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FAT LEVEL IN BODY OF JUVENILE ATLANTIC SALMON (*Salmo salar* L.), AND SEA TROUT (*Salmo trutta m. trutta* L.), AND METHOD OF ESTIMATION FROM MORPHOMETRIC DATA

Piotr Dębowski, Stefan Dobosz*, Stanisław Robak*, Zygmunt Usydus***

*The Stanisław Sakowicz Inland Fisheries Institute in Olsztyn
**Marine Fisheries Institute in Gdynia

ABSTRACT. Average fat levels in one and two years old sea trout (*Salmo trutta m. trutta* L.) and two years old Atlantic salmon (*S. salar* L.) measured in May were similar, about 9% of fresh weight. One year old salmon showed higher fat content – about 11%. Fat level and fish measurements: body length, weight, and depth correlated, and so did fat level and morphometric data. Equations of multiple regression explained 66-99% of fat content variation.

Key words: SALMON, SEA TROUT, ESTIMATION OF FAT LEVEL

INTRODUCTION

Body fat content is a measure of energetic resources in fish. Low fat content in salmonid parr may result in high mortality, especially in winter (Gardiner, Geddes 1980). Also successful fish maturation depends, among other, on body fat content. Low fat level may inhibit maturation of salmon parr males (Rowe, Thorpe 1990), and fish showing earlier fat level increase in spring are more likely to reach maturation in autumn (Rowe et al. 1991). Thus, development of non-destructive method of body fat level estimation would be useful for predicting sexual maturation of fish in a given year. This could be of great importance for the fishery practice.

The only non-destructive and simple method was developed by Simpson et al. (1992), who found relationships between body fat level and simple body measures in Atlantic salmon (*Salmo salar* L.) parr. The relationships explained 40-94% of fat level variation in fish of different size, and in different seasons. Testing such relationships for various morphometric data sets for hatchery-reared Atlantic salmon and sea trout juveniles was the aim of the present study.

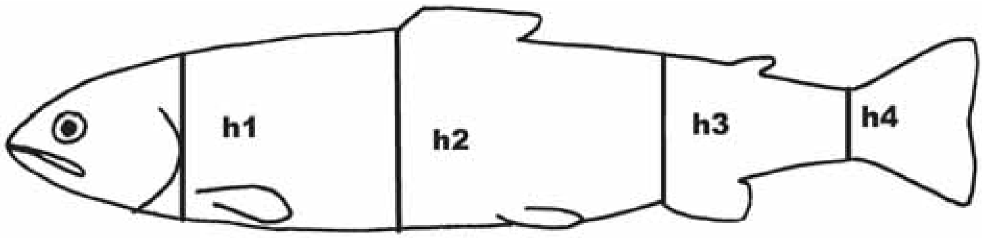

Fig. 1. Fish body heights.

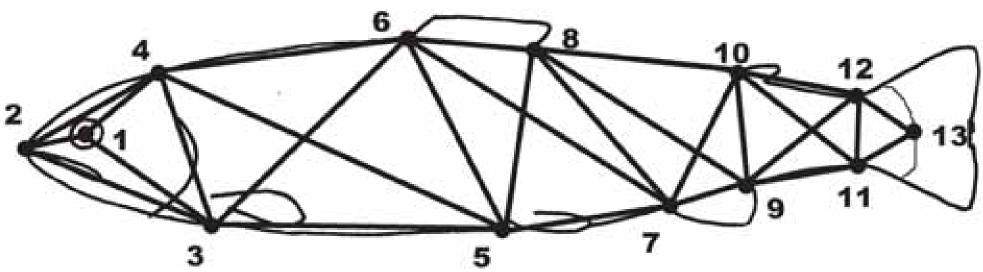

Fig. 2. Truss network.

MATERIAL AND METHODS

One and two years old salmon from Świerzenko Hatchery (Aquamar), and sea trout at the same age from the Dept. of Salmonid Fish Breeding of Inland Fishery Institute in Rutki were used in the experiment. All fish were fed the same commercial feed of increasing fat content 17-20%. The measurements were done on May 15 (salmon), and May 6 (sea trout) 1997. The fish were killed, weighed and filmed using a video camera. The picture was then reproduced on a computer screen, and the fish were measured using image analysis system MultiScan (Dębowski et al. 1998). Two series of measurements were performed – one including simple measurements, such as caudal body length (L), and four heights (h1, h2, h3, h4) (Fig. 1), and another one including so-called truss network (Winans 1984), modified by Dębowski et al. (1998) (Fig. 2). The data of the first series were expressed as the height-length ratio in order to skip fish body length variation. The data obtained using truss network were standardised according to the formula (Karakousis et al. 1993):

$$S = lnY - \beta\ (lnL - lnL_m)$$

where:
S – standardised measurement,
Y – crude measurement,
β – regression coefficient of lnY and lnL,
L – caudal fish body length,
L_m – average fish length in each group.

Fulton's fish condition coefficient was also calculated according to the formula:

$$CF = W \cdot L^{-3}$$

where:
W – fish body weight.

In order to evaluate body fat content, the fish were minced and dried at 60°C for 3 days. Fat was extracted with petroleum ether according to Soxleth's method. The results were expressed as percentage of fresh fish body weight.

Stepwise regression analysis was applied to determine fat content (F) versus caudal length (L), weight (W), and the four heights (H1, H2, H3, and H4, where Hi = hi * L^{-1}) for the first data series, and for F versus L, and standardised Si, j distances (where i, j – points in Fig. 2) for the second series.

RESULTS AND DISCUSSION

Basic fish characteristics are shown in Tab. 1. Condition coefficient of two years old trout was significantly ($p<0.05$) higher compared to one year old fish. No such difference was observed in salmon. Fat level in both year-classes of trout, and in two years old salmon was very similar, and reached about 9%. Fat content in one year old salmon was significantly higher ($p<0.01$), and exceeded 11% of fresh weight.

TABLE 1

Characteristics of fish (average values and ranges in parentheses).

Species	Salmon		Trout	
age	1	2	1	2
length (mm) (L)	149 (124 - 168)	199 (164 - 231)	147 (110 - 175)	227 (205 - 256)
weight (g) (W)	41 (22 - 63)	98 (52 - 145)	32 (12 - 55)	125 (83 - 189)
number	15	14	19	10
condition factor (CF)	1.21 (1.11 - 1.34)	1.20 (1.07 - 1.31)	0.96 (0.80 - 1.09)	1.05 (0.89 - 1.25)
fat level (%) (F)	11.2 (6.9 - 15.6)	8.9 (5.7 - 12.8)	9.1 (7.4 - 10.6)	9.1 (6.2 - 11.0)

Fat content in trout and salmon of the two age groups increased with the condition coefficient, and (except two years old salmon) - with fish body length (Tab. 2). Regression equations for the first data series (length, weight, fish body height) explained 77-99% of fat level variation, and allowed highly accurate estimation (Fig. 3), especially if high variability within the sample – from 35 in one year old trout to 80% in two years old salmon - was taken into consideration.

TABLE 2

Relationships between fat level (F) and the first set of measurements (W=weight, CF=condition factor, L=length, H1= relative body height as on Fig. 1)

Age	Salmon	Trout
1	F=-75.346-0.567W+26.921CF+0.517L R^2=0.87; p<0.001	F=-2.724+6.364CF+0.038L R^2=0.77; p<0.001
2	F=-7.393+46.381CF-224.039H1 R^2=0.93; p<0.001	F=-8.390+7.166CF+0.042L R^2=0.99; p<0.001

TABLE 3

Relationships between fat level (F) and the second set of measurements (L=length, $S_{i,j}$=standardised distance between points "i" and "j" on Fig. 2)

Age	Salmon	Trout
1	F=-0.921+0.079L R^2=0.69; p<0.001	F=-106.903+0.039L+28.955$S_{3,6}$-18.994$S_{9,10}$+29.761$S_{10,11}$-13.179$S_{10,12}$ R^2=0.94; p<0.001
2	F=-183.516+47.855$S_{3,6}$ R^2=0.71; p<0.001	F=-156.180+58.658$S_{10,11}$-25.559$S_{10,12}$-21.614$S_{11,12}$+31.433$S_{12,13}$ R^2=0.96; p<0.002

Regression coefficients in the second data series ranged from 0.69 to 0.96 (Tab. 3). One year old salmon showed positive correlation between fat level and body length, and two years old fish – between fat level and point 3 to 6 distance (front part of the body). In trout similar correlations were found for several measures, mainly in the rear part of the body (Fig. 4 b, c), and produced very accurate fat level estimations (Fig. 5).

The relationships obtained allow for a simple and reliable fat content estimation. Their accuracy would be, however, lower for fish from other hatcheries, of other body size, and in other seasons.

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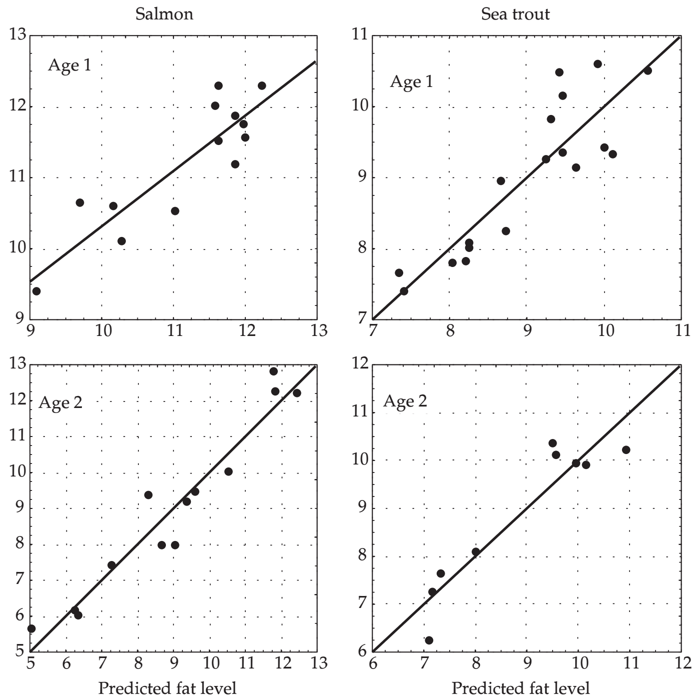

Fig. 3. Relationship between fat contents: observed and predicted using the first data set (Tab. 2).

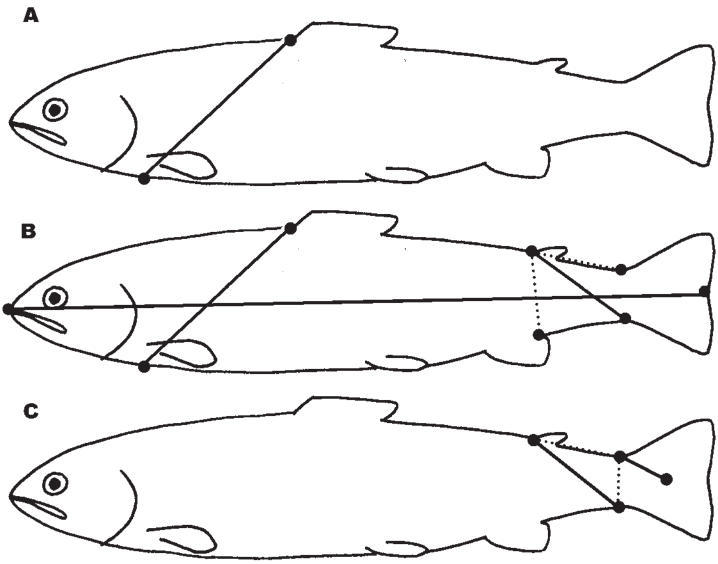

Fig. 4. Measurements correlating with fat level (solid line – positive relationship, broken line – negative relationship), A – two years old salmon, B – one year old trout, C – two years old trout.

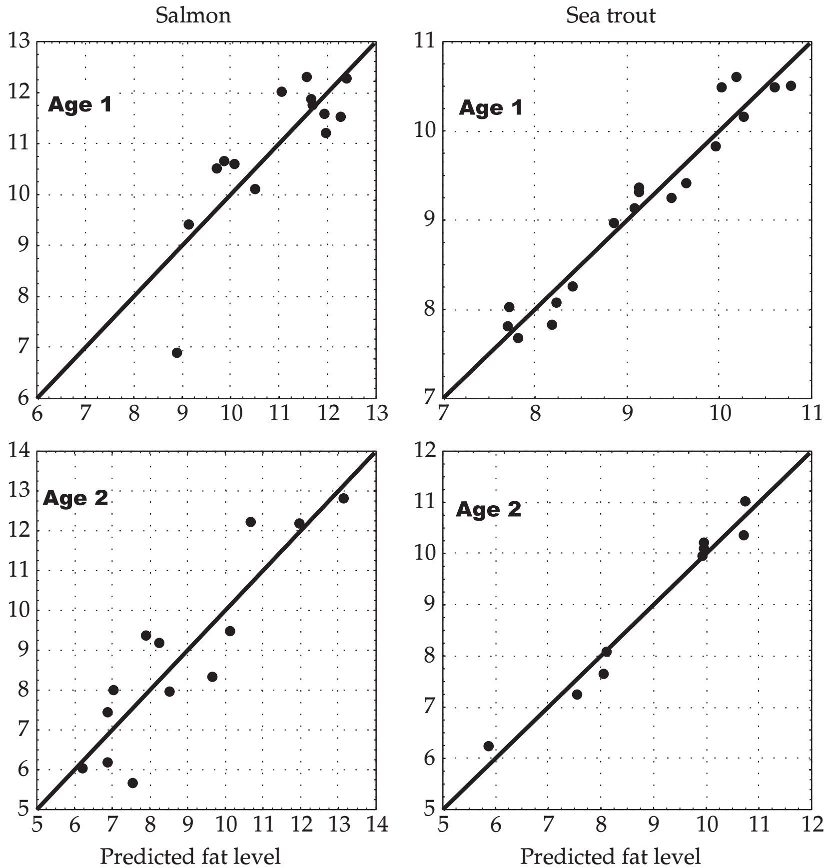

Fig. 5. Relationship between fat contents: observed and predicted using the second data set (Tab. 3).

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STRESZCZENIE

POZIOM TŁUSZCZU W CIELE MŁODOCIANEGO ŁOSOSIA (*Salmo salar* L.) I TROCI (*Salmo trutta m. trutta* L.) ORAZ METODA JEGO SZACOWANIA NA PODSTAWIE DANYCH MORFOMETRYCZNYCH

Średnia zawartość tłuszczu u jedno i dwuletnich troci (*Salmo trutta m. trutta* L.) i dwuletnich łososi (*Salmo salar* L.) w maju była podobna i wynosiła ok. 9% mokrej masy. Więcej tłuszczu miały jednoroczne łososie – ok. 11%. Znaleziono zależności pomiędzy poziomem tłuszczu a prostymi pomiarami ryb: masą, długością i wysokościami ciała (rys. 1, tab. 1), a także między poziomem tłuszczu a pomiarami morfometrycznymi przeprowadzonymi metodą „truss network" (rys. 2, tab. 3) przy zastosowaniu analizy komputerowej obrazów ryb zarejestrowanych kamerą video. Uzyskane równania regresji wielokrotnej wyjaśniały od 69 do 99% zmienności zawartości tłuszczu w ciele ryb. Zaprezentowana metoda może znaleźć praktyczne zastosowanie w przyżyciowej ocenie poziomu zapasów energetycznych u młodocianych ryb obu badanych gatunków.

ADRESY AUTORÓW:

Dr Piotr Dębowski
Pracownia Rybactwa Rzecznego
Instytut Rybactwa Śródlądowego
80-761 Gdańsk, ul. Reduta Żbik 5

Dr Stefan Dobosz
Zakład Hodowli Ryb Łososiowatych Rutki
Instytut Rybactwa Śródlądowego
83-330 Żukowo

Mgr inż. Stanisław Robak
Zakład Ichtiobiologii
Instytut Rybactwa Śródlądowego
10-719 Olsztyn, ul. Oczapowskiego 10

Dr Zygmunt Usydus
Zakład Technologii Przetwórstwa
Morski Instytut Rybacki
81-332 Gdynia, ul. Kołłątaja 1