Distribution of Juvenile Chinook, Coho and Sockeye Salmon in Shuswap Lake — 1978-1979; Biophysical Inventory of Littoral Areas of Shuswap Lake, 1978

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DISTRIBUTION OF JUVENILE CHINOOK, COHO AND SOCKEYE SALMON IN SHUSWAP LAKE - 1978 - 1979; BIOPHYSICAL INVENTORY OF LITTORAL AREAS OF SHUSWAP LAKE, 1978.

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ABSTRACT

Littoral rearing distribution and migration patterns of juvenile chinook, coho and sockeye salmon in Shuswap Lake are examined. Two years of beach seining results indicate that juvenile salmon rear primarily in the vicinities of Mara Lake-Sicamous Narrows, southern portions of Salmon Arm (only until the late spring), Sicamous Narrows to Cinnemousun Narrows and the area near the outlet of Shuswap Lake (Adams River). It is also evident that in the cycle year large concentrations of sockeye juveniles may, in some areas, displace rearing coho and chinook.

Marking studies show that young chinook and coho rearing in the Sicamous Narrows area may migrate back into Mara Lake, or swim up the eastern shores of Shuswap Lake to rear in Anstey Arm before moving through Cinnemousun Narrows and along the southern shore of the main arm of Shuswap Lake toward the outlet and the Thompson River.

A biophysical lakeshore inventory to define important zones with respect to potential salmon habitat was carried out. This revealed that not all foreshore areas designated as excellent fish habitat are heavily utilized and that many zones classified as poor habitat are located along primary migration routes for juvenile salmon.

RESUME

La distribution d'élevage littorale et les modèles de migration de jeunes saumons chinook, coho, et sockeye du lac Shuswap ont été examinés. Les résultats de prises à la seine de plage durant deux années indiquent que les jeunes saumons se cabrent principalment dans les environs de Mara Lake - Sicamous Narrows, les portions sud de Salmon Arm (seulement la fin du printemps), Sicamous Narrows à Cinnemousin Narrows, et l'étendue près de la débouchée du lac Shuswap (Riviere Adams). Il est aussi evident que dans l'année cycle les concentrations énormes de jeunes sockeyes peuvent, dans quelques étendues, déplacer les cohos et 'les chinooks séjournant.

Les études de marquage démontrent que les jeunes chinooks et cohos séjournant dans les entendues de Sicamous Narrows, peuvent émigrer dans le lac Mara, ou peuvent se deriger vers les rivages de l'est du lac Shuswap pour se cadrer dans Anstey Arm avant de se dériger vers Cinnemousin Narrows et le long de la rivage sud de l'étendue principale du lac Shuswap vers la débouchée et la rivière Thompson.

Une inventaire biophysique des rivages du lac a été étudiée pur définir les zones importantes d'habitat d'élevage pour les saumons. Cette étude a révelé que tous les étendues decrivant zones d'habitats d'élevage excellentes ne sont pas tous utilizés et que plusieurs étendues classifiés comme zones d'habitats d'élevage mediocres se situent le long des principales routes de migration des jeunes saumons.

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

Shoreline development of Shuswap Lake for industrial, residential and recreational purposes is increasing rapidly. Expanding timber harvesting operations in the Shuswap Lake watershed have created a demand for suitable landing and log storage sites along lake foreshore areas. The desirability of the Shuswap area as a retirement or recreational residence has resulted in a population growth in the area (6%) which is more than twice as great as the Province of British Columbia as a whole (Harrison, 1977). The greatest demand for subdivision property has naturally occurred where lakeshore access is readily available. Marinas, resorts, and service industries in the Shuswap area are also expanding in response to increasing recreational demands, and many of these businesses are directly dependent on shoreline areas in Shuswap Lake.

Several species of Pacific salmon utilize the Shuswap Lake watershed (ten year average salmon escapements are: chinook (*Oncorhynchus tshawytscha*) 13,446; coho (*O. kisutch*) 5,631; sockeye (*O. nerka*) 1,598,550 (cycle year); and pink (*O. gorbuscha*) (odd year) 810). (Brown *et al*., MS 1979). Juvenile chinook, coho and sockeye salmon utilize the foreshore areas extensively for rearing and migration purposes. Serious resource use conflicts may therefore develop unless shoreline areas essential to the production of juvenile salmon are identified and preserved. Accordingly, a study was initiated in 1978 which was designed to define the primary salmon rearing and migration areas in the lake and to assess the entire foreshore area of the lake with regard to the rearing habitat which it affords young salmon. The 1979 study program was designed as a continuation of the 1978 research as it was undertaken to determine any changes in rearing distribution of chinook and coho salmon resulting from competition with the large number of sockeye salmon fry produced by the 1978 dominant cycle year and to define the rearing areas and migration patterns of juvenile salmon in the vicinity of Salmon Arm. The latter work was undertaken at the request of the Environmental Protection Service which was concerned with an extension of the Salmon Arm sewage outfall and in response to proposed foreshore developments along the Salmon Arm waterfront.

This report presents the results of the two year lake sampling program as well as describing the biophysical inventory of Shuswap Lake completed in 1978. The inventory, an assessment of the relative value to rearing or migrating juvenile salmonids of foreshore habitat in the lake, is discussed in relation to use of the lakeshore areas by juvenile chinook, coho and sockeye salmon in 1978 and 1979.

1. METHODS

1.1 Lake Sampling

1.1.1 Fish Distribution

In 1978 foreshore utilization of Shuswap Lake by juvenile chinook and coho salmon was estimated by beach seining at 43 sites around the lake. Seine sites (Figure 1) were chosen with the intention of sampling representative littoral areas throughout the whole Shuswap Lake system. Seining was repeated 9 times during the period from April to October (Table 1) using two 30 x 2.5m beach seines (constructed of ½cm and 1cm stretched nylon mesh). If no salmonids were captured in the first set, a second set was made in the vicinity to ensure that no salmon were rearing or migrating near the site.

TABLE 1: BEACH SEINE SAMPLING DATES - SHUSWAP LAKE, 1978

Time Period	Date
1	Apr 4 - 5
2	Apr 25 - 27
3	May 16 - 18
4	May 30 - Jun 1
5	Jun 13 - 15
6	Jul 5 - 6
7	Jul 25 - 27
8	Aug 28 - 31
9	Oct 3 - 5

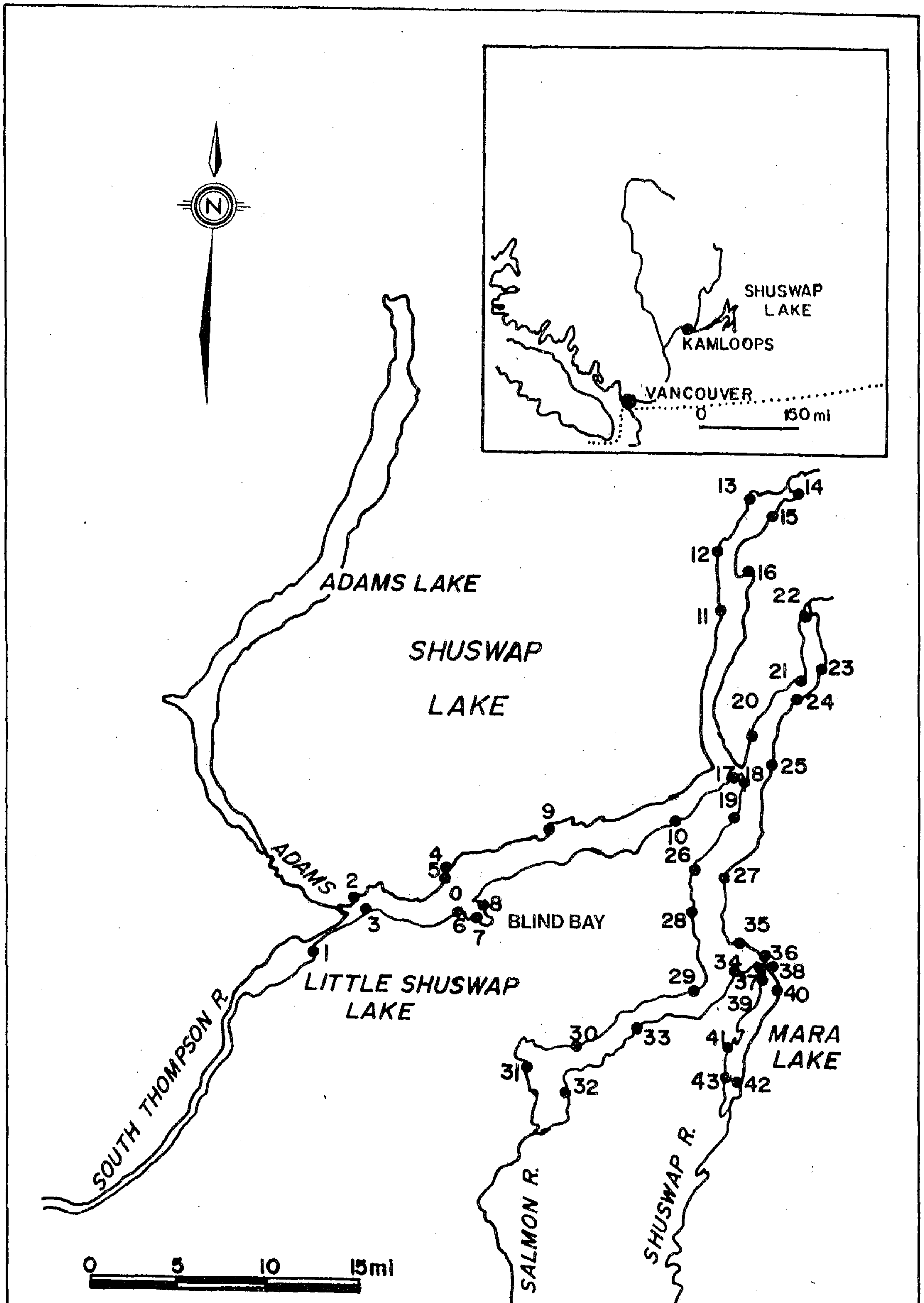


FIGURE 1 *SHUSWAP LAKE STUDY AREA - SEINING SITES 1978*

This procedure was repeated in 1979 although beach seining took place at only 27 sites around Shuswap Lake (Figure 1a). Seine sites were chosen on the basis of 1978 study results and to provide a representative sample of the littoral area adjacent to Salmon Arm. Seining was repeated 6 times during the period of greatest salmon foreshore utilization (mid-April to mid-July; Table 1a).

TABLE 1a: BEACH SEINE SAMPLING DATES - SHUSWAP LAKE, 1979

Time Period	Date
1	Apr 25 - 26
2	May 10 - 11
3	May 30 - 31
4	Jun 5 - 6
5	Jun 26 - 27
6	Jul 10 - 11

1.1.2 Temperature

In both 1978 and 1979 surface water temperatures were taken to the nearest 0.5°C at each seining site on each sampling date using a calibrated pocket thermometer. In 1978 temperature profiles were recorded at stations 4-7, 18-19, 35, 36, 39, and 40 (benthos and zooplankton sampling sites) during sampling periods 2, 5, and 7 using a YSI model 43 Tele-thermometer.

1.1.3 Zoobenthos Sampling

In 1978 dredge samples were collected at 2 and 5 m depths using a standard ponar dredge (1^2 ft. area) at sampling sites 4-7, 18, 19, 35, 36, and 39-41 during sampling periods 2, 5, and 7 (sites chosen were potential resource use conflict areas). Samples were preserved in 5% formalin and transferred to the Fisheries and Marine Service laboratory in Vancouver where they were sieved using 250 u mesh screens and identified to the genus level using a dissecting microscope.

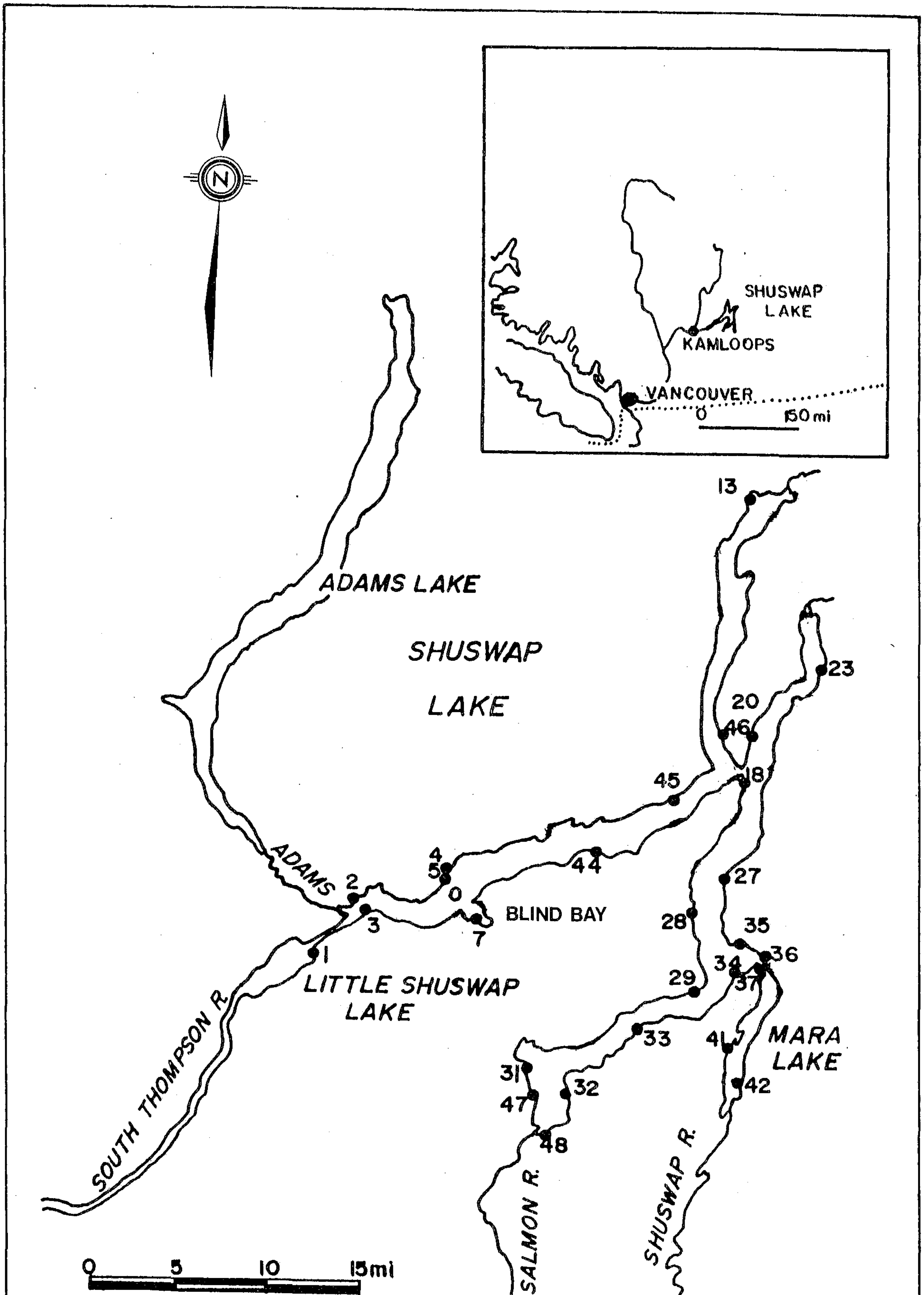


FIGURE 1a *SHUSWAP LAKE STUDY AREA - SEINING SITES 1979*

no benthos sampling was conducted in 1979.

1.1.4 Zooplankton Sampling

Ten meter vertical hauls were made at station 4-7, 18, 19, 35, 36, and 39-41 during sampling periods 2, 5, and 7 in 1978 using a Wisconsin net with a mouth diameter of 0.5 m and a pore opening of 250 microns. Sites chosen were the same as those selected for benthos sampling. Samples were preserved in 5% formalin and transferred to the Fisheries and Marine Service laboratory in Vancouver where they were identified to the species level using a compound miscroscope.

No plankton sampling was conducted in 1979.

1.1.5 Stomach Sample Analysis

In 1978 ten chinook salmon were taken for stomach content analysis at sites 1, 2 and 41 on April 26 (second sampling date); site 4-7, 18, 19 and 34 during June 13 - 15 (fifth sampling period); and sites 35 - 37 on July 26 - 27 (seventh sampling date). The sample fish were preserved in 5% formalin and transferred to the Fisheries Management Service laboratory in Vancouver where they were measured and their stomach contents were removed for analysis under a dissecting microscope.

No stomach content analysis was done in 1979.

1.2 Sicamous Narrows Dye-Marking Program

In order to determine the period of residency and migration patterns of young salmon in Sicamous Narrows, 3, 122 chinook and coho juveniles were seined from sites 36-39 on May 30, June 1 and June 13, 1978, and held in a 1:30,000 solution of Bismarck Brown Y dye (B.D.C. Chemical Co.) for 3 - 4 hours. The fish were kept in a 50 gal. plastic wading pool (partially immersed in lake water to ensure temperature regulation) into which compressed air was continuously bubbled for the duration of the dye-marking. Following the dyeing the marked fish, which were readily identifiable by their bright orange fins, were released back into the Narrows at station 36. A sample of 100 dyed fish was held for 24 hrs. in a marquisette livebox in order to determine marking mortality.

Sampling sites within and just outside Sicamous Narrows (34 - 41) were seined once a day for a week following dye-marking using the equipment described in Section 1.1.1 above, in order to determine how long marked fish remained within the Narrows area. Numbers of marked fish caught during regular sampling periods at other sites in Shuswap Lake were also recorded.

1.3 River Sampling

In addition to lake sampling, the South Thompson River between Chase and Kamloops was also sampled for the presence of rearing or migrating juvenile salmon in 1979. Six sampling sites were seined on June 14 using a 30 x 2.5 m beach seine (½ and 1 cm stretched nylon mesh). Surface water temperatures were taken at each seine site.

2. RESULTS

2.1 Lake Sampling

2.1.1 Fish Distribution

Juvenile chinook and coho salmon distribution determined by the 1978 beach seining program is shown in Figure 2. Seining results indicate that very few young salmon utilized the Shuswap shoreline areas before April 25 or after the sixth of July. The largest numbers of juvenile chinook and coho were caught during sampling period four (May 30 - June 1) and five (June 13 - 15). The greatest concentrations of fish were seined at stations 35-43 in Sicamous Narrows and Mara Lake, stations 24-26 near Cinnemousun Narrows, and stations 2, 3, and 6 near the outlet of Shuswap Lake. At some sampling sites (1-3, 5, 27, 35, 40-42) substantial numbers of young salmon were caught throughout the entire spring to early summer period (sampling dates 2-7) while at other locations few salmon were seined on any sampling date (stations 9-11, 16, 18, and 30).

The 1979 beach seining program determined the distribution of juvenile chinook, coho and sockeye as shown in Figure 3. Seining results indicate that relatively low numbers of chinook and coho salmon juveniles utilize the Salmon Arm area of Shuswap Lake (sites 31, 32, 47 and 48). No sockeye fry were caught during any of the sampling periods. Seine catches at sites 32, 33, and 29 suggest that salmon juveniles which originate in the Salmon River migrate along the southern shoreline of Salmon Arm toward Sicamous during late May and early June and reside in other portions of the Shuswap system thereafter. Large numbers of rearing and migrating salmon were found

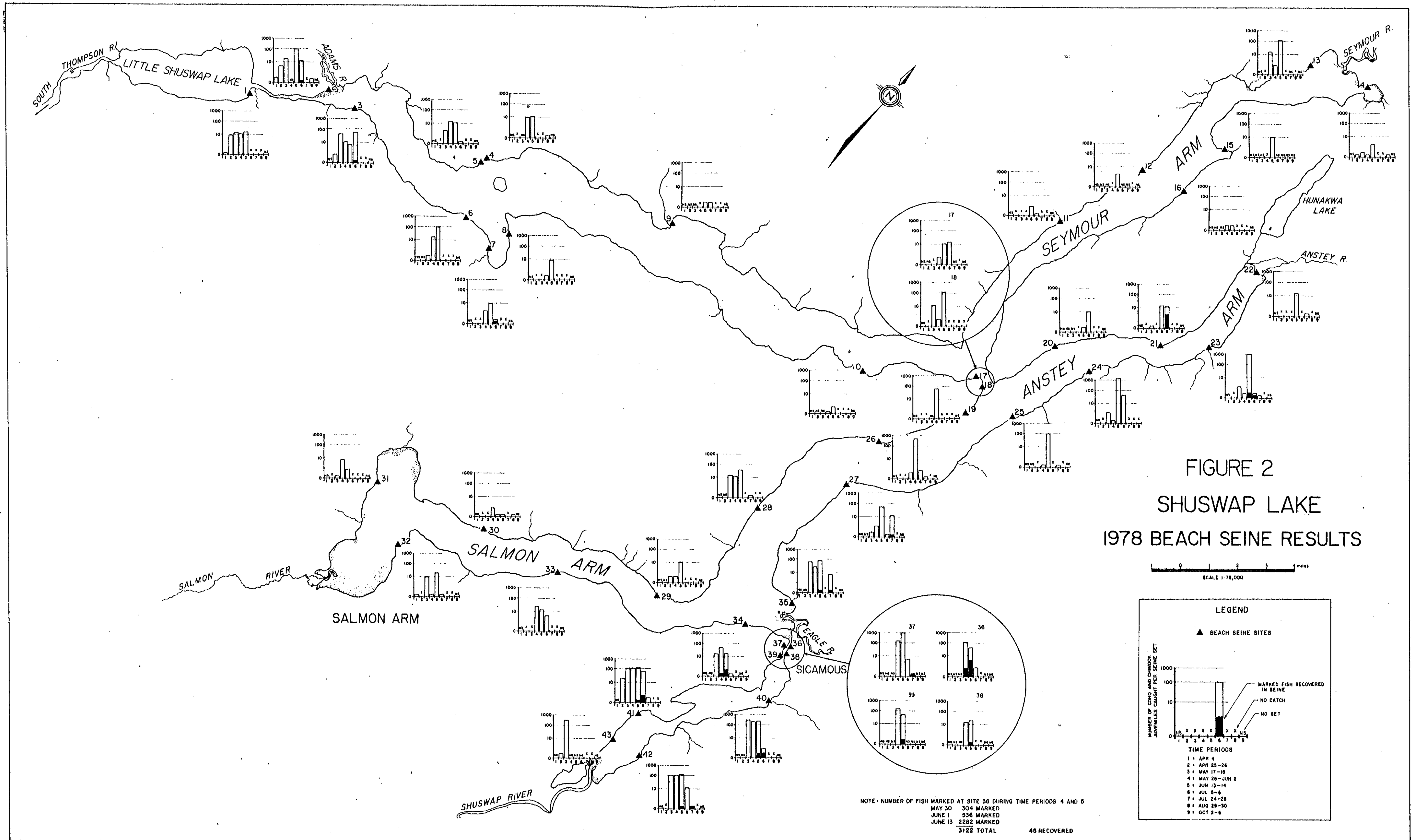


FIGURE 2
SHUSWAP LAKE
1978 BEACH SEINE RESULTS

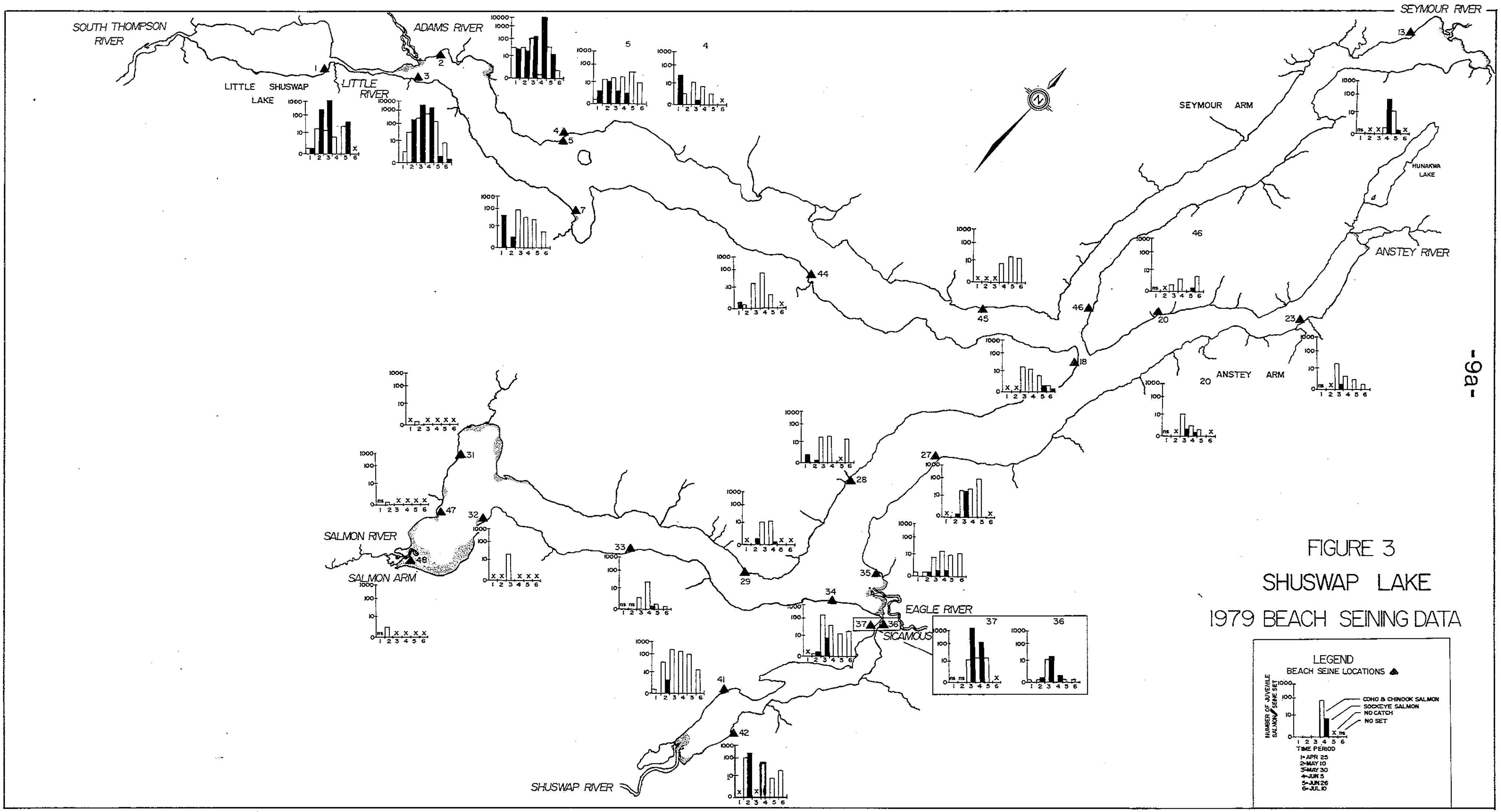


FIGURE 3
SHUSWAP LAKE
1979 BEACH SEINING DATA

in Mara Lake (sites 41 and 42), the vicinity of Sicamous Narrows (sites 34, 35, and 37) and south central Shuswap Lake (sites 1-3, 5, and 7). Moderate salmon catches were made at sites 4, 44, 45, 18, 13, 23, and 36. Utilization of foreshore areas at sites 46 and 20 was low.

Comparison of seining results in 1979 with those of 1978 suggests the following: In the vicinity of the Adams River and Blind Bay, chinook and coho salmon catches were much greater than those obtained in 1978. Sockeye fry were present in larger numbers than coho and chinook salmon until early June but their numbers declined toward the end of the seining season. The predominant species in 1979, sockeye, were only occasionally taken in beach seining activities during the 1978 season. In the northern region of Seymour Arm (site 13) sockeye fry predominated in catches in early June but more chinook than sockeye juveniles were seined in late June sampling. These results, when compared with those of 1978, suggest that sockeye fry may displace chinook fry during the littoral phase of their life cycle.

Juvenile sockeye were found in small numbers in foreshore areas adjacent to seining sites 44-46, 18, 20, 23, 27-29 and 33-35 in 1979. No sockeye fry were found at these sites in 1978. Chinook and coho catches at these sites in 1979 were comparable with those of 1978 except at stations 34 and 35: seine catches were higher in 1979 than 1978 at site 34 while at site 35 the opposite was found.

In the Salmon Arm area, seine catches of chinook and coho fry were higher in 1978 than 1979. Small numbers of fish were recorded from late April until early July in 1978 but in 1979 fish were caught only during mid to late May. No sockeye juveniles were seined in Salmon Arm in either 1978 or 1979.

Salmon catches in the Sicamous Narrows - Mara Lake region were good in both 1978 and 1979. However, seine catches at sites 36 and 42 were lower in 1979. At sites 36 and 37 sockeye were the predominant fish taken in 1979: they apparently displaced chinook and coho juveniles found occupying these sites in large numbers in 1978.

2.1.2 Temperature

Surface water temperatures recorded at beach seine locations throughout the 1978 sampling program are given in Table 2. Temperatures at all sites gradually increased during the summer until sampling period 7, when maximum temperatures were recorded (mean temperature recorded for all seine sites during time period 7 was 24.6°C). Thereafter, surface water temperatures gradually decreased.

For the 1979 sampling program, surface water temperatures recorded at beach seine locations are given in Table 2a. Again, temperatures at all sites increased as the summer progressed, however, those recorded in the vicinity of Salmon Arm (sites 31, 32, 47, and 48) remained close to the tolerance level for salmon (23-24°C; Brett, 1952) during the late June and mid-July sampling periods.

Temperature profiles recorded in 1978 at seine sites 4-7, 18, 19, 35, 36, 39, and 40 are presented in Figure 4. Profiles suggest that the development of a small thermocline occurs in Shuswap Lake as early as April 27, and that by July 26 a thermocline of 10-15°C is evident between 3 and 9 meters. Stations 36 and 39 did not exhibit any appreciable change in temperature from the surface to the lake bottom, due to the shallowness of Sicamous Narrows and the effect of a current passing through the Narrows from the surface outflow of Mara Lake. The shallowness of Captain's Village Marina (site 4) precluded any large change in water temperature.

2.1.3 Zoobenthos

Species diversity and abundance of benthic organisms determined by dredging at selected sites in 1978 in Shuswap Lake are presented in Table 3. Forty-nine taxa of benthic invertebrates were identified from samples taken in the lake during time periods 2, 5, and 7 (April 25-27, June 13-15, and July 25-27). Overall diversity was greatest during time period 5. The sampling sites with the greatest faunal diversity were stations 7, 18, 36, and 27 (21, 24, 21, and 20 taxa recorded respectively) in time period 2;

TABLE 2 SURFACE WATER TEMPERATURES RECORDED AT BEACH SEINE SITES - SHUSWAP LAKE, 1978

SEINE SITE	1	2	3	4	5	6	7	8	9	10	11	12	13	14
TIME PERIOD-TEMPERATURE														
1	4	5.5	-	-	-	-	-	-	-	-	-	-	-	-
2	6	7.5	7	-	8.5	-	8.8	8	-	-	8	-	8	9.5
3	10	11	9	-	12	11	12.5	14	-	-	13	-	13	15
4	10	-	12	12.5	13	14	14	13.5	-	-	14	14	13	13
5	12.5	16	16	16.5	16	16	16.5	16	17	-	14.5	16.5	17	17.5
6	17	21	21	22	20.5	22	22	22.5	22	22.5	21	22	23	23
7	20	25	23.5	24.5	24.5	25	25	26	26	25	25	-	25	26
8	22.5	22.8	-	21.4	-	21.4	21	21	21.4	21	20	19.5	19	19.5
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-

SEINE SITE	15	16	17	18	19	20	21	22	23	24	25	26	27	28
TIME PERIOD-TEMPERATURE														
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	7	7	5.5	-	4.5	8	7	8	-	-	8.5	-
3	-	-	13	12.5	12	-	11.5	11.5	10	11.5	10	12	11.5	14
4	13	15	16	14	-	13	12	11.5	11.5	13	12.5	13.5	12	12
5	17	16.5	16	16	15	17	16	16	16	16.5	17	16	17	14
6	-	21.5	23	23	22.5	21.5	22	22	20	21	23	23	22	23.5
7	-	24.5	24	23.5	23.5	24	23.5	23	22.5	24	24	21	21.5	20.5
8	-	20.5	19	19	19.5	19	19	19.5	19	19	19.5	20.2	19.7	20.5
9	-	-	-	-	-	-	-	-	-	14	-	-	-	14

SEINE SITE	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
TIME PERIOD-TEMPERATURE															
1	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-
2	-	9.5	10.5	13	9	10	10	-	-	-	9.5	-	10	10	10
3	11	11	14	15	12.5	12	12	-	-	-	-	14	14.5	11.5	12
4	14.5	15	14.5	15	15.5	14.5	12	14	12.5	-	12	14.5	14.5	14	-
5	15.5	18	18	18.5	18	16.5	15	15.5	14	-	-	16	16	15	-
6	21	22	23	21.5	22.5	22	24	20	21.5	22	-	20	23	19	-
7	23	25.5	24.5	25	24.5	24	22	23	22	24	-	26	25.5	25	24.5
8	20.8	21	21.7	21.4	20.5	-	20.8	-	-	-	-	21.7	21.4	21.7	21.4
9	-	-	-	-	-	14	-	-	-	-	-	14	14	-	-

TABLE 2a: SURFACE WATER TEMPERATURES RECORDED AT BEACH SEINE SITES- SHUSWAP LAKE, 1979

Seine Site	1	2	3	4	5	7	13	18	20	23	27	28	29	31	32
Date - Temp. ^{o}C															
Apr. 25	7	11	5	8	7	8	-	5	-	-	7	8	4	10	18
May 10	9	11	10	-	11	10	9	6	6	4	4	6	6	10	13
May 30	10	11	11	12	13	14	13	13	15	14	15	15	13	17	16
Jun. 5	15	15	14	14	14	14	13	13	13	14	14	15	14	17	17
Jun. 26	12	18	17	18	18	18	22	20	20	22	22	22	22	22	23
Jul. 10	17	20	18	20	19	18	21	20	20	20	19	20	20	22	22

Seine Site	33	34	35	36	37	41	42	44	45	46	47	48
Date - Temp. ^{o}C												
Apr. 25	-	4	9	10	-	11	11	4	4	-	-	-
May 10	-	7	9	11	-	13	12	6	8	6	12	11
May 30	16	16	16	15	14	14	-	12	13	13	15	16
Jun. 5	18	14	14	15	15	14	-	13	15	13	-	-
Jun. 26	20	21	22	20	19	20	21	20	21	21	22	24
Jul. 10	21	20	20	20	20	21	20	20	19	19	21	-

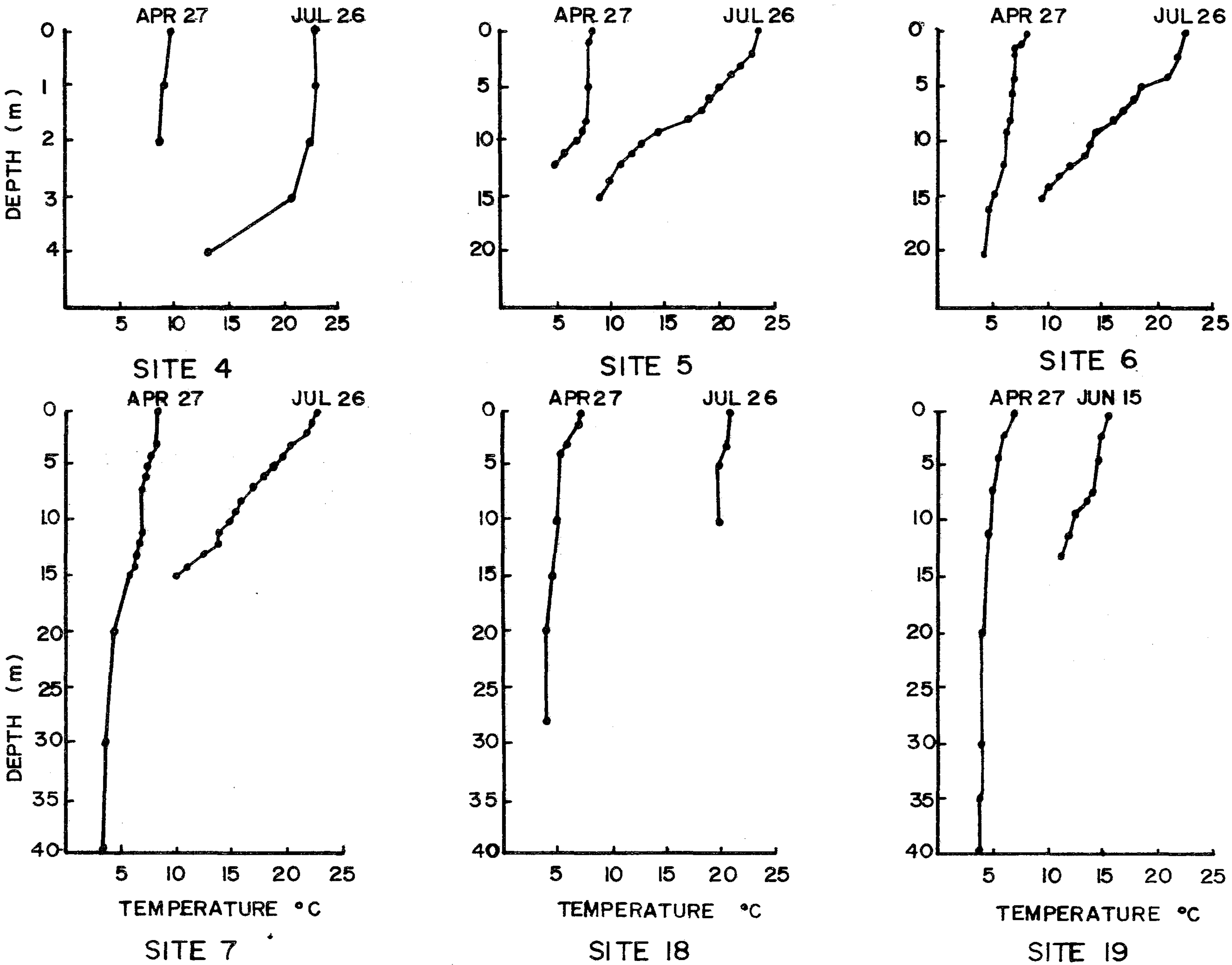


FIGURE 4 TEMPERATURE PROFILES - SHUSWAP LAKE 1978

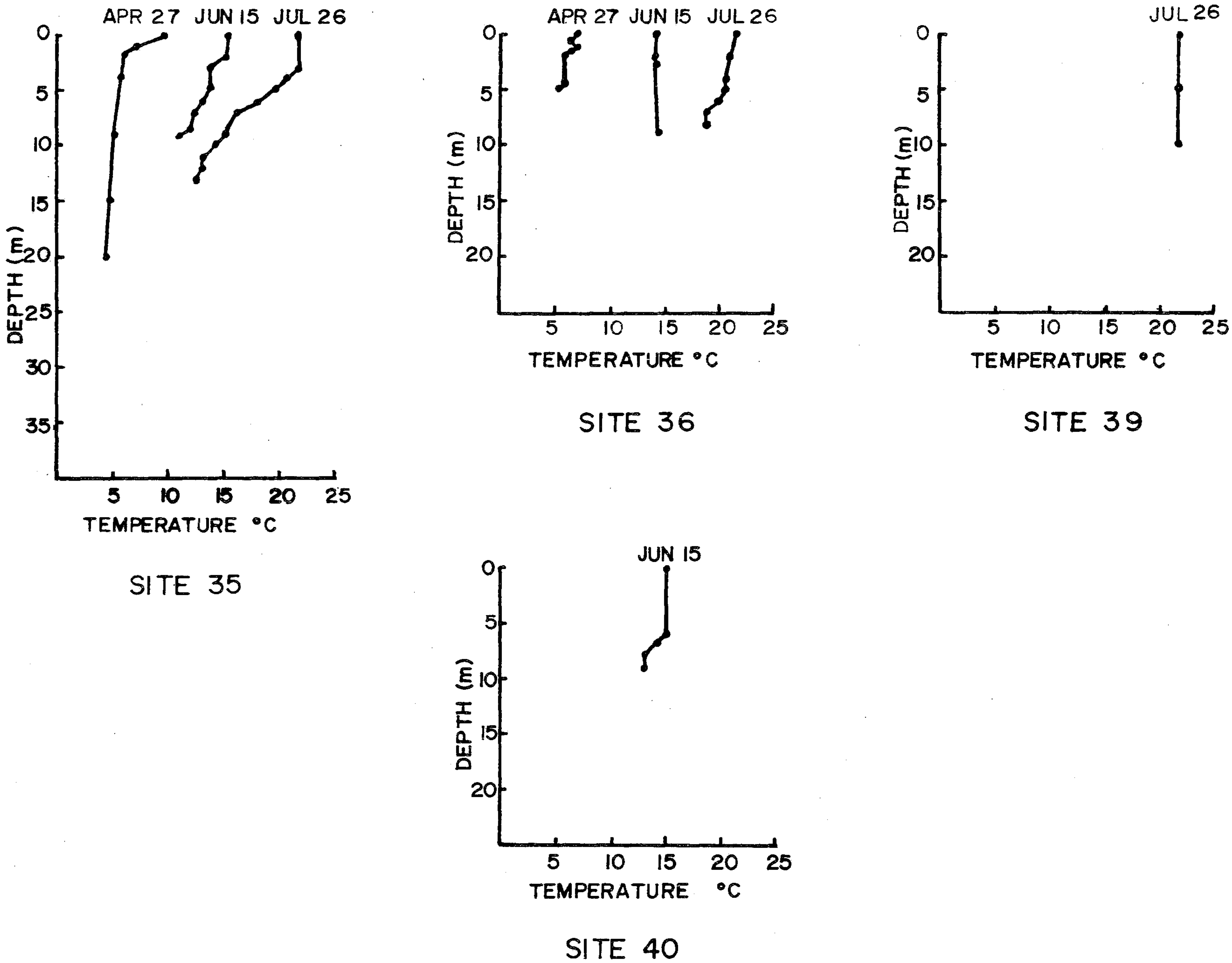


FIGURE 4 cont.

TABLE 3 - BENTHIC INVERTEBRATES - NUMBER OF ORGANISMS/m^2 - SHUSWAP LAKE, 1978

TIME PERIOD 2

SAMPLE SITE

ORGANISM	4		5		6		7		18		19		35		36		37		40		41	
	2m	3.5m	2m	5m	2m	5m	2m	5m	2m	5m	2m	5m	2m	5m	2m	5m	2m	3m	2m	5m	2m	5m
Phylum Coelenterata																						
Order Hydroida													14					114				
Phylum Platyhelminthes																						
Phylum Nematoda											300	1544			7436						1087	744
Phylum Tardigrada		72	1659	29	114	114	2517	114	57	143	14	172	1602	4004	343	515	86	858			2088	572
Phylum Annelida																						
Class Oligochaeta		14	114	29		458	228	1730		72	29	114	1115	1301	114		43	2574				
Class Hirudinea			57				14	615	29				72									
Phylum Mollusca																						
Class Gastropoda										14							14	14				
Class Pelecypoda																		229				
Phylum Arthropoda																						
Class Crustacea																						
Subclass Brachiopoda																						
Sida crystallia																						
Daphnia sp.																						
Bosmina sp.																		57				
Ilyocryptus sordidus				29										458		57						
Graptoleberis testudinaria																						
Eurycercus lamellatus																						
Camptocercus rectirostris																						
Acroperus harpae																						
Alona sp.	29					114	114		86			57				57	14	57				114
Chydorus sphaericus			114	286		114	228		200	529	29	57				229	14	114			143	57
Pleuroxis sp.																						
Subclass Ostracoda	43	72	572	29		114	572	343	57				1830	1945	343	229		57			572	172
Subclass Copepoda																						
Epischura nevadensis	14									29							14					
Diaptomus ashlandi				114						14	100	57						57				
Copepodites																						
Cyclops capillatus																						
Macrocyclops albidus							114		29													
Eucyclops sp.	114						114		57												114	57
Paracyclops sp.	57		858	114		229	228			14			229	114		172					29	
Cyclops vernalis											57											
Cyclops bicuspidatus		14		57		14		114		43	86					57					29	57
Order Harpacticoida	14	14	1544	601	114	1945	1258	1258	572	2531	1115	10182	1144	229	1030	686	100	13328			114	286
Subclass Malacostraca																						
Hyalella azteca				14		572		386	229	14			14	29		29	172	329				
Class Insecta																						
Order Collembola	100	472	114	143			343		29	14	43	57		114		14					29	
Order Coleoptera																						
Order Diptera adult		14														57						
pupae	29		57	72			143	14	543	72			43	200		386	106	787				57
Chironomidae (larvae)	29	86	9324	2860	19562	19248	13900	9996	4776	1516	1473	4633	32304	14271	12584	9896	1344	16302			8723	8580
Heleidae larva	14		114		114	129	315	744	372	29	57	343	315	758	572	601	14	86			86	172
Order Ephemeroptera						14	215	129	29	14		114	14	686		57	14	429				
Order Lepidoptera																						
Order Hymenoptera																						
Order Thysanoptera																						
Order Plecoptera																						
Order Trichoptera			57						57	43	14					29		43				57
Order Odonata				14			129	29														
Order Psocoptera									29													
Subphylum Chelicerata																						
Order Acari	14	14	57		114	343	358	400	343	172	72		29	257	229	114	243	315			29	57
Order Araneida	14	29						29					14									114
Misc. Eggs		14				114	572	3432	315	72	72	629	2746	5749	2631	229		872			629	801
TOTAL # ORGANISMS	472	815	14643	3103	20020	23524	364	18747	7808	5334	3461	17961	41484	30115	25282	13413	2245	36622			13671	11898

TABLE 3 - (cont'd.)

TIME PERIOD 5

SAMPLE SITE

ORGANISM	4		5		6		7		18		19		35		36		37		40		41	
	2m	3.5m	2m	5m	2m	5m	2m	5m	2m	5m	2m	5m	2m	5m	2m	5m	2m	3m	2m	5m	2m	5m
Phylum Coelenterata																						
Order Hydroida									4462	4833						3203	3546			257		
Phylum Platyhelminthes			14	14						386										43		
Phylum Nematoda																						
Phylum Tardigrada	114	14	14			1144		57							629	11326	343			14		
Phylum Annelida																						
Class Oligochaeta	14	215	14	286	1702	4848		1459	13270	2031			2545	3618	315	19[illegible]5	4662		200	601		
Class Hirudinea										57												
Phylum Mollusca																						
Class Gastropoda										300						229			29	443		
Class Pelecypoda								57						57			114					
Phylum Arthropoda																						
Class Crustacea																						
Subclass Brachiopoda																				29		
Sida crystallia																				29		
Daphnia sp.													29			229			14			
Bosmina sp.		14		858	14	229			229	57			400	172			114		29	172		
Ilyocryptus sordidus				515						172					200	915	229		14	57		
Graptoleberis testudinaria					229					744									14	1802		
Eurycercus lamellatus				200				100					129			2717			86	486		
Camptocercus rectirostris					14					286			257		29					86		
Acroperus harpae			100		14								29						43	29		
Alona sp.		29	57	686	114			229	343	57			257	57	458	3546	3661		186	429		
Chydorus sphaericus		14	43	172	72	458		543					372	57	172	1030	229		601	400		
Pleuroxis sp.			2							229			114									
Subclass Ostracoda	72				57	4347		86	114	57			315	1487	1473	3918	801		629	29		
Subclass Copepoda																						
Epischura nevadensis																						
Diaptomus ashlandi	29	14	29	686	43			29	343	114			29			114			200	29		
Copepodites														114					844	458		
Cyclops capillatus																				143		
Macrocyclops albidus				57	14			29		400			915	114		114			358	915		
Eucyclops sp.		14	257	57	43	229							400	343	343		114		515	315		
Paracyclops sp.			29	1087		686				57			57	629	372	801	458		129	86		
Cyclops vernalis		43	29		14												458		29	143		
Cyclops bicuspidatus	14		29	229	14	229			686	229			86	57	29		229		14			
Order Harpacticoida		43	29	5034		1602		1144	229	1144			57	1030	400	7093	16931		186	2345		
Subclass Malacostraca																						
Hyalella azteca										243			143			114			143	400		
Class Insecta																						
Order Collembola	72	29	14	14	400	229		100	229				114	686	958	686	701		57	257		
Order Coleoptera			14	57				43					14		14					14		
Order Diptera adult					43			57					14									
pupae		29			186	14		43					486	172	129	143			29	57		
Chironomidae (larvae)	300	1931	1216	1058	1130	20492		3675	6406	1959			4290	572	2331	6321	8151		1387	686		
Heleidae larvae					43	72		143	114	172			57	1015	143	1716	114		14			
Order Ephemeroptera				14	14			43					400						72	200		
Order Lepidoptera						14																
Order Homoptera		14																				
Order Hymenoptera		14						14														
Order Thysanoptera																						
Order Plecoptera																						
Order Trichoptera			43			14		29	14	29			29		57	143	143		57	14		
Order Odonata																				14		
Order Psocoptera																						
Subphylum Chelicerata																						
Order Acari		29	14	57	72	1144		400	229	229			458	286	43	114	458		400	143		
Order Araneida		14	57		14	29										14	14			14		
Misc. Eggs		43	186	343	1902	11125		315	572	1559			486	1544		686	2360		29	143		
TOTAL # ORGANISMS	615	2503	2217	11426	6135	46933		8594	27242	15344			12484	17160	7994	46547	43715		6306	11240		

TABLE 3 (cont'd.)

TIME PERIOD 7

SAMPLE SITE

ORGANISM	4		5		6		7		18		19		35		36		37		40		41	
	2m	3.5m	2m	5m	2m	5m	2m	5m	2m	5m	2m	5m	2m	5m	2m	5m	2m	3m	2m	5m	2m	5m
Phylum Colenterata																						
Order Hydroida	57		57	2059				286	186				572	972	14							
Phylum Platyhelminthes				14				29						29								
Phylum Nematoda																						
Phylum Tardigrada	1602		57	229		458			29						486		7779					
Phylum Annelida																						
Class Oligochaeta	1544		3990	13113		2974	1845	944	3732	3432			5534	14200	6020		4462					
Class Hirudinea								29	229					29								
Phylum Mollusca																						
Class Gastopoda				186		458	229	200	114	229				529								
Class Pelecypoda				3103		229			72	458												
Phylum Arthropoda																						
Class Crustacea																						
Subclass Brachiopoda																						
Sida crystallia								57									14					
Daphnia sp.																						
Bosmina sp.	114			114			229	57	29				229									
Ilyocryptus sordidus	515			1916										458								
Graptoleberis testudinaria																						
Eurycercus lamellatus	57			143																		
Camptocercus rectirostris																						
Acroperus harpae	57						458															
Alona sp.	57		286	1216				114	57	229			915		915		5734					
Chydorus sphaericus	114		286	472		229	3432	29	143	458			1830		286		1830					
Pleuroxis sp.			57																			
Subclass Ostracoda	114		114	958		4605	1373	143	143	1373			2974	12813			10611					
Subclass Copepoda																						
Epischura nevadensis																						
Diaptomus ashlandi							458		29													
Copepodites																	229					
Cyclops capillatus				114																		
Macrocyclops albidus			57						57													
Eucyclops sp.	686			229		229	229		329				801				915					
Paracyclops sp.	458		57	1258		686			172				1716		57		2517					
Cyclops vernalis	114						458						114									
Cyclops bicuspidatus				1387		458	229	57	57								458					
Order Harpacticoida			1201	33290		42557	2746	114	1258	29058			343	134992	644		20592					
Subclass Malacostraca																						
Hyalella azteca				243				29	57	1144			14									
Class Insecta																						
Order Collembola	129			57		915		57		229												
Order Coleoptera				29						14												
Order Diptera adult				114						229												
pupae			129	14		229	686		29	229			343	29	29							
Chironomidae (larvae)	5677		6764	10868		20549	28271	1173	4204	13728			27899	5277	772		18504					
Heleidae larvae				129		257			86	229					14							
Order Ephemeroptera						29	229		200	72			343									
Order Lepidoptera				114																		
Order Homoptera						229																
Order Hymenoptera																						
Order Thysanoptera	57																					
Order Plecoptera																						
Order Trichoptera			72	57		243	257		200	14			129									
Order Odonata																						
Order Psocoptera																						
Subphylum Chelicerata																						
Order Acari	57			114			1144	57	200	1144			458	14			11445					
Order Araneida	29			14		29		29						14								
Misc. Eggs	1773		458	1444		915	1373	887	458	915			686	12813	343		1602					
TOTAL # ORGANISMS	13213		13585	73145		76276	43644	4290	12098	53182			44902	182168	9581		76391					

stations 6, 35, 36, and 40 (27, 29, 27, and 28 taxa recorded respectively) during time period 5; and stations 5, 7, and 18 (31, 25, and 27 taxa recorded respectively) during time period 7. Those sites with the most limited species diversity were stations 6 and 19 (14 and 16 taxa recorded respectively) during time period 2; stations 4, 7, and 37 (19, 21, and 21 taxa recorded respectively) in time period 5; and stations 36 and 37 (11 and 14 taxa recorded respectively) during time period 7.

The abundance of benthic animals was also examined. During the three sampling dates the total number of organisms dredged at 5 m was, in most cases, equal to, or greater than, the number dredged at 2 m. In addition, the number of benthic invertebrates collected during time period 7 was three times the number recorded at the same sampling locations in time periods 2 and 5.

The most abundant organisms taken in benthic samples (all depths and sites combined; individuals/m^2) appear in Table 3a.

TABLE 3a: BENTHIC INVERTEBRATES - TOTAL NUMBER OF ORGANISMS/M^2 WITH ALL DEPTHS AND SITES COMBINED - SHUSWAP LAKE, 1978

Organism	Time Period 2	5	7
Phylum Tardigrada	15,073		
Order Harpacticoida	38,065	37,267	266,795
Class Oligochaeta		37,725	61,790
Subclass Ostracoda			35,221
Chironomidae (larvae)	191,407	61,905	143,686
Misc. Eggs	18,877	21,293	

The sampling stations showing the greatest abundance of benthic animals were sites 6, 7, 35, 36, and 37 (43; 544; 40,111; 71,599; 38,695; and 38,867 invertebrates per m^2 counted respectively) during time period 2;

sites 6, 18, and 36 (53,068; 42,586; and 54,541 invertebrates counted respectively) in time period 5 and sites 5, 6, 35, and 37 (86,730; 76,276; 227,070; and 76,391 invertebrates counted respectively) during time period 7.

2.1.4 Zooplankton

A summary of the 1978 net plankton catch results is given in Table 4. Thirty species of organisms were found in plankton samples taken during time periods 2, 5, and 7. Overall diversity was greatest during time period 2. Sampling stations showing the greatest diversity of plankton were: stations 7 and 35 (16 and 18 species recorded respectively) in time period 2; stations 35 and 36 (13 and 10 species recorded respectively) during time period 5; and stations 35 and 37 (13 and 10 species recorded respectively) in time period 7.

Plankton collected during time period 5 was two to three times as abundant as plankton collected in time periods 2 and 7. Sampling stations exhibiting greatest zooplankton abundance were site 5 (3,709 plankters/m^3 counted) during time period 2; site 18 (18,304 plankters/m^3 counted) in time period 5 and sites 6 and 18 (4,752 and 8,800 plankters/m^3 counted respectively) during time period 7.

The most abundant plankters (per m^3) appear in Table 4a:

TABLE 4a: ZOOPLANKTON - TOTAL NUMBER OF ORGANISMS/M^3 WITH ALL SITES COMBINED - SHUSWAP LAKE, 1978

	Time Period		
Organism	2	5	7
Bosmina spp.	2,016	7,943	1,847
Cyclops bicuspidatus	4,371	11,500	
Daphnia spp.		11,877	8,591
Diaphanosoma leuchtenbergianum			3,364
Diaphtomus ashlandi	3,352	19,342	3,309
Epischura nevadensis			1,566

TABLE 4 ZOOPLANKTON (NUMBER OF ORGANISMS/m^3) SHUSWAP LAKE, 1978

TIME PERIOD 2

SAMPLE SITE

ORGANISM	4	5	6	7	18	19	35	36	37	40
Phylum Coelenterata										
Order Hydroida				6				3		
Phylum Annelida										
Class Oligochaeta				4			16			
Phylum Arthropoda										
Class Crustacea										
Subclass Brachiopoda										
Leptodora kindtii										
Sida crystallia										
Diaphanosoma leuch - tenbergianum				2	8					
Daphnia sp.		20	10	6	36		28	10	12	112
Scapholeberis kingii										
Bosmina sp.		4	66	38	172		700	44	156	836
Eurycercus lamellatus							2			
Camptocercus rectirostris										
Acroperus harpae				6			4			
Alona sp.										
Chydorus sphaericus			10	38			18			
Subclass Ostracoda				14			30			
Subclass Copepoda										
Epischura nevadensis										
Diaptomus ashlandi		620	319	246	556		136	963	372	140

TABLE 4 (cont'd.)

TIME PERIOD 2

SAMPLE SITE

ORGANISM	4	5	6	7	18	19	35	36	37	40
Macrocyclops albidus				4						
Euclops sp.		4		2			2			
Cyclops bicuspidatus		3,052	1,494	1,314	656		130	197	54	224
Cyclops capillatus							6			
Order Harpacticoida							6		4	
Order Amphipoda										
Hyalella azteca				4			14		4	
Class Insecta										
Order Collembola										
Order Coleoptera		4								
Order Diplura										
Order Diptera										
Chironomid larvae				2			40		4	
Family Heleidae (larvae)							2			
Order Ephemeroptera					1		10			
Order Trichoptera										
Order Odonata (nymph)				2			2			
Class Arachneida										
Order Acari			1	18			8		4	
Total # Organisms		3,709	1,900	1,704	1,429		1,454	1,217	610	1,312

TABLE 4 (cont'd.)

TIME PERIOD 5

SAMPLE SITE

ORGANISM	4	5	6	7	18	19	35	36	37	40
Phylum Coelenterata										
Order Hydroida								2		
Phylum Annelida										
Class Oligochaeta										
Phylum Arthropoda										
Class Crustacea										
Subclass Brachiopoda										
Leptodora kindtii							8	2	14	
Sida crystallia		8					8		8	16
Diaphanosoma leuchtenbergianum								2		
Daphnia sp.	692	128	288	472	8,096	40		288	705	1,168
Scapholeberis kingii										
Bosmina sp.	1,505	544	1,472	2,016	1,024	736	280	30	176	160
Eurycercus lamellatus							16			
Camptocercus rectirostris							8			
Acroperus harpae							8			
Alona sp.								2		
Chydorus sphaericus		8				24	48	8	8	16
Subclass Ostracoda										
Subclass Copepoda										
Epischura nevadensis	41						16	14		
Diaptomus ashlandi	1,492	2,672	1,112	2,008	5,952	2,228	840	238	644	2,096

TABLE 4 (cont'd.)

TIME PERIOD 5

SAMPLE SITE

ORGANISM	4	5	6	7	18	19	35	36	37	40
Macrocylops albidus						8	8			
Euclops sp.	14			8		8	16			
Cyclops bicuspidatus	786	848	2,784	896	3,232	1,728	240	182	244	560
Cyclops capillacus										
Order Harpacticoida										
Order Amphipoda										
Hyalella azteca										
Class Insecta										
Order Collembola										
Order Coleoptera										
Order Diplura		16								
Order Diptera										
Chironomid larvae	14									
Family Heleidae (larvae)							8			
Order Ephemeroptera										
Order Trichoptera										
Order Odonata (nymph)										
Class Arachneida										
Order Acari									8	
Total # Organisms	4,544	4,224	5,656	5,400	18,304	4,832	1,504	768	1,807	4,016

TABLE 4 (cont'd.)

TIME PERIOD 7

ORGANISM	SAMPLE SITE 4	5	6	7	18	19	35	36	37	40
Phylum Coelenterata										
Order Hydroida										
Phylum Annelida										
Class Oligochaeta										
Phylum Arthropoda										
Class Crustacea										
Subclass Brachiopoda										
Leptodera kindtii	7	2	16				8		3	
Sida crystallia	7	10	288	8	160		4			
Diaphanosoma leuchtenbergianum			272	40	2,400		508	111	33	
Daphnia sp.	227	88	2,512	284	4,160		208	1,063	49	
Scapholeberis kingii							4	10		
Bosmina sp.	312	340	304	108	544		172		67	
Eurycercus lamellatus							4		3	
Camptocercus rectirostris							4			
Acroperus harpae										
Alona sp.										
Chydorus sphaericus							24		8	
Subclass Ostracoda										
Subclass Copepoda										
Epischura nevadensis	37	50	624	108	672		64	8	3	
Diaptomus ashlandi	268	88	720	396	736		396	587	118	

TABLE 4 (cont'd.)

TIME PERIOD 7

SAMPLE SITE

ORGANISM	4	5	6	7	18	19	35	36	37	40
Macrocylops albidus										
Euclops sp.	14									
Cyclops bicuspidatus	37	22	16	4	96		152	21	56	
Cyclops capillatus										
Order Harpacticoida										
Order Amphipoda										
Hyalella azteca										
Class Insecta										
Order Collembola				4						
Order Coleoptera										
Order Diplura										
Order Diptera										
Chironomid larvae							4			
Family Heleidae (larvae)										
Order Ephemeroptera										
Order Trichoptera										
Order Odonata (nymph)										
Class Arachneida										
Order Acari					32				3	
Total # Organisms	909	600	4,752	952	8,800		1,552	1,870	343	

2.1.5 Fish Stomach Contents

Food organisms food in the stomach contents of juvenile chinook salmon in Shuswap Lake in 1978 are listed in Table 5. Thirty of thirty-one species found in fish stomachs were also present in benthos or zooplankton samples collected at sampling site 4-7, 18, 19, 35-37, 40 or 41. An adult Hemipteran insect found in the stomach of a fish seined at site 35 on July 27 was the only organism not represented in invertebrates found in the lake sampling.

Of the organisms identified, Dipteran pupae and adults, Daphnia spp. Chironomid Larvae, Homopteran adults, and Ephemeropteran nymphs occurred most often in fish stomachs that were analysed. Percentage organism occurrence in fish stomach contents was not related to prevalence of organisms found in zooplankton or zoobenthos samples. Numerically, Daphnia spp. were the most abundant invertebrates found in any of the stomachs in which they were present. Dipteran pupae and larvae, Chironomid larvae, Cyclops bicuspidatus, and Epischura nevadensis were also represented in large number in fish stomachs in which they were found.

2.2 Sicamous Narrows Dye-Marking Program

One hundred fifty-nine dye-marked fish were recaptured in Shuswap Lake following marking experiments conducted May 30, June 1, and June 13, 1978. Of these, 114 were seined between time periods 5 and 6, and 6 and 7, at sites in or adjacent to Sicamous Narrows and 45 were caught during time periods 4 to 7 at sampling sites 2, 3, 7, 21, 23, 27, and 34-42 (Table 6 and Figure 1).

Mortality of dye-marked fish after 24 hours was 19%. High death rates were apparently due to the warm temperature at which fish were marked (14-15° C as compared to 8.1-9.5°C recommended by Ward and Verhoeven, 1963) and the use of pure oxygen (which may have caused respiratory stress) rather than air for dyeing-tank aeration.

Dye-marked salmon were still easily distinguished from unmarked fish 6 weeks after marking (July 25-27) however, since no marked fish were taken during the August 28-31 period, it is probable that most of the colour associated with the dye had worn off by that date.

TABLE 5 STOMACH CONTENTS OF JUVENILE CHINOOK SALMON SHUSWAP LAKE, 1978

SITE	DATE	NO. FISH SAMPLED	$\overline{X}$ FISH LT. (mm)	NO. EMPTY STOMACHS	ORGANISM	% ORGANISM OCCURRENCE IN STOMACHS CONTAINING FOOD	$\overline{X}$ NO. ORGANISMS/ STOMACH IN WHICH THEY OCCURRED
1	Apr 26	10	34.2	3	Diptera pupae	43	2.3
					Diptera adult	57	1.8
					Eurycercus lamellatus	14	1
					Eucyclops sp	14	3
					Harpacticoida	29	4.5
					Daphnia sp	43	26.3
					Cyclops bicuspidatus	29	34
					Thysanoptera adult	14	1
					Homoptera adult	14	1
					Diaptomus ashlandi	14	1
2	Apr 26	10	35.4	4	Collembola	33	2.5
					Diptera adult	66	4.5
					Diptera pupae	33	1
					Coleoptera adult	17	2
					Ephemeroptera nymph	33	1
					Macrocyclops albidus	17	1
					Cyclops bicuspidatus	17	14
					Chironomidae larvae	17	1
					Daphnia sp	17	1

TABLE 5 (cont'd.)

SITE	DATE	NO. FISH SAMPLED	$\bar{X}$ FISH LT. (mm)	NO. EMPTY STOMACHS	ORGANISM	% ORGANISM OCCURRENCE IN STOMACHS CONTAINING FOOD	$\bar{X}$ NO. ORGANISMS/ STOMACH IN WHICH THEY OCCURRED
4	Jun 13	10	48.4	0	Araneida	60	1.3
					Homoptera adult	40	1.3
					Diptera adult	90	3.2
					Chironomidae larvae	100	23.9
					Collembola	20	1.5
					Psocoptera adult	50	1.4
					Thysanoptera adult	10	2
					Ephemeroptera nymph	10	1
					Tricoptera adult	10	1
					Plecoptera nymph	10	1
					Epischura nevadensis	20	1
					Coleoptera adult	20	1
					Hymenoptera adult	10	1
					Bosmina sp	10	2
					Acari	10	1
					Diptera pupae	60	7.8
5	Jun 13	10	53.9	0	Ephemeroptera nymph	40	1.5
					Diptera pupae	70	2.7
					Chironomid larvae	80	10.9
					Trichoptera adult	10	1
					Plecoptera nymph	30	1
					Homoptera adult	30	1.3
					Diptera adult	50	6
					Alona sp	10	1
					Psocoptera adult	10	1
					Chydorus sphaericus	10	1
					Acari	10	1
					Coleoptera adult	10	1
					Araneida	10	1
					Hymenoptera adult	10	1

TABLE 5 (cont'd.)

SITE	DATE	NO. FISH SAMPLED	$\bar{X}$ FISH LT. (mm)	NO. EMPTY STOMACHS	ORGANISM	% ORGANISM OCCURRENCE IN STOMACHS CONTAINING FOOD	$\bar{X}$ NO. ORGANISMS/ STOMACH IN WHICH THEY OCCURRED
6	Jun 16	6	59.7	0	Acari	100	2.2
					Diptera adult	100	110.5
					Diptera pupae	100	23.3
					Cyclops bicuspidatus	100	35.3
					Chironomid larvae	83	2.3
					Araneida	17	1
					Hymenoptera adult	33	1.5
					Homoptera adult	33	1
					Lepidoptera adult	17	1
					Bosmina sp	17	5
					Daphnia sp	33	160.5
7	Jun 13	9	59.6	0	Plecoptera nymph	78	5.3
					Diptera pupae	100	83.5
					Trichoptera adult	56	1.8
					Ephemeroptera nymph	22	1
					Araneida	11	1
					Diptera adult	56	1.6
					Cyclops bicuspidatus	11	1
					Chironomid larvae	33	2
					Acari	22	1
					Bosmina	44	6.5
					Heleidae larvae	11	1
					Diaptomus ashlandi	11	1
					Daphnia sp	22	84.5
					Homoptera	33	1.7
					Coleoptera adult	11	1
18	Jun 14	10	55	0	Diptera adult	30	1
					Daphnia sp	100	635.5
					Diptera pupae	30	2.7
					Chironomid larvae	10	1
					Homoptera adult	10	2
					Ephemeroptera nymph	10	1
					Cyclops bicuspidatus	10	10

TABLE 5 (cont'd.)

SITE	DATE	NO. FISH SAMPLED	$\bar{X}$ FISH LT. (mm)	NO. EMPTY STOMACHS	ORGANISM	% ORGANISM OCCURRENCE IN STOMACHS CONTAINING FOOD	$\bar{X}$ NO. ORGANISMS/ STOMACH IN WHICH THEY OCCURRED
19	Jun 14	10	51.7	0	*Daphnia sp*	100	619.5
					Homoptera adult	10	1
					Sida crystallina	10	5
					Epischura nevadensis	30	2.7
					Diptera pupae	50	5.4
					Cyclops bicuspidatus	50	3.4
					Bosmina sp	10	1
					Harpacticoida	10	1
					Diptera adult	10	4
					Acari	10	2
19	Jun 15	9	45.2	0	Ephemeroptera nymph	78	2.1
					Diptera pupae	22	2
					Diptera adult	22	2.5
					Homoptera adult	44	1.3
					Hymenoptera adult	22	1
					Epischura nevadensis	11	5
34	Jun 13	10	52.2	0	Diptera adult	40	1.3
					Daphnia sp	100	239.4
					Epischura nevadensis	60	84.7
					Leptodora kindtii	50	6
					Sida crystallina	10	5
					Cyclops bicuspidatus	40	6
					Diptera pupae	40	2.8
					Bosmina sp	10	1

TABLE 5 (cont'd.)

SITE	DATE	NO. FISH SAMPLED	$\bar{X}$ FISH LT. (mm)	NO. EMPTY STOMACHS	ORGANISM	% ORGANISM OCCURRENCE IN STOMACHS CONTAINING FOOD	$\bar{X}$ NO. ORGANISMS/ STOMACH IN WHICH THEY OCCURRED
35	Jul 27	10	66.3	0	Diptera pupae	90	59.7
					Diptera adult	80	11.5
					Eurycercus lamellatus	10	1
					Ephemeroptera adult	20	1.5
					Homoptera adult	30	8.3
					Araneida	10	1
					Lepidoptera adult	10	1
					Hymenoptera adult	10	1
					Trichoptera larvae	30	1.3
					Hemiptera adult	10	1
					Prosoptera adult	20	1.5
					Chydorus sphaericus	10	1
					Alona sp	10	1
					Ephemeroptera nymph	10	1
					Trichoptera adult	10	10
37	Jul 26	1	50	1	—	—	—
41	Apr 26	10	39.7	0	Lepidoptera larvae	90	20.9
					Diptera pupae	80	6.4
					Diptera adult	80	11.3
					Eurycercus lamellatus	10	1
					Thysanoptera adult	20	1
					Chironomid larvae	50	8.4
					Homoptera adult	10	1
					Araneida	10	2
					Ephemeroptera nymph	20	1.5
					Scapholeberis kingi	10	1
36	Jun 13	12	53.3	8	Diptera pupae	25	2
					Diptera adult	25	1
					Bosmina sp.	50	1.5
					Daphnia sp.	100	34.8
37	Jun 13	11	54	10	*Daphnia sp.*	100	6
					Diptera adult	100	2

TABLE 6: RECOVERY OF MARKED FISH - SHUSWAP LAKE, 1978

Seine Site	2	3	7	21	23	27	34	35	36	37	38	39	40	41	42
Date	Number Marked Fish Caught														
May 30 - Jun 1							1		4						
Jun 13 - 15					2		3	1	8		1	2	2	1	1
Jun 14									96						
Jun 15									6						
Jun 17							2								
Jun 19							2								
Jul 5 - 6	1	1	1	6	1								2	3	
Jul 11								2		3	1		2		
Jul 25 - 27						1		1		1					1

2.3 River Sampling

Distribution of juvenile chinook, coho and coho salmon in the South Thompson River determined by beach seining in 1979 has been presented in Figure 5. The greatest concentration of rearing/migrating fish occurred just south of Chase (site a) where more than 5,000 fish were caught (predominantly sockeye fry). Smaller numbers of salmon fry and smolts were found throughout the rest of the lower river with the largest numbers of fish being seen in backeddies and slackwater areas in the vicinity of tributary streams or overhanging vegetation.

Chinook fry were present in all seine catches; sockeye fry were caught at sites a and e; coho fry were seen only at site f, and one coho smolt was seined at site b.

3. DISCUSSION

3.1 Fish Distribution

Shuswap Lake studies in 1978 confirm the presence of large numbers of juvenile chinook and coho salmon in the shoreline zones of many areas in the lake from late April until mid-July. In particular, large numbers of juvenile fish appear to rear and migrate in littoral areas in the vicinity of Mara Lake-Sicamous Narrows (seine sites 34-42), southern portions of Salmon Arm (sites 17, 18, 26-28), the southerly regions of Anstey Arm (sites 21, 23-25), the northern tip of Seymour Arm (site 13) and the outlet of Shuswap Lake (seine sites 1-6). Seining efforts revealed an apparent scarcity of young salmon in northern portions of Salmon Arm, northern reaches of Anstey Arm, most of Seymour Arm, or the main arm of Shuswap Lake from Cinnemousun Narrows to the vicinity of Blind Bay.

Beach seining activities in 1979 revealed the presence of large numbers of chinook, coho and sockeye salmon from the southern region of Mara Lake to Quartzite Point (sample site 27) and from Eagle Bay (sample site 44) to Little Shuswap Lake, suggesting that distribution of juvenile fish in 1979 was similar to that observed in 1978. Few salmon were observed in foreshore areas in Salmon, Seymour or Anstey Arms.

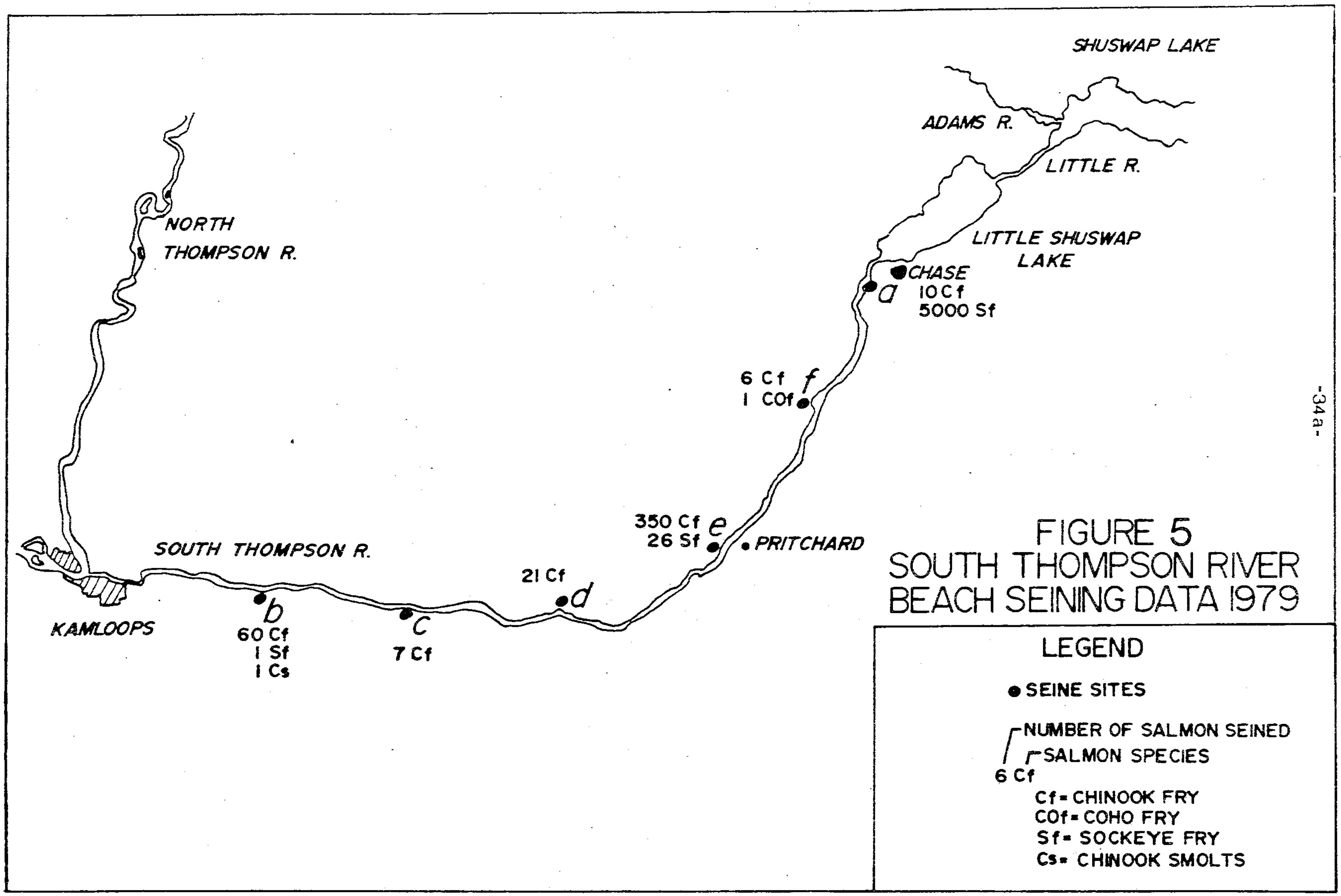


FIGURE 5
SOUTH THOMPSON RIVER
BEACH SEINING DATA 1979

The presence of juvenile fish in different areas of Shuswap Lake is probably related to the proximity of suitable rearing habitat (environments which provide adequate food and shelter), the presence of adjacent spawning streams, and/or the fact that the area lies on a salmon migration route within the lake. Thus, shoreline zones in the vicinity of chinook, coho and sockeye spawning areas (Shuswap, Eagle, Salmon, Anstey, Seymour and Adams Rivers) and along smolt out-migration routes (eastern and western shores of Mara Lake - Sicamous Narrows, southern shore of Salmon Arm, eastern and western shores of the lake from Sicamous to Cinnemousun Narrows, eastern and middle western shores of Anstey Arm, northern and southern shores of main Shuswap Lake west of Blind Bay) support the majority of the juvenile salmon in the lake. Despite fairly good escapements observed in the Salmon River in the fall of 1978 (350 chinook; 1,500 coho; and 434 sockeye counted, Brown et al., MS 1979), the extensive shallows characterized by high temperatures and turbidity in the vicinity of Salmon Arm probably limit the use of the area by rearing fish. Data collected in 1978 and 1979 support this conclusion and suggest that juvenile salmon which utilize Salmon Arm foreshore areas do so only briefly in April and early May before migrating to other basins in the Shuswap Lake system.

In Seymour and Anstey Arms adult escapements of chinook and coho salmon were low (none of either species observed in the Seymour River; 75 coho counted in the Anstey River) while sockeye escapements were moderate to high (62,150 and 1,327 fish observed in each river respectively) in 1978 (Brown et al., MS 1979). This information suggests that considerable numbers of young sockeye should have reared in littoral areas adjacent to the mouths of the above-mentioned rivers. However, since only small numbers of these fish were caught during beach seining operations, it is possible that the majority of juvenile fish originating in the Seymour and Anstey Rivers migrate toward the outlet of Shuswap Lake (and more favorable feeding areas) shortly after emergence from their natal stream.

In some areas of the Shuswap system, the large concentrations of sockeye fry in 1979 in foreshore areas may have displaced rearing coho and chinook. This effect was apparent at sample sites 2, 36, and 37 (Figure 3) despite sizeable escapements of chinook and coho salmon to the Adams (2,200 chinook, 150 coho), Eagle (400 chinook; 2,000 coho) and Shuswap (10,750 chinook and 3,350 coho) Rivers in 1978 (Brown et al., MS 1979). In some instances, such large schools of sockeye fry were encountered that numbers of fish were visually estimated and some chinook or coho fry may not have been counted. The utilization of foreshore areas by juvenile salmon may also be related to water temperatures within the littoral zone. Temperatures recorded at most seining locations approached critical levels (20-24°C; Brett, 1952) during the mid-summer sampling periods and probably accounted for the lower number of juvenile salmon being observed in foreshore areas during those times. Graham and Russell (1979) suggest that young chinook salmon rear in shoreline areas until temperatures exceed 16.1°C. Results of this investigation suggest that juvenile salmon continue to utilize many foreshore areas at temperatures as high as 22°C, but that these fish move into deeper, colder water and do not return to littoral areas when water temperatures reach 23°C or more (evidence Table 2 and field notes for sample site 35, time period 7: no fish were seined on July 25 when the water was 28°C, but following a strong windstorm, the water temperature had decreased on July 26 to 22°C and 9 juvenile coho were caught at the site). Rising water temperatures in the spring may also stimulate out-migration of chinook and coho smolts from the lake into the Thompson River system.

Zooplankton and zoobenthos sampling indicate that substantial populations of fish food organisms occupy foreshore pelagic and substrate habitats at sampling sites where juvenile fish were most frequently found. Planktonic and benthic animals were most abundant following freshet conditions in the lake and would be available to juvenile salmon as soon as they arrived at lakeshore rearing areas following emergence and migration from stream incubation sites in April and May. Stomach content analyses of young salmon seined in foreshore areas corroborate the relationship between availability of food organisms and the presence of juvenile chinook and coho in the littoral zone (sampling stations with the greatest species diversity and abundance of benthic and planktonic animals were also the sites most frequented by young fish). In addition, substantial numbers of young chinook and coho salmon may overwinter in offshore pelagic zones adjacent to productive littoral areas in which they spend the spring and early summer, in order that they may utilize both open water planktonic and littoral benthic food resources when food becomes less available during the winter.

3.2 Sicamous Narrows Dye-Marking Program

The 1978 marking studies showed that juvenile salmon rearing in or migrating through Sicamous Narrows may stay in the Narrows for extended periods of time, migrate back into Mara Lake to rear in shoreline areas, or swim up the eastern shoreline of the lake to rear in Anstey Arm before moving through Cinnemousun Narrows and along the southern shore of the main arm of Shuswap Lake toward the outlet and the Thompson River.

An indication of migration timing may also be inferred from the dye-marking program. Salmon marked on May 30, June 1 and June 13 at Sicamous Narrows were seined at sample sites in Anstey Arm and in the vicinity of the Adams River during seining periods 5 and 6 (June 13-14 and July 5-6). This suggests that salmon fry originating in the Shuswap and Eagle River systems require from two to six weeks to migrate through Shuswap Lake during the initial phase of their downstream migration.

The length of residence of juvenile fish in each area of the lake and the total population of fish produced from each major river system cannot be estimated without a more extensive marking program involving fish populations from the Shuswap, Salmon, Eagle, Anstey, Seymour and Adams Rivers.

3.3 River Sampling

Seining results in 1979 indicate that distribution of salmon juveniles in the South Thompson River is related to the availability of suitable rearing habitat and the proximity of beach seining sites to Shuswap Lake. The large number of sockeye fry found at a site near Chase probably came from spawning grounds in the river just below the outlet of Little Shuswap Lake (escapement to the South Thompson River in 1978 was 9,800 sockeye, Brown et al., MS 1979) or from populations of fry hatched in the Little or Adams Rivers which migrated out of Shuswap Lake at the beginning of freshet (Goodlad, Gjernes, and Brannon, 1974). Chinook fry may have originated both in the Shuswap system (90 day old migrant fry) and in the South Thompson River where 3,500 adults spawned in 1978 (Brown et al., MS 1979).

The small number of coho (1 fry and 1 smolt) seined in the South Thompson together with the lack of any recorded adult coho escapement to the river in 1978 suggest that these fish originated in Shuswap Lake and that the majority of the sockeye and chinook juveniles are therefore South Thompson River fish. It is possible that had a second seining series been conducted at a later date (mid-July or early August) a greater proportion of fish caught in the river may have been Shuswap Lake fish (as indicated by a greater proportion of smolts, some of which may have been marked by Fisheries and Oceans' staff studying chinook populations in the Shuswap River).

1978 BIOPHYSICAL LAKESHORE INVENTORY

1. METHODS

A biophysical inventory of the littoral zone of Shuswap, Little Shuswap and Mara Lake was undertaken during the 1978 summer high water period to assess the relative value to rearing or migrating juvenile salmonids of foreshore habitat in the Shuswap system. The inventory was conducted by visually estimating differences in littoral width, slope and substrate composition and by noting the presence of aquatic vegetation, fallen trees, inflowing streams and cultural development of each of the 370 shoreline zones observed. The extent of the littoral area was defined as the maximum depth at which the lake bottom remained visible (approximately 8 m) and a new shoreline zone was assigned with each major change in substrate composition. Inventory characteristics were determined from a boat following the shoreline at a speed of approximately 4 m.p.h. and simultaneously transferred to recording sheets (Appendix 1).

Each of four major characteristics which determine the suitability of the littoral zone as a rearing or migrating habitat for salmon juveniles (littoral width, littoral slope, substrate composition, presence of additional habitat characteristics) was assigned a rating based on its relative contribution to the total foreshore habitat. This rating system is defined below:

Littoral width (A1)	# Habitat Pts.	Littoral Slope (A2)	# Habitat Pts.
0 - 2 m	1	$>45^{\circ}$	2
2.1 - 6 m	3	$15 - 45^{\circ}$	6
6.1 - 10 m	5	$<45^{\circ}$	9
10.1 - 20 m	7		
>20 m	9		

Substrate Composition (A3)	# Habitat Pts.	Additional Habitat (A4)	# Habitat Pts.
sand	0.2/ea. 10% of substrate	weeds sparse	2
bedrock	0.3/ea. 10% of substrate	weeds abundant	4
gravel/cobble	0.7/ea. 10% of substrate	inflowing streams	2
mud/silt	0.9/ea. 10% of substrate	inflowing rivers	4
		fallen trees	1
		overhanging vegetation	1

Maximum number of habitat points per rating category: A1=9, A2=9, A3=9, A4=10.

Since littoral width varies according to littoral slope, rating categories A1 and A2 were combined so that the maximum possible habitat rating for each inventory zone was:

$$\frac{A1 + A2}{2} + A3 + A4 = 28$$

2. RESULTS

The 370 zones designated in the shoreline inventory are depicted in Figure 6. The number of habitat points assigned to each zone on the basis of littoral slope, width, substrate composition, and additional habitat characteristics (Table 7) was used to rate it as excellent, good, average, fair or poor according to the quality of salmon habitat it provided. The following table summarizes this information.

Classification	No. Habitat Pts.	No. Zones	Shoreline Length (m)	% of Total Shoreline Length
excellent	19.7 - 28	16	37,500	9.22
good	15.5 - 19.6	107	158,890	39.08
average	12.7 - 15.4	149	140,835	34.64
fair	9.9 - 12.6	63	52,675	12.96
poor	0 - 9.8	35	16,625	4.09

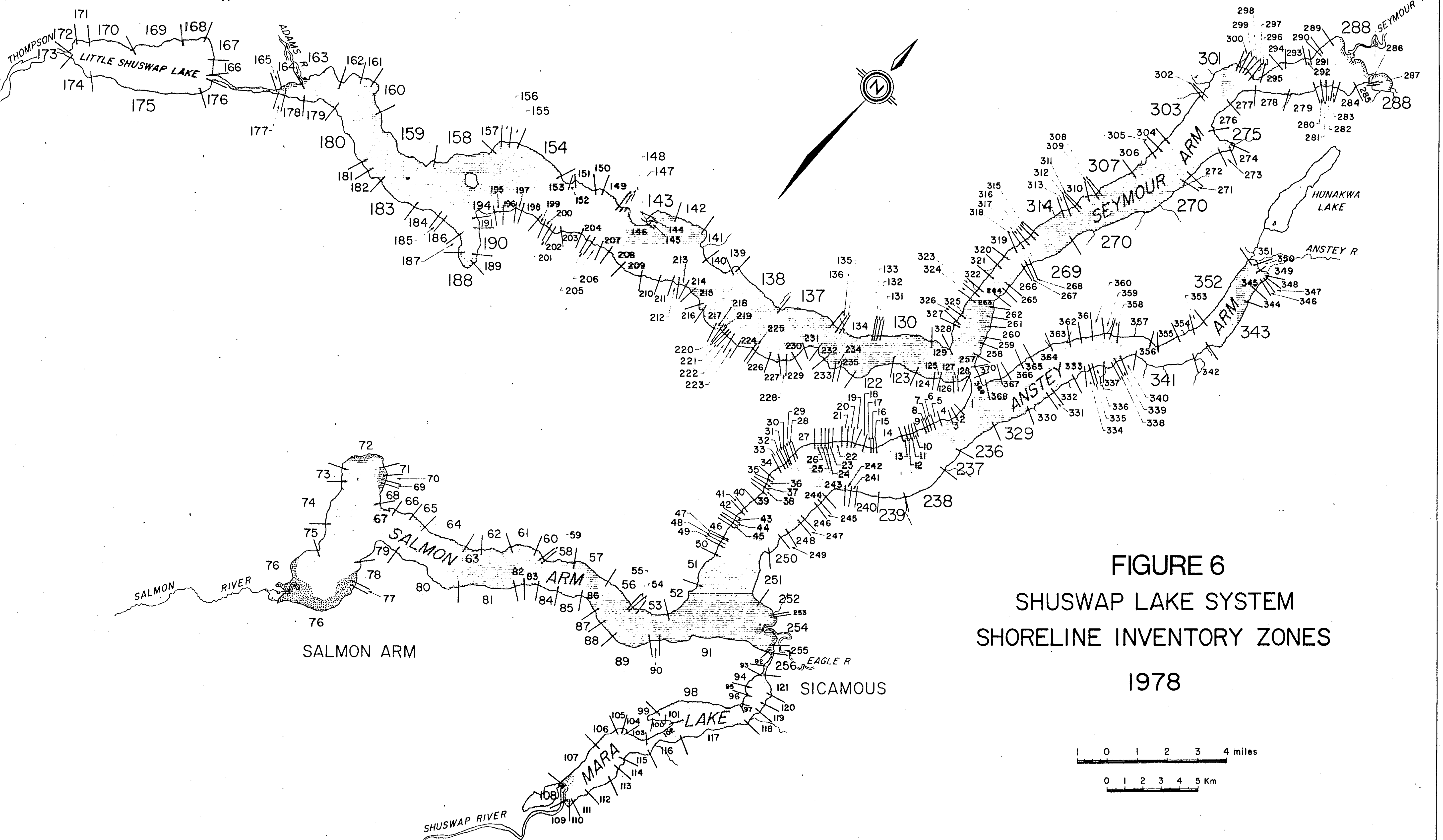


FIGURE 6
SHUSWAP LAKE SYSTEM
SHORELINE INVENTORY ZONES
1978

TABLE 7: SHORELINE INVENTORY SUMMARY AND JUVENILE SALMON HABITAT SUITABILITY RATING - SHUSWAP LAKE, 1978

Zone	No. Habitat Pts./Rating Category A1	A2	A3	A4	Total No. Habitat Pts. (max. 28)	Rating
1	7	6	5	2	13.5	Average
2	5	6	6.5	0	12	Fair
3	5	2	2.9	1	7.4	Poor
4	5	6	6.5	1	13	A
5	5	6	4.5	1	11	F
6	7	6	6.5	0	13	A
7	3	2	3.4	1	6.9	P
8	3	2	2.5	1	6	P
9	7	6	5.5	1	13	A
10	3	2	3	1	6.5	P
11	5	6	5.5	0	11	F
12	3	2	3	0	5.5	P
13	5	6	6.5	1	13	A
14	5	6	4	2	11.5	F
15	5	2	5	1	9.5	P
16	3	2	3.4	1	6.9	P
17	3	2	3	1	6.5	P
18	5	6	7	1	13.5	A
19	1	2	3	1	5.5	P
20	3	2	3	1	6.5	P
21	3	6	3	1	8.5	P
22	3	6	2.7	3	10.2	F
23	5	9	3.7	1	11.7	F
24	5	9	6	1	14	A
25	3	2	3	1	6.5	P
26	7	9	6.5	1	15.5	Good
27	7	9	6.5	1	15.5	G
28	3	2	3	1	6.5	P
29	5	9	7	2	16	G
30	5	9	7	3	17	G
31	5	6	3	3	11.5	F
32	5	6	7	1	13.5	A
33	3	2	3	1	6.5	P
34	5	9	7	1	15	A
35	5	9	7	5	19	G
36	5	6	7	2	14.5	A
37	3	6	2.5	1	8	P
38	3	6	7	1	12.5	F
39	1	2	3	2	6.5	P
40	3	6	6.6	2	13.1	A

TABLE 7: (Cont'd.)

Zone	No. Habitat Pts./Rating Category A1	A2	A3	A4	Total No. Habitat Pts. (max. 28)	Rating
41	5	6	3.8	2	11.3	F
42	5	6	7	4	16.5	G
43	5	2	6	0	9.5	P
44	5	9	3	0	10	F
45	7	9	6.5	1	15.5	G
46	5	6	3.8	3	12.3	F
47	5	6	7	1	13.5	A
48	5	6	6.6	1	13.1	A
49	5	6	7	1	13.5	A
50	5	6	3	1	9.5	P
51	7	6	7	3	16.5	G
52	7	6	4.6	3	14.1	A
53	3	2	3	3	8.5	P
54	5	6	7	1	13.5	A
55	5	6	3	1	9.5	P
56	5	6	6.2	3	14.7	A
57	7	6	7	5	18.5	G
58	5	6	7	3	16.5	G
59	5	6	7	1	13.5	A
60	5	6	7	3	15.5	G
61	5	6	7	1	13.5	A
62	7	6	6	3	15.5	G
63	5	6	6.6	3	15.1	A
64	5	6	7	3	15.5	G
65	5	6	7	1	13.5	A
66	5	6	6	1	12.5	F
67	7	9	6.9	4	17.4	G
68	7	6	7	3	16.5	G
69	5	9	7	3	17	G
70	7	9	8.6	3	19.6	G
71	5	6	5.5	2	13	A
72	5	6	8.8	3	17.3	G
73	7	9	3.5	3	14.5	A
74	7	6	5.1	3	14.6	A
75	7	9	2.5	3	13.5	A
76	9	9	9	8	26	Excellent
77	9	9	7	6	22	E
78	9	9	7.7	6	22.7	E
79	7	6	7	3	16.5	G
80	7	6	4	2	12.5	F

TABLE 7: (Cont'd.)

Zone	No. Habitat Pts./Rating Category A1	A2	A3	A4	Total No. Habitat Pts. (max. 28)	Rating
81	7	6	7	2	15.5	G
82	7	6	7	3	16.5	G
83	5	6	7	0	12.5	F
84	5	6	7	2	14.5	A
85	7	6	7	2	15.5	G
86	5	6	6.2	1	12.7	A
87	7	9	6.5	5	19.5	G
88	5	6	6.6	3	15.1	A
89	5	6	6	3	14.5	A
90	7	6	7	3	16.5	G
91	5	6	6.6	5	17.1	G
92	7	9	6.5	5	19.5	G
93	7	9	7.6	5	20.6	E
94	7	6	6.7	5	18.2	G
95	7	9	8.3	6	22.3	E
96	7	9	6.5	4	18.5	G
97	7	9	5.8	6	19.8	E
98	7	9	6.8	4	18.8	G
99	7	9	3.5	4	15.5	G
100	7	6	4.5	3	14	A
101	7	9	6.5	3	17.5	G
102	7	6	6.2	2	14.7	A
103	3	2	3	1	6.5	P
104	7	6	7	3	16.5	G
105	7	9	2	3	13	A
106	7	9	7	3	18	G
107	7	9	7	3	18	G
108	9	9	9	10	28	E
109	7	6	2	3	11.5	F
110	9	9	2	4	15	A
111	7	9	2.5	5	15.5	G
112	7	6	7	3	16.5	G
113	7	6	2	5	13.5	A
114	7	6	4.5	5	16	G
115	7	6	7	3	16.5	G
116	7	6	3	5	14.5	A
117	7	6	7	5	18.5	G
118	7	9	7	5	20	E
119	7	6	7	3	16.5	G
120	7	9	7	3	18	G

TABLE 7: (Cont'd.)

Zone	No. Habitat Pts./Rating Category A1	A2	A3	A4	Total No. Habitat Pts. (max. 28)	Rating
121	7	9	5.5	3	16.5	G
122	7	6	7	3	16.5	G
123	7	9	6.1	1	15.1	A
124	7	6	4.2	1	11.7	F
125	7	6	6.6	1	14.1	A
126	7	6	5	3	14.5	A
127	7	6	4.6	1	12.2	F
128	7	6	6.6	1	14.1	A
129	5	6	3.8	1	10.3	F
130	5	6	7	3	15.5	G
131	7	6	5.5	3	15	A
132	7	6	7	1	14	A
133	7	6	5	0	11.5	F
134	7	6	7	2	15.5	G
135	7	9	6	1	15	A
136	7	9	7	2	17	G
137	7	9	7	0	15	A
138	7	9	7	2	17	G
139	7	9	7	0	15	A
140	7	9	6.5	2	16.5	G
141	7	9	5	2	15	A
142	7	6	7	1	14.5	A
143	7	6	6	1	13.5	A
144	7	6	9	6	21.5	E
145	7	9	5.5	3	16.5	G
146	7	6	7	3	16.5	G
147	5	9	7	0	14	A
148	5	6	3.4	0	8.9	P
149	7	9	6.5	0	14.5	A
150	7	9	5	2	15	A
151	7	9	6.5	2	16.5	G
152	7	6	3.5	0	10	F
153	7	9	6	0	14	A
154	7	9	6	3	17	G
155	7	6	5.5	0	12	F
156	5	6	7	0	12.5	F
157	7	6	3.5	0	10	F
158	3	6	6.6	3	14.1	A
159	7	9	6	3	17	G
160	7	9	4.8	8	20.8	E

TABLE 7: (Cont'd.)

Zone	No. Habitat Pts./Rating Category A1	A2	A3	A4	Total No. Habitat Pts. (max. 28)	Rating
161	7	9	6.5	3	17.5	G
162	7	6	5.5	5	17	G
163	7	6	6	9	21.5	E
164	7	6	9	7	22.5	E
165	7	6	4	1	11.5	F
166	7	9	5	1	14	A
167	7	9	2	1	11	F
168	7	9	4.5	2	14.5	A
169	9	9	6	1	16	G
170	7	6	7	1	14.5	A
171	7	9	7	1	16	G
172	7	9	5.6	3	16.6	G
173	7	9	7	2	17	G
174	7	9	3	5	16	G
175	7	6	7	3	16.5	G
176	7	6	5	2	13.5	A
177	7	6	7	3	16.5	G
178	7	6	6	3	15.5	G
179	7	6	7	3	16.5	G
180	7	6	5.5	3	15	A
181	7	6	7	3	16.5	G
182	7	6	5	3	14.5	A
183	7	6	5	3	14.5	A
184	7	6	7	1	14.5	A
185	7	6	5	1	12.5	F
186	7	6	6	0	12.5	F
187	7	6	6.5	2	15	A
188	7	9	5.5	5	18.5	G
189	7	6	6	3	15.5	G
190	7	6	7	3	16.5	G
191	7	6	5.8	2	14.3	A
192	5	6	3	1	9.5	P
193	7	6	6.2	1	13.7	A
194	7	9	7	2	17	G
195	7	9	7	0	15	A
196	5	9	7	0	14	A
197	7	9	7	0	15	A
198	7	9	7	0	15	A
199	7	9	7	0	15	A
200	7	9	7	1	16	G

TABLE 7: (Cont'd.)

Zone	No. Habitat Pts./Rating Category A1	A2	A3	A4	Total No. Habitat Pts. (max. 28)	Rating
201	7	9	7	1	16	G
202	7	9	7	0	15	A
203	7	9	7	0	15	A
204	7	9	7	2	17	G
205	7	9	3.5	0	11.5	F
206	7	9	7	0	15	A
207	7	9	7	0	15	A
208	5	2	7	0	10.5	F
209	7	9	7	0	15	A
210	7	9	7	2	17	G
211	7	9	7	0	15	A
212	7	9	6.5	0	14.5	A
213	7	9	7	1	16	G
214	5	6	3	0	8.5	P
215	7	9	7	0	15	A
216	7	9	3.7	0	11.7	F
217	7	9	7	0	15	A
218	7	9	7	0	15	A
219	7	9	7	0	15	A
220	7	9	7	0	15	A
221	7	9	7	0	15	A
222	7	9	7	0	15	A
223	7	9	7	0	15	A
224	7	9	7	0	15	A
225	7	9	7	0	15	A
226	7	6	7	0	13.5	A
227	7	6	6	5	17.5	G
228	7	6	7	3	16.5	G
229	7	6	7	3	16.5	G
230	7	6	5.5	1	13	A
231	7	6	7	3	16.5	G
232	7	6	7	3	16.5	G
233	7	6	7	3	16.5	G
234	7	6	7	3	16.5	G
235	7	6	5.5	1	13	A
236	7	6	5.4	4	15.9	G
237	7	6	6.6	7	20.1	E
238	7	6	7	5	18.5	G
239	7	6	7	1	14.5	A
240	7	6	6.6	1	14.1	A

TABLE 7: (Cont'd.)

Zone	No. Habitat Pts./Rating Category A1	A2	A3	A4	Total No. Habitat Pts. (max. 28)	Rating
241	7	6	7	1	14.5	A
242	7	6	7	1	14.5	A
243	7	6	7	3	16.5	G
244	7	9	7	4	17.5	G
245	5	6	7	0	12.5	F
246	1	2	3.4	1	5.9	P
247	7	6	7	1	14.5	A
248	5	6	6.6	2	14.1	A
249	7	9	7	0	15	A
250	7	9	7	0	15	A
251	3	6	6.2	2	12.7	A
252	7	6	7	0	13.5	A
253	7	9	7	0	15	A
254	7	9	9	6	23	E
255	7	9	2	2	12	F
256	7	9	4.1	4	16.1	G
257	7	6	6.6	0	13.1	A
258	7	9	7	1	16	G
259	7	9	7	0	15	A
260	7	9	6.5	0	14.5	A
261	7	6	6.2	1	13.7	A
262	7	6	6.5	0	13	A
263	3	2	3.7	1	7.2	P
264	5	6	6	1	12.5	F
265	5	2	3.4	0	6.9	P
266	7	6	6.5	1	14	A
267	3	2	6.2	1	9.7	P
268	7	6	7	2	15.5	G
269	5	6	5.5	3	14	A
270	5	6	6.6	3	15.1	A
271	3	2	3.4	1	6.9	P
272	5	6	7	0	12.5	F
273	7	6	6.5	0	13	A
274	7	9	3.2	4	15.2	A
275	10	6	6.5	3	17.5	G
276	3	6	7	1	12.5	F
277	7	6	6.5	0	13	A
278	7	6	6.5	1	14	A
279	7	9	6.5	1	15.5	G
280	9	9	6	2	17	G

TABLE 7: (Cont'd.)

Zone	No. Habitat Pts./Rating Category A1	A2	A3	A4	Total No. Habitat Pts. (max. 28)	Rating
281	7	6	4.5	1	12	F
282	7	9	2.5	2	12.5	F
283	7	6	6	2	14.5	A
284	7	9	3.7	4	15.7	G
285	7	6	6.5	3	16	G
286	5	9	2.7	4	13.7	A
287	5	6	6.5	2	14	A
288	7	9	2.7	9	19.7	E
289	5	6	4	1	10.5	F
290	7	9	5.5	0	13.5	A
291	7	9	3.9	2	13.9	A
292	7	6	5.5	2	14	A
293	5	6	6.5	2	14	A
294	5	6	7	1	13.5	A
295	5	6	6	1	12.5	F
296	7	9	3	3	14	A
297	7	9	6	2	16	G
298	7	9	4	2	14	A
299	7	6	6.5	0	13	A
300	7	9	3	2	13	A
301	7	6	5.5	5	17	G
302	7	6	3.5	2	12	F
303	3	2	5.4	3	10.9	F
304	7	6	6	1	13.5	A
305	5	6	6.2	1	12.7	A
306	7	6	5.5	5	17	G
307	5	6	6.5	3	15	A
308	5	6	3.5	0	9	P
309	3	6	4.5	1	10	F
310	5	6	6.5	1	13	A
311	3	6	5	1	10.5	F
312	1	2	4.6	0	6.1	P
313	5	6	5	1	11.5	F
314	3	6	6.5	3	14	A
315	7	6	3.5	4	14	A
316	5	6	6	4	15.5	G
317	5	6	6	0	11.5	F
318	5	6	5	0	10.5	F
319	7	6	6.5	3	16	G
320	3	2	5.8	1	9.3	P

TABLE 7: (Cont'd.)

Zone	No. Habitat Pts./Rating Category A1	A2	A3	A4	Total No. Habitat Pts. (max. 28)	Rating
321	5	6	6	3	14.5	A
322	5	6	6.3	1	12.8	A
323	7	6	4.5	6	17	G
324	3	6	6.1	1	11.6	F
325	3	2	5.3	3	10.8	F
326	1	2	3.8	1	6.3	P
327	7	6	4.5	3	14	A
328	5	6	6	2	13.5	A
329	3	2	7	0	9.5	P
330	7	6	5	4	15.5	G
331	7	9	2.7	2	12.7	A
332	7	9	6	0	14	A
333	7	9	6	4	18	G
334	5	6	3.5	2	11	F
335	3	6	6.5	2	13	A
336	5	6	6	0	11.5	F
337	7	6	4	6	16.5	G
338	7	6	6.5	0	13	A
339	7	6	6.5	0	13	A
340	5	6	6	0	11.5	F
341	1	2	5.7	3	10.2	F
342	7	6	5	4	15.5	G
343	7	9	6	3	17	G
344	5	6	6.6	1	13.1	A
345	7	6	6.5	0	13	A
346	5	6	6	1	12.5	F
347	5	6	6	3	14.5	A
348	5	6	6	3	14.5	A
349	7	9	4	9	21	E
350	7	9	5	4	17	G
351	7	6	3.7	8	18.2	G
352	5	6	6	5	16.5	G
353	3	6	6.5	0	11	F
354	5	6	4.5	3	13	A
355	3	6	6	1	11.5	F
356	5	6	7	2	14.5	A
357	5	6	6.1	1	12.6	F
358	3	2	5.4	0	7.9	P
359	5	6	6	3	14.5	A
360	5	6	6.2	0	11.7	F
361	5	6	5	3	13.5	A
362	7	6	6.5	1	14	A
363	7	6	6	0	12.5	F
364	7	6	5	0	11.5	F
365	7	6	6	0	12.5	F
366	7	6	6.5	0	13	A
367	7	6	6	0	12.5	F
368	7	6	6.5	0	13	A
369	5	6	6.5	0	12	F
370	5	6	6	0	11.5	F

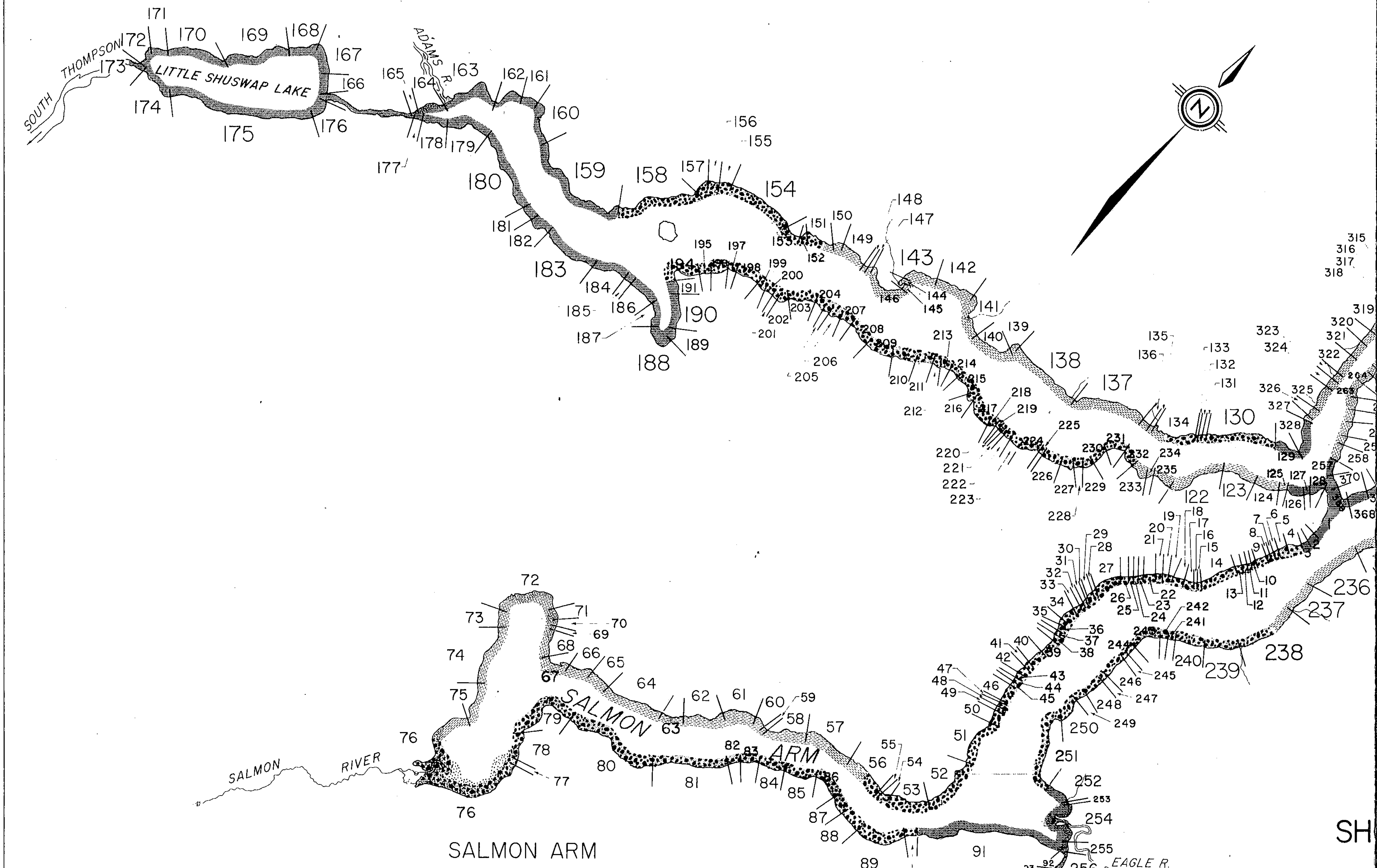
Results of the inventory suggest that 48.3% of the Shuswap Lake foreshore provides good or excellent juvenile salmon habitat and that 82.9% of the shoreline is potentially suitable for rearing salmonid fish. The best rearing areas are provided in zones 76-78, 93, 95, 97, 108, 118, 144, 160, 163-164, 237, 254, 288 and 349 (Figure 6).

3. DISCUSSION

Inventory of the littoral region in Shuswap Lake provides valuable information regarding potential salmon habitat. However, actual foreshore use by juvenile salmon must also be considered in a total watershed management plan. Accordingly, a composite figure relating beach seining data from the 1978 and 1979 Shuswap sampling programs to biophysical inventory zones was prepared (Figure 7). This figure suggests that not all foreshore areas designated as excellent fish habitat are heavily utilized and that many zones classified as poor habitat are located along primary migration routes for juvenile salmon leaving the lake. Responsible foreshore management should, therefore, consider both potential and actual lakeshore use by young salmon before decisions regarding development are made.

Sicamous Narrows, for example, is designated as providing good to excellent habitat (zones 92, 93, and 256) and was used extensively by rearing and migrating salmon in 1978 and 1979. Any alteration or disturbance of littoral areas in the Narrows must, therefore, be prevented. Habitat zones 236 and 237 near Anstey Arm also contain good to excellent fish habitat but, since they are used only occasionally by juvenile salmon, development of their foreshore zones is probably less critical. Some zones in the main arm of the lake are rated as only fair habitat (165, 167, 185, and 186), but since all salmon in Shuswap system migrate through these zones on their way to the Thompson River, development of their littoral areas must be restricted.

Use of the biophysical inventory, which defines important habitat zones, and beach seining data, which describes use by juvenile salmon of lakeshore areas (Figure 7), together with field inspection of all major development proposals, should allow efficient and responsible management of foreshore regions in the Shuswap watershed. Only responsible management will protect the integrity of the valuable salmon resource for which Shuswap Lake is famous.


SOUTH THOMPSON
LITTLE SHUSWAP LAKE
ADAMS R.
SALMON RIVER
SALMON ARM
EAGLE R.
SALMON ARM

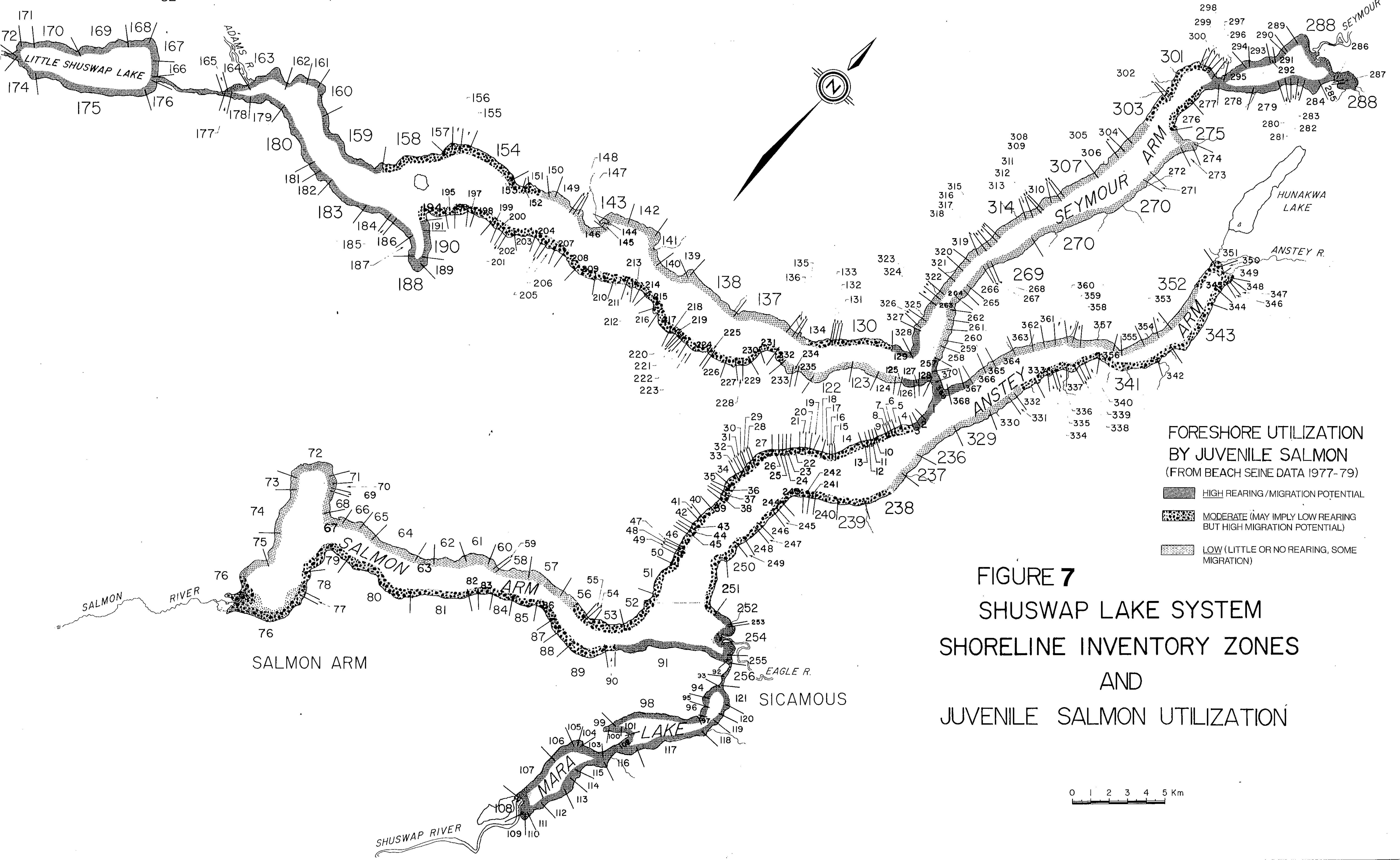


FIGURE 7
SHUSWAP LAKE SYSTEM
SHORELINE INVENTORY ZONES
AND
JUVENILE SALMON UTILIZATION

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BIOPHYSICAL LAKE INVENTORY - SHUSWAP LAKE 1978

DATE ______

ARM/BASIN ______

MAP/PHOTO. REF. NO. ______

SHORELINE ZONE NO. ______

SHORELINE LENGTH (km) ______

LITTORAL WIDTH (m) ______

BEACH WIDTH (m) ______

COMMENTS:

______

______

______

______

______

______

______

______

______

1 LITTORAL SUBSTRATE

SUBSTRATE COMPOSITION %

- BEDROCK ______
- COBBLE ______
- GRAVEL ______
- SAND ______
- SILT/MUD ______

SUBSTRATE VEGETATION

- WEEDS ______
- PERIPHYTON ______
- BARREN ______

ADDITIONAL CHARACTERS

- FALLEN TREES ______
- REFUSE ______

LITTORAL SLOPE

- GRADUAL ($<15^{o}$) ______
- INTERMEDIATE ($15-45^{o}$) ______
- STEEP ($>45^{o}$) ______

RIVER/CREEK:

- INFLOW ______
- OUTFLOW ______
- WIDTH AT MOUTH (m) ______
- NAME ______

2 LAKESHORE

SHORELINE VEGETATION %

- CONIFEROUS ______
- DECIDUOUS ______
- SHRUBS ______
- GRASSES ______
- MARSH ______
- BARREN ______

SHORELINE CHARACTERS

- DEGRADING ______
- AGRADING ______
- SLUMPAGE ______
- STABLE ______
- VEGETATION OVERHANG ______

CULTURAL USE

- NONE/NATURAL ______
- PROV.PARK/PUBLIC BEACH ______
- PRIVATE HOMES ______
- MARINAS ______
- LOGGING ACTIVITIES ______

BEACH SUBSTRATE % COMPOSITION

- BEDROCK ______
- COBBLE ______
- GRAVEL ______
- SAND ______
- SILT/MUD ______

BEACH SLOPE

- GRADUAL ($<15^{o}$) ______
- INTERMEDIATE ($15-45^{o}$) ______
- STEEP ($>45^{o}$) ______

Appendix I