# INVESTIGATIONS OF THE SPRING SPAWNING FISH POPULATIONS IN THE ATHABASCA AND CLEARWATER RIVERS UPSTREAM FROM FORT MCMURRAY

Volume I

by

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Aquatic Environments Limited

for
ALBERTA OIL SANDS ENVIRONMENTAL
RESEARCH PROGRAM

Project WS 1.6.1
December 1979

The Hon. J.W. (Jack) Cookson
Minister of the Environment
222 Legistlative Building
Edmonton, Alberta

and

The Hon. John Fraser
Minister of the Environment
Environment Canada
Ottawa, Ontario

Sirs:

Enclosed is the report "Investigations of the Spring Spawning Fish Populations in the Athabasca and Clearwater Rivers Upstream from Fort McMurray: Volume I".

This report was prepared for the Alberta Oil Sands Environmental Research Program, through its Water System, under the Canada-Alberta Agreement of February 1975 (amended September 1977).

Respectfully,

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Chairman, Steering Committee, AOSERP
Deputy Minister, Alberta Environment

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# INVESTIGATIONS OF THE SPRING SPAWNING FISH POPULATIONS IN THE ATHABASCA AND CLEARWATER RIVERS UPSTREAM FROM FORT McMURRAY

## DESCRIPTIVE SUMMARY

### BACKGROUND

Previous AOSERP fisheries studies have documented critical spawning habitats in the Athabasca River upstream of Fort McMurray for lake whitefish from Lake Athabasca (see AOSERP Report #36). Knowledge of the fall spawning pattern of this important fish resource through the current oil sands mining region is of paramount importance for assessing and regulating industrial activity. However, a question which remained regarded the extent to which the spawning habitat upstream of Fort McMurray was utlized by spring spawning species such as northern pike, walleye, and goldeye. Answers to this question would provide enough information to enable the refining of management policies affecting the water and habitat quality of the mainstem river system.

This study intended to describe the habitat and biology of the major spring spawning fish populations of the Athabasca and Clearwater rivers. Detailed objectives are found in the introduction of the report.

### ASSESSMENT

Results for this research project have been presented in two volumes: the first volume contains the summary of results along with discussion and conclusions and the second volume comprises details of sampling locations and catches. Volume I received review by scientists at Alberta Fish and Wildlife Division and the University of Manitoba, whereas Volume II remains as unedited material. These reports detail fish utilization of the Athabasca and Clearwater rivers immediately upstream of Fort McMurray during the spring season and thus complete the fisheries picture for that important region.

The Alberta Oil Sands Environmental Research Program accepts the two volume report "Investigations of the Spring Spawning Fish Populations in the Athabasca and Clearwater Rivers Upstream from Fort McMurray" as an important and valid document and thanks the researchers, D.B. Tripp and P.J. McCart, for their contribution. Volume I will receive wide distribution whereas Volume II will be made available through AOSERP open file.

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# ABSTRACT

Fisheries investigations were undertaken in the spring of 1978 (28 April to 25 June) in the Athabasca and Clearwater rivers upstream of Fort McMurray. The major objectives of the studies were to determine what spring spawners utilized these sections of the Athabasca and Clearwater rivers; to locate and describe their spawning grounds; and to describe the timing of spawning, hatching, and emergence in relation to environmental factors such as water temperature, turbidity, dissolved oxygen concentrations, and stream flow.

Large numbers of longnose suckers spawned during mid May in the Athabasca River from Fort McMurray upstream to the Cascade Rapids, the same area used by fall spawning lake whitefish. The major concentrations were located just below the Mountain and Cascade rapids. There was no evidence of major spawning concentrations of this species elsewhere in the present study area. Shortly after spawning, longnose suckers left the project study area and presumably returned to the Peace-Athabasca Delta.

Northern pike and burbot spawning and rearing areas were identified in the Clearwater River upstream of its junction with the Christina River. There was little or no spawning by either species in the Clearwater River downstream of the Christina River or in the Athabasca River upstream of Fort McMurray.

No major concentrations of spawning walleye were located. However, based on the distribution of young-of-the-year, it appears that at least some walleye spawned at various localities in the Athabasca River from the Mountain Rapids to as far upstream as the Grand Rapids. There is no evidence that walleye spawned in the Clearwater River within the AOSERP study area.

Lake whitefish young-of-the-year probably emerged and moved downstream out of the present study area before spring break-up. Longnose sucker young-of-the-year emerged at the beginning of June followed by pike, walleye, and white sucker young-of-the-year later in June.

The Athabasca River, and to a lesser extent the Clearwater River, provide valuable habitat for a number of minor species including flathead chub, longnose dace, and lake chub. Large numbers of juvenile goldeye also use the area as feeding grounds during the open-water period.

# ACKNOWLEDGEMENTS

The field assistance of William Grant and Daniel McCart is gratefully acknowledged. Valuable assistance during the preparation of this manuscript was provided by Joyce Harris and Cecilia Gossen.

The authors would also like to thank the personnel of the AOSERP Mildred Lake Research Facility for their support and assistance.

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# 1. INTRODUCTION

## 1.1 BACKGROUND

The Alberta Oil Sands Environmental Research Program (AOSERP) has, as part of its mandate, the responsibility of determining the baseline status of various aquatic ecosystems in the AOSERP study area (Figure 1) in order to assess the probable impact of oil sands development. This study, an investigation of spring spawning fish populations in the Athabasca and Clearwater rivers upstream of Fort McMurray, was conducted in an area where little information was previously available.

Until now, the only studies on spawning fish in the mainstem Athabasca and Clearwater rivers upstream of Fort McMurray have been those of Jones et al. (1978) on fall spawning lake whitefish. Earlier studies by Griffiths (1973) on the Clearwater River were conducted upstream of and outside the present boundaries of the AOSERP study area while those on the Athabasca River were located near the Great Canadian Oil Sands (GCOS)[1] plant downstream of Fort McMurray. Recently completed studies by Tripp and Tsui (in prep.) were concentrated on several tributary streams and lakes in the southern portion of the AOSERP study area. They identified major spawning runs of northern pike, longnose suckers, and white suckers in the Christina River but provided little additional information on spring spawners in the Athabasca River.

Studies on the Athabasca River downstream of Fort McMurray (Bond and Berry in prep.a, in prep.b; McCart et al. 1977) show, however, the importance of the Athabasca River as a major migration route for several important fish species. Both longnose and white suckers, for example, have been shown to move upstream early in the spring to spawn in several major tributaries of the Athabasca River. These include the Muskeg (Bond and Machniak 1977, 1979), Steepbank (Machniak and Bond 1979), and MacKay (Bond et al. in prep.; McCart et al. 1978) rivers. There has been no evidence, however, of spawning by either sucker species in the Athabasca River itself. After spawning, most suckers appear to return to the Peace-Athabasca Delta and Lake Athabasca.

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[1] GCOS amalgated with Sun Oil Company in August 1979, after the writing of this report was completed, to become Suncor, Inc.

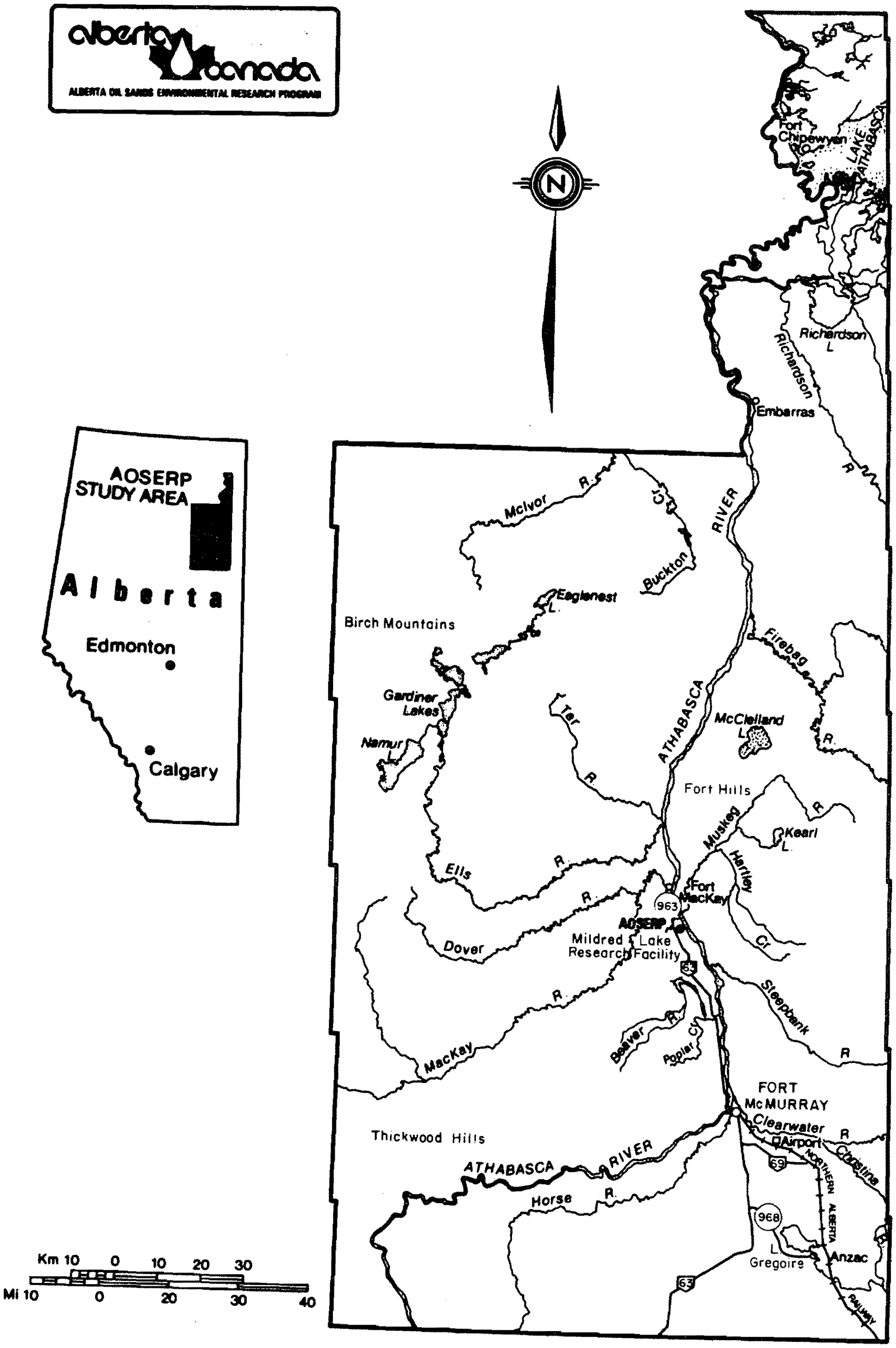


Figure 1. The AOSERP study area.

Large numbers of goldeye also migrate upstream shortly after spring break-up. This migration consists almost exclusively of immature fish in the 230 to 300 mm range and probably represents a movement by prespawning age fish from overwintering areas in the Peace-Athabasca Delta to feeding grounds in the Athabasca River. Jones et al. (1978) indicate that they move as far upstream as the Grand Rapids on the Athabasca River (140 km above Fort McMurray) and the Christina River on the Clearwater River (25 km above Fort McMurray). They are also taken in the lower reaches of the MacKay (McCart et al. 1978) and Christina (Tripp and Tsui in prep.) rivers but not in smaller tributaries such as the Muskeg and Steepbank rivers (Bond and Machniak 1977, 1979; Machniak and Bond 1979). Catches decline in the fall as goldeye move back downstream to overwintering areas.

In the fall, lake whitefish migrate upstream from Lake Athabasca to spawn in the Athabasca River. Jones et al. (1978) indicate that spawning occurs as far upstream as the Cascade Rapids (38 km upstream of Fort McMurray). The largest concentration, however, is located immediately below the Mountain Rapids, approximately 15 km upstream of Fort McMurray. After spawning (13 to 25 October 1977), lake whitefish quickly return to the Peace-Athabasca Delta and Lake Athabasca.

The migratory patterns and major spawning areas of other species, such as northern pike and walleye, in the Athabasca River are not known as well as those of lake whitefish, goldeye, longnose suckers, and white suckers. Catches of northern pike in the mainstem rivers are generally small, sporadic, and seldom useful for describing seasonal movements. A small upstream migration has been described for the Muskeg River (Bond and Machniak 1977, 1979) although it was composed largely of spent and immature northern pike. Most pike spawning has been presumed to occur in marshy backwaters along the Athabasca River and in the Athabasca River Delta. The only major spawning area yet described for northern pike in the AOSERP study area occurs in the Christina River (Tripp and Tsui in prep.), a tributary of the Clearwater River.

Studies on the Athabasca River indicate that walleye enter the Athabasca River under the ice and may commence spawning shortly before spring break-up. Females, however, are rarely sampled which may indicate that they leave the spawning areas immediately after spawning. Ripe and recently spent males, on the other hand, are commonly sampled throughout the lower Athabasca River. Post-spawning runs of spent males have been identified in the Steepbank (Machniak and Bond 1979) and MacKay (Bond et al. in prep; McCart et al. 1978) rivers. The definite location of any walleye spawning areas in the Athabasca River is unknown. The most likely locations are suggested to be in the rocky, faster flowing reaches of the Athabasca or Clearwater rivers upstream of Fort McMurray (Bond and Berry in prep.b).

## 1.2 OBJECTIVES

The overall objective of this study was to describe the habitat and biology of the major spring spawning species during the spring in the Athabasca and Clearwater rivers upstream of Fort McMurray. More specifically, the objectives were:

1. To identify and describe the spawning characteristics of major fish species during the spring in the Athabasca and Clearwater rivers upstream of Fort McMurray to the boundaries of the AOSERP study area;
2. To describe, delineate, and quantify actual and potential spring spawning areas by species;
3. To describe the time frame of spawning, hatching, fry development, and emergence for each species in relation to environmental factors; and
4. To describe and quantify the downstream movement of fry (including fall spawning whitefish) in relation to natural environmental factors.

To meet these objectives, a three-man crew was used to conduct field investigations on the Athabasca and Clearwater rivers from spring break-up until the end of June 1978. Eighteen stations, 16 on the Athabasca River, six on the Clearwater River, and two on the Christina River, were selected for routine sampling. The locations of the above stations were similar to those in Jones et al. (1978). Thirteen additional stations were also sampled on one or two occasions to further delineate actual and potential spring spawning areas. Of these, five were located on the Clearwater River upstream of the AOSERP study area.

Each station was sampled with standard gillnet gangs, large mesh beach seines, and minnow seines, depending on ice conditions, water levels, and the amount of debris present in the rivers. Initially, the efforts were concentrated on sampling larger fish in order to describe the seasonal movements, spawning period, spawning area, and basic life history of each major species. After spawning, drift netting and small mesh seining along inshore areas were also emphasized in order to describe the emergence times, downstream movements, and distribution of young-of-the-year.

This report consists of two volumes. Volume I is an explanatory text complete with summary tables and maps, while Volume II contains detailed site descriptions, catch data, and dissection data.

Volume II has been released as Open File 4, copies of which can be viewed at designated libraries. Copies can be purchased directly from Riley's Reproductions and Printing Ltd., 10180-108 Street, Edmonton, Alberta. For further information, please contact Program Management at AOSERP.

## 2. MATERIALS AND METHODS

The study began in late April 1978, prior to ice break-up on the Athabasca and Clearwater rivers. There was an initial helicopter reconnaissance of the Athabasca River, upstream of Mountain Rapids, on 27 April. At that time, this was the only open water along the Athabasca River in the AOSERP study area. After break-up (29 April for both rivers), a jet-powered riverboat was used to reach sampling sites on the Clearwater River and its tributary, the Christina River, and on the Athabasca River as far upstream as Cascade Rapids. A helicopter was used to sample the Athabasca River upstream of Cascade Rapids to the limit of the AOSERP study area.

The locations of sampling stations are indicated in Figure 2. Routine sampling stations were visited at 2 to 10 day intervals. At each visit, the stations were gillnetted and/or seined, depending on conditions. The variable mesh gillnets used were standard gangs consisting of six individual panels 3.0 m long and 2.4 m deep of the following mesh sizes: 3.8, 5.1, 6.3, 7.6, 8.9, and 10.2 cm stretch mesh.

Gillnets were set for periods from 2 to 24 hours, depending primarily on stream conditions. It was not possible to set nets for long periods when large amounts of debris were present. Records were kept of the duration of sets and the numbers of each species caught.

The seines used were of two types: a large mesh beach seine 30.5 m long and 2.4 m deep and 5.1 cm stretch mesh; and a pole-mounted small mesh minnow seine 1.2 m deep and 3.0 m in length constructed of 3.2 mm nylon marquissette.

Beach seining was done in quiet backwater areas from the shoreline with the aid of jet boats. Records were kept of the number of hauls and the catch of each species. Minnow seining was done along the shoreline and careful records kept of the number of hauls, the length of shoreline seined, and the catch of each species.

At some of the routine sampling stations (Stations 7, 11, 12, and 15 on the Athabasca and Stations 17 and 21 on the Clearwater River), drift samples were taken to collect fish eggs

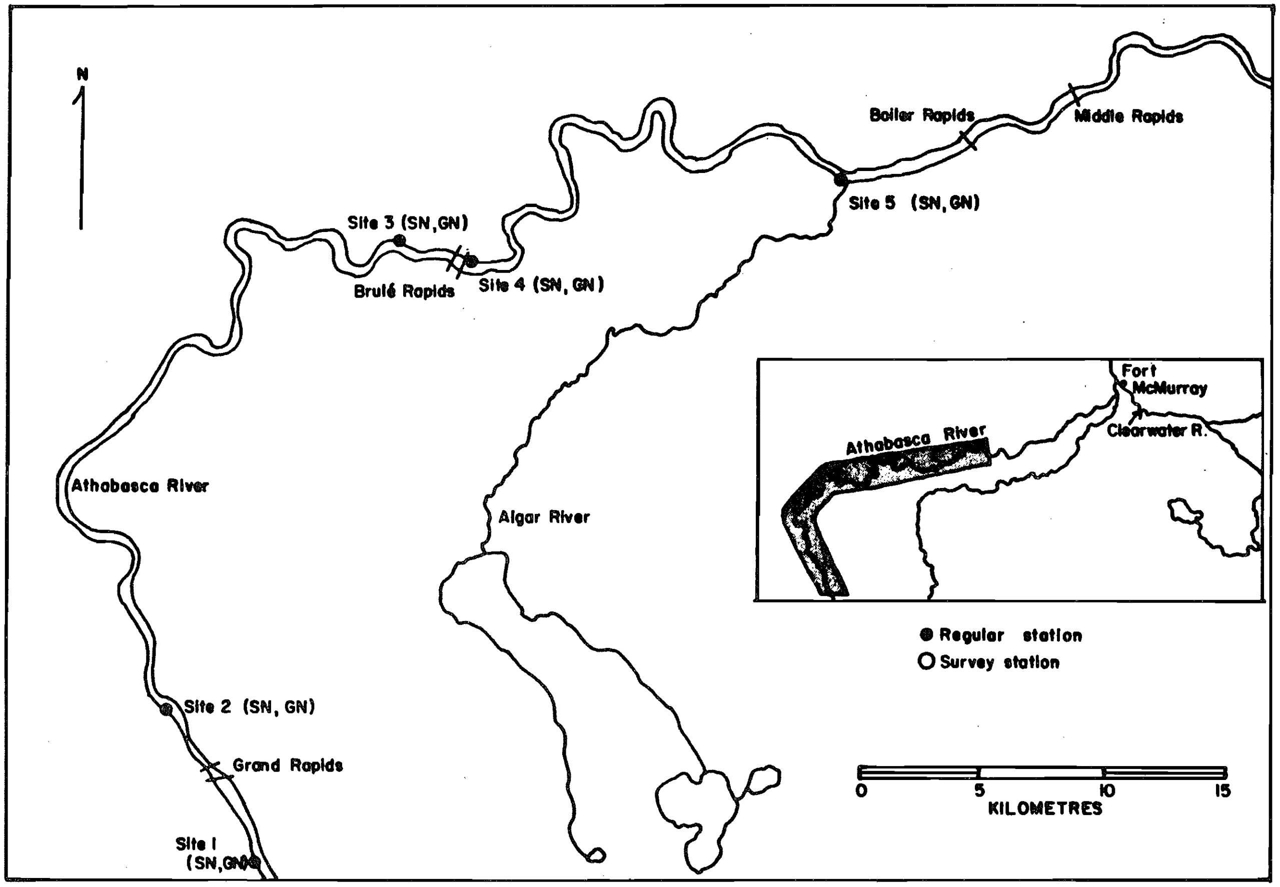
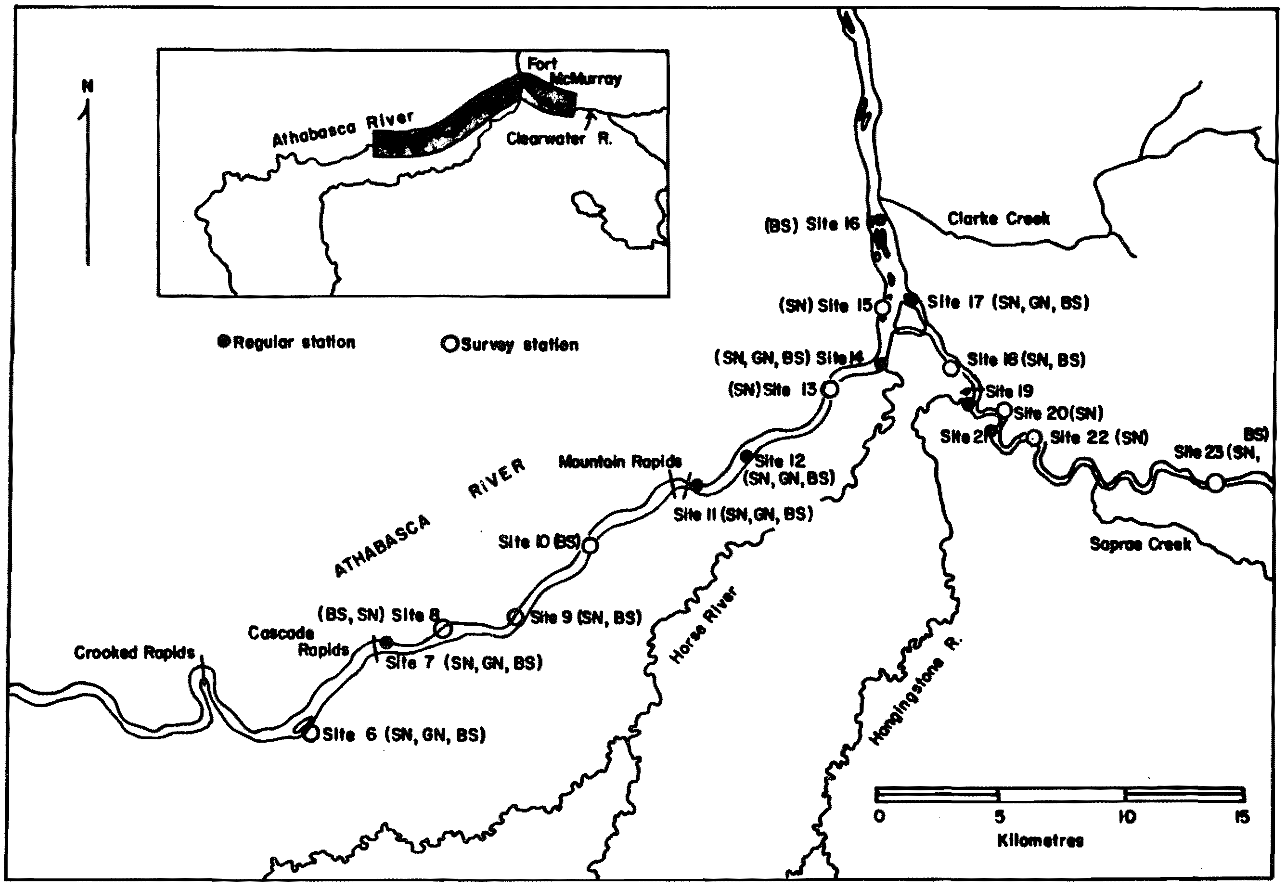


Figure 2. The project study area showing locations at regular and survey sampling stations and the sampling methods used at each station. GN=standard gillnet gang, SN=minnow seine, BS=beach seine. (Continued).



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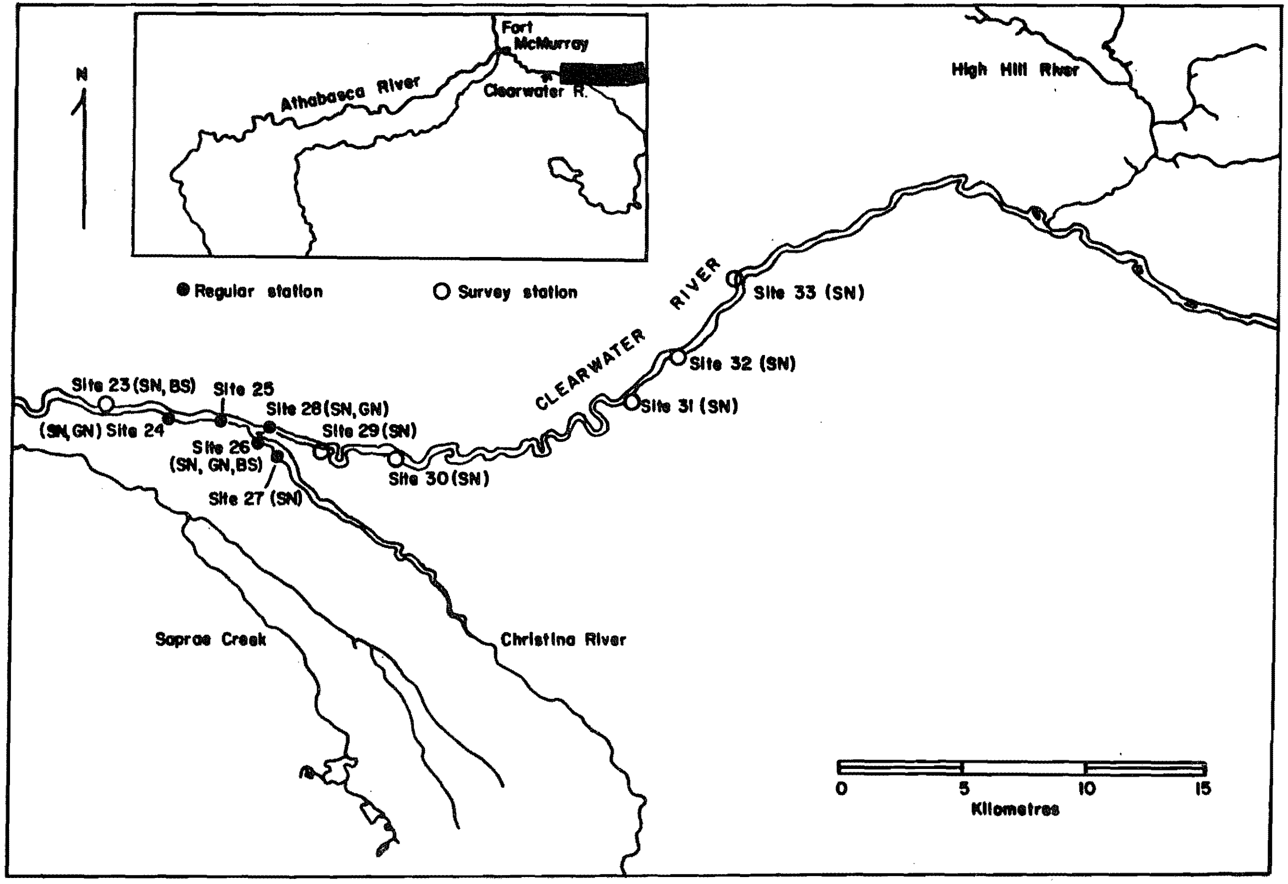


Figure 2. Concluded.

and newly emerged fry. The sampling apparatus has an opening 30.5 $cm^2$ and a mesh size of 600 μm. The apparatus was fished just below the water surface. Records were kept of the velocity of water through the net and of the duration of the sampling effort so that the catch could be related to the volume of water sampled. Normally, the drift nets were fished for 5 to 15 minute periods.

Survey sampling stations were sampled less frequently than the routine stations. The survey stations were sampled in an attempt to delineate the spawning grounds of spring spawners and to locate concentrations of fry. The same sampling methods were used at the routine sampling sites.

A large number of longnose suckers were marked by partial finclips and released alive. Three distinctive marks were used depending on area of capture:

1. Fish captured at the mouth of the Clearwater River and in the Athabasca River downstream of Fort McMurray were marked by the partial removal of the left pelvic fin;
2. Fish captured in the Athabasca River from Fort McMurray upstream to Mountain Rapids were marked by partial removal of the right pectoral fin; and
3. Fish captured in the Athabasca River from Mountain Rapids upstream to Cascade Rapids were marked by partial removal of the left pectoral fin.

All subsequent catches were examined for recaptured fish.

Captured fish were either retained for detailed life history analysis in the laboratory or released alive. The latter were examined for evidence of maturity and spawning condition. As they approached spawning, it was possible to identify mature fish in the field as:

1. Mature-green: fish that would spawn, generally characterized by large body size, large gonads, and secondary evidence of maturity such as nuptial tubercles and body colouration;
2. Mature-ripe: fish from which sex products could be

extruded by gentle pressure on the abdomen; and

3. Spawned-out: fish which had recently completed spawning as indicated by a flaccid abdomen and the absence or diminished volume of sex products expressed by gentle pressure on the abdomen.

Fish retained for detailed life history analysis were dissected in the laboratory. Each fish was measured to the nearest millimetre and eggs to the nearest 0.1 mm by calculating the mean diameter of 10 unpreserved eggs of the largest size class lined up in a row. Gonads were removed and weighed to the nearest 0.1 g. For fecundity determination, a weighed subsample, including both eggs and ovarian tissue, amounting to about 10% of total gonad weight, was preserved in 10% formalin for later enumeration. Eggs in the subsample were counted under magnification and the total fecundity calculated by direct proportion.

After dissection, gonads were classified as mature or immature. Mature gonads were further classified as green, ripe, or spawned-out in a manner similar to that described above. Additional criteria included egg size, gonad weight, looseness of eggs, colouration, and vascularization of the gonads.

Otoliths were used for determining the age of all fish species taken during this study with the exception of northern pike and walleye which were aged with scales. Otoliths were read with the aid of a binocular microscope using Nordeng's (1961) criteria for the identification of annuli. Scales were read with the aid of a projecting microscope using Lagler's (1956) criteria for the identification of annuli. Each fish was aged by two independent readers. Differences in age were reconciled during a third joint reading by the two observers.

Fish stomachs contents were examined in the laboratory and identified to major taxa (order or family) or other suitable category (e.g., insect parts, digested material, fish remains). Data on the presence or absence of various items were used to calculate frequency of occurrence for various food items. A more detailed analysis of stomach contents was not undertaken because most of the samples were dead specimens taken in overnight gillnet sets and the stomachs were therefore in an advanced state of decomposition.

Throughout the course of the study, water temperature (pocket thermometer) and dissolved oxygen levels (Hach OX-10 Dissolved Oxygen Kit) were measured at approximately 5 day intervals at various sites along the Athabasca and Clearwater rivers. Turbidity samples were also collected in 500 mL hand held bottles and preserved with 1 mL $CuSO_4$ for later reading on a Hach Turbidimeter.

## 3. THE STUDY AREA

The area under study extends upstream of Fort McMurray on both the Athabasca and Clearwater rivers to the southern and eastern limits of the AOSERP study area (Figure 1). It includes the mouth of the Christina River, a major tributary of the Clearwater River. Within the present study area, the Athabasca flows a distance of approximately 140 km at an average gradient of 1.0 m/km. The banks are approximately 150 to 200 m high and forested with the usual elements of a spruce/aspen boreal forest.

In this reach of the Athabasca River, there are several sets of rapids that have a major influence on the distribution of fish species. These are the Mountain and Cascade rapids which are formed of sills of limestone bedrock stretching almost completely across the river. An earlier study (Jones et al. 1978) demonstrated that the areas just downstream of these rapids are major spawning areas for lake whitefish. Even at low flows, the rapids are a major obstacle to fish migrations. Rapids upstream of the Cascade Rapids (e.g., Grand, Brule, Boiler, and Middle rapids) are discontinuous and do not appear to form a serious barrier to fish movements.

Coarse gravels are the predominant substrate in the section of the Athabasca River under study.

The Clearwater River is a slower, meandering river. Within the present study area, it flows a distance of approximately 65 km at a gradient of 0.2 m/km before joining the Athabasca River at Fort McMurray. Its banks are generally low and eroding, especially along the outside curve of meanders. Most of the substrate is sand. The river is dotted with numerous islands, particularly in the upper reaches of the present study area. The side channels formed by these islands often have extensive growths of aquatic macrophytes.

A total of 33 stations was sampled during the study period, 27 April to 26 June 1978. Of these, 17 were regular stations that were sampled at intervals throughout the study. The remaining 16 stations include those sampled during preliminary surveys to locate concentrations of spring spawning fish species or recently emerged fry. The locations of sampling stations are shown in Figure 2, together with the sampling methods used at each station. A description of each sampling location is included in Volume II (Tripp and McCart 1979).

## 3.1 DISCHARGE

The seasonal patterns of daily discharge rates for the Athabasca River downstream of Fort McMurray and for the Clearwater River at Draper, Alberta, are shown in Figure 3 for the period 1 April to 30 June 1978. At Fort McMurray, spring break-up on both rivers occurred 28 April although there was an earlier peak in discharge in the Athabasca River on 21 April. This earlier peak did not dislodge ice in the river at Fort McMurray and caused the ice to pile up as far upstream as the Mountain Rapids. The Athabasca River upstream of the Mountain Rapids, however, was free of ice for one week prior to break-up downstream.

During the study period, discharge rates in the Athabasca River ranged from 252 $m^3/s$ on 1 April to a peak of 1498 $m^3/s$ on 4 May. Discharge dropped to 711 $m^3/s$ on 20 May but there was a second major peak of 2132 $m^3/s$ on 19 June as a result of heavy precipitation and spring runoff upstream of the study area.

Discharge in the Clearwater River was considerably more stable than on the Athabasca River, rising from a base flow of 61 $m^3/s$ on 1 April to a peak of 309 $m^3/s$ on 30 April. Discharge dropped very slowly thereafter.

## 3.2 DISSOLVED OXYGEN

Dissolved oxygen concentrations were similar in the Athabasca and Clearwater rivers (Figure 3). Values were highest just after break-up and then declined through to mid-June. The highest levels were recorded in the Clearwater on 29 April and 17 May (11.0 mg/L), the lowest on 5 June and 10 June (8.0 mg/L). In the Athabasca, the highest value was recorded 5 May (10.4 mg/L) and the lowest on 10 June (8.0 mg/L).

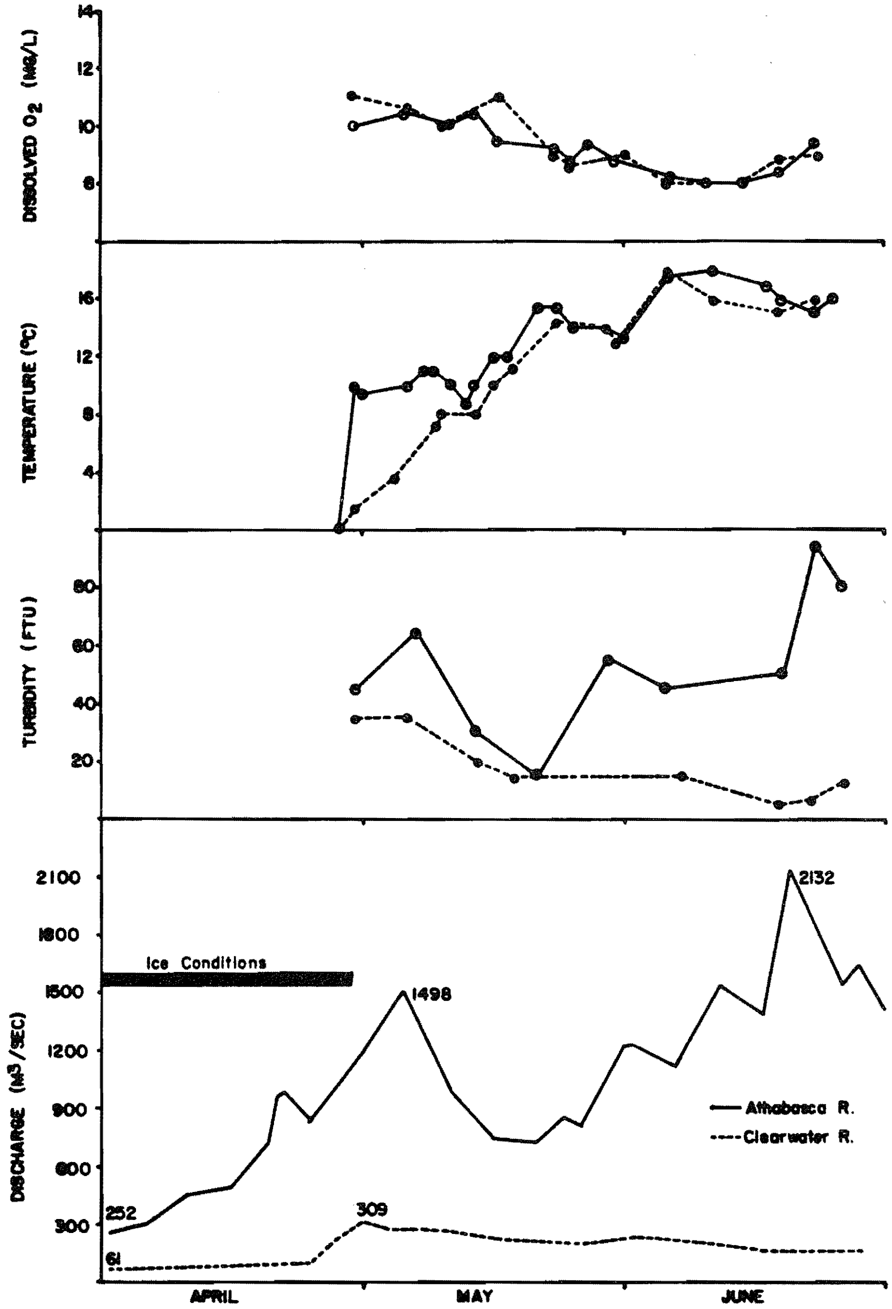


Figure 3. Seasonal dissolved oxygen levels, water temperature, turbidity, and daily discharge in the Athabasca and Clearwater rivers, 28 April to 25 June 1978. (Stream discharge data provided by Water Survey of Canada.)

In both rivers, the recorded values were close to saturation at all times and the declines in concentration were largely the result of increasing water temperatures since the oxygen carrying capacity of water declines as temperature increases.

## 3.3 TEMPERATURE

Water temperatures in the Athabasca River upstream of the Mountain Rapids were 9 to 10°C on 27 April, approximately one week after the break-up of the upper reaches of the Athabasca. Water temperatures downstream of the Mountain Rapids therefore increased rapidly (Figure 3) when the ice broke up at Fort McMurray on 29 April, flooding the lower section of the Athabasca River with warm water. Temperatures increased gradually thereafter in both the Athabasca and Clearwater rivers, reaching a maximum of 18°C in early June.

## 3.4 TURBIDITY

The seasonal pattern of turbidity in the Athabasca and Clearwater rivers, April to June 1978, is shown in Figure 3. Values in the Athabasca ranged from highs of 65 FTU's (Formazin Turbidity Units) on 6 May, and 95 FTU's on 22 June during periods of peak discharge, to 15 FTU's on 15 May at low flow. Turbidity was highest (35 FTU's) on the Clearwater just after break-up, 30 April to 5 June, and then declined to 4.7 FTU's 18 June.

## 3.5 WATER QUALITY

Additional information on various water quality parameters in the Athabasca River upstream of Fort McMurray is summarized in Table 1 (telephone conversation with A.M. Akena, Pollution Control Division, Alberta Environment; January 1979).

Table 1. Water quality in the Athabasca River 100 m upstream of the Horse River, 13 June 1978.

| | | | | | |
|---|---|---|---|---|---|
| Temperature (°C) | | 17.5 | TIC | (mg/L) | 23.5 |
| pH | | 8.0 | Dissolved Organic Carbon | (mg/L) | 23.5 |
| Conductivity (μmhos/cm @ 25°C) | | 110 | Total Nitrogen | (mg/L) | 0.079 |
| D.O. | (mg/L) | 9.0 | Ammonium | (mg/L) | 0.04 |
| Ca. | (mg/L) | 24.9 | Kjeldahl N | (mg/L) | 0.75 |
| Mg | (mg/L) | 7.0 | Phenol | (mg/L) | 0.004 |
| Na | (mg/L) | 4.3 | Oil & Grease | (mg/L) | 0.6 |
| K | (mg/L) | 0.8 | $NO_3$ | (mg/L) | 0.074 |
| Cl | (mg/L) | 1.1 | $NO_2$ | (mg/L) | 0.005 |
| $SO_4$= | (mg/L) | 17.1 | COD | (mg/L) | 61 |
| Total Alkalinity | (mg/L) | 90.7 | Chromium$^{+6}$ | (mg/L) | 0.003 |
| Bicarbonate | (mg/L) | 111.0 | Cu | (mg/L) | 0.004 |
| Hardness | (mg/L) | 91.0 | Fe | (mg/L) | 7.5 |
| Fl | (mg/L) | 0.5 | Pb | (mg/L) | 0.012 |
| Tannin and Lignin | (mg/L) | 0.5 | Mn | (mg/L) | 0.283 |
| Total Phosphate | (mg/L) | 0.032 | Zn | (mg/L) | 0.007 |
| Orthophosphate | (mg/L) | 0.009 | Va | (mg/L) | 0.006 |
| Filterable Residue | (mg/L) | 102 | Se | (mg/L) | 0.0009 |
| Filterable Residue--inorganic | (mg/L) | 83 | Hg | (mg/L) | <0.001 |
| Non-filterable | (mg/L) | 405 | Ni | (mg/L) | 0.004 |
| Non-filterable--fixed | (mg/L) | 363 | Al | (mg/L) | 0.63 |
| Turbidity | (JTU's) | 180 | Co | (mg/L) | 0.002 |
| Reactive Silica | (mg/L) | 4.0 | Bo | (mg/L) | 0.02 |
| Sulphide | (mg/L) | <0.01 | Free $CO_2$ | (mg/L) | 1.7 |
| Hummic Acid | (mg/L) | <1 | | | |
| Fulvic Acid | (mg/L) | 4 | | | |
| TOC | (mg/L) | 29.5 | | | |

# 4. RESULTS AND DISCUSSION

## 4.1 SPECIES COMPOSITION AND RELATIVE ABUNDANCE

During the course of the study, 24 species of fish, representing 12 families, were collected in the study area (Table 2). Of these, 11 species (mountain whitefish, goldeye, northern pike, longnose dace, flathead chub, lake chub, fathead minnow, longnose sucker, burbot, trout-perch, and walleye) accounted for over 95% of the total catch.

The longnose sucker was the most abundant species overall, constituting 42.5% of the total catch (beach seine, minnow seine, and gillnet catches combined). In beach seines alone, 95% of the catch was longnose suckers. Goldeye dominated the gillnet catch (31.5%), followed by flathead chub (17.3%), walleye (17.1%), and longnose suckers (15.4%). In minnow seines, flathead chub and longnose suckers were equally abundant (approximately 23%), followed by longnose dace (15.1%) and lake chub (13.9%). Sucker fry, however, were not included in the results since the fry of longnose and white suckers could not be accurately distinguished. Both species were therefore more abundant in minnow seine catches than the tabulated results indicate.

In Table 3, the relative abundance of fish species is presented by stream section: the Athabasca River upstream of the Cascade Rapids; the Athabasca downstream of the Cascade Rapids to Fort McMurray; and the Clearwater River. Longnose suckers dominated the total catch in each area. In the Athabasca River, flathead chub and either walleye or longnose dace were the next most abundant fish species. In the Clearwater River, northern pike, lake chub, and longnose dace were the most commonly sampled species in addition to longnose suckers.

Lake whitefish, yellow perch, and slimy sculpin were absent in the Athabasca River upstream of the Cascade Rapids but present elsewhere. Dolly Varden and brook stickleback were absent in samples taken in the Athabasca River downstream of Cascade Rapids and from the Clearwater drainage. Brassy minnow

Table 2. List of common and scientific names of fish species captured in this study with four-letter codes and a catch summary for each species.

| | | | Number Captured | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Beach Seine | | Gillnet | | Minnow Seine | | Total | |
| Common Name | Scientific Name | Code | N | % | N | % | N | % | N | % |
| Dolly Varden | *Salvelinus malma* | DOLL | 0 | 0.0 | 1 | 0.2 | 0 | 0.0 | 1 | 0.0 |
| lake whitefish | *Coregonus clupeaformis* | LKWT | 2 | 0.1 | 5 | 0.9 | 13 | 0.2 | 20 | 0.3 |
| mountain whitefish | *Prosopium williamsoni* | MTWT | 3 | 0.1 | 1 | 0.2 | 104 | 2.0 | 108 | 1.4 |
| Arctic grayling | *Thymallus arcticus* | GRAY | 0 | 0.0 | 3 | 0.6 | 8 | 0.2 | 11 | 0.1 |
| goldeye | *Hiodon alosoides* | GOLD | 32 | 1.4 | 167 | 31.5 | 0 | 0.0 | 199 | 2.5 |
| northern pike | *Esox lucius* | PIKE | 15 | 0.7 | 58 | 10.9 | 100 | 1.9 | 173 | 2.2 |
| longnose dace | *Rhinichthys cataractae* | LNDC | 0 | 0.0 | 0 | 0.0 | 784 | 15.1 | 784 | 9.9 |
| flathead chub | *Platygobio gracilis* | FHCB | 12 | 0.6 | 92 | 17.3 | 1227 | 23.7 | 1331 | 16.8 |
| lake chub | *Couesius plumbeus* | LKCB | 0 | 0.0 | 0 | 0.0 | 721 | 13.9 | 721 | 9.1 |
| pearl dace | *Semotilus margarita* | PLDC | 0 | 0.0 | 0 | 0.0 | 3 | 0.1 | 3 | 0.0 |
| finescale dace | *Chrosomus neogaeus* | FSDC | 0 | 0.0 | 0 | 0.0 | 3 | 0.1 | 3 | 0.0 |
| fathead minnow | *Pimephales promelas* | FHMN | 0 | 0.0 | 0 | 0.0 | 336 | 6.5 | 336 | 4.2 |
| emerald shiner | *Notropis atherinoides* | EMSH | 0 | 0.0 | 0 | 0.0 | 52 | 1.0 | 52 | 0.7 |
| spottail shiner | *Notropis hudsonius* | SPSH | 0 | 0.0 | 0 | 0.0 | 40 | 0.8 | 40 | 0.5 |
| brassy minnow | *Hybognathus hankinsoni* | BRMN | 0 | 0.0 | 0 | 0.0 | 5 | 0.1 | 5 | 0.1 |
| longnose sucker | *Catostomus catostomus* | LNSK | 2094 | 95.3 | 82 | 15.4 | 1179 | 22.8 | 3355 | 42.5 |
| white sucker | *Catostomus commersoni* | WTSK | 24 | 1.1 | 12 | 2.3 | 33 | 0.6 | 69 | 0.9 |
| burbot | *Lota lota* | BURB | 5 | 0.2 | 19 | 3.6 | 63 | 1.2 | 87 | 1.1 |
| Trout-perch | *Percopsis omiscomaycus* | TRPH | 0 | 0.0 | 0 | 0.0 | 194 | 3.7 | 194 | 2.5 |

continued...

Table 2. Concluded.

| | | | Number Captured | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Beach Seine | | Gillnet | | Minnow Seine | | Total | |
| Common Name | Scientific Name | Code | N | % | N or % | | N | % | N | % |
| brook stickleback | *Culaea inconstans* | BKST | 0 | 0.0 | 0 | 0.0 | 2 | 0.0 | 2 | 0.0 |
| yellow perch | *Perca flavescens* | YWPH | 0 | 0.0 | 0 | 0.0 | 4 | 0.1 | 4 | 0.0 |
| walleye | *Stizostedium vitreum* | WALL | 10 | 0.5 | 91 | 17.1 | 271 | 5.2 | 372 | 4.7 |
| slimy sculpin | *Cottus cognatus* | SLSC | 0 | 0.0 | 0 | 0.0 | 24 | 0.5 | 24 | 0.3 |
| spoonhead sculpin | *Cottus ricei* | SPSC | 0 | 0.0 | 0 | 0.0 | 14 | 0.3 | 14 | 0.2 |
| Total ........................................... | | | 2197 | 100.0 | 531 | 100.0 | 5180 | 100.0 | 7908 | 100.0 |

Table 3. Relative abundance of fish species in gillnet, beach seine, and minnow seine catches from the Athabasca River upstream of the Cascade Rapids, the Athabasca downstream of the Cascade Rapids to Fort McMurray, and the Clearwater River including the mouth of the Christina River, 28 April to 25 June 1978.

| Percent of Total Catch in Each Area | | | | | |
|---|---|---|---|---|---|
| >20% | 10 to 20% | 5 to 10% | 1 to 5% | <1% | Absent |
| Athabasca River Above the Cascade Rapids | | | | | |
| longnose sucker | flathead chub<br>walleye | mountain whitefish<br>lake chub<br>flathead minnow | goldeye<br>northern pike<br>longnose dace<br>emerald shiner<br>white sucker<br>burbot<br>trout-perch | Dolly Varden<br>Arctic grayling<br>pearl dace<br>finescale dace<br>spottail shiner<br>brassy minnow<br>brook stickleback<br>spoonhead sculpin | lake whitefish<br>yellow perch<br>slimy sculpin |
| Athabasca River Below the Cascade Rapids | | | | | |
| longnose sucker | longnose dace<br>flathead chub | lake chub | goldeye<br>fathead minnow<br>trout-perch<br>walleye | lake whitefish<br>mountain whitefish<br>Arctic grayling<br>northern pike<br>pearl dace<br>finescale dace<br>emerald shiner<br>spottail shiner<br>brassy minnow<br>white sucker<br>burbot<br>yellow perch<br>slimy sculpin<br>spoonhead sculpin | Dolly Varden<br>brook stickleback |
| Clearwater and Christina Rivers | | | | | |
| longnose sucker | northern pike<br>longnose dace<br>lake chub | goldeye | lake whitefish<br>flathead chub<br>white sucker<br>burbot<br>trout-perch<br>walleye | mountain whitefish<br>Arctic grayling<br>pearl dace<br>finescale dace<br>fathead minnow<br>emerald shiner<br>spottail shiner<br>yellow perch<br>slimy sculpin | Dolly Varden<br>brassy minnow<br>brook stickleback<br>spoonhead sculpin |

and spoonhead sculpin were also absent from the latter.

Rainbow trout (Jones et al. 1978), northern redbelly dace, ninespine stickleback, and Iowa darter (Bond and Berry in prep.a,b) were the only species previously reported from the Athabasca and Clearwater rivers in the AOSERP study area not captured in this study.

Data summarizing the total fishing effort and catch per unit effort for each sampling method and each sampling area are presented in Table 4. Catch per unit effort was highest for beach seining in the Athabasca downstream of the Cascade Rapids largely because of the large concentrations of longnose suckers in this area. Gillnet catch per unit effort was also highest in this area. Catch per unit effort for minnow seining was highest in the lower Athabasca when sucker fry are excluded from the results but highest in the Clearwater River when they are included.

## 4.2 LIFE HISTORIES OF MAJOR SPECIES

### 4.2.1 Goldeye

4.2.1.1 Distribution and movements. Previous studies (e.g., McCart et al. 1977; Jones et al. 1978; Bond and Berry in prep.b) have shown that goldeye in the Athabasca River are almost exclusively large juveniles which apparently move upstream from the Peace-Athabasca Delta and use the river as a summer feeding area.

In the spring of 1978, juvenile goldeye were found throughout the study area, as far upstream as the Grand Rapids on the Athabasca River and the mouth of the Christina River, a tributary to the Clearwater River.

Goldeye first appeared in both the Athabasca and Clearwater rivers around the middle of May. While there were fluctuations in both gillnet and seine catches (Figures 4 and 5) from mid-May to the end of the study period, goldeye were present in both streams throughout the study period. It is more likely that the fluctuations were due to sampling error than to any significant

Table 4. Summary of gillnetting, beach seining and minnow seining catch per unit effort in the present study area, 28 April to 25 June 1978.

| Sampling Method | Athabasca above the Cascades | Athabasca below the Cascades | Clearwater Christina | Total |
|---|---|---|---|---|
| Gillnetting | | | | |
| Total hours | 330.0 | 241.0 | 284.5 | 855.5 |
| Total fish | 147 | 197 | 158 | 502 |
| Fish per hour | 0.45 | 0.82 | 0.56 | 0.59 |
| Beach Seining | | | | |
| Total hauls | 2 | 64 | 22 | 88 |
| Total fish | 1 | 2109 | 78 | 2 188 |
| Fish per haul | 0.50 | 32.95 | 3.55 | 24.86 |
| Minnow seining | | | | |
| Total hauls | 45 | 162 | 74 | 281 |
| Total distance (m) | 550 | 2 447 | 602 | 3 599 |
| Total fish[a] | 847 | 6 136 | 886 | 3 599 |
| Total fish[b] | 1 164 | 6 503 | 3 421 | 11 088 |
| Catch per metre[a] | 1.54 | 2.51 | 1.47 | 2.19 |
| Catch per metre[b] | 2.12 | 2.66 | 5.68 | 3.08 |

[a] excluding sucker young of the year

[b] including sucker young of the year

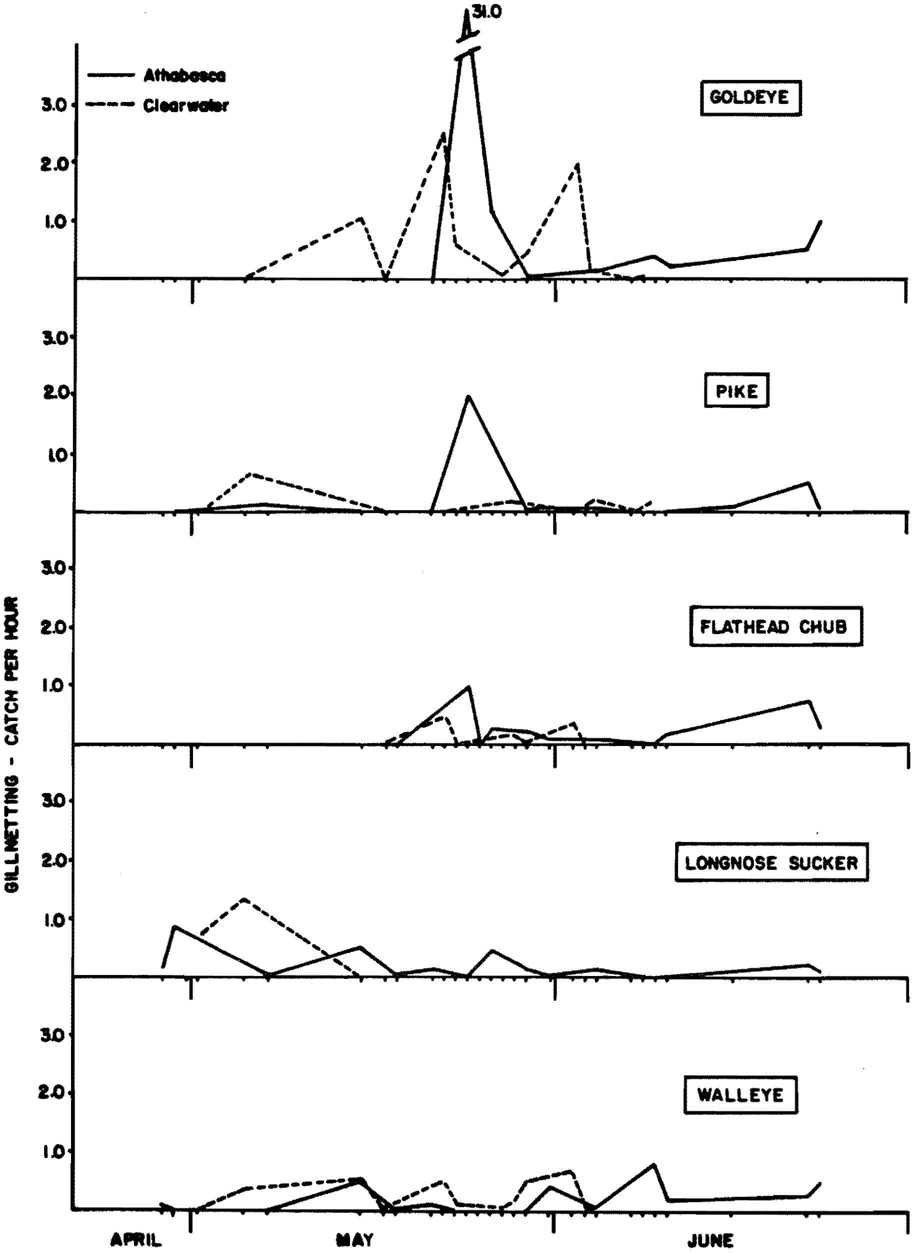


Figure 4. Seasonal patterns of catch per gillnet hour for goldeye, pike, flathead chub, longnose sucker, and walleye in the Athabasca and Clearwater rivers upstream of Fort McMurray, 28 April to 23 June 1978. Sampling times are indicated by short vertical bars on the horizontal axis.

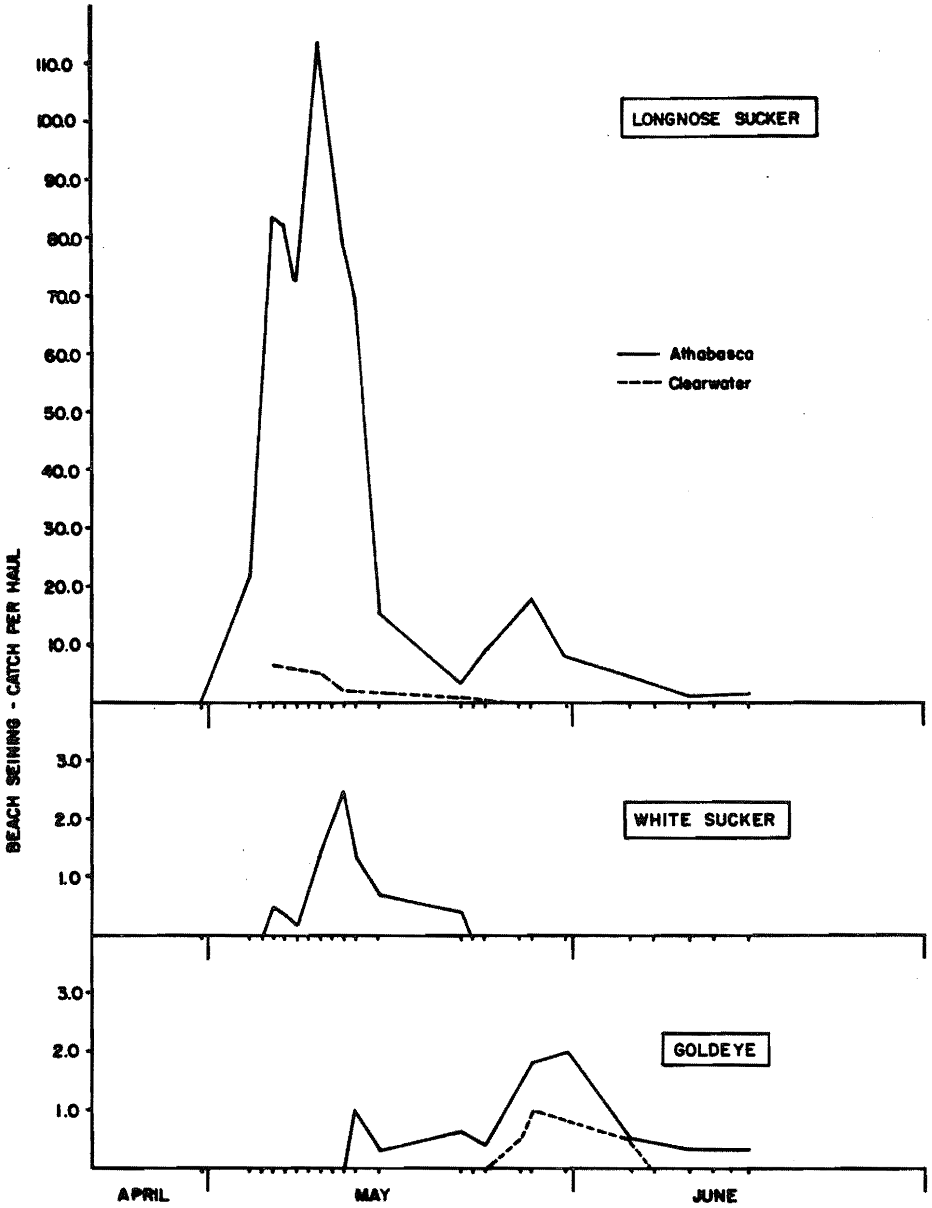


Figure 5. Seasonal patterns of catch per beach seine haul for longnose suckers, white suckers, and goldeye in the Athabasca and Clearwater rivers upstream of Fort McMurray, 28 April to 15 June 1978. Sampling times are indicated by short vertical bars on the horizontal axis.

changes in the distribution of fish.

4.2.1.2 Length-frequency. The length-frequency distribution of 31 goldeye captured in the study area is presented in Figure 6.

As has been reported by other investigators in the AOSERP study area (McCart et al. 1977; McCart et al. 1978; Bond and Berry in prep.a,b; Jones et al. 1978), captured goldeye fell within a restricted length range (250 to 374 mm). These are thought to be immature fish which move upstream from Lake Athabasca and the Peace-Athabasca Delta on a feeding migration (Kennedy and Sprules 1967; Kooyman 1972; Donald and Kooyman 1977).

4.2.1.3 Age and growth. Age-length data for 31 goldeye captured in the study area are presented in Table 5.

Goldeye in the sample ranged in age from 5 to 8 years and in fork length from 250 to 374 mm. Approximately 74% of the sample were age 5. Individuals in this age group are larger (25 to 30 mm) on average than those reported elsewhere in the AOSERP study area (McCart et al. 1977; McCart et al. 1978; Bond and Berry in prep.b).

4.2.1.4 Age at maturity. None of the 31 goldeye examined was mature. These data further substantiate that the upper portions of the Athabasca River drainage within the AOSERP study area are used primarily as feeding areas by immature goldeye from the Peace-Athabasca Delta.

4.2.1.5 Sex ratios. Female goldeye (N=21) outnumbered males (N=10) though the difference was not significant ($X^2=1.95$, $P<0.05$). McCart et al. (1977) report a sex ratio favouring males (76%) and McCart et al. (1978) and Bond and Berry (in prep.b) report ratios favouring females (69% and 64%, respectively) during other studies in the AOSERP study area.

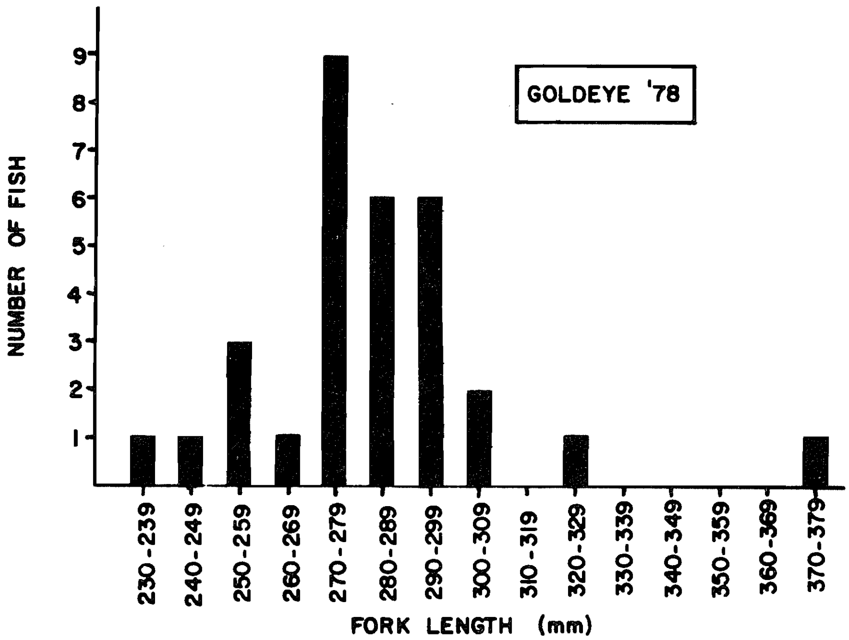


Figure 6. Length-frequency distribution of goldeye taken from the Athabasca and Clearwater rivers upstream of Fort McMurray, 28 April to 25 June 1978.

Table 5. Age-length relationship with age-specific sex ratios and percent maturity for goldeye taken from the project study area, 28 April to 25 June 1978.

| | Fork Length (mm) | | | | Males | | | Females | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | Mean | S.D. | S.E. | Range | N | % | % Mature | N | % | % Mature | Unsexed | Total |
| 5 | 286.1 | 25.9 | 5.4 | 250-374 | 9 | 39 | 0 | 14 | 61 | 0 | 0 | 23 |
| 6 | 272.7 | 22.3 | 9.1 | 235-295 | 1 | 17 | 0 | 5 | 83 | 0 | 0 | 6 |
| 7 | 274 | | | | 0 | 0 | | 1 | 100 | 0 | 0 | 1 |
| 8 | 272 | | | | 0 | 0 | | 1 | 100 | 0 | 0 | 1 |
| Totals | | | | | 10 | 32 | 0 | 21 | 68 | 0 | 0 | 31 |

4.2.1.6 Length-weight relationship. Length-weight regression formulae were calculated separately for male and female goldeye; however, analysis of covariance did not reveal any significant differences in either slope ($F=1.03$, $P>0.05$) or intercept ($F=1.03$, $P>0.05$). Data were therefore combined and the following relationship was determined for the total sample:

$$\log_{10} \text{Fork Length (mm)} = 2.55 \log_{10} \text{Weight (g)} - 3.87$$

$$(r=0.91,\ P<0.05,\ N=31)$$

4.2.1.7 Food habits. Percent occurrence of food items in 30 goldeye stomachs is shown in Table 6. Although a large proportion of the contents were unidentifiable, aquatic and terrestrial insects predominated.

### 4.2.2 Northern Pike

4.2.2.1 Distribution and movements. There is no evidence from previous studies in the AOSERP study area that northern pike undertake extensive migrations such as those which characterize lake whitefish, goldeye, and longnose sucker. It seems likely that the majority of pike remain in the study area throughout the year, although they undoubtedly undertake short migrations between overwintering, spawning, and summer feeding areas.

In the spring of 1978, larger juvenile and adult pike were found throughout the project study area (Figure 7) from late April until late June when the study ended. Catches were generally small and the data cannot be used to describe patterns of movements (Figure 4).

4.2.2.2 Spawning. *Spawning period.* The first ripe males (Table 7) were captured on 5 May and the first ripe female on 11 May. Spawned-out females were first taken on 27 May although a green female was taken as late as 31 May. These data suggest that the spawning period was largely concentrated in the last half of May. An unusual feature of the data was the occurrence of a high

Table 6. Frequency of occurrence of food items in stomachs of northern pike, goldeye, and walleye taken from the present study area, 28 April to 25 June 1978. Percent occurrence values are based only on stomachs which contained food.

| | Northern Pike | | Goldeye | | Walleye | |
|---|---|---|---|---|---|---|
| Food Item | N | % | N | % | N | % |
| Insects | | | | | | |
| Corixidae | 0 | 0.0 | 2 | 7.4 | 1 | 3.2 |
| Plecoptera | 0 | 0.0 | 3 | 11.1 | 3 | 9.7 |
| Ephemeroptera | 0 | 0.0 | 1 | 3.7 | 0 | 0.0 |
| Odonata | 0 | 0.0 | 1 | 3.7 | 1 | 3.2 |
| Hymenoptera | 0 | 0.0 | 1 | 3.7 | 0 | 0.0 |
| Coleoptera | 0 | 0.0 | 1 | 3.7 | 0 | 0.0 |
| Fish | | | | | | |
| Goldeye | 1 | 6.7 | 0 | 0.0 | 0 | 0.0 |
| Flathead chub | 4 | 26.7 | 0 | 0.0 | 3 | 9.7 |
| Longnose sucker | 1 | 6.7 | 0 | 0.0 | 0 | 0.0 |
| Brook stickleback | 1 | 6.7 | 0 | 0.0 | 0 | 0.0 |
| Burbot | 1 | 6.7 | 0 | 0.0 | 0 | 0.0 |
| Sculpin sp. | 0 | 0.0 | 0 | 0.0 | 1 | 3.2 |
| Insect Remains | 0 | 0.0 | 12 | 44.4 | 0 | 0.0 |
| Fish Remains | 6 | 40.0 | 1 | 3.7 | 16 | 51.6 |
| Bird Remains | 1 | 6.7 | 0 | 0.0 | 0 | 0.0 |
| Digested Matter | 1 | 6.7 | 13 | 48.2 | 9 | 29.0 |
| Vegetable Matter | 1 | 6.7 | 6 | 22.2 | 1 | 3.2 |
| Stomachs Containing Food | 15 | | 27 | | 31 | |
| Empty Stomachs | 56 | | 3 | | 66 | |
| Stomachs Analysed | 71 | | 30 | | 97 | |

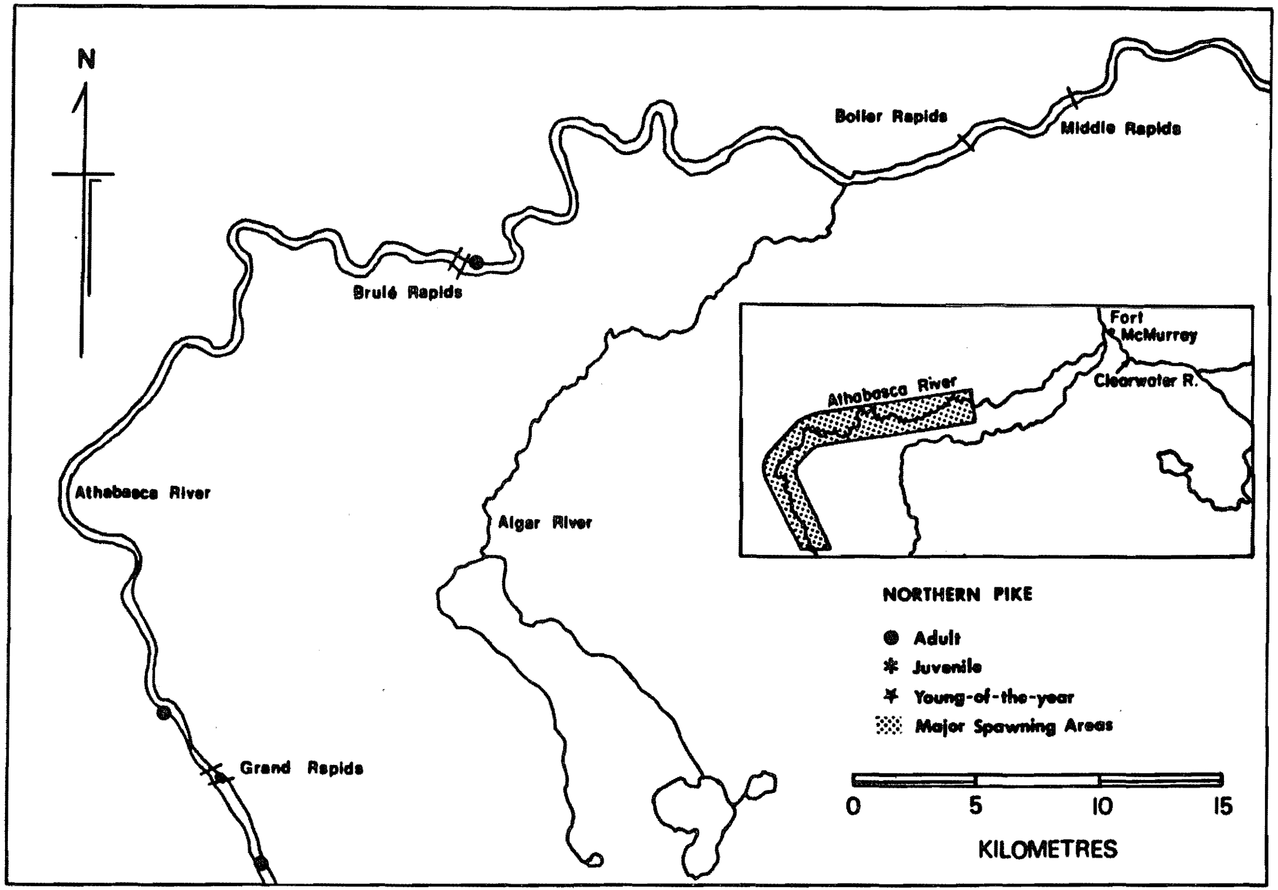


Figure 7. Locations where pike were taken in the present study area. Major spawning areas are also indicated. (Continued).

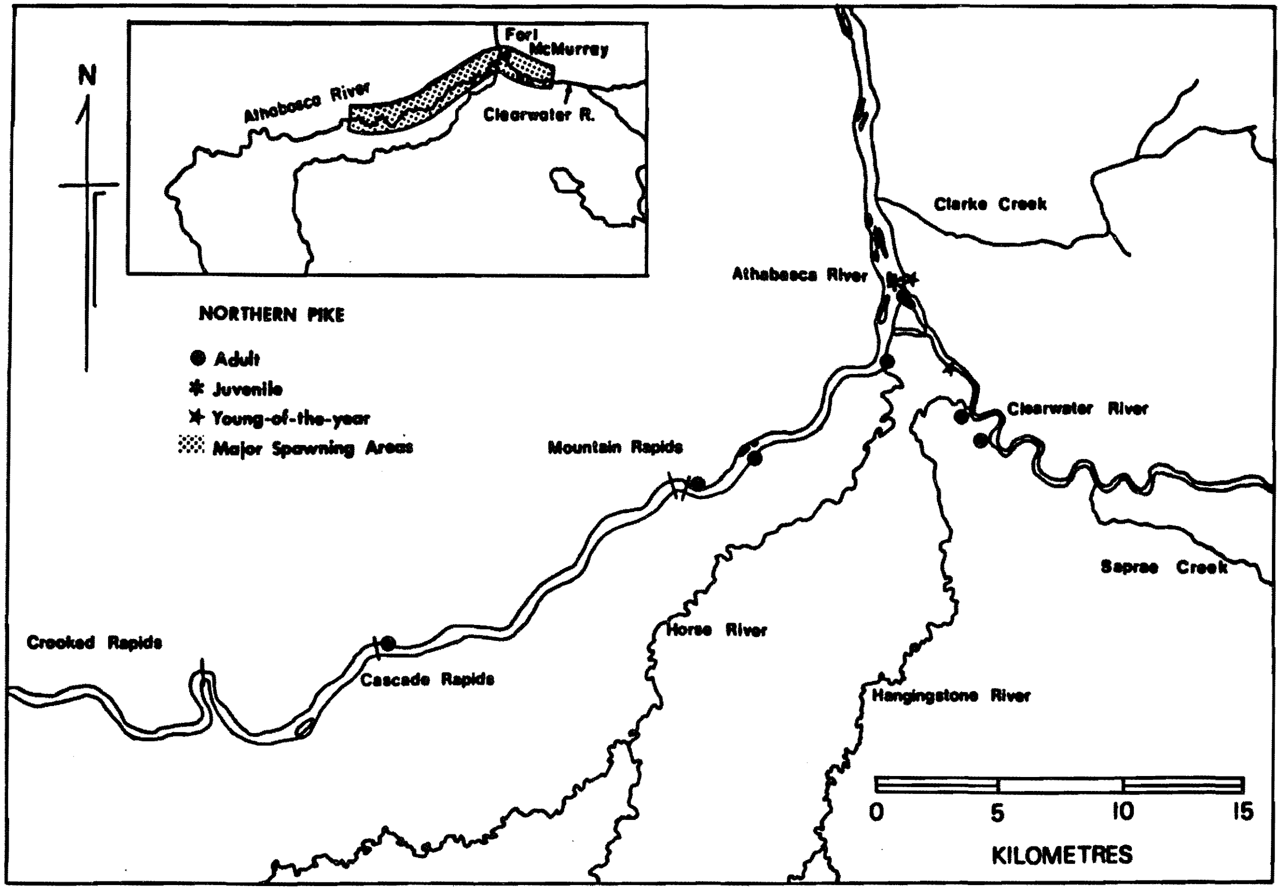


Figure 7. Continued.

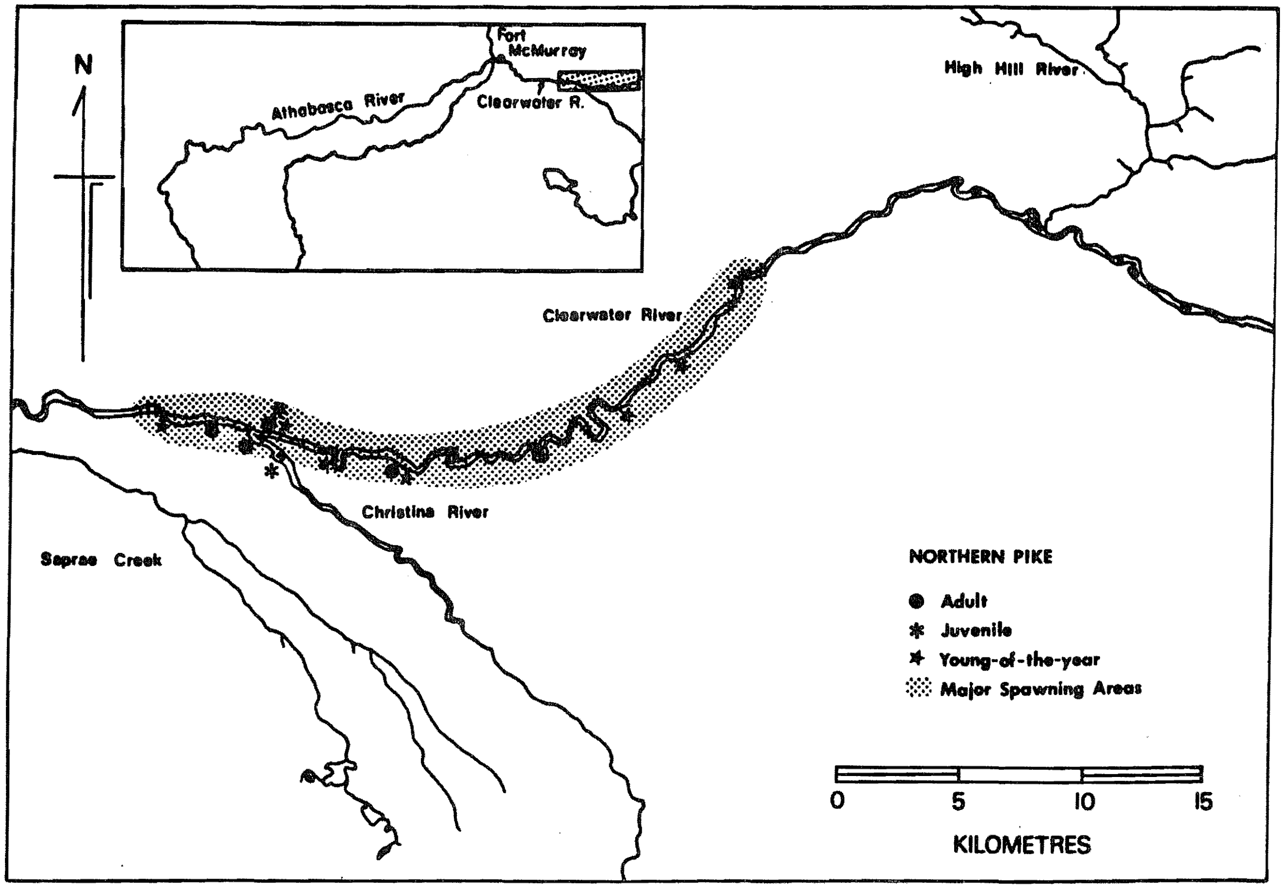


Figure 7. Concluded.

Table 7. Spawning condition of northern pike from the Athabasca and Clearwater rivers, 28 April to 23 June 1978. N=number examined; G=green; R=ripe; SO=spawned out; RE=reabsorbing eggs.

| Date | Males | | | | Females | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Day/Month | N | G | R | SO | N | G | R | SO | RE |
| 28/4 | 3 | 3 | | | 3 | 3 | | | |
| 5/5 | 3 | 1 | 2 | | 1 | 1 | | | |
| 7/5 | 6 | 6 | | | 3 | 3 | | | |
| 8/5 | 1 | 1 | | | | | | | |
| 11/5 | 1 | 1 | | | 2 | 1 | 1 | | |
| 13/5 | 1 | 1 | | | | | | | |
| 21/5 | 1 | | 1 | | 1 | 1 | | | |
| 24/5 | 1 | | | 1 | | | | | |
| 26/5 | | | | | 1 | 1 | | | |
| 27/5 | 1 | | | 1 | 2 | 1 | | 1 | |
| 28/5 | 3 | 3 | | | 7 | 5 | | 2 | |
| 29/5 | 1 | | | 1 | 1 | | | 1 | |
| 31/5 | | | | | 2 | 1 | | 1 | |
| 3/6 | 4 | | | 4 | 3 | | | 2 | 1 |
| 4/6 | 3 | | | 3 | 1 | | | | 1 |
| 8/6 | 2 | | | 2 | 4 | | | | 4 |
| 9/6 | 1 | | | 1 | | | | | |
| 13/6 | 1 | 1 | | | | | | | |
| 14/6 | 1 | 1 | | | 4 | | | 3 | 1 |
| 22/6 | 1 | | | 1 | 1 | | | 1 | |
| 23/6 | 1 | | | 1 | | | | | |
| Totals | 36 | 18 | 3 | 15 | 36 | 17 | 1 | 11 | 7 |

proportion (7 of 36 mature females sampled) of mature females which appeared not to have successfully spawned and were in the process of re-absorbing their eggs. All of these fish were taken in the Athabasca and not in the Clearwater. In rivers, this species typically spawns in weedy backwaters and the presence of unspawned fish may reflect the absence of suitable spawning areas in the Athabasca River.

*Spawning areas and fry emergence.* There is no direct evidence of the location of spawning grounds for northern pike in the project study area. There is, however, indirect evidence from the distribution of young-of-the-year that a major spawning ground for this species in the project study area is located in the Clearwater River upstream of its junction with the Christina River (Figure 7). In the upper Clearwater, catches of young-of-the-year pike in backwaters and side channels were very high, 2.65 fry per metre of shore seined compared with only 0.05 fry per metre seined downstream of the Christina River. No young-of-the-year pike were taken from the Athabasca River at any time during the study.

The upper Clearwater River, which is characterized by many islands and quiet, shallow, side channels, does appear to have excellent spawning habitat for northern pike. The side channels range from 1 or 2 m to more than 10 m in width and from less than 0.15 m to more than 1 m in depth. The substrate is largely composed of heavy silt and organic debris with a dense cover of aquatic macrophytes. In June, the latter was formed primarily of Mares-tail *(Hippuris vulgaris)* with pickerel weed *(Potomogeton richardsoni)* and other pond weeds *(P. pectinatus, Myriophyllum exalbescens)* also present. A dense growth of partly submerged *Equisetum* sp. and occasionally *Scirpus* sp. often dominated the bank vegetation. Current speed was usually negligible.

The first young-of-the-year pike were captured 7 June. The mean fork length of 30 pike taken on 13 June was 30.9 ± 6.04 mm. The scarcity of young-of-the-year pike in the lower Clearwater River may indicate that during the first few weeks of their life they do not move far from the spawning areas.

4.2.2.3 Length-frequency. The length-frequency distribution of 75 northern pike captured in the study area from late April to mid-June 1978 is presented in Figure 8. Pike ranged in fork length from 362 to 872 mm but approximately 87% of the sample fell in the 425 to 649 mm length range. Other studies in the AOSERP study area (Jones et al. 1978; McCart et al. 1977; Bond and Berry in prep.a,b) report similar size distributions.

4.2.2.4 Age and growth. Age-length data for 75 northern pike captured in the project study area are presented in Table 8.

Pike in the study sample ranged in age from 5 to 12 years and in fork length from 362 to 872 mm. The growth curve determined for the study sample is approximately intermediate between that of the MacKay River (McCart et al. 1978) and the curve determined for a sample of pike obtained from the project study area during the fall of 1977 (Jones et al. 1978). Growth curves reported by other investigators in the AOSERP study area (Griffiths 1973; McCart et al. 1977) and North Wabasca Lake, Alberta (Turner 1968) are also presented for comparison (Figure 9). All fish in these studies were aged from scales. Differences in observer interpretation of annulus criteria may account for much of the reported variability in growth rate for northern pike, particularly within the relatively restricted geographic area of the AOSERP study area.

4.2.2.5 Age at maturity. Age, maturity, and sex were determined for 75 northern pike captured in the study area. All males taken were mature; however, females with immature gonads were present in age classes 5, 8, and 9. Ages at first maturity of 2 to 3 years (Bond and Machniak 1979; Bond and Berry in prep.a) and 4 to 5 years (Jones et al. 1978) have been reported by other investigators in the AOSERP study area.

4.2.2.6 Fecundity. Fecundity was determined for 16 mature northern pike ranging in fork length from 518 to 872 mm. Average fecundity was 42 614 ± 12 330 ($\bar{x}$ ± SE, range 9 486 to 91 915) eggs

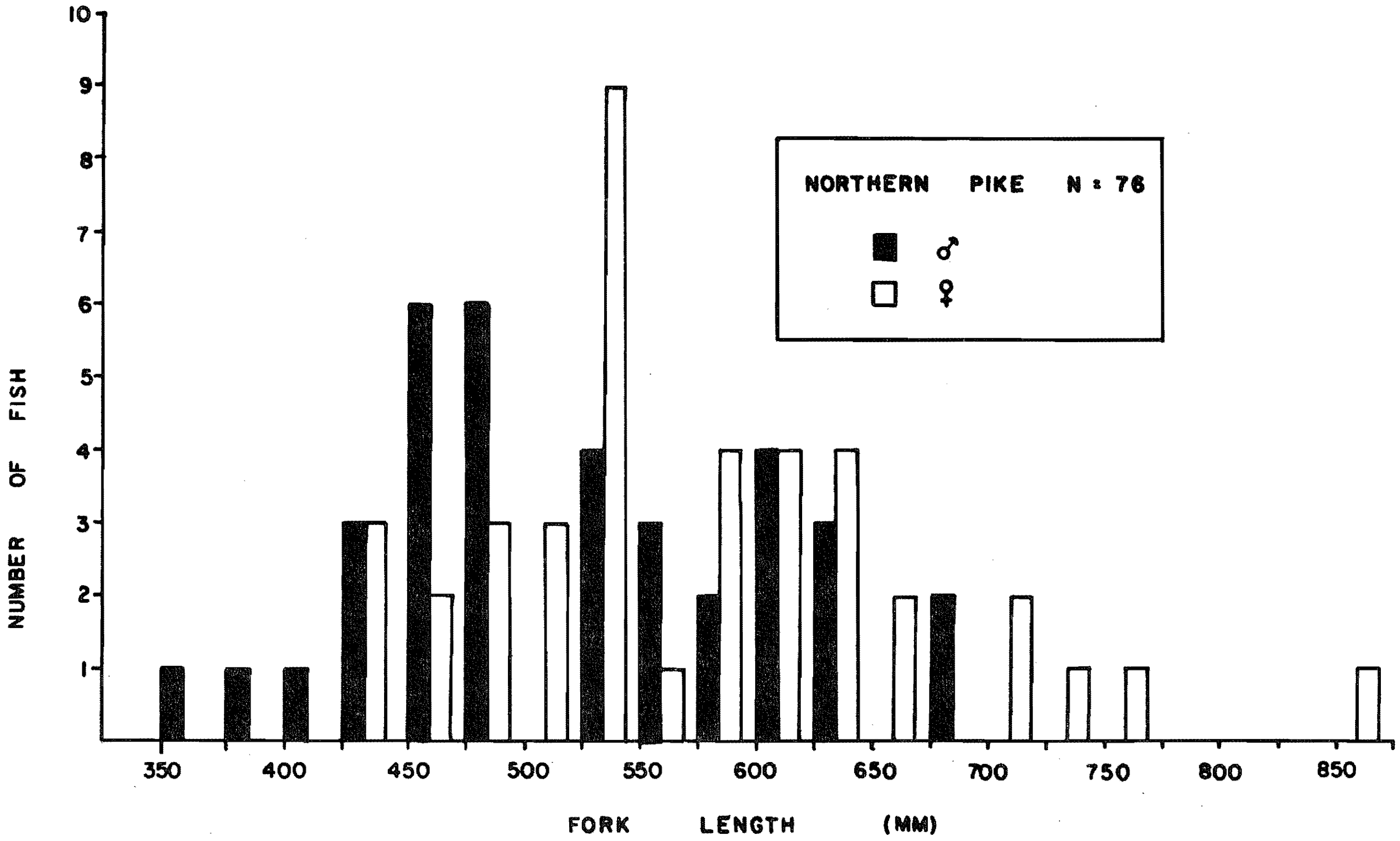


Figure 8. The length-frequency distribution of male and female northern pike taken in the Athabasca and Clearwater rivers upstream of Fort McMurray, 28 April to 25 June 1978.

TABLE 8 . Age-length relationship with age-specific sex ratios and percent maturity for northern pike taken from the present study area, 28 April to 25 June, 1978.

| | Fork Length (mm) | | | | Males | | | Females | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | Mean | S.D. | S.E. | Range | N | % | % Mature | N | % | % Mature | Unsexed | Total |
| 5 | 457.4 | 65.0 | 24.6 | 362-549 | 4 | 57 | 100 | 3 | 43 | 66 | 0 | 7 |
| 6 | 506.4 | 68.8 | 17.8 | 415-627 | 9 | 60 | 100 | 6 | 40 | 100 | 0 | 15 |
| 7 | 545.4 | 69.1 | 16.3 | 435-646 | 9 | 50 | 100 | 9 | 50 | 100 | 0 | 18 |
| 8 | 541.2 | 77.7 | 22.4 | 428-670 | 6 | 50 | 100 | 6 | 50 | 83 | 0 | 12 |
| 9 | 612.8 | 99.8 | 30.1 | 519-845 | 3 | 27 | 100 | 8 | 73 | 88 | 0 | 11 |
| 10 | 677.3 | 65.0 | 26.6 | 575-765 | 2 | 33 | 100 | 4 | 67 | 100 | 0 | 6 |
| 11 | 627.5 | 62.5 | 31.3 | 578-710 | 1 | 25 | 100 | 3 | 75 | 100 | 0 | 4 |
| 12 | 716.0 | 220.6 | 156.0 | 560-872 | 1 | 50 | 100 | 1 | 50 | 100 | 0 | 2 |
| Totals | | | | | 35 | 47 | 100 | 40 | 53 | 93 | 0 | 75 |

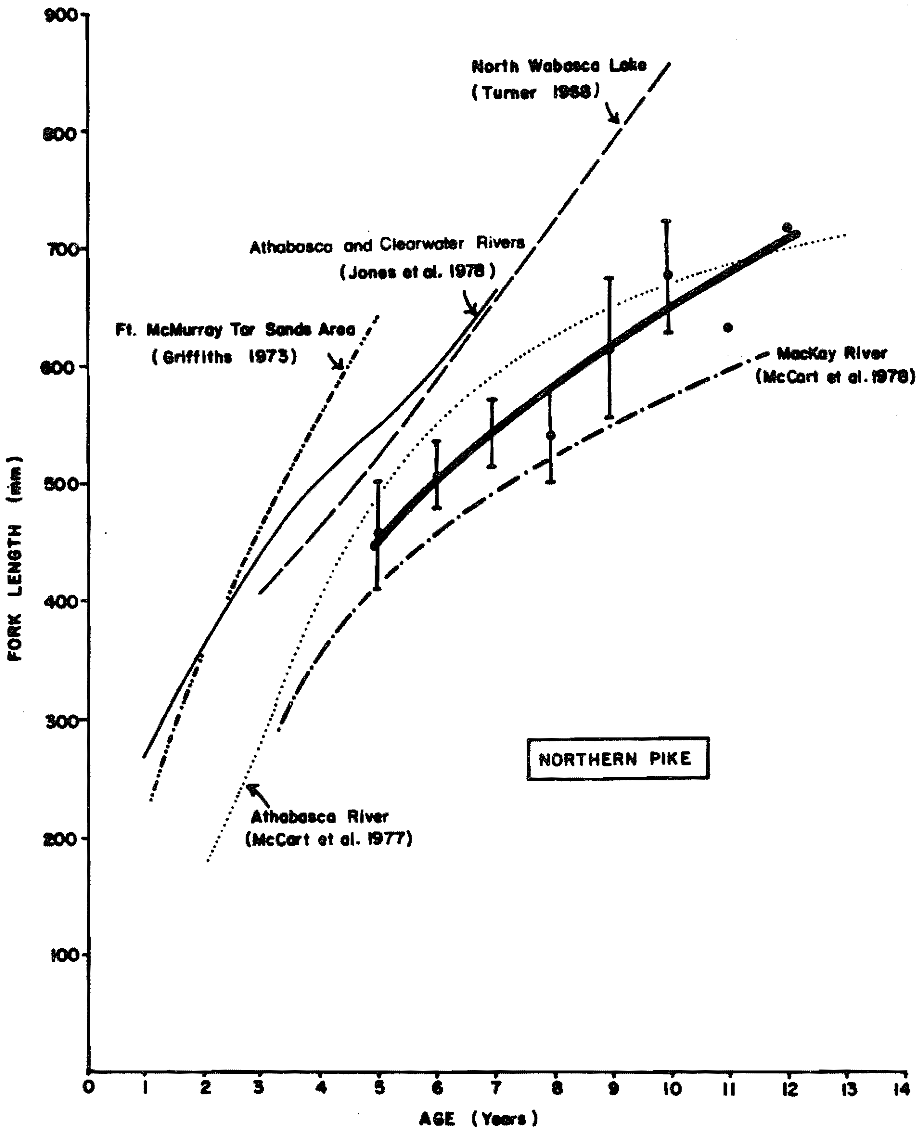


Figure 9. Comparison of growth rates of northern pike collected in this study and northern pike collected in five other studies in Alberta. Symbols for samples taken in this study are: points with vertical bars= mean fork lengths ± one standard error; points= mean fork lengths for age groups containing less than five fish.

per female. Fecundity was significantly correlated with length $(r=0.81, P<0.05)$ (Figure 10):

$$\text{Log}_{10}\ \text{Fecundity} = 4.19\ \text{Log}_{10}\ \text{Fork Length (mm)} - 7.28$$

4.2.2.7 Sex ratios. Female northern pike (53%) outnumbered males in the study sample; however, the sex ratio did not differ significantly from a 1:1 ratio $(X^2=0.13;\ P>0.05)$.

4.2.2.8 Length-weight relationship. Length-weight regression formulae were determined separately for male and female pike; however, analysis of covariance did not reveal significant differences in either slope $(F=0.53, P>0.05)$ or intercept $(F=3.50, P>0.05)$. Data were therefore combined and the following relationship was determined for the total sample:

$$\text{Log}_{10}\ \text{Length (mm)} = 3.45\ \text{Log}_{10}\ \text{Weight (g)} - 6.40$$

$$r=0.97,\ P<0.05,\ N=76$$

4.2.2.9 Food habits. Of 71 northern pike examined, 79% (56) had empty stomachs. Identifiable items in stomachs containing food included remains of flathead chub, burbot, goldeye, longnose sucker, stickleback, and bird bones (Table 6).

### 4.2.3 Flathead Chub

4.2.3.1 Distribution and movements. Flathead chub are common in both the Athabasca River and its major tributaries including the Clearwater River. The biology of the species is, however, little known. In the project study area, few large fish, susceptible to capture by gillnets, were taken prior to mid-May (Figure 4). Smaller fish, however, were taken in minnow seine samples in the project study area throughout the study period with catches peaking in late June (Figure 11). These data suggest that there may be migrations of both juvenile and adult flathead chub between the study area and other parts of the Athabasca drainage.

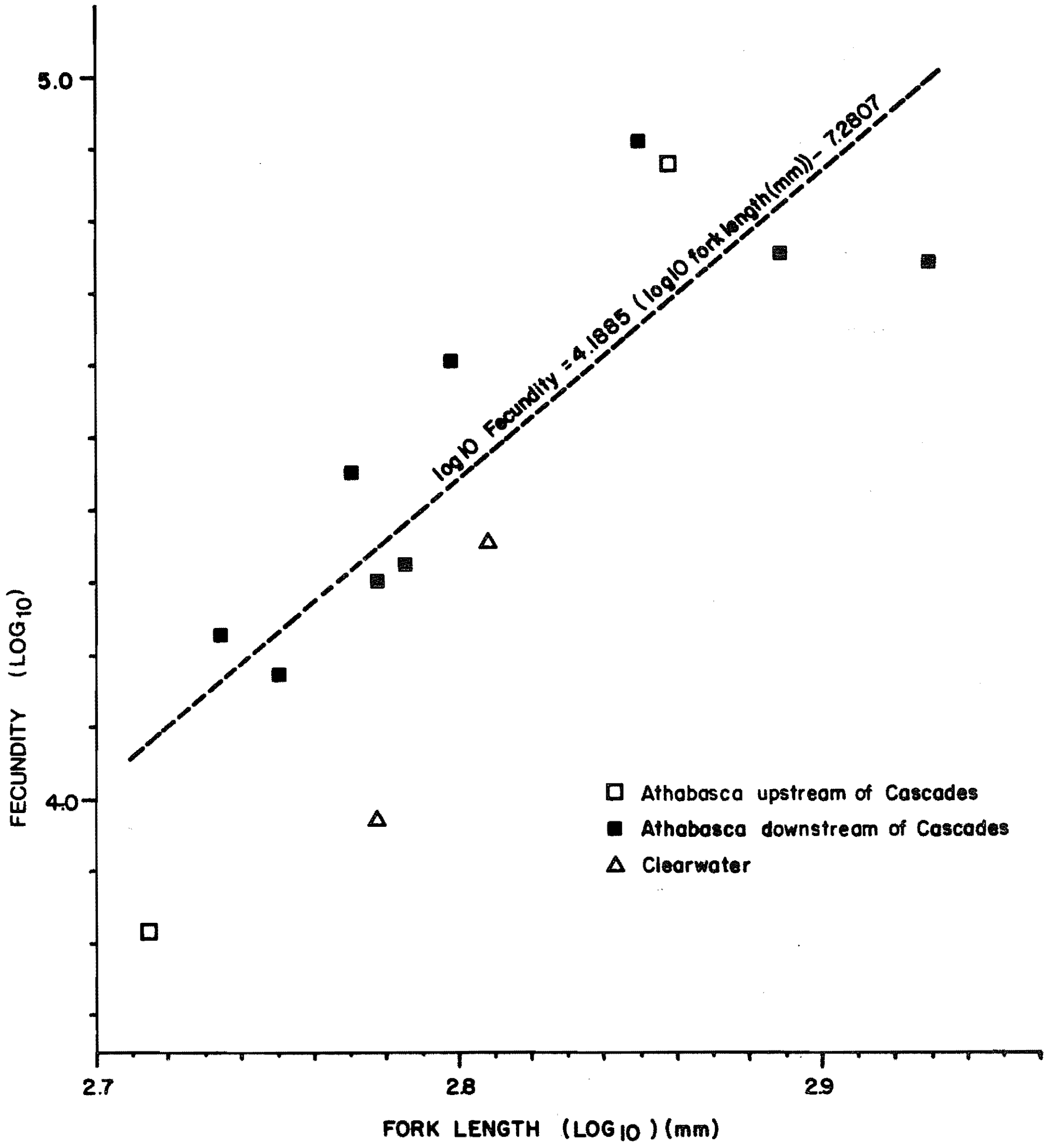


Figure 10. Length-fecundity relationship for northern pike taken in the present study area, 28 April to 25 June 1978.

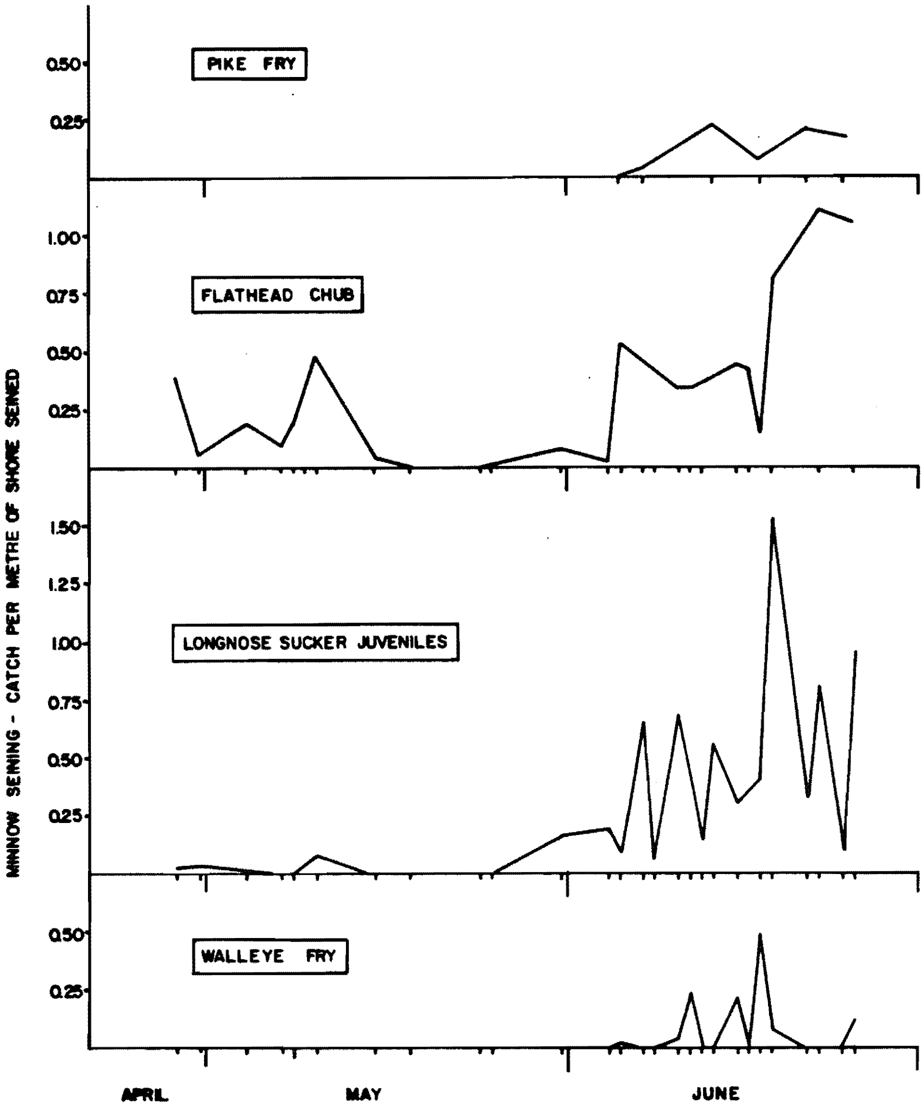


Figure 11. Seasonal patterns of abundance for pike fry, flathead chub, longnose sucker juveniles, and walleye fry taken by minnow seine in the Athabasca and Clearwater rivers, 28 April to 25 June 1978. Data are combined for the Athabasca and Clearwater rivers and expressed as catch per metre of shoreline seined. Sampling times are indicated by short vertical bars on the horixontal axis.

4.2.3.2 Spawning. No ripe fish were taken during the course of the study and it is not known if the species spawns within the project study area. The spawning habits of flathead chub are not well known. The spawning season appears to be in summer (July and August) rather than in spring and the species may have spawned in the project study area after the termination of the study on 26 June.

4.2.3.3 Length-frequency. The length-frequency distribution for 20 flathead chub sampled in the project study area is presented in Figure 12. Chub ranged in length from 170 to 295 mm and were evenly distributed throughout this range. Although none was retained for analysis, immature juveniles ranging in length from approximately 40 to 80 mm were also very abundant in small mesh seine collections.

4.2.3.4 Age and growth. Age-length data for 16 flathead chub are presented in Table 9. Flathead chub were aged from scales.

Fish in the study sample ranged in age from 3 to 8 and in length from 170 to 295 mm. The growth curve derived for the study population approximates those determined for flathead chub captured in other areas of the AOSERP study area (Figure 13).

4.2.3.5 Age at maturity. Immature flathead chub as old as age 6 occurred in the study sample (Table 8). Other researchers in the AOSERP study area report ages at first maturity of 2 to 3 (McCart et al. 1977; Bond and Berry in prep.b) and 4 to 5 (Bond and Berry in prep.a) for this species.

4.2.3.6 Sex ratios. There were significantly more females (81%, $X^2=4.0$, $P<0.05$, N=18) than males in the study sample. Bond and Berry (in prep.a,b) and McCart et al. (1977) also report sex ratios favouring females, 68, 77, and 78%, respectively, in other portions of the AOSERP study area.

4.2.3.7 Length-weight relationships. Length-weight regression formulae were determined separately for males and females:

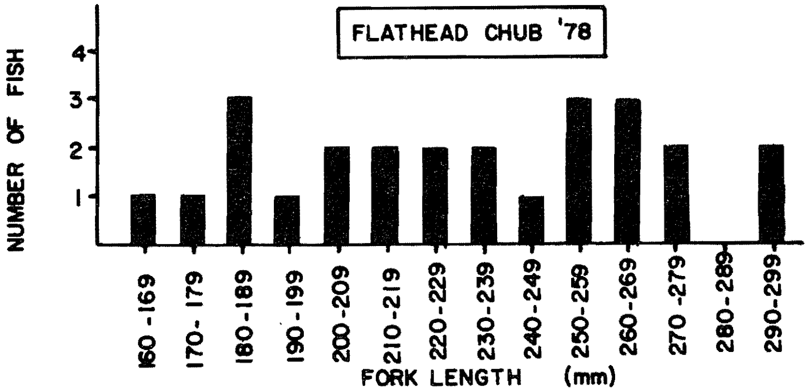


Figure 12. Length-frequency distribution of flathead chub taken from the Athabasca and Clearwater rivers upstream of Fort McMurray, 28 April to 25 June 1978.

Table 9. Age-length relationship with age-specific sex ratios and percent maturity for flathead chub taken from the present study area, 28 April to 25 June 1978.

| | Fork Length (mm) | | | | Males | | | Females | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | Mean | S.D. | S.E. | Range | N | % | % Mature | N | % | % Mature | Unsexed | Total |
| 3 | 184.3 | 13.6 | 7.8 | 170-197 | 0 | | | 0 | | | 3 | 3 |
| 4 | | | | | 0 | | | 0 | | | 0 | 0 |
| 5 | 232.0 | 37.0 | 16.5 | 178-273 | 1 | 20 | 100 | 4 | 80 | 50 | 0 | 5 |
| 6 | 251.8 | 29.3 | 9.3 | 210-295 | 2 | 20 | 50 | 7 | 70 | 86 | 1 | 10 |
| 7 | 246 | | | | 0 | 0 | | 1 | 100 | 100 | 0 | 1 |
| 8 | 275 | | | | 0 | 0 | | 1 | 100 | 100 | 0 | 1 |
| Totals | | | | | 3 | 19 | 67 | 13 | 81 | 77 | 4 | 20 |

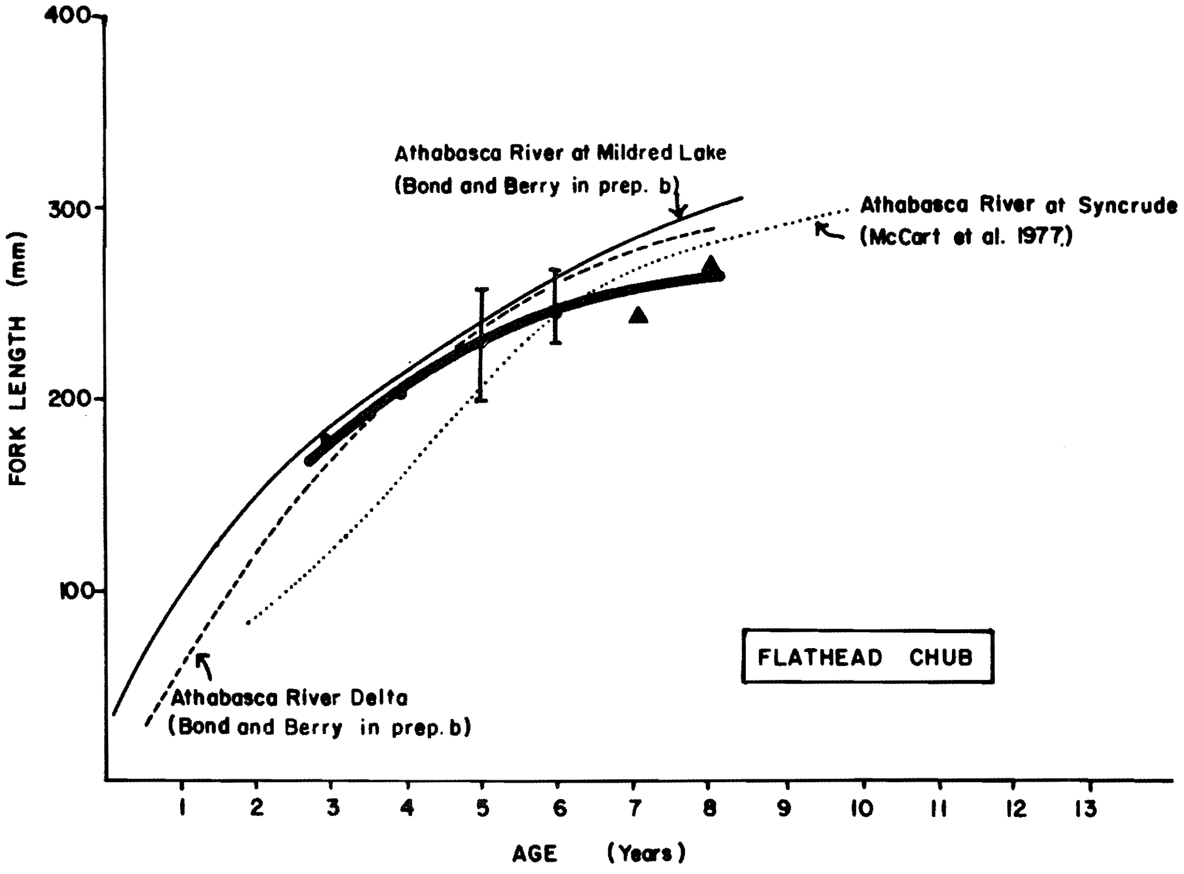


Figure 13. Comparison of growth rates of flathead chub collected in this study and flathead chub collected in three other studies in the AOSERP study area. Symbols for samples collected in this study are: points plus vertical bars= mean fork lengths ± one standard error; points= mean fork lengths for age groups containing less than five fish; triangles= individual fork lengths.

males:

$\text{Log}_{10}$ Length (mm) = 2.66 $\text{Log}_{10}$ Weight (g) - 4.16

$r=0.83$, $P<0.05$, $N=4$

females:

$\text{Log}_{10}$ Length (mm) = 2.95 $\text{Log}_{10}$ Weight (g) - 4.82

$r=0.97$, $P<0.05$, $N=17$

These relationships were compared by analysis of covariance and were found to differ significantly in slopes ($F=219.7$, $P<0.05$) but not in intercepts ($F=0.98$, $P>0.05$).

## 4.2.4 Longnose Sucker

4.2.4.1 Distribution and movements. Longnose suckers are a major species in the AOSERP study area both in terms of their numbers and in their importance as a forage species. Several studies have documented major longnose sucker spawning runs into tributaries of the Athabasca River downstream of Fort McMurray. These include the Muskeg (Bond and Machniak 1977, 1979), Steepbank (Machniak and Bond 1979), and MacKay rivers (McCart et al. 1978; Bond et al. in prep.). A large spawning run also occurs in the Christina River, a tributary of the Clearwater River (Tripp and Tsui in prep.). Undoubtedly, other large tributaries of the lower Athabasca, such as the Ells and Firebag rivers, are also important spawning areas for longnose suckers.

Earlier studies on the Athabasca River have shown a peak in the numbers of mature longnose suckers during late April and May, coinciding with spawning runs into tributary streams (Bond and Berry in prep.b; McCart et al. 1977). There was no evidence, however, that longnose suckers were spawning in the Athabasca River itself downstream of Fort McMurray and it was assumed that all spawning took place in tributaries.

In the present study, large adult, small juvenile, and young-of-the-year longnose suckers were found throughout the project study area (Figure 14). By far the largest concentrations of adults, however, were located in the Athabasca River downstream

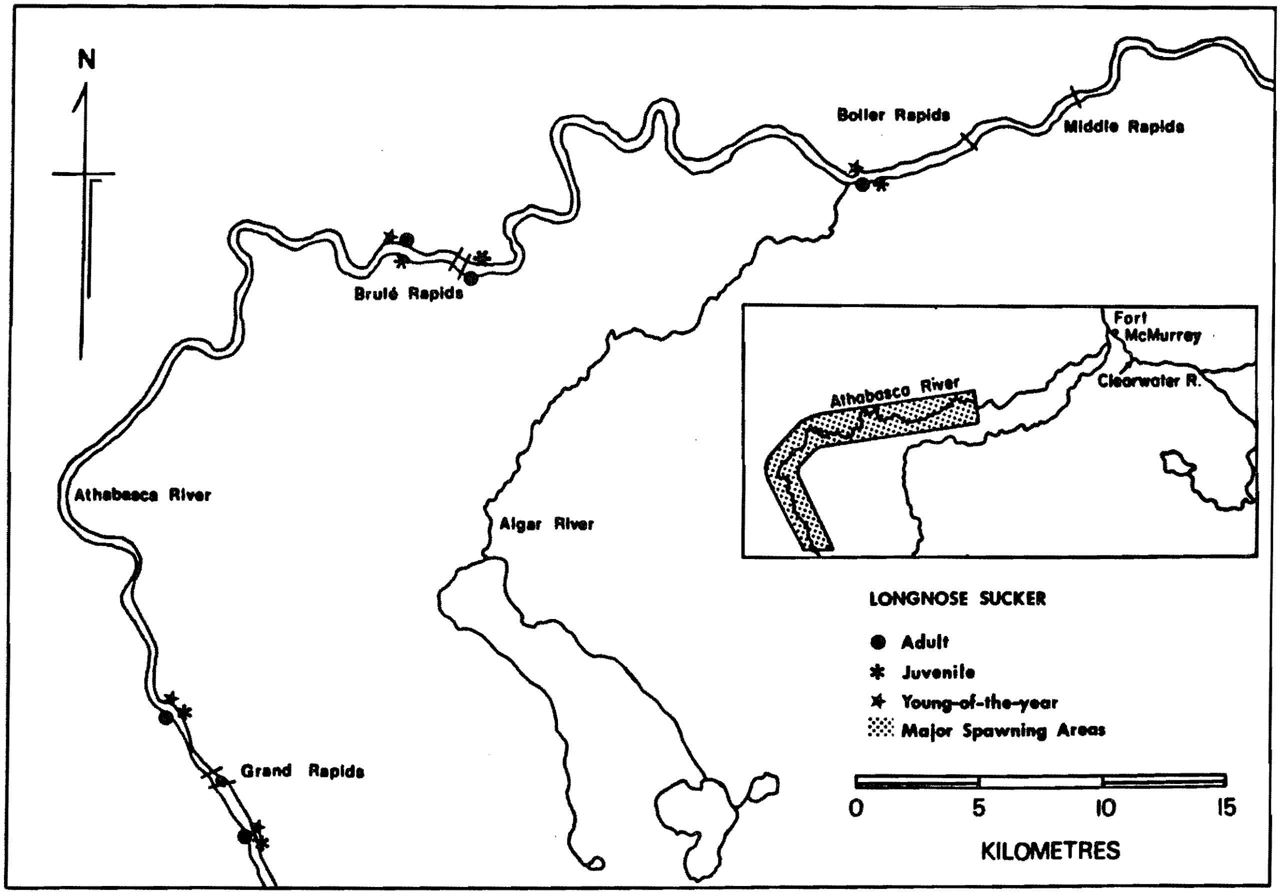


Figure 14. Locations where longnose suckers were taken in the present study area. Major spawning areas are also indicated. (Continued).

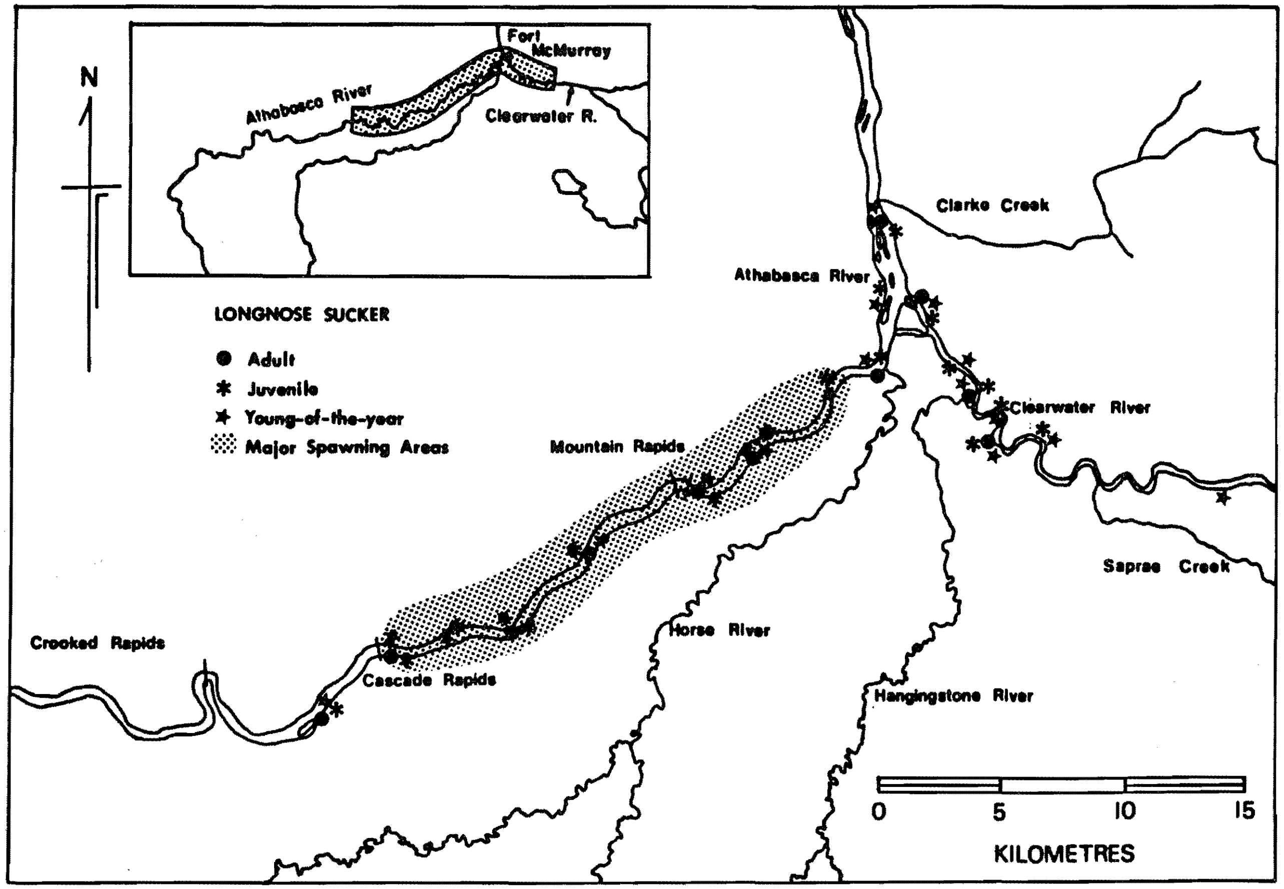


Figure 14. Continued.

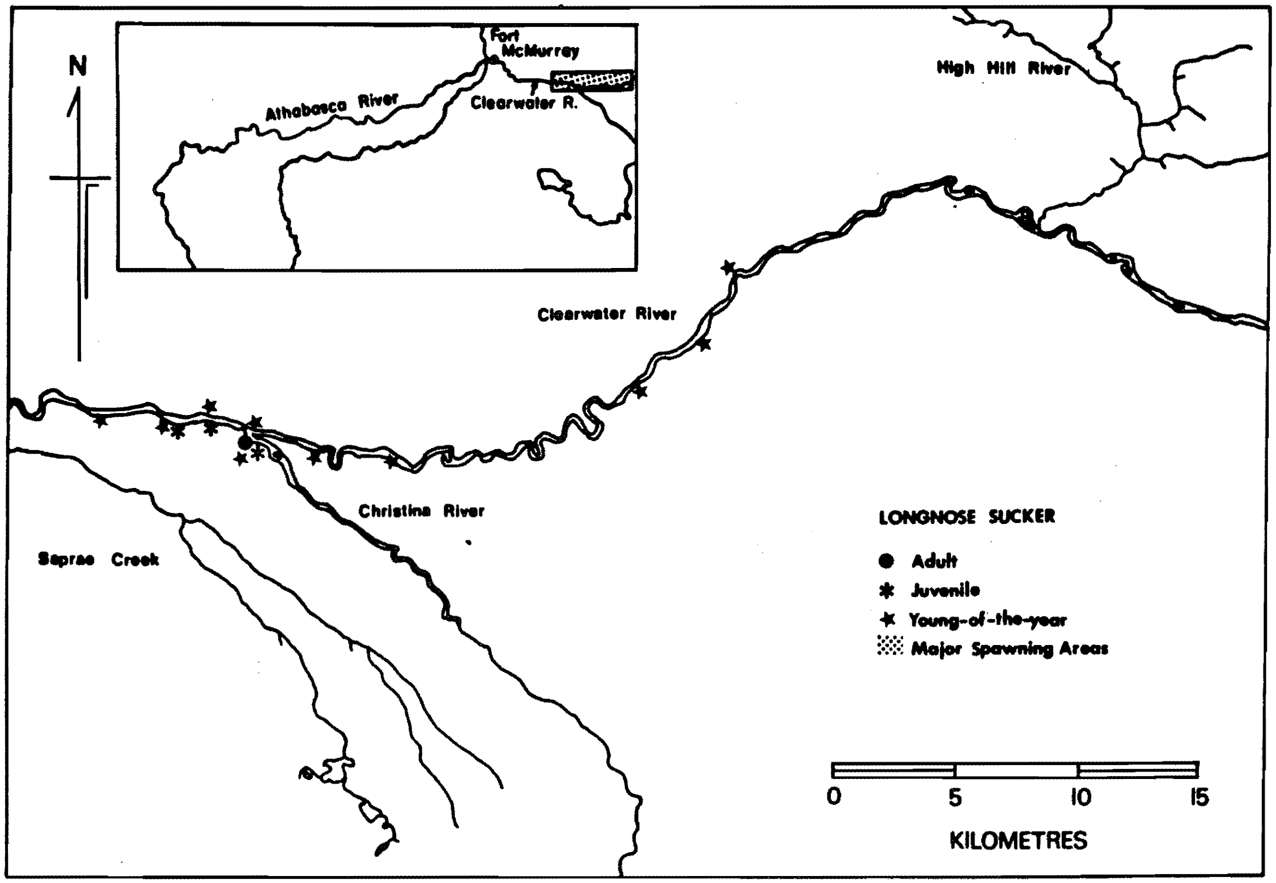


Figure 14. Concluded.

of the Cascade Rapids to a point a few kilometres downstream of Mountain Rapids. Based on age-length and length-frequency data which will be discussed later, these suckers are considered to be part of a migratory population that moves upstream from Lake Athabasca to spawn in the Athabasca River upstream of Fort McMurray. This population is considered to be distinct from a population of smaller, slower growing longnose suckers inhabiting the Athabasca River upstream of Cascade Rapids. The spawning locations of the latter are unknown.

Figure 5 shows the large increases in beach seine catches in the Athabasca River upstream of Fort McMurray which occurred when mature longnose suckers arrived in early to mid-May. Far fewer longnose suckers were captured in the Clearwater River though there is evidence of a small peak coinciding with that in the Athabasca River. By mid-June, few mature longnose suckers were present in the study area downstream of Cascade Rapids.

Major concentrations of spawning longnose suckers were located downstream of Mountain and Cascade rapids (25 and 32 km upstream of Fort McMurray, respectively). Probably few longnose suckers migrate any further upstream. Although some longnose suckers were observed struggling over low bedrock sills at the edge of the Cascade Rapids, it is probable that these, in combination with the equally difficult Little Cascade Rapids located a few kilometres upstream, are an almost impassable barrier to upstream movements for most of the year.

A total of 1982 longnose suckers captured in the Athabasca River downstream of the Cascade Rapids were marked with distinctive fin clips. Eight of these were recaptured, five of them at the same location where they were marked. Of the remaining three, two marked at the Mountain Rapids were recaptured below the Cascade Rapids on 12 May, indicating an upstream movement. The final recapture was a spent individual initially marked at Mountain Rapids which was recaptured 28 May in the Athabasca River downstream of Fort McMurray indicating a downstream migration shortly after spawning.

The small percentage of recaptures (0.4%) suggests that a large population of longnose suckers, probably numbering in the hundreds of thousands, spawns in the Athabasca River between the Cascade Rapids and Fort McMurray.

4.2.4.2 Spawning. *Spawning period.* Longnose sucker spawning occurred between 10 May and 23 May (Table 10). The first ripe females were captured on 12 May although four spawned-out females had been captured the previous day. Spawning probably peaked on 15 May as indicated by the large number of eggs collected in drift samples (Figure 15). After 22 May, no drifting eggs were taken. By that date, the number of longnose suckers in the spawning areas was also greatly reduced and all females were spawned-out.

During the spawning season, water temperatures ranged from 9°C at the onset of spawning to 15°C at the end and dissolved oxygen levels from 9.2 to 10.4 mg/L. During the same period, water levels and turbidity were at their lowest since break-up on 29 April (Figure 3), ranging from 650 to 950 $m^3/s$ and 15 to 31 FTU's, respectively.

*Spawning areas.* Figure 14 shows the locations of known and possible spawning areas for longnose suckers in the project study area. The best documented and probably the most important of these is the Athabasca River from Fort McMurray upstream to the Cascade Rapids, the same area used by fall spawning lake whitefish (Jones et al. 1978).

It is likely that, within this section of the Athabasca River, most longnose suckers spawn just downstream of the Mountain and Cascade rapids. Although direct observations of spawning could not be made because of poor visibility, a large number of longnose suckers was observed in these areas, splashing and rolling on the water surface during the peak spawning period. Longnose sucker catches were also high at the Mountain and Cascade rapids, averaging 53.8 (range 0 to 374) and 44.9 (range 0 to 163) suckers per beach seine haul, respectively, compared with 16.3 (range 0 to 80) suckers per beach seine elsewhere.

Table 10. Summary of longnose sucker spawning in the Athabasca and Clearwater rivers, 28 April to 22 June 1978. N= number examined, G= green, R= ripe, SO = spawned out.

| Date | MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| (day/month) | N | G | R | SO | N | G | R | SO |
| 28/4 | 3 | 3 | | | 4 | 4 | | |
| 30/4 | | | | | 18 | 18 | | |
| 01/5 | | | | | 1 | 1 | | |
| 04/5 | 58 | 42 | 16 | | 96 | 96 | | |
| 05/05 | 20 | 19 | 1 | | 18 | 18 | | |
| 06/05 | 78 | 73 | 5 | | 90 | 90 | | |
| 07/05 | 116 | 92 | 24 | | 130 | 130 | | |
| 08/05 | 208 | 179 | 29 | | 205 | 205 | | |
| 09/05 | 6 | 6 | | | 5 | 5 | | |
| 10/05 | 95 | 65 | 30 | | 135 | 135 | | |
| 11/05 | 1 | | 1 | | 9 | 5 | | 4 |
| 12/05 | 91 | 59 | 32 | | 185 | 177 | 7 | 1 |
| 13/05 | 65 | 43 | 22 | | 140 | 133 | 6 | 1 |
| 15/05 | 37 | | 20 | 17 | 21 | 6 | 7 | 8 |
| 21/05 | 1 | | 1 | | 7 | 5 | | 2 |
| 22/05 | 14 | | | 14 | 6 | | | 6 |
| 24/05 | 30 | | 1 | 29 | 14 | | | 14 |
| 26/05 | | | | | 1 | | | 1 |
| 27/05 | 2 | | | 2 | 2 | | | 2 |
| 28/05 | 42 | | | 42 | 59 | | | 59 |
| 04/06 | | | | | 3 | | | 3 |
| 14/06 | | | | | 1 | 1 | | |
| 22/06 | | | | | 1 | | | 1 |
| Total | 867 | 581 | 182 | 104 | 1151 | 1029 | 20 | 102 |

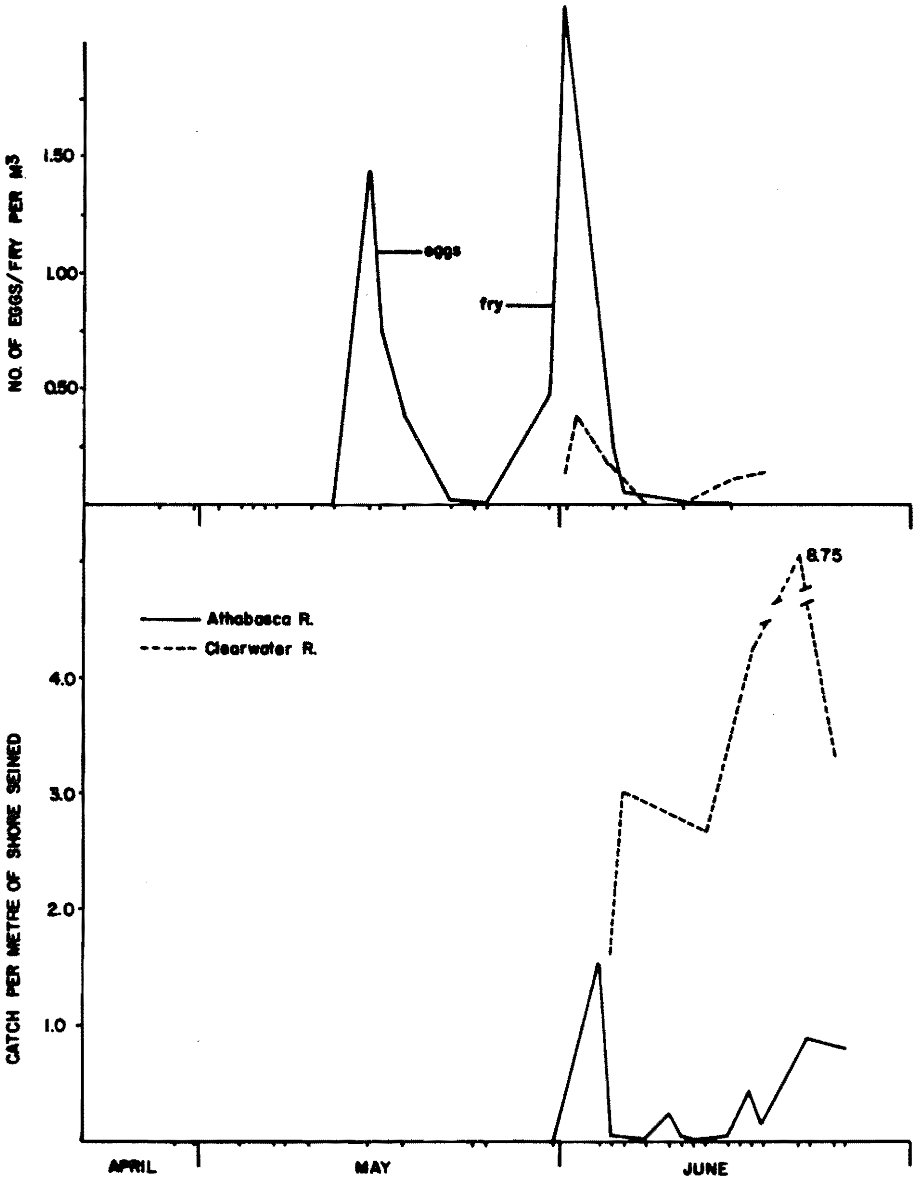


Figure 15. Seasonal abundance of eggs and sucker fry in drift samples and sucker fry in minnow seines on the Athabasca and Clearwater rivers, 28 April to 25 June 1978. Sampling dates are indicated by short vertical bars on the horizontal axis.

Figures 16 and 17 are schematic maps of the lower sections of the Mountain and Cascade rapids showing the locations where stream depth and substrate composition were determined on 19 June 1978. Data describing the depth and substrate at each sampling point are presented in Tables 11 (Mountain Rapids) and 12 (Cascade Rapids). These data are further summarized in Figures 18 and 19 for a series of depth and substrate profiles at several locations across the river. For the Mountain Rapids, the stream profiles, from top to bottom (Figure 18), were based on the following sample points: 4 to 10, 11 to 16, 17 to 22, 23 to 28, 29 to 34; for the Cascade Rapids (Figure 19): 1 to 12, 29 to 38, 39 to 46.

Maximum depth downstream of the Mountain Rapids ranged from 3.0 to 5.0 m (Figure 18). The substrate is composed largely of rubble with boulders along the left bank facing upstream and along the base of the rapids. Sandy substrates are confined to a few locations along quiet edges of the river while gravel substrates are found mixed in with rubble near the left bank, 50 to 250 m downstream of the rapids. Surface velocity ranged from 1.7 to 2.1 m/s across most of the river during high water periods and 0.7 to 1.8 m/s during low water periods.

Maximum depth at the Cascade Rapids ranged from 4.5 m at the base of the rapids to 2.8 m farther downstream (Figure 19). Bedrock and coarse rubble dominate the substrate near the rapids, changing to rubble farther downstream with increasing amounts of gravel and sand near the edge of the river. Surface velocities at the Cascade Rapids varied more than those at the Mountain Rapids, ranging from 0.4 to 2.1 m/s.

The Athabasca River upstream of Cascade Rapids was not sampled intensively during the spawning period and no fish in spawning condition were captured. Later in the summer, however, young-of-the-year suckers were captured in the vicinity of tributary streams suggesting that longnose suckers in this section spawn in tributaries rather than in the mainstem.

In the Clearwater River, substrates are predominantly sand and suitable spawning areas for longnose suckers, which prefer

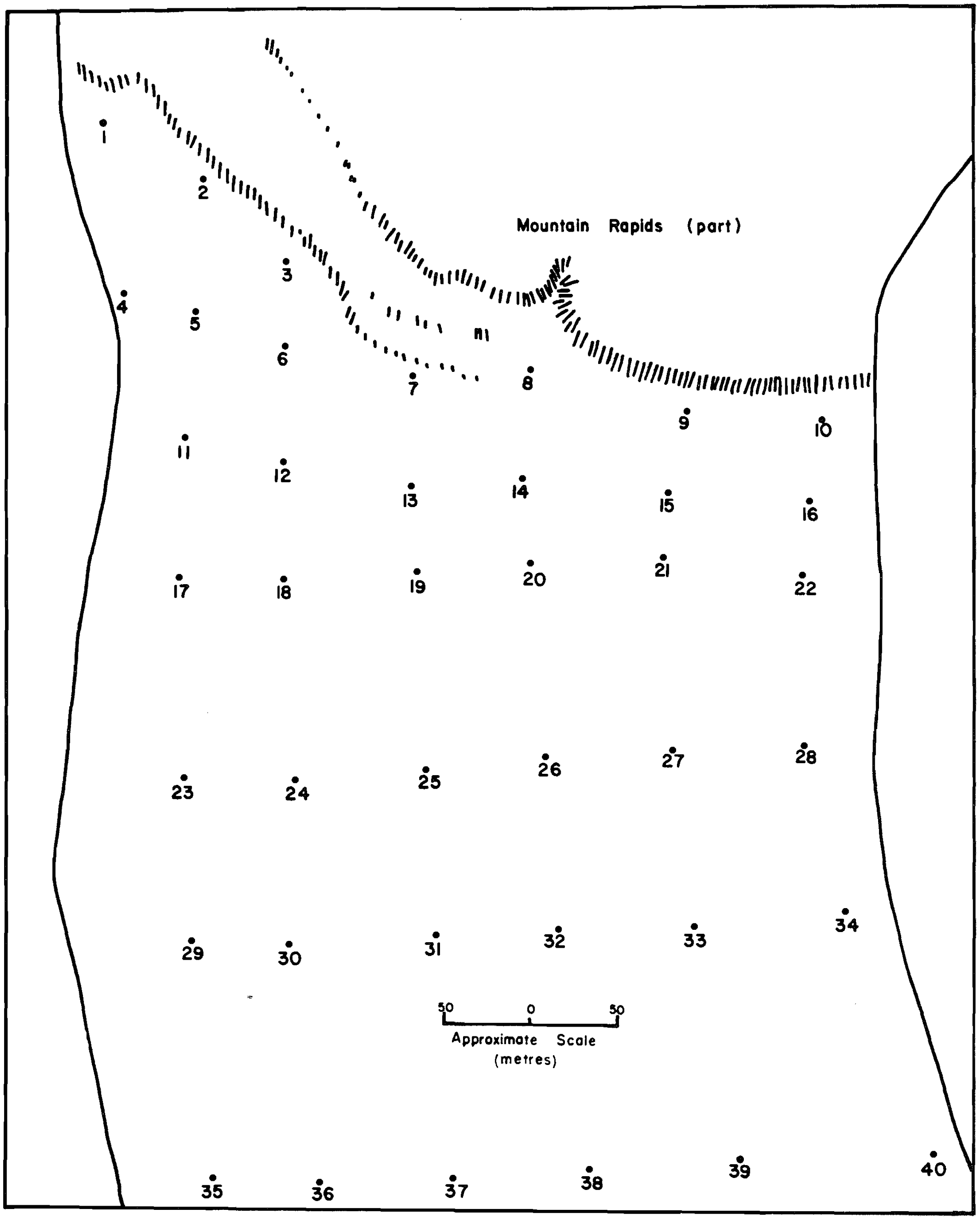


Figure 16. Schematic diagram of the Mountain Rapids (in part) showing the location of sampling points for depth and substrate composition.

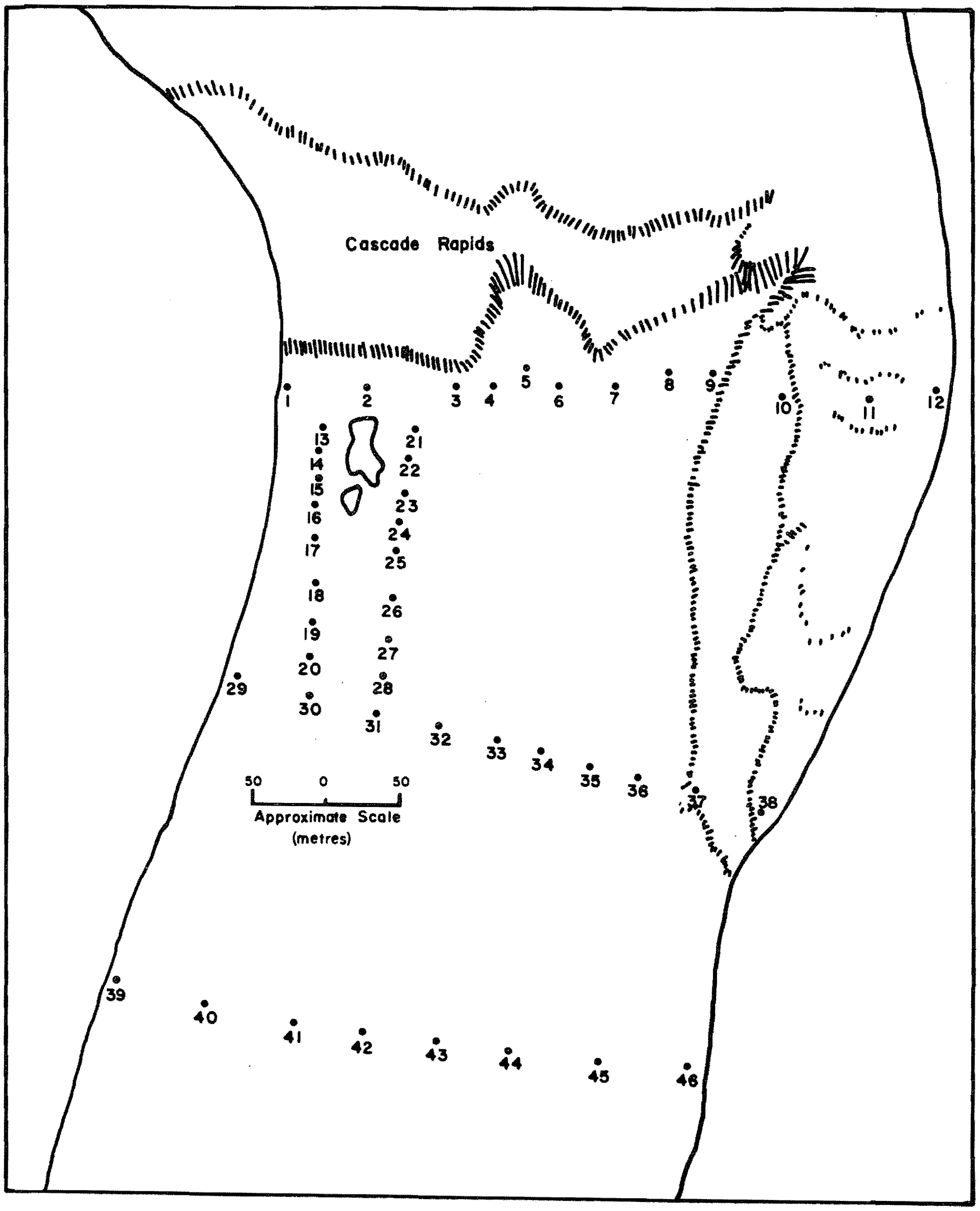


Figure 17. Schematic diagram of the Cascade Rapids showing the location of sampling points for depth and substrate composition.

Table 11. Stream depth and substrate composition downstream of the Mountain Rapids, 19 June 1978, at locations shown in Figure 16.

| Location | Depth (m) | Major Substrate | Location | Depth (m) | Major Substrate |
|---|---|---|---|---|---|
| 1 | 2.1 | bedrock | 21 | 3.0 | rubble |
| 2 | 2.2 | bedrock | 22 | 1.0 | rubble |
| 3 | 2.2 | bedrock | 23 | 2.1 | rubble, sand |
| 4 | 0.9 | rubble, gravel | 24 | 2.8 | rubble, sand |
| 5 | 1.5 | rubble, gravel | 25 | 2.3 | rubble |
| 6 | 1.1 | rubble, gravel | 26 | 2.5 | rubble |
| 7 | 2.1 | boulder, rubble | 27 | 3.0 | rubble |
| 8 | 3.9 | rubble | 28 | 1.0 | sand |
| 9 | 5.0 | boulder, rubble | 29 | 1.7 | boulder |
| 10 | 4.0 | sand | 30 | 2.2 | rubble |
| 11 | 1.9 | rubble, gravel | 31 | 3.0 | rubble |
| 12 | 1.2 | rubble, gravel | 32 | 2.2 | rubble |
| 13 | 1.9 | boulder, rubble | 33 | 2.8 | rubble |
| 14 | 2.1 | rubble | 34 | 1.0 | rubble, silt |
| 15 | 4.0 | rubble | 35 | 2.1 | boulder |
| 16 | 3.5 | rubble | 36 | 3.0 | rubble |
| 17 | 2.2 | boulder, rubble, gravel | 37 | 3.4 | rubble |
| 18 | 1.7 | rubble, gravel, sand | 38 | 1.9 | rubble |
| 19 | 2.5 | rubble | 39 | 2.0 | rubble |
| 20 | 3.5 | rubble | 40 | 0.5 | rubble |

Table 12. Stream depth and substrate composition downstream of the Cascade Rapids, 19 June 1978, at locations shown in Figure 17.

| Location | Depth (m) | Major Substrate | Location | Depth (m) | Major Substrate |
|---|---|---|---|---|---|
| 1 | 3.7 | bedrock, sand | 24 | 1.8 | rubble |
| 2 | 2.9 | rubble | 25 | 2.0 | rubble, gravel |
| 3 | 4.2 | rubble | 26 | 2.8 | rubble, sand |
| 4 | 4.5 | rubble | 27 | 1.5 | rubble, sand |
| 5 | 4.0 | bedrock | 28 | 2.0 | rubble, sand |
| 6 | 4.0 | bedrock, rubble | 29 | 0.5 | rubble, silt |
| 7 | 2.5 | rubble | 30 | 2.4 | rubble |
| 8 | 4.5 | rubble | 31 | 2.1 | rubble |
| 9 | 0.2 | bedrock | 32 | 2.8 | rubble |
| 10 | 0.2 | bedrock | 33 | 2.8 | rubble |
| 11 | 0.5 | bedrock, rubble, gravel | 34 | 2.2 | rubble, gravel, sand |
| 12 | 0.5 | bedrock, rubble, gravel | 35 | 2.5 | rubble, gravel, sand |
| 13 | 0.7 | rubble, gravel | 36 | 0.7 | sand |
| 14 | 0.7 | rubble, gravel | 37 | 0.2 | gravel, sand |
| 15 | 0.8 | rubble, gravel | 38 | 0.4 | gravel, sand |
| 16 | 0.7 | rubble, gravel | 39 | 1.4 | sand, silt |
| 17 | 0.9 | rubble, gravel | 40 | 2.0 | gravel, sand |
| 18 | 1.5 | rubble | 41 | 1.9 | rubble, gravel |
| 19 | 1.8 | rubble | 42 | 1.8 | rubble, gravel |
| 20 | 2.0 | rubble | 43 | 1.9 | rubble, gravel |
| 21 | 2.0 | rubble, gravel | 44 | 3.2 | rubble, gravel |
| 22 | 1.7 | rubble, gravel | 45 | 2.2 | rubble, gravel, sand |
| 23 | 1.1 | rubble, gravel | 46 | 1.6 | rubble, sand |

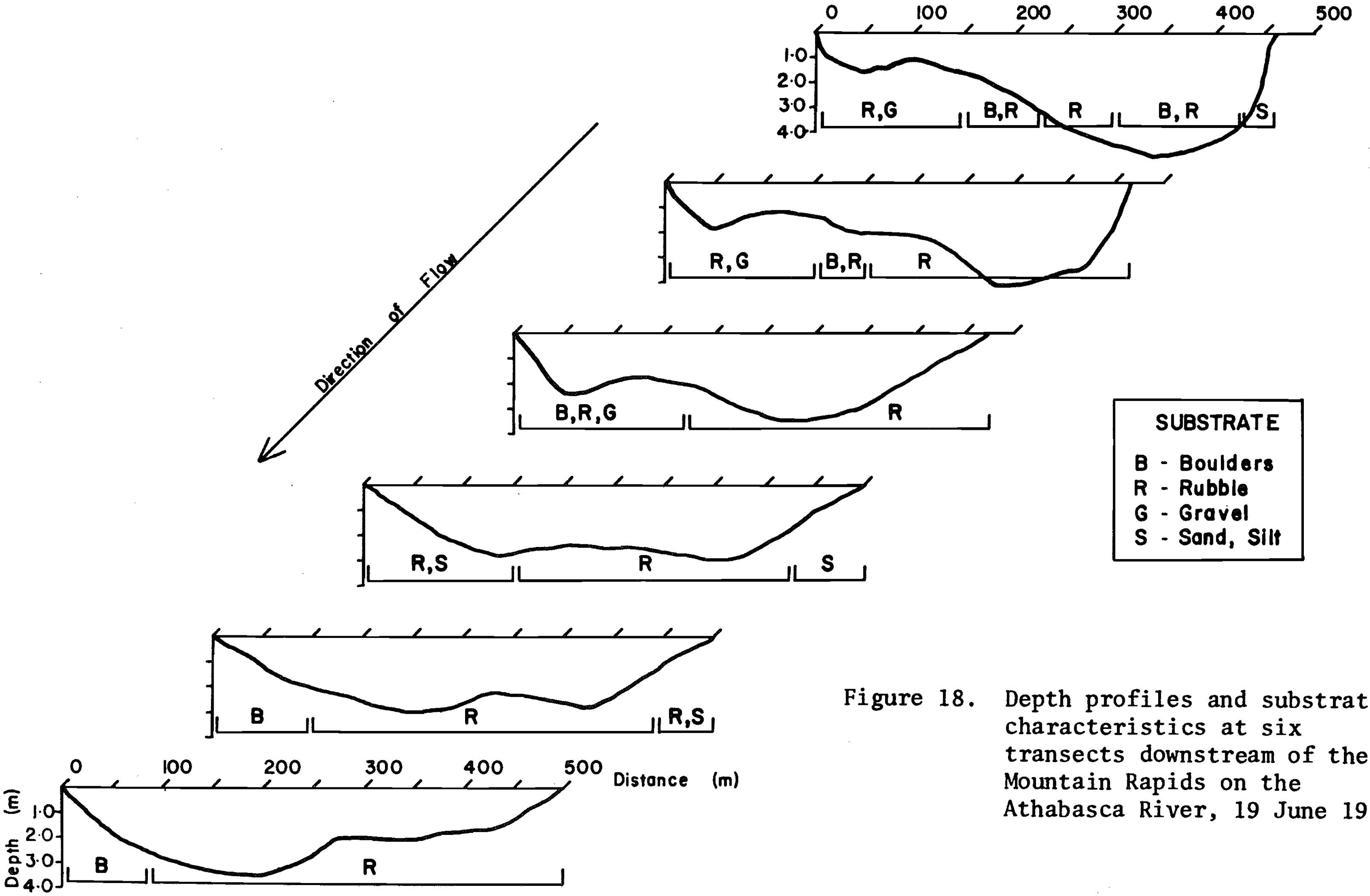


Figure 18. Depth profiles and substrate characteristics at six transects downstream of the Mountain Rapids on the Athabasca River, 19 June 1978.

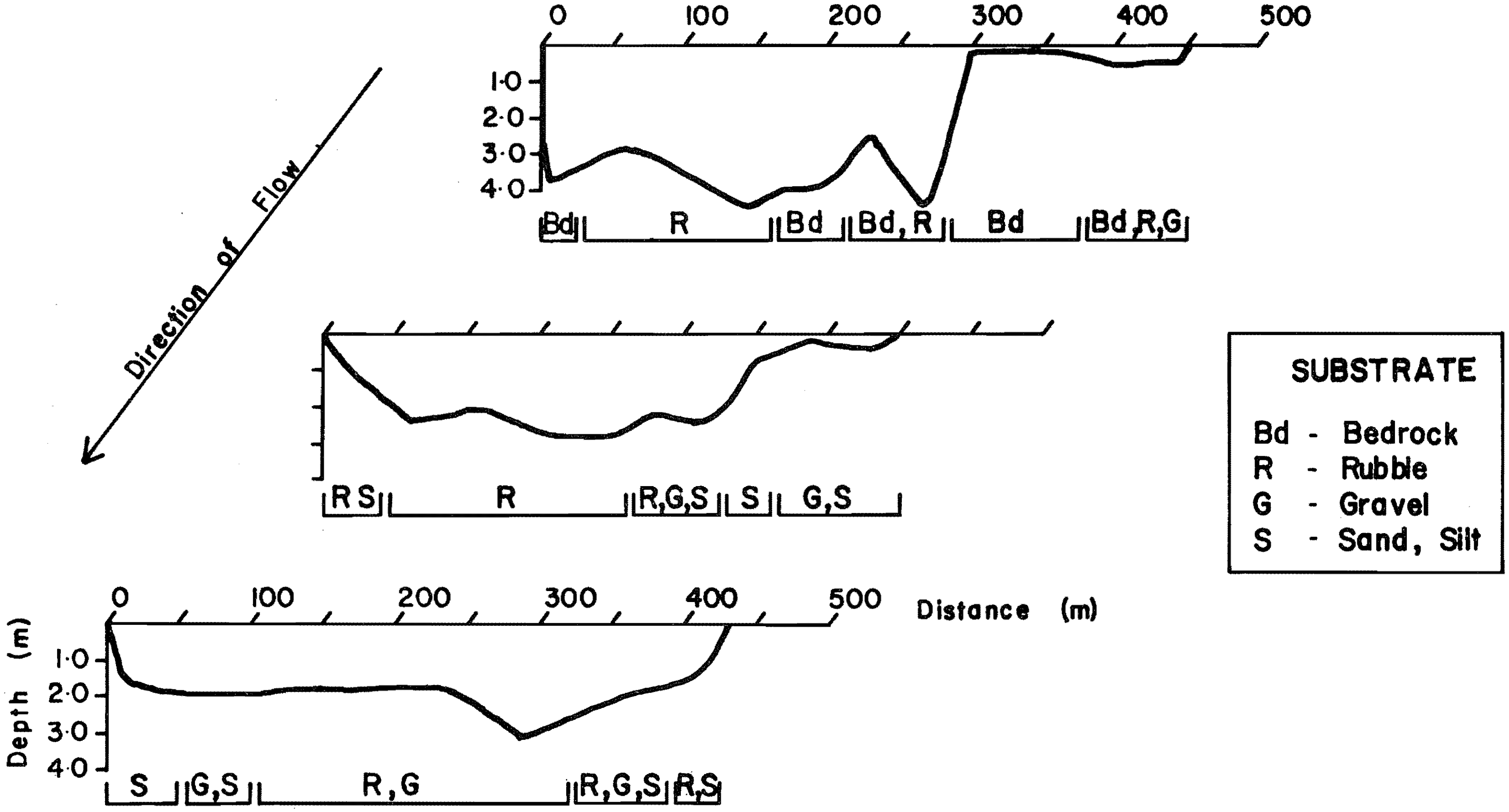


Figure 19. Depth profiles and substrate characteristics at three transects downstream of the Cascade Rapids on the Athabasca River, 19 June 1978.

coarser substrates for spawning, are limited. The sucker fry captured in the Clearwater probably drifted out of the Christina River, a known spawning area for both longnose and white suckers. Few fry were captured in the Clearwater River upstream of its junction with the Christina River.

4.2.4.3 Fry emergence and downstream migration. In the Athabasca River, recently emerged sucker fry were first collected in drift samples taken 30 May (Figure 15). The numbers of fry peaked 1 June and then dropped very quickly. By 11 June, relatively few fry were drifting down the river. During this period, water temperatures ranged from 14 to 18°C, dissolved oxygen concentrations from 8.0 to 8.8 mg/L, turbidity from 45 to 60 FTU's, and discharge rates from 1050 to 1500 $m^3/s$. The incubation period (i.e., the period between peak spawning and peak emergence) was 17 days, from 15 May to 1 June, approximately 235 centigrade degree days.

The timing of the peak downstream movement of fry in the Clearwater River was similar but there was a greater, secondary peak in mid-June which did not occur in the Athabasca River.

Data describing the diel periodicity of drift rates of sucker fry in the Athabasca and Clearwater rivers are presented in Table 13. The data cover two 24 h periods, 1 and 2 June and 19 and 20 June. On 1 and 2 June, drift rates were highest in the evening at 1800 and 2100 h and lowest in the morning at 0600 and 0900 h. Because, however, the differences between replicates were quite variable, no definite conclusions can be drawn. On 19 and 20 June, drift rates on the Athabasca River were much lower than during the earlier period (a mean 0.07 compared with 0.22 fish/$m^3$) and there was no obvious diel pattern. The Clearwater River was sampled only once, 19 and 20 June. The mean drift rate (0.09 fish/$m^3$) was similar to that on the Athabasca River during the same period. Again, there was no obvious diel pattern in movements.

Drift rates measured 1 June along a transect across the Athabasca River indicated that drift rates were generally highest away from the stream edges in areas of high velocity (Table 14).

Table 13. Diel drift rates for sucker fry in the Athabasca and Clearwater rivers, 1 to 2 June and 19 to 20 June 1978. Drift rates are the mean of three replicates.

| Time (Hours) | Athabasca River, 1-2 June |  | Athabasca River, 19-20 June |  | Clearwater River, 19-20 June |  |
|---|---|---|---|---|---|---|
|  | Drift Rate (No./m$^3$) | Range | Drift Rate (No./m$^3$) | Range | Drift Rate (No./m$^3$) | Range |
| 1200 | 0.12 | 0.09-0.18 | 0.14 | 0.06-0.28 | 0.16 | 0.09-0.22 |
| 1500 | 0.22 | 0.19-0.27 | 0.02 | 0.00-0.07 | 0.14 | 0.00-0.43 |
| 1800 | 0.59 | 0.20-1.01 | 0.15 | 0.00-0.28 | 0.01 | 0.00-0.04 |
| 2100 | 0.37 | 0.11-0.80 | 0.10 | 0.00-0.21 | 0.05 | 0.00-0.09 |
| 2400 | 0.22 | 0.00-0.54 | 0.11 | 0.00-0.27 | 0.07 | 0.00-0.13 |
| 0300 | 0.13 | 0.09-0.19 | 0.03 | 0.00-0.09 | 0.21 | 0.16-0.26 |
| 0600 | 0.06 | 0.00-0.09 | 0.02 | 0.00-0.07 | 0.00 | 0.00 |
| 0900 | 0.08 | 0.00-0.16 | 0.00 | 0.00 | 0.01 | 0.00-0.04 |
| 1200 | 0.21 | 0.02-0.33 | 0.03 | 0.00-0.09 | 0.14 | 0.09-0.17 |
| Mean Rates | 0.22 | 0.00-1.01 | 0.07 | 0.00-0.28 | 0.09 | 0.00-0.43 |

Table 14. Drift rates for sucker fry across the Athabasca River, 1 June 1978.

| Transect Point | 1 (Outside Bank) | 2 | 3 | 4 | 5 | 6 | 7 (Inside Bank) |
|---|---|---|---|---|---|---|---|
| Velocity (m/sec) | 0.74 | 1.83 | 1.19 | 1.22 | 1.19 | 1.28 | 0.73 |
| Volume Filtered ($m^3$) | 41.1 | 51.1 | 33.2 | 13.6 | 33.2 | 35.7 | 20.4 |
| Number of Fry/$m^3$ | 0.12 | 3.80 | 3.01 | 4.63 | 1.57 | 0.00 | 0.00 |

Not all fry drift downstream out of the project study area. Some move inshore and take up residence there as indicated by catch per unit effort data for minnow seining (Figure 15). The data suggest, however, that this is more likely to occur where velocities are low (as in the Clearwater River) than where velocities are high (as in the Athabasca River). In the former, catch per unit effort was much higher throughout the study period.

The secondary peak in abundance which occurred in both rivers around 22 June is probably the result of increasing numbers of recently emerged white sucker fry that were not differentiated from longnose sucker fry. Though the data are few, it appears that white suckers spawn later in the spring than longnose suckers.

4.2.4.4 Juveniles. From 28 April to 30 May, immature longnose suckers ranging from 40 to 100 mm fork length were scarce (Figure 11) in the project study area. In June, however, their numbers increased rapidly throughout the study area. It is not known whether this increase is the result of an upstream migration or an inshore movement from overwintering areas located in the deeper parts of the Athabasca River or tributary streams.

4.2.4.5 Length-frequency. The length-frequency distribution of 205 longnose suckers captured in three subdivisions of the project study area, from early September to early November 1977 (Jones et al. 1978) and from late April to mid-June 1978, is presented in Figure 20. The total sample was subdivided into three sets:

1. Athabasca River upstream of Cascade Rapids;
2. Athabasca River downstream of Cascade Rapids; and
3. Clearwater River.

The sets were treated separately in this analysis.

It is apparent that, while the ranges of lengths recorded for each sub-area are similar, the Athabasca River sample from downstream of the Cascade Rapids contains more large fish than the upstream sample. The Clearwater River sample is approximately intermediate. Student's t-test analysis of these data revealed

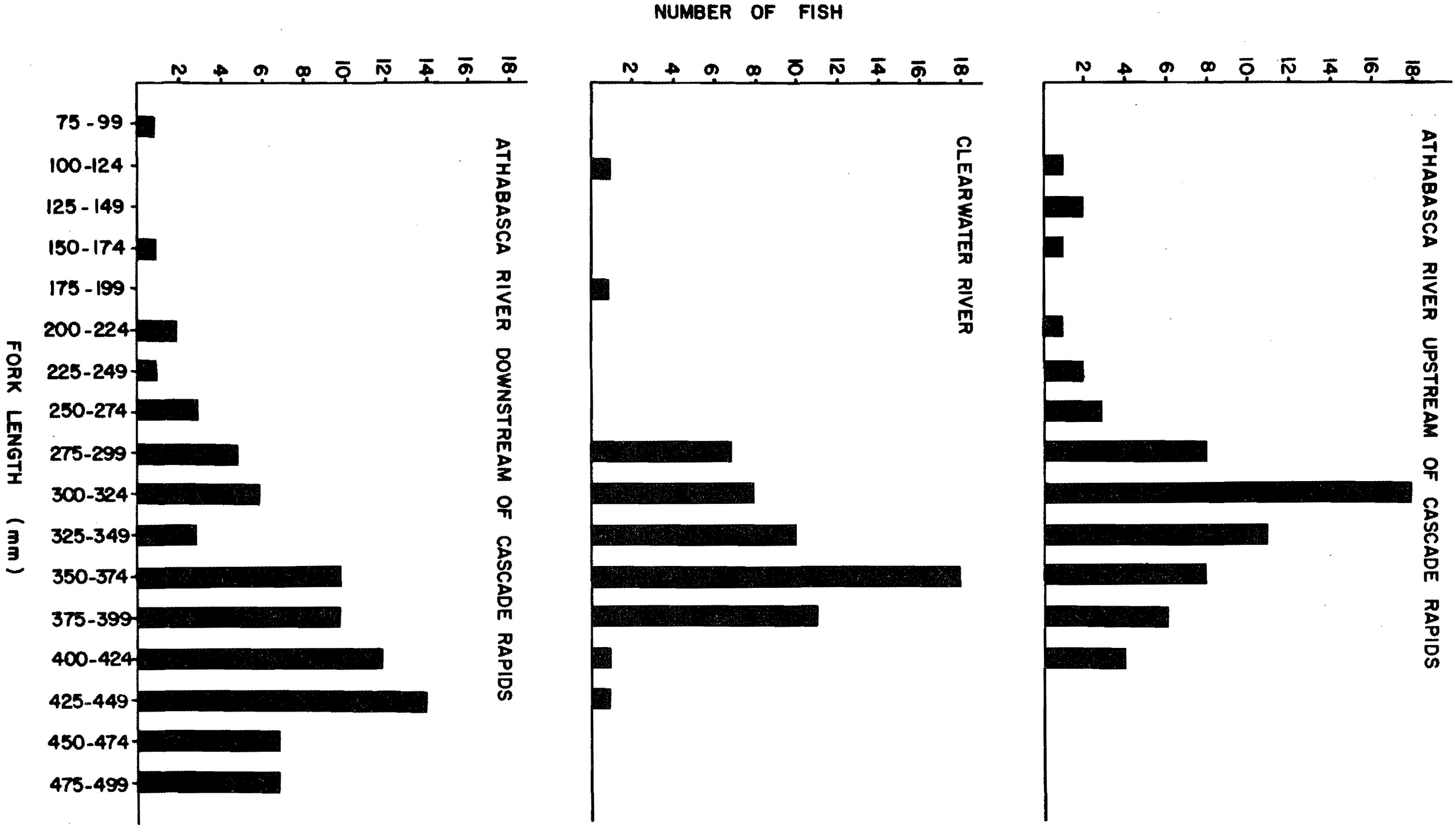


Figure 20. Length-frequencies for longnose suckers taken from the Athabasca River upstream of the Cascade Rapids, Clearwater River, and the Athabasca River downstream of the Cascade Rapids, 28 April to 25 June 1978.

significant differences ($P<0.05$) in comparison of mean lengths (upstream=314 mm, downstream=384 mm, Clearwater=342 mm fork length) between samples.

The observed differences in mean size between sampling areas suggest the existence of at least two sub-populations of longnose sucker in the study area:

1. A smaller, slower growing, resident population which utilizes the Athabasca River, both upstream and downstream of the Cascade Rapids, throughout the year; and
2. A larger, faster growing, migratory form (probably originating in Lake Athabasca) which does not penetrate upstream of the Cascade Rapids.

Fish in the Clearwater River, which are intermediate in length, may represent a third, distinct population or result from an intermingling of the other two. The former interpretation is suggested by the fact that the length-frequency distribution of suckers in the Clearwater does not completely overlap the length-frequency distributions of longnose suckers in the Athabasca River, either upstream or downstream of the Cascade Rapids. Secondly, a comparison of mean fork length at age 11, the only age for which there are sufficient data, shows a significant difference between the three stream sections (Table 15).

Length-frequency distributions previously reported in the AOSERP study area (Bond and Berry in prep.a,b; Bond and Machniak 1979; McCart et al. 1977) broadly overlap those of longnose suckers taken during this study.

Few juvenile longnose suckers were captured in either the Athabasca or Clearwater rivers. While this may be because of sampling bias, it is more likely that juvenile longnose suckers have a distribution quite different from the larger, adult segment of the population.

Table 15. Mean fork lengths for age 11 longnose suckers taken from the present study area, 28 April to 25 June 1978.

| | Fork Length (mm) | | | | |
|---|---|---|---|---|---|
| Location | N | $\bar{x}$ | 2 SE | t | P |
| Athabasca River above Cascades | 7 | 305.1 | 20.6 | | |
| | | | | 2.7681 | <0.05 |
| Clearwater River | 11 | 343.3 | 17.6 | | |
| | | | | 2.1245 | <0.05 |
| Athabasca River below Cascades | 10 | 383.4 | 34.6 | | |

4.2.4.6 Age and growth. Age-length data for longnose suckers (27 captured in the Athabasca River above Cascade Rapids, 41 captured downstream of the Cascade Rapids, and 42 captured in the Clearwater River) are presented in Tables 16, 17, and 18, respectively. Otolith ages were used in all calculations for this species.

Longnose suckers captured above Cascade Rapids were, on average, slower growing than those sampled from below (Figure 21). The growth curve for the Clearwater River sample is approximately intermediate.

In Figure 22, the age-length relationship of longnose suckers captured during this study is compared with growth rates reported for populations elsewhere in the AOSERP study area (Bond and Machniak 1977; McCart et al. 1977, 1978) and in Alberta (Rawson and Elsey 1950). Longnose suckers captured above the Cascade Rapids grow at a very slow rate, comparable to that reported for a population inhabiting an alpine lake (Pyramid Lake) in Alberta (Rawson and Elsey 1950). The growth curves for the samples captured in the Athabasca River downstream of Cascade Rapids and in the Clearwater River, however, fall within the range previously described for earlier samples from the AOSERP study area.

The maximum age determined for longnose sucker captured during this study was 20 years. Elsewhere in the AOSERP study area, maximum ages of 13 (Bond and Machniak 1977; McCart et al. 1977, Jones et al. 1978), 14 (Bond and Berry in prep.a), 17 (McCart et al. 1978), and 19 years (Bond and Berry in prep.b) have been reported.

It is probable that some of the apparent variation in growth rates between samples of longnose sucker from the AOSERP study area is ascribable to differences in aging techniques (e.g., scales, otoliths, fin rays) and differences in the criteria used to identify annuli. A detailed comparison of various aging techniques and the criteria used in identifying annuli on various structures is warranted.

Table 16. Age-length relationship with age-specific sex ratios and percent maturity for longnose suckers taken in the present study area on the Athabasca River upstream of Cascade Rapids, 28 April to 25 June 1978.

| | Fork Length (mm) | | | | Males | | | Females | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | Mean | S.D. | S.E. | Range | N | % | % Mature | N | % | % Mature | Unsexed | Total |
| 3 | 117 | | | | 0 | | | 0 | | | 1 | 1 |
| 4 | | | | | 0 | | | 0 | | | 0 | 0 |
| 5 | 140.5 | 13.4 | 9.5 | 131-150 | 0 | | | 0 | | | 2 | 2 |
| 6 | 168 | | | | 0 | | | 0 | | | 1 | 1 |
| 7 | | | | | 0 | | | 0 | | | 0 | 0 |
| 8 | 279.3 | 4.0 | 2.3 | 275-283 | 0 | 0 | | 3 | 100 | 33 | 0 | 3 |
| 9 | 234.7 | 11.7 | 6.7 | 222-245 | 1 | 33 | 0 | 2 | 67 | 50 | 0 | 3 |
| 10 | 304 | | | | 1 | 100 | 0 | 0 | 0 | | 0 | 1 |
| 11 | 305.1 | 27.2 | 10.3 | 274-348 | 2 | 33 | 50 | 4 | 67 | 100 | 1 | 7 |
| 12 | 311.2 | 37.9 | 19.0 | 256-337 | 0 | 0 | | 3 | 100 | 67 | 1 | 4 |
| 13 | 304 | | | | 0 | 0 | | 1 | 100 | 100 | 0 | 1 |
| 14 | | | | | 0 | | | 0 | | | 0 | 0 |
| 15 | | | | | 0 | | | 0 | | | 0 | 0 |
| 16 | | | | | 0 | | | 0 | | | 0 | 0 |
| 17 | | | | | 0 | | | 0 | | | 0 | 0 |
| 18 | 389.7 | 28.0 | 16.2 | 358-411 | 0 | 0 | | 3 | 100 | 100 | 0 | 3 |
| 19 | | | | | 0 | | | 0 | | | 0 | 0 |
| 20 | 409 | | | | 0 | 0 | | 1 | 100 | 100 | 0 | 1 |
| Totals | | | | | 4 | 19 | 25 | 17 | 81 | 76 | 6 | 27 |

Table 17. Age-length relationship with age-specific sex ratios and percent maturity for longnose suckers taken in the present study area on the Athabasca River downstream of Cascade Rapids, 28 April to 25 June 1978.

| | Fork Length (mm) | | | | Males | | | Females | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | Mean | S.D. | S.E. | Range | N | % | % Mature | N | % | % Mature | Unsexed | Total |
| 7 | 202 | | | | 0 | 0 | | 1 | 100 | 0 | 0 | 1 |
| 8 | | | | | 0 | | | 0 | | | 0 | 0 |
| 9 | 309 | 12.7 | 9.0 | 300-318 | 2 | 100 | 0 | 0 | 0 | | 0 | 2 |
| 10 | 354.4 | 44.8 | 20.0 | 291-388 | 2 | 40 | 50 | 3 | 60 | 67 | 0 | 5 |
| 11 | 383.4 | 54.7 | 17.3 | 309-445 | 1 | 10 | 0 | 9 | 90 | 89 | 0 | 10 |
| 12 | 418.0 | 32.5 | 23.0 | 395-441 | 0 | 0 | | 2 | 100 | 100 | 0 | 2 |
| 13 | 374.2 | 69.6 | 31.1 | 257-427 | 0 | 0 | | 5 | 100 | 60 | 0 | 5 |
| 14 | 393.0 | 77.1 | 34.5 | 273-458 | 2 | 40 | 50 | 3 | 60 | 67 | 0 | 5 |
| 15 | 450 | | | | 0 | 0 | | 1 | 100 | 100 | 0 | 1 |
| 16 | 470.3 | 18.0 | 6.8 | 441-497 | 1 | 14 | 100 | 6 | 86 | 100 | 0 | 7 |
| 17 | | | | | 0 | | | 0 | | | 0 | 0 |
| 18 | 477 | | | | 0 | 0 | | 1 | 100 | 100 | 0 | 1 |
| 19 | | | | | 0 | | | 0 | | | 0 | 0 |
| 20 | 457.0 | 1.4 | 1.0 | 456-458 | 0 | 0 | | 2 | 100 | 100 | 0 | 2 |
| Totals | | | | | 8 | 20 | 38 | 33 | 80 | 82 | 0 | 41 |

Table 18. Age-length relationship with age-specific sex ratios and percent maturity for longnose suckers taken in the present study area in the Clearwater River, 28 April to 25 June 1978.

| | Fork Length (mm) | | | | Males | | | Females | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | Mean | S.D. | S.E. | Range | N | % | % Mature | N | % | % Mature | Unsexed | Total |
| 5 | 115 | | | | 0 | | | 0 | | | 1 | 1 |
| 6 | 195 | | | | 0 | | | 0 | | | 1 | 1 |
| 7 | 218 | | | | 1 | 100 | 0 | 0 | 0 | | 0 | 1 |
| 8 | 285 | | | | 1 | 100 | 100 | 0 | 0 | | 0 | 1 |
| 9 | 294 | | | | 0 | 0 | | 1 | 100 | 0 | 0 | 1 |
| 10 | 332.8 | 32.3 | 14.4 | 280-358 | 2 | 40 | 0 | 3 | 60 | 100 | 0 | 5 |
| 11 | 343.3 | 29.2 | 8.8 | 314-415 | 9 | 82 | 100 | 2 | 18 | 100 | 0 | 11 |
| 12 | 348.8 | 33.0 | 11.7 | 309-391 | 5 | 62 | 100 | 3 | 38 | 67 | 0 | 8 |
| 13 | 369.7 | 21.2 | 6.7 | 331-393 | 4 | 40 | 100 | 6 | 60 | 67 | 0 | 10 |
| 14 | 427.7 | 49.9 | 28.8 | 386-414 | 0 | 0 | | 3 | 100 | 100 | 0 | 3 |
| 15 | 413.5 | 37.5 | 26.5 | 387-440 | 0 | 0 | | 2 | 100 | 100 | 0 | 2 |
| Totals | | | | | 22 | 53 | 86 | 20 | 47 | 80 | 0 | 42 |

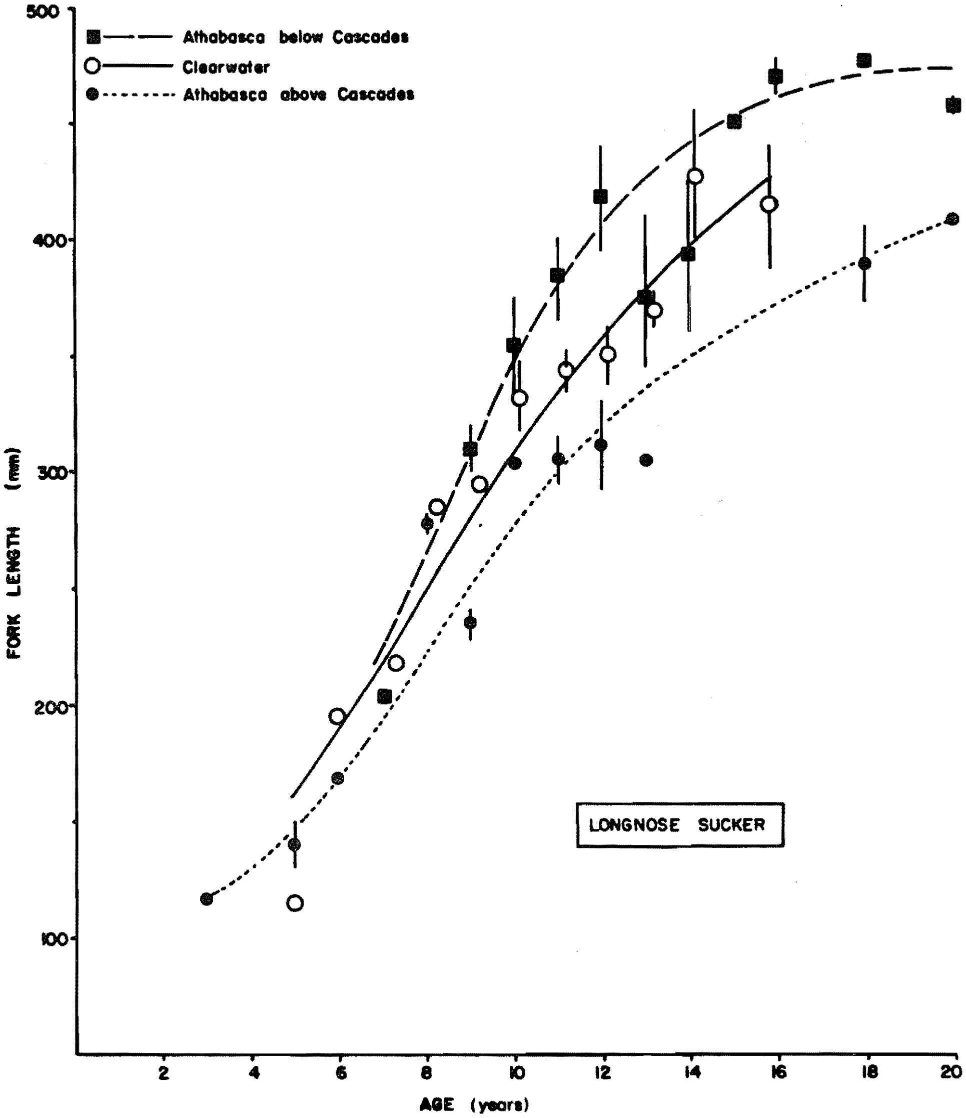


Figure 21. Comparison of growth rates of longnose suckers taken in the Athabasca River upstream of the Cascade Rapids, in the Athabasca River downstream of the Cascade Rapids, and in the Clearwater River, 28 April to 25 June 1978. Points with vertical lines are mean fork lengths ± one standard error. Single points are individual fork lengths.

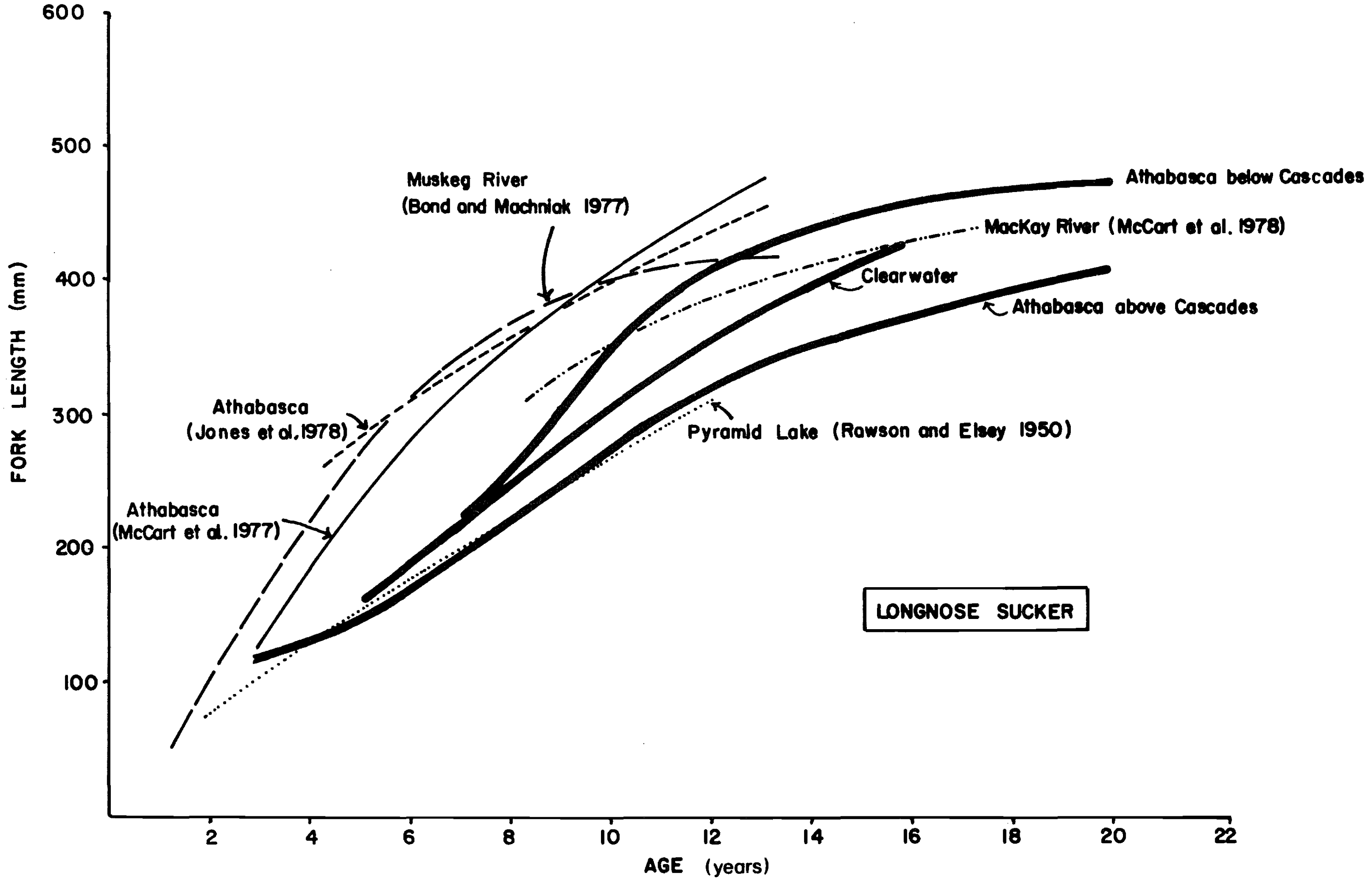


Figure 22. Comparison of growth rates of longnose suckers collected from three areas in this study and longnose suckers collected in five other studies in Alberta.

4.2.4.7 Age at maturity. Age, maturity, and sex were determined for 104 longnose suckers from the project study area (Tables 16 to 18). The youngest mature male and female were both age 8 and were captured, respectively, in the Clearwater River and in the Athabasca River above Cascade Rapids. Some individuals as old as 14 years of age had immature gonads suggesting that some fish may not spawn every year. Other investigators in the AOSERP study area report ages at first maturity for this species of from 5 (Bond and Machniak 1977; Jones et al. 1978) to 8 years (Bond and Berry in prep.a). Tripp and McCart (1974) report that longnose suckers in the Donnelly River, N.W.T., mature for the first time at age 9 to 12 years. Variations in aging technique probably account for some of the reported range in age at maturity within the AOSERP study area.

4.2.4.8 Sex ratios. There was no significant difference in the number of males and females ($X^2=3.20$, $P>0.05$, 53% females) in the total sample, including aged and unaged fish, for which sex was determined (N=1756). Other researchers (Bond and Machniak 1977; McCart et al. 1977; McCart et al. 1978, Bond and Berry in prep.b) in the AOSERP study area also report balanced sex ratios.

4.2.4.9 Length-weight relationships. Analysis of covariance showed a significant difference between the slopes of the length-weight relationships (Table 19) for samples (males, females, and unsexed fish) taken from the Athabasca River upstream of the Cascade Rapids and the Clearwater River (F=13.9) and between the intercepts of samples taken from the lower Athabasca and Clearwater rivers (F=8.0). There were, however, no significant differences in other comparisons.

4.2.4.10 Fecundity. Fecundity was determined for 30 mature longnose suckers captured in the project study area (Figure 23). Individuals varied in fork length from 309 to 497 mm and in fecundity from 6623 to 53 768 eggs. The mean length and fecundity of the sample were 402.0 mm (SE=7.02) and 21 842.6 eggs (SE=1431.1),

Table 19. Logarithmic ($Log_{10}$) length-weight relationships for longnose suckers taken in the Athabasca and Clearwater rivers upstream of Fort McMurray, 28 April to 25 June 1978.

| Location | Sample | N | Mean Length (mm) | Mean Weight (g) | Slope | Intercept | Sxy | rxy |
|---|---|---|---|---|---|---|---|---|
| Athabasca R. upstream of Cascade Rapids | -males | 4 | 279.9 | 285.8 | 2.973 | -4.824 | 0.113 | 0.987 |
| | -females | 16 | 320.2 | 408.6 | 3.016 | -4.946 | 0.033 | 0.988 |
| | -males, females, unsexed fish | 26 | 272.6 | 255.2 | 2.959 | -4.801 | 0.028 | 0.997 |
| Athabasca R. downstream of Cascade Rapids | -males | 8 | 350.8 | 549.4 | 2.907 | -4.658 | 0.037 | 0.995 |
| | -females | 33 | 398.0 | 793.0 | 3.174 | -5.353 | 0.053 | 0.983 |
| | -males, females, unsexed fish | 41 | 388.3 | 739.8 | 3.129 | -5.232 | 0.050 | 0.984 |
| Clearwater River | -males | 23 | 327.3 | 455.2 | 3.248 | -5.510 | 0.040 | 0.976 |
| | -females | 20 | 374.9 | 709.4 | 3.057 | -5.019 | 0.030 | 0.992 |
| | -males, females, unsexed fish | 44 | 344.1 | 534.7 | 3.167 | -5.560 | 0.035 | 0.990 |

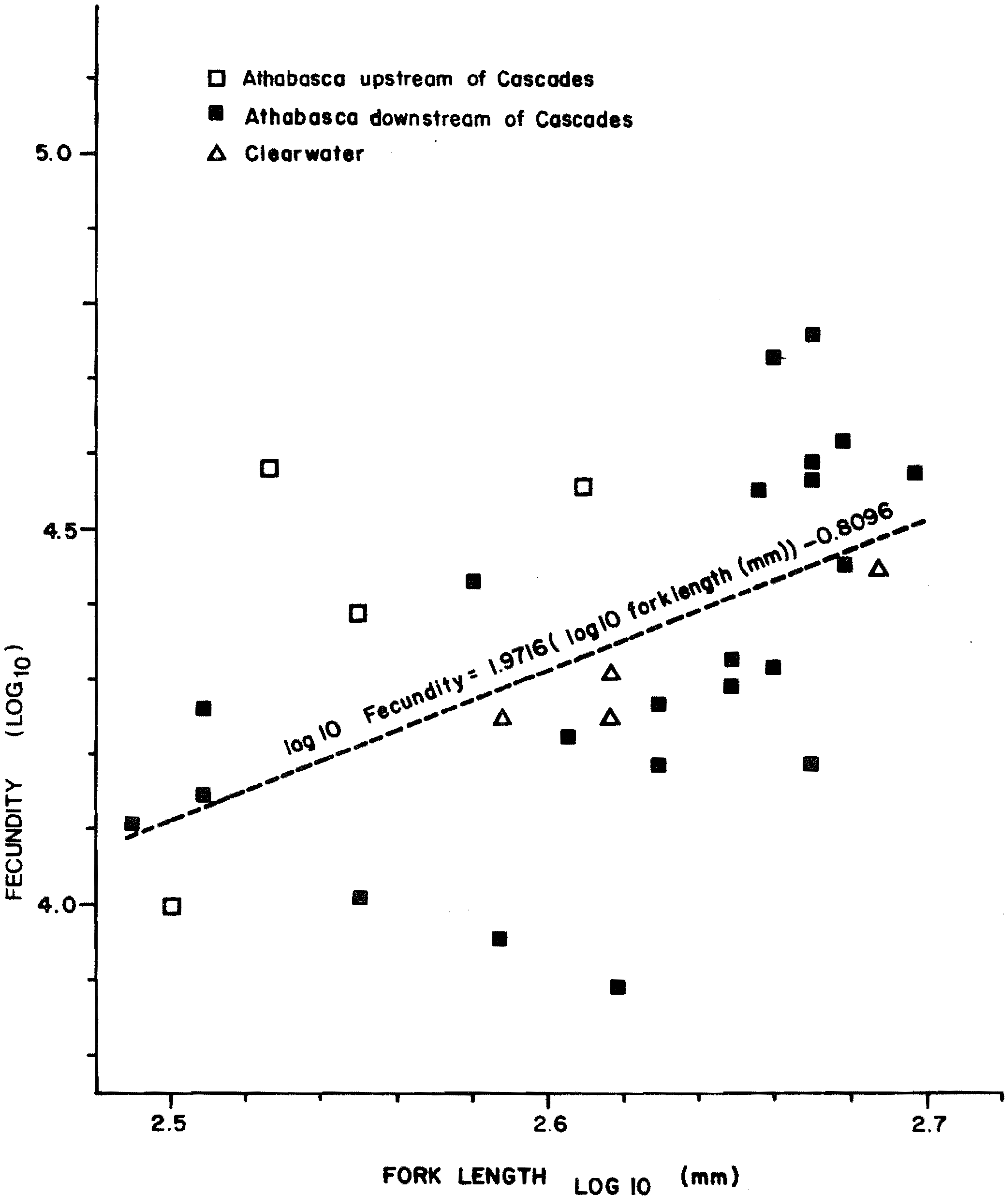


Figure 23. Length-fecundity relationship for longnose suckers taken in the project study area, 28 April to 26 June 1978.

respectively. Fecundity was significantly correlated with fish size ($r=0.56$, $P<0.05$):

$$\text{Log}_{10}\ \text{Fecundity} = 1.97\ \text{Log}_{10}\ \text{Fork Length (mm)} - 0.08$$

4.2.4.11 Food habits. Longnose sucker stomach contents were generally unidentifiable under field conditions and therefore no feeding data are presented for this species.

### 4.2.5 White Suckers

4.2.5.1 Distribution and movements. White suckers are found throughout the AOSERP study area in both the Athabasca River and its tributaries. Spawning appears to be concentrated in tributaries and major spawning runs have been documented in the Muskeg (Bond and Machniak 1977, 1979), Steepbank (Machniak and Bond 1979), MacKay (McCart et al. 1978; Bond et al. in prep.), and Christina rivers (Tripp and Tsui in prep.). There is no evidence to date indicating that white suckers spawn in the Athabasca River itself. Tagging studies (Bond and Berry in prep.a,b) have shown that some white suckers tagged in the Athabasca River and its tributaries (e.g., the Muskeg River) migrate downstream, following spawning in the spring, to the Peace-Athabasca Delta and Lake Athabasca.

In the spring of 1978, white suckers were taken in beach seines in the Athabasca River below the Cascade Rapids between 5 May and 23 May and none thereafter (Figure 5). Only two white suckers were ever captured in beach seines in the Clearwater River although they are known to spawn in its tributary, the Christina River. Catch per beach seine haul was 0.38 white suckers per haul in the Athabasca compared with 0.09 per haul in the Clearwater River. Fewer fish were sampled in gillnets although catch per gillnet hour was higher in the Clearwater River (0.04) than in the lower (0.01) or upper (0.01) Athabasca River. Overall, white suckers (excluding young-of-the-year) constituted 0.9% of the total catch in beach seines, gillnets, and minnow seines.

4.2.5.2 Spawning. *Spawning period.* The first ripe male was captured on 15 May and the first spawned-out male on 8 June (Table 20). Although ripe females were never captured during the study, the fact that all females taken up to 24 May were green and two captured after 29 May were spawned-out indicates that spawning probably occurred in the last week of May. This was approximately one week after longnose suckers had spawned in the Athabasca River. Similar differences in time between longnose and white sucker spawning have been reported elsewhere (Geen et al. 1966; Bond and Machniak 1979).

*Spawning areas.* Evidently, there is no appreciable white sucker spawning in the Athabasca River although there appear to be suitable spawning areas characterized by fast-flowing water over gravel substrates. Nor does there appear to be any spawning in the Clearwater River, although, as with longnose suckers, spawning areas are limited since the Clearwater River has a sandy substrate. Spawning is probably concentrated in various tributaries such as the Christina River.

4.2.5.3 Fry emergence. The seasonal pattern of abundance for sucker fry in minnow seines taken in the Athabasca and Clearwater rivers was discussed earlier under the emergence and downstream migration of longnose sucker fry (Figure 15). Fry of the two species were not distinguished and the second major peak for catches taken in the Clearwater River, 21 June, and the second minor peak in the Athabasca River, 22 June, are probably a combination of the two species. The length-frequency distribution of sucker fry taken from the Clearwater River 24 June (Figure 24) shows a distinct bimodality. Since white suckers spawn after longnose suckers, the smaller fry averaging 17 mm are probably white suckers while the larger fry averaging 22 to 23 mm are probably longnose suckers. Peak emergence of white sucker fry likely occurred 22 June.

4.2.5.4 Length-frequency. The length-frequency distribution of 41 white suckers captured in the project study area from late April

Table 20. Spawning condition of white suckers taken from the Athabasca and Clearwater rivers, 5 May to 13 June 1978. N= number examined; G= green; R= ripe; SO= spawned-out.

| Date | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| (Day/Month) | N | G | R | SO | N | G | R | SO |
| 5/5 | 1 | 1 | | | 1 | 1 | | |
| 7/5 | 3 | 3 | | | | | | |
| 8/5 | | | | | 1 | 1 | | |
| 10/5 | | | | | 3 | 3 | | |
| 12/5 | 4 | 4 | | | 10 | 10 | | |
| 15/5 | 1 | | 1 | | 1 | 1 | | |
| 21/5 | 1 | | 1 | | 2 | 2 | | |
| 24/5 | | | | | 1 | 1 | | |
| 29/5 | | | | | 1 | | | 1 |
| 3/6 | | | | | 1 | | | 1 |
| 8/6 | 3 | | | 3 | | | | |
| 13/6 | 1 | | | 1 | | | | |
| Totals | 14 | 8 | 2 | 4 | 21 | 19 | 0 | 2 |

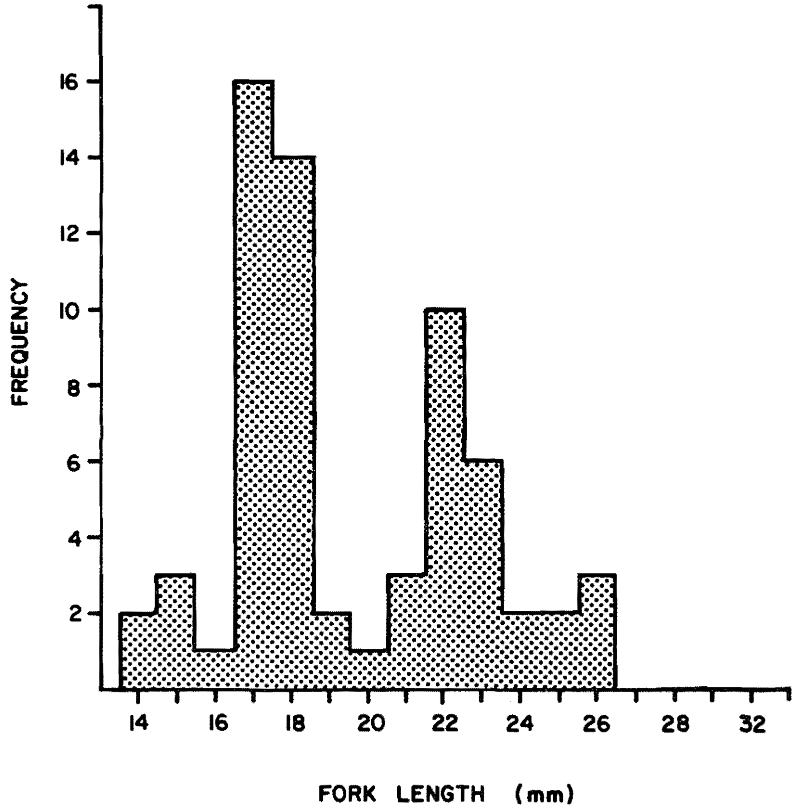


Figure 24. Length-frequency distribution of sucker fry taken in the Clearwater River, Site 24, on 24 June 1978. N=65.

to mid June-1978, is presented in Figure 25. Few individuals smaller than 350 mm fork length were captured in either beach seines or gillnets. Jones et al. (1978) captured white suckers primarily in the length range 300 to 400 mm in the same study area sampled during the present study. As with longnose sucker, the absence of juveniles may be due to sampling bias but is more likely due to differences in the distributions of juveniles and adults.

4.2.5.5 Age and growth. Age-length data for 37 white suckers captured in the project study area are presented in Table 21 and in Figure 26.

White suckers in the sample ranged in age from 10 to 18 years and in fork length from 263 to 520 mm. The growth curve for the study sample is approximately intermediate between those determined for populations elsewhere in the AOSERP study area (Figure 26). White suckers taken in the present study were both older and larger than those taken by Jones et al. (1978) in the same study area. As with longnose suckers, variation in aging techniques and criteria for establishment of annuli probably account for at least some of the variability in growth rates reported for this species in the AOSERP study area.

4.2.5.6 Age at maturity. Age, maturity, and sex were determined for 37 white suckers. There was only one immature specimen (age 12) in the aged sample. Elsewhere in the AOSERP study area, ages at first maturity of 3 to 4 (Bond and Machniak 1977), 5 to 6 (Jones et al. 1978), and 8 to 12 (McCart et al. 1978) have been reported.

4.2.5.7 Sex ratios. There were fewer males (14) than females (23) in the aged sample, but the difference was not significant ($X^2$=1.05, $P<0.05$). Jones et al. (1978) report a similar preponderance of females (78%) in a sample of white suckers taken from the same study area in the fall of 1977. Bond and Machniak (1977) and Bond and Berry (in prep.b) also report significantly more females (62% and 55%, respectively) than males in the spring spawning runs

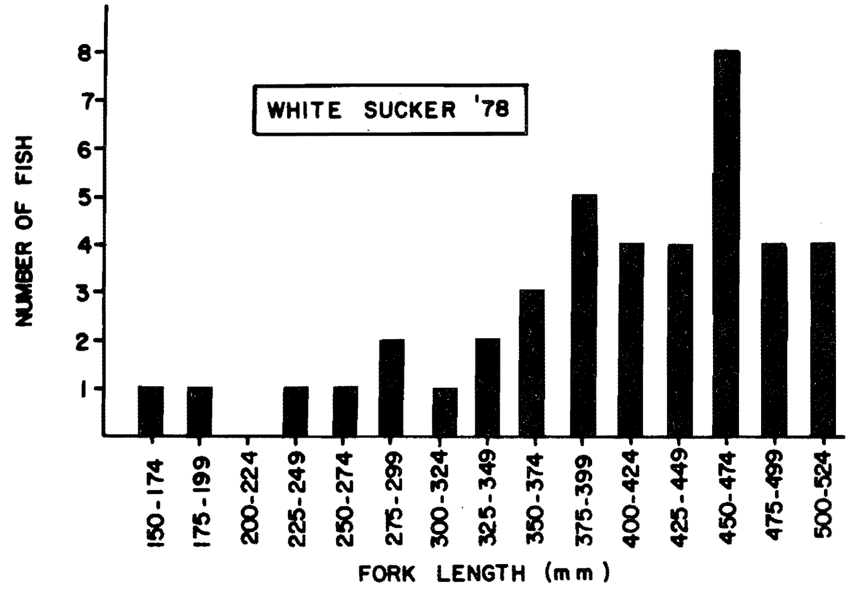


Figure 25. Length-frequency distribution of white suckers taken from the Athabasca and Clearwater rivers upstream of Fort McMurray, 28 April to 25 June 1978.

Table 21. Age-length relationship with age-specific sex ratios and percent maturity for white sucker taken from the present study area, 28 April to 25 June 1978.

| | Fork Length (mm) | | | | Males | | | Females | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | Mean | S.D. | S.E. | Range | N | % | % Mature | N | % | % Mature | Unsexed | Total |
| 10 | 378.8 | 48.2 | 24.1 | 328-442 | 2 | 50 | 100 | 2 | 50 | 100 | 0 | 4 |
| 11 | 383.3 | 59.9 | 24.5 | 285-466 | 5 | 83 | 100 | 1 | 17 | 0 | 0 | 6 |
| 12 | 416.9 | 65.1 | 17.4 | 263-485 | 6 | 43 | 100 | 8 | 57 | 88 | 0 | 14 |
| 13 | 442.6 | 60.8 | 23.0 | 330-506 | 1 | 14 | 100 | 6 | 86 | 100 | 0 | 7 |
| 14 | 510 | | | | 0 | 0 | | 1 | 100 | 100 | 0 | 1 |
| 15 | 467.0 | 25.5 | 18.0 | 449-485 | 0 | 0 | | 2 | 100 | 100 | 0 | 2 |
| 16 | 492.0 | 39.6 | 28.0 | 464-520 | 0 | 0 | | 2 | 100 | 100 | 0 | 2 |
| 17 | | | | | 0 | | | 0 | | | 0 | 0 |
| 18 | 452 | | | | 0 | 0 | | 1 | 100 | 100 | 0 | 1 |
| Totals | | | | | 14 | 38 | 100 | 23 | 62 | 91 | 0 | 37 |

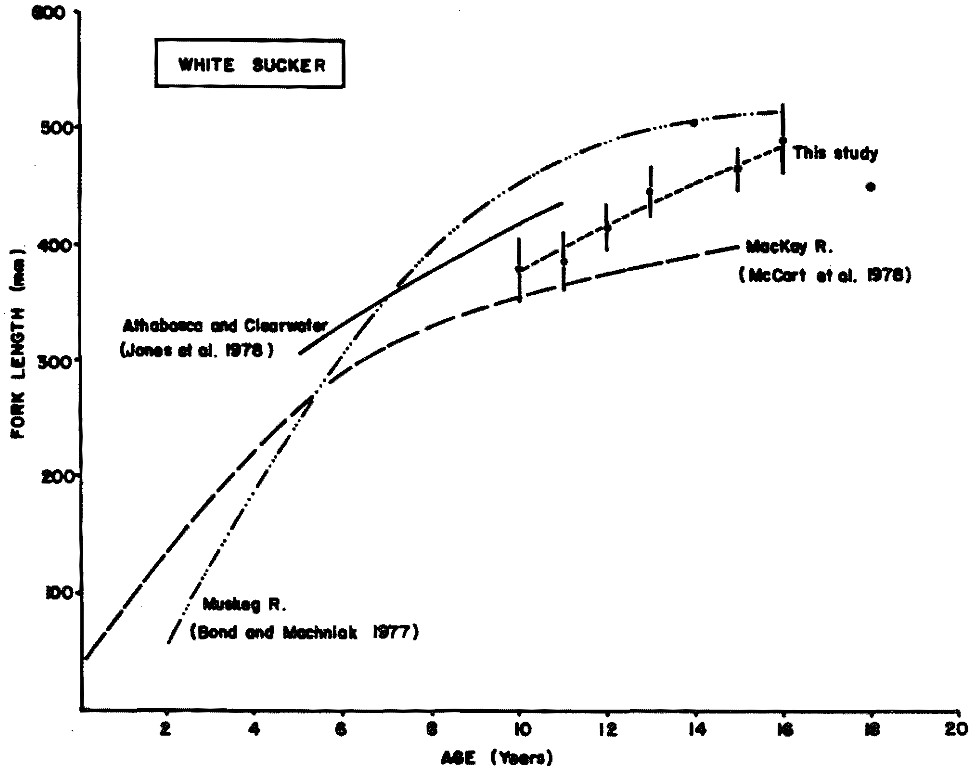


Figure 26. Comparison of growth rates of white suckers collected in this study and white suckers collected in three other studies in the AOSERP study area. Symbols for samples taken in this study are: Points with vertical bars= mean fork lengths ± one standard error; points= individual fork lengths.

of white sucker in the Muskeg River. Elsewhere, balanced sex ratios have been reported (McCart et al. 1977, 1978).

4.2.5.8 Length-weight relationships. No significant differences in slope ($F=2.85$, $P>0.05$) or intercept ($F=0.49$, $P>0.05$) were observed in the length-weight relationships of males and females. The length-weight relationship determined for the combined sample is as follows:

$$\mathrm{Log}_{10}\ \text{Fork Length (mm)} = 3.32\ \mathrm{Log}_{10}\ \text{Weight (g)} - 5.66$$

$$r=0.98,\ P<0.05,\ N=37$$

4.2.5.9 Fecundity. Fecundity was determined for 19 mature white suckers ranging in fork length from 385 to 520 mm. Average fecundity was 43 140 (range 16 640 to 124 030) eggs per female. Fecundity was significantly correlated with fork length ($r=0.67$, $P<0.05$) as follows (Figure 27):

$$\mathrm{Log}_{10}\ \text{Fecundity} = 4.19\ \mathrm{Log}_{10}\ \text{Fork Length (mm)} - 6.54$$

4.2.5.10 Food habits. As with longnose sucker, stomach contents of white suckers were too finely ground to permit detailed analysis. Therefore, no feeding data are presented for this species.

### 4.2.6 Walleye

4.2.6.1 Distribution and movements. Earlier studies indicate that Richardson Lake in the Peace-Athabasca Delta is a major spawning area for walleye (Bidgood 1968, 1971, 1973; Dietz 1973) in the Athabasca Drainage. Other studies have indicated that there is a large migration up the Athabasca River in early spring (McCart et al. 1977; Bond and Berry in prep.a,b). This migration is assumed to be a spawning migration from Lake Athabasca although few ripe females have ever been captured in the Athabasca River during the spring spawning period and there have been no direct observations of spawning. Most of the walleye taken in the river in early spring have been spent males and females with sex ratios favouring males ranging from 63% (Bond and Berry in prep.b) to 97% (Bond and Berry in prep.a). Similar

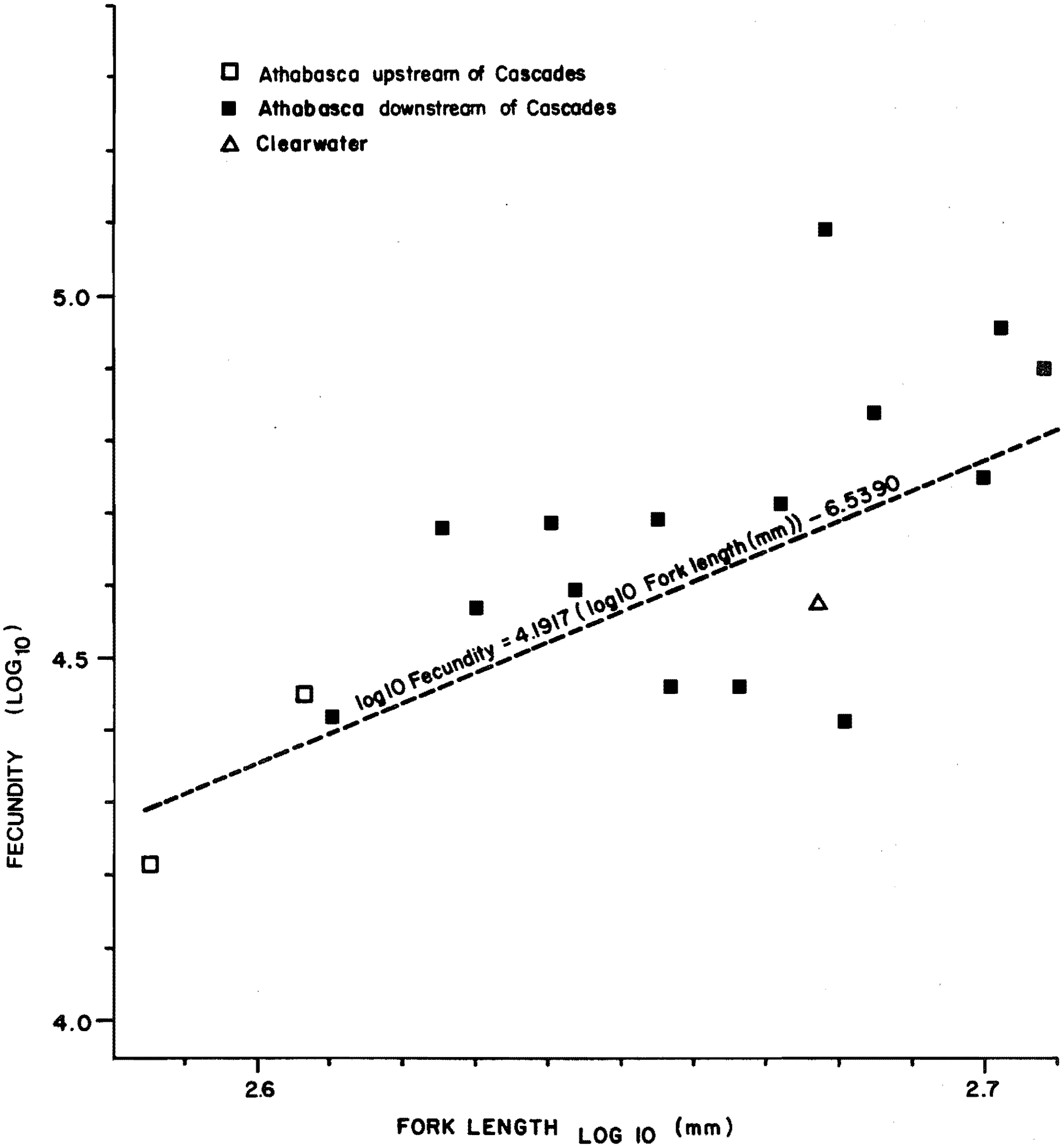


Figure 27. Length-fecundity relationship for white suckers taken in the present study area, 28 April to 25 June 1978.

migrations composed almost entirely of ripe and recently spawned-out males have been documented during early May in several tributaries of the Athabasca River including the Muskeg (Bond and Machniak 1979), Steepbank (Machniak and Bond 1979), and MacKay rivers (Bond et al. in prep.; McCart et al. 1978).

Walleye tagged in the Athabasca River in the spring have been recaptured in the Peace-Athabasca Delta and Lake Athabasca indicating a downstream migration after spawning. Tagged walleye have also, however, been recaptured as far upstream as the town of Jarvie on the Pembina River indicating that extensive upstream movements also occur (Bond in prep.). It may be that the greater number of fish recaptured in the Peace-Athabasca Delta and Lake Athabasca region, compared to areas upstream of the AOSERP study area, reflects the more intensive fishing effort in the former and consequently greater chance of recapturing marked fish.

The distribution of adult, juvenile, and young-of-the-year walleye taken during this study is shown in Figure 28. In total, 101 walleye (excluding young-of-the-year) were captured in gillnets and beach seines, most of them from the Athabasca River downstream of the Cascade Rapids. Gillnet catch per hour ranged from 0.25 in the Athabasca River downstream of the Cascade Rapids to 0.14 in the Clearwater River and 0.06 in the Athabasca River upstream of the Cascade Rapids. Few walleye were captured in beach seines in either the Athabasca (N=8) or Clearwater rivers (N=2).

Figure 4 shows the seasonal pattern of catch per gillnet hour for walleye in the Athabasca and Clearwater rivers. Walleye were first captured 28 April. Catches thereafter were relatively even. There was no evidence of major migrations or concentrations of fish. The slight variations in catch were more likely related to differences in netting efficiency than in changes in fish density.

4.2.6.2 Spawning. *Spawning period*. The first ripe male was captured 28 April and the first spawned-out male 15 May (Table 22). The mature females taken during the study (N=7) were all captured from 13 May to 14 June and all were spawned-out indicating that

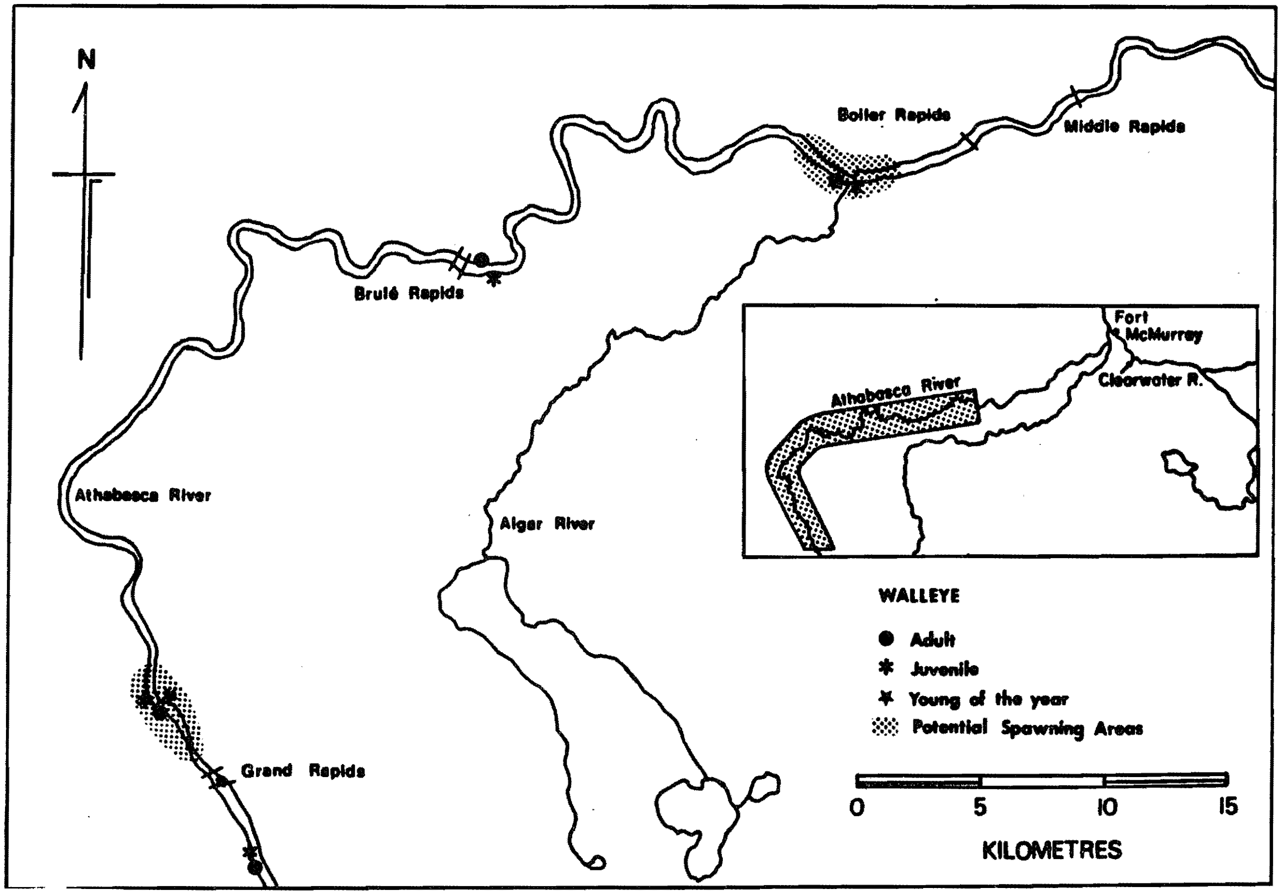


Figure 28. Locations where walleye were taken in the present study area. Potential spawning areas are also indicated. (Continued).

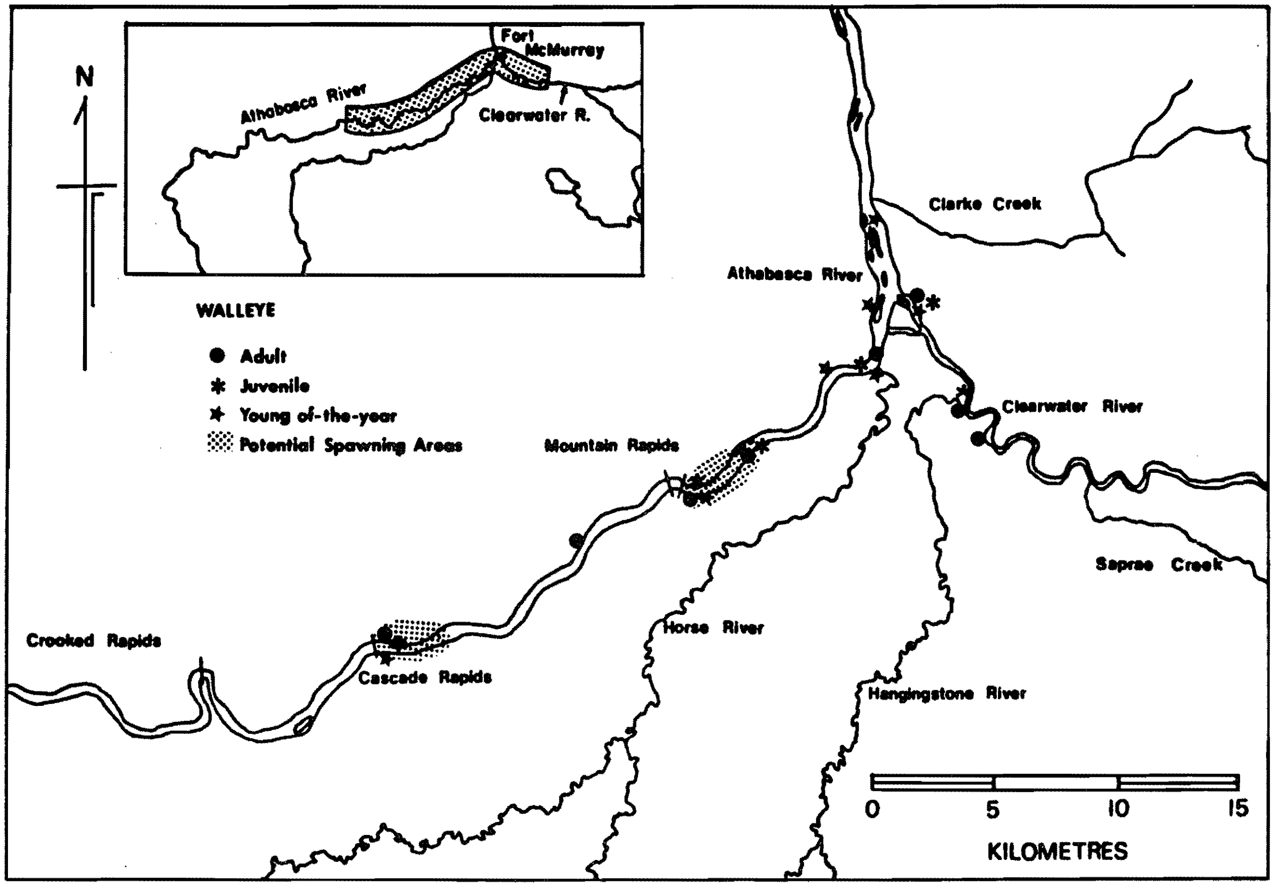


Figure 28. Continued.

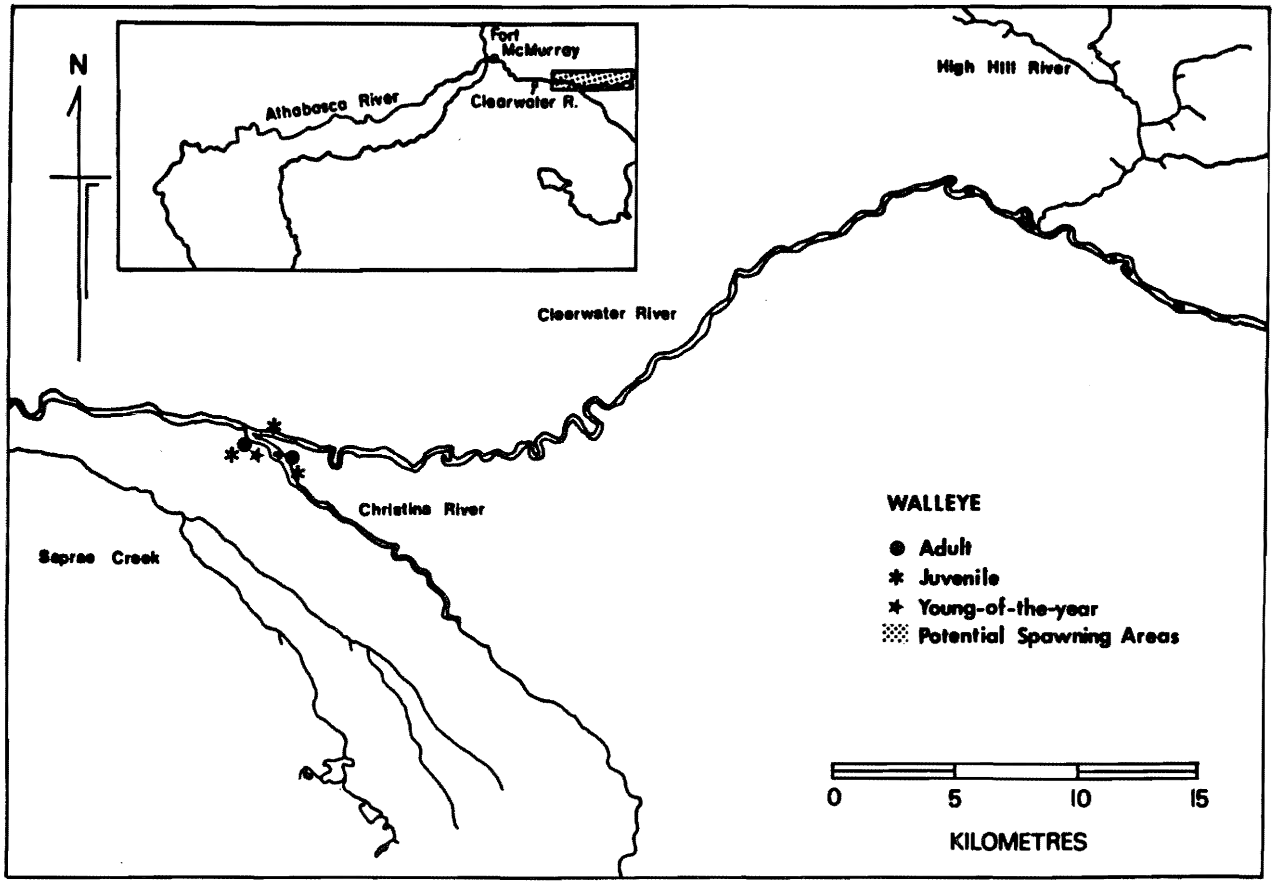


Figure 28. Concluded.

Table 22. Spawning condition of walleye from the Athabasca and Clearwater rivers, 28 April to 23 June 1978. N= number examined, G= green, R= ripe, SO= spawned-out.

| Date | MALES | | | | FEMALES | | | |
|---|---|---|---|---|---|---|---|---|
| | N | G | R | SO | N | G | R | SO |
| 28/4 | 1 | | 1 | | | | | |
| 05/5 | 1 | | 1 | | | | | |
| 13/5 | | | | | 1 | | | 1 |
| 15/5 | 6 | | 1 | 5 | | | | |
| 21/5 | 11 | | | 11 | | | | |
| 22/5 | 1 | | | 1 | | | | |
| 23/5 | | | | | 1 | | | 1 |
| 24/5 | 2 | | | 2 | | | | |
| 26/5 | 2 | | | 2 | | | | |
| 28/5 | 1 | | | 1 | 1 | | | 1 |
| 29/5 | 8 | | | 8 | 1 | | | 1 |
| 02/6 | 1 | | | 1 | | | | |
| 03/6 | 3 | | | 3 | | | | |
| 04/06 | 3 | | | 3 | 1 | | | 1 |
| 08/6 | 1 | | | 1 | | | | |
| 09/6 | | | | | 1 | | | 1 |
| 10/6 | 1 | | | 1 | | | | |
| 14/6 | | | | | 1 | | | 1 |
| 22/6 | 1 | | | 1 | | | | |
| 23/6 | 1 | | | 1 | | | | |
| Total | 44 | 0 | 3 | 41 | 7 | 0 | 0 | 7 |

spawning was completed by 13 May. The scarcity of mature females and relatively high temperatures at this time suggests, however, that spawning occurred much earlier, at least in that segment of the Athabasca River upstream of the Mountain Rapids. Water temperatures in the Athabasca River upstream of Mountain Rapids reached 10°C as early as 28 April, even though the Athabasca River downstream of the Mountain Rapids was still frozen.

*Spawning areas*. Because few walleye spawners were taken during the study, neither the location(s) of spawning areas nor the extent of spawning runs in the study area are known. Based on the distribution and relative abundance of walleye young-of-the-year, however, spawning appeared to be concentrated in the Athabasca River upstream of the Cascade Rapids. Evidently little spawning occurred in the Clearwater River. Catches of young-of-the-year in minnow seines ranged from 0.23 per metre shoreline seined in the Athabasca River upstream of the Cascade Rapids to 0.05 in the lower Athabasca River and 0.01 in the Clearwater River. The largest concentrations were located downstream of the Grand Rapids, Mountain Rapids, and the mouth of the Algar River (Figure 28).

4.2.6.3 Fry emergence. The seasonal pattern of abundance of walleye young-of-the-year is shown in Figure 11. Young-of-the-year were first taken on 5 June, downstream of the Mountain Rapids. Catches reached maximum densities on 17 June and then declined. Mean fork length for young-of-the-year sampled on 5 June was 14.1 ± 0.3 mm (2 SE, N=6) and 21.4 ± 0.8 mm (2 SE, N=37) 15 June.

4.2.6.4 Length-frequency. The length-frequency distribution of 103 walleye captured in the study area from late April to mid-June 1978 is presented in Figure 29. Walleye ranged in fork length from 85 to 580 mm with fish in the 325 to 499 mm range comprising over 90% of the total. Similar length-frequency distributions have been reported elsewhere in the Athabasca River within the AOSERP study area (McCart et al. 1977; Bond and Berry in prep.a,b; Jones et al. 1978).

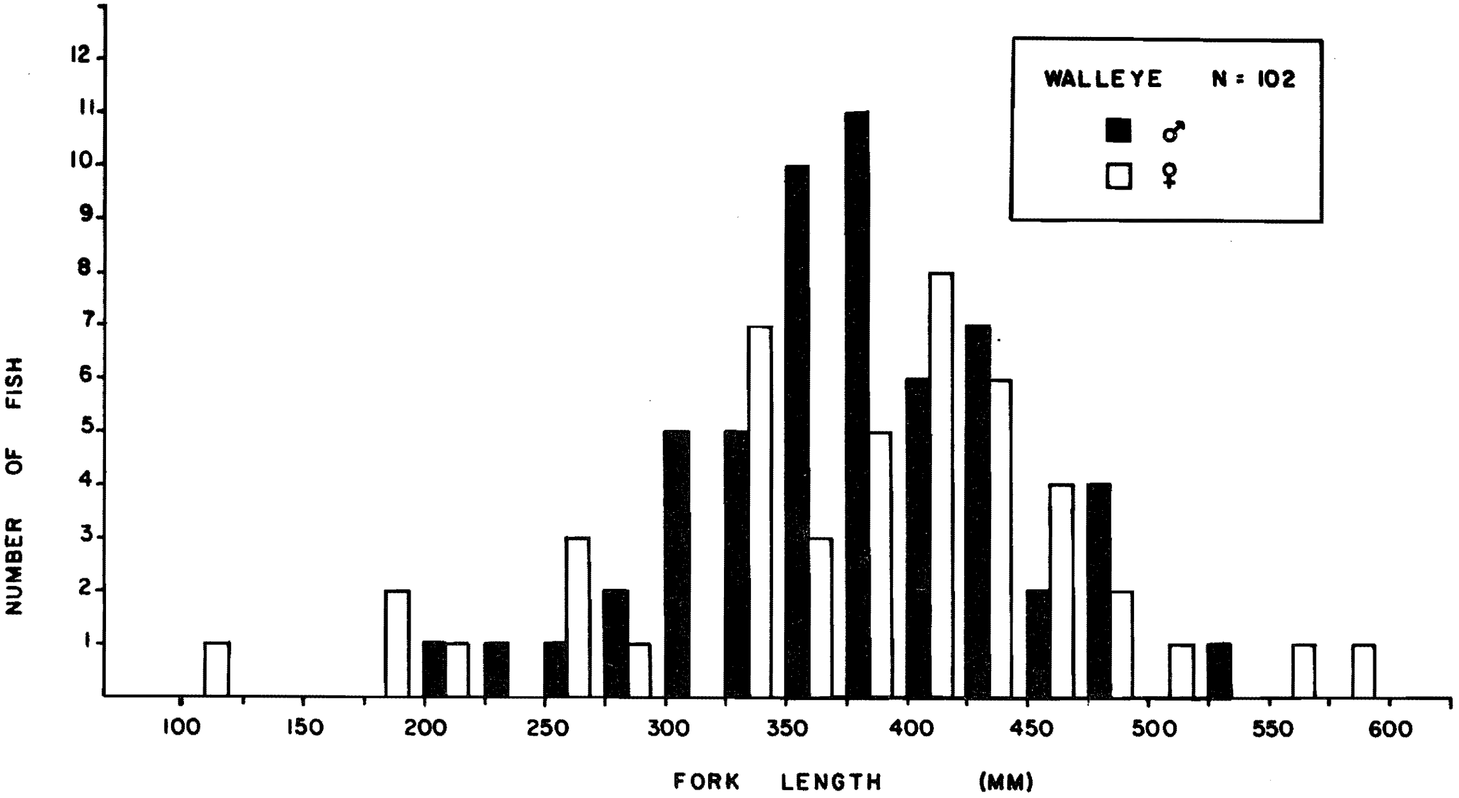


Figure 29. The length-frequency distribution of male and female walleye taken in the Athabasca and Clearwater rivers upstream of Fort McMurray, 28 April to 25 June 1978.

4.2.6.5 Age and growth. Age-length data for 100 walleye captured in the project study area are presented in Table 23. Ages were determined from scales.

Walleye in the study sample ranged in age from 2 to 13 years, and in fork length from 85 to 580 mm. Fish younger than six years were rare. The growth curve determined for the study population approximates that of the MacKay River, Alberta, population (Figure 30). The growth rate is slower, however, than that determined for several other AOSERP study area samples and two lake resident populations in Alberta.

4.2.6.6 Age at maturity. Age and sex were determined for 99 walleye captured in the project study area. The earliest maturing females and males in the study sample were age 5 and 6, respectively. In general, however, females matured much later than males. The presence of individuals with immature gonads in the older age classes (i.e., 12 years) may indicate that not all walleye in the study population spawn every year once maturity is reached. Elsewhere in the AOSERP study area, ages at first maturity of 3 to 4 years (Bond and Berry in prep.a,b) and 5 to 7 years (McCart et al. 1978; Jones et al. 1978) have been reported.

4.2.6.7 Sex ratios. Males outnumbered females (57% male, total N=99) in the sample of walleye from the study area but the difference was not significant ($X^2=0.96$, $P<0.05$).

Sex ratios favouring males (63 to 97%) are reported by other investigators in the AOSERP study area (McCart et al. 1977, 1978; Bond and Machniak 1979; Bond and Berry in prep.a; Jones et al. 1978). Bond and Berry (in prep.b), however, report a nearly balanced sex ratio for this species in the Peace-Athabasca River Delta.

4.2.6.8 Length-weight relationships. Length-weight regression formulae were determined separately for males and females:

Table 23. Age-length relationship with age-specific sex ratios and percent maturity for walleye taken from the present study area, 28 April to 25 June 1978.

| | Fork Length (mm) | | | | Males | | | Females | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | Mean | S.D. | S.E. | Range | N | % | % Mature | N | % | % Mature | Unsexed | Total |
| 2 | 85 | | | | 0 | | | 1 | 100 | 0 | 0 | 1 |
| 3 | 217.0 | 27.1 | 15.6 | 189-243 | 1 | 33 | 0 | 2 | 67 | 0 | 0 | 3 |
| 4 | 246.0 | 42.4 | 30.0 | 216-276 | 1 | 50 | 0 | 1 | 50 | 0 | 0 | 2 |
| 5 | 270.0 | 4.2 | 3.0 | 267-273 | 0 | 0 | | 2 | 100 | 0 | 0 | 2 |
| 6 | 359.2 | 69.4 | 23.1 | 253-466 | 5 | 56 | 40 | 4 | 44 | 25 | 0 | 9 |
| 7 | 361.9 | 75.1 | 23.8 | 270-481 | 7 | 70 | 71 | 3 | 30 | 0 | 0 | 10 |
| 8 | 359.0 | 40.6 | 12.9 | 308-428 | 5 | 50 | 60 | 5 | 50 | 0 | 0 | 10 |
| 9 | 379.9 | 32.8 | 7.2 | 319-436 | 13 | 62 | 85 | 8 | 38 | 0 | 0 | 21 |
| 10 | 391.9 | 45.1 | 12.5 | 328-477 | 9 | 69 | 89 | 4 | 31 | 25 | 0 | 13 |
| 11 | 430.0 | 37.8 | 11.4 | 368-491 | 5 | 45 | 100 | 6 | 55 | 17 | 0 | 11 |
| 12 | 425.1 | 59.2 | 17.9 | 325-512 | 5 | 50 | 80 | 5 | 50 | 40 | 1 | 11 |
| 13+ | 479.0 | 80.8 | 30.6 | 397-580 | 5 | 71 | 100 | 2 | 29 | 100 | 0 | 7 |
| Totals | | | | | 56 | 57 | 77 | 43 | 43 | 16 | 1 | 100 |

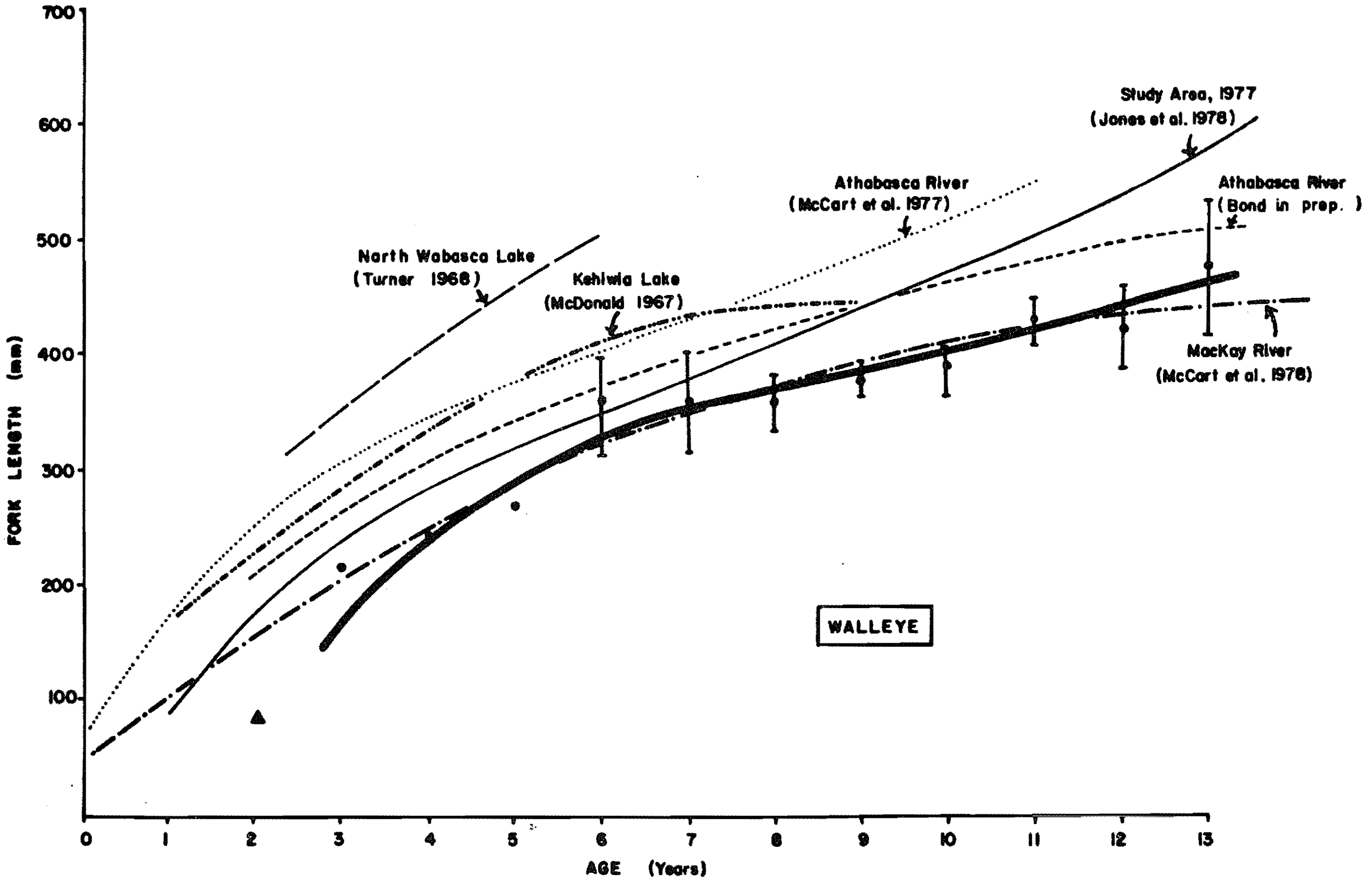


Figure 30. Comparison of growth rates of walleye collected in this study and walleye collected in six other studies in Alberta. Symbols for the samples taken in the present study are: points plus vertical bars= mean fork length ± one standard error; single points, mean fork lengths for age groups containing less than five fish; triangles= individual fork lengths.

males:

$\text{Log}_{10}$ Length (mm) = 3.23 $\text{Log}_{10}$ Weight (g) - 5.59

$r=0.99, P<0.05, N=56$

females:

$\text{Log}_{10}$ Length (mm) = 2.26 $\text{Log}_{10}$ Weight (g) - 3.09

$r=0.95, P<0.05, N=43$

These relationships were compared by analysis of covariance and were found to differ significantly in slopes ($F=37.49$, $P<0.05$) but not in intercept ($F=0.84$, $P>0.05$).

4.2.6.9 Food habits. Of 97 walleye examined, 68% had empty stomachs. Fish (flathead chub, sculpins) and unidentified fish remains occurred most frequently in those stomachs which contained food.

### 4.2.7 Other Species

Other species are those for which few or no individuals were retained for detailed analysis. These include Dolly Varden, lake whitefish, mountain whitefish, Arctic grayling, longnose dace, lake chub, pearl dace, finescale dace, fathead minnow, emerald shiner, spottail shiner, brassy minnow, burbot, trout-perch, brook stickleback, yellow perch, slimy sculpin, and spoonhead sculpin. In what follows, various aspects of their distribution, movements, and life history are discussed.

4.2.7.1 Dolly Varden. A single Dolly Varden juvenile, 265 mm fork length, was gillnetted upstream of the Brule Rapids (Site 3) on 21 May. It had probably drifted downstream from the headwaters of the Athabasca River where the species is native (Paetz and Nelson 1970). Dolly Varden in small numbers have been reported elsewhere in the AOSERP study area from the Athabasca (Bond and Berry in prep.b), Muskeg (Bond and Machniak 1979), and Steepbank rivers (Machniak and Bond 1979).

4.2.7.2 Lake whitefish. Two localities in the Athabasca River, one downstream of Cascade and one downstream of Mountain Rapids, are major spawning grounds for lake whitefish which migrate upstream out of Lake Athabasca (Jones et al. 1978). However, few recently emerged young-of-the-year were present when the study commenced on 28 April. The Athabasca River upstream of the Mountain Rapids was open for at least a week before break-up downstream and water temperatures were high (10$^{o}$C) by 28 April. It is likely that these high temperatures, in the areas of heaviest egg deposition, stimulated emergence and downstream movement.

From 30 May to 24 June, 20 lake whitefish young-of-the-year, ranging from 26 to 45 mm fork length, were collected in the present study area. Of these, only two were taken in the Athabasca River downstream of Mountain Rapids and none were taken upstream of the Mountain Rapids. In the Clearwater River, fry (N=18) were taken as far upstream as the mouth of the Christina River, indicating that at least some whitefish spawning occurs in these areas.

A total of seven larger whitefish were sampled in beach seines and gillnets during the study, all of them in the Clearwater and Christina rivers. Of these, four were dissected and found to be immature, ranging from 298 to 354 mm in length and 5 to 7 years in age.

4.2.7.3 Mountain whitefish. Four mountain whitefish were taken in beach seines and gillnets: in the Athabasca River downstream of the Cascade Rapids (24 May), in the Athabasca River near Clark Creek (6 May), and in the mouth of the Christina River (5 May).

Young-of-the-year (N=104) were sampled as early as 30 April although the majority were taken between 19 June and 17 June (Figure 31). The major concentrations of young-of-the-year were located at the mouths of tributary streams in the Athabasca River upstream of the Cascade Rapids. Catch per metre shoreline seined was considerably greater in this area (0.15) than in the Athabasca River downstream of the Cascade Rapids (0.01). One young-of-the-year was collected at the mouth of the Clearwater River, 17 June.

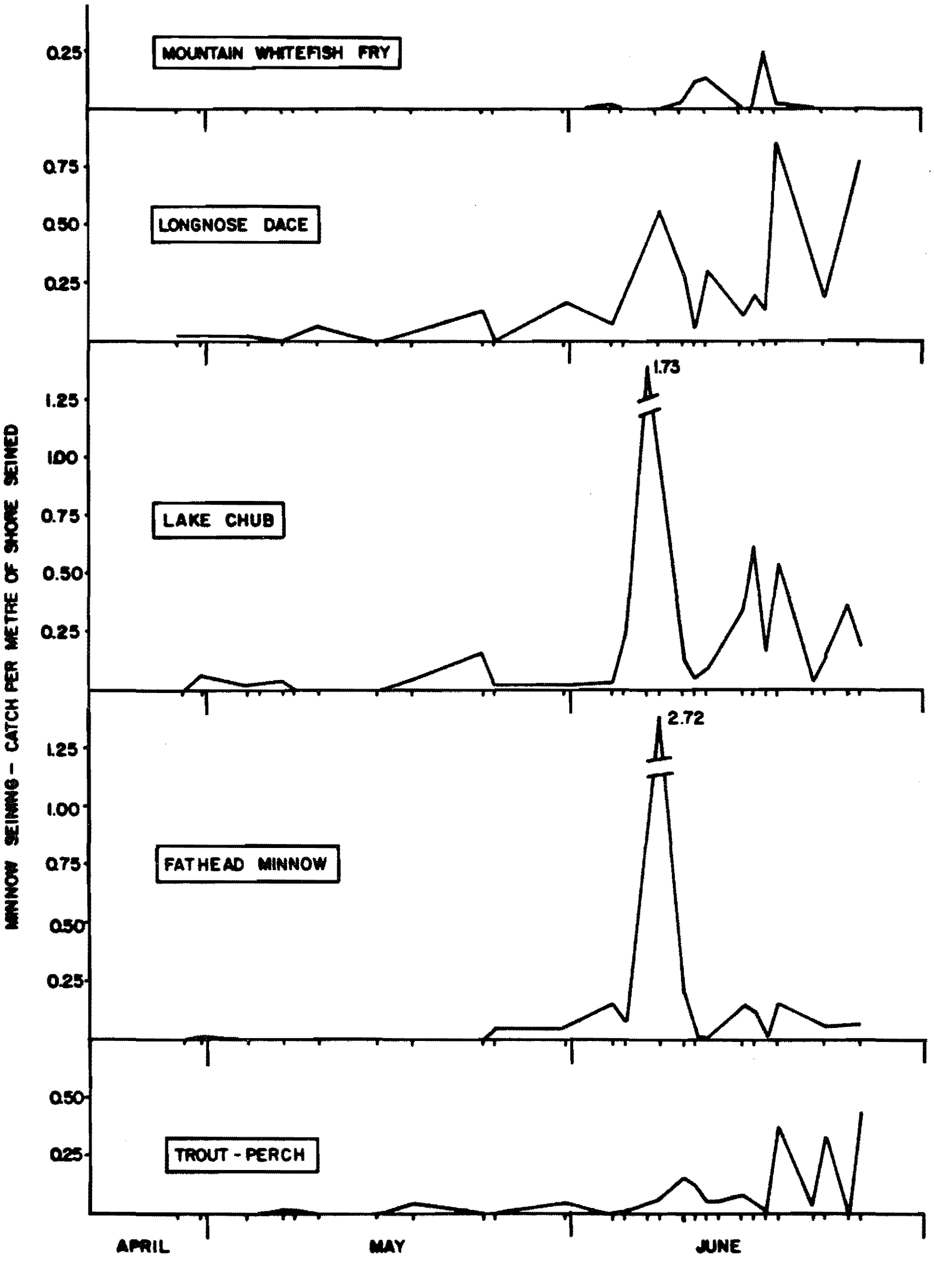


Figure 31. Seasonal patterns of catch per metre of shoreline seined for mountain whitefish fry, longnose dace, lake chub, fathead minnow, and trout-perch in the Athabasca and Clearwater rivers, 28 April to 25 June 1978. Sampling times are indicated by short vertical bars on the horizontal axis.

4.2.7.4 Arctic grayling. Jones et al. (1978) showed that grayling do not spend much time in the present study area during the open water period. They found that catches in the Athabasca and Clearwater rivers did not increase until late fall when both water temperatures and levels had dropped. Similar downstream migrations, presumably to overwintering areas, have been described in the Muskeg (Bond and Machniak 1979) and Steepbank rivers (Machniak and Bond 1979).

Only three Arctic grayling (excluding young-of-the-year) were captured in the project study area: one at the mouth of the Clearwater River (3 June) as well as one upstream and one downstream of the Grand Rapids on the Athabasca River (4 June). Grayling fry (N=8) were taken between 8 June and 18 June at several locations in the Athabasca River downstream of Mountain Rapids.

4.2.7.5 Longnose dace. During the study period, longnose dace were the third most abundant species taken in minnow seines (15.1%) and overall (9.9%). Locations where longnose dace were captured are shown in Figure 32. Catches were greatest in the Athabasca River downstream of the Cascades (0.25 fish per metre shoreline seined) followed by the Clearwater (0.17 fish per metre) and upper Athabasca (0.10 per metre) rivers. The seasonal pattern of abundance (Figure 31) shows a substantial increase in June, suggesting a possible upstream migration from overwintering grounds located elsewhere in the AOSERP study area.

4.2.7.6 Lake chub. During the study period, 721 lake chub, constituting 9.1% of the total catch, were taken. Figure 32 shows capture locations. The highest densities were recorded in the Clearwater River, near the mouths of the Hangingstone and Christina rivers, and the lowest densities in the Athabasca River upstream of the Cascade Rapids. Catches per metre shoreline seined ranged from 0.28 in the Clearwater River to 0.21 in the lower Athabasca River and 0.15 in the upper Athabasca River.

The seasonal pattern of abundance (Figure 31) shows a

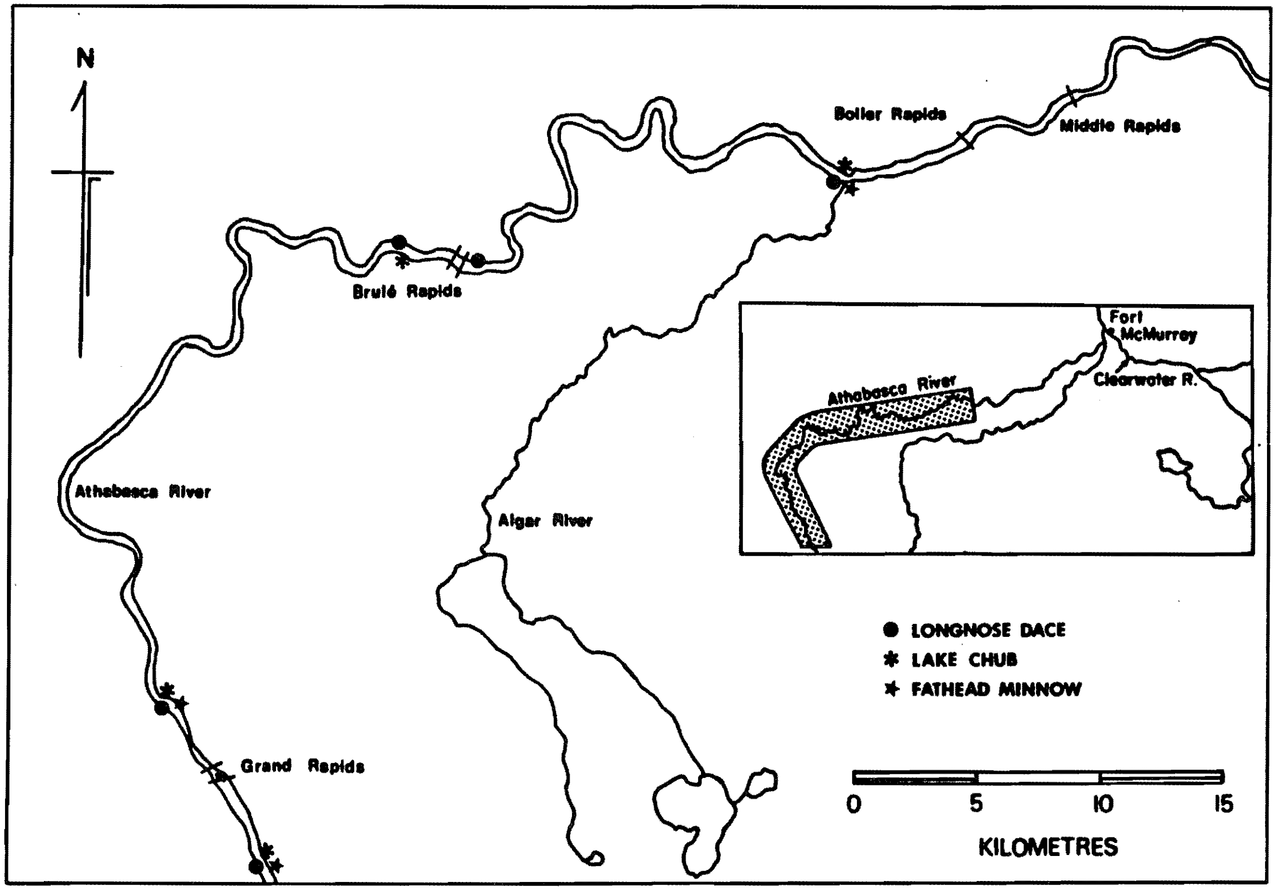


Figure 32. Locations where longnose dace, lake chub, and fathead minnows were taken in the present study area. (Continued).

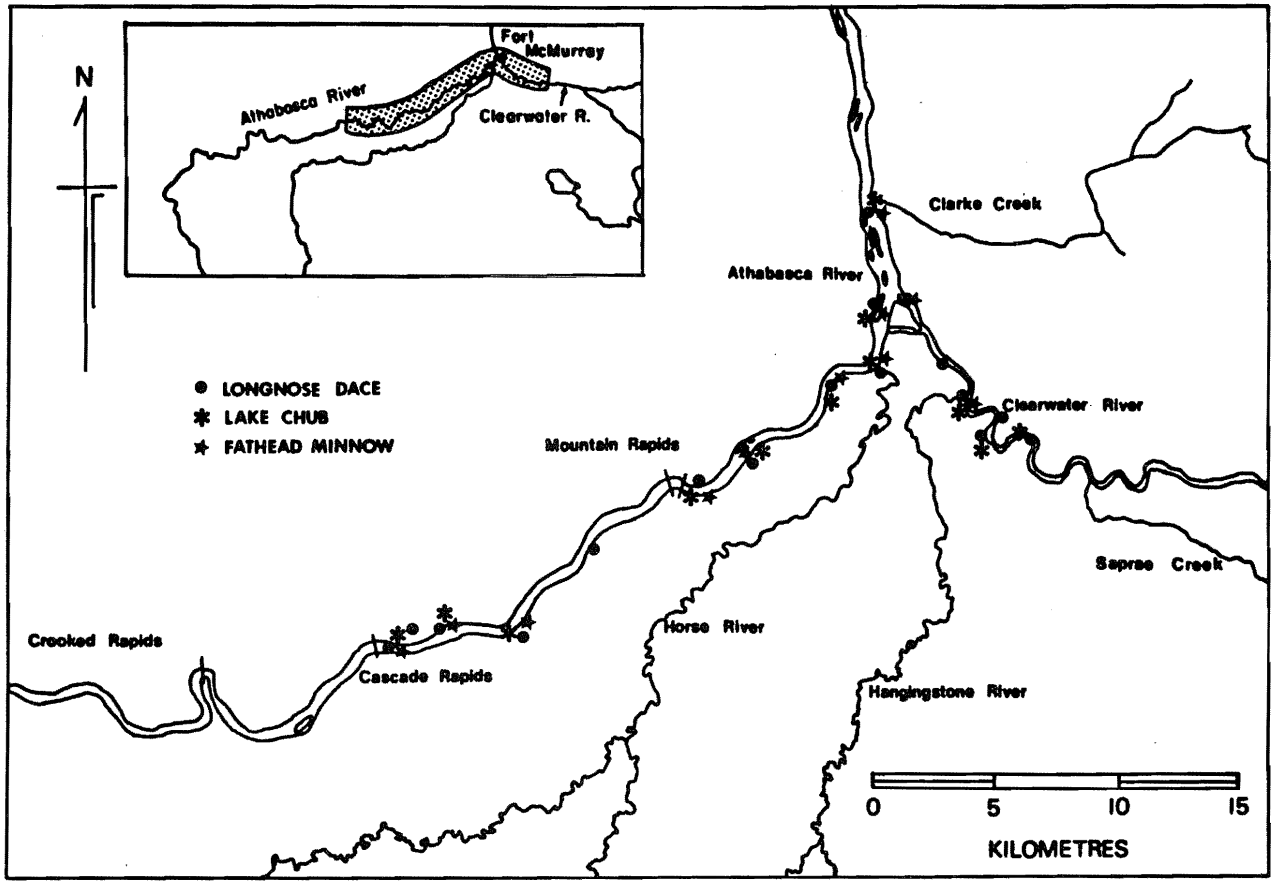


Figure 32. Continued.

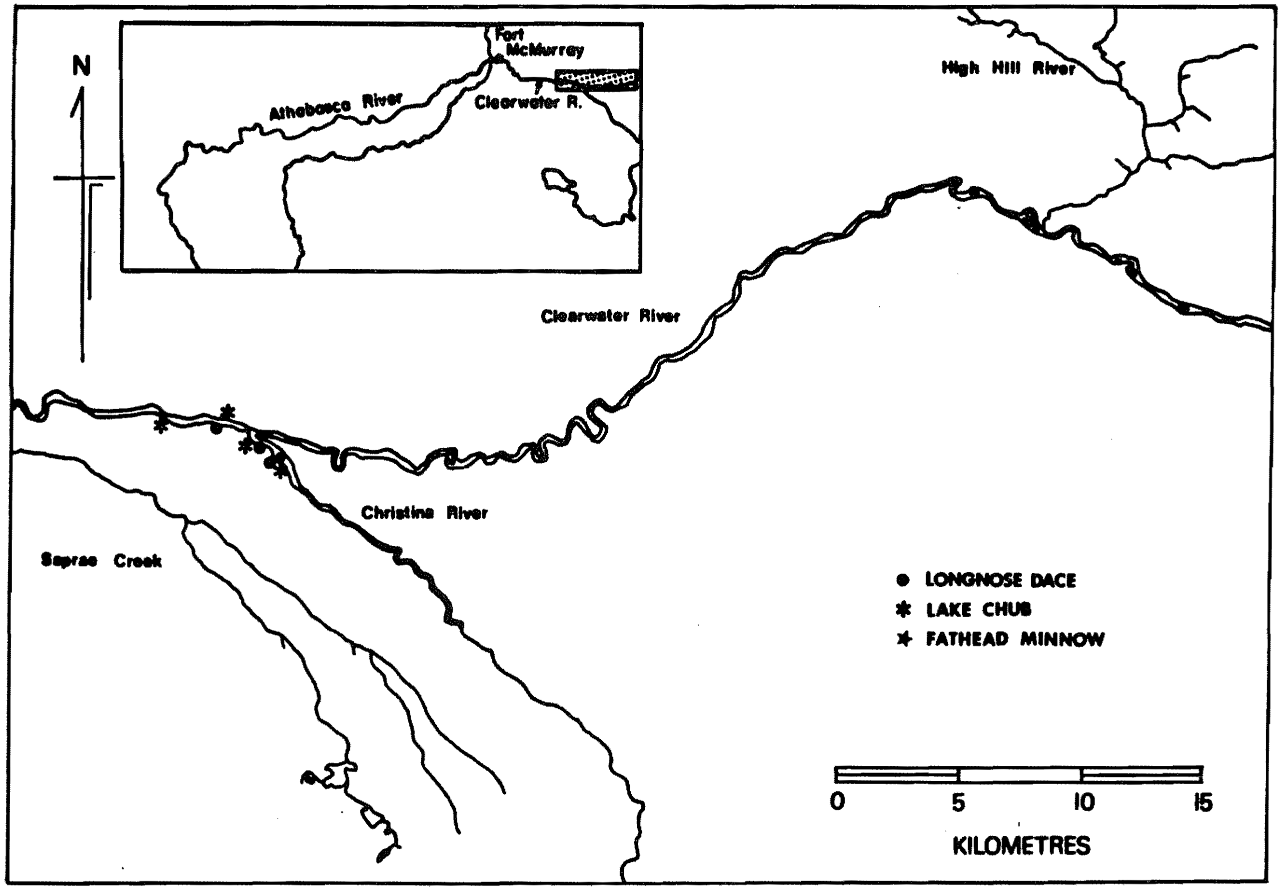


Figure 32. Concluded.

pattern similar to that of longnose dace. Densities were low in late April and May but rose sharply in June.

4.2.7.7 Pearl dace. Three pearl dace were captured in minnow seines downstream of the Mountain Rapids on 10 June, in the Athabasca River near Clark Creek on 25 June, and at the mouth of the Christina River on 21 June.

4.2.7.8 Finescale dace. Three finescale dace were taken: one in the upper Athabasca River at the mouth of the Algar River on 4 June and two at the mouth of the Christina River on 5 May and 24 June.

4.2.7.9 Fathead minnow. A total of 336 fathead minnows, constituting 4.2% of the total catch, was sampled during the study. Figure 32 shows the locations where fathead minnows were taken. Most were collected in the Athabasca River downstream of the Cascade Rapids with the highest concentrations downstream of the Mountain Rapids and at the mouth of the Horse River. A few (N=5) fathead minnows were captured in the Clearwater River near its mouth. Catches per metre shoreline seined ranged from 0.12 in the lower Athabasca River to 0.08 in the upper Athabasca River and 0.1 in the Clearwater River.

As with longnose dace and lake chub, fathead minnow densities were lowest in late April and most of May but peaked suddenly in early June (Figure 31), suggesting a rapid migration from overwintering areas located elsewhere in the AOSERP study area.

4.2.7.10 Emerald shiner. From 4 June to 25 June, 52 emerald shiners, representing 1.0% of the total catch in minnow seines, were collected in the Athabasca and Clearwater rivers. Locations where emerald shiners were taken are shown in Figure 33. Catches per metre shoreline seined ranged from 0.04 in the Athabasca upstream of the Cascade Rapids to 0.01 in the lower Athabasca and Clearwater rivers.

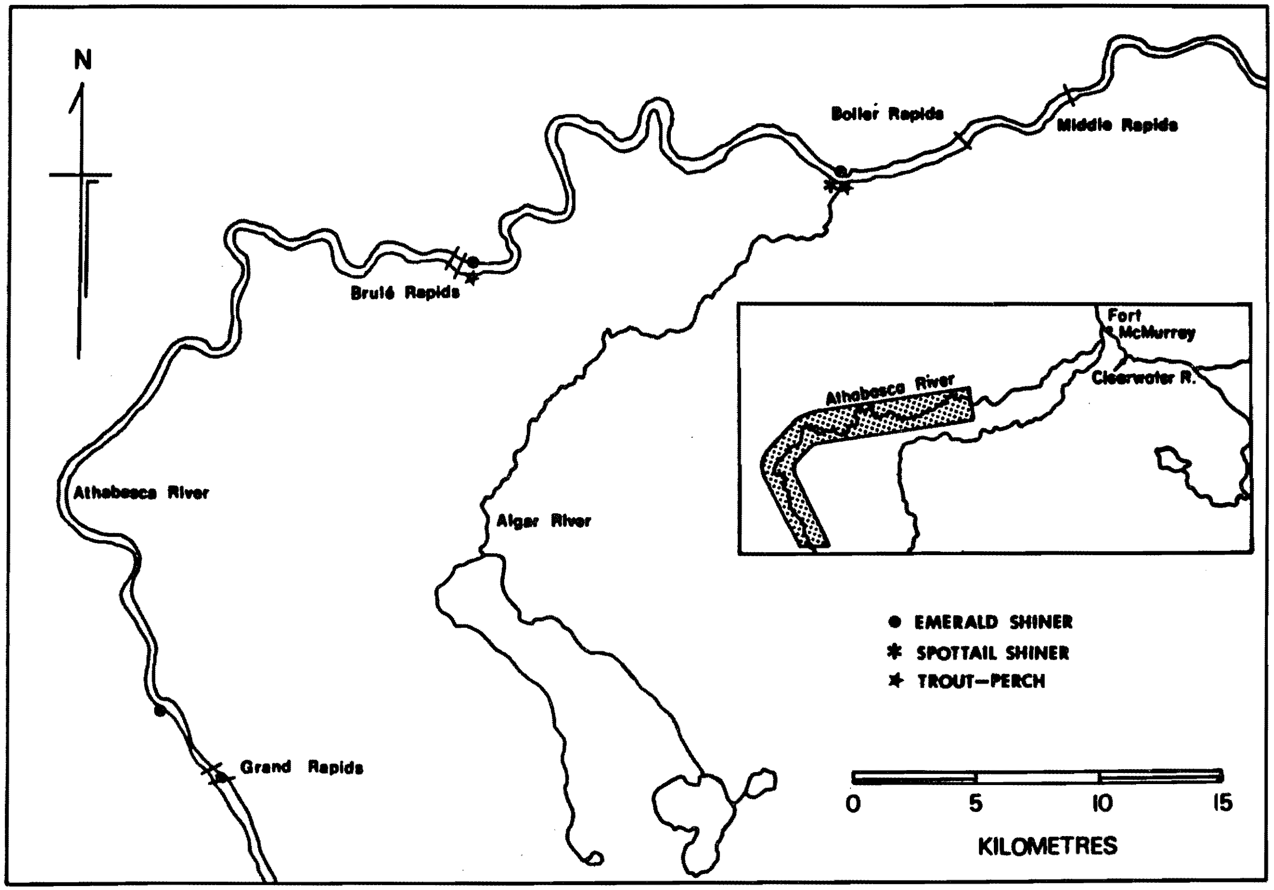


Figure 33. Locations where emerald shiner, spottail shiner, and trout-perch were taken in the present study area. (Continued.

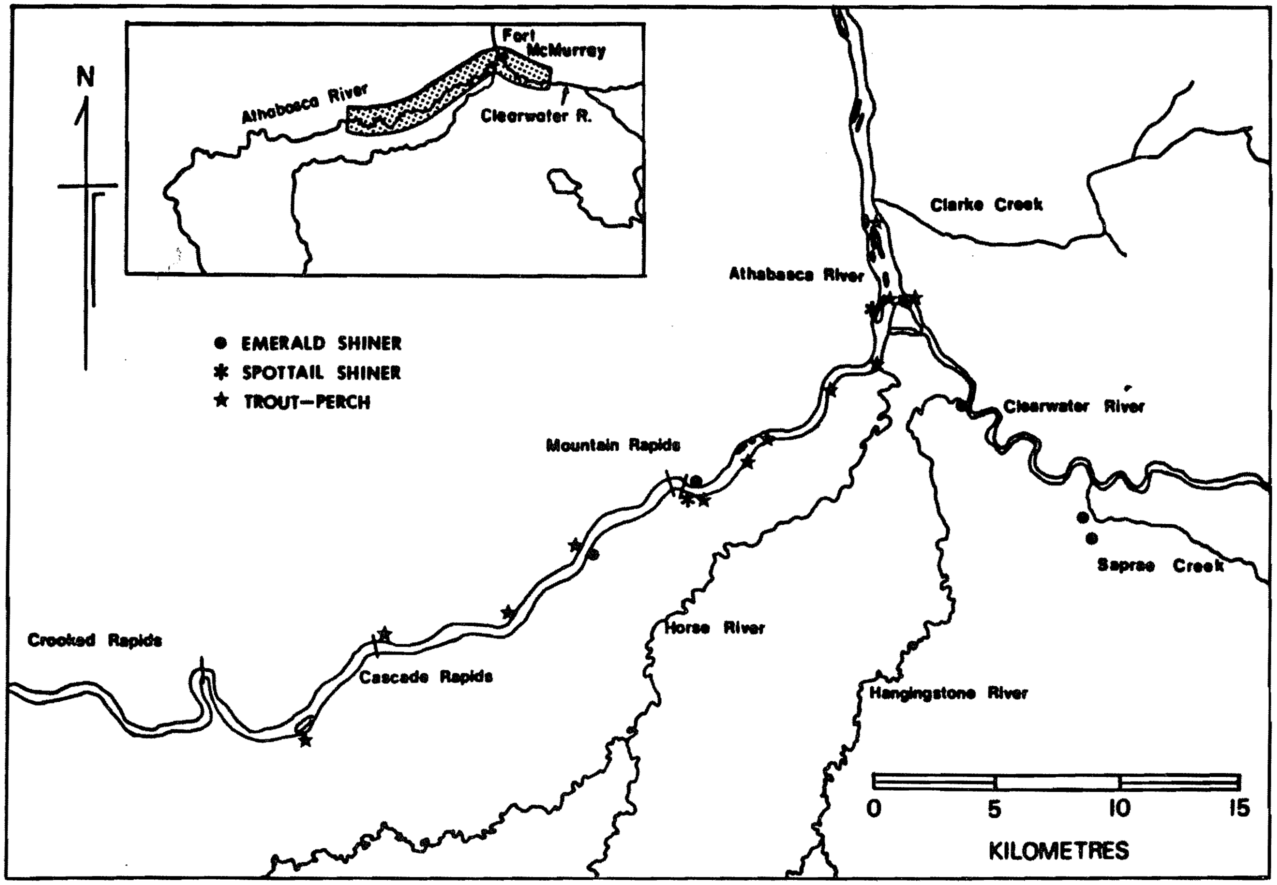


Figure 33. Continued.

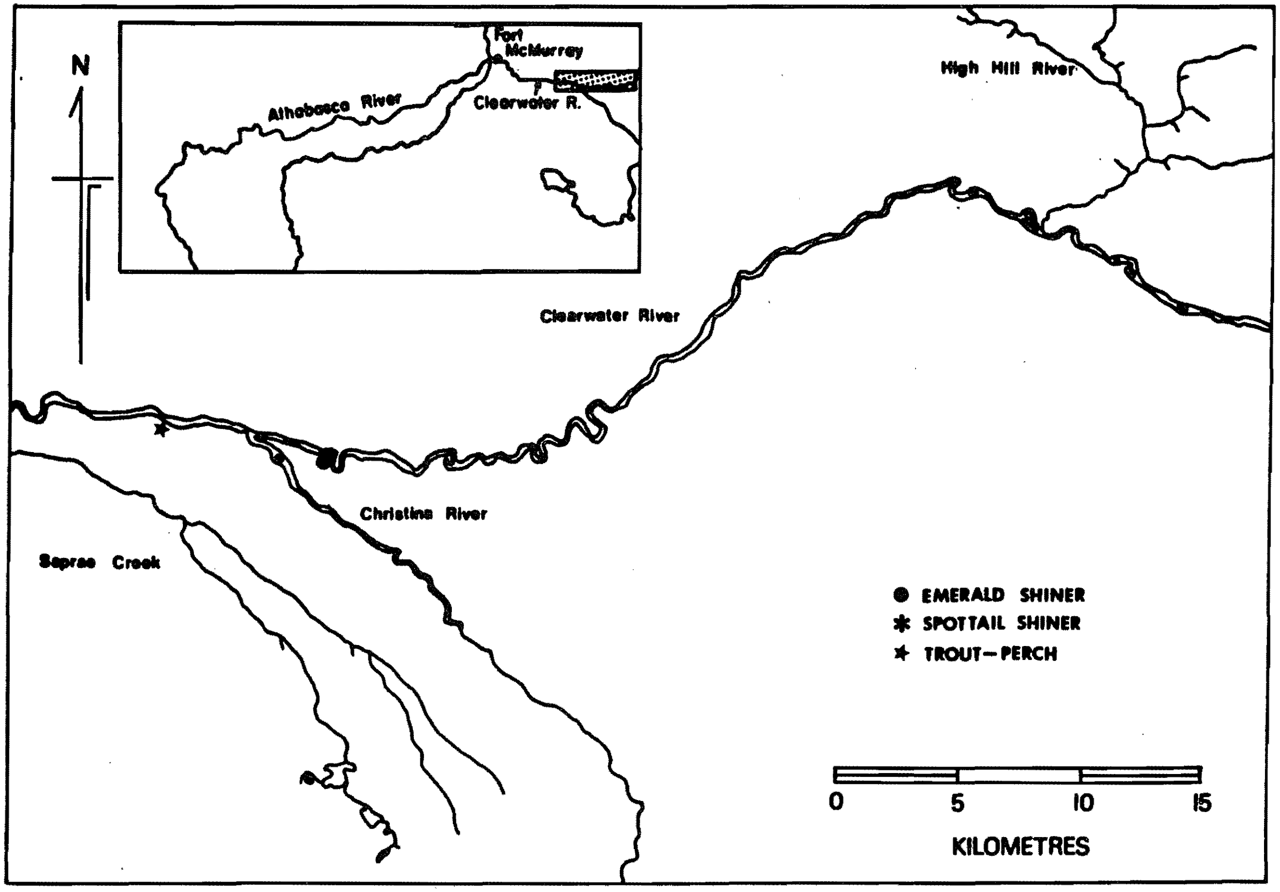


Figure 33. Concluded.

4.2.7.11 Spottail shiners. A total of 40 spottail shiners were captured between 11 and 25 June. Their distribution (Figure 33) largely overlapped the distribution of emerald shiners. Catches per metre shoreline seined ranged from 0.02 in the upper Athabasca River to 0.01 in the lower Athabasca. One spottail shiner was captured at the mouth of the Clearwater River.

4.2.7.12 Brassy minnow. Bond and Berry (in prep.a) report collecting brassy minnows in the mainstem of the Athabasca River downstream of Fort McMurray. During the course of this study, six brassy minnows were collected in the Athabasca River upstream and downstream of Brule Rapids, at the mouth of the Algar River, and just downstream of the Mountain Rapids. None was collected in the Clearwater River although they have been reported from one other tributary of the Athabasca River, the House River (Bishop 1975).

4.2.7.13 Burbot. A total of 19 adult and juvenile burbot was sampled in beach seines and gillnets, mainly from the Athabasca River. The catch data suggest that there may have been a greater density of burbot in the Athabasca River upstream (0.04 fish per hour) than downstream of the Cascade Rapids (0.02 fish per hour). Because of the low and sporadic catches throughout the study period, however, no definite conclusions can be drawn regarding the relative distribution of burbot.

Burbot young-of-the-year were abundant in shallow, weedy side channels of the Clearwater River upstream of its junction with the Christina River. This area has been previously described in this report as a major spawning area for northern pike. The presence of burbot young-of-the-year together with young-of-the-year northern pike suggest that the spawning areas for the two species overlap considerably. Between 13 and 24 June, 63 burbot young-of-the-year were taken in the Clearwater River, 56 of them upstream of the Christina. Catches of young-of-the-year burbot in the latter area averaged 1.5 fish per metre of shore seined compared to 0.01 downstream.

Figure 34 shows the locations where young-of-the-year and older burbot were collected as well as probable spawning areas for burbot in the present study area.

4.2.7.14 Trout-perch. From 28 April to 25 June, 194 trout-perch, constituting 2.5% of the total catch, were sampled, most of these in the Athabasca River downstream of Cascade Rapids. Relatively few trout-perch were sampled in the Athabasca River upstream of the Cascades or in the Clearwater River. Catches of trout-perch per metre of shoreline seined ranged from 0.10 in the lower Athabasca to 0.02 in the upper Athabasca and Clearwater rivers. Figure 33 shows the location where trout-perch were taken.

The seasonal pattern of abundance was similar to those se described for longnose dace, lake chub, and fathead minnow (Figure 31). Catches were low throughout most of the study period but generally increased in late June.

4.2.7.15 Brook stickleback. Two brook sticklebacks were captured on the Clearwater River at Site 24 on 21 June.

4.2.7.16 Yellow perch. Four small, juvenile yellow perch were collected at the mouth of the Clearwater River (25 June) and in the Athabasca River near the mouth of Conn Creek.

4.2.7.17 Slimy sculpin. Figure 35 shows the locations where slimy sculpins were taken. Of 24 slimy sculpins collected during the study period, 19 were captured in the Athabasca River downstream of the Cascade Rapids while five were sampled from the Clearwater River. No slimy sculpins were captured in the Athabasca River upstream of the Cascade Rapids.

4.2.7.18 Spoonhead sculpin. Figure 35 shows the locations where a total of 14 spoonhead sculpins was taken in the present study area. They were captured in the Athabasca River, from Fort McMurray

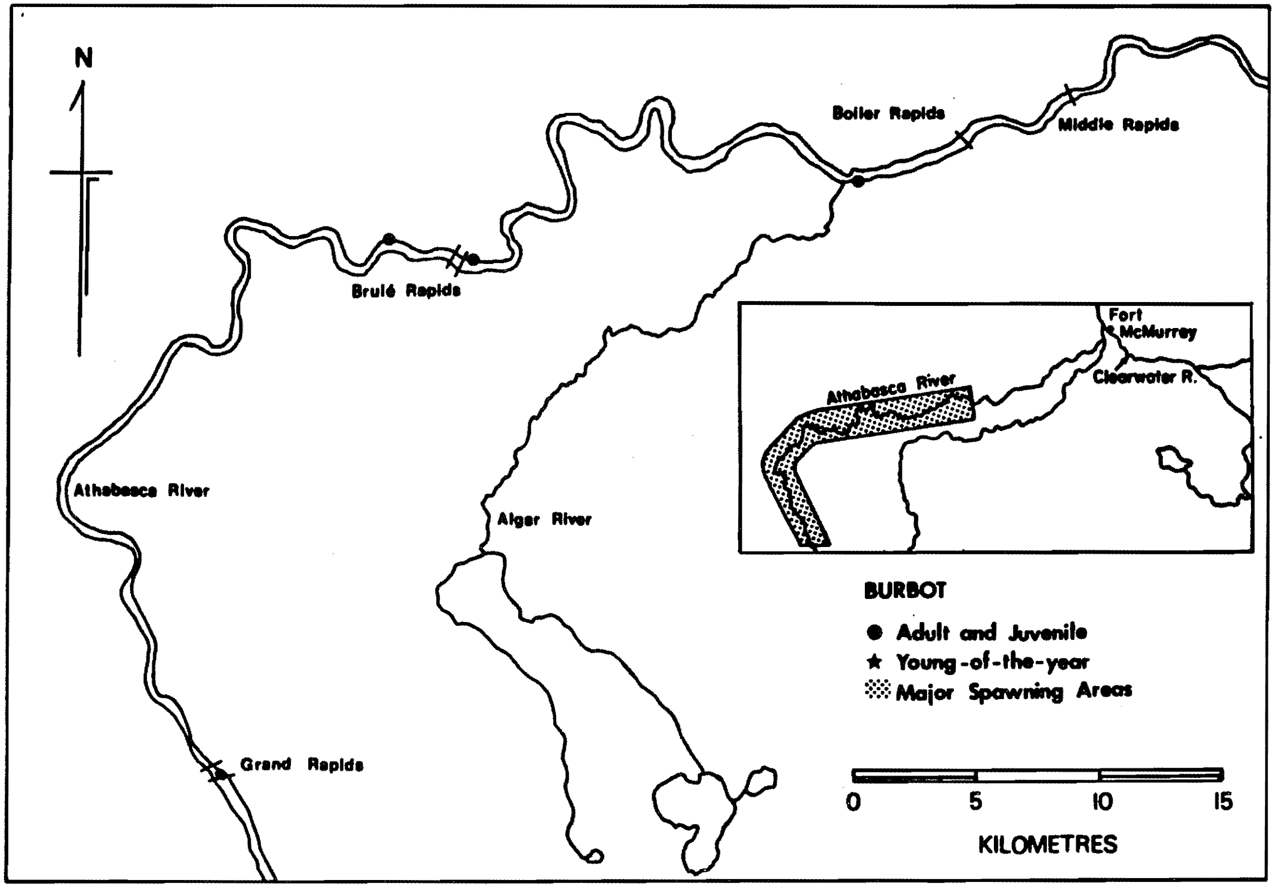


Figure 34. Locations where young-of-the-year and older burbot were taken in the present study area. Major spawning areas are also indicated. (Continued).

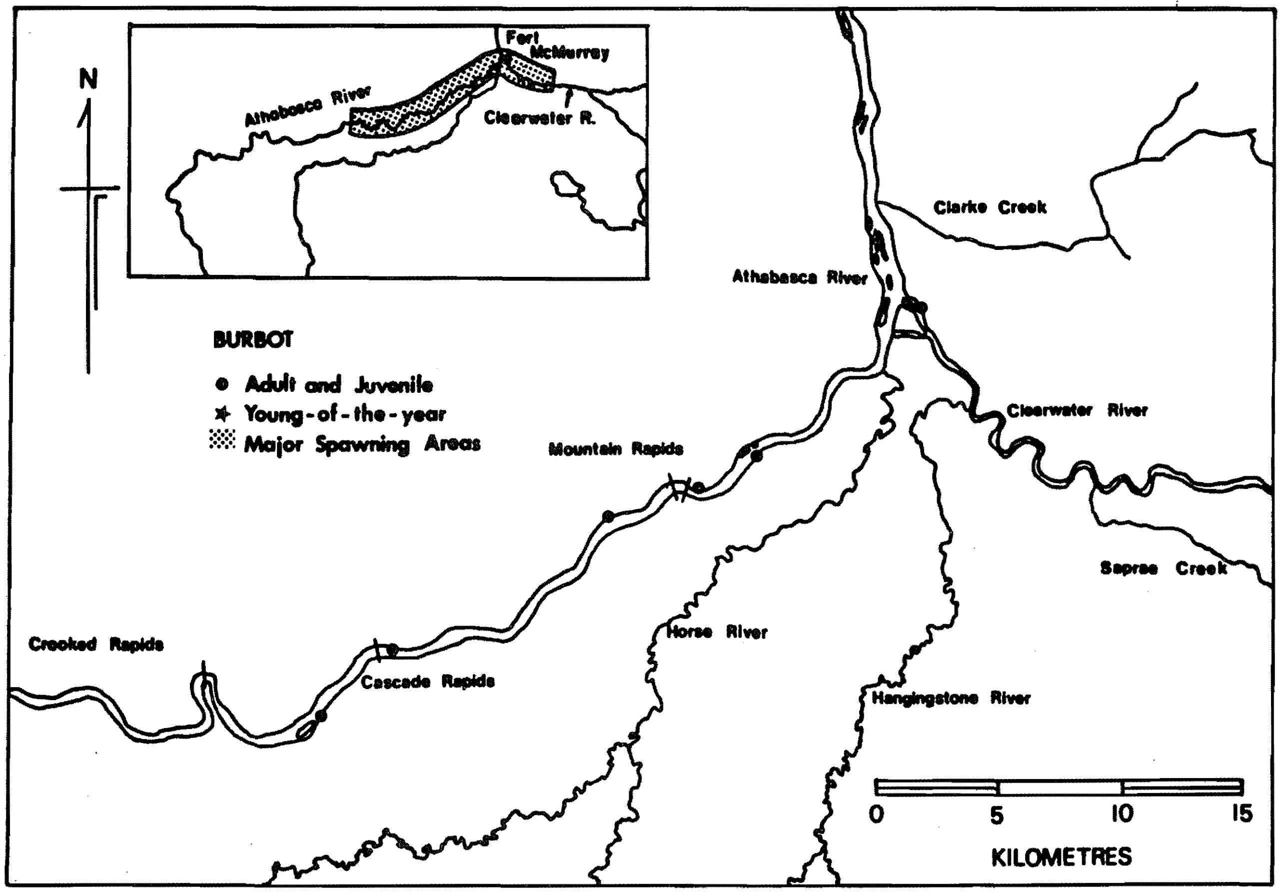
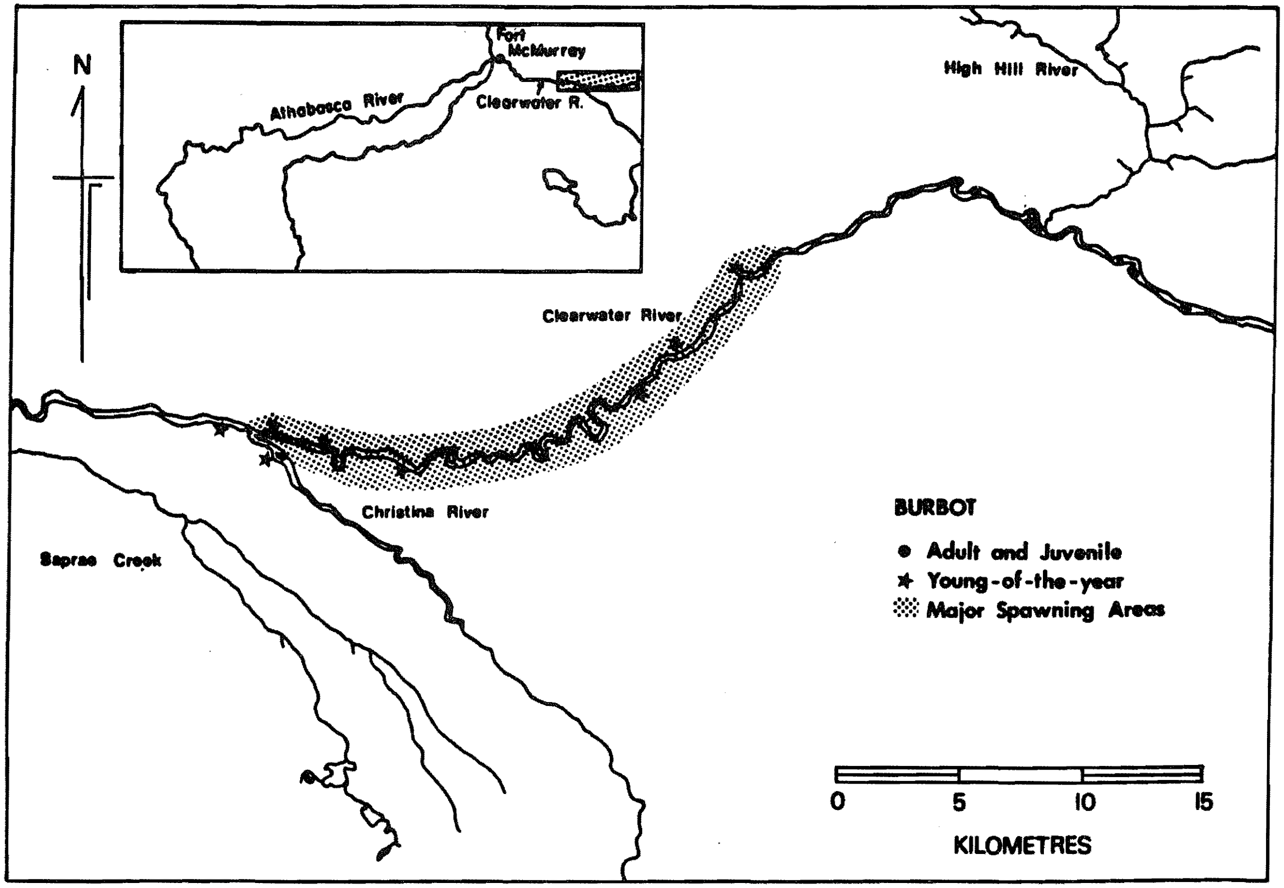


Figure 34. Continued.



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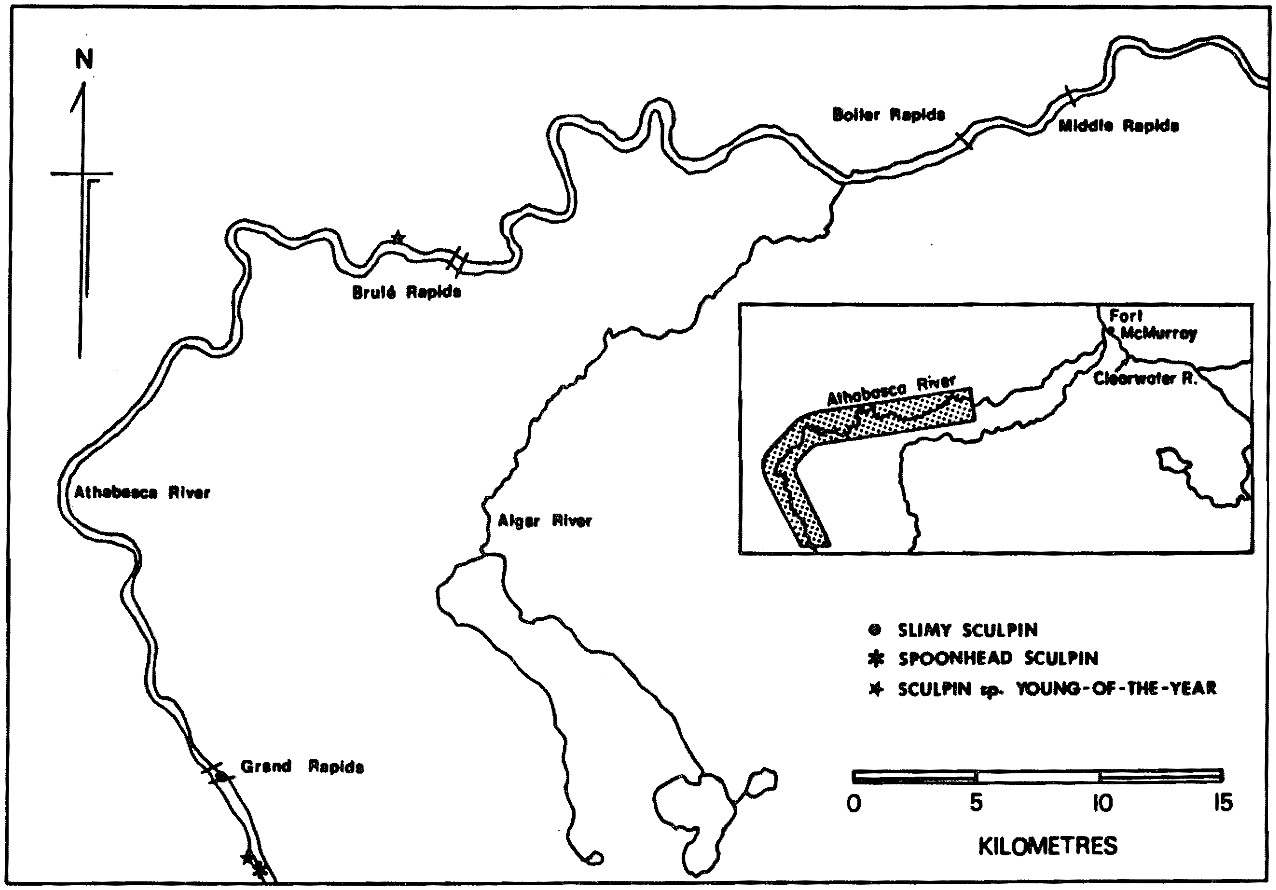

Figure 35. Locations where slimy sculpin, spoonhead sculpin, and unidentified sculpin young-of-the-year were taken in the present study area. (Continued).

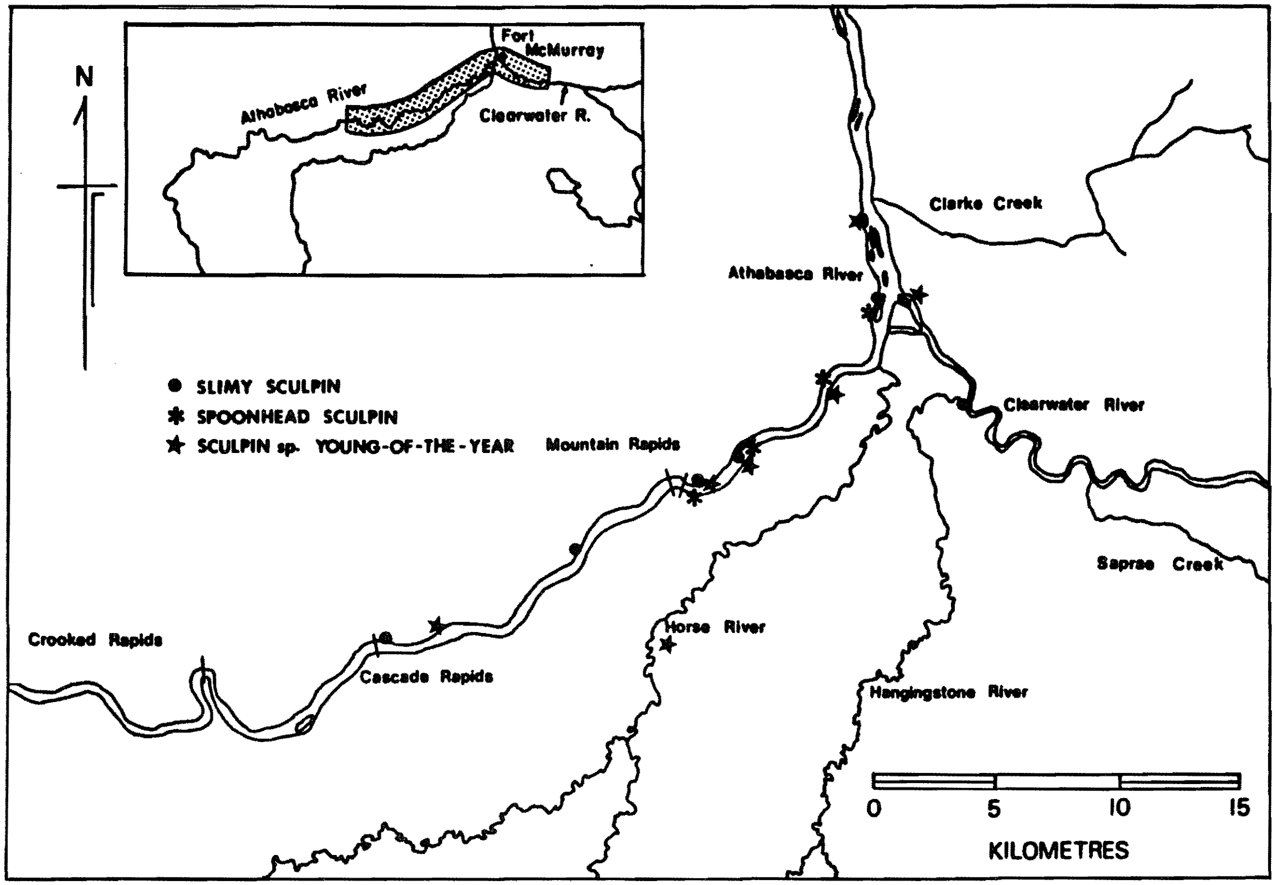

Figure 35. Continued.

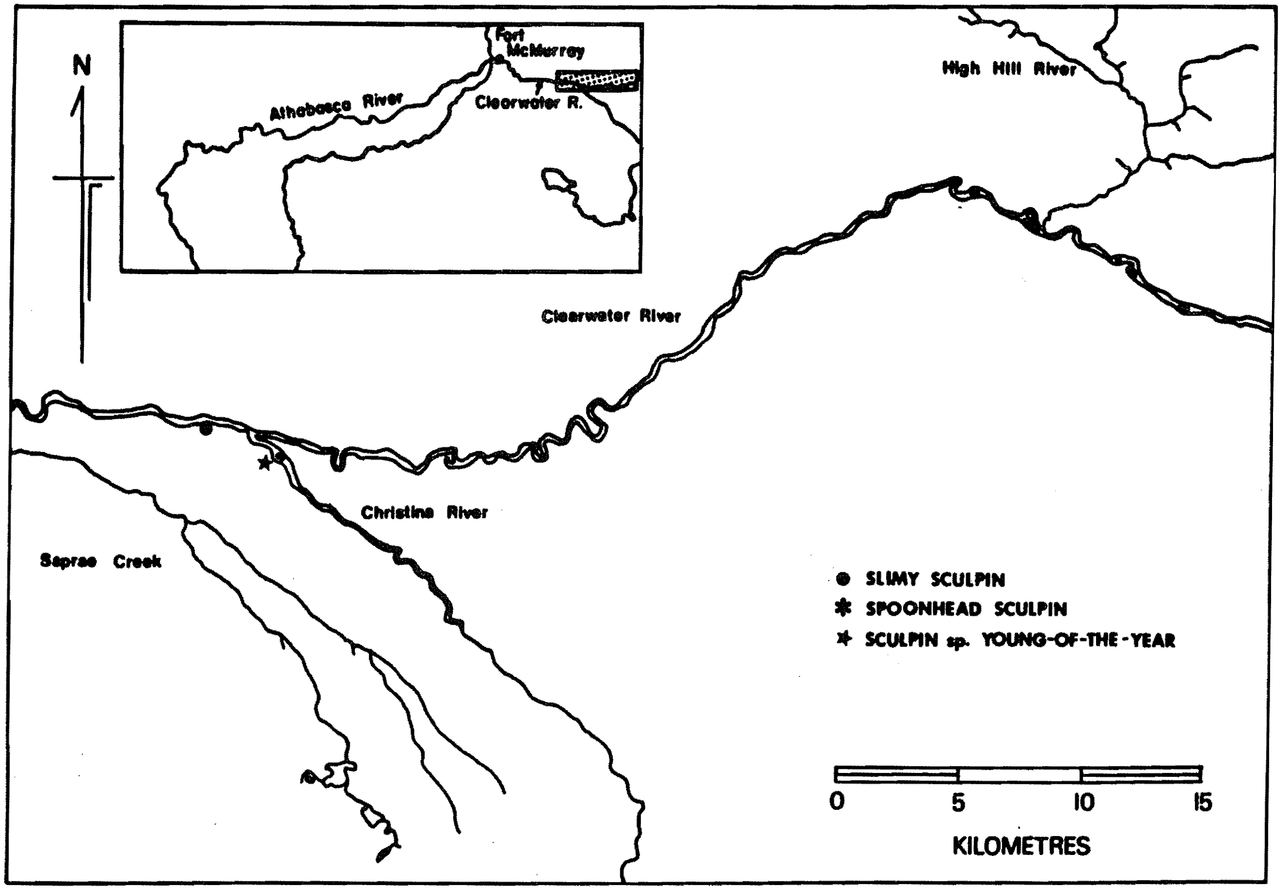

Figure 35. Concluded.

upstream to above the Grand Rapids, but were not taken in the Clearwater River.

## 5.0 GENERAL DISCUSSION AND SUMMARY

The chief objectives of this study were to determine what major spring spawning fish species utilize the Athabasca and Clearwater rivers upstream of Fort McMurray and, as far as possible, to locate and describe their spawning grounds and to describe the timing of spawning, hatching, and emergence.

These objectives were approximated for longnose suckers only. It was determined that the Athabasca River from Fort McMurray upstream to the Cascade Rapids is critical spawning habitat for large numbers of longnose suckers that presumably migrate upstream from the Peace-Athabasca Delta and Lake Athabasca. The number of longnose suckers marked and then recaptured during this study was too small to estimate the size of the spawning population; however, the number is likely to be in the hundreds of thousands.

It is unlikely that any significant numbers of longnose suckers migrating upstream from the lower Athabasca River manage to get by the Cascade Rapids which also appear to be major barriers for several other fish species. Large numbers of fall spawning lake whitefish, for example, migrate as far upstream as the Cascade Rapids but no farther (Jones et al. 1978). Tripp and Tsui (in prep.) also show a dramatic drop in goldeye and walleye gillnet catches upstream of the Cascade Rapids compared with catches downstream of the Cascade Rapids.

Longnose suckers taken upstream of the Cascade Rapids are considered distinct from those taken downstream of the Cascade Rapids largely on the basis of different age-length relationships. Indirect evidence from the distribution of recently emerged young-of-the-year in this area suggests that spawning occurs in the mainstem Athabasca. However, they probably spawn in various tributaries of the upper Athabasca River as well.

There is probably very little longnose sucker spawning in the Clearwater River, within the AOSERP study area. Sucker young-of-the-year rearing in the lower reaches of the Clearwater River is probably the result of downstream movements from spawning areas located upstream, such as the Christina River (Tripp and Tsui in prep.)

In 1978, longnose suckers spawned in the Athabasca River from 10 May to 23 May, peaking on 15 May. After spawning, spent fish quickly left the study area, presumably to feeding and overwintering areas located farther downstream. Young-of-the-year emerged around 1 June in the Athabasca River and were quickly carried downstream by the current. Large numbers of young-of-the-year remained in the Clearwater River where current speeds are considerably slower than those in the Athabasca River.

The spawning period, major spawning areas, and size of the spawning population for walleye in the Athabasca and Clearwater rivers upstream of Fort McMurray are still unknown. Walleye catches were low throughout the study period and none were taken in spawning condition. Possibly, walleye moved upstream, spawned, and then left the study area before spring break-up was completed. Young-of-the-year walleye were captured as early as 5 June 1978 at various locations from the Mountain Rapids upstream to the Grand Rapids. They were, however, not abundant. None was taken in the Clearwater River.

It is possible that 1978 was an abnormal year during which no major walleye spawning run occurred, since in most years, walleye are apparently much more abundant. During this study, angling success was extremely low near Fort McMurray in areas which, in the past, have always been an excellent fishing area according to personal interviews with Alberta Fish and Wildlife Officers and many residents of Fort McMurray.

Spring break-up on the Athabasca River at Fort McMurray was delayed because of ice jams extending upstream as far as the Mountain Rapids. The resulting drop in water temperatures from 10°C above the Mountain Rapids to 0°C downstream of the Mountain Rapids may have curtailed walleye spawning. Walleye normally spawn at temperatures ranging from 6.7 to 8.9°C (Scott and Crossman 1973). In addition, ice jamming at the Mountain Rapids may have prevented further upstream movements through a combination of reduced swimming abilities at low water temperatures (Jones et al.

1974) and increased flow rates.

The weedy side channels, cut-offs, and backwaters along the Clearwater River upstream of its confluence with the Christina River are critical spawning and rearing habitat for northern pike and burbot. Small young-of-the-year of both species were very abundant in these areas while few were taken in the Clearwater River downstream of the Christina River or in the Athabasca River upstream of Fort McMurray.

The Clearwater River upstream of its junction with the Christina River was not sampled until after young-of-the-year northern pike had already emerged. The spawning, hatching, and emergence times for northern pike in this area are therefore unknown. It is possible that the northern pike spawning in the upper Clearwater River are a segment of the large spawning runs of northern pike described in the Christina River (Tripp and Tsui in prep.).

An additional objective of the study was to describe the downstream movements of lake whitefish young-of-the-year. However, few were captured despite intensive sampling immediately after break-up suggesting that they probably emerged and moved downstream out of the present study area before spring break-up was completed.

The Athabasca River and, to a lesser extent, the Clearwater River, provide valuable habitat for a number of smaller species. Of these, flathead chub, longnose dace, and lake chub are the most numerous. Large numbers of pre-spawning age goldeye also use the Athabasca and Clearwater rivers upstream of Fort McMurray as feeding grounds during the open water period. Spawning by other spring spawners such as Arctic grayling and white suckers is probably confined to smaller tributaries.

## 6. REFERENCES CITED

Bidgood, B.F. 1968. Ecology of walleyes in Richardson Lake-Lake Athabasca. Alberta Recreation, Parks and Wildlife. Fish. Res. Rep. 1. 21 pp.

Bidgood, B.F. 1971. Ecology of walleyes, *Stizostedion v. vitreum*, in Richardson Lake-Lake Athabasca complex. Pages 187-203 in R.E. Reinelt, K. Kellerhals, M.A. Molot, W.M. Schultz, and W.E. Stevens, eds. Proc. Peace-Athabasca Delta Symposium. Univ. of Alberta, Edmonton.

Bidgood, B.F. 1973. Walleyes and water levels in Lake Athabasca. in Ecological Investigations, the Peace-Athabasca Delta Project, Technical Appendices, Vol. 2, Appendix E.

Bishop, F.G. 1975. A new distribution record for brassy minnow in northwestern Alberta. Canadian Field-Naturalist 89:319-320.

Bond, W.A. in prep. A summary report of investigations of the fishery resources of the Athabasca River downstream of Fort McMurray, Alberta. Prep. for the Alberta Oil Sands Environmental Research Program by Fisheries and Environment Canada, Fisheries and Marine Service. AOSERP Project AF 4.3.2.

Bond, W.A., and D.K. Berry. in prep.a. First interim report on an investigation of the fishery resources of the Athabasca River downstream of Fort McMurray, Alberta. Prep. for the Alberta Oil Sands Environmental Research Program by Fisheries and Environment Canada, Fisheries and Marine Service. AOSERP Project AF 4.3.2.

Bond, W.A., and D.K. Berry. in prep.b. Second interim report on an investigation of the fishery resources of the Athabasca River downstream of Fort McMurray, Alberta. Prep. for the Alberta Oil Sands Environmental Research Program by Fisheries and Environment Canada, Fisheries and Marine Service. AOSERP Project AF 4.3.2.

Bond, W.A., and K. Machniak. 1977. Interim report on an intensive study of the fish fauna of the Muskeg River watershed of northeastern Alberta. Prep. for the Alberta Oil Sands Environmental Research Program by Fisheries and Environment Canada, Department of Fisheries. AOSERP Report 26. 137 pp.

Bond, W.A., and K. Machniak. 1979. Second interim report on an intensive study of the fish fauna of the Muskeg River watershed of northeastern Alberta. Prep. for the Alberta Oil Sands Environmental Research Program by Fisheries and Environment Canada, Freshwater Institute. AOSERP Project AF 4.5.1.

Bond, W.A., K. Machniak, M. Orr, D. Rudi, and D. Miller. in prep. Fisheries and aquatic habitat investigations in the MacKay River watershed of northeastern Alberta. Prep. for the Alberta Oil Sands Environmental Research Program by Fisheries and Environment Canada, Fisheries and Marine Service. AOSERP Project WS 1.3.1.

Dietz, K.G. 1973. The life history of walleye *(Stizostedion vitreum vitreum)* in the Peace-Athabasca Delta. Fish and Wildl. Div., Alta. Dept. Lands and Forests, Man. Rep. 52 pp.

Donald, D.B., and A.H. Kooyman. 1977. Migration and population dynamics of the Peace-Athabasca Delta goldeye population. Canadian Wildlife Service. Occasional Paper No. 31. 19 pp.

Geen, G.H., T.G. Northcote, G.F. Hartman, and C.C. Lindsey. 1966. Life histories of two species of catostomid fishes in Sixteen Mile Lake, British Columbia, with special reference to inlet stream spawning. J. Fish. Res. Board Can. 23(11):1761-1788.

Griffiths, W.E. 1973. Preliminary fisheries survey of the Fort McMurray tar sands area. Fish and Wildlife Division, Alberta Dept. of Lands and Forests. 622 pp.

Jones, D.R., J.W. Kiceniuk, and O.S. Bamford. 1974. Evaluation of the swimming performance of several fish species from the Mackenzie River. J. Fish. Res. Board Can. 31:1641-1647.

Jones, M.L., G.J. Mann, and P.J. McCart. 1978. Fall fisheries investigations in the Athabasca and Clearwater rivers upstream of Fort McMurray: Volume I. Prep. for the Alberta Oil Sands Environmental Research Program by Aquatic Environments Limited. AOSERP Report 37. 71 pp.

Kennedy, W.A., and W.M. Sprules. 1967. Goldeye in Canada. Fish. Res. Board Can. Bull. 161. 45 pp.

Kooyman, A.H. 1972. Status of goldeye, *Hiodon alosoides,* populations in the Peace-Athabasca Delta. Peace-Athabasca Delta Project: ecological investigations. Vol. 2.

Kristensen, J., B.S. Ott, and A.D. Sekerak. 1976. Walleye and goldeye fisheries investigations in the Peace-Athabasca Delta--1975. Prep. for Alberta Oil Sands Environmental Research Program by L.G.L. Ltd. AOSERP Report 2. 103 pp.

Lagler, K.F. 1956. Freshwater fishery biology, 2nd ed. Wm. C. Brown Co., Dubuque, Iowa. 421 pp.

Machniak, K., and W.A. Bond. 1979. An intensive study of the fish fauna of the Steepbank River watershed of northeastern Alberta. Prep. for the Alberta Oil Sands Environmental Research Program by Fisheries and Environment Canada, Freshwater Institute. AOSERP Project AF 4.5.2.

McCart, P., P.T.P. Tsui, W. Grant, and R. Green. 1977. Baseline studies of aquatic environments in the Athabasca River near Lease 17. Environmental Research Monograph 1977-2, Syncrude Canada Ltd. 205 pp.

McCart, P.J., D. Tripp, P.T.P. Tsui, W. Grant, and R. Green. 1978. Baseline study of the water quality and aquatic resources of the MacKay River, Alberta. A report to Syncrude Canada Ltd. 200 pp.

McDonald, D. 1967. Kehiwin Lake. Province of Alberta, Dept. of Lands and Forests. 47 pp.

Nordeng, H. 1961. On the biology of char (*Salvelinus alpinus*, L.) in Salangen, North Norway. Nytt. Magasin for Zoologi 10:67-123.

Paetz, M.J., and J.S. Nelson. 1970. The fishes of Alberta. Government of Alberta. 282 pp.

Rawson, D.S., and J.E. Elsey. 1950. Reduction in the longnose sucker population of Pyramid Lake, Alberta, in an attempt to improve angling. Trans. Amer. Fish. Soc. 78(1948):13-31.

Scott, W.B., and E.J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Board Can. Bull. 184. 966 pp.

Tripp, D.B., and P.J. McCart. 1974. Life histories of grayling (*Thymallus arcticus*) and longnose suckers (*Catostomus catostomus*) in the Donnelly River system, N.W.T. Pages in P.J. McCart ed. Life histories of anadromous and freshwater fish in the western Arctic. Arctic Gas Biological Report Series 20(1). 91 pp.

Tripp, D.B., and P.J. McCart. 1979. Investigations of the spring spawning fish populations in the Athabasca and Clearwater rivers upstream of Fort McMurray, Volume II. Prep. for the Alberta Oil Sands Environmental Research Program by the Aquatic Environments Limited. AOSERP O.F. 4. 94 pp.

Tripp, D.B., and P.T.P. Tsui. in prep. Fisheries and habitat investigations in the southern portion of the AOSERP study area. Prep. for the Alberta Oil Sands Environmental Research Program by Aquatic Environments Limited. AOSERP Project WS 1.6.2.

Turner, W.R. 1968. Preliminary biological survey of Wabasca Lakes area, 1967. Province of Alberta, Dept. of Lands and Forests. 70 pp.

## 7. 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 |
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| 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" |
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| 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. | | Alberta Oil Sands Environmental Research Program Interim Report to 1978 covering the period April 1975 to November 1978 |
| 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 |

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| 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 |
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| 45. | VE 3.3 | Interim Report on Physiology and Mechanisms of Air-Borne Pollutant Injury to Vegetation, 1975 to 1978 |
| 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. |
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