THE UNIVERSITY OF MANITOBA

PERIODIC CHANGES IN THE CONDITION OF THE ARCTIC CHARR (SALVELINUS ALPINUS) OF THE NAUYUK LAKE SYSTEM

by

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Starvation experiments were conducted on 400-mm hatchery-reared immature charr at temperatures ranging from 1°C to 10°C. No mortalities were recorded in 8 months. Pattern of tissue catabolism changed with temperature. Losses in mass were 7.8% (1°C) and 10.9% (4°C) for 10.4% and 16.8% decreases in total energy content, much less than the 30% loss measured in Nauyuk Lake charr (400-mm length-class). This 30% loss measured in the field is the actual cost of starvation for 400-mm immature charr in a 10-month period. Charr derived 65% of their metabolic needs from lipids and 35% from proteins. The contribution of liver and skeletal muscle to the total loss is discussed. In 1977, the immature charr recovered from that loss in their 2-month summer migration to sea. In June, postspawners contained 35% to 40% less energy than immature charr though maturing charr were in better condition than immature charr 12 months earlier. The smaller the charr, the less the time required to fully recover. In general, the production of gonads drains energy reserves to the extent of preventing charr from maturing 2 years in succession. Medium-size postspawners have the lowest lipid and protein contents (1.4% and 17.6% in June). Medium-size immature charr have the highest contents in fall (11.2% and 22.4%). These values can be as low as 0.5% and 13.6% (700-mm postspawner) and as high as 13.8% and 25.0% (700-mm immature charr in fall). These results and conclusions are discussed in terms of life-history strategies.

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INTRODUCTION

Trends in evolution indicate that natural selection tends to limit fluctuations in plants and animals, hence populations tend towards increasing stability and improved capacity for the acquisition and regulation of energy (Glandsdorff and Prigogine 1971, Van Valen 1976, Johnson 1980 and 1981). Such trends are noticeable during the process of succession (Borman and Likens 1979). Similarly, higher vertebrates have developed thermo-regulatory mechanisms that enable them to withstand the more pronounced fluctuations in temperature experienced on land relative to their original aquatic habitat (Richards 1973).

Thus endotherms maintain their body temperature close to 40°C whereas lower vertebrates generally lose heat to the environment as rapidly as it is produced, therefore maintaining body temperature in equilibrium with the surrounding. This is not universal as tunas are known to maintain body temperatures 10°C above the ambient water due to countercurrent heat exchangers in their circulatory system (Carey and Teal 1969), presumably to facilitate high-speed swimming. As chemical processes are temperature dependent, temperature control allows improved control and regulation of bodily functions.

Fish perceive the heat intensity in their environment. They select suitable temperatures in a temperature gradient (McCauley and Tait 1970). Therefore, temperature fluctuations can induce fish to move to maintain suitable conditions. There are numerous papers in the literature that relate movements of fish and temperature (Templeman and Hodder 1965 for instance).

Suitable temperatures and the range of thermal conditions they can tolerate are not the same for all fish; however, the thermal tolerance range of fish can change within the constraints of their genome. Short term changes in the thermal tolerance range have been referred to as acclimation (Fry 1971). This occurs in fish exposed to a mean temperature that differs from that responsible for setting the present range. The process of acclimatization (Fry 1971) is a seasonal phenomenon that preadapts fish to predictable cycles in temperature. Tolerance to low temperatures becomes resistance to frost in fish that inhabit the polar seas. Those fish decrease the freezing point of their blood thereby lessening the risk of ice crystals formation in their tissues (DeVries 1971, 1976).

There is a positive correlation between heat intensity of the environment and basal metabolic rate (Beamish 1964a for instance), locomotion (Brett et al. 1958, Beamish 1970), and the metabolism of nutrients, from their digestion in the gut to their mobilization from the tissues (summarized by Beamish et al. 1975, see also Elliott 1972, 1975a, b, c, d, 1976). Transfer to low temperatures can also cause fish to switch to alternative pathways for the metabolism of nutrients. Hochachka and Somero (1971) and recently Peres (1979) have summarized the literature. From data on the metabolic rate of polar fish, Scholander et al. (1953) and later Wohlschlag (1960) concluded that the metabolic rate in polar fish was higher than that predicted from the extrapolation to cold temperatures of the curve of metabolic rate versus temperature in tropical fish. That conclusion has been rejected conclusively by Holeton (1974).

Thus, low temperatures tend to limit production of fish through reduction of metabolic rate and locomotion. Similarly, low temperatures limit the production of resources. Natural selection fixes the proportion of resources fish can divert to maintenance and production of gonads by controlling the frequency of maturation, the number of young, their size, and the interaction between mortality and production of gonads for instance. Cole (1954) demonstrated how those individual traits bear on the rate of natural increase. Individual traits are interrelated. They are the reproductive tactics that populations need to face particular environmental conditions (summarized by Stearns 1976, 1980). Provided these parameters are constant, structure of the population is stable (Lotka 1922).

Particularly relevant to the development of suitable reproductive tactics is the time interval between maturations. Many fish that inhabit northern lakes tend to mature at intervals of two years or more (Miller and Kennedy 1948, Sprules 1952). The mechanism for intermittent maturation has never been examined. Food resources have been found to influence the reproductive characteristics of Salmo gairdneri (rainbow trout) (Scott 1962) and Melanogrammus aeglefinus (haddock) (Hislop et al. 1978). However, Leggett and Carscadden (1978) concluded that the reproductive characteristics of Alosa sapidissima (shad) could not be explained in terms of food abundance in the pre-reproductive period. Starvation throughout the cold months and reproduction are the main drain on the energy reserves charr build up during summer feeding. The hypothesis that the cost for the production of gonads in situations of low food resources limits the frequency of reproduction and hence bears on life-history patterns in charr was tested.

From his research in the Northwest Territories, Johnson (1972, 1976, 1980) concluded that characteristically charr populations are dominated by a relatively uniform group of large individuals. This structure persists through time and it is suggested that the mechanism has evolved to ensure greatest stability in the group (Johnson 1981). Modal length is restored following intensive fishing but it is variable from lake to lake. Metabolic processes determine the modal length for a given environmental complex and hence may contribute to the homeostatic mechanism. This research investigated how periodic changes in the condition of the arctic charr of the Nauyuk Lake system are related to length.

The arctic charr (Salvelinus alpinus) is the most northerly distributed freshwater fish. In Canada, this salmonid is present in the Northwest Territories and throughout the Arctic Islands (Scott and Crossman 1973). Johnson (1980) has made an extensive review of the literature on charr. Their success in the Arctic suggests that charr have met the constraints of high latitudes, namely the fluctuations in climate, low temperatures and resources of low variability.

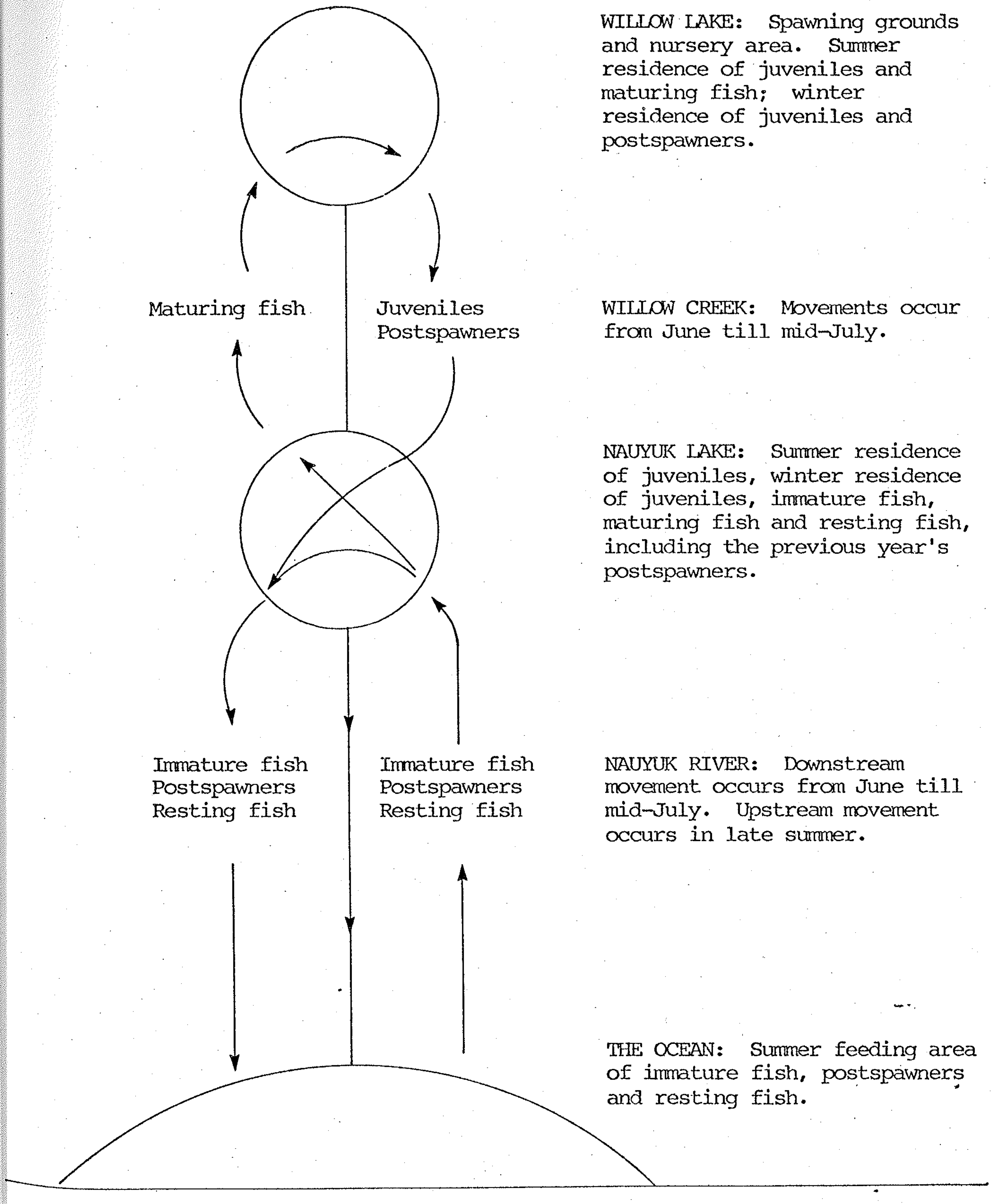
STUDY AREA

The study area, the Nauyuk Lake system, is located south of Victoria Island on the Kent Peninsula (68°22'N, 107°40'W). Anadromous arctic charr are present within two lakes in that system, Willow Lake and Nauyuk Lake (Figure 1.1).

Willow Lake is one out of several headwater lakes of the Nauyuk Lake system but the only one that is of significance in the life of the charr. It has a maximum depth of 12 m and it is more than 2 square kilometers in surface area. In mid-June, melting of snow causes the lake to discharge into Willow Creek which is a tributary of Nauyuk Lake. Willow Creek is half a kilometer in length. Near its head, it divides into several narrow interlaced channels cut in the peat of the tundra. In summer, the water level drops, so that by late July the creek has become impassable to large fish. It remains so till the following spring.

Nauyuk Lake is the largest lake of the system. It has a maximum length of 6.5 km, the maximum depth is 52 m and the surface area is 28 square kilometers. Nauyuk Lake is connected to Parry Bay and the Arctic Ocean via the Nauyuk River. The river bed is 8 m wide and the river is 200 m long. Water flows over morainal deposits, from mid-June until fall. Contrary to Willow Creek, Nauyuk River is passable to large fish till late-September.

Salvelinus alpinus, S. namaycush (lake trout) and Pungitius pungitius (ninespine stickleback) inhabit Willow Lake. They are also present in Nauyuk Lake along with Coregonus clupeaformis (lake whitefish), C. autumnalis (arctic cisco), C. sardinella (least cisco) and Myoxocephalus quadricornis (fourhorn sculpin).



WILLOW LAKE: Spawning grounds and nursery area. Summer residence of juveniles and maturing fish; winter residence of juveniles and postspawners.

WILLOW CREEK: Movements occur from June till mid-July.

NAUYUK LAKE: Summer residence of juveniles, winter residence of juveniles, immature fish, maturing fish and resting fish, including the previous year's postspawners.

NAUYUK RIVER: Downstream movement occurs from June till mid-July. Upstream movement occurs in late summer.

THE OCEAN: Summer feeding area of immature fish, postspawners and resting fish.

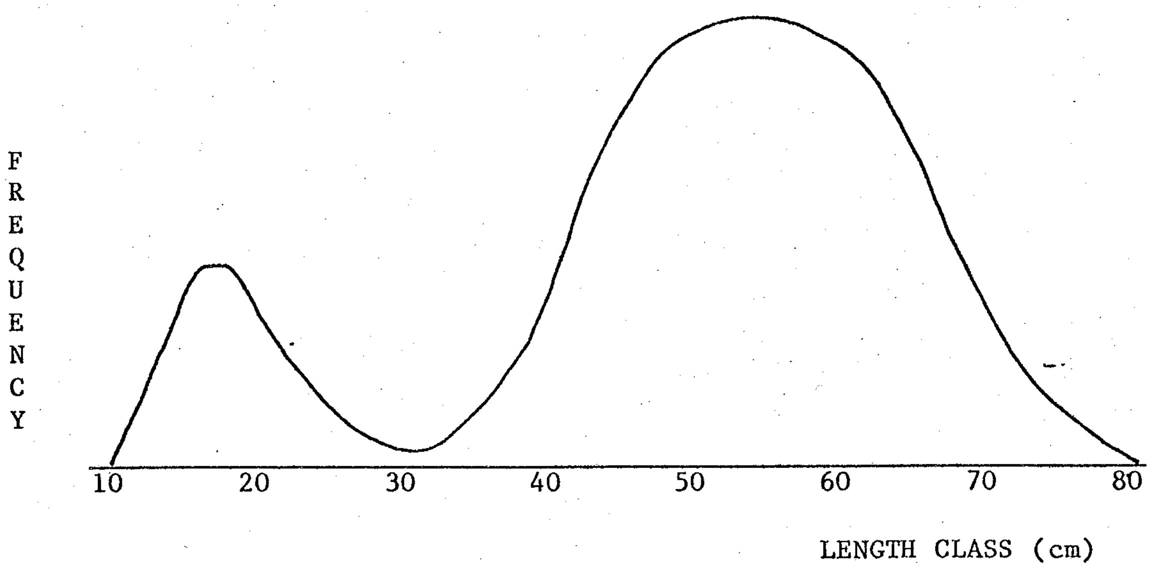
Figure 1.1 The movements of arctic charr in the Nauyuk Lake system.

THE ARCTIC CHARR POPULATION

The arctic charr population has been under study since 1974. The biology of the migratory segment of that population has been described by Johnson and Campbell (1975, 1976), Campbell and Johnson (1976), and Johnson (1976, 1980).

Since 1974, weirs have been operated both in Willow Creek and in Nauyuk River, catching the totality of fish moving between Willow Lake and Nauyuk Lake, and most fish moving between Nauyuk Lake and the sea. In each year, the charr caught in Willow Creek were measured, weighed, tagged and released, whereas in Nauyuk River charr were counted but only 20 to 25% were measured, weighed, tagged and released.

Migrating fish in that system must go down Nauyuk River to reach the sea where they feed. Downstream movement takes place from mid-June till mid-July. The length-frequency distribution of fish in the run has been shown to be bimodal (Johnson 1976):



This general configuration was maintained without major change between 1974 and 1980. Smaller fish (16 to 24 cm) are first-time migrants. Larger fish (40 to 86 cm) are postspawners, resting fish or immature fish*. These fish spend the summer at sea where they feed on _Mallotus villosus_ (capelin) and _Ammodytes hexapterus_ (sand lance). The mean time spent at sea is 50 days. The return migration from the sea to Nauyuk Lake takes place from the beginning of August till September.

Fish returning from the sea pass the winter in Nauyuk Lake. Those fish that survive the winter go back to sea the following year unless they initiate the maturation process (less than 5% of them). Maturing fish generally do not go to sea the year they spawn; they move up to Willow Lake where the spawning grounds are located. This movement of maturing fish from Nauyuk Lake to Willow Lake takes place in June and July coincident with the main seaward migration. Maturing fish spend the summer in Willow Lake. Spawning takes place in fall. In the fall, Willow Creek is not passable to fish so that postspawners must overwinter in Willow Lake. At the same time as maturing fish are moving up Willow Creek in spring, postspawners move downstream joining the fish that overwintered in Nauyuk Lake in their feeding migration to the sea. Downstream movement is concluded by small fish leaving the nursery areas and colonizing the watershed.

The catch curves for length of charr caught in Willow Creek and Nauyuk River in 1976 are drawn in Figure 1.2. These curves are indicative of population structure and cannot be explained in terms of selectivity (Johnson 1976).

* Maturing fish are those fish that are to spawn in the fall of the current year. Immature fish are those fish that never reached sexual maturity. Fish that spawned in the previous fall are postspawners. Resting fish are those fish that spawned previously, excluding the maturing fish and the postspawners.

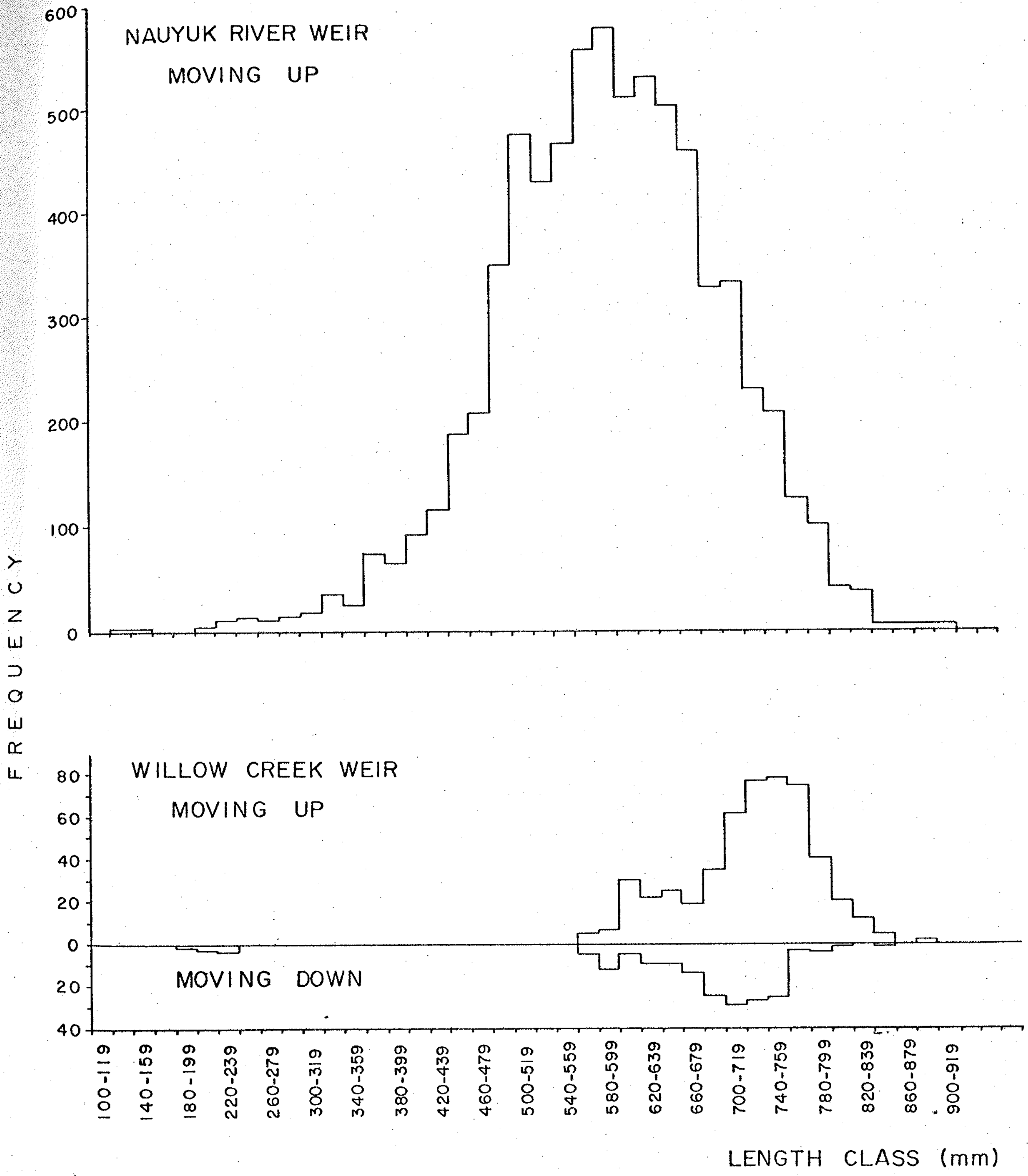


Figure 1.2 Catch curves for length of charr caught in Willow Creek and Nauyuk River (1 run only) in 1976.

METHODS AND MATERIAL

For the purpose of this investigation it was necessary to partition the population as in Table 1. However, current research at the Nauyuk L. station precluded killing much more than 100 fish. Fortunately, a mass of data on the length and weight of this stock has been collected. The procedure was to retrieve these data and to link them with data on condition (proximate analysis). This was done in 5 stages: 1) calculate the length-weight relationships, 2) calculate from (1) the mean weight at desired length and thence the mean condition index, 3) carry out proximate analysis, 4) develop predictive regressions of proximate analysis data versus condition index, and 5) predict the proximate analysis values from mean condition index in (2).

Fishery biologists describe the length-weight relationship of fish by the formula $W = aL^b$. W = weight, L = length, and a and b are constants. Deviations from the predicted values (line) are referred to as variations in condition. Such deviations can be measured by various indices. For this study, Hile's (1936) condition index has been selected: $K = (W/L^3) \times 100$. K = condition index, W = weight (g), L = length (cm). Within the year, periodic changes occur in the weight of individual fish following periods of maturation, starvation, etc., resulting in changes in the relationship between length and weight. The condition index is a measure of the relationship between length and weight (Le Cren 1951). Since changes in the relationship between length and weight reflect changes in the total energy content, the condition index can be used to predict the lipid content and the protein content and from that the total energy content.

Table 1. The runs of fish investigated in the present study.

Maturing fish going up Willow Creek in 1976.	(I)
Maturing fish going up Willow Creek in 1977.	(II)
Postspawners going down Willow Creek in 1977.	(III)
Postspawners going up Nauyuk River in 1977.	(IV)
Immature fish and resting fish (excluding previous fall's spawners) going up Nauyuk River in 1976.	(V)
Immature fish and resting fish (excluding previous fall's spawners) going up Nauyuk River in 1977.	(VI)
Immature fish and resting fish (excluding previous fall's spawners) going down Nauyuk River in 1977.	(VII)

FIELD WORK

Samples were collected in 1976 and 1977. Two counting fences were set up to examine the passage of fish in Willow Creek and Nauyuk River. The totality of fish passing through Willow C. and a random selection of those fish passing through Nauyuk R. were measured, weighed, tagged and released. Thus 5000 pairs of data were collected from which to calculate the length-weight relationships.

More than 100 fish were collected in 1977 for proximate analysis in the laboratory. These fish were collected from the four runs: 1) ascending to Willow Lake and 2) descending from Willow Lake, 3) moving down to sea and 4) returning. Runs 1 and 2 coincide in time, but they were monitored individually in a two-way fence. Run 1 is made of maturing fish heading towards the reproductive grounds located in Willow Lake. Run 2 is made of postspawners returning from Willow Lake to the sea via Nauyuk Lake and Nauyuk River (Johnson and Campbell 1975, Campbell and Johnson 1976). This was confirmed by dissection in the laboratory. Runs 3 and 4 do not coincide in time. They can be monitored individually by merely reversing the fence in summer. Runs 3 and 4 are heterogeneous; they are made of immature fish, resting fish and postspawners. Postspawners were tagged in Willow Creek and thus can be discriminated on the basis of their tag number. However, there was no means to distinguish immature fish from resting fish. Therefore, they were pooled and can collectively be referred to as immatures.

To standardize for length and to investigate length-correlated changes in the relation between body composition (proximate analysis) and condition index, the population was further divided into length-classes. Length-classes were selected on the basis of previous years' length-frequency distributions (Johnson 1980) to cover the total range in length of fish in the four runs. Table 2 summarizes the number of charr collected for proximate analysis per run and per length-class (1977). Current research programs at the station precluded killing more fish than was essential to the investigation. These fish were not taken randomly. They were selected to maximize the range in condition index per run and per length-class. That is meant to increase Σx^2 (x = deviation from mean value of the independent variate) and consequently to decrease the standard error of the regression coefficients of predictive regressions of proximate analysis data versus condition index.

Those fish selected for proximate analysis were killed in a solution of tricaine methanesulfonate (M.S. 222, Sandoz Pharmaceuticals Ltd). Then they were tagged, placed in plastic bags and stored at -10°C. Insulated boxes were used to take the fish to the laboratory. There they were stored at -35°C for less than 12 months prior to dissection and analysis.

Proximate analysis was carried out on both somatic (muscle and liver) and germinal (gonad) tissues to assess their individual contributions to the periodic maturation and starvation related changes in the condition of the fish. Proximate analysis was also carried out on the remaining carcass, this being required to derive the proximate analysis of individuals. The muscle sample was taken from the back and weighed to the nearest milligram; the sample area extended from behind the head to caudal peduncle and from mid-dorsal line to lateral line. The sample did not include the skin, the layer of fat beneath the skin and close to

Table 2. Number of charr collected in Willow Creek and Nauyuk River* for proximate analysis (1977), broken down into length-classes (mid-points). The range in length within length-classes can be calculated from the data in Table C1.

Category	Location/Direction	Length-class								
		220	400	500	550	600	650	700	750	800
Maturing fish	Willow Creek to Willow L.	–	–	–	2	5	4	5	2	–
Postspawners	Willow Creek to Nauyuk L.	–	–	–	2	4	5	6	4	–
Immatures	Nauyuk River to sea	9	4	7	–	6	–	4	–	3
Immatures	Nauyuk River to Nauyuk L.	4	6	6	–	6	–	6	–	2
Postspawners	Nauyuk River to Nauyuk L.	–	–	–	0	4	3	3	4	–

* This table does not include 12 juveniles coming from the nursery areas and caught in Willow Creek (WCD 180-210-240 in Table C1) nor the 6 mature fish caught in Nauyuk River in fall (NRUS in Table C1).

the lateral line, nor red muscle. Liver and both gonads were dissected out and weighed to the nearest milligram. Stomach was examined for food content and notes taken on the general condition of the fish. Finally, the remaining carcass was homogenized. Carcass weight was calculated from total weight of fish and total weight of dissected tissues.

PROXIMATE ANALYSIS

Moisture

Moisture content was determined by weight difference following drying at 100°C for 24 hours and cooling in a desiccator (A.O.A.C. 1975).

Ash

Samples were placed in an oven at 100°C for 24 hours, transferred to a muffle furnace and heated at 550°C for 8 hours, then cooled in a desiccator. Content was determined by difference (A.O.A.C. 1975).

Proteins

The protein content was determined from the nitrogen content (not corrected for non-protein nitrogen) of one-gram samples. Assuming that the nitrogen content of proteins is 16%, nitrogen data were multiplied by 6.25 to yield the protein content. Total nitrogen content was determined by a new method that consists of a micro-Kjeldahl digestion followed by the Berthelot reaction. This method was first described by Haslemore and Rougham (1976); it was modified for use with fish tissues by A. Lutz (personal communication). Following preliminary tests, further modifications had to be brought to the original method. The procedure followed is described in Appendix A.

Lipids: colorimetric method

The lipid content of two-gram samples was measured colorimetrically. A combination of two methods was used, the Bligh and Dyer (1959) method and the Kibrick and Skupp (1953) method as modified by Fales (1971). Since many modifications were brought to the original methods (A. Lutz, personal communication), an outline of the procedure is presented in Appendix B.

Lipids: gravimetric method

The Bligh and Dyer (1959) method was used to measure the lipid content of large samples (25 grams). The method consists in homogenizing the sample with two reagents, chloroform and methanol, to extract the lipids. The solution is further diluted with chloroform and water, and then filtered through a filter paper into a separatory funnel. The filtrate separates into two layers; the bottom layer contains the purified lipid dissolved in chloroform. That layer is isolated in a preweighed flask. The chloroform is evaporated and the flask is weighed; the difference in weight represents the total weight of the lipids in the sample.

Some modifications were made to the original method. Bligh and Dyer used 100-gram samples whereas 25-gram samples were used in this study, so the reagents were scaled down accordingly. They also suggested that the filtrate be caught in a graduate cylinder and the volume of the bottom layer be measured, the lipid content could then be estimated from a portion of that layer; the whole bottom layer was used in the present study. Lastly, Bligh and Dyer dried the lipid extracts over phosphoric anhydride in a vacuum desiccator; the extracts in this study were dried under a stream of air.

ENERGY

Forty fish subjected to starvation were sampled to determine the proximate analysis of the residual carcass. The samples that had been utilized to measure the moisture content were subsequently utilized to determine the energy content. Duplicate measurements were made using the Gallenkamp bomb calorimeter (Model CB-370). The bomb was calibrated with a certified thermochemical standard (benzoic acid). Separate calibrations were made for each crucible. Correction was made for the constant heat gain from the firing current and the firing cotton. However, no correction was made for the energy content of residues. The sample size ranged from 574 to 736 mg (dry weight). For a detailed description of the methodology, see Grodzinski et al. (1975) and Wiegert (1976).

From the contents in lipids and proteins and the heat equivalents for lipids and proteins reported in the literature (Brody 1945), the mean energy content of the residual carcass was calculated. This calculated value was compared with the measured value. The measured value underestimated the calculated value by 4%. These 4% can be accounted for by the heat content of residues, nitric acid and partially burnt material (Wiegert 1976). Therefore, the content was calculated from the lipid and protein contents using the following conversion factors: 23.64 kJ g^{-1} (proteins) and 39.54 kJ g^{-1} (lipids) (Brody 1945).

RESULTS

LENGTH-WEIGHT RELATIONSHIPS

The length-weight relationships were calculated as power curves for the runs of charr listed in Table 1 (Table 3). The raw data are not included in the thesis. Notice the high values of r^2. From Table 3, the mean weight of a charr at exact length can be calculated (Table 4). For instance, the length-weight relationship of maturing charr moving to Willow Lake in 1977 (Run II in Table 1) was: $Y = (1.765 \times 10^{-5})\ X^{2.9044}$. The mean weight of 600-mm maturing charr in 1977 was $(1.765 \times 10^{-5})\ 600^{2.9044}$: 2068 g. Mean condition index can be calculated as $(2068/60.0^3) \times 100$: 0.96.

PROXIMATE ANALYSIS

Lengths, weights and condition indices of individual fish are listed in Appendix C (Table C1). Proximate analysis data are listed in Tables C2-C5. Sample numbers refer to the numbers given to fish sampled in the field. The first two letters refer to the location: WC = Willow Creek, NR = Nauyuk River. The third letter refers to the direction: D = charr moving downstream, U = charr moving upstream. The first three figures refer to the length-class (mm) the fish belonged to. The next figure is either "0" or "1". The former is used in all cases except for those fish given the code NRU and which had spawned in the fall of the previous year (that is "1" stands for postspawners returning from the sea). Finally, the last digit is the number of the sample within its length-class. For instance, NRU60002 was caught in Nauyuk River on its way up the stream; it is included in the 600 mm length-class and it had not spawned in the fall of the previous year. In some cases, NRU is followed by an "S"; those were mature fish.

Table 3. Length-weight relationships of charr taken in the weirs, where a and b are the constants in the power curve and r^2 the coefficient of determination.

Run	Number of fish	a	b	r^2
I	531	7.198×10^{-5}	2.6974	.90
II	225	1.765×10^{-5}	2.9044	.91
III	472	1.790×10^{-5}	2.8581	.89
IV	112	5.387×10^{-4}	2.3686	.78
V	987	7.326×10^{-6}	3.0602	.99
VI	1080	8.017×10^{-6}	3.0485	.99
VII	1805	7.218×10^{-6}	3.0326	.94

Table 4. Mean weight (g) of charr at exact length (mm), calculated from the length-weight relationships of Table 3.

Length class	Run						
	I	II	III	IV	V	VI	VII
220					108	111	92
400					673	686	562
500					1331	1355	1105
550	1775	1606	1216	1677	1782	1811	1476
600	2245	2068	1560	2058	2326	2361	1921
650	2785	2609	1961	2484	2971	3014	2449
700	3402	3236	2424	2956	3728	3777	3066
750	4098	3954	2952	3475	4604	4662	3780
800	4877	4769	3550	4044	5609	5675	4597

The second column refers to either the total weight of the gonads (Table C2), the total weight of the liver (Table C3), the total weight of the muscle sample (Table C4) or the total weight of the residual carcass (Table C5). The next columns in these tables refer to the composition of the sample. Results are in g/(g wet weight). Multiplying those figures by the figures in the second column, we obtain the total contents in the gonads (Table C6), the liver (Table C7), the muscle sample (Table C8) and the residual carcass (Table C9). Adding the total contents of gonads, liver, muscle sample and residual carcass, we obtain the total weight of moisture, ash, lipids and proteins in the whole fish (Table C10). Blanks are left wherever results were missing.

Thus charr NRD 60001 (600-mm length-class immature fish taken in Nauyuk River moving downstream) measured 592 mm and 2294 g (Table C1). Gonads, liver and muscle sample were 36.311 g (Table C2), 38.468 g (Table C3) and 71.809 g (Table C4). Carcass weight was calculated by difference (2294 - (36.311 + 38.468 + 71.809) = 2147.412) (Table C5). The moisture content in the gonad for example is the product of gonad weight (36.311 g) and proportion of moisture in that gonad 0.739 (Table 2): 26.834 g (Table C6). Total moisture content of NRD 60001 is the sum of moisture content in the gonad (26.834 g, Table C6), the liver (27.620 g, Table C7), the muscle sample (52.062 g, Table C8) and the carcass (1415.145 g, Table C9): 1521.661 g (Table C10).

RELATIONSHIP BETWEEN PROXIMATE ANALYSIS AND CONDITION INDEX

Next proximate analysis data (Table C10) and condition index values (Table C1) were related mathematically. Hile's (1936) condition index was selected to measure the extent of deviations from the power curve. Since power of L in $(W/L^3) \times 100$ is constant, the condition index is homogeneous throughout the runs (Table 1), that is provided W and L are the same, the condition index is the same no matter the runs. Therefore the condition index is a common measure throughout the population. That the proximate analysis of charr of same length and weight but taken from various runs is the same, has to be assumed (Figures D1 to D3).

Moisture, lipid and protein contents

Taking length-classes individually and pooling within length-classes the categories of Table 2, linear regressions have been calculated:

$$\text{Parameter (g)} = a + b \sin^{-1} \left[((W/L^3) \times 100) - 0.4\right]^{0.5}$$

Transformation of condition index to radians restores normality of the data. The constant value 0.4 makes the condition index less than 1.0 as $\sin^{-1} X^{0.5}$ for $X > 1.0$ does not exist. Regressions are listed in Tables D1 (Moisture), D2 (Lipids) and D3 (Proteins). F-tests demonstrate that regression on condition index explained a significant proportion of the variance in the proximate analysis data. Then regression lines in Tables D2 and D3 were tested for homogeneity

F-test results for the regression lines of proximate analysis data versus condition index (transformed).

Length class	Moisture content	Lipid content	Protein content
220	<.25	**	<.10
400	**	**	**
500	**	**	**
550	**	*	*
600	**	**	**
650	**	**	**
700	**	**	**
750	**	**	**
800	**	*	**

*	$\alpha = .05$
**	$\alpha = .01$

of variances. Bartlett's test (Sokal and Rohlf 1969) showed variances to be heterogeneous ($\alpha = .05$). The analysis of covariance for heterogeneous variances was carried out following Sokal and Rohlf (1969). Regression coefficients are not homogeneous ($\alpha = .05$).

Consider for instance the regression of protein content of 750-mm charr on condition index. Following Table D3, the regression reads:

$$Y = -40.63 + 1063.53\ X'$$

$$r^2 = 0.83 \qquad n = 10$$

Thus 10 charr of the 750-mm length-class had their protein content measured. These data are drawn from Table C1 (column 3) and Table C10 (column 2):

Sample number	Protein content	Condition index	Transformed (radians)
WCD75001	652.260	.714	.595
WCD75002	693.101	.760	.644
WCD75003	365.436	.563	.416
WCD75004	461.735	.687	.565
WCU75002	956.512	.927	.812
NRU75011	797.553	.923	.808
NRU75012	797.966	.927	.812
NRU75013	757.122	.821	.706
NRU75014	816.479	.923	.808
NRUS04	839.525	1.040	.927

The regression involves columns 2 and 4.

Mineral content

Mineral content (ash) is best predicted from total weight of charr pooling both length-classes and categories in Table 2.

Mineral content = -1.5529 + 0.0202 Total weight

F = 5254

r^2 = .9872 (70 data pairs)

PREDICTIONS

Proximate analyis values of charrs in this population can now be predicted provided they fit in one of the length-classes and their length and weight were measured. Collection year has no relevance. Such calculations were made for the runs of charrs listed in Table 1, by combining mean weights in Table 4 or mean condition index values derived from Table 4, to the linear regressions. Results are listed in Tables 5 to 11. Confidence intervals are those of the regression lines (α = .05). Finally, the content in energy was derived from the proximate analysis values (Table 12).

Take for example the 600-mm maturing charr in 1976 (Run I in Table 1). Their mean weight is 2245 g (Table 4). Mean condition index is $(2245/60.0^3) \times 100 = 1.039$. Transformed condition index is 0.926.

Moisture content is 493.54 + 1082.08 (0.93) = 1500 g (Table D1)

Mineral content is -1.5529 + 0.0202 (2245) = 43.8 g

Lipid content is -251.66 + 531.49 (0.93) = 243 g (Table D2)

Protein content is -13.22 + 521.28 (0.93) = 472 g (Table D3)

Total content in energy is (243 X 39.54) + (472 X 23.64) = 20766 KJ

Table 5. Proximate analysis (g) of the standard maturing charr moving to Willow Lake in 1976 (Run I in Table 1). Intervals are those of the regression lines (∝ = .05).

Length class	Mean weight	Condition index	Transformed C.I.	Moisture content	Mineral content	Lipid content	Protein content
550	1775	1.07	0.96	1197 ± 125	34.3 ± 0.9	179 ± 62	384 ± 79
600	2245	1.04	0.93	1500 ± 33	43.8 ± 0.8	243 ± 24	472 ± 21
650	2785	1.01	0.90	1891 ± 88	54.7 ± 0.9	252 ± 26	601 ± 35
700	3402	0.99	0.88	2308 ± 59	67.2 ± 1.0	299 ± 14	698 ± 30
750	4098	0.97	0.86	2793 ± 165	81.2 ± 1.3	318 ± 63	874 ± 82
800	4877	0.95	0.84	3373 ± 160	97.0 ± 1.7	455 ± 173	968 ± 97

Table 6. Proximate analysis (g) of the standard maturing charr moving to Willow Lake in 1977 (Run II in Table 1). Intervals are those of the regression lines ($\alpha = .05$).

Length class	Mean weight	Condition index	Transformed C.I.	Moisture content	Mineral content	Lipid content	Protein content
550	1606	0.96	0.85	1090 ± 90	30.9 ± 0.9	136 ± 45	340 ± 57
600	2068	0.96	0.84	1402 ± 31	40.2 ± 0.8	195 ± 22	425 ± 19
650	2609	0.95	0.84	1811 ± 74	51.2 ± 0.8	208 ± 20	554 ± 29
700	3236	0.94	0.83	2236 ± 57	63.8 ± 1.0	255 ± 14	655 ± 29
750	3954	0.94	0.82	2714 ± 144	78.3 ± 1.2	282 ± 52	831 ± 72
800	4769	0.93	0.82	3326 ± 162	94.8 ± 1.6	435 ± 174	946 ± 98

Table 7. Proximate analysis (g) of the standard postspawners moving down Willow Lake in 1977 (Run III in Table 1). Intervals are those of the regression lines ($\alpha = .05$).

Length class	Mean weight	Condition index	Transformed C.I.	Moisture content	Mineral content	Lipid content	Protein content
550	1216	0.73	0.61	858 ± 93	23.0 ± 1.0	42 ± 46	244 ± 58
600	1560	0.72	0.60	1143 ± 51	30.0 ± 0.9	67 ± 36	300 ± 32
650	1961	0.71	0.60	1494 ± 70	38.1 ± 0.8	32 ± 26	367 ± 27
700	2424	0.71	0.59	1893 ± 93	47.4 ± 0.8	44 ± 27	450 ± 47
750	2952	0.70	0.58	2245 ± 167	58.1 ± 0.9	66 ± 72	576 ± 77
800	3550	0.69	0.57	2734 ± 250	70.2 ± 1.1	190 ± 269	676 ± 151

Table 8. Proximate analysis (g) of the standard postspawners moving up Nauyuk River in 1977 (Run IV in Table 1). Intervals are those of the regression lines ($\alpha = .05$).

Length class	Mean weight	Condition index	Transformed C.I.	Moisture content	Mineral content	Lipid content	Protein content
550	1677	1.01	0.89	1129 ± 101	32.3 ± 0.9	151 ± 51	356 ± 64
600	2058	0.95	0.84	1402 ± 31	40.0 ± 0.8	195 ± 22	425 ± 19
650	2484	0.90	0.79	1745 ± 65	48.6 ± 0.8	172 ± 16	515 ± 25
700	2956	0.86	0.75	2122 ± 62	58.2 ± 0.9	185 ± 16	587 ± 31
750	3475	0.82	0.71	2499 ± 120	68.6 ± 1.0	183 ± 41	714 ± 57
800	4044	0.79	0.67	2971 ± 202	80.1 ± 1.3	288 ± 218	784 ± 122

Table 9. Proximate analysis (g) of the standard immature moving up Nauyuk River in 1976 (Run V in Table 1). Intervals are those of the regression lines ($\alpha = .05$).

Length class	Mean weight	Condition index	Transformed C.I.	Moisture content	Mineral content	Lipid content	Protein content
220	108	1.01	0.90	88 ± 36	0.6 ± 1.4	4.3 ± 1.1	31 ± 14
400	673	1.05	0.94	485 ± 22	12.0 ± 1.2	52 ± 7	139 ± 8
500	1331	1.06	0.95	888 ± 13	25.3 ± 1.0	109 ± 16	272 ± 8
550	1782	1.07	0.96	1197 ± 125	34.4 ± 0.8	179 ± 62	384 ± 79
600	2326	1.08	0.97	1543 ± 35	45.4 ± 0.8	264 ± 25	492 ± 22
650	2971	1.08	0.97	1983 ± 108	58.5 ± 0.9	304 ± 34	656 ± 42
700	3728	1.09	0.98	2451 ± 74	73.8 ± 1.2	388 ± 17	783 ± 37
750	4604	1.09	0.98	3027 ± 243	91.4 ± 1.5	426 ± 103	1002 ± 121
800	5609	1.10	0.99	3728 ± 188	111.8 ± 2.0	602 ± 202	1130 ± 114

Table 10. Proximate analysis (g) of the standard immature moving up Nauyuk River in 1977 (Run VI in Table 1). Intervals are those of the regression lines ($\alpha = .05$).

Length class	Mean weight	Condition index	Transformed C.I.	Moisture content	Mineral content	Lipid content	Protein content
220	111	1.04	0.93	91 ± 41	0.7 ± 1.4	4.7 ± 1.2	33 ± 16
400	686	1.07	0.96	492 ± 23	12.3 ± 1.2	55 ± 7	142 ± 9
500	1355	1.08	0.97	898 ± 14	25.8 ± 0.9	115 ± 17	281 ± 9
550	1811	1.09	0.98	1216 ± 132	35.0 ± 0.8	186 ± 66	392 ± 83
600	2361	1.09	0.98	1554 ± 36	46.1 ± 0.8	269 ± 26	498 ± 23
650	3014	1.10	0.99	2010 ± 114	59.3 ± 0.9	319 ± 37	672 ± 44
700	3777	1.10	0.99	2465 ± 76	74.7 ± 1.2	396 ± 18	792 ± 38
750	4662	1.10	1.00	3066 ± 258	92.6 ± 1.6	444 ± 110	1023 ± 128
800	5675	1.11	1.00	3751 ± 191	113.1 ± 2.1	612 ± 206	1141 ± 116

Table 11. Proximate analysis (g) of the standard immature moving down Nauyuk River in 1977 (Run VII in Table 1). Intervals are those of the regression lines ($\sigma = .05$).

Length class	Mean weight	Condition index	Transformed C.I.	Moisture content	Mineral content	Lipid content	Protein content
220	92	0.86	0.75	71 ± 21	0.3 ± 1.4	2.5 ± 0.7	23 ± 7
400	562	0.88	0.76	421 ± 28	9.8 ± 1.2	25 ± 8	114 ± 11
500	1105	0.88	0.77	796 ± 18	20.8 ± 1.0	55 ± 17	239 ± 12
550	1476	0.89	0.77	1013 ± 75	28.3 ± 0.9	104 ± 38	308 ± 48
600	1921	0.89	0.78	1338 ± 33	37.2 ± 0.8	163 ± 24	393 ± 21
650	2449	0.89	0.78	1732 ± 63	47.9 ± 0.8	164 ± 16	508 ± 25
700	3066	0.89	0.78	2165 ± 59	60.4 ± 0.9	211 ± 15	613 ± 30
750	3780	0.90	0.78	2636 ± 129	74.8 ± 1.2	246 ± 43	789 ± 64
800	4597	0.90	0.78	3231 ± 167	91.3 ± 1.5	396 ± 180	903 ± 101

Table 12. Total energy content (kJ) of the standard charr as calculated from their lipid and protein contents.

Length class	Run I	II	III	IV	V	VI	VII
220					903	966	643
400					5342	5532	3683
500					10740	11190	7825
550	16155	13415	7429	14386	16155	16621	11393
600	20766	17757	9741	17757	22069	22409	15736
650	24172	21321	9941	18975	27528	28499	18494
700	28323	25567	12378	21192	33852	34381	22834
750	33235	30795	16226	24115	40531	41739	28379
800	40874	39563	23493	29921	50516	51172	37005

PERIODIC CHANGES IN THE CONDITION OF THE IMMATURES

Immatures can be used as a control to measure the relative extent of periodic changes in the condition of mature charr. This section bears on periodic changes in the condition of the immatures. Winter losses are contrasted to summer gains. Then results of laboratory experiments are introduced to assess losses due to starvation in controlled conditions as a control to losses measured in the field.

Winter losses

Winter losses were assessed for the immatures in the winter 1976-1977. Table 13 was produced by subtracting the spring run values (Table 11) from those of the previous fall run (Table 9). Loss in weight increases with increasing length (Figure 2) as does the percent weight loss (Figure 3). Notice however that the slope of the curve of percent weight loss vs length decreases with increasing length. Total lipid and total protein losses increase with increasing length (Figure 4) parallel to weight loss, but as these two factors contribute the same weight to the total weight loss of the fish, proteins (being of lower energy content) contribute less to the total loss of energy (Figure 5).

The ratio $\Delta X/Xo : \Delta W/Wo$, where ΔX = change in content, Xo = content in fall, ΔW = weight loss, and Wo = total weight of fish in fall, yielded the following figures:

moisture	0.73
ash	1.03
lipids	2.34
proteins	1.16

The low ratio for moisture indicates that the proportion of water increased, while the ratio close to 1.0 recorded for ash indicates that the proportion of ash did not change markedly. The high ratios recorded for lipids and to a lesser extent for proteins indicate that these parameters decreased markedly in winter. When the proportion does not change, the ratio is 1.00.

Observations suggest that no feeding takes place in winter. Stomachs of charr moving out of the system in spring were examined, and the majority were found to contain no food. Similarly, 40 fish caught through the ice in November were examined and stomachs were found to be empty. Further evidence stems from starvation experiments conducted in the laboratory.

Summer gains

The net results of the feeding migration were assessed, by subtracting the relevant values in Table 11 from those in Table 10. Summer gain and winter loss of energy are contrasted in Figure 6. Therefore, in 1977, the summer gain more than compensated for the preceding winter loss. However, whether the net changes measured match the changes that actually took place is not known: charr might have taken food in winter to meet their metabolic needs beyond the reserves stored in summer, but it turns out that it is not essential for them to do this to survive.

Starvation experiments

Starvation experiments were set up in order to assess losses under controlled conditions. Fish were selected from a stock reared from wild eggs collected at Willow Lake in 1974. Following hatching, these fish were kept under standard hatchery conditions. Fifty-four fish were selected, tagged and divided into four groups. The tagged fish were then transferred to test tanks where they were progressively acclimated to the test photoperiod (80 minutes of dim light daily simulating Arctic winter light conditions) and the test temperature. Temperatures were selected to cover the range of temperature charr are likely to experience in fresh water: 0.0-10.0°C. Since 0.0°C was technically impractical to achieve, we selected* 1.0°C (treatment A), 4.0°C (treatment B), 7.0°C (treatment C) and 10.0°C (treatment D). The schedules of acclimation are presented in Appendix E.

Following acclimation, the fish were measured and weighed to nearest g. Initially, there was no statistical difference ($\alpha = .01$) in mean length and mean weight between fish of treatment A and fish of treatment B (Table 14) and between fish of treatment C and fish of treatment D (Table 15). However, the analysis of variance showed that both initial lengths and weights of fish in treatments A and B differed from those of fish in treatments C and D ($\alpha = .01$). Throughout the investigations, which lasted 250 days, the weight was measured and fish samples were taken periodically, but the sampling schedule differed for the two sets of experiments (A-B vs C-D). Therefore, differences in weight loss between the two sets of experiments have to be interpreted cautiously. The results are shown in Tables 16, 17, 18 and 19.

Besides minor mortalities resulting from the periodic removal of fish for sampling, there was no mortality in the course of these experiments. Including fish that starved for less than 250 days, mean

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* The mean temperatures achieved were: 1.3 ± 0.5°C (A), 4.0 ± 0.9°C (B), 7.1 ± 0.6°C (C) and 10.1 ± 0.4°C (D). Means and standard deviations were calculated from daily readings.

Table 13. Mean losses (Δ) incurred by the immatures due to starvation in winter. W = weight, L = lipids, P = proteins, E = energy.

Length class	ΔW (g)	ΔL (g)	ΔP (g)	ΔE (kJ)
220	16	1.8	8	260
400	111	27	25	1659
500	226	54	33	2915
550	306	75	76	4762
600	405	101	99	6333
650	522	140	148	9034
700	662	177	170	11018
750	824	180	213	12152
800	1012	206	227	13511

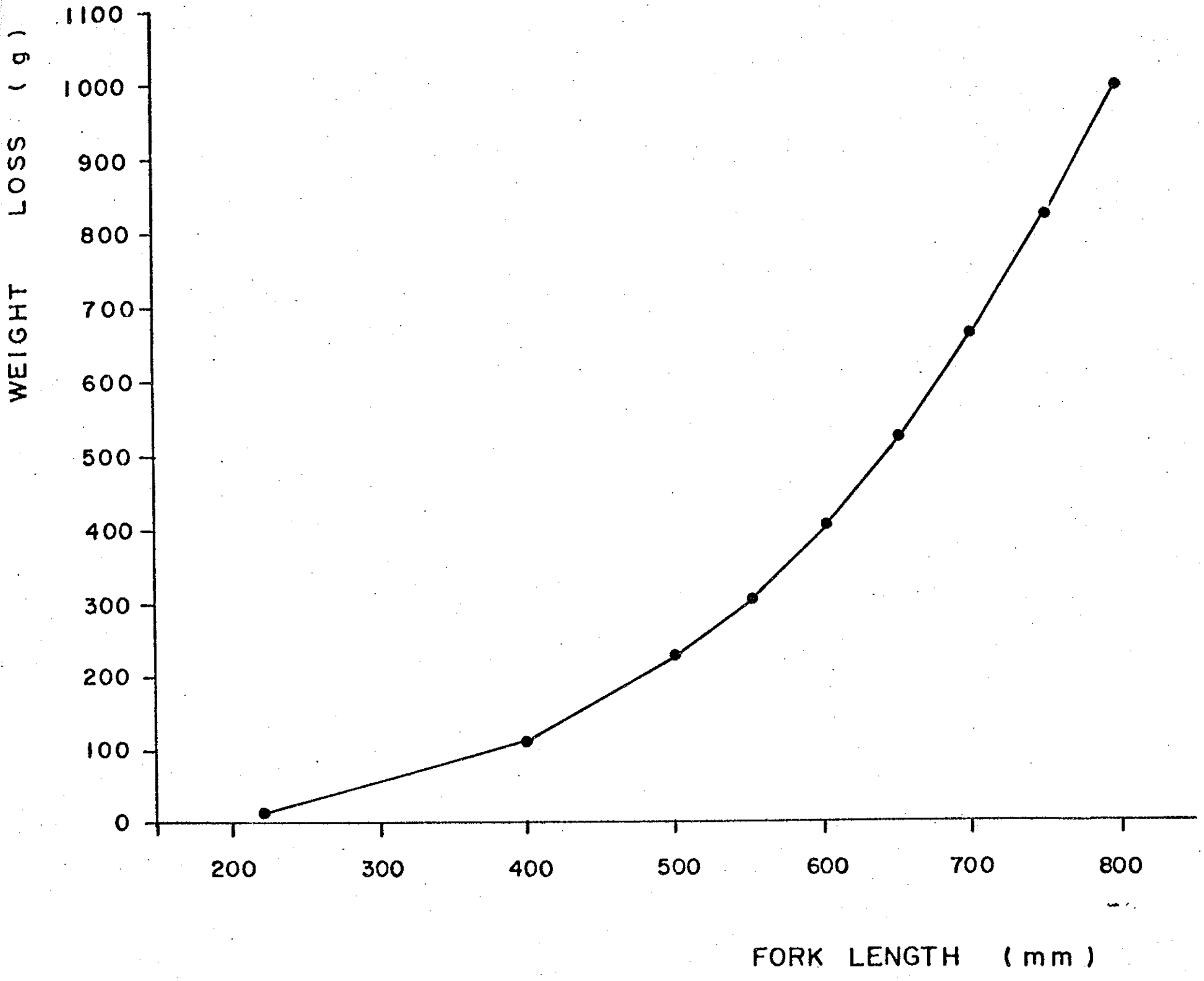

Figure 2. Winter loss in weight of immatures in relation to fork length (1976-1977).

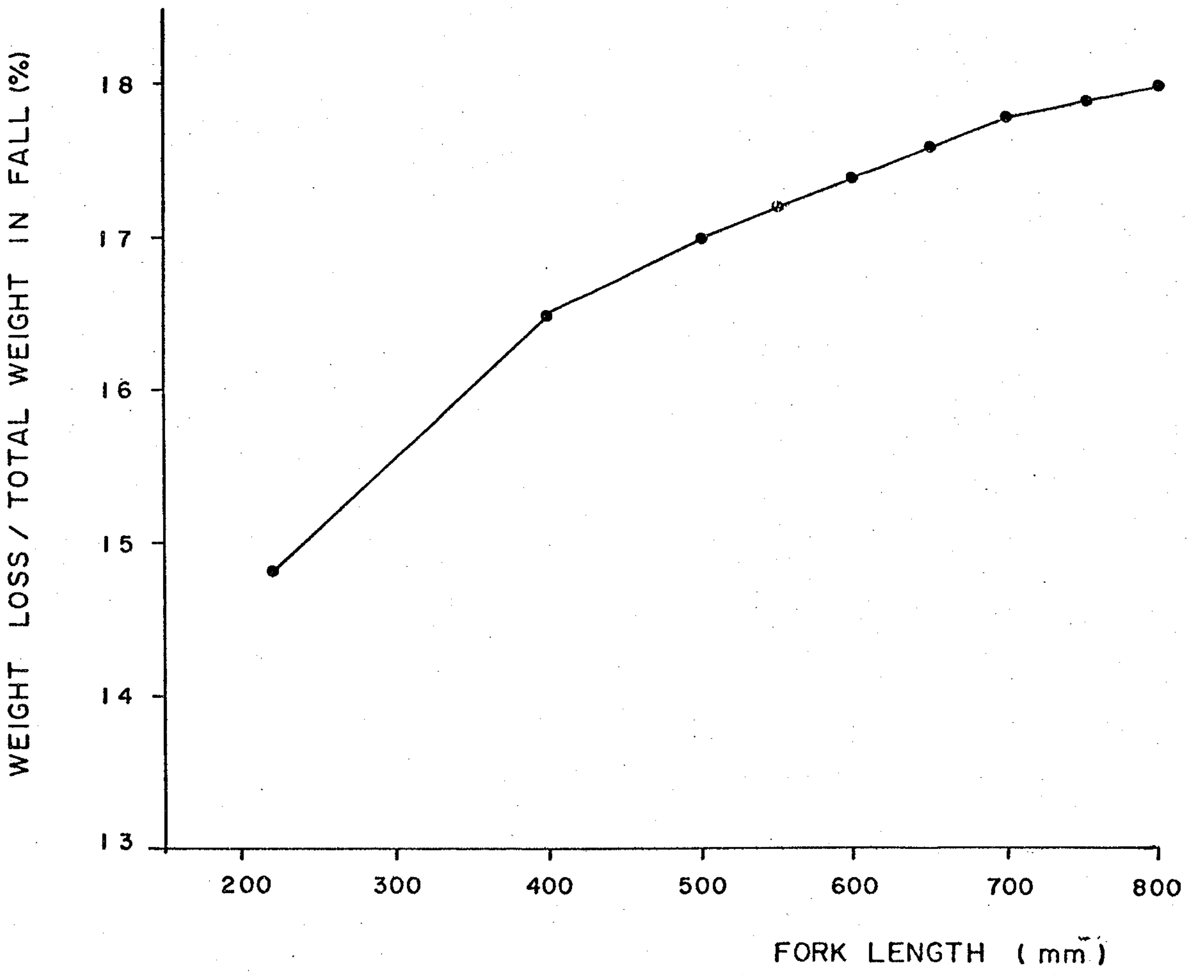

Figure 3. Winter loss in weight of immatures as percentage of total weight in fall in relation to fork length.

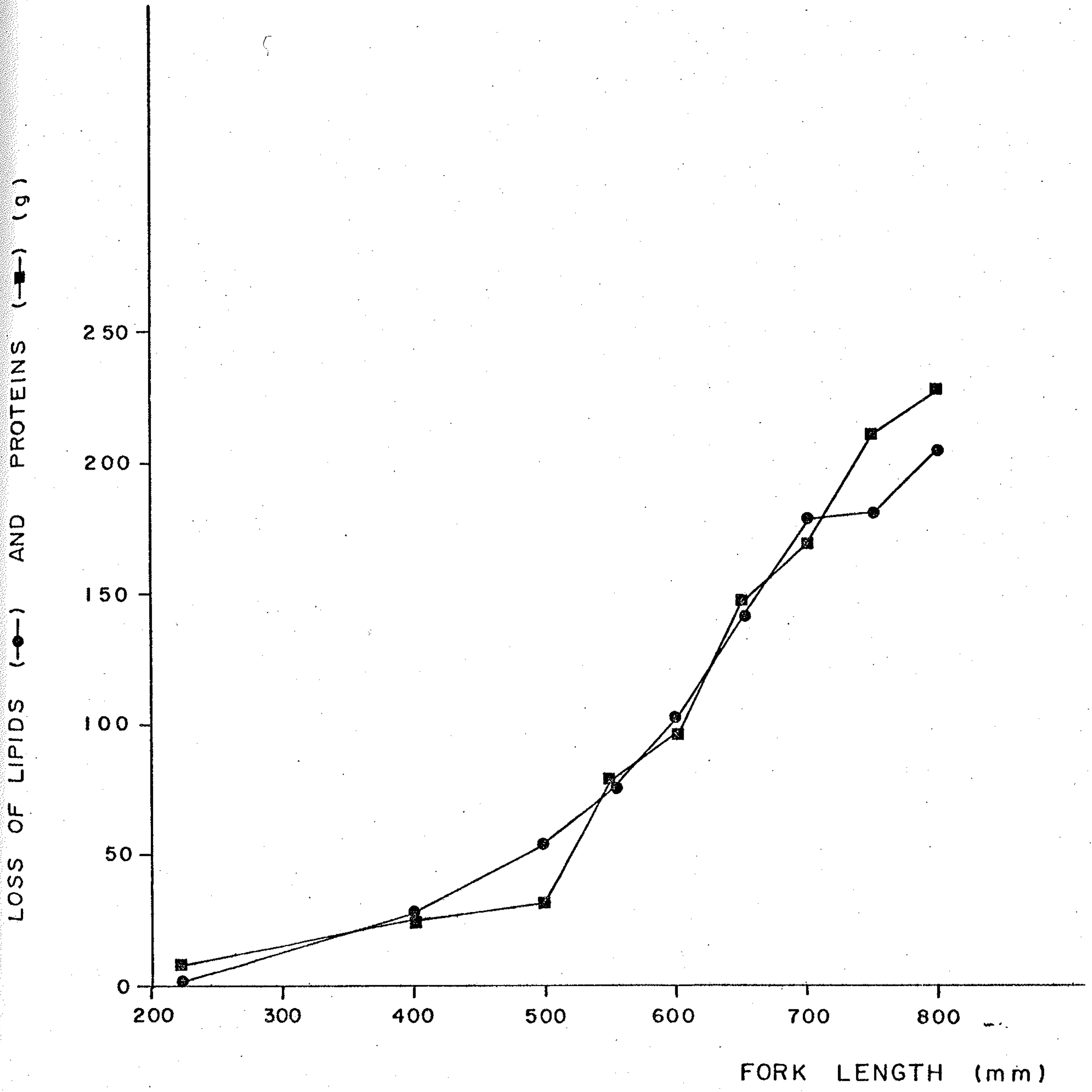

Figure 4. Winter loss of lipids and proteins in immatures in relation to fork length.

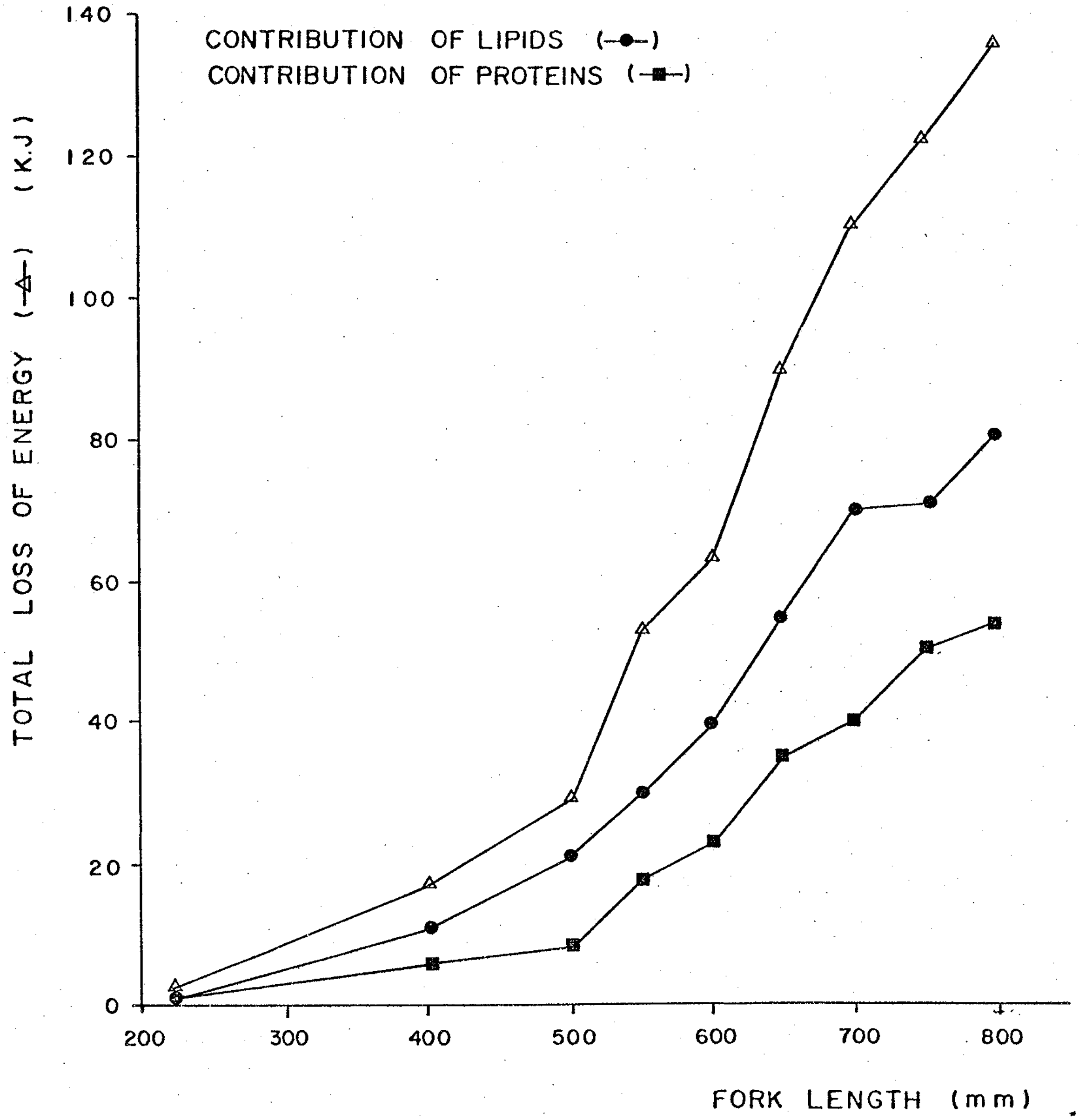

Figure 5. Total loss of energy and contribution of lipids and proteins to total loss in immatures, in relation to fork length.

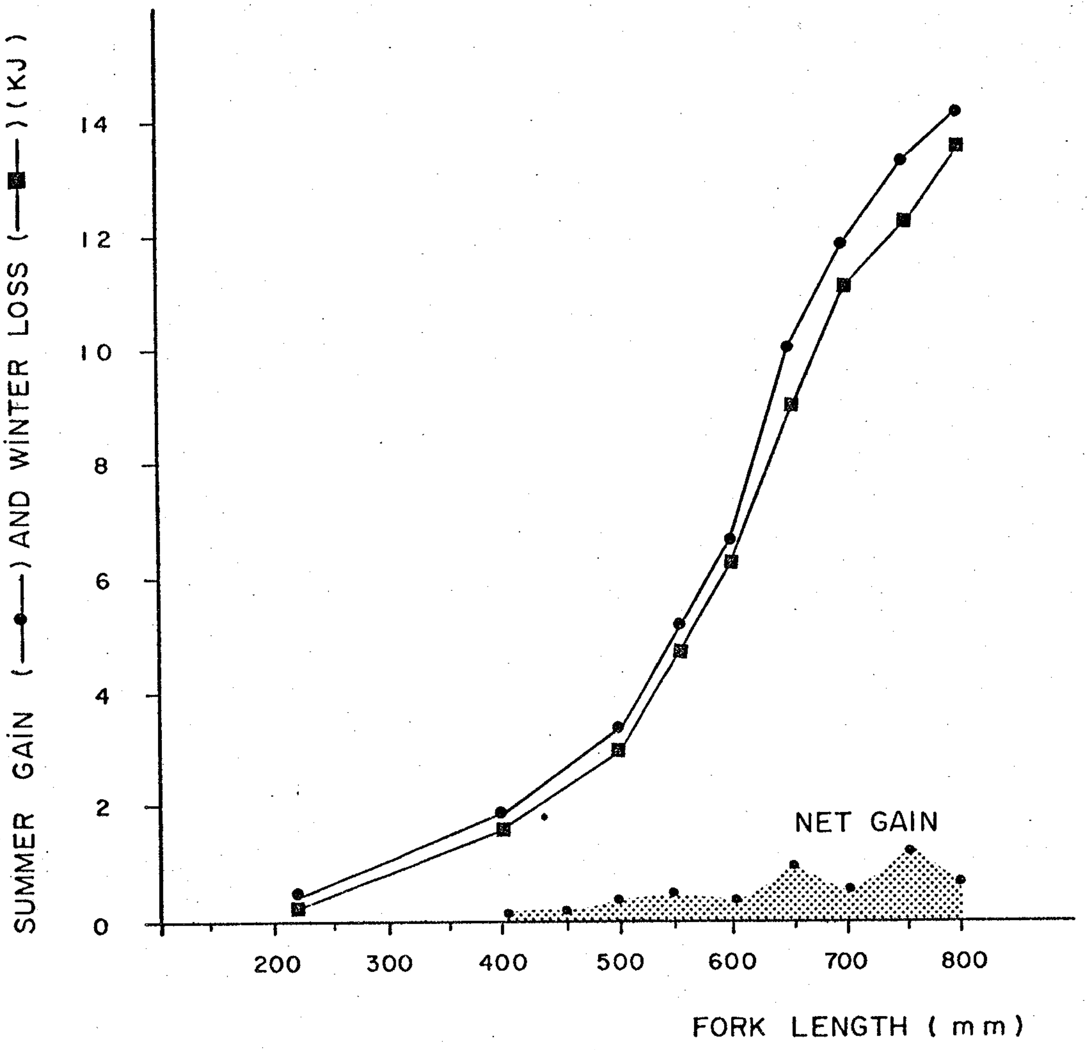

Figure 6. Summer gain and winter loss of energy in immatures, in relation to fork length.

Table 14. Lengths (mm) and weights (g) of fish at the start of the experiment (treatments A and B).

	1.0°C		4.0°C	
	Length	Weight	Length	Weight
	367	623	388	567
	399	667	424	749
	398	708	400	655
	409	686	387	657
	415	851	425	864
	380	632	429	930
	365	522	423	840
	410	805	366	509
	422	805	388	628
	441	873	437	890
	429	811	427	800
	420	784	431	810
	412	853	410	772
Mean	407	740	410	744
St.deviation	20.2	108.2	22.2	130.2

Table 15. Lengths (mm) and weights (g) of fish at the start of the experiment (treatments C and D).

	7.0°C		10.0°C	
	Length	Weight	Length	Weight
	382	599	377	543
	356	608	369	574
	376	537	375	559
	386	573	364	542
	380	644	382	576
	385	575	383	593
	383	569	378	532
	388	600	382	611
	359	498	369	549
	359	509	387	613
	364	502	354	530
	374	521	393	621
	376	544	383	586
	385	552	381	554
Mean	375	559	377	570
St.deviation	11.2	44.0	10.1	30.8

Table 16. Decrease in weight (g) of fish starved at 1.0°C.

Tag number	Day of observation						
	Start	10	50	100	150	200	250
S2935	623	630	592				
S2936	667	654	623	628	629	629	626
S2937	708	692					
S2938	686	677	660	652	634	597	546
S2942	851	844	820	797	796	806	806
S2946	632	640	605				
S2947	522	521	499	499	499	496	488
S2951	805	793	774	780			
S2952	805	778					
S2954	873	872	849	848	846	846	838
S2956	811	811	785	780			
S2957	784	774	757	748	749	753	740
S2959	853	840	796	786	789	795	793

Table 17. Decrease in weight (g) of fish starved at 4.0°C.

Tag number	Day of observation						
	Start	10	50	100	150	200	250
S2934	567	552	528	499	481	481	482
S2939	749	747	720	669			
S2940	655	649	616	594	576	583	582
S2941	657	635					
S2943	864	859	831	804	800	807	801
S2944	930	918	882	844	834	856	830
S2945	840	842	770				
S2948	509	508	473				
S2949	628	627	587	543	520	516	520
S2950	890	850					
S2953	800	796	755	734	725	725	734
S2955	810	803	765	729	722	729	733
S2958	772	773	730	690			

Table 18. Decrease in weight (g) of fish starved at 7.0°C.

Tag number	Day of observation							
	Start	10	25	50	100	150	200	250
S2918	599				547	524		
S2919	608				551	543	539	521
S2920	537	499						
S2921	573			544				
S2922	644				569	563	553	
S2923	575				519			
S2924	569				506	487		
S2925	600				556	551	536	
S2928	498			443				
S2929	509				447			
S2930	502		464					
S2931	521				453	443	439	424
S2932	544		503					
S2933	552	517						

Table 19. Decrease in weight (g) of fish starved at 10.0°C.

Tag number	Day of observation							
	Start	10	25	50	100	150	200	250
S2902	543	516						
S2903	574				512	497		
S2904	559				506	494	469	446
S2905	542				499	488		
S2906	576			528				
S2907	593		542					
S2908	532			492				
S2909	611		576					
S2910	549				500			
S2912	613				576	561	529	
S2913	530				483	465	433	
S2914	621				557	542	518	501
S2915	586	548						
S2917	554				510			

weight loss was less for fish in treatment A (43 g or 5.8%) than for fish in treatment B (69 g or 9.4%) ($\alpha = .05$); the condition index dropped from 1.10 and 1.08 to 1.08 and 0.98 in treatments A and B respectively. Not including those fish that were killed throughout the experiment, percent weight losses were 7.8 and 10.9%. However, the means are not statistically different ($\alpha = .05$), partly because of the 150-g weight-loss of fish number S2938 (treatment A).

The changes in energy content were calculated from the mean condition index, using the regressions of Table D2 and Table D3. Mean losses amounted to 600 and 940 kJ in treatments A and B respectively. Not including fish that starved for less than 250 days, mean losses were 780 and 1090 kJ. Interestingly, on a percent basis, these changes in energy content (10.4 and 16.8%) are much larger than the corresponding weight losses (5.8 and 9.4%).

The plots of Figure 7 and Figure 8 show that more than 80% of the total weight loss takes place within the first 100 days in treatments A and B. Then, the curves flatten out. This flattening takes place earlier at the lowest temperature (within 50 days) and later at the next lowest temperature (within 100 days), and is largely responsible for the difference in total weight observed after 250 days. In treatments C and D (Figure 9, Figure 10), there is no such flattening in the curve of weight loss vs time.

PERIODIC CHANGES IN THE CONDITION OF MATURING FISH AND POSTSPAWNERS

Individual charr in the Nauyuk Lake charr population have been shown not to mature 2 years in succession. Periodic changes in the condition of maturing charr and postspawners are examined in this

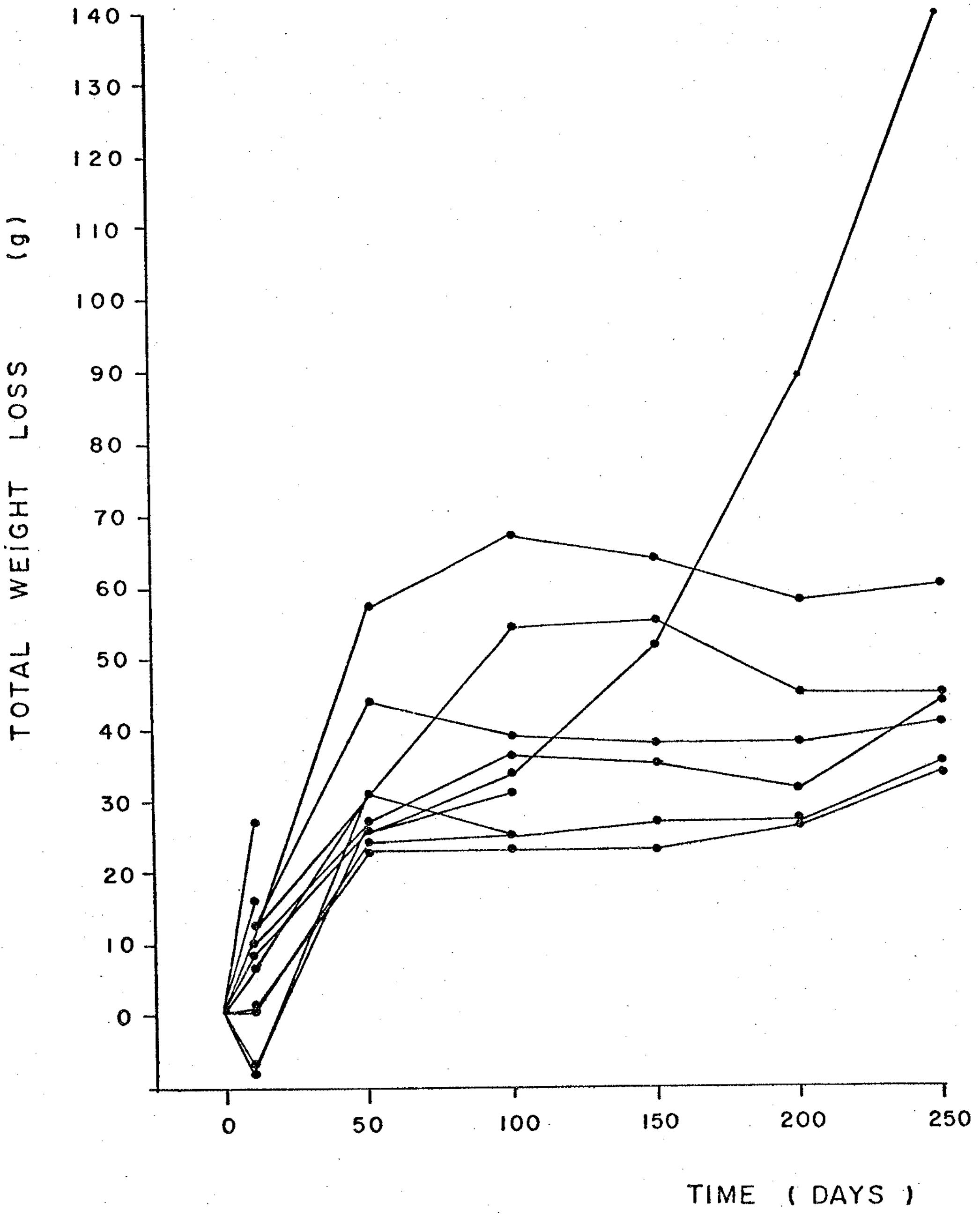

Figure 7. Total weight loss in starved fish in relation to time. Water temperature was 1°C.

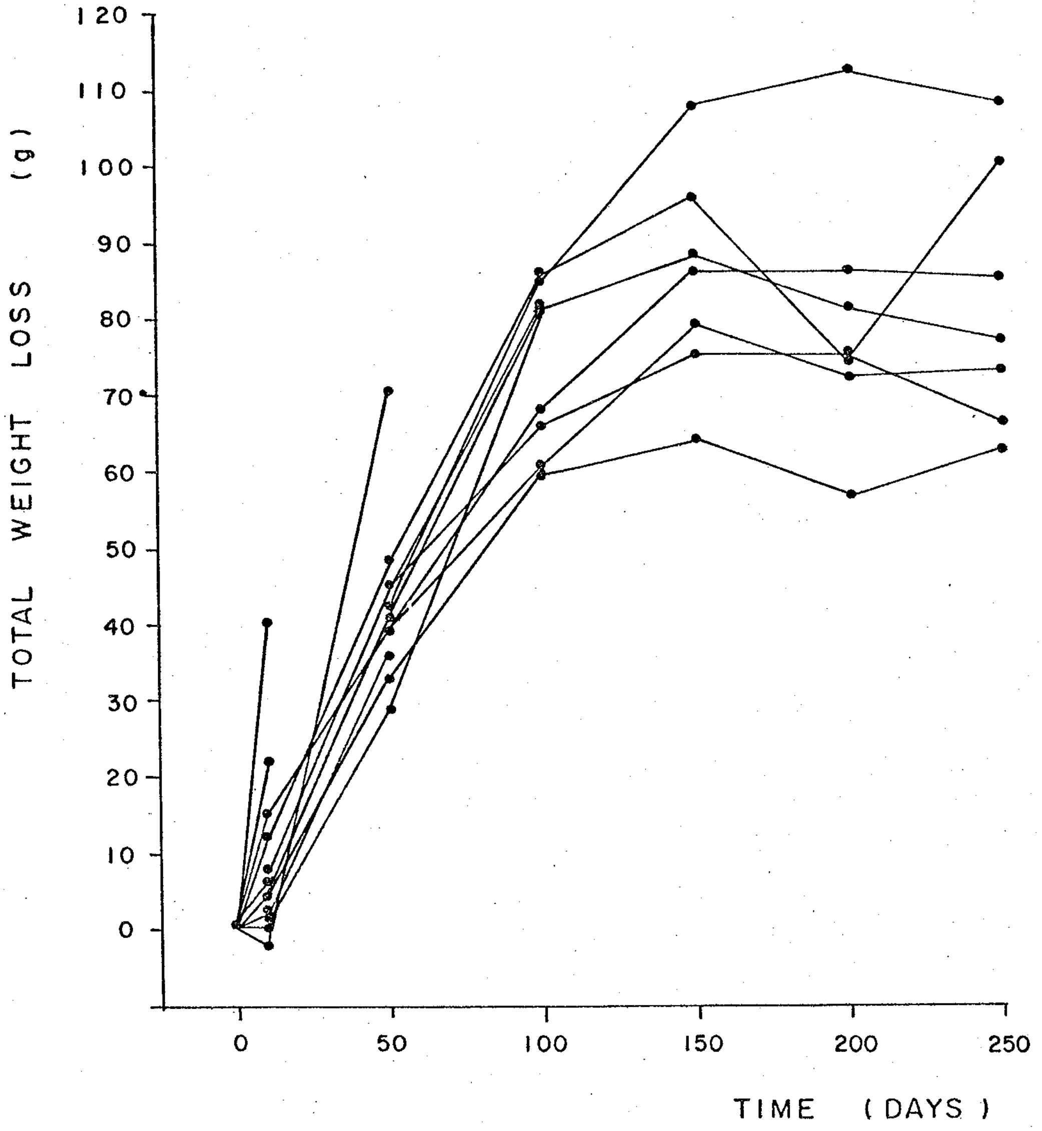

Figure 8. Total weight loss in starved fish in relation to time. Water temperature was 4°C.

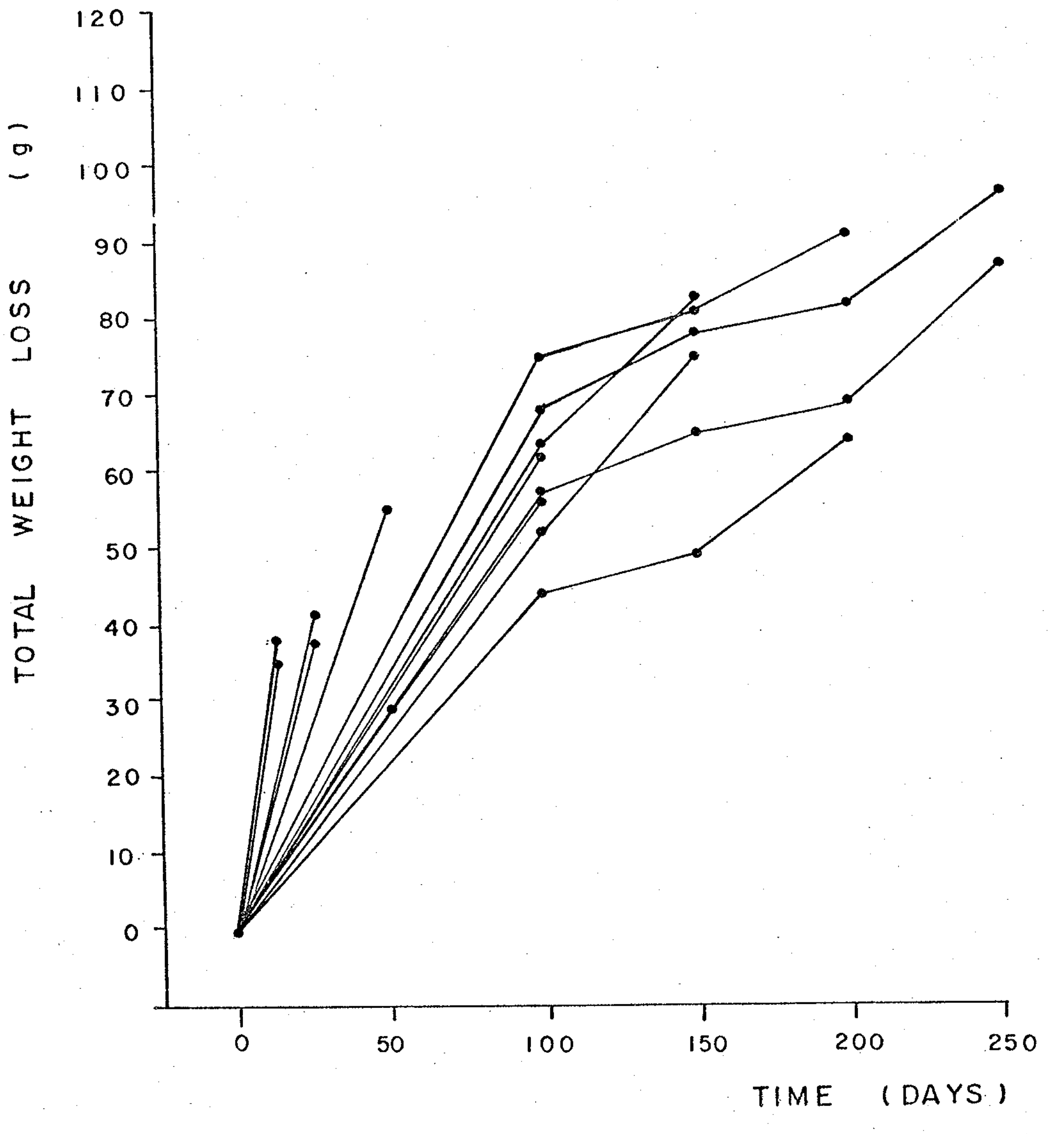

Figure 9. Total weight loss in starved fish in relation to time. Water temperature was 7°C.

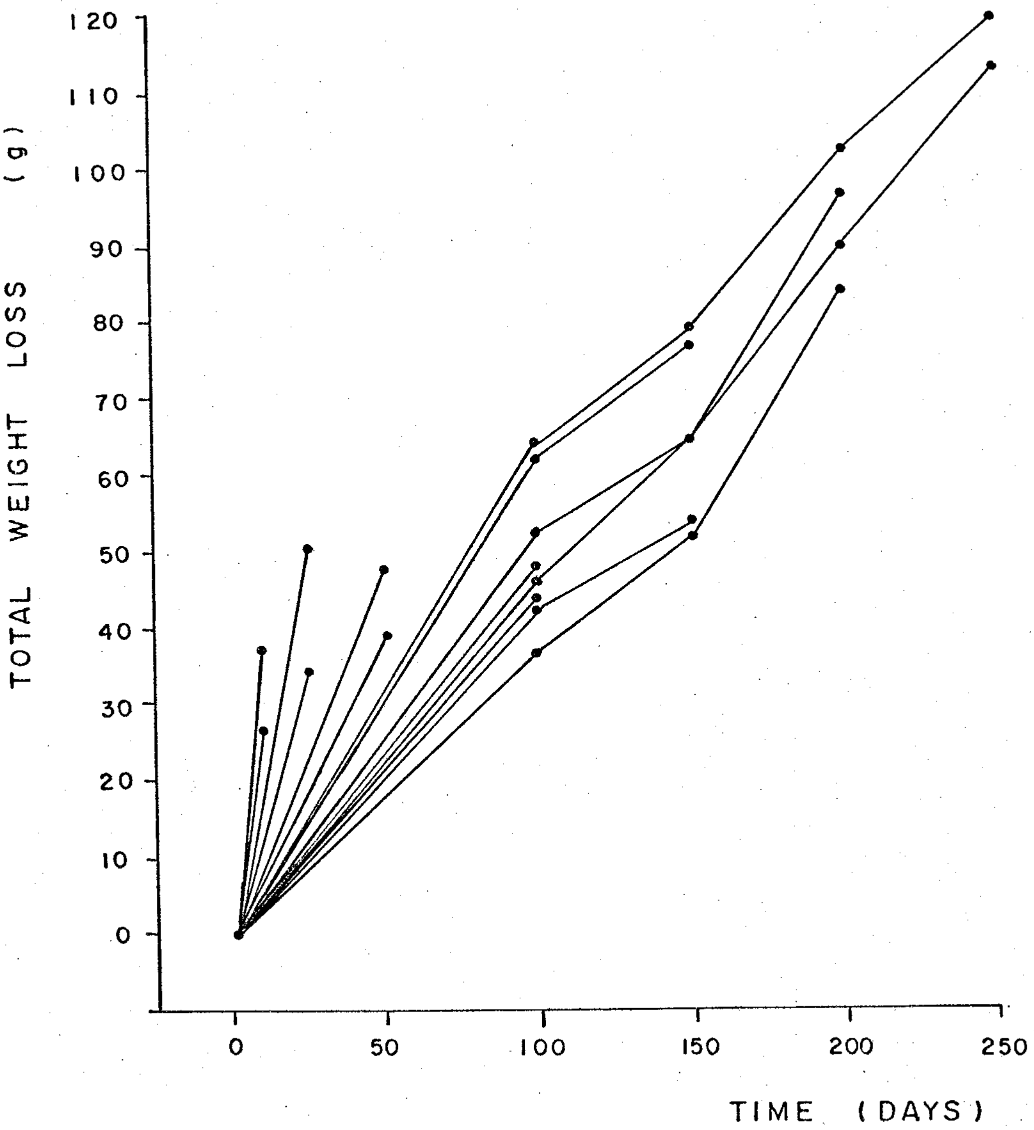

Figure 10. Total weight loss in starved fish in relation to time. Water temperature was 10°C.

section. These changes were then contrasted with periodic changes in the condition of immatures. Making the assumptions that a certain threshold body condition must be reached for the maturation process to be triggered and that that threshold is more or less constant, the possibility that production of gonads drains so much energy as to prevent charr from maturing 2 years in succession was examined.

The body condition of maturing charr moving to Willow Lake in the spring of 1976 is assessed in Table 5. That of postspawners moving down to Nauyuk Lake is assessed in Table 7. Subtracting the data in Table 7 from those in Table 5, the combined costs of maturation and starvation to charr that spawned in 1976-77 can be determined (Table 20): the mean cost is 52%. Thus in 1977, because they had spent the previous summer in Willow Lake and because they had shed gametes in fall 1976, the body condition of postspawners in spring (Table 12, column 3) was poor compared with that of immatures (Table 12, column 7). They contained from 35 to 46% less energy: 35% (550-mm), 38% (600-mm), 46% (650-mm), 46% (700-mm), 43% (750-mm), 37% (800-mm). Yet maturing charr moving to Willow Lake in 1977 (Table 12, column 2) were in a better condition than immatures moving to sea in 1977 (Table 12, column 7); they contained from 15% (550-mm) to 6% (800-mm) more energy. Making the assumption that the latter difference was similar in 1976, this would mean that maturation roughly cost from 6000 KJ for a 550-mm charr to 16000 KJ for a 800-mm charr (Table 12, column 2 minus column 3).

How much time will it take for postspawners to recover? The net effect of the summer feeding migration on postspawners was assessed by subtracting the data in Table 7 from those in Table 8 (Table 21).

Table 20. Mean losses (Δ) incurred by maturing fish due to production of gonads and starvation. W = weight, L = lipids, P = proteins, E = energy.

Length class	ΔW (g)	ΔL (g)	ΔP (g)	ΔE (KJ)
550	559	137	140	8727
600	685	176	172	11025
650	824	220	234	14231
700	978	255	248	15945
750	1146	252	298	17009
800	1327	265	292	17381

Table 21. Summer increase in weight (W), lipid (L), protein (P) and total energy contents in postspawners.

Length class	ΔW (g)	ΔL (g)	ΔP (g)	ΔE (kJ)
550	461	109	112	6957
600	498	128	125	8016
650	523	140	148	9034
700	532	141	137	8814
750	523	117	138	7889
800	494	98	108	6428

Total weight increased most in 700-mm postspawners, but the percent increase decreased with length, smaller fish putting on proportionately more flesh than larger fish. Storage of energy increased to a maximum at 650-mm and then decreased to a minimum at 800-mm.

Storage of energy in postspawners (Table 12, column 4 minus column 3) is contrasted with that in immatures (Table 12, column 6 minus column 7) in Figure 11. Throughout the summer of 1977, postspawners in the 550-600-mm length-classes had partially made up for their lag in condition behind the immatures. Postspawners in the 650, 700, 750 and 800-mm length-classes have seen that lag increase that summer. Therefore in late summer, postspawners still contain less energy than immatures. This difference (Table 12, column 6 minus column 4) is compared with summer storage of energy in immatures (Table 12, column 6 minus column 7) in Figure 12. Recall postspawners cannot be differentiated from immatures more than one year following reproduction. Thus, Figure 12 shows that 650-mm fish require at least another full summer such as that of 1977 to recover (their 1977 summer increase in energy content is equal to the difference in energy content between 650-mm postspawners and immatures in fall). Smaller fish would need less (that difference is smaller) and larger fish would need more (that difference is larger), so that the time needed for postspawners in general to catch up to immatures invariably is more than one year such as 1977.

STORAGE OF ENERGY AND POPULATION STRUCTURE

The modal length of the migratory segment of the charr population (excluding recruits) in the Nauyuk Lake system is close to 600 mm. Proximate analysis data show that this coincides to a peak in reserves of energy contained per gram.

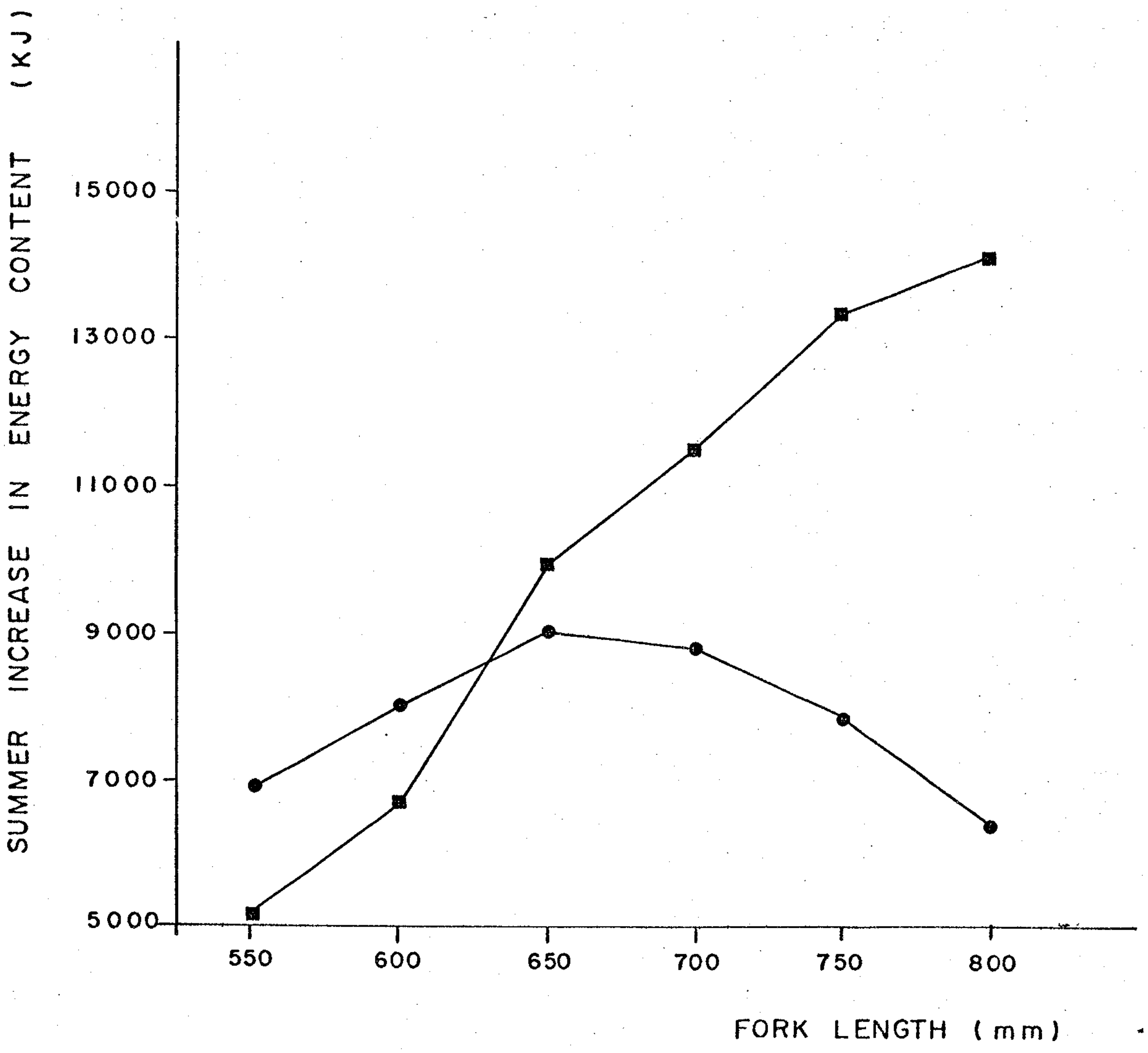

Figure 11. Summer increase in energy content in postspawners (—●—) and in immatures (—■—), in relation to fork length.

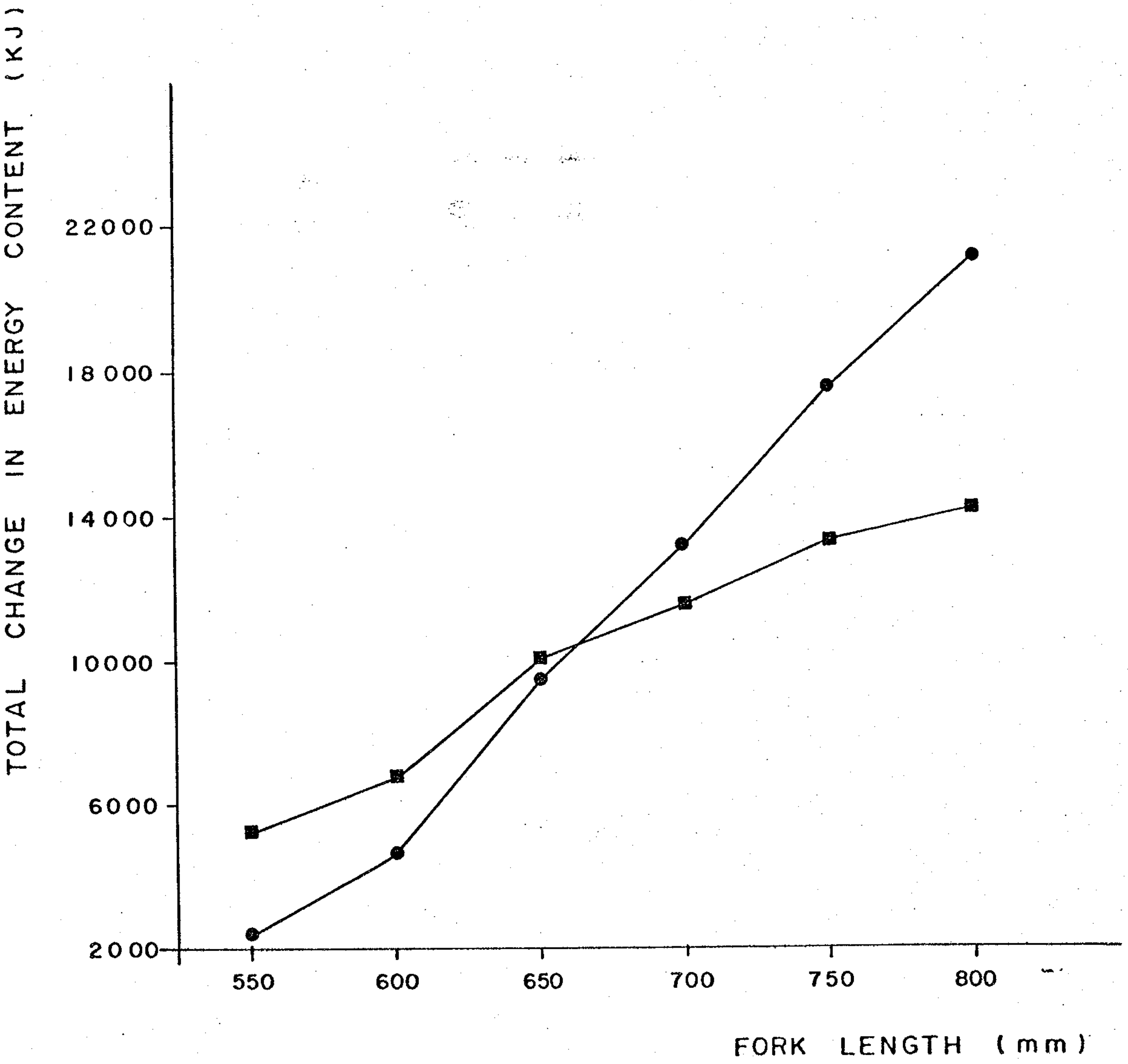

Figure 12. The difference in energy content between postspawners and immatures in fall (—●—) contrasted to the summer increase in energy content of immatures (—▨—), in relation to fork length.

Consider the length-classes (L) of Table 22. Assuming the condition index is 1.00, total weight (W) can be calculated from the relationship: $1.00 = (W/L^3) \times 100$. Lipid and protein contents were calculated from Table D2 and Table D3. Then lipid and protein contents per gram have been calculated by dividing total lipid and total protein contents by total weight. These values were then multiplied by the conversion factors for lipids ($39.54\ \mathrm{KJ\text{-}g^{-1}}$) and proteins ($23.64\ \mathrm{KJ\text{-}g^{-1}}$) (Table 22). Fish in the 600-mm length class had the highest energy content per gram. This peak matches the peak in fat content as protein content was rather constant throughout length-classes. Thus from Table 10 and Table 11, the energy contents per gram can be determined for immatures (Table 23). Charr in the 600-mm length-class had the highest contents. Subtraction reveals that 650-mm charr benefitted the most from summer migration.

RELATIVE CONTRIBUTION OF LIVER AND MUSCLE TO TOTAL RESERVES

The liver

The proximate analysis of the liver has been done separately for 600-mm charr. The results are plotted against condition index in Figures 13 to 16. Moisture content changes with condition index, but the ash content does not. Lipid content also changes with condition index while protein content does not. There is a linear relationship between the logarithm of lipid content in that organ (Y) and condition index X (transformed). Thus for 600-mm charr:

$$Y = -1.47 + 2.23\ X$$

$$n = 26 \qquad r^2 = 0.83$$

Table 22. Calculation of the quantity of energy stored per gram. The condition index is assumed to be 1.00. Thus transformed condition index is 0.89.

Length class	Weight (g)	Lipids (g)	Proteins (g)	Lipids (kJ-g^{-1})	Proteins (kJ-g^{-1})	Total energy (kJ-g^{-1})
220	106	4	30	1.49	6.69	8.18
400	640	44	132	2.72	4.88	7.60
500	1250	91	261	2.88	4.94	7.82
550	1664	151	356	3.59	5.06	8.65
600	2160	221	451	4.05	4.94	8.99
650	2746	245	594	3.53	5.11	8.64
700	3430	308	706	3.55	4.87	8.42
750	4219	345	906	3.23	5.08	8.31
800	5120	504	1022	3.89	4.72	8.61

Table 23. Summer increase in the energy content of immatures.

Length class	Energy ($kJ-g^{-1}$) fall	Energy ($kJ-g^{-1}$) spring	ΔE ($kJ-g^{-1}$)
220	8.70	6.99	1.71
400	8.06	6.55	1.51
500	8.26	7.08	1.18
550	9.18	7.72	1.46
600	9.49	8.19	1.30
650	9.46	7.55	1.91
700	9.10	7.45	1.65
750	8.95	7.51	1.44
800	9.02	8.05	0.97

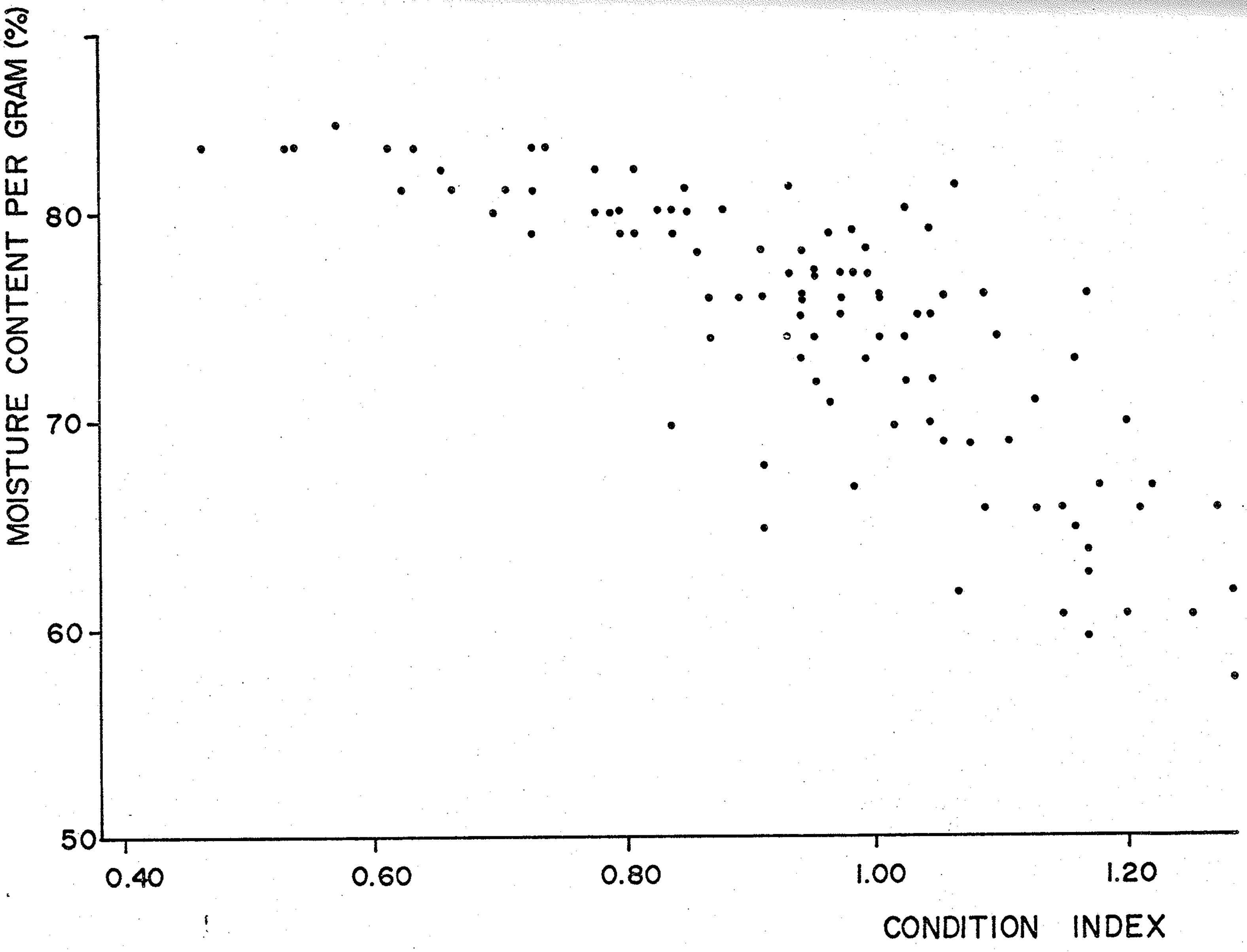

Figure 13. Moisture content per gram of liver in relation to condition index.

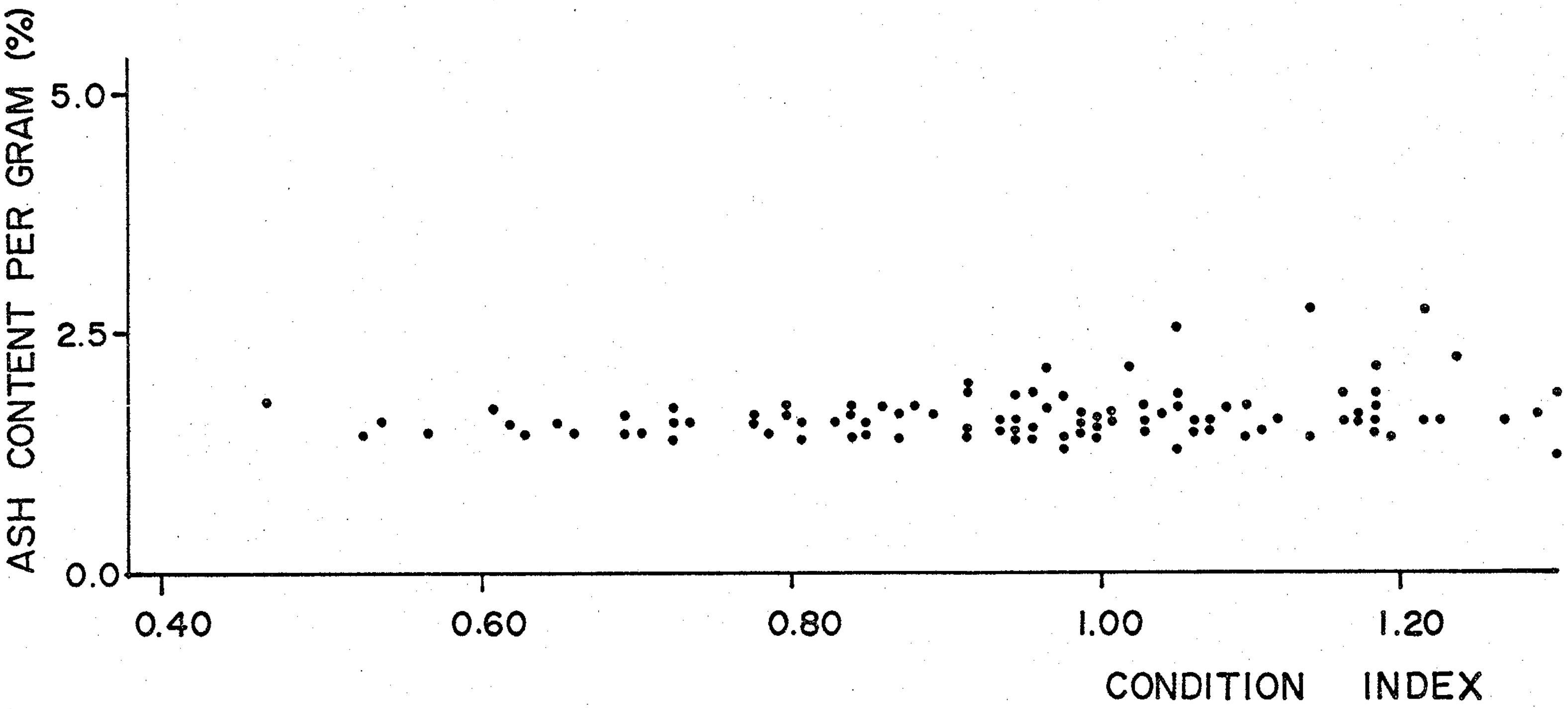

Figure 14. Ash content per gram of liver in relation to condition index.

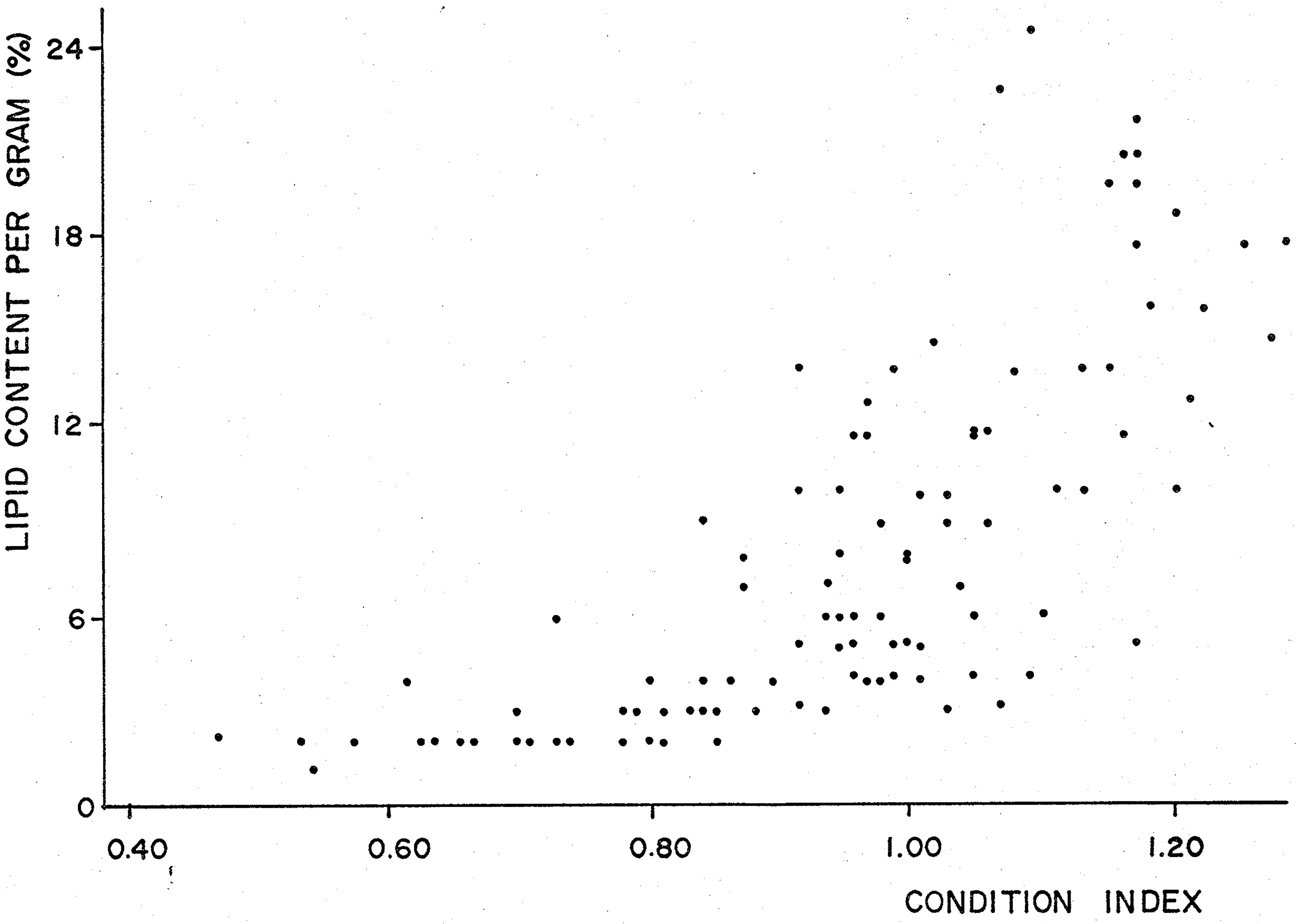

Figure 15. Lipid content per gram of liver in relation to condition index.

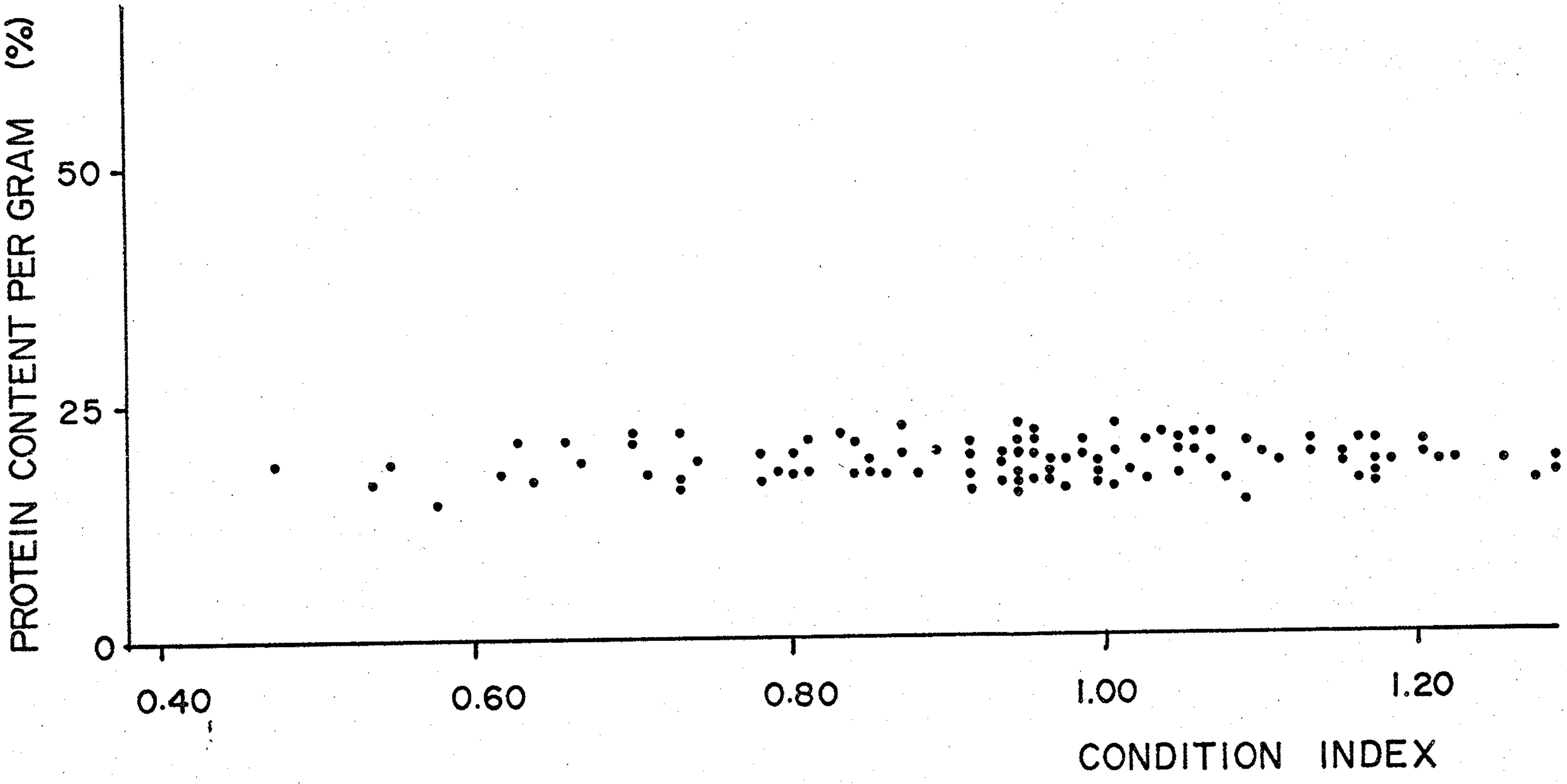

Figure 16. Protein content per gram of liver in relation to condition index.

From the mean condition index values of 600-mm immatures in run VI (moving up Nauyuk R.) (0.98) and run VII (moving down Nauyuk R.) (0.78), storage of lipid in the liver can be calculated: 205 ± 4 kJ and 74 ± 4 kJ ($\alpha = .05$). This was less than 2% of total energy storage.

The contribution of proteins was calculated taking into consideration the fact that there is no relationship between protein content and condition index. From Table C3, the mean protein content of liver is 4.28 ± 0.44 $kJ\text{-}g^{-1}$. Total protein content of liver can be calculated from mean content per gram (4.28 kJ) and liver weight. Liver weight is derived from the linear regression:

$$Y = -4.61 + 1.88\ X$$

$$n = 27 \qquad r^2 = 0.83$$

$Y = \log_{10}$ (liver weight), $X = \log_{10}$ (total weight). The regression was calculated from the data in Table C1 and Table C3 (600-mm length-class). Thus the protein content in the liver of immatures increases from 156 ± 5 kJ to 231 ± 5 kJ ($\alpha = .05$) in summer (1977). This is less than 1% of total change in summer.

The muscle

Since no measurement was made of the total mass of skeletal muscle, the percent lipid and protein contents ($kJ\text{-}g^{-1}$) were considered (Figures 17 and 18). Changes in the lipid and protein contents are coupled with inverse changes in moisture content. Therefore, though changes in the lipid and protein contents do take place, they are not measured accurately on a per gram basis (Figure 19). This bias can be rectified by dividing the data by the total energy content per gram (lipid and protein contents pooled) (Figures 20 and 21).

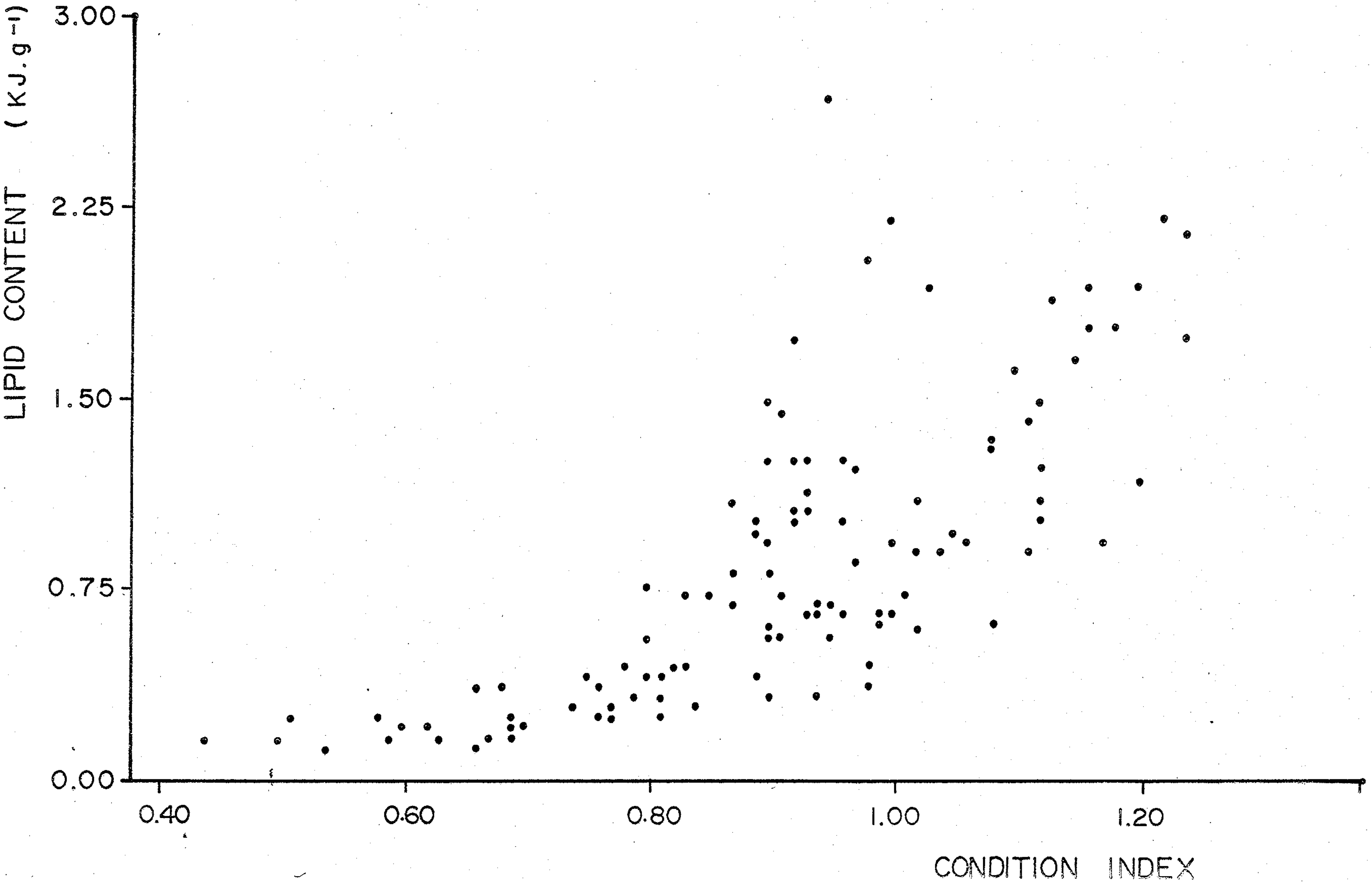

Figure 17. Lipid content as energy content per gram in skeletal muscle in relation to condition index.

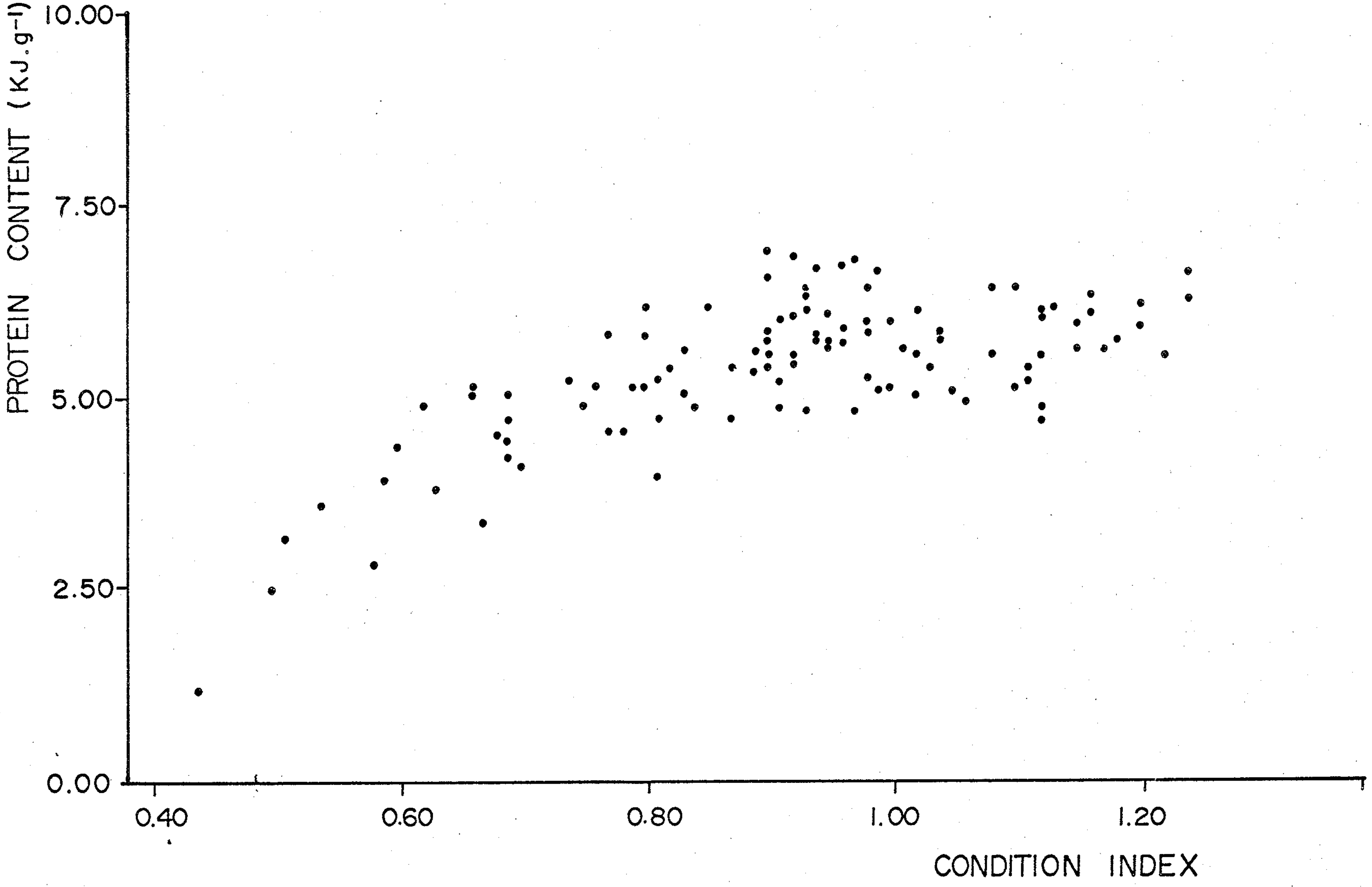

Figure 18. Protein content as energy content per gram in skeletal muscle in relation to condition index.

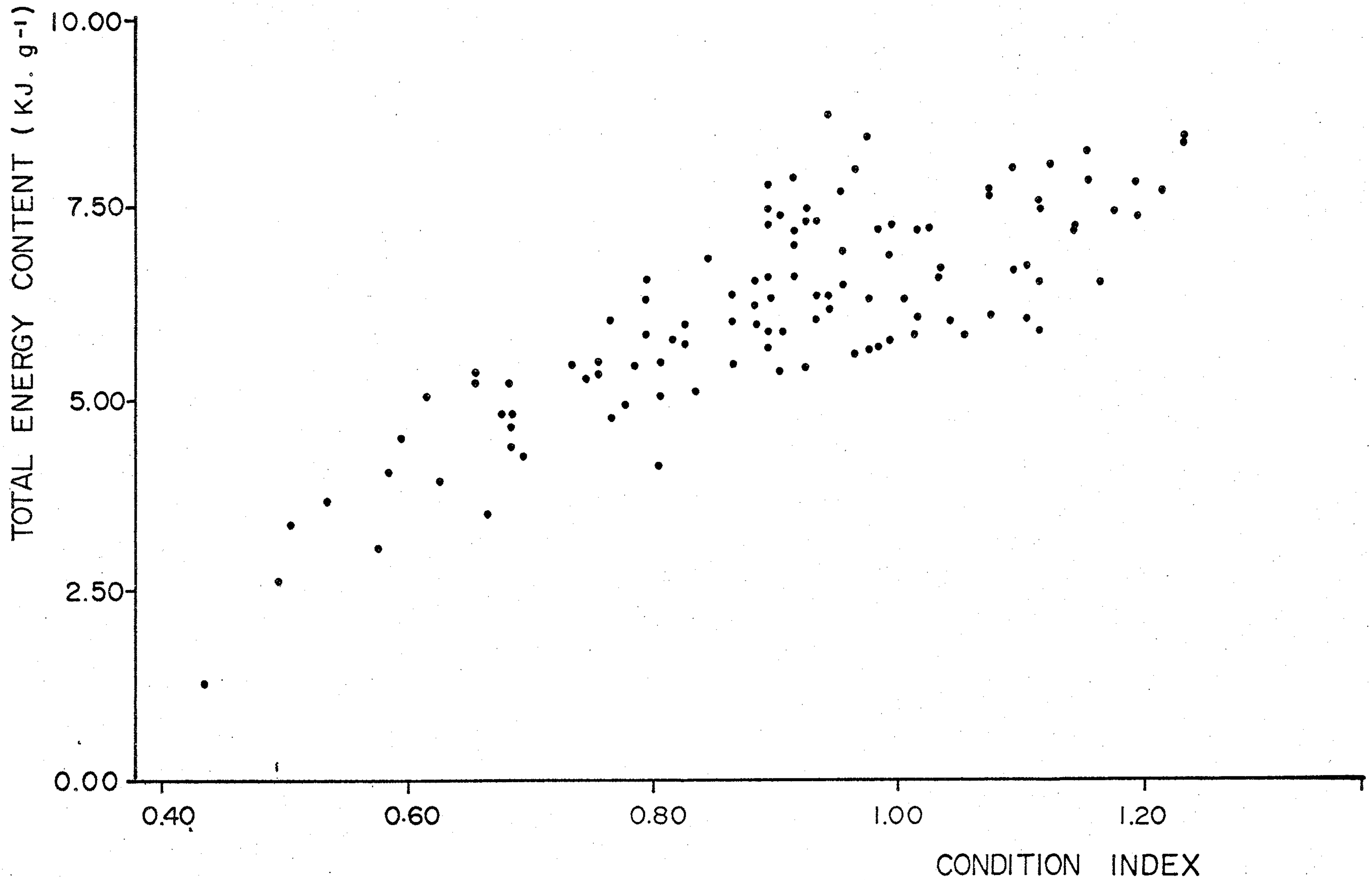

Figure 19. Total energy content per gram in skeletal muscle in relation to condition index.

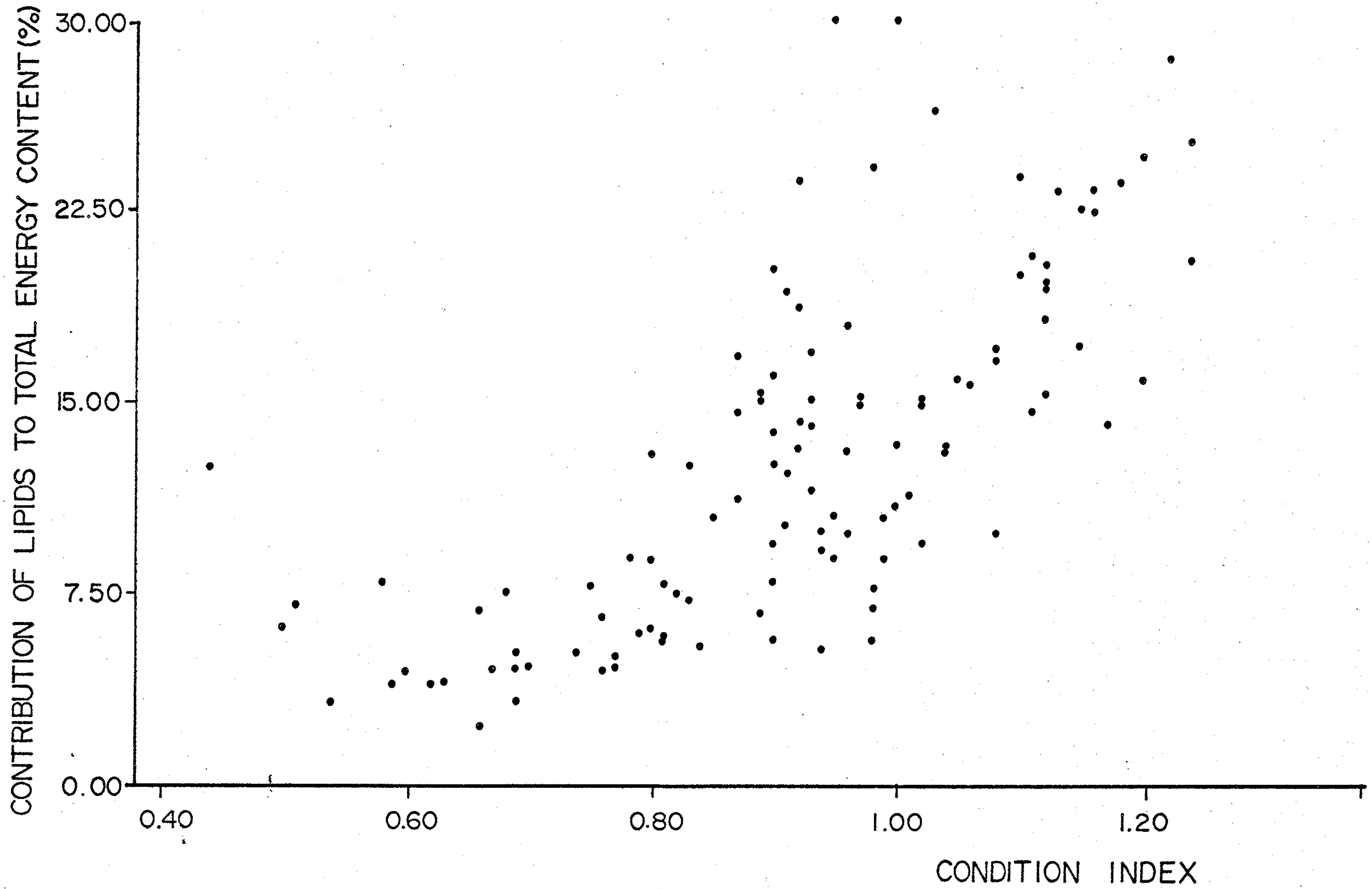

Figure 20. Lipid content as percentage of total energy content in skeletal muscle in relation to condition index.

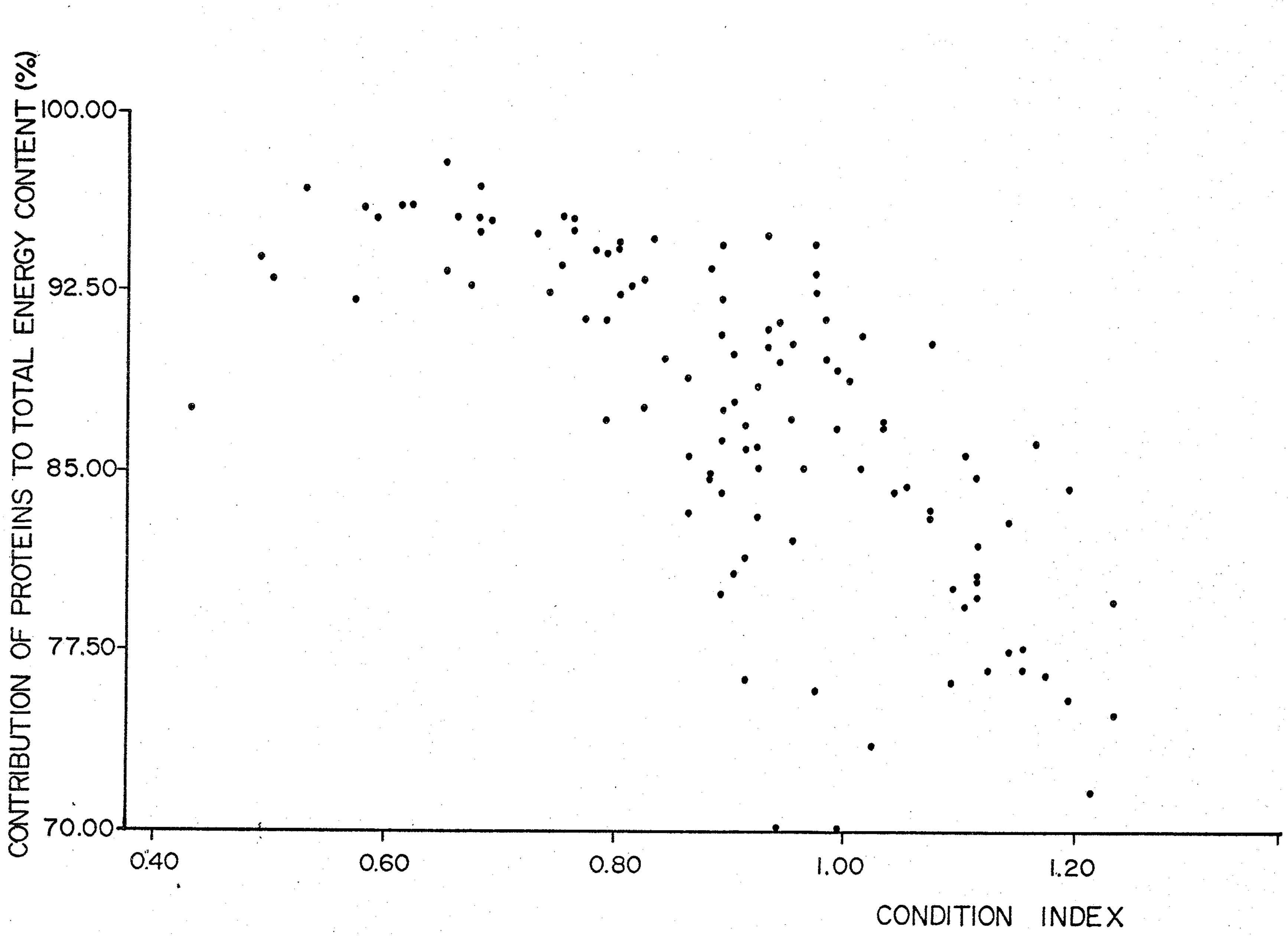

Figure 21. Protein content as percentage of total energy content in skeletal muscle in relation to condition index.

From condition index values of 1.25 to 1.00, the protein content per gram is maintained whereas the lipid content decreases, so that the contribution of proteins to the total content increases while that of lipids decreases. For values of 1.00 to 0.80, both lipids and proteins are mobilized. Since the contribution of proteins to the total content still increases, it is concluded that the contribution of lipids in that range is more significant. From 0.80 to 0.60, protein content decreases rapidly while lipid content decreases slowly. The relative contribution of lipids and proteins is nearly constant. Below 0.60, the lipids that are left cannot be used as a source of energy, while proteins are consumed more intensively as they become the sole source of energy; so, the contribution of proteins to the total energy content decreases while that of lipids increases.

DISCUSSION

The conclusion was reached that the production of gonads generally drains energy reserves to the extent of preventing charr from maturing 2 years in succession, provided a certain threshold body condition must be reached to trigger the maturation of gonads. The conclusion was also reached that the population structure and the variable capacity of charr to store energy are related in such a way that the dominant class (modal length class) in the population is made of charr having the highest energy content per gram. The results leading to these conclusions are discussed below together with incidental results. This is followed by a discussion of the drawbacks of the methodological procedure.

The Nauyuk Lake charr population can be partitioned into 4 categories based on maturity: maturing charr, immature charr, postspawners and resting charr, but the border line between the latter two is to some extent arbitrary: postspawners are considered as resting charr 12 months post spawning. These resting charr could not be differentiated from the immature charr so that they had to be pooled. Nevertheless, pooling charr into less than 4 categories tends to mask the changes that were measured, making the conclusions conservative.

Selecting length-classes inside those categories to cover the total range in length for the migratory segment of the population does not take into consideration concurrent changes in length. Thus it can be biased to some extent. Charr in any length-class were selected on the basis of their condition index to get a wide range in condition index. Since this procedure is not random and because the numbers of samples are small, population statistics were not derived from these data.

Caulton and Bursell (1977) recommend proximate analysis data be related to condition index. They demonstrated that there is a strong correlation between condition index and proximate analysis in *Tilapia rendalli* (a tropical cichlid): they concluded that the use of percentages and the relationship between the moisture content and the lipid content for predicting the latter should be discouraged, since both variables contribute to total weight, the proportion of which is measured. The calculations are based on the postulate that the proximate analysis predicted from the condition index is the same throughout the years, the sexes or the categories.

The energy content was calculated from proximate analysis data and from Brody's (1945) conversion constants. Craig et al. (1978) have shown that calculating the energy content from proximate analysis data and Brody's conversion constants resulted in higher values (by 4%) than from calorimetry. They made corrections for non-protein nitrogen in the proximate analysis data and for nitric acid in the calorimetry data. Not correcting for non-protein nitrogen tends to increase the difference whereas not correcting for nitric acid tends to reduce that difference. Not correcting for these 2 factors resulted in a 4% difference in our data between the 2 methods. Shewan (1951) analysed the non-protein fraction. The percentage ranged from 34-38% in rays (Shewan 1951) to a low 2% for salmonids (Brett et al. 1969).

STARVATION IN THE LABORATORY

Starvation experiments were conducted on 400-mm hatchery-reared immature charr. Temperatures were selected to cover the range in temperatures that charr are likely to meet in the Nauyuk Lake system. Temperatures of 1°C and 4°C match the range in conditions that prevail in lakes 10 months a year. The lowest test temperature is near the lethal limit. Freezing point of body fluids ranges from -0.50°C to -0.65°C (Prosser and Brown 1961). Temperatures of 7°C and 10°C match the summer conditions in the Nauyuk Lake system. They are close to hatchery conditions and much lower than the higher lethal temperatures for salmonids (more than 20°C).

Hatchery charr are resistant to prolonged periods of starvation. No mortalities were recorded in 8 months including the 10°C treatment. Not including those charr killed throughout the experiments, the losses in weight were 7.8% (1°C) and 10.9% (4°C). This means as little as 10.4% and 16.8% decreases in total energy content. Since they have low basal metabolic requirements, fish can tolerate long periods of starvation (Brett and Groves 1979). Love (1958) determined that Gadus morhua (cod) can survive more than 200 days at 9°C. Maturing male Anguilla anguilla (eel) were starved for 3 years (Boëtius and Boëtius 1967). Love (1970) also mentions the case of an individual A. anguilla that was starved for 1515 days at 15°C.

Pattern of catabolism is also related to temperature. Initially, the loss is substantial in all treatments. Then the curve of cumulative loss in weight tends to level out, 50 days from the start at 1°C and 100 days from the start at 4°C. This indicates that catabolism decreased to a minimum level at 1°C and 4°C. There is no such leveling at 7°C and 10°C. The pattern in catabolic rate at 1°C and 4°C is consistent with that monitored by Kaushik and Luquet (1977) who measured the loss in weight and proximate content of muscle in starved Salmo gairdneri and Fromm (1963) and Savitz (1971) who measured the nitrogen excretion rate of starved S. gairdneri and Lepomis macrochirus (bluegill) respectively.

Measured loss in percentage is more substantial in terms of energy than in terms of mass as starvation is associated to an increase in the moisture content of muscle (Creach and Cournede 1965, Dave et al. 1975) due to an increase in the volume of extracellular space (Creach and Gas 1971). However, this moisture gain is less than the decrease in mass caused by the catabolism of body reserves.

Random locomotion contributed to measured losses in some of the treatments. Hatchery charr reduced random locomotion as temperature decreased to 6°C in the preacclimation period. In treatments A (1°C) and B (4°C) charr congregated on the bottom and remained still throughout the 8-month starvation period including tank-cleaning sessions. This was not so in treatments C (7°C) and D (10°C). Physical activity decreases in starvation as demonstrated in oxygen consumption measurements (Beamish 1964b). Temperatures below 6°C markedly reduced random locomotion in _Salmo trutta_ (Elliott 1975a). See also Brett et al. (1958) on Pacific salmon. Temperature is a controlling factor that sets limits to the metabolic rate (Fry 1971). Near 0°C, metabolic rate is much reduced and just meets basal metabolic requirements leaving no room for locomotion.

Hatchery charr ceased to take food as the temperature decreased below 6°C in the preacclimation period. The same tendency has been noted in _S. trutta_ (Lien 1978). Thus charr have to rely on their body reserves to meet their basal metabolic requirements near 0°C. Decreasing temperatures bring on a decrease in the basal metabolic requirements. Maintenance requirements decreased more than 6-fold from 20°C to 1°C in _Oncorhynchus nerka_. The main limiting factor at low temperature may be the rate of digestion. Rate of digestion tends to 0 near 0°C (Brett et al. 1969).

Wohlschlag et al. (1968) demonstrated that there are seasonal changes in the metabolism of charr that were preacclimated to the same test temperature. Thus hatchery charr may have been in a different physical state from that of charr currently following natural cycles in environmental conditions.

STARVATION IN NAUYUK LAKE

Starvation in Nauyuk Lake resulted in a 15 to 18% reduction in the mass of immature charr in a 10-month period for a 30% reduction in their energy content. Taking into consideration the fact that hatchery-reared charr (400-mm length-class) lost 10.4 to 16.8% of their reserve of energy in 8 months, and the empty stomachs that were examined in winter, this 30% loss must be the actual cost of starvation for 400-mm immature charr in a 10-month period. Immature charr in 1977 recovered from that loss in their 2-month summer migration to sea.

This 30% reduction resulted from the catabolism of both lipid and protein reserves. Fish derive their caloric requirements from the proteins in their diet (Gerking 1955). This is not so in starved fish as starvation brings on a decrease in the mass of lipids (Idler and Clemens 1959, Wilkins 1967, Savitz 1971, Caulton 1978) followed by a decrease in the mass of proteins (Templeman and Andrews 1956, Love 1958 and 1970, McBride et al. 1960). Nauyuk Lake charr derived 65% of their metabolic needs from lipids and 35% from proteins. That lipids contribute more energy than proteins to starving fish has been demonstrated in *L. macrochirus* (Savitz 1971) and *Micropterus salmoides* (largemouth bass) (Niimi 1972).

Starving fish derived part of their metabolic requirements from their skeletal muscle. Since the changes in total mass of skeletal muscle were not measured, this can only be discussed in relative terms. For condition index in the range 1.00 to 1.25, charr relied on their lipid reserves; in the range 0.80 to 1.00, charr relied both on their lipid and protein reserves. Caulton (1978) demonstrated the pattern of tissue catabolism to be closely related to condition in S. trutta. Trout in good condition derived 25% of their metabolic needs from proteins. That percentage increased to 65% as the condition of trout decreased to a low level. Parker and Vanstone (1966) demonstrated this pattern in Oncorhynchus gorbuscha. Starving fish convert nitrogenous substances to collagen. This collagen is later catabolized to make up for the low lipid reserves (McBride et al. 1960). These changes in the relative lipid and protein contents of muscle in charr bring an inverse change in the moisture content. This was shown by Creach and Cournede (1965) and Dave et al. (1975). Love (1970) concluded to the reliability of moisture content determinations to measure the condition of fish.

Though the lipid content of the liver ranged from 2.8 to 30% in Nauyuk Lake charr, the liver contributed less than 2% to total energy storage in 600-mm immature charr. In contrast, G. morhua (Love 1958) store their primary reserves of energy in the liver. Similarly to arctic charr, S. trutta did not accumulate much fat in their liver (Swift 1955, Lusk 1969). Salmonids have been shown to store the greater part of their reserves near the pyloric caeca and the intestine (Jensen 1980).

THE CASE OF MATURING CHARR AND POSTSPAWNERS

Provided a certain threshold body condition must be reached to trigger the maturation of gonads, the conclusion is reached that the production of gonads generally drains energy reserves to the extent of preventing charr from maturing 2 years in succession. Individual charr in the Nauyuk Lake system have been shown not to mature 2 years in succession. Though the maturing charr in 1976 started in better condition than the immature charr in June 1976, following spawning and 1 year later, they contained 35 to 46% less energy than the immature charr of that year (1977). Contrasting the postspawners' summer gain in energy with that of the immature charr reveals that postspawners require more than 1 summer migration to the sea (the summer 1977 has not been exceptionally good or bad) to catch up to the immature charr. Smaller postspawners recover more readily. This is also the case in G. morhua (Love 1960).

That a threshold body condition must be reached to initiate the maturation of gonads can be postulated from the literature: Scott (1962), Bagenal (1969), Wootton (1973), Hislop et al. (1978) concluded that restriction of food and thus poor condition resulted in low maturation rate or no maturation. That can also be postulated from the fact that maturing charr are in better condition than the immature charr in June. MacCallum and Regier (personal communication) reached the same conclusion on landlocked charr.

The Nauyuk Lake charr population is similar in characteristics to most northern charr populations (Johnson 1980). Individual charr rarely mature 2 years in succession in northern populations (Miller and Kennedy 1948, Sprules 1952, Healey 1978). Maturing charr do not have access to Willow Lake past late July and consequently they cannot go to sea the year they produce gonads; this has little consequence since in many stocks, charr do not migrate to sea in the year they spawn (Moore 1975). Since charr have to be killed to determine their sex and because current research programs in Nauyuk Lake precluded killing many, partitioning charr on the basis of their sex was not possible. The sex ratio in some spawning runs can be as high as 10M to 1F. Following the production of gonads, males tend to become the less skinny (Love 1970, Craig 1977, Lien 1978). This may not be so in the Nauyuk Lake charr population (Johnson, personal communication).

The range in lipid content measured in charr is consistent with those previously reported in the literature (Niimi and Beamish 1974), but is much less than the 1-30% variation measured in herring (Wilkins 1967). Seasonal variations of protein content on the other hand are much larger than those reported in the literature (Niimi 1972, Niimi and Beamish 1974, Elliott 1976). Medium-size postspawners have the lowest lipid and protein contents (1.4% and 17.6% in June). Medium-size immature charr have the highest contents in fall (11.2% and 22.4%). The contents of a 700-mm female postspawner in poor condition were 0.5% and 13.6%. Highest contents were those of a 700-mm male immature charr returning from the sea: 13.8% and 25.0%. That charr store large reserves of energy is consistent with Slobodkin and Richman's (1961) conclusion that animals having to go through long periods of starvation store large reserves of energy.

The possibility for charr, particularly postspawners, to survive long periods of starvation, tells us nothing concerning their capacity to recover. To recover, postspawners still need their reserves of energy to meet their basal metabolic requirements, move to sea and chase food. Therefore there must be a limit beyond which no recovery is possible.

THE NATURE OF LIMITATIONS TO PRODUCTION OF GONADS

The above conclusions are relevant to current theories on life-history strategies, not in that they corroborate or not the predictions of the models (Stearns 1976) but rather in that they indicate their limitations. The Nauyuk Lake charr population is similar in characteristics to most northern charr populations. Their structure has been described and thoroughly discussed by Johnson (1972, 1976, 1980), though the mechanism that maintains the structure is still debated (Johnson 1976, Power 1978, Healey 1980). That structure persists through time and is regained following perturbation. This lead Johnson (1981) to conclude that there is cohesion in individual populations. This cohesion is mediated through life-history traits. Stochastic and deterministic models postulate that these traits join into strategies to solve particular problems in particular situations (Stearns 1976). That individual traits have been linked together through natural selection has not been demonstrated. Stearns (1976) states that individual traits may rather interact more with physiological traits. Nauyuk Lake charr are K-strategists and their mortality rate likely is most variable in juvenile stages. The models predict that in such a situation the number of times that a female breeds increases (Dobzhansky 1950, MacArthur 1962, Lewontin 1965, Pianka 1970, Murphy 1968, Schaffer 1974). That prediction is not consistent with the conclusion that individual charr in the Nauyuk Lake charr population rarely mature 2 years in succession. Since the 2-month migration to sea does not permit the full recovery of postspawners in time, the duration of summer becomes the limiting factor to the production of gonads, thus preventing the expression of this trait.

The dominant class (modal length-class) in the population is made of charr having the highest energy content per gram. Modal length is likely to be a function of resources in the environment (Clarke 1979). Thus, this particularity of modal length charr must contribute to their dominance in the population or follow from a set of traits that make them the dominant class in the population. The energy content is likely to be involved in a mechanism that permits the start or the continuation of the process that leads to the production of gonads, provided the environmental conditions have triggered the release of hormones that control that production (Hoar 1969, Liley 1969). The nature of that mechanism is not known.

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APPENDIX A

DESCRIPTION OF THE METHOD USED TO DETERMINE THE NITROGEN CONTENT

Prepare the digestion mixture. Weigh 10 g of potassium sulphate into a 100-ml volumetric flask. Add 10 ml of distilled water and 50 ml of concentrated sulphuric acid. Add 0.10 g of selenium and mix. Cool and make to 100 ml with sulphuric acid.

Prepare the color reagent. Dissolve 50 g of reagent grade phenol and 0.25 g of reagent grade sodium nitroprusside in distilled water, and make to one litre. Prepare the alkaline hypochlorite reagent. Dissolve 25 g of reagent grade sodium hydroxide and 2.1 g of sodium hypochlorite in distilled water, and make to one litre.

Weigh sample to within one milligram in a tared 250-ml volumetric flask. Add 1.0 ml of concentrated sulphuric acid. Heat to charring. Add 30% hydrogen peroxide until clear. Cool and dilute to 100 ml with distilled water. Take an aliquot of stock nitrogen standard (500 kg NH_3-N ml^{-1}) and add to a test tube. Take a 0.5-ml aliquot of the digest and add to a test tube. Use an empty tube as a blank. Add 0.5 ml of 30% hydrogen peroxide and 0.5 ml of digestion mixture to each tube. Place test tubes in a heating block and heat samples to 150°C for 30 minutes, and then, to 320°C for two hours. Remove test tubes and cool. Add 10 ml of distilled water and mix. Take a 0.5 ml aliquot from each tube and add to new test tubes. Add 4.0 ml of the color reagent and then 4.0 ml of the alkaline hypochlorite reagent and mix. Read absorbance at a wavelength of 630 nm. The absorbance of the blank is used to correct the absorbance of the standard and that of the unknown.

The nitrogen content of the aliquot is calculated from the equation of the calibration curve. The total nitrogen content is obtained by multiplying the nitrogen content of the aliquot by the volume of the solution (250 ml) and dividing by the volume of the aliquot (0.5 ml).

APPENDIX B

DESCRIPTION OF THE COLORIMETRIC METHOD USED TO DETERMINE THE LIPID CONTENT.

Weigh sample to within 1 mg in a tared 50-ml Erlenmeyer flask. Add 5.0 ml of chloroform, 10.0 ml of methanol and 2.4 ml of water to the sample and homogenize for 2 seconds with a Polytron. Add 5.0 ml of water and homogenize for 10 seconds. Filter through a Coors' Buchner funnel into a 25 ml graduate cylinder using Whatman no 1 filter paper. The filtrate will separate into two layers. The methanolic layer is at the surface and the chloroform layer containing the lipids is at the bottom. Measure the volume of the chloroform layer and aspirate the surface layer.

Pipette 0.100 and 0.200 ml of standard (one gram of oleic acid diluted to 100 ml with chloroform) into test tubes. Also pipette an aliquot of the chloroform layer into a test tube. The volume of aliquot required may range from 0.025 to 0.200 ml depending on the lipid content of the sample. Evaporate the chloroform contained in the test tubes under a stream of air. To each tube, including a blank, add 2.0 ml of potassium dichromate (0.167 M) and 4.0 ml of concentrated sulphuric acid. Mix and place in an oven at 115°C for 30 minutes. Cool for three minutes at room temperature. Add 20.0 ml of distilled water and mix. Read absorbance at a wavelength of 600 nm.

The lipid content of the aliquot is calculated from the equation of the calibration curve. Multiplying the lipid content of the aliquot by the volume of the bottom layer and dividing by the volume of the aliquot, the total lipid content of the sample is obtained.

APPENDIX C

THE PROXIMATE ANALYSIS DATA

Table C1. Length weight and condition index*

Sample number	Length (mm)	Weight (g)	Condition index
WCD18001	173	42	0.811
WCD18002	180	47	0.737
WCD18003	178	49	0.887
WCD18004	187	49	0.780
WCD21001	200	64	0.788
WCD21002	200	61	0.725
WCD21003	215	78	0.765
WCD21004	211	76	0.809
WCD24001	234	96	0.749
WCD24002	236	115	0.883
WCD24003	237	114	0.856
WCD24004	241	118	0.843
WCD55001	540	946	0.635
WCD55002	544	1066	0.714
WCD60001	583	1068	0.606
WCD60002	605	1392	0.677
WCD60003	590	1231	0.621
WCD60004	616	1541	0.685
WCD65001	661	1566	0.597
WCD65002	660	1976	0.713
WCD65003	661	1914	0.710
WCD65004	643	1292	0.517
WCD65005	654	2067	0.786
WCD70001	715	2303	0.650
WCD70002	706	2607	0.789
WCD70003	692	2225	0.717
WCD70004	698	2624	0.831
WCD70005	692	3155	0.972
WCD70006	710	1550	0.455
WCD75001	753	2967	0.714
WCD75002	763	3375	0.760
WCD75003	758	2231	0.563
WCD75004	748	2556	0.687
WCU55001	557	1435	0.868
WCU55002	548	1549	0.987
WCU60001	606	2153	1.022
WCU60002	603	1895	0.935
WCU60003	605	2029	0.937

APPENDIX C

THE PROXIMATE ANALYSIS DATA

Table C1. Length weight and condition index* (continued)

Sample number	Length (mm)	Weight (g)	Condition index
WCU60004	593	1888	0.935
WCU60005	607	2080	0.930
WCU65001	663	2557	0.926
WCU65002	661	2847	1.004
WCU65003	653	2516	0.952
WCU65004	642	2413	0.954
WCU70001	690	3207	1.050
WCU70002	695	3176	0.976
WCU70003	702	2817	0.824
WCU70004	687	2909	0.925
WCU70005	693	3450	1.082
WCU75001	766	4242	0.968
WCU75002	762	3936	0.927
WCU80001	806	4720	0.921
NRD18001	175	36	0.709
NRD18002	183	44	0.767
NRD21001	207	66	0.789
NRD21002	216	62	0.635
NRD21003	205	57	0.662
NRD21004	211	66	0.735
NRD24001	235	102	0.824
NRD24002	235	113	0.871
NRD24003	242	107	0.769
NRD40001	410	561	0.842
NRD40002	409	528	0.818
NRD40003	400	476	0.781
NRD40004	403	549	0.856
NRD50001	509	1196	0.940
NRD50002	502	1133	0.917
NRD50003	491	1040	0.912
NRD50004	505	1064	0.854
NRD50005	499	1188	0.982
NRD50006	505	1004	0.808
NRD50007	493	1169	1.001
NRD60001	592	2294	1.128
NRD60003	597	2062	0.982
NRD60004	593	2075	1.007
NRD60005	596	1584	0.775

APPENDIX C

THE PROXIMATE ANALYSIS DATA

Table C1. Length weight and condition index* (continued)

Sample number	Length (mm)	Weight (g)	Condition index
NRD60006	604	1965	0.917
NRD60007	590	1705	0.847
NRD70002	690	3057	0.953
NRD70003	694	2946	0.909
NRD70004	690	3120	0.950
NRD70006	712	3619	1.020
NRD80002	798	5120	1.031
NRD80003	790	4797	0.998
NRD80004	801	2701	0.529
NRU21001	214	93	0.980
NRU21002	206	91	1.110
NRU24001	245	136	0.952
NRU24002	242	142	1.044
NRU40001	406	756	1.136
NRU40002	415	760	1.063
NRU40003	399	720	1.133
NRU40004	395	701	1.136
NRU40005	413	825	1.192
NRU40006	391	643	1.104
NRU50001	506	1367	1.088
NRU50002	492	1339	1.142
NRU50003	501	1456	1.185
NRU50004	499	1432	1.223
NRU50005	492	1225	1.041
NRU50006	501	1475	1.201
NRU60001	595	2515	1.225
NRU60002	598	2427	1.141
NRU60003	591	2308	1.124
NRU60004	613	2672	1.176
NRU60005	600	2643	1.245
NRU60006	615	2907	1.264
NRU70001	687	3505	1.095
NRU70002	702	3649	1.070
NRU70003	697	3725	1.116
NRU70004	700	3955	1.166
NRU70005	708	3878	1.099
NRU70006	688	4109	1.265

APPENDIX C

THE PROXIMATE ANALYSIS DATA

Table C1. Length weight and condition index* (continued)

Sample number	Length (mm)	Weight (g)	Condition index
NRU80001	814	6134	1.150
NRU80002	790	5696	1.168
NRU60011	600	2188	1.028
NRU60012	600	2040	0.963
NRU60013	608	2017	0.917
NRU60014	605	2210	1.007
NRU65011	660	2741	0.967
NRU65012	638	2452	0.955
NRU65013	650	2450	0.892
NRU70011	702	3001	0.887
NRU70012	717	3310	0.912
NRU70013	694	2925	0.886
NRU75011	768	4092	0.923
NRU75012	739	3665	0.927
NRU75013	746	3357	0.821
NRU75014	740	3638	0.923
NRUS01	715	3681	1.015
NRUS02	620	2096	0.890
NRUS03	707	3274	0.962
NRUS04	726	3864	1.040
NRUS05	599	2465	1.145
NRUS06	552	1787	1.058

* Condition index values are based on fish weights as measured in the field; these weights are not included in this table.

APPENDIX C

THE PROXIMATE ANALYSIS DATA

Table C2. Proximate analysis of the gonads.

Sample number	Weight of gonads (g)	Moisture ($g{-}g^{-1}$)	Ash ($g{-}g^{-1}$)	Lipids ($g{-}g^{-1}$)	Proteins ($g{-}g^{-1}$)
WCD18001	0.013	.615			
WCD18002	0.040	.725			
WCD18003	0.142	.817			
WCD18004	0.021	.714			
WCD21001	0.030	.733			
WCD21002	0.132	.826			
WCD21003	0.022	.682			
WCD21004	0.153	.810			
WCD24001	0.230	.822			
WCD24002	0.070	.743			
WCD24003	0.032	.719			
WCD24004	0.038	.684			
WCD55001	6.892	.809	.010	.039	.127
WCD55002	12.374	.852	.010	.022	.071
WCD60001	8.247	.811	.011	.024	.158
WCD60002	11.555	.841	.011	.020	.126
WCD60003	16.369	.859	.011	.025	.060
WCD60004	12.758	.801	.011	.042	.117
WCD65001	11.889	.867	.012	.014	.102
WCD65002	16.115	.853	.012	.017	.133
WCD65003	24.804	.836	.011	.020	.099
WCD65004	16.318	.850	.011	.010	.078
WCD65005	14.435	.807	.011	.028	.117
WCD70001	2.777	.801	.013	---	---
WCD70002	23.872	.799	.012	.037	.130
WCD70003	21.356	.795	.012	.030	.131
WCD70004	12.860	.821	.012	.016	.141
WCD70005	48.573	.835	.012	.015	.099
WCD70006	15.181	.922	.007	.012	.055
WCD75001	63.545	.785	.012	.043	.146
WCD75002	39.681	.816	.014	.036	.129
WCD75003	2.270	---	---	---	.181
WCD75004	6.236	.830	.012	.010	.181
WCU55001	46.126	.681	---	.082	.152
WCU55002	49.129	.644	---	.082	.166
WCU60001	77.361	.682	.017	.074	.219
WCU60002	52.827	.708	.017	.068	.208
WCU60003	64.692	.648	.019	.086	.239

APPENDIX C

THE PROXIMATE ANALYSIS DATA

Table C2. Proximate analysis of the gonads (continued).

Sample number	Weight of gonads (g)	Moisture $(g\text{-}g^{-1})$	Ash $(g\text{-}g^{-1})$	Lipids $(g\text{-}g^{-1})$	Proteins $(g\text{-}g^{-1})$
WCU60004	59.902	.665	.020	.078	.182
WCU60005	63.099	.679	---	.066	.159
WCU65001	18.075	.799	.017	.032	.153
WCU65002	42.039	.814	.019	.023	.147
WCU65003	125.816	.636	---	.079	.179
WCU65004	68.297	.693	.018	.073	.189
WCU70001	44.159	.808	.019	.027	.159
WCU70002	30.278	.820	---	.019	.155
WCU70003	94.077	.663	.017	.069	.237
WCU70004	71.892	.703	.015	.070	.150
WCU70005	63.186	.689	.013	.072	.205
WCU75001	58.996	.813	.020	.027	.144
WCU75002	41.362	.807	.020	.031	.126
WCU80001	52.250	.814	.017	.022	.143
NRD18001	0.056	.839			
NRD18002	0.014	.643			
NRD21001	0.018	.722			
NRD21002	0.017	.706			
NRD21003	0.107	.841			
NRD21004	0.022	.727			
NRD24001	0.019	.737			
NRD24002	0.141	.823			
NRD24003	0.152	.829			
NRD40001	0.174	.730			
NRD40002	0.163	.712			
NRD40003	1.221	.821			
NRD40004	0.171	.749			
NRD50001	10.792	.787	.012	.052	.130
NRD50002	6.067	.789	.012	.038	.153
NRD50003	0.623	.748	---	---	---
NRD50004	0.517	.723	---	---	---
NRD50005	7.709	.768	.012	.038	.153
NRD50006	4.856	.804	.012	.038	.153
NRD50007	16.025	.823	.012	.056	.119
NRD60001	36.311	.739	.013	.110	.204
NRD60003	25.650	.789	.011	.055	.125
NRD60004	1.669	.756	.017	.022	.198
NRD60005	1.306	.765	.017	.022	.198

APPENDIX C

THE PROXIMATE ANALYSIS DATA

Table C2. Proximate analysis of the gonads (continued).

Sample number	Weight of gonads (g)	Moisture ($g\text{-}g^{-1}$)	Ash ($g\text{-}g^{-1}$)	Lipids ($g\text{-}g^{-1}$)	Proteins ($g\text{-}g^{-1}$)
NRD60006	1.652	.756	.017	.022	.198
NRD60007	1.081	.759	.017	.022	.198
NRD70002	4.866	.786	.022	.027	.179
NRD70003	2.973	.806	.022	.027	.179
NRD70004	36.190	.808	.011	.072	.110
NRD70006	4.861	.785	.022	.027	.179
NRD80002	12.935	.800	.017	.032	.149
NRD80003	9.587	.808	.017	.021	.183
NRD80004	4.846	.829	.017	.022	.172
NRU21001	0.012	.500			
NRU21002	0.097	.825			
NRU24001	0.211	.848			
NRU24002	0.130	.854			
NRU40001	0.250	.712			
NRU40002	2.428	.794			
NRU40003	0.260	.746			
NRU40004	1.084	.822			
NRU40005	0.994	.833			
NRU40006	0.250	.728			
NRU50001	5.404	.776			
NRU50002	4.881	.749	.013	.034	.141
NRU50003	0.813	.763	---	---	---
NRU50004	0.839	.778	---	---	---
NRU50005	6.420	.788	.013	.034	.141
NRU50006	0.589	.694	---	---	---
NRU60001	21.852	.759	.012	.073	.131
NRU60002	19.473	.766	.012	.060	.122
NRU60003	1.666	.768	---	.026	.207
NRU60004	16.381	.756	.013	.054	.128
NRU60005 M	0.223	.596	---	---	---
NRU60005 F	15.775	.720	.010	.099	.136
NRU60006	22.068	.782	.012	.060	.129
NRU70001	2.066	.736	.020	.030	.203
NRU70002	3.798	.757	.020	.030	.203
NRU70003	3.161	.735	.020	.030	.203
NRU70004	3.598	.736	.020	.030	.203
NRU70005	2.850	.770	.020	.030	.203
NRU70006	5.195	.748	.020	.030	.203

APPENDIX C

THE PROXIMATE ANALYSIS DATA

Table C2. Proximate analysis of the gonads (continued).

Sample number	Weight of gonads (g)	Moisture ($g-g^{-1}$)	Ash ($g-g^{-1}$)	Lipids ($g-g^{-1}$)	Proteins ($g-g^{-1}$)
NRU80001	8.928	.781	.014	.026	.186
NRU80002	5.151	.768	.014	.026	.186
NRU60011	20.685	.752	.012	---	.168
NRU60012	15.765	.800	.010	.034	.127
NRU60013	20.649	.780	.010	.054	.128
NRU60014	16.024	.760	.011	.042	.122
NRU65011	25.760	.814	.012	.050	.135
NRU65012	17.370	.775	.012	.038	.132
NRU65013	17.918	.804	.010	.032	.111
NRU70011	20.125	.798	.011	.037	.143
NRU70012	24.651	.800	.012	.042	.136
NRU70013	25.394	.805	.011	.024	.125
NRU75011	42.897	.802	.012	.060	.137
NRU75012	33.301	.790	.011	.048	.129
NRU75013	22.355	.782	.012	.044	.146
NRU75014	41.690	.802	.012	.037	.133
NRUS01	70.557	.756	.040	.037	.218
NRUS02	329.60	.629	---	.077	.272
NRUS03	55.564	.708	.050	.043	.245
NRUS04	84.900	.727	.035	.038	.215
NRUS05	268.82	.644	---	.076	.167
NRUS06	237.80	.638	---	.077	.270

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THE PROXIMATE ANALYSIS DATA

Table C3. Proximate analysis of the liver.

Sample number	Weight of liver (g)	Moisture $(g\text{-}g^{-1})$	Ash $(g\text{-}g^{-1})$	Lipids $(g\text{-}g^{-1})$	Proteins $(g\text{-}g^{-1})$
WCD18001	0.698	.811			
WCD18002	0.587	.807			
WCD18003	0.788	.812			
WCD18004	0.838	.802			
WCD21001	1.237	.810	.014	.030	.168
WCD21002	1.009	.788	.014	.030	.168
WCD21003	1.191	.778	.014	.030	.168
WCD21004	1.427	.778	.014	.030	.168
WCD24001	1.730	.798	.014	.030	.168
WCD24002	2.043	.790	.014	.030	.168
WCD24003	1.680	.776	.014	.030	.168
WCD24004	1.868	.791	.014	.030	.168
WCD55001	13.304	.810	.015	.024	.202
WCD55002	15.226	.799	.015	.022	.154
WCD60001	13.808	.805	.015	.022	.199
WCD60002	17.355	.791	.016	.022	.196
WCD60003	21.649	.816	.014	.022	.159
WCD60004	25.040	.791	.014	.027	.214
WCD65001	23.170	.817	.017	.041	.168
WCD65002	51.638	.824	.013	.017	.155
WCD65003	37.247	.816	.015	.063	.159
WCD65004	17.022	.823	.014	.018	.159
WCD65005	52.667	.813	.013	.021	.166
WCD70001	27.072	.800	.014	.019	.179
WCD70002	44.202	.778	.015	.026	.199
WCD70003	45.879	.822	.015	.020	.183
WCD70004	48.334	.797	.015	.017	.183
WCD70005	77.968	.774	.014	.051	.167
WCD70006	21.830	.824	.017	.017	.175
WCD75001	48.116	.780	.017	.022	.207
WCD75002	71.293	.813	.015	.020	.162
WCD75003	36.673	.830	.014	.022	.137
WCD75004	49.284	.801	.014	.015	.173
WCU55001	26.351	.752	.016	.040	.194
WCU55002	34.860	.690	.021	.154	.168
WCU60001	53.568	.710	.025	.122	.188
WCU60002	32.276	.776	.017	.040	.163
WCU60003	42.921	.700	.021	.131	.166

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Table C3. Proximate analysis of the liver (continued).

Sample number	Weight of liver (g)	Moisture ($g-g^{-1}$)	Ash ($g-g^{-1}$)	Lipids ($g-g^{-1}$)	Proteins ($g-g^{-1}$)
WCU60004	41.650	.702	.017	.119	.185
WCU60005	37.811	.761	.018	.039	.192
WCU65001	34.251	.714	.014	.116	.160
WCU65002	53.960	.710	.017	.103	.164
WCU65003	57.342	.752	.018	.044	.182
WCU65004	46.793	.696	.027	---	.189
WCU70001	48.475	.680	.017	.141	.158
WCU70002	50.902	.749	.015	.101	.154
WCU70003	56.165	.778	.016	.027	.168
WCU70004	64.009	.753	.018	.060	.215
WCU70005	77.417	.683	.015	.101	.175
WCU75001	55.547	.756	.015	.077	.158
WCU75002	67.227	.764	.013	.061	.197
WCU80001	88.015	.746	.015	.099	.151
NRD18001	0.522	.801	---	---	---
NRD18002	0.709	.797	---	---	---
NRD21001	0.814	.779	.016	.026	.191
NRD21002	0.807	.808	.016	.026	.191
NRD21003	0.643	.801	.016	.026	.191
NRD21004	1.055	.804	.016	.026	.191
NRD24001	1.260	.794	.016	.026	.191
NRD24002	1.816	.787	.016	.026	.191
NRD24003	1.430	.752	.016	.026	.191
NRD40001	9.067	.769	.017	.043	.170
NRD40002	9.536	.787	.017	.039	.170
NRD40003	9.613	.788	.017	.022	.170
NRD40004	7.334	.790	.017	.033	.170
NRD50001	22.724	.643	.019	---	.155
NRD50002	23.095	.768	.013	.061	.171
NRD50003	18.316	.795	.015	.026	.155
NRD50004	14.900	.730	.016	.075	.223
NRD50005	18.389	.749	.016	.050	.219
NRD50006	15.140	.789	.015	.028	.210
NRD50007	18.191	.790	.014	.032	.201
NRD60001	38.468	.718	.016	.123	.164
NRD60003	41.844	.730	.015	.040	.186
NRD60004	30.310	.739	.016	.072	.207
NRD60005	25.681	.780	.016	.040	.193

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THE PROXIMATE ANALYSIS DATA

Table C3. Proximate analysis of the liver (continued).

Sample number	Weight of liver (g)	Moisture ($g\text{-}g^{-1}$)	Ash ($g\text{-}g^{-1}$)	Lipids ($g\text{-}g^{-1}$)	Proteins ($g\text{-}g^{-1}$)
NRD60006	29.798	.768	.015	.052	.195
NRD60007	29.052	.751	.013	.071	.191
NRD70002	58.965	.741	.012	.092	.153
NRD70003	50.113	.764	.015	.061	.179
NRD70004	59.840	.760	.013	.055	.179
NRD70006	74.881	.686	.012	.121	.195
NRD80002	94.519	.745	.014	.086	.188
NRD80003	97.202	.728	.015	.092	.163
NRD80004	47.198	.821	.015	.013	.177
NRU21001	1.697	.764	.018	.061	.198
NRU21002	1.830	.707	.018	.061	.198
NRU24001	2.502	.761	.018	.061	.198
NRU24002	2.105	.716	.018	.061	.198
NRU40001	20.323	.627	.021	.213	.177
NRU40002	24.941	.654	.013	.248	.145
NRU40003	18.666	.641	.015	.208	.195
NRU40004	17.593	.632	.014	.177	.199
NRU40005	21.824	.665	.022	.163	.177
NRU40006	16.512	.677	.015	---	.183
NRU50001	36.780	.571	.011	---	.148
NRU50002	39.189	.587	.018	.222	.167
NRU50003	34.313	.601	.013	---	.167
NRU50004	40.663	.526	.020	---	.169
NRU50005	30.868	.611	.015	.225	.214
NRU50006	38.056	.536	.010	---	.164
NRU60001	71.073	.603	.015	.181	.184
NRU60002	58.693	.615	.015	.197	.164
NRU60003	56.114	.603	.018	.205	.185
NRU60004	64.268	.654	.015	.130	.185
NRU60005	70.846	.650	.016	.154	.165
NRU60006	70.500	.574	.011	.206	.174
NRU70001	80.044	.646	.027	.144	.198
NRU70002	83.975	.728	.014	.061	.188
NRU70003	71.783	.654	.015	.137	.189
NRU70004	90.423	.603	.027	.190	.197
NRU70005	75.734	.699	.013	.105	.191
NRU70006	81.986	.612	.018	.179	.184

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THE PROXIMATE ANALYSIS DATA

Table C3. Proximate analysis of the liver (continued).

Sample number	Weight of liver (g)	Moisture ($g-g^{-1}$)	Ash ($g-g^{-1}$)	Lipids ($g-g^{-1}$)	Proteins ($g-g^{-1}$)
NRU80001	130.934	.659	.013	.160	.179
NRU80002	133.556	.690	.015	.102	.192
NRU60011	57.036	.682	.015	.116	.209
NRU60012	49.718	.755	.016	.048	.198
NRU60013	57.023	.740	.013	.052	.199
NRU60014	67.513	.608	.019	---	---
NRU65011	74.772	.720	.013	.075	.184
NRU65012	72.868	.656	.014	.139	.202
NRU65013	73.926	.641	.013	.138	.153
NRU70011	76.559	.749	.014	.052	.202
NRU70012	70.535	.733	.014	.070	.189
NRU70013	72.575	.671	.019	.105	.194
NRU75011	91.949	.746	.014	.050	.186
NRU75012	87.127	.727	.014	.051	.208
NRU75013	72.395	.692	.013	.094	.196
NRU75014	92.458	.717	.013	.078	.155
NRUS01	48.948	.783	.017	.041	.174
NRUS02	43.672	.773	.018	.033	.168
NRUS03	43.815	.783	.015	.037	.186
NRUS04	52.385	.796	.014	.032	.180
NRUS05	51.445	.748	.017	.049	.200
NRUS06	38.761	.754	.017	.042	.204

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Table C4. Proximate analysis of the muscle sample.

Sample number	Weight of sample (g)	Moisture $(g\text{-}g^{-1})$	Ash $(g\text{-}g^{-1})$	Lipids $(g\text{-}g^{-1})$	Proteins $(g\text{-}g^{-1})$
WCD18001	5.414	.798	.015	.011	.189
WCD18002	6.322	.790	.015	.011	.189
WCD18003	5.883	.797	.015	.011	.189
WCD18004	8.303	.788	.015	.011	.189
WCD21001	6.924	.801	.014	.010	.204
WCD21002	7.598	.785	.014	.010	.204
WCD21003	8.985	.789	.014	.010	.204
WCD21004	9.898	.789	.014	.010	.204
WCD24001	9.145	.785	.014	.011	.196
WCD24002	10.266	.797	.014	.009	.196
WCD24003	12.626	.787	.014	.009	.196
WCD24004	12.290	.773	.014	.010	.196
WCD55001	70.951	.805	.019	.005	.203
WCD55002	70.672	.816	.015	.004	.196
WCD60001	46.048	.855	.010	.004	.163
WCD60002	70.723	.808	.017	.003	.214
WCD60003	70.882	.807	.016	.005	.180
WCD60004	72.065	.785	.018	.009	.210
WCD65001	73.025	.867	.010	.006	.118
WCD65002	71.413	.821	.012	.005	.176
WCD65003	71.894	.807	.017	.006	.184
WCD65004	72.791	.891	.011	.004	.103
WCD65005	71.794	.799	.017	.006	.190
WCD70001	71.029	.852	.011	.004	.158
WCD70002	71.029	.797	.012	.007	.243
WCD70003	70.304	.812	.011	.005	.171
WCD70004	75.390	.817	.017	.006	.164
WCD70005	72.842	.753	.014	.014	.236
WCD70006	71.853	.941	.007	.004	.048
WCD75001	71.980	.803	.012	.006	.210
WCD75002	70.933	.800	.011	.007	.218
WCD75003	71.552	.869	.012	.003	.149
WCD75004	71.588	.849	.013	.004	.140
WCU55001	71.718	.741	.013	.018	.259
WCU55002	59.153	.725	.014	.030	.285
WCU60001	71.266	.708	.012	.055	.214
WCU60002	68.478	.735	.013	.031	.226
WCU60003	71.701	.735	.013	.043	.231

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Table C4. Proximate analysis of the muscle sample (continued).

Sample number	Weight of sample (g)	Moisture $(g{-}g^{-1})$	Ash $(g{-}g^{-1})$	Lipids $(g{-}g^{-1})$	Proteins $(g{-}g^{-1})$
WCU60004	70.635	.739	.012	.026	.287
WCU60005	70.875	.748	.013	.018	.217
WCU65001	82.000	.738	.013	.028	---
WCU65002	71.070	.730	.012	.051	.268
WCU65003	70.627	.732	.013	.031	.256
WCU65004	71.461	.725	.013	.028	.267
WCU70001	71.912	.730	.011	.048	.224
WCU70002	71.627	.744	.013	.025	.281
WCU70003	71.925	.754	.013	.014	.242
WCU70004	72.319	.735	.013	.023	.240
WCU70005	72.517	.739	.014	.023	.207
WCU75001	71.110	.721	.012	.067	.254
WCU75002	56.584	.715	.014	.036	.251
WCU80001	72.483	.732	.014	.037	.244
NRD18001	4.346	.800	---	---	---
NRD18002	4.327	.789	---	---	---
NRD21001	7.147	.804	.014	.009	.187
NRD21002	5.113	.824	.014	.009	.187
NRD21003	5.964	.794	.014	.009	.187
NRD21004	6.827	.798	.014	.009	.187
NRD24001	13.844	.789	.015	.008	.217
NRD24002	14.969	.776	.015	.008	.217
NRD24003	12.656	.779	.015	.007	.217
NRD40001	47.007	.773	.013	.011	.224
NRD40002	46.220	.764	.013	.010	.259
NRD40003	46.922	.779	.013	.006	.215
NRD40004	72.499	.772	.013	.007	.203
NRD50001	71.585	.738	.012	.025	.253
NRD50002	72.275	.753	.014	.020	.232
NRD50003	72.889	.762	.012	.010	.234
NRD50004	71.678	.763	.013	.011	.233
NRD50005	72.536	.751	.013	.016	.246
NRD50006	71.461	.759	.015	.008	.214
NRD50007	71.395	.753	.012	.011	.246
NRD60001	71.809	.725	.012	.035	.224
NRD60003	71.812	.730	.012	.031	.239
NRD60004	72.364	.746	.014	.015	.213
NRD60005	71.395	.756	.013	.009	.215

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THE PROXIMATE ANALYSIS DATA

Table C4. Proximate analysis of the muscle sample (continued).

Sample number	Weight of sample (g)	Moisture ($g\text{-}g^{-1}$)	Ash ($g\text{-}g^{-1}$)	Lipids ($g\text{-}g^{-1}$)	Proteins ($g\text{-}g^{-1}$)
NRD60006	71.715	.764	.013	.008	.225
NRD60007	71.722	.747	.013	.018	.210
NRD70002	72.019	.755	.014	.016	.202
NRD70003	72.416	.747	.013	.024	.222
NRD70004	72.113	.744	.013	.026	.265
NRD70006	71.623	.739	.014	.023	.251
NRD80002	71.708	.714	.014	.075	.232
NRD80003	72.220	.757	.014	.009	.251
NRD80004	71.341	.872	.012	.006	.132
NRU21001	13.080	.762	.015	.013	.231
NRU21002	12.978	.759	.015	.016	.231
NRU24001	15.796	.760	.015	.011	.219
NRU24002	18.134	.754	.015	.011	.219
NRU40001	71.472	.736	.013	.030	.197
NRU40002	69.498	.728	.015	.022	.245
NRU40003	71.135	.728	.014	.022	.217
NRU40004	46.837	.741	.014	.027	.203
NRU40005	71.705	.732	.014	.023	.236
NRU40006	70.581	.735	.015	.015	.231
NRU50001	28.845	.712	.015	.068	.227
NRU50002	70.738	.721	.014	.037	.253
NRU50003	69.104	.719	.014	.044	.255
NRU50004	71.186	.729	.016	.029	.260
NRU50005	71.828	.733	.013	.027	.257
NRU50006	69.995	.726	.013	.044	.240
NRU60001	71.860	.710	.014	.048	.248
NRU60002	71.160	.726	.015	.025	.232
NRU60003	72.152	.716	.015	.040	.269
NRU60004	71.976	.714	.015	.048	.265
NRU60005	72.109	.707	.014	.055	.232
NRU60006	73.335	.707	.015	.053	.264
NRU70001	71.540	.716	.013	.032	.268
NRU70002	71.713	.730	.013	.024	.213
NRU70003	71.903	.721	.013	.040	.214
NRU70004	71.994	.704	.013	.041	.236
NRU70005	72.154	.712	.013	.033	.269
NRU70006	71.137	.696	.013	.043	.277

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Table C4. Proximate analysis of the muscle sample (continued).

Sample number	Weight of sample (g)	Moisture ($g-g^{-1}$)	Ash ($g-g^{-1}$)	Lipids ($g-g^{-1}$)	Proteins ($g-g^{-1}$)
NRU80001	71.222	.684	.014	.047	.259
NRU80002	72.053	.715	.014	.031	.250
NRU60011	71.700	.741	.014	.018	.235
NRU60012	70.942	.764	.013	.008	.242
NRU60013	71.778	.758	.013	.014	.224
NRU60014	71.830	.729	.013	.016	.278
NRU65011	71.781	.757	.013	.017	.238
NRU65012	71.354	.731	.013	.017	.280
NRU65013	72.124	.746	.013	.020	.197
NRU70011	71.154	.746	.013	.017	.224
NRU70012	72.428	.737	.013	.025	.233
NRU70013	70.976	.730	.015	.027	.224
NRU75011	71.721	.756	.013	.015	.290
NRU75012	47.526	.744	.013	.014	.204
NRU75013	71.829	.752	.013	.019	.215
NRU75014	72.181	.742	.013	.031	.274
NRUS01	71.564	.784	.011	.016	.215
NRUS02	72.017	.762	.011	.021	.201
NRUS03	71.301	.783	.010	.016	.241
NRUS04	72.804	.761	.012	.022	.210
NRUS05	72.341	.741	.012	.037	.256
NRUS06	71.330	.741	.012	.022	.241

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Table C5. Proximate analysis of the residual carcass.

Sample number	Weight of carcass (g)	Moisture ($g\text{-}g^{-1}$)	Ash ($g\text{-}g^{-1}$)	Lipids ($g\text{-}g^{-1}$)	Proteins ($g\text{-}g^{-1}$)
WCD18001	35.875	.776	.024	.012	.175
WCD18002	40.051	.776	.024	.012	.175
WCD18003	42.187	.776	.024	.012	.175
WCD18004	39.838	.776	.024	.012	.175
WCD21001	55.809	.784	.021	.032	.216
WCD21002	52.261	.784	.021	.032	.216
WCD21003	67.802	.784	.021	.032	.216
WCD21004	64.522	.784	.021	.032	.216
WCD24001	84.895	.772	.025	.016	.204
WCD24002	102.621	.772	.025	.016	.204
WCD24003	99.662	.772	.025	.016	.204
WCD24004	103.804	.772	.025	.016	.204
WCD55001	854.853	.795	.022	.013	.203
WCD55002	967.728	.802	.020	.007	.220
WCD60001	999.897	.831	.024	.007	.153
WCD60002	1292.367	.805	.018	.016	.229
WCD60003	1122.100	.799	.017	.008	.174
WCD60004	1431.137	.745	.022	.052	.217
WCD65001	1457.916	.848	.031	.006	.164
WCD65002	1836.934	.807	.023	.018	.191
WCD65003	1780.055	.792	.026	.008	.192
WCD65004	1185.869	.834	.025	.008	.149
WCD65005	1928.104	.766	.022	.039	.171
WCD70001	2202.122	.849	.026	.006	.144
WCD70002	2467.897	.761	.022	.040	.210
WCD70003	2087.461	.804	.029	.009	.171
WCD70004	2487.416	.802	.022	.015	.193
WCD70005	2955.617	.723	.021	.078	.185
WCD70006	1441.136	.854	.035	.005	.141
WCD75001	2783.359	.763	.027	.044	.222
WCD75002	3193.093	.790	.021	.026	.207
WCD75003	2120.505	.830	.029	.007	.163
WCD75004	2428.892	.819	.027	.007	.182
WCU55001	1290.805	.704	.017	.088	.247
WCU55002	1405.058	.670	.015	.106	.207
WCU60001	1950.805	.647	.018	.158	.194
WCU60002	1741.419	.692	.016	.102	.196
WCU60003	1849.686	.667	.018	.131	.196

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Table C5. Proximate analysis of the residual carcass (continued).

Sample number	Weight of carcass (g)	Moisture (g-g^{-1})	Ash (g-g^{-1})	Lipids (g-g^{-1})	Proteins (g-g^{-1})
WCU60004	1715.813	.679	.017	.106	.211
WCU60005	1908.215	.708	.018	.080	.210
WCU65001	2422.674	.697	.019	.106	.217
WCU65002	2679.931	.682	.020	.115	.197
WCU65003	2262.215	.691	.019	.094	.252
WCU65004	2226.449	.690	.017	.094	.239
WCU70001	3042.454	.677	.018	.116	.230
WCU70002	3023.193	.713	.022	.095	.250
WCU70003	2594.833	.726	.019	.055	.243
WCU70004	2700.780	.693	.017	.102	.206
WCU70005	3236.880	.675	.020	.114	.183
WCU75001	4056.347	.688	.021	.067	.264
WCU75002	3770.827	.694	.019	.089	.245
WCU80001	4507.252	.696	.020	.104	.199
NRD18001	31.076	---	---	---	.220
NRD18002	38.950	---	---	---	.220
NRD21001	58.021	.801	.024	.013	.180
NRD21002	56.063	.801	.024	.013	.180
NRD21003	50.286	.801	.024	.013	.180
NRD21004	58.096	.801	.024	.013	.180
NRD24001	86.877	.781	.023	.014	.253
NRD24002	96.074	.781	.023	.014	.253
NRD24003	96.762	.781	.023	.014	.253
NRD40001	504.752	.756	.020	.042	.222
NRD40002	472.081	.757	.020	.040	.203
NRD40003	418.244	.774	.021	.025	.188
NRD40004	468.996	.761	.021	.030	.199
NRD50001	1090.899	.698	.018	.095	.237
NRD50002	1031.563	.720	.016	.074	.213
NRD50003	948.172	.756	.018	.041	.234
NRD50004	976.905	.742	.017	.052	.209
NRD50005	1089.366	.719	.019	.074	.211
NRD50006	912.543	.752	.017	.041	.217
NRD50007	1067.389	.733	.016	.059	.295
NRD60001	2147.412	.659	.019	.122	.190
NRD60003	1922.694	.685	.016	.107	.211
NRD60004	1970.657	.716	.019	.081	.239
NRD60005	1485.618	.741	.022	.051	.204

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Table C5. Proximate analysis of the residual carcass (continued).

Sample number	Weight of carcass (g)	Moisture ($g\text{-}g^{-1}$)	Ash ($g\text{-}g^{-1}$)	Lipids ($g\text{-}g^{-1}$)	Proteins ($g\text{-}g^{-1}$)
NRD60006	1861.835	.747	.018	.043	.193
NRD60007	1603.145	.706	.018	.082	.200
NRD70002	2921.150	.717	.019	.074	.238
NRD70003	2820.498	.709	.020	.080	.199
NRD70004	2951.857	.698	.019	.086	.192
NRD70006	3467.635	.688	.020	.098	.207
NRD80002	4940.838	.668	.020	.126	.187
NRD80003	4617.991	.739	.019	.047	.212
NRD80004	2577.615	.835	.033	.006	.176
NRU21001	78.211	.744	.021	.053	.203
NRU21002	76.095	.744	.021	.053	.203
NRU24001	117.491	.757	.022	.036	.192
NRU24002	121.631	.757	.022	.036	.192
NRU40001	663.955	.702	.020	.084	.199
NRU40002	663.133	.712	.017	.088	.189
NRU40003	629.939	.694	.018	.098	.229
NRU40004	635.486	.708	.018	.075	.199
NRU40005	730.477	.690	.018	.101	.205
NRU40006	555.657	.720	.020	.066	.202
NRU50001	1295.971	.659	---	.115	.198
NRU50002	1224.192	.667	.018	.115	.226
NRU50003	1351.770	.672	---	.117	.195
NRU50004	1319.312	.682	.018	.104	.215
NRU50005	1115.884	.692	.019	.095	.220
NRU50006	1366.360	.679	---	.106	.200
NRU60001	2350.215	.637	.017	.144	.204
NRU60002	2277.694	.648	.019	.124	.234
NRU60003	2178.068	.663	.020	.122	.232
NRU60004	2519.375	.640	.018	.139	.240
NRU60005	2484.047	.639	.018	.145	.194
NRU60006	2741.097	.642	.018	.139	.214
NRU70001	3351.350	.663	.017	.121	.223
NRU70002	3489.514	.686	.019	.096	.194
NRU70003	3578.153	.668	.017	.111	.258
NRU70004	3788.985	.653	.019	.129	.207
NRU70005	3727.262	.674	.019	.094	.208
NRU70006	3950.682	.639	.017	.139	.252

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Table C5. Proximate analysis of the residual carcass (continued).

Sample number	Weight of carcass (g)	Moisture ($g-g^{-1}$)	Ash ($g-g^{-1}$)	Lipids ($g-g^{-1}$)	Proteins ($g-g^{-1}$)
NRU80001	5922.916	.661	.020	.117	.216
NRU80002	5485.240	.660	.019	.125	.203
NRU60011	2038.579	.689	.019	.089	.205
NRU60012	1903.575	.748	.021	.040	.244
NRU60013	1867.550	.709	.019	.078	.193
NRU60014	2054.633	.673	.018	.109	.211
NRU65011	2568.687	.713	.020	.075	.204
NRU65012	2290.408	.692	.023	.076	.219
NRU65013	2286.032	.714	.019	.074	.201
NRU70011	2833.162	.710	.021	.069	.222
NRU70012	3142.386	.710	.020	.077	.200
NRU70013	2756.055	.693	.018	.082	.204
NRU75011	3885.433	.709	.021	.078	.194
NRU75012	3497.046	.720	.020	.058	.219
NRU75013	3190.421	.725	.022	.064	.227
NRU75014	3277.741	.701	.021	.074	.237
NRUS01	3489.931	.753	.019	.046	.188
NRUS02	1650.711	.704	.022	.079	.208
NRUS03	3103.320	.723	.024	.064	.198
NRUS04	3653.911	.716	.021	.068	.218
NRUS05	2072.394	.686	.017	.121	.257
NRUS06	1439.109	.694	.016	.092	.199

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Table C6. Composition of the gonads.

Sample number	Moisture (g)	Ash (g)	Lipids (g)	Proteins (g)
WCD18001	.008			
WCD18002	.029			
WCD18003	.116			
WCD18004	.015			
WCD21001	.022			
WCD21002	.109			
WCD21003	.015			
WCD21004	.124			
WCD24001	.189			
WCD24002	.052			
WCD24003	.023			
WCD24004	.026			
WCD55001	5.576	.069	.269	.875
WCD55002	10.543	.124	.272	.879
WCD60001	6.688	.091	.198	1.303
WCD60002	9.718	.127	.231	1.456
WCD60003	14.061	.180	.409	.982
WCD60004	10.219	.140	.536	1.493
WCD65001	10.308	.143	.166	1.213
WCD65002	13.746	.193	.274	2.143
WCD65003	20.736	.273	.496	2.456
WCD65004	13.870	.180	.163	1.273
WCD65005	11.649	.159	.404	1.689
WCD70001	2.224	.036	---	---
WCD70002	19.074	.286	.883	3.103
WCD70003	16.978	.256	.641	2.798
WCD70004	10.558	.154	.206	1.813
WCD70005	40.558	.583	.729	4.809
WCD70006	13.997	.106	.182	.835
WCD75001	49.883	.763	2.732	9.278
WCD75002	32.380	.556	1.429	5.119
WCD75003	------	---	---	4.109
WCD75004	5.176	.075	.062	1.129
WCU55001	31.412	---	3.782	7.011
WCU55002	32.154	---	4.094	8.288
WCU60001	52.760	1.315	5.725	16.942
WCU60002	37.402	.898	3.592	10.988
WCU60003	41.920	1.229	5.564	15.461

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Table C6. Composition of the gonads (continued).

Sample number	Moisture (g)	Ash (g)	Lipids (g)	Proteins (g)
WCU60004	39.835	1.198	4.672	10.902
WCU60005	42.844	---	4.165	10.033
WCU65001	14.442	.307	.578	2.766
WCU65002	34.220	.799	.967	6.180
WCU65003	80.019	---	9.940	22.521
WCU65004	47.330	1.229	4.986	12.908
WCU70001	35.680	.839	1.192	7.021
WCU70002	24.828	---	.575	4.693
WCU70003	62.373	1.599	6.491	22.296
WCU70004	50.540	1.078	5.032	10.784
WCU70005	43.535	.821	4.549	12.953
WCU75001	47.964	1.180	1.593	8.495
WCU75002	33.379	.827	1.282	5.212
WCU80001	42.532	.888	1.150	7.472
NRD18001	.047			
NRD18002	.009			
NRD21001	.013			
NRD21002	.012			
NRD21003	.090			
NRD21004	.016			
NRD24001	.014			
NRD24002	.116			
NRD24003	.126			
NRD40001	.127			
NRD40002	.116			
NRD40003	1.002			
NRD40004	.128			
NRD50001	8.493	.130	.561	1.403
NRD50002	4.787	.073	.231	.928
NRD50003	.466	---	---	---
NRD50004	.374	---	---	---
NRD50005	5.921	.093	.293	1.180
NRD50006	3.904	.058	.185	.743
NRD50007	13.189	.192	.897	1.907
NRD60001	26.834	.472	3.994	7.407
NRD60003	20.238	.282	1.411	3.206
NRD60004	1.262	.028	.037	.330
NRD60005	.999	.022	.029	.259

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Table C6. Composition of the gonads (continued).

Sample number	Moisture (g)	Ash (g)	Lipids (g)	Proteins (g)
NRD60006	1.249	.021	.036	.327
NRD60007	.820	.018	.024	.214
NRD70002	3.825	.107	.131	.871
NRD70003	2.396	.065	.080	.532
NRD70004	29.242	.398	2.606	3.981
NRD70006	3.816	.107	.131	.870
NRD80002	10.348	.220	.414	1.927
NRD80003	7.746	.163	.201	1.754
NRD80004	4.017	.082	.107	.834
NRU21001	.006			
NRU21002	.080			
NRU24001	.179			
NRU24002	.111			
NRU40001	.178			
NRU40002	1.928			
NRU40003	.194			
NRU40004	.891			
NRU40005	.828			
NRU40006	.182			
NRU50001	4.194			
NRU50002	3.656	.063	.166	.688
NRU50003	.620	---	---	---
NRU50004	.653	---	---	---
NRU50005	5.059	.083	.218	.905
NRU50006	.409	---	---	---
NRU60001	16.586	.262	1.595	2.863
NRU60002	14.916	.234	1.168	2.376
NRU60003	1.280	---	.043	.345
NRU60004	12.384	.213	.885	2.097
NRU60005 M	.132	---	---	---
NRU60005 F	11.358	.158	1.562	2.145
NRU60006	17.257	.265	1.324	2.847
NRU70001	1.521	.041	.062	.419
NRU70002	2.875	.076	.114	.771
NRU70003	2.323	.063	.095	.642
NRU70004	2.648	.072	.108	.730
NRU70005	2.195	.057	.086	.579
NRU70006	3.886	.104	.156	1.055

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Table C6. Composition of the gonads (continued).

Sample number	Moisture (g)	Ash (g)	Lipids (g)	Proteins (g)
NRU80001	6.973	.125	.232	1.661
NRU80002	3.956	.072	.134	.958
NRU60011	15.555	.248	---	3.475
NRU60012	12.612	.158	.536	2.002
NRU60013	16.106	.206	1.115	2.643
NRU60014	12.178	.176	.673	1.955
NRU65011	20.969	.309	1.238	3.478
NRU65012	13.462	.208	.660	2.293
NRU65013	14.406	.179	.573	1.989
NRU70011	16.060	.221	.745	2.878
NRU70012	19.721	.296	1.035	3.353
NRU70013	20.442	.279	.609	3.174
NRU75011	34.403	.515	2.574	5.877
NRU75012	26.308	.366	1.598	4.296
NRU75013	17.482	.268	.984	3.264
NRU75014	33.435	.500	1.543	5.545
NRUS01	53.341	2.822	2.611	15.381
NRUS02	207.318	---	25.379	89.651
NRUS03	39.339	2.778	2.389	13.613
NRUS04	61.722	2.972	3.226	18.254
NRUS05	173.120	---	20.430	44.893
NRUS06	151.716	---	18.311	64.206

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Table C7. Composition of the liver.

Sample number	Moisture (g)	Ash (g)	Lipids (g)	Proteins (g)
WCD18001	.566			
WCD18002	.474			
WCD18003	.640			
WCD18004	.672			
WCD21001	1.002	.017	.037	.208
WCD21002	.795	.014	.030	.170
WCD21003	.927	.017	.036	.200
WCD21004	1.110	.020	.043	.240
WCD24001	1.381	.024	.052	.291
WCD24002	1.614	.029	.061	.343
WCD24003	1.304	.024	.050	.282
WCD24004	1.478	.026	.056	.314
WCD55001	10.776	.200	.319	2.687
WCD55002	12.166	.228	.335	2.345
WCD60001	11.115	.207	.304	2.748
WCD60002	13.728	.278	.382	3.402
WCD60003	17.666	.303	.476	3.442
WCD60004	19.807	.351	.676	5.359
WCD65001	18.930	.394	.950	3.893
WCD65002	42.550	.671	.878	8.004
WCD65003	30.394	.559	2.347	5.922
WCD65004	14.009	.238	.306	2.707
WCD65005	42.818	.685	1.106	8.743
WCD70001	21.658	.379	.514	4.846
WCD70002	34.389	.663	1.149	8.796
WCD70003	37.713	.688	.918	8.396
WCD70004	38.522	.725	.822	8.845
WCD70005	60.347	1.092	3.976	13.021
WCD70006	17.988	.371	.371	3.820
WCD75001	37.530	.818	1.059	9.960
WCD75002	57.961	1.069	1.426	11.549
WCD75003	30.439	.513	.807	5.024
WCD75004	39.476	.690	.739	8.526
WCU55001	19.816	.422	1.054	5.112
WCU55002	24.053	.732	5.368	5.857
WCU60001	38.033	1.339	6.535	10.071
WCU60002	25.046	.549	1.291	5.261
WCU60003	30.045	.901	5.623	7.125

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Table C7. Composition of the liver (continued).

Sample number	Moisture (g)	Ash (g)	Lipids (g)	Proteins (g)
WCU60004	29.238	.708	4.956	7.705
WCU60005	28.774	.681	1.475	7.260
WCU65001	24.455	.480	3.973	5.480
WCU65002	38.312	.917	5.558	8.849
WCU65003	43.121	1.032	2.523	10.436
WCU65004	32.568	1.263	---	8.844
WCU70001	32.963	.824	6.835	7.659
WCU70002	38.126	.764	5.141	7.839
WCU70003	43.696	.899	1.517	9.436
WCU70004	48.199	1.152	3.841	13.762
WCU70005	52.876	1.161	7.819	13.548
WCU75001	41.994	.833	4.277	8.776
WCU75002	51.361	.874	4.101	13.244
WCU80001	65.659	1.320	8.714	13.290
NRD18001	.418	---	---	---
NRD18002	.565	---	---	---
NRD21001	.634	.013	.021	.155
NRD21002	.652	.013	.021	.154
NRD21003	.515	.010	.017	.123
NRD21004	.848	.017	.027	.202
NRD24001	1.000	.020	.033	.241
NRD24002	1.429	.029	.047	.347
NRD24003	1.075	.023	.037	.273
NRD40001	6.973	.154	.390	1.541
NRD40002	7.505	.162	.372	1.621
NRD40003	7.575	.163	.211	1.634
NRD40004	5.794	.125	.242	1.247
NRD50001	14.612	.432	---	3.522
NRD50002	17.737	.300	1.409	3.949
NRD50003	14.561	.275	.476	2.839
NRD50004	10.877	.238	1.118	3.323
NRD50005	13.773	.294	.919	4.027
NRD50006	11.945	.227	.424	3.179
NRD50007	14.371	.255	.582	3.656
NRD60001	27.620	.615	4.732	6.309
NRD60003	30.546	.628	1.674	7.783
NRD60004	22.399	.485	2.182	6.274
NRD60005	20.031	.411	1.027	4.956

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Table C7. Composition of the liver (continued).

Sample number	Moisture (g)	Ash (g)	Lipids (g)	Proteins (g)
NRD60006	22.885	.447	1.550	5.811
NRD60007	21.818	.378	2.063	5.549
NRD70002	43.693	.708	5.425	9.022
NRD70003	38.286	.752	3.057	8.970
NRD70004	45.478	.778	3.291	10.711
NRD70006	51.368	.899	9.061	14.602
NRD80002	70.417	1.323	8.129	17.770
NRD80003	70.763	1.458	8.943	15.844
NRD80004	38.750	.708	.614	8.354
NRU21001	1.297	.031	.104	.336
NRU21002	1.200	.031	.104	.336
NRU24001	1.904	.045	.153	.495
NRU24002	1.507	.038	.128	.417
NRU40001	12.743	.427	4.329	3.597
NRU40002	16.311	.324	6.185	3.616
NRU40003	11.965	.280	3.883	3.640
NRU40004	11.119	.246	3.114	3.501
NRU40005	14.513	.480	3.557	3.863
NRU40006	11.179	.248	---	3.022
NRU50001	21.001	.405	---	5.443
NRU50002	23.004	.705	8.700	6.545
NRU50003	20.622	.446	---	5.730
NRU50004	21.389	.813	---	6.872
NRU50005	18.860	.463	6.945	6.606
NRU50006	20.398	.381	---	6.241
NRU60001	42.857	1.066	12.864	13.077
NRU60002	36.096	.880	11.563	9.626
NRU60003	33.837	1.010	11.503	10.381
NRU60004	42.031	.964	8.355	11.890
NRU60005	46.050	1.134	10.910	11.690
NRU60006	40.467	.776	14.523	12.267
NRU70001	51.708	2.161	11.526	15.849
NRU70002	61.134	1.176	5.123	15.787
NRU70003	46.946	1.077	9.834	13.567
NRU70004	54.525	2.441	17.180	17.813
NRU70005	52.938	.985	7.952	14.465
NRU70006	50.175	1.476	14.675	15.085

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Table C7. Composition of the liver (continued).

Sample number	Moisture (g)	Ash (g)	Lipids (g)	Proteins (g)
NRU80001	86.286	1.702	20.949	23.437
NRU80002	92.154	2.003	13.623	25.463
NRU60011	38.899	.856	6.616	11.921
MRU60012	37.537	.795	2.387	9.844
NRU60013	42.197	.741	2.965	11.348
NRU60014	41.048	1.283	---	---
NRU65011	53.836	.972	5.603	13.758
NRU65012	47.801	1.020	10.129	14.719
NRU65013	47.387	.961	10.202	11.311
NRU70011	57.343	1.072	3.981	15.465
NRU70012	51.702	.987	4.938	13.331
NRU70013	48.698	1.379	7.620	14.080
NRU75011	68.594	1.287	4.598	17.103
NRU75012	63.341	1.220	4.444	18.122
NRU75013	50.097	.941	6.805	14.189
NRU75014	66.292	1.202	7.212	14.331
NRUS01	38.326	.832	2.007	8.517
NRUS02	33.758	.786	1.441	7.337
NRUS03	34.307	.657	1.621	8.150
NRUS04	41.698	.733	1.676	9.429
NRUS05	38.481	.875	2.521	10.289
NRUS06	29.226	.659	1.628	7.907

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Table C8. Composition of the muscle sample.

Sample number	Moisture (g)	Ash (g)	Lipids (g)	Proteins (g)
WCD18001	4.320	.081	.060	1.023
WCD18002	4.994	.095	.070	1.195
WCD18003	4.689	.088	.065	1.112
WCD18004	6.543	.125	.091	1.569
WCD21001	5.546	.097	.069	1.412
WCD18002	5.964	.106	.076	1.550
WCD21003	7.089	.126	.090	1.833
WCD21004	7.810	.139	.099	2.019
WCD24001	7.179	.128	.101	1.792
WCD24002	8.182	.144	.092	2.012
WCD24003	9.937	.177	.114	2.475
WCD24004	9.500	.172	.123	2.409
WCD55001	57.116	1.348	.355	14.403
WCD55002	57.668	1.060	.283	13.852
WCD60001	39.371	.460	.184	7.506
WCD60002	57.144	1.202	.212	15.135
WCD60003	57.202	1.134	.354	12.759
WCD60004	56.571	1.297	.649	15.134
WCD65001	63.313	.730	.438	8.617
WCD65002	58.630	.857	.357	12.569
WCD65003	58.018	1.222	.431	13.228
WCD65004	64.857	.801	.291	7.498
WCD65005	57.363	1.221	.431	13.641
WCD70001	60.517	.781	.284	11.223
WCD70002	56.610	.852	.497	17.260
WCD70003	57.087	.781	.355	12.146
WCD70004	61.594	1.282	.452	12.364
WCD70005	54.850	1.020	1.020	17.191
WCD70006	67.614	.503	.287	3.449
WCD75001	57.800	.864	.432	15.116
WCD75002	56.746	.780	.497	15.463
WCD75003	62.179	.859	.215	10.661
WCD75004	60.778	.931	.286	10.022
WCU55001	53.143	.932	1.291	18.575
WCU55002	42.886	.828	1.775	16.859
WCU60001	50.456	.855	3.920	15.251
WCU60002	50.331	.890	2.123	15.476
WCU60003	52.700	.932	3.083	16.563

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Table C8. Composition of the muscle sample (continued).

Sample number	Moisture (g)	Ash (g)	Lipids (g)	Proteins (g)
WCU60004	52.199	.848	1.837	20.272
WCU60005	53.015	.921	1.276	15.380
WCU65001	60.516	1.066	2.296	---
WCU65002	51.881	.853	3.625	19.047
WCU65003	51.699	.918	2.189	18.081
WCU65004	51.809	.929	2.001	19.080
WCU70001	52.496	.791	3.452	16.108
WCU70002	53.290	.931	1.791	20.127
WCU70003	54.231	.935	1.007	17.406
WCU70004	53.154	.940	1.663	17.357
WCU70005	53.590	1.015	1.668	15.011
WCU75001	51.270	.853	4.764	18.062
WCU75002	40.458	.792	2.037	14.203
WCU80001	53.058	1.015	2.682	17.686
NRD18001	3.477	---	---	---
NRD18002	3.414	---	---	---
NRD21001	5.746	.100	.064	1.337
NRD21002	4.213	.072	.046	.956
NRD21003	4.735	.083	.054	1.115
NRD21004	5.448	.096	.061	1.277
NRD24001	10.923	.208	.111	3.004
NRD24002	11.616	.225	.120	3.248
NRD24003	9.859	.190	.089	2.746
NRD40001	36.336	.611	.517	10.530
NRD40002	35.312	.601	.462	11.971
NRD40003	36.552	.610	.282	10.088
NRD40004	55.969	.942	.507	14.717
NRD50001	52.830	.859	1.790	18.111
NRD50002	54.423	1.012	1.446	16.768
NRD50003	55.541	.875	.729	17.056
NRD50004	54.690	.932	.788	16.701
NRD50005	54.475	.943	1.161	17.844
NRD50006	54.239	1.072	.572	15.293
NRD50007	53.760	.857	.785	17.563
NRD60001	52.062	.862	2.513	16.085
NRD60003	52.423	.862	2.226	17.163
NRD60004	53.984	1.013	1.086	15.414
NRD60005	53.975	.928	.643	15.350

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Table C8. Composition of the muscle sample (continued).

Sample number	Moisture (g)	Ash (g)	Lipids (g)	Proteins (g)
NRD60006	54.790	.932	.574	16.136
NRD60007	53.576	.932	1.291	15.062
NRD70002	54.374	1.008	1.152	14.548
NRD70003	54.095	.941	1.738	16.076
NRD70004	53.652	.937	1.875	19.110
NRD70006	52.929	1.003	1.647	17.977
NRD80002	51.200	1.004	5.378	16.636
NRD80003	54.655	1.011	.650	18.122
NRD80004	62.209	.856	.428	9.417
NRU21001	9.967	.196	.170	3.022
NRU21002	9.850	.195	.208	2.998
NRU24001	12.005	.237	.174	3.459
NRU24002	13.673	.272	.199	3.971
NRU40001	52.603	.929	2.144	14.080
NRU40002	50.595	1.043	1.529	17.027
NRU40003	51.786	.996	1.565	15.436
NRU40004	34.706	.656	1.265	9.508
NRU40005	52.488	1.004	1.649	16.922
NRU40006	51.877	1.059	1.059	16.304
NRU50001	20.538	.433	1.962	6.548
NRU50002	51.002	.990	2.617	17.897
NRU50003	49.686	.967	3.041	17.622
NRU50004	51.895	1.139	2.064	18.508
NRU50005	52.650	.934	1.939	18.460
NRU50006	50.816	.910	3.080	16.799
NRU60001	51.021	1.006	3.449	17.821
NRU60002	51.662	1.067	1.779	16.509
NRU60003	51.661	1.082	2.886	19.409
NRU60004	51.391	1.080	3.455	19.074
NRU60005	50.981	1.010	3.966	16.729
NRU60006	51.848	1.100	3.887	19.360
NRU70001	51.223	.930	2.289	19.173
NRU70002	52.350	.932	1.721	15.275
NRU70003	51.842	.935	2.876	15.387
NRU70004	50.684	.936	2.952	16.991
NRU70005	51.374	.938	2.381	19.409
NRU70006	49.511	.925	3.059	19.705

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Table C8. Composition of the muscle sample (continued).

Sample number	Moisture (g)	Ash (g)	Lipids (g)	Proteins (g)
NRU80001	48.716	.997	3.347	18.446
NRU80002	51.518	1.009	2.234	18.013
NRU60011	53.130	1.004	1.291	16.850
NRU60012	54.200	.922	.568	17.168
NRU60013	54.408	.933	1.005	16.078
NRU60014	52.364	.934	1.149	19.969
NRU65011	54.338	.933	1.220	17.084
NRU65012	52.160	.928	1.213	19.979
NRU65013	53.805	.938	1.443	14.208
NRU70011	53.081	.925	1.210	15.938
NRU70012	53.379	.942	1.811	16.876
NRU70013	51.812	1.065	1.916	15.899
NRU75011	54.221	.932	1.076	20.799
NRU75012	35.359	.618	.665	9.695
NRU75013	54.015	.934	1.365	15.443
NRU75014	53.558	.938	2.238	19.778
NRUS01	56.106	.787	1.145	15.386
NRUS02	54.877	.792	1.512	14.475
NRUS03	55.829	.713	1.141	17.184
NRUS04	55.404	.874	1.602	15.289
NRUS05	53.605	.868	2.677	18.519
NRUS06	52.856	.856	1.569	17.191

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THE PROXIMATE ANALYSIS DATA

Table C9. Composition of the residual carcass.

Sample number	Moisture (g)	Ash* (g)	Lipids (g)	Proteins (g)
WCD18001	27.839	.908	.431	6.278
WCD18002	31.080	1.014	.481	7.009
WCD18003	32.737	1.069	.506	7.383
WCD18004	30.914	1.009	.478	6.972
WCD21001	43.754	1.236	1.786	12.055
WCD21002	40.973	1.158	1.672	11.288
WCD21003	53.157	1.502	2.170	14.645
WCD21004	50.585	1.430	2.065	13.937
WCD24001	65.539	2.239	1.358	17.319
WCD24002	79.223	2.707	1.642	20.935
WCD24003	76.939	2.629	1.595	20.331
WCD24004	80.137	2.738	1.661	21.176
WCD55001	679.608	---	11.113	173.535
WCD55002	776.118	---	6.774	212.900
WCD60001	830.914	---	6.999	152.984
WCD60002	1040.355	---	20.678	295.952
WCD60003	896.558	---	8.977	195.245
WCD60004	1066.197	---	74.419	310.557
WCD65001	1236.313	---	8.747	239.098
WCD65002	1482.406	---	33.065	350.854
WCD65003	1409.804	---	14.240	341.771
WCD65004	989.015	---	9.487	176.695
WCD65005	1476.928	---	75.196	329.706
WCD70001	1869.602	---	13.213	317.106
WCD70002	1878.070	---	98.716	518.258
WCD70003	1678.319	---	18.787	356.956
WCD70004	1994.908	---	37.311	480.071
WCD70005	2136.911	65.482	230.538	546.789
WCD70006	1230.730	53.214	7.206	203.200
WCD75001	2123.703	---	122.468	617.906
WCD75002	2522.543	---	83.020	660.970
WCD75003	1760.019	---	14.844	345.642
WCD75004	1989.263	---	17.002	442.058
WCU55001	908.727	---	113.591	318.329
WCU55002	941.389	---	148.936	290.847
WCU60001	1262.171	---	308.227	378.456
WCU60002	1205.062	---	177.625	341.318
WCU60003	1233.741	---	242.309	362.539

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Table C9. Composition of the residual carcass (continued).

Sample number	Moisture (g)	Ash* (g)	Lipids (g)	Proteins (g)
WCU60004	1165.037	---	181.876	362.037
WCU60005	1351.016	36.237	152.657	400.725
WCU65001	1688.604	---	256.803	525.720
WCU65002	1827.713	---	308.192	527.946
WCU65003	1563.191	---	212.648	570.078
WCU65004	1536.250	---	209.286	532.121
WCU70001	2059.741	---	352.925	699.764
WCU70002	2155.537	---	287.203	755.798
WCU70003	1883.849	---	142.716	630.544
WCU70004	1871.641	---	275.480	556.361
WCU70005	2184.894	68.299	369.004	592.349
WCU75001	2790.767	---	271.775	1070.876
WCU75002	2616.954	---	335.604	923.853
WCU80001	3137.047	95.103	468.754	896.943
NRD18001	---	---	---	6.837
NRD18002	---	---	---	8.569
NRD21001	40.279	1.470	.754	10.444
NRD21002	46.535	1.420	.729	10.091
NRD21003	67.851	1.273	.654	9.052
NRD21004	75.034	1.471	.755	10.457
NRD24001	67.851	2.108	1.216	21.980
NRD24002	75.034	2.332	1.345	24.307
NRD24003	72.447	2.251	1.299	23.469
NRD40001	381.593	10.650	21.200	112.055
NRD40002	357.365	9.961	18.883	95.832
NRD40003	323.721	9.266	10.456	78.630
NRD40004	356.906	10.391	14.070	93.330
NRD50001	761.448	20.716	103.635	258.543
NRD50002	742.725	17.413	76.336	219.723
NRD50003	716.818	18.006	38.875	221.872
NRD50004	724.864	17.520	50.799	204.173
NRD50005	783.254	21.836	80.613	229.856
NRD50006	686.232	16.366	37.414	198.022
NRD50007	782.396	18.017	62.976	314.880
NRD60001	1415.145	43.045	261.984	408.008
NRD60003	1317.045	32.455	205.728	405.688
NRD60004	1410.990	39.501	159.623	470.987
NRD60005	1100.843	34.482	75.767	303.066

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Table C9. Composition of the residual carcass (continued).

Sample number	Moisture (g)	Ash* (g)	Lipids (g)	Proteins (g)
NRD60006	1390.791	35.356	80.059	359.334
NRD60007	1131.820	30.444	131.458	320.629
NRD70002	2094.465	58.555	216.165	695.234
NRD70003	1999.733	59.513	225.640	561.279
NRD70004	2060.396	59.170	253.860	566.757
NRD70006	2385.733	73.167	339.828	717.800
NRD80002	3300.480	104.252	622.546	923.937
NRD80003	3412.695	92.568	217.046	979.014
NRD80004	2152.309	89.739	15.466	453.660
NRU21001	58.189	1.732	4.145	15.877
NRU21002	56.615	1.686	4.033	15.447
NRU24001	88.941	2.727	4.230	22.558
NRU24002	92.075	2.823	4.379	23.353
NRU40001	466.096	14.009	55.772	132.127
NRU40002	472.151	11.893	58.356	125.332
NRU40003	437.178	11.963	61.734	144.256
NRU40004	449.924	12.068	47.661	126.462
NRU40005	504.029	13.872	73.778	149.748
NRU40006	400.073	11.724	36.673	112.243
NRU50001	854.045	---	149.037	256.602
NRU50002	816.536	23.247	140.782	276.667
NRU50003	908.389	---	158.157	263.595
NRU50004	899.771	25.054	137.208	283.652
NRU50005	772.192	22.368	106.009	245.495
NRU50006	927.758	---	144.834	273.272
NRU60001	1497.087	42.151	338.431	479.444
NRU60002	1475.946	45.656	282.434	532.980
NRU60003	1444.059	45.957	265.724	505.312
NRU60004	1612.400	47.843	350.193	604.650
NRU60005	1587.306	47.172	360.187	481.905
NRU60006	1759.784	52.054	381.013	586.595
NRU70001	2221.945	60.107	405.513	747.351
NRU70002	2393.807	69.948	334.993	676.966
NRU70003	2390.206	64.175	397.175	923.164
NRU70004	2474.207	75.951	488.779	784.320
NRU70005	2512.175	74.713	350.363	775.271
NRU70006	2524.486	70.856	549.145	995.572

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Table C9. Composition of the residual carcass (continued).

Sample number	Moisture (g)	Ash* (g)	Lipids (g)	Proteins (g)
NRU80001	3915.047	124.973	692.981	1279.350
NRU80002	3620.258	109.952	685.655	1113.504
NRU60011	1404.581	40.863	181.434	417.909
NRU60012	1423.874	42.174	76.143	464.472
NRU60013	1324.093	37.435	145.669	360.437
NRU60014	1382.768	39.017	223.955	433.528
NRU65011	1831.474	54.200	192.652	524.012
NRU65012	1584.962	55.576	174.071	501.599
NRU65013	1632.227	45.824	169.166	459.492
NRU70011	2011.545	62.768	195.488	628.962
NRU70012	2231.094	66.305	241.964	628.477
NRU70013	1909.946	52.338	225.997	562.235
NRU75011	2754.772	86.082	303.064	753.774
NRU75012	2517.873	73.788	202.829	765.853
NRU75013	2313.055	74.049	204.187	724.226
NRU75014	2297.696	72.619	242.553	776.825
NRUS01	2627.918	69.956	160.537	656.107
NRUS02	1162.101	38.313	130.406	343.348
NRUS03	2243.700	78.576	198.613	614.457
NRUS04	2616.200	80.952	248.466	796.553
NRUS05	1421.662	37.169	250.760	532.605
NRUS06	998.742	24.292	132.398	286.383

* Corrected for skin and bones left around the blades in meat grinder.

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Table C10. Total weight of moisture, ash, lipids, and proteins.

Sample number	Moisture (g)	Ash (g)	Lipids (g)	Proteins (g)
WCD18001-04	36.409	---	---	---
WCD21001-04	54.746	1.466	2.043	14.889
WCD24001-04	85.676	2.759	1.726	22.420
WCD55001	753.076	---	12.056	191.500
WCD55002	856.495	---	7.664	229.976
WCD60001	888.088	---	7.685	164.541
WCD60002	1120.945	---	21.503	315.945
WCD60003	985.487	---	10.216	212.428
WCD60004	1152.794	---	76.280	332.543
WCD65001	1328.864	---	---	252.821
WCD65002	1597.332	---	34.574	373.570
WCD65003	1518.952	---	17.514	363.377
WCD65004	1081.751	---	---	188.173
WCD65005	1588.758	---	77.137	353.779
WCD70001	1953.911	---	14.011	333.175
WCD70002	1988.143	---	101.245	547.417
WCD70003	1790.097	---	20.701	380.296
WCD70004	2105.582	---	---	503.093
WCD70005	2292.396	68.177	236.263	581.810
WCD70006	1330.329	---	---	211.304
WCD75001	2268.916	---	126.691	652.260
WCD75002	2669.630	---	86.372	693.101
WCD75003	1854.312	---	---	365.436
WCD75004	2094.693	---	18.089	461.735
WCU55001	1013.098	---	119.718	349.027
WCU55002	1040.482	---	160.173	321.851
WCU60001	1403.420	---	---	420.720
WCU60002	1317.841	---	184.631	373.043
WCU60003	1358.406	---	---	401.688

APPENDIX C

THE PROXIMATE ANALYSIS DATA

Table C10. Total weight of moisture, ash, lipids, and proteins (continued).

Sample number	Moisture (g)	Ash (g)	Lipids (g)	Proteins (g)
WCU60004	1286.309	---	193.341	400.916
WCU60005	1475.649	37.889	383.040	433.398
WCU65001	1788.017	---	---	559.058
WCU65002	1952.126	---	---	562.022
WCU65003	1738.030	---	227.300	621.116
WCU65004	1667.957	---	216.273	572.953
WCU70001	2180.880	---	364.404	730.552
WCU70002	2271.781	---	294.710	788.457
WCU70003	2044.149	---	151.731	679.682
WCU70004	2023.534	---	286.016	598.264
WCU70005	2334.895	71.296	383.040	633.861
WCU75001	2931.947	---	281.996	---
WCU75002	2742.152	---	343.024	956.512
WCU80001	3298.296	98.326	481.300	935.391
NRD18001	---	---	---	---
NRD18002	---	---	---	---
NRD21001-04	50.279	1.510	0.751	11.341
NRD24001-03	83.830	2.462	1.432	26.538
NRD40001	425.029	11.450	22.107	124.126
NRD40002	400.298	10.724	19.717	109.424
NRD40003	368.850	10.039	10.949	90.352
NRD40004	418.797	11.458	14.819	109.294
NRD50001	837.383	22.137	---	281.579
NRD50002	819.672	18.798	79.422	241.368
NRD50003	787.386	19.156	40.080	241.767
NRD50004	790.805	18.690	52.705	224.197
NRD50005	856.391	23.166	82.986	252.907
NRD50006	756.320	17.723	38.325	217.237
NRD50007	863.716	19.321	65.240	---
NRD60001	1521.661	44.994	273.223	437.809
NRD60003	1420.252	34.227	211.039	433.840
NRD60004	1488.635	41.027	162.928	493.005
NRD60005	1175.848	35.843	77.466	323.631

APPENDIX C

THE PROXIMATE ANALYSIS DATA

Table C10. Total weight of moisture, ash, lipids, and proteins (continued).

Sample number	Moisture (g)	Ash (g)	Lipids (g)	Proteins (g)
NRD60006	1469.715	36.756	82.219	381.608
NRD60007	1208.034	31.772	134.836	341.454
NRD70002	2196.356	60.378	222.873	719.675
NRD70003	2094.510	61.271	230.515	586.857
NRD70004	2188.768	61.283	261.632	600.559
NRD70006	2493.846	75.176	350.667	751.249
NRD80002	3432.445	106.799	636.467	960.270
NRD80003	3545.859	95.200	226.840	1014.734
NRD80004	2256.285	---	16.615	472.265
NRU21001-02	68.602	1.936	4.382	---
NRU24001-02	105.183	3.071	4.632	27.127
NRU40001	511.620	15.365	62.245	149.804
NRU40002	540.985	13.260	66.070	145.975
NRU40003	501.123	13.239	67.182	163.332
NRU40004	496.640	12.970	52.040	139.471
NRU40005	571.858	15.356	78.984	170.533
NRU40006	463.311	13.031	---	131.569
NRU50001	899.778	---	---	268.593
NRU50002	894.198	25.005	152.265	301.797
NRU50003	979.317	---	---	286.947
NRU50004	973.708	27.006	---	309.032
NRU50005	848.761	23.848	115.111	271.466
NRU50006	999.381	---	147.914	296.312
NRU60001	1607.551	44.845	356.339	513.205
NRU60002	1578.620	47.837	296.944	561.491
NRU60003	1530.837	48.049	280.156	535.447
NRU60004	1718.206	50.100	362.880	637.711
NRU60005	1684.469	49.316	375.063	512.469
NRU60006	1869.356	54.195	400.747	621.069
NRU70001	2326.397	63.239	419.390	782.792
NRU70002	2510.166	72.132	341.951	708.799
NRU70003	2491.317	66.250	409.980	952.760
NRU70004	2582.064	79.400	509.019	819.854
MRU70005	2618.142	76.693	360.782	809.724
NRU70006	2628.058	73.361	567.035	1031.417

APPENDIX C

THE PROXIMATE ANALYSIS DATA

Table C10. Total weight of moisture, ash, lipids, and proteins (continued).

Sample number	Moisture (g)	Ash (g)	Lipids (g)	Proteins (g)
NRU80001	4057.022	127.797	717.509	1322.894
NRU80002	3767.886	113.036	701.646	1158.118
NRU60011	1512.165	42.971	189.341	450.155
NRU60012	1528.223	44.049	---	493.486
NRU60013	1436.804	39.315	150.754	390.506
NRU60014	1488.358	41.410	225.777	465.952
NRU65011	1960.617	56.414	200.768	558.332
NRU65012	1698.385	57.732	186.073	538.590
NRU65013	1747.825	47.902	181.384	487.000
NRU70011	2138.029	64.986	201.424	663.243
NRU70012	2355.896	68.530	249.748	662.037
NRU70013	2030.898	---	236.142	595.388
NRU75011	2911.990	88.816	311.312	797.553
NRU75012	2642.881	75.992	209.536	797.966
NRU75013	2434.649	76.192	213.341	757.122
NRU75014	2450.981	---	253.546	816.479
NRUS01	2775.691	---	---	695.391
NRUS02	1458.054	---	158.738	454.811
NRUS03	2373.175	---	203.764	653.404
NRUS04	2755.001	---	---	839.525
NRUS05	1686.868	42.944	276.388	606.306
NRUS06	1232.540	29.374	153.906	375.687

APPENDIX D

THE RELATIONSHIP BETWEEN PROXIMATE ANALYSIS AND CONDITION INDEX.

Table D1. Linear regressions of moisture content (Y (g)) on transformed condition index (X'). Condition index (X) is transformed to $\sin^{-1} (X - 0.4)^{0.5}$.

Length class	Equation	Number of pairs of data	Coefficient of determination
220	$Y = -15.04 + 114.35 X'$	7	0.34
400	$Y = 149.43 + 357.13 X'$	10	0.83
500	$Y = 401.72 + 511.66 X'$	13	0.93
550	$Y = 268.65 + 966.79 X'$	5	0.94
600	$Y = 493.54 + 1082.08 X'$	27	0.89
650	$Y = 701.86 + 1320.86 X'$	12	0.88
700	$Y = 1047.75 + 1431.95 X'$	26	0.79
750	$Y = 1109.97 + 1956.46 X'$	11	0.76
800	$Y = 1386.12 + 2365.20 X'$	6	0.96

APPENDIX D

THE RELATIONSHIP BETWEEN PROXIMATE ANALYSIS AND CONDITION INDEX.

Table D2. Linear regressions of lipid content (Y (g)) on transformed condition index (X'). Condition index (X) is transformed to $\sin^{-1} (X - 0.4)^{0.5}$.

Length class	Equation	Number of pairs of data	Coefficient of determination
220	$Y = -\ 6.32 + 11.81\ X'$	6	0.90
400	$Y = -87.12 + 147.71\ X'$	9	0.92
500	$Y = -174.38 + 298.09\ X'$	9	0.87
550	$Y = -196.11 + 390.28\ X'$	5	0.91
600	$Y = -251.66 + 531.49\ X'$	24	0.82
650	$Y = -408.04 + 733.91\ X'$	8	0.96
700	$Y = -476.26 + 881.41\ X'$	23	0.95
750	$Y = -455.34 + 899.69\ X'$	9	0.81
800	$Y = -368.90 + 980.91\ X'$	6	0.77

APPENDIX D

THE RELATIONSHIP BETWEEN PROXIMATE ANALYSIS AND CONDITION INDEX.

Table D3. Linear regressions of protein content (Y (g)) on transformed condition index (X'). Condition index (X) is transformed to $\sin^{-1} (X - 0.4)^{0.5}$.

Length class	Equation	Number of pairs of data	Coefficient of determination
220	$Y = -18.68 + 55.08\ X'$	5	0.71
400	$Y = 8.56 + 139.13\ X'$	10	0.83
500	$Y = 96.76 + 184.67\ X'$	12	0.84
550	$Y = -0.93 + 400.79\ X'$	5	0.87
600	$Y = -13.22 + 521.28\ X'$	27	0.82
650	$Y = -101.62 + 781.05\ X'$	12	0.94
700	$Y = -53.22 + 853.53\ X'$	26	0.84
750	$Y = -40.63 + 1063.53\ X'$	10	0.83
800	$Y = 60.54 + 1080.43\ X'$	6	0.93

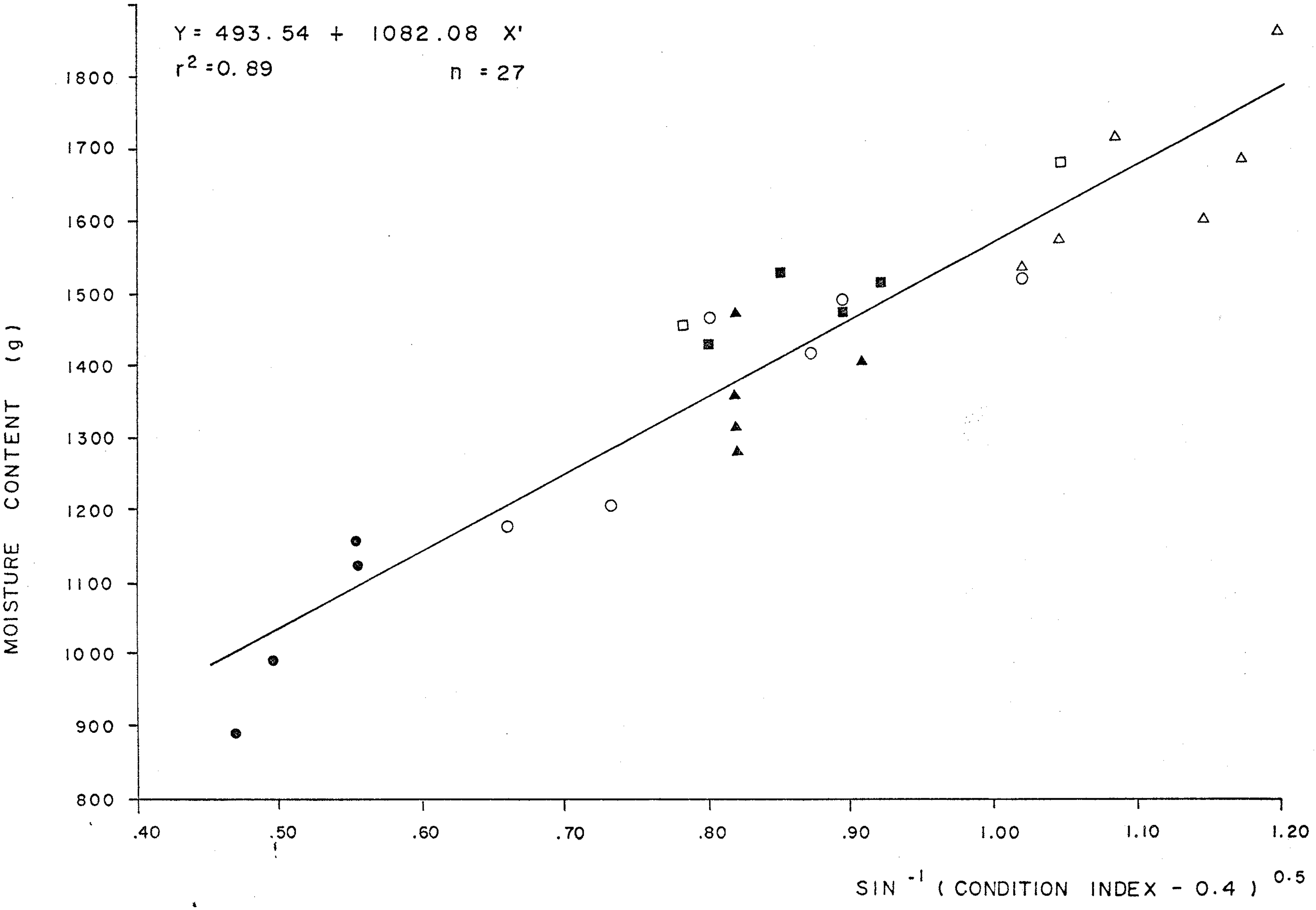

Figure D1. Regression of moisture content on transformed condition index for 600-mm charr: WCD (●), WCU (▲), NRD(○), NRU (△), NRU1 (■), NRUS (□).

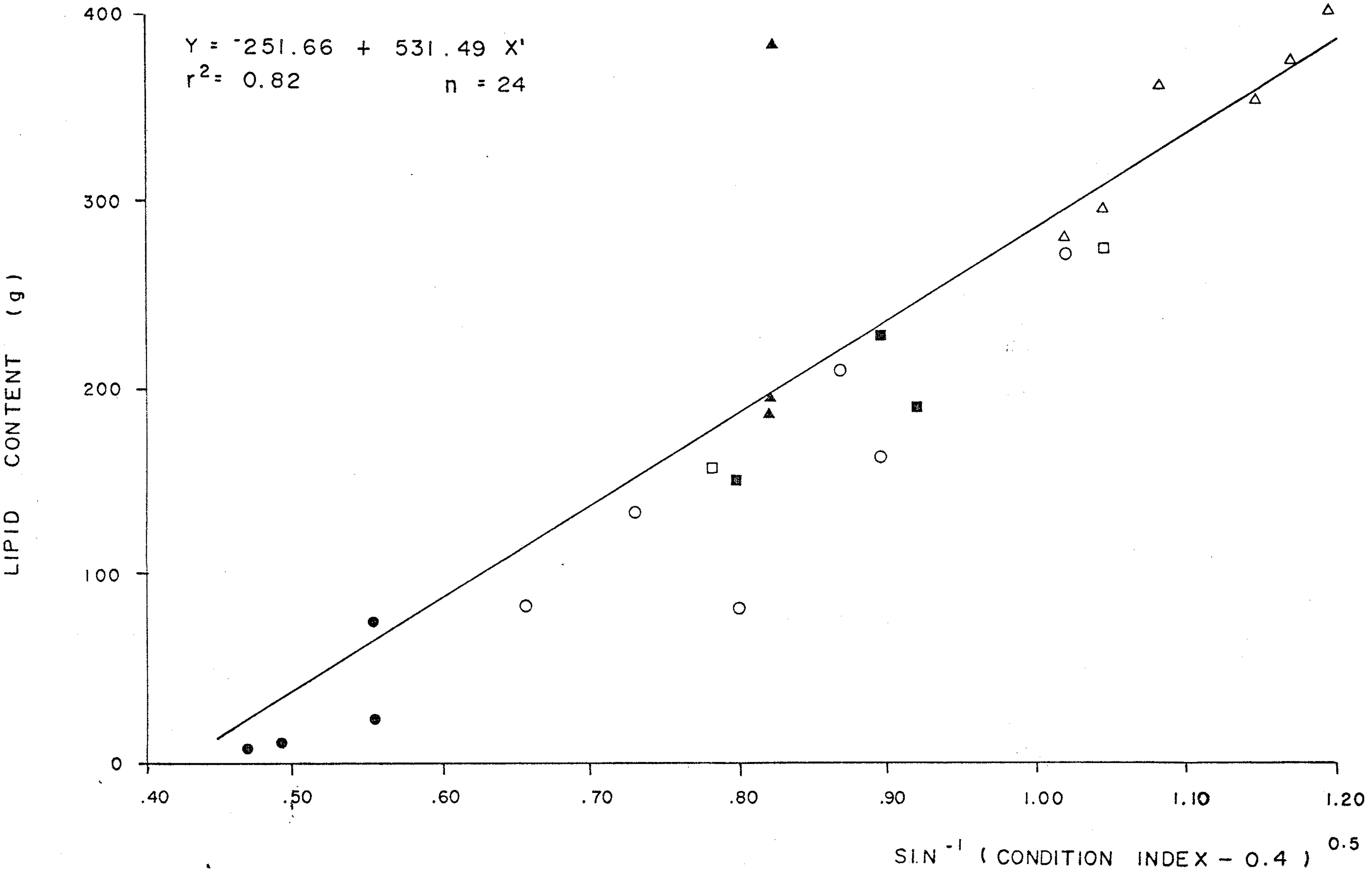

Figure D2. Regression of lipid concent on transformed condition index for 600-mm charr: WCD (●), WCU (▲), NRD(○), NRU (△), NRU1 (▣), NRUS (□).

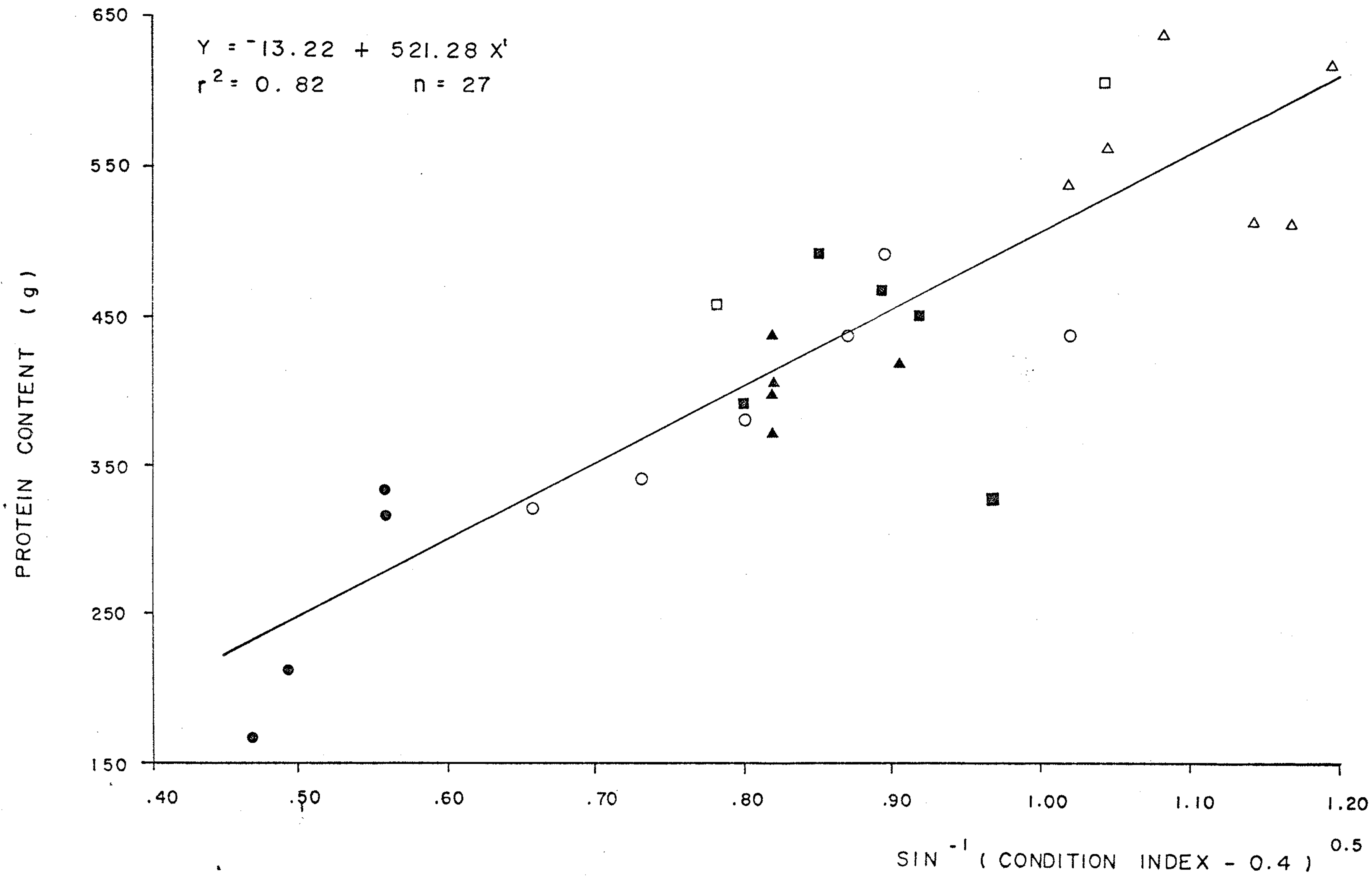

Figure D3. Regression of protein content on transformed condition index for 600-mm charr: WCD (●), WCU (▲), NRD(○), NRU (△), NRU1 (▨), NRUS (□).

APPENDIX E

THE SCHEDULE OF ACCLIMATION

The photoperiod in the hatchery was more or less constant: 8h of light during the week and no light in the weekend. Water temperature ranged from 8 to 12°C. The schedule of acclimation was designed to progressively reduce the photoperiod and the temperature. Throughout the period of acclimation, fish were fed with commercial fish food. However, fish resumed feeding when the photoperiod was reduced to 5 hours of light and the temperature to 6°C.

1.0°C			4.0°C		
Day	T (°C)	Light (h)	Day	T (°C)	Light (h)
26 05	10.0	8	26 05	10.0	8
27 05	9.2	7	27 05	9.2	7
28 05	8.1	7	28 05	8.1	7
29 05	7.5	7	29 05	7.5	7
30 05	6.0	5	30 05	6.0	5
31 05	5.7	5	31 05	5.7	5
01 06	5.2	5	01 06	5.2	5
02 06	4.8	5	02 06	4.8	5
03 06	4.2	5	03 06	4.2	5
04 06	4.2	5	04 06	4.2	5
05 06	4.2	3	05 06	4.2	3
06 06	2.9	3	06 06	4.2	3
07 06	2.1	3	07 06	3.9	3
08 06	1.8	80 min.	08 06	4.4	80 min.
7.0°C			10.0°C		
14 02	10.0	8	14 02	10.0	8
15 02	7.0	6	15 02	10.3	6
16 02	7.0	4	16 02	10.2	4
17 02	7.0	2	17 02	10.2	2
18 02	7.3	80 min.	18 02	10.3	80 min.