RESEARCH PROJECT SEGMENT

State: ALASKA

Name: Sport Fish Investigations of Alaska.

Project No.: F-9-7

Study No.: G-III

Study Title: LAKE AND STREAM INVESTIGATIONS

Job No.: G-III-D

Job Title: Population Studies of Game Fish and Evaluation of Managed Lakes in the Upper Cook Inlet Drainage.

Period Covered: July 1, 1974 to June 30, 1975.

ABSTRACT

A lake stocking study evaluates survival and growth of two strains of rainbow trout, *Salmo gairdneri*, and coho salmon, *Oncorhynchus kisutch*, in four study lakes.

Length-weight relationships indicate that growth of Ennis, Montana rainbow trout may initially be superior to the Winthrop, Washington strain but at the conclusion of the second season of growth, no significant difference in size exists.

Growth of rainbow trout in Long Lake reflected the influence of reinfestation by threespine sticklebacks, *Gasterosteus aculeatus*.

Growth of Kodiak, Alaska coho salmon appeared superior to the Green River, Washington strain.

Survival of age I rainbow in Short Pine Lake was very low, probably less than 15%.

Coho survival in Loon Lake was approximately 40% but estimates are biased by an unknown mortality incurred when smolts attempted to migrate out an overflow stream.

Data suggest that the conversion factor derived from the British Columbia stocking schedule may overestimate the numbers of fry needed to equal a fingerling plant of desired size.

Results of a limnological study of ten study lakes are presented. Water chemistry data are included.

A plankton index was devised and compared to the morphoedaphic index. Study lakes are ranked according to their relative biological productivity.

Rotenone treatment of lakes is shown to detrimentally affect return of zooplankton communities the following spring. Both zooplankton volume and seasonal succession of zooplankton were influenced.

Effect of rotenone treatment on Johnson and Memory lakes is discussed. Deterioration rate of rotenone and post-treatment plankton levels were assessed.

RECOMMENDATIONS

1. Determine survival, growth and total yield of fry and fingerling plants of Winthrop, Washington and Ennis, Montana strains of rainbow trout in Christiansen, Marion, and Memory lakes.

2. Johnson Lake post treatment stocking study should be resumed to evaluate survival, growth and total yield of rainbow trout in a competitor-free environment. The lake should receive a fingerling plant of Winthrop, Washington and Ennis, Montana rainbow trout at a density of 300 per acre.

3. Evaluation of environmental effects of rotenone treatment on Johnson and Memory lakes should continue.

4. Limnological sampling should continue on Matanuska Lake to provide data representative of a productive, untreated lake.

OBJECTIVES

1. To determine survival, growth and total yield of stocked game fishes in landlocked lakes of the area.

2. To determine limnological conditions which influence survival and growth of game fishes in lakes of the area.

3. To determine the effect of rotenone treatment of food organisms utilized by game fishes in lakes of the area.

4. To provide recommendations for the management of stocked lakes and to direct the course of future studies.

TECHNIQUES USED

Plankton samples were collected bimonthly using a 0.5 m ring-type plankton net of 130 m mesh size. A permanent sampling station was established over the maximum depth of the lake. Three vertical hauls were made from each depth of 5 m and 30 m or the bottom, whichever was less. The content of each haul was washed into bottles containing 40% ethyl alcohol. Samples for identification were preserved in 70% ethyl alcohol. Samples were placed in graduated centrifuge tubes and centrifuged for three minutes at 2,000 rpm in a model CS International Centrifuge. The volume was read to the nearest 0.1 ml and included not only zooplankton but also organic and in-organice detritus. The volume of detritus was recorded when it exceeded 0.1 ml.

Zooplankton were identified at the University of Alaska, College, Alaska. A series of five aliquots was taken from each plankton sample and the zooplankton identified to species. The number of individuals of each species in an aliquot was determined and its percentage abundance for that sample date was calculated.

To facilitate collection of bottom organisms a permanent transect line was established with stations at 12, 9, 6, 3, 1, 015 m depths on Johnson Lake and 6, 3, 1, 0.5 m depths on Memory Lake. A Petite Ponar Grab, sampling an area of 91.4 cm^2, was used to take bimonthly bottom samples from each station.

Grab contents were identified by station depth and immediately washed through a #20 mesh metal seive. Invertebrate organisms were later picked from each sample within 24 hours and preserved in 70% ethyl alcohol.

Fish populations were sampled using 120 X 6-foot variable mesh monofilament gill nets composed of five different mesh panels from 1/2-2 inch bar measure. Nets were usually fished for 24 hours. Fish were seined using a 50 x 6 foot drag seine.

Qualitative analysis of rotenone in water followed methods developed by the University of Wyoming (Post, 1955).

Fish shocking operations were conducted using an electroshocking apparatus mounted aboard a 24-foot river boat. A description of this unit and the technique employed may be found in Kalb (1974).

All fish measurements were expressed in fork length to the nearest millimeter and in weight to the nearest gram.

In lakes receiving plants of both game fish strains, the right or left ventral fin was removed at Fire Lake Hatchery to identify the respective fish stock.

Fish to be adipose fin clipped were first anesthetized in MS-222 and then held for 24 hours before release. Fish captured by seine in Loon Lake were marked and released the same day.

Water samples were collected with a Kemmerer water sampler and dissolved oxygen levels were determined by PAO titration. Alkalinity, hardness and pH were determined using the Hach AL-36-WR Field Test Kit.

Water temperature was measured with a YSI Tele-thermometer and conductivity with a Hach Model 2510 Conductivity Meter.

FINDINGS

Lake Stocking Evaluation Study

Lake stocking studies were initiated during the previous job segment to provide information leading to eventual development of a standard stocking procedure allowing optimum survival and growth of game fish in lakes of varying limnological characteristics. For a more complete discussion of project design refer to Kalb (1974).

The objectives of the preliminary phase of this study have been defined as:

1. Compare survival and growth of fry and fingerling plants in Long, Seymour, Loon and Short Pine lakes.
2. Evaluate relative success of Winthrop, Washington; Ennis, Montana rainbow trout, *Salmo gairdneri* strains; Kodiak, Alaska, and Green River, Washington coho salmon, *Oncorhynchus kisutch*, strains.
3. Evaluate the British Columbia stocking curve (Smith et. al. 1969) for converting numbers of large fish to equivalent numbers of smaller fish.

An initial stocking schedule was implimented in 1973 and revised in 1974 after Marion and Christiansen lakes failed to completely detoxify until fall, 1973. The stocking schedule for both years is presented in Table 1. Stocking density of Marion Lake was reduced from the higher density developed in 1973 as water chemistry data indicated the lake to be less productive than first believed.

Morphometric data for the study lakes in the Matanuska-Susitna Valleys are described by Kalb (1974).

Survival and growth data from Long, Seymour, Short Pine, and Loon lakes were to be determined in this job segment. Electrofishing was to provide fish for mark and recapture studies resulting in point estimates of population size. Use of the boat-mounted shocker, however, was not successful in Loon, Seymour, and Long lakes because of a multitude of problems and complications including low conductivity of lake waters, absence of total darkness during the sampling periods, and lake morphometry.

Samples were obtained to determine growth of age I+ rainbow trout and coho salmon by using a combination of variable mesh gill net, electroshocker, and drag seine.

All study lakes were sampled in late fall to obtain growth estimates after one full summer period and all but Seymour Lake were sampled more frequently. A summary of that length-weight data is presented in Table 2.

Table 1. Lake Stocking Evaluation Study, Stocking Schedule, 1973-1974.

Lake	Date Stocked	Strain*	Size (Fish/lb.)	Stocking Density** (Fish/acre)	Stocking Proportion*** (Fry/fingerling)	Number of Fish
			RAINBOW TROUT			
Long	7/ 6/73	W	1,178	300	3.75/1	41,700
		E	107			11,100
Seymour	7/ 6/73	W	1,178	300	1/0	257,600
Short Pine	7/26/73	W	125	300	1/1	7,800
		E	112			7,800
Christiansen	6/25/74	W	1,043	150	3.75/1	50,000
		E	176			13,500
Marion	6/25/74	W	1,043	75	3.75/1	16,000
		E	176			4,300
Memory	6/24/74	W	975	150	1/0	46,400
			COHO SALMON			
Loon	8/ 8/73	K	143	300	1/1	16,270
		GR	133			16,135

* W - Winthrop, Wash.
E - Ennis, Mont.
K - Kodiak, Ak.
GR - Green River, Wash.

** Density based on size of fingerlings.
***Developed from British Columbia stocking curve.

Table 2. Summary of Length-Weight Data of Stocked Game Fish, 1974-1975.

Lake	Date	Method of Capture	Fish* Strain		No. Captured	Length (mm) Range	Length (mm) Mean	Length (mm) S.D.	Weight (g) Range	Weight (g) Mean	Weight (g) S.D.	Condition** Factor
					RAINBOW TROUT							
Seymour	9/20/74	Gill Net	W		216	208-371	276	23	145-708	283	74	1.35
Short Pine	5/22/74	Shocker	W		53	110-235	171	24	23-118	67	24	1.34
			E		28	135-262	187	26	36-186	87	33	1.35
	5/30/74	Shocker	W		151	112-238	180	22				
			E		128	126-270	199	29				
	6/12/74	Gill Net	W		84	145-290	211	27				
			E		113	165-280	224	25				
	10/ 4/74	Gill Net	W		17	265-361	332	25	327-680	541	103	1.48
			E		32	260-380	333	28	2990735	548	112	1.48
Long	5/ 9/74	Gill Net	W		65	103-205	157	30	14- 95	45	22	1.16
			E		52	211-282	237	16	100-245	148	32	1.11
	9/17/74	Gill Net	W		203	115-254	224	17	45-227	155	29	1.20
			E		115	255-348	290	24	117-517	297	88	1.22
					COHO SALMON							
Loon	5/25/74	***	K		74	109-162	127	9	14- 45	25	5	1.22
			GR		379	102-139	118	6	9- 36	20	3	1.22
	7/17/74	Seine	K		386	112-178	148	17	18- 68	43	12	1.33
			GR		268	122-164	145	6	25- 59	39	6	1.28
	9/18/74	Gill Net	K		303	131-221	178	18	27-145	72	24	1.28
			GR		158	140-190	167	11	36- 77	57	9	1.22
	2/ 7/75	Gill Net	K	Total	80	146-222	183	20	36-118	71	24	1.16
				Immature	57	146-205	173	14	36-100	59	15	1.14
				Mature	23	186-222	207	10	73-118	100	14	1.13
			GR	Total	97	153-200	173	11	41- 86	57	9	1.10
				Immature	95	153-195	172	11	41- 77	57	8	1.12
				Mature	2		192	11		84	3	1.19

* W = Winthrop, Wash.; E = Ennis, Montana; K = Kodiak, Alaska; GR = Green River, Wash.

** $C = \frac{100,000\ W}{L^3}$

***Coho mortalities collected after attempted outmigration

Growth of Rainbow Trout:

To review growth in the three study lakes containing rainbow trout, attention should be directed to fish size, time of stocking, and stocking density. Since the latter two variables were essentially equivalent for both strains, the size of the individual strains need only be considered. The variables are presented in Table 1.

Rainbow in Short Pine Lake on the Kenai Peninsula were initially sampled by electroshocker on May 22, 1974. Mean length and weight at that time were 171 mm and 67 g for Winthrop fish, and 187 mm and 87 g for Ennis stock. Student's t-test of comparison indicates a 95% probability that the difference between means of the two strains is significant. Similar tests on May 30 and June 12, 1974 further support the significant difference between the size of Winthrop and Ennis fish. Although data from these samples suggest a slightly superior growth by Ennis stock, a final fall sample on October 4 indicated no significant difference between the two strains.

To obtain additional and perhaps a more representative expression of growth, fork length was regressed on weight for samples taken on May 22 and October 4, 1974. Those linear regressions are summarized in Table 3. Analysis of co-variance was then used to determine if there was a difference in growth relationships between strains. Regression analysis for May 22 show Ennis stock gained weight at a greater rate with increase in length than Winthrop stock and the lines were significantly different at the 99% confidence level. At some time during the summer growth, increase in weight exceeded increase in length and slopes (b of the regression equation $\hat{Y}=\bar{Y}+bX$) for Winthrop and Ennis stocks on October 4 were 3.62 and 3.65, respectively. Analysis of co-variance showed no significant difference in this length-weight relationship, suggesting that growth by both strains at this larger size is similar.

The high slope values for October 4 probably exceed the "ideal" isometric cube value due to active feeding and increase in weight throughout the summer growth period by both rainbow strains.

Rainbow trout of Winthrop origin when sampled on September 20, 1974 in Seymour Lake had reached a mean size of 276 mm and 283 g. The length-weight regression of the sample is given in Table 3. Growth of the Winthrop fish expressed by b 2.96 is significantly different from the regressions of Short Pine rainbow sampled on October 4. This is expected as the Seymour fish were planted as fry; however, their growth should be considered as notable.

Long Lake was the only lake stocked in 1973 with Winthrop and Ennis stocks of different sizes (Table 1). This phase of the lake study was to compare growth of both strains at different sizes in the same waters and evaluate the suitability of the British Columbia stocking curve to Alaskan conditions. Unfortunately, the resulting data are marred by the reinfestation of Long Lake with threespine sticklebacks, *Gasterosteus aculeatus*. Observations in early 1974 revealed large numbers of sticklebacks had been present

Table 3. Summary of Length-Weight Regression Data for Stocked Game Fish, 1974-1975.

Lake	Date	Strain*		Sample Size	Regression Equation ($\hat{Y} = \bar{Y}+bX$)	Correlation Coefficient (r)
RAINBOW TROUT						
Seymour	9/20/74	W		216	$\hat{Y}=-534.9 + 2.96X$	0.939
Short Pine	5/22/74	W		53	$\hat{Y}=-92.6 + 0.94X$	0.971
		E		28	$\hat{Y}=-143.1 + 1.23X$	0.971
	10/ 4/74	W		17	$\hat{Y}=-663.8 + 3.62X$	0.883
		E		32	$\hat{Y}=-668.1 + 3.65X$	0.919
Long	5/ 9/74	W		65	$\hat{Y}=-65.7 + 0.70X$	0.954
		E		52	$\hat{Y}=-285.3 + 1.83X$	0.888
	9/17/74	W		203	$\hat{Y}=-215.5 + 1.57X$	0.919
		E		115	$\hat{Y}=-716.5 + 3.50X$	0.966
COHO SALMON						
Loon	9/18/74	K		303	$\hat{Y}=-145.4 + 1.22X$	0.941
		GR		158	$\hat{Y}=-69.3 + 0.75X$	0.890
	2/ 7/75	K	Total	80	$\hat{Y}=-137.4 + 1.14X$	0.974
			Immature	57	$\hat{Y}=-118.0 + 1.02X$	0.940
		GR	Total	97	$\hat{Y}=-64.5 + 0.71X$	0.858
			Immature	95	$\hat{Y}=-57.4 + 0.66X$	0.856

* W - Winthrop, Wash., E - Ennis, Mont., K- Kodiak, Ak., GR - Green River, Wash.

in Long Lake for some time and it must be assumed this competitor was detrimental to both growth and survival of rainbow trout. It is most probable a complete kill was never achieved in 1972 due to numbers of active subterranean springs.

A comparison of condition factors, given in Table 2, of both strains of Long Lake rainbow with condition factors of rainbow in Short Pine and Seymour lakes, reflects the possible influence by a competitor species. Mean length of Ennis fish from Long Lake on September 17 is significantly smaller than that of Ennis fish from Short Pine Lake on October 4 even though the Long Lake fish were planted earlier, at a larger size, and in what is considered more productive waters than Short Pine Lake.

Growth of Winthrop fish in Long Lake on September 17 was also considerably less than those in Seymour Lake which were planted at the same size and time.

Analysis of co-variance indicated a significant difference in mean length and weight of the Ennis strain from Long Lake on September 17 and Short Pine Lake on October 4, yet there is no difference in the growth relationships as expressed by their linear regressions. This is to say even though the Ennis rainbow in each lake were dissimilar in mean size, their growth in length to weight was at a similar rate.

Survival of Rainbow Trout:

Initial population estimates for Short Pine Lake were attained by adipose marking rainbow trout captured with boat-mounted electroshockers. On May 23, 1974, 366 marked rainbow comprising both strains were released into the lake. Observed mortalities totaled 5.7%. Recapture efforts using the electroshocker extended from May 28-May 30, catching a total of 289 fish. Recaptured marked fish numbered 100 and their percentage composition was identical to the composition of the total marked group on May 23, 1974. Summary of catch and recapture data for all sampling dates is given in Table 4. All unmarked rainbow were adipose clipped and released in addition to the original marked individuals. Observed mortality after 24 hours was 6.2%.

An estimate of population size using the above data in Bailey's modification of the Petersen formula (Ricker, 1958) is 1,050 fish and the 95% confidence limits are $907<N<1,249$. This estimate represents a survival of but 7% of the total rainbow plant. To obtain additional data, six variable mesh gill nets were fished for a cumulative of 270 hours and raised on June 12. A total of 208 rainbow were captured, but only seven were marked fish. This very low proportion of marked fish may be attributed to the selectivity of gill nets for larger fish. This selectivity is discussed in detail by Watsjold (1975). Length frequencies shown in Figure 1 graphically illustrate the size difference between the two capture methods; the figure implies that not all of the marked fish in Short Pine Lake were available to gill net sampling on June 12. Size range selectivity of nets precluded an unknown yet significant proportion of marked fish and any population estimate based on these data would be strongly biased.

Table 4. Summary of Mark and Recapture Data, Short Pine Lake, 1974.

Date	Method of Capture	Fish* Strain	Numbers Captured Unmarked	Marked	Total Catch	** %	Total Marked	** *	Marked*** Fish Available
5/23	Shocker	W		187	366		366	51	
		E		167				46	
		NC		12				3	
5/30	Shocker	W	100	51	289	52	100	51	366
		E	82	46		44		46	
		NC	7	3		4		3	
6/12	Gill Net	W	84	3	208	42	7	43	537
		E	113	4		56		57	
		NC	4			2			
6/19	Shocker	W	7	14	35	60	23	61	530
		E	5	7		34		30	
		NC		2		6		9	
10/4	Gill Net	W	14	3	51	33	11	27	507
		E	25	7		63		64	
		NC	1	1		4		9	

* W - Winthrop, Wash., E - Ennis, Mont., NC - No ventral clip.
** Percentage composition by strain.
*** Total number of marked fish available at beginning of sampling period.

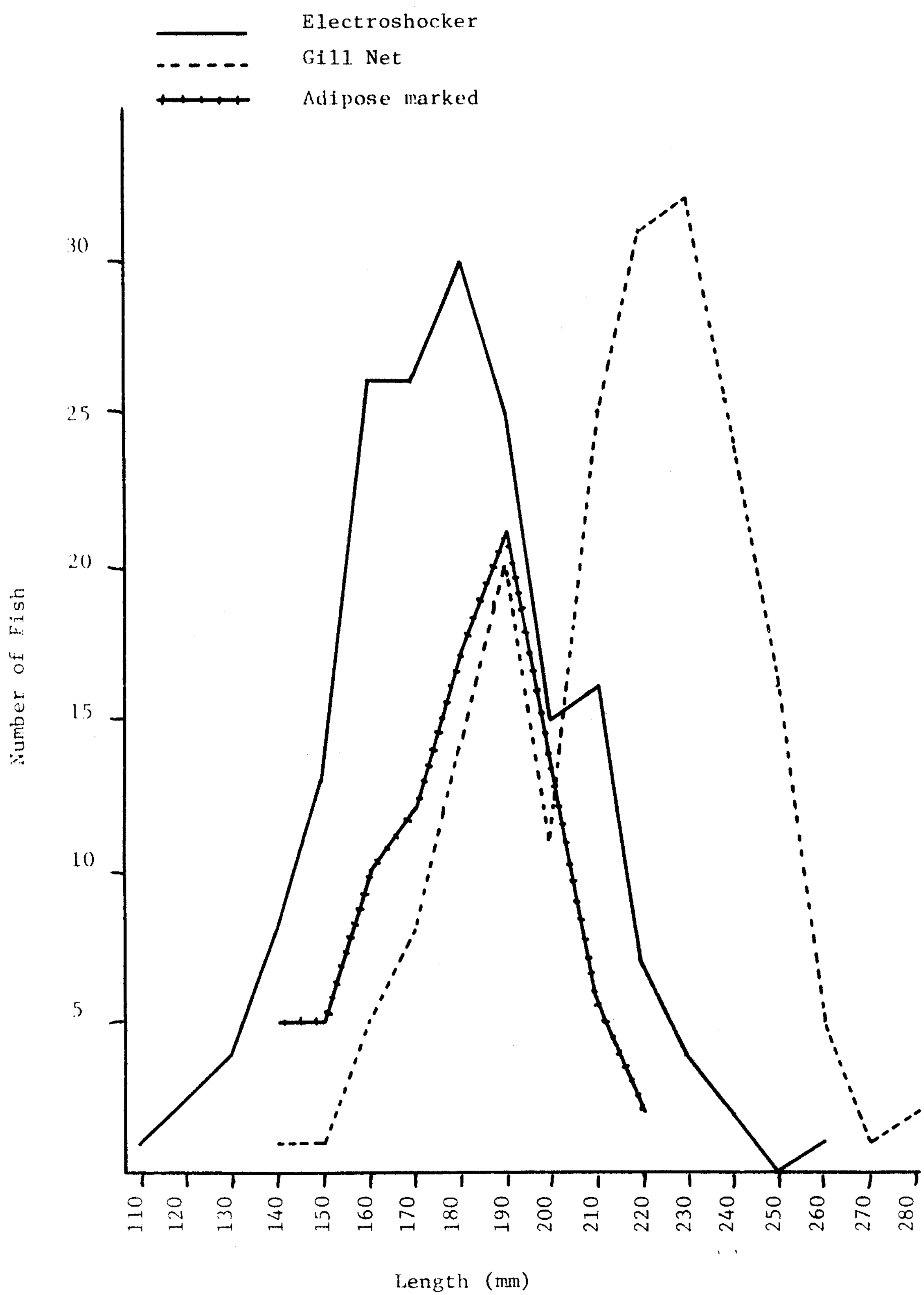

Figure 1. Length Frequency of Rainbow Trout Captured by Electroshocker and Gillnet in Short Pine Lake, 1974.

It is believed the difference in habitats sampled by the two methods also influenced catch composition. The electroshocker most effectively captured fish inhabiting the shallow littoral areas and was operated in open water with negative results. Gill nets were placed in a variety of areas and depths.

The gill net data of June 12 implies that:

1. A certain segment of the Short Pine Lake rainbow population was not sampled by electroshocker.

2. The smaller size range captured in gill nets and expressed by the peak in the 190-199 mm size class probably reflects a substantial segment of the lake population.

3. Because of sampling bias and lack of data the approximate proportion of the population represented by the larger fish is unknown.

Two additional attempts to estimate population size were made, but sample sizes were too small to be precise. On June 19 electroshocking captured 35 fish, 23 being marked, which gives an estimate of 795 fish with 95% confidence limits of $636<n<1,060$. When gill net mortality from June 12 is added to this estimate the resulting sum approximates the estimate of May 30 but again does not include the larger size class of rainbow.

The gill net sample of October 4 captured 51 rainbow including 11 marked fish. This estimate of 2,110 fish and an interval of $1,400<N<4,225$ may be the most representative estimate as the smaller marked rainbow should have reached a size more susceptible to gillnetting. The large confidence interval results from small sample size.

Determination of population size in Short Pine Lake was further complicated when it was discovered on October 4 that the lake was reinfested with sticklebacks and coho salmon, the result of an illegal transplant from a neighboring stream. Abundance of both species is believed low, yet coho must have been present during spring sampling as five were found with adipose marks. Not expecting coho to be present, these five salmon were probably mistaken for rainbow, marked and designated within the no ventral clip category. Exclusion of this category from the population estimates makes little appreciable difference, so the data was left as recorded.

It is apparent that due to gear selectivity, sampling error, and mortality of marked fish after release, an accurate estimate of population size in Short Pine Lake is not available. Data nevertheless implies that in a lake of low productivity survival of fingerling planted at 300 fish/acre following chemical treatment may be very low, possibly less than 15%.

Comparison of individual survival of Winthrop and Ennis strains planted as fingerling is similarly complicated by gear selectivity. Winthrop stock composed a larger percentage of the electroshocker catch while the gill nets caught predominately the Ennis strain. An appreciable difference in survival of the two strains may exist; however, present data is inconclusive and additional evaluation is warranted.

Coho Salmon:

In May, 1974 spring run-off raised the surface level of Loon Lake to the extent that resulting overflow diverted into a previously dry stream bed at the southwest end of the lake. Smolt-sized coho of both Kodiak, Alaska and Green River, Washington strains attempted to migrate through this outlet. However, the overflow dissipated underground within several hundred yards and approximately 5,000 smolts trapped in the stream section were captured by seine and returned to the lake. Further smolt migration was prevented by construction of a barrier at the outlet.

Several thousand mortalities were found in the stream area and a random sample was collected for analysis. The sample comprised 628 smolt, 74% being of Green River origin. A smaller number were measured and the results given for May 25 in Table 2.

Unfortunately, high stress conditions caused by crowding, high water temperatures, and subsequent seining and handling possibly inflicted a mortality on those smolt released and any survival estimate of the two strains is biased by this occurrance.

Growth of Coho Salmon:

Data collected on September 18, 1974 and shown in Table 2, suggests growth of the Kodiak strain to be superior to Green River coho. Difference between length-weight regressions for each strain was significant at the 99% confidence level. Additional gillnetting from February 3-7, 1975 captured 177 coho. Cursory inspection of the results as given for the total sample in Table 2 would indicate superior size and growth of Kodiak stock as in earlier data.

Mature males accounted for 29% of the total Kodiak fish captured in the February sample and when length-weight data are calculated for only immature fish of both strains, a new perspective on growth is evident. No significant difference exists between mean lengths of immature fish, the size difference of the total sample being accountable to the larger size of mature males. It appears that coho salmon upon reaching sexual maturity demonstrate a sudden increase in growth that is not representative of immature fish. This accelerated growth of maturing male coho was also noted by Redick (1970).

It is possible that a percentage of the Kodiak fish in the September sample also demonstrated an accelerated growth rate due to approaching sexual maturity. This would cause a similar bias in the data to indicate a greater mean size than the sexually immature Green River strain.

The two coho strains captured by seine on July 17 show no significant difference in mean length. An increased growth rate due to maturity would not be expected in this sample as coho of both strains would be sexually immature at this early date.

Although there is no difference in the mean length of immature Kodiak and Green River strains, their length-weight regressions still conclusively indicate a superior growth condition (expressed as b in the regression equation) by Kodiak fish as shown in Table 3. The condition factor calculated for each sampling period also supports this assumption.

It is significant that 29% of the Kodiak strain on February 7 were mature fish but only 2% of Green River fish had matured. Early maturation of Kodiak coho would have obvious management implications.

Survival of Coho Salmon:

Estimates of population size and survival of coho salmon strains in Loon Lake have been subjected to an unknown degree of error introduced by the attempted out-migration of smolt-sized coho as previously described. Smolt mortality would more heavily bias the Green River coho strain as these fish comprised the majority of the out-migrant smolt.

Coho salmon were captured for adipose marking, using a 50-foot drag seine. This method was utilized as previous attempts to obtain coho with electroshocker were unsuccessful, primarily because of low water conductivity.

Seining activities on July 12, 16, and 17, 1974 resulted in 676 coho marked and released. Since marked fish were recaptured beginning the second day, seine catch data were applied to a Schnabel multiple census estimate of population size. Because of the short seining period there was a likelihood of non-random mixing of marked and unmarked fish and a modified Schnabel formulae by Schumacher and Eschmeyer was used (Ricker, 1958). Mark and recapture data are summarized in Table 5.

The final estimate derived for July 17 was 12,458 fish and a 95% confidence range of $11{,}072<N<4{,}245$. This represents a survival of 38% with an interval of 34 to 44%. The greatest sources of error in this method would be due to a short sampling period, making it difficult for random mixing of marked fish, and mortality of marked fish after release.

Another population estimate was derived from a gill net catch in September, 1974 using marked fish from the seine operation. Catches from September 13 and 18 gave a total of 453 coho; of those, 14 were adipose marked. Using Bailey's modification of Peterson's formulae an estimate of 20,460 is obtained with 95% confidence interval of $13{,}950<N<38{,}363$. The very wide confidence interval of this estimate suggests the presence of an unacceptable degree of sampling error which may be attributed to: (a) a proportionately higher mortality of marked fish; (b) the low percentage of marked fish available in proportion to the total population; (c) the small size of the gill net catch in proportion to the total population.

Assuming the estimate from gill net catch data to be subject to excessive error the earlier multiple census estimate will be considered as expressing survival of coho salmon in Loon Lake. The first year survival of 38% would have been higher had the larger size classes not suffered mortality during the attempted out-migration.

Table 5. Summary of Mark and Recapture Data, Loon Lake, 1974-1975.

Date	Method of Capture	Fish Strain	Numbers Captured		Marked** Fish Available	% *** Composition
			Unmarked	Marked		
7/12/74	Seine	K	189			
		GR	47			
		NC	2			
7/16/74	Seine	K	149	5	238	
		GR	134	1		
		NC	10			
7/17/74	Seine	K	48	3	531	
		GR	87	1		
		NC	10	2		
Seine Total		K			386	57
		GR			268	40
		NC			22	3
9/13/74	Gill Net	K	136	6	676	
		GR	72	4		
		NC	20			
9/18/74	Gill Net	K	119	2		
		GR	86	2		
		NC	20			
Gill Net Total		K	255	8		56
		GR	158	6		35
		NC	40			9
2/7/75	Gill Net	K	73	7		41
		GR	96	1		50
		NC	17			9

* K - Kodiak, Ak., GR - Green River, Wash., NC - No ventral clip.
** Total number of marked fish available at beginning of sampling period.
*** Percentage composition by strain.

It is difficult to assess actual survival of individual strains because of the higher mortality incurred by Green River smolts. As shown in Table 4, the percentage of each strain captured by seine in July, 1974 and gill netting in September was similar, indicating these percentages probably represent the composition of the coho population at that time.

The proportion between Kodiak and Green River strains in the February, 1975 gill net catch (Table 5) shows a change in population composition had occurred. This change may be contributed to a reduction in total numbers of the Kodiak stock due to mortality following sexual maturation. Apparently this did not occur in Green River stock to such a large degree.

British Columbia Stocking Curve

The British Columbia stocking curve was developed as a means to equate numbers of fry to numbers of fingerling so numbers of fry planted produce catchable-size adults approximately equal in number to that produced by a fingerling plant of stated size. This method, described in detail by Kalb (1974), was used to determine numbers of Winthrop fry planted in Seymour Lake and numbers of Winthrop fry and Ennis fingerling planted in Long Lake.

Age 1+ Ennis and Winthrop rainbow in Long Lake should have been present in approximately equal numbers. Gill net catches of May 9 and September 17, 1974, however, show fry composition slightly greater than fingerling. This suggests the conversion schedule may overestimate numbers of fry needed to equal survival of the fingerling plant.

These results, though, are inconclusive as reinfestation of Long Lake by threespine sticklebacks adversely affected survival of both rainbow strains and additional information is needed.

Christiansen and Marion lakes were both stocked in 1974 with Winthrop fry and Ennis fingerling as determined by the British Columbia stocking schedule. Results of sampling these lakes in 1975 will provide further insight to the suitability of this technique.

Limnological Study

A generally accepted premise when relating fish production to surrounding environmental factors is the dominate influence of productivity of rearing water upon survival and growth of fish species. This productivity is commonly measured by defining physical and biological variables existing in a body of water. Any such expression of the degree of productivity in specific lake waters could become a basis for considering use of certain game fish species or relating stocking intensity.

A limnological sampling program began in June, 1973 to define selected variables in study lakes and was discussed by Kalb (1974). This same program continued through the 1974 field season with no change in sampling design other than (a) exclusion of two lakes, Meirs and Harriet, and (b) samples were taken bimonthly.

Water Chemistry:

Water chemistry determinations were made on all 10 study lakes.

Dissolved oxygen sampling began May, 1974 and continued on a monthly basis through October. Water chemistry and temperature profiles were recorded bimonthly in conjunction with each plankton sampling date.

Dissolved oxygen and temperature determinations on three selected dates are presented in Table 6. These dates represent typical conditions for spring turnover, summer stabilization and fall turnover in each lake. Dissolved oxygen and water chemistry of Lucille and Matanuska lakes are presented by Watsjold (1975).

Table 7 is a summary of water chemistry characteristics for the study lakes.

Plankton Sampling:

Measurement of plankton abundance and species composition were selected as practical methods of indicating biological productivity. Shown in Figure 2 is the frequency of the mean centrifuge volume obtained from plankton tows during the 1974 sampling season. A summary of that data is given in Table 8.

The centrifuge volumes of zooplankton for Loon and Seymour lakes are considerably underestimated due to large volumes of gelatinous substances preventing efficient centrifuging of samples in July and August. This substance was attributed to a cladoceran, Holopedium gibberum, in Loon Lake and to a gelatinous form of algae in Seymour Lake. A low centrifuge volume was derived for Lucille Lake when very large numbers of an amphipod, Gammarus lacustris, clogged the plankton net.

A primary objective of the plankton sampling program was to develop a plankton index relative to biological productivity of each lake. This indexing system must take into consideration the volume of water suitable to plankton production as this area may be somewhat less than the total lake volume.

While morphometric characteristics are evident physical determinants of the productive region in a lake, the lake itself is comprised of basically two separate regions: the upper waters of photosynthetic production (the trophogenic zone) and the lower strata of decomposition (tropholytic zone).

During summer stagnation the trophogenic zone is essentially the epilimnion (often including the metalimnion) which is frequently expressed as the area of high dissolved oxygen concentration since it includes the region of water mixing and photosynthetic activity.

In shallow lakes, represented by Lucille, Loon, Seymour, and Memory, the trophogenic zone encompasses the entire water column. In a deeper lake, however, the epilimnion may fluctuate throughout the summer, the actual extent of the trophogenic zone essentially less than total lake volume yet

Table 6. Dissolved Oxygen-Temperature Determinations on Selected Dates for the Study Lakes, 1974.

Lake	Depth (m)	D.O. (ppm)	Temp. (°F)	D.O. (ppm)	Temp. (°F)	D.O. (ppm)	Temp. (°F)
		5/20/74		7/1/74		10/17/74	
Seymour	1	11.0	55	9.3	70	11.2	37.5
	3	11.3	53	10.2	69.5	12.2	37.5
	5	10.9	51	7.9	68.5	11.9	37.5
		6/11/74		9/4/74		10/24/74	
Long	1	11.1	62	10.5	60	9.0	41
	3	11.3	61	10.7	59	10.6	41
	6	12.3	52	10.5	59	10.5	41
	9	10.7	45	10.7	50	10.5	41
	12	8.0	42	6.0	45	10.6	41
	15	6.4	41	0.6	44	10.2	41
		6/12/74		9/4/74		10/30/74	
Johnson	1	10.0	63	10.1	59	9.2	39
	3	10.0	61	10.1	59	9.1	39
	6	11.6	49	8.7	58	9.1	39
	9	7.3	42	3.6	49	9.1	39
	12	7.6	39	0.5	40	9.0	39
		5/14/74		9/3/74		10/31/74	
Memory	1	11.9	49	8.6	60	12.8	39
	3	11.9	48	8.1	59	12.9	39
	6	11.8	46	5.0	58	12.6	39
		6/11/74				9/16/74	
Short Pine	1	11.0	59			11.0	55
	3	11.0	58			10.2	55
	6	12.0	53			10.0	55
	9	11.5	48			9.8	55
		5/20/74		7/1/74		10/17/74	
Loon	1	11.1	54	8.6	69.5	11.2	38
	3	10.8	52	9.1	69	11.0	38
	5	10.2	50	6.1	67	11.1	38
		6/5/74		8/15/74		10/28/74	
Christiansen	1	10.3	56	9.6	65	10.5	38
	3	11.6	55	9.8	65	10.6	38
	6	10.6	45	9.8	64	10.7	38
	9	10.0	41	12.0	49	10.5	38
	10	9.3	40	12.8	43	10.5	38
	15	5.6	39	5.0	39	10.5	38
	18	4.8	39	3.7	39	10.5	38
	21	3.0	39	0.5	39	10.4	38
		5/20/74		8/27/74		10/17/74	
Marion	1	11.3	51	9.5	60	10.9	41
	3	11.4	48	9.4	60	11.1	41
	6	11.5	45	9.1	60	11.2	41
	9	11.7	44	9.4	60	11.0	41
	12	11.6	43	6.1	54	11.1	41

Table 7. Summary of Water Chemistry Characteristics for the Study Lakes, 1974.

Lake	Sampling Period	pH		Total Alkalinity as $CaCO_3$ (ppm)		Total Hardness as $CaCO_3$ (ppm)		Conductivity (micromhos/cm)	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range
Seymour	5/20 - 10/17/74	8.2	7.5-8.7	71.5	51.3 - 85.5	69.9	68.4 - 85.5	92	80-100
Long	5/14 - 10/24/75	8.6	8.2-8.8	130.4	119.7 - 136.8	121.1	102.6 - 136.8	210	190-250
Johnson	5/15 - 10/39/75	8.3	7.5-8.7	93.3	85.5 - 102.6	78.4	68.4 - 85.5	122	114-130
Short Pine	6/11 - 10/ 9/74	8.3	6.7-9.3	136.8		43.1 -	34.2 - 51.3	39	35- 45
Loon	5/20 - 10/17/74	7.1	6.7-7.5	24.9	17.1 - 34.2	23.3	17.1 68.4	14	7- 18
Memory	5/14 - 10/31/74	7.3	7.0-7.8	35.6	34.2 - 51.3	34.2		40	35- 50
Christiansen	5/22 - 10/28/74	7.5	7.2-7.8	38.9	34.2 51.3	32.6	17.1 - 34.2	40	33- 47
Marion	5/20 - 10/17/74	7.9	6.8-7.2	24.1	17.1 - 34.2	29.9	17.1 - 34.2	10	8- 13

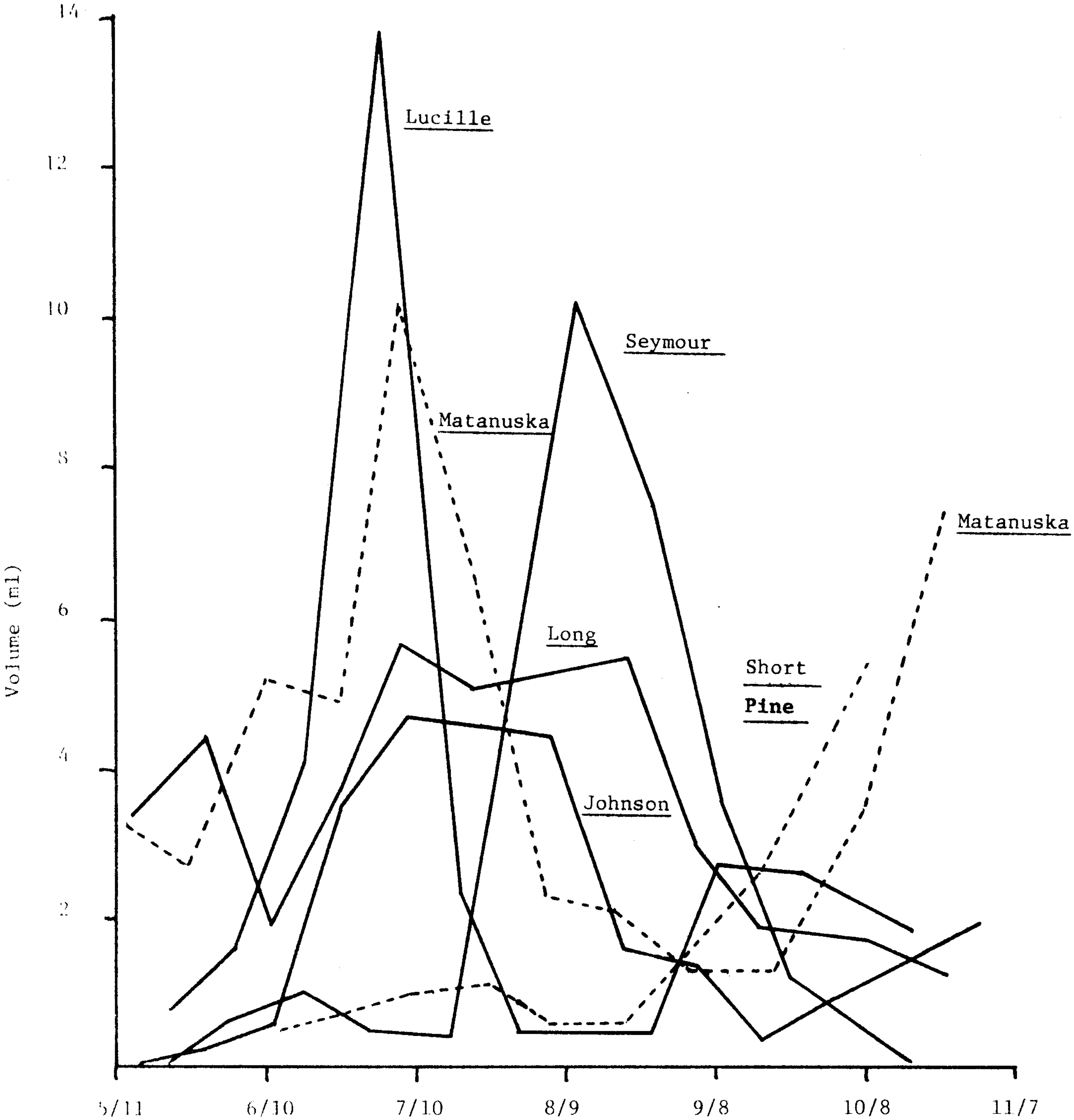

Figure 2. Mean Plankton Volumes in Study Lakes, 1974.

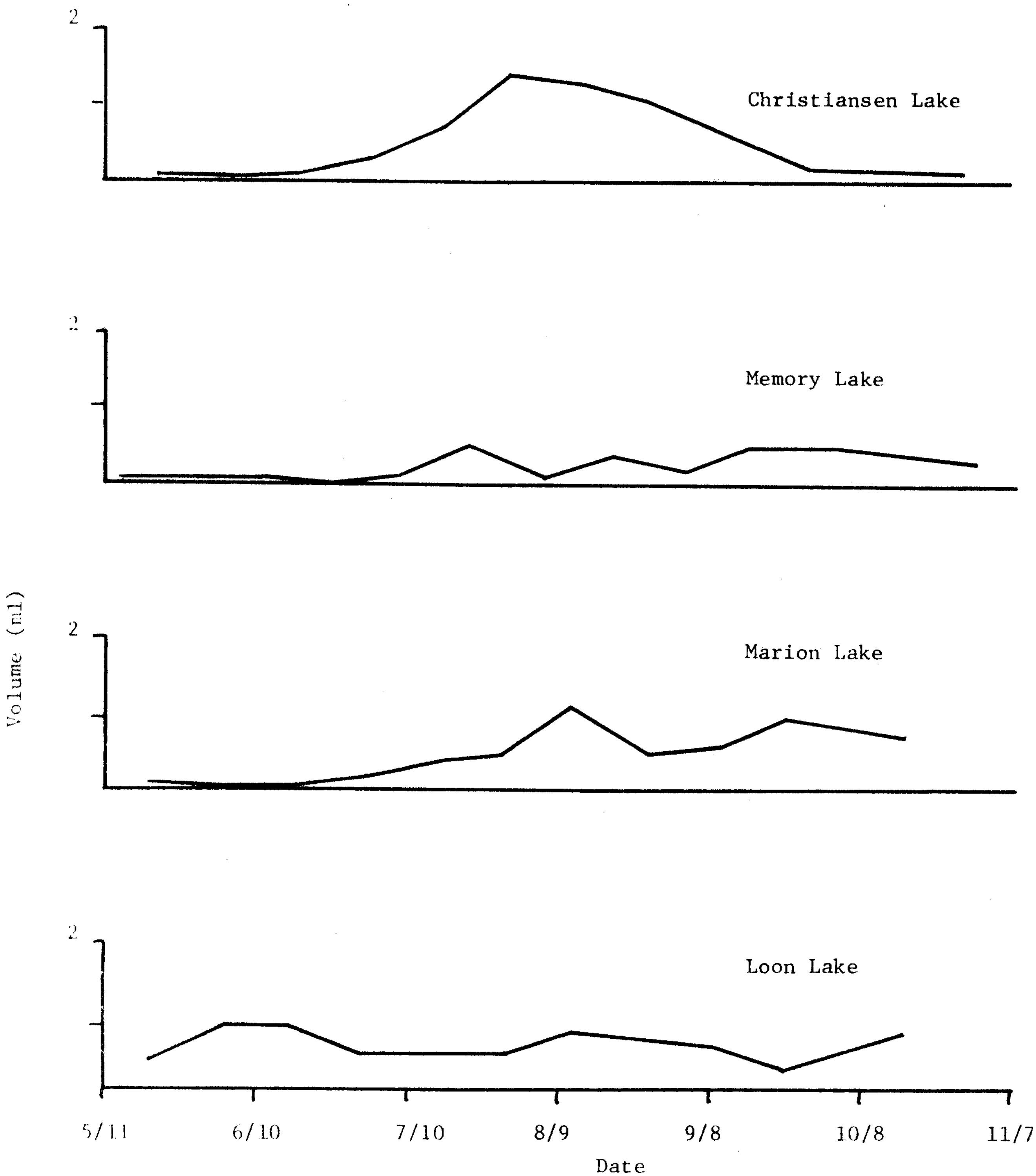

Figure 2. Contd. Mean Plankton Volume in Study Lakes, 1974.

Table 8. Summary of Plankton Volumes and Indexes for the Study Lakes, 1974.

Lake	Depth (m)	Centrifuge Volume (ml) Seasonal Range	Seasonal Total	Seasonal Average	PI 1973	PI 1974	MEI
Lucille	4	0.4-13.8	30.6	3.06	7.00	7.65	23.5
Seymour	3	<0.1-10.3	25.0	2.5	1.67	8.33	14.6
Long	5	0.4- 1.7	9.6	0.8	2.87	3.58	9.4
	13	1.2- 5.7	42.8	3.56			
Matanuska	5	0.3- 2.8	19.4	1.61	16.19	5.46	8.3
	22	1.3-10.2	48.7	4.05			
Johnson	5	<0.1- 1.2	7.6	0.63	4.89	3.09	7.4
	11	<0.1- 4.7	24.2	2.01			
Short Pine	5	0.3- 1.9	6.6	0.82	0.63	1.95	2.1
	8	0.5- 5.4	12.5	1.56			
Loon	3.5	0.3- 0.9	5.7	0.63	2.29	1.8	1.3
Memory	3.5	<0.1- 0.5	2.9	0.24	0.86	0.69	5.6
Christiansen	5	<0.1- 0.4	2.0	0.18	0.25	0.45	1.8
	20	<0.1- 1.4	5.8	0.53			
Marion	5	<0.1- 0.6	2.7	0.24	0.10	0.46	0.5
	10	<0.1- 1.1	5.1	0.46			

possibly greater than in shallow lakes. This greatly complicates quantitative comparison between the two lake types.

To define the trophogenic zone in deeper lakes, an approximation of that zone is expressed as the maximum depth of high dissolved oxygen penetration estimated from dissolved oxygen profiles. This dissolved oxygen depth for each sampling date was divided into the mean centrifuge volume for that same date. The average of these values was then determined and multiplied by a factor of 10 resulting in the plankton index for that lake.

The plankton index (PI) of shallow lakes was calculated by dividing the seasonal average centrifuge volume by the depth of the plankton tow, then multiplying by a factor of 10. A summary of PI values for 1973 and 1974 is found in Table 8.

If study lakes are arranged according to numerical value of their PI, a ranking of relative productivity is established. Although the seasonal average centrifuge volume of Lucille and Seymour lakes is less than Long and Matanuska lakes, ranking of the former are higher as the PI value is a projection of plankton production per unit of water area.

Another estimator of biological productivity was needed to serve as a comparison with the PI to determine its suitability as an indicator of productivity. The morphoedaphic index (MEI) was chosen for this purpose as it has been commonly considered an estimator of production from biotic communities. This index, derived from a measure of dissolved nutrient concentration (conductivity) and morphoemetry (mean depth) of a lake, is described by Ryder et al (1974) as a convenient method of rapidly calculating potential productivity from unexploited north temperate lakes.

MEI values assigned to each lake, found in Table 8, appear to correspond to associated PI values. Analysis of the regression of 1974 PI on MEI, depicted in Figure 3, gives a highly significant (99%) correlation of 0.88, indicating strong agreement of the two systems.

Regression of PI on MEI for 1973 was also calculated and is shown in Figure 4. The correlation coefficient of these data, omitting the value for Matanuska Lake, is 0.779. The PI for Matanuska Lake was considered nonrepresentative as large volumes of filamentous algae clogged the plankton net in early summer.

The 1973 PI values differ substantially from 1974 values as all lakes but Lucille, Matanuska, Johnson, and Memory had been subjected to fall rotenone treatment which retarded zooplankton activity (Kalb, 1974). Although 1973 and 1974 PI values were different, their relationship to the MEI was similar in both years. Comparison of the PI-MEI linear regressions by analysis of covariance shows no significant difference between the slopes for 1973 and 1974.

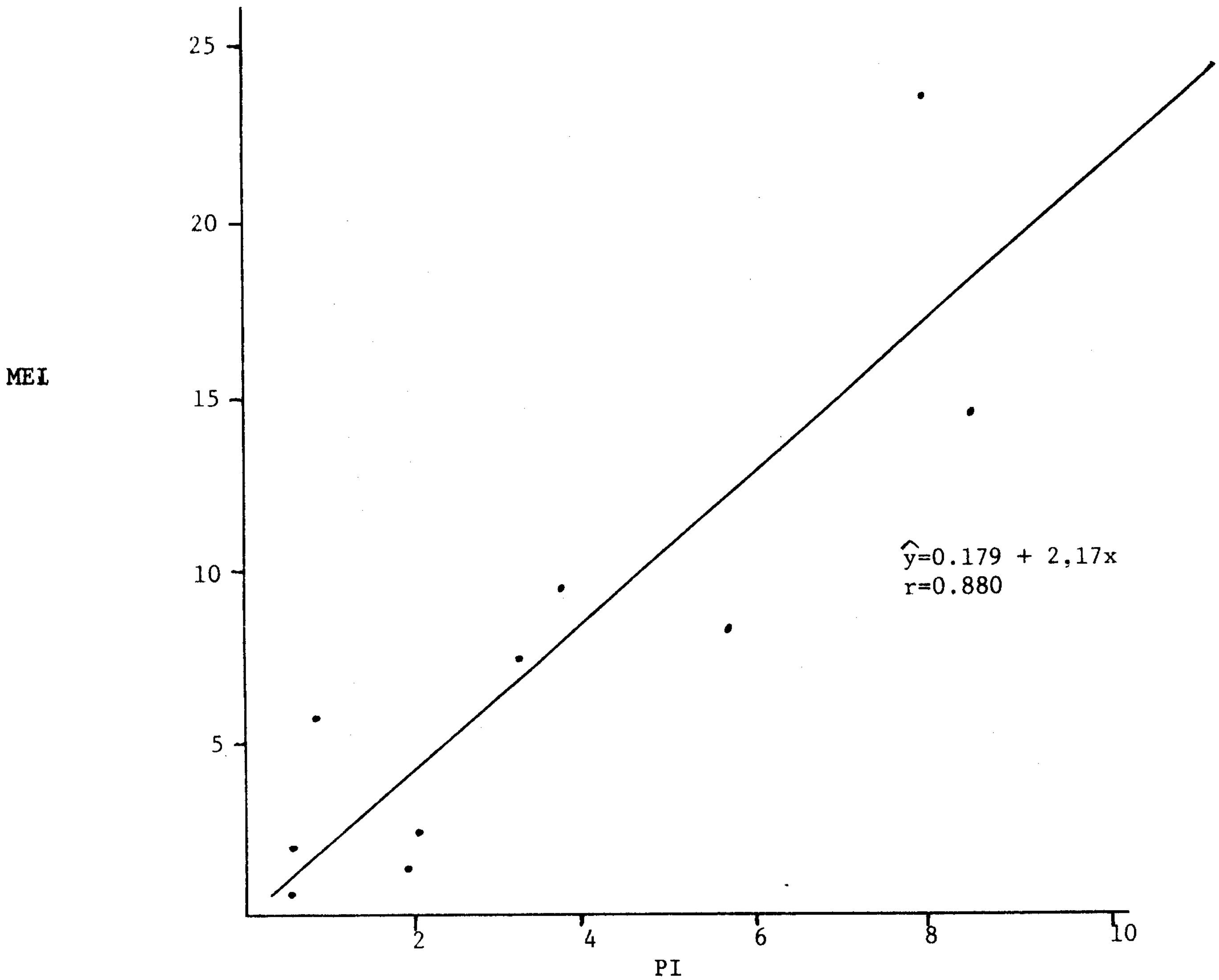

Figure 3. Linear Regression of Plankton Index (PI) on Morphoedaphic Index (MEI), 1974

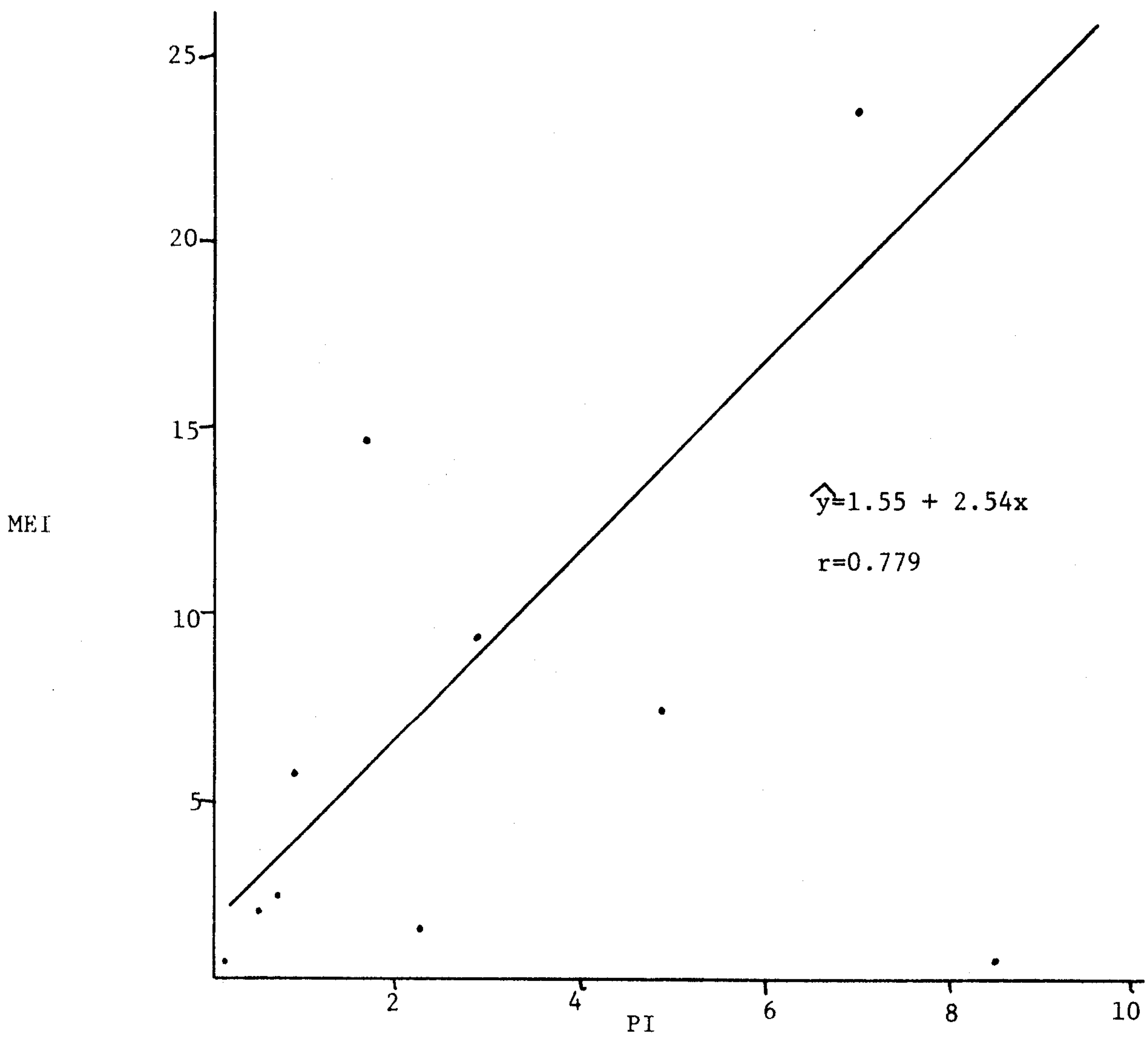

Figure 4. Linear Regression of Plankton Index (PI) on Morphoedaphic Index (MEI), 1973

The highly significant relationship between the MEI and PI indicates the PI may indeed be a representative indicator of biological productivity in study lakes. Sources of sampling error exist, however, that detract from the practicality of using PI as a reliable indicator. Several of the sampling errors encountered in this investigation are:

1. Unknown quantities of detritus that are present in plankton samples, possibly increasing volume.

2. Cyclic changes in the plankton community that would escape being recorded if plankton sampling were not frequent enough.

3. Error introduced through centrifuging techniques, i.e., different settling rates, and densities of different organisms.

4. Error introduced by an inconsistency of sampling techniques.

It is also questionable if the PI would remain stable from one year to the next as there are many environmental factors affecting plankton production.

The MEI itself remains more stable, reflecting only major changes in the environment, and is calculated much more readily than PI, suggesting its promise as a ready index of biological productivity.

On each sampling date an additional plankton haul was made from the maximum lake depth for purposes of identification. During this job segment, organisms in the 1973 and 1974 samples were identified by species and size compositions were recorded. A list of organisms found in the study lakes is given in Table 9. Species occurring only incidentally (less than 1% of the volume) are so designated.

Figure 5 illustrates the seasonal succession of zooplankton in the study lakes for both 1973 and 1974. The various geometric shapes representing the catch composition of each species express percentage abundance of that organism for each sample day.

In 1973 a variation of seasonal plankton abundance in chemically treated and untreated lakes was noted (Kalb, 1974). Low plankton abundance in chemically treated lakes was attributed to retardation of plankton productivity by application of rotenone the previous fall. Although there are no pre-treatment plankton samples from these lakes, the post-treatment seasonal succession of organisms suggests that at the beginning of seasonal plankton production in 1973 less complex organisms, such as rotifers and protozoans, were the initial forms to re-establish in any numbers. Species succession progressed to cladoceran or copepod dominance shortly afterward. This seasonal succession occurred in Loon, Lucille, Seymour, Long, and Short Pine lakes (Figure 5).

In 1974 cladocerans and copepods were the dominant species present in initial samples from the same lakes. Rotifers, if present at all, occurred only in small numbers. This is the inverse of the successional pattern

Table 9. Organisms Occurring in Study Lakes Compiled from Plankton Samples for 1973 and 1974.

	Lucille		Seymour		Matanuska		Long		Johnson		Short Pine		Loon		Memory		Christiansen		Martin	
	73	74	73	74	73	74	73	74	73	74	73	74	73	74	73	74	73	74	73	74
Protozoa																				
Bursaria truncata																	X*			
Rotifera																				
Asplanchna sp.	X		X		X	X	X	X	X	X	X		X		X	X	X	X		
Keratella quadratta	X		X		X	O	O	X	X						X		X			
Kellicottia longispina				O		O	X	X	X	X	X	O	X		X	O		X		
Rhinoglena frontalis			X																	
Cladocera																				
Daphnia longispina				X	X	X	X	X	X	X		X		X	X	O		X		O
Daphnia pulex	X	X	X								X	X	X		X					
Bosmina coregoni	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X
Sida crystallina		O					X						X					O		X
Holopedium gibberum						X						X		X						X
Chydorus sphaericus													O	X				X		
Polyphemus pediculus												X								
Copepoda																				
Epischura nevadensis	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X		X		X
Cyclops scutifer				X		X		X		X				O						
Cyclops capillatus		X													X					
Cyclops vernalis										X										
Mesocyclops edax					X		X													
Diaptomus pribilofensis	X											X								
Amphipoda																				
Gammarus lacustris		X								X						O				
Ostracoda	X						O								O					
Insecta																				
Corixidae			O							O			O			O			X	
Chironomidae	O		O							O						O		O	O	

*X Denotes presence; O denotes occurrance less than 1% of volume.

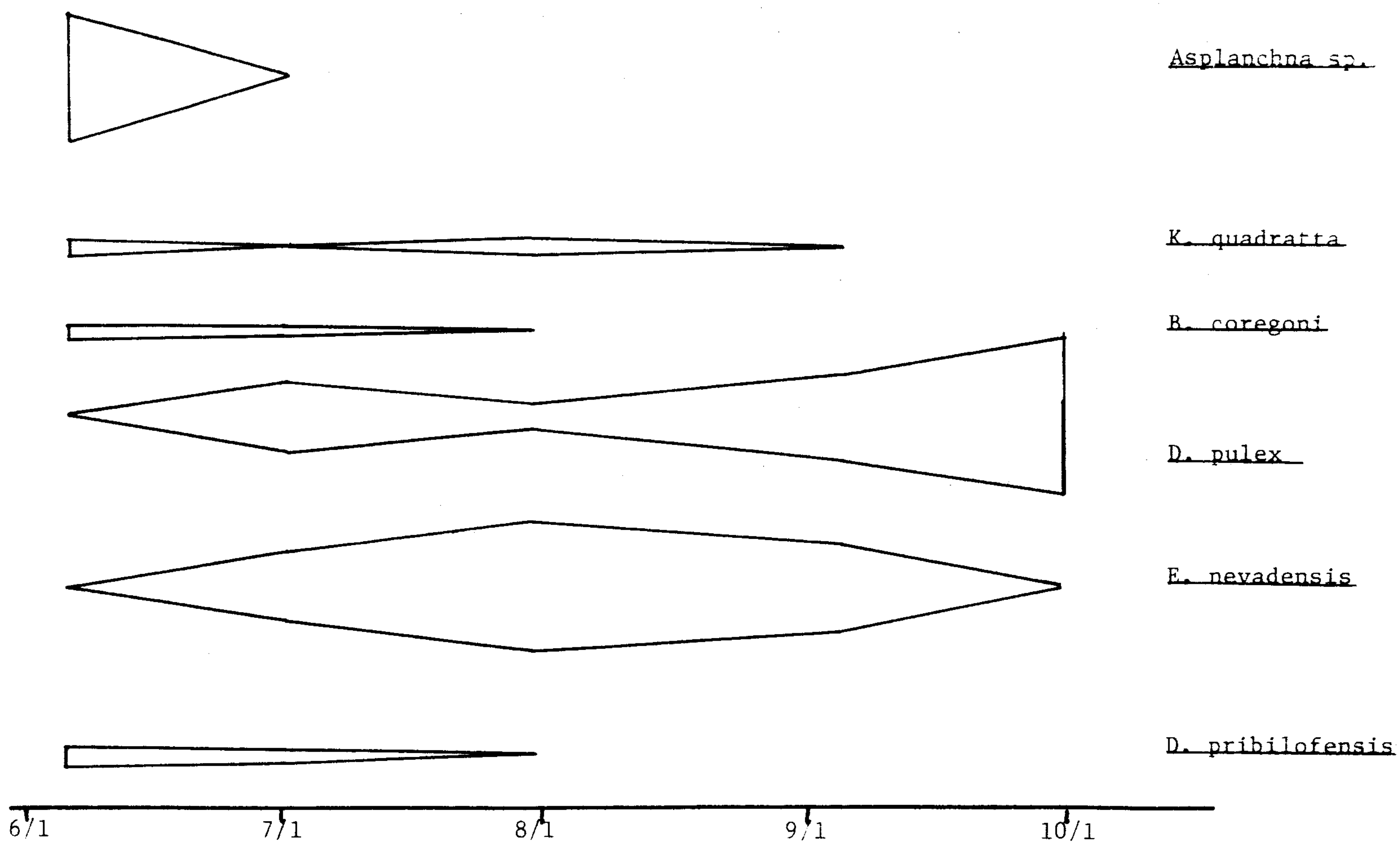

Figure 5. Lucille Lake 1973

Figure 5. Seasonal Succession of Zooplankton in Study Lakes as Determined by Species Catch Composition, 1973-1974

0 - Denotes occurrence less than 1% of catch

Relative width of geometric figures is the approximate relative species composition of the plankton community by numbers on sampling dates.

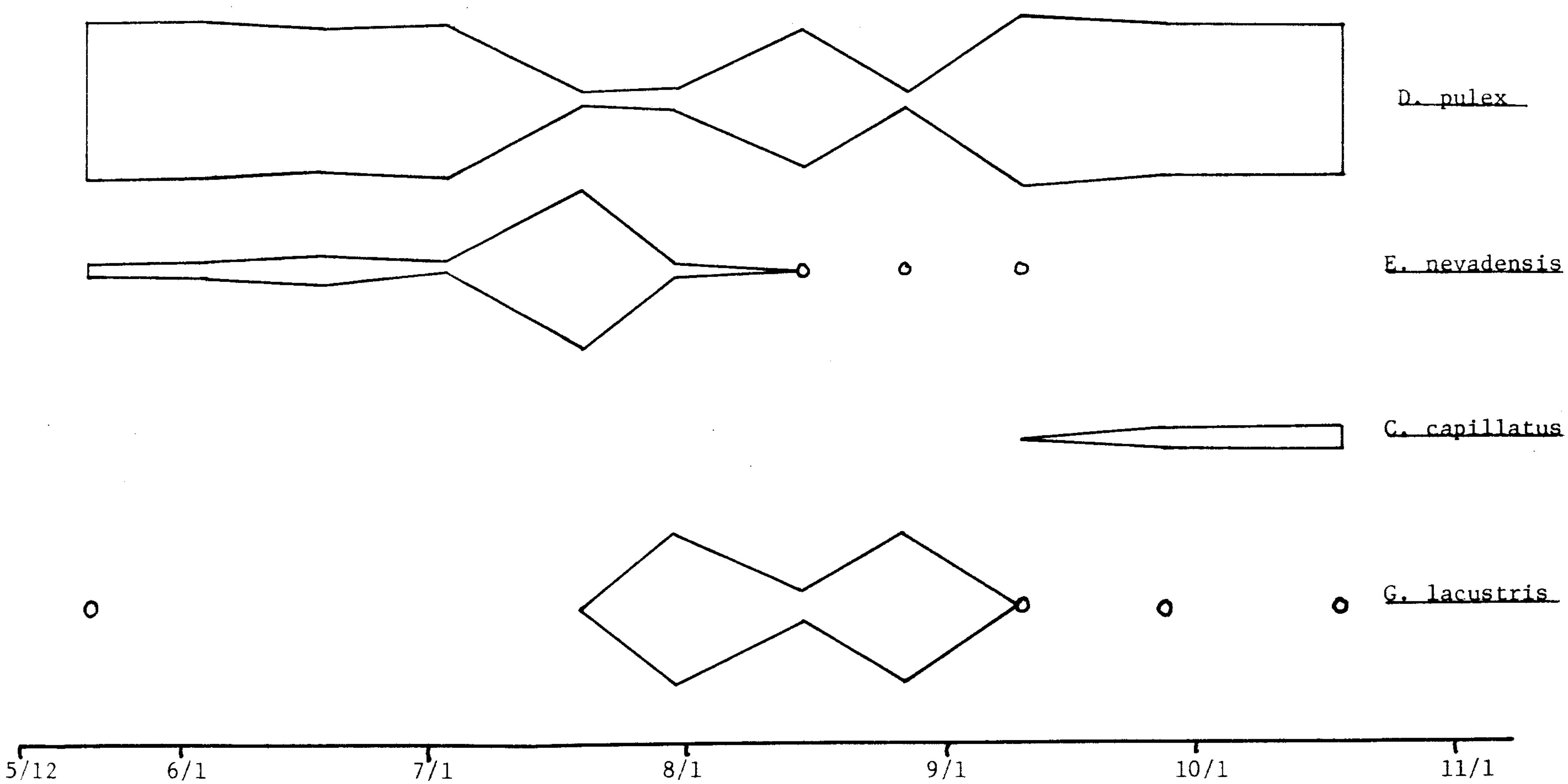

Figure 5 (cont.). Lucille Lake 1974

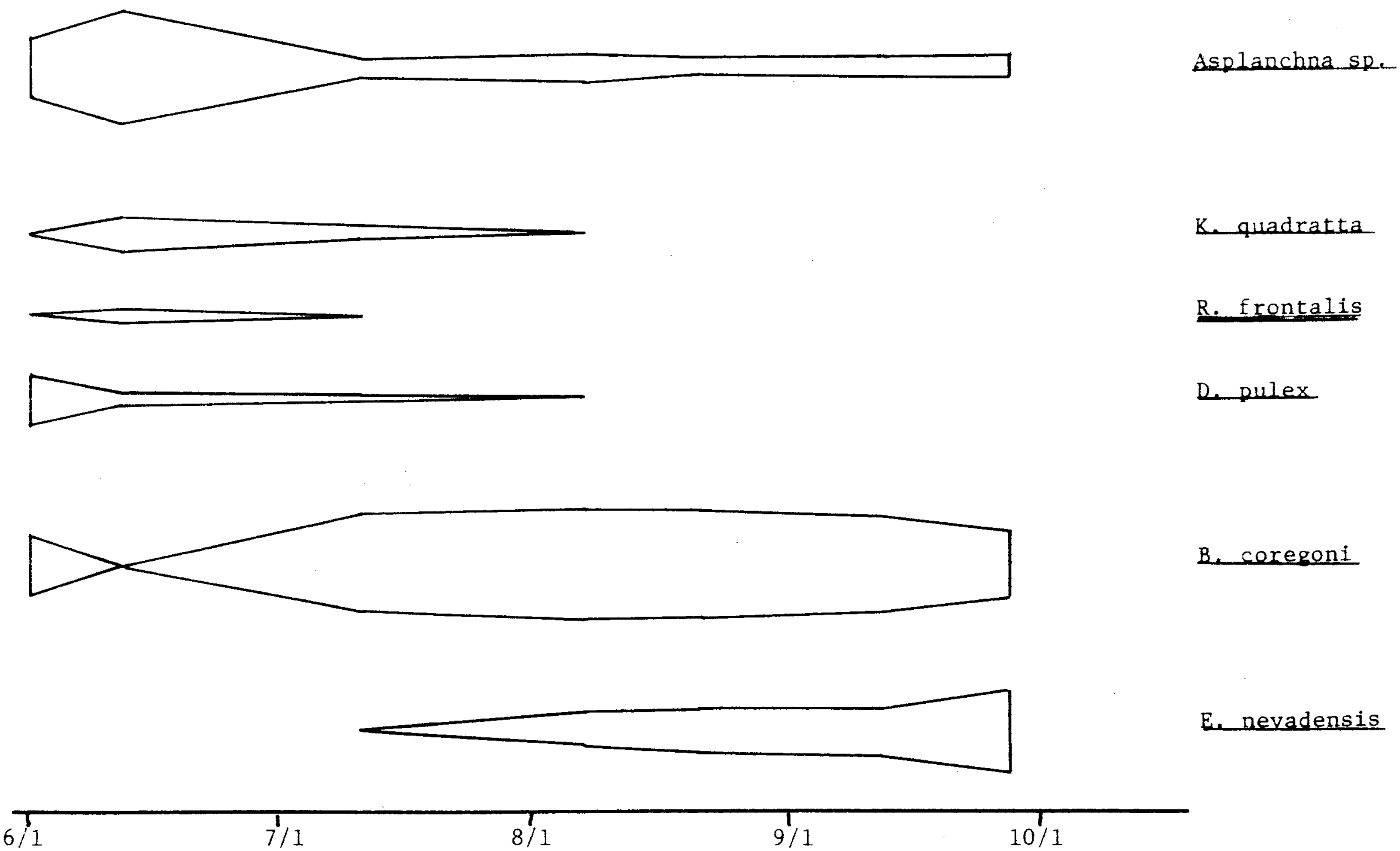

Figure 5 (cont.). Seymour Lake 1973

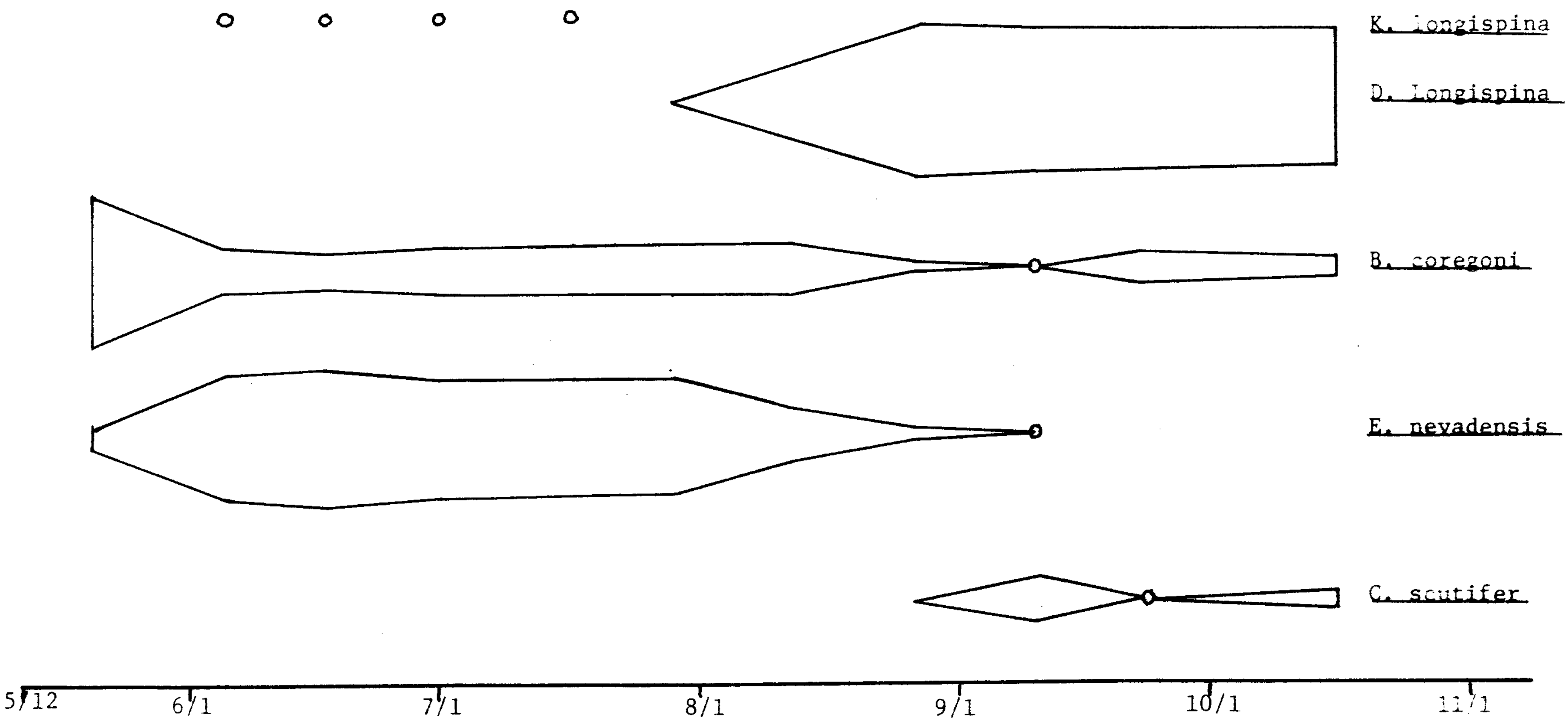

Figure 5 (cont.). Seymour Lake 1974

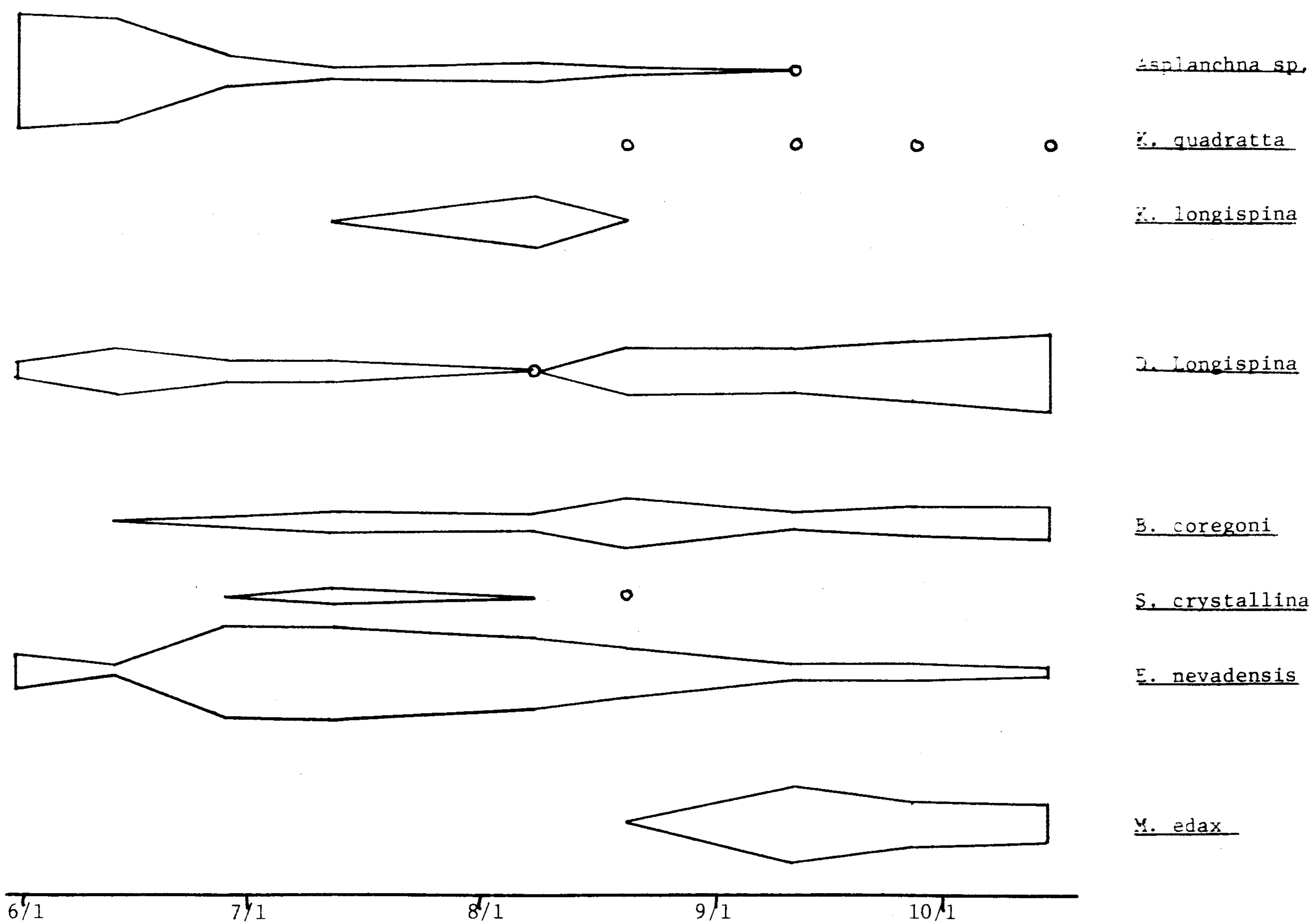

Figure 5 (cont.). Long Lake 1973

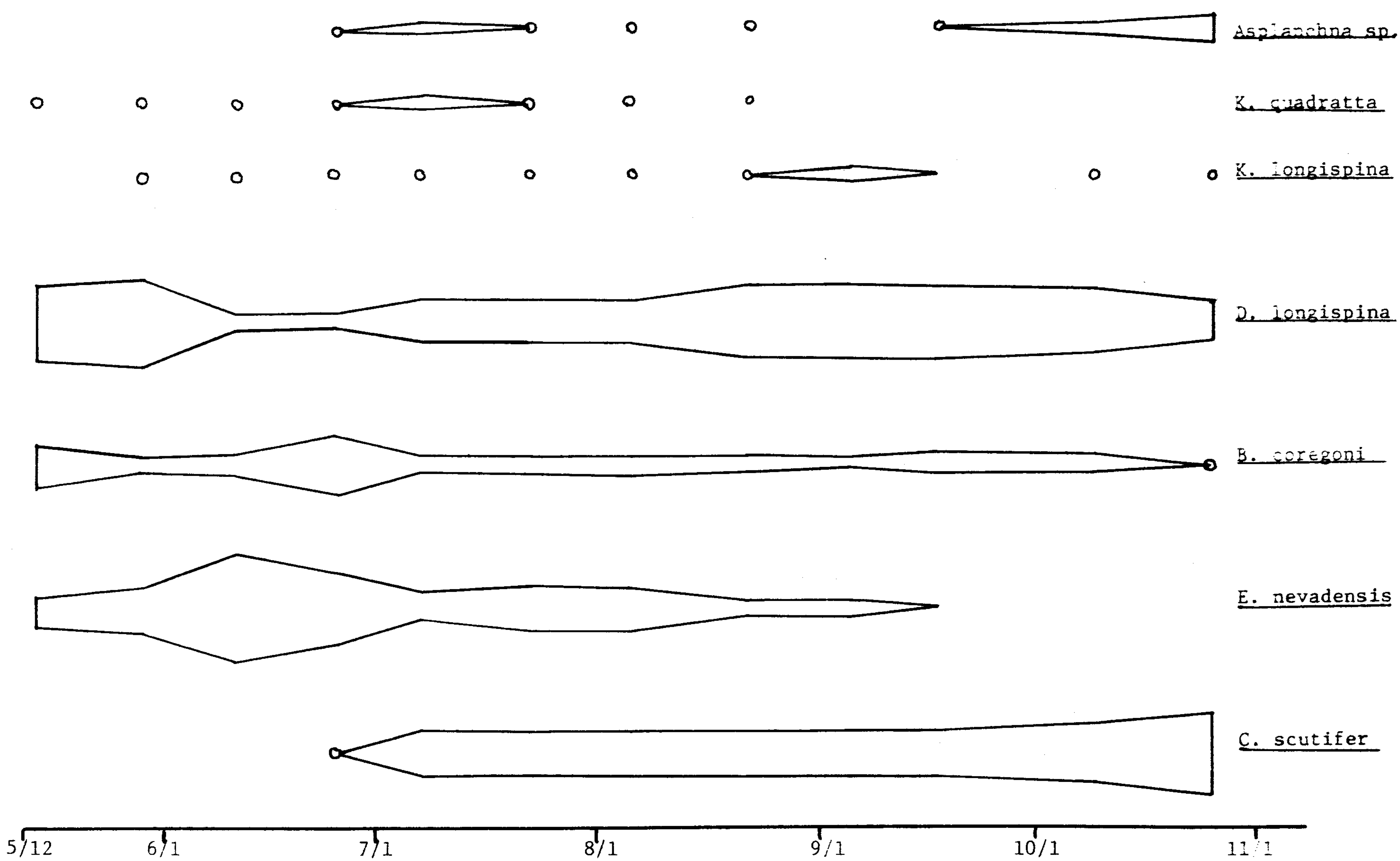

Figure 5 (cont.). Long Lake 1974

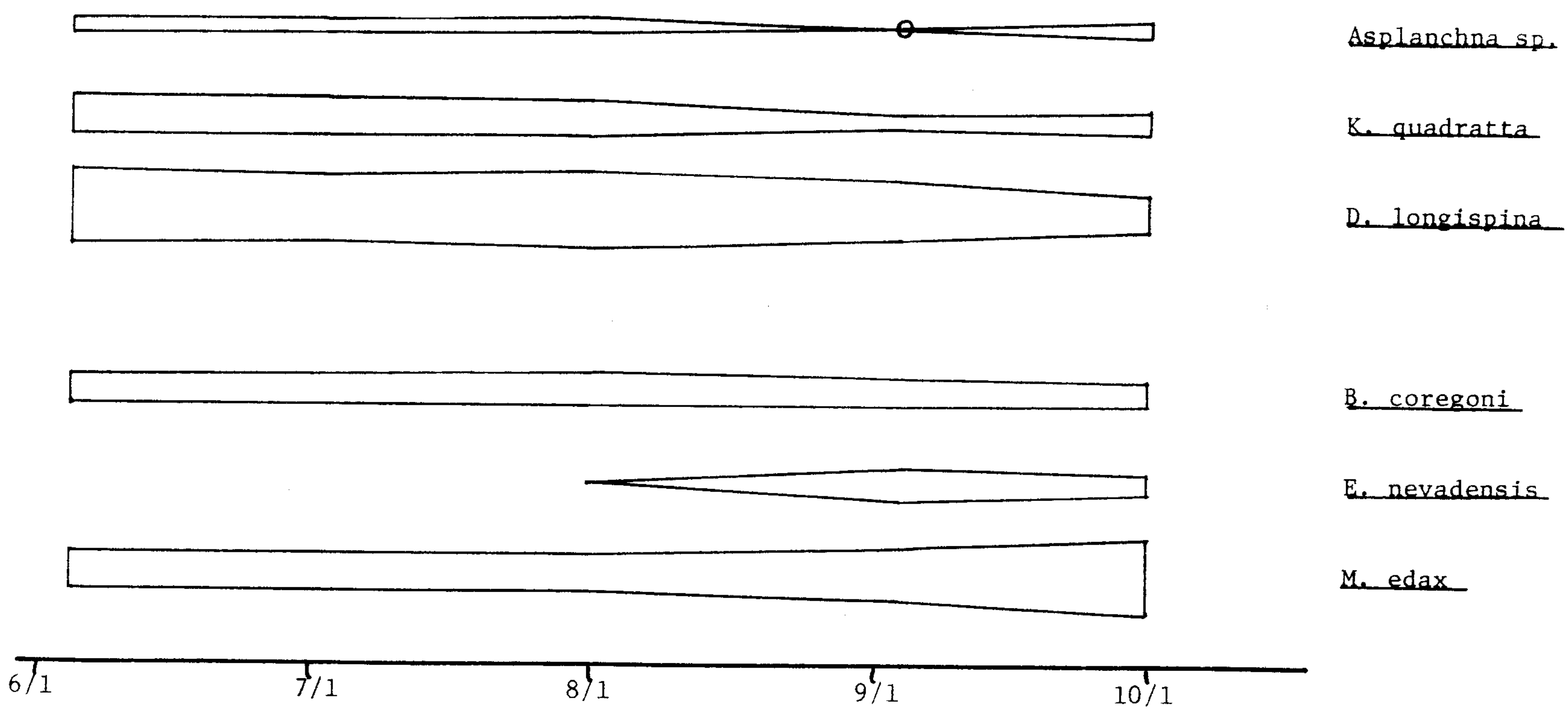

Figure 5 (cont.). Matanuska Lake 1973

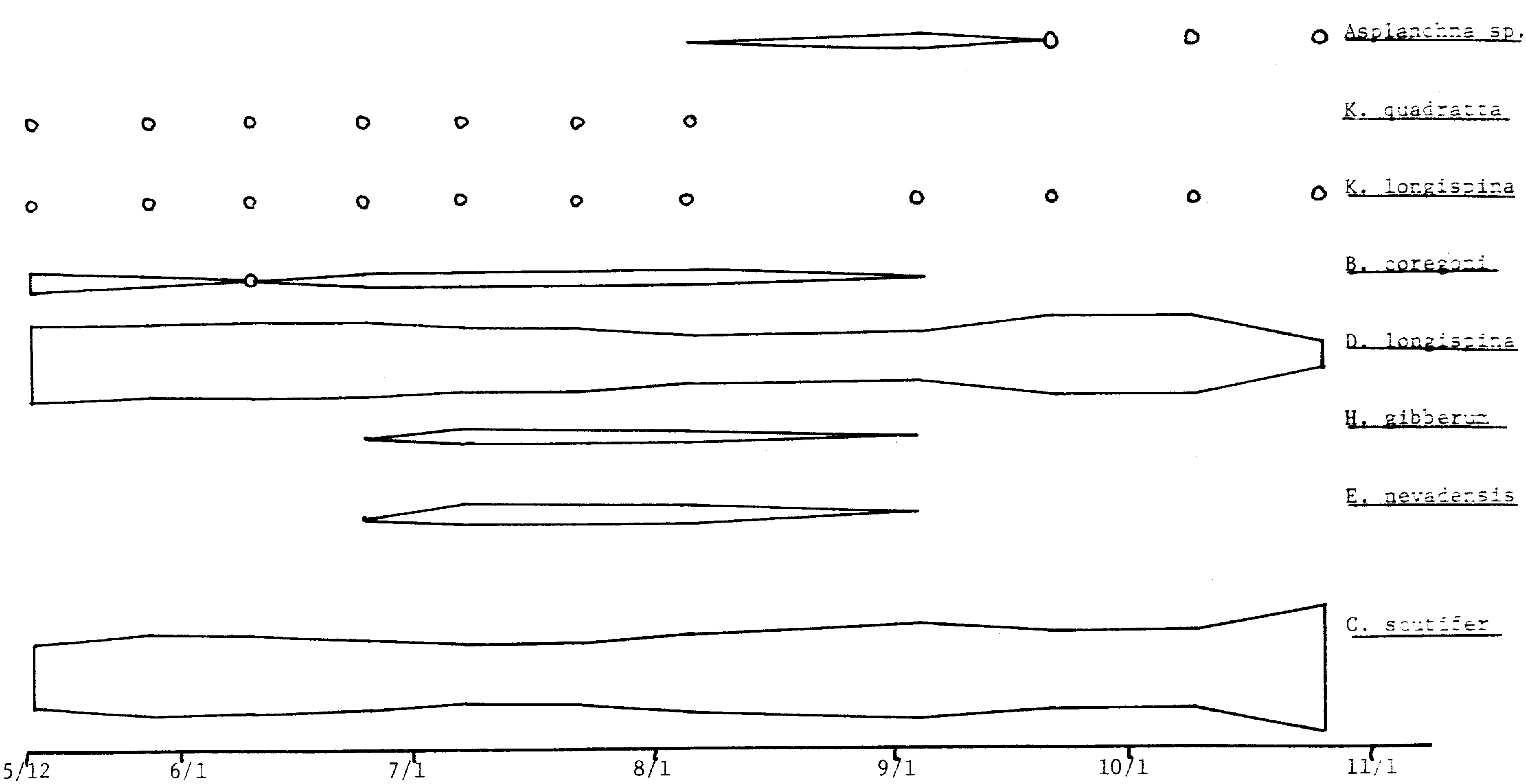

Figure 5 (cont.). Matanuska Lake 1974

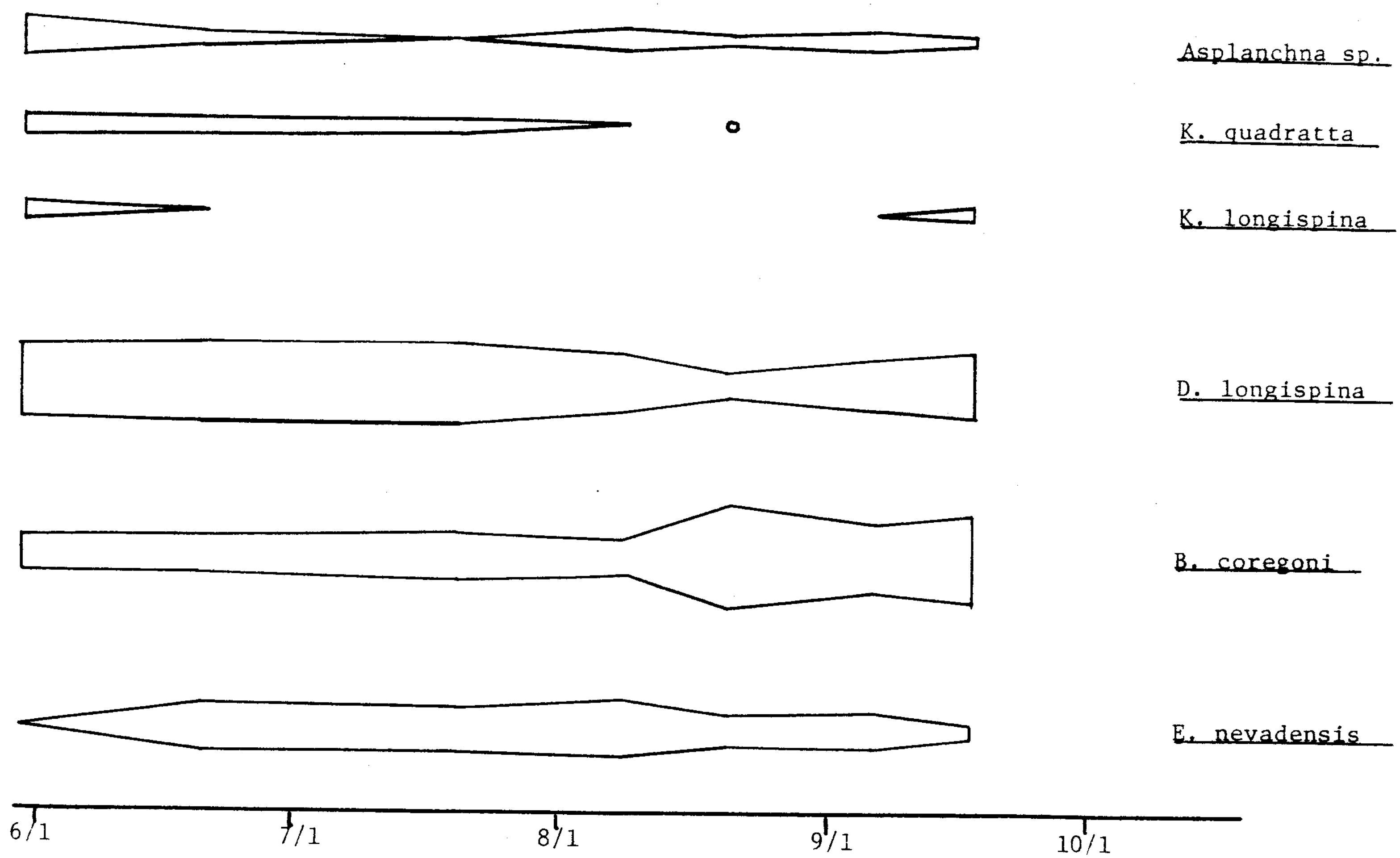

Figure 5 (cont.). Johnson Lake 1973

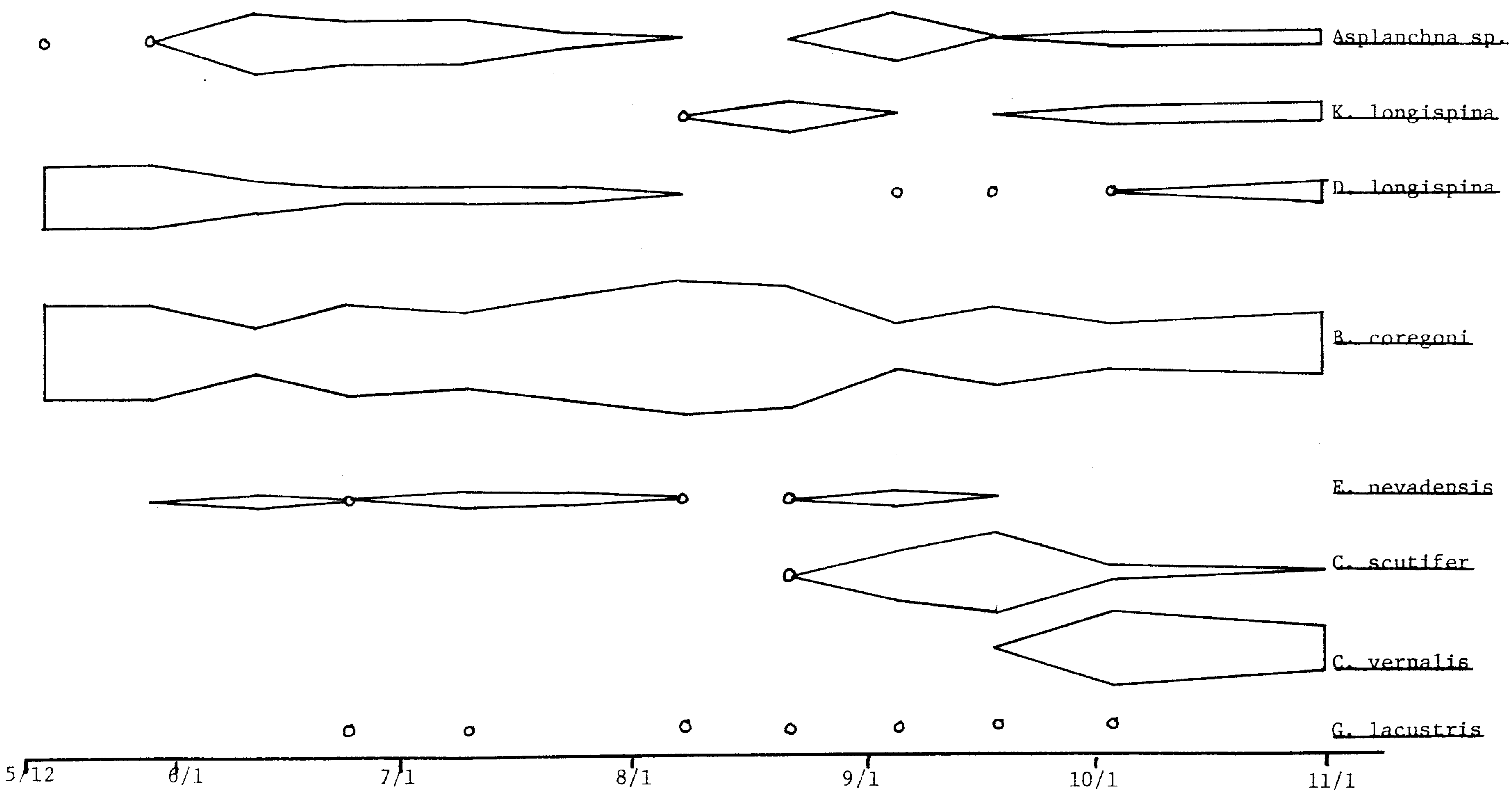

Figure 5 (cont.). Johnson Lake 1974

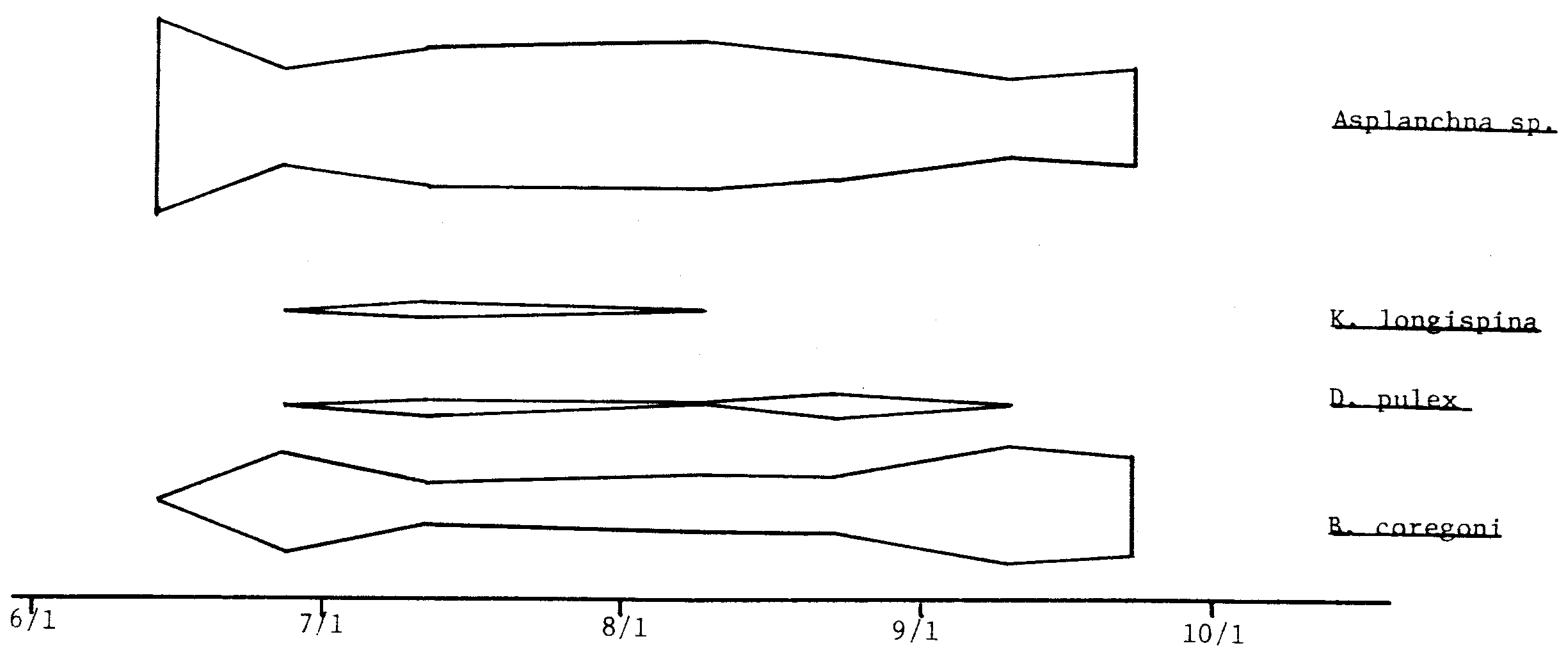

Figure 5 (cont.). Short Pine Lake 1973

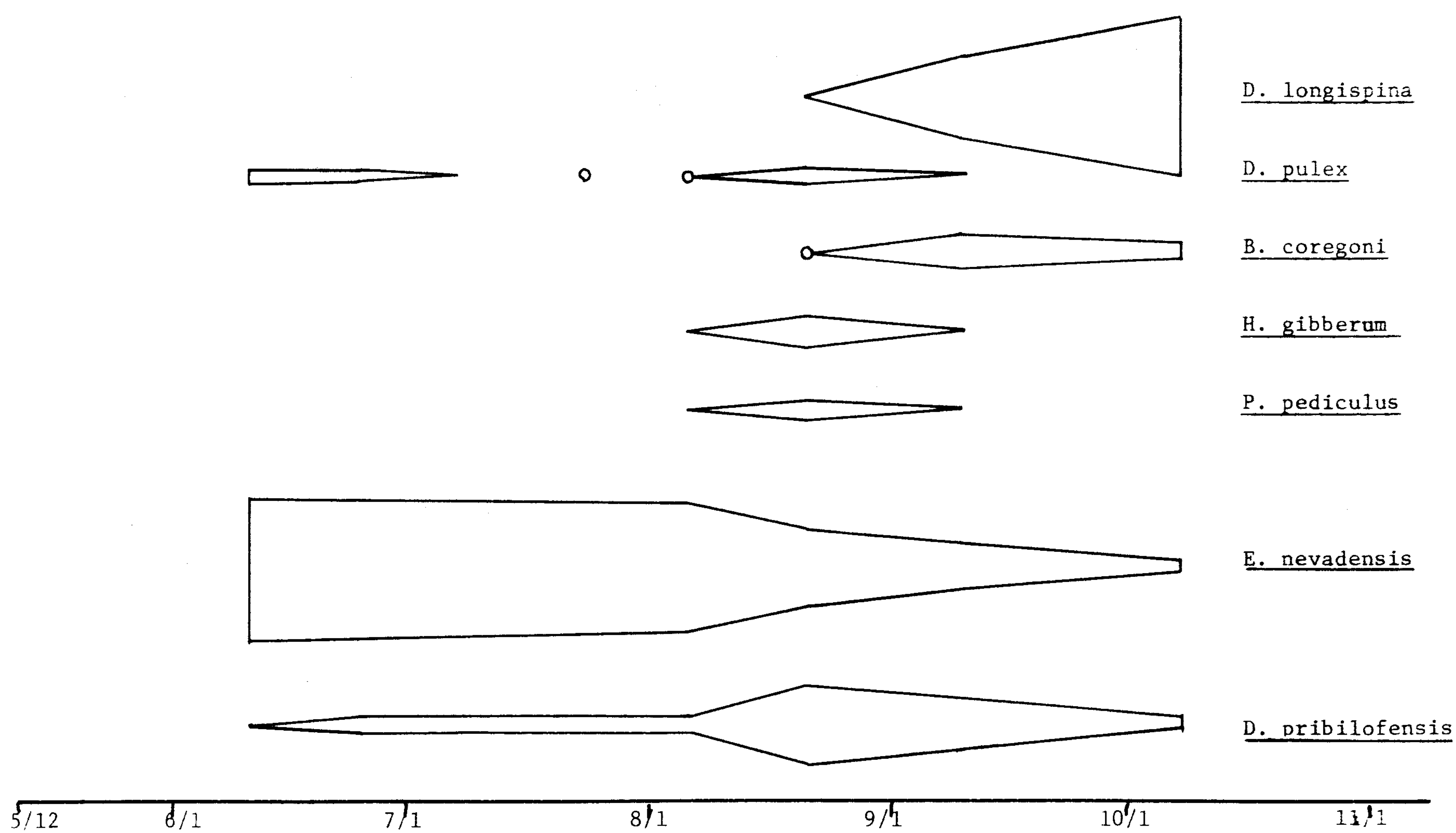

Figure 5 (cont.). Short Pine Lake 1974

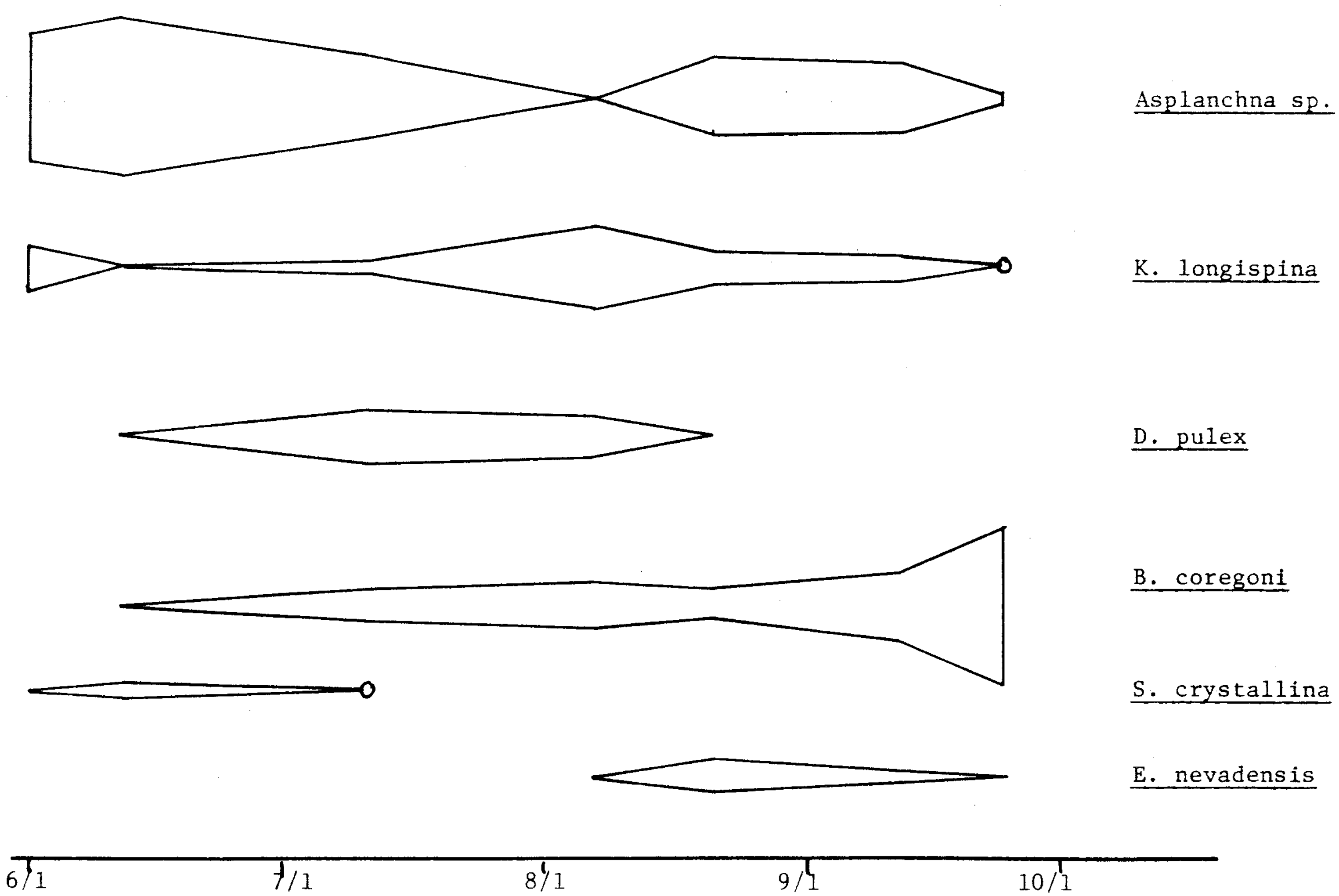

Figure 5 (cont.) Loon Lake 1973

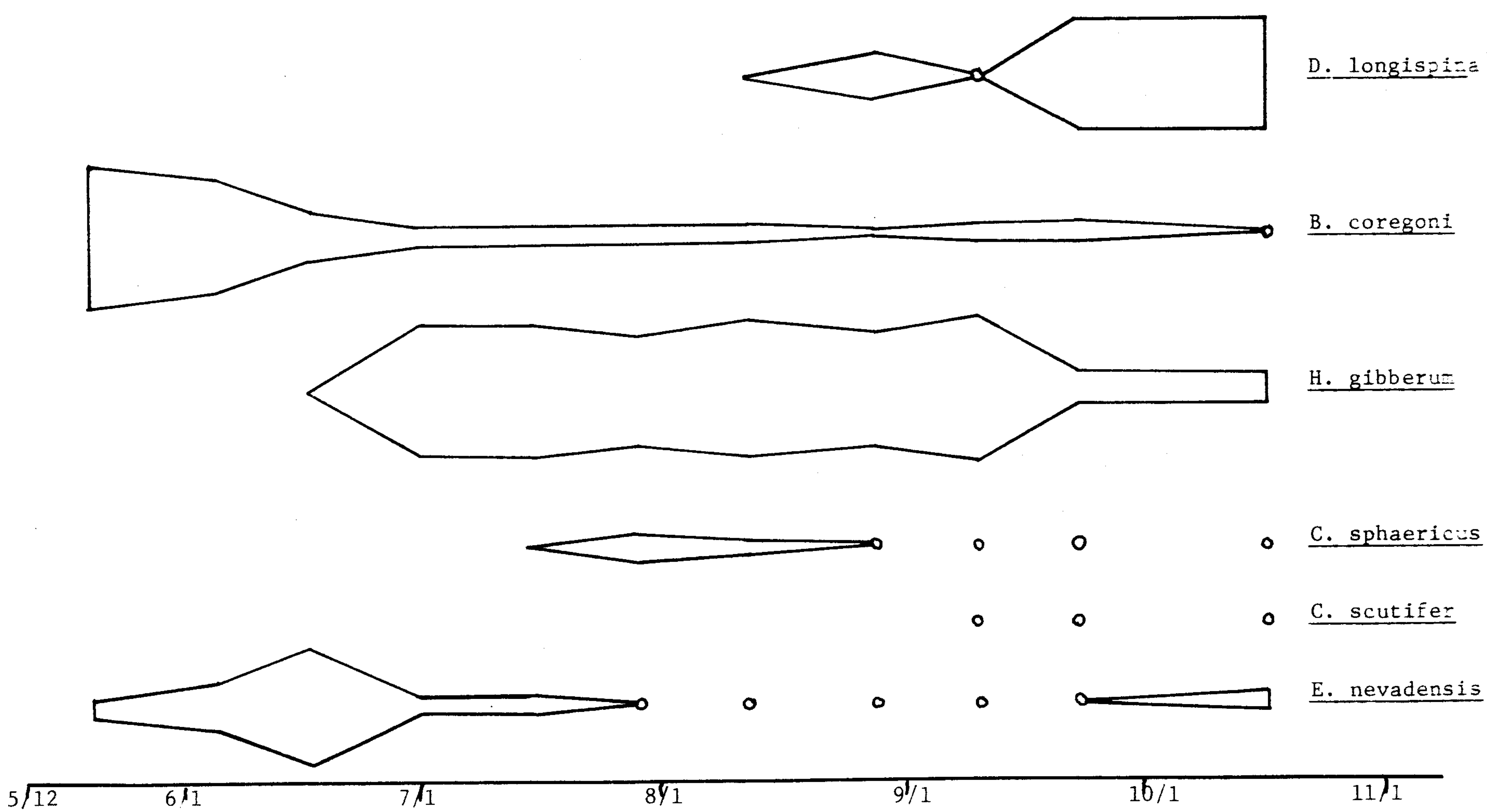

Figure 5 (cont.). Loon Lake 1974

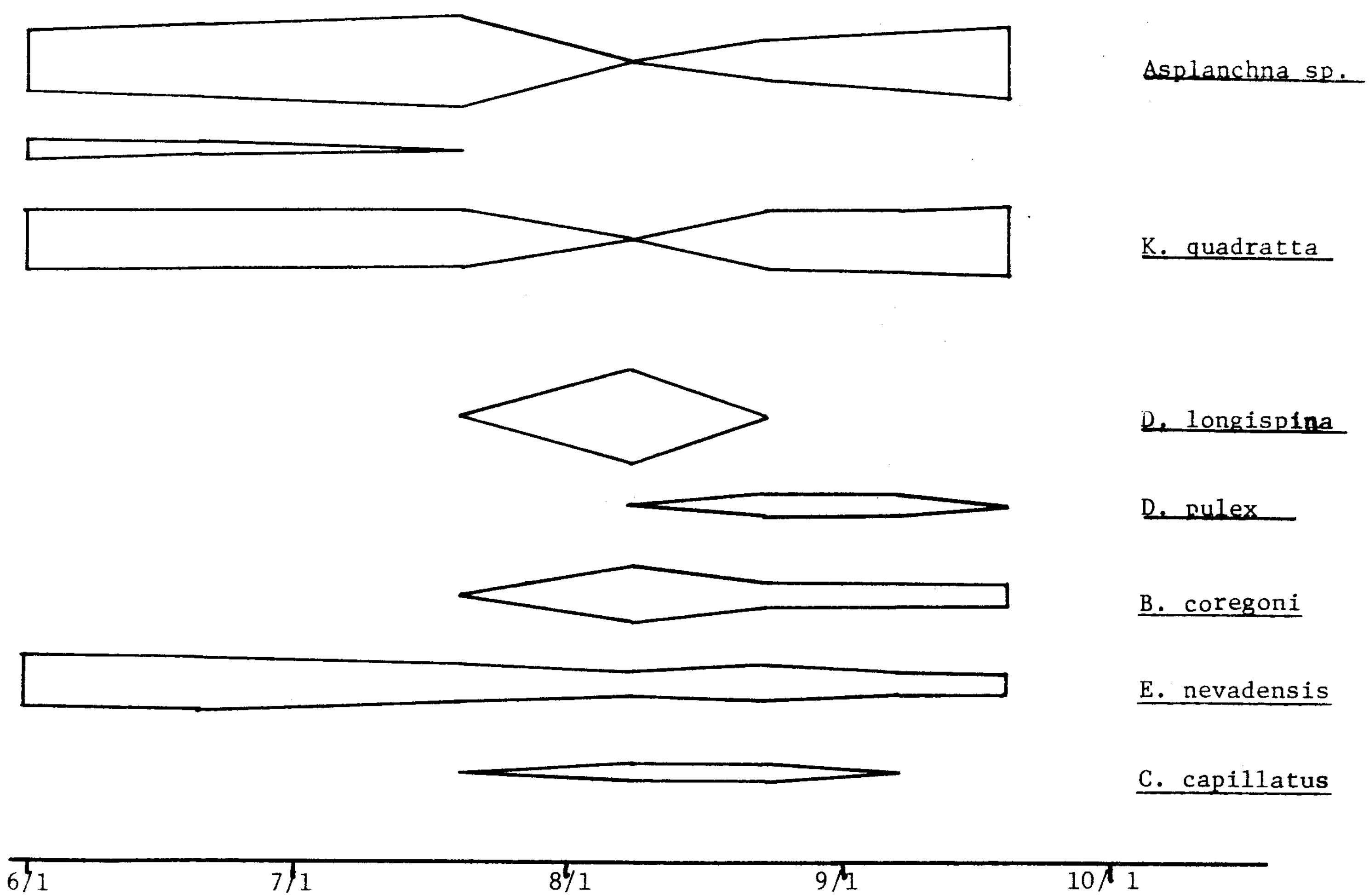

Figure 5 (cont.). Memory Lake 1973

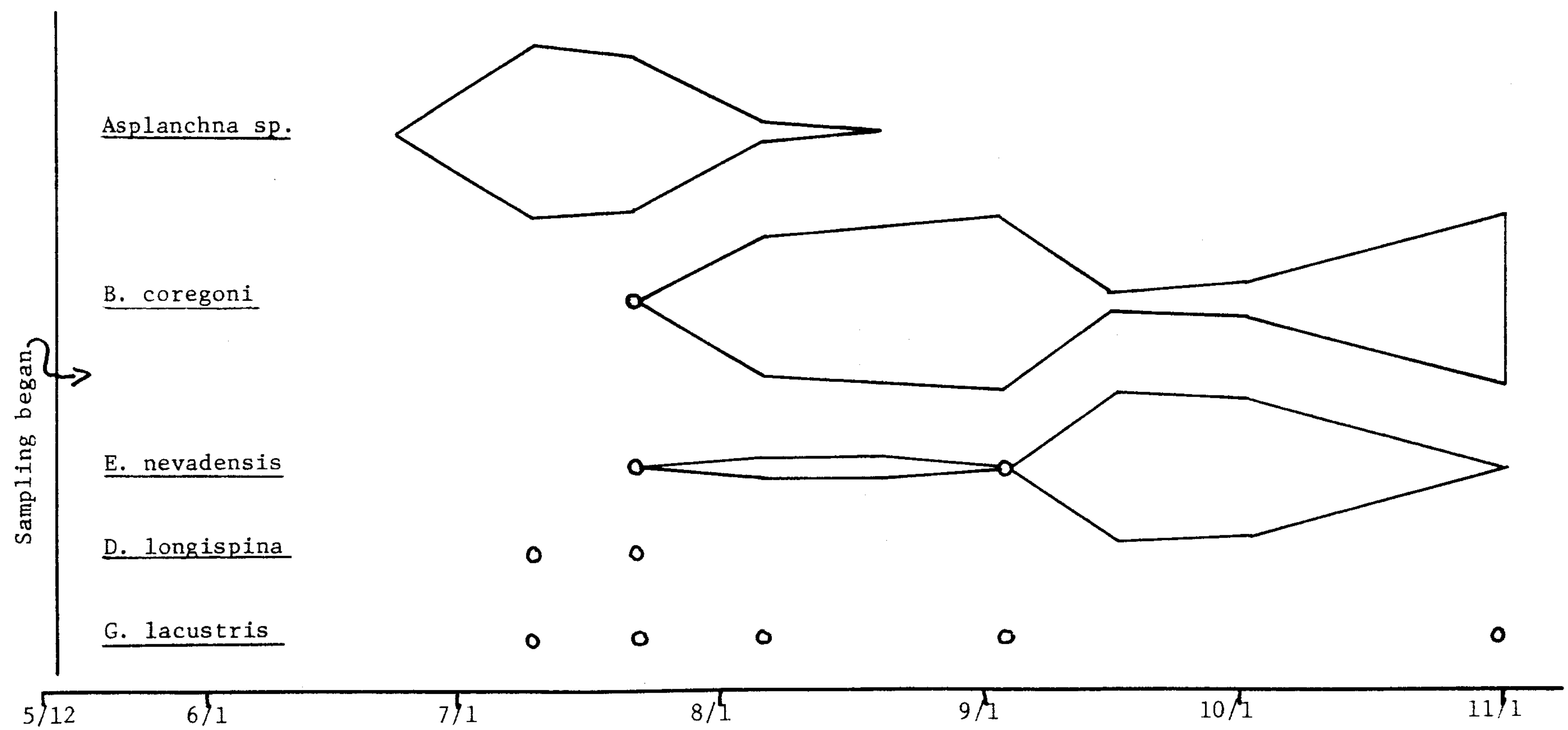

Figure 5 (cont.). Memory Lake 1974

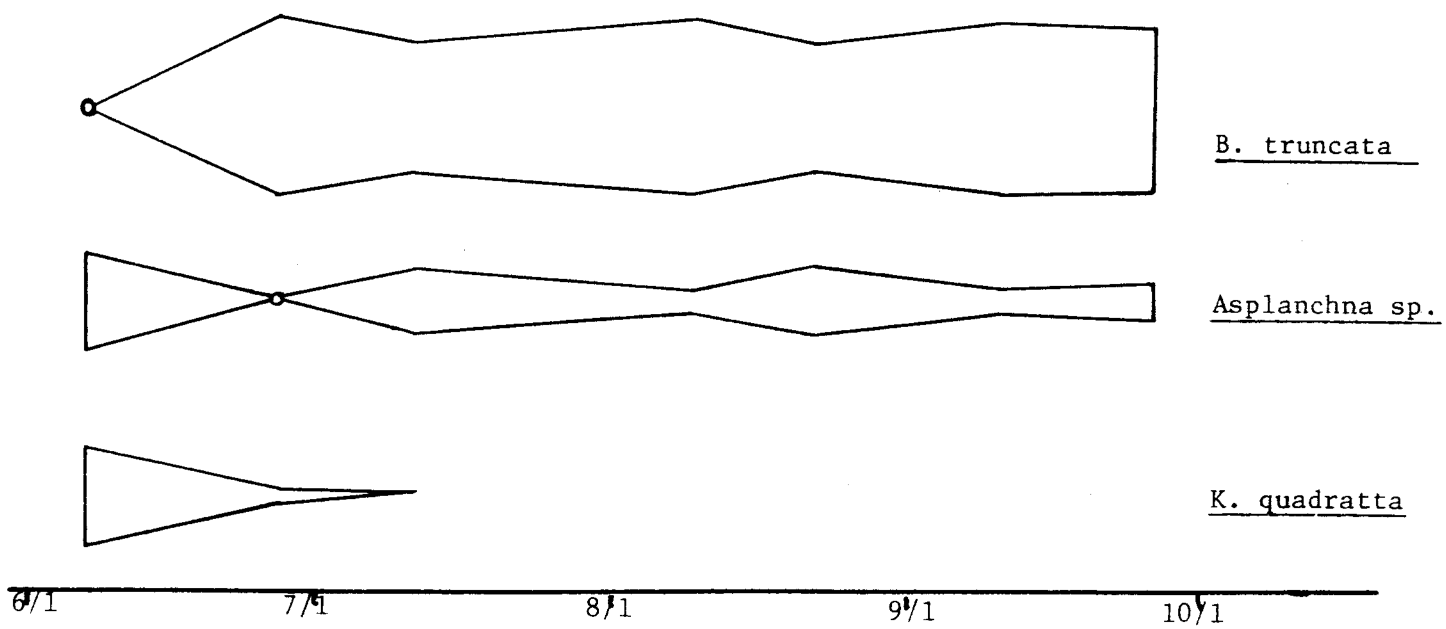

Figure 5 (cont.). Chirstiansen Lake 1973

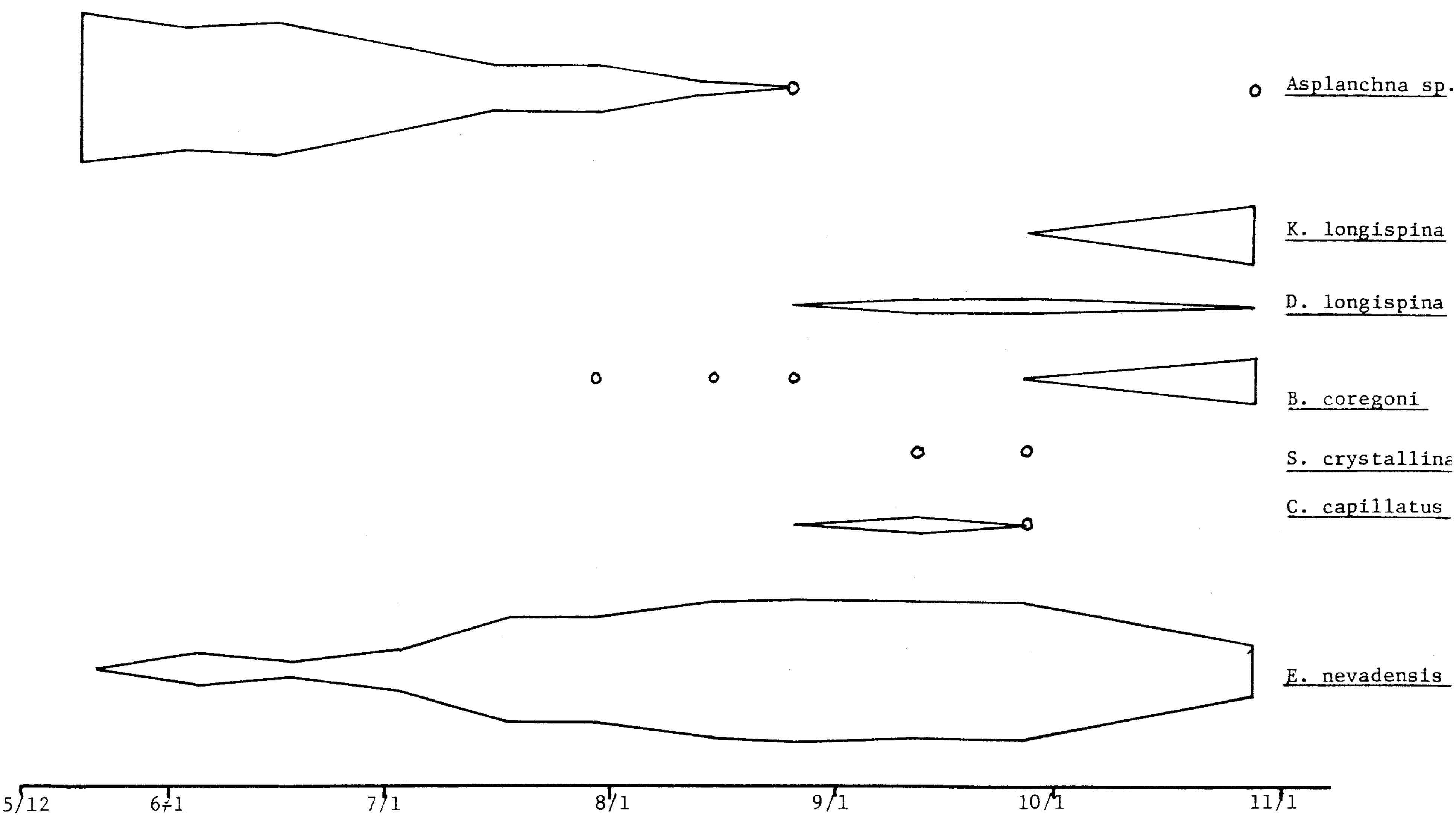

Figure 5 (cont.). Christiansen Lake 1974

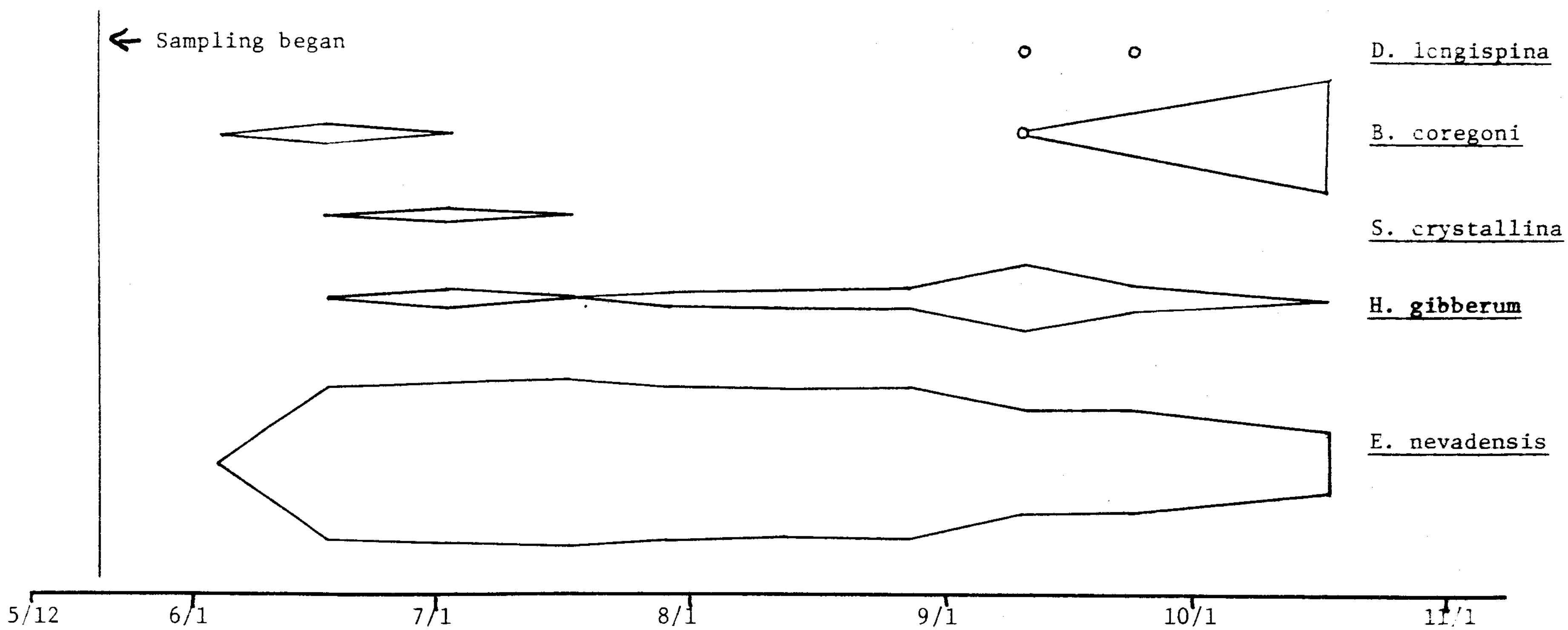

Figure 5 (cont.). Marion Lake 1974

established the season after chemical treatment and may imply a return to a more stabilized zooplankton community.

Rotifer populations in untreated lakes, however, did not account for a large percentage of the 1973 plankton community. This was observed in Matanuska, Johnson, Harriet, and Marion lakes, as shown in Figure 5. An exception is the relatively unproductive Memory Lake, where rotifers were abundant throughout the 1973 sampling season.

Low concentrations persisted in several treated lakes prolonging toxicity until fall, 1973. No organisms were found in Marion Lake in 1973 other than two insect larvae forms and recorded plankton abundance was actually only detritus. On the resumption of sampling in 1974, Marion Lake again seemed to be void of plankton until early June when crustacean species first appeared.

The lower depths of Christiansen Lake also remained toxic in 1973 and only rotifer and protozoan forms developed in the upper waters. Asplanchna sp. dominated the first samples taken from Christiansen Lake in 1974, the crustacean species establishing later in the summer.

In fall 1973, Johnson and Memory lakes were chemically treated with rotenone to remove undesirable fish populations. This treatment appeared to retard plankton abundance in Memory Lake;as early 1974 samples were void of organisms. Plankton did not begin to reappear until the end of June, beginning with Asplanchna sp., and succeeding to crustacean species. Plankton succession and abundance seemed typical of the pattern established in other chemically treated lakes.

Johnson Lake was treated at a concentration of 0.6 ppm and early detoxification occurred under winter ice. The first 1974 samples from Johnson Lake contained large amounts of algal detritus; however, Daphnia longispina and Bosmina coregoni were the dominant zooplankton present. Plankton abundance began to increase relatively early (mid-June) though the total plankton centrifuge volume remained below pre-treatment levels. Rotifers or protozoans have been the initial forms to appear in post-treatment samples from other rehabilitated study lakes; however, in Johnson Lake rotifers appeared only incidentally in early samples and did not increase in numbers until June. Dominance of crustacean species in Johnson Lake after chemical treatment is possibly due to early rotenone detoxification and the high nutrient concentration of the lake water.

For comparative purposes, two general categorical distinction does not reveal any apparent relationship to species composition. Most plankton species occurred commonly in lakes of both categories. Epischura nevadensis and B. coregoni, were found in all study lakes, and Asplanchna sp. was present in all but Marion Lake.

Several interesting exceptions were the appearance of Bursaria truncata in 1973 in Christiansen Lake, and the presence of Cyclops scutifer in only productive lakes in 1974. Major changes in species composition from 1973 to 1974 did not occur in most lakes and other than differences attributed to chemical treatment, resulting compositional changes may be natural.

The abundance of zooplankton available as food items to game fish stocked in the study lakes was approximated by separating all organisms in the 1974 identification samples into 1 mm size classes. This size distinction is based on studies by Galbraith (1967) and Brynildsen and Kempinger (1973) which noted the importance of zooplankton size as an influence upon rainbow trout food selection. These authors found that rainbow trout commonly select only plankton organisms greater than 1 mm in length.

Sizes greater than 1 mm were attained primarily by cladoceran and copepod species in the 10 study lakes. Among the cladocerans, D. pulex, D. longispina, and H. gibberum were predominantly from 1-2 mm in length, and the copepods, E. nevadensis and C. scutifer occurred at a similar size. Diaptomus pribilofensis exceeded 1 mm infrequently whereas the amphipod G. lacustris was predominately greater than 1 mm.

Abundance of the larger zooplankton size classes was derived from the species percentage composition in each study lake. The following figures represent percentage occurrence in the season's total zooplankton production of organisms 1 mm or greater in size. In Lucille Lake 62% were larger zooplankton, the majority of those being G. lacustris. In Johnson and Memory lakes, however, only 7 and 10%, respectively, were the larger organisms. In all other study lakes 24-40% of the total production were organisms larger than 1 mm. Although this substantiates the presence of larger zooplankton forms in all study lakes, the extent that they are utilized as food items by game fish is unknown.

The amphipod, G. lacustris, is a very capable swimmer inhabiting open water areas as well as the littoral zone. Low percentages of G. lacustris in catch composition does not reflect its abundance in study lakes because of its high avoidance to capture. Although Table 9 records G. lacustris appearing in only three lakes, it was observed in all study lakes except Christiansen and Marion. Its abundance in Lucille Lake in July and August, 1974 is most notable as the straining bucket of the plankton net was overflowing with amphipods in each tow. G. lacustris, which may attain a length of 20 mm and commonly exceeds 10 mm, may represent the single most important fish food item in many study lakes.

Organisms listed in Table 9 were all captured in open water over the maximum lake depth and should not be considered as the only zooplankton present in the respective lakes. Other zooplankton species may inhabit the littoral areas and niches other than open water that would not have been collected by the method employed in this study. It is quite possible any shallow water species present may be an important food item for rearing rainbow trout and coho salmon.

Environmental Impact of Rotenone Treatment on Two Matanuska Valley Lakes

The present practice of chemically treating lakes just before formation of winter ice cover is known to significantly reduce the deterioration rate of rotenone. Since this prolonged toxicity is believed to hinder re-establishment of invertebrate organisms in the productive season following rehabilitation, a study was initiated to determine the severity of the detrimental effects of rotenone on those organisms.

Pre-treatment assessment of plankton and benthic communities in Johnson and Memory lakes began on May 31, 1973. This pre-treatment data and project design are discussed by Kalb (1974).

Johnson and Memory lakes were chemically treated in September, 1973 with 0.6 ppm and 0.8 ppm Pro-Noxfish to remove resident fish populations. Duration of rotenone toxicity in the two lakes was determined by using live fish suspended in cages and the chemical test for rotenone as described by Post (1955). By February 26, 1974 the concentration in Johnson Lake had dropped to approximately 0.2 ppm as determined by the chemical method. Chinook salmon fingerling, O. tshawytscha, were suspended in cages at 10 foot intervals to the bottom on April 1, 1974. After four days all fish were still alive indicating detoxification had occurred.

Memory Lake still retained slightly greater than 0.2 ppm rotenone when tested on February 26, 1974. Chinook salmon were similarly suspended in Memory Lake on April 1 at the 5 and 12-foot levels; however, 50% mortality was incurred by the third day in the bottom cages. On the fourth day 80% of the fish had died at both depths, suggesting toxic levels of rotenone were still present. Adequate concentrations of dissolved oxygen were found at all depths.

A control group of fingerling was also suspended in an untreated lake with no loss of fish.

Comprehensive limnological sampling was continued in this job segment to monitor the re-establishment of invertebrate organisms following detoxification.

The first plankton hauls in Johnson Lake, taken on May 15, 1974 contained a very low centrifuge plankton volume of less than 0.1 ml. Mean volume did not increase above 1 ml until June 24, 1974 when a measurement of 3.5 ml was obtained. At this time the recovery of the plankton community seemed established and centrifuge volumes increased until August 6, 1974.

In 1973 pre-treatment centrifuge volumes from Johnson Lake were higher than in 1974, beginning at 2.9 ml on May 30, 1973 and reaching a peak of 8.1 ml on June 20, 1973. Average centrifuge volume was also greater in 1973, 4.4 ml compared to 2.01 ml in 1974.

Species composition of Johnson Lake following chemical treatment was similar to pre-treatment patterns (Figure 5). Two species of copepods, C. scutifer and C. vernalis, were new to Johnson Lake in 1974.

Plankton sampling began May 14, 1974 on Memory Lake but no organisms were recorded until June 24 when Asplanchna sp. appeared. Species composition had changed substantially from 1973 and only two crustacean forms appeared by July. D. longispina occurred only incidentally in July samples. An increase in centrifuge volume of the July 22, 1974 sample corresponds to the appearance of the crustacean species, yet seasonal centrifuge volumes remained slightly less than pre-treatment values.

G. lacustris, were captured in both lakes indicating a substantial increase in abundance from the previous year. This increase is probably due to the absence of fish grazing on the amphipods.

The reduced abundance of organisms in the two lakes and early absence of zooplankton in Memory Lake implies that rotenone treatment and the prolonged toxicity is detrimental to the return of a stabilized plankton community. Decreased plankton abundance and changes in species succession were also recorded in 1973 for study lakes chemically treated the previous fall. This was more thoroughly discussed in the section on limnological studies and further substantiates the above contention.

Low nutrient value of lake waters may also influence the re-establishment rate of zooplankton. Changes in species composition were more notable among lakes of low productivity. Plankton abundance in these lakes remained suppressed for a longer period of time. Productive lakes also reflected the detrimental effects of rotenone treatment but seemed to recover more rapidly.

Bottom samples were taken along transects in Johnson and Memory lakes in both 1973 and 1974. Invertebrate organisms in the 1973 samples have been identified to genus but 1974 samples remain unprocessed. A summary of the pre- and post-treatment bottom data will be presented in the following job segment after samples for both years have been analyzed.

Plankton and bottom sampling will resume in 1975 after breakup of winter ice cover.

ACKNOWLEDGEMENTS

The author would like to extend his appreciation to Roger Nash and Jacqueline LaPerriere of the Institute of Water Resources, Universtity of Alaska, for their assistance in identifying plankton and benthic organisms.

LITERATURE CITED

Brynildson, O.M., and J.J. Kempinger. 1973. Production food and harvest of trout in Nebish Lake, Wisconsin. Wis. Dept. Nat. Resour. Tech. Bull. Vol. 56: 20 pp.

Galbraith, M.G. 1967. Size selective predation on daphnia by rainbow trout and yellow perch. Trans. Am. Fish. Soc. 96(1): 1-10.

Kalb, C.J. 1974. Population studies of game fish and evaluation of managed lakes in the Upper Cook Inlet drainage. Fed. Aid in Fish Restoration, Annual Performance Report, 1973-1974. Preject F-9-6, Vol. 15: 23 pp.

Post, G. 1955. A simple chemical test for rotenone in water. Prog. Fish Culturist, 17(4): 190-191.

Redick, R. 1970. Inventory, Cataloging and population sampling of the sport fish and sport fish waters of the Cook Inlet drainage. Fed. Aid in Fish Restoration, Annual Report of Progress, 1969-1970, Project F-9-2, Vol. 11: 189-210.

Ricker, W.E. 1958. Handbook of computations for biological statistics of fish population. Bull. Fish. Res. Bd. Canada, Vol. 119: 330 pp.

Ryder, R.A., S.R. Kerr, K.H. Loftus, and H.A. Regier, 1974. The morphoedaphic index; a fish yield estimator-review and evaluation. J. Fish. Res. Bd. Canada, 31(5): 663-688.

Smith, S.F., T.G. Halse, G.E. Stringer, and R.A.H. Sparrow. 1959. The development and initial testing of a rainbow trout stocking formulae in British Columbia lakes. Fish. Mgt. Rpt. B.C. Fish and Wildlife Branch, Vol. 60: 18 pp.

Watsjold, D. 1975. Inventory, cataloging and population sampling of the sport fish and sport fish waters in Upper Cook Inlet. Fed. Aid in Fish Restoration, Annual Performance Report, 1974-1975. Project F-9-7. Vol. 16 (In Press).

Prepared by:

Carl J. Kalb
Fishery Biologist

Approved by:

s/Wm. Michael Kaill, Chief
Sport Fish Research

s/Rupert E. Andrews, Director
Division of Sport Fish