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Contributions to the Life History of the Shorthead Sculpin, Cottus confusus, in the Big Lost River, Idaho: Age, Growth, and Fecundity

Abstract

Age, growth, and fecundity were examined for 513 shorthead sculpin, *Cottus confusus*, collected from the Big Lost River, Idaho. Age determination by otoliths revealed six age classes, with growth being fastest the first year (33 mm) and slowing to approximately 10 to 12 mm a year thereafter. Age class composition and condition varied with the habitat. Condition also fluctuated seasonally. Fecundity ranged from 184 to 511 eggs and was proportional to length.

Introduction

The shorthead sculpin, *Cottus confusus*, occurs mainly in the Puget Sound and Columbia River drainages (Bailey and Bond, 1963); it also occurs in the isolated Lost River system. The occurrence of *C. confusus* in the Big Lost River can be attributed to an ancestoral connection between the Lost and the Snake Rivers. Sculpin are of little economic importance, but their abundance in most western streams (MacPhee, 1966) makes understanding their life history necessary in order to understand these stream systems.

Distribution patterns suggest that competition may exist between *C. confusus* and other sculpin, thereby limiting the downstream migration of *C. confusus* or the upstream migration of other sculpin (Maughan and Saul, 1979). This limited distribution has also resulted in the placement of *C. confusus* on the rare or endangered species list of Canadian fishes (McAllister, 1970). Specific data on the life history of the species are inadequate in many areas. The purpose of this paper is to describe the age, growth, and fecundity of *C. confusus*.

Methods and Materials

The study was conducted on a section of the Big Lost River which runs through the Idaho National Engineering Laboratory (INEL) (Andrews, 1972; Overton and Johnson, 1976). The results are based on 513 shorthead sculpin collected in the autumn of 1976 and the spring of 1977 by means of AC and DC electrofishing gear.

The autumn collection (25 September and 2 and 3 October 1976) was made over a 2 km section of the river below the INEL diversion dam. The spring sample (13 and 24 April 1977) was restricted to three sampling stations immediately below the

INEL diversion dam because of low water. These three sampling stations appeared to be representative of the major habitats found in that portion of the river. Site one consisted of deep fast water with a boulder and fine gravel substrate, race. Site two was shallow water with moderate current, and fine gravel and marl substrate, riffle. Site three was of moderate depth, with slow current and fine gravel interspersed with large boulders, pool-rubble area.

Standard and total lengths of preserved specimens were taken to the nearest 1 mm and weight to the nearest 0.1 gram. Otoliths were removed and sex determined by dissection. Age was determined by examination of otoliths (Bailey, 1952). Calculated lengths to the time of annulus completion were determined by the formula, $L = F + (SL - F/R_0)Ra$, where L is the calculated standard length, F is the L-intercept as calculated by a linear regression of standard length and otolith radius, R_a is the otolith radius in ocular micrometer units from the focus to the annulus, R_0 is the otolith radius in ocular micrometer units from the focus to the anterior margin of the otolith, and SL is the standard length (Everhart *et al.*, 1975).

Condition coefficients were calculated by the formula, $K = 10^5\ W/L^3$, after Lagler (1952), where K is the condition coefficient, W is the weight in grams, and L is the total length in mm. Total length was used for the determination of conditions to produce results of the same magnitude as other published accounts of condition. The relationship between total and standard length can be described by the formula, $SL = 0.53 + 0.79\ TL$. Condition was analyzed by sex, age, size, season, and sample location using analysis of variance and multiple range testing (Zar, 1974).

Fecundity was measured by direct count of ova. The relationships between fecundity and standard length, weight, age, and condition were established by linear, exponential, and multilinear regression analysis, respectively (Zar, 1974).

Results

The determination of age by examination of otoliths revealed 6 year classes (Table 1). The relationship between the standard length of the sculpin and the anterior radius of the otolith was determined to be a linear regression with a correlation coefficient of 0.95. This strong relationship adds validity to the use of otoliths as an aging tool and allows the determination of a correction factor (–1.52 mm). The relationship can be described by the formula, $SL = 1.34\ R_a - 1.52$.

TABLE 1. Calculated standard lengths at annulus formation of **Cottus confusus** in the Big Lost River, Idaho.

Year Class	Number of fish	Annulus Number				
		1	2	3	4	5
1976	92					
1975	63	33.9				
1974	50	34.2	46.9			
1973	44	32.6	44.4	56.1		
1972	26	29.5	41.0	54.2	66.1	
1971	14	34.7	45.3	54.0	66.1	77.5
Weighted mean length at annulus formation		33.2	44.7	55.1	66.1	77.5
Mean annual growth		33.2	11.5	10.4	11.0	11.4

Sculpin attain a length of approximately 33 mm SL during the first year, after which growth slows to approximately 10 to 12 mm a year (Table 1). Growth of the population from October through mid-April, if the two samples are taken to be representative of the population as a whole, was 2.9 to 5.4 mm. This growth represents approximately 11 to 47 percent of the mean annual growth (Table 2).

TABLE 2. Mean standard length at capture, and growth of **Cottus confusus** from October through mid-April in the Big Lost River, Idaho.

	Autumn		Spring			
Age Class	Length Mean	Number of Fish	Mean Length	Number of Fish	Growth (mm) Autumn-Spring	% of Mean Annual Growth
1	34.4	14	38.0	78	3.6	11
2	43.8	6	46.7	57	2.9	25
3	55.8	6	58.9	44	3.1	30
4	66.1	23	70.7	21	4.6	42
5	76.7	14	82.1	12	5.4	47
6	87.4	9	91.0	5	3.6	*

*Percent of annual growth could not be determined because annulus had not yet formed.

The length-weight relationships were determined for three groups of sculpin: autumn 1976, pre-spawn 1977, and post-spawn 1977. Since no difference was observed between the sexes, as determined by analysis of covariance, data were combined. Growth relationships were of the allometric type following the general formula, $W = aL^b$, where a and b are empirically determined constants. The autumn sample can be represented by the formula $W = 9.36\ L^{3.25}(10^{-6})\ (r = 0.99)$, the pre-spawn sample by the formula, $W = 1.29\ L^{3.22}(10^{-5})\ (r = 0.99)$, and the post-spawn sample by the formula, $W = 3.43\ L^{2.97}(10^{-5})\ (r = 0.98)$. The relationships were statistically different ($P < 0.05$) at all levels, as determined by analysis of covariance.

An analysis of condition factors revealed no significant difference between the sexes, as determined by the Student t-test, so data were combined. Condition of age class in the spring sample revealed no significant differences. However, autumn conditions were significantly different by age class ($0.05 > P > 0.02$) with a trend for an increase in condition with an increase in age (Fig. 1). Likewise, size class—condition comparisons revealed no difference in the spring, but significant differences existed in the autumn, with a trend for condition to increase with size. Significant differences in condition also existed between the autumn and post-spawn spring sculpin, with the autumn sculpin exhibiting a lower relative condition; the effect was most pronounced in the smaller, younger fish.

Distinct habitats were sampled in the spring and fish collected in each area were characterized by relative condition and age class composition. Significant differences existed between habitats for condition and age, which suggests the lack of appreciable exchange between areas (Fig. 2). The race and riffle situations were similar in terms of age class composition, while the pool-rubble area had a significantly greater proportion of older fish ($0.02 > P > 0.01$). The pool-rubble area was assumed to be the spawning ground for the sculpin because of the high concentration of sexually ripe sculpin found in the pre-spawn sample; however, no actual spawning activity or egg clusters were observed. In terms of condition, the riffle and pool-rubble areas were

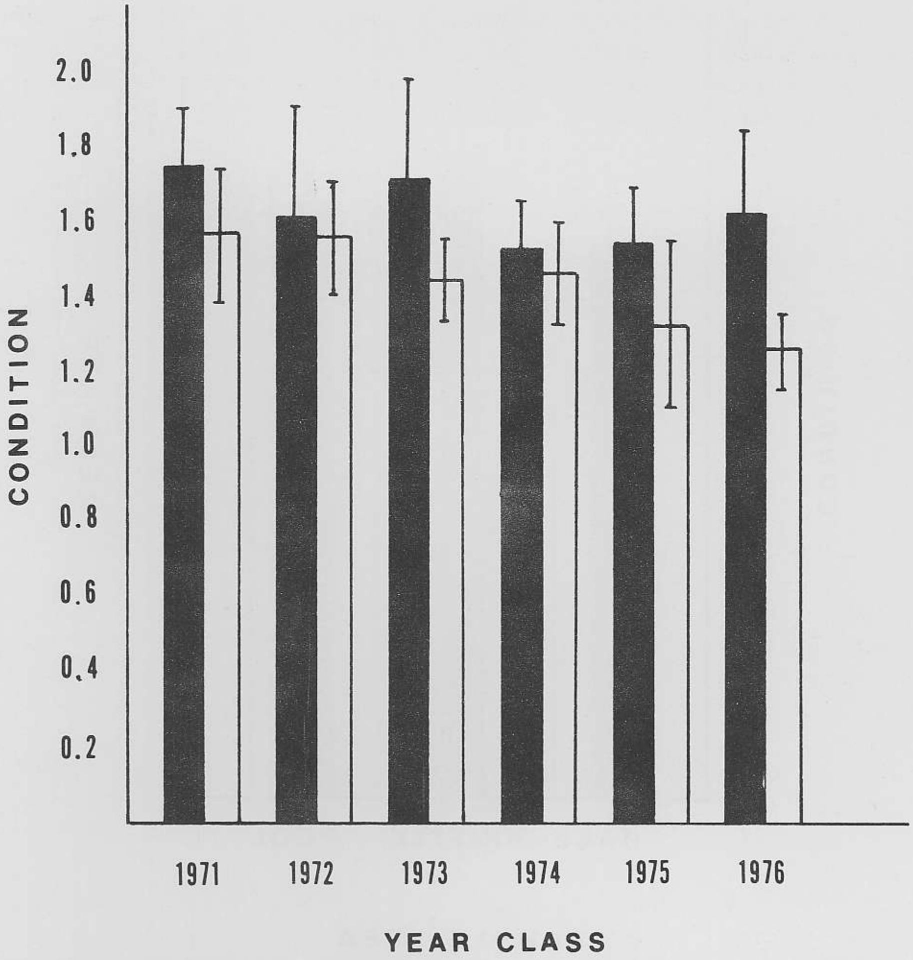

Figure 1. Condition-year class relationship for autumn and spring *C. confusus* in the Big Lost River, Idaho. Bars represent mean condition plus standard deviation, with black bars being spring and white bars being autumn.

similar, with the race situation producing a significantly lower condition ($0.01 > P > 0.005$).

The sculpin in the Big Lost River spawned over a very restricted time period; all females collected on 13 April 1977 were ripe, and females collected at the same location on 24 April 1977 were spent. This rapid spawn could be related to a dramatic reduction in water flow over this same period.

Twenty ripe females were collected in the pre-spawn sample and subjected to direct egg counts. Fecundity ranged from 184 eggs in a 53 mm 3 year old fish to 511 eggs in a 71 mm 4 year old fish. Age class 2 females were immature, and age classes 5 and 6 were not collected at that time. An analysis of the data revealed a linear relationship between the number of eggs and the standard body length to have the most significant correlation ($r = 0.91$) (Fig. 3). The relationship can be expressed by the formula, $F = 14.15\ SL - 531$, where F is the fecundity. Weight, age, and condition

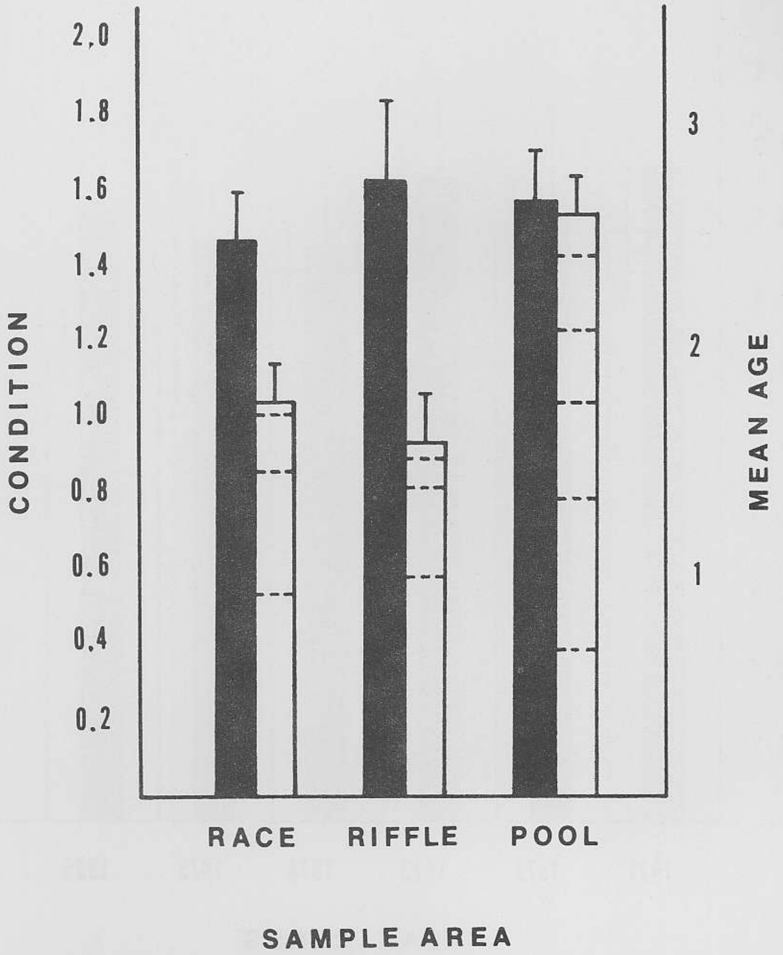

Figure 2. The relationship of condition and age class composition to habitat for *C. confusus* in the Big Lost River, Idaho. Black bars represent mean condition plus standard deviation; white bars represent mean age plus standard deviation. Dotted lines represent progressive year class proportions of the sample with the 1976 year class on the bottom.

did not exhibit an increased correlation to fecundity when analyzed by linear or exponential relationships. Correlation was not increased when analyzed by multilinear regressions involving length, age, and fecundity ($r = 0.85$), or length, weight, and fecundity ($r = 0.90$). No correlation was found between individual egg size (diameter and weight) and length, age, weight, or condition. These results establish length of individual fish to be the best predictive factor for fecundity of the shorthead sculpin in the Big Lost River.

Discussion

Growth of shorthead sculpin exhibited strong seasonal and age class relationships. There is a trend for the percentage of the mean annual growth occurring during the October through April period to increase with each age class (Table 2). This trend may follow

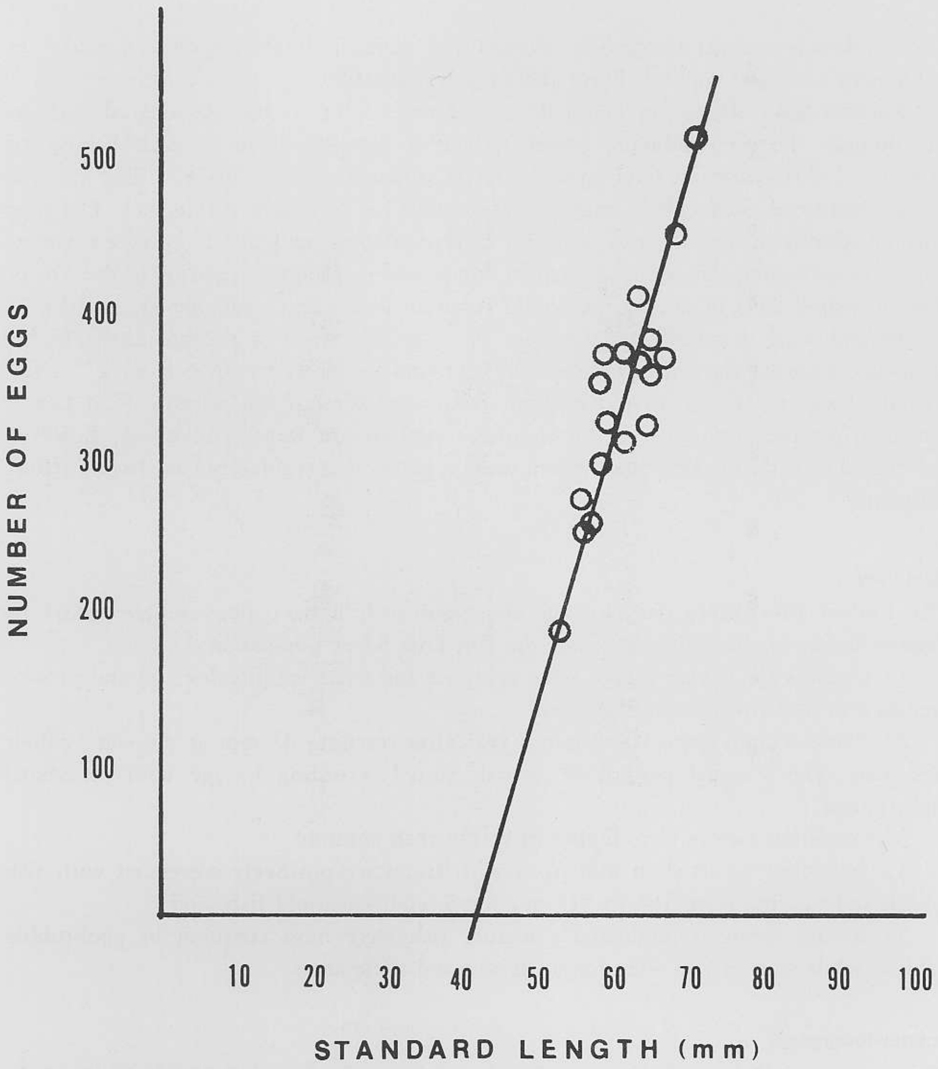

Figure 3. Length-fecundity of *C. confusus* in the Big Lost River, Idaho.

changes in the food habits of the different sizes of sculpin. Food habit data (Cannamela, Gasser, and Johnson, 1978) indicate that the majority of the October-April growth occurs in the early spring.

Weight and condition also varied seasonally and with age. The pre-spawn spring sample was significantly heavier after age 2, which was undoubtedly due to gonad development. Weight-condition differences were also significant between autumn and post-spawn spring sculpin. The increase observed from the autumn to post-spawn spring may be attributed to an increased feeding activity for the populations as a whole in the spring (Cannamela *et al.*, 1978). The more dramatic increase seen in the younger fish (year classes 1976, 1975, Fig. 1), may have resulted from increased food availability and high expenditures of energy for the formation of reproductive products in older fish during the pre-spawn period. The piute sculpin, *Cottus beldingii*, also exhibits a seasonal fluctuation of condition which is likely related to gonadal development and food supply (Ebert and Summerfelt, 1969).

Relative food abundance could be a causative factor in the observed differences in condition between habitats; however, benthic samples taken in each habitat revealed no difference in food availability (Cannamela *et al.*, 1978). The physical characteristics of each habitat may be responsible for condition differences. The high current velocity in the race area could act to restrict foraging activity, or cause a greater expenditure of energy in terms of securing forage and maintaining position in the stream. This increased level of energy use would result in less energy available for growth.

Fecundity of shorthead sculpin from the Big Lost River was significantly higher than that reported elsewhere. Patten (1971) found fecundity to range from 47 in fish 61 mm long to 217 in 86 mm sculpin from two Washington streams. The factors which affect the fecundity of the shorthead sculpin are largely unknown; however, the degree of variation between the two areas suggests that regulatory cues have a strong influence.

Summary

The limited life history data for the shorthead sculpin have been supplemented by determination of the following from the Big Lost River population:

1) Otoliths for 6 year classes were analyzed and their validity for age and growth studies was confirmed for this species;

2) These sculpin grew 10-12 mm a year after reaching 33 mm at the end of their first year. The seasonal pattern of growth varied according to age with no sexual dimorphism;

3) Condition factors were higher in spring than autumn;

4) Spawning occurred in mid-April with fecundity positively correlated with fish length and ranging from 184 to 511 ova for 3- and 4-year-old fish; and

5) In the spring, reproductively mature fish were most common in pool-rubble habitat, while smaller fish were found in race and riffle areas.

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