FISHERIES AND AQUATIC HABITAT INVESTIGATIONS IN THE MACKAY RIVER WATERSHED OF NORTHEASTERN ALBERTA

by

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RESEARCH PROGRAM
and
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The Hon, J.W. (Jack) Cookson
Minister of the Environment
222 Legislative Building
Edmonton, Alberta

and

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

Sirs:

Enclosed is the report "Fisheries and Aquatic Habitat Investigations in the MacKay River Watershed of Northeastern Alberta".

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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FISHERIES AND HABITAT INVESTIGATIONS IN THE MACKAY RIVER WATERSHED OF NORTHEASTERN ALBERTA

DESCRIPTIVE SUMMARY

BACKGROUND

The MacKay River basin is the largest basin on the west side of the Athabasca in the Athabasca Oil Sands region. The lower parts of this basin are part of the lease holding of Syncrude Canada Limited and this project was supported and partially funded by Syncrude.

The general objective of this study was to describe the baseline states of the fish component of the MacKay River watershed. This study was part of a broadly based fisheries investigation of the Athabasca River and selected tributaries in the oil sands region of northeastern Alberta. Please refer to the following AOSERP research reports for more fisheries information: Nos. 26 and 76 (Muskeg), 36 (Clearwater), 61 (Steepbank), 84 and 89 (Athabasca), and 92 (Christina, Gregoire, and Hangingstone).

ASSESSMENT

This report was reviewed by scientists at the Universities of Alberta and Guelph, the oil sands industry, and Alberta Environment. It is the impression of AOSERP that the researchers have succeeded in describing fish utilization of the MacKay River watershed and that the report contributes to the information on the fisheries resource in the Athabasca Oil Sands region of northeastern Alberta.

The Alberta Oil Sands Environmental Research Program accepts the report "Fisheries and Habitat Investigations in the MacKay River Watershed of Northeastern Alberta" as an important and valid document and thanks the researchers for their efforts.

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TABLE OF CONTENTS

		Page
DECLARATION		ii
LETTER OF TRANSMITTAL		iii
DESCRIPTIVE SUMMARY		iv
LIST OF TABLES		xiii
LIST OF FIGURES		xix
ABSTRACT		xxiii
ACKNOWLEDGEMENTS		xxv
1.	INTRODUCTION	1
2.	RESUME OF CURRENT STATE OF KNOWLEDGE	3
3.	DESCRIPTION OF THE STUDY AREA	5
4.	MATERIALS AND METHODS	13
4.1	Counting Fence Construction	13
4.2	Counting Fence Operation	14
4.2.1	Trap Checks	14
4.2.2	Tagging	15
4.2.3	Dead Samples	15
4.3	Other Fish Collection Techniques	16
4.3.1	Gillnets	17
4.3.2	Small Fish Collections	17
4.3.3	Larval Fish	17
4.4	Laboratory Techniques	19
4.4.1	Fish Identification	19
4.4.2	Age Determination	19
4.4.3	Fecundity	20
4.4.4	Food Habits	20
4.4.5	Length and Weight of Small Fish	20
4.4.6	Data Analysis	21
4.5	Aquatic Habitat Analysis	21
4.5.1	Reach Definition and Description	21
4.5.2	Point Samples	22
4.6	Limitations of Methods	23
4.6.1	Counting Fence	23
4.6.2	Gillnets	24
4.6.3	Small Fish Collections	25
4.6.4	Drift Nets	26
4.6.5	Winter Sampling	26
4.6.6	Habitat Analysis	26

TABLE OF CONTENTS (CONTINUED)

		Page
5.	RESULTS AND DISCUSSIONS	28
5.1	General	28
5.2	Life Histories of Fish Species	38
5.2.1	White Sucker	38
5.2.1.1	Seasonal Timing of Upstream Migration	38
5.2.1.2	Diel Timing of Upstream Migration	40
5.2.1.3	Spawning Times and Locations	45
5.2.1.4	Seasonal Timing of Downstream Migration	46
5.2.1.5	Spawning Mortality	46
5.2.1.6	Size Composition of Migrant White Suckers	47
5.2.1.7	Age Composition of Migrant White Suckers	52
5.2.1.8	Sex Ratio of Migrant White Suckers	52
5.2.1.9	Tagging Results	52
5.2.1.10	Fecundity	55
5.2.1.11	Egg Size and Ovary Weight	57
5.2.1.12	Age and Growth	58
5.2.1.13	Sex and Maturity	58
5.2.1.14	Length-Weight Relationship	63
5.2.1.15	Downstream Movement of Fry	63
5.2.1.16	Growth of Young-of-the-Year	68
5.2.1.17	Food Habits	73
5.2.1.18	Rearing Areas	74
5.2.1.19	Overwintering	74
5.2.2	Longnose Sucker	76
5.2.2.1	Seasonal Timing of Upstream Migration	76
5.2.2.2	Diel Timing of Upstream Migration	76
5.2.2.3	Spawning Times and Locations	79
5.2.2.4	Seasonal Timing of Downstream Migration	79
5.2.2.5	Spawning Mortality	80
5.2.2.6	Size Composition of Migrant Longnose Suckers	80
5.2.2.7	Age Composition of Migrant Longnose Suckers	83
5.2.2.8	Sex Ratio of Migrant Longnose Suckers	83
5.2.2.9	Tagging Results	86
5.2.2.10	Fecundity	86
5.2.2.11	Egg Size and Ovary Weight	88
5.2.2.12	Age and Growth	89
5.2.2.13	Sex and Maturity	92
5.2.2.14	Length-Weight Relationship	95
5.2.2.15	Growth of Young-of-the-Year	95
5.2.2.16	Food Habits	96
5.2.2.17	Rearing Areas	100
5.2.2.18	Overwintering	100
5.2.3	Walleye	100
5.2.3.1	Distribution and Movements	100
5.2.3.2	Spawning	102
5.2.3.3	Age and Growth	103
5.2.3.4	Sex and Maturity	108

TABLE OF CONTENTS (CONTINUED)

		Page
5.2.3.5	Food Habits	108
5.2.4	Northern Pike	109
5.2.4.1	Distribution and Movements	109
5.2.4.2	Spawning	110
5.2.4.3	Age and Growth	111
5.2.4.4	Growth of Young-of-the-Year	114
5.2.4.5	Sex and Maturity	114
5.2.4.6	Food Habits	117
5.2.5	Arctic Grayling	117
5.2.5.1	Distribution and Movements	117
5.2.5.2	Spawning	118
5.2.5.3	Age and Growth	119
5.2.5.4	Sex and Maturity	122
5.2.5.5	Fecundity	122
5.2.5.6	Food Habits	125
5.2.5.7	Overwintering	126
5.2.6	Flathead Chub	126
5.2.6.1	Distribution and Movements	126
5.2.6.2	Spawning	127
5.2.6.3	Age and Growth	127
5.2.6.4	Sex and Maturity	129
5.2.6.5	Fecundity and Egg Size	132
5.2.6.6	Food Habits	132
5.2.7	Goldeye	133
5.2.7.1	Distribution and Movements	133
5.2.7.2	Spawning	134
5.2.7.3	Age and Growth	134
5.2.7.4	Sex and Maturity	134
5.2.7.5	Food Habits	137
5.2.8	Other Large Fishes	137
5.2.8.1	Burbot	137
5.2.8.2	Lake Whitefish	138
5.2.8.3	Mountain Whitefish	139
5.2.8.4	Yellow Perch	140
5.2.9	Lake Chub	140
5.2.9.1	Distribution and Relative Abundance	140
5.2.9.2	Spawning	142
5.2.9.3	Age and Growth	146
5.2.9.4	Sex and Maturity	151
5.2.9.5	Food Habits	151
5.2.10	Trout-Perch	155
5.2.10.1	Distribution and Relative Abundance	155
5.2.10.2	Spawning	157
5.2.10.3	Age and Growth	158
5.2.10.4	Sex and Maturity	160
5.2.10.5	Food Habits	163

TABLE OF CONTENTS (CONTINUED)

		Page
5.2.11	Slimy Sculpin	164
5.2.11.1	Distribution and Relative Abundance	164
5.2.11.2	Spawning	164
5.2.11.3	Age and Growth	166
5.2.11.4	Sex and Maturity	170
5.2.11.5	Food Habits	170
5.2.12	Longnose Dace	172
5.2.12.1	Distribution and Relative Abundance	172
5.2.12.2	Spawning	172
5.2.12.3	Age and Growth	172
5.2.12.4	Sex and Maturity	174
5.2.12.5	Food Habits	175
5.2.13	Finescale Dace	175
5.2.13.1	Distribution and Relative Abundance	175
5.2.13.2	Spawning	177
5.2.13.3	Age and Growth	178
5.2.13.4	Sex and Maturity	178
5.2.13.5	Food Habits	181
5.2.14	Pearl Dace	181
5.2.14.1	Distribution and Relative Abundance	181
5.2.14.2	Spawning	181
5.2.14.3	Age and Growth	182
5.2.14.4	Sex and Maturity	182
5.2.14.5	Food Habits	184
5.2.15	Brook Stickleback	184
5.2.15.1	Distribution and Relative Abundance	184
5.2.15.2	Spawning	184
5.2.15.3	Age and Growth	185
5.2.15.4	Sex and Maturity	185
5.2.15.5	Food Habits	185
5.2.16	Other Small Fishes	187
5.2.16.1	Spottail Shiner	187
5.2.16.2	Spoonhead Sculpin	188
5.2.16.3	Emerald Shiner	188
5.3	Habitat Analysis	188
5.3.1	MacKay River Mainstem	188
5.3.1.1	Reach 1	188
5.3.1.2	Reach 2	193
5.3.1.3	Reach 3	194
5.3.1.4	Reach 4	196
5.3.1.5	Reach 5	197
5.3.1.6	Reach 6	198
5.3.2	Dover River	199
5.3.2.1	Reach 1	199
5.3.2.2	Reach 2	202
5.3.2.3	Reach 3	203
5.3.2.4	Reach 4	203

TABLE OF CONTENTS (CONTINUED)

		Page
5.3.3	Dunkirk River	204
5.3.3.1	Reach 1	204
5.3.3.2	Reach 2	207
5.3.3.3	Reach 3	207
5.3.4	Snipe Creek	208
5.3.4.1	Reach 1	208
5.3.4.2	Reach 2	209
6.	CONCLUSION	210
7.	REFERENCES CITED	212
8.	APPENDIX	224
8.1	Mean Water Temperatures (±0.5°C) Recorded for Each Check Period Plus Daily Maximum and Minimum Temperatures and Relative Water Levels (cm) during the Spring Fence Operation on the MacKay River, 1978	224
8.2	Daily Water Temperatures and Relative Water Levels Recorded at the MacKay River Fence Site during the Autumn Gillnetting Program, 1978	226
8.3	Total Number of Larval Fishes Collected in Drift Nets at Three Stations Along a Transect Upstream of the MacKay River Counting Fence during June 1978	228
8.4	Total Numbers of Larval Fishes Collected in Drift Nets at Three Stations Along a Transect in the Dover River (Site 12) and at One Station in the MacKay River 20 m Upstream of the Dover River, 1978	232
8.5	Number (N), Percentage Composition (%), and Catch-per-Unit-Effort (C/E) for Fish Captured by Seines at Each Sampling Location in the MacKay River Watershed during 1978	234
8.6	Dates of Tagging and Recapture, Location of Recapture, Distances Travelled, and Elapsed Time between Release and Recapture for Fish Tagged at the MacKay River Counting Fence, 1978 and Subsequently Recaptured Outside the MacKay River Watershed or during the Autumn Gillnetting Program	248
8.7	Site Descriptions for MacKay River Watershed Small Fish Collection Sites	253
8.8	Summary of Physical and Water Quality Data Obtained at Small Fish Collection Sites in the MacKay River Watershed between May and October 1978	258

TABLE OF CONTENTS (CONCLUDED)

		Page
8.9	Percentage Composition by Numbers for Major Benthic Macroinvertebrate Groups at Each Sampling Site in the MacKay River Watershed during 1978	261
8.10	Percentage Composition by Numbers for Major Benthic Macroinvertebrates (Identified to Family) at Each Sampling Site in the MacKay River Watershed, 20 to 22 May 1978	267
9.	LIST OF AOSERP RESEARCH REPORTS	270

LIST OF TABLES

		Page
1.	Sampling Dates for Small Fish Seine Collections in the MacKay River Watershed, 1978	18
2.	List of Fish Species Captured in the MacKay River Drainage during 1978	29
3.	Summary of Fish Recorded at MacKay River Counting Fence, 1978	30
4.	Summary of Gillnet Catches during the Spring Operation in the MacKay River, 1978	31
5.	Number of Fish Captured Each Day during the Autumn Gillnetting Program in the MacKay River, 1978	33
6.	Distribution and Percentage Composition for Fish Captured at Each Location in the MacKay River Watershed, 1978	35
7.	Daily Summary for Fish Captured in Seines during September and October 1978 at the MacKay River Fence Site	36
8.	Summary of Tag Releases and Recaptures for Fish Tagged at the MacKay River Upstream Trap, 1978	39
9.	Summary of Fish Enumerated during the Spring Counting Fence Operation in the MacKay River, 1978	41
10.	Summary of Diel Timing of the Upstream Migration of White Suckers in the MacKay River, 1978	44
11.	Length-Frequency Distribution of White Suckers during the Spring Upstream Migration in the MacKay River, 1978 ..	48
12.	Sex Ratio for White Suckers during the Upstream Migration, MacKay River, 1978	54
13.	Fecundity Estimates for White Suckers Sampled during the 1978 MacKay River Spawning Migration	56
14.	Age-Length Relationship (Derived from Fin Rays and Otoliths) for White Suckers Captured in the MacKay River Watershed, 1978, Sexes Separate and Combined Sample (Includes Unsexed Fish)	59

LIST OF TABLES (CONTINUED)

Page

15. Age-Weight Relationship for White Suckers Captured in the MacKay River Watershed, 1978, Sexes Separate and Combined Sample (Includes Unsexed Fish) 60

16. Age-Specific Sex Ratios and Maturity for White Suckers from the MacKay River Drainage, 1978 62

17. Comparison of Mean Fork Langths and Mean Weights of Young-of-the-Year (Age 0+) and Juvenile (Age 1+) White Suckers Collected from the MacKay, Dover, and Dunkirk Rivers, 1978 69

18. Food Habits of Young-of-the-Year and Juvenile Longnose and White Suckers Captured in the MacKay River, 1978 75

19. Summary of Diel Timing of the Upstream Migration of Longnose Suckers in the MacKay River, 1978 78

20. Length-Frequency Distribution of Longnose Suckers during the Spring Upstream Migration in the MacKay River, 1978 .. 81

21. Sex Ratio for Longnose Suckers during the Upstream Migration, MacKay River, 1978 85

22. Fecundity Estimates for Longnose Suckers Sampled during the 1978 MacKay River Spawning Migration 87

23. Age-Length Relationship (Derived from Fin Rays and Otoliths) for Longnose Suckers Captured in the MacKay River Watershed, 1978, Sexes Separate and Combined Sample (Includes Unsexed Fish) 90

24. Age-Weight Relationship for Longnose Suckers Captured in the MacKay River Watershed, 1978, Sexes Separate and Combined Sample (Includes Unsexed Fish) 93

25. Age-Specific Sex Ratios and Maturity for Longnose Suckers from the MacKay River Drainage, 1978 94

26. Comparison of Mean Fork Lengths and Mean Weights of Young-of-the-Year (Age 0+) and Juvenile (Age 1+) Longnose Suckers Collected from the MacKay, Dover, and Dunkirk Rivers, 1978 97

LIST OF TABLES (CONTINUED)

Page

27. Age-Length and Age-Weight Relationships, Age-Specific Sex Ratios, and Maturity for Walleye Captured in the MacKay River, 1978 106

28. Age-Length and Age-Weight Relationships, Age-Specific Sex Ratios, and Maturity for Northern Pike Captured in the MacKay River, 1978 113

29. Length and Weight Relationships of Young-of-the-Year Northern Pike Captured in the MacKay Watershed, 1978 116

30. Age-Length and Age-Weight Relationships, Age-Specific Sex Ratios, and Maturity for Arctic Grayling Captured in the MacKay River, 1978 121

31. Actual Egg Counts for Five Arctic Grayling Sampled during the 1978 Spawning Migration, MacKay River, 1978 .. 124

32. Age-Length and Age-Weight Relationships, Age-Specific Sex Ratios, and Maturity for Flathead Chub Captured in the MacKay River, 1978 130

33. Age-Length and Age-Weight Relationships, Age-Specific Sex Ratios, and Maturity for Goldeye, Burbot, Lake Whitefish, and Mountain Whitefish from the MacKay River, 1978 136

34. Length and Weight Relationships of Young-of-the-Year Yellow Perch Captured in the MacKay River Watershed, 1978 141

35. Average Catch-per-Unit-Effort by Month for Lake Chub Captured by Seines at Each Sampling Location in the MacKay River Watershed, 1978 143

36. Age-Length (Dreived from Otoliths) and Age-Weight Relationships, Age-Specific Sex Ratios, and Maturity of Small Fishes Captured from the MacKay River Drainage, 1978 148

37. Sex and Maturity Ratios by Size Class for Lake Chub from the MacKay River, 1978 152

38. Food Habits of Small Fishes Collected from the MacKay River, 1978 153

LIST OF TABLES (CONTINUED)

Page

39. Average Catch-per-Unit Effort by Month for Trout-Perch Captured by Seines at Each Sampling Location in the MacKay River Watershed, 1978 156

40. Sex and Maturity by Size Class for Trout-Perch Captured from the MacKay River, 1978 162

41. Sex and Maturity Ratios by Size Class for Slimy Sculpin Captured from the MacKay River, 1978 171

42. Sex and Maturity Ratios by Size Class for Longnose Dace Captured from the MacKay River, 1978 178

43. Sex and Maturity Ratios by Size Class for Finescale Dace Captured from the MacKay River, 1978 180

44. Physical Characteristics of the MacKay River Mainstem ... 189

45. Documented Distributions of Adult and Young Fish in the MacKay River Mainstem Based on Catch Data Obtained in April to October 1978, and on Reports by Other Individuals 192

46. Physical Characteristics of the Dover River 200

47. Documented Distributions of Adult and Young Fish in the Dover and Dunkirk Rivers Based on Catch Data in April to October 1978 201

48. Physical Characteristics of the Dunkirk River and Snipe Creek 205

49. Mean Water Temperatures ($\pm 0.5^{o}C$) for Each Check Period Plus Daily Maximum and Minimum Temperatures and Relative Water Levels (cm) during the Spring Fence Operation on the MacKay River, 1978 225

50. Daily Water Temperatures and Relative Water Levels Recorded at the MacKay River Fence Site during the Autumn Gillnetting Program, 1978 227

51. Total Numbers of Larval Fishes Collected in Drift Nets at Three Stations along a Transect Upstream of the MacKay River Counting Fence during June 1978 229

LIST OF TABLES (CONTINUED)

Page

52. Total Numbers of Larval Fishes Collected in Drift Nets at Three Stations along a Transect in the Dover River (Site 12) and One Station in the MacKay River 20 m Upstream of the Dover River, 1978 233

53. Number (N), Percentage Composition (%), and Catch-per-Unit-Effort (C/E) for Fish Captured by Seines at Each Sampling Location in the MacKay River Watershed during May 1978 235

54. Number (N), Percentage Composition (%), and Catch-per-Unit-Effort (C/E) for Fish Captured by Seines at Each Sampling Location in the MacKay River Watershed during June 1978 236

55. Number (N), Percentage Composition (%), and Catch-per-Unit-Effort (C/E) for Fish Captured by Seines at Each Sampling Location in the MacKay River Watershed during July 1978 238

56. Number (N), Percentage Composition (%), and Catch-per-Unit-Effort (C/E) for Fish Captured by Seines at Each Sampling Location in the MacKay River Watershed during August 1978 240

57. Number (N), Percentage Composition (%), and Catch-per-Unit-Effort (C/E) for Fish Captured by Seines at Each Sampling Location in the MacKay River Watershed during September 1978 242

58. Number (N), Percentage Composition (%), and Catch-per-Unit-Effort (C/E) for Fish Captured by Seines at Each Sampling Location in the MacKay River Watershed during October 1978 243

59. Number (N), Percentage Composition (%), and Catch-per-Unit-Effort (C/E) for Fish Captured by Seines at Each Sampling Location in the MacKay River Watershed during 1978; All Data Combined 245

60. Dates of Tagging and Recapture, Location of Recapture, Distances Travelled, and Elapsed Time between Release and Recapture for Fish Tagged at the MacKay River Counting Fence, 1978 and Subsequently Recaptured Outside the MacKay River Watershed or during the Autumn Gillnetting Operation 249

LIST OF TABLES (CONCLUDED)

Page

61. Summary of Physical and Water Quality Data Obtained at Small Fish Collection Sites in the MacKay River Watershed between May and October 1978 259

62. Percentage Composition by Numbers for Major Benthic Macroinvertebrate Groups at Each Sampling Site in the MacKay River Watershed, 20 to 27 May 1978 262

63. Percentage Composition by Numbers for Major Benthic Macroinvertebrate Groups at Each Sampling Site in the MacKay River Watershed, 15 to 17 June 1978 263

64. Percentage Composition by Numbers for Major Benthic Macroinvertebrate Groups at Each Sampling Site in the MacKay River Watershed, 14 to 15 July 1978 264

65. Percentage Composition by Numbers for Major Benthic Macroinvertebrate Groups at Each Sampling Site in the MacKay River Watershed, 16 to 17 August 1978 265

66. Percentage Composition by Numbers for Major Benthic Macroinvertebrate Groups at Each Sampling Site in the MacKay River Watershed, 10 to 14 October 1978 266

67. Percentage Composition by Numbers for Major Benthic Macroinvertebrates (Identified to Family) at Each Sampling Site in the MacKay River Watershed, 20 to 22 May 1978 268

LIST OF FIGURES

Page

1. The AOSERP Study Area 6

2. Map of the MacKay River Drainage Basin Indicating the Location of the Counting Fence and Small Fish Collection Sites 7

3. Discharge of the MacKay River from 11 April to 30 October 1978 10

4. Seasonal Timing of the White Sucker Upstream Migration in the MacKay River, 1978 43

5. Length-Frequency Distribution for White Suckers during the Upstream Migration in the MacKay River, 1978 49

6. Seasonal Changes in Length-Frequency Distribution for White Suckers during the Upstream Migration in the MacKay River, 1978 50

7. Length-Frequency Distribution for White Suckers Captured during the Spring Post-Spawning Period in the MacKay River, 1978 51

8. Age Composition for White Suckers Sampled during the Counting Fence Operation, MacKay River, 1978 53

9. Growth in Fork Length for White Suckers from the MacKay River and from Several Other Areas 61

10. Length-Frequency Distribution of Sucker Fry Captured in Drift Nets throughout the Period of Downstream Migration in the MacKay River, 1978 65

11. Diel Timing of Downstream Sucker Fry Migration in the MacKay River, 1978 66

12. Diel Timing of Sucker Fry Migration as Determined by Drift Net Catches at the Mouth of the Dover River and in the MacKay River just Upstream of the Dover River, 15 to 16 June 1978 67

13. Seasonal Timing of the Longnose Sucker Upstream Migration in the MacKay River, 1978 77

LIST OF FIGURES (CONTINUED)

Page

14. Length-Frequency Distribution for Longnose Suckers during the Upstream Migration in the MacKay River, 1978 82

15. Age Composition for Longnose Suckers Sampled during the Counting Fence Operation, MacKay River, 1978 84

16. Growth in Fork Length for Longnose Suckers from the MacKay River and from Several Other Areas 91

17. Length-Frequency Distribution for Walleye Captured during the Spring Fence Operation, MacKay River, 1978 ... 104

18. Growth in Fork Length for Walleye from the MacKay River and from Several Other Areas 107

19. Length-Frequency Distribution for Northern Pike Captured during the Spring Fence Operation, MacKay River, 1978 112

20. Growth in Fork Length for Northern Pike from the MacKay River and from Several Other Areas 115

21. Length-Frequency Distribution for Arctic Grayling Captured during the Spring Fence Operation, MacKay River, 1978 120

22. Growth in Fork Length for Arctic Grayling from the MacKay River and from Several Other Areas 123

23. Length-Frequency Distribution for Flathead Chub Captured during the Spring Fence Operation, MacKay River, 1978 128

24. Growth in Fork Length for Flathead Chub from the MacKay River and from Several Other Areas 131

25. Length-Frequency Distribution for Goldeye Captured during the Spring Fence Operation, MacKay River, 1978 ... 135

26. Length-Frequency Distribution of Cyprinid Fry Captured in Drift Nets from the MacKay River, 2 to 19 June 1978 145

27. Length-Frequency Distribution for Lake Chub from the MacKay River, 1978 147

LIST OF FIGURES (CONCLUDED)

Page

28. Length-Frequency Distribution for Trout-Perch from the MacKay River, 1978 159

29. Growth in Fork Length for Trout-Perch from the MacKay River and from Several Other Areas 161

30. Length-Frequency Distribution for Slimy Sculpin Fry Captured in Drift Nets from the MacKay River, 2 to 19 June 1978 165

31. Diel Timing of Downstream Cottid Fry Migration in the MacKay River, 1978 167

32. Length-Frequency Distribution for Slimy Sculpin from the MacKay River, 1978 168

33. Growth in Total Length for Slimy Sculpins from the MacKay River and from Several Other Areas 169

34. Length-Frequency Distribution for Longnose Dace from the MacKay River, 1978 173

35. Length-Frequency Distribution for Finescale Dace from the MacKay River, 1978 179

36. Length-Frequency Distribution for Pearl Dace from the MacKay River, 1978 183

37. Length-Frequency Distribution for Brook Stickleback from the MacKay River, 1978 186

38. Map of MacKay River Watershed Indicating Reach Boundaries and Point Sample Locations 110

ABSTRACT

The fish fauna of the MacKay River watershed was studied during the open-water period in 1978, and the aquatic habitat within the watershed was described in terms of various physical parameters. Fish movements into and out of the MacKay River were monitored using a partial counting fence, gillnets, and small mesh seines. Small mesh seines were also used throughout the watershed and throughout the summer to collect small fish. During June, drift nets were employed to monitor the downstream movements of drifting fry. Floy tags were applied to 3509 migrant fish in an attempt to determine the length of time spent in the MacKay River watershed by individual fish and to define migration patterns within the lower Athabasca River system. The general biology of the various fish species was described in terms of age and growth patterns, food habits, fecundity, etc.

Spawning migrations of white suckers (69%) and longnose suckers (21%) accounted for most of the 5775 fish passed through the upstream trap or gillnetted during the spring operation. Post-spawning feeding movements of walleye (6%) and northern pike (2%) made up most of the remainder of spring migrants, while small numbers of Arctic grayling, flathead chub, goldeye, lake whitefish, and burbot were also captured. Results from small mesh seines indicated large upstream movements of lake chub and trout-perch during late April and early May.

Suckers of both species began to leave the MacKay River watershed in late May, shortly after spawning, but downstream movement patterns could not be monitored. Some migrant suckers apparently remain in the tributary all summer as small numbers were gillnetted during the autumn. Most migrant fish of other species also appear to leave the MacKay River watershed prior to freeze-up.

Downstream fry movements in June involved suckers, lake chub, trout-perch, and slimy sculpins. Most sucker and lake chub fry drifted out of the watershed during the summer but many remained in the tributary until October. Few young-of-the-year trout-perch

were captured during the autumn indicating that these fish had left the MacKay River during the summer.

Only 39 (1%) of the fish tagged were recaptured outside the MacKay River watershed, of which 36 (92%) were white suckers. Most of these white suckers were recaptured in Lake Athabasca.

The resident fish fauna of the MacKay River watershed consists largely of brook stickleback, pearl dace, finescale dace, longnose dace, and slimy sculpin. A resident northern pike population appears to be present in the vicinity of the confluence of the Dunkirk and MacKay rivers.

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1. INTRODUCTION

The possibility of disturbance to some lake and river systems of the lower Athabasca River drainage as a result of the present and proposed development of the Athabasca Oil Sands has raised concern as to the potential effect of such development on fish populations of the area.

Activities related to the mining of the oil sands as well as the increased urbanization of the area may affect the fishery in numerous ways. Blockage or diversion of streams may interfere with migrations, preventing fish from reaching traditional spawning and feeding areas. In some cases, such areas may be lost altogether. Activities in close proximity to streams may result in increased siltation with resultant increased mortality of eggs and fry (Griffiths and Walton 1978). Deterioration of water quality as a result of increased input of domestic wastes, herbicides, and other toxic materials may affect fish directly through increasing the mortality rates of adults, eggs, or fry, or indirectly by reducing the availability of food organisms (Machniak 1977; Lake and Rogers 1979; Costerton and Geesey 1979). Increased human population and improved access may result in over-exploitation of fish stocks and destruction of spawning and nursery areas. In most cases, the effect of such disturbances will be local (Jantzie 1977); however, in the case of migratory populations, e.g., from Lake Athabasca, such local effects may be manifested over a much wider area.

The fishery of the lower Athabasca River drainage represents a valuable resource in terms of commercial, sport, and domestic usage. Because of this, the Alberta Oil Sands Environmental Research Program (AOSERP) initiated a series of projects to assess the baseline state of the fishery resources in this area. The intent of these projects was to provide information that would permit minimization of the possible adverse effects of development on the fish populations of the Athabasca River and its tributary streams, and to establish a data base against which future changes can be measured.

The MacKay River, the largest watershed on the west side of the Athabasca River within the AOSERP area, was investigated during 1978. The general objective of the study, as specified in the terms of reference agreed to by AOSERP, Syncrude Canada Ltd., and the Department of Fisheries and Environment, was to describe the baseline states of the fish resources and the aquatic habitat of the MacKay River watershed, and to provide a quantitative estimate of the significance of this watershed to the fisheries of the Athabasca River system.

Specific items of work for the study were as follows:

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

2. RESUME OF CURRENT STATE OF KNOWLEDGE

Prior to the commencement of the present study, little information was available concerning the fish fauna of the MacKay River watershed. Griffiths (1973) investigated the MacKay and Dover rivers as part of a broad regional study to assess the sport fishery potential of a large number of streams in the oil sands area. Subsequent to this, Renewable Resources Consulting Services Ltd. (RRCS) collected fish from the MacKay River in October 1975 (Lutz and Hendzel 1977). Aquatic Environments Ltd., under contract to Syncrude Canada Ltd., completed a baseline study of the aquatic resources (water quality, periphyton, benthic invertebrates, and fish) of the MacKay River within the boundaries of Syncrude Leases 17 and 22 in 1977 (McCart et al. 1978). M. Orr collected fish from two small lakes in the upper reaches of the MacKay River watershed in September 1977 (Herbert 1979).

Griffiths documented the presence of 12 fish species in the MacKay River watershed. Eight species (walleye, yellow perch, northern pike, burbot, white sucker, longnose sucker, trout-perch, and lake chub) were captured near the MacKay's confluence with the Athabasca River and three species (northern pike, trout-perch, and lake chub) were taken in the mid-reaches of the stream. In the mid-reaches of the Dover River, he recorded seven species (white and longnose suckers, trout-perch, brook stickleback, pearl dace, slimy sculpin, and lake chub), while four species were captured near the mouth (white sucker, trout-perch, lake chub, and longnose dace). He rated both the Dover and Dunkirk rivers low in sport fisheries potential with only the lower reaches of the MacKay River being of some importance to sport fish (walleye and northern pike).

RRCS collected four fish species (longnose sucker, lake whitefish, northern pike, and walleye) at the mouth of the MacKay River in mid-October 1975.

Nineteen species of fish, representing 10 families, were collected in the lower reaches of the MacKay River during 1977 by McCart et al. (1978). Although it did not enumerate any spawning runs, this study suggested an important role for the MacKay River in terms of providing spawning areas for longnose and white suckers. It also noted that the stream was an important summer feeding area for goldeye, northern pike, and walleye, and supported large populations of forage species (lake chub and trout-perch). This study, while extending the knowledge of the fish fauna of the MacKay River, left many questions unanswered. Because it concentrated on the region within Leases 17 and 22, it obtained no information on the resident fish populations of the mid- to upper reaches of the MacKay River and its major tributaries (Dover and Dunkirk) or on the extent to which these areas are utilized by migrant populations and small fish.

Mr. Orr collected three species of fish (brook stickleback, white sucker, and northern pike) from the upper reaches of the watershed.

Previous studies did not permit an adequate description of the fish resources of the MacKay River watershed. The composition and distribution of resident species within the watershed were yet to be described. Quantification of migrant populations that utilize the MacKay River watershed on a seasonal basis and a clear description of such seasonal utilization patterns were required. Areas within the watershed that are critical in the life histories of the various species were yet to be defined. Life history patterns and general biological features of all species required further elucidation.

3. DESCRIPTION OF THE STUDY AREA

The MacKay River drains an area of 5517 km^2 and is the largest watershed on the west side of the Athabasca River in the AOSERP study area (Figure 1). In its lower reaches, the river passes through the northwest corner of Syncrude Lease 17 and bisects Syncrude Lease 22 (Figure 2). Lease 17 is the site of Syncrude's present mining operation although no mining activities occur within the MacKay River watershed. No mining activities are presently being conducted on Lease 22. The MacKay River enters the Athabasca River approximately 60 km downstream of Fort McMurray near the village of Fort MacKay (Figure 1) and directly across the Athabasca River from the Muskeg River watershed for which a new synthetic crude oil plant (Alsands) is proposed.

The MacKay River mainstem travels approximately 200 km from its headwaters to its confluence with the Athabasca River (RRCS 1975). Two major tributaries, the Dover River (drainage area 984 km^2) and the Dunkirk River (drainage area 2183 km^2), enter it from the northwest, about 27 and 147 km, respectively, from its mouth (Figure 2). The only other major tributary is Snipe Creek, a tributary of the Dunkirk River, which has a drainage area of 489 km^2 [Northwest Hydraulic Consultants Ltd. (NHCL) 1974].

The mainstem of the MacKay River originates in the Algar Plains and, in its central watershed, drains large areas of flat, muskeg terrain. The river eventually descends into the Clearwater Lowland near its confluence with the Athabasca River (RRCS 1975). The headwaters of the Dunkirk River are situated on the south slope of the Birch Mountain Uplands and drain a large area of lakes and muskeg. Most of these lakes are 2.5 to 24.5 km^2 in area (NHCL 1974). The total length of the Dunkirk River is about 150 km (RRCS 1975). The Dover River flows generally northeast and drains a large,flat area of muskeg and marsh at the south base of the Birch Mountains. The total length of the Dover River is 103 km (RRCS 1975).

The climate of the study area is continental, characterized by cold winters, short, cool summers, and wide seasonal temperature fluctuations (Intercontinental Engineering of Alberta Ltd. 1973).

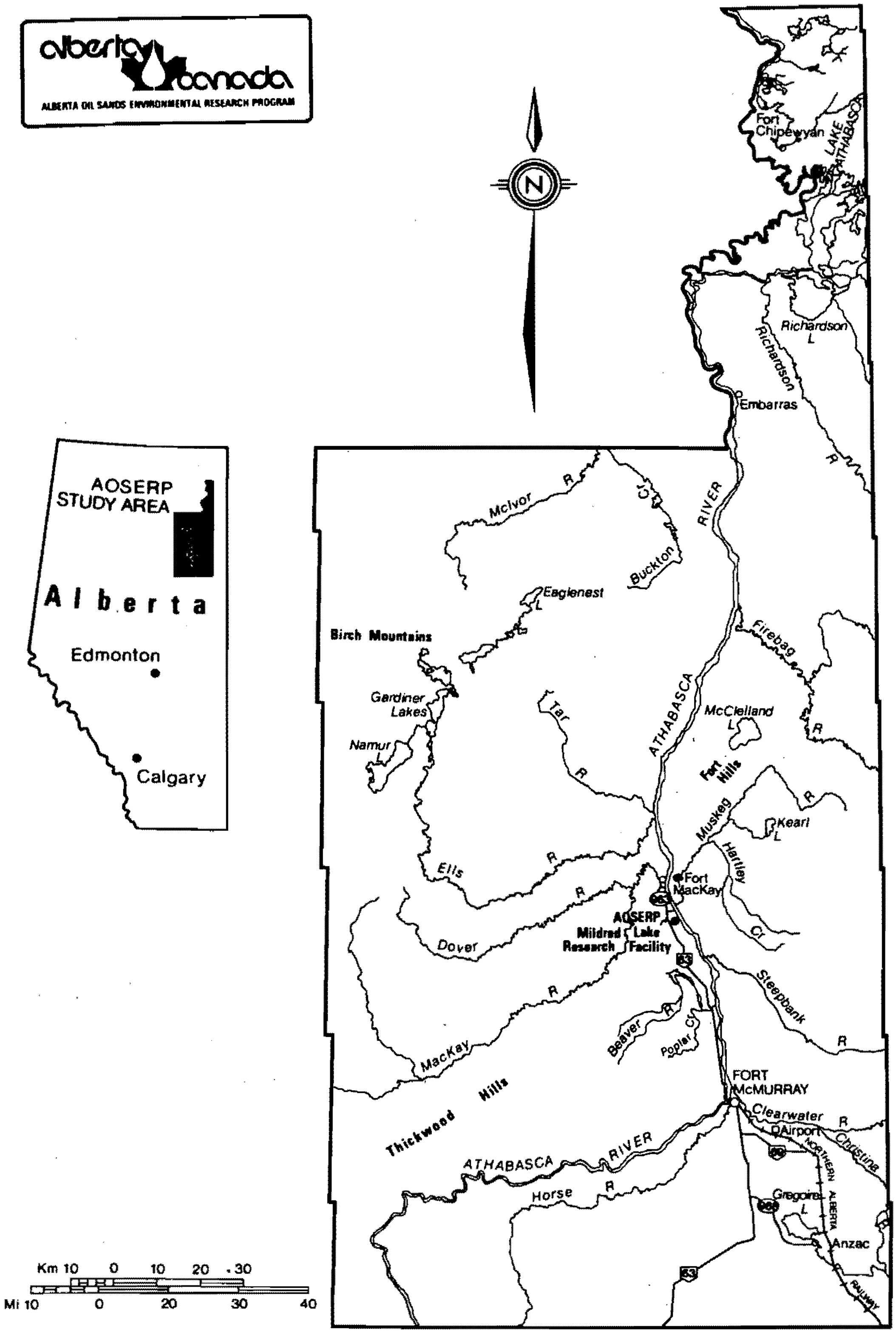

Figure 1. The AOSERP study area.

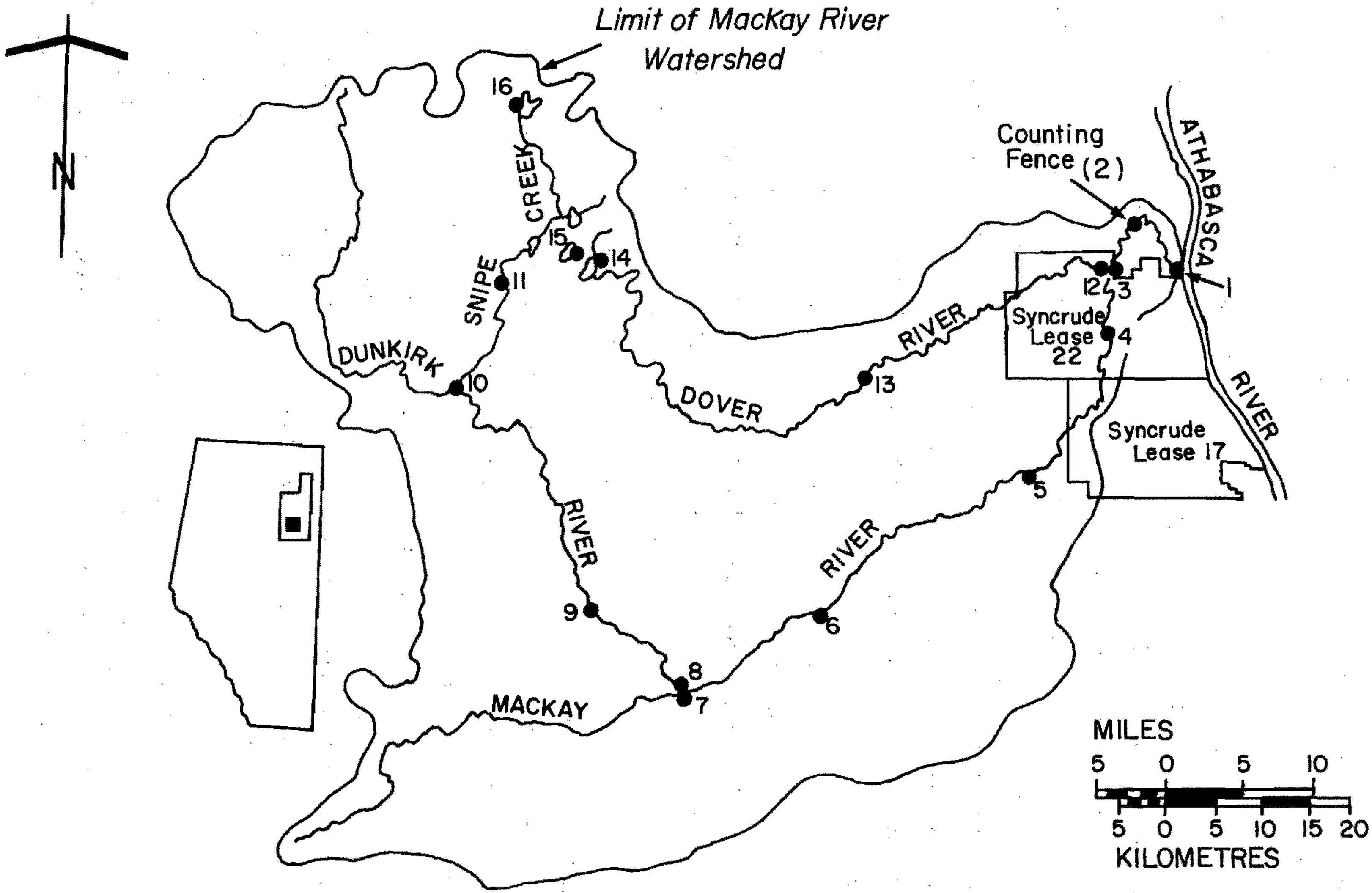

Figure 2. Map of the MacKay River drainage basin indicating the location of the counting fence and small fish collection sites.

The mean annual precipitation on the MacKay River watershed is about 51 cm (NHCL 1974).

Vegetation over most of the basin is mixed spruce and sparsely treed muskeg, due probably to the poorly drained soil conditions and the existing topography. The vegetation in the uplands and in the valley of the lower MacKay River is mixed spruce and deciduous forest and treed muskeg (NHCL 1974).

The underlying materials in the middle and upper portions of the MacKay, Dover, and Dunkirk rivers are predominantly till and lacustrine clay and silt (NHCL 1974). In the lower reaches of the MacKay River, the channel is generally stable, being confined frequently by outcroppings of McMurray Oil Sands and carbonate bedrock.

Extensive beaver activity in the upper Dunkirk and Dover rivers has resulted in a large series of pool impoundments in these areas. The pools are deep (1.2 to 1.8 m) with overhanging logs and brush-covered banks. The upper reaches of the MacKay River mainstem are predominantly pool water with flooded muskeg near the headwaters. The stream substrate in the upper MacKay watershed is mainly silt and organic detritus with very little sand or gravel. The middle reaches of the MacKay River are characterized by alternating pools and riffles in a ratio of 3:1 (Griffiths 1973). The river in this region has an average width of about 25 m and an average depth of 0.6 to 1.2 m. The substrate is mainly boulders and rubble in the riffles with boulders, gravel, and silt in the pools. The banks are well vegetated with grasses and willows, with an adjacent forest of poplar, spruce, and alder. The mid- to lower reaches of the Dunkirk and Dover rivers are similar to the MacKay River in pool to riffle ratio and substrate. The lower reaches of the MacKay River are mainly pool with some short gravel riffles. The substrate is mainly mud and silt in the pools with gravel and sand in the riffles. The average width is about 40 m and the average depth 0.5 to 0.8 m. The banks are covered with willow and poplar and show extensive flood erosion.

The MacKay River generally freezes over in late October and remains ice covered until late April. Ice on the MacKay River started to break up on 19 April in 1978 and the last day of ice conditions was 26 April (Water Survey of Canada 1979). Under ice cover, water temperatures remain near 0°C (NHCL 1975; McCart et al. 1978), but the stream can warm quickly in the spring and reach high temperatures in mid-summer. A maximum water temperature of 20°C was recorded on 4 June 1978 and daily temperature fluctuations of up to 5°C were observed (Appendix 8.1).

Discharge records for the MacKay River (Water Survey of Canada 1979) showed a mean daily discharge during 1978 of 18.2 m^3/s (range 0.3 to 118.4 m^3/s). After the spring flood, water levels gradually declined throughout the summer until heavy precipitation in late August and early September resulted in a drastic flood (Figure 3). The substantial water volume of the MacKay River at this time delayed the usual autumn decline in water temperature and ice formation.

In the autumn, a maximum water temperature of 9°C was recorded with daily minimum temperatures ranging from 5.5 to 8.0°C (Appendix 8.2); ice formation started on 5 November (Water Survey of Canada 1979).

NHCL (1975) measured several physical parameters of the MacKay, Dunkirk, and Dover rivers at selected sites during mid-winter. In the lower MacKay River (8 km from the Athabasca) and in the lower Dover River (0.8 km upstream of its mouth), average water depths of 12 and 40 cm, respectively, were recorded under the ice. Discharge rates of 0.28 and 0.12 m^3/s, respectively, were recorded at these two sites. At the mouth of the Dunkirk, and on the MacKay River 0.4 km downstream of the Dunkirk, no flow was observed and the water was presumed to be pooled. Average water depths at these sites were 70 and 43 cm, respectively. Therefore, assuming adequate oxygen levels, parts of the MacKay watershed would appear to be favourable for overwintering fish.

McCart et al. (1978) present and discuss the physical and water quality characteristics of the lower reaches of the MacKay

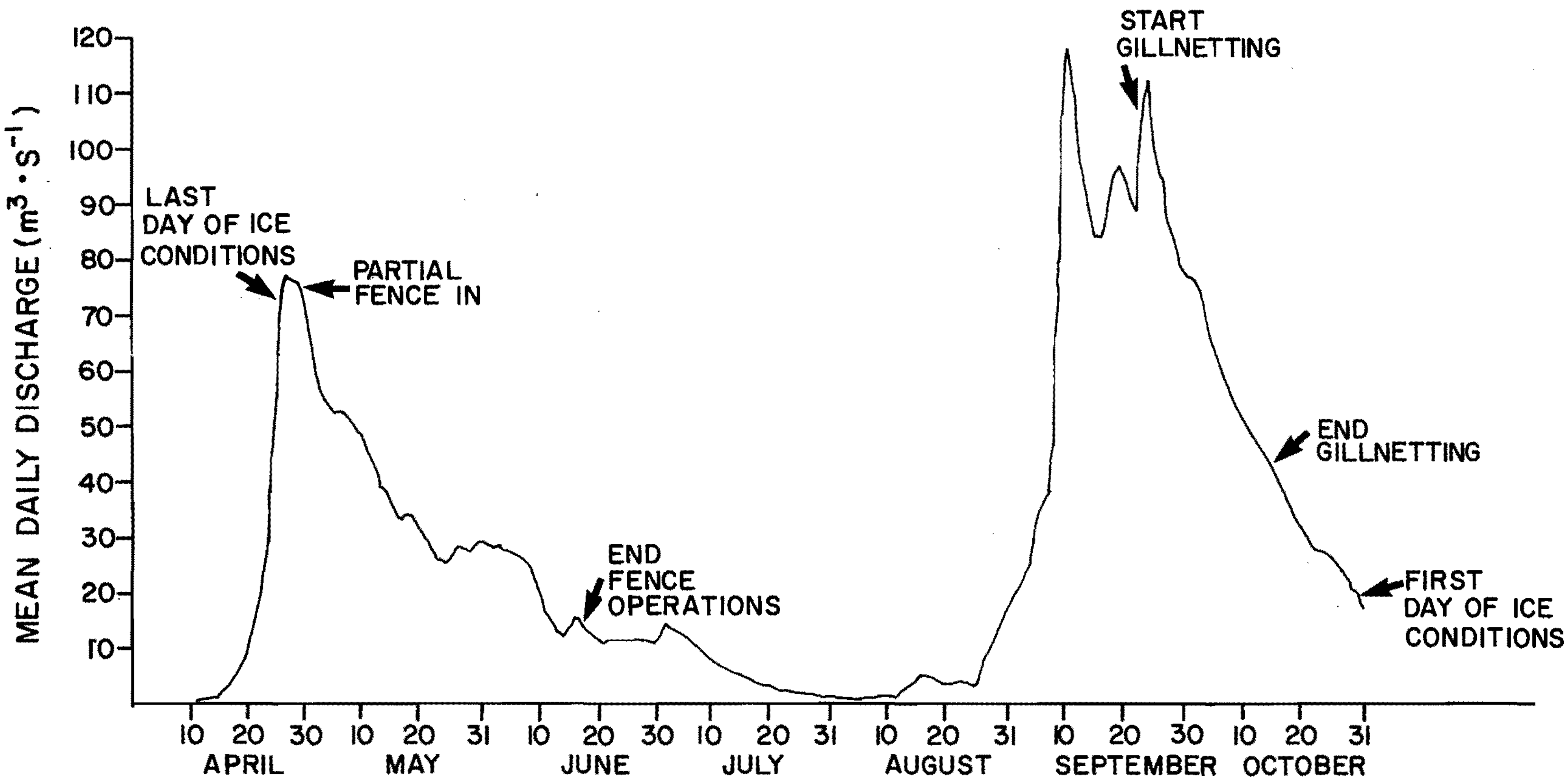

Figure 3. Discharge of the MacKay River from 11 April to 30 October 1978.

River (the region downstream of Site 5)(Figure 2). In 1977, specific conductance was lowest during the summer (June and July) and increased 3.8 times from mid-summer to mid-winter with a high of 672 µmho/cm for January samples. This trend in conductivity was paralleled by increases in total dissolved solids and total ion concentrations. All three parameters illustrate that concentrations of dissolved substances are highest in winter and lowest during the period of maximum discharge (and dilution) in spring and summer. pH values were in the neutral to slightly alkaline range (7.0 to 7.8). Turbidity and suspended sediments were highest in June, following the spring flood, and lowest during periods of minimal discharge. The MacKay water is discoloured from the bitumen and muskeg, yet carries little suspended sediment and has little or no bed load except during flood periods (NHCL 1974). Dissolved oxygen values in 1977 ranged from 7.9 mg/L in January to 11.3 mg/L in September (McCart et al. 1978).

The data of McCart et al. (1978) illustrate that there is an increase in concentration of all the major ions (Ca^{++}, Mg^{++}, Na^{+}, K^{+}, Cl^{-}, $SO_4^{=}$, HCO_3^{-}) from summer to winter, with the water being generally of the calcium bicarbonate type. During the winter, as salinity increases, there is a shift toward the sodium chloride type.

Overall, concentrations of macronutrients (total dissolved nitrogen and phosphorus and reactive silicate) were highest in winter and lowest during the ice-free season (McCart et al. 1978). Total organic carbon (TOC) ranged from 16.9 mg/L to 39.7 mg/L and was highest in mid-winter (January). The high TOC values were apparently related to the presence of exposed oil sands along the MacKay River. McCart et al. (1978) also reported that, particularly during the winter, values for oil and grease, phenols, boron, iron, nitrogen, and cadmium all exceeded the recommended standards set in Surface Water Quality Criteria (Alberta Department of Health 1970).

Additional physical and chemical data for the MacKay River are presented in Seidner (in prep.).

The MacKay River presently supports a limited sports fishery for walleye, northern pike, and goldeye. Most angling occurs near the mouth of the river and angling activity is most intense on weekends, shortly after spring break-up (McCart et al. 1978).

There is no domestic fishery on the MacKay River itself but residents of Fort MacKay do gillnet the Athabasca River near the mouth of the MacKay River (McCart et al. 1978).

4. MATERIALS AND METHODS

Study of the fish fauna of the MacKay River began on 21 April and terminated on 15 October 1978. During this period, various methods were utilized in an attempt to collect fish throughout the watershed. The major emphasis, however, was placed on the construction and operation of a two-way counting fence to monitor movements of fish within the MacKay River. The fence was established approximately 11 km upstream from the confluence of the MacKay River with the Athabasca River at a site at which, it was believed, a sizeable portion of the fish moving into the tributary from the main river could be enumerated. The fence was operated from 29 April to June 18 but the construction and operation of a fall counting fence were impossible owing to extremely high water levels in September and October. Gillnets and small mesh seines, therefore, were utilized in an effort to monitor fish movements during the autumn.

4.1 COUNTING FENCE CONSTRUCTION

The fence and traps were constructed of 2.5 cm by 2.5 cm welded wire fabric as described by Bond and Machniak (1977). Fence panels rested on steel support stakes driven into the stream bed, except in mid-stream, where the hard substrate necessitated replacing the steel stakes with wooden cribs (2.4 m high). These cribs were constructed of poplar logs and were weighted down with rocks. Once in place, the fence panels were anchored by piling rocks on the skirting that had been attached to the bottom of the panels.

Ideally, the counting fence was to have been constructed so as to form a complete temporary barrier to migrating fish. Fish travelling upstream or downstream would encounter the fence at some point and lead along it into one of the holding boxes. Unfortunately, deep water and swift current prevented the closing of the fence until 28 May, by which time most fish movement was over. Until 28 May, therefore, the fence consisted of two V-shaped structures near the banks, with from 40 to 60% of the river's width being open.

A partial upstream fence was operational by 1700 h on 29 April. This structure blocked approximately 20% of the river's width at the time of its installation and was situated near the right bank. Receding water levels in early May necessitated the dismantling and relocation of this structure twice subsequent to 29 April. On 2 May, it was moved a short distance upstream along the right bank, and on 12 May it was moved to deeper water on the left side of the river. On 12 May, the partial upstream fence was blocking 14 m (28%) of the river's width and the partial downstream fence, located near the right bank, was blocking 17 m (34%).

4.2 COUNTING FENCE OPERATION

The operation of a counting fence of this type is highly labour intensive, especially during high water periods. Debris carried by the river tends to clog the openings in the wire mesh, placing great pressure on the structure. Frequent cleaning is required to remove such debris and prevent the fence being washed out. Fluctuating water levels can also create situations that necessitate the dismantling and relocation of the fence.

A partial upstream fence was operated from 29 April to 18 June 1978, during which period the trap was checked three to seven times daily. The downstream trap was checked three to five times daily from 8 May to 15 June.

4.2.1 Trap Checks

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

Relative water levels, taken from a metre stick placed in the stream, and water temperature, measured by a Taylor max-min thermometer or pocket thermometer, were recorded at each trap check. Daily temperature values recorded during the spring fence operation are given in Appendix 8.1. The fence was cleaned as required and examined for holes.

4.2.2 Tagging

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

Fork length (± 1.0 mm) was recorded for each fish tagged (total length for burbot) and the sex noted if possible. Tagged fish were not weighed and no body structures were retained for age determination. A portable 2500 W generator enabled the fence crew to tag fish during the late evening and at night. Care was taken at all times not to impede the progress of the fish any more than necessary. When large numbers of fish were observed entering the trap, tagging was curtailed and the remaining fish were enumerated and passed through.

The tagging program was well publicized by posters and press releases and a two dollar reward was offered for returned tags. Tag returns were made by sport fishermen along the Athabasca River, by domestic fishermen on the Athabasca River and Lake Athabasca, and by commercial fishermen on Lake Athabasca.

4.2.3 Dead Samples

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

4.3 OTHER FISH COLLECTION TECHNIQUES

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

Monthly helicopter surveys were used to collect fish throughout the watershed (Figure 2) in an effort to acquire information on the summer distribution and relative abundance of fish in the MacKay River study area.

4.3.1 Gillnets

Gillnets were utilized primarily in early spring (21 April to 3 May) and during the autumn (24 September to 15 October). Spring sampling was conducted in order to detect fish movements occurring prior to the installation of the counting fence. Individual sets varied from 2 to 48 h. During the autumn, gillnets were substituted for a counting fence because of high water levels. At that time, three or four 24 h sets were made daily at suitable sites near the counting fence location (Figure 2). The gillnets employed were either 9.1 m long by 2.4 m deep with 10.2 cm (stretched mesh) braided nylon, or research gangs, 18.1 m long by 2.4 m deep composed of equal lengths of 3.8, 5.1, 6.4, 7.6, 8.9, and 10.2 cm (stretched mesh) braided nylon. On occasion, during the summer, gillnets were also used in upstream locations to capture large fish. All fish taken in gillnets were subjected to complete biological analysis.

4.3.2 Small Fish Collections

Thirteen stream sites and one lake (Lake 16) in the MacKay River watershed were sampled for small fish in 1978 (Figure 2). Each site consisted of 100 to 200 m of stream channel or lakeshore which was sampled where possible in a standard unit of effort (five seine hauls of approximately 6 to 8 m per site). Most sites were sampled four or five times during the summer but the region around the fish fence was sampled more frequently (Table 1). Daily seine collections were made at the fence site during the autumn (24 September to 15 October) to monitor the abundance of small fish which might indicate downstream movements.

The small fish collection sites also served as point sample locations for purposes of habitat analysis.

4.3.3 Larval Fish

Drift nets were used to monitor movements of larval fish between 30 May and 19 June. A single drift net was installed near the right bank just upstream of the fence site on 30 May. A second sampler was installed near the left bank on 3 June and a third was

Table 1. Sampling dates for small fish seine collections in the MacKay River watershed, 1978.

	Date Samples Taken at Each Collection Site[a]													
Month / Site	1	2	3	4	5	6	7	8	9	10	11	12	13	Lake 16
May		3, 10, 16, 24, 31		21	20	20	20	20	20	20		20	20	
June		7, 14	4, 15, 16	17	17	17	16	16	16	16		4, 15, 16	16	
July	22, 29	7, 14	15	15	15	15	15	15	14	14		14	14	
August	4, 12, 18, 26	16	16		17	17	17	17	17	17	17	16	16	16
September		25 to 30	16									16	16	
October		1 to 14	14	14	14	14	14	14	14	14		14	14	

[a] Collection sites are those indicated in Figure 2.

placed in mid-stream on 4 June. All drift nets were installed so that the top of the sampler was just below the water surface. These three nets were constructed of 505 μm Nitex, were 90 cm long, and had a mouth opening of 30 x 45 cm. Samplers were usually checked three times daily, at 1200, 1800, and 2200 h. On three occasions, however, (8 to 9 June, 11 to 12 June, and 15 to 16 June) nets were checked every 2 h over a 24 h period. At each check, fry were removed from the nets and preserved in 10% formalin.

In addition to the above, drift nets were used to capture drifting fry from the Dover River and from the MacKay River just upstream of the Dover. Three nets with a mouth opening of 15 x 15 cm, 45 cm long, and constructed of 505 μm Nitex were installed for a period of 24 h in the Dover River, just upstream of its mouth, on 4 to 5 June. These nets were also used in the Dover and in the MacKay River upstream of the Dover on 15 to 16 June, during which time they were checked every 2 h over a 24 h period.

4.4 LABORATORY TECHNIQUES

4.4.1 Fish Identification

Preserved fish specimens were identified using taxonomic keys and descriptions given by Paetz and Nelson (1970) and McPhail and Lindsey (1970). Larval fish were identified using the references of Fish (1932), Norden (1961), and Mansueti and Hardy (1967). While some larvae could be identified to species, larval catostomids were often identified only to genus and small cyprinids were identified only to family.

4.4.2 Age Determination

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

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

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

4.4.3 Fecundity

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

4.4.4 Food Habits

The stomach contents of preserved fish were removed and the food items identified to the lowest possible taxon (usually order or family). Results were expressed as percentage frequency of occurrence and percentage of total number.

4.4.5 Length and Weight of Small Fish

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

4.4.6 Data Analysis

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

Length-weight relationships are described by the power equation:

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

where: W = weight (g)

L = fork or total length (mm)

a = y-intercept

b = slope of the regression line

sb = standard deviation of b.

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

4.5 AQUATIC HABITAT ANALYSIS

An effort was made to characterize the aquatic habitat of the MacKay River utilizing the procedures described by Brown et al. (1978). In this system, streams are divided into reaches which differ from each other in their physical characteristics. A helicopter survey is used to produce average values for various parameters over each entire reach and site-specific information is gathered from sample points within each reach.

4.5.1 Reach Definition and Description

A reach is a section of stream whose physical properties (habitat characteristics) are relatively homogeneous throughout its length. According to Brown et al. (1978), reach boundaries are located in regions where the topography changes drastically, or significant changes in water quality, channel forms and/or flow character occur.

Tentative reach boundaries for the MacKay, Dover, and Dunkirk rivers were assigned by reference to National Topographical Series maps (1:50 000) and available gradient information (RRCS 1975). These were later verified in the field. Aerial photo interpretation, a recommended method for assigning tentative reach boundaries, was not used in the present study.

General descriptions of each reach were acquired during an aerial survey of the MacKay watershed. At that time, observations were recorded on various aspects of the aquatic habitat. These characteristics, which include velocity, substrate, pools, riffles, riparian vegetation etc., are presented as averages of these parameters over the length of the reach.

4.5.2 Point Samples

Point sample locations had originally been selected during the spring for fish sampling purposes (Figure 2). Site-specific information on biological and physical parameters was collected between May and October 1978 at these sites. At each site, stream width was measured and the depth was taken at three locations across the channel. A rough estimate of stream velocity was obtained by floating a small chip a distance of 5 m and timing it. This was also done at three locations across the channel. The substrate composition at the site was estimated in terms of fines (< 2 mm), gravel (2 to 64 mm), larges (> 64 mm), and bedrock. Riparian and aquatic vegetation were noted and water temperature was recorded using a pocket thermometer. At every second site, dissolved oxygen was determined using a Hach field kit (Model AL-36-B) and pH was estimated by means of a Hach colour comparator. Specific conductance was measured using a Beckman RB-3 conductivity meter.

Five seine hauls (3.2 mm oval mesh) or 15 to 20 dipnet efforts were made at each location. Fish captured were preserved in 10% formalin in the field and were later identified to species, measured, and weighed.

The benthic macro-invertebrate fauna was sampled at monthly intervals at most sites using a long-handled dipnet having a round aperture and constructed of 202 µm Nitex. In areas where the current permitted, benthic invertebrates were gathered using the kick method. In making such collections, the collector walked upstream, disturbing the substrate with his foot and holding the net in such a way that the dislodged animals were swept into it. Where deep water or insufficient current did not permit the use of this method, benthic macroinvertebrates were collected by running the dipnet along the stream bed. Benthos was preserved in 10% formalin for later analysis.

In the laboratory, the larger animals were first removed from each kick sample. The sample was then mixed thoroughly and a portion was withdrawn. All animals in this portion were then sorted from the associated debris under 10X magnification into major taxa (Chironomidae, Ephemeroptera, Plecoptera, Trichoptera, Simuliidae, Oligochaeta, and others). Additional portions were examined, if necessary, until at least 300 animals had been removed. These organisms were enumerated and percentage composition of the fauna was calculated. Samples collected during May were identified to the family level.

4.6 LIMITATIONS OF METHODS

4.6.1 Counting Fence

The primary objective of the present study was to enumerate and describe the migrant fish populations that utilize the MacKay River on a seasonal rather than a year-round basis. The best possible means of achieving such an objective is, undoubtedly, a counting fence. Fences of the type described in this study have been used successfully to enumerate fish runs in other tributaries in the AOSERP study area (Bond and Machniak 1977, 1979; Machniak and Bond 1979). Since it was expected that spring and autumn would be the times of most intensive movement for the major fish species found in the AOSERP study area, the MacKay River counting fence was to concentrate on those periods. Unfortunately, however, the high water levels encountered in the MacKay River during 1978 did not permit a full fence operation. Only a partial fence was possible during the spring when MacKay River discharge exceeded 75 m^3/s; the installation of a fence of any description was impossible during the autumn when the discharge exceeded 115 m^3/s (Figure 3).

The partial upstream trap that was operated for most of the spring period did not permit a total count of the migrant fish populations during their upstream runs. Furthermore, it is not possible to say what proportion of upstream migrants were trapped or if all species were equally susceptible to capture. It is known that fish moved upstream along both banks; however, it is not known to what extent fish migrated in midstream. Nevertheless, the partial upstream fence did provide important information as to the nature and timing of upstream migrations.

The downstream trap, in contrast to the upstream trap, captured few fish. This may have been a result of a tendency on the part of downstream migrants to move in midstream rather than near shore. Downstream movement patterns following the spawning season cannot, therefore, be described on the basis of the results of the present study.

The physical demands of constructing and operating the spring counting fence left the field staff with little time to fly the watershed in search of fish on spawning grounds. Thus, no observational data were collected regarding spawning locations or the extent of movement by non-resident fish within the MacKay River watershed. It is felt, however, that the high turbidity of the MacKay River at that time of the year would have rendered such an effort futile in any event.

4.6.2 Gillnets

The problems associated with sampling the fish populations of large rivers are well known and relate to conditions of current, fluctuating water levels, and water-borne debris. These conditions severely limit the choice of sampling sites as well as the efficiency of the gear employed. Essentially, sampling sites used in this study were confined to areas in which the current was reduced to such a level as to permit the use of the gillnets. These, invariably, were limited to small, near-shore back eddies, and catches made in such areas may not be truly representative of the overall situation.

Gillnets are known to be highly selective for size of fish. Essentially, each mesh size tends to capture fish of a particular size range. This range varies with species and depends not only on the size of the fish but on whether it is of a species that tends to be captured by wedging itself in a mesh (e.g., lake whitefish, flathead chub, suckers) or by entangling itself by teeth or spines (e.g., pike, walleye, goldeye). Fish captured by entangling usually demonstrate a wider size range in a particular mesh size. Because of the limited size range over which a gillnet of a given mesh size is effective, fish populations are best sampled by employing gangs of gillnets of varying mesh sizes, whose selectivity curves overlap broadly. Most of the gillnets used in the present study were research gangs consisting of six mesh sizes. Such gangs were considered effective for collecting most northern fish species by Rawson (1951) and Hatfield et al. (1972). However, gillnets are considered less effective during floods when debris can quickly clog or damage them.

During the present study, gillnets were used mainly as a tool for detecting the presence or absence of fish during the spring and autumn flood periods when other collection techniques were not feasible. In terms of the larger fish species, they are thought to have performed adequately in this regard.

4.6.3 Small Fish Collections

The small mesh seines (3.2 mm) utilized in the present study are considered to have been highly effective in identifying the presence of small fish in most areas of the MacKay River watershed. However, their usefulness was limited in deep water, in fast current, and in areas where large stones or snags interfered with the seining process. Thus, many of the hauls made in the upper reaches of the watershed (Sites 7, 8, 10, and 13) may have underestimated the number of fish present. Catch efficiency in all areas was probably reduced greatly during the autumn flood period.

4.6.4 Drift Nets

The main purpose of the drift nets was to detect the time of fry emergence and to monitor the downstream fry migrations. In these endeavours, some success was achieved. It was not possible, however, to quantify these fry migrations except in relative terms. The efficiency of the drift nets is believed to have decreased very rapidly as a result of clogging of the nets with water-borne debris and a quantitative estimate of the migrations would have required a much more intensive sampling effort than was possible in the present study.

4.6.5 Winter Sampling

Because no winter sampling was conducted, the present study produced no information on fish utilization of the MacKay River watershed at that time of the year.

4.6.6 Habitat Analysis

The types of physical and biological parameters that needed to be identified for 1:50 000 scale map inventory work were discussed during an AOSERP aquatic habitat workshop held in September 1978 (Wrangler and Seidner 1979) by T. Chamberlin and T. Harding of the Resource Analysis Branch of the British Columbia Ministry of Environment. They cautioned that considerable practice was required to acquaint individuals with reach boundary identification and point sample selection before watersheds could be inventoried and mapped properly. In addition, they emphasized that uniform methodology (parameter estimation and data collection) was essential to the procedure and was best handled by training prior to going into the field. Because the staff who conducted present study were not trained in biophysical analysis, the data collected are of a preliminary nature and may be of limited use in terms of their application to an integrated habitat analysis of the watersheds in the AOSERP study area.

A biophysical map was not prepared for the MacKay River watershed although data were gathered which would permit construction of such a map as described by Brown et al. (1978).

5. RESULTS AND DISCUSSION

5.1 GENERAL

Field work during the open-water period of 1978 documented the presence in the MacKay River watershed of 20 fish species representing 10 families (Table 2). Emerald shiners, reported from the mouth of the MacKay River by McCart et al. (1978), were not captured during the present study.

A total of 5577 fish (10 species) were counted through the partial upstream fence (Table 3) and an additional 198 fish (4 species) were gillnetted during the spring upstream migrations (Table 4). White suckers (68.6%) and longnose suckers (21.4%) comprised the majority of these fish, while walleye (6.3%), northern pike (1.6%), Arctic grayling (0.8%), and flathead chub (0.7%) made up most of the remainder. It was not possible to say what proportion of the total upstream movement was captured by the partial fence operation.

By 15 June, 209 fish had been recorded at the partial downstream fence (Table 3). Many of these fish (83 white suckers and 40 longnose suckers) were either dead or in very poor physical condition. Many more fish had returned downstream by this date but were able to avoid the fence. Large numbers of fish (mainly suckers) were seen drifting downstream past the fence site in mid-channel during the last 10 days of May.

It was not possible to monitor the autumn downstream fish movements by means of a counting fence because of the high water levels in the MacKay River. However, an autumn gillnetting program suggested that some migrant fish remained in the MacKay River watershed throughout the summer. Seventy-seven fish (8 species) were captured in gillnets during the autumn (Table 5). White suckers (36.4%), northern pike (29.9%), longnose suckers (19.5%), and walleye (7.8%) comprised the majority of fish taken.

Young-of-the-year suckers appeared and were captured in large numbers in drift nets set in the lower Dover River and lower MacKay River during the first half of June. Young-of-the-year

Table 2. List of fish species captured in the MacKay River drainage during 1978.

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

Table 3. Summary of fish recorded at MacKay River counting fence, 1978.

Species	Number of Fish	
	Upstream Trap	Downstream Trap
White sucker	3934	108[a]
Longnose sucker	1072	56[a]
Walleye	364	5
Northern pike	87	15
Arctic grayling	45	4
Flathead chub	43	11
Goldeye	21	0
Lake whitefish	5	0
Burbot	5	8
Lake chub	0	2
Trout-perch	1	0
Total	5577	209

[a] Includes fish found dead on the downstream panels of the fence.

Table 4. Summary of gillnet catches during the spring operation in the MacKay River, 1978.

Date / Effort (h)	Location[a] (km)	Type of Gillnet	Number of Fish: Longnose suckers	White suckers	Arctic grayling	Northern pike	Total
21 to 23 April							
48[b]	-10	Research gang	0	0	0	0	0
27 April							
4	0	Research gang	0	0	0	0	0
4	0	Research gang	0	0	0	0	0
28 April							
16[b]	0	Research gang	0	0	0	0	0
4	0	Research gang	0	0	0	0	0
4	0	Research gang	0	0	0	0	0
29 April							
16[b]	+8	10.2 cm x 9.1 m	0	0	0	0	0
8	+8	10.2 cm x 9.1 m	0	1	0	0	1
7	-2.2	10.2 cm x 9.1 m	38	2	0	0	40
7	-1.3	10.2 cm x 9.1 m	10	4	1	0	15
7	+3.5	Research gang	10	2	2	0	14

continued ...

Table 4. Concluded.

Date / Effort (h)	Location[a] (km)	Type of Gillnet	Number of Fish: Longnose suckers	White suckers	Arctic grayling	Northern pike	Total
30 April							
15[b]	+3.5	Research gang	9	0	0	0	9
7	+4.5	10.2 cm x 9.1 m	5	1	0	0	6
8	-1.3	10.2 cm x 9.1 m	15	1	0	0	16
8	-1.3	10.2 cm x 9.1 m	28	8	0	1	37
7	+3.5	Research gang	30	0	1	0	31
7	+4.5	10.2 cm x 9.1 m	3	0	0	0	3
2 May							
2	-1.3	10.2 cm x 9.1 m	14	3	0	1	18
25 May							
17[b] (2 nets)	-1.3	10.2 cm x 9.1 m	1	1	0	1	3
27 May							
17[b] (2 nets)	-1.3	10.2 cm x 9.1 m	1	4	0	0	5
Totals			164	27	4	3	198

[a] The location is approximate distance (km) upstream (+) or downstream (-) of the counting fence.

[b] Overnight set.

Table 5. Number of fish captured each day during the autumn gill-netting program in the MacKay River, 1978[a].

Date	White sucker	Northern pike	Longnose sucker	Walleye	Lake whitefish	Arctic grayling	Goldeye	Burbot	Total
	Number of Fish								
24 Sept.	1	0	1	0	0	0	0	0	2
25	1	0	0	0	0	0	0	0	1
26	3	4	0	0	0	0	1	0	8
27	1	0	1	0	0	0	0	0	2
28	0	0	1	0	0	1	0	0	2
29	1	0	1	3	0	0	0	0	5
30	0	1	1	0	1	0	0	1	4
1 Oct.	0	0	0	1	1	0	0	0	2
2	0	5	1	0	0	0	0	0	6
3	0	1	0	0	0	0	0	0	1
4	3	2	0	1	0	0	0	0	6
5	0	0	0	0	0	0	0	0	0
6	6	0	2	1	0	0	0	0	9
7	1	2	1	0	0	0	0	0	4
8	2	0	2	0	0	0	0	0	4
9	1	0	1	0	0	0	0	0	2
10	3	0	2	0	0	0	0	0	5
11	2	3	0	0	0	0	0	0	5
12	0	0	1	0	0	0	0	0	1
13	1	0	0	0	0	0	0	0	1
14	0	0	0	0	0	0	0	0	0
15	2	5	0	0	0	0	0	0	7[b]
Totals	28	23	15	6	2	1	1	1	77

[a] Fish were captured between the fence site (Site 2) and the hydrology gauging station (3 km downstream).

[b] Includes two northern pike captured at Site 3 and one northern pike and one white sucker each at Sites 4 and 6, respectively.

cyprinids, cottids, and trout-perch were also captured in drift nets at that time, although in much smaller numbers (Appendices 8.3 and 8.4).

Seine collections taken throughout the MacKay River watershed during the open-water period produced 15 764 fish of 16 species (Appendix 8.5). An additional 135 fish, including three species not captured in seines (mountain whitefish, goldeye, and flathead chub), were taken during the summer by dipnets, minnow traps, angling gear, and gillnets. These additional fish have been included in Table 6 which indicates the overall distribution and relative abundance of the various species in the MacKay River watershed. The majority of fish shown in Table 6 (79%) were captured in seines at the fence site during the autumn (Table 7).

Overall, lake chub were the most abundant small fish in seine samples, accounting for 50.0% of the total catch in that gear. Young-of-the-year and juvenile suckers (27.1%) and trout-perch (19.3%) accounted for most of the remainder. Slimy sculpins (1.2%), longnose dace (0.8%), finescale dace (0.6%), and yellow perch (0.4%) occurred in smaller numbers (Appendix 8.5).

Lake chub were captured at all sites except Site 11 and Lake 14 but were most common at Sites 2, 3, and 5 in the MacKay River, Site 9 in the Dunkirk River, and Site 12 in the Dover River. McCart et al. (1978) found lake chub were the dominant species in the region bounded by Leases 17 and 22 (Figure 2). Young-of-the-year suckers of both species were most common in the mid-reaches of the MacKay River watershed during the early summer. Longnose suckers were particularly abundant at Sites 4, 5, and 6, while white suckers were common at Sites 5 and 6 (MacKay River), Site 9 (Dunkirk River), and Site 12 (Dover River). McCart et al. (1978) found that sucker fry were most common in the region upstream of Lease 22, indicating that spawning areas of both species extend some distance upstream. Trout-perch occurred at most sampling sites but, during June, July, and August, were most common at Sites 4, 5, 10, and 12. Finescale dace were restricted in distribution and were usually taken at sites where

Table 6. Distribution and percentage composition for fish captured at each location in the MacKay River watershed, 1978[a].

Species	MacKay River														Dunkirk River								Dover River				Total	
	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Site 8		Site 9		Site 10		Site 11		Site 12		Site 13			
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Lake chub	107	37.3	6876	52.9	157	71.0	35	11.2	177	40.6	57	11.8	1	2.6	7	50.0	224	54.4	1	3.0	0	0.0	209	39.7	34	23.8	7885	49.6
Trout-perch	44	15.3	2846	21.9	9	4.1	56	17.9	12	2.8	0	0.0	0	0.0	1	7.1	28	6.8	22	66.7	0	0.0	12	2.3	8	5.6	3038	19.1
Longnose sucker	2	0.7	1733	13.3	10	4.5	196	62.8	80	18.3	114	23.6	4	10.3	0	0.0	34	8.3	0	0.0	0	0.0	25	4.7	16	11.2	2214	13.9
White sucker	37	12.9	1296	10.0	9	4.1	11	3.5	73	16.7	275	56.8	1	2.6	1	7.1	114	27.7	4	12.1	0	0.0	225	42.7	62	43.4	2108	13.3
Slimy sculpin	9	3.1	144	1.1	7	3.2	2	0.6	10	2.3	0	0.0	0	0.0	1	7.1	7	1.7	0	0.0	0	0.0	8	1.5	7	4.1	195	1.2
Longnose dace	10	3.5	54	0.4	16	7.2	9	2.9	15	3.4	3	0.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	3.4	0	0.0	125	0.8
Finescale dace	0	0.0	2	<0.1	10	4.5	0	0.0	41	9.4	28	5.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18	3.4	0	0.0	99	0.6
Northern pike	1	0.4	20	0.2	3	1.4	1	0.3	0	0.0	4	0.8	32	82.1	2	14.3	2	0.5	1	3.0	0	0.0	0	0.0	0	0.0	66	0.4
Yellow perch	62	21.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	1.4	64	0.4
Pearl dace	0	0.0	0	0.0	0	0.0	0	0.0	24	5.5	1	0.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	12	2.3	0	0.0	37	0.2
Brook stickleback	0	0.0	5	<0.1	0	0.0	2	0.6	3	0.7	0	0.0	1	2.6	2	14.3	3	0.7	4	12.1	0	0.0	0	0.0	14	9.8	34	0.2
Walleye	4	1.4	6	<0.1	0	0.0	0	0.0	0	0.0	2	0.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	12	0.1
Spottail shiner	11	3.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	11	0.1
Arctic grayling	0	0.0	1	<0.1	0	0.0	0	0.0	1	0.2	0	0.0	0	0.0	0	0.0	0	0.0	1	3.0	0	0.0	0	0.0	0	0.0	3	<0.1
Burbot	0	0.0	3	<0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	<0.1
Mountain whitefish	0	0.0	2	<0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	<0.1
Flathead chub	0	0.0	1	<0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	<0.1
Goldeye	0	0.0	1	<0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	<0.1
Spoonhead sculpin	0	0.0	1	<0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	<0.1
Total	287		12 991		221		312		436		484		39		14		412		33		0		527		143		15 899	

[a] This table includes all fish taken in seines (Appendix 8.5) as well as 135 fish that were captured in dipnets, minnow traps, gillnets, and angling gear during the summer. It does not include fish shown in Tables 3, 4, and 5.

Table 7. Daily summary for fish captured in seines during September and October, 1978, at the MacKay River fence site.[a,b]

Date	Number of Fish										
	Lake chub	Trout-perch	Longnose sucker	White sucker	Slimy sculpin	Longnose dace	Northern pike	Brook stickleback	Finescale dace	Burbot	Total
25 September	53	48	33	15	7	0	0	0	0	0	156
26	13	48	4	0	10	5	0	0	0	0	80
27	15	4	9	0	15	5	0	1	0	0	49
28	32	4	7	0	4	4	0	1	1	0	53
29	26	6	13	1	6	1	0	0	0	1	54
30	29	11	4	4	2	2	0	1	0	1	54
1 October	142	48	54	15	4	0	0	0	0	0	263
2	0	0	1	3	0	0	0	0	0	0	4
3	309	152	77	30	1	0	0	0	0	0	569
4	500	100	54	21	0	0	0	0	0	0	675
5	500	100	80	40	0	0	0	0	0	0	720
6	1000	1000	500	500	0	0	0	0	0	0	3000
7	1000	250	250	125	0	0	0	0	0	0	1625
8	1000	0	20	40	10	10	1	0	0	0	1081

continued ...

Table 7. Concluded.

Date	Number of Fish										Total
	Lake chub	Trout-perch	Longnose sucker	White sucker	Slimy sculpin	Longnose dace	Northern pike	Brook stickleback	Finescale dace	Burbot	
9 October	500	100	200	200	3	0	0	0	0	0	1003
10	0	0	0	0	0	0	0	0	0	0	0
11	700	600	100	102	0	0	2	0	0	0	1504
12	100	100	50	50	5	0	0	0	0	0	305
13	328	70	40	25	47	0	2	2	1	0	515
14	450	150	150	50	10	0	0	0	0	0	810
Totals	6697	2791	1646	1221	124	27	5	5	2	2	12 520

[a] Normally fish were either kept or counted and released unharmed. Where catches exceeded 300 fish, the total number of fish was estimated.

[b] The number of fish indicated represents the actual or estimated total catch produced by five hauls of a 3 m seine over a distance of approximately 6 to 8 m per haul, except for 11 and 14 October, when only three hauls were made.

smaller tributaries entered the mid-reaches of the MacKay River (Sites 3, 5, 6, and 12). Species such as longnose dace and slimy sculpin were more common in the lower reaches of the MacKay River watershed, whereas brook stickleback appear to be more common in the upper reaches.

The relative abundance of the various small fish species varied throughout the summer as the result of the appearance of young-of-the-year and, especially, as a result of downstream migrations in October. Large increases in the catch-per-unit-effort values for lake chub, longnose suckers, white suckers, and trout-perch at Site 2 during October (Table 7, Appendix 8.5) indicated a migration of these small fish out of the watershed at that time.

Floy tags were applied to 3509 fish (Table 8), the majority of which were white suckers (73.1%), longnose suckers (17.8%), walleye (6.6%), and northern pike (1.7%). Fish were tagged only during the spring fence operation and, except for one fish, all were tagged during the upstream run. Recaptures at the fence site during the spring (n = 56) provided little information on the length of time spent by migrant fish in the MacKay River watershed since 80% were recaptured at the upstream trap (Appendix 8.6). Results to date, for fish tagged at the fence site and recaptured outside the MacKay River watershed, show a return rate of only 1.1% (Table 8). The highest recapture rates obtained outside the watershed were for white suckers (1.4%) and walleye (0.9%).

5.2 LIFE HISTORIES OF FISH SPECIES

5.2.1 White Sucker

5.2.1.1 Seasonal timing of upstream migration. The movement of white suckers into spawning streams appears to be triggered by increasing water temperatures in the tributaries following spring break-up, and often begins when the daily maximum water temperature in the spawning stream approaches 10°C (Geen et al. 1966; Bond 1972).

Table 8. Summary of tag releases and recaptures for fish tagged at the MacKay River upstream trap, 1978.

Species	Number Tagged	Percent of Total Number Tagged	Number of Fish Recaptured			
			At Fence Site		Outside MacKay Watershed	
			Spring	Autumn	N	%
White sucker	2565	73.1	37[a] (3)[b]	1	36	1.4
Longnose sucker	625	17.8	2[a] (5)[b]	0	1	0.2
Walleye	232	6.6	4[a]	0	2	0.9
Northern pike	60	1.7	1[a]	2	0	0.0
Goldeye	10	0.3	0	0	0	0.0
Flathead chub	9	0.3	0	0	0	0.0
Arctic grayling	4	0.1	0	0	0	0.0
Burbot	4	0.1	(1)[b]	0	0	0.0
Total	3509		44[a] (9)[b]	3	39	1.1

[a] Upstream trap.

[b] Fish found dead on the downstream portion of the fence.

Decreases in water temperature have been shown to retard the progress of the migration (Geen et al. 1966; Tremblay 1962). White suckers were present in small numbers and were beginning to move upstream in the MacKay River by 29 April, on which date the maximum water temperature was 4.5°C (Table 9, Figure 4). Peak movement was recorded on 13 May (n = 569) and 14 May (n = 401) when water temperatures reached 11 and 13°C, respectively. Although white suckers continued to be taken at the upstream trap until operations terminated on 18 June, the upstream migration was essentially complete by 18 May as 94% of the upstream captures had occurred by that date.

The daily pattern of captures shown in Figure 4 seems to be in some conflict with the pattern usually observed, i.e., that the number of migrants increases as the water warms to 10°C. Between 4 and 6 May, as the water temperature rose from 7 to 10.5°C, the number of migrant white suckers captured in the upstream trap actually decreased. The number then increased on 8 and 9 May when the water temperatures dropped. The apparent contradiction may be attributable to a reduction in the efficiency of the upstream trap as a result of rapidly decreasing water levels between 29 April and 12 May (Figure 4). As mentioned previously, decreasing water levels necessitated moving the upstream trap to deeper water on the opposite side of the river on 12 May.

5.2.1.2 Diel timing of upstream migration. The majority of white suckers (89%) moved upstream between noon and midnight with 51% being captured between 1500 and 2100 h (Table 10). Maximum upstream movements occurred each day when stream temperatures were at or near their daily highs (Appendix 8.1). Other studies have also shown that white suckers tend to run during the evening hours (Raney and Webster 1942; Geen et al. 1966; Bond 1972; Bond and Machniak 1977; Machniak and Bond 1979). The diel timing of the migration can vary, however, from year to year in the same stream. Maximum upstream movements (73%) occurred in late afternoon and early evening in 1976 in the Muskeg River (Bond and Machniak 1977), but in 1977, the majority of fish (78%) moved upstream at night (Bond and Machniak 1979).

Table 9. Summary of fish enumerated during the spring counting fence operation in the MacKay River, 1978.

Date	Upstream Trap: White Sucker	Longnose Sucker	Walleye	Northern pike	Arctic grayling	Flathead chub	Goldeye	Daily Totals	Downstream Trap: White sucker	Longnose sucker	Northern pike	Flathead chub	Burbot	Walleye	Daily Totals[c]
29 April	11[a]	69[a]	0	0	6[a]	0	0	87[ab]							
30	66[a]	183[a]	0	1[a]	18[a]	0	0	267[a]							
1 May	200	239	0	3	13	0	0	455							
2	82[a]	216[a]	1	8[a]	5	0	0	312[a]							
3	361	181	15	16	1	0	0	574							
4	295	72	43	10	2	0	0	422							
5	268	49	39	13	0	0	0	369							
6	127	14	34	8	0	0	0	183							
7	211	7	10	3	0	0	0	232[b]							
8	273	15	9	3	0	0	0	301[b]			Trap Installed				0
9	319	7	5	3	0	0	1	337[b]	0	0	0	0	0	0	0
10	58	7	3	4	0	0	0	74[b]	0	0	0	0	0	0	0
11	7	1	2	2	0	0	0	12	0	0	0	0	0	0	0
12	6	3	2	0	0	1	0	12	0	0	0	0	0	0	0
13	569	8	5	1	0	2	0	586[b]	0	0	0	0	0	0	0
14	401	8	12	1	0	1	1	425[b]	0	0	0	0	0	0	1[d]
15	248	5	6	0	0	0	1	260	0	0	1	0	0	0	1
16	129	5	1	1	1	4	1	142	0	0	0	0	0	0	0
17	113	9	11	0	0	2	0	135	0	0	0	0	0	0	1[d]
18	58	5	11	0	0	0	0	74	1	1	0	0	0	0	2
19	12	2	17	1	0	1	3	36	0	2	1	0	0	0	3
20	19	11	17	2	1	0	5	55	4	0	0	0	0	0	4
21	8	10	13	2	0	1	1	35	9	0	1	0	0	0	10
22	11	12	13	0	0	1	2	39	15	2	0	0	1	0	19[d]
23	6	17	2	1	0	2	0	28	38	1	0	0	1	0	40
24	3	12	3	0	0	0	0	18	9	2	1	2	2	0	16
25	2	5	2	0	0	0	0	9	7[a]	2[a]	1[a]	0	0	0	10[a]
26	1	5	0	0	0	0	0	6	2	0	1	0	0	0	3
27	4	2	4	0	0	1	0	11	7[a]	1[a]	0	0	0	0	8[a]
28	5	6	8	0	0	1	0	20	6	4	0	1	0	0	11
29	4	5	7	1	0	1	0	18	3	18	1	3	2	2	29
30	2	3	9	1	0	1	0	17[b]	4	9	0	2	0	2	18[d]
31	2	0	6	1	0	1	0	10	0	0	0	0	1	0	1

continued...

Table 9. Concluded.

Date	Upstream Trap: White sucker	Longnose sucker	Walleye	Northern pike	Arctic grayling	Flathead chub	Goldeye	Daily Totals	Downstream Trap: White sucker	Longnose sucker	Northern pike	Flathead chub	Burbot	Walleye	Daily Totals[c]
1 June	0	5	15	0	0	1	1	22	0	1	0	1	0	1	3
2	8	6	15	1	0	4	1	35	2	5	1	1	0	0	9
3	1	0	3	0	0	3	1	8	1	3	1	1	1	0	8[d]
4	0	1	1	0	0	1	1	5[b]	0	0	0	0	0	0	0
5	0	1	1	0	0	3	0	5	0	2	0	0	0	0	3[d]
6	1	1	3	0	0	2	0	7	0	2	1	0	0	0	3
7	2	5	3	0	1	0	0	11	0	0	1	0	0	0	1
8	4	0	1	1	0	0	0	6	0	0	2	0	0	0	2
9	0	0	0	1	0	0	0	1	0	1	2	0	0	0	3
10	1	2	1	0	0	1	1	6	0	0	0	0	0	0	0
11	12	4	3	0	0	0	0	19	0	0	0	0	0	0	0
12	7	10	2	0	0	1	0	20	0	0	0	0	0	0	0
13	10	3	3	0	1	3	0	20	0	0	0	0	0	0	0
14	9	3	1	0	0	1	0	14	0	0	0	0	0	0	0
15	7	0	1	1	0	1	0	10	Operations Terminated						
16	4	0	0	0	0	0	0	4							
17	7	2	1	0	0	2	1	13							
18	7	0	0	0	0	0	0	7							
Totals	3961	1236	364	90	49	43	21	5775	108	56	15	11	8	5	209
%	68.6	21.4	6.3	1.6	0.8	0.7	0.4		51.7	26.8	7.2	5.3	3.8	2.4	

[a] Includes gillnet fish (see Table 4).

[b] Other species counted through the upstream trap: five lake whitefish, 7, 9 (two fish), and 10 May (two fish); five burbot, 8, 13, 14, and 30 May, and 4 June; one trout-perch, 29 April.

[c] Includes fish found dead on the downstream panels of the fence.

[d] Other species counted through the downstream trap: four Arctic grayling, 22 and 30 May, and 3 and 5 June; two lake chub, 7 and 14 May.

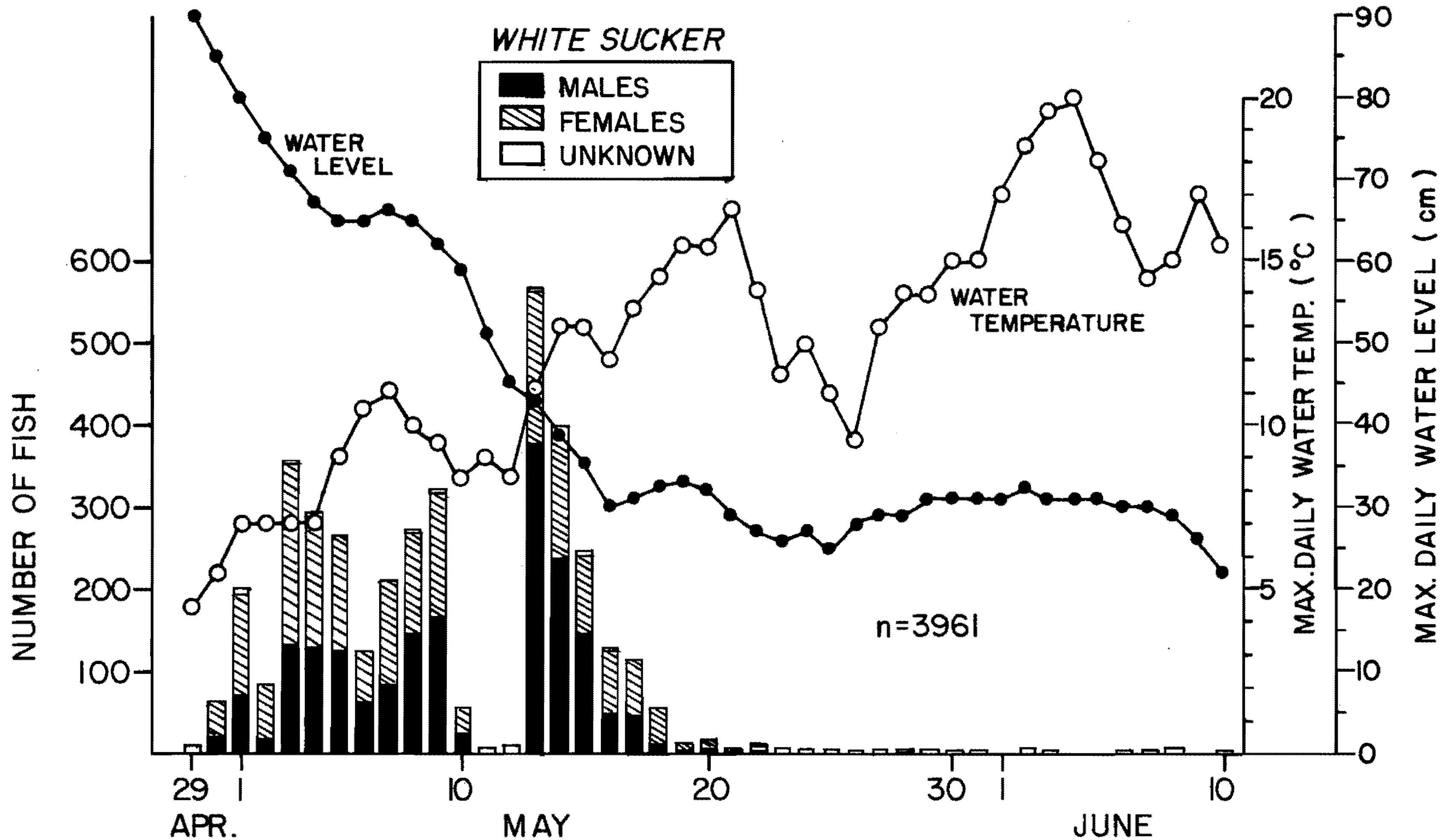

Figure 4. Seasonal timing of the white sucker upstream migration in the MacKay River, 1978.

Table 10. Summary of diel timing of the upstream migration of white suckers in the MacKay River, 1978. Fish that were counted at times other than those indicated were included in the next check period.

Date	Number of Fish Counted at Each Trap Check					Total
	1200 h	1500 h	1800 h	2100 h	2400 h	
29 April	ND[a]	ND	9[b]	ND	2	11[b]
30	1	2	32[b]	22	9	66[b]
1 May	7	73	71	37	12	200
2	2	ND	57[b]	21	2	82[b]
3	60	121	109	66	5	361
4	11	77	35	166	6	295
5	7	54	67	112	28	268
6	7	69	6	9	36	127
7	5	18	87	38	63	211
8	17	25	76	19	136	273
9	35	77	117	38	52	319
10	9	5	3	1	40	58
11	4	0	2	1	0	7
12	2	ND	ND	3	1	6
13	0	66	210	190	103	569
14	53	133	81	108	26	401
15	60	72	98	4	14	248
16	24	15	15	27	48	129
17	34	48	ND	18	13	113
18	22	14	8	3	11	58
19	7	ND	4	1	0	12
20	11	ND	4	2	2	19
21	4	ND	ND	ND	4	8
22	3	ND	7	ND	1	11
23	6	ND	0	ND	0	6
24	0	ND	2	ND	1	3
25	2	ND	ND	ND	0	2
26	0	ND	1	ND	0	1
27	0	ND	0	ND	4	4
28	2	ND	1	ND	2	5
29	1	ND	1	ND	2	4
30	1	ND	0	ND	1	2
31	1	ND	0	ND	1	2
1 to 18 June	39	ND	21	ND	20	80
Totals	437	869	1124	886	645	3961
% Grand Total	11.0	21.9	28.4	22.4	16.3	

[a] ND indicates that no trap check was performed.

[b] Includes fish captured in gillnets.

5.2.1.3 Spawning times and locations. White suckers probably spawned in the MacKay watershed in mid-May 1978. The first ripe fish were captured at the upstream trap on 30 April; however, most fish were not fully ripe until about 5 to 8 May. The first spent fish (males) were captured on 16 May and by 22 May all fish taken were spawned out. Young-of-the-year suckers were first captured at the fence site on 2 June. Although no distinction could be made between the fry of white and longnose suckers, young of both species are believed to have been present in drift samples taken early in June.

White suckers have been reported to spawn in a variety of habitats, including lake margins and quiet reaches in stream mouths (Scott and Crossman 1973). Optimal conditions, however, probably involve shallow, running water and a gravel substrate (Geen 1958). Bond (1972) suggested the possible importance of the presence of deep pool adjacent to the spawning site. Areas that appear to satisfy these requirements are few in the MacKay River downstream of the mouth of the Dover, but are common in the region between Sites 3 and 6 (Figure 2). The lower reaches of the Dunkirk and Dover rivers also possess areas suitable for white sucker spawning.

Since no attempt was made to observe the spawning act itself during the present study, evidence for spawning in various locations is indirect, based on the capture of young-of-the-year or adult fish. During May, ripe or mature white suckers were captured in gillnets or were observed in several areas of the MacKay River watershed upstream of the fence site. An adult-sized female was seen in the shallows of Site 12 (Dover River) on 20 May. On the same day, a ripe female (480 mm) was captured at the mouth of the Dunkirk and a mature female (355 mm) was taken at Site 9. Recently emerged suckers (10 to 16 mm total length) were captured at Site 12 on 4 June and on 15 to 16 June. Drifting fry were also captured from the MacKay River upstream of the Dover (Site 3) on 15 to 16 June, confirming the presence of spawning sites upstream of this location. On 16 June, young-of-the-year suckers, at least some of which were probably white suckers, were taken at the mouth of the Dunkirk (Sites 7 and 8). These young fish ranged from 10 to 14.5 mm in total length and had emerged recently.

Subsequent sampling on 14 to 15 July produced young-of-the-year white suckers (15 to 34 mm) at Sites 12 (n = 191) and 13 (n = 17) of the Dover River and Site 9 (n = 57) of the Dunkirk. McCart et al. (1978) found that white sucker fry were distributed throughout the lower MacKay River watershed during the summer, but that they were most abundant in the region between Sites 4 and 5 (Figure 2). Young-of-the-year white suckers were also common at Sites 5 and 6 of the MacKay River during the present study.

5.2.1.4 Seasonal timing of downstream migration. Failure to construct a complete counting fence prevented a detailed analysis of the downstream migration. Downstream migrants easily avoided the partial downstream trap. Adult white suckers were observed moving downstream in the MacKay River between 17 and 28 May 1978. These fish travelled in mid-channel, thus missing the partial downstream fence. Captures of some spent white suckers (n = 108) at the downstream trap did occur, however, between 20 May and 3 June (Table 9) with the largest numbers being taken on 22 May (n = 15 and 23 May (n = 38). Suckers in the Muskeg River (Bond and Machniak 1977) continued to pass downstream through 30 July. In the Steepbank River (Machniak and Bond 1979), the capture of white suckers in the downstream trap during September and October suggested that some individuals tend to remain in that tributary throughout the summer and indicated that this tendency was greatest in immature fish. During the present study, adult white suckers were captured in the MacKay River by gillnets in July, August, and October, indicating that at least some adults remain in the river throughout the summer.

5.2.1.5 Spawning mortality. Eighty-three white suckers were found dead or in poor physical condition along the downstream panels of the counting fence. Observations of fish encountering the fence indicated that post-spawning suckers had little stamina and were being carried along by the current. Bond and Machniak (1977) observed that suckers, taken in the Muskeg River between 18 June and 30 July 1976, were often blind in one or both eyes, displayed signs of physical deterioration, and were heavily infested with the parasitic copepod *Argulus* sp. A mortality rate of 16 to 20% was observed by Geen et al. (1966) for spawning white suckers in British Columbia.

5.2.1.6 <u>Size composition of migrant white suckers</u>. Fork lengths were determined for 3940 white suckers during the upstream migration (Table 11, Figure 5). Migrant suckers ranged in length from 213 to 597 mm with 80% being in the 350 to 499 mm range. The single mode observed in the MacKay River sample differed from the situation reported for white sucker runs in the Muskeg River (Bond and Machniak 1977, 1979) and the Steepbank River (Machniak and Bond 1979), where two or three modes were seen in the length-frequency distribution.

As in the Muskeg River (Bond and Machniak 1977, 1979) and Steepbank River (Machniak and Bond 1979), early migrants in the MacKay River tended to be smaller than those moving upstream later in the run. White suckers taken between 30 April and 6 May (36% of the total captured) had a modal fork length in the 360 to 379 mm range with 76% of the fish being between 340 and 419 mm (Figure 6). From 7 to 20 May, inclusive, suckers had a modal length in the 420 to 439 mm range. Sixty-five percent of the fish in this group (which accounted for 61% of all upstream white suckers captured) were between 400 and 499 mm, and 81% were between 380 and 519 mm in fork length (Figure 6).

After spawning, larger white suckers apparently leave the spawning stream first, while smaller, immature fish tend to remain in the tributary longer. Bond and Machniak (1979) observed that 95% of downstream migrants captured through 15 June in the Muskeg River exceeded 350 mm. Machniak and Bond (1979) obtained similar results in the spring and found that suckers captured in a downstream trap during the autumn tended to be juvenile fish. During the present study, insufficient downstream fish were captured to permit a description of the variation in length-frequency distribution during the downstream run. Among downstream fish measured during the spring, 97% exceeded 360 mm in fork length (Figure 7). White suckers taken during

Table 11. Length-frequency distribution of white suckers during the spring upstream migration in the MacKay River, 1978.

Fork Length (mm)	Male	Female	Unknown	Total
210 to 219	2	0	1	3
220 to 229	0	0	1	1
230 to 239	0	0	0	0
240 to 249	0	0	3	3
250 to 259	0	0	5	5
260 to 269	1	0	1	2
270 to 279	0	2	7	9
280 to 289	1	3	5	9
290 to 299	0	2	12	14
300 to 309	4	15	12	31
310 to 319	1	13	9	23
320 to 329	12	22	9	43
330 to 339	24	47	5	76
340 to 349	63	51	7	121
350 to 359	103	80	7	190
360 to 369	102	125	4	231
370 to 379	90	148	2	240
380 to 389	86	191	6	283
390 to 399	106	119	0	225
400 to 409	108	118	0	226
410 to 410	139	99	0	238
420 to 429	138	77	0	215
430 to 439	135	90	0	225
440 to 449	118	97	0	215
450 to 459	144	87	0	231
460 to 469	102	88	0	190
470 to 479	114	59	0	173
480 to 489	92	59	0	151
490 to 499	71	62	0	133
500 to 509	50	67	0	117
510 to 519	36	60	0	96
520 to 529	30	58	0	88
530 to 539	16	43	0	59
540 to 549	5	29	0	34
550 to 559	1	25	0	26
560 to 569	1	7	0	8
570 to 579	1	3	0	4
580 to 589	0	1	0	1
590 to 599	0	1	0	1
Totals	1896	1948	96	3940

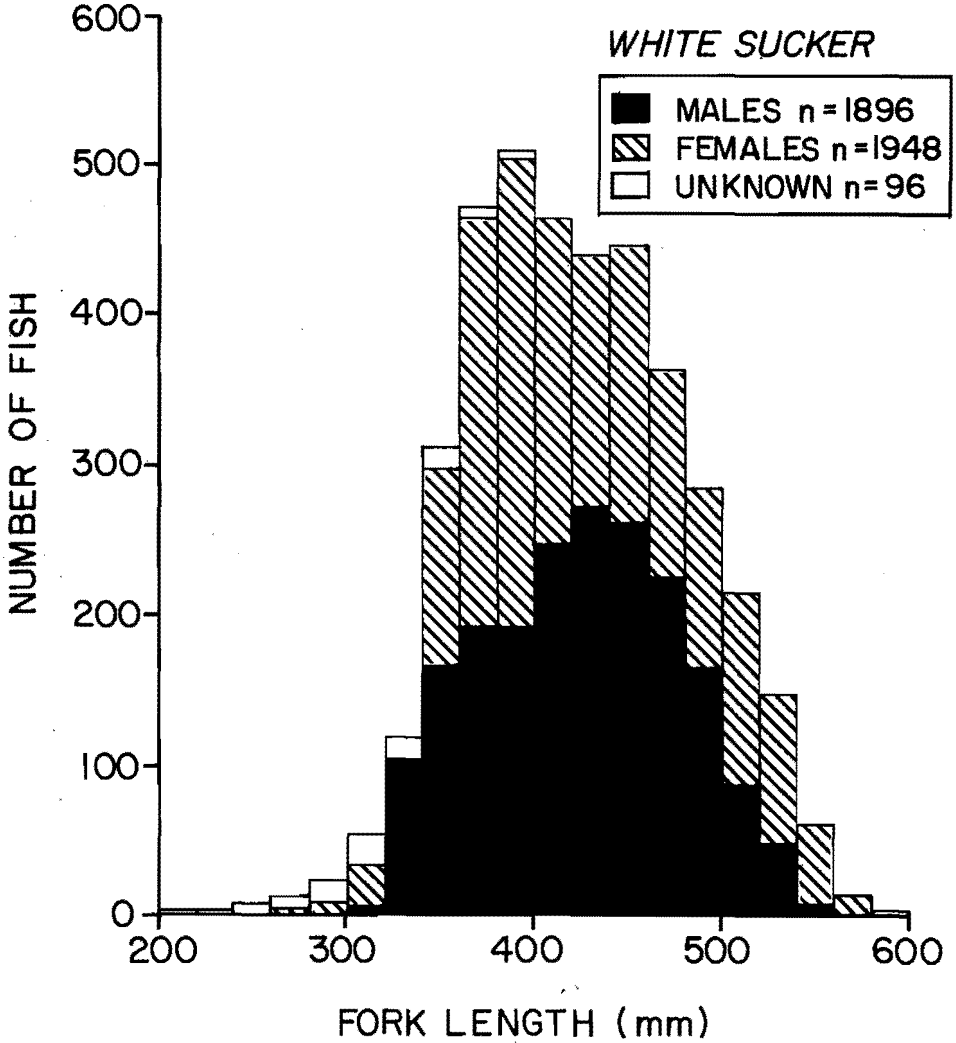

Figure 5. Length-frequency distribution for white suckers during the upstream migration in the MacKay River, 1978.

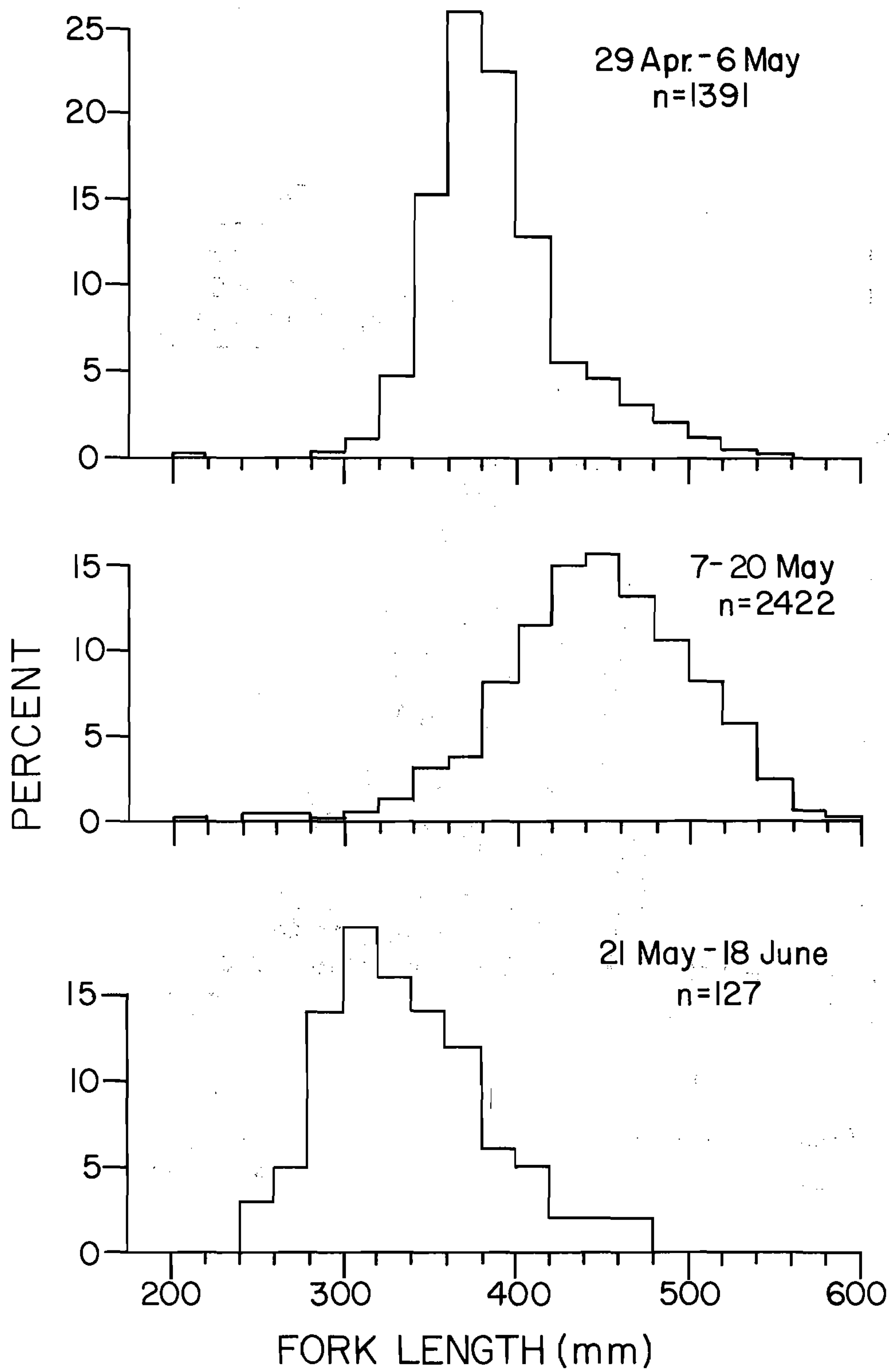

Figure 6. Seasonal changes in length-frequency distribution for white suckers during the upstream migration in the MacKay River, 1978.

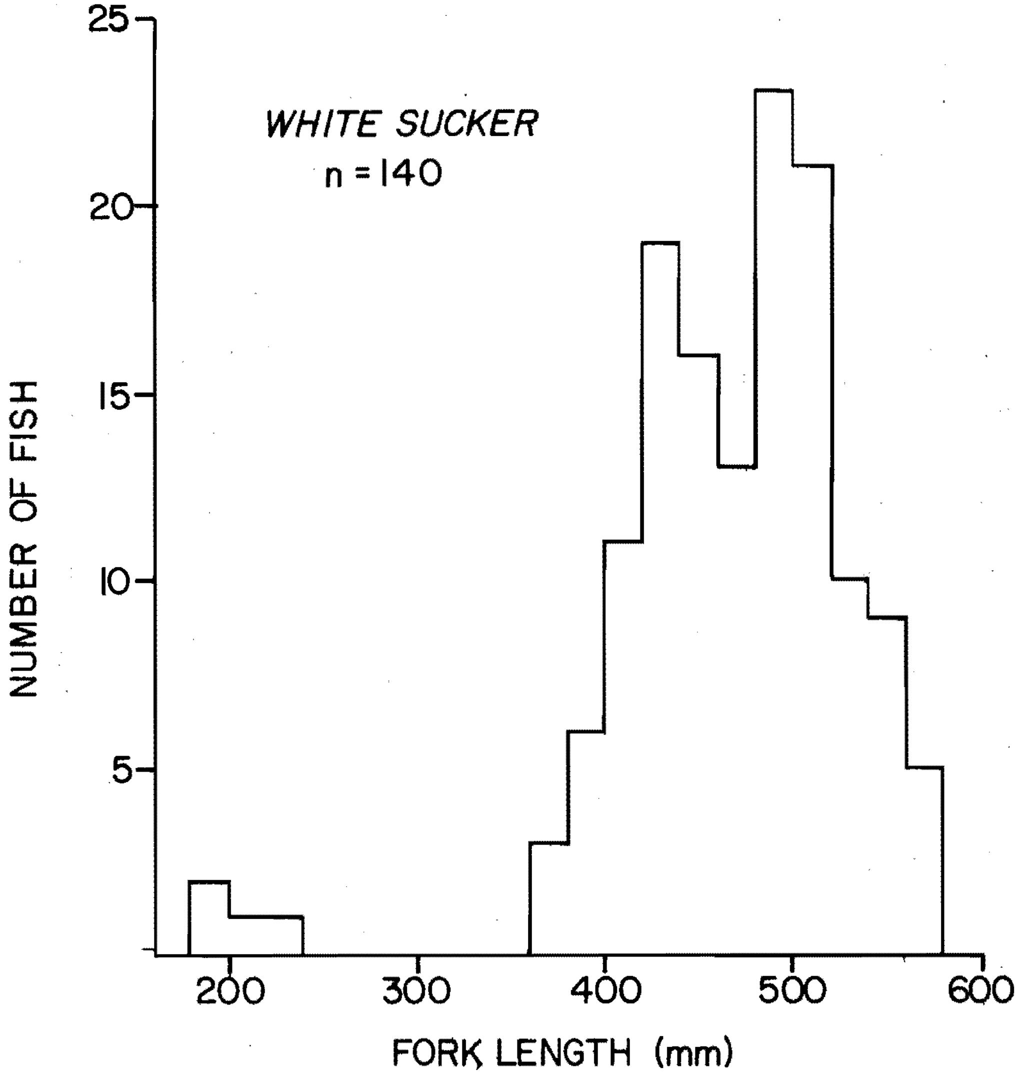

Figure 7. Length-frequency distribution for white suckers captured during the spring post-spawning period in the MacKay River, 1978.

the autumn (n = 28) ranged in size from 335 to 425 mm and most were juvenile fish.

5.2.1.7 Age composition of migrant white suckers. Migrant white suckers, captured during the upstream migration in the MacKay River in 1978, ranged in age from four to 17 years with the majority of fish (89%) being six to 14 years old inclusive (Figure 8). In the Muskeg River (Bond and Machniak 1979), suckers captured during the 1977 spring run ranged in age from three to 16 years, but most spawners belonged to age groups eight to 12 inclusive.

5.2.1.8 Sex ratio of migrant white suckers. Sex was determined for 3844 white suckers during the upstream migration with females (51%) being slightly more numerous than males (Table 12). Female white suckers (61%) were significantly more abundant than males in the 1977 Steepbank River run (Machniak and Bond 1979) while in the 1977 Muskeg River run, males (55%) outnumbered females (Bond and Machniak 1979).

The sex ratio in the MacKay River upstream run varied with time. The early portion of the run (29 April to 7 May) was dominated by female fish, while in the latter part (8 to 15 May), males outnumbered females (Table 12). This appears to be the reverse of the situation observed in previous runs monitored in tributaries of the AOSERP study area (Bond and Machniak 1977, 1979; Machniak and Bond 1979), and is contrary to reports of most studies, which have found that male white suckers tend to precede females onto the spawning grounds. Geen et al. (1966), however, noted that the sex ratio of migrant white suckers during the run can vary from year to year.

5.2.1.9 Tagging results. A total of 2565 white suckers were tagged in the MacKay River during 1978. The recapture of only three tagged suckers at the downstream trap points out the ineffectiveness of the operation to monitor the out-migration of spawners. Thirty-six tagged white suckers were recaptured, however, outside the watershed (Table 8,

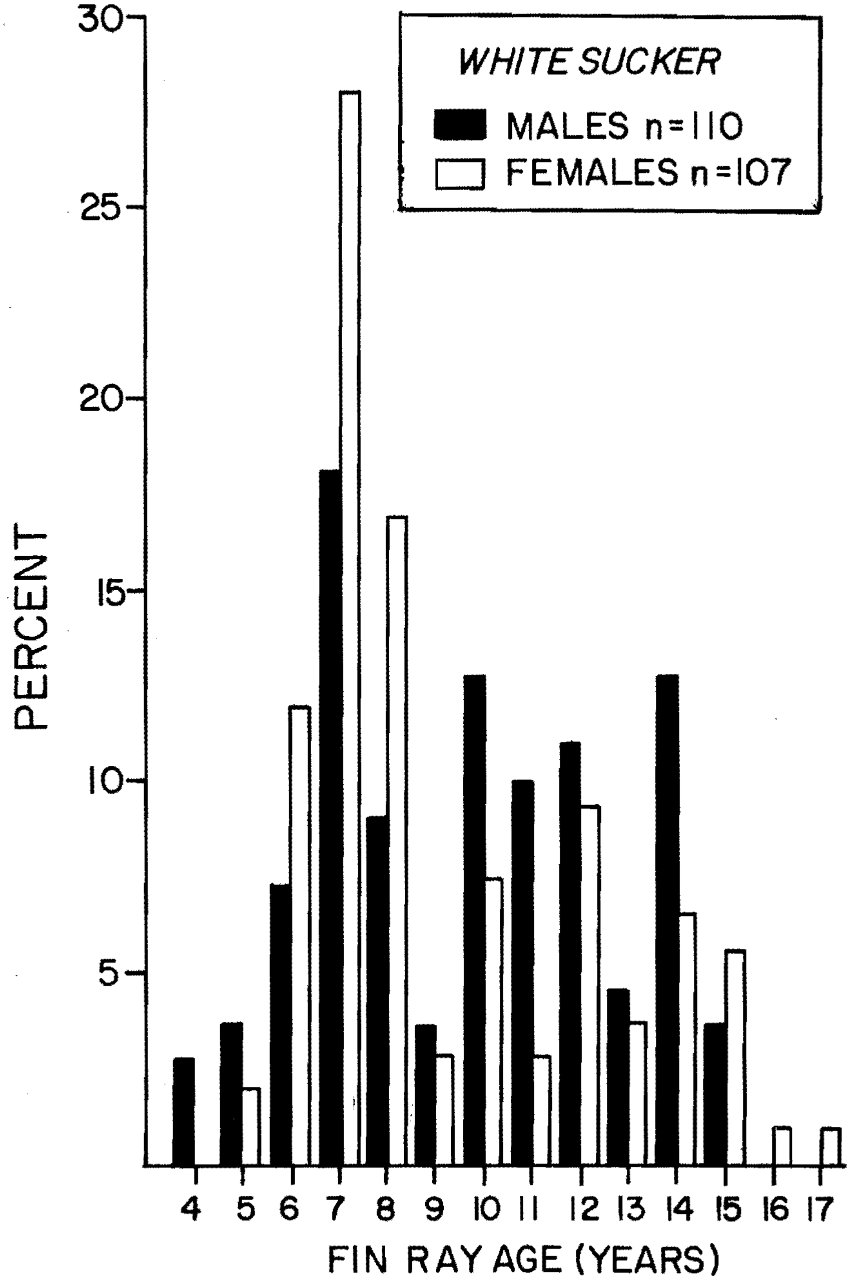

Figure 8. Age composition for white suckers sampled during the counting fence operation, MacKay River, 1978.

Table 12. Sex ratio for white suckers during the upstream migration, MacKay River, 1978.

Date	Number of Fish				Percent Males[a]
	Males	Females	Unknown	Total	
29 April	2[b]	7[b]	2	11[b]	18
30	22[b]	38[b]	6	66[b]	37
1 May	71	125	4	200	36
2	19[b]	63[b]	0	82[b]	23
3	137	222	2	361	38
4	130	165	0	295	44
5	127	140	1	268	48
6	62	65	0	127	49
7	84	126	1	211	40
8	145	125	3	273	54
9	163	154	2	319	51
10	23	35	0	58	40
11	2	5	0	7	29
12	2	4	0	6	33
13	382	180	7	569	68
14	246	151	4	401	62
15	147	97	4	248	60
16	56	69	4	129	45
17	46	66	1	113	41
18	11	47	0	58	19
19	1	10	1	12	9
20	8	11	0	19	42
21	4	4	0	8	50
22	2	4	5	11	33
23	2	4	0	6	33
24	0	2	1	3	0
25	0	1	1	2	0
26	0	1	0	1	0
27	0	3	1	4	0
28	2	2	1	5	50
29	0	3	1	4	0
30	0	1	1	2	0
31	0	1	1	2	0
1 to 18 June	8	28	44	80	22
Totals	1904	1959	98	3961	
%	49	51			

[a] Based on fish of known sex.

[b] Includes gillnet fish.

Appendix 8.6). All recaptures came from the Athabasca delta and Lake Athabasca, and most occurred in June, one to two months after they were tagged. Tag return information from this and other studies (Shell Canada Ltd. 1975; Bond and Berry 1980b; Bond and Machniak 1977, 1979; Machniak and Bond 1979) indicates that white suckers that spawn in the MacKay River, and other tributaries of the AOSERP study area, belong to the Lake Athabasca population and return to the lake during the summer to feed and overwinter. The recapture of one tagged white sucker in the autumn (Table 8) suggests that some adult fish remain in the MacKay River watershed throughout the summer.

During 1976 and 1977, Floy tags were applied to 2163 white suckers during studies of other tributaries in the AOSERP study area (Bond and Machniak 1977, 1979; Machniak and Bond 1979). McCart et al. (1978) reported recapturing none of these in the MacKay River in 1977. During the present study, however, six white suckers, tagged in the Muskeg River in 1976 and 1977 (Bond and Machniak 1977, 1979), and five others, tagged in the Steepbank River in 1977 (Machniak and Bond 1979), were captured at the upstream trap. Bond and Machniak (1979) noted that white suckers in the Muskeg River demonstrated considerable fidelity to their spawning stream as large numbers of those tagged in 1976 (> 20%) returned in 1977 to spawn in the same stream. Geen et al. (1966) reported that white suckers returned to spawn in Frye Creek, British Columbia for up to six years.

5.2.1.10 <u>Fecundity</u>. Fecundity was estimated gravimetrically for 13 female white suckers in spawning condition. The estimated total number of eggs per female (size range 375 to 535 mm) ranged from 21 600 to 66 440 (Table 13) with an average of 41 269 eggs per female. The results are similar to those reported by other authors for white suckers in the AOSERP study area (Bond and Machniak 1977, 1979; Tripp and McCart 1980). In the Bigoray River, Alberta, a tributary of the Athabasca, Bond (1972) reported white sucker fecundity to range from 15 983 to 60 242 with an average of 34 502 eggs per female.

Table 13. Fecundity estimates for white suckers sampled during the 1978 MacKay River spawning migration.

Fork Length (mm)	Weight (g)	Number of Eggs			Relative Fecundity	
		Left Ovary	Right Ovary	Total	(Eggs/cm)	(Eggs/g)
535	2500	27 743	27 081	54 824	1024.8	21.9
533	2680	32 400	34 040	66 440	1246.5	24.8
533	2390	32 421	31 567	63 988	1200.5	26.8
529	2220	26 045	24 537[a] (+0.8%)[b]	50 582	956.2	22.8
524	2300	ND[c]	ND	60 118	1147.3	26.1
465	1640	ND	ND	45 688	982.5	27.9
449	1310	16 400	14 823	31 223	695.4	23.8
438	1435	ND	ND	41 591[a] (-0.2%)[b]	949.6	30.0
386	820	12 238	13 714	25 952	672.3	31.7
383	700	ND	ND	21 600	564.0	30.9
382	800	12 363	13 000	25 363	664.0	31.7
380	730	14 087[a] (-1.9%)[b]	12 000	26 087	686.5	35.7
375	700	11 048	12 000	23 048	614.6	32.9

[a] Actual egg counts.

[b] Deviation of estimated counts from actual number.

[c] No data.

Length-relative fecundity for MacKay River white suckers ranged from 564.0 to 1246.5 ova per cm of fork length, while weight-relative fecundity varied from 21.9 to 35.7 eggs per g of body weight.

Where the right and left ovaries were estimated separately, the left ovary, in five out of nine cases, contained more eggs than the right (average 20 527; range 11 048 to 32 421 eggs). Bond and Machniak (1979), however, reported that, in the Muskeg River, the right ovary contained more eggs than the left in nine out of 10 cases.

Regression analysis indicated a significant ($P < 0.01$), positive correlation between fecundity and fork length ($n = 13$, $r = 0.965$) and fecundity and body weight ($r = 0.982$) for MacKay River white suckers. A similar correlation between fecundity and fork length was obtained for white suckers captured in the Muskeg River (Bond and Machniak 1979) and Athabasca River (Tripp and McCart 1980). The relationship between fecundity and fork length for MacKay River white suckers is expressed by the equation:

$$\log_{10}\text{Fecundity} = 2.664 \log_{10}\text{Fork Length (mm)} - 2.488; \quad sb = 0.220$$

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

$$\log_{10}\text{Fecundity} = 0.761 \log_{10}\text{Weight (g)} - 2.194; \quad sb = 0.044$$

5.2.1.11 Egg size and ovary weight. The mean egg diameter for 28 mature and ripe female white suckers was 1.9 mm (range 1.5 to 2.2 mm). Average egg diameter for seven females in the Steepbank River (Machniak and Bond 1979) was 1.6 mm (range 1.5 to 1.9 mm). Stewart (1926) reported an egg diameter of 2 mm before water hardening.

The mean ovary weight for five ripe females was equivalent to 10.2% of body weight (range 7.5 to 16.6%). Bond (1972) found that the ovaries of white suckers comprised, on the average, 11.8% of the body weight just prior to spawning.

5.2.1.12 Age and growth. The growth rate of MacKay River white suckers (Tables 14 and 15) is similar to that reported for white suckers in the Muskeg River (Bond and Machniak 1977, 1979). Growth was also similar (Figure 9) to that of white suckers in Waswanipi Lake, Quebec (Magnin et al. 1973). MacKay River suckers (Figure 9) grew more slowly than those from George Lake, Ontario (Beamish 1970) and Lake of the Woods, Ontario (Chambers 1963), but faster than those in the Bigoray River, Alberta (Bond 1972), Muskellunge Lake, Wisconsin (Spoor 1938), and Lake Alder, Quebec (Verdon 1977).

Female suckers from the MacKay River were generally longer than males of the same age with the difference in mean fork length being significant ($P < 0.05$) in age groups 10 and 13 to 15 inclusive (Table 14). Significant differences in length at a given age were also observed among older white suckers (age groups 7 to 14) in the Muskeg River (Bond and Machniak 1977, 1979). Female suckers also tended to be heavier than males of the same age with differences in mean weight being statistically significant ($P < 0.05$) for age groups 10, 11, and 13 to 15 inclusive (Table 15). Other investigators have also noted that female white suckers tend to grow faster than males, achieve larger sizes, and live longer (Spoor 1938; Raney and Webster 1942; Smith 1952; Hayes 1956; Lalancette (1973).

A maximum fin-ray age of 17 years was obtained for white suckers during the present study of the MacKay River. This was also the maximum age reported from the Muskeg River (Bond and Machniak 1977). Using otoliths, Tripp and McCart (1980) obtained a maximum age of 18 years for white suckers from the Athabasca River. White suckers from the James Bay area of Quebec (Verdon 1977) are reported to have maximum fin-ray ages of 19 to 25 years.

5.2.1.13 Sex and maturity. Age and sex were determined for 217 white suckers of which 110 (51%) were males (Table 16).

The youngest mature white sucker observed in the MacKay River was a four-year-old male, while the youngest mature female was age 6. Most fish of both sexes were sexually mature by age 7

Table 14. Age-length relationship (derived from fin rays and otoliths) for white suckers captured in the MacKay River watershed, 1978, sexes separate and combined sample (includes unsexed fish).

Age	Males				Females				All Fish				t-test
	N	Mean	S.D.	Range	N	Mean	S.D.	Range	N	Mean	S.D.	Range	
2	1	119.0			0				1	119.0			
3	0				1	176.0			1	176.0			
4	3	215.0	3.00	212 to 218	0				5	205.4	13.48	188 to 218	
5	4	299.0	41.39	268 to 351	2	307.5	0.71	307 to 308	6	310.5	33.11	268 to 351	
6	8	358.9	23.59	308 to 385	13	372.8	34.52	293 to 425	21	367.5	30.94	293 to 425	0.999
7	20	395.6	32.31	335 to 452	30	409.3	32.07	374 to 485	50	403.8	32.55	335 to 485	1.481
8	10	413.2	35.34	361 to 455	18	412.8	33.58	370 to 477	28	412.9	33.56	361 to 477	0.027
9	4	448.3	24.14	419 to 478	3	450.7	50.80	397 to 498	7	449.3	33.96	397 to 498	0.085
10	14	449.6	40.20	360 to 485	8	499.6	43.22	430 to 539	22	467.8	47.23	360 to 539	2.736[a]
11	11	462.9	32.66	381 to 487	3	506.3	43.29	457 to 538	14	472.2	38.09	381 to 538	1.923
12	12	477.4	17.78	450 to 507	10	521.1	47.65	421 to 568	22	497.3	40.42	421 to 568	2.951[a]
13	5	491.4	16.12	468 to 506	4	541.0	7.16	533 to 548	9	513.4	28.85	468 to 548	5.663[a]
14	14	491.5	27.47	478 to 525	7	535.6	17.25	512 to 560	21	506.2	32.14	478 to 560	6.521[a]
15	4	480.0	36.94	432 to 511	6	535.2	15.89	514 to 550	10	513.1	37.51	432 to 550	3.303[a]
16	0				1	554.0			1	554.0			
17	0				1	555.0			1	555.0			
Totals	110				107				219				

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

Table 15. Age-weight relationship for white suckers captured in the MacKay River watershed, 1978, sexes separate and combined sample (includes unsexed fish).

Age	Males				Females				All Fish				t-test
	N	Mean	S.D.	Range	N	Mean	S.D.	Range	N	Mean	S.D.	Range	
2	1	19.3			0				1	19.3			
3	0				1	62.2			1	62.2			
4	3	103.3	23.09	90 to 130	0				5	94.0	20.74	80 to 130	
5	4	343.3	153.73	240 to 620	2	350.0	28.28	330 to 370	6	391.7	148.78	240 to 620	
6	8	622.5	156.82	400 to 900	13	727.7	184.13	340 to 950	21	687.6	178.01	340 to 950	1.341
7	20	914.5	244.40	550 to 1380	30	1017.5	325.99	580 to 1720	50	976.3	297.74	550 to 1720	1.204
8	10	1058.5	291.38	655 to 1460	18	1051.7	306.25	690 to 1640	28	1054.1	295.58	655 to 1640	0.058
9	4	1492.5	314.05	1140 to 1900	3	1356.7	476.06	900 to 1850	7	1434.3	360.73	900 to 1900	0.459
10	14	1356.4	361.48	710 to 1920	8	1845.0	548.53	1200 to 2450	22	1534.1	488.93	710 to 2450	2.527[a]
11	11	1562.7	377.94	740 to 2040	3	2146.7	546.38	1540 to 2600	14	1687.9	466.51	740 to 2600	2.182[a]
12	12	1761.0	272.26	1350 to 2200	10	2165.0	612.87	960 to 2650	22	1944.6	492.13	960 to 2650	2.060
13	5	1842.0	190.71	1630 to 2050	4	2345.0	127.15	2160 to 2450	9	2065.6	307.45	1630 to 2450	4.504[a]
14	14	1858.6	321.10	1800 to 2400	7	2498.6	302.51	2040 to 2860	21	2071.9	435.94	1800 to 2860	4.384[a]
15	4	1795.0	447.33	1400 to 2240	6	2416.7	253.90	1930 to 2600	10	2168.0	453.40	1400 to 2600	2.836[a]
16	0				1	2550.0			1	2550.0			
17	0				1	3100.0			1	3100.0			
Totals	110				107				219				

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

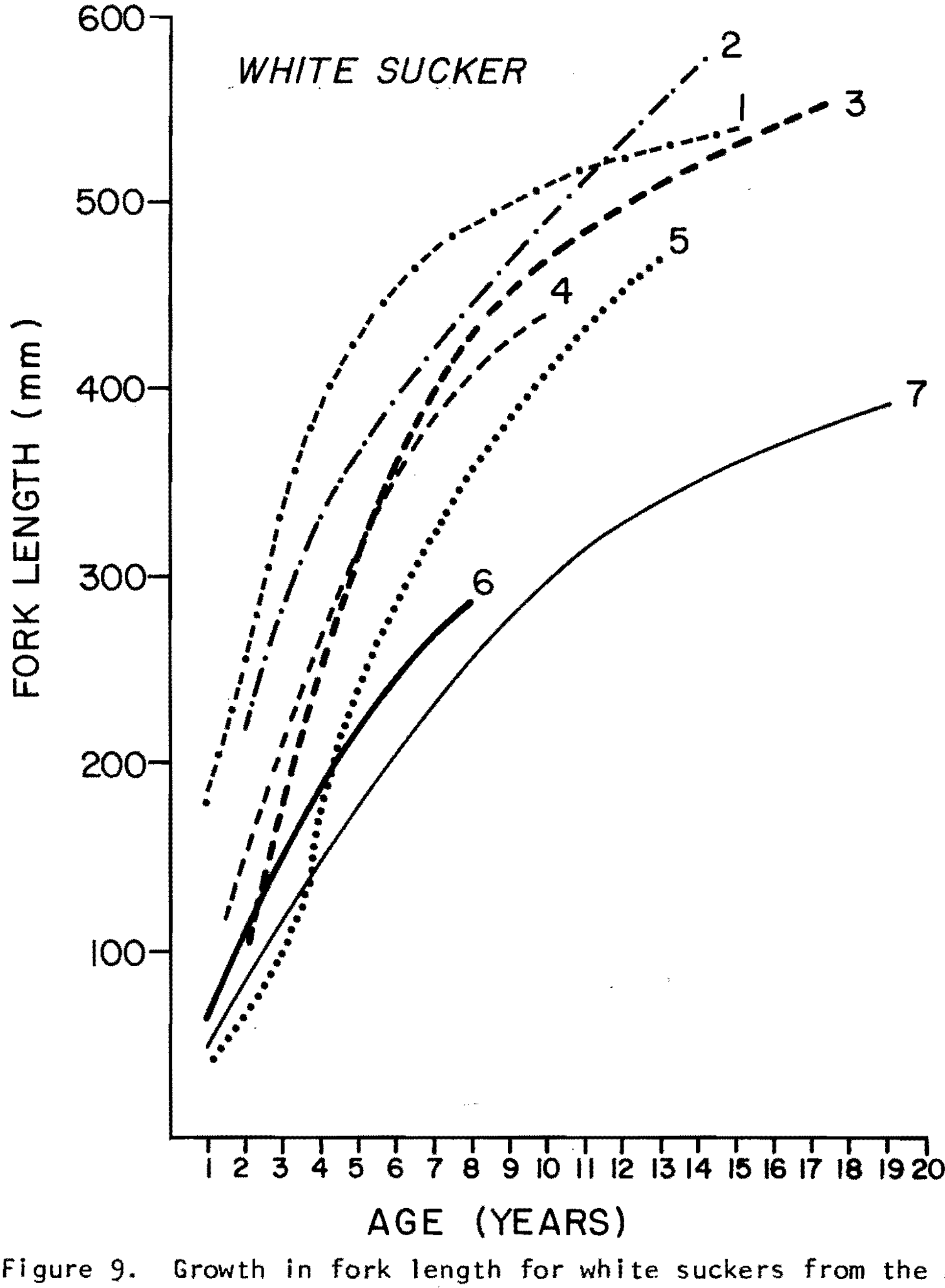

Figure 9. Growth in fork length for white suckers from the MacKay River and from several other areas: 1. George Lake, Ont. (Beamish 1970); 2. Lake of the Woods, Ont. (Chambers 1963); 3. MacKay River, Alta. (Present Study); 4. Waswanipi Lake, P.Q. (Magnin et al. 1973); 5. Bigoray River, Alta. (Bond 1972); 6. Muskellunge Lake, Wis. (Spoor 1938); and 7. Lake Alder, P.Q. (Verdon 1977).

Table 16. Age-specific sex ratios and maturity for white suckers from the MacKay River drainage, 1978. Sex ratios were based only on fish for which sex was determined by gonadal inspection.

Age	Females			Males			Unsexed Fish	Total
	N	%	% Mature	N	%	% Mature		
2	0	0	ND	1	100	0	0	1
3	1	100	0	0	0	ND	0	1
4	0	0	ND	3	100	33	2	5
5	2	33	0	4	67	75	0	6
6	13	62	69	8	38	87	0	21
7	30	60	97	20	40	95	0	50
8	18	64	95	10	36	100	0	28
9	3	43	100	4	57	100	0	7
10	8	36	100	14	64	100	0	22
11	3	21	100	11	79	100	0	14
12	10	45	100	12	55	100	0	22
13	4	44	100	5	56	100	0	9
14	7	33	100	14	67	100	0	21
15	6	60	100	4	40	100	0	10
16	1	100	100	0	0	0	0	1
17	1	100	100	0	0	0	0	1
Totals	107	49%		110	51%		2	219

(Table 16). Within the AOSERP study area, white suckers may mature as early as age 3 (Bond and Machniak 1977) but most do not mature until age 4 or 5 (Bond and Machniak 1979; Machniak and Bond 1979). The youngest ages at maturity recorded for white suckers (age 2 to 3) were reported from Gamelin Lake, Quebec (Lalancette 1976).

5.2.1.14 Length-weight relationship. The following length-weight relationships were determined from white suckers captured during the counting fence operation. Both upstream and downstream fish were included. For male white suckers (n = 109, r = 0.991, range 212 to 525 mm), the relationship between fork length and body weight is described by the equation:

$$\log_{10}W = 3.460(\log_{10}L) - 6.041;\ sb = 0.045$$

For female white suckers (n = 106, r = 0.982, range 307 to 568 mm), the length-weight relationship is expressed by the equation:

$$\log_{10}W = 3.312(\log_{10}L) - 5.659;\ sb = 0.063$$

The above relationships are similar to those recorded for white suckers in the AOSERP study area by Bond and Machniak (1977, 1979), Machniak and Bond (1979), and Tripp and McCart (1980). Analysis of covariance indicated no significant differences ($P > 0.05$) between adjusted means ($F = 1.927$) or slopes ($F = 3.683$) of the length-weight regressions of MacKay River male and female white suckers.

5.2.1.15 Downstream movement of fry. The downstream migration of sucker fry, monitored at the fence site, began on 2 June. Drift net samples taken between 2 and 19 June suggested that the downstream movement peaked between 7 and 14 June and that the major part of the migration was complete by 19 June. Twenty-four hour runs on 8 to 9 June and 11 to 12 June produced 7818 and 9915 sucker fry, respectively, while a similar run on 15 to 16 June yielded only 1970 young suckers (Appendix 8.3).

It is believed that the sucker fry migrating downstream in the MacKay River during the first half of June represented a combination of white and longnose suckers. Unfortunately, it was not possible to distinguish between the two species. Geen et al. (1966) separated the two sucker species on the basis of size; smaller fry appearing on 6 June were identified as longnose suckers and a larger group appearing on 11 June were believed to be white suckers. In the MacKay River samples, a few very small fry (6 to 9 mm) were probably longnose suckers; however, the length-frequency distribution of fry in these samples was unimodal and changed little throughout the sampling period (Figure 10).

Most authors have reported that migrations of sucker fry occur at night with little movement during the day (Geen et al. 1966; Bond 1972; Clifford 1972; Gale and Mohr 1978). In clear streams, fry probably begin to drift with the onset of darkness because the ability to orient visually is lost. Such an explanation has been offered for the downstream drift of chum salmon fry (Hoar 1953), trout fry (Northcote 1962), and sucker fry (Geen et al. 1966). It might be expected that, in turbid streams such as the MacKay River was in early June, downstream movement could begin at any time of day. Certainly the pattern of downstream movement observed at the fence site was not as clear cut as has been observed in other studies. Figure 11 indicates that fry were captured at the fence site at all hours of the day with a tendency for the largest numbers to be taken between sunrise and 1400 h. Another driftnet, set in the MacKay River upstream of the Dover River, captured more fry in late afternoon, although this net was not kept in the stream all night (Figure 12, Appendix 8.4). On the other hand, a more classic situation was observed during a 24 h run in the less turbid Dover River (Figure 12, Appendix 8.4).

Apart from the possible effect of turbidity, the observed pattern of downstream drift probably depends also on the distance of the sampler downstream of the emergence site. Fry emerging at different locations and drifting downstream at equal rates could produce the types of pattern observed in Figure 11.

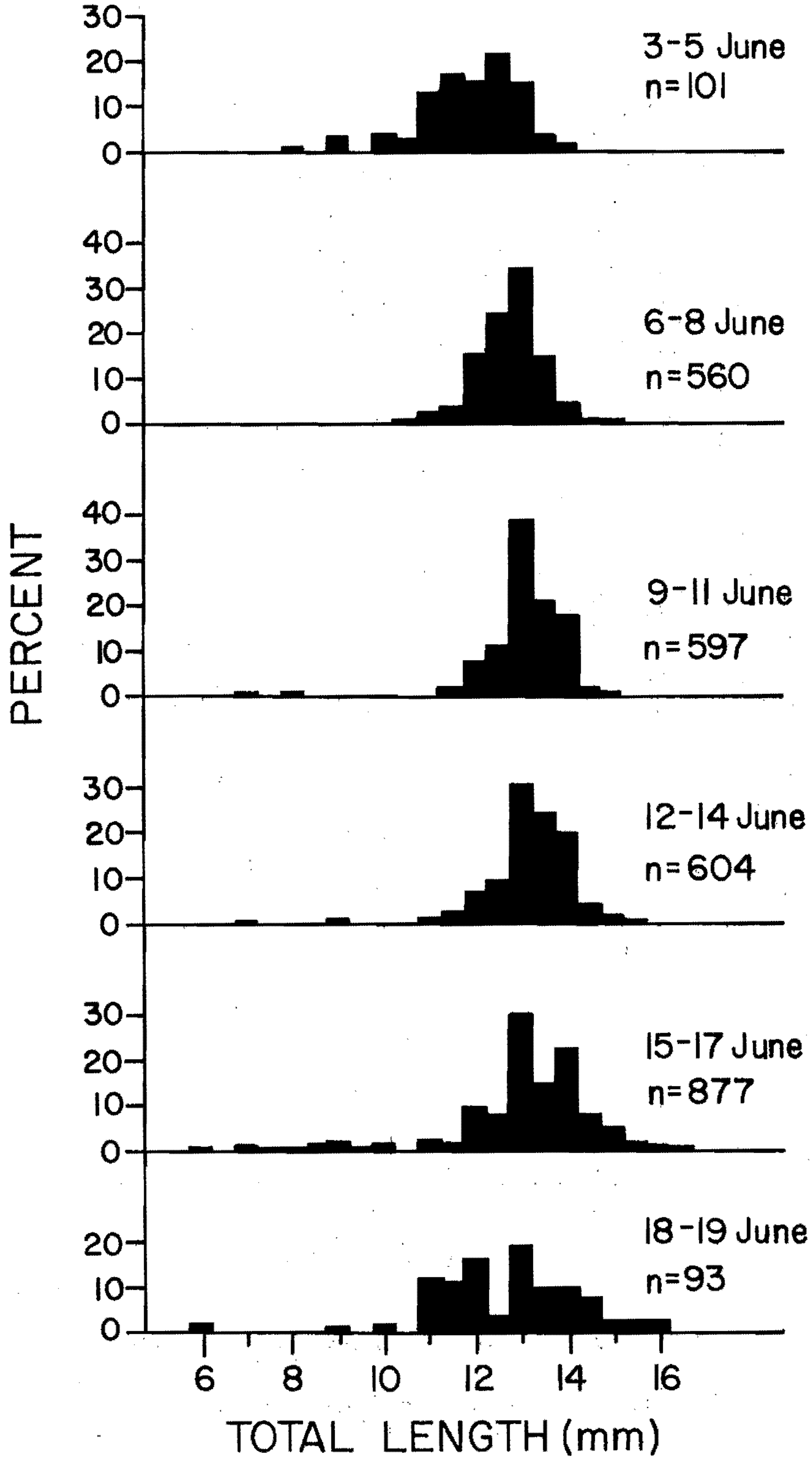

Figure 10. Length-frequency distribution of sucker fry captured in drift nets throughout the period of downstream migration in the MacKay River, 1978.

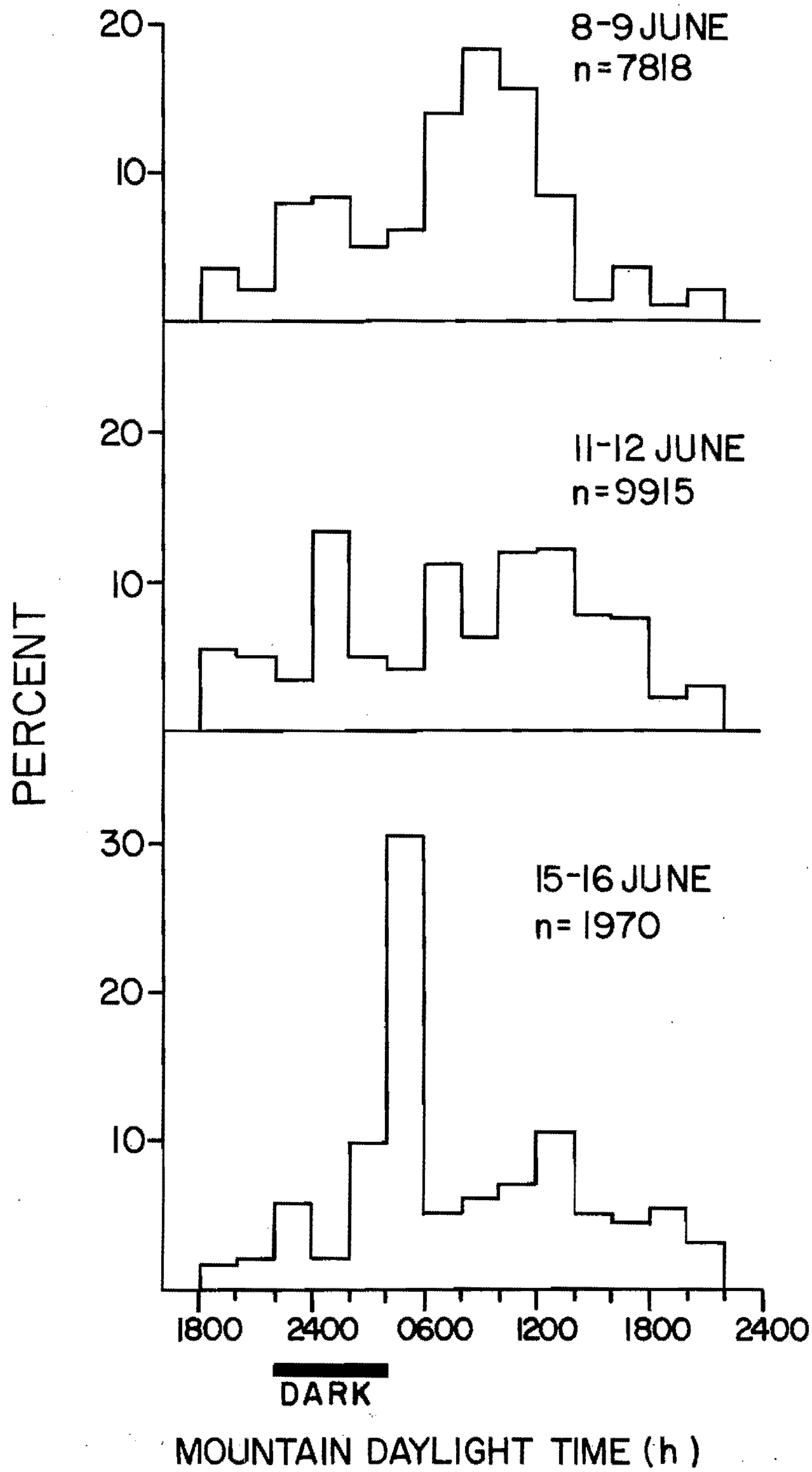

Figure 11. Diel timing of downstream sucker fry migration in the MacKay River, 1978.

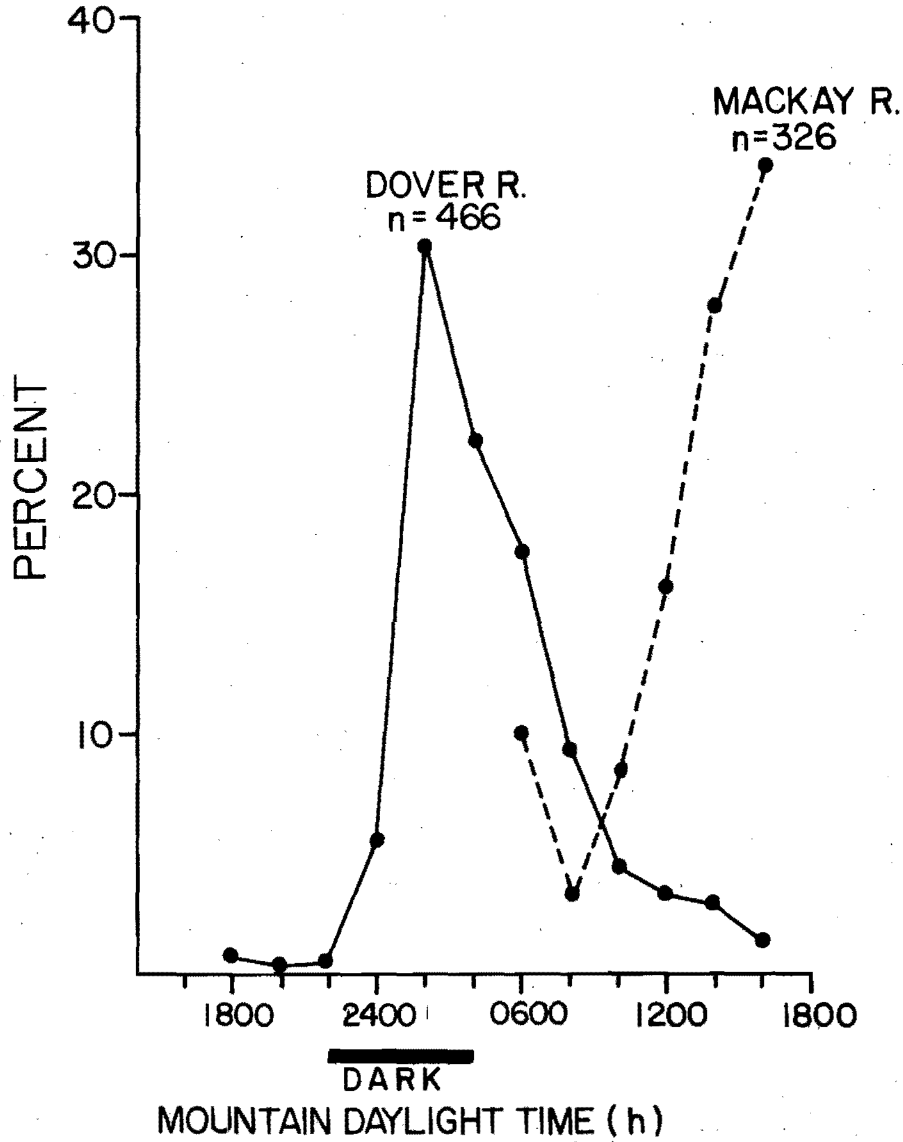

Figure 12. Diel timing of sucker fry migration as determined by drift net catches at the mouth of the Dover River and in the MacKay River just upstream of the Dover River, 15 to 16 June 1978.

Sucker fry tended to drift in mid-channel of the MacKay River where the current was generally stronger. Overall, 71% of the fry captured at the fence site were taken in the mid-stream trap (Appendix 8.3). Gale and Mohr (1978) captured more fry near shore in the Susquehanna River, Pennsylvania, but felt that greater numbers passed downriver in the channel because of the larger volume of water there.

No data are available concerning the vertical distribution of sucker fry during their downstream migration in the MacKay River. Clifford (1972) found that white sucker fry were more abundant near the surface than near the substrate in the Bigoray River, Alberta. He observed, however, that when fry were small (about 12 mm) and slender, considerable numbers were captured in the lower part of the water column, but as they became larger (17 to 23 mm) and more robust, they moved actively downstream and were never captured in the lower drift net.

It was not possible, during the present study, to quantify the downstream fry migrations. There is no doubt, however, that the number of sucker fry transported downstream in the MacKay River during June was very large, and that, by the end of June, only a small proportion of the 1978 white and longnose sucker year classes remained in the MacKay River watershed. Many of those left in the watershed after June remained in the watershed during the summer. However, catch-per-unit-effort in small mesh seines increased rapidly at the fence site during October (Appendix 8.5) indicating a further movement of young-of-the-year suckers out of the MacKay River at that time.

5.2.1.16 <u>Growth of young-of-the-year</u>. Young-of-the-year white suckers captured in the lower Dover River (n = 191) had a mean fork length of 25.1 mm (range 19 to 34 mm) by 14 July. The mean length of fry captured at this site (Site 12) had increased to 39.9 mm by 16 August (Table 17). Fry taken at Sites 1 to 5, inclusive, of the MacKay River, grew at a rate similar to those in the lower Dover,

Table 17. Comparison of mean fork lengths and mean weights of young-of-the-year (age 0+) and juvenile (age 1+) white suckers collected from the MacKay, Dover, and Dunkirk rivers, 1978. Numbers in parentheses indicate ranges.

Age and Capture Site	Date of Capture	Number of Fish	Mean Fork Length (mm) ± Std. Dev.	Mean Weight (g) ± Std. Dev.
Age 0+				
MacKay River				
Sites 2 and 5	14 to 15 July	4	28.8 ± 4.99 (21 to 32)	0.2 ± 0.20 (0.1 to 0.5)
Site 1	22 to 29 July	7	35.7 ± 5.65 (25 to 42)	0.56 ± 0.25 (0.2 to 0.9)
Site 1	12 August	16	39.1 ± 7.53 (25 to 52)	0.91 ± 0.49 (0.2 to 2.0)
Sites 1, 2, 3, and 5	16 to 18 August	44	40.0 ± 6.20 (25 to 53)	0.85 ± 0.46 (0.2 to 2.0)
Site 6	17 August	90	29.7 ± 2.19 (25 to 35)	0.33 ± 0.19 (0.2 to 0.6)
Site 1	26 August	3	41.3 ± 9.45 (34 to 52)	0.90 ± 0.87 (0.3 to 1.9)
Site 2	25 to 30 September	9	45.7 ± 10.84 (30 to 61)	1.41 ± 0.82 (0.4 to 2.8)
Site 2	1 to 3 October	4	46.3 ± 2.63 (44 to 49)	1.30 ± 0.18 (1.1 to 1.5)

continued ...

Table 17. Continued.

Age and Capture Site	Date of Capture	Number of Fish	Mean Fork Length (mm) ± Std. Dev.	Mean Weight (g) ± Std. Dev.
Sites 2, 3, and 4	13 to 14 October	12	47.9 ± 7.65 (39 to 64)	1.51 ± 0.71 (0.8 to 3.2)
Site 6	14 October	2	32.5 ± 0.71 (32 to 33)	0.6 (0.6 to 0.6)
Dover River				
Site 12	14 July	191	25.1 ± 2.47 (19 to 34)	0.29 ± 0.06 (0.15 to 0.50)
Site 13	14 July	17	20.4 ± 3.06 (17 to 30)	0.20 ± 0.06 (0.15 to 0.40)
Sites 12 and 13	16 August	62	39.9 ± 4.25 (25 to 50)	0.42 ± 0.20 (0.15 to 1.35)
Site 12	14 October	1	37	0.6
Dunkirk River				
Site 9	14 July	57	19.6 ± 2.76 (15 to 25)	0.18 ± 0.07 (0.1 to 0.3)
Sites 9 and 10	17 August	46	30.5 ± 4.53 (21 to 44)	0.45 ± 0.18 (0.2 to 1.1)
Site 8	14 October	1	31	0.3

continued ...

Table 17. Continued.

Age and Capture Site	Date of Capture	Number of Fish	Mean Fork Length (mm) ± Std. Dev.	Mean Weight (g) ± Std. Dev.
Age 1+				
MacKay River				
Sites 2 and 5	3 to 31 May	50	37.0 ± 5.66 (27 to 51)	0.54 ± 0.31 (0.3 to 1.5)
Sites 2, 3, 4, and 5	14 to 17 June	43	39.2 ± 7.44 (27 to 60)	0.75 ± 0.49 (0.2 to 2.3)
Sites 2 and 5	14 to 15 July	3	39.7 ± 1.53 (38 to 41)	0.77 ± 0.08 (0.70 to 0.85)
Site 5	17 August	1	73	4.50
Site 2	3 October	1	85	7.80
Dover River				
Sites 12 and 13	20 May	3	30.3 ± 8.62 (21 to 38)	0.27 ± 0.21 (0.1 to 0.5)
Site 13	4, 15, and 16 June	12	37.1 ± 6.02 (31 to 51)	0.64 ± 0.38 (0.3 to 1.5)
Sites 12 and 13	16 August	2	69.0 ± 14.14 (59 to 79)	5.90 ± 0.71 (5.4 to 6.4)
Dunkirk River				
Site 9	20 May	1	35	0.4

continued ...

Table 17. Concluded.

Age and Capture Site	Date of Capture	Number of Fish	Mean Fork Length (mm) ± Std. Dev.	Mean Weight (g) ± Std. Dev.
Sites 9 and 10	16 June	5	32.0 ± 2.12 (30 to 35)	0.38 ± 0.11 (0.2 to 0.5)
Site 9	14 July	1	44	1.0
Sites 9 and 10	17 August	6	62.8 ± 4.07 (59 to 70)	3.02 ± 0.71 (2.5 to 4.4)

reaching mean fork lengths of 45.7 and 47.9 mm by the end of September and mid-October, respectively (Table 17). Bond and Berry (1980b) reported that white suckers in the Athabasca River had completed most of their first year's growth by late August and had reached mean lengths of 43.4 (range 33 to 67 mm) and 46.8 mm (range 35 to 68 mm) by September and October, respectively. White suckers in the Bigoray River, Alberta had completed 93% of their first year's growth by 20 August (Bond 1972).

Sucker fry from the Dunkirk River and Site 6 of the MacKay River appear to grow more slowly than those in the lower reaches (Table 17). Young-of-the-year collected on 14 July at Site 9 had a mean fork length of 19.6 mm (range 15 to 25 mm) and by 17 August, averaged 30.5 mm (range 21 to 44 mm). Those taken from Site 6 on 17 August had a mean fork length of 29.7 mm (range 25 to 35 mm). The smaller size of suckers in the upper MacKay watershed may result from a later spawning period or a poorer food supply in that area.

Overall, growth of white sucker fry in the AOSERP study area appears to be rather slow in comparison to some other areas. Hubbs and Creaser (1924) reported a mean length of 72 mm by September in Douglas Lake, Michigan. White suckers in Gamelin Lake, Quebec measured 76.2 mm in October and continued to grow until December (Lalancette 1976).

5.2.1.17 Food habits. One hundred and sixty-three white sucker stomachs were examined in the field during the spring counting fence operation. Of these, 96% were empty or contained only traces of food while the remainder were one quarter full to full of digested matter. During the autumn gillnetting program, 27 white suckers were examined for stomach contents and only four fish contained food items (Diptera). In the Bigoray River, Bond (1972) reported that 60% of adults examined contained some food and that adult suckers fed almost exclusively on immature insects (Chironomidae, Simuliidae, Trichoptera, and Ephemeroptera). Eder and Carlson (1977) found that white suckers fed primarily on chironomid larvae and pupae in the St. Vrain River, Colorado.

The diet of young-of-the-year and juvenile (age 1+) suckers in the MacKay River (Table 18) consisted mainly of immature aquatic insects (Chironomidae, Ephemeroptera, and Simuliidae). Other food items noted were Crustacea (Cladocera, Copepoda, and Ostracoda), Pelecypoda, Hirudinea, Hydracarina, and Nematoda. Bond (1972) found that small suckers fed mainly on chironomid larvae, small Crustacea, rotifers, diatoms, and desmids. Young-of-the-year white suckers in Lake Gamelin, Quebec consumed mainly zooplankton (Cladocera and Copepoda), while age 1 and older suckers fed mainly on crustaceans, insects, and vegation (Lalancette 1977a).

5.2.1.18 Rearing areas. Large numbers of young-of-the-year white and longnose suckers appear in the Athabasca River in mid-June and drift downstream to nursery areas in the lower delta or Lake Athabasca (Bond and Berry 1980b). The movement of sucker fry out of the tributaries, while greatest in June, continues throughout the summer and the spawning streams, therefore, also serve an important rearing function. During the present study, young-of-the-year white suckers were captured as far upstream as Site 7 on the MacKay River, Site 10 on the Dunkirk River, and Site 13 on the Dover River (Figure 2). They occurred at all sampling sites downstream of these locations and were usually most abundant in back eddies near shore or in other areas of reduced current. The largest concentrations of young-of-the-year were found at Sites 1, 2, 5, 6, 9, and 12 (Figure 2).

5.2.1.19 Overwintering. Most young-of-the-year suckers leave the MacKay River during their first summer; however, a small percentage apparently remains in the tributary over the winter. Yearling white suckers were captured at Sites 2, 3, 4, 5, 9, 10, 12, and 13 (Figure 2) in May and June 1978. Tagging results indicate that the larger and older fish overwinter in Lake Athabasca although some

Table 18. Food habits of young-of-the-year and juvenile longnose and white suckers captured in the MacKay River, 1978.

Food Items	White Suckers		Longnose Suckers	
	% Freq.[a]	% No.	% Freq.[a]	% No.
Class Insecta				
Diptera				
Chironomidae	64.0	56.2	59.0	63.8
Simuliidae	10.0	1.2	7.7	0.2
Unidentified Diptera	10.0	ND	12.8	2.0
Trichoptera	4.0	0.4	7.7	0.6
Ephemeroptera	16.0	3.0	35.9	2.0
Coleoptera	0.0	0.0	2.6	0.1
Miscellaneous				
Annelida				
Oligochaeta	2.0	0.2	5.1	0.1
Hirudinea	4.0	0.4	0.0	0.0
Arachnida				
Hydracarina	6.0	1.0	7.7	0.3
Nematoda	2.0	0.1	5.1	0.5
Crustacea				
Cladocera	6.0	+[b]	0.0	0.0
Copepoda	6.0	+[b]	2.6	0.1
Ostracoda	8.0	3.3	5.1	28.5
Mollusca	4.0	0.4	2.6	1.5
Pelecypoda	12.0	31.8	7.7	0.2
Digested Matter	36.0		35.9	
Debris (Tar sands, stones)	2.0		2.5	
Total Stomachs	50		40	
Empty (% of Total)	0.0		2.5	

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

[b] Copepoda and Cladocera were omitted from percent number calculations as they had a low percent frequency of occurrence but sometimes occurred in high numbers.

evidence that some overwintering occurs within the MacKay River has been provided by McCart et al. (1978) who captured one white sucker near Site 4 (Figure 2) on 13 to 15 January 1978.

5.2.2 Longnose Suckers

5.2.2.1 Seasonal timing of upstream migration. The 1978 longnose sucker migration into the MacKay River began approximately 29 April (Table 9, Figure 13) on which date the maximum water temperature was 4.5°C. Gillnets, set between 21 and 28 April captured no longnose suckers (Table 4). While longnose suckers continued to enter the upstream trap throughout the period of fence operation, 66% of the total catch was taken between 30 April and 3 May, and the upstream run was essentially complete by 5 May (Table 9, Figure 13). Peak upstream movements were observed on 1 May (n = 216) when the maximum daily water temperature was 7.0°C (Figure 12). Longnose sucker spawning migrations appear to be initiated by rising water temperatures following the spring break-up. Geen et al. (1966) observed that the spawning migration in British Columbia was associated with a water temperature of 5.0°C. Bailey (1969) reported that, in the Brule River, Wisconsin, spawning runs (over a seven year period) peaked at an average water temperature of 13.8°C (range 10.9 to 14.4°C). Previous studies in the AOSERP study area (Bond and Machniak 1977, 1979; Machniak and Bond 1979) have reported longnose sucker migrations to peak at maximum daily water temperatures of from 9.0 to 14.5°C.

5.2.2.2 Diel timing of upstream migration. The majority of longnose suckers (86%) moved upstream between noon and midnight with maximum movement usually occurring in the early evening (Table 19). Similar results have been observed for other longnose sucker runs, both within the AOSERP study area (Bond and Machniak 1977, 1979; Machniak and Bond 1979) and elsewhere (Geen et al. 1966).

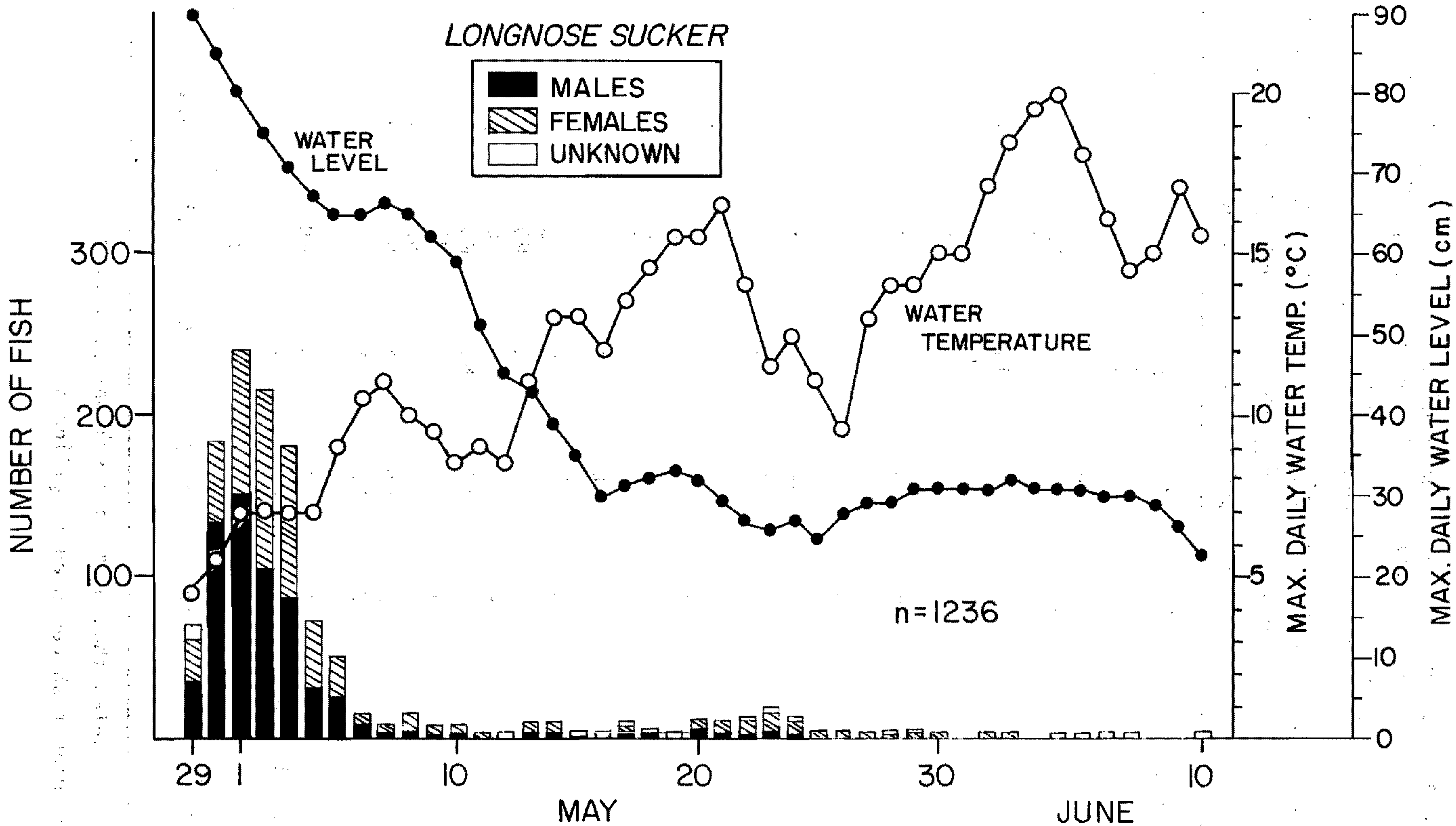

Figure 13. Seasonal timing of the longnose sucker upstream migration in the MacKay River, 1978.

Table 19. Summary of diel timing of the upstream migration of longnose suckers in the MacKay River, 1978. Fish that were counted at times other than those indicated were included in the next check period.

Date	Number of Fish Counted at Each Trap Check					Total
	1200 h	1500 h	1800 h	2100 h	2400 h	
29 April	ND[a]	ND	58[b]	ND	11	69[b]
30	0	2	131[b]	28	22	183[b]
1 May	7	87	113	22	10	239
2	8	ND	137[b]	63	8	216[b]
3	61	53	21	42	4	181
4	11	2	4	50	5	72
5	2	18	14	10	5	49
6	7	1	0	0	6	14
7	1	0	1	1	4	7
8	2	1	0	0	12	15
9	3	0	1	0	3	7
10	3	3	1	0	0	7
11	0	0	0	0	1	1
12	1	ND	ND	2	0	3
13	1	ND	5	1	1	8
14	3	3	0	1	1	8
15	0	2	1	1	1	5
16	0	0	2	2	1	5
17	5	ND	1	2	1	9
18	2	1	0	2	0	5
19	0	ND	1	0	1	2
20	3	ND	3	5	0	11
21	9	ND	ND	ND	1	10
22	7	ND	4	ND	1	12
23	9	ND	5	ND	3	17
24	4	ND	5	ND	3	12
25	3	ND	ND	ND	2	5
26	1	ND	2	ND	2	5
27	1	ND	ND	ND	1	2
28	2	ND	2	ND	2	6
29	2	ND	1	ND	2	5
30	2	ND	1	ND	0	3
31	0	ND	0	ND	0	0
1 to 18 June	17	ND	11	ND	15	43
Totals	177	173	525	232	129	1236
% Grand Total	14.3	14.0	42.5	18.8	10.4	

[a] ND indicates that no trap check was performed.

[b] Includes fish captured in gillnets.

5.2.2.3 Spawning times and locations. Longnose suckers probably spawned in the MacKay River watershed in mid-May 1978. Ripe fish were captured at the fence site from 30 April to 20 May; the first spent fish were taken on 18 May; and, by 20 May, virtually all longnose suckers of both sexes were spawned out. Young-of-the-year suckers were first captured at the fence site on 2 June (Appendix 8.3) and, although longnose and white sucker fry could not be distinguished at that time, both species are believed to have been present.

Because no attempt was made to locate fish on spawning grounds during May, no observational evidence exists with respect to longnose sucker spawning sites in the MacKay River watershed. Geen et al. (1966) reported that longnose suckers spawn over gravel 0.5 to 10.0 cm in diameter, at a water depth of 15.2 to 27.9 cm, and at a water velocity of 30 to 35 cm/s. Such areas are present throughout the middle and lower reaches of the MacKay River watershed but the most likely spawning areas appear to be upstream of the Dover River. McCart et al. (1978) found sucker fry to be widely distributed in the lower reaches of the MacKay River, but that they were most abundant in the region between Sites 4 and 5 (Figure 2). These authors felt that most longnose suckers spawned upstream of Lease 17 (Figure 2). Results of the present study tend to confirm the conclusion of McCart et al. (1978). During July 1978, young-of-the-year longnose suckers were captured at Sites 1, 2, 4, 6, and 12 (Figure 2), with the largest collections being taken at Sites 4 and 6. Subsequent sampling throughout the watershed produced young-of-the-year longnose suckers at Sites 2, 3, 5, 6, 9, 12, and 13 (Figure 2). The relatively small collections made in the Dover and Dunkirk rivers suggest that these tributaries have less importance than the MacKay River mainstem as longnose sucker spawning sites.

5.2.2.4 Seasonal timing of downstream migration. The post-spawning, downstream migration of longnose suckers could not be monitored in detail because of the inefficiency of the partial downstream fence. It is likely, however, that the main downstream movement of longnose suckers occurred during late May and early June. Of 56 fish captured at the downstream trap, 71% were taken between 28 May and 3 June, having spent from 18 to 35 days in the MacKay River watershed (Appendix 8.6). In the Muskeg River, Bond and Machniak (1979) observed that 61.2% of longnose suckers had returned downstream by 15 June 1977. Bond and Machniak (1977) monitored downstream movements of longnose suckers in the Muskeg River until the end of July 1976, by which time 77.2% of upstream migrants had returned downstream. Most of these fish (81.6%) had been in the tributary less than 30 days. Brown and Graham (1954) reported that the average time spent by spawning longnose suckers in Pelican Creek, Wyoming was 17 days for males and 19 days for females.

Only 15 longnose suckers were captured in the MacKay River during the autumn gillnetting program (Table 5), suggesting that most longnose suckers had left the stream by that time. Eight of the fish captured were adults. McCart et al. (1978) had captured 88% of their longnose suckers by 21 August. Machniak and Bond (1979) reported longnose suckers leaving the Steepbank River in September and October and found that most (88%) of these were immature fish less than 320 mm in fork length.

5.2.2.5 Spawning mortality. Forty longnose suckers were found dead or in poor condition at the MacKay River fence site during May and June. Bond and Machniak (1977, 1979) reported low post-spawning mortalities for longnose suckers in the Muskeg River. Geen et al. (1966) estimated post-spawning mortality to be 11 to 28% and considered survival of longnose suckers to be very high.

5.2.2.6 Size composition of migrant longnose suckers. Fork lengths were obtained for 1225 longnose suckers during the 1978 upstream migration, of which sex was determined for 1168 individuals (Table 20 and Figure 14). While lengths ranged from 204 to 479 mm, the majority of fish (88%) were between 330 and 449 mm. Within this size range, females with a modal length in the 410 to 419 mm interval,

Table 20. Length-frequency distribution of longnose suckers during the spring upstream migration in the MacKay River, 1978.

Fork Length (mm)	Male	Female	Unknown	Total
200 to 209	0	0	2	2
210 to 219	0	0	1	1
220 to 229	0	0	1	1
230 to 239	0	0	1	1
240 to 249	0	0	3	3
250 to 259	0	0	5	5
260 to 269	0	0	9	9
270 to 279	0	1	13	14
280 to 289	2	5	7	14
290 to 299	1	11	8	20
300 to 309	1	11	4	16
310 to 319	2	16	3	21
320 to 329	7	5	0	12
330 to 339	20	12	0	32
340 to 349	39	9	0	48
350 to 359	57	20	0	77
360 to 369	78	26	0	104
370 to 379	84	26	0	110
380 to 389	103	49	0	152
390 to 399	96	66	0	162
400 to 409	70	76	0	146
410 to 419	32	84	0	116
420 to 429	13	52	0	65
430 to 439	4	42	0	46
440 to 449	1	24	0	25
450 to 459	0	12	0	12
460 to 469	1	4	0	5
470 to 479	2	4	0	6
Totals	613	555	57	1225

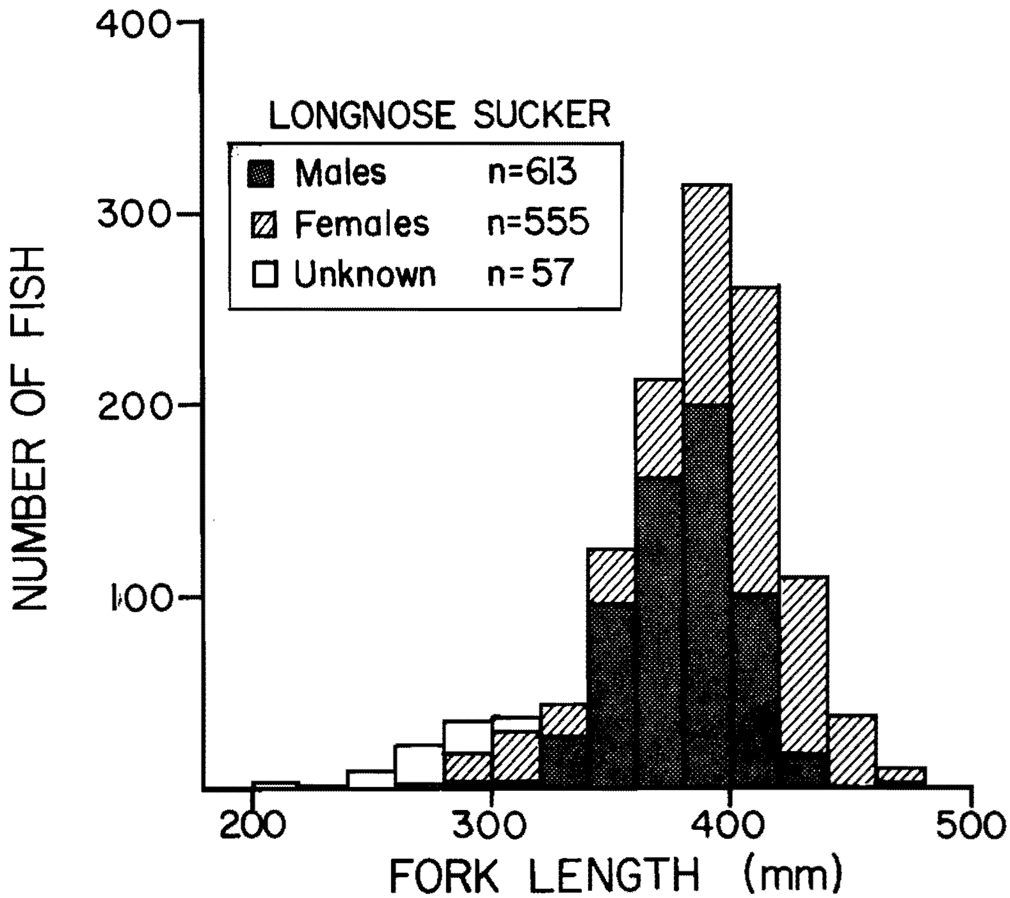

Figure 14. Length-frequency distribution for longnose suckers during the upstream migration in the MacKay River, 1978.

were clearly larger than males, which had a modal length in the 380 to 389 mm interval (Table 20). Similar results have been obtained for longnose sucker runs in the Muskeg (Bond and Machniak 1977, 1979) and Steepbank (Machniak and Bond 1979) rivers of the AOSERP study area.

5.2.2.7 Age composition of migrant longnose suckers. Longnose suckers captured during the 1978 upstream run in the MacKay River ranged in age from four to 13 years, the majority (95%) being age 8 to 12 inclusive (Figure 15). Similar results have been reported for longnose suckers during spring migrations in the Muskeg River (Bond and Machniak 1977, 1979), the Steepbank River (Machniak and Bond 1979), the Athabasca River (McCart et al. 1977), and the Clearwater River (Tripp and McCart 1980).

5.2.2.8 Sex ratio of migrant longnose suckers. Sex was determined for 1170 longnose suckers during the upstream migration, of which 615 (53%) were males. The sex ratio, therefore, did not differ significantly overall from unity ($X^2 = 3.08$, $P > 0.05$). However, the sex ratio did vary with time during the upstream run. The early part of the migration (29 April to 1 May) was dominated by males (65%), while females (53%) outnumbered males between 2 and 5 May (Table 21). Most other studies in the AOSERP study area have also reported approximately equal numbers of male and female longnose suckers (McCart et al. 1977; Bond and Machniak 1977; Bond and Berry 1980b; McCart et al. 1978; Tripp and McCart 1980). Machniak and Bond (1979), however, observed that females (56%) were significantly more numerous than males during the upstream migration in the Steepbank River, and Bond and Machniak (1979) found that males (53%) outnumbered females by a significant margin in the Muskeg River in 1977. In the Hay River, NWT, Harris (1962) reported that females outnumbered males during the spawning run by a ratio of 10:1. Geen et al. (1966) and Kendel (1975) both noted that male longnose suckers tend to precede the females onto the spawning grounds and to remain longer.

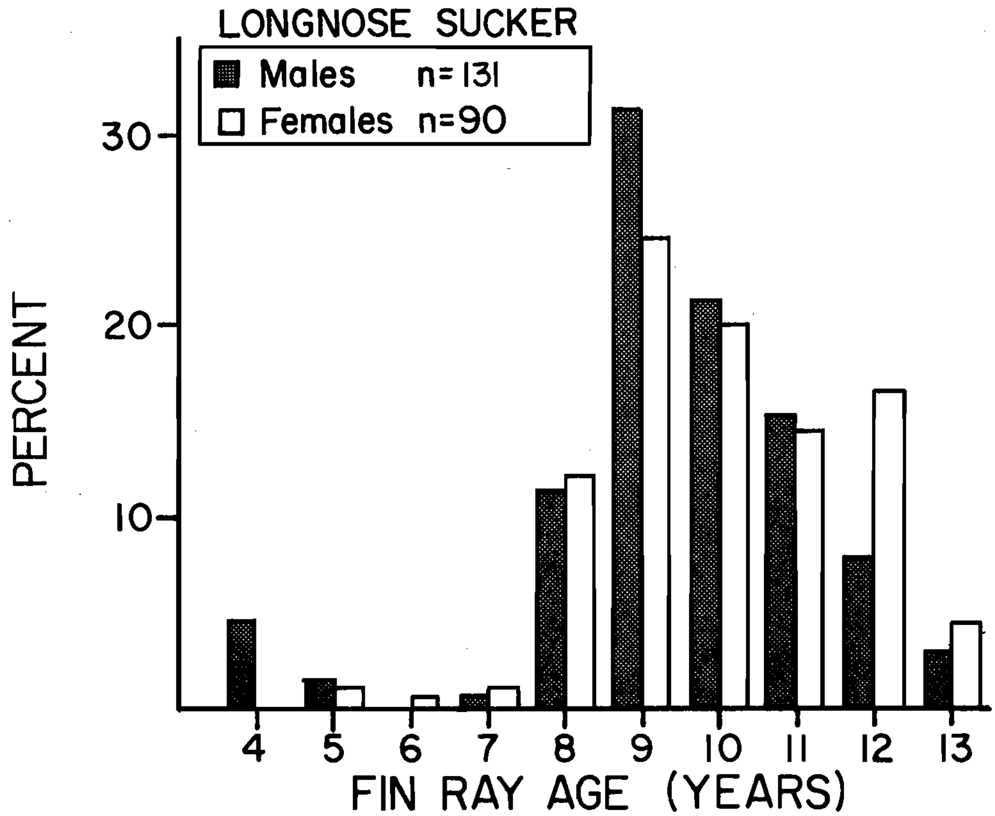

Figure 15. Age composition for longnose suckers sampled during the counting fence operation, MacKay River, 1978.

Table 21. Sex ratio for longnose suckers during the upstream migration, MacKay River, 1978.

Date	Number of Fish				Percent Males[a]
	Males	Females	Unknown	Total	
29 April	34[b]	26[b]	9	69[b]	57
30	132[b]	51[b]	0	183[b]	72
1 May	149	90	0	239	62
2	103[b]	113[b]	0	216[b]	48
3	85	94	2	181	47
4	30	41	1	72	42
5	24	24	1	49	50
6	8	6	0	14	57
7	2	5	0	7	29
8	4	11	0	15	27
9	3	4	0	7	43
10	3	4	0	7	43
11	0	1	0	1	0
12	0	1	2	3	0
13	3	4	1	8	43
14	3	5	0	8	38
15	1	1	3	5	50
16	0	2	3	5	0
17	5	2	2	9	71
18	3	1	1	5	75
19	0	1	1	2	0
20	5	5	1	11	50
21	3	6	1	10	33
22	1	9	2	12	10
23	4	9	4	17	31
24	3	7	2	12	30
25	0	4	1	5	0
26	1	3	1	5	25
27	0	2	0	2	0
28	1	3	2	6	25
29	0	4	1	5	0
30	0	0	3	3	0
31	0	0	0	0	0
1 to 18 June	5	16	22	43	24
Totals	615	555	66	1236	
%	53	47			

[a] Based on fish of known sex.

[b] Includes gillnet fish.

5.2.2.9 Tagging results. Floy tags were applied to 625 longnose suckers in the MacKay River during 1978. By 6 June, five tagged fish had been recaptured at the downstream trap while a sixth was taken in June in Lake Athabasca (Table 8, Appendix 8.6). No captures were made during the autumn gillnetting program. Such a low rate of tag returns provides little information by itself with respect to longnose sucker movements. However, the capture of one longnose sucker in Lake Athabasca lends support to the evidence provided by Bond and Machniak (1979), Machniak and Bond (1979), and Bond and Berry (1979a, 1979b) that suggests that longnose suckers that spawn in tributaries of the AOSERP study area belong to the Lake Athabasca population and return to the lake during the summer to feed and overwinter.

During 1976 and 1977, Floy tags were applied to 4739 longnose suckers during studies on other tributaries in the AOSERP study area (Bond and Machniak 1977, 1979; Machniak and Bond 1979). McCart et al. (1978) captured none of these tagged fish in the MacKay River during 1977. During the present study, one longnose sucker, tagged in the Muskeg River in 1977, was recaptured. The paucity in the MacKay River, of longnose suckers tagged in other tributaries during previous years, tends to confirm the suggestion that there may be a strong homing tendency on the part of this species. Bond and Machniak (1979) reported that Muskeg River longnose suckers demonstrated considerable fidelity to their spawning stream as more than 20% of those tagged in 1976 returned to the Muskeg River in 1977.

5.2.2.10 Fecundity. Fecundity was estimated gravimetrically for 12 female longnose suckers in spawning condition. The estimated number of eggs per female (373 to 475 mm fork length) ranged from 14 305 to 30 345 (Table 22) and averaged 22 900. Actual egg counts on four ovaries revealed errors of from + 1.0% to -9.4% for estimated values. The number of eggs per female in the Steepbank River averaged 29 502 and ranged from 22 932 to 49 448 for longnose suckers of similar size (Machniak and Bond 1979). Tripp and McCart (1980) recorded a

Table 22. Fecundity estimates for longnose suckers sampled during the 1978 MacKay River spawning migration.

Fork Length (mm)	Weight (g)	Number of Eggs: Left Ovary	Right Ovary	Total	Relative Fecundity (Eggs/cm)	(Eggs/g)
475	1320	ND[a]	ND	28 090	591.4	21.3
445	1000	14 345	16 000	30 345	681.9	30.4
440	1000	ND	ND	23 813	541.2	23.8
427	1060	12 067	11 866	23 933	560.5	22.6
426	940	12 625	14 432	27 057	635.1	28.8
418	960	12 207	13 248[b] (-2.1%)[c]	25 455	609.0	26.5
417	1000	12 267	14 915[b] (-9.4%)[c]	27 182	651.9	27.2
410	880	ND	ND	19 290	470.5	21.9
402	860	ND	ND	15 181[b] (-2.5%)[c]	377.6	17.7
400	780	ND	ND	20 200	505.0	25.9
398	810	ND	ND	19 944	501.1	24.6
372	700	ND	ND	14 305[b] (+1.0%)[c]	384.5	20.4

[a] No data

[b] Actual egg counts.

[c] Deviation of estimated counts from actual numbers.

mean fecundity of 21 843 eggs (range 6 623 to 53 768 eggs) for longnose suckers (309 to 497 mm) collected in the Athabasca River upstream of Fort McMurray. Egg production for suckers from Lake Superior (Bailey 1969) ranged from 14 000 to 35 000 and averaged 24 000 for fish between 353 and 450 mm.

Where the right and left ovaries were estimated separately, the right ovary, in four out of five cases, contained more eggs than the left (average 14 649; range 13 248 to 16 000 eggs). Bond and Machniak (1977, 1979) and Machniak and Bond (1979) reported similar results for longnose suckers in the Muskeg and Steepbank rivers.

Length-relative fecundity for MacKay River longnose suckers ranged from 377.6 to 681.9 ova per cm of fork length (average 554.2), while weight-relative fecundity varied from 17.7 to 30.4 eggs per g of body weight (average 24.8).

Regression analysis indicated a significant ($P < 0.01$) positive correlation between fecundity and fork length ($n = 12$, $r = 0.816$) and fecundity and body weight ($r = 0.769$). The relationship between fecundity and fork length is expressed by the equation:

$$\log_{10}\text{Fecundity} = 3.130 \log_{10}\text{Fork Length (mm)} - 3.856;$$
$$sb = 0.700$$

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

$$\log_{10}\text{Fecundity} = 1.129 \log_{10}\text{Weight (g)} - 0.997;$$
$$sb = 0.297$$

5.2.2.11 Egg size and ovary weight. Eggs of 38 mature and ripe females captured during the spring run ranged in size from 1.6 to 2.0 mm with a mean diameter of 1.8 mm. Machniak and Bond (1979) recorded a similar egg size for Steepbank River longnose suckers. Females from the AOSERP study area appear to have a smaller egg size than that reported for other areas. The average egg diameter for Great Slave Lake suckers was 3.0 mm (Harris 1962). Lake Superior fish had a mean egg diameter of 2.2 mm (Bailey 1969), while Tripp and

McCart (1974) reported a mean egg diameter of 2.0 mm for Donnelly River longnose suckers.

The mean ovary weight for seven ripe females was equivalent to 10.5% of the mean body weight (range 8.5 to 12.4%). Tripp and McCart (1974) and Machniak and Bond (1979) recorded higher mean values for ovary weight/body weight; respectively, 12.8% for Donnelly River females and 12.5% for Steepbank River fish. The mean ovary weight of spent females was not determined during the present study; however, Machniak and Bond (1979) calculated a mean value of 1.4% of total body weight (range 0.9 to 21.%) for spent longnose suckers from the Steepbank River.

5.2.2.12 Age and growth. Longnose suckers captured from the MacKay River watershed during the present study ranged from age 0+ to age 13. As mentioned previously, most fish taken during the spring spawning run were age 8 to 12 inclusive. The maximum age recorded for longnose suckers in the AOSERP study area is 20 years (Tripp and McCart 1980).

Most growth in length of MacKay River longnose suckers was achieved during the first eight years of life, by which age suckers had a mean fork length of 387 mm (Table 23). After age 8, the rate of growth decreased considerably. The age-length relationship for MacKay River suckers is similar to that reported for longnose suckers in most previous studies from the AOSERP study area (McCart et al. 1977; Bond and Machniak 1977, 1979; Jones et al. 1978; Bond and Berry 1980a, 1980b; Machniak and Bond 1979). Longnose suckers captured in the Athabasca River upstream of the Cascade Rapids, however, apparently grow at a very slow rate (Tripp and McCart 1980), comparable to that reported for suckers in Pyramid Lake, Alberta (Rawson and Elsey 1950). MacKay River suckers (Figure 16) grow much faster than Pyramid Lake fish (Rawson and Elsey 1950) and slightly faster that Donnelly River suckers (Tripp and McCart 1974). They do not, however, grow as rapidly as suckers from Great Slave Lake

Table 23. Age-length relationship (derived from fin rays and otoliths) for longnose suckers captured in the MacKay River watershed, 1978, sexes separate and combined sample (includes unsexed fish).

Age	Males				Females				All Fish				t-test
	N	Mean	S.D.	Range	N	Mean	S.D.	Range	N	Mean	S.D.	Range	
2	4	103.5	11.68	89 to 116	2	113.0	4.24	110 to 116	6	106.7	10.46	89 to 116	
3	0				2	153.5	20.51	139 to 168	6	159.7	12.14	139 to 172	
4	6	217.0	7.07	207 to 225	0				30	199.3	17.24	171 to 230	
5	2	258.0	39.59	230 to 286	1	231.0			5	238.6	29.34	206 to 286	
6	0				1	216.0			2	284.5	33.23	261 to 308	
7	1	367.0			1	324.0			3	322.3	45.52	276 to 367	
8	15	382.7	9.39	363 to 400	11	392.0	24.84	356 to 435	26	386.6	17.84	356 to 435	2.423[a]
9	41	389.1	16.81	358 to 419	22	415.5	17.76	378 to 446	63	389.3	21.24	358 to 446	2.626[a]
10	28	394.1	16.80	354 to 423	18	418.6	21.26	386 to 454	46	403.7	22.03	354 to 454	3.176[a]
11	20	402.0	15.88	373 to 432	13	424.1	15.03	400 to 453	33	410.7	18.83	373 to 453	3.550[a]
12	10	403.7	9.67	388 to 415	15	423.1	23.81	395 to 475	25	415.4	21.45	388 to 475	6.148[a]
13	4	407.0	10.42	393 to 418	4	445.8	27.12	417 to 479	8	426.4	28.12	393 to 479	2.667[a]
Totals	131				90				253				

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

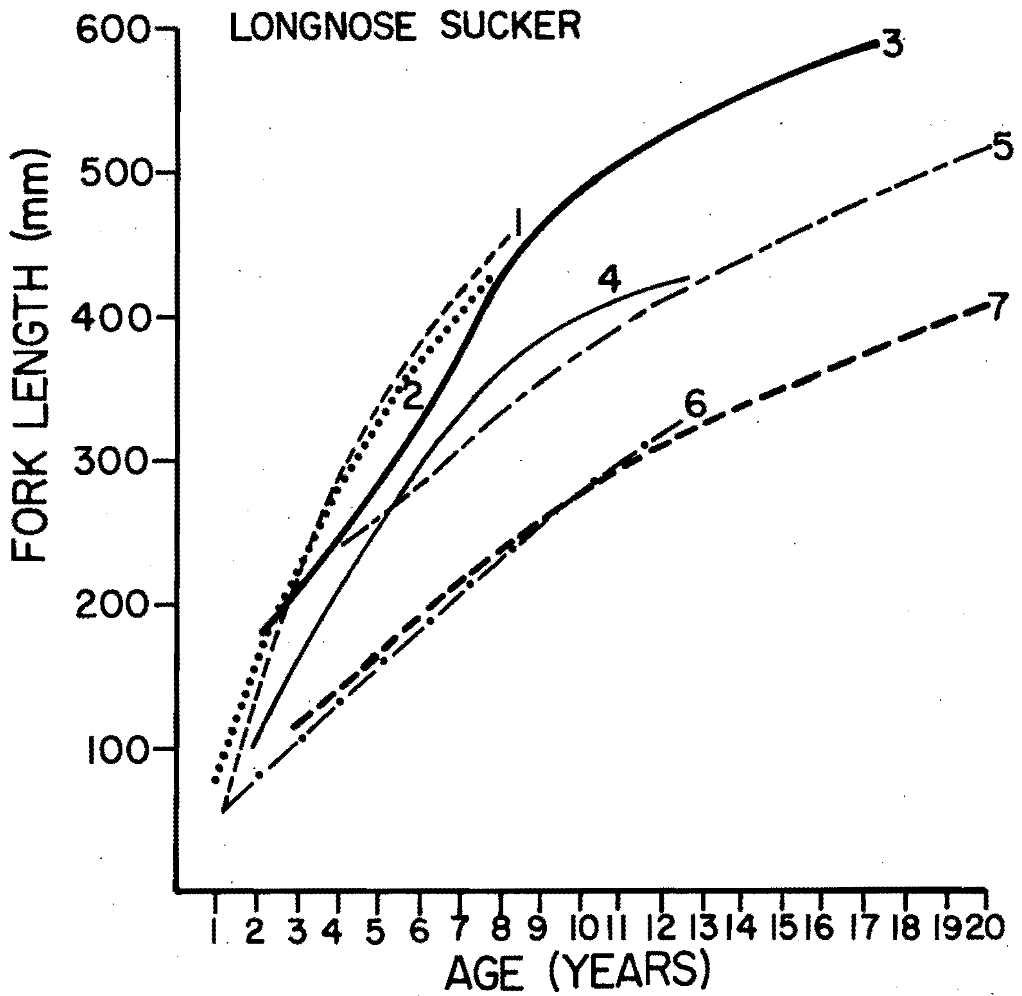

Figure 16. Growth in fork length for longnose suckers from the MacKay River and from several other areas: 1. Yellowstone Lake, Wyo. (Brown and Graham 1954); 2. Western Lake Superior (Bailey 1969); 3. Great Slave Lake South (Harris 1962); 4. MacKay River (Present Study); 5. Donnelly River, N.W.T. (Tripp and McCart 1974); 6. Pyramid Lake, Alta. (Rawson and Elsey 1950); and 7. Athabasca River (Tripp and McCart 1980).

(Harris 1962), Yellowstone Lake (Brown and Graham 1954), or Lake Superior (Bailey 1969).

Female suckers were longer than males of the same age with the difference in mean fork length being significant ($P < 0.05$) in age groups eight to 13 inclusive (Table 23). Bond and Machniak (1977, 1979) and Machniak and Bond (1979) observed similar differences in mean length between the sexes, with females being significantly larger than males. Lalancette and Magnin (1970) noted that females were always approximately 10 mm longer than males in the same age group. Harris (1962), however, reported no such difference between the sexes, indicating that they increase in length at about the same rate.

During the first few years of life, MacKay River longnose suckers added weight slowly with age 4 fish averaging 95 g. The rate of weight gain then increased for the next three to four years, decreasing again after age 9. Female longnose suckers were generally heavier than males of the same age with the differences in mean weight being statistically significant ($P < 0.05$) at age 9, 10, 11, and 13 (Table 24).

5.2.2.13 <u>Sex and maturity</u>. Age and sex were determined for 221 longnose suckers, of which 60% were males (Table 25). Although few five- to seven-year old fish were captured, the earliest age of sexual maturity for MacKay River longnose suckers appears to be age 7, and virtually all fish were sexually mature by age 8. Machniak and Bond (1979) reported similar results, but observed that both male and female longnose suckers begin to mature at age 6. Bond and Machniak (1977) and Tripp and McCart (1980) found some longnose suckers as old as 13 and 14 years, respectively, with immature gonads and suggested that not all AOSERP area suckers spawn every year.

Longnose suckers spawn at younger ages in the southern part of their range than in more northern areas. Geen et al. (1966) found most spawners to be five to 11 years old in Frye Creek, British

Table 24. Age-weight relationship for longnose suckers captured in the Mackay River watershed, 1978, sexes separate and combined sample (includes unsexed fish).

Age	Males				Females				All Fish				t-test
	N	Mean	S.D.	Range	N	Mean	S.D.	Range	N	Mean	S.D.	Range	
2	4	13.2	4.85	7.3 to 18.1	2	17.9	1.34	17.0 to 18.9	6	14.8	4.54	7.3 to 18.9	
3	0				2	39.6	7.64	34.2 to 45.0	6	48.9	16.08	34.2 to 80.0	
4	6	121.7	14.72	100 to 140	0				30	94.5	22.72	70 to 140	
5	2	225.0	91.92	160 to 290	1	140.0			5	166.0	74.36	90 to 290	
6	0				1	230.0			2	275.0	63.64	230 to 320	
7	1	600.0			1	410.0			3	406.7	195.02	210 to 600	
8	15	739.3	73.34	600 to 860	11	810.0	172.74	510 to 1060	26	769.2	127.34	510 to 1060	1.427
9	41	764.6	107.61	540 to 970	22	957.5	138.65	725 to 1260	63	831.9	150.24	540 to 1260	6.122[a]
10	28	796.4	95.69	580 to 930	18	974.9	159.59	800 to 1320	46	866.3	151.25	580 to 1320	4.752[a]
11	20	797.0	87.73	650 to 950	13	1001.5	143.52	780 to 1320	33	877.6	150.31	650 to 1320	5.097[a]
12	10	853.0	95.46	680 to 990	15	986.7	203.21	780 to 1320	25	933.2	178.81	680 to 1320	1.933
13	4	840.0	64.81	760 to 910	4	1060.0	146.97	880 to 1180	8	950.0	157.75	760 to 1180	2.739[a]
Totals	131				90				253				

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

Table 25. Age-specific sex ratios and maturity for longnose suckers from the MacKay River drainage, 1978. Sex ratios were based only on fish for which sex was determined by gonadal inspection.

Age	Females			Males			Unsexed Fish	Total
	N	%	% Mature	N	%	% Mature		
2	2	33	0	4	67	0	0	6
3	2	100	0	0	0	0	4	6
4	0	0	ND	6	100	0	24	30
5	1	33	0	2	67	0	2	5
6	1	100	0	0	0	ND	1	2
7	1	50	0	1	50	100	1	3
8	11	42	82	15	58	100	0	26
9	22	35	100	41	65	98	0	63
10	18	39	94	28	61	100	0	46
11	13	39	100	20	61	100	0	33
12	15	60	100	10	40	100	0	25
13	4	50	100	4	50	100	0	8
Totals	90	40%		131	60%		32	253

Columbia, while in Wyoming, the majority of spawning run suckers were from four to seven years old (Brown and Graham 1954). Most spawners in the Hay River, NWT were age 10 to 12 inclusive (Harris 1962), while in the Donnelly River, NWT, the majority of spawning longnose suckers were 11 to 18 years old (Tripp and McCart 1974). The youngest age of first sexual maturity reported for longnose suckers is two years in Colorado (Hayes 1956) and the oldest is nine years for Great Slave Lake (Harris 1962) and the Donnelly River (Tripp and McCart 1974).

5.2.2.14 Length-weight relationship. The following length-weight relationships were determined for longnose suckers captured in the MacKay River during 1978. For male longnose suckers (n = 127, r = 0.989, range 207 to 432 mm), the relationship between fork length and body weight is described by the equation:

$$\log_{10}W = 3.076(\log_{10}L) - 5.090;\ sb = 0.041$$

For female longnose suckers (n = 87, r = 0.979, range 168 to 479 mm), the length-weight relationship is described by the equation:

$$\log_{10}W = 3.184(\log_{10}L) - 5.365;\ sb = 0.073$$

Analysis of covariance indicated no significant difference ($P < 0.05$) between the adjusted means ($F = 1.181$) or slopes ($F = 1.938$) of the length-weight regressions for male and female suckers.

5.2.2.15 Growth of young-of-the-year. Young longnose suckers remain in the gravel for a period of 1 to 2 wk before emerging, and about a month after the beginning of the spawning migration, they begin to move out of the spawning stream at a size of 10 to 12 mm total length (Geen et al. 1966). In 1978, longnose suckers had probably completed spawning by mid-May in the MacKay River watershed. Sucker fry were first captured on 2 June and were abundant at Site 2 until drift sampling operations terminated on 19 June (Appendix 8.3). During this period, sucker fry ranged from 6 to 16 mm total length, with a modal length of 13 mm (Figure 10). As mentioned previously, it was not possible to distinguish between the two species of suckers at this stage although both were undoubtedly present.

Young-of-the-year longnose suckers, captured from the MacKay River watershed on 14 and 15 July 1978, ranged from 17 to 35 mm in fork length with a mean length of 23.5 mm (Table 26). Fry captured on 16 to 17 August had a mean fork length of 35.3 mm (range 22 to 47 mm), while those taken between 25 September and 14 October ranged from 29 to 57 mm with a mean fork length of 47.3 mm. Yearling longnose suckers, captured in the MacKay River watershed during May 1978, ranged from 28 to 80 mm with a mean fork length of 44.1 mm (Table 26). The growth rate for longnose sucker fry in the MacKay River watershed appears to be similar to that reported for the Donnelly River (Tripp and McCart 1974) where fish attained a mean fork length of 44.3 mm by the end of August. However, the rate of growth for the relatively small number of longnose suckers that spend their entire first summer in the MacKay River watershed may differ from that of the majority which drift back to Lake Athabasca.

5.2.2.16 Food habits. Field analysis of stomachs during the spawning season indicated that few suckers feed at that time. Of 193 stomachs examined, 76% contained only a trace of food or were empty. The remainder were one-quarter full to full of immature aquatic insects and plant matter. Of 15 longnose suckers examined in the MacKay River during the autumn, only two contained any food (digested matter). Machniak and Bond (1979) indicated that Diptera (Chironomidae and Simuliidae) and Trichoptera were the most common immature insects found in the stomachs of adult suckers from the Steepbank River. In Yellowstone Lake, Brown and Graham (1954) recorded a diet consisting principally of algae and aquatic plants with some aquatic insects (Ephemeroptera, Coleoptera, and Trichoptera). Bond and Berry (1980a) reported a diet consisting mainly of aquatic insects and pelecypods for suckers captured in the Athabasca River.

The food of young-of-the-year and juvenile (age 1+) longnose suckers from the MacKay River consisted mainly of immature aquatic insects (Chironomidae, Ephemeroptera, Simuliidae, and Trichoptera).

Table 26. Comparison of mean fork lengths and mean weights of young-of-the-year (age 0+) and juvenile (age 1+) longnose suckers collected from the MacKay, Dover, and Dunkirk rivers, 1978. Numbers in parentheses indicate ranges in length and weight.

Age and Capture Site	Date of Capture	Number of Fish	Mean Fork Length (mm) ± Std. Dev.	Mean Weight (g) ± Std. Dev.
Age 0+				
MacKay River				
Sites 2 and 4	14 to 15 July	213	23.3 ± 3.37 (17 to 35)	0.13 ± 0.09 (0.1 to 0.4)
Sites 2, 3,and 6	16 to 17 August	30	35.8 ± 5.25 (27 to 46)	0.54 ± 0.28 (0.2 to 1.2)
Site 2	25 to 30 September	16	50.9 ± 6.06 (38 to 57)	1.75 ± 0.59 (0.8 to 3.1)
Sites 2, 3, and 5	1 to 14 October	28	46.1 ± 7.86 (29 to 57)	1.35 ± 0.60 (0.3 to 2.4)
Dover River				
Site 12	14 July	11	27.0 ± 2.45 (24 to 31)	0.33 ± 0.07 (0.25 to 0.45)
Sites 12 and 13	16 August	14	35.7 ± 5.79 (28 to 47)	0.60 ± 0.28 (0.3 to 1.1)
Site 13	14 October	3	39.3 ± 4.51 (35 to 44)	0.87 ± 0.35 (0.5 to 1.2)

continued ...

Table 26. Continued.

Age and Capture Site	Date of Capture	Number of Fish	Mean Fork Length (mm) ± Std. Dev.	Mean Weight (g) ± Std. Dev.
Dunkirk River				
Site 9	17 August	28	37.2 ± 6.20 (22 to 46)	0.74 ± 0.30 (0.2 to 1.3)
Age 1+				
MacKay River				
Sites 2, 4, and 5	3 to 31 May	115	44.1 ± 10.67 (28 to 80)	1.07 ± 0.95 (0.2 to 4.8)
Site 3	15 July	4	48.5 ± 6.75 (42 to 58)	1.50 ± 0.75 (0.9 to 2.6)
Site 2	16 August	1	52	1.7
Site 2	25 to 30 September	21	63.4 ± 7.05 (55 to 81)	3.16 ± 1.14 (1.7 to 5.6)
Sites 2, 3, and 5	1 to 14 October	7	75.7 ± 7.43 (62 to 84)	5.43 ± 1.40 (2.9 to 6.8)
Dover River				
Site 12	20 May	2	35.5 ± 0.71 (35 to 36)	0.45 ± 0.07 (0.4 to 0.5)
Site 12	4 June	9	39.3 ± 4.61 (33 to 46)	0.70 ± 0.25 (0.5 to 1.1)

continued ...

Table 26. Concluded.

Age and Capture Site	Date of Capture	Number of Fish	Mean Fork Length (mm) ± Std. Dev.	Mean Weight (g) ± Std. Dev.
Site 12	16 August	1	57	2.1
Dunkirk River				
Site 9	16 June	2	36.0 ± 1.41 (35 to 37)	0.55 ± 0.07 (0.5 to 0.6)
Site 9	17 August	2	66.0 ± 5.66 (62 to 70)	3.35 ± 1.06 (2.6 to 4.1)

Other food items noted included Hydracarina, Oligochaeta, Pelecypoda, Ostracoda, and Nematoda (Table 18). Machniak and Bond (1979) reported similar results for young suckers captured in the Steepbank River.

5.2.2.17 Rearing areas. Large numbers of young-of-the-year longnose and white suckers appear in the Athabasca River in mid-June and drift downstream to nursery areas in the lower delta or Lake Athabasca (Bond and Berry 1980b). The movement of sucker fry out of the tributaries, while greatest in June, continues throughout the summer and the spawning streams, therefore, also serve an important rearing function. During the present study, young-of-the-year longnose suckers were captured as far upstream as Site 6 on the MacKay River, Site 9 on the Dunkirk River, and Site 13 on the Dover River (Figure 2). They occurred at most sampling sites downstream of these locations and were usually most numerous in small back eddies near shore. The largest concentrations of young-of-the-year longnose suckers were taken at Site 4 on 15 July and at Site 2 in October.

5.2.2.18 Overwintering. Most young-of-the-year suckers leave the MacKay River watershed during their first summer. The majority probably drift out of the watershed in June (Appendix 8.3) but an increase in catch-per-unit-effort in small mesh seines at the fence site during October (Appendix 8.5) indicated that many remain in the tributary during the summer and do not leave until late autumn. The capture of yearling longnose suckers in May and June 1978 at Sites 2, 4, 5, 9, and 12, however, indicates that some small suckers overwinter in the MacKay River watershed. Most of the larger and older fish probably overwinter in Lake Athabasca.

5.2.3 Walleye

5.2.3.1 Distribution and movements. Walleye are abundant in the Athabasca River during the early spring when a large upstream spawning migration occurs (McCart et al. 1977; Bond and Berry 1980a, 1980b; Bond in prep.). Their abundance decreases, however, after mid-May as a post-spawning dispersal takes place. Tag return evidence from other studies (Bond and Berry 1980a, 1980b) indicates that the walleye found in the Athabasca River in early spring are part of the Lake Athabasca population and that they return to the lake to overwinter. The return to the lake is very rapid in some cases but some fish, males especially, tend to linger in the Mildred Lake area, sometimes entering tributaries (McCart et al. 1978; Machniak and Bond 1979). Individual walleye may wander extensively in the Athabasca River system and movements of up to 600 km have been reported (Bond and Berry 1980b).

A total of 364 walleye were counted through the upstream trap during the spring counting fence operation on the MacKay River in 1978 (Table 9). The first walleye was captured on 2 May but most were taken between 3 and 8 May (43%) and from 15 to 22 May (24%). Only five walleye were captured at the downstream trap.

The precise distance of incursion by walleye into the MacKay River is not known. However, Bond and Berry (1980b) reported that a walleye, tagged 27 April 1977 near the mouth of the MacKay River, was recaptured on 17 August 1977, 60 km upstream in the tributary. During the present study, walleye were gillnetted on 16 July and 17 August at Site 6 (Figure 2), approximately 120 km upstream from the mouth.

Although this study was unable to document the downstream walleye migration, the available evidence suggests that walleye leave the MacKay River watershed during the summer and that few, if any, overwinter in the tributary. McCart et al. (1978) reported that walleye were most abundant in the lower reaches of the MacKay River (Sites 1 to 4) during May, but that catches had declined by late September. The mouth of this tributary (Site 1) is a popular spot for walleye angling, particularly during the early summer, and anglers were also observed as far upstream as the Dover River (Site 3) in May and June 1978. Angling drops off, however, in June and July when walleye numbers decline, and by autumn, few people fish the river (McCart et al. 1978). Only six walleye were gillnetted in the autumn during the present study (Table 6).

A total of 232 walleye were tagged in the MacKay River during 1978 but only two have been recaptured outside the MacKay River watershed (Table 8, Appendix 8.6). One walleye, tagged at the upstream trap on 14 May was recaptured at Fort MacKay (Figure 1) on 13 June. The other, tagged on 12 May, was recaptured in the Athabasca River 28 km upstream of the mouth of the MacKay River on 22 October 1978.

5.2.3.2 Spawning. Walleye normally spawn at ice break-up, with water temperatures ranging from 5.6 to 11.1°C (Scott and Crossman 1973). Preferred spawning sites are in rapids over clean gravel or rubble at depths less than 1.5 m (Machniak 1975a). As mentioned previously, a walleye spawning migration occurs in the Athabasca River in early spring. Results presented by Bond and Berry (1980b) indicate that this migration occurs under ice-cover and that spawning takes place at or before ice break-up. The most likely spawning location in the vicinity of the MacKay River is the rapids area of the Athabasca River upstream of Fort McMurray. Tripp and McCart (1980) found that water temperatures upstream of Mountain Rapids had reached 10°C by 28 April 1978 and reported that walleye had probably completed spawning considerably before 13 May.

Areas with apparent potential for walleye spawning are present within the MacKay River watershed, especially between Sites 3 and 6 (Figure 2). The results of the present study, however, suggest that walleye did not spawn in the MacKay River in 1978. Walleye were not captured in the MacKay River until 2 May 1978. Most (94%) of the walleye examined at the counting fence were males. Some of these were immature; however, most were recently spent. The presence of large numbers of spent males and the paucity of females suggest that this upstream movement was of a post-spawning nature similar to that reported in the Steepbank River by Machniak and Bond

(1979). Two ripe female walleye were captured at the MacKay River upstream trap on 14 May and a ripe male was taken on 17 May. Water temperatures in the MacKay River on these days ranged from 10 to 13.5°C (Appendix 8.1). These may have been fish that were unsuccessful in spawning and wandered into the MacKay River during post-spawning movements.

Walleye fry are found commonly around tributary mouths within the AOSERP study area during the summer (McCart et al. 1977; Bond and Berry 1980a, 1980b). Such areas, it appears, afford ideal habitat for the feeding and rearing of young fish. Bond and Berry (1980a, 1980b) report that most young-of-the-year walleye drift out of the Mildred Lake area during late June and July.

McCart et al. (1978) captured young-of-the-year walleye as far as 20 km upstream in the MacKay River, but took only 14 specimens during the 1977 study and suggested that, if spawning did occur in the river, it was limited. Bond and Berry (1980a) captured 39 walleye fry 8 km upstream in the MacKay River on 9 July 1976. These fish had a mean fork length of 61.5 mm (range 50 to 83 mm) and could easily have swum upstream from the Athabasca River. Only one young-of-the-year walleye was captured in the MacKay River during the present study. That fish had a fork length of 39 mm and was taken at the mouth of the tributary on 22 July.

5.2.3.3 <u>Age and growth</u>. Walleye captured from the MacKay River during spring 1978 ranged in fork length from 200 to 593 mm, with those in the 300 to 460 mm range accounting for 73% of the total samples (Figure 17). Virtually all walleye sexed (94%) were males. McCart et al. (1978) found 83% of MacKay River walleye to be between 300 and 475 mm and reported that 92% of walleye captured were males. Other investigators in the AOSERP study area have observed similar size distributions for Athabasca River walleye, with male fish comprising 57 to 97% of the samples (McCart et al. 1977; Bond and Berry 1980a, 1980b; Jones et al. 1978; Tripp and McCart 1980).

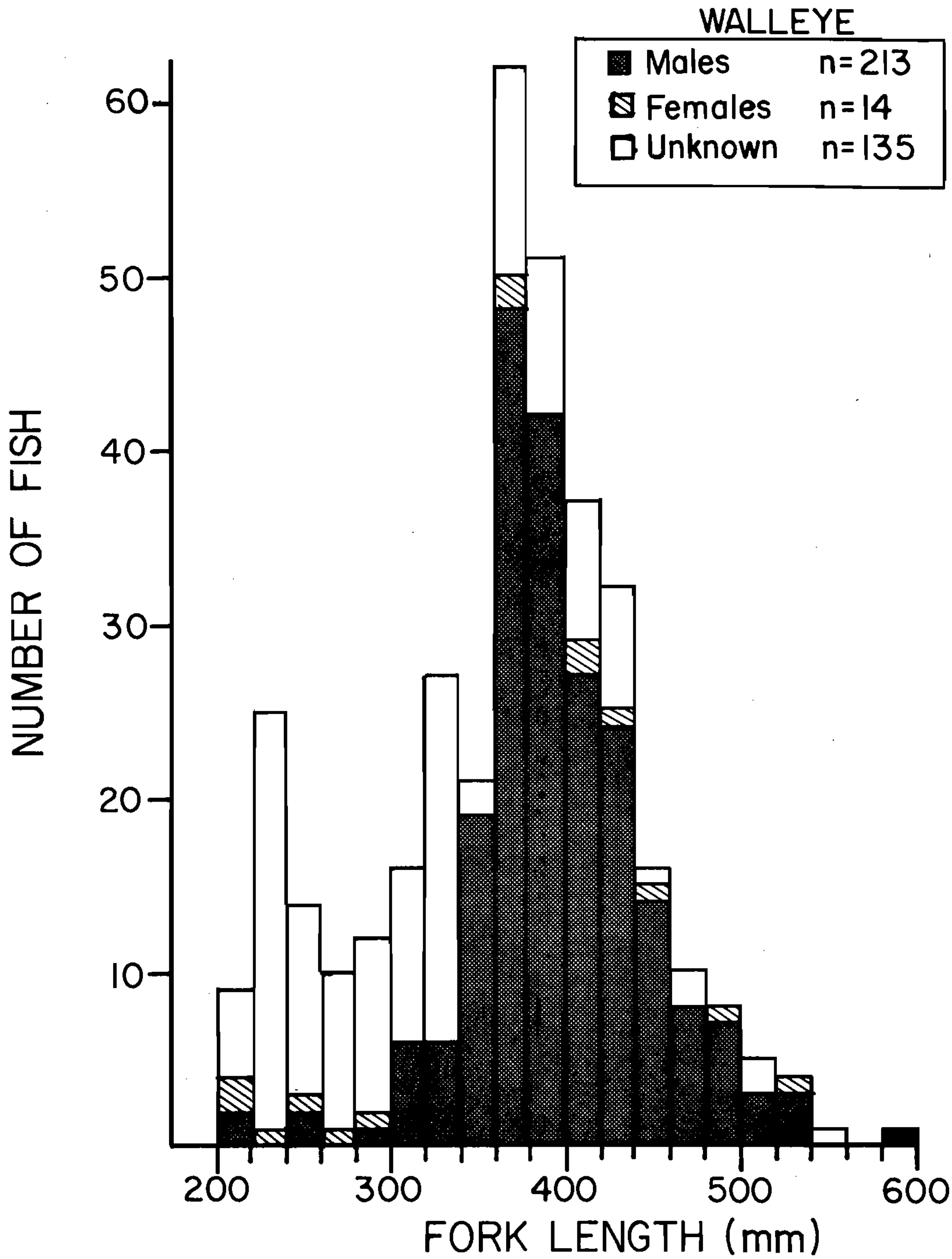

Figure 17. Length-frequency distribution for walleye captured during the spring fence operation, MacKay River, 1978.

Scale age was determined for 78 MacKay River walleye during the present study. These fish varied in fork length from 39 to 506 mm and ranged in age from young-of-the-year to nine years (Table 27). Most of the fish examined (96%) were age 2 to 7 inclusive. McCart et al. (1978) reported scale ages for MacKay River walleye to range from age 0+ to age 14, with 70% of the sample being age 5 to 11, inclusive. Bond and Berry (1980a, 1980b) found that, in 1976 and 1977, walleye in age groups 4 to 8, inclusive, comprised 76 and 85%, respectively, of the Athabasca River sample. In the Peace-Athabasca Delta, Kristensen and Pidge (1977) reported that most walleye were three to 11 years old. The maximum age recorded for walleye in the AOSERP study area is 15 years (Bond and Machniak 1977; Kristensen and Pidge 1977; Jones et al. 1978).

The age-length relationship for MacKay River walleye (Table 27) compares favourably with that reported for walleye in most previous studies in the AOSERP study area (Kristensen et al. 1976; Kristensen and Pidge 1977; McCart et al. 1977; Bond and Berry 1980a, 1980b; Jones et al. 1978; Machniak and Bond 1979). The growth rate obtained during the present study, however, is more rapid than that observed for walleye in the MacKay River during 1977 (McCart et al. 1978) or in the Athabasca River upstream of Fort McMurray (Tripp and McCart 1980). The apparent difference in growth rates between the present study and the latter two studies is probably a function of small sample sizes plus the fact that most of the aged fish in the latter studies were older than age 6 while, in the present study, 90% of the sample was age 6 or younger.

Figure 18 shows that MacKay River walleye have a growth rate similar to that reported from Lac la Ronge (Rawson 1957) and Lake Athabasca (Kristensen et al. 1976), but more rapid than that recorded for the Hay River, NWT (Bond et al. 1978) or Lake Waswanipi, Quebec (Magnin et al. 1973). Walleye in southern waters (Spirit Lake, Iowa and Lake Ontario) grow much faster (Rose 1951; Payne 1964) and achieve larger sizes than fish in the AOSERP study area.

Table 27. Age-length and age-weight relationships, age-specific sex ratios, and maturity for walleye captured in the MacKay River, 1978.

Scale Age	Fork Length (mm)			Weight (g)			Males			Females			Total[a]
	Mean	S.D.	Range	Mean	S.D.	Range	N	%	% Mature	N	%	% Mature	
0	39.0			0.5			0	ND	ND	0	ND	ND	1
1							0	ND	ND	0	ND	ND	0
2	227.5	15.29	200 to 244	109.7	29.43	60 to 140	3	43	0	4	57	0	15
3	284.4	24.04	254 to 334	223.5	78.67	70 to 390	6	75	17	2	25	0	13
4	322.8	24.84	289 to 357	335.0	97.25	230 to 510	4	100	75	0	0	ND	8
5	365.1	16.55	328 to 391	486.3	85.31	370 to 620	10	83	100	2	17	0	12
6	404.3	23.03	345 to 433	698.6	128.50	430 to 930	16	76	87	5	24	100	21
7	438.7	19.63	407 to 456	803.3	103.47	680 to 930	5	83	100	1	17	100	6
8	477.0			1500.0			1	100	100	0	ND	ND	1
9	506.0			1370.0			1	100	100	0	ND	ND	1
Totals							46	77		14	23		78

[a] Includes unsexed fish.

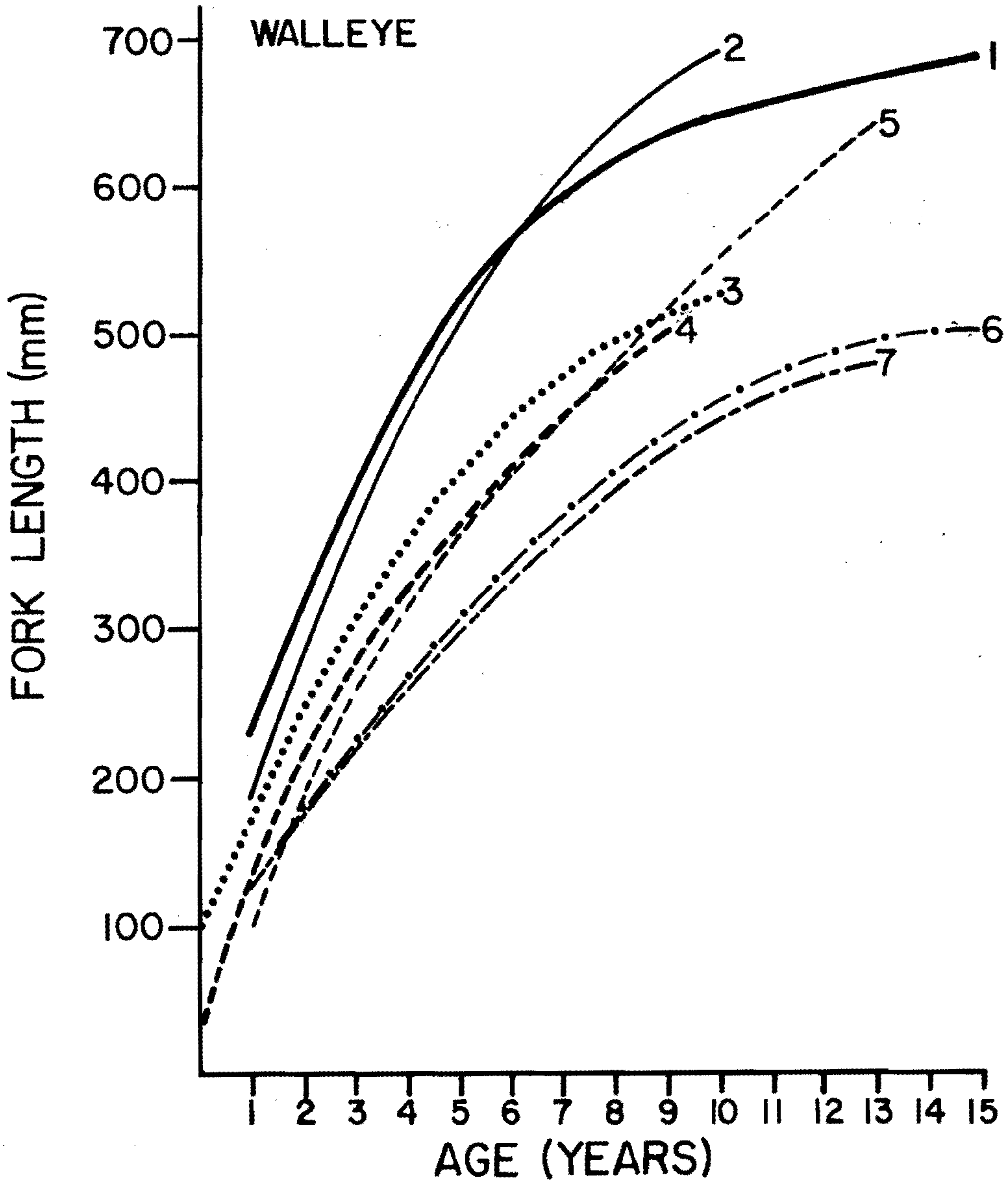

Figure 18. Growth in fork length for walleye from the MacKay River and from several other areas: 1. Lake Ontario (Payne 1964); 2. Spirit Lake, Iowa (Rose 1951); 3. Lake Athabasca (Kristensen et al. 1976); 4. MacKay River (Present Study); 5. Lac la Ronge, Sask. (Rawson 1957); 6. Lake Waswanipi, P.Q. (Magnin et al. 1973); and 7. Hay River, N.W.T. (Bond et al. 1978).

The length-weight relationship for MacKay River walleye (n = 77, r = 0.984, range 200 to 506 mm) is described by the equation:

$$\log_{10}W = 3.260(\log_{10}L) - 5.667; \; sb = 0.068$$

The value of the exponent is similar to that reported for walleye in the Mildred Lake area by Bond and Berry (1980a, 1980b).

5.2.3.4 Sex and maturity. Age and sex were determined for 60 walleye, of which 77% were males (Table 27). The youngest mature males were three years old (17%) while the youngest mature females were age 6. Male walleye usually mature at two to four years of age and females at three to six years (Scott and Crossman 1973). Other studies in the AOSERP area have noted that male walleye tend to mature at a younger age than females, and that the age at maturity ranges from three to seven years (Bond and Berry 1980a, 1980b; McCart et al. 1978; Machniak and Bond 1979; Jones et al. 1978; Tripp and McCart 1980). In Lac la Ronge, Saskatchewan, few walleye spawned before age 7 and most spawning individuals were 10 to 12 years old (Rawson 1957). Bond et al. (1978) reported that walleye mature at age 7 or 8 on the south shore of Great Slave Lake.

5.2.3.5 Food habits. Stomachs of 62 walleye were examined in the field during the spring fence operation. Sixty-nine percent of these were empty or contained only a trace of food, 23% were one-quarter to three-quarters full, and the remainder were entirely full. Walleye consumed mainly fish (longnose and white suckers, cyprinids, slimy sculpins, and trout-perch) but some insects (Odonata and Rhagionidae) were included in the diet. Tripp and McCart (1980) found that 68% of walleye examined in the spring had empty stomachs, with fish remains (flathead chub and sculpins) being the most frequent food item in stomachs that contained food. Of five walleye examined in the MacKay River during the autumn, four had empty stomachs and one contained fish remains. Jones et al. (1978) reported that 70% of stomachs sampled in the autumn were empty and that fish remains (slimy sculpins and burbot) and insects (Plecoptera and Corixidae) occurred in stomachs with food items.

One young-of-the-year walleye, captured on 22 July at Site 1, had fed on Ephemeroptera nymphs. Bond and Berry (1980a) found that young walleye consumed mainly fish (trout-perch, sculpins, yellow perch, and suckers) with some insects (Ephemeroptera, Diptera, and Hemiptera) included in the diet.

5.2.4 Northern Pike

5.2.4.1 Distribution and movements. Northern pike are a common fish species throughout the lower Athabasca River drainage (Bond and Berry 1980a, 1980b). In the early spring, pike from the Athabasca River migrate into tributary streams, and, while some of these migrant pike spawn within the tributaries, such spring movements appear to be associated primarily with feeding (Bond and Machniak 1979; Machniak and Bond 1979). These authors suggest that pike occupy the lower reaches of some tributaries throughout the summer and return to the Athabasca River prior to freeze-up. Within the Athabasca River, pike have demonstrated little tendency to travel great distances. Small watersheds, such as the Muskeg and Steepbank rivers, apparently support no permanent resident pike populations. During the present study, a spring migration of northern pike was documented into the MacKay River and evidence was obtained to suggest that a resident pike population may also occupy this watershed.

Ninety northern pike were passed through the upstream trap during the spring fence operation (Table 9). The majority (79%) of these fish were captured between 1 and 10 May, during which period the daily maximum water temperature varied from 7.0 to 11.0°C. Most pike examined (89%) were males, the majority of which were spawned out. Gillnetting downstream of the fence site between 24 and 29 April produced only one pike, suggesting that few pike had moved upstream prior to 1 May. During the autumn, 19 northern pike were gillnetted near the fence site.

Although few northern pike had entered the MacKay River prior to 1 May 1978, angling at the mouth of the Dunkirk River, 147 km upstream from the Athabasca River, produced nine northern pike on 30 April at a time when the lower 10 km of the Dunkirk River were still ice covered. These, and other pike captured in this area later in the summer, had a yellowish tinge, often seen in fish that have spent considerable time in brown water, and it is felt that they represent a resident population. This region of the MacKay River watershed provides attractive habitat for northern pike as it is fairly deep (1 to 2 m) and slow flowing and has extensive areas of submerged vegetation. A resident pike population is also known to inhabit Lake 14 (Figure 2) in the Dover watershed, where 17 mature pike (443 to 680 mm fork length) were gillnetted on 20 to 21 September 1977 (Herbert 1979).

Tags were applied to 60 northern pike during the present study. One tagged fish was recaptured at the upstream trap during the spring and two were taken in the MacKay River during the autumn gillnetting program (Table 8, Appendix 8.6). No direct evidence can be adduced, therefore, as to the distance of incursion by migrant pike into the MacKay River watershed, the length of time spent in the watershed by migrant pike, or the extent of movement within the Athabasca River.

The capture of 19 northern pike near the fence site during the autumn may indicate a movement of pike from the MacKay River watershed back to the Athabasca River at that time. On the other hand, McCart et al. (1978) have shown that some northern pike over-winter within the lower reaches of the MacKay River.

5.2.4.2 Spawning. Northern pike usually spawn in April or early May, immediately following ice break-up, at water temperatures of 4.4 to 11.1°C (Scott and Crossman 1973). Spawning occurs in a variety of habitats in shallow water (<50 cm) over submerged vegetation (Machniak 1975b). The MacKay River contains few areas suitable for pike spawning downstream of Site 4 (Figure 2) and only two young-of-the-year were taken in this region (at Sites 1 and 2) during 1978. McCart et al. (1978) also failed to capture young-of-the-year pike in this part of the river despite extensive sampling.

The fence operation failed to detect a major upstream movement of pike into the MacKay watershed in 1978. Although small numbers of ripe males (n = 2) and ripe females (n = 2) were captured, most of the pike examined were spent males, suggesting that most fish had spawned elsewhere prior to entering the MacKay River. Post-spawning movements of northern pike have also been reported in other tributaries of the AOSERP study area during early May (Bond and Machniak 1977, 1979; Machniak and Bond 1979). On the basis of the available data, it is believed that spawning by migrant northern pike in the MacKay River watershed, if any, is minor.

Spawning by resident pike is thought to occur upstream of Site 6 (Figure 2) where the most suitable pike spawning habitat in the MacKay watershed occurs. Six ripe male pike and three mature females were captured at the mouth of the Dunkirk River on 30 April and a spent male was taken on 21 May at the same location. Young-of-the year (n = 9, range 20 to 42 mm fork length) were first captured at Site 7 (Figure 2) on 16 June, and another (33 mm) was taken at Site 9 of the Dunkirk River on the same date. During the summer, further young-of-the-year pike were collected from Sites 7 (n = 5), 9 (n = 1), and 10 (n = 1).

5.2.4.3 Age and growth. Pike captured in the MacKay watershed during 1978 (n = 154) ranged in fork length from 20 to 738 mm, with 68% of the sample being in the 325 to 575 mm size range (Figure 19). Pike taken from the MacKay River in 1977 ranged from 210 to 717 mm, with most fish in the 425 to 575 mm range (McCart et al. 1978). Other studies in the AOSERP study area (McCart et al. 1977; Bond and Berry 1980a, 1980b; Bond and Machniak 1977, 1979; Machniak and Bond 1979; Jones et al. 1979; Tripp and McCart 1980) have reported similar size distributions. Pike ranged in age from age 0+ to age 9 and in weight from 0.1 to 2840.0 g. Excluding young-of-the-year, the majority of pike aged (75%) were three to six years old inclusive (Table 28). McCart et al. (1978) reported a maximum age of 11 years for MacKay River pike with most (81%) being four to seven years old. The maximum age recorded for pike from the AOSERP study

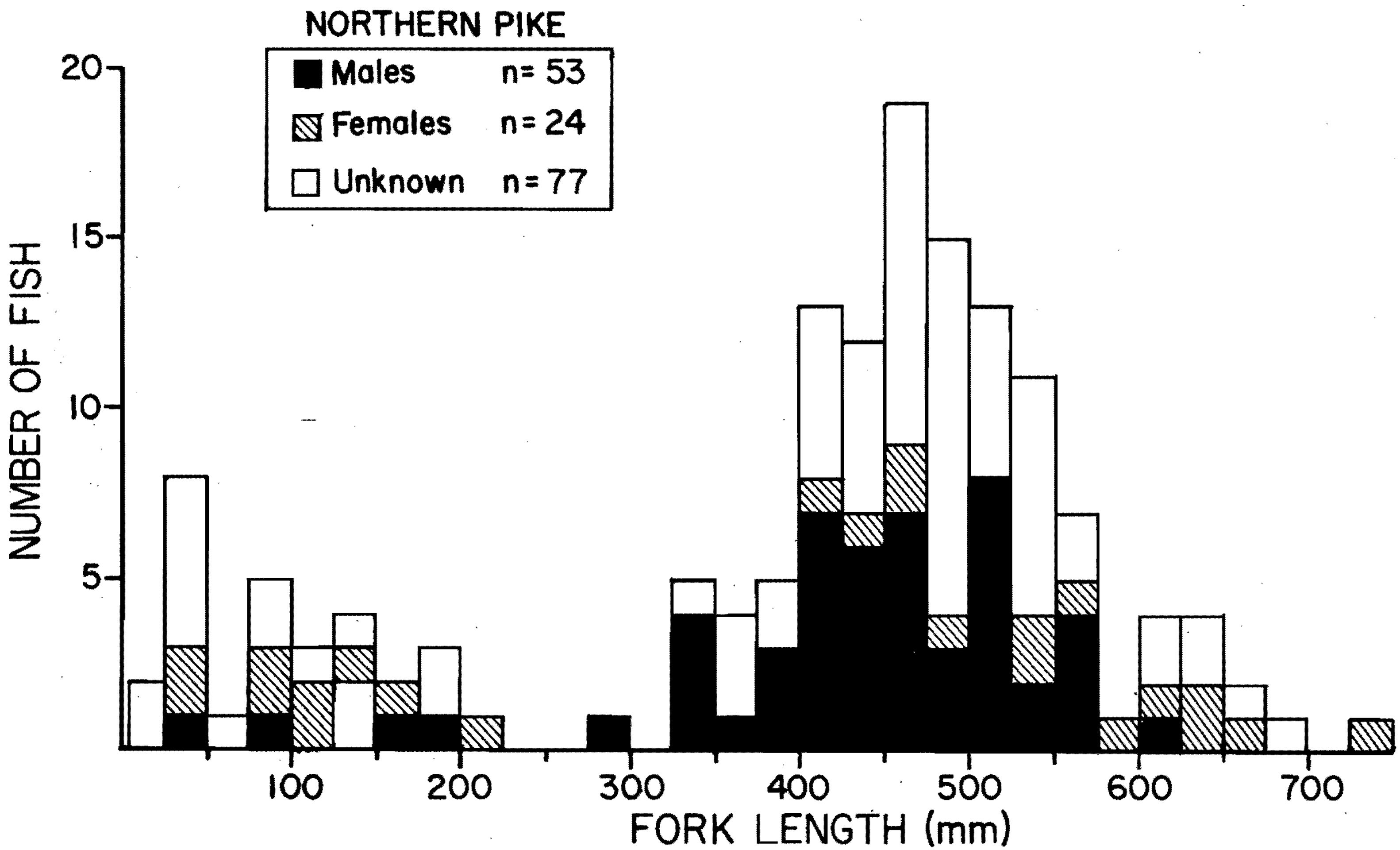

Figure 19. Length-frequency distribution for northern pike captured during the spring fence operation, MacKay River, 1978.

Table 28. Age-length and age-weight relationships, age-specific sex ratios, and maturity for northern pike captured in the MacKay River, 1978.

Scale Age	Fork Length (mm)			Weight (g)			Males			Females			Total[a]
	Mean	S.D.	Range	Mean	S.D.	Range	N	%	% Mature	N	%	% Mature	
0	72.4	42.54	20 to 152	5.2	6.4	0.1 to 21.3	3	27	0	8	73	0	22
1	158.6	23.01	135 to 185	35.0	13.11	20 to 50	2	100	0	0	0	ND	5
2	200.0	11.31	192 to 208	58.4	11.24	50 to 66	1	50	0	1	50	0	2
3	325.4	19.57	297 to 342	240.0	55.23	170 to 320	4	80	50	1	20	0	5
4	402.9	26.11	345 to 433	450.5	112.13	320 to 690	9	82	67	2	18	100	11
5	485.2	36.63	427 to 543	799.4	251.16	425 to 1300	10	56	100	8	44	100	18
6	544.4	19.53	517 to 569	1111.4	134.34	990 to 1320	7	100	100	0	0	ND	7
7	586.3	23.79	565 to 612	1370.0	125.29	1250 to 1500	0		ND	3	100	100	3
8	639.7	17.47	625 to 659	1943.3	399.54	1620 to 2390	0		ND	3	100	100	3
9	738.0			2840.0			0		ND	1	100	100	1
Totals							36	57		27	43		77

[a] Includes unsexed fish.

area is 13 years for the Athabasca River (McCart et al. 1977) and 24 years for a female pike from Lake Athabasca (Miller and Kennedy 1948).

The growth rate of northern pike from the MacKay River compares favourably with that reported previously for pike in the AOSERP study area (Griffiths 1973; McCart et al. 1977; Bond and Berry in prep.a, in prep.b; Bond and Machniak 1979; Jones et al. 1978). MacKay River pike grow more rapidly than those from Lake Athabasca (Miller and Kennedy 1948), but much more slowly than those reported by Van Engel (1940) for Wisconsin Lakes and by Clark and Steinbach (1959) for pike from Lake Erie (Figure 20). During the first five years of life, MacKay River pike appear to grow at a rate identical to that reported for pike in Lac Hélène, Quebec (Boucher and Magnin 1977) and Lake Waskesiu, Saskatchewan (Rawson 1932). After age 5, however, pike from the MacKay River grow more rapidly than those from the other two lakes (Figure 20).

The length-weight relationship for northern pike ($n = 52$, $r = 0.942$, range 139 to 738 mm) captured from the MacKay River in 1978 is described by the equation:

$$\log_{10}W = 2.960(\log_{10}L) - 5.078; \; sb = 0.149$$

5.2.4.4 Growth of young-of-the-year. Pike fry captured at the mouth of the Dunkirk River ($n = 10$) on 16 June had a mean fork length of 31.7 mm and ranged in size from 20 to 42 mm (Table 29). Young pike grew rapidly and, by 15 July, had a mean length of 85.4 mm (range 67 to 100 mm). By mid-August, pike fry ($n = 4$) had attained a mean length of 123.0 mm (range 99 to 152 mm). The rate of growth probably slows down in late summer as three fish, captured 13 to 14 October, ranged in fork length from 97 to 145 mm with a mean of 118.7 mm. Bond and Berry (1980b) reported young-of-the-year pike from the Athabasca River to reach a maximum length of 185 mm during their first year.

5.2.4.5 Sex and maturity. Sex was determined for 77 northern pike (Figure 19) of which 53 (69%) were males. This represents a

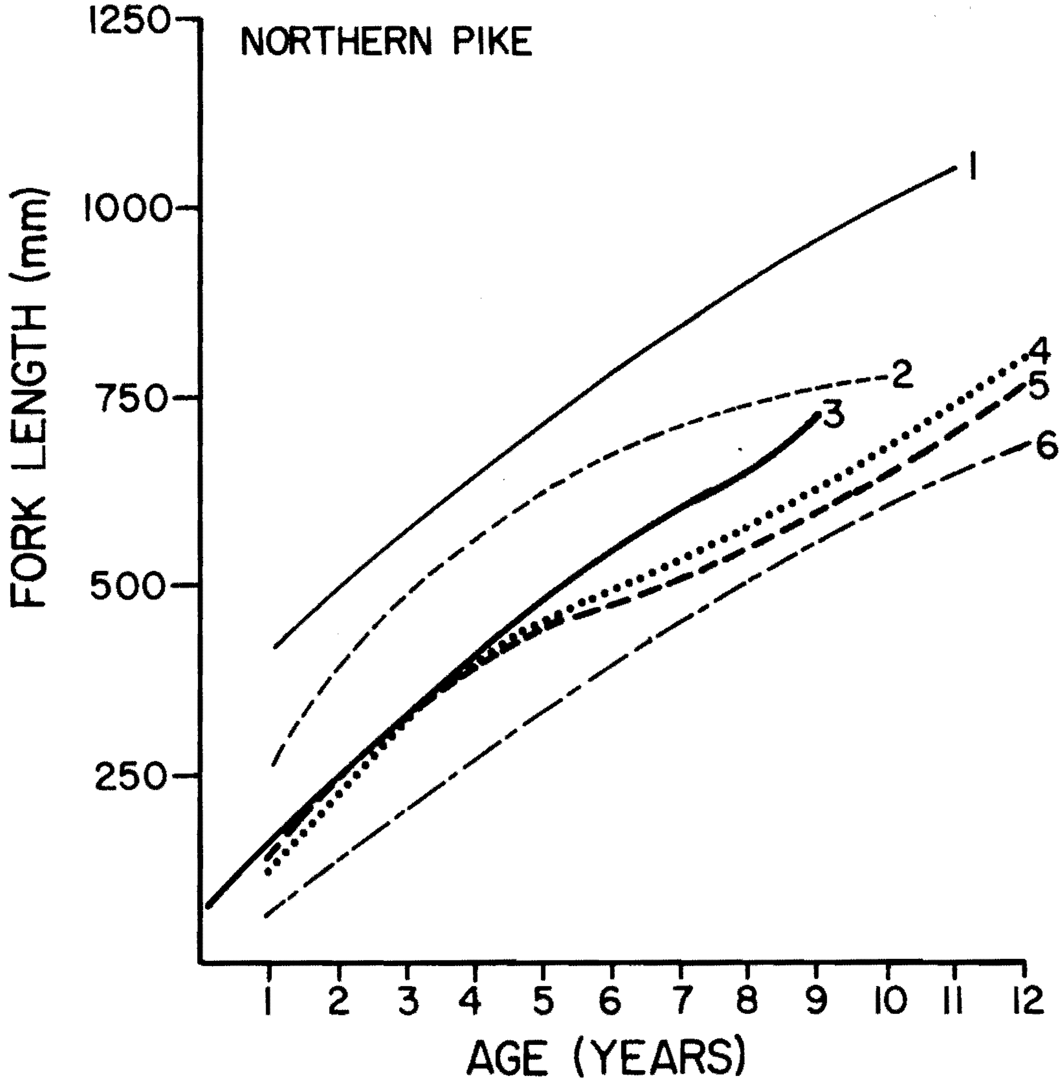

Figure 20. Growth in fork length for northern pike from the MacKay River and from several other areas: 1. Wisconsin lakes (Van Engel 1940); 2. Lake Erie (Clark and Steinbach 1959); 3. MacKay River (Present Study); 4. Lac Hélêne, P.Q. (Boucher and Magnin 1977); 5. Lake Waskesiu, Sask. (Rawson 1932); and 6. Lake Athabasca (Miller and Kennedy 1948).

Table 29. Length and weight relationships of young-of-the-year northern pike captured in the MacKay watershed, 1978.

Date of Capture	Fork Length (mm)			Weight (g)			Number of Fish
	Mean	S.D.	Range	Mean	S.D.	Range	
16 June	31.7	6.55	20 to 42	0.4	0.30	0.1 to 0.9	10
15 July	85.4	12.42	67 to 100	4.4	1.60	1.9 to 6.1	5
4 to 17 Aug.	123.0	24.10	99 to 152	12.9	6.65	6.8 to 21.3	4
13 to 14 Oct.	118.7	24.34	97 to 145	12.3	6.76	5.7 to 19.2	3
Total							22

significant difference from a 1:1 ratio (X^2 = 10.92, P <0.05). McCart et al. (1978) reported a 1:1 sex ratio for pike in the MacKay River during 1977 and Bond and Berry (1980a, 1980b) reported that male and female pike occurred in equal numbers in the Athabasca River. Jones et al. (1978) found that females (58%) outnumbered males in late autumn.

The earliest age at which mature pike were observed during the present study was three years for males and four years for females (Table 28). Similar results for pike in the AOSERP area have also been reported by Bond and Berry (1980a, 1980b), McCart et al. (1978), Bond and Machniak (1977, 1979), Machniak and Bond (1979), Jones et al. (1978), and Tripp and McCart (1980).

5.2.4.6 Food habits. Twenty-eight northern pike stomachs were examined during the spring and early summer, of which 16 (57%) were empty or contained only traces of food. Nine stomachs were one-quarter to three-quarters full while the remainder (n = 3) were full. A few pike stomachs contained immature aquatic insects (Odonata and Ephemeroptera), but fish and fish remains (Arctic grayling, longnose and white suckers, brook stickleback, and lake chub) comprised most of the food volume. Eighteen pike were examined during the autumn, of which 11 contained no food. The rest had consumed a fish diet similar to that observed during the spring. Of 17 northern pike taken in Lake 14 (Figure 2) at the headwaters of the Dover River in September 1977, five had empty stomachs while the remainder had consumed brook stickleback (Herbert 1979). Most of the stomachs containing stickleback also contained partially digested fish which may also have been stickleback.

5.2.5 Arctic Grayling

5.2.5.1 Distribution and movements. In late April and early May, Arctic grayling migrate from the Athabasca River into some tributaries of the AOSERP study area where they are known to spawn (Bond and Machniak 1977, 1979; Machniak and Bond 1979). Migrant grayling remain in the tributaries throughout the summer to feed, returning to the Athabasca River just prior to freeze-up (Machniak and Bond 1979). Rising water temperatures in the spring (Rawson 1950; Reed 1964; Schallock 1966; Bishop 1967) and declining water temperatures in the late autumn (Schallock 1966; Machniak and Bond 1979) appear to influence these seasonal movements. Gillnets captured no Arctic grayling in the MacKay River between 21 and 28 April but took four on 29 and 30 April (Table 4). Forty-five grayling were captured in the upstream trap between 29 April and 13 June, while four were taken at the downstream trap between 22 May and 5 June (Table 9). The grayling migration into the MacKay River was essentially over by 2 May, by which time 91% of the adult fish captured (n = 32) had passed the fence site. The maximum water temperature on 2 May was 7°C (Appendix 8.1). In the Steepbank River, the grayling spawning migration was over by the end of April at which time the daily maximum water temperature in that stream had reached 8°C (Machniak and Bond 1979).

Because the counting fence was not in operation until 29 April, and because it was only a partial fence, there is little doubt that the size of the Arctic grayling run into the MacKay River watershed was underestimated. Nevertheless, it is felt that the size of the grayling population utilizing this watershed for spawning and for feeding is small compared with those utilizing the Muskeg and Steepbank rivers. McCart et al. (1977) captured only two grayling in the MacKay River during the open-water period in 1977, but suggested that grayling may occur in areas upstream of Lease 17 (Figure 2) or in the Dunkirk and Dover rivers. The present study, however, took only two grayling upstream of the fence site in 1978, one at Site 5 in the MacKay River and the other at Site 10 in the Dunkirk River (Figure 2).

Floy tags were applied to only four Arctic grayling during the present study, none of which was recovered (Table 8).

5.2.5.2 Spawning. Grayling generally spawn over gravel or rocky bottoms with water depth appearing not to be an important factor.

Grayling in tributaries of the southern Athabasca River drainage spawn in May at stream temperatures of 4.5° to 11°C (Ward 1951). Machniak and Bond (1979) stated that spawning was probably complete by 3 May 1977 in the Steepbank River of the AOSERP study area. During the present study, Arctic grayling spawning was not observed and the location of spawning areas and the precise period of spawning are, therefore, unknown.

The first mature grayling (3 males) captured during the present study were taken on 29 April when the maximum recorded water temperature was 4.5°C. Five ripe females were taken at the counting fence on 1 May and the last mature grayling was recorded on 3 May when the maximum water temperature was 7°C. Water temperatures were within the appropriate range for grayling spawning from 29 April (possibly earlier) to 7 May and it is likely that most, if not all spawning, was completed by the latter date. Areas of gravel that seem to be suitable as grayling spawning locations are found most commonly in the MacKay River from the confluence of the Dover River to Site 6 and in the lower reaches of the Dover and Dunkirk rivers (Figure 2). Only one young-of-the-year grayling, however, was collected from the MacKay River watershed during the present study. This fish (94 mm in fork length) was captured on 14 October at Site 5.

5.2.5.3 Age and growth. Grayling captured from the MacKay River in 1978 ranged in fork length from 66 to 378 mm although only three fish were less than 190 mm (Figure 21). Grayling ranged in age from age 0+ to age 7 with the majority being ages 2, 3, and 5 (Table 30). The maximum age recorded for MacKay River grayling (seven) is similar to that reported by other authors for this species in the Athabasca drainage; age 5 for the Namur River (Turner 1968), age 6 for Martin Creek (Ward 1951), Lake Athabasca (Miller 1946), and the Fort McMurray area (Griffiths 1973), and age 7 for the Muskeg (Bond and Machniak 1977) and Steepbank rivers (Machniak and Bond 1979). The oldest grayling reported from the AOSERP study area has been an age 12 (otolith-based) unsexed grayling, 375 mm in length (Bond and Berry 1980b). Maximum ages recorded elsewhere for grayling are

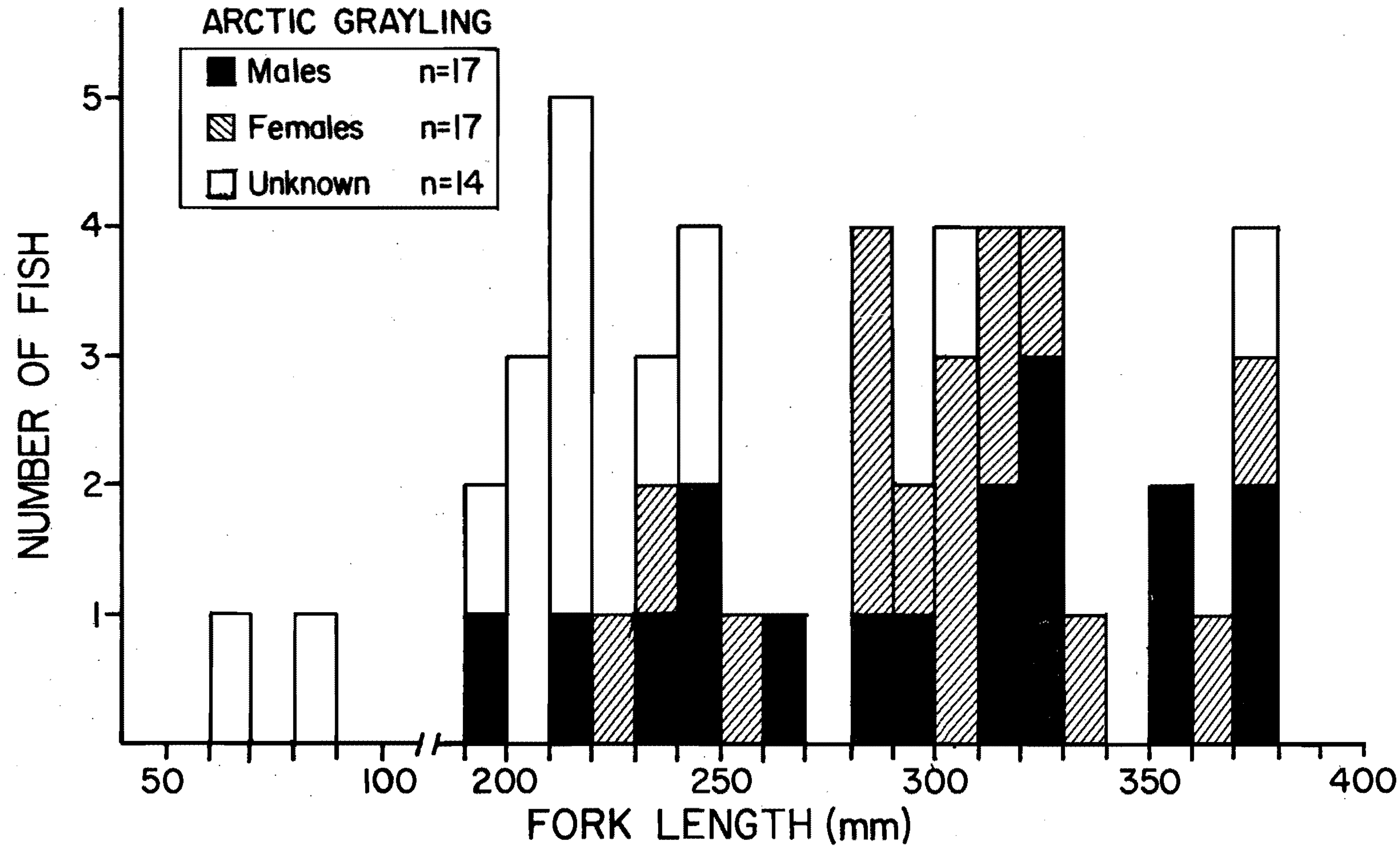

Figure 21. Length-frequency distribution for Arctic grayling captured during the spring fence operation, MacKay River, 1978.

Table 30. Age-length and age-weight relationships, age-specific sex ratios, and maturity for Arctic grayling captured in the MacKay River, 1978.

Scale Age	Fork Length (mm)			Weight (g)			Males			Females			Total[a]
	Mean	S.D.	Range	Mean	S.D.	Range	N	%	% Mature	N	%	% Mature	
0	94.0			8.2			0	ND	ND	0	ND	ND	1
1	76.0	14.14	66 to 86	5.3	2.55	3.5 to 7.1	0	0	ND	1	100	0	2
2	199.6	14.41	180 to 218	85.7	20.09	60 to 120	2	50	0	2	50	0	7
3	237.0	12.76	213 to 252	142.2	30.83	100 to 190	3	38	67	5	62	60	9
4	277.0	15.56	266 to 288	225.0	35.36	200 to 250	2	100	100	0	0	ND	2
5	306.5	15.83	283 to 324	336.7	51.64	280 to 400	2	33	100	4	67	100	6
6	341.0	25.71	312 to 361	450.0	90.00	360 to 540	2	67	100	1	33	100	3
7	378.0		378 to 378	660.0		660 to 660	2	100	100	0	0	ND	2
Totals							13	50		13	50		32

[a] Includes unsexed fish.

22 years (otolith-based) for the Firth River, Yukon Territory (Craig and Poulin 1975) and 12 years (scale-based) for Great Slave Lake (Bishop 1967) and Great Bear Lake (Falk and Dahlke 1974).

Arctic grayling from the MacKay River grow at a rate similar to that reported for populations from southern tributaries of the Athabasca River (Ward 1951) and from other tributaries of the AOSERP study area (Griffiths 1973; Bond and Machniak 1977, 1979; Machniak and Bond 1979). MacKay River grayling (Figure 22) grow faster than those in the Chatanika River, Alaska (Schallock 1966) and Vermillion and Hodgson creeks, Northwest Territories (Tripp and McCart 1974). However, they grow more slowly and do not achieve the large sizes of fish from Great Bear Lake (Falk and Dahlke 1974) and Great Slave Lake (Bishop 1967).

The mathematical relationship between body weight and fork length for Arctic grayling (sexes combined) from the MacKay River watershed (n = 32, r = 0.997, range 66 to 378 mm) is described by the equation:

$$\log_{10}W = 3.0360\log_{10}L) - 5.047; sb = 0.046$$

5.2.5.4 Sex and maturity. Sex and maturity were determined for 26 Arctic grayling during the present study, with males and females occurring in equal numbers (Table 30). The earliest age of sexual maturity was three years for both sexes. Ward (1951) observed that male grayling began to mature at age 2, that 75% of both sexes were mature at age 3, and that all fish were mature by age 4. Bond and Machniak (1977, 1979) and Machniak and Bond (1979) reported similar results in the Muskeg and Steepbank rivers, respectively. Grayling in Alaska, however, reach sexual maturity between ages 5 and 8, the oldest age of maturity reported for grayling in North America (Craig and Poulin 1975).

5.2.5.5 Fecundity. Actual egg counts were performed on five mature female grayling captured 1 May 1978 during the spring upstream migration. These fish ranged in fork length from 229 to 312 mm and the total number of eggs per female ranged from 1400 to 5000 (Table 31),

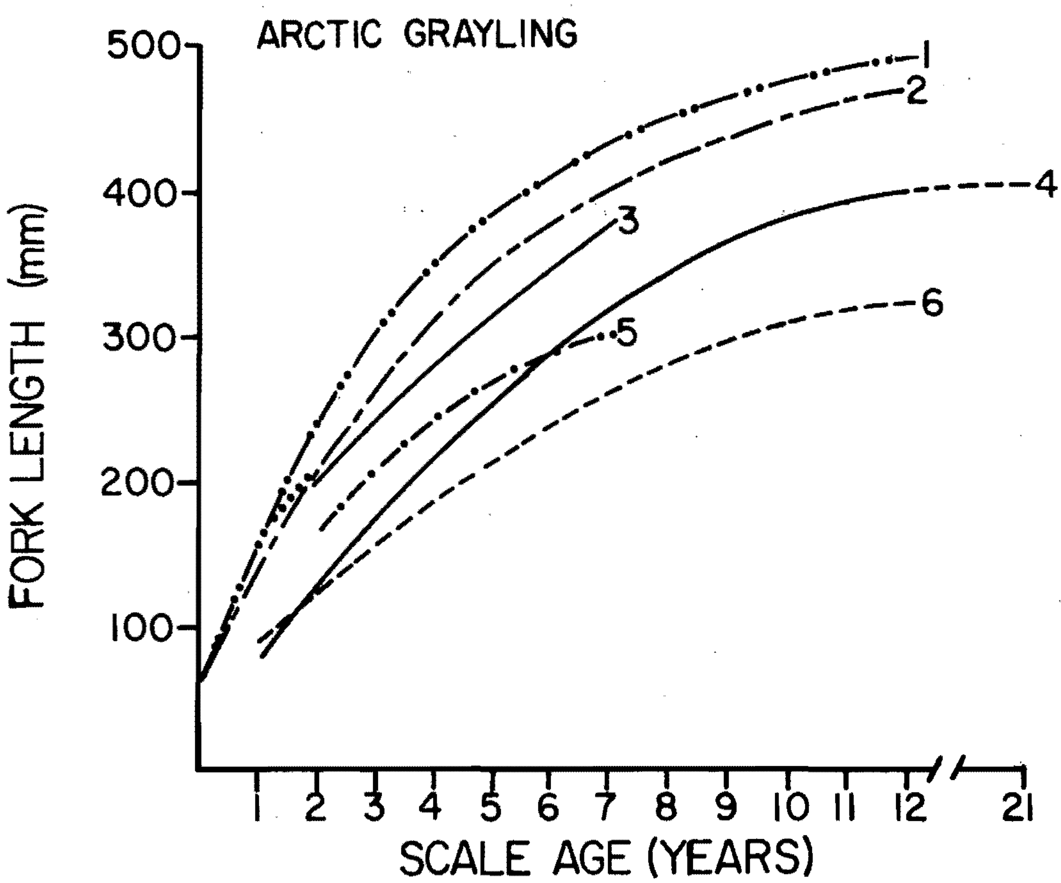

Figure 22. Growth in fork length for Arctic grayling from the MacKay River and from several other areas: 1. Great Bear Lake, N.W.T. (Falk and Dahlke 1974); 2. Great Slave Lake, N.W.T. (Bishop 1967); 3. MacKay River (Present Study); 4. Chatanika River, Alaska (Schallock 1966); 5. Vermillion Creek, N.W.T. (Tripp and McCart 1974); and 6. Hodgson Creek, N.W.T. (Tripp and McCart 1974).

Table 31. Actual egg counts for five Arctic grayling sampled during the 1978 spawning migration, MacKay River, 1978.

Fork Length (mm)	Weight (g)	Number of Eggs			Relative Fecundity	
		Left Ovary	Right Ovary	Total	(Eggs/cm)	(Eggs/cm)
312	360	2 380	2 092	4 472	143.3	12.4
302	340	2 446	2 564	5 010	165.9	14.7
297	280	ND[a]	ND	3 906	131.5	14.0
283	280	1 353	1 669	3 022	106.8	10.8
229	100	ND	ND	1 442	63.0	14.4

[a] No data.

with a mean value of 3570. Studies in other areas indicate that grayling fecundity can vary considerably, but that the average number of eggs per female is probably 4000 to 7000 (Scott and Crossman 1973). Ward (1951) reported a range of 574 to 7039 eggs per female (254 to 343 mm) for grayling captured in Cold Creek.

Length-relative fecundity for the five MacKay River grayling ranged from 63.0 to 165.9 ova per cm of fork length (Table 31), while weight-relative fecundity varied from 10.8 to 14.7 eggs per g of body weight. The average length-relative fecundity of 122.2 ova per cm for the MacKay sample is considerably less than that of 218.0 reported by Tack (1971) and that of 250.0 found by Bishop (1971). The average weight-relative fecundity, on the other hand, 13.3 ova per g, is similar to that reported by other authors. Brown (1938), Ward (1951), and Bishop (1971) reported average weight-relative fecundities of 12.6, 13.1, and 10.9, respectively.

The egg size for the five mature females ranged from 1.7 to 2.2 mm with a mean diameter of 2.0 mm. Tripp and McCart (1974) observed that egg size increased rapidly from 1.9 to 2.3 mm during the period of spring break-up and that the average egg diameter was 2.5 mm at spawning.

5.2.5.6 Food habits. Studies of the food habits of Arctic grayling indicate that this species is extremely opportunistic, feeding on a wide variey of food items. Many authors (Kruse 1959; Bishop 1967; Reed 1964) have stressed the importance of aquatic insects in the diet, while others (Miller 1946; Rawson 1950; Wojcik 1955; Schallock 1966) have found terrestrial insects to make up a large proportion of the food. During the present study, 24 grayling stomachs were examined in the field during the spring migration. Only eight of these were empty. The rest were one-quarter full to full, the contents consisting mainly of immature aquatic insects of the orders Hemiptera, Trichoptera, and Odonata. The contents of three stomachs, examined in the laboratory, supported the findings of other authors that grayling consume a great variety of food items. Present in these stomachs were Corixidae, Notonectidae, Odonata, Ephemeroptera, Coleoptera, Hymenoptera, Plecoptera, and Diptera.

5.2.5.7 Overwintering. Ward (1951) indicated that some Athabasca River grayling overwinter in beaver ponds and deep pools of tributaries. Machniak and Bond (1979) suspect that young-of-the-year grayling overwinter in tritubaries of the AOSERP study area rather than in the Athabasca River. Juvenile grayling have been observed under the ice in the nearby Muskeg River drainage (Bond and Machniak 1977). It is unknown whether any Arctic grayling overwinter within the MacKay River watershed. However, a northern pike captured 30 April 1978 at the mouth of the Dunkirk River had a juvenile grayling in its stomach, suggesting that some overwintering does occur. Deep pools and beaver dams in the upper reaches of the MacKay, Dover, and Dunkirk rivers appear to be suitable places for overwintering. McCart et al. (1978) captured four adult grayling under the ice in early December near the mouth of the MacKay River but could not say whether these fish had come from the MacKay River itself or from other tributaries in the area that are known to support grayling.

5.2.6 Flathead Chub

5.2.6.1 Distribution and movements. Flathead chub are usually found in large, muddy rivers and are often very abundant (Olund and Cross 1961; Paetz and Nelson 1970). Bishop (1975) reported flathead chub to be the most abundant species in the Peace River, while McCart et al. (1977) and Bond and Berry (1980a, 1980b) stated that the species was common in the lower Athabasca River. Studies on the Muskeg River (Bond and Machniak 1977, 1979), the Steepbank River (Machniak and Bond 1979), and the Clearwater River (Jones et al. 1978) suggest that few chub enter tributaries within the AOSERP study area. During the present study, 43 flathead chub were captured at the upstream trap, the majority (70%) being taken between 16 May and 6 June (Table 9). Eleven chub were taken at the downstream trap between 24 May and 3 June, suggesting that chub did not travel far upstream of the fence site and did not remain long. No flathead chub were captured upstream of the fence site during this study and none was taken during the autumn gillnetting program. McCart et al. (1978) captured only three flathead chub near the mouth of the MacKay River.

Floy tags were applied to only nine flathead chub during the present study, none of which was recaptured (Table 8).

5.2.6.2 Spawning. Details of the spawning habits of flathead chub are unknown but spawning apparently occurs in summer (Scott and Crossman 1970). Bishop (1975) stated that in the Peace River, Alberta spawning occurred in July. In Iowa, Martyn and Schmulbach (1978) determined that chub spawned from mid-July to mid-August over a water temperature range of 18.5 to 25.0°C. Within the AOSERP study area, the flathead chub spawning period extends from early June to mid-August although most spawning probably occurs in June (Bond and Berry 1980b). Since chub are rarely taken in clear water (McPhail and Lindsey 1970), spawning probably occurs within the Athabasca River where Bond and Berry (1980b) reported capturing young-of-the-year (16 to 31 mm fork length) during July. During the present study, mature flathead chub were captured at the upstream trap as early as 24 May and several ripe individuals (both males and females) were taken between 3 and 14 June. However, no young-of-the-year chub were taken either in this study or by McCart et al. (1978). It is not known, therefore, whether any flathead chub spawn within the MacKay River watershed. Any spawning that does occur within this watershed is probably limited to the region downstream of the fence site.

5.2.6.3 Age and growth. Flathead chub measured at the upstream trap (n = 41) in the MacKay River ranged in fork length from 100 to 287 mm, although only five fish were less than 200 mm (Figure 23). Bond and Berry (1980b) noted that, while flathead chub ranged in fork length from 12 to 322 mm, the length frequency distribution

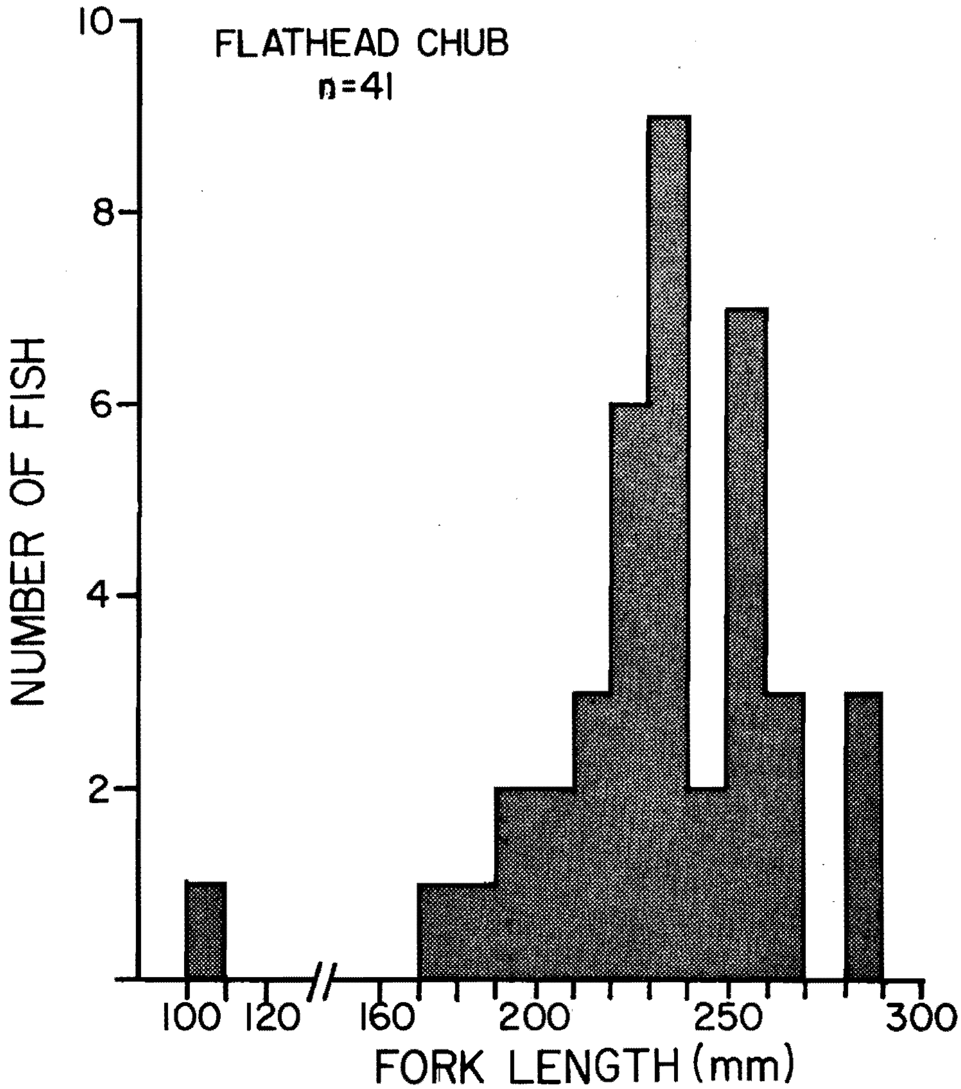

Figure 23. Length-frequency distribution for flathead chub captured during the spring fence operation, MacKay River, 1978.

varied between their two study areas. In the Mildred Lake area, 70% of the catch consisted of fish greater than 150 mm, but, in the Delta area, nearly 90% of the chub were less than 90 mm in fork length. This suggests that the latter region might be an important rearing area for flathead chub while the former (upstream) area is used for spawning. Scale ages for MacKay River flathead chub (n = 28) ranged from two to eight years with most fish (89%) being between four and seven years old (Table 32). Other authors have reported similar ages for flathead chub in the AOSERP study area, with fish ranging between age 0+ and age 10 (McCart et al. 1977; Bond and Berry 1980a, 1980b; Tripp and McCart 1980). Maximum ages recorded for flathead chub are 10 years in the Athabasca River (McCart et al. 1977) and Peace River (Bishop 1975) and 12 years in the Mackenzie River (Hatfield et al. 1972).

A comparison of MacKay River chub (Figure 24) with chub from the Athabasca River (McCart et al. 1977; Bond and Berry 1980b; Tripp and McCart 1979) and the Peace River, Alberta (Bishop 1975) shows that these northern Alberta populations have similar growth rates. However, chub from Perry Creek, Iowa (Martyn and Schmulbach 1978) and the Mackenzie River, NWT (Hatfield et al. 1972) grow at a slower rate that Alberta populations.

The length-weight relationship for flathead chub (n = 28, r = 0.989, range 100 to 294 mm) sampled from the MacKay River is described by the equation:

$$\text{Log}_{10}W = 3.303(\log_{10}L) - 5.612; \ sb = 0.093$$

Length-weight relationships for both sexes are reported to be similar (Bond and Berry 1980b; Martyn and Schmulbach 1978).

5.2.6.4 <u>Sex and maturity</u>. Seventeen mature flathead chub were sampled during the spring upstream movement, of which 65% were females. Overall, females (54%) in the aged sample (Table 32) were not significantly more abundant than males (X^2 = 0.152, P>0.05). Bond and Berry (1980b), however, found that females (68%) were significantly more abundant than male chub in the Mildred Lake area, and other studies in the AOSERP area (Bond and Berry 1980a;

Table 32. Age-length and age-weight relationships, age-specific sex ratios, and maturity for flathead chub captured in the MacKay River, 1978.

Age	Fork Length (mm)			Weight (g)			Males			Females			Total[a]
	Mean	S.D.	Range	Mean	S.D.	Range	N	%	% Mature	N	%	% Mature	
2	100			9.9			0	ND	ND	0	ND	ND	1
3	ND			ND			0	ND	ND	0	ND	ND	0
4	189.2	6.26	179 to 196	79.0	2.24	75 to 80	4	100	100	0	ND	ND	5
5	216.1	13.30	200 to 236	126.3	18.27	105 to 160	5	62	100	3	38	33	8
6	240.2	11.27	221 to 252	188.3	47.08	110 to 250	3	50	67	3	50	100	6
7	265.7	10.56	254 to 283	246.7	36.15	200 to 290	0	0	ND	6	100	100	6
8	293.0	1.41	292 to 294	350.0	28.28	330 to 370	0	0	ND	2	100	100	2
Totals							12	46		14	54		28

[a] Includes unsexed fish.

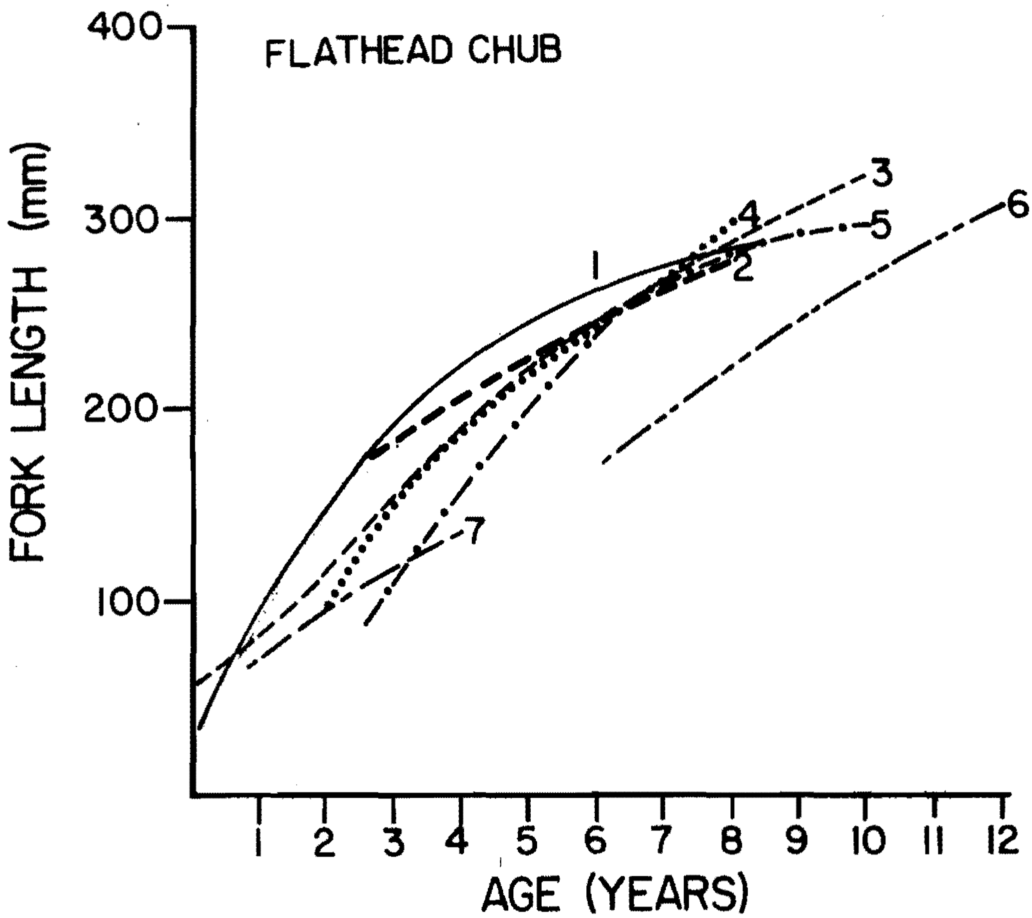

Figure 24. Growth in fork length for flathead chub from the MacKay River and from several other areas:
1. Athabasca River (Bond and Berry 1980b);
2. Athabasca River (Tripp and McCart 1980);
3. Peace River (Bishop 1977); 4. MacKay River (Present Study); 5. Athabasca River (McCart et al. 1977);
6. Mackenzie River (Hatfield et al. 1972); and
7. Perry Creek, Iowa (Martyn and Schmulbach 1978).

McCart et al. 1977; Tripp and McCart 1980) have also reported sex ratios favouring females (77 to 81%). Martyn and Schmulbach (1978) reported a sex ratio of 1.13:1 in favour of females in Perry Creek, Iowa.

The earliest age at which sexually mature fish were observed was four years for males and five years for females (Table 32). Bond and Berry (1980b) found the earliest age at maturity was age 3, although most chub were not sexually mature until age 5. Peace River chub (Bishop 1975) also did not become sexually mature until age 4, while Perry Creek chub (Martyn and Schmulbach 1978) matured when only two years of age.

5.2.6.5 Fecundity and egg size. Actual egg counts were performed on ovaries removed from three mature female flathead chub (fork length 207 to 283 mm) captured in the MacKay River during the spring fence operation. Fecundity ranged from 6460 to 12 689 with an average of 9827 eggs per female. Bond and Berry (1980b) reported an average fecundity of 10 564 eggs per female (range 7000 to 15 170) for Athabasca River chub with a fork length range of 235 to 297 mm. The mean number of ova per female in Perry Creek, Iowa was 4974 (range 826 to 13 073) for fish between 100 and 134 mm fork length (Martyn and Schmulbach 1978). Egg diameters for four mature MacKay River chub varied from 1.3 to 1.7 with a mean of 1.5 mm.

5.2.6.6 Food habits. Twenty-three flathead chub stomachs were examined in the field during the spring, of which 70% were empty or contained just a trace of food. The remainder were one-quarter full to full of insect remains and digested material. The diet of Athabasca River chub was extremely varied but consisted primarily of mature and immature stages of terrestrial and aquatic insects (Bond and Berry 1980b). Diptera larvae were the most common food item, but other insect groups noted included Ephemeroptera, Hemiptera, Hymenoptera, Coleoptera, and Trichoptera. In the Peace River, chub fed mainly on terrestrial drift insects such as Hymenoptera, Hemiptera, and Trichoptera (Bishop 1975). Similarly, Olund and Cross

(1961) reported that adult forms of terrestrial insects (Coleoptera, Diptera, and Orthoptera) were the dominant food of flathead chub.

5.2.7 Goldeye

5.2.7.1 Distribution and movements. The lower Athabasca River provides a major summer feeding area for immature goldeye that are believed to be pre-spawning members of the population that spawns in the Peace-Athabasca delta (Bond and Berry 1980a, 1980b). Goldeye enter the Athabasca River in early spring and are abundant in the Mildred Lake area by the time of ice break-up in late April (Bond and Berry 1980b). While abundant in the Athabasca River throughout the summer, few goldeye enter clear tributaries (Bond and Machniak 1977, 1979; Machniak and Bond 1979). They do, however, enter the lower reaches of some of the large tributaries, such as the Ells River, when high water levels occur in the Athabasca River (Dr. D. Barton, University of Waterloo, verbal communication with W.A. Bond, June 1977). In late summer or autumn, goldeye leave the Athabasca River to return to overwintering areas in Lake Athabasca, the Peace-Athabasca Delta, or the Peace River (Bond and Berry 1980b). During the present study, only 21 goldeye were recorded at the upstream trap (Table 9). None was captured at the downstream trap and only one goldeye was taken during the autumn gillnetting program (Table 5). Floy tags were applied to 10 goldeye, none of which has been recaptured.

It is not known how long goldeye remain in the MacKay River or how far upstream they move. Anglers, however, were seen catching goldeye at Site 3 (Figure 2) in mid-June 1978. McCart et al. (1978) took goldeye in the same region until July. Results of the present study and of McCart et al. (1978) indicate that goldeye leave the MacKay River by September. It is probable that most goldeye leave the MacKay River during July when the turbidity of the water and the level of suspended sediments decrease (McCart et al. 1978).

5.2.7.2 Spawning. Major goldeye spawning areas occur in the Peace-Athabasca Delta (Kristensen et al. 1976; Kristensen and Pidge 1977; Donald and Kooyman 1977). There is no evidence, however, that goldeye spawn in the MacKay River or in the Athabasca River within the AOSERP study area. Immature goldeye captured during the summer in the lower Athabasca River are believed to be members of the population that spawns in the delta (Bond and Berry 1980a, 1980b).

5.2.7.3 Age and growth. Goldeye (n = 21) captured in the MacKay River during the present study ranged in fork length from 258 to 318 mm, the majority (59%) being between 275 and 299 mm (Figure 25). McCart et al. (1978) reported that MacKay River goldeye ranged in size from 232 to 287 mm. Studies in the Athabasca River (McCart et al. 1977; Bond and Berry 1980a, 1980b; Jones et al. 1978; Tripp and McCart 1980) have observed similar size distributions for goldeye, with most fish being between 225 and 300 mm. Eight goldeye (five males) for which age and sex were determined (Table 33) were found to be immature four- to six-year-old fish. McCart et al. (1978) reported that all goldeye sampled from the MacKay River in 1977 were immature four- to six-year-old fish. The age-length relationship for goldeye from the MacKay River is similar to that recorded for fish in the lower Athabasca River (McCart et al. 1977; Bond and Berry 1980a, 1980b; Jones et al. 1978). In the Athabasca River south of Fort McMurray, Tripp and McCart (1980) found goldeye ranged in age from five to eight years and in fork length from 250 to 374 mm.

5.2.7.4 Sex and maturity. Virtually all goldeye captured in the lower Athabasca River were sexually immature and no ripe individuals have ever been reported from the area. No mature goldeye were observed in the MacKay River during the present study (Table 33). The earliest age at which goldeye (males) apparently achieve sexual maturity in the AOSERP area is age 6 (Bond and Berry 1980a, 1980b).

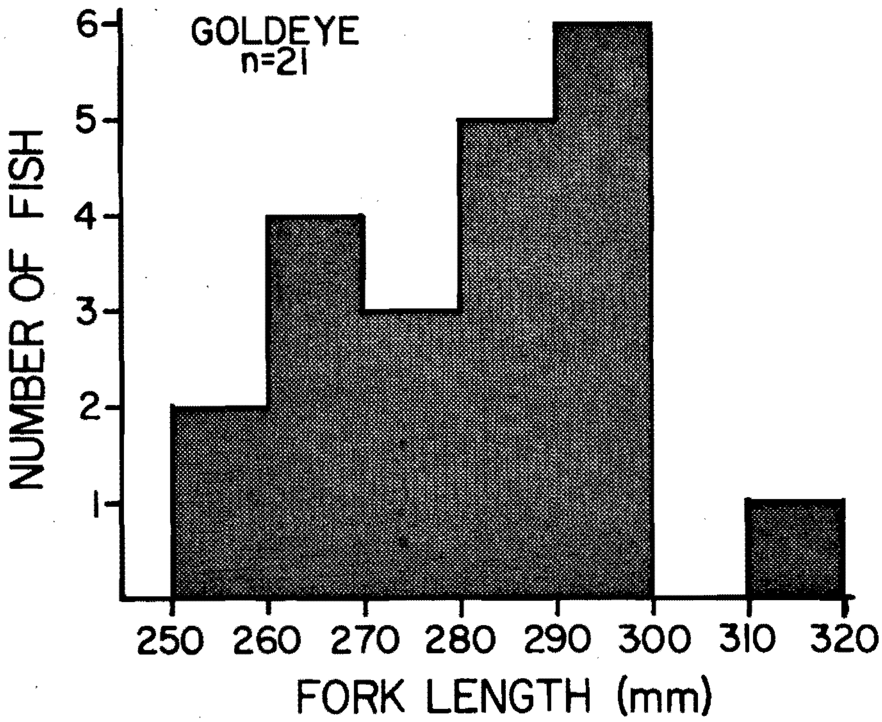

Figure 25. Length-frequency distribution for goldeye captured during the spring fence operation, MacKay River, 1978.

Table 33. Age-length and age-weight relationships, age-specific sex ratios, and maturity for goldeye, burbot, lake whitefish, and mountain whitefish from the MacKay River, 1978.

Species/ Age	Fork Length (mm)			Weight (g)			Males			Females			Total[b]
	Mean	S.D.	Range	Mean	S.D.	Range	N	%	% Mature	N	%	% Mature	
Goldeye													
4	269.5	10.61	262 to 277	215.0	7.07	210 to 220	1	100	0	0	0	ND	2
5	290.8	5.85	284 to 298	264.2	19.85	245 to 295	3	75	0	1	25	0	6
6	306.3	14.57	290 to 318	330.0	55.68	280 to 390	1	33	0	2	67	0	3
Totals							5	63		3	37		11
Burbot[a]													
3	301.3	28.11	265 to 349	196.4	67.37	140 to 330	3	60	0	2	40	0	7
4	423.0			410.0			0	ND	ND	0	ND	ND	1
5	497.5	2.12	496 to 499	557.5	81.32	500 to 615	2	100	100	0	0	ND	2
Totals							5	71		2	29		10
Lake whitefish													
6	338.5	7.78	333 to 344	505.0	7.07	500 to 510	1	50	0	1	50	0	2
7	360.0	11.31	352 to 368	595.0	7.07	590 to 600	1	50	100	1	50	100	2
8	376.0			750.0			1	100	100	0	0	0	1
Totals							3	60		2	40		5
Mountain whitefish													
5	309.0	14.14	299 to 319	335.0	63.64	290 to 380	2	100	ND	0	0	ND	2
Totals							2	100					2

[a] Total length.

[b] Includes unsexed fish.

Of the eight MacKay River goldeye for which sex was determined in 1978, five were males. McCart et al. (1978) found that females (n = 22) outnumbered the males (n = 10) in the MacKay River, but particularly in age group 6 (81%). Male and female goldeye occurred in equal numbers in the Athabasca River in 1976 and 1977 (Bond and Berry 1980a, 1980b), although females accounted for the vast majority of six-year-old fish (68 to 79%). The preponderance of female goldeye among age 6 fish in the Athabasca River is though to reflect the fact that males begin to spawn at age 6 while most females do not spawn until age 7.

5.2.7.5 Food habits. Stomachs of 10 goldeye were examined in the field during the spring. All stomachs contained some food, with eight being three-quarters full to full of insects (Odonata, Corixidae, Notonectidae, Diptera, and Coleoptera). Other food items noted were fish remains and fish eggs. McCart et al. (1978) reported that goldeye in the MacKay River consumed a wide variety of food items ranging from benthic invertebrates to surface insects. Bond and Berry (1980a) found that goldeye in the Athabasca River fed mainly on immature insects (Plecoptera, Ephemeroptera, Hemiptera, and Hymenoptera), although such items as fish, frogs, mice, and plant material were also noted.

5.2.8 Other Large Fishes

5.2.8.1 Burbot. Burbot are common throughout Alberta (Paetz and Nelson 1980) but are not abundant in the lower Athabasca River during the summer (Bond and Berry 1980a, 1980b). Bond and Berry (1980b) found large burbot to be common in the Athabasca River in early spring and reported fry appearing in June. They speculated that burbot utilize the Mildred Lake area of the Athabasca River, or areas upstream of it, for spawning purposes. Recent evidence suggests that burbot spawn in the Clearwater River (Figure 1) upstream of its junction with the Christina River (Tripp and McCart 1980). Little is known regarding the movements of burbot in the

AOSERP study area but it is believed that, after spawning, most return to the cooler waters of Lake Athabasca. Some burbot apparently enter tributaries, however, as Machniak and Bond (1979) captured 43 burbot moving out of the Steepbank River during the autumn.

Burbot were taken in small numbers in the MacKay River during the present study but none was captured upstream of the fence site (Table 6). Five burbot (198 to 589 mm total length) were recorded at the upstream trap between 8 and 30 May, while eight (180 to 496 mm) were taken at the downstream trap between 22 May and 3 June (Table 9). During the autumn, one juvenile burbot (265 mm) was gillnetted (Table 5) and two others (134 and 240 mm) were seined at Site 2. McCart et al. (1978) captured only two burbot in the MacKay River during 1977.

Age was determined for 10 MacKay River burbot, of which seven were sexed (Table 33). The oldest burbot captured were five-year-old maturing males, 496 and 499 mm in total length. Jones et al. (1978) recorded a maximum age of 12 years for burbot in the AOSERP study area.

The stomachs of nine burbot were examined in the field during the spring, only one of which was empty. The remainder contained fish remains (longnose dace, burbot, slimy sculpins, and other unidentifiable species), with some insect remains (Ephemeroptera).

5.2.8.2 Lake whitefish. Lake whitefish are known to migrate through the AOSERP study area during the late summer and autumn (Bond and Berry 1980a, 1980b). At that time, large numbers can often be taken in tributary mouths which seem to serve as resting spots during the migration. Spawning occurs in rapids areas of the Athabasca River upstream of Fort McMurray (Jones et al. 1978). After spawning, most whitefish are believed to return to Lake Athabasca (Bond and Berry 1980b; Jones et al. 1978), although some may overwinter within the Athabasca River and small numbers have been observed to move into the Muskeg River (Bond and Machniak 1977, 1979) and Steepbank River (Machniak and Bond 1979) during the spring migrations of other species. Kendel (1975) observed that whitefish migrated into a Yukon stream during the spawning period of Arctic grayling and longnose suckers and fed on their eggs.

Only five lake whitefish were captured at the upstream trap of the MacKay River counting fence during the present study (Table 9). No lake whitefish were taken in the watershed during the summer or autumn. McCart et al. (1978) also captured lake whitefish in this tributary during May but not thereafter. The absence of lake whitefish during the autumn suggests that this species does not utilize the MacKay River for spawning.

The five lake whitefish captured during the present study ranged in fork length from 333 to 376 mm and in scale age from six to eight years (Table 33). Whitefish stomachs examined in the field were either empty or contained only traces of insect remains. Bond and Berry (1980a) noted that aquatic insects made up 93% of the food volume of lake whitefish in the Athabasca River during the summer.

5.2.8.3 Mountain whitefish. Studies on the Muskeg River (Bond and Machniak 1977, 1979) and the Steepbank River (Machniak and Bond 1979) indicate that mountain whitefish migrate into some tributaries of the AOSERP study area in the early spring and leave sometime during the summer. Little else is known about the movements of mountain whitefish in this area. In the Sheep River, Alberta, mountain whitefish were observed to undergo a complex movement pattern involving spring and summer feeding, pre-spawning, spawning, and post-spawning-overwintering movements (Davies and Thompson 1976).

No mountain whitefish were captured in the MacKay River during the spring counting fence operation and none was taken during the summer. Two specimens were captured, however, during the autumn gillnetting program (Table 5). These fish were both five year old males with fork lengths of 299 and 319 mm (Table 33). Neither had any food in its stomach. McCart et al. (1978) captured one mountain whitefish near the mouth of the MacKay River in mid-June.

For more details on the life history of mountain whitefish in the AOSERP study area, see Griffiths (1973), Bond and Machniak (1977), Jones et al. (1978), and Machniak and Bond (1979).

5.2.8.4 Yellow perch. Young-of-the-year yellow perch occur commonly around tributary mouths of the AOSERP study area during July and August (McCart et al. 1977; Bond and Berry 1980a, 1980b; Machniak and Bond 1979). These fry are thought to originate from lakes of the southern Athabasca drainage and drift down to the study area.

Sixty-two young-of-the-year yellow perch were collected from the mouth of the MacKay River (Site 1) during the present study (Table 6). These fry varied in fork length from 33 to 53 mm, the mean length increasing from 36.1 to 44.0 mm between 22 July and 26 August (Table 34). Sex was determined for 26 perch fry of which 69% were males.

In addition to the perch taken at the river mouth, two fry were captured at Site 13 of the Dover River (Figure 2) on 14 July. These fry, identified as perch according to Norden (1961), measured 16 and 17 mm in length (Table 35) and probably originated in one of the headwater lakes of the Dover River watershed (possibly Lake 14). According to Turner (1968), yellow perch are common in lakes of the Birch Mountains; however, their presence in the lakes of the upper MacKay River watershed has not been confirmed.

The stomachs of 59 perch fry were examined in the field and 23 (39%) contained no food. The remaining stomachs were nearly all full of immature aquatic insects, predominantly Chironomidae, Ephemeroptera, and Odonata. Bond and Berry (1980a) reported a diet of Diptera larvae and pupae and Ephemeroptera nymphs and adults for young-of-the-year yellow perch from the Athabasca River.

5.2.9 Lake Chub

5.2.9.1 Distribution and relative abundance. Lake chub was the most abundant species taken in the MacKay River watershed during 1978,

Table 34. Length and weight relationships of young-of-the-year yellow perch captured in the MacKay River watershed, 1978.

Date of Capture	Fork Length (mm)			Weight (g)			Number of Fish
	Mean	S.D.	Range	Mean	S.D.	Range	
14 July	16.5	ND	16 to 17	0.5	ND	0.5 to 0.5	2
22 July	36.1	3.46	33 to 44	0.6	0.22	0.3 to 1.1	16
29 July	40.5	3.62	35 to 47	0.9	0.25	0.6 to 1.4	22
4 August	43.3	4.30	33 to 49	1.0	0.32	0.3 to 1.5	21
26 August	44.0	7.94	38 to 53	1.0	0.72	0.5 to 1.8	3
Total							64

accounting for 50.0% of the total seine catch (Appendix 8.5). Chub were captured at all sampling sites except Site 11 and Lake 16 but were most abundant at Sites 2, 3, 5, 9, and 12 (Table 35). The capture of large numbers of lake chub at Sites 5, 9, and 12 on 20 May 1978 suggests that many lake chub may overwinter within the MacKay River watershed. However, variations in catch-per-unit-effort at Site 2 indicate a substantial upstream migration of lake chub in early May and a large downstream run during October (Table 35). During May, the average catch-per-unit-effort recorded at the fence site was 7.3 chub per seine haul. Chub were considerably more abundant early in the month as values of 10.3, 15.7, and 8.0 were recorded on 3, 10, and 16 May, respectively. Catch-per-unit-effort values at Site 2 remained low during June, July, and August, but an average of 98.9 lake chub per seine haul was obtained in October. The apparent reduction in abundance observed for upstream sites during October (Table 35) may indicate that most chub had vacated these areas to participate in the downstream migration or may simply reflect a decrease in seining efficiency at that time as a result of high water levels. In 1977, McCart et al. (1978) found that the abundance of lake chub increased dramatically in the area just upstream of Lease 17 (Figure 2) during mid-August. A similar increase in abundance on 28 September 1977 near the mouth of the Dover River (Site 3) suggested that a downstream migration was underway at that time. It is not known whether lake chub return to the Athabasca River during the autumn or overwinter in the lower reaches of the MacKay River.

5.2.9.2 <u>Spawning</u>. Lake chub usually undertake spawning migrations from lakes to tributary streams in early spring (Scott and Crossman 1973). Brown (1969) noted that chub were first observed in the Montreal River, Saskatchewan when the water temperature was 4°C and that spawning occurred in shallow water among and underneath large rocks during late May when water temperatures reached 10°C. Bond and Machniak (1979) stated that lake chub probably spawned in late May or early June in the Muskeg River of the AOSERP study area.

Table 35. Average catch-per-unit-effort by month for lake chub captured by seines at each sampling location in the MacKay River watershed, 1978.

	Catch-per-unit-effort (No. of Fish per Seine Haul)						
Site[a]	May	June	July	Aug.	Sept.	Oct.	Total
1	ND[b]	ND	1.2	4.8	ND	ND	3.6
2	7.3[c]	0.7	0.8	2.2	5.6	98.9	48.4
3	ND	5.2	8.1	1.0	0.8	7.8	4.9
4	0.8	1.3	3.6	ND	ND	1.0	1.7
5	11.7	5.2	0.4	11.8	ND	1.6	6.6
6	0.0	0.0	7.6	3.8	ND	0.0	2.3
7	0.0	0.0	0.0	0.0	ND	ND	0.0
8	ND	0.0	ND	0.0	ND	ND	0.0
9	11.6	8.6	1.4	22.8	ND	0.4	9.0
10	ND	0.2	0.0	0.0	ND	0.0	0.1
11	ND	ND	ND	0.0	ND	ND	0.0
12	10.4	6.6	7.8	5.0	1.2	3.2	5.8
13	ND	0.0	1.5	6.0	ND	0.2	2.1
Lake 16	ND	ND	ND	0.0	ND	ND	0.0

[a] Sites are those shown in Figure 2.

[b] ND indicates no seining done.

[c] Catch-per-unit-effort was 10.3, 15.7, and 8.0 lake chub per seine haul on 3, 10, and 16 May, respectively.

Evidence from the present study suggests that lake chub spawned in the MacKay River watershed in late May or early June 1978.

High catch-per-unit-effort values indicated that a large upstream migration of lake chub passed the MacKay River fence site during early May 1978 when maximum daily water temperatures were 7.0 to 13.0°C. Maturing male and female lake chub were first captured near the fence site between 3 and 10 May and two ripe males (75 and 100 mm fork length) were taken at the same location on 18 and 24 May. Mature lake chub were also collected near the mouth of the Dover River (Site 12) on 20 May and in the Dunkirk River (Site 10) on 16 June. A ripe female was taken on 17 June at Site 4 (Figure 2). Among the larval fish taken in drift nets between 2 and 19 June, 236 were cyprinids (Appendices 8.3 and 8.4). These young fish ranged in total length from 5 to 14 mm with the majority (81%) being between 6 and 8 mm (Figure 26). Since lake chub is one of the first minnow species to spawn in the spring, followed closely by longnose dace (Brown et al. 1970; Bartnik 1970), it is likely that most, if not all, of these larval cyprinids were lake chub. The first identifiable young-of-the-year lake chub (size range 11 to 25 mm) were captured on 14 and 15 July at Sites 2, 4, 9, 12, and 13 (Figure 2). The largest collections on these dates were made at Site 4 of the MacKay River (n = 12, mean fork length 16.1 mm, range 11 to 19 mm) and Site 12 of the Dover River (n = 28, mean fork length 196 mm, range 15 to 24 mm). Young-of-the-year were also captured at Sites 1, 3, 5, 6, 7, and 8 (Figure 2) during the course of the study.

As mentioned previously, larval cyprinids were captured moving downstream in the MacKay and Dover rivers between 2 and 19 June. Although the numbers captured were relatively small, fry showed a tendency to migrate at night and along the right bank (Appendices 8.3 and 8.4). Pavlov et al. (1977) observed that, in rivers of the USSR, most cyprinid larvae migrated at night. Very young fry tended to migrate near the water surface but the vertical distribution shifted as the fry increased in size. They also noted that cyprinid larvae, 6 to 10 mm long, migrated downstream

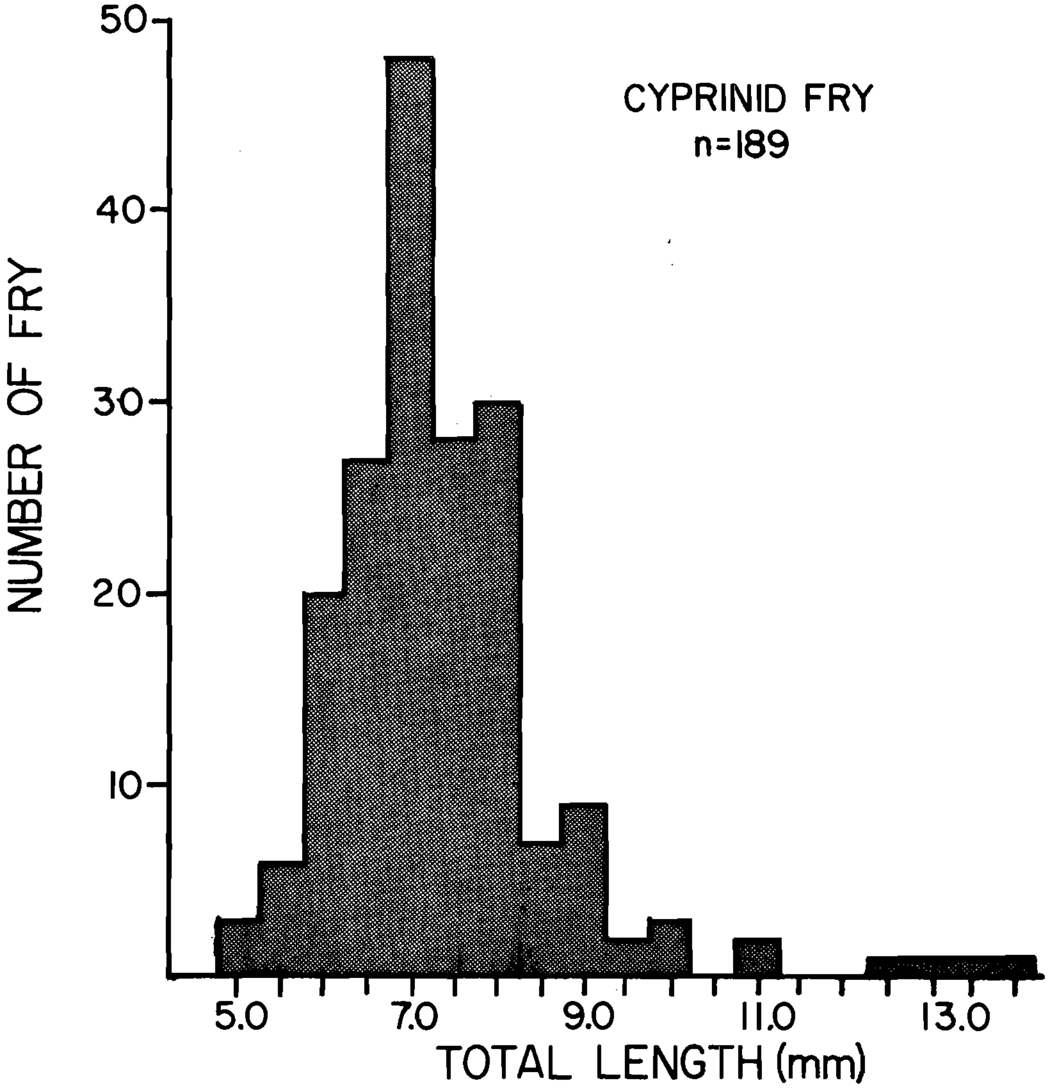

Figure 26. Length-frequency distribution of cyprinid fry captured in drift nets from the MacKay River, 2 to 19 June 1978.

predominantly along the banks. Similar results were reported by Gale and Mohr (1978) for cyprinids in the Susquehanna River, Pennsylvania.

5.2.9.3 Age and growth. Lake chub, captured from the MacKay River watershed in 1978, ranged in fork length from 11 to 100 mm (Figure 27), with those in the 20 to 44 mm size range accounting for 83% of the total sample. Bond and Berry (1980b) found lake chub from the Athabasca River to range from 17 to 94 mm in fork length, with 63% being in the 25 to 39 mm range. Steepbank River lake chub measured 21 to 108 mm with the majority (89%) being between 27 and 46 mm (Machniak and Bond 1979).

During the present study, the length-frequency for lake chub varied throughout the summer. In May and June, the population was dominated by age 1 fish as 84% of all chub captured were between 25 and 44 mm in fork length. In July, the appearance of young-of-the-year produced a bi-modal distribution in which 45% of the sample were between 15 and 24 mm (young-of-the-year) and 36% were between 35 and 49 mm (mostly age 1). By mid-August, age 1 fish appeared to be less abundant than previously and the samples were dominated by age 0 fish as 85% of all chub were between 20 and 34 mm in length. Young-of-the-year were also abundant in the autumn, by which time it appeared that they had completed their year's growth. In September and October, 69% of all chub taken in the MacKay River watershed were between 25 and 44 mm in fork length, the same size range that had predominated in May and June.

Otolith ages were determined for 119 MacKay River lake chub, the oldest of which was a five-year-old male, 100 mm in fork length (Table 36). Maximum ages reported from other studies are: age 4+ for chub from western Labrador (Bruce and Parsons 1976) and age 5 for the Muskeg River (Bond and Machniak 1977), the Steepbank River (Machniak and Bond 1979), British Columbia (Geen 1955), and Saskatchewan (Brown 1969).

Growth of lake chub in the AOSERP study area (current study; Bond and Machniak 1977; Machniak and Bond 1979) is similar to

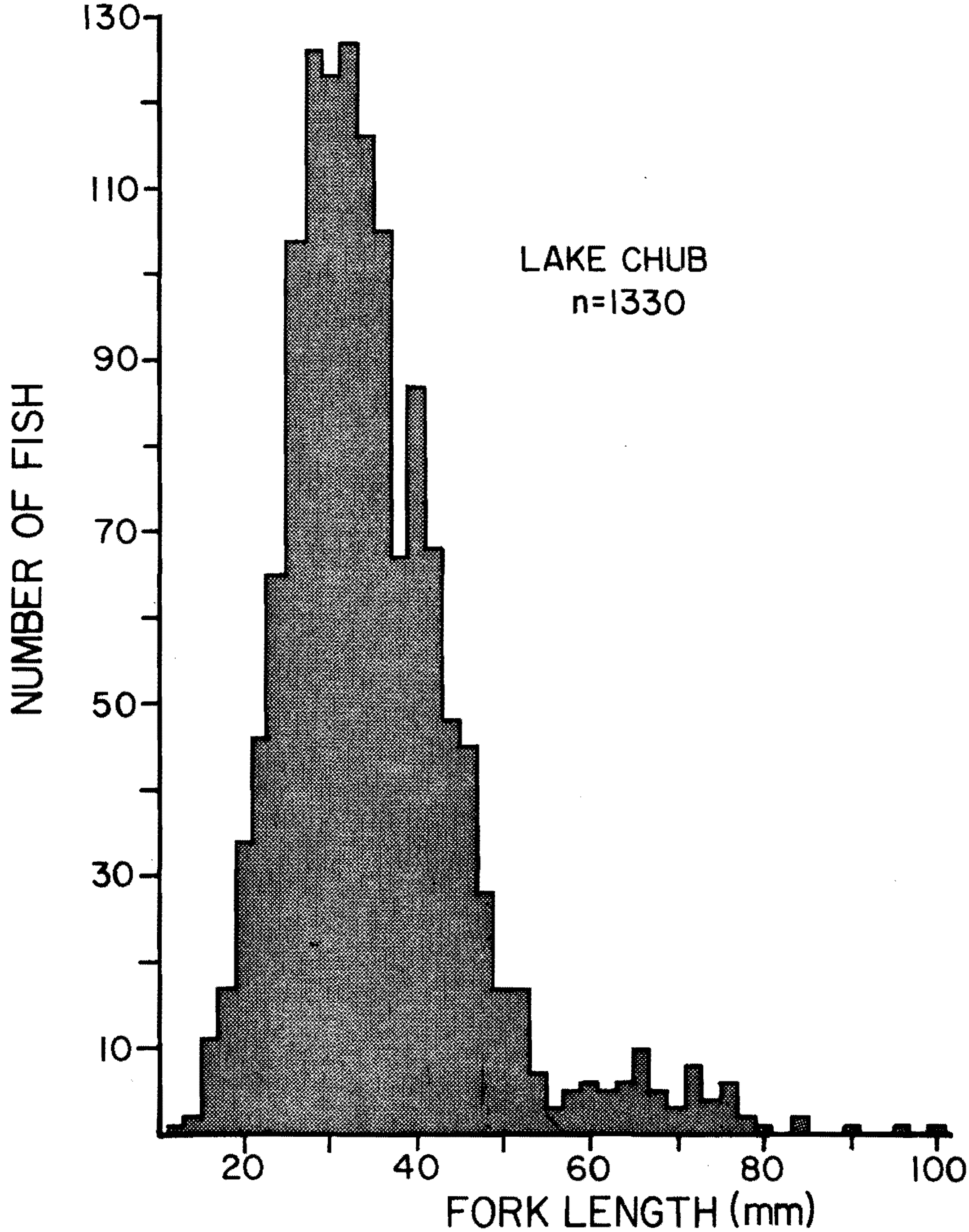

Figure 27. Length-frequency distribution for lake chub from the MacKay River, 1978.

Table 36. Age-length (dreived from otoliths) and age-weight relationships, age-specific sex ratios, and maturity of small fishes captured from the MacKay River drainage, 1978.

Species/Age	Females			Males			Unsexed Fish	Sample Size	Fork or Total Length (mm)			Weight (g)		
	N	%	% Mature	N	%	% Mature			Mean	S.D.	Range	Mean	S.D.	Range
Lake chub														
0	0	ND	ND	0	ND	ND	21	21	18.1	4.85	11 to 24	0.2	0.08	0.1 to 0.3
1	22	69	0	10	31	0	17	49	37.9	7.20	27 to 51	0.7	0.43	0.2 to 1.4
2	14	61	0	9	39	67	2	25	57.8	6.83	48 to 69	2.4	0.89	1.0 to 4.0
3	9	43	100	12	57	100	0	21	74.1	4.16	65 to 83	5.2	1.10	3.2 to 7.8
4	2	100	100	0	0	ND	0	2	92.5	4.95	89 to 96	10.5	1.73	9.3 to 11.7
5	0	ND	ND	1	100	100	0	1	100.0			8.5		
Totals	47	59	23	32	41	59	40	119						
Trout-perch														
0	16	69	0	7	31	0	12	35	25.1	5.40	12 to 35	0.2	0.09	0.1 to 0.4
1	20	57	0	15	43	27	1	36	39.5	5.23	28 to 47	0.8	0.30	0.2 to 1.5
2	15	71	80	6	29	100	1	22	53.2	4.29	45 to 58	1.8	0.40	1.1 to 2.5
3	12	50	83	12	50	100	0	24	66.4	3.66	60 to 72	3.5	0.62	2.3 to 4.4
4	1	86	100	6	14	100	0	7	80.7	4.79	75 to 87	6.8	1.75	4.0 to 8.9
Totals	64	58	36	46	42	61	14	124						
Slimy sculpin[a]														
0	1	100	0	0	0	ND	13	14	21.7	4.69	15 to 34	0.4	0.56	0.1 to 0.6
1	12	60	0	8	40	13	1	21	39.7	4.38	31 to 47	0.8	0.27	0.3 to 1.3
2	1	50	100	1	50	100	0	2	62.5	4.95	59 to 66	3.2	0.28	3.0 to 3.4
3	6	67	100	3	33	100	0	9	75.4	1.88	73 to 79	5.3	1.01	3.9 to 7.3
4	0	0	ND	9	100	100	0	9	84.9	2.93	81 to 89	9.3	1.69	7.4 to 11.6
Totals	20	49	35	21	51	67	14	55						

Continued ...

Table 36. Continued.

Species/Age	Females			Males			Unsexed Fish	Sample Size	Fork or Total Length (mm)			Weight (g)		
	N	%	% Mature	N	%	% Mature			Mean	S.D.	Range	Mean	S.D.	Range
Longnose dace														
0	4	80	0	1	20	0	19	24	24.8	7.27	17 to 39	0.2	0.21	0.1 to 0.8
1	7	64	0	4	36	0	4	15	34.7	5.08	27 to 45	0.4	0.25	0.2 to 1.1
2	3	33	67	6	67	100	1	10	56.5	4.67	49 to 62	2.3	0.68	1.3 to 3.2
3	1	20	100	4	80	100	0	5	68.6	4.67	64 to 76	4.1	1.02	3.2 to 5.6
Totals	15	50	20	15	50	67	24	54						
Finescale dace														
1	8	53	0	7	47	0	1	16	34.1	4.36	25 to 42	0.5	0.23	0.3 to 0.9
2	22	81	100	5	19	80	0	27	53.6	5.71	45 to 64	1.8	0.81	0.9 to 3.4
3	1	100	100	0	0	ND	0	1	74.0			4.8		
Totals	31	72	74	12	28	33	1	44						
Pearl dace														
0	0	ND	ND	0	ND	ND	3	3	21.7	4.51	17 to 26	0.1	0.06	0.1 to 0.2
1	9	56	0	7	44	0	5	21	30.9	4.79	25 to 44	0.4	0.19	0.2 to 0.9
Totals	9	56	0	7	44	0	8	24						
Brook stickleback[a]														
0	1	100	0	0	0	ND	2	3	24.7	4.72	21 to 30	0.2	0.12	0.1 to 0.3
1	3	33	67	6	67	50	0	9	37.9	3.72	33 to 43	0.7	0.25	0.2 to 0.8
2	3	43	100	4	57	100	0	7	51.4	3.82	46 to 57	1.5	0.24	1.2 to 1.8
3	2	100	100	0	0	ND	0	2	60.5	3.55	58 to 63	2.2	0.14	2.1 to 2.3
Totals	9	47	78	10	53	70	2	21						

Continued ...

Table 36. Concluded.

Species/Age	Females N	Females %	Females % Mature	Males N	Males %	Males % Mature	Unsexed Fish	Sample Size	Fork or Total Length (mm) Mean	S.D.	Range	Weight (g) Mean	S.D.	Range
Spottail shiner														
0	0	0	ND	1	100	0	4	5	25.2	3.11	20 to 28	0.2	0.06	0.2 to 0.3
1	4	67	0	2	33	0	0	6	39.0	2.97	34 to 42	0.7	0.20	0.4 to 0.9
Totals	4	57	0	3	43	0	4	11						
Spoonhead sculpin[a]														
3	0	0	ND	1	100	100	0	1	73.0			4.6		
Totals	0	0	ND	1	100	100	0	1						

[a] Total length.

that reported for western Labrador (Bruce and Parsons 1976) where chub attain an average fork length of 101 mm at age 4+.

The mathematical relationship between fork length and body weight for lake chub (sexes combined) captured from the MacKay River watershed in 1978 (n = 145, r = 0.988, range 11 to 100 mm) is described by the equation:

$$\log_{10}W = 2.704(\log_{10}L) - 4.389;\ sb = 0.035$$

This relationship is similar to that reported for lake chub from the Muskeg River (Bond and Machniak 1977) and Steepbank River (Machniak and Bond 1979).

5.2.9.4 Sex and maturity. Female lake chub (56%) were significantly more abundant than males ($X^2 = 11.50$, $P > 0.001$) in the sexed sample (n = 785). Males, however, were more numerous among the larger lake chub (> 55 mm) in the MacKay River sample (Table 37). Machniak and Bond (1979) and Bond and Machniak (1978) reported that females were slightly more abundant than males in the Steepbank River (52%) and Muskeg River (51%), respectively. Brown (1969) observed that males outnumbered females in samples taken during the spawning season because they spent a longer time on the spawning grounds.

The smallest size at maturity for lake chub from the MacKay River was 50 to 54 mm for males and 65 to 69 mm for females (Table 37). The minimum age of maturity was two years for males and three years for females (Table 36). Bruce and Parsons (1976) also found that males matured at a younger age (2+) than females, while Bond and Machniak (1977) reported the minimum age of sexual maturity to be three years for both sexes in the Muskeg River. A similar age of maturity was reported for chub in Labrador (Bruce and Parsons 1976) and in Saskatchewan (Brown et al. 1970).

5.2.9.5 Food habits. Lake chub from the MacKay River watershed fed mainly on immature insects of the orders Diptera, Ephemeroptera, and Trichoptera, with some Crustacea, Arachnida, and Nematoda included in the diet (Table 38). Chironomid larvae were the most

Table 37. Sex and maturity ratios by size class for lake chub from the MacKay River, 1978. Sex ratios were based only on fish for which sex was determined.

Fork Length (mm)	Sample Size	Males		Females		% Unsexed	Sex Ratio	
		% Immature	% Mature	% Immature	% Mature		% Female	% Male
0 to 9	0	ND	ND	ND	ND	ND	ND	ND
10 to 14	2	ND	ND	ND	ND	100	ND	ND
15 to 19	42	ND	ND	ND	ND	100	ND	ND
20 to 24	132	100	0	100	0	92	55	45
25 to 29	305	100	0	100	0	69	58	42
30 to 34	291	100	0	100	0	42	55	45
35 to 39	219	100	0	100	0	19	57	43
40 to 44	156	100	0	100	0	4	60	40
45 to 49	83	100	0	100	0	1	56	44
50 to 54	31	92	8	100	0	6	59	41
55 to 59	13	71	29	100	0	8	42	58
60 to 64	11	29	71	100	0	0	36	64
65 to 69	17	0	100	0	100	0	41	59
70 to 74	14	0	100	0	100	0	43	57
75 to 79	9	0	100	0	100	0	56	44
80 to 84	2	0	100	0	100	0	0	100
85 to 89	1	ND	ND	ND	ND	0	100	0
90 to 94	0	ND	ND	0	100	ND	ND	ND
95 to 99	1	ND	ND	ND	ND	ND	100	0
100 to 104	1	0	0	0	100	ND	0	100
Total	1330	91%	9%	96%	4%	41%	56%	44%

Table 38. Food habits of small fishes collected from the MacKay River, 1978.

Food Items	Lake Chub		Trout-perch		Slimy Sculpin		Longnose Dace		Brook Stickleback		Pearl Dace	
	% Freq.[a]	% No.	% Freq.[a]	% No.	% Freq.[a]	% No.	% Freq.[a]	% No.	% Freq.[a]	% No.	% Freq.[a]	% No.
Class Insecta												
Diptera												
Chironomidae	47.5	18.6	73.5	52.7	50.0	50.0	60.7	32.0	63.6	35.3	60.0	55.6
Simuliidae	8.2	2.9	11.8	1.8	9.4	1.0	42.9	56.0	9.1	9.4	20.0	22.2
Chaoborinae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.2	4.7	0.0	0.0
Rhagionidae	0.0	0.0	2.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified Dipterans	0.0	0.0	0.0	0.0	3.1	ND	3.6	0.1	0.0	0.0	0.0	0.0
Trichoptera	8.2	2.9	26.5	6.5	28.1	6.5	14.3	0.4	9.1	1.2	0.0	0.0
Plecoptera	0.0	0.0	5.9	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ephemeroptera	37.7	23.8	64.7	16.0	59.4	30.9	53.6	11.2	54.5	14.1	40.0	22.2
Hemiptera												
Corixidae	1.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Odonata	1.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insect Remains	0.0	0.0	2.9	0.6	0.0	0.0	0.0	0.0	9.1	1.2	0.0	0.0
Terrestrial Insects	4.9	1.3	2.9	0.3	0.0	0.0	0.0	0.0	9.1	3.5	0.0	0.0
Miscellaneous												
Annelida												
Oligochaeta	0.0	0.0	2.9	0.3	3.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Hirudinea	0.0	0.0	2.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arachnida												
Hydracarina	1.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Continued ...

Table 38. Concluded.

Food Items	Lake Chub		Trout-perch		Slimy Sculpin		Longnose Dace		Brook Stickleback		Pearl Dace	
	% Freq.[a]	% No.	% Freq.[a]	% No.	% Freq.[a]	% No.	% Freq.[a]	% No.	% Freq.[a]	% No.	% Freq.[a]	% No.
Nematoda	36.1	21.2	0.0	0.0	37.5	7.1	3.6	0.4	0.0	0.0	0.0	0.0
Crustacea												
Cladocera	1.6	25.4	2.9	0.3	3.1	2.6	0.0	0.0	27.3	9.4	0.0	0.0
Copepoda	1.6	2.3	0.0	0.0	0.0	0.0	0.0	0.0	36.4	18.8	0.0	0.0
Ostracoda	1.6	0.3	2.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mollusca												
Gastropoda	0.0	0.0	0.0	0.0	9.4	1.6	0.0	0.0	9.1	2.3	0.0	0.0
Pelecypoda	1.6	0.3	8.8	27.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Digested Matter	32.8	ND	8.8	ND	15.6	ND	25.0	ND	9.1	ND	11.1	ND
Debris (tar sand, stones)	13.1	ND	0.0	ND	3.1	ND	0.0	ND	9.1	ND	0.0	ND
Total stomachs	66		39		33		31		13		8	
Empty (% of Total)	7.6		12.8		3.0		9.7		15.4		37.5	

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

frequently occurring food item, being found in 47.5% of all stomachs that contained food. Ephemeroptera nymphs had a frequency of occurrence of 37.7% and made up 23.8% of the diet in terms of numbers. Cladocera, although occurring in only 1.6% of stomachs containing food, accounted for 25.4% of all food items observed. Bond and Berry (1980b) reported that Athabasca River chub fed predominantly on aquatic insects of the orders Diptera, Ephemeroptera, and Hymenoptera. Chironomidae and other immature aquatic insects form the major part of the diet in some Ontario populations with small amounts of Cladocera and algae also being consumed (Scott and Crossman 1973).

5.2.10 Trout-perch

5.2.10.1 Distribution and relative abundance. One of the most abundant and widely distributed forage fish species in the AOSERP study area, trout-perch accounted for 19.3% of all fish taken in seines from the MacKay River watershed during 1978 (Appendix 8.5). Trout-perch were captured as far upstream as Site 10 on the Dunkirk River and Site 13 on the Dover River, but seemed to be more abundant in the lower reaches of the watershed. They were not taken in Lake 16 or at Sites 6, 7, and 11, and only one specimen was captured at Site 8 (Figure 2).

Through most of the 1978 sampling period, trout-perch were captured only in small numbers (Table 39, Appendix 8.5). However, they appeared to be present in considerable numbers at Site 2 on 3 May when a catch-per-unit-effort of 12.3 fish per seine haul was recorded. The early season abundance indicated that an upstream migration was in progress at the time. This migration had passed the fence site by 10 May and the average catch-per-unit-effort between 10 and 31 May was only 0.4. Catch-per-unit-effort values for trout-perch remained low at Site 2 throughout June, July, August, and September but increased dramatically to 40.5 in October (Table 39) as a large downstream migration occurred. The autumn downstream migration indicates that most trout-perch leave the MacKay River

Table 39. Average catch-per-unit-effort by month for trout-perch captured by seines at each sampling location in the MacKay River watershed, 1978.

Site[a]	Catch-per-unit-effort (No. of Fish per Seine Haul)						
	May	June	July	Aug.	Sept.	Oct.	Total
1	ND[b]	ND	1.3	1.6	ND	ND	1.5
2	2.1[c]	0.2	0.6	0.4	4.0	40.5	20.0
3	ND	0.0	0.4	0.0	0.0	1.2	0.3
4	0.2	4.8	3.6	ND	ND	1.6	2.7
5	0.0	1.6	0.6	0.0	ND	0.2	0.4
6	0.0	0.0	ND	0.0	ND	0.0	0.0
7	0.0	0.0	0.0	0.0	ND	ND	0.0
8	ND	0.5	ND	0.0	ND	ND	0.1
9	3.8	0.2	0.4	0.2	ND	1.0	1.1
10	ND	0.0	2.7	2.1	ND	0.2	1.2
11	ND	ND	ND	0.0	ND	ND	0.0
12	0.0	0.6	2.0	0.0	0.0	0.0	0.3
13	ND	0.0	0.0	1.6	ND	0.0	0.5

[a] Sites are those shown in Figure 2.

[b] Indicates no seining done.

[c] Catch-per-unit-effort was 12.3 trout-perch per seine haul on 3 May.

watershed for overwintering areas in the Athabasca River. However, the presence of age 1 fish at Site 9 on 20 May 1978 suggests that some trout-perch overwinter within the MacKay River watershed.

5.2.10.2 Spawning. Trout-perch usually spawn in early spring, most often in May (Scott and Crossman 1973). Lawler (1954) observed that, in Heming Lake, Manitoba, trout-perch ascend small tributaries in May to spawn on silt and boulder bottoms at water temperatures of 4.4° to 10.0°C. In West Virginia, spawning occurred from mid-April to the end of May at a temperature of about 15°C (Muth 1975). Trout-perch in the AOSERP study area spawn from early May to mid-June in the lower reaches of some tributaries. Bond and Berry (1980b) reported a decrease in the abundance of ripe trout-perch in Athabasca River samples during May 1977, suggesting a movement out of the Athabasca River onto spawning grounds in tributary streams. Machniak and Bond (1979) captured ripe trout-perch between 14 May and 14 June 1977 in the Steepbank River. Also in 1977, McCart et al. (1978) captured large numbers of young-of-the-year trout-perch (11 to 15 mm long) between 14 and 17 June in the lower reaches of the MacKay River and Bond and Berry (1980b) documented the appearance of trout-perch fry in the Athabasca River during the latter part of June.

During the present study, ripe or near ripe male and female trout-perch were captured at the counting fence (Site 2) from 29 April to 14 June 1978 and at Site 4 on 17 June. The main spawning migration is believed to have passed the fence site prior to 10 May. Spent fish were first captured on 14 June at Site 2 and on 17 June at Site 4 (Figure 2). Neither ripe nor spent trout-perch were captured upstream of Site 4 although mature fish (age 3+ and 4+) were taken at Site 10 of the Dunkirk River and at Site 13 of the Dover River on 16 and 17 August, respectively. Young-of-the-year trout-perch (n = 8) were first captured on 9 June. These fry, taken in drift nets near the counting fence (Appendix 8.3), had an average total length of 7 mm and had hatched out recently.

The appearance of recently emerged fry in drift nets on 9 June suggests that many young trout-perch drift out of the spawning stream into the Athabasca River soon after hatching. However, some young-of-the-year remain in the MacKay River watershed throughout the summer. Collections of fry (mean length 20.7 mm, range 12 to 26 mm) at Sites 2, 9, and 12 on 14 July suggests that these areas are used as spawning areas by trout-perch. Young-of-the-year trout-perch were also taken at Sites 1, 2, 4, 9, and 13 later in the summer.

5.2.10.3 Age and growth. Trout-perch, captured in seines, ranged in fork length from 12 to 87 mm (Figure 28), with the majority (75%) being in the 25 to 54 mm range. McCart et al. (1978) found MacKay River trout-perch to range from 11 to 89 mm in fork length. In the Athabasca River, trout-perch ranged in fork length from 12 to 89 mm, with those in the 25 to 49 mm range accounting for 69% of the total sample (Bond and Berry 1980b). Machniak and Bond (1979) found that the length-frequency distribution of Steepbank River trout-perch varied throughout the summer. In that stream, trout-perch captured early in the year (10 May to 14 June) ranged in fork length from 36 to 86 mm, while those captured later in the summer were young-of-the-year, 23 to 39 mm in length. Similarly, the length-frequency of trout-perch from the MacKay River was observed to vary. Fish captured between 29 April and 17 June ranged in fork length from 27 to 83 mm, with 86% being in the 30 to 55 mm size range (mostly 1+ and 2+ fish). Between 14 July and 18 August, young-of-the-year dominated the catch as 60% of the sample (range 12 to 82 mm) was between 12 and 35 mm in length. After 26 August, few young-of-the-year were taken and most fish (85%) were age 1+, 2+, and 3+, ranging in size from 38 to 71 mm.

Otolith ages were determined for 124 trout-perch, the oldest of which was a four-year-old male, 87 mm in fork length (Table 36). Maximum age reported for trout-perch from the MacKay River is five years (McCart et al. 1978). Elsewhere, maximum ages reported for this species are four years for Lake Winnipeg, Manitoba (Ratynski 1978), six years for the Mackenzie Delta (de Graaf and Machniak 1977),

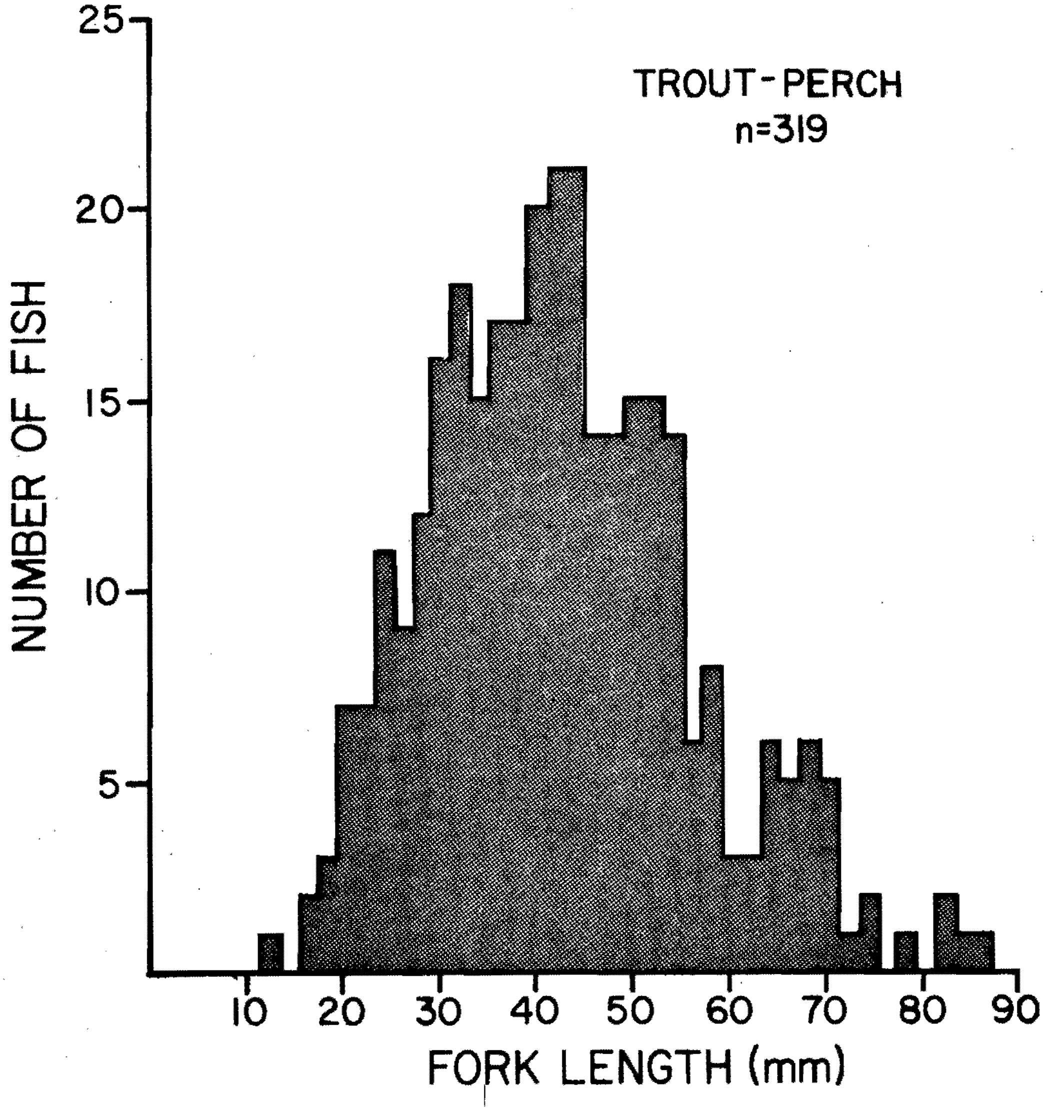

Figure 28. Length-frequency distribution for trout-perch from the MacKay River, 1978.

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

The growth rate of trout-perch in the MacKay River, as determined by the present study, is faster than that presented by McCart et al. (1978) for this river, but appears similar to that reported for other tributaries in the AOSERP area (Bond and Machniak 1977, 1979; Machniak and Bond 1979) and for the Athabasca River (Bond and Berry 1980b). A comparison of growth curves for trout-perch populations from the MacKay River and from other areas is presented in Figure 29. Where data in other studies were presented as total lengths, they were converted to fork lengths using the mathematical relationship between total length and fork length calculated for Great Slave Lake trout-perch (W. A. Bond, Unpublished data). This relationship is described by the equation:

$$TL = 1.095\,FL + 1.211\text{ mm}$$

where TL = Total length (mm)

and FL = Fork length (mm)

The growth rate of MacKay River trout-perch (present study) is similar to that reported for this species in the Mackenzie Delta (de Graaf and Machniak 1977) and in Lake Superior (Bostock 1967). It is not as rapid, however, as that of trout-perch populations in Lake Winnipeg (Ratynski 1978) and the Mackenzie River (Stein et al. 1973), and is considerably slower than was the case for trout-perch in Lake Michigan (House and Wells 1973) and the Lower Red Lakes, Minnesota (Magnuson and Smith 1963).

The length-weight relationship for trout-perch (sexes combined) from the MacKay River watershed (n = 319, r = 0.978, range 11 to 87 mm) is described by the equation:

$$\log_{10}W = 2.917(\log_{10}L) - 4.770;\ sb = 0.035$$

5.2.10.4 Sex and maturity. Sex was determined for 287 trout-perch during the present study (Table 40). The overall sex ratio of 54% females did not differ significantly from unity ($X^2 = 1.84$, $P > 0.05$).

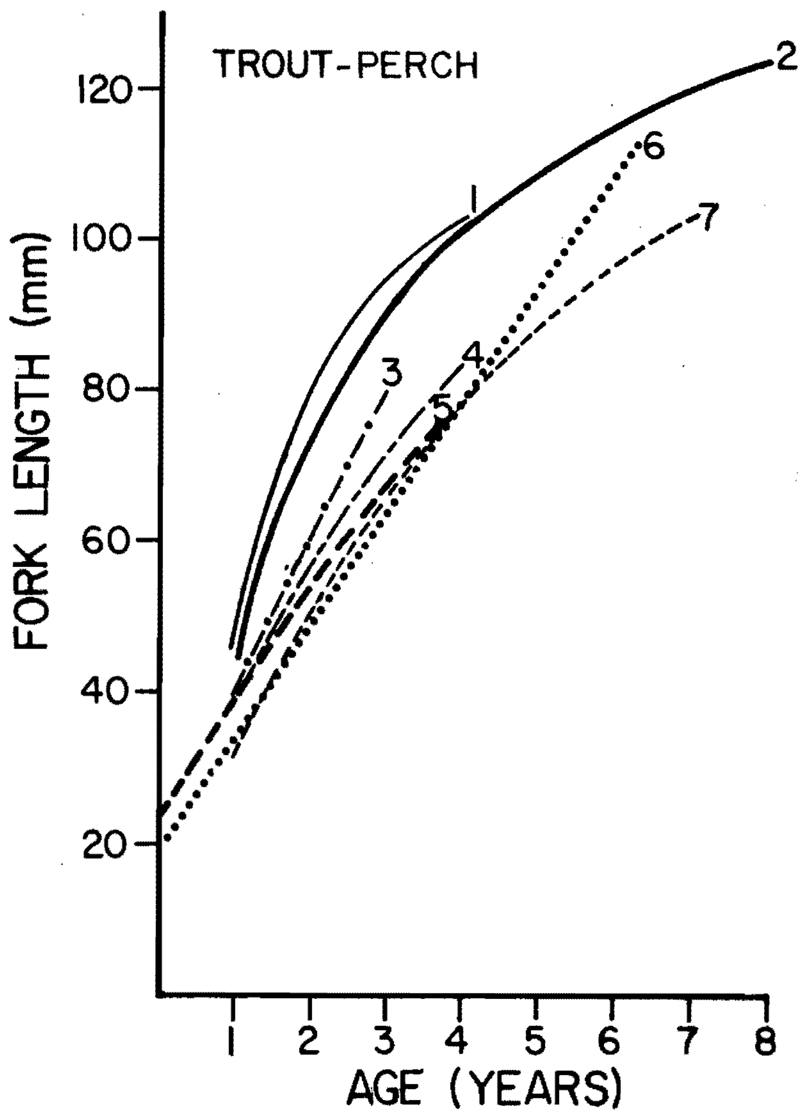

Figure 29. Growth in fork length for trout-perch from the MacKay River and from several other areas: 1. Lower Red Lakes, Minn. (Magnuson and Smith 1963); 2. Lake Michigan (House and Wells 1973); 3. Mackenzie River (Stein et al. 1973); 4. Lake Winnipeg, Man. (Ratynski 1978); 5. MacKay River (Present Study); 6. Mackenzie River Delta (deGraaf and Machniak 1977); and 7. Lake Superior (Bostock 1967).

Table 40. Sex and maturity ratios by size class for trout-perch captured from the MacKay River, 1978. Sex ratios were based only on fish for which sex was determined.

Fork Length (mm)	Sample Size	Males		Females		% Unsexed	Sex Ratio	
		% Immature	% Mature	% Immature	% Mature		% Female	% Male
0 to 9	0	ND	ND	ND	ND	ND	ND	ND
10 to 14	1	ND	ND	ND	ND	100	ND	ND
15 to 19	5	ND	ND	ND	ND	100	ND	ND
20 to 24	18	100	0	100	0	28	69	31
25 to 29	28	100	0	100	0	43	63	37
30 to 34	43	100	0	100	0	9	64	36
35 to 39	40	100	0	100	0	3	56	44
40 to 44	48	92	8	100	0	2	49	51
45 to 49	42	77	23	79	21	2	46	54
50 to 54	39	4	96	50	50	3	32	68
55 to 59	19	0	100	20	80	5	83	17
60 to 64	10	0	100	0	100	0	40	60
65 to 69	13	0	100	17	83	0	46	54
70 to 74	6	0	100	0	100	0	67	33
75 to 79	3	0	100	0	100	0	67	33
80 to 84	2	ND	ND	0	100	0	100	0
85 to 89	2	ND	ND	0	100	0	100	0
Total	319	61%	39%	73%	27%	10%	54%	46%

During the spawning season, 16 mature fish were captured, of which 13 (81%) were males. Machniak and Bond (1979) found that 83% of mature fish captured during the spring in the Steepbank River were males. Although the sample sizes were small in both cases, the indication is that males may outnumber females by a considerable margin in the spring. Other studies have also reported a preponderance of male trout-perch during the spawning season (Lawler 1954; Magnuson and Smith 1963; Muth 1975).

Male trout-perch from the MacKay River tend to achieve sexual maturity at a smaller size and at a younger age than females. The smallest mature males observed during the present study were in the 40 to 44 mm size range while the smallest mature females were in the 45 to 49 mm range (Table 40). Twenty-seven percent of male trout-perch were mature at age 1 while females were not mature before age 2 (Table 36). Bond and Berry (1980b) found that, in the Athabasca River, 17% of males and 4% of females were mature at age 1, while at age 2, the corresponding figures were 86% and 65%. Other authors have also reported that male trout-perch mature earlier than females (Magnuson and Smith 1963; House and Wells 1973; Ratynski 1978).

5.2.10.5 Food habits. Trout-perch from the MacKay River watershed had fed predominantly on immature forms of Diptera, Ephemeroptera, Trichoptera, and Plecoptera (Table 38). Chironomid larvae occurred in 73.5% of all stomachs that contained food and accounted for 52.7% of the diet in terms of numbers. Ephemeroptera nymphs had a frequency of occurrence of 64.7% and made up 16.0% of all food items. Trichoptera larvae occurred in 26.5% of all stomachs containing food and made up 6.5% of the total number of food items observed, while Pelecypoda had corresponding values of 8.8% and 27.8%. Small quantities of Annelida, Arachnida, Nematoda, and Crustacea were also consumed by trout-perch (Table 38). Previous studies in the AOSERP area have reported a similar diet (Bond and Berry 1980b; McCart et al. 1978; Machniak and Bond 1979). Kinney (1950) noted that insect larvae, especially Chironomidae and Ephemeroptera, were particularly important in the diet of trout-perch. Amphipoda and

Chironomidae larvae and pupae were important in the diet of trout-perch of all ages in Lake Winnipeg (Ratynski 1978).

5.2.11 Slimy Sculpin

5.2.11.1 Distribution and relative abundance. Slimy sculpins are rarely taken in the AOSERP section of the Athabasca River (McCart et al. 1977; Bond and Berry 1980a, 1980b; Tripp and McCart 1980; Jones et al. 1978). They are common, however, in tributary streams of the AOSERP study area (Griffiths 1973; Bond and Machniak 1979; Machniak and Bond 1979). A total of 195 slimy sculpins were captured from the MacKay River watershed during the present study (Table 6; Appendix 8.5) of which 124 (64%) were collected at Site 2 during the autumn (Table 7). Sculpins were captured at all sampling sites except Sites 6, 7, 10, 11, and Lake 16, but appeared to be most common in gravelly areas in the lower reaches of the MacKay River mainstem (Sites 1 to 5), the Dunkirk (Site 9), and the Dover (Sites 12 and 13). Bond and Machniak (1979) also found slimy sculpins to be associated with gravelly areas within the Muskeg watershed.

5.2.11.2 Spawning. Slimy sculpins spawn over rocky bottoms shortly after ice break-up in early spring. Spawning occurred in late April in Valley Creek, Minnesota and fry were first observed in June (Petrosky and Waters 1975). Van Vliet (1964) reported that, in the Montreal River, Saskatchewan, spawning occurred during early May at a water temperature of about 8°C. A similar period of spawning probably occurred for slimy sculpins in the MacKay River. A ripe male sculpin (81 mm in total length) and a ripe female (73 mm) were collected at the fence site on 10 May and the first spent fish (a male) was taken on 24 May at the same location. The first spent female was taken on 17 June at Site 5.

Young-of-the-year sculpins first appeared in drift net samples on 2 June at the fence site. Between 2 and 19 June, 486 sculpin fry, ranging in total length from 4.5 to 9.5 mm (Figure 30), were captured at this site (Appendix 8.3). Drift nets also took

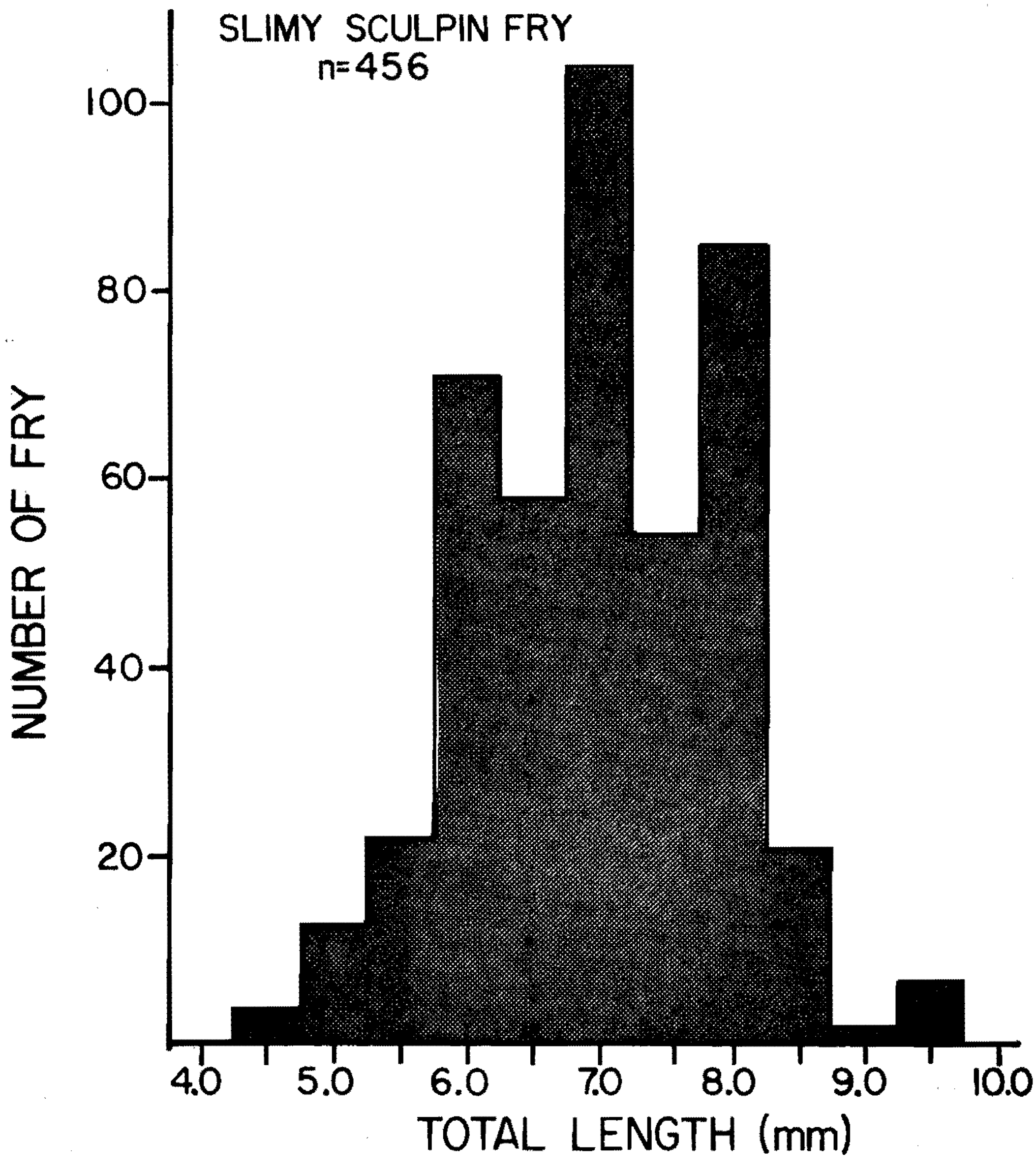

Figure 30. Length-frequency distribution for slimy sculpin fry captured in drift nets from the MacKay River, 2 to 19 June 1978.

sculpin fry at Site 12 of the Dover River (n = 3) and at Site 3 of the MacKay River just upstream of the Dover (n = 2) on 15 to 16 June (Appendix 8.4). Sculpin fry tended to drift at night and along the right bank (Figure 31, Appendix 8.3), a pattern also observed for cyprinids (Appendix 8.3).

By 14 July, young-of-the-year sculpins (n = 7), captured at Site 2, had a mean total length of 20.3 mm (range 18 to 24 mm). Slimy sculpin fry were also collected at Sites 1, 3, and 5 of the MacKay mainstem, Sites 12 and 13 of the Dover River, and Site 9 of the Dunkirk River during the course of the study.

5.2.11.3 Age and growth. Slimy sculpins captured in seines ranged from 15 to 89 mm in total length (Figure 32) with the majority (68%) being in the 31 to 46 mm size range. Otolith ages, determined for 55 slimy sculpins (Table 36), ranged up to four years but the majority of the population appeared to consist of young-of-the-year and one-year-old fish. Four years is the maximum age reported for slimy sculpins in the AOSERP study area (Bond and Machniak 1977; Machniak and Bond 1979). Craig and Wells (1976) found the oldest and largest slimy sculpin in the Chandalar River, Alaska to be a seven-year-old male, 104 mm in total length.

The age-length relationship for MacKay River sculpins is similar to that reported for other AOSERP tributaries (Bond and Machniak 1977, 1979; Machniak and Bond 1979) and for Cree River, Saskatchewan (Van Vliet 1964)(Figure 33). The growth rate for MacKay River sculpins is slightly faster than that of sculpins from the Chandalar River, Alaska (Craig and Wells 1976) and the Mackenzie Delta (de Graaf and Machniak 1977), but slower than that reported for populations from the Montreal River and Lac la Ronge, Saskatchewan (Van Vliet 1964) and Valley Creek, Minnesota (Petrosky and Waters 1975).

The common length-weight relationship (sexes combined) for slimy sculpins from the MacKay River (n = 117, r = 0.985, range 15 to 89 mm) is described by the equation:

$$\log_{10}W = 2.916(\log_{10}L) - 4.731; \ sb = 0.049$$

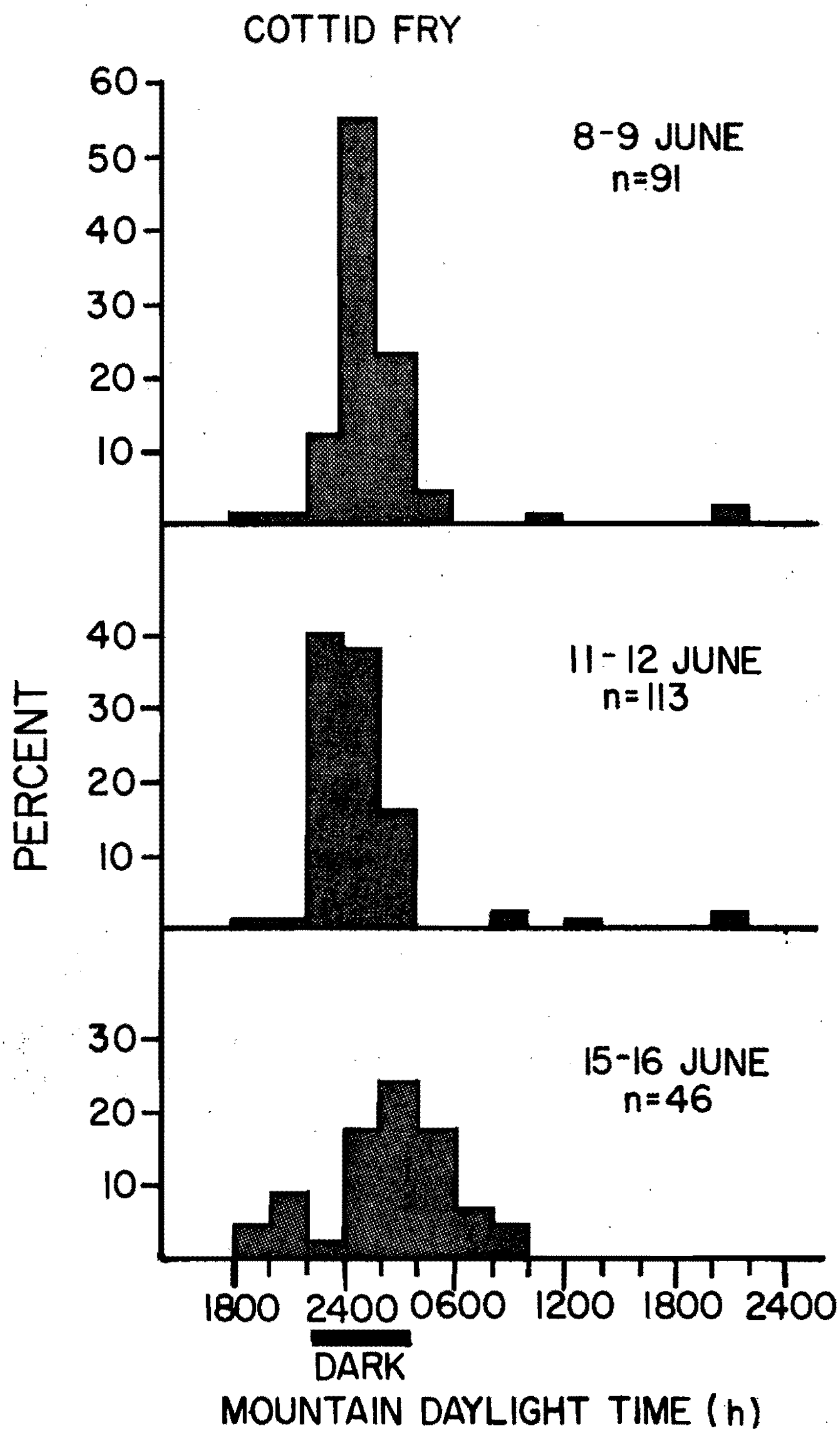

Figure 31. Diel timing of downstream cottid fry migration in the MacKay River, 1978.

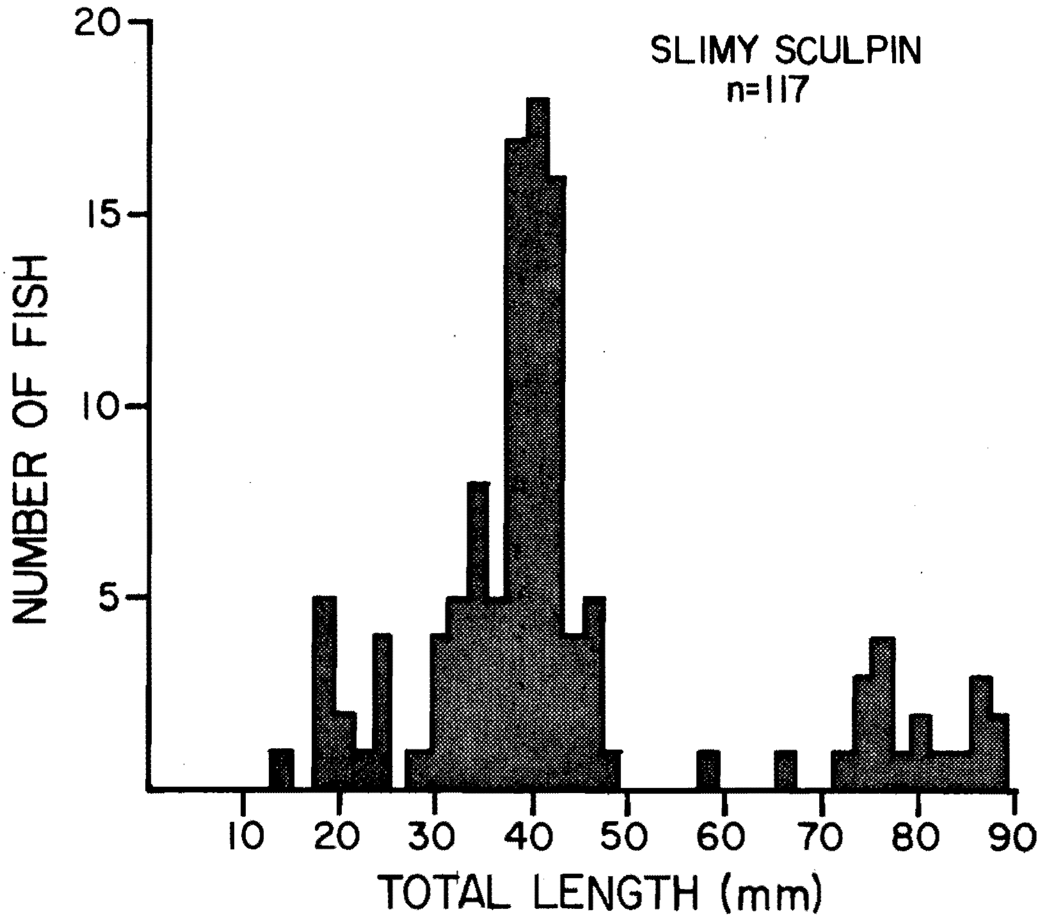

Figure 32. Length-frequency distribution for slimy sculpins from the MacKay River, 1978.

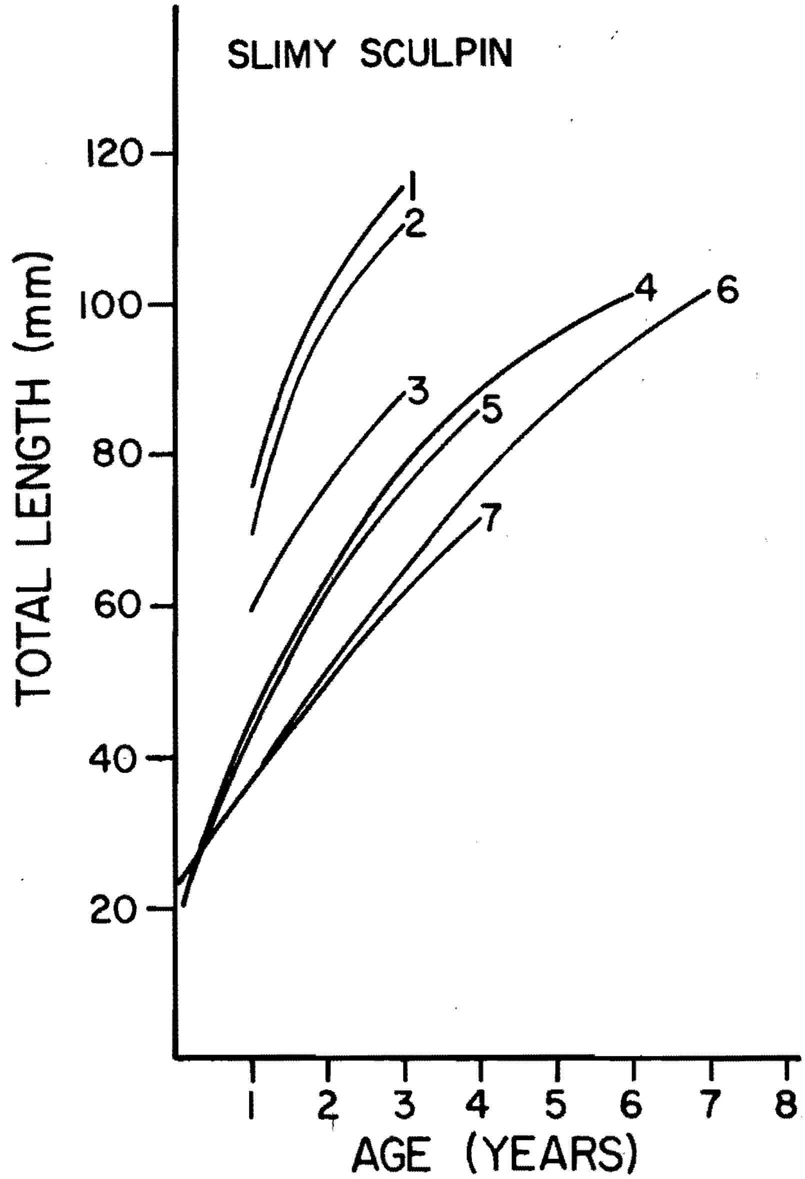

Figure 33. Growth in total length for slimy sculpins from the MacKay River and from several other areas: 1. Valley Creek, Minn. (Petrosky and Waters 1975); 2. Montreal River, Sask. (Van Vliet 1964); 3. Lac la Ronge, Sask. (Van Vliet 1964); 4. Cree River, Sask. (Van Vliet 1964); 5. MacKay River (Present Study); 6. Chandalat River, Alaska (Craig and Wells 1964); and 7. Mackenzie Delta (de Graaf and Machniak 1977).

The value of the exponent (2.916) is considerably higher than that (2.4467) reported for slimy sculpins in the Steepbank River (Machniak and Bond 1979). Values of 3.445 and 3.059 were reported for slimy sculpins from the Muskeg River in 1976 (Bond and Machniak 1977) and 1977 (Bond and Machniak 1979), respectively.

5.2.11.4 Sex and maturity. Female slimy sculpins comprised 55% of the sexed sample (Table 41), but the sex ratio did not differ significantly from unity (n = 95, $X^2 = 0.853$, $P > 0.05$). Other studies in AOSERP tributaries (Bond and Machniak 1977, 1979; Machniak and Bond 1979) and elsewhere (Van Vliet 1964; Craig and Wells 1976) have also reported no significant differences in numbers of male and female slimy sculpins.

The smallest mature male captured in the MacKay River was 66 mm in total length, while the smallest mature female was 59 mm. Both sexes appear to achieve sexual maturity for the first time at age 2 (Table 36). In the Steepbank River (Machniak and Bond 1979), the smallest mature sculpins were males in the 45 to 49 mm size class and, as in the MacKay River, maturity was first reached at two years of age. Petrosky and Waters (1975) reported that some slimy sculpins matured at age 1 in Minnesota, and that most were mature by two years of age. Slimy sculpins in the Chandalar River, Alaska mature at age 3 or 4 when they are 65 to 75 mm in total length (Craig and Wells 1975).

5.2.11.5 Food habits. Stomach analysis of 33 slimy sculpins revealed a diet of Diptera larvae (Chironomidae and Simuliidae), Ephemeroptera nymphs, Trichoptera larvae, and Nematoda (Table 38). The principal foods of slimy sculpins in the Steepbank River (Machniak and Bond 1979) and in the Chandalar River, Alaska (Craig and Wells 1976) were also found to be immature aquatic insects (Diptera larvae and Plecoptera and Ephemeroptera nymphs).

Table 41. Sex and maturity ratios by size class for slimy sculpin captured from the MacKay River, 1978. Sex ratios were based only on fish for which sex was determined.

Fork Length (mm)	Sample Size	Males		Females		% Unsexed	Sex Ratio	
		% Immature	% Mature	% Immature	% Mature		% Female	% Male
0 to 14	0	ND	ND	ND	ND	ND	ND	ND
15 to 19	6	ND	ND	ND	ND	100	ND	ND
20 to 24	5	ND	ND	ND	ND	100	ND	ND
25 to 29	3	ND	ND	ND	ND	100	ND	ND
30 to 34	13	100	0	100	0	38	63	37
35 to 39	26	100	0	100	0	12	43	57
40 to 44	37	100	0	100	0	0	68	32
45 to 49	7	100	0	100	0	0	86	14
50 to 54	0	ND	ND	ND	ND	ND	ND	ND
55 to 59	1	ND	ND	0	100	0	100	0
60 to 64	0	ND	ND	ND	ND	ND	ND	ND
65 to 69	1	0	100	ND	ND	0	0	100
70 to 74	4	0	100	0	100	0	50	50
75 to 79	5	0	100	0	100	0	60	40
80 to 84	3	0	100	ND	ND	0	0	100
85 to 89	6	0	100	ND	ND	0	0	100
Totals	117	67%	33%	88%	12%	19%	55%	45%

5.2.12 Longnose Dace

5.2.12.1 Distribution and relative abundance. Scott and Crossman (1973) reported that longnose dace are characteristic of gravel or bouldery areas of swift-flowing streams. Since the adults live in crannies between stones, they are difficult to capture (McPhail and Lindsey 1970), and, therefore, are probably under-represented in seine catches. Longnose dace made up only 0.8% of all fish captured in seines in the MacKay River watershed during 1978 (Appendix 8.5). This species was most common in the lower reaches of the MacKay River mainstem (Sites 2, 3, and 5) and the Dover River (Site 12). It was not captured in the MacKay River upstream of Site 6 or in the Dunkirk River (Table 6). Similarly, Bond and Machniak (1977, 1979) and Machniak and Bond (1979) noted that longnose dace were more abundant in the lower reaches of AOSERP streams where a gravel or rocky substrate occurred.

5.2.12.2 Spawning. Bartnik (1970) reported that, in streams of southern Manitoba, spawning occurred in late May when daily maximum water temperatures exceeded 15°C, and took place over a substrate of coarse gravel in water velocities greater than 45 cm/s. Alberta dace have been reported to spawn from early June to mid-August (Paetz and Nelson 1970). Longnose dace probably spawn between late May and early June in the AOSERP study area (Bond and Machniak 1979). A ripe female dace was found in the stomach of a burbot taken at the MacKay River fence site on 24 May 1979, and a spent female was captured in the same area on 31 May. Maturing males were also collected at this location on 16 and 24 May. The first young-of-the-year dace were collected on 14 to 15 July at Sites 2, 4, and 12. These fish (n = 6) averaged 20.5 mm in fork length (range 17 to 24 mm). Longnose dace fry were also captured at Sites 1 and 5 during the course of the study.

5.2.12.3 Age and growth. Longnose dace (n = 115), taken from the MacKay River watershed in 1978, ranged in fork length from 17 to 76 mm with those in the 25 to 40 mm size range accounting for 69% of the total sample. The length-frequency distribution (Figure 34) varied, however, throughout the summer. The longnose dace

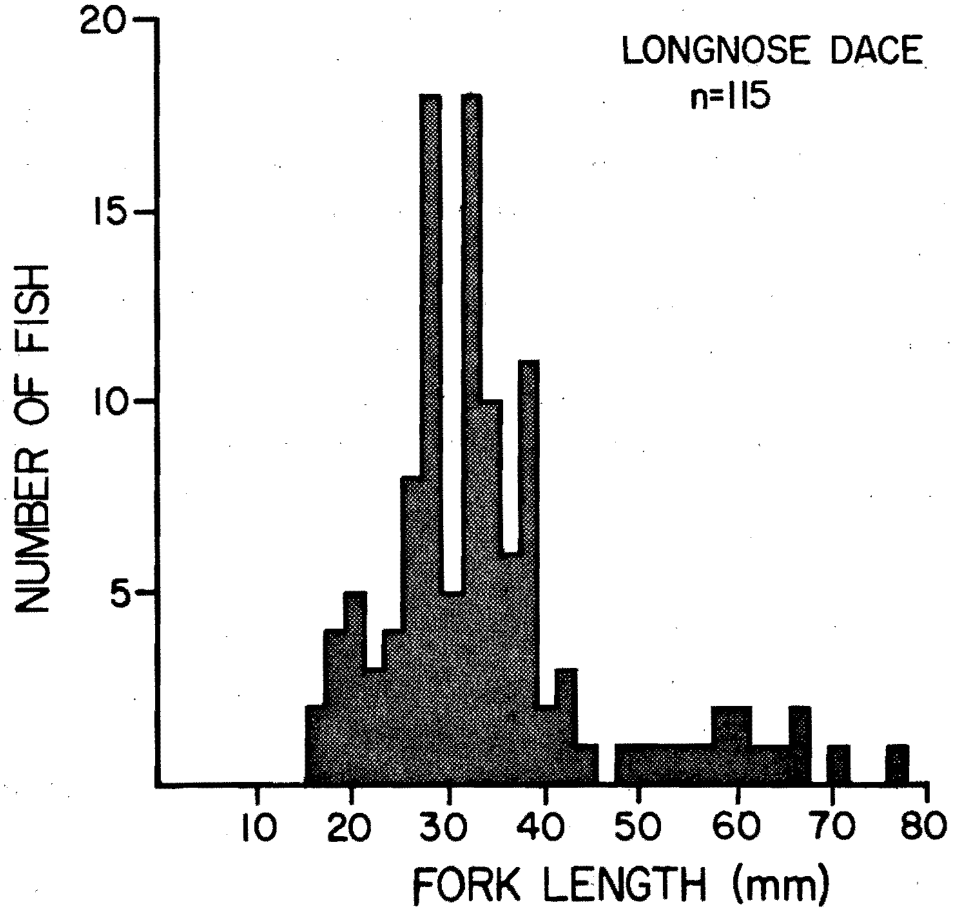

Figure 34. Length-frequency distribution for longnose dace from the MacKay River, 1978.

represented in Figure 34 belong, with few exceptions, to two year classes: young-of-the-year and age 1. Young-of-the-year dace (n = 13), captured between 14 July and 12 August, had a mean fork length of 20.2 mm (range 17 to 23 mm). Dace fry collected on 16 to 26 August (n = 12) ranged from 23 to 33 mm in length with a mean of 26.8 mm and, by late September (n = 18), averaged 28.9 mm (range 24 to 34 mm). One-year-old dace, captured in May and June (n = 35), had a mean fork length of 32.2 mm (range 20 to 45 mm) and, by mid-August, this age group (n = 12) had a mean fork length of 42.5 mm (range 38 to 56 mm). McCart et al. (1978) also reported that virtually all longnose dace captured in the MacKay River in 1977 were immature juveniles and young-of-the-year, 10 to 40 mm in fork length.

Longnose dace, aged from otoliths (n = 54), ranged in age from 0+ to three years (Table 36). Three years was also the maximum age reported for this species in the Muskeg River (Bond and Machniak 1977) and in the Steepbank River (Machniak and Bond 1979). The maximum age reported elsewhere for longnose dace is five years (Reed 1959; Reed and Moulton 1973; Brazo et al. 1978), with females tending to live longer than males.

Growth in length of longnose dace in the MacKay River (Table 36) is similar to that reported in previous tributary studies in the AOSERP study area (Bond and Machniak 1977, 1979; Machniak and Bond 1979) and that reported by Reed (1959) for a population in Pennsylvania. It is much slower, however, than reported for Massachusetts (Reed and Moulton 1973) and Lake Michigan (Brazo et al. 1978). Fish from the latter population had a mean total length of 110 mm by age 3.

The length-weight relationship for longnose dace from the MacKay River (n = 115, r = 0.967, range 17 to 76 mm) is described by the equation:

$$\log_{10}W = 2.849(\log_{10}L) - 4.690; \; sb = 0.071$$

5.2.12.4 <u>Sex and maturity</u>. Sex was determined for 47 longnose dace and, although males (57%) outnumbered females in the sample, the sex ratio did not differ significantly from unity ($X^2 = 1.043$, $P > 0.05$). Most of the fish (62%) for which sex was determined were immature one-year-olds (30 to 49 mm). Among the larger fish (> 50 mm), males comprised 71% of the sample (Table 42), whereas, in the Steepbank River (Machniak and Bond 1979), females predominated in the larger size classes. In Lake Winnipeg, Gee and Machniak (1972) observed that males outnumbered females at age 2, but that most of the larger and older dace were females.

Only 14 longnose dace, three females and 11 males, were judged to be sexually mature (Table 42). The smallest size at maturity was 45 to 49 mm for a male dace, which corresponds to a fish of age 1. Brazo et al. (1978) observed that a small percentage of age 1 fish (males) were sexually mature, but that most fish matured at age 2 in Lake Michigan. Similarly, Bartnik (1970) and Gibbons and Gee (1972) found that longnose dace mature for the first time at age 2. Most dace in the MacKay River probably mature at a similar age.

5.2.12.5 Food habits. The principal foods of longnose dace in the MacKay River (Table 38) were Diptera larvae (Chironomidae and Simuliidae), Ephemeroptera, and Trichoptera. Reed (1959) reported that almost 90% of dace food consisted of adult or immature stages of Simuliidae, Chironomidae, and Ephemeroptera. Gibbons and Gee (1972) also found that the diet of longnose dace consisted mainly of immature aquatic insects. In Michigan, longnose dace consumed mainly Chironomidae, fish eggs, terrestrial Diptera, and Coleoptera during the spring, but, in autumn, the diet consisted primarily of Hymenoptera and Coleoptera (Brazo et al. 1978).

5.2.13 Finescale Dace

5.2.13.1 Distribution and relative abundance. Finescale dace usually occur in cool, boggy lakes and streams (McPhail and Lindsey 1970) and are often found in association with northern redbelly dace (*Chrosomus eos*), pearl dace, and brook stickleback (Scott and

Table 42. Sex and maturity ratios by size class for longnose dace captured from the MacKay River, 1978. Sex ratios were based only on fish for which sex was determined.

Fork Length (mm)	Sample Size	Males		Females		% Unsexed	Sex Ratio	
		% Immature	% Mature	% Immature	% Mature		% Female	% Male
0 to 14	0	ND	ND	ND	ND	ND	ND	ND
15 to 19	6	ND	ND	ND	ND	100	ND	ND
20 to 24	10	ND	ND	ND	ND	100	ND	ND
25 to 29	28	100	0	100	0	82	80	20
30 to 34	30	100	0	100	0	57	38	62
35 to 39	20	100	0	100	0	55	44	56
40 to 44	5	100	0	100	0	0	40	60
45 to 49	2	0	100	100	0	0	50	50
50 to 54	2	0	100	100	0	0	50	50
55 to 59	4	0	100	ND	ND	25	0	100
60 to 64	4	0	100	0	100	0	75	25
65 to 69	2	0	100	ND	ND	0	0	100
70 to 74	1	0	100	ND	ND	0	0	100
75 to 79	1	0	100	ND	ND	0	0	100
Totals	115	63%	37%	85%	15%	59%	43%	57%

Crossman 1973). In the AOSERP study area, finescale dace appear to have a restricted distribution and have only occasionally been reported from the Athabasca River and its tributary streams (Griffiths 1973; Bond and Berry 1980b; Tripp and McCart 1980). Nelson and Paetz (1972) noted that finescale dace are common, however, in the Little Buffalo and Sass rivers of Wood Buffalo National Park. A total of 99 finescale dace were captured in the MacKay River watershed during 1978 (Table 6, Appendix 8.5). The majority were collected in the mid-reaches of the MacKay River (Sites 5 and 6) and near the mouth of the Dover River (Sites 3 and 12). Finescale dace were not captured in the upper reaches of the MacKay or Dover rivers and were totally absent from the Dunkirk River. Neither Griffiths (1973) nor McCart et al. (1978) recorded the presence of finescale dace in the MacKay River watershed.

The largest collections of finescale dace during the present study were made at sites where small, permanent tributaries entered the MacKay River (Sites 5 and 6). It is not known, however, if these small streams are utilized by finescale dace. Finescale dace were captured at other than tributary-associated sites in the MacKay River only in the autumn, when two fish were taken at the fence site (Table 7). High water levels at that time may have forced these small fish downstream. Bond and Berry (1980b) and Tripp and McCart (1980) also observed that most finescale dace collected from the Athabasca River were taken at tributary-associated sites. Cross (1967) noted that *Chrosomus* are confined to small, clear, permanent streams and are common only near sources of springs.

5.2.13.2 Spawning. Finescale dace probably spawn during June in northern Ontario (Scott and Crossman 1973). In Minnesota, Stasiak (1978a) found that finescale dace spawned from late April to the end of May when water temperatures exceeded 15°C. He also described the spawning behavior of finescale dace and noted its similarity to that of other cyprinids (lake chub, pearl dace, and redbelly dace). Lagendre (1969) reported that finescale dace hybridize readily with redbelly dace and that the resulting hybrids are apparently fertile.

Finescale dace hatch out in six days at 20°C and average 4.2 mm total length at emergence (Stasiak 1978a).

Finescale dace in the AOSERP area probably spawn in the early summer. The only young-of-the-year fish (31 and 35 mm fork length) taken during the present study were collected at Site 6 on 14 October. Juvenile dace (age 1+) were, however, captured during May and June at Sites 3, 5, and 12 (Figure 2). These fish (n = 26) averaged 34 mm in fork length and ranged between 25 and 40 mm.

5.2.13.3 Age and growth. Finescale dace from the MacKay River watershed ranged in fork length from 25 to 74 mm (Figure 35), the majority (80%) being in the 31 to 54 mm size range. Otolith ages were determined for 44 finescale dace, and the oldest fish aged was a three-year-old female, 74 mm in fork length (Table 36). The maximum ages recorded for this species are in Minnesota (Stasiak 1978a), where males lived to age 5 and females to age 6.

A comparison of the age-length relationship of MacKay River dace (Table 36) with that reported by Stasiak (1978a) for a Minnesota population indicates that dace in the MacKay River grow more rapidly but have a shorter lifespan. The largest females in Minnesota attain a size of only 85 mm in standard length by age 6, but apparently grow faster than male dace after attaining sexual maturity.

The common length-weight relationship for finescale dace captured in the MacKay watershed (n = 95, r = 0.968, range 25 to 74 mm) is expressed by the equation:

$$\log_{10}W = 3.132(\log_{10}L) - 5.170; \; sb = 0.085$$

5.2.13.4 Sex and maturity. Female finescale dace (67%) outnumbered males in the sexed sample (Table 43), the sex ratio being significantly different from unity ($X^2 = 10.79$, $P < 0.05$). Stasiak (1978a) observed a sex ratio of 1.5:1 in favour of males during the spawning season, but stated that the sexes occurred in equal numbers at other times of the year. It appears that both sexes mature at age 2 in the MacKay River (Table 36). In French Creek, Minnesota, some

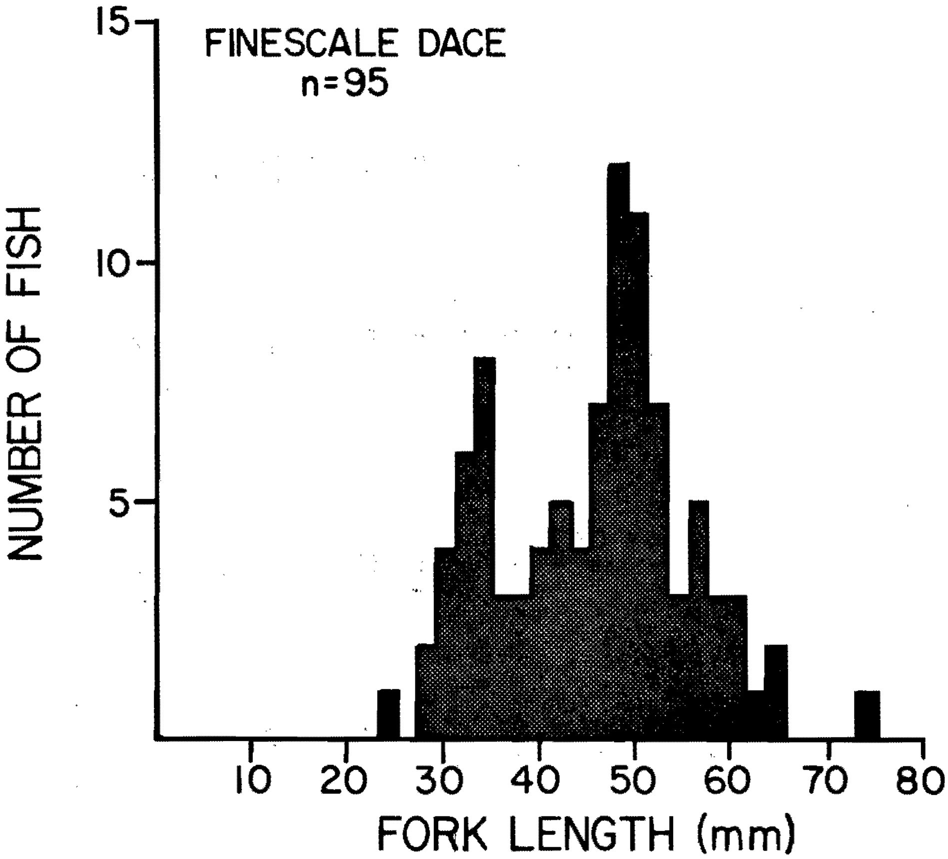

Figure 35. Length-frequency distribution for finescale dace from the MacKay River, 1978.

Table 43. Sex and maturity ratios by size class for finescale dace captured from the MacKay River, 1978. Sex ratios were based only on fish for which sex was determined.

Fork Length (mm)	Sample Size	Males		Females		% Unsexed	Sex Ratio	
		% Immature	% Mature	% Immature	% Mature		% Female	% Male
0 to 24	0	ND	ND	ND	ND	ND	ND	ND
25 to 29	3	100	0	100	0	0	33	67
30 to 34	16	100	0	100	0	13	50	50
35 to 39	8	100	0	100	0	0	62	38
40 to 44	10	100	0	100	0	10	89	11
45 to 49	21	100	0	100	0	10	81	19
50 to 54	20	0	100	21	79	5	75	25
55 to 59	9	0	100	0	100	0	44	56
60 to 64	6	0	100	0	100	0	67	33
65 to 69	0	ND	ND	ND	ND	ND	ND	ND
70 to 74	1	ND	ND	0	100	0	100	0
Totals	95	58%	42%	67%	33%	6%	67%	33%

finescale dace were mature as early as age 1, but most matured at two years of age (Stasiak 1978a).

5.2.13.5 Food habits. Stomach analysis of 85 finescale dace indicated that 82% were empty or contained only traces of food. Of the stomachs containing food, only four had food items of an identifiable nature (Diptera and insect and fish remains). Scott and Crossman (1973) observed that insects are the principal food of finescale dace, but that some Crustacea and plankton are also consumed.

5.2.14 Pearl Dace

5.2.14.1 Distribution and relative abundance. Pearl dace usually occur in cool bog ponds, creeks, and lakes (Scott and Crossman 1973). Nelson and Paetz (1972) found them in Wood Buffalo National Park in the same areas as finescale dace and lake chub. Pearl dace are seldom found in the Athabasca River (Bond and Berry 1980a; Tripp and McCart 1980), but occur commonly in tributaries of the AOSERP study area (Griffiths 1973; Bond and Machniak 1979) where they can occur in large numbers (Machniak and Bond 1979). During the present study, only 37 pearl dace were collected from the MacKay River watershed (Table 6). Twenty-four were taken on 17 June at Site 5, while 12 were captured on 20 May at Site 12. Griffiths (1973) documented the presence of pearl dace at a point in the Dover River upstream from Site 13 (Figure 2). McCart et al. (1978) captured no pearl dace in the MacKay River in 1977.

5.2.14.2 Spawning. The time and location of pearl dace spawning in the MacKay River watershed is unknown. No mature pearl dace were collected during the present study; however, three young-of-the-year (17 to 26 mm fork length) were captured on 14 July at Site 5 (Figure 2). In Alberta, pearl dace probably spawn from May to early summer (Paetz and Nelson 1970), and spawning is believed to occur in late May or early June in the AOSERP study area (Machniak and Bond 1979). According to Fava and Tsai (1974), pearl dace spawn from late April to early June in Maryland when water temperatures are 13 to 15°C. Langlois (1929) stated that spawning takes place in clear water 18 to 24 in deep (46 to 61 cm) on sand or gravel in a weak or moderate current.

5.2.14.3 Age and growth. Pearl dace from the MacKay River watershed ranged in fork length from 17 to 44 mm (Figure 36), with the majority of fish (71%) being in the 25 to 32 mm size range. Machniak and Bond (1979) reported similar results for the Steepbank River with 91% of fish in the 21 to 38 mm size range. Except for three young-of-the-year, all of the pearl dace in the aged sample (Table 36) were one-year-olds having a mean fork length of 30.9 mm (range 25 to 44 mm). The maximum age recorded for pearl dace in the AOSERP study area is four years (Bond and Machniak 1979). A maximum age of four years was also reported for pearl dace in Maryland (Fava and Tsai 1974), Quebec (Lalancette 1977b), and Nebraska (Stasiak 1978b).

A comparison of the age-length relationship for pearl dace in the AOSERP study area (current study; Bond and Machniak 1979; Machniak and Bond 1979) with that reported for populations in Ontario (Loch 1969), Maryland (Fava and Tsai 1974), Quebec (Lalancette 1977b), and Nebraska (Stasiak 1978b) indicates that pearl dace from the AOSERP area have a relatively slow rate of growth.

The mathematical relationship between fork length and body weight for MacKay River pearl dace ($n = 35$, $r = 0.939$, range 17 to 44 mm) is described by the equation:

$$\log_{10}W = 2.564(\log_{10}L) - 4.295;\ sb = 0.163$$

5.2.14.4 Sex and maturity. Sex was determined for 24 pearl dace from the MacKay River (all age 1) and the sex ratio was 1:1. Lalancette (1977b) and Stasiak (1978b) also found an overall sex ratio of 1:1, but reported differences among the older age groups because of the higher mortality rate of males.

No mature pearl dace were observed among the aged sample (Table 36). However, Machniak and Bond (1979) reported that the earliest age of maturity in the Steepbank River appeared to be two

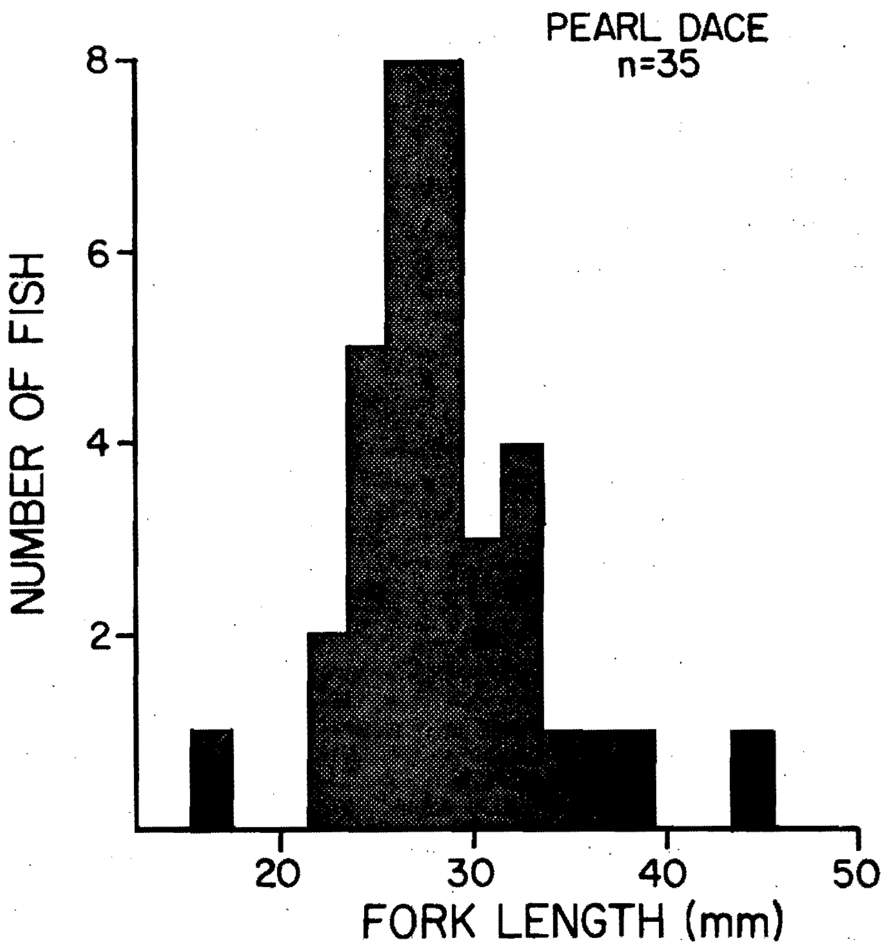

Figure 36. Length-frequency distribution for pearl dace from the MacKay River, 1978.

years. Both sexes matured at the end of their first year in Maryland (Fava and Tsai 1974) and Nebraska (Stasiak 1978b), while in Lake Gamelin, Quebec, pearl dace reached sexual maturity at age 2 (Lalancette 1977b).

4.2.14.5 Food habits. Eight pearl dace stomachs were examined for food items, of which three were empty (Table 38). The principal foods of pearl dace in the MacKay River appear to be immature aquatic insects (Chironomidae, Simuliidae, and Ephemeroptera). Lalancette (1977b) reported a diet of insects, zooplankton, plants, and organic detritus for Lake Gamelin pearl dace. In Nebraska, Stasiak (1978b) observed that pearl dace were active feeders in early spring, and that younger dace (< 54 mm) consumed mainly Diptera larvae and adults with some crustaceans (Copepoda and Cladocera).

5.2.15 Brook Stickleback

5.2.15.1 Distribution and relative abundance. Brook stickleback are widely distributed in tributary streams of the AOSERP study area (Griffiths 1973) where they are usually found in greatest abundance in headwater reaches (Bond and Machniak 1977, 1979; Machniak and Bond 1979). During the present study, stickleback were captured at eight sampling sites (Table 6) but were never taken in abundance. This species is known to be present in the upper Dover River. Mr. M. R. Orr seined 12 and 36 stickleback from Lakes 14 and 15 (Figure 38), respectively, in September 1977 (Herbert 1979). Northern pike in Lake 14 were found to have fed heavily on brook stickleback. McCart et al. (1978) captured only one brook stickleback in the lower reaches of the MacKay River watershed (downstream of Site 5) during 1977.

5.2.15.2 Spawning. Most brook stickleback in Alberta spawn in late spring and early summer (Paetz and Nelson 1970). No mature or ripe stickleback were captured during the present study, but spent fish were taken in the Dover River (Site 13) on 14 July. Young-of-the-year stickleback were not collected until 16 August, when two fish (21 to 33 mm total length) were captured at Site 13. Additional young-of-the-year (30 to 31 mm) were captured on 14 October at Sites 8 (n = 1), 9 (n = 1), and 13 (n = 3). Spawning of brook stickleback in the MacKay watershed probably occurs at approximately the same time as in the Muskeg River where Bond and Machniak (1979) captured young-of-the-year as early as 19 June.

5.2.15.3 Age and growth. Stickleback from the MacKay River watershed ranged from 21 to 63 mm in total length (Figure 37), with most fish (61%) in the 29 to 42 mm size range. In the Steepbank River, young-of-the-year fish in the 19 to 23 mm size class comprised 65% of the total sample (Machniak and Bond 1979). The bulk of most stickleback populations is made up of fish in their first year (Winn 1960). Twenty-one brook stickleback were aged by otoliths (Table 36), the oldest being a three year old female, 63 mm in total length. A comparison of the age-length relationship, for brook stickleback taken from the MacKay watershed with those reported from the Muskeg River (Bond and Machniak 1977, 1979) and the Steepbank River (Machniak and Bond 1979), indicate similar growth among these AOSERP study area populations.

The common length-weight relationship for brook stickleback taken in the MacKay River watershed during 1978 (n = 31, r = 0.982, range 21 to 63 mm) is described by the equation:

$$\log_{10}W = 2.909(\log_{10}L) - 4.807; \; sb = 0.104$$

5.2.15.4 Sex and maturity. Male and female brook stickleback occurred in equal numbers in the sexed sample (n = 28) and the minimum age of sexual maturity was age 1 for both sexes (Table 36).

5.2.15.5 Food habits. Stomach analysis of 13 stickleback (Table 38) revealed a diet of Diptera larvae and pupae (Chironomidae, Chaoborinae, and Simuliidae), Ephemeroptera nymphs, Trichoptera larvae, and Crustacea (Cladocera and Copepoda). Other foods included Gastropoda and terrestrial insects. Scott and Crossman (1973) report that brook

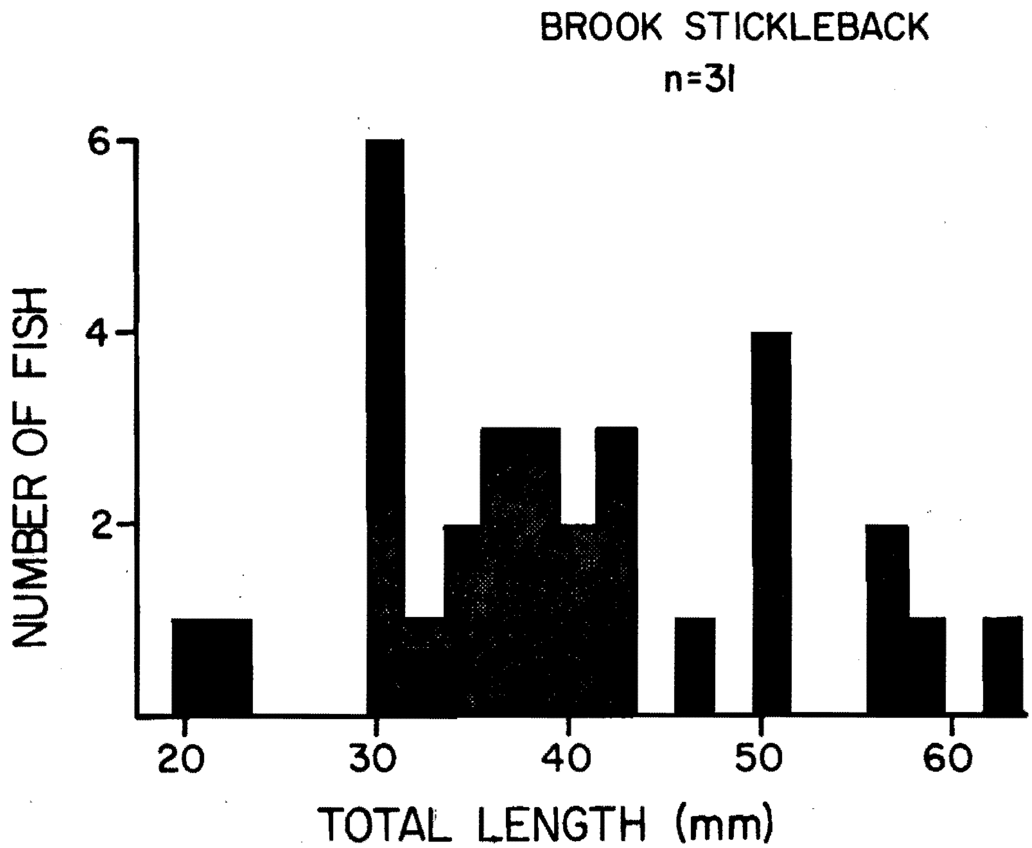

Figure 37. Length-frequency distribution for brook stickleback from the MacKay River, 1978.

stickleback consume aquatic insect larvae and Crustacea as well as Gastropoda, Oligochaeta, Arachnida, and fish eggs. Brook stickleback from Lake 14 (Figure 2) had consumed Chironomidae, Copepoda, Cladocera, Ostracoda, and Amphipoda (Herbert 1979).

5.2.16 Other Small Fishes

5.2.16.1 Spottail shiner. This species is probably more typical of the Athabasca River than of the tributaries of the AOSERP study area. Bond and Berry (1980b) found shiners throughout the lower Athabasca River, but in greatest abundance in the delta area. Only 11 spottail shiners (Table 6) were captured in the MacKay River during the present study. All were taken at Site 1 in late July and August. Six of these fish were one-year-olds that ranged in fork length from 34 to 42 mm (Table 36) with a mean length of 39 mm. Five young-of-the-year spottail shiners were also captured, the first on 4 August and the remainder between 12 and 18 August. Spottail shiner fry averaged 25 mm and ranged in fork length from 20 to 28 mm. Sex was determined for seven spottails, of which four were females. Spottail shiners in the AOSERP area are believed to mature at age 2 with spawning probably occurring in late June or early July (Bond and Berry 1980b). Maximum age recorded for spottail shiners in the AOSERP study area is three years (Bond and Berry 1980b).

Except for one stomach containing Diptera larvae, most stomachs were empty or contained unidentifiable insect remains. In the Athabasca River, spottail shiners fed predominantly on aquatic insects (Diptera, Ephemeroptera, Plecoptera, and Lepidoptera) with some Cladocera, Copepoda, and plant material included in their diet (Bond and Berry 1980b). Anderson and Brazo (1978) observed that, during the spring and summer, the spottail shiner diet consisted mainly of terrestrial Diptera and fish eggs, while in the autumn, Chironomid larvae and unidentified terrestrial insects were most important.

5.2.16.2 Spoonhead sculpin. Little is known of the biology of this sculpin (Scott and Crossman 1973) but spoonhead sculpins usually occur in large muddy rivers (Paetz and Nelson 1970). One mature male sculpin (age 3, 73 mm in total length) was taken at Site 2 of the MacKay River on 10 May (Table 36). Griffiths (1973) and McCart et al. (1978) reported capturing spoonhead sculpins near the mouth of the MacKay River.

5.2.16.3 Emerald shiner. Emerald shiners are one of the most abundant forage fish species found in the Athabasca River (Bond and Berry 1980a, 1980b) but are seldom captured in tributaries of the AOSERP study area (Griffiths 1973; Bond and Machniak 1977, 1979; Machniak and Bond 1979). No emerald shiners were collected from the MacKay River watershed during the present study; however, McCart et al. (1978) recorded their presence near the mouth of the MacKay River during May and June 1977.

5.3 HABITAT ANALYSIS

5.3.1 MacKay River Mainstem

The mainstem of the MacKay River was divided into six reaches on the basis of gradient differences, flow characteristics, channel form, and other physical features (Table 44, Figure 38). Point samples, taken at seven locations (Figures 2 and 38, Appendix 8.7) along the main river between April and October, provided site-specific information with respect to certain physical and chemical parameters (Appendix 8.8) as well as information on fish (Table 6) and benthic macro-invertebrates (Appendices 8.9 and 8.10). Collectively, this information defines the aquatic habitat of the MacKay River mainstem and permits an assessment of fish utilization in each reach.

5.3.1.1 Reach 1. This reach (Figure 38) extends upstream from the confluence of the Athabasca and MacKay rivers for a distance of approximately 5 km. The entrenchment in Reach 1 is similar to that

Table 44. Physical characteristics of the MacKay River mainstem.

	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
Distance Upstream of Confluence (km)	0 to 5	5 to 31.5	31.5 to 82.5	82.5 to 115.5	115.5 to 139	139 to 171[a]
Width (m)	45	35	25	20	20	15
Gradient (m/km)	1.3	1.5	2.3	4.1	0.5	1.1
Velocity (m/s)[b]	0.5	<0.7	1.5	ND	<0.5	<0.1
Mean Depth (m)[b]	0.8	0.6	0.5	ND	0.8	>1.0
Substrate Composition (%)						
Fines (<2 mm)	90	20	10	10	25	95
Gravels (2 to 64 mm)	10	50	50	35	60	5
Larges (>64 mm)	0	20	30	50	10	0
Bedrock	0	10	10	5	< 5	0
Riparian Vegetation (%)						
Coniferous Trees	10	20	20	20	30	25
Deciduous Trees	60	50	65	55	20	5
Deciduous Shrubs	25	25	10	20	40	40
Grasses	5	5	5	5	10	30
Bank Materials	clay, sand, bitumen	clay, bitumen, larges, bedrock	larges, gravel, bedrock	larges, gravel, some bedrock	larges, sand, clay	clay
River Channel Characteristics						
Thread	single	single	single	single	single	single
Form	straight	meandering	irregular to irregular meander	irregular to tortuous meander	straight to irregular	straight to meandering
Flow Character	placid	swirling	swirling to broken	broken	placid	placid
Pool: Riffle Ratio	10:1	4:1	1:2	1:5	10:1	beaver impounded

[a] Survey ended at km 171, not necessarily end of reach.

[b] Based on monthly survey data from point samples.

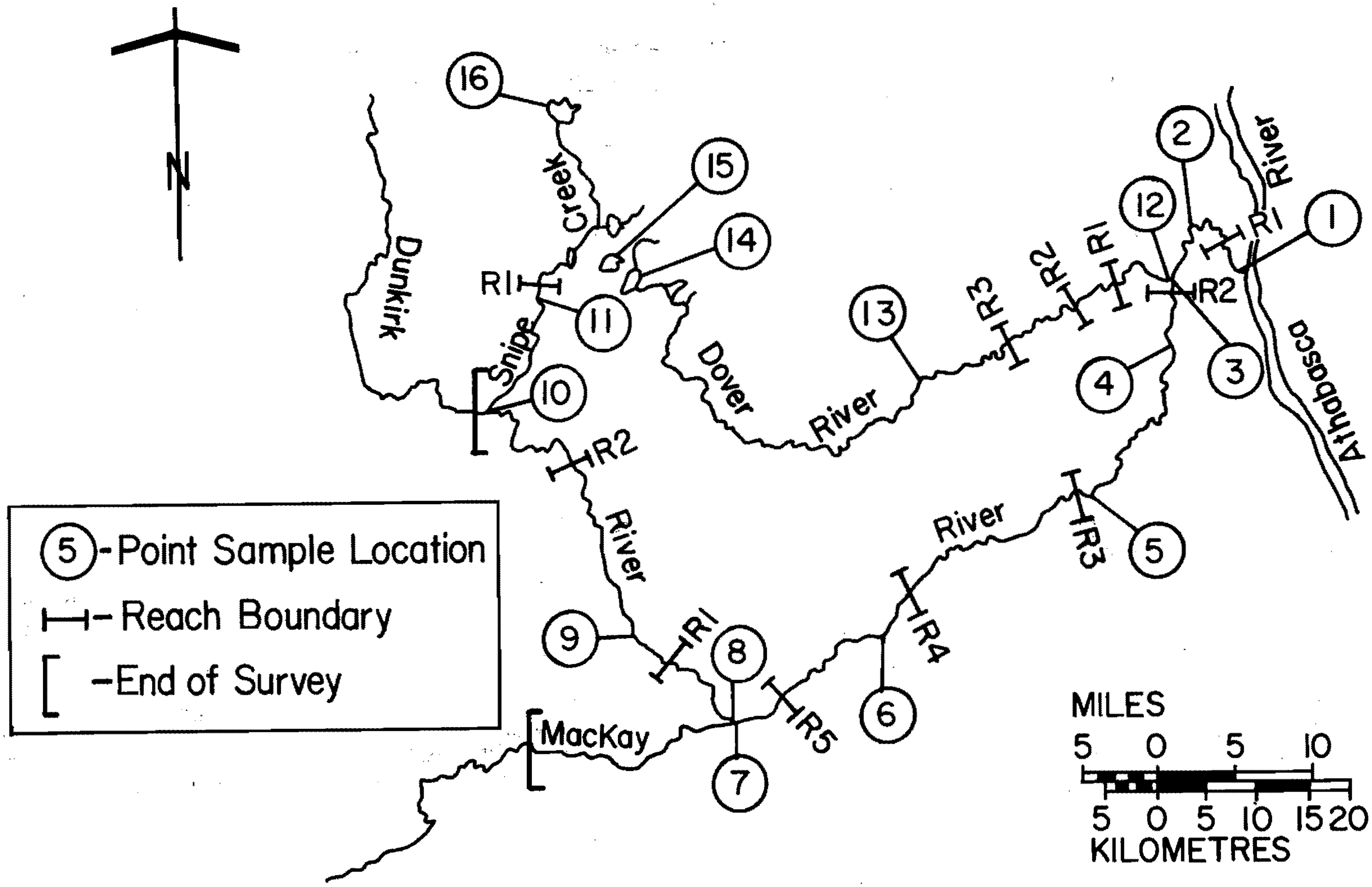

Figure 38. Map of MacKay River watershed indicating reach boundaries and point sample locations.

of the Athabasca River (40 to 50 m) since this region lies within the Athabasca floodplain. During flood periods, the Athabasca River can back up into the MacKay River as much as 3 km and, therefore, the flow regime of the Athabasca River can greatly affect the width, depth, and flow of the MacKay River within much of Reach 1. Reach 1 has a low gradient (1.3 m/km) and low velocity (< 0.5 m/s) and pool-like conditions often prevail. The substrate is very homogeneous throughout the reach and is comprised mainly of fines (90%) and small gravel (10%). The river has eroded the fairly unstable banks to a height of 2 to 3 m in some locations. Riparian vegetation along Reach 1 is 60% deciduous trees (aspen, balsam), 30% deciduous shrubs (willow, alder), and 10% coniferous trees (white spruce).

Since Reach 1 is frequently inundated by the Athabasca River, it is to be expected that virtually all fish species occurring in the MacKay or Athabasca rivers will be found in this region. In fact, the documented fish presence in Reach 1 includes the adults of 11 species and the fry and/or juveniles of 15 species (Table 45).

Reach 1 had little potential for spawning by any of the fish species encountered within the MacKay River. Although white suckers, longnose suckers, Arctic grayling, lake chub, and trout-perch are known to migrate through this reach in April and May in order to reach upstream spawning areas, none of these species is believed to spawn in Reach 1. The placid water conditions that prevail throughout much of this reach appear to provide excellent rearing habitat for the young of most species. Although no benthos was collected from Reach 1 during this study, McCart et al. (1978) report that the dominant invertebrate forms are Oligochaeta and Ephemeroptera, but that, since the area is located in the depositional zone of the stream, it has a reduced faunal diversity and standing crop. This probably results in poor feeding conditions for fish species that feed predominantly on benthic invertebrates (lake whitefish, mountain whitefish, and white and longnose suckers). However, the large numbers of young-of-the-year fish (especially suckers) found in the mouth area of the MacKay River (Griffiths 1973; Bond and Berry 1980a, 1980b; McCart et al. 1978) provide abundant

Table 45. Documented distributions of adult and young fish in the MacKay River mainstem based on catch data obtained in April to October 1978, and on reports by other individuals.[a]

Species	Reach 1		Reach 2		Reach 3		Reach 5		Reach 6	
	Adults	Fry/ Juveniles	Adults	Fry/ Juveniles	Adults	Fry/ Juveniles	Adults	Fry/ Juveniles	Adults	Fry/ Juveniles
White sucker	+[b]	+	+	+	+	+	+	+		+
Longnose sucker	+[b]	+	+	+	+[d]	+		+		
Northern pike	+[b]	+	+	+	+		+		+	+
Walleye	+	+	+	+	+[d]	+[d]	+			
Yellow perch		+								
Burbot	+[e]	+[b]		+						
Lake whitefish	+[c]		+							
Mountain whitefish		+[d]	+							
Goldeye		+[d]		+						
Arctic grayling	+[d]		+	+		+				
Flathead chub	+[d]		+	+						
Lake chub	+[d]	+	+	+	+	+	+	+		+
Trout-perch	+	+	+	+	+	+				
Slimy sculpin		+	+	+	+	+				
Longnose dace		+	+	+	+	+	+			
Finescale dace				+	+	+	+	+		
Pearl dace						+		+		
Brook stickleback		+[e]	+		+	+				+
Spoonhead sculpin		+[d]	+							
Spottail shiner		+		+[d]						
Emerald shiner	+[d]									

[a] Reach 4 was not sampled.

[b] Reported by Griffiths (1973).

[c] Reported by Renewable Resources Consulting Services Ltd. (Lutz and Hendzel 1977).

[d] Reported by McCart et al. (1978).

[e] Reported by Bond and Berry (1980b) in mouth of MacKay River.

forage for piscivorous species such as northern pike, walleye, and goldeye. Reach 1 may be important to lake whitefish and walleye in terms of providing resting areas during their upstream migrations in the Athabasca River. The reach probably serves a similar function for migrant white and longnose suckers that spawn upstream of the MacKay River (Bond and Berry 1980b). Although unquantified, some overwintering is known to occur in this reach. McCart et al. (1978) reported capturing Arctic grayling, northern pike, and longnose suckers in this area during December and January.

5.3.1.2 Reach 2. This area is a transitional zone, comprising approximately 26 km of stream between the mouth reach and the steeper gradient zone of the MacKay River that is found upstream of the Dover River confluence (Figure 38). The average width of the river channel in Reach 2 is about 35 m and the pool to riffle ratio is 4:1. The stream velocity (< 0.7 m/s) and gradient (1.5 m/km) are moderate as the river follows a well-entrenched, convoluted meander pattern, being deeply cut into the McMurray Oil Sands formation. The stream is frequently confined by steep banks (40 to 50 m) of Devonian limestone overlain by bitumen. The substrate is comprised mainly of fines (20% - mostly sand), small gravels (50%), and rubble (20%). Exposed bitumen deposits are found commonly on the stream bottom. Near the Dover River, the current is faster and the substrate material coarser than in the downstream portion of the reach. Riparian vegetation in Reach 2 is mostly deciduous trees (60%), shrubs (25%), and conifers (10%). The uplands are well-forested with few or no areas of muskeg. Little aquatic vegetation is present.

Benthic samples taken at Sites 2 and 3 revealed an invertebrate fauna consisting largely of Ephemeroptera (28%) and Chironomidae (19%)(Appendix 8.9). McCart et al. (1978) found that in this reach, where exposed bitumen is a common feature of the substratum, the benthic community is dominated by Oligochaeta, Simuliidae, and Ephemeroptera. The benthic association appears to conform to that described by Barton and Wallace (in prep.) for streams cutting through oil sands deposits.

Most fish species occurring in the MacKay or Athabasca rivers are found in Reach 2. Documented fish presence in this reach includes the adults of 14 species and the fry and/or juveniles of 14 species (Table 45). Some of the gravel areas provide suitable spawning grounds for white and longnose suckers, longnose dace, trout-perch, and slimy sculpins. The shallow, gravelly areas of Reach 2 also provide rearing areas for young-of-the-year fish such as sculpins and longnose dace. The more abundant benthic fauna in this area provides an excellent food source for most fish species. Piscivorous fish taken in Reach 2 include walleye, northern pike, burbot, and goldeye, all of which are thought to be migrant fish from the Athabasca River.

On 17 February 1975 (NHCL 1975), there was only 12 cm of water under 0.8 m of ice at the Water Survey of Canada gauging station (8 km upstream from the MacKay's confluence with the Athabasca River) which suggests that fish movements and/or over-wintering would be restricted in certain areas of this reach, especially during low winter flows. McCart et al. (1978), however, captured one white sucker at the upper end of Reach 2 in mid-January, which indicates that overwintering conditions are apparently suitable in deep pools where water depths and oxygen levels are adequate.

5.3.1.3 Reach 3. In this reach, the MacKay River leaves the flat central portion of its watershed and begins to cut through the McMurray Oil Sands formation that overlies the Waterways limestone. The river channel is frequently confined by limestone outcroppings with the canyon proper of the MacKay River extending from km 31 to approximately km 83 (Figure 38). However, the river valley is widened with evidence of old river meander loops and oxbow lakes on the terrace above the existing river bed elevation. Valley walls are steep (35 to 40 m) with exposed limestone bedrock. The gradient in this reach is generally steeper (2.3 m/km) and the water velocity is rapid (1.5 m/s). The river channel is 25 m wide and the overall pool to riffle ratio is about 1:2. The pools are generally small and shallow and separated by long gravel riffles, providing a wide variety of habitats. The river bottom is comprised chiefly of large materials (rubble, boulders) and coarse gravels in riffle areas, with sand, fine gravel, boulders, and silt in pools. However, substrate particle size tends to decrease from the upper to the lower end of this reach. Riparian vegetation along Reach 3 was estimated as 75% deciduous trees (aspen, balsam poplar), 10% spruce, and 10% deciduous shrubs (willows). In many areas, however, where the river contacts the limestone cliffs, little riparian vegetation is found. At low water levels, much gravel and boulder is exposed and the riparian vegetation seldom overhangs the stream. Small amounts of aquatic vegetation occur in pool areas.

Benthic samples were taken at two sites (Sites 4 and 5) within Reach 3. The most abundant benthic invertebrates were Chironomidae (42%), Ephemeroptera (22%), Trichoptera (7%), and Oligochaeta (6%)(Appendix 8.9). Griffiths (1973) reported a bottom fauna consisting of Plecoptera, Ephemeroptera, Odonata, and Trichoptera in the upper end of this reach (Site 5). The diversity of substrates found in Reach 3 and the combination of pools and riffles lead one to expect a great diversity of benthic organisms in this region. This is confirmed by McCart et al. (1978), who identified 86 invertebrate taxa within Reach 3.

The documented fish fauna of Reach 3 includes adults of 10 species and fry and/or juveniles of 11 species (Table 45). Of the species recorded at the counting fence during the spring (Reach 2), only Arctic grayling, northern pike, white suckers, longnose suckers, and walleye have been recorded in Reach 3. This suggests that species such as lake whitefish, mountain whitefish, burbot, flathead chub, and goldeye, although entering the MacKay River in small numbers, probably do not ascend the tributary beyond the Dover River confluence.

The gravel riffles of Reach 3 provide excellent spawning areas for white suckers, longnose suckers, Arctic grayling, longnose dace, slimy sculpins, lake chub, and trout-perch. Suitable spawning sites for walleye and lake whitefish also occur in Reach 3; however, neither species appears to spawn within the MacKay River watershed. Large numbers of sucker fry are found in this reach throughout June, July, and August and excellent rearing is also present for longnose dace and slimy sculpins. Rearing for Arctic grayling is moderately good in the shallow, gravel riffles and pools of Reach 3, although only one young-of-the-year grayling was taken during the present study. The extremely abundant benthic fauna in Reach 3 provides an excellent food source for white and longnose suckers and virtually all fish species found in this region of the river. Forage for northern pike, walleye, and burbot is also excellent, especially during summer when sucker fry and other small fish are common. The extent of overwintering in Reach 3 is unknown, although isolated pools along river bends may provide suitable overwintering sites.

5.3.1.4 Reach 4. Reach 4 (Figure 38), extending from km 83 to km 115, is predominantly a long series of broken riffles as the MacKay River descends from the Algar Plain into the Clearwater Lowland. This region has the steepest gradient (4.1 m/km) of all reaches in the MacKay River with a rapid, shallow water flow. The stream has cut a deep, narrow (20 m wide), tortuously meadering channel through this area. The river channel is still confined frequently by 30 m high limestone cliffs. The river substrate in this reach is composed predominantly of larges (50% boulders and rubble) and gravel (35%)(Table 44). The riparian vegetation is 55% deciduous trees (aspen, balsam, and birch), 20% conifers (white spruce), 20% shrubs (willow, alder), and 5% grasses. No aquatic vegetation was observed.

No fish or benthos sampling was conducted in Reach 4; however, fry of five species and adults of three larger species (white sucker, northern pike, and walleye) have been captured upstream in Reach 5. Because of the rapid flow and large substrate size, the spawning potential of this reach may be somewhat limited, although some grayling, suckers, sculpins, and longnose dace may spawn here. It is expected that the benthic invertebrate fauna of this area is dominated by fast water genera of Ephemeroptera, Plecoptera, Diptera, and Trichoptera.

5.3.1.5 Reach 5. This portion of the MacKay River extends from km 115 to km 139 (Figure 38) and is a transitional zone between the low gradient muskeg region of Reach 6 and the steep gradient of Reach 4. The river channel is confined occasionally by Waterways limestone in an area covered with treed muskeg. The gradient (0.5 m/km) and water velocity (0.5 m/s) are low, as the stream flows fairly smoothly over a uniform substrate consisting largely of fines (25%), small gravel (60%), and scattered boulders (10%). The riparian vegetation along Reach 5 is 40% deciduous trees (aspen, balsam poplar), 30% conifers (white spruce), and 20% deciduous shrubs (willow, alder). Some aquatic vegetation develops in quiet, near-shore areas.

Benthos was sampled only at Site 6 (Figure 38) and consisted chiefly of Chironomidae (54%) and Ephemeroptera (13%)(Appendix 8.9).

The fish fauna of Reach 5 is considerably less diverse than observed in downstream areas. Only eight fish species were captured in Reach 5 (Table 45) with young white and longnose suckers accounting for 79% of the total sample (Table 6). Lake chub (12%) and finescale dace (6%) also appear to be common. It seems likely that relatively few migrants from the Athabasca River ascend this high into the watershed, although two walleye were captured in gillnets at Site 6.

There appears to be little spawning potential in this area for any large fish species other than northern pike. Griffiths (1973) reported capturing juvenile pike just upstream of this reach. Large numbers of white sucker fry were captured at Site 6 and longnose sucker fry were also taken. Some sucker spawning may have occurred in gravelly areas of Reach 5 upstream of Site 6, or these small fish may have drifted downstream from spawning areas in the lower Dunkirk River. The short, gravel riffles, alternating with long, shallow pools in this reach, provide ideal rearing habitat for young fish. The presence of two beaver dams at the upper end of Reach 5 suggests that the potential for overwintering exists as winter water levels would probably be adequate in such locations.

5.3.1.6 Reach 6. Reach 6 (Figure 38), extending from km 139 to km 171 (the end of the AOSERP study area), occurs in a marsh-like region of treed muskeg. This low-gradient (1.1 m/km) reach is typically deep (> 1 m), slow moving (< 0.1 m/s), and well-vegetated with grasses and sedges. Through most of the reach, the substrate is homogeneous and composed chiefly of clay-silt and organic detritus. The low, clay banks are well-vegetated with willows and grasses. Beaver dams occur with greater frequency outside the AOSERP study area as the headwaters of the stream are approached.

Benthos was sampled only at Site 7, the confluence of the Dunkirk River, in an area where maximum depth is about 1.5 m. Chironomidae and Oligochaeta comprised the bulk of the invertebrate fauna samples (Appendix 8.9). The very uniform physical conditions found in this reach are probably reflected in the benthic community by a greatly reduced species deversity. Barton and Wallace (in prep.) found that the benthic diversity in muskeg regions of AOSERP streams was lower than that of other reaches.

The fish community in Reach 6 is also severely restricted as only four species (northern pike, brook stickleback, white sucker, and lake chub) were represented in samples taken at Site 7 (Table 45). Pike appear to be the most abundant fish species at this site and, as mentioned previously, these pike probably represent a resident population. There appears to be little spawning potential in Reach 6 for any species other than northern pike and brook stickleback. Ripe and mature northern pike were angled in this reach on 30 April 1978 and young-of-the-year pike were taken here throughout the summer. The extensive aquatic vegetation and placid water provide ideal pike spawning habitat. Griffiths (1973) also reported capturing juvenile pike in this reach in September 1972. Sucker fry, observed at Site 7 on 20 May 1978, were probably spawned in the lower Dunkirk River (Site 9). These young fish provide excellent forage for northern pike.

Winter measurements, taken 0.4 km downstream of the confluence of the Dunkirk River by NHCL (1975), indicate an average water depth of 0.4 m under 0.5 m of ice in mid-February. Although no winter fish sampling was conducted during the present study, adult pike were captured in the early spring, which suggests overwintering by this species in the area. In addition, the stomachs of these pike contained the remains of brook stickleback and Arctic grayling. Brook stickleback are undoubtedly a year-round resident of this reach and some overwintering by Arctic grayling may occur.

5.3.2 Dover River

The Dover River was divided into four reaches on the basis of gradient differences, flow characteristics, substrate, and channel form (Table 46, Figure 38). Point samples were taken at two sites (Sites 12 and 13) and information on physical and chemical parameters (Appendix 8.8), fish (Table 47), and benthic invertebrates (Appendix 8.9) was collected at these locations.

5.3.2.1 Reach 1. The lower 13 km of the Dover River are characterized by a steep gradient (4.5 m/km), moderate water velocity (< 0.6 m/s), and a mean depth of 0.5 m. This reach has an average width of approximately 9 m and a pool to riffle ratio, estimated by the present study, of 2:1. Griffiths (1973) stated that the pool to riffle ratio in this area was approximately 3:1. The substrate in Reach 1 consists mainly of larges (coarse gravel, rubble, and boulders)(40%) with smaller areas of fine gravel (40%) and sand (15%). In this region, the stream is confined frequently by unstable sand-clay banks with exposed limestone and bitumen outcroppings. Riparian vegetation is estimated to be 45% deciduous trees (poplar, alder), 30% conifers (spruce), and 10% deciduous shrubs (willows) which seldom overhang the stream. Much of the gravel and boulder substrate is exposed at low water levels.

Benthic samples were taken at one location (Site 12) within Reach 1. At this site, where the substrate consisted primarily of limestone rubble, coarse gravel, and bitumen, the most abundant invertebrates were Ephemeroptera (51%), Oligochaeta (15%), and Chironomidae (10%)(Appendix 8.9). Griffiths (1973) reported a diverse bottom fauna in this area consisting mainly of Plecoptera, Ephemeroptera, and Diptera.

Table 46. Physical Characteristics of the Dover river.

	Reach 1	Reach 2	Reach 3	Reach 4
Distance Upstream of Confluence (km)	0 to 13	13 to 26	26 to 43	43 to 152
Width (m)	9	7	6	3
Gradient (m/km)	4.5	2.4	1.0	1.6
Velocity (m/s)[a]	< 0.6	ND	ND	< 0.3
Mean Depth (m)[a]	0.5	ND	ND	> 1.0
Substrate Composition (%)				
Fines (< 2 mm)	15	60	80	95
Gravels (2 to 64 mm)	40	25	10	5
Larges (> 64 mm)	40	10	10	0
Bedrock	5	< 5	0	0
Riparian Vegetation (%)				
Coniferous Trees	30	40	30	20
Deciduous Trees	45	30	10	10
Deciduous Shrubs	10	20	40	45
Grasses	5	10	20	25
Bank Materials	larges, sand, clay, some limestone and bitumen	sand, clay, some larges	clay	clay
River Channel Characteristics				
Thread	single	single	single	single
Form	meandering	irregular	irregular	irregular
Flow Character	swirling	swirling to placid	placid	placid
Pool : Riffle Ratio	2:1	10:1	beaver impounded	beaver impounded

[a] Based on monthly survey data from point samples.

Table 47. Documented distributions of adult and young fish in the Dover and Dunkirk rivers based on catch data in April to October 1978.

Species	Dover River				Dunkirk River					
	Reach 1		Reach 4		Reach 1		Reach 2		Reach3	
	Adults	Fry/ Juveniles	Adults	Fry/ Juveniles	Adults	Fry/ Juveniles	Adults	Fry/ Juveniles	Adults	Fry/ Juveniles
White sucker	+	+		+	+	+		+		+
Longnose sucker		+		+				+		
Northern pike						+		+		+
Yellow perch				+						
Arctic grayling										+
Lake chub	+	+	+	+		+	+	+	+	
Trout-perch	+	+	+	+		+	+	+	+	+
Slimy sculpin		+	+	+		+		+		
Longnose dace	+	+								
Finescale dace		+								
Pearl dace		+		+[b]						
Brook stickleback			+	+		+	+	+	+	

[a] Reach 2 and 3 of Dover River were not sampled.

[b] Reported by Griffiths (1973).

The documented fish fauna of Reach 1 of the Dover River includes the adults of four species and the fry and/or juveniles of eight species (Table 47). The gravel riffle areas in this reach provide excellent spawning conditions for white and longnose suckers, lake chub, trout-perch, slimy sculpins and longnose dace and it is likely that all these species spawned in Reach 1 during 1978. Young-of-the-year suckers were abundant at Site 12 by mid-June when they were captured in drift nets (Appendix 8.4). Although white and long-nose sucker fry could not be distinguished at that time, white suckers were considerably more abundant in the area later in the summer and it is possible that Reach 1 of the Dover River is more important to white than to longnose suckers in terms of providing spawning areas. Young-of-the-year cyprinids (probably lake chub) and slimy sculpins were also taken in drift nets in mid-June (Appendix 8.4). Although Reach 1 may have some spawning potential for lake whitefish, walleye, and Arctic grayling, it does not appear that these species utilize the Dover River for spawning purposes.

Because of the extensive beaver activity that occurs upstream of Reach 1, fish movement within the Dover River is severely restricted and, consequently, it seems likely that only this reach is of major significance to migrant fish from the MacKay River.

The extent of overwintering in Reach 1 is unknown, although moderately deep pools (0.7 to 1.0 m) do occur in this region. Winter measurements, taken 0.8 km upstream from the Dover's confluence with the MacKay River (NHCL 1975), indicate a water depth of 0.4 m under 0.5 m of ice cover and a discharge of 0.12 m^3/s, which suggests that overwintering may be possible for some species in this region.

5.3.2.2 Reach 2. Reach 2 of the Dover River comprises approximately 13 km of stream between km 13 and km 26 (Figure 38), and is a transitional zone between the low gradient Reach 3 and the steep gradient Reach 1. In this reach, the stream channel is occasionally confined by limestone outcroppings and moderate clay-sand banks. The channel pattern is an irregular meander, the gradient is moderate (2.4 m/km), and the average channel width is approximately 7 m. The reach has a pool to riffle ratio of approximately 10:1. The substrate in pools consists mainly of sand, silt, and organic debris while riffles are comprised of coarse gravel. Despite the gradient of 2.4 m/km, the flow in Reach 2 is slow owing to the large number of beaver dams (n = 35). As mentioned previously, the presence of these structures probably places severe restrictions on any upstream movement of large fish species such as suckers, pike, walleye, etc. At the same time, the deep (> 1.0 m) beaver impoundments provide potential overwintering areas for a variety of species.

No fish or benthic invertebrates were sampled from Reach 2. Spawning potential appears to be confined to a few short gravel riffles which may be utilized by suckers and other forage species such as slimy sculpins, longnose dace, lake chub, and trout-perch.

5.3.2.3 Reach 3. Upstream of Reach 2 the Dover River flows through a poorly drained, treed muskeg region. Reach 3 (km 26 to km 43) (Figure 38) is similar to Reach 2 although it is more cluttered with beaver dams (> 50) resulting in poor flow and deep pools. The average stream width in Reach 3 is approximately 6 m and the low clay banks are vegetated with overhanging willows and grasses. Occasional coarse gravel riffle areas occur but the stream bottom consists mainly of clay-silt and organic debris (80% fines).

No fish or benthos were sampled from this reach. One overnight gillnet set was made at the lower end of the reach in late May but no fish were captured.

5.3.2.4 Reach 4. The portion of the Dover River upstream of km 43 is multi-branched, as a number of smaller tributaries come off the Birch Mountain Uplands and drain a large area of muskeg and headwater lakes. The gradient in Reach 4 is low (1.6 m/km) and the stream is deep (> 1 m) and slow-flowing (< 0.3 m/s)(Table 46). The substrate is predominantly clay-silt and organic debris with occasional patches of sand and fine gravel. The stream is cluttered with beaver dams, woody debris, and overhanging logs. Emergent grasses and reeds occur near the banks.

Sampling of Reach 4 was restricted to one site (Site 13) during 1978. The benthos at this location was dominated by Chironomidae (30%), Ephemeroptera (11%), Oligochaeta (4%), and Trichoptera (3%)(Appendix 8.9). Griffiths (1973) found the bottom fauna in this area to be comprised of Plecoptera, Ephemeroptera, Odonata, and Trichoptera.

Seven species of fish were captured at Site 13 during the present study including the adults of lake chub, slimy sculpin, trout-perch, and brook stickleback (Table 47). Pearl dace, taken in this area by Griffiths (1973), were not captured. Juvenile white suckers (age 0+ and 1+), longnose suckers (age 1+), and yellow perch (age 0+) were also captured at Site 13, suggesting that spawning and overwintering by these species may occur within Reach 4. Because of the many beaver dams downstream of Site 13, however, it seems unlikely that migrant fish from the MacKay River could ascend this high in the watershed during 1978. Another possibility is that resident populations of these species have been established in the headwater lakes of the Dover River, e.g., Lakes 14 and 15 (Figure 38), and young fish enter the Dover River from these. Adult white suckers have been reported from Lake 14 along with adult pike and brook stickleback, while stickleback have also been reported form Lake 15 (Herbert 1979). Although no yellow perch have been captured in Lakes 14 and 15, they are known to occur in other lakes of the Birch Mountains (Turner 1968).

5.3.3 Dunkirk River

The Dunkirk River was divided into three reaches (to the end of the AOSERP study area) on the basis of gradient differences, flow characteristics, bottom substrate, and channel form (Table 48, Figure 38). Point samples were taken in each reach and information was collected with respect to certain physical and chemical parameters (Appendix 8.8), fish (Table 47), and benthic macroinvertebrates (Appendix 8.9).

5.3.3.1 Reach 1. Reach 1 of the Dunkirk River includes the lower 16 km of the stream to the junction with the MacKay River (Figure 38),

Table 48. Physical characteristics of the Dunkirk River and Snipe Creek.

	Dunkirk River			Snipe Creek	
	Reach 1	Reach 2	Reach 3	Reach 1	Reach 2
Distance Upstream of Confluence (km)	0 to 16	16 to 52	52 to 85[a]	0 to 31	31 to 46
Width (m)	13	15	8	3	2
Gradient (m/km)	0.4	0.5	>2.1	1.2	12.4
Velocity (m/s)[b]	<0.1	0.3	<0.3	<0.1	ND
Mean Depth (m)[b]	>1.0	0.6	>1.0	>1.0	ND
Substrate Composition (%)					
Fines (< 2 mm)	90	50	90	95	90
Gravels (2 to 64 mm)	10	30	10	5	10
Larges (> 64 mm)	0	20	0	0	0
Bedrock	0	0	0	0	0
Riparian Vegetation (%)					
Coniferous Trees	10	50	10	20	35
Deciduous Trees	5	20	5	10	5
Deciduous Shrubs	65	20	60	60	40
Grasses	20	10	25	10	20
Bank Materials	clay	sand, clay larges	clay	clay	clay
River Channel Characteristics					
Thread	single	single	single	single	single
Form	irregular meander	irregular	irregular	irregular	straight to irregular
Flow Character	placid	swirling	placid	placid	placid
Pool : Riffle Ratio	>10:1	9:1	>10:1	beaver impounded	>10:1

[a] Survey ended at km 85, not necessarily end of reach.

[b] Based on monthly data from point samples.

and is similar in nature to Reach 6 of the MacKay. The reach is basically a placid pool with low gradient (0.4 m/km), reduced velocity (< 0.1 m/s), and a mean depth of a metre or more (Table 48). The average width of the Dunkirk River in this area is approximately 13 m and the low, clay banks are well-vegetated with grasses (20%) and overhanging willows (65%). During high water periods, the stream overflows these banks and wanders through a marsh-like area of treed muskeg. Evidence of old meanders indicates that the banks in this reach are unstable. The substrate is composed mainly of fines (90%) with small areas of fine gravel (10%). Organic detritus litters the bottom in most areas.

The fish community in Reach 1 is severely restricted with only six species being captured at Site 8 (Table 47). Throughout the reach, emergent and submerged vegetation provides ideal spawning and rearing habitat for northern pike and brook stickleback. There is little spawning potential, however, for any other fish species in this area. Although no adult northern pike were captured in Reach 1 of the Dunkirk River, this area is undoubtedly used by the resident pike population that is believed to inhabit the vicinity. As mentioned previously, ripe and mature northern pike were angled from the MacKay River at the mouth of the Dunkirk River on 30 April and pike fry were also collected in this reach. Young-of-the-year suckers (species unknown) were observed near Site 8 on 20 June 1978 and this quiet area provides excellent rearing habitat for such young fish. These sucker fry are thought to have been spawned at Site 9 of the Dunkirk River. Whether the adult fish migrated upstream to this point from the Athabasca River or represent a resident population is not known. Measurements taken by NHCL (1975) indicated a water depth of 0.7 m under 0.4 m of ice cover in mid-February and suggest that over-wintering is possible in Reach 1 of the Dunkirk River.

Benthos samples taken at Site 8 were dominated by Chironomidae which accounted for 41% of all animals collected in mid-August and 64% in mid-October (Appendix 8.9). Ephemeroptera comprised approximately 10% of the bottom fauna in terms of numbers.

5.3.3.2 Reach 2. Reach 2 of the Dunkirk River extends from km 16 to km 52 (Figure 38). This section of stream has an irregular pattern, a gradient of 0.5 m/km, a flow rate of 0.3 m/s, and an average depth of approximately 0.6 m (Table 48). The pool to riffle ratio is about 9:1. The stream channel in this reach is confined occasionally within moderate (5 to 10 m high) sand-clay banks and there is evidence of river erosion to a height of 2 to 3 m. Near the upper end of the reach, the channel is narrower (10 m) and the clay banks are lower (up to 1 m) but well-vegetated with grasses and willows in an area of treed muskeg. Overall, riparian vegetation along Reach 2 was estimated as 20% deciduous trees (aspen, balsam poplar), 20% shrubs (willow, alder), and 50% conifers (white spruce) The river bottom is comprised mainly of sand (50%) and gravel (30%) with scattered boulders.

Gravel areas in Reach 2 offer suitable spawning sites for suckers, Arctic grayling, lake chub, trout-perch, slimy sculpin, and longnose dace. Spawning potential for northern pike and brook stickleback is limited. Fry and/or juveniles of seven fish species were captured in Reach 2 (Table 47) but it is not known whether the spawners are residents or migrated in from downstream. In view of the distances involved, however, it seems likely that at least lake chub, trout-perch, slimy sculpin, and brook stickleback are resident fish. Small numbers of age 1 white and longnose suckers and larger numbers of age 1 trout-perch and lake chub were captured at Site 9 in May and June, suggesting that some overwintering occurs in Reach 2.

Chironomidae (25 to 67%) and Ephemeroptera (17 to 37%) were the most abundant invertebrate groups in samples taken at Site 9 (Appendix 8.9).

5.3.3.3 Reach 3. This region (Figure 38) is poorly drained, marsh-like muskeg. The gradient is about 2.1 m/km but increases (average 6 m/km) as the stream comes off the Birch Mountain Uplands and drains a number of headwater lakes outside the AOSERP study area. The stream is deep (> 1 m) and slow flowing (< 0.3 m/s) with extensive beaver pools. The substrate consists mainly of clay-silt and organic debris with some sand and fine gravels. The riparian vegetation is mostly deciduous shrubs (willows), grasses, and sedges. During periods of flood, water overflows the low banks and the limits of the stream become difficult to define.

Only six species of fish were taken in Reach 3 (Table 47). This region appears to have little spawning potential although both adult and fry/juvenile trout-perch were collected in this area. One juvenile Arctic grayling was also observed and it is possible that younger grayling overwinter in this region where water depths appear to be adequate. The invertebrate fauna is limited largely to Chironomidae (88%) and Oligochaeta (3%)(Appendix 8.9). Barton and Wallace (in prep.) found that Oligochaeta and Chironomidae were the most abundant benthic groups in muskeg regions of streams in the AOSERP area.

5.3.4 Snipe Creek

Snipe Creek was divided into two reaches on the basis of observed differences in gradient, substrate, channel form, and flow (Table 48, Figure 38). Point samples were taken in August at two sites, one in Reach 1 and the other in Lake 16, to obtain information with respect to certain physical and chemical parameters (Appendix 8.8), benthic macroinvertebrates (Appendix 8.9), and fish.

5.3.4.1 Reach 1. The lower 31 km of Snipe Creek are characterized by low gradient (1.2 m/km), slow current (< 0.1 m/s), and a clay-silt, organic detritus substrate (Table 48). The low clay banks (< 1 m) are well-vegetated with overhanging brush (willows) and grasses. The average width and depth of Snipe Creek within Reach 1 are approximately 3 m and 1 m, respectively. Emergent grasses and reeds grow along the banks and woody debris (logs and brush) clutter most of the stream making seining difficult. Site 11 (Figure 38) was sampled only once during the present study (in mid-August) and no fish were collected. The apparent lack of fish in this reach may result from low oxygen levels as an oxygen reading of only 4.0 mg/L was recorded at Site 11. Brook stickleback may be the only fish species in the area capable of tolerating low oxygen conditions. Chironomidae was the dominant invertebrate group taken at Site 11, making up 50% of the total sample (Appendix 8.9).

5.3.4.2 Reach 2. Reach 2 of Snipe Creek includes the area between Reach 1 and Lake 16 (Figure 38). Although the reach has an extremely steep gradient (12.4 m/km), beaver activity and woody debris have created stagnant pool conditions throughout most of its length. The low clay banks are vegetated with overhanging willows and grasses and show signs of stream erosion. No point sample was taken in Snipe Creek within Reach 2; however, Lake 16, from which the stream drains, was sampled once on 17 August. The south shore of Lake 16 has a cobble beach which was seined extensively with no results. Aquatic macrophytes were abundant along the shoreline and Amphipoda were numerous among the vegetation. A kick sample taken approximately 15 m offshore on a hard, clay-silt bottom was dominated by Chironomidae (28%) and Oligochaeta (16%)(Appendix 8.9). Shoreline vegetation was estimated to be 70% spruce and 30% willows.

6. CONCLUSION

The major significance of the MacKay River watershed to the fisheries of the lower Athabasca River drainage appears to be as a spawning, rearing, and summer feeding area for white suckers, longnose suckers, lake chub, and trout-perch, a conclusion also reached by McCart et al. (1978). These species, while of no direct economic value to man in the AOSERP area, provide an important forage base for such piscivorous fishes as walleye, northern pike, goldeye, and burbot. In total, they contribute an enormous amount of biomass annually to the aquatic system. Although spawning areas could not be determined precisely, potential spawning sites for these species occur throughout the lower 125 km of the MacKay River mainstem as well as in the lower reaches of the Dunkirk and Dover rivers.

Migrant suckers begin to leave the MacKay River watershed in late May, shortly after spawning. This out-migration probably continues throughout the summer. Tag return evidence suggests that suckers of both species belong to the Lake Athabasca population and return to the lake to overwinter. Lake chub and trout-perch that migrate into the MacKay River in late April and early May apparently remain in the tributary until late autumn before returning to the Athabasca River.

Sucker fry drift out of the MacKay River watershed in large numbers during June. Many, however, remain in the tributary throughout the summer and a further downstream migration occurs in late autumn. Lake chub and trout-perch fry also begin to drift downstream in early June. Many lake chub fry remain in the MacKay River watershed throughout the summer, leaving in late autumn, while most young trout-perch leave the tributary before September. Yearling white and longnose suckers, lake chub, and trout-perch were captured in the MacKay River watershed in May, indicating that some young-of-the-year fish overwinter within the tributary.

A small migration of Arctic grayling was observed in the MacKay River and some spawning undoubtedly occurred. In other AOSERP tributaries, adult grayling remain in the tributaries throughout the summer to feed and return to the Athabasca River just prior to freeze-up. Young-of-the-year grayling are believed to spend their first winter in the spawning stream.

The MacKay River watershed also provides important summer feeding habitat for walleye, goldeye, flathead chub, lake whitefish, and burbot with walleye being the most abundant. Walleye have been captured as far upstream as Site 6 and goldeye have been taken upstream of Site 3; however, these species appear to use mainly the lower reaches of the tributary. None of these species has ever been reported from the Dover River and no evidence was obtained during the present study to suggest that any of them spawn within the MacKay River watershed. Most are thought to leave the tributary before freeze-up. The mouth region of the MacKay River may be important to these species as a resting area during their migrations in the Athabasca River, and may provide nursery areas for the young of several species.

A migration of northern pike also entered the MacKay River in early May. This was a post-spawning migration and it is clear that the lower reaches of the MacKay River watersehd are utilized as a summer feeding area by northern pike from the Athabasca River. Apart from this migrant group, the MacKay River watershed also harbours a resident pike population in the vicinity of the Dunkirk River mouth where adults were captured in late April and where young-of-the-year were taken in mid-June. A resident pike population is also known to inhabit Lake 14 at the headwaters of the Dover River.

Other than northern pike, the resident fish fauna of the MacKay River watershed consists largely of five species of forage fish. Although brook stickleback were not captured in large numbers, they were most common in low-gradient areas of the upper watershed and are known to be abundant in Lakes 14 and 15 at the headwaters of the Dover River. Finescale dace were most common at Sites 5 and 6 and seem to prefer tributary-associated sites. Pearl dace were captured at only three locations, the majority being taken at Sites 5 and 12. Slimy sculpins and longnose dace were found in gravelly areas and were most abundant downstream of Site 6 in the MacKay River and at Site 12 of the Dover River.

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8. APPENDIX

8.1 MEAN WATER TEMPERATURES ($\pm$ 0.5°C) RECORDED FOR EACH CHECK PERIOD PLUS DAILY MAXIMUM AND MINIMUM TEMPERATURES AND RELATIVE WATER LEVELS (cm) DURING THE SPRING FENCE OPERATION ON THE MacKAY RIVER, 1978. (TABLE 49).

Table 49. Mean water temperatures (±0.5°C) for each check period plus daily maximum and minimum temperatures and relative water levels (cm) during the spring fence operation on the MacKay River, 1978.

Date	Temperature at Time of Trap Check						Daily Values			Relative Water Level
	Overnight[b]	1200	1500	1800	2100	2400	Maximum	Minimum	Mean	
24 April	ND	ND	ND	ND	ND	ND	0.5	ND	ND	ND
25	0.5	ND	ND	ND	ND	ND	0.5	0.5	0.50	ND
26	0.5	ND	ND	ND	ND	ND	1.0	0.5	0.75	ND
27	0.5	ND	ND	ND	ND	ND	1.0	0.5	0.75	ND
28	0.5	ND	ND	ND	ND	ND	4.0	0.5	2.25	ND
29	ND	Trap	Installed		ND	ND	4.5	ND	ND	90
30	4.5	5.0	5.5	5.5	5.5	5.0	5.5	4.5	5.00	85
1 May	4.5	5.0	6.0	6.5	5.5	5.5	7.0	4.5	5.75	80
2	5.5	6.5	ND	7.0	7.0	5.5	7.0	5.5	6.25	75
3	5.5	6.5	7.0	7.0	7.0	7.0	7.0	5.5	6.25	71
4	6.0	6.5	7.0	7.0	7.0	7.0	7.0	6.0	6.50	67
5	5.5	7.0	7.0	7.0	8.0	8.0	9.0	5.5	7.25	65
6	6.0	8.0	8.0	8.0	10.0	10.5	10.5	6.0	8.25	65
7	6.0	6.5	8.0	8.0	8.0	8.5	11.0	6.0	8.50	66
8	6.5	9.0	9.0	10.0	9.0	9.0	10.0	6.5	8.25	65
9	8.0	8.5	9.0	9.0	9.0	8.5	9.5	6.5	8.00	62
10	7.0	8.0	8.0	8.5	8.5	8.5	8.5	5.5	7.00	59
11	6.0	7.0	7.0	7.0	7.0	7.0	9.0	6.0	7.50	51
12	6.0	6.5	ND	7.0	7.0	8.0	8.5	6.0	7.25	45
13	ND	ND	11.0	11.0	10.0	10.0	11.0	9.5	10.25	43
14	10.0	12.0	ND	12.0	11.5	ND	13.0	10.0	11.50	39
15	ND	ND	13.0	12.0	ND	11.5	13.0	ND	12.25[d]	35
16	ND	ND	11.5	ND	12.0	12.0	12.0	ND	11.75	30
17[c]	ND	13.0	ND	13.5	12.5	ND	13.5	ND	13.00	31
18	ND	12.5	13.0	14.5	14.0	14.0	14.5	ND	13.50	32
19	ND	14.0	ND	15.5	15.0	14.0	15.5	ND	14.75	33
20	ND	14.0	ND	15.5	ND	ND	15.5	ND	14.75	32
21	ND	15.5	ND	ND	16.0	16.5	16.5	ND	16.00	29
22	ND	14.0	ND	ND	13.0	ND	14.0	ND	13.50	27
23	ND	11.5	ND	11.5	11.0	ND	11.5	ND	11.25	26
24	ND	11.0	ND	12.5	12.0	ND	12.5	ND	11.75	27
25	ND	11.0	ND	ND	10.0	ND	11.0	ND	10.50	25
26	ND	9.0	ND	9.5	9.5	ND	9.5	ND	9.25	28
27	ND	9.5	ND	ND	13.0	13.0	13.0	ND	11.25	29
28	ND	13.5	ND	ND	14.0	ND	14.0	ND	13.75	29
29	ND	13.0	ND	14.0	13.5	ND	14.0	ND	13.50	31
30	ND	13.0	ND	15.0	15.0	ND	15.0	ND	14.00	31
31	ND	14.5	ND	15.0	15.0	ND	15.0	ND	14.75	31
1 June	ND	15.0	ND	17.0	17.0	ND	17.0	ND	16.00	31
2	ND	16.5	ND	18.5	18.0	ND	18.5	ND	17.50	32
3	ND	ND	ND	19.5	ND	18.5	19.5	ND	19.00	31
4	ND	18.5	ND	20.0	19.5	ND	20.0	ND	19.25	31
5	ND	17.5	ND	18.0	16.5	ND	18.0	ND	17.25	31
6	ND	15.0	ND	16.0	15.0	ND	16.0	ND	15.50	30
7	ND	14.5	ND	14.5	14.0	ND	14.5	ND	14.25	30
8	ND	13.0	ND	15.0	15.0	ND	15.0	ND	14.00	29
9	ND	15.0	ND	17.0	17.0	ND	17.0	ND	16.00	26
10	ND	15.5	ND	15.0	14.0	ND	15.5	ND	15.00	22
11	ND	14.0	ND	16.0	15.5	ND	16.0	ND	15.00	18
12	ND	15.5	ND	17.0	17.0	ND	17.0	ND	16.25	15
13	ND	16.0	ND	18.0	17.5	ND	18.0	ND	17.00	13
14	ND	17.5	ND	17.0	17.0	ND	17.5	ND	17.25	13
15	ND	17.5	ND	18.0	ND	ND	18.0	ND	17.75	12
16	ND	17.0	ND	17.5	ND	ND	17.5	ND	17.25	12
17	ND	ND	ND	ND	16.0	ND	16.0	ND	ND	11
18	ND	15.0	ND	ND	ND	ND	15.0	ND	ND	11

[a] Temperatures shown are means for the period (usually three hours) immediately preceding the time of the trap check.
[b] Overnight lows are the minimum temperatures as recorded at the 1200 h check time. Those shown for the 1200 check are the maximum temperatures.
[c] Water temperatures were recorded with a pocket thermometer from 17 May to 18 June inclusive.
[d] Mean values from 15 May to 16 June inclusive represent average daytime temperatures.

8.2 DAILY WATER TEMPERATURES AND RELATIVE WATER LEVELS RECORDED AT THE MacKAY RIVER FENCE SITE DURING THE AUTUMN GILLNETTING PROGRAM, 1978 (TABLE 50).

Table 50. Daily water temperatures and relative water levels recorded at the MacKay River fence site during the autumn gillnetting program, 1978.

Date	Water Temperature (C)			Relative Water Level (cm)
	Maximum	Minimum	Mean	
24 Sept.	8.5	ND	ND	120
25	9.0	8.0	8.50	114
26	8.0	7.5	7.75	101
27	8.0	ND	ND	96
28	8.0	5.0	6.50	91
29	8.0	6.5	7.25	88
30	9.0	8.0	8.50	85
1 Oct.	8.0	6.0	7.00	86
2	9.0	8.0	8.50	83
3	8.5	7.5	8.00	81
4	8.0	6.0	7.00	79
5	7.0	6.0	6.50	75
6	7.0	6.0	6.50	70
7	7.0	6.0	6.50	67
8	7.0	6.0	6.50	63
9	8.0	6.5	7.25	60
10	8.0	6.0	7.00	60
11	7.0	6.0	6.50	56
12	7.0	5.5	6.25	53
13	7.0	5.5	6.25	50
14	6.5	5.5	6.00	50
15	6.0	5.5	5.75	47

8.3 TOTAL NUMBERS OF LARVAL FISHES COLLECTED IN DRIFT NETS AT THREE STATIONS ALONG A TRANSECT UPSTREAM OF THE MacKAY RIVER COUNTING FENCE DURING JUNE 1978 (TABLE 51).

Table 51. Total numbers of larval fishes collected in drift nets at three stations along a transect upstream of the Mackay River counting fence during June 1978.

Date / Sampling Time (h)	No. of catostomid fry per location: Left Bank	Mid-Channel	Right Bank	Interval Total	No. of cottid fry per location: Left Bank	Mid-Channel	Right Bank	Interval Total	No. of cyprinid fry[a] per location: Left Bank	Mid-Channel	Right Bank	Interval Total	Grand Total
2 June													
1800	ND	ND	6	6	ND	ND	0	0	ND	ND	0	0	6
2200	ND	ND	13	13	ND	ND	49	49	ND	ND	8	8	70
3 June													
1200	ND	ND	26	26	ND	ND	57	57	ND	ND	13	13	96
1800	Installed Sampler	ND	3	3	Installed Sampler	ND	9	9	Installed Sampler	ND	0	0	12
2400	0	ND	2	2	0	ND	9	9	0	ND	0	0	11
4 June													
1200	5	ND	35	40	0	ND	23	23	0	ND	8	8	71
1800	1	Installed Sampler	5	6	0	Installed Sampler	0	0	0	Installed Sampler	0	0	6
2200	7	8	26	41	0	0	0	0	0	0	0	0	41
5 June													
1200	13	23	11	47	0	1	3	4	2	0	0	2	53
1800	1	19	4	24	0	2	0	2	0	0	0	0	26
2200	3	67	35	105	0	0	3	3	0	1	0	1	109
6 June													
1200	0	25	2	27	0	0	1	1	0	1	0	1	29
1800	1	27	11	39	0	0	0	0	0	0	0	0	39
2200	2	18	1	21	0	0	0	0	0	0	0	0	21
7 June													
1200	0	51	172	223	0	0	7	7	0	0	0	0	230
1800	1	75	12	88	0	0	2	2	0	0	0	0	90
2200	6	22	131	209	0	0	2	2	1	0	2	3	214
8 June													
1200	3	168	19	190	0	2	0	2	0	0	0	0	192
1800	33	452	244	729	0	1	3	4	0	0	0	0	733
2000	10	238	43	291	0	0	1	1	0	1	0	1	293
2200	0	144	30	174	0	0	1	1	0	0	0	0	175
2400	0	517	118	635	9	0	2	11	0	0	0	0	646
9 June													
0200	3	606	64	673	4	1	45	50	0	1(1)	0	2	725
0400	3	326	68	397	0	3	18	21	0	0	0	0	418
0600	13	204	282	499	1	1	2	4	0	0	0(2)	2	505
0800	21	793	277	1091	0	0	0	0	0(1)	0	0	1	1092
1000	16	1380	45	1441	0	0	0	0	0	0	0	0	1441
1200	15	1237	22	1274	0	0	1	1	0(1)	0	0	1	1276
1400	11	636	15	662	0	0	0	0	0	0	0	0	662

continued ...

Table 51. Continued.

Date / Sampling Time (h)	No. of catostomid fry per location: Left Bank	Mid-Channel	Right Bank	Interval Total	No. of cottid fry per location: Left Bank	Mid-Channel	Right Bank	Interval Total	No. of cyprinid fry[a] per location: Left Bank	Mid-Channel	Right Bank	Interval Total	Grand Total
9 June													
1600	8	111	8	127	0	0	0	0	0	0	0	0	127
1800	6	256	24	286	0	0	0	0	0	0	0	0	286
2000	3	69	17	89	0	0	0	0	0	0	0	0	89
2200	0	158	21	179	0	0	2	2	0	0	0(3)	3	184
10 June													
1200	0	297	6	303	0	1	4	5	0	0	0	0	308
1800	4	298	53	355	0	1	0	1	0	0	0	0	356
2200	0	103	3	106	0	0	0	0	0	0	0	0	106
11 June													
1200	0	235	2	237	0	1	0	1	0	0	0	0	238
1800	26	793	2	821	0	0	0	0	0	0	0	0	821
2000	51	404	108	563	0	0	1	1	0	0	0	0	564
2200	7	364	130	501	1	0	0	1	2	1	0	3	505
2400	14	54	307	375	0	1	44	45	0	0	3	3	423
12 June													
0200	40	1260	41	1341	13	28	2	43	1	2	0	3	1387
0400	28	252	214	494	4	4	10	18	3	0	0	3	515
0600	85	332	6	423	0	0	0	0	3	0	0	3	426
0800	27	880	226	1133	0	0	0	0	0	0	0	0	1133
1000	11	571	43	625	2	0	0	2	0	0	0	0	627
1200	93	1050	49	1192	0	0	0	0	0	0	0	0	1192
1400	286	861	80	1227	0	0	1	1	0	0	0	0	1228
1600	273	465	24	762	0	0	0	0	0	0	0	0	762
1800	447	280	16	743	0	0	0	0	1	0	0	1	744
2000	39	187	16	242	0	0	0	0	0	0	0	0	242
2200	14	277	3	294	0	1	1	2	0	0	0	0	296
13 June													
1200	25	106	90	221	6	1	7	14	0	0	0	0	235
1800	112	162	195	469	0	1	0	1	0	0	0	0	470
2200	83	15	25	123	1	1	0	2	1	0	0	1	126
14 June													
1200	13	195	80	288	0	5	8	13	0	0	0	0	301
1800	13	200	51	264	0	1	3	4	0	0	0	0	268
2200	68	130	364	562	0	0	1	1	0	0	0	0	563
15 June													
1200	4	123	3	130	0	3	0	3	0	4	0	4	137
1600	24	89	29	142	0	0	0	0	0	0	0	0	142
1800	29	36	39	104	0	0	4	4	0	0	0	0	108
2000	11	9	15	35	0	0	2	2	1	1	0	2	39

Continued ...

Table 51. Concluded.

Date Sampling Time (h)	No. of catostomid fry per location			Interval Total	No. of cottid fry per location			Interval Total	No. of cyprinid fry[a] per location			Interval Total	Grand Total
	Left Bank	Mid-Channel	Right Bank		Left Bank	Mid-Channel	Right Bank		Left Bank	Mid-Channel	Right Bank		
15 June													
2200	3	13	25	41	1	1	2	4	1	0	0	1	46
2400	9	56	46	111	0	0	1	1	0	5	14	19	131
16 June													
0200	4	27	12	43	1	4	3	8	0	4	0	4	55
0400	5	14	166	185	0	4	7	11	1	5	14	20	216
0600	19	6	544	569	3	0	5	8	2	0	2	4	581
0800	7	15	77	99	0	1	2	3	1	0	2	3	105
1000	4	47	62	113	0	0	2	2	0	0	5	5	120
1200	0	39	90	129	0	0	0	0	0	0	1	1	130
1400	5	89	101	195	0	0	0	0	0	0	2	2	197
1600	20	24	53	97	0	1	2	3	1	0	1	2	102
1800	11	16	59	86	0	0	3	3	0	0	0	0	89
2000	4	35	61	100	0	0	0	0	0	1	0	1	101
2200	3	57	3	63	1	0	0	1	0	1	0	1	65
17 June													
1200	1	26	0	27	0	2	1	3	1	0	0	1	31
1800	29	10	13	52	0	0	4	4	0	0	0	0	56
2200	5	5	4	14	0	0	0	0	0	0	0	0	14
18 June													
1200	7	1	1	9	0	0	0	0	0	0	0	0	9
1800	16	39	2	57	0	0	1	1	0	0	0	0	58
2200	2	14	6	22	0	0	0	0	0	0	0	0	22
19 June													
1200	10	16	0	26	4	1	0	5	0	6	0	6	37
Totals	2 176	18 207	5 387	25 770	51	74	361	486	24	35	80	139	26 395

[a] Trout-perch fry captured are indicated in parentheses.

8.4 TOTAL NUMBERS OF LARVAL FISHES COLLECTED IN DRIFT NETS AT THREE STATIONS ALONG A TRANSECT IN THE DOVER RIVER (SITE 12) AND AT ONE STATION IN THE MacKAY RIVER 20 m UPSTREAM OF THE DOVER RIVER, 1978 (TABLE 52).

Table 52. Total numbers of larval fishes collected in drift nets at three stations along a transect in in the Dover River (Site 12) and one station[a] in the MacKay River 20 m upstream of the Dover River, 1978.

Date Sampling Time (h)	No. of catostomid fry per location: Left Bank	Mid-Channel	Right Bank	Interval Total	No. of cyprinid and cottid[b] fry per location: Left Bank	Mid-Channel	Right Bank	Interval Total	Grand Total
4-5 June									
1500 to 1500	14	48	37	99	0	0	0	0	99
15 June									
IN 1600									
1800	1	0	3	4	0	0	1	1	5
2000	0	0	2	2	0	0	1	1	3
2200	0	3	0	3	0	0	0	0	3
2400	13	6	7	26	5(1)	0	23	28(1)	55
16 June									
0200	50	34	57	141	0(1)	3	10(1)	13(2)	156
0400	39	7	58	104	1	0	1	2	106
0600	30	33[a]	52	82	1	4(1)[a]	4	5	87
0800	22	11	21	43	0	1(1)	9	9	52
1000	8	28	12	20	0	2	1	1	21
1200	6	53	11	17	1	3	11	12	29
1400	5	91	11	16	0	0	7	7	23
OUT 1600	4	110	4	8	0	5	3	3	11
Totals	192	98 326[a]	275	565 326[a]	8(2)	3 15[a](2)	71(1)	82(3)	650 343[a]

[a] Left bank of the MacKay River.

[b] Number of cottids captured are indicated in parentheses.

8.5 NUMBER (N), PERCENTAGE COMPOSITION (%), AND CATCH-PER-UNIT-EFFORT (C/E) FOR FISH CAPTURED BY SEINES AT EACH SAMPLING LOCATION IN THE MacKAY RIVER WATERSHED DURING 1978 (TABLES 53 TO 59).

Table 53. Number (N), percentage composition (%), and catch-per-unit-effort (C/E) for fish captured by seines at each sampling location in the MacKay River watershed during May 1978.

Species	Site 2			Site 4			Site 5			Site 6			Site 7			Site 9			Site 12			Total		
	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E
Lake chub	153	52.6	7.3	4	36.4	0.8	82	44.1	11.7	0	0.0	0.0	0	0.0	0.0	58	74.4	11.6	52	77.6	10.4	349	55.1	7.1
Trout-perch	45	15.5	2.1	1	9.1	0.2	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	19	24.4	3.8	0	0.0	0.0	65	10.3	1.3
Longnose suckers	46	15.8	2.2	1	9.1	0.2	70	37.6	10.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	1.5	0.2	118	18.6	2.4
White suckers	29	8.4	1.4	0	0.0	0.0	23	12.4	3.3	0	0.0	0.0	0	0.0	0.0	1	1.3	0.2	1	1.5	0.2	54	8.5	1.1
Slimy sculpins	3	1.0	0.1	1	9.1	0.2	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	4	0.6	0.1
Longnose dace	12	4.1	0.6	4	36.4	0.8	9	4.8	1.3	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	1.5	0.2	26	4.1	0.5
Finescale dace	0	0.0	0.0	0	0.0	0.0	2	1.1	0.3	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	2	0.3	<0.1
Northern pike	2	0.7	0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	2	0.3	<0.1
Yellow perch	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Pearl dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	12	17.9	2.4	12	1.9	0.2
Brook stickleback	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Walleye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spottail shiner	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Arctic grayling	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Burbot	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Mountain whitefish	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Goldeye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spoonhead sculpin	1	0.3	<0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	0.2	<0.1
Total	291			11			186			0			0			78			67			633		
Number of Seine Hauls	21			5			7			3			3			5			5			49		

Table 54. Number (N), percentage composition (%), and catch-per-unit-effort (C/E) for fish captured by seines at each sampling location in the MacKay River watershed during June 1978.

Species	Site 2			Site 3			Site 4			Site 5			Site 6			Site 7		
	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E
Lake chub	7	50.0	0.7	52	76.5	5.2	8	16.3	1.3	26	29.5	5.2	0	0.0	0.0	0	0.0	0.0
Trout-perch	2	14.3	0.2	0	0.0	0.0	29	59.2	4.8	8	9.1	1.6	0	0.0	0.0	0	0.0	0.0
Longnose suckers	2	14.3	0.2	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
White suckers	1	7.1	0.1	6	8.8	0.6	10	20.4	1.7	26	29.5	5.2	0	0.0	0.0	0	0.0	0.0
Slimy sculpins	1	7.1	0.1	0	0.0	0.0	0	0.0	0.0	1	1.1	0.2	0	0.0	0.0	0	0.0	0.0
Longnose dace	1	7.1	0.1	0	0.0	0.0	2	4.1	0.3	2	2.3	0.4	0	0.0	0.0	0	0.0	0.0
Finescale dace	0	0.0	0.0	10	14.7	1.0	0	0.0	0.0	4	4.5	0.8	0	0.0	0.0	0	0.0	0.0
Northern pike	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	10	100.0	3.3
Yellow perch	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Pearl dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	21	23.9	4.2	1	100.0	0.1	0	0.0	0.0
Brook stickleback	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Walleye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spottail shiner	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Arctic grayling	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Burbot	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Mountain whitefish	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Goldeye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spoonhead sculpins	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Total	14			68			49			88			1			10		
Number of Seine Hauls	10			10			6			5			7			3		

Continued ...

Table 54. Concluded.

Species	Site 8			Site 9			Site 10			Site 12			Site 13			Total		
	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E
Lake chub	0	0.0	0.0	43	84.3	8.6	1	50.0	0.2	66	63.5	6.6	0	0.0	0.0	203	51.3	3.0
Trout-perch	1	50.0	0.5	1	2.0	0.2	0	0.0	0.0	1	1.0	0.6	0	0.0	0.0	42	10.6	0.6
Longnose suckers	0	0.0	0.0	2	3.9	0.4	0	0.0	0.0	9	8.7	0.9	0	0.0	0.0	13	3.3	0.2
White suckers	0	0.0	0.0	4	7.8	0.8	1	50.0	0.2	7	6.7	0.7	7	100.0	1.8	62	15.7	0.9
Slimy sculpins	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	2	0.5	<0.1
Longnose dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	7	6.7	0.7	0	0.0	0.0	12	3.0	0.2
Finescale dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	14	13.5	1.4	0	0.0	0.0	28	7.1	0.4
Northern pike	1	50.0	0.5	1	2.0	0.2	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	12	3.0	0.2
Yellow perch	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Pearl dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	22	5.6	0.3
Brook stickleback	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Walleye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spottail shiner	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Arctic grayling	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Burbot	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Mountain whitefish	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Goldeye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spoonhead sculpins	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Total	2			51			2			104			7			396		
Number of Seine Hauls	2			5			5			10			4			67		

Table 55. Number (N), percentage composition (%), and catch-per-unit-effort (C/E) for fish captured by seines at each sampling location in the MacKay River watershed during July 1978.

Species	Site 1			Site 2			Site 3			Site 4			Site 5			Site 6		
	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E
Lake chub	12	15.6	1.2	8	17.8	0.8	57	93.4	8.1	18	7.6	3.6	2	11.8	0.4	38	12.9	7.6
Trout-perch	13	16.9	1.3	6	13.3	0.6	3	4.9	0.4	18	7.6	3.6	3	17.6	0.6	0	0.0	0.0
Longnose suckers	2	2.6	0.2	19	42.2	1.9	0	0.0	0.0	195	82.6	39.0	0	0.0	0.0	76	25.9	15.2
White suckers	7	9.1	0.7	1	2.2	0.1	0	0.0	0.0	0	0.0	0.0	6	35.3	1.2	180	61.2	36.0
Slimy sculpins	0	0.0	0.0	7	15.6	0.7	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Longnose dace	0	0.0	0.0	4	8.9	0.4	0	0.0	0.0	3	1.3	0.6	1	5.9	0.2	0	0.0	0.0
Finescale dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	2	11.8	0.4	0	0.0	0.0
Northern pike	0	0.0	0.0	0	0.0	0.0	1	1.6	0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Yellow perch	38	49.4	3.8	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Pearl dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	3	17.6	0.6	0	0.0	0.0
Brook stickleback	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	2	0.8	0.4	0	0.0	0.0	0	0.0	0.0
Walleye	1	1.3	0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spottail shiner	4	5.2	0.4	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Arctic grayling	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Burbot	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Mountain whitefish	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Goldeye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spoonhead sculpins	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Total	77			45			61			236			17			294		
Number of Seine Hauls	10			10			7			5			5			5		

Continued ...

Table 55. Concluded.

Species	Site 7			Site 9			Site 10			Site 12			Site 13			Total		
	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E
Lake chub	0	0.0	0.0	7	10.1	1.4	0	0.0	0.0	39	15.4	7.8	3	13.6	1.5	184	16.8	3.0
Trout-perch	0	0.0	0.0	2	2.9	0.4	8	88.9	2.7	10	3.9	2.0	0	0.0	0.0	63	5.8	1.0
Longnose suckers	4	44.4	0.8	0	0.0	0.0	0	0.0	0.0	11	4.3	2.2	0	0.0	0.0	307	28.1	5.0
White suckers	0	0.0	0.0	57	82.6	11.4	1	11.1	0.3	190	74.8	38.0	17	77.3	8.5	459	42.0	7.4
Slimy sculpins	0	0.0	0.0	3	4.3	0.6	0	0.0	0.0	2	0.8	0.4	0	0.0	0.0	12	1.1	0.2
Longnose dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	2	0.8	0.4	0	0.0	0.0	10	0.9	0.2
Finescale dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	2	0.2	<0.1
Northern pike	5	55.5	1.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	6	0.5	0.1
Yellow perch	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	2	9.1	1.0	40	3.7	0.6
Pearl dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	3	0.3	0.1
Brook stickleback	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	2	0.2	<0.1
Walleye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	0.1	<0.1
Spottail shiner	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	4	0.4	0.1
Arctic grayling	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Burbot	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Mountain whitefish	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Goldeye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spoonhead sculpins	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Total	9			69			9			254			22			1093		
Number of Seine Hauls	5			5			3			5			2			62		

Table 56. Number (N), percentage composition (%), and catch-per-unit-effort (C/E) for fish captured by seines at each sampling location in the MacKay River watershed during August 1978.

Species	Site 1			Site 2			Site 3			Site 5			Site 6			Site 7			Site 8		
	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E
Lake chub	95	45.9	4.8	11	23.4	2.2	5	20.0	1.0	59	54.6	11.8	19	12.7	3.8	0	0.0	0.0	0	0.0	0.0
Trout-perch	31	15.0	1.6	2	4.3	0.4	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Longnose suckers	0	0.0	0.0	2	4.3	0.4	1	4.0	0.2	0	0.0	0.0	38	25.3	7.6	0	0.0	0.0	0	0.0	0.0
White suckers	30	14.5	1.5	22	46.8	4.4	2	8.0	0.4	12	11.1	2.4	90	60.0	18.0	0	0.0	0.0	0	0.0	0.0
Slimy sculpins	9	4.3	0.5	0	0.0	0.0	1	4.0	0.2	1	0.9	0.2	0	0.0	0.0	0	0.0	0.0	1	100.0	0.2
Longnose dace	10	4.8	0.5	10	21.3	2.0	16	64.0	3.2	2	1.9	0.4	3	2.0	0.6	0	0.0	0.0	0	0.0	0.0
Finescale dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	32	29.6	6.4	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Northern pike	1	0.5	0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	2	100.0	0.4	0	0.0	0.0
Yellow perch	24	11.6	1.2	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Pearl dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Brook stickleback	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	2	1.9	0.4	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Walleye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spottail shiner	7	3.4	0.4	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Arctic grayling	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Burbot	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Mountain whitefish	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Goldeye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spoonhead sculpins	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Total	207			47			25			108			150			2			1		
Number of Seine Hauls	20			5			5			5			5			5			5		

Continued ...

Table 56. Concluded.

Species	Site 9			Site 10			Site 11			Site 12			Site 13			Total		
	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E
Lake chub	114	56.4	22.8	0	0.0	0.0	0	0.0	0.0	30	43.5	5.0	30	31.3	6.0	363	39.3	4.7
Trout-perch	1	0.5	0.2	13	81.3	2.1	0	0.0	0.0	0	0.0	0.0	8	8.3	1.6	55	6.0	0.7
Longnose suckers	32	15.8	6.4	0	0.0	0.0	0	0.0	0.0	2	2.9	0.3	13	13.5	2.6	88	9.5	1.1
White suckers	51	25.2	10.2	2	12.5	0.3	0	0.0	0.0	26	37.7	4.3	38	39.6	7.6	273	29.6	3.5
Slimy sculpins	4	2.0	0.8	0	0.0	0.0	0	0.0	0.0	4	5.8	0.7	3	3.1	0.6	23	2.5	0.3
Longnose dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	7	10.1	1.2	0	0.0	0.0	48	5.2	0.6
Finescale dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	32	3.5	0.4
Northern pike	0	0.0	0.0	1	6.3	0.2	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	4	0.4	0.1
Yellow perch	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	24	2.6	0.3
Pearl dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Brook stickleback	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	4	4.2	0.8	6	0.7	0.1
Walleye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spottail shiner	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	7	0.8	0.1
Arctic grayling	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Burbot	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Mountain whitefish	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Goldeye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spoonhead sculpins	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Total	202			16			0			69			96			923		
Number of Seine Hauls	5			6			5			6			5			77		

Table 57. Number (N), percentage composition (%), and catch-per-unit-effort (C/E) for fish captured by seines at each sampling location in the MacKay River watershed during September, 1978.

Species	Site 2			Site 3			Site 12			Total		
	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E
Lake chub	168	37.7	5.6	4	66.7	0.8	6	75.0	1.2	178	38.7	4.5
Trout-perch	121	27.1	4.0	0	0.0	0.0	0	0.0	0.0	121	26.3	3.0
Longnose suckers	70	15.7	2.3	0	0.0	0.0	0	0.0	0.0	70	15.2	1.8
White suckers	20	4.5	0.7	0	0.0	0.0	0	0.0	0.0	20	4.3	0.5
Slimy sculpins	44	9.9	1.5	2	33.3	0.4	1	12.5	0.2	47	10.2	1.2
Longnose dace	17	3.8	0.6	0	0.0	0.0	1	12.5	0.2	18	3.9	0.5
Finescale dace	1	0.2	<0.1	0	0.0	0.0	0	0.0	0.0	1	0.2	0.1
Northern pike	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Yellow perch	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Pearl dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Brook stickleback	3	0.7	0.1	0	0.0	0.0	0	0.0	0.0	3	0.7	0.2
Walleye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spottail shiner	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Arctic grayling	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Burbot	2	0.4	0.1	0	0.0	0.0	0	0.0	0.0	2	0.4	0.1
Mountain whitefish	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Goldeye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spoonhead schlpin	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Total	446			6			8			460		
Number of Seine Hauls	30			5			5			40		

Table 58. Number (N), percentage composition (%), and catch-per-unit-effort (C/E) for fish captured by seines at each sampling location in the MacKay River watershed during October, 1978.

Species	Site 2			Site 3			Site 4			Site 5			Site 6		
	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E
Lake chub	6 529	54.1	98.9	39	70.9	7.8	5	35.7	1.0	8	21.6	1.6	0	0.0	0.0
Trout-perch	2 670	22.1	40.5	6	10.9	1.2	8	57.1	1.6	1	2.7	0.2	0	0.0	0.0
Longnose suckers	1 576	13.1	23.9	5	9.1	1.0	0	0.0	0.0	10	27.0	2.0	0	0.0	0.0
White suckers	1 201	9.9	18.2	1	1.8	0.2	0	0.0	0.0	6	16.2	1.2	2	6.5	0.4
Slimy sculpins	80	0.7	1.2	4	7.3	0.8	1	7.1	0.2	8	21.6	1.6	0	0.0	0.0
Longnose dace	10	0.1	0.2	0	0.0	0.0	0	0.0	0.0	1	2.7	0.2	0	0.0	0.0
Finescale dace	1	<0.1	<0.1	0	0.0	0.0	0	0.0	0.0	1	2.7	0.2	28	90.3	5.6
Northern pike	5	<0.1	0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	3.2	0.0
Yellow perch	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Pearl dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Brook stickleback	2	<0.1	<0.1	0	0.0	0.0	0	0.0	0.0	1	2.7	0.2	0	0.0	0.0
Walleye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spottail shiner	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Arctic grayling	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	2.7	0.2	0	0.0	0.0
Burbot	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Mountain whitefish	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Goldeye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spoonhead sculpins	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Total	12 074			55			14			37			31		
Number of Seine Hauls	66			5			5			5			5		

Continued ...

Table 58. Concluded.

Species	Site 9			Site 10			Site 12			Site 13			Total		
	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E
Lake chub	2	18.2	0.4	0	0.0	0.0	16	94.1	3.2	1	6.7	0.2	6 600	53.8	62.3
Trout-perch	5	45.5	1.0	1	20.0	0.2	0	0.0	0.0	0	0.0	0.0	2 691	22.0	25.4
Longnose suckers	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	3	20.0	0.6	1 594	13.0	15.0
White suckers	0	0.0	0.0	0	0.0	0.0	1	5.9	0.2	0	0.0	0.0	1 211	9.9	11.4
Slimy sculpins	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	4	26.7	0.8	97	0.8	0.9
Longnose dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	11	0.1	0.1
Finescale dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	30	0.2	0.3
Northern pike	1	9.1	0.2	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	7	<0.1	0.1
Yellow perch	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Pearl dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Brook stickleback	3	27.3	0.6	4	80.0	0.8	0	0.0	0.0	7	46.7	1.4	17	0.1	0.2
Walleye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spottail shiner	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Arctic grayling	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	<0.1	<0.1
Burbot	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Mountain whitefish	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Goldeye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spoonhead sculpins	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Total	11			5			17			15			12 259		
Number of Seine Hauls	5			5			5			5			106		

Table 59. Number (N), percentage composition (%), and catch-per-unit-effort (C/E) for fish captured by seines at each sampling location in the MacKay River watershed during 1978; all data combined.

Species	Site 1			Site 2			Site 3			Site 4			Site 5		
	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E
Lake chub	107	37.7	3.6	6 876	53.2	48.4	157	73.0	4.9	35	11.3	1.7	177	40.6	6.6
Trout-perch	44	15.5	1.5	2 846	22.0	20.0	9	4.2	0.3	56	18.1	2.7	12	2.8	0.4
Longnose suckers	2	0.7	0.1	1 715	13.3	12.1	6	2.8	0.2	196	63.2	9.3	80	18.3	3.0
White suckers	37	13.0	1.2	1 274	9.9	9.0	9	4.2	0.3	10	3.2	0.5	73	16.7	2.7
Slimy sculpins	9	3.2	0.3	135	1.0	1.0	7	3.3	0.2	2	0.6	0.1	10	2.3	0.4
Longnose dace	10	3.5	0.3	54	0.4	0.4	16	7.4	0.5	9	2.9	0.4	15	3.4	0.6
Finescale dace	0	0.0	0.0	2	<0.1	<0.1	10	4.7	0.3	0	0.0	0.0	41	9.4	1.5
Northern pike	1	0.4	<0.1	7	0.1	<0.1	1	0.5	<0.1	0	0.0	0.0	0	0.0	0.0
Yellow perch	62	21.8	2.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Pearl dace	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	24	5.5	0.9
Brook stickleback	0	0.0	0.0	5	<0.1	<0.1	0	0.0	0.0	2	0.6	0.1	3	0.7	0.1
Walleye	1	0.4	<0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spottail shiner	11	3.9	0.4	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Arctic grayling	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	0.2	<0.1
Burbot	0	0.0	0.0	2	0.0	<0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Mountain whitefish	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Goldeye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spoonhead sculpins	0	0.0	0.0	1	<0.1	<0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Total	284			12 917			215			310			436		
Number of Seine Hauls	30			142			32			21			27		

Continued ...

Table 59. Continued.

Species	Site 6			Site 7			Site 8			Site 9			Site 10		
	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E
Lake chub	57	12.0	2.3	0	0.0	0.0	0	0.0	0.0	224	54.5	9.0	1	3.1	0.1
Trout-perch	0	0.0	0.0	0	0.0	0.0	1	33.3	0.1	28	6.8	1.1	22	68.8	1.2
Longnose suckers	114	23.9	4.6	4	19.0	0.3	0	0.0	0.0	34	8.3	1.4	0	0.0	0.0
White suckers	272	57.1	10.9	0	0.0	0.0	0	0.0	0.0	113	27.5	4.5	4	12.5	0.2
Slimy sculpins	0	0.0	0.0	0	0.0	0.0	1	33.3	0.1	7	1.7	0.3	0	0.0	0.0
Longnose dace	3	0.6	0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Finescale dace	28	5.9	1.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Northern pike	1	0.2	<0.1	17	81.0	1.1	1	33.3	0.1	2	0.5	0.1	1	3.1	0.1
Yellow perch	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Pearl dace	1	0.2	<0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Brook stickleback	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	3	0.7	0.1	4	12.5	0.2
Walleye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spottail shiner	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Arctic grayling	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Burbot	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Mountain whitefish	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Goldeye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spoonhead sculpins	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Total	476			21			3			411			32		
Number of Seine Hauls	25			16			10			25			19		

Continued ...

Table 59. Concluded.

Species	Site 11			Site 12			Site 13			Total		
	N	%	C/E	N	%	C/E	N	%	C/E	N	%	C/E
Lake chub	0	0.0	0.0	209	40.3	5.8	34	24.3	2.1	7 877	50.0	19.5
Trout-perch	0	0.0	0.0	11	2.1	0.3	8	5.7	0.5	3 037	19.3	7.5
Longnose suckers	0	0.0	0.0	23	4.4	0.6	16	11.4	1.0	2 190	13.9	5.4
White suckers	0	0.0	0.0	225	43.4	6.3	62	44.3	3.9	2 079	13.2	5.1
Slimy sculpins	0	0.0	0.0	7	1.3	0.2	7	5.0	0.4	185	1.2	0.5
Longnose dace	0	0.0	0.0	18	3.5	0.5	0	0.0	0.0	125	0.8	0.3
Finescale dace	0	0.0	0.0	14	2.7	0.4	0	0.0	0.0	95	0.6	0.2
Northern pike	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	31	0.2	0.1
Yellow perch	0	0.0	0.0	0	0.0	0.0	2	1.4	0.1	64	0.4	0.2
Pearl dace	0	0.0	0.0	12	2.3	0.3	0	0.0	0.0	37	0.2	0.1
Brook stickleback	0	0.0	0.0	0	0.0	0.0	11	7.9	0.7	28	0.2	0.1
Walleye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	<0.1	<0.1
Spottail shiner	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	11	0.1	<0.1
Arctic grayling	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	<0.1	<0.1
Burbot	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	2	<0.1	<0.1
Mountain whitefish	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Goldeye	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Spoonhead sculpins	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	<0.1	<0.1
Total	0			519			140			15 764		
Number of Seine Hauls	5			36			16			404		

8.6 DATES OF TAGGING AND RECAPTURE, LOCATION OF RECAPTURE, DISTANCES TRAVELLED, AND ELAPSED TIME BETWEEN RELEASE AND RECAPTURE FOR FISH TAGGED AT THE MacKAY RIVER COUNTING FENCE, 1978 AND SUBSEQUENTLY RECAPTURED OUTSIDE THE MacKAY RIVER WATERSHED OR DURING THE AUTUMN GILLNETTING PROGRAM (TABLE 60).

Table 60. Dates of tagging and recapture, location of recapture, distances travelled, and elapsed time between release and recapture for fish tagged at the MacKay River counting fence, 1978 and subsequently recaptured outside the MacKay River watershed or during the autumn gillnetting operation.

Species	Date Tagged	Location Recaptured	Date Recaptured	Distance Travelled[a] (km)	Elapsed Time (Days)
White sucker	30 April	MacKay River Upstream Trap	3 May/78	0	3
	30 April	MacKay River Upstream Trap	13 May/78	0	13
	1 May	MacKay River Upstream Trap	3 May/78	0	2
	1 May	MacKay River Upstream Trap	4 May/78	0	3
	1 May	MacKay River Upstream Trap	6 May/78	0	5
	1 May	MacKay River Upstream Trap	3 May/78	0	2
	1 May	MacKay River Upstream Trap	13 May/78	0	12
	1 May	MacKay River Upstream Trap	8 May/78	0	7
	1 May	MacKay River Upstream Trap	3 May/78	0	2
	1 May	MacKay River Upstream Trap	5 May/78	0	4
	1 May	MacKay River Upstream Trap	7 May/78	0	6
	1 May	MacKay River Upstream Trap	4 May/78	0	3
	2 May	MacKay River Upstream Trap	6 May/78	0	4
	3 May	MacKay River Downstream Fence	24 May/78	0	21
	3 May	MacKay River Fence Site	13 Oct./78	0	163
	3 May	MacKay River Upstream Trap	5 May/78	0	2
	3 May	MacKay River Upstream Trap	7 May/78	0	4
	3 May	MacKay River Upstream Trap	5 May/78	0	2
	3 May	MacKay River Upstream Trap	5 May/78	0	2
	3 May	Mouth Athabasca River[b]	June/78	-254	33 to 57
	4 May	Athabasca Delta	late June/78	-250	~50
	5 May	MacKay River Upstream Trap	13 May/78	0	8

continued ...

Table 60. Continued.

Species	Date Tagged	Location Recaptured	Date Recaptured	Distance Travelled (km)	Elapsed Time (Days)
White sucker	5 May	MacKay River Upstream Trap	8 May/78	0	3
	5 May	Mouth Athabasca River[b]	June/78	-254	28 to 55
	6 May	MacKay River Upstream Trap	14 May/78	0	8
	6 May	MacKay River Upstream Trap	13 May/78	0	7
	6 May	MacKay River Upstream Trap	8 May/78	0	2
	6 May	MacKay River Upstream Trap	10 June/78	0	35
	6 May	MacKay River Upstream Trap	14 May/78	0	8
	6 May	Mouth Athabasca River[b]	June/78	-254	27 to 54
	7 May	MacKay River Upstream Trap	8 May/78	0	1
	7 May	Mouth Athabasca River[b]	June/78	-254	26 to 53
	8 May	Potato Island[b]	June/78	-275	25 to 52
	8 May	Mouth Athabasca River[b]	June/78	-254	25 to 52
	9 May	MacKay River Upstream Trap	10 May/78	0	1
	9 May	Athabasca Delta	late June/78	-250	~45
	9 May	MacKay River Upstream Trap	13 May/78	0	4
	9 May	MacKay River Upstream Trap	14 May/78	0	5
	9 May	Mouth Athabasca River[b]	June/78	-254	24 to 51
	9 May	Richardson Lake	24 July/79	-235	441
	10 May	MacKay River Upstream Trap	17 May/78	0	7
	13 May	Goose Island[b]	June/78	-260	20 to 47
	13 May	MacKay River Upstream Trap	18 May/78	0	5
	13 May	8 km S.W. Old Fort Point[b]	June/78	-258	20 to 47
	13 May	MacKay River Upstream Trap	13 May/78	0	< 1
	13 May	Mouth Athabasca River[b]	June/78	-254	20 to 47
	13 May	Mouth Athabasca River[b]	June/78	-254	20 to 47
	13 May	Richardson Lake	12 July/79	-235	425

Continued ...

Table 60. Continued.

Species	Date Tagged	Location Recaptured	Date Recaptured	Distance Travelled (km)	Elapsed Time (Days)
White sucker	14 May	Fort Chipewyan[b]	early Nov./78	-280	~175
	14 May	Lake Athabasca	20 June/79	~250	402
	14 May	Mouth Athabasca River[b]	June/78	-254	19 to 46
	14 May	MacKay River Upstream Trap	15 May/78	0	1
	14 May	MacKay River Upstream Trap	16 May/78	0	2
	14 May	8 km S.W. Old Fort Point[b]	June/78	-258	19 to 46
	14 May	Potato Island[b]	June/78	-275	19 to 46
	14 May	MacKay River Downstream Fence	25 May/78	0	11
	15 May	MacKay River Downstream Fence	20 May/78	0	5
	15 May	MacKay River Upstream Trap	16 May/78	0	1
	15 May	Mouth Athabasca River[b]	June/78	-254	18 to 45
	15 May	MacKay River Upstream Trap	16 May/78	0	1
	15 May	8 km S.W. Old Fort Point[b]	June/78	-258	18 to 45
	15 May	Potato Island[b]	June/78	-260	18 to 45
	15 May	Mouth Athabasca River[b]	June/78	-254	18 to 45
	15 May	Goose Island[b]	June/78	-260	18 to 45
	15 May	Mouth Athabasca River[b]	June/78	-254	18 to 45
	15 May	Mouth Athabasca River[b]	June/78	-254	18 to 45
	15 May	Fort Chipewyan[b]	June/78	-280	18 to 45
	15 May	Fort Chipewyan[b]	June/78	-280	18 to 45
	15 May	Mouth Athabasca River[b]	19 June/78	=254	35
	15 May	Mouth Athabasca River[b]	June/78	-254	18 to 45
	15 May	Goose Island[b]	June/78	-260	18 to 45
	15 May	N. of Jackfish Creek	21 Aug./78	-232	98
	15 May	Lake Athabasca	22 June/79	~250	403

Continued ...

Table 60. Concluded.

Species	Date Tagged	Location Recaptured	Date Recaptured	Distance Travelled[a] (km)	Elapsed Time (Days)
White sucker	17 May	Mouth Athabasca River[b]	June/78	-254	15 to 45
	17 May	MacKay River Upstream Trap	17 May/78	0	< 1
	18 May	MacKay River Downstream Fence	26 May/78	0	8
	19 May	Goose Island[b]	June/78	-260	14 to 41
Longnose sucker	1 May	MacKay River Downstream Fence	19 May/78	0	18
	1 May	MacKay River Downstream Trap	5 June/78	0	35
	3 May	MacKay River Downstream Fence	29 May/78	0	26
	3 May	MacKay River Downstream Trap	6 June/78	0	34
	6 May	Goose Island[b]	June/78	-260	27 to 54
	12 May	MacKay River Upstream Trap	21 May/78	0	9
	24 May	MacKay River Upstream Trap	3 June/78	0	10
	28 May	MacKay River Downstream Fence	29 May/78	0	1
Walleye	4 May	MacKay River Upstream Trap	14 June/78	0	41
	5 May	MacKay River Upstream Trap	7 May/78	0	2
	12 May	GCOS Plant Site	22 Oct./78	+28	163
	14 May	Fort MacKay	13 June/78	-13	30
	22 May	MacKay River Upstream Trap	22 May/78	0	< 1
	22 May	MacKay River Upstream Trap	5 June/78	0	14
Northern pike	3 May	MacKay River Fence Site	4 Oct./78	0	154
	6 May	MacKay River Upstream Trap	10 May/78	0	4
	21 May	Hydrology Site - MacKay River	26 Sept./78	-3	128
Burbot	30 May	MacKay River Downstream Fence	31 May/78	0	1

[a] Distance shown is approximate distance from counting fence to recapture point and + or - designates upstream or downstream from MacKay River in Athabasca.

[b] Lake Athabasca.

8.7 SITE DESCRIPTIONS FOR MacKAY RIVER WATERSHED SMALL FISH COLLECTION SITES

The sampling areas described below refer to the small fish collection sites indicated in Figures 2 and 38.

Site 1 Tp 94, R 11 Sec. 23 SE 1/4 W4

The mouth region of the MacKay River is approximately 45 m wide and 0.8 m deep. The current is slow and the homogeneous substrate consists mainly of sand-silt with some fine gravel and tar sands. The moderate clay banks are from 2 to 4 m high and covered mainly with willows. The sampling site itself was located about 1 km upstream of the MacKay's confluence with the Athabasca River. At high flow periods the Athabasca River backs up into the MacKay River for a distance of up to 3 km.

Site 2 Tp 95, R 11 Sec. 4 SE 1/4 W4

This site included the counting fence which was located 11 km upstream of the MacKay's confluence with the Athabasca River. The site comprised a shallow pool, approximately 43 m wide and 0.5 to 1 m deep, situated just upstream of a shallow riffle area. Within the pool, the substrate was mainly sand-silt with some gravel. The riffle substrate consisted primarily of rubble and coarse gravel underlain by limestone bedrock. The banks were moderate (2 to 5 m high) and covered with grasses, willows, poplar, and black spruce. Inland from the banks, steep Devonian limestone cliffs (50 m) overlain by Oil Sands confine the stream. Aquatic vegetation was sparse although algae covered many of the rocks. Nineteen fish species were taken at or near Site 2 but some species, such as flathead chub, spoonhead sculpin, mountain whiteifsh, and lake whitefish, probably do not ascend the MacKay River much beyond this site.

Site 3 Tp 94, R 11 Sec. 19 SE 1/4 W4

This site, located at the confluence of the Dover River, included a pool section (0.3 to 0.9 m deep) just upstream of the confluence and a downstream gravel riffle region. Stream width was approximately 30 m and the water flow was moderate (1 m/s). The substrate was a heterogeneous mixture of larges (boulders, rubble) and gravel in the riffle and sand-silt with scattered boulders in the pool. Lake chub, trout-perch, longnose sucker, white sucker, slimy sculpin, longnose dace, finescale dace, and northern pike were captured at this site; however, lake chub was the most abundant species taken, comprising 71% of the total catch. In addition, fishermen have been observed angling for walleye, northern pike, and goldeye at this location.

<u>Site 4</u> Tp 93, R 11 Sec. 31 SW 1/4 W4

The sampling site was situated in a region of broken riffles comprised of coarse gravel and rubble. Water depth was approximately 0.2 to 0.5 m and the stream width was 25 m. The sampling area was located opposite a small tributary. The banks were moderate and covered with willows, poplar, alder, and spruce. Some aquatic vegetation (grasses, reeds) was present in quiet nearshore areas. Fish captured at this site included lake chub, trout-perch, longnose sucker, white sucker, slimy sculpin, longnose dace, northern pike, and brook stickleback; however, young-of-the-year longnose suckers were the most abundant fish taken, comprising 62.8% of the total catch.

<u>Site 5</u> Tp 92, R 12 Sec. 16 SW 1/4 W4

The site included a long (200 m), coarse gravel riffle area followed by a pool opposite a small tributary. The banks were moderate (2 to 4 m high) and covered with spruce, poplar, and deciduous shrubs. Stream width was about 24 m and water depth varied from 0.2 to 1 m. Flow was relatively rapid (1.5 m/s) as the river flows swiftly over long stretches of shallow bouldery riffles and pools are infrequent. Fish captured at this location included lake chub, trout-perch, longnose sucker, white sucker, slimy sculpin, longnose dace, finescale dace, pearl dace, brook stickleback, and

Arctic grayling. The most abundant species were lake chub (40.9%) and longnose sucker (18.5%).

Site 6   Tp 90, R 15 Sec. 27 SE 1/4 W4

The sampling site was located opposite a small (2 m wide) tributary draining an area of treed muskeg. The area sampled consisted of a shallow pool (34 m wide and 0.5 to 0.8 m deep) and a short riffle section. The substrate of the pool was mainly sand-silt with a few scattered boulders (up to 1 m in width), while the upstream riffle region had coarse gravel, rubble bottom. There were macrophytes in the pool area and rocks were covered with moss and algae. The banks were low (1 to 2 m) and well-vegetated with grasses, sedges, and willows. Young-of-the-year white suckers (56.1%) and longnose suckers (23.3%) made up the bulk of fish captured at this location. Other species taken included lake chub, longnose dace, finescale dace, northern pike, pearl dace, and walleye,

Site 7   Tp 89, R 16 Sec. 31 NW 1/4 W 4

Located at the confluence of the Dunkirk River in a region of placid pool waters, the MacKay River, at this site, was approximately 17 m wide and 1.5 m in average depth. The stream bottom was mainly mud-silt and organic detritus. The site was situated in a muskeg region surrounded by tall grasses and sedges with some spruce, poplar, and willows. Aquatic macrophytes were abundant, offering ideal spawning and rearing habitat for northern pike and brook stickleback. Only four species were taken in this area with northern pike (91.4%) being the most abundant fish.

Site 8   Tp 89, R 16 Sec. 31 NE 1/4 W 4

This site was located in the mouth region of the Dunkirk River. Due to the depth of the area (1.5 m) and the soft organic debris bottom, seining was difficult at times. Dipnets, angling gear, and gillnets were also utilized in an attempt to collect fish in this area. The banks were low (1 to 2 m) and well vegetated with grasses, brush (willows), and spruce. Six fish species were collected with lake chub, northern pike, and brook stickleback being the most common species taken in this area.

Site 9 Tp 90, R 17 Sec. 31 NW 1/4 W 4

This site was located at the abandoned Water Survey of Canada gauging station on the Dunkirk River. The sampling area included a shallow gravel pool (0.2 to 0.8 m deep) with a stream width of 27.5 m. The banks were moderate (2 to 3 m) with grasses, overhanging brush, and white spruce. The coarse gravel in this area was covered with algae, while aquatic macrophytes were present in quiet nearshore pool areas. Lake chub (54.4%) and young-of-the-year white suckers (27.7%) were the dominant fish in this location.

Site 10 Tp 93, R 19 Sec. 13 SW 1/4 W 4

Located near the confluence of Snipe Creek, the stream width was approximately 8 m and the water depth varied from 0.5 to 1.5 m. The clay banks were moderate (1 to 3 m) with overhanging brush (willows). There was some aquatic vegetation present and the substrate consisted mainly of clay-silt, fine gravel, and sand. Flow was slow since impoundment pools, logs, and other woody debris were common in this area. Only 33 fish were taken at this location with trout-perch accounting for 66.7% of the total catch. Other species occurring in this area included lake chub, white sucker, northern pike, brook stickleback, and Arctic grayling.

Site 11 Tp 94, R 18 Sec. 16 NW 1/4 W 4

Located on Snipe Creek, this site was situated in an area of treed muskeg surrounded by tall grasses and heavy brush (willows). Stream width was approximately 3 m and depth exceeded 1 m. Woody debris cluttered the stream and the substrate was primarily clay-silt and organic detritus. Some grasses and reeds occurred along stream banks. The area was sampled once with seines and dipnets but no fish were collected.

Site 12 Tp 94, R 11 Sec. 19 SE 1/4 W4

This site was located in the mouth region of the Dover River and included a series of riffle and pool habitats. In the riffle areas sampled, the substrate consisted mainly of limestone rubble and coarse gravel while shallow pool areas (0.3 to 0.8 m deep) were comprised of sand and gravel with scattered rubble. Clay banks (2 to 4 m) showed high water erosion and were covered with grasses and poplar and spruce trees. Some outcroppings of oil sands occurred near exposed limestone banks. Current was moderate (0.5 m/s) with grasses and some macrophytes in quiet nearshore areas. Young-of-the-year white sucker, (42.9%) and lake chub (39.8%) were the most frequently captured fish species in the area. Other fish captured included trout-perch, longnose sucker, slimy sculpin, longnose dace, finescale dace, and pearl dace.

Site 13 Tp 93, R 14 Sec. 21 SW 1/4 W 4

Located on the west (mainstem) branch of the Dover River, this site was in an area of treed muskeg. The width of the stream at this point was approximately 7 m with an average depth of 1 m. The substrate was mainly mud-silt with some sand and fine gravel. Banks were gradual with overhanging brush (willows) and spruce trees. Aquatic vegetation (grasses and reeds) was common along the banks. Fallen logs, overhanging brush, and woody debris made seining difficult in this area. Fish captured at this site included white sucker, lake chub, longnose sucker, brook stickleback, trout-perch, slimy sculpin, and yellow perch fry.

Lake 16 Tp 96, R 18 Sec. 14 SW 1/4 W 4

Located at the headwaters of Snipe Creek, this lake was seined once but no fish were captured. Cobble and sand banks are found along the south shore and extensive areas of macrophytes are present. Shore vegetation was mainly deciduous shrubs, spruce, and grasses.

8.8 SUMMARY OF PHYSICAL AND WATER QUALITY DATA OBTAINED AT SMALL FISH COLLECTION SITES IN THE MacKAY RIVER WATERSHED BETWEEN MAY AND OCTOBER 1978 (TABLE 61).

Table 61. Summary of physical and water quality data obtained at small fish collection sites in the MacKay River watershed between May and October 1978.

Date	Site	Water Depth (m)	Water Flow (cm/s)	Conductivity (µmhos/cm)	pH	Dissolved Oxygen (mg/L)	Water Temperature (°C)
20 to 21 May	4	ND	70	135	8.5	9.0	15.5
	5	0.6	80	90	8.5	9.0	15.5
	6	>1.0	43	160	8.0	ND	14.5
	7	1.5	23	150	7.5	7.0	14.5
	9	0.8	ND	158	8.0	8.0	13.5
	10	1.5	ND	135	7.5	9.0	12.0
	12	0.6	90	245	8.5	10.0	15.5
	13	1.3	29	207	8.0	9.0	15.0
16 to 17 June	4	1.1	122	200	8.5	9.0	14.0
	5	0.7	152	180	8.5	8.0	14.0
	6	0.6	69	180	8.0	8.0	15.0
	7	ND	ND	170	8.0	7.0	17.0
	9	0.4	53	190	8.5	9.0	16.0
	10	0.8	30	180	8.0	8.0	14.0
	12	0.3	31	280	8.0	8.0	15.0
	13	>1.0	ND	320	8.0	8.5	15.0
14 to 15 July	2	0.3	20	ND	ND	ND	18.5
	4	0.9	20	220	9.0	8.0	21.0
	5	0.6	14	180	9.0	9.0	19.5
	6	0.5	21	220	8.5	8.0	19.0
	7	0.9	Nil	200	8.5	8.0	19.0
	10	>1.0	18	260	8.0	8.0	17.0
	12	0.2	33	320	9.0	9.0	18.5
	13	0.7	15	280	8.5	8.0	15.5

continued ...

Table 61. Concluded.

Date	Site	Water Depth (m)	Water Flow (cm/s)	Conductivity (μmhos/cm)	pH	Dissolved Oxygen (mg/L)	Water Temperature (°C)
16 to 17 August	2	0.5	56	400	8.5	8.0	19.0
	3	0.6	40	380	8.5	8.0	18.0
	5	0.4	56	295	8.5	7.0	16.0
	6	0.6	9	310	7.5	8.0	17.5
	7	0.9	4	215	7.5	7.0	17.0
	8	1.1	5	255	8.5	7.0	17.0
	9	0.5	20	350	9.0	8.0	14.0
	10	0.7	25	330	8.5	7.0	14.0
	11	1.0	6	370	8.0	4.0	13.0
	12	0.3	44	500	8.5	8.0	18.0
	13	0.4	26	615	8.5	8.0	16.0
	Lake 16	ND	ND	180	8.5	8.0	16.0
16 September	3	>1.0	>200	230	ND	ND	10.0
	12	0.9	56	140	ND	ND	9.5
	13	>1.0	50	ND	ND	ND	9.0
13 to 14 October	2	>1.5	ND	180	8.0	9.0	5.5
	3	1.0	87	260	8.5	7.0	4.0
	4	ND	ND	170	ND	ND	5.0
	5	1.0	50	165	ND	ND	5.0
	6	>1.0	ND	170	ND	ND	5.0
	7	>1.0	ND	165	ND	ND	5.0
	8	>1.0	ND	170	ND	ND	4.5
	9	>1.0	ND	175	7.8	7.0	4.0
	10	1.5	ND	180	ND	ND	4.0
	12	0.7	50	260	8.5	7.0	4.5
	13	1.2	ND	255	ND	ND	4.0

8.9 PERCENTAGE COMPOSITION BY NUMBERS FOR MAJOR BENTHIC MACRO-INVERTEBRATE GROUPS AT EACH SAMPLING SITE IN THE MacKAY RIVER WATERSHED DURING 1978 (TABLES 62 TO 66).

Table 62. Percentage composition by numbers for major benthic macroinvertebrate groups at each sampling site in the MacKay River watershed, 20 to 27 May 1978.

Sites	MacKay River (Mainstem)				Dunkirk River		Dover River	
	2	4	5	6	9	10	12	13
Chironomidae	30	52	59	91	56	42	22	51
Simuliidae	0	23	1	<1	<1	0	0	2
Ephemeroptera	35	9	3	5	11	0	2	0
Plecoptera	0	3	2	<1	<1	0	0	0
Trichoptera	<1	<1	2	1	2	0	0	0
Oligochaeta	3	9	19	1	2	30	56	16
Other taxa	32	4	14	1	28	28	20	31
Number Animals Counted	344	156	628	1152	1013	114	93	68
Percentage of Sample Counted	50	100	100	100	100	100	100	100

Table 63. Percentage composition by numbers for major benthic macroinvertebrate groups at each sampling site in the MacKay River watershed, 15 to 17 June 1978.

	MacKay River (Mainstem)					Dunkirk River		Dover River	
Sites	3	4	5	6	7	9	10	12	13
Chironomidae	11	43	47	36	5	25	61	8	36
Simuliidae	8	0	0	0	0	6	0	0	0
Ephemeroptera	53	30	37	29	3	28	0	65	7
Plecoptera	<1	0	0	0	0	<1	0	0	0
Trichoptera	2	3	2	6	<1	4	0	1	2
Oligochaeta	2	14	9	<1	<1	7	11	2	16
Other taxa	23	8	5	28	91	29	29	23	39
Number Animals Counted	1131	502	803	605	1235	3518	28	1038	370
Percentage of Sample Counted	100	50	50	25	100	100	100	25	50

Table 64. Percentage composition by numbers for major benthic macroinvertebrate groups at each sampling site in the MacKay River watershed, 14 to 15 July 1978.

	MacKay River (Mainstem)				Dunkirk River		Dover River
Site	2	4	5	6	9	10	13
Chironomidae	3	50	43	33	49	54	16
Ephemeroptera	21	21	30	35	37	11	16
Trichoptera	5	7	5	3	2	3	4
Oligochaeta	0	9	<1	<1	<1	6	3
Other taxa	71	13	23	28	11	26	62
					(<1 Odonata)		
Number Animals Counted	1503	271	463	390	298	35	1538
Percentage of Sample Counted	50	100	100	100	100	25	50

Table 65. Percentage composition by numbers for major benthic macroinvertebrate groups at each sampling site in the MacKay River watershed, 16 to 17 August 1978.

	MacKay River (Mainstem)					Dunkirk River			Snipe Creek	Dover River		Snipe Lake
Sites	2	3	5	6	7	8	9	10	11	12	13	16
Chironomidae	23	55	31	44	67	41	67	88	50	32	65	28
Ephemeroptera	35	12	15	11	8	9	7	1	4	25	12	1
Trichoptera	11	2	14	3	3	3	5	<1	0	5	<1	0
Oligochaeta	2	15	0	4	17	2	2	3	0	5	<1	16
Other taxa	29	16	40	38	5	44	19	8	46	33	22	55
Number Animals Counted	454	1129	329	950	167	86	956	547	24	495	338	159
Percentage of Sample Counted	100	100	12.5	25	25	12.5	25	100	100	100	100	100

Table 66. Percentage composition by numbers for major benthic macroinvertebrate groups at each sampling site in the MacKay River watershed, 10 to 14 October 1978.

	MacKay River (Mainstem)					Dunkirk River			Dover River	
Sites	2	3	4	5	6	8	9	10	12	13
Chironomidae	39	24	53	45	72	64	52	55	7	49
Ephemeroptera	31	5	0	21	2	10	20	< 1	< 1	< 1
Trichoptera	1	0	0	8	< 1	< 1	< 1	< 1	0	< 1
Oligochaeta	3	49	0	3	< 1	< 1	4	0	77	2
Other taxa	26	22	47	23	24	25	24	40	15	48
Number Animals Counted	204	41	17	288	309	679	342	839	213	718
Percentage of Animals Counted	100	100	100	50	12.5	100	100	25	25	50

8.10 PERCENTAGE COMPOSITION BY NUMBERS FOR MAJOR BENTHIC MACRO-INVERTEBRATES (IDENTIFIED TO FAMILY) AT EACH SAMPLING SITE IN THE MacKAY RIVER WATERSHED, 20 to 22 MAY 1978 (TABLE 67).

Table 67. Percentage composition by numbers for major benthic macroinvertebrates (identified to family) at each sampling site in the MacKay River watershed, 20 to 22 May 1978.

	MacKay River (Mainstem)			Dunkirk River		Dover River
Sites	4	5	6	9	10	13
Trichoptera						
Limnephilidae	0	0	<1	0	0	0
Leptoceridae	0	<1	<1	0	0	0
Hydropsychidae	0	1	<1	1	0	0
Brachycentridae	0	<1	0	<1	0	0
Heliopsychidae	0	0	0	<1	0	0
Glossosomatidae	0	0	0	<1	0	0
Unidentified	<1	<1	0	0	0	0
Ephemeroptera						
Baetidae	0	3	4	6	0	0
Caenidae	0	0	<1	0	0	0
Siphlonuridae	6	0	0	0	0	0
Ephemerellidae	0	0	0	<1	0	0
Baetiscidae	0	0	0	<1	0	0
Ephemerillidae	0	0	0	4	0	0
Heptageniidae	0	0	0	<1	0	0
Unidentified	3	<1	<1	0	0	0
Plecoptera						
Perlodidae	0	<1	<1	<1	0	0
Nemouridae	0	<1	<1	0	0	0
Pteronarcidae	2	1	0	<1	0	0
Chloroperlidae	0	1	0	1	0	0
Unidentified	1	0	0	0	0	0

continued ...

Table 67. Concluded.

	MacKay River (Mainstem)			Dunkirk River		Dover River
Sites	4	5	6	9	10	13
Diptera						
Simuliidae	23	1	<1	<1	0	2
Psychodidae	0	0	<1	0	0	0
Empididae	2	1	<1	<1	0	0
Chironomidae	52	59	91	56	42	51
Ceratopogonidae	<1	0	<1	<1	8	11
Dolichopodidae	<1	0	0	0	<1	0
Unidentified	0	0	<1	0	<1	0
Coleoptera						
Elmidae	0	0	0	2	0	0
Odonata						
Gomphidae	2	<1	0	<1	0	0
Collembola	0	0	0	0	<1	0
Mollusca						
Sphaeridae	0	1	0	22	0	2
Planorbidae	0	0	0	<1	0	7
Physidae	0	0	0	0	4	0
Acarina	2	1	<1	2	4	7
Nematoda	0	10	<1	<1	8	15
Oligochaeta	9	19	1	2	30	16
Copepoda	0	0	<1	<1	4	0
Number Animals Counted	156	628	52	1013	114	68
Percentage of Sample Counted	100	100	100	100	100	100

9. AOSERP RESEARCH REPORTS

1.		AOSERP First Annual Report, 1975
2.	AF 4.1.1	Walleye and Goldeye Fisheries Investigations in the Peace-Athabasca Delta--1975
3.	HE 1.1.1	Structure of a Traditional Baseline Data System
4.	VE 2.2	A Preliminary Vegetation Survey of the Alberta Oil Sands Environmental Research Program Study Area
5.	HY 3.1	The Evaluation of Wastewaters from an Oil Sand Extraction Plant
6.		Housing for the North--The Stackwall System
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8.	AF 1.2.1	The Impact of Saline Waters upon Freshwater Biota (A Literature Review and Bibliography)
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13.	ME 2.3.1	Plume Dispersion Measurements from an Oil Sands Extraction Plant, March 1976
14.		
15.	ME 3.4	A Climatology of Low Level Air Trajectories in the Alberta Oil Sands Area
16.	ME 1.6	The Feasibility of a Weather Radar near Fort McMurray, Alberta
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18.	HY 1.1	Interim Compilation of Stream Gauging Data to December 1976 for the Alberta Oil Sands Environmental Research Program
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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
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25.	ME 3.5.1	Review of Pollutant Transformation Processes Relevant to the Alberta Oil Sands Area

26.	AF 4.5.1	Interim Report on an Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta
27.	ME 1.5.1	Meteorology and Air Quality Winter Field Study in the AOSERP Study Area, March 1976
28.	VE 2.1	Interim Report on a Soils Inventory in the Athabasca Oil Sands Area
29.	ME 2.2	An Inventory System for Atmospheric Emissions in the AOSERP Study Area
30.	ME 2.1	Ambient Air Quality in the AOSERP Study Area, 1977
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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.
47.	TF 1.1.1	A Visibility Bias Model for Aerial Surveys for Moose on the AOSERP Study Area
48.	HG 1.1	Interim Report on a Hydrogeological Investigation of the Muskeg River Basin, Alberta
49.	WS 1.3.3	The Ecology of Macrobenthic Invertebrate Communities in Hartley Creek, Northeastern Alberta
50.	ME 3.6	Literature Review on Pollution Deposition Processes
51.	HY 1.3	Interim Compilation of 1976 Suspended Sediment Date in the AOSERP Study Area
52.	ME 2.3.2	Plume Dispersion Measurements from an Oil Sands Extraction Plan, June 1977

53. HY 3.1.2 Baseline States of Organic Constituents in the Athabasca River System Upstream of Fort McMurray
54. WS 2.3 A Preliminary Study of Chemical and Microbial Characteristics of the Athabasca River in the Athabasca Oil Sands Area of Northeastern Alberta
55. HY 2.6 Microbial Populations in the Athabasca River
56. AF 3.2.1 The Acute Toxicity of Saline Groundwater and of Vanadium to Fish and Aquatic Invertebrates
57. LS 2.3.1 Ecological Habitat Mapping of the AOSERP Study Area (Supplement): Phase I
58. AF 2.0.2 Interim Report on Ecological Studies on the Lower Trophic Levels of Muskeg Rivers Within the Alberta Oil Sands Environmental Research Program Study Area
59. TF 3.1 Semi-Aquatic Mammals: Annotated Bibliography
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64. LS 21.6.1 A Review and Assessment of the Baseline Data Relevant to the Impacts of Oil Sands Development on Large Mammals in the AOSERP Study Area
65. LS 21.6.2 A Review and Assessment of the Baseline Data Relevant to the Impacts of Oil Sands Development on Black Bears in the AOSERP Study Area
66. AS 4.3.2 An Assessment of the Models LIRAQ and ADPIC for Application to the Athabasca Oil Sands Area
67. WS 1.3.2 Aquatic Biological Investigations of the Muskeg River Watershed
68. AS 1.5.3 AS 3.5.2 Air System Summer Field Study in the AOSERP Study Area, June 1977
69. HS 40.1 Native Employment Patterns in Alberta's Athabasca Oil Sands Region
70. LS 28.1.2 An Interim Report on the Insectivorous Animals in the AOSERP Study Area
71. HY 2.2 Lake Acidification Potential in the Alberta Oil Sands Environmental Research Program Study Area
72. LS 7.1.2 The Ecology of Five Major Species of Small Mammals in the AOSERP Study Area: A Review
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74. AS 4.5 Air Quality Modelling and User Needs
75. WS 1.3.4 Interim Report on a Comparative Study of Benthic Algal Primary Productivity in the AOSERP Study Area
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78. LS 22.1.1 Habitat Relationships and Management of Terrestrial Birds in Northeastern Alberta

79.	AF 3.6.1	The Multiple Toxicity of Vanadium, Nickel, and Phenol to Fish.
80.	HS 10.2 & HS 10.1	History of the Athabasca Oil Sands Region, 1980 to 1960's. Volumes I and II.
81.	LS 22.1.2	Species Distribution and Habitat Relationships of Waterfowl in Northeastern Alberta.
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83.	LS 22.2	The Distribution, Foraging Behaviour, and Allied Activities of the White Pelican in the Athabasca Oil Sands Area.
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