WOODS HOLE LABORATORY REFERENCE DOCUMENT NO. 82-25

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Preliminary Evaluation of the Results of Analyses of the Stomach Contents of Silver Hake (*Merluccius bilinearis*) Aboard Ship and in the Laboratory Ashore[1]

by

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APPROVED FOR DISTRIBUTION

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INTRODUCTION

Two sampling methods for examining the stomach contents of silver hake (Merluccius bilinearis) are evaluated. The stomach contents of silver hake were examined for this study because silver hake's importance in the Northwest Atlantic ecosystem is well established, and silver hake are presently being intensively sampled by personnel at the Northeast Fisheries Center (NEFC) of the National Marine Fisheries Service located in Woods Hole, Massachusetts. Both sampling schemes studied here are presently utilized by personnel at the NEFC and are described as quantitative and qualitative sampling methods. Quantitative sampling refers to stomach samples which are preserved and returned to the laboratory ashore for subsequent processing. Qualitative sampling involves analyzing stomach contents and recording data aboard ship. The purpose of this paper is to evaluate the kinds of information which can be obtained from each sampling method, and to examine any differences, advantages, or disadvantages between the two sampling schemes.

METHODS

The stomachs of 501 silver hake were removed during NEFC Cruise DELAWARE II No. 81-08 conducted during 7-17 December 1981. All fish were caught with bottom trawl in continental shelf waters within a 10 nautical mile by 10 nautical mile square site (center at 40°50'; 70°20') located south of Martha's Vineyard, Massachusetts (Figure 1). Towing commenced at randomly chosen sites every three hours (e.g., 0300, 0600, 0900, etc.) over three 24-hour periods. Bottom water depth at the operation area ranged from 37 to 55 meters; bottom water temperature varied from 6.3°C to 9.0°C. Observations on the stomach contents of 394 individual fish were recorded aboard ship. The stomach contents of 280 fish were preserved and examined at the laboratory.

Quantitative sampling involves removing and combining the stomachs (and stomach contents) from fish within specified length intervals and preserving them in 10% Formalin aboard ship (small fish are preserved whole). Samples are returned to the Woods Hole Laboratory of the NEFC for subsequent processing. Stomach content information is ultimately recorded as the number of prey, size of prey, and weight of each prey group for specified fish length categories on a quantitative logsheet (Figure 2). After the stomach content data have been analyzed, the stomachs, stomach contents, and formaldehyde preservative are discarded.

Qualitative sampling requires the removal of stomachs, individual emptying and examination of their contents, and recording of all pertinent information on a qualitative logsheet aboard ship (Figure 3). Examination of the stomach contents includes estimating the total volume of the stomach contents in cubic centimeters with the aid of a calibrated measuring instrument, and determining the approximate percentage of the total volume made up by each individual prey category identified. The

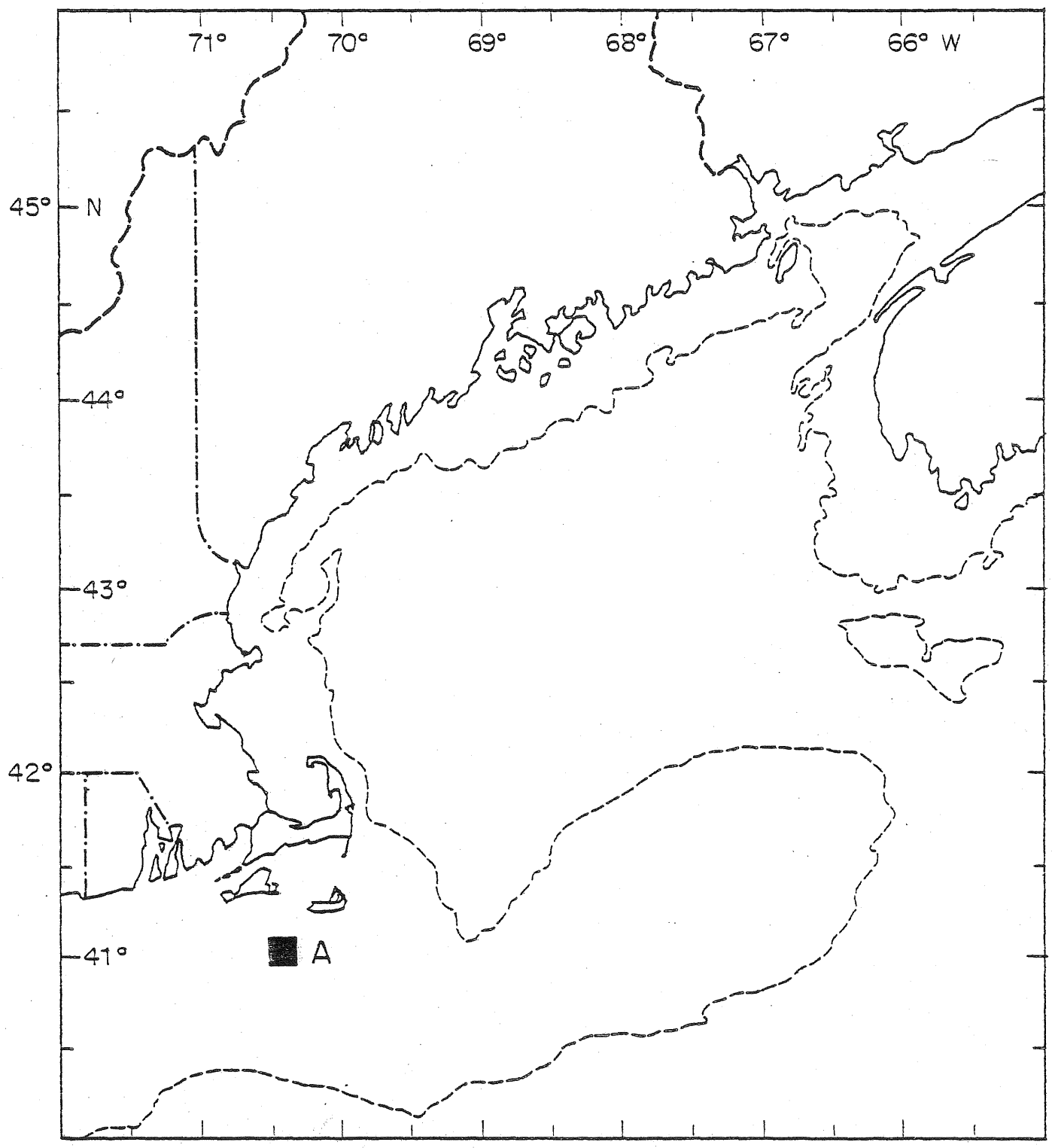

Figure 1. Area (A) sampled for silver hake during NEFC DELAWARE II Cruise No. 81-08 in December 1981.

CRUISE DOP. 81-02 STN 371 DEPTH (M) _____ SPECIES Silver Hake

HOUR _____ TEMP _____ SEX _____ MATURITY _____ LENGTH (CM) 21-35

FISH EATEN (MM) MAX _____ MIN _____ AVG _____ No. STOMACHS 4 No. EMPTY _____

TAXONOMIC GROUP	PREY CODE	WEIGHT	VOL.	No.
PORIFERA	01 0 00 00 00 00			
COELENTERATA	05 0 00 00 00 00			
Hydrozoa	05 1 00 00 00 00			
Siphonophora	05 1 03 00 00 00			
Anthozoa	05 2 00 00 00 00			
Ceriantharia	05 2 11 00 00 00			
CTENOPHORA	06 0 00 00 00 00			
CESTODA	07 1 00 00 00 00			
TREMATODA	07 2 00 00 00 00			
NEMERTEA	09 0 00 00 00 00			
ACANTHOCEPHALA	10 0 00 00 00 00			
NEMATODA	11 3 00 00 00 00	0.008		2
POLYCHAETA	21 0 00 00 00 00			
Spionidae	21 1 01 04 00 00			
Flabelligeridae	21 2 01 02 00 00			
Maldanidae	21 2 01 01 00 00			
Ophiliidae	21 2 01 04 00 00			
Amaotrypane	21 2 01 04 01			
Sternaspidae	21 2 01 07 00 00			
Terebellidae	21 4 01 03 00 00			
Sabellidae	21 6 01 01 00 00			
POLYCHAETA TUBES	21 7 00 00 00 00			
Aphroditidae	21 8 01 01 00 00			
Eunicidae	21 8 01 08 00 00			
Glyceridae	21 8 01 10 00 00			
Goniadidae	21 8 01 11 00 00			
Lumbrinereidae	21 8 01 13 00 00			
Nephtyidae	21 8 01 14 00 00			
Nereidae	21 8 01 15 00 00			
Onuphidae	21 8 01 16 00 00			
Polynoidae	21 8 01 22 00 00			
SIPUNCULIDA	31 0 00 00 00 00			

TAXONOMIC GROUP	PREY CODE	WEIGHT	VOL.	No.
CRUSTACEA	41 1 00 00 00 00			
Amphipoda	41 1 01 00 00 00			
Caprellidae	41 1 01 09 00 00			
Gammaridae	41 1 01 12 00 00	0.025		1
Ampeliscidae	41 1 01 02 00 00			
Aoridae	41 1 01 05 00 00			
Corophiidae	41 1 01 10 00 00			
Gammaridae	41 1 01 12 99 99			
Haustoriidae	41 1 01 13 00 00			
Lysianassidae	41 1 01 18 00 00			
Hyperiidae	41 1 01 14 00 00			
Hyperia galba		0.720		21
AMPHIPODA TUBES	41 1 01 99 99 99			
Decapoda	41 1 02 00 00 00			
Axiidae	41 1 02 01 00 00			
Axius serr.	41 1 02 01 01 01			
Calocar. temp	41 1 02 01 02 02			
Cancridae	41 1 02 04 00 00			
Cancer borea.	41 1 02 04 01 01			
Cancer irror.	41 1 02 04 01 02			
Crangonidae	41 1 02 05 00 00			
Crangon sept.	41 1 02 05 02 01			
Geryon quin.	41 1 02 10 01 01			
Spirontocaris	41 1 02 14 07			
Majidae	41 1 02 16 00 00			
Hyas	41 1 02 16 05			
Libinia	41 1 02 16 06			
Paguridae	41 1 02 22 00 00			
Pagurus pubes	41 1 02 22 02 06			
Pagurus	41 1 02 22 02			
Pandalidae	41 1 02 24 00 00			
Dichelo. lepe	41 1 02 24 01 01			
Pandalus bor.	41 1 02 24 03 01			
Pasiphaeidae	41 1 02 26 00 00			
Penaeidae	41 1 02 27 00 00			
Portunidae	41 1 02 30 00 00			
Decapod larvae	41 1 02 98 98 98			
UNID. CRAB	41 1 02 99 99 98			
UNID. SHRIMP	41 1 02 99 99 97			

TAXONOMIC GROUP	PREY CODE	WEIGHT	VOL.	No.
Isopoda	41 1 03 00 00 00			
Cirolana	41 1 03 04 01			
Chiridotea	41 1 03 08 01			
Cumacea	41 1 04 00 00 00			
Euphausiacea	41 1 05 00 00 00			
Meganyct. norve	41 1 05 01 03 01			
Mysidacea	41 1 06 00 00 00			
Neomysis amer.	41 1 06 03 11 01	4.271		13
Cirripedia	41 1 07 00 00 00			
Balanus	41 1 07 02 01			
Copepoda	41 1 08 00 00 00			
Calanoida	41 1 08 91 91 91			
Calanus	41 1 08 02 01			
Centropages	41 1 08 04 01			
Pseudocal.	41 1 08 43 05			
Ostracoda	41 1 09 00 00 00			
CRUSTACEA EGGS	41 1 99 96 96 96			
CRUSTACEA LARVAE	41 1 99 98 98 98			
PYCNOGONIDA	41 2 00 00 00 00			
MOLLUSCA	51 0 00 00 00 00			
Pelecypoda	51 2 00 00 00 00			
Pecten	51 2 02 07 03			
Placopecten	51 2 02 07 04			
Yoldia	51 2 04 02 02			
Gastropoda	51 4 00 00 00 00			
Buccinum	51 4 08 01 01			
Nassarius	51 4 08 06 01			
Busycon	51 4 08 07 01			
Colus	51 4 08 07 02			
Neptunea	51 4 08 07 03			
GASTROPODA OPER.	51 4 96 96 96 96			
GASTROPODA EGGS	51 4 97 97 97 97			
Pteropoda	51 4 06 00 00 00			
Cephalopoda	51 5 00 00 00 00			
Loligo	51 5 01 09 01			
Illex	51 5 01 11 01			
Rossia	51 5 01 13 01			
Octopoda	51 5 02 00 00 00			
MOLLUSCA SHELLS	51 9 99 99 99 98			
CHAETOGNATHA	55 0 00 00 00 00			
Sagitta elegans	55 1 01 01 03 02			
ECHINODERMATA	61 0 00 00 00 00			
Echinoidea	61 2 00 00 00 00			
Strongy. drobach	61 2 02 02 01 01			
Echinarc. parma.	61 2 04 01 01 01			
Ophiuroidea	61 3 00 00 00 00			
Amphipholis	61 3 02 02 06			

TAXONOMIC GROUP	PREY CODE	WEIGHT	VOL.	No.
Ophiura sarsi	61 3 02 10 13 02			
HOLOTHUROIDEA	61 5 00 00 00 00			
BRYOZOA	70 0 00 00 00 00			
Entoprocta	70 2 00 00 00 00			
LARVACEA	75 0 00 00 00 00			
Oikopleura	75 1 01 03 02			
ASCIDIACEA	76 0 00 00 00 00			
THALIACEA	77 0 00 00 00 00			
Salpidae	77 1 02 01 00 00			
PISCES	82 0 00 00 00 00			
HERRINGS	82 3 08 06 00 00			
Alewife	82 3 08 06 01 06			
Atl. herring	82 3 08 06 03 01			
Round herring	82 3 08 06 05 02			
Myctophidae	82 3 18 05 00 00			
Gadidae-Codfishes	82 3 13 02 00 00			
Fourbeard rockl.	82 3 13 02 05 01			
Atlantic cod	82 3 13 02 06 02			
Silver hake	82 3 13 02 10 02			
Amer. sand lance	82 3 21 03 01 01			
L. H. sculpin	82 3 21 23 24 04			
S. H. sculpin	82 3 21 23 24 08			
Atl. mackerel	82 3 21 65 06 01			
Blackbelly rosefi	82 3 21 67 01 01			
Redfish	82 3 21 67 06 30			
Scup	82 3 21 71 06 02			
Butterfish	82 3 21 74 37 05			
Northern searobin	82 3 21 79 03 03			
FLATFISHES	82 3 23 00 00 00			
Bothidae	82 3 23 01 00 00			
Pleuronectidae	82 3 23 03 00 00			
Yellowtail flo	82 3 23 03 10 02			
Windowpane	82 3 23 03 12 01			
FISH BONES	82 9 99 99 91 91			
FISH SCALES	82 9 99 99 93 93			
FISH EGGS	82 9 99 99 96 96			
FISH LARVAE	82 9 99 99 98 98			
ANIMAL REMAINS	84 0 00 00 00 00			
ANIMAL EGGS	84 9 99 99 99 97			
FECAL REMAINS	85 0 00 00 00 00			
PLANT REMAINS	91 0 00 00 00 00			
SAND	93 1 00 00 00 00			
ROCK	93 2 00 00 00 00			

PREY	LGTH	PREY	LGTH	PREY	LGTH	NOTES
Gammaridae	13 mm					
Hyperia galba	9-10 mm					
Meganyct. norvegica	35-37 mm	42, 37, 37, 37, 32 mm				

CRUSE	STRATA	TOW	YEAR	PREY MAX	PREY MIN	PREY AVG	FISH LGTH MAX	FISH LGTH MIN	FISH LGTH AVG	EMPTY	PRED	LGTH	SX	SAMPLE	TIME	M	D	Pcs	SS
1 2 3	4 5	6 7	12 13	14 15	16 17	18 19	20 21	22 23	24 25	26 27	28 29	30 31	32	33 34	35 36	37		68	69

DEPTH 9 10 11 TEMP 59 60 61 LOG NUMBER 63 64 65 66 67

Figure 2. Example of the quantitative logsheet used to record stomach content information at the laboratory.

FEEDING ECOLOGY LOGSHEET Technician/Recorder Michaels Morris Watch Chief Bowman

Vessel - Cruise: DeII 31-08

Station: 26

Predator: Silver hake

Length (cm)	26	31	31	37	25	18	17	26	30	42
Sex & Maturity	♀ ♂ I 0 R S Re	♀ ♂ I 0 R S Re	♀ ♂ I 0 R S Re	♀ ♂ I 0 R S Re	♀ ♂ I 0 R S Re	♀ ♂ I 0 R S Re	♀ ♂ I 0 R S Re	♀ ♂ I 0 R S Re	♀ ♂ I 0 R S Re	♀ ♂ I 0 R S Re
Fullness Est. (cc)	empty	empty	6.5 empty	10.5 empty	empty	empty	empty	empty	empty	20.0 empty
State of Digestion	FR PD WD	FR PD WD	FR PD WD	FR PD WD	FR PD WD	FR PD WD	FR PD WD	FR PD WD	FR PD WD	FR PD WD
PREY SPECIES (list to genus or species if possible)										
POLYCHAETA										
CRUSTACEA										
AMPHIPODA										
MYSIDACEA										
EUPHAUSIACEA			50 (15) 2-3cm							
DECAPOD SHRIMP										
CRABS										
MOLLUSCA										
BIVALVIA										
GASTROPODA										
CEPHALOPODA										
ECHINODERMATA										
FISCES *(Incloses Length)										
Am. sand lance			50 (2) 3.9							
Atlantic mackerel				100 (4) 32.3						100 (1) 36cm
COMMENTS			Euphs - Fresh Sand L - PD							
PATHOLOGY: I - Intestine, L - Liver, S - Spleen, K - Kidney, SB - Swim Bladder (haddock only).	L S I SB K	L S I SB K	L S I SB K	L S I SB K	L S I SB K	L S I SB K	L S I SB K	L S I SB K	L S I SB K	L S I SB K

Figure 3. Example of the qualitative logsheet used to record stomach content information aboard ship.

above data and other information concerning prey such as number, size, state of digestion, and other observations (e.g., heads only) are recorded for each predator along with fish length, sex, maturity, and pathological observations. Representative samples of dominant prey not readily identifiable aboard ship are preserved and returned to the laboratory for identification.

For this study a qualitative examination of the stomach contents of individual fish was performed at sea and each fish's stomach and contents preserved separately. At the laboratory, the stomach contents of each fish were weighed and combined according to specified length categories; then a quantitative analysis was performed on the grouped stomachs. The above method ultimately provided data necessary to compare estimated volumes and actual weights, along with information for comparisons of data obtained for various prey categories identified from each sampling method.

Quantitative and qualitative food data are presented for each predator length category as the percentage of the total stomach contents weight or volume made up by various prey groups. When appropriate, subtotals of major prey groups are offset to the left. The actual weight or volume of each prey group can be calculated by multiplying the mean stomach content weight or volume times the number of fish examined times the percentage indicated times 0.01 (all necessary data are supplied in tables). Qualitative data are summarized in the same manner as quantitative data to facilitate comparisons. However, qualitative data may be summarized differently, and other analysis methods utilized, to provide additional information such as percentage occurrence of prey groups or the foods consumed by fish in different length categories.

RESULTS

The relationship between estimated volumes and actual weights of the stomach contents of 115 individual silver hake (excluding empties) was derived from linear regression. It can be seen in Figure 4 that the estimated volumes tend to be quite variable for a given weight, but on the average the actual weight only tends to be slightly more than the estimated volume (e.g., estimated volumes of 3, 4, and 5 cc, on the average, represent weights of about 3.7, 4.8, and 5.9 grams, respectively).

Results of stomach content analyses aboard ship and in the laboratory, for the same group of fish, are presented in Table 1. The identification of invertebrate organisms is more precise for samples examined at the laboratory compared to those analyzed at sea (e.g., within "CRUSTACEA", the Amphipoda, Decapoda, and Mysidacea were often classified to species level for quantitative samples while samples examined at sea were typically classified into broader prey groups). Identification of fish prey was slightly more accurate for stomach contents examined at sea than those analysed at the laboratory. It can be seen in the listing of food for fish 21-30 cm in length (the largest

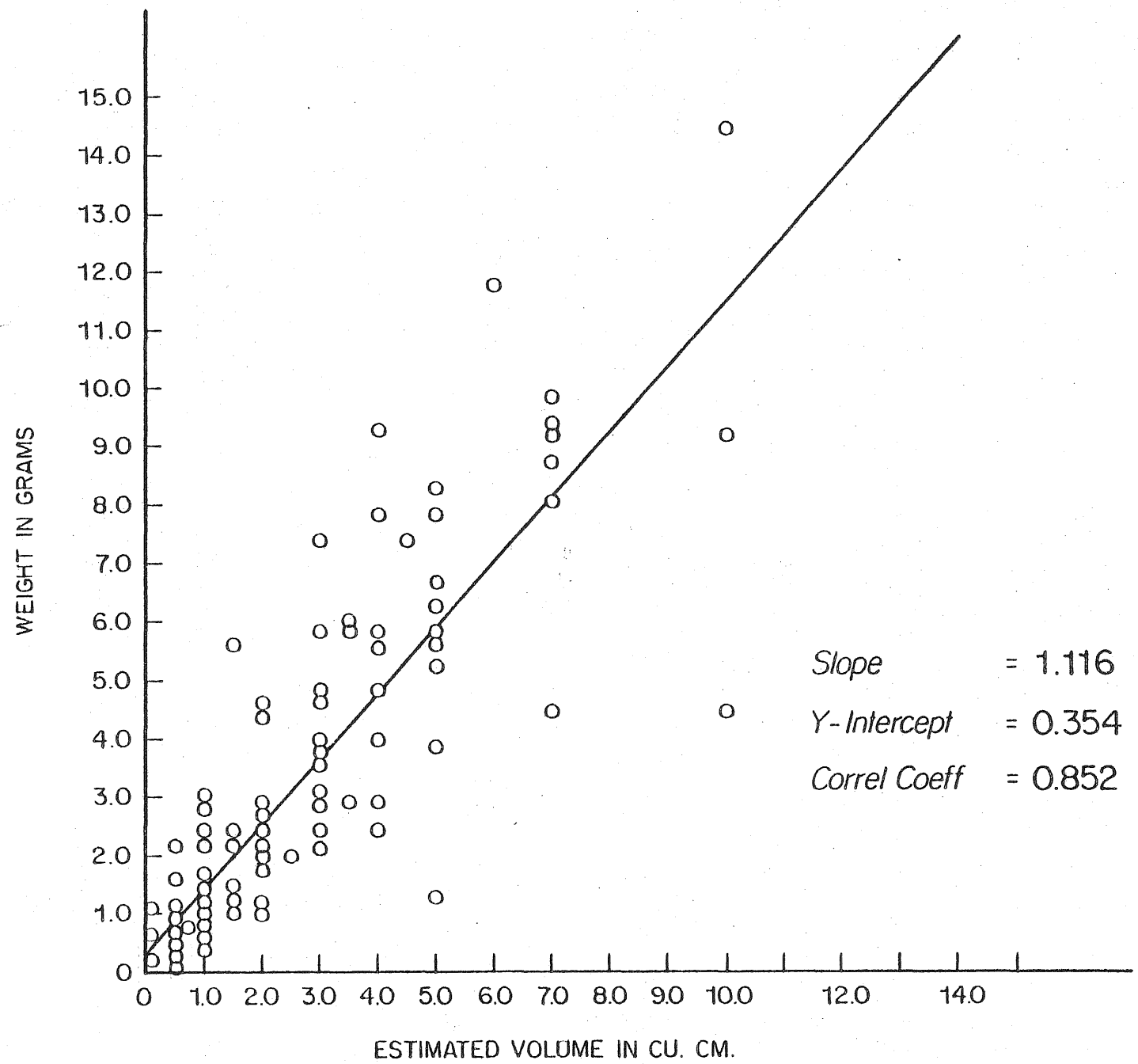

Figure 4. Regression of volume (obtained at sea) versus actual weight (determined in laboratory) of the stomach contents of 115 silver hake. Note that estimated volumes tend to be slightly less than the actual weight.

Table 1. Results of analysis of stomach contents aboard ship (presented as a percentage of the estimated total stomach contents volume in cubic centimeters) and at the laboratory (given as a percentage of the total stomach contents weight in grams) for the same groups of fish. Data represents stomach contents of silver hake caught south of Martha's Vineyard during NEFC DELAWARE II Cruise No. 81-08 in December 1981.

	Fish length category (cm)					
	21-30		31-35		>35	
Stomach contents	% wt.	% vol.	% wt.	% vol.	% wt.	% vol.
POLYCHAETA	0.1	0.1	-	1.1	-	-
CRUSTACEA	33.1	32.0	50.6	56.7	77.2	66.4
Amphipoda	0.7	0.9	0.9	0.2	0.3	-
Gammarus annulatus	0.2	-	-	-	-	-
Gammarus sp.	0.2	-	0.2	-	0.1	-
Leptocheirus pinguis	0.2	-	0.3	-	0.2	-
Unidentified Gammaridea	0.1	-	0.4	-	-	-
Unidentified Amphipoda	-	0.9	<0.1	0.2	-	-
Decapoda	26.5	29.0	49.4	56.5	71.9	66.4
Crangon septemspinosa	19.4	18.6	41.0	35.5	66.9	48.9
Dichelopandalus leptocerus	5.9	-	4.0	-	5.0	-
Unidentified Pandalidae	1.2	8.4	4.4	8.9	-	17.5
Decapod shrimp	-	2.0	-	12.1	-	-
Decapod crab	-	<0.1	-	-	-	-
Mysidacea	4.7	2.0	0.3	-	-	-
Neomysis americana	4.7	-	0.3	-	-	-
Unidentified Mysidacea	-	2.0	-	-	-	-
Unidentified Crustacea	1.2	0.1	-	-	-	-
PISCES	65.3	66.4	49.3	40.6	27.8	33.6
American sand lance	10.4	16.5	40.1	16.4	-	-
Silver hake	30.4	24.3	3.5	3.3	21.2	24.7
Red hake	-	2.2	-	-	-	-
Unidentified hake	-	0.2	-	-	-	-
Unidentified Pisces	24.5	23.1	5.7	20.9	6.6	8.9
CHAETOGNATHA	<0.1	-	-	-	-	-
Sagitta elegans	<0.1	-	-	-	-	-
MISCELLANEOUS	1.5	1.5	0.1	1.6	-	-
No. of fish examined	113	113	28	28	10	10
No. of empty stomachs	20	20	11	11	5	5
Mean stom. cont. wt. (g) or vol. (cc)	2.012	2.035	2.266	1.629	1.906	1.700

and most representative group sampled) that red hake and "other hakes" are included within "PISCES" in the percentage volume column but not the percentage weight column. However, generally, the identification of major fish prey was similar for both analysis methods (e.g., American sand lance and silver hake were identified as the principal fish prey utilizing either procedure).

Percentages (of total weight or volume) calculated for prey groups identified utilizing either processing method resulted in a reliable determination of the major prey being consumed. For instance, the percentages of Crangon septemspinosa (Table 1) calculated for the stomach contents were 19.4%, in terms of weight, and 18.6%, in terms of volume, for fish within the 21-30 cm length category. Generally, the percentage volumes listed for broader prey classifications are similar to the percentages calculated for weight if the species of prey groups are summed to the broader classifications. For example, Amphipoda account for 0.9% of the prey represented in the percentage volume column for 21-30 cm fish; the percentage weights of species and other groups of amphipods represented in the percentage weight column for the same size fish add to 0.7%, a comparable percentage. Regardless of which particular data set is examined, it can be concluded that silver hake, "other Pisces", Crangon septemspinosa, American sand lance and pandalid shrimp (Dichelopandalus leptocerus) are the principal foods (in order of importance for fish 21-30 cm in length). It should be noted here that representative samples of prey groups not readily identified aboard ship are customarily preserved and returned to the laboratory for identification (i.e., as part of the qualitative sampling scheme). Because of this, identification of species such as Dichelopandalus leptocerus (Decapoda) and Neomysis americana (Mysidacea) would be known when utilizing the qualitative sampling scheme.

Percentage occurrence information for various prey groups identified aboard ship may be found in Table 2. Percentage occurrence data are useful for determining the percentage of a population which feeds on particular prey. Percentage occurrence data are not obtainable from samples returned to the laboratory for processing because the stomach contents are combined and analyzed together to represent only specified predator length categories and not individual fish (in addition, it is difficult to determine the number of empty stomachs included in quantitative samples because the stomach contents often fall out of the stomach and float freely in the preservative before the samples are analyzed). It can be seen in Table 2, for fish within the 21-30 cm length category, that almost half (48.7%) of the fish examined ate Crangon septemspinosa, and 20.4% of the fish consumed pandalid shrimp (Dichelopandalus leptocerus). Both silver hake and American sand lance were eaten by slightly more than 10% of the fish sampled (13.3% and 11.5%, consecutively).

The stomach contents of additional fish were examined aboard ship to determine if substantial shifts in the percentage of prey consumed or new prey groups would occur by increasing the number of samples

Table 2. Percentage occurrence of prey groups identified in the stomachs of silver hake caught south of Martha's Vineyard in December 1981.

	Fish length category (cm)		
	21-30	31-35	>35
Stomach contents	% occur.	% occur.	% occur.
POLYCHAETA	0.9	3.6	-
CRUSTACEA	65.5	46.4	50.0
Amphipoda	7.1	3.6	-
Decapoda	60.2	46.4	50.0
Crangon septemspinosa	48.7	39.3	50.0
Unidentified Pandalidae	20.4	17.9	30.0
Decapod shrimp	6.2	7.1	-
Decapod crab	0.9	-	-
Mysidacea	4.4	-	-
Unidentified Crustacea	0.9	-	-
PISCES	46.0	35.7	20.0
American sand lance	11.5	7.1	-
Silver hake	13.3	3.6	10.0
Red hake	0.9	-	-
Unidentified hake	0.9	-	-
Unidentified Pisces	28.3	17.9	10.0
MISCELLANEOUS	4.4	3.6	-
No. of fish examined	113	28	10
No. of empty stomachs	20	11	5
Mean stom. cont. wt. (g) or vol. (cc)	2.035	1.629	1.700

collected. The results of examining the food consumed by almost three times as many fish (113 versus 301 individual fish within the 21-30 cm fish length category; refer to bottom of Tables 1 and 3, respectively) revealed no additional prey groups were identified, and the percentage volumes and occurrence of prey in the diet were similar to data already reported on (compare data given in Table 3 to that given in Tables 1 and 2). Likewise, the additional food data for fish in other length categories resulted in few new prey items or large shifts in percentage volume or occurrence information for various prey groups.

DISCUSSION

Only slight differences are noted between data sets obtained from silver hake stomach contents examined aboard ship and in the laboratory ashore. Individual estimated volumes of stomach contents of a given weight are variable, but when averaged, the data is almost directly comparable with more accurate weight data obtained in the laboratory. Generally, the stomach content volumes estimated at sea tend to be slightly less, on the average, than the actual weights. Identification of fish prey appears slightly better at sea than in the laboratory. Classification of invertebrate species is less precise aboard ship than when examinations are conducted ashore in the laboratory. However, the preservation of representative samples of stomach contents (to be examined at the laboratory) when qualitatively sampling aboard ship resolves the difficulty of identifying invertebrates at sea. It is important to mention that personnel who examined the stomach contents of fish at sea for this study were not all experienced biologists, but rather student volunteers with little fisheries or invertebrate training and other NEFC personnel not totally familiar with invertebrate organisms. Only the chief scientist was thoroughly familiar with most invertebrate organisms encountered in fish stomachs, and he spent limited time identifying organisms with the technicians because of other duties. Regardless, with minimal supervision from one knowledgeable biologist technicians rapidly became familiar with the most common prey groups. Both percentage volume and percentage weight information are dependable measures for identifying major prey species, and the results presented here illustrate the similarity of data obtained by utilizing either stomach processing method.

Additional scientific information can be obtained when utilizing the qualitative sampling method. For example, the food consumed by fish within any specified length interval (e.g., a specific year class) can be determined. Observations on the food of fishes with signs of disease or of different sex, and maturity stage (e.g., when fish are spawning) can readily be obtained. Another consideration is that fish found in the stomach contents are more likely to be accurately measured and identified aboard ship (when fish prey are in pieces) since technicians are familiar with the species and sizes of each species caught in the trawl hauls (many of the same species caught serve as prey for fish eating species).

Table 3. Percentage volume of the total stomach contents and percentage occurrence of prey identified in the stomach contents of 394 silver hake caught with bottom trawl south of Martha's Vineyard in December 1981.

	Fish length category (cm)							
	11-20		21-30		31-35		>35	
Stomach contents	% vol.	% occur.	% vol.	% occur.	% vol.	% occur.	% vol.	% occur.
POLYCHAETA	-	-	0.2	1.0	1.1	5.1	-	-
CRUSTACEA	93.6	68.2	41.6	63.8	45.8	45.8	62.4	58.3
Amphipoda	1.3	4.5	0.8	6.3	0.5	6.8	-	-
Decapoda	84.7	63.6	39.3	59.8	45.3	45.8	62.4	58.3
Crangon septemspinosa	72.0	54.5	22.7	48.2	25.9	32.2	46.3	58.3
Unidentified Pandalidae	12.0	4.5	12.2	20.3	9.6	16.9	14.0	33.3
Decapod shrimp	-	-	4.4	8.0	9.8	10.2	2.1	8.3
Decapod crab	-	-	<0.1	0.3	-	-	-	-
Mysidacea	7.6	13.6	1.4	3.7	-	-	-	-
Unidentified Crustacea	-	-	0.1	0.7	-	-	-	-
PISCES	6.4	4.5	55.5	33.9	51.9	35.6	37.1	33.3
American sand lance	-	-	10.2	5.0	23.8	6.8	-	-
Silver hake	-	-	22.6	9.6	6.4	5.1	25.7	16.7
Red hake	-	-	1.9	0.7	-	-	-	-
Unidentified hake	-	-	0.2	0.3	-	-	-	-
Unidentified Pisces	6.4	4.5	20.6	20.6	21.7	22.0	11.4	16.7
MISCELLANEOUS	-	-	2.7	4.3	1.2	5.1	0.5	8.3
No. of fish examined	22		301		59		12	
No. of empty stomachs	6		55		17		5	
Mean stom. cont. wt.(g) or vol. (cc)	0.357		1.503		1.534		2.008	

The state of digestion of stomach contents is also recorded when stomach contents are examined aboard ship. The state of digestion of prey is helpful in determining when fish eat, their digestion rate, and relative condition of prey found in the stomachs. Finally, because information is available for individual fish (rather than for fish length groups), the percentage occurrence of various prey and the number of empty stomachs can be calculated. It should be noted here that specific prey names, sizes, weights, and numbers can be determined from limited representative samples preserved at sea and returned to the laboratory for detailed examination. Therefore, specific prey information obtained by preserving large numbers of stomach content samples to be examined at the laboratory cannot be considered an advantage.

Availability of fish food data acquired from the two sampling methods deserves mention. Immediately after trawl retrieval, fisheries personnel aboard ship become aware of foods being consumed by fishes when stomach contents are examined at sea. Usually, technicians show additional interest and tend to be more observant when performing stomach content analyses at sea. Instances of predation on fish species of commercial importance (especially juveniles of these species) or unusual predation patterns (fish feeding on mollusk viscera without mollusk shell in the stomachs) have been reported during ship to shore communications on several occasions. In cases when a significant observation is made shipboard personnel may be requested to divert ship's operations for the purpose of gathering additional scientific samples. Another advantage of stomach content examination at sea is that within one day after the ship's return, summary tables indicating food consumed can be compiled for selected fish species for determination of major species of fish prey. Such rapid analyses of food data may be more useful to fisheries assessment and management scientists than quantitative data for which it is customary to wait at least five years. Slow turnaround times for scientific information can be a disadvantage to scientists trying to detect and react to major changes in fish stocks in a fluctuating ecosystem. Thus, examination of the stomach contents of fish at sea and rapid analyses of the data ashore is a method of sampling useful for monitoring the Northwest Atlantic ecosystem (without an analysis time lag), and which allows research assessment and modeling efforts to react to change almost immediately.

Items other than the compatibility or differences of the stomach content data must also be considered. For example, examination of stomach contents at sea requires more time than removing and preserving stomachs. However, time is seldom the limiting factor at sea when utilizing either sampling method since steaming between trawling stations usually provides ample time for either sampling scheme. Preserving large numbers of samples at sea requires separation of stomachs from fish within specified length categories (and their placement into appropriate jars), completion of internal and jar cap labels, proper dilution of preservative, and storage on the ship, all of which require time, although not quite as much time as analyzing the stomach contents.

Time involved in post-cruise removal, storage, cataloging, and subsequent examination of preserved samples is substantial. Processing stomach contents in the laboratory has traditionally been an arduous, time-consuming task. Identifying, counting, and weighing individual prey groups is time intensive. Transportation of samples to and from storage areas and contractors requires additional time. Preparation of contracts for stomach content processing, cataloging of samples, disposal of processed samples, and recycling of jars often requires substantial manpower. In comparison, the filing of logsheets obtained from examination of stomach contents at sea requires little manpower.

Storage of samples is basically troublesome compared to filing logsheets. Samples must be stored in a heated area to prevent freezing. Loss of power or heat system failure during severe winter months could be catastrophic. Potentially, the contents of hundreds of jars could freeze and crack their containers, thus causing massive spillage of formaldehyde in the storage building and result in a severe health hazard (as well as the loss of samples). Fading and weathering of labels, evaporation of preservative, and failure to add preservative, regularly occurs when samples are stored and frequently results in subsequent loss of a portion of the samples. In particular, the failure to add preservative (or enough preservative) at sea becomes most unpleasantly evident during hot summer months when jars crack or explode as a result of putrefaction.

Financial aspects of processing stomach contents on contract or in the laboratory are dramatic compared to at sea examinations. Analyses aboard ship are essentially complete except for processing the limited number of representative samples preserved for determining the identities and percentages of species within prey groups such as amphipods or polychaetes, which would be impractical to identify at sea. In contrast, the expense of heated storage, contracting biological firms for processing, and the additional personnel needed for the storage, cataloging, and processing is substantial when handling large quantities of samples (presently it costs approximately $4.00 per stomach for processing alone). Returning large numbers of silver hake stomachs to the laboratory for subsequent processing on a regular basis seems inefficient.

Overall, the scientific data and other considerations noted above concerning the two sampling methods suggests the results obtained from quantitative sampling are not superior to those obtained from qualitative sampling; and that the cost, labor, time, etc., of quantitatively sampling silver hake does not seem warranted.