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Growth, Feeding and Fecundity of Fish in Gleniffer Lake (Dickson Dam Reservoir)

Alberta
ENVIRONMENTAL CENTRE

GROWTH, FEEDING AND FECUNDITY OF FISH IN GLENIFFER LAKE (DICKSON DAM RESERVOIR)

by

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TABLE OF CONTENTS

		Page
	LIST OF TABLES	iii
	LIST OF FIGURES	v
	SUMMARY	vii
	PROJECT TEAM	ix
	ACKNOWLEDGMENTS	ix
1.	INTRODUCTION	1
	1.1 Background	1
	1.2 Purpose of Study	1
2.	STUDY AREA	4
	2.1 Red Deer River	4
	2.2 History of Dam and Reservoir Facility	4
	2.3 History of Fish Plantings	5
3.	MATERIALS AND METHODS	5
	3.1 Fish Collections	5
	3.1.1 Beach Seine	5
	3.1.2 Gill Net	9
	3.2 Aging Methods	10
	3.3 Stomach Content Analysis	11
	3.4 Fecundity Analysis	11
	3.5 Statistical Methods	12
4.	RESULTS	12
	4.1 Length/Weight Relation	12
	4.2 Length/Age Relation	19

TABLE OF CONTENTS

Page

4.3 Stomach Contents 27

4.3.1 Mountain Whitefish 27

4.3.2 Rainbow Trout 27

4.3.3 Northern Pike 28

4.3.4 Burbot 28

4.4 Fecundity 28

5. DISCUSSION 32

REFERENCES 39

LIST OF TABLES

Table 1. Summary of information on Dickson Dam, Gleniffer Lake and surrounding area 6

Table 2. Summary of fish plantings carried out at Gleniffer Lake .. 7

Table 3. Description of beach seine sites 7

Table 4. Aging structures used in this study 9

Table 5. Regression parameters relating wet weight (g) (dependent variable) to fork length (mm) (independent variable) in fish caught by gill net from Gleniffer Lake during 1984-1987 13

Table 6. t-test of regression slops relating age to weight for fish caught during 1984, 1985, 1986 and 1987 19

LIST OF TABLES (continued)

Page

Table 7. Regression parameters relating fork length (mm) (independent variable) to age (years) (dependent variable) in fish caught by gill net from Gleniffer Lake during 1984-1987 20

Table 8. t-test of regression slopes relating age to fork length for fish caught during 1984, 1985, 1986 and 1987 21

Table 9. Fork length (mm) of fish of standard age (years) collected by gill net from Gleniffer Lake during 1984-1987 27

Table 10. Summary of stomach content analyses 29

Table 11. Consumption of fish by northern pike and burbot in Gleniffer Lake 1984-87 30

Table 12. Regression parameters relating length (mm) to calculated total number of eggs in fish caught by gill net from Gleniffer Lake during 1984-1987 32

Table 13. Mean fork length (mm) of mountain whitefish at age 3+ and 6+ years in various lakes and rivers 33

Table 14. Mean fork length (mm) of rainbow trout at age 3+ and 6+ years in various lakes 34

Table 15. Mean fork length (mm) of northern pike at age 3+ and 6+ years in various Alberta lakes 36

Table 16. Mean fork length (mm) of burbot at age 3+ and 6+ years in various lakes 37

Table 17. Mean fork length (mm) of white sucker at age 3+ and 6+ years in various lakes 38

LIST OF TABLES (continued)

Page

Table 18. Mean fork length (mm) of longnose sucker at age 3+ and 6+ years in various lakes and rivers 38

LIST OF FIGURES

Figure 1. Location of Gleniffer Lake 2

Figure 2. Beach seine sampling sites 8

Figure 3. Gill net sampling sites 8

Figure 4. Linear regression analysis (±95% confidence limits) relating weight to length of mountain whitefish and rainbow trout collected by gill net from Gleniffer Lake during 1984-87 14

Figure 5. Linear regression analysis (±95% confidence limits) relating weight to length of northern pike collected by gill net from Gleniffer Lake during 1984-87 15

Figure 6. Linear regression analysis (±95% confidence limits) relating weight to length of burbot collected by gill net from Gleniffer Lake during 1984-87 16

Figure 7. Linear regression analysis (±95% confidence limits) relating weight to length of longnose sucker collected by gill net from Gleniffer Lake during 1984-87 17

LIST OF FIGURES

Page

Figure 8. Linear regression analysis (±95% confidence limits) relating weight to length of white sucker collected by gill net from Gleniffer Lake during 1984-87 18

Figure 9. Linear regression analysis (±95% confidence limits) relating length to age of mountain whitefish and rainbow trout collected by gill net from Gleniffer Lake during 1984-87 22

Figure 10. Linear regression analysis (±95% confidence limits) relating length to age of northern pike collected by gill net from Gleniffer Lake during 1984-87 23

Figure 11. Linear regression analysis (±95% confidence limits) relating length to age of burbot collected by gill net from Gleniffer Lake during 1984-87 24

Figure 12. Linear regression analysis (±95% confidence limits) relating length to age of white sucker collected by gill net from Gleniffer Lake during 1984-87 25

Figure 13. Linear regression analysis (±95% confidence limits) relating length to age of longnose sucker collected by gill net from Gleniffer Lake during 1984-87 26

Figure 14. Linear regression analysis (±95% confidence limits) relating length to calculated total number of eggs of burbot, northern pike, rainbow trout, longnose sucker and white sucker collected by gill net from Gleniffer Lake during 1984-87 31

SUMMARY

Fish were collected by gill net and beach seine from a newly formed reservoir (Gleniffer Lake, Alberta) during a four-year period (1984-1987). The reservoir is located west of the City of Red Deer on the Red Deer River. Collections were made in the reservoir at standard sites and times throughout the study. Length, weight and age were determined for mountain whitefish (Prosopium williamsoni), northern pike (Esox lucius), burbot (Lota lota), white sucker (Catostomus commersoni), and longnose sucker (Catostomus catostomus). In addition, stomach content analysis was completed on mountain whitefish, rainbow trout, northern pike and burbot; fecundity was determined for rainbow trout (Oncorhynchus mykiss), northern pike, burbot, white sucker and longnose sucker. From these collections it was observed that:

i) mountain whitefish were initially trapped by the impoundment of the Red Deer River, but either died out or emigrated from the reservoir by 1985;

ii) growth of mountain whitefish and rainbow trout from the reservoir was greater than that observed for populations in many other Alberta lakes;

iii) based on back-calculated growth rates, young (<3 years old) northern pike apparently grew better in the Red Deer River than Gleniffer Lake whereas older pike (6+ years old) grew better in the reservoir than the river; this may have

reflected a temporary reduction in food for young pike in the first years after impoundment;

iv) although growth of burbot was largely unaffected by impoundment, reduced growth of young burbot was noted during 1985;

v) white sucker and longnose sucker grew significantly faster in the reservoir than the Red Deer River;

vi) although rainbow trout were planted in large numbers in the reservoir, they did not form a significant part of the diet of predacious species such as northern pike and burbot;

vii) the diet of mountain whitefish and rainbow trout was typical of that reported elsewhere in Canada and the USA;

viii) fecundity of rainbow trout, northern pike, burbot, white sucker, and longnose sucker was typical of that reported for other northern temperate zone lakes.

PROJECT TEAM

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1. INTRODUCTION

1.1 Background

Gleniffer Lake, located on the Red Deer River west of the City of Red Deer, was formed with the completion of the Dickson Dam in 1983 (Figure 1). The reservoir has an area of 1734 ha at full storage and measures approximately 11 km in length and 2 km in width. The facility provides two primary benefits: i) an assured water supply for downstream communities, and ii) improved water quality downstream.

During the spring and summer, runoff water is captured in the reservoir. Enough water is released during the winter to ensure a minimum flow of at least 16 $m^3 s^{-1}$. This rate of flow meets the present needs of downstream industries and communities including the Cities of Red Deer and Drumheller, and allows for future growth.

1.2 Purpose of Study

Because of its size and accessibility, the reservoir has the potential to become a significant sport fishing facility. The purpose of this report is to describe the growth, feeding and fecundity of major fish species in the reservoir. Such information is useful in managing the fisheries and, in particular, determining the nature and extent of fish plantings, and the relative success of different fish species.

A previous report (Alberta Environmental Centre, 1989a) concerning fish in the reservoir indicated that:

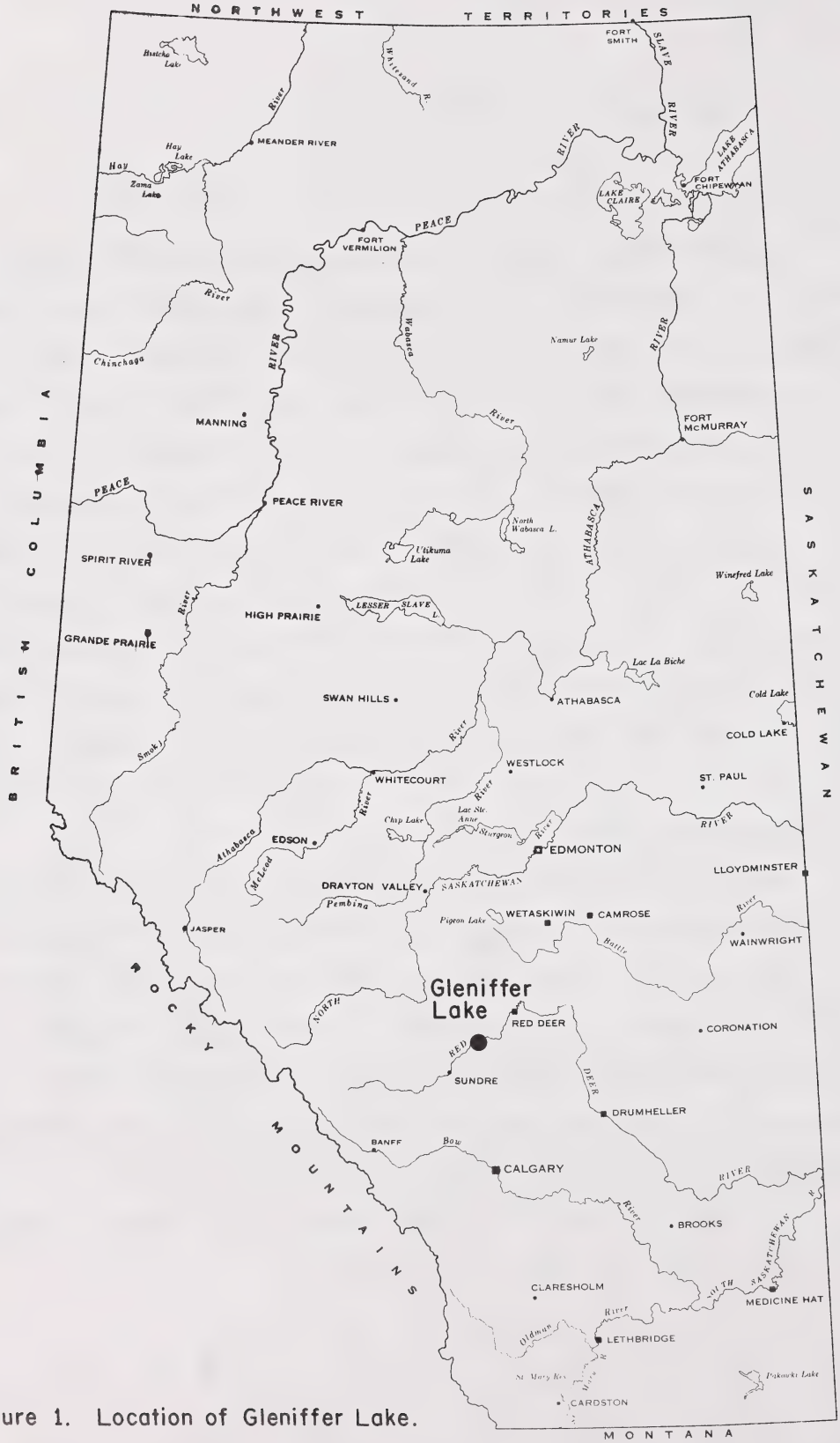

Figure 1. Location of Gleniffer Lake.

i) the most frequently captured species in the reservoir were white sucker (Catostomus commersoni), longnose sucker (Catostomus catostomus), northern pike (Esox lucius), and burbot (Lota lota). Although rainbow trout (Oncorhynchus mykiss) had been planted in large numbers in the reservoir, they made up only a small part of the catch;

ii) the catch per unit effort (CUE) using gill nets was low, ranging from 1 - 4.7 fish (all species) per 1000 m net per h;

iii) planted rainbow trout and brown trout (Salmo trutta) apparently failed to spawn in the reservoir;

iv) the populations of northern pike, white sucker, longnose sucker and burbot apparently expanded immediately after impoundment, and later decreased in numbers;

v) the most frequently captured fish by anglers were rainbow trout, brown trout and northern pike;

vi) the CUE for angling was extremely low; depending on year, 11-45 h were required to angle one fish.

Another report (Alberta Environmental Centre, 1989b) concerning mercury in fish from the reservoir indicated that:

i) residues were low, generally <500 $\mu g\ kg^{-1}$ (0.5 ppm) in all species;

ii) there was no increase in tissue residues as the reservoir aged;

iii) no limits needed to be placed on consumption of fish from Gleniffer Lake.

2. STUDY AREA

2.1 Red Deer River

The Red Deer River originates in Banff National Park at an elevation of approximately 1830 m above sea level. The river flows 185 km through the Rocky Mountains to Gleniffer Lake which is at an elevation of 948 m above sea level at Full Storage Level (FSL). The drainage area to this point is 5520 km^2. The river continues a further 571 km eastward across parkland and prairies where it joins the South Saskatchewan River near Alberta's border with Saskatchewan.

2.2 History of Dam and Reservoir Facility

Technical studies began in 1971 and, after five years of investigations and a series of public hearings, a decision was made to build the dam. Clearing of the site and construction of access roads began in February 1980. By the spring of 1983, the dam was completed and the reservoir began filling.

The service spillway can handle any major flood of a magnitude occurring once in 10,000 years. In the unlikely event of a larger flood, an emergency spillway could be used to divert excess flow. A flood forecasting system using remote rainfall gauges and satellite communications gives early warning to operators about oncoming floods. The diversion tunnels are equipped for installation of hydroelectric power facilities, if needed. A summary of information on the dam and reservoir is listed in Table 1.

2.3 History of Fish Plantings

Rainbow trout and cutthroat trout (Salmo clarki) were first planted in Gleniffer Lake in 1983 (Table 2). The introductions of rainbow trout continued through 1987, but no further cutthroat trout were planted beyond 1983. Brown trout were introduced to the reservoir only during 1984. Total plantings for all species exceeded one million fish.

3. MATERIALS AND METHODS

3.1 Fish Collections

Fish used in this study were collected with gill nets and beach seine during 1984, 1985, 1986 and 1987.

3.1.1 Beach Seine

The seine net was 18 m in length, 1.8 m in depth with a center bag of 1.8 m x 1.8 m. The mesh was 6.4 mm delta white nylon except for the bag which had a mesh of 3.2 mm.

Four sites in each of three basins (west, central and east) were selected for a total of 12 sites (Figure 2, Table 3). These sites were sampled once a month from May through September.

After capture, fish were given a lethal dose of the anaesthetic MS222, weighed and measured, and then preserved in 10% formalin for later identification and enumeration. Stomach contents and gonads were preserved in a 10% formalin solution.

Table 1. Summary of information on Dickson Dam, Gleniffer Lake and surrounding area.

DAM	
Crest Length	650 m
Height	40 m
Volume of Fill	3,600,000 m^3
Crest Elevation	952 m
TUNNELS (2)	
Length	525 m
Diameter	5.5 m
Design Discharge	38 $m^3 s^{-1}$
SPILLWAY	
Weir Elevation	940.5 m
Weir Length	60 m
Structure Length	235 m
Vertical Gates (5)	8.6 x 9.6 m
Design Discharge	2,600 $m^3 s^{-1}$
EMERGENCY SPILLWAY	
Channel Width	130 m
Design Discharge	2,800 $m^3 s^{-1}$
RESERVOIR	
Flooded Area (Full Storage LeveL)	1,734 ha
Usable Storage	203 10^6 m^3
Reservoir Length	11 km
Reservoir Width	2 km
Full Storage Level	948 m elevation
Annual Flush Rate	5.5 x
Proportion of Incoming Sediment Retained	88 %
Annual Amount of Sediment Retained	290,000 m^3
Life Expectancy	500 yrs
DYKES	
Length (North Side)	3.0 km
Length (South Side)	3.7 km
DRAINAGE BASIN	
Area	5,520 km^2
Mean Run-off	32 $m^3 yr^{-1}$

Table 2. Summary of fish plantings carried out at Gleniffer Lake.

Year	Species	Month(s) Planted	Number Planted	Length (cm)
1983	Rainbow Trout	Sept.	61,557	4.8- 20
1983	Cutthroat Trout	Sept.	135,635	~ 5.5
1984	Rainbow Trout	June, Aug., Sept.	152,600	6.4 - >20
1984	Brown Trout	Aug., Sept.	67,100	5.2 - >20
1985	Rainbow Trout	May, June, Aug.	498,500	5.6 - 12
1986	Rainbow Trout	Aug.	180,00	>15
1986	Rainbow Trout	Sept., Oct.	375	>20
1987	Rainbow Trout	Aug.	242	>20
TOTALS 83-87	Rainbow Trout		893,274	4.8- >20
	Cutthroat Trout		135,635	5.5
	Brown Trout		67,100	5.2- >20
GRAND TOTAL	Trout (all species)		1,096,009	4.8 - >20

SOURCE: Fish Planting Lists (1983-1987) issued by Alberta Forestry, Lands and Wildlife.

Table 3. Description of beach seine sites.

Location (see Fig. 2)	Maximum Depth (m)	Description of Bottom Texture
East A	2	Cobble, sand
East B	2	Soft sand/clay
East C	2	Gravel, soft sand/clay
East D	7.5	Cobble
Central A	2.5	Sand/gravel
Central B	3	Sand
Central C	2	Soft sand/clay
Central D	4.5	Cobble, some sand
West A	4	Sand
West B	2.5	Sand
West C	3	Cobble, sand
West D	4	Sand

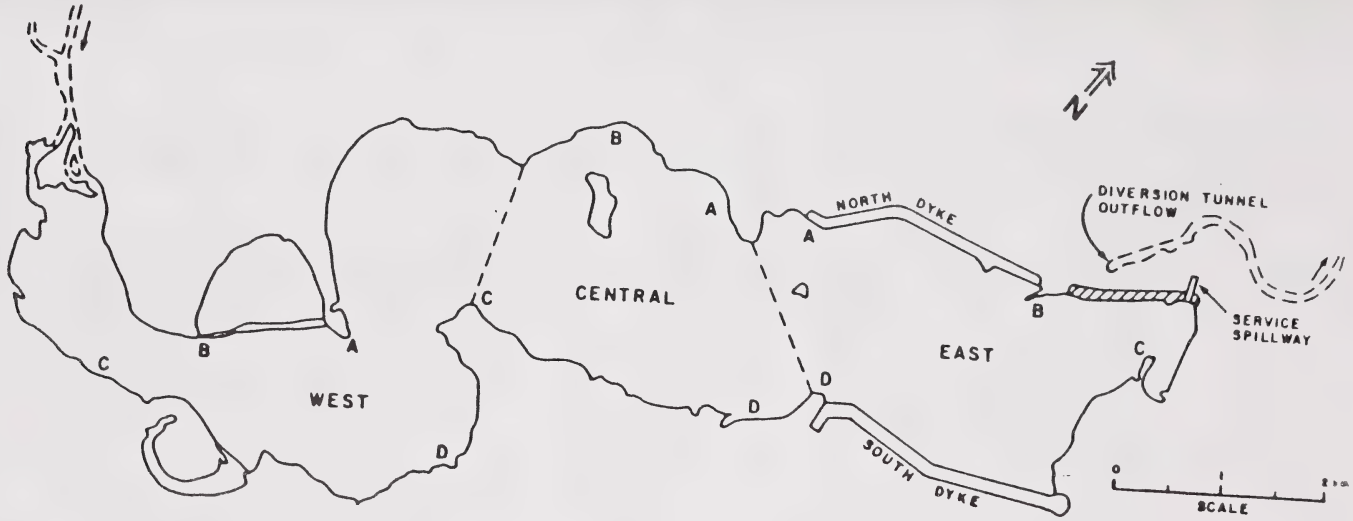

Figure . . . n seine sampling sites.

Figure 3. Gill net sampling sites. Deep set (>10 m); shallow set (<10 m).

3.1.2 Gill Net

Multi-panel gill nets, measuring 50 m in length, were used in all collections. The nets, 1.8 m deep, were made of green or colourless monofilament nylon. Two nets were usually tied together, yielding a total length of 100 m. Mesh sizes were 1.9, 2.5, 3.8, 5.1, 5.4, 7.6, 8.9, 10.2, 11.4 and 12.7 cm.

There were two sampling sites in each of the three basins (Figure 3). One site was situated in shallow (<10 m) water and the other in deep (>10 m) water. Selection of an actual site was based on its suitability for gill netting, specifically minimum slope and minimum debris content.

Each net was set in the morning and left for 24 h. The fish were taken to a field laboratory where the species, fork length, and wet weight of each fish were determined. Condition factor ($Weight^3$/Fork Length) was calculated. Stomach contents and ovaries were preserved in a 10% formalin solution. Aging structures were also taken (Table 4).

Table 4. Aging structures used in this study.

Species	Structure	Year
Mountain Whitefish	Fin ray	1984
Rainbow Trout	Fin ray	1986
Burbot	Otolith	1984, 1985, 1986
Northern Pike	Cleithrum Operculum	1985, 1986, 1987 1984
White Sucker	Fin ray Scales	1984, 1986, 1987 1985
Longnose Sucker	Fin ray	All years

3.2 Aging Methods

All aging structures were placed in labelled envelopes. In the laboratory, the envelopes and structures were frozen at -20°C until preparation. The preparation procedures used prior to aging were:

Scales

- Five scales were selected at random.
- The scales were cleaned with water and/or mildly basic solution and placed between two glass slides.
- The sides were taped, labelled and stored in a slide tray.

Fin Rays

- Two fin rays were air dried for 2-5 days.
- The proximal end of each ray was coated with epoxy and allowed to set for 24 h.
- The ray was cut into 1-mm sections using a jeweller's saw.
- The sections were mounted with Diatex mounting fluid on a glass slide.
- The slides were labelled and stored in a slide tray.

Cleithra and Opercula

- One of each structure was first cleaned with warm water and soft brushes, then air dried and allowed to clear.
- Both structures were returned to the labelled scale envelope before evaluation.

Otoliths

- Two otoliths were removed from each fish.
- Larger otoliths were sectioned and allowed to air dry. Small otoliths were air dried without sectioning.
- All structures were returned to the labelled envelope before evaluation.

Ages were determined for each specimen through the enumeration of annuli.

3.3 Stomach Content Analysis

The field-preserved stomach samples of rainbow trout, northern pike, mountain whitefish and burbot were sorted in the laboratory and identified according to five taxonomic classifications. Ingested fish were identified to species whenever possible. After identification, the samples were dried at 55°C to constant weight. Stomachs of other species were not examined due to time and financial restraints.

3.4 Fecundity Analysis

The ovary was sampled in six areas (2 x posterior, 2 x middle, 2 x anterior). A total of 1000 eggs (250 for rainbow trout) was counted from each of the six samples. The enumerated eggs were then dried to constant weight. The remainder of the ovary was also dried, thereby permitting an estimate to be made of total egg numbers.

Because mountain whitefish were caught only in 1984, at a time prior to sexual maturation, no determination of fecundity could be made of that species.

3.5 Statistical Analysis

The following relationships were expressed as linear regressions: fork length-weight, fork length-age, fork length-number of eggs. Linear regression was used because it provided the best fit for the majority of data. The regression slopes relating fork length to age and fork length to weight were analyzed using the t-test.

4. RESULTS

4.1 Length/Weight Relation

The species collected in sufficient numbers to warrant analysis were northern pike, white sucker, longnose sucker, mountain whitefish, burbot, and rainbow trout. Mountain whitefish were collected only during 1984 whereas rainbow trout were collected in sufficient numbers to warrant analysis during 1986 and 1987. Only 3 brown trout, 1 brook trout (Salvelinus fontinalis) and 1 dolly varden (Salvelinus malma) and no cutthroat trout were caught during the entire study.

The linear regressions relating wet weight to fork length of the above-noted species are listed in Table 5 and graphed in Figures 4-8. The slopes of these regressions were analyzed using t-test (Table 6). In the case of rainbow trout and northern pike, there were no significant differences among slopes during the study. This means that the length-weight relationship remained constant for both species in all years. Burbot, on the other hand, carried more weight in fish of standard length caught in 1986 and 1987 compared to 1985. This can possibly be related to improved feeding conditions as the reservoir

Table 5. Regression parameters relating wet weight (g) (dependent variable) to fork length (mm) (independent variable) in fish caught by gill net from Gleniffer Lake during 1984-1987.

Year	Slope	Y-intercept	r^2	Mean Condition Factor*	N
		MOUNTAIN WHITEFISH			
1984	1.991	-318	0.89	1.06	24
		RAINBOW TROUT			
1986	13.38	-4893	0.96	1.33	11
1987	8.15	-2236	0.60	1.43	6
		NORTHERN PIKE			
1984	6.063	-1905	0.59	0.89	23
1985	8.201	-3018	0.90	0.82	35
1986	7.685	-2740	0.86	0.77	20
1987	6.946	-2148	0.85	0.76	25
		BURBOT			
1984	3.366	-861	0.89	0.61	11
1985	4.595	-1441	0.91	0.57	10
1986	5.472	-1796	0.90	0.59	13
1987	6.968	-2870	0.97	0.50	6
		WHITE SUCKER			
1984	5.069	-1110	0.91	1.47	31
1985	3.831	-694	0.94	1.37	54
1986	4.939	-1087	0.93	1.39	50
1987	4.959	-1078	0.94	1.44	67
		LONGNOSE SUCKER			
1984	3.876	-762	0.91	1.35	56
1985	5.376	-1304	0.88	1.32	117
1986	6.161	-1621	0.84	1.30	116
1987	5.048	-1168	0.93	1.27	80

* $Weight^3/Length$

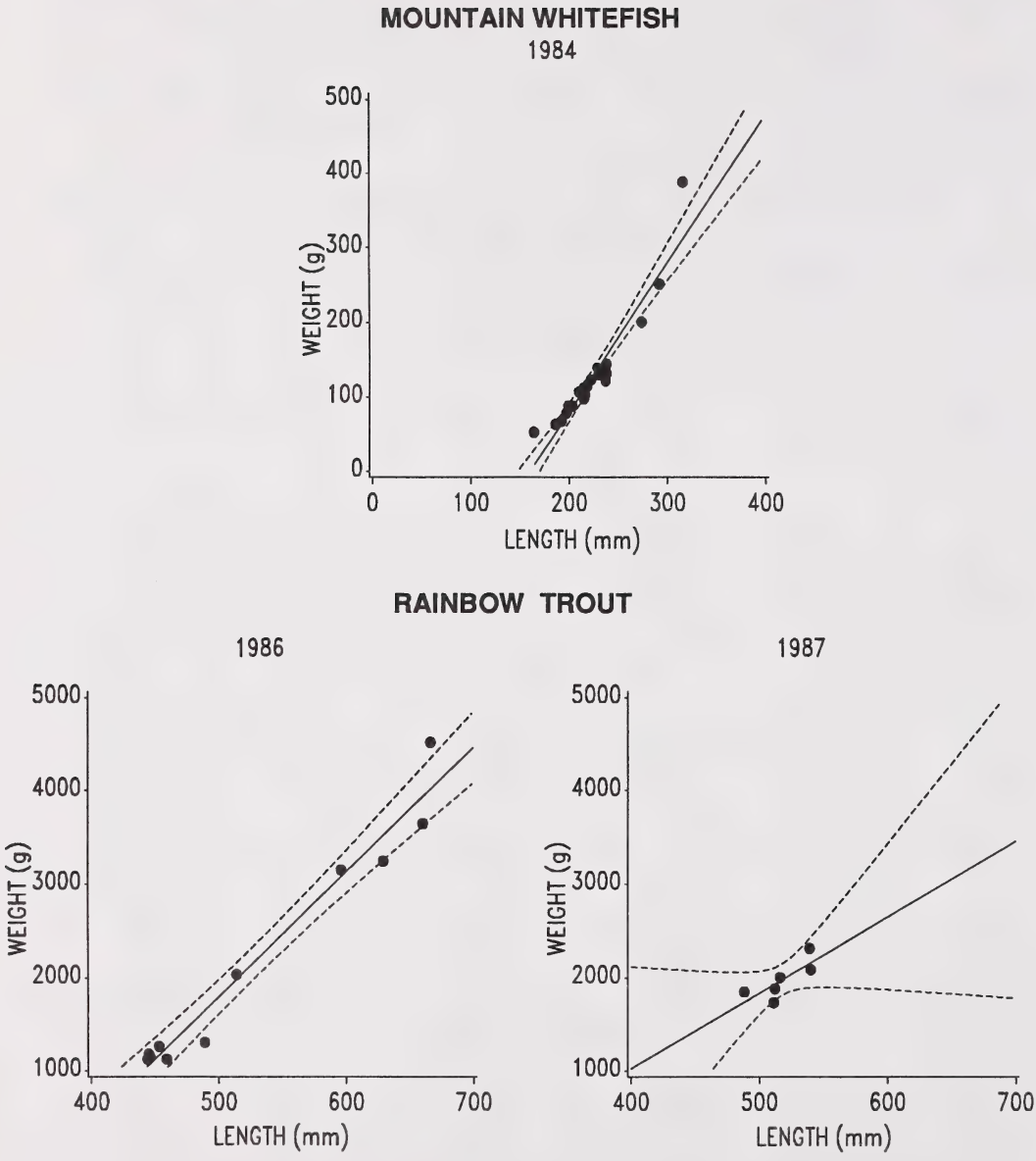

Figure 4. Linear regression analysis (±95% confidence limits) relating weight to length of mountain whitefish and rainbow trout collected by gill net from Gleniffer Lake during 1984-87.

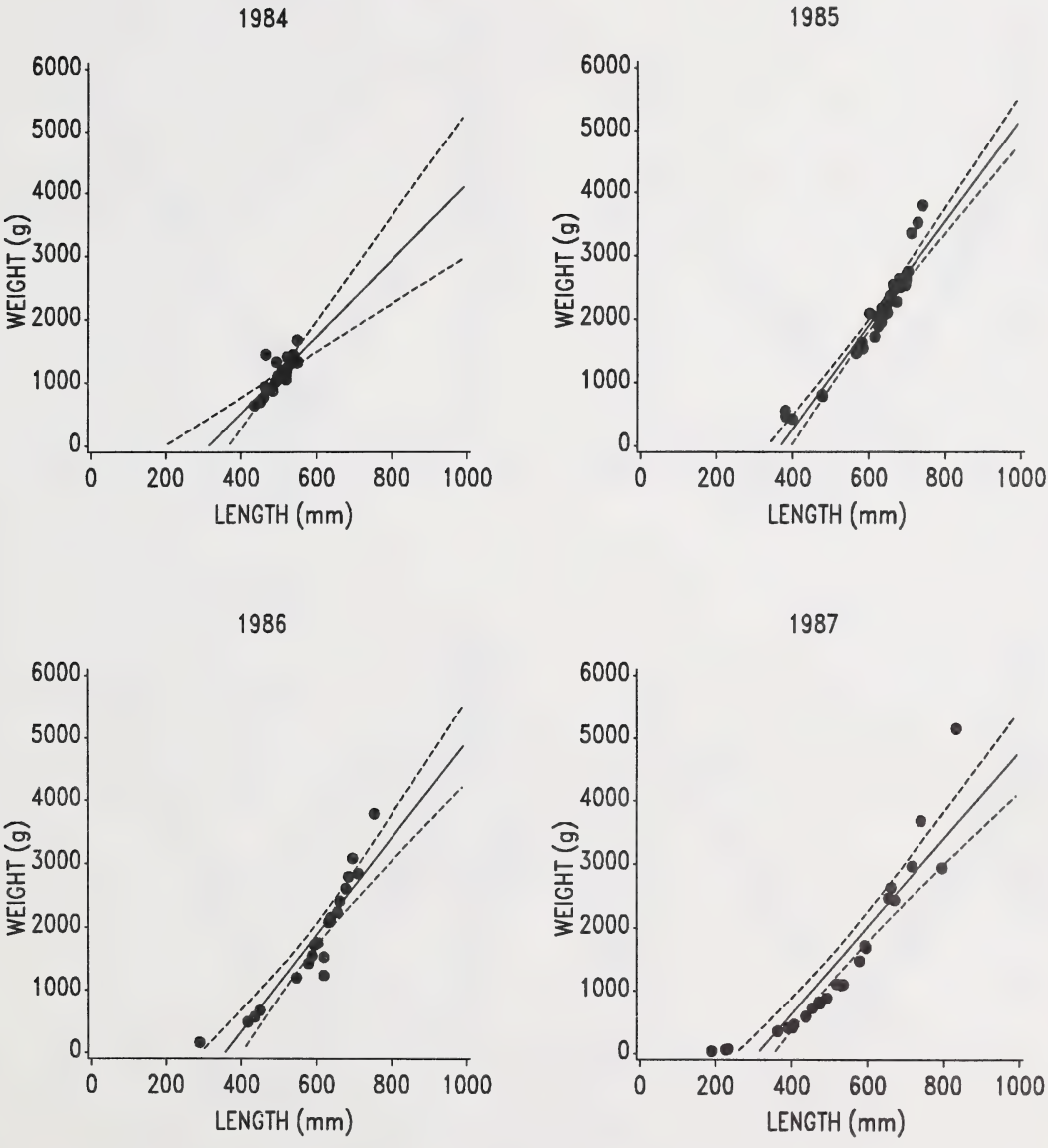

Figure 5. Linear regression analysis (±95% confidence limits) relating weight to length of northern pike collected by gill net from Gleniffer Lake during 1984-87.

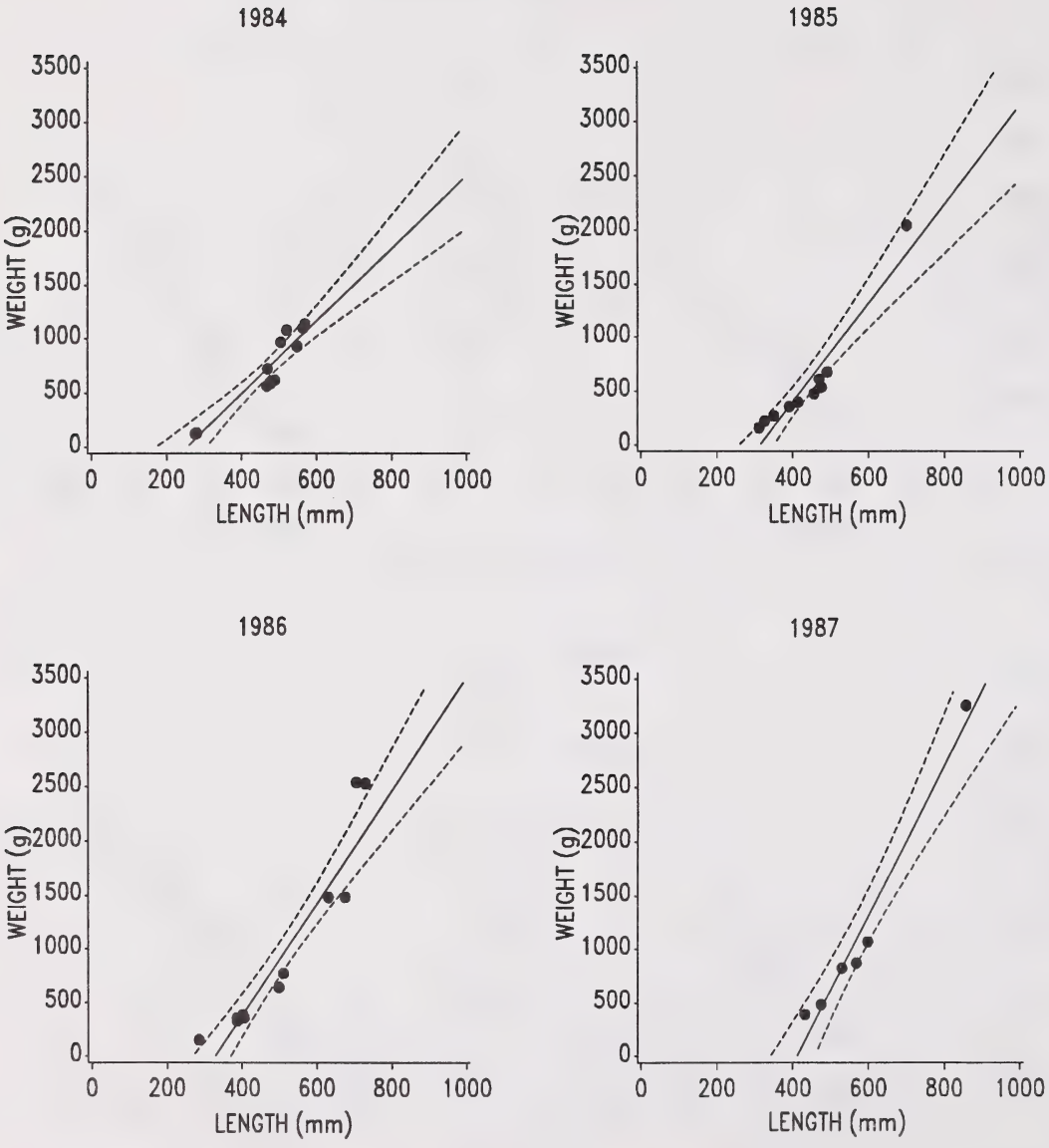

Figure 6. Linear regression analysis (±95% confidence limits) relating weight to length of burbot collected by gill net from Gleniffer Lake during 1984-87.

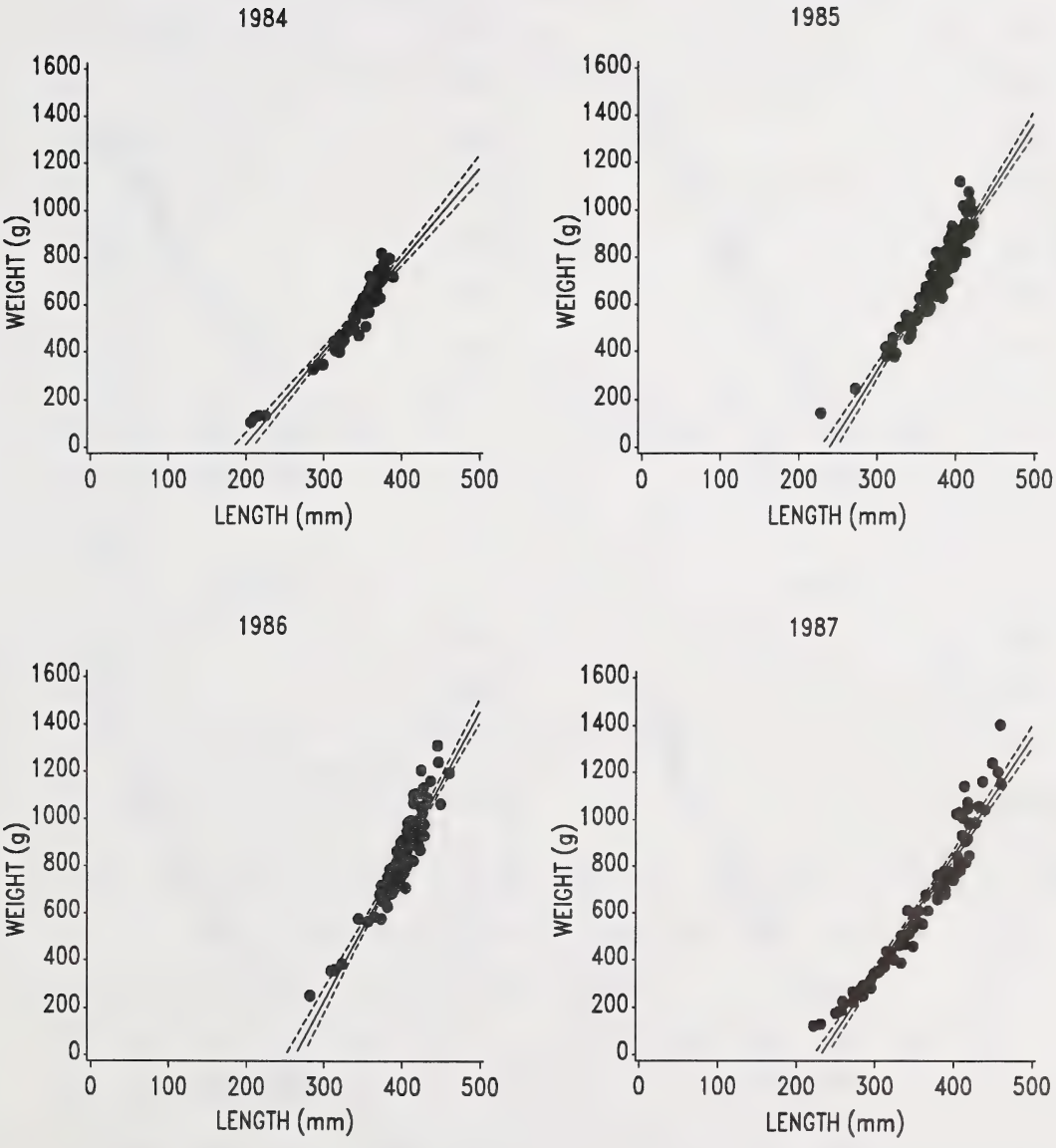

Figure 7. Linear regression analysis (±95% confidence limits) relating weight to length of longnose sucker collected by gill net from Gleniffer Lake during 1984-87.

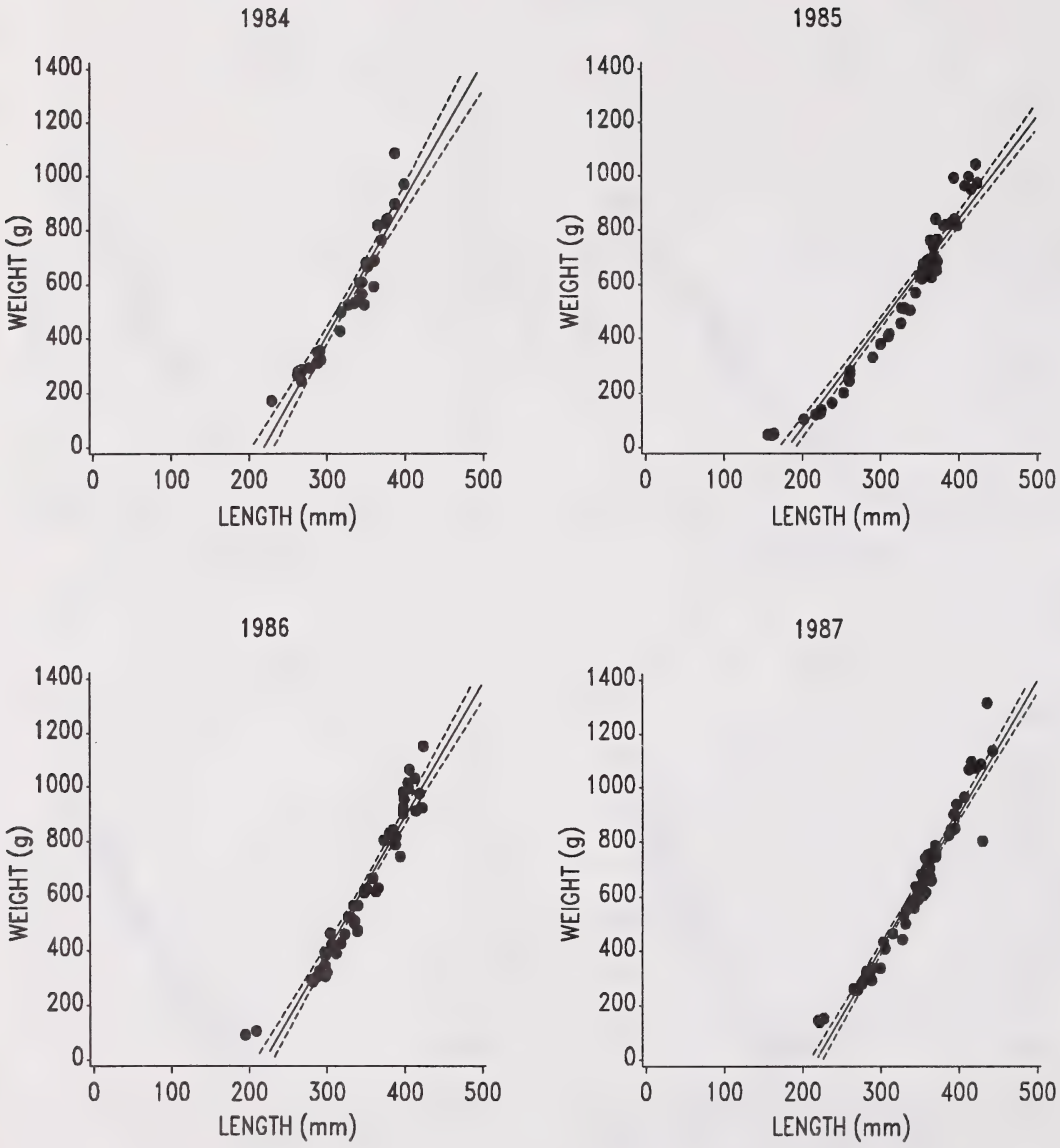

Figure 8. Linear regression analysis (±95% confidence limits) relating weight to length of white sucker collected by gill net from Gleniffer Lake during 1984-87.

Table 6. t-test of regression slopes relating age to weight for fish caught during 1984, 1985, 1986, and 1987.

Species/Year	1985	1986	1987
Rainbow Trout			
1986			NS
Northern Pike			
1984	NS	NS	NS
1985		NS	NS
1986			NS
Burbot			
1984	NS	S	S
1985		NS	S
1986			S
White Sucker			
1984	S	NS	NS
1985		S	S
1986			NS
Longnose Sucker			
1984	S	S	S
1985		S	NS
1985			S

S = significant at P=0.05
NS= not significant at P=0.05

aged (see Discussion). Although the same situation applied to longnose sucker, the relationship between weight and length in white sucker did not change in 1984, 1986 and 1987.

4.2 Length/Age Relation

The regression slopes relating age and fork length for fish collected in different years were analyzed using t-test (Tables 7 and 8; Figures 9-13). In the case of longnose sucker, white sucker and northern pike, fish at standard age had a greater fork length in

Table 7. Regression parameters relating fork length (mm) (independent variable) to age (years) (dependent variable) in fish caught by gill net from Gleniffer Lake during 1984-1987.

Year	Slope	Y-intercept	r^2	N
		MOUNTAIN WHITEFISH		
1984	22.4	153	0.45	24
		RAINBOW TROUT		
1986	73.2	134	0.42	11
1987	-6.6	553	0.12	6
		NORTHERN PIKE		
1984	13.4	446	0.05	23
1985	37.7	372	0.67	35
1986	61.7	237	0.70	20
1987	68.4	170	0.94	25
		BURBOT		
1984	31.1	274	0.65	11
1985	70.5	107	0.88	10
1986	45.5	208	0.31	13
1987	68.8	106	0.79	6
		WHITE SUCKER		
1984	31.8	217	0.61	31
1985	82.9	89	0.72	54
1986	71.9	89	0.54	50
1987	53.2	135	0.74	67
		LONGNOSE SUCKER		
1984	26.1	228	0.37	56
1985	31.0	247	0.44	117
1986	10.5	353	0.08	116
1987	50.1	115	0.59	80

Table 8. t-test of regression slopes relating age to fork length for fish caught during 1984, 1985, 1986 and 1987.

Species/Year	1985	1986	1987
Rainbow Trout			
1986			S
Northern Pike			
1984	NS	S	S
1985		NS	S
1986			NS
Burbot			
1984	S	NS	NS
1985		NS	NS
1986			NS
White Sucker			
1984	S	S	S
1985		NS	NS
1986			NS
Longnose Sucker			
1984	NS	S	S
1985		NS	S
1986			S

S = significant at P=0.05.
NS= not significant at P=0.05.

1987 than in 1984. Burbot, on the other hand, showed no significant change in the length/age relationship between 1984 and 1987.

The length/age relationship for rainbow trout was significantly different between 1986 and 1987, presumably reflecting the introduction of hatchery-reared fish of different length. For example, trout aged 3+ years averaged 354 mm in length in 1986, increasing to 523 mm in 1987 (Table 9). However, trout decreased in length (from 523 to 513 mm) between ages 3+ and 6+.

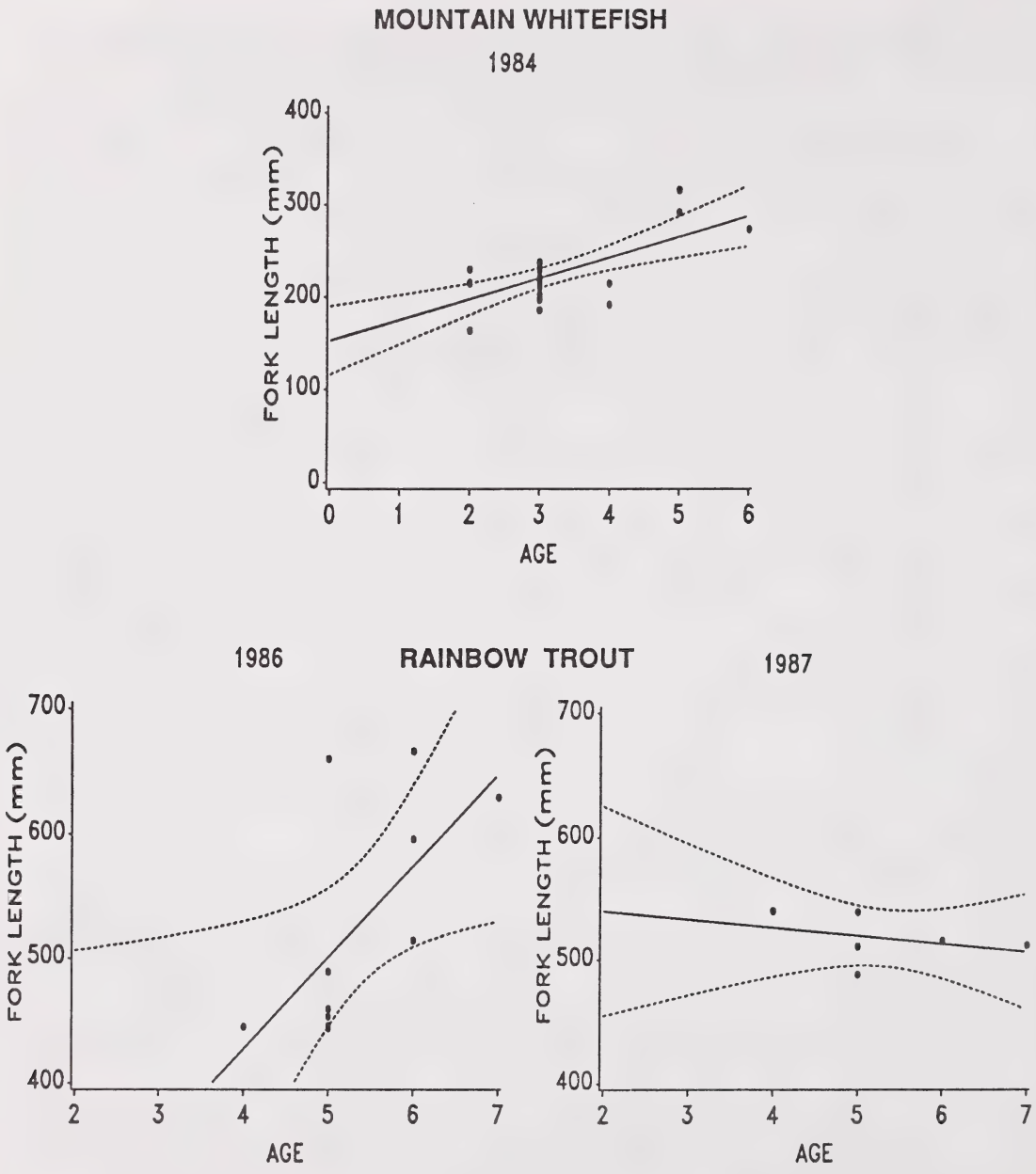

Figure 9. Linear regression analysis (±95% confidence limits) relating length to age of mountain whitefish and rainbow trout collected by gill net from Gleniffer Lake during 1984-87.

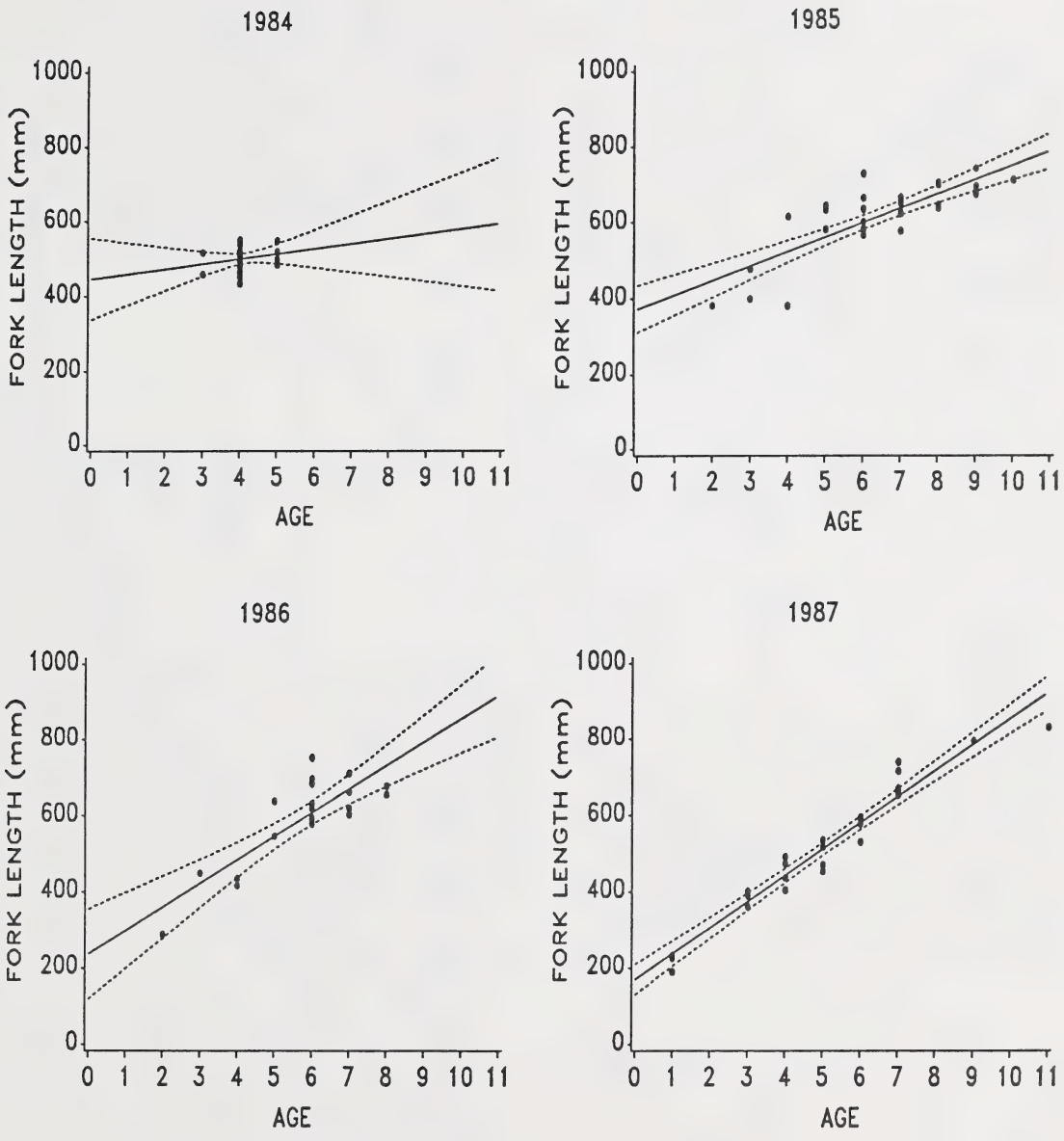

Figure 10. Linear regression analysis (±95% confidence limits) relating length to age of northern pike collected by gill net from Gleniffer Lake during 1984-87.

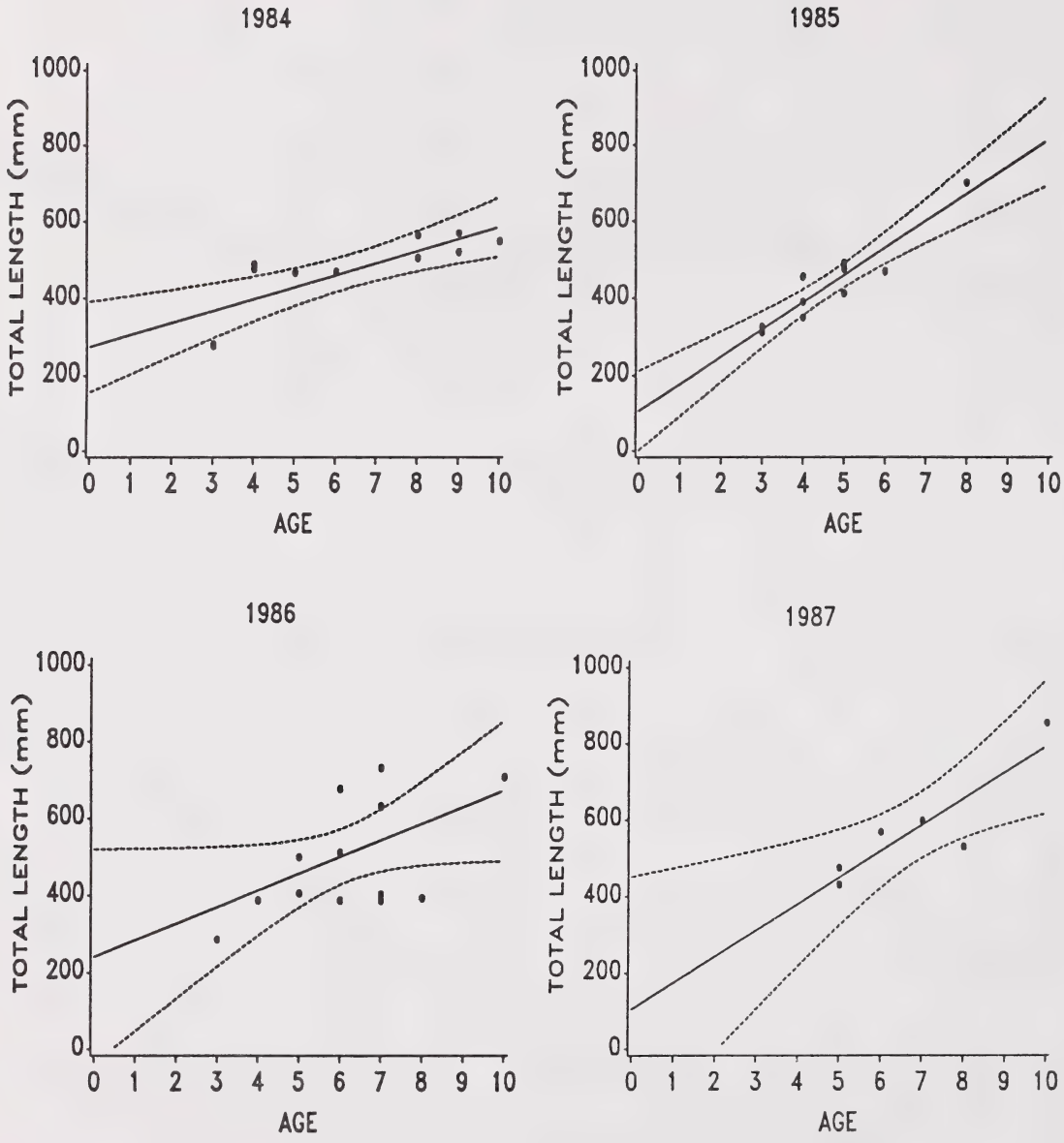

Figure 11. Linear regression analysis (±95% confidence limits) relating length to age of burbot collected by gill net from Gleniffer Lake during 1984-87.

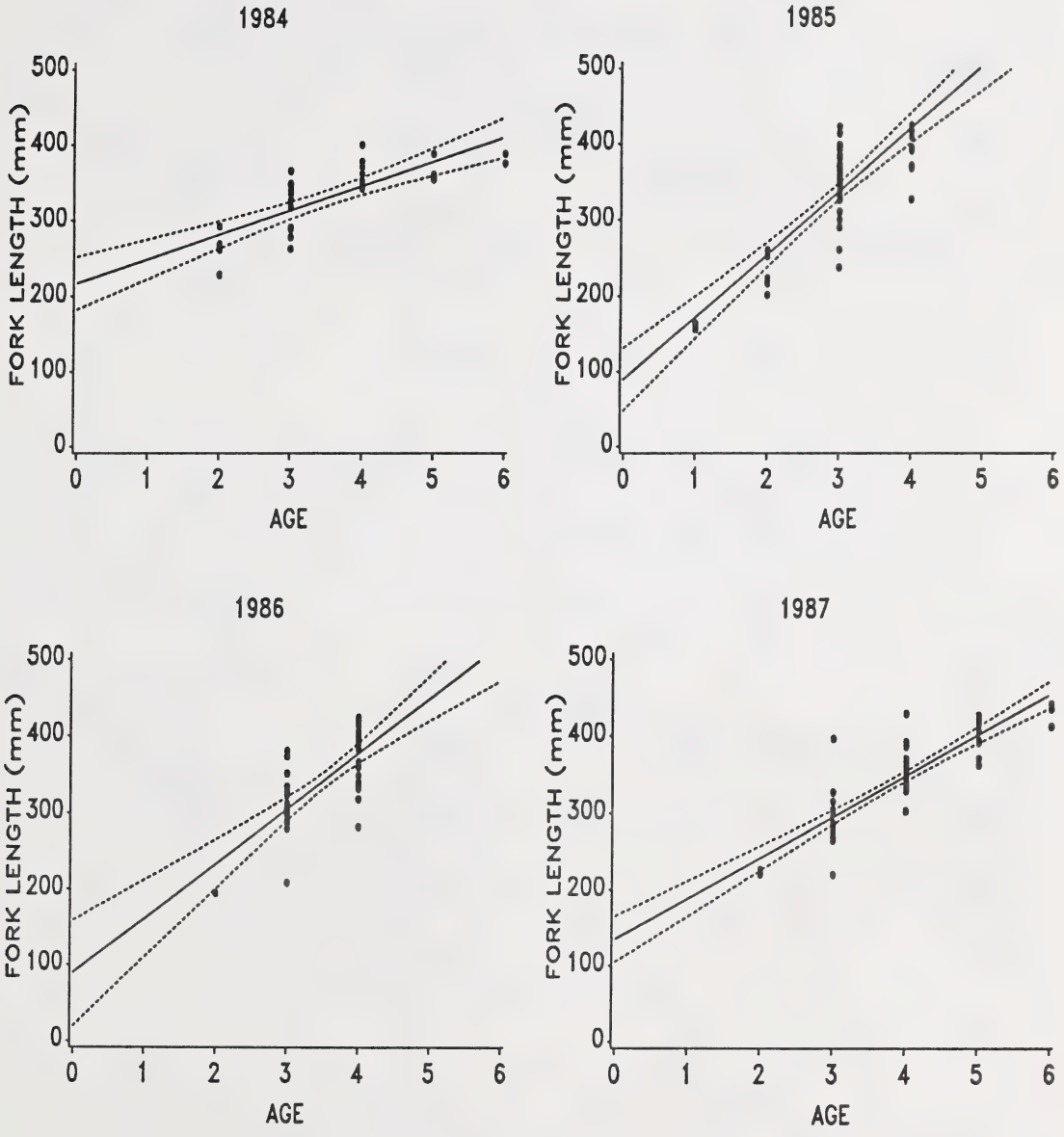

Figure 12. Linear regression analysis (±95% confidence limits) relating length to age of white sucker collected by gill net from Gleniffer Lake during 1984-87.

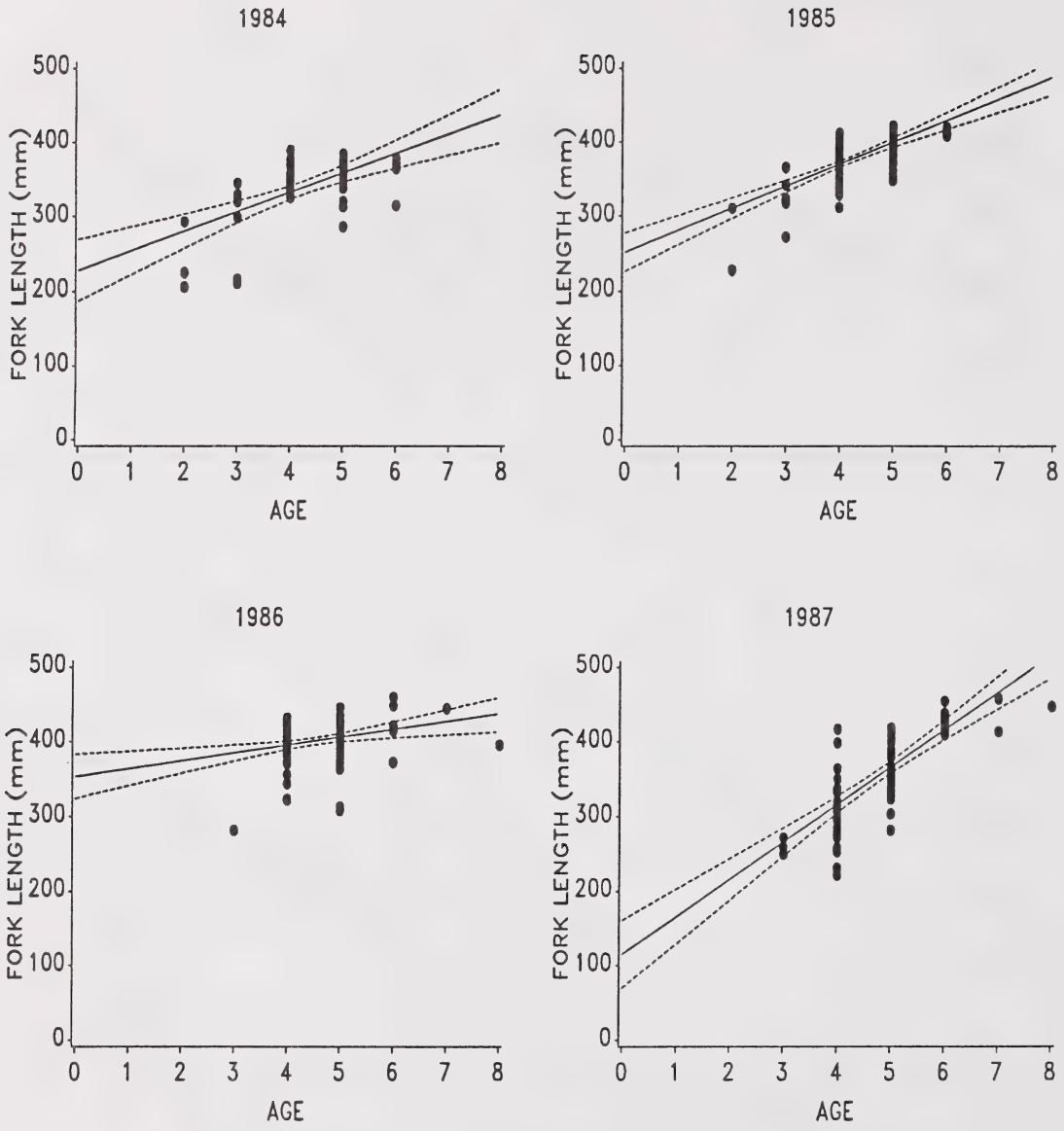

Figure 13. Linear regression analysis (±95% confidence limits) relating length to age of longnose sucker collected by gill net from Gleniffer Lake during 1984-87.

Table 9. Fork length (mm) of fish of standard age (years) collected by gill net from Gleniffer Lake during 1984-1987.

	Standard Age											
	3+	6+	3+	6+	3+	6+	3+	6+	3+	6+	3+	6+
Year	Mountain Whitefish		Rainbow Trout		Northern Pike		Burbot		White Sucker		Longnose Sucker	
1984	220	287	ND	ND	486	526	367	461	312	408	306	384
1985	ND	ND	ND	ND	485	598	318	530	338	586	340	433
1986	ND	ND	354	573	422	607	344	481	305	520	385	417
1987	ND	ND	523	513	375	580	312	520	295	454	265	415

ND = no data

4.3 Stomach Contents

4.3.1 Mountain Whitefish

This species, collected only in 1984, fed mainly on cladocerans (Daphnia sp.) and insects (Table 10). The cladoceran component accounted for 95-99% of the dry weight of stomach contents, which ranged from 0.03 to 0.31 g dry weight per fish.

4.3.2 Rainbow Trout

Although rainbow trout were captured in all years, detailed stomach analysis was limited to the 1986 and 1987 collections, which included a relatively large number of specimens. In both years, insects were present in the stomachs of most fish (Table 10), whereas

plant material and unidentified remains were also found in many stomachs. The total weight of stomach contents ranged from 0.01 g to 5.5 g dry weight per fish.

4.3.3 Northern Pike

The majority of stomachs of northern pike collected in 1985 and 1986 were empty (Tables 10 and 11). In 1984 and 1987, however, fish and unidentified remains were found in the majority of stomachs. The most frequently consumed fish were stickleback (Gasterosteus sp.), sucker (unidentified) and mountain whitefish (Prosopium williamsoni) (only in 1984) (Tables 10 and 11). Only one rainbow trout was found in the pike stomachs. Weight of stomach contents ranged from 0.0 g to 20.4 g dry weight per fish.

4.3.4 Burbot

Burbot were also piscivorous - approximately 45% of all stomach examined contained fish (Tables 10 and 11). The most frequently ingested species was stickleback (unidentified). Insects were also numerically important (Table 10) but, in terms of weight, formed <1% of ingested material (Table 10). Weight of stomach contents ranged from 0.0 g to 5.4 g dry weight per fish.

4.4 Fecundity

Based on the regression parameters in Table 12, burbot of standard fork length (600 mm) contained approximately 774 x 10^3 eggs/fish.

Table 10. Summary of stomach content analyses.

Year	Number of Fish	Number of Stomachs Containing Item				
		Fish	Insects	Cladocerans	Molluscs	Unidentified Remains
			MOUNTAIN WHITEFISH			
1984	45	0	25	31	0	12
			RAINBOW TROUT			
1986	17	0	12	1	1	8
1987	8	0	8	1	4	7
			NORTHERN PIKE			
1984	25	13	4	1	0	6
1985	35	8	0	0	0	0
1986	20	2	0	0	0	0
1987	25	11	0	0	0	10
			BURBOT			
1984	12	5	5	0	1	2
1985	11	5	4	1	0	3
1986	13	6	5	0	0	5
1987	6	3	2	0	1	1

Northern pike of the same length contained 48 x 10^3 eggs/fish. The corresponding number of eggs/fish for rainbow trout (500 mm), longnose sucker (400 mm) and white sucker (400 mm) is 4300, 32,200 and 43,700 respectively. In all species, the number of eggs increased with the length of the fish (Figure 14).

Table 11. Consumption of fish by northern pike and burbot in Gleniffer Lake 1984-87.

Year	Number of Fish	Number of Stomachs Containing Fish	Number and Species of Ingested Fish					
			Mountain Whitefish	Rainbow Trout	Sucker (species unknown)	Stickleback (species unknown)	Burbot	Unidentified
				NORTHERN PIKE				
1984	25	13	11	1	1	34	0	12
1985	35	8	0	0	5	0	1	5
1986	20	2	0	0	2	0	0	0
1987	25	11	1	0	12	0	0	9
				BURBOT				
1984	12	5	0	0	0	13	0	14
1985	11	5	0	0	0	29	1	14
1986	13	6	0	0	0	29	1	14
1987	6	3	0	0	0	0	0	3

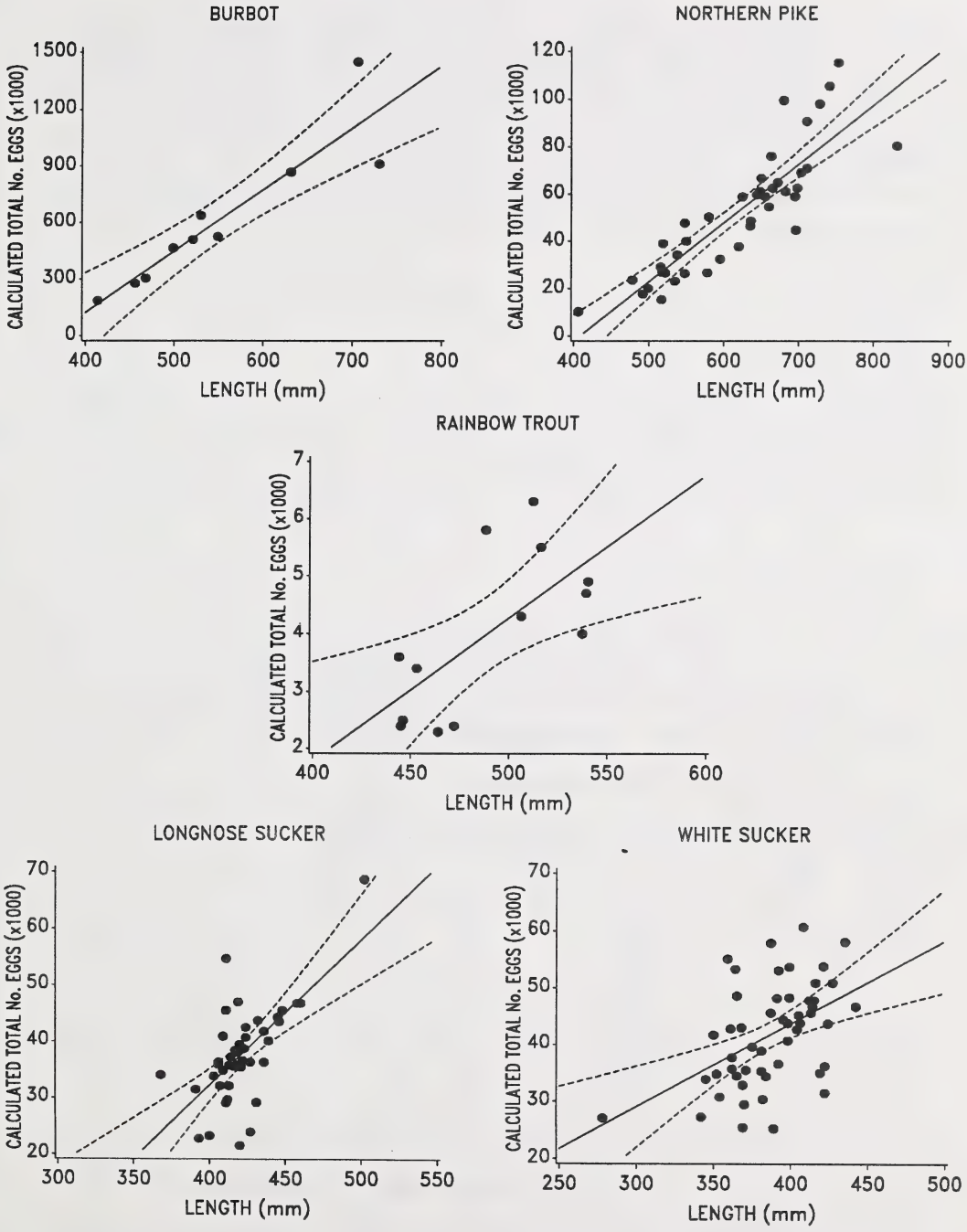

Figure 14. Linear regression analysis (±95% confidence limits) relating length to calculated total number of eggs of burbot, northern pike, rainbow trout, longnose sucker and white sucker collected by gill net from Gleniffer Lake during 1984-87.

Table 12. Regression parameters relating length (mm) to calculated total number of eggs in fish caught by gill net from Gleniffer Lake during 1984-1987.

Species	Slope	Y-intercept	r^2	N
Rainbow Trout	24.9	-8,154	0.46	13
Northern Pike	248.9	-101,500	0.76	41
Burbot	3250	-1,176,100	0.84	10
White Sucker	145.9	-14,649	0.29	51
Longnose Sucker	259.0	-71,449	0.42	42

5. DISCUSSION

Mountain whitefish apparently were trapped by impoundment of the Red Deer River in 1983. Although inhabiting the reservoir for another year, the population either died out or emigrated from the reservoir by 1985. This is typical of whitefish populations in other parts of Canada. For example, Bodaly *et al*. (1984) attributed the post-impoundment collapse of the lake whitefish (*Coregonus clupeaformis*) to emigration from the reservoir. Similarly, increased sedimentation in reservoirs reduces the rate of survival of lake whitefish eggs (Fudge and Bodaly, 1984).

Because mountain whitefish could have spent no more than 1 year in the reservoir prior to capture in 1984, most of their growth was due to life in the river rather than the reservoir. These whitefish were

relatively large compared to lake-dwelling fish, but were slightly smaller than those from the North Saskatchewan River (Table 13). No comparative records appear to be available regarding growth of mountain whitefish in the Red Deer River upstream of the reservoir.

Because rainbow trout of different age and size were planted in Gleniffer Lake, reliable determinations of growth after release cannot be made. In 1986, for example, the average fork length of 3+ years trout was 343 mm whereas, in 1987, the corresponding length was 523 mm. This reflects the planting of relatively large hatchery reared fish in the 1984-year class. In comparison to other lakes, the

Table 13. Mean fork length (mm) of mountain whitefish at age 3+ and 6+ years in various lakes and rivers.

	Age (Years)		
Lake/River	3+	6+	Reference
Gleniffer Lake, AB	220	287	This study
Bow Lake, AB	104	142	1
Pyramid Lake, AB	150	268	2
Kananaskis Lake, AB	171	267	1
Waterton Lake, AB	171	260	1
Lake Minnewanka, AB	171	273	1
Ghost River Reservoir, AB	199	NR	1
Cultus Lake, BC	218	305	1
North Saskatchewan River, AB	247	334	3

SOURCES: 1. McHugh (1941)
2. Rawson and Elsey (1948)
3. Alberta Forestry, Lands and Wildlife (1989)
NR = not reported

trout planted in Gleniffer Lake were relatively large at age 3+ years (Table 14), but this reflects a combination of growth in the hatchery and reservoir.

Northern pike which were 3+ years old and caught in 1984 must have been spawned in 1981 and presumably spent the first 2-3 years of their life in the Red Deer River. On the other hand, pike of the same age

Table 14. Mean fork length (mm) of rainbow trout at age 3+ and 6+ years in various lakes.

Lake	Age (Years) 3+	6+	Reference
Gleniffer, AB (1986)	354	573	This study
Gleniffer, AB (1987)	523	513	This study
Pyramid, AB	190	376	1
Okanagan, BC	290	NR	1
Kootenay, BC	303	590	1
Watch, BC	291	NR	1
Cluculz, BC	275	NR	1
Lightning, BC	183	NR	1
Pennask, BC	203	NR	1
Loon, BC	213	NR	1
Bouche, BC	222	NR	1
Big Bar, BC	247	NR	1
Kelly, BC	252	NR	1
Beaver, BC	257	NR	1
Dairy, BC	354	NR	1
Knouff, BC	356	NR	1
Pavilion, BC	380	NR	1
Glimpse, BC	387	NR	1
Peterhope, BC	468	NR	1

SOURCE: 1. Larkin et al. (1956)
NR = not reported

captured in 1987 were spawned in 1984 and had presumably spent all of their life in the reservoir. From Table 15, it is apparent that the 1987-caught fish were much smaller than the 1984-caught fish, implying that the river provided better habitat for the growth of young pike than the reservoir. The specific factors influencing the difference in growth are not known at this time. From age 3+ to 6+ years, pike grew much faster in the reservoir than the river (Table 15). It is possible that impoundment of the river significantly curtailed the production of fry and other potential food fish for young pike. As the reservoir matured, however, reproduction of potential food species increased. Rainbow trout, introduced in large numbers to the reservoir, was not a significant food of northern pike.

Fork length of northern pike at age 6+ years was comparable to fish from many other Alberta lakes (Table 15). For comparison the age 3+ pike caught in 1987 from the reservoir were shorter than fish from 10 other lakes listed in Table 15. Once again, the factors influencing the differences in growth are not known.

The growth of burbot was largely unaffected by impoundment, with the apparent exception of 1984-1985. During that period, the regression slopes relating length to age changed significantly: 3+ year old fish caught in 1985 were smaller than those caught in 1984 while 6+ year old burbot were larger in 1985 than 1984. As with northern pike, it appears that the river provided better habitat for the growth of young burbot whereas the reservoir was better for the growth of older burbot. This trend was not apparent in subsequent

Table 15. Mean fork length (mm) of northern pike at age 3+ and 6+ years in various Alberta lakes.

Lake	Age (Years) 3+	6+	Reference
Gleniffer (1984)	486	526	This study
Gleniffer (1985)	485	598	This study
Gleniffer (1986)	422	607	This study
Gleniffer (1987)	375	580	This study
Amisk	431	NR	1
Beaver	488	561	1
Cold	463	635	1
Elinor	411	485	1
Garner	508	571	1
Lac La Biche	476	666	1
Lac Ste. Anne	385	NR	1
Muriel	490	595	1
Pinehurst	464	601	1
Touchwood	431	591	1

SOURCE: 1. Alberta Forestry, Lands and Wildlife (1983-1986)
NR = not reported

years (Table 7). The overall growth of burbot in the reservoir was intermediate between populations in northern and more temperate lakes (Table 16).

White sucker and longnose sucker grew significantly faster in the reservoir than in the river (Tables 7, 8). The older fish were most affected whereas young suckers showed no increase in growth. As with northern pike, it appears that the absence of a good food base during the first years of impoundment limited growth. Suckers feed primarily on benthic invertebrates, a group of organisms that would be virtually

Table 16. Mean fork length (mm) of burbot at age 3+ and 6+ years in various lakes.

Lake	Age (Years) 3+	6+	Reference
Gleniffer, AB (1984)	367	461	This study
Gleniffer, AB (1985)	318	530	This study
Gleniffer, AB (1986)	344	481	This study
Gleniffer, AB (1987)	312	520	This study
Heming, MN	279	399	1
Superior, WI	300	439	2
Erie, ON	376	540	1
Simcoe, ON	432	572	1

SOURCES: 1. Scott and Crossman (1973)
2. Becker (1983)

eliminated during reservoir construction but which could rapidly recolonize the substrate. This reflects the ability of many invertebrate species such as insects to complete their life cycle in <1 year and to move long distances. Sucker growth in the reservoir was relatively rapid, even when compared to populations in more temperate climates (Tables 17, 18).

Since only one rainbow trout was found in the stomachs of 34 northern pike from the reservoir, it appears that the rate of predation is low. Similarly, no trout were found in the stomachs of burbot (42 specimens examined). This means that the success of the planting program for the reservoir was probably not diminished by the presence of predacious species.

Table 17. Mean fork length (mm) of white sucker at age 3+ and 6+ years in various lakes.

Lake	Age (Years) 3+	6+	Reference
Gleniffer, AB (1984)	312	408	This study
Gleniffer, AB (1985)	338	586	This study
Gleniffer, AB (1986)	305	520	This study
Gleniffer, AB (1987)	295	454	This study
Waskslv, SK	120	300	1
Muskellunge, WI	163	262	2
Lake of the Woods, ON	284	396	1
George, ON	336	452	1
Michigan, WI	362	430	2
Winnebago, WI	406	498[a]	2

SOURCES: 1. Scott and Crossman (1973)
2. Becker (1983)

[a] females only

Table 18. Mean fork length (mm) of longnose sucker at age 3+ and 6+ years in various lakes and rivers.

Lake/River	Age (Years) 3+	6+	Reference
Gleniffer, AB (1984)	306	384	This study
Gleniffer, AB (1985)	340	433	This study
Gleniffer, AB (1986)	385	417	This study
Gleniffer, AB (1987)	265	415	This study
Pyramid, AB	107	178	1
Great Slave Lake (northern), NWT	170	314	1
Great Slave Lake (whole lake), NWT	177	288	2
Great Slave Lake (southern), NWT	203	308	1
North Saskatchewan River, SK	323	439	1

SOURCES: 1. Scott and Crossman (1973)
2. Harris (1962)

The diet of the other species examined in this study is typical of that reported elsewhere in Canada and the USA (Scott and Crossman, 1973; Becker, 1983).

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