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Diurnal Variation in the Feeding Intensity and Catchability of Silver Hake (*Merluccius bilinearis*)

by

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ABSTRACT

Silver hake (*Merluccius bilinearis*) feeding intensity and catchability during periods of daylight and darkness has been examined. A variety of free-swimming crustaceans (i.e., *Crangon septemspinosa*, *Dichelopandalus leptocerus*, and *Monoculodes intermedius*) made up the largest part of the silver hake diet. Examination of stomach fullness, intestinal fullness, the number of empty stomachs, state of digestion of prey, and the ratio of the stomach contents weight to the intestinal contents weight during different time periods shows that silver hake feed at night. Their feeding period begins just after dusk and continues until pre-dawn, with the majority of their prey being taken between dusk and midnight. Prey are broken down in the stomach and passed into the intestine after a period of approximately 15 hours. The intestine is emptied after a further 9 hours has elapsed, which results in a total digestive tract evacuation time of about 24 hours. The ability of several types and sizes of trawls to catch silver hake has been evaluated. Catch data from various studies, most of which were rigidly controlled trawl comparison experiments show that pelagic trawls, off bottom trawls, and bottom trawls with roller gear tend to pass over silver hake during the day, while bottom trawls with chain-disc sweeps and cable sweeps catch large quantities of silver hake during daylight hours. These data establish that silver hake are located on or immediately above the bottom during the day and that they are off bottom at night. It is suggested that a high opening trawl to catch silver hake at night, combined with a chain-disc sweep to increase the day catch, would substantially increase the overall silver hake catches by a vessel operating on a 24-hour per day basis.

INTRODUCTION

Research by Edwards and Bowman (1979) indicated that silver hake (*Merluccius bilinearis*) plays the principal predatory role in regulating the ecosystem in the Northwest Atlantic. Surprisingly, little quantitative data have been published concerning the feeding habits or behavior of silver hake. One of the first papers dealing with the food of silver hake was by Nichols and Breder (1927) who noted that 75 herring, approximately 7 centimeters long, were found in the stomach of one 59 centimeter silver hake. Large silver hake eat mostly fish, but will also take squid when they are available, while smaller silver hake feed on shrimp such as *Pandalus* sp. (Bigelow and Schroeder, 1953; Jensen and Fritz, 1960;

Vinogradov, 1972). Recent papers by Edwards and Bowman (1979) and Langton and Bowman (1980) presented similar results on the diet of silver hake.

The only information on diurnal variation in the feeding intensity of silver hake is by Edwards and Bowman (loc. cit.). Their study identified silver hake as a night feeder, however, no detailed data were presented to establish the exact time(s) of feeding activity.

It has been documented that the diurnal vertical migration of demersal fish species causes variation in bottom trawl catches (Beamish 1966). Catches of most groundfish are generally larger by day than by night (Konstantinov, 1958; Parrish et al., 1964; Woodhead, 1964). However, Sissenwine and Bowman (1978) noted that the catchability of silver hake was greater during hours of darkness than during hours of daylight, but they only speculated on the reason for this phenomenon. This paper describes the daily feeding pattern of silver hake and explains how their behavior effects their availability to bottom trawls.

METHODS AND MATERIALS

All silver hake feeding data were gathered during a feeding chronology study jointly conducted by American and Russian scientists aboard the Russian research vessel BELOGORSK, operated by the Atlantic Research Institute of Marine Fisheries and Oceanography (AtlantNIRO), Kaliningrad, USSR, in September of 1978. The ship fished the Russian Hake 815 bottom trawl for 30 minutes once every three hours for two days, on the southern part of Georges Bank. The study area covered approximately 100 square miles (10 miles by 10 miles) and was selected on the basis of the 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 shown was one where the least variation in these parameters would be likely to occur (Figure 1). A total of 498 digestive tracts was collected from fish ranging in length from 21 cm to 40 cm, inclusive.

The stomachs and intestines of silver hake were removed while at sea and individually wrapped in gauze, labeled and preserved in 10 percent Formalin. At the Northeast Fisheries Center's (NEFC) laboratory in Woods Hole, Massachusetts, the stomachs were removed from the Formalin and opened over a 0.25 mm mesh opening screen sieve and flushed with seawater to remove the odor of the Formalin. Stomach contents were then damp dried with absorbent paper and immediately weighed to the nearest 0.001 g. The same procedure was followed when processing the contents of the intestine. Once weighed the stomach contents were transferred to a dish and prey organisms were sorted, counted, identified, and weighed to the nearest 0.001 g. Also noted were observations regarding the general condition (i.e., state of digestion) of the prey found in the stomach which were recorded as either more than one-half digested, one-half digested, or less than one-half digested.

Food data are presented in terms of the percentage weight each prey made up of the total stomach contents weight, mean stomach content weight, percentage of empty stomachs, mean intestinal content weight, state of digestion, and as a ratio of the stomach contents weight to the intestinal contents weight (hereinafter referred to as the S/I ratio). The S/I ratio is particularly useful for determining the feeding periods of fish, providing they have marked daily behavioral cycles (Edwards and Bowman, 1979). When the ratio is more than one it shows that the fish's stomach

contains more material than its intestine, and if it is less than one it indicates that the intestine contains more than the stomach. If fish have a digestion cycle of more than 24 hours the ratio would most likely be useless because the stomach would contain more material than the intestine for long periods of time. However, when the ratio fluctuates substantially above and below a value of 1.0 over a 24-hour period, it shows the fish population is feeding one or possibly more times a day. Meal size has little effect on the results since small and large meals (either eaten by the same size or different size fish) are given equal weight once they are converted into a ratio.

The ability of several types and sizes of trawls to catch silver hake has been evaluated. These trawls included bottom trawls with both chain-disc and cable sweeps; bottom trawls with varying size roller gear; off-bottom trawls with large steel bobbins suspended from the footrope; and a commercial mid-water trawl. A brief description of the trawls and their individual characteristics (headrope and footrope lengths and footrope rigging), is outlined in Table 1. A detailed listing of all cruises, trawl types, areas of operation and other pertinent information can be found in Table 2. Many of the daylight versus darkness catches of silver hake were collected during a series of rigidly controlled trawl comparison experiments. These data were found to be useful in determining the behavior of silver hake.

Between August 1973 and September 1975, a total of 81 ship days at sea were spent evaluating the relative fishing power of the standard Yankee No. 36 and modified Yankee No. 41 trawls (see Table 2). These efforts were jointly and cooperatively conducted by scientists and research vessels

from the NEFC and AtlantNIRO. All comparative fishing power experiments were conducted by a pair of vessels--either two USA vessels or one each USA and USSR. For the study an area of 100 square miles (10 x 10 miles) was divided into four quadrants, each of which was subdivided into 25 one-mile square blocks. Each block represented a potential fishing station for the experiment. The two vessels engaged in the experiment operated simultaneously within the same quadrant for a period of two complete 24-hour days before moving onto the next quadrant. Each vessel independently completed its series of comparative tows at pre-selected random stations. The experiment was designed to have each vessel fish both the Yankee No. 36 and modified Yankee No. 41 trawl an equal number of times during periods of daylight and darkness. The sequence in which the two trawls were fished with regards to the periods of daylight-darkness was randomized. Tows during these experiments were 30 minutes in duration at a vessel speed of 3.5 knots in the direction of the following station.

Individual catches were processed according to routine groundfish survey procedures established at the NEFC. Our calculations of the day and night catches included only the number of silver hake greater than 20 cm caught at stations which occurred from 0900 to 1500 (day) and from 2100 to 0300 (night). This procedure eliminated any bias which could be caused by the presence of a few large fish if the data had been presented in terms of kilograms per tow. It also reduced the possibility that the large numbers of smaller silver hake often caught (whose habits may differ from the larger ones) would influence the number caught per tow. The time periods of day and night were chosen because they represent light and dark periods throughout the year in the study area.

RESULTS

Food Composition

Analysis of the stomach contents of silver hake showed that the composition of the diet was fairly consistent over time. A variety of crustaceans made up the largest part (96.7% by weight) of the silver hake diet (Table 3) throughout the 48-hour study period. Decapod shrimp were the most important crustacean prey and were represented mainly by *Crangon septemspinosa* (28.0%) and *Dichelopandalus leptocerus* (10.1%). In addition, decapod shrimp which could not be identified because of their state of digestion accounted for 27.4% of the stomach contents. Other decapods found in the stomachs included unidentified Pandalidae (1.7%), *Axius serratus* (0.2%), Decapod larvae (0.1%), Thalassinoidea (+), and *Sclerocrangon boreas* (+).

Amphipods made up 26.8% of the silver hake stomach contents. *Monoculodes intermedius* was preyed on the most heavily (9.9%). Other amphipods included *Parathemisto gaudichaudi* (2.7%), *Haploops* (1.1%), *Ampelisca* (1.0%), *Monoculodes edwardsii* (0.6%), and *Pontogeneia inermis* (0.5%). The remaining amphipods and one other crustacean group, the Cumacea, were either not identified to species or contributed little to the food of silver hake (Table 3).

Other prey groups of silver hake were Pisces (2.8%), which were identified as *Merluccius bilinearis* (1.0%), Gadidae (0.5%), and *Limanda ferruginea* (0.1%), along with small amounts of Cephalopoda (0.4%) and Chaetognatha (0.1%).

Feeding Periodicity

Stomach fullness is the most direct evidence for evaluating feeding periodicity. The mean stomach content weight is an indication of stomach fullness for a population. In Figure 2 it can be seen that silver hake stomachs are fullest during the period between midnight and dawn. Just after dusk the stomachs begin to fill, are at peak fullness after midnight (indicating that feeding has for the most part ceased), and begin to empty at dawn and continue to empty throughout the day.

The number of empty stomachs in each time period is another measure of feeding intensity. If only a small percentage or none of the fish caught during a certain time period have empty stomachs, it follows that the population has recently completed a feeding period, providing they have less than a 24-hour stomach evacuation rate. Figure 3 shows that at dawn all the silver hake collected had some food in their stomachs. Conversely, at dusk a large percentage of the total number of fish had empty stomachs, indicating that silver hake feed during the period between dusk and dawn.

Examination of the rate of intestinal filling is another method useful for determining the feeding periodicity of fish. When the intestine begins to fill the fish is likely near the end of a feeding cycle (Edwards and Bowman 1979). The data given in Figure 4 shows that the weight of the material in the intestines of silver hake steadily increases from midnight until noon. Thus, the food in the stomach begins to pass into the intestine after midnight and continues being passed until noon, indicating that most silver hake cease feeding just after midnight.

Food condition (or state of digestion) is an observation helpful in determining when fish eat. Fresh food in the stomach shows that the prey were recently taken by the fish. When the condition of the stomach contents is substantially reduced by the digestive processes the food has probably been in the stomach for some time. The condition of the silver hake stomach contents is presented in Figure 5 as the percentage of the fish in the sample whose stomach contents were less than half digested, half digested, and more than half digested for each time period. The number of fish whose food was less than one-half digested increased continuously from dusk to midnight, after which the percentage decreased to a minimum following dawn. Throughout the day few of the fish stomachs contained food which was less than one-half digested, suggesting that silver hake don't feed during the day. The percentage of fish with half digested food steadily increased from dusk to midnight, at which time approximately 50% of the fish stomachs contained half digested food. From midnight until noon the number of fish with half digested food remained at approximately 50%, but by early afternoon the percentage was at a minimum (about 15%). More than 80% of the silver hake samples in the early afternoon had food more than half digested in their stomachs (Figure 5). This observation is important for two reasons. First, it establishes that silver hake only feed once per day, and second, that silver hake break down their food in less than 24 hours.

The S/I ratio was used to determine when silver hake feed as well as the time it takes them to digest their food. It can be seen in Figure 6 that the percentage of fish with S/I ratios more than 1.0 increases steadily from dusk to just after midnight (as the fish feed their stomachs fill). A comparison of the histograms in each time period also shows

the number of fish in the population with ratios greater than 1.0 decreases continuously from midnight to dusk (as the quantity of food in the stomachs is reduced by the digestive processes, the intestines begin to fill). Based on the relationship between the S/I ratios over 24 hours the average stomach evacuation time for silver hake is close to 15 hours (from approximately 0430 hours until 1930 hours). The intestine evacuation time is roughly 9 hours (from approximately 1915 hours to 0430 hours). The complete digestion cycle takes approximately 24 hours.

Catchability

Bottom trawling by the USSR R/V BELOGORSK in September of 1978 resulted in large catches of silver hake at night (Figure 7). An examination of the ability of seven different types and sizes of trawls to catch silver hake in different areas and seasons helped to clarify why so few silver hake were caught during periods of daylight. Table 2 presents the results of a total of 229 and 242 research trawl tows during periods of daylight and darkness, respectively. The trawls rigged with roller gear (Standard Yankee No. 36 and two-seam Modified Yankee No. 41), regardless of the diameter of the rollers, catch more silver hake at night than during the day. Likewise, the two off-bottom trawls (Russian-Hake 815 and Japanese commercial) also caught more silver hake during hours of darkness than during hours of daylight. Conversely, the two bottom trawls rigged with a chain-disc and cable sweep (3/4 Yankee No. 36 and Russian 27.1 meter) caught more silver hake during the day period than at night. Pelagic trawling during the day, although limited (3 hours total trawl time), resulted

in no silver hake being caught. Of particular interest is that the day versus night catches of similarly constructed trawls with different sweep arrangements, such as the Yankee No. 36 trawl rigged with roller gear and the 3/4 Yankee No. 36 rigged with a chain-disc sweep, are different. A ship towing the 3/4 Yankee No. 36 trawl caught more silver hake during the day than at night (ratio 1.3:1) while two companion ships towing a Yankee No. 36 trawl and a modified No. 41 Yankee trawl, both with roller gear, caught more silver hake at night than during the day (ratio of 4.5:1 and 2.0:1, respectively). Our evaluation of these data is that silver hake are found on or immediately above the bottom during daylight hours and are off the bottom at night (Figure 8).

DISCUSSION

This study confirms the results of earlier reports that smaller sized silver hake feed mainly on decapod shrimp and other small crustaceans (Bigelow and Schroeder, 1953; Jensen and Fritz, 1960; and Vinogradov, 1972). Most silver hake prey are included among the predominant species caught in plankton tows. Free-swimming organisms such as *Crangon septemspinosa*, *Dichelopandalus leptocerus*, and *Monoculodes* are often found off bottom during the night when silver hake feed (Whitely, 1948; Gosner, 1971; Welsh, 1970; Hagerman, 1970; and Wilcox, 1972).

The results have shown, through various methods, that silver hake feed at night. Their feeding period begins just after dusk and continues until pre-dawn, with the majority of their prey being taken between dusk and midnight. Examination of the S/I ratios has established that smaller crustaceans are broken down in the stomachs and passed into the intestine

of silver hake ranging in length from 21 cm to 40 cm after a period of approximately 15 hours. The intestine is emptied after a further 9 hours has elapsed, which results in a total digestive tract evacuation time of about 24 hours. These data confirm the report by Edwards and Bowman (1979) that silver hake feed at night and have a digestive system which operates on a 24-hour cycle.

The availability of silver hake to various trawl types has shown that silver hake are located close to the bottom during the day and that they are off-bottom at night. Pelagic trawls, off-bottom trawls, and bottom trawls with roller gear tend to pass over silver hake during the day, while bottom trawls with chain-disc and cable sweeps catch large quantities of silver hake during daylight hours. At first it seemed unlikely to us that bottom trawls with rollers, which are designed to catch demersal fish, could pass over large quantities of silver hake during daylight hours. However, visual observations by Edwards and Emery (1968) provided some evidence to explain how this might occur. During dives aboard the research submarine ALVIN they observed silver hake settling into depressions on the bottom about 1200 hours and remaining there until 1800 hours. Apparently, bottom trawls with rollers are relatively inefficient, compared to bottom trawls with chain-disc and cable sweeps, at catching fish located in these depressions.

Further evidence of silver hake being on the bottom and unavailable to bottom trawls with rollers during the day was obtained during a multiship survey of the megafauna in the Veatch Canyon region in June of 1973 (Uzmann et al., 1977). During the survey, a manned submersible was used

to estimate, among other things, the abundance of the megafauna. All submersible data was collected during daylight hours between 0730 and 1750. Two other ships, one which towed a bottom trawl and the other a benthic sled equipped with a 35-mm camera, during day and night periods, gathered data which was compared to the visual estimates of the megafaunal abundance. During the manned submersible operations silver hake were repeatedly seen lying on the bottom. The submersible, often only approximaterly 15 cm off the bottom, frequently passed over silver hake which did not move when the craft approached. Some silver hake, however, would move ahead of the submersible only to be overrun a short time later. Seldom, if ever, were silver hake seen rising far off the bottom or continuously avoiding the submersible (personal communication, Joseph Uzmann, 1979). Silver hake abundance was calculated from visual counts made during the operations to estimate trawl catchability. The trawl catches (bottom trawl with roller gear), were consistently less than the visual estimates obtained via the submersible. This implies that bottom trawls with roller gear only a catch a portion of the silver hake at night and even fewer during periods of daylight.

After considering the behavior of silver hake and their availability to several trawl types it seems that relatively few trawls can effectively catch silver hake both day and night. A high opening trawl (to catch them at night) combined with a chain-disc sweep (to increase the day catch) would meet the requirements of a trawl which would substantially increase the catches of silver hake by a vessel operating on a 24-hour per day basis. The fishing effort and efficiency (i.e., time, cost of fuel and labor)

could be dramatically reduced by equipping fishing vessels seeking silver hake with a trawl incorporating the above features. The expected yield per tow would be larger, which would result in less time and fuel being needed to catch similar amounts of fish. Of special interest is that the catchability of most groundfish appears to be similar to that of silver hake, and accordingly, the catches of other species may likely be increased also (Beamish, 1966; Sissenwine and Bowman, 1978).

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Table 1. Summary of trawl types with headrope and footrope lengths, sweep arrangement and catch ratios of mean number of silver hake taken per 30-minute trawl tow, in daylight and darkness, and total number of sampling tows during periods of daylight (0900-1500 hrs) and darkness (2100-0300 hrs).

Trawl design	Type trawl	Headrope length (meters)	Footrope length (meters)	Sweep arrangements 1/	Catch ratio of number of silver hake per tow: Daylight/Darkness	Catch ratio of number of silver hake per tow: Darkness/Daylight	Total number of sampling tows: Daylight	Total number of sampling tows: Darkness
1. 3/4 Yankee No. 36	Bottom	11.9	16.5	9.5 cm Chain + 11.4 cm diameter rubber discs	1.3:1	-	10	9
2. Russian 27.1 meter	Bottom	27.1	27.4	Ground rope-Steel cable	1.6:1	-	24	31
3. Standard Yankee No. 36	Bottom	18.3	24.4	Roller Gear	-	3.3:1	87	94
4. Two-seam Modified Yankee No. 41	Bottom	24.4	30.5	Roller gear (30.5, 35.6 40.6 & 45.7 cm rollers)	-	6.1:1	73	75
5. Russian-Hake 815	Off-bottom	32.0	48.0	Steel bobbins	-	25.5:1	4	4
6. Japanese commercial	Off-bottom	53.5	72.0	Steel bobbins	-	3.0:1	28	28
7. Japanese commercial	Midwater	60.2	60.2	Cable	0	0	3 2/	1 3/

1/ Sweep arrangements:

1. Chain. -- lengths of chain seized directly to footrope.

2. Ground rope. -- 22 mm diameter cable fitted to the footrope.

3. Roller gear. -- constructed of solid rubber rollers 40.6 cm in diameter.

4. Roller gear. -- constructed of spoked rubber rollers 45.7 cm at center of sweep, tapering towards both wings with 40.6 cm, 35.6, and 30.5 diameter rollers.

5-6. Steel bobbins. -- Bobbins are approximately 61 cm in diameter spaced about 3.5 meters apart attached to a hanging line by drop chains 60 cm to 90 cm in length.

7. Cable. -- 2.5 cm in diameter seized to hanging line.

2/ & 3/. Tows of 60 minutes duration.

Table 2. Catches of silver hake during 30-minute trawl tows by cruise, area, gear, and periods of daylight and darkness.

Vessel and Cruise dates	Study area	Type study	Trawl design and type	Daylight (0900-1500 hrs) Number of tows	Daylight (0900-1500 hrs) $\bar{x}$ number fish/tow	Darkness (2100-0300 hrs) Number of tows	Darkness (2100-0300 hrs) $\bar{x}$ number fish/tow	Catch ratio of the number of silver hake per tow: Daylight/Darkness	Catch ratio of the number of silver hake per tow: Darkness/Daylight
1. R/V BLESK (USSR) Sept. 14-25, 1971	Southern New England	Trawl evaluation-fisheries survey	Russian 27.1 meter-Bottom	24	341.1	31	214.7	1.6:1	-
2. R/V Atlantic Twin March 30-April 13, 1973	Area Center 41°15.5'N 72°17.0'W	Fishing power comparison	3/4 Yankee No. 36-Bottom	10	11.7	9	8.8	1.3:1	-
3. R/V Cameron (Canada) June 23-July 1, 1972	Canadian waters	Fishing power comparison	Standard Yankee No. 36-Bottom	5	0	7	9.0	-	9.0:1
4. R/V Albatross IV June 23-July 1, 1972	Canadian waters	Fishing power comparison	Standard Yankee No. 36-Bottom	6	2.0	8	9.0	-	1.5:1
5. R/V Delaware II March 30-April 13, 1973	Area Center 41°15.5'N 72°17.0'W	Fishing power comparison	Standard Yankee No. 36-Bottom	12	4.0	11	18.0	-	4.5:1
6. R/V Albatross IV Aug. 27-Sept. 7, 1973	Area Center 40°50.0'N 70°20.0'W	Fishing power comparison	Standard Yankee No. 36-Bottom	10	19.2	11	28.9	-	1.5:1
7. R/V Belogorsk (USSR) Aug. 27-Sept. 7, 1973	Area Center 40°50.0'N 70°20.0'W	Fishing power comparison	Standard Yankee No. 36-Bottom	11	6.1	9	13.0	-	1.2:1
8. R/V Albatross IV Sept. 6-17, 1974	Area Center 40°50.0'N 70°20.0'W	Fishing power comparison	Standard Yankee No. 36-Bottom	8	2.6	9	37.0	-	14.2:1
9. R/V Belogorsk (USSR) Aug. 27-Sept. 7, 1973	Area Center 40°50.0'N 70°20.0'W	Fishing power comparison	Standard Yankee No. 36-Bottom	2	0	8	3.1	-	3.1:1
10. R/V Albatross IV Sept. 3-19, 1975	Area Center (Part 1) 40.0°50.0'N 70.0°20.0'W	Fishing power comparison	Standard Yankee No. 36-Bottom	16	5.6	14	19.2	-	3.4:1
11. R/V Belogorsk (USSR) Sept. 3-19, 1975	(Part 2) 41.0°24.0'N 66.0°53.4'W	Fishing power comparison	Standard Yankee No. 36-Bottom	17	6.2	17	15.3	-	2.5:1

Table 2. Cont'd.

Vessel and Cruise dates	Study area	Type study	Trawl design and type	Daylight (0900-1500 hrs)		Darkness (2100-0300 hrs)		Catch ratio of the number of silver hake per tow	
				Number of tows	$\bar{x}$ number fish/tow	Number of tows	$\bar{x}$ number fish/tow	Daylight/Darkness	Darkness/Daylight
12. R/V Albatross IV March 30-April 13, 1973	Area Center 41°15.5'N 72°17.0'W	Fishing power comparison	Two-Seam Modified Yankee No. 41-Bottom	10	24.0	11	48.0	-	2.0:1
13. R/V Albatross IV Aug. 27-Sept. 7, 1973	Area Center 40°50'N 70°20'W	Fishing power comparison	Two-Seam Modified Yankee No. 41-Bottom	11	8.2	10	34.6	-	4.2:1
14. R/V Belogorsk (USSR) Aug. 27-Sept. 7, 1973	Area Center 40°50'N 70°20'W	Fishing power comparison	Two-Seam Modified Yankee No. 41-Bottom	10	8.2	11	132.5	-	16.2:1
15. R/V Albatross IV Sept. 6-17, 1974	Area Center 40°50'N 70°20'W	Fishing power comparison	Two-Seam Modified Yankee No. 41-Bottom	8	11.5	10	107.5	-	9.3:1
16. R/V Belogorsk (USSR) Sept. 6-17, 1974	Area Center 40°50'N 70°20'W	Fishing power comparison	Two-Seam Modified Yankee No. 41-Bottom	13	7.0	9	98.4	-	14.1:1
17. R/V Albatross IV Sept. 3-19, 1975	Area Center(Pt 1) 40°50'N 70°20'W	Fishing power comparison	Two-Seam Modified Yankee No. 41-Bottom	15	17.9	14	95.1	-	5.3:1
18. R/V Belogorsk (USSR) Sept. 3-19, 1975	Area Center(Pt 2) 41°24.'N 66°53.4'W	Fishing power comparison	Two-Seam Modified Yankee No. 41-Bottom	6	18.8	10	73.5	-	3.9:1
19. R/V Belogorsk (USSR) Sept. 28-30, 1978	Georges Bank	Food Habits Study	Russian-Hake 815-Off Bottom	4	25.8	4	658.8	-	25.5:1
20. R/V Suzuka Maru (Japan), July 19-27, 1977	Southeast Georges Bank to Hudson Canyon	Squid Survey	Japanese Commercial-Off Bottom	28	5.0	28	15.0	-	3.0:1
21. R/V Suzuka Maru (Japan), July 19-27, 1977	Southeast Georges Bank to Hudson Canyon	Squid Survey	Japanese Commercial-Midwater	3 1/	0	1 2/	0	-	-

1/ & 2/ Tows of 60-minute duration.

Table 3. List of prey and their corresponding percentage in terms of weight of all prey taken by silver hake collected on the southern part of Georges Bank during September of 1978. Subtotals of major and minor prey categories are offset and underlined or offset and given in parenthesis, respectively. (+ indicates <0.1%).

Prey	Percentage weight
POLYCHAETA	+
CRUSTACEA	96.7
Amphipoda	(26.8)
Haploops	1.1
Byblis serrata	+
Ampelisca macrocephala	+
Ampelisca	1.0
Unidentified Ampeliscidae	1.4
Trichophoxus epistomus	+
Unciola dissimilis	+
Leptocheirus pinguis	+
Unidentified Aoridae	+
Ancnyx sarsi	+
Pontogeneia inermis	0.5
Monoculodes edwardsi	0.6
Monoculodes intermedius	9.9
Unidentified Oedicerotidae	0.2
Unidentified Gammaridea	7.6
Parathemisto gaudichaudi	2.7
Unidentified Hyperiidea	1.6
Cumacea	(+)
Decapoda	(67.5)
Crangon septemspinosa	28.0
Sclerocrangon boreas	+
Dichelopandalus leptocerus	10.1
Unidentified Pandalidae	1.7
Axius serratus	0.2
Unidentified Thalassinoidea	+
Unidentified Decapoda shrimp	27.4
Unidentified Decapoda larvae	0.1
Unidentified Crustacea	(2.4)

Table 3. Cont'd.

Prey	Percentage weight
CHAETOGNATHA	0.1
CEPHALOPODA	0.4
PISCES	2.8
Merluccius bilinearis	1.0
Unidentified Gadidae	0.5
Limanda ferruginea	0.1
Unidentified Pisces	1.2

Number of silver hake collected	498
Number of empty stomachs	75
Mean weight per stomach (g)	0.193

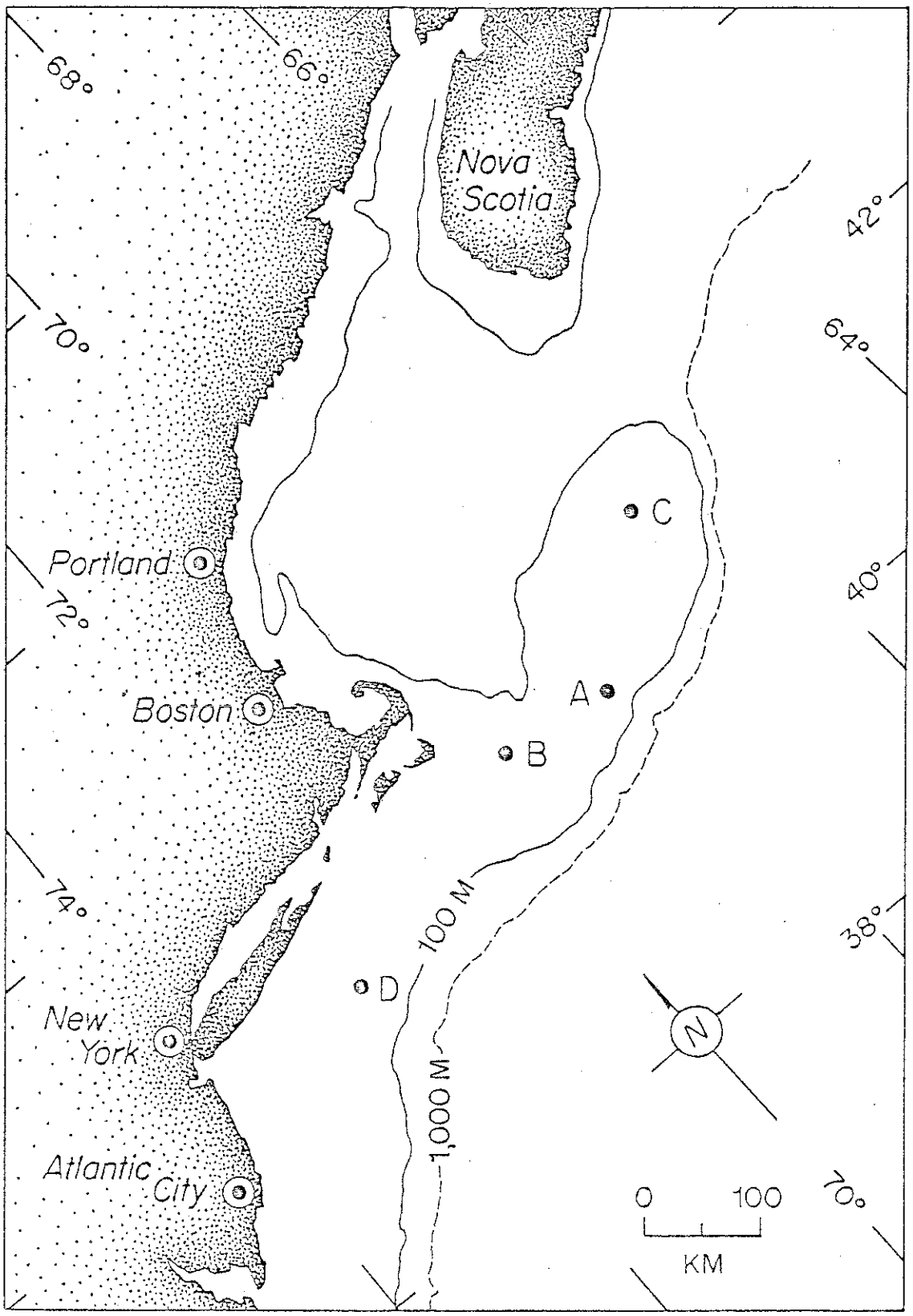

Figure 1. Location of feeding chronology study (A) conducted in September of 1978. Sites B, C, and D are areas where trawl comparison experiments were completed between the years of 1971 and 1975, inclusive.

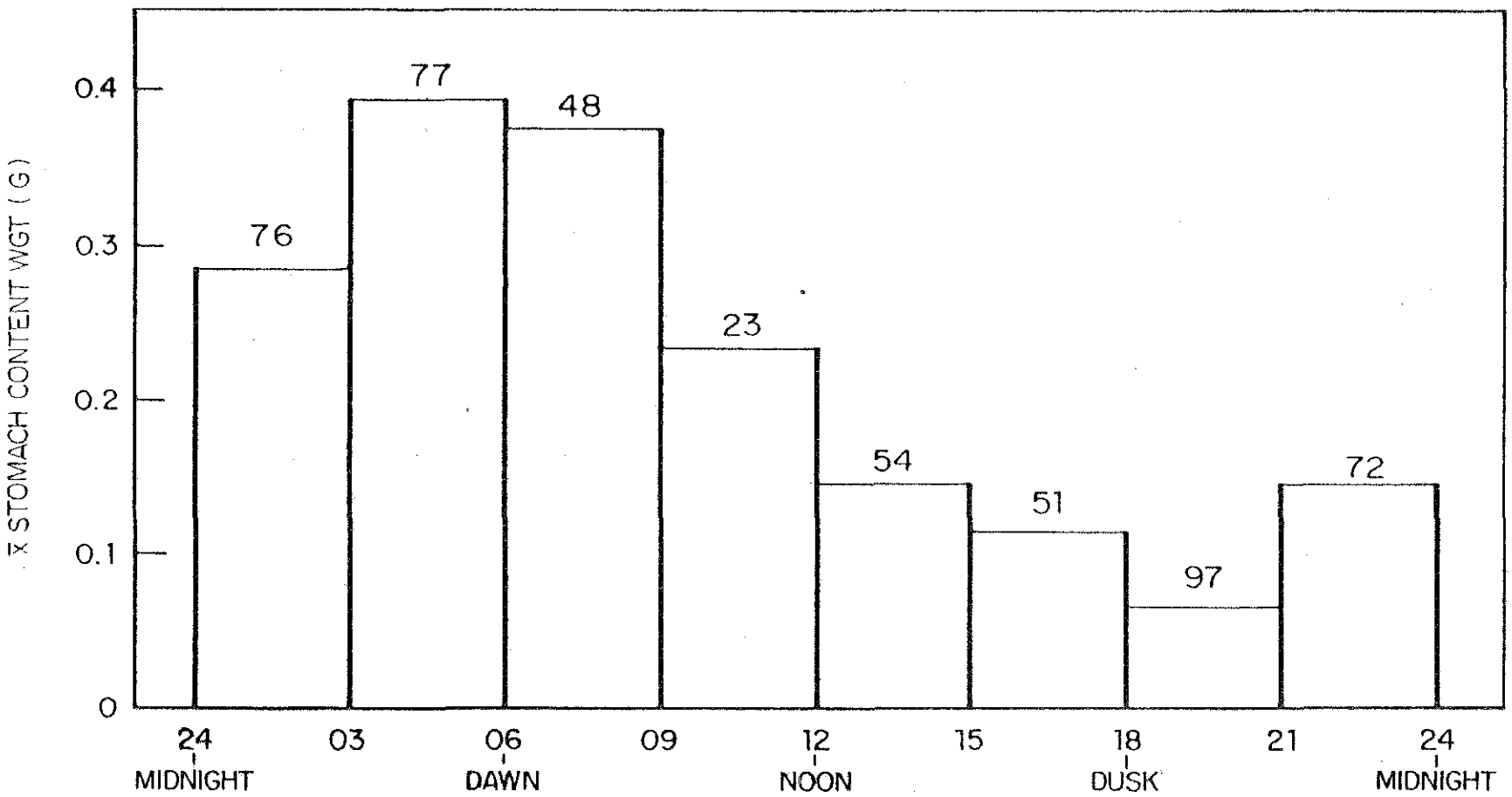

Figure 2. Mean stomach content weight of silver hake versus time of day. Silver hake were collected during a 48-hour study conducted on the southern part of Georges Bank in September of 1978. The number of fish sampled in each time period is given just above the histogram.

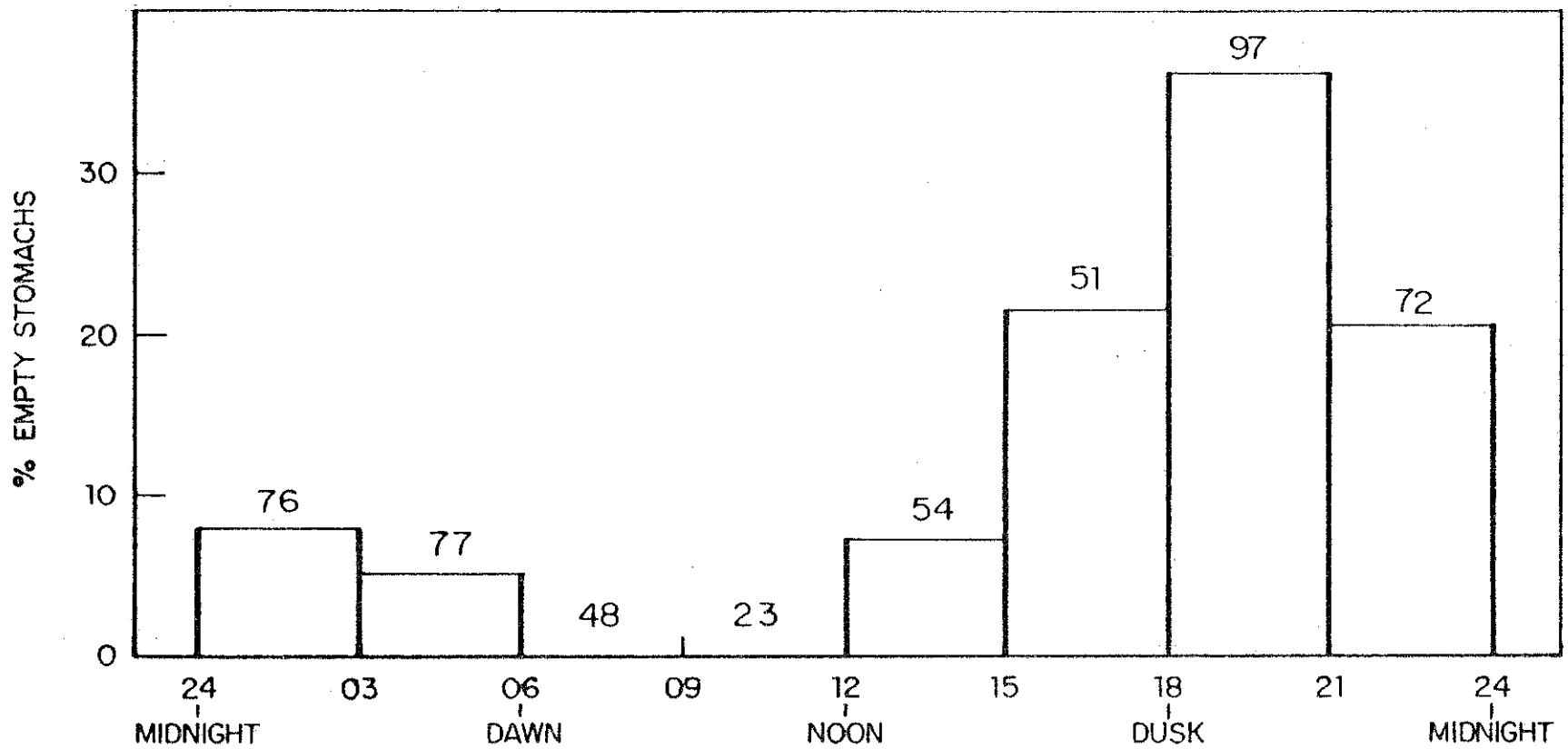

Figure 3. Percentage of silver hake examined in each time period which had empty stomachs. The number of fish sampled in each time period is given just above the histogram. All fish were caught while bottom trawling from the USSR R/V BELOGORSK.

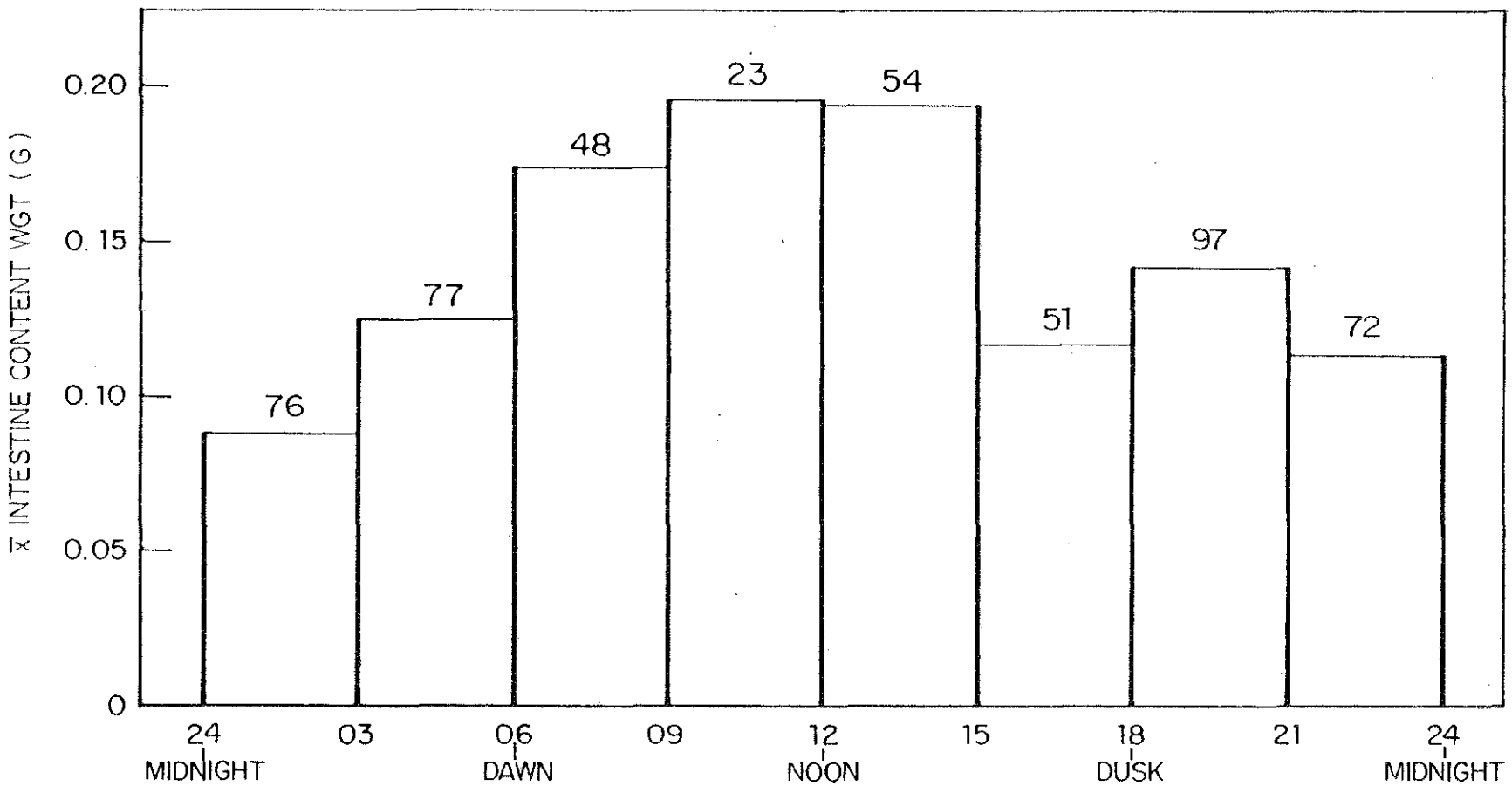

Figure 4. Diurnal variation in the mean weight of silver hake intestinal contents. The number of intestines examined in each time period is given above the histogram.

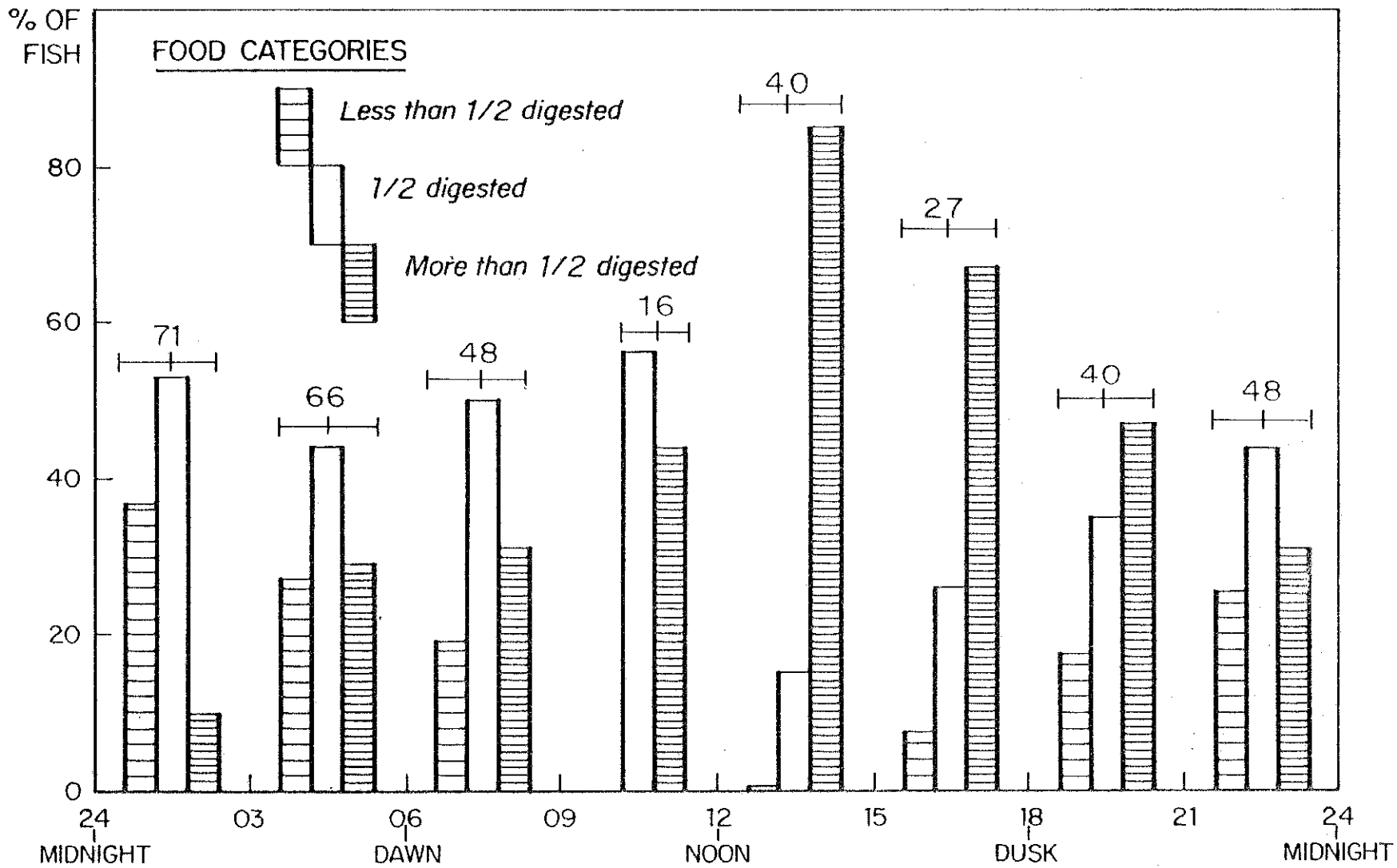

Figure 5. Presentation of three categories of the state of digestion of silver hake stomach contents at various times of the day. The number of fish sampled in each time period is given above the corresponding histograms.

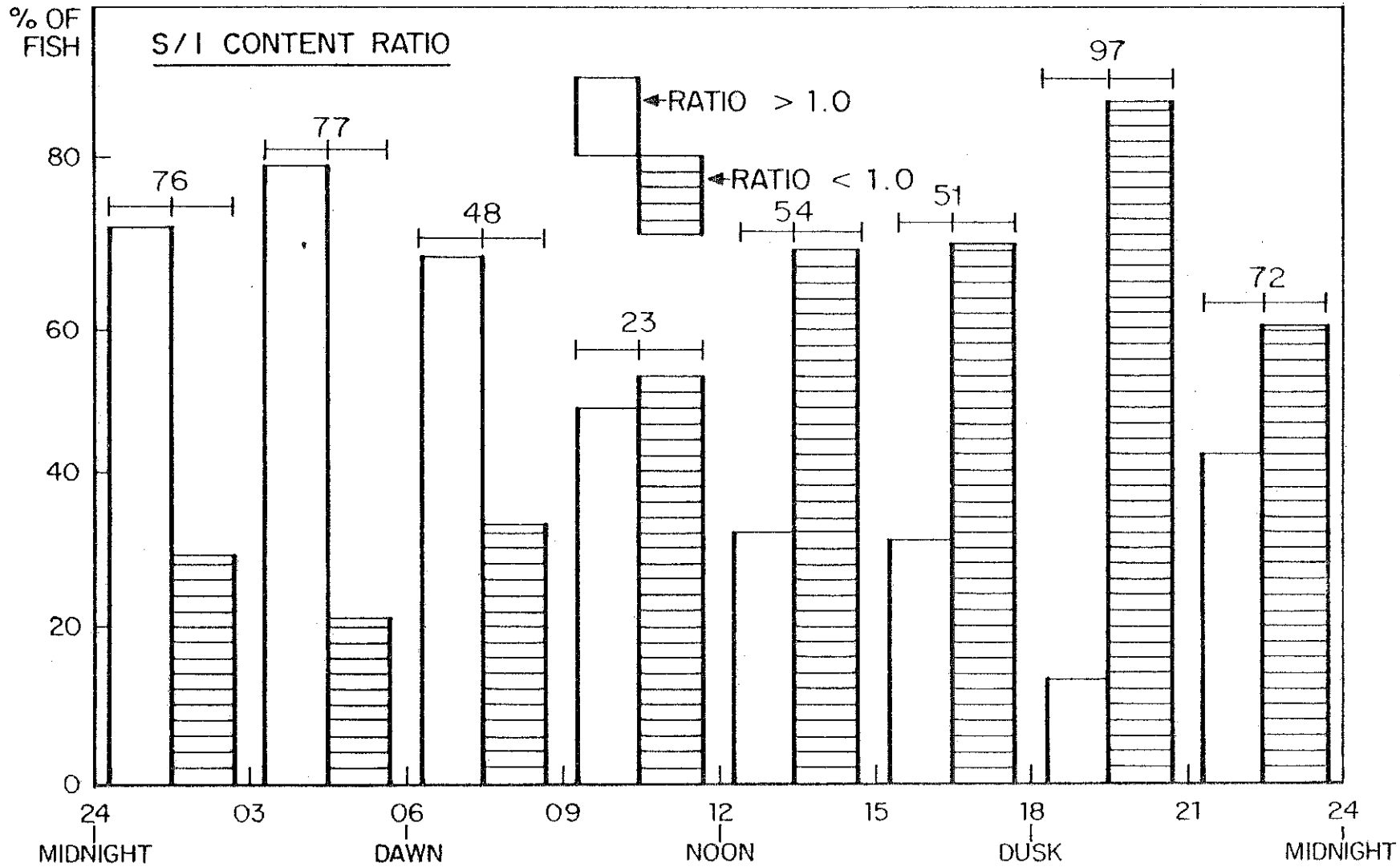

Figure 6. Ratio of the stomach contents weight to the intestinal contents weight of silver hake (S/I ratio) versus time. The number of fish sampled in each time period is given at the top of each histogram.

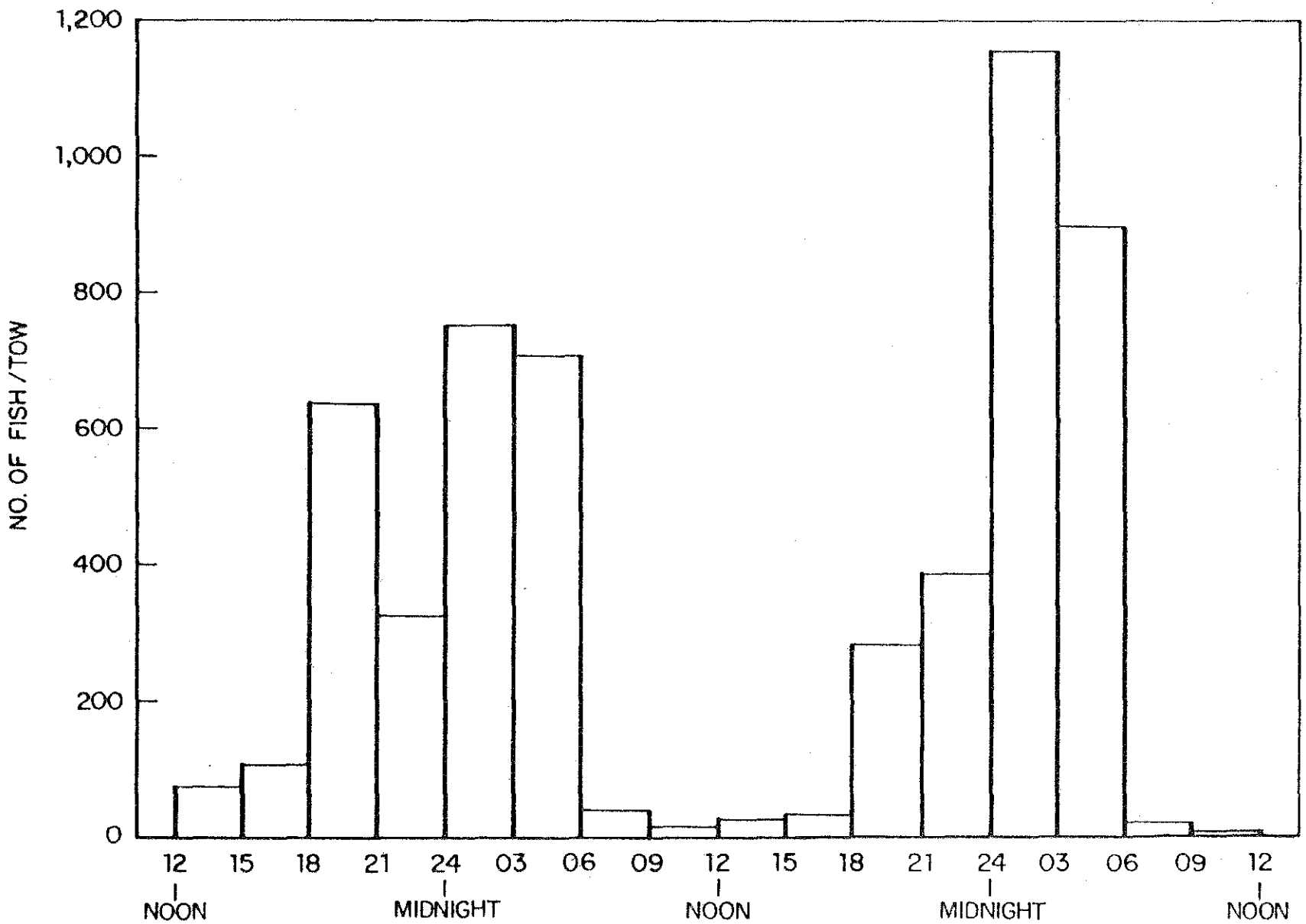

Figure 7. Catch per tow of silver hake during the 48-hour feeding chronology study conducted on the southern part of Georges Bank in September of 1978. The USSR R/V BELOGORSK fished the Russian Hake 815 off-bottom trawl throughout the study.
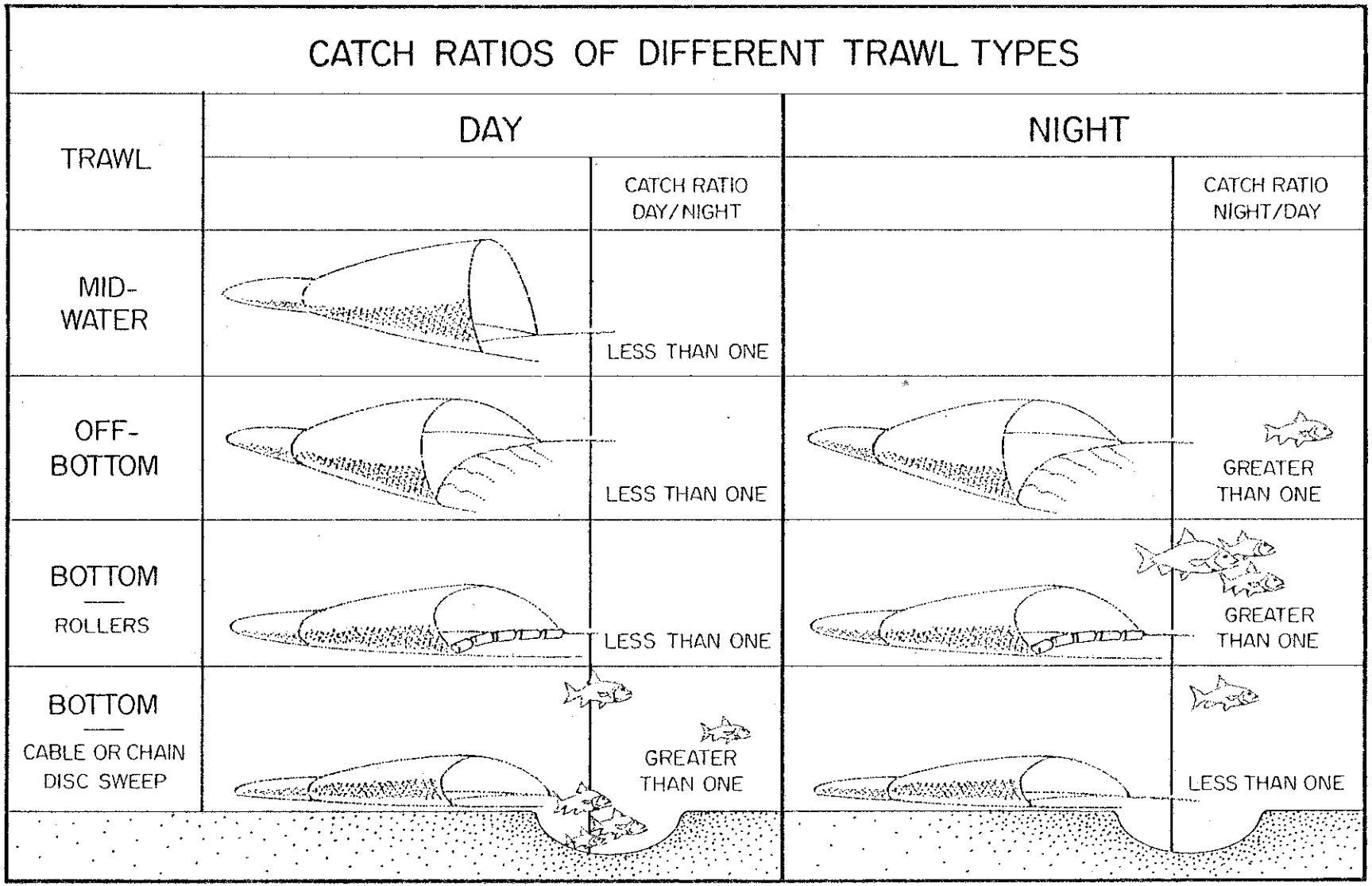
Figure 8. Graphic presentation of our interpretation of the day versus night catchability data gathered during trawl comparison experiments conducted on Georges Bank. Note that fish located on or close to the bottom during daylight and off bottom at night would result in the observed catch ratios.