FOOD OF SILVER HAKE, *MERLUCCIUS BILINEARIS*

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ABSTRACT

Stomach contents of 2,622 silver hake collected in the Northwest Atlantic have been analyzed. Fish were collected on bottom trawl surveys conducted from 1973 to 1976. The mean fish fork length (FL) was 20 cm and the average stomach content weight was 1.5 g. Silver hake <20 cm FL prey mostly on amphipods, decapod shrimp, and euphausiids. Fish 20 cm FL and longer take increasing proportions of fish and squid as part of their diet. Stomach contents of male and female fish of similar size indicate that females eat larger quantities of food (particularly more fish) than the males. The females are also, on the average, longer than the males. Silver hake feed primarily at night. Feeding begins near dusk and continues until just after midnight. In the spring a second feeding period seems to occur near noon. Silver hake feed intensively during spring. Their stomachs contain almost twice as much food in spring as they do in autumn. Significant differences were noted in the intensity of feeding between areas. Stomachs of fish, caught in the Middle Atlantic, contain the largest quantities of food. The species of prey taken by silver hake are highly variable and likely reflect prey availability during different years and seasons in various areas. When silver hake spawn, their dietary intake is reduced. The diet of fish taken in deep water (>150 m) is mostly euphausiids and squid, and the quantity of food found in their stomachs is less than that in stomachs taken from fish collected at depths <150 m.

Silver hake, *Merluccius bilinearis* (Mitchill 1814), is a Northwest Atlantic gadiform fish whose range extends from continental shelf waters off South Carolina to the Newfoundland Banks. It is most abundant in offshore waters extending from New York to Cape Sable, Nova Scotia (Bigelow and Schroeder 1953).

Previous investigations have shown that large silver hake eat mostly fish and/or squid, while smaller silver hake feed on euphausiids, amphipods, and decapod shrimp. Among the first to report these findings were Nichols and Breder (1927), who noted 75 herring about 7 cm long in the stomach of a 59 cm fish. Bigelow and Schroeder (1953) reported that silver hake are extremely voracious and will prey on smaller silver hake or any other of the schooling fishes such as young herring, mackerel, menhaden, alewives, or silversides. Evaluation of other studies on the diet of silver hake caught in various areas and during different years establishes that the prey of silver hake is very predictable in that it is usually comprised of a variety of fish, squid, and crustaceans (Jensen and Fritz 1960; Schaefer 1960; Vinogradov 1972; Noskov and Vinogradov 1977; Bowman and Langton 1978; Langton and Bowman 1980). Investigations by Swan and Clay (1979), Edwards and Bowman (1979), and Bowman and Bowman (1980) have shown that silver hake feed mostly at night.

Until recently the potential impact of silver hake on the Northwest Atlantic ecosystem had not been determined. Edwards and Bowman (1979) estimated the annual consumption of the principal predators in the Northwest Atlantic. They concluded that silver hake alone could potentially consume almost 10% of the standing crop of all fish within the study area annually, the bulk of which would be small or juvenile fish. They suggested that silver hake, more than any other species, plays the principal predatory role in regulating the Northwest Atlantic ecosystem. The purpose of this report is to document the quantities and types of food eaten by silver hake during the years 1973-76, and further, to identify feeding trends which may be of consequence when attempting to precisely determine silver hake's impact on other fish populations.

METHODS AND MATERIALS

A total of 325 samples from 2,622 silver hake stomachs was collected during eight MARMAP (Marine Resources Monitoring, Assessment, and Prediction) bottom trawl survey cruises conducted by the National Marine Fisheries Service during spring and fall 1973-76 (Table 1). The cruise periods were as follows: 16 March-15 May 1973; 26 September-20 November 1973; 12 March-4 May 1974; 20 September-14 November 1974; 4 March-12 May 1975; 15 October-18 November 1975; 4 March-8 May 1976; 20 October-23 November 1976. On spring cruises a two-seam modified Yankee No. 41 trawl was

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TABLE 1.—Number of silver hake stomachs examined from each geographic area by year and season.

Year	Season	Number examined		
		Middle Atlantic	Southern New England	Georges Bank
1973	Spring	39	105	48
	Fall	144	129	191
1974	Spring	189	93	103
	Fall	54	117	157
1975	Spring	68	100	92
	Fall	91	120	146
1976	Spring	111	125	63
	Fall	93	129	115
Totals		789	918	915

fished, and during fall cruises a standard Yankee No. 36 was used. The cod end and upper belly of both trawls were lined with 13 mm mesh netting to retain smaller fish. A scheme of stratified random trawling was conducted within the study area (Fig. 1), and fishing continued over 24 h/d[2]. All tows were 30 min in duration at a vessel speed of 3.5 kn in the direction of the next station.

Sampling of stomachs was concentrated in three areas: Middle Atlantic, Southern New England, and Georges Bank (Fig. 1). Fish within two length groups (≥20 cm and <20 cm) were randomly selected (50 fish/group) during each cruise from the bottom trawl survey catches in each area. At each station within a particular area no more than 10 fish were taken for each of the two length groups, and fish were not sampled at two consecutive stations. The only exception to this collection method occurred when it appeared (during the cruise) that 50 large or 50 small fish would not be collected within a particular area. In this case, all fish caught were collected in an attempt to obtain the minimum sample size. Stomachs of large fish were excised aboard ship; individually wrapped in gauze with a label denoting vessel, cruise, species, fork length (FL), sex, and maturity; and preserved in 3.7% formaldehyde (small fish were preserved whole).

In the laboratory the preserved stomachs were individually opened, and their contents emptied onto a 0.25 mm mesh opening screen sieve to permit washing without loss of any food items. The stomach contents were sorted, identified, counted, and damp dried on absorbent paper. Major prey items and commonly occurring but relatively minor prey, in terms of weight, were identified to species whenever possible. The wet weight of all stomach content groups was determined to the nearest 0.001 g and all information recorded. A stomach was considered empty when no food items could be identified and the material found in the stomach weighed <0.001 g. Data were analyzed with FORTRAN IV programs written for use on a Honeywell SIGMA 7[3] computer system located in Woods Hole, Mass.

Food data are presented in terms of the mean stomach content weight, adjusted stomach content weight (discussed below), and the percentage weight

[2]Further details of the bottom trawling techniques may be obtained from the Resource Surveys Investigation, Northeast Fisheries Center Woods Hole Laboratory, National Marine Fisheries Service, NOAA, Woods Hole, MA 02543.

[3]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

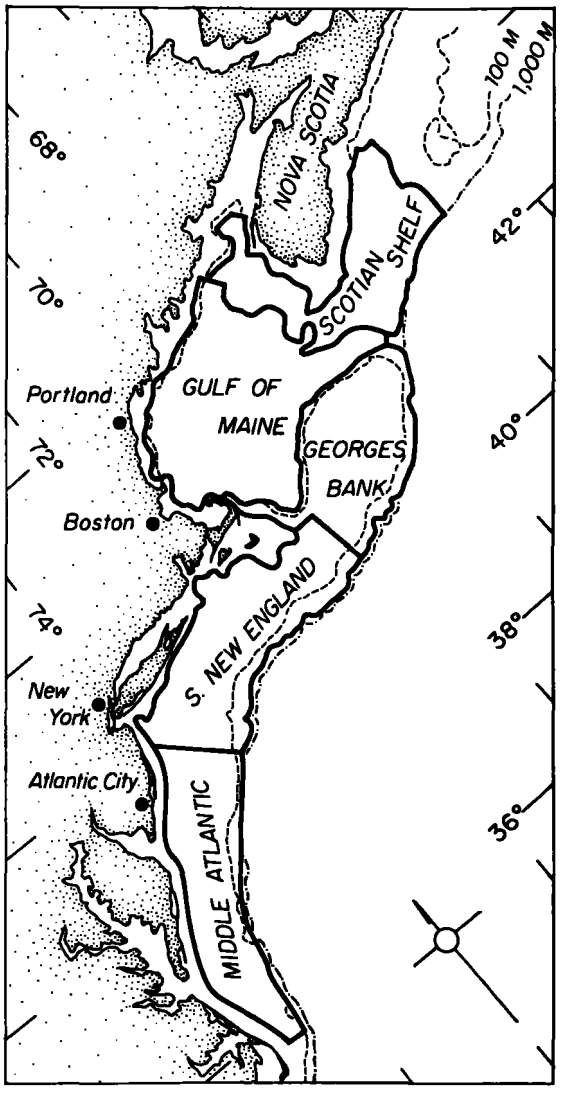

FIGURE 1.—Offshore areas sampled during bottom trawl surveys conducted by the Northeast Fisheries Center between the years of 1973 and 1976, inclusive.

each prey group made up of the total stomach contents weight. All tables follow a standard format to aid in making comparisons. In the tables, subtotals of the percentage weight of major stomach content groups are offset to the left. The minor prey groups are discussed in further taxonomic detail in the text.

Adjusted stomach content weights are weights adjusted by a correction factor which allows direct comparison of the stomach content weights of different-sized fish. Adjustment of the stomach content weights was necessary, before any quantitative comparisons could be made between variables such as sex or area. Observations on stomach tissue weight (excluding contents), mean stomach content weight, and whole fish weight (Fig. 2) revealed that neither the mean stomach content weight nor the stomach tissue weight is proportional to the body weight of different-sized fish. Stomach tissue weights of 526 silver hake were gathered during a study jointly conducted by American and Soviet scientists on Georges Bank, September 1978, aboard the Soviet RV *Belogorsk* (operated by the Atlantic Research Institute of Marine Fisheries and Oceanography, Kaliningrad, USSR). Mean stomach content weight data were derived from the 1973-76 food data given in this report, and the fish body weights were calculated using the silver hake length-weight equation described by Wilk et al. (1978). Silver hake weighing <100 g, or >300 g, have larger stomachs (stomach tissue weight being an indication of stomach size), and stomachs which contain on the average more food in terms of percentage body weight, than fish weighing between 100 and 300 g. Since both the stomach tissue weight and the mean stomach content weight were disproportionate when presented as percentage body weight for different-sized fish (but were generally proportionate relative to each other), and because the mean stomach content weight data was much more variable than the stomach tissue weight data, the data adjustment was based on stomach tissue weight rather than on body weight or mean stomach content weight. The following equation was used to adjust the stomach content weights:

$$\bar{A}_L = \frac{\bar{x}l}{\bar{w}l}$$

where $\bar{A}_L$ = Adjusted stomach content value. The adjusted stomach content value was converted to grams by multiplying it by the stomach tissue weight of a 30 cm FL fish.

$\bar{x}l$ = Mean stomach content weight of all fish at a given length.

$\bar{w}l$ = Mean stomach tissue weight of silver hake at a given length.

The adjusted stomach content data for fish 4 (0.3 g) to 15 (21 g) cm FL and 24 (90 g) to 35 (292 g) cm FL are presented separately in forthcoming sections.

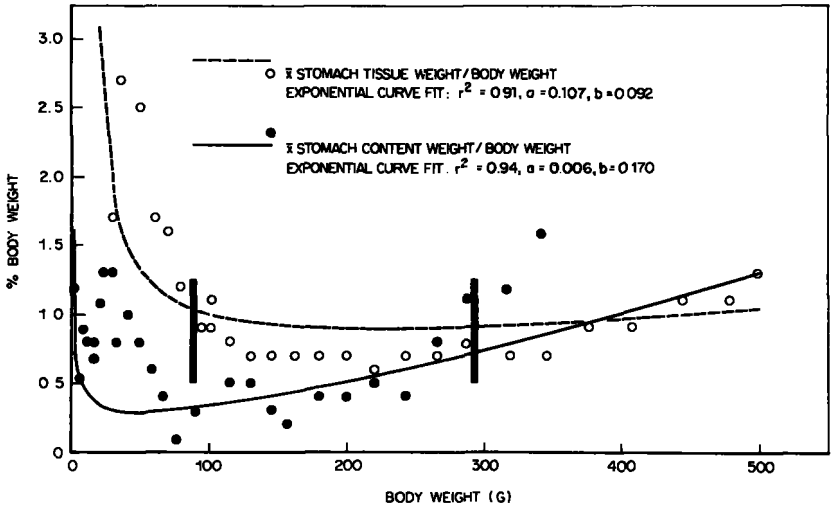

FIGURE 2.—Percentage body weight made up by the stomach tissue weight and the stomach content weight of different size silver hake. Area enclosed by solid lines represents more than 80% (excluding juveniles) of the silver hake population (fish 2-7 yr old), based on survey data. Stomach tissue weight/fish length and stomach content weight/fish length data were fit to an exponential curve (form $y = ae^{bx}$). The data are presented in terms of body weight for illustrative purposes.

These two length groups were chosen because the food consumption of fish <1 yr old (4-15 cm FL) differs substantially from the food consumption of older fish (evident from Figure 2). In addition, too few fish outside these length ranges were sampled to warrant inclusion in any of the calculations dealing with comparisons between data sets. An analysis of variance (one way) was used to test the observed differences among sample means (e.g., between geographic areas).

RESULTS

The contents of 2,622 silver hake stomachs, of which 803 (30.4%) were empty, were analyzed. Fish sampled averaged 20 cm FL and had, including the empty ones, a mean stomach content weight of 1.5 g. Sources of potential variation in the data presented below include size, sex, and maturity stage of fish, as well as the time of day, area, year, season, bottom depth, and temperature when or where the fish were caught. Each variable considered in this analysis is treated separately, i.e., the data were pooled over other variables with no attempt to determine the possible confounding effects of different variables on the results. Dietary trends noted within each particular variable examined should be considered only as preliminary observations.

Composition of the Diet

Overall, in terms of percentage weight, the diet of silver hake consists almost entirely of fish (80.0%), crustaceans (10.2%), and squid (9.2%), as can be seen in Table 2. The importance of crustaceans to the diet is overshadowed by the fish portion because large silver hake eat heavier meals consisting primarily of fish. However, Table 2 is useful because it serves as a composite list of the prey types commonly found in the stomachs of silver hake. Fish such as silver hake, *Merluccius bilinearis*; Atlantic mackerel, *Scomber scombrus*; butterfish, *Peprilus triacanthus*; herring (Clupeidae); American sand lance, *Ammodytes americanus*; scup, *Stenotomus chrysops*; Atlantic saury, *Scomberesox saurus*; and longfin hake, *Phycis chesteri*, each make up >0.1% of the stomach contents. The "Other Pisces" category, most of which could not be identified, accounts for a substantial portion (52.0%) of the "Pisces" group. Fishes which could be identified within this category (all contributed <0.1% to the diet) include summer flounder, *Paralichthys dentatus*; redfish, *Sebastes marinus*; codfishes (Gadidae); and flatfishes (Pleuronectiformes).

Crustacea in the diet is represented principally by euphausiids (mostly *Meganyctiphanes norvegica*, 3.7%, and *Euphausia*, <0.1%) and decapods such as the Crangonidae (mainly *Crangon septemspinosa*, 1.4%, and *Sclerocrangon boreas*, <0.1%), Pandalidae (almost exclusively *Dichelopandalus leptocerus*, 2.0%, although some *Pandalus borealis*, <0.1%, was also found), Pasiphaeidae (only *Pasiphaea multidentata*, 0.1%), and other unidentified decapods (0.4%) which were mostly shrimp (0.3%). Amphipods found in the stomachs consist primarily of the families Ampeliscidae (<0.1% each of *Ampelisca agaxxizi*, *A. spinipes*, *A vadorum*, and *Byblis serrata*), Oedicerotidae (<0.1% of *Monoculodes edwardsi* and *M. intermedius*), and Hyperiidae (exclusively the genus *Parathemisto*, 0.1%). The remaining crustacean groups are the Mysidacea (comprised of *Neomysis americana*, 0.7%, and *Erythrops*, <0.1%), Cumacea (mostly *Leptocuma*, <0.1%, and some unidentified diastylids, <0.1%), Copepoda (almost all identified as calanoids, <0.1%), and "Other Crustacea" (all of which was well-digested crustacean remains, 0.3%).

The only other stomach contents identified were the cephalopods (*Loligo pealei*, 4.7%, and *Rossia*,

TABLE 2.—Dietary composition of 2,622 silver hake caught in the Northwest Atlantic during the years 1973-76. (+ indicates <0.1%.)

Prey	Percentage weight	
Polychaeta	0.1	
Crustacea	10.2	
Amphipoda	1.3	
Ampeliscidae		1.0
Oedicerotidae		0.1
Hyperiidae		0.1
Other Amphipoda		0.1
Decapoda	3.9	
Crangonidae		1.4
Pandalidae		2.0
Pasiphaeidae		0.1
Other Decapoda		0.4
Euphausiacea	4.0	
Mysidacea	0.7	
Cumacea	+	
Copepoda	+	
Other Crustacea	0.3	
Cephalopoda	9.2	
Loligo		7.6
Other Cephalopoda		1.6
Pisces	80.0	
Scomberesox saurus		1.5
Clupeidae		2.7
Merluccius bilinearis		9.2
Phycis chesten		0.2
Ammodytes americanus		1.8
Scomber scombrus		7.5
Stenotomus chrysops		1.6
Peprilus triacanthus		3.5
Other Pisces		52.0
Miscellaneous	0.5	
No. of stomachs examined	2,622	
No. of empty stomachs	803	
Mean stomach content weight (g)	1.477	
Mean fish FL (cm)	20.3	

<0.1%), Polychaeta, and the "Miscallaneous" category, which consisted of small amounts (<0.1%) of Echinodermata, Chaetognatha, unrecognizable digested matter, and sand.

The percentage weights of various prey of silver hake within specified length groups are listed in Table 3. Silver hake <20 cm FL eat mostly crustaceans (>80% on the average), whereas the food of individuals >20 cm FL is mostly fish and squid (average over 50%). Stomachs of silver hake 3-5 cm FL contain the largest percentages of smaller crustacean forms, such as amphipods and copepods. Decapods, euphausiids, and mysids, which are generally larger organisms (see Gosner 1971), make up the largest percentage of the diet of fish 6-20 cm FL.

Diet Differences Between Males and Females

The diet of male and female silver hake differs in both quality and quantity of food (Table 4). The stomachs of males have the largest percentage of crustaceans, while those of females have the largest percentage of fish and squid. The mean stomach content weight of the males is only about one-fifth that of the females. Males also occur less frequently in the samples (42% of the fish collected were males) and are generally smaller than the females (mean FL males, 28.4 cm; females, 32.1 cm). Since female fish are, on the average, longer than the males, the differences noted above had to be dealt with in considerably more detail.

A comparison of the data in Tables 5 (food of males) and 6 (food of females) indicates that males and females within the same size groupings consume different types and amounts of food. The same dietary patterns noted for male and female fish in the preceding paragraph can be seen within most of the individual length groups in these two tables (e.g., when males and females within the same size group are compared, the stomachs of the females contain larger quantities of food and higher percentages of fish and squid). The number of males sampled generally exceeds the number of females for length groups <30 cm, while females dominate the length groups >30 cm.

A subset of the data were analyzed separately using only fish lengths for which 20 or more individuals each of males and females were sampled (Fig. 3). This group of fish (ranging in FL from 24 to 34 cm) is fairly representative of the adult silver hake population sampled. The mean stomach content weight (Fig. 3A), percentage crustaceans (Fig. 3B), and percentage fish and squid (Fig. 3C) data presented graphically illustrate the differences between the diet of male and female silver hake of the same length. The stomachs of females contain more food, on the average, than those of males; the stomachs of males contain higher percentages of crustaceans than females; and the stomachs of females contain more fish and squid than those of males. Adjustment (by stomach tissue weight) of the mean stomach content weights given in Figure 3A revealed that the stomachs of females contain, on the average, 1.5 times the quantity of food found in the stomachs of males.

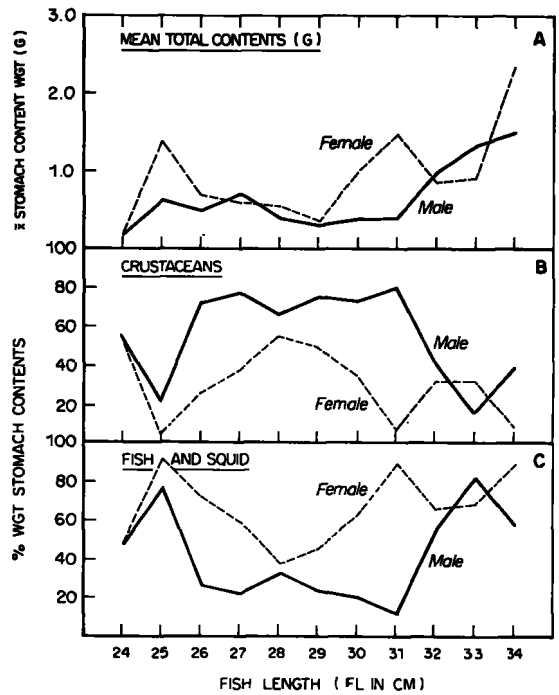

FIGURE 3.—A) Mean stomach content weight of male and female silver hake versus fish length, B) percentage of total stomach content weight made up by crustaceans for male and female silver hake, C) percentage of total stomach content weight made up by fish and squid for male and female silver hake.

Diurnal Variation in Feeding Intensity

The adjusted mean stomach content weight data presented in Figures 4 and 5 indicate the feeding periods of silver hake vary by season and size of fish. In autumn, the stomachs of larger fish (24-35 cm FL) are fullest just after midnight, while smaller fish (4-15 cm FL) have the fullest stomachs in late afternoon

TABLE 3.—Percentage composition (by weight) of the diet of silver hake versus fish length for silver hake collected in the Northwest Atlantic from 1973 through 1976. (+ indicates <0.1%.)

Prey	Length category (cm)										
	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	>50
Polychaeta	—	0.4	0.5	—	0.1	0.3	0.2	+	0.1	—	—
Crustacea	89.7	80.3	81.6	77.3	28.0	55.5	21.3	2.3	0.5	0.2	0.2
Amphipoda	58.7	18.9	6.1	1.2	1.7	1.3	0.7	+	+	—	+
Ampeliscidae	11.0	4.9	0.1	0.5	0.6	0.5	0.2	+	—	—	+
Oedicerotidae	3.1	3.4	4.1	0.1	+	0.2	0.1	+	—	—	—
Hyperiidae	42.1	6.2	0.3	0.4	0.6	0.4	0.3	—	—	—	—
Other Amphipoda	2.5	4.4	1.6	0.2	0.5	0.2	0.1	+	+	—	—
Decapoda	11.8	23.9	31.1	7.0	16.2	20.0	10.5	1.6	0.3	0.1	0.1
Crangonidae	7.7	16.0	18.7	3.7	4.3	6.1	4.3	0.3	0.1	—	+
Pandalidae	—	1.7	5.3	2.1	10.7	12.0	4.3	1.2	0.2	—	0.1
Pasiphaeidae	—	—	—	—	—	—	0.8	—	—	—	—
Other Decapods	4.1	6.2	7.1	1.2	1.2	1.9	1.1	0.1	—	0.1	—
Euphausiacea	1.9	5.7	23.7	64.4	7.8	26.4	8.8	0.6	0.2	0.1	—
Mysidacea	4.2	22.1	12.8	3.9	0.2	6.7	0.6	+	+	—	0.1
Cumacea	0.8	1.1	0.2	+	0.2	+	+	—	—	—	—
Copepoda	1.7	+	+	—	+	—	—	—	—	—	—
Other Crustacea	10.6	8.6	7.7	0.8	1.9	1.1	0.7	0.1	+	+	+
Cephalopoda	—	—	—	—	17.8	3.4	14.9	14.3	0.1	12.0	—
Loligo	—	—	—	—	15.3	—	13.5	10.0	—	12.0	—
Other Cephalopoda	—	—	—	—	2.5	3.4	1.4	4.3	0.1	+	—
Pisces	4.8	13.9	14.0	19.9	52.8	38.7	62.4	83.4	98.9	87.8	99.8
Scomberesox saurus	—	—	—	—	—	—	—	5.6	—	—	—
Clupeidae	—	—	—	—	—	—	3.5	3.5	8.0	—	—
Merluccius bilinearis	—	2.0	4.0	—	22.1	5.0	6.9	24.2	5.9	—	—
Phycis chesteri	—	—	—	—	—	—	1.2	—	—	—	—
Ammodytes americanus	—	6.3	2.0	—	—	+	3.1	0.4	7.7	—	—
Scomber scombrus	—	—	—	—	—	—	7.8	8.8	6.1	—	15.5
Stenotomus chrysops	—	—	—	—	—	—	—	—	10.5	6.8	—
Peprilus triacanthus	—	—	—	—	—	—	2.7	3.4	—	—	20.6
Other Pisces	4.8	5.6	8.0	19.9	30.7	33.7	37.2	37.5	60.7	—	63.7
Miscellaneous	5.5	5.4	3.9	2.8	1.3	2.1	1.2	+	0.4	+ 81.0	—
No. of stomachs examined	344	603	216	86	243	444	428	147	61	28	22
No. of empty stomachs	60	75	38	26	108	192	189	63	29	11	12
Mean stom. cont. wt. (g)	0.066	0.025	0.104	0.370	0.452	0.545	1.440	7.278	10.321	32.081	20.262
Mean fish FL (cm)	4.5	7.7	12.5	18.0	23.5	28.2	32.6	37.7	42.8	47.9	54.4

and just after midnight (Fig. 4). During springtime, large silver hake have substantial quantities of food in their stomachs (almost twice as much as during autumn) for two time periods, one near dusk and the other just before noon. Smaller fish have the most food in their stomachs just after midnight during spring (Fig. 5). No indication of a particular prey being eaten at a particular time of day was noted.

Diet Within Geographic Areas

Stomach content data for silver hake collected in various geographic areas (i.e., Middle Atlantic, Southern New England, and Georges Bank) are presented in Table 7. Fish is by far the dominant prey of silver hake within all geographic areas. Silver hake caught in the Middle Atlantic have the highest percentage of fish in their diet (Middle Atlantic, 87.5%; Southern New England, 78.4%; Georges Bank, 76.4%), but most was unidentified (60.4%). Silver hake (20.8%) and herring (Clupeidae, 3.2%) make up

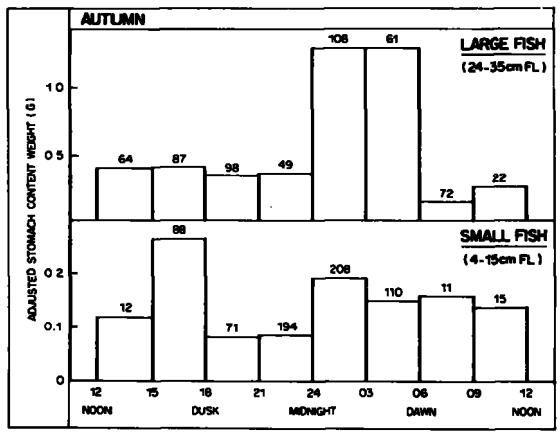

FIGURE 4.—Adjusted mean stomach content weight of large (24-35 cm FL) and small (4-15 cm FL) silver hake collected in the autumn versus time of day. The number of fish sampled in each time period is given just above the histogram.

TABLE 4.—Stomach contents of male and female silver hake collected in the Northwest Atlantic during 1973-76. Data are expressed as a percentage weight. (+ indicates <0.1%.)

Prey	Male	Female
Polychaeta	0.2	+
Crustacea	35.0	4.5
Amphipoda	0.6	0.2
Ampeliscidae	0.2	0.1
Oedicerotidae	0.1	+
Hyperiidae	0.2	0.1
Other Amphipoda	0.1	+
Decapoda	11.9	2.3
Crangonidae	5.1	0.6
Pandalidae	5.5	1.5
Pasiphaeidae	—	+
Other Decapoda	1.3	0.2
Euphausiacea	18.8	1.7
Mysidacea	2.7	0.2
Cumacea	+	+
Copepoda	+	—
Other Crustacea	1.0	0.1
Cephalopoda	4.3	10.4
Loligo	3.4	8.6
Other Cephalopoda	0.9	1.8
Pisces	59.1	84.6
Scomberesox saurus	—	1.8
Clupeidae	—	3.2
Merluccius bilinearis	22.6	7.6
Phycis chesteri	—	0.2
Ammodytes americanus	1.4	2.0
Scomber scombrus	3.8	8.4
Stenotomus chrysops	—	1.9
Peprilus triacanthus	3.3	3.7
Other Pisces	28.0	55.8
Miscellaneous	1.4	0.5
No. examined	613	842
No. of empty stomachs	252	354
Mean stom. cont. wt. (g)	0.853	4.204
Mean fish FL (cm)	28.4	32.1
Length range (cm)	6-59	7-64

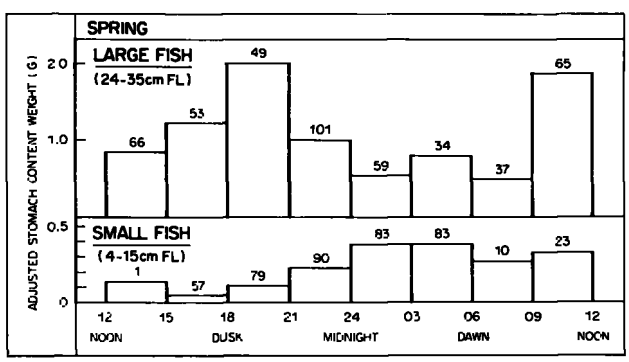

FIGURE 5.—Adjusted mean stomach content weight of large (24-35 cm FL) and small (4-15 cm FL) silver hake collected in springtime versus time of day. The number of fish sampled in each time period is given just above the histogram.

TABLE 5.—Composition of the diet of male silver hake in terms of percentage weight versus fish length. (+ indicates <0.1%.)

Prey	Length group (cm) 5-10	11-15	16-20	21-25	26-30	31-35	36-40	>41
Polychaeta	—	—	—	0.3	+	0.3	—	—
Crustacea	19.2	64.1	97.2	29.3	73.1	32.7	3.8	1.9
Amphipoda	—	—	2.7	1.4	1.0	0.2	0.1	+
Ampeliscidae	—	—	1.9	0.6	0.4	+	0.1	+
Oedicerotidae	—	—	—	—	0.1	0.1	+	—
Hyperiidae	—	—	0.8	0.6	0.4	0.1	—	—
Other Amphipoda	—	—		0.2	0.1	+	+	—
Decapoda	0.3	1.9	1.1	10.7	19.1	15.0	2.6	1.5
Crangonidae	—	1.9	0.6	1.5	7.4	7.7	0.9	0.1
Pandalidae	—	—	—	8.3	9.8	5.7	1.7	—
Pasiphaeidae	—	—	—	—	—	—	—	—
Other Decapoda	0.3	—	0.5	0.9	1.9	1.6	—	1.4
Euphausiacea	—	50.3	92.7	14.2	41.4	15.9	+	—
Mysidacea	11.3	11.9	—	—	10.4	0.8	0.2	0.4
Cumacea	—	—	—	0.4	+	+	—	—
Copepoda	—	—	0.7	+	—	—	—	—
Other Crustacea	7.6	—	—	2.6	1.2	0.8	0.9	—
Cephalopoda	—	—	—	4.4	0.2	8.3	2.5	—
Loligo	—	—	—	—	—	8.1	—	—
Other Cephalopoda	—	—	+	4.4	0.2	0.2	2.5	—
Pisces	71.4	21.6	—	64.1	23.6	57.2	93.7	98.1
Scomberesox saurus	—	—	—	—	—	—	—	—
Clupeidae	—	—	—	—	—	—	—	—
Merluccius bilinearis	—	—	—	10.0	5.0	7.7	70.0	66.2
Phycis chesteri	—	—	—	—	—	—	—	—
Ammodytes americanus	50.8	21.6	—	—	—	3.1	—	—
Scomber scombrus	—	—	—	—	—	9.2	—	—
Stenotomus chrysops	—	—	—	—	—	—	—	—
Peprilus triacanthus	—	—	+	—	—	8.0	—	—
Other Pisces	20.6	+	2.8	54.1	18.6	29.2	23.7	31.9
Miscellaneous	9.4	14.3		1.9	3.1	1.5	—	—
No. examined	12	5	20	119	248	178	21	8
No. empty	4	0	4	50	109	73	9	3
Mean stom. cont. wt. (g)	0.030	0.435	0.414	0.400	0.456	1.215	3.565	7.282
Mean fish FL (cm)	8.4	13.4	19.1	23.7	28.5	32.2	37.1	50.9

TABLE 6.—Composition of the diet of female silver hake in terms of percentage weight versus fish length. (+ indicates <0.1%.)

Prey	Length group (cm) 5-10	11-15	16-20	21-25	26-30	31-35	36-40	>41
Polychaeta	—	—	—	—	0.4	0.1	+	+
Crustacea	8.7	100.0	75.2	27.9	39.9	13.0	2.0	0.2
Amphipoda	0.3	—	0.3	1.8	1.3	0.8	+	+
Ampeliscidae	—	—	—	0.7	0.5	0.2	+	—
Oedicerotidae	—	—	—	+	0.3	+	+	—
Hyperiidae	0.3	—	0.1	0.5	0.3	0.4	—	—
Other Amphipoda	—	—	0.2	0.6	0.2	0.2	+	+
Decapoda	—	95.4	7.2	21.1	20.3	5.9	1.4	0.1
Crangonidae	—	95.4	1.8	6.6	5.1	1.9	0.2	+
Pandalidae	—	—	4.7	12.9	13.3	3.1	1.1	0.1
Pasiphaeidae	—	—	—	—	—	+	—	—
Other Decapoda	—	—	0.7	1.6	1.9	0.9	0.1	—
Euphausiacea	7.5	4.0	66.8	3.3	13.5	5.2	0.6	0.1
Mysidacea	0.9	—	—	0.3	3.8	0.5	+	+
Cumacea	—	—	—	0.1	+	+	—	—
Copepoda	—	—	—	—	—	—	—	—
Other Crustacea	—	0.6	0.9	1.3	1.0	0.6	+	+
Cephalopoda	—	—	—	28.4	6.1	18.7	15.1	5.9
Loligo	—	—	—	27.2	—	16.6	10.7	5.8
Other Cephalopoda	—	—	—	1.2	6.1	2.1	4.4	0.1
Pisces	81.9	—	22.0	42.9	51.8	66.7	82.7	93.6
Scomberesox saurus	—	—	—	—	—	—	6.1	—
Clupeidae	—	—	—	—	—	5.4	3.8	2.8
Merluccius bilinearis	—	—	—	31.9	5.0	6.6	20.8	—
Phycis chesteri	—	—	—	—	—	—	—	—
Ammodytes americanus	81.9	—	—	—	0.1	3.2	0.5	2.7
Scomber scombrus	—	—	—	—	—	7.3	9.5	9.3
Stenotomus chrysops	—	—	—	—	1.6	—	—	3.7
Peprilus triacanthus	—	—	—	—	—	—	3.6	5.0
Other Pisces	—	—	22.0	11.0	45.1	44.2	38.4	70.1
Miscellaneous	9.4	—	2.8	0.8	1.8	1.5	0.2	0.3
No. examined	9	3	22	113	202	259	126	103
No. empty	2	0	3	45	83	120	54	47
Mean stom. cont. wt. (g)	0.099	0.152	0.670	0.571	0.673	1.597	8.185	17.826
Mean fish FL (cm)	8.0	12.0	18.5	23.4	28.0	32.9	37.7	46.0

TABLE 7.—Geographic breakdown of the prey found in the stomachs of silver hake caught in the Northwest Atlantic during the years 1973-76. Data are expressed as a percentage weight. (+ indicates <0.1%).

Prey	Middle Atlantic	Southern New England	Georges Bank
Polychaeta	0.1	0.1	0.1
Crustacea	7.3	7.3	16.4
Amphipoda	0.5	0.2	0.4
Ampeliscidae	0.1	0.1	0.1
Oedicerotidae	0.2	+	0.1
Hyperiidae	0.1	0.1	0.1
Other Amphipoda	0.1	+	0.1
Decapoda	4.9	2.6	6.5
Crangonidae	2.4	1.0	1.3
Pandalidae	1.8	1.2	4.4
Pasiphaeidae	0.4	—	+
Other Decapoda	0.3	0.4	0.8
Euphausiacea	1.2	3.4	7.9
Mysidacea	0.3	0.7	1.2
Cumacea	—	0.1	+
Copepoda	+	+	+
Other Crustacea	0.4	0.3	0.4
Cephalopoda	4.3	13.7	6.7
Loligo	2.9	13.0	6.7
Other Cephalopoda	1.4	0.7	+
Pisces	87.5	78.4	76.4
Scomberesox saurus	—	—	6.1
Clupeidae	3.2	1.3	5.0
Merluccius bilinearis	20.8	7.9	0.4
Phycis chesteri	—	—	0.8
Ammodytes americanus	1.7	0.4	4.8
Scomber scombrus	—	6.0	21.1
Stenotomus chrysops	—	4.1	—
Peprilus triacanthus	1.4	2.2	8.9
Other Pisces	60.4	56.5	29.3
Miscellaneous	0.8	0.5	0.4
No. of stomach examined	789	918	915
No. of empty stomachs	180	357	268
Mean stom. cont. wt. (g)	1.544	1.815	1.080
Mean fish FL (cm)	17.5	22.5	20.8
Length range (cm)	3-57	3-59	3-64

the majority of the identified fish prey. The stomachs of silver hake caught in Southern New England contain fairly high percentages of silver hake (7.9%), Atlantic mackerel (6.0%), and scup (4.1%). Silver hake caught on Georges Bank eat mostly Atlantic mackerel (21.1%), butterfish (8.9%), Atlantic saury (6.1%), herring (Clupeidae, 5.0%), and American sand lance (4.8%). Evidence of the cannibalistic nature of silver hake is seen in all three areas. In addition, silver hake taken as prey comprise the highest percentage of identified fish in both the Middle Atlantic and Southern New England (Table 7).

Crustaceans are most important in the diet of silver hake collected from Georges Bank (16.4%). Euphausiids (7.9%), decapods (mostly pandalid shrimp, 4.4%, and crangonid shrimp, 1.3%), and mysids (1.2%) account for the majority of crustacean prey consumed on Georges Bank. In the Middle Atlantic and Southern New England, Crustacea is of equal importance (7.3%) as a food. For Middle Atlantic fish, decapods (4.9%) and euphausiids (1.2%) make up the majority of crustacean prey identified in the stomachs. In Southern New England, euphausiids (3.4%) and decapods (2.6%) account for most of the Crustacea.

The Cephalopoda was the only other prey group recognized as an important food of silver hake. Fish in Southern New England eat the largest quantities of squid (13.7%). Silver hake sampled on Georges Bank and in the Middle Atlantic also take fairly large amounts of squid as prey (6.7% and 4.3%, respectively).

A comparison between the quantities of food in the stomachs of fish from each area revealed that Middle Atlantic silver hake have about two to three times more food in their stomachs (on the average) than fish from Southern New England or Georges Bank. Stomach content data for fish 24-35 cm FL from each area were adjusted for fish length; the adjusted mean stomach content weights were Middle Atlantic, 1.328 g; Southern New England, 0.593 g; and Georges Bank, 0.707 g. The quantity of food in the stomachs of Middle Atlantic silver hake is significantly different (with 95% confidence) from the quantity in the stomachs of fish from Southern New England ($F = 6.862$ exceeds $F_{0.05,\,1,21} = 4.32$). The adjusted mean stomach content weights of small (4-15 cm FL) silver hake from each area were Middle Atlantic, 0.149 g; Southern New England, 0.198 g; and Georges Bank, 0.214 g.

Yearly and Seasonal Differences

Percentages of various prey categories in the silver hake diet between years, seasons, and geographic areas indicate the stomach contents are quite variable (Table 8). For example, in the Middle Atlantic, the Crustacea portion of the diet of silver hake varies from 3.1% (spring 1973) to 70.0% (fall 1976). Similar variability can be seen in the percentages listed for most of the prey categories. Much of the observed variation is probably due to differences in predator lengths (note mean fish FL's given at the bottom of Table 8). Only one prey, the American sand lance, was noted as being unique in the diet of silver hake. American sand lance was only found in the stomachs of silver hake collected in the spring during 1975 and 1976. The largest percentage weights of American sand lance were derived from samples collected only during the spring of 1976 in all three areas. Another observation is that fish sampled in the spring tend to be larger (see mean lengths at bottom of Table 8) than those collected in the autumn.

The adjusted stomach content data for large and small silver hake from all areas and years combined indicate that about twice as much food is found in the stomachs during spring than in autumn. The adjust-

TABLE 8.—Annual and seasonal breakdown of the stomach contents for silver hake collected in the Middle Atlantic, Southern New England, and Georges Bank. Data are expressed as a percentage weight for fish collected during the spring (S) and autumn (F) of 1973-76. (+ indicates present but <0.1%.)

	1973		1974		1975		1976	
Prey	S	F	S	F	S	F	S	F
MIDDLE ATLANTIC								
Polychaeta	—	—	0.1	—	0.5	—	1.6	—
Crustacea	3.1	4.2	9.6	6.5	24.7	4.7	34.0	70.0
Amphipoda	+	0.4	1.2	1.2	1.3	2.7	2.1	15.2
Ampeliscidae	—	0.2	+	0.7	—	0.3	0.6	1.3
Oedicerotidae	—	+	1.1	—	0.4	—	0.9	—
Hyperiidae	—	0.1	—	0.5	+	2.1	—	12.1
Other Amphipoda	+	0.1	0.1	+	0.9	0.3	0.6	1.8
Decapoda	3.1	3.3	3.7	5.1	8.9	0.4	22.9	46.6
Crangonidae	1.4	0.5	2.0	4.4	5.9	0.3	11.1	25.8
Pandalidae	1.0	2.4	—	0.7	2.6	—	11.7	13.3
Pasiphaeidae	0.6	—	—	—	—	—	—	—
Other Decapoda	0.1	0.4	1.7	+	0.4	0.1	0.1	7.5
Euphausiacea	—	0.2	4.4	—	14.4	0.3	+	—
Mysidacea	—	+	—	—	—	—	5.4	—
Cumacea	—	+	+	+	0.1	—	+	—
Copepoda	—	—	+	+	—	+	—	—
Other Crustacea	+	0.3	0.3	0.2	+	1.3	3.6	8.2
Cephalopoda	—	14.9	9.7	—	25.2	—	6.3	—
Loligo	—	12.4	—	—	24.9	—	—	—
Other Cephalopoda	—	2.5	9.7	—	0.3	—	6.3	—
Pisces	96.5	80.9	79.5	93.0	46.6	93.7	54.8	5.2
Scomberesox saurus	—	—	—	—	—	—	—	—
Clupeidae	—	—	—	91.5	—	—	—	—
Merluccius bilinearis	23.3	49.0	—	—	4.0	—	—	—
Phycis chesteri	—	—	—	—	—	—	—	—
Ammodytes americanus	—	—	—	—	10.7	—	19.8	—
Scomber scombrus	—	—	—	—	—	—	—	—
Stenotomus chrysops	—	—	—	—	—	—	—	—
Peprilus triacanthus	—	—	—	—	24.4	—	—	—
Other Pisces	73.2	31.9	79.5	1.5	7.5	93.7	35.0	5.2
Miscellaneous	0.4	+	1.1	0.5	3.0	1.6	3.3	24.8
No. examined	39	144	193	54	67	91	111	93
No. empty	11	52	26	10	7	23	22	29
Mean stom. cont. wt. (g)	19.960	0.982	0.466	0.793	1.057	0.243	0.606	0.075
Mean fish FL (cm)	33.9	18.0	14.1	12.9	19.8	13.5	21.7	16.9
Length range (cm)	20-53	4-45	3-46	4-37	5-44	3-40	8-57	3-35
SOUTHERN NEW ENGLAND								
Polychaeta	0.1	—	+	—	+	+	0.2	+
Crustacea	2.8	12.5	3.3	46.1	7.9	17.0	19.8	2.2
Amphipoda	+	1.7	+	4.0	0.1	0.8	0.2	0.5
Ampeliscidae	—	1.6	+	1.5	0.1	0.2	+	+
Oedicerotidae	—	—	—	—	+	—	+	+
Hyperiidae	—	0.1	—	1.9	+	0.5	0.1	0.5
Other Amphipoda	+	+	+	0.6	+	0.1	0.1	+
Decapoda	1.8	8.4	0.1	13.7	6.9	9.7	5.5	1.2
Crangonidae	0.2	0.9	+	4.5	2.0	0.4	4.7	0.2
Pandalidae	0.9	7.3	—	7.0	1.8	9.1	0.8	1.0
Pasiphaeidae	—	—	—	—	—	—	—	—
Other Decapoda	0.7	0.2	0.1	2.2	3.1	0.2	—	+
Euphausiacea	0.5	0.9	3.2	23.5	0.8	4.9	9.9	+
Mysidacea	0.3	+	—	—	0.1	0.9	3.8	—
Cumacea	+	—	+	1.7	+	—	+	+
Copepoda	—	+	—	+	—	+	—	—
Other Crustacea	0.2	1.5	—	3.2	+	0.7	0.4	0.5
Cephalopoda	78.9	1.6	0.3	—	20.2	—	—	2.8
Loligo	78.2	—	—	—	20.2	—	—	—
Other Cephalopoda	0.7	1.6	0.3	—	—	—	—	2.8
Pisces	18.2	85.9	95.6	45.2	70.1	82.9	79.8	94.5
Scomberesox saurus	—	—	—	—	—	—	—	—
Clupeidae	—	—	—	—	—	31.8	—	—
Merluccius bilinearis	0.2	0.7	—	2.3	5.5	1.6	—	44.9
Phycis chesteri	—	—	—	—	—	—	—	—
Ammodytes americanus	—	—	—	—	1.6	—	1.8	—
Scomber scombrus	—	—	15.7	—	—	—	—	—
Stenotomus chrysops	—	—	—	—	—	—	—	24.7
Peprilus triacanthus	14.7	—	—	—	—	—	—	—
Other Pisces	3.3	85.2	79.9	42.9	63.0	49.5	78.0	24.9
Miscellaneous	+	+	0.8	8.7	1.8	0.1	0.2	0.5
No. examined	105	119	93	117	100	120	125	140
No. empty	33	86	40	38	41	31	43	45
Mean stom. cont. wt. (g)	2.406	0.401	6.902	0.107	0.952	0.581	2.181	1.970
Mean fish FL (cm)	15.9	27.5	31.2	16.8	24.4	18.1	23.0	22.9
Length range (cm)	6-47	4-49	9-59	4-37	6-55	4-55	3-53	4-54

TABLE 8.—*Continued.*

Prey	1973 S	1973 F	1974 S	1974 F	1975 S	1975 F	1976 S	1976 F
GEORGES BANK								
Polychaeta	—	—	—	—	+	+	+	—
Crustacea	70.8	15.0	41.8	18.2	10.9	5.9	18.7	6.0
Amphipoda	1.4	0.4	0.3	1.3	0.2	0.4	0.9	0.1
Ampeliscidae	0.1	0.3	+	0.7	—	0.2	—	0.1
Oedicerotidae	—	+	+	0.3	0.1	+	—	—
Hyperiidae	—	—	—	—	—	0.1	0.8	+
Other Amphipoda	1.3	0.1	0.3	0.3	0.1	0.1	0.1	+
Decapoda	60.7	13.9	2.5	12.6	1.0	3.2	2.8	4.5
Crangonidae	1.9	2.0	1.3	2.1	0.5	1.6	0.6	2.1
Pandalidae	44.5	11.6	—	8.3	—	1.1	2.0	2.2
Pasiphaeidae	—	—	0.1	—	—	—	—	—
Other Decapoda	14.3	0.3	1.1	2.2	0.5	0.5	0.2	0.2
Euphausiacea	2.3	0.2	31.2	2.8	9.4	0.5	14.8	+
Mysidacea	—	0.1	7.8	1.6	0.2	1.7	—	0.1
Cumacea	+	+	—	+	—	+	—	—
Copepoda	—	+	—	+	—	+	—	—
Other Crustacea	5.9	0.4	+	0.1	0.1	0.1	0.2	1.3
Cephalopoda	—	—	—	—	—	—	12.8	56.4
Loligo	—	—	—	—	—	—	12.8	56.2
Other Cephalopoda	—	—	—	—	—	—	—	0.2
Pisces	23.7	84.9	57.9	81.8	88.1	94.1	68.5	35.8
Scomberesox saurus	—	—	—	68.8	—	—	—	—
Clupeidae	—	—	—	—	—	39.2	—	—
Merluccius bilinearis	—	—	—	4.1	—	—	—	—
Phycis chesteri	—	—	—	—	3.2	—	—	—
Ammodytes americanus	—	—	—	—	—	—	31.6	—
Scomber scombrus	—	31.0	—	—	63.7	—	—	—
Stenotomus chrysops	—	—	—	—	—	—	—	—
Peprilus triacanthus	—	45.1	—	—	—	—	—	—
Other Pisces	23.7	8.8	57.9	8.9	21.2	54.9	36.9	35.8
Miscellaneous	5.5	0.1	0.3	+	1.0	+	—	1.8
No. examined	48	198	103	157	92	146	63	115
No. empty	24	39	39	27	18	39	34	48
Mean stom. cont. wt. (g)	0.340	1.029	0.996	0.577	2.629	0.906	2.478	0.767
Mean fish FL (cm)	31.4	16.6	24.2	16.0	24.5	18.1	29.7	22.3
Length range (cm)	27-42	4-54	8-49	4-40	11-54	4-48	10-64	3-55

ed mean stomach content weights are presented in Table 9 for each season, year, and geographic area. In almost every year, in all areas, the stomachs of similar-sized fish contain larger quantities of food in the spring than in the fall. Only two exceptions were noted to this trend (for which there is no ready explanation): Large fish collected on Georges Bank in 1973 and small fish collected on Georges Bank in 1974.

TABLE 9.—Annual and seasonal breakdown of the adjusted mean stomach content weight data of large (24-35 cm FL) and small (4-15 cm FL) silver hake gathered from three geographical areas in the Northwest Atlantic during 1973-76. (S = spring, F = autumn.)

Area	1973 S	1973 F	1974 S	1974 F	1975 S	1975 F	1976 S	1976 F	Averages S	Averages F
Middle Atlantic										
Large fish										
Adjusted weight (g)	5.545	1.081	0.995	0.325	2.203	0.912	0.936	0.149	2.420	0.617
Number in sample	26	68	44	9	26	29	38	43		
Small fish										
Adjusted weight (g)	—	0.108	0.180	0.096	0.148	0.142	0.207	0.155	0.178	0.131
Number in sample	—	61	136	33	31	45	47	42		
Southern New England										
Large fish										
Adjusted weight (g)	0.242	0.122	0.488	0.303	0.694	0.657	0.987	0.976	0.603	0.515
Number in sample	17	67	51	33	47	49	63	58		
Small fish										
Adjusted weight (g)	0.256	0.036	0.200	0.074	0.414	0.184	0.205	0.149	0.269	0.111
Number in sample	73	15	4	49	35	62	39	58		
Georges Bank										
Large fish										
Adjusted weight (g)	0.400	0.743	0.916	0.576	1.239	0.506	0.735	0.734	0.823	0.640
Number in sample	43	58	50	53	32	57	27	51		
Small fish										
Adjusted weight (g)	—	0.140	0.321	0.325	0.566	0.106	0.473	0.117	0.453	0.183
Number in sample	—	119	36	95	16	80	9	50		
							Ave. large fish adj. wt.		1.282	0.591
							Ave. small fish adj. wt.		0.300	0.142

Maturity Stage Versus Diet

Information on maturity was gathered in conjunction with food data for 759 adult silver hake (Table 10). Gonads were classified as 1) resting - gonad small in size and relatively translucent, 2) developing - gonad enlarged and either cream (males) or yellow-orange (females) colored, 3) ripe - gonad fills most of gut cavity, reproductive material either runs freely from an incision in the gonad or is extruded with pressure on abdomen of fish, 4) spent - gonad is flaccid, hemorrhaging is often evident.

TABLE 10.—Relationship between the adjusted stomach content weight and maturity stage of silver hake. Fish were caught on spring and autumn bottom trawl survey cruises conducted in the Northwest Atlantic from 1973 to 1976.

Stomach content data	Maturity stage:	Resting	Developing	Ripe	Spent
	Adj. weight (g):	0.826	1.004	0.122	1.292
No. of fish examined		379	297	29	54
Mean fish FL (cm)		28.6	30.6	31.3	31.2
Length range (cm)		24-35	24-35	27-34	25-35

No particular prey type is found in the stomachs of fish in specific maturity stages; all mature silver hake eat mostly fish. However, the stomachs of spawning (ripe) silver hake contain an average of about nine times less food than the stomachs of fish otherwise classified (Table 10). During pre- and postspawning periods, stomachs contain the largest quantities of food (1.0 and 1.3 g, respectively).

Influence of Depth

Analysis of samples from silver hake caught at different bottom water depth ranges (27->365 m) revealed that the average length of fish, food type consumed, and quantity of food in the stomachs, varies with depth (Table 11). The majority (69.4%) of silver hake were caught at depths between 38 and 110 m. Considering only the depth ranges where more than 50 fish were sampled (i.e., 27-220 m, and representing 95.6% of all silver hake collected) the mean FL of fish increases with an increase in depth. Also, the percentage weight of euphausiids and squid in the stomachs tends to increase at deeper bottom depths, while the percentage weight of fish in the diet shows a corresponding decrease. The adjusted mean stomach content data for both small and large fish are given in Table 12. The data are from only those depth ranges from which more than 20 fish (within a size group) were collected. The adjusted stomach content weight of small silver hake steadily decreases from the 27-37 m depth range (0.3 g) to the 111-146 m depth range (0.1 g). The quantity of food found in stomachs of large fish is variable; it steadily decreases between the 27-37 m and 74-110 m depth ranges; increases at the 111-146 m range; and from 111-146 m to 257-293 m continues to decrease (Table 12). Overall, the trend is for fish sampled at deeper depths to have less food, on the average, in their stomachs. It should be mentioned here that silver hake are known to regurgitate part or all of their stomach contents when they are retrieved from deep water depths (pers. obs.). Although fish which show obvious signs of regurtitation (e.g., everted stomach) are not sampled on survey cruises, some fish may regurgitate and not be discernable from those which did not. This phenomenon, in part (other factors such as the decrease in abundance of typical prey of silver hake with an increase in depth or decrease in bottom water temperature may also be important in this regard, see Williams and Wigley 1977) could explain the decrease noted in stomach content weights with an increase in water depth.

DISCUSSION

The diet of silver hake consists almost exclusively of a combination of fish, crustaceans, and squid. The relative importance of each particular prey group as a food of silver hake is, for the most part, dependent on the size of the predator and/or the availability of the prey (Bigelow and Schroeder 1953; Jensen and Fritz 1960; Fritz 1962; Dexter 1969; Vinogradov 1972).

The composition of the diet of male and female silver hake is known to differ (Vinogradov 1972; Bowman 1975). The present investigation confirms earlier reports that females feed predominantly on fish and that males eat mostly crustaceans. In addition, it has been established that the stomachs of females contain larger quantities of food than the amounts in the stomachs of males of similar size. Since the rate of growth in fishes is directly related to their dietary intake, it is not surprising that females grow faster than males (Schaefer 1960).

Bowman and Bowman (1980) studied diurnal varia-

TABLE 11.—Breakdown by depth range of the stomach contents of silver hake caught at bottom water depths ranging from 27 to 365 m. Data expressed as a percentage weight. (+ indicates present but <0.1%).

Prey	Bottom depth range (m)									
	27-37	38-73	74-110	111-146	147-183	184-220	221-256	257-293	294-329	330-365
Polychaeta	0.4	+	+	—	—	0.1	—	—	—	—
Crustacea	14.1	6.6	6.1	7.1	18.5	37.1	21.8	8.3	4.3	34.0
Amphipoda	0.5	0.4	0.5	0.2	0.1	0.3	0.2	+	—	0.7
Ampeliscidae	0.1	0.1	0.1	0.2	+	0.3	—	—	—	—
Osdicerotidae	0.3	+	0.1	—	—	—	—	—	—	—
Hyperiidae	+	0.2	0.2	+	0.1	—	0.1	+	—	0.7
Other Amphipoda	0.1	0.1	0.1	+	—	+	0.1	+	—	—
Decapoda	8.2	4.3	4.3	1.5	0.3	7.8	0.5	0.6	—	10.7
Crangonidae	5.2	1.4	0.9	0.2	+	0.3	+	—	—	—
Pandalidae	1.8	2.5	2.8	1.0	—	5.8	—	—	—	—
Pasiphaeidae	1.0	—	—	—	—	—	—	0.1	—	—
Other Decapoda	0.2	0.4	0.6	0.3	0.3	1.7	0.5	0.5	—	10.7
Euphausiacea	3.8	0.7	1.0	5.2	16.1	29.0	20.1	5.9	3.5	22.6
Mysidacea	0.8	0.9	0.1	+	1.8	—	—	1.4	0.8	—
Cumacea	+	+	+	—	—	—	—	—	—	—
Copepoda	+	+	+	+	—	—	—	—	—	—
Other Crustacea	0.8	0.3	0.2	0.2	0.2	0.1	1.0	0.4	—	—
Cephalopoda	0.4	2.4	9.4	—	54.0	53.6	—	—	—	—
Loligo	—	2.0	7.4	—	53.7	—	—	—	—	—
Other Cephalopoda	0.4	0.4	2.0	—	0.3	53.6	—	—	—	—
Pisces	83.4	90.5	83.8	92.9	27.2	8.2	77.5	91.6	93.2	65.8
Scomberesox saurus	—	3.6	—	—	—	—	—	—	—	—
Clupeidae	—	1.3	4.2	—	12.8	—	—	—	—	—
Merluccius bilinearis	23.8	15.4	+	—	—	—	—	—	—	—
Phycis chesteri	—	—	0.8	—	—	—	—	—	—	—
Ammodytes americanus	4.1	2.9	—	1.3	—	—	—	—	—	—
Scomber scombrus	—	5.8	23.4	—	—	—	—	—	—	—
Stenotomus chrysops	—	3.9	—	—	—	—	—	—	—	—
Peprilus triacanthus	—	1.0	9.9	—	9.2	—	—	—	—	—
Other Pisces	55.5	56.6	45.5	91.6	5.2	8.2	77.5	91.6	93.2	65.8
Miscellaneous	1.7	0.5	0.7	+	0.3	0.9	0.7	0.1	2.5	0.2
No. examined	330	1,136	752	172	120	93	50	45	9	15
No. empty	68	282	262	98	43	31	20	20	1	4
Mean stom. cont. wt. (g)	1.531	1.530	1.232	2.221	3.375	0.802	1.185	1.885	4.129	0.768
Mean fish FL (cm)	17.3	18.0	20.7	25.5	29.2	25.0	21.1	31.8	32.2	28.0
Length range (cm)	3-49	3-57	3-64	3-53	12-47	57-52	9-49	12-51	31-34	21-34

TABLE 12.—Adjusted mean stomach content data for large (24-35 cm FL) and small (4-15 cm FL) silver hake sampled within various ranges of bottom water depth. All samples were obtained during bottom trawl survey cruises and conducted in the Northwest Atlantic.

Bottom depth range (m)	Large fish (24-35 cm FL)		Small fish (4-15 cm FL)	
	Adjusted weight (g)	Number of fish	Adjusted weight (g)	Number of fish
27-37	1.240	85	0.252	190
38-73	1.020	384	0.183	600
74-110	0.612	295	0.136	334
111-146	1.260	93	0.116	25
147-183	0.946	94	—	—
184-220	0.296	44	—	—
257-293	0.082	25	—	—

tion in the feeding intensity of silver hake on Georges Bank in September 1978. They found that silver hake feed more intensively at night than during daylight. The findings of the present study are similar to those reported earlier (for the same size fish collected in autumn), but also indicate that an additional feeding period may occur around noon during springtime. No such pattern of feeding has been noted for adult silver hake in the past.

Differences in the composition and/or quantity of food in the stomachs of silver hake collected within various geographic areas have been observed previously by Schaefer (1960), Vinogradov (1972), and Langton and Bowman (1980). Two items are particularly noteworthy concerning the diet of silver hake in the different geographic areas studied here. The first is the large quantity of food in the stomachs of silver hake from the Middle Atlantic (on the average two or three times more than the quantities in the stomachs of Southern New England and Georges Bank fish). The second is the high percentage weight (20.8%) of silver hake in the diet of silver hake caught in the Middle Atlantic. Of interest is that Langton and Bowman (1980) also found that silver hake caught in the Middle Atlantic area (during the period 1969-72) are more cannibalistic than silver hake in other areas of the Northwest Atlantic.

Vinogradov (1972) concluded that the differences he observed in the feeding of silver hake in the Northwest Atlantic during 1965-67 were "due to variations from area to area in the species composition of the fish food and the rate of feeding." Vinogradov's mention of "the rate of feeding" referred to the variation in feeding intensity of silver hake throughout the year. He found silver hake feed most intensively in the spring-summer and autumn periods. During the summer (when silver hake spawn) and winter, he noted that the feeding rate diminishes. The data presented here, in conjunction with other published and unpublished data, tend to corroborate Vinogradov's conclusions. Silver hake caught in spring have twice as much food in their stomachs as those caught in fall (data from present study for 24-35 cm FL fish—1.3 g, spring; 0.6 g, fall). The stomachs of spawning silver hake contain small quantities of food (0.1 g) compared with fish with developing (1.0 g) or spent (1.3 g) gonads (data from present study). Fish >20 cm FL collected during late summer-early autumn have small quantities of food (mean stomach content weight of 0.2 g) in their stomachs (Bowman and Bowman 1980). The stomach contents of silver hake collected on Georges Bank during the winter (December-January) of 1976-77 were analyzed by Bowman and Langton (1978). They found the mean stomach content weight of fish 20 cm FL and larger to be 0.4 g. The stomachs of silver hake (all >29 cm FL) collected in February (late winter) of 1977 on Georges Bank, by American and Polish scientists aboard the Polish RV *Wieczno* (conducting research in conjunction with the Woods Hole Laboratory), contained an average of 0.1 g of food (unpublished data available from the author). The pattern of feeding intensity for silver hake throughout the year, based on the above information, is intensive feeding in the spring and early summer; curtailment of feeding in summer and early autumn (during spawning); resumption of feeding in the autumn, but to a lesser degree than in the spring; and finally a reduction in feeding throughout the winter. Somewhat similar feeding patterns have been established for other species of marine fish (Tyler 1971).

Grosslein et al. (1980) reported an increase in bottom trawl survey catches of American sand lance in 1976 in the Northwest Atlantic. The population upsurge of American sand lance combined with the high percentage weights of American sand lance found in silver hake stomach contents during 1976 is an indication of silver hake's opportunistic predatory behavior. Availability of prey is probably one of the most important factors in determining what types and how much food silver hake eat.

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