Northwest Atlantic Fisheries Organization

Serial No. N828

NAFO SCR Doc. 84/VI/43

SCIENTIFIC COUNCIL MEETING - JUNE 1984

Fat Content in Muscles, Gonads and Liver of Silver Hake, *Merluccius bilinearis* (Mitchill) and Red Hake, *Urophycis chuss* (Walbaum) Caught on the Shelf of Southern New England (Hudson Canyon) in the End of Winter

by

V. I. Vinogradov

Atlantic Research Institute of Marine Fisheries and Oceanography (AtlantNIRO)
5 Dmitry Donskoy Street, Kaliningrad, 236000, USSR

Abstract

Fat content in muscles and gonads of silver hake and red hake is low and relatively constant. Any indication of fat content in the entire fish organism can be given by the amount of fat in the liver, which is fat depot for these species. Since fat content in the organism is proportional to liver weight, the latter may be used for calculation of fat content in the organism, which is especially useful for field investigations. Fat reserves in the fish organism can be estimated using formulas $y = 0.54x - 0.50$ for silver hake, and $y = 0.35x - 0.09$ for red hake, where y is fat reserve and x is liver weight.

Introduction

Among major factors that characterize food supply for fish throughout their yearly life cycle are fatness and condition factor. The fish belonging to different systematic groups accumulate fat in different organs. In Cyprinidae, Clupeidae and Pleuronectidae fat accumulates in hypodermic tissue, muscles and on the intestine. For Macruridae and Gadidae the liver serves as fat depot (Podrazhanskaya, Yarzhombek, 1970; Shevchenko, 1971). However fat content in different parts of the fish body is subject to considerable fluctuations due to biological condition, age and sex of the fish, season, state of food resources and other environmental features (Shulman, 1960;

Minder, Khobotilova, 1966; Maslennikova, 1966). The availability of fat reserves in the body of the fish varies during the year depending on functional peculiarities of the organism, which manifest themselves in one or another time period of the life cycle. Hence, there exists a close agreement between the fat accumulation rate, as one of the major indices of physiological condition of the fish after wintering, and the strength of the spring spawning migrations, maturation rate and the quantity and quality of sex cells. The present paper is aimed at calculation of rates of fat accumulation in muscles, gonads and liver of silver and red hakes during pre-spawning migrations. Based on actual data a fat content to liver weight ratio was determined for these fish, since in Gadoids all physiological processes affect the liver above all (Minder and Minder, 1967). The results are given as formulas suitable for calculation of total fat content in the organism, which is especially useful for field investigations (Shubnikov, 1962).

Materials and Methods

Samples of muscles, gonads and liver, and the morphometric data for silver and red hakes caught simultaneously in March 1978 in the Hudson Canyon area on the shelf of Mid-Atlantic US states at the 120 m depth were used for the study. The fish was represented by the individuals at maturity stages I-III and some immature silver hake specimens.

Batches (2 g) of raw defrosted tissues of muscles, gonads and liver (Lapin, Chernova, 1970) were carefully ground together with anhydrous sodium sulfate and thoroughly washed by ethyl ether on sterile cotton filters using the express-method according to GOST 13893-68 and the method by Krivobok and Tarkovskaya (1962). 57 silver hake and 42 red hake specimens were processed.

The variational statistics method (Plokhinsky, 1970) was applied to analyse the data for fat content in raw tissues of liver (%) and the weight of liver (% of gutted fish weight).

Relative weight of liver multiplied by its fat content gave the value of fat reserve in liver (% of gutted fish weight).

Results

As reported by Minder and Khobotilova (1966), fatness of muscle tissues of the Northwest Atlantic silver hake is 2.6% on the average ranging from 1.2 to 4.1%. Our data (table 1) showed that fatness of silver hake muscles fluctuated between 0.4 and 1.9% which constituted 0.8% on the average. With the growth of the body length fat content in male and female muscles increases from 0.8 to 1.1% and from 0.7 to 0.9% respectively, which can be explained by earlier maturation of males. As is evident from the data presented in table 1, the fluctuations of fatness of silver hake muscles as well as variation of its values for males, females and immature specimens, are insignificant and remain more or less constant during the year, as is the case with the Baltic cod (Maslennikova, 1966) and silver hake (Minder, Khobotilova, 1966).

Like in silver hake, fat content in red hake muscles fluctuates from 0.4 to 1.7% with the mean value of 0.8% (table 1).

Fat content in silver hake gonads fluctuates from 0.3 to 14.3% and makes up 3.5% on the average. Fat content in male gonads somewhat exceeds that in females and decreases in both males and females with the growth of the body length. Mean fat content decreases almost two times with the increase of relative weight of gonads from 0.1 to 3.3% (table 2). Although the gonads are not fully developed in March, the mean value of fat content given in % of the gutted fish weight increases with the increase of the relative weight of gonads. Absolute values of fat content are low and range between 0.01 to 0.1%.

Fat content in red hake gonads is considerably lower, comprising 1.6% on the average and fluctuating from 0.3 to 4.6% (table 2). Mean fat content decreases almost twice with the increase of relative weight of gonads from 0.2 to 2.5%.

Conversely, fat content given in % of the gutted fish weight increases from 0.01 to 0.4% with the increase of the relative weight of gonads. Although there is no indication of the increase of fat content in male or female gonads with the growth of the body length, it is twice as high in males as in females, which can be attributed to earlier maturation of males. These comparisons suggest that, in all likelihood, the process of slow accumulation of fat in gonads of both silver and red hake parallels the process of maturation, for which fat requirements are beyond doubt.

The liver of silver hake and the other Gadidae contains 24.7% of fat on the average (1.7-78.7%) (table 1). Considerable fluctuations of fat content in liver are caused by numerous factors. Apart from individual differences, variations in age and sex and feeding conditions in different parts of the sea in winter are very important. Since, in Gadidae, all physiological processes affect the liver above all, the studies are focused on this organ. Relative weight of liver is linearly related to its fat content, and both absolute and relative fat content (% of gutted fish weight for both species) increase with the increase of the liver weight. Table 3 contains mean values and ranges of absolute and relative fat content in liver for silver and red hakes.

The data presented in table 4 indicate a positive correlation between the weight and fat content in silver and red hake liver and the value of the fat reserve in liver (correlation factors were 0.94 and 0.86 respectively for silver hake, and 0.82 and 0.77 for red hake).

The analysis of regression of the liver fat reserve value relative to the weight and fat content of the liver showed that a dependence between these values can be described by equations of straight line ($y = Ax + B$) for regression by weight, by exponentional function ($y = AB^{x1}$) for regression by fat content for silver hake, and by logarithmic function

($y = A + B \lg X_2$) for regression by fat content for red hake, where y is the fat reserve value, x is the weight of liver; x_1 is fat content in silver hake liver, X_2 is fat content in red hake liver, and A and B are regression factors. The analysis of regression of the fat reserve value by fat content in liver separately for males and females, and for males and females combined showed that for red hake both the logarithmic dependence and high correlation factors have approximately one small error; a power dependence for silver hake males and exponential functions for males and females combined and separately for females also have a small error. Evidently, in March, fat accumulates in livers of red hake males and females evenly, and in silver hake males more slowly than in females.

Due to low and relatively constant fat content in the other organs and tissues of silver hake (to 4%) and red hake (to 1%) (Minder, Khobotilova, 1966; Kleimenov, 1971), fat content in the entire fish organism can be determined from the liver weight.

It should be noted that the relative liver weight and its fat content are subject to large fluctuations and depend on feeding conditions. However the comparison of mean values showed distinctly that the liver weight and its fat content are linearly related to the age of the fish, and to fat content in liver and the relative weight of the latter. Therefore utilization of the concept of the relative weight of liver for characteristic of fatness of these Gadoid species is well-grounded.

From the above-stated it follows that the liver weight and its fat content in silver and red hakes are accurate enough indices for evaluation of fat reserve in the organism, which can be calculated from the presented formulae summed with the fat content values for the other organs and tissues.

Conclusions

1. In March fat content in silver hake muscles fluctuates from 0.4 to 1.9% and constitutes 0.8% on the average. Compared with females, fat content in male muscles increases more marked-

ly with the growth of the body length.

2. In the same period fat content in red hake muscles fluctuates from 0.4 to 1.7% and constitutes 0.8% on the average.

3. Fat content in silver and red hake gonads is on the average 3.5% and 1.6% respectively.

4. Fat content in per cent of the gutted fish weight increases with the increase of the relative weight of gonads from 0.01 to 0.1 for silver hake, and from 0.01 to 0.04 for red hake.

5. Relative weight of liver is linearly related to its fat content, which indicates that both the absolute and relative fat content (in % of gutted fish weight) increase with the increase of liver weight in both species.

6. Due to low and relatively constant fat content in the other organs and tissues of silver and red hakes, fat content in the entire fish organism can be determined from the weight of liver and calculated from the formulae:

$y = 0.54x - 0.50$ for silver hake,

and $y = 0.35x - 0.09$ for red hake,

where x is weight of liver.

References

KLEIMENOV I.YA., 1971. Food value of the fish. M., "Pishchevaya promyshlennost", p. 1-150.

KRIVOBOK M.N., TARKOVSKAYA V.I., 1962. Determination of fat content in the fish body. In Coll.: "Manual for the methods of investigation of fish physiology", M. Edit. Acad. of Sci. USSR, p. 134-142.

LAPIN V.I., CHERNOVA E.G., 1980. On the methods for extraction of fat from raw fish tissues. "Voprosy ikhtiologii", vol. 10, iss. 4(63), p. 753-761.

MASLENNIKOVA N.B., 1966. Fat content in flesh, eggs and liver of the Baltic cod at different developmental stages. Coll. of scientific-technological information of VNIRO, vol. 12, p. 78-82.

Methods for determination of fat content. GOST 13893-68. 1972. Fish, fish products and supplementary materials. GOST USSR, M. Edit. of standards, p. 268-275.

MINDER L.P., MINDER R.A., 1967. Food and technological value of some gadoid fishes. Trudy of PINRO, iss. 22, p. 39-109.

MINDER R.A.,, KHOBOTILOVA L.D., 1964. Technochemical characteristic of new fishery objects. "Rybnoe khoziaistvo", N 10, p. 65-68.

MINDER R.A., KHOBOTILOVA L.D., 1966. Weight and chemical composition of some commercial fishes of the Northwest Atlantic and Barents Sea. Trudy of PINRO, iss. 18, p. 83-145.

PLOKHINSKY N.A., 1970. The biometry. M. Edit. MGU (Moscow St. Univers.). 367 p.

PODRAZHANSKAYA S.G., YARZHOMBEK A.A., 1970. Weight of the Baltic cod and Atlantic grenadier liver as an index of fat content in the organism. Trans. of young scientists of VNIRO, iss. 4, p. 88-90.

SHEVCHENKO V.V., 1971. On dynamics of fat accumulation and growth of the North Sea haddock during the spring-summer period. Trans. of young scientists of VNIRO, iss. 87(7), p. 163-170.

SHUBNIKOV D.A., 1962. Methods for determination of fat content in field. Coll. "Manual for methods of investigation of fish physiology". M. Edit. Acad. of Sci. USSR, p. 143-146.

SHULMAN G.E., 1960. The dynamics of fat content in the fish body. Successes of modern biology. Iss. 49, 2, p. 225-239.

Table 1 Fat content in muscles, gonads and liver of males and females of silver and red hake of varying size in the southern New England (March 1978)

Length of fish, cm	Sex	Fat content in liver, %	Fat content in liver, % of gutted fish weight	Fat content in gonads, %	Fat content in gonads, % of gutted fish weight	Fat content in muscles, %	No. of analysis
				Silver hake			
21-25	juvenile	4.0-24.6*	0.02-0.43	-	-	0.7-1.4	6
		8.2	0.10			0.9	
	males	4.5-13.2	0.05-0.13	2.8-14.3	0.006-0.017	0.5-1.0	5
22-25		7.7	0.08	7.7	0.012	0.8	
	females	2.8-78.7	0.03-1.11	1.8-9.1	0.006-0.034	0.5-1.1	9
		16.0	0.21	4.8	0.020	0.7	
	males	1.7-47.3	0.01-1.78	1.0-13.3	0.002-0.096	0.5-1.3	11
26-35		29.8	0.76	3.2	0.025	0.8	
	females	5.0-42.0	0.05-2.30	0.3-4.3	0.004-0.036	0.5-1.5	9
		20.7	0.56	2.1	0.018	0.7	

Table 1 (continued)

Length of fish, cm	Sex	Fat content in liver, %	Fat content in liver, % of gutted fish weight	Fat content in gonads, %	Fat content in gonads, % of gutted fish weight	Fat content in muscles, %	No. of analysis
36-55	males	36.3-45.1 40.7	1.07-1.83 1.45	1.4 - 2.5 2.0	0.039-0.072 0.056	0.9-1.3 1.1	2
	females	19.8-53.8 38.6	0.40-2.61 1.56	0.9-5.8 2.6	0.010-0.123 0.047	0.4-1.9 0.9	15
				Red hake			
30-35	males	19.1-39.2 28.4	0.29-1.36 0.66	0.6-4.6 2.7	0.006-0.050 0.030	0.5-1.4 0.8	10
	females	18.8-47.0 29.8	0.07-1.14 0.70	0.5-4.1 1.2	0.003-0.032 0.011	0.4-1.6 0.8	17
36-45	males	36.3	1.19	2.6	0.033	1.7	1
	females	8.8-47.0 31.6	0.09-1.50 0.89	0.3-2.6 0.9	0.004-0.024 0.010	0.4-1.4 0.7	14

* in numerator - range (from - to); in denominator - mean value

Table 2 Fat content in gonads of silver and red hake depending on their relative weight

Relative weight of gonads, %	0.09-0.50	0.19-0.50	0.51-1.00		1.01-1.50	
	1*	2*	1	2	1	2
Fat content in gonads, %	1.7-14.3** / 5.4	1.2-4.6 / 3.0	1.3-9.1 / 3.2	0.4-4.1 / 1.6	0.3-4.0 / 2.2	0.3-3.9 / 1.6
Fat content in gonads in % of gutted fish weight	0.02-0.034 / 0.013	0.003-0.015 / 0.008	0.008-0.057 / 0.022	0.004-0.032 / 0.012	0.004-0.052 / 0.027	0.004-0.050 / 0.020
No. of analysis	17	3	10	17	10	17

Relative weight of gonads, %	1.51-2.00		2.01-2.50		2.51-3.00	3.01-3.30
	1*	2*	1	2	1	1
Fat content in gonads, %	1.0-4.5 / 2.1	0.9-3.3 / 2.2	1.0-5.8 / 2.6	1.3-2.2 / 1.8	1.0-4.2 / 2.4	2.9
Fat content in gonads in % of gutted fish weight	0.017-0.088 / 0.038	0.014-0.050 / 0.034	0.022-0.123 / 0.057	0.032-0.044 / 0.038	0.025-0.117 / 0.068	0.096
No. of analysis	5	3	3	2	5	1

Note: 1* - silver hake; 2* - red hake

** in numerator - range (from - to)
in denominator - mean value

Table 3 Fat content in liver of silver and red hake depending on its relative weight

Relative weight, %	0.43-1.00	0.35	1.01-2.00		2.01-3.00	
	1*	2*	1	2	1	2
Fat content in liver, %	1.7-10.3** / 6.4	21.0	2.8-78.7 / 15.5	8.8-34.1 / 24.3	5.0-39.4 / 28.5	18.8-47.0 / 31.2
Fat content in liver in % of gutted fish weight	0.01-0.09 / 0.05	0.07	0.03-1.11 / 0.22	0.09-0.64 / 0.42	0.12-1.08 / 0.59	0.41-1.13 / 0.75
No, of analysis	8	1	20	8	12	24

Relative weight, %	3.01-4.00		4.01-5.00		5.01-5.48
	1*	2*	1	2	1
Fat content in liver, %	21.6-47.3 / 36.8	32.2-41.6 / 38.6	40.0-53.8 / 47.1	22.6-33.5 / 28.1	42.0-48.7 / 45.5
Fat content in liver in % of gutted fish weight	0.65-1.78 / 1.32	0.98-1.50 / 1.18	1.82-2.61 / 2.10	1.09-1.36 / 1.22	2.30-2.53 / 2.37
No. of analysis	9	7	5	2	3

Note: 1* - silver hake; 2* - red hake

** in numerator - range (from - to)
in denominator - mean value

Table 4

Indices of fat content in liver	Silver hake	Red hake
Weight of liver in % of gutted fish weight	0.43-5.48* / 2.34	0.35-4.82 / 2.46
Fat content in % of liver weight (fatness)	1.7-78.7 / 24.7	8.8-47.0 / 30.2
Fat content in % of gutted fish weight (fat reserve)	0.01-2.61 / 0.75	0.07-1.50 / 0.76
Correlation between liver weight and fat reserve	0.94 ± 0.01	0.82 ± 0.03
Correlation between fat content in liver and fat reserve value	0.86 ± 0.02	0.77 ± 0.04
Regression of fat reserve value by weight	$y = 0.54\ x - 0.50$	$y = 0.35\ x - 0.09$
Regression of fat reserve value by fat content	$y = 0.05 \cdot 1.1^x$	$y = 1.9\ \lg x - 2.0$
No. of examined specimens	57	42

Note: * in numerator - range (from - to)
in denominator - mean value