Fish Community of Shuswap Lake's Foreshore

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ABSTRACT

Brown, T.G. and Winchell, P. 2004. Fish community of Shuswap Lake's foreshore. Can. Tech. Rep. Fish. Aquat. Sci. 2568: viii + 39 p.

The fish community of Shuswap Lake's seasonally flooded foreshore was examined from April to September over three years. Different methods were used to capture and enumerate fish including beach seining, pole seining, minnow trapping, and night snorkel surveys. Fourteen fish species were identified, however the near-shore fish community was dominated by three species; sculpins (*Cottus asper,* 54%), redside shiners, (*Richardsonius balteaus,* 27%), and chinook juveniles (*Oncorhynchus tshawytscha,* 12%). Minnow trapping was not considered a viable method of capturing a representative selection of fish along the lake edge.

Day and night pole seining was compared and significantly more total fish ($P < .0001$), chinook juveniles ($P < .0001$), redside shiners, ($P< .0001$), sculpins ($P < .0001$) and minnows ($P < .01$) were captured at night within the first 3 m of the lake edge. Chinook night catch was from 100 to 1000 times greater than day catch. Larger chinook juveniles were captured by pole seine at night but not during the day, while larger chinook juveniles were captured during the day with the beach seine. This indicates a strong diurnal movement of larger fish between the deep and shallow littoral zone. Lunar cycle did not appear to influence the number of fish caught at night.

The number of young salmonids occupying the lake margins declined rapidly from April to July. Chinook fry were first captured on March 28, numbers peaked on April 25-26, and a few isolated individuals (7 total) were captured by pole seine or seen during the night snorkels in August. Coho fry were first seen on April 10, numbers peaked mid-June and they were never captured after July. Sockeye fry were first captured on March 28, numbers peaked mid-April, and none were seen along the shoreline after July. Thus, some Shuswap Lake foreshore locations were occupied by coho and sockeye salmon fry from late-March to late-July. A few chinook young resided along the lake shore for a slightly longer period.

Fine texture exposed beaches (sand, small gravels) supported significantly more chinook fry ($P <.01$) than coarse exposed beaches (cobble, boulder). The coarse exposed beaches supported more redside shiners during each of the three years of study; however this result was not significant. Protected sites (i.e., backchannels and lake alcoves with limited exposure to wave action) supported more coho salmon, (*O. kisutch*) and juvenile northern pikeminnow (*Ptychocheilus oregonesis*) than exposed sites ($P < .0001$). Locations disturbed by anthropogenic activities (i.e. riparian removal and lake shore construction), supported less salmon juveniles than undisturbed locations, however this result was not significant.

Features considered important in characterizing juvenile salmonids lake edge habitat include, the vicinity of natal streams, gentle sloping shores with an extensive littoral zone, and fine textured substrate. The importance of delta-lakefront habitat in Shuswap Lake must be stressed. Coho fry distribution was noticeably limited to shoreline irregularities or flooded backwater areas close to natal streams. Chinook fry were more numerous on exposed beaches, but numbers were highest near natal rivers. Chinook 1+ juveniles were fewer in number, were captured at most foreshore sites, and when captured were always from exposed beaches.

RÉSUMÉ

Brown, T.G. and Winchell, P. 2004. Fish community of Shuswap Lake's foreshore. Can. Tech. Rep. Fish. Aquat. Sci. 2568: viii + 39 p.

Nous avons examiné, sur trois années consécutives, entre avril et septembre, la communauté des poissons qui fréquentent les berges annuellement inondées du lac Shuswap. Différentes méthodes ont été utilisées pour capturer et énumérer les poissons, notamment l'utilisation de sennes de plage, de sennes à perche, de pièges à petits poissons et de relevés effectués la nuit en plongée au tuba. Au total, quatorze espèces de poissons ont été identifiées mais la communauté des poissons qui vivent près des berges était dominée par trois espèces : le Chabot (*Cottus asper,* 54 %), le Méné rose (*Richardsonius balteaus,* 27 %) et les jeunes saumons quinnats (*Oncorhynchus tshawytscha,* 12%). Le piégeage des petits poissons n'a pas été retenu comme étant une méthode viable pour la capture d'une sélection représentative des poissons qui fréquentent les bords du lac.

Nous avons comparé les résultats obtenus à l'aide de la seine à perche entre les traits effectués de jour et les traits effectués de nuit. Un nombre significativement plus grand de poissons ($P < 0,0001$), de jeunes saumons quinnats ($P < 0,0001$), de ménés roses, ($P < 0,0001$), de chabots ($P < 0,0001$) et de ménés ($P < 0,01$) ont été capturés la nuit, à moins de 3 m des berges. Les prises nocturnes de saumons quinnats furent 100 à 1000 fois plus nombreuses que les prises diurnes. La seine à perche n'a permis de capturer les gros spécimens de jeunes saumons quinnats que la nuit, tandis que la seine de plage a permis de capturer les plus gros spécimens durant le jour. Ce résultat suggère qu'il existe un mouvement journalier marqué des plus gros poissons entre les eaux profondes et la zone moins profonde près des berges. Le cycle lunaire n'a apparemment eu aucune influence sur le nombre de poissons capturés la nuit.

Le nombre de jeunes salmonidés fréquentant les marges du lac décline fortement entre avril et juillet. Les alevins de saumons quinnats ont été capturés pour la première fois le 28 mars et les prises atteignirent leur maximum le 25-26 avril. Quelques spécimens isolés (7 au total) ont été capturés à l'aide de la seine à perche ou observés en août, lors des sorties de nuit en plongée au tuba. Les alevins de saumons cohos ont été observés pour la première fois le 10 avril et leur nombre est passé par un maximum à la mi-juin. Aucun n'a été capturé après juillet. Les alevins de saumons rouges ont été capturés pour la première fois le 28 mars, leur nombre est passé par un maximum à la mi-avril et aucun n'a été observé près des berges après juillet. Quelques emplacements

le long des berges du lac Shuswap ont donc été occupés simultanément par des alevins de saumons cohos et de saumons rouges entre fin mars et fin juillet. Quelques jeunes saumons quinnats sont restés légèrement plus longtemps à proximité de la berge.

Les plages exposées faites de sable ou de petits graviers abritaient un nombre significativement plus important d'alevins de saumons quinnats (P <0,01) que les plages exposées comportant de gros cailloux et des rochers. Ces dernières abritaient en revanche un plus grand nombre de ménés roses, quelle que soit l'année considérée à l'intérieur de l'étude qui dura trois ans, mais ce résultat ne s'est pas avéré significatif. Les sites protégés (c.-à-d. les canaux et les baies retirés et abrités de l'action des vagues) abritaient un plus grand nombre de saumons cohos (*O. kisutch*) et de jeunes sauvagesses du Nord (*Ptychocheilus oregonensis*) que les sites exposés (P < .0001). Les sites perturbés par des activités anthropogéniques (c.-à-d. élimination de la végétation riparienne et construction sur les berges du lac) abritaient moins de jeunes saumons que les sites non perturbés mais ce résultat ne s'est pas avéré non plus significatif.

Parmi les éléments considérés comme étant importants pour la caractérisation des habitats ripariens utilisés par les jeunes salmonidés, on peut citer la proximité des ruisseaux natals, la faiblesse des pentes de la berge et l'étendue de la zone littorale ainsi que la finesse du substrat. L'importance de l'habitat situé devant le delta formé par les cours d'eau alimentant le lac Shuswap doit être soulignée. Remarquablement, les alevins de saumons cohos se cantonnaient aux irrégularités rencontrées le long des berges ou dans les bras morts inondés situés près des cours d'eau natals. Les alevins de saumons quinnats étaient plus nombreux sur les plages exposées et les effectifs maximums étaient observés près des rivières natales. Les jeunes saumons quinnats de plus de 1 an étaient en petit nombre et ont été capturés sur la plupart des sites en bordure des berges, toujours sur des plages exposées.

INTRODUCTION

The foreshore of Shuswap Lake has been documented as an important rearing area and migration route for Thompson River sockeye (*Oncorhynchus nerka*), chinook (*O. tshawytscha*), and coho (*O. kisutch*) salmon (Fedorenko and Pearce 1982; Graham and Russell 1979; Russell et al. 1980). Other fish species important to the ecology of the lake also utilize the lake shore. Juvenile salmonids can exploit previously dry lake margins from April to June as the lake water levels rise. A portion of the diet of juvenile coho and chinook salmon captured from the littoral zone of Shuswap Lake consisted of near shore benthic invertebrates (Brown and Winchell 2002; Davies et al. 1996; Russell et al. 1980.)

The foreshore (littoral zone) and the riparian zones of large lakes such as Shuswap Lake are under considerable pressure from urbanization (Fig. 1); substrate is removed for private beach creation and collected in rows, riparian vegetation is cut, protective walls are built, emergent vegetation is removed, and small marshy bays are altered. This study was designed to define the role of Shuswap Lake's littoral zone as juvenile salmon fish habitat and assess the potential impacts of foreshore and riparian development. An examination of the fish community is only a small component of the overall ecology of juvenile salmonids rearing along the foreshore of a large lake. In this paper we examined the fish community of Shuswap Lake's seasonally flooded foreshore. We described the abundance, distribution, and habitat utilization of these fish. We compared the various methods used to capture fish and discussed their utility. A previous paper examined the benthic community of Shuswap Lake (Brown et al. 2004). Fish diets will be examined in a later paper.

STUDY AREA

SHUSWAP LAKE

Shuswap Lake is located in the southern interior of British Columbia within the South Thompson River drainage (Fraser River). The lake collects the waters from an area of 25,000 km^2, has a perimeter of 956 km (Kramer 2004), has a surface area of 310 km^2, and a maximum depth of 162 m (Williams et al. 1989a). The lake has a water residence time of 2.1 years (Nidle and Shortreed 1996). Thirty-four permanent streams and rivers flow into Shuswap Lake. However, 5 major rivers (Adams, Seymour, Salmon, Shuswap and Eagle) represent most of the inflow. Shuswap Lake is a multi-basin lake consisting of four arms or five reaches (Main, Salmon, Sicamous, Anstey, and Seymour). The Main Arm of Shuswap Lake was the only area examined during the three years of study (Fig. 2).

The lowest lake water levels occur in March and the highest lake levels occur in June/July. Water levels are routinely recorded as metres above sea level. Davies et al. (1996) reported an average annual difference in water levels of 3.3 m, with a mean high water of 348.3 m above the geodetic chart datum and a mean low water level of

345.0 m. During the three years of study the largest single day increases in lake levels occurred on; May 26/1999 at 16.0 cm, May 22/2000 at 12.6 cm, and May 28/2001 at 16.1 cm. The maximum recorded lake level for each of the three years of study were; 349.22 m on July 15/1999, 348.33 m on July 1/2000, and 347.92 m on June 11/2001 (Kramer 2004). Kramer (1999) described how snow melt processes contributed to lake levels and examined the potential of flooding along the shores of Shuswap Lake.

SITE DESCRIPTIONS

In three years of study we characterized twenty-two locations and systematically surveyed them for fish (Fig. 2 and Table 1). Both sides of the lake were accessible by road and most of the waterfront property had been developed for recreational use. The disturbed foreshores included the right-of-ways of roads and the railway where riparian vegetation had been cleared to the lake edge as well as private properties where lawns and houses had replaced natural vegetation. A few sections of the shore have remained relatively undisturbed (i.e. Roderick Haig-Brown Park, Scotch Creek delta, lower lake outlet).

Almost the entire main arm of Shuswap Lake's foreshore is exposed to wave action and very few protected bays and alcoves exist along either shore. The exposed foreshore locations were divided into two substrate types. Cobble/rock beaches were associated with steeper shores, while sand, silt, and fine gravel substrates were found on the gently sloping beaches and were common to the delta-lakefronts of the inflowing rivers. In 2000, we examined four locations that were flooded during high water in May to July and we considered these to be partially isolated from the lake's wave actions. These sites were located in backchannels, depressions, and at the bottom of a bay. The substrates consisted of fine material (mud/silt) and patches or beds of sedges and rushes were common.

Table 1. Shuswap Lake study locations, years sampled, substrate, exposure, and riparian status is indicated. Methods employed include: M = minnow traps, BS = beach seine, SK = snorkel count, NP = night pole seine, and DP = day pole seine. Location 13 was seined twice in 1999. Locations were either exposed to the open lake = EXP or flooded backchannels, wetlands or weedy = FLD.

Site	1999	2000	2001	Substrate		Riparian Status
01	M,BS,DP			sand	EXP	Undisturbed Cottonwoods and Conifers
02	M,BS,DP	DP,NP	SK,DP,NP	sand	EXP	Undisturbed Cottonwoods-Delta
03		DP,NP	SK,DP,NP	sand	EXP	Undisturbed Cottonwoods
04	M,BS,DP			sand	EXP	Undisturbed Cottonwoods-Delta
05	M,BS,DP			sand	EXP	Disturbed lawns and houses
06	M,BS,DP			cobble	EXP	Undisturbed Conifers

Site	1999	2000	2001	Substrate		Riparian Status
07	M,BS,DP	DP,NP	SK,DP,NP	sand	EXP	Undisturbed Cottonwoods and willows
08	M,BS,DP			sand	EXP	Disturbed houses, cement wall
09	M,BS,DP			cobble	EXP	Disturbed brush fringe to road
10	M,BS,DP	DP,NP	SK,DP,NP	cobble	EXP	Undisturbed Conifers
11		DP,NP	SK,DP,NP	cobble	EXP	Undisturbed Conifers
12	M,BS,DP			cobble	EXP	Undisturbed Conifers
13	M,BS,DP	DP,NP	SK,DP,NP	cobble	EXP	Undisturbed Conifers
13a	BS			cobble rows	EXP	Disturbed houses, cement wall
14	M,BS,DP, NP	DP,NP	SK,DP,NP	sand/gravel	EXP	Disturbed brush fringe to road
15	M,BS,DP			cobble	EXP	Disturbed brush fringe to road
16	M,BS,DP, NP			sand	EXP	Disturbed lawns and houses
17	M,BS,DP, NP			cobble	EXP	Disturbed brush fringe to road
18	M,BS,DP, NP	DP,NP	SK,DP,NP	cobble	EXP	Undisturbed Conifers and willows
20		NP		mud/veg	FLD	Undisturbed Cottonwoods/flooded sedges
21		NP		mud/veg	FLD	Disturbed Grasses/sedges to road
22		DP,NP	DP,NP	mud/veg	FLD	Undisturbed Cottonwoods/sedges/ channels
23		NP		mud/veg	FLD	Undisturbed Cottonwoods-willows/grasses

FISHERIES RESOURCE

Thirty fish species are listed for the South Thompson drainage (MacPhail and Carveth 1994). Two trout species, two char, whitefish, and all five salmon species have been recorded in the Shuswap Lake drainage. These fish species are utilized in the commercial, recreational, and food fisheries. Three salmon species; chinook (*O. tshawytscha*), coho (*O. kisutch*), and sockeye (*O. nerka*) are common and their young have been previously captured within the littoral areas of Shuswap Lake (Russell et al. 1980).

Salmon spawn in many of the 34 permanent streams and rivers flowing into Shuswap Lake and sockeye salmon also spawn on the lake shore (Birch 1988). Maximum sockeye returns exceed: 1,000,000 to the Adams River; 100,000 to the Seymour River; 10,000 to the Anstey River, Scotch Creek, Eagle River, and Shuswap Lake; 1,000 to Salmon River, Tappen Creek, Reinecker Creek, Shuswap River and Ross Creek; and 100 to Canoe Creek and Onyx Creek. Maximum chinook returns exceed: 10,000 to the Shuswap River; 1,000 to the Adams River, Salmon River and Eagle River; and 100 to the Anstey River. Coho escapement is difficult to enumerate and coho have the potential to spawn in most streams. The largest returns are to the Eagle River (>10,000) and to the Salmon, Shuswap and Adams Rivers (>1,000). Occasionally returns of up to 1,000 pink salmon (*O. gorbuscha*) have been recorded in the Adams and Anstey Rivers, and although chum salmon carcasses (*O. keta*) have been found in the Adams River (Welch and Till 1996), this should be considered an unusual occurrence.

METHODS

SAMPLING DESIGN

The study design and methods changed for each of the three years of sampling. However, six sites were sampled in all three years. In 1999, 16 exposed foreshore locations were sampled for fish (Appendix 1; Tables 1-3). The objective in 1999 was to compare different sampling methods and to detect differences in shoreline habitat types. These locations represented two substrate types (sandy and cobble) and two riparian types (cleared of trees and treed). Four methods were employed to capture fish. These included; day pole seining (June 8-20), night pole seining (July 13), beach seining (June 21-24), and minnow ®Gee trapping (July 8-11). Each location was sampled once by beach seine, minnow traps, and day pole seine. Four locations were sampled by pole seine at night.

In 2000, 12 locations representing three substrate types were sampled from June 2 to September 12 using a pole seine (Appendix 1; Table 4). Four sandy exposed foreshore locations and four cobble exposed foreshore locations were sampled ten times during the day and six times at night. Four flooded sand/mud bottomed sites, supporting the growth of emergent vegetation, and protected from strong wave action (either alcoves or backchannels), were sampled four times at night. Location 22 (sand/mud backchannel) was sampled an additional six times during the day and two more times at night.

In 2001, the same eight exposed foreshore sites sampled in 2000 were sampled from March 28 to August 28 (Appendix 1; Table 5). Each location was sampled with a pole seine six times during the day and nine times at night. Location 22, a backchannel site, was also sampled with a pole seine twice at night and twice during the day. At each of the exposed foreshore locations, eight snorkel surveys were conducted at night within 24 hr of a corresponding night pole seine.

FISH CAPTURE

A beach seine was used to capture littoral residing fish in June 1999 (Appendix 1; Table 1). The beach seine used (30-m long x 1.5-m deep with 1-cm stretched arms and 0.5 cm stretched nylon mesh cod-end) was similar to that described by Russell et al. (1980). All sampling took place during the day. Two beach seines were conducted at each location except at location 13, where four seines were completed (Table 2). The additional seines at location 13a were conducted within the sandy spaces between piled rows of rocks and boulders approximately 200 m from location 13. The net was set by boat and after both ends were secured on shore the net was hauled to the beach. The haul displaced a wetted area estimated to be 10-m wide and 25-m long (250 m^2). If a seine snagged on the bottom during its retrieval then all the contents would be dumped and another clean retrieval would be attempted over a slightly different course. The beach seine was capable of sampling further from shore and in slightly deeper water than the other techniques.

Minnow trapping was used to capture fish from the littoral area of Shuswap Lake in July 1999 (Appendix 1; Table 2). Each minnow ®Gee trap was baited with a spoonful of canned sardines in oil, contained in a perforated plastic sandwich bag and left for 24 hr to attract fish. A series of 10 minnow traps, spaced approximately 5 m apart, were strung on a line. Two lines (20 traps total) were set by boat at each location at a depth of approximately 2-3 m. Catch/trap may be indicative of the relative fish abundance at each location, but it is impossible to equate catch/trap to densities. Bottom oriented fish would be more likely to enter the traps.

Snorkel surveys were used in 2001 to estimate the number of fish visible within the shallow margins of Shuswap Lake at night (Appendix 1; Table 6). All snorkel surveys were conducted within 24 hr of a comparable night pole seine, thus the two estimates could be compared. Each snorkel survey consisted of a snorkel diver swimming approximately 4-5 m from shore, looking towards the shore and counting all fish visible with a diving light. A second person would walk the shore recording the numbers and counting any additional fish residing in water too shallow for the swimmer to see. Four 10 m sections of foreshore were enumerated at each location.

There were limitations to the snorkel survey. First, only the exposed foreshore locations could be enumerated in this manner. The backchannels and flooded areas were not surveyed. Second, the snorkel survey could only estimate the number of fish seen within the water column. Thus sculpins, due to their cryptic colouration and bottom dwelling behaviour, were not enumerated. Third, the species of fish was harder to characterize underwater. We were however confident of our juvenile chinook and redside shiner identifications.

A pole seine was used to capture fish along the margins of Shuswap Lake during each of the three years during both day and night (Appendix 1; Tables 3-6). The seine was 3-m wide, 1.5-m high, had a lead line along the bottom, and was made from 2-mm mesh. It was operated by two persons, at a maximum distance from shore of 3 to 4 m, and a maximum depth of 1 m. Thus, only the shallowest margins of the lake were sampled. When pursed the net fished a width of approximately 2 m. Each set consisted of dragging the net over a different 10 m long section of the flooded foreshore (20 m^2 / set) at each location.

The backchannel sites (locations 20-23) that contained some woody debris and emergent vegetation were difficult to sample due to the high probability of snagging the small pole seine. This was especially true at night as lights were used after the net was hauled to shore to identify and enumerate the catch, but lights were not used during the actual fishing. Often only two or three sets would be conducted in the back channel locations and these are indicated in Appendix 1.

All chinook, sockeye and coho were length measured expect on those occasions when more than 35 fish of a given species were captured at one location. A representative sample would then be measured and the rest would be counted and released. During each year of the study a selection of salmon juveniles were preserved in 5% formalin. These were saved for future stomach analysis. All non-salmonids were identified where possible to species, counted, and at various times throughout the study they were measured. All larger non-salmonids were measured. Samples of fish were also preserved for later examination when field identification was questionable.

DISTANCE FROM SHORE

On April 26/01 at Roderick Haig-Brown Park (Location 2) at night, the number of chinook salmon fry residing at various distances from shore were estimated. A line starting at the wetted perimeter of the lake (0 point) was held perpendicular to the shore by a wader standing 4-5 m from shore in less than 1 m depth of water. The line was marked at 0, 0.5, 1.5, 2.5, and 3.5 m, thus creating four intervals. The corresponding average water depths in cm for each marked point were 0, 5, 23, 37, and 52. All chinook fry that resided within 2.5 m on each side of the line (5 m total shoreline distance) were counted for each interval. This process was repeated eight times at different sites. The water was clear, substrate was light coloured sand, gradient was slight, and the chinook fry were darker in colour and easy to count when highlighted with night lights. We noted very little fish disturbance or movement during the estimates as the fry appeared to hold their positions.

RESULTS

FISH SPECIES

A total of 30 fish species are listed for the Thompson River watershed (MacPhail and Carveth 1994). Many of these species (Table 2) are unlikely to be found along the shores of Shuswap Lake or to be captured by the methods that were employed. Fourteen fish species were identified, however not every fish captured could be individually examined, especially at night in the field. We could not be certain that all the *Catostomus* were longnose suckers (some may have been large scale suckers) or that all whitefish were *Prosopium williamsoni*, and it was impossible to differentiate small *Salvelinus* sp. Thus these genera may contain more than one species.

Along the foreshore of Shuswap Lake in spring, three species; prickly sculpin (*Cottus asper*), redside shiner (*Richardsonius balteatus*), and juvenile chinook salmon, represented 93% of all the fish captured (Table 2). Two salmon species (coho and sockeye) represented 2%, 3 minnows (Northern pikeminnow (*Ptychocheilus oregonesis)*, longnose dace (*Rhinichthys cataractae)* and leopard dace *(R. falcatus*)) represented 4%, and the remaining 6 species combined represented 1% of the fish captured. A complete list of all catches by year, location and methods has been included in Appendix 1.

Table 2. List of Thompson River fish species (original list by MacPhail and Carveth1994; chum salmon identified by Welch and Till 1996). The number and percentage of total catch by species (minnow trapping excluded) are indicated. Highlighted areas indicate where misidentification was possible.

Species Name	Common Name	Percent	Number
Lampetra ayresi	River lamprey		
Acipenser transmontanus	White sturgeon		
Acrocheilus alutaceus	Chiselmouth		
Couesius plumbeus	Lake chub	< 1%	20
Cyprinus carpio	Carp		
Mylocheilus caurinus	Peamouth chub		
Ptychocheilus oregonesis	Northern pikeminnow	> 1%	187
Rhinichthys cataractae	Longnose dace	> 1%	116
R. falcatus	Leopard dace	> 1%	198
Richardsonius balteatus	Redside shiner	27%	3560
Catostomus catostomus	Longnose sucker	< 1%	29
C. columbianus	Bridgelip sucker		
C. commersoni	White sucker		
C. macrocheilus	Largescale sucker	?	
C. platyrhynchus	Mountain sucker		
Oncorhynchus clarki lewisi	Cutthroat trout (westslope)		
O. keta	Chum salmon		

Species Name	Common Name	Percent	Number
O. gorbuscha	Pink salmon		
O. kisutch	Coho salmon	> 1%	164
O. mykiss mykiss	Rainbow trout	< 1%	8
O. nerka	Sockeye salmon (Kokanee)	> 1%	124
O. tshawytscha	Chinook salmon	12%	1649
Salvelinus confluentus	Bull trout	?	
S. namaycush	Lake trout	< 1%	28
Lota lota	Burbot	< 1%	9
Coregonus clupeaformis	Lake whitefish	?	
Prosopium coulteri	Pygmy whitefish	?	
P. williamsoni	Mountain whitefish	< 1%	42
Cottus asper	Prickly sculpin	54%	7115
C. cognatus	Slimy sculpin		
C. rhotheus	Torrent sculpin		

DIFFERENCES BETWEEN METHODS OF CAPTURE

Fish Community

In July 1999, a total of 320 minnow Gee traps were set for 24 hr at 16 locations along the margins of Shuswap Lake. These traps captured 345 fish of which 84% were sculpins, 10% were redside shiners, and 6% were a mix of seven other fish species (Fig. 3). Only one fish was a salmonid (a sockeye fry). It is possible that if the traps were set earlier in the year more salmonids might have been captured. However, it is more likely that the preponderance of sculpins within the traps is indicative of their bottom dwelling behaviour which permitted their capture in minnow traps placed on the lake bottom. Other fish species feeding in the water column would be less likely to be captured. Minnow trapping was not considered a viable method of capturing a representative selection of fish residing along the shores of the lake and it was not continued during later years.

A beach seine was used to capture littoral zone fish in June 1999 from the main arm of Shuswap Lake. We sampled approximately 8,000 m^2 of the lake foreshore and caught 1,031 fish or 0.13 fish / m^2. Redside shiners were the most numerous fish (70%, Fig. 4) and 514 of 718 were from two rocky locations. Sculpins were also taken in the beach seines (12.8%) but their capture was relatively less common than it was for the minnow traps. Chinook juveniles were netted at 9 of 16 locations and represented 10% of the fish captured. Sockeye juveniles were captured at 6 of 16 locations and these represented 2.7% of the total catch. It thus appears that the salmonids and redside shiners were more susceptible to capture by beach seine than minnow trap.

In 1999, a pole seine was used to sample 640 m^2 of the shallowest foreshore during the day (Fig. 5) and 80 m^2 at night (Fig. 6). We captured 221 fish or

0.35 fish / m^2 during the day, and 324 or 4.05 fish / m^2 at night. Pole seining was considered the most viable method of sampling the lake edges. A portion of the fish captured during the day were chinook (22%), however 46 of 48 were taken from one location. During the day, small sculpins (43%) and redside shiners (34%) dominated. Only 4 locations were sampled by pole seine at night. In later years these 4 locations were shown to support high numbers of redside shiners and very few salmonids. Thus, the large portion of redside shiners (77%) and lack of chinook juveniles captured by the pole seine at night in 1999 is indicative of the location and not necessarily the method.

In 2000, day and night pole seines were conducted from June to September. No pole seines were initiated before June when the greatest number of salmonid fry would have been available along the lake shore. Day catches were composed mainly of sculpins (56%) and redside shiners (40%), while less than 3% of the fish caught were salmonids (Fig. 7). Night catch (Fig. 8), was also composed mainly of sculpins (61%) and redside shiners (24%). However, more salmonids were caught at night (5.4% chinook, 2.3% coho, and 1.5% sockeye).

In 2001, day and night pole seines were conducted from March through to August. Greater fishing effort was used than in 1999 and seining was initiated earlier in the year than in 2000. Thus the 2001 day catches (Fig. 9) and night catches (Fig. 10) should be more representative of the lake-edge, spring fish community than either of the 1999 or 2000 pole seine catches. The same fish species were present both day and night, but the relative composition of the shoreline community changed. Sculpins (56% night, 75% day) and redside shiners (15% night, 7% day) dominated. The relative proportion of chinook ranged from 25% at night to 5% during the day. All of the day caught coho fry (6%) were obtained from a backchannel (location 22) in which they were isolated from the main lake.

During the day in the clear water of the lake edge we could look ahead of the pole seine and see if fish were avoiding the net. We did not use lights while fishing at night and we were concerned that fish could avoid the pole seine. Thus, the number of fish captured at night would not be representative of the number of fish residing along the lake edge. In 2001 we conducted a series of 8 snorkel surveys at eight locations within one day of a night pole seine survey (paired n = 64). For comparison only the most visible fish, redside shiners and chinook, were considered.

The number of redside shiners captured in the night pole seines (Fig. 11) was highly correlated to the number of redside shiners seen during the night snorkel surveys (linear correlation; $P < .0001$). However, fewer redside shiners were captured by pole seine than were seen during the snorkel surveys (0.47 times). This was especially evident after June. It is possible that a portion of the very small redside shiners noted later in the year, may have passed through the net. It is also possible that from June to September, redside shiners occupied the shoreline slightly further from the lake edge (1-2 m). They would have been less catchable with the pole seine, but were still counted during the snorkel surveys. Thus, our estimates of the redside shiner population (pole seine) are likely an underestimate of the observed redside shiner numbers, especially after June (Fig. 11).

The number of chinook captured in the night pole seines (Fig. 12) was highly correlated to the number of chinook seen during the night snorkel surveys (linear correlation; $P < .0001$). Although slightly more chinook were taken with the pole seine than were counted during the snorkel surveys (1.17 times), the two estimates were similar. Thus, our estimates of the night time chinook population (pole seine) are representative of the numbers of chinook present along the shoreline.

Fish Size

There were differences in the size of fish captured by the various fishing methods. Although both the beach seine and pole seine were used during the day, the beach seine fished deeper water further from shore. Chinook juveniles netted with the beach seine and with the night pole seine were bimodal in fork-length distribution (Fig. 13) and were larger than those taken with the pole seine during the day. The largest chinook were likely 1+ year fish that had reared through the winter in either the lake or adjacent rivers. The sockeye juveniles captured in 1999 by beach seine were also bimodal in length distribution. It is possible the larger sockeye (85-120 mm, all captured from location 5) were kokanee. The three largest pikeminnows (> 17 cm) were captured with the beach seine. The size difference of fish captured by the two fishing methods indicates the presences of larger older salmonids and larger non salmonid fish in slightly deeper water during the day.

The difference in size of the fish captured by the day and night pole seines indicates that the larger fish are present at night in the shallow lake margins, but are not present during the day. The pole seine was operated during both day and night in shallow water within 3 m of the lake edge. Larger chinook juveniles were not captured during the day by pole seine along the exposed lake edges, but were often taken at night (Fig. 13 and 14). The largest chinook (69 mm) captured during the day was from a confined backchannel and the next largest (63 mm) from an exposed shoreline. The largest non salmonid fish taken with the pole seine during the day were sculpins and these were < 85 mm in length. Pikeminnows, sucker sp. and sculpins > 85 mm were often captured with the night pole seine. Thus, there must be a strong diurnal movement of larger fish between deep and shallow (< 1.0 m) lake edge habitats.

COBBLE VS. SANDY LOCATIONS

During the three years of study; cobble, sandy, and mud/vegetated foreshore locations were sampled. However, the study design and methods differed between years. In 1999, the day pole seine and beach seine effort was divided equally between eight cobble and eight sandy substrate locations. An additional 50 fish (47 redside shiners) were captured in the two beach seines positioned between the cobble rows at location 13. The catch of 764 fish within the eight cobble locations and one windrow location (675 by beach seine and 89 by pole seine) was dominated by redside shiners

(93%) and sculpins (6%). Only a few chinook juveniles (1%) were taken from the rocky areas. A total of 489 fish were taken from the eight sandy locations of which 357 were by beach seine and 122 were by pole seine. The majority were sculpins (37%), chinook (29%), redside shiners (19%), sockeye (6%) coho (1%) and small fish < 25 mm in length that were tentatively identified as lake trout (char) fry (5.7%).

The eight sandy locations supported more juvenile salmonids than the eight cobble locations in 1999 (Fig. 15). The total number of juvenile salmon (chinook, coho, and sockeye combined) was greater on the sandy foreshores (Table 3, One Way ANOVA on Ranks; P < .001) as were the number of chinook (P < .01) and sockeye (P < .01). Not enough coho were captured to permit analysis, however all coho were obtained from three sandy locations. Although more redside shiners were taken on the cobble foreshore than on the sandy foreshore (Fig. 16), this result was not significant (P = 0.28). Sculpins were netted at 14 of 16 locations and if minnow trap catches are included, then they were captured at every site. Although more sculpins were netted on sandy sites this result was also not significant (P = 0.08).

Table 3. Comparison of fish densities (fish / 1000 m^2) between 8 cobble/boulder locations and 8 sandy locations for 1999. ANOVA on Ranks was not calculated where catch was insufficient (INSF).

			Sand		Cobble		One Way ANOVA
	Catch	No. of Sites	Mean	1SE	Mean	1SE	P
Chinook	152	12	31.03	15.37	1.72	0.65	0.005
Coho	6	3	1.29	0.71	0.00	0.00	INSF
Sockeye	29	6	6.25	2.76	0.00	0.00	0.010
Total salmonid	185	13	38.58	15.90	1.72	0.65	0.001
Sculpin	226	14	38.15	12.48	9.48	3.00	0.083
Redside shiner	792	10	17.67	11.32	153.02	77.68	0.279
Pikeminnow	9	3	1.72	1.30	0.22	0.22	INSF
Leopard dace	5	4	0.65		0.43		INSF
Longnose dace	2	2	0.43		0		INSF
Sucker	5	1	1.08		0		INSF
Lake trout	27	1	5.82		0		INSF
Total	1253	16 sites	105.39		164.39		

In 2000, four sand, four cobble, and four mud/veg/backchannel locations were sampled repeatedly (Table 4). There was a significant difference (One Way ANOVA on Ranks, P < 0.01) among the substrate types for total fish density as fish density was significantly higher at mud/veg locations than at rocky foreshore sites (Dunn's test, P < 0.05). A greater density of total salmonids, coho, and pikeminnow was obtained at the mud sites than at either the cobble or sand sites (Dunn's test, P < .05). A greater density of chinook juveniles and longnose dace was found at the mud/veg locations than at the cobble sites (Dunn's test, P < .05). Sculpin density was significantly greater on the sandy foreshore locations than on the cobble locations (Dunn's test, P < .05). More redside shiners were obtained from the cobble locations (0.34 fish / m^2 ± 0.21 1SE) and mud/veg locations (0.35 fish / m^2 ± 0.32 1SE) than from the sandy locations (0.23 fish / m^2 ± 0.21 1SE). More chinook were captured on mud/veg locations (0.19 fish / m^2 ± 0.05 1SE) than on the sandy locations (0.077 fish / m^2 ± 0.03 1SE) or on the cobble foreshore (0.014 fish / m^2 ± 0.03 1SE).

Table 4. Comparison of fish densities (fish / 1000 m^2) between four mud/veg locations, four cobble/boulder locations and four sandy locations for 2000. ANOVA on Ranks was estimated for species with larger catches and not for those where catch was insufficient (INSF). Dunn's test was used to identify substrate types that differed from the others.

			Mud/Veg (n=24)		Cobble (n=64)		Sand (n=62)		One Way ANOVA
Species	Catch	Occ %	Mean	SE (1)	Mean	SE (1)	Mean	SE (1)	P
Chinook	245	22.0	96.88	52.52	5.27	2.21	34.88	17.13	0.0123
Coho	108	12.7	142.00	83.50	0.20	0.20	3.50	2.08	0.0001
Sockeye	69	8.0	5.28	3.08	0.20	0.20	14.32	9.83	0.0600
Total salmonid	422	27.3	243.75	131.75	5.47	2.21	52.69	21.64	0.0001
Sculpin	3473	96.0	344.79	59.61	218.36	25.09	417.81	68.54	0.0289
Redside shiner	1714	44.7	266.70	206.82	162.11	54.88	126.61	54.88	0.3460
Pikeminnow	130	24.7	63.54	30.32	9.57	5.38	4.44	75.00	0.0001
Leopard dace	100	23.3	8.33	4.68	8.79	2.49	10.28	3.90	0.7188
Longnose dace	55	15.3	11.46	8.51	8.01	2.54	1.41	0.87	0.0244
Whitefish spp.	13	2.7							INSF
sucker spp.	8	5.3							INSF
Burbot	1	1.3							INSF
Lake chub	13	2.0							INSF
Lake trout?	2	2.0							INSF
Total fish			944.79	231.91	413.28	66.92	619.89	108.39	0.0019

In 2001, four sandy and four cobble/boulder locations were sampled 15 times each (Table 5). Significantly more fish / 1000 m^2 were captured over the sandy foreshore sites (One Way ANOVA on Ranks, P < 0.01). Chinook (P < 0.0001), sculpins (P < 0.01), and whitefish (P < 0.01) were significantly denser at the sandy locations than at the cobble locations. Longnose dace were significantly denser on the cobble sites (P < 0.01). Redside shiners were more common on the cobble beaches, however this result was not significant (P = 0.10).

Table 5. Comparison of fish densities (fish / 1000 m^2) between four sandy locations and four cobble/boulder locations for 2001. ANOVA on Ranks was estimated for species with larger catches and not for those where catch was insufficient (INSF).

			Sand (n =60)		Cobble (n = 60)		One Way ANOVA
Species	Catch	Occ %	Mean	SE (1)	Mean	SE (1)	P
Chinook	1242	28.3	256.67	153.38	2.08	0.80	0.0001
Coho	11	5.0	1.04	0.54	1.25	1.25	0.1822
Sockeye	24	7.5	4.17	1.96	0.83	0.66	0.0826
Total salmonid	1277	35.0	261.88	153.52	4.17	2.01	0.0001
Sculpin	3076	90.8	445.63	67.08	195.20	27.38	0.0052
Shiner	768	37.5	42.50	14.31	117.50	35.24	0.0999
Pikeminnow	32	12.5	3.96	1.24	2.71	1.90	0.1462
Leopard dace	84	27.5	6.88	2.53	10.63	3.28	0.1725
Longnose dace	37	11.7	0.21	0.21	7.50	2.40	0.0063
Whitefish	29	5.8	6.04	3.58	0.00	0.00	0.0067
Sucker	1	0.8	0.00	0.00	0.21	0.21	INSF
Burbot	5	2.5	0.42	0.42	0.63	0.46	INSF
Lake chub	4	2.5	0.42	0.29	0.42	0.42	INSF
Rainbow trout	8	1.7	1.67	1.31	0.00	0.00	INSF
Unknown	1	0.8	0.21	0.21	0.00	0.00	INSF
Total	5322		769.79	165.66	338.96	52.03	0.0053

A mud/veg site (location 22) was sampled four times in 2001. Catch from this single site represented 41 of the 50 juvenile coho captured in 2001. Coho density was 0.188 coho / m^2 ± 0.032 1SE, while chinook density was 0.054 / m^2 ± 0.036 1SE. The relatively higher density of juvenile coho found in the one site examined in 2001 is consistent with the results for mud/veg sites in 2000.

DISTURBED VS. UNDISTURBED RIPARIAN ZONES

The riparian zones of the 16 locations surveyed for fish in 1999 (Table 1) were characterized as either undisturbed sites (near 100% native riparian trees and high brush) or disturbed locations (subjectively estimated at < 20 % of shoreline supported any trees or high brush). The disturbed foreshore locations lacked any appreciable inputs of litter material from the directly adjacent lands. These locations either bordered roads or had been subjected to extensive residential shoreline development (Fig. 1). Although more fish were captured at the undisturbed locations (2.75 fish / m ± 1.11 1SE) than from the disturbed locations (1.17 fish / m ± 0.34 1SE), this result was not significant (t-test; P = 0.20).

NIGHT VS. DAY

During our first spring of study, 1999, night sampling was restricted to two sets of pole seines at four locations and day sampling included four sets of pole seines at 16 locations. Although night sampling was very limited in 1999, we captured more fish at night (324) than during the day (221). The majority of these fish were redside shiners and sculpins. When the four locations sampled both day and night were compared, the number of redside shiners taken at night was significantly greater than during the day (Mann-Whitney Rank Sum Test, $P < .01$). We captured 3.1 redside shiners / m of shore at night compared to 0.2 redside shiners / m of shore during the day. The number of sculpins taken at night was greater than during the day, but not significantly so (Mann-Whitney Rank Sum Test, $P < .46$). Two burbot were captured in overnight Gee traps.

Eight exposed foreshore locations were sampled with a pole seine six times at night and ten times during the day in 2000 (Fig. 17). This produced a series of 48 paired day/night samples (eight locations and six sample dates; Fig. 18). Significantly more fish (Paired t-test; $P < .0001$) were captured at night. At night 1.747 fish / m of shore ± 0.378 C.I (where C.I = 95% confidence interval) were captured compared to a day time catch of (0.80 fish / m of shore ± .50 C.I. Significantly more chinook (Signed Rank Test; $P < .0001$) were captured at night (0.106 fish / m of shore ± 0.092 C.I) than during the day (0.0009 fish / m of shore ± .0013 C.I.). Significantly more sculpins ($P < .0001$), redside shiners ($P < .01$), leopard dace ($P < .0001$), and pikeminnow ($P < .01$) were captured at night. Only two burbot were captured in 2000 and both were caught at night.

Eight exposed foreshore locations were sampled with a pole seine nine times at night and six times during the day in 2001 (Fig. 19). A series of 48 paired day and night samples (eight locations and six sample dates) can be compared (Fig. 20). Significantly more fish (Signed Rank Test; $P < .0001$) were captured at night (1.753 fish / m of shore ± 0.776 C.I) than during the day (0.207 fish / m of shore ± .074 C.I.). Significantly more chinook (Signed Rank Test; $P < .0001$) were captured at night (0.576 fish / m of shore ± 0.764 C.I) than during the day (0.0094 fish / m of shore ± .0036 C.I.). Significantly more sculpins ($P < .0001$), redside shiners ($P < .0001$), leopard dace ($P < .0001$), longnose dace ($P < .01$) and minnow pike ($P < .01$) were captured at night. Five burbot were caught during the night pole seines while none were caught during the day. An additional five burbot were counted within the lake shallows at night during the snorkel surveys.

LUNAR CYCLE

In 2000 and 2001, sampling dates were matched to new and full moon dates (sampling ever two weeks). Six night sampling dates corresponded to the full moon and six corresponded to the new moon. This is illustrated in Figs 18 and 20. We initially hypothesized that fish would avoid the near shore lake edge when nights were bright (full moon). This was not evident as new moon total fish density (1.81 ± 0.38 1SE fish/m of shore), was similar (t-test; $P = 1.0$) to full moon density (1.67 ± 0.11 1SE fish/m of shore). Chinook new moon density (0.18 ± 0.06 1SE fish/m of shore) was similar (t-test; P = 0.79) to full moon density (0.15 ± 0.07 1SE fish/m of shore). Redside shiner new moon density (0.33 ± 0.10 1SE fish/m of shore.), was similar (t-test; P = 0.73) to full moon density (0.38 ± 0.08 1SE fish/m of shore). It is likely that even if lunar periodicity influenced fish nearshore abundance its effect would be masked by the overwhelming changes in seasonal abundance.

SEASONAL CHANGES AND DISTRIBUTION

Salmonid abundance and size changed over the 2001 season. The first chinook fry were captured in late March at the mouth of Adams River (location 2). The size of chinook fry captured at this location remained the same or declined slightly from late-March to mid-May (Fig. 21). Small chinook fry less than 30 mm in length (some of which were noted to be unbuttoned), were captured as late as May 10/01 at this location. Chinook fry were 2-5 mm larger at locations further from the mouth of the Adam's River (locations 5 and 7) by early May and 10-15 mm larger by mid-June. This implies that the population of chinook fry near the river mouth was constantly being replaced by freshly emerged fry from the river and older fry were dispersing along the lake foreshore. In 2001 chinook fry catches appeared to peak from late April to early May (Fig. 12). The backchannels had gone dry by the end of July 2001 and all coho residing within them would have perished. Salmon juveniles were difficult to catch along the shoreline after June, although a few chinook were caught at night as late as August 29/2001.

The initial study design (1999) to compare sandy and cobble foreshore locations is somewhat compromised by the fact that the sites near the lake outlet as well as near the mouth of the Adams River were sandy while the sites further away tended to have cobble/boulder beaches. Thus, six of eight locations in the lower arm were sandy foreshore sites, while two of eight locations in the upper arm were sandy. The catch of salmonids was greater closer to the lake outlet (3 / 100 m^2) than it was above Blind Bay (1 / 100 m^2), but not significantly so (Mann-Whitney Rank Sum Test; P = .13).

Locations 1 and 2 and associated backchannels (location 22), near the mouth of the Adams River were the best locations for catching salmonids. The majority of the chinook were captured at location 2. In 1999, 2000, and 2001 the catch from this one site represented 52%, 31%, and 83% of the total chinook catch. The majority of the chinook were fry and over the three years of study, only 2.6% of the chinook were 1+ fish (estimate based on fork-length frequency). These juveniles were captured at eleven different exposed foreshore locations and no single location dominated.

In early spring chinook fry leave the Adams River and occupy the immediate foreshore of Shuswap Lake. On April 26/2001 the number of chinook fry relative to distance from shore (Fig. 22 was examined on the foreshore of Roderick Haig-Brown's Park. The highest densities of chinook fry (11.5 chinook / m^2) were within 0.5 m of the lake edge, within the shallowest water (<.5 cm), at night. Chinook density declined rapidly as distance from the lake edge and depth increased. We estimated chinook density to be 1.4 chinook / m^2 at 3 m from shore (53-cm depth). During the previous day at this location only two chinook fry (or .025 chinook / m^2) had been captured.

Sockeye fry (< 60 mm by August) and juveniles (> 70 mm in April) were never abundant along the foreshore of Shuswap Lake. In 1999 (June 17-23), only 7 sockeye fry and 23 juveniles were captured and in 2000 (June 2-18) only 20 fry. It is possible that earlier sampling during the first two years of study would have yielded higher densities of sockeye fry. In 2001 (March 28 to May 10) a total of 24 sockeye fry were taken and these were from the mouth of the Adams River. Sockeye fry were most numerous in July 2000 at location 2 near the mouth of the Adams River. In 1999, the majority of sockeye (28/30) were captured in a beach seine and it is possible the 14 sockeye (85-120 mm) captured at location 5 were kokanee. This site had a steep drop-off and the beach seine would have been fishing further from shore than the pole seine. In 2001, juvenile sockeye (> 70 mm) were captured in March and April and sockeye fry (< 45 mm) were captured between April 25 and May 10.

Recently emerged coho fry were seen on March 28/01 in a spawning channel near the mouth of the Adams River. These fry did not appear to disperse along the lake foreshore. In the three years of study, juvenile coho distribution was very limited. The abundance and distribution of juvenile coho rearing along the lake shore appeared related to the proximity of the site to a natal coho stream and to the degree of protection the site offered from the open lake. Eight coho were captured from three locations in 1999. Three were captured within 200 m of the Adams River and four were captured within 300 m of Ross Creek. These streams are known for coho spawning. In 2000, a total of 108 coho salmon fry were caught. Ninety-three coho were obtained from backchannel habitat (locations 20 and 22) associated with the delta lakefront area of the Adams River. The remaining fifteen coho were caught along the exposed sandy lake foreshore (location 2) within 200 m of the Adams River. In 2001, thirty-nine of fifty coho were caught from a single backchannel site (location 20) and four were netted from the exposed lake foreshore within 100 m of the Adams River. Thus over the three years of study, 127 coho were taken from flooded backchannels separated from the lake's wave action, 26 from exposed sandy beaches in close proximity to a natal stream, and 8 from other foreshore locations.

In 1999 more redside shiners were captured at the eight locations furthest from the lake outlet (997) than from the eight locations nearest the lake outlet (79). This result was significant (Mann-Whitney Rank Sum; $P < .01$). Larval redside shiners (some < 20 mm) were common throughout the lake in mid June (2001) and peak redside shiner abundance occurred soon after. Prickly sculpins were caught at every location and distribution was considered to be relatively uniform (Fig. 16). Numerous larval sculpins were captured on July 9/2001. The other fish species we identified were never captured in enough numbers to establish any definitive patterns of distribution, although over the three years of study the catch of leopard dace, pikeminnow, and suckers was consistently higher at location 7.

DISCUSSION

Pole seining was the most effective way to capture fish along the shallow lake edge, especially when operated at night. The pole seine sampled a consistent portion of the lake foreshore (< 1-m deep and 2-3 m from shore), was highly mobile, required only a two person crew, was less prone to snagging over cobble substrate, and was quick and easy to operate. The pole seine enabled us to measure the diurnal shift of fish between the deeper littoral and shallow littoral zones (< 1 m depth).

A beach seine was also considered an efficient means of sampling deeper waters further from shore and had the advantage of capturing larger fish during the day. This was the method used by others to sample the shores of Shuswap Lake (Fedorenko and Pearce 1982; Graham and Russell 1979; Russell et al. 1980). However, this method required a larger crew, a suitable boat, took considerable time per location, and was awkward if not dangerous to operate at night. Also, the effectiveness of a seine net is reduced in habitats containing boulders and snags (Weaver et al. 1993; Pierce et al. 1990). It is more difficult to differentiate between shallow and deep littoral zone catches and this limits the assessment of diel nearshore movements. Pierce et al. (2001) were unable to obtain statistically significant differences in nearshore diel fish densities using a large beach seine but were successful when using a pulsed-DC boat electrofisher.

The use of baited minnow trapping for sampling the littoral zones of lakes is arguable. Fedorenko and Cook (1982) successfully used Gee minnow traps to sample the shores of Chilliwack Lake for juvenile coho salmon. More recently, large numbers of juvenile coho were successfully collected from the shores of Chilliwack Lake using Gee traps (J. Hume, Fisheries and Oceans Canada, Cultus Lake Laboratory, Cultus Lake, pers. comm.). It is of interest to note that no sculpins were captured in Chilliwack Lake (J. Hume, Fisheries and Oceans Canada, Cultus Lake Laboratory, Cultus Lake, pers. comm.). It is possible their presence along other lake shores may force coho and chinook into other habitats (sympatric separation) or it is possible their presences may have prevented salmonid entry into the Gee traps. Bryant et al. (1996) tried using minnow traps to capture fish in Margaret Lake (Alaska) and found they did not effectively capture juvenile fish in the littoral zone. Weaver et al. (1993) omitted minnow trap catch data from their analysis of sampling methods because they proved ineffective in capturing fish. We didn't consider minnow trapping to be a viable method of sampling the shores of Shuswap Lake unless you wished to capture sculpins and little else.

Pole seining at night was significantly more effective than pole seining during the day. More fish of every species were captured at night than during the day. Chinook fry and juveniles were 100 to 1000 times more abundant at night (2000, 106.2 / km; 2001, 576 / km) than during the day (2000, 0.1 / km; 2001, 8.3 / km). All 14 of the burbot were captured with night pole seines or seen during the night snorkel surveys. Larger fish of all species were absent from the lake near shore during the day.

Significantly more redside shiners were present during the night within the shallow lake edge (< 1-m depth) than during the day. This finding is similar to that of

Hanych et al. (1983) who documented the nocturnal inshore movement of mimic shiners (*Notropis volucellus*) into less than 1-m deep waters in one Minnesota Lake and contrasts the movements of golden shiners (*Notemigonus crysoleucas*) in Michigan lakes from littoral to limnetic zones at sunset (Hall et al. 1979). Redside shiners have been described as having a tendency to remain close inshore during the daylight hours and feed within the limnetic zone at night (Larkin and Smith 1964) similar to the behaviour described for golden shiners. We suspect that redside shiners and other minnow species although considered to be inshore during the day are still avoiding the shallowest lake edge or littoral fringe. Our sampling and the sampling of Hanych et al. (1983) would have been conducted within the littoral fringe.

The possible reasons for the strong diurnal behaviour were not clear and multiple hypotheses exist. It may be a means of reducing predation risk. Williams et al. (1989b) noted that larger piscivorous fish in Shuswap Lake (rainbow trout, whitefish and burbot) moved into shallow waters at dusk and back to deeper waters during the night. They also reported the stomachs of fish predators captured in the early morning contained more fry than those caught at other times. Telemetered rainbow trout in Lake Washington were primarily found nearshore, spent 90% of their time in the top 3 m of water and supplemented their diet with nearshore fish (Warner and Quinn 1995). Other possible reasons for diel migrations may include UV avoidance (Bothwell et al. 1994; Kelly and Bothwell 2002), avoidance of higher water temperatures (Russell et al.1980), and increased feeding opportunities as a greater number and weight of larval aquatic insects was measured at night in shallow habitat (Brown et al. 2004). In oligotrophic Ontario lakes the night-time feeding rates of small fish residing within the littoral fringe (<.2 m) were 10x higher than at deeper (1-2 m) habitats (Collins et al. 1995).

The community structure of the lake edge fish population appeared to differ from that of neighboring rivers and creeks, and mid lake. In a survey of seven South Thompson stream and river systems (Sebastian 1983), rainbow trout, sculpins, and coho juveniles were the most dominant fish species. Mid-water trawls of Shuswap Lake captured 99% sockeye (Goodlad et al. 1974, Hume et al. 1996). In our study, three fish species dominated the foreshore of Shuswap Lake from March to August and represented 93% of all the fish captured. Prickly sculpins were the most numerous, were found everywhere, and although more were captured on sandy beaches, they appeared to be more uniformly distributed along the lake shore than other fish species. Redside shiners were more prevalent on cobble/rocky foreshores further from the lake outlet and large numbers were captured in a few sets (clustered distribution). Their numbers peaked in late summer following the appearance of large numbers of larval redside shiners in July. The most numerous salmonid species captured was chinook.

Chinook fry heavily utilized the foreshore of Shuswap Lake from March though June. Our capture success along the lake margins declined rapidly in July, a finding similar to that noted by other authors (Russell et al. 1980; Davies et al. 1996; Federenko and Pearce 1982; Graham and Russell 1979). Russell et al. (1980) contended the absence of rearing fish was due to high water temperatures (> 22 ^{0}C) in the littoral areas. The fry were most abundant in April and May and the highest densities occur along the exposed lake foreshores of the delta type habitats associated with inflowing rivers such as the Adams River. The highest densities of chinook fry that we recorded (12 / m^2) were at night, in April, within the first 0.5 m of shore, and at depths of less than 7 cm. It appears the population occupying these locations is continually being replaced as smaller recently emerged individuals enter the lake through April and May and older fry disperse along the lake edge. Our findings would agree with downstream studies completed on the neighboring North Thompson River (Scott et al. 1982). This study reported emigrations starting prior to April, peak chinook fry emigration from tributaries to the North Thompson in mid-April, peak emigration from the North Thompson River in mid-May, and a downstream movement lasting for 80 days.

Some littoral fishes are dependent upon terrestrial detritus for part of their energy input and the littoral zones of lakes should not be isolated from surrounding riparian forests (France 1997). The removal of riparian vegetation along the shores of a large interior lake must be considered to be a cumulative habitat loss rather than a site specific impact. Jennings et al. (1999) suggested that habitat management should also consider the cumulative effects of small habitat modifications such as rock riprap placement and retaining walls. Collins et al. (1995) noted that lawn-edged shorelines exhibited less fish activity, less feeding, and more wave disturbance than undeveloped fringe habitats. Although more salmonids were captured at the undisturbed Shuswap Lake locations (treed riparian zone), no significant relationship was found between fish numbers and riparian status. We speculate this lack of a significant relationship was due to in part due to the fact that the fish (especially juvenile chinook) appeared to constantly migrate along the lake edge and were not necessarily associated with any specific location.

Graham and Russell (1979) suggested that some juvenile chinook remained in the lake to over-winter. We captured chinook juveniles (68 to 132 mm) throughout the Main Arm of Shuswap Lake on all exposed beaches in spring. We could not verify if these were lake reared or had over-wintered in neighboring rivers and streams. The majority were captured during the day with a beach seine that fished deeper water than the other methods. The remainder were captured during the night in shallow water (< 1-m depth) with the pole seine. This indicates that juvenile chinook (1+) do utilize the exposed shallow lake foreshore at night but reside in deeper water further from shore during the day. In three years of study, the largest chinook captured during the day (69 mm) was from a backchannel and no chinook > 63 mm was ever captured along the exposed foreshore during the day.

Russell et al. (1980) noted that during dominant sockeye salmon cycle years, sockeye fry concentrations along the foreshore were very large and in some locations displaced rearing coho and chinook. Observations on Quesnel Lake on fish migrating from the Horsefly River indicated that sockeye fry occupied a nearshore zone of 5 m and had a nearshore dispersal rate of 2 km/day during their first five weeks (Morton and Williams 1990). These sockeye fry remained close to shore during both day and night and did not exhibit diel lateral movements. They became pelagic by mid-June or the sixth week after lake entry. Diel vertical migrations of pelagic sockeye salmon have been well documented (Narver 1970; Hartman and Burgner 1972; McDonald 1973; Clarke and Levy 1988; Morton and Williams 1990; Levy 1990). The data from Margaret Lake (Alaska) did not suggest diel lateral movement of sockeye fry between pelagic and littoral zones (Bryant et al. 1996). Davies et al. (1996) reported that sockeye fry were abundant in Shuswap Lake near the mouth of the Adams River in May 1995 but were not captured by beach seine in June.

At no time during this study did sockeye salmon fry dominate the lakeshore. Peak emergence from the Adams River has historically ranged from May 3 to May 17 for the years 1967-1976 (Williams and Saito 1989) and May 13 was considered the average peak of fry emergence (Goodlad et al. 1974). We did capture more sockeye juveniles along the lake edge at night, however catch was not consistent and numbers were never great enough to permit a clear analysis of diel horizontal movements. We suspect that sockeye fry dispersed from the immediate lake edge (< 1 m deep) soon after entering the lake. Although they may reside and migrate in slightly deeper nearshore waters during May-June (Williams and Saito 1989), they would have been hard to capture with a pole seine. Sockeye fry were not captured after July 11/2001 along the lake edge.

Previous studies on Shuswap Lake have indicated that coho distribution is very limited and the largest catches were in backwater areas and not on exposed beaches (Graham and Russell 1979, Russell et al. 1980). No coho salmon juveniles were ever captured in seine nets from May to August 1995 by Davies et al. (1996). They did not survey backchannel locations but did examine beds of aquatic vegetation. Juvenile coho catches in a number of interior lakes appear to be associated with slough/alcove habitats and aquatic vegetation (K. Simpson cited in Brown 2000). We observed that the abundance and distribution of juvenile coho rearing along the lake shore appeared related to the proximity of the site to a natal coho stream and to the degree of protection the site offered from the open lake. Bryant et al. (1996) speculated that proximity to the source of fry recruitment may be more important in establishing coho distribution than other habitat features. The most important coho habitats were flooded backchannels and weedy habitat associated with shoreline irregularities. An especially important set of backchannels was situated near the mouth of the Adams River. Few coho juveniles were ever captured from the exposed foreshore except when this foreshore was within 200 m of a natal stream.

An evaluation of the lake littoral zone features important to salmonid habitat within Shuswap Lake was done by Russell et al. (1980). They developed an index of habitat value that incorporated slope, littoral distance, substrate, and additional site specific features such as the vicinity of in flowing rivers and streams, overhanging vegetation, and woody debris. They recognized that a gentle slope and extensive littoral zone were correlated and were important features for juvenile salmonid rearing. Their habitat index is strongly weighted towards beaches with expansive littoral zones, <15% gradient, emergent vegetation, and proximal to an inflowing stream or river. Our findings were very similar to those of Russell et al. (1980). However, their index rates boulder/cobble substrates as 3.5 times better for rearing salmonids than sandy foreshore. We found the opposite, that sandy foreshore sites supported higher densities of rearing chinook and sockeye fry than cobble/boulder sites. Garland et al. (2002) found that in May along the shore of Lake Wallula (Columbia River impoundment), fewer subyearling chinook utilized riprap habitats than unaltered shorelines. They noted that that larger substrate sizes had the lowest probability of chinook presence. We suspect the relationship between substrate type and slope/littoral distance is strong. Fine sediments are retained in the shallow (<1.5 m) littoral zone (Cyr 1998) and lake sediment deposition is correlated with fetch, depth, slope, plant presence, and sediment organic matter content (Petticrew and Kaltf 1991). The gently sloped Shuswap Lake beaches with expansive littoral zones were the ones with sandy/silt substrates. Thus, Russell et al. (1980) index incorporates a bias towards sandy/silt beaches within the slope and littoral distance features and this masks the substrate type.

The importance of delta-lakefront habitat in Shuswap Lake has been previously documented (Graham and Russell 1979). Our study re-emphasizes the importance of this habitat. We found the highest densities of chinook, coho, and sockeye fry along the shores of Shuswap Lake near the mouth of the Adams River from March to July. Juvenile chinook (1+) were widely distributed along the lake edge. This implies that the entire foreshore of Shuswap Lakes supports some chinook rearing and must be considered to be chinook habitat. Coho rearing habitat was very limited and the specific locations used by coho fry should be identified and protected. The sensitive nature of these sites (flooded backchannels and alcoves) is a cause for concern. Unless protected, these areas could easily be altered by lake shore development.

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FIGURES

Fig. 1. Shuswap Lake foreshore development (location 13).

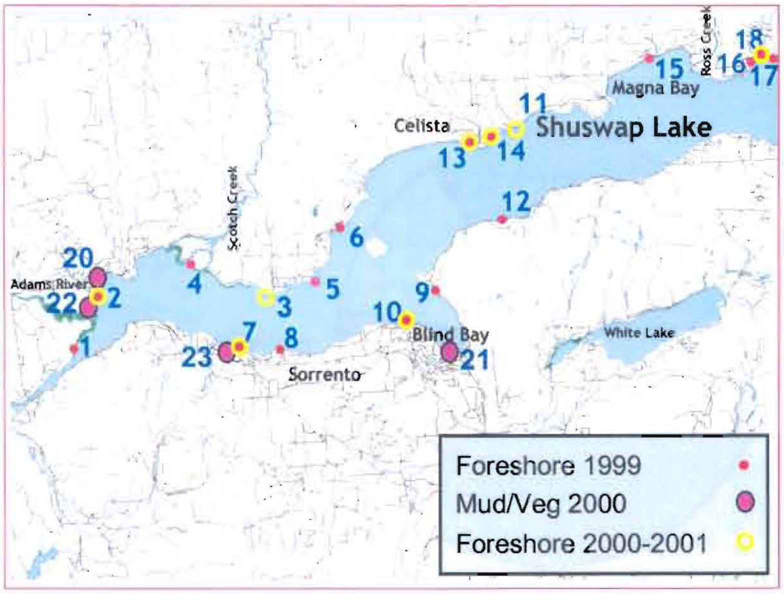

Fig. 2. Map of Shuswap Lake's main arm; indicating study locations for three years of study.

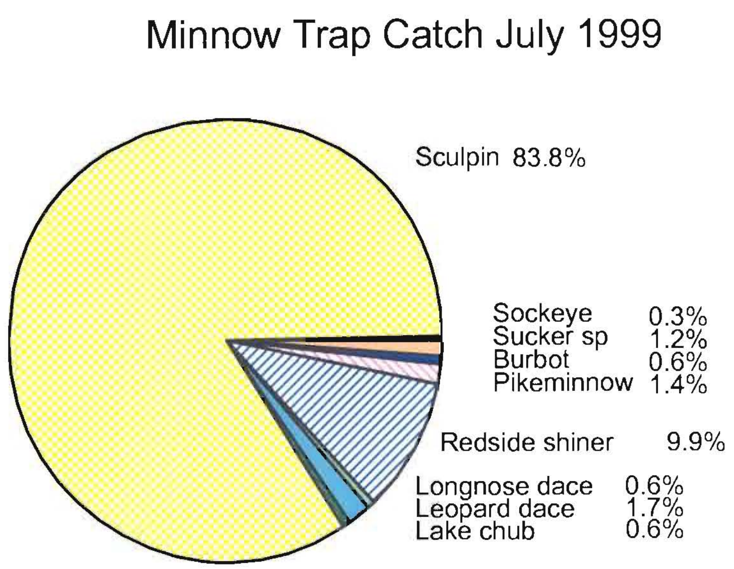

Fig. 3. Relative fish species composition of minnow Gee trap catches in July 1999. Twenty traps were set at each of 16 locations.

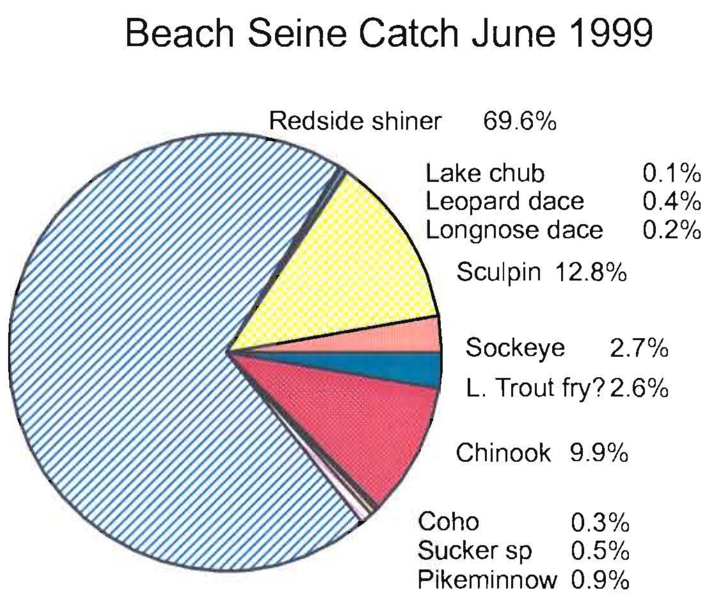

Fig. 4. Relative fish species composition of beach seines in June 1999. Two beach seines were set during the day at each of 16 locations.

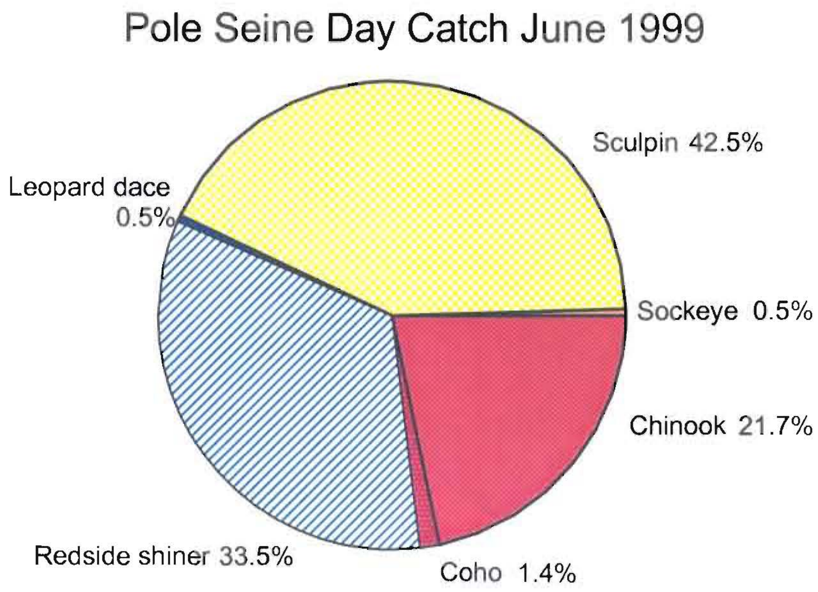

Fig. 5. Relative fish species composition of daylight pole seines in June 1999. Four sets of 10 m shore length distance were set at each of 16 locations.

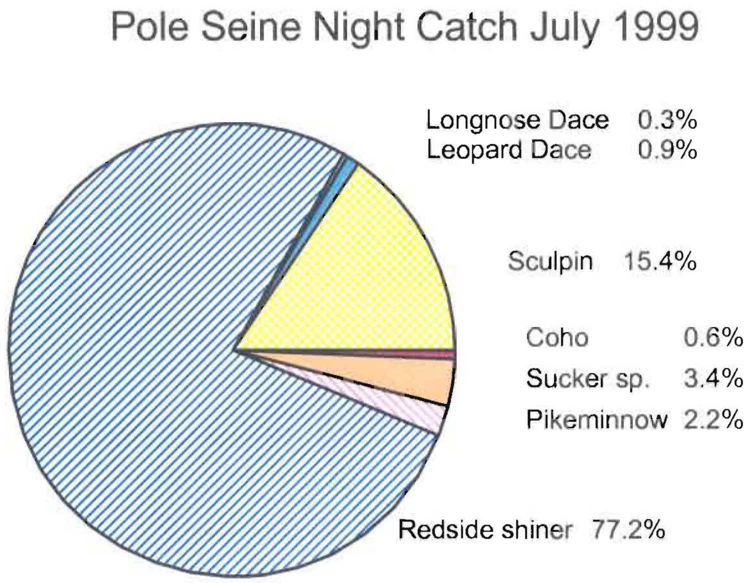

Fig. 6. Relative fish species composition of night pole seines taken in July 1999. Sampling was limited to two sets of 10 m shore length distance at each of 4 locations.

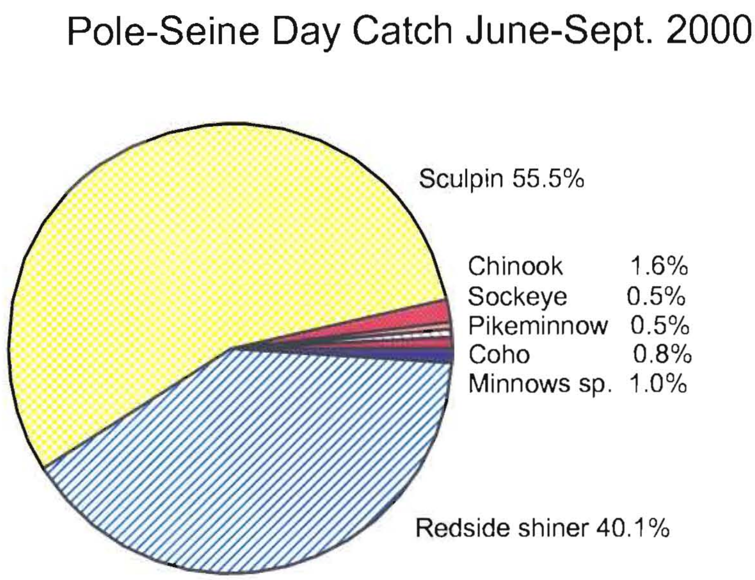

Fig. 7. Relative fish species composition of daylight pole seines taken from June to September 2000. Sampling at eight exposed foreshore locations consisted of ten sampling series; each series consisted of four sets of 10 m at each location. One backchannel/vegetated location was also sampled six times for a total of 11 sets of 10 m.

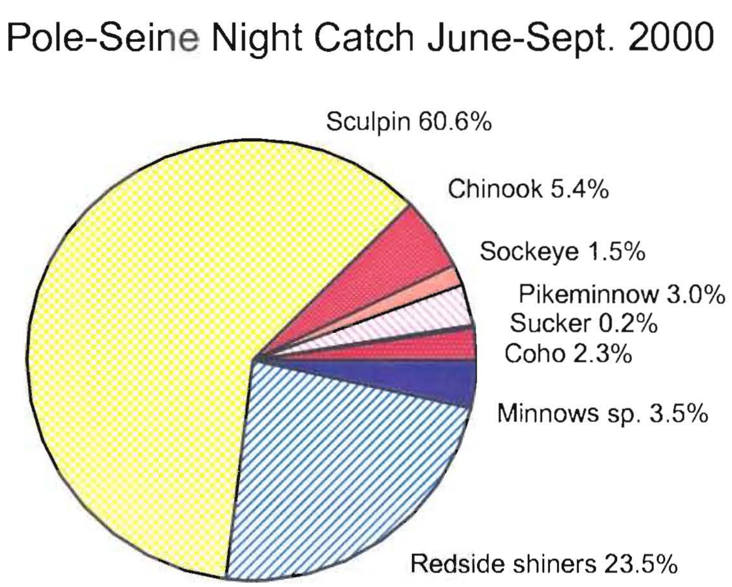

Fig. 8. Relative fish species composition of night-time pole seines taken from June to September 2000. Sampling at eight exposed foreshore locations consisted of six sampling series; each series consisted of four sets of 10 m. Four backchannel/vegetated locations were sampled four times for a total of 37 sets of 10 m.

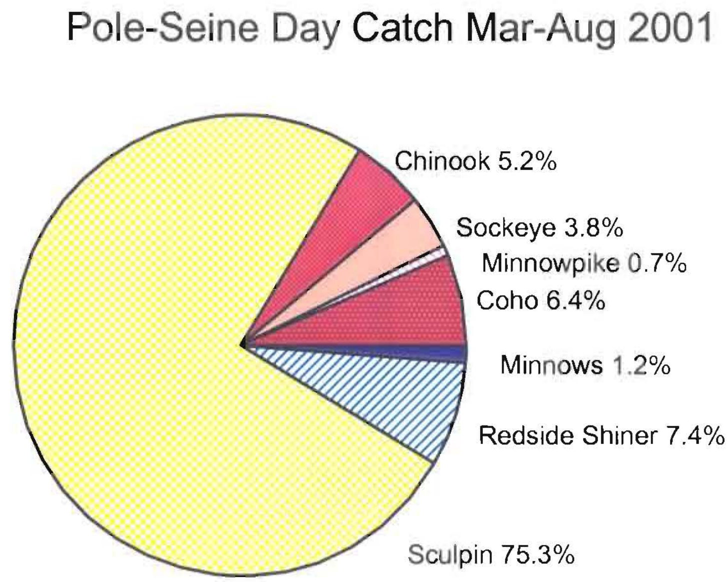

Fig. 9. Relative fish species composition of daylight pole seines. Twenty-four sets of 10 m were completed at each of eight locations from March 28 to July 11/2001.

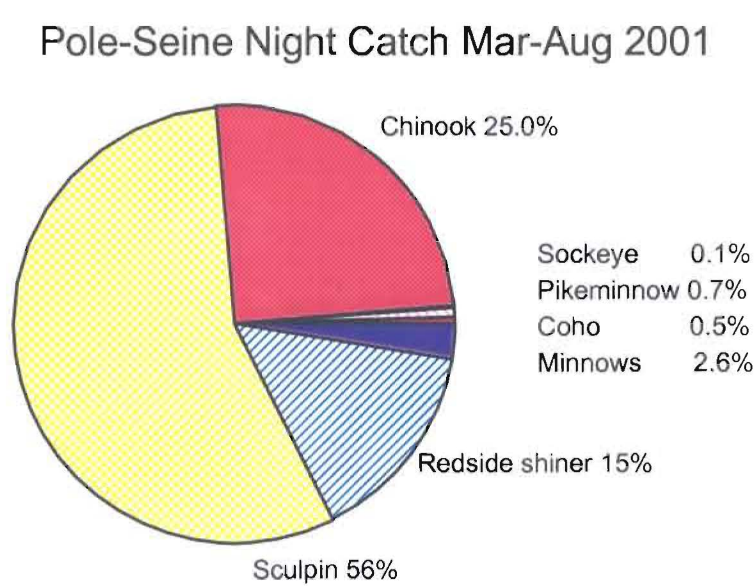

Fig. 10. Relative fish species composition of night pole-seines. Thirty-six sets of 10 m were completed at each of eight locations from March 28 to September 12/2001.

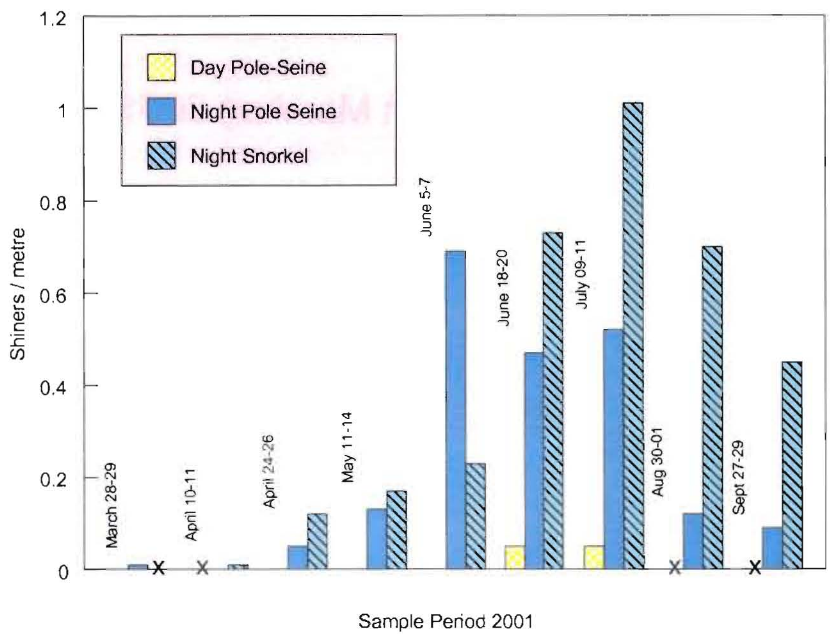

Fig. 11. Comparison of three sampling methods used in 2001; day pole-seine (six estimates), night pole-seine (nine estimates), and night snorkel (eight estimates). Each estimate of redside shiners per m of shore length is based on sampling 320 m of beach within 3 m of shore.

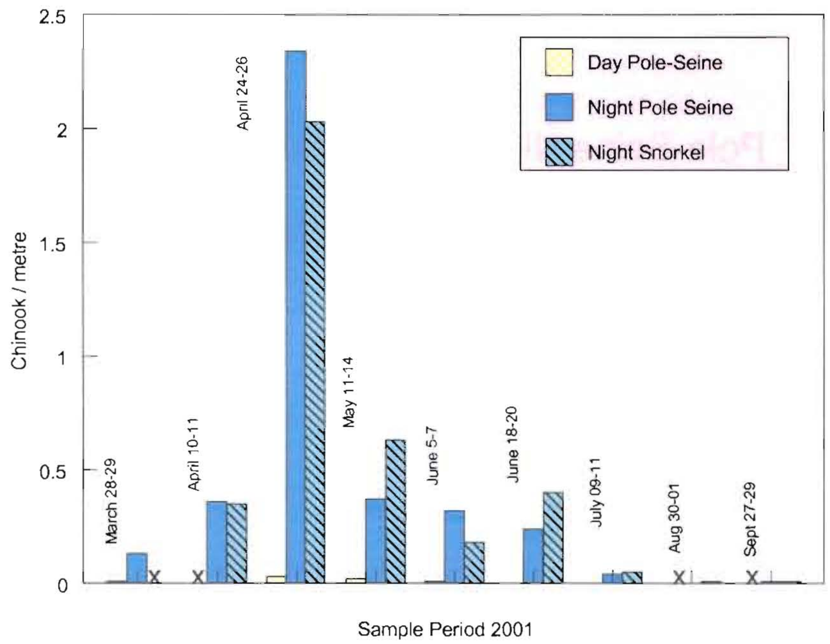

Fig. 12. Comparison of three sampling methods used in 2001; day pole-seine (six estimates), night pole-seine (nine estimates), and night snorkel (eight estimates). Each estimate of chinook / m of shore length is based on sampling 320 m of beach within 3 m of shore.

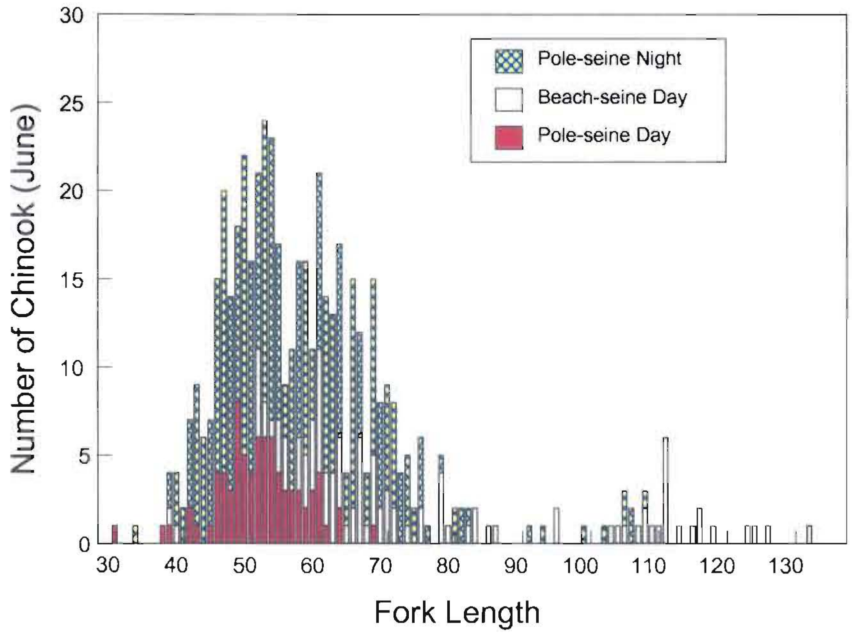

Fig. 13. The combined fork-length frequency distribution for chinook captured in June (199-2001) by three different sampling methods.

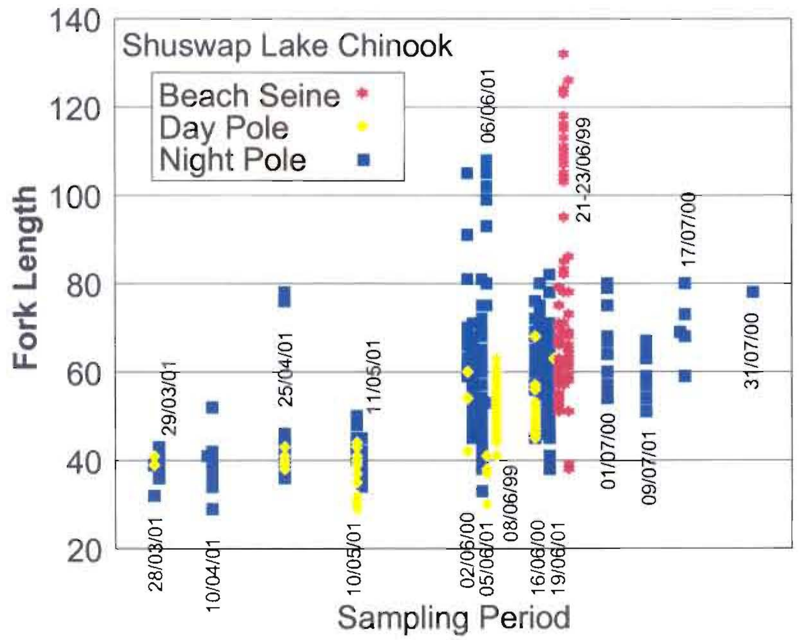

Fig. 14. The fork-lengths of all chinook measured during different sampling periods (1999-2001).

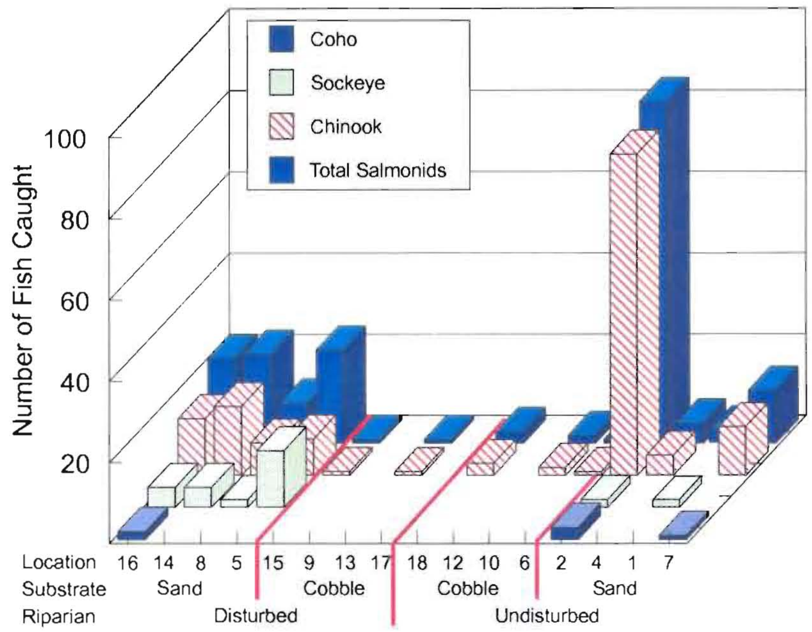

Fig. 15. Comparison of substrate types and riparian status by location for all salmonids. The number of fish caught is the total catch for all methods used in 1999.

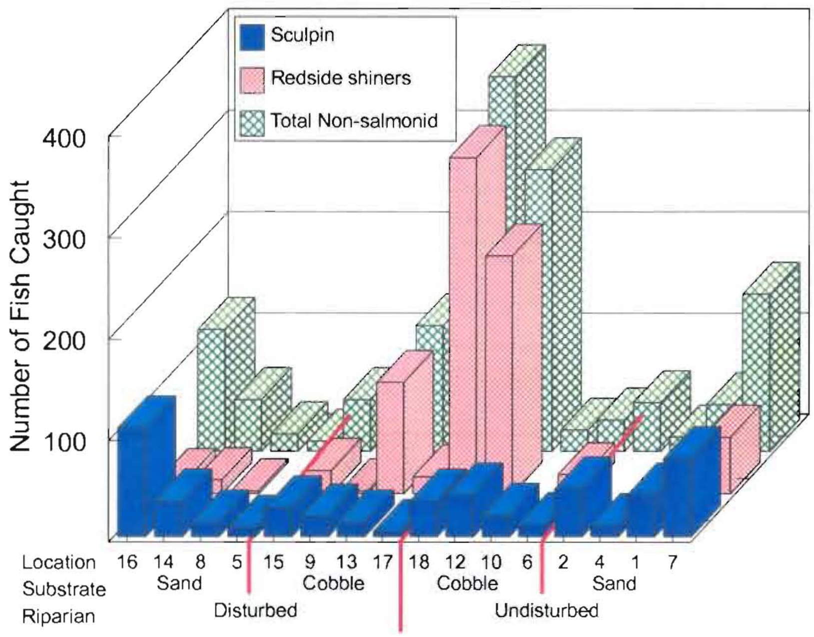

Fig. 16. Comparison of substrate types and riparian status by location for sculpins, redside shiners, and all non-salmonids captured by all methods used in 1999.

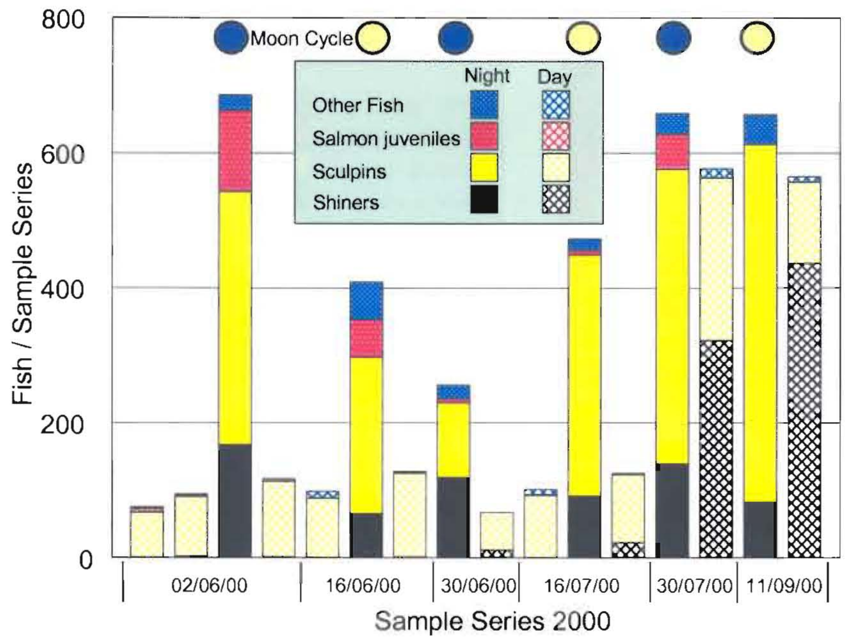

Fig. 17. Comparison of the fish catch during ten day and six night pole-seine sampling series in 2000. A sample series consisted of four sets at each of eight locations (320 m of shoreline or 640 m^2).

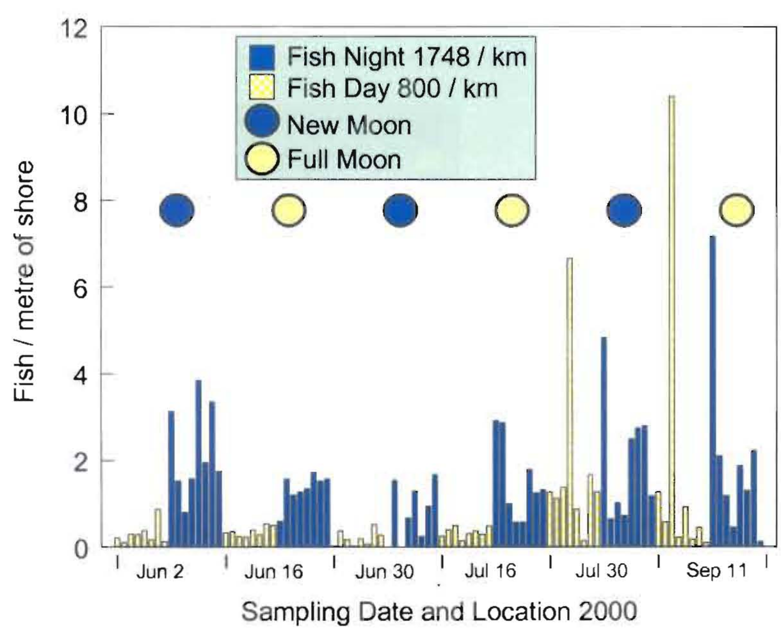

Fig. 18. Comparison of paired day and night total fish catches (fish per m of shore) at each of eight locations during six sampling periods in 2000.

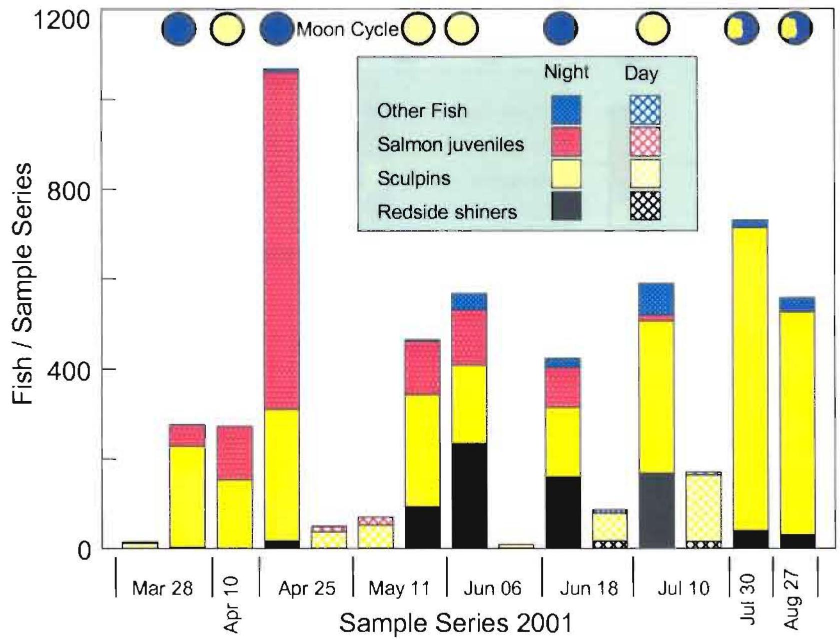

Fig. 19. Comparison of the fish catch during six day and nine night pole-seine sampling series in 2001. A sample series consist of four sets at each of eight locations (320 m of shoreline or 640 m^2).

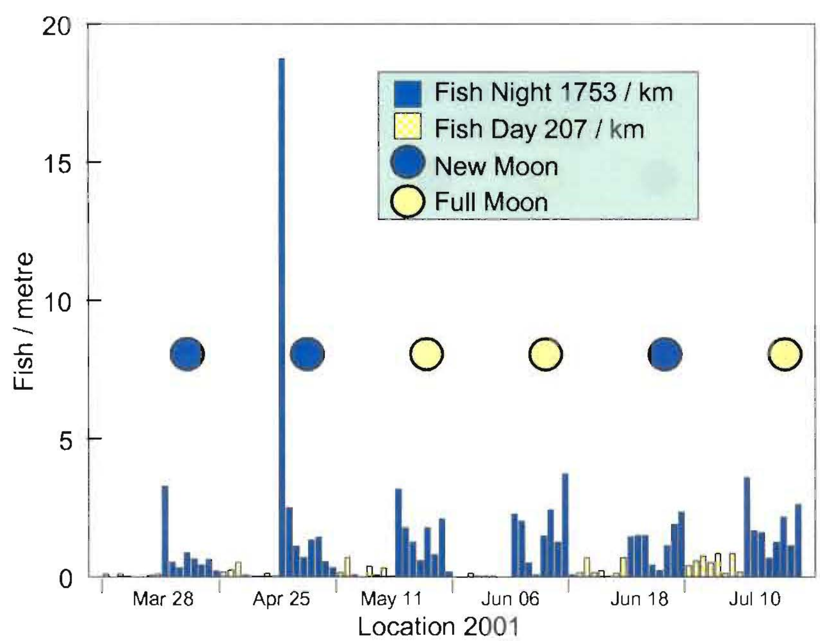

Fig. 20. Comparison of paired day and night total fish catches (fish per m of shore) at each of eight locations during six sampling periods in 2001.

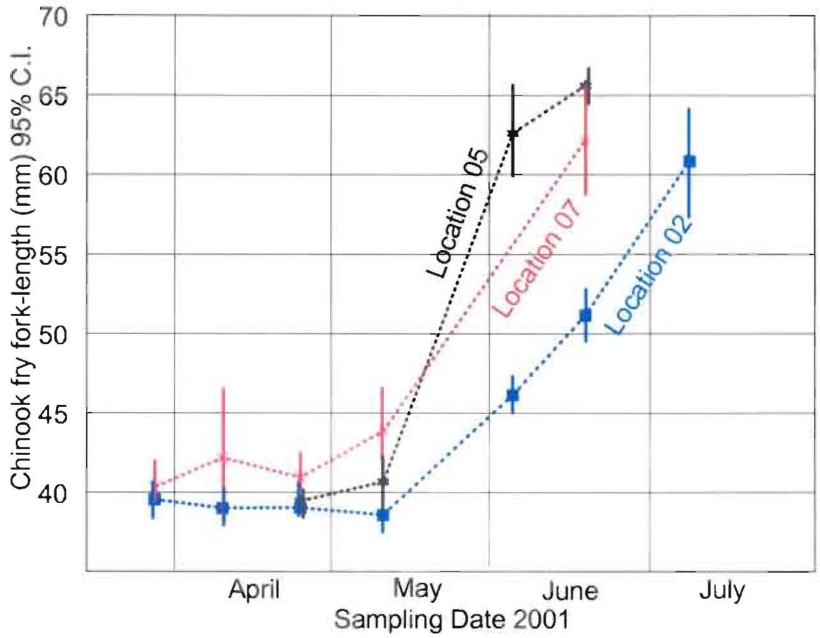

Fig. 21. Chinook fry fork-length (with 95% confidence interval) for three locations from March to July/2001.

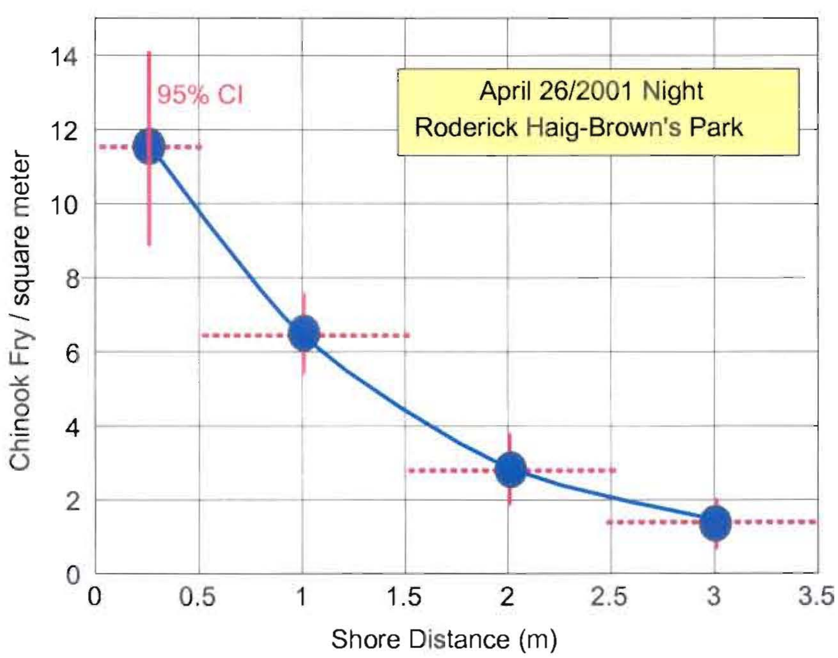

Fig. 22. The relationship between chinook fry density (fry / m^2 with 95% confidence interval) and distance from the wetted lake edge at location 2 on April 26/2001.

APPENDIX 1. SHUSWAP LAKE FORESHORE FISH CATCH (1999-2001)

Table 1. Beach Seine Catch for 1999 (June 21-24).

Table 2. Minnow G-trap catch for 1999 (July 8-11).

Table 3. Daylight Pole-seine Catch for 1999(June 8-20).

Table 4. Night Pole-seine Catch for 1999 (July 13).

Table 5. Catch Data for Pole-seines 2000.

Table 6. Pole-seine and Snorkel Catch 2001.

Table 1. Beach Seine Catch for 1999 (June 21-24)

		Fish Species										
Location	Set	Sculpin	Chinook	Coho	LChub	LeopDace	LnoseDace	Shiner	Sockeye	Pikeminnow	Sucker	Trout/fry
1	1	2							2	1		
1	2	16						1		1		27
2	1	30	30	2			1		1			
2	2	14	3						1			
4	1		1									
4	2		4									
5	1	6	8						14			
5	2	1	1			1						
6	1	1										
6	2	1	1									
7	1	8	4	1			1	1				
7	2	9	8			1		53		6	5	
8	1	2	6									
8	2		1					1	2			
9	1											
9	2	7				1						
10	1											
10	2											
12	1	1						190		1		
12	2	2										
13	1		1					42				
13	2	2						5				
13	3	1						5				
13	4							56				
14	1	3	13			1			3			
14	2	2	4									
15	1							22				
15	2											
16	1	13	2					13				
16	2	9	12						5			
17	1							1				
17	2							4				
18	1	1			1			11				
18	2	1	3					313				
Total		132	102	3	1	4	2	718	28	9	5	27
Occurance		22	17	2	1	4	2	13	7	4	1	1

Table 2. Minnow Gee trap Catch for 1999 (July 8-11)

Location	Set	Sculpin	Burbot	LChub	Leopdace	Lnosedace	Shiner	Sockeye	Minnowpike	Sucker
		Fish Species								
1	1	8								
1	2	8							2	
2	1	1								
2	2	2								
4	1	7								1
4	2	4		1						
5	1	2								
5	2									
6	1	7					16			
6	2	3					3			
7	1	28			1				1	2
7	2	32			4	1	2			1
8	1	9					2			
8	2									
9	1	4							1	
9	2	3					3			
10	1	5								
10	2	14								
12	1	25					1			
12	2	13	1							
13	1	2					1			
13	2	9					1			
14	1	2					1			
14	2	6			1			1		
15	1	7								
15	2	14					1			
16	1	15								
16	2	34								
17	1		1							
17	2	5					2			
18	1	11		1		1	1		1	
18	2	9								
Total		289	2	2	6	2	34	1	5	4
Occurance		28	2	2	3	2	12	1	4	3

Table 3. Daylight Pole-Seine Catch for 1999 (June 8-20)

			Fish Species					
Location	Set	Date	Sculpin	Chinook	Coho	Leopard dace	Redside shiner	Sockeye
1	1	18/06/99	2					
1	2		1					
1	3		3					
1	4		1					
2	1	08/06/99		3				
2	2							
2	3							
2	4			43	1			
4	1	09/06/99						
4	2							
4	3							
4	4							
5	1	09/06/99						
5	2							
5	3							
5	4							
6	1	09/06/99						
6	2							
6	3							
6	4							
7	1	20/06/99						
7	2							
7	3							
7	4							
8	1	20/06/99	1	1				
8	2		2					
8	3							
8	4							
9	1	18/06/99				1		
9	2		6					
9	3							
9	4							
10	1	20/06/99	1					
10	2							
10	3							
10	4		1					
12	1	17/06/99					15	
12	2						29	
12	3							
12	4							
13	1	17/06/99						
13	2							
13	3							
13	4							
14	1	17/06/99	8					
14	2		5					1
14	3		6				13	
14	4		3					
15	1	10/06/99						
15	2		1					
15	3		3					
15	4		3	1				
16	1	10/06/99	16		2			
16	2		9					
16	3		6					
16	4		5					
17	1	19/06/99						
17	2							
17	3						4	
17	4						6	
18	1	19/06/99	2					
18	2		3					
18	3		5					
18	4		1				7	
Total			94	48	3	1	74	1
Occurance			24	4	2	1	6	1

Table 4. Night Pole-Seine Catch for 1999 (July 13/99)								
		Fish Species						
Location	Sets	Sculpin	Coho	Loepard dace	Longnose dace	Redside shiner	Pikeminnow	Sucker
14	1	9		1		15	2	
14	2	3				14	1	
16	1	24	2			132	3	8
16	2	12				46		3
17	1			1				
17	2					1		
18	1	1		1	1	11		
18	2	1				31	1	
Total		50	2	3	1	250	7	11
Occurance		6	1	3	1	7	4	2

Table 5. Catch Data for Pole-seines 2000.

Run	Location	Date	Method	Sets	Chinook	Coho	Sockeye	Sculpin	Redside shiner	Pikeminnow	Leop dace	LNose dace	White	Sucker	Burbot	LChub	LTrout
1	02	06/02/00	DP	2			3	1									
1	03	06/02/00	DP	4				5									
1	07	06/02/00	DP	4				6		1							
1	10	06/02/00	DP	4	1			2		2							
1	11	06/02/00	DP	4				18									
1	13	06/02/00	DP	4				6									
1	14	06/02/00	DP	4				26									
1	18	06/02/00	DP	4	1			3									
1	22	06/02/00	DP	2	1	1		5									
2	02	06/02/00	DP	2			3	4									
2	03	06/02/00	DP	4				1									
2	07	06/02/00	DP	4				10	1								
2	10	06/02/00	DP	4				15									
2	11	06/02/00	DP	4				8									
2	13	06/02/00	DP	4				8		1							
2	14	06/02/00	DP	4				36	1								
2	18	06/02/00	DP	4				6									
2	22	06/02/00	DP	2		1											
3	02	06/03/00	NP	3	58	7	1	28									
3	03	06/03/00	NP	4	23			33	5								
3	07	06/03/00	NP	4	12			12	2	6							
3	10	06/03/00	NP	4	4			59									
3	11	06/02/00	NP	4	9			70	73			2					
3	13	06/02/00	NP	4	5			31	39		3						
3	14	06/02/00	NP	4	1			87	42		4						
3	18	06/02/00	NP	4				56	6	3	4	1					
3	22	06/03/00	NP	1	22	40	1	3			2	4					
4	02	06/03/00	DP	3	2		2										
4	03	06/03/00	DP	4				7									
4	07	06/03/00	DP	4				18									
4	10	06/03/00	DP	4				14	1								
4	11	06/03/00	DP	4				20									
4	13	06/03/00	DP	4				5									
4	14	06/03/00	DP	4				42									
4	18	06/03/00	DP	4				6									
4	22	06/03/00	DP	1	1	3											
5	02	06/16/00	DP	2				6					10				
5	03	06/16/00	DP	4				11									
5	07	06/16/00	DP	4				7									
5	10	06/16/00	DP	4				10									
5	11	06/16/00	DP	4				9									
5	13	06/16/00	DP	4				15									
5	14	06/16/00	DP	4				17									
5	18	06/16/00	DP	4				13									
5	22	06/16/00	DP	2	28	2											
6	02	06/17/00	NP	4	13	2	6	3									
6	03	06/17/00	NP	4	25			37	1								
6	07	06/16/00	NP	2	5			15		2	2						
6	10	06/16/00	NP	4	3			33	5	1	9						
6	11	06/17/00	NP	4	1			51	2								
6	13	06/17/00	NP	4				30	32	1	4	2					
6	14	06/17/00	NP	4				44			16	1					
6	18	06/17/00	NP	4	1			19	25	5	4	9					
6	23	06/16/00	NP	2	4		1	31	4								
7	02	06/17/00	DP	4			1	3									
7	03	06/17/00	DP	4				18									
7	07	06/17/00	DP	4				11	1		1						
7	10	06/17/00	DP	4				9									
7	11	06/17/00	DP	4				23									
7	13	06/17/00	DP	4				8									
7	14	06/17/00	DP	4				26									
7	18	06/17/00	DP	4				26				1					
8	20	06/18/00	NP	2	5	3		43	8	4	1			1			
8	21	06/17/00	NP	2				20	9	29				1			
8	22	06/18/00	NP	2	2	13	2	4	1	2							
8	23	06/17/00	NP	2				19		3							
9	03	07/01/00	NP	4	5			47	9	1							
9	10	06/30/00	NP	4				25	2								
9	13	07/01/00	NP	4				6	38	1	4	3					

9	20	07/01/00	NP	2		1		30	1	2							
9	21	06/30/00	NP	2				6	10	1	1						
9	22	07/01/00	NP	2	5	2		16	2	1							
9	23	06/30/00	NP	2				23	1	2	2						
10	02	07/01/00	DP	4				1									
10	03	07/01/00	DP	4				15									
10	07	07/01/00	DP	4				5	2								
10	10	07/01/00	DP	4				1									
10	11	07/01/00	DP	4				8									
10	13	07/01/00	DP	4				3									
10	14	07/01/00	DP	4				21									
10	18	07/01/00	DP	4				2	9								
11	11	07/02/00	NP	4				8	2								
11	14	07/02/00	NP	4				17	15		6						
11	18	07/02/00	NP	4	1			8	53	2	1	2					
12	02	07/17/00	NP	4	2	3		112									
12	03	07/17/00	NP	4	1			92	21		1						
12	07	07/16/00	NP	2				20									
12	10	07/16/00	NP	4	1			16	4			1		1			
12	20	07/17/00	NP	2	1	1		24	1								
12	21	07/16/00	NP	4				20						1		5	
12	22	07/17/00	NP	2	1	16		15	4	8		2					
12	23	07/16/00	NP	2				22		4							
13	02	07/17/00	DP	4				14									
13	03	07/17/00	DP	4				17									
13	07	07/17/00	DP	4				4								8	
13	10	07/17/00	DP	4			1	2									
13	11	07/17/00	DP	4				22									
13	13	07/17/00	DP	4				2									
13	14	07/17/00	DP	4				23									
13	18	07/17/00	DP	4				8									
13	22	07/17/00	DP	2		3		1				1					
14	11	07/17/00	NP	4				20	1		1			1			
14	13	07/17/00	NP	4				39	30		1	2					
14	14	07/17/00	NP	4				41	7		2						
14	18	07/17/00	NP	4				18	28	2	1	2		2			
15	02	07/18/00	DP	4				16									
15	03	07/18/00	DP	4				18									
15	07	07/18/00	DP	4				7	14	2							
15	10	07/18/00	DP	4													
15	11	07/18/00	DP	4				20	2								
15	13	07/18/00	DP	4				6	2								
15	14	07/18/00	DP	4				22									
15	18	07/18/00	DP	4				12	4								
15	22	07/18/00	DP	2		6		5									
16	02	07/31/00	NP	4	1	3	48	140					2				
16	03	07/31/00	NP	4				17	7			1					1
16	07	07/30/00	NP	4				36	2	1	2						
16	10	07/30/00	NP	4				19	7		3						
16	11	07/31/00	NP	4				49	50		1						
16	13	07/31/00	NP	4				55	50		4	1					
16	14	07/31/00	NP	4				96	9		7						
16	18	07/30/00	NP	4				25	14	1	2	5					
17	02	07/31/00	DP	4				48	2		1						
17	03	07/31/00	DP	4				39	2			4					
17	07	07/31/00	DP	4				23	32								
17	10	07/31/00	DP	4				9	258								
17	11	07/31/00	DP	4				35									
17	13	07/31/00	DP	4				4				2					
17	14	07/31/00	DP	4				87									
17	18	07/31/00	DP	4				16	28			7					
18	20	08/01/00	NP	2				13		1				1			
18	21	07/31/00	NP	2				23	15	2							
18	22	07/31/00	NP	2		1			200	1							
18	23	07/31/00	NP	2				15		1							
19	02	09/12/00	NP	4				283	3				1				
19	03	09/12/00	NP	4				82	2								
19	07	09/12/00	NP	4				42		3		1			1		
19	10	09/12/00	NP	4				17				1					
19	11	09/11/00	NP	4				35	12	27	1						
19	13	09/11/00	NP	4				26	24	1	1						
19	14	09/11/00	NP	4				42	41	1	5						

19	18	09/11/00	NP	4				4			1						
20	02	09/12/00	DP	4				51									
20	03	09/12/00	DP	4				15	7		1						
20	07	09/12/00	DP	4				13	399	3	1						
20	10	09/12/00	DP	4				9									
20	11	09/12/00	DP	4				15	22								
20	13	09/12/00	DP	4					7								
20	14	09/12/00	DP	4				17	1								
20	18	09/12/00	DP	4				1		2							1

Table 6. Pole-seine and Snorkel Catch 2001.																			
Run	Loc	Date	Method		Chin	Coho	Sock	Sculpin	Shiner	Minnow	Leop	LNose	White	Sucker	Burbot	LChub	LTrout	RBT	Unk
1	02	28/03/01	DP					4											
1	07	28/03/01	DP		3		1												
1	10	28/03/01	DP					1											
1	11	28/03/01	DP	Null															
1	14	28/03/01	DP					2											
1	18	28/03/01	DP	Null				4											
1	03	28/03/01	DP	Null															
1	13	28/03/01	DP	Null															
2	02	29/03/01	NP		42		2	87											
2	07	28/03/01	NP				2	11											
2	10	28/03/01	NP					34							1				
2	11	28/03/01	NP					26											
2	14	28/03/01	NP					25											
2	18	28/03/01	NP					8											
2	03	28/03/01	NP		1			19	1										
2	13	28/03/01	NP					16	1										
3	02	10/04/01	NP		107			41											
3	07	10/04/01	NP		8		1	20											
3	10	10/04/01	NP					9											
3	11	10/04/01	NP				1	7											
3	14	10/04/01	NP			1		8											
3	18	10/04/01	NP					11											
3	03	10/04/01	NP		1			34											
3	13	10/04/01	NP					23											
4	02	10/04/01	SS		64		2												
4	07	11/04/01	SS		44														
4	10	11/04/01	SS		1														
4	11	10/04/01	SS		1														
4	14	10/04/01	SS						2										
4	18	10/04/01	SS	Null															
4	03	10/04/01	SS		3										2				
4	13	10/04/01	SS						1										
5	02	25/04/01	NP		725	1		24											
5	07	25/04/01	NP		15			29											
5	10	25/04/01	NP		1			27											
5	11	25/04/01	NP					50	2		1								
5	14	25/04/01	NP					16	4	2									
5	18	24/04/01	NP					12			1								
5	03	25/04/01	NP		7		2	90	1										
5	13	24/04/01	NP					46	9		1	1							
6	02	25/04/01	DP		2			5											
6	07	25/04/01	DP		4		4	12		1									
6	10	25/04/01	DP					3											
6	11	25/04/01	DP					1											
6	14	25/04/01	DP					5											
6	18	25/04/01	DP					1											
6	03	25/04/01	DP		2			8											
6	13	25/04/01	DP					1											
7	02	26/04/01	SS		603														
7	07	25/04/01	SS		29				1										
7	10	25/04/01	SS		4														
7	11	26/04/01	SS		1				1										
7	14	26/04/01	SS		10				2										
7	18	26/04/01	SS						5										
7	03	26/04/01	SS		2														
7	13	26/04/01	SS						30		1								

8	02	10/05/01	DP		4			2											
8	07	10/05/01	DP		2			1											
8	10	10/05/01	DP	Null															
8	11	10/05/01	DP				3	12											
8	14	10/05/01	DP				8	5											
8	18	10/05/01	DP					1											
8	03	10/05/01	DP		1			27											
8	13	10/05/01	DP					3											
9	02	11/05/01	NP		99	1		26					1						
9	07	10/05/01	NP		5			44			1								
9	10	10/05/01	NP		1			22											
9	11	11/05/01	NP					41	28		1	1							
9	14	11/05/01	NP					42	42										
9	18	11/05/01	NP					5	2										
9	03	11/05/01	NP		12			55	3	1									
9	13	11/05/01	NP					15	17										
10	02	13/05/01	SS		114				2										
10	07	13/05/01	SS		47														
10	10	13/05/01	SS		8				2						1				
10	11	14/05/01	SS		7				7										
10	14	14/05/01	SS		1				38										
10	18	14/05/01	SS	Null															
10	03	14/05/01	SS		24				2										
10	13	14/05/01	SS						4										
11	02	05/06/01	NP		74			16											1
11	07	05/06/01	NP					16	1	2	1								
11	10	05/06/01	NP					3											
11	11	06/06/01	NP		1			32	22		4								
11	14	06/06/01	NP		1			16	31		2								
11	18	06/06/01	NP		3	6		27	102	9	1	1							
11	03	05/06/01	NP		24			48	4	3	2								
11	13	06/06/01	NP		1			17	72	1	5	1							
11	22	05/06/01	NP (2)		6	6			1	4									
12	02	06/06/01	DP	Null															
12	07	06/06/01	DP					5											
12	10	06/06/01	DP					1											
12	11	06/06/01	DP					1											
12	14	06/06/01	DP	Null															
12	18	06/06/01	DP	Null															
12	03	06/06/01	DP	Null															
12	13	06/06/01	DP					1											
12	22	06/06/01	DP (3)		4	10						1							
13	02	06/06/01	SS		8														
13	07	06/06/01	SS		1														
13	10	06/06/01	SS		4				3										
13	11	06/06/01	SS						13										
13	14	06/06/01	SS						9		3								
13	18	07/06/01	SS		1				23			1			1				
13	03	06/06/01	SS		42				2										
13	13	06/06/01	SS						25										
14	02	19/06/01	NP		44			14											
14	07	19/06/01	NP		5			42	1	2	10								
14	10	19/06/01	NP		1			9	4		3								
14	11	19/06/01	NP		1			3	5										
14	14	18/06/01	NP					41	34		1								
14	18	18/06/01	NP					14	77	1	1	1							
14	03	19/06/01	NP		30			20	7	3									
14	13	18/06/01	NP					12	31		2								
14	22	19/06/01	NP (2)			6			1			4							
15	02	19/06/01	DP										3						

15	07	19/06/01	DP					25		2	1								
15	10	19/06/01	DP					5			1								
15	11	19/06/01	DP					9											
15	14	19/06/01	DP					5											
15	18	19/06/01	DP					11	16		1								
15	03	19/06/01	DP					6											
15	13	19/06/01	DP					1											
15	22	19/06/01	DP (3)			17		1											
16	02	20/06/01	SS		90				1				2						
16	07	20/06/01	SS		1														
16	10	20/06/01	SS						9	5	1				1				
16	11	20/06/01	SS		1				58	1	2								
16	14	20/06/01	SS						34		18								
16	18	19/06/01	SS						85										
16	03	20/06/01	SS		35				9										
16	13	20/06/01	SS						36										
17	02	09/07/01	NP		13			113					16					2	
17	07	09/07/01	NP					60			4								
17	10	09/07/01	NP					7	1	1	13	5							
17	11	10/07/01	NP					42	8										
17	14	10/07/01	NP					10	31	2	2								
17	18	10/07/01	NP					6	86	1	6	5		1					
17	03	10/07/01	NP					56	6		5								
17	13	10/07/01	NP					45	35		2	5							
18	02	10/07/01	DP					10										6	
18	07	10/07/01	DP					30											
18	10	10/07/01	DP					20			1								
18	11	10/07/01	DP					30	4										
18	14	10/07/01	DP					33	1										
18	18	10/07/01	DP					2	5										
18	03	10/07/01	DP					23											
18	13	10/07/01	DP						5										
19	02	11/07/01	SS		15		6		7				7						7
19	07	11/07/01	SS						13		2								
19	10	11/07/01	SS								1								
19	11	11/07/01	SS						38		3			3					
19	03	11/07/01	SS						27		2								
19	13	10/07/01	SS						28		1								
19	14	10/07/01	SS						85		5								
19	18	10/07/01	SS						125		2								
20	02	31/07/01	NP			2		160	2				6						
20	07	31/07/01	NP					200											
20	10	31/07/01	NP					54			1	3							
20	11	30/07/01	NP					33	2			1							
20	14	30/07/01	NP					121	11		2								
20	18	30/07/01	NP					6	4										
20	03	31/07/01	NP					82	9				1						
20	13	31/07/01	NP					17	11		2								
21	02	01/08/01	SS		1				35				3						
21	07	01/08/01	SS						1		2								
21	10	31/07/01	SS						1										
21	11	31/07/01	SS						8										
21	14	31/07/01	SS						43		10								
21	18	31/07/01	SS						92					1					
21	03	01/08/01	SS		1				2										
21	13	31/07/01	SS						42										
22	02	29/08/01	SS		3				1				6						
22	07	29/08/01	SS								1								
22	10	29/08/01	SS	Null															
22	11	28/08/01	SS						53	1									

22	14	28/08/01	SS						55	2			2						
22	18	28/08/01	SS						10										
22	03	28/08/01	SS	Null															
22	13	28/08/01	SS						26							1			
23	02	28/08/01	NP					85	3				1			1			
23	07	27/08/01	NP					102		1	1				2				
23	10	27/08/01	NP					37			3	6							
23	11	28/08/01	NP					76	9										
23	14	28/08/01	NP		1			58	12		1					1			
23	18	28/08/01	NP					2				1							
23	03	28/08/01	NP					100				1	1						
23	13	28/08/01	NP		1			35	6		1	5			2	2			