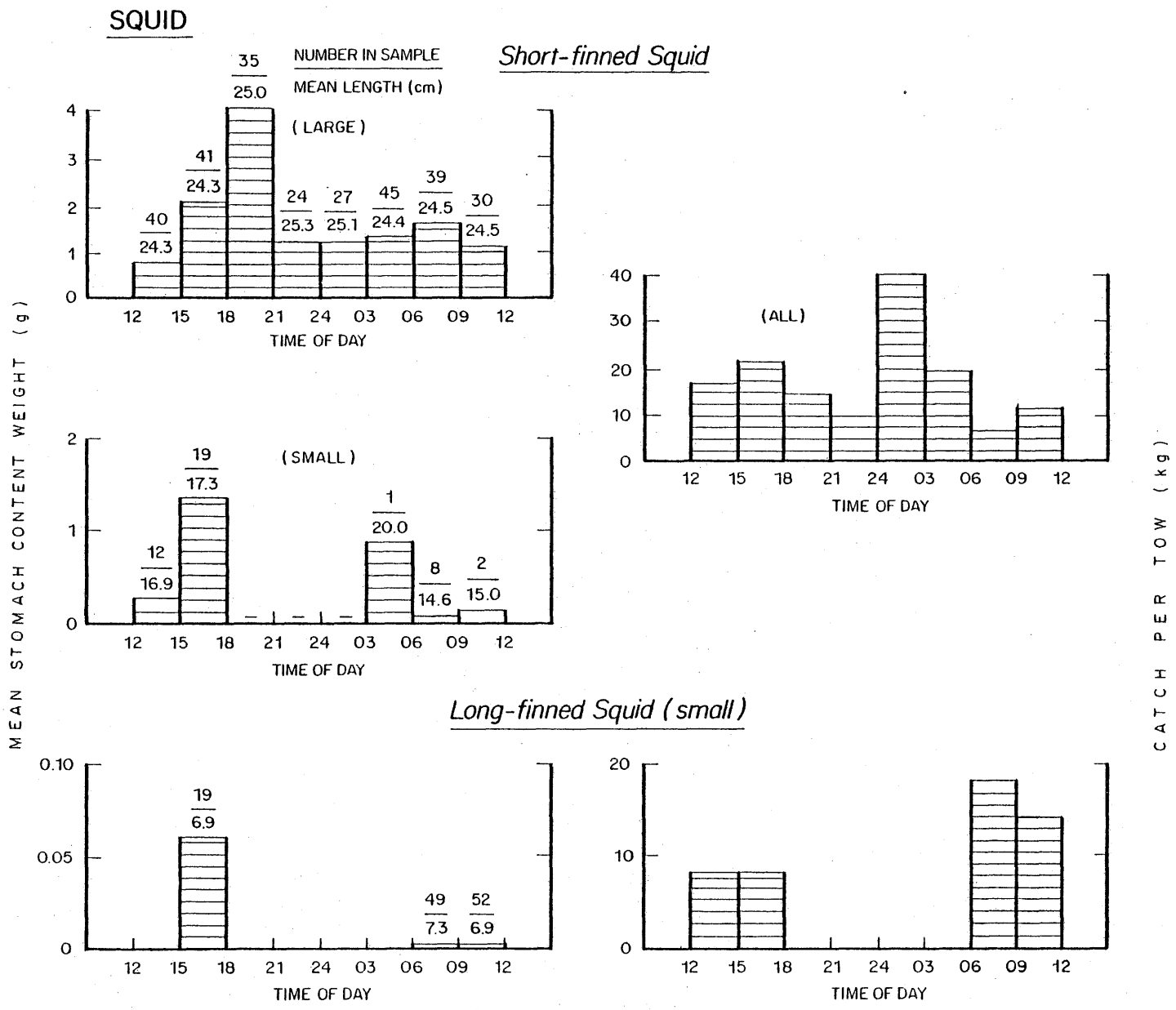

Figure 6. Feeding and catchability data by time of day for the "squids" caught during a USSR BELOGORSK cruise in September of 1978 on the Southern part of Georges Bank.

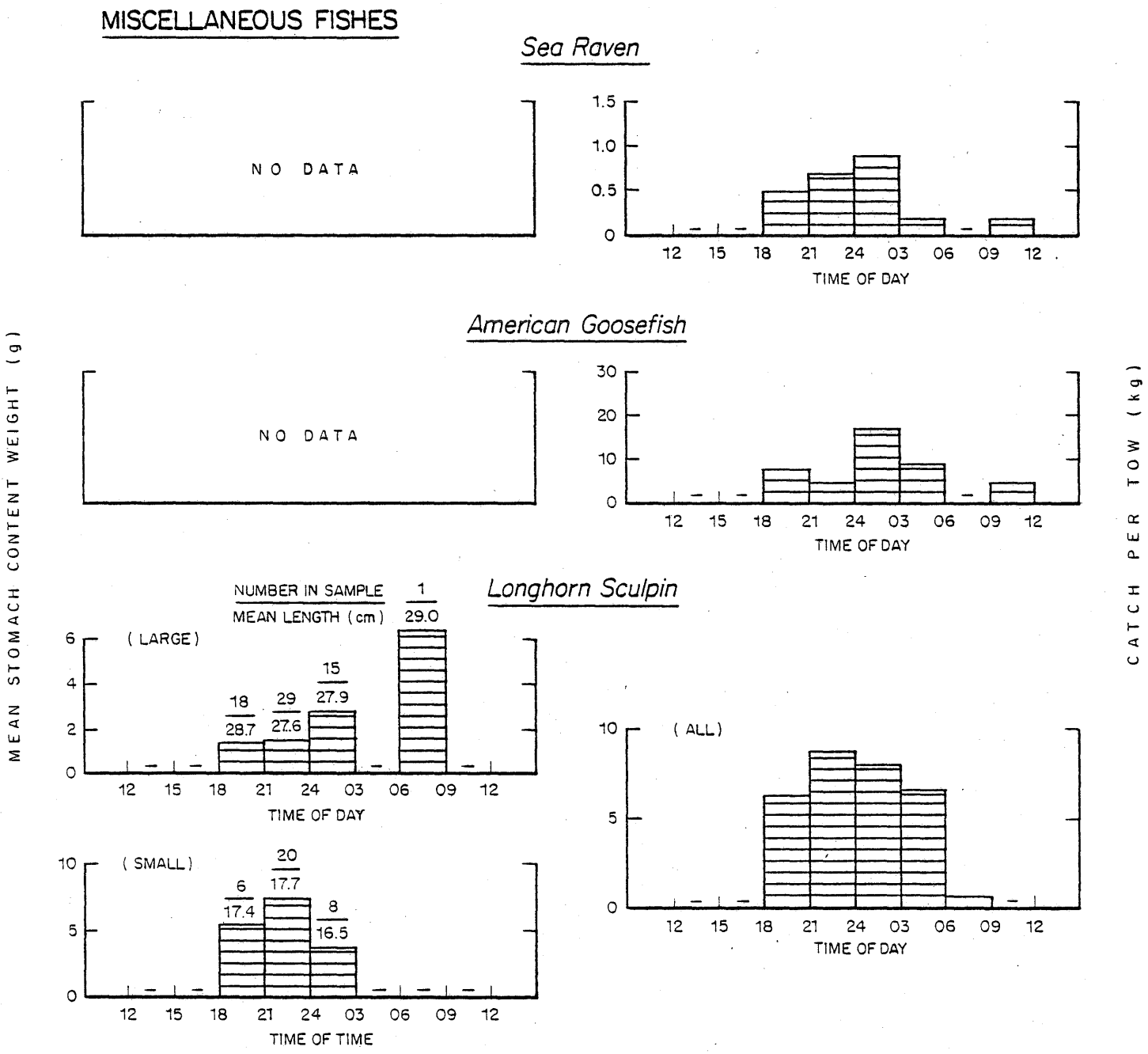

Figure 7. Feeding and catchability data by time of day for the "miscellaneous fishes" caught during a USSR BELOGORSK cruise in September of 1978 on the Southern part of Georges Bank.