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Condition and Growth of White Suckers, *Catostomus commersoni*, in Lake 302, a Double-Basin Acidified Lake in the Experimental Lakes Area

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by

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ABSTRACT

Chalanchuk, S.M. 1986. Condition and growth of white suckers, *Catostomus commersoni* in Lake 302, a double-basin acidified lake in the Experimental Lakes Area. Can. Tech. Rep. Fish. Aquat. Sci. 1476: iv + 13 p.

A population of white suckers, *Catostomus commersoni*, in a double basin lake, Lake 302, in the Experimental Lakes Area, northwestern Ontario, was studied periodically from May, 1973 to June, 1985. Pre-acidification values for condition and growth of white suckers were determined for data from 1973 to 1981. Acidification of the north basin, Lake 302N, with nitric acid (HNO_3), and the south basin, Lake 302S, with sulfuric acid (H_2SO_4) began in 1982. After two years of acidification, condition and growth of white suckers in both basins have not changed significantly from background values. Condition and growth of white suckers in Lake 302 were also compared to those of white suckers in Lake 223, a lake previously acidified with sulfuric acid. Trends in condition and growth of Lake 302 suckers are similar to trends shown by Lake 223 suckers.

Key words: condition; growth; acidification; sulphuric acid; nitric acid.

RÉSUMÉ

Chalanchuk, S.M. 1986. Condition and growth of white suckers, *Catostomus commersoni* in Lake 302, a double-basin acidified lake in the Experimental Lakes Area. Can. Tech. Rep. Fish. Aquat. Sci. 1476: iv + 13 p.

Une population de meuniers noirs, *Catostomus commersoni*, dans un lac à deux bassins - il s'agit du lac 302, qui se trouve dans la Région des Lacs Expérimentaux, dans le nord-ouest de l'Ontario - a fait l'objet d'études périodiques de mai 1973 à juin 1985. Les valeurs concernant l'état et la croissance des meuniers noirs pendant la période préalable à l'acidification ont été établies à partir de données pour les années 1973 à 1981. L'acidification dans le bassin nord - lac 302N - et dans le bassin sud - lac 302S - a été entreprise en 1982 respectivement avec de l'acide nitrique (HNO_3) et de l'acide sulfurique (H_2SO_4). Deux ans plus tard, l'état et la croissance des meuniers noirs dans les deux bassins n'avaient pas changé de façon significative par rapport aux données de base. On a comparé l'état et la croissance des meuniers noirs du lac 302 à ceux des meuniers noirs dans le lac 223, où l'acidification avait été faite auparavant avec de l'acide sulfurique; dans les deux cas, les tendances en ce qui concerne l'état et la croissance des meuniers sont similaires.

Mots-clés: état; croissance; acidification; acide sulfurique; acide nitrique.

INTRODUCTION

The effects of increased acidity on fishes have been summarized by several researchers (Fromm 1980: Haines 1981; Leivestad 1982: Schindler et al., 1985). Although mechanisms responsible for losses of fish populations due to acid stress are fairly well understood, more information is needed about the effects of the specific types of acid in acid precipitation on fish populations.

Some effects of different acids on behavior and survival of fish have been compared in recent laboratory studies. Ellgaard and Gilmore (1984) tested the effects of four acids on survival of bluegill sunfish, Lepomis machrochirus, a relatively acid-tolerant species. They suggested that the concentration of hydrogen ion (H^+), rather than the type of acid, was the most important factor causing fish toxicity due to acid stress. Graham and Wood (1981) compared the effects of two types of acid on rainbow trout, Salmo gairdneri, a relatively acid-sensitive species. They found that both water hardness and acid type were important in determining toxicities to fish.

Sulfuric acid (H_2SO_4) and nitric acid (HNO_3) are the two major constituents of acid precipitation in eastern North America. The former presently comprises approximately two-thirds of the acid component of precipitation; the latter comprises approximately one-third (Haines 1981). Although Canadian officials have pledged to reduce sulphur emissions by 30 percent (of 1980 levels) by 1993, officials of the United States have not signed similar agreements (Rosencranz 1986). As well, nitrogen oxide emissions have been steadily increasing in North America.

Mills (1984), Chalanchuk (1985), and Schindler et al., (1985) have documented changes in abundance, growth, condition, and recruitment of several species of fish in response to whole-lake additions of sulfuric acid. However, the effects of the increasingly important nitric acid component of acid precipitation are not fully understood. The availability of a double-basin lake, Lake 302 (L302), in the Experimental Lakes Area (ELA), northwestern Ontario, provided an opportunity for comparing the responses of fish populations in natural ecosystems to these two major acid types.

The purpose of this report is to discuss the condition factors and growth of white suckers, Catostomus commersoni, in each basin of L302 in response to known additions of H_2SO_4 and HNO_3. Background data for these parameters were determined for pre-acidification years and compared to values for two years of acidification. Condition factors and growth of fish in L302 were also compared to values for fish in L223 (acidified with sulfuric acid).

MATERIALS AND METHODS

Lake 302 is a small lake in the ELA, northwestern Ontario, that is separated into two basins by a vinyl-impregnated nylon curtain. A curtain was initially installed in July, 1974, during an hypolimnetic nutrient injection experiment (Schindler et al. 1980). However, gaps at the curtain-sediment interface allowed some exchange of fish and epilimnetic water to occur between basins. The curtain was lifted in 1978 and fish and water moved freely until June, 1981. Because no differences in condition factors and growth for fish occurred between basins, data collected from both basins were combined into whole lake values prior to June, 1981. In June, 1981, a new curtain was installed. It effectively segregated the north basin from the south basin. Occasional holes, caused by rocks at the bottom of the curtain, were promptly repaired, and although some water exchange occurred, movement of fish between basins was minimal (K.H. Mills and S.M. Chalanchuk, Freshwater Institute, Winnipeg, MB, Unpublished data). Consequently, after June, 1981, data for fish from each basin in L302 were treated separately.

The north basin (L302N) (Ao = 12.8 ha, Zmax = 13 m) is similar in size to the south basin (L302S) (Ao = 10.9 ha, Zmax = 10 m). Time-weighted mean pH of the epilimnia in 1981, prior to acidification, was 6.72 in L302N and 6.75 in L302S (Cruikshank 1984). In June, 1982, acidification of both basins began. L302S has received additions of sulfuric acid; L302N has received additions of nitric acid. Similar amounts of H^+ have been added to each basin (31-44 kg per year). The pH of epilimnia in 1984 was ≈6.24 in L302N and 5.60 in L302S (M.A. Turner, Freshwater Institute, Winnipeg, MB, personal communication). Background chemistry, bathymetry, and further information regarding acid additions can be found in Armstrong and Schindler (1971), Brunskill and Schindler (1971), and Cruikshank (1984).

Fish species present in L302 besides white suckers are lake whitefish (Coregonus clupeaformis), slimy sculpin (Cottus cognatus), and several cyprinids. Cyprinid species in L302 include fathead minnow (Pimephales promelas), pearl dace (Semotilus margarita), finescale dace (Phoxinus neogaeus), and northern red-belly dace (Phoxinus eos).

White suckers were sampled during spring (May to June), summer (July to August), and fall (September to October). In some years, fish were sampled during only one or two of these periods, usually spring or fall. Fish were captured by Beamish-style trap nets (Beamish 1972) in 1973 and modified versions of the Beamish-style trap net in 1977 and 1981 - 1985. Small mesh, multifilament gill nets (bar mesh 25-45 mm) were used exclusively in fall, 1979 and as an additional capture method during falls, 1982-1984. Gill nets were set for ≈ 15 min. Fish were promptly removed and held overnight to assess gill net mortality before they were sampled. Trap nets were set for two or three day periods. Fish were sampled immediately after they were removed from trap nets.

Sampling procedures were similar during all years, with the exception of 1979. During that year, all white suckers captured (56) were killed rather than released. The removal of this number of fish, <10% of the population, was not enough to confound future results (K.H. Mills, Freshwater Institute, Winnipeg, MB, personal communication). In all other years, white suckers were anaesthetized with methane tricaine sulphonate (MS222®), weighed (to the nearest g), and measured for fork length (to the nearest mm). They were then examined for sex, marked by tags or scars, and fin-clipped for aging purposes. Fish with fork lengths >250 mm were tagged with Floy® gun tags in 1973, and with modified Carlin tags (White and Beamish 1972) in 1977. During 1981 - 1985, fish with fork lengths >350 mm were tagged with modified Carlin tags. In addition, beginning in 1981, all fish were batch-marked according to sampling period by scarring dorsal or anal rays (Welch and Mills 1981). Two or three rays of a pectoral fin were removed (for aging purposes) from fish captured for the first time. To validate the fin-ray method of aging white suckers in L302, two or three rays of an unclipped pectoral or pelvic fin were removed from recaptured fish if time elasped since last capture was greater than one year. All fish were allowed to recover and then were released to the same basin from which they had been captured.

Ages were determined from pectoral or pelvic fin rays. Fin rays were air-dried in envelopes, epoxied, and sectioned with a jeweller's saw (using fine-toothed blades, sizes 7/0 - 8/0) or with a Buehler® Isomet+,low-speed saw. Fin sections were cleared with toluene, fixed with Permount® or Diatex® and viewed with a compound microscope equipped with viewing screen at ≈160× power. Aging techniques and validation of ages were the same as those described in Chalanchuk (1984). Individually tagged fish as old as 12 years were "correctly" aged after three to four year intervals.

Condition factors of white suckers were determined using Fulton's formula (Bagenal and Tesch 1978):

$$K = \frac{100\ w}{l^3}$$

where w = observed weight of fish (g), and
l = observed length of fish (cm).
Condition factors were determined at seasonal intervals for each year.

Growth curves were constructed by plotting mean fork lengths at age and mean weights at age. Summary growth curves were fitted by eye. Upper and lower extremes in growth rates for suckers from other lakes were taken from Beamish (1973) and Chalanchuk (1985).

RESULTS AND DISCUSSION

A slight increase in mean condition factors of white suckers in L302 occurred since acidification (Fig. 1). Although increases were not statistically significant from one year to the next, condition factors for suckers in spring, 1985, after two years of acidification, were significantly higher than for suckers in spring, 1982, prior to acidification. An initial increase in condition factors of white suckers with decreases in pH also occurred in L223, another experimentally acidified lake in the ELA (Chalanchuk 1985). Highest condition factors for white suckers in this lake occurred when pH was ≈5.93, after two years of acidification.

Curtain installation did not affect condition factors. Values from summer, 1981, to spring, 1982, were within the range of values for condition factors from summer, 1977 to spring, 1981. This lack of difference between basins is consistent with results obtained for a population of lake whitefish in another double - basin lake that was subsequently separated by a vinyl curtain (Mills 1981).

Mean condition factors for white suckers in the north basin were similar to those for suckers in the south basin from 1982 - 1985. Fish from L302N were in better condition than fish from L302S in all years except 1985, but differences were usually not significant. In 1981, differences in condition factors between basins occurred, but were not consistent. Fish in L302S were in better condition than fish in L302N during summer, 1981; the reverse was true the following fall. At present, there seems to be no logical explanation for this reversal in trend of condition factors.

During each year, mean condition factors were highest during spring sampling intervals. White suckers in L302 spawn during late May. Many of the fish sampled during the spring would, therefore, have had fully developed gonads contributing to their total weights and consequently higher condition factors than during summer or fall. There was some indication of a reduction in seasonal variability after acidification. Condition factors ranged from 1.08 to 1.26 prior to summer, 1982, and from 1.14 to 1.25 after summer, 1982. A decrease in variability of condition factors also occurred for white suckers in L223 (Chalanchuk 1985). However, more data are necessary to determine whether condition factors for white suckers in L302 are following the trend of reduced variability that occurred for white suckers in L223 as acidity increased.

Condition factors were similar for all length groups during spring intervals (Table 1). Highest condition factors did not follow any trend. Some years fish with fork lengths <200 mm were in best condition; other years fish with fork lengths >200 mm were in best condition.

Condition factors for males and females at spring sampling periods were similar (Fig. 2). Although females were in slightly better condition than males from 1981 - 1984, differences within each basin were usually not significant. No differences between basins in condition factors of males were observed. Females in L302N were generally in better condition than all other fish in both basins until spring, 1985.

No significant differences in growth curves for suckers occurred between basins after curtain installation and prior to acidification (Fig. 3). Weights at age during fall, 1981 and lengths at age during spring, 1982 were within the normal background limits of growth of L302 fish.

Growth rates of L302 suckers during the first two years of acidification did not change significantly from background values (Fig. 4a and b). Fish aged two to five years had higher weights at age in 1983 and 1984 in L302N than in other years, but these differences were not significant. In L302S, fish aged two to six had higher weights at age in 1983 and 1984 than in other years; these differences were also not significant. In L223, growth rates of white suckers aged two to six years increased as lake pH declined to 5.5 (Chalanchuk 1985). The pH of L302S in 1984 (5.60) was similar to the pH of L223 in 1980 (5.59) when growth rates of young suckers was fastest. Although increases in weight at age after acidification for young suckers in L302 are not statistically significant, the trend is similar to the increase in growth of young suckers with decreases in pH that occurred in L223.

No differences between basins in growth rates of white suckers have been observed since the beginning of acidification. White suckers in L302N grew at similar rates to those in L302S from fall, 1981 - fall, 1984 (Fig. 5a and 5b). Fish had both similar lengths and similar weights at age in both basins during corresponding spring and fall intervals.

Growth rates of L302 suckers were within the range of growth for suckers as reported by Beamish (1973) (Fig. 6). Growth curves for L302 fish plateaued at approximately nine years of age, which is similar to other lakes. Most, if not all, suckers are sexually mature by nine years of age, and growth in length after sexual maturity usually becomes extremely slow.

Growth rates, based on fork lengths, of L302 suckers from 1973 - 1984 were similar to those of L223 fish during 1971 - 1978, but lower than L223 fish during 1980 - 1982 (Fig. 7). The pH of L223 from 1971-1978 was >5.93, but during 1980 - 1982 decreased from 5.59 to 5.02. In L302, pH values were similar to the 1971 - 1978 values of pH in L223, but higher than the 1980 - 1982 values for pH in L223. Maximum lengths attained by L302 white suckers were similar to those attained by L223 white suckers. However, maximum weights attained by L302 white suckers were lower than those of L223 white suckers. Growth rates of L302 white suckers, based on weights, were therefore, always lower than rates for white suckers in L223. These length-weight relationships were reflected in condition factors. White suckers in L302 had lower condition factors than those reported for L223 white suckers (Chalanchuk 1985).

Trophic structures in L302 and L223 are different and responses of fish populations to acidification will probably differ accordingly. Prior to acidification of L223, the major fish species occurring in the lake were lake trout (<u>Salvelinus namaycush</u>), white suckers, fathead minnows, and slimy sculpins (Mills 1984). By 1983 (pH = 5.13), only white suckers, lake trout, and a few pearl dace remained, due to reproductive failures and increased predation (Schindler et al. 1985). In contrast, L302 lacks a major piscivore such as lake trout, and competition for food will likely be a more important factor. Dipterans, especially chironomids, are major food sources for white suckers and whitefish in other lakes in the Experimental Lakes Area. (Chalanchuk 1985; Mills 1985). In addition, in L302, they comprise the most important food item for slimy sculpins (Mohr 1984). Although chironomids and chaoborids dominate the benthic fauna of ELA lakes (Davies 1980), any decrease in biomass of dipterans would have repercussions on each of the major fish species. A dietary overlap also occurs within cyprinid species, especially pearl dace and fathead minnows (Tallman et al. 1984). Fathead minnows are fairly acid-sensitive and will likely succumb to the increased acidity first, as they did in L223. Any of the three dace species could move into the vacant niche, although pearl dace are more likely to do so because their diet is more similar to that of fathead minnows.

In summary, condition and growth of L302 white suckers have not changed significantly during the first two years of acidification. Although the changes in condition factors and growth of L302 white suckers are not statistically significant, trends seem to be similar to those which occurred for L223 white suckers. The mean pH of the epilimnia in each basin of L302 is still higher than values at which significant changes in growth of suckers in L223 occurred. To date, no differences in growth and condition factors have occurred due to differences in acid type. However, the epilimnetic pH of L302S, the basin receiving sulfuric acid, is decreasing at a faster rate than that of L302N, the basin receiving nitric acid, despite similar inputs of H^+. One can, therefore, speculate that significant effects of acidification on fish will occur sooner in L302S than in L302N.

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Table 1. Mean condition factors ± 95% confidence limits of white suckers at annual spring intervals from 1981 to 1985, for eight fork length groups. Numbers in parentheses are sample sizes. After 1981, values are separated by basin. "N" denotes north basin, "S" denotes south basin.

Fork-length group	Spring 1981		Spring 1982	Spring 1983	Spring 1984	Spring 1985
51-100		N	1.13 ± 0.010 (2)	1.19 ± 0.210 (11)	1.06 ± 0.000 (1)	1.15 ± 0.380 (4)
		S	-	0.94 ± 0.074 (5)	1.10 ± 0.104 (16)	0.82 ± 0.000 (1)
101-150	1.40 ± 0.226 (73)	N	1.36 ± .0524 (2)	-	-	-
		S	1.18 ± 0.308 (3)	-	1.22 ± 0.54 (7)	1.14 ± 0.000 (1)
151-200	1.17 ± 0.034 (328)	N	1.18 ± 0.014 (208)	1.20 ± 0.098 (3)	1.19 ± 0.118 (6)	1.29 ± 0.098 (2)
		S	1.18 ± 0.040 (283)	1.22 ± 0.016 (73)	1.16 ± 0.024 (22)	1.23 ± 0.040 (7)
201-250	1.15 ± 0.008 (219)	N	1.15 ± 0.008 (390)	1.18 ± 0.012 (69)	1.22 ± 0.026 (27)	1.28 ± 0.164 (15)
		S	1.14 ± 0.012 (135)	1.21 ± 0.018 (248)	1.21 ± 0.014 (88)	1.24 ± 0.068 (8)
251-300	1.17 ± 0.040 (11)	N	1.19 ± 0.034 (171)	1.18 ± 0.010 (95)	1.21 ± 0.012 (114)	1.23 ± 0.022 (31)
		S	1.14 ± 0.058 (31)	1.20 ± 0.032 (61)	1.20 ± 0.010 (156)	1.24 ± 0.024 (28)
301-350	1.18 ± 0.032 (90)	N	1.18 ± 0.018 (70)	1.20 ± 0.012 (61)	1.22 ± 0.008 (218)	1.21 ± 0.010 (142)
		S	1.16 ± 0.056 (27)	1.20 ± 0.014 (61)	1.23 ± 0.016 (95)	1.24 ± 0.020 (36)
351-400	1.22 ± 0.014 (199)	N	1.26 ± 0.016 (197)	1.27 ± 0.020 (54)	1.28 ± 0.010 (144)	1.23 ± 0.014 (83)
		S	1.24 ± 0.010 (139)	1.20 ± 0.018 (112)	1.23 ± 0.012 (135)	1.25 ± 0.020 (48)
401-450	1.21 ± 0.38 (42)	N	1.28 ± 0.028 (38)	1.29 ± 0.026 (32)	1.27 ± 0.010 (86)	1.24 ± 0.056 (11)
		S	1.25 ± 0.018 (49)	1.20 ± 0.026 (27)	1.23 ± 0.028 (23)	1.24 ± 0.048 (14)
overall mean	1.19 ± 0.020 (1062)	N	1.19 ± 0.008 (1078)	1.20 ± 0.010 (325)	1.24 ± 0.006 (597)	1.22 ± 0.013 (289)
		S	1.19 ± 0.018 (667)	1.20 ± 0.010 (587)	1.21 ± 0.006 (542)	1.24 ± 0.012 (143)

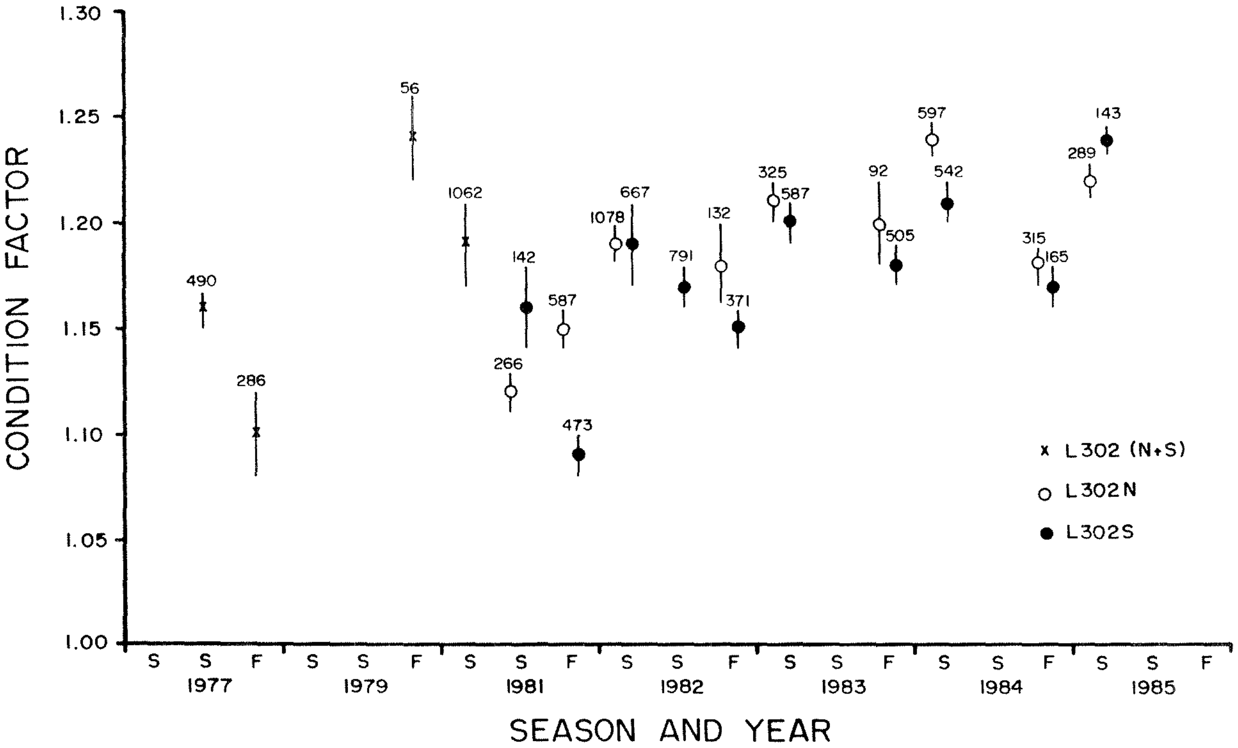

Fig. 1. Condition factors of white suckers in L302 at seasonal intervals from fall 1977 to spring 1985. Numbers beside points represent sample sizes, bars represent 95% confidence intervals.

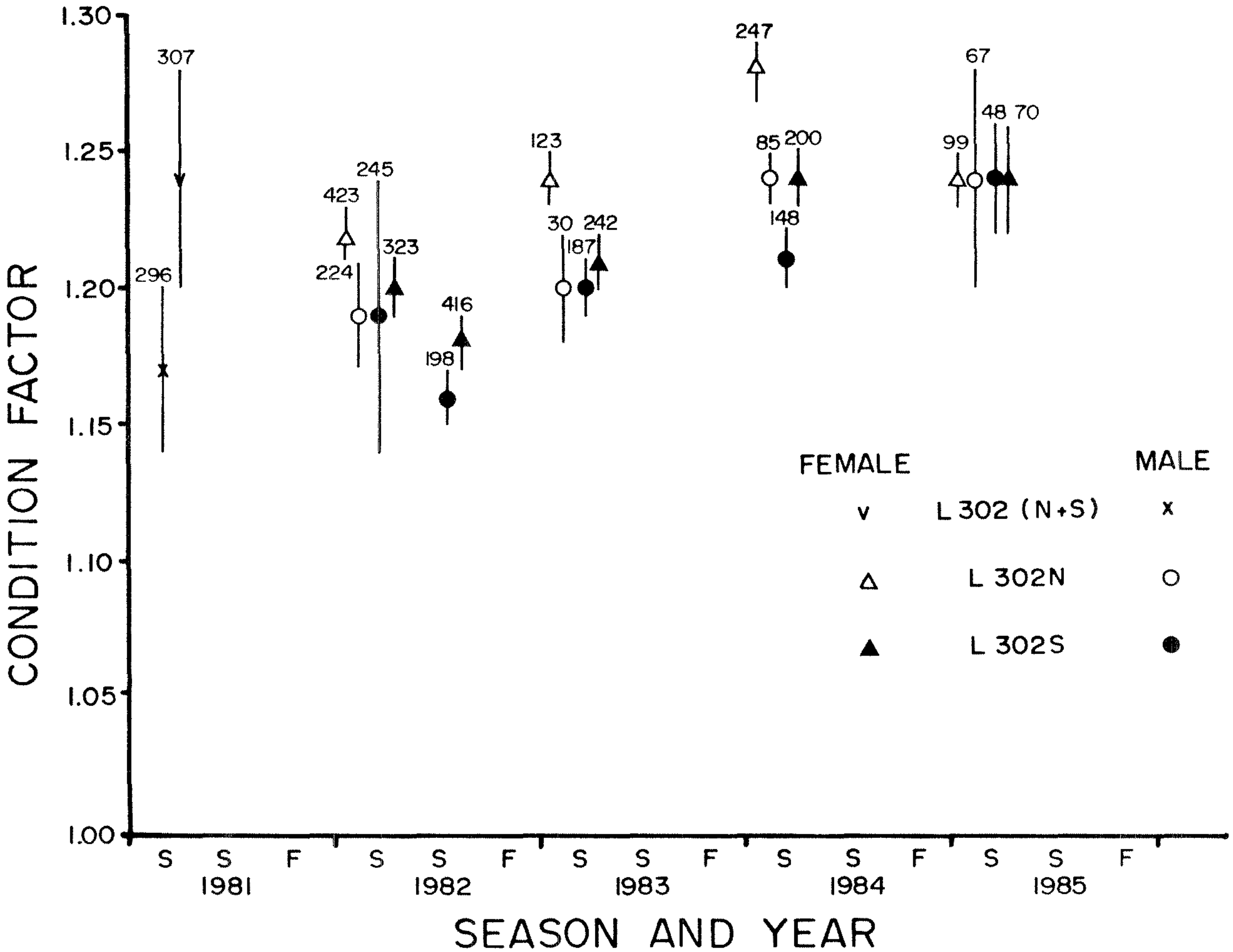

Fig. 2. Condition factors of female and male white suckers in L302N and L302S from spring 1981 to spring 1985. Numbers beside points represent sample sizes, bars represent 95% confidence intervals.

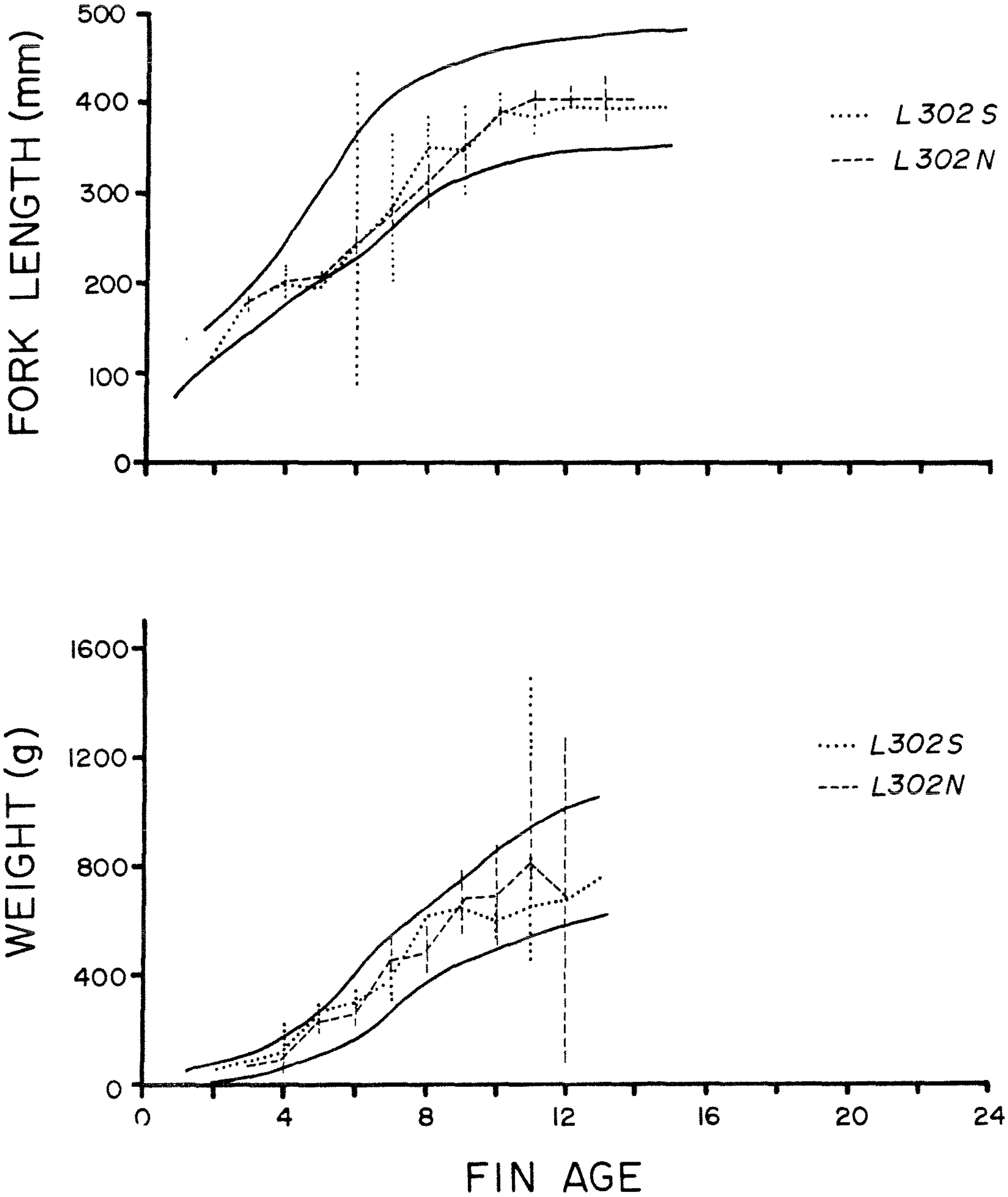

Fig. 3. Growth curves of white suckers in L302 after curtain installation from 1981 to 1982, based on fork lengths during spring intervals, and based on weights during fall intervals. Solid lines represent background limits prior to curtain installation in June, 1981. Bars represent 95% confidence intervals.

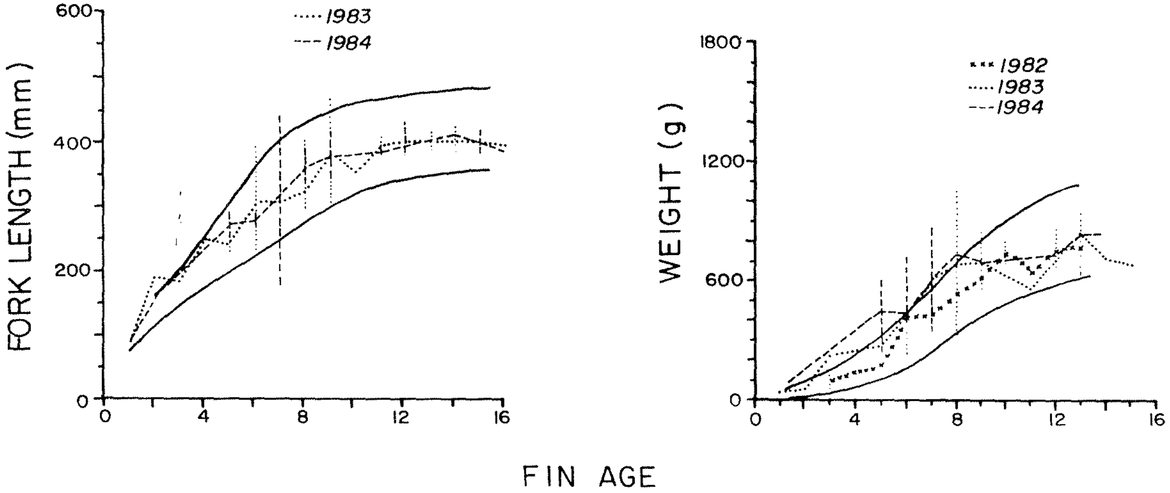

Fig. 4a. Growth curves of white suckers in L302S, based on fork lengths during spring intervals, and based on weights during fall intervals, in 1983 and 1984. Solid lines represent background limits prior to acidification in June, 1982. Bars represent 95% confidence intervals.

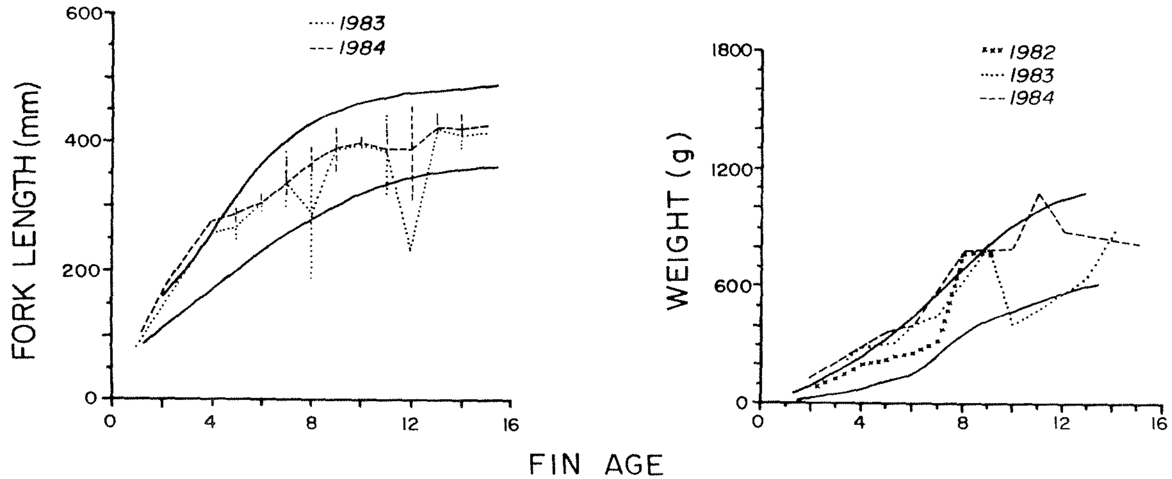

Fig. 4b. Growth curves of white suckers in L302N, based on fork lengths during spring intervals, and based on weights during fall intervals, in 1983 and 1984. Solid lines represent background limits prior to acidification in June, 1982. Bars represent 95% confidence intervals.

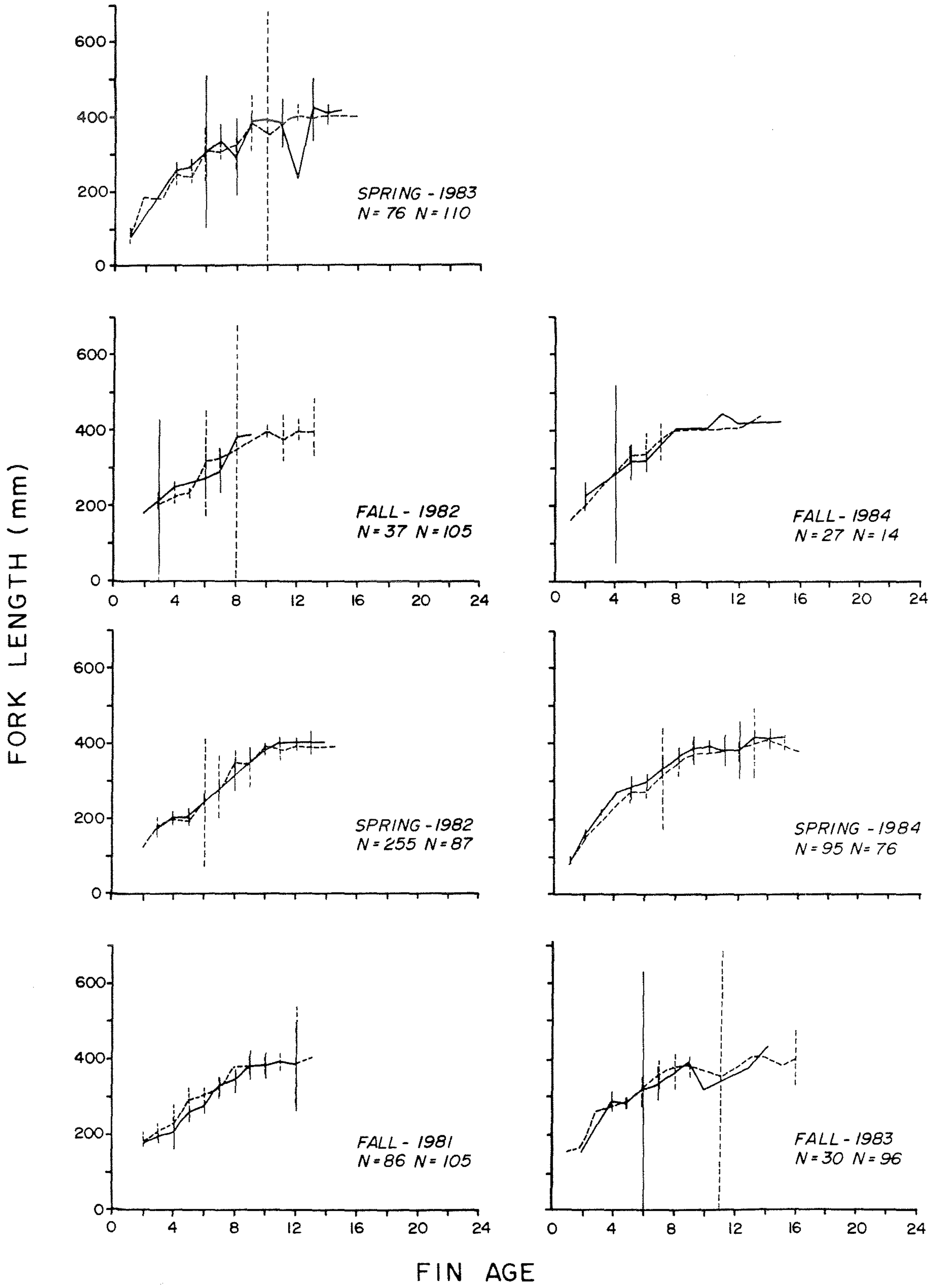

Fig. 5a. Growth curves of white suckers in L302, based on fork lengths from fall 1981 to fall 1984. Solid lines represent curves for fish from L302N; dotted lines represent curves for fish from L302S. Bars represent 95% confidence intervals.

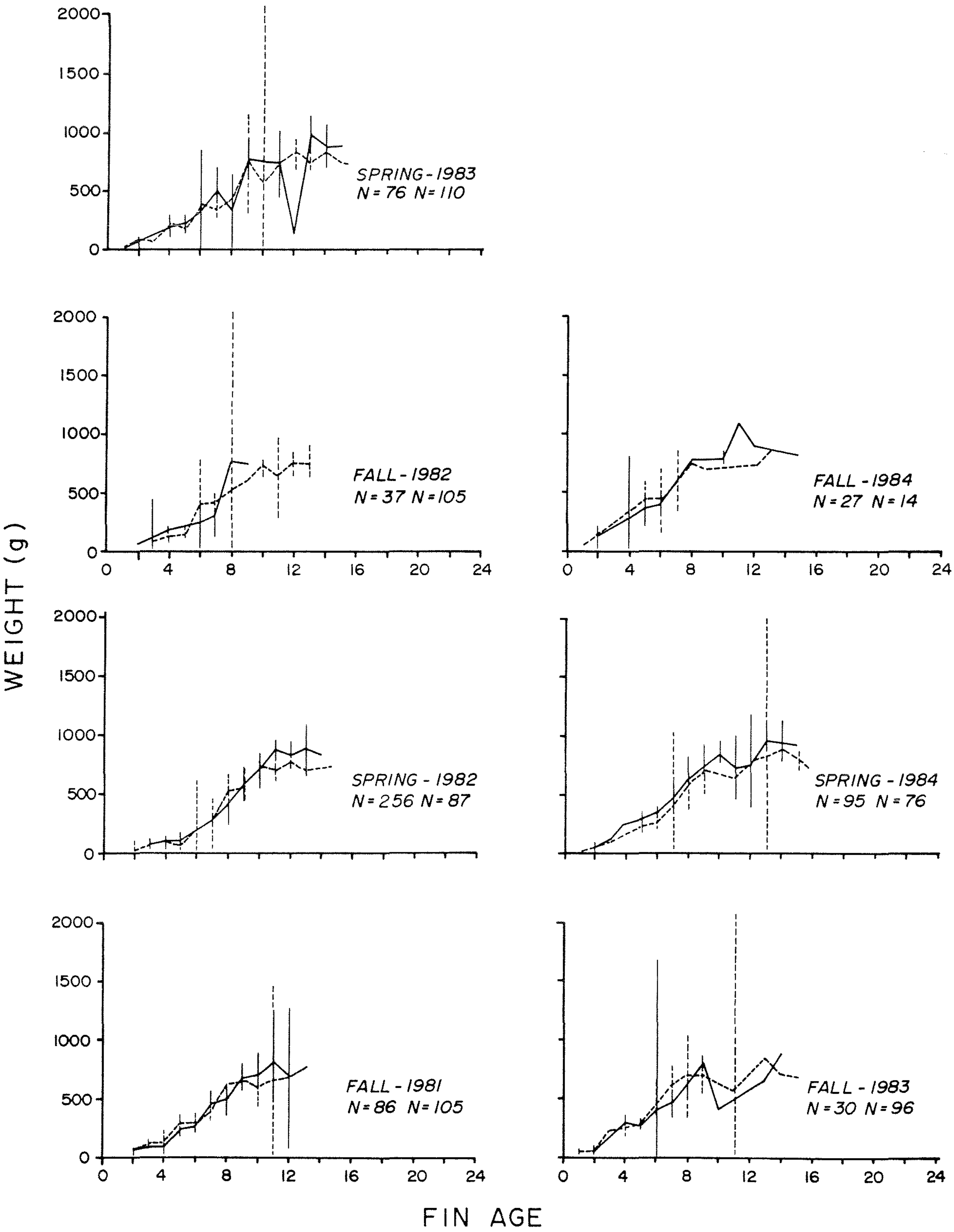

Fig. 5b. Growth curves of white suckers in L302, based on weights, from fall 1981 to fall 1984. Solid lines represent curves for fish from L302N; dotted lines represent curves for fish from L302S. Bars represent 95% confidence intervals.

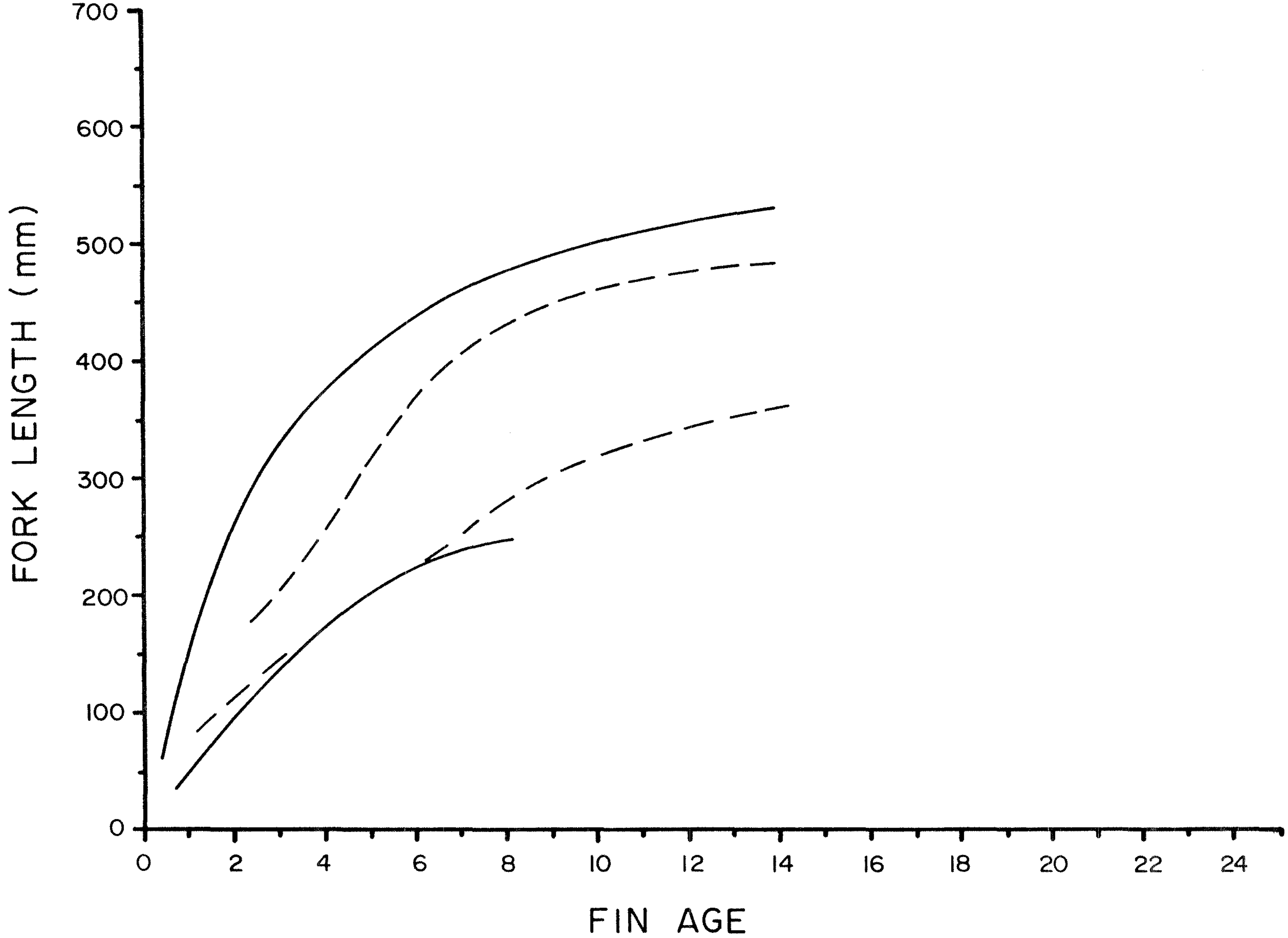

Fig. 6. Growth curves of white suckers, based on fork lengths, in L302 in comparison to other populations of white suckers. Solid black lines indicate the limits of range of growth as taken from Beamish (1973) Fig. 7. Dotted lines indicate limits of range of growth of L302 suckers.

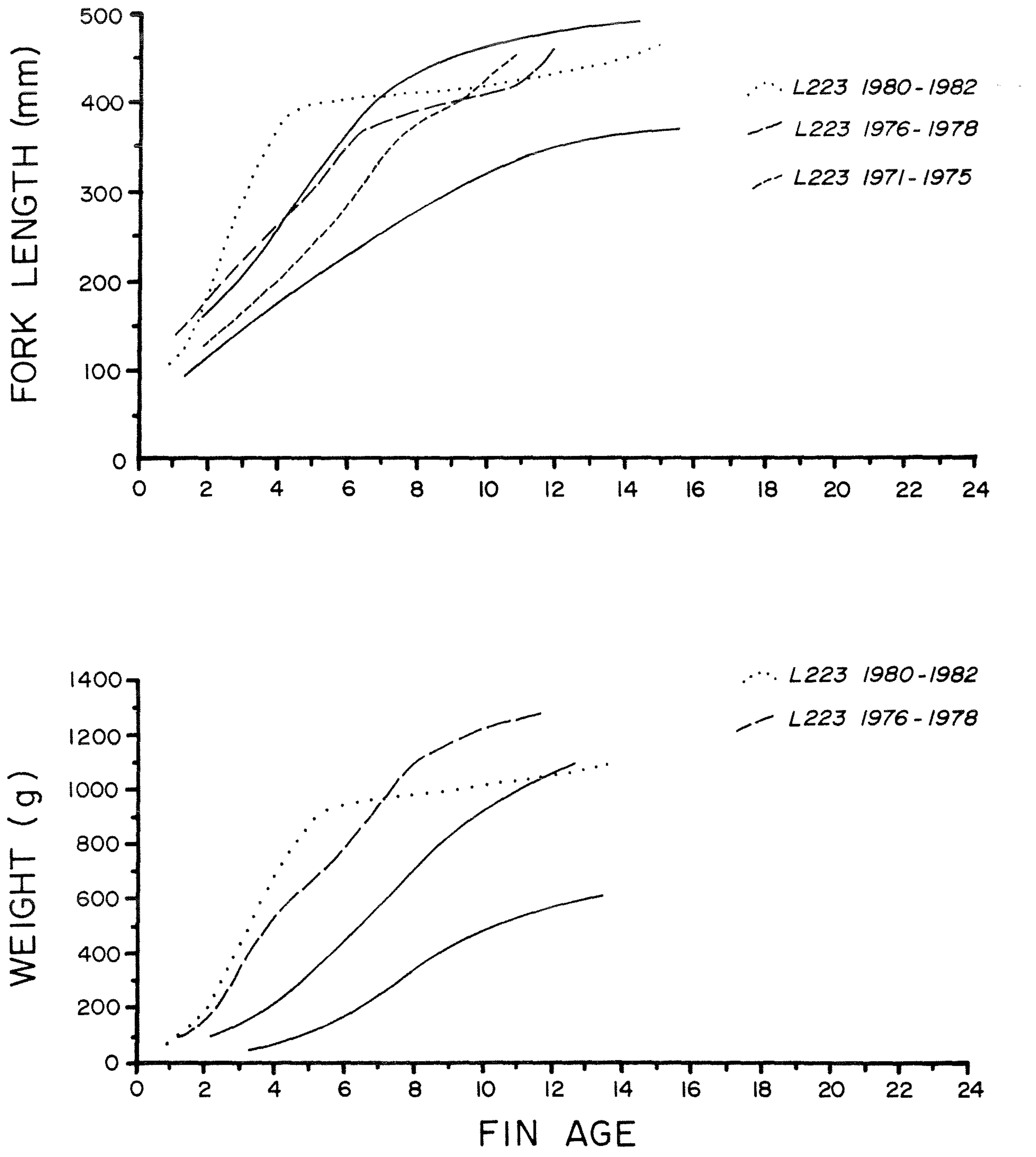

Fig. 7. Growth curves of white suckers, based on fork lengths and weights, in L302 in comparison to L223. Growth curves for L223 are taken from Chalanchuk (1985) Fig. 5, Figure 7a and Figure 7b. Solid lines indicate limits of range of growth of L302 suckers.