Canadian Technical Report of
Fisheries and Aquatic Sciences 1227

February 1984

THE GENERAL ECOLOGY OF THE SLIMY SCULPIN (*Cottus cognatus*) IN LAKE 302 OF THE EXPERIMENTAL LAKES AREA, NORTHWESTERN ONTARIO

by

L.C. Mohr

Western Region
Department of Fisheries and Oceans
Winnipeg, Manitoba R3T 2N6

This is the 164th Technical Report,
from the Western Region, Winnipeg

Cat. no. Fs 97/6-1227 ISSN 0706-6457

Correct citation for this publication is:

Mohr, L.C. 1984. The general ecology of the slimy sculpin (Cottus cognatus) in Lake 302 of the Experimental Lakes Area, northwestern Ontario. Can. Tech. Rep. Fish. Aquat. Sci. 1227: iv + 16 p.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Mohr, L.C. 1984. The general ecology of the slimy sculpin (Cottus cognatus) in Lake 302 of the Experimental Lakes Area, northwestern Ontario. Can. Tech. Rep. Fish. Aquat. Sci. 1227: iv + 16 p.

The general ecology of the slimy sculpin (Cottus cognatus) from Lake 302 of the Experimental Lakes Area, Ontario was studied during the openwater season of 1982. The largest sculpin caught was 111 mm in length, weighed 16.86 grams and was aged 6+. Length-weight relationships were similar for both male and female sculpins. Condition was higher in males than in females with both sexes peaking in condition in June and declining throughout the summer. Growth was best for sculpins aged 0+ to 2+, averaging 22.7 mm per year. The population as a whole had a survival rate of 36%. Sculpins of both sexes matured at age 2+ and were 65-70 mm in length. They spawned in late May with fry hatching in late June. Chironomids and chaoborids were the most common food items used by sculpins (66% and 41%, respectively) during the spring and summer. In the fall these were replaced by young cyprinids and other larger prey species. Sculpins tended to congregate in the metalimnion of the lake where optimal oxygen concentrations and temperatures occurred.

Key words: life history; growth; diets; spatial distribution; reproduction.

RESUME

Mohr, L.C. 1984. The general ecology of the slimy sculpin (Cottus cognatus) in Lake 302 of the Experimental Lakes Area, northwestern Ontario. Can. Tech. Rep. Fish. Aquat. Sci. 1227: iv + 16 p.

Pendant la saison des eaux libres de 1982, on a étudié l'écologie générale du chabot visqueux (Cottus cognatus) dans le lac 302 de la Région des Lacs Expérimentaux, en Ontario. Le plus grand chabot pêché mesurait 111 mm de long, pesait 16,86 grammes et avait plus de 6 ans. Tous les chabots, tant les mâles que les femelles, présentaient un rapport poids-longueur semblable. Les mâles étaient en meilleur état que les femelles, l'état des deux sexes connaissant un apogée en juin et se détériorant progressivement au cours de l'été. Les chabots à partir de la naissance jusqu'à plus de deux ans accusaient le meilleur taux de croissance, c'est-à-dire de 22,7 mm par année. En général, le taux de survie des chabots s'élevait à 36%. Mâles et femelles ont atteint la maturité après l'âge de 2 ans alors qu'ils mesuraient de 65 à 70 mm de long. La fraie a eu lieu à la fin de mai et les oeufs sont éclos à la fin du mois suivant. Au printemps et en été, les chabots se nourrissaient principalement de chironomidés et de chaoboridés qui constituaient respectivement 66 et 41% de leur régime alimentaire. En automne, ils mangeaient surtout des jeunes cyprinidés et autres espèces plus grosses. Les chabots se tenaient généralement dans le métalimnion du lac, là où la concentration d'oxygène et la température leur étaient plus favorables.

Mots clés: antécédents; taux de croissance; régimes alimentaires; répartition géographique; reproduction.

INTRODUCTION

Data were collected on the slimy sculpin (*Cottus cognatus*) from Lake 302 (L302) in the Experimental Lakes Area (ELA) (Cleugh and Hauser 1971) during the openwater season of 1982. Samples also were collected from Lake 226 (L226) and were used for comparative purposes. The purpose of this project was to establish background data on the life history of this species prior to a whole lake acidification experiment in L302, a double basin lake, where the relative effects of sulfuric (H_2SO_4) and nitric (HNO_3) acids on an aquatic ecosystem will be compared (D.W. Schindler, personal communication) and to determine if differences occurred between L302N (North basin) and L302S (South basin).

The slimy sculpin was studied for several reasons. A previous whole lake acidification experiment in L223 at ELA, described in Schindler et al. (1980), resulted in a marked reduction in slimy sculpin abundance in that lake. Lake 223, with a pH in 1982 of 5.2 (time-weighted annual mean) (D.W. Schindler, unpublished data), is now almost devoid of slimy sculpins (I. Davies, personal communication). While the effects of acidification are well known for many fishes (Beamish et al. 1975; Spry et al. 1981), very little is known for the slimy sculpin.

The slimy sculpin is by far the most widespread of the genus *Cottus* (Van Vliet 1964). Scott and Crossman (1973) list its North American range as: from Alaska and the Northwest Territories south to Virginia and from southern British Columbia east to New Brunswick. Slimy sculpin occurrence is quite restricted in the southern portions of the three prairie provinces probably due to lack of suitable habitat (Van Vliet 1964), but it occurs ubiquitously across the Precambrian Shield, the geographic region most susceptible to acid precipitation.

In a survey of the ELA region, Beamish et al. (1976) found the slimy sculpin in 24 of 109 lakes. This species was found in a wide variety of lake sizes (9-1 300 ha), and almost all these lakes were deep (>9 m). Slimy sculpins seem to occur only in lakes with well developed hypolimnia as is the case with L302.

The slimy sculpin also is commonly found in streams and rivers. The slimy sculpin shares its lentic environment with such species as Arctic grayling (*Thymallus arcticus*), brook trout (*Salvelinus fontinalis*) and rainbow trout (*Salmo gairdneri*) as well as various dace, logperch, darters and trout perch (Craig and Wells 1976; Petrosky and Waters 1975; Van Vliet 1964). In L302 and L226, the slimy sculpin co-occurs with lake whitefish (*Coregonus clupeaformis*) and white suckers (*Catostomus commersoni*), while in L223, another ELA lake, it co-occurs with lake trout (*Salvelinus namaycush*) and white suckers.

Very little has been published on the biology of the slimy sculpin. The most extensive study to date was conducted by Van Vliet (1964) on slimy sculpins in northern Saskatchewan rivers and lakes. Unfortunately, this is not in published form and therefore not readily accessible. Craig and Wells (1976) studied a slimy sculpin population in an Alaskan arctic stream while Petrosky and Waters (1975) studied slimy sculpin production in a Minnesota trout stream.

METHODS

Slimy sculpins were collected in L302 from May 6, 1982 to October 20, 1982. Sculpins were caught by metal minnow traps (10 mm mesh), trap nets (3 mm mesh) and night scuba diving with a suction gun. Sculpins were collected in L226 from September 29, 1982 to October 28, 1982 using only trapnets (3 mm mesh). These fish were used primarily for comparative purposes.

Most minnow traps were baited with an oatmeal-dough mixture and distributed throughout both basins of L302 (Fig. 1). Trap nets were set parallel to shore with the pot set at a depth of approximately 2-3 m. Nets were moved to different locations throughout the sampling period, alternating them between the two basins of L302. Six linear transects were established along the bottom of L302, three in each basin. Sites were chosen that would be representative of bottom types and contours of the lake (Fig. 1). On August 19, 1982, two night dives were made in each basin and a 5 m long, 1 m wide area was surveyed in each 2 m contour interval along each transect.

Most sculpins were returned to the laboratory immediately after capture for processing, while others were preserved in 10% formalin and sampled later. Total lengths were measured to the nearest 1mm and weights were measured to the nearest 0.01 g. Length-weight relationships were derived using all 392 specimens caught in L302. Recorded values were used in the equation $W = aL^n$, where W = weight in g, L = total length in mm and n and a are constants.

The coefficient of condition (K) was calculated using the following equation:

$$K = \frac{\text{weight (g)} \cdot 10^5}{\text{length (mm)}^3}$$

The K factor was computed for different sexes, ages, habitat and sampling period.

Ages were determined for all fish from otoliths. Similar techniques have been used successfully in the past (Van Vliet 1964; Craig and Wells 1976). Otoliths were removed from the chambers of the labyrinth of the fish, placed in parafilm to preserve moisture and stored until reading. A binocular microscope set at 20x, with reflected light on a black background, was used to observe otoliths. The otoliths were placed in a culture slide with a liquid mixture of 2 parts benzyl benzoate, 1 part methyl salicylate which cleared the external coating of the otoliths and facilitated age determination. The heavily calcified exterior of some otoliths was removed by grinding on a dry honing stone. Grinding was conducted very cautiously so that annuli on the otolith periphery were not removed. Opaque zones on the otolith were designated as summer growth while translucent rings represented winter growth (Bailey

1952; Van Vliet 1964).

Catch-curve survival rates were calculated for slimy sculpin populations from L302 and L226, Lac la Ronge, Cree River and Montreal River (Van Vliet 1964), and Chandalar River (Craig and Wells 1976) using a technique described by Robson and Chapman (1961).

The stomach of each sculpin was removed by opening the body cavity of the fish and cutting the esophagus at the posterior end of the oral cavity and cutting the pyloric valve where it joined the intestine (Bailey 1952). Stomachs were stored in 10% formalin. Later each stomach was emptied and the volume of the contents were measured by water displacement. Using a binocular microscope, stomach contents were identified and counted. The number of empty stomachs was tabulated and excluded from further statistical analyses.

Sex and state of maturity of all sculpins were determined by visual examination of the gonads. No further attempt was made to sex immature fish.

RESULTS AND DISCUSSION

Length and Weight

Length frequency distributions were prepared for 392 slimy sculpins caught in L302 (Fig. 2). No size or frequency differences were found between the north and south basin and therefore results were grouped together. The largest sculpin caught in L302 was a female aged 6+, 111 mm in length and 16.86 g in weight. In L226, a female aged 6+, 128 mm in length and 30.34 in weight was caught. Van Vliet (1964) found that sculpins commonly were over 110 mm in length in rivers, but in lakes were rarely over 80 mm. The largest sculpin caught by Craig and Wells (1976) in an Alaskan stream was aged 7+, 104 mm long and weighted only 14.1 g. Apparently, sculpins attain larger maximum sizes in southern lakes than in northern lakes.

Length-weight relationships were calculated for all slimy sculpins caught in L302 and L226. These were compared with results from other studies in Table 1 and Fig. 3. No differences in length-weight relationships were found between L302 north and L302 south. Both L302 and L226 had length-weight relationships similar to those from other studies.

Condition

Male sculpins had significantly higher condition factors (see Fig. 4) than female sculpins for June through October in L302 (t-tests; $P<0.05$), but no significant difference occurred between sexes in May. Lowest condition for males occurred just after ice out and spawning and peaked in June. Condition decreased throughout the summer and started to increase again in October. Females also were in lowest condition after ice out and spawning with a peak in June and July. Female condition decreased throughout the summer and fall. Condition factors of both male and female sculpins were similar only in May which is to say, at time of spawning. The condition of female sculpins never reached that of male sculpins throughout the summer which could reflect the large loss of gonodal weight in females following spawning. This is not as pronounced in males. Petrosky and Waters (1975) suggest that growth is greatest in spring and early summer and least in the fall. Assuming that increased condition is an indication of increased growth, results from L302 would be consistent with those of Petrosky and Waters (1975).

Growth

The growth curve of the L302 slimy sculpin population was compared to growth curves for several other sculpin populations (Fig. 5) (Van Vliet 1964; Craig and Wells 1976). Growth of L302 sculpins was in the middle of the range of growth rates of populations documented by these authors. The two northern sculpin populations (Cree and Chandalar Rivers) did not grow as large as L302 sculpins but generally lived longer; age 6+ and 7+ respectively. The Montreal River sculpins grew to a larger size than did L302 sculpins and also were very short-lived compared to L302 and other sculpin populations.

In L302, fish aged 0+ averaged 28.6 mm in length. Up to age 2+, growth averaged 22.7 mm per year and thereafter growth decreased to an average rate of 9.3 mm per year (Table 2). This rate of growth was similar to that of the Chandalar River sculpins (10.8 mm per year) (Craig and Wells 1976), the difference being that Chandalar sculpins only reached an average of 36.6 mm in length by age 1+ compared to 53.3 mm at age 1+ for L302 sculpins. Allowing for differences in time of capture, L226 sculpins had growth rates similar to L302 sculpins except that Lake 226 sculpins aged 4+ and over grew to a larger size and at a faster rate than did L302 sculpins.

The two most northerly sculpin populations, Cree River and Chandalar River, had the highest survival rate (70%) while the fastest growing, more southerly Montreal River population, had the lowest survival rate (10%) (Table 3). The L302 population had a survival rate of 36% and L226 had a survival rate of 61%. In general, annual survival rates were related inversely to growth.

Diet

Lake 302 sculpins fed on a wide variety of organisms but larval and pupal dipterans were the most important group of food items (Tables 4, 5). Chironomid larvae were found in 66% of all sculpin stomachs while chaoborids were found in 41% of stomachs examined. Craig and Wells (1975) found chironomid larvae in 76% of sculpin stomachs they examined. Chironomids are very abundant in ELA lakes so it is not surprising that this group was the largest component of the sculpin diet. In October sculpins shifted to larger prey species such as abundant young cyprinids. Other seasonal variations in sculpin diet can be seen in Table 4. Unidentified material in sculpin stomachs consisted of rocks, plants, algae, insect eggs and any unidentifiable partially digested material. The slimy sculpin is very opportunistic in its feeding habits. In the future, changes in benthic and zooplankton species abundance in the lake may be reflected in the changes in the sculpin stomach contents.

Stomachs from older sculpins (>3+) contained less variety of species than younger sculpins. Older sculpins also relied more on pupal and nymph stages of organisms while younger sculpins preferred larval stages. The few young of the year (0+) sculpins examined (n = 3), had eaten primarily dipteran and trichopteran larvae.

The number of empty stomachs found in L302 sculpins was relatively consistent throughout the sampling period. An inverse relationship existed between the number of empty stomachs and age of the fish (Table 5). Ebert and Summerfelt (1969) state that percentage of empty stomachs varies inversely with depth of habitation. This would suggest that older fish travel to greater depths in lakes while younger fish are confined to shallower depths and a more limited food supply.

Only one instance of cannibalism was observed in L302 and that was the case of an age 3+ sculpin caught in October which had an age 0+ sculpin (≈ 30 mm) in its stomach. Petrosky and Waters (1975) reported the presence of sculpin eggs in male stomachs during the spawning season. This was not evident in L302. At this point it is not apparent whether cannibalism was selective or accidental.

Large increases in stomach volume with increase in age (Table 4, 5) of L302 sculpins was correlated to changes in prey size. Northcote (1954) related diet changes to length and more specifically to mouth size which limited the size of the food organisms for two other cottid species. Stomach volumes increased from May through October. A large increase in June could have been related to the post spawning period when sculpins were replenishing their energy reserves lost during spawning.

Stomach contents were also examined from slimy sculpins caught in L226 in October 1982. Dipterans and fish remains were the two most prominent food items found; 64% and 65% respectively. The diet of L226 sculpins contained a smaller variety of items than did L302 sculpins. Ephemeroptera nymphs and trichoptera nymphs were the only other prey species that L226 sculpins consumed in significant amounts.

Mean stomach volumes for L226 sculpins in October were only slightly higher than those for L302 sculpins in the same time period. Sculpins aged >3+ had greater volumes than did L302 sculpins of the same ages. This corresponds to the preference of large sculpins from L226 for cyprinids as prey species. For sculpins aged 3+ or more, cyprinids occurred in an average of 88% of all L226 slimy sculpin stomachs. In L302 sculpin stomachs this number was only 28%.

Cannibalism was also evident in L226. Six sculpins were caught in L226 that had young sculpins (age 0+) in their stomachs. In all but one case these stomachs also contained small cyprinids.

Several sculpins caught in L302 contained tapeworms in their body cavities. The stomach contents (volume and numbers of organisms) of the sculpins were not affected by these parasites. However, the fish had reduced gonad size or no gonadal development. This may prove to be an important indicator during acidification stress.

Reproduction

Spawning of slimy sculpins in L302 was not observed in 1982. However, the state of gonads of females caught in May and June were used to estimate their spawning period. Ripe females were caught on May 18 and 20 and as late as June 2, 1982. All females caught after June 16, 1982 were spent. Spawning probably took place between mid-May and early June. Van Vliet (1964) believed that water temperature was the primary factor influencing spawning, incubation period and hatching date for slimy sculpins. He found sculpins generally spawn in water around 8°C and hatch at approximately 19°C. The first recorded temperature after ice-out in L302 in 1982 was 10.5°C on May 12, 1982. Water temperature reached 18-19°C by the end of June in L302. Using Van Vliet's (1964) estimate of incubation period (28 days), sculpins in L302 probably spawned in late May and fry hatched in late June. This would be consistent with other studies that list slimy sculpin spawning in other geographical regions as occurring from late April to early June and lasting for approximately one week (Van Vliet 1964; Craig and Wells 1976; Petrosky and Waters 1975).

The age and size at maturity of L302 sculpins were similar for both males and females. A few fish reached maturity at age 1+ while 93% were mature by age 2+. Maturity corresponded very closely to a minimum size range of 65-70 mm which was similar to the size of maturity obtained by sculpins in Van Vliet's (1964) study. In general, southern sculpin populations reached maturity by age 2+ (Van Vliet 1964; Petrosky and Waters 1975) while in more northerly populations, sculpins reached maturity at ages 3+ or 4+ (Craig and Wells 1976; Van Vliet 1964).

Mature females from L302 had developed ovaries with new eggs in October of 1982. Most female sculpins aged 1+, which were immature in the spring, had well developed eggs by fall in preparation for spawning the following spring. A definite visual increase in egg size and gonad size was observed from September to the end of October although this was not quantified.

Potential sculpin spawning sites are shown in Fig. 1. These were based on the capture of age 0+ sculpins in June and July at these sites. They were all areas of shallow depth (0.5-1.5 m) with gravel and sand bottoms interspersed with various sizes of rocks and boulders.

Spatial Distribution

On August 19, 1982, four night dives along preset transects were conducted in L302 (Fig. 1). A total of 25 slimy sculpins were observed in the south basin and 89 in the north basin. This difference could indicate a larger population in the north basin than in the south since equal areas were covered in both basins. At present it is assumed there is no movement of sculpins between basins due to the curtains partitioning the lake into 2 basins.

Van Vliet (1964) believed that many factors can influence the distribution of sculpins in a lake: food availability, habitat, water temperature, oxygen concentration, territory size, light penetration or combinations of these factors. Oxygen concentration, water temperature and dipteran emergence data are available for L302 and are discussed here.

The maximum depth in the two basins of L302 differed (N = 13m; S = 10m) and, therefore, results from each basin were treated separately (Fig. 6).

Most sculpins in the south basin were found from 5-8 m in depth (Fig. 6). Oxygen levels from the surface to 7 m were well above 2 $mg \cdot L^{-1}$, the concentration for avoidance determined by Bond (1963; as cited in Van Vliet (1964)) and above the 1.5 $mg \cdot L^{-1}$ lethal concentration for reticulate sculpins (Davison et al.1959). At the 8 m depth the oxygen concentration was 2.66 $mg \cdot L^{-1}$ but dropped to 0.15 $mg \cdot L^{-1}$ at 9 m. Lack of adequate oxygen at this depth corresponded to lack of sculpins seen. Almost all of the sculpins in the south basin were found in water with temperatures of 9-18°C. Symons et al. (1976) suggested a mean preferred temperature of 13.1°C and Otto and Rice (1977) found that 10°C was the preferred temperature. Both studies suggested that sculpins occupy a wide range of temperatures. This was evident also in L302 data. Most sculpins were aggregated in the metalimnion in the south basin (Fig. 6). This included the area of optimal temperature and optimal oxygen concentrations.

Dipteran emergence occurred only above the 7 m depth in the south basin of L302 (I. Davies, unpublished data). The greatest yield occurred in water less than 2.5 m deep and yet no sculpins were seen in this range. This suggests that sculpins may migrate to take advantage of food supplies and then return to cooler, more favorable habitat. However more information is necessary before any conclusions can be drawn.

In the north basin, sculpins were not found in water shallower than 4 m. Only one individual was recorded deeper than 8 m, the majority occurred in the 6-8 m depth (67%) with a smaller number (32%) found in the 4-6 m depth range (Fig. 6). Oxygen concentrations were adequate down to the 6 m depth and then dropped to 0.24 $mg \cdot L^{-1}$ at the 8 m level. This drop in oxygen concentration parallels the drop in sculpin numbers at the 8 m depth. Water temperature in the north basin ranged from 7-19°C in the 4-8 m depth respectively. The majority of sculpins in L302N were found in temperatures of 9-14°C, in the optimal range. As in the south basin, most sculpins in the north basin aggregated in the metalimnion where optimal oxygen and temperature conditions existed.

Dipteran emergence in the north basin of L302 occurred primarily in the 0-2 m depth range. Emergence dropped as depth increased and virtually no emergence took place below 6 m (I. Davies, unpublished data). As in the south basin, sculpins in the north basin were seen well below the depth of maximum dipteran abundance and again a migration pattern could account for the abundance of dipterans in the diet.

While the above data are from one sampling date, seasonal variations probably do occur in sculpin distribution. Otto and Rice (1977) and Symons et al. (1976) both state that sculpins are capable of recognizing and selecting optimal temperature ranges and Bond (1963; cited in Van Vliet (1964) states that slimy sculpins have oxygen concentration preferences and avoidance reactions to low oxygen levels. In L302 sculpin diet changed throughout the open water season. Because oxygen and temperature regimes also change seasonally, the spatial distribution of slimy sculpins probably changes to take advantage of optimal environmental conditions. Further research should be conducted to verify slimy sculpin distribution in lakes and to compare changes of diet and possible diurnal migrations to spatial distribution.

ACKNOWLEDGMENTS

Many thanks to those who provided helpful criticisms at various stages of this study. K.H. Mills was particularly helpful with data analysis and manuscript composition. Special thanks to S.M. Chalanchuk for assistance in collecting data and to D. Allan for help in setting up underwater transects and for introducing me to night SCUBA diving.

REFERENCES

BAILEY, J.E. 1952. The life history and ecology of the sculpin _Cottus bairdi punctulatus_ in southwestern Montana. _Copeia 1952_: 243-255.

BEAMISH, R.J., W.L. LOCKHART, J.C. VAN LOON, and H.H. HARVEY. 1975. Longterm acidification of a lake and resulting effects on fishes. Ambio 4: 92-102.

BEAMISH, R.J., L.M. BLOUW, and G.A. McFARLANE. 1976. A fish and chemical study of 109 lakes in the Experimental Lakes Area (ELA), northwestern Ontario, with appended reports on lake ageing errors and the northwestern Ontario baitfish industry. Can. Fish. Mar. Serv. Tech. Rep. 607: 116 p.

BOND, C.E. 1963. Distribution and ecology of freshwater sculpins Genus _Cottus_ in Oregon. Ph.D. thesis, Univ. of Michigan, Horace H. Rackham School of Grad. Studies. 186 p.

CLEUGH, T.R., and B.W. HAUSER. 1971. Results of the initial survey of the Experimental Lakes Area, northwestern Ontario. J. Fish. Res. Board. Can. 28: 129-137.

CRAIG, P.C., and J. WELLS. 1976. Life history notes for a population of slimy sculpin (Cottus cognatus) in an Alaskan arctic stream. J. Fish. Res. Board Can. 33: 1639-1642.

DAVISON, R.C., W.P. BREESE, C.E. WARREN, and P. DOUDOROFF. 1959. Experiments on the dissolved oxygen requirements of cold-water fishes. Sewage Ind. Wastes 31: 950-956.

EBERT, V.W., and R.C. SUMMERFELT. 1969. Contributions to the life history of the piute sculpin Cottus beldingii Eigenmann and Eigenmann, in Lake Tahoe. Calif. Fish and Game 55(2): 100-120.

NORTHCOTE, T.G. 1954. Observations on the comparative ecology of two species of fish, Cottus asper and Cottus rhotheus, in British Columbia. Copeia (1): 25-28.

OTTO, R.G., and J.O. RICE. 1977. Response of a freshwater sculpin (Cottus cognatus gracilis) to temperature. Trans. Am. Fish. Soc. 106: 89-94.

PETROSKY, C.E., and T.F. WATERS. 1975. Annual production by the slimy sculpin population in a small Minnesota trout stream. Trans. Am. Fish. Soc. 104: 237-244.

ROBSON, D.S., and D.G. CHAPMAN. 1961. Catch curves and mortlity rates. Trans. Am. Fish. Soc. 90: 181-189.

SCHINDLER, D.W., R. WAGEMANN, R.B. COOK, T. RUSZCZYNSKI, and J. PROKOPOWICH. 1980. Experimental acidification of Lake 223, Experimental Lakes Area: background data and first three years of acidification. Can. J. Fish. Aquat. Sci. 37: 342-354.

SCOTT, W.B., and E.J. CROSSMAN. 1973. Freshwater fishes of Canada. Bull. Fish. Res. Board Can. 184: 966 p.

SPRY, D.J., C.M. WOOD, and P.V. HODSON. 1981. A literature review: the effects of environmental acidification on fishes with reference to heavy metals. Can. Tech. Rep. Fish. Aquat. Sci. 999: 145 p.

SYMONS, P.E.K., J.L. METCALFE, and G.D. HARDING. 1976. Upper lethal and preferred temperature of the slimy sculpin, Cottus cognatus. J. Fish. Res. Board Can. 33: 180-183.

VAN VLIET, W.H. 1964. An ecological study of Cottus cognatus Richardson in northern Saskatchewan. M. Sc. thesis, Univ. Saskatchewan, Saskatoon, Sask. 155 p.

Table 1. Comparison of length-weight regressions from 5 different slimy sculpin populations.

Lake	Regression	Source
L302	Log_{10} w+(g) = -4.02 + 2.45 Log_{10} TL(mm)	this study
Chandalar R.	Log_{10} w+(g) = -4.92 + 2.98 Log_{10} TL(mm)	Craig and Wells, 1976
Lac La Ronge	Log_{10} w+(g) = -4.90 + 2.98 Log_{10} TL(mm)	Van Vliet, 1964
L226	Log_{10} w+(g) = -5.88 + 3.49 Log_{10} TL(mm)	this study
Montreal R	Log_{10} w+(g) = -5.24 + 3.27 Log_{10} TL(mm)	Van Vliet, 1964

Table 2. Age-length relationships and maturity for slimy sculpins in L302 and L226 at the Experimental Lakes Area (ELA), 1982.

	L302** Total length (mm)					L226** Total length (mm)			
Age	N	Mean	Range	% mature	Age	N	Mean	Range	% mature
0^+	12	28.6	(16-24)	0	0^+	12	42.1	(33-48)	0
1^+	213	53.3	(36-69)	6.6	1^+	69	60.2	(45-69)	7.1
2^+	132	74.0	(64-85)	93.2	2^+	136	74.1	(66-81)	88.0
3^+	27	86.6	(80-94)	100	3^+	106	84.9	(79-94)	100
4^+	6	94.8	(91-98)	100	4^+	66	96.8	(89-108)	100
5^+	1	100.0	-	100	5^+	6	111.1	(108-116)	100
6^+	1	111.0	-	100	6^+	7	122.6	(119-128)	100
Total	392					402			

* = L302 data collected May-October
** = L226 data collected October

Table 3. Survival rates for 6 slimy sculpin populations using data from cited sources and from 2 ELA lakes.

Lake	Survival rate	95% confidence
Lake 302	0.36	± 0.0398
Lake 226	0.61	± 0.0312
[1]Cree River	0.70	± 0.0642
[1]LaRonge Lake	0.21	± 0.0922
[1]Montreal River	0.10	± 0.0452
[2]Chandalar River	0.70	± 0.0443

[1]Van Vliet (1964)

[2]Craig and Wells (1976)

Table 4. Monthly frequency of occurrence of food items in slimy sculpin stomachs from L302, Experimental Lakes Area, 1982.

Food item	May	June	July	% occurrence August	September	October	Total
Diptera: Chironomid (larvae)	81.3	74.1	77.9	73.3	42.3	13.0	66.1
Choaborus (larvae)	6.3	29.3	27.3	6.7	23.1	4.3	20.9
Chaoborus (pupae)	6.3	25.9	37.7	3.3	-	-	20.0
Bryozoa	-	27.6	66.2	16.7	-	-	31.3
Cladocera	18.8	10.3	2.6	16.7	26.9	17.4	11.7
Ostracoda	6.3	3.4	2.6	3.3	3.8	-	3.0
Copepoda	12.5	6.9	13.0	13.3	30.8	-	12.2
Ephemeroptera (nymph)	-	10.3	7.8	3.3	19.2	8.7	8.7
Hemiptera	-	12.1	1.3	3.3	3.8	-	4.8
Trichoptera (larvae)	18.8	5.2	6.5	13.3	-	4.3	4.3
(nymph)	-	5.2	2.6	3.3	7.7	8.7	7.0
Acari	-	3.4	2.6	-	-	-	1.7
Nemata	-	15.5	5.2	10.0	15.4	8.7	10.0
Fish remains	-	1.7	1.3	3.3	11.5	51.6	7.8
Other	-	6.8	6.5	6.6	3.8	-	5.2
Unidentified Material	43.8	10.3	10.4	20.0	7.7	-	12.6
Empty	27.3	25.6	20.6	16.7	27.8	25.8	23.3
Number of stomachs	22	78	97	36	36	31	300
Mean volume (mL)	0.007	0.044	0.017	0.021	0.060	0.370	0.049

Table 5. Frequency of occurrence of food items in different age classes of slimy sculpins from L302, Experimental Lakes Area, 1982.

Food item	% occurrence 0^+	1^+	2^+	3^+	4+
Diptera: Chironomid (larvae)	100	77.7	57.3	54.5	42.9
Choaborus (larvae)	-	17.5	21.9	31.8	28.6
Chaoborus (pupae)	-	18.4	18.8	27.3	42.9
Bryozoa	50.0	28.2	32.3	36.4	42.9
Cladocera	-	14.6	8.3	9.1	14.3
Ostracoda	-	3.9	3.1	-	-
Copepoda	-	15.5	10.4	4.5	14.3
Ephemeroptera (nympth)		2.9	13.5	18.2	-
Hemiptera	-	1.9	8.3	4.5	-
Trichoptera (larvae)	50.0	6.8	2.1	-	-
(nymph)	-	3.9	10.4	4.5	14.3
Acari	-	1.9	1.0	4.5	-
Nemata	-	4.9	9.4	31.8	14.3
Fish remains	-	1.0	11.5	13.6	42.9
Other	50.0	6.9	3.0	-	14.3
Unidentified Material	-	4.9	3.1	13.6	-
Empty	33.3	23.7	24.4	18.5	12.5
Number of stomachs	3	135	127	27	8
Mean volume (mL)	0.005	0.011	0.068	0.117	0.469

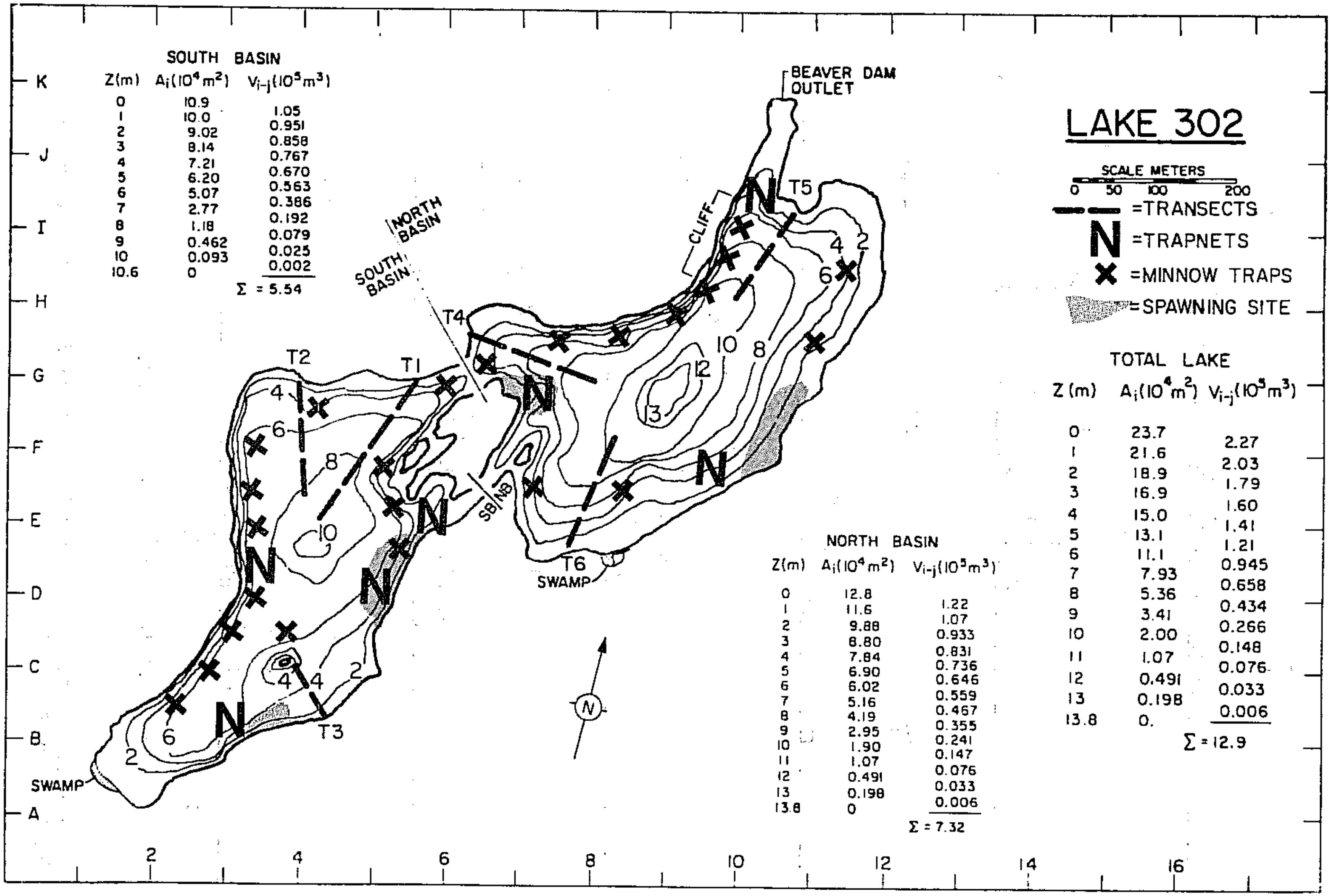

Fig. 1. Bathymetric map of L302, Experimental Lakes Area, showing locations of trapnets and minnow traps used to capture fish and possible spawning sites.

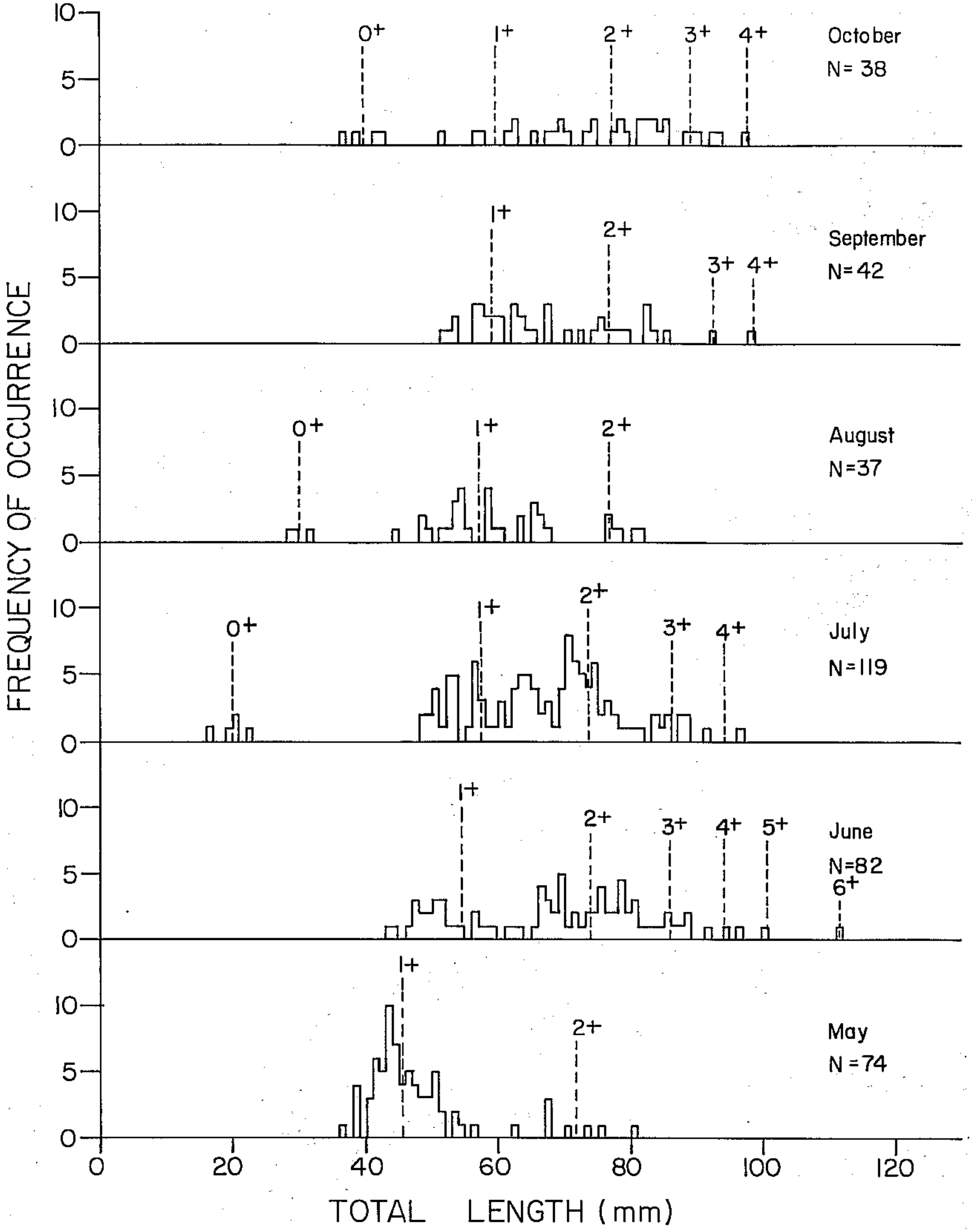

Fig. 2. Length frequency and age at length relationships for 392 slimy sculpins caught in L302, Experimental Lakes Area, 1982.

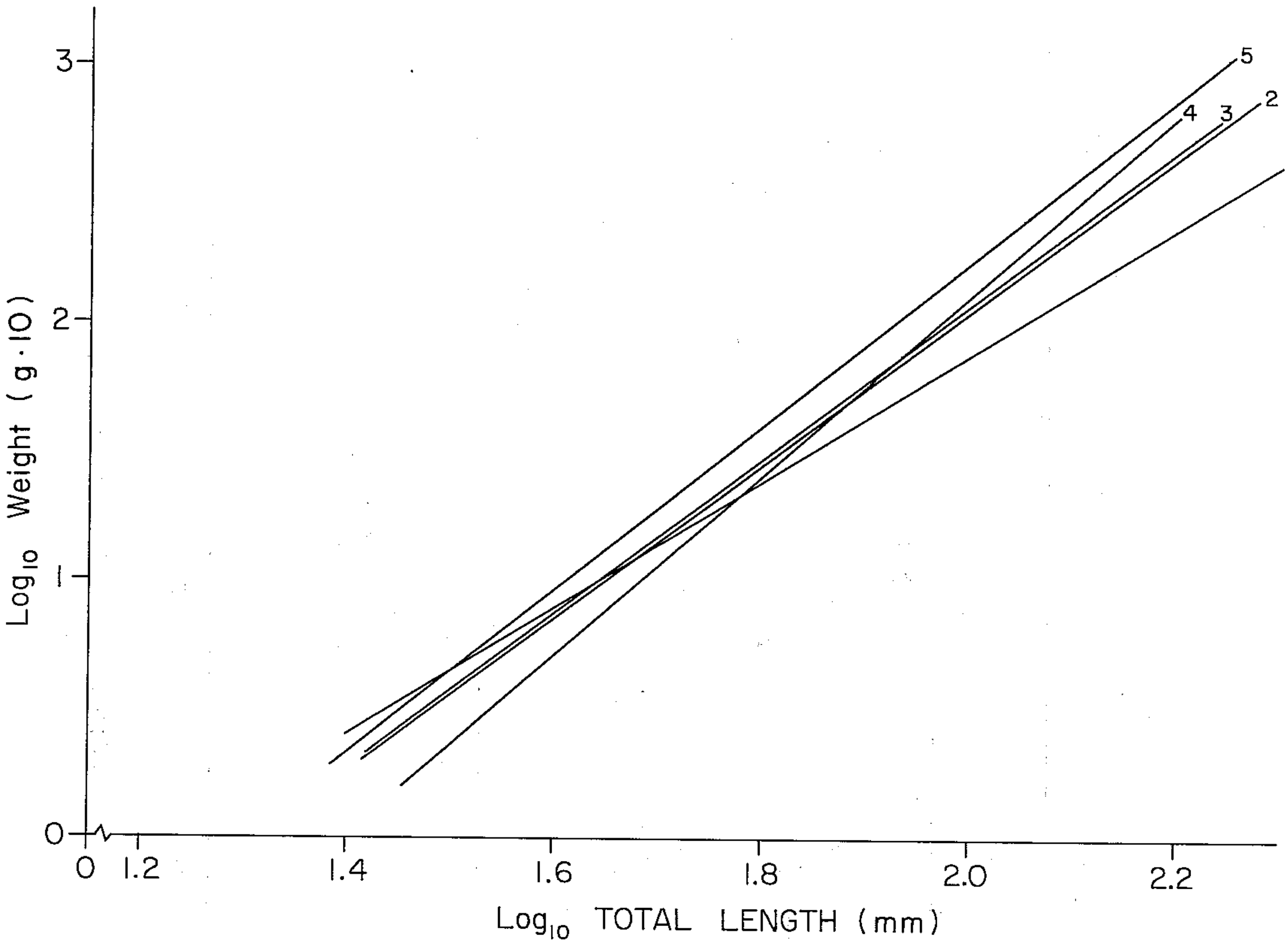

Fig. 3. Length-weight regressions from 5 slimy sculpin populations: L302(1), Chandalar River(2)(Craig and Wells 1976), Lac La Ronge(5) (Van Vliet 1964), L226(4), Montreal River(5) (Van Vliet 1964).

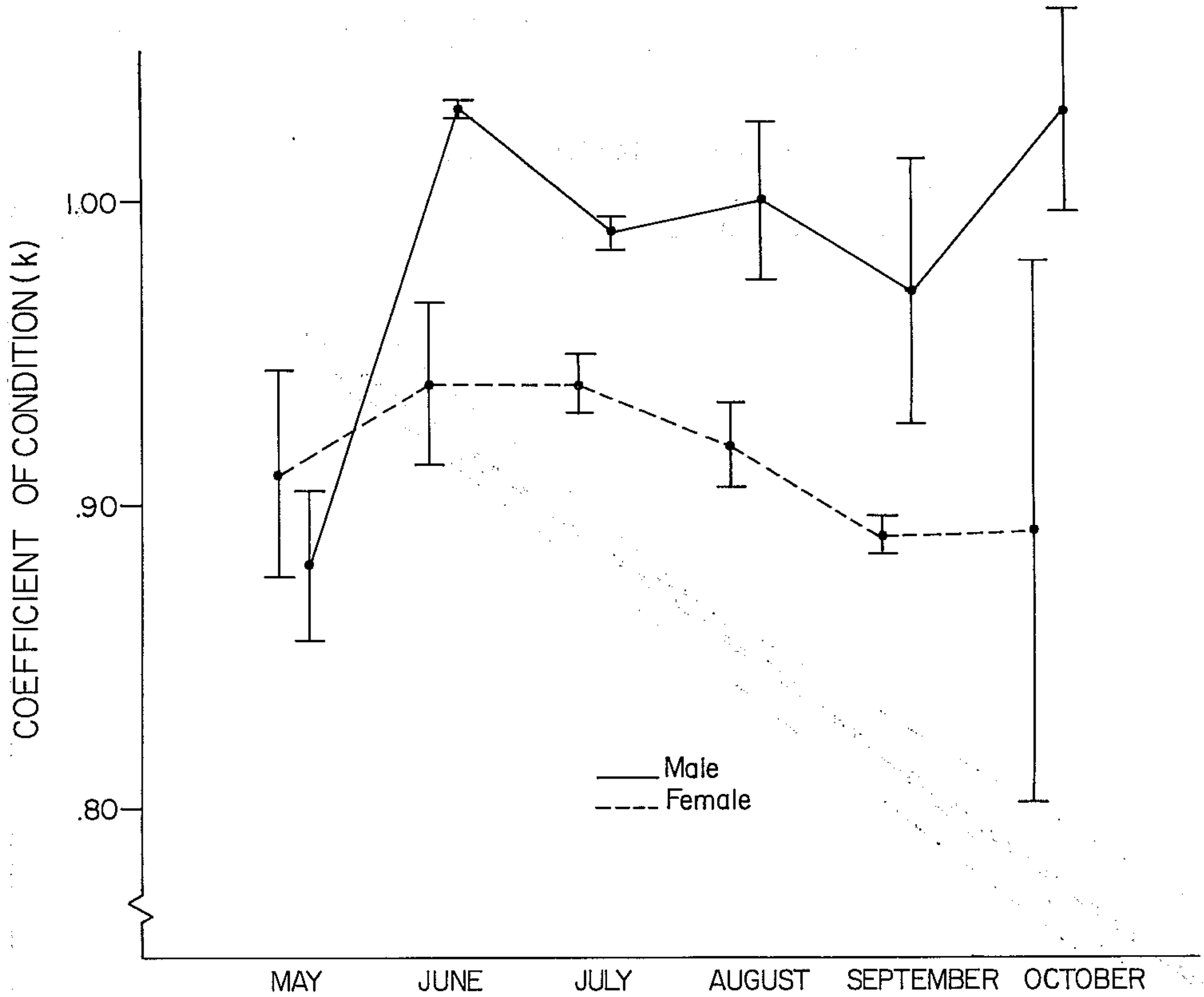

Fig. 4. Seasonal condition comparison for male and female slimy sculpins caught in L302, Experimental Lakes Area, 1982, with 95% confidence intervals.

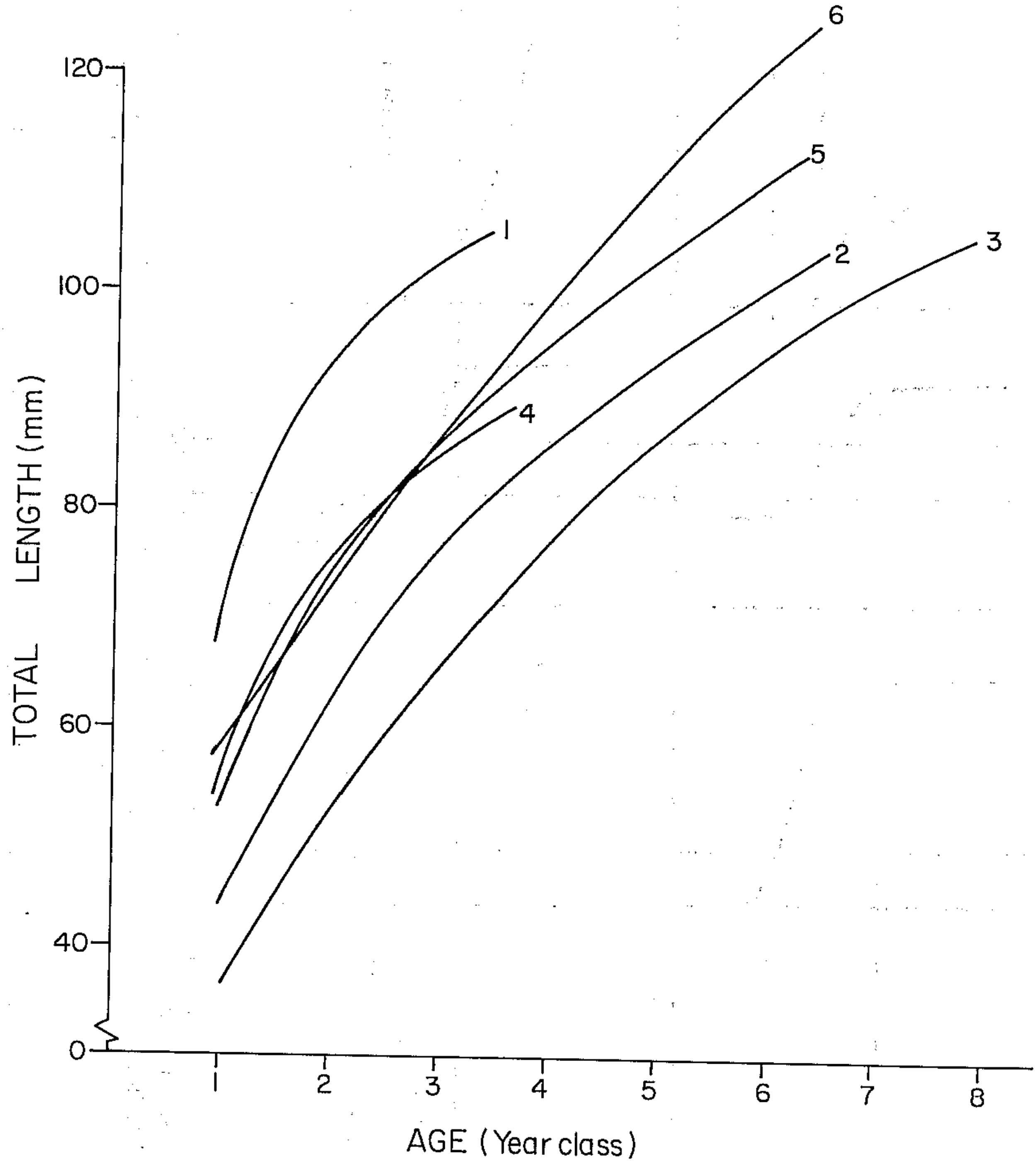

Fig. 5. Comparison of 1982 growth rates of L302(5) slimy sculpins to L226(6), Lac La Ronge(4), Montreal River(1) and Cree River(2) sculpins (Van Vliet 1964), and Chandalar River (3) (Craig and Wells 1976) sculpins.

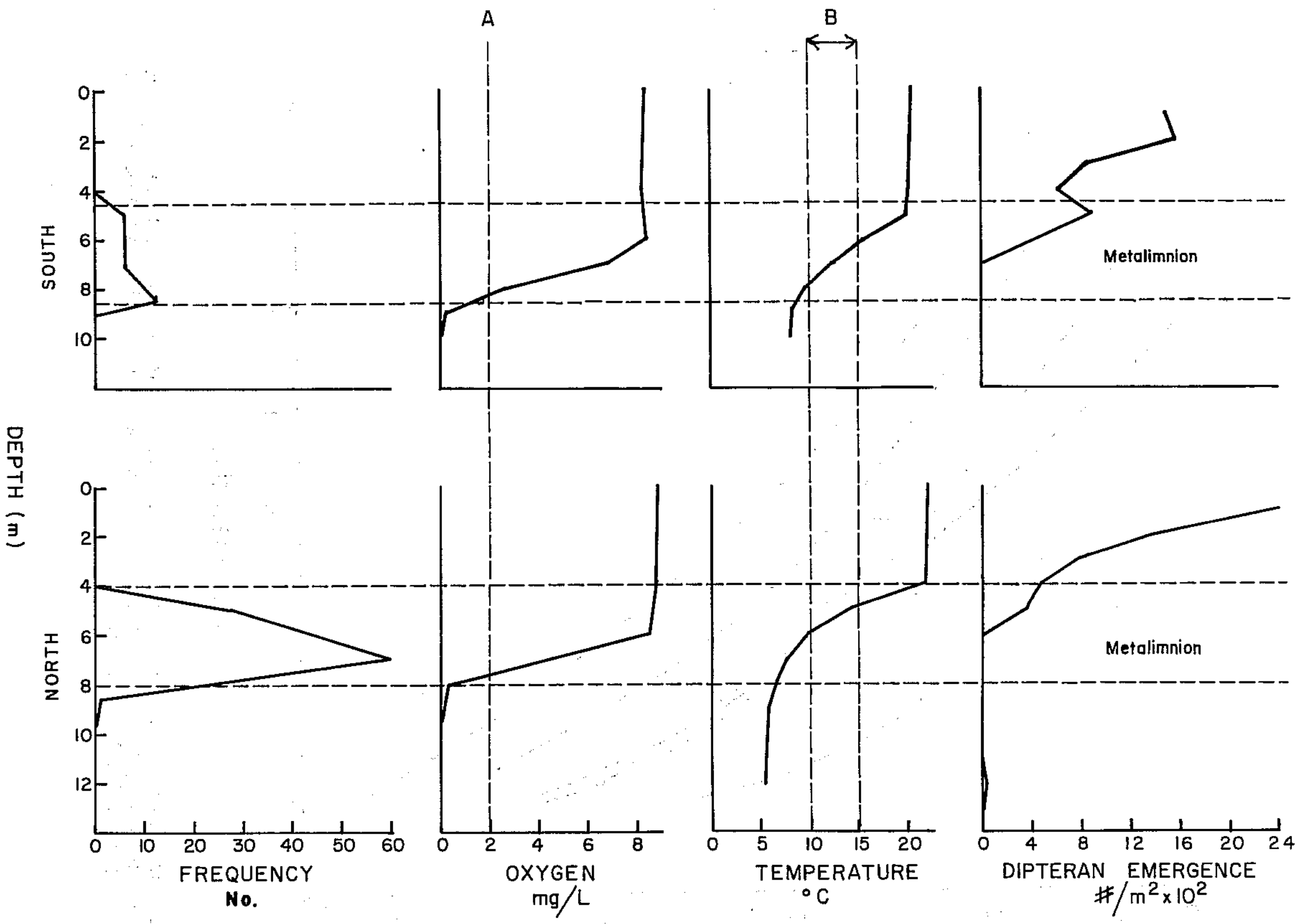

Fig. 6. Association of slimy sculpin abundance, oxygen concentration, temperature and dipteran emergence at various depths of both basins of L302, August 19, 1982. A = minimal O_2 concentration; B = optimal temperature range.