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STOMACH CONTENTS, LENGTH-WEIGHT RELATIONSHIP, AND GUT MORPHOLOGY OF ATLANTIC SAURY, SCOMBERESOX SAURUS (WALBAUM)*

by

Beth Hiler[1] and Ray E. Bowman[2]

APPROVED FOR DISTRIBUTION
M. D. Grosslein
(APPROVING OFFICIAL)
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(DATE)

[1]Colgate University
Hamilton, New York 13346

[2]National Marine Fisheries Service
Northeast Fisheries Center
Woods Hole Laboratory
Woods Hole, Massachusetts 02543

National Marine Fisheries Service
Northeast Fisheries Center
Woods Hole, Massachusetts 02543

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ABSTRACT

Atlantic saury (*Scomberesox saurus*, Walbaum) were collected from surface waters between Gilbert and Oceanographer canyons (southwestern edge of Georges Bank) to determine their length-weight relationship, gut morphology, and source of food. Fish were obtained on November 5, 1981 by attracting them at night with artificial light, and subsequently towing two pelagic trawls, one from each side of the ship, through observed concentrations. Examination of the stomach contents of 30 fish revealed the prey of saury to be principally Euphausiacea and Siphonophora (tentative identifications). The relationship between length and weight, expressed by the equation $W = aL^b$, where $a = 6.0844 \times 10^{-6}$; $b = 2.8684$ ($r^2 = 0.6786$), was based on 88 specimens. The mean fish fork length was 322 mm, and the mean weight was 97.8 g. Digestive tract measurements of the Atlantic saury showed that saury have unusually large stomachs in relation to their intestine. It was also determined from a series of linear regressions that as Atlantic saury increase in size, the weight of their stomach and intestine decrease when expressed as a percentage of the total body weight. However, the weight of the stomach decreased at a faster rate than the weight of the intestine. An exponential regression of the percentage body weight of stomach contents to fish length (or weight) indicates the percentage body weight made up by the stomach contents also decreased as saury increase in size.

INTRODUCTION

Atlantic saury (Scomberesox saurus, Walbaum) is distributed from the coasts of the U.S.A. and Canada to the Norwegian and Barents Seas and from the northwest coast of Africa to the northeast coast of South America. The densest concentrations of Atlantic saury in the North Atlantic occur within the waters of the Gulf Stream and the North Atlantic Drift from at least 13° to 70°W depending on the season. During winter months, large concentrations congregate in the vicinity of the Great South Channel in the Northwest Atlantic (Nesterov and Grudtsev, 1980). Atlantic saury undertake considerable seasonal migrations. The northwards migration (spring-summer) is apparently related to feeding and the southwards migration (autumn-winter) is likely related to spawning and overwintering (Sauskan and Semenov, 1968; Zilanov and Bogdanov, 1968; Dadnik, 1975).

Atlantic saury is the most significant plankton feeder in the upper pelagic waters of Atlantic temperate zones (Zilanov and Bogdanov, 1968). As a plankton predator the Atlantic saury has low food selectivity. Changes in the type of food consumed, depending on area, season or time, indicate that this species has a high feeding plasticity. Apparently, it is this characteristic which allows saury to adapt to life in the open part of the ocean, where food is relatively inaccessible (Nesterov, 1981). Atlantic saury has been found in the stomachs of several species of squid, blue shark, swordfish, dolphins, sea birds, and the small whale dolphin. It has also

been found in the stomachs of cod, silver hake, and spiny dogfish. The Atlantic saury is a member of the tertiary level of the trophic food chain, which includes "predatory plankton" and "plankton-eating fish." It is also an important intermediate link between organisms of the first two trophic levels and nekton predators of the fourth and fifth trophic levels, as well as sea birds (Nesterov, 1981).

In this study we examine the type and quantity of food consumed, and determine the length-weight relationship and gut morphology of Atlantic saury collected in Northwest Atlantic waters.

METHODS

Collection

Fish were collected during a study jointly conducted by American and Soviet scientists aboard the Soviet research vessel BUGOSLAV, operated by the Polar Research Institute of Fisheries and Oceanography (PINRO), located in Murmansk, USSR, during November 1981.

Two pelagic trawls (one hung from port and one from starboard) were towed at five knots during hours of darkness. The trawls were fitted to the sides of the vessel, suspended from horizontal booms, and held open vertically by 400 kilogram weights hung on the outboard end of the footropes of the nets. Each net was approximately 32 meters long, and had a mouth opening of 25 square meters. The body of the trawl was made up of sections with meshes varying from 12-20 millimeters. Bright lights were directed towards the water ahead of the vessel to attract as well as locate fish concentrations. All Atlantic saury

for this analysis were obtained on the night (0300-0500) of November 11, 1981, at one station located at 40°20.8' latitude and 68°04.4' longitude (bottom water depth of 150-170 meters and generally between Gilbert and Oceanographer canyons on the southwestern edge of Georges Bank). Fish were frozen and returned to the Woods Hole Laboratory of the Northeast Fisheries Center, located in Woods Hole, Massachusetts for analysis.

Analysis

Fish were air thawed during January 1983, and the lengths and weights of 88 specimens were obtained (fork length (FL) in millimeters, and weight to the nearest one tenth of a gram). Digestive tracts of 39 fish were excised and weighed, and the stomach contents of 30 fish were examined under a dissecting microscope, sorted, weighed and the data recorded on logs. Gut morphological measurements included total digestive tract, stomach, and intestine weights.

RESULTS

Length-weight relationship

A total of 88 Atlantic saury were examined. Fish ranged in size from 285-393 mm FL (length frequency given in Figure 1) and from 61.8-172.1 g. We found the relationship between weight and length to be $W = 6.0844 \times 10^{-6} L^{2.8684}$; where L = length in mm; and W = weight in g (Figure 2). The mean fish FL was 322 mm, and the mean fish weight was 97.8 g (see Table 1 for a listing of all measurements obtained for individual fish).

Stomach contents

Stomach content examinations and gut morphological measurements were not obtained for all 88 fish because the tissue of some of the specimens was in an advanced state of decomposition. The stomach contents of 30 fish were examined, but the material found in the stomachs was in very poor condition, most likely because stomach acids continued to digest the bolus during freezing and thawing. Major prey were tentatively identified as Euphausiacea and Siphonophora, but could conclusively only be identified as Crustacea and animal remains (Table 2).

Gut morphology

Gut morphological measurements obtained for 39 fish showed that on the average the weight of the stomach tissue was 6.95 times heavier than the weight of the intestine (see right-hand column in Table 1 and Figure 3). It can be seen from the linear regressions shown in Figures 4 and 5 that the percentage body weight of the total digestive tract, as well as both the stomach tissue weight and the intestine tissue weight, decreased as the fish gets larger. Note that the stomach tissue decreases at a faster rate (slope, a, 2.1285) than the intestinal tissue (slope, a, 0.4942) when both are expressed as percentage body weight. This is also evident from Figure 3 which presents the S/I ratio calculations (stomach tissue weight/intestine tissue weight) for fish of various lengths. Also of interest is that as saury increase in size (either length or weight) there is a tendency for the percentage body weight of the stomach contents to decrease (Figures 6 and 7). An exponential regression resulted in a higher r value (better fit) than the linear regression for this data, in terms of both length and weight.

DISCUSSION

It was difficult to obtain positive identification of the prey types taken by Atlantic saury. The poor condition of the material in the stomachs was likely a result of using freezing as the method of preservation. During freezing and thawing the digestive acids already present in the stomachs likely continued to digest the food. In addition, since adult saury feed during daylight hours (Nesterov, 1981), the food in the stomachs was probably already partially digested when the fish were collected. The body tissue also began to decompose during the thawing process which made it impossible to obtain gut morphological measurements on all the fish sampled. However, previous research on the feeding habits of Atlantic saury provides some conclusive data. The principal food items in the region of Georges Bank (by volume) are Copepoda, mainly members of the genus Centropages (43.7%), Euphausiacea (14.6%), and the larvae of Decapoda (8.4%). Coelenterata (Siphonophora), Chaetognatha, fish and Mollusca are of lesser importance as food (Dudnik et al., 1981; Nesterov, 1981). Nesterov's study also showed that in the Great Newfoundland Bank area the food of Atlantic saury includes Copepoda, among which Calanus finmarchicus (55.1%) predominated, Amphipoda (30.2%), and Euphausiacea (10.5%), with Mollusca (Limacina sp.) and Decapoda larvae occurring in small quantities. Prey of Atlantic saury caught in waters off Nova Scotia consists of Euphausiacea (Meganyctiphanes norvegica, 52.9%), Hyperiidea (27.3%), Copepoda, Mollusca and young fish. The widest spectrum of food taken by Atlantic saury was noted for fish sampled in waters off Cape Hatteras. Here its food consists of the larvae of Decapoda (53.7%), Hyperiidea (14.8%), Mollusca (mainly Carolinia, 10.1%), Copepoda,

Ostracoda, Foraminifera and other prey in small quantities, Euphausiacea (50.1%), mainly Nematoscelis megalops and Meganyctiphanes norvegica, fish (19.7%), Hyperiidea (11.5%) and Copepoda (5.1%) are among the most important food items of the Atlantic saury in the region of the Azores (Nesterov, 1981).

Dudnik et al. (1980) expressed the length-weight relationship of Atlantic saury as $W = 0.0068\ L^{3.0045}$. However, apparently because of an error in their original calculations, Dudnik et al. (1981) reexamined the data and found the relationship to be $W = 0.003328\ L^{3.0045}$, which is in close alignment with our results ($W = 6.0844 \times 10^{-6}\ L^{2.8684}$; see Figure 2). It should be noted that the former study's measurements are in centimeters and grams and our measurements are in millimeters and grams. Also worthy of mention is that freezing is known to cause as much as a -6.36 to -11.16 percentage weight change in fish when they are air thawed (Anthony and Chenoweth, 1965). The negative difference in our length-weight relationship compared to that of Dudnik (1981) is close to this range. Fish examined for the present study were all adults 3-4+ years of age based on the results of previous studies (Nesterov, 1974; Dudnik et al., 1981).

Gut morphological measurements revealed the Atlantic saury has an unusually large stomach compared to its intestine (see Edwards and Bowman, 1979 for gut measurements of other fishes). Nikolsky (1963) states that the size of the stomach in fishes is closely related to their feeding behavior and to the size of ingested prey. In fishes which swallow large prey or consume large amounts of food at a single feeding, the stomach is usually large. Saury likely fall into the latter category since their stomachs contained fairly large quantities of food (almost 1 %, BW), long after feeding ceased, and in spite of the freezing and thawing process.

The percentage body weight of both stomach and intestine tissue of Atlantic saury decrease, as fish increase in size. The percentage body weight of the stomach tissue apparently decreased at an even faster rate than the intestinal tissue. Also noted was that the percentage body weight of the stomach contents decreases exponentially as the fish increase in size. These trends have been noted in other fish species as well (Bowman, 1980A, 1980B). One possible hypothesis for these observations is that when the growth rate decreases as fish get older, they need proportionally less food than young fish which grow rapidly in terms of percentage of body weight. Since young fish need proportionally more food to accommodate their rapid growth, they probably have a larger stomach and intestine, in relation to their total body weight than their older counterparts.

The r value (coefficient of variation of the sample) for most of the regressions was low. The reason for this was possibly due to the poor condition of the fish examined. Further study to determine the prey of Northwest Atlantic saury, quantitatively in terms of percentage weight of each prey of the total stomach contents, and the daily ration of this species, seems appropriate since their importance as a predator and prey in the Northwest Atlantic ecosystem is well established.

ACKNOWLEDGMENTS

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BIBLIOGRAPHY

Anthony V.C. and J. Chenoweth. 1965. VIII. Changes in length and weight of Maine sardines due to freezing, brining and salting. ICNAF Redbook, Part III, Selected Papers. p. 181-189.

Bowman, R.E. 1980A. Food of silver hake (Merluccius bilinearis). Nat. Mar. Fish. Serv., Northeast Fish. Ctr., Woods Hole Lab. Ref. Doc. No. 80-31, 46 p.

Bowman, R.E. 1980B. Food of Northwest Atlantic juvenile haddock. M.A. Thesis, Bridgewater State College. April 1980, 95 p.

*Chigirinskiy, A.I. and A.F. Volkov. 1971. Some morphological features and age related changes in the feeding habits of the Atlantic saury (Scomberesox saurus, Walbaum). J. of Ichthyology 11(5): 751-758.

Dudnik, Yu.I. 1975. Some features of the geographical distribution of the Atlantic saury Scomberesox saurus in the South Atlantic in winter. J. of Ichthyology 15(2): 182-188.

Dudnik, Yu.I.., V.K. Zilanov, V.D. Kudrin, V.A. Nesvetov, and A.S. Nesterov. 1980. Results of Soviet investigations of the biology of the Atlantic saury, Scomberesox saurus (Walbaum), in the Northwest Atlantic. Northwest Atlantic Fisheries Organization, Serial No. N154. NAFO SCR Doc. 80/VI/99.

Dudnik, Yu.I., V.K. Zilanov, V.D. Kudrin, V.A. Nesvetov, and A.S. Nesterov. 1981. Distribution and biology of Atlantic saury, Scomberesox saurus (Walbaum), in the Northwest Atlantic. Northwest Atlantic Fisheries Organization. NAFO Sci. Coun. Studies. No. 1: 23-29.

Edwards, R.L. and R.E. Bowman. 1979. Food consumed by continental shelf fishes. In: Predator-prey systems in fish communities and their role in fisheries management. Sport Fishing Institute, Publ., Wash., D.C., p. 387-406.

Hartmann, J. 1970. Juvenile saury pike (Scomberesox saurus, Walb.), an example of ichthyoneuston. Journal Du Counseil 33(2): 245-255.

Nesterov, A.A. 1974. Age and growth of the North Atlantic saury (Scomberesox saurus). J. of Ichthyology 14: 398-403.

Nesterov, A.A. 1981. The feeding of Scomberesox saurus (Scomberesocidae) and its trophic relationships in the epipelagic zone of the ocean. J. Ichthyology 21(2): 55-69.

Nesterov, A.A. and M.E. Grudtsev. 1980. Investigations of the Georges Bank Atlantic saury, Scomberesox saurus (Walb.), in November-December 1979. Northwest Atlantic Fisheries Organization, Serial No. N184. NAFO SCR Doc. 80/IX/115.

*Nesterov, A.A. and T.A. Shiganova. 1976. The eggs and larvae of the Atlantic saury, Scomberesox saurus of the North Atlantic. J. of Ichthyology 16(2): 277-283.

Nikolsky, G.V. 1963. The ecology of fishes. Publ., Academic Press, New York. 352 p.

*Osipov, V.G. 1975. Distribution of saury (Scomberesox saurus) fingerlings in the vicinity of New Zealand. J. of Ichthyology 15(3): 495-496.

Sauskan, V.I. and G.N. Semenov. 1968. The North Atlantic saury. Annales Biologiques, Vol. 25, p. 250-252.

Zilanov, V.K. and S.I. Bogdanov. 1968. Results of research on Scomberesox saurus in the northeastern Atlantic in 1968. Annales Biologiques, Vol. 25, p. 252-255.

*Zilanov, V.K. and A.A. Nesterov. 1974. On feeding of the North Atlantic saury (Scomberesox saurus). International Council for the Exploration of the Sea, C.M. J:3, p. 1-4.

*Not cited in text but of interest.

Table 1. Length, weight, gut content, and gut morphological measurements obtained for Atlantic saury caught on the night of November 11, 1981, while towing pelagic trawls from the Soviet R/V BUGOSLAV.

Length (mm)	Weight (g)	Stomach Contents (g)	% BW of Stom. Cont.	Stomach Tissue (g)	% BW of Stom. Tiss.	Intestine Tissue (g)	% BW of Intest. Tiss.	Empty Digestive Tract (g)	% BW of Empty Digest. Tract	Stomach Tissue (g) Intestine Tissue (g)
285	67.1	0.34	0.51	1.38	2.06	0.13	0.19	1.48	2.21	10.61
286	62.1			0.89	1.43	0.36	0.58	1.36	2.19	2.47
290	77.9	0.38	0.49	1.36	1.75	0.11	0.14	1.51	1.94	12.36
291	69.3	0.75	1.08	1.25	1.80	0.10	0.14	1.35	1.95	12.50
293	74.9	1.67	2.23	1.21	1.62	0.47	0.63	1.78	2.38	2.57
295	73.0	0.62	0.85	1.27	1.74	0.17	0.23	1.40	1.92	7.47
295	72.6			1.00	1.38	0.15	0.21	1.15	1.58	6.67
296	69.9	0.71	1.02							
296	61.8			0.95	1.54	0.26	0.42	1.35	2.18	3.65
296	77.5	0.52	0.67	1.32	1.70	0.15	0.19	1.52	1.96	8.80
296	79.3	1.20	1.51	1.21	1.53	0.15	0.19	1.35	1.70	8.07
299	87.6	1.31	1.50	1.24	1.42	0.26	0.30	1.40	1.60	4.77
300	87.7	0.38	0.43	1.66	1.89	0.41	0.47	2.02	2.30	4.05
300	76.9									
300	73.9									
302	81.1									
304	75.8									
304	89.4									
305	89.1									
307	68.8									
307	84.8									
309	90.2									
309	89.9									
309	94.5									
309	83.6									
310	88.5	1.57	1.77	0.96	1.08	0.10	0.11	1.09	1.23	9.60
310	84.3									
311	89.0									
311	88.9									
311	88.0									
312	92.9									
312	90.7									
313	86.8									
314	88.2	0.97	1.10	1.47	1.67	0.20	0.23	1.69	1.92	7.35
314	90.0									
315	89.0	0.86	0.97	1.11	1.25	0.15	0.17	1.26	1.42	7.40
315	85.5									
315	95.6	0.25	0.26	1.16	1.21	0.41	0.43	1.54	1.61	2.83
315	80.6									
315	81.8									
316	74.4	1.33	1.79	0.61	0.82	0.32	0.43	0.95	1.28	1.91
318	82.7									
319	85.3									
320	88.3									
320	91.6	0.73	0.80	1.48	1.62	0.17	0.19	1.63	1.78	8.71
321	101.1									
321	99.0	0.82	0.83	1.64	1.66	0.18	0.18	1.79	1.81	9.11
322	88.2									
323	87.1									
323	100.5									
323	91.5									
324	86.7									
324	98.4									

Table 1. (Continued)

Length (mm)	Weight (g)	Stomach Contents (g)	% BW of Stom. Cont.	Stomach Tissue (g)	% BW of Stom. Tiss.	Intestine Tissue (g)	% BW of Intest. Tiss.	Empty Digestive Tract (g)	% BW of Empty Digest. Tract	Stomach Tissue (g) / Intestine Tissue (g)
324	90.1									
324	105.6									
324	111.7									
325	97.3									
325	122.0	0.16	0.13	0.98	0.80	0.14	0.11	1.15	0.94	7.00
325	89.7	1.07	1.19	0.83	0.93	0.12	0.13	1.00	1.11	6.92
325	97.2	2.16	2.22	0.74	0.76	0.30	0.31	0.99	1.02	2.47
325	116.8	1.14	0.98	1.74	1.50	0.24	0.21	1.98	1.70	7.25
326	105.1									
326	97.3	0.30	0.31	1.37	1.41	0.13	0.13	1.53	1.57	10.54
327	112.2	0.28	0.25	2.25	2.01	0.18	0.16	2.40	2.14	12.50
327	104.4	0.28	0.27	1.32	1.26	0.18	0.17	1.50	1.44	7.33
327	113.6									
327	106.7									
329	95.9									
329	106.6	0.74	0.69							
329	111.0									
330	104.0									
330	69.5									
331	83.3	0.48	0.58	1.66	1.99	0.22	0.26	1.87	2.24	7.55
332	109.4	0.42	0.38	1.97	1.81	0.25	0.23	2.20	2.02	7.88
332	110.1									
332	96.7	0.48	0.50	1.67	1.73	0.36	0.37	2.03	2.10	4.64
334	84.0	0.55	0.65	1.64	1.95	0.24	0.29	1.81	2.15	6.83
334	91.9	2.95	3.21	1.04	1.13	0.41	0.45	1.37	1.49	2.54
334	109.3	0.96	0.88	1.68	1.54	0.27	0.25	1.87	1.71	6.22
334	112.3	0.54	0.48	1.87	1.67	0.21	0.19	2.02	1.80	8.90
334	78.5	0.70	0.89	1.38	1.76	0.21	0.27	1.56	1.99	6.57
338	115.1									
341	137.3	1.22	0.89	1.75	1.26	0.46	0.34	2.17	1.58	3.76
344	116.2	0.46	0.40	1.60	1.38	0.21	0.18	1.78	1.53	7.62
347	111.9									
356	132.9	0.11	0.08	2.00	1.50	0.18	0.14	2.15	1.62	11.11
368	172.1	1.21	0.70	2.55	1.48	0.30	0.17	2.88	1.67	8.50
393	157.3	0.56	0.36	2.39	1.52	0.60	0.38	2.95	1.86	3.98

Table 2. Stomach contents of various size Atlantic saury caught at night in surface waters off the southwestern edge of Georges Bank in November 1981.

	Length Category (mm)							
	≤315 mm		316-330 mm		≥331 mm		Total	
Stomach contents	% occurrence	% weight	% occurrence	% weight	% occurrence	% weight	% occurrence	% weight
Crustacea[1]	25	39.8	42	35.1	67	71.0	40.2	45.6
Animal remains[2]	58	60.2	83	64.9	50	29.0	66.4	54.4
Number of fish examined	12		12		6		30	
Number of empty stomachs	2		0		0		2	
Mean stomach content weight (g)	0.35		0.80		0.81		0.70	
Mean fish FL (mm)	303		324		340		319	

1 Tentatively identified as Euphausiacea

2 Tentatively identified as Siphonophora

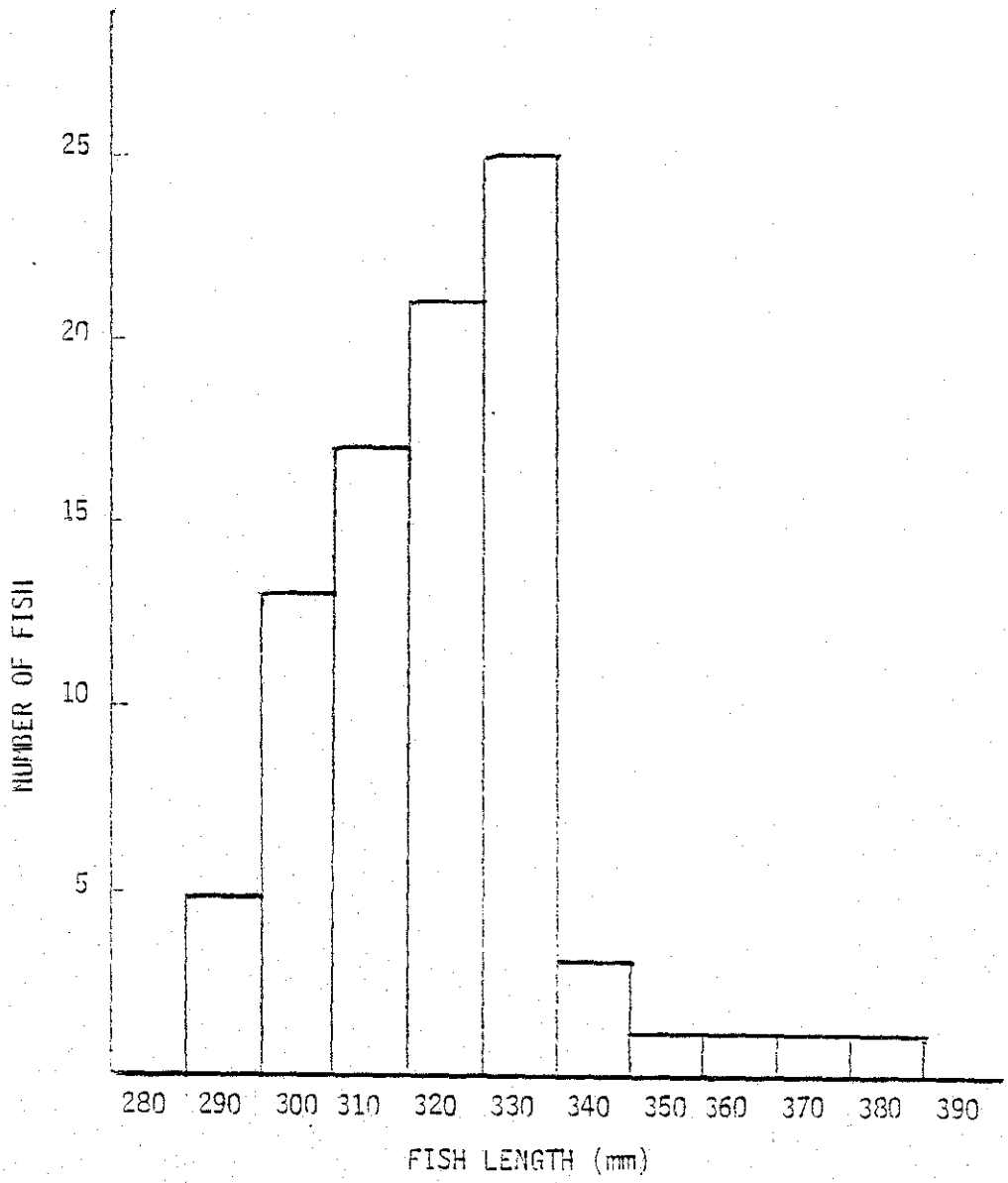

Figure 1. Length frequency of Atlantic saury caught on the night of November 11, 1981, while towing pelagic trawls from the Soviet R/V BUGOSLAV.

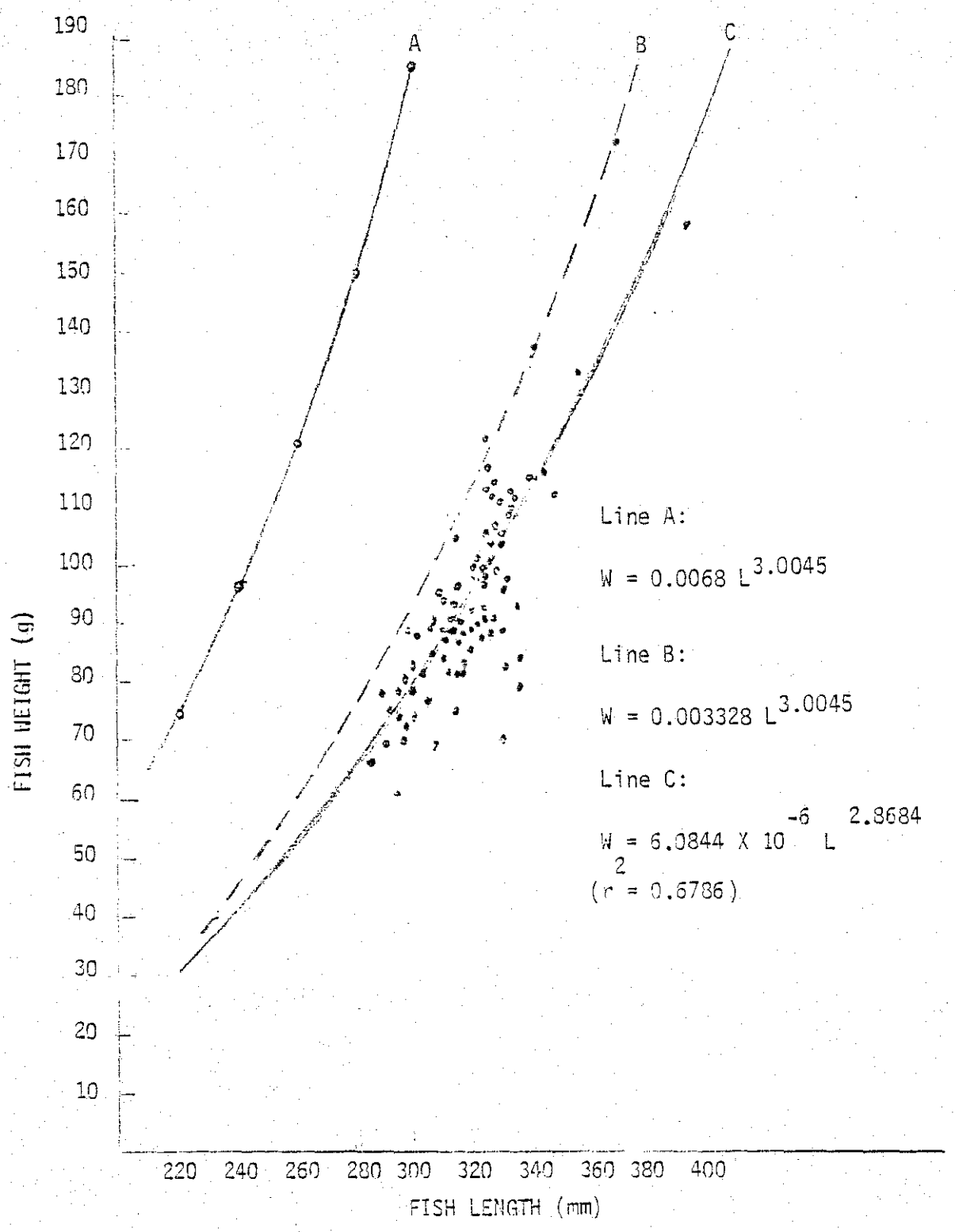

Figure 2. Regression lines, for length-weight relationship of Atlantic saury, determined by American and Soviet scientists. Line A from Dudnik et al., 1980 (likely an error in the calculation of this line - see text). Line B from Dudnik et al., 1981. Line C from authors (including individual points for each fish).

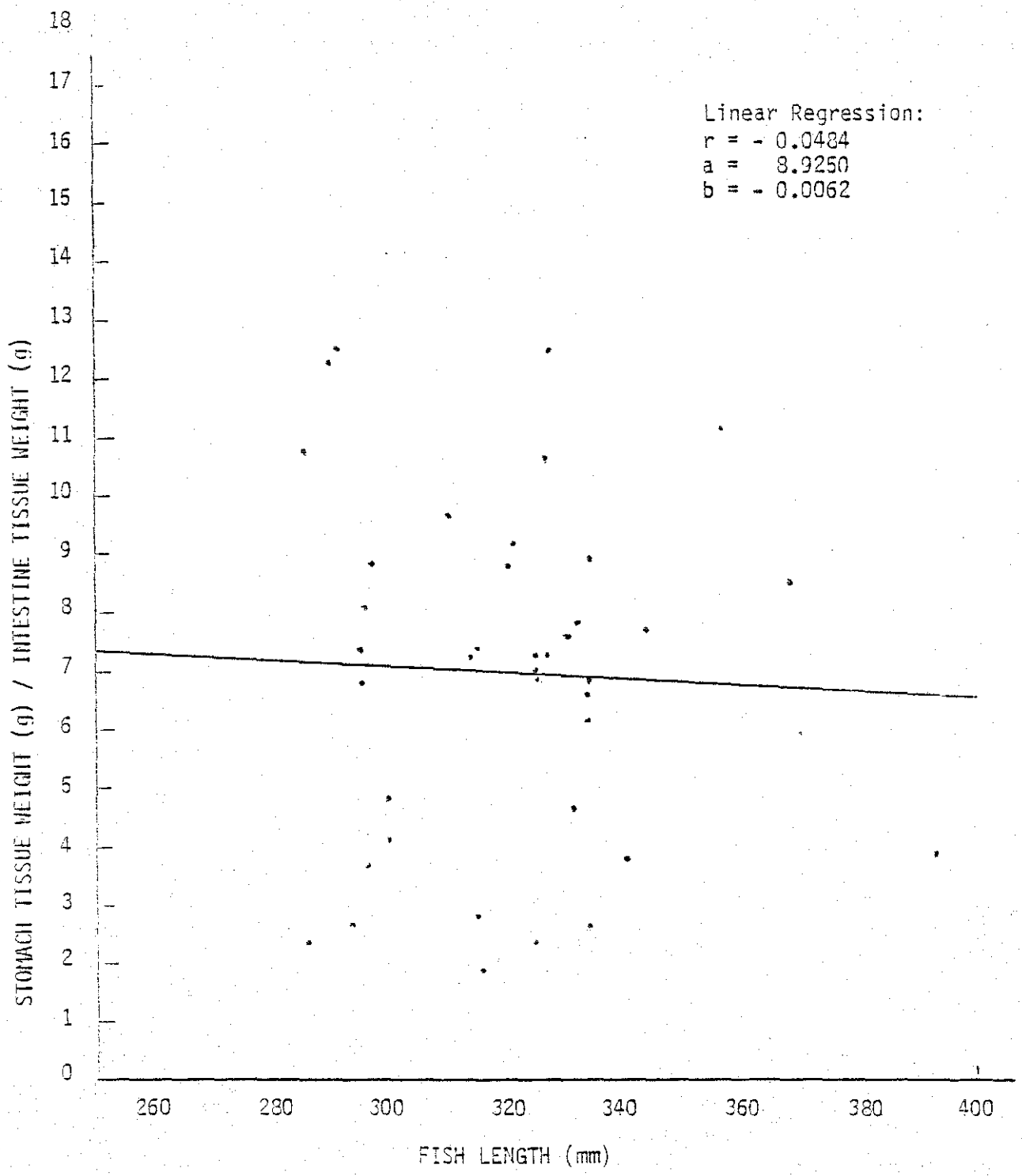

Figure 3. Stomach tissue weight divided by intestine tissue weight plotted against fish length for 39 Atlantic saury caught in surface waters off the southwestern edge of Georges Bank in November 1981. Linear regression of the data is of the form $y = ax + b$.

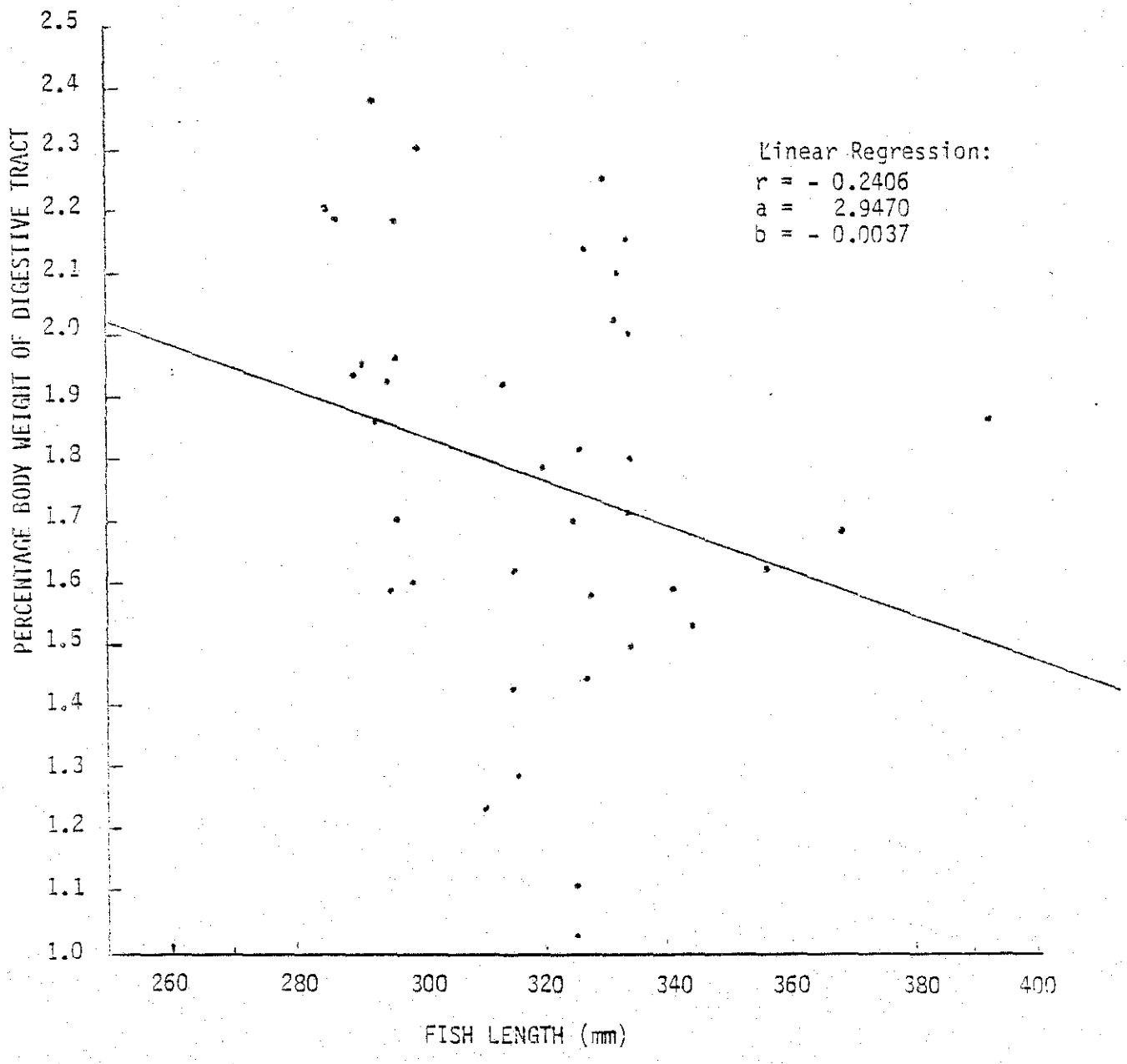

Figure 4. Regression of precentage body weight or digestive tract weight to fish length for 39 Atlantic saury caught in surface waters of southern Georges Bank in November 1981. Regression is of the form y = ax + b.

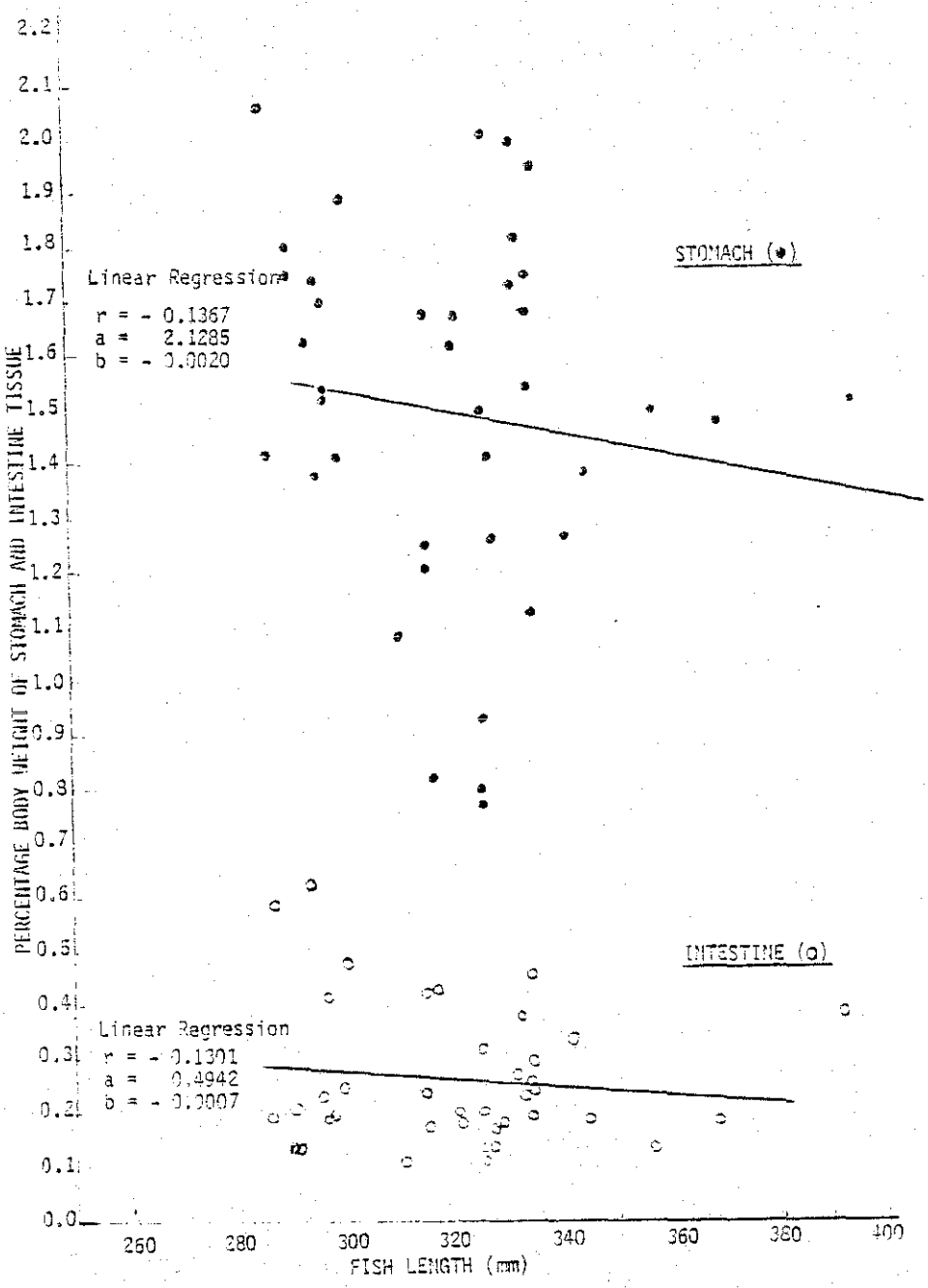

Figure 5. Linear regression of percentage body weight of both stomach tissue weight and intestine tissue weight to fish length for Atlantic saury collected from waters of southern Georges Bank in November 1981.

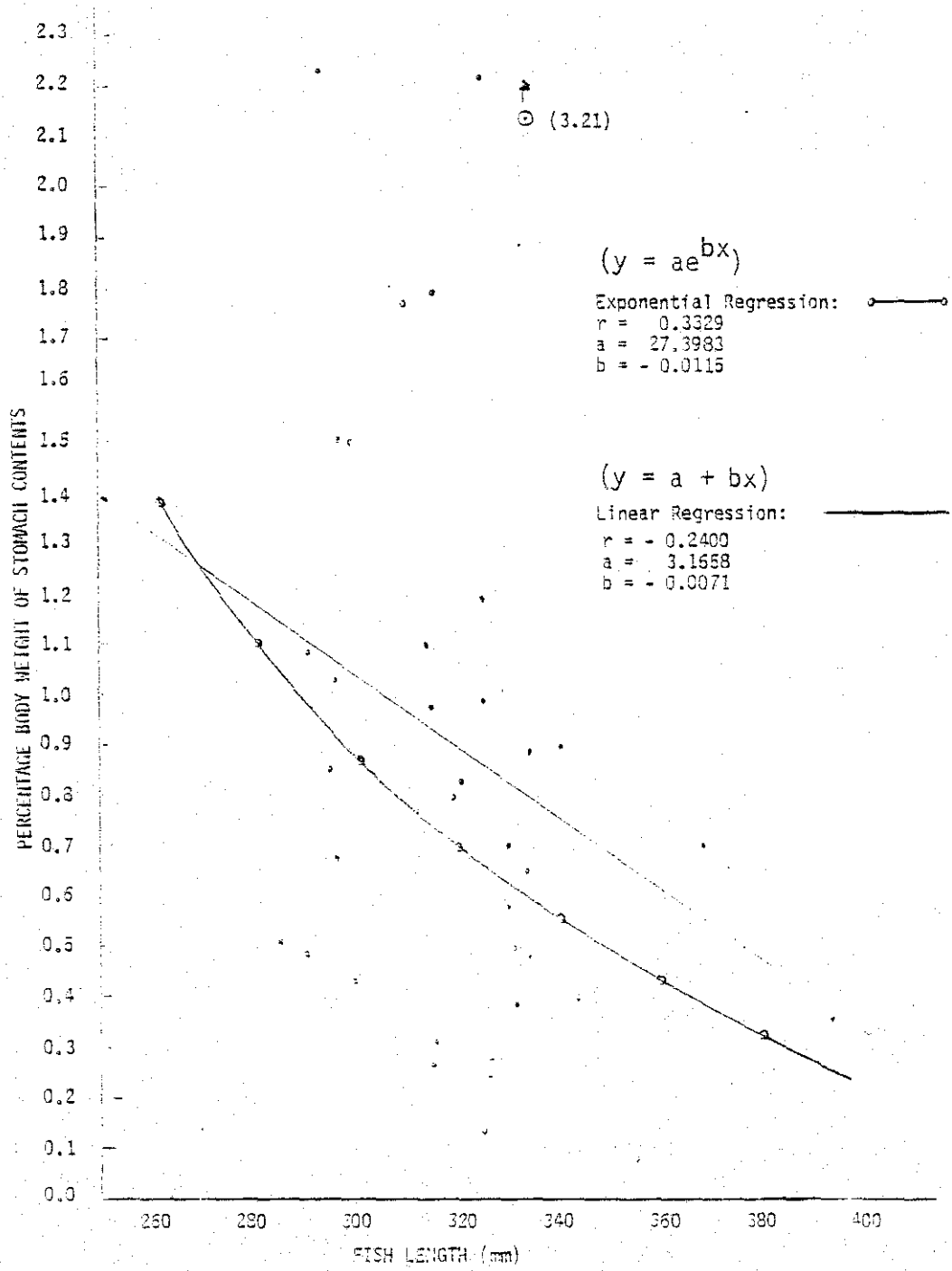

Figure 6. Exponential and linear regressions of percentage body weight of stomach contents of Atlantic saury to fish length. Note that the r value of the exponential regression is higher than the r value of the linear regression.

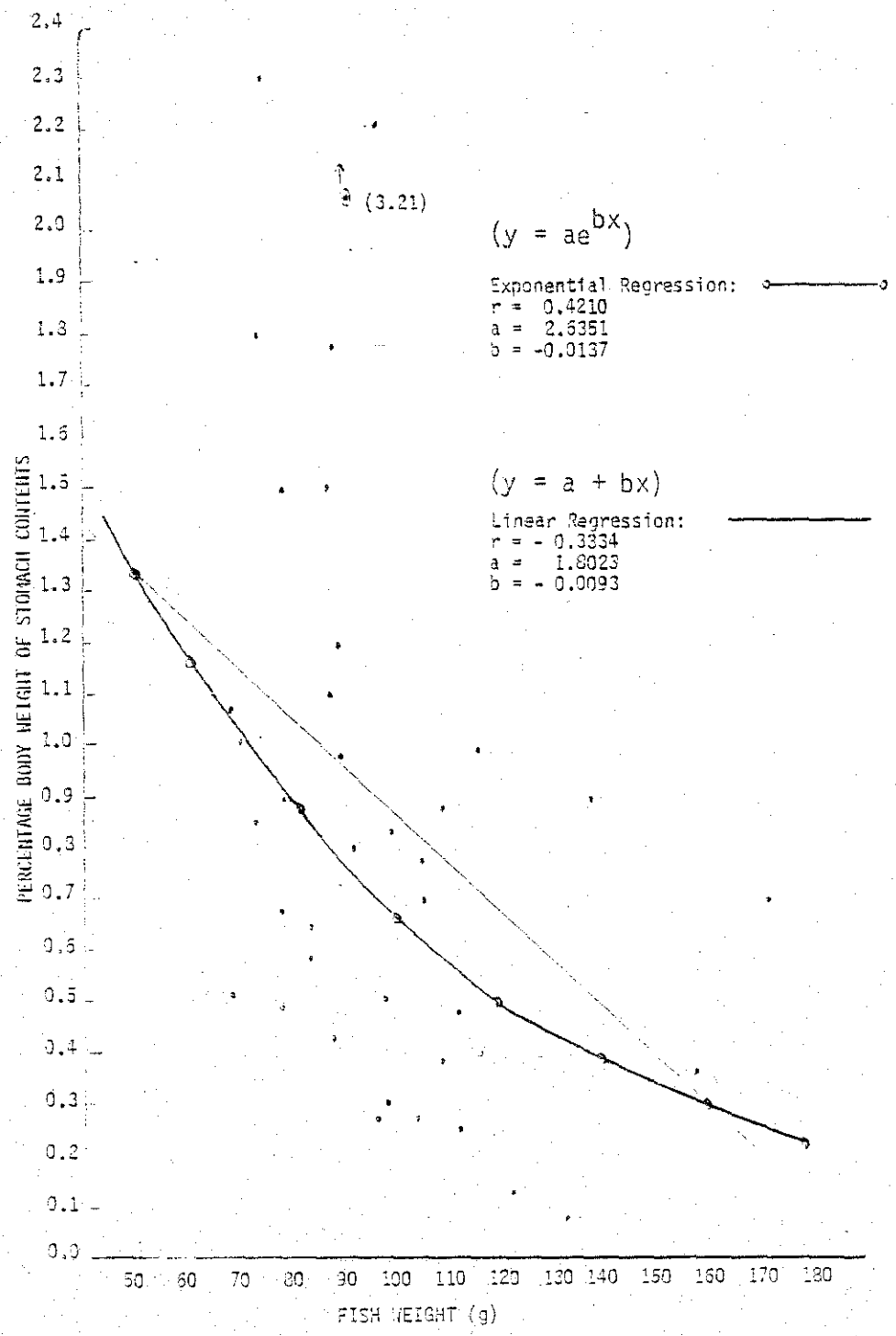

Figure 7. Exponential and linear regressions of percentage body weight of stomach contents of Atlantic saury to fish body weight. Note that the r value of the exponential regression is higher than the r value of the linear regression.