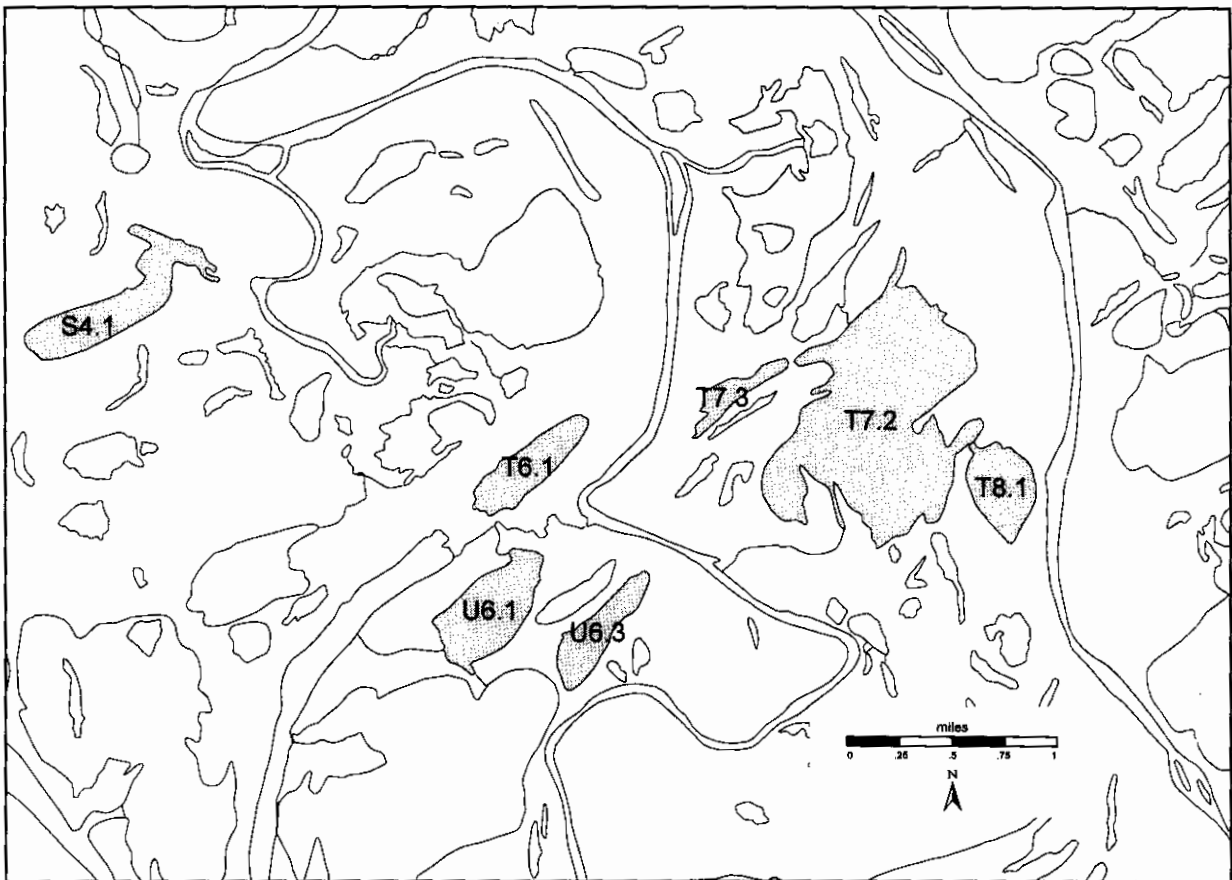


ALPINE DEVELOPMENT AREA LAKES CONTOUR MAPS AND VOLUME ESTIMATES

Final Report

December 1998



Prepared by:

MJM Research
1012 Shoreland Drive
Lopez Island, WA

Prepared for:

ARCO Alaska, Inc.
700 G Street
Anchorage, AK

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Lawrence L. Moulton
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Alpine Development Area Lakes Contour Maps and Volume Estimates

Introduction

This report transmits the results of mapping lake contours and estimating lake volumes for seven lakes in the Alpine Development Area. I was requested to develop volumetric estimates for the following lakes (Figure 1):

S4.1 (L9315 or B8533)

T6.1 (L9313)

T7.2 (L9282 or B8534)

T7.3 (L9342)

U6.1 (L9312)

T8.1 (L9283)

U6.3 (L9310)

A volumetric estimate for Lake T8.1 was not specifically requested, but is included since this lake is connected to T7.2 and would contribute to the volume of that lake complex during summer.

Additional information on each lake is also included.

Methods

Depth measurements used to develop the contour maps were taken at various times from 1995 to 1998. Depths taken during summer (1995-1998) were read with an Eagle SupraPro ID depth sounder. During winter, depths were measured through the ice with a Polar Vision hand-held sonar unit. Both sonar units were checked against a measuring tape in 24 ft of water and found to be highly accurate. Error was less than 0.1 ft.

Transect positions were determined by marking the beginning and end locations of the transects on base maps of the lakes. Individual depth measurements were located with a hand-held GPS receiver while traversing the lake with either a boat or float tube. The readings were converted to distance measurements and the resulting points were plotted on the known location of the transect. During winter, the transect was again determined by marking the beginning and end locations of the transects on base maps of the lakes. GPS coordinates of the end points were also recorded. The individual depth readings were a measured distance apart, with the distance between measurements varying with the size of the lake. On large lakes, such as T7.2, the depth measurements were 100 ft apart, while on small lakes, such as T7.3, the depth measurements were 25 ft apart.

Depth measurements were plotted on base maps of each lake. Initial plots of transects obtained during summer appeared erratic because of error caused by U.S. Department of Defense scrambling of the civilian GPS signal. Transects were manually smoothed to better represent the course covered by the boat or float tube. Transects obtained during winter were straight lines, thus smoothing was not necessary.

Contours were drawn around regions containing depths greater than the indicated contour line. The area encompassed by each contour was then obtained from the GIS program used to generate the contour plot. Total estimated volume was obtained by summing the volumes represented by each contour interval. Estimated volumes were calculated as cubic feet and gallons.

Results and Discussion

Lake volumes were estimated for all seven lakes (Table 1). Also included are the volumes in the portions of the lakes deeper than 7 feet and the likely allowable winter withdrawal. The volume deeper than 7 feet represents the likely volume of water present at maximum ice thickness, thus this is an estimate of the water present in late winter. The water likely to be allowable for winter use is 15% of the winter volume. Alaska Department of Fish and Game has been using this 15% guideline to allow winter water use while retaining some measure of protection for wintering fish.

If special arrangements are made for a variance from the 15% guideline, the allowable withdrawal will, of course, be different.

Contour maps were generated for each referenced lake (Figures 2 to 8). The contour maps were based on 69 to 304 depth measurements per lake, with the number of measurement somewhat dependent on lake size (Table 2). The maps are best interpretations of available depth information, but because of the wide spacing between transects on some lakes, there are likely to be inaccuracies in the mapped representations.

An appendix containing existing information for each lake is attached.

The amount of water available for withdrawal has traditionally been estimated by applying the formula for the volume of a cone to the lake surface area and maximum depth. The estimated volumes for the seven lakes were obtained from both cone volume method and contour method to compare the two methods (Table 3). There was considerable variation in the differences in estimated between the two methods, with the contour method providing up to 63% more water to 34% less water. On average, the contour method provided about 9% more water than the cone volume method. The results indicate that the cone volume method likely provides a reasonable estimate for a one-time water use.

Table 1. Estimated volumes for selected Alpine Project Area lakes.

(volume estimates based on contour mapping developed from depth measurements obtained during 1995-1998 Alpine Project Fish Surveys)

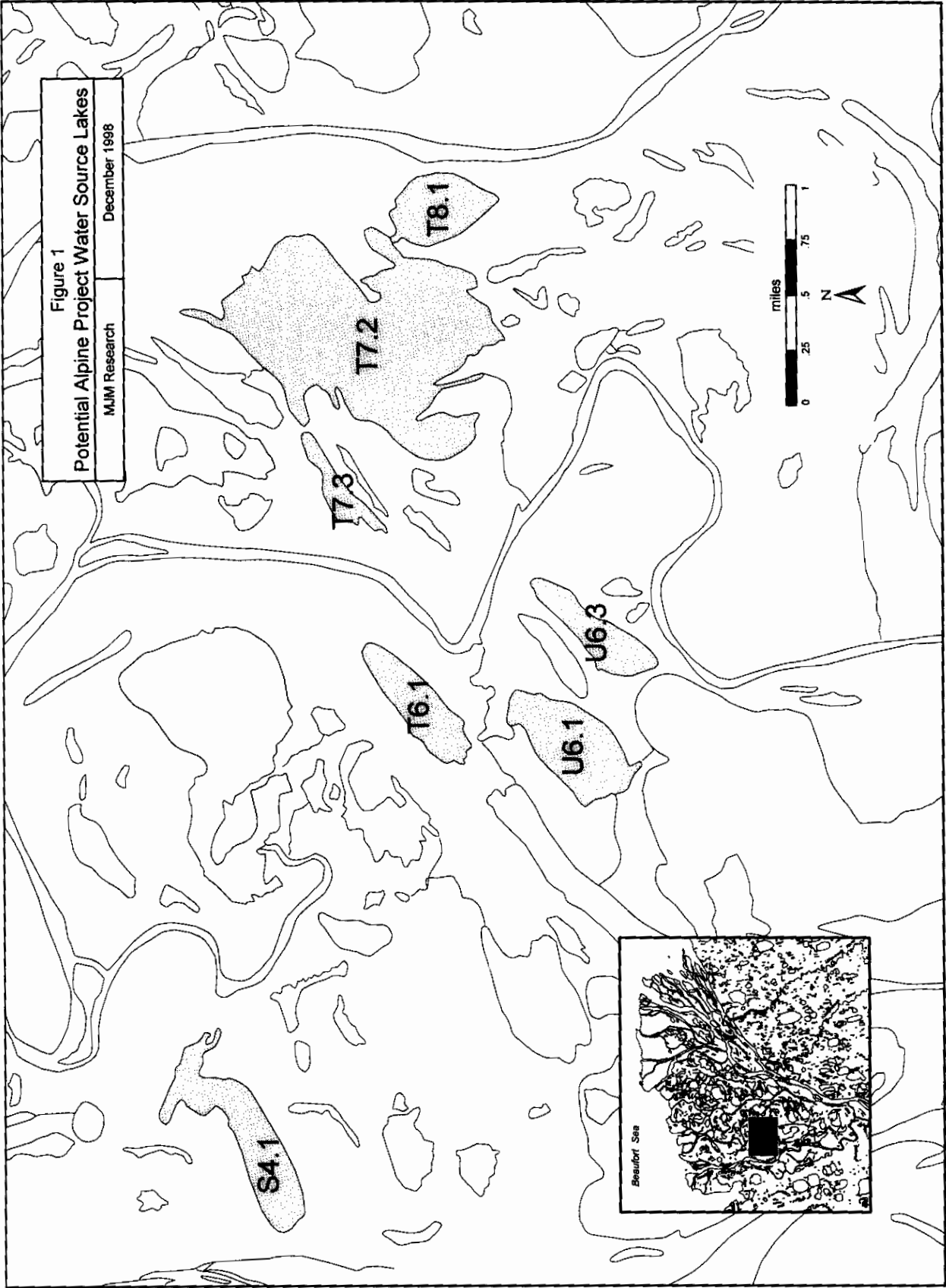
ERG Lake Number	Investigator Number	Max. Depth (ft)	Area (acres)	Estimated Volume (million cf)	Estimated Volume (million gals)	Volume below 7 ft (million gals)	15% of Volume below 7 ft (million gals)
S4.1	B8533	25.2	114.5	67.97	508.36	269.37	40.41
T6.1	L9313	12.3	68.9	24.69	184.64	44.93	6.74
T7.2	B8534	28.0	480.4	224.44	1,678.65	711.73	106.76
T7.3	L9342	11.5	25.3	8.98	67.20	13.07	1.96
T8.1	L9283	10.5	74.3	26.84	200.75	45.64	6.85
U6.1	L9312	14.1	99.9	39.84	297.99	94.33	14.15
U6.3	L9310	24.1	60.5	28.27	211.40	84.38	12.66

Table 2. Number of depth readings by lake

ERG Lake Number	Investigator Number	Number of Readings
S4.1	B8533	166
T6.1	L9313	239
T7.2	B8534	304
T7.3	L9342	76
T8.1	L9283	69
U6.1	L9312	126
U6.3	L9310	137

Table 3. Comparison of estimated available winter water based on volume-of-cone method and contour method.

ERG Lake Number	Investigator Number	Cone Method (million gals.)	Contour Method (million gals.)	Percent Difference
S4.1	B8533	33.61	40.41	+20.2
T6.1	L9313	5.89	6.74	+14.5
T7.2	B8534	162.69	106.76	-34.4
T7.3	L9342	1.95	1.96	+0.3
T8.1	L9283	4.20	6.85	+63.2
U6.1	L9312	11.43	14.15	+23.7
U6.3	L9310	16.70	12.66	-24.2
Mean Difference:				+9.1

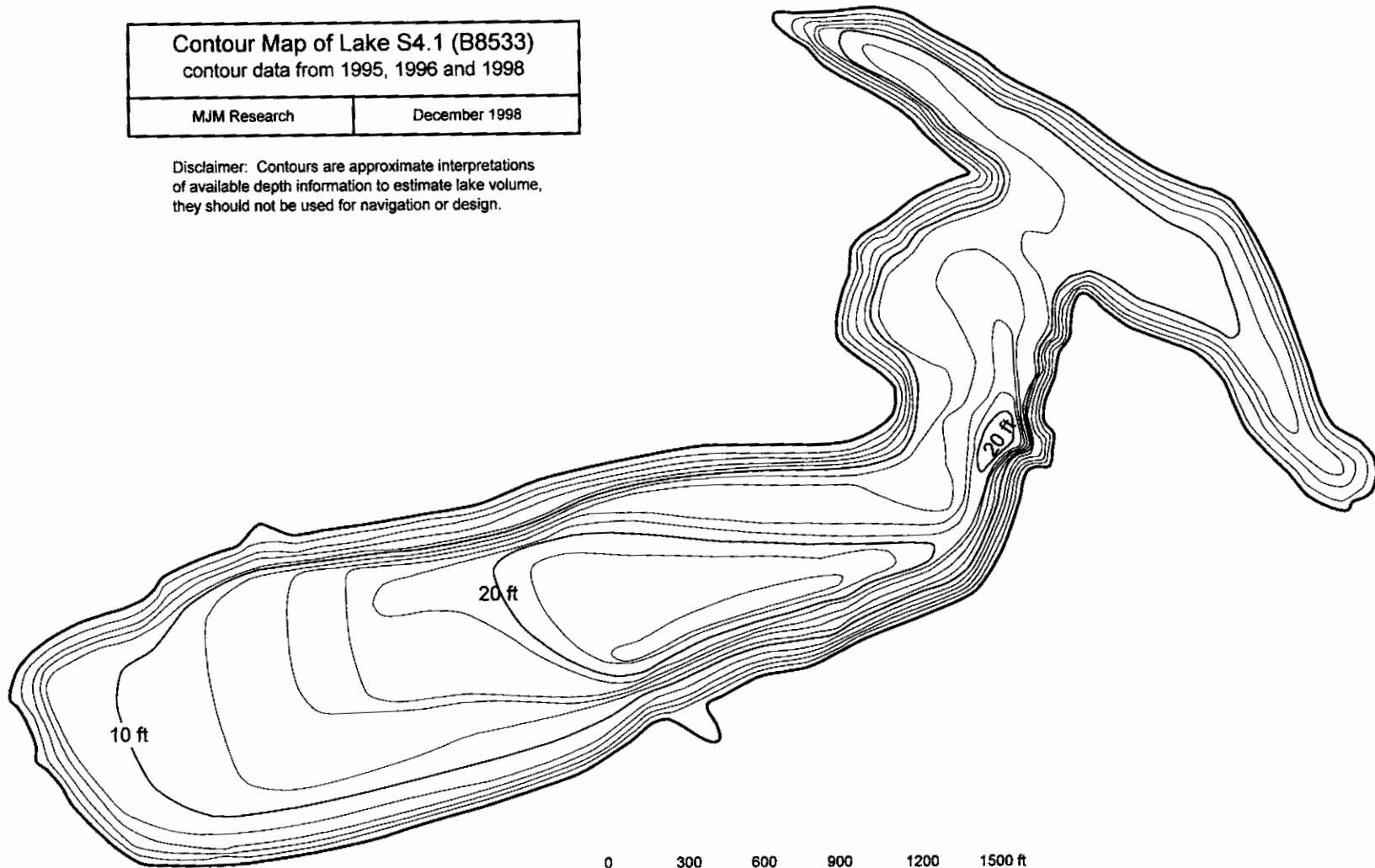


Contour Map of Lake S4.1 (B8533)
contour data from 1995, 1996 and 1998

MJM Research

December 1998

Disclaimer: Contours are approximate interpretations
of available depth information to estimate lake volume,
they should not be used for navigation or design.



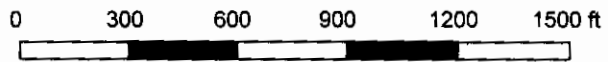
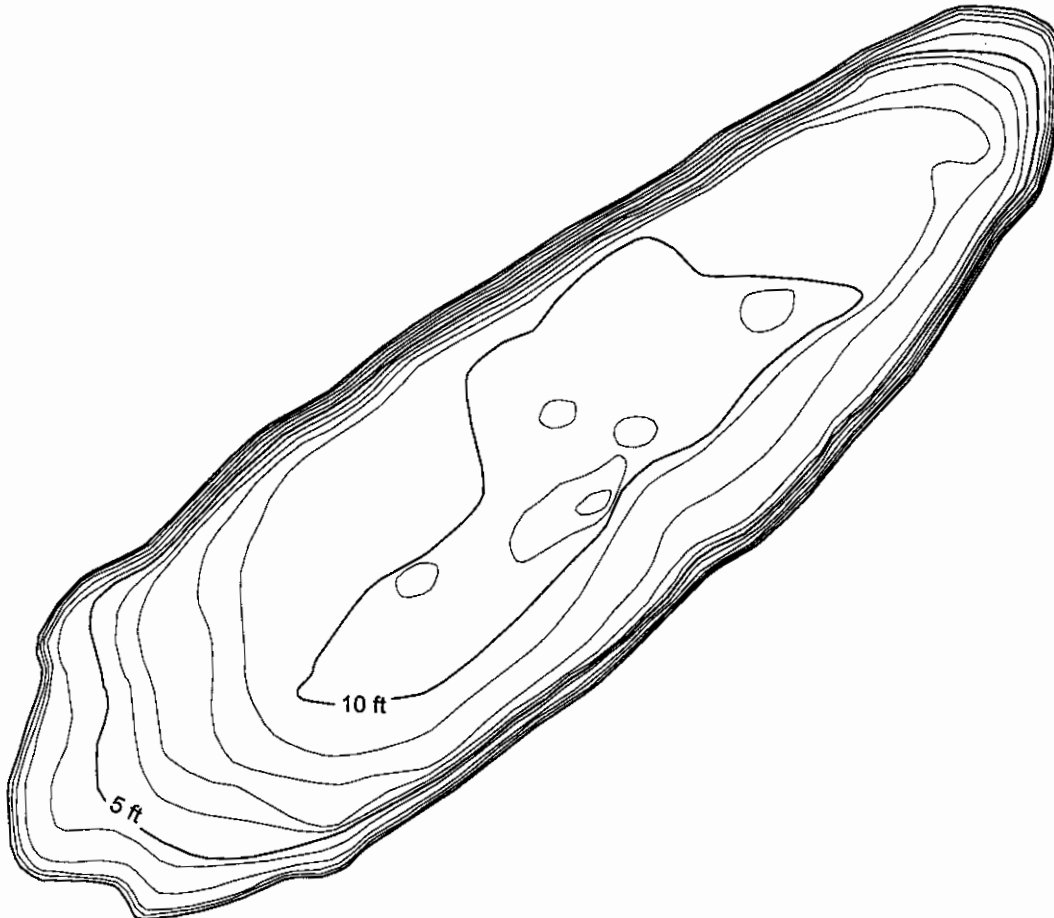
Contour Map of Lake T6.1 (L9313)

contour data from 1995, 1996 and 1998

MJM Research

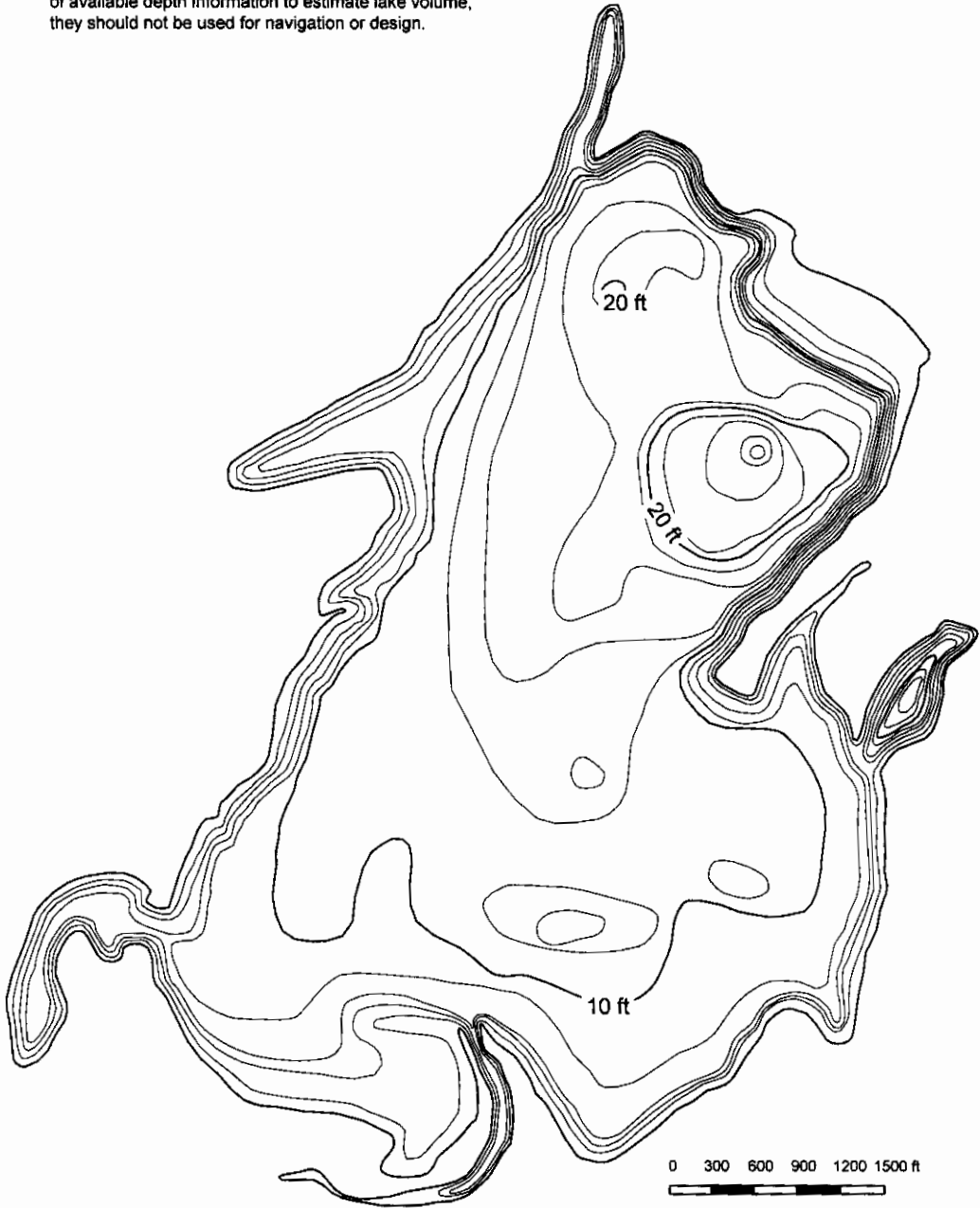
December 1998

Disclaimer: Contours are approximate interpretations of available depth information to estimate lake volume, they should not be used for navigation or design.



Contour Map of Lake T7.2 (B8534)	
contour data from 1995 and 1998	
MJM Research	December 1998

Disclaimer: Contours are approximate interpretations of available depth information to estimate lake volume, they should not be used for navigation or design.

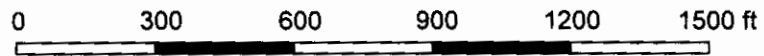
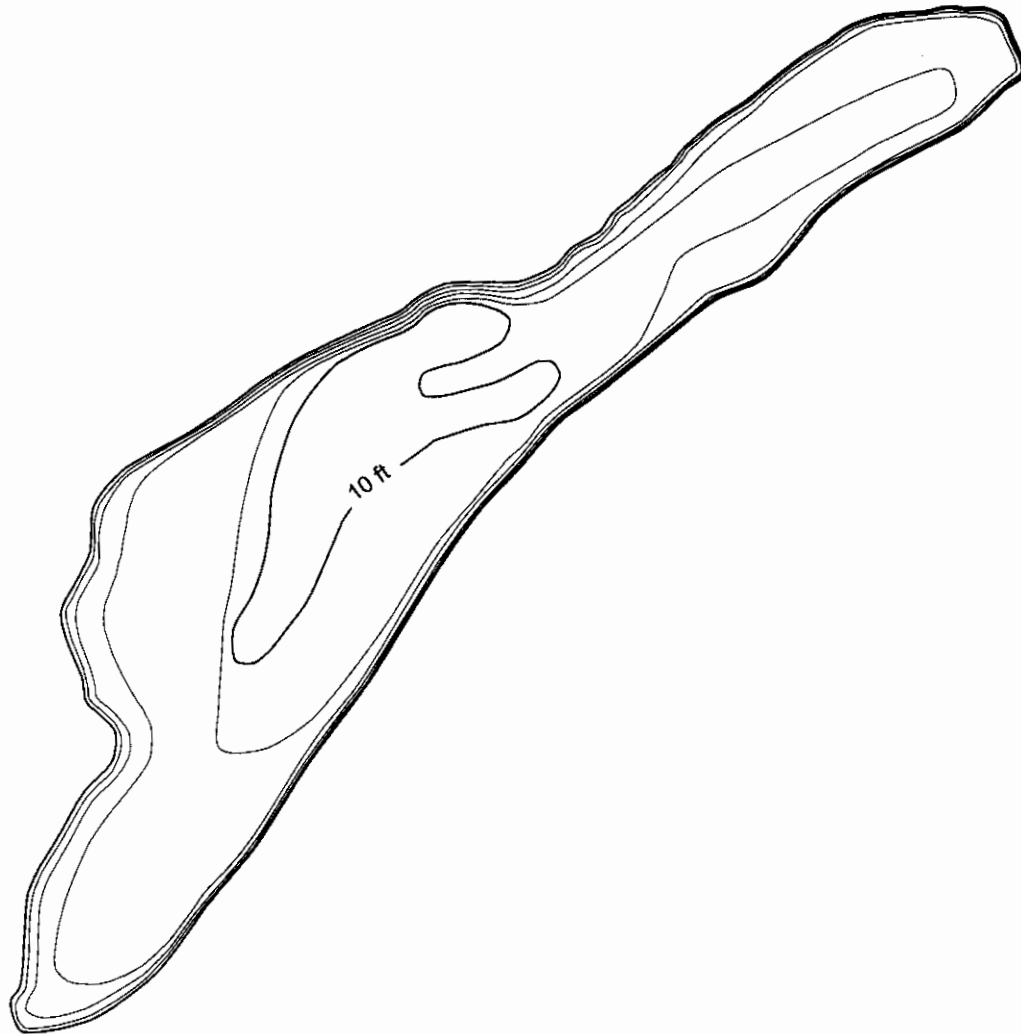


Contour Map of Lake T7.3 (L9342)
contour data from 1995 and 1998

MJM Research

December 1998

Disclaimer: Contours are approximate interpretations of available depth information to estimate lake volume, they should not be used for navigation or design.

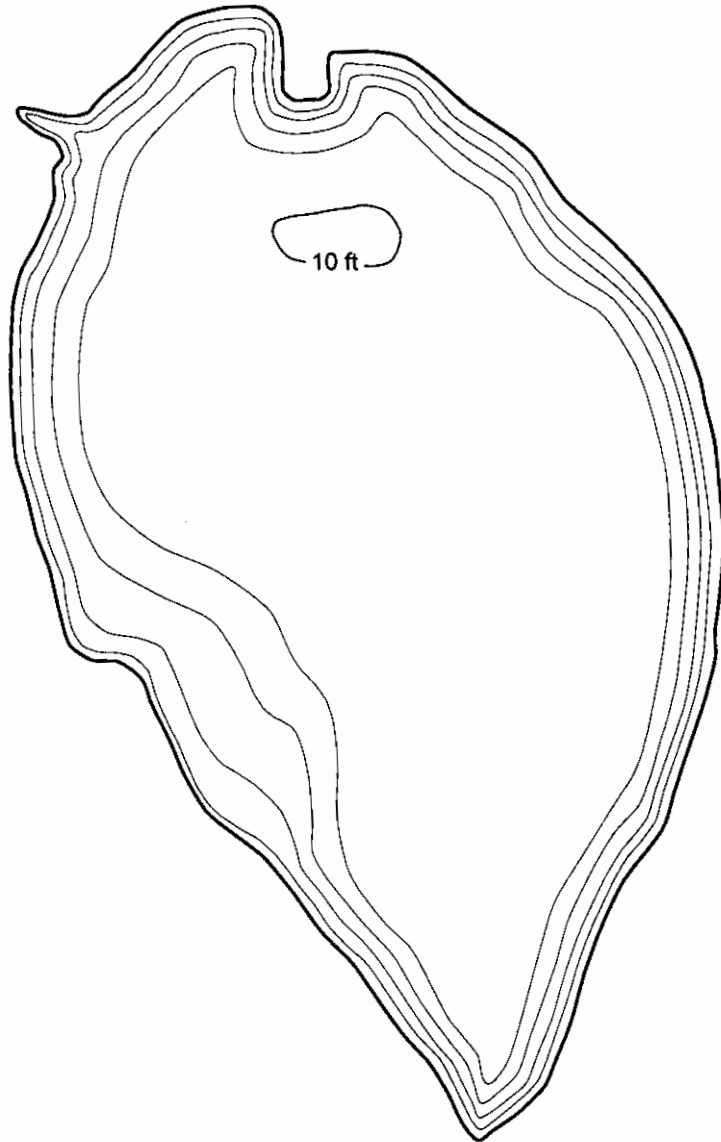


Contour Map of Lake T8.1 (L9283)
contour data from 1995 and 1998

MJM Research

December 1998

Disclaimer: Contours are approximate interpretations
of available depth information to estimate lake volume,
they should not be used for navigation or design

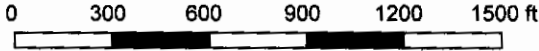
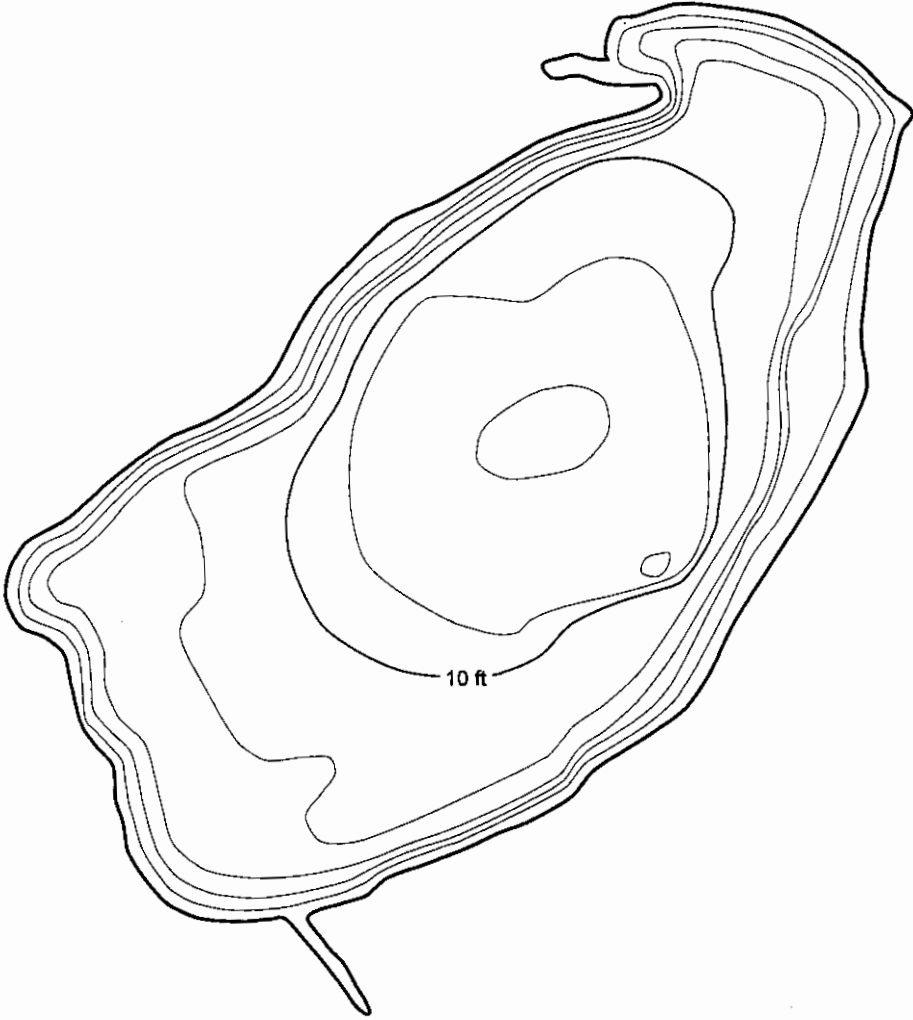


Contour Map of Lake U6.1 (L9312)
depth contours based on 1995, 1997 and 1998 data

MJM Research

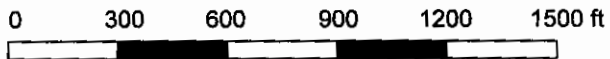
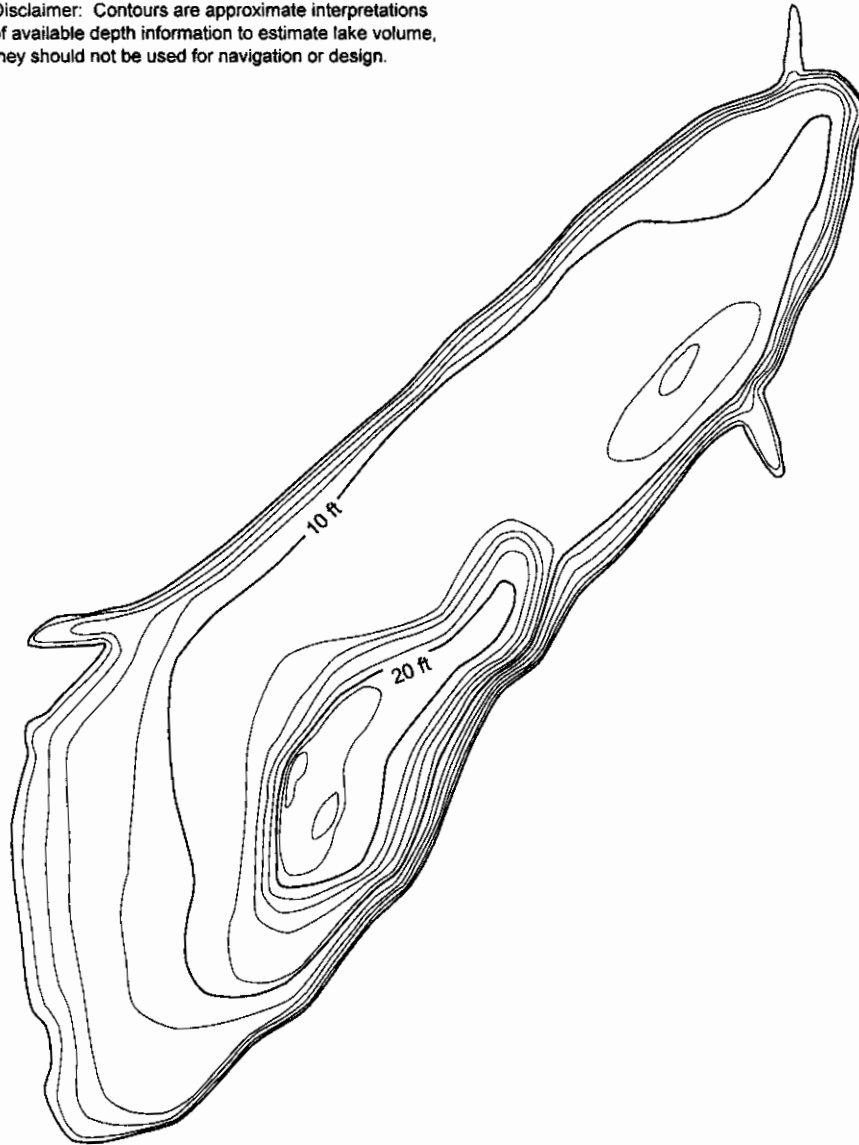
December 1998

Disclaimer: Contours are approximate interpretations of available depth information to estimate lake volume, they should not be used for navigation or design.



Contour Map of Lake U6.3 (L9310) contour data from 1995, 1997 and 1998	
MJM Research	December 1998

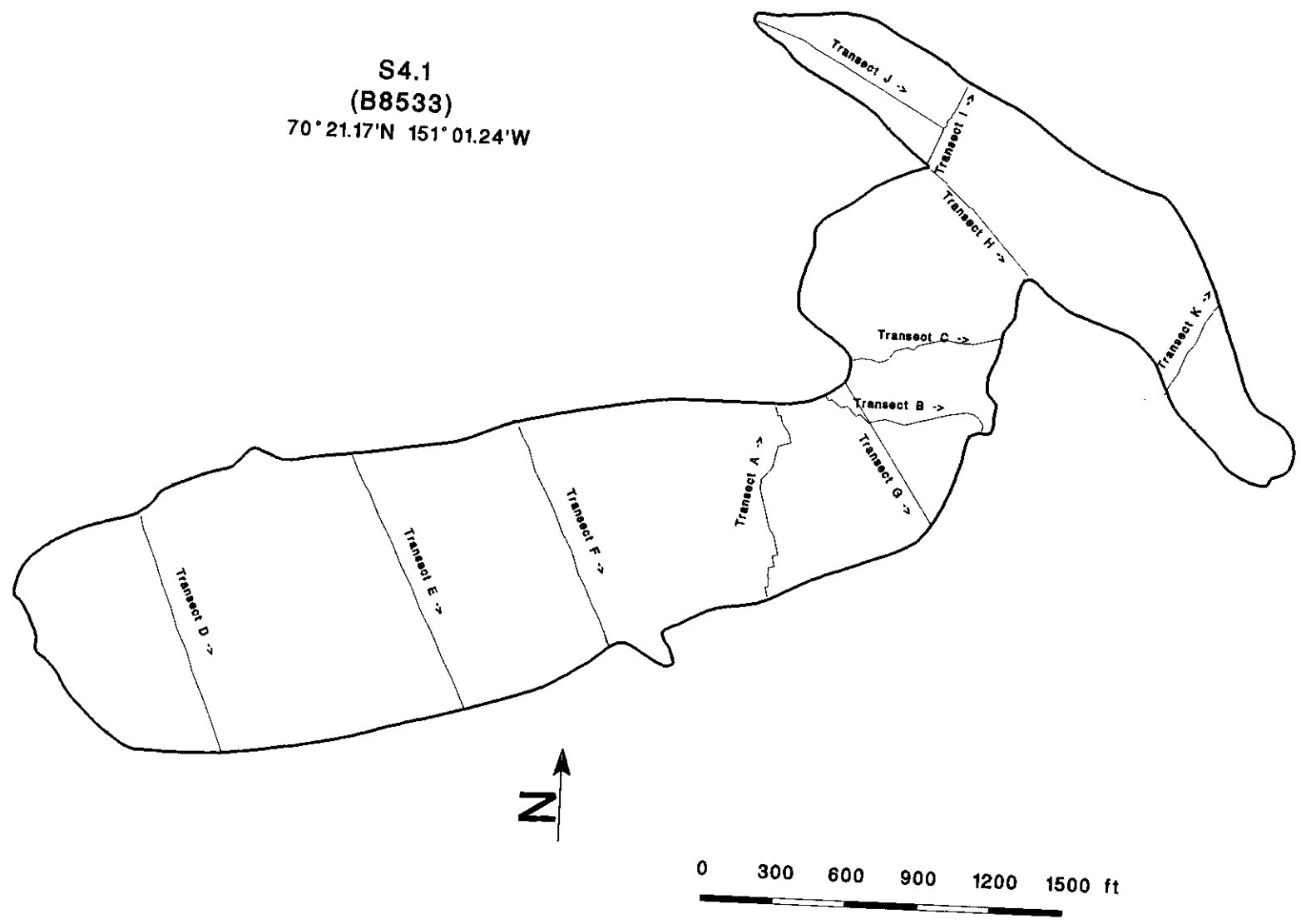
Disclaimer: Contours are approximate interpretations of available depth information to estimate lake volume, they should not be used for navigation or design.



Individual Lake Information Packets

S4.1
(B8533)
70°21.17'N 151°01.24'W

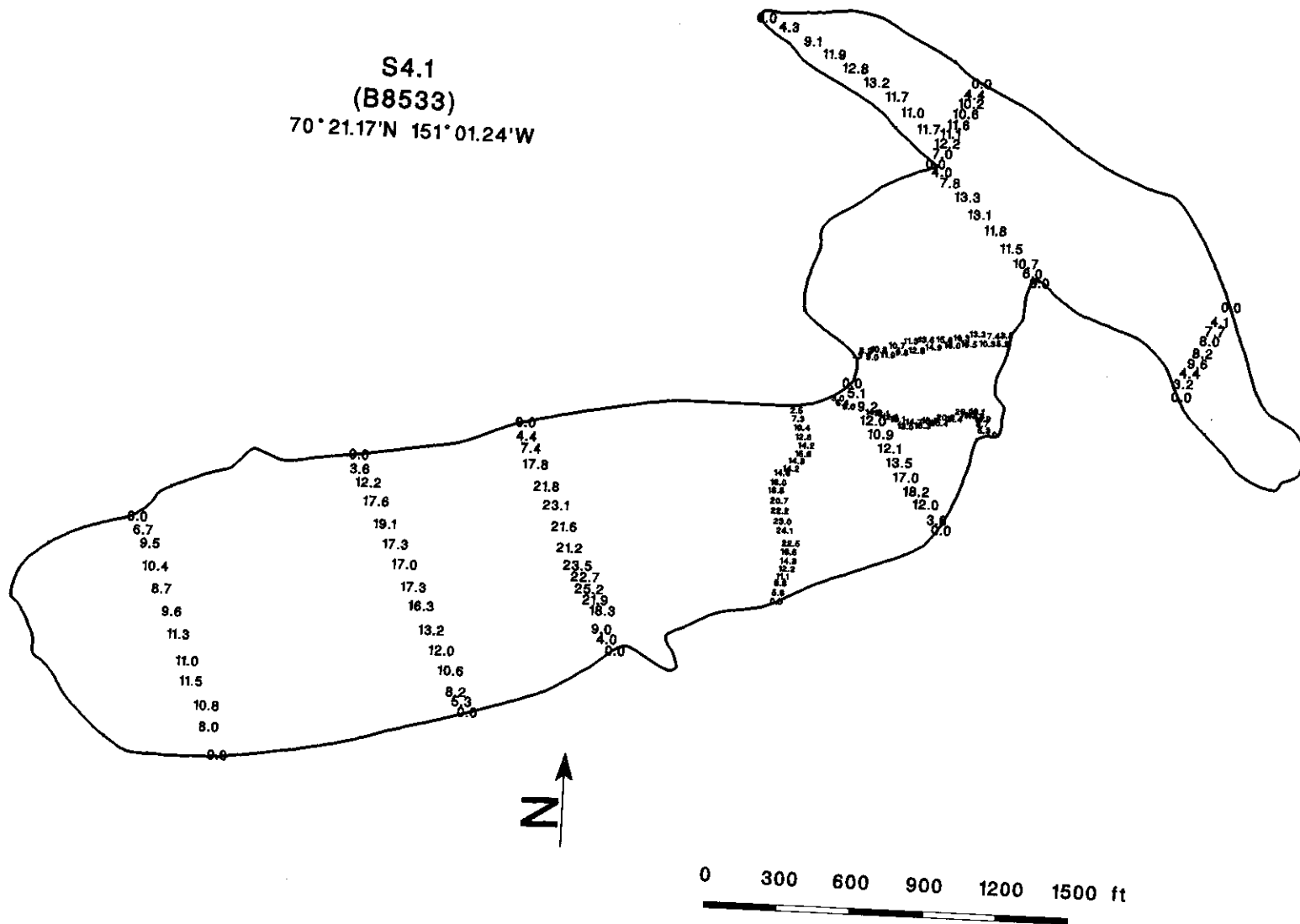
A-1



Bathymetric transects surveyed on lake S4.1 (B8533), 1995-1998.

A-2

S4.1
(B8533)
70°21.17'N 151°01.24'W



Depths recorded on lake S4.1 (B8533), 1995-1998.

Lake S4.1

Other Names: B8533; L9315
Location: 70°21.17'N 151°01.24'W
USGS Quad Sheet: Harrison Bay B-2: T12N R4E, Sect 36
Habitat: Perched Lake (Infrequent Flooding)
Area: 114 acres
Maximum Depth: 24.1 feet
Active Outlet: No
Spec. Conductance: 230 μ S/cm (1985)
 166 μ S/cm (1995)
pH: 7.5 (1985)
Calculated Volume: 508.4 million gallons
Permittable Volume: 40.4 million gallons

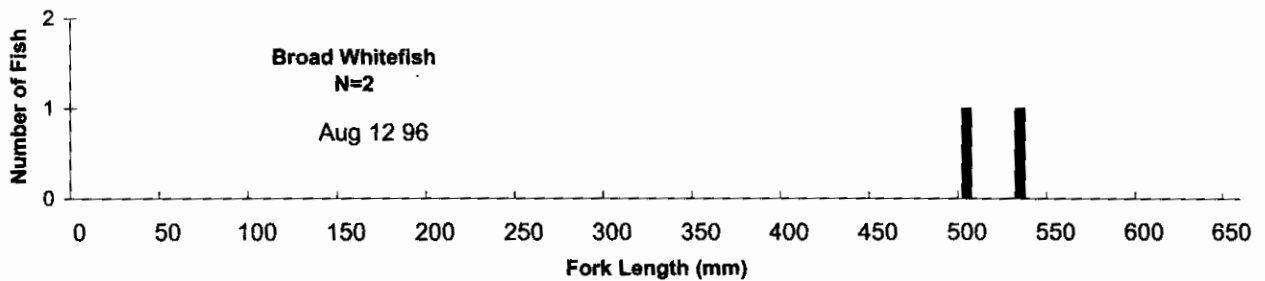
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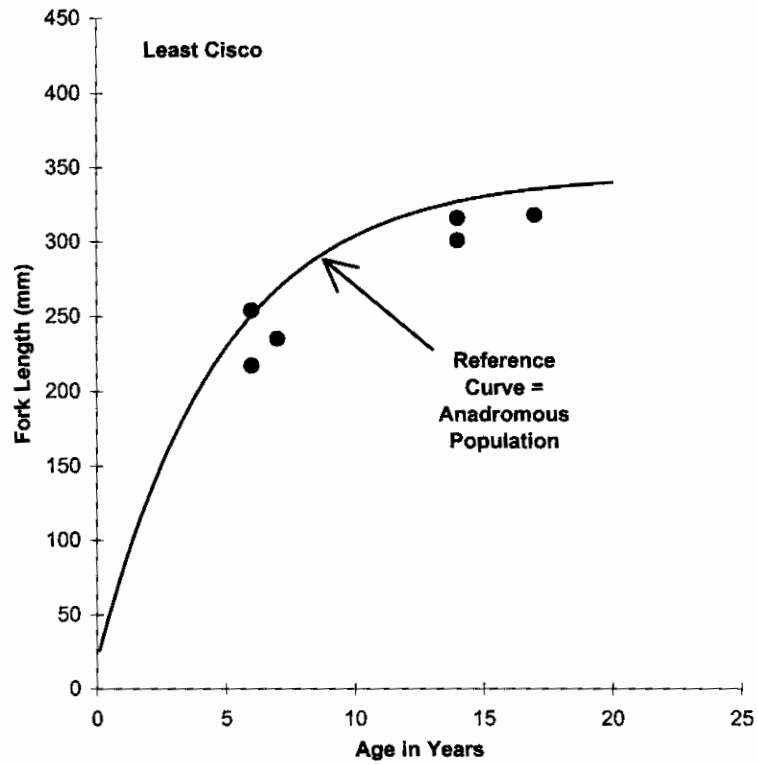
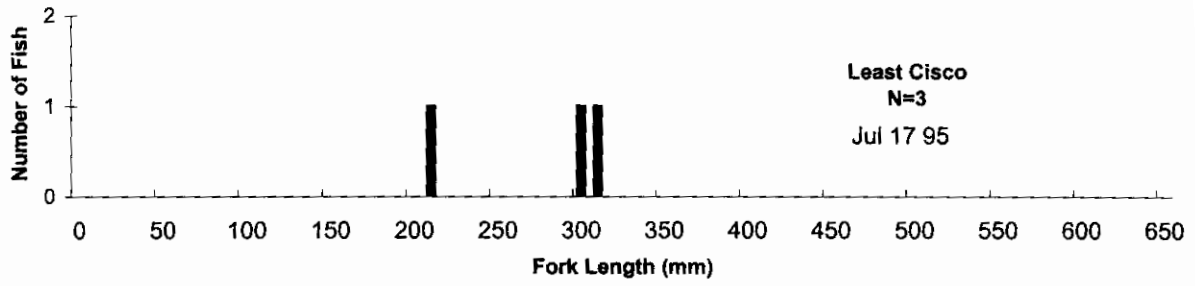
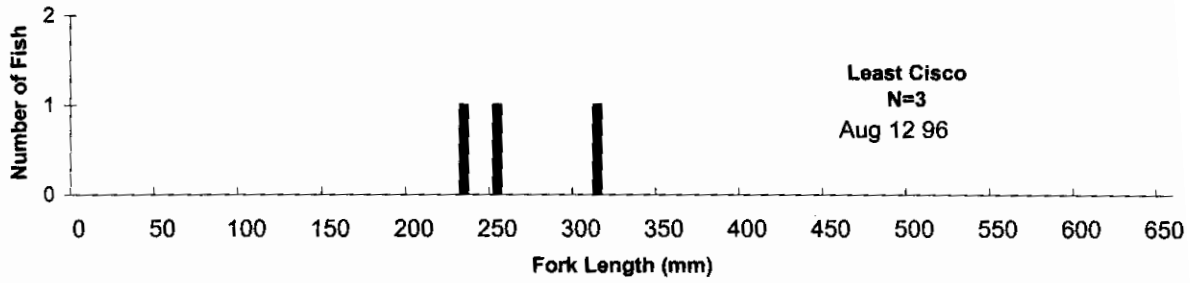
Year of Test	Chloride (mg/l)	Sodium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
1985					51		Bendock & Burr 1986
1993	19	11.0	2.4	4.7	22	46	J. Lobdell

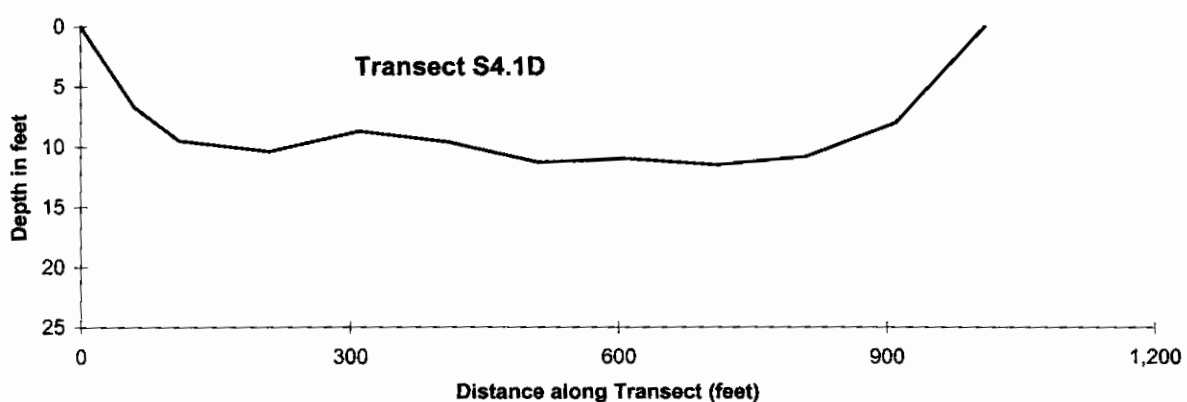
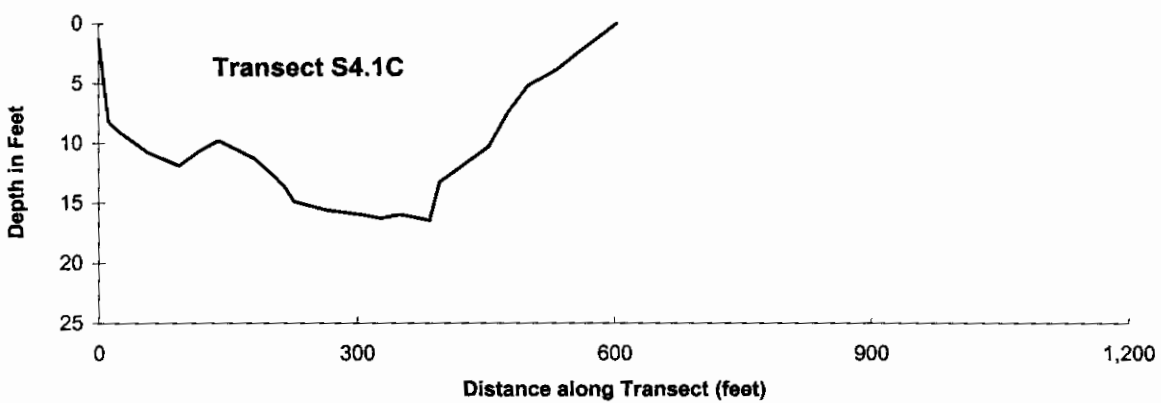
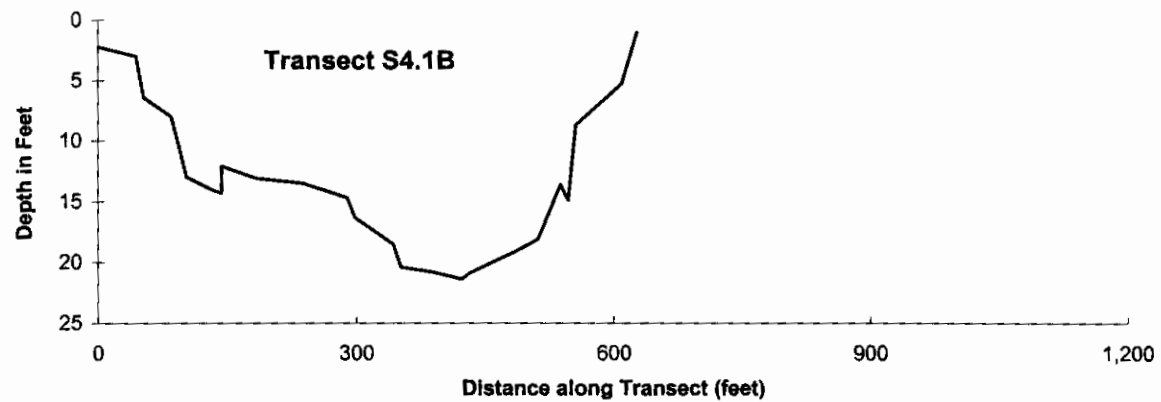
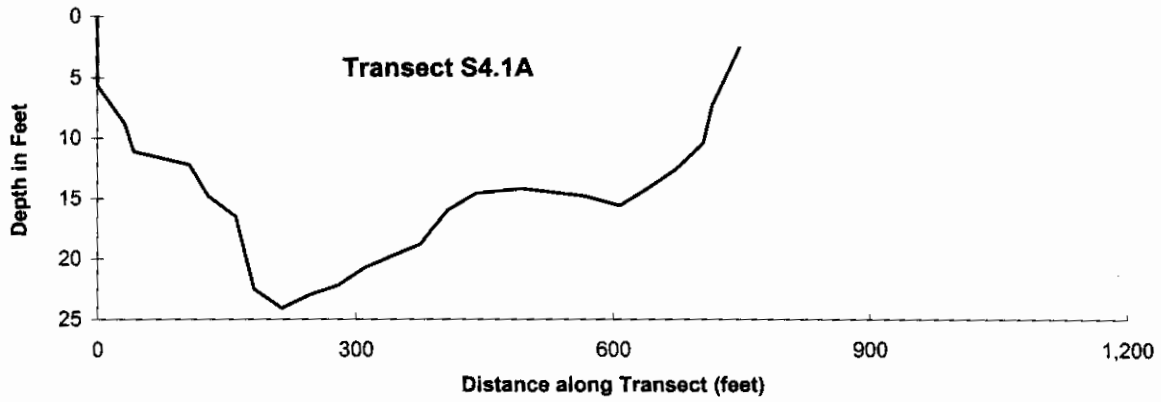
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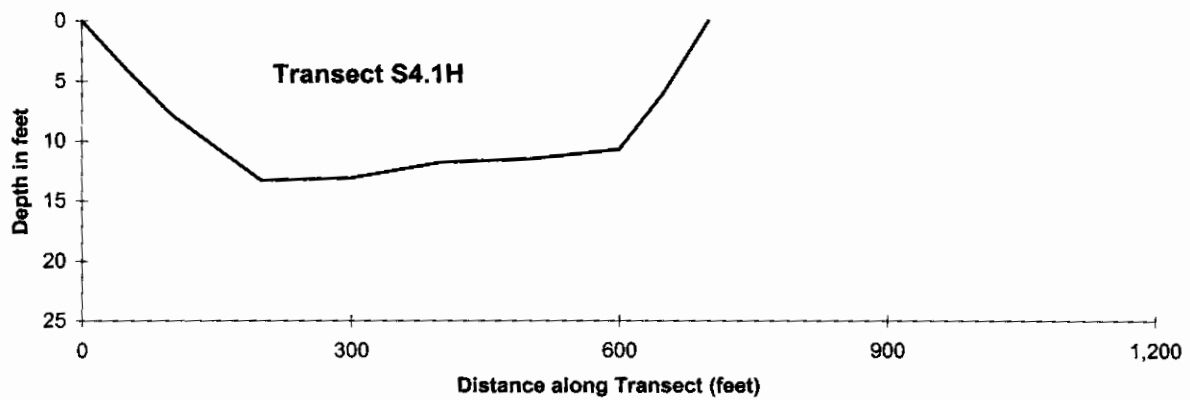
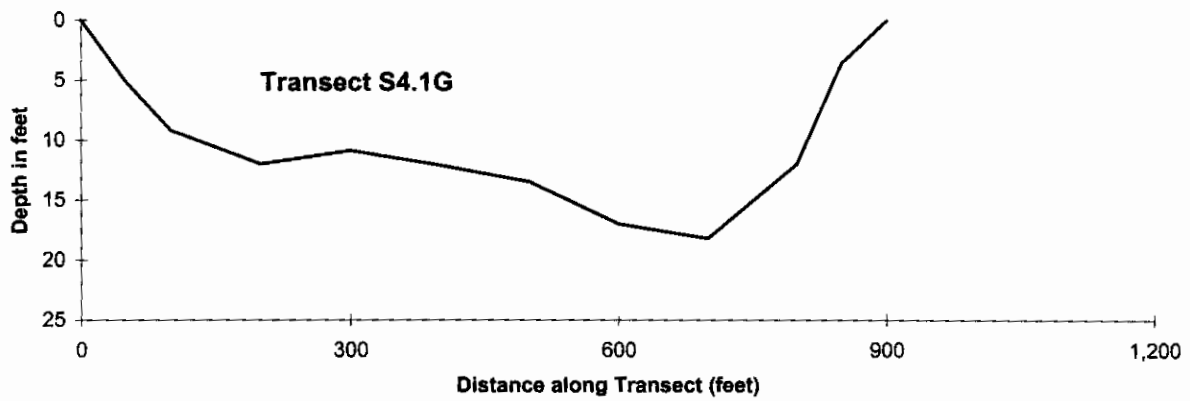
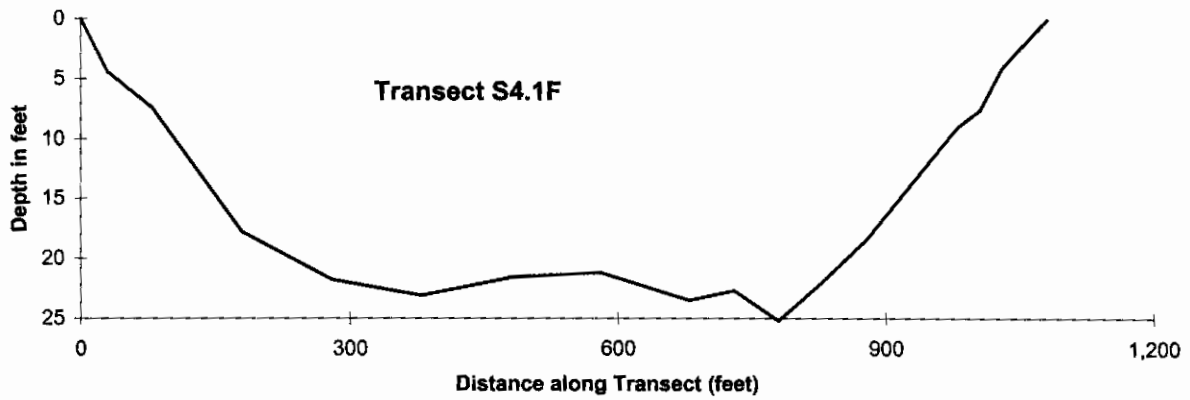
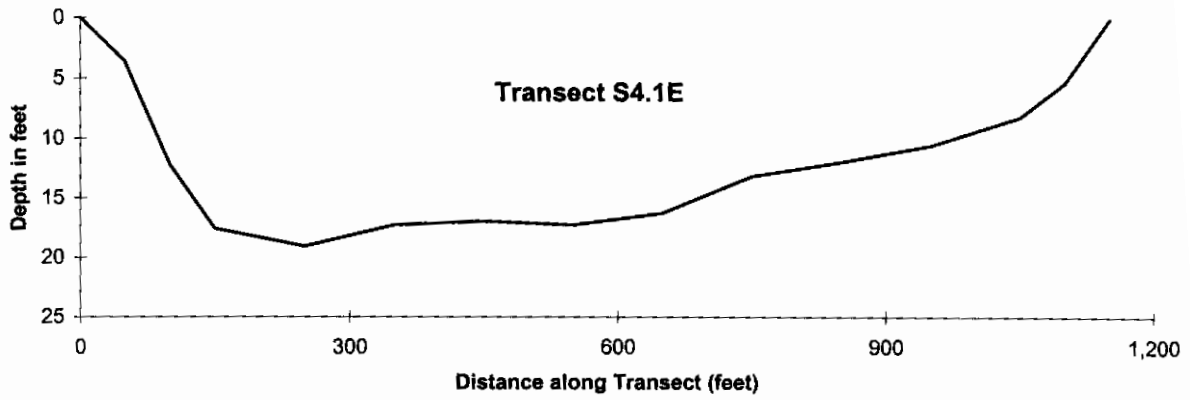
Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Jul 16-19, 1985	~24	Broad whitefish	?	
			Least cisco	?	
Fyke Net	Jul 17 95	23.7	Least cisco	3	217-318
			9spine stickleback	1,680	
Minnow Trap	Jul 17 95	48.3	9spine stickleback	1	
Set Line	Jul 17 95	23.8	None	0	
Gill Net	Aug 12 96	11.7	Broad whitefish	2	507-534
			Least cisco	3	235-316
			Round whitefish	4	304-421

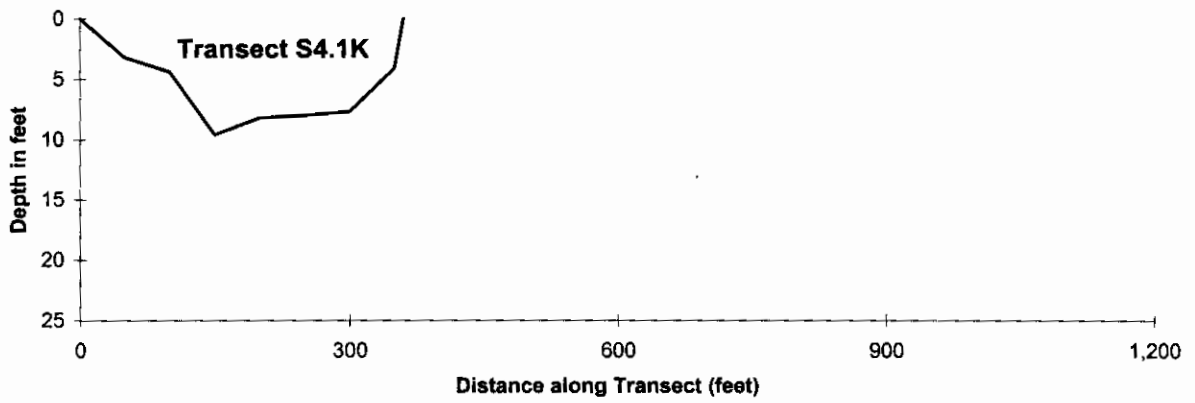
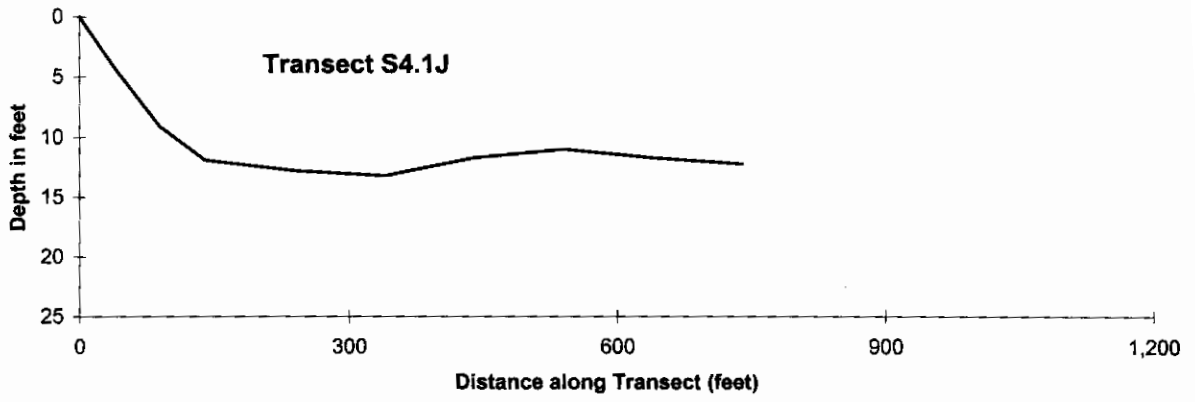
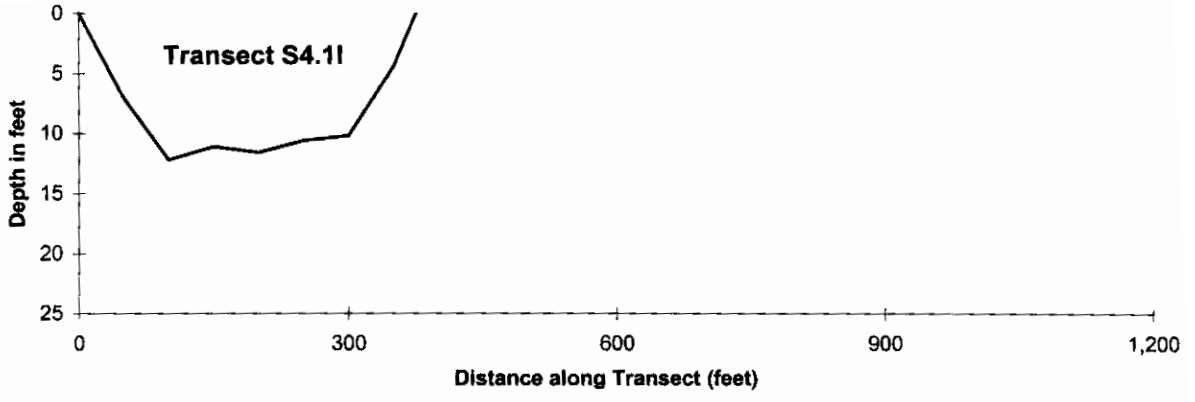
Source of 1985 data: Bendock and Burr 1986



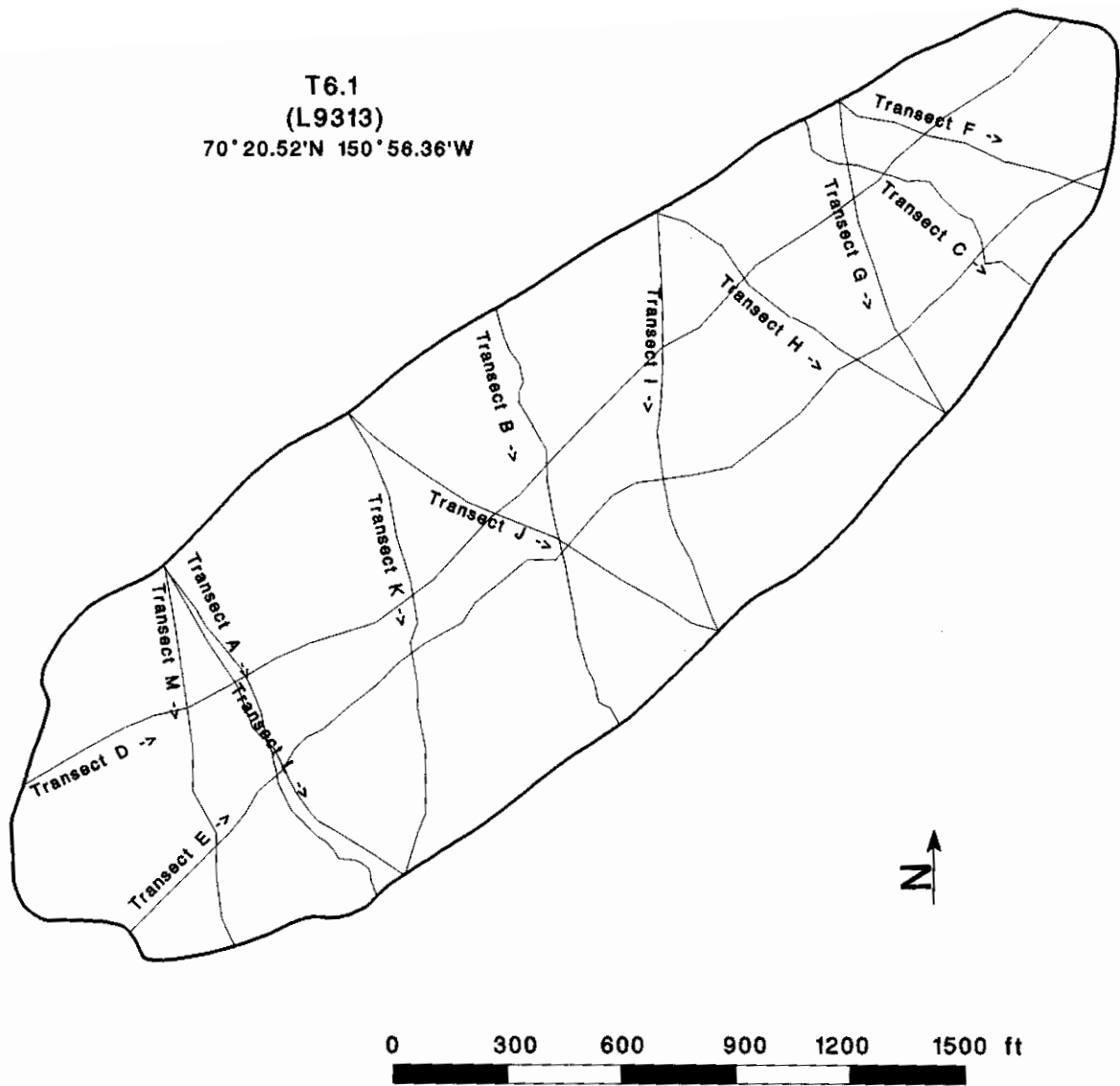






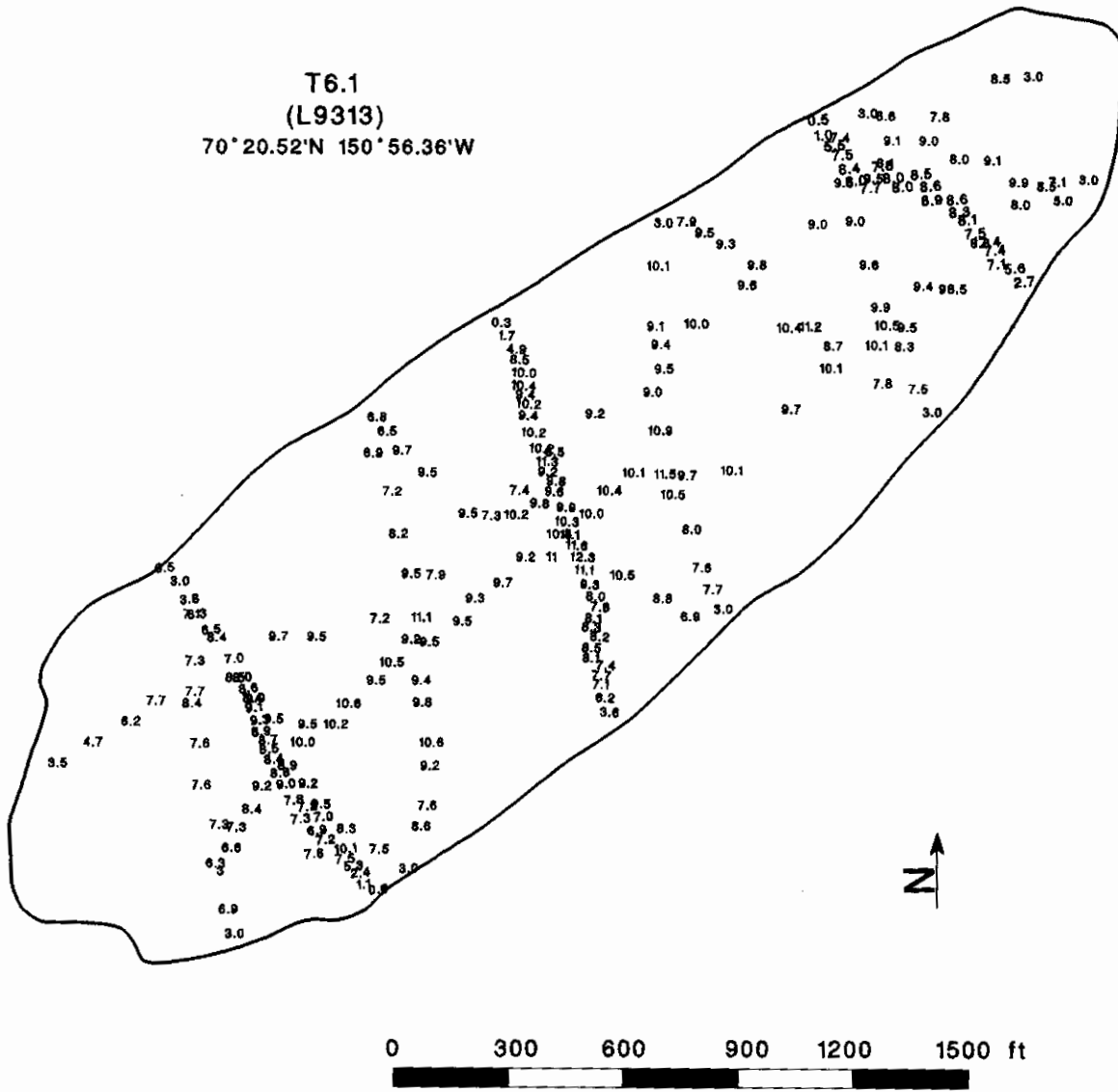


T6.1
(L9313)
70°20.52'N 150°56.36'W



Bathymetric transects surveyed on lake T6.1 (L9313), 1995-1998.

T6.1
(L9313)
70°20.52'N 150°56.36'W



Depths recorded on lake T6.1 (L9313), 1995-1998.

Lake T6.1

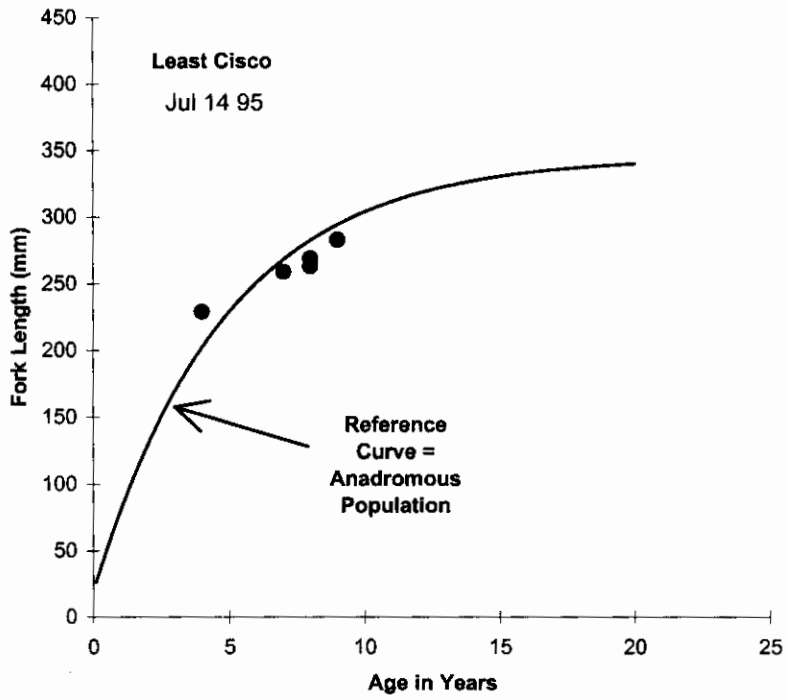
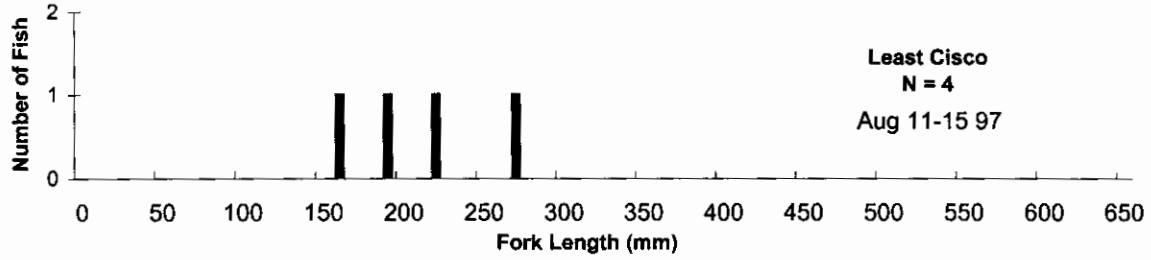
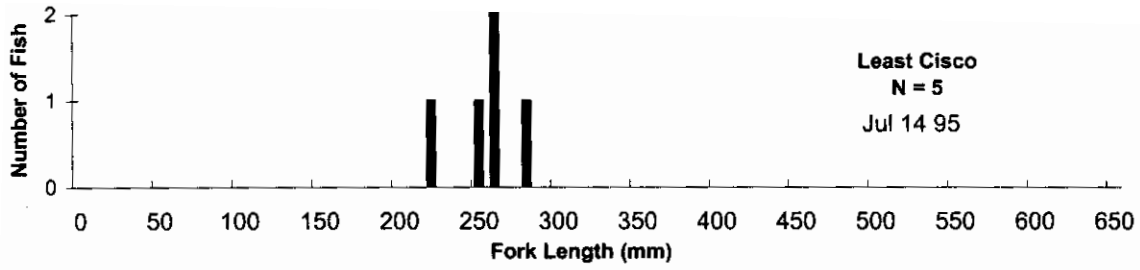
Other Names: L9313
Location: 70°20.52'N 150°56.36'W
USGS Quad Sheet: Harrison Bay B-2: T11N R5E, Sect 5
Habitat: Perched Lake (Infrequent Flooding)
Area: 69 acres
Maximum Depth: 12.3 feet
Active Outlet: No
Spec. Conductance: 107 µS/cm
pH: 7.7
Calculated Volume: 184.6 million gallons (based on depth contours)
Permittable Volume: 6.7 million gallons

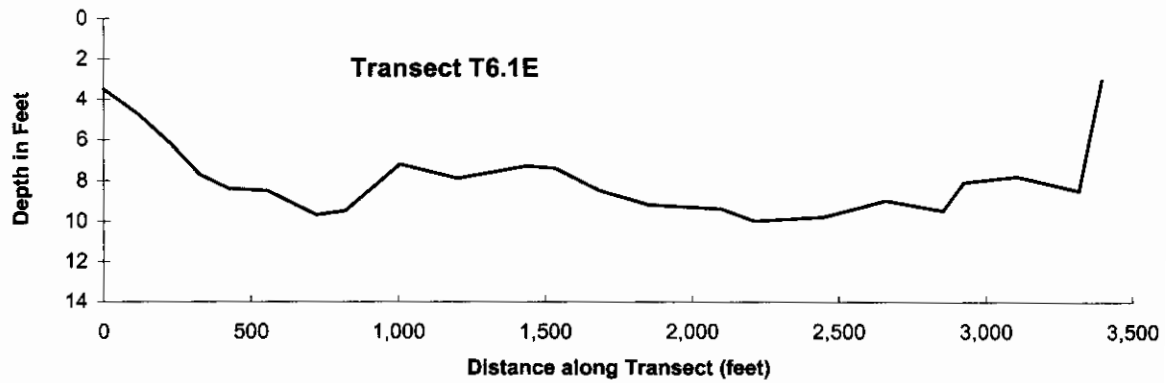
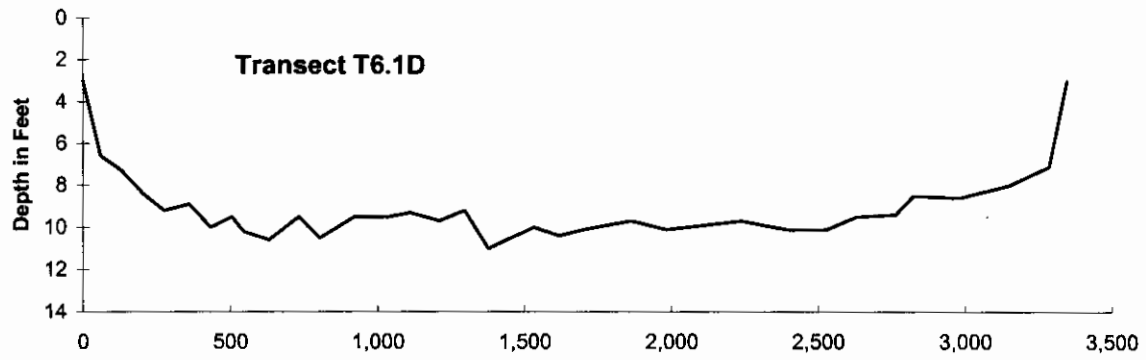
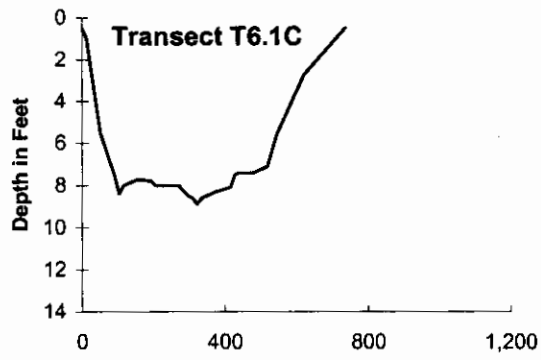
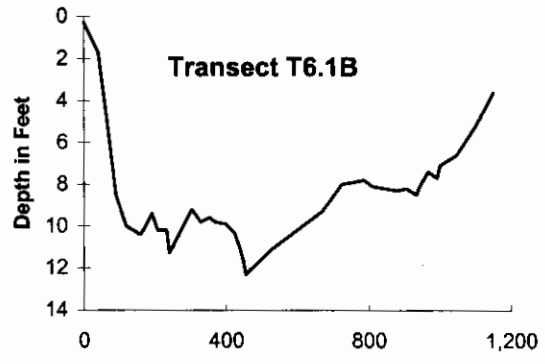
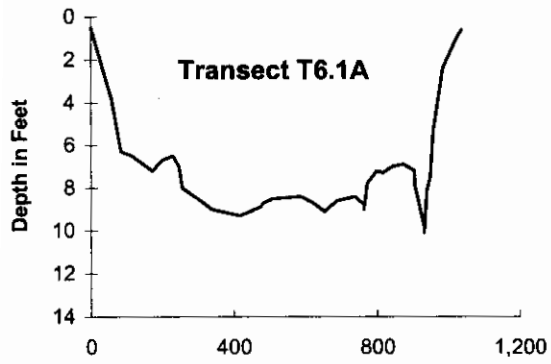
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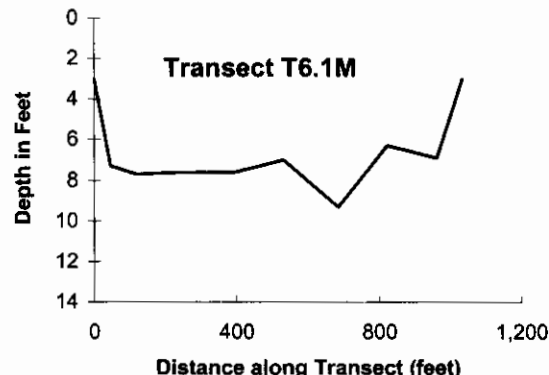
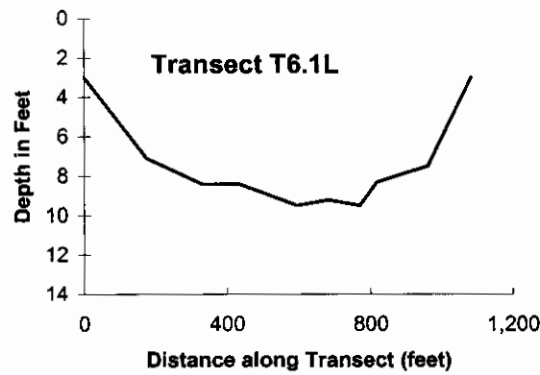
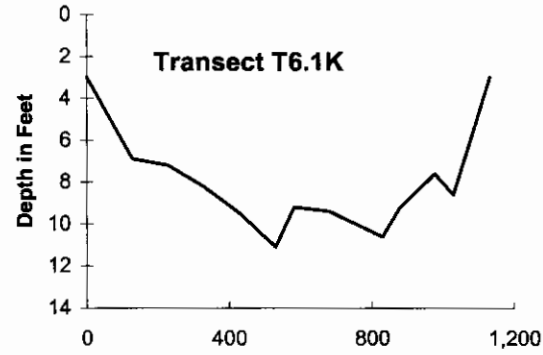
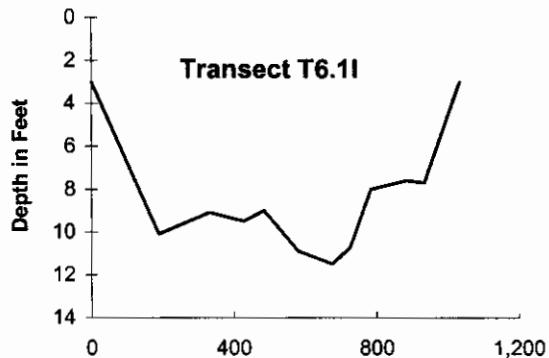
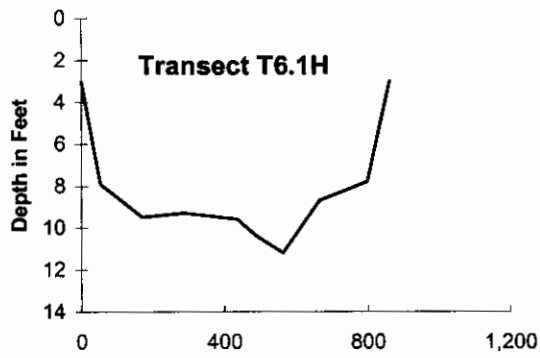
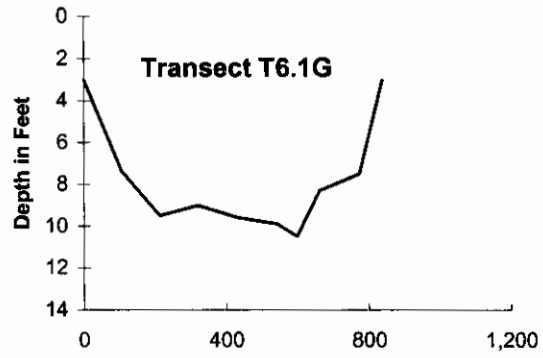
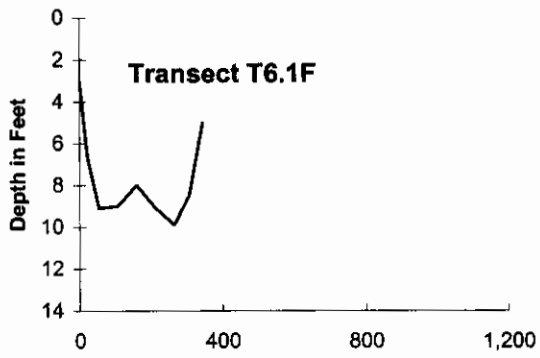
Year of Test	Chloride (mg/l)	Sodium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Total Hardness [CaCO3] (mg/l)	Total Dissolved Solids (mg/l)	Source
1993	19	9.3	3.1	8	33	54	J. Lobdell

Catch Record:

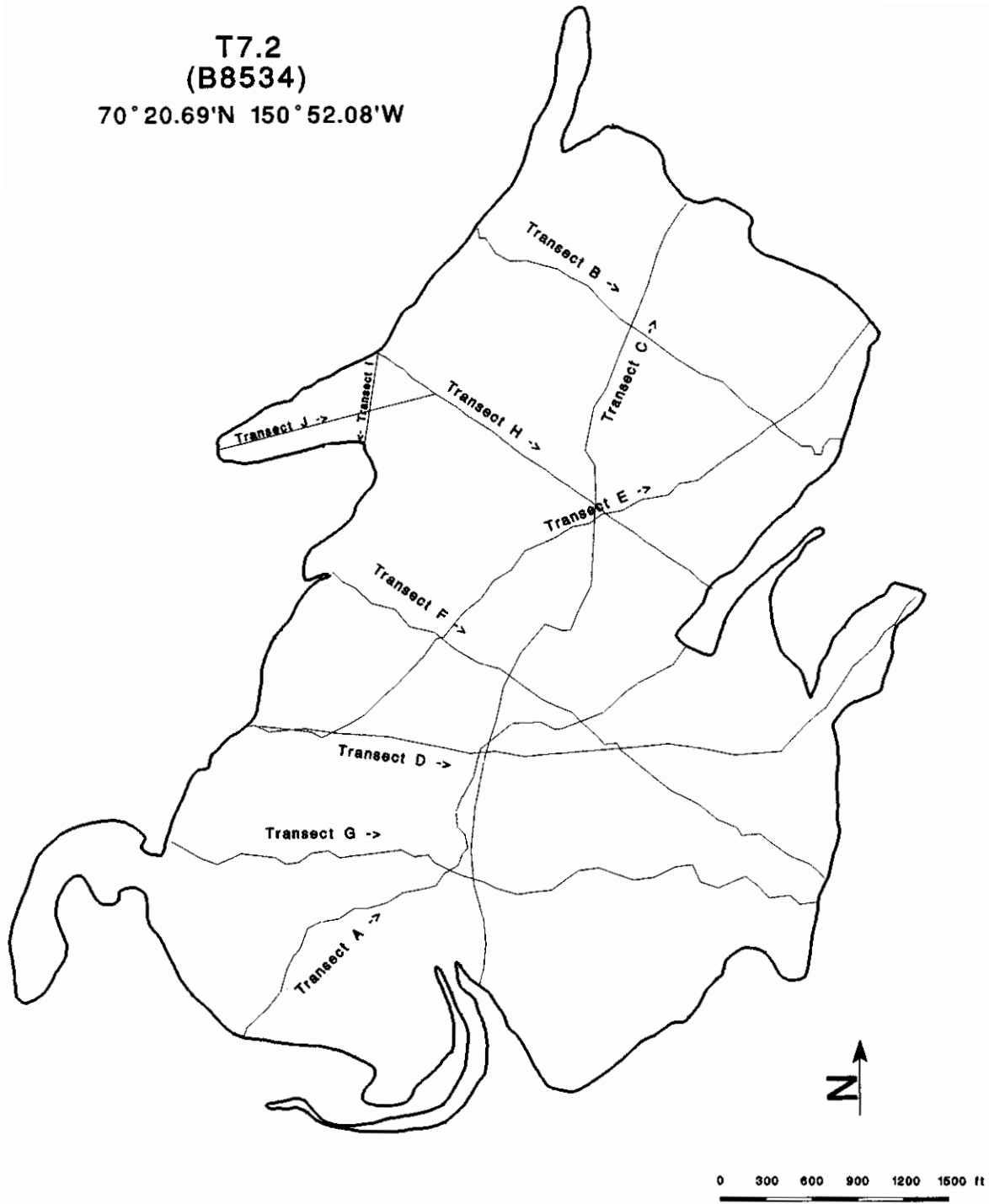
Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Fyke Net	Jul 14 95	23.3	Least cisco	5	229-283
			Alaska blackfish	6	42-90
			9spine stickleback	63	
Fyke Net	Jul 26 95	20.7	9spine stickleback	9	
Minnow Trap	Jul 15 95	43.2	9spine stickleback	9	
Set Line	Jul 15 95	21.6	None	0	
Set Line	Jul 16 95	24.3	None	0	
Gill Net	Nov 1 95	20.6	None	0	
Gill Net	Aug 8 96	9.1	None	0	
Fyke Net	Aug 11-15 97	91.2	Least cisco	4	167-276
			Alaska blackfish	12	79
			Slimy sculpin	1	





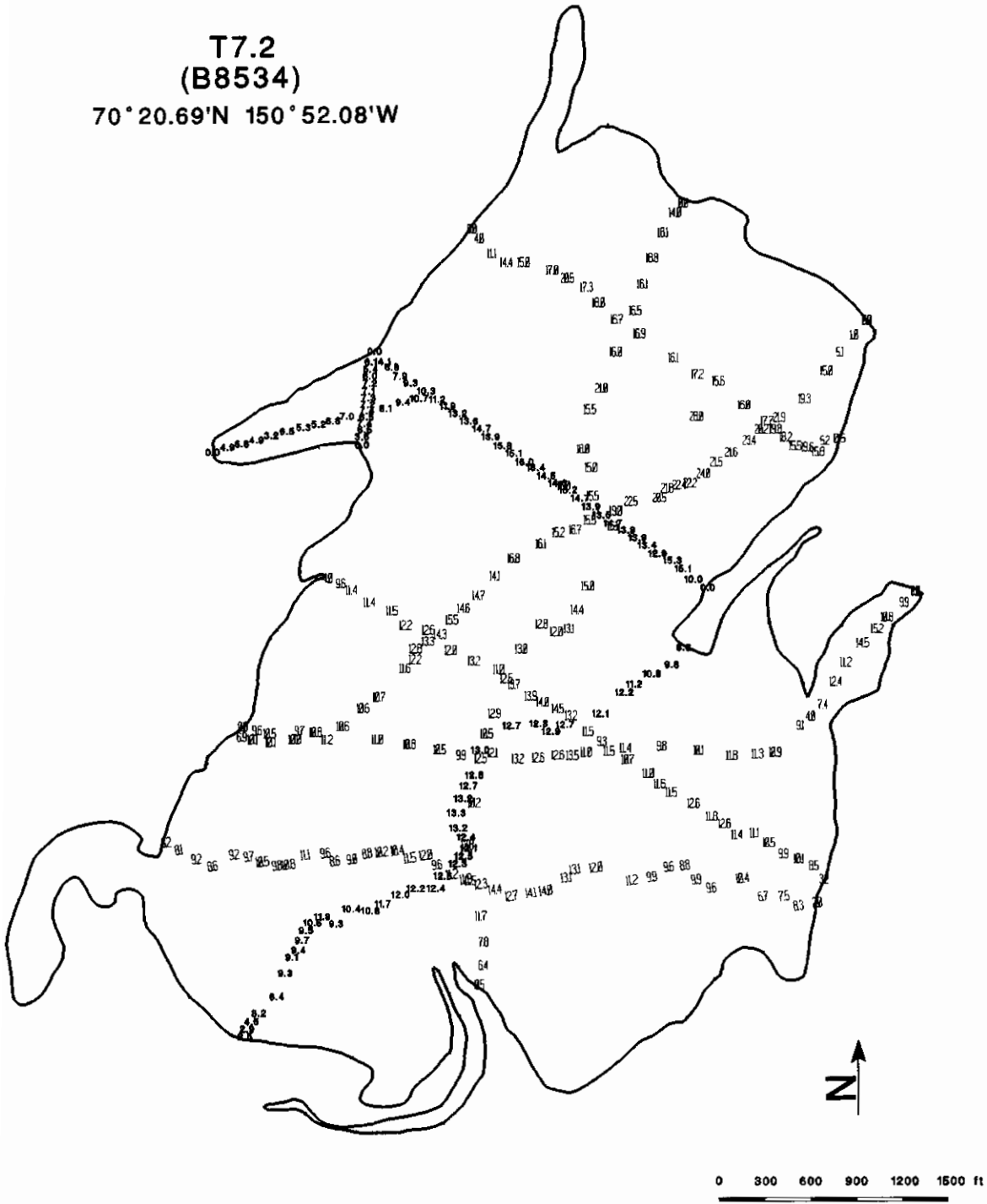


T7.2
(B8534)
70°20.69'N 150°52.08'W

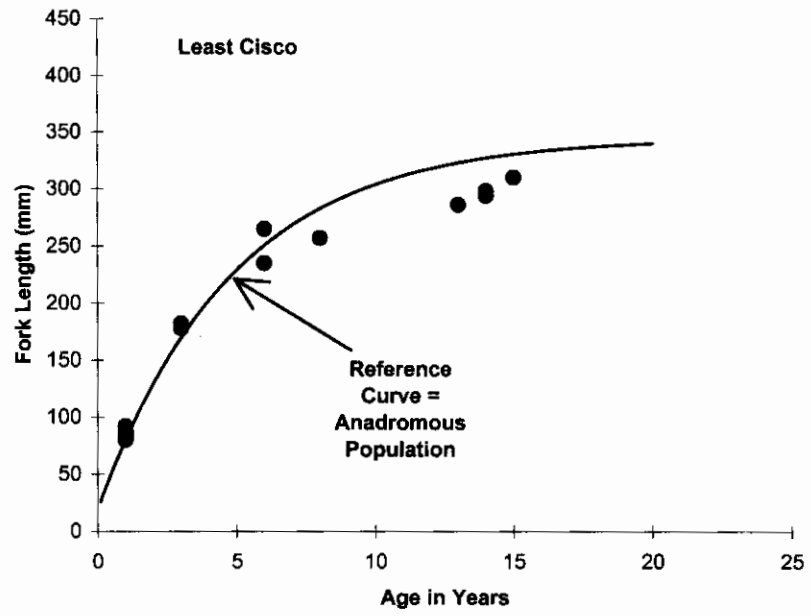
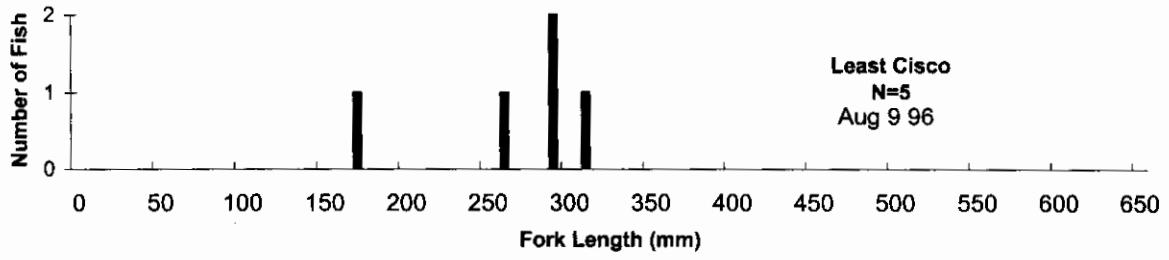


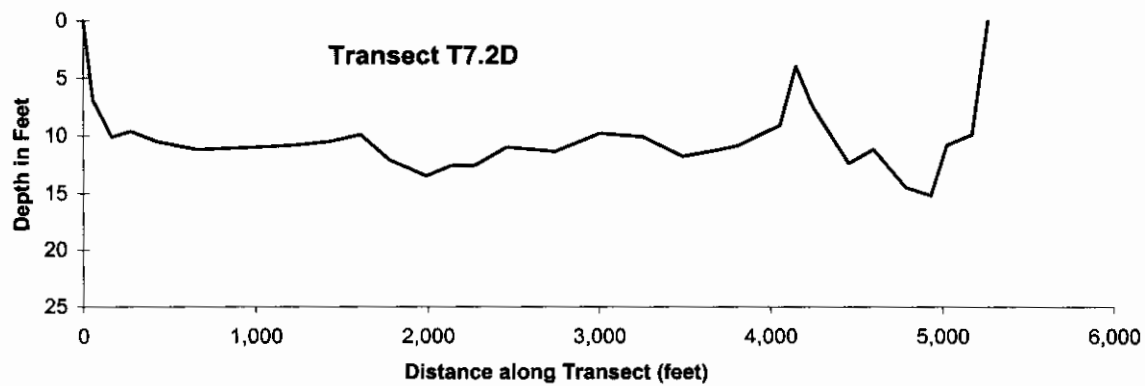
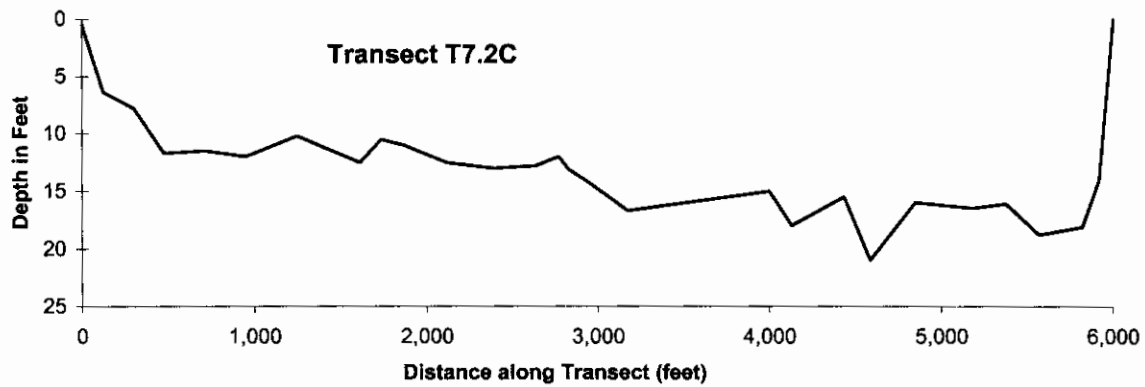
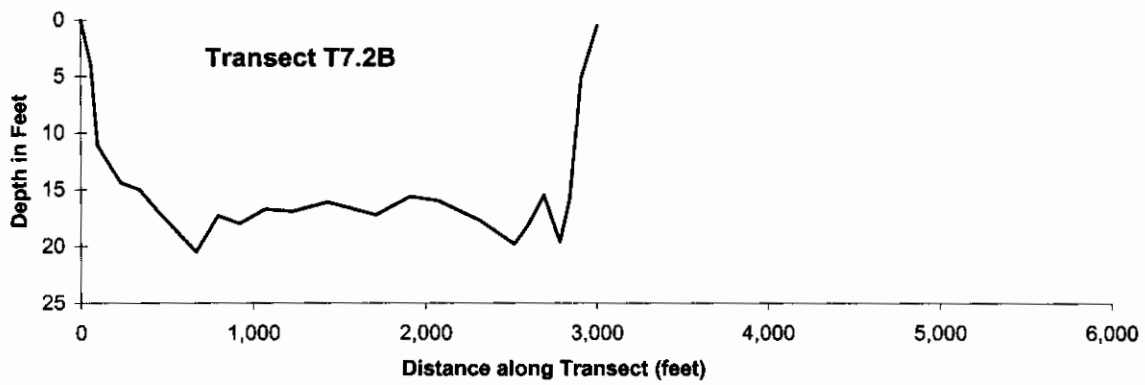
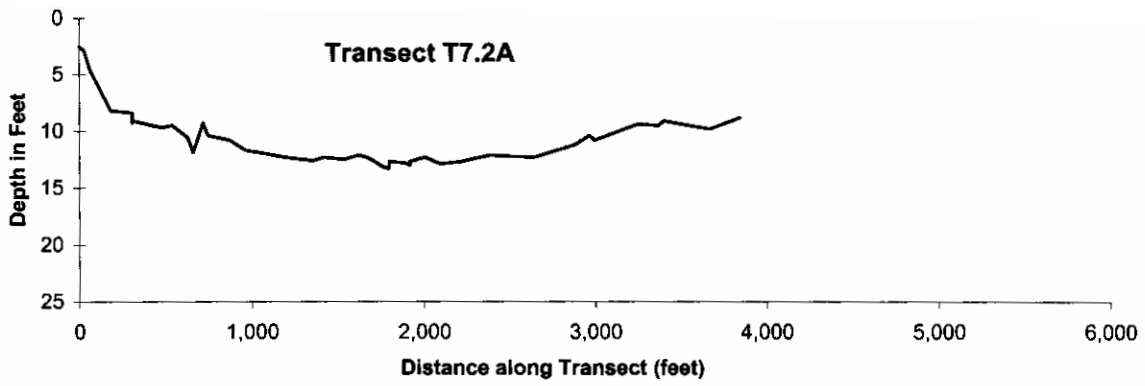
Bathymetric transects surveyed on lake T7.2 (B8534), 1995-1998.

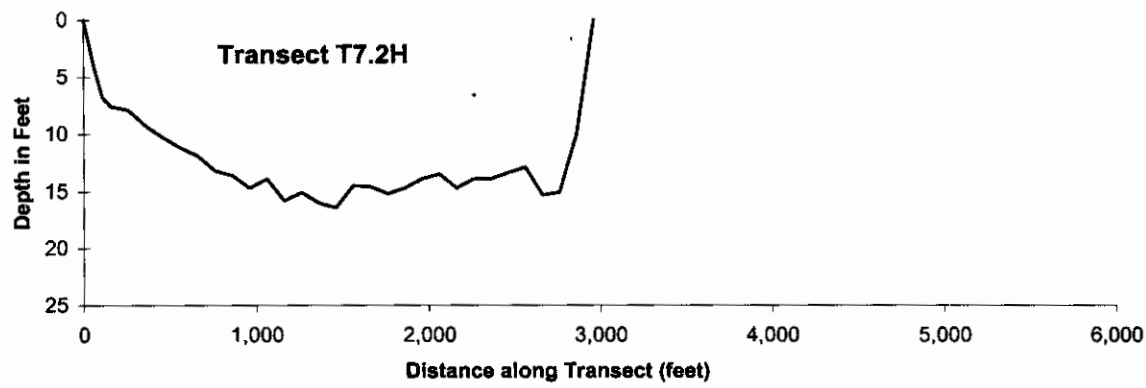
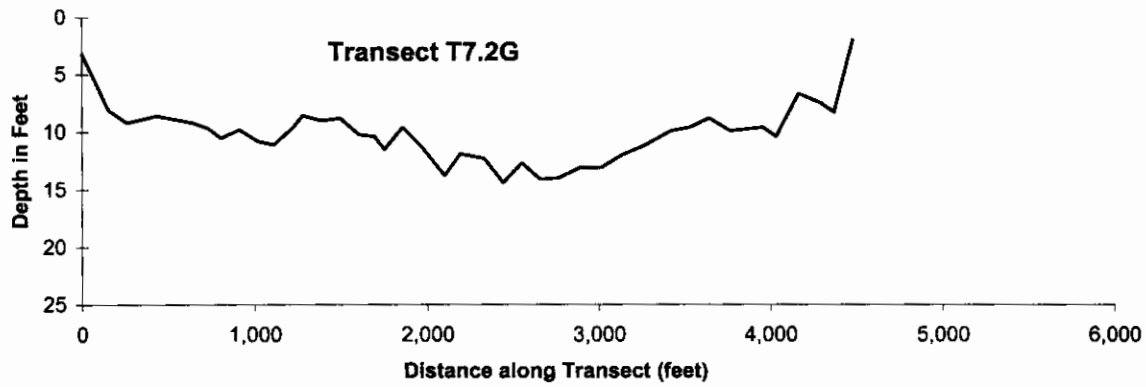
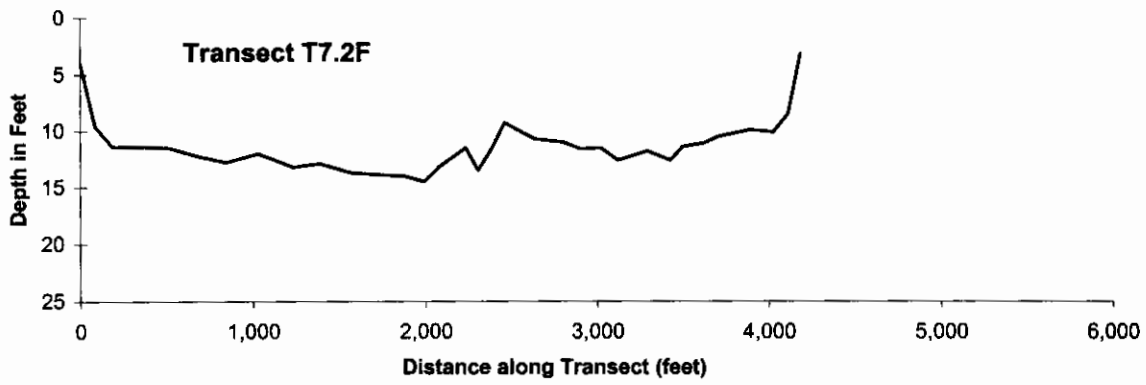
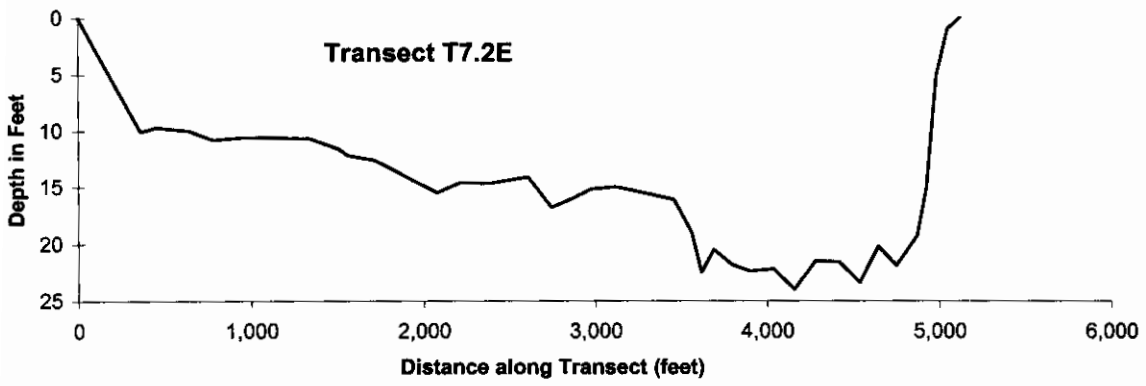
T7.2
(B8534)
70°20.69'N 150°52.08'W

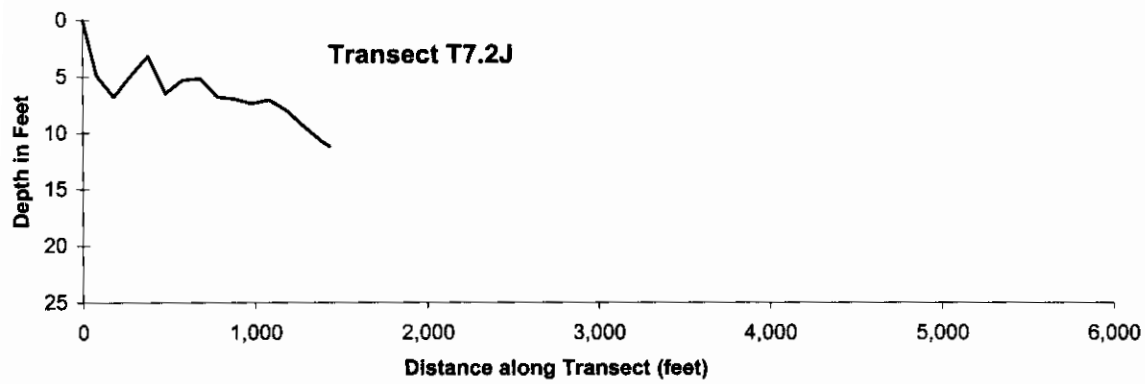
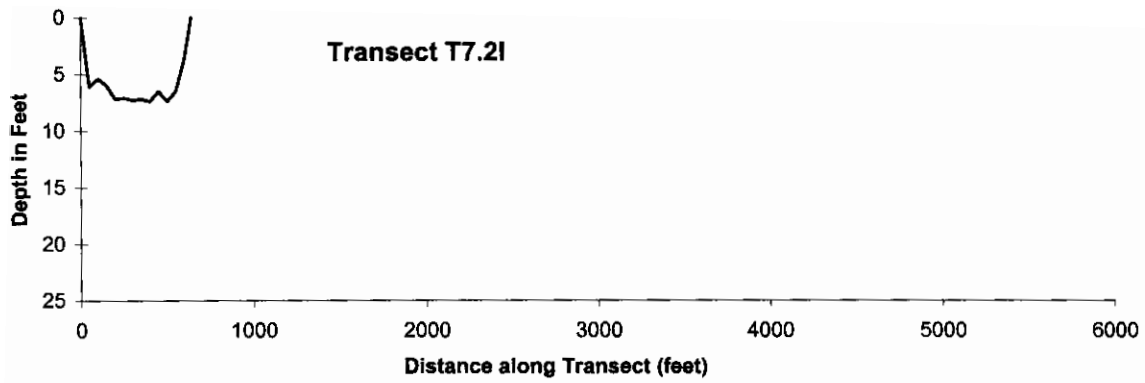


Depths recorded on lake T7.2 (B8534), 1995-1998.

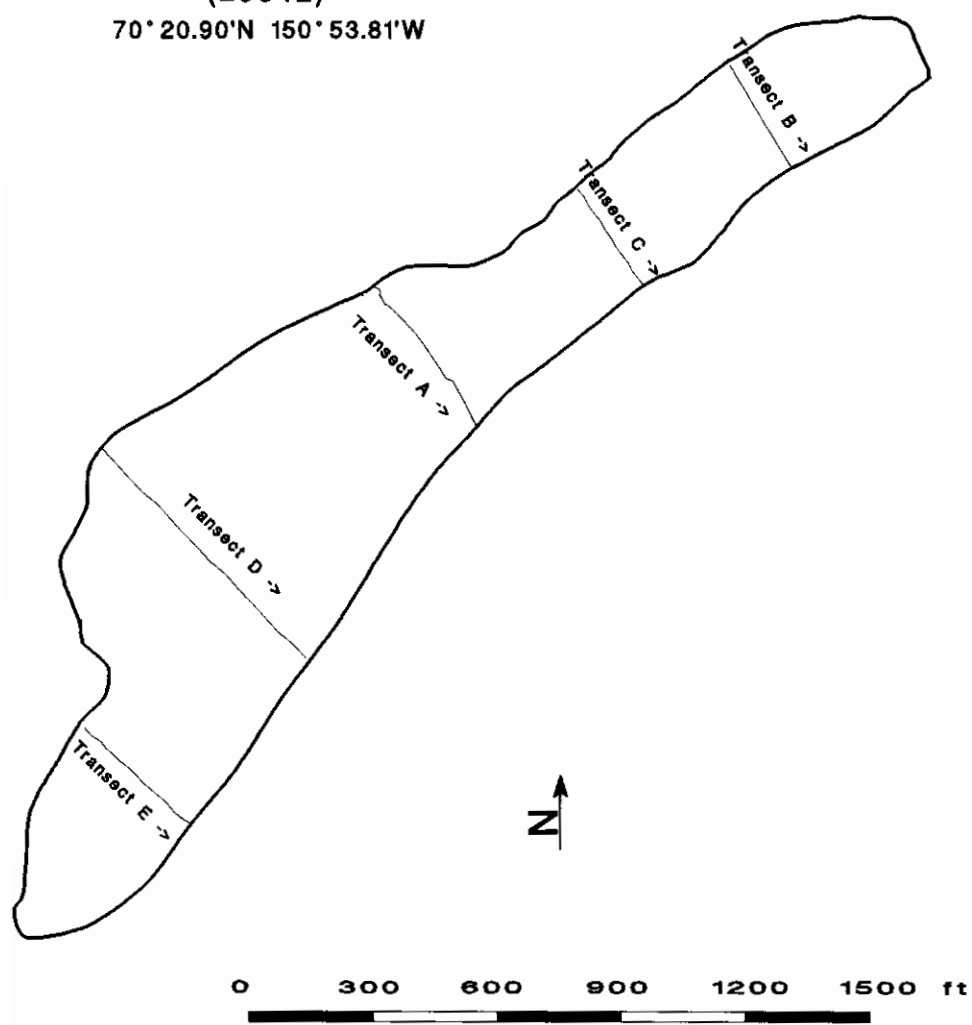






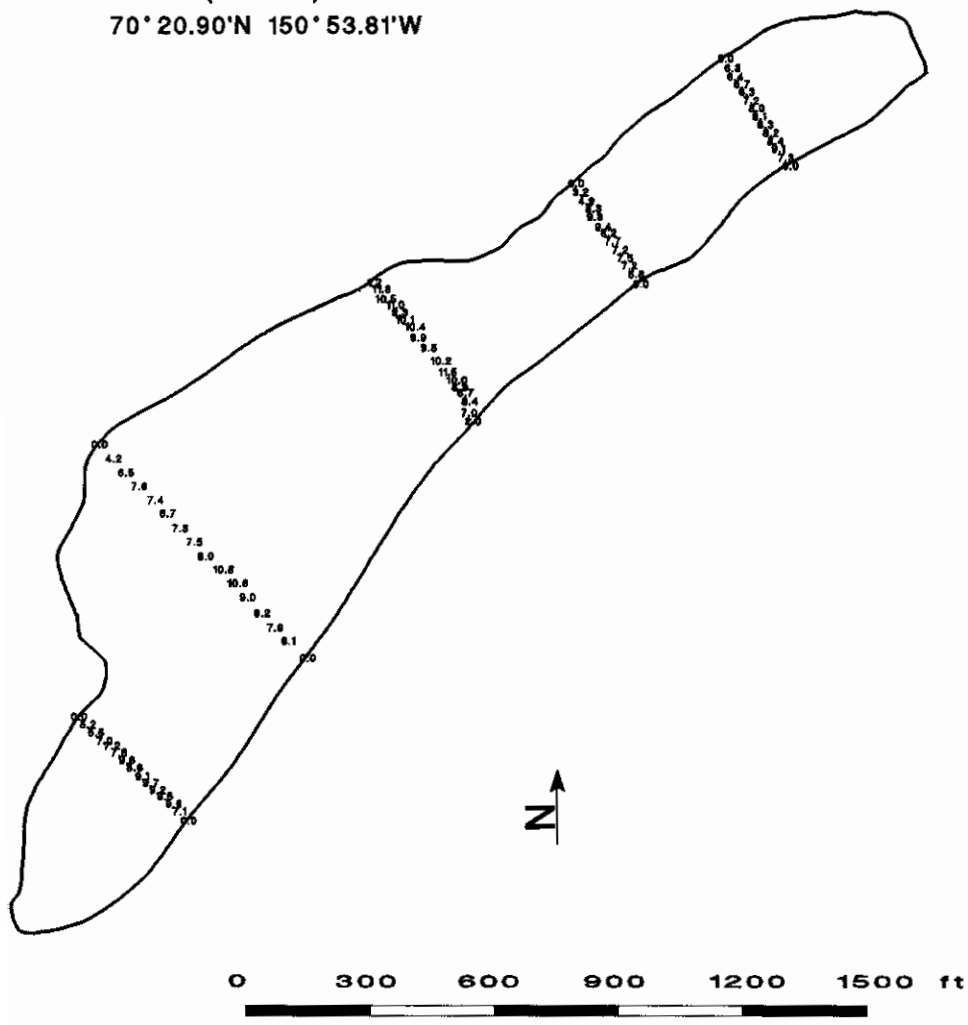


T7.3
(L9342)
70° 20.90'N 150° 53.81'W



Bathymetric transects surveyed on lake T7.3 (L9342), 1995-1998.

T7.3
(L9342)
70° 20.90'N 150° 53.81'W



Depths recorded on lake T7.3 (L9342), 1995-1998.

Lake T7.3

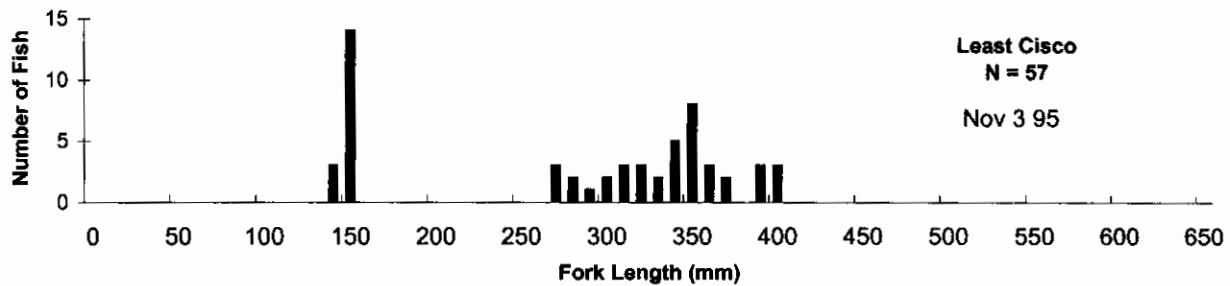
Other Names: L9342
Location: 70°20.90'N 150°53.81'W
USGS Quad Sheet: Harrison Bay B-2: T12N R5E, Sect 33
Habitat: Perched Lake (Infrequent Flooding)
Area: 25 acres
Maximum Depth: 11.8 feet
Active Outlet: No
Spec. Conductance: 84 µS/cm
Calculated Volume: 67.2 million gallons
Permittable Volume: 2.0 million gallons

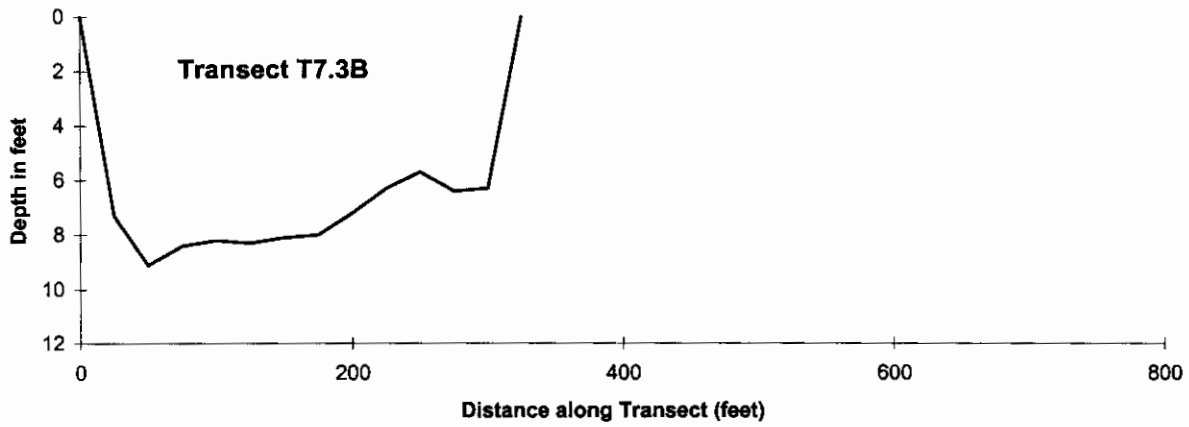
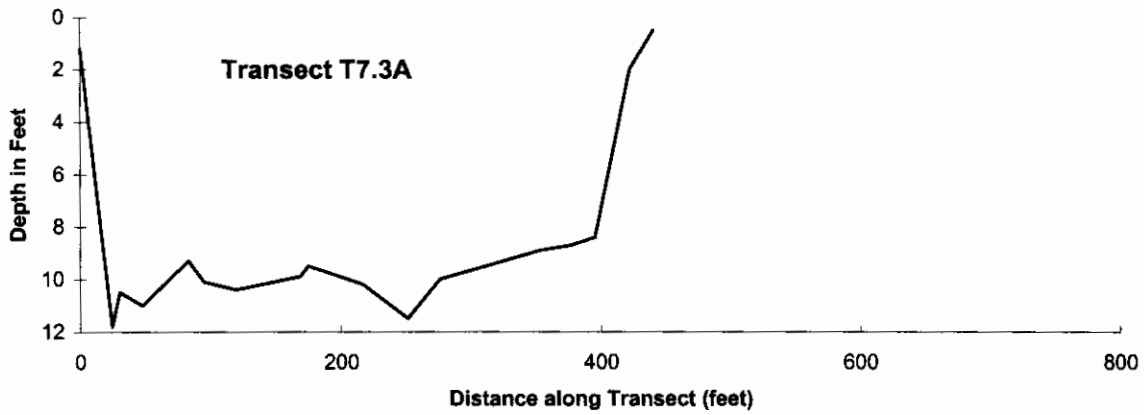
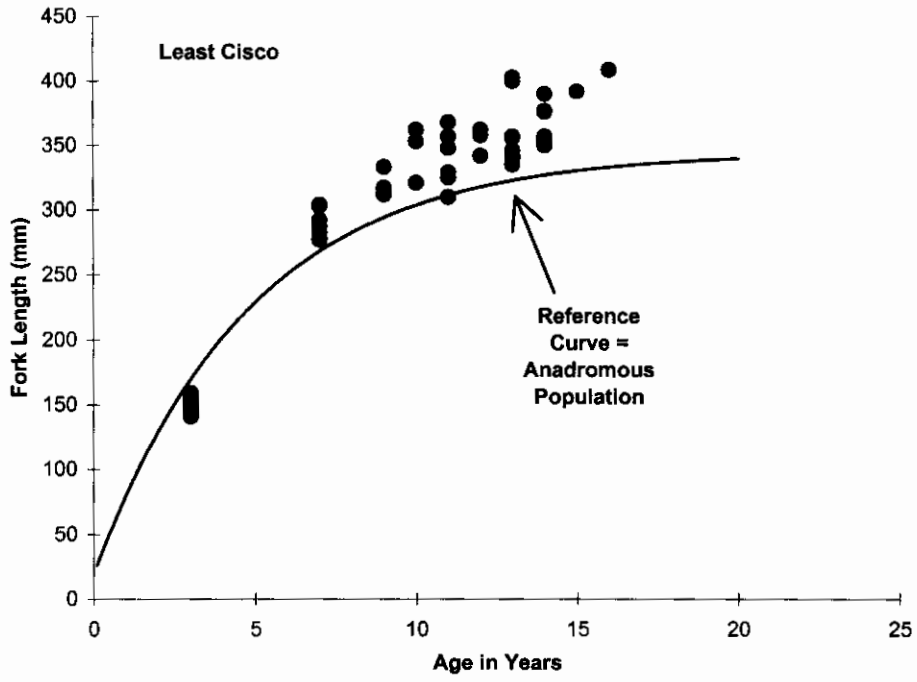
Water Quality:

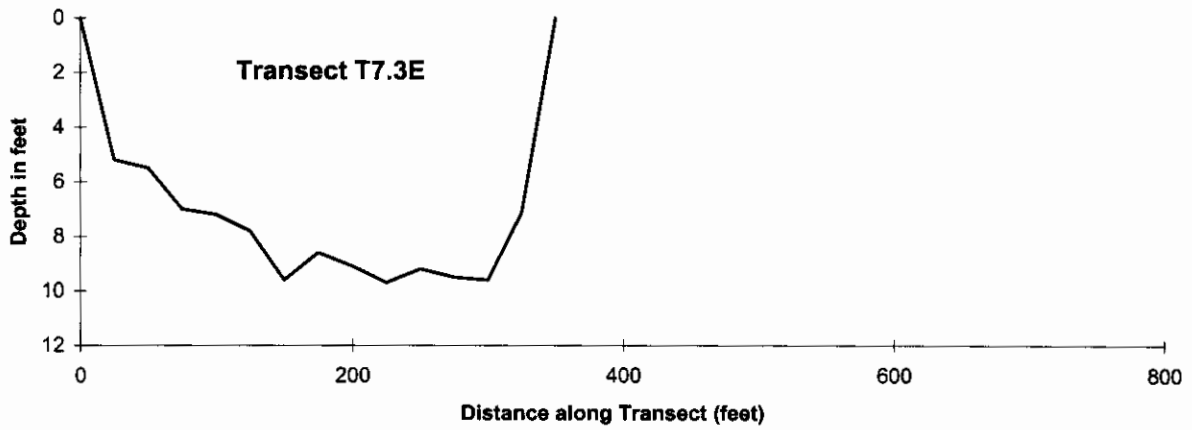
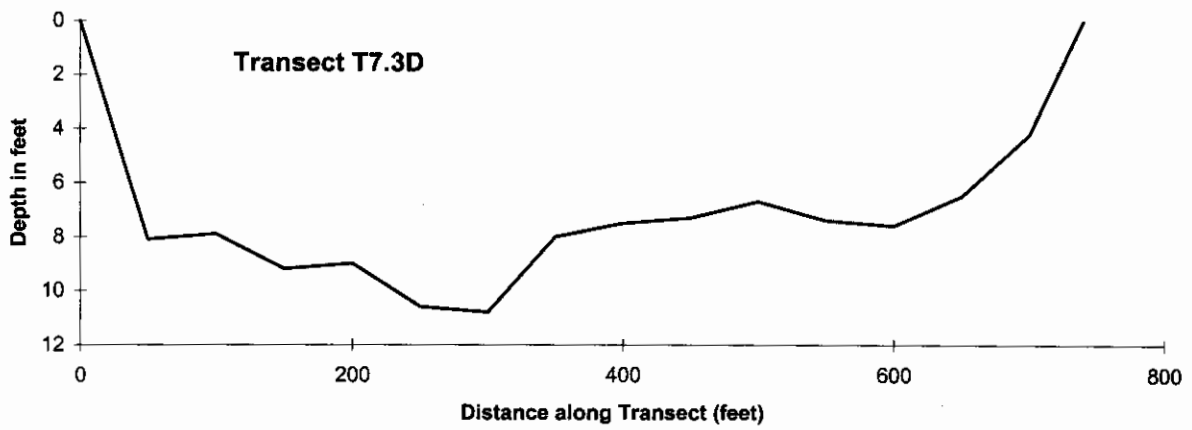
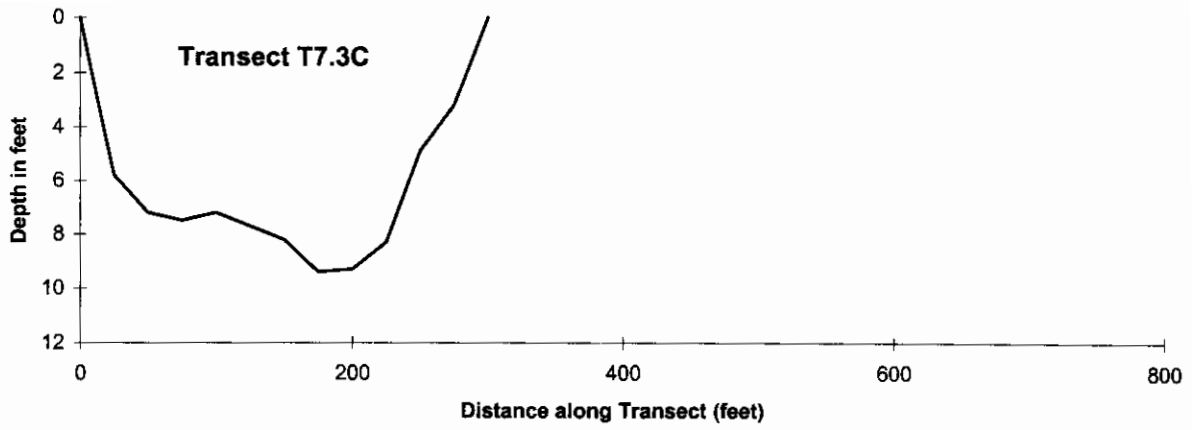
Year of Test	Chloride (mg/l)	Sodium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Total Hardness [CaCO3] (mg/l)	Total Dissolved Solids (mg/l)	Source
1993	14	5.3	3.2	7.4	32	87	J. Lobdell

Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Fyke Net	Jul 12 95	19.9	None	0	
Fyke Net	Jul 13 95	23.2	9spine stickleback	860	
Fyke Net	Jul 24 95	18.5	Least cisco 9spine stickleback	1 68	141
Minnow Trap	Jul 18 95	41.2	9spine stickleback	6	
Set Line	Jul 18 95	19.9	None	0	
Gill Net	Nov 3 95	23.7	Least cisco Alaska blackfish	57 1	277-409

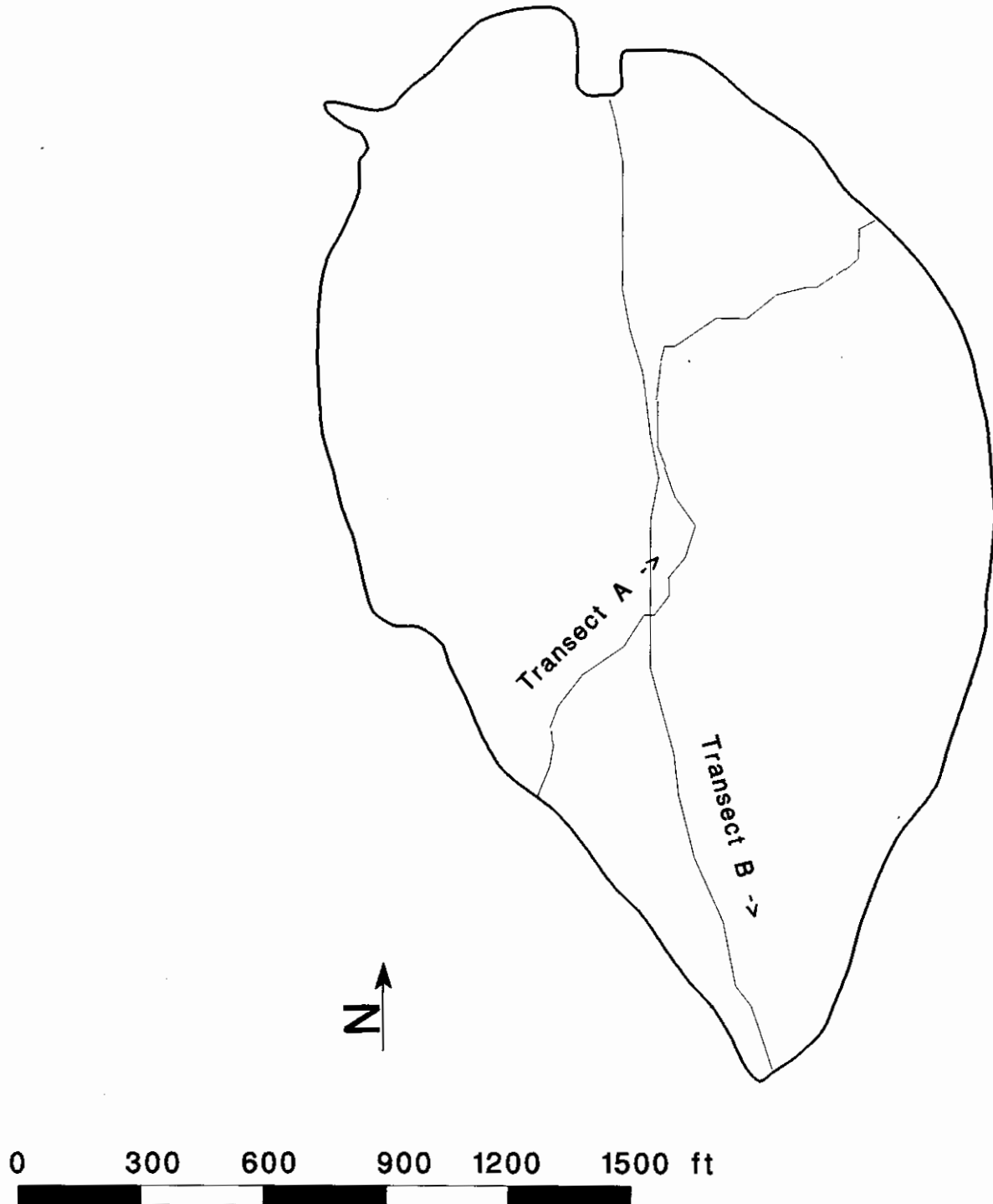






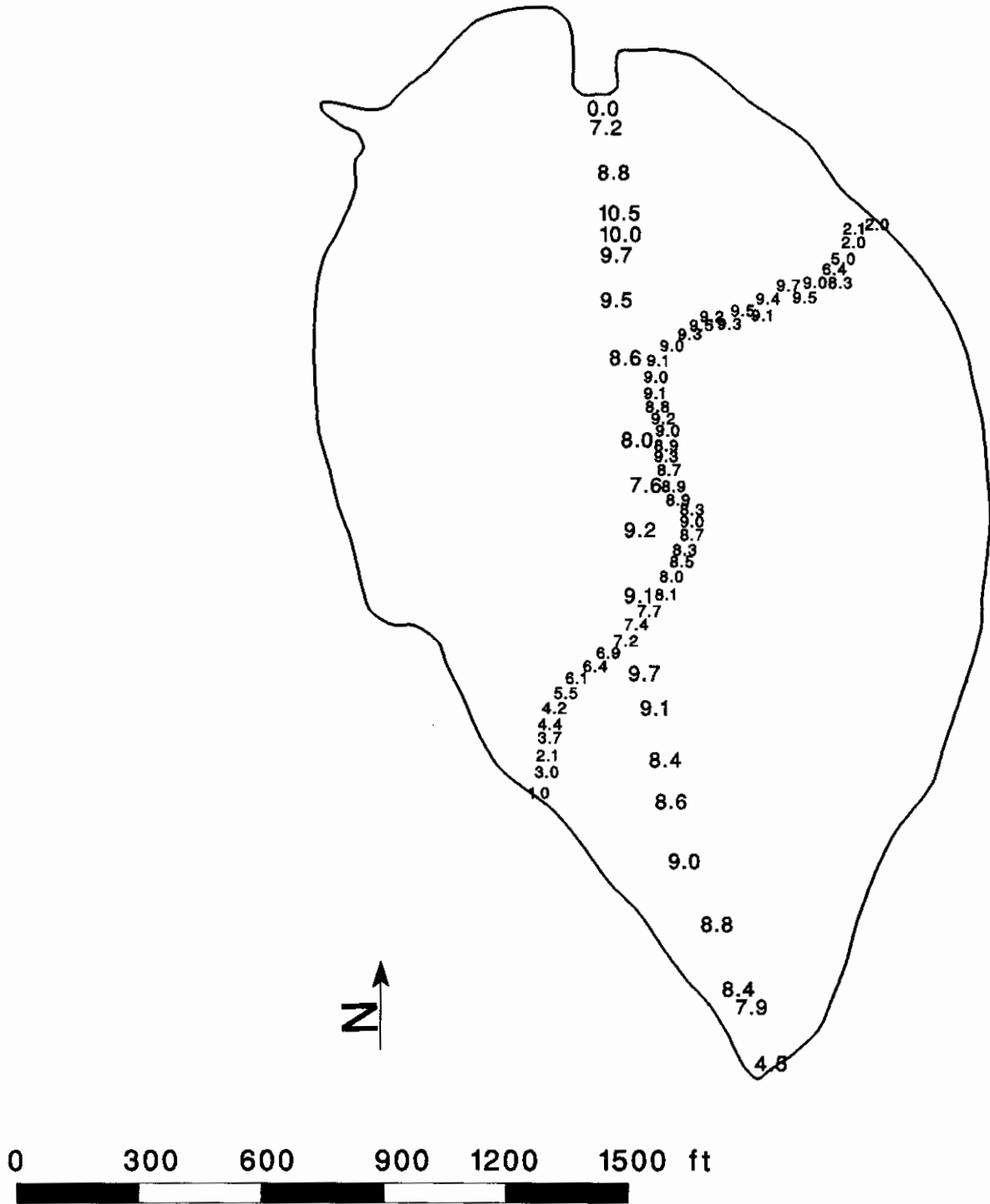
**T8.1
(L9283)**

70° 20.42'N 150° 50.45'W



Bathymetric transects surveyed on lake T8.1 (L9283), 1995-1998.

T8.1
(L9283)
70° 20.42'N 150° 50.45'W



Depths recorded on lake T8.1 (L9283), 1995-1998.

Lake T8.1

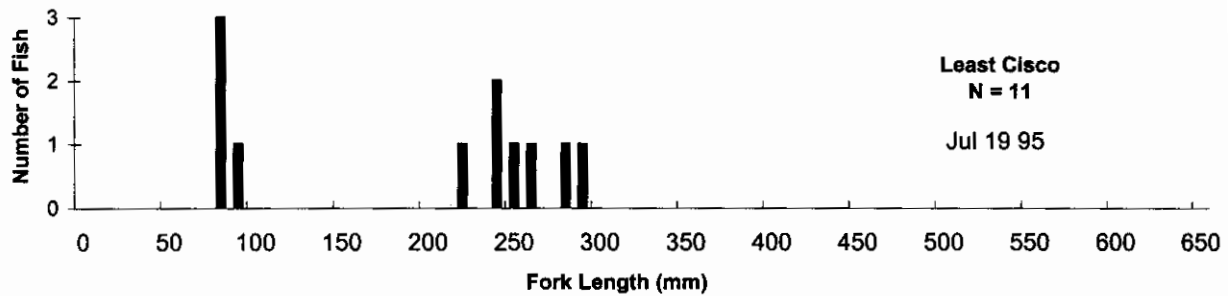
Other Names: L9283
Location: 70°20.42'N 150°50.45'W
USGS Quad Sheet: Harrison Bay B-2: T11N R5E, Sect 3
Habitat: Perched Lake (Frequent Flooding)
Area: 74 acres
Maximum Depth: 9.5 feet
Active Outlet: No
Spec. Conductance: 234 μ S/cm
Calculated Volume: 200.8 million gallons
Permittable Volume: 6.9 million gallons

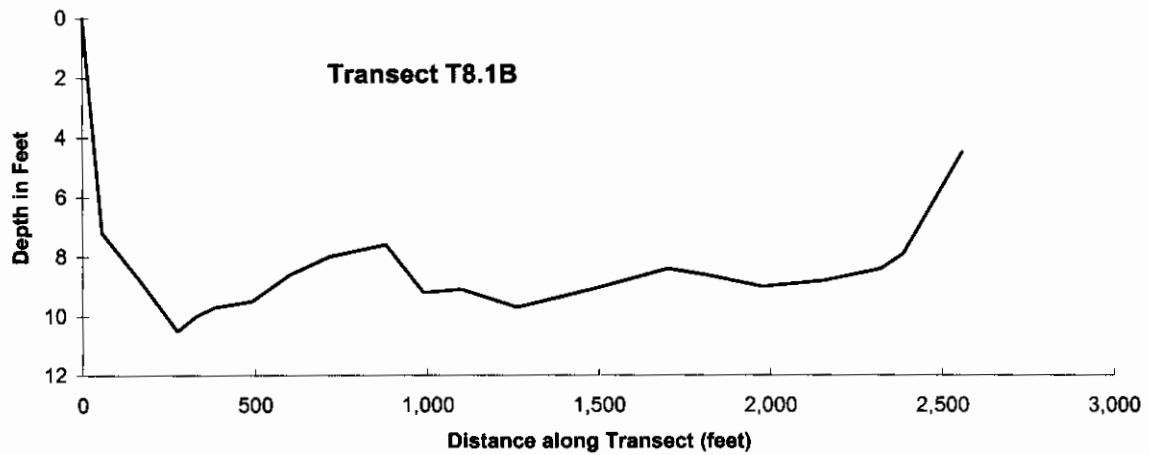
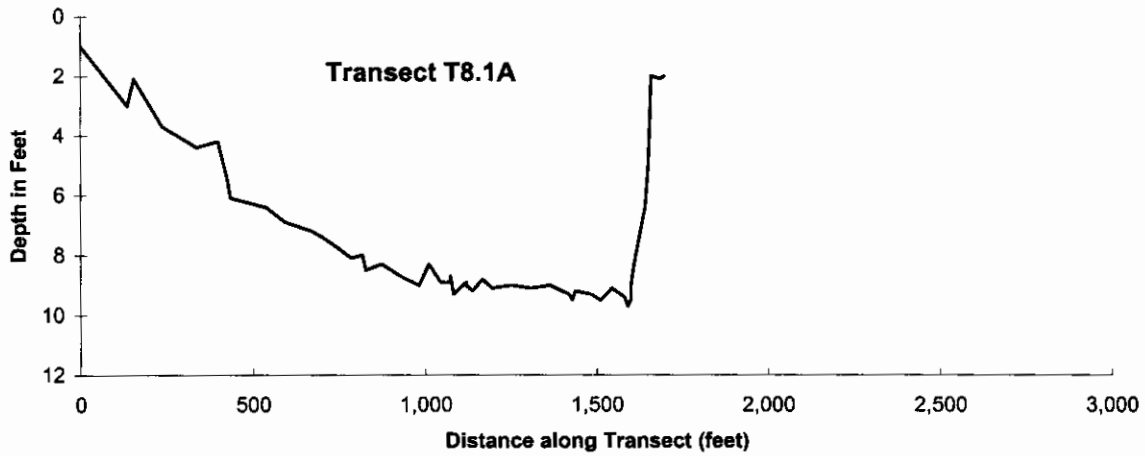
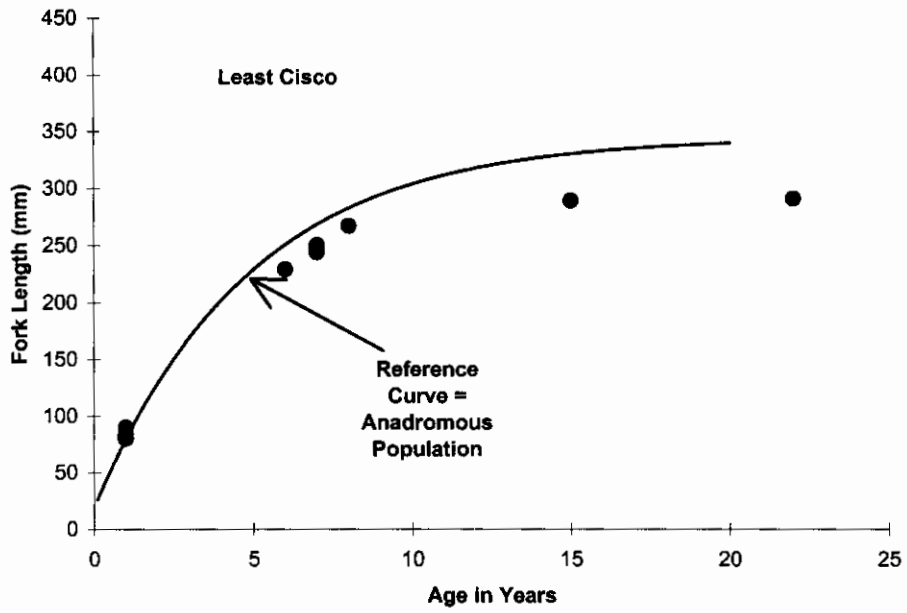
Water Quality:

Year of Test	Chloride (mg/l)	Sodium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
1992	2.8	1.8	3.2	29	86	110	J. Lobdell

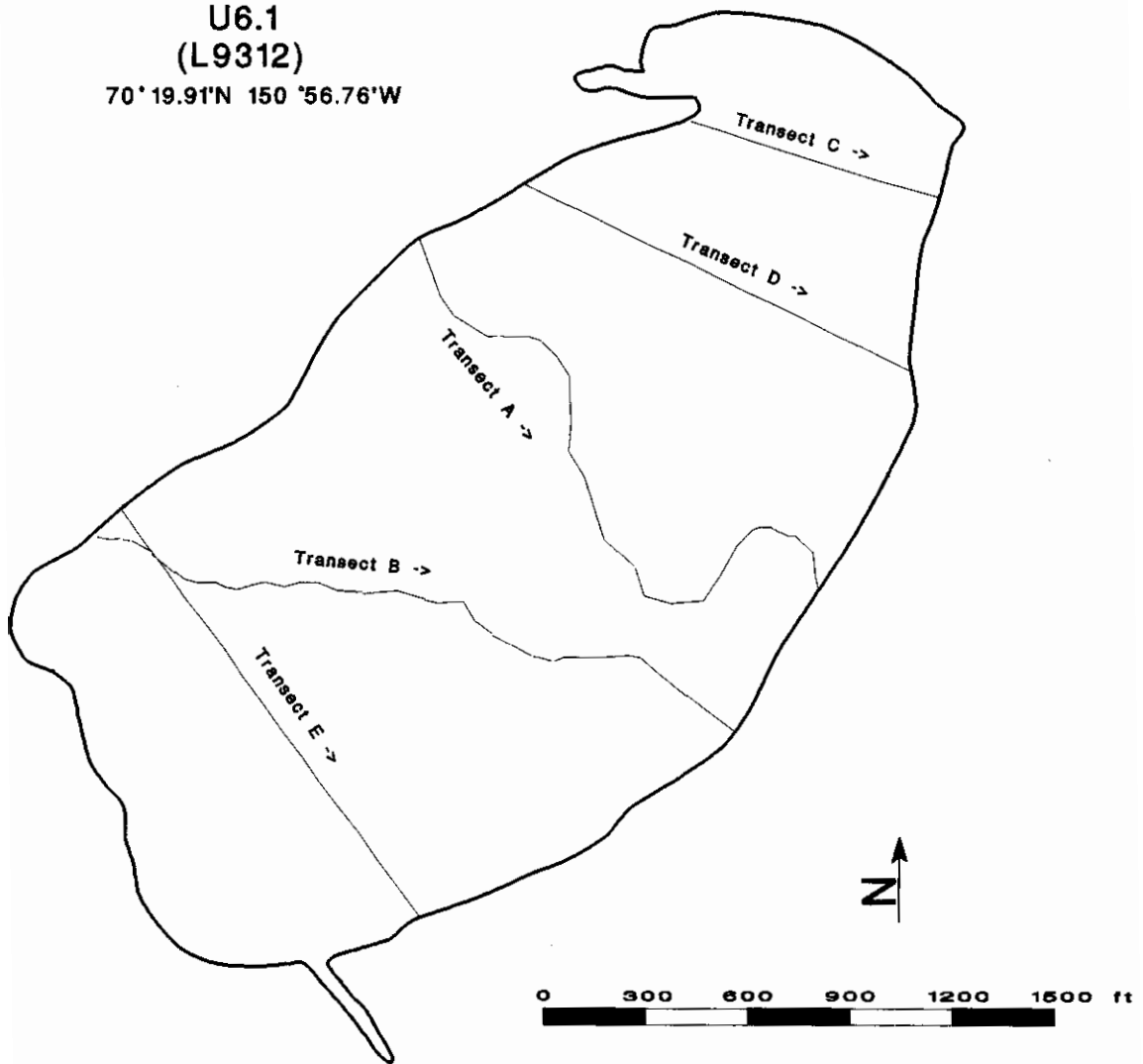
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Fyke Net	Jul 19 95	20.9	Least cisco	11	80-291
			Alaska blackfish	2	
Minnow Trap	Jul 19 95	41.6	9spine stickleback	45	
Set Line	Jul 19 95	20.8	None	0	



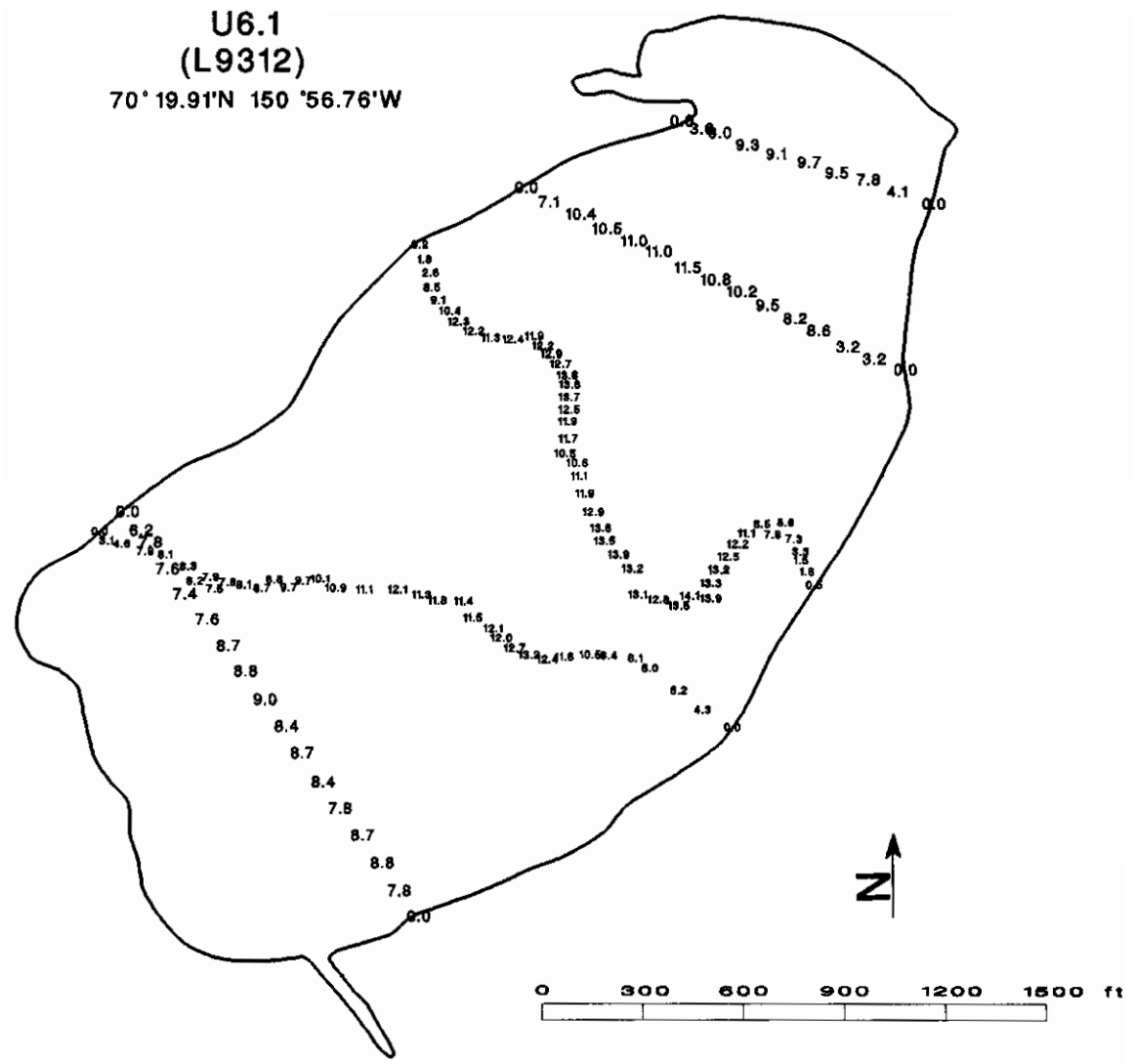


U6.1
(L9312)
70°19.91'N 150°56.76'W



Bathymetric transects surveyed on lake U6.1 (L9312), 1995-1998.

U6.1
(L9312)
70° 19.91'N 150° 56.76'W



Depths recorded on lake U6.1 (L9312), 1995-1998.

Lake U6.1

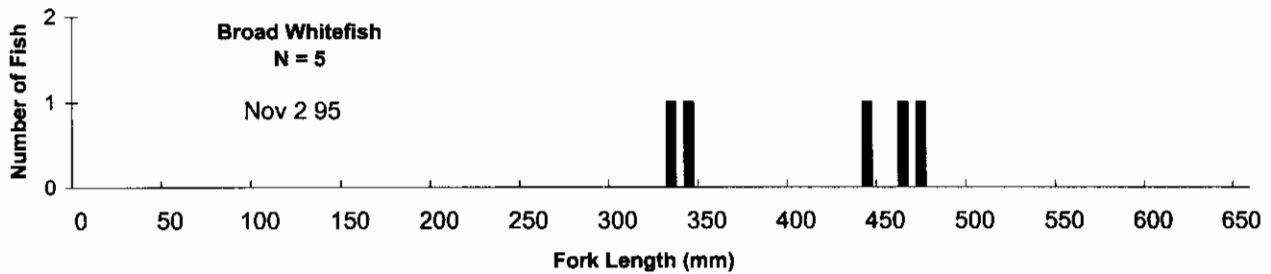
Other Names: L9312
Location: 70°19.91'N 150°56.76'W
USGS Quad Sheet: Harrison Bay B-2: T11N R5E, Sect 5
Habitat: Perched Lake (Infrequent Flooding)
Area: 100 acres
Maximum Depth: 14.1 feet
Active Outlet: No
Spec. Conductance: 60 μ S/cm
pH: 7.7-8.2
Calculated Volume: 298.0 million gallons
Permittable Volume: 14.2 million gallons

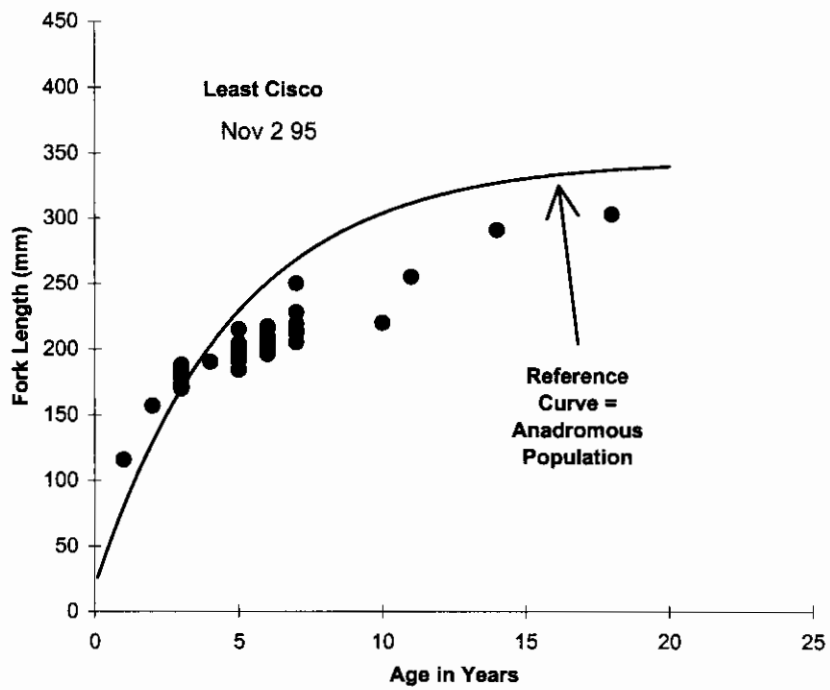
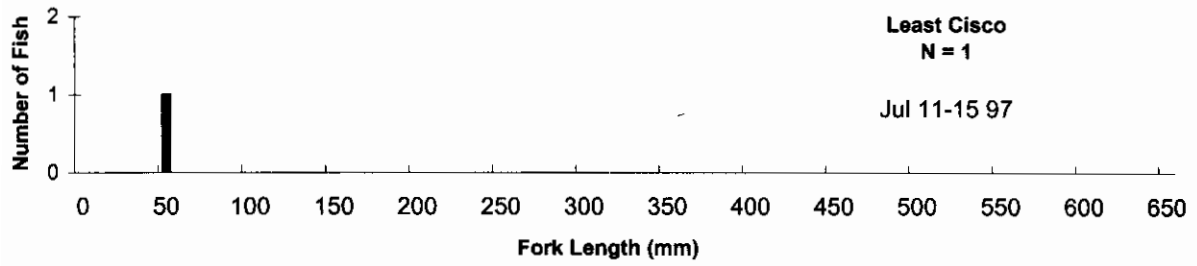
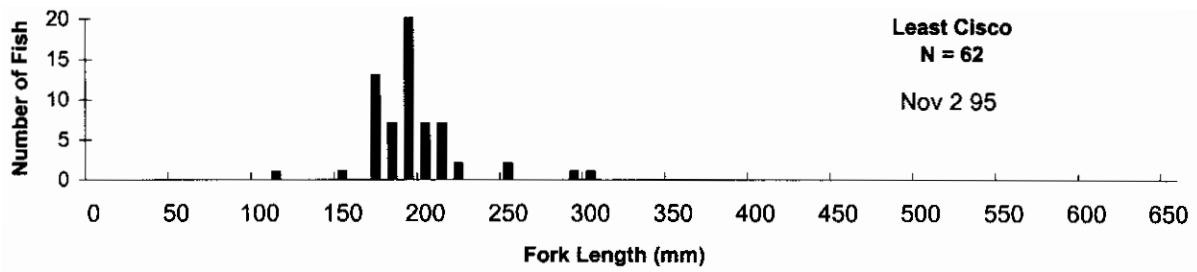
Water Quality:

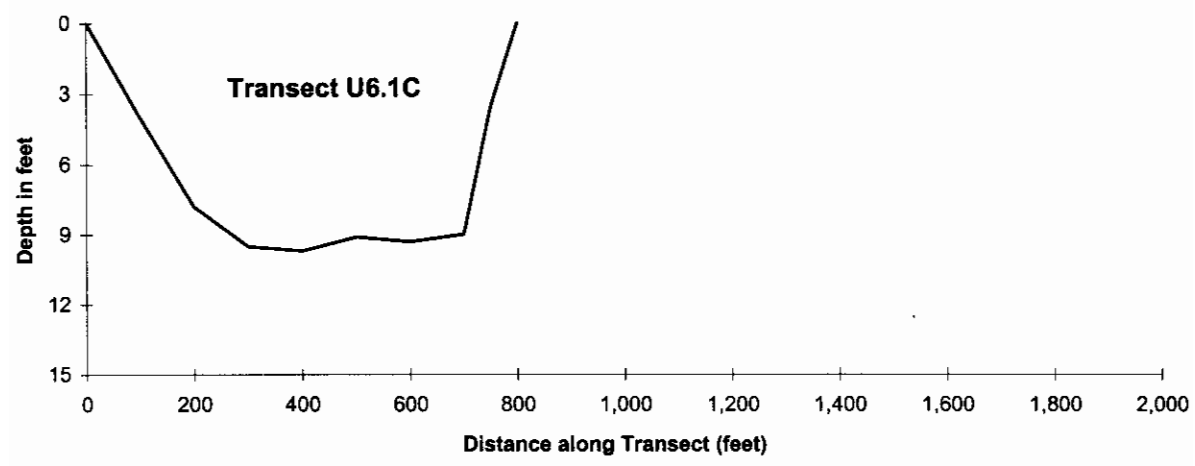
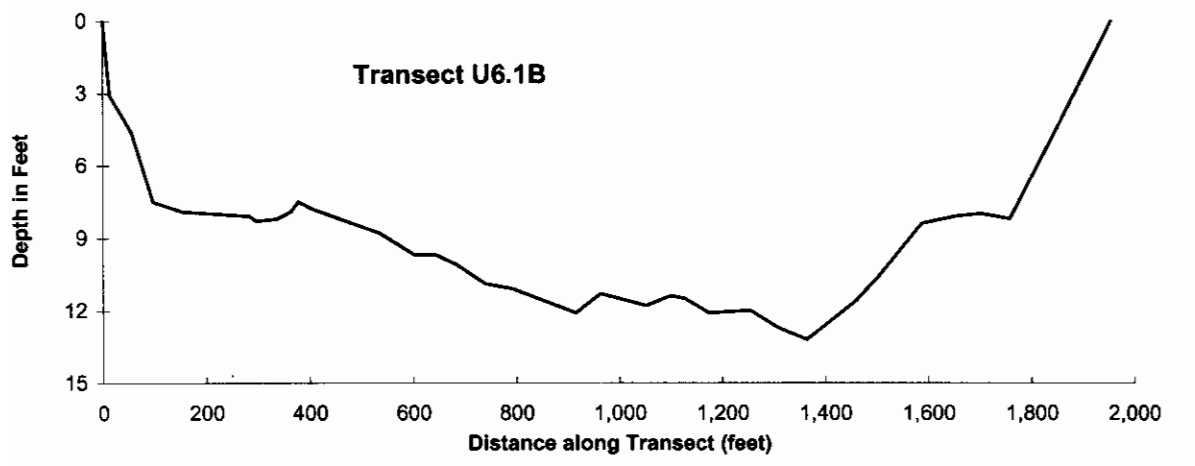
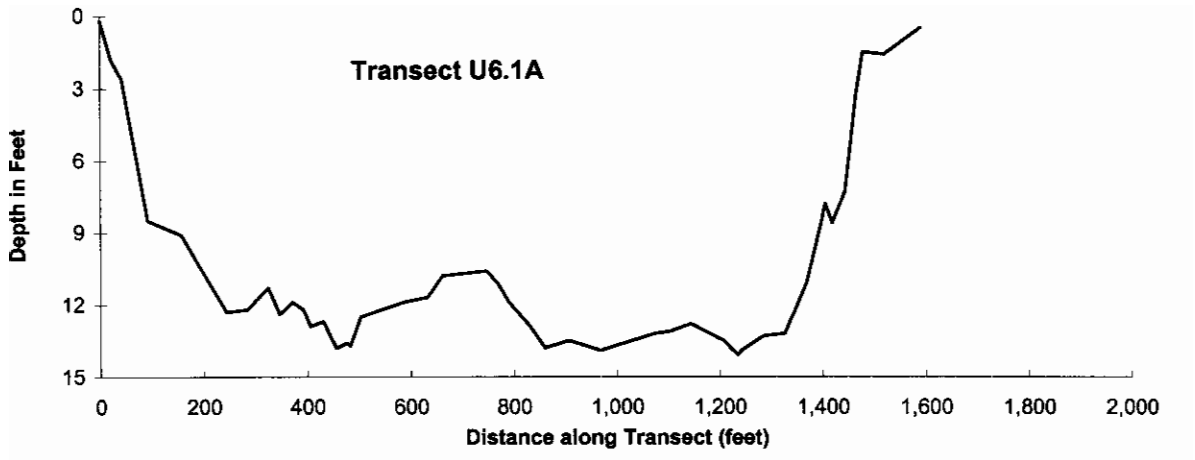
Year of Test	Chloride (mg/l)	Sodium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
1993	8	4.5	2.1	7.2	27	150	J. Lobdell

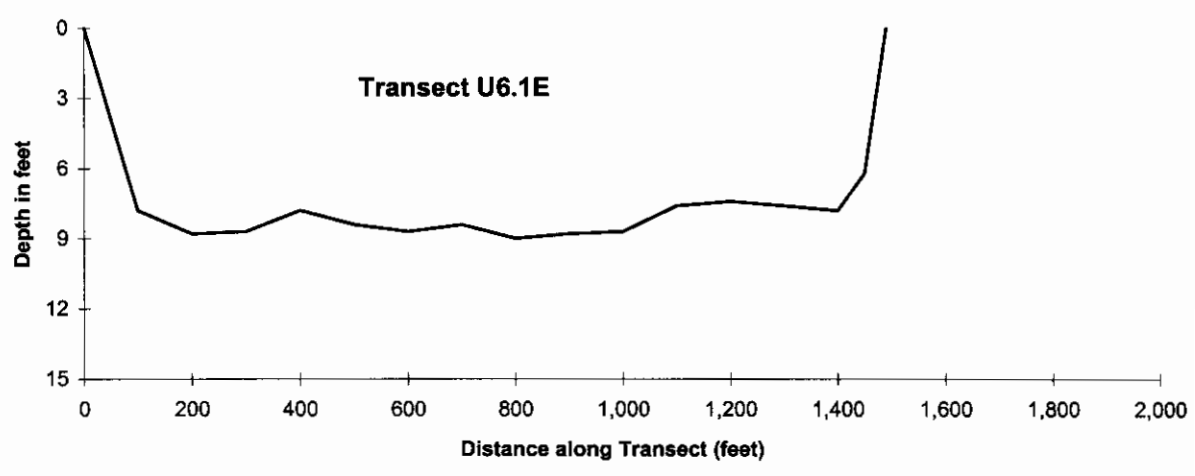
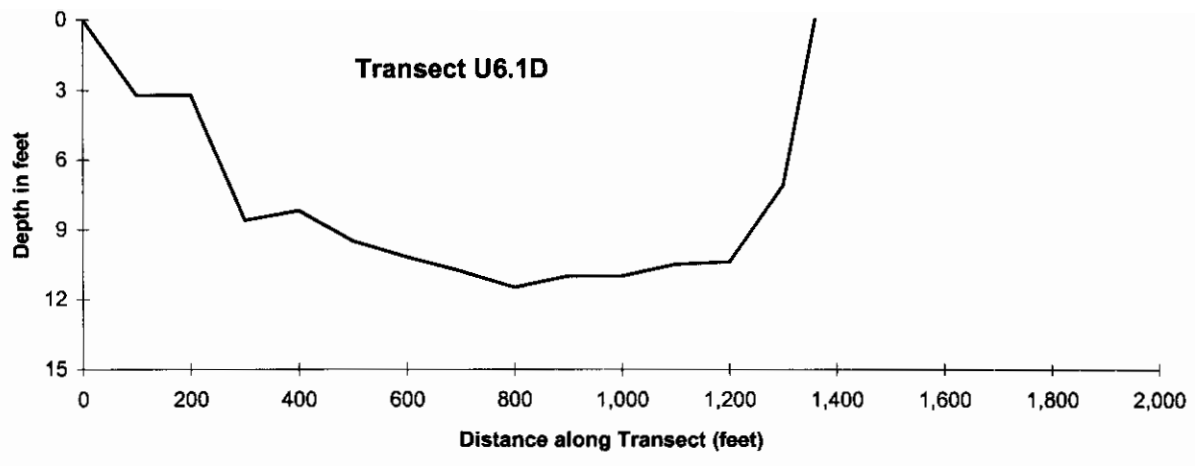
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Fyke Net	Jul 14 95	23.9	Alaska blackfish	1	
			Slimy sculpin	1	
			9spine stickleback	10	
Fyke Net	Jul 26 95	20.0	Broad whitefish	1	428
			9spine stickleback	2	
Minnow Trap	Jul 14 95	48.6	Slimy sculpin	2	
			9spine stickleback	1	
Set Line	Jul 14 95	23.5	None	0	
Gill Net	Nov 2 95	21.7	Least cisco	62	116-303
			Broad whitefish	5	334-470
Fyke Net	Jul 11-15 97	116.6	Least cisco	1	56
			Alaska blackfish	5	70
			Slimy sculpin	8	38-84
			9spine stickleback	57	

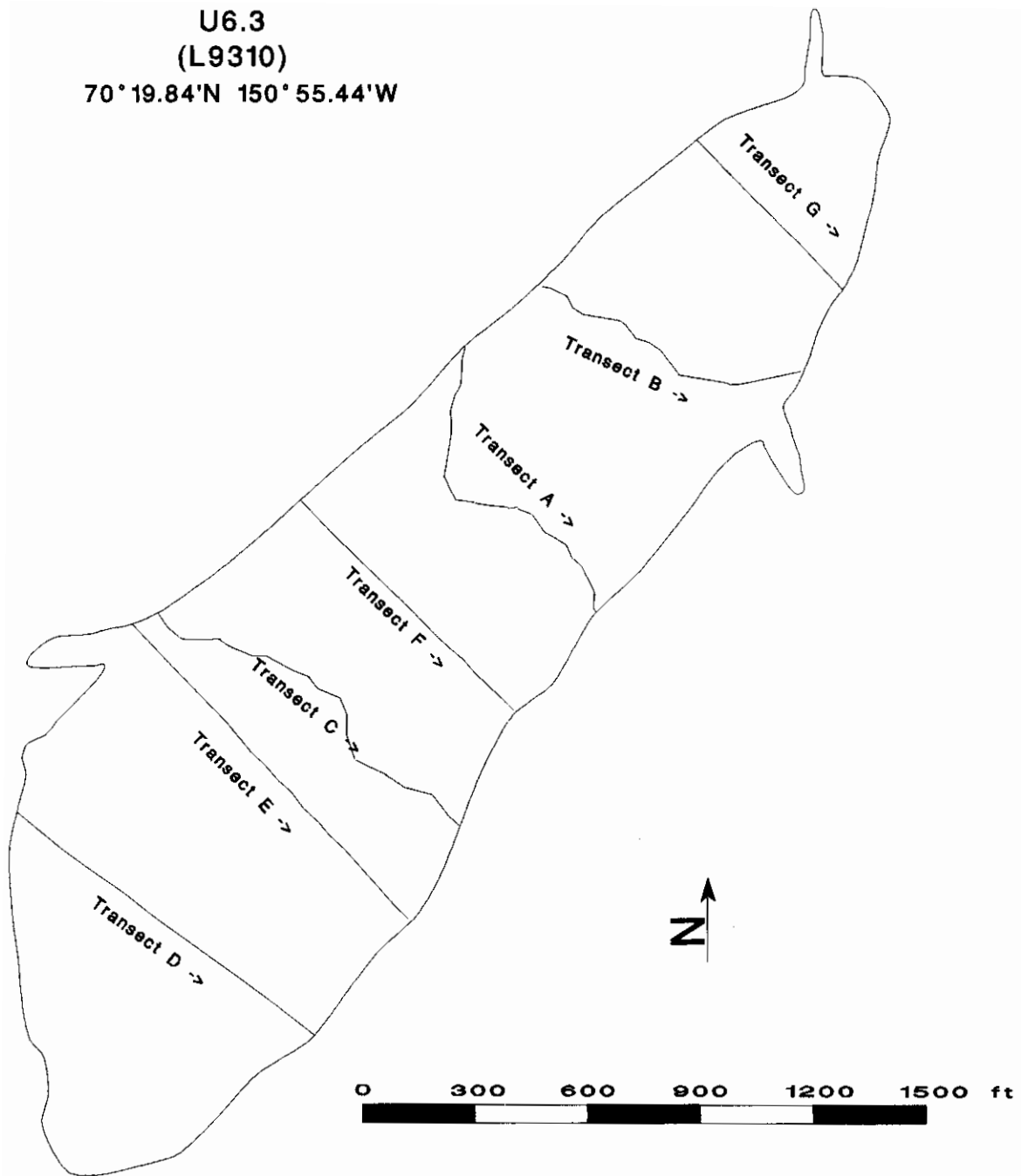






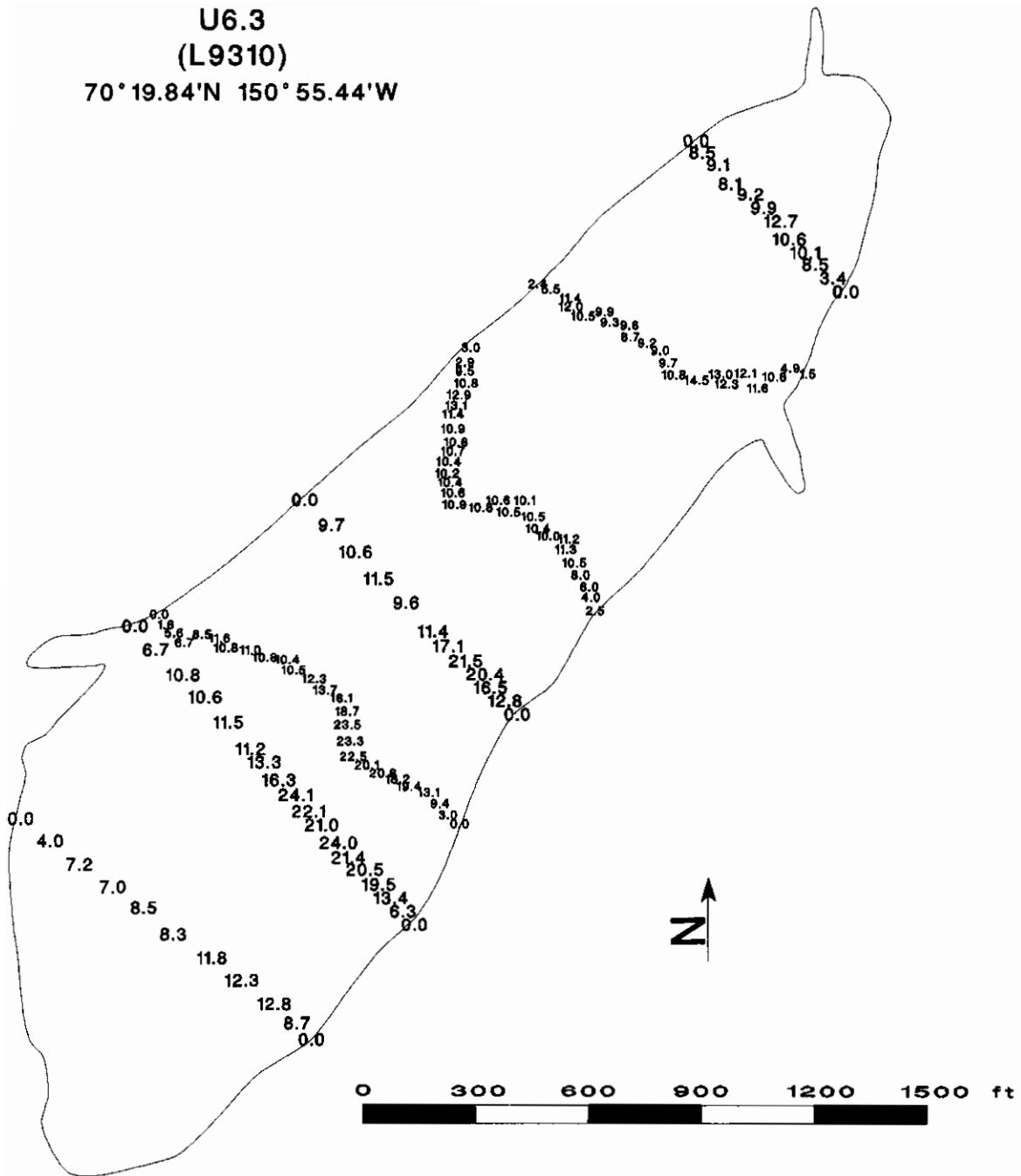


U6.3
(L9310)
70°19.84'N 150°55.44'W



Bathymetric transects surveyed on lake U6.3 (L9310), 1995-1998.

U6.3
(L9310)
70° 19.84'N 150° 55.44'W



Depths recorded on lake U6.3 (L9310), 1995-1998.

Lake U6.3

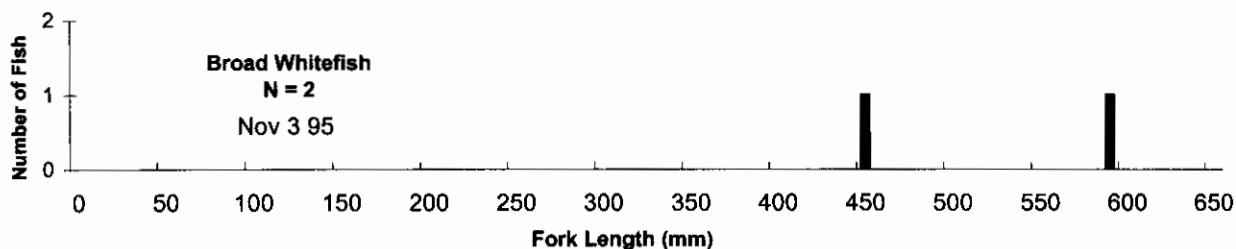
Other Names: L9310
Location: 70°19.84'N 150°55.44'W
USGS Quad Sheet: Harrison Bay B-2: T11N R5E, Sect 5
Habitat: Perched Lake (Infrequent Flooding)
Area: 61 acres
Maximum Depth: 23.5 feet
Active Outlet: No
Spec. Conductance: 126 µS/cm
pH: 7.9-8.1
Calculated Volume: 211.4 million gallons
Permittable Volume: 12.7 million gallons

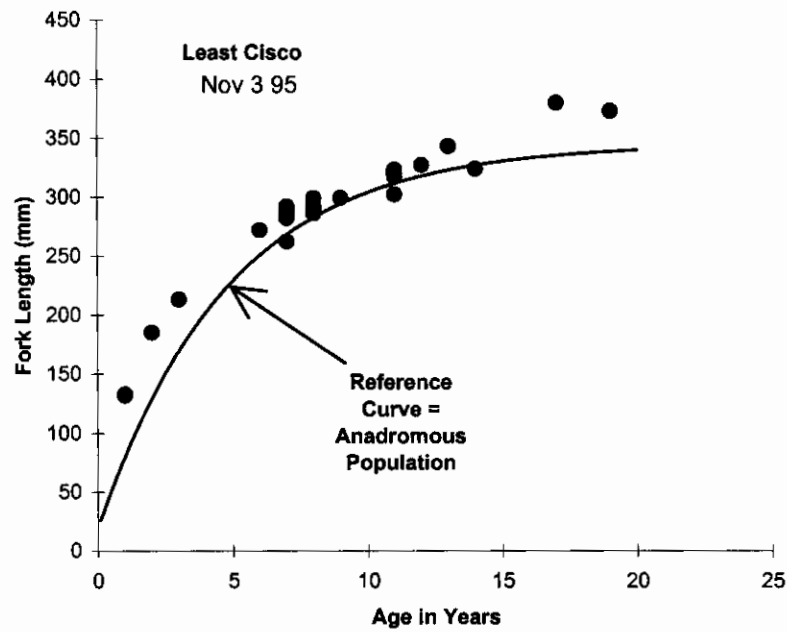
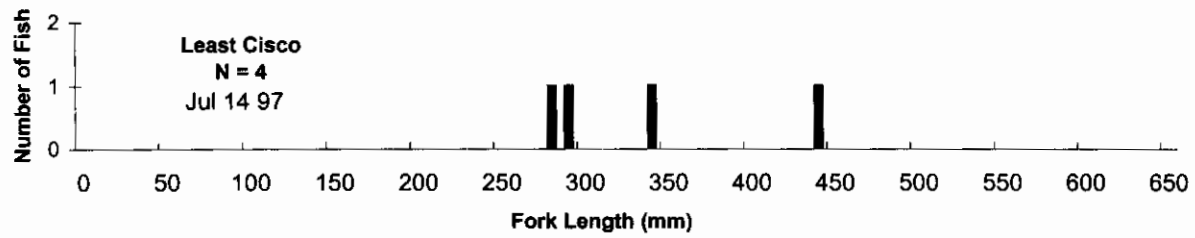
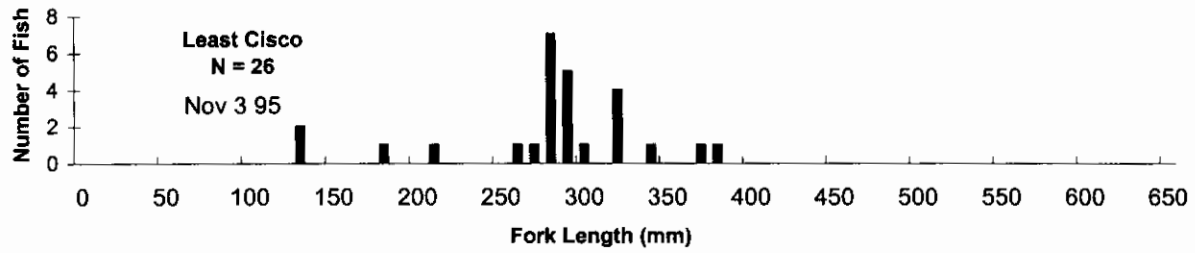
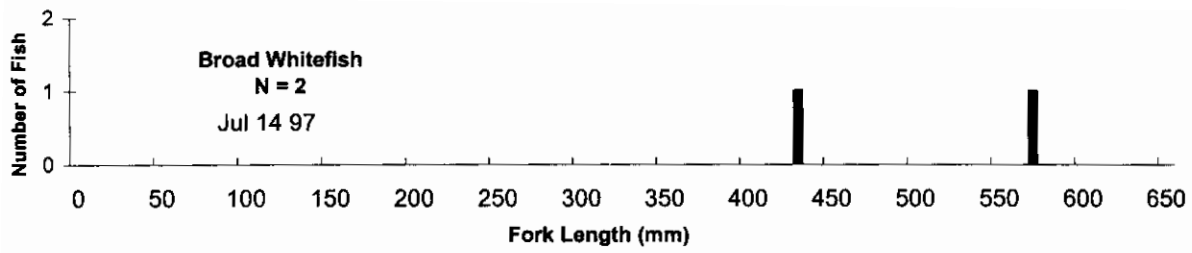
Water Quality:

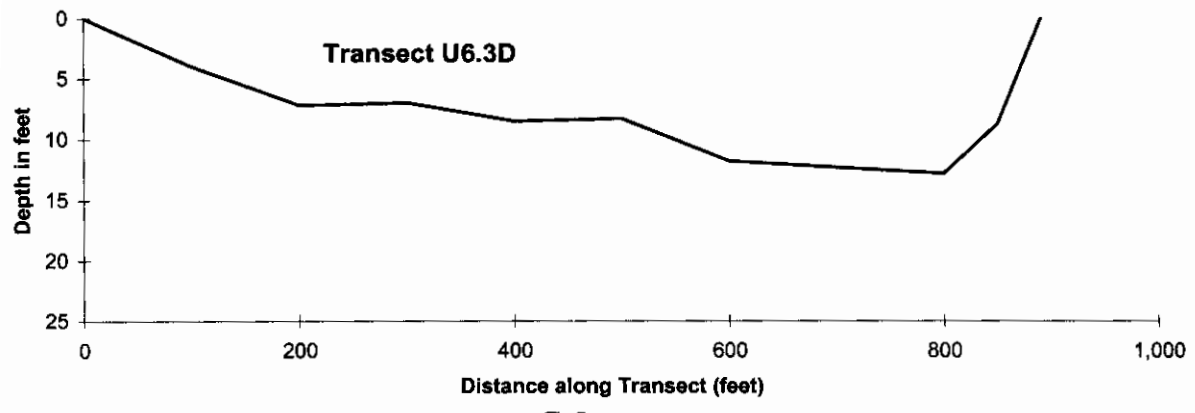
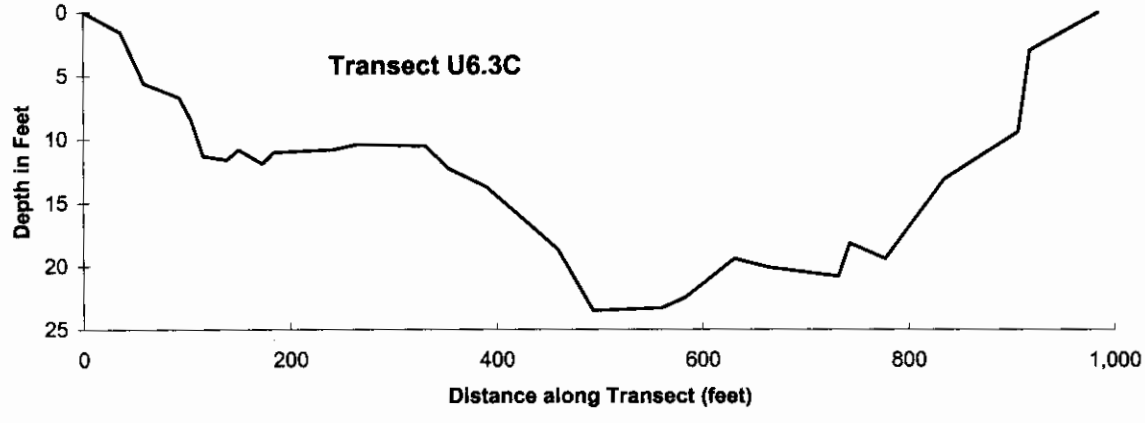
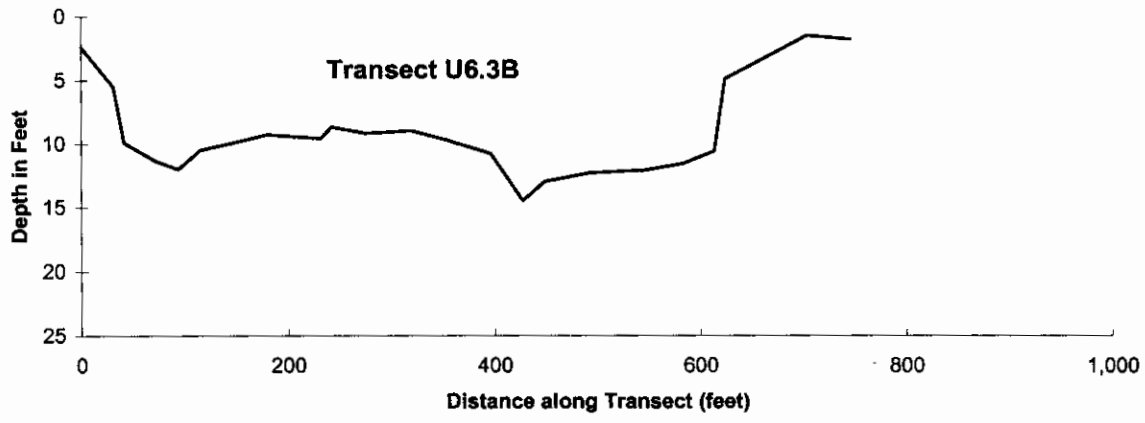
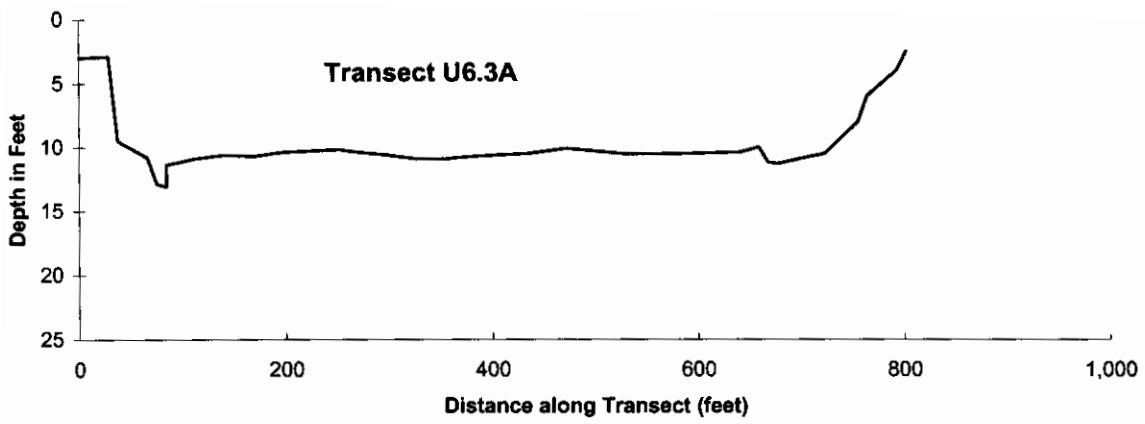
Year of Test	Chloride (mg/l)	Sodium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Total Hardness [CaCO3] (mg/l)	Total Dissolved Solids (mg/l)	Source
1993	10	4.8	3.7	11	43	130	J. Lobdell

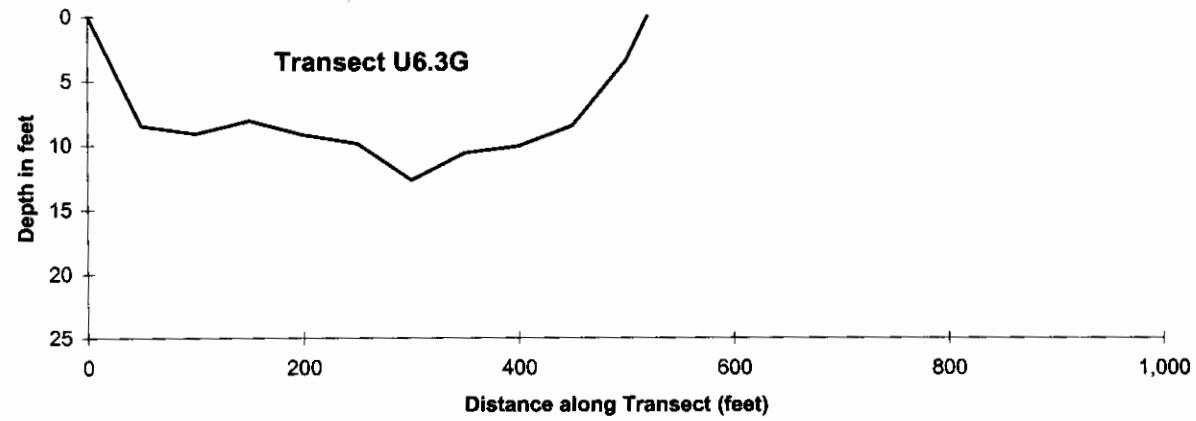
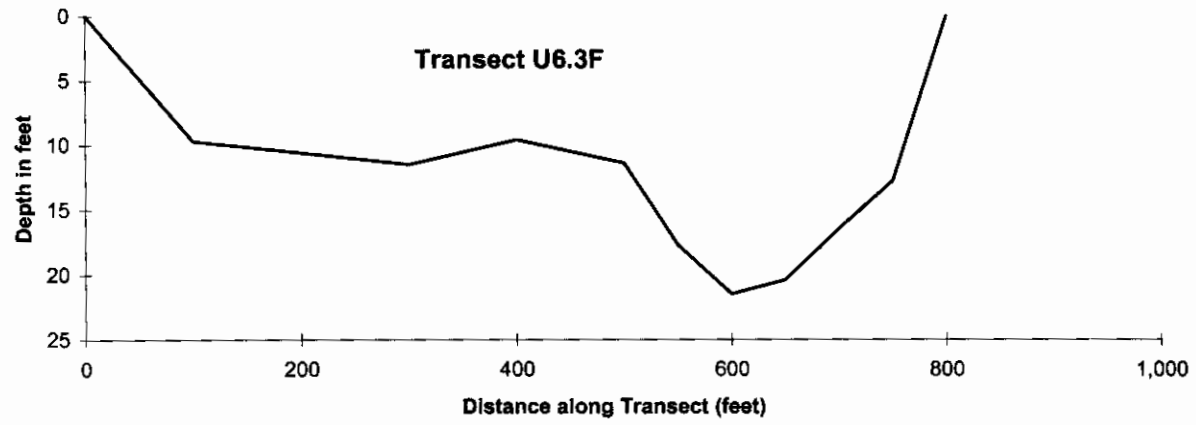
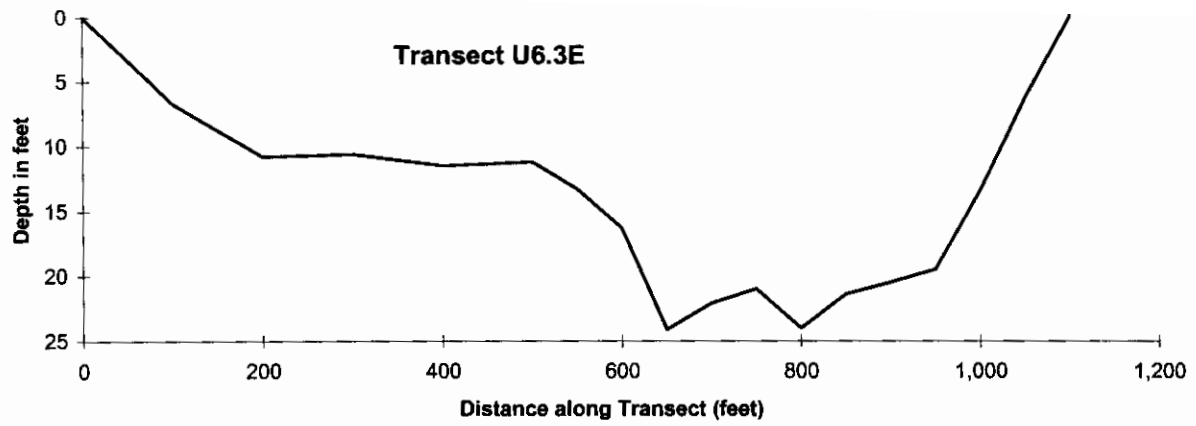
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Fyke Net	Jul 13 95	18.3	Alaska blackfish	1	
			Slimy sculpin	3	
			9spine stickleback	130	
Fyke Net	Jul 25 95	20.3	Least cisco	1	317
			Alaska blackfish	1	
			9spine stickleback	41	
Minnow Trap	Jul 13 95	37.4	None	0	
Set Line	Jul 13 95	18.1	None	0	
Gill Net	Nov 3 95	22.7	Least cisco	26	132-380
			Broad whitefish	2	457-594
Fyke Net	Jul 12-15 97	94.6	Least cisco	1	283
			Alaska blackfish	2	108
			Slimy sculpin	6	52-74
			9spine stickleback	37	
Gill Net	Jul 14 97	4.9	Broad whitefish	2	437-576
			Least cisco	5	298-446









Depths obtained at lake T7.2 on November 2, 1998.

T7.2H		T7.2I		T7.2J	
Distance (ft)	Depth (ft)	Distance (ft)	Depth (ft)	Distance (ft)	Depth (ft)
0	0.0	0	0.0	0	0.0
60	4.1	50	6.1	80	4.9
110	6.8	100	5.4	180	6.8
160	7.6	150	6.0	280	4.9
260	7.9	200	7.2	380	3.2
360	9.3	250	7.1	480	6.5
460	10.3	300	7.3	580	5.3
560	11.2	350	7.2	680	5.2
660	11.9	400	7.4	780	6.8
760	13.2	450	6.5	880	7.0
860	13.6	500	7.4	980	7.4
960	14.7	550	6.5	1,080	7.1
1,060	13.9	600	3.6	1,180	8.0
1,160	15.8	640	0.0	1,280	9.4
1,260	15.1			1,380	10.7
1,360	16.0			1,430	11.2
1,460	16.4				
1,560	14.5				
1,660	14.6				
1,760	15.2				
1,860	14.7				
1,960	13.9				
2,060	13.5				
2,160	14.7				
2,260	13.9				
2,360	13.9				
2,460	13.4				
2,560	12.9				
2,660	15.3				
2,760	15.1				
2,860	10.0				
2,960	0.0				