MYSIS MONITORING IN WESTERN MONTANA LAKES

1983-1987

Prepared by

Scott Rumsey, Fisheries Biologist
Montana Department of Fish, Wildlife and Parks
Kalispell, MT, USA

Supplement to Progress Report
F-7-R-37, Job I-a

Job Title:

Inventory of waters of the project area.

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ABSTRACT

Opossum shrimp (*Mysis relicta*) were introduced into a total of 12 northwest Montana lakes during 1968, 1975, and 1976 in an attempt to supplement food organisms for trout and salmon. The Montana Department of Fish, Wildlife and Parks (MDFWP) initiated a monitoring program in June, 1983, to provide information on *Mysis* populations in lakes where introductions were successful. Six lakes were sampled from 1983 until 1987. They include: Ashley, Little Bitterroot, McGregor, Flathead, Swan, and Whitefish lakes. Flathead Lake was not planted, but received mysids as a result of downstream drift from Whitefish, Swan or Ashley lakes. The average lakewide densities of mysids from these lakes fluctuated substantially during the sampling period. Ashley, Little Bitterroot, and McGregor lakes generally maintained peak densities below 100 individuals m^2 whereas Flathead, Swan, and Whitefish lakes exceeded 100 m^2. Cladoceran zooplankton (*Daphnia*) exhibit an inverse density relationship when compared with *Mysis* in all lakes.

BACKGROUND

Mysis relicta have been introduced into numerous lakes in northwestern U. S. and Canada to supplement food organisms for trout and salmon. Many studies indicate that mysid populations may have significant adverse impacts on kokanee (*Oncorhynchus nerka*) populations. During 1968, 1975, and 1976 opossum shrimp were introduced into a total of 12 lakes in northwest Montana (Figure 1): Ashley, Bull, Crystal, Dickey, Holland, Little Bitterroot, McGregor, Middle Thompson, Spar, Swan, Tally, and Whitefish. The success of these introductions has been assessed periodically since 1975 and includes downstream lakes that received *Mysis* through drift (Domrose 1982).

Six lakes were found to contain *Mysis* populations following initial introductions. In 1983, monitoring was initiated on these lakes: Ashley, Little Bitterroot, Flathead, McGregor, Swan, and Whitefish lakes (Figure 2). *Mysis* populations in Flathead resulted from downstream drift from Swan, Whitefish or Ashley lakes.

Mysis life history investigations are also being conducted by the University of Montana Biological Station at Yellow Bay on Flathead Lake (Bukantis 1984). In addition, Bonneville Power Administration's Flathead Kokanee study is presently investigating kokanee/*Mysis* interactions on Flathead Lake (Beattie et al. 1986). Data collected prior to 1985 on this project was compiled by Rumsey (1985).

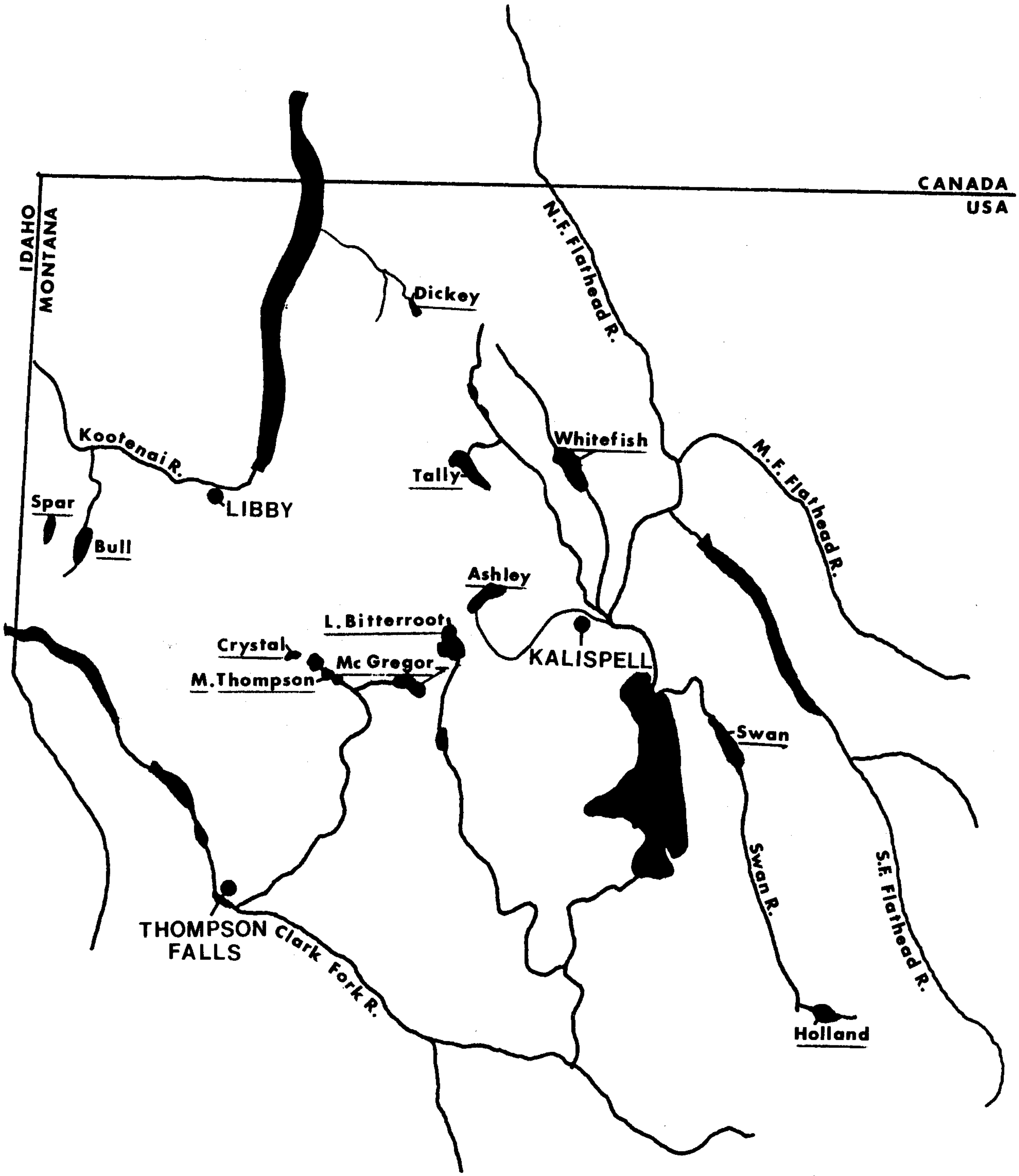

Figure 1. Location of Mysis introductions into northwestern Montana lakes underlined (Domrose 1982).

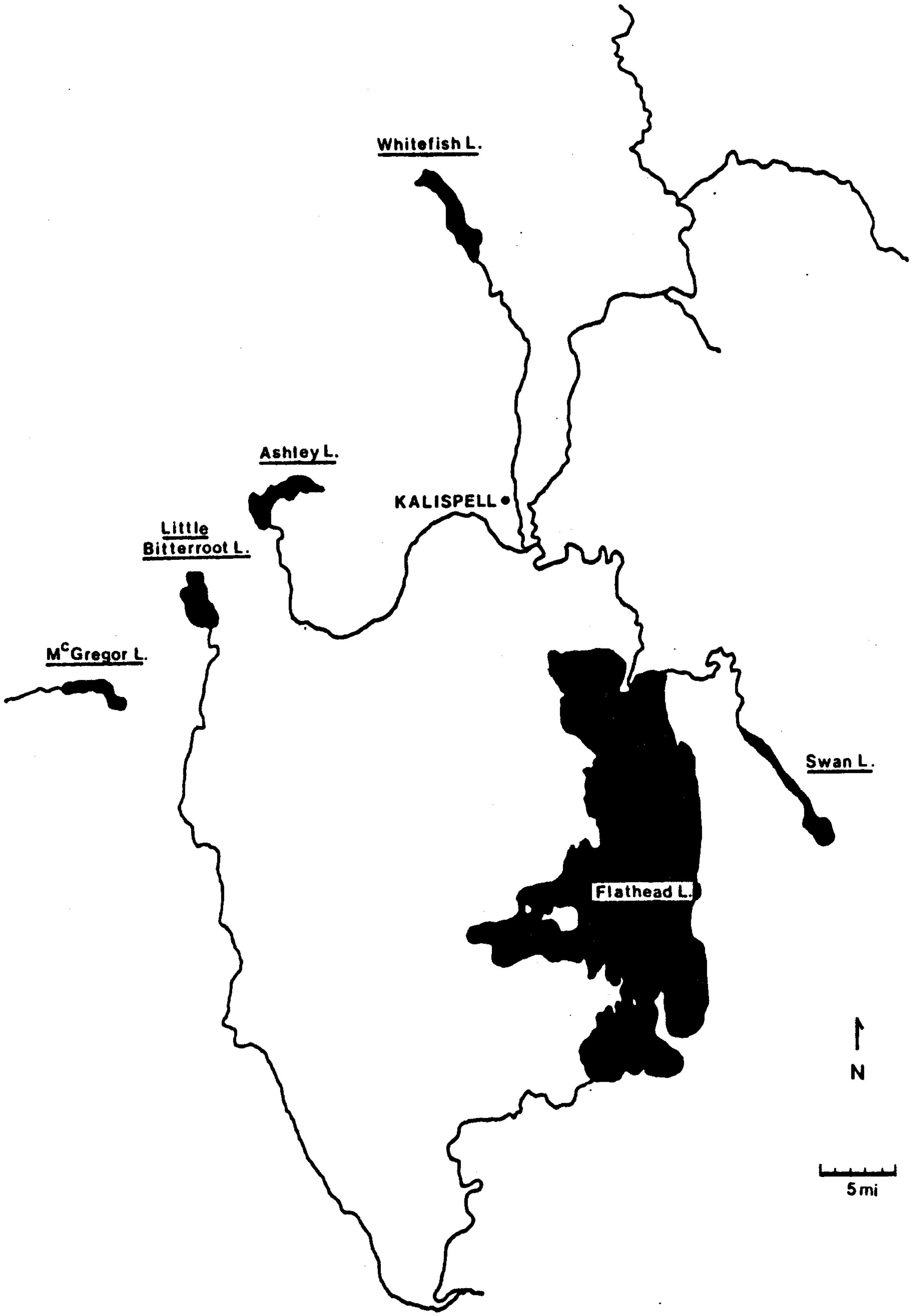

Figure 2. Six lakes selected for *Mysis* monitoring in northwestern Montana.

OBJECTIVES

The primary objective of this project is to determine fisheries potential of lakes and streams by obtaining chemical, physical, and biological parameters for management of sport fish species. A secondary objective is to provide baseline data for assessing changes in the zooplankton and fish communities of lakes where mysid shrimp and kokanee coexist.

PROCEDURES

Six lakes containing mysid shrimp populations were selected for annual monitoring in 1983: Ashley, Little Bitterroot, Flathead, McGregor, Swan, and Whitefish. Two sampling stations were designated in sub-basins of greatest depth in each lake with the exception of Flathead where three stations were selected (Appendix A).

During 1983 a conical, Wisconsin-style, one meter diameter, 1350 micron mesh net was used to collect *Mysis*. Replicate 30 meter vertical hauls were taken at each station. To increase sampling efficiency in 1984, a 500 micron mesh net was used to sample the entire water column at each station. Through net comparisons (Rumsey 1985), it was discovered that all juvenile mysids were not captured by the 1350 micron mesh.

Replicate total depth hauls were retrieved at a rate of approximately 0.35 meters per second. *Mysis* samples were preserved in 10 percent formalin, counted under a stereoscope, and categorized as juveniles or adults (<10 mm and ≥10 mm respectively). Average density, expressed as the number per square meter, was calculated as the mean of the stations sampled.

Mysid samples were collected during the "dark" phases of the moon in early June approximately two hours after sunset. Water temperature profiles and zooplankton samples were also taken at one station in each lake immediately prior to *Mysis* sampling. Zooplankton samples were collected, beginning in 1985, with a 0.5 meter Wisconsin net of 153 micron nitex mesh. Zooplankton were preserved in 4 percent formalin mixed with 40 grams per liter sucrose.

Zooplankton samples were diluted to obtain 50-100 individuals in one milliliter subsamples. Cladocerans and copepods were identified and counted in a Sedgewick-Rafter counting cell under 40 power magnification. Four subsamples were counted from each haul and the results were averaged from the duplicate hauls to estimate the density of each genus at each station.

During 1985 and 1986 concurrent *Mysis* and zooplankton sampling was conducted monthly on Swan and Whitefish lakes using the described methods to monitor fluctuations occurring throughout the year. These lakes were selected because *Mysis* populations were well established, containing densities above 100 individuals/m^2. Swan Lake also supports what is considered to be a substantial kokanee population, where Whitefish Lake no longer contains detectable numbers of kokanee.

A list of Mysis utilization by gamefish species was also compiled from regional MDFWP files. Fish were collected primarily from standard gill nets and stomachs analyzed for species composition. Other collection methods involved midwater trawls, purse seines, and angling (Beattie and Fraley 1987).

RESULTS

The average lakewide densities of mysids from the lakes monitored fluctuated substantially from June, 1983 to June, 1987 (Table 1). Ashley, Little Bitterroot, and McGregor lakes generally maintained lower peak densities (less than 100/m²) than Flathead, Swan, and Whitefish lakes. Maximum Mysis densities of all lakes during the period occurred in Swan Lake during June, 1986 (251.6). Flathead Lake had the most dramatic increase of mysids where they climbed from zero to 176.5 within a four-year period (1983-1986). Little Bitterroot Lake has maintained the most consistent density of Mysis throughout the period. Numbers from the remaining lakes have been very erratic, precluding interpretation without additional information. Temperature profiles for monitored lakes are provided in Appendix B.

Table 1. Average lakewide June Mysis densities (no/m²) from selected lakes.

Lake	Size	*1983	1984	1985	1986	1987
Ashley	Juveniles (<10mm)	0	4.3	3.8	25.8	70.7
	Adults(≥10mm)	1.3	8.7	8.3	11.2	15.6
	Combined	1.3	13.0	12.1	37.0	86.3
L.Bitterroot	Juveniles	0	8.6	12.7	19.4	8.6
	Adults	7.3	15.9	9.2	7.0	13.1
	Combined	7.3	24.5	21.9	26.4	21.7
Flathead	Juveniles	0	5.1	2.6	156.1	144.0
	Adults	0	0	16.8	20.4	25.6
	Combined	0	5.1	19.4	176.5	169.6
McGregor	Juveniles	0	8.3	0.6	7.0	15.6
	Adults	6.1	5.4	3.2	4.8	14.7
	Combined	6.1	13.7	3.8	11.8	30.3
Swan	Juveniles	0	37.9	69.4	108.9	53.2
	Adults	20.1	33.1	25.5	142.7	169.4
	Combined	20.1	71.0	94.9	251.6	222.6
Whitefish	Juveniles	0	67.5	207.0	151.9	52.9
	Adults	18.5	18.8	22.0	23.9	12.1
	Combined	18.5	86.3	229.0	175.8	65.0

*30 meter hauls using a larger mesh net were used in 1983.

Mysis populations in northwest Montana lakes became established (detectable) approximately six years following initial introductions (Table 2). It is not known when *Mysis* first drifted downstream from Whitefish, Swan, or Ashley lakes into Flathead, however, the first specimen was collected in 1981. All lakes, with the exception of Swan and Flathead, contained detectable densities of mysids in the mid-1970's. Mysid populations in Swan and Flathead became established in 1980 and 1984 respectively.

Table 2. *Mysis* introduction and establishment dates in Montana lakes presently being monitored.

Lake	Mysis Introduction	Mysis Establishment*
Ashley	1968	1974
Little Bitterroot	1968	1974
McGregor	1968	1974
Whitefish	1968	1976
Swan	1975	1980
Flathead	1981**	1984

*Detectable densities.

**Date first collected.

Cladoceran zooplankton populations have become severely depressed or extinct in many lakes during high *Mysis* densities (Grossnickle 1982, Reiman and Falter 1981, Richards, et al. 1975, Morgan et al 1978, Daley, et al. 1981, Langeland 1981, Kinsten and Olsen 1981). Fluctuations are occurring in the crustacean zooplankton densities in the lakes monitored (Table 3).

Table 3. Mean lakewide crustacean zooplankton densities (no./liter) from regional Mysis monitoring lakes during June, 1985-1987.

		Cladocerans			Copepods			
Lake	Year	Daphnia	Bosmina	Total	Epischura	Diaptomus	Cyclops	Total
Ashley	1985	0.6	0.3	0.9	0.5	-0-	8.0	8.5
	1986	1.4	0.7	2.1	-0-	-0-	14.3	14.3
	1987	-0-	21.6	21.6	-0-	-0-	13.7	13.7
Little Bitterroot	1985	0.1	0.6	0.7	0.5	-0-	6.0	6.5
	1986	-0-	1.6	1.6	0.2	-0-	10.3	10.5
	1987	0.8	26.5	27.3	0.1	-0-	13.4	13.5
Flathead	1985	2.9	0.8	3.7	0.1	25.8	1.8	27.7
	1986	0.1	0.1	0.2	0.1	13.0	0.8	13.9
	1987	0.1	-0-	0.1	0.9	3.1	0.4	4.4
McGregor	1985	4.4	0.1	4.5	0.2	0.2	0.1	0.5
	1986	3.5	-0-	3.5	0.2	-0-	-0-	0.2
	1987	1.7	0.1	1.8	-0-	0.1	-0-	0.1
Swan	1985	-0-	-0-	-0-	0.1	5.2	1.0	6.1
	1986	-0-	-0-	-0-	0.3	1.4	0.9	2.6
	1987	-0-	0.4	0.4	2.3	8.2	-0-	10.5
Whitefish	1985	0.4	0.3	0.7	0.1	-0-	11.0	11.1
	1986	3.3	1.5	4.8	-0-	-0-	11.4	11.4
	1987	3.6	5.7	9.3	5.9	0.1	-0-	6.0

In Little Bitterroot Lake from 1985 to 1987, mysid densities have remained relatively stable (21.9, 26.4, 21.7 respectively). Daphnia numbers similarly had little variation during the same period (0.1, 0, 0.8). In contrast, Ashley, McGregor, and Flathead lakes all exhibited an increase in Mysis with decreasing Daphnia numbers. Flathead Lake showed the most dramatic change where Mysis increased from 19.4 to 169.6 and Daphnia dropped from 2.9 to 0.1 for the period 1985 through 1987. Swan Lake mysids also increased, however, Daphnia remained undetectable during sampling. Whitefish Lake was the only exception where mysids dropped significantly (229.0 to 65.0) and Daphnia increased (from 0.4 to 3.6). The remaining cladoceran, Bosmina, generally followed Daphnia trends, except in Ashley and Little Bitterroot lakes where numbers increased substantially (0.9 to 21.6, and 0.7 to 27.3 respectively).

Monthly samples of Mysis and crustacean zooplankton were collected in Swan lake from June of 1985 until July of 1986 (Table 4). Cladocerans began to increase in the July 1985 samples and remained until September (Figure 3). Copepods exhibited similar population fluctuations, however, peak densities reached 19.12 per liter in September, where cladocerans peaked at 1.83 per liter in August. Total mysid densities from Swan lake peaked during December at 744.9/m^2. Juvenile Mysis (less than 10 mm) had increased in size and were exceeding ten millimeters after the July samples.

Table 4. Swan Lake Crustacean Zooplankton/liter and Mysis/m² in 1985 and 1986.

	Cladocerans			Copopods				Total
Date	Daphnia	Bosmina	Total	Diaptomus	Epischura	Cyclops	Total	Mysis
6/17	0.01	-0-	0.01	5.17	0.12	0.93	6.22	94.9
7/25	0.37	0.85	1.22	7.76	-0-	2.10	9.86	303.5
8/19	0.96	0.87	1.83	6.43	0.01	4.58	11.02	263.7
9/19	0.37	0.19	0.56	6.70	0.12	12.30	19.12	192.7
10/22	-0-	-0-	-0-	4.04	0.16	11.94	16.14	238.5
12/18	-0-	0.01	0.01	2.43	-0-	2.84	5.27	744.9
4/14	No sample							104.1
5/14	-0-	-0-	-0-	1.86	0.10	0.25	2.21	152.9
7/01	-0-	0.02	0.02	1.44	0.25	0.89	2.58	251.6

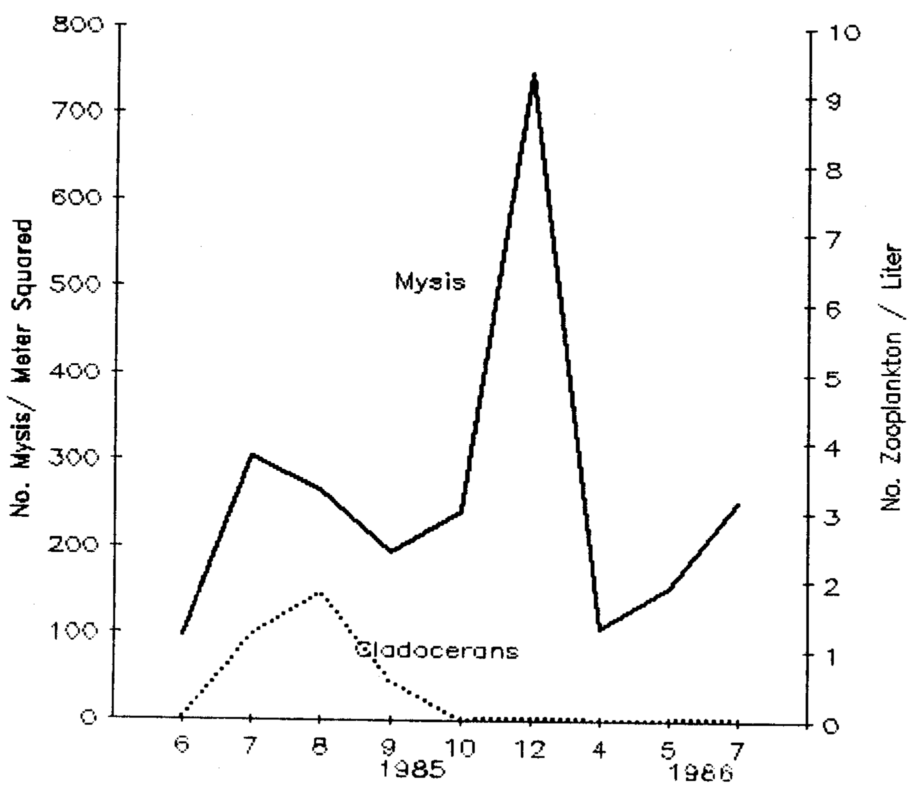

Figure 3. Monthly Mysis and cladoceran zooplankton densities in Swan Lake 1985-1986.

Monthly samples of Mysis and crustacean zooplankton were also collected in Whitefish Lake from June of 1985 until June of 1986 (Table 5). Cladoceran

Table 5. Whitefish Lake crustacean zooplankton/liter and Mysis m^2 during 1985 and 1986.

	Cladocerans			Copopods				Total
Date	Daphnia	Bosmina	Total	Diaptomus	Epischura	Cyclops	Total	Mysis
6/13	0.42	0.26	0.68	-0-	0.08	11.02	11.10	229.0
07/23	4.02	1.25	5.27	-0-	0.12	6.71	6.83	159.6
08/14	1.83	0.62	2.45	-0-	0.16	8.06	8.22	81.9
09/18	1.19	1.19	2.38	-0-	0.14	12.72	12.86	81.2
10/24	1.49	1.11	2.60	-0-	0.02	9.57	9.59	41.4
12/30	0.13	1.09	1.22	0.01	-0-	7.12	7.13	89.8
05/12	0.02	0.18	0.20	-0-	-0-	5.58	5.58	107.3
06/30	3.32	1.53	4.85	0.02	0.02	11.36	11.40	175.8

zooplankton reached higher densities in Whitefish Lake with the peak of 5.27 per liter occurring in July (Figure 4). Copepods increased to a maximum of 12.86 per liter during September of 1985. The peak Mysis density of $229/m^2$ occurred during the first sample in June of 1985. Juvenile Mysis were declining in numbers until September when all specimens exceeded 10 mm.

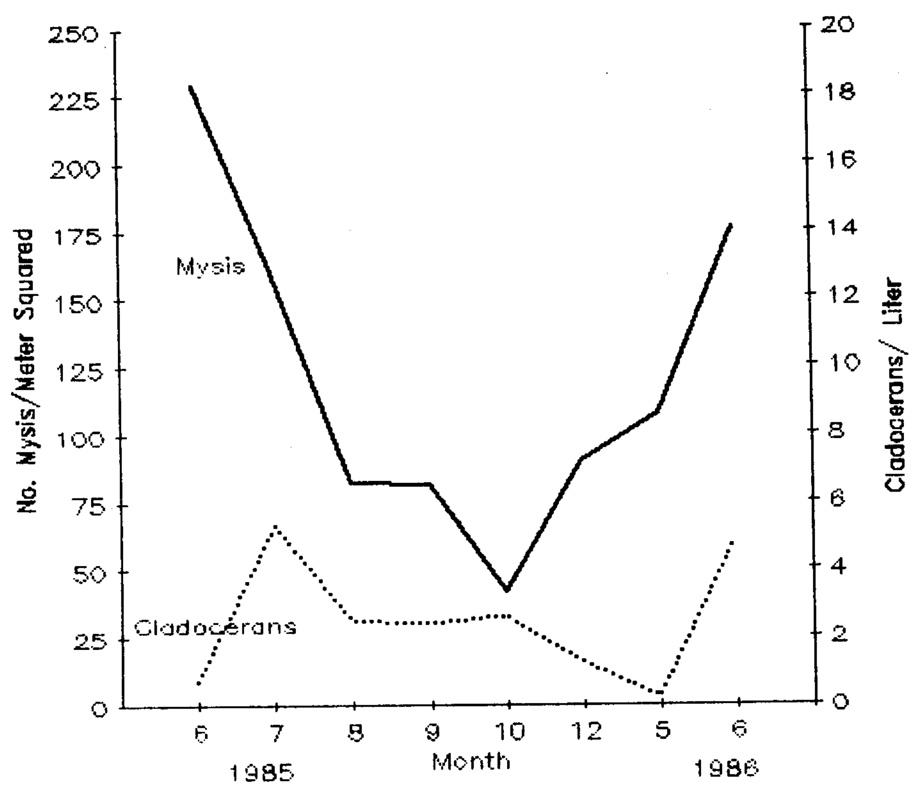

Figure 4. Monthly Mysis and cladoceran zooplankton densities in Whitefish Lake, 1985-1986.

Utilization of Mysis by gamefish has not been well documented in Montana. A list is provided for future reference (Table 6).

Table 6. Utilization of Mysis by gamefish through stomach analysis in monitored lakes.

Lake	Known Mysis Use	Unknown
Ashley	Kok	Eb, Pwf, RbxWct, Wct, Yct
Little Bitterroot	Kok, Rb, RbxWct	Eb, Pwf, Wct, Yct
McGregor	Lt, Rb	Eb, Kok, Mwf, Wct, Yct
Flathead	DV, Kok, Lt, Lwf, Mwf, Wct	Eb, LmB, Pwf
Swan	DV	Eb, Kok, LmB, Mwf, Np, Pwf, Rb, RbxWct, Wct, Yct
Whitefish	Lt, Lwf, Mwf	DV, Eb, Gr, Kok, LmB, Np, Pwf, Rb, Wct, Yct

DV = bull trout
Eb = eastern brook trout
Gr = arctic grayling
Kok = kokanee
LmB = largemouth bass
Lt = lake trout
Lwf = lake whitefish
Np = northern pike
Pwf = pygmy whitefish
Rb = rainbow trout
RbxWct = rainbow cutthroat
Wct = Westslope cutthroat trout
Yct = Yellowstone cutthroat trout

DISCUSSION AND RECOMMENDATIONS

Mysis have been established in all monitored lakes for several years. The population in Flathead Lake is the most recent, having been introduced through passive transport from Whitefish, Swan, or Ashley lakes. Annual monitoring of several lakes has provided baseline information on Mysis and crustacean zooplankton populations. This data is useful in depicting trends only because of the collection methods and sampling frequency. Further interpretation must consider limnological conditions, species distribution, and natural population cycling. Monthly sampling in Swan and Whitefish lakes provided more specific information depicting relative abundance and timing of fluctuations in Mysis and zooplankton populations.

Prediction of future mysid densities is extremely difficult when observing the variation in the lakes sampled. Bukantis (1984) predicted peak densities of 1000-2000/m^2 in Flathead Lake, based on the trophic level. It appears that Mysis may level out at a much lower density with the numbers declining from 1986 to 1987. Determining the key parameters that dictate mysid carrying capacity has not been possible with the available data.

The impact of Mysis on fish communities in the lakes monitored varies considerably and is not well understood. At one extreme, Whitefish Lake experienced a complete kokanee collapse by 1976 in the presence of Mysis. On the other hand, Ashley, Little Bitterroot, and Swan lakes all support large numbers of kokanee despite a wide range of mysid densities. During 1987, Flathead Lake experienced a near total recruitment failure of adult kokanee spawners. The previous year spawner numbers were greatly reduced. Summer angler catch rates were also the lowest on record for 1986 and 1987.

Mysids are obviously competing with kokanee for reduced numbers of cladoceran zooplankton in Flathead lake. The greatest impact has been recognized during juvenile kokanee growth and is presently being assessed (Beattie and Clancey 1987). However, present kokanee declines cannot solely be attributed to mysids, due to their low densities during 1984 ($5.1/m^2$) when the 1987 kokanee adults were fry. At that time, cladoceran zooplankton did not appear to be severely depressed.

Additional research is being conducted on Flathead Lake regarding kokanee and Mysis interactions (Beattie and Clancey 1987). Artificial enhancement methods for kokanee are also being studied, and will include hatchery and pen rearing that will result in late season fry releases. These late releases will plant kokanee fry during cladoceran zooplankton blooms. Juvenile salmon survival will then be assessed through mid-water trawling, acoustics, and other pertinent methods (Hanzel 1986).

Continued monitoring of the six Mysis lakes is recommended to follow zooplankton and mysid density trends. More emphasis should be placed on lakes where kokanee populations coexist with varying populations of Mysis (Ashley, Little Bitterroot, and Swan lakes). Abundance, mortality, food habits, and growth indices for kokanee in these lakes should also be measured. Utilization of mysids by additional fish species should also be studied to further understand the interactions occurring. It appears that viable kokanee populations coexisting with Mysis are a somewhat rare situation which warrants additional study.

Prepared by: Scott Rumsey

Date: February 18, 1988

Waters referred to: Ashley Lake 07-5220
Flathead Lake 07-6400
Little Bitterroot Lake 07-7300
McGregor Lake 05-9216
Swan Lake 07-9000
Whitefish Lake 07-9540

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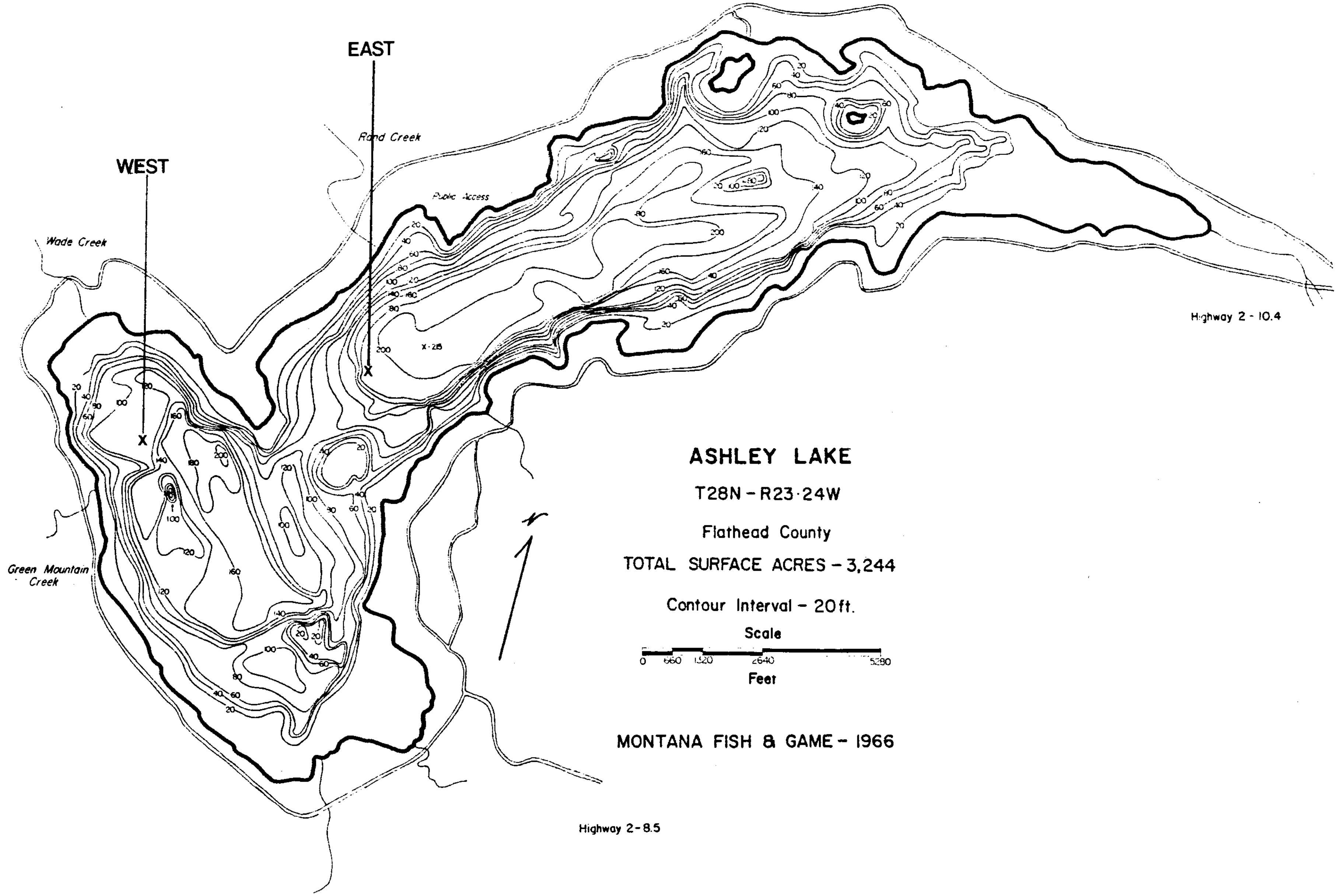
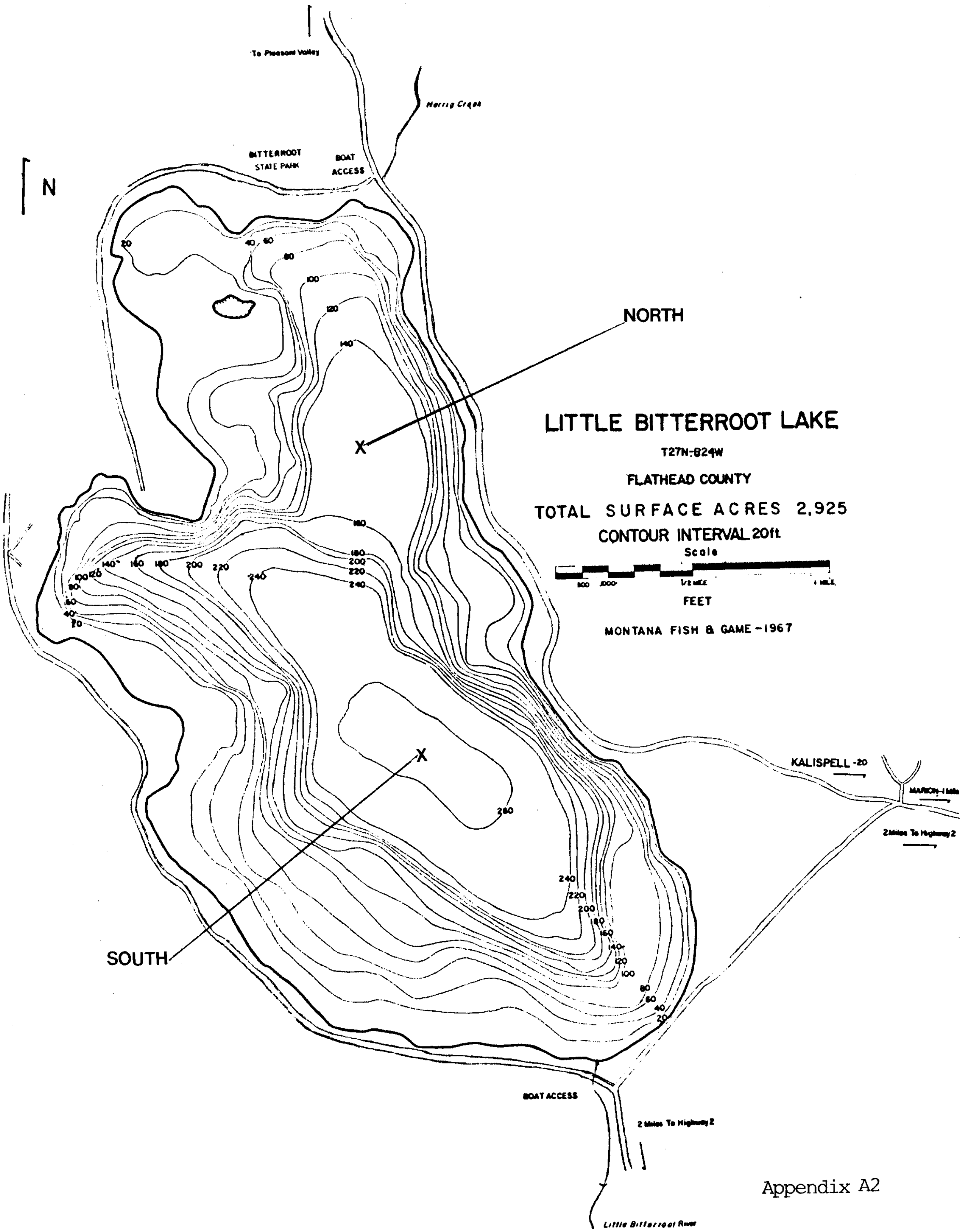
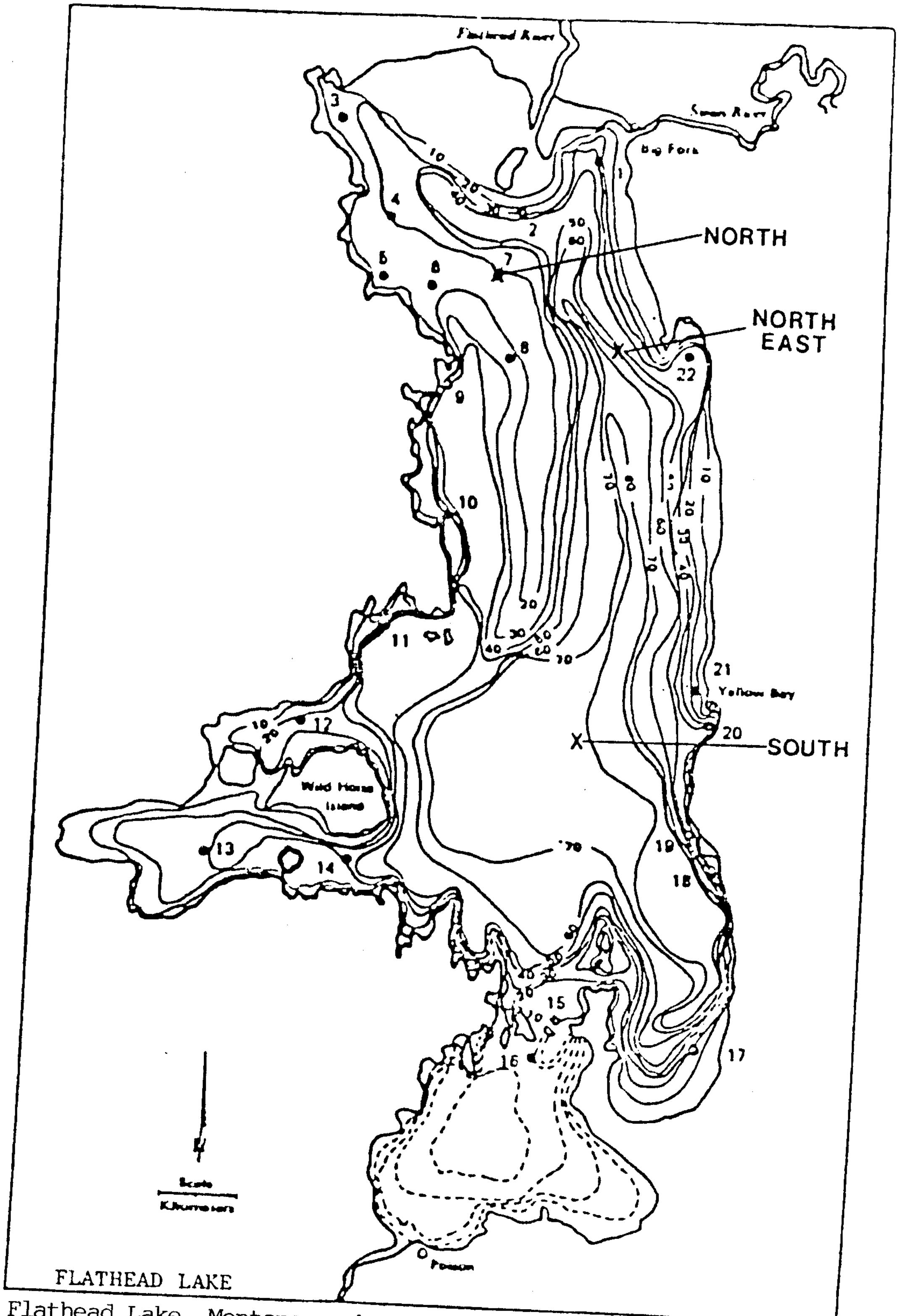

EAST
WEST
Rand Creek
Public Access
Wade Creek
Green Mountain Creek
Highway 2 - 10.4
Highway 2 - 8.5
ASHLEY LAKE
T28N - R23·24W
Flathead County
TOTAL SURFACE ACRES - 3,244
Contour Interval - 20 ft.
Scale
0 660 1320 2640 5280
Feet
MONTANA FISH & GAME - 1966

Appendix A1

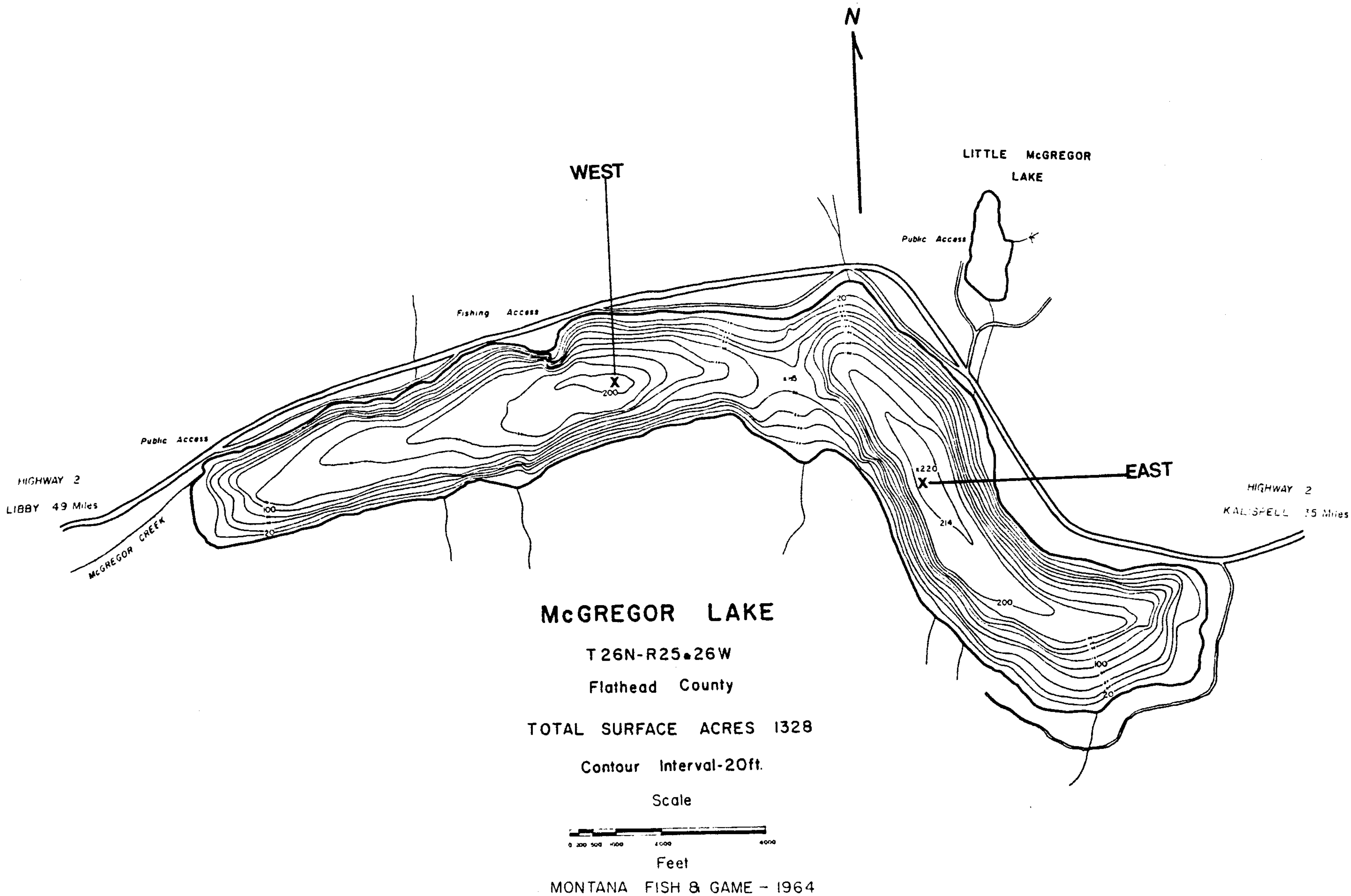

To Pleasant Valley
Herrig Creek
BITTERROOT STATE PARK
BOAT ACCESS
N
NORTH
SOUTH
LITTLE BITTERROOT LAKE
T27N-R24W
FLATHEAD COUNTY
TOTAL SURFACE ACRES 2,925
CONTOUR INTERVAL 20ft.
Scale
FEET
MONTANA FISH & GAME - 1967
KALISPELL -20
BOAT ACCESS
2 Miles To Highway 2
Little Bitterroot River

Appendix A2

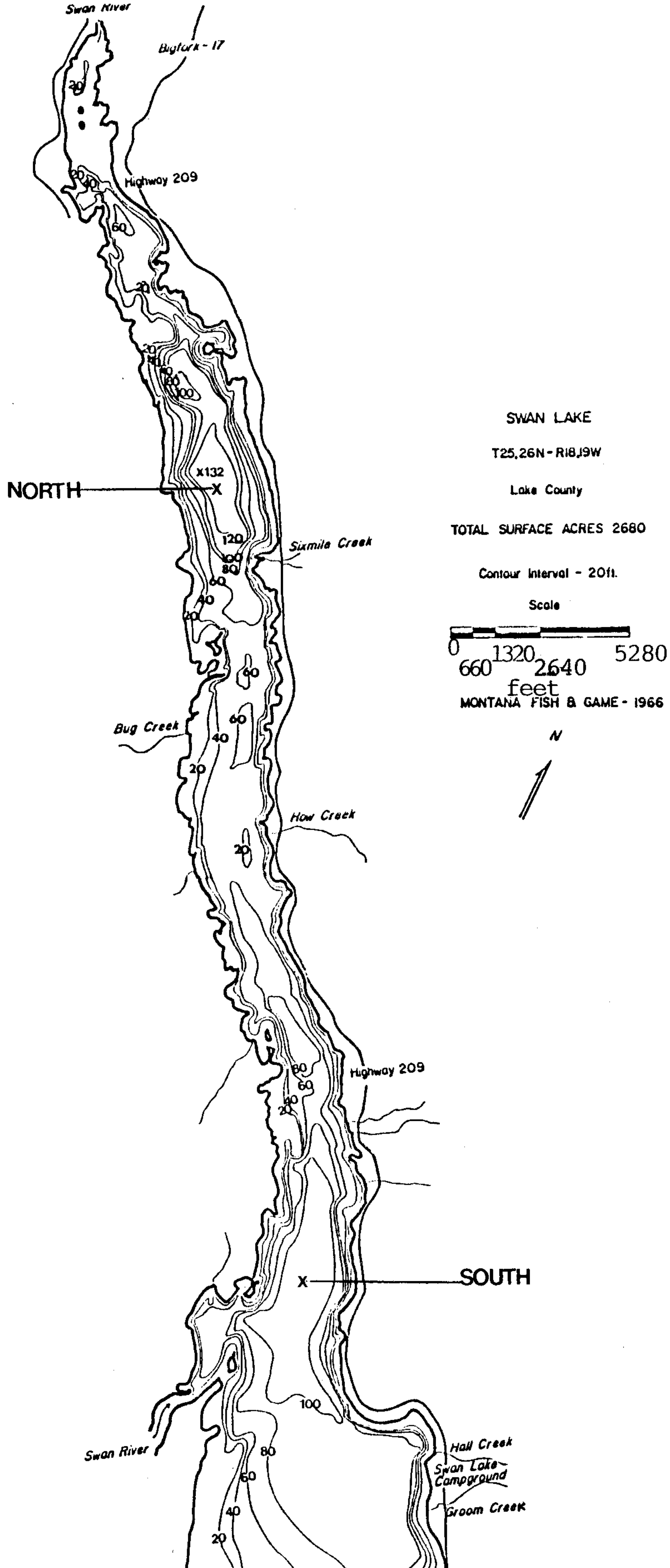


Flathead Lake, Montana, showing bottom contours (meters) and sampling stations.

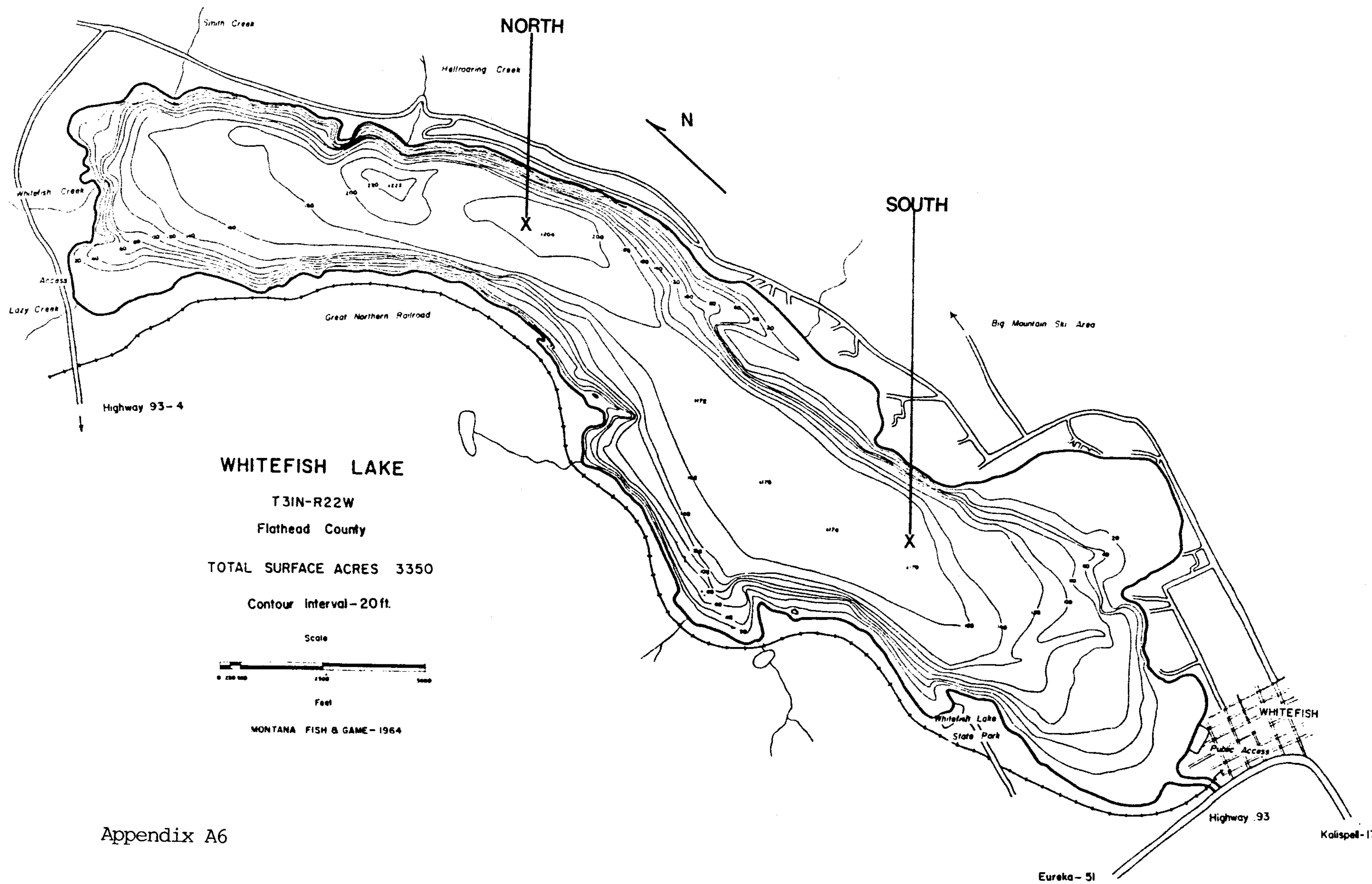
Appendix A3


WEST
N
LITTLE McGREGOR LAKE
Public Access
Fishing Access
Public Access
HIGHWAY 2
LIBBY 49 Miles
McGREGOR CREEK
EAST
HIGHWAY 2
KALISPELL 35 Miles
200
100
20
220
214
McGREGOR LAKE
T26N-R25&26W
Flathead County
TOTAL SURFACE ACRES 1328
Contour Interval-20ft.
Scale
Feet
MONTANA FISH & GAME - 1964

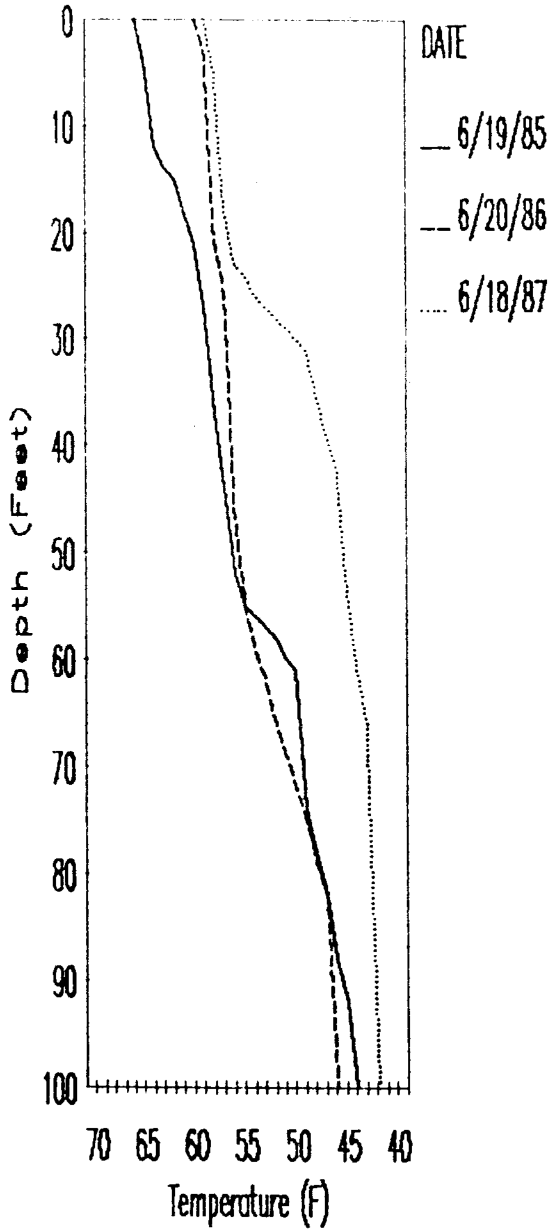
Appendix A4


Swan River
Bigfork - 17
Highway 209
SWAN LAKE
T25,26N - R18,19W
Lake County
TOTAL SURFACE ACRES 2680
Contour Interval - 20ft.
Scale
0 660 1320 2640 5280
feet
MONTANA FISH & GAME - 1966
N
NORTH
X132
Sixmile Creek
Bug Creek
Haw Creek
Highway 209
SOUTH
Swan River
Hall Creek
Swan Lake Campground
Groom Creek
Seeley Lake - 54
Spring Creek

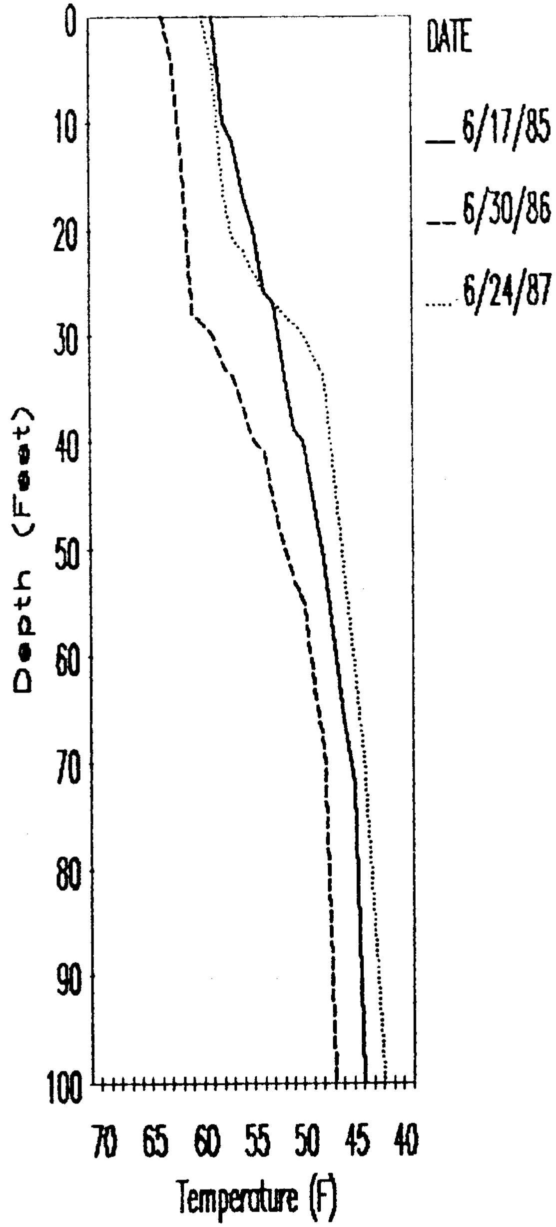
Appendix A5


WHITEFISH LAKE
T31N-R22W
Flathead County
TOTAL SURFACE ACRES 3350
Contour Interval - 20 ft.
Scale
Feet
MONTANA FISH & GAME - 1964
NORTH
SOUTH
N
Smith Creek
Hellroaring Creek
Whitefish Creek
Access
Lazy Creek
Great Northern Railroad
Highway 93-4
Big Mountain Ski Area
Whitefish Lake State Park
WHITEFISH
Public Access
Highway 93
Kalispell-17
Eureka-51

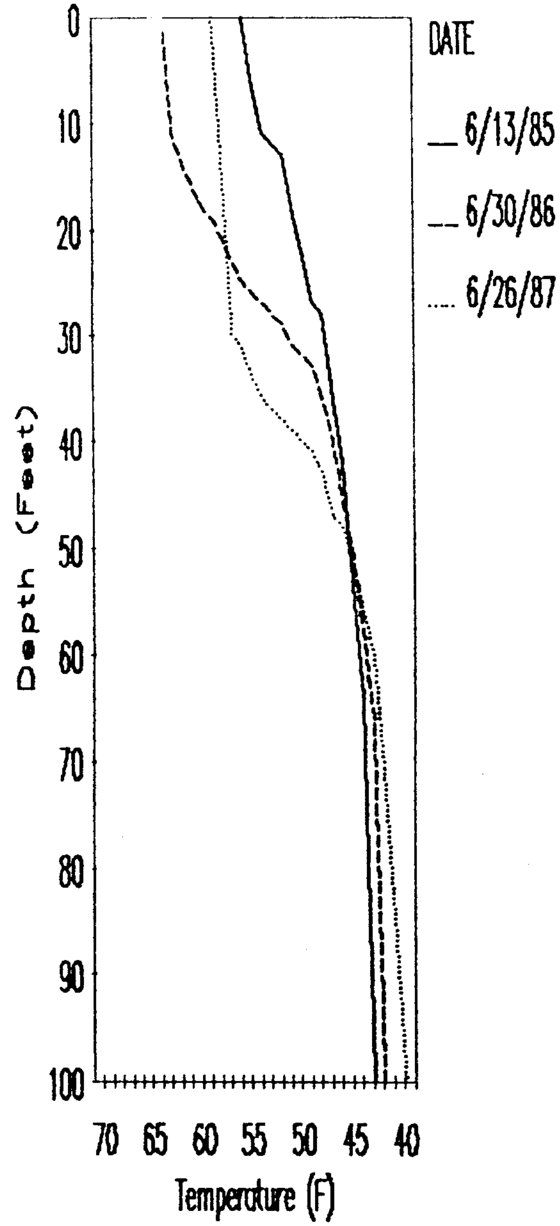
Appendix A6



FLATHEAD LAKE June 85-87

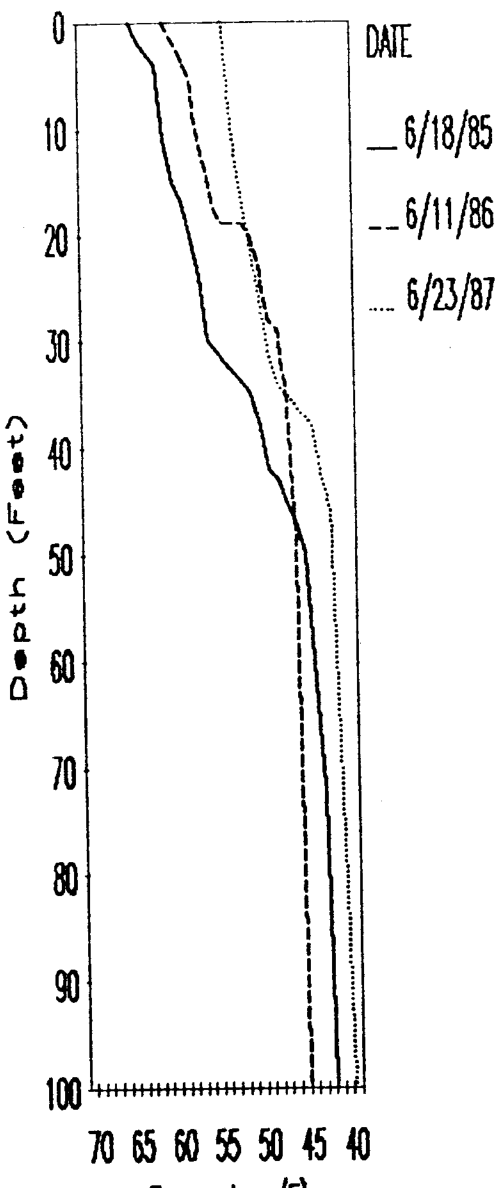


SWAN LAKE June 85-87

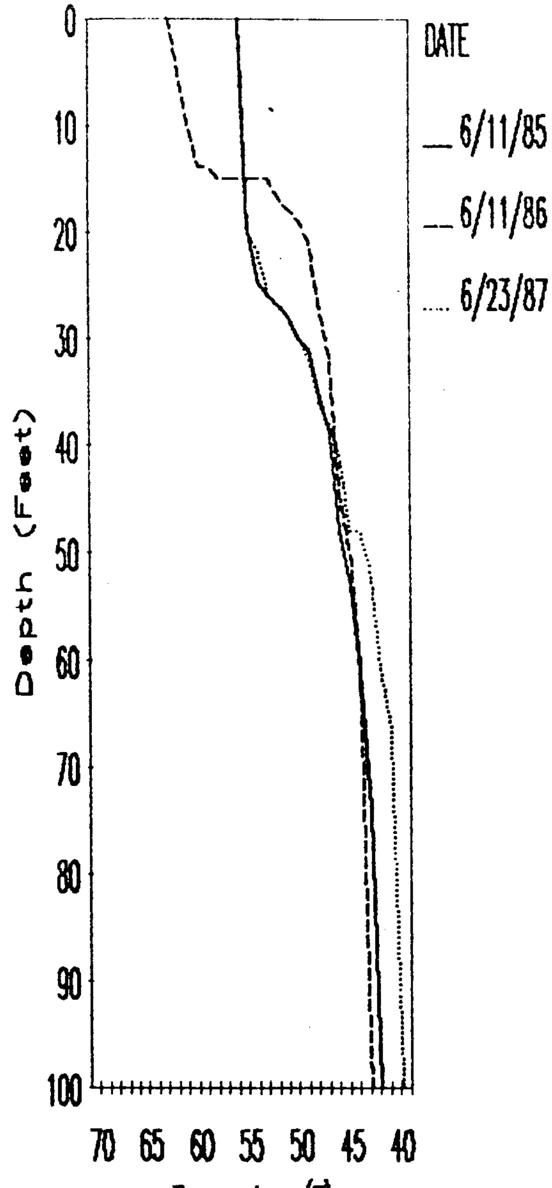


WHITEFISH LAKE June 85-87

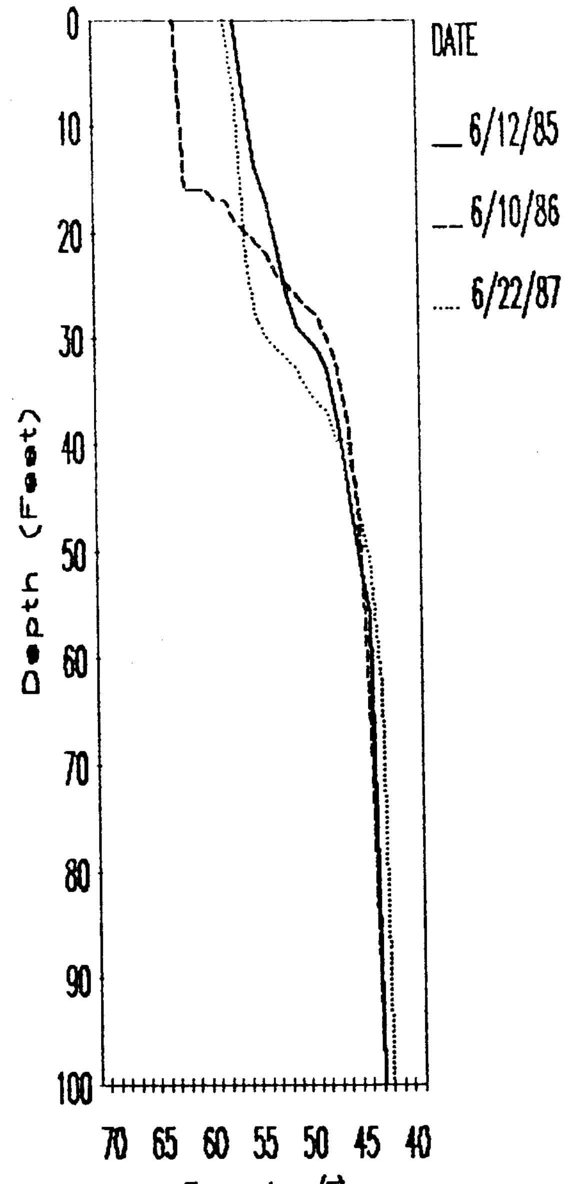
Appendix B1



ASHLEY LAKE June 85-87



L.BITTERROOT LAKE June 85-87



McGREGOR LAKE June 85-87

Appendix B1