AN INTENSIVE STUDY OF THE FISH FAUNA OF THE STEEPBANK RIVER WATERSHED OF NORTHEASTERN ALBERTA

by

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONCLUDED)

LIST OF TABLES

LIST OF TABLES (CONTINUED)

Page

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONCLUDED)

LIST OF FIGURES

LIST OF FIGURES (CONCLUDED)

ABSTRACT

A study of the fish fauna of the Steepbank River was conducted during the open water period, 1977. Utilization of the Steepbank system by migrant fish from the Athabasca River was assessed by means of a two-way counting fence. Fish movements were monitored from 25 April to 29 May, and from 12 September to 15 October. Small mesh seines were used throughout the watershed and throughout the summer to collect small fish. Floy tags were applied to 3466 migrant fish in an effort to determine the length of time spent by migrant fish in the Steepbank watershed and migration patterns within the lower Athabasca River system.

Spawning migrations of longnose suckers (52%), Arctic grayling (20%), and white suckers (14%) accounted for most of the 7272 fish passed through the upstream trap during the spring operation. An upstream feeding migration of mountain whitefish (7%) and post-spawning movements of northern pike (3%) and walleye (3%) were also observed at this time.

Most migrant suckers of both species left the Steepbank watershed shortly after spawning, although small numbers of immature fish apparently remained in the tributary throughout the summer and were captured moving downstream in October. Most young-of-the-year suckers drifted out of the Steepbank River during June. Arctic grayling remained in the mid-reaches of the Steepbank River throughout the summer and did not leave the watershed until just prior to freeze-up. A total of 1789 grayling were counted through the downstream trap in the fall. It is suggested that young-of-the-year grayling overwinter in the Steepbank River and do not join the migrant population until the autumn of their second year.

Only 1.4% of the fish tagged were recaptured outside the Steepbank watershed. Northern pike demonstrated little tendency to move around while walleye and suckers moved great distances.

The resident fish fauna of the Steepbank River consists largely of pearl dace, brook stickleback, lake chub, longnose dace and slimy sculpin.

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1. INTRODUCTION

The proposed development of the Athabasca Oil Sands is expected to introduce large scale disturbance to some lake and river systems of the lower Athabasca River drainage. Especially susceptible is that section of the surface-mineable area for which the Alberta Energy Resources Conservation Board (AERCB) has granted development approval. Local disruption in the form of land clearing, muskeg drainage and removal, stream diversions, and the construction of access routes will affect the water quality and quantity of streams in addition to the physical alterations produced. Other activities that may affect water quality include tailings pond seepages and saline minewater discharges. The diversion or blockage of streams may affect fish spawning runs. Traditional fish rearing, feeding, and overwintering areas might be disturbed or lost altogether. In the case of migrant fish populations, such local disruptions could be felt over much wider areas.

In order to minimize the adverse effects of development on fish populations of the Athabasca River and its tributaries, the Alberta Oil Sands Environmental Research Program (AOSERP), through its Aquatic Fauna Technical Research Committee, initiated an integrated series of projects to assess the baseline state of the fish resources of the area. The work, which began in 1976, involves a broadly based fisheries investigation of the Athabasca River as well as site-intensive study of selected tributaries. Tributaries selected for intensive study are those considered to be most immediately imperilled by future surface mining operations or by increased pressure from growing human population.

The Steepbank River, a medium sized watershed on the east side of the Athabasca River, was chosen for intensive study during 1977. This watershed lies close to the developmental centre of the oil sands area and adjacent to the Muskeg River watershed in which the AERCB has approved the construction of two synthetic crude oil plants. It is unlikely that developments in the adjacent watershed will leave the Steepbank River unaffected.

The proximity of the Steepbank watershed to Fort McMurray is also a major concern. This river is reported to support a potentially valuable sport fishery for Arctic grayling as well as providing spawning and rearing areas for other species of fish. As the population of Fort McMurray grows, increased angling pressure and human activities generally are likely to be diverted to the Steepbank system. Such activities elsewhere have resulted in over-exploitation of fish populations and destruction of spawning and rearing areas.

The general objective of the present study, as outlined in the terms of reference agreed to by AOSERP and the Department of Fisheries and Environment, was to describe the baseline states of the fish resources and the aquatic habitat of the Steepbank River watershed, and to provide a quantitative estimate of the significance of this watershed to the fisheries of the Athabasca River system.

Specific objectives for the study were as follows:

1. To enumerate the migrant populations of those fish species utilizing the Steepbank River watershed on a seasonal basis;
2. To describe the timing of the seasonal and daily movements of various fish populations into and out of the Steepbank River watershed, and to obtain information concerning the age, growth, sex ratio, fecundity, food habits, etc., of these fish;
3. To determine the extent of movement of the various non-resident fish populations within the Steepbank River watershed, and to locate spawning and nursery areas;
4. To apply conventional (Floy) tags to migrant fish to permit definition of their migration routes within the Athabasca River system;
5. To monitor the downstream migration of fry of various species hatched within the Steepbank River watershed, and to estimate recruitment of these species to the Athabasca River system;
6. To assess the resident fish species of the Steepbank River watershed in terms of relative abundance,

distribution and general biology; and

7. To describe, in detail, the aquatic habitat of the Steepbank River watershed. This was to be done on the basis of a parameter list provided by another AOSERP sub-project. However, since the list was not available, this portion of the study was not carried out.

2. RESUME OF CURRENT STATE OF KNOWLEDGE

Prior to the commencement of the present study little information was available concerning the fish fauna of the Steepbank River watershed.

The Steepbank River underwent a preliminary investigation by Griffiths (1973) as part of a broad regional study to assess the sport fishery potential of a large number of streams in the AOSERP area. Subsequent to this, Renewable Resources Consulting Services Ltd. (RRCS) collected fish from the Steepbank in October 1975 (Lutz and Hendzel 1977). D. Barton made several collections during the fall of 1976 while sampling aquatic invertebrates (telephone conversation between D. Barton and W. A. Bond, 30 March 1977).

Griffiths documented the presence of 12 fish species in the Steepbank River, 11 of which he found near the mouth. He recorded four species (longnose sucker, trout-perch, lake chub, and longnose dace) at the confluence of the North Steepbank and Steepbank rivers. Griffiths identified the presence, in the Steepbank River, of a population of Arctic grayling that he suggested could represent a future recreational source. He recommended further study of this population, stressing its susceptibility to environmental disturbance.

RRCS collected four fish species (northern pike, Arctic grayling, lake whitefish and white sucker) at the mouth of the Steepbank in October 1975. During the same period, they captured six species (walleye, northern pike, Arctic grayling, lake whitefish, white sucker and longnose sucker) at the confluence of the North Steepbank and Steepbank rivers.

Dr. Barton observed that slimy sculpin and brook stickleback were present in the upper reaches of the Steepbank River.

It is not possible, from the data available, to construct an adequate description of the fish resources of the Steepbank River. The composition and distribution of resident species within the watershed are presently unknown. No information is available regarding the size of the various migrant populations that utilize the Steepbank River on a seasonal basis or on the patterns of such seasonal utilization. Areas of the watershed that are critical in the life histories of the various species are unknown. Life history patterns and general biological features of all species require elucidation.

3. DESCRIPTION OF THE STUDY AREA

The headwaters of the Steepbank River are situated in the Muskeg Mountain uplands, from which the river travels approximately 118 km before entering the Athabasca River on the east side, 42 km downstream from Fort McMurray (Figure 1). The North Steepbank River, the only major tributary, joins the Steepbank approximately 32 km upstream from its confluence with the Athabasca River after draining 526 km^2 north of the main stream (Figure 2).

The total area drained by the Steepbank River system is 1424 km^2, of which the majority is treed muskeg (Northwest Hydraulic Consultants Ltd. (NHCL) 1975). In the uplands and along the river there is a mixture of deciduous and evergreen forest. The headwater regions contain a number of small, shallow, eutrophic lakes (Griffiths 1973).

The climate of the study area is continental, characterized by cold winters, short, cool summers, and wide temperature fluctuations (Intercontinental Engineering of Alberta Ltd. 1973). Precipitation records for the Steepbank basin show the annual precipitation to be 59.7 cm, of which 33.5 cm falls between May and September (NHCL 1975).

The surficial deposits in the upper watershed consist primarily of thick glacial drift (ground moraine), while those in the central area of the basin are glaciofluvial and glaciolacustrine in origin (outwash sand and gravel or silt and clay). These deposits are generally underlain by sandstones, shales, and siltstones of Cretaceous origin. Outcrops of Devonian limestone and dolomite and Cretaceous tar sand are common near the mouth of the basin (RRCS 1975). The thick drift present in the basin probably stores relatively large amounts of groundwater during wet periods (NHCL 1975).

Extensive beaver activity in the upper Steepbank and North Steepbank rivers has resulted in impoundment of 90 to 95% of the channel in those areas (Griffiths 1973). The middle reaches are characterized by alternating pools and riffles with brush-covered, overhanging banks. The substrate is mainly boulders and rubble in the riffles, with boulders, sand, and silt in the pools. The

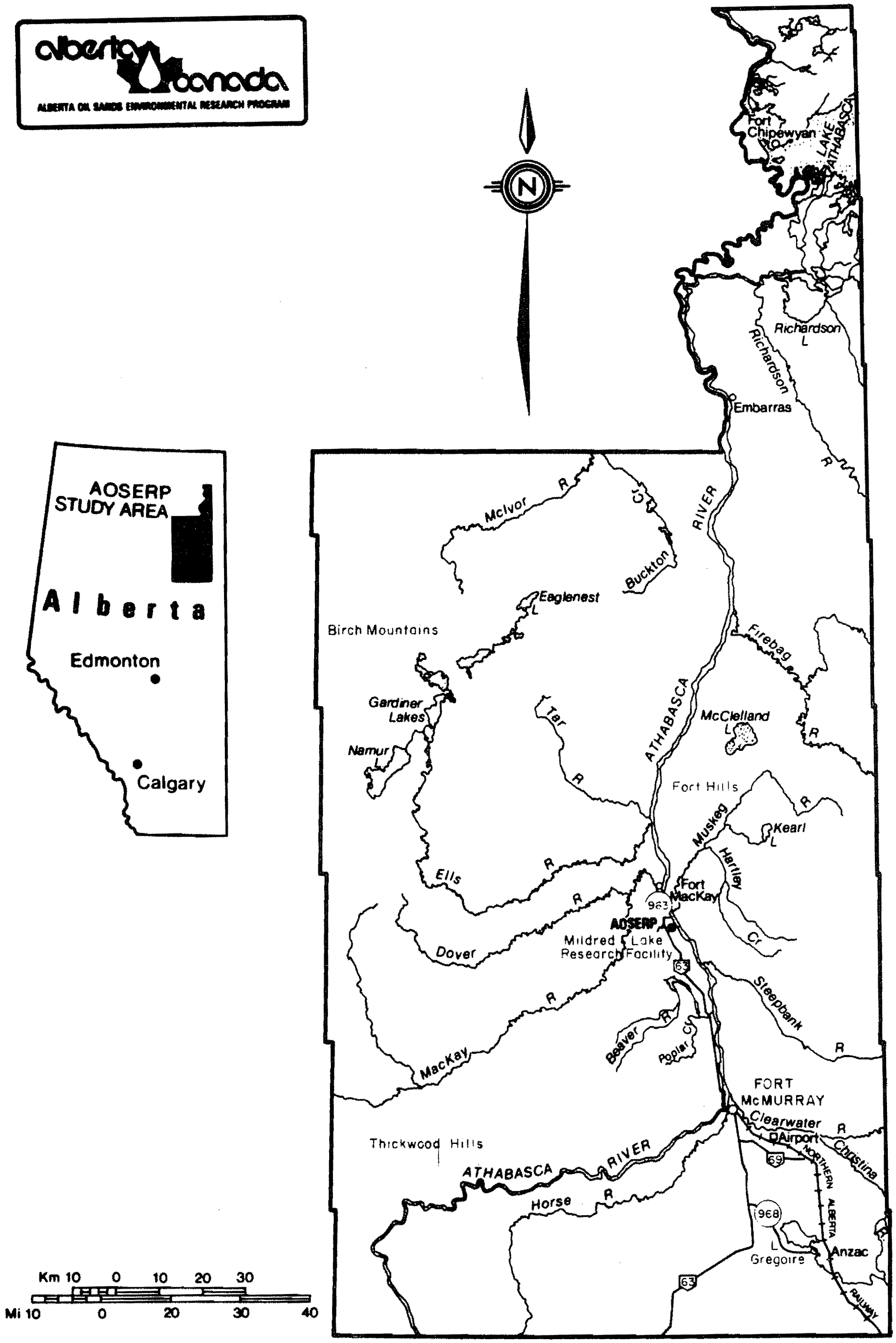

Figure 1. Map of the AOSERP study area indicating the location of the Steepbank River.

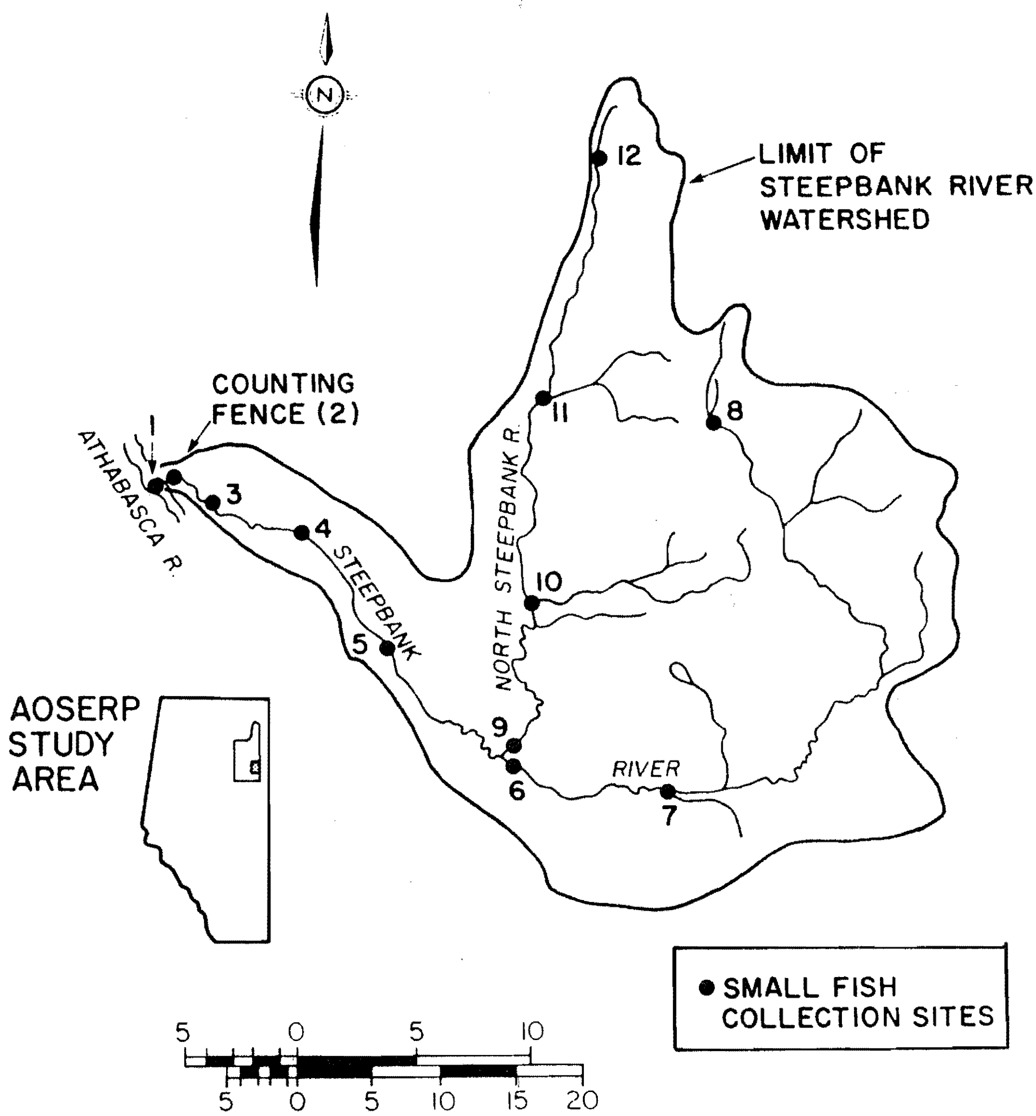

Figure 2. Map of the Steepbank River drainage basin indicating the location of the counting fence and small fish collection sites.

substrate in the lower reaches is mainly gravel, boulders, and tar sands in the riffles with silt, sand, and tar sand in the pools. The banks are vegetated with grass, willows, and a forest of poplar and spruce.

The Steepbank River generally freezes over in late October and remains ice-covered until late April. Ice left the stream on 20 April 1977 (Figure 3). The maximum daily water temperature was 5.5°C on 25 April and a reading of 19.0°C was recorded on 5 May. Considerable cooling can occur at night, and daily fluctuations of up to 9.0°C were observered (Appendix 8.1).

Discharge records for the Steepbank River (Water Survey of Canada 1978) showed a mean daily discharge in 1977 of 3.03 m^3/sec (range 0.25-13.06 m^3/sec). Discharge fluctuations during the period of the present study are shown in Figure 3. Following the spring break-up in late April, water levels began to decline. However, heavy precipitation in late May resulted in a rapid run-off, which, combined with back-flooding from the Athabasca River, terminated fence operations. The mean daily discharge during the spring fence operation was 8.33 m^3/sec (range 4.90-13.06 m^3/sec). During the fall fence operation, mean daily discharge averaged 2.55 m^3/sec (range 2.04-3.23 m^3/sec).

The physical and chemical characteristics of Steepbank River water are given in Table 1. More complete physical and chemical data for this stream are presented by Seidner (in prep.).

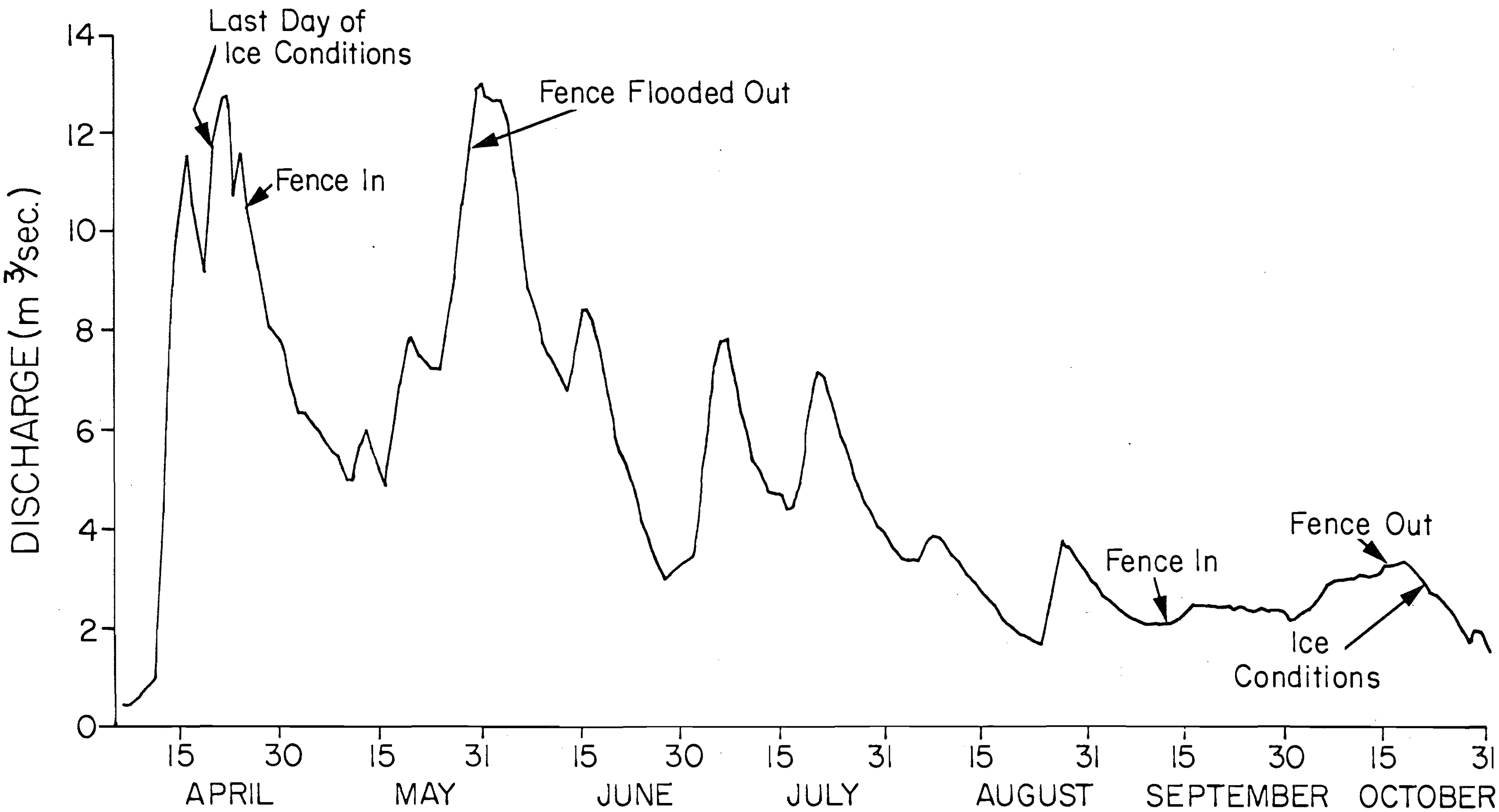

Figure 3. Discharge of the Steepbank River from 1 April to 31 October 1977.

Table 1. Summary of physical and chemical characteristics of the Steepbank River on several dates, 1977.[a]

Parameter[b]	Date			
	3 March	18 May	15 Aug.	11 Oct.
pH (pH units)	7.8	7.6	7.9	8.1
Total alkalinity	314.4	85.0	123.2	125.2
Total hardness	245.9	75.5	114.0	110.7
Specific conductance (µmhos/cm @ 25°C)	590	172	230	222
Turbidity (JTU)	1.3	33.0	1.1	6.7
Apparent colour (Relative units)	10	110	90	100
Humic acid	<1.0	<1.0	<1.0	<1.0
Oil and Grease	<0.1	<0.1	1.4	2.4
Total Filterable Residue	366	107	138	146

[a] Data from Seidner (in prep.).
[b] Except as indicated, data are expressed as mgL^{-1}.

4. MATERIALS AND METHODS

Study of the fish fauna of the Steepbank River began on 25 April 1977 and terminated on 15 October 1977. During this period various methods were utilized in an attempt to collect fish throughout the watershed. The major emphasis, however, was placed on the construction and operation of a two-way fish counting fence to monitor spring and fall movements of fish in the Steepbank River. The fence was established approximately 1 km upstream from the confluence of the Steepbank with the Athabasca River, enabling us to enumerate virtually all fish moving into the tributary from the main river. The fence was operated from 25 April to 29 May and from 12 September to 15 October.

4.1 COUNTING FENCE CONSTRUCTION

The counting fence was installed in such a way as to form a complete temporary barrier to fish. It was constructed of 2.5 cm by 2.5 cm welded wire fabric and was similar in detail to that described by Bond and Machniak (1977). Fish travelling upstream or downstream encountered the fence at some point and were led into one of the holding boxes where they could be worked with.

4.2 COUNTING FENCE OPERATION

The operation of a counting fence of this type is highly labour intensive, especially during the high water period generally encountered in the spring. Debris carried by the river tends to clog the openings in the wire mesh, placing great pressure on the structure. Frequent cleaning is required to remove such debris and prevent the fence being washed out.

4.2.1 Sampling Schedule

The upstream portion of the spring fence was completed by 1600 hours on 25 April and the downstream part was finished by 1 May. This fence was operated until 29 May when high flood waters completely submerged it, making operation impossible. High water levels persisted for about 10 days (Figure 3), damaging the fence to such an extent that re-installation was deemed impractical.

During the period of operation, traps were checked three to seven times daily (Table 2).

Construction of the fall fence was completed by 1400 h on 11 September. Traps were checked two to six times daily from that time until 15 October (Table 3).

4.2.2 Trap Checks

Each trap check was performed by two persons, one working inside the trap and the other serving as recorder. The number of fish of each species was recorded, and as many fish as possible were measured and sexed. The development of pearl organs by male white and longnose suckers, and the large dorsal fin of the male grayling, made it possible to distinguish between the sexes for these species without sacrificing the fish. The only exceptions were smaller fish that were either females or immature males, and for such fish no sex was recorded. Handling of fish was minimized by using a scoop constructed of PVC pipe and rochelle netting, and fish were passed through the fence in the direction in which they were moving.

Relative water level, taken from a metre stick placed in the stream, and water temperature, measured by a Taylor max-min thermometer, were recorded at each trap check. Daily temperature values recorded during the spring and fall operations are given in Appendices 8.1 and 8.2 respectively.

The fence was cleaned daily as required and examined for holes.

4.2.3 Tagging

Numbered Floy anchor tags (Type FD-68B) were applied to as many fish (mainly suckers) as was practicable. Tags were inserted into the left side of the fish near the base of the dorsal fin. No anaesthetic was used, and the risk of infection was minimized by rinsing the tagging gun in disinfectant and in fresh water before each insertion.

Depending on the species, either fork or total length (±1.0 mm) was recorded for each fish tagged, and the sex noted if

Table 2. Sampling schedule for the Steepbank River counting fence, spring, 1977.

Date	Time of Fence Check[a]					
	0900	1200	1500	1800	2100	2400
25 April	+		1530	2015		
26	+	1300	1630	2000		
27	+	+	+	+	+	+
28	+	+	+	+	+	+
29	+	+	+	+	+	+
30	+	+	+	+	+	+
1 May	+	+	+	+	+	+
2	+	+	+	+	+	+
3	+	+	+	+	+	+
4	+	+	+	+	+	+
5	0300 +	+	+	+	+	+
6	+	+	+	+	+	+
7	+	+	+	+	+	+
8	+	+	+	+	+	+
9	+	+	+	+	+	+
10	+	+	+	+	+	+
11	+	+	+	+	+	+
12	0300 +	+	+	+	+	+
13	+	+	+	+	+	+
14	+	+	+	+	+	+
15	+	+	+	+	+	+
16	+	+	+	+	+	+
17	+	+	+	+	+	+
18	+	+	+	+	+	+
19	+	+	+	+	+	2300
20	+	+	+	+	+	+
21	+	+	+	+	+	+
22	+	+	+	+	+	+
23	+			+	+	+
24			+	+	+	+
25		+		+	+	+
26		+		+	+	+
27		+		+	+	+
28		+		+	+	
29	+	Operations terminated				

[a] Actual check time indicated where different from scheduled check time.

Table 3 . Sampling schedule for the Steepbank River counting fence, fall, 1977.

Date	Time of Fence Check[a]			
	1200	1800	2100	2400
12 Sept.	+	2030		
13	+		+	+
14	+		+	+
15		+	+	
16	+	+	+	
17	+	+	+	+
18	+	+	+	+
19	+	+	+	+
20	+	+	+	+
21	+	+	+	+
22	+	+	+	+
23	+	+	+	+
24	+	+	+	+
25	+	+	+	+
26	+	+	+	+
27	+	+	+	+
28	+		+	+
29	+	+	+	+
30	+	+	+	+
1 Oct.	+	+	+	+
2	+		+	+
3	+	+	+	+
4	+		+	+
5	+	+	+	+
6	+	+		+
7	+	+	2200	+
8	+	+	2200	+
9	+	+	+	+
10	+ 1630	+	+ 2300	+
11	+	+	+	+
12	+	+	+	+
13	+	+	+	+
14	+	+	+	+
15	+	Operations terminated		

[a] Actual check time indicated where different from scheduled check time.

possible. Tagged fish were not weighed and no body structures were retained for age determination. A portable generator enabled the fence crew to tag fish during the late evening and at night. Care was taken at all times not to impede the progress of the fish any more than necessary. When fish were observed to be backing up in front of the trap, tagging was curtailed and the remaining fish were simply passed through and enumerated.

The tagging program was well publicized by posters and press releases, and a two-dollar reward was offered for returned tags. Tag returns were made by sport fishermen along the Athabasca River, by domestic fishermen on the Athabasca River and Lake Athabasca, and by commercial fishermen on Lake Athabasca. Personnel of LGL Ltd., Environmental Research Associates, Edmonton, and Aquatic Environments Ltd., Calgary, also returned tags, while others were recovered by fishery crews working on the Athabasca River (Bond and Berry in prep. b), the Muskeg River (Bond and Machniak in prep.), and the MacKay River (Machniak et al. in prep.).

4.2.4 Dead Samples

Small numbers of fish were sacrificed each day for life history analysis. Fork or total length (±1.0 mm) and weight (±20 g) were recorded for each fish. Weights for some small fish were determined on a triple beam balance (±0.1 g). Sex and stage of maturity were determined by examination of the gonads. A fish was considered to be mature if it appeared that it would spawn or had already spawned in the year of capture. A ripe fish was a mature fish whose gonads were close to spawning condition and from which sexual products could be expressed by application of pressure to the abdomen. A spent or spawned out fish was a mature fish which had obviously spawned shortly before it was captured. Egg size was obtained by removing 10 eggs, lining them up on a measuring board, and calculating the average diameter. Ovaries for fecundity work were removed from a number of longnose suckers, white suckers, and Arctic grayling and weighed fresh on a triple beam balance (±0.1 g). These ovaries were then preserved in Gilson's fluid. Stomach contents were noted, and a small number of stomachs were preserved in 10% formalin for a more detailed assessment of food habits. Scales were removed from the appropriate body location (Hatfield et al. 1972) for ageing of grayling, mountain whitefish, pike, walleye, and lake whitefish. Otoliths (ear bones) were taken from burbot, and for suckers, the left pectoral fin was retained for age determination.

4.3 OTHER FISH COLLECTION TECHNIQUES

Apart from the counting fence, fish were collected by various methods, including small mesh seines (3.2 mm oval mesh), commercial minnow traps, dip nets, drift nets, and angling. Large fish captured by these methods were dead sampled or measured and tagged. Small fish were initially preserved in 10% formalin and later transferred to 40% isopropyl alcohol for laboratory analysis.

An attempt was made to quantify the downstream fry migrations using a bomb drift sampler (Burton and Flannagan 1976). However, the 202 µm Nitex utilized in construction of the sampler quickly became clogged with debris, rendering the sampler ineffective. Drift samplers, as a consequence, were useful only in identifying the starting time of the fry migration.

Monthly helicopter surveys were used to collect fish throughout the watershed (Figure 2). A float trip was undertaken between 31 July and 2 August in an effort to acquire information on the summer distribution and relative abundance of fish between Area 7 (Figure 2) and the mouth of the Steepbank.

4.3.1 Small Fish Collection Sites

Small fish were collected from 12 areas in the Steepbank River watershed (Figure 2). Each area consisted of from 100 to 200 m of stream channel which was sampled where possible in a standard unit of effort (5 seine hauls of approximately 6 to 8 m per area).

It was not possible to sample all areas on a regular basis in 1977, and some upper stations in the North Steepbank River (Areas 11 and 12) were sampled only once or twice. Most areas, however, were sampled three or four times during the summer and the region around the fish fence was sampled more frequently (Table 4). Complete habitat descriptions for each area are given in Appendix 8.3.

Table 4. Sampling schedule for small fish seine collections in the Steepbank River drainage, 1977[a]

Date	Steepbank River								North Steepbank			
Area	1	2	3	4	5	6	7	8	9	10	11	12
20 May		(3,10,17, 24, 31)	+(1)		+	+(1)			+		+	
19 June		(7,11,14)	+		+	+		+	+			
30 July	+(18)	+(10,18)	(22)	(22)		(22,31)	+	+	(31)	+	+	+
19 August	(6,13,20)	(6,13,20, 23)	+(2,22)	(1)	+	+	+		+	+		
15 September		+	+	+		+	+	+	+	+		
13 October			+		+	+	+	+	+	+		

[a] Actual collection dates are indicated in parentheses where different from scheduled date.

4.4 LABORATORY TECHNIQUES

4.4.1 Fish Identification

Preserved fish specimens were identified using taxonomic keys and descriptions given by Paetz and Nelson(1970) and McPhail and Lindsey (1970). While most fish could be identified to species, larval catostomids could often be identified only to genus.

4.4.2 Age Determination

Ages were determined by the scale method for Arctic grayling, mountain whitefish, lake whitefish, walleye, and northern pike. Several scales from each fish were cleaned and mounted between two glass slides, and the annuli were interpreted from the image produced by an Eberback microprojector.

Longnose and white suckers were aged from cross sections of pectoral fin rays as described by Beamish amd Harvey (1969) and Beamish (1973). After embedding the dried fin rays in epoxy, thin sections (0.5 mm to 1.0 mm) were cut by hand using a jeweller's saw with No. 6 and No. 7 blades. These sections were then mounted in Permount on glass slides and read under a compound microscope.

Ages for all other fish species were determined from otoliths. Otoliths were stored in a 1:1 glycerine and water mixture and read whole under a dissecting microscope using reflected light. Where required, the otolith was ground by hand on a carborundum. Independent age determinations were made by three people in all cases. Where discrepancies existed among the three results, the readers conferred until a consensus was achieved.

4.4.3 Fecundity

Fecundity was determined for longnose and white suckers and Arctic grayling using the gravimetric method of estimation described by Healey and Nicol (1975). The ovarian tissue was removed from the sample and the separated eggs dried to constant weight. The weight of a subsample of eggs was determined and the total number of ova then derived by extrapolation. The accuracy of the estimates was assessed by performing total counts on several ovaries.

4.4.4 Food Habits

The stomach contents of preserved fish were removed and the food items identified to the lowest possible taxon using keys and descriptions from Pennak (1953). Results were expressed as percentage frequency of occurrence, percentage of total number and, in some cases, percentage of total volume.

4.4.5 Length and Weight of Small Fish

Small, preserved fish specimens were measured to the nearest 1.0 mm (0.5 for larval fishes) and weighed to the nearest 0.1 g on a triple beam balance.

4.4.6 Data Analysis

Data were analyzed for graphic and tabular presentation using a Hewlett-Packard Model 9810-A programmable calculator.

Length-weight relationships are described by the power equation:

$$\log_{10}W = a + b\,(\log_{10}L);\ sb =$$

where: W = weight in grams,

L = fork or total length in millimetres,

a = y-intercept,

b = slope of the regression line, and

sb = standard deviation of b.

Date summaries and raw data are presently on file at the Freshwater Institute in Winnipeg.

4.5 LIMITATIONS OF METHODS

The primary objective of the present study was to enumerate and describe the migrant fish populations that utilize the Steepbank River on a seasonal rather than a year-round basis. The best possible means of achieving such an objective is, undoubtedly, a counting fence. However, this apparatus, like any other, has certain limitations.

Because the fence was not operated year round, in the present study, it can be argued that the results produced are incomplete. This certainly cannot be denied as there is little doubt that fish movements did not cease on the days when the fence was not operated. However, it is essential to strike some kind of balance between the effort expended and the results obtained. Since it was expected that spring and fall would be the times of most intensive movement for the major fish species found in the AOSERP study area, the fence operations concentrated on these periods.

The 2.5 cm x 2.5 cm wire mesh used in construction of the of the counting fence is believed to have been highly effective in catching fish longer than 150 mm in fork length. Fish smaller than this, although sometimes found in the trap, were able to pass through the apertures. Seasonal movements of small fish (such as trout-perch) could not, therefore, be monitored.

The spring counting fence was operated in varying degrees of completion between 25 April and 29 May. Daily checks were made for holes developing under the structure, and such holes were plugged when discovered. Current also tended to erode the banks near the ends of the fence allowing water to pass. After 15 May, high water sometimes passed over the middle section of the counting fence and some fish (suckers) were observed crossing the fence at that point (going downstream). The effect of these factors would be an underestimation of the number of fish passing the fence site during the spring operation. We feel, however, that the number missed was small, relative to the total number counted. A much larger underestimation (especially of Arctic grayling) probably resulted from the fact that the fence could not be installed until five days after ice-out. The fall fence operation encountered no such difficulties because of lower water levels at that time (Figure 3).

The question of how the presence of the counting fence affected the behaviour of the migrating fish cannot be answered by our experience on the Steepbank River where the turbidity of the water prevented observation. However, on the Muskeg River, Bond and Machniak (in prep.) observed that suckers moving upstream quickly located the entrance to the upstream trap and showed little hesitation in entering it. At times of heavy migrations, suckers backed up below the fence but continued to seek a way through. During the downstream run, suckers seemed more aware of the trap's presence and appeared reluctant to enter it. Kendel (1975) suggested that longnose sucker post-spawning downstream movement was delayed by the presence of a counting fence.

The physical demands of operating the counting fence between 25 April and 15 May left the field staff with no time to fly the watershed in search of fish on spawning grounds. Thus no observational evidence could be collected regarding spawning locations, or the extent of movement of non-resident fish within the Steepbank River watershed.

The small mesh seines (3.2 mm) utilized in the present study are considered to have been highly effective in identifying the presence of small fish in the Steepbank watershed. However, in deep water, in fast current, and in areas with an uneven bottom (stones or other snags), their value is limited. Thus, many of the hauls made in the mid-reaches of the watershed (Areas 4, 5, 6, 7, 9 and 10) probably underestimated the fish populations of these areas. These areas, undoubtedly, would have been more efficiently sampled by an electro-fisher or toxicant.

No winter sampling was carried out during the present study. Therefore, no information was collected on fish utilization of the Steepbank watershed during that period of the year.

5. RESULTS AND DISCUSSION

5.1 FISH SPECIES OF THE STEEPBANK RIVER

Field work during the open water period of 1977 documented the presence, in the Steepbank River, of 23 fish species representing 10 families (Table 5). Spoonhead sculpins, reported from the lower reaches of the Steepbank River by Griffiths (1973), were not captured during the present study.

The fish fauna of the Steepbank River can be divided into three categories on the basis of the extent to which this watershed forms part of the home range of the various populations. The first category contains a number of species that appear to be more typical of the Athabasca River, Lake Athabasca, or other areas outside the Steepbank watershed. It includes goldeye, lake cisco, lake whitefish, Dolly Varden, flathead chub, northern redbelly dace, spottail shiner, brassy minnow, fathead minnow, burbot, and yellow perch. These species are seldom encountered in the Steepbank River upstream of the fence site, and are most likely to be captured near the river mouth.

The second category includes five species that appear to have established permanent resident populations within the Steepbank River watershed. These are pearl dace, brook stickleback, slimy sculpin, longnose dace, and lake chub. The home range for fish in this category is more or less restricted to the Steepbank watershed.

The third category includes a number of species to which the Steepbank River represents a small but important portion of their home range. These species, while inhabiting areas outside of, and, in some cases, great distances from the Steepbank River for part of the year, return to the tributary periodically to spawn and/or feed. The Steepbank watershed may also provide rearing and overwintering areas for juvenile members of some of these populations. The species included in this group are white sucker, longnose sucker, Arctic grayling, mountain whitefish, northern pike, trout-perch, and walleye.

Table 5. List of fish species captured in the Steepbank River drainage during 1977.

Family and Species Names	Common Names
Family Hiodontidae	
Hiodon alosoides (Rafinesque)	Goldeye
Family Salmonidae	
Coregonus clupeaformis (Mitchill)	Lake whitefish
Coregonus artedii LeSueur	Lake cisco
Prosopium williamsoni (Girard)	Mountain whitefish
Thymallus arcticus (Pallas)	Arctic grayling
Salvelinus malma (Walbaum)	Dolly Varden
Family Esocidae	
Esox lucius Linnaeus	Northern pike
Family Cyprinidae	
Semotilus margarita nachtriebi (Cox)	Northern pearl dace
Platygobio gracilis (Richardson)	Flathead chub
Couesius plumbeus (Agassiz)	Lake chub
Rhinichthys cataractae (Valenciennes)	Longnose dace
Chrosomus eos Cope	Northern redbelly dace
Notropis hudsonius (Clinton)	Spottail shiner
Hybognathus hankinsoni Hubbs	Brassy minnow
Pimephales promelas Rafinesque	Fathead minnow
Family Catostomidae	
Catostomus commersoni (Lacépède)	White sucker
Catostomus catostomus (Forster)	Longnose sucker
Family Percopsidae	
Percopsis omiscomaycus (Walbaum)	Trout-perch
Family Gadidae	
Lota lota (Linnaeus)	Burbot
Family Gasterosteidae	
Culaea inconstans (Kirtland)	Brook stickleback
Family Cottidae	
Cottus cognatus Richardson	Slimy sculpin
Family Percidae	
Perca flavescens (Mitchill)	Yellow perch
Stizostedion vitreum vitreum (Mitchill)	Walleye

5.2 RELATIVE ABUNDANCE AND DISTRIBUTION

A total of 7272 fish (16 species) were counted through the upstream trap during the spring operation of the counting fence (Table 6). Longnose suckers (52.4%) and Arctic grayling (19.9%) comprised the majority, while white suckers (13.6%), mountain whitefish (6.9%), northern pike (3.3%), and walleye (3.1%) made up most of the remainder.

By 29 May, the last day on which the spring counting fence was operated, 2010 fish had been enumerated at the downstream trap (Table 6). Remaining in the Steepbank River beyond 29 May were 2146 longnose suckers (56.3% of the total number of longnose suckers counted going upstream), 1421 Arctic grayling (98.2%), 858 white suckers (86.5%), 448 mountain whitefish (89.1%), 205 northern pike (86.5%), 137 walleye (61.7%), and small numbers of several other species (Table 6).

A total of 2265 fish (nine species) were passed through the downstream trap during the fall operation of the counting fence (Table 7). Arctic grayling accounted for 79.0% of the downstream fish enumerated at that time, while white suckers (11.3%) and longnose suckers (5.3%) made up most of the remainder.

Because the counting fence was not operated from 29 May to 12 September or beyond 15 October, it is not possible to say with certainty whether fish continued to move in and out of the Steepbank River during the summer or after 15 October. However, in the adjacent Muskeg River, Bond and Machniak (1977) showed that longnose and white suckers and northern pike continued to return downstream throughout June and July while Arctic grayling remained in the tributary. We believe that most of the upstream migrants left unaccounted for by our downstream counts (2025 longnose suckers, 602 white suckers, 442 mountain whitefish, 163 northern pike, and 134 walleye) moved out of the Steepbank watershed during the summer rather than after 15 October, and that few, if any, migrant fish overwintered in the watershed.

Collections made throughout the Steepbank watershed during the summer produced 3611 small fish (Table 8). Suckers accounted for 51.7% of this total, the majority (>98%) being

Table 6. Summary of fish recorded at the Steepbank River counting fence during the spring, 1977.

Species	Number of Fish	
	Upstream Trap	Downstream Trap
Longnose sucker	3811	1665
Arctic grayling	1447	26
White sucker	992	134
Mountain whitefish	503	55
Northern pike	237	32
Walleye	222	85
Lake whitefish	39	4
Goldeye	7	1
Dolly Varden	4	0
Burbot	2	7
Trout-perch	2	1
Flathead chub	2	0
Longnose dace	1	0
Slimy sculpin	1	0
Lake cisco	1	0
Lake chub	1	0
Total	7272	2010

Table 7. Summary of fish recorded at the Steepbank River counting fence during the fall, 1977.

Species	Number of Fish	
	Downstream Trap	Upstream Trap
Arctic grayling	1789	5
White sucker	256	7
Longnose sucker	121	0
Burbot	43	3
Northern pike	42	6
Mountain whitefish	6	3
Dolly Varden	4	1
Walleye	3	6
Lake chub	1	0
Total	2265	31

Table 8. Number of fish captured by seine, minnow trap, drift net, and dipnet at each small fish collection site in the Steepbank River drainage, 1977.

Species	Steepbank River																North Steepbank								Total	
	Area 1		Area 2[a]		Area 3		Area 4		Area 5		Area 6		Area 7		Area 8		Area 9		Area 10		Area 11		Area 12			
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Lake whitefish			1	<0.1																					1	<0.1
Mountain whitefish			1	<0.1																					1	<0.1
Arctic grayling									1	1.6			2	6.9					2	1.8					5	0.1
Pearl dace	1	2.0	107	4.7	245	66.8	2	8.7	11	17.7	1	1.2			185	40.7			8	7.2			14	10.9	574	15.6
Lake chub			179	7.8	4	1.1	1	4.3	15	24.2	55	67.1					1	50.0	11	9.9					266	7.4
Longnose dace	1	2.0	138	6.0	37	10.1	1	4.3	8	12.9	6	7.3					1	50.0							192	5.3
Redbelly dace			1	<0.1																					1	<0.1
Brassy minnow			2	0.1																					2	<0.1
Fathead minnow			1	<0.1																					1	<0.1
Spottail shiner	2	3.9	15	0.7																					17	0.5
Sucker spp			1395	60.7	63	17.2					2	2.4	1	3.4					4	3.6					1465	40.6
White sucker	5	9.8	105	4.6	1	0.3			16	25.8			1	3.4					6	5.4					134	3.7
Longnose sucker	17	33.3	199	8.7	16	4.4	17	73.9	6	9.6	4	4.9	1	3.4					8	7.2					268	7.4
Trout-perch	12	23.5	52	2.2	1	0.3	1	4.3	3	4.8			1	3.4											70	1.9
Burbot			6	0.3																					6	0.2
Brook stickleback			1	<0.1									2	6.9	262	57.7			67	60.4	14	63.6	94	89.1	440	12.2
Slimy sculpin	1	2.0	8	0.3			1	4.3	2	3.2	14	17.1	21	72.4	7	1.5			5	4.5	8	36.4			67	1.9
Yellow perch	12	23.5	89	3.9																					101	2.8
Totals	51		2300		367		23		62		82		29		454		2		111		22		108		3611	

[a]Other species recorded from fence operations include: goldeye, lake cisco, Arctic grayling, Dolly Varden, northern pike, flathead chub, and walleye.

young-of-the-year. Young-of-the-year suckers were extremely abundant in Area 2 during June when they could be seen along the shoreline in large numbers. Young suckers were not taken in large numbers after June.

Excluding suckers, pearl dace was the most abundant small fish in the samples, accounting for 32.9% of the total catch. Also occurring commonly were brook stickleback (25.2%), lake chub (15.3%), longnose dace (11.0%), yellow perch (5.8%), trout-perch (4.0 %), and slimy sculpin (3.8%).

Pearl dace were captured at nine of the 12 sampling sites but were most common in areas 2, 3, and 8. Brook stickleback were largely restricted to the upper reaches of the Steepbank (Area 8) and North Steepbank (Areas 10, 11 and 12) where they comprised 62.9% of the total catch. Lake chub appeared to be most common in the lower and middle reaches of the Steepbank River (Areas 2 to 6) and the lower reaches of the North Steepbank (Areas 9 and 10). Longnose dace were captured as far upstream as Areas 6 and 9. However, this species was apparently most abundant in the lower reaches (Areas 2 and 3) of the watershed.

5.3 TAGGING RESULTS

5.3.1 Tag Releases and Recaptures

Floy tags were applied to 3466 fish (Table 9), the majority of which were longnose suckers (73.3%), white suckers (14.3%), northern pike (4.7%), walleye (3.8%), and Arctic grayling (2.8%). Fish were tagged during both the spring and fall fence operations, although most tags were applied during the spring upstream (72.4%) and downstream (20.6%) runs.

Recaptures at the fence site (n = 723) provided an indication of the length of time spent by some migrant fish in the Steepbank watershed. However, results to date, for fish tagged at the fence site and recaptured outside the Steepbank watershed, show a return rate of only 1.4% (Table 9). The highest recapture rates obtained outside the watershed were for walleye (10.5%) and northern pike (9.9%), while longnose and white suckers had recapture

Table 9. Summary of tag releases and recaptures for fish tagged at the Steepbank River counting fence during spring and fall, 1977.

Species	Number of Fish Tagged						Number of Fish Recaptured			
	Spring		Fall		Total		At Fence Site		Outside Steepbank Watershed	
	Up	Down	Up	Down	N	%	Spring	Fall	N	%
Longnose sucker	1886	655	0	6	2541	73.3	568	3	8	0.3
White sucker	385	29	1	79	494	14.3	66	21	10	2.0
Northern pike	130	0	3	29	162	4.7	18	6	16	9.9
Walleye	103	26	2	2	133	3.8	38	1	14	10.5
Arctic grayling	0	0	0	98	98	2.8	0	0	1	1.0
Burbot	2	4	0	19	25	0.7	0	0	0	0.0
Mountain whitefish	8	0	0	1	9	0.3	1	0	1	11.1
Goldeye	2	0	0	0	2	<0.1	1	0	0	0.0
Lake whitefish	1	0	0	0	1	<0.1	0	0	0	0.0
Dolly Varden	0	0	0	1	1	<0.1	0	0	0	0.0
Total	2511	714	6	235	3466		692	31	50	1.4

rates of 0.3% and 2.0% respectively.

5.3.2 Movement of Tagged Fish

The recapture of tagged fish can provide useful information concerning the extent and timing of fish movements. However, a degree of caution usually must be exercised in the interpretation of the results. In the first place, one can never be absolutely certain that the movement exhibited by an individual fish is representative of all fish in the population. Secondly, since it is obvious that no tags will be recovered from areas where no fishing effort occurs, it can be argued that recaptures merely serve to identify fishing areas.

There is no question that, in the AOSERP study area, considerably more fishing effort is expended downstream from Fort McMurray than upstream. As well, in some cases, low recovery rates make it impossible to form firm conclusions as to general movement trends. Nevertheless, results from the present and several other studies (Bond and Machniak 1977, in prep.; Bond and Berry in prep.a, in prep.b; Machniak et al. in prep.; Jones et al. 1978; Kristensen and Pidge 1977) are beginning to identify patterns of fish movement within the AOSERP study area.

5.3.2.1 Longnose suckers. A total of 2535 longnose suckers were tagged in the Steepbank River during 1977. During the spring fence operation, 1880 fish were tagged during the upstream run, and by 29 May, 568 had returned through the downstream trap (Table 9). Only three tagged fish were recovered at the downstream trap during the fall, suggesting that few longnose suckers spend the entire summer in this watershed. Eight longnose suckers were recaptured outside the Steepbank River watershed. Seven of these were caught either in the Athabasca delta or in Lake Athabasca itself (Appendix 8.4). Two longnose suckers, tagged at the fence site, travelled 262 km downstream to the Athabasca delta in 20 and 24 days respectively. One fish had travelled 218 km in just five days when it was recaptured along the west shore of Richardson Lake (Figure 1) on 24 May.

The recapture rate for longnose suckers in the present study (0.3%) is very low. However, these results, plus those of other studies (Bond and Berry in prep.b; Bond and Machniak in prep.; and Machniak et al. in prep.), suggest that longnose suckers that spawn in the Steepbank River and other tributaries of the AOSERP study area, belong to the Lake Athabasca population and return to the lake during the summer or fall to overwinter.

5.3.2.2 White suckers. Floy tags were applied to 494 white suckers in the Steepbank River during 1977. By 29 May, 66 of the 385 fish that were tagged during the upstream run, had returned through the downstream trap (Table 9). The recapture of 21 tagged fish at the fall downstream trap may indicate that, compared to longnose suckers, white suckers tend to remain longer in the tributary. As will be mentioned later, this tendency to remain in the tributary during the summer is apparently more common in immature fish than in adults. Ten white suckers were recaptured outside the Steepbank watershed (Appendix 8.4). Three of these were netted in Lake Athabasca or in the Athabasca delta (Fletcher Channel), while five were captured moving upstream in the MacKay River in May 1978 (Machniak et al. in prep.).

The recapture rate for white suckers in the present study (2.0%) is very low. Nevertheless, tag return evidence from this and other studies (Bond and Berry in prep.b; Bond and Machniak in prep.; Shell Canada Ltd. 1975; Machniak et al. in prep.) suggests that white suckers that spawn in the Steepbank River and other tributaries of the AOSERP study area, belong to the Lake Athabasca population, and return to the lake during summer or fall to overwinter.

5.3.2.3 Northern pike. By 29 May, only 18 of the 130 northern pike, tagged during the spring upstream migration, had been recaptured at the downstream trap (Table 9). Six tagged pike were recaptured at the downstream trap during the fall fence operation. Ten percent of all pike tagged in the Steepbank River in 1977 (n = 162) were recaptured outside the watershed, and all recaptures were made between the mouth of the Hangingstone River (just upstream of Fort McMurray) and the mouth of the MacKay River (Appendix 8.4). Thus, pike demonstrated no tendency to travel great distances. Similar findings were reported by Bond and Berry (in prep.a, in prep.b) and Bond and Machniak (1977, in prep.).

Pike in the AOSERP study area appear to concentrate in the lower reaches of tributary streams during the summer and to move up and down the tributaries to some extent (Bond and Machniak in prep.). They probably leave the tributaries in the fall to overwinter in the Athabasca River.

5.3.2.4 Walleye. Tags were applied to 133 walleye. A total of 103 walleye were tagged during the spring upstream run, and by 29 May, 38 had returned through the downstream trap (Table 9). Only one tagged walleye was recaptured at the fall fence. This fish was taken 20 September in the upstream trap (Appendix 8.4). Fourteen walleye were recaptured outside the Steepbank watershed for a return rate of 10.5%.

Walleye, unlike northern pike, appear to travel great distances and to wander extensively. One walleye, tagged in the Steepbank River on 9 May, was recaptured in Lake Athabasca near Fort Chipewyan, having travelled 288 km downstream in 28 days. Another was recaptured at the mouth of Parallel Creek (a tributary of the Athabasca River) in mid-September, having travelled 403 km upstream in approximately 113 days. Bond and Berry (in prep.b) documented movement of one walleye a distance of approximately 600 km upstream of the AOSERP study area, but suggested that walleye that spawn in the AOSERP area are members of the Lake Athabasca population and return to the lake to overwinter.

5.3.2.5 Mountain whitefish. Only nine mountain whitefish were tagged during the present study of which one was recaptured. This fish, tagged 1 May, was recaptured 5 May at the mouth of the Steepbank River (Appendix 8.4).

5.3.2.6 Arctic grayling. Ninety-eight grayling were tagged during their fall downstream migration and only one recapture has been reported (Table 9). This grayling was angled at the Poplar Creek bridge on 15 October, having moved 15 km in five days (Appendix 8.4).

5.4 LIFE HISTORIES OF FISH SPECIES

5.4.1 Arctic Grayling

5.4.1.1 Seasonal timing of upstream migration. Arctic grayling spawning migrations appear to be initiated by increasing water temperatures, and often begin with ice break-up (Brown 1938; Rawson 1950; Reed 1964; Schallock 1966; Bishop 1971). Tack (1972) reported that, in Alaska, the first grayling arrived on the spawning grounds when the water temperature was 0°C. The ice on the Steepbank River broke on 17 April 1977, and ice conditions persisted until 20 April. The daily maximum water temperature was 5.5°C on 25 April when fence operations commenced. It was obvious on that date that the upstream migration was well under way as 102 grayling were counted through the upstream trap (Table 10). Grayling continued to move upstream throughout May (Table 10 and Figure 4). However, the migration was essentially over by the end of April as 75.9% of the grayling counted had passed upstream by 1 May.

5.4.1.2 Diel timing of upstream migration. Although the initiation of grayling spawning migrations appears generally to be controlled by rising water temperatures following the spring break-up, such migrations usually exhibit a pronounced diel periodicity. This periodicity appears to be related to daily fluctuations in water temperature, although varying light intensity may also be important (Fabricius and Gustafson 1955). Gustafson (1948) found that the most intensive upstream movement of European grayling (*Thymallus thymallus*) occurred between 1600 and 2400 h, i.e., at a time when the water temperature was decreasing from its daily maximum. The upstream migration of Arctic grayling in the present study occurred mainly during the daytime, as 70% were counted through the

Table 10. Summary of fish enumerated during the spring counting fence operation in the Steepbank River, 1977.

Date	Upstream Trap								Downstream Trap							
	Longnose sucker	White sucker	Arctic grayling	Northern pike	Mountain whitefish	Yellow walleye	Lake whitefish	Daily Totals	Longnose sucker	White sucker	Arctic grayling	Northern pike	Mountain whitefish	Yellow walleye	Lake whitefish	Daily Totals
25 April	43	8	102	1	0	0	0	154								
26	58	13	143	1	3	0	0	217								
27	18	16	236	0	9	0	0	279								
28	48	58	192	1	25	0	0	325[a]								
29	112	58	181	3	20	0	2	377[a]								
30	28	6	244	1	18	0	1	298								
1 May	134	42	95	3	27	0	1	302								
2	570	138	56	4	34	4	1	807								
3	166	86	38	13	32	5	3	343				Trap Closed				
4	521	104	19	9	23	3	1	680								
5	251	104	14	9	12	10	0	400								
6	115	51	10	14	21	6	2	219								
7	153	52	9	15	6	4	1	241[a]								
8	137	51	5	16	5	2	0	216								
9	137	16	15	10	16	16	3	213								
10	105	40	19	25	7	22	2	220								
11	83	33	10	22	43	27	4	230[a]	251	17	3	2	12	2	0	288[b]
12	160	16	8	16	8	27	2	239[a]	215	22	2	3	1	18	0	261
13	156	13	8	8	10	11	6	212	106	15	8	4	2	14	0	150[b]
14	95	4	7	14	7	6	2	136[a]	103	8	2	1	2	4	1	121
15	86	5	7	6	1	3	3	112[a]	37	5	1	2	0	6	0	51
16	31	3	5	4	7	0	0	50	167	1	1	2	0	2	0	173
17	19	3	3	1	13	3	0	42	207	9	0	0	9	0	0	225
18	6	0	4	0	24	0	1	35	146	15	4	2	9	3	0	179
19	8	3	0	1	10	3	0	25	159	11	3	3	2	0	0	178
20	33	6	1	4	12	9	0	67[a]	61	11	1	4	0	1	2	80
21	124	7	1	7	17	13	2	172[a]	85	6	0	0	3	6	0	102[b]
22	148	14	3	2	26	11	0	205[a]	25	1	1	1	6	5	0	42[b]
23	78	11	1	2	13	16	0	121	14	5	0	0	2	6	0	27
24	27	8	2	8	13	6	1	65	20	2	0	3	1	6	0	32
25	55	7	1	9	6	9	0	87	14	0	0	1	1	5	0	21
26	32	7	5	3	20	4	0	73[a]	18	1	0	1	0	6	0	27[b]
27	24	5	2	4	9	2	1	47	10	0	0	1	2	0	0	13
28	48	3	1	1	6	0	0	59	27	5	0	2	3	1	1	40[b]
29	2	1	Operations			Terminated		3			Operations			Terminated		
Totals	3811	992	1447	237	503	222	39	7272	1665	134	26	32	55	85	4	2010
%	52.4	13.6	19.9	3.3	6.9	3.1	0.5		82.8	6.7	1.3	1.6	2.7	4.2	0.2	

[a] Other species counted through the upstream trap: one sculpin, 28 April; two burbot, 29 April and 11 May; two trout-perch, 7 May, 12 May; seven goldeye, 11 May; four Dolly Varden, 15 May, 20 May (two fish) and 26 May; one lake chub, 21 May; one longnose dace, 22 May; two flathead chub, 12 May, 26 May; one lake cisco, 14 May

[b] Other species counted through the downstream trap: one trout-perch, 11 May; seven burbot, 13 May, 21 May (two fish), 22 May (two fish), 26 May and 28 May; and one goldeye, 22 May.

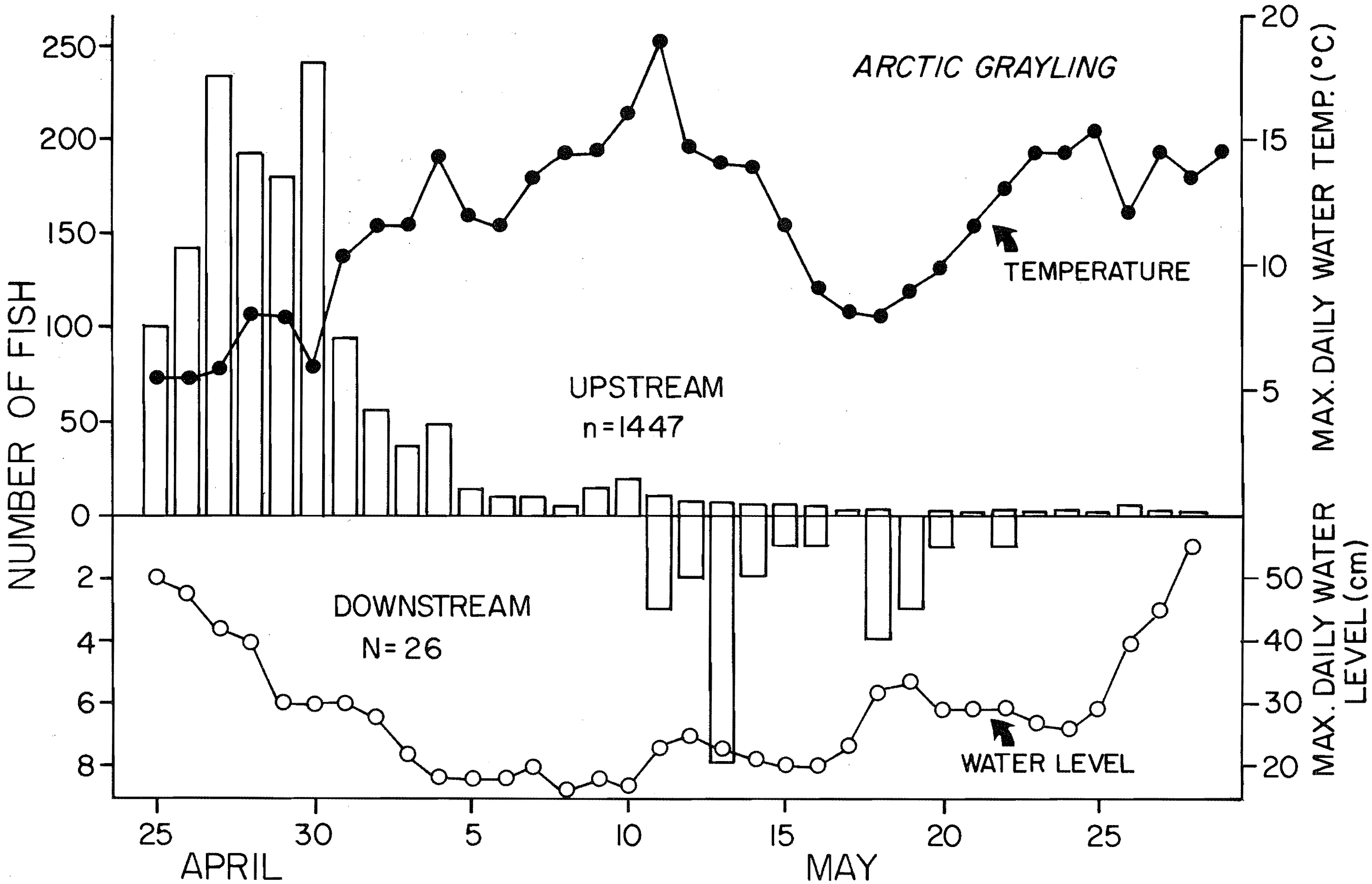

Figure 4. Seasonal timing of the spring grayling migration, Steepbank River, 1977.

fence between 0900 and 2100 h (Table 11). Water temperatures during this period were usually rising or were at or near the daily maximum (Appendix 8.1).

5.4.1.3 Spawning. Grayling generally spawn over gravel or rocky bottom with water depth appearing not to be an important factor. Fabricius and Gustafson (1955) observed that most European grayling spawned over gravel riffles in water so shallow that the backs of the fish were visible. A similar observation was reported by Kruse (1959) for grayling in Wyomimg. Grayling in tributaries of the southern Athabasca drainage spawn in May at stream temperatures of 4.5 to 11°C (Ward 1951). Tack (1972) noted that, in Alaska, spawning was first observed when the stream temperature was 4°C and that by 10°C, spawning was completed. Records over a 10 year period at Black Lake, a Shield lake in northern Saskatchewan, indicate that, although spawning occurs over a three week period, the peak spawning period lasts only three days to a week (Johnson 1971; Kratt and Smith 1977). Brown (1938) stated that, in Montana, the spawning season for stream populations occurred earlier in the spring and extended over a longer period than that of lake populations.

Spawning of Arctic grayling was not observed in the Steepbank River during this study, and therefore, the precise spawning areas and time of spawning cannot be identified. However, areas of gravel that seem to be suitable as spawning sites for grayling are found all along the Steepbank River, up to 5 to 8 km past the confluence of the North Steepbank, and in the lower reaches of the North Steepbank itself. Water temperatures were within the appropriate range for grayling spawning from 25 April (possibly earlier) to 3 May, and it is likely that most, if not all, spawning was completed by the latter date. Grayling captured at the counting fence prior to 3 May were near ripe but were never observed to have freely running sexual products. Twelve grayling, captured after 4 May, were dissected and nine of these were spawned out.

Without observing the spawning act itself, spawning areas can often be identified by the presence of newly hatched fry. However, only three young-of-the-year grayling were taken in the

Table 11. Summary of diel timing of the upstream migration of Arctic grayling in the Steepbank River, 1977. Fish that were counted at times other than those indicated were included in the next check period.

Date	Number of Fish Counted at Each Check						Total
	0900	1200	1500	1800	2100	2400	
25 April	3	ND	60	ND	39	ND	102
26	0	ND	65	26	52	ND	143
27	49	15	53	50	62	7	236
28	55	46	30	29	23	9	192
29	69	21	18	13	34	26	181
30	127	26	39	23	23	6	244
1 May	14	3	39	20	17	2	95
2	7	18	9	13	8	1	56
3	7	4	4	13	10	0	38
4	3	5	2	3	6	0	19
5	6	3	1	3	1	0	14
6	4	1	1	3	1	0	10
7	5	1	2	1	0	0	9
8	0	0	3	1	0	1	5
9	3	1	5	5	0	1	15
10	9	6	1	1	0	2	19
11	5	0	2	1	2	0	10
12	1	1	3	1	2	0	8
13	4	2	1	1	0	0	8
14	2	1	1	2	1	0	7
15	1	0	2	2	2	0	7
16	3	0	0	0	0	2	5
17	0	0	0	1	1	1	3
18	1	0	0	3	0	0	4
19	0	0	ND	ND	ND	0	0
20 - 29	1	3	1	5	6	1	17
Totals	379	157	342	220	290	59	1447
% Grand Total	26.2	10.9	23.6	15.2	20.0	4.1	

the Steepbank watershed during the present study. One fry (20 mm long) was captured 19 June in Area 5 (Figure 2) while others (79 and 86 mm) were taken in Area 7 later in the summer. Other young-of-the-year were observed upstream of the forks, on both the Steepbank and North Steepbank during the summer, although never in large numbers. The apparent paucity of young-of-the-year grayling may be related to the severe flood conditions that obtained in late May and early June (Figure 3). This flood coincided with the time at which grayling fry would have been emerging from the gravel and may have resulted in the removal from the watershed of fry that were not yet physically capable of coping with the current. Poor sampling efficiency in seining difficult areas as well as the monthly sampling program (which possibly could have missed times and areas where fry were most numerous) may have contributed to the lack of captured young grayling.

5.4.1.4 Summer residence of migrant grayling. Unlike the typical pattern observed in most northern streams where adults leave the tributary soon after spawning (Craig and Poulin 1975), grayling that enter the Steepbank during the spring migration remain in the tributary throughout the summer and do not leave until just prior to freeze-up in the autumn. Thus, the situation in the Steepbank River is similar to that observed in the upper Athabasca River by Ward (1951) and in the Muskeg River of the AOSERP study area by Bond and Machniak (1977).

A float trip during the period 31 July to 2 August, from Area 7 to the mouth of the Steepbank River (Figure 2), revealed that mid-summer distribution and relative abundance of grayling in the main stem (Steepbank River). Monthly helicopter surveys confirmed the continued summer residence of grayling and provided additional information of areas occupied.

Angling results during the float trip indicated that the largest grayling appeared to be near the upstream portion of pools, whereas smaller individuals occupied the downstream ends. Fabricius and Gustafson (1955) noted that, during the summer feeding period, European grayling tended to school with the largest males occupying the most favourable locations. The smaller males and the females occupied the less favourable locations. Reed (1964) and Vascotto and Morrow (1973) observed similar behaviour in Arctic grayling.

During the summer, adult grayling and juveniles (age 1+ and 2+) occupied the area between Areas 7 and 4 of the Steepbank River, and as far upstream as Area 10 on the North Steepbank (Figure 2). Most fish, however, including most of the larger ones, appeared to be concentrated in the mainstem between Areas 7 and 5 where the gradient is somewhat less than in the lower reaches. By mid-September, the adult grayling had vacated this area, leaving only immature fish. Griffiths (1973) indicated the presence of mature grayling in the mid-reaches of the Steepbank (Areas 3 to 5) on 21 September 1972. Adult grayling and most juveniles arrived in the lower reaches of the Steepbank River in early October, and in mid-October they left the stream. Young-of-the-year grayling and some juveniles still remained in the mid-reaches of the Steepbank and in the lower North Steepbank at this time.

5.4.1.5 <u>Seasonal and diel timing of downstream migration</u>. During the spring fence operation, only 26 grayling passed through the downstream trap (Table 10 and Figure 4). However, a definite downstream migration was observed during the fall (Table 12 and Figure 5). Compared with the spring upstream run, the fall migration was more concentrated. The main downstream movement began on 6 October, about 170 days after the spring upstream migration began. The maximum and minimum daily water temperatures at this time were 5.5 and 3.5°C respectively (Appendix 8.2). The downstream migration peaked on 10 October when 46% of the grayling caught in the fall passed through the downstream trap. The maximum and minimum water temperatures recorded on this date were 2.0 and 0.5°C respectively. Fish were still trickling downstream when fence operations terminated on 15 October.

Ward (1951) reported grayling movements out of tributaries of the Athabasca River, but did not mention temperature as being a controlling factor. However, Schallock (1966) observed that the

Table 12. Summary of fish enumerated during the fall counting fence operation in the Steepbank River, 1977.

Date	Downstream Trap: Longnose sucker	White sucker	Arctic grayling	Northern pike	Burbot	Daily Totals	Upstream Trap: White sucker	Arctic grayling	Northern pike	Walleye	Daily Totals
12 September	1	0	0	0	0	1	0	0	0	0	0
13	3	0	0	0	0	3	0	0	0	1	2[b]
14	3	0	0	1	0	4	2	0	0	0	2
15	0	0	0	0	0	0	0	0	0	0	1[b]
16	6	5	0	2	0	14[a]	0	1	0	0	2[b]
17	22	10	0	3	1	37[a]	0	0	0	0	0
18	8	7	0	2	0	17	1	0	0	0	1
19	2	0	0	1	0	4[a]	1	0	0	0	2[b]
20	1	0	1	0	0	2	1	0	0	2	3
21	3	0	0	0	1	5[a]	1	0	2	0	5[b]
22	4	1	0	0	0	5	0	0	0	0	0
23	3	0	0	0	1	4	1	0	1	1	3
24	3	1	0	0	0	6[a]	0	1	0	2	4[b]
25	0	0	0	1	0	2[a]	0	0	1	0	1
26	1	0	0	0	0	1	0	0	0	0	0
27	0	0	0	1	0	1	0	0	1	0	1
28	2	0	0	0	0	2	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0
30	2	9	0	1	0	12	0	0	0	0	0
1 October	1	0	0	0	0	2[a]	0	1	0	0	1
2	2	0	1	0	0	3	0	0	1	0	1
3	2	0	0	1	0	4[a]	0	0	0	0	0

continued...

Table 12. Concluded.

Date	Downstream Trap: Longnose sucker	White sucker	Arctic grayling	Northern pike	Burbot	Daily Totals	Upstream Trap: White sucker	Arctic grayling	Northern pike	Walleye	Daily Totals
4 October	0	0	1	0	0	1	0	0	0	0	0
5	2	6	3	0	1	12	0	0	0	0	0
6	0	28	53	2	0	84[a]	0	0	0	0	0
7	7	33	189	4	1	234	0	2	0	0	2
8	5	14	190	2	5	216					
9	6	44	468	5	7	531[a]					
10	9	63	826	8	15	924[a]					
11	1	22	11	5	1	40					
12	4	8	25	1	1	39	Trap Closed				
13	6	3	2	0	5	16					
14	6	2	19	1	4	32					
15	6	0	0	1	0	7					
Totals	121	256	1789	42	43	2265	7	5	6	6	31
%	5.3	11.3	79.0	1.8	1.9		22.6	16.1	19.4	19.4	

[a] Other species counted through the downstream trap: six mountain whitefish, 19 and 24 September, 3, 9, and 10 October (two fish); four Dolly Varden, 16 September, 1, 6 and 10 October; three walleye, 17, 24, and 25 September; and one lake chub, 21 September.

[b] Other species counted through the upstream trap: three mountain whitefish, 13, 16, and 19 September; three burbot, 21 September (two fish) and 24 September; and one Dolly Varden, 15 September.

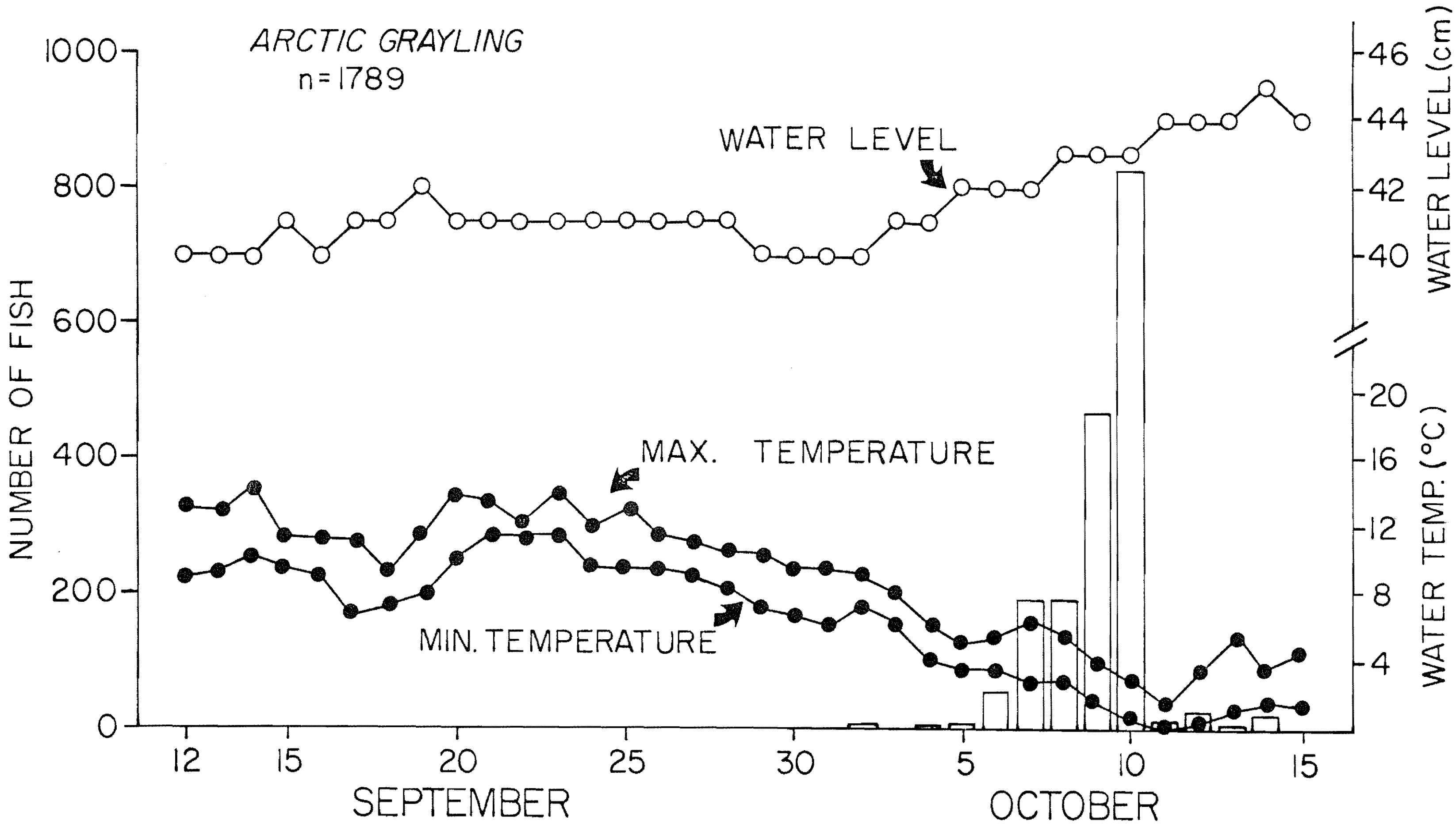

Figure 5. Seasonal timing of the fall downstream grayling migration, Steepbank River, 1977.

one factor controlling the migration is the appearance of cold weather: "The earlier the cold weather arrives and the greater its severity, the earlier the fish migrate out of the tributaries into the river proper". The downstream migration in his study seemed to occur when the minimum daily water temperatures in the tributaries ranged from 0 to 1°C.

The fall downstream migration in the Steepbank River took place mainly in the early evening as 61% of the grayling passed the fence between 1800 and 2100 h (Table 13). A similar timing for the downstream run was reported for the European grayling by Gustafson (1948).

5.4.1.6 Size composition of migrant grayling. During the spring counting fence operation, fork lengths were determined for 1447 Arctic grayling (Table 14). Migrant grayling ranged in length from 94 to 390 mm although only one was less than 160 mm.

The length-frequency of grayling varied through the course of the spring run (Figure 6). The initial phase of the run was dominated by large, mature grayling, and these were followed by immature fish (mainly two-year olds). Craig and Poulin (1975) indicated a similar pattern of upstream movement for grayling in northern streams. A noticeable feature of the length-frequency distribution in the upstream run is its bimodality, with the gap occurring at the 240 to 249 mm interval. Because virtually all upstream fish were measured, the bimodal distribution is real and not a product of sampling bias. An age-length analysis suggests that this effect was not caused by the presence of a weak year class, but by differences in growth rates, either between age 2 and age 3 fish, or between fish within the age 3 group.

During the fall migration, fork lengths were obtained for 1072 Arctic grayling (Table 15). Grayling ranged in length from 130 to 294 mm. The size distribution for grayling in three phases of the downstream run (Figure 7) shows that the largest fish (adults) were the first to leave the stream followed by smaller (juvenile) grayling. The observation that the bimodal length-frequency distribution noted during the spring is not

Table 13. Summary of diel timing of the downstream migration of Arctic grayling in the Steepbank River, 1977. Fish that were counted at times other than those indicated were included in the next time check period.

Date	Number of Fish Counted at Each Trap Check				Total
	1200	1800	2100	2400	
12 to					
30 September	0	0	1	0	1
1 October	0	0	0	0	0
2	0	ND	1	0	1
3	0	0	0	0	0
4	0	ND	1	0	1
5	0	2	ND	1	3
6	0	0	ND	53	53
7	1	0	127	61	189
8	1	0	172	17	190
9	1	244	157	66	468
10	14	117	610	85	826
11	1	1	2	7	11
12	6	17[a]	0	2	25
13	0	0	1	1	2
14	0	2	14	3	19
15	0	Operations terminated			0
Totals	24	383	1086	296	1789
% Grand Total	1.3	21.4	60.7	16.5	

a Includes 16 fish angled.

Table 14. Length-frequency distribution of Arctic grayling during the spring migration, Steepbank River, 1977.

Fork Length (10 mm intervals)	Male	Female	Unknown	Total
90-99	0	0	1	1
160-169	0	0	2	2
170-179	0	0	6	6
180-189	1	2	10	13
190-199	2	2	21	25
200-209	6	12	83	101
210-219	4	5	150	159
220-229	4	2	124	130
230-239	1	2	110	113
240-249	1	3	77	81
250-259	6	8	94	108
260-269	12	9	105	126
270-279	18	8	112	138
280-289	27	9	69	105
290-299	20	10	62	92
300-309	23	6	33	62
310-319	23	4	25	52
320-329	18	3	19	40
330-339	12	2	16	30
340-349	14	2	8	24
350-359	12	2	8	22
360-369	7	1	4	12
370-379	1	0	1	2
380-389	2	0	0	2
390-399	1	0	0	1
Totals	215	92	1140	1447

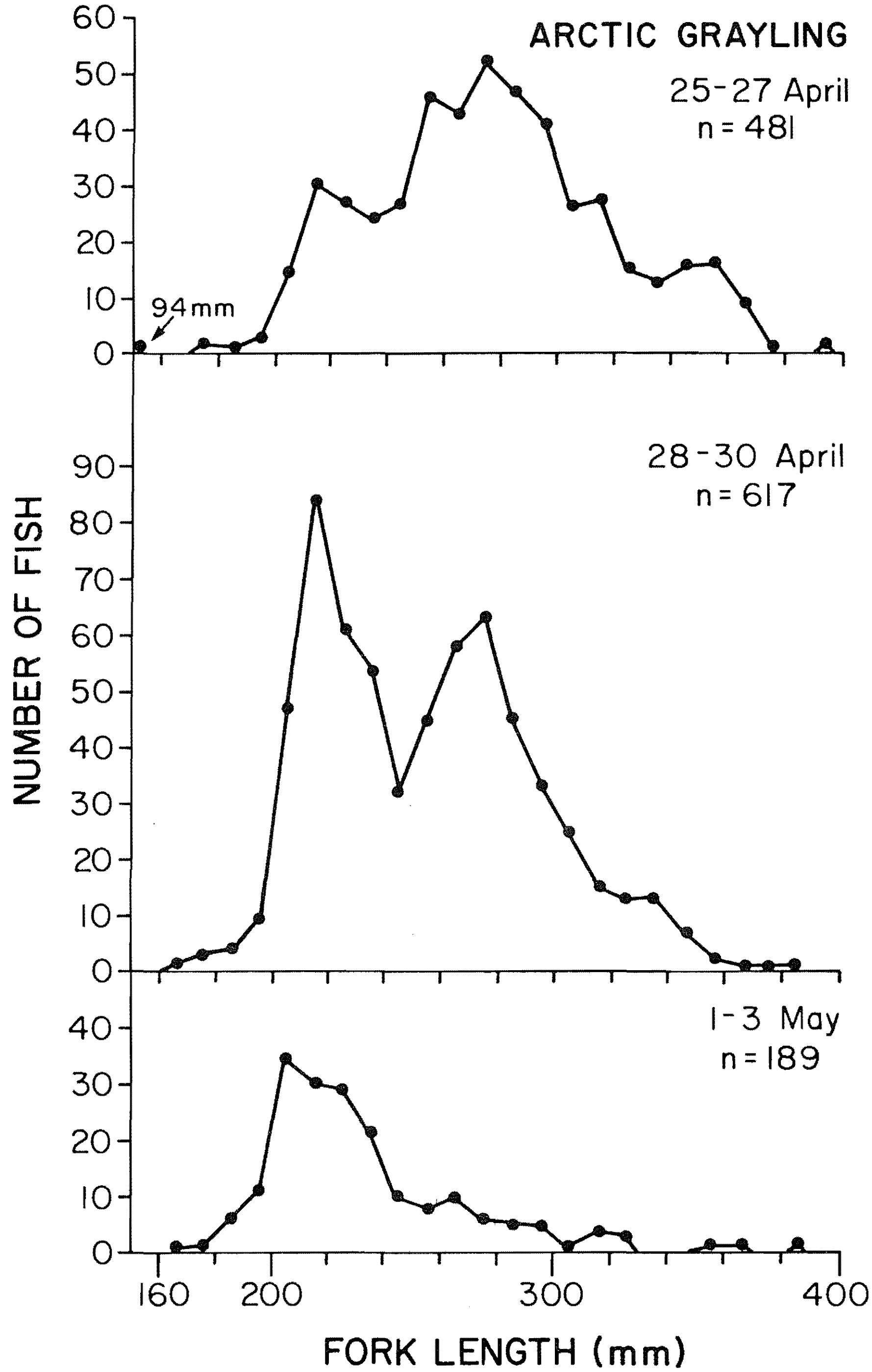

Figure 6. Length-frequency distribution for Arctic grayling during three time periods of upstream migration in the Steepbank River, spring, 1977.

Table 15. Length-frequency distribution of Arctic grayling during the fall migration, Steepbank River, 1977.

Fork Length (10 mm intervals)	Male	Female	Unknown	Total
130-139	0	0	1	1
170-179	0	0	2	2
180-189	0	0	5	5
190-199	0	0	9	9
200-209	0	0	10	10
210-219	1	0	16	17
220-229	0	0	16	16
230-239	0	0	16	16
240-249	1	0	21	22
250-259	2	1	29	32
260-269	1	2	48	51
270-279	1	1	67	69
280-289	4	6	70	80
290-299	5	12	84	101
300-309	12	10	109	131
310-319	13	11	91	115
320-329	19	18	81	118
330-339	17	14	83	114
340-349	9	3	45	57
350-359	9	2	50	61
360-369	8	0	23	31
370-379	2	0	9	11
380-389	1	0	1	2
390-399	0	0	1	1
Totals	105	80	887	1072

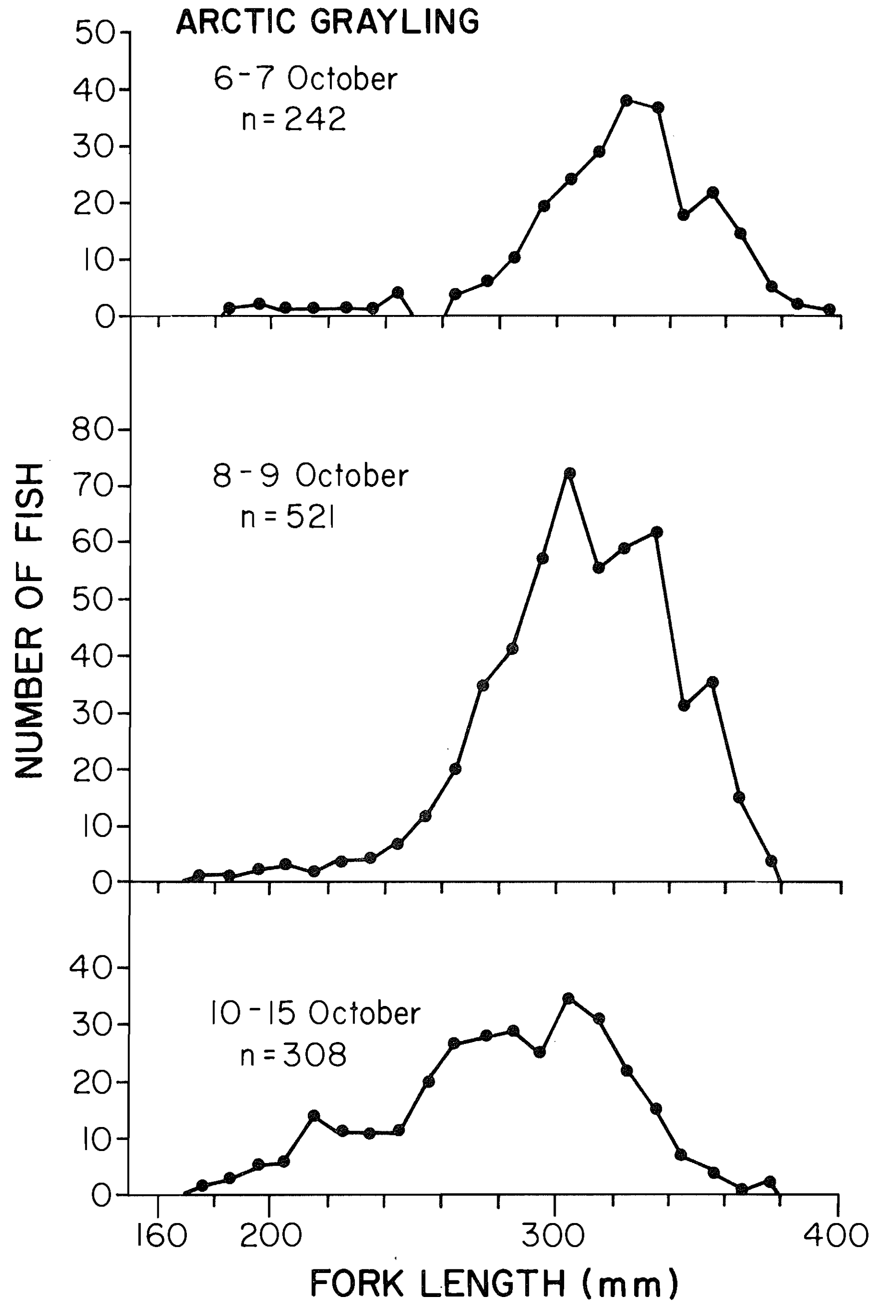

Figure 7. Length-frequency distribution for Arctic grayling during three time periods of downstream migration in the Steepbank River, fall, 1977.

evident in the fall sample (Table 15) is explained by the fact that a greater proportion of the fish was measured during the early part of the downstream run than in the later stages. For example, between 6 and 9 October, 85% of all grayling were measured. However, because of the very large catch at 2100 h on October (Table 13), most grayling were not measured at that time, the result being that only 35% of the catch was measured during the period 10 to 15 October. It was clear, however, that most fish captured on those dates were smaller than those taken in earlier stages of the downstream migration. Angling results indicated that juvenile grayling (170 to 230 mm) were still present upstream of the counting fence on 15 October.

5.4.1.7 Age composition of migrant grayling. Scale ages were determined for 191 Arctic grayling captured in the Steepbank River in 1977. This total included 125 fish taken during the spring fence operation, 20 angled in mid-summer, and 46 captured in the fall. Because the sample was not selected on a random basis, it cannot be said to reflect accurately the age composition of the grayling population. Nevertheless, the data do indicate the age range of migrant grayling, and our knowledge of the age and growth characteristics of this population (presented in a later section), combined with the length-frequency data (Table 14), permits a fairly accurate description of the age composition of the run.

Grayling ranged in age from one to seven years. One year old grayling apparently did not participate in the upstream migration as seine hauls, made at weekly intervals near the fence site, produced no fish of this age group. Approximately half of the grayling participating in the spring upstream migration were two year olds and immature three year old fish (<260 mm). The majority of the spawners were three (mostly males), four, and five years of age.

5.4.1.8 Sex ratio of migrant grayling. As reported by Rawson (1950), Wojcik (1955), and Bishop (1971), male grayling have a dorsal fin which is considerably larger than that of female grayling. During the present study, this criterion was used, where possible, to identify male fish. Of 307 Arctic grayling for which sex was determined by this method during the spring migration, 70% were males. This represents a significant deviation (X^2 = 49.28, $P < 0.001$) from the usual 1:1 ratio. However, this sex ratio is probably biased since males were more conspicuous to the sampler and when uncertain there was a tendency to record no sex for fish that were probably females. Mature grayling, dead sampled during the course of the spring run (n = 50), exhibited a 1:1 sex ratio. Bishop (1971) observed a male to female ratio of 1.3:1 in Providence Creek, N.W.T. and Brown (1938) found a ratio of 3:1 for males in a Montana grayling run.

Male grayling probably migrate to the spawning area somewhat earlier than females. Males outnumbered females during the early part of the spawning run in Grebe Lake, Wyoming, but the overall sex ratio was 1:1 (Kruse 1959). In Cold Creek, Alberta, the ratio was 3:1 for males early in the run but later changed to 5:1 in favour of the females (Ward 1951).

The ratio of males to females in the fall downstream migration was based on sexing fish externally (n = 139) during four different periods of the run and on 46 dead sampled grayling. The sex ratio indicated a 1.3:1 ratio of males to females but this was not statistically significant (X^2 = 3.378, $P > 0.05$). The sex ratio did not appear to vary with time during the downstream migration. Gustafson (1948) reported no sexual difference during the downstream run.

5.4.1.9 Fecundity. Gravimetric fecundity estimates were done for seven mature female grayling captured during the spring upstream migration. These fish ranged in fork length from 265 to 365 mm. Actual counts on all ovaries revealed errors of from +3.5 to -8.5% for the estimated values. The total number of eggs per female ranged from 2206 to 8546 (Table 16), with a mean value of 4689.

Studies in other areas indicate that grayling fecundity can vary considerably, but that the average number of eggs per

Table 16. Fecundity of Arctic grayling sampled during the 1977 Steepbank River spawning migration.

Fork Length (mm)	Weight (g)	Total Number of Eggs			Relative Fecundity	
		Estimated	Actual	Deviation	(cm)	(g)
275	322	3105	3395	-8.5	123.5	10.5
288	330	3906	3831	+2.0	133.0	11.6
290	310	2182	2206	-1.1	76.1	7.1
300	290	3743	3799	-1.5	126.6	13.1
315	390	4342	4497	-3.4	142.8	11.5
354	550	8848	8546	+3.5	241.4	15.5
365	500	6420	6551	-2.0	179.5	13.1

female is probably 4000 to 7000 (Scott and Crossman 1973). Tripp and McCart (1974) showed that the average fecundity of Donnelly River grayling was 6518 eggs (range 3243 to 9230) for fish between 268 and 393 mm fork length. Ward (1951) reported a range of 574 to 7039 eggs per female (254 to 343 mm) for grayling captured in Cold Creek. Bishop (1971) found an average of 9670 eggs per female (range 6120 to 15 905) for grayling in Providence Creek (254 to 432 mm in fork length).

Length-relative fecundity for Steepbank River grayling ranged from 76.1 to 241.4 ova per cm of fork length (Table 16) while weight-relative fecundity varied from 7.1 to 15.5 eggs per gram of body weight. The average length-relative fecundity for the Steepbank sample (146.1 ova per cm) is considerably less than that (218.0) reported by Tack (1971) and that (250.0) found by Bishop (1971). The average weight-relative fecundity (11.8 ova per g) was similar to that reported by other authors. Brown (1938), Ward (1951), and Bishop (1971) reported average weight-relative fecunditites of 12.6, 13.1, and 10.9, respectively.

Regression analysis indicated a significant ($P < 0.01$) positive correlation between fecundity and fork length ($n = 7$, $r = 0.857$) and fecundity and weight ($r = 0.898$) for Steepbank River grayling. The mathematical relationship between fecundity and fork length is expressed by the equation:

$$\log_{10}\text{Fecundity} = 3.5249 \log_{10}\text{Fork Length(mm)} - 5.1520$$

The relationship between fecundity and body weight is expressed:

$$\log_{10}\text{Fecundity} = 1.5977 \log_{10}\text{Weight(g)} - 0.4766$$

5.4.1.10 Egg size and gonad weight. The egg size for eight mature females captured in late April ranged from 2.0 to 2.3 mm with a mean diameter of 2.1 mm. Gillies (1975) reported that the diameter of grayling eggs before water hardening ranged from 2.5 to 2.7 mm. Tripp and McCart (1974) observed that egg size increased rapidly from 1.9 to 2.3 mm during the period of spring break-up, and that, at spawning, average egg diameter was 2.5 mm.

Females captured in the Steepbank River during the fall (n = 5) had an average egg diameter of 1.5 mm with a range of 1.4 to 1.8 mm.

The mean ovary weight for spawning females was equivalent to 10.6% of total body weight (range 8.9 to 12.4%). The highest recorded value was observed in a four-year old female with a fork length of 300 mm, body weight 290 g, and ovary weight of 36.0 g. The mean ovary weight for five spent females, captured in May, was equivalent to 1.3% of body weight (range 0.7 to 2.1%.

5.4.1.11 Age and growth. Growth in fork length (Table 17) proceeds at a constant rate until age 3 or 4, when the growth rate begins to decline. The decrease in growth rate occurs at about the age when grayling begin to mature sexually.

Grayling from the Steepbank River have almost identical growth patterns to those reported for populations from streams in southern tributaries of the Athabasca River (Ward 1951), and in other tributaries of the AOSERP study area (Griffiths 1973; Bond and Machniak 1977).

Steepbank grayling grow at a rate similar to that reported for grayling from Great Bear Lake (Falk and Dahlke 1974) and Great Slave Lake (Bishop 1967) for their first year or two, but thereafter, fish from the two lake populations achieve higher growth rates (Figure 8). Steepbank River grayling show higher growth rates throughout their lives than populations from the Chatanika River, Alaska (Schallock 1966) and Vermillion and Hodgson creeks, Northwest Territories (Tripp and McCart 1974).

Male grayling from the Steepbank River were generally longer than females of the same age, with the difference being significant ($P < 0.05$) for age 4 and age 6 fish (Table 17). Bond and Machniak (1977) indicated a tendency for males to be larger than females in the Muskeg River. Other investigators have reported similar growth differences between the sexes (Miller 1946; Gustafson 1948; Ward 1951; Kruse 1959; Bishop 1967). Reed (1964) found that immature grayling show little or no sexual difference in growth, whereas mature males appear to grow faster

Table 17. Age-length relationship (derived from scales) for Arctic grayling captured in the Steepbank River, 1977, sexes separate and combined sample (includes unsexed fish).

Age	Males				Females				All Fish				t-test
	N	Mean	S.D.	Range	N	Mean	S.D.	Range	N	Mean	S.D.	Range	
1	0	ND			0	ND			1	158.0			
2	24	206.5	13.96	178-228	52	207.7	13.74	174-239	85	206.1	14.77	170-239	0.352
3	10	264.1	15.68	244-288	8	250.8	19.14	220-281	18	258.2	18.10	220-288	1.623
4	22	305.1	15.47	283-328	26	291.4	12.89	269-325	48	297.7	15.59	269-328	3.348[a]
5	13	333.2	15.46	306-356	14	328.8	16.86	307-359	27	330.9	16.05	306-359	0.705
6	6	360.5	6.60	354-370	4	340.5	21.99	315-365	10	352.5	17.09	315-370	2.145[a]
7	1	381.0			1	354.0			2	367.5	19.09	354-381	
Totals	76				105				191				

[a] Indicates significant differences between means for males and females (Student's t-test; $P < 0.05$).

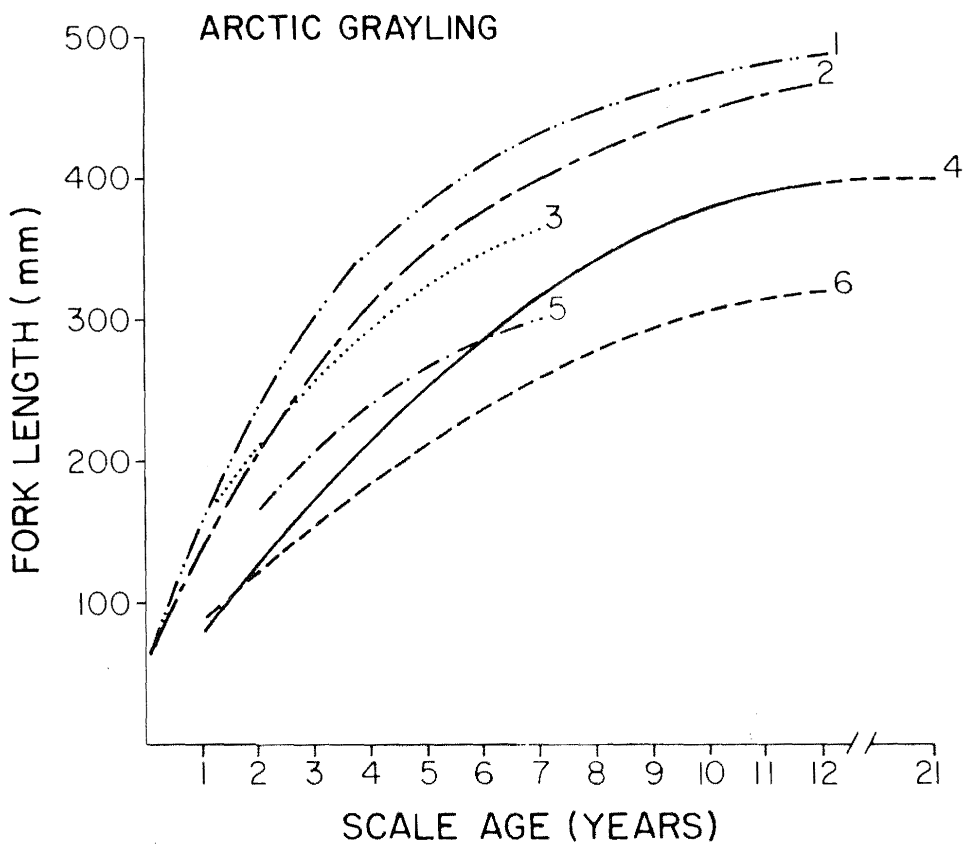

Figure 8. Growth in fork length for Arctic grayling from the Steepbank River and from several other areas: 1. Great Bear Lake (Falk and Dahlke 1974), 2. Great Slave Lake (Bishop 1967), 3. Steepbank River (present study), 4. Chatanika River (Schallock 1966), 5. Vermillion Creek (Tripp and McCart 1974), and 6. Hodgson Creek (Tripp and McCart 1974).

than mature females.

Arctic grayling gained weight rapidly in the Steepbank River, and males were generally heavier than females. Weight differences between the sexes were significant ($P < 0.05$) for age groups 4 and 6 (Table 18). Male grayling in the eastern part of Great Slave Lake were heavier than females from age 2 to age 12 (Bishop 1967).

The maximum age recorded for Steepbank River grayling was seven years. This is similar to the maximum ages recorded by other authors for grayling in the Athabasca drainage; age 5 for the Namur River (Turner 1968), age 6 for Martin Creek (Ward 1951), Lake Athabasca (Miller 1946) and the Fort McMurray area (Griffiths 1973), and age 7 for Prairie Creek (Ward 1951). The oldest grayling reported to date from the AOSERP study area has been an age 12 (otolith-based) male, 354 mm in fork length, (Jones et al. 1978), and an age 8 (scale-based) unsexed grayling, 375 mm in length (Bond and Berry, in prep.b). Maximum ages reported elsewhere for grayling are 22 years (otolith-based) for the Firth River, Yukon Territory (Craig and Poulin 1975) and 12 years (scale-based) for Great Slave Lake (Bishop 1967) and Great Bear Lake (Falk and Dahlke 1974).

5.4.1.12 Sex and maturity. Sex (by gonadal inspection) and age were determined for 181 Arctic grayling captured in the Steepbank River in 1977 (Table 19). Females comprised 58% of the total sample, and outnumbered males in age groups 2, 4, and 5.

The earliest age of sexual maturity was three years for both males and females. Sixty percent of males were mature at age 3, compared to only 38% for females. Except for one female, all fish were mature by age 4. In the Muskeg River, the earliest age of sexual maturity was two years for males and three years for females (Bond and Machniak 1977). Ward (1951) observed that male grayling began to mature at age 2, that 75% of both sexes were mature at age 3, and that all grayling were mature by age 4. Craig and Poulin (1975) reported that grayling in Alaska reached sexual maturity between age 5 and age 8, the oldest age of maturity

Table 18. Age-weight relationship for Arctic grayling captured in the Steepbank River, 1977, sexes separate and combined sample (includes unsexed fish).

Age	Males				Females				All Fish				t-test
	N	Mean	S.D.	Range	N	Mean	S.D.	Range	N	Mean	S.D.	Range	
1	0	ND			0	ND				60.0			
2	24	87.9	16.65	66-120	52	94.2	21.39	67-140	85	91.6	22.34	50-140	1.274
3	10	180.0	33.58	150-250	8	154.3	59.33	70-244	18	168.6	47.12	70-250	1.162
4	22	304.7	50.07	220-410	26	277.4	39.97	210-380	48	289.9	46.46	210-410	2.101[a]
5	13	391.2	47.75	300-470	14	376.9	55.97	280-470	27	383.7	51.69	280-470	0.711
6	6	487.5	37.38	440-580	4	428.8	50.72	390-500	10	464.0	50.54	390-530	2.121[a]
7	1	527.0			1	550.0			2	538.5	16.26	527-550	
Totals	76				105				191				

a Indicates significant difference between means for males and females (Student's t-test; $P<0.05$).

Table 19. Age-specific sex ratios and maturity for Arctic grayling from the Steepbank River, 1977. Sex ratios were based only on fish for which sex was determined.

Age	Females			Males			Unsexed Fish	Total
	N	%	% Mature	N	%	% Mature		
1	0	0	0	0	0	0	1	1
2	52	68	0	24	32	0	9	85
3	8	44	38	10	56	60	0	18
4	26	54	96	22	46	100	0	48
5	14	52	100	13	48	100	0	27
6	4	40	100	6	60	100	0	10
7	1	50	100	1	50	100	0	2
Totals	105	58%		76	42%		10	191

for grayling in North America.

5.4.1.13 Length-weight relationship. The following length-weight relationships were determined for Arctic grayling captured in the Steepbank River.

For male Arctic grayling ($n = 76$, $r = 0.990$, range 178 to 381 mm) the relationship between fork length and body weight is described by the equation:

$$\log_{10} W = 3.0813 (\log_{10} L) - 5.1889; \; sb = 0.0517$$

For female grayling ($n = 105$, $r = 0.978$, range 174 to 365 mm) the length-weight relationship is expressed by the equation:

$$\log_{10} W = 3.1026 (\log_{10} L) - 5.2247; \; sb = 0.0653$$

Analysis of covariance indicated no significant difference ($P < 0.05$) between adjusted means ($F = 3.746$) or the slopes ($F = 0.060$) of the length-weight regressions of male and female grayling.

5.4.1.14 Growth of young-of-the-year. Arctic grayling spawned in the Steepbank River watershed between late April and early May 1977. According to Gillies (1975), hatching of eggs begins in 11 to 22 days, depending on water temperature. Newly hatched grayling fry usually spend three to four days in the gravel before emerging (Kratt and Smith 1977).

Few young-of-the-year grayling were captured in the Steepbank River during the summer. This may have been a result of the flood that occurred in late May and early June which may have removed many newly hatched fry from the watershed, or our collection methods may have been inadequate. Other researchers have also experienced difficulties in obtaining young grayling (Wojcik 1955; Reed 1964; Schallock 1966).

A single young-of-the-year grayling (20 mm in fork length) was collected from Area 5 (Figure 2) on 19 June. Another (79 mm in fork length) was captured on 19 August in Area 7, while a third (86 mm) was taken at the same site on 13 October.

Bond and Machniak (1977) reported rapid summer growth of grayling fry in the Muskeg River, where fish attained a mean fork length of 85 mm (range 71 to 101 mm) by 11 September. Other investigators have shown that growth in length is rapid during the first year of life (Gustafson 1948; Wojcik 1955; Reed 1964; Schallock 1966; Scott and Crossman 1973; Tripp and McCart 1974).

5.4.1.15 Food habits. A total of 108 grayling stomachs were examined in the field during the spring migration and only 11 were found empty. Most stomachs (72%) were one quarter full, the contents consisting mainly of aquatic and terrestrial insects (Hempitera, Diptera, Coleoptera, and Hymenoptera). Bishop (1971) noted that, before spawning, adult grayling fed only incidentally, but that after spawning, they fed actively.

Apart from those stomachs examined in the field, 18 stomachs, taken from fish captured throughout the study period, were examined in the laboratory. The results of the analysis (Table 20), confirm the findings of Rawson (1950) and Bishop (1967) that grayling consume a great variety of immature and adult aquatic and terrestrial insects. Hymenoptera, Trichoptera, Hemiptera, and Diptera were the most common food items in terms of frequency of occurrence, being found in 37.5 to 62.5% of all stomachs containing food. Other common foods, occurring in 18.8 to 31.3% of all stomachs containing food, were Plecoptera, Odonata, Homoptera, and Coleoptera. Nearly 70% of the stomachs contained insect remains. Other food items included oligochaetes, leeches, water mites, fish eggs, and fish.

Volumetrically, Trichoptera larvae (14.6%) and Odonata nymphs (9.2%) dominated the stomach contents with insect remains accounting for 43.7% of the total.

Some investigators (Kruse 1959; Bishop 1967; Reed 1964) have shown aquatic insects to be the most important food items for Arctic grayling. Others (Miller 1946; Rawson 1950; Wojcik 1955; Schallock 1966) have found terrestrial forms to be important in the diet of this species. By all accounts, grayling appear to be opportunistic feeders and, in addition to the above, have been reported to feed upon fish (grayling, ninespine stickleback, and

Table 20. Food habits of the larger fish species collected from the Steepbank River, 1977.

Food Items	Arctic Grayling			Longnose Suckers			White Suckers		
	% Freq.[a]	% No.	% Vol.	% Freq.[a]	% No.	% Vol.	% Freq.[a]	% No.	% Vol.
<u>Class Insecta</u>									
Diptera									
Chironomidae	12.5	1.0	0.3	57.1	46.5	2.3	66.7	88.3	9.1
Simuliidae	6.3	0.5	0.2	57.1	12.9	1.5	66.7	7.7	9.1
Tipuliidae	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.2	3.0
Rhagionidae	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.1	3.0
Tabanidae	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.4	9.1
Unidentified Dipterans	37.5	8.3	1.9	85.8	3.6	6.6	100.0	2.1	6.0
Trichoptera	56.3	20.9	14.6	85.7	18.9	9.9	0.0	0.0	0.0
Plecoptera	18.8	2.6	0.5	57.1	4.8	7.3	0.0	0.0	0.0
Ephemeroptera	12.5	3.7	0.7	57.1	7.5	11.0	100.0	0.3	18.2
Coleoptera	18.8	2.1	0.6	14.3	0.6	1.0	0.0	0.0	0.0
Hemiptera	37.5	32.5	4.9	28.6	0.9	0.7	0.0	0.0	0.0
Hymenoptera	62.5	11.5	4.5	14.3	0.3	0.7	33.3	0.1	3.0
Odonata	31.3	3.1	9.2	0.0	0.0	0.0	33.3	0.1	3.0
Homoptera	18.8	2.1	1.5	28.6	0.6	3.6	0.0	0.0	0.0
Lepidoptera	6.3	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Orthoptera	6.3	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Neuroptera	0.0	0.0	0.0	14.3	0.3	0.6	0.0	0.0	0.0
Insect Remains	68.8	0.0	43.7	0.0	0.0	0.0	0.0	0.0	0.0
<u>Miscellaneous</u>									
Oligochaeta	6.3	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Hirudinea	6.3	0.5	1.5	14.3	0.3	1.2	0.0	0.0	0.0
Arachnida	12.5	1.0	0.3	14.3	0.3	0.1	33.3	0.1	3.0
Acarina	0.0	0.0	0.0	28.6	0.6	0.3	0.0	0.0	0.0
Hydracarina	0.0	0.0	0.0	14.3	0.3	0.7	0.0	0.0	0.0
Nematoda	0.0	0.0	0.0	14.3	0.9	1.2	33.3	0.7	1.5
Nematomorpha	25.0	4.7	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Fish eggs	6.3	3.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Fish	6.3	0.5	4.2	0.0	0.0	0.0	0.0	0.0	0.0
Vegetation	0.0	0.0	0.0	42.9	0.0	2.8	0.0	0.0	0.0
Digested matter	0.0	0.0	0.0	85.7	0.0	49.1	33.3	0.0	30.3
Debris (sticks, stones, tar sands)	18.8	0.0	9.2	0.0	0.0	0.0	33.3	0.0	3.0
Total stomachs	18			10			3		
Empty (% of Total)	11.1			30.0			0.0		

[a] Based on stomachs that contained some food.

cisco), fish eggs, lemmings, and amphipods (Miller 1946; Reed 1964; McPhail and Lindsey 1970).

The food habits of young-of-the-year grayling in the Steepbank River were not examined due to a lack of fish captured. However, in the Muskeg River, young-of-the-year fed mainly on larval Chironomidae, Simuliidae, and Trichoptera and on nymphal Ephemeroptera (Bond and Machniak 1977, in prep.). Kruse (1959) reported that young-of-the-year and yearling grayling subsisted mainly on *Daphnia* and on Diptera larvae and pupae. Grayling fry in Providence Creek fed primarily on Ephemeroptera nymphs and Diptera pupae (Bishop 1971).

5.4.1.16 Overwintering. The upper reaches beyond the confluence of the Steepbank and North Steepbank rivers contain deep pools and beaver impoundments which appear to be suitable for overwintering. Although the catch data are scarce, visual observations indicate that age 0+ grayling remain in this region at least until mid-October. Ward (1951) indicated that some Athabasca grayling overwinter in beaver ponds and deep pools of tributaries. Juvenile grayling have been observed under the ice in the Muskeg River drainage (Bond and Machniak 1977). It is suspected that most young-of-the-year grayling overwinter and spend another summer in the Steepbank River before emigrating in the fall with the adult migrant grayling. This would appear to enhance the survival of young fish which would not be exposed to the rigors of migration or predation by piscivorous fish.

5.4.2 Longnose Sucker

5.4.2.1 Seasonal timing of upstream migration. Longnose sucker spawning migrations appear to be initiated by increasing water temperatures. Geen et al. (1966) observed that the spawning migration was associated with a water temperature of 5°C in British Columbia. Bailey (1969) reported that in the Brule River, Wisconsin, spawning runs (over a seven-year period) peaked at an average water temperature of 13.0°C (range 10.9 to 14.4°C). The

1977 spawning migration into the Steepbank River was in progress by 25 April (Table 10 and Figure 9), on which date the maximum water temperature was 5.5°C. However, the main portion of the run did not begin until almost a week later. Fifty-four percent of the recorded longnose sucker movement occurred between 29 April and 7 May, during which time the maximum daily water temperature ranged from 6.0 to 14.5°C. Peak upstream movements were observed on 2 May (n = 570) and 4 May (n = 521) when maximum water temperatures were 11.5 and 14.5°C respectively (Figure 9). The 1977 longnose sucker spawning run in the Steepbank River preceded by several days that in the adjacent Muskeg River (Bond and Machniak in prep.).

5.4.2.2 Diel timing of upstream migration. The majority of longnose suckers (77%) moved upstream between noon and midnight with maximum movement usually occurring between 1800 and 2400 hours (Table 21). Similar results have been observed for other longnose sucker runs, both within the AOSERP study area (Bond and Machniak 1977, in prep.) and elsewhere (Geen et al. 1966).

5.4.2.3 Spawning period. The actual spawning period for longnose suckers in 1977 probably lasted from one to two weeks. Ripe males were first noted on 2 May while no ripe females were collected until 7 May. Ripe males and females were taken in the upstream trap as late as 10 May, and by 12 May all fish recorded at the downstream trap were spawned out. Geen et al. (1966) reported a spawning period of brief duration, with some adults leaving the spawning stream as early as five days after the migration began.

5.4.2.4 Spawning areas. Spawning of longnose suckers was not observed within the lower 2 km of the Steepbank River despite daily surveillance by field personnel, and it must be assumed that no spawning occurred in that area. No attempts were made to locate fish on spawning grounds in upstream areas. Rather, it was hoped that we would be able to define spawning sites on the basis of fry distribution during June. Unfortunately, the severe flood in late

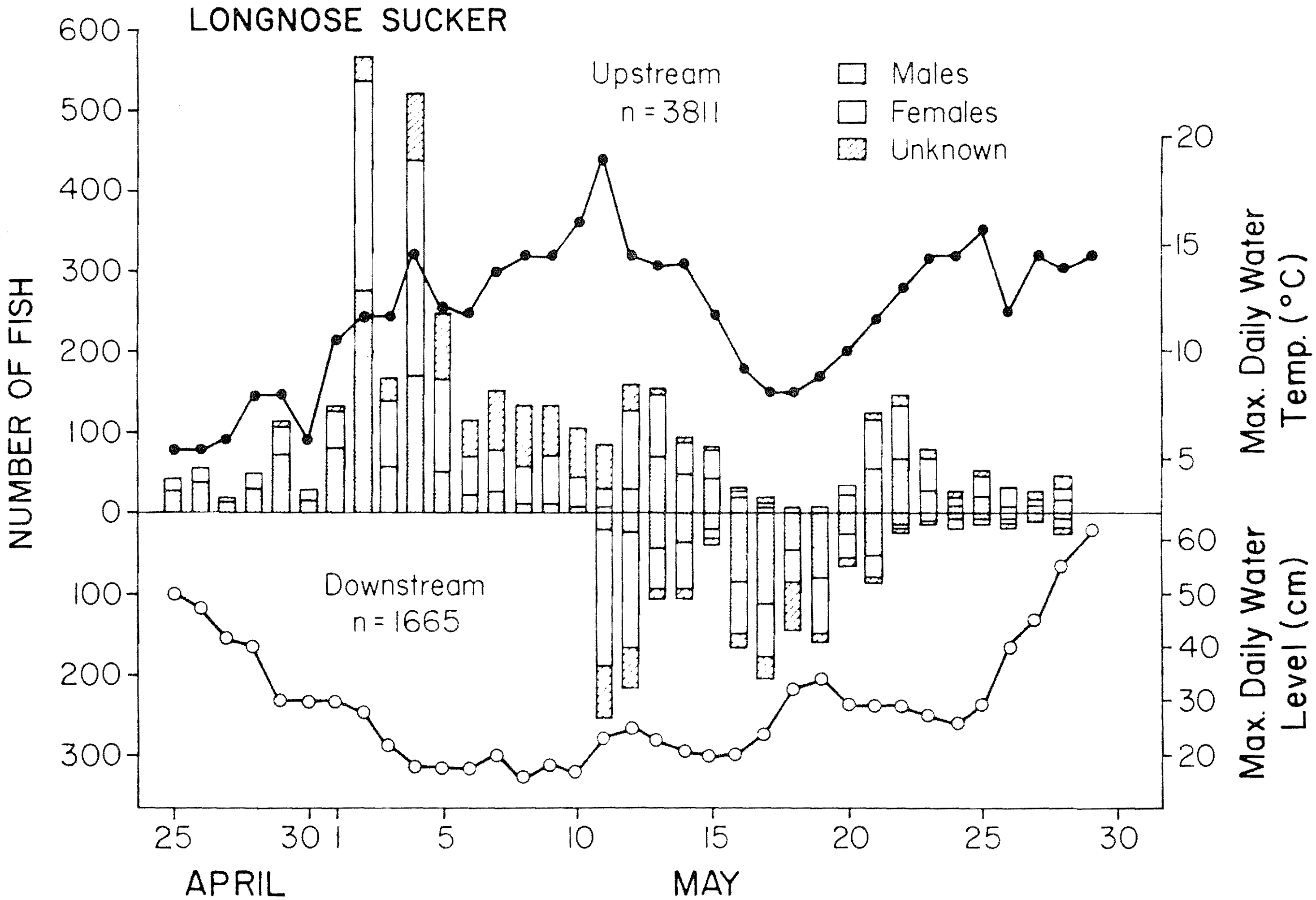

Figure 9. Seasonal timing of spring migration of longnose suckers in the Steepbank River, 1977.

Table 21. Summary of diel timing of the upstream migration of longnose suckers in the Steepbank River, 1977. Fish that were counted at times other than those indicated were included in the next check period.

Date	Number of Fish Counted at Each Trap Check						Total
	0900	1200	1500	1800	2100	2400	
25 April	2	ND[a]	5	ND	36	ND	43
26	0	ND	3	10	45	ND	58
27	3	0	1	7	6	1	18
28	0	2	22	16	3	5	48
29	0	1	26	79	5	1	112
30	0	0	25	3	0	0	28
1 May	0	0	12	16	106	0	134
2	6	11	191	146	158	58	570
3	27	34	20	3	29	53	166
4	62	41	97	87	104	130	521
5	74	9	28	77	35	28	251
6	23	5	7	22	13	45	115
7	19	5	7	39	17	66	153
8	45	1	10	14	10	57	137
9	33	1	6	22	2	73	137
10	15	0	10	30	7	43	105
11	23	1	11	14	18	16	83
12	7	30	18	6	44	55	160
13	37	6	32	16	20	45	156
14	42	1	7	7	3	35	95
15	55	3	2	3	8	15	86
16	24	2	0	0	0	5	31
17	2	1	1	2	0	13	19
18	0	0	0	1	0	5	6
19	0	0	ND	ND	ND	8	8
20	18	ND	ND	8	6	1	33
21	26	3	9	19	33	34	124
22	20	5	3	36	13	71	148
23	56	ND	ND	3	5	14	78
24	ND	ND	11	4	2	10	27
25	ND	27	ND	6	5	17	55
26	ND	26	ND	2	4	0	32
27	ND	2	ND	12	3	7	24
28	ND	41	ND	3	4	ND	48
29	2	0	Operations		terminated		2
Totals	621	258	564	713	744	911	3811
% Grand Total	16.3	6.8	14.8	18.7	19.5	23.9	

[a] No data.

May and early June coincided with the emergence of the newly-hatched fry, and apparently washed much of the new year class out of the watershed. Few young-of-the-year suckers were captured in the Steepbank River after mid-June. Nevertheless, the capture of small numbers of young-of-the-year as far upstream as the junction of the Steepbank and North Steepbank rivers suggests that a large portion of the river may be used for spawning purposes. Large longnose suckers (possibly mature adults) were observed in the mid-reaches of the Steepbank River (Areas 3 to 5) between 31 July and 1 August. It is not known whether these fish had spawned in these areas or had moved up or downstream after spawning.

Geen et al. (1966) reported that longnose suckers spawned over gravel 0.5 to 10.0 cm in diameter, at a water depth of 15.2 to 27.9 cm, and at a water velocity of 30 to 45 cm/s. Such areas are common throughout the lower Steepbank watershed, including the North Steepbank as far upstream as Area 10 (Figure 2).

5.4.2.5 <u>Length of time spent in Steepbank River</u>. During the upstream migration, tags were applied to 1880 longnose suckers. By 29 May, 568 tagged fish had been recaptured at the downstream trap. Sixty-eight of these were recaptured within 24 hours of tagging and were excluded from the analysis. Three fish, tagged in the spring, were recaptured in the downstream trap during the fall fence operation.

Since the fence was not operated all summer, it is not possible to provide a complete picture as to the amount of time spent in the Steepbank River by individual fish. From the tag returns available, it would appear that some individuals may stay in the tributary up to 157 days. However, in the Muskeg River, most longnose suckers had left by mid-June (Bond and Machniak 1977), and a similar pattern is expected in the Steepbank. Tagged fish leaving the Steepbank River in May 1977 had been in the tributary up to 28 days, but the majority had spent only from seven to 17 days in the Steepbank (Figure 10). Brown and Graham (1954) reported that the average time spent in Pelican Creek, Wyomimg, by spawning longnose suckers, was 19 days for females and 17 days for males.

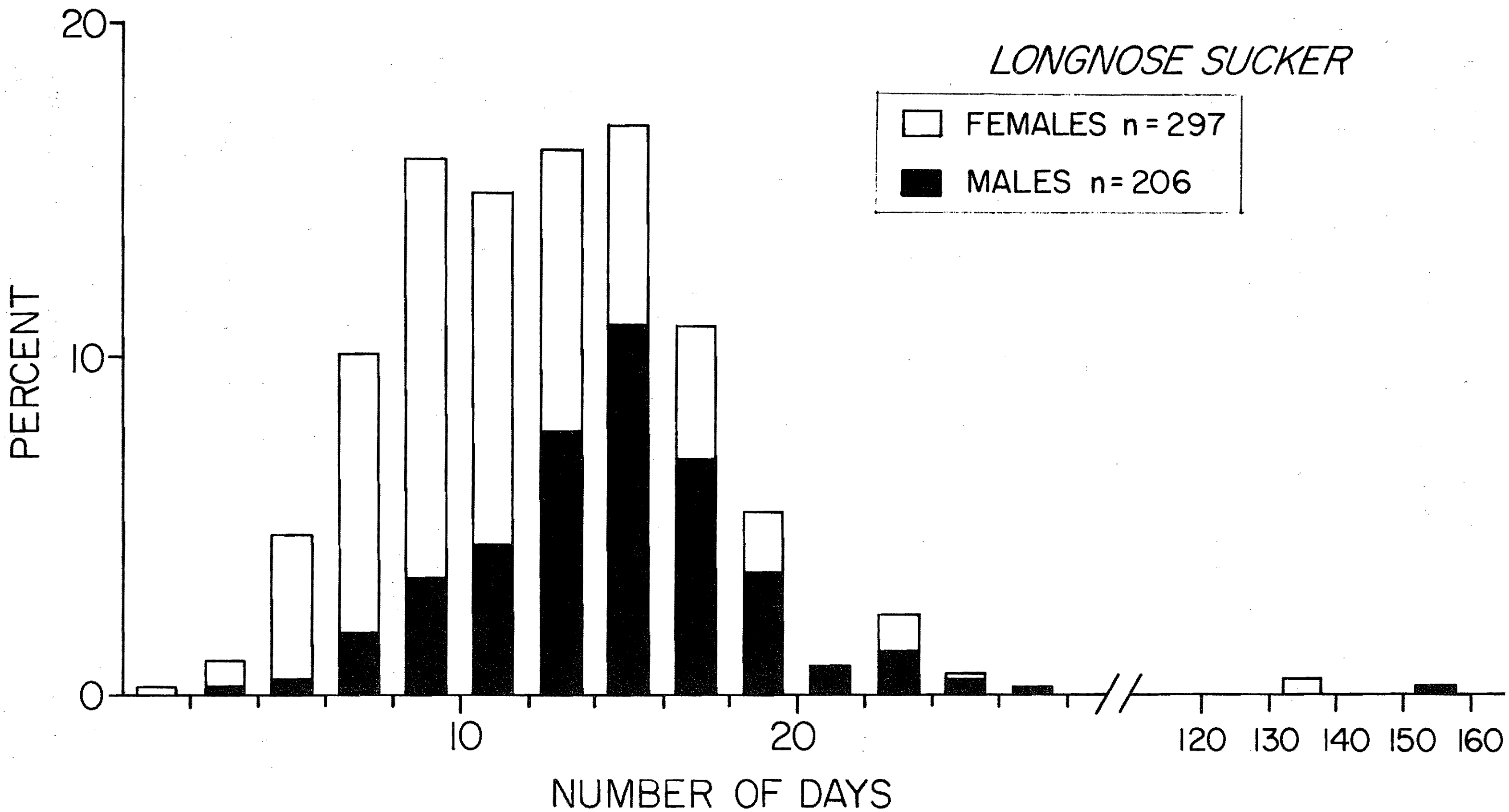

Figure 10. Number of days spent in the Steepbank River by individual longnose suckers, 1977.

5.4.2.6 Seasonal and diel timing of downstream migration. The main movement of spent longnose suckers from the Steepbank River began on 10 May, approximately six to eight days after the main upstream spawning migration began. Returning spawners (approximately 20 to 30 fish) were first observed upstream of the counting fence on the evening of 10 May, and the downstream trap was opened at 0900 hours on 11 May. Eighty-four percent of the downstream movement occurring during the period of the spring study took place between 11 and 19 May (Table 10, Figure 9). By 29 May, 1665 longnose suckers, or 44% of the total enumerated upstream run, had passed through the downstream trap. The majority of these were spent fish.

The downstream migration of longnose suckers took place mainly at night when water temperatures (Appendix 8.1) were near or declining from the daily maximum. The most intense downstream movement occurred between 2100 and 2400 h (Table 22), as 50% of all fish were taken at the midnight check. The majority of longnose suckers in the Muskeg River also moved downstream at night (Bond and Machniak in prep.). Geen et al. (1966) reported that downstream movement of longnose suckers ceased in the early morning when water temperatures reached the daily minimum.

A total of 121 longnose suckers left the Steepbank River during the fall fence operation (Table 12). Only 12% of longnose suckers captured in the fall downstream trap were adults (>300 mm). The remainder were immatures, which apparently tend to remain in the tributaries longer than the spawners.

Because the counting fence was not operated during the summer, it is not possible to say with certainty what fish movements occurred at that time. However, it is likely that the downstream movement continued through the summer, and that by mid-October, few if any migrant suckers remained in the Steepbank watershed. Studies on the Muskeg River (Bond and Machniak 1977) have shown that, while most longnose suckers had returned downstream by mid-June, some downstream movement continued at least through 30 July.

Table 22. Summary of diel timing of the downstream migration of longnose suckers in the Steepbank River, 1977. Fish that were counted at times other than those indicated were included in the next check period.

Date	Number of Fish Counted at Each Trap Check						Total
	0900	1200	1500	1800	2100	2400	
11 May	trap opened	39	27	2	39	144	251
12	95	7	6	13	4	90	215
13	30	2	6	10	1	57	106
14	19	1	8	31	3	41	103
15	3	3	0	9	1	21	37
16	3	1	1	0	2	160	167
17	30	3	2	6	32	134	207
18	40	0	0	14	1	91	146
19	44	65	ND	ND	ND	50	159
20	28	ND	ND	14	13	96	161
21	8	16	50	1	1	9	85
22	14	0	4	2	1	4	25
23	1	ND	ND	2	1	10	14
24	ND[a]	ND	3	11	1	5	20
25	ND	3	ND	5	1	5	14
26	ND	9	ND	4	1	4	18
27	ND	5	ND	1	1	3	10
28	ND	20	ND	6	1	ND	27
29	0	Operations terminated					0
Totals	315	174	107	131	104	834	1665
% Grand Total	18.9	9.9	6.4	7.9	6.2	50.1	

[a] No data.

5.4.2.7 Spawning mortality. Forty-six longnose suckers were found dead on the fence in the Steepbank River. However, only a dozen or so of these fish were mature spawners, and most downstream fish appeared to be in good physical condition. Geen et al. (1966) produced mortality estimates of 11 to 28%, and considered survival of spawning longnose suckers to be very high.

5.4.2.8 Size composition of migrant longnose suckers. Fork lengths were obtained for 3736 longnose suckers during the 1977 upstream migration, of which sex was determined in 3007 cases (Table 23 and Figure 11). While migrant longnose suckers ranged in fork length from 182 to 499 mm, the majority (74%) were in the 320 to 449 mm size range. Most fish in this group were adults (spawners). A second, smaller mode appearing in the length-frequency polygon (Figure 11) represented immature fish.

Female longnose suckers were generally larger than males (Figure 11). Females had a modal length in the 400 to 419 mm range, while the modal length interval for males was 360 to 379 mm. Similar differences in size between the sexes were observed in longnose suckers from the Muskeg River (Bond and Machniak 1977, in prep.).

The adult suckers apparently leave the stream soon after spawning. Of the 1570 longnose suckers measured during the spring at the downstream trap (size range 174 to 486 mm), 99% were adult size spawners (>320 mm). However, suckers taken at the downstream trap during the fall varied in fork length from 161 mm to 387 mm with most (79%) being immature fish between 180 and 270 mm (Figure 12).

5.4.2.9 Age composition of migrant longnose suckers. Migrant suckers in the Steepbank River ranged in age from four to 13 years, the majority of spawners (75%) being age 7 to 11 inclusive. Similar results were obtained for longnose suckers from the Muskeg River (Bond and Machniak 1977, in prep.) and MacKay River (Machniak et al. in prep.). Longnose suckers spawn at younger ages in the southern parts of their range than in more northern areas. In Wyoming, the majority of spawning run suckers were four to seven years

Table 23. Length-frequency distribution of longnose suckers during the spring upstream migration in the Steepbank River, 1977.

Fork Length (10 mm intervals)	Male	Female	Unknown	Total
180-189	1	0	3	4
190-199	1	1	26	28
200-209	1	1	56	58
210-219	1	0	77	78
220-229	0	0	73	73
230-239	0	0	77	77
240-249	1	3	81	85
250-259	1	4	53	58
260-269	3	4	58	65
270-279	0	11	45	56
280-289	3	14	45	62
290-299	4	22	42	68
300-309	5	46	27	78
310-319	5	52	16	73
320-329	12	59	9	80
330-339	33	61	3	97
340-349	71	63	7	141
350-359	170	72	5	247
360-369	224	104	6	334
370-379	212	131	4	347
380-389	180	143	5	328
390-399	188	184	7	379
400-409	96	182	2	280
410-419	62	152	1	215
420-429	25	121	0	146
430-439	12	95	0	107
440-449	4	73	0	77
450-459	0	47	1	48
460-469	1	31	0	32
470-479	1	9	0	10
480-489	0	4	0	4
490-499	0	1	0	1
Totals	1317	1690	729	3736

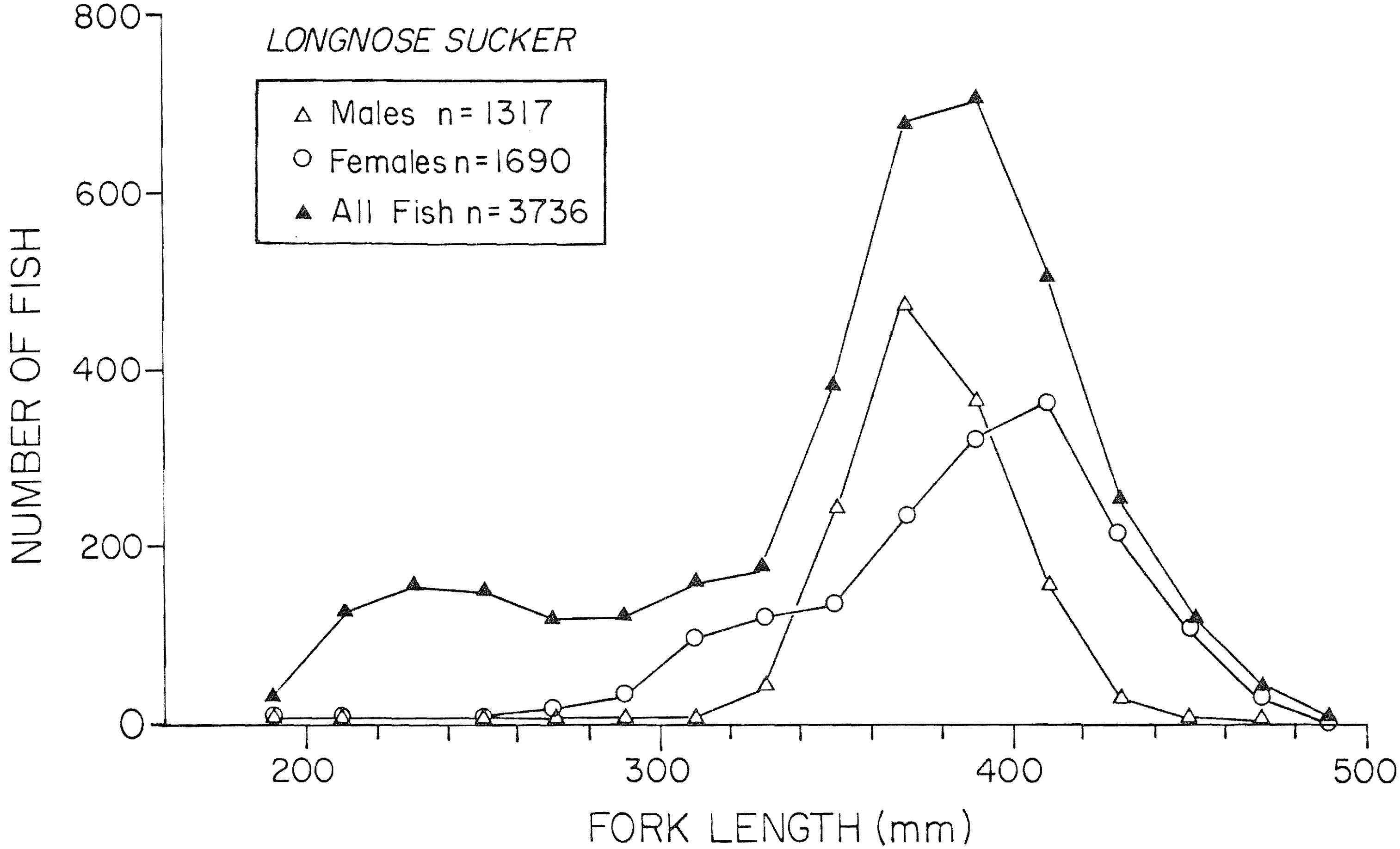

Figure 11. Length-frequency distribution for longnose suckers during the spring upstream migration in the Steepbank River, 1977.

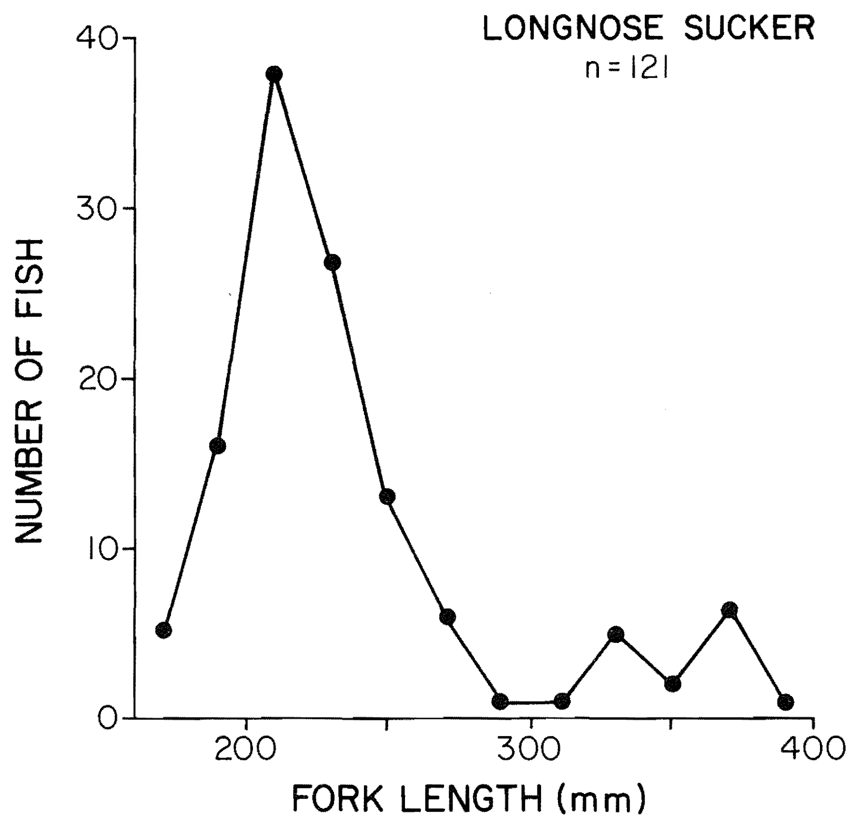

Figure 12. Length-frequency distribution for longnose suckers during the fall downstream migration in the Steepbank River, 1977.

old (Brown and Graham 1954), while Geen et al. (1966) found most spawners to be five to 11 years old in Frye Creek, British Columbia. In the Hay River, N.W.T., most spawners were age 10 to 12 inclusive (Harris 1962) while in the Donnelly River, N.W.T., the majority of spawning longnose suckers were 11 to 18 years old with a maximum age of 22 years (Tripp and McCart 1974).

Our age sample of migrants (n = 149) was not entirely representative of the total upstream migration. Immature fish (age groups 4 to 6) were over-represented (45% of aged sample). Longnose suckers of the younger age group comprised only 23% of the size frequency while the latter age group formed the bulk (70%) of those fish in the 320 to 449 mm size range.

5.4.2.10 Sex ratio of migrant longnose suckers. Sex was determined for 3059 longnose suckers during the upstream migration, of which 1726 (56%) were females. This represents a significant departure from a 1:1 ratio (X^2 = 50.49, P< 0.001). The sex ratio was also observed to vary with time during both the upstream and downstream runs. The early part of the upstream migration (25 April to 2 May) was dominated by males, the latter (3 May to 13 May) by females (Table 24). Female suckers tended to spend less time in the tributary than the males, and outnumbered the males during the early stages of the downstream run (Table 25). Results from the Steepbank River agree with those presented by other authors for this species. In the Hay River, N.W.T., Harris (1962) reported females outnumbering males during the spawning run by a ratio of 10:1. Geen et al. (1966) and Kendel (1975) both indicated that male longnose suckers tend to precede the females onto the spawning grounds and to remain longer.

5.2.4.11 Fecundity. Ovaries were removed from 14 female longnose suckers in spawning condition and fecundity estimated gravimetrically. The estimated total number of eggs per female (size range 389 to 489 mm fork length) ranged from 22 932 to 49 448 (Table 26) and averaged 29 502. Actual counts on four ovaries revealed errors of from +6.1% to -4.1% for estimated values. Egg production for

Table 24. Sex ratio for longnose suckers during the upstream migration, Steepbank River, 1977.

Date	Number of Fish Males	Females	Unknown	Total	Percent Males[a]
25 April	24	19	0	43	56
26	36	22	0	58	62
27	12	6	0	18	67
28	26	22	0	48	54
29	70	39	3	112	64
30	16	12	0	28	57
1 May	79	51	4	134	61
2	274	261	35	570	51
3	56	80	30	166	41
4	169	270	82	521	39
5	49	116	86	251	30
6	19	52	44	115	27
7	25	50	78	153	33
8	10	48	79	137	17
9	10	60	67	137	14
10	6	39	60	105	13
11	5	24	54	83	17
12	29	99	32	160	23
13	68	78	10	156	47
14	48	42	5	95	53
15	41	43	2	86	49
16	19	9	3	31	68
17	7	5	7	19	58
18	5	1	0	6	83
19	3	5	0	8	38
20	20	12	1	33	63
21	55	61	8	124	47
22	65	69	14	148	49
23	25	43	10	78	37
24	9	14	4	27	39
25	20	27	8	55	43
26	4	27	1	32	13
27	9	8	7	24	53
28	19	12	17	48	61
29	1	0	1	2	100
Totals	1333	1726	752	3811	
%	44	56			

[a]Based on fish of known sex.

Table 25. Sex ratio for longnose suckers during the downstream migration, Steepbank River, 1977.

Date	Number of Fish				Percent Females[a]
	Males	Females	Unknown	Total	
11 May	20	171	60	251	90
12	23	143	49	215	86
13	43	50	13	106	54
14	35	60	8	103	63
15	19	12	6	37	39
16	83	69	15	167	45
17	109	70	28	207	39
18	46	42	58	146	48
19	79	72	8	159	48
20	24	37	0	61	61
21	52	31	2	85	37
22	12	11	2	25	48
23	8	6	0	14	43
24	7	10	3	20	59
25	6	7	1	14	54
26	6	8	4	18	57
27	8	1	1	10	11
28	5	12	10	27	71
Totals	585	812	268	1665	

[a]Based on fish of known sex.

Table 26. Fecundity estimates for 14 longnose suckers sampled during the 1977 Steepbank River spawning migration.

Fork Length (mm)	Weight (g)	Number of Eggs			Relative Fecundity	
		Left Ovary	Right Ovary	Total	(cm)	(g)
389	920	13 250	14 193	27 443	705.5	29.8
401	800	12 533	13 667	26 200	653.4	32.8
411	890	ND[c]	ND	22 932	557.9	25.8
413	910	ND	ND	23 625	572.0	25.9
414	870	ND	ND	26 615	642.9	30.6
415	1030	ND	ND	32 325	778.9	31.4
420	1110	ND	ND	25 612	609.8	23.1
420	990	ND	ND	31 379	747.1	31.7
425	1090	ND	ND	27 448	645.8	25.2
426	1070	ND	ND	28 062	658.7	26.2
429	1000	13 222[a] (+6.1%)[b]	15 844[a] (-0.6%)[b]	29 066[a]	677.5	29.1
440	1120	13 299[a] (+4.3%)[b]	14 714[a] (-4.1%)[b]	28 013[a]	636.7	25.0
462	1290	ND	ND	34 865	754.7	27.0

[a] Actual egg counts.
[b] Deviation of estimated counts from actual number.
[c] No data.

suckers from Great Slave Lake (Harris 1962) ranged between and 60 000 eggs with an average of 35 000 for fish between 450 and 568 mm fork length. The number of eggs in the ovaries of suckers from Lake Superior (Bailey 1969) ranged from 14 000 to 35 000 and averaged 24 000 for fish between 353 and 450 mm. Tripp and McCart (1974) reported an average fecundity of 49 000 (range 24 000 to 108 000) for females in the Donnelly River (size range 425 to 525 mm).

Where the right and left ovaries were counted separately, the right ovary always contained more eggs than the left (average 14 605; range 13 667 to 15 844 eggs).

Length-relative fecundity ranged from 557.9 to 990.9 ova per cm of fork length while weight-relative fecundity varied from 23.1 to 32.8 eggs per gram of body weight.

Regression analysis indicated a significant ($P<0.01$) positive correlation between fecundity and fork length ($n = 14$, $r = 0.818$) and fecundity and body weight ($r = 0.840$). The relationship between fecundity and fork length is expressed by the equation:

$$\log_{10} \text{Fecundity} = 2.5559 \log_{10} \text{Fork Length (mm)} - 2.2567;$$
$$sb = 0.5183$$

while the relationship between fecundity and body weight is expressed by the equation:

$$\log_{10} \text{Fecundity} = 0.8267 \log_{10} \text{Weight (g)} - 1.8600;$$
$$sb = 0.1607$$

5.4.2.12 Egg size and gonad weight. Eggs of mature and ripe females (n = 20) captured during the spring run ranged in size from 1.6 to 2.1 mm with a mean diameter of 1.8 mm. Females from the study area appear to have a smaller egg size than that reported form other areas. Egg diameter of suckers from Great Slave Lake was 3.0 mm (Harris 1962), Lake Superior fish averaged 2.2 mm (Bailey 1969), and Tripp and McCart (1974) reported an egg diameter of 2.0 mm for Donnelly River longnose suckers.

The mean ovary weight for spawning females was equivalent to 12.5% of the mean body weight (range 10.3 to 15.2%). The highest recorded value was observed in a 12-year old female with a fork length of 462 mm, body weight 1290 g and ovary weight 195.6 g. Tripp and McCart (1974) recorded a mean value of 12.8% for ovary weight/body weight. The mean ovary weight of spent females (n = 19) was equal to 1.4% of total body weight with values ranging from 0.9 to 2.1%.

Testis weight accounted for 4.3 to 6.5% of the total body weight (mean 5.1%) in ripe males (n = 13). Values ranged from 0.4 to 2.7% with a mean of 1.5% for spent males (n = 16).

5.4.2.13 Age and growth. Most growth in length of Steepbank River suckers was achieved during the first eight years of life at which age longnose suckers had a mean fork length of 369 mm (Table 27). After age 8, the rate of growth decreased considerably. Growth of Steepbank River suckers is identical to that reported for longnose suckers in previous studies from the AOSERP study area (McCart et al. 1977; Bond and Machniak 1977, in prep.; Jones et al. 1978; Bond and Berry in prep.a, in prep.b). Steepbank River suckers (Figure 13) grow faster than Pyramid Lake fish (Rawson and Elsey 1950) and slightly faster than Donnelly River suckers (Tripp and McCart 1974). However, they do not grow as rapidly as suckers from Great Slave Lake (Harris 1962) or Yellowstone Lake (Brown and Graham 1954).

Tripp and McCart (1974) noted that some of the variation in growth between sucker populations might be attributable to the method of aging. These authors used otoliths to age their fish, and McCart et al. (1977) and Jones et al. (1978) used the same technique in aging suckers from the AOSERP study area. The present study, as well as several other studies (Bond and Machniak 1977, in prep.; Bond and Berry in prep.a, in prep.b), have utilized fin rays to age suckers in the study area. Apparently both methods give comparable results (Mr. Barry Corbett, Graduate Student, Trent University, Ontario, verbal communication, February 1978). Beamish (1973) found that, for longnose suckers beyond the age of maturity, ages obtained by scales differ by as much as five years from those derived from fin rays and, therefore, growth curves derived by the scale method should be viewed with distrust.

Table 27. Age-length relationship (derived from fin rays and otoliths) for longnose suckers captured in the Steepbank River, 1977, sexes separate and combined sample (includes unsexed fish).

Age	Males				Females				All Fish				t-test
	N	Mean	S.D.	Range	N	Mean	S.D.	Range	N	Mean	S.D.	Range	
1	12	50.3	8.78	38-66	6	44.0	3.69	41-50	27	49.6	9.27	35-69	1.615
2	0	ND			0	ND			1	107.0			
3	1	117.0			2	122.0	14.14	112-132	3	120.3	10.41	112-132	
4	4	195.0	8.87	182-202	7	187.6	5.88	178-195	22	190.7	6.01	178-202	0.724
5	5	222.8	23.87	202-260	5	206.6	6.11	200-213	31	211.7	14.43	190-260	1.471
6	8	284.1	18.54	259-318	3	291.7	38.68	247-314	14	284.1	24.24	247-318	0.459
7	6	323.3	31.73	295-380	6	332.5	34.90	293-389	12	327.9	32.16	293-389	0.467
8	7	369.1	26.26	334-411	8	369.3	28.06	309-400	15	369.2	26.25	309-411	0.014
9	11	379.5	22.80	345-414	7	408.7	18.24	376-425	18	390.8	25.27	345-425	2.849[a]
10	4	383.5	4.65	379-388	7	415.3	9.83	401-428	11	403.7	17.93	379-428	6.001[a]
11	6	398.8	32.95	346-426	10	422.2	18.98	390-444	16	413.4	26.73	346-444	1.821[a]
12	1	405.0			6	439.2	22.70	414-470	7	434.3	24.42	405-470	
13	2	400.0	21.21	385-415	1	499.0			3	433.0	59.09	385-499	
Totals	67				68				180				

[a] Indicates significant difference between means for males and females (Student's t-test; $P < 0.05$).

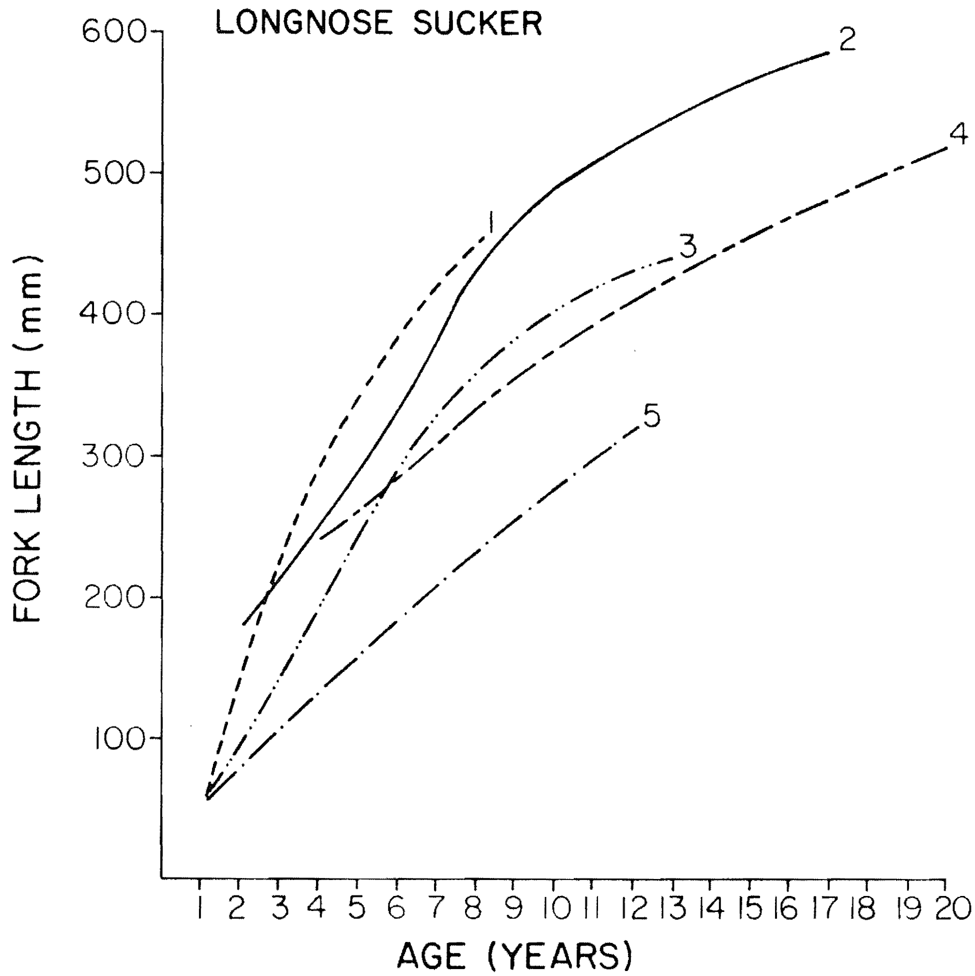

Figure 13. Growth in fork length for longnose sucker from the Steepbank River and from several other areas: 1. Yellowstone Lake (Brown and Graham 1954), 2. Great Slave Lake South (Harris 1962), 3. Steepbank River (present study), 4. Donnelly River (Tripp and McCart 1974), and 5. Pyramid Lake, Alberta (Rawson and Elsey 1950).

Female suckers were generally longer than males of the same age with the difference in mean fork length being significant ($P < 0.05$) in age groups 9 to 11 inclusive (Table 27). Bond and Machniak (1977) observed significant differences in mean length between sexes in age groups 7 to 11 inclusive for Muskeg River suckers, Brown and Graham (1954) also found that females were significantly larger than males while Lalancette and Magnin (1970) noted that females were always approximately 10 mm longer than males in the same age group. Harris (1962), however, reported no such difference between the sexes, indicating that they increase in length at about the same rate.

During the first few years of life longnose suckers added weight slowly with age 4 fish averaging 80 g (Table 28). The rate of weight gain then increased for the next three to four years, decreasing again after age 9. Female longnose suckers were generally heavier than males of the same age with the differences in mean weight being statistically significant (Student's t-test) for age groups 9 to 11 inclusive (Table 28).

5.4.2.14 Sex and maturity. Of 135 longnose suckers aged and sexed, 50% were females (Table 29). Both male and female longnose suckers begin to mature at age 6, and virtually all fish were sexually mature by age 8. The youngest age of first sexual maturity reported for longnose suckers is two years in Colorado (Hayes 1956) and the oldest is nine years for Great Slave Lake (Harris 1962) and the Donnelly River (Tripp and McCart 1974).

5.4.2.15 Length-weight relationship. Analysis of covariance indicated no significant differences ($P > 0.05$) between adjusted means ($F = 1.436$) or slopes ($F = 0.111$) of the length-weight regressions of male and female longnose suckers. The combined length-weight relationship (includes unsexed fish) for longnose suckers ($n = 149$, $r = 0.996$, range 178 to 499 mm) is exposed by the equation:

$$\log_{10} W = 3.1671 (\log_{10} L) - 5.3438; \; sb = 0.0246$$

Table 28. Age-weight relationship for longnose suckers captured in the Steepbank River, 1977, sexes separate and combined sample (includes unsexed fish).

Age	Males				Females				All Fish				t-test
	N	Mean	S.D.	Range	N	Mean	S.D.	Range	N	Mean	S.D.	Range	
1	12	1.6	0.25	0.6-3.4	6	1.0	0.33	0.7-1.5	27	1.4	0.82	0.6-3.4	1.668
2	0	ND			0	ND			1	11.0			
3	1	15.1			2	21.9	5.94	17.7-26.1	3	19.6	5.75	15.1-26.1	
4	4	83.3	11.67	68-95	7	77.4	4.79	70-84	22	80.3	7.48	68-100	1.208
5	5	121.4	42.05	92-190	5	89.2	9.63	80-103	31	102.9	24.01	78-190	1.669
6	8	272.9	67.76	190-400	3	322.7	126.18	178-410	14	274.7	82.41	178-410	0.872
7	6	411.5	149.34	299-700	6	483.3	233.67	350-920	12	447.4	185.16	299-920	0.654
8	7	633.9	264.00	430-1140	8	620.0	133.84	380-810	15	626.5	197.18	380-1140	0.131
9	11	688.2	180.10	440-1030	7	854.3	181.65	570-1090	18	752.8	194.08	440-1090	1.901[a]
10	4	735.0	45.09	700-800	7	938.6	120.61	800-1110	11	864.5	141.02	700-1110	3.189[a]
11	6	755.0	175.93	470-880	10	939.0	164.14	590-1150	16	870.0	186.94	470-1150	2.115[a]
12	1	840.0			6	1081.7	262.25	670-1420	7	1047.1	256.24	670-1420	
13	2	715.0	162.63	600-830	1	1680.0			3	1036.7	568.88	600-1680	
Totals	67				68				180				

[a] Indicates significant difference between means for males and females (Student's t-test; $P < 0.05$).

Table 29. Age-specific sex ratios and maturity for longnose suckers from the Steepbank River drainage, 1977. Sex ratios were based only on fish for which sex was determined.

Age	Females			Males			Unsexed Fish	Total
	N	%	% Mature	N	%	% Mature		
1	6	33	0	12	67	0	9	27
2	0	0	0	0	0	0	1	1
3	2	67	0	1	33	0	0	3
4	7	64	0	4	36	0	11	22
5	5	50	0	5	50	0	21	31
6	3	27	33	8	73	13	3	14
7	6	50	100	6	50	33	0	12
8	8	53	100	7	47	86	0	15
9	7	39	100	11	61	100	0	18
10	7	64	100	4	36	100	0	11
11	10	63	100	6	37	83	0	16
12	6	86	100	1	14	100	0	7
13	1	33	100	2	67	100	0	3
Totals	68	50%		67	50%		45	180

5.2.4.16 <u>Growth of young-of-the-year</u>. Young longnose suckers remain in the gravel for a period of one to two weeks before emerging, and about a month after the spawning migration they begin to move out of the spawning stream at a size of 10 to 12 mm total length (Geen et al. 1966). In 1977, longnose suckers had completed spawning by mid-May in the Steepbank River. Sucker fry were first captured on 30 May and were abundant in Area 2 until field operations terminated on 15 June. Most of the suckers collected during this time comprised a single mode in the length-frequency distribution (Figure 14). The modal length of young suckers (presumably longnose suckers) was 12 mm total length (range 7 to 13 mm). A few larger young-of-the-year suckers (total length range 16 to 21 mm) were also collected during this period and were thought to be white suckers. Lalancette and Magnin (1970) captured young-of-the-year longnose suckers in the Valin River, Quebec, on 17 June with a mean total length of 13.4 mm (range 9 to 18 mm). Longnose suckers from Yellowstone Lake ranged in total length from 11 to 15 mm with an average of 13 mm approximately a month after the spawning run (Brown and Graham 1954).

Growth of young-of-the-year longnose suckers from the Steepbank River is given in Table 30. Forty-two longnose suckers captured on 2 August had a mean fork length of 35.5 mm (range 26 to 42 mm). One young-of-the-year sucker taken in the Steepbank River on 13 October had a mean fork length of only 39 mm. It appears that most suckers vacate the spawning stream soon after emerging from the gravel, and hence growth of "resident" young suckers may not be indicative of fish that drift back to the lake (Lake Athabasca). Sucker fry in the AOSERP study area appear to have a growth rate intermediate between that of Pelican Creek (Brown and Graham 1954) and Hay River suckers (Harris 1962). Fry taken from Pelican Creek on 7 September averaged 23.5 mm (range 19 to 30 mm) while suckers captured on 15 August in the Hay River averaged 50 mm (range 33 to 66 mm). The growth rate of Steepbank fry appears similar to that reported for Donnelly River suckers (Tripp and McCart 1974) where fish attained a mean fork length of 44.3 mm by the end of August.

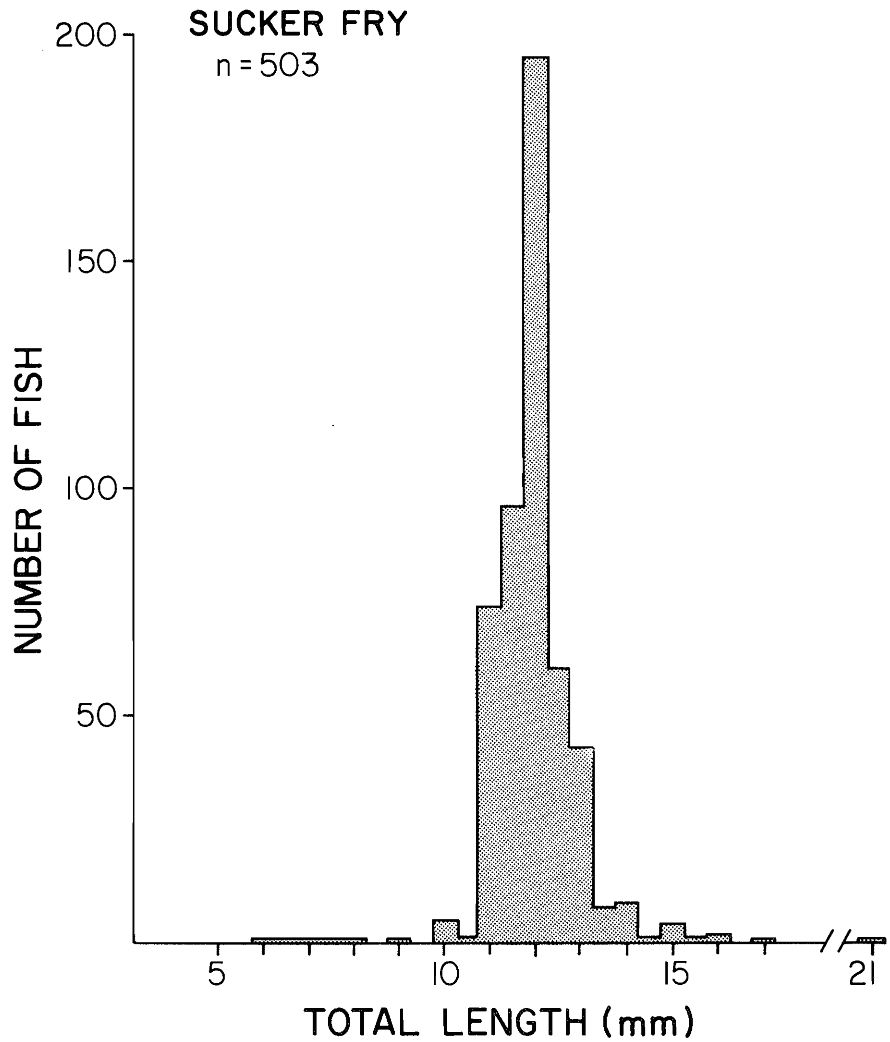

Figure 14. Length-frequency distribution for sucker fry captured in the Steepbank River during June, 1977.

Table 30. Comparison of mean fork lengths and mean weights of young-of-the-year suckers collected from the Steepbank River watershed, 1977. Numbers in parentheses indicate ranges.

Species	Date	Number of Fish	Mean Fork Length (mm) ± Std. Dev.	Mean Weight (g) ± Std. Dev.
Longnose suckers	18 June	26	32.6 ± 3.55 (25 - 43)	0.39 ± 0.13 (0.2 - 0.6)
	30 June	78	32.7 ± 4.59 (22 - 43)	0.37 ± 0.16 (0.1 - 0.8)
	2 August	31	32.3 ± 3.51 (26 - 42)	0.37 ± 0.15 (0.2 - 0.8)
	6 August	42	35.5 ± 4.74 (26 - 45)	0.57 ± 0.23 (0.2 - 1.1)
	19 August	6	33.5 ± 3.78 (31 - 41)	0.42 ± 0.15 (0.3 - 0.7)
	13 October	1	39.0	0.6
White suckers	18 October	22	29.4 ± 3.23 (25 - 36)	0.30 ± 0.09 (0.2 - 0.5)
	6 August	62	32.9 ± 3.50 (22 - 42)	0.44 ± 0.13 (0.1 - 0.8)
	13 August	7	35.9 ± 3.89 (28 - 40)	0.43 ± 0.14 (0.2 - 0.6)
	19-23 August	23	40.4 ± 4.75 (33 - 52)	0.81 ± 0.29 (0.4 - 1.5)
	13 October	4	37.5 ± 4.36 (34 - 43)	0.60 ± 0.12 (0.5 - 0.7)

5.4.2.17 Food habits. Field analysis of stomachs during the spawning season indicated that most suckers did not feed at this time. Of 136 stomachs examined, 80% contained no food. The remainder contained traces of food (15%) and 5% were one-quarter full to full with insect and plant matter. Bond and Machniak (1977) reported a similar situation for suckers captured in the Muskeg River.

Laboratory analysis of the stomach contents of 10 adult suckers captured during the spring spawning period indicated that immature insects were the most important food (Table 20). In terms of frequency of occurrence, Diptera (Chironomidae and Simuliidae) and Trichoptera were the most common food items, with about 86% of the stomachs containing them. Other foods, occurring in about 30 to 60% of the stomachs were Plecoptera, Ephemeroptera, Homoptera, Hemiptera Acarina. Nearly 50% of the total volume of sucker stomach contents was found to be digested material. Of the identifiable foods, Ephemeroptera (11%), Plecoptera (7%), and Trichoptera (10%) were the most important items. Other foods eaten were Neuroptera, Hirudinea, Hydracarina, and vegetation.

Longnose suckers are bottom feeders, consuming Amphipods, Trichoptera, Chironomidae larvae and pupae, Ephemeroptera, Ostracoda, Gastropoda, Copepoda, Cladocera, and plants (Scott and Crossman 1973). In Yellowstone Lake, Brown and Graham (1954) recorded a diet consisting principally of algae and aquatic plants with some aquatic insects (Ephemeroptera, Coleoptera, and Trichoptera). Chironomidae were the principal food of longnose suckers in the Saskatchewan River (Reed 1962). Bond and Berry (in prep.a) reported a diet consisting mainly of aquatic insects and pelecypods for suckers captured in the Athabasca River.

The food of young-of-the-year and juvenile (age 1+) suckers from the Steepbank River consisted mainly of immature aquatic insects (Chironomidae, Simuliidae, and Trichoptera) with some vegetation (Table 31).

Table 31. Food habits of young-of-the-year and juveniles of the larger fish species captured in the Steepbank River, 1977.

Food Items	Species									
	Longnose Suckers		White Suckers		Yellow Perch		Mountain Whitefish		Burbot	
	% Freq.[a]	% No.	% Freq.[a]	% No.	% Freq.[a]	% No.	% Freq.[a]	% No.	% Freq.[a]	% No.
Class Insecta										
Diptera										
Chironomidae	46.2	32.3	25.0	50.0	66.7	6.1	0.0	0.0	0.0	0.0
Simuliidae	23.1	32.3	0.0	0.0	33.3	38.8	100.0	6.9	0.0	0.0
Tipuliidae	7.7	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhagionidae	0.0	0.0	0.0	0.0	33.3	2.0	0.0	0.0	0.0	0.0
Ceratopogonidae	7.7	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified Dipterans	0.0	0.0	25.0	50.0	66.7	12.2	0.0	0.0	0.0	0.0
Trichoptera	15.4	12.9	0.0	0.0	33.3	4.1	0.0	0.0	100.0	100.0
Plecoptera	7.7	3.2	0.0	0.0	66.7	16.3	0.0	0.0	0.0	0.0
Ephemeroptera	7.7	3.2	0.0	0.0	33.3	6.1	100.0	93.1	0.0	0.0
Coleoptera	0.0	0.0	0.0	0.0	33.3	2.0	0.0	0.0	0.0	0.0
Hymenoptera	0.0	0.0	0.0	0.0	66.7	12.2	0.0	0.0	0.0	0.0
Lepidoptera	7.7	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insect Remains	7.7	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous										
Vegetation	15.4	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Digested Matter	84.6	0.0	87.5	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Debris (sticks, sand)	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total stomachs	14		8		3		1		1	
Empty (% of Total)	7.1		0.0		0.0		0.0		0.0	

[a] Based on stomachs that contained some food.

5.4.3 White Sucker

5.4.3.1 Seasonal timing of upstream migration. White sucker spawning migrations appear to be initiated by increasing water temperatures and often begin when the daily maximum water temperature in the spawning stream approaches 10°C (Geen et al. 1966; Bond 1972). White suckers had begun their upstream migration in the Steepbank River by 25 April 1977 and continued to move upstream until 29 May (Table 10 and Figure 15). However, the majority of upstream migrants (78%) passed the fence between 28 April and 8 May. During this period water temperatures were generally increasing and daily maximums ranged from 6.0 to 14.5°C. Stream temperature first reached 10°C on 1 May, and the peak of the migration passed the fence site between 2 and 5 May (Table 10 and Figure 15).

5.4.3.2 Diel timing of upstream migration. Most white suckers (77.7%) moved upstream between noon and midnight with maximum movements usually occurring between 1800 and 2400 hours (Table 32). Maximum movements took place when the stream temperature was near, or decreasing from, the daily maximum (Appendix 8.1). Other studies have shown that the major part of the migration takes place at night (Raney and Webster 1942; Geen et al. 1966; Bond 1972; Bond and Machniak, in prep.).

5.4.3.3 Spawning. The spawning period of white suckers lasted approximately one to two weeks. The first ripe male was captured at the upstream trap on 2 May and the first ripe female was taken on 7 May. By 20 May all fish caught at the downstream trap were spawned out.

Spawning grounds of white suckers in the Steepbank River are unknown since no attempts were made to locate spawning fish upstream of the fence area. Most spawning probably occurred in downstream reaches of the stream although young-of-the-year white suckers were captured as far upstream as Areas 7 and 10 (Figure 2) in late summer (August). According to the literature, spawning

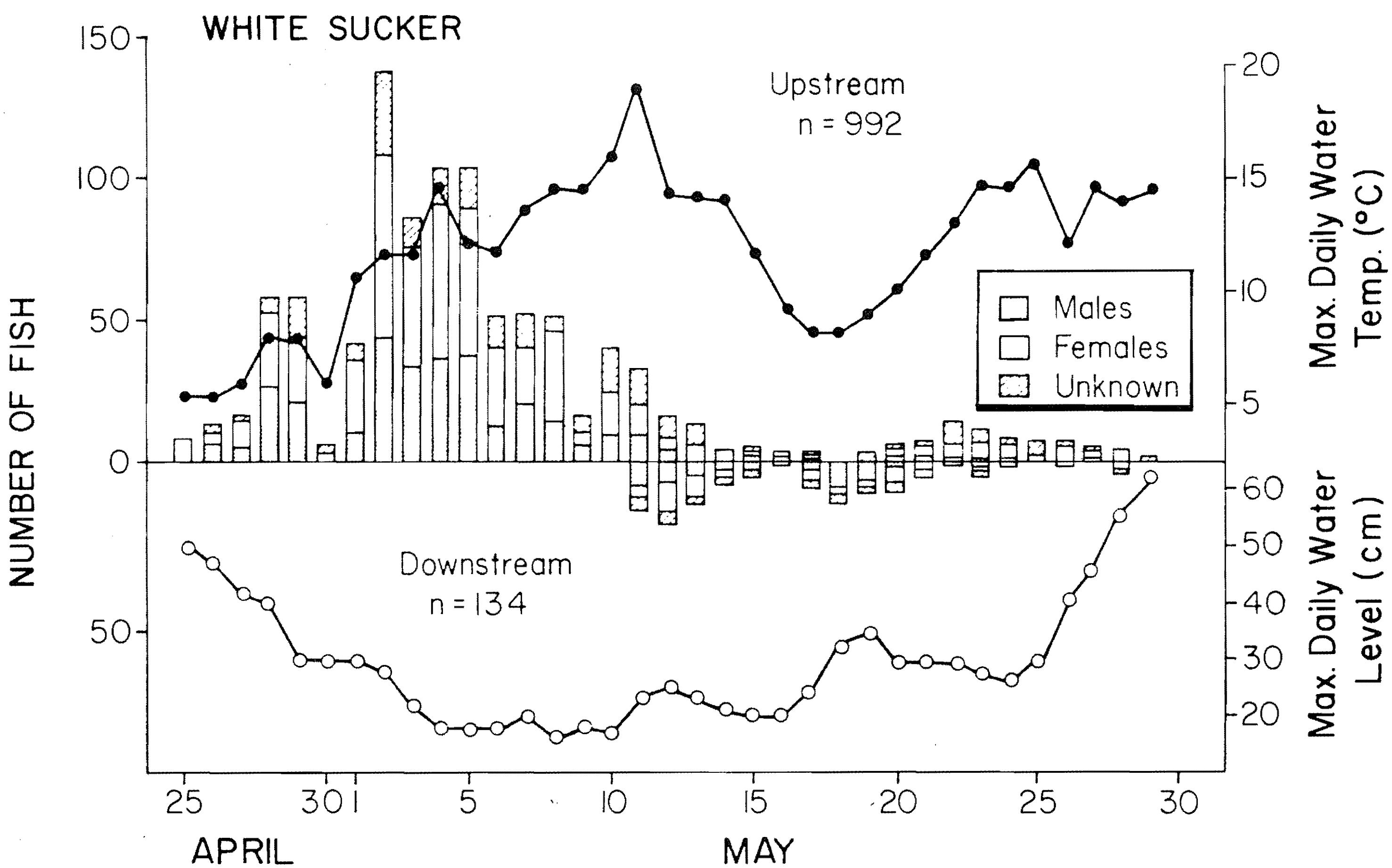

Figure 15. Seasonal timing of the spring migration of white suckers in the Steepbank River, 1977.

Table 32. Summary of diel timing of the upstream migration of white suckers in the Steepbank River, 1977. Fish which were counted at times other than those indicated were included in the next check period.

Date	Number of Fish Counted at Each Trap Check						Total
	0900	1200	1500	1800	2100	2400	
25 April	0	ND[a]	0	ND	8	ND	8
26	0	ND	2	2	9	ND	13
27	4	0	0	1	7	4	16
28	0	1	12	6	34	5	58
29	3	1	20	22	9	3	58
30	0	0	4	0	0	2	6
1 May	0	0	0	3	26	13	42
2	3	4	22	39	52	18	138
3	23	3	12	5	11	32	86
4	16	3	16	9	18	42	104
5	48	2	6	25	7	16	104
6	7	0	2	9	5	28	51
7	7	0	0	10	3	32	52
8	28	0	0	5	1	17	51
9	5	0	0	2	0	9	16
10	7	0	0	1	2	30	40
11	15	1	1	4	9	3	33
12	1	2	4	0	2	7	16
13	2	1	2	0	2	6	13
14	2	0	0	0	0	2	4
15	1	0	0	0	1	3	5
16	3	0	0	0	0	0	3
17	0	0	0	1	0	2	3
18	0	0	0	0	0	0	0
19	1	0	ND	ND	ND	2	3
20	4	ND	ND	2	0	0	6
21	1	0	0	1	2	3	7
22	1	0	0	4	0	9	14
23	4	ND	ND	0	1	6	11
24	ND	ND	3	1	0	4	8
25	ND	5	ND	0	1	1	7
26	ND	7	ND	0	0	0	7
27	ND	2	ND	2	0	1	5
28	ND	2	ND	1	0	ND	3
29	1	0	Operations		terminated		1
Totals	187	34	106	155	210	300	992
% Grand Total	18.9	3.4	10.7	15.6	21.2	30.2	

[a] No data.

sites are usually located in shallow water with a gravel bottom. Geen (1958) indicated that white suckers had two main spawning requirements: running water less than 31 cm deep and a gravel substrate. White suckers are also known to spawn on lake margins or quiet reaches in the mouths of blocked streams (Scott and Crossman 1973). Bond (1972) observed spawning in quiet reaches (i.e. downstream end) of a large pool of the Bigoray River, Alberta.

5.4.3.4 Length of time spent in the Steepbank River. The length of time spent by individual white suckers in the spawning stream was determined from fish tagged going upstream and recaptured passing through the downstream trap. The majority of adult spawners returned downstream within 16 days (Figure 16). Geen et al. (1966) reported adults moved off the spawning grounds in 10 to 14 days. Juvenile white suckers, however, tend to remain in the stream longer than adults with some fish staying up to 163 days.

5.4.3.5 Seasonal and diel timing of downstream migration. The main downstream movement of spent fish started approximately two weeks after the spawning migration began (Figure 15). The highest count of downstream fish occurred on 12 May (n = 22), and while white suckers continued to trickle downstream most adult spawners had returned downstream by 21 May.

The majority of downstream migrants were captured at night between 2100 and 2400 h (46%) with 28% being taken between 2400 and 0900 h (Table 33). A similar timing of downstream movement was observed in the Muskeg River (Bond and Machniak 1977, in prep.). The maximum movement of white suckers occurred each day following the period of highest water temperature (Appendix 8.1). Bond (1972) noted that the downstream migration usually occurred when stream temperatures were decreasing.

During the fall fence operation, 256 white suckers were passed through the downstream trap. Eighty percent of these suckers left the Steepbank River between 6 and 11 October (Table 12).

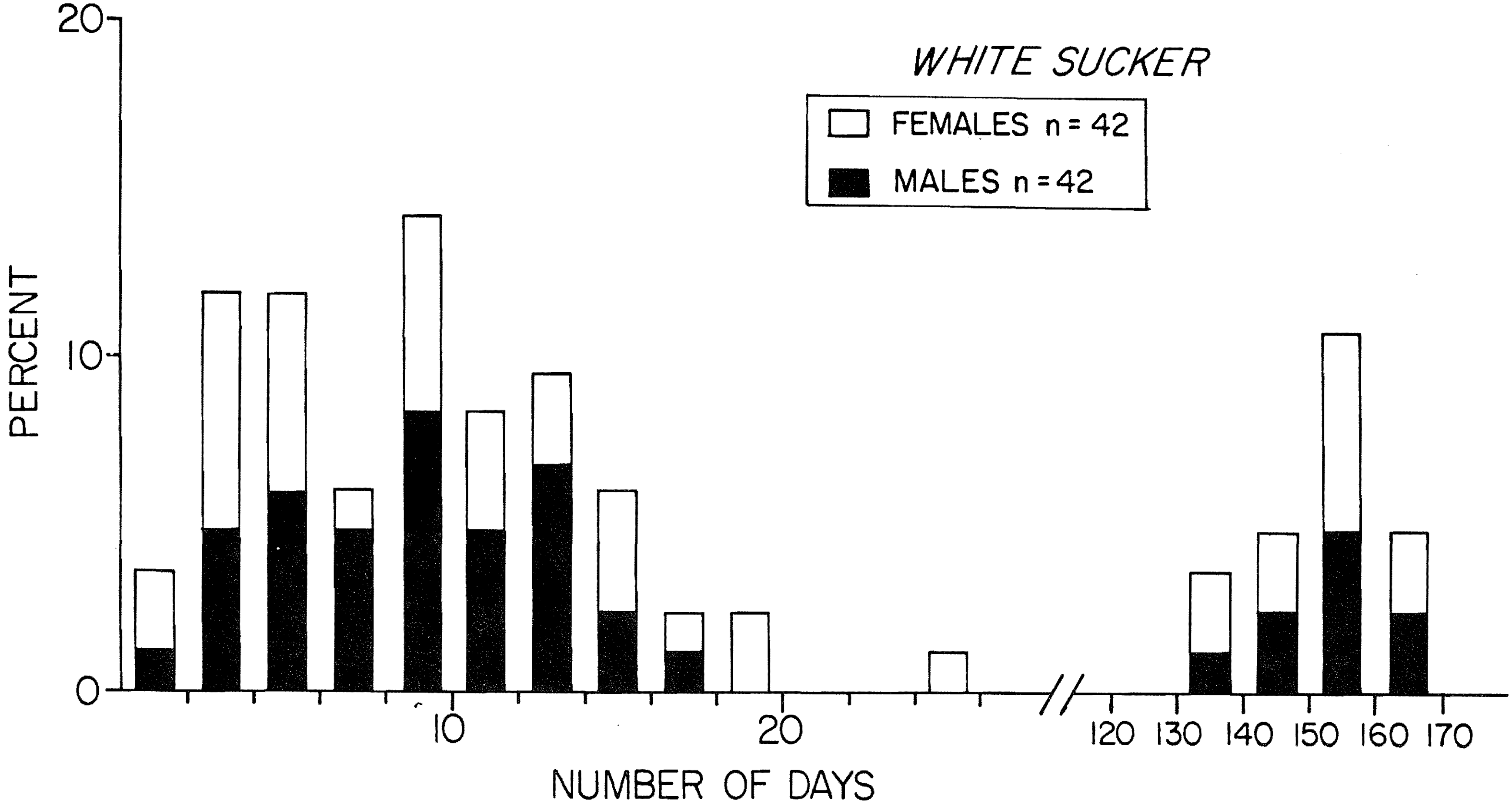

Figure 16. Number of days spent in the Steepbank River by individual white suckers, 1977.

Table 33. Summary of diel timing of the downstream migration of white suckers in the Steepbank River, 1977.

Date	Number of Fish Counted at Each Trap Check						Total Fish
	0900	1200	1500	1800	2100	2400	
11 May	Trap opened	7	6	0	0	4	17
12	5	3	0	0	2	12	22
13	7	0	1	1	0	6	15
14	1	0	1	0	0	6	8
15	0	0	0	0	0	5	5
16	0	0	0	0	0	1	1
17	1	0	0	0	0	8	9
18	4	0	0	0	0	11	15
19	7	2	ND	ND	ND	2	11
20	9	ND	ND	1	1	0	11
21	1	1	2	0	0	2	6
22	1	0	0	0	0	0	1
23	1	ND	ND	1	0	3	5
24	ND [a]	ND	0	1	0	1	2
25	ND	0	ND	0	0	0	0
26	ND	0	ND	1	0	0	1
27	ND	0	ND	0	0	0	0
28	ND	4	ND	1	0	ND	5
29	ND	Operations terminated				ND	ND
Totals	37	17	10	6	3	61	134
% Grand Total	27.6	12.7	7.5	4.5	2.2	45.5	

[a] No data.

5.4.3.6 Spawning mortality. Only 11 white suckers were found dead in the Steepbank River. This apparent low mortality was probably due to the paucity of older spawners. A mortality rate of 16 to 20% was observed by Geen et al. (1966) for spawning white suckers in Frye Creek, British Columbia.

5.4.3.7 Size composition of migrant white suckers. Fork lengths were determined for 977 white suckers during the spring fence operation (Table 34) and upstream migrants ranged in length from 181 mm to 542 mm. Sixty-five percent of the fish were between 300 and 430 mm (Figure 17) and there appeared to be no size difference between male and female suckers. Compared to the Muskeg River runs in 1976 and 1977 (Bond and Machniak 1977, in prep.) large spawners (>400 mm) were few in number. The above authors found that females were longer than males among larger spawners in the Muskeg River. Other investigators have also reported similar results with male white suckers being generally smaller than females (Raney and Webster 1942; Dence 1948; Geen et al. 1966). Taking 300 mm as the average minimum length at maturity for white suckers, at least 28% of the fish passed upstream were juvenile suckers (non-spawners) and many of the migrants were apparently first-time spawners.

The larger white suckers leave the spawning stream first. Ninety percent of the white suckers measured during the downstream run in the Steepbank River were fish greater than 350 mm fork length. Similarly, Bond and Machniak (in prep.) observed that 95% of downstream migrants in the Muskeg River exceeded 350 mm. Many of the juvenile and smaller maturing suckers remain in the Steepbank River until the fall. White suckers captured during the fall migration ranged in size from 178 to 411 mm but 85% were less than 350 mm (Figure 18).

5.4.3.8 Age composition of migrant white suckers. The majority of suckers in the age sample (90%) were between three and seven years old, and the oldest suckers were 11-year old females. Maximum age reported in the AOSERP study area is 17 years (Bond

Table 34. Length-frequency distribution of white suckers during the spring upstream migration in the Steepbank River, 1977.

Fork Length (10 mm intervals)	Male	Female	Unknown	Total
180 - 189	1	1	1	3
190 - 199	0	0	4	4
200 - 209	0	0	9	9
210 - 219	2	0	14	16
220 - 229	2	0	19	21
230 - 239	4	0	18	22
240 - 249	3	1	27	31
250 - 259	9	3	21	33
260 - 269	9	4	26	39
270 - 279	6	11	19	36
280 - 289	5	12	13	30
290 - 299	5	13	14	32
300 - 309	6	27	2	35
310 - 319	10	23	7	40
320 - 329	8	24	3	35
330 - 339	16	33	5	54
340 - 349	29	46	1	76
350 - 359	31	38	0	69
360 - 369	33	39	0	72
370 - 379	33	39	0	72
380 - 389	24	27	2	53
390 - 399	24	34	0	58
400 - 409	13	25	0	38
410 - 419	12	18	0	30
420 - 429	8	15	0	23
430 - 439	2	7	0	9
440 - 449	5	10	0	15
450 - 459	4	5	0	9
460 - 469	6	5	0	11
470 - 479	2	3	0	5
480 - 489	3	3	0	6
490 - 499	2	0	0	2
500 - 509	1	2	0	3
510 - 519	1	3	0	4
520 - 529	0	2	0	2
530 - 539	0	1	0	1
540 - 549	0	1	0	1
Totals	304	468	205	977

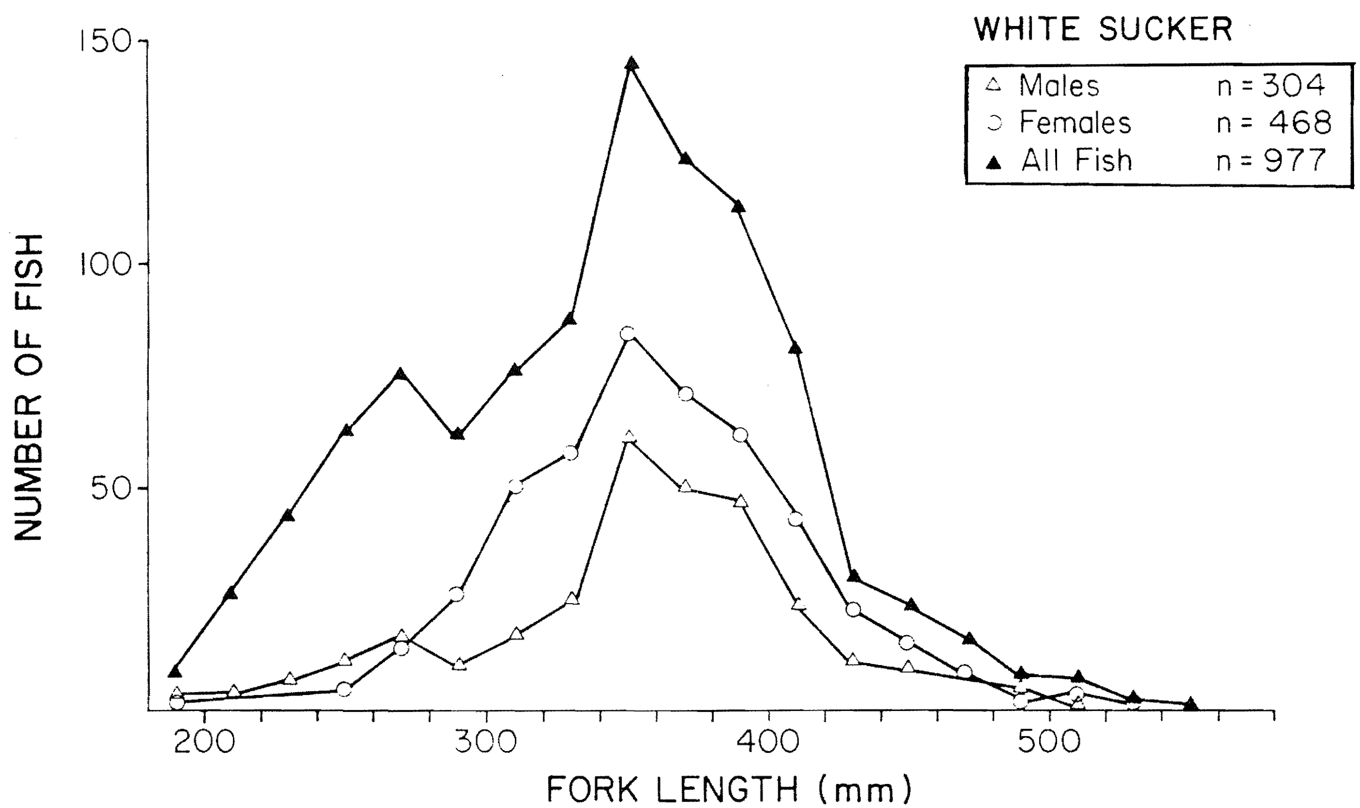

Figure 17. Length-frequency distribution for white suckers during the spring upstream migration in the Steepbank River, 1977.

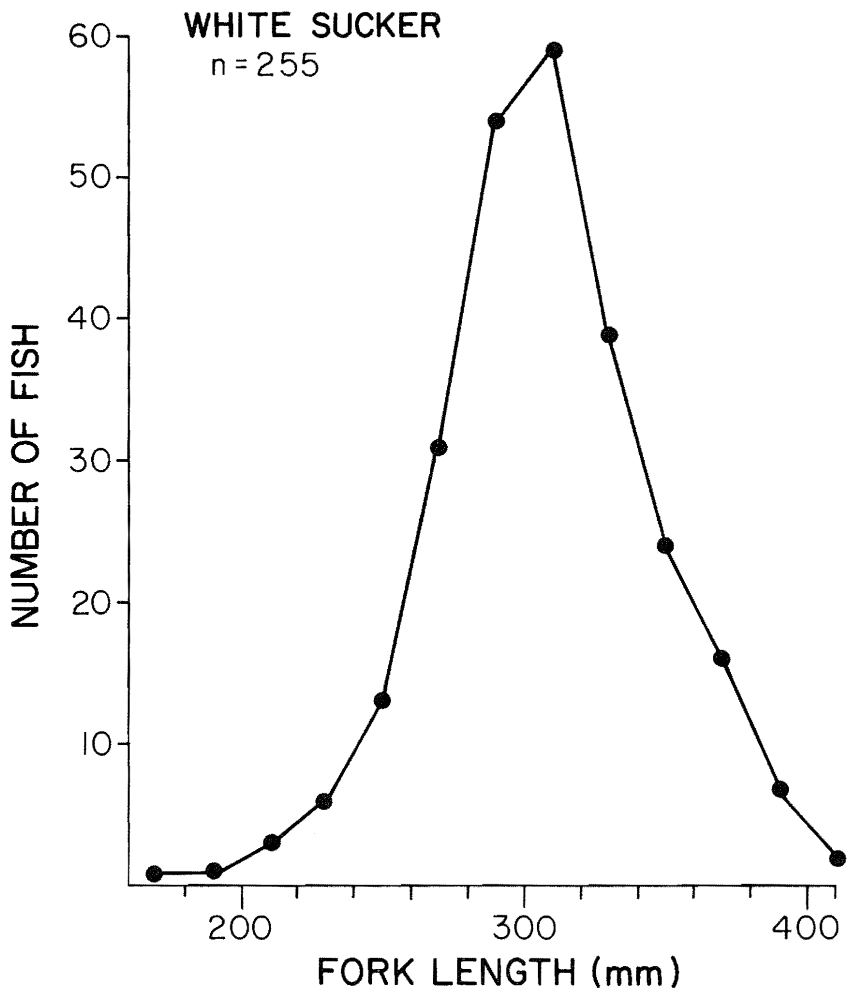

Figure 18. Length-frequency distribution for white suckers during the fall downstream migration in the Steepbank River, 1977.

and Machniak 1977). The age composition reflects the lack of larger and older suckers in the Steepbank River spawning run. In contrast, the Muskeg River runs (1976 and 1977) were comprised of large suckers (400 to 587 mm) that ranged in age from seven to 17 years as well as the younger and smaller size groups of suckers observed in the Steepbank River (Bond and Machniak 1977, in prep.).

5.4.3.9 Sex ratio of migrant white suckers. Sex was determined for 772 white suckers during the upstream migration and 61% were females (Table 35). This represents a significant deviation ($X^2 = 34.75$, $P < 0.001$) from the 1:1 ratio. Females were more numerous (62%) than males in the Muskeg River in 1976 (Bond and Machniak 1977). However, in 1977 males (55%) outnumbered females (Bond and Machniak, in prep.).

The sex ratio during the upstream run varied with time, the early portion of the run being dominated by males and the latter by females (Table 35). A similar situation was reported for runs monitored by Geen et al. (1966), Bond (1972), and Bond and Machniak (1977, in prep.). The ratio of males to females in the descending run indicated no clear pattern for returning white suckers (Table 36).

5.4.3.10 Sex and maturity. Fifty-one percent of the white suckers aged and sexed (n = 72) were females (Table 37). The earliest age at sexual maturity was four years for female white suckers and five years for males (Table 37). The youngest ages at maturity reported for white suckers are two to three years (Lalancette 1976) and age three to four (Spoor 1938; Beamish 1973; Bond and Machniak 1977).

5.4.3.11 Fecundity. Ovaries were removed from four female white suckers in spawning condition and fecundity estimated gravimetrically. The estimated total number of eggs per female (size range 344 to 487 mm) ranged from 20 733 to 52 051 (Table 38) with an average of 32 420 per female. Bond (1972) reported a range of 15 983 to 60 242 with an average of 34 502 eggs per female.

Length-relative fecundity ranged from 524.9 to 1068.8

Table 35. Sex ratio for white suckers during the upstream migration, Steepbank River, 1977.

Date	Number of Fish				Percent Males[a]
	Males	Females	Unknown	Total	
25 April	0	8	0	8	0
26	6	4	3	13	60
27	5	9	2	16	36
28	26	21	11	58	55
29	21	21	16	58	50
30	0	3	3	6	0
1 May	10	26	6	42	28
2	44	65	29	138	40
3	33	43	10	86	43
4	36	55	13	104	40
5	37	53	14	104	41
6	12	25	14	51	32
7	20	20	12	52	50
8	14	32	5	51	32
9	5	5	6	16	50
10	9	16	15	40	36
11	9	11	13	33	45
12	4	4	8	16	50
13	0	6	7	13	0
14	2	1	1	4	67
15	2	1	2	5	67
16	1	2	0	3	33
17	1	1	1	3	50
18	0	0	0	0	0
19	0	3	0	3	0
20	2	3	1	6	40
21	2	4	1	7	33
22	1	5	8	14	17
23	1	6	4	11	14
24	1	5	2	8	17
25	0	2	5	7	0
26	0	6	1	7	0
27	1	3	1	5	25
28	0	0	3	3	0
29	0	0	1	1	0
Totals	305	469	218	992	
%	39	61			

[a] Based on fish of known sex.

Table 36 . Sex ratio for white suckers during the downstream migration, Steepbank River, 1977.

Date	Number of Fish				Percent Females[a]
	Males	Females	Unknown	Total	
11 May	8	5	4	17	38
12	7	11	4	22	61
13	5	8	2	15	62
14	3	3	2	8	50
15	3	1	1	5	25
16	0	1	0	1	100
17	3	3	3	9	50
18	9	3	3	15	25
19	7	2	2	11	22
20	1	7	3	11	88
21	3	3	0	6	50
22	1	0	0	1	0
23	2	2	1	5	50
24	0	2	0	2	100
25	0	0	0	0	0
26	0	1	0	1	100
27	0	0	0	0	0
28	0	3	2	5	100
Totals	52	55	27	134	

[a] Based on fish of known sex.

Table 37. Age-specific sex ratios and maturity for white suckers captured in the Steepbank River, 1977.

Age	Females			Males			Unsexed Fish	Total
	N	%	% Mature	N	%	% Mature		
1	12	80	0	3	20	0	2	17
2	0	0	0	0	0	0	0	0
3	2	67	0	1	33	0	2	5
4	5	45	20	6	55	0	4	15
5	7	30	29	16	70	44	0	23
6	6	75	50	2	25	100	0	8
7	1	17	100	5	83	100	0	6
8	0	0	0	1	100	100	0	1
9	0	0	0	1	100	100	0	1
10	0	0	0	0	0	0	0	0
11	4	100	100	0	0	0	0	4
Totals	37	51%		35	49%		8	80

Table 38. Fecundity estimates for four white suckers sampled during the 1977 Steepbank River spawning migration.

Fork Length (mm)	Weight (g)	Total Number of Eggs	Relative Fecundity	
			(cm)	(g)
344	610		677.2	38.2
395	800		524.9	25.9
423	1050		794.3	32.0
487	2020		1068.8	25.8

ova per cm of fork length while weight-relative fecundity varied from 25.8 to 38.2 eggs per gram of body weight.

5.4.3.12 Egg size and gonad weight. The mean egg diameter for seven mature and ripe female white suckers was 1.6 mm (range 1.5 to 1.9 mm). Average egg diameter for 14 females in the Bigoray River (Bond 1972) was 1.5 mm (range 1.4 to 1.8 mm). The egg size of a maturing female caught in October in the Steepbank River was 1.2 mm.

For spawning females (n = 7) in the Steepbank River, the mean ovary weight was equivalent to 10.5% of body weight (range 7.0 to 16.9%), and for spent females (n = 2) 1.1%. Bond (1972) found the ovaries comprised on the average 11.8% of the body weight just prior to spawning.

Testis weight of spawning males (n = 6) average 4.8% body weight (range 4.2 to 5.8%) and for spent males (n = 30) 0.8% with a range of 0.6 to 1.3%. Males in Colorado had an average 8% weight loss at spawning while females lost 14% of their body weight (Bassett 1957).

5.4.3.13 Growth. Growth in length and weight (Table 39) appears similar to that reported for white suckers in the Muskeg River (Bond and Machniak 1977, in prep.). Because of the lack of older fish in the Steepbank sample growth differences between males and females were not apparent. Bond and Machniak (1977, in prep.) found significant sexual differences in length at age among older fish (age groups 7 to 14) in the Muskeg River. A similar difference but among younger fish was recorded by Verdon and Magnin (1977) in Lac Croche, Quebec, where females were significantly larger than males at age 3 and ages 5 to 7 inclusive. Other investigators have also noted that females grow faster than males, achieve larger sizes and live longer (Spoor 1938; Raney and Webster 1942; Smith 1952; Hayes 1956; Lalancette 1973).

5.4.3.14 Length-weight relationship. The following length-weight relationships were determined from white suckers captured during the counting fence operation. Both upstream and downstream

Table 39. Age-length relationship (derived from fin rays and otoliths) and age-weight relationship for white suckers captured in the Steepbank River watershed, 1977, sexes combined (includes unsexed fish).

Age	Fork Length (mm)			Weight (g)			Male	Female	Total
	Mean	S.D.	Range	Mean	S.D.	Range			
1	51.2	8.29	36-61	1.6	0.64	0.5-2.5	3	12	17
2	ND[a]			ND			0	0	0
3	191.8	7.79	181-201	106.0	52.95	76-200	1	2	5
4	257.1	44.16	203-344	227.9	149.09	80-610	6	5	15
5	313.7	29.51	257-395	410.1	140.58	220-800	16	7	23
6	358.5	30.06	290-390	621.9	168.82	280-890	2	6	8
7	410.0	32.66	371-445	971.7	271.40	670-1240	5	1	6
8	418.0			1160.0			1	0	1
9	394.0			850.0			1	0	1
10	ND			ND			0	0	0
11	440.3	32.14	416-487	1347.5	492.03	920-2020	0	4	4
Totals							35	37	80

[a] No data.

fish are included. For male white suckers (n = 32, r = 0.995, range 188 to 418 mm) the relationship between fork length and body weight is described by the equation:

$$\log_{10} W = 3.3371 (\log_{10} L) - 5.7316; sb = 0.0585$$

For female white sucker (n = 25, r = 0.952, range 181-487 mm) the length-weight relationship is expressed by the equation:

$$\log_{10} W = 2.8807 (\log_{10} L) - 4.5639; sb = 0.1929$$

Analysis of covariance indicated a significant difference ($P < 0.05$) between slopes (F = 5.185), but not the adjusted means (F = 1.508) of the length-weight relationships of male and female white suckers.

5.4.3.15 Growth of young-of-the-year. Geen et al. (1966) reported an egg incubation time of eight days at 11°C, and that newly hatched suckers remained in the gravel for a period of one to two weeks prior to commencing downstream migration. By mid-June 1977, sucker fry were abundant in the lower reach of the Steepbank River. The majority of fry had a modal length of 12 mm while a few suckers ranged in length from 16 to 21 mm (Figure 15). These larger fry are thought to be white suckers. About a month after spawning, Geen et al. (1966) found two size groups of fry, those from 10 to 12 mm being largely longnose suckers and those from 12 to 14 being, for the most part, white suckers. A somewhat similar bimodal distribution was observed in 1976 and 1977 in the Muskeg River (Bond and Machniak in prep.).

By July, young-of-the-year white suckers (n = 22) had a mean fork length of 29.4 mm (range 25 to 36 mm). Fork length increased to 35.9 mm by 13 August and four fish taken 13 October averaged 37.5 mm, suggesting a decline in growth rate in late summer (Table 30). Bond and Berry (in prep.b) reported that most of first year's growth was completed by late August with young-of-the-year suckers having mean fork lengths of 43.4 mm (range 33 to 67 mm) and 46.8 mm (range 35 to 68 mm) in September and October respectively. White suckers in the Bigoray River, Alberta, completed 93%

of their first year's growth by 20 August (Bond 1972). Growth of white sucker fry in the AOSERP study area appears to be rather slow in comparison to some other areas. Hubbs and Creaser (1924) reported that sucker fry in Douglas Lake, Michigan, attained an average length of 72 mm by September; whereas in Gamelin Lake, Quebec (Lalancette 1976) fish measured 76.2 mm in October and continued to grow until December. Growth appears to be similar to that reported for Assumption Lake, Quebec (Fortin 1967) and Waskesiu Lake, Saskatchewan (Campbell 1935) where suckers averaged 56.2 mm in length on 10 October and 55.2 mm on 5 September respectively.

5.4.3.16 Food habits. Thirty-eight white sucker stomachs were examined in the field during the spring operation. Of these, 35 were empty or contained only traces of food, the remainder were one-half full to full of digested matter. Three adult sucker stomachs were analyzed in the laboratory and were found to contain mainly Diptera larvae (Chironomidae and Simuliidae) and Ephemeroptera nymphs. Other food items noted were Hymenoptera, Odonata nymphs, and Arachnida (Table 20). Bond (1972) reported that 60% of adults examined in the Bigoray River contained some food and that adult suckers fed almost exclusively on immature insects (Chironomidae, Simuliidae, Trichoptera, and Ephemeroptera).

Eight young-of-the-year and age 1+ white suckers were examined for food habits (Table 31). Seven of the fish stomachs contained partially digested matter while one sucker contained chironomid larvae, insect remains, and some vegetation. Young-of-the-year sucker in Gamelin Lake, Quebec, fed mainly on zooplankton (Cladocera and Copepoda) while age one and older suckers consumed crustaceans, insects, and vegetation (Lalancette 1977a). Bond (1972) found that small suckers fed mainly on chironomid larvae, small Crustacea, rotifers, diatoms, and desmids.

5.4.4 Mountain Whitefish

5.4.4.1 Seasonal movements. A total of 503 mountain whitefish were counted through the upstream trap during the spring fence operation (Table 10). Although the upstream migration peaked on 11 May, when 43 whitefish were passed through the trap, the major movement of mountain whitefish (42%) occurred between 28 April and 6 May. A secondary influx of whitefish (31%) entered the trap between 17 and 26 May. Mountain whitefish tended to move upstream during daylight hours at the time of rising water temperatures. The largest catches (80%) were recorded between 0900 and 1800 hours (Table 40). There was no distinct downstream movement of mountain whitefish during the period of fence operation as only 55 fish were recorded in the downstream trap (Table 10).

In the fall fence operation, only six mountain whitefish were captured in the downstream trap, suggesting that most whitefish had left the Steepbank River at some time during the summer. Davies and Thompson (1976) observed a complex movement pattern for mountain whitefish in the Sheep River, Alberta, involving spring feeding, summer feeding, prespawning, spawning, and post-spawning-overwintering movements. They found whitefish migrate into tributary streams during the spring for feeding purposes and leave in June. Similarly, studies on the Muskeg River (Bond and Machniak 1977) indicate mountain whitefish remain in the stream until July, the majority (61%) leaving between 1 and 13 June. Davies and Thompson (1976) note whitefish move back into the larger rivers during June when stream temperatures rise and water levels decline in the smaller tributaries. Some stream-dwelling populations, however, remain in tributaries all summer. In Idaho (Pettit and Wallace 1975), mountain whitefish move into tributaries during late spring and early summer, remain in the upper reaches until spawning in November, then, with completion of spawning, return downstream to overwinter in the deeper pools of large rivers.

5.4.4.2 Spawning. Mountain whitefish generally spawn during late fall or early winter over a gravel and rubble substrate. Those in

Table 40. Summary of diel timing of the upstream movement of mountain whitefish in the Steepbank River, 1977.

Date	Number of Fish Counted at Each Trap Check						Total
	0900	1200	1500	1800	2100	2400	
26 April	0	ND [a]	0	3	0	ND	3
27	0	1	1	2	3	2	9
28	2	5	7	8	2	1	25
29	3	5	6	3	3	0	20
30	5	8	2	1	2	0	18
1 May	4	0	8	2	13	0	27
2	0	13	9	10	2	0	34
3	4	13	6	5	4	0	32
4	5	8	8	2	0	0	23
5	0	1	5	3	2	1	12
6	1	2	3	13	2	0	21
7	1	3	0	0	1	1	6
8	1	2	0	1	1	0	5
9	3	0	11	1	1	0	16
10	1	1	1	3	0	1	7
11	14	2	9	10	7	1	43
12	1	1	2	1	1	2	8
13	3	4	2	0	0	1	10
14	1	0	1	4	1	0	7
15	1	0	0	0	0	0	1
16	0	0	0	0	3	4	7
17	1	4	2	0	5	1	13
18	11	1	3	6	0	3	24
19	5	0	ND	ND	ND	5	10
20	4	ND	ND	4	2	2	12
21	6	2	4	0	4	1	17
22	12	5	7	1	0	1	26
23	5	ND	ND	4	4	0	13
24	ND	ND	6	3	2	2	13
25	ND	4	ND	1	1	0	6
26	ND	11	ND	8	1	0	20
27	ND	3	ND	2	2	2	9
28	ND	4	ND	2	0	ND	6
29	0	ND	Operations terminated				0
Totals	94	103	103	103	69	31	503
% Grand Total	18.7	20.5	20.5	20.5	13.7	6.2	

[a] No data.

Montana, spawn in October and early November at temperatures of 5.5°C or below (Brown 1952).

Spawning started as early as 29 September in the Sheep River and continued until 18 October, during which time water temperatures ranged from 8°C to 0°C (Thompson and Davies 1976).

Brown (1952) and Stalnaker and Gresswell (1974) reported that mountain whitefish prefer gravel to rock areas for spawning and that no nest preparation is undertaken. Water depths at spawning sites in the Sheep River ranged from 30.5 to 63.5 cm and average water velocities varied from 89.5 to 102.7 cm/s (Thompson and Davies 1976). The spawning substrate was composed of small rocks (5-10 cm) to very large rocks and rubble (30 to 50 cm in diameter).

The available literature indicates mountain whitefish spawn during the evening or night. In Montana, eggs deposited in late October or early November hatched in early March (Brown 1952).

The present study produced no evidence to suggest that mountain whitefish spawn in the Steepbank River. Only one juvenile fish (105 mm, age 1+) was captured in area 2 on 31 May and no spawning movements were observed during the fall.

Spawning areas of mountain whitefish in the AOSERP study area are at present unknown. Mountain whitefish apparently do not spawn in regions of the Athabasca River where lake whitefish are known to spawn (Jones et al. 1978), Griffiths (1973), however, reported large numbers of young-of-the-year mountain whitefish in the High Hill River as well as the Clearwater River during late August and September which suggests that spawning may occur in some tributaries of the AOSERP study area. Griffiths also found juvenile whitefish in an unnamed tributary of the Marguerite River, in the Firebag River watershed (Figure 1).

5.4.4.3 Length-frequency distribution. Mountain whitefish passing through the upstream trap ranged from 182 to 461 mm in fork length with the majority (68%) being between 250 and 330 mm (Figure 19).

5.4.4.4 Age and growth. A total of 96 mountain whitefish were sampled and aged from the Steepbank River. These fish ranged in

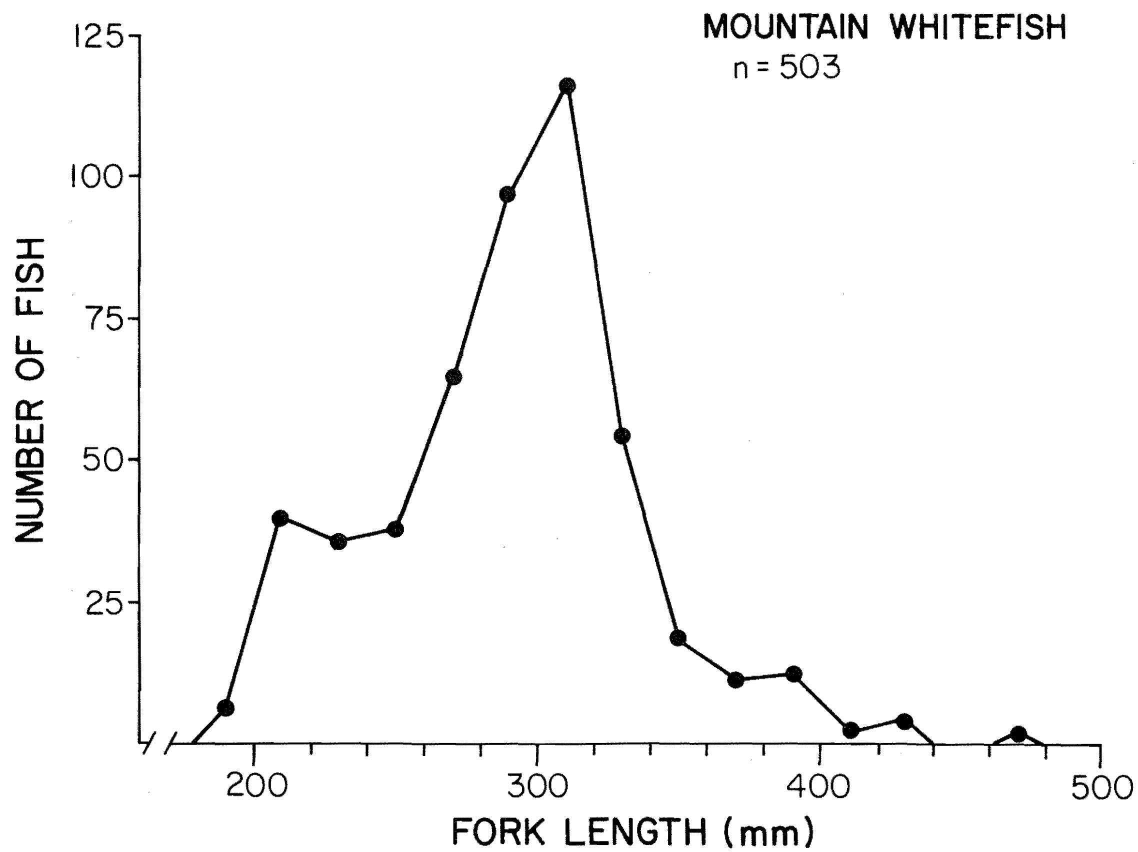

Figure 19. Length-frequency distribution for mountain whitefish captured in the Steepbank River, 1977.

fork length from 105 to 413 mm and in age from one to eight years (Table 41).

Maximum ages reported elsewhere for mountain whitefish are: 17 to 18 in Bow Lake, Alberta (McHugh 1942), age 16 in Rock Lake, Alberta (Lane 1969) and Phelps Lake, Wyoming (Hagen 1970), and age 14 in Clearwater River, Idaho (Pettit and Wallace 1975). Ages recorded for stream-dwelling whitefish are generally younger than those of lake populations. Pettit and Wallace (1975) noted that most fish were under age 10 in Idaho, Brown (1971) reported a maximum age of eight in Montana, and Thompson and Davies (1976) recorded a maximum age of eight years in the Sheep River.

Growth in fork length was rapid for the first four years of life (Table 41) with a mean fork length of 290 mm being reached by age 4. Although females tended to be slightly larger than males of the same age for ages 2,4, and 5 (Table 41), there were no significant differences between the sexes (Student's t-test). Other investigators have also found no difference in growth rates between male and female mountain whitefish (McHugh 1942; Hagen 1970; Thompson and Davies 1976).

Where sample sizes permitted, mean weight at each age for male and female whitefish were compared but no significant differences were found (Table 42). Thompson and Davies (1976) reported a similar situation for Sheep River whitefish.

Growth of Steepbank River mountain whitefish is rapid (Figure 20) although not as fast as that of whitefish under favourable conditions in Montana (Brown 1971). Stream-dwelling mountain whitefish (Brown 1971; this study; Pettit and Wallace 1975; Thompson and Davies 1976) appear to grow considerably better than most reported lake-dwelling whitefish in Alberta (Rawson and Elsey 1950; Lane 1969).

5.4.4.5 Sex and maturity. Age and sex were determined for 83 mountain whitefish of which 52% were females (Table 43). However, the sex ratio did not differ significantly from unity ($X^2 = 0.108$, $P > 0.05$). The earliest age of sexual maturity was two years for males and three years for females. Thompson and Davies (1976) found

Table 41. Age-length relationship (derived from scales) for mountain whitefish captured in the Steepbank River, 1977, sexes separate and combined sample (includes unsexed fish).

Age	Males				Females				All Fish				t-test
	N	Mean	S.D.	Range	N	Mean	S.D.	Range	N	Mean	S.D.	Range	
1	0	ND			1	105.0			1	105.0			
2	8	214.1	10.38	199-233	5	215.4	6.19	205-220	24	211.0	15.34	170-233	0.251
3	6	251.0	16.84	227-273	11	249.8	11.77	230-265	19	256.5	29.11	227-265	0.173
4	22	288.5	14.73	264-316	10	293.9	17.89	272-329	32	290.2	15.70	264-329	0.899
5	2	296.5	14.85	286-307	10	317.1	10.91	308-345	12	313.7	13.48	286-345	
6	1	365.0			3	360.7	13.05	347-374	4	361.8	10.87	347-373	
7	0	ND			2	383.0	15.56	372-394	2	383.0	15.56	372-394	
8	1	413.0			1	403.0			2	408.0	7.07	403-413	
Totals	40				43				96				

Table 42. Age-weight relationship for mountain whitefish captured in the Steepbank River, 1977, sexes separate and combined sample (includes unsexed fish).

Age	Males				Females				All Fish				t-test
	N	Mean	S.D.	Range	N	Mean	S.D.	Range	N	Mean	S.D.	Range	
1	0	ND			1	12.0			1	12.0			
2	8	116.8	24.26	98-160	5	114.2	11.54	98-129	24	107.4	25.18	58-160	0.222
3	6	177.3	48.27	101-250	11	181.1	40.02	115-183	19	181.4	40.41	101-250	0.174
4	22	288.5	52.57	190-409	10	308.0	61.97	220-400	32	294.6	55.42	190-409	0.920
5	2	320.0	14.14	310-330	10	388.1	56.30	345-530	12	376.8	57.57	310-530	
6	1	560.0			3	580.0	62.45	510-630	4	575.0	51.96	510-630	
7	0	ND			2	750.0	42.43	720-780	2	750.0	42.43	720-780	
8	1	958.0			1	940.0			2	949.0	12.73	940-958	
Totals	40				43				96				

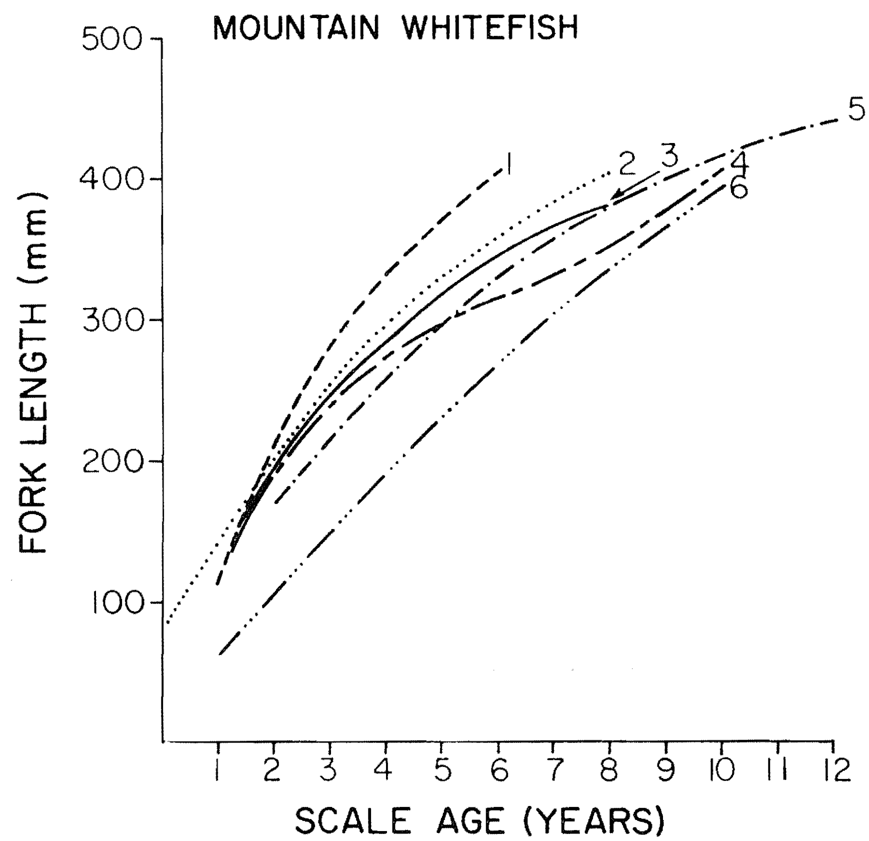

Figure 20. Growth in fork length for mountain whitefish from the Steepbank River and from several other areas. 1. Montana streams (Brown 1971), 2. Steepbank River (present study), 3. Sheep River Alberta (Thompson and Davies 1976), 4. Kelly Creek, Idaho (Pettit and Wallace 1975), 5. Rock Lake, Alberta (Lane 1969), and 6. Pyramid Lake, Alberta (Rawson and Elsey 1950).

Table 43. Age-specific sex ratios and maturity for mountain whitefish from the Steepbank River, 1977.

Age	Females			Males			Unsexed Fish	Total
	N	%	% Mature	N	%	% Mature		
1	1	100	0	0	0	0	0	1
2	5	38	0	8	62	13	11	24
3	11	65	73	6	35	67	2	19
4	10	31	70	22	69	77	0	32
5	10	83	90	2	17	100	0	12
6	3	75	100	1	25	100	0	4
7	2	100	100	0	0	0	0	2
8	1	50	100	1	50	100	0	2
Totals	43	52%		40	48%		13	96

that the earliest age of sexual maturity was two years for Sheep River whitefish with most fish being mature by age 4.

5.4.4.6 Length-weight relationship. A comparison of length-weight relationships indicated no significant difference ($P > 0.05$) between male and female mountain whitefish in slope ($F = 0.254$) or elevation ($F = 0.026$). Therefore, the data for the two sexes were combined (includes unsexed fish).

For mountain whitefish ($n = 96$, $r = 0.988$, range 105 to 413 mm) the relationship between fork length and body weight is described by the equation:

$$\log_{10} W = 3.2104 (\log_{10} L) - 5.4434; \; sb = 0.0522$$

5.4.4.7 Food habits. A total of 74 mountain whitefish stomachs were examined in the field during the spring and fall fence operations. Of these, 65% were empty or contained only traces of food, 31% were one-quarter to three-quarters full and only 4% were full. The identifiable contents consisted mainly of aquatic insects (Notonectidae, Corixidae, and Trichoptera). One juvenile mountain whitefish had fed on Simuliidae and Ephemeroptera (Table 31).

The mountain whitefish is primarily a bottom feeder (McHugh 1942), the most important food being immature aquatic insects. The diet of whitefish in the Sheep River consisted principally of Diptera, Ephemeroptera, Trichoptera, and terrestrial invertebrates (Thompson and Davies 1976). In the Snake River, Wyoming, whitefish fed heavily on Chironomidae (Diptera) and Trichoptera (Pontius and Parker 1973). Jones et al. (1978). reported a diet consisting mainly of aquatic insects (Trichoptera larvae, and Plecoptera and Ephemeroptera nymphs) for mountain whitefish captured in the Athabasca River during the fall of 1977.

5.4.5 Northern Pike

5.4.5.1 Seasonal movements and distribution. A total of 237 northern pike were passed through the upstream trap during the spring fence operation (Table 10). The majority of fish (72%)

moved upstream between 3 and 14 May with the movement peaking on 10 May. Throughout the summer, northern pike seem to be confined to the lower reaches and mouth area of the Steepbank River. Angling results in 1977 indicate that most pike did not ascend more than 5 to 8 km upstream. Renewable Resources Consulting Services Ltd., however, reports capturing eight northern pike as far upstream as area 6 (Figure 2) in October 1975 (Lutz and Hendzel 1977).

Tagging results indicate that pike generally move around very little during the summer (Appendix 8.4). Similar observations on pike movement in the AOSERP study area have been made by Bond and Berry (in prep.a, in prep.b). Diana et al. (1977) noted that while pike appear to be sedentary, they actually do move about and revisit the same areas several times.

During the fall fence operation, 42 northern pike left the Steepbank River. The majority (62%) moved out between 6 and 11 October (Table 12).

5.4.5.2 Spawning. Northern pike usually spawn in April or early May, immediately following ice break-up, at water temperatures of 4.4 to 11.1°C (Scott and Crossman 1973). Spawning occurs in a variety of habitats in shallow water (< 50 cm) over submerged vegetation (Machniak 1975a). The Steepbank River drainage does not appear to contain suitable spawning areas for northern pike. Even though water levels were high, the necessary spawning substrate (vegetation) was not present.

Although there was a large upstream movement of pike into the Steepbank River during the early part of May, 36% of the fish sampled (n = 44) were immature males. Of the mature males (n = 19), two had not yet spawned, two were ripe, and 14 were spent. Seven mature females were captured and, of these, three were spawned out while four were in the process of resorbing their eggs.

No young-of-the-year pike were collected from the Steepbank River during 1977.

5.4.5.3 Length-frequency distribution. Pike captured in the spring upstream trap ranged in size from 292 to 750 mm with 91%

of the fish being in the 325 to 600 mm size range (Figure 21). Pike caught in the fall downstream trap (Figure 21) ranged in fork length from 346 to 654 mm. Bond and Berry (in prep.a, in prep.b) found that the majority (73%) of pike in the Athabasca River were between 320 and 619 mm long.

5.4.5.4 Age and growth. Pike sampled from the Steepbank River ranged in age from two to seven years, and in weight from 153 to 2170 g. The majority of fish (68%) were three or four years old (Table 44).

The growth rate of northern pike is rapid and compares favourably with that reported in the previous studies on pike in the AOSERP study area (Griffiths 1973; McCart et al. 1977; Bond and Machniak 1977, in prep.; Bond and Berry in prep.a, in prep.b; Jones et al. 1978). Female northern pike in the study area grow faster than males (Bond and Berry in prep.a; Bond and Machniak in prep.).

5.4.5.5 Sex and maturity. Of 42 northern pike for which age and sex was determined, 83% were males (Table 44). Overall, male and female northern pike occurred in equal numbers in the Athabasca River (Bond and Berry in prep.a) while Jones et al. (1978) reported female pike (58%) outnumbered males in the late fall.

In the Steepbank River, the earliest age at which mature fish were observed was three years for males and four years for females. Previous studies in the AOSERP study area have found similar ages at maturity and that males mature earlier than females.

5.4.5.6 Length-weight relationship. The length-weight relationship for northern pike (n = 45, r = 0.986, range 272 to 653 mm) captured in the Steepbank River is described by the equation:

$$\log_{10} W = 3.0566\ (\log_{10} L) - 5.3172;\ sb - 0.0799$$

5.4.5.7 Food habits. A total of 43 northern pike stomachs were examined in the field. Of these 56% were empty or contained just a trace of food, 21% were one-quarter to three-quarters full and the

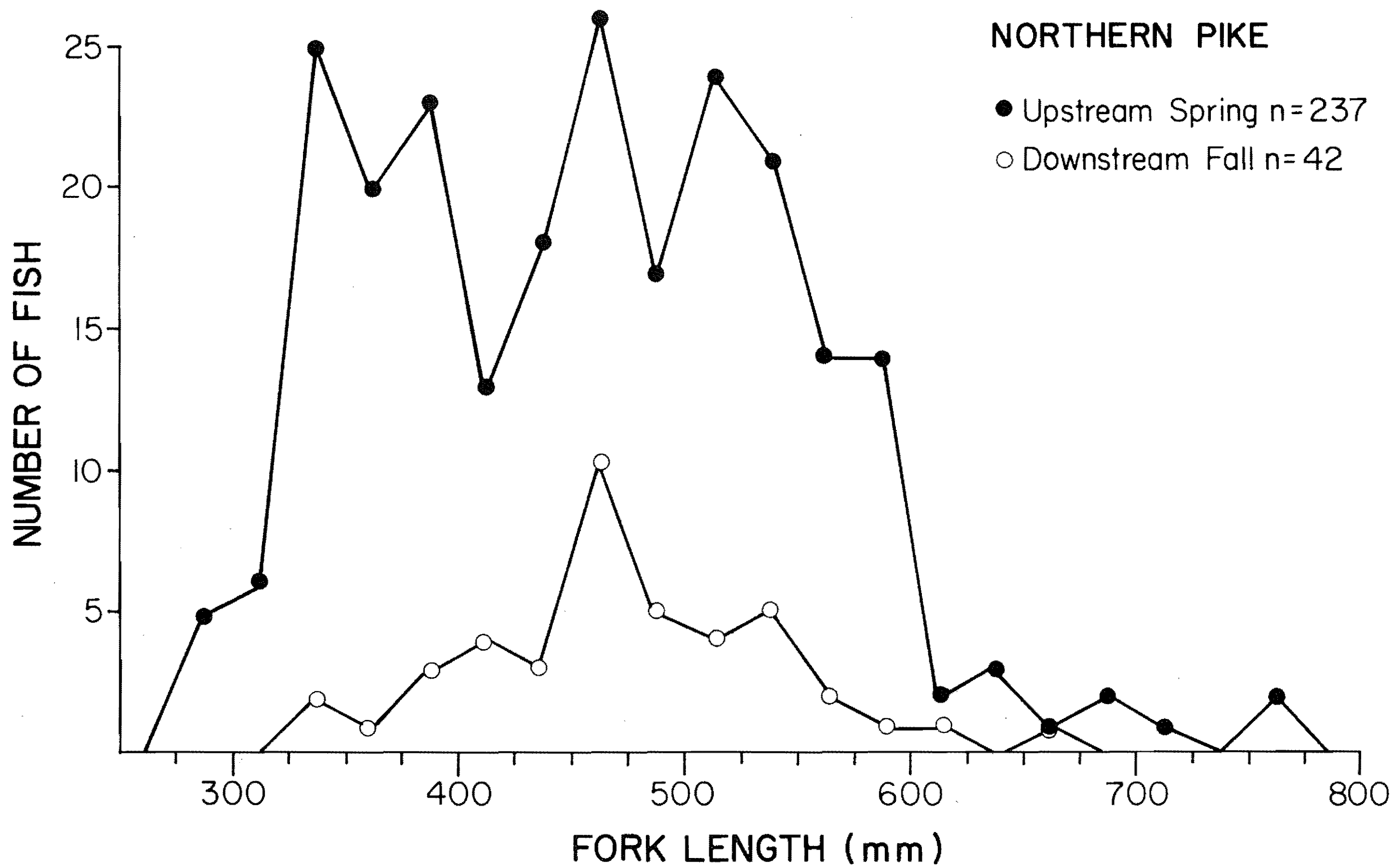

Figure 21. Length-frequency distribution for northern pike during the spring upstream and fall downstream migrations in the Steepbank River, 1977.

Table 44. Age-length relationship (derived from scales) and age-weight relationship for northern pike captured in the Steepbank River, 1977, sexes combined (includes unsexed fish).

Age	Fork Length (mm)			Weight (g)			Number of Fish		
	Mean	S.D.	Range	Mean	S.D.	Range	Male	Female	Total
2	295.3	23.60	272-328	182.3	39.18	153-240	3	0	4
3	340.1	22.85	300-386	268.2	67.31	190-433	20	0	20
4	419.7	32.52	366-476	491.6	141.54	346-770	8	2	10
5	479.8	43.50	434-543	780.0	258.36	337-1180	3	1	5
6	549.5	34.65	525-574	1315.0	403.05	1030-1600	0	2	2
7	624.3	43.73	574-653	1676.7	516.37	1140-2170	1	2	3
Totals							35	7	44

remainder (23%) were full. Fish remains (mountain whitefish, lake chub, longnose and white sucker, burbot, longnose dace, trout-perch, and brook stickleback) comprised most of the food volume. A few pike contained aquatic insects (Odonata and Coleoptera). Other investigators in the study area have reported a similar piscivorous habit with fish comprising up to 95% of the food volume (Bond and Berry in prep.a).

5.4.6 Walleye

5.4.6.1 Seasonal movements and distribution. A total of 222 walleye were counted through the upstream trap during the spring operation (Table 10). The first upstream walleye was captured on 2 May, but the majority were taken between 9 and 13 May (46%) and from 20 to 25 May (29%). Eighty-five walleye had returned through the downstream trap by 29 May, with most (49%) being taken between 12 and 15 May (Table 10). Only three walleye were counted through the fall downstream trap.

Lutz and Hendzel (1977) reported the capture of three walleye in Area 6 (Figure 2) in October 1975. There is a possibility, therefore, that some walleye remained in the Steepbank River beyond the time of the fall fence operation (15 October). However, it is believed that most walleye returned to the Athabasca River in late spring or early summer.

Tagging results from this and other studies (Bond and Berry in prep.a, in prep.b). indicate that walleye in the AOSERP study area tend to move considerable distances during the course of the year. One walleye, tagged in the Steepbank River, was recaptured in Lake Athabasca, having travelled 288 km downstream in 28 days. Another walleye had moved 403 km upstream in the Athabasca River in approximately 113 days (Appendix 8.4).

5.4.6.2 Spawning. Walleye normally spawn at ice break-up over a water temperature range of 5.6 to 11.1°C (Scott and Crossman 1973). Machniak (1975b) observed that walleye have been reported to spawn on a wide variety of substrata but appear to prefer clean gravel at depths less than 1.5 m. Bond and Berry (in prep.b) reported that a walleye spawning migration was underway in the Athabasca River in mid-April 1977 and that the first spent female was taken on 1 May. They also reported that water temperatures in the Athabasca River had reached 13°C by the first week of May, which would suggest that spawning had finished by that time.

As mentioned previously, no walleye were captured in the Steepbank River until 2 May 1977, and most of those captured moving upstream were taken after 9 May. Virtually all walleye (99%) taken at the upstream trap were males. Some of these were immatures but most were recently spent and still expressed milt upon application of pressure to the abdomen. The presence of spent males and the absence of females indicates that the upstream migration in the Steepbank River was of a post-spawning nature. Machniak (1975b) noted that male walleye often remain in the vicinity of the spawning area longer than the females.

Although the locations of walleye spawning sites in the AOSERP area have not been identified, the occurrence of recently spent males in the Steepbank River as early as 2 May suggests that spawning occurred nearby. The authors suspect that walleye spawn in the rapids area of the Athabasca River upstream of Fort McMurray and possibly in the Clearwater River. Lake whitefish have been documented as spawning in the fall below Mountain and Cascade rapids, upstream of Fort McMurray (Jones et al. 1978). Machniak (1975b) noted that some lake whitefish and walleye populations often spawn in similar areas.

Young-of-the-year walleye are often captured around the mouth of the Steepbank River (McCart et al. 1977; Bond and Berry in prep.a, in prep.b). However, walleye fry are commonly found in most tributary mouths within the AOSERP study area during the early summer. It appears that such areas afford ideal habitat for the feeding and rearing of young walleye.

5.4.6.3 Length-frequency distribution. Walleye ranged in fork length from 230 to 547 mm, the majority (92%) falling in the 300 to 400 mm size group (Figure 22). Bond and Berry (in prep.a, in prep.b)

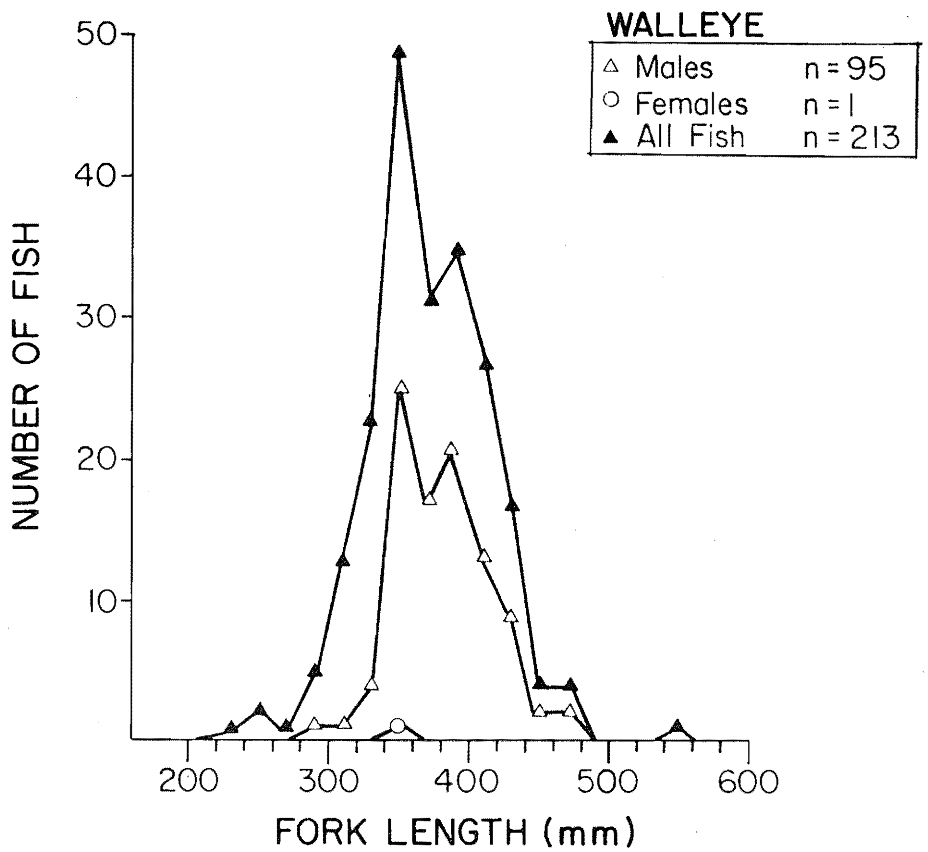

Figure 22. Length-frequency distribution for walleye from the Steepbank River, 1977.

reported the majority of walleye (82%) in the Athabasca River were between 300 and 499 mm in size.

5.4.6.4 Age and growth. Seventy-four percent of the walleye aged ($n = 34$) were three or four years old, the oldest being age 6 (Table 45). Bond and Berry (in prep.a, in prep.b) found that, in 1976 and 1977, walleye in age groups 4 to 8 inclusive comprised 76% and 85% of the Athabasca River catch respectively. Maximum age recorded for walleye in the AOSERP study area is 15 years (Bond and Machniak 1977; Kristensen and Pidge 1977; Jones et al. 1978).

The age-length relationship (Table 45) indicates that growth of walleye is rapid and compares favourably with that reported for walleye in previous studies in the AOSERP area (Kristensen et al. 1976; Kristensen and Pidge 1977; Bond and Berry in prep.a, in prep.b). The latter authors found female walleye tended to be larger than males of the same age both in fork length and weight.

5.4.6.5 Sex and maturity. Age and sex were determined for 32 walleye, all of which were males (Table 45). The earliest age at which males mature was three years (37.5%). At age 4, 80% of males were mature. Bond and Berry (in prep.a) noted that males tended to mature at a younger age than females, the youngest mature male being age 3.

5.4.6.6 Length-weight relationship. The length-weight relationship for male walleye ($n = 34$, $r = 0.909$, range 200-440 mm) is described by the equation:

$$\log_{10} W = 2.2473 (\log_{10} L) - 3.0825; \ sb = 0.1821$$

The value of the exponent is considerably lower than that found for males in the Mildred Lake area by Bond and Berry (in prep.a, in prep.b).

5.4.6.7 Food habits. Thirty-three walleye stomachs were examined in the field during the spring fence operation. Twenty of these were empty, seven contained only a trace of food, four

Table 45. Age-length relationship (derived from scales) and age-weight relationship for walleye captured in the Steepbank River, 1977, sexes combined (includes unsexed fish).

Age	Fork Length (mm)			Weight (g)			Number of Fish		
	Mean	S.D.	Range	Mean	S.D.	Range	Male	Female	Total
2	200.0			220.0			1	0	1
3	314.9	18.65	283-350	303.4	50.45	220-440	8	0	9
4	349.0	16.28	314-380	420.0	59.67	330-490	15	0	16
5	405.8	30.99	353-428	700.0	175.50	430-880	5	0	5
6	425.3	18.90	404-440	743.3	98.66	630-810	3	0	3
Totals							32	0	34

were one-quarter to one-half full, and two stomachs were entirely full. Walleye stomachs contained fish remains (sucker spp., burbot, Arctic grayling, and trout-perch) with some insects (Odonata). Bond and Berry (in prep.a) found that walleye fed mainly on fish (80% of volume) and immature insects (Plecoptera, Odonata, and Ephemeroptera).

5.4.7 Lake Whitefish

5.4.7.1 Seasonal movements. A total of 39 lake whitefish were counted through the upstream trap during spring operations, 56% of which moved into the Steepbank between 9 and 15 May (Table 10). Only four whitefish had left the tributary by 29 May. Bond and Machniak (1977, in prep.) also observed that some lake whitefish migrated into the Muskeg River during the spring migrations of other species. Kendel (1975) noted that humpback (lake) whitefish moved into Giltana Creek, Yukon, during the same period as grayling and suckers. He observed that whitefish stomachs contained grayling and sucker eggs and suggested that this feeding activity might be the stimulus for their movement.

Lake whitefish appear to be confined to the lower reaches of the Steepbank River. Bond and Machniak (1977) reported a similar distribution for whitefish in the Muskeg River. Renewable Resources Consulting Services Ltd., however, reported capturing lake whitefish as far upstream as the North Steepbank in October 1975 (Lutz and Hendzel 1977).

No lake whitefish were captured during the fall fence operation suggesting that all lake whitefish had left the tributary during the summer.

5.4.7.2 Spawning. Lake whitefish spawn during October in the rapids area of the Athabasca River upstream of Fort McMurray (Jones et al. 1978). Information regarding pre- and post-spawning movements of lake whitefish in the AOSERP study area is contained in Jones et al. (1978) and Bond and Berry (in prep.b).

Only one young-of-the-year lake whitefish was captured in the Steepbank River in 1977. This fish was taken at the fence site on 10 July and measured 47 mm fork length.

5.4.7.3 Length-frequency distribution. Lake whitefish captured in the Steepbank River ranged in fork length from 285 to 470 mm although only two fish exceeded 370 mm (Figure 23).

5.4.7.4 Age and growth. Twenty-eight lake whitefish were aged and sexed, of which 86% were age 4 or 5 (Table 46). The oldest whitefish were age 7 females. Bond and Berry (in prep.a, in prep.b) noted that most whitefish (95%) in the Athabasca River were age 4 to 8 inclusive. The maximum age recorded for lake whitefish in the AOSERP study area is 13 years (Bond and Berry in prep.b; Jones et al. 1978).

A comparison of the age-length relationship (Table 46) for Steepbank River lake whitefish with those reported by other investigators (McCart et al. 1977; Bond and Berry in prep.a, in prep.b; Jones et al. 1978) indicates similar growth rates.

5.4.7.5 Sex and maturity. Female lake whitefish outnumbered males in the sample by 16 to 12 (Table 46), but the sex ratio was not significantly different from unity ($X^2 = 0.571$, $P > 0.05$). Previous studies in the area also report that the sexes occur in equal numbers.

The earliest age of sexual maturity appears to be four years for both male and female lake whitefish. Bond and Berry (in prep.a, in prep.b) reported a similar age of sexual maturity for whitefish in the Athabasca River.

5.4.7.6 Length-weight relationship. The length-weight relationship for lake whitefish (n = 28, r = 0.895, range 280 to 406 mm) samples from the Steepbank River is described by the equation:

$$\log_{10} W = 2.4988 (\log_{10} L) - 3.6367; \text{ sb} = 0.2441$$

5.4.7.7 Food habits. Twenty-eight lake whitefish stomachs were examined in the field during the spring fence operation and most (92%) were empty. The contents of the remainder consisted mainly

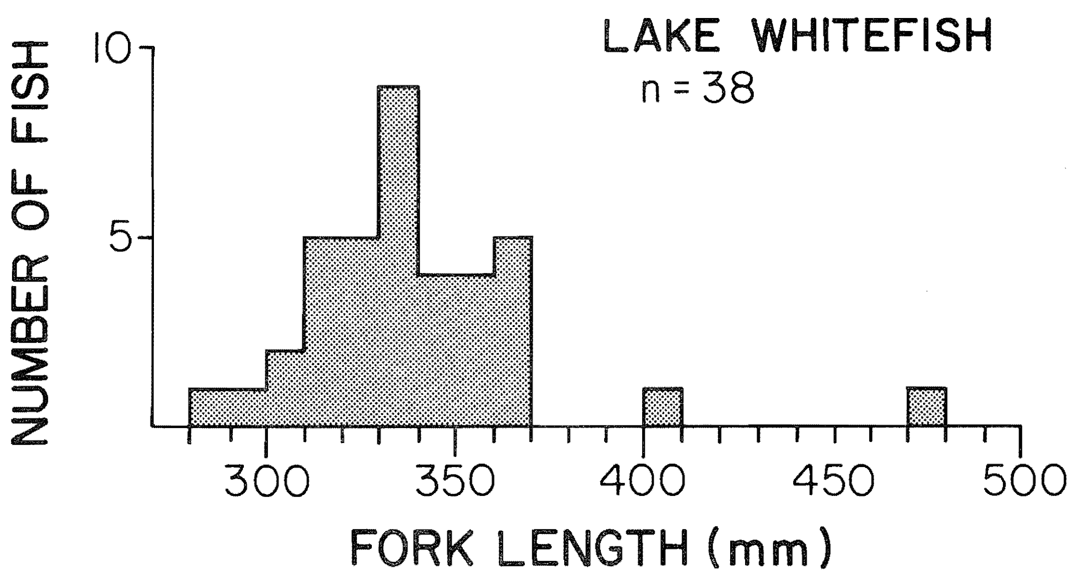

Figure 23. Length-frequency distribution for lake whitefish from the Steepbank River, 1977.

Table 46. Age-length relationship (derived from scales) and age-weight relationship for lake whitefish captured in the Steepbank River, 1977, sexes combined (includes unsexed fish).

Age	Fork Length (mm)			Weight (g)			Number of Fish		
	Mean	S.D.	Range	Mean	S.D.	Range	Male	Female	Total
4	316.1	16.18	280-338	410.2	59.83	310-510	3	12	15
5	343.0	11.50	331-361	494.2	43.54	420-540	7	2	9
6	361.0	1.41	360-362	615.0	63.64	570-660	2	0	2
7	397.0	12.73	388-406	730.0	282.84	530-930	0	2	2
Totals							12	16	28

of aquatic insects (Rhagionidae and Hemiptera) and molluscs (Pelecypoda and Gastropoda). Bond and Berry (in prep.a) found that aquatic insects made up 93% of the food volume of lake whitefish, while Jones et al. (1978) noted that, after spawning, most whitefish stomachs were full of whitefish eggs.

5.4.8 Burbot

5.4.8.1 Seasonal movements. Only two burbot were recorded at the upstream trap and seven at the downstream trap (Table 10) during spring fence operations. Six additional fish were taken in minnow traps in area 2 (Table 8). During the fall operation a total of three burbot were recorded at the upstream trap. However, 43 burbot (Table 12) were counted moving out of the Steepbank River, the majority (63%) leaving between 8 and 10 October. These fish (n = 41) ranged in total length from 281 to 583 mm (Figure 24). The size range indicates most of the burbot were immature fish that had probably spent the summer in the Steepbank River.

5.4.8.2 Spawning. Bond and Berry (in prep.b) suggested that burbot may spawn in the Mildred Lake area of the Athabasca River where large fish were common in early spring and fry appeared in June. It is speculated that burbot migrate from Lake Athabasca to spawn in the Athabasca River proper or its tributaries.

Sorokin (1971) observed that, in the U.S.S.R., burbot begin to migrate into small rivers and tributaries in September when water temperature falls to 10 to 12°C. Distance travelled may be considerable with some fish migrating up to 400 km. The migration of burbot to the spawning grounds can last from September through February with spawning occurring about the middle of January. After spawning there is a downstream migration of fish into the lower reaches of rivers. Sorokin (1971) noted that burbot spawned over stony bottoms in fairly deep areas around the mouths of streams and channels where water exchange is slow.

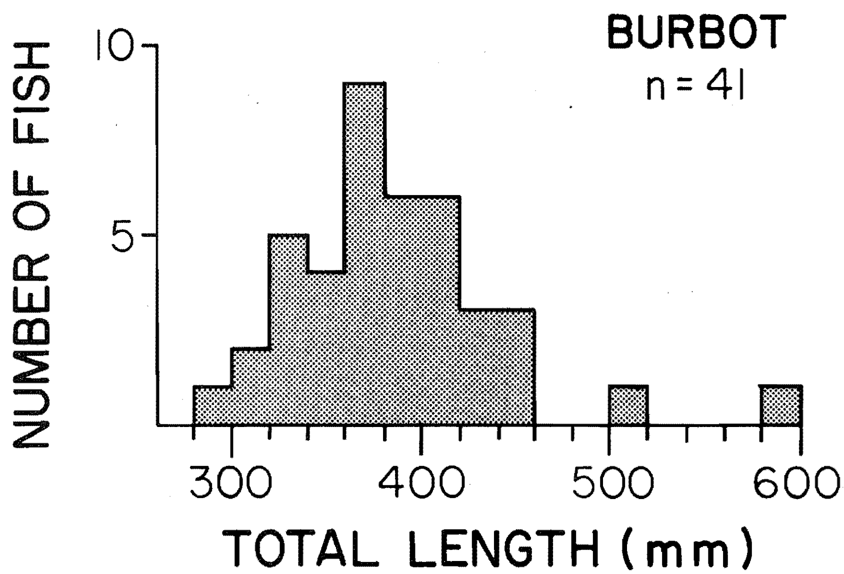

Figure 24. Length-frequency distribution for burbot from the Steepbank River, 1977.

5.4.8.3 Age and growth. Thirteen burbot were aged and nine fish were sexed (Table 47). The youngest fish were two burbot fry and the oldest was a maturing 6 year old male, 448 mm in total length. Six of the nine burbot sexed were males. Jones et al. (1978) recorded a maximum age of 12 years for the AOSERP sudy area.

5.4.8.4 Food habits. Five burbot stomachs were examined in the field. Four of these were empty or contained traces of insects, while one was full of unidentified fish remains. One juvenile burbot (Table 31) contained Trichoptera nymphs and digested material. Bond and Berry (in prep.a) found young burbot fed on immature aquatic insects.

5.4.9 Other Larger Fishes

5.4.9.1 Dolly Varden. Four Dolly Varden were captured at the upstream trap between 15 and 26 May (Table 10). Three of these fish were aged and sexed (Table 47) and found to be 3 years old (fork length range 177 to 223 mm). All three fish (two females and one male) were immature.

One Dolly Varden (fork length 247 mm) was captured at the upstream trap on 15 September. Four Dolly Varden were recorded at the downstream trap on 16 September and on 1, 6, and 10 October (Table 12). The first three fish measured 235, 294, and 327 mm respectively while the last one taken and tagged was 338 mm.

Dolly Varden are common in the headwaters of the Peace, Athabasca, Red Deer, Bow, and Oldman drainages (Paetz and Nelson 1970). Maturity is usually reached in the fifth year and spawning occurs in the fall. Their occurrence in the AOSERP area is rare although several were taken in the Muskeg River (Bond and Machniak in prep.) and Athabasca River (Bond and Berry in prep.b) during 1977.

5.4.9.2 Goldeye. Seven goldeye (range 266 to 296 mm) were taken at the upstream trap on 11 May. The five fish (four females) for which age and sex were determined (Table 47) were found to

Table 47. Age-length and age-weight relationships, age-specific sex ratios, and maturity of minor species captured from the Steepbank River, 1977.

Species/Age	Females			Males			Unsexed Fish	Sample Size	Fork Length (mm)			Weight (g)		
	N	%	% Mature	N	%	% Mature			Mean	S.D.	Range	Mean	S.D.	Range
Burbot[a,d]														
0+	0	0	0	0	0	0	2	2	41.5	0.71	41-42	0.6	0.07	0.5-0.6
2	2	40	0	3	60	0	2	7	129.1	16.99	111-154	14.7	7.18	5.3-22.6
3	0	0	0	2	100	0	0	2	197.5	9.19	191-204	38.7	10.54	31.2-46.1
5	1	100	0	0	0	0	0	1	373.0			280.0		
6	0	0	0	1	100	100	0	1	448.0			490.0		
Totals	3			6			4	13						
Dolly Varden[a]														
3	2	67	0	1	33	0	0	3	204.0	24.02	177-223	88.1	28.45	59.5-116.4
Total	2			1				3						
Goldeye[b]														
5	4	80	0	1	20	0	0	5	277.2	12.87	266-296	216.0	46.69	170-280
Total	4			1				5						
Lake cisco[b]														
5	0	0	0	1	100	100	0	1	266.0			208.5		
Total				1				1						

continued...

Table 47. Concluded.

Species/Age	Females			Males			Unsexed Fish	Sample Size	Fork Length (mm)			Weight (g)		
	N	%	% Mature	N	%	% Mature			Mean	S.D.	Range	Mean	S.D.	Range
Flathead chub[b]														
3	0	0	0	0	0	0	1	1	181.0			73.9		
Total							1	1						
Yellow perch[c]														
0+	1	33	0	2	67	0	98	101	37.4	5.40	25-54	0.6	0.26	0.1-1.1
Total	1			2			98	101						

[a] Aged by otoliths.
[b] Aged by scales.
[c] Aged by length-frequency.
[d] Total length.

be immature five year olds.

Two goldeye were tagged, one of which was subsequently recaptured on 22 May at the downstream trap.

Five goldeye stomachs were examined in the field. Four stomachs were empty or contained only a trace of food and one was half full of digested matter. Bond and Berry (in prep.a) found goldeye fed mainly on immature insects (Plecoptera, Ephemeroptera, Hemiptera and Hymenoptera).

Goldeye are reported to undergo extensive migrations in the AOSERP study area. For additional information regarding life history of goldeye in the area see Kristensen et al. (1976), Kristensen and Pidge (1977), McCart et al. (1977), and Bond and Berry (in prep.a, in prep.b).

5.4.9.3 Flathead chub. Two flathead chub were recorded at the upstream trap on 12 and 26 May (Table 10). One ripe female (248 mm in fork length) was measured and released on 26 May while the other fish (181 mm) was aged (Table 47) and found to be three years old.

The flathead chub is rarely taken in tributary streams of the AOSERP study area but is quite common in the Athabasca River (McCart et al. 1977; Bond and Berry in prep.a, in prep.b). For more details on the life history of flathead chub see the above authors.

5.4.9.4 Yellow perch. Young-of-the-year yellow perch were common in areas 1 and 2 of the Steepbank River (Figure 2) from mid-July to early August. Twelve perch were seined from Area 1 while 89 fish were taken from Area 2 (Table 8). These fish ranged in size from 25 to 54 mm with a mean fork length of 37.4 mm and a mean weight of 0.6 g (Table 47). Only three fish were sexed and two of these were males.

Stomach analysis showed (Table 31) that yellow perch had fed mainly on immature aquatic insects (chironomids and other Diptera, Plecoptera, and Hymenoptera). Bond and Berry (in prep.a) reported a diet of Diptera larvae and pupae and Ephemeroptera nymphs and adults.

Perch are thought to have originated from lakes of the Athabasca drainage and drifted down to the study area. They occur commonly around tributary mouths in the AOSERP area during July and August (McCart et al. 1977; Bond and Berry in prep.a, in prep.b).

5.4.9.5 Lake cisco. One lake cisco was captured at the upstream trap on 14 May. This fish was a five year old maturing male, 266 mm in fork length, and weighed 208.5 g (Table 47).

Cisco are common to lakes in the Birch Mountain area (Turner 1968) and lakes in the southern Athabasca drainage such as Lesser Slave Lake and Lac la Biche (Paetz and Nelson 1970).

5.4.10 Pearl Dace

5.4.10.1 Distribution and relative abundance. Pearl dace were the most abundant small fish taken in the Steepbank River watershed in 1977, comprising 31% of the total catch (excluding suckers). Pearl dace were collected in 10 of the 12 sampling areas with the largest number of specimens (n = 245) collected at Area 3 (Table 8). Dace were also abundant in headwater reaches (Area 8) in association with brook stickleback.

5.4.10.2 Spawning. No ripe male or female pearl dace were collected from the Steepbank River watershed during the course of this study. However, spawning probably occurred in late May or early June. Young-of-the-year fish were first captured on 18 July (fork length 21 to 27 mm) in Area 2 and subsequently in areas 1, 3, 5, and 8 (Figure 2) during later sampling efforts.

According to Fava and Tsai (1974) spawning takes place from late April to early June in Maryland when water temperatures are 13 to 15°C but Langlois (1929) found dace spawning in water temperatures of 17.2 to 18.3°C in Michigan. The latter author also provides a brief description of the spawning areas and behaviour of pearl dace. The males are territorial and spawning takes place in clear water 46 to 61 cm deep on sand or gravel in a weak or moderate current.

5.4.10.3 Age and growth. Pearl dace ranged in fork length from 19 to 56 mm (Figure 25) with the majority (91%) being in the 21 to 38 mm size range. Based on otoliths (Table 48), the oldest fish in the sample were two year olds having a mean fork length of 47.3 mm (range 41-to 56 mm). However, it is clear that most of the dace captured were young-of-the-year. The maximum age reported for pearl dace in the AOSERP study area is four years (Bond and Machniak in prep.). Loch (1969) reported a maximum age of three years in an Ontario population while age 4 was the maximum age in Maryland (Fava and Tsai 1974) and Quebec (Lalancette 1977b).

5.4.10.4 Sex and maturity. Female pearl dace comprised 53% of our sexed sample (n = 64) but the sex ratio did not differ significantly from unity (X^2 = 0.250, P > 0.005). Lalancette (1977b) also found an overall sex ratio of 1:1, but reported differences among age groups because of the higher mortality rate of males. A sex ratio of 2:1 in favour of males was reported by Fava and Tsai (1974) in pearl dace from Hamilton Run, Maryland, but the ratio varied with time of sampling.

The smallest size at which sexual maturity was attained by Steepbank River pearl dace was 40 to 44 mm for males and 45 to 49 mm for females. No mature fish were observed among the aged sample (Table 48). However, the minimum age of sexual maturity appears to be age 2. This is also the age at which sexual maturity was reached in Lake Gamelin, Quebec (Lalancette 1977b), while Fava and Tsai (1974) found that, in Maryland, both sexes matured at the end of their first year.

5.4.10.5 Length-weight relationship. The length-weight relationship for pearl dace from the Steepbank River as determined for both sexes combined (n = 304, r = 0.492, range 19 to 56 mm) is described by the equation:

$$\log_{10} W = 2.9112 (\log_{10} L) - 4.8906; \; sb = 0.0595$$

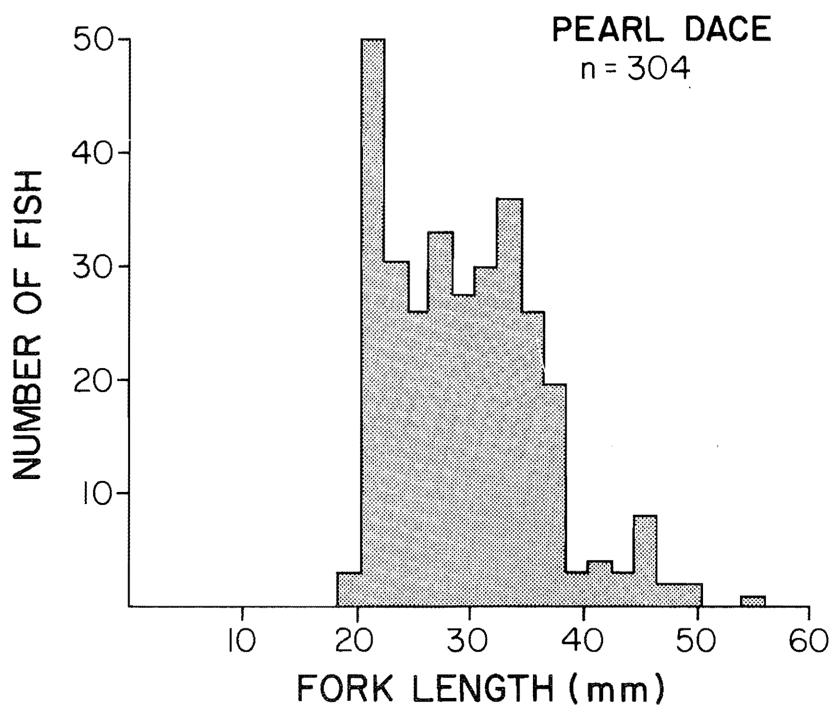

Figure 25. Length-frequency distribution for pearl dace from the Steepbank River, 1977.

Table 48. Age-length (derived from otoliths and length frequencies) and age-weight relationships, age specific sex ratios and maturity of small fishes captured from the Steepbank River, 1977.

Species/Age	Females			Males			Unsexed Fish	Sample Size	Fork Length (mm)			Weight (g)		
	N	%	% Mature	N	%	% Mature			Mean	S.D.	Range	Mean	S.D.	Range
Pearl dace														
0+	2	50	0	2	50	0	19	23	29.4	4.85	19-39	0.3	0.15	0.1-0.6
1	5	71	0	2	29	0	2	9	37.7	6.56	23-45	0.6	0.20	0.4-0.9
2	3	75	0	1	25	0	0	4	47.3	6.34	41-56	1.1	0.33	0.7-1.5
Totals	10			5			21	36						
Lake chub														
0+	0	0	0	0	0	0	14	14	29.9	4.12	22-38	0.3	0.12	0.1-0.6
1	18	60	0	12	40	0	7	37	36.3	6.32	26-49	0.5	0.27	0.2-1.3
2	7	64	0	4	36	0	1	12	49.1	5.21	41-58	1.3	0.32	0.7-2.1
3	0	0	0	0	0	0	0	0	ND [a]			ND		
4	0	0	0	0	0	0	0	0	ND			ND		
5	1	100	100					1	100.0			9.1		
Totals	26			16			22	64						
Brook stickleback [a]														
0+	18	86	0	3	14	0	5	26	28.8	6.22	15-38	0.3	0.12	0.1-0.5
1	8	80	57	2	20	100	0	10	38.6	3.34	34-43	0.5	0.15	0.2-0.7
2	10	72	100	4	18	100	0	14	49.4	5.88	43-61	1.3	0.50	0.8-2.3
3	1	100	100	0	0	0	0	1	67.0			2.8		
Totals	37			9			5	51						

continued ...

Table 48. Continued.

Species/Age	Females N	Females %	Females % Mature	Males N	Males %	Males % Mature	Unsexed Fish	Sample Size	Fork Length (mm) Mean	Fork Length (mm) S.D.	Fork Length (mm) Range	Weight (g) Mean	Weight (g) S.D.	Weight (g) Range
Longnose dace														
0+	0	0	0	0	0	0	10	10	25.3	3.97	20-35	0.2	0.11	0.1-0.5
1	38	60	0	25	40	0	6	69	44.3	8.07	31-59	1.0	0.63	0.3-2.5
2	0	0	0	2	100	50	0	2	60.0	7.07	55-65	2.4	1.20	1.5-3.2
3	1	50	100	1	50	100	0	2	80.0	2.83	78-82	5.0	0.07	4.9-5.0
Totals	39			28			16	83						
Trout-perch														
0+	10	77	0	3	23	0	11	24	30.6	3.99	23-39	0.4	0.18	0.1-0.8
1	7	58	0	5	42	0	0	12	43.6	3.90	36-48	1.0	0.30	0.5-1.5
2	4	21	0	15	79	87	0	19	57.5	4.60	50-66	2.4	0.58	1.4-3.2
3	1	17	100	5	83	100	0	6	71.2	2.48	68-75	4.1	0.35	3.9-4.3
4	1	50	100	1	50	100	0	2	83.5	3.54	81-86	6.4	0.99	5.7-7.1
Totals	23			29			11	63						
Slimy sculpin[b]														
0+	3	75	0	1	25	0	21	25	27.0	5.99	11-35	0.2	0.11	0.1-0.5
1	2	40	0	3	60	0	3	8	43.1	3.40	40-49	0.9	0.27	0.8-1.4
2	1	25	100	3	75	100	0	4	53.5	2.38	50-55	1.7	0.41	1.3-2.1
3	1	33	100	2	67	100	0	3	68.7	2.52	66-71	3.7	0.61	3.0-4.1
4	0	0	0	1	100	100	0	1	79.0			6.7		
Totals	7			10			24	41						

continued...

Table 48. Concluded.

Species/Age	Females			Males			Unsexed Fish	Sample Size	Fork Length (mm)			Weight (g)		
	N	%	% Mature	N	%	% Mature			Mean	S.D.	Range	Mean	S.D.	Range
Spottail shiner														
1	8	57	0	6	43	0	3	17	38.9	8.05	26-55	0.6	0.39	0.2-1.7
Totals	8			6			3	17						
Brassy minnow														
1	0	0	0	1	100	100	0	1	44.0			0.9		
2	1	100	100	0	0	0	0	1	60.0			2.1		
Totals	1			1			0	2						
Fathead minnow														
2	1	100	100	0	0	0	0	1	56.0			1.8		
Totals	1			0			0	1						
Northern redbelly dace														
1	1	100	0	0	0	0	0	1	38.0			0.5		
Total	1			0			0	1						

[a] No data.

[b] Total length.

5.4.10.6 Food habits. The stomach contents of 10 pearl dace were examined microscopically. Three stomachs contained no food while, of the remainder, 86% contained mostly digested material. The only identifiable food items were adult Coleoptera (Table 49). Lalancette (1977b) found a diet of insects, zooplankton, plants, and organic detritus in Lake Gamelin pearl dace. McPhail and Lindsey (1970) reported the occurrence of Coleoptera, filamentous algae, and *Chara* in dace stomachs.

5.4.11 Brook Stickleback

5.4.11.1 Distribution and relative abundance. A total of 440 brook stickleback were collected from the study area, the majority (81%) being captured from headwater reaches of the Steepbank and North Steepbank rivers, i.e., Areas 8 and 12 (Figure 2). Excluding suckers, this species accounted for 25% of all small fishes taken (Table 8).

5.4.11.2 Spawning. Most brook stickleback in Alberta spawn in late spring and early summer (Paetz and Nelson 1970). Mature and maturing male and female stickleback were collected in areas 11 and 12 of the North Steepbank River (Figure 2) in May. Young-of-the-year brook stickleback (10 to 22 mm total length) were first taken in Area 12 on 22 July. Stickleback fry were also collected in Areas 8, 10, and 11 during the course of the study.

5.4.11.3 Age and growth. Stickleback from the Steepbank and North Steepbank rivers ranged from 10 to 67 mm in total length (Figure 26) with fish in the 19 to 23 mm size range comprising 65% of the sample. Otolith ages, determined for 51 brook stickleback (Table 48), ranged up to three years (a female, 67 mm in total length), but the bulk of the population consisted of fish in their first year. According to Winn (1960), the bulk of most stickleback populations is made up of young-of-the-year fish, although two and three year old fish may be present.

The growth rate for Steepbank River stickleback is similar

Table 49. Food habits of small fishes collected from the Steepbank River, 1977.

Food Items	Species													
	Trout-perch		Lake Chub		Longnose Dace		Brook Stickleback		Pearl Dace		Slimy Sculpin		Spottail Shiner	
	% Freq.[a]	% No.	% Freq.[a]	% No.	% Freq.[a]	% No.	% Freq.[a]	% No.	% Freq.[a]	% No.	% Freq.[a]	% No.	% Freq.[a]	% No.
Class Insecta														
Diptera														
Chironomidae	59.1	59.4	19.0	18.8	35.7	3.2	36.4	48.7	0.0	0.0	22.2	15.9	0.0	0.0
Simuliidae	18.2	8.7	9.5	6.3	57.1	85.4	9.1	1.7	0.0	0.0	11.1	11.0	0.0	0.0
Tipuliidae	9.1	1.4	0.0	0.0	7.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Culicidae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1	1.2	0.0	0.0
Unidentified Dipterans	45.4	15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.1	42.7	0.0	0.0
Trichoptera	4.5	0.7	9.5	9.4	0.0	0.0	9.1	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Plecoptera	22.7	5.8	9.5	6.3	28.6	1.7	9.1	0.9	0.0	0.0	22.2	6.1	0.0	0.0
Ephemeroptera	13.6	6.5	28.6	25.0	57.1	7.5	18.2	4.3	0.0	0.0	22.2	6.1	0.0	0.0
Coleoptera	0.0	0.0	4.8	3.1	0.0	0.0	0.0	0.0	14.3	100.0	0.0	0.0	0.0	0.0
Hemiptera	0.0	0.0	4.8	3.1	0.0	0.0	0.0	0.0	0.0	0.0	11.1	1.2	0.0	0.0
Hymenoptera	4.5	0.7	9.5	6.3	21.4	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Odonata	0.0	0.0	0.0	0.0	7.1	0.2	9.1	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Homoptera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepidoptera	4.5	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insect Remains	4.5	0.0	23.8	0.0	14.3	0.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous														
Nematoda	0.0	0.0	0.0	0.0	7.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nematomorpha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	100.0
Arachnida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gastropoda	0.0	0.0	4.8	3.1	0.0	0.0	0.0	0.0	0.0	0.0	11.1	1.2	0.0	0.0
Ostracoda	0.0	0.0	0.0	0.0	0.0	0.0	36.4	41.9	0.0	0.0	11.1	14.6	0.0	0.0
Vegetation	4.5	0.0	9.5	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Digested Matter	40.9	0.0	38.1	0.0	28.6	0.0	45.5	0.0	85.7	0.0	11.1	0.0	33.3	0.0
Debris (sticks, stones, tar sands)	0.0	0.0	0.0	0.0	7.1	0.0	0.0	0.0	14.3	0.0	11.1	0.0	33.3	0.0
Total stomachs	28		22		17		12		10		9		5	
Empty (% of Total)	21.4		4.5		17.6		8.3		30.0		0.0		40.0	

[a] Percentage frequency of occurrence, based on stomachs that contained some food.

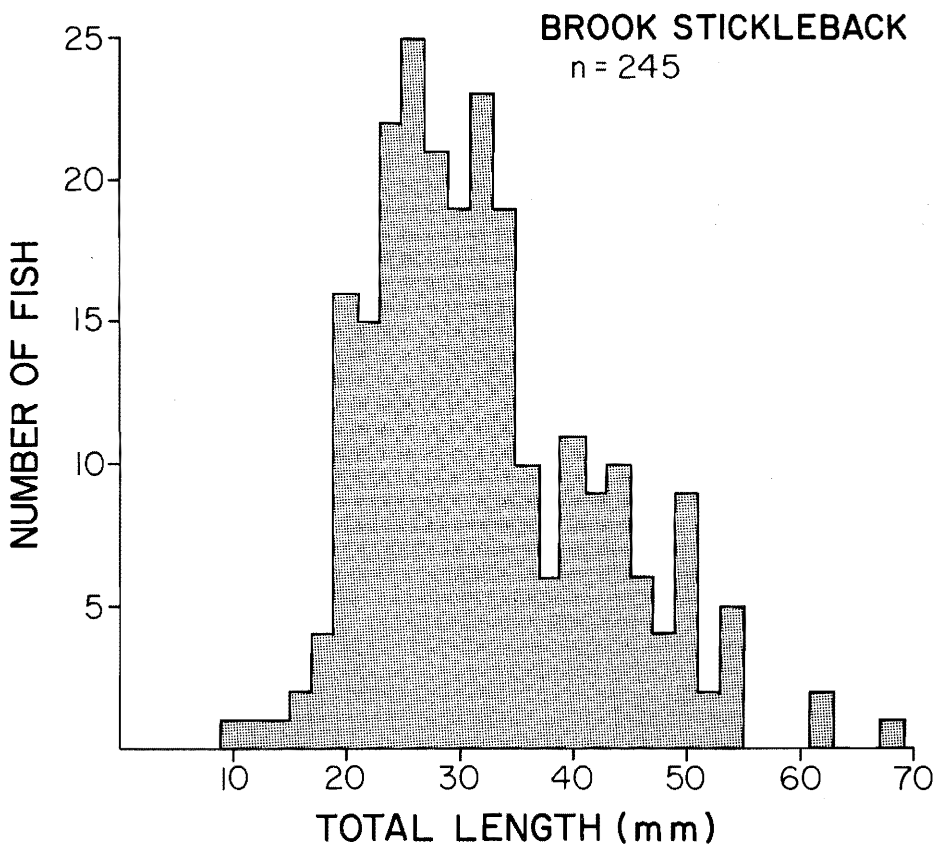

Figure 26. Length-frequency distribution for brook stickleback from the Steepbank River, 1977.

to that reported for Muskeg River fish (Bond and Machniak 1977).

5.4.11.4 Sex and maturity. Female brook stickleback comprised 65% of the total sample of fish sexed (n = 127) and were significantly more abundant than males ($X^2 = 11.976$, $P < 0.001$).

The smallest mature fish were in the 30 to 34 mm size class and the minimum age of maturity was age 1 for both sexes (Table 48).

5.4.11.5 Length-weight relationship. The common length-weight relationship (sexes combined) for brook stickleback from the study area (n = 245, r = 0.920, range 10 to 67 mm) is described by the equation:

$$\log_{10} W = 2.4260 (\log_{10} L) - 4.1605; \; sb = 0.0661$$

The value of the exponent, 2.4260, is considerably lower than that reported for brook stickleback (3.0435) in the Muskeg River (Bond and Machniak 1977).

5.4.11.6 Food habits. Brook stickleback in the Steepbank River had fed mainly on chironomid (Diptera) larvae, Ephemeroptera nymphs, and Ostracoda (Table 49). Scott and Crossman (1973) report that brook stickleback consume aquatic insect larvae and Crustacea as well as Gastropoda, Oligochaeta, Arachnida, and fish eggs. Algae have also been reported in the stomachs of some individuals (Winn 1960).

5.4.12 Lake Chub

5.4.12.1 Distribution and relative abundance. Excluding suckers, lake chub made up 15% of all small fish captured in the Steepbank River watershed (Table 8). This species was common in the lower and mid-reaches of the Steepbank River (Areas 2 to 6) and in the lower reaches of the North Steepbank (Areas 9 and 10).

5.4.12.2 Spawning. The lake chub usually undergoes a spawning migration from lakes to tributary streams early in the spring (Scott and Crossman 1973). A ripe female chub (108 mm) was recorded in the upstream trap on 7 May and a mature female (100 mm) was taken as late as 19 June in Area 6. In the Montreal River, Saskatchewan, lake chub were observed spawning in shallow water (about 5 cm) amongst and underneath large rocks from 21 to 27 May when the water temperatures reached 10°C (Brown 1969). Young-of-the-year chub (range 27 to 35 mm fork length) were first captured in the Steepbank River on 6 August in Area 2. Lake chub fry were also collected in areas 5 and 10 (Figure 2) during the course of the study.

5.4.12.3 Age and growth. Lake chub from the study area ranged in fork length from 21 to 108 mm (Figure 27), the majority (89%) being in the 27 to 46 mm size range. Otolith ages were determined for 64 lake chub, and the oldest fish aged was a five year old female, 100 mm fork length (Table 48). Maximum ages reported from other areas are: age 5, Muskeg River (Bond and Machniak 1977), age 4+ for western Labrador chub (Bruce and Parsons 1976), and age 5 in British Columbia (Geen 1955).

Growth of lake chub in the AOSERP study area (current study; Bond and Machniak 1977) appears to be similar to that reported for western Labrador (Bruce and Parsons 1976) where chub reach an average length of 101 mm at age 4+. Geen (1955) indicated that females grow faster and lived longer than males.

5.4.12.4 Sex and maturity. Although males (52%) outnumbered females in the sexed sample (n = 152), the sex ratio did not differ significantly from unity ($X^2 = 0.237$, $P > 0.05$). Bruce and Parsons (1976) reported an overall sex ratio of 1.7:1 in favour of male chub in Mile 66 Brook, western Labrador. Brown (1969) observed that males outnumbered females in samples taken during the spawning season because they spent a longer time on the spawning grounds.

Except for the two large females taken in the spring, all of the lake chub collected from the Steepbank River were classified as immature, age 0+ to 2+ fish. Bond and Machniak (1977) reported the minimum age of sexual maturity to be three years for both sexes

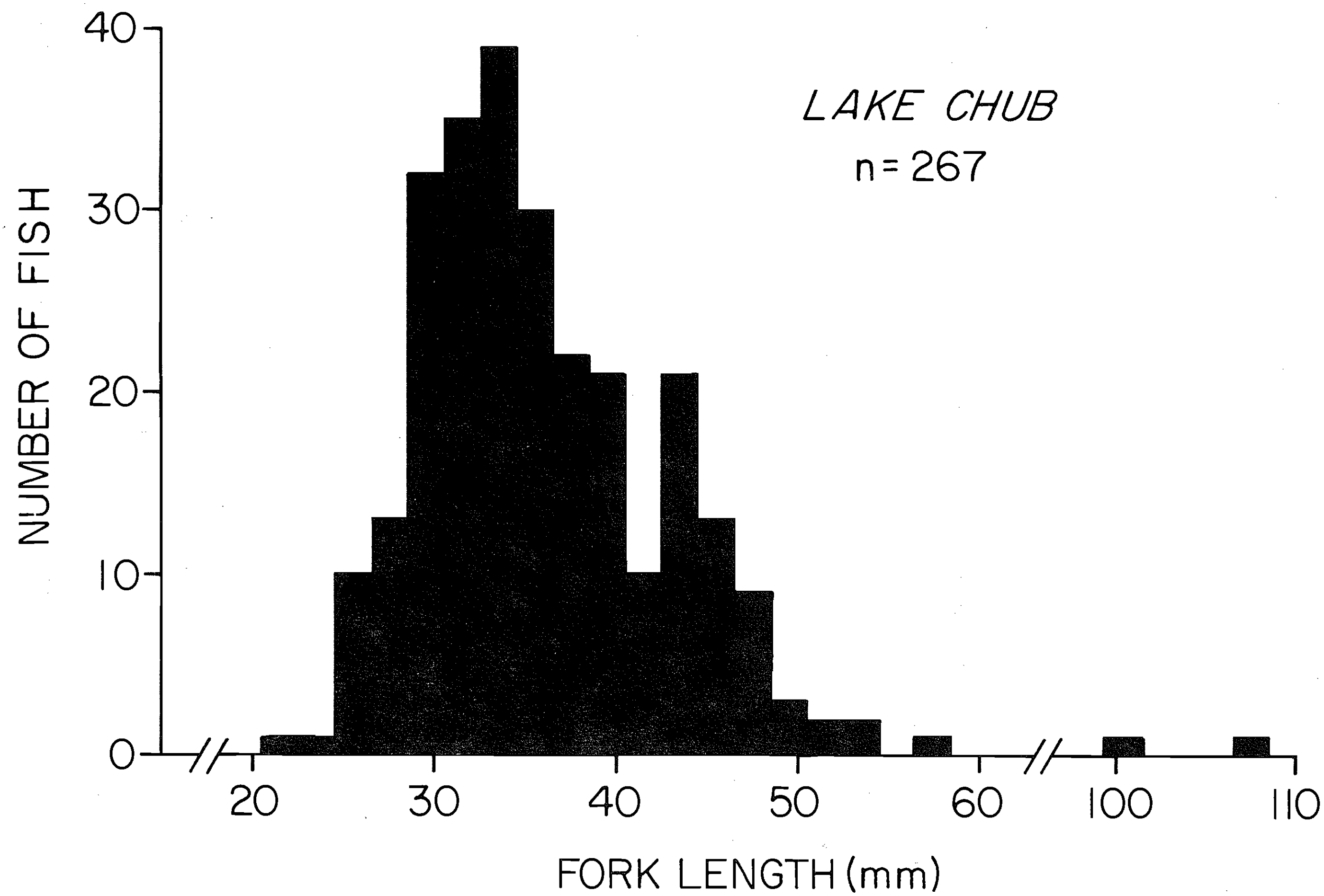

Figure 27. Length-frequency distribution for lake chub from the Steepbank River, 1977.

in the Muskeg River. Similarly, age at first maturity for females was age 3+ in both Mile 66 Brook (Bruce and Parsons 1976) and Lac la Ronge (Brown et al. 1970), the former study gave the mean fork length of mature 3+ female chub as 86 mm. However, males appeared to mature at an earlier age (2+) in Labrador (Bruce and Parsons 1976).

5.4.12.5 Length-weight relationship. The following length-weight relationship (sexes combined) was calculated for lake chub (n = 266, r = 0.943, range 21 to 100 mm).

$$\log_{10} W = 2.6456\ (\log_{10} L) - 4.4097;\ sb = 0.0573$$

5.4.12.6 Food habits. Lake chub in the Steepbank River fed mainly on immature aquatic insects (Diptera, Ephemeroptera, Plecoptera and Trichoptera) with some Gastropoda and vegetation also included in the diet (Table 49). Stomach analysis for some Ontario populations indicates that Chironomidae and other aquatic insect larvae form the major part of the lake chub diet with small amounts of Cladocera and algae also being consumed (Scott and Crossman 1973).

5.4.13 Longnose Dace

5.4.13.1 Distribution and relative abundance. Longnose dace are characteristic of gravel or bouldery areas of swift-flowing streams (Scott and Crossman 1973). Because adults live in crannies between stones they are difficult to capture (McPhail and Lindsey 1970), and, therefore, are probably under-represented in seine catches.

Longnose dace made up 10.7% of all small fish (excluding suckers) captured in the Steepbank River watershed. This species was most common in the lower reaches of the Steepbank (Areas 2 and 3) and was absent from areas upstream of the confluence of the North Steepbank and Steepbank rivers (Table 8).

5.4.13.2 Spawning. Although no ripe longnose dace were encountered during the spring, young-of-the-year dace were taken at several locations. Dace fry were first captured in Area 2 on 18 July (size range 21 to 24 mm fork length) and were particularly abundant in Area

3 where 37 fish (size range 17 to 25 mm) were taken on 2 August. Young-of-the-year were also collected in Area 5 (Figure 2).

Bartnik (1970) reported that, in streams of southern Manitoba, spawning occurred in late May when daily maximum water temperatures exceeded 15°C, and took place over a substrate of coarse gravel in water velocities greater than 45 cm/sec. However, in Alberta, longnose dace are reported to spawn from early June to mid-August (Paetz and Nelson 1970).

5.4.13.1 Age and growth. Longnose dace (n = 192) from the Steepbank watershed ranged in fork length from 15 to 82 mm with those in the 33 to 44 mm range accounting for 57% of the total sample. The length-frequency distribution (Figure 28) varied, however, throughout the summer. The fish represented in Figure 28 belong, with few exceptions, to two year classes. Young-of-the-year, captured between 18 July and 2 August (n = 39), had a mean fork length of 21.5 mm (range 17 to 25 mm). Young-of-the-year taken on 19 August (n = 5) ranged from 23 to 28 mm in length with a mean of 25.0 mm. One year old dace captured in May and June (n = 27) had a mean fork length of 39.9 mm (range 28 to 48 mm). By mid-July, age 1 dace (n = 27) ranged in length from 40 to 53 mm with a mean of 45.0 mm, and by mid-August this age group (n = 28) had a mean fork length of 54.5 mm (range 48 to 61 mm).

Growth of longnose dace in the Steepbank River (Table 48) appears to be similar to that reported by Reed (1959) for a population in Pennsylvania. The oldest fish captured in the Steepbank were three year olds ranging in fork length from 78 to 82 mm. Reed (1959) reported a maximum age of four years for males and five years for females.

5.4.13.4 Sex and maturity. Of the sexed sample (n = 138), female longnose dace had a greater overall abundance (58%) than males, but the sex ratio did not differ significantly from unity ($X^2 = 3.507$, $P > 0.05$). Most of the fish for which sex was determined were immature one year olds (25 to 59 mm). It is interesting to note that, while the sex ratio over this size range was 1:1, the smaller fish (25 to 39 mm) were predominantly males (56%) while the larger fish (40 to 59 mm)

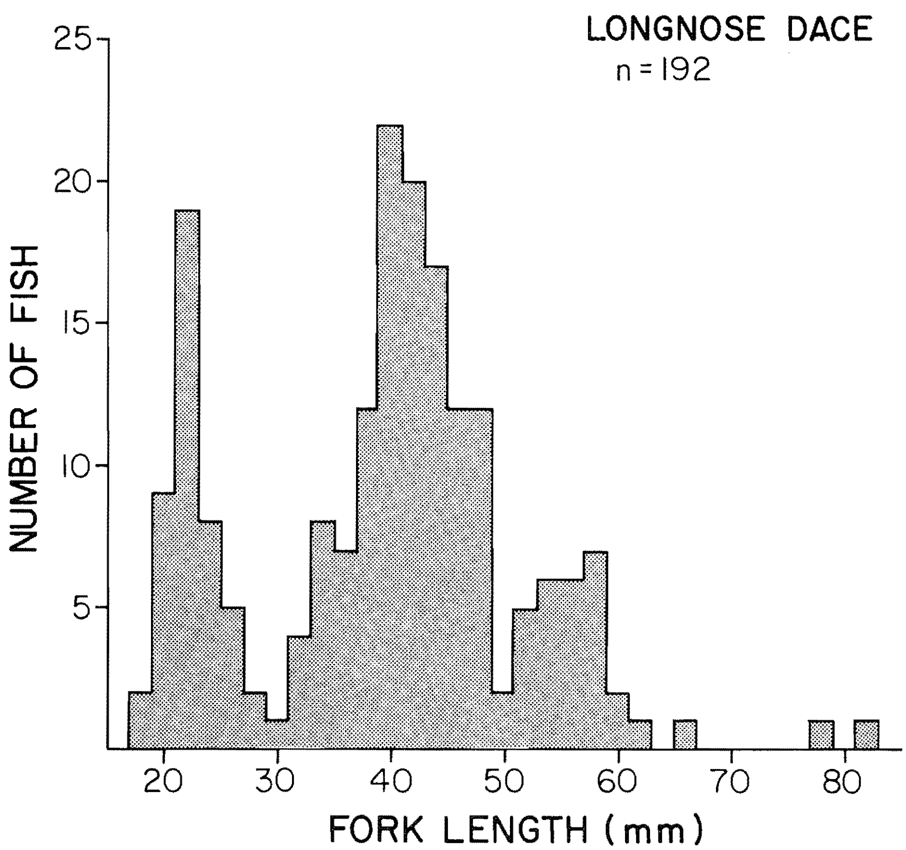

Figure 28. Length-frequency distribution for longnose dace from the Steepbank River, 1977.

were mostly females (64%) Gee and Machniak (1972) reported that, in Lake Winnipeg, males outnumbered females at age 2, but that most of the older fish were females.

Only five longnose dace, one female and four males, were judged to be sexually mature. The smallest size at maturity was 40 to 44 mm for a male dace, which corresponds to a fish of age one (Table 48). Most dace in the Steepbank River probably mature as two year olds. Gibbons and Gee (1972) also report that longnose dace mature for the first time at age 2.

5.4.13.5 Length-weight relationship. The following length-weight relationship (sexes combined) was derived for longnose dace (n = 192, r = 0.984, range 15 to 82 mm) taken in the Steepbank River.

$$\log_{10} W = 2.7596 (\log_{10} L) - 4.6179; \; sb = 0.0368$$

5.4.13.6 Food habits. Stomach analysis of 17 dace revealed a diet of Diptera larvae (Chironomidae and Simuliidae) and Ephemeroptera and Plecoptera nymphs (Table 49). Gibbons and Gee (1972) also found the diet of longnose dace to consist mainly of immature aquatic insects. Reed (1959) reported that almost 90% of the food consisted of adult or immature stages of Simuliidae, Chironomidae, and Ephemeroptera.

5.4.14 Trout-perch

5.4.14.1 Distribution and relative abundance. Excluding suckers, trout-perch comprised 3.8% of the total catch of small fish in the Steepbank River watershed (Table 8). Trout-perch were collected at six of the eight areas on the main Steepbank River, but were most common in Areas 1 (n = 12) and 2 (n = 52) near the mouth. This species was never found in the extreme upper reaches of the watershed, i.e., Areas 8, 11, and 12 (Figure 2).

5.4.14.2 Spawning. Bond and Berry (in prep.b) reported capturing ripe male and female trout-perch in the Athabasca River during late April and early May 1977. W. A. Bond captured ripe males and a 10 mm long fry 5 km upstream in the Ells River (Figure 1) on 8 June, indicating that trout-perch spawned in that tributary in late May or early June. The lower reaches of the Steepbank River also appear to be used as a spawning area by trout-perch from the Athabasca River. Ripe male and female trout-perch were collected in rea 2 (Figure 2) of the Steepbank River from 14 May to 14 June. Young-of-the-year, while captured as far upstream as Area 7 (Figure 2), were apparently more numerous in the lower reaches. A single young-of-the-year, 29 mm in fork length, was captured at the fence site on 18 July, and 12 others (29 to 39 mm) were taken at the same location on 6 August. Small numbers of fry were also captured in Areas 1, 3, and 5 during the summer.

Lawler (1954) reported that, at Heming Lake, Manitoba, trout-perch ascend small tributaries in May to spawn on silt and boulder bottoms at 4.4 to 10.0°C. In Beech Fork, West Virginia, trout-perch spawning occurred from mid-April until the end of May (about 6 wk) at a water temperature of approximately 15°C (Muth 1975). Field observations indicated that spawning occurred at night over gravelly riffles. Trout-perch that spawn in lakes apparently have a later and more protracted reproductive period than those that spawn in streams. Trout-perch spawned from late June or early July until late September in Lake Michigan (House and Wells 1973) and from May to August in Lower Red Lake, Minnesota (Magnuson and Smith 1963).

5.4.14.3 Age and growth. Trout-perch ranged in fork length from 23 to 86 mm (Figure 29). However, the length-frequency distribution varied throughout the year. Between 10 May and 14 June, 39 trout-perch were captured, of which 38 were taken at the fence site. These fish varied in age from one to four years, and in fork length from 36 to 86 mm (Table 48). All trout-perch taken from the Steepbank River between 18 July and 13 October were young-of-the-year. These fish ($n = 31$) ranged from 23 to 39 mm in fork length with a mean of 31 mm. The maximum age for trout-perch in the Steepbank River, and in Alberta generally (Paetz and Nelson 1970), appears to be four years. Maximum ages recorded elsewhere are six years for the Mackenzie Delta (de Graaf and Machniak 1977), seven years for

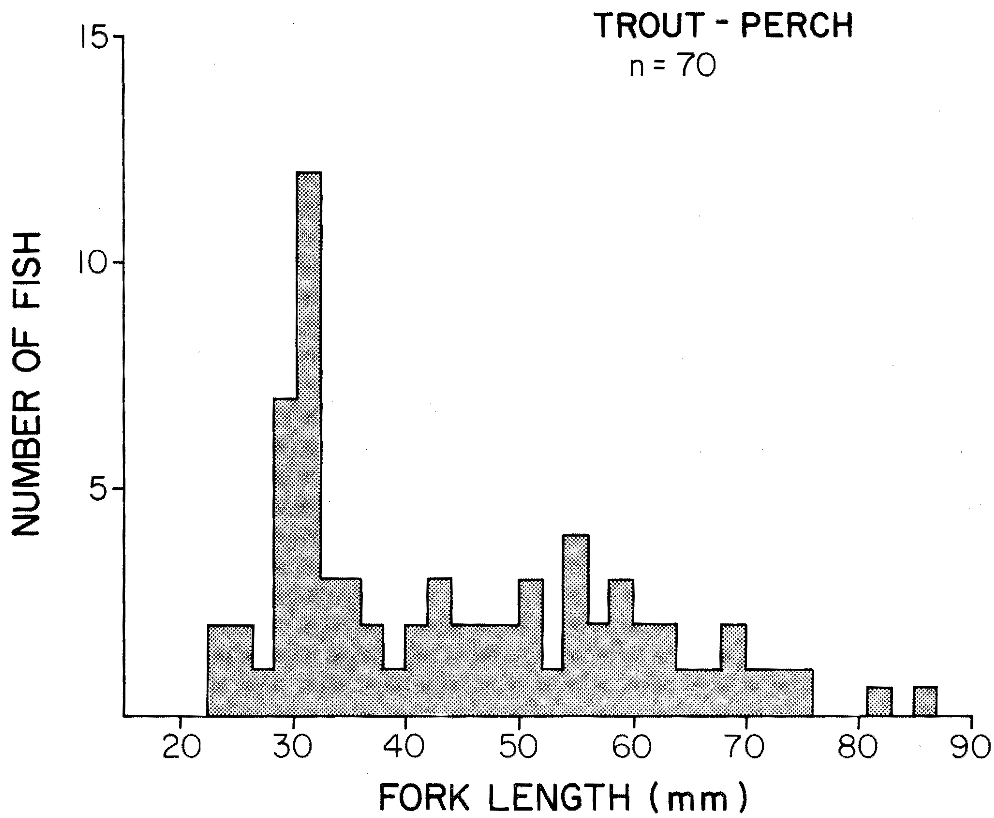

Figure 29. Length-frequency distribution for trout-perch from the Steepbank River, 1977.

Lake Superior (Bostock 1967), and eight years for Lake Michigan (House and Wells 1973). These authors and Magnuson and Smith (1963) observed that females live longer than males.

Growth of trout-perch in the Steepbank River appears to be similar to that reported for the Mackenzie Delta (de Graaf and Machniak 1977) and Lake Superior (Bostock 1967). However, growth is considerably slower than that recorded in Lake Michigan (House and Wells 1973) and the Lower Red Lakes, Minnesota (Magnuson and Smith 1963), where age 2 fish had mean total lengths of 83 and 90 mm respectively.

5.4.14.4 Sex and maturity. Sex was determined for 58 trout-perch, and although males (53%) outnumbered females in the sample, the sex ratio did not differ significantly from unity ($X^2 = 0.276$, $P > 0.05$). However, of the mature fish (n = 24) captured in Area 2 between 14 May and 14 June, 83% were males. Lawler (1954), Muth (1975), and Magnuson and Smith (1963) reported a similar preponderance of males during the spawning season. The latter authors suggested that the preponderance of males during the reproductive season is probably an asset to successful fertilization.

The smallest size at maturity was 50 to 54 mm for male trout-perch and 70 to 74 mm for females. The minimum age at which sexual maturity was observed was two years for males and three years for females (Table 48). Other authors have also reported that male trout-perch mature earlier than females. House and Wells (1973) observed that a few fish of both sexes were mature at the end of their first year, 84% of the males and 50% of the females by the end of their second year, and all fish by the end of their third year. Bond and Berry (in prep.b) found that in the Athabasca River, 17% of males and 4% of females were mature at age 1 while at age 2 the corresponding figures were 86% and 65%.

5.4.14.5 Length-weight relationship. The length-weight relationship for trout-perch from the Steepbank River (n = 70, r = 0.984, range 23 to 86 mm) is described by the equation:

$$\log_{10} W = 3.0471 (\log_{10} L) - 5.0076; \quad sb = 0.0666$$

5.4.14.6 Food habits. Trout-perch from the Steepbank River fed mainly on Chironomidae larvae and pupae, other Diptera, and Plecoptera and Ephemeroptera nymphs (Table 49). Kinney (1950) indicated that insect larvae, especially midges (Chironomidae) amd mayflies (Ephemeroptera), were particularly important in the diet of trout-perch.

5.4.15 Slimy Sculpin

5.4.15.1 Distribution and relative abundance. Slimy sculpins accounted for 3.7% of all small fish taken in the Steepbank River (excluding suckers). This species was most common in the region of the confluence of the North Steepbank and Steepbank rivers and the mid-reach of the North Steepbank (Figure 2). Slimy sculpins made up 72% of the catch in Area 7, 36% in Area 11, and 17% in Area 6 (Table 8).

5.4.15.2 Spawning. Slimy sculpins spawn in the early spring over rocky bottoms. Spawning occurred in late April in Valley Creek, Minnesota, and fry were first observed in June (Petrosky and Waters 1975). Craig and Wells (1976) estimated that slimy sculpins spawned a week after spring break-up in the Chandalar River drainage, Alaska. A similar period of spawning probably occurred for slimy sculpin in the Steepbank River. A mature female sculpin (total length 50 mm) was captured on 1 May in the reach upstream of Area 7. This fish had an egg size of 1.5 mm. Mature and spent males were collected until 11 June in Area 2. The first young-of-the-year sculpin (10 mm in total length) was taken in Area 8 on 19 June and subsequent samples of slimy sculpin fry were collected from Areas 2, 4, 6, 7, 10, and 11 (Figure 2) during the course of the study.

5.4.15.3 Age and growth. Slimy sculpins ranged in size from 10 to 79 mm total length (Figure 30), with fish in the 25 to 34 mm length class being the most common (51% of sample). Otolith ages were determined for 41 slimy sculpins and the oldest fish in the sample was a 79 mm four-year old male (Table 48). The oldest and largest

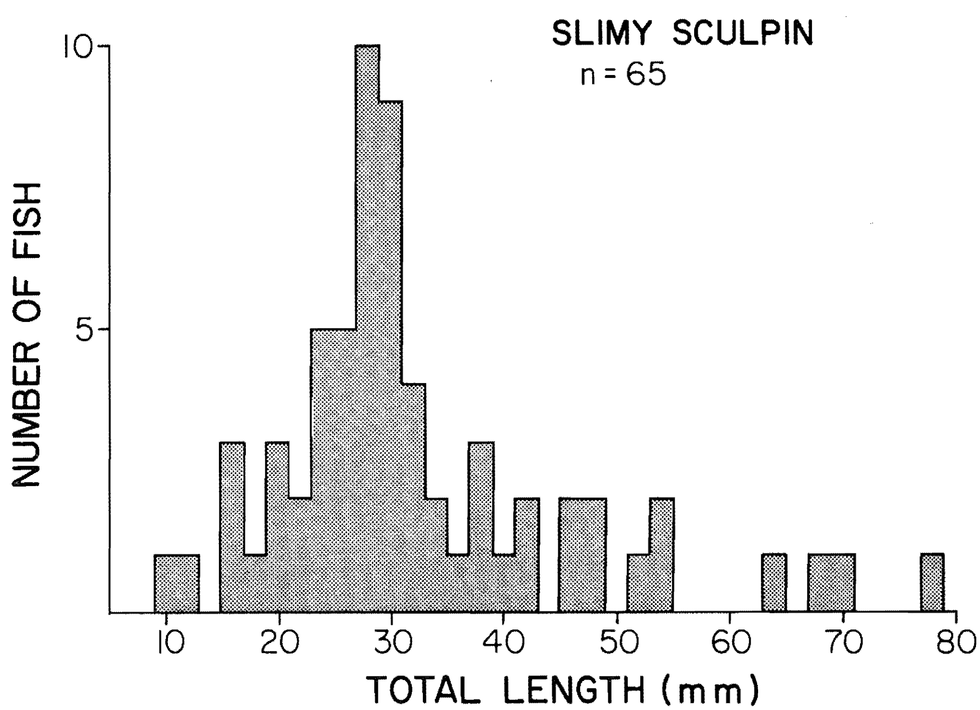

Figure 30. Length-frequency distribution for slimy sculpin from the Steepbank River, 1977.

sculpin captured in the Chandalar River, Alaska, was a seven year old male, 104 mm total length (Craig and Wells 1976). In Saskatchewan (Van Vliet 1964), the largest sculpins were five to six years old.

A comparison of the age-length relationship for slimy sculpins taken from the AOSERP study area (this study Bond and Machniak 1977) with those reported from the Chandalar River (Craig and Wells 1976) and the Mackenzie Delta (de Graaf and Machniak 1977) indicate similar growth among these populations. Growth of the above populations is, however, considerably slower than that described by Petrosky and Waters (1975) for Valley Creek, Minnesota, or by Van Vliet (1964) for the Montreal River and Lac la Ronge, Saskatchewan.

5.4.15.4 Sex and maturity. Twenty-one slimy sculpins were sexed, of which 11 were males. Van Vliet (1964) and Craig and Wells (1976) reported no significant differences between total numbers of males and females in their samples.

The smallest mature sculpins in the Steepbank River were males in the 45 to 49 mm size class. The minimum age of maturity was age 2 for both males and females (Table 48). In Minnesota, most slimy sculpins were mature by age 2 and some as early as age 1 (Petrosky and Waters 1975). Craig and Wells (1976), however, found that age at sexual maturity corresponded closely with a minimum size of 65 to 75 mm (age 3 to 4) in the Chandalar River. The same authors also reported that the age of sexual maturity was similar for both sexes.

5.4.15.5 Length-weight relationship. The following length-weight relationship was calculated for slimy sculpins ($n = 65$, $r = 0.927$, range 11 to 79 mm) taken from the Steepbank River:

$$\log_{10} W = 2.4467 (\log_{10} L) - 4.1079; \; sb = 0.1248$$

5.4.15.6 Food habits. The principal foods of slimy sculpins in the Steepbank River (Table 49) were aquatic insects (Diptera, Plecoptera, and Ephemeroptera). Petrosky and Waters (1975) indicated the most important foods found in Minnesota sculpin stomachs were *Gammarus* (Amphipoda), Diptera and Trichoptera larvae, and snails (Gastropoda). Other foods included Ephemeroptera, Isopoda, Coleoptera adults and larvae, Annelida, Ostracoda, Nematoda, and sculpin eggs. The diet of Alaskan sculpins consisted mainly of Diptera larvae and Plecoptera and Ephemeroptera nymphs (Craig and Wells 1976).

Schallock (1966) suggested that slimy sculpins and grayling might be competitors since they shared many of the same food items. Although both species consume similar foods in the Steepbank River, they probably feed at different levels in the water column.

5.4.16 Other Small Fishes

5.4.16.1 Spottail shiner. This species is probably more typical of the Athabasca River than of the tributaries of the AOSERP study area. Bond and Berry (in prep.b) found it throughout the lower Athabasca River, but in greatest abundance in the delta area.

Only 17 spottail shiners (Table 8) were captured in the Steepbank River in the present study during May and July and none were found upstream of Area 2. All fish were one year olds that ranged in fork length from 26 to 55 mm (Table 48) with a mean length of 37.4 mm. Sex was determined for 14 spottails, of which eight were females.

Spottail shiners in the AOSERP area are believed to mature at age 2 with spawning probably occurring in late June or early July (Bond and Berry in prep.b).

5.4.16.2 Brassy minnow. Berry (1977) first reported the presence of brassy minnow in the Athabasca River proper in 1976. Two brassy minnows were captured in the Steepbank River in Area 2 (Table 8) during 1977. One fish, taken on 10 May, was a maturing female (age 2, fork length 60 mm) while the other was a spent male (age 1, fork length 44 mm) captured on 21 May (Table 48).

5.4.16.3 Fathead minnow. Fathead minnows are common in the upper Athabasca watershed and Wood Buffalo National Park (Paetz and Nelson

1970). One fathead minnow was taken at the fence site on 29 May. This fish was a mature female, 56 mm fork length, and age 2 (Table 48).

5.4.16.4 Northern redbelly dace. Northern redbelly dace usually occur in boggy lakes, creeks, and ponds (Scott and Crossman 1973). One immature female (age 1, 28 mm fork length) was taken in Area 2 on 31 May. Griffiths (1973) reported capturing redbelly dace near the mouth of the Steepbank River.

5.4.16.5 Spoonhead sculpin. Spoonhead sculpins occur in muddy rivers and large lakes (Paetz and Nelson 1970). Although no spoonhead sculpin were captured in the study area during this study, Griffiths (1973) recorded its presence in the lower reaches of the Steepbank River.

6. CONCLUSIONS

The Steepbank River provides spawning habitat for longnose suckers, white suckers, Arctic grayling, and trout-perch which migrate from the Athabasca River into the tributary in late April and early May. Although precise spawning locations were not located, potential spawning sites for these species occur throughout the lower 45 km of the Steepbank River as well as in the lower 10 km of the North Steepbank.

Longnose and white suckers began to leave the watershed by mid-May, approximately two to three weeks after the commencement of the upstream runs. This downstream movement probably continued throughout the summer, and some fish remained in the tributary until just prior to freeze-up. Sucker fry began to emerge by 30 May, and most are believed to have drifted out of the tributary during June. Small numbers of young-of-the-year probably remained behind to overwinter in the Steepbank watershed. The majority of fry, as well as the adults, probably overwinter in Lake Athabasca.

Suckers are seldom highly ranked when considered in terms of their direct importance to man. However, in the lower Athabasca drainage they occur in large numbers and are known to spawn in several other tributaries besides the Steepbank River. Because of their high fecundity, an enormous amount of sucker biomass is contributed annually to the system. Although the significance of this contribution has not been quantified, it is likely that piscivorous fishes such as pike, walleye, burbot, and goldeye depend on young suckers for a large part of their annual food intake.

Unlike suckers, Arctic grayling did not leave the Steepbank River following the spawning period but remained in the tributary throughout the summer to feed. During the summer feeding period most grayling occupied that portion of the river between Areas 4 and 7 and as far upstream as Area 10 on the North Steepbank. The most preferred area, however, seemed to extend from about 5 km downstream to about 5 km upstream of the confluence of the North Steepbank on the main river. The gradient in this region is considerably less and the water considerably deeper than it is further downstream. Large grayling (age 1+ and older) left the watershed just prior to freeze-up and are thought to overwinter in the Athabasca River. Young-of-the-year may remain in the tributary over their first winter and join the migrant population at the end of their second summer. Thus, the Steepbank watershed provides not only spawning habitat for Arctic grayling, but also summer feeding areas for adult and juveniles and rearing and possibly overwintering sites for young-of-the-year. It is also possible that, in the tributary, the grayling (especially young-of-the-year) are less susceptible to predation and severe environmental fluctuations than they would be in the Athabasca River, thereby increasing their survival rate.

The grayling population of the Steepbank River is considered extremely important both because of its aesthetic value and because it represents a potential recreational source. However, this species is highly sensitive to habitat disturbances and is easily over-exploited by angling. The maintenance of this population then, will depend upon adequate protection of its habitat and upon the application of a sound fisheries management program.

The Steepbank River provides summer feeding for mountain whitefish, northern pike, and walleye, as well as for small numbers of lake whitefish and burbot. These species are thought to utilize mainly the lower reaches of the tributary. However, pike, walleye, and lake whitefish have been captured as far upstream as Area 6 (Lutz and Hendzel 1977). No evidence was found to suggest that any of these species spawn within the Steepbank watershed and most of the fish are thought to have left the tributary before freeze-up. The mouth region of the Steepbank River may be important as resting areas for walleye and lake whitefish during spawning migrations in the Athabasca River and may provide nursery areas for young-of-the-year fish of several species.

The resident fish fauna of the Steepbank watershed consists largely of five species of forage fish. The fauna of the upper watershed (upstream of Area 7 on the Steepbank and upstream of Area 10 on the North Steepbank) is restricted to brook stickleback, pearl dace, and slimy sculpin. Most lake chub and longnose dace occurred downstream of Area 6 while pearl dace were found throughout the watershed.

Several species of fish, considered to be more typical of the Athabasca River than of the Steepbank, are sometimes taken in the extreme lower reaches of the tributary. Their presence in the Steepbank is probably incidental and it is felt that they seldom proceed more than 1 km upstream in the tributary.

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8. APPENDICES

8.1 MEAN WATER TEMPERATURES (±0.5°C) RECORDED FOR EACH THREE-HOUR PERIOD PLUS DAILY MAXIMUM AND MINIMUM TEMPERATURES DURING THE SPRING FENCE OPERATION ON THE STEEPBANK RIVER, 1977.

Table 50. Mean water temperatures (±0.5°C) recorded for each three-hour period[a] plus daily maximum and minimum temperatures during the spring fence operation on the Steepbank River, 1977.

Date	Time of Trap Check						Daily Values		
	0900	1200	1500	1800	2100	2400	Maximum	Minimum	Mean
25 April	ND[b]	ND	ND	ND	ND	ND	5.5	0.5	3.00
26	ND	ND	ND	ND	ND	ND	5.5	1.5	3.50
27	ND	3.0	5.0	6.0	6.0	6.0	6.0	3.0	4.50
28	3.5	6.0	8.0	8.0	7.5	7.0	8.0	3.5	5.75
29	4.5	6.0	8.0	7.0	6.5	6.0	8.0	4.5	6.25
30	4.5	4.5	4.0	5.5	6.0	4.0	6.0	3.0	4.50
1 May	1.5	5.0	6.0	8.5	8.5	8.0	10.5	1.5	6.00
2	5.0	7.0	9.0	10.5	10.5	9.0	11.5	5.0	8.25
3	7.0	8.0	8.5	9.0	9.0	9.0	11.5	7.0	9.25
4	7.0	9.0	10.5	11.5	13.0	11.5	14.5	7.0	10.75
5	8.5	9.0	11.0	11.5	11.5	10.0	12.0	8.5	10.25
6	6.5	7.5	9.5	11.0	11.5	10.5	11.5	6.5	9.00
7	8.0	8.5	11.5	13.0	13.0	12.5	13.5	8.0	10.75
8	9.5	11.0	12.5	13.5	13.5	13.0	14.5	9.5	12.00
9	10.0	10.5	12.5	14.0	13.5	12.0	14.5	9.0	11.75
10	10.5	13.0	14.5	16.0	16.5	16.0	16.0	10.5	13.25
11	13.5	14.0	16.0	18.0	17.0	16.0	19.0	13.5	16.25
12	11.5	ND	11.0	ND	12.0	13.0	14.5	9.5	12.00
13	9.5	10.5	12.0	13.0	13.0	12.0	14.0	9.0	11.50
14	ND	10.5	11.5	13.0	12.5	11.5	14.0	9.5	11.75
15	11.5	8.5	10.5	10.5	9.0	9.5	11.5	7.0	9.25

continued...

Table 50. Concluded.

Date	Time of Trap Check						Daily Values		
	0900	1200	1500	1800	2100	2400	Maximum	Minimum	Mean
16 May	8.5	6.5	7.0	6.0	6.5	5.5	9.0	5.0	7.00
17	5.0	5.0	6.0	6.5	7.0	7.5	8.0	4.5	6.25
18	5.5	6.5	ND	7.0	7.0	7.0	8.0	5.5	6.75
19	6.0	6.5	ND	ND	ND	8.5	9.0	6.0	7.50
20	8.0	ND	ND	9.0	10.0	9.5	10.0	8.0	9.00
21	8.0	9.5	11.0	ND	11.0	10.5	11.5	8.0	9.75
22	9.5	ND	11.0	12.5	ND	13.0	13.5	9.5	11.25
23	11.0	ND	ND	12.0	13.5	12.5	14.5	11.0	12.75
24	ND	ND	11.5	12.5	13.5	14.0	14.5	10.5	12.50
25	ND	13.0	ND	14.5	15.5	14.5	15.5	12.0	13.25
26	ND	ND	ND	12.0	ND	12.0	12.0	11.5	11.75
27	ND	10.5	ND	ND	13.0	14.0	14.5	10.0	12.25
28	ND	13.0	ND	ND	12.0	ND	13.5	11.0	12.00
29	ND	ND	ND	ND	ND	ND	14.5	10.0	12.25

[a] Temperatures shown are means for the period (usually three hours) immediately preceding the time of the trap check. Those shown for the 0900 check are the overnight low temperatures.

[b] No data.

8.2 MEAN WATER TEMPERATURES (±0.5°) RECORDED FOR PERIODS BETWEEN TRAP CHECKS, PLUS DAILY MAXIMUM AND MINIMUM TEMPERATURES DURING THE FALL FENCE OPERATION ON THE STEEPBANK RIVER, 1977.

Table 51. Mean water temperatures (±0.5°C) recorded for periods between trap checks[a], plus daily maximum and minimum temperatures during the fall fence operation on the Steepbank River, 1977.

Date	Time of Trap Check				Daily Values		
	1200	1800	2100	2400	Maximum	Minimum	Mean
12 September	9.0	ND[b]	ND	ND	13.0	9.0	11.00
13	9.5	ND	11.0	11.0	13.0	9.5	11.25
14	10.0	ND	10.5	ND	14.5	10.0	12.25
15	ND	10.5	ND	ND	11.0	9.5	10.25
16	9.0	10.0	9.5	ND	11.0	9.0	10.00
17	6.5	8.5	10.0	8.0	11.0	6.5	8.75
18	7.0	8.5	9.0	9.0	9.5	7.0	8.25
19	8.0	11.0	11.0	10.5	11.5	8.0	9.75
20	10.0	12.0	13.0	12.5	14.0	10.0	12.00
21	11.5	13.0	13.0	13.0	13.5	11.5	12.50
22	11.5	12.0	11.5	11.5	12.0	11.5	11.75
23	11.5	13.0	13.5	12.0	14.0	11.5	12.75
24	9.5	12.0	12.0	11.5	12.0	9.5	10.75
25	9.5	10.5	11.0	11.5	13.0	9.5	11.25
26	10.0	11.0	10.5	11.0	11.5	9.5	10.50
27	9.0	10.5	10.5	9.5	11.0	9.0	10.00
28	8.5	9.5	10.0	9.0	10.5	8.5	9.50
29	7.0	10.0	9.5	9.0	10.5	7.0	8.75
30	6.5	8.5	9.0	8.5	9.5	6.5	8.00
1 October	6.0	8.0	9.0	8.5	9.5	6.0	7.75
2	8.0	ND	8.0	7.5	9.0	7.0	8.00
3	6.5	7.0	ND	6.5	8.0	6.0	7.00

continued...

Table 51. Concluded.

Date	Time of Trap Check 1200	1800	2100	2400	Daily Values Maximum	Minimum	Mean
4 Oct.	5.0	ND	5.5	4.5	6.0	4.0	5.00
5	4.0	4.5	ND	4.0	5.0	3.5	4.25
6	3.5	ND	4.5	4.5	5.5	3.5	4.50
7	3.0	4.5	5.0	5.5	6.5	3.0	4.00
8	4.0	4.5	ND	3.5	5.5	3.0	4.25
9	2.0	2.5	2.5	2.0	4.0	1.5	2.75
10	0.5	1.5	1.0	2.0	3.0	0.5	1.75
11	0.0	1.0	1.0	1.0	1.5	0.0	0.75
12	0.5	2.5	3.0	3.0	3.5	0.5	2.00
13	1.0	3.5	4.0	4.0	5.5	1.0	3.25
14	1.5	3.0	3.0	ND	3.5	1.5	2.50
15	1.5	ND	ND	ND	4.5	1.5	3.00

[a] Temperatures shown for 1200 hours are the overnight lows.

b No data.

8.3 SITE DESCRIPTIONS FOR STEEPBANK RIVER SMALL FISH COLLECTION SITES

The sampling areas described below refer to the small fish collection sites indicated in Figure 2.

Area 1. Tp92, R10, Sec. 36 SW1/4 W4

The mouth of the Steepbank River is fronted by a large tar sand delta that is exposed at low flow periods of the Athabasca River. At such times the mouth area sampled is approximately 10 to 12 m wide and 0.3 to 1.3 m deep. The current is moderate and the substrate consists of sand and silt with some gravel and tar sands. The banks are from 1 to 3 m high and covered mainly with willows. At high flow periods the Athabasca River backs up into the Steepbank for a distance of up to 1 km.

Area 2. Tp92, R10, Sec. 36 NW1/4 W4

This area included the counting fence which was located upstream of an island in the Steepbank River approximately 1 km upstream of its confluence with the Athabasca River. This area included a wide, shallow pool, approximately 16 m wide and 0.5 to 1 m deep, situated between two riffles. The substrate in the upstream riffle consisted of large limestone boulders and rubble while the downstream riffle was composed of coarse gravel and tar sand. Within the pool, the substrate was mainly mud-silt with some gravel and sand. The banks were moderate and covered with grasses, willows, poplar and black spruce. Aquatic vegetation was sparse although algae covered many of the rocks. During the flood that occurred in late May and early June, water from the Athabasca River was backed up almost to the counting fence site. All 23 fish species taken in the present study were found in Area 2, but some, such as goldeye, flathead chub etc., probably do not ascend the Steepbank much beyond this site.

Area 3. Tp92, R9, Sec. 29 SW1/4 W4

This site was located at the Water Survey of Canada Gauging Station. The sampling area included a pool, 0.3 to 1.3 m deep with steep limestone banks (5 m high) followed by a 100 m long, multi-channeled riffle. The pool bottom was mud-silt with scattered boulders while the riffle had a substrate of rubble and tar sand with some coarse gravel. Current was moderate with aquatic grasses in quiet areas near shore. White suckers, longnose suckers, longnose dace, lake chub, and trout-perch were captured at this site, however, pearl dace was the most abundant fish taken, comprising 66.8% of the total catch.

Area 4. Tp92, R9, Sec. 23 SE1/4 W4

The sampling site included a riffle area followed by a pool in front of a bitumen slide. The banks were gentle and grass covered. Stream width was approximately 13 m and depth varied from 0.1 to 0.8 m. The substrate was mainly rubble with some fine gravel and sand. Some aquatic vegetation (reeds) was present in quiet water near shore. In this section, pools are infrequent, the gradient is increased, and the river flows swiftly over long stretches of shallow, bouldery riffles. Fish captured at this site included longnose suckers, trout-perch, pearl dace, lake chub, longnose dace, and slimy sculpin.

Area 5. Tp91, R8, Sec. 32 SE1/4 W4

The site included a riffle area in a region with a succession of riffles and pools. In the riffle sampled, the substrate consisted of large boulders and rubble with some sand and gravel. Water depth was approximately 0.1 to 0.5 m while the stream was up to 14 m in width. Flow was relatively rapid through this area. Rocks were covered with algae and the banks vegetated by grasses and willows. Fish captured at this site included white suckers, longnose suckers, lake chub, pearl dace, longnose dace, trout-perch, slimy sculpin, and Arctic grayling.

Area 6. Tp90, R7, Sec. 32 SE1/4 W4

This area was located at the confluence of the North Steepbank and Steepbank rivers. There was a large deep pool (14 m wide and 0.3 to 1.5 m deep) just downstream of the mouth of North Steepbank with a bouldery riffle area upstream of the confluence. The substrate of the pool was mainly silt and sand with some coarse gravel and rubble. The upstream riffle region had large boulders (0.5 to 1.2 m) with sand and fine gravel. Lake chub made up 67.1% of all fish captured at this site. Other fish taken included slimy sculpin, longnose dace, pearl dace, and longnose sucker. Two unidentified sucker fry were also captured at this site.

Area 7. Tp90, R6, Sec. 20 NW1/4 W4

At this station, the Steepbank River had a width of approximately 8 to 10 m and depth of 0.3 to 0.8 m. The channel flow was slowed from beaver impoundments upstream. Riffle areas were infrequent and long stretches of pools (0.5 to 1.5 m deep) were common. There was heavy algal and moss growth on rocks in riffles. The banks were gradual with overhanging brush (willows) and black spruce. In some of the quieter reaches, dense mats of aquatic vegetation were present. Slimy sculpin accounted for 72.4% of all fish captured in this area. Other species found included pearl dace, brook stickleback, longnose sucker, white sucker, and trout-perch.

Area 8. Tp93, R6, Sec, 12 NW1/4 W4

Located at headwaters of Steepbank River. The stream was approximately 2 to 6 m in width with a depth of 20 to 40 cm. Water flow was slow and the stream bottom was mud with some sand and detritus. The site was situated in a marshy muskeg region surrounded by tall grasses. Only brook stickleback (58.1%) , pearl dace (40.8%), and slimy sculpin were taken at this site.

Area 9. Tp90, R7, Sec. 32 NE1/4 W4

A bouldery-rubble riffle locatedjust upstream of the mouth on the North Steepbank River. The current was swift and there was sand and fine gravel interspersed among rubble and boulders. Due to the irregular bottom of the site, seining was difficult and at times rather inefficient. The banks were gradual with some brush (willows) and spruce trees. Only two fish, one lake chub and one pearl dace, were captured at this site.

Area 10. Tp91, R7, Sec. 33 NE1/4 W4

This site was located in a region of pools and riffles on the North Steepbank River. The banks were moderate (1.0 to 1.2 m high) with grasses and overhanding brush with tall spruce trees (> 10 m). Width of stream was approximately 8 to 10 m with an average depth of 30 to 80 cm. The coarse gravel and rubble in the riffles were covered with algae, while aquatic plants (grasses and reeds) were present in the quieter reaches of pools. The substrate of pools was mainly sand and silt. Brook stickleback was the dominant fish species at this location accounting for 60.4% of the total catch. Other species occurring in this area were lake chub, pearl dace, Arctic grayling, longnose sucker, white sucker, and slimy sculpin.

Area 11. Tp93, R7, Sec. 15 SW1/4 W4

The banks were gentle with overhanging grasses and willows. Flow was slow as impoundment pools were common. Depth ranged from 0.6 to 1.0 m and the bottom was mainly mud-silt with some sand. Aquatic vegetation was sparse. Only brook stickleback (n = 14) and slimy sculpin (n = 8) were captured at this site.

Area 12. Tp95, R6, Sec. 6 SE1/4 W4

At the headwaters of the North Steepbank River. The stream width was approximately 2 to 3 m and the water depth averaged 40 to 50 cm. The banks were covered with grasses and some brush. There was some aquatic vegetation present and the bottom substrate was mainly of mud and fine gravel. Brook stickleback (89.1%) and pearl dace were the only fish captured in this area.

8.4 DATES OF TAGGING AND RECAPTURE, LOCATION OF RECAPTURE, DISTANCES TRAVELLED, AND ELAPSED TIME BETWEEN RELEASE AND RECAPTURE FOR FISH TAGGED AT THE STEEPBANK RIVER COUNTING FENCE, 1977, AND SUBSEQUENTLY RECAPTURED OUTSIDE THE STEEPBANK RIVER WATERSHED, OR DURING THE FALL COUNTING FENCE OPERATION.

Table 52. Dates of tagging and recapture, location of recapture, distances travelled, and elapsed time between release and recapture for fish tagged at the Steepbank River counting fence, 1977, and subsequently recaptured outside the Steepbank watershed, or during the fall counting fence operation.

Species	Date Tagged	Location Recaptured	Date Recaptured	Distance Travelled[a] (km)	Elapsed Time (Days)
Walleye	5 May	Mouth Poplar Creek	5 Aug.	+14	92
	6 May	Mouth Horse Creek	11 Sept.	+45	128
	9 May	GCOS intake	17 Aug.	+3	100
	9 May	Fort Chipewyan[b]	6 June	-288	28
	10 May	Steepbank Downstream Trap	13 May	0	3
	Second Recap.	Mouth Steepbank River	31 July	-1	82
	10 May	13 km S. Fort McMurray	5 Sept.	+54	118
	10 May	Steepbank Downstream Trap	12 May	0	2
	Second Recap.	Mile 155, Athabasca River	June	-206	20-50
	11 May	Mouth MacKay River	26 May	-19	15
	12 May	Clearwater River	19 Aug.	+38	99
	12 May	Steepbank Downstream Trap	13 May	0	1
	Second Recap.	Mouth Poplar Creek	26 Sept.	+14	137
	20 May	GCOS intake	16 Aug.	+3	88
	25 May	Mouth Muskeg River	1 Aug.	-16	68
	14 May	Steepbank Downstream Trap	15 May	0	1
	Second Recap.	Steepbank Upstream Trap	25 May	0	11
	Third Recap.	Mouth Parallel Creek	mid-Sept.	+403	∿125
	11 May	Steepbank Downstream Trap	12 May	0	1
	Second Recap.	Mouth Poplar Creek	28 May	+14	382
	3 May	Steepbank Upstream Trap	20 Sept.	0	140

continued...

Table 52. Continued.

Species	Date Tagged	Location Recaptured	Date Recaptured	Distance Travelled (km)	Elapsed Time (Days)
Northern pike	8 May	Mile 23.1 R Athabasca River	25 Oct.	+5	170
	Second Recap.	Poplar Creek	23 May/78	+14	380
	8 May	Stony Island-Athabasca River	18 Aug.	+19	102
	9 May	Stony Island-Athabasca River	18 Aug.	+19	101
	10 May	Mile 25.1R Athabasca River	20 Oct.	-2	163
	10 May	Mouth Poplar Creek	8 Oct.	+14	151
	10 May	Mouth Hangingstone River	10 Oct.	+42	153
	11 May	Mouth MacKay River	3 Aug.	-19	84
	11 May	Stony Island-Athabasca River	18 Aug.	+19	99
	13 May	Mouth Muskeg River	24 July	-16	72
	11 May	Steepbank Downstream Trap	22 May	0	11
	Second Recap.	Mouth Poplar Creek	2 July	+14	52
	23 May	Mouth Muskeg River	6 June	-16	14
	7 Oct.	Mile 25.1 R Athabasca River	20 Oct.	-2	13
	10 Oct.	Stony Island-Athabasca River	mid-Oct.	+19	∿ 5
	24 May	Mouth MacKay River	16 June/78	-19	388
	3 May	Mouth MacKay River	8 July/78	-19	431
	1 May	Steepbank Downstream Trap	7 Oct.	0	159
	7 May	Steepbank Downstream Trap	8 Oct.	0	154
	8 May	Steepbank Downstream Trap	18 Oct.	0	133
	8 May	Steepbank Downstream Trap	14 Sept.	0	129
	12 May	Steepbank Downstream Trap	16 Sept.	0	127
	15 May	Steepbank Downstream Trap	10 Oct.	0	148

continued...

Table 52. Continued.

Species	Date Tagged	Location Recaptured	Date Recaptured	Distance Travelled (km)	Elapsed Time (Days)
Longnose sucker	2 May	Athabasca Delta	22 June	-264	50
	6 May	Old Fort Bay[b]	14 June	-310	39
	12 May	Mouth Main Ch. Athabasca River[b]	1 June	-262	20
	2 May	Steepbank Downstream Trap	13 May	0	11
	Second Recap.	Poplar Island-Mamawi Lake	23 June	-302	52
	3 May	Steepbank Downstream Trap	19 May	0	16
	Second Recap.	W. shore Richardson Lake	24 May	-218	21
	9 May	Steepbank Downstream Trap	19 May	0	10
	Second Recap.	Fort Chipewyan[b]	6 June	-288	28
	19 May	Mouth Grayling Creek	19 Oct.	-168	153
	23 May	E. side Big Channel	16 June	-262	24
White sucker	11 May	Mile 25.9L Athabasca River	20 Oct.	-1	162
	10 May	Steepbank Downstream Trap	12 May	0	2
	Second Recap.	Old Fort Bay[b]	31 May	-310	21
	7 May	Steepbank Downstream Trap	12 May	0	5
	Second Recap.	5 km N.W. Goose Island[b]	June	-272	24-54
	15 May	Mouth Fletcher Channel[b]	16 June	-254	32
	29 Apr.	Mouth Steepbank River	10 Oct.	-1	164
	4 May	MacKay River Upstream Trap	17 May/78	-30	378
	4 May	MacKay River Upstream Trap	1 May/78	-30	362
	8 May	Steepbank Downstream Trap	12 May/77	0	4
	Second Recap.	MacKay River Upstream Trap	20 May/78	-30	377
	11 May	MacKay River Upstream Trap	4 May/78	-30	357
	23 May	MacKay River Upstream Trap	3 May/78	-30	345

continued...

Table 52. Continued.

Species	Date Tagged	Location Recaptured	Date Recaptured	Distance Travelled (km)	Elapsed Time (Days)
	29 Apr.	Steepbank Downstream Trap	9 Oct.	0	163
	29 Apr.	Steepbank Downstream Trap	5 Oct.	0	159
	29 Apr.	Steepbank Downstream Trap	9 Oct.	0	163
	29 Apr.	Steepbank Downstream Trap	9 Oct.	0	163
	29 Apr.	Steepbank Downstream Trap	9 Oct.	0	163
	1 May	Steepbank Downstream Trap	7 Oct.	0	160
	2 May	Steepbank Downstream Trap	9 Oct.	0	160
	3 May	Steepbank Downstream Trap	6 Oct.	0	156
	4 May	Steepbank Downstream Trap	7 Oct.	0	156
	4 May	Steepbank Downstream Trap	10 Oct.	0	159
	4 May	Steepbank Downstream Trap	16 Sept.	0	136
	4 May	Steepbank Downstream Trap	10 Oct.	0	159
	4 May	Steepbank Downstream Trap	30 Sept.	0	150
	7 May	Steepbank Downstream Trap	7 Oct.	0	153
	7 May	Steepbank Downstream Trap	18 Sept.	0	134
	8 May	Steepbank Downstream Trap	11 Oct.	0	156
	8 May	Steepbank Downstream Trap	5 Oct.	0	150
	8 May	Steepbank Downstream Trap	30 Sept.	0	145
	12 May	Steepbank Downstream Trap	7 Oct.	0	148
	21 May	Steepbank Downstream Trap	7 Oct.	0	139
	23 May	Steepbank Downstream Trap	7 Oct.	0	137
Mountain whitefish	1 May	Mouth Steepbank River	5 May	-1	4
Arctic grayling	10 Oct.	Poplar Creek Bridge	15 Oct.	+15	5

Table 52. Concluded.

[a] Distance shown is approximate distance from counting fence to recapture point and + or - designates upstream or downstream from Steepbank River in Athabasca. Note that, on occasion, movement was downstream in Athabasca River and later upstream in another tributary.

[b] Lake Athabasca.

9. AOSERP RESEARCH REPORTS

1. AOSERP First Annual Report, 1975
2. AF 4.1.1 Walleye and Goldeye Fisheries Investigations in the Peace-Athabasca Delta--1975
3. HE 1.1.1 Structure of a Traditional Baseline Data System
4. VE 2.2 A Preliminary Vegetation Survey of the Alberta Oil Sands Environmental Research Program Study Area
5. HY 3.1 The Evaluation of Wastewaters from an Oil Sand Extraction Plant
6. Housing for the North--The Stackwall System
7. AF 3.1.1 A Synopsis of the Physical and Biological Limnology and Fisheries Programs whithin the Alberta Oil Sands Area
8. AF 1.2.1 The Impact of Saline Waters upon Freshwater Biota (A Literature Review and Bibliography)
9. ME 3.3 Preliminary Investigations into the Magnitude of Fog Occurrence and Associated Problems in the Oil Sands Area
10. HE 2.1 Development of a Research Design Related to Archaeological Studies in the Athabasca Oil Sands Area
11. AF 2.2.1 Life Cycles of Some Common Aquatic Insects of the Athabasca River, Alberta
12. ME 1.7 Very High Resolution Meteorological Satellite Study of Oil Sands Weather: "A Feasibility Study"
13. ME 2.3.1 Plume Dispersion Measurements from an Oil Sands Extraction Plant, March 1976
14.
15. ME 3.4 A Climatology of Low Level Air Trajectories in the Alberta Oil Sands Area
16. ME 1.6 The Feasibility of a Weather Radar near Fort McMurray, Alberta
17. AF 2.1.1 A Survey of Baseline Levels of Contaminants in Aquatic Biota of the AOSERP Study Area
18. HY 1.1 Interim Compilation of Stream Gauging Data to December 1976 for the Alberta Oil Sands Environmental Research Program
19. ME 4.1 Calculations of Annual Averaged Sulphur Dioxide Concentrations at Ground Level in the AOSERP Study Area
20. HY 3.1.1 Characterization of Organic Constituents in Waters and Wastewaters of the Athabasca Oil Sands Mining Area
21. AOSERP Second Annual Report, 1976-77
22.
23. AF 1.1.2 Acute Lethality of Mine Depressurization Water on Trout Perch and Rainbow Trout
24. ME 1.5.2 Air System Winter Field Study in the AOSERP Study Area, February 1977.
25. ME 3.5.1 Review of Pollutant Transformation Processes Relevant to the Alberta Oil Sands Area

26. AF 4.5.1 Interim Report on an Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta
27. ME 1.5.1 Meteorology and Air Quality Winter Field Study in the AOSERP Study Area, March 1976
28. VE 2.1 Interim Report on a Soils Inventory in the Athabasca Oil Sands Area
29. ME 2.2 An Inventory System for Atmospheric Emissions in the AOSERP Study Area
30. ME 2.1 Ambient Air Quality in the AOSERP Study Area, 1977
31. VE 2.3 Ecological Habitat Mapping of the AOSERP Study Area: Phase I
32. AOSERP Third Annual Report, 1977-78
33. TF 1.2 Relationships Between Habitats, Forages, and Carrying Capacity of Moose Range in northern Alberta. Part I: Moose Preferences for Habitat Strata and Forages.
34. HY 2.4 Heavy Metals in Bottom Sediments of the Mainstem Athabasca River System in the AOSERP Study Area
35. AF 4.9.1 The Effects of Sedimentation on the Aquatic Biota
36. AF 4.8.1 Fall Fisheries Investigations in the Athabasca and Clearwater Rivers Upstream of Fort McMurray: Volume I
37. HE 2.2.2 Community Studies: Fort McMurray, Anzac, Fort MacKay
38. VE 7.1.1 Techniques for the Control of Small Mammals: A Review
39. ME 1.0 The Climatology of the Alberta Oil Sands Environmental Research Program Study Area
40. WS 3.3 Mixing Characteristics of the Athabasca River below Fort McMurray - Winter Conditions
41. AF 3.5.1 Acute and Chronic Toxicity of Vanadium to Fish
42. TF 1.1.4 Analysis of Fur Production Records for Registered Traplines in the AOSERP Study Area, 1970-75
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46. VE 3.4 Interim Report on Ecological Benchmarking and Biomonitoring for Detection of Air-Borne Pollutant Effects on Vegetation and Soils, 1975 to 1978.
47. TF 1.1.1 A Visibility Bias Model for Aerial Surveys for Moose on the AOSERP Study Area
48. HG 1.1 Interim Report on a Hydrogeological Investigation of the Muskeg River Basin, Alberta
49. WS 1.3.3 The Ecology of Macrobenthic Invertebrate Communities in Hartley Creek, Northeastern Alberta
50. ME 3.6 Literature Review on Pollution Deposition Processes
51. HY 1.3 Interim Compilation of 1976 Suspended Sediment Date in the AOSERP Study Area
52. ME 2.3.2 Plume Dispersion Measurements from an Oil Sands Extraction Plan, June 1977

53. HY 3.1.2 Baseline States of Organic Constituents in the Athabasca River System Upstream of Fort McMurray
54. WS 2.3 A Preliminary Study of Chemical and Microbial Characteristics of the Athabasca River in the Athabasca Oil Sands Area of Northeastern Alberta
55. HY 2.6 Microbial Populations in the Athabasca River
56. AF 3.2.1 The Acute Toxicity of Saline Groundwater and of Vanadium to Fish and Aquatic Invertebrates
57. LS 2.3.1 Ecological Habitat Mapping of the AOSERP Study Area (Supplement): Phase I
58. AF 2.0.2 Interim Report on Ecological Studies on the Lower Trophic Levels of Muskeg Rivers Within the Alberta Oil Sands Environmental Research Program Study Area
59. TF 3.1 Semi-Aquatic Mammals: Annotated Bibliography
60. WS 1.1.1 Synthesis of Surface Water Hydrology
61. AF 4.5.2 An Intensive Study of the Fish Fauna of the Steepbank River Watershed of Northeastern Alberta
62. TF 5.1 Amphibians and Reptiles in the AOSERP Study Area
63.
64. LS 21.6.1 A Review of the Baseline Data Relevant to the Impacts of Oil Sands Development on Large Mammals in the AOSERP Study Area
65. LS 21.6.2 A Review of the Baseline Data Relevant to the Impacts of Oil Sands Development on Black Bears in the AOSERP Study Area
66. AS 4.3.2 An Assessment of the Models LIRAQ and ADPIC for Application to the Athabasca Oil Sands Area
67. WS 1.3.2 Aquatic Biological Investigations of the Muskeg River Watershed
68. AS 1.5.3 AS 3.5.2 Air System Summer Field Study in the AOSERP Study Area, June 1977
69. HS 40.1 Native Employment Patterns in Alberta's Athabasca Oil Sands Region
70. LS 28.1.2 An Interim Report on the Insectivorous Animals in the AOSERP Study Area
71. HY 2.2 Lake Acidification Potential in the Alberta Oil Sands Environmental Research Program Study Area
72. LS 7.1.2 The Ecology of Five Major Species of Small Mammals in the AOSERP Study Area: A Review
73. LS 23.2 Distribution, Abundance and Habitat Associations of Beavers, Muskrats, Mink and River Otters in the AOSERP Study Area, Northeastern Alberta
\- -- Interim Report to 1978
74. AS 4.5 Air Quality Modelling and User Needs
75. LS 2.1 Interim Report on the Soils Inventory of the AOSERP Study Area

76. AF 4.5.1 An Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta

77. HS 20.1 Overview of Local Economic Development in the Athabasca Oil Sands Region Since 1961.

78. LS 22.1.1 Habitat Relationships and Management of Terrestrial Birds in Northeastern Alberta.

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