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DISTRIBUTION, ABUNDANCE, AND SIZE OF JUVENILE SOCKEYE SALMON AND ASSOCIATED SPECIES IN THE IGUSHIK LAKES

by

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INTRODUCTION

The Igushik Lakes study is part of the Bristol Bay Rehabilitation and Enhancement Opportunities Program sponsored by the Alaska Department of Fish and Game. During the month of August 1974, the Fisheries Research Institute was contracted to investigate juvenile sockeye salmon (*Oncorhynchus nerka*) and associated species in the Igushik lakes. The objectives of the study were to determine their (1) distribution and relative abundance, (2) size and growth rate, (3) food habits, and (4) the abundance of their food. To achieve these objectives, personnel sampled the lakes with a beach seine, tow net, echosounder, plankton net, and benthic grab (Fig. 1 and 2).

Two lakes make up the Igushik system. Lake Ualik is the upper lake and drains into Lake Amanka via the Kathleen River. The Igushik River flows from Lake Amanka into Bristol Bay. The two lakes have similar surface areas and depths, but very different shapes and shorelines. Lake Ualik has a fairly uniform shoreline. The ratio of the length of the shoreline to the length of the circumference of a circle with an area equal to that of the lake is 1.78 (Burgner et al. 1969). Lake Amanka, on the other hand, has a shoreline development ratio of 3.94 with bays, arms, points, and other irregularities in the shoreline. A sill (between Areas B and C) divides Lake Amanka into two distinct basins.

In spite of the fact that the lakes are relatively small and contain only 9 percent of the total lake surface area of the major lake systems draining into Nushagak Bay, the Igushik lakes contribute about 20 percent of the Nushagak runs.

Because of delays caused by the weather and difficulties in obtaining and transporting suitable boats and personnel, sampling was conducted only during the latter part of August. Such a limited sampling period places severe limitations on the conclusions that can be drawn about the lake system; therefore, this study could only provide preliminary information for conducting future investigations to better understand the nature of the lakes. This report is a summary of the sampling program and the results of the analysis of the data.

METHODS

Beach Seine

Littoral fish were sampled at ten stations around each lake using a tapered 104-ft by 16-ft beach seine with an 8-ft long center section of 1/4-inch mesh (net and set description in Pella 1968). The stations were selected in advance by choosing points that were evenly distributed around the lakes. The actual sites were suitable beaches nearest to the selected points. Each lake was sampled twice. The sampling dates were approximately two weeks apart. (Amanka: August 12 and 30, and

Ualik: August 15 and 27). In Lake Ualik, large numbers of beach-spawning sockeye salmon made sampling difficult, often damaging the juvenile fish in the net and in one instance (August 27, Ualik, Sta. 5) making a satisfactory set impossible.

The other fish caught in the beach seine were immediately preserved in 10 percent formalin. Catches larger than about 500 fish were subsampled.

Tow Net

Pelagic fish were sampled with a 9-ft square by 27-ft tow net with a 1/8-inch mesh liner in the cod end (net and set procedure described in Rogers 1967). Nine surface and one subsurface tow (using depressors attached to the net spreader bars) were made in Lake Ualik between the hours of 10:00 P.M. and 1:00 A.M. on August 22-23. Seven surface and four subsurface tows were made in Lake Amanka between the hours of 10:00 A.M. and 3:00 A.M. on August 31-Septmeber 1. The tows lasted five minutes and strained an estimated 3,493 m^3 of water each. The total catches were immediately preserved in 10 percent formalin for later measurement and enumeration.

Echosounding

The night preceding townet sampling on both lakes, a Simrad Echosounder (Model 512-5) was used to make a hydroacoustic survey of the pelagic fish population. Five transects were made on Lake Ualik and six on Lake Amanka between the hours of 10:00 P.M. and 3:00 A.M. The boat speed was estimated by dividing the distance covered (determined from a map), by the time elapsed during the transect, and it averaged 1.7 m/sec. We used Rogers' (1967) plastic template method for counting fish marks on the echograms. The counts were then adjusted to compensate for the size of the transmission beam (Appendix Table 1).

Measurement and Enumeration of Catches

At least 48 hours after collection, the fish from both the beach seine and townet catches were counted (Appendix Tables 2 and 3) and measured (fork length) to the nearest millimeter (Fig. 3 and Appendix Fig. 1). In catches with more than 200 threespine sticklebacks (*Gasterosteus aculeatus*), 200 were selected as randomly as possible to insure that the subsample contained a representative size distribution. The specimens were retained in 10 percent formalin after measurement for stomach contents removal at a later date.

Stomach Contents Removal

For stomach contents removal, size groups were determined from length frequency graphs. In sockeye, threespine sticklebacks, ninespine sticklebacks (*Pungitius pungitius*), and char (*Salvelinus alpinus*), the size groups correspond approximately to age groups.

Because of large numbers of small (10 to 20 mm) sculpins, the two species present in the lakes (*Cottus aleuticus*) and (*Cottus cognatus*) could not be separated efficiently. Both species were combined and treated as one "species" group. A few stomachs from specimens identified to species were compared and contained essentially the same benthic and littoral food organisms. Roger (1971) noted some differences in the diets of the two species in the Lake Iliamna area, but he suggested that these differences were caused by size and geographical differences (lake vs stream dwellers) in the two species. In the Igushik lakes, both species occur together with no noticeable diet differences among the identified specimens examined.

The catch from each beach seine and townet station was divided into size groups (Table 1). From each size group, we selected 10 specimens for stomach content removal. If a size group contained less than ten, but more than three, the whole group was taken. In a few cases of species with small numbers such as Alaska blackfish (*Dallia pectoralis*) less than three fish were taken from a size group.

The contents were removed only from the stomach or foregut (anterior to the pyloric sphincter), and placed in five percent formalin. Contents from each station-species-size group were combined in one container. Later the samples from stations in each of the three lake areas were combined into area-species-size group samples (Table 2). Smith (1947) demonstrates that composite samples of this type are representative of the food taken by the majority of fish. The fork length and relative fullness were recorded and any visible parasites were noted.

The combined stomach contents samples were examined under a dissecting microscope. Hynes (1950) reviewed several methods for examination of stomach contents. The large numbers of small fish to be processed made volumetric or gravimetric methods impractical. The numbers method was chosen because although it does not stress the nutritional or quantitative importance of different-sized organisms to the diet of the fish, it gives a better idea of the feeding habits of the fish, and is less subjective than the points method. Initially, we tried a method similar to the points method in which the volume of each food item was judged by eye and expressed as a percentage of the volume of the total sample. This method was useful in giving importance to larger organisms or partially digested but still identifiable material; however, the method was discontinued because of investigator bias. With experience, the investigator could identify more kinds of partially digested material. Thus samples examined first contained a large percentage of "unidentifiable" material and later samples contained little matter that could not be identified.

In actual counting of organisms, only whole or nearly whole food items were counted to minimize bias due to the person's counting familiarity with the species involved and to unequal digestive rates as suggested by Hess and Rainwater (1939). More slowly digested organisms were still favored over very delicate ones, probably causing a snail to be counted while a pelagic cyclopod eaten at the same time might already be digested and not be counted.

Samples with more than about 300 organisms or equivalent digested matter were diluted with a known volume of water. Three subsamples were taken with a one-ml Stemple pipette and the organisms counted. The average of the three subsample counts was multiplied by the appropriate factor to obtain an estimate of the total number of each food item in the sample (Rogers 1968) (Appendix Tables 4 and 5).

Benthic Samples

We used an Eckman grab to sample the bottom fauna. The grab removed an approximate six-inch square of substrate. The substrate material was strained through a sieve bucket with a bottom of 30-mesh wire (12 divisions per cm). The sieved organisms, detritis, and gravel were larger than approximately 0.5-mm. They were preserved in 2 percent neutral formalin for later sorting and counting.

Two samples were taken in the vicinity of all but one beach seine station on Lake Amanka (August 25 and 30). The substrate near station #7 was too rocky to make a satisfactory grab. Replicate samples were taken at each station at a depth of between four and nine meters.

Only the lower end of Lake Ualik was sampled (September 8). Five stations were sampled at two depths between four and nine meters (Table 3).

The preserved samples were examined in the laboratory under a dissecting microscope. Organisms were identified to practical taxonomic groups and counted. We attempted to subsample some of the samples; however, some samples contained small numbers of organisms and the subsamples in those cases did not contain numbers of organisms representative of the entire sample. In all cases, we counted the total sample (Appendix Table 6).

Zooplankton

Vertical plankton hauls were made from near the bottom to the surface at three stations on each lake (Table 4). We made the hauls with a marine plankton net of #6 mesh and a 0.5-m opening, and immediately preserved the samples in 2 percent formalin. The settled volume of the samples was recorded after allowing the samples to settle in graduated cylinders for 30 minutes. Water was then added to dilute the sample to a known volume and three one-mm subsamples were taken with a Stemple pipette. The numbers of each species of zooplankton were counted and the averages of the three subsample counts were used to estimate the total numbers of each plankter (Waters 1967) (Appendix Table 7).

RESULTS AND CONCLUSIONS

Population Estimation – Echosounding

The following equation for estimating the total population of a species of fish in a lake is modified from that used by Rogers (1967).

$$N = (\bar{c}_s (V/v) \bar{r}_1) + (\bar{c}_d (V/v) \bar{r}_2 (\bar{r}_3))$$

$\bar{c}_s$ is the geometric mean of the surface townet catches, $\bar{c}_d$ is the geometric mean of the subsurface townet catches (Table 6), V is the volume of water in the lake available to the tow net (greater than 20 m deep), v is the volume of water covered by a standard tow, $\bar{r}_1$ is the geometric mean of the vertical availability ratios at 0-3 m depth of the transects, $\bar{r}_2$ is the geometric mean of the vertical availability ratios at 3-18 m, and r_3 is the geometric mean of the horizontal availability ratios at 3-18 m. Availability ratios (r_1,r_2,r_3) for each transect and their means are given in Table 5.

Table 7 gives the estimated populations of sockeye fry and threespine sticklebacks in the Igushik lakes. Sockeye fingerlings, char, and sculpins were also caught in the townet catches, but in too small numbers to make an estimate of their total population size. Our Lake Ualik subsurface tows contained no fish. Therefore, the ratio of the number of fish in the subsurface tows to that of the surface hauls in Lake Amanka was used to obtain a subsurface mean catch for Lake Ualik from the surface tows.

Although the area of Lake Amanka is only 89 percent of the area of Lake Ualik, Lake Amanka contained approximately eight times as many fish as Lake Ualik. Sockeye fry in Lake Amanka outnumber threespine sticklebacks about three to one. In Lake Ualik, sockeye fry and threespine sticklebacks occur in about equal numbers. About 75 percent of the spawning takes place in Lake Ualik, with 23 percent of the spawning in the Kathleen and Ongoke rivers. The remaining three percent of the Igushik spawners use Lake Amanka.[1] The large numbers of fry in Lake Amanka are probably Ualik and river-hatched fish moving downstream to use Lake Amanka as a nursery area.

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[1]Michael L. Nelson, 1974, Preliminary report on spawning ground surveys in the Igushik and Tikchik lake systems, 1974, *in* Kenneth P. Parker and Lewis H. Barton, December 17, 1974, the Bristol Bay Rehabilitation and Enhancement Opportunities Program, A Progress Report, Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage, Alaska.

The 1973 sockeye run was small (0.083 million fish, unpublished ADF&G reports). Since the relative size of the parent run is a good index of the relative population of fry in the lake the following year, 1974 was probably a low year for sockeye fry in the Igushik lakes.

Relative Abundance and Distribution - Beach Seine

In analysis of the beach seine catches, each set is assumed to be a unit of effort and catch per unit of effort is proportional to the true population size if the availability of fish to the sampling net is constant (Pella 1968). Because the beach seine sampling took place in the late summer during the period when sockeye fry and threespine sticklebacks are moving into the limnetic zone of the lake, the assumption that the availability of fish to the sampling net is the same as earlier in the summer is not valid. The beach seine catch means, therefore, are not a valid index of the whole population of fish. However, they can be used as a measure of the relative abundance and distribution of the fish in the lake during the period of sampling.

Geometric means of the beach seine catches of five fish species by lake area, and their sums are given in Table 8. The sum of the means for all the fish in all areas of Lake Amanka are greater on the first sampling date than on the second date. This decrease in numbers could be due to the late summer offshore migration, especially in the case of the threespine sticklebacks whose numbers decreased threefold. We do not know why the sum of the mean catches (and all of the individual species) increased on the second sampling date in Lake Ualik.

Threespine sticklebacks were the most abundant species of fish in all areas of both lakes except Area C in Lake Amanka on the second sampling date where ninespines were the most abundant species.

Alaska blackfish and round whitefish (*Prosopium cylindraceum*) were occasionally caught, most commonly in the shallower, more vegetated areas of the lakes near the outlets (Area C).

The relative numbers of sockeye fry were low; however, the numbers are higher than the 0.4 geometric mean obtained for sockeye fry in Lake Aleknagik for the period July 21 to August 5, 1974.[2] Except for the first sampling date on Lake Ualik (sockeye fry excepted) and for the char fry, the mean catches of all species of fish in the Igushik lakes

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[2]Donald E. Rogers, 1974, Alaska Salmon Studies, the study of red salmon in the Nushagak District. Fisheries Research Institute Periodic Report Number 1, October 15, 1974. Contract No. 03-5-208-92.

are larger than the 1974 late summer means for Lake Aleknagik. Perhaps the Lake Aleknagik fish moved offshore earlier and more suddenly than the Igushik fish.

Parker and Barton[3] mention that it has been hypothesized that the barrier dividing the Lake Amanka basin into two arms may be preventing natural stocks from using both arms. Area C constitutes one "arm" and Areas A and B make up the other "arm." The mean catches from Lake Amanka do not indicate any such preference of one "arm" over the other.

The relative abundance or density of fish in Lake Ualik was greater in Area C (the outlet end of the lake) on both sampling dates.

Size of Fish

Mean lengths of sockeye fry (age 0), threespine sticklebacks (age I) and Arctic char fry in beach seine catches in Lake Aleknagik during the early summer sampling period, 1974 (ending July 20) were larger than the mean lengths for any early summer period since sampling began in 1962. The mean lengths of sockeye fry, age I threespine sticklebacks and Arctic char fry (Table 9) in both Amanka and Ualik were comparable to early August mean lengths for Lake Aleknagik indicating that 1974 was probably a good year for early summer growth in the Igushik lakes as well as in Lake Aleknagik.

The beach seine catches are not good indicators of the total lake population since the fish were moving offshore during the sampling period. The catches show this period of movement in their length means by the lack of growth in some areas or negative growth in others. An estimate of the growth rate from the two dates of beach seine catches would not be reliable and our pelagic samples are for one night only, making it impossible to use the pelagic fish for calculating a growth rate representative of the whole lake over a period of time.

The length frequency graphs (Fig. 3) show the length means of the townet catches for sockeye fry and threespine sticklebacks are larger than the means for the beach seine catches in both Lake Amanka and Lake Ualik suggesting that the larger fish moved into the limnetic region first.

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[3] Kenneth P. Parker and Lewis H. Barton, December 17, 1974. The Bristol Bay Rehabilitation and Enhancement Opportunities Program, A Progress Report, Alaska Department of fish and Game, Division of Commercial Fisheries, Anchorage, Alaska.

Zooplankton

Lake Ualik contained more zooplankton than Lake Amanka during the period sampled (Fig. 4). The station in Lake Ualik with the lowest concentration (Sta. 3) had more than twice as much zooplankton as the station in Lake Amanka with the highest concentration (Sta. 1), measured in ml/m^3.

The concentrations at all three stations in Lake Amanka were fairly low, less than 0.6 ml/m^3. The zooplankton density in Lake Ualik shows a definite trend increasing toward the upper end of the lake. That end, or Area A was not sampled. However, if the trend continued, the concentration values at the upper end of the lake (Area B) might be as high as 6.6 ml/m^3. The mean beach seine catches show a relatively high density of fish in Area C of Lake Ualik, corresponding to the low density of zooplankton. Rogers and Siler (1969) show further evidence from lakes in the Wood River system of the cropping effect of a high density of fish on a relatively fixed supply of food such as zooplankton. The length data are not adequate to show if the presumed increased competition by the high numbers of fish for the small amount of food in Area C of Lake Ualik had any effect on the growth of the fish.

The zooplankton hauls contained six species of zooplankton: three cladocerans, *Bosmina coregoni*, *Daphnia longiremis*, and *Holopedium gibberum*, the cyclopoid, *Cyclops scutifer*, the calanoid, *Diaptomus gracilis*, and *Asplanchna* sp., a rotifer.

The Lake Amanka zooplankton population was 75-80 percent cladocerans. *Bosmina* was more abundant in samples 1 and 2 and *Daphnia* was dominant in sample 3. The percentage composition of cladocerans and copepods was more evenly distributed in Lake Ualik except in Sample C (the area of low density) where 54 percent of the organisms were *Diaptomus* (Fig. 5).

Bottom Samples

About 20 categories of organisms were found in the bottom grabs. Those groups such as littoral cladocerans, ostracods, copepods, mites, etc. which seemed to be incidental in the grab, that is, those which do not inhabit the substrate, were not counted.

Encysted harpacticoids (*Canthocamptus stashlynoides*) were found occasionally in samples and in one case (Ualik, Sta. 4), one grab contained over 1,000 cysts. Although the harpacticoid cysts were on the substrate, they were not included in the organism counts but were considered to be "inactive" members of the benthic community.

The counts of bottom organisms from each grab varied widely in number. The numbers of organisms counted in replicate samples at one station were often just as variable as the counts from two different stations. Even the substrate and debris in replicate grabs were often very different, for example, one grab might be very sandy, while the second grab in the same location might be very muddy with lots of rooted aquatic vegetation.

Table 10 gives the counts of the benthic organisms in the two lakes by area. The total mean counts per grab per area for Lake Ualik were larger than those for Lake Amanka. Diptera larvae (predominantly Chironomidae) and Oligochaetes were the most common organisms in all areas of both lakes. Snails, clams, and nematodes were the next most common categories except in Lake Ualik, Area B, where polychaetes outnumbered snails. In the other areas polychaetes occurred in low numbers followed by leeches, Trichopter larvae, and Planaria.

Reeves (1968) showed a decrease in the total wet weight of benthic organisms per square foot with depth in lakes of southwestern Alaska. We did not weigh the Igushik samples, but the variation in weight of the organisms should be fairly proportional to the variation in numbers. Plots of total numbers of organisms per grab vs depth showed no correlation between density of organisms and depth at the depths sampled (7-9 m). Reeves used depth intervals of ten meters to make his comparisons and took his first sample at 11 m. The trend of decreasing bottom fauna with depth may not be apparent at such small depth intervals and shallow depths.

Food - Stomach Contents

The stomachs of the size groups of each species contained essentially the same kinds of organisms. There were some differences in the sizes of the food items among the fish size groups, but few differences in species composition of the food items in the stomach contents. The species diet compositions for the two lakes are shown in Fig. 6.

The major difference in the diets of fish between the two lakes was in the amount of pelagic zooplankton found in the stomachs of those fish eating pelagic zooplankton, i.e. sockeye, char, threespine sticklebacks, and ninespine sticklebacks.

Pelagic zooplankton rarely appeared in the stomachs of Lake Amanka sockeye fry and threespine sticklebacks, and only on the second sampling date. The density of pelagic zooplankton in the plankton hauls was low in all three areas of Lake Amanka. Littoral cladocerans constituted a major part of the diet of all species in Lake Amanka (Appendix Table 8).

In Lake Ualik, on the other hand, where pelagic zooplankton was more abundant, pelagic zooplankton was an important part of the diets of the plankton feeders. The amount of pelagic zooplankton in the stomachs of sockeye and threespine sticklebacks increased with the increase in density of zooplankton from Area C to Area A (Fig. 7). The transition from pelagic to littoral zooplankton in ninespine stickleback stomachs from each area was more abrupt than in sockeye and threespine stickleback stomachs.

Ninespine sticklebacks ate 83 percent pelagic zooplankton (of the zooplankton consumed) in Area A, and one percent and a trace in Areas B and C respectively.

Sculpin and Alaska blackfish stomachs contained predominantly littoral zooplankton, mollusks, and diptera larvae. Round whitefish stomachs contained fewer mollusks and more aquatic insects than those of the other bottom feeders indicating that the whitefish spend more time feeding higher in the littoral water column.

Ninespine sticklebacks fed primarily on littoral cladocerans in Lake Amanka.

Surface insects were the predominant food item of sockeye fry in Lake Amanka and to a lesser degree in Lake Ualik, whereas the threespine sticklebacks ate only trace amounts of surface insects. However, adult insect parts in threespine stickleback stomachs were nearly always well broken and although insect material may have made up a significant part of the stomach content mass, the insects were not counted because there were no whole or nearly whole bodies present. Pupae seemed to retain their shape better in the sticklebacks' stomachs than adult insects did. Counts of pupae in sticklebacks are more representative of their actual numbers than the counts of adult insects.

The food of sockeye and threespine sticklebacks from townet catches was predominantly pelagic zooplankton (Fig. 8). Occasionally insect pupae, adults, and littoral cladocerans were found in the stomachs. In Lake Amanka, sockeye and threespine sticklebacks preferred *Bosmina* in Areas A and B where it was the dominant plankter. However, the percentage of *Bosmina* in the stomachs was greater than the percentage available as indicated by plankton samples. In Area C, where *Daphnia* was more abundant in plankton samples, threespine sticklebacks still ate *Bosmina* in large numbers, while sockeye fry ate *Cyclops* in the same numbers as *Bosmina* and a higher proportion of *Daphnia*.

Sockeye fry from townet samples in Lake Ualik ate more of all species of zooplankton, with *Bosmina* dominant, although calanoids were the most abundant organism in the water.

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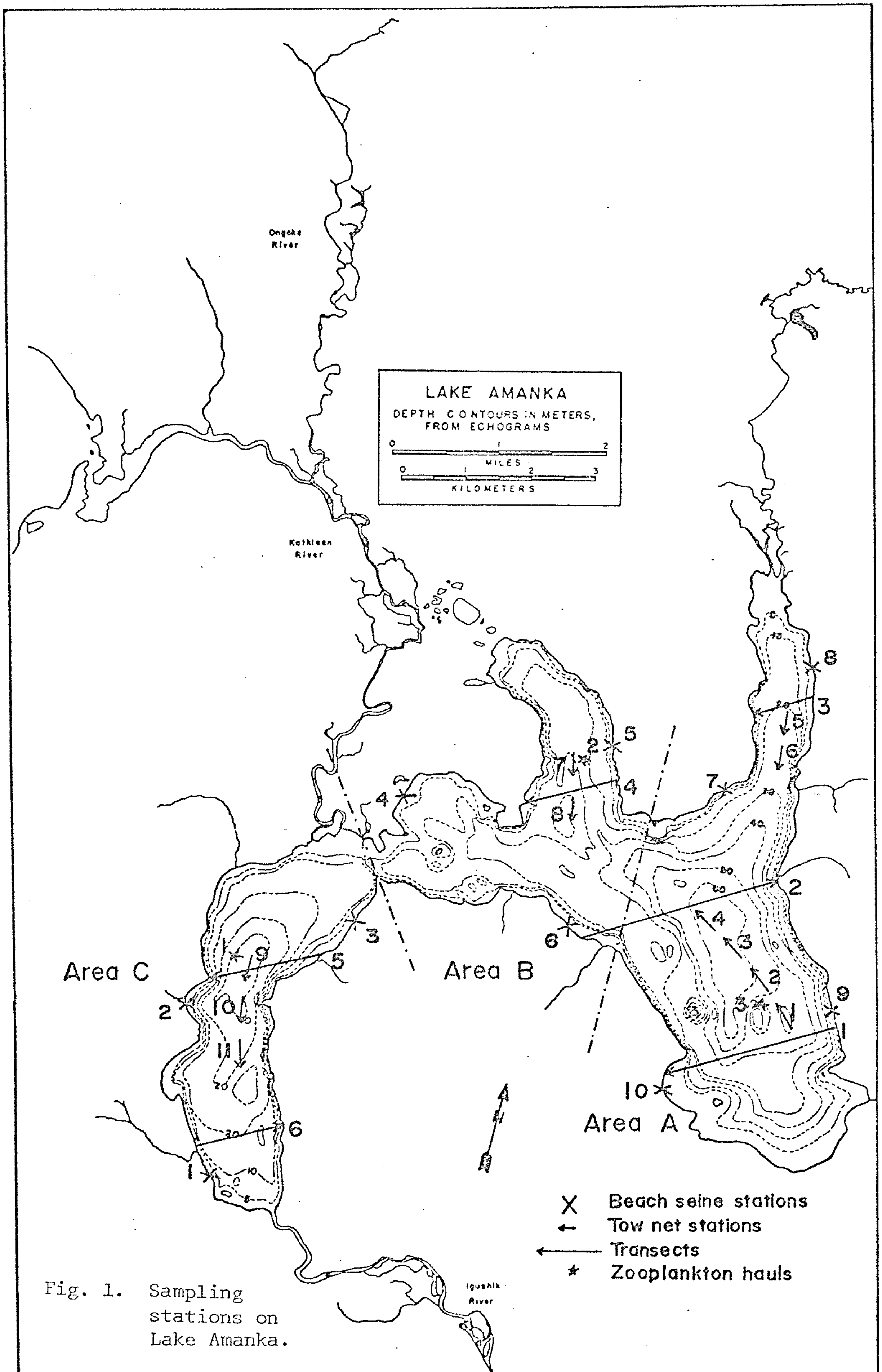


Fig. 1. Sampling stations on Lake Amanka.

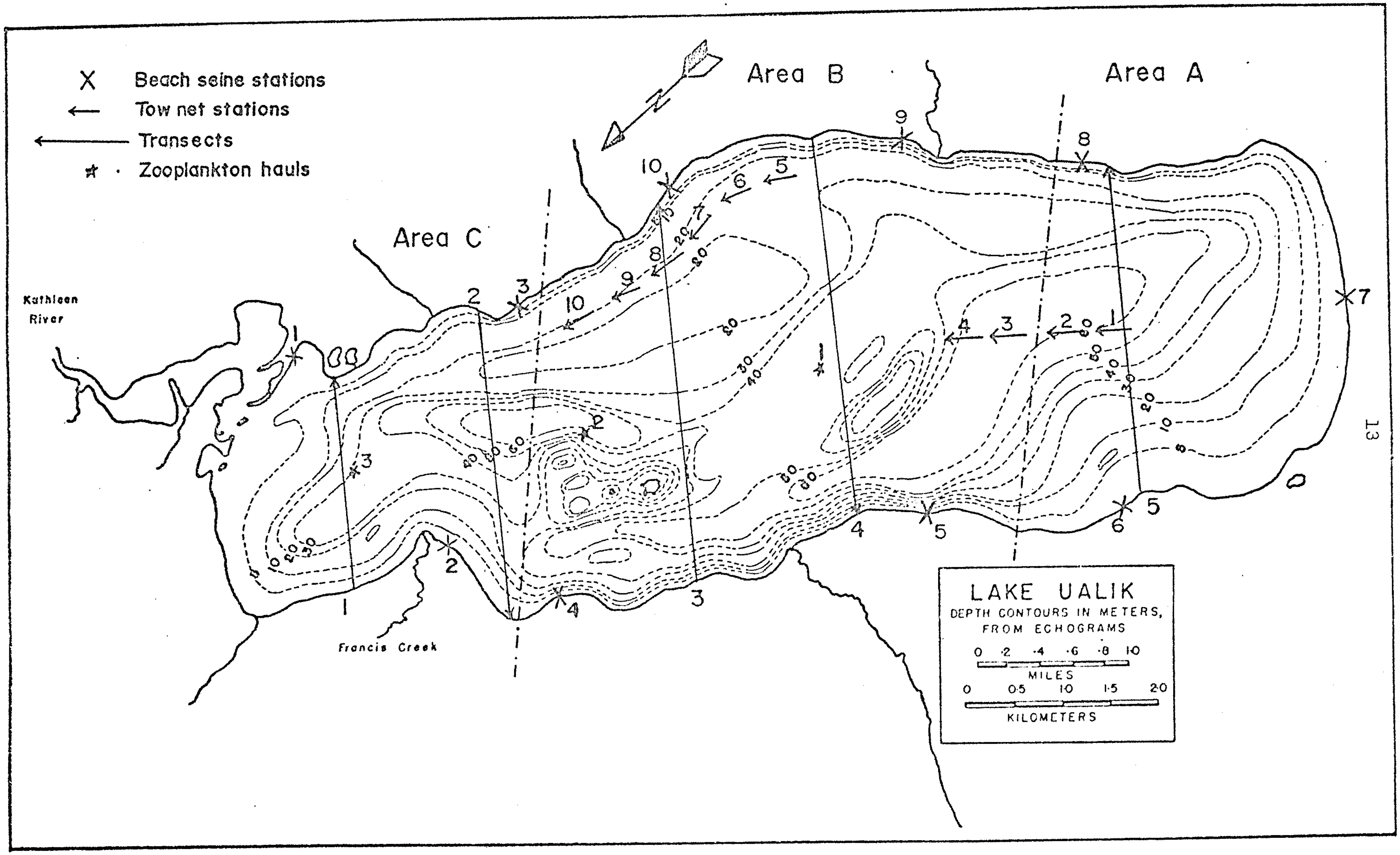


Fig. 2. Sampling stations on Lake Ualik.

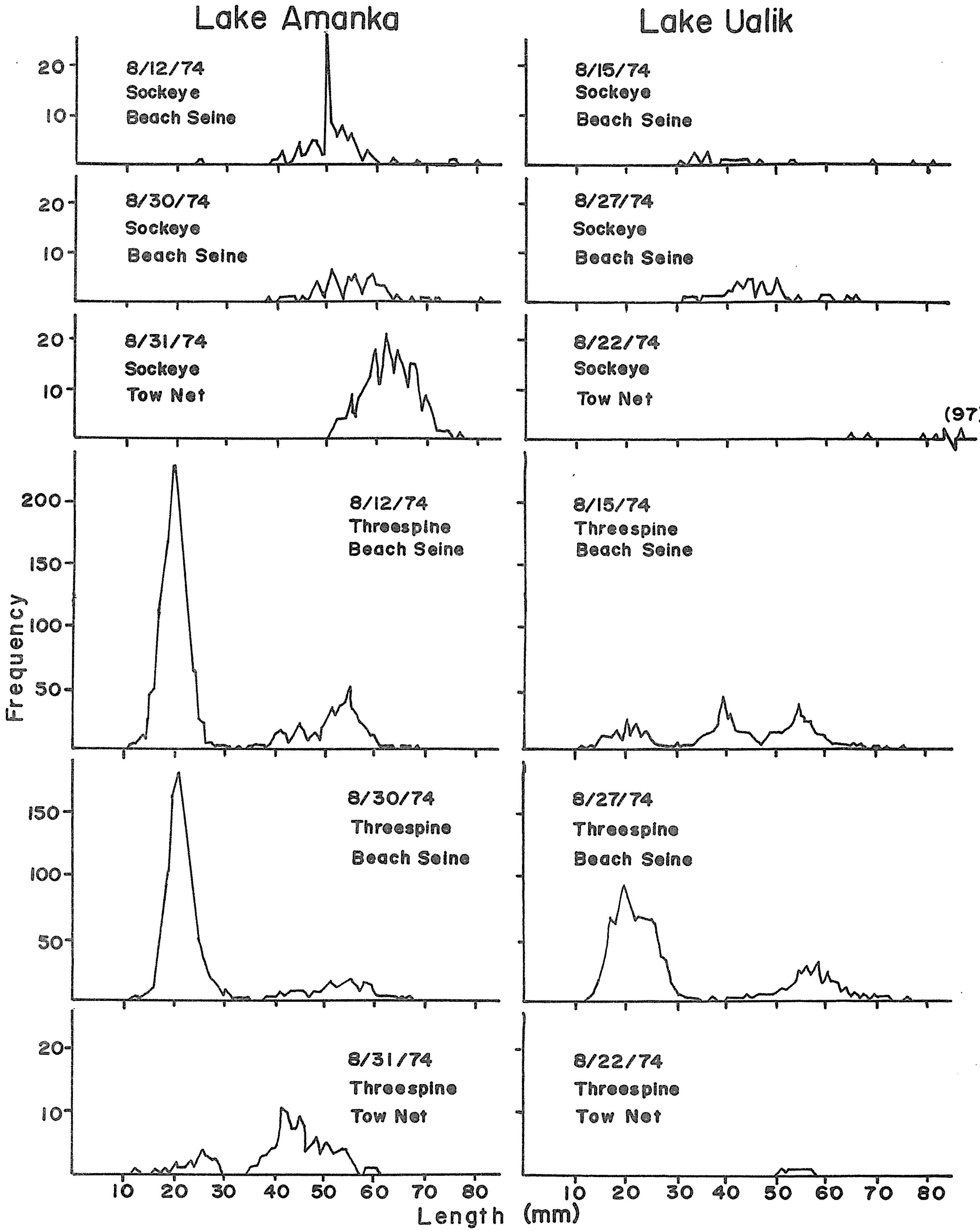


Fig. 3. Length frequency for juvenile sockeye salmon and threespine stickleback from beach seine and townet catches.

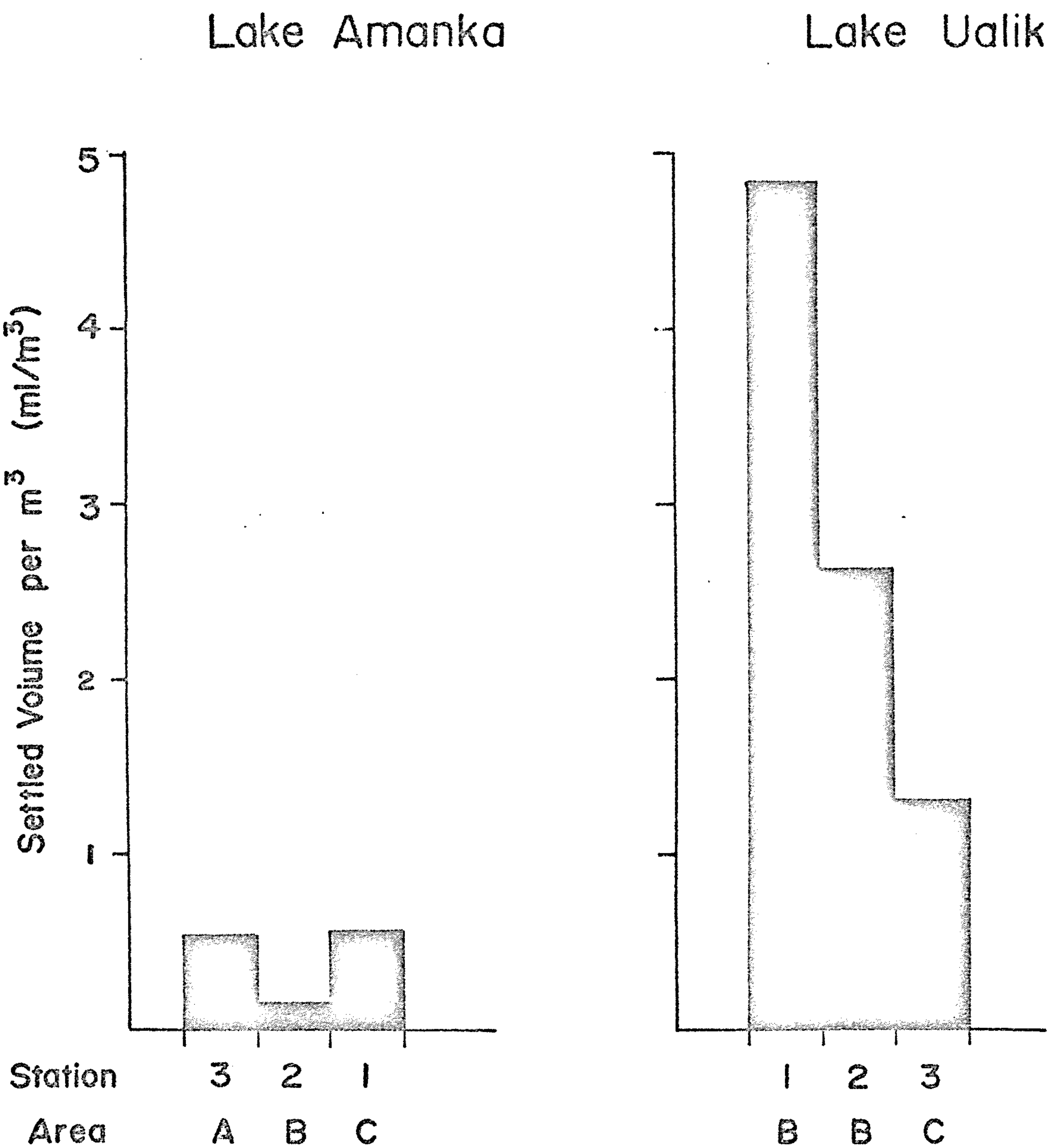


Fig. 4. Density of zooplankton in ml/m^3.

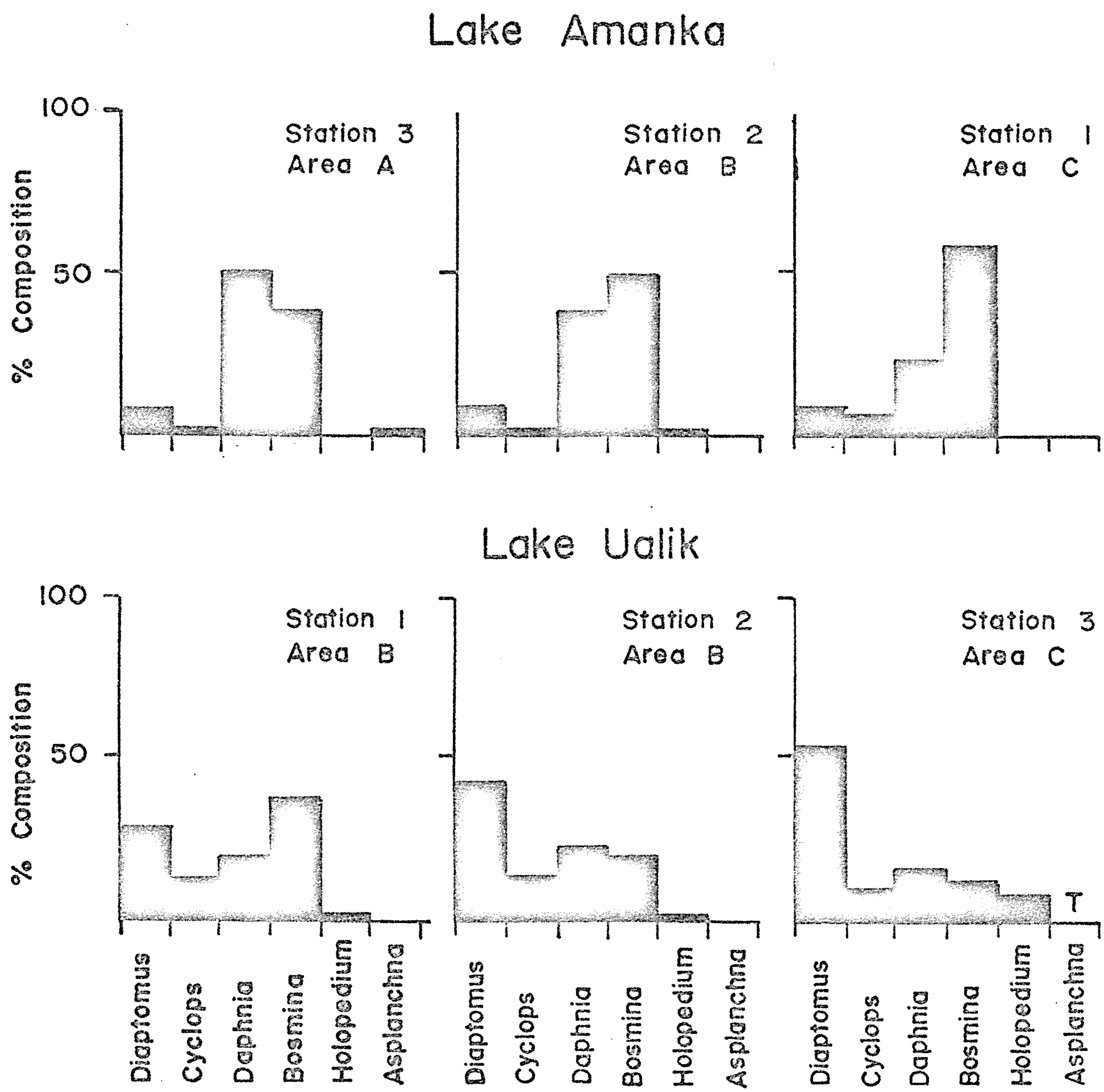


Fig. 5. Species composition of zooplankton.

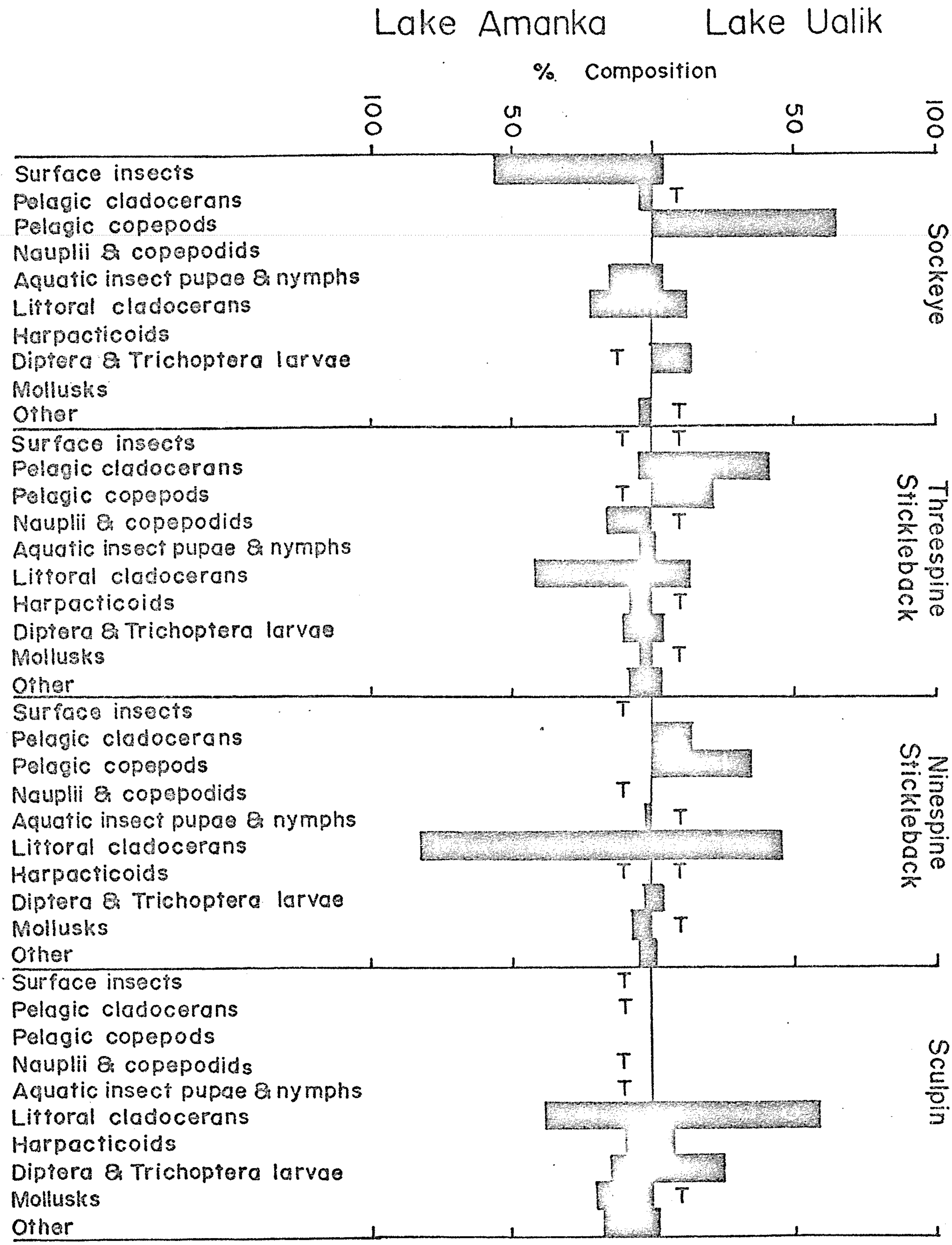


Fig. 6. Percentage composition of stomach contents for all species of fish (size groups combined).

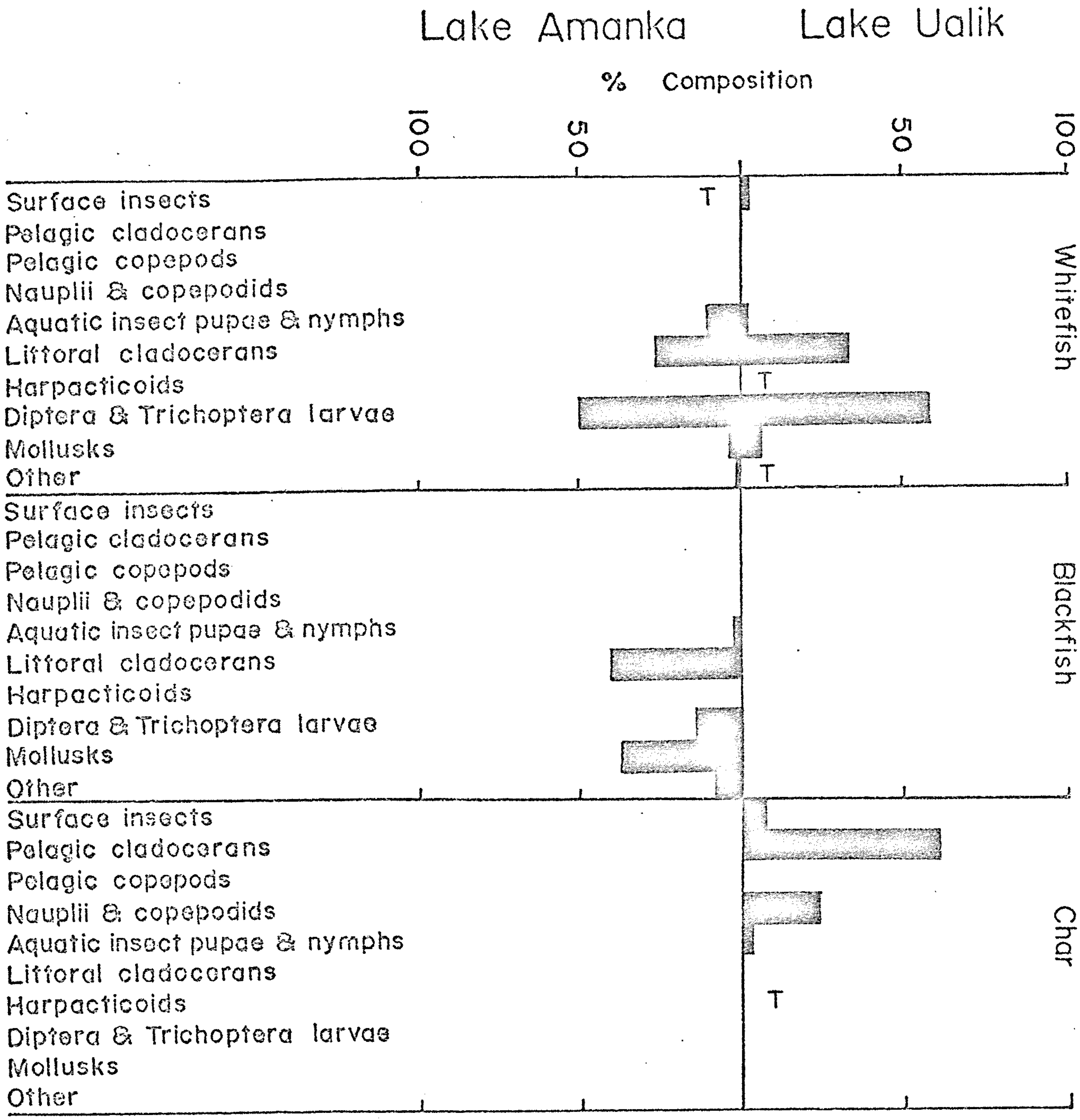


Fig. 6. Percentage composition of stomach contents for all species of fish (size groups combined) - Continued.

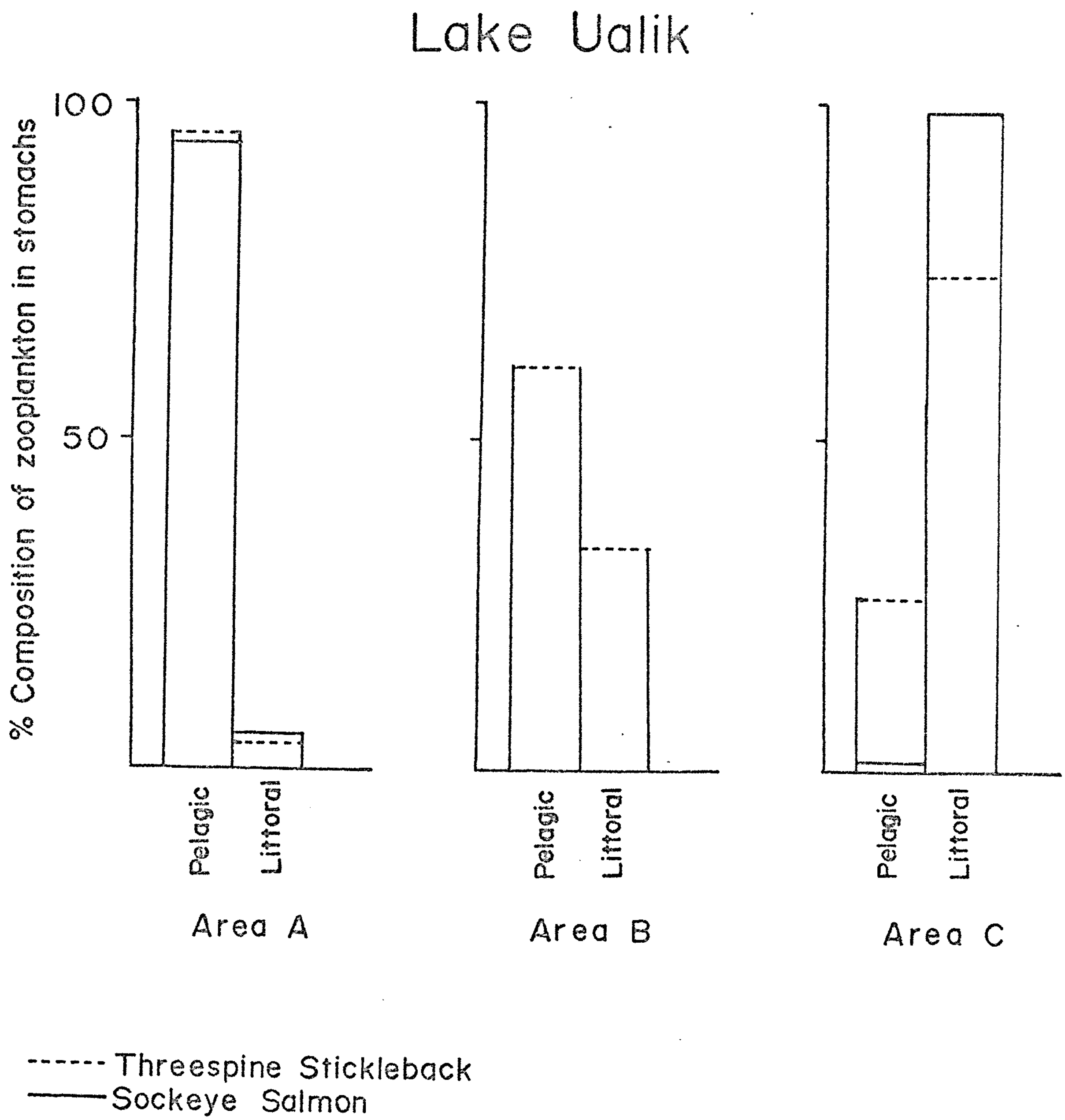


Fig. 7. Pelagic and littoral zooplankton from Lake Ualik sockeye and threespine sticklebacks' stomachs shown as a percentage of the total zooplankton stomach contents.

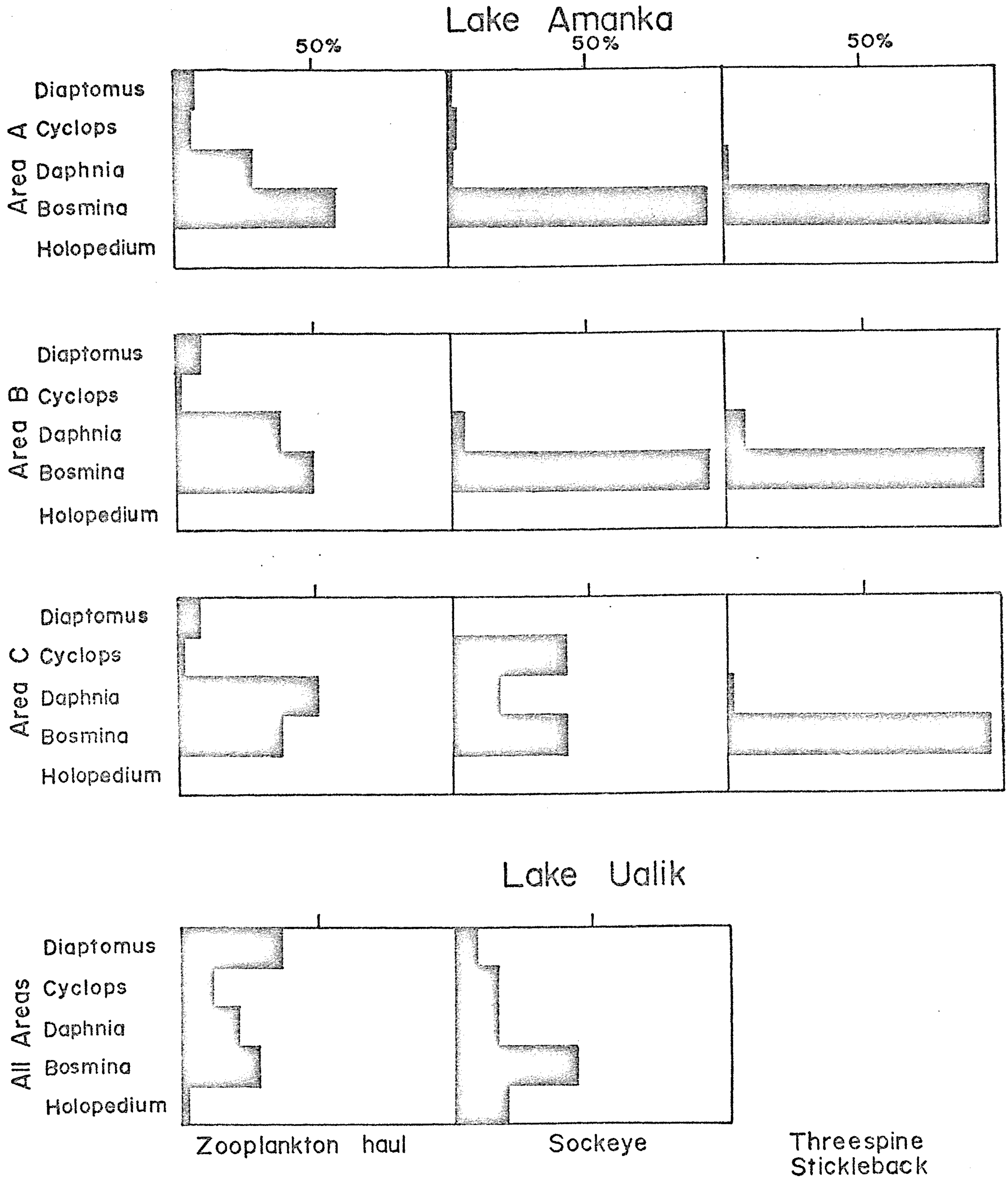


Fig. 8. Species composition of zooplankton hauls and stomach contents of fish from townet catches.

Table 1. Size groups of fish used in stomach content analysis

Species	Lake	0	I	II	III
		Size groups (Length range in mm)			
Sockeye	Amanka	24-77			
	Ualik	20-77			
Threespine stickleback	Amanka	10-33	34-47	48-68	
	Ualik	10-32	33-49	50-76	
Ninespine stickleback	Amanka	10-18	19-32	33-40	41-62
	Ualik	14-21	22-32	33-49	50-58
Sculpin	Amanka	11-28	29-47	48-58	59-75
	Ualik	13-29	30-40	41-59	60-67
Arctic char	Ualik	31-47			
Round whitefish	Amanka	51-95	97-129		
	Ualik	51-95	97-129		
Alaska blackfish	Amanka	18-25	38-62	95-100	

Table 2. Numbers of fish selected for stomach contents removal

		Lake Amanka					Lake Ualik				
			Areas					Areas			
Species	Size Group	Date	A	B	C	Total	Date	A	B	C	Total
Sockeye	0	8/21	1	14	20	47	8/15	14	0	0	14
	0	8/30	53	10	9	72	8/27	38	0	13	51
Threespine stickleback	0	8/12	40	30	35	105	8/15	10	0	30	40
	I		28	14	22	64		20	0	0	20
	II		30	21	23	74		20	13	24	57
	0	8/30	40	30	29	99	8/27	15	30	30	75
	I		26	8	13	47		10	7	4	21
	II		27	10	20	57		30	26	24	80
Ninespine stickleback	0	8/12	0	0	0	0	8/15	0	0	0	0
	I		16	20	31	67		0	0	4	4
	II		0	20	20	40		0	0	5	5
	III		12	0	0	12		0	0	0	0
	0	8/30	0	0	4	4	8/27	0	0	0	0
	I		13	17	25	55		16	13	20	49
	II		0	10	24	34		15	3	7	25
	III		0	0	23	23		6	0	0	6
Scuplin	0	8/12	29	26	5	60	8/15	20	20	30	70
	I		16	7	0	23		0	11	3	14
	II		0	0	0	0		0	0	2	2
	III		0	0	0	0		0	0	0	0
	0	8/30	37	10	17	64	8/27	17	25	20	62
	I		3	0	3	6		5	8	0	13
	II		0	0	0	0		3	0	0	3
	III		10	0	0	10		0	0	0	0
Arctic char	0	8/15	0	0	0	0	8/15	10	0	10	20
	0	8/30	0	0	0	0	8/27	3	3	0	6
Round whitefish	0	8/12	2	0	0	2	8/15	0	0	0	0
	I		0	0	3	3		0	0	0	0
	0	8/30	0	7	0	7	8/27	0	0	0	0
	I		0	1	0	1		4	7	4	15
Alaska blackfish	0	8/12	0	0	0	0	8/15	0	0	0	0
	I		3	0	0	3		0	0	0	0
	II		0	0	0	0		0	0	0	0
	0	8/30	0	0	11	11	8/27	0	0	0	0
	I		0	0	7	7		0	0	0	0
	II		0	0	1	1		0	0	0	0
Grand Total:			398	255	345	998		256	166	232	654

Table 3. Depths of benthic samples

Lake	Date	Station	Sample No. 1 depth (m)	Sample No. 2 depth (m)
Amanka	8/25	1	7	7
		2	6	6
		3	4	4
		4	5	5
		5	9	9
	8/30	6	8	8
		8	8	8
		9	6	6
		10	5	5
Ualik	9/8	1	4	8
		2	8	6
		3	5	9
		4	4	7
		10	5.5	7

Table 4. Depths of zooplankton hauls

Lake	Date	Station	Depth (m)
Amanka	8/27	1	40
		2	20
		3	40
Ualik	9/8	1	35
		2	35
		3	20

Table 5. Availability ratios for each transect calculated from adjusted numbers of echogram marks

Lake	Transect No.	Horizontal 3-6 m	Vertical 3-18 m	Horizontal 3-18 m
Amanka	1	1.997	2.162	1.700
	2	1.286	2.669	1.291
	3	4.957	1.545	4.588
	4	5.209	1.255	6.188
	5	3.925	2.859	2.270
	6	11.847	2.128	10.048
Geometric means		4.022	2.049	3.559
Ualik	1	2.505	3.551	1.593
	2	1.835	1.880	1.568
	3	1.218	1.401	1.207
	4	7.746	1.291	1.174
	5	2.298	1.257	2.465
Geometric means		2.636	1.769	2.341

Table 6. Sums of geometric means of tow-net catches of five fish species by lake area

Lake	Date	Area	No. hauls	Sockeye		Stickleback		Sculpin	Char fry	Sum
				Fry	Fingerling	Threespine	Ninespine			
Amanka	8/31/74	A	6	15.8	0	8.1	0	0.1	0.1	24.2
		B	2	24.2	0	9.0	0	0	0	33.2
		C	3	13.1	0	19.5	0	0	0	33.6
Total			11	16.3	0	10.6	0	0.1	0.1	27.0
Ualik	8/22/74	A	3	0.4	0.3	0	0	0	0	0.7
		B	7	0.2	0	0.4	0	0.2	0	0.8
Total			10	0.3	0.1	0.3	0	0.1	0	0.8

Table 7. Populations of juvenile sockeye salmon and threespine stickleback estimated from tow-net catches and echogram marks

Date	Lake	Depth region	Sockeye fry	Threespine stickleback
8/30-31	Amanka	0-3 m	1,184,820	696,431
		3-18 m	1,465,321	115,017
Total			2,650,141	811,448
8/22-23	Ualik	0-3 m	210,780	176,600
		3-18 m	233,433	26,245
Total			234,213	202,845

Table 8. Sums of geometric means beach-seine catches of five fish species by lake area

Lake	Date	Area	No. hauls	Sockeye Fry	Sockeye Fingerling	Stickleback Threespine	Stickleback Ninespine	Sculpin	Char fry	Sum
Amanka	8/12/74	A	4	5.8	0	406.7	11.2	30.9	0.3	454.9
		B	3	4.0	0	272.0	27.8	38.4	0.3	342.5
		C	3	24.8	0.8	969.1	159.9	21.6	0	1176.2
Total			10	8.3	0.2	467.8	33.2	29.6	0.2	539.1
	8/30/74	A	4	10.6	0.5	274.2	12.6	20.5	0	318.4
		B	3	2.8	0	141.7	18.8	34.7	0	198.0
		C	3	2.7	0	61.0	93.0	11.4	0	168.1
Total			10	4.9	0.2	143.5	26.1	20.2	0	194.8
Ualik	8/15/74	A	3	3.0	0.3	34.7	2.6	32.5	2.7	75.8
		B	4	0.4	0	5.5	0.2	24.2	0.2	30.5
		C	3	1.4	0	90.5	3.8	61.4	1.8	158.9
Total			10	1.3	0.1	23.0	1.5	35.0	1.2	62.0
	8/27/74	A	3	2.4	0	76.8	12.1	27.9	0.6	119.8
		B	3	0.4	0	139.4	8.2	43.3	0.6	191.9
		C	3	2.3	0.3	417.7	29.3	67.7	0.4	517.7
Total			9	1.5	0.1	165.0	14.4	43.5	0.5	225.0

Table 9. Geometric means and mean lengths of beach-seine catches by sampling area

Species	Date	Area A $\bar{C}$	Area A $\bar{L}$	Area B $\bar{C}$	Area B $\bar{L}$	Area C $\bar{C}$	Area C $\bar{L}$	Weighted means $\bar{C}$	Weighted means $\bar{L}$
				Lake Amanka					
Age 0 Sockeye	8/12	5.8	50.7	4.0	50.8	24.8	51.6	8.6	51.4
	8/30	10.6	57.3	2.8	48.9	2.7	49.0	4.4	54.5
Age 0 Threespine stickleback	8/12	355.2	19.7	168.0	20.1	305.8	18.9	263.1	19.5
	8/30	200.0	22.0	134.0	22.1	36.8	22.3	99.9	22.1
Age I Threespine stickleback	8/12	18.2	40.9	10.5	43.0	92.6	42.8	26.4	42.6
	8/30	11.7	43.7	2.7	42.9	2.8	43.8	5.6	43.6
Age II Threespine stickleback	8/12	24.2	53.2	11.9	53.7	152.8	54.5	36.8	54.3
	8/30	107.1	54.5	2.5	51.6	14.7	56.0	17.1	54.6
Age I Ninespine stickleback	8/12	3.1	27.7	11.5	25.5	44.6	26.8	8.3	26.6
	8/30	8.7	27.0	15.9	27.3	62.6	29.7	20.8	29.0
Age II Ninespine stickleback	8/12	1.1	34.0	1.9	36.1	6.6	35.6	2.6	35.5
	8/30	0	-	1.3	40.0	8.2	39.9	1.8	39.9
Age 0 Arctic char	8/12	0	-	0	-	0	-	0.1	46.0
	8/30	0	-	0	-	0	-	0	-

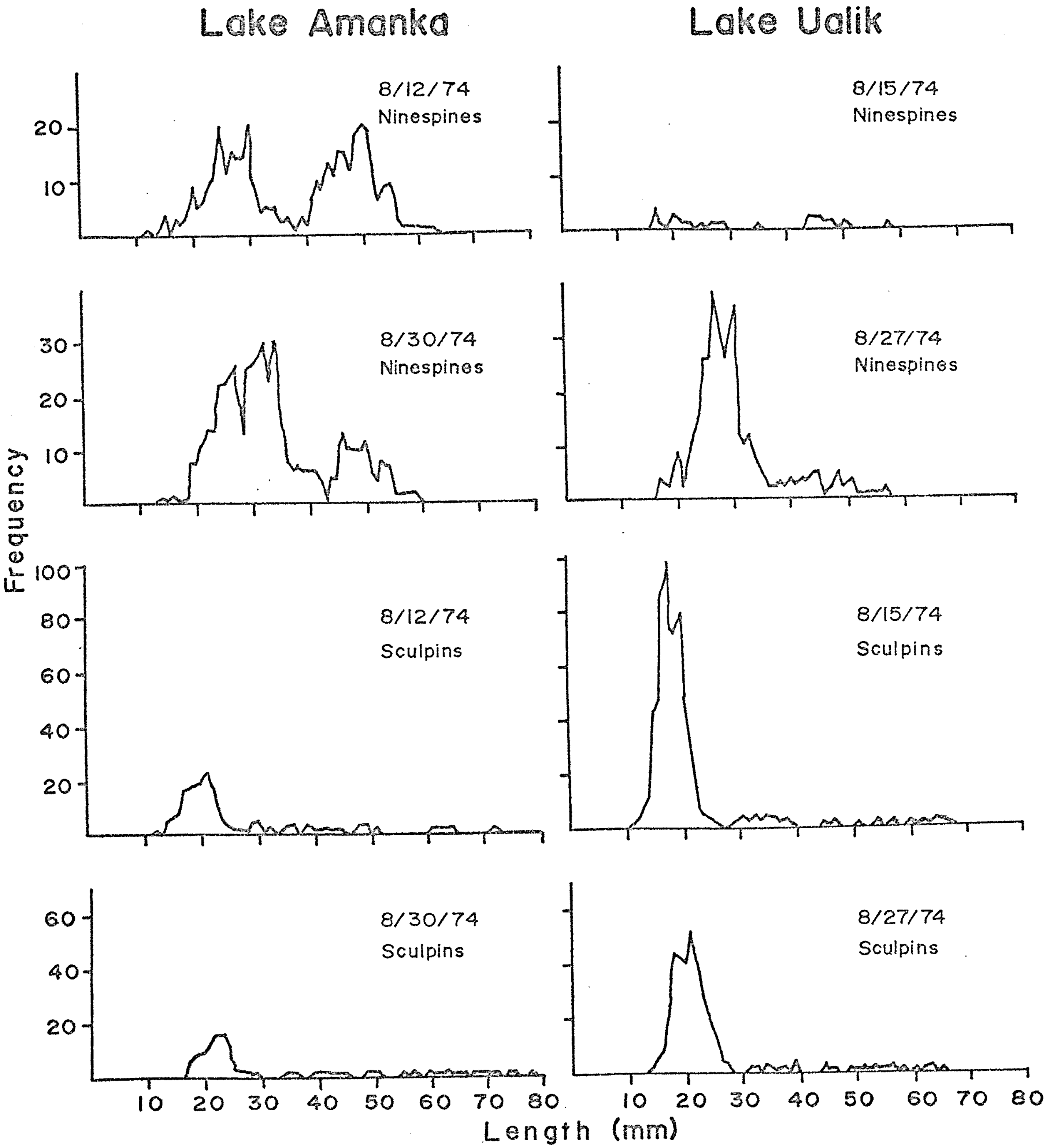
Table 9. Geometric means and mean lengths of beach-seine catches by sampling area - continued

Species	Date	Area A $\bar{C}$	Area A $\bar{L}$	Area B $\bar{C}$	Area B $\bar{L}$	Area C $\bar{C}$	Area C $\bar{L}$	Weighted means $\bar{C}$	Weighted means $\bar{L}$
				Lake Ualik					
Age 0 Sockeye	8/15	3.7	43.5	0.6	32.3	1.2	42.4	1.5	42.1
	8/27	2.4	44.2	0.4	35.0	2.3	53.0	1.5	47.3
Age 0 Threespine stickleback	8/15	4.7	23.4	0.4	23.8	37.8	20.5	5.8	20.9
	8/27	32.4	23.9	113.4	23.0	238.0	23.9	97.0	23.6
Age I Threespine stickleback	8/15	11.2	39.8	112.4	37.0	2.3	41.6	15.6	37.3
	8/27	2.4	44.1	3.2	46.5	6.3	45.7	3.7	45.6
Age II Threespine stickleback	8/15	25.8	54.3	3.5	56.2	26.0	55.3	13.8	54.9
	8/27	31.3	55.0	15.3	56.8	106.5	57.8	37.4	57.1
Age I Ninespine stickleback	8/15	0.3	22.0	0.2	27.0	2.0	23.0	0.6	23.2
	8/27	7.7	27.4	5.8	26.1	35.4	27.5	11.9	27.3
Age II Ninespine stickleback	8/15	1.0	44.3	0	-	1.3	44.5	0.7	44.4
	8/27	5.1	41.7	1.3	37.7	16.0	39.2	5.2	39.7
Age 0 Arctic char	8/15							0.4	41.1
	8/27							0.5	39.7

Table 10. Average and percentage composition of counts of benthic organisms per grab for lake areas

Organisms	Area A Number	Area A Percent	Area B Number	Area B Percent	Area C Number	Area C Percent
			Lake Amanka			
Diptera larvae	114.50	51	22.50	21	25.17	23
Oligochaete	59.33	27	31.00	29	34.00	31
Snail	61.67	8	13.83	13	20.00	19
Clam	9.33	4	14.50	14	7.17	7
Nematode	13.50	6	13.16	13	18.00	17
Polychaete	4.33	2	6.67	6	3.50	3
Leech	3.33	1	3.17	3	0.17	T
Trichoptera larvae	1.50	1	0.67	1	-	-
Planaria	-	-	0.17	T	0.17	T
Total per grab	222.49	100	105.67	100	108.18	100
			Lake Ualik			
Diptera larvae			129.00	26	134.83	39
Oligochaete			146.25	29	53.67	15
Snail			43.50	9	42.67	12
Clam			27.50	5	36.33	10
Nematode			89.00	18	45.17	13
Polychaete			65.00	13	30.67	9
Leech			1.75	T	4.33	1
Trichoptera larvae			1.50	T	2.83	1
Planaria			0.75	T	-	-
Total per grab			504.25	100	350.50	100

APPENDICES



Appendix Fig. 1. Length frequency of ninespine sticklebacks and sculpins from beach seine catches.

Appendix Table 1. Adjusted marks from echograms

Lake	Transect No.	Depth (m)	Depth intervals (m)					
			3-6	6-9	9-12	12-15	15-18	6-18
			August 21, 1974					
Ualik	1	<20	339	126	9	0	0	135
		>20	225	296	244	34	0	574
Ualik	2	<20	195	30	21	4		55
		>20	234	101	78	25	2	206
Ualik	3	<20	77	13	7	5	1	26
		>20	354	87	30	24	1	142
Ualik	4	<20	1,226	139	47	25	14	225
		>20	182	32	12	5	4	53
Ualik	5	<20	346	57	11	2	0	70
		>20	226	54	3	1	0	58
			August 30, 1974					
Amanka	1	<20	468	155	76	9	2	242
		>20	469	163	170	134	77	545
Amanka	2	<20	124	68	75	59	10	212
		>20	432	246	212	165	98	721
Amanka	3	<20	45	10	3	3	0	16
		>20	11	2	2	2	0	6
Amanka	4	<20	233	67	36	21	1	125
		>20	55	7	2	0	5	14
Amanka	5	<20	268	39	14	13	0	66
		>20	92	27	18	23	103	171
Amanka	6	<20	427	141	88	67	46	342
		>20	39	18	14	9	3	44

Appendix Table 2. Beach-seine catches by station, 1974

Species	Date	1	2	3	4	5	6	7	8	9	10
		Stations									
		Lake Amanka									
Age 0 Sockeye	8/12/74	66	255	0	8	0	13	10	12	2	4
	8/30/74	6	6	0	2	1	8	45	32	1	5
Age I Sockeye	8/12/74	0	5	0	0	0	0	0	0	0	0
	8/30/74	0	0	0	0	0	0	0	4	0	0
Threespine stickleback	8/12/74	579	830	1,893	304	1,257	52	676	2,490	90	179
	8/30/74	102	192	11	287	56	176	40	4,384	475	66
Ninespine stickleback	8/12/74	591	175	39	50	6	66	10	60	2	10
	8/30/74	140	420	13	71	11	8	12	80	7	3
Sculpin	8/12/74	33	25	12	22	69	37	160	33	6	26
	8/30/74	4	18	19	59	35	20	15	80	14	10
Age 0 Arctic char	8/12/74	0	0	0	0	0	2	2	0	0	0
	8/30/74	0	0	0	0	0	0	0	0	0	0
		Lake Ualik									
Age 0 Sockeye	8/15/74	6	1	0	1	1	0	0	7	7	0
	8/27/74	2	0	11	2	-	0	0	38	0	0
Age I Sockeye	8/15/74	0	0	0	0	0	0	0	0	1	0
	8/27/74	0	0	1	0	-	0	0	0	0	0
Threespine stickleback	8/15/74	113	83	79	11	1	4	0	266	169	14
	8/27/74	332	690	318	420	-	44	42	341	31	145
Ninespine stickleback	8/15/74	9	0	10	0	1	0	3	3	2	0
	8/27/74	348	0	80	96	-	0	0	139	15	7
Sculpin	8/15/74	69	56	60	2	107	123	416	9	8	9
	8/27/74	196	30	52	20	-	40	27	85	9	100
Age 0 Arctic char	8/15/74	0	22	0	1	0	0	2	0	16	0
	8/27/74	0	0	2	0	-	3	0	0	3	0

Appendix Table 3. Tow-net catches by station

Species	Stations 1	2	3	4	5	6	7	8	9	10	11
Lake Amanka 8/31/74											
Age 0 Sockeye	40	1	6	17	32	66	52	11	4	27	19
Threespine stickleback	10	1	5	5	21	33	10	8	11	29	23
Arctic char	0	0	0	0	0	1	0	0	0	0	0
Sculpin	0	0	0	0	1	0	0	0	0	0	0
Lake Ualik 8/22/74											
Age 0 Sockeye	0	2	0	1	0	0	0	0	2	0	
Age I Sockeye	1	0	0	0	0	0	0	0	0	0	
Threespine	0	0	0	0	0	0	0	1	5	0	
Sculpin	0	0	0	0	0	0	2	0	0	0	

Appendix Table 4. Percentage composition of food items in the stomach contents of fish from beach seine catches

							Percentage composition								
							Insects			Littoral		Pelagic			
Date	Area	Species	Size group	Mean length	No. of fish	No. organisms per stomach	Adult	Pupae	Larvae	Cladocera	Copepod	Cladocera	Copepod	Snail	Misc.
LAKE AMANKA															
8/12	A	Sockeye	0	51.4	13	21.6	61	32		7					[illegible]
		Threespine	0	20.9	40	41.0			7	61	1		28		3
			I	40.4	28	40.0	2	5	4	70	8				11
			II	53.5	30	28.4	7	5	1	81	2			1	3
		Ninespine	I	27.9	16	8.1		5	13	63	3			7	9
			III	50.5	12	22.6	6	6	13	43				7	25
		Sculpin	0	19.3	29	6.3			13	68	13			1	5
			I	36.2	17	6.3			34	8	8			37	13
		Whitefish	0	52.5	2	31.5		79	16						5
	B	Sockeye	0	49.6	14	40.0	62	19		19					
		Threespine	0	21.5	30	22.1				68	4		28		
			I	43.9	14	81.9		3		96	1				
			II	55.2	21	50.8		4		82	10			1	3
		Ninespine	I	25.5	20	12.2		1	4	92					3
			III	45.3	15	30.1			2	98					
		Sculpin	0	19.4	26	5.3			4	70	16			6	4
			I	43.0	7	7.3			18	43				10	29
	C	Sockeye	0	52.2	20	12.0		42		50					8
		Threespine	0	21.8	35	25.7			5	88			7		
			I	41.4	22	96.4			1	89	4		3	3	
			II	54.7	23	113.9			1	91				8	
		Ninespine	I	26.8	21	44.0		6	2	91					1
			III	49.0	20	76.0				83				10	7

Appendix Table 4. Percentage composition of food items in the stomach contents of fish from beach seine catches - Continued

Date	Area	Species	Size group	Mean length	No. of fish	No. organisms per stomach	Percentage composition: Insects: Adult	Insects: Pupae	Insects: Larvae	Littoral: Cladocera	Littoral: Copepod	Pelagic: Cladocera	Pelagic: Copepod	Snail	Misc.
8/12	C	Sculpin	0	19.6	5	6.2			19	39	23			19	
		Whitefish	I	123.0	3	71.3		5	86					7	2
		Blackfish	I	50.7	3	8.3			16	20				32	32
8/30	A	Sockeye	0	56.3	53	22.3	87	9	1	3					
		Threespine	0	22.7	40	31.2			9	49	1		30		11
			I	43.1	21	54.3	2	1	7	51	25	2		1	11
			II	54.6	27	32.6	1		31	58		2		3	5
		Ninespine	I	27.5	13	5.7			11	43				24	22
		Sculpin	0	20.7	37	5.5			10	18	15			9	48
			I	40.3	3	19.0			26					55	19
			II	55.7	10	9.3			9					85	6
	B	Sockeye	0	48.4	11	25.4	43	8		4		43	1		1
		Threespine	0	21.0	30	15.6			2	81	5	1	10		1
			I	42.0	8	19.5	1	3	1	92	1	1			1
			II	48.8	10	14.2			5	85	3	6			1
		Ninespine	I	27.5	17	22.9		1		94	T			1	4
			II	35.2	10	24.8			1	96	T			2	1
		Sculpin	0	21.9	10	11.2			12	75	2			8	3
		Whitefish	0	66.8	8	13.6	1	2	3	94					
	C	Sockeye	0	48.4	9	52.1	3	3	2	72					20
		Threespine	0	21.4	29	17.6			6	37		18	35		4
			I	43.4	13	26.3		2	1	37	4	44	3		4
			II	56.3	20	63.5			1	85		7		2	5

Appendix Table 4. Percentage composition of food items in the stomach contents of fish from beach seine catches - Continued

Date	Area	Species	Size group	Mean length	No. of fish	No. organisms per stomach	Percentage composition: Insects Adult	Insects Pupae	Insects Larvae	Littoral Cladocera	Littoral Copepod	Pelagic Cladocera	Pelagic Copepod	Snail	Misc.
8/30	C	Ninespine	0	16.0	4	9.3			3	81	8		8		
			I	25.5	25	8.6			2	79	T			12	7
			II	44.0	24	7.8		2	3	73	1			12	9
			III	49.5	20	16.1		1	13	53	1			30	2
		Sculpin	0	20.8	17	4.8			22	33	8			15	22
			I	41.7	3	13.9			10	90					
		Blackfish	0	20.8	11	4.1		4	2	59	2			20	13
			I	52.0	7	3.4			25	25				33	17
			II	95.0	1	4.9			17	50				33	
LAKE UALIK															
8/15	A	Sockeye	0	40.9	14	204.8	6	5				2	87		
		Threespine	0	22.6	10	26.6			1	10		71	18		
			I	40.3	20	96.5	1	1				29	69		
			II	55.5	20	356.0	1	1		3		11	84	T	
		Sculpin	0	18.8	20	5.5			10	79	7			1	3
		Char	0	47.2	10	7.9	24	76							
	B	Threespine	II	53.9	13	150.0	3	4	24			57		1	11
		Sculpin	0	19.0	10	9.7		6	49	45					
			I	32.9	11	4.3			51	47					2
	C	Threespine	0	21.6	30	8.6		2	21	19	10	12	34		12
			II	57.8	24	44.6		1	17	50	6	20			6
		Ninespine	I	23.8	4	21.2			4	86					10
			II	46.0	5	15.4			43	56					1

Appendix Table 4. Percentage composition of food items in the stomach contents of fish from beach seine catches - Continued

Date	Area	Species	Size group	Mean length	No. of fish	No. organ-isms per stomach	Percentage composition							Snail	Misc.
							Insects			Littoral		Pelagic			
							Adult	Pupae	Larvae	Cladocera	Copepod	Cladocera	Copepod		
8/15	C	Sculpin	0	18.0	20	5.6	1		30	48	11			3	7
			I	34.0	3	9.0			70	11				4	15
			II	45.5	2	25.5			6	8				86	
			III	61.5	2	41.0			65	5				17	12
		Char	0	45.5	10	4.1	12	53	10	17					7
LAKE UALIK															
8/27	A	Sockeye	0	43.5	38	177.1	2	5		7		19	67		
		Threespine	0	21.2	15	103.3			6	1		50	43		
			I	43.6	10	342.0		T	T			91	9		
			II	57.8	30	167.6		T	T	11	1	76	12		
		Ninespine	I	26.3	16	26.7		2	2	22	T	35	38	1	T
			II	42.5	15	35.4		2	1	35		28	32		2
			III	50.5	6	178.7		1	1	4	T	16	78		T
		Sculpin	0	18.5	17	5.0		1	19	48	17	4		4	7
			I	34.8	5	2.4		17	41	25	17				
			II	56.0	3	2.7			25	38		12			25
		Whitefish	I	104.0	4	114.3	1	7	87	3				2	T
		Char	0	41.3	3	165.0	7	14		T		79			
	B	Threespine	0	21.8	30	70.0	1	1	13	23	1	21	30		
			I	46.7	7	22.6		4	3	48		30	15		1
			II	56.6	26	50.8	2	4	1	29		45	17	2	
		Ninespine	I	26.0	13	38.3			5	91	1	1		1	1
			II	35.3	3	26.3			46	54					

Appendix Table 4. Percentage composition of food items in the stomach contents of fish from beach seine catches - Continued

Date	Area	Species	Size group	Mean length	No. of fish	No. organisms per stomach	Percentage composition: Insects			Littoral		Pelagic		Snail	Misc.
							Adult	Pupae	Larvae	Cladocera	Copepod	Cladocera	Copepod		
8/27	B	Sculpin	0	18.5	25	6.9			6	88				3	3
			I	24.8	12	5.0			18	60	8			14	
		Whitefish	I	119.6	7	240.0	1	3	54	38	1			3	
		Char	0	34.3	3	58.0	1	30	1	9		59			
	C	Sockeye	0	52.4	13	129.2	6	2		68		1	21		2
		Threespine	0	22.3	30	50.3			3	50		3	44		
			I	49.0	4	155.0				67		10	23		
			II	57.4	24	74.3		2	2	71	3	2	20		T
		Ninespine	I	27.9	20	15.0			5	90	1			2	2
			II	38.7	7	47.1		1	T	98	T	T		1	T
		Sculpin	0	18.9	20	4.5			9	65			15	10	1
		Whitefish	I	116.0	4	72.8		1	26	55				17	1

Appendix Table 5. Percentage composition of food items in the stomach contents of fish from townet catches

Date	Area	Species	Size group	Mean length	No. of fish	No. organisms per stomach	Insects		Littoral		Percentage composition Pelagic					Misc.
							Adult	Pupae	Cladocera	Copepod	*Daphnia*	*Bosmina*	*Cyclops*	*Diaptomus*	*Holopedium*	
LAKE AMANKA																
8/30	A	Sockeye	0	66.1	46	210.7			T		2	94	3	1		
		Threespine	I	42.7	21	15.1		2			1	96				
			II	54.2	20	48.5				1	2	95		1		1
	B	Sockeye	0	60.8	20	202.0	T	1			5	93	1			
		Threespine	0	25.3	4	47.0		1			10	89				
			I	40.0	7	52.4		1			3	96				
	C	Sockeye	0	57.1	14	10.1		1			16	42	41			
		Threespine	0	25.4	5	25.4					2	98				
			I	42.9	14	8.1			4		1	93	2			
			II	53.3	16	4.3		2			8	90				
LAKE UALIK																
8/21	All	Sockeye	0	70.7	3	523.3		1			15	44	15	7	18	
			I	92.0	3	1586.7					15	33	19	1	32	

Appendix Table 6. Counts and percentage composition of benthic organisms from bottom samples

Sta. No.:	1		1		2		2		3		3		4		5		5	
Depth: (m)	7		7		6		6		4		4		5		9		9	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Lake Amanka																		
Chironomid larvae	34	27	12	19	20	19	21	28	61	24	3	20	1	5	13	14	56	40
Oligochaete	51	41	38	58	50	46	34	45	27	10	4	27	3	14	49	54	58	36
Snails	14	11	3	5	19	18	14	19	65	25	5	33	9	43	12	13	11	7
Clams	20	16	6	9	8	7	-	-	7	3	2	13	5	24	7	8	9	5
Nematodes	6	5	6	9	9	8	6	8	81	31	-	-	-	-	3	3	12	7
Polychaetes	-	-	-	-	1	1	-	-	19	7	1	7	-	-	-	-	1	1
Leech	-	-	-	-	1	1	-	-	-	-	-	-	3	14	5	6	3	2
Trichoptera larvae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	2	1
Planaria	-	-	-	-	-	-	-	-	1	T	-	-	-	-	-	-	1	1
Totals:	125	100	65	100	108	100	75	100	261	100	15	100	21	100	91	100	163	100

Sta. No.:	6		6		8		8		9		9		10		10	
Depth: (m)	8		8		8		8		6		6		5		5	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Chironomid larvae	47	16	7	20	277	66	213	68	118	32	17	33	32	32	30	43
Oligochaete	62	20	11	31	59	14	56	18	170	45	27	52	28	28	16	23
Snails	38	13	4	12	31	7	16	5	23	6	4	7	12	12	14	20
Clams	56	19	5	14	21	5	20	6	7	2	1	2	6	6	1	1
Nematodes	59	19	5	14	27	7	1	T	30	8	2	4	18	18	3	4
Polychaetes	37	12	2	6	4	1	1	T	9	2	-	-	4	4	6	9
Leech	4	1	1	3	-	-	2	1	14	4	1	2	-	-	-	-
Trichopera larvae	-	-	-	-	-	-	5	2	4	1	-	-	-	-	-	-
Planaria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Totals:	303	100	35	100	419	100	314	100	375	100	52	100	100	100	70	100

Appendix Table 6. Counts and percentage composition of benthic organisms from bottom samples - Continued

Sta. No.:	1		1		2		2		3		3		4		4		10		10	
Depth:(m)	4		8		8		6		5		9		4		7		5.5		7	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Lake Ualik																				
Dipt. larv.	270	67	133	42	120	34	110	30	129	24	42	36	369	24	50	18	2	67	95	45
Oligochaete	28	7	34	10	80	23	62	17	87	16	31	27	442	29	97	34	-	-	46	22
Snails	31	8	33	10	45	13	25	7	95	18	27	23	105	7	53	19	-	-	16	8
Clams	42	10	75	23	25	7	8	2	57	11	11	10	40	3	26	9	-	-	44	21
Nematode	2	1	12	4	37	10	102	27	118	22	-	-	335	22	14	5	-	-	7	3
Polychaete	9	2	32	10	41	12	53	14	47	9	2	2	220	15	39	14	-	-	1	T
Leech	6	1	4	1	2	1	10	3	2	T	2	2	2	T	3	1	1	33	1	T
Trichop. larv.	15	4	-	-	1	T	-	-	2	T	-	-	4	T	-	-	-	-	2	1
Planaria	-	-	-	-	-	-	-	-	-	-	-	-	3	T	-	-	-	-	-	-
Totals:	403	100	328	100	351	100	370	100	537	100	115	100	1520	100	282	100	3	100	212	100

Appendix Table 7. Total numbers and settled volume of zooplankton from hauls

	Lake Amanka 8/27/74			Lake Ualik 9/8/74		
Station No.	1	2	3	1	2	3
Depth (m):	40	20	40	20	35	35
Diaptomus gracilis	2,666	252	2,534	25,165	31,335	8,667
Cyclops scutifer	2,466	52	466	11,500	9,000	1,600
Daphnia longiremis	12,066	1,053	15,600	18,335	16,665	2,567
Bosmina coregoni	23,934	1,400	11,866	33,165	14,330	2,000
Holopedium gibberum	0	27	0	1,165	1,000	1,267
Asplanchna sp.	0	0	200	0	0	67
Total	41,132	2,784	30,666	89,830	72,330	16,168
Settled volume (ml) (1/2 hr)	4.60	0.60	4.15	19.0	18.0	9.0

Appendix Table 8. Littoral zooplankton identified from stomach contents and benthic grabs

Cladocera
- *Alona affinis*
- *Eurycercus lamellatus*
- *Acroperus harpae*
- *Alona quadrangularis*
- *Alonella dentifera*
- *Graptoleberis testudinaria*
- *Drepanothrix dentata*
- *Chydorus sphaericus*
- *Chydorus* sp.

Cyclopoida
- *Cyclops capillatus*

Harpacticoida
- *Canthocamptus staphylinoides*
- *Canthocamptus assimilis*
- *Attheyella alaskaensis*
- *Attheyella idahoensis*
- *Attheyella dogieli*
- *Attheyella nordenskioldii*