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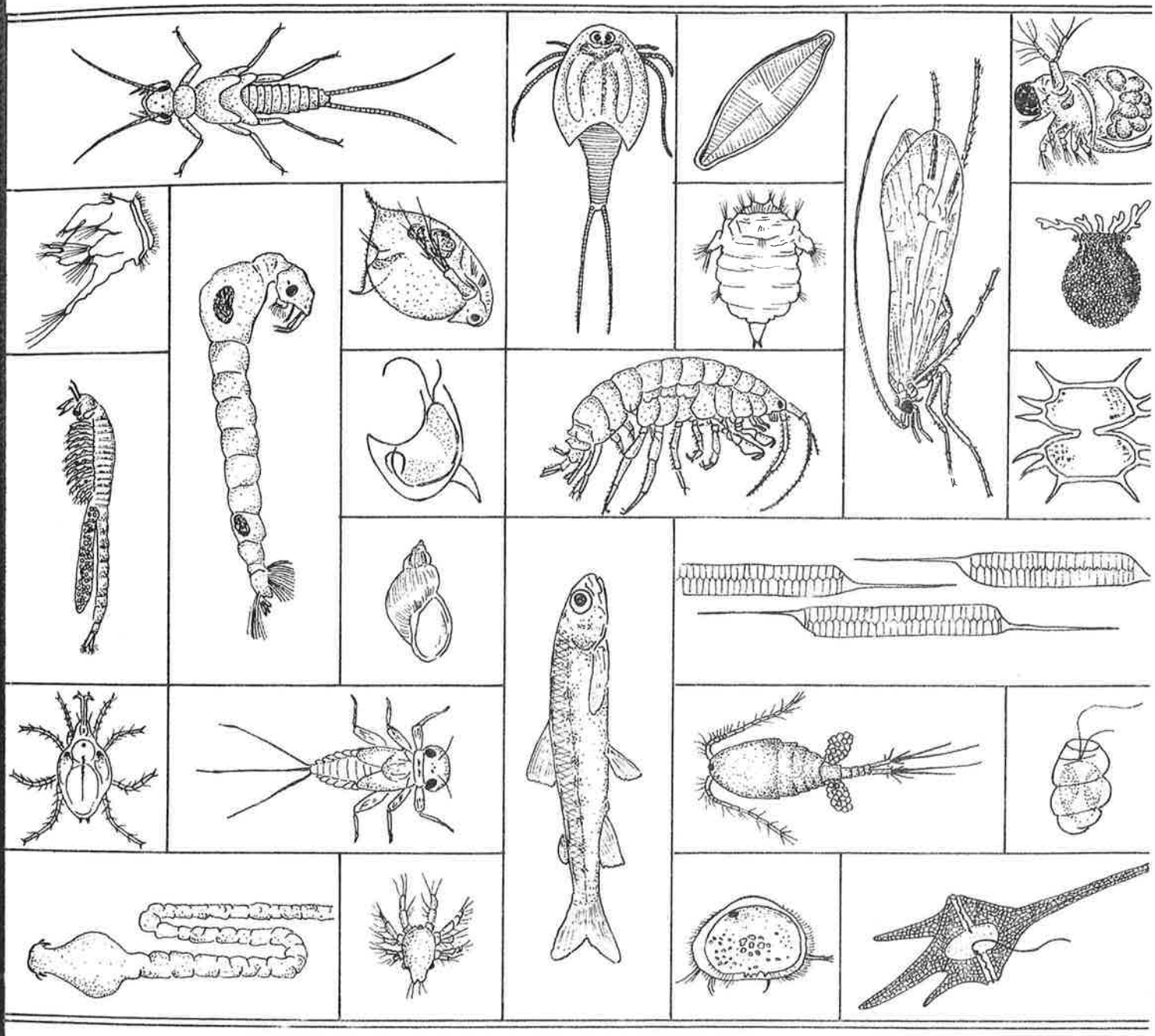
KOOTENAY NATIONAL PARK



Prepared for
PARKS CANADA

by

Canadian Wildlife Service

Edmonton, Alberta

1984

LIMNOLOGICAL STUDIES IN KOOTENAY NATIONAL PARK

Part One: The Lakes

D.B. DONALD and D.J. ALGER

Lake	Number*	Grid Reference	Area (ha)	Maximum Depth (m)
Cobb	2	11U/NG 794124	2.5	8.0
Daer	8	11U/NG 741275	9.4	1.0
Dog	5	11U/NG 756258	15.1	4.7
Floe	25	11U/NG 613558	57.5	61.0
Kaufman	38	11U/NG 533799	14.4	10.0
Kootenay Pond	18	11U/NG 675381	2.6	6.0
Meadow Creek Beaver Pond		11U/NG 739231	2.0	2.0
Nixon Pond	6	11U/NG 754211	3.2	1.0
Olive	1	11U/NG 753139	2.0	3.5
Storm (Upper)	37	11U/NG 686741	7.9	20.0
Talc	29	11U/NG 774593	7.5	27.0
K4	4	11U/NG 758251	3.4	0.5
K10	10	11U/NG 597349	0.4	0.5
K13	13	11U/NG 646369	2.5	6.0
K16	16	11U/NG 666357	5.7	2.0
K20	20	11U/NG 679317	0.6	3.8
K24	24	11U/NG 672383	1.2	1.0
K36	36	11U/NG 681738	2.9	6.0

*From Ward (1974)

LIMNOLOGICAL STUDIES IN KOOTENAY NATIONAL PARK

PART ONE

THE LAKES

by

D. B. Donald
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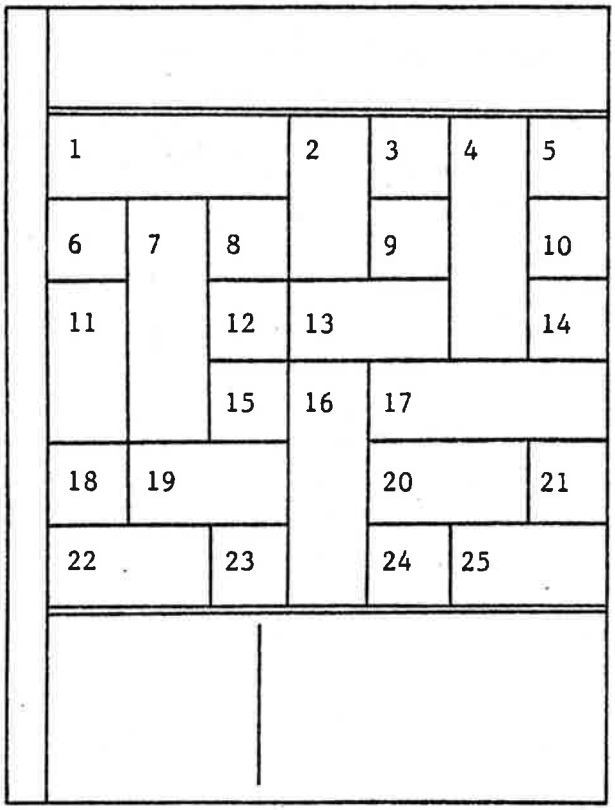


THE COVER

The cover design attempts to portray representative organisms from many of the major taxa occurring in the waters of the Canadian mountain national parks. Some of the sketches are rather generalized. The approximate maximum dimension for each organism is given.

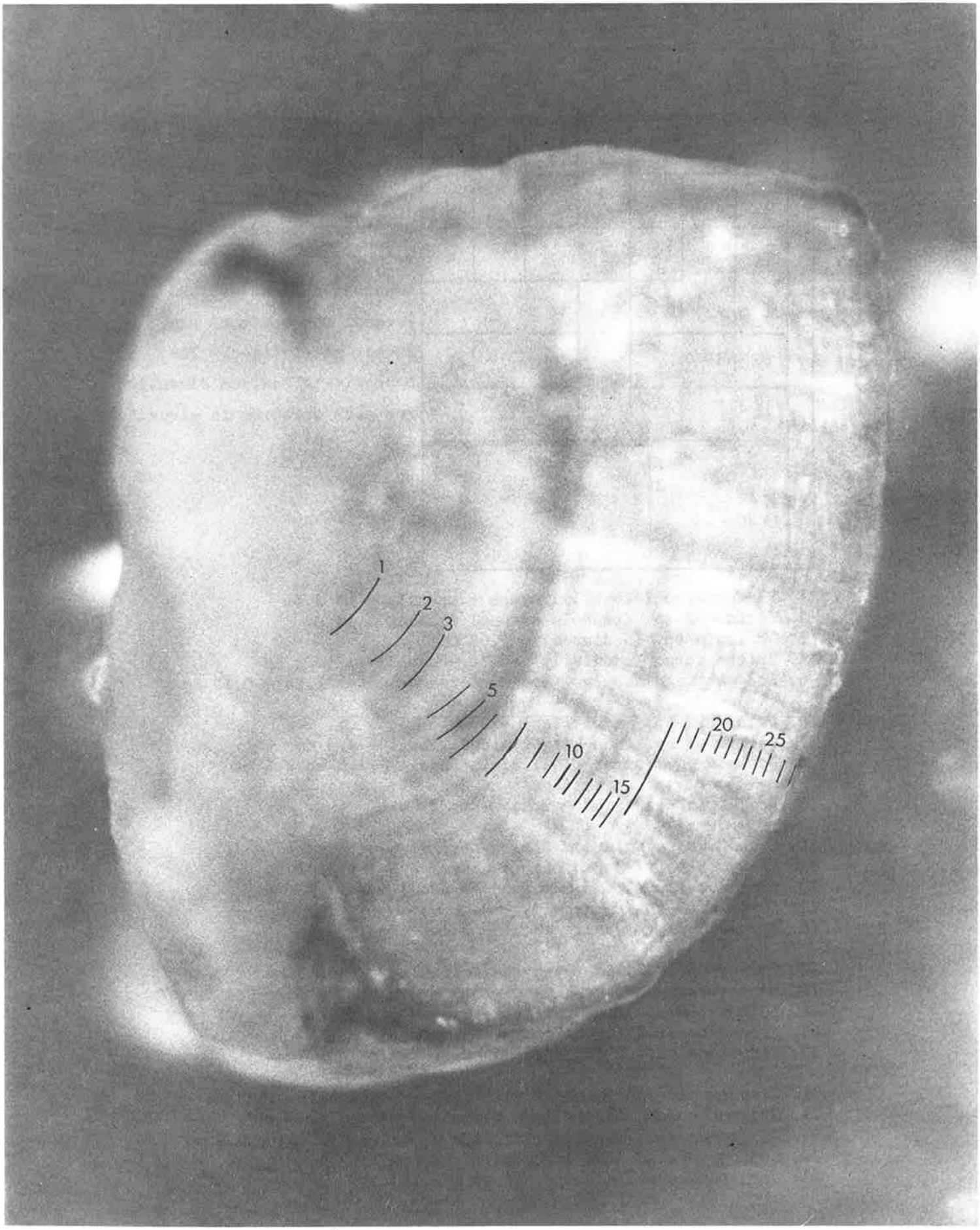
1. Plecopteran (stonefly) nymph - usually 1 to 3 cm
2. *Lepidurus* sp. (tadpole shrimp) - about 2 cm
3. *Navicula* sp. (a diatom) - 0.03 mm
4. Trichopteran (caddisfly) adult - usually 1 to 2 cm
5. *Polyphemus pediculus* (a cladoceran or water flea - 0.15 cm

6. *Hexarthra* sp. (a rotifer) - 0.4 mm
7. *Chaoborus* sp. (non-biting midge) larva - 1.5 cm
8. *Daphnia* sp. (water flea) adult female - 1.5 to 2.5 mm
9. *Synchaeta* sp. (a rotifer) - 0.4 mm
10. *Difflugia* sp. (a protozoan) - 0.25 mm

11. *Branchinecta paludosa* (fairy shrimp) adult female - 2.5 cm
12. *Chrysolykos planctonicus* (a chrysophyte) - 0.02 mm
13. *Gammarus lacustris* (amphipod or scud) - 2.5 cm
14. *Xanthidium* sp. (a desmid) - 0.03 mm
15. *Lymnaea* sp. (a snail) shell - 1 cm

16. *Prosopium coulteri* (pygmy whitefish) - 10 to 13 cm
17. *Rhizosolenia eriensis* (a diatom) - 0.07 mm
18. *Lohmanella* sp. (water mite) - 0.6 mm
19. Ephemeropteran (mayfly) nymph - 3 to 15 mm
20. *Eucyclops agilis* (a copepod) adult female - 1.5 mm

21. *Pseudokephyrion pseudospirale* (a chrysophyte) - 0.008 mm
22. *Triaenophorus* sp. (a fish tapeworm) - 1 to 10 cm
23. *Diaptomus* sp. (copepod) nauplius or larva - 0.05 to 0.1 mm
24. *Cyclocypris* sp. (an ostracod) - 0.5 mm
25. *Ceratium hirundinella* (a dinoflagellate) - 0.4 mm


1
2
3
5
10
15
20
25

Frontispiece

Polished otolith from a female longnose sucker (Catostomus catostomus) taken from Dog Lake in May 1982. This fish weighed 1157 g. The otolith shows 27 annuli and thus indicates that this fish was at least 27 years old when caught. Longnose sucker from Dog Lake increase the known longevity of this species of sucker by a decade.

Abstract

This report summarizes limnological and fisheries data collected from 18 lakes located in Kootenay National Park, British Columbia. Information on lake morphometry, physical and chemical parameters, benthic and zooplankton communities, and aspects of fish populations is presented.

Lake area ranged from 0.6 to 57.5 hectares, maximum depth from 0.5 to 60 metres, Secchi disc visibility from 2.5 to 20 metres, and total dissolved solids from 45 to 278 mg/litre.

When compared with lakes from the other mountain national parks, zooplankton species diversity was low, and community types were poorly represented. Benthic communites were typical of other mountain lakes. No unusual or rare invertebrate species were found with the possible exception of one copepod species.

Fish were present in 7 of the 18 lakes surveyed, although in one lake (Floe) fish will probably die out by the mid 1980's. Brook trout, an exotic species to the Park, was either the only or the dominant species in 5 of these lakes. In Olive Lake growth of brook trout was exceptionally poor. In 1982 age-5 fish weighed only 51 g. Growth of brook trout in other lakes ranged from poor (95 g at age-5) to superior (1078 g at age-5).

The total number of trout two-years-old and older in Cobb, Dog, and Olive lakes was about 49, 983, and 1662 fish respectively. Trout population size and density in these 3 lakes were primarily related to the availability and guality of spawning sites and not to

other factors such as fishing mortality or the quantity of preferred food organisms.

Three lakes (Cobb, Floe, and Kootenay Pond) do not have suitable spawing sites for trout and should be considered for stocking with hatchery reared westslope cutthroat trout (Salmo clarki lewisi). This fish is the only Salmo species native to the Kootenay River watershed. Other lakes are not suitable for stocking because of morphometric limitations, dense populations of other species of fish, or access limitations.

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List of Tables

List of Figures

ACKNOWLEDGEMENTS

We are grateful for the assistance on numerous occasions of Brian R. Sheehan of the Warden Service, Kootenay National Park. J. Kilistoff gave us some additional catch records from Kaufmann Lake, and R.S. Anderson identified the zooplankton collected during this survey and provided numerous zooplankton records obtained in the early 1970's. Funding was by Parks Canada to the Canadian Wildlife Service.

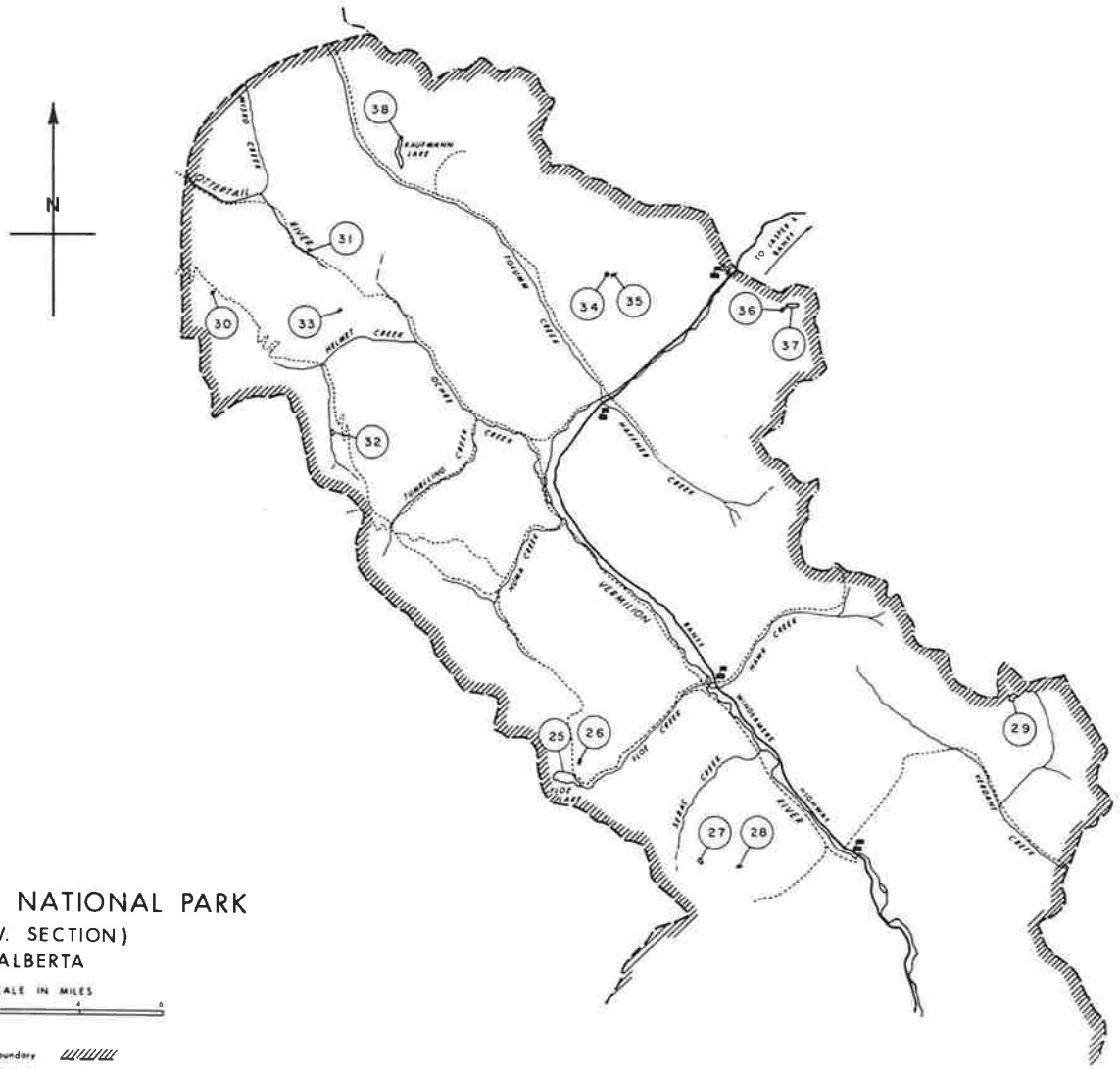
INTRODUCTION

This report is the first of two reports that summarize information collected during a limnological and fisheries survey of lakes and streams in Kootenay National Park (Fig.1). The survey was carried out from 1981 to 1983. This report, Part I, contains information on the lakes, their morphometry, water chemistry, benthos, zooplankton, and fish populations. Part II contains information on the streams.

Eighteen lakes were surveyed during the study, but emphasis was placed on those lakes that supported fish, and in particular on three lakes that are visited frequently by anglers. For these lakes (Cobb, Dog, and Olive) detailed measurements of fish population size, growth, and feeding habits were made. The effect anglers have on fish populations in these three lakes was also evaluated.

Each lake is considered with respect to its potential for drinking water, fish introductions, and angler harvest. Recommendations and some considerations with respect to fish stocking are given near the end of the report.

Previous to our report, studies on aspects of fisheries management, water chemistry, and zooplankton distribution have been carried out in Kootenay National Park. These reports and publications are listed in an annotated bibliography located at the end of this report. Reference to many of these documents is also included in the text.



KOOTENAY NATIONAL PARK

(N.W. SECTION)

ALBERTA

SCALE IN MILES

0 2 4 6

Park Boundary

Main Highway

Secondary Road

Trails

Warden's Cabin

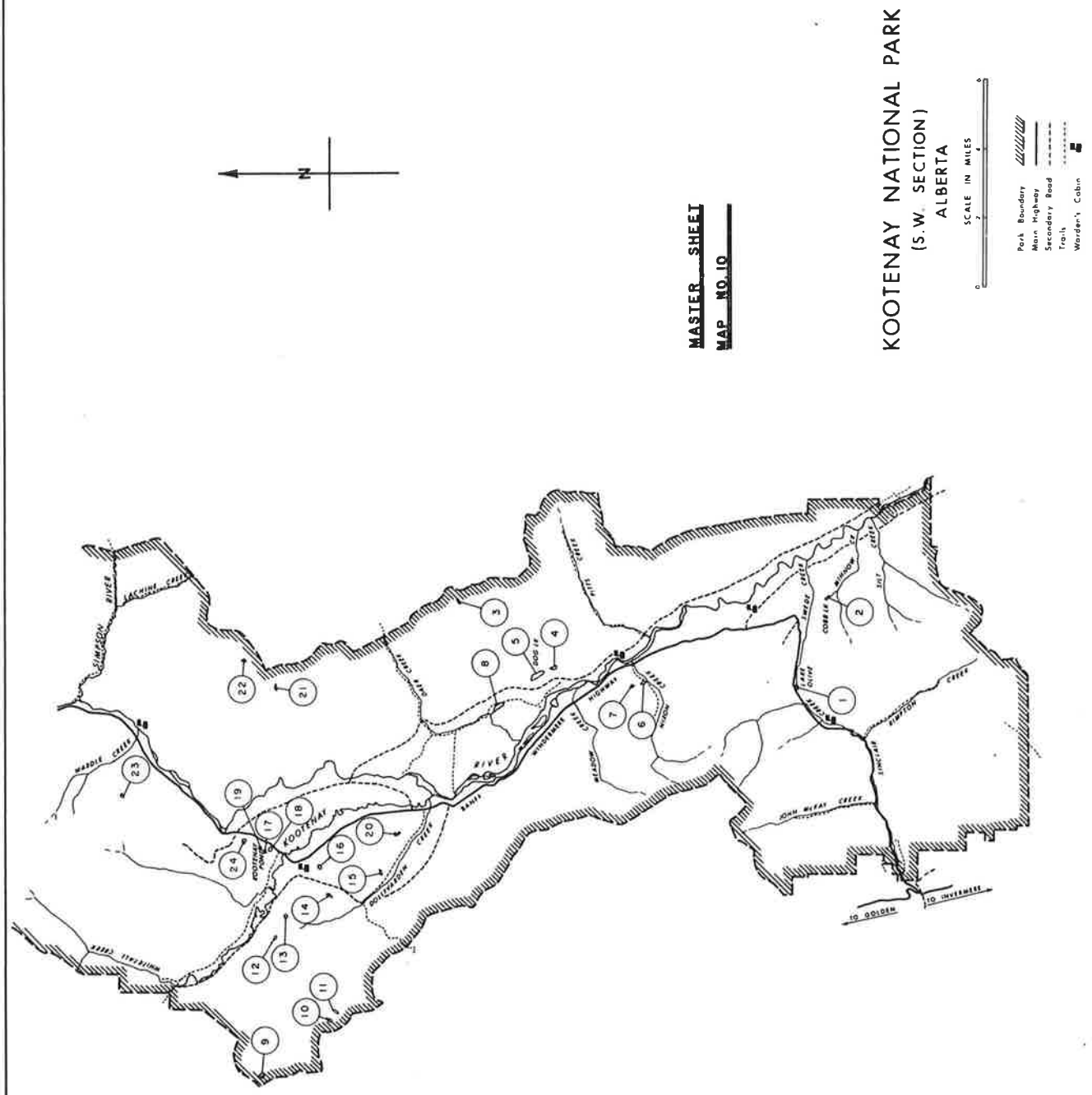


Figure 1. Map of Kootenay National Park. Each lake is identified by a number. (from Ward 1974).

METHODS

Readers are referred to Appendix B of Anderson and Donald (1977) for general technical references (green pages), to Apprendix C (also green pages) for the principal taxonomic references used in this study, and to Appendix A (pink pages) for the glossary of terms. The main laboratory and field methods are summarized below:

1. Bathymetric maps were prepared from aerial photos, upon which sounding data were incorporated. Sounding was done with a Furuno Depth Recorder (Model FE-400) or with a leaded line. Lake areas were determined by planimetry.
2. Lake volumes, mean depths, and shoreline development were calculated according to Wetzel (1975).
3. Temperatures were measured with a transistorized thermistor (Yellow Springs Instrument Company) calibrated against a glass-stem mercury thermometer at each use.
4. Light penetration was estimated with a black and white Secchi disc 20 cm in diameter. When the disc could be seen to the lake bottom, "+" is used to indicate that water clarity was sufficient to have allowed the disc to be seen at even greater depths than actually existed.
5. Break-up data were compiled from personal observations, and Warden Service records.
6. Water analyses were done by the Calgary laboratory of the Inland Waters Directorate, Water Quality Branch, Environment Canada.

7. Zooplankton was collected with a #20-mesh (apertures approximately 65x65 micrometres) conical plankton net. Samples were fixed and preserved in 5% formalin in the field. The efficiency of the plankton net was assumed to be 25% based on earlier investigations (Anderson 1970, and unpublished data). Therefore, counts given have been multiplied by 4 to more realistically represent actual numbers. However, numbers fluctuate within a certain range throughout the main growing season and from year to year. Thus, values given in the Results section represent levels of abundance for each species, at one point in time. Rotifer abundance is by estimate only, because the plankton net is not quantitative for these organisms (i.e. some are small enough to pass the net; rotifers tend to stick to nets, vials, sorting trays). Rotifer abundance is estimated according to the following "order of magnitude" scale:

x = <0.1 individual/litre

xx = >0.1 - 1 individual/litre

xxx = >1 - 10 individual/litre

xxxx = >10 - 100 individual/litre

xxxxx = >100-1000 individual/litre

A few historic zooplankton samples lacking quantitative data (e.g. net size or tow length) are estimated by the same scale.

Total counts were made of all zooplankton specimens in a sample except for the copepod nauplii. Where numbers of nauplii per sample ran into the thousands, samples were split before the nauplii

were counted. Counting was done under a stereo-dissecting microscope; identifications (usually requiring dissection of specimens) were made under a compound microscope. The principal taxonomic keys used were those of Brooks, Wilson, and Yeatman (In: Edmondson 1969) and Cook (1956), supplemented by keys and revisions of Brooks (1957), Flöbner (1972), Kiefer (1978), Saether (1970), and Smirnov (1971).

8. Benthic invertebrates were collected with a 15 cm x 15 cm Ekman style grap by random sampling where, ideally, one or two samples were taken from random locations on each metre-depth contour. Benthic samples were generally collected in summer, but for Cobb and Olive lakes, they were also taken in spring, fall, and winter. Samples were sieved through a screen-bottom bucket (mesh aperture: 0.36 mm x 0.52 mm) and the sample residue was either hand picked in the field or in the laboratory. Identification, counting and weighing were done in the laboratory.
9. Fish from lakes were collected with monofilament survey nets of mixed mesh sizes (10 yards of each of 1, 1½, 2, 3, and 4 inch stretched-measure apertures)[1]. Freshweights were determined to the nearest gram and fork-lengths to the nearest millimetre. Stomachs and otoliths were retained for laboratory analysis.

---

[1]Manufacturer's dimensions, which were approximately equal to 9.14 metres of each of 2.54 cm, 3.81 cm. 7.62 cm and 10.16 cm stretched-mesh apertures.

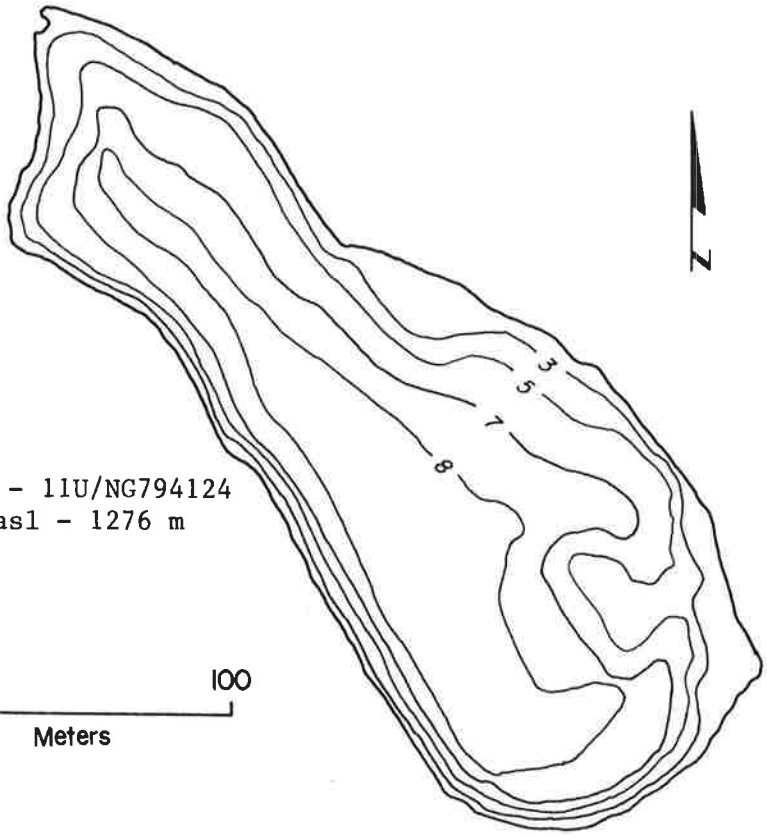
10. Stomach contents were preserved in dilute formaldehyde in the field. Content volume was determined volumetrically, where the stomach content of each fish was given a total of 10 points. Then, each food category in a stomach was assigned from 1 to 10 points, depending on its contribution to the total volume of stomach contents. This method is similar to the "points method" which Hynes (1950) found to be the most satisfactory in studying the food of sticklebacks. Points scored by each food-item category in a sample of (N) fish were summed and then expressed as a percentage of the total points (N x 10) assigned to the sample. No special consideration was given to differences in the quantity of food in each stomach. Empty stomachs were not included in calculations.

11. The age of each fish was determined (by DBD) from otoliths. The annual formation of a light and dark band on otoliths is often, but not always, distinct on old fish (see Reimers 1979). Otoliths were either read directly or, if the annuli were indistinct, they were smoked (Christensen 1964) or polished first. Most otoliths were examined on two or more occasions before a final decision was made on the age of a particular fish. Fish were considered to be one-year-old when the first annulus was present at the edge of the otolith. Verification of the ages determined for fish from Floe Lake was possible because stocking records indicated the year fish were introduced. The mean length and weight for trout at each age in a lake were then calculated from age-length or weight data. Growth curves were fitted by eye.

12. The number of fish in three lakes (Cobb, Dog, Olive) was estimated using the Petersen Method. This method is described in detail in Ricker (1975). Fish caught prior to the mark-recapture program for age and stomach content analyses were added to the Petersen estimate of population size. Fish were marked and recaptured using survey type gill nets. These nets were set throughout a lake and were examined usually every 15 to 30 minutes for newly caught fish. These fish were placed in a tub of water to see if they were injured; if not they were marked by removing either the adipose, pelvic, or pectoral fin; and then were released. A substantial part of the fish from Dog and Olive lakes was caught at and shortly after sunset.

RESULTS

COBB LAKE



K2
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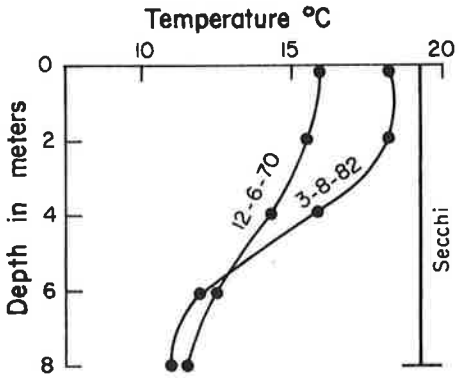
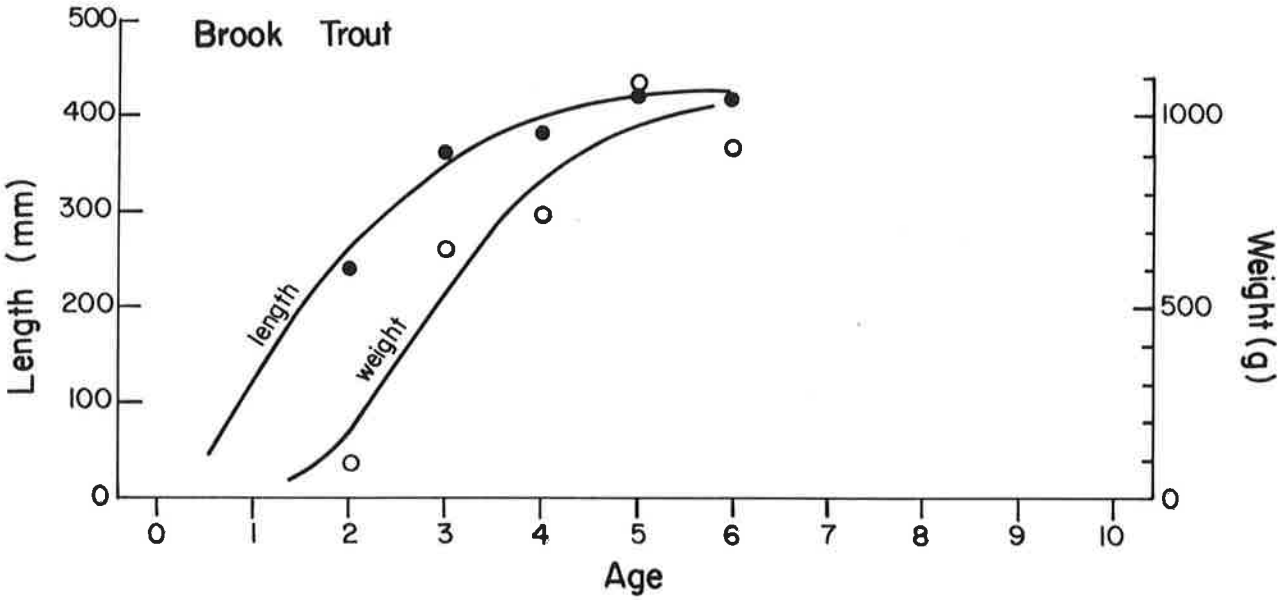


Volume X 10^4	14.9 m^3
Area	2.5 ha
Mean depth	5.9 m
Maximum depth	8.0 m
Shoreline development	1.3
Shoal area (% <5 m deep)	29%
Water level fluctuation	0.5 m
Drainage basin area	450.5 ha
Total dissolved solids	202.9 mg/l
pH	8.2
Break-up	early May
Freeze-up	early November

COBB LAKE


Brook Trout
Length (mm)
500
400
300
200
100
0
length
weight
1000
500
0
Weight (g)
0 1 2 3 4 5 6 7 8 9 10
Age

COBB LAKE

ZOOPLANKTON

Date	12 Jun 70	9 Aug 72	21 Jul 81	18 May 82	21 Sep 82	2 Dec 82
No. samples ($\bar{x}$)	2	2	2	2	2	2
Depth (metres)	8	8	8	7	8	7
Copepoda						
Diaptomus tyrrelli	15.40	17.59	13.92		72.34	12.38
diaptomid nauplii		11.79	4.77	5.51	0.28	
Orthocyclops modestus	0.15	0.62	0.26	2.26	0.10	0.02
Diacyclops thomasi	0.10					0.15
Eucyclops agilis	0.01					0.02
Macrocyclops albidus						0.01
Microcyclops varians rubellus			0.26		0.09	
cyclopoid nauplii	0.10	2.08	4.11	3.71	0.53	
Cladocera						
Daphnia rosea	0.02	6.11				
Daphnia pulicaria (?)			5.04	0.97	12.52	0.77
Eurycercus lamellatus	0.03					
Alona guttata			0.01		0.03	
Chydorus sphaericus	0.03					
Scapholeberis kingi	0.02	0.07				
Diaphanosoma brachyurum	2.15	6.44	0.01		0.14	
other groups						
Chaoborus flavicans						0.08
Chaoborus brunskilli				0.07	0.13	
chironomid larvae	0.01		0.03		0.03	
mites			0.01		0.01	
Mean nos. crustacean plankters/litre[a]	18.01	44.70	28.38	12.45	86.03	13.35
Rotifera[b]						
Kellicottia longispina	xx	xx	xxxxx	xxxx	xxx	xxx
Keratella hiemalis	xxx		xxxx	xx		
Keratella cochlearis	xx	xx	xxxx		xx	
Polyarthra dolichoptera	xx	xxxx	xxxx			
Synchaeta oblonga	xxx		xx		xx	
Euchlanis dilatata			x			
Conochilus unicornis	xxx	xxxx	xxxx		xxx	

a. corrected for plankton net inefficiency (see methods)

b. estimated abundance by "order of Magnitude" (see methods)

COBB LAKE

MACROINVERTEBRATES

PHYLUM CLASS	Order	Family*	Number collected per m^2 May	July	Sept	Dec
ASCHELMINTHES						
NEMATODA			6	31	344	18
ANNELIDA						
OLIGOCHAETA			43	160	246	37
HIRUDINEA			6	191	55	129
MOLLUSCA						
GASTROPODA						
	Basommatophora	Valvatidae*	-	25	-	-
PELECYPODA						
	Eulamellibranchia	Sphaeriidae*	480	812	701	387
ARTHROPODA						
CRUSTACEA						
	Ostracoda		197	400	1839	732
	Amphipoda	Talitridae*	1292	1806	3752	664
ARACHNOIDEA						
	Hydracarina		37	6	43	74
INSECTA						
	Ephemeroptera		18	74	55	135
	Odonata	Coenagrionidae*	6	6	6	18
	Trichoptera		31	37	25	25
	Coleoptera	Dytiscidae*	-	-	6	-
	Diptera	Tabanidae*	-	6	-	-
		Chironomidae*	4219	2411	8961	4723
		Culicidae*	264	37	37	400
		Heleidae*	283	461	633	646
		Dixidae*	6	-	-	-
total number of invertebrates			6888	6463	16703	7988
total weight (grams)			13.29	9.17	11.43	11.80
total number of samples			7	7	7	7

COBB LAKE

FISH SPECIES

- Salvelinus fontinalis (brook trout) date collected 10-7-81

CATCH DATA

Age	Length (mm)		Weight (g)		
	Mean	Standard Deviation	Mean	Standard Deviation	Number Examined
1	235	-	188	-	1
2	240	10.61	189	14.85	2
3	364	9.37	653	69.44	6
4	383	44.72	744	224.95	4
5	422	15.95	1078	183.52	3
6	418	24.75	921	153.44	2
14	397	-	804	-	1

STOMACH ANALYSES

Stomachs examined	19
Number empty	1

Food	Percent by volume
Chironomidae	22
Chaoborus	33
Odonata	18
Hyalella	17
Trichoptera	8
Ephemeroptera	2
Corixidae	+

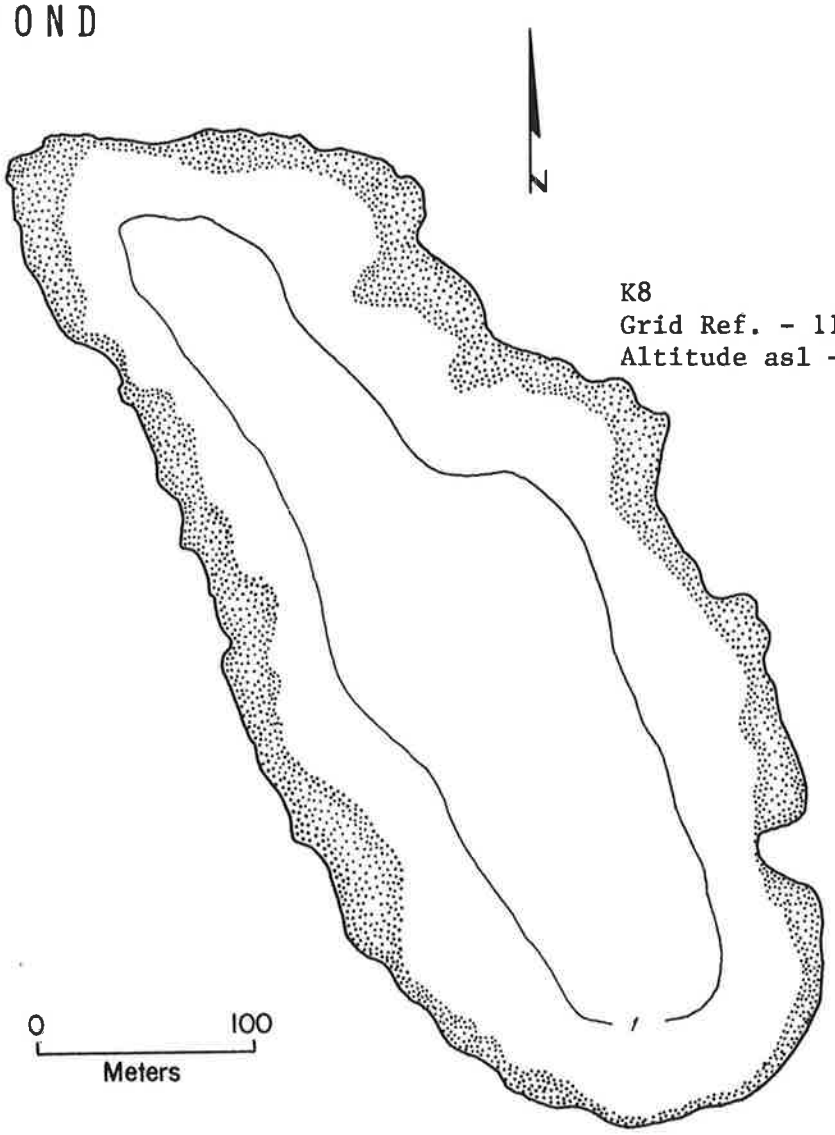
COBB LAKE

POPULATION STATISTICS

Brook trout

June 1982, number marked (t_1	20
October 1982, number of marked fish recaptured	5
in a sample of	7
Mortality (at t_1)	21
Population size (N)	49
95% confidence limits of N	34-86
Number of fish per hectare	20
Total number of fish >100 g but <500 g	11
Total number of fish >500 g but <1000 g	31
Total number of fish >1000 g	7

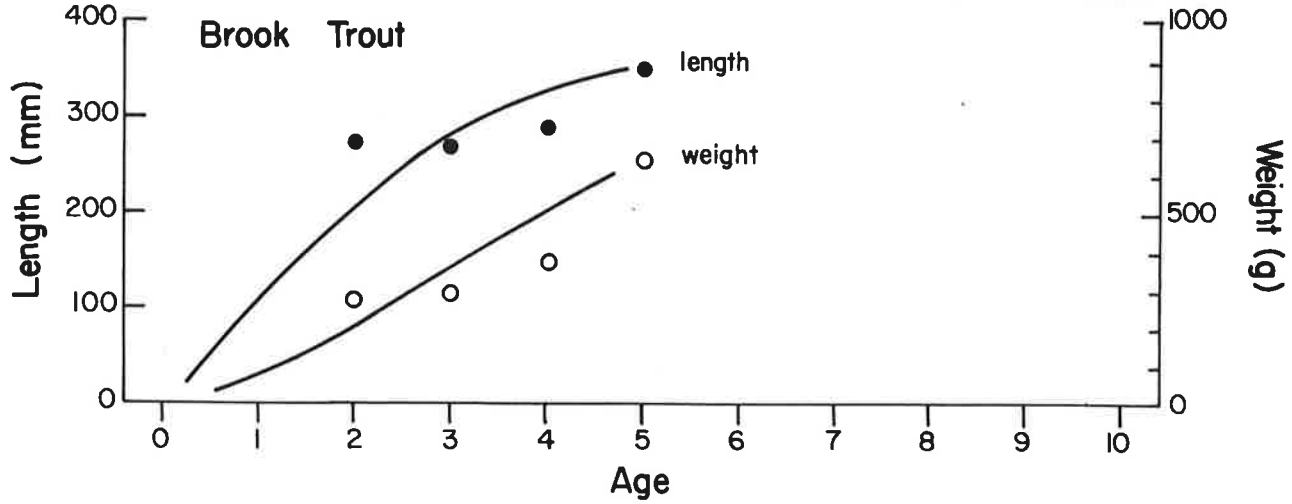
DAER POND

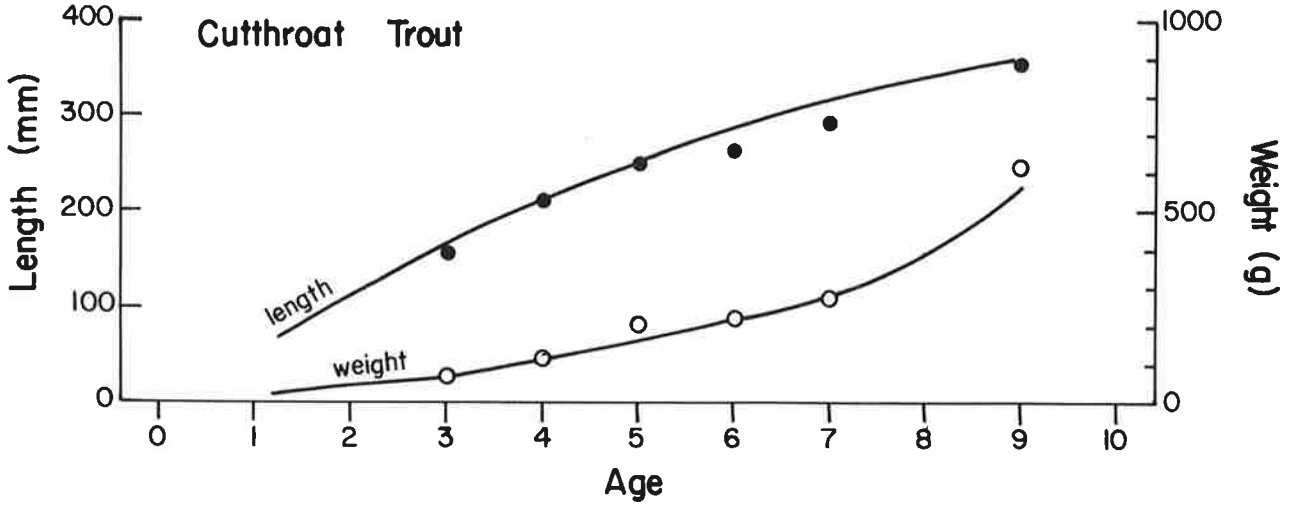


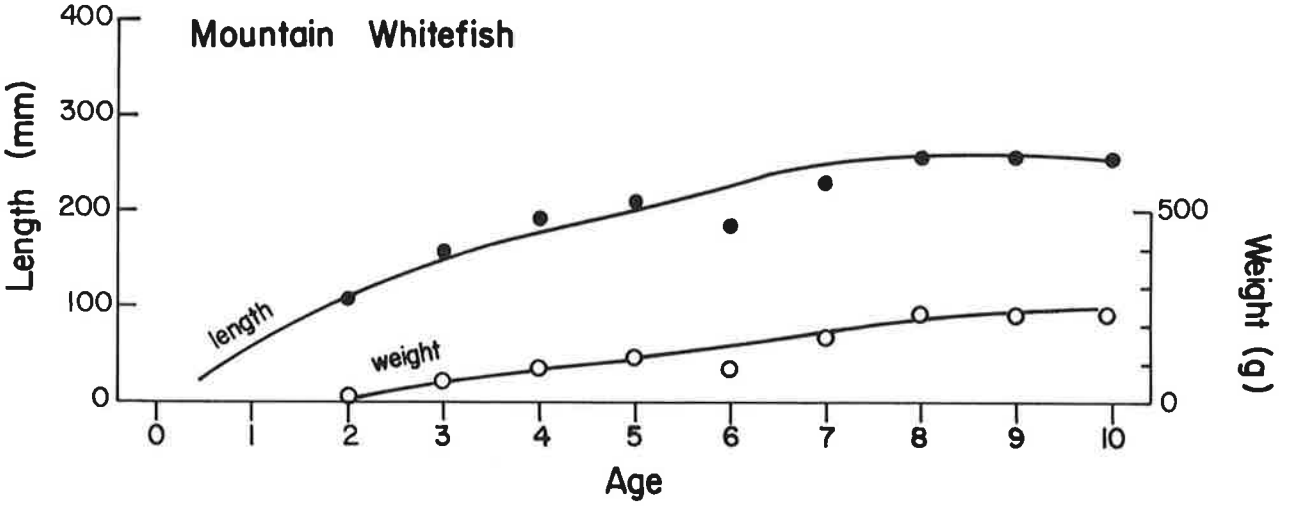
K8
Grid Ref. - 11U/NG741275
Altitude asl - 1187 m

Volume X 10^4	6.2 m^3	Water level fluctuation	0.5 m
Area	9.4 ha	Drainage basin area	305.7 ha
Mean depth	0.7 m	Total dissolved solids	112.2 mg/l
Maximum depth	1.0 m	pH	8.3
Shoreline development	1.3	Break-up	early May
Shoal area (% <5 m deep)	100%	Freeze-up	early November

DAER POND


Brook Trout
length
weight
Length (mm)
Weight (g)
Age
0
100
200
300
400
500
1000
0 1 2 3 4 5 6 7 8 9 10


Cutthroat Trout
length
weight
Length (mm)
Weight (g)
Age
0
100
200
300
400
500
1000
0 1 2 3 4 5 6 7 8 9 10


Mountain Whitefish
length
weight
Length (mm)
Weight (g)
Age
0
100
200
300
400
500
0 1 2 3 4 5 6 7 8 9 10

DAER POND

ZOOPLANKTON

Date	23 Jul 81
No. samples ($\bar{x}$)	2
Depth (metres)	5(horiz)
Copepoda	
Acanthocyclops vernalis	0.07
Paracyclops fimbriatus poppei	0.10
cyclopoid nauplii	0.44
cyclopoid copepodids	0.14
harpacticoids	0.01
Cladocera	
Alona affinis	0.02
Alona quadrangularis	0.02
Chydorus sphaericus	0.43
Eurycercus lamellatus	0.01
Daphnia rosea	0.18
Ceriodaphnia reticulata	0.13
Scapholeberis kingi	0.03
Polyphemus pediculus	0.14
Sida crystallina	0.10
other groups	
dipteran larvae	0.27
other insect larvae	0.01
Mean nos. crustaceans/litre[a]	1.82
Rotifera[b]	
Synchaeta (?)	x
Polyarthra vulgaris	xxx

a. corrected for plankton net inefficiency (see methods)

b. estimated abundance by "order of magnitude" (see methods)

DAER POND

MACROINVERTEBRATES

PHYLUM CLASS	Order	Family*	Genus	species	Number collected per m^2
ASCHELMINTHES					
NEMATODA					181
ANNELIDA					
OLIGOCHAETA					276
HIRUDINEA					9
MOLLUSCA					
GASTROPODA					
	Basommatophora	Planorbidae*			43
PELECYPODA					
		Sphaeriidae*			706
ARTHROPODA					
CRUSTACEA					
	Ostracoda				2260
	Amphipoda	Gammaridae*	Gammarus	lacustris	640
		Talitridae*	Hyalella	azteca	1850
ARACHNOIDEA					
	Hydracarina				34
INSECTA					
	Ephemeroptera	Caenidae*	Caenis		52
	Trichoptera	Limnephilidae*			9
	Odonata	Coenagriidae*			17
	Diptera	Chironomidae*			3821
		Heleidae*			276

total number of invertebrates	10,174
total weight (grams)	7.84
total number of samples	5
date collected	9-7-81

DAER POND

FISH SPECIES

	date collected
- Prosopium williamsoni (mountain whitefish)	9-7-81
- Salmo clarki (cutthroat trout)	23-6-82
- Salvelinus fontinalis (brook trout)	27-6-82
- Catostomus Catostomus (longnose sucker)	

CATCH DATA

- mountain whitefish

Age	Length (mm) Mean	Length (mm) Standard Deviation	Weight (g) Mean	Weight (g) Standard Deviation	Number Examined
2	122	-	19	-	1
3	158	7.55	51	10.97	3
4	189	11.29	91	20.52	11
5	206	16.38	119	31.56	9
6	184	20.51	86	33.94	2
7	228	10.61	168	10.21	6
8	255	9.50	231	33.14	4
9	256	13.20	237	40.16	7
10	255	6.43	232	28.10	3
15	259	-	242	-	1

- cutthroat trout

3	159	50.78	66	7.73	5
4	214	30.98	120	47.11	14
5	251	45.25	200	111.04	11
6	264	-	222	-	1
7	296	38.89	272	65.76	2
8					
9	356	-	618	-	1

- brook trout

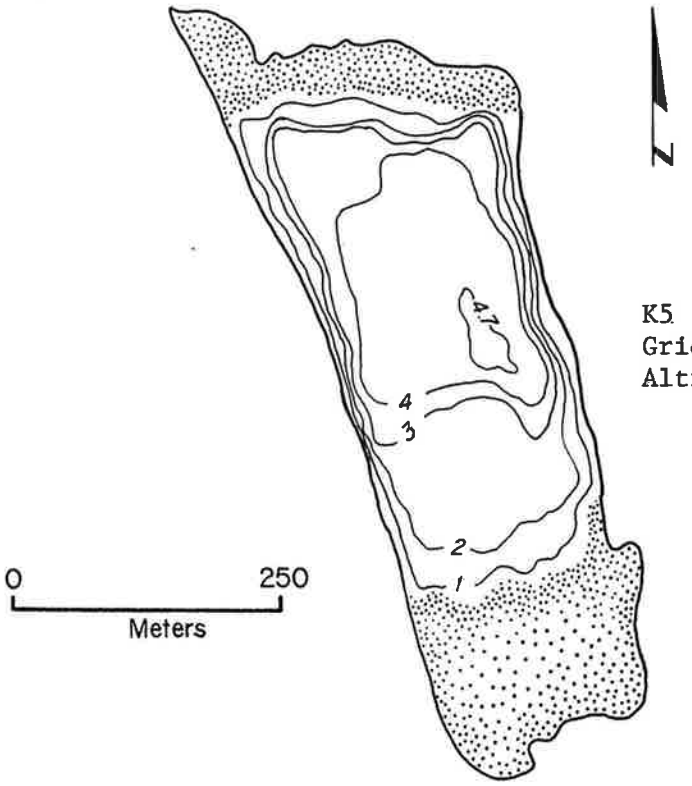
2	277	32.53	273	103.24	2
3	272	-	291	-	1
4	289	52.43	371	225.78	6
5	354	38.18	645	260.22	2

DAER POND

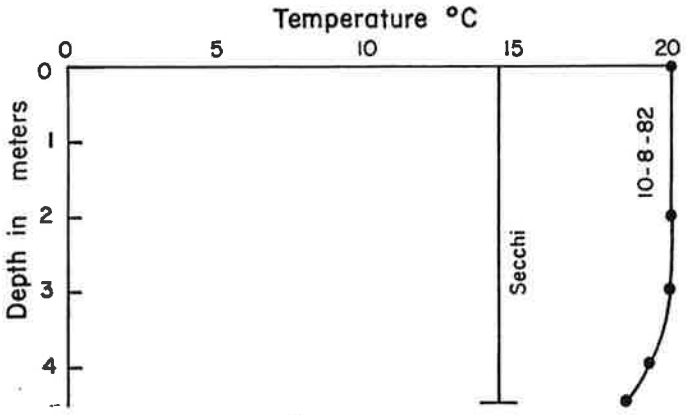
STOMACH ANALYSES

Fish species	Mountain Whitefish	Cutthroat Trout	Brook Trout
Stomachs examined	30	28	8
Number empty	2	0	0
Food	Percent by volume		
Amphipoda	61	15	22
Trichoptera	14	37	27
Chironomidae	11	5	25
Odonata	6	13	8
Daphnia	5	6	-
Hirudinea	2	-	-
Tipulidae	1	-	-
Oligochaeta	+	-	1
Dytiscidae	+	4	6
Planorbidae	+	3	-
Sphaeriidae	+	-	-
Terrestrial insects	-	8	-
Lymnaeidae	-	5	3
Heleidae	-	1	-
Notonectidae	-	1	-
Plecoptera	-	+	-
Hydracarina	-	-	8

DOG LAKE

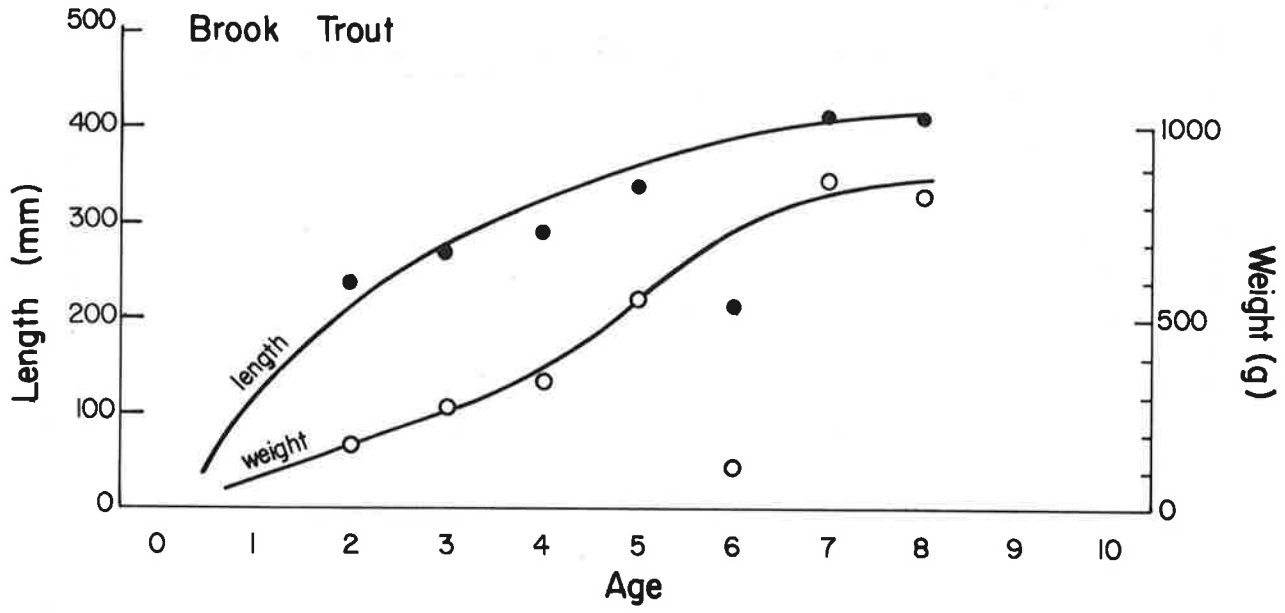


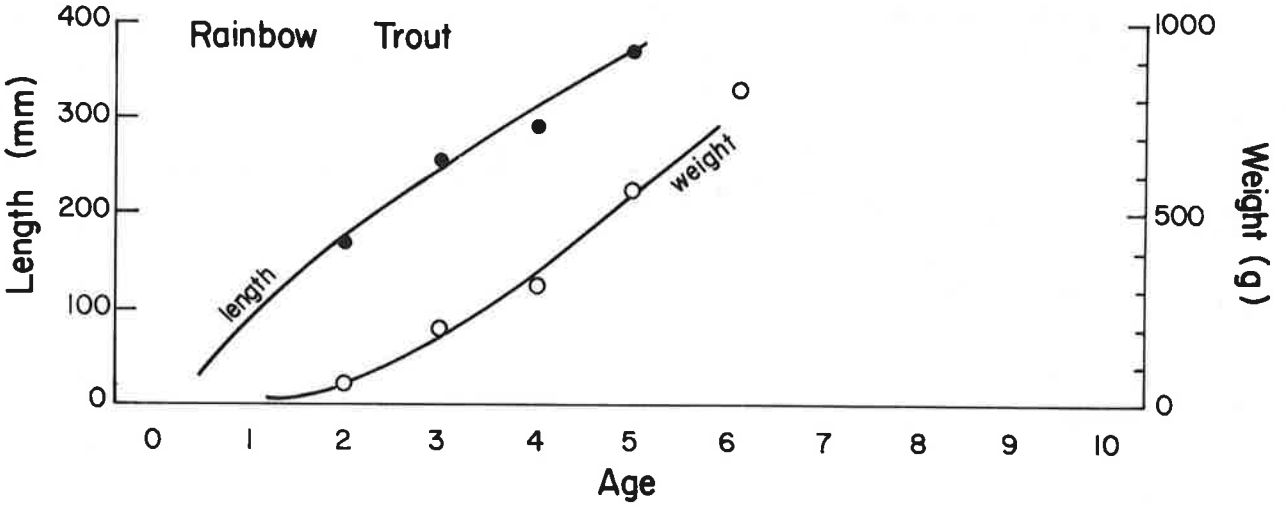
K5
Grid Ref. - 11U/NG756258
Altitude asl - 1183 m



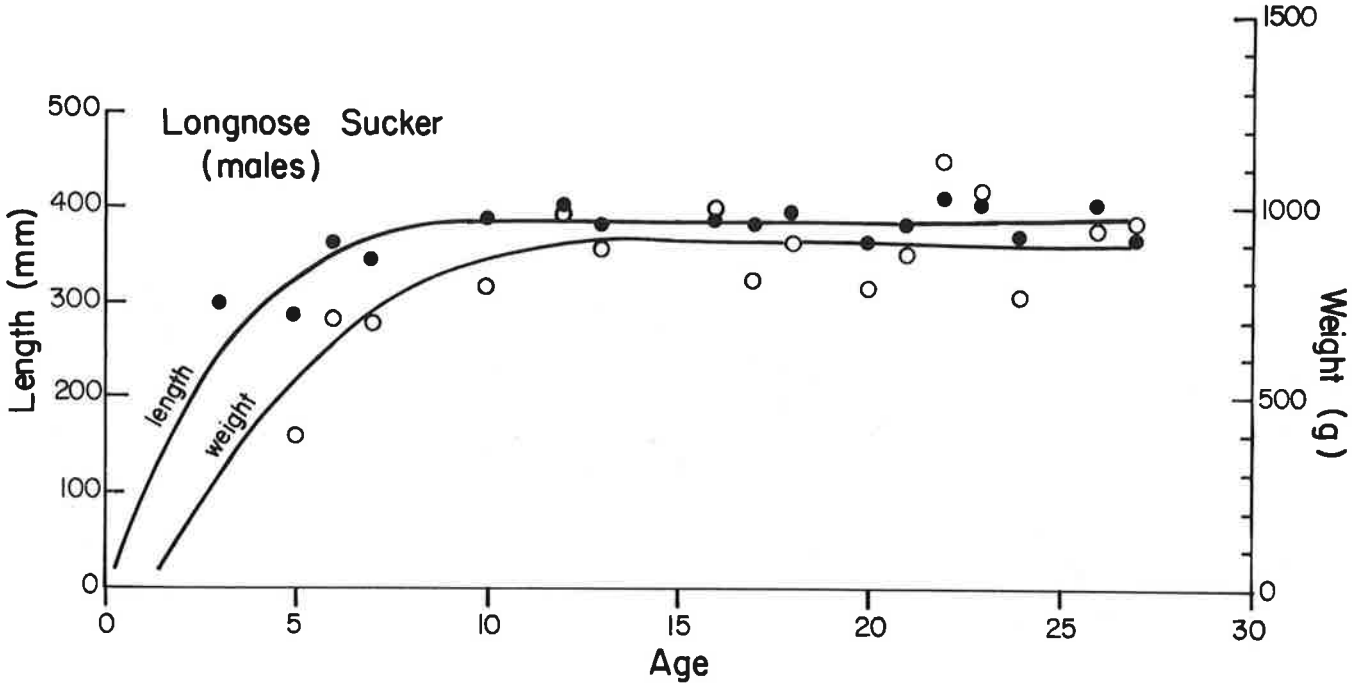
Volume X 10^4	31.6 m^3	Water level fluctuation	0.5 m
Area	15.1 ha	Drainage basin area	2080.3 ha
Mean depth	2.1 m	Total dissolved solids	182.6 mg/l
Maximum depth	4.7 m	pH	8.3
Shoreline development	1.4	Break-up	early May
Shoal area (% <5 m deep)	100%	Freeze-up	early November

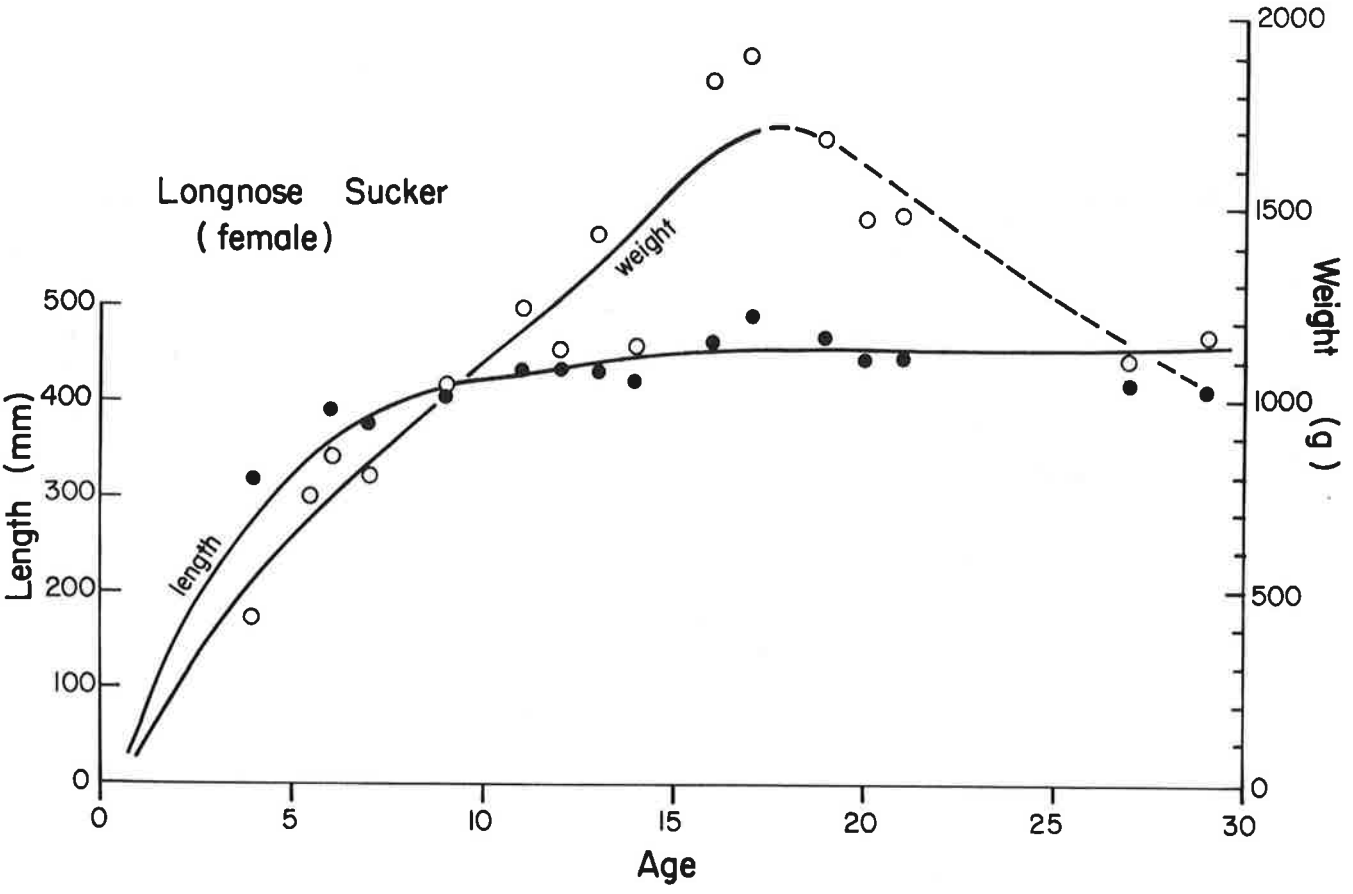
DOG LAKE


Brook Trout
Length (mm)
Weight (g)
length
weight
Age
0
100
200
300
400
500
1000
0 1 2 3 4 5 6 7 8 9 10


Rainbow Trout
Length (mm)
Weight (g)
length
weight
Age
0
100
200
300
400
500
1000
0 1 2 3 4 5 6 7 8 9 10

DOG LAKE


Longnose Sucker
(males)
Length (mm)
Weight (g)
length
weight
Age
0
100
200
300
400
500
0
500
1000
1500
0
5
10
15
20
25
30


Longnose Sucker
(female)
Length (mm)
Weight (g)
length
weight
Age
0
100
200
300
400
500
0
500
1000
1500
2000
0
5
10
15
20
25
30

DOG LAKE

ZOOPLANKTON

Date	12 Jun 70	22 Jul 81	27 Sep 81
No. samples ($\bar{x}$)	2	2	2
Depth (metres)	3.2	4	3.5
Copepoda			
Diaptomus leptopus	57.58	0.07	
diaptomid nauplii		0.97	0.49
Macrocyclops albidus	3.89	0.33	0.03
Acanthocyclops vernalis		0.15	
Eucyclops agilis		0.10	
cyclopoid copepodids		0.83	1.11
cyclopoid nauplii		44.29	4.87
Cladocera			
Daphnia rosea	31.22	43.47	5.22
Ceriodaphnia affinis	67.57		
Ceriodaphnia quadrangula			
Eurycercus lamellatus		0.17	0.08
Alona affinis		0.22	
Chydorus sphaericus		1.11	0.21
Graptoleberis testudinaria		0.14	0.02
Diaphanosoma brachyurum	5.97	0.33	0.06
Polyphemus pediculus	0.07	0.22	
other groups			
Chaoborus flavicans		0.14	
dipteran larvae		0.27	0.06
mites		0.10	
enchytraeids		0.07	
naidids		0.15	0.04
rhabdocoels		0.06	
ostracodes	1.80	0.64	0.08
Hyallela azteca			0.02
Mean nos. crustacean plankters/litre[a]	166.30	92.40	12.09
Rotifera[b]			
Keratella quadrata	xxxx	xxx	xxxx
Keratella cochlearis	xx	xx	xxxx
Polyarthra vulgaris	xx	xxxx	xxx
Asplanchna priodonta	x	xxxx	xx
Synchaeta oblonga			xxx
Lecane luna			x
Conochilus unicornis	xxxx	xxxx	

a. corrected for plankton net inefficiency (see methods)
b. estimated abundance by "order of magnitude" (see methods)

DOG LAKE

MACROINVERTEBRATES

PHYLUM CLASS	Order	Family*	Genus	species	Number collected per m^2
ASCHELMINTHES					
NEMATODA					549
ANNELIDA					
OLIGOCHAETA					517
HIRUDINEA					5
	Rhynchobdellida	Glossiphoniidae*			22
MOLLUSCA					
GASTROPODA					5
	Basommatophora	Lymnaeiidae*			22
		Planorbidae*			134
	Mesogastropoda	Valvatidae*			323
PELECYPODA					
	Eulamellibranchia	Sphaeriidae*			1470
ARTHROPODA					
CRUSTACEA					
	Ostracoda				468
	Amphipoda	Gammaridae*	Gammarus	lacustris	296
		Talitridae*	Hyalella	azteca	1860
ARACHNOIDEA					
	Hydracarina				65
INSECTA					
	Ephemeroptera				27
	Trichoptera				48
	Diptera	Tabanidae*			5
		Chironomidae*			4115
		Culicidae*	Chaoborus		129
		Heleidae*			172

total number of invertebrates	10,232
total weight (grams)	14.40
total number of samples	8
date collected	23-6-81

DOG LAKE

FISH SPECIES

- Salvelinus fontinalis (brook trout)
- Salmo gairdneri (rainbow trout)
- Catostomus catostomus (longnose sucker)

date collected 23-6-81, 23-9-81, 14-5-82

CATCH DATA

- brook trout

Age	Length (mm) Mean	Standard Deviation	Weight (g) Mean	Standard Deviation	Number Examined
2	239	16.66	167	38.94	11
3	273	35.27	267	115.11	17
4	292	42.44	339	139.61	12
5	341	37.05	549	187.29	13
6	213	-	116	-	1
7	413	15.82	864	191.37	3
8	410	-	829	-	1

- rainbow trout

2	167	21.01	53	16.17	3
3	256	36.52	193	86.03	15
4	291	56.93	322	209.35	7
5	367	28.50	588	158.23	6

STOMACH ANALYSES

- brook trout

Date collected	14-5-82	23-6-81	23-9-81
Stomachs examined	9	25	19
Number empty	2	4	0
Food	**Percent by volume**		
Odonata	67	27	11
Chironomidae	20	25	-
Trichoptera	11	6	37
Amphipoda	2	35	13
Hirudinea	-	4	-
Chaoborus	-	1	34
Daphnia	-	1	+
Lymnaeidae	-	1	-
Terrestrial insects	-	+	-
Valvata	-	+	-
Ephemeroptera	-	-	2
Tipulidae	-	-	2
Diptera	-	-	1

DOG LAKE

STOMACH ANALYSES

- rainbow trout

Date collected	14-5-82	23-6-81	23-9-81
Stomachs examined	9	20	14
Number empty	3	3	0

Food	Percent by volume		
Chironomidae	62	55	4
Odonata	19	11	9
Amphipoda	18	+	33
Heleidae	1	1	-
Trichoptera	-	26	1
Daphnia	-	3	34
Terrestrial insects	-	3	-
Chaoborus	-	1	12
Gastropoda	-	-	3
Sphaeriidae	-	-	1
Ephemeroptera	-	-	1
Annelida	-	-	1
Dytiscidae	-	-	1
Hydracarina	-	-	+

CATCH DATA

DOG LAKE

- longnose sucker (males)

Age	Length (mm)		Weight (g)		
	Mean	Standard Deviation	Mean	Standard Deviation	Number Examined
3	299	-	407	-	1
4	-	-	-	-	-
5	290	-	399	-	1
6	363	5.66	715	53.74	2
7	344	-	702	-	1
10	389	-	793	-	1
11	-	-	-	-	-
12	401	-	988	-	1
13	384	18.68	895	159.21	5
16	393	26.81	989	155.89	4
17	382	21.92	815	130.11	2
18	397	20.51	913	191.63	2
19	-	-	-	-	-
20	365	-	795	-	1
21	383	14.10	877	122.60	5
22	409	-	1124	-	1
23	403	10.61	1038	180.31	2
24	373	-	765	-	1
25	-	-	-	-	-
26	402	-	945	-	1
27	365	-	955	-	1

DOG LAKE

CATCH DATA

- longnose sucker (females)

Age	Length (mm)		Weight (g)		
	Mean	Standard Deviation	Mean	Standard Deviation	Number Examined
4	318	0.00	439	4.95	2
5	-	-	-	-	-
6	388	8.49	855	18.38	2
7	375	-	799	-	1
8	-	-	-	-	-
9	403	8.49	1024	16.97	2
10	-	-	-	-	-
11	431	7.37	1243	73.91	3
12	429	-	1132	-	1
13	427	-	1437	-	1
14	420	21.21	1136	130.81	2
15	-	-	-	-	-
16	460	-	1835	-	1
17	491	31.82	1905	246.78	2
18	-	-	-	-	-
19	464	-	1687	-	1
20	441	28.28	1475	491.44	2
21	442	-	1484	-	1
27	414	-	1099	-	1
28	-	-	-	-	-
29	410	-	1157	-	1
30	-	-	-	-	-
31	430	-	1066	-	1

DOG LAKE

POPULATION STATISTICS

Brook trout

September 1981, number marked (t_1)	148
May 1982, number of marked fish recaptured	35
in a sample of	129
Mortality (at t_1)	77
Population size (N)	615
95% confidence limits of N	467-843
Number of fish per hectare	41
Total number of fish >100 g but <500 g	486
Total number of fish >500 g but <1000 g	111
Total number of fish >1000 g	18

Rainbow trout

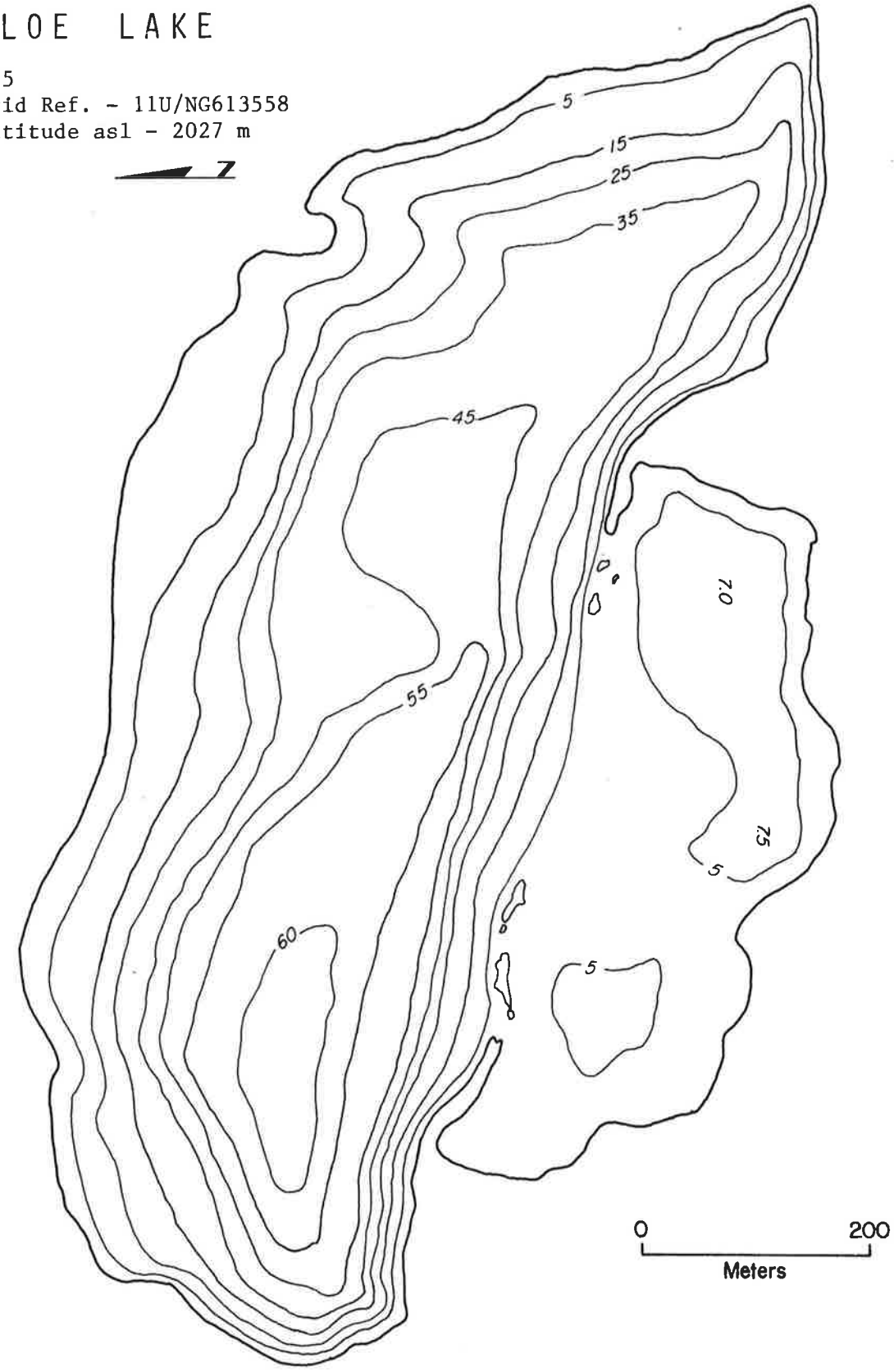
September 1981, number marked (t_1)	80
May 1982, number of marked fish recaptured	9
in a sample of	40
Mortality (at t_1)	36
Population size (N)	368
95% confidence limits of N	219-700
Number of fish per hectare	24
Total number of fish >100 g but <500 g	288
Total number of fish >500 g but <1000 g	9
Total number of fish >1000 g	0

Longnose sucker

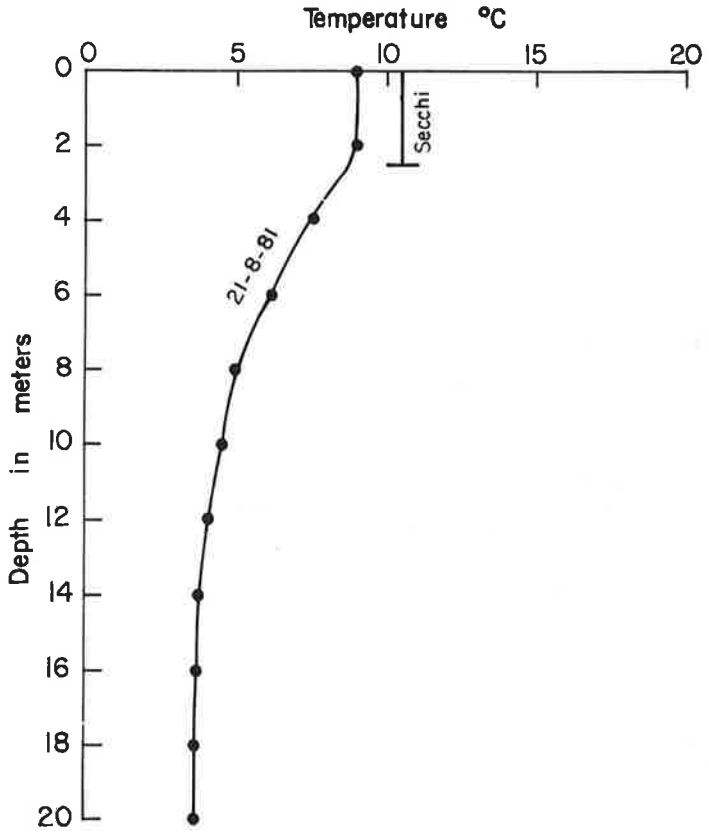
During the mark - recapture program we handled about 52% of the brook trout population of Dog Lake. All suckers caught during this program were removed from the lake. Our total catch of longnose sucker was 63 fish, and therefore this catch would be about half the sucker population. The total population of sucker would then be about $100 \div 52 \times 63 = 121$ fish.

FLOE LAKE

K25
Grid Ref. - 11U/NG613558
Altitude asl - 2027 m

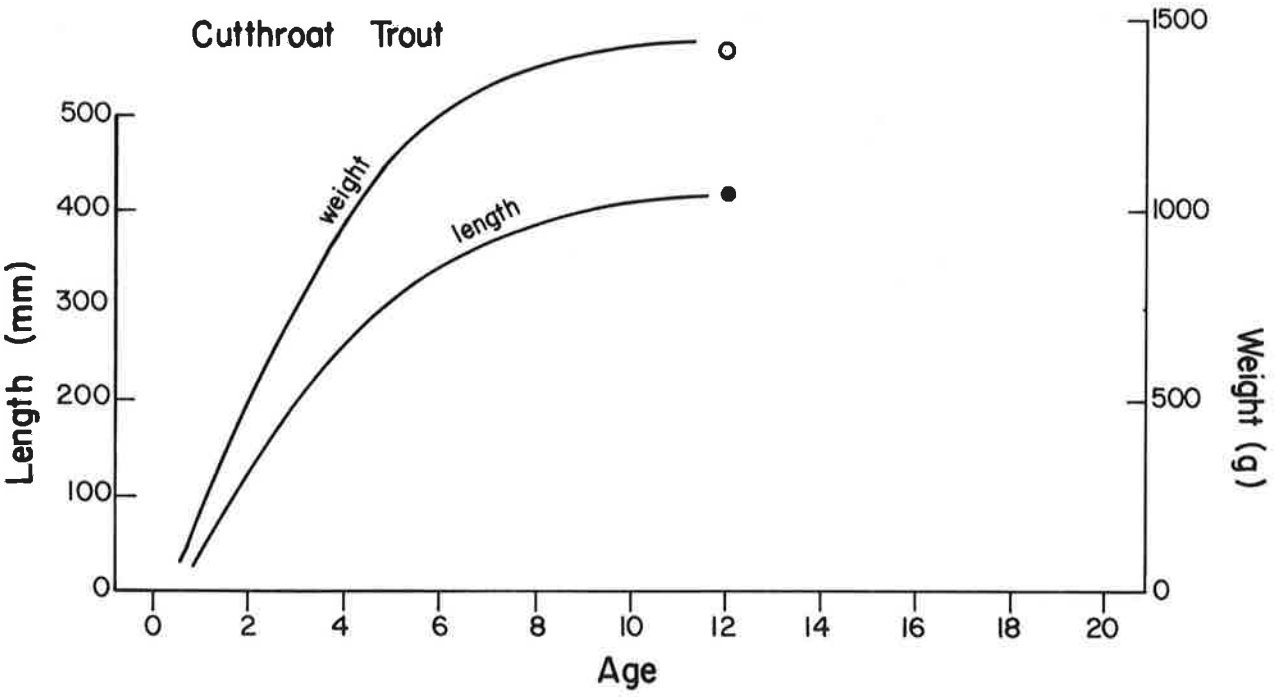


FLOE LAKE



Volume X 10^4	1377.2 m^3	Water level fluctuation	1.0 m
Area	57.5 ha	Drainage basin area	491.7 ha
Mean depth	24.0 m	Total dissolved solids	55.6 mg/l
Maximum depth	61.0 m	pH	8.2
Shoal area (% <5 m deep)	26%	Break-up	late July
Shoreline development	1.5	Freeze-up	late October

FLOE LAKE


Cutthroat Trout
Length (mm)
Weight (g)
Age
weight
length
0
100
200
300
400
500
500
1000
1500
0
2
4
6
8
10
12
14
16
18
20

FLOE LAKE

ZOOPLANKTON

Date	12 Sep 70	29 Aug 73	21 Aug 81
No. samples ($\bar{x}$)	6	2	2
Depth (metres)	15	17	20
Copepoda			
Diaptomus arcticus	0.13	1.73	0.98
diaptomid nauplii	0.02	0.02	0.48
Orthocyclops modestus			0.01
Acanthocyclops vernalis	0.01		0.01
cyclopoid nauplii			0.01
Cladocera			
Chydorus sphaericus	0.02		
other groups			
dipteran larvae	0.01		0.01
Mean nos. crustaceans/litre[a]	0.18	1.75	1.50
Rotifera	nil	nil	nil

a. corrected for plankton net inefficiency (see methods)

FLOE LAKE

MACROINVERTEBRATES

PHYLUM CLASS	Order	Family*	Genus	species	Number collected per m^2
ASCHELMINTHES					
NEMATODA					6
ANNELIDA					
OLIGOCHAETA					232
ARTHROPODA					
CRUSTACEA					
	Ostracoda				34
ARACHNOIDEA					
	Hydracarina				40
INSECTA					
	Ephemeroptera				9
	Diptera	Chironomidae*			3275

total number of invertebrates	3596
total weight (grams)	3.82
total number of samples	15
date collected	27-7-82

FLOE LAKE

FISH SPECIES

- Salmo clarki (cutthroat trout)

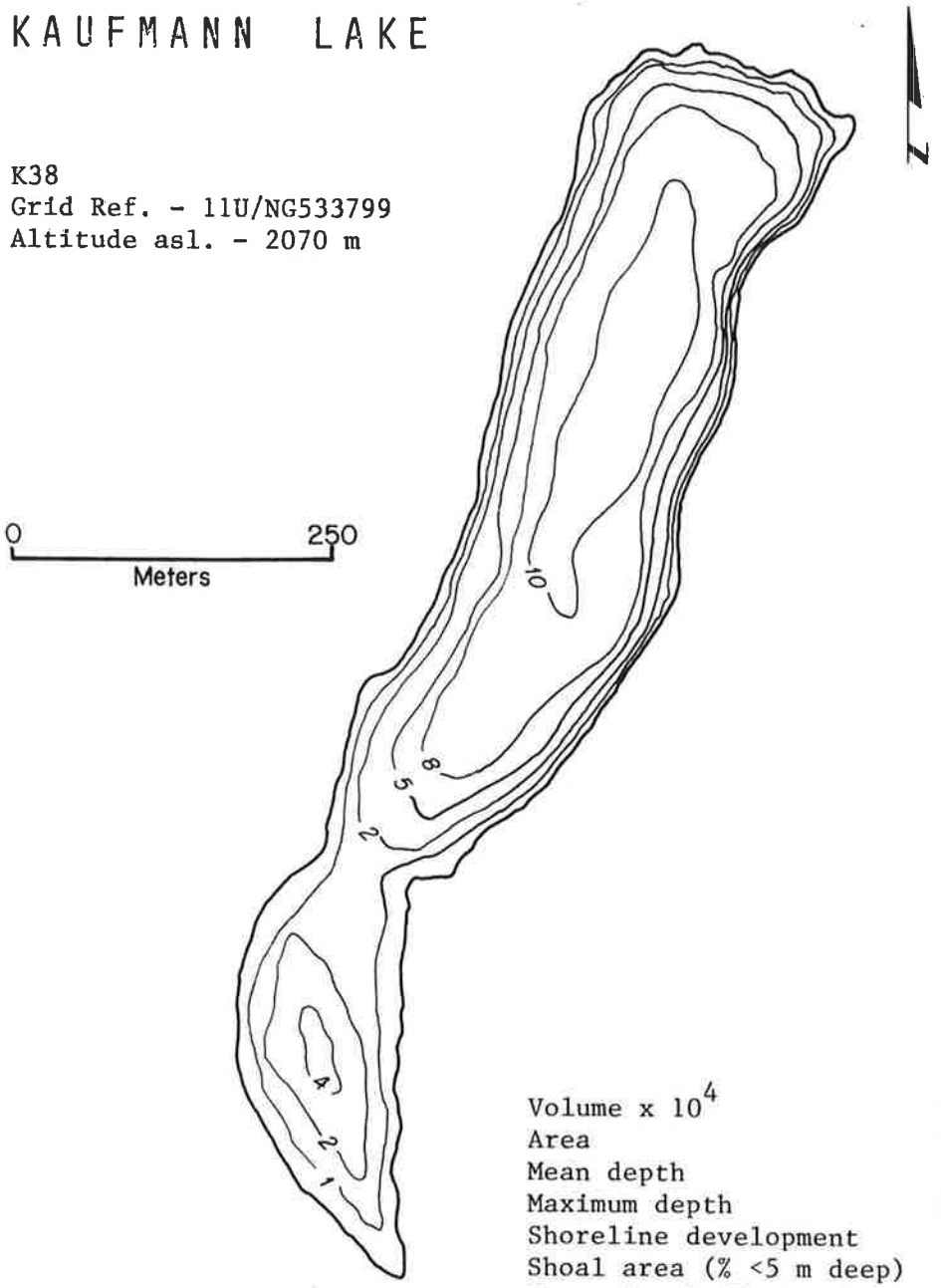
Date collected
28-7-82

CATCH DATA

Age	Length (mm)		Weight (g)		
	Mean	Standard Deviation	Mean	Standard Deviation	Number Examined
12	419	9.90	1427	176.78	2

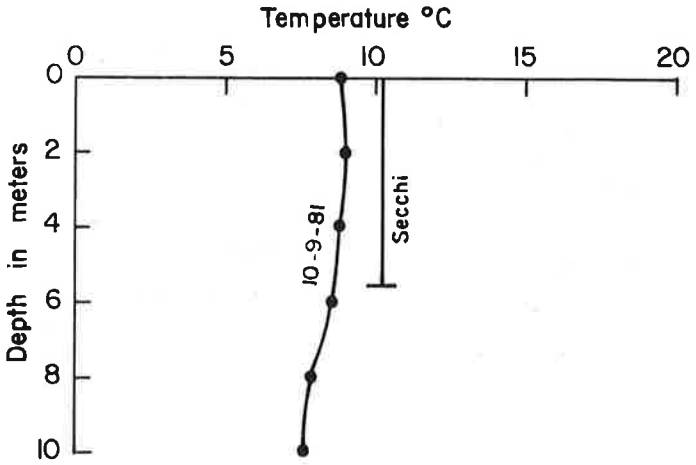
KAUFMANN LAKE

K38
Grid Ref. - 11U/NG533799
Altitude asl. - 2070 m

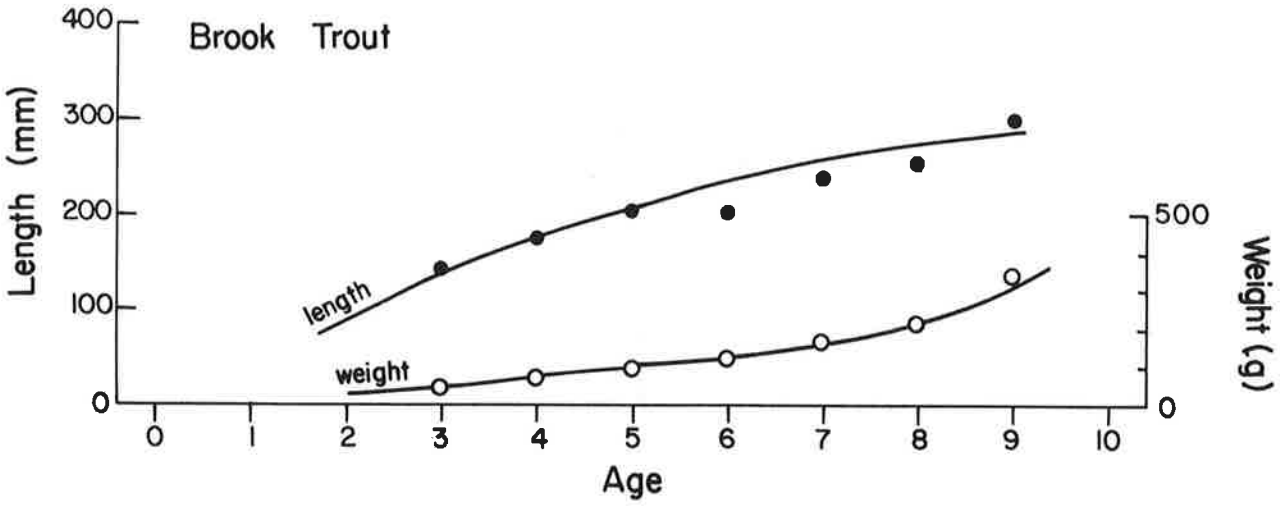


Volume x 10^4	74.5 m^3
Area	14.4 ha
Mean depth	5.2 m
Maximum depth	10.0 m
Shoreline development	1.7
Shoal area (% <5 m deep)	51 %
Water level fluctuation	0.5 m
Drainage basin area	582.4 ha
Total dissolved solids	79.4 mg/1
pH	8.2
Break-up	late June
Freeze-up	mid October

KAUFMANN LAKE



KAUFMANN LAKE



KAUFMANN LAKE

ZOOPLANKTON

Date	10 Sep 81
No. samples ($\bar{x}$)	2
Depth (metres)	10
Copepoda	
Acanthocyclops vernalis (?) copepodids only	0.51
cyclopoid nauplii	48.29
Cladocera	
Alona guttata	0.01
other groups	
chironomid larvae	0.01
mites	0.01
Mean nos. crustaceans/litre[a]	48.81
Rotifera[b]	
Polyarthra dolichoptera	xxxxx
Keratella hiemalis	x
Lecane luna	x

a. corrected for plankton net inefficiency (see methods)

b. estimated abundance by "order of magnitude" (see methods)

KAUFMANN LAKE

MACROINVERTEBRATES

PHYLUM CLASS	Order	Family*	Genus	species	Number collected per m^2
ASCHELMINTHES					
NEMATODA					60
ANNELIDA					
OLIGOCHAETA					142
MOLLUSCA					
PELECYPODA		Sphaeriidae*			1840
ARTHROPODA					
CRUSTACEA					
	Ostarcoda				288
			Cyclocypris		2550
ARACHNOIDEA					
	Hydracarina				108
INSECTA					
	Trichoptera				22
	Diptera	Chironomidae*			8110

total number of invertebrates	13,120
total weight (grams)	24.53
total number of samples	10
date collected	12-9-81

KAUFMANN LAKE

FISH SPECIES

- Salvelinus fontinalis (brook trout) — dates collected 13-9-79, 12-9-81

CATCH DATA

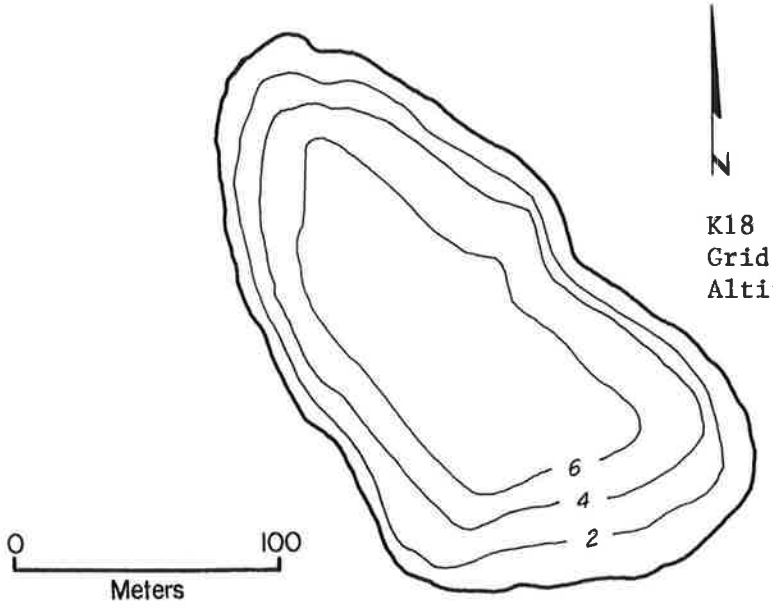
Age	Length (mm)		Weight (g)		
	Mean	Standard Deviation	Mean	Standard Deviation	Number Examined
2	148	-	38	-	1
3	165	32.16	45	9.72	15
4	176	13.37	68	33.77	14
5	204	16.52	95	31.77	11
6	206	51.03	124	80.25	3
7	240	-	163	-	1
8	255	-	222	-	1
9	298	-	350	-	1
10	-	-	-	-	-
11	300	-	614	-	1

STOMACH ANALYSES

Date collected	12-9-81
Stomachs examined	26
Number empty	1

Food	Percent by volume
Trichoptera	49
Chironomidae	33
Terrestrial insects	7
Ephemeroptera	6
Plecoptera	2
Sphaeriidae	1
Hydracarina	1
other	1
Simulidae	+
Amphipoda	+

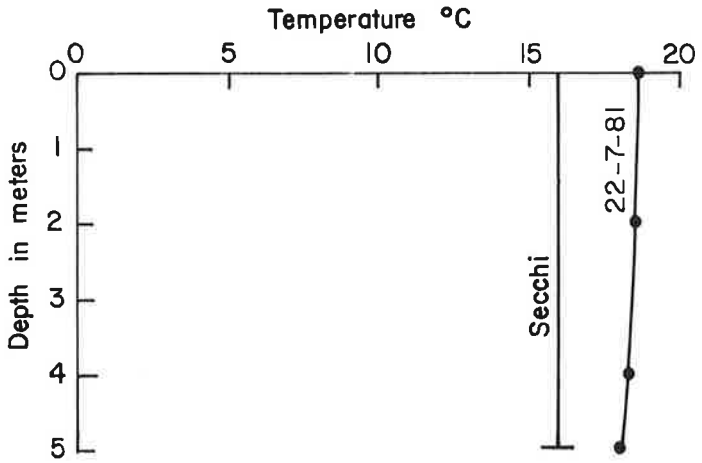
KOOTENAY POND



K18
Grid Ref. - 11U/NG675381
Altitude asl - 1213 m

Volume X 10^4	10.7 m^3
Area	2.6 ha
Mean depth	4.1 m
Maximum depth	6.0 m
Shoreline development	1.1
Shoal area (% <5 m deep)	54 %
Water level fluctuation	2.0 m
Drainage basin area	308.9 ha
Total dissolved solids	233.9 mg/1
pH	8.1
Break-up	early May
Freeze-up	early November

KOOTENAY POND



KOOTENAY POND

ZOOPLANKTON

Date	11 Jun 70	9 Aug 72	22 Jul 81
No. samples ($\bar{x}$)	2	2	2
Depth (metres)	4.2	7.5	5.0
Copepoda			
Diaptomus leptopus	11.40	3.92	0.59
diaptomid nauplii			12.50
Macrocyclops albidus			0.01
Eucyclops agilis	42.09		
Acanthocyclops vernalis		0.44	22.14
cyclopoid nauplii		0.96	46.21
Cladocera			
Daphnia pulex/pulicaris (?)	6.57	2.80	4.67
Ceriodaphnia quadrangula		10.06	
Diaphanosoma brachyurum		1.24	
other groups			
Gammarus lacustris			0.01
Chaoborus flavicans			0.03
ostracodes	0.59	0.30	
Mean nos. crustacean plankters/litre[a]	60.06	19.42	86.15
Rotifera[b]			
Keratella quadrata	xx	xx	xxxxx
Keratella cochlearis	xxx	xxx	xxx
Polyarthra vulgaris	xxx	xxxx	xxx
Hexarthra sp.		xx	
Asplanchna priodonta		xxx	

a. corrected for plankton net inefficiency (see methods)

b. estimated abundance by "order of magnitude" (see methods)

KOOTENAY POND

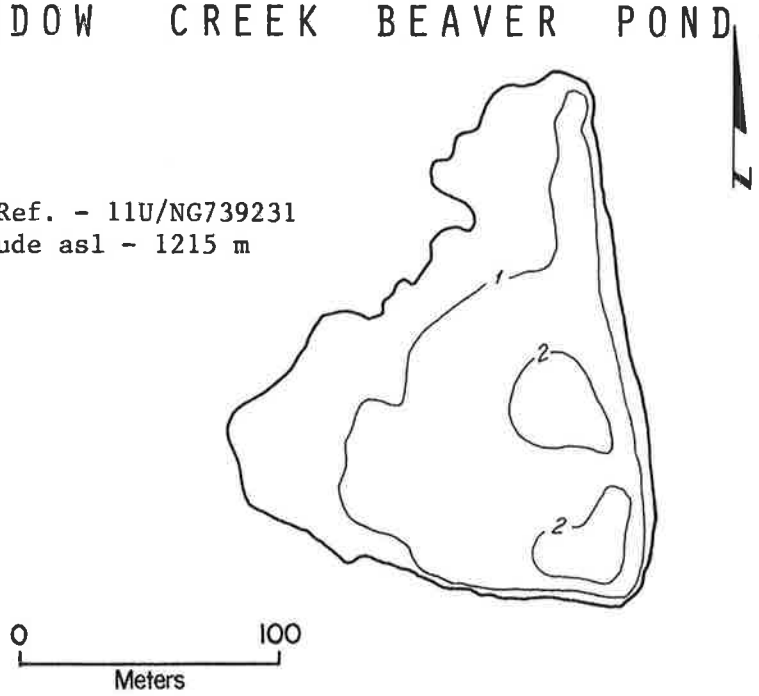
MACROINVERTEBRATES

PHYLUM CLASS	Order	Family*	Genus	species	Number collected per m^2
ASCHELMINTHES					
NEMATODA					585
ANNELIDA					
OLIGOCHAETA					34
HIRUDINEA					95
MOLLUSCA					
PELECYPODA					
	Eulamellibranchia	Sphaeriidae*			422
ARTHROPODA					
CRUSTACEA					
	Ostracoda				672
	Amphipoda	Gammaridae*	Gammarus	lacustris	827
		Talitridae*	Hyalella	azteca	1137
ARACHNOIDEA					
	Hydracarina				17
INSECTA					
	Ephemeroptera				17
	Trichoptera				60
		Limnephilidae*			9
	Odonata	Coenagrionidae*	Enallagma		9
	Diptera	Heleidae*			9
		Culicidae*	Chaoborus		43
		Chironomidae*			1782

total number of invertebrates	5,718
total weight (grams)	12.47
total number of samples	5
date collected	25-6-82

MEADOW CREEK BEAVER POND

Grid Ref. - 11U/NG739231
Altitude asl - 1215 m



Volume X 10^4	2.2 m^3
Area	2.0 ha
Mean depth	1.1 m
Maximum depth	2.0 m
Shoreline development	1.3
Shoal area (% <5 m deep)	100 %
Water level fluctuation	0.5 m
Drainage basin area	1280.7 ha
Total dissolved solids	176.8 mg/l
pH	8.0
Break-up	early May
Freeze-up	early November
Temperature (24-7-81)	19.8 C
Secchi depth	bottom +

MEADOW CREEK BEAVER POND

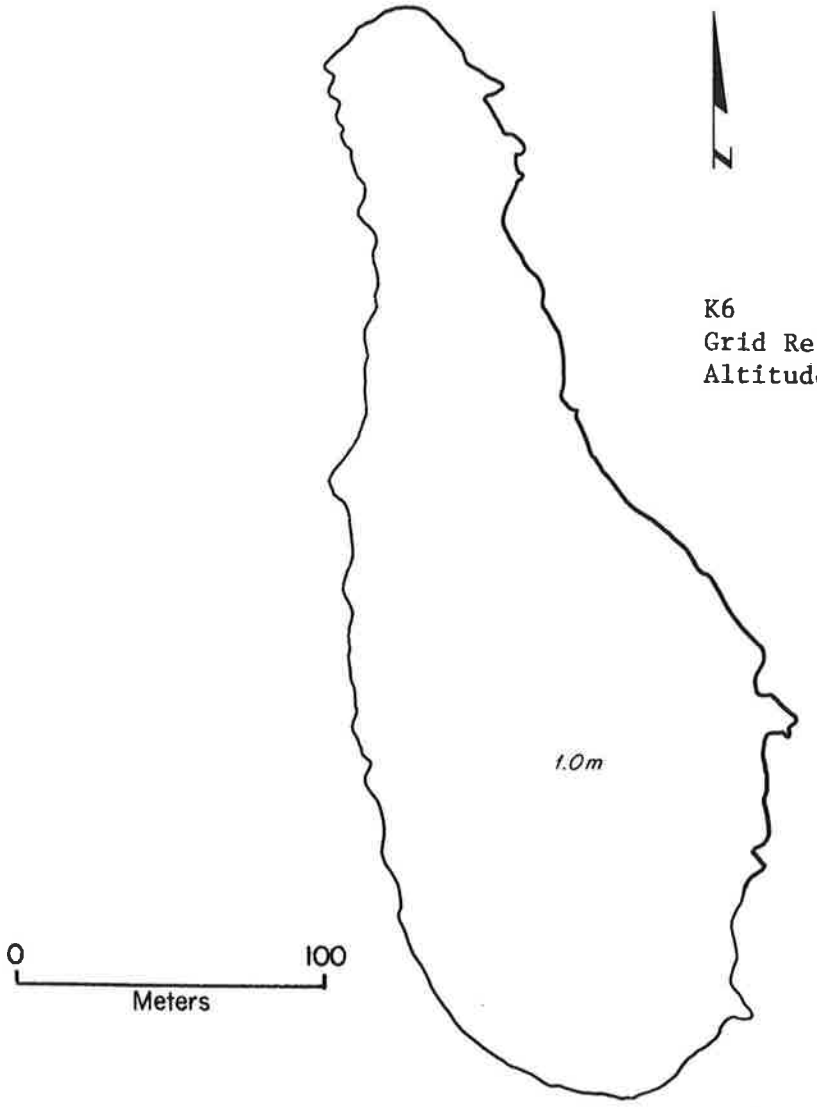
ZOOPLANKTON

Date	24 Jul 81
Depth (metres)	1.5
No. samples ($\bar{x}$)	2
Copepoda	
Acanthocyclops vernalis	0.19
cyclopoid nauplii	0
Cladocera	
Chydorus sphaericus	0.04
Scapholeberis kingi	0.04
other groups	
enchytraeids	0.07
rhabdocoels	0.04
dipteran larvae	0.07
dipteran pupae	0.04
Mean nos. crustaceans/litre[a]	0.27
Rotifera[b]	
Notholca squamula	x
Euchlanis dilatata	x

a. corrected for plankton net inefficiency (see methods)

b. estimated abundance by "order of magnitude" (see methods)

NIXON POND



K6
Grid Ref. - 11U/NG754211
Altitude asl - 1183 m

Volume X 10^4	1.1 m^3	Water level fluctuation	0.5 m
Area	3.2 ha	Drainage basin area	176.9 ha
Mean depth	0.3 m	Total dissolved solids	174.9 mg/l
Maximum depth	1.0 m	pH	8.3
Shoreline development	1.4	Break-up	early May
Shoal area (% <5 m deep)	100 %	Freeze-up	early November
Secchi depth	bottom +	Temperature(27-06-81)	17.7 C

NIXON POND

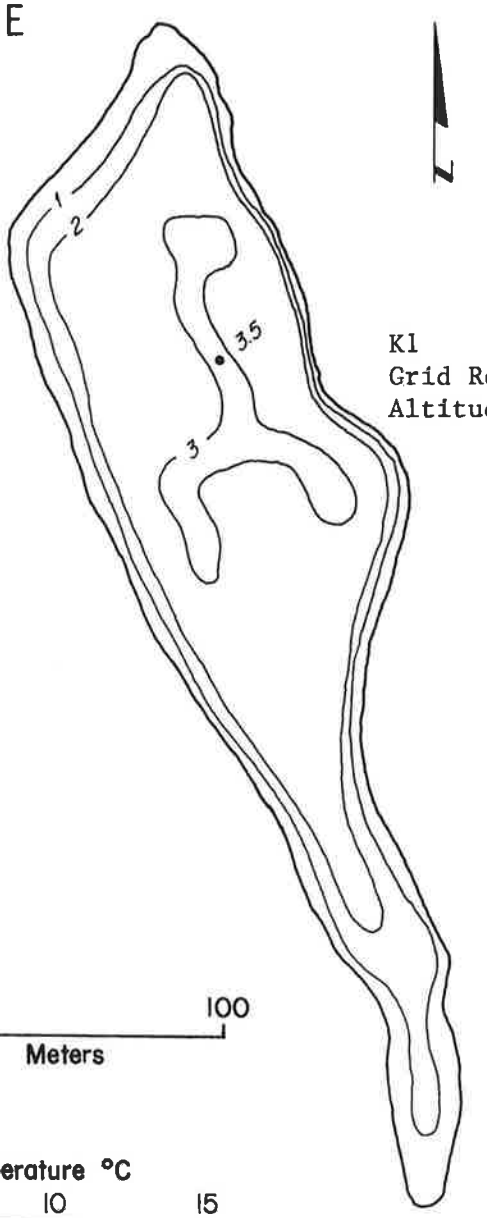
ZOOPLANKTON

Date	11 Jun 70	27 Jun 81
No. samples ($\bar{x}$)	3	2
Tow (metres)	5 m horiz.	5 m horiz.
Copepoda		
Diaptomus leptopus	xxxx	0.04
diaptomid nauplii	xx	6.32
cyclopoid copepodids (some prob. *Macrocyclops albidus*)	xx	1.72
cyclopoid nauplii	x	65.26
Cladocera		
Daphnia pulicaria/schödleri (?)	xx	14.05
Daphnia rosea	xxxx	
Ceriodaphnia reticulata		0.02
Eurycercus lamellatus	x	
Alona guttata		0.09
Chydorus sphaericus	xx	0.14
Scapholeberis kingi	x	
Diaphanosoma brachyurum	x	0.85
Polyphemus pediculus		0.22
other groups		
Chaoborus americanus	xxx	0.50
corixids	x	
mites	x	0.01
Mean nos. crustacean plankters/litre[a]	50 (est.)	88.71
Rotifera[b]		
Notholca acuminata		x
Keratella quadrata		xxxx
Keratella cochlearis	xxxx	x
Polyarthra vulgaris	xx	xxxxx
Asplanchna priodonta		x
Synchaeta oblonga		x
Euchlanis dilatata		x
Euchlanis triquetra		x
Conochilus unicornis		xx

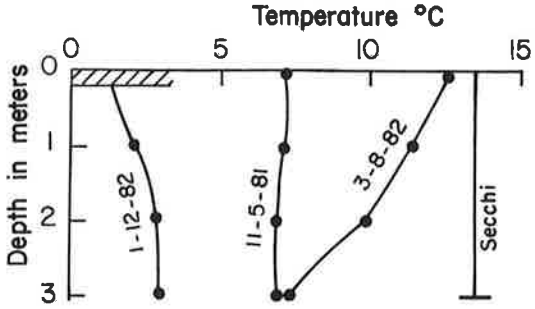
a. corrected for plankton net inefficiency (see methods)

b. estimated abundance by "order of magnitude" (see methods)

OLIVE LAKE

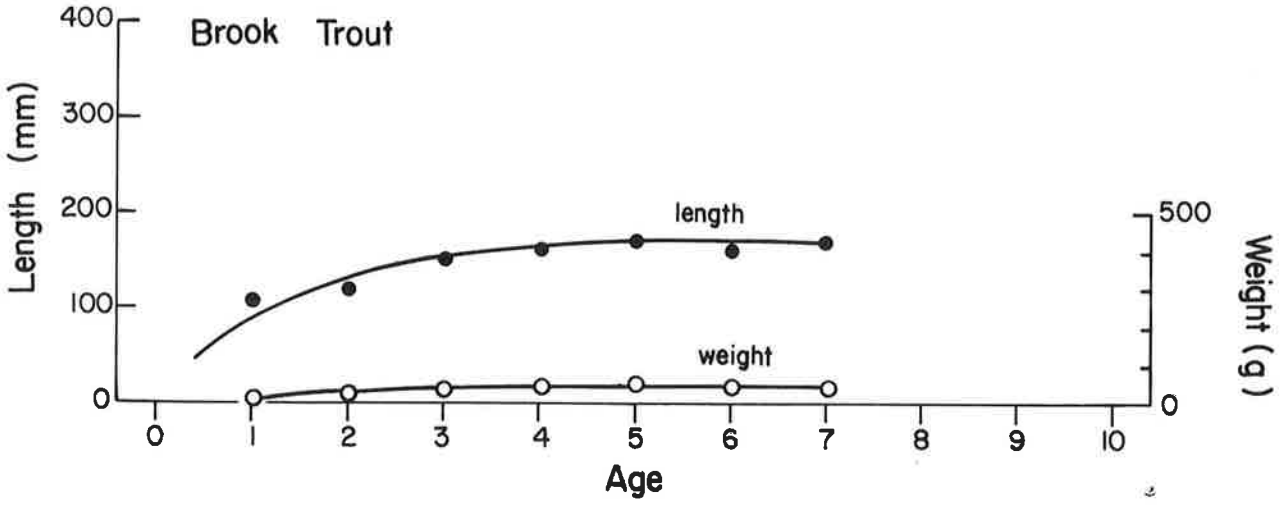


K1
Grid Ref. - 11U/NG753139
Altitude asl - 1631 m



Volume X 10^4	3.9 m^3	Water level fluctuation	0.5 m
Area	2.0 ha	Drainage basin area	293.6 ha
Mean depth	2.0 m	Total dissolved solids	168.6 mg/l
Maximum depth	3.5 m	pH	7.9
Shoreline development	1.7	Break-up	early May
Shoal area (% <5m deep)	100 %	Freeze-up	late October

OLIVE LAKE


Brook Trout
Length (mm)
400
300
200
100
0
length
weight
500
0
Weight (g)
0
1
2
3
4
5
6
7
8
9
10
Age

OLIVE LAKE

ZOOPLANKTON

Date	11 Jun 70	9 Aug 72	22 Jul 81	11 May 82	20 Sep 82	2 Dec 82
No. samples ($\bar{x}$)	2	3	2	2	2	2
Depth (metres)	3.8	3.2	2	3	3.5	2
Copepoda						
Macrocyclops albidus						0.42
Acanthocyclops vernalis			0.08			
Eucyclops agilis			0.44	0.04	0.03	0.19
Diacyclops thomasi	56.96	19.25	127.37	0.50	3.17	9.60
cyclopoid nauplii		0.54	33.52	0.98	0.02	0.11
Cladocera						
Chydorus sphaericus			0.25		0.02	0.11
Scapholeberis kingi		1.13	4.61		0.02	
other groups						
mites		0.10				
ostracodes		0.07	0.03			
chironomid larvae			0.06			0.08
Mean nos. crustacean plankters/litre[a]	56.96	20.92	166.27	1.52	3.26	10.43
Rotifera[b]				nil	nil	nil
Kellicottia longispina			x			
Keratella quadrata (?)	x					
Keratella cochlearis	xx					
Polyarthra vulgaris	xxxx	xxxx	xxxx			

a. corrected for plankton net inefficiency (see methods)

b. estimated abundance by "order of magnitude" (see methods)

OLIVE LAKE

MACROINVERTEBRATES

PHYLUM CLASS	Order	Family*	Number collected per m^2 May	June	Sept	Dec
PLATYHELMINTHES						
TURBELLARIA			-	22	-	-
ASCHELMINTHES						
NEMATODA			86	344	100	17
ANNELIDA						
OLIGOCHAETA			144	187	7	215
MOLLUSCA						
PELECYPODA						
	Eulamellibranchia	Sphaeriidae*	660	631	739	637
ARTHROPODA						
CRUSTACEA						
	Ostracoda		438	553	2300	8929
	Amphipoda	Gammaridae*	57	79	330	95
ARACHNOIDEA						
	Hydracarina		-	-	7	-
INSECTA						
	Diptera	Chironomidae*	4068	7591	4632	11934
total number of invertebrates			5453	9407	8115	21827
total weight (grams)			7.01	8.29	9.49	18.18
total number of samples			6	6	6	5

OLIVE LAKE

FISH SPECIES

- Salvelinus fontinalis (brook trout)

dates collected
07-10-81
17-05-82
11-06-82

CATCH DATA

Age	Length (mm)		Weight (g)		
	Mean	Standard Deviation	Mean	Standard Deviation	Number Examined
1	107	6.25	13	1.71	9
2	118	9.40	19	4.56	22
3	148	15.41	38	10.06	18
4	160	6.24	46	6.16	19
5	167	12.92	51	12.71	11
6	161	7.27	46	5.13	11
7	174	13.57	44	6.21	4

STOMACH ANALYSES

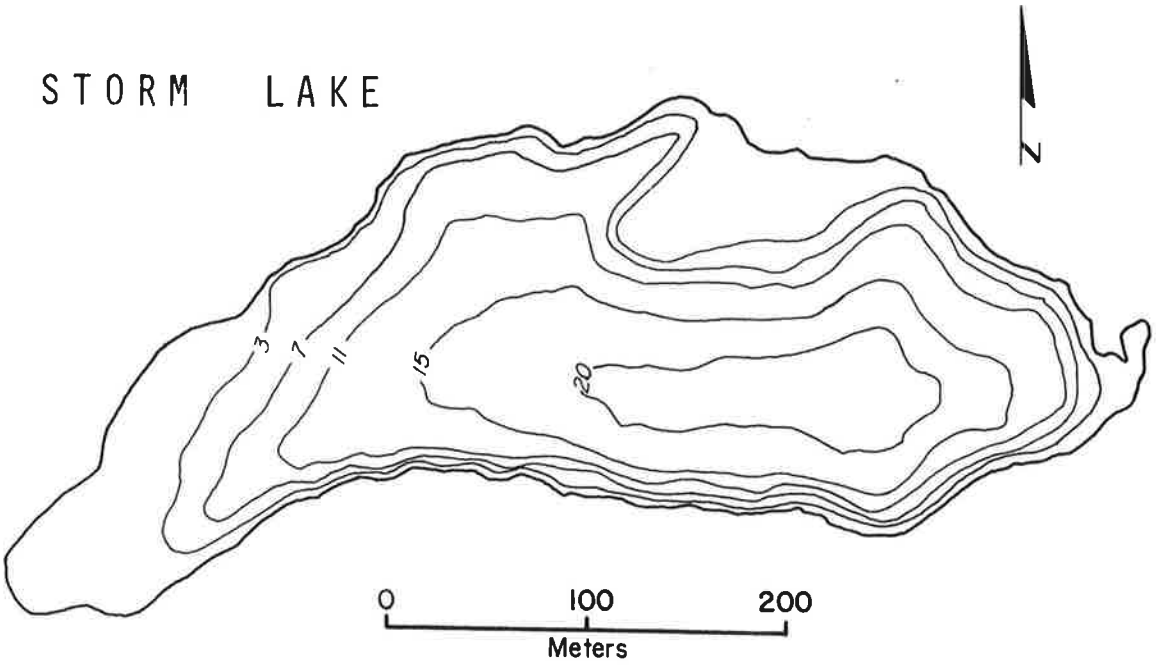
Month	May	June	July	August	Sept.	Oct.	Dec.
Stomachs examined	26	25	25	27	27	25	9
Number empty	2	2	4	4	2	2	2
Food	Percent by volume						
Chironomidae	77	18	52	78	62	13	1
Gammarus	10	18	21	2	24	12	98
Terrestrial insects	7	55	11	8	9	66	-
Sialidae	4	-	-	-	-	-	-
Trichoptera	1	-	-	2	2	-	1
Sphaeriidae	1	-	-	-	-	1	+
Emphemeroptera	+	-	11	+	1	-	-
Physidae	+	-	-	-	2	-	-
Dytiscidae	-	5	-	+	-	-	-
Plecoptera	-	4	1	-	-	-	-
Heleidae	-	+	-	-	-	-	-
Salvelinus	-	-	4	-	-	3	-
Odonata	-	-	-	5	-	1	-
Cladocera	-	-	+	3	-	4	-
Corixidae	-	-	-	1	+	+	-
Gerridae	-	-	-	1	-	-	-

OLIVE LAKE

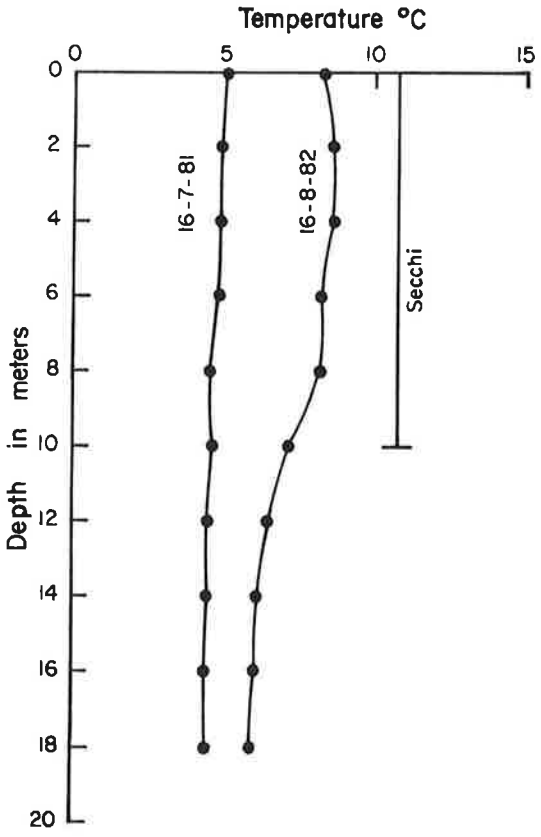
POPULATION STATISTICS

Brook trout

May 1982, number marked (t_1)	259
June to August, number of marked fish recaptured	30
in sample of	189
Mortality (at t_1)	69
Population size (N)	1662
95% confidence limits of N	1197-2399
Number of fish per hectare	831
Total number of fish >100 g but <500g	0
Total number of fish >500 g but <1000g	0
Total number of fish < 1000 g	0



K37
Grid Ref. - 11U/NG686741
Altitude asl - 2241 m



Volume X 10^4	77.9 m^3
Area	7.9 ha
Mean depth	9.8 m
Maximum depth	20.0 m
Shoreline development	1.4
Shoal area (% <5 m deep)	31 %
Water level fluctuation	0.5 m
Drainage basin area	169.9 ha
Total dissolved solids	45.3 mg/l
pH	8.1
Break-up	mid July
Freeze-up	mid October

STORM LAKE

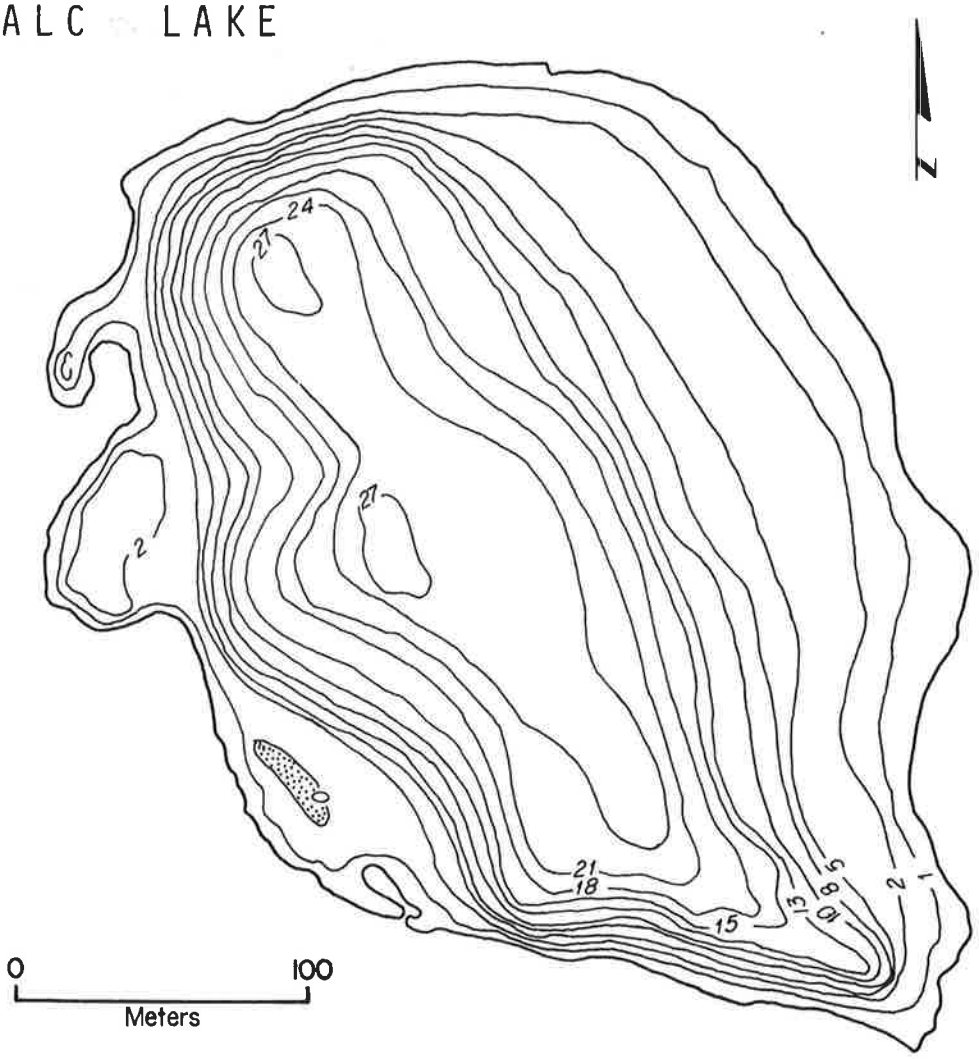
ZOOPLANKTON

Date	30 Sep 70	16 Jul 81
No. samples ($\bar{x}$)	3	2
Depth (metres)	16	16 ($\bar{x}$)
Copepoda		
Diaptomus arcticus	3.32	1.42
diaptomid nauplii		0.90
Eucyclops speratus	0.21	
Acanthocyclops vernalis		0.03
cyclopoid nauplii		0.50
Cladocera		
Daphnia middendorffiana	0.76	0.07
other groups		
Gammarus lacustris	0.06	0.02
chironomid larvae		0.01
Mean nos. crustacean plankters/litre[a]	4.29	2.92
Rotifera[b]		
Kellicottia longispina	xxxx	xxx

a. corrected for plankton net inefficiency (see methods)

b. estimated abundance by "order of magnitude" (see methods)

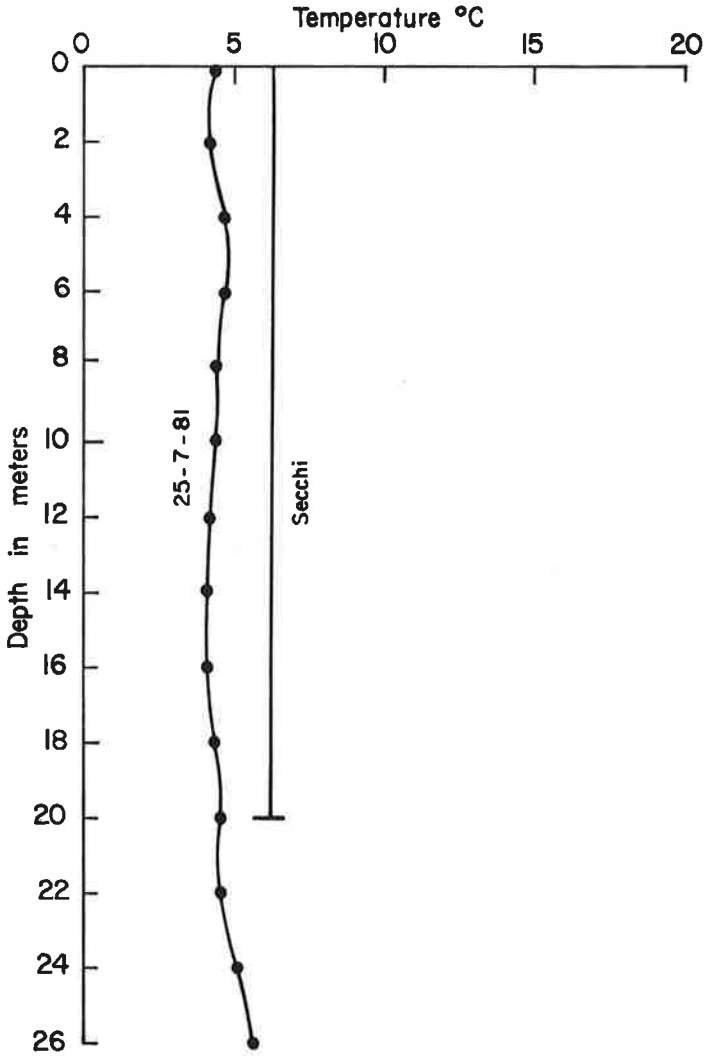
TALC LAKE



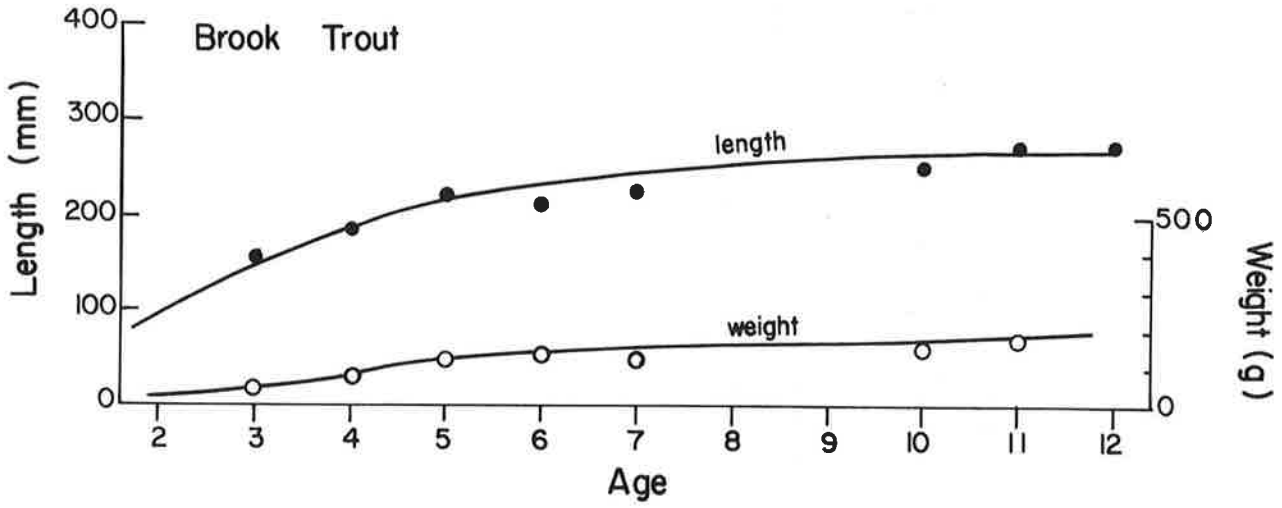
K29
Grid Ref. 11U/NG774593
Altitude asl - 2176 m

Volume X 10^4	81.7 m^3	Water level fluctuation	0.5 m
Area	7.5 ha	Drainage basin area	135.0 ha
Mean depth	10.9 m	Total dissolved solids	102.7 mg/l
Maximum depth	27.0 m	pH	8.3
Shoreline development	1.3	Break-up	mid July
Shoal area (% <5 m deep)	41 %	Freeze-up	mid October

TALC LAKE


Temperature °C
0
5
10
15
20
0
2
4
6
8
10
12
14
16
18
20
22
24
26
Depth in meters
25-7-81
Secchi

TALC LAKE


Brook Trout
Length (mm)
400
300
200
100
0
length
weight
500
0
Weight (g)
2
3
4
5
6
7
8
9
10
11
12
Age

TALC LAKE

ZOOPLANKTON

Date	25 Jul 1981
No. samples ($\bar{x}$)	2
Depth (metres)	26
Copepoda	
Diaptomus (immature; probably *arcticus*)	16.23
diaptomid nauplii	1.07
cyclopoid early copepodids	0.01
cyclopoid nauplii	0.09
Cladocera	
Daphnia pulex/pulicaria (?)	0.01
Mean nos. crustaceans/litre[a]	17.41
Rotifera[b]	
Kellicottia longispina	xxxx
Keratella hiemalis	xx

a. corrected for plankton net inefficiency (see methods)

b. estimated abundance by "order of magnitude" (see methods)

TALC LAKE

MACROINVERTEBRATES

PHYLUM CLASS	Order	Family*	Genus	species	Number collected per m^2
ASCHELMINTHES					
NEMATODA					22
ANNELIDA					
OLIGOCHAETA					1160
MOLLUSCA					
PELECYPODA					
		Sphaeriidae*			3440
ARTHROPODA					
CRUSTACEA					
	Ostracoda				11
INSECTA					
	Diptera	Chironomidae*			6288
		total number of invertebrates			10,921
		total weight (grams)			15.21
		total number of samples			4
		date collected			25-6-81

TALC LAKE

FISH SPECIES

- Salvelinus fontinalis (brook trout) date collected 26-7-81

CATCH DATA

Age	Length (mm)		Weight (g)		
	Mean	Standard Deviation	Mean	Standard Deviation	Number Examined
3	158	11.95	47	10.94	15
4	185	22.12	76	21.47	33
5	221	18.38	123	30.41	2
6	212	40.61	131	16.91	11
7	225	-	124	-	1
10	248	-	152	-	1
11	270	7.07	174	25.46	2
12	274	-	188	-	1

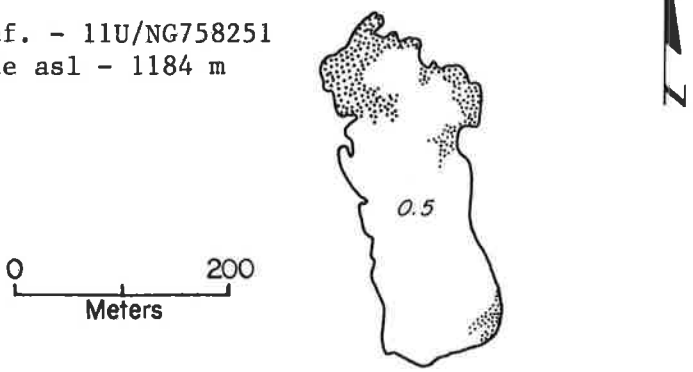
STOMACH ANALYSES

Stomachs examined	25
Number empty	0

Food	Percent by volume
Chironomidae	56
Plecoptera	20
Trichoptera	14
Terrestrial insects	4
Amphipoda	3
Dytiscidae	2
Sphaeriidae	1

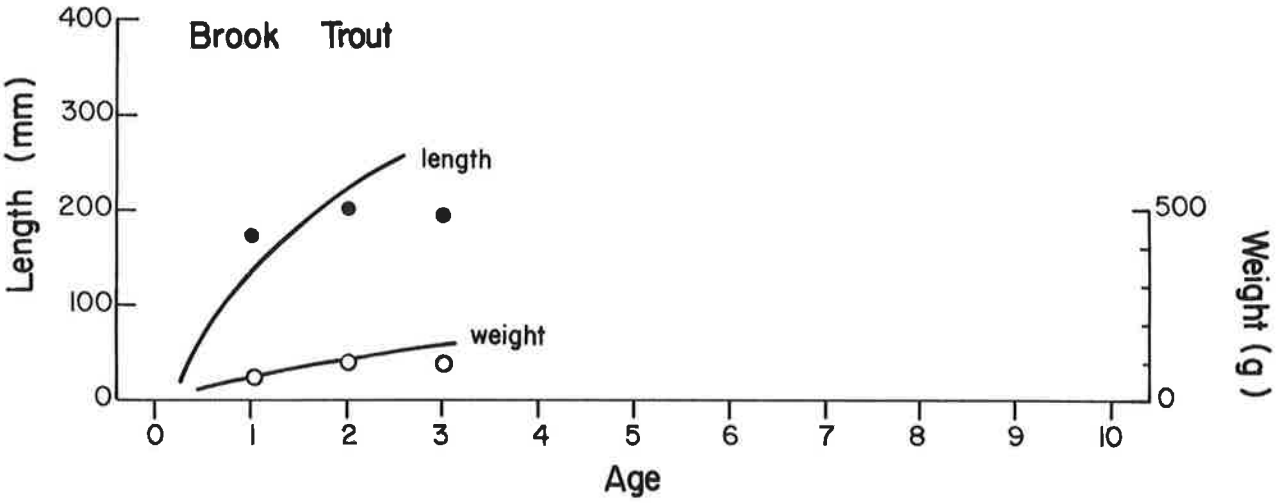
K 4

K4
Grid Ref. - 11U/NG758251
Altitude asl - 1184 m



Volume X 10^4	1.7 m^3
Area	3.4 ha
Mean depth	0.5 m
Maximum depth	0.5 m
Shoreline development	1.4
Shoal area (% <5 m deep)	100%
Water level fluctuation	0.5 m
Drainage basin area	106.4 ha
Total dissolved solids	186.4 mg/l
pH	8.2
Break-up	late April
Freeze-up	early November
Secchi depth	bottom +
Temperature (22-07-81)	22.0 C

K 4


Brook Trout
Length (mm)
400
300
200
100
0
length
weight
500
0
Weight (g)
0
1
2
3
4
5
6
7
8
9
10
Age

K 4

ZOOPLANKTON

Date	22 Jul 81
No. samples ($\bar{x}$)	2
Depth (metres)	5
Copepoda	
Diaptomus leptopus	0.56
diaptomid nauplii	0.00
Microcyclops varians rubellus	0.06
Cladocera	
Daphnia rosea	20.97
Sida crystallina	0.01
Polyphemus pediculus	0.59
Alona affinis	0.01
Alona rectangula	0.02
Chydorus sphaericus	0.43
Scapholeberis kingi	1.63
other groups	
Chaoborus sp.	0.02
chironomid larvae	0.02
ostracodes	0.08
mites	0.03
Hydra sp.	0.02
Mean nos. crustaceans/litre[a]	24.28
Rotifera[b]	
Asplanchna priodonta	x

a. corrected for plankton net inefficiency (see methods)
b. estimated abundance by "order of magnitude" (see methods)

K 4

FISH SPECIES

- Salvelinus fontinalis (brook trout) date collected 14-6-82

CATCH DATA

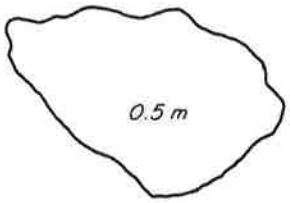
Age	Length (mm)		Weight (g)		
	Mean	Standard Deviation	Mean	Standard Deviation	Number Examined
1	174	-	66	-	1
2	202	12.48	112	24.80	14
3	193	-	98	-	1

STOMACH ANALYSES

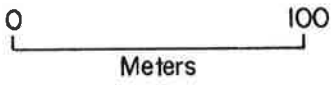
Stomachs examined	16
Number empty	2

Food	Percent by volume
Amphipoda	36
Terrestrial insects	29
Odonata	20
Trichoptera	7
Hirudinea	3
Gerridae	3
Dytiscidae	2

K 10



K10
Grid Ref. - 11U/NG597349
Altitude asl - 2254 m



Volume X 10^4	0.1 m^3
Area	0.4 ha
Mean depth	0.3 m
Maximum depth	0.5 m
Shoreline development	1.1
Shoal area (% <5 m deep)	100 %
Water level fluctuation	1.0 m
Drainage basin area	21.5 ha
Total dissolved solids	78.8 mg/l
pH	8.4
Break-up	early July
Freeze-up	mid October
Secchi depth	bottom +
Temperature (7-08-82)	9.4 C

K 10

ZOOPLANKTON

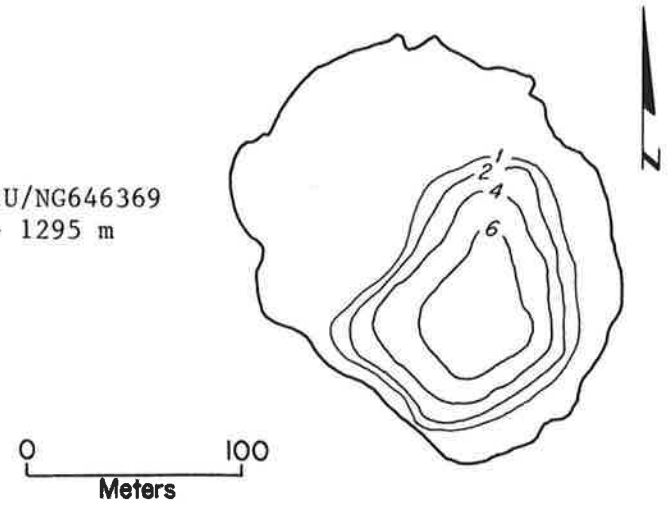
Date	7 Aug 82
No. samples ($\bar{x}$)	2
Depth (metres)	1
Copepoda	
cyclopoid early copepodids	0.22
cyclopoid nauplii	27.81
Cladocera	
nil	-
Mean nos. crustaceans/litre[a]	28.03
Rotifera[b]	
Polyarthra dolichoptera	*xx*
Euchlanis dilatata	*xxx*

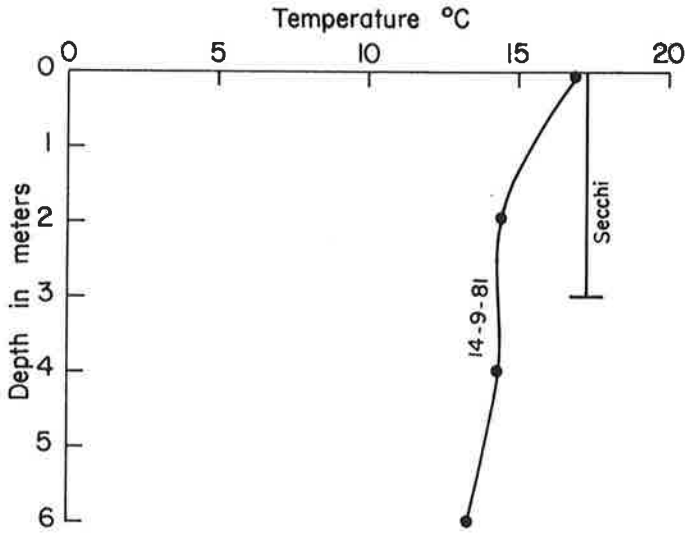
a. corrected for plankton net inefficiency (see methods)

b. estimated abundance by "order of magnitude" (see methods)

K 13

K13
Grid Ref. - 11U/NG646369
Altitude asl - 1295 m





Volume X 10^4	4.6 m^3	Water level fluctuation	0.5 m
Area	2.5 ha	Drainage basin area	35.4 ha
Mean depth	1.8 m	Total dissolved solids	218.5 mg/l
Maximum depth	6.0 m	pH	8.3
Shoreline development	1.1	Break-up	early May
Shoal area (% <5 m deep)	85 %	Freeze-up	early November

K 13

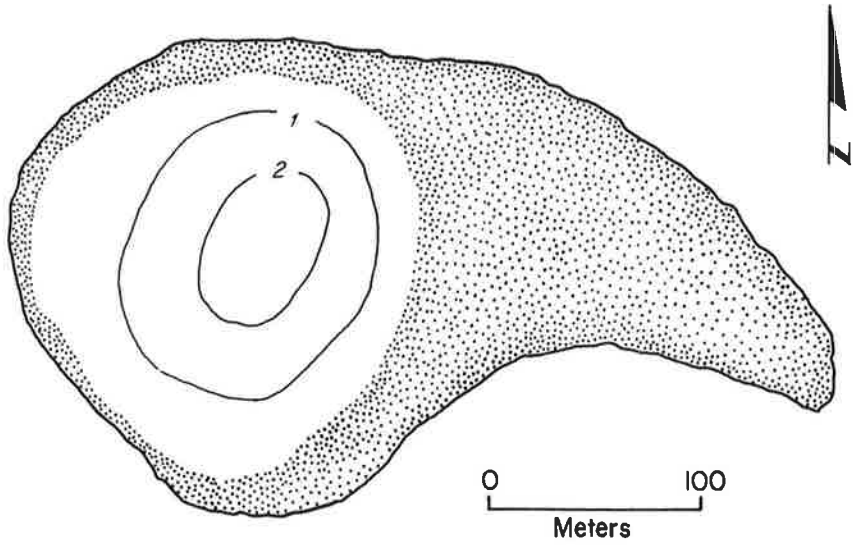
ZOOPLANKTON

Date	14 Sep 81
No. samples ($\bar{x}$)	2
Depth (metres)	6
Copepoda	
Diaptomus leptopus	2.23
diaptomid nauplii	7.70
cyclopoid copepodids (poss. *Acanthocyclops vernalis*)	8.66
cyclopoid nauplii	69.19
Cladocera	
Daphnia sp. (immature)	0.13
Ceriodaphnia quadrangula	0.03
Diaphanosoma leuchtenbergianum	1.96
other groups	
Gammarus lacustris	0.01
Chaoborus americanus	0.25
Mean nos. crustacean plankters/litre[a]	89.90
Rotifera[b]	
Kellicottia longispina	xxx
Keratella quadrata	xxxxx
Keratella cochlearis	xxx
Polyarthra vulgaris	xxx
Lecane luna	x

a. corrected for plankton net inefficiency (see methods)

b. estimated abundance by "order of magnitude" (see methods)

K 16



K16
Grid Ref. - 11U/NG666357
Altitude asl - 1265 m

Volume X 10^4	4.0 m^3
Area	5.7 ha
Mean depth	0.7 m
Maximum depth	2.0 m
Shoreline development	1.2
Shoal area (% <5 m deep)	100 %
Water level fluctuation	0.5 m
Drainage basin area	72.0 ha
Total dissolved solids	143.8 mg/l
pH	8.0
Break-up	early May
Freeze-up	early November
Secchi depth	bottom +
Temperature (27-06-81)	18.1 C

K 16

ZOOPLANKTON

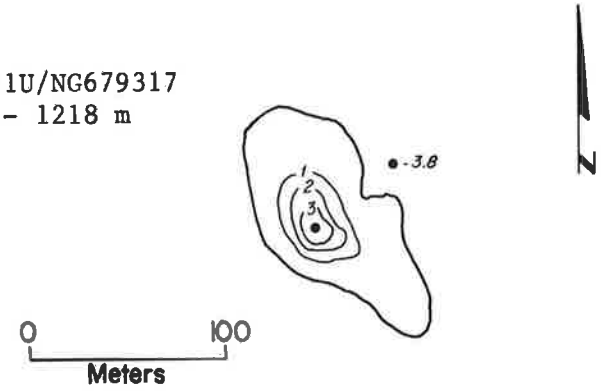
Date	27 Jun 81
No. samples ($\bar{x}$)	2
Depth (metres)	2
Copepoda	
Diaptomus leptopus	0.80
diaptomid nauplii	2.05
Macrocyclops albidus	0.33
cyclopoid nauplii	0.47
Cladocera	
Daphnia pulex	7.05
Simocephalus vetulus	0.08
Chydorus sphaericus	0.47
other groups	
Gammarus lacustris	0.03
Chaoborus flavicans	0.83
chironomid larvae	0.06
gastropods	0.03
pelecypods	0.03
Mean nos. crustacean plankters/litre[a]	11.25
Rotifera[b]	
Keratella quadrata	xxx
Keratella cochlearis	xxx
Polyarthra vulgaris	xxx
Synchaeta oblonga	xx
Asplanchna priodonta	xx
Ploesoma lenticulare (?)	xxx

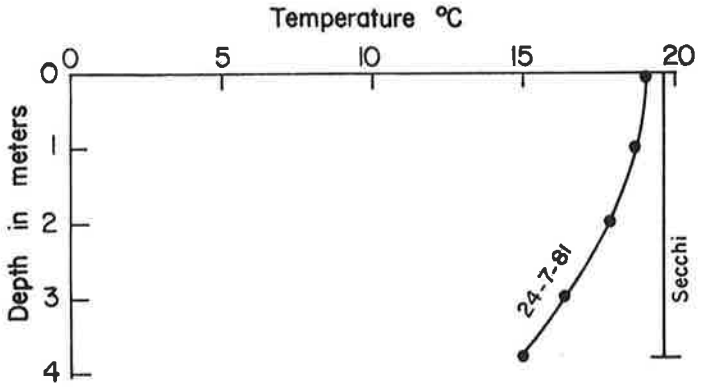
a. corrected for plankton net inefficiency (see methods)

b. estimated abundance by "order of magnitude" (see methods)

K 20

K20
Grid Ref. - 11U/NG679317
Altitude asl - 1218 m





Volume X 10^4	0.5 m^3	Water level fluctuation	0.5 m
Area	0.6 ha	Drainage basin area	39.0 ha
Mean depth	0.8 m	Total dissolved solids	277.5 mg/l
Maximum depth	3.8 m	pH	8.4
Shoreline development	1.2	Break-up	early May
Shoal area (% <5 m deep)	100%	Freeze-up	early November

K 20

ZOOPLANKTON

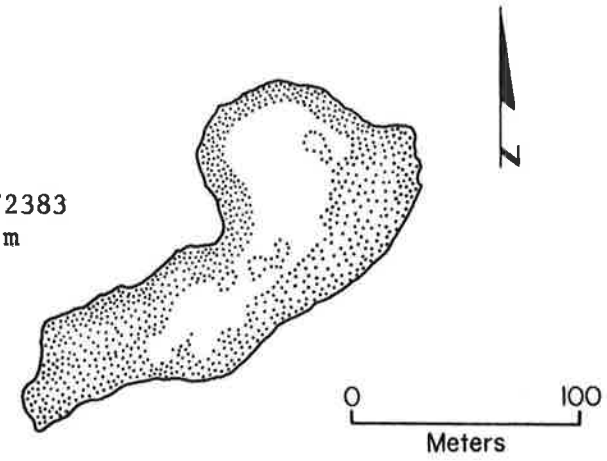
Date	24 Jul 81
No. samples ($\bar{x}$)	2
Depth (metres)	3
Copepoda	
Diaptomus leptopus	0.76
diaptomid nauplii	1.02
Orthocyclops modestus } *Eucyclops agilis* }	1.11
cyclopoid nauplii	10.62
Cladocera	
Daphnia pulex/pulicaria (?)	1.70
Chydorus sphaericus	0.33
Diaphanosoma brachyurum	34.43
other groups	
Chaoborus americanus	0.67
chironomid larvae	0.19
ostracodes	0.07
mites	0.05
Mean nos. crustaceans/litre[a]	49.97
Rotifera[b]	
Keratella quadrata	xxxx
Keratella cochlearis	xxxx
Polyarthra vulgaris	xxxx

a. corrected for plankton net inefficiency (see methods)

b. estimated abundance by "order of magnitude" (see methods)

K 24

K24
Grid Ref. - 11U/NG672383
Altitude asl - 1214 m



Volume X 10^4	0.4 m^3
Area	1.2 ha
Mean depth	0.3 m
Maximum depth	1.0 m
Shoreline development	1.4
Shoal area (% <5 m deep)	100 %
Water level fluctuation	2.5 m
Drainage basin area	308.9 ha
Total dissolved solids	224.9 mg/1
pH	7.6
Break-up	early May
Freeze-up	early November
Secchi depth	bottom +
Temperature (22-07-81)	19.8 C

K 24

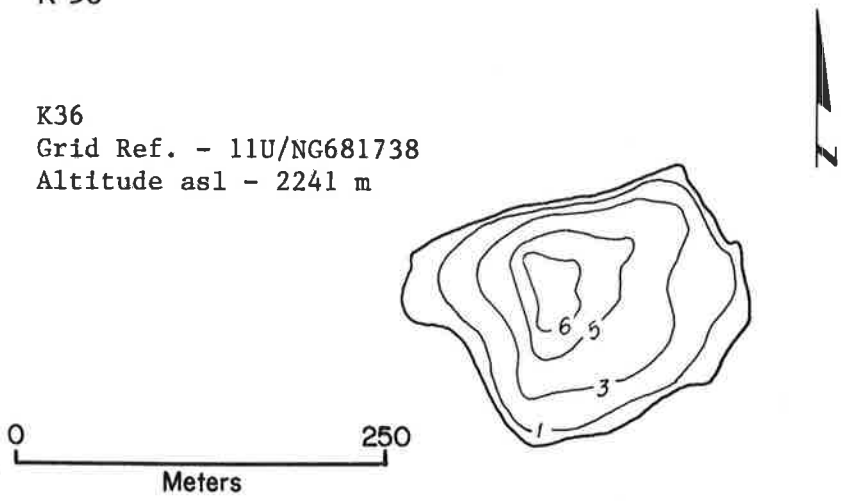
ZOOPLANKTON

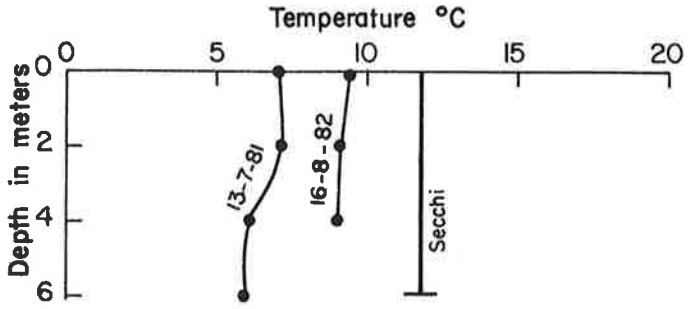
Date	11 Jun 70	11 Jun 70	22 Jul 81
No. samples ($\bar{x}$)	1	1	2
Depth (metres)	3.8	horiz.	5 m horiz.
Copepoda			
Diaptomus leptopus	22.78	xx	0.13
diaptomid nauplii			0.80
Diacyclops navus			1.84
Acanthocyclops vernalis			1.17
Microcyclops varians rubellus			3.74
Paracyclops fimbriatus poppei	6.72	x	
Eucyclops agilis		xx	
cyclopoid nauplii			0.75
Cladocera			
Daphnia pulex (?)	34.89	xx	
Daphnia longispina (?)			0.18
Ceriodaphnia quadrangula			0.09
Simocephalus vetulus			0.65
Diaphanosoma leuchtenbergianum			1.04
Polyphemus pediculus			15.71
Alona guttata			0.57
Chydorus sphaericus		xx	32.30
Pleuroxus denticulatus			0.39
Scapholeberis kingi		xxx	0.04
other groups			
Hyallela azteca	0.03	x	
Chaoborus punctipennis (?)			0.01
chironomid larvae			1.02
corixids			0.02
zygopterans			0.04
gastropods			0.01
naidids			0.01
ostracodes			0.31
Mean nos. crustaceans/litre[a]	64.39		59.40
Rotifera[b]			
Keratella quadrata	xxx		
Asplanchna priodonta			xx
Polyarthra vulgaris			xx
Monostyla lunata			xx
Lecane luna			xx
Euchlanis dilatata			xx
Mytilina ventralis			x
Mytilina mucronata			xx
Trichotria pocillum			x

a. corrected for plankton net inefficiency (see methods)
b. estimated abundance by "order of magnitude" (see methods)

K 36

K36
Grid Ref. - 11U/NG681738
Altitude asl - 2241 m





Volume X 10^4	8.3 m^3	Water level fluctuation	0.5 m
Area	2.9 ha	Drainage basin area	169.9 ha
Mean depth	2.9 m	Total dissolved solids	-
Maximum depth	6.0 m	pH	-
Shoreline development	1.1	Break-up	early July
Shoal area (% <5 m deep)	83 %	Freeze-up	mid October

K 36

ZOOPLANKTON

Date	16 Jul 81
No. samples ($\bar{x}$)	2
Depth (metres)	5
Copepoda	
Diaptomus arcticus	1.82
diaptomid nauplii	0.74
Acanthocyclops vernalis	0.01
Cladocera	
Daphnia (middendorffiana?)	0.29
other groups	
Gammarus lacustris	0.01
chironomid larvae	0.01
Mean nos. crustacean plankters/litre[a]	2.86

Rotifera

nil

a. corrected for plankton net inefficiency (see methods)

SUMMARY AND DISCUSSION OF RESULTS

Water chemistry

Table 1 summarizes values for the major and minor ions, nutrients, and some physical parameters of the water from lakes in Kootenay National Park. In general, the water from the lakes is typical of other lakes found along the Continental Divide (for example Mayhood and Anderson 1976, Donald and Anderson 1982). The lakes can be classified as fresh, non-saline (Table 2) and are poor in nutrients. The major ions are calcium, magnesium and bicarbonate.

Although on a continental basis, all lakes in the park fall into the same salinity classification, there are differences from lake to lake. The significance of these differences with respect to trout growth and production will be discussed later.

Table 3 compares the acceptable or desirable levels of several dissolved substances for drinking water with the maximum concentration found from lakes in Kootenay National Park. Dissolved substances in the water from all lakes is well within standards set for drinking water (Table 3). However, some substances were not measured. For example, mercury, molybdenum, and polychlorinated biphenyls were not measured, but the probability that these or numerous other similar substances would be present in measurable amounts is low (see Block and Gummer 1976 and selenium in Table 1).

Gummer and Block (1979) found levels of arsenic in Sinclair Creek that were above the acceptable level for drinking water. They determined that these high concentrations were derived from mineral hot springs in this area. Arsenic was not present in detectable amounts in other areas

Table 1. Summary of water chemistry data for lakes, Kootenay National Park.

	Sampling date	Turbidity (J.T.U.)	pH (laboratory)	Color (relative units)	Specific conductance (uS/cm)	Alkalinity (total)*	Hardness (total)*	Total dissolved solids	Bicarbonate*	Carbonate*	Sulphate
Cobb Lake	14-9-81	0.6	8.2	10	409	197	210.1	218.3	240.1	0.0	20.0
Daer Lake	13-9-81	1.5	8.3	5	277	133	139.4	112.2	162.1	0.0	9.0
Dog Lake	13-9-81	0.9	8.3	10	345	176	182.9	182.6	214.5	0.0	5.0
Floe Lake	13-9-81	1.8	8.2	5	109	52	58.9	55.6	63.4	0.0	2.0
Kaufmann Lake	12-9-81	0.9	8.2	5	150	72	79.2	79.4	87.8	0.0	7.0
Kootenay Pond	13-9-81	1.4	8.3	5	410	185	195.7	231.2	225.5	0.0	16.0
Meadow Creek Beaver Pond	14-9-81	2.5	8.0	5	357	175	161.3	176.8	213.3	0.0	9.0
Nixon Pond	14-9-81	1.7	8.3	20	304	146	163.1	174.9	178.0	0.0	9.0
Olive Lake	14-9-81	0.5	8.1	5	314	147	165.8	161.5	179.2	0.0	12.0
Storm Lake (K37)	13-9-81	0.5	8.0	10	90	36	45.0	45.3	43.9	0.0	5.0
Talc Lake	13-9-81	0.3	8.3	5	209	67	104.7	102.7	81.7	0.0	27.0
K3	13-9-81	0.9	8.2	5	146	71	74.2	77.3	86.5	0.0	6.0
K4	13-9-81	0.6	8.2	10	359	185	180.5	186.4	225.5	0.0	3.0
K10	13-9-81	0.8	8.4	5	150	51	74.3	78.8	61.0	0.0	22.0
K13	14-9-81	1.3	8.3	20	385	205	209.0	218.5	249.9	0.0	7.0
K16	14-9-81	0.9	8.0	10	263	131	133.7	143.8	159.7	0.0	2.0
K20	14-9-81	0.8	8.4	20	514	282	277.4	277.5	338.9	0.0	5.0
K24	13-9-81	0.9	7.6	50	436	197	205.3	224.9	240.1	0.0	12.0
Cobb Lake	9-8-72	1.5	8.1	-	335	171	189.0	187.4	208.5	0.0	14.1
Kootenay Pond	11-6-70	2.3	7.9	-	288**	132	142.0	-	161.0	0.0	13.7
Kootenay Pond	9-8-72	1.5	8.2	-	427	197	217.0	236.6	240.2	0.0	18.5
Nixon Pond	11-6-70	1.7	8.3	-	209**	104	114.0	-	127.0	0.0	9.1
Olive Lake	9-8-72	0.5	7.7	-	322	156	171.0	175.7	190.2	0.0	14.1
Storm Lake (K37)	3-9-70	0.6	7.8	-	98	41	50.5	-	49.7	0.0	8.3

* expressed as $CaCO_3$ "equivalent", all other values in mg/liter.

** at 25°C, all other values at about 20°C.

Chloride	Fluoride	Silica (reactive)	Nitrogen (dissolved NO_2-NO_3)	Nitrogen (total as N)	Phosphorus (total as inorganic P)	Carbon (total organic)	Calcium	Magnesium	Sodium	Potassium	Arsenic	Selenium	Boron
0.5	0.07	7.8	0.01	0.28	0.004	5.5	17.2	22.4	1.4	0.7	<0.0005	<0.0005	0.08
0.5	0.10	3.6	0.01	0.29	0.004	4.1	32.4	14.2	2.0	0.6	<0.0005	<0.0005	0.07
0.5	0.32	9.8	0.01	0.24	0.003	4.0	33.5	24.1	3.1	0.6	<0.0005	<0.0005	0.08
0.1	<0.05	1.0	0.04	0.09	<0.003	11.2	16.5	4.3	0.2	0.1	<0.0005	<0.0005	0.02
0.2	<0.05	2.0	0.07	0.13	<0.003	0.3	18.2	8.2	0.2	0.1	<0.0005	<0.0005	0.10
17.0	0.13	11.0	0.01	0.55	0.006	7.1	35.0	26.3	13.0	1.7	<0.0005	<0.0005	0.08
0.4	0.05	5.4	<0.01	0.24	0.005	0.24	40.2	14.8	1.4	0.5	<0.0005	<0.0005	0.06
0.6	0.08	18.0	0.04	1.1	0.004	10.6	37.3	17.0	2.6	0.9	<0.0005	<0.0005	0.07
0.8	0.08	4.4	0.06	0.14	<0.003	1.3	36.2	18.3	0.9	0.4	<0.0005	<0.0005	0.05
0.2	<0.05	2.6	0.06	0.11	<0.003	0.96	10.6	4.5	0.3	0.2	<0.0005	<0.0005	0.02
0.2	<0.05	1.8	0.05	0.07	<0.003	0.28	20.0	13.3	<0.1	<0.1	<0.0005	<0.0005	<0.02
0.2	<0.05	1.2	0.02	0.25	<0.003	0.65	20.0	5.9	0.3	0.2	<0.0005	<0.0005	0.04
0.5	0.33	10.0	<0.01	0.32	<0.003	4.2	37.5	21.1	2.2	0.8	<0.0005	<0.0005	0.07
0.2	<0.05	0.6	0.13	0.24	0.003	0.68	15.9	8.4	0.3	0.2	<0.0005	<0.0005	0.03
0.9	0.07	14.0	0.01	0.55	<0.003	11.4	47.1	22.2	3.5	0.7	<0.0005	<0.0005	1.10
0.7	0.05	9.6	<0.01	1.1	<0.003	14.7	41.0	7.6	1.5	2.7	<0.0005	<0.0005	0.21
0.6	0.16	9.4	<0.01	0.46	0.003	8.7	35.4	45.9	11.0	0.8	<0.0005	<0.0005	0.11
8.7	0.11	5.6	<0.01	0.75	0.007	12.5	55.5	16.2	7.1	1.5	<0.0005	<0.0005	0.12
0.3	0.06	5.2	0.03	-	<0.003	5.0	45.9	18.1	0.4	0.5	-	-	-
9.5	0.13	8.4	-	-	-	-	13.9	26.2	10.2	1.2	-	-	-
11.6	0.11	8.4	-	-	-	5.0	39.5	28.8	10.1	1.2	-	-	-
0.18	0.09	5.0	-	-	-	-	23.0	13.8	2.5	0.5	-	-	-
0.4	0.06	4.0	-	-	-	3.0	53.0	9.4	0.4	0.2	-	-	-
<0.1	<0.05	2.6	-	-	-	-	12.5	4.7	0.5	0.4	-	-	-

Table 2. Classification of inland waters according to the level of total dissolved solids* . The maximum value for Kootenay National Park is also shown.

Total dissolved solids mg/litre	Classification	Kootenay Maximum mg/litre
0 - 1000	Fresh, non-saline	277.5
1001 - 3000	Slightly saline	
3001 - 10000	Moderately saline	
10001 - 100000	Saline	
>100001	Brine	

* data taken from McNeely et al. (1979).

Table 3. The acceptable or desirable levels of several dissolved substances for drinking water* compared to the maximum concentration recorded for lakes in Kootenay National Park.

	Acceptable or Desirable Maximum Concentration mg/l	Kootenay Maximum mg/l	Lake
Calcium	200	47.1	K13
Fluoride	1.2	0.33	K4
Hardness (total)	500	277.4	K20
Magnesium	150	45.9	K20
Phosphorus	0.2	0.007	K24
Sulphate	250	27.0	Talc
Total dissolved solids	500	277.5	K20
Nitrogen	10	1.1	K16
Selenium	0.01	0.0005	all lakes
Sodium	270	13.0	Kootenay Pond

*Data from McNeely et al. (1979).

of the Park. Our results for dissolved arsenic from lakes confirm that this substance is restricted to a small area in the Park.

Physical and morphometric characteristics of the lakes

The lakes in Kootenay National Park are generally typical of other lakes in the mountain national parks. Their range in elevation (1183 to 2254 metres asl), area (0.6 to 57.5 hectares), and maximum depth (0.5 to 60 metres) are not unusual. Although the maximum depth of Floe Lake (60 metres) is relatively deep for lakes in the mountain national parks, this depth is exceeded in Marvel (BNP), Louise (BNP), Minnewanka (BNP), Maligne (JNP), McArthur (YNP), and Waterton (WLNP) lakes. Waterton (upper lake) is the deepest lake in the mountain national parks and has a maximum depth of 135 metres.

The clarity of water as indicated by a Secchi disc ranged from 2.5 metres in Floe Lake to 20 metres in Talc Lake. The clarity of the water in Talc Lake was unusual. Anderson (1974) gives a maximum clarity of 19 metres Secchi depth for two of 340 lakes surveyed in and near the mountain national parks. Thus Talc Lake has the distinction of water clarity unsurpassed by other lakes in the seven mountain national parks. However, Secchi disc depths of over 40 metres are known for some exceptionally clear lakes in other regions (Wetzel 1975).

Zooplankton

Thirty-four species of crustacean zooplankton were identified from samples taken from lakes in the Park. There were 3 species of calanoid

Copepoda, 9 species of cyclopoid Copepoda and 22 species of Cladocera, giving a total of 34 species. This number is about 30% of the number of species that Anderson (1974) identified from an extensive survey of zooplankton communities in the mountain national parks. Based on the calanoid copepods present in a lake, Anderson (1974) classified zooplankton communities into nine different types. Only 4 (types IV, IIC, V and VI) of these nine communities were present in the Park. Thus, zooplankton species and communities are not well represented in Kootenay National Park.

A cyclopoid species, Paracyclops fimbriatus poppei, collected from K24 and Daer Pond has not been previously recorded from samples taken from the mountain national parks (Anderson 1974). Although this species may be relatively rare in the mountain parks, it is widely distributed in southern North America (Pennak 1978).

Benthos

The benthos of lakes and ponds in Kootenay National Park was dominated by Chironomidae (midges), Sphaeriidae (fingernail clams), and Ostracoda. Amphipods (freshwater shrimp) were also abundant in some lakes. Amphipods are the preferred food of brook trout in mountain lakes, and their abundance directly influences growth of this trout species (Donald et al. 1980). Other Orders of benthic invertebrates were generally rare, although in certain lakes some were present in moderate numbers.

The benthos found in the Park is typical of other mountain lakes, and no unusual or rare benthic communities were found. However, the

taxonomy of some Orders or Families of aquatic invertebrates are poorly known. For example, species of larval chironomids or oligochaetes could be rare or unusual for this region.

In general, the standing stock of benthos in lakes is greatest between 1 and 10 metres of depth and decreases thereafter (see Brinkhurst 1974). Most lakes in Kootenay National Park are less than 10 metres deep, and therefore little evidence of change with depth in standing stock of benthos was detected for these lakes. However, for the deeper lakes such as Floe (Fig. 2), after the 10 metre depth zone there was a marked decrease in benthic fauna with increase in depth. The importance of this pattern with respect to fish distribution is obvious. In order to maximize the chance of locating food, trout should remain close to shore. Numerous gill net catches from deep lakes in the mountain parks indicate that fish densities are greatest in shallow water near shore.

Salmonid distribution

Populations of brook trout were present in Daer, Cobb, Dog, Kaufmann, Olive, and Talc lakes. Cutthroat trout were present in Daer and Floe lakes and rainbow trout were present in Dog Lake. Gill net sets in all other lakes did not produce fish, and these lakes probably do not have resident fish populations. With the exception of Floe Lake, all of the trout populations are maintained by natural recruitment. In Floe Lake, natural recruitment does not occur and this population will probably disappear by the mid 1980s.

Native and naturally occurring populations of trout or other fishes were probably present in Daer, Dog, and Olive lakes at the beginning of the twentieth century, but other lakes would not have had

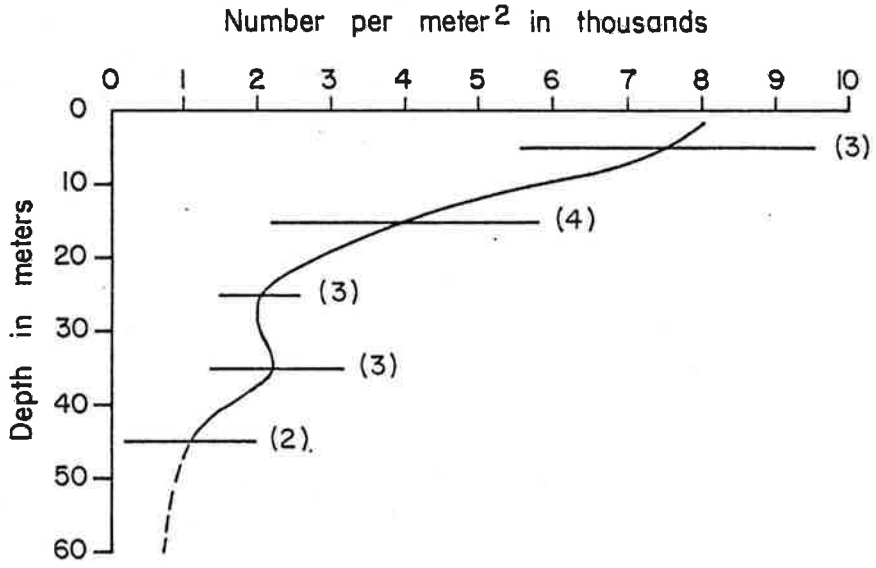


Figure 2. The relationship between the number of benthic invertebrates per metre square and depth in Floe Lake, July 27, 1982. Horizontal lines show the standard error of the mean and values in parentheses indicate the number of samples taken at each 10 metre contour interval.

fish at that time. The small creeks that flow from Daer and Dog lakes to the Kootenay River do not have obstructions or waterfalls that would be a barrier to trout.

It is of interest that Cobb, Olive, and Talc lakes all had populations of cutthroat trout at sometime in the past (Table 4). The populations in Cobb and Talc lakes were introduced, and may not have been able to maintain themselves through natural recruitment. However, the population in Olive Lake was probably a naturally occurring native race. We base this statement on data and comments in Solman (1947 and 1948). Solman (1948) reports a personal communication from Warden Thomson that "prior to 1928 Olive Lake supported a very large population of small cutthroat trout". Thus, cutthroat trout were known to occur in Olive Lake at least 15 years before the first recorded introduction of hatchery reared fish (see Table 4).

The 1958 reclamation program - Dog Lake

In 1958 Dog Lake supported an abundant population of longnose sucker and lake chub (park files). In order to improve angling, this lake was poisoned with rotenone in September 1958. Gill net catches in 1981 and 1982 indicate that the lake chub population was eliminated, but a small population of longnose sucker has recolonized this lake. The formal fisheries literature indicates that longnose sucker can live for up to 19 years, but states that some ageing techniques could underestimate age by as much as 5 years (Scott and Crossman 1973). The maximum age of the 63 suckers caught in Dog Lake was 31 years and several individuals were over 20-years-old (see Frontispiece - this report). Our

Table 4. Summary of fish stocking records for Kootenay National Park.

Lake	Stocking data	Species Stocked: Rainbow Trout	Cutthroat Trout	Brook Trout
Cobb	First year stocked	1945	1939	1947
	Number of years stocked	5	1	19
	Mean number stocked	6,600	10,000	2,600
	Maximum number stocked	15,000	10,000	7,000
Dog	First year stocked	1946	1939	1941
	Number of years stocked	17	1	16
	Mean number stocked	3,900	30,000	3,200
	Maximum number stocked	15,000	30,000	9,000
Floe	First year stocked		1949	
	Number of years stocked		11	
	Mean number stocked		7,300	
	Maximum number stocked		10,000	
Kaufmann[a]	First year stocked			1965
	Number of years stocked			2
	Mean number stocked			4,500
	Maximum number stocked			5,000
Kootenay Pond[b]	First year stocked	1955		1960
	Number of years stocked	15		7
	Mean number stocked	1,200		720
	Maximum number stocked	3,500		2,000
Meadow Creek Beaver Pond	First year stocked	1939		1972
	Number of years stocked	2		1
	Mean number stocked			
	Maximum number stocked			
Olive	First year stocked	1943	1939	1947
	Number of years stocked	6	3	23
	Mean number stocked	1,400	4,700	700
	Maximum number stocked	5,000	8,000	2,500
Talc	First year stocked		1957	1964
	Number of years stocked		1	3
	Mean number stocked		5,000	1,700
	Maximum number stocked		5,000	2,000

[a] In 1960, 5,000 eyed eggs of golden trout were stocked.
[b] In 1954, 100 splake were introduced.

results increase the known longevity of longnose sucker by a decade. These old fish either escaped the effects of the toxicant by remaining close to a spring or recolonized the lake via the outlet creek. Reintroduction by fishermen using "live bait" is also a possibility. Longnose sucker are apparently rare in the Park, but were caught at one other site (Daer Pond).

Growth of trout

Growth of brook trout in Kootenay National Park was highly variable (Fig. 3). Age - 5 fish ranged in weight from 51 g in Olive Lake to 1078 g in Cobb Lake. Although growth of brook trout in Cobb Lake was well above average, growth in Olive Lake was extremely slow. Growth of brook trout in Olive Lake is less than in any other of over 40 lakes surveyed in the mountain national parks in recent years. A search of the formal fisheries literature indicates that growth in this lake is surpassed (in the negative sense) by only one other lake in North America. This other lake, Bunny Lake, is an alpine lake that occurs at 3322 metres asl in California (Reimers 1958). Brook trout could not spawn successfully in Bunny Lake, and disappeared in 1974.

Growth of brook trout in mountain lakes in western North America depends primarily on: (1) abundance of amphipods, (2) the specific conductance or TDS of the lake water, (3) maximum depth, and (4) trout density (Donald et al. 1980; Rabe 1967; Rabe and Dyer 1967). Amphipods or freshwater shrimp are a preferred food of brook trout, and TDS is probably related to the overall diversity and productivity of other trout food organisms (Northcote and Larkin 1956). The cause of the relationship between brook trout growth and maximum depth of a lake is

not certain. Deep lakes tend to be large, and these lakes may have less recruitment per hectare than smaller lakes. However, Table 5 clearly shows that when lakes such as Cobb Lake have an abundance of amphipods and a small population of brook trout, growth is substantial. When brook trout are abundant and food organisms scarce, growth is poor (Olive Lake, Table 5). The small differences in maximum depth between Cobb, Dog, and Olive lakes would have a negligible effect on growth (Table 5).

Growth curves for rainbow and cutthroat trout are shown in Figure 4. In general, growth of these species in lakes in the Park was relatively poor, although old fish would be of an acceptable size to most fishermen. Age-5 rainbow trout in Dog Lake averaged only 588 g in weight. In some lakes in the mountain national parks, rainbow trout can exceed 3000 g at this same age. Relatively slow growth in Dog Lake can probably be attributed to the presence of brook trout and longnose sucker. Both species increase the overall density of fish and they may compete with rainbow trout for food (see Results, Rawson and Elsey 1948) and space.

Factors favourable to growth of cutthroat trout in lakes have not yet been determined. However, it is possible that low TDS (Floe Lake) and dense populations of other fish species (Daer Pond) have a negative effect on growth for this species (see Results).

Trout population size, longevity, and angler catch - Cobb, Dog and Olive lakes

The total population of trout that was two-years-old and older in Cobb, Dog, and Olive lakes was about 49, 983, and 1662 fish respectively.

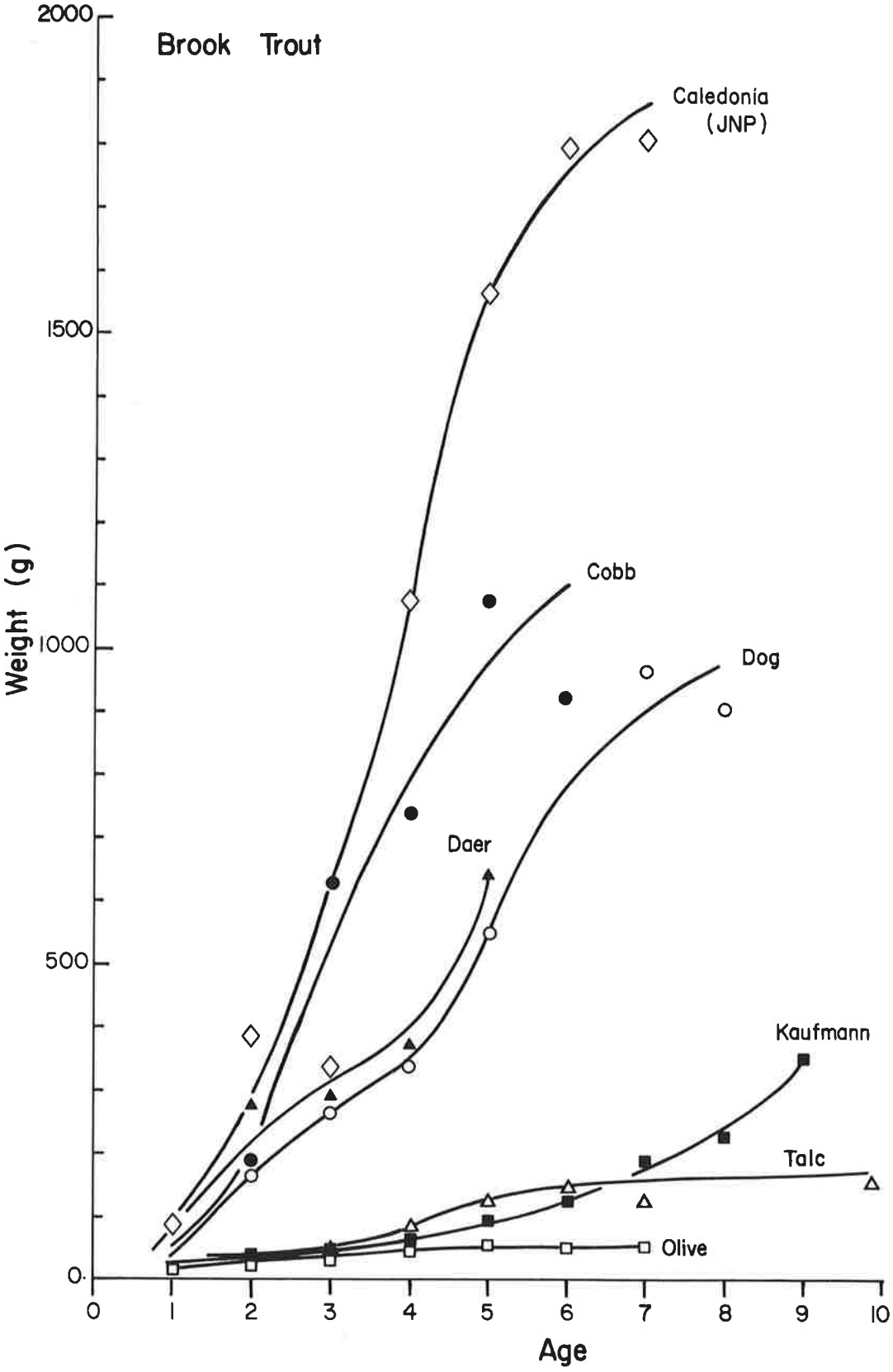

Brook Trout
Caledonia (JNP)
Cobb
Dog
Daer
Kaufmann
Talc
Olive
Weight (g)
2000
1500
1000
500
0
0
1
2
3
4
5
6
7
8
9
10
Age

Figure 3. Relationship between age and weight for brook trout populations from 6 lakes in Kootenay National Park. The minimum (Olive Lake - Kootenay National Park) and maximum (Caledonia Lake - Jasper National Park) growth of brook trout in lakes from the mountain national parks is also shown.

Table 5. The weight of brook trout at age-5 in Cobb, Dog, and Olive lakes compared to the density of trout, abundance of amphipods, TDS, and maximum depth of these lakes. These factors are known to influence growth of brook trout in mountain lakes (see Donald et al. 1980).

Lake	Weight at age-5 g	Brook trout Number/hectare	Amphipods Number per metre^2	TDS mg/l	Maximum Depth m
Cobb	1078	20	1879	218	8.0
Dog	549	41	2156	183	4.7
Olive	56	831	140	162	3.5

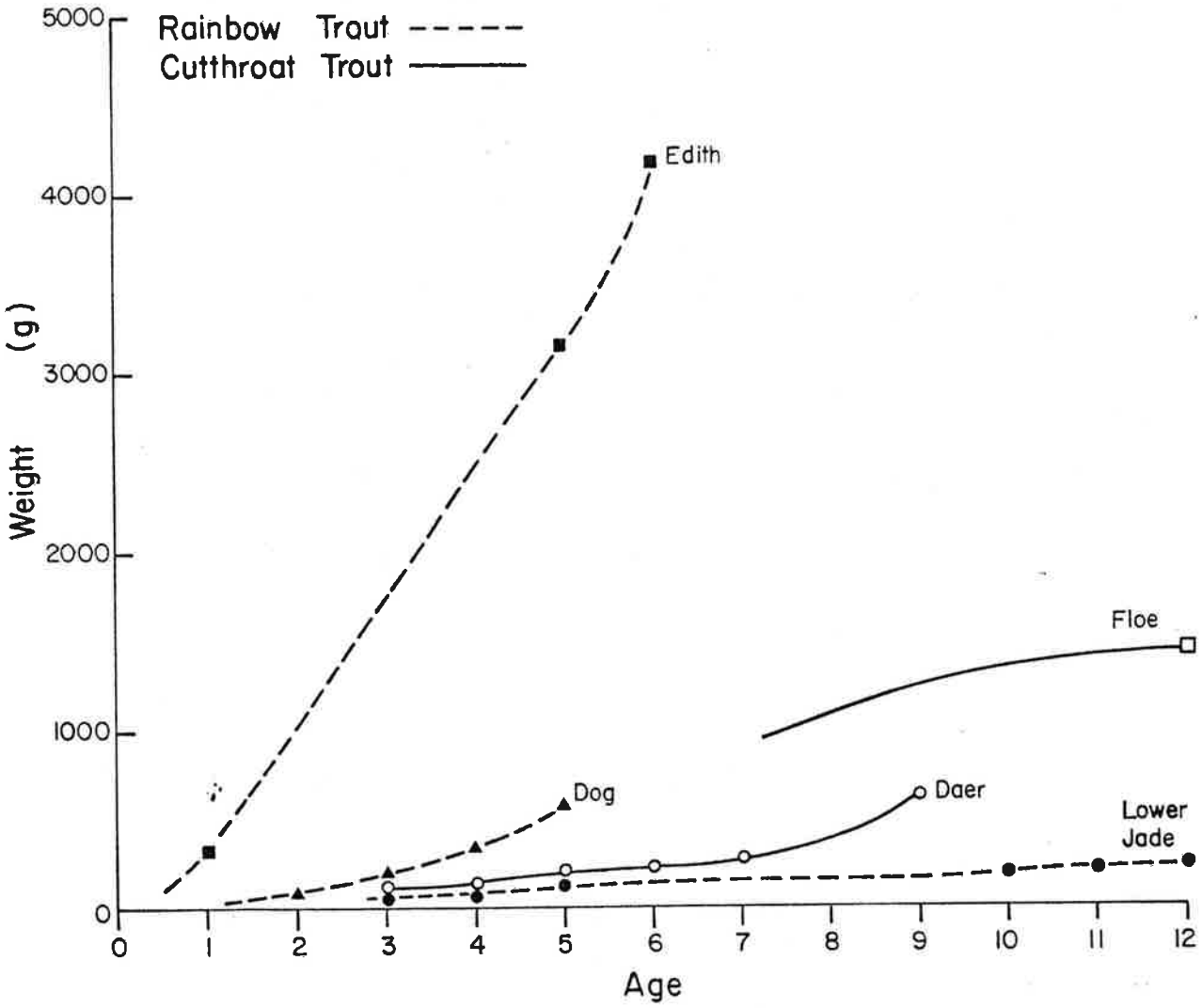


Figure 4. Relationship between age and weight for rainbow trout and cutthroat trout from 3 lakes in Kootenay National Park. Examples of age - weight relationships for rainbow trout from populations with slow growth (Lower Jade Lake - Mount Revelstoke National Park) and superior growth (Edith Lake - Jasper National Park) are also shown.

be determined accurately. Approximate total mortality (fishing plus natural mortality) can be calculated from catch data provided in the Results and formulae in Richer (1975). The approximate total annual mortality for fish 3 years old and older was 59% per year for rainbow trout and 44% per year for brook trout from Dog Lake, and 41% per year for brook trout from Cobb Lake. High fishing mortality can reduce or replace natural mortality. Therefore, we suggest that the total annual catch of trout from Cobb and Dog lakes should not exceed 50% of the present population or about 25 and 490 fish respectively. However, fishing mortality in the order of 25% of the 1982 population size should provide better fishing over the long term. High exploitation rates could reduce the average age and thus the size of fish caught. With very heavy exploitation, the total number of fish caught could decrease.

Olive Lake supports a dense population of very slow growing brook trout (see Results). At present, few anglers fish this lake because fish do not grow to an acceptable size (about 200 g), and those anglers who do fish this lake probably release most of their catch. A theoretical annual catch of 800 fish (50% annual fishing mortality) from this lake may not be unreasonable at the 1982 population size and growth rate.

The poor growth in Olive Lake is at least in part caused by the high density of fish (Table 5). In theory, substantial reduction of the number of fish in this lake each year might improve growth. If a reduction program was carried out each year for several years and then curtailed, the population would probably return to the 1982 weight structure and density.

Approximate brook trout growth in mountain lakes can be determined by the formula:

$W_5 = 109.24 \log_e A + 6.46 MD + 1.18S - 208.8$, where

W_5 = the mean weight of brook trout at age-5 in grams,

A = the number of amphipods per metre square,

MD = the maximum depth in metres, and

S = the specific conductance in $umho.cm^{-2}$

(from Donald et al. 1980). This formula or model is probably most reliable when recruitment is low to moderate. Thus, with a substantial reduction in recruitment or population density in Olive Lake, age-5 trout should grow to about 724 g ($W_5 = 109.24 (\text{Log}_e 140) + 6.46 (3.5) + 1.18 (314) - 208.8$). This size would be acceptable to most anglers.

Stocking considerations and recommendations

Westslope cutthroat trout (Salmo clarki lewisi) were the only Salmo species native to the Kootenay River watershed (Behnke 1979), and therefore, this race should be the only species stocked in Kootenay National Park. There is another important reason for stocking this race. At least in Canada, the distribution and range of westslope cutthroat trout has been substantially reduced because of introductions of exotic species such as brook trout, or through hybridization with other races or species of Salmo (Paetz and Nelson 1970).

Rainbow trout (Salmo gairdneri) were not native to the Kootenay River watershed (MacCrimmon 1971) and should not be stocked in the Park.

Although there are numerous small lakes or ponds in Kootenay National Park, few of these provide suitable habitat for trout. Most of

for angling. For these reasons, we recommend stocking 10,000 fingerling westslope cutthroat trout every 5 years. This every 5 year stocking schedule is suggested because angler harvest will be light and some trout are expected to live for 10 or more years. A 5 year stocking interval would also reduce the cost of transporting fish to this lake.

Kootenay Pond is the most accessible lake in the Park, and has been stocked frequently in the past. This lake has the highest potential for fish production of the lakes in Kootenay National Park (TDS = 234 mg litre, mean depth = 4.1 metres). Food organisms preferred by trout, freshwater shrimp or amphipods, caddisfly larvae, and damselfly larvae are abundant (see Results). The potential for fish production in Kootenay Pond on a per hectare basis is exceeded by no more than 5 other lakes in the seven mountain national parks. However, this lake can become deoxygenated and "winter kills" during some years. A review of Parks Canada files indicate that this lake "winter killed" in 1961, 1963, 1971, and 1976.

A search of a few water depth records indicates that depth of Kootenay Pond can vary from year to year. For example, in June 1970 and 1982 the maximum depth was 4.2 m and 6 m respectively. Shoreline vegetation suggests that maximum depth could reach as much as 8 metres in some years. The occurrence of fish "winter kill" could be related to year-to-year differences in maximum depth.

We recommend that stocking of Kootenay Pond be resumed with the understanding that Parks Canada would carefully measure maximum depth and oxygen levels each March and monitor fish mortality in early May. The objective of these surveys would be to determine relationships between

depth and fish mortality. If low water levels are responsible for anoxic conditions and fish mortality, then stocking could be discontinued in years when water levels might cause fish "winter kill".

An annual stocking rate of 1500 fingerling westslope cutthroat trout per year is recommended for Kootenay Pond. At this stocking density growth should be rapid, fish should become vulnerable to angling during their second summer or at age-1, and most individuals should be caught before they reach age-3. Thus, even with complete "winter kill" in an occasional year, no more than 2 year classes would be lost.

There are no published methods for determining stocking density for cutthroat trout, although Donald and Anderson (1982) have developed a preliminary method for determining stocking density of a close relative, rainbow trout. Although the stocking densities suggested for Cobb, Floe and Kootenay Pond were determined subjectively, they were based on formula presented by Donald and Anderson (1982); the availability of preferred trout food organisms in each lake (Donald et al. 1980, Donald and Anderson 1982); as well as a large formal literature that documents the importance of TDS and mean depth in determining fish production (see Ryder et al. 1974).

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Solman, V.E.F. 1947. Limnological investigations. Kootenay National Park, 1947. Department of Indian Affairs and Northern Development, National and Historic Parks Branch.

Four sites (Dolly Varden Creek, Olive Lake, Cobb Lake, and Dog Lake) were investigated during the summer of 1947. This report provides useful data on species composition at these sites as well as some limnological data. For example, Olive Lake supported cutthroat trout that appeared to have slow or poor growth. A comment in the report suggests that cutthroat trout may have been native to this lake. No fish were collected from Dolly Varden Creek or Cobb Lake. Six brook trout were taken from Dog Lake with gill nets. The largest brook trout from Dog Lake weighed 1447 g.

Solman, V.E.F. 1948. Limnological investigations. Kootenay National Park, 1948. Department of Indian Affairs and Northern Development, National and Historic Parks Branch.

This report summarizes limnological and fisheries data collected from Olive and Floe lakes during August 1948. A sample of cutthroat trout were collected from Olive Lake. All fish were small. Cutthroat trout was known to be present in Olive Lake prior to 1928. A general description of Floe Lake is given, and the report recommends that cutthroat trout be stocked in this lake.

Ward, J.C. 1974. The fishes and their distribution in the mountain national parks of Canada. Can. Wildl. Serv. Report. 46 pp. + 4 appendices.

A general discussion of the fish species which occur in Kootenay and other Canadian mountain national parks south of the sixtieth parallel. Maps and tables showing the locations of the lakes and the suspected present distributions of fishes are presented in the appendices. The evidence upon which the report is based is largely anecdotal, having been gleaned from the author's eighteen years experience in the mountain parks as a fishery biologist.

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During the period between May 29 and September 12, 1979, a total of 621 fish were netted from 12 selected high elevation mountain lakes in the western National Parks and examined for microbial fish pathogens. None of these fish were found to yield pathogenic bacteria, virus or protozoa. The conclusion from this study is that these fish populations being free of pathogens may be a source of fish and/or eggs and milt for future fisheries management operations. Kaufmann Lake in Kootenay National Park was included in this study.