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A comparison of slimy sculpin (*Cottus cognatus*) populations in arctic lakes with and without piscivorous predators

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Abstract

Arctic slimy sculpin were sampled by passive trapping in lakes containing the predators lake trout and burbot (LT lakes), and lakes lacking sculpin predators (NoLT lakes). Sculpin food abundance (chironomid biomass) from the rocky littoral zone was compared with that from the deep water sediment zone. Distribution, size, growth, age, condition and relative abundance of sculpin were examined.

Spatial distribution of sculpin was different between lake types, with more and larger sculpin found over the sediment zone in NoLT lakes. There were no seasonal patterns evident in this distribution and catch per unit effort was not significantly different between LT and NoLT lakes. Biomass of chironomids, the major food of the sculpin, was higher in the sediments than on the rocks, suggesting that sediments should be the preferred environment in the absence of piscivores. Longevity of sculpins varied between IV and VIII years and was not correlated with lake type. Sculpin size frequency distributions were shifted toward slightly larger fish in NoLT lakes. Sculpin growth curves and condition estimates did not reveal a difference between lake types, but comparison of mean ototlith interannular distances between lake types showed a trend, significant in year 4, toward more growth in no lake trout lakes. These results suggest that the presence of piscivores is an important factor limiting arctic slimy sculpin distribution and may act in concert with food supply to impact sculpin growth.

Introduction

Fish predation on benthos has implications for benthic community structure (Gilinsky, 1984) and can regulate abundance or biomass of benthic invertebrates (Crowder & Cooper, 1982; Hershey, 1985). Through cascading effects on alternate trophic levels, piscivores can regulate lake productivity (Carpenter *et al.*, 1985). To minimize predation risk, prey fishes employ optimal feeding strategies (Pyke *et al.*, 1977), which can influence their habitat use (Mittelbach, 1981, 1986; Crowder & Cooper, 1982; Brandt, 1986a, b; Werner & Hall, 1988), and result in habitat selections that offer lower prey abundance than higher risk habitats (Mittelbach, 1981, 1986; Werner *et al.*, 1983a, b; Power, 1984).

Arctic lakes are simplified systems in which predation appears to an important factor controlling benthic abundances (Hershey, 1985, 1990; Merrick *et al.*, 1991). Slimy sculpin (*Cottus cognatus* Richardson), small, bottom-dwelling fish found in lakes and streams throughout northern North America (Scott & Crossman, 1973), are widely distributed in Alaska (Craig & Wells, 1976). Sculpin have been shown to be important in the trophic interactions of lakes near the Toolik Lake Long Term Ecological Research (LTER) site by controlling the densities of their main prey item, chironomid larvae (Hershey, 1985; Goyke

& Hershey, 1992). Similarly, lake trout (*Salvelinus namaycush*), present in some LTER lakes, control the abundance and size distribution of their major prey, the snail *Lyrnnaea elodes* (Hershey, 1990, Merrick *et al.*, 1991).

Lakes in this area host up to 5 fish species; two of these species are predators on sculpin: lake trout (Petrosky & Waters, 1975; Moyle, 1977; Merrick, 1989) and burbot (*Lota lota*) (Van Vliet, 1964; Godkin *et al.*, 1982). Lake trout in Toolik area lakes feed predominantly on snails, but 12% of lake trout stomachs that have been analyzed also contained sculpin (Merrick *et al.*, 1992). Growth efficiency models (Kerr, 1971) suggest that stunted lake trout may require occasional larger prey items to attain large body size (Konkle & Sprules, 1986). Burbot are voracious predators whose role in Toolik-area lakes is not well understood. In many lakes and rivers they will feed on any available prey (Becker, 1983) and burbot in North Slope lakes are known to eat slimy sculpin (K.L. Hanson, pers. observation).

Prey exposure is a major determinant of prey risk in benthic food chains (Ware, 1973; Hershey & Dodson, 1985; Hershey, 1987), and increased spatial heterogeneity may allow prey items a refuge from predation (Crowder & Cooper, 1982; Gilinsky, 1984; Hershey, 1985, Luecke, 1990). Sculpin in arctic lakes inhabit both the rocky littoral zone and the bare sediments of deeper water, and these habitats may host different food sources. Slimy sculpin may exhibit different behavior in the presence and absence of predation threat, which could have implications for sculpin growth and population structure.

In this study, slimy sculpin populations were sampled in 4 lakes containing lake trout and burbot, and 3 lakes containing no predators in order to determine whether the presence of piscivores affected distribution, size, age, growth and condition, and relative abundance of sculpin. Chironomid biomass on substrates was examined to determine if prey abundance differed among habitats used by sculpin. Sculpin were also sampled in 2 lakes which were manipulated by experimental removal and addition of lake trout to examine growth history, but distribution data from manipulated lakes were not included in the analyses.

Study area

All lakes sampled were in the vicinity of the Toolik Lake LTER site (68°N, 149°W) (Fig. 1), located 24 km north of the Brooks Mountain Range and 200 km south of Prudhoe Bay, Alaska. This is a region of rolling tundra with numerous, highly oligotrophic lakes (Miller *et al.*, 1986). The open-water season is short, usually lasting about 3 months and surface water temperatures vary seasonally from approximately 0–18 °C (M. C-. Miller, Univ. of Cincinnati, pers. comm.).

Lakes were categorized according to the presence or absence of lake trout, which are the major predator on sculpin. Our knowledge of burbot,

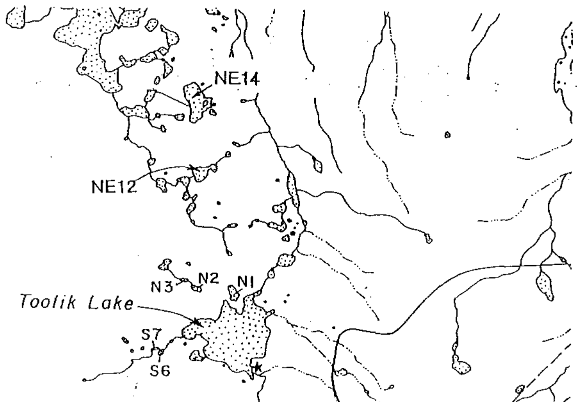


Fig. 1. Study area lakes within the Toolik Lake LTER site. Star indicates location of Toolik Lake Research Station. Distribution of fish species among numbered study lakes is as indicated in Table 1.

the other piscivorous predator on sculpin, is more limited, but our observations suggest that they usually co-occur with lake trout. Lakes N-1, NE-14, Toolik and I-8 contained sculpin, lake trout, and burbot and were categorized as 'lake trout' (LT) lakes. Lakes S-7, S-6, N-2 and N-3 hosted sculpin but no significant predators on sculpin, and were termed 'no lake trout' (NoLT) lakes. These lakes vary in size from 2–149 ha and in average depth from 5–25 m. Arctic grayling were present in all lakes, except possibly NE-14. Round whitefish also were present in I-8 and Toolik.

Methods

Sculpin were captured using unbaited traps constructed from clear glass jars and lucite funnels (McDonald *et al.*, 1982). The traps were tethered in pairs and placed on the lake bottom across four depth substrate zones designated: zone 1 (shallow/rock), zone 2 (mid-depth/rock), zone 3 (mid-depth/rock-sediment interface) and zone 4 (deep/sediments.) Jar traps were set in three replicate sites per lake; fishing effort was 24 jars/lake. All traps were within 25 m of shore.

Traps in N-2, N-3, S-7, N-l, NE-14, Toolik, and S-6 were checked by boat or raft approximately every 3 days for 5 weeks from late June through early August in 1988. Lakes S-6 and I-8 were similarly sampled in 1989. Sculpin were recovered from traps, weighed wet, and measured for total length (TL) to the nearest millimeter. Approximately half of the sculpin trapped in each lake were preserved in 95% ethanol for later aging. When measurements could not be performed in the field, preserved weights were converted to fresh weights by the linear regression formula ($Y = -0.06 + 1.27X$), calculated from 38 specimens ranging from 0.30 to 6.40 g; dessication averaged 16%. Length shrinkage was negligible.

Saggital otoliths were removed from sacrificed fish and placed in glycerine to promote clearing (Cailliet *et al.*, 1986). Otoliths were examined whole using a dissecting microscope and reflected light. The numbers of annuli were determined, and measurements from focus to each annulus were made using a camera lucida and digitizing pad. The ability to accurately distinguish annuli on whole otoliths was verified by mounting and grinding one each from 12 otolith pairs. Further aging verification was provided by Robert Muth, Colorado State University Larval Fish Laboratory.

Invertebrates were sampled in the rock zone of each lake by selecting 4 rocks which covered approximately $^2/_3$ the bottom surface area of a 30×40 cm (top dimensions) dishpan, giving an estimated rock area of 363 cm^2. This sampling was conducted to confirm the assumption that rocks offer sculpin less food than sediments. Rocks were scrubbed with a stiff brush and the resulting sample was strained through a 70 μm net and preserved in 95% ethanol. One sample per lake was taken in July 1988 and in August 1989. Invertebrates were removed by sorting each sample in a clear glass dish over a light table. Insects were identified to family and measured for length using a dissecting microscope, camera lucida and digitizing pad. Lengths for chironomids and caddisflies were converted to dry biomass using the formulae: $w = 0.0051$ ($TL^{2.32}$) and $w = 0.0049$ ($TL^{2.84}$), respectively (Smock, 1980). Mean biomass of chironomids and caddisflies, and chironomids alone, was calculated for the rock zone of LT and NoLT lakes. Data were compared to chironomid biomass estimates from the sediment zone (Goyke & Hershey, this issue) using t-tests.

Sculpin distribution was enumerated by pooling replicate site counts. Zone totals were converted to percentages in each lake. Distribution by treatment was calculated as mean percent of 4 LT or 3 NoLT lakes. Lakes S-6 and NE-12 were not included in the sculpin distribution study because these lakes were the site of a lake trout introduction and removal experiments, respectively, initiated simultaneously with the present study. For the remaining lakes, data from the two rock zones were combined and averaged. Distribution between LT and NoLT treatments was analyzed by t-test for each zone.

All young-of-year (yoy) sculpin were recorded and compiled in a separate data set. Fish 20 mmTL or larger were measured to the nearest mm. Fish smaller than approximately 20 mmTL were preserved in 95% ethanol and measured in the lab with a dissecting microscope and digitizing pad to the nearest 0.1 mm. Several yoy otoliths were examined to assist in aging older fish, but most yoy fish were categorized to age class strictly by size.

Seasonal distribution was plotted as cumulative percent over time, using the cumulative total fish per zone divided by the cumulative total captured, and recalculated for each sampling date. A seasonal change, though not expected might have occurred if breeding males had comprised a large portion of the fish sampled.

Growth curve estimates were made from age-length means (Bagenal & Tesch, 1978) and from 2 types of back-calculated means (Carlander, 1981). Since growth studies integrate historical effects on the fish rather than current effects, Lake S-6 and NE-12 data were used in growth comparisons. Sculpin from Lake I-8 were not sacrificed, thus these were not included in the growth analysis. Age-length growth curves were plotted from the average TL of each age group. Back-calculation procedures used a linear least squares equation (regression method) and a proportional equation (Fraser-Lee method). The y-intercept value in the proportional equation, ($a = 10.97$), was the mean value from the TL/otolith regressions of 7 lakes. Growth curves were statistically compared between lake types by using a t-test on the slopes of the mean TL least-squares regression lines. Interannulus distance at each age were also compared directly to avoid assumptions inherent in back calculation methods. In these comparisons, mean interannulus distance (or focus to annulus distance for year I growth) for years I–IV of growth was calculated for all fish in a given lake. These values were used as the variates representing growth in the analysis. Only ages I–IV were used because older fish were not present in all lakes. Statistical comparisons of mean growth at ages I–IV in 4 No LT lakes and 4 LT lakes were made using t-tests on $\log_e$ transformed interannular distances.

All fish from a given zone in a lake were pooled, and mean TL and weight was calculated by zone in each lake. T-tests were used to compare TL and weight of fish in each zone between LT and NoLT lakes using the mean value/lake for the respective zones as the variate. To determine if sculpin were largest in the sediment zone and smallest in the rock zone in all lakes, distributions were compared using the Page test for the ordered alternatives: sediments > interface > rocks (Hollander & Wolfe, 1973).

Fish condition was compared using the slope of the line: log weight/log TL. This method was selected over K-factors to measure fish condition, sensu Cone (1989), due to errors encountered when comparing fish of different lengths. Slopes were compared by t-test between LT and NoLT lakes.

Catch per unit effort (CPUE) was calculated by:

$$\text{Catch per day} = \frac{\text{total \# fish captured per lake}}{\text{\# sampling days}},$$

$$\text{Catch per trap} = \frac{\text{catch per day}}{\text{24 traps per lake}}.$$

CPUE was analyzed by t-test comparing 3 LT and 3 NoLT catch per trap values.

Results

Over 1000 slimy sculpin were trapped, with a size range from 8.3 mm TL (yoy) to 93 mm TL. The maximum individual weight recorded was 7.35 g (lake N-3).

The percentages of slimy sculpin captured over each of 3 zones differed significantly among lakes ($t = 3.12$, $p = 0.017$, Fig. 2). NoLT lakes showed higher percentages of fish over the sediment than in other zones. In LT lakes, sculpin catch was distributed more evenly over rock, interface and sediment.

There were no apparent seasonal shifts in distribution across 4 substrate zones during sam-

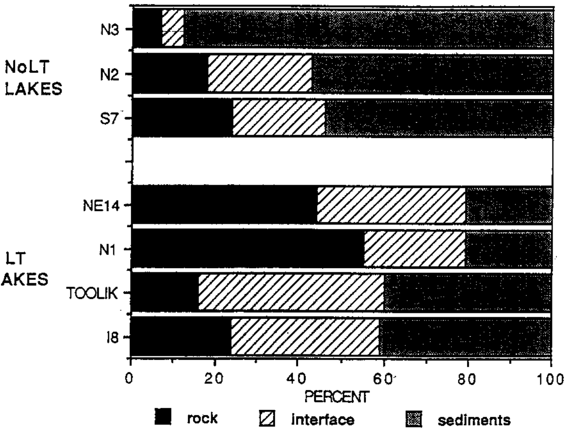


Fig. 2. Percentage distribution of sculpin trapped in rocky, interface, and soft-sediment zones of each study lake. NoLT lakes showed higher percentages of fish over the sediments than in the other zones ($T = 3.12$, $p < 0.02$).

pling from late June – early August, 1988. NoLT lakes consistently had more sculpin over sediments throughout the season than in other zones.

As expected, chironomid biomass estimates from the rocks of both LT and NoLT lakes were significantly less than the biomass estimates from sediment zones in Toolik-area LTER lakes (Table 1; sediment data from Goyke & Hershey, this issue). Goyke & Hershey (1992) found significantly less chironomid biomass in NoLT lake sediments than in the sediments of LT lakes. Chironomid biomass appeared less in LT lake rock zones than in NoLT rock zones, but the difference was not significant (Table 1). Incidence of relatively large caddisfly larvae was low; when caddisflies were included in biomass estimates, rock biomass was still significantly less than sediment biomass (Table 1).

Table 1. Mean (SE) sculpin food availability (chironomid and caddisfly biomass, g/m^2) in rocky and soft-sediment zones of study area lakes. Sediment data from Goyke & Hershey, 1992.

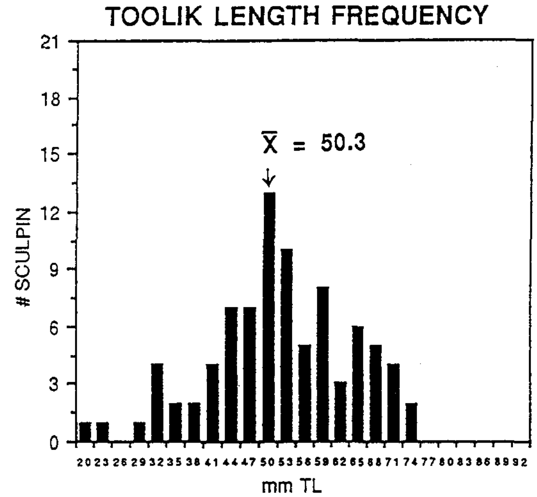
	Chiron. only			
	Sediments	Rock	*t*	*p*
LT	1.23 (0.16)	0.08 (0.04)	6.94	<0.001
NoLT	0.64 (0.07)	0.29 (0.16)	2.05	<0.05
	Chiron. + caddis			
	Sediments	Rock	*t*	*p*
LT	1.23 (0.16)	0.29 (0.14)	4.40	<0.001
NoLT	0.64 (0.07)	0.31 (0.17)	1.77	<0.05

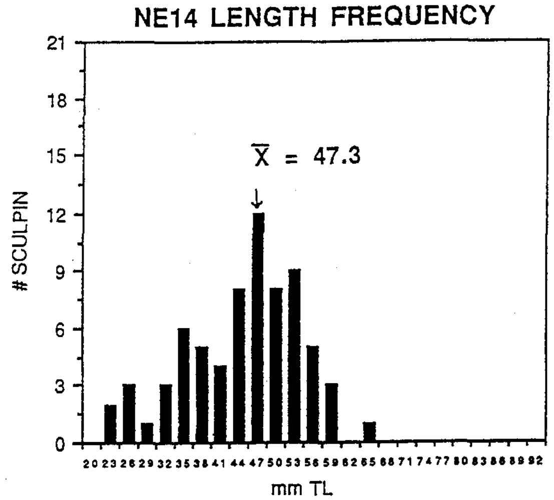
The sculpin length frequency distributions (Fig. 3) do not give a clear indication of age classes in most lakes. LT and NoLT size distributions overlap, with NoLT distributions shifted slightly toward larger TL's.

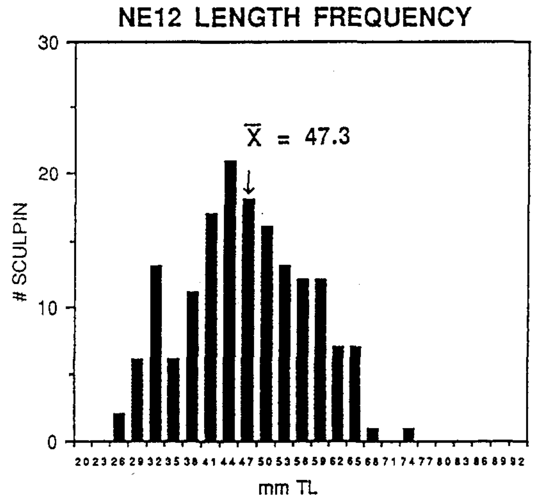
Sculpin mean TL's and weights by lake and zone show a significant trend toward smaller sculpin in the rock zone, larger sculpin at the interface, and largest sculpin in the sediment zone in each lake regardless of the presence of piscivores (Page test for ordered alternatives, length $p < 0.05$, weight $p < 0.01$; Table 2). Between LT

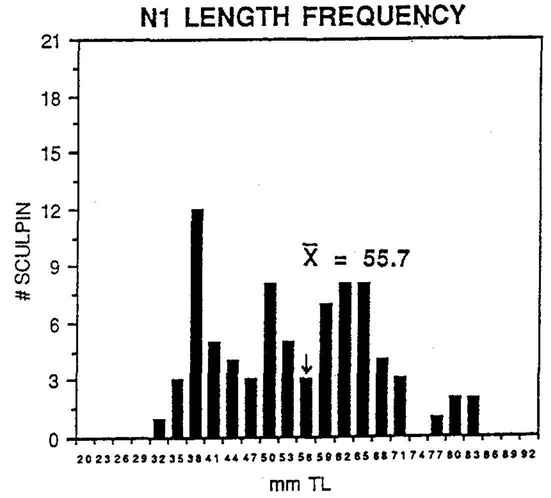
Table 2. Mean length and weight of sculpin captured in rocky, interface, and soft-sediment zones of study area lakes. Page tests show that sediments > interface > rocks for length ($L = 104$, $n = 8$, $p = 0.05$) and weight ($L = 108$, $n = 8$, $p < 0.01$).

Lake	Mean total length (mm) by zone		
	Rock zones 1 & 2	Interface zone 3	Sediment zone 4
Toolik	43.5	53.8	53.1
N1	54.5	56.4	48.7
NE14	45.8	43.7	49.0
NE12	46.9	41.9	51.0
S7	54.6	59.9	59.4
N2	44.7	47.5	57.7
N3	56.3	55.0	80.2
S6	49.5	54.5	58.7
Lake	Mean weight (g) by zone		
	Rock zones 1 & 2	Interface zone 3	Sediment zone 4
Toolik	0.86	1.39	1.44
N1	1.47	1.78	1.35
NE14	0.86	0.67	1.08
NE12	0.89	0.68	1.26
S7	1.59	2.02	2.10
N2	0.73	0.92	1.62
N3	2.17	1.25	5.36
S6	1.04	1.53	1.80









and NoLT lake-types, sculpin from the sediment zone but not other zones had significantly greater total length ($df = 6$, $t = 2.929$, $t < 0.05$,) and weight ($df = 6$, $t = 2.524$, $p < 0.05$) in NoLT lakes (Table 2).

Sculpin in LT lakes aged I–VI in Toolik Lake, I–V years in NE 14, and I–IV in N-1 and NE-12 (Fig. 4a). Sculpin captured from NoLT lakes N-3, S-6, and S-7 aged I–IV years, and sculpin from NoLT lake N-2 aged I–VIII years (Fig 4b). Mean age of sculpin from 4 NoLT lakes was 2.7 ± 0.4 and mean age of sculpin from 4 LT lakes was 2.8 ± 0.3. These means were not significantly different.

Sculpin growth curves of TL by back-calculation using a linear and a proportional equation were similar to slightly lower than population growth curves from actual age-length. The slopes of these lines vary slightly between each of the 3 analyses, but the rank of each lake remains nearly the same (Table 3). There was no significant difference between the mean of slopes from LT and NoLT growth curves regardless of technique. However, examination of interannular distances indicated a slight but consistent trend toward faster growth in NoLT lakes. Interannular distance was significantly greater for year IV growth in NoLT lakes ($t = 2.46$, $df = 6$, $p < 0.05$), but not

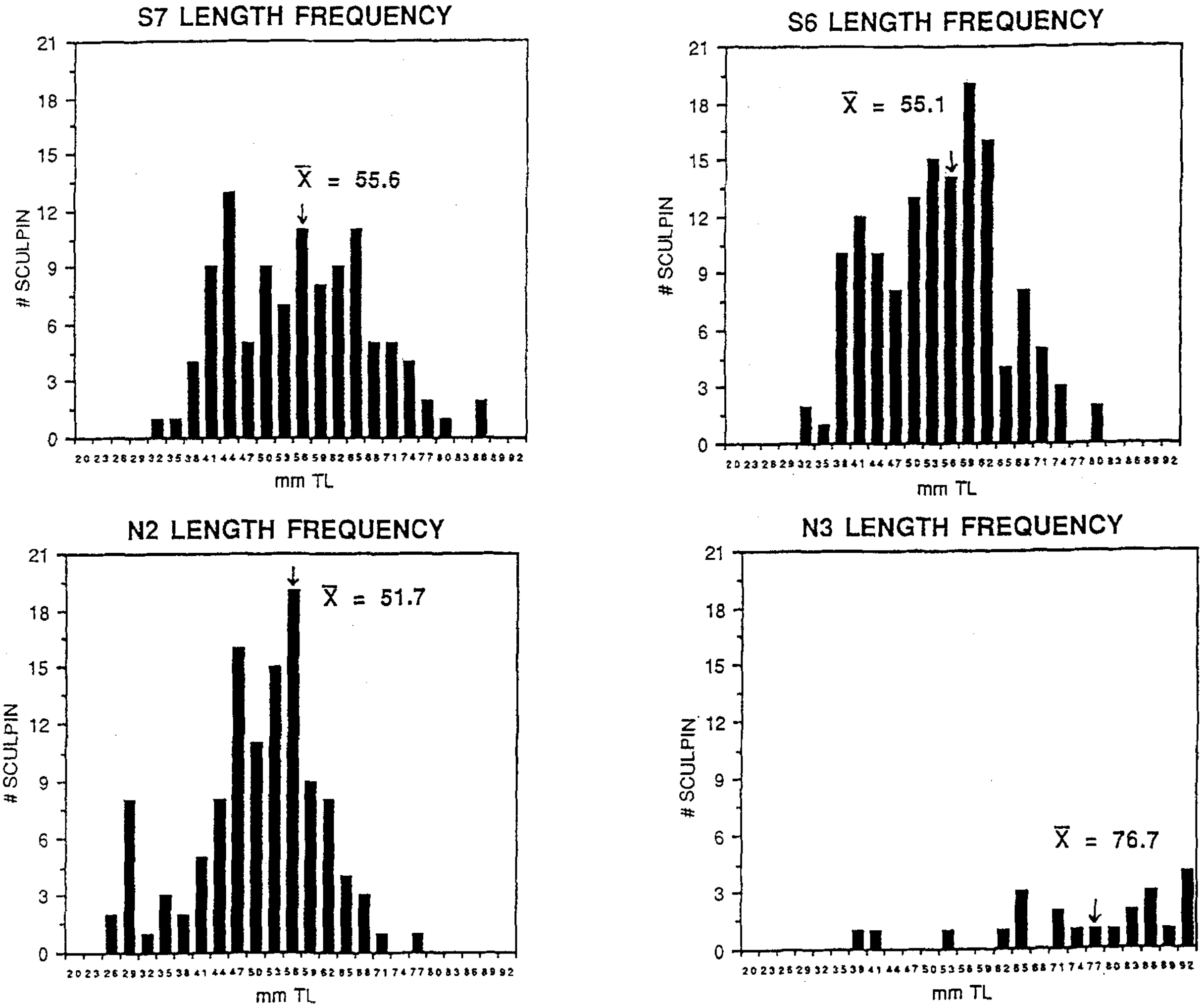


Fig. 3. Length-frequency distribution of sculpin in LT (3a) and NoLT (3b) lakes.

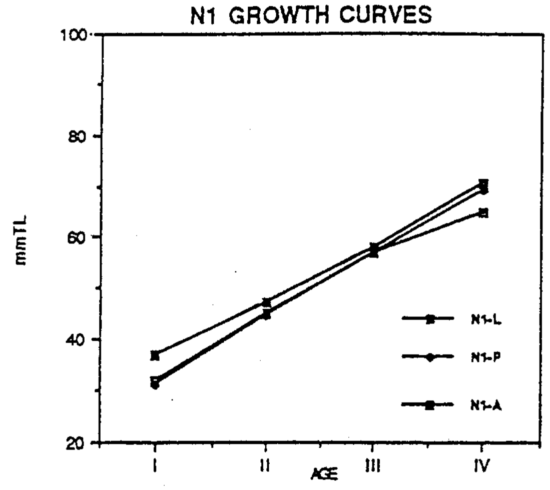
significantly different in other years, although the trend was in the direction of faster growth in NoLT lakes (Table 4).

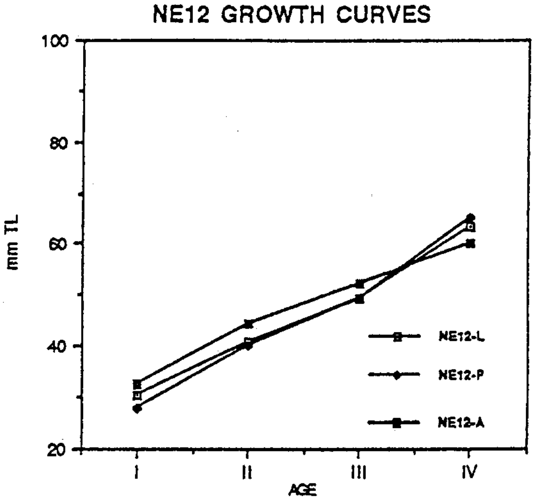
Fish condition analyzed by log weight/log TL regression resulted in slopes measuring from 2.93 to 3.17, with 3.0 indicating isometric growth (Table 5). Slopes overlapped and showed no significant difference between sculpin condition in LT and NoLT lakes.

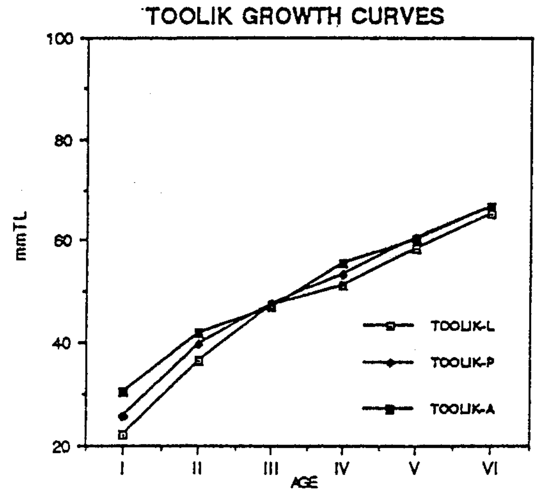
Sculpin catch per unit effort (CPUE) ranged from 0.087 to 0.39 fish per trap. The highest CPUE was in NoLT lakes N-2 and S-7, with the remaining NoLT lake, N-3, showing the lowest CPUE overall. Mean CPUE for NoLT lakes (0.29) was very similar to the mean in LT lakes (0.28).

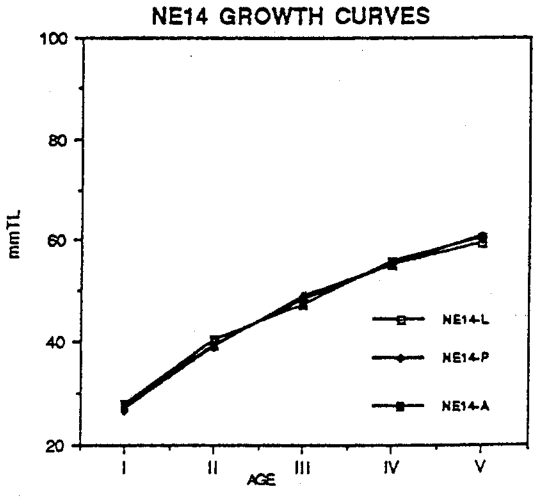
Discussion

Slimy sculpin have adapted to a variety of cold-water habitats, both lacustrine and lotic, as evidenced by their wide-spread distribution in northern North America (Scott & Crossman, 1973). Although some sculpin behaviors undoubtably change with respect to geographic locality, such as nocturnalism versus diurnalism in response to light intensity (Van Vliet, 1964; Emery, 1973;









Eriksson, 1978, Müller, 1978a, b; Selgeby, 1988), many life history parameters can be expected to be similar in all habitats. Sculpin life history was not the focus of this study, but it cannot be separated from the ecological implications of the data presented. Slimy sculpin behavior in northern Saskatchewan was studied extensively by Van Vliet (1964). Conducting both field and laboratory experiments, he observed that breeding males establish and aggressively defend nest sites in rocky crevices. During spawning, females were attracted to nest sites and laid eggs on the underside of rocks. Males remained in nests to fan egg masses and protect them from predation. Parental care by the male continued for the entire incubation period (28–29 days at 8-18 °C), and after egg hatching for 2–3 days until the fry began feeding. Van Vliet terms slimy sculpin behavior during the rest of the year as 'solitary.'

Young of the year (yoy) sculpin were trapped in this study beginning on July 4, 1988. Sculpin at earliest capture dates were 8.3 to 10.2 mmTL, had yolk absorbed, a full complement of adult fin rays (sensu Heufelder, 1982), and were estimated to be 5 days old using the criteria of Van Vliet (1964). Assuming a 28–29 day incubation period (Van Vliet, 1964), this sets the earliest spawning date near June 1 for that year and confirms that

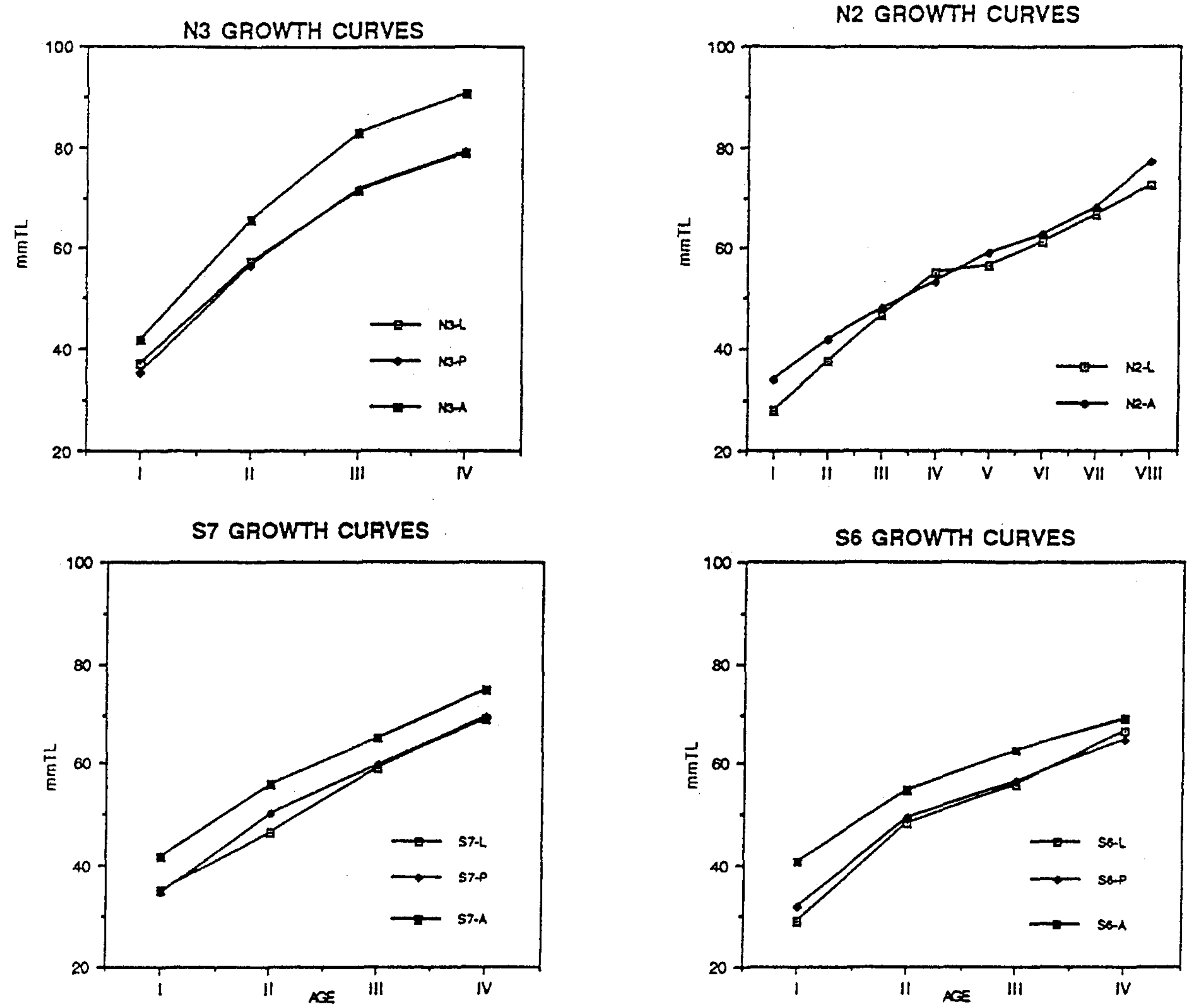


Fig. 4. Sculpin growth curves determined for LT lakes (4a) and NoLT lakes (4b). L = linear regression back-calculation method, P = proportional back-calculation method, and A = method using age-length means.

sculpin in this area are probably spawning at ice-out in the small lakes. The ability to trap yoy fish was important to aging verification (Jearld, 1983) and to add insights to early growth patterns.

Breeding male sculpin are known to leave the nesting area after yoy dispersal (Van Vliet, 1964). This probably results in a shift in habitat for them, and possibly other fish they may displace. Analyzing the adult distribution throughout the sampling period of late June to mid-August showed no seasonal change in habitat distribution which might be attributed to cessation of male breeding behavior. However, the percentage of the population comprised of breeding males is probably small and would likely not to have strongly influenced the observed patterns of sculpin distribution. Also, males may have already left nests when sampling began.

Other seasonal changes are probably initiated near the end of the open-water season. Little is known about the winter behavior of arctic fishes and we can only surmise that both predator and prey undergo major changes from the constant daylight (Eriksson, 1978, Müller, 1978a, b), changing water temperatures, spawning and feeding modes of summer. Age analysis

Table 3. Slopes calculated from growth curves using three methods (see text).

NoLT lakes	Actual TL/age	Linear back-calc	Proportional back-calc
N2	5.74	5.96	–
S6	9.38	11.18	12.06
S7	10.9	11.44	11.21
N3	16.25	14.63	13.90
LT lakes			
Toolik	6.99	7.85	8.11
NE14	8.05	8.41	7.97
NE12	9.16	12.10	10.73
N1	11.17	12.68	11.16

Table 4. Mean (SE) focus to annulus distances (year I) and interannular distances (years II–IV) for sculpin in LT and NoLT lakes. P-values indicate outcome of t-tests on $\log_e$ transformed data for each year.

Growth (year)	NoLT lakes		LT lakes		*P*-value
	(mean)	(SE)	(mean)	(SE)	
Year I	0.44	0.02	0.39	0.02	<0.2
Year II	0.34	0.04	0.30	0.01	>0.5
Year III	0.25	0.03	0.24	0.01	>0.5
Year IV	0.28	0.04	0.19	0.01	<0.05*

of otoliths implies growth during winter is markedly reduced (Van Vliet, 1964), but fish are presumed to be foraging at some level (Müller, 1978a, b; Hershey & McDonald, 1985). The effects of fish predation can differ according to season (Gilinsky, 1984), and during the dark arctic winter, visual feeders like lake trout (Kettle & O'Brien, 1978) may become more reliant on tactile senses, making them less effective piscivores. At the same time, slimy sculpin likely move into deeper water. Mousseau & Collins (1987) reported slimy sculpin in Ontario lakes moved to hypolimnetic waters in August or September. In the arctic, much of the littoral zone freezes solid and sculpin must move off the rocks by winter. Correspondingly, habitat for each sculpin would be reduced.

Table 5. Slopes calculated from log weight/total length data (see text).

NoLT lakes	Log wt/TL regression	SE	*n*	R^2
N2	3.03	0.15	113	0.79
S6	3.00	0	117	0.95
S7	3.17	0.08	70	0.96
N3	2.93	0.11	33	0.95
LT lakes				
Toolik	2.94	0.11	67	0.92
NE14	3.09	0.13	37	0.94
NE12	3.00	0	134	0.96
N1	3.04	0.13	35	0.94

The presence of sculpin across all three zones in both LT and NoLT lakes may be due to intraspecific behavior in sculpin populations. Van Vliet (1964) reported that in aquaria observations, sculpin quickly established a 'pecking order', with the larger, more aggressive fish dominant in terms of food consumption and habitat. Brandt (1986) found smaller, younger slimy sculpin inhabiting shallower depths than larger individuals in Lake Ontario. In arctic lakes, larger sculpin probably use those habitats with more food in order to find sufficient prey to meet their greater metabolic needs. This hypothesis is supported by a significant trend toward larger fish in the sediment and interface zones than in the rock zone of both LT and NoLT lakes (Table 2).

During the summer, adult sculpin in NoLT lakes were most prevalent in the sediment zone. Sculpin distribution in LT lakes shows a significantly smaller percentage of sculpin captured over the sediments, and more sculpin in the interface and rock zones, which afford refugia from predators. This may reflect the necessity for sculpin to balance predator threat against food availability, because chironomid biomass data indicates the sediments offer more food. This result has potentially important bioenergetic implications for sculpins because these arctic sculpin appear to be food limited (McDonald *et al.*, 1982; Hershey & McDonald, 1985).

Fish growth is closely correlated with diet, and growth in many fish species has been shown to be slow at higher latitudes (Craig & Wells, 1976; Johnson, 1976; Power, 1978). In many cases arctic systems support fewer and smaller prey items than temperate ones. The diet of Toolik-area sculpins is 84% chironomid larvae (Hershey, 1985). A 5-year old slimy sculpin feeding on amphipods in Lake Superior can grow to 2 × the length and 3 × the weight of arctic sculpin, despite colder summer water temperatures (4–5.5 °C) in Lake Superior (data from Selegby, 1988). A diet of mainly chironomid larvae limits arctic sculpin growth, and chironomids are less abundant in rocky areas than on sediments. Goyke & Hershey (1992) found chironomid diversity, density and biomass to be significantly less in the sediments of NoLT lakes than in LT lakes, and attributed this to the impact of sculpin feeding behavior on the sediments in the absence of predators. A reciprocal relationship, less chironomids in the rock zone of LT lakes than in the rock zone of NoLT lakes, appeared to exist, but was not statistically significant. However, rock zone sampling was far less extensive than sediment zone sampling (Goyke & Hershey, 1992), thus there was considerably less power to detect a difference between lake types in the rock zone. A trend toward lower chironomid biomass in the rock zone of LT lakes could indicate sculpins rely more on feeding in rock areas when in the presence of predators. In lakes containing predators, the threat of predation may reduce sculpin individual habitat size, and/or reduce the amount of time sculpin actually spend feeding. Larger overall weights and total lengths from fish captured over the sediments in NoLT lakes suggests sculpin feed more readily and openly in the absence of predators.

The implications of sculpin distribution differences between lake types, in conjunction with resource differences in the rock and sediments zones, suggests that sculpin growth and population structure could be different in lakes with and without predators. TL frequency diagrams showed a tendency for larger-sized sculpin in NoLT lakes. The sexual maturity of slimy sculpin, as in most fish, is largely determined by reaching a minimum size. Aging of Toolik-area sculpin reveals there is variability in the longevity of fish by lake, with fish in some populations living only to age IV and others showing a maximum age of VIII. The maximum attainable size for slimy sculpin in this area appears to be approximately 95 mm TL, regardless of age. This implies very different growth rates among lakes. Age-length growth curves and growth curves by back-calculation gave varying slopes, but did not show a clear distinction between growth rates in LT and NoLT lakes. The condition index of the slope of the log weight/length regression line also shows no pattern.

Examination of interannular distances does indicate that sculpin grew more during year IV in NoLT lakes. This significantly higher year IV growth is consistent with the pattern of greater use of the sediment habitat in these lakes. Higher overall growth rate of all year IV sculpin in NoLT lakes contrasted with smaller mean size of sediment-dwelling fish in the same lakes probably reflects the fact that a higher proportion of the populations are using the sediments when predators are absent. Lower food abundance on the sediments has been attributed to sculpin predation (Goyke & Hershey, 1992), but lack of a consistent concomitant growth response combined with an apparent maximum size regardless of lake type, implies that predator threat determines distribution within a lake, but that predation and food supply are closely related factors affecting growth of sculpin in these arctic lakes.

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