Analysis of Tule Lake Water Quality and Sucker Telemetry, 1992-1995

3/30/2000
Mark Buettner

U.S. Bureau of Reclamation, Mid-Pacific Region, Klamath Basin Area Office
6600 Washburn Way, Klamath Falls, Oregon 97603

Introduction

The U.S. Bureau of Reclamation (Reclamation) conducted water quality monitoring from 1992-1995 and radio telemetry studies of adult shortnose and Lost River suckers from 1993-1995 at Tule Lake, California. Study objectives were to characterize the temporal and spatial distribution of water quality, determine temporal and spatial distribution of adult suckers, locate summer refugial areas for adult suckers, and determine the relation of sucker distribution to water quality. This report is intended to provide a brief summary of the radio telemetry and water quality study.

Methods

Water quality monitoring was conducted in Sumps 1A and 1B using Hydrolab multi-parameter instruments (Datasonde 3, Hydrolab Corp., Austin, Texas) that measured temperature, pH, dissolved oxygen (DO) and specific conductance. In 1992 and 1993, continuous Hydrolab data was collected at one site in the southern portion of Sump 1A and at another site in the northwestern corner of 1B during summer and fall (Figure 1). Sites were selected based on presumed fish habitat locations. In spring and winter, continuous Hydrolab monitoring only occurred in the English Channel (Sump 1A). In 1994 and 1995, continuous water quality monitoring only occurred in Sump 1A. Hydrolabs were positioned approximately 0.2 m above the bottom at sites that ranged from 0.8-1.2 m deep. Data was recorded hourly at each continuous site.

Instantaneous profile Hydrolab data was collected 2-5 times per year at up to 17 sites in 1A and 13 sites in 1B (Figure 1). Water quality information was measured at 0.1 m and 0.5 m below the surface and 0.2 m above the bottom. At sites greater than 1.2 m deep, water quality was also monitored at 1.0 m.

We summarized water quality data using Microsoft EXCEL software v. 97 SR-1 and SPSS for Windows release 9.0.0. Near bottom continuous water quality data was plotted using a box and whisker data analysis technique. The graphs display the median, 25 -75th percentiles, 10-90th percentiles, and outliers.

Adult suckers were captured using trap nets from the English Channel in April 1993, radio-tagged and released (Table 1, Scoppettone et al. 1995). Radio tags were surgically implanted using anesthesia and sterile techniques that minimized trauma to the fish. Attempts to locate the tagged fish were made by fixed wing aircraft at 1-2 month intervals during the winter, and every two weeks by aircraft and thrust boats in spring, summer and fall. Upon locating a fish, coordinates were obtained with a geographical positioning system (GPS) unit (accuracy 3-100 m depending on the unit). Additionally, water quality and bottom depth were recorded at each fish location throughout 1993 and intermittently in 1994. Water quality parameters were measured at 0.1 m below the surface and 0.2 m off the bottom. Water temperature, dissolved oxygen, specific conductance and pH were measured with a calibrated Hydrolab multi-parameter instrument (Datasonde 3 or Surveyor).

Radio-tagged sucker locations were plotted by month using ArcView software. Fish location water quality (near bottom) data were summarized using box and whisker plots computed using SPSS software.

Results

Radio-tagged suckers

Five adult Lost River suckers and five adult shortnose suckers were captured in Sump 1A, radio-tagged, and released in April 1993 (Table 1). Lost River and shortnose sucker movements were similar throughout the monitoring period with both species intermixed (Figures 3-26). Radio-tagged suckers remained in Sump 1A throughout the study. However, one Lost River sucker was located in Sump 1B on a single date in April 1995. During May 1993, fish moved from the English Channel where they were first captured to the southern shoreline of Sump 1A (Figure 4). By the end of June, they concentrated in the ADonut Hole@ area located in the south central portion of 1A (Figures 5-6). They remained there until late October when they began dispersing in a northerly direction in Sump 1A (Figures 7-9). By November most suckers were concentrated in the northwest corner of Sump 1A (Figure 10). They remained there until April 1994 (Figures 11-14) when most moved to the English Channel area (Figure 15). In May 1994, they again grouped up in the ADonut Hole@ area as they had in 1993 (Figure 16). They remained there until September (Figures 17-19). By November 1994, radio-tagged suckers were in the northwest corner of Sump1A as they were in November 1993 (Figures 20-24). They remained there through February. In April three of five remaining radio-tagged fish were located in the English Channel (Figure 25). By May only three radio tags remained operational and were found in the English Channel (Figure 26). No radio tracking occurred after May 1995.

Water Quality at Fish Locations

Radio-tagged suckers were located in water depths ranging from 0.5-1.5 m with most readings 0.9-1.0 m (Figure 27, Table 3). Water temperatures ranged from 6.5 C to 23 C (Figure 28). Near bottom pH values ranged from 8.4 to 9.9 with most readings between 9.3-9.5 (Figure 29). DO concentrations at fish locations varied from 4.7-14.1 mg/l (Figure 30). Most values were above 7.0 mg/l. Specific conductance varied widely at fish locations ranging from about 290 to 1030 uS/cm (Figure 31).

Water Quality - Continuous and Profile Monitoring

Continuous Hydrolab

Continuous Hydrolab data was collected concurrently in Sump 1A in the south-central area of the sump (near the ADonut Hole@ area) and Sump 1B in the northwestern corner during summer and fall, 1992 and 1993 (Figure 2). Water temperatures were similar at both sites throughout the monitoring period (Figure 32). pH values were consistently higher in Sump 1B than Sump 1A during 1992 but not 1993 (Figure 33). Sump 1B had substantially more high pH values (>9.5) during the summer than Sump 1A in1992 and 1993. During July 1992 and September 1993 all readings were above10 at the Sump 1B site.

DO values were consistently lower from June through October 1992 and June through August 1993 in Sump 1B than Sump 1A (Figure 34). In 1992, DO seldom dropped below 4 mg/l in Sump 1A. Sump 1B had many readings below 4 mg/l with minimum values below 2 mg/l (excluding outliers) in August, September and October (Figure 34). In 1993, DO at both continuous Hydrolab sites were higher than 1992. DO concentrations were mostly above 6 mg/l except for May. Minimum values were 3.5 mg/l in Sump1A and 4.5 mg/l in Sump 1B.

Water temperature ranged from near 0 C during the winter to 24-28 C in summer (Figure 32). Water temperatures were generally warmer during the summers of 1992 and 1994 than 1993 and 1995. Maximum water temperatures were near 28 C in 1992 and 1994 respectively. Maximum temperatures during 1993 were 24.5 C and 26.5 C in 1995.

pH during the four year study ranged from about 7.7 to 10.5 (Figure 33). pH was generally higher during the late spring and summer than other months for all four years. pH distributions were similar by year for Sump 1A sites except for January 1993 and May 1994. Low pH values (<8.5) were measured in January 1993 during a period of extended ice-cover. During May 1994 pH was mostly around 10 and was associated with an algal bloom.

DO concentrations were mostly 6 mg/l and greater at Sump 1A continuous Hydrolab sites for 1992-1995. May through September readings were typically lower than other months for all years (Figure 34). However, during January 1993, extremely low DO was recorded. These conditions were associated with a thick ice-cover that persisted from December 1992 to February 1993. During the summers of 1992 and 1994, DO values below 6 mg/l were noted for each month with monthly DO minimums ranging from 0-3 mg/l.

Instantaneous Profile Hydrolab

Spatial distribution of water quality was monitored 2-5 times each year at up to 17 sites in Sump 1A and up to 13 sites in Sump 1B (Figure 2). Water temperature was the least variable parameter by sampling site (Figure 35). Most of the variation noted between sites was associated with the time of day when measurements were taken with warmer temperatures usually recorded later in the day.

pH values were highly variable on any given sampling date throughout Sumps 1A and 1B (Figure 36). For example, on 8/12/92 pH ranged from 7.2-9.9 at Sump 1A sites and 7.3-10.3 for Sump 1B sites. Some of this variation was related to the time of day that measurements were taken. Early morning measurements were generally lower than late afternoon measurements due to the effect of the daily photosynthesis cycle. Sump 1A sites 14-17 frequently had lower pH values. These sites were probably influenced by inflow from the Lost River and were also adjacent to emergent wetland areas that generally have lower pH water than open water areas. The highest pH values for any given sample date were usually recorded in Sump 1B (Figure 40). Also the percentage of sites with high pH (>9.5) was usually higher in Sump 1B versus Sump 1A during the summer.

DO concentrations in Sumps 1A and 1B were highly variable temporally and spatially (Figure 37). For example, on 8/12/92 DO ranged from 0.5 to 13.1 mg/l with sites in both sumps having high and low values. Some of the variation between sites was related to the time of day the sites were sampled. Daily fluctuations of several milligrams per liter were commonly recorded with low values in the morning and higher values in the afternoon. DO levels at Sump 1B sites were generally lower than Sump 1A sites for most sample dates (Figure 37). On 8/12/92 most Sump 1B sites had DO less than 4 mg/l compared to only a couple of sites in 1A.

Specific conductance was also highly variable temporally and spatially (Figure 38). Sump 1A sites were more variable than those in 1B ranging from about 200-1000 uS/cm during many sampling dates. Sump 1B sites typically ranged from about 300-800 uS/cm.

Water quality at the three continuous Hydrolab sites (1A , 1A EC, and 1B) were comparable to the other sample sites for temperature (Figure 35-38). Site 1A generally had specific conductance values that were among the highest for all sites. pH and DO at site 1A were generally towards the middle of the distribution of all sites.

Discussion

Lost River and shortnose suckers remained in Sump 1A throughout the study. Their use of Sump 1A may be related to better water quality conditions that generally occurred there compared to Sump 1B. The most important water quality parameters seemed to be pH and DO. Potentially stressful and lethal levels of high pH (>10.0) (Saiki et al. 1999, Meyer et al. 2000) were much more common in Sump 1B than Sump1A. Sump 1B also had more potentially stressful (< 4 mg/l) and lethal DO (<2 mg/l) than Sump 1A (Saiki et al. 1999, Meyer et al. 2000).

Both species of suckers concentrated in a small area of Sump 1A called the ADonut Hole@during the summer months. DO and pH values were less variable there than other water quality sampling sites in Sumps 1A and 1B. DO rarely dropped below potentially stressful levels (4 mg/l) and lethal levels (<2 mg/l) were absent. pH rarely exceeded stressful levels (>10) at this site. The ADonut Hole@ site was unique in that rooted aquatic plant growth was generally low or absent and the water was frequently quite turbid compared to other sites during the summer. The bottom substrate at this location was firmer and composed of clay and other inorganic sediment particles compared to the softer and highly organic peat substrates found elsewhere. High fish densities may reduce rooted plant growth in this area and contribute to the turbidity by stirring up the sediment. We found no specific evidence of springs or groundwater seeps based on water quality monitoring. The ADonut Hole@ area is strategically located near other areas in Sump 1A that suckers use during different seasons including the northwest corner in fall and winter and the Lost River and English Channel in spring.

Adult suckers were generally located in water depths greater than 0.8 m. The area of Sump 1A that is this deep and greater is small. There is also evidence that both sumps have filled in substantially over the last several decades due to sedimentation. Unless, actions are taken to

Although sucker spawning migrations from Tule Lake up the Lost River were documented during 1993-1995, none of the radio-tagged fish migrated upstream. This suggests that spawning behavior may have been affected by the radio-tagging activity, fish do not spawn every year, or that these fish may try to spawn in the English Channel area where they were originally captured.

This study highlights the concern over the lack of deep water areas (> 3 feet) remaining in Sump 1A and continuing sedimentation and filling that is occurring.

References

Meyer, J.S., H.M. Lease, and H.L. Bergman. Chronic toxicity of low dissolved oxygen concentrations, elevated pH, and elevated ammonia concentrations to Lost River suckers (*Deltistes luxatus*) and swimming performance of Lost River suckers at various temperatures. Completion Report. University of Wyoming. Laramie. 56pp.

Saiki, M.K., D.P. Monda, and B.L. Bellerud. 1999. Lethal levels of selected water quality variables to larval and juvenile Lost River and shortnose suckers. Environmental Pollution 105:37-44.

Scoppettone, G.G., S. Shea, and M.E. Buettner. 1995. Information on population dynamics and life history of shortnose suckers (*Chasmistes brevirostris*) and Lost River suckers (*Deltistes luxatus*) in Tule and Clear Lakes. Completion Report. National Biological Service-Northwest Biological Science Center Reno Field Station. 79pp.

TABLE 1. Lost River and Shortnose suckers radio-tagged in Tule Lake, California, 1993.

Fish ID	Frequency (khz)	Species	Sex	Length (FL)	Weight (grams)	Date Tagged
A	164.435	LRS	F	625	2930	4/27/93
B	164.65	SNS	F	457	1571	4/22/93
C	164.515	LRS	F	636	2905	4/27/93
D	164.537	SNS	M	440	1299	4/21/93
E	164.565	SNS	M	500	1985	4/21/93
F	164.584	SNS	F	508	2146	4/22/93
G	164.614	LRS	M	650	2636	4/21/93
H	164.636	LRS	M	649	2851	4/27/93
I	164.684	LRS	F	658	3215	4/27/93
J	164.715	SNS	F	493	1904	4/22/93
K	164.914	LRS	F	600	3305	4/26/93

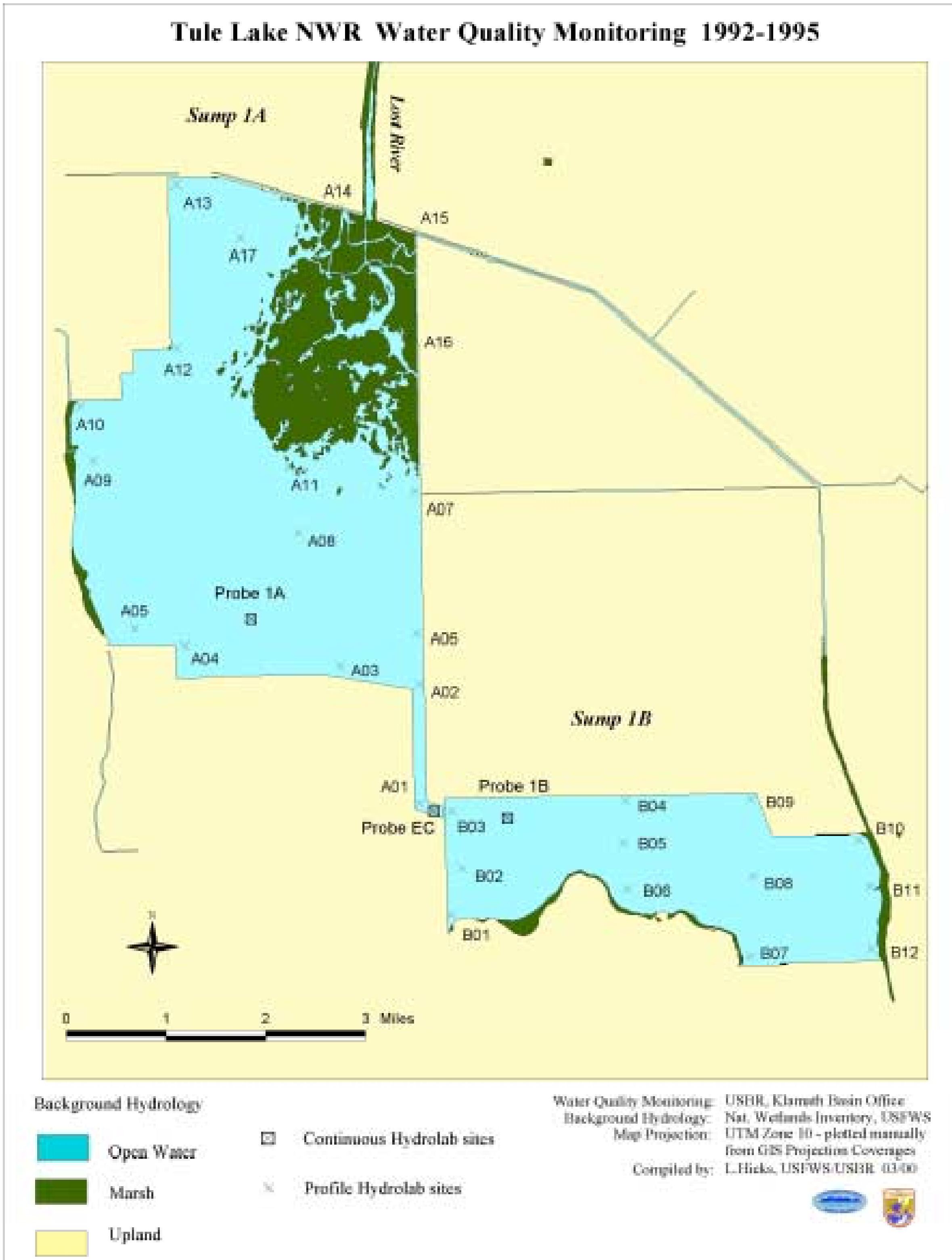

Tule Lake NWR Water Quality Monitoring 1992-1995
Sump 1A
Lost River
A13
A14
A15
A17
A16
A12
A10
A09
A11
A07
A08
Probe 1A
A05
A06
A04
A03
A02
Sump 1B
A01
Probe 1B
Probe EC
B03
B04
B09
B05
B10
B02
B06
B08
B11
B01
B07
B12
0
1
2
3 Miles
Background Hydrology
Open Water
Marsh
Upland
Continuous Hydrolab sites
Profile Hydrolab sites
Water Quality Monitoring: USBR, Klamath Basin Office
Background Hydrology: Nat. Wetlands Inventory, USFWS
Map Projection: UTM Zone 10 - plotted manually from GIS Projection Coverages
Compiled by: L.Hicks, USFWS/USBR 03/00

Figure 1

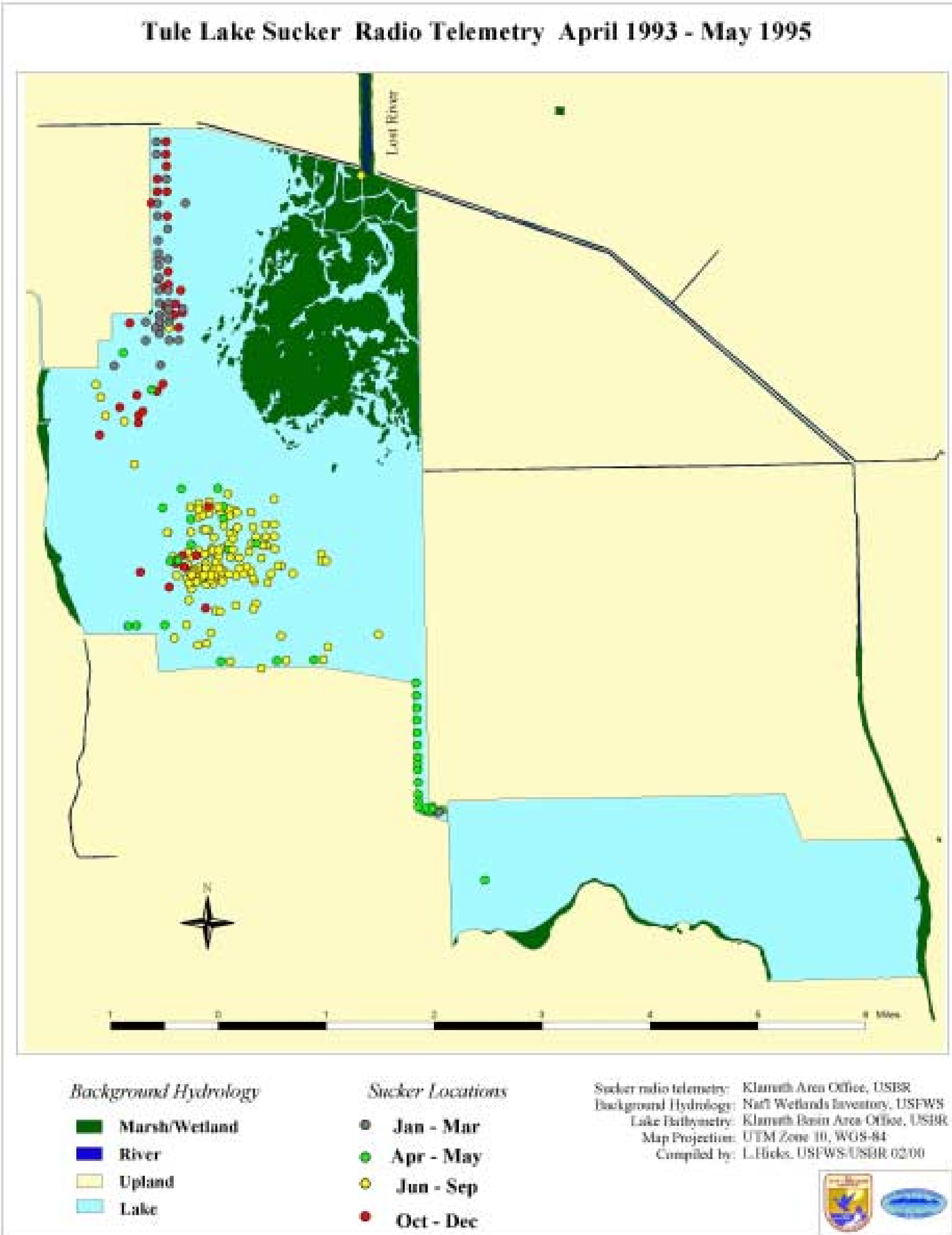

Tule Lake Sucker Radio Telemetry April 1993 - May 1995
Lost River
Miles
Background Hydrology
Marsh/Wetland
River
Upland
Lake
Sucker Locations
Jan - Mar
Apr - May
Jun - Sep
Oct - Dec
Sucker radio telemetry: Klamath Area Office, USBR
Background Hydrology: Nat'l Wetlands Inventory, USFWS
Lake Bathymetry: Klamath Basin Area Office, USBR
Map Projection: UTM Zone 10, WGS-84
Compiled by: L.Hicks, USFWS/USBR 02/00

Figure 2

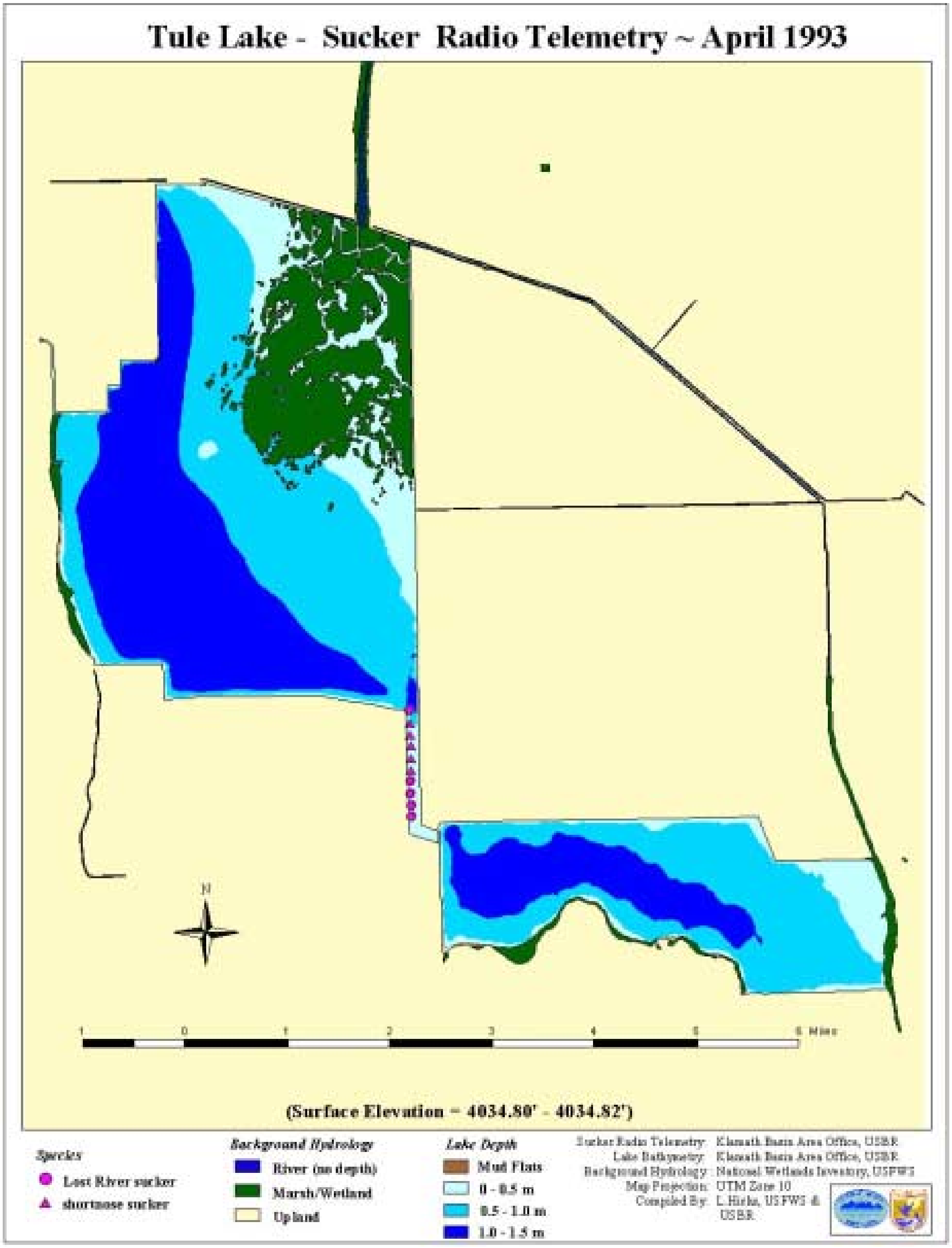

Tule Lake - Sucker Radio Telemetry ~ April 1993
N
1 0 1 2 3 4 5 6 Miles
(Surface Elevation = 4034.80' - 4034.82')
Species
Lost River sucker
shortnose sucker
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L. Hicks, USFWS & USBR

Figure 3

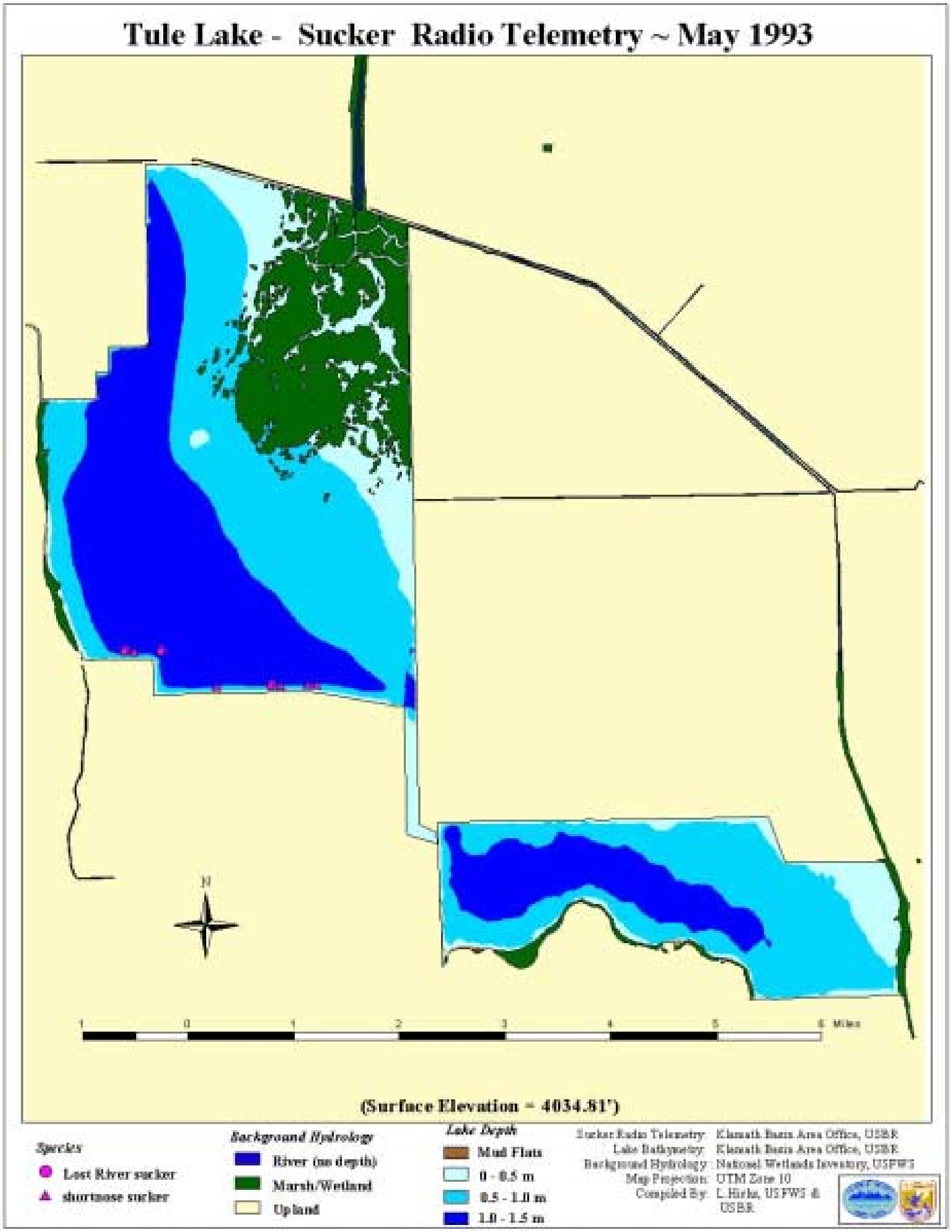

Tule Lake - Sucker Radio Telemetry ~ May 1993
N
1
0
1
2
3
4
5
6 Miles
(Surface Elevation = 4034.81')
Species
Lost River sucker
shortnose sucker
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hicks, USFWS & USBR

Figure 4

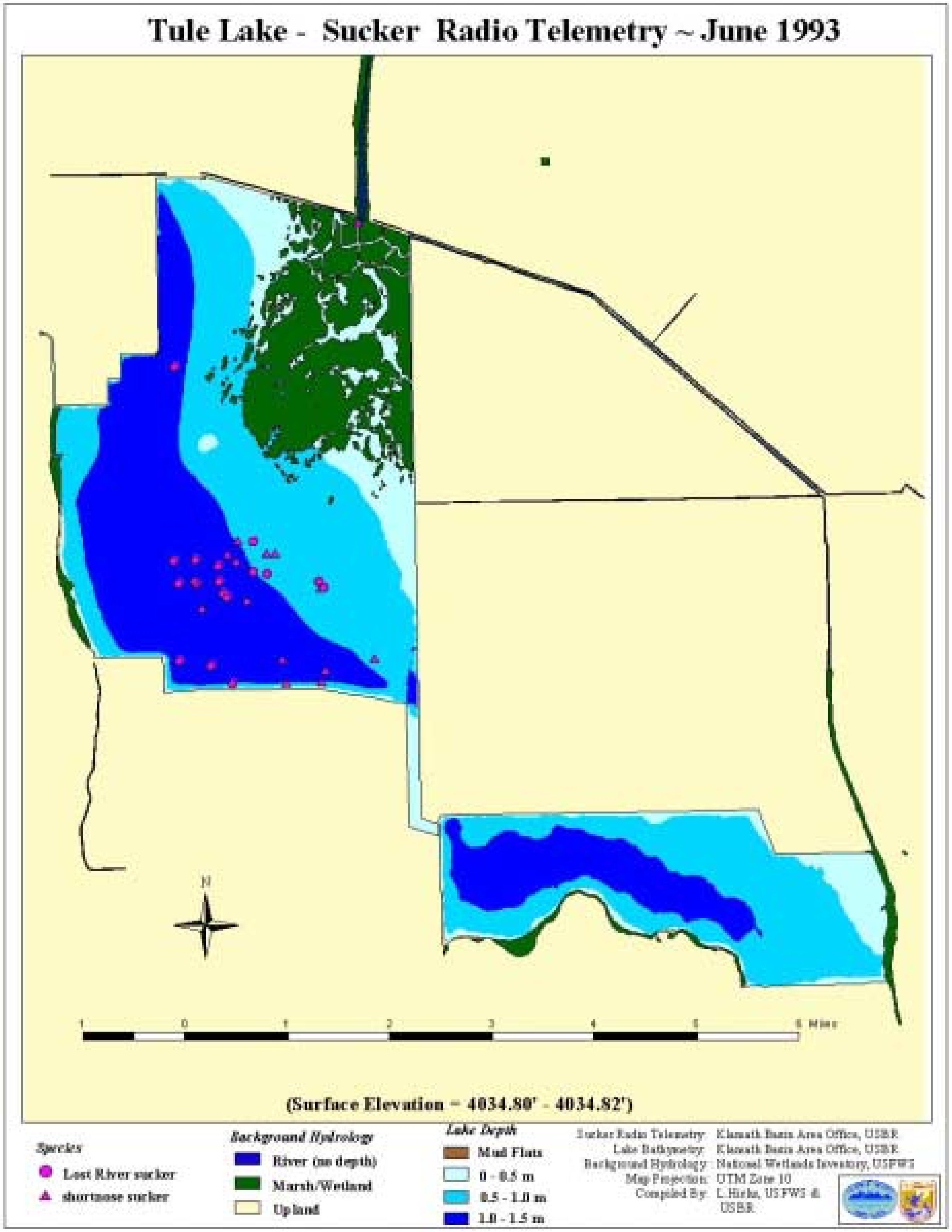

Tule Lake - Sucker Radio Telemetry ~ June 1993
N
1
0
1
2
3
4
5
6 Miles
(Surface Elevation = 4034.80' - 4034.82')
Species
Lost River sucker
shortnose sucker
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hirka, USFWS & USBR

Figure 5

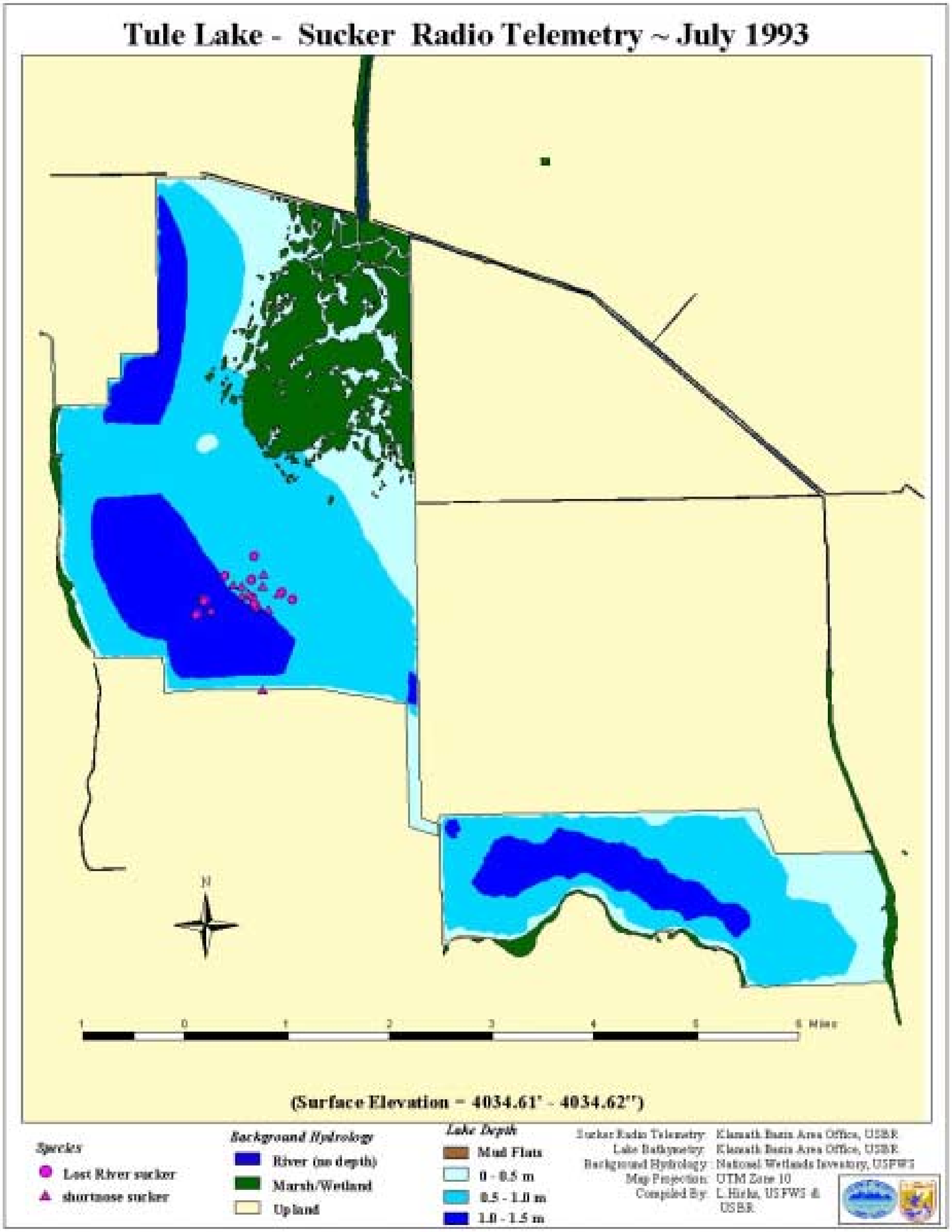

Tule Lake - Sucker Radio Telemetry ~ July 1993
N
0
1
2
3
4
5
6 Miles
(Surface Elevation = 4034.61' - 4034.62'')
Species
Lost River sucker
shortnose sucker
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hicks, USFWS & USBR

Figure 6

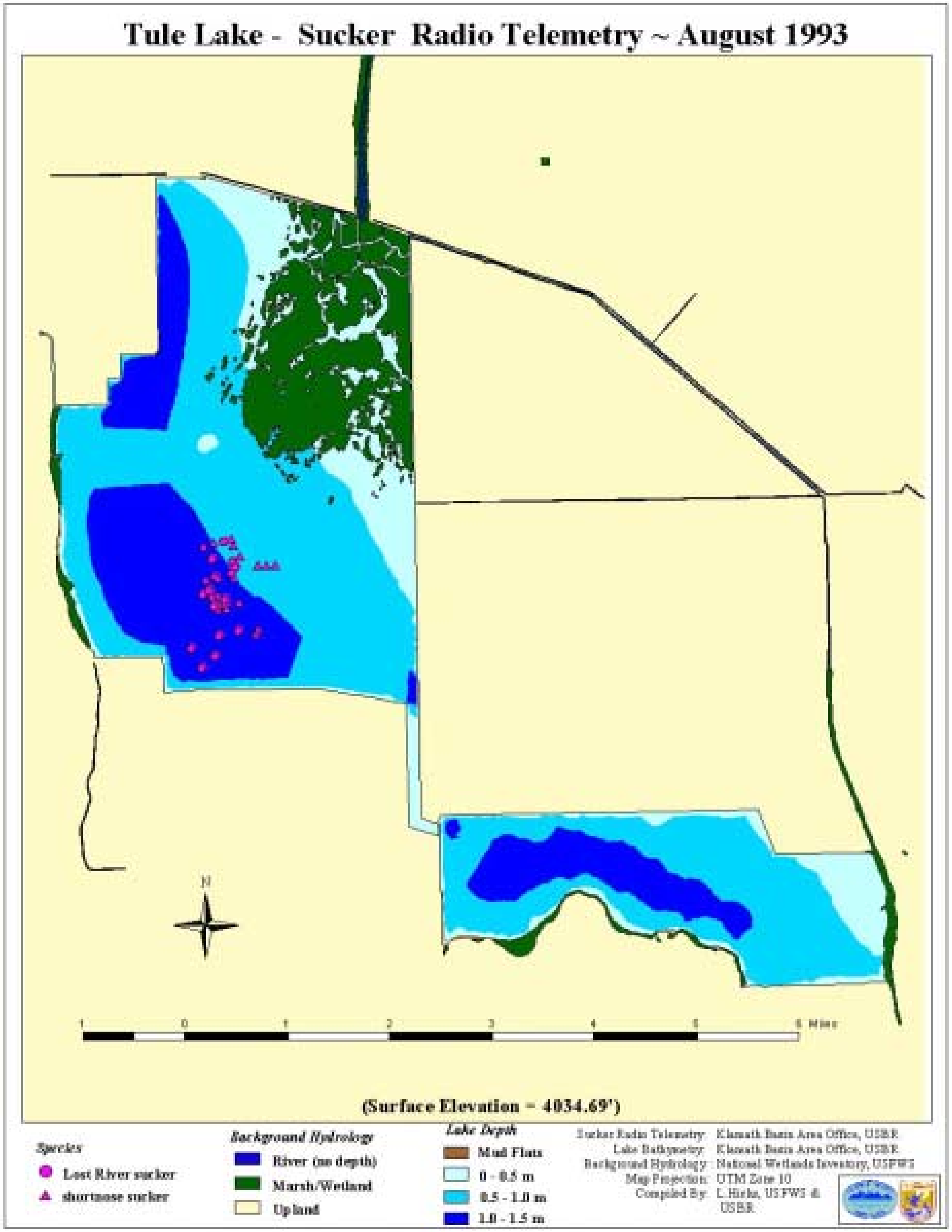

Tule Lake - Sucker Radio Telemetry ~ August 1993
N
(Surface Elevation = 4034.69')
Species
Lost River sucker
shortnose sucker
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hirks, USFWS & USBR

Figure 7

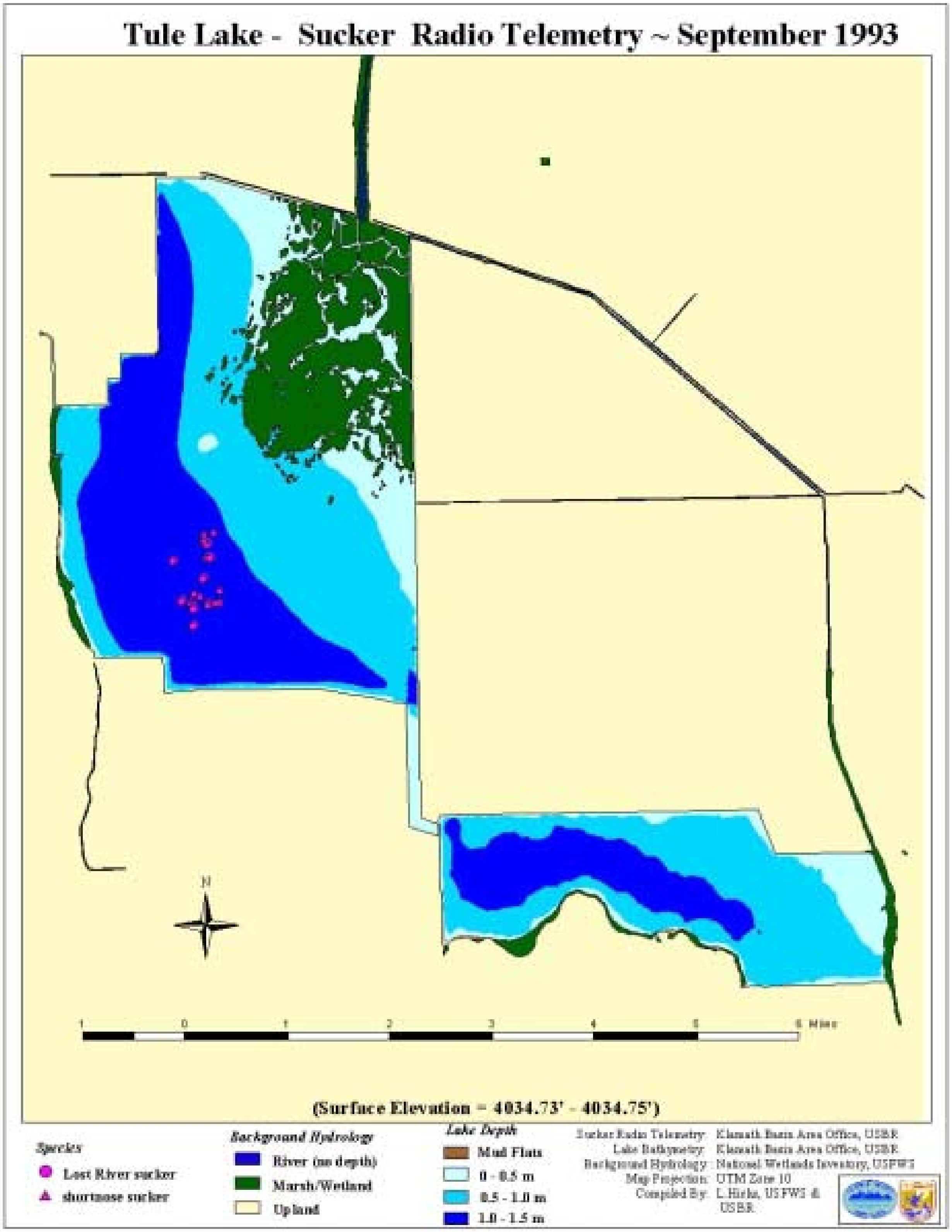

Tule Lake - Sucker Radio Telemetry ~ September 1993
N
1
0
1
2
3
4
5
6 Miles
(Surface Elevation = 4034.73' - 4034.75')
Species
Lost River sucker
shortnose sucker
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hicks, USFWS & USBR

Figure 8

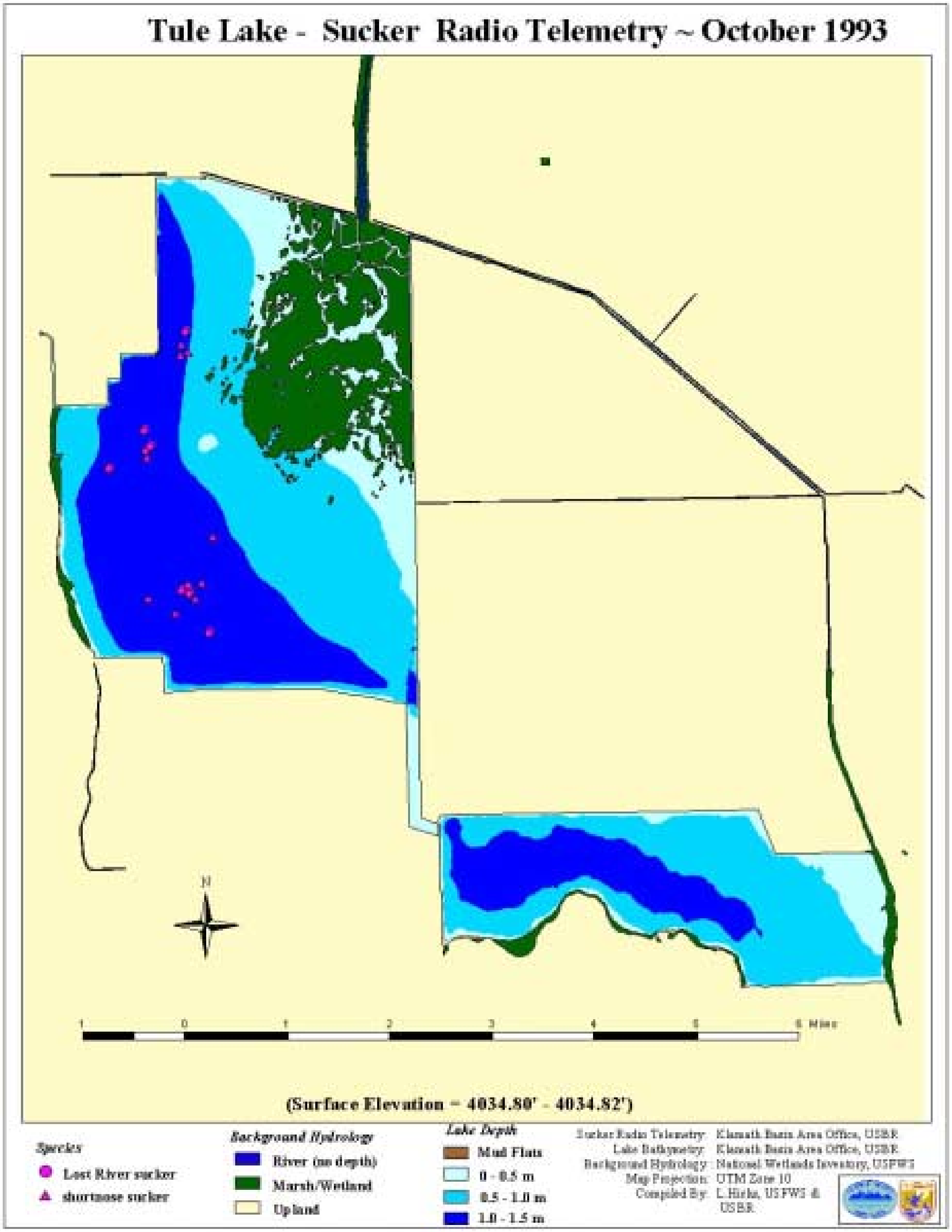

Tule Lake - Sucker Radio Telemetry ~ October 1993
N
1
0
1
2
3
4
5
6 Miles
(Surface Elevation = 4034.80' - 4034.82')
Species
Lost River sucker
shortnose sucker
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hicks, USFWS & USBR

Figure 9

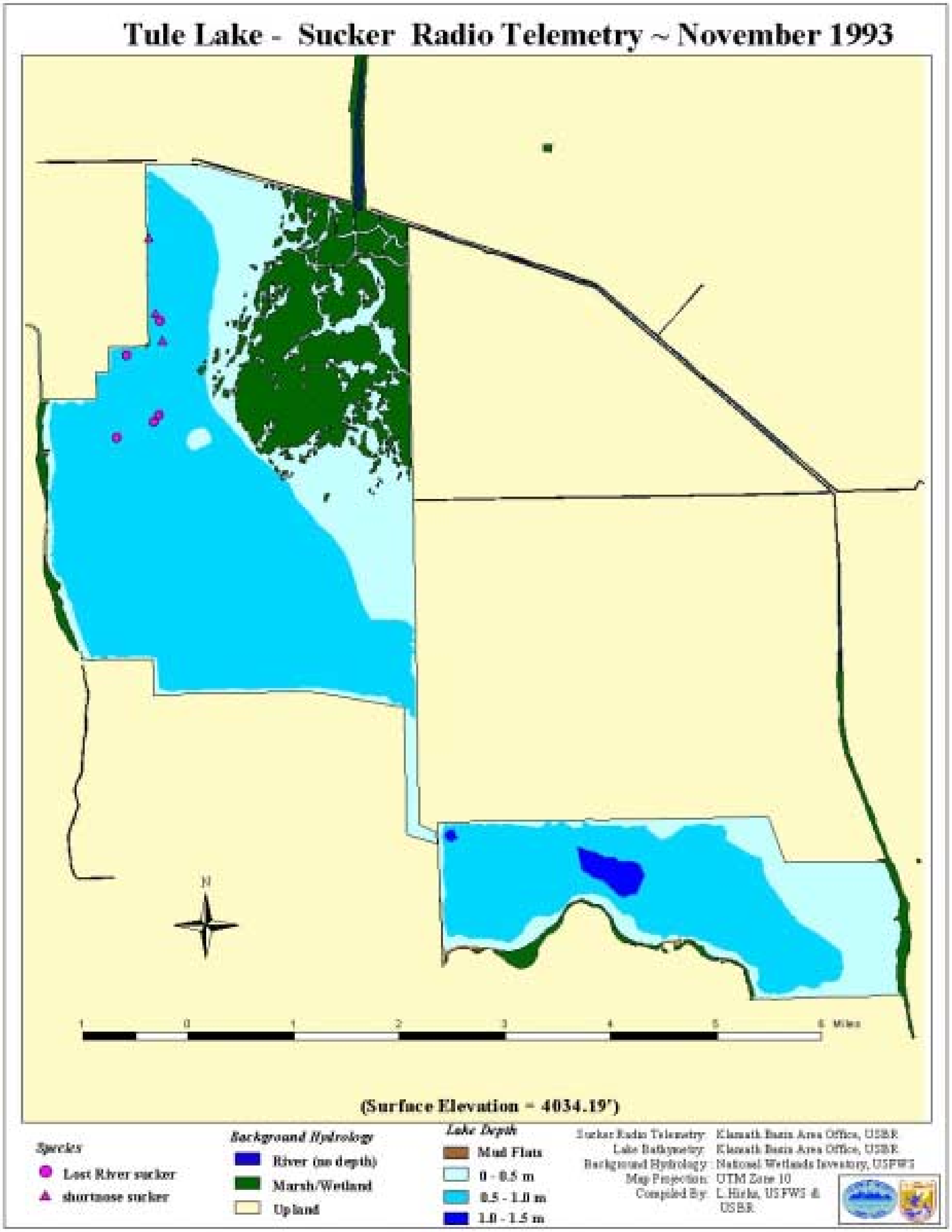
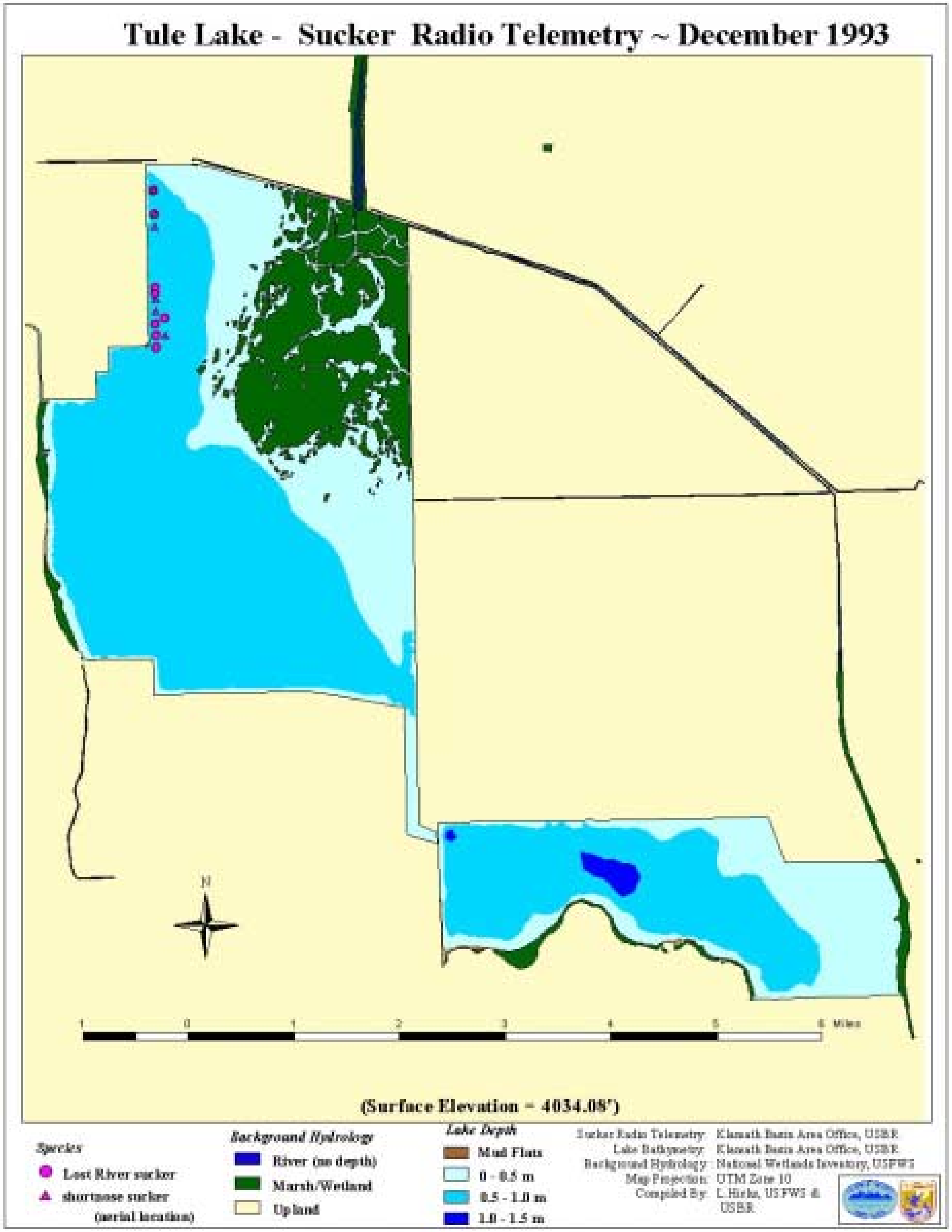
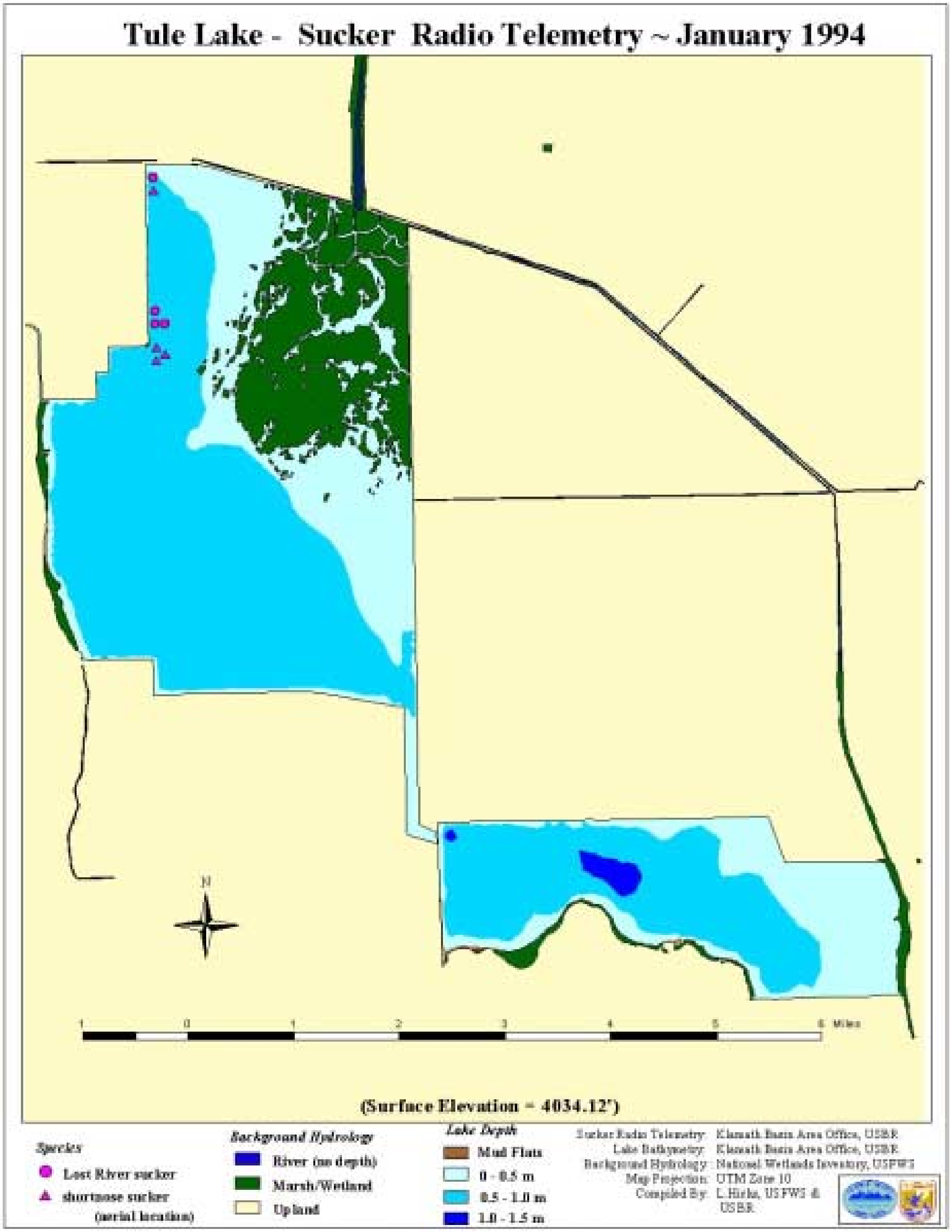

Tule Lake - Sucker Radio Telemetry ~ November 1993
N
1
0
1
2
3
4
5
6 Miles
(Surface Elevation = 4034.19')
Species
Lost River sucker
shortnose sucker
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hicks, USFWS & USBR

Figure 10



Tule Lake - Sucker Radio Telemetry ~ December 1993
N
1
0
1
2
3
4
5
6 Miles
(Surface Elevation = 4034.08')
Species
Lost River sucker
shortnose sucker
(aerial location)
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hicks, USFWS & USBR

Figure 11



Tule Lake - Sucker Radio Telemetry ~ January 1994
N
1 0 1 2 3 4 5 6 Miles
(Surface Elevation = 4034.12')
Species
Lost River sucker
shortnose sucker
(aerial location)
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hicks, USFWS & USBR

Figure 12

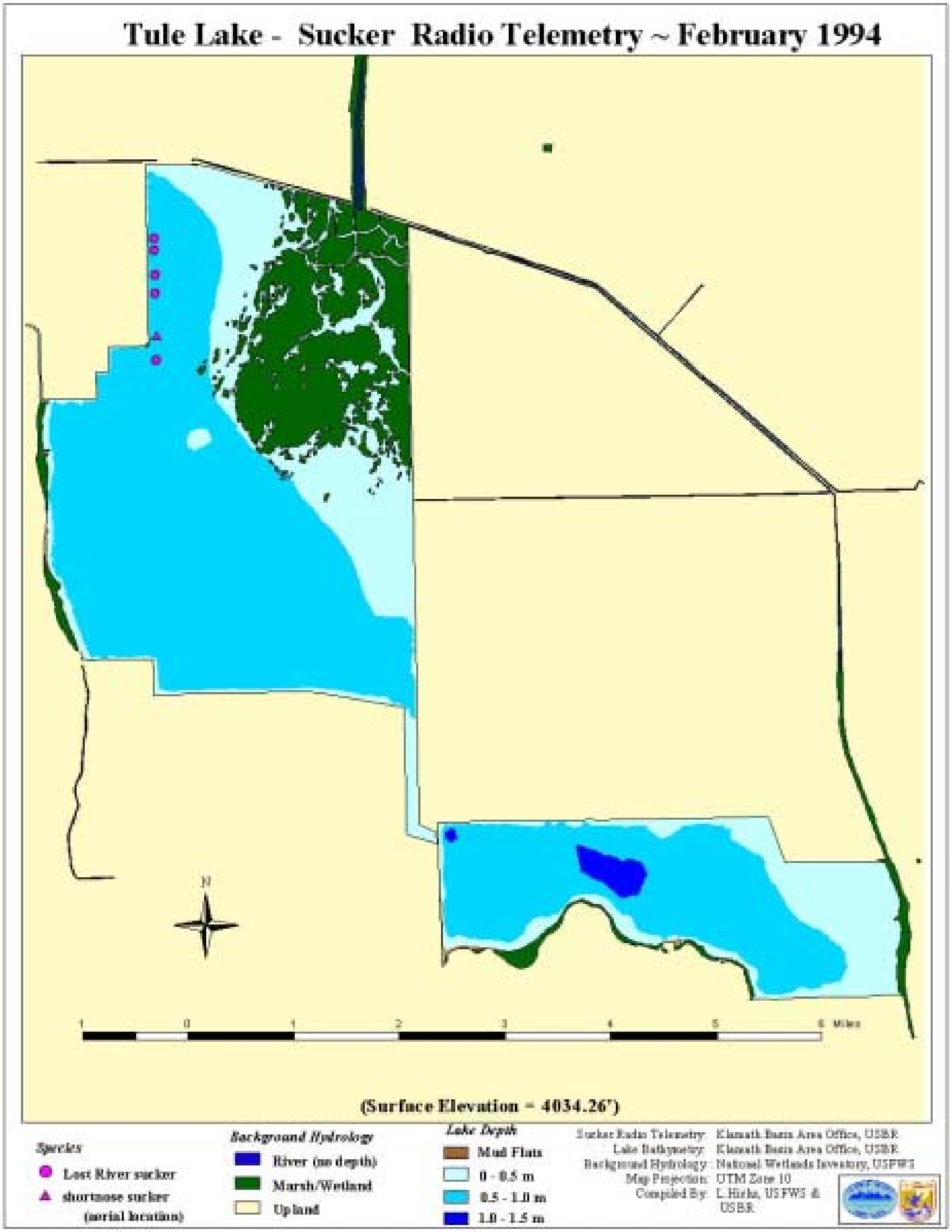

Tule Lake - Sucker Radio Telemetry ~ February 1994
N
1 0 1 2 3 4 5 6 Miles
(Surface Elevation = 4034.26')
Species
Lost River sucker
shortnose sucker
(aerial location)
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By:

Figure 13

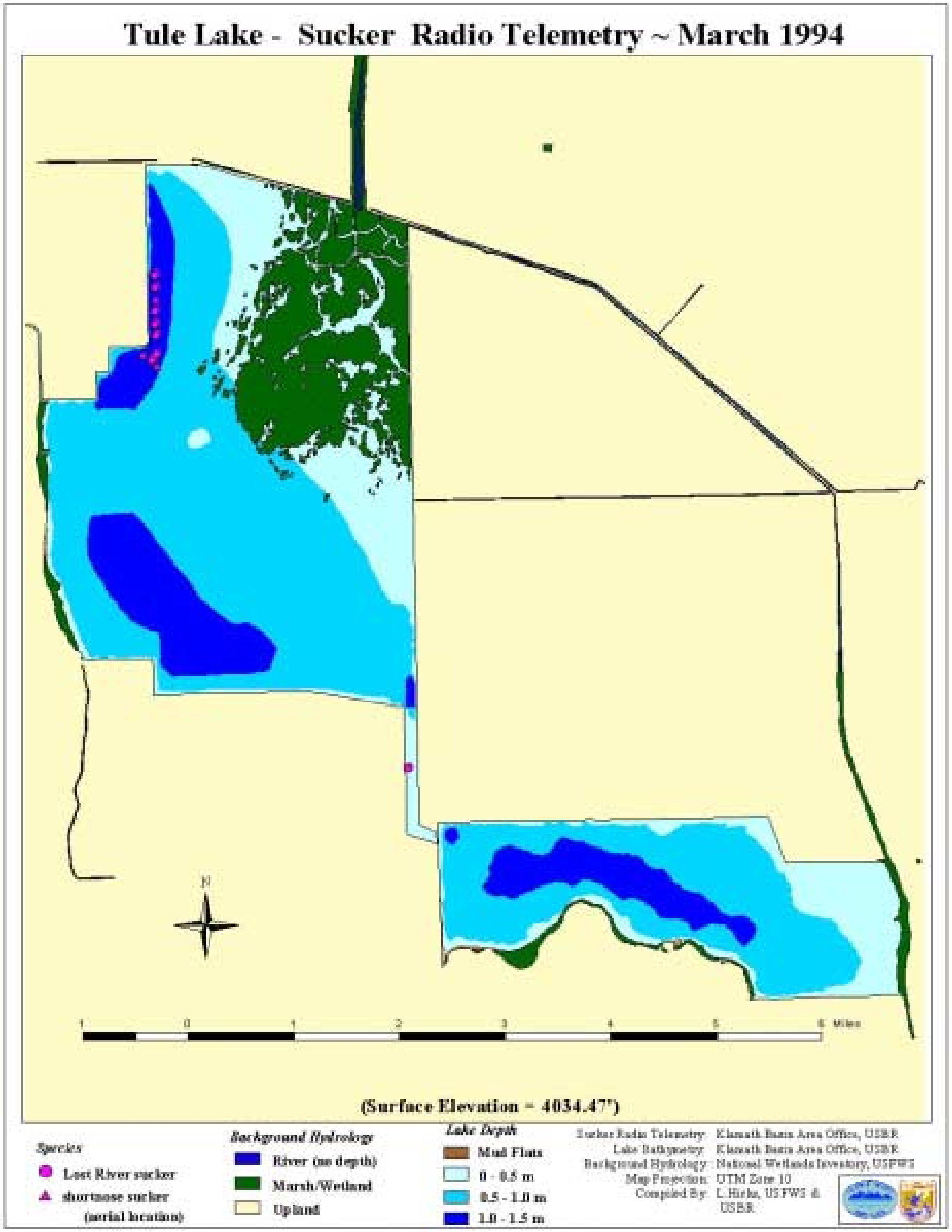

Tule Lake - Sucker Radio Telemetry ~ March 1994
N
1 0 1 2 3 4 5 6 Miles
(Surface Elevation = 4034.47')
Species
Lost River sucker
shortnose sucker
(aerial location)
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L. Hicks, USFWS & USBR

Figure 14

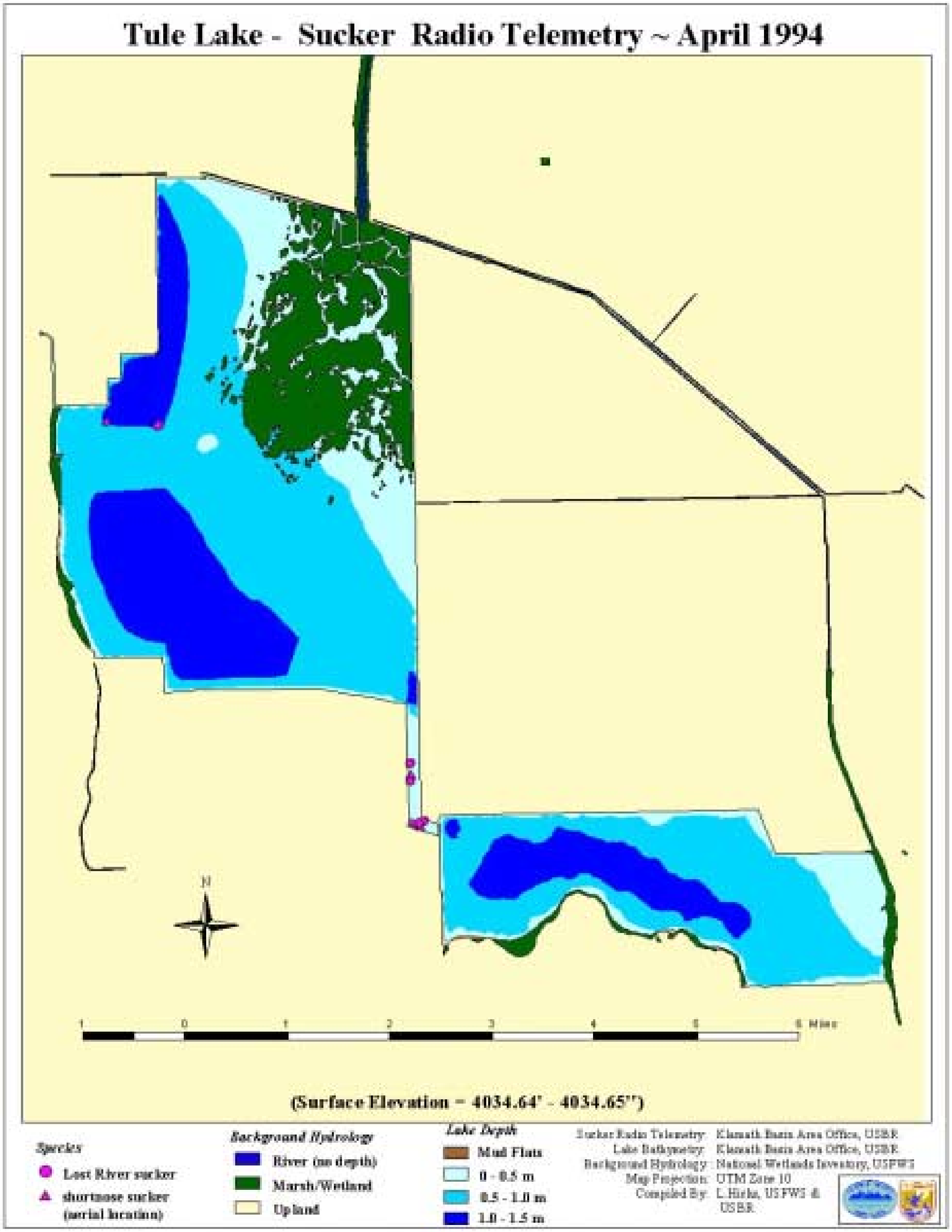

Tule Lake - Sucker Radio Telemetry ~ April 1994
N
1
0
1
2
3
4
5
6 Miles
(Surface Elevation = 4034.64' - 4034.65'')
Species
Lost River sucker
shortnose sucker
(aerial location)
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hicks, USFWS & USBR

Figure 15

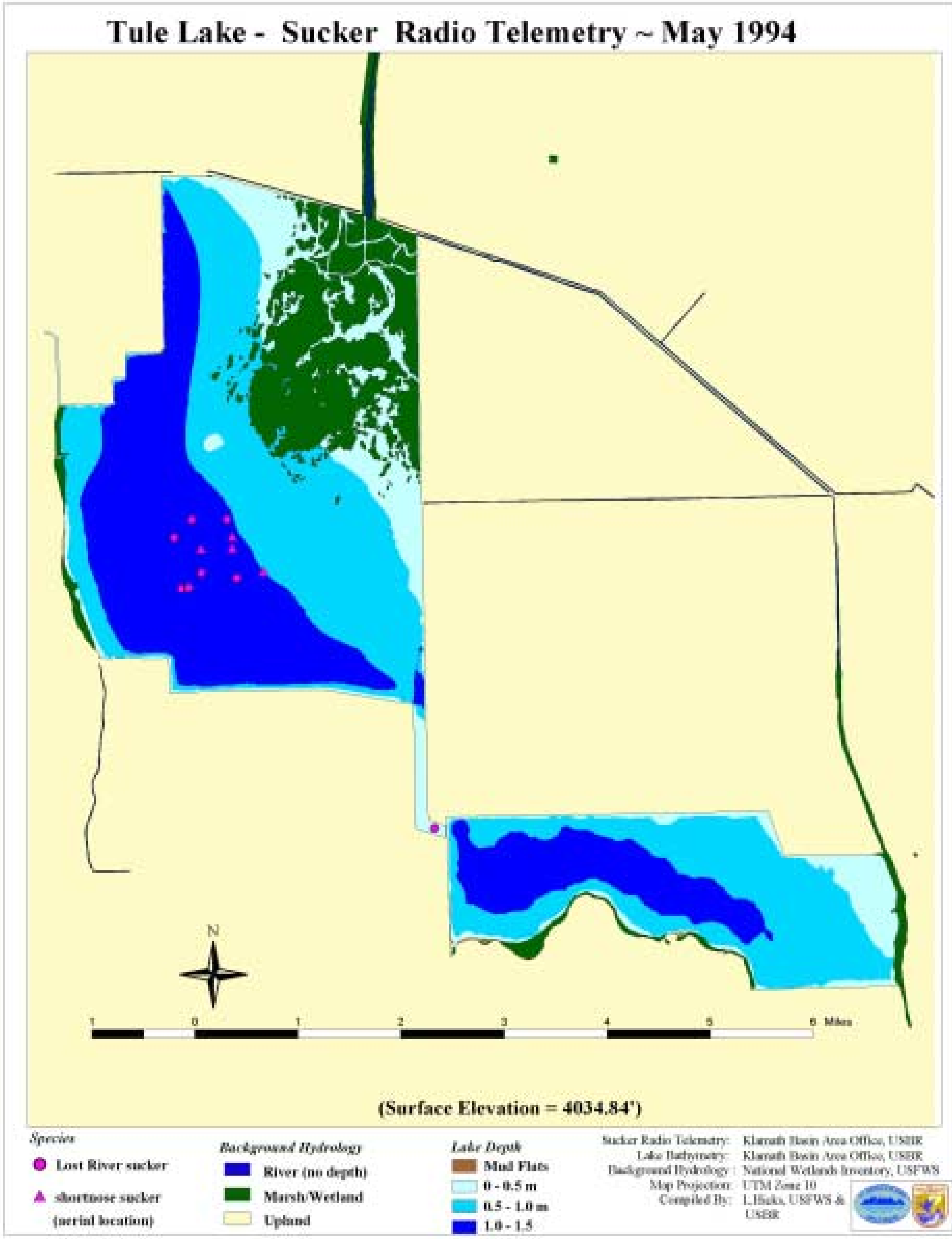

Tule Lake - Sucker Radio Telemetry ~ May 1994
N
1
0
1
2
3
4
5
6 Miles
(Surface Elevation = 4034.84')
Species
Lost River sucker
shortnose sucker
(aerial location)
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hicks, USFWS & USBR

Figure 16

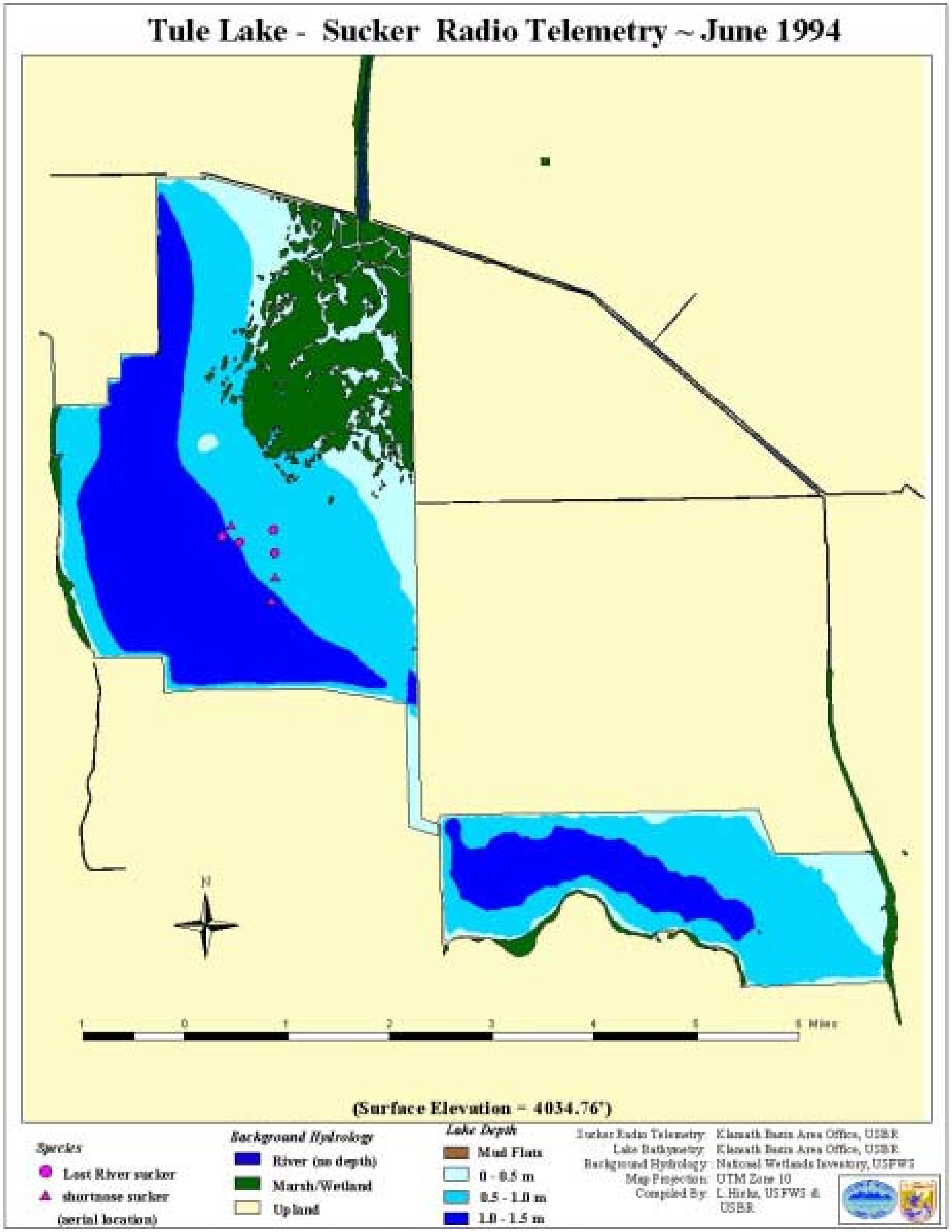

Tule Lake - Sucker Radio Telemetry ~ June 1994
N
1
0
1
2
3
4
5
6 Miles
(Surface Elevation = 4034.76')
Species
Lost River sucker
shortnose sucker
(aerial location)
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hirla, USFWS & USBR

Figure 17

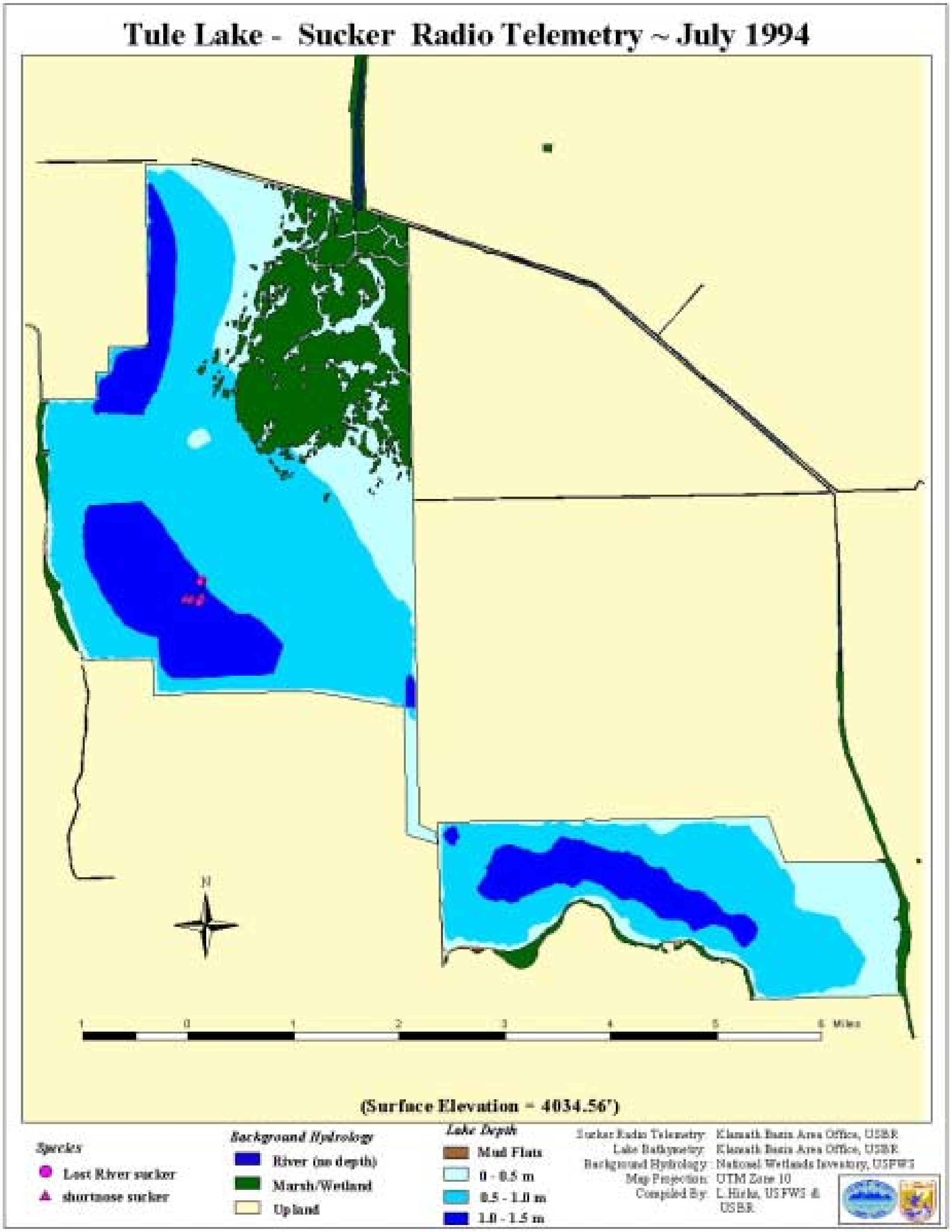
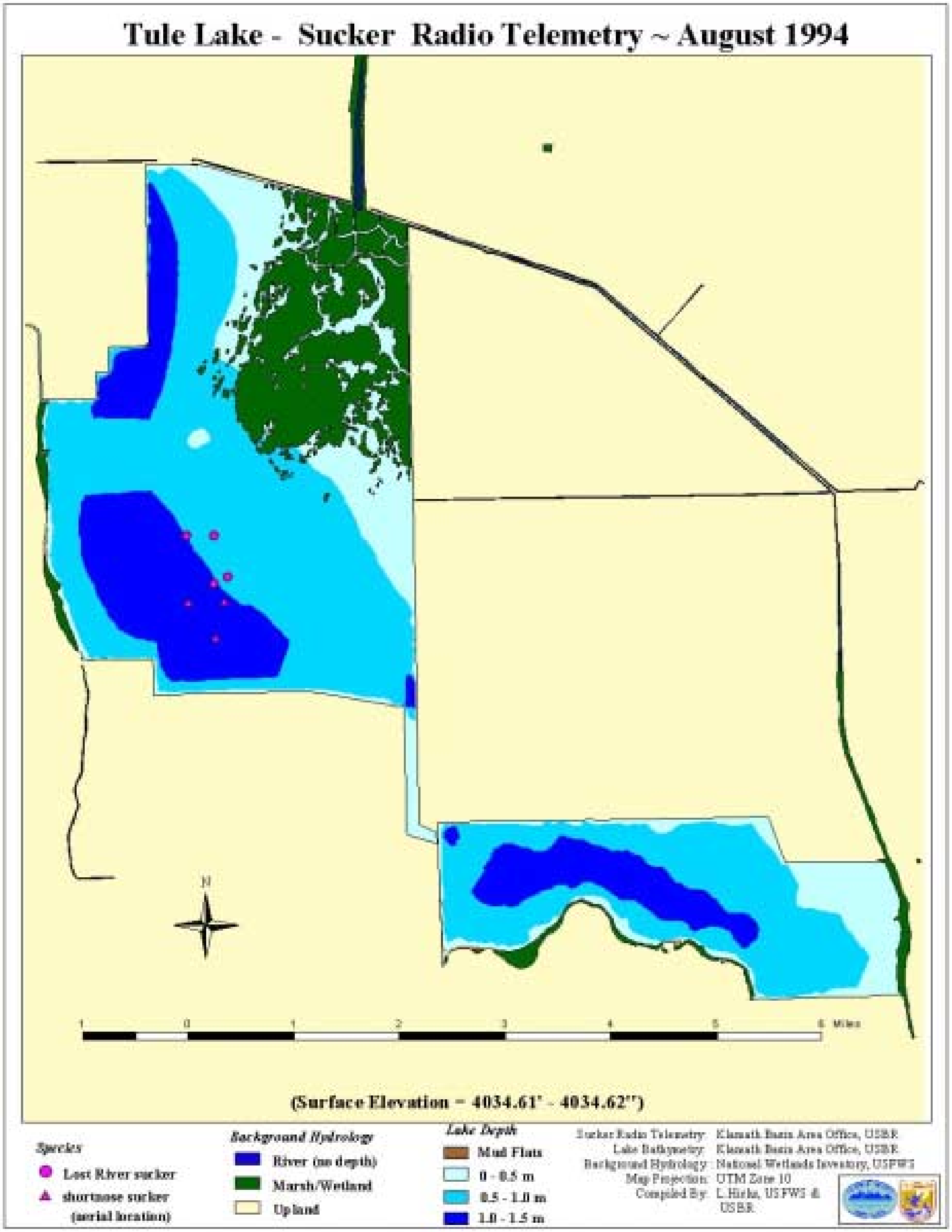

Tule Lake - Sucker Radio Telemetry ~ July 1994
N
1
0
1
2
3
4
5
6 Miles
(Surface Elevation = 4034.56')
Species
Lost River sucker
shortnose sucker
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hicks, USFWS & USBR

Figure 18



Tule Lake - Sucker Radio Telemetry ~ August 1994
N
1
0
1
2
3
4
5
6 Miles
(Surface Elevation = 4034.61' - 4034.62'')
Species
Lost River sucker
shortnose sucker
(aerial location)
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hicks, USFWS & USBR

Figure 19

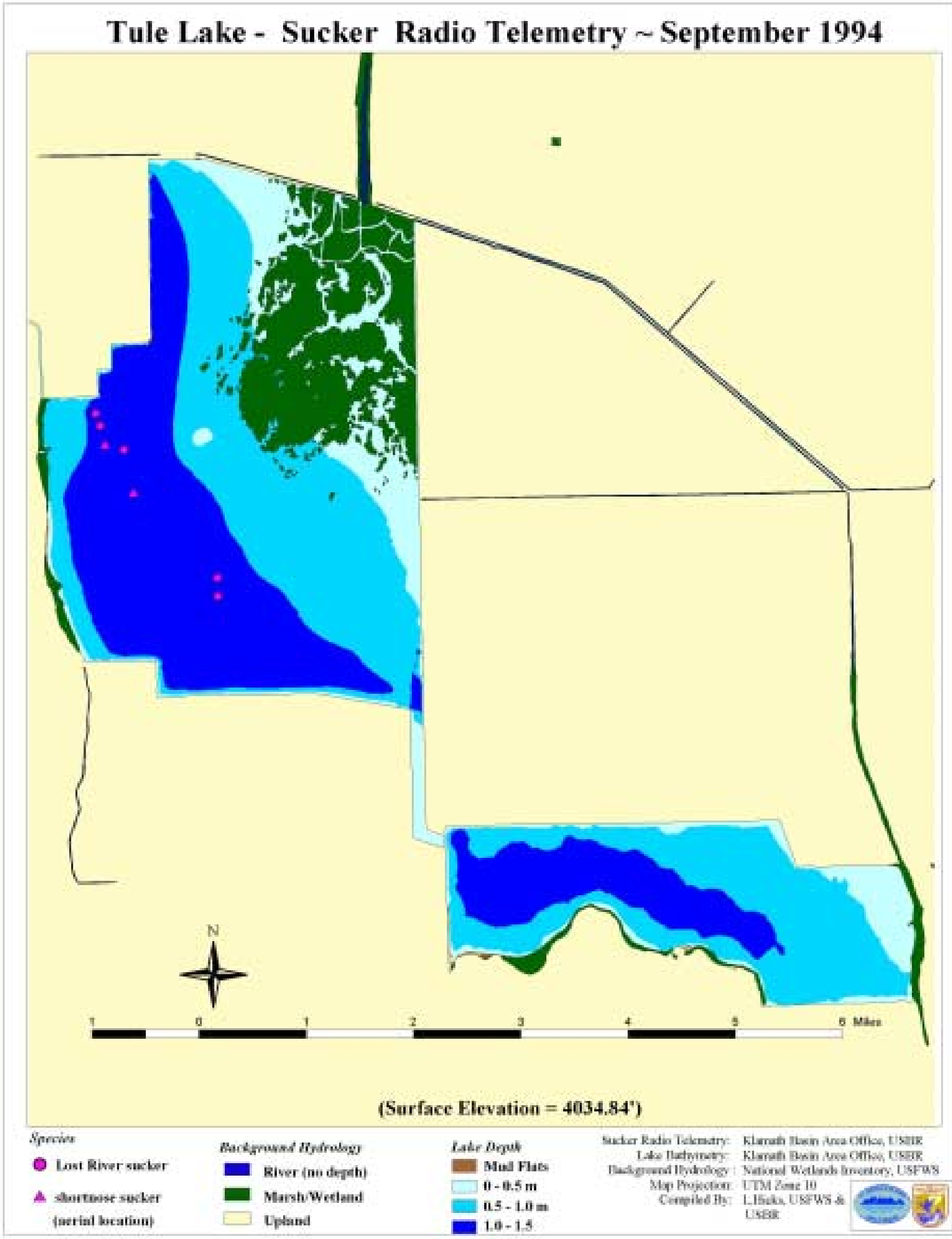

Tule Lake - Sucker Radio Telemetry ~ September 1994
N
1 0 1 2 3 4 5 6 Miles
(Surface Elevation = 4034.84')
Species
Lost River sucker
shortnose sucker
(aerial location)
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hicks, USFWS & USBR

Figure 20

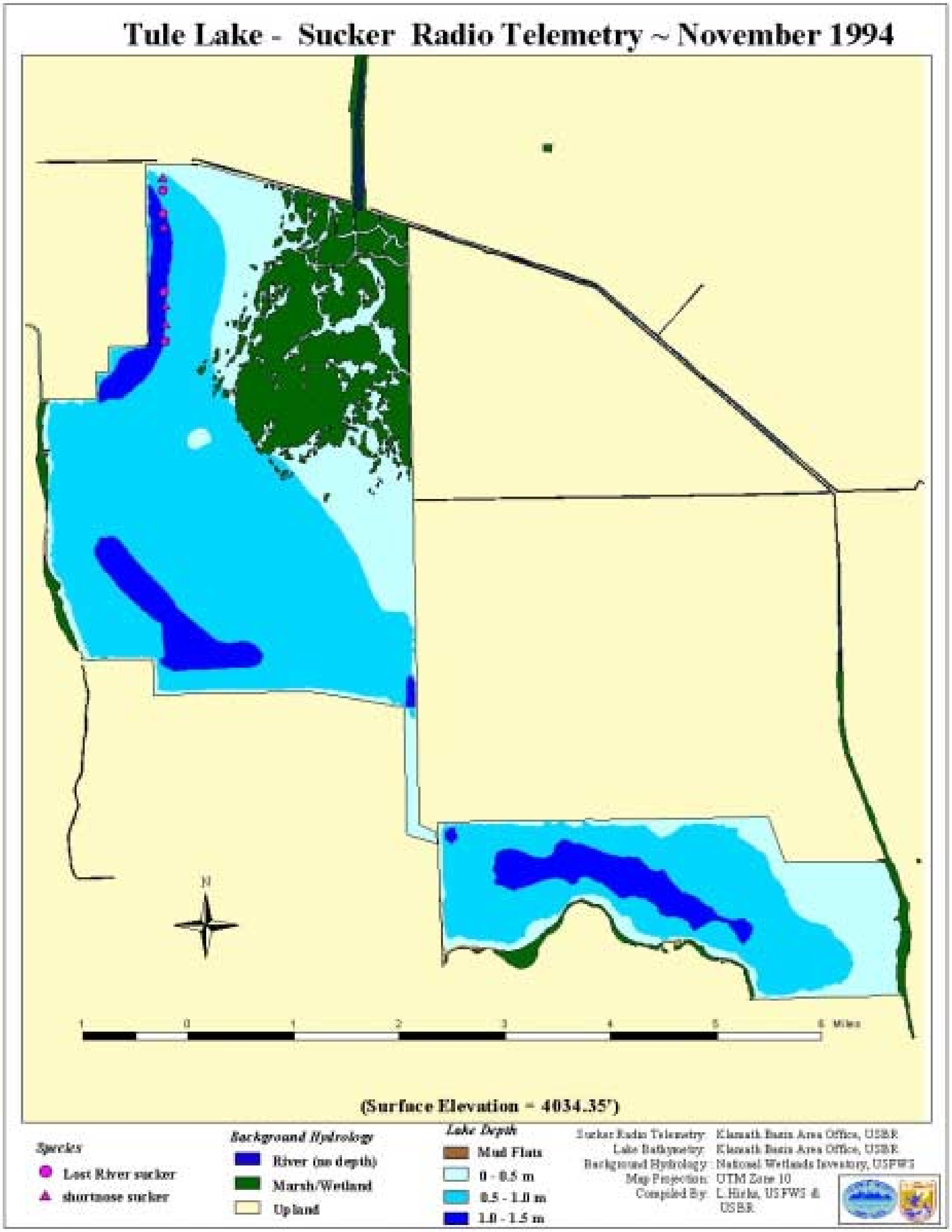
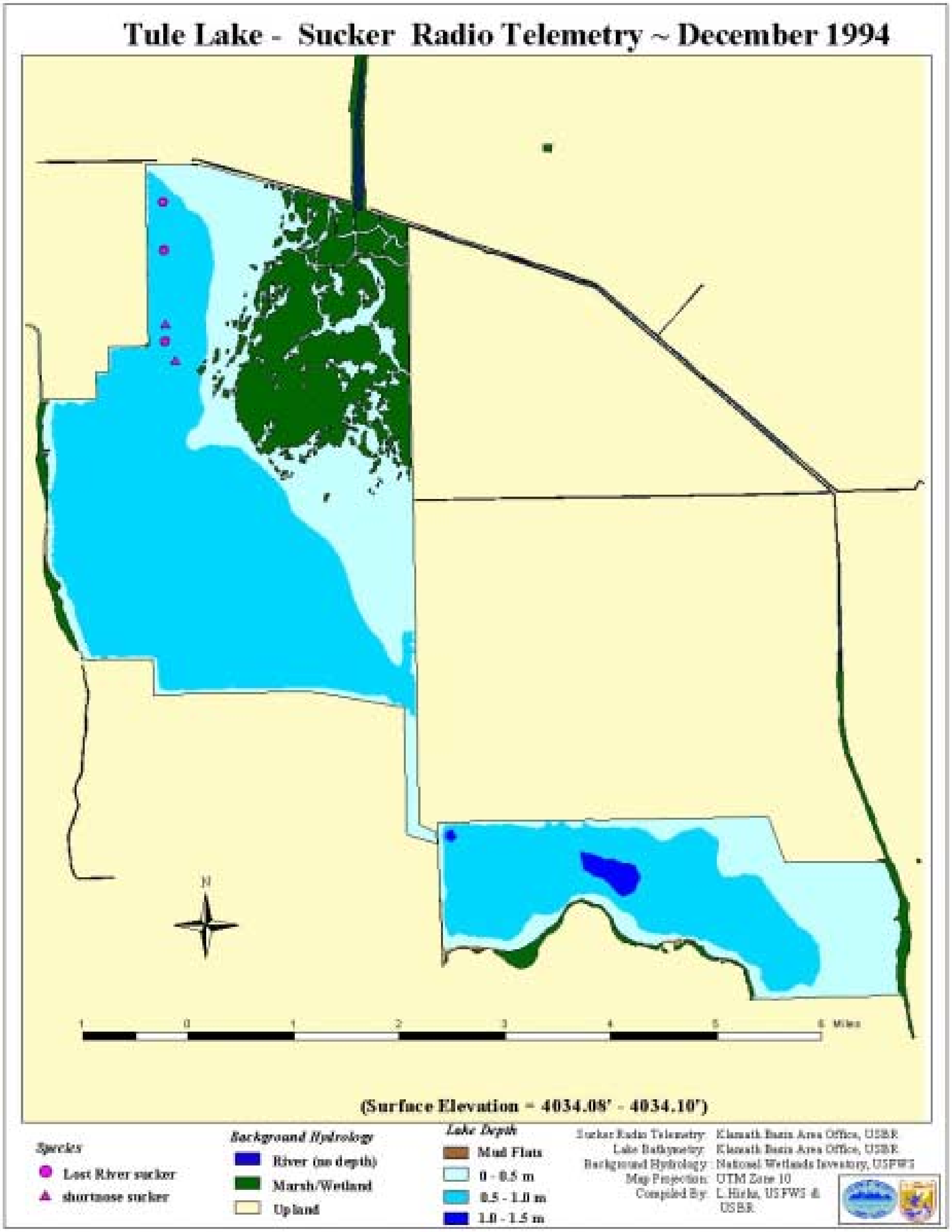

Tule Lake - Sucker Radio Telemetry ~ November 1994
N
1 0 1 2 3 4 5 6 Miles
(Surface Elevation = 4034.35')
Species
Lost River sucker
shortnose sucker
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hicks, USFWS & USBR

Figure 21



Tule Lake - Sucker Radio Telemetry ~ December 1994
N
1 0 1 2 3 4 5 6 Miles
(Surface Elevation = 4034.08' - 4034.10')
Species
Lost River sucker
shortnose sucker
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L. Hirha, USFWS & USBR

Figure 22

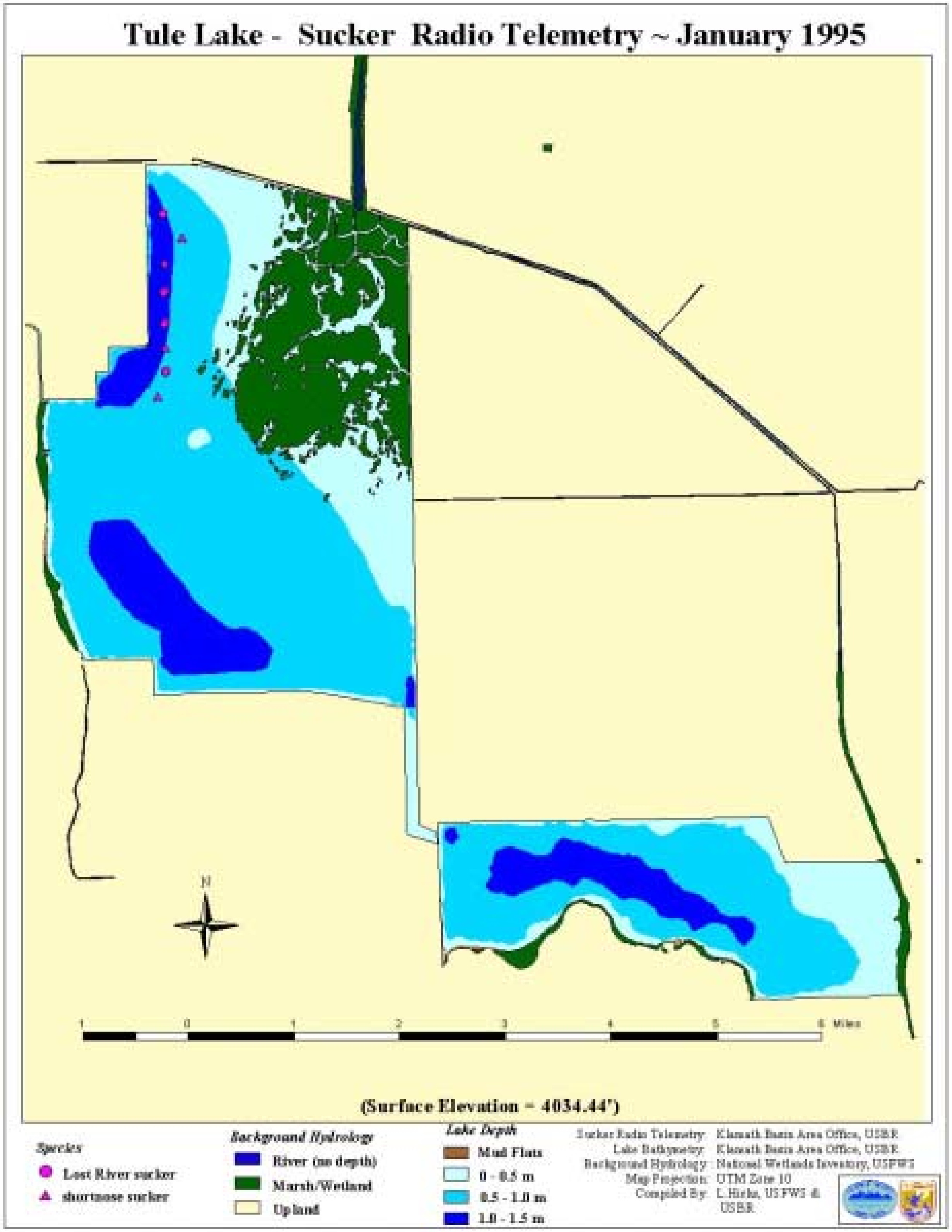
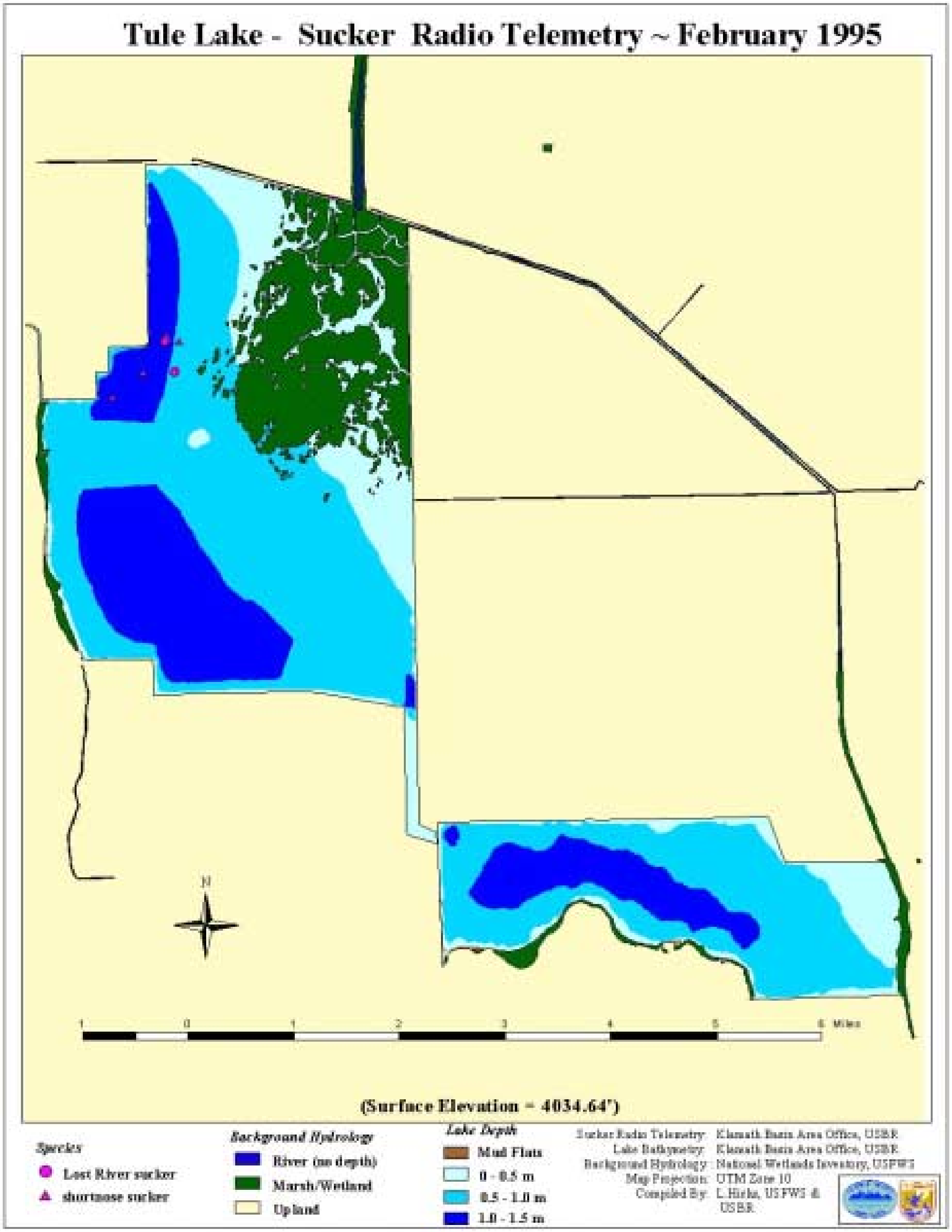

Tule Lake - Sucker Radio Telemetry ~ January 1995
N
1 0 1 2 3 4 5 6 Miles
(Surface Elevation = 4034.44')
Species
Lost River sucker
shortnose sucker
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hicks, USFWS & USBR

Figure 23



Tule Lake - Sucker Radio Telemetry ~ February 1995
N
1 0 1 2 3 4 5 6 Miles
(Surface Elevation = 4034.64')
Species
Lost River sucker
shortnose sucker
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L. Hicks, USFWS & USBR

Figure 24

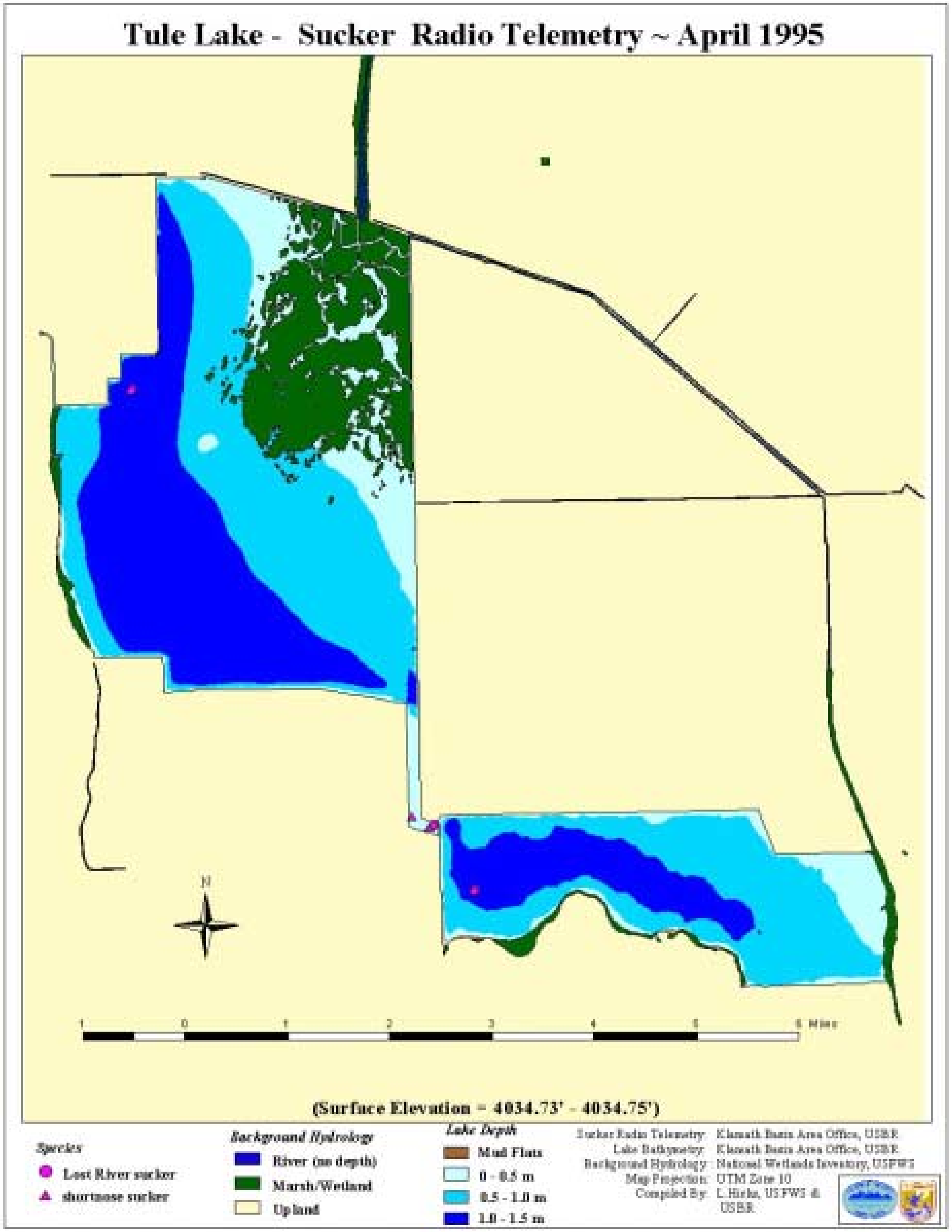

Tule Lake - Sucker Radio Telemetry ~ April 1995
N
1 0 1 2 3 4 5 6 Miles
(Surface Elevation = 4034.73' - 4034.75')
Species
Lost River sucker
shortnose sucker
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L.Hicks, USFWS & USBR

Figure 25

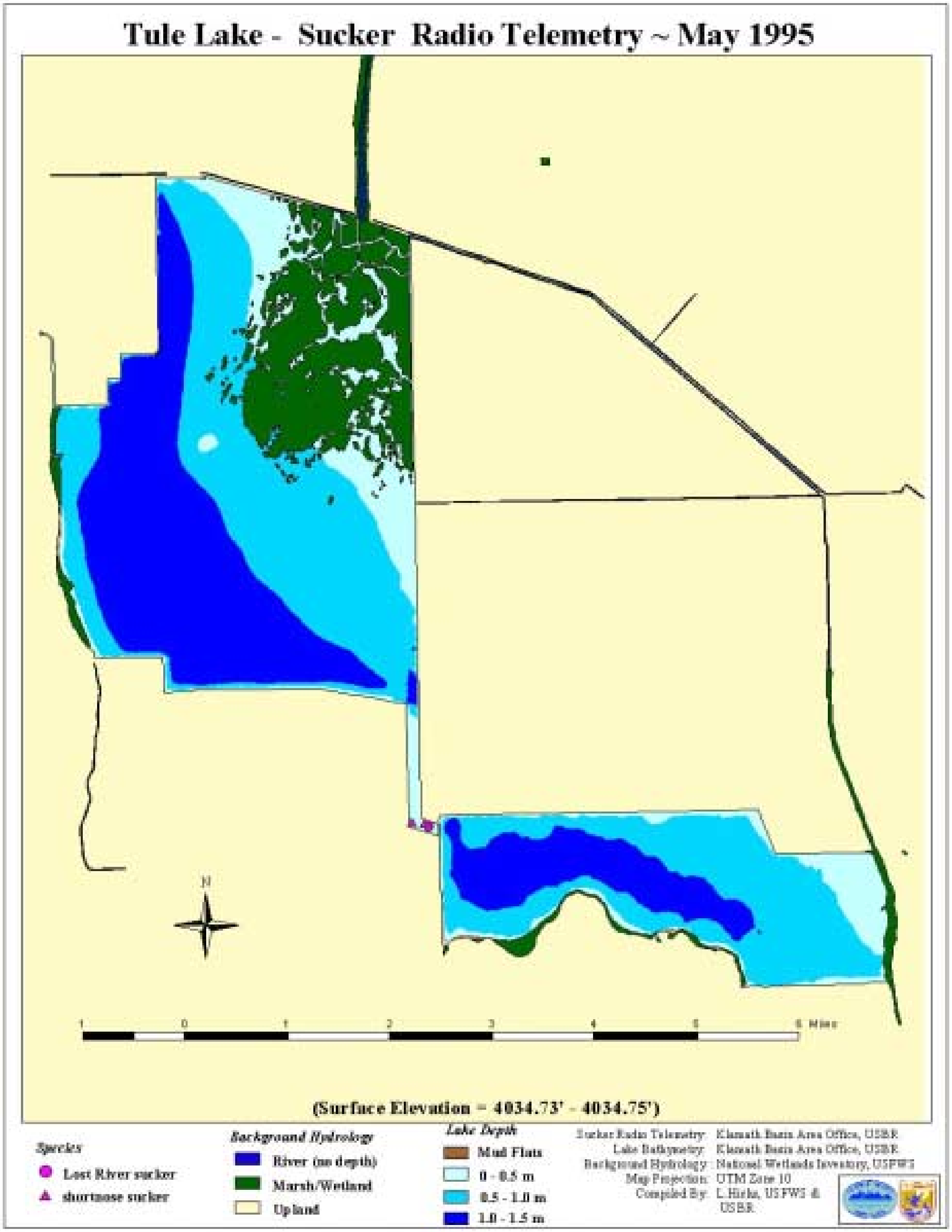

Tule Lake - Sucker Radio Telemetry ~ May 1995
N
(Surface Elevation = 4034.73' - 4034.75')
Species
Lost River sucker
shortnose sucker
Background Hydrology
River (no depth)
Marsh/Wetland
Upland
Lake Depth
Mud Flats
0 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
Sucker Radio Telemetry: Klamath Basin Area Office, USBR
Lake Bathymetry: Klamath Basin Area Office, USBR
Background Hydrology: National Wetlands Inventory, USFWS
Map Projection: UTM Zone 10
Compiled By: L. Hicks, USFWS & USBR

Figure 26

Table 2. Radio-tagged suckers and associated water quality, Tule Lake National Widllife Refuge, California, 1993-1995

USBR-TULE LAKE RADIO TELEMETRY
4/21/93 THRU 5/4/95

DATE	FISH	TIME	LATDEG	LATMINSEC	LONGDEG	LONGMINSEC	AIR °C	STEMP °C	SDO (mg/l)	SCOND (aeS/cm)	SPH (units)	BDEPTH (m)	BTEMP °C	BDO (mg/l)	BCOND (aeS/cm)	BPH (units)
21-May-93	C			52.80		32.50						1.0	13.78	8.70	986	8.47
21-May-93	B		41	52.80	121	32.80						1.0	14.02	8.00	864	8.50
21-May-93	E		41	52.50	121	31.90						1.0	14.52	7.72	895	8.46
21-May-93	H		41	52.50	121	31.30						1.0	14.55	7.67	893	8.43
21-May-93	J		41	52.50	121	31.20						1.0	14.68	7.65	890	8.43
21-May-93	F		41	52.50	121	30.80						1.0	14.81	7.98	900	8.49
07-Jun-93	H		41		121		17	12.38	9.52	916	8.40	0.9	12.38	9.81	917	8.40
07-Jun-93	I		41		121			12.28	9.48	809	8.47	0.9	12.28	9.36	809	8.47
07-Jun-93	B		41		121			12.16	9.77	793	8.64	0.9	12.03	10.12	795	8.64
07-Jun-93	A		41		121			12.79	9.64	836	8.47	0.9	12.74	8.91	836	8.47
07-Jun-93	D		41		121			12.89	8.08	811	8.49	1.0	12.87	7.68	814	8.48
09-Jun-93	H		41	53.50	121	31.95	27	19.06	9.39	917	8.43	1.0	14.37	10.32	904	8.43
09-Jun-93	G		41	53.45	121	31.55		17.29	10.63	909	8.49	0.9	13.41	8.99	903	8.53
30-Jun-93	B		41	53.30	121	30.80	29	20.64	7.71	906	8.81	0.9	18.98	6.81	902	8.79
30-Jun-93	I		41	53.30	121	30.75		20.51	7.65	895	8.79	0.8	20.38	8.40	893	8.80
01-Jul-93	J		41	53.23	121	32.14		21.90	7.02	927	8.72	0.9	19.10	6.97	909	8.67
01-Jul-93	A		41	53.22	121	31.56		19.54	7.79	908	8.70	0.8	18.57	7.34	911	8.66
01-Jul-93	F		41	53.13	121	31.39		22.65	8.33	926	8.77	0.8	18.12	7.58	894	8.78
01-Jul-93	H		41	53.14	121	31.52		21.71	7.87	927	8.72	0.8	18.29	7.45	901	8.79
01-Jul-93	D		41	53.33	121	31.45		21.64	8.44	929	8.79	0.7	18.82	7.90	923	8.75
01-Jul-93	E		41	53.43	121	31.44		19.42	9.62	911	8.86	0.8	18.52	8.16	899	8.82
01-Jul-93	C		41	53.26	121	31.23		19.63	9.71	907	8.85	0.7	19.30	9.22	905	8.83
01-Jul-93	G		41	53.16	121	31.54		21.60	8.16	917	8.78	0.8	20.62	7.92	923	8.79
14-Jul-93	J		41	53.34	121	31.78		19.08	8.35	961	9.14	1.0	18.85	7.86	961	9.14
14-Jul-93	F		41	53.34	121	31.69		19.10	9.70	960	9.15	1.0	19.05	8.97	959	9.15
14-Jul-93	G		41	53.38	121	31.58		19.08	9.10	963	9.18	1.5	19.07	9.63	963	9.18
14-Jul-93	G		41	53.41	121	31.88		18.93	8.48	962	9.16	1.0	18.94	8.20	962	9.18
14-Jul-93	J		41	53.25	121	31.69		18.78	8.76	958	9.20	1.0	18.83	8.60	960	9.20
14-Jul-93	F		41	53.12	121	32.05		18.73	8.70	946	9.28	1.0	18.80	8.31	943	9.28
15-Jul-93	B		41	52.44	121	31.47		17.42	8.07	965	9.20	0.9	16.85	7.11	959	9.20
15-Jul-93	D		41	53.26	121	31.61		18.01	8.84	967	9.18	0.8	17.46	8.63	962	9.18
15-Jul-93	E		41	53.26	121	31.27		18.48	8.60	951	9.23	0.8	18.20	8.48	945	9.23
15-Jul-93	A		41	53.58	121	31.53		18.69	8.95	956	9.16	0.8	18.48	8.79	960	9.16
15-Jul-93	I		41	53.09	121	32.21		20.06	8.36	948	9.24	0.8	19.50	7.55	951	9.23
15-Jul-93	C		41	53.20	121	31.11		19.25	8.52	957	9.22	0.9	18.89	7.60	956	9.20
15-Jul-93	H		41	53.20	121	32.11		19.27	8.78	960	9.18	0.9	19.22	8.49	952	9.18
02-Aug-93	F	1230	41	53.73	121	31.80	31	22.80	8.50	903	9.50	0.9	20.70	7.70	903	9.50
02-Aug-93	G		41	52.80	121	32.27		24.11	8.11	913	9.40	0.9	20.00	8.02	910	9.47
02-Aug-93	I		41	52.74	121	32.00		23.20	8.30	905	9.45	0.9	19.80	8.20	908	9.50
02-Aug-93	C		41	53.71	121	31.88		24.40	8.50	910	9.45	0.9	20.30	7.80	905	9.50
02-Aug-93	E		41	53.67	121	31.78		23.80	8.50	903	9.50	0.9	20.20	8.00	903	9.50
02-Aug-93	A		41	53.53	121	31.78		25.00	8.00	900	9.40	0.9	21.30	7.80	894	9.50
02-Aug-93	H		41	53.49	121	31.75		25.90	7.70	900	9.40	0.9	21.60	8.00	893	9.50
02-Aug-93	B		41	53.50	121	31.30		25.70	7.50	912	9.40	0.8	21.10	7.80	901	9.50
02-Aug-93	J		41	53.50	121	31.40	33	25.90	7.60	908	9.40	0.9	20.70	8.80	901	9.50
02-Aug-93	D		41	53.50	121	31.50		25.50	8.00	902	9.40	0.9	21.70	8.80	893	9.50
12-Aug-93	B	1140	41	53.19	121	31.72	23	20.22	7.80	982	9.41	0.9	17.46	7.14	980	9.39
12-Aug-93	I	1150	41	53.18	121	31.87		20.60	7.48	984	9.42	0.9	17.90	6.87	986	9.38
12-Aug-93	D	1200	41	53.14	121	31.87		19.25	7.46	994	9.40	0.9	17.89	6.94	977	9.39
12-Aug-93	H	1210	41	53.23	121	32.01		20.67	7.24	979	9.41	0.9	18.11	6.44	955	9.43
12-Aug-93	C	1225	41	52.91	121	31.95		20.65	7.87	950	9.46	0.9	17.68	6.39	979	9.37
12-Aug-93	G	1235	41	52.95	121	31.73		21.17	7.33	914	9.55	0.9	17.50	6.71	980	9.37
12-Aug-93	E	1250	41	52.96	121	31.52		21.94	7.85	882	9.63	0.9	18.12	7.95	866	9.72
12-Aug-93	F	1330	41	53.38	121	32.10		20.20	7.40	963	9.42	0.9	18.26	7.74	949	9.45
12-Aug-93	A	1400	41	53.41	121	31.98		22.38	7.70	1030	9.41	0.7	17.87	7.56	1005	9.39
12-Aug-93	J	1415	41	53.58	121	31.70		20.46	7.59	1016	9.43	0.6	17.27	7.51	991	9.39
18-Aug-93	I	1335	41	53.16	121	31.96	28	23.14	7.45	830	9.43	1.1	19.64	7.78	832	9.47
18-Aug-93	F		41	52.92	121	31.54	32	23.48	7.42	842	9.42	1.1	19.54	8.28	821	9.48
18-Aug-93	H		41	53.26	121	32.12	32	22.80	7.90	844	9.42	1.1	18.75	9.10	842	9.49
18-Aug-93	B		41	53.25	121	31.95	32	23.38	7.84	841	9.41	1.1	19.21	8.22	835	9.47
18-Aug-93	G	1430	41	52.64	121	32.15	32	23.57	7.23	839	9.41	1.1	19.02	8.48	830	9.46
18-Aug-93	J		41	53.70	121	32.00	32	22.30	7.91	837	9.43	1.1	20.03	7.59	832	9.45
18-Aug-93	D		41	53.13	121	31.97	32	23.70	7.45	838	9.42	1.1	19.44	8.92	839	9.49
18-Aug-93	A		41	53.22	121	31.88	32	23.76	7.40	855	9.40	1.1	19.35	9.21	829	9.49
18-Aug-93	C		41	53.56	121	32.01	33	22.55	7.80	873	9.44	1.1	18.92	9.58	856	9.51
18-Aug-93	E	1540	41	53.67	121	32.11	29	23.01	8.73	890	9.44	1.1	18.29	10.04	875	9.51
26-Aug-93	E	1340	41	53.40	121	31.77	33	18.97	7.95	804	9.54	1.0	17.04	9.83	740	9.62
26-Aug-93	I	1355	41	53.44	121	31.80	33	18.73	8.12	814	9.54	1.0	16.88	9.68	761	9.62
26-Aug-93	H	1410	41	53.16	121	32.00	33	19.14	8.30	766	9.56	1.0	16.64	9.51	722	9.63

Table 2. Radio-tagged suckers and associated water quality, Tule Lake National Widllife Refuge, California, 1993-1995

DATE	FISH	TIME	LATDEG	LATMINSEC	LONGDEG	LONGMINSEC	AIR °C	STEMP °C	SDO (mg/l)	SCOND (aeS/cm)	SPH (units)	BDEPTH (m)	BTEMP °C	BDO (mg/l)	BCOND (aeS/cm)	BPH (units)
26-Aug-93	A	1420	41	53.29	121	32.05	33	18.39	8.51	766	9.59	1.0	16.54	9.69	750	9.65
26-Aug-93	J	1430	41	53.40	121	31.97	33	19.37	8.65	794	9.55	1.0	16.52	10.06	747	9.64
07-Sep-93	C	1030	41	53.18	121	32.07	21	21.67	8.18	717	9.66	1.2	21.14	7.93	717	9.66
07-Sep-93	B	1040	41	53.18	121	32.08	21	21.82	8.10	712	9.64	1.1	21.22	8.10	713	9.65
07-Sep-93	D	1050	41	53.25	121	32.17	22	21.25	8.04	739	9.63	1.1	21.14	8.04	735	9.62
07-Sep-93	I	1125	41	53.57	121	32.07	22	21.99	8.15	765	9.61	1.0	20.76	8.46	757	9.62
07-Sep-93	G	1135	41	53.55	121	32.46	23	22.51	8.19	761	9.60	1.0	20.62	8.17	754	9.61
07-Sep-93	H	1145	41	53.68	121	32.07	23	21.75	8.22	760	9.51	1.0	20.41	8.39	752	9.62
07-Sep-93	J	1155	41	53.79	121	32.00	23	21.76	8.35	755	9.62	1.0	20.30	8.87	757	9.65
07-Sep-93	E	1205	41	53.78	121	32.11	24	22.89	8.08	766	9.60	1.0	19.96	9.20	759	9.66
07-Sep-93	F	1215	41	53.73	121	32.11	24	23.34	7.96	769	9.58	1.0	20.65	8.59	749	9.63
07-Sep-93	A	1225	41	53.57	121	32.04	24	23.38	8.13	764	9.58	1.0	21.22	8.97	754	9.62
22-Sep-93	G	1320	41	53.21	121	32.36	21	14.93	9.28	624	9.73	0.9	14.60	9.70	643	9.76
22-Sep-93	I	1335	41	53.18	121	32.26	21	15.21	11.40	646	8.20	0.9	14.43	10.35	669	9.79
22-Sep-93	E	1345	41	53.18	121	32.26	21	15.21	11.40	646	8.20	0.9	14.43	10.35	669	9.79
22-Sep-93	D	1410	41	53.20	121	31.95	18	15.77	9.61	674	9.77	0.9	14.36	11.03	682	9.81
22-Sep-93	J	1435	41	53.20	121	31.99	19	16.05	9.63	678	9.77	0.9	14.51	11.16	684	9.82
22-Sep-93	F	1420	41	53.31	121	31.94	19	15.88	10.16	673	9.75	0.9	14.28	11.50	671	9.81
22-Sep-93	H	1445	41	53.13	121	32.23	19	16.47	9.38	623	9.71	0.9	15.35	9.87	631	9.78
22-Sep-93	A	1500	41	53.00	121	32.24	19	16.55	9.22	619	9.70	0.9	15.38	9.93	596	9.76
22-Sep-93	B	1515	41	53.28	121	32.24	20	16.02	9.78	629	9.70	0.9	14.70	11.50	669	9.89
22-Sep-93	C	1525	41	53.39	121	32.12	20	16.05	9.80	635	9.71	0.9	15.06	11.60	651	9.78
08-Oct-93	J	1100	41	53.36	121	32.30	16	13.33	8.51	543	9.30	1.1	12.77	8.81	557	9.59
08-Oct-93	G		41	53.30	121	32.37		13.02	8.82	511	9.48	1.1	12.90	9.01	518	9.50
08-Oct-93	I		41	53.27	121	32.28	19	13.35	8.78	524	9.40	1.1	12.69	9.18	522	9.32
08-Oct-93	D		41	53.23	121	32.22	19	13.37	8.65	521	9.25	1.1	13.02	9.08	524	9.25
08-Oct-93	B		41	53.36	121	32.15		13.88	8.55	529	9.25	1.1	12.59	9.52	542	9.39
08-Oct-93	F		41	53.75	121	32.01		14.92	8.52	604	9.54	1.1	12.69	9.41	604	9.64
08-Oct-93	C		41	52.93	121	32.06		15.12	7.70	494	9.39	1.1	13.02	8.53	506	9.22
22-Oct-93	F	1400	41	53.11	121	32.45	19	13.09	11.72	540	9.34	1.0	12.43	14.07	540	9.36
22-Oct-93	B		41	53.23	121	32.75	20	14.38	12.19	581	9.27	1.0	12.30	12.58	574	9.27
25-Oct-93	I		41	54.34	121	33.17	19	14.88	8.17	614	9.26	0.5	12.48	9.45	602	9.43
25-Oct-93	D		41	54.44	121	32.75	19	14.28	6.84	600	9.34	0.9	11.97	6.77	605	9.36
25-Oct-93	C		41	54.50	121	32.74	20	14.11	7.10	602	9.33	0.9	12.51	6.83	608	9.35
25-Oct-93	G		41	54.53	121	32.70	21	14.81	7.66	609	9.34	0.9	11.70	7.37	618	9.35
25-Oct-93	H		41	54.66	121	32.76	20	14.92	8.36	602	9.34	0.9	11.68	8.09	445	9.33
25-Oct-93	A		41	55.50	121	32.27	20	14.33	9.67	334	9.44	1.0	12.16	9.38	351	9.45
25-Oct-93	B		41	55.32	121	32.25	20	14.71	10.38	316	9.49	1.0	12.64	10.51	325	9.49
25-Oct-93	E		41	55.39	121	32.33	20	14.71	10.38	316	9.49	1.0	12.64	10.51	325	9.49
25-Oct-93	J		41	55.30	121	32.34	20	14.01	10.02	358	9.39	1.0	12.03	8.96	372	9.27
08-Nov-93	C	1430	41	54.56	121	32.95		9.30	12.07	501	9.12	0.7	6.91	10.47	502	9.16
08-Nov-93	I	1435	41	54.69	121	32.54		8.26	13.20	482	9.31	0.5	7.96	13.77	482	9.39
08-Nov-93	G		41	54.74	121	32.48		8.52	15.29	397	9.47	0.5	7.78	14.01	365	9.45
08-Nov-93	E		41	55.36	121	32.43		7.76	13.01	290	9.67	1.0	6.50	12.55	284	9.72
08-Nov-93	A		41	55.53	121	32.46		8.09	11.33	310	9.26	1.0	6.92	10.95	322	9.29
08-Nov-93	F		41	56.21	121	32.57		7.11	13.08	311	9.49	0.9	7.19	11.87	330	9.48
08-Nov-93	J		41	55.59	121	32.51		7.96	11.73	329	9.39	0.9	6.86	13.79	366	9.54
08-Nov-93	H		41	55.24	121	32.83		7.14	15.32	328	9.49	1.0	7.02	11.93	331	9.49
08-Nov-93	D							6.88	13.09	320	9.52	1.0	6.68	11.51	330	9.51
31-May-94	I	1345	41	53.32	121	32.43	16	18.74	6.50	813		1.0	18.72	6.54	797	
31-May-94	H		41	53.33	121	32.36		18.64	6.80	814		1.0	18.62	6.72	812	
31-May-94	A	1419	41	53.32	121	32.35		18.58	7.31	815		1.0	18.58	7.01	815	
31-May-94		WATER Q. @ OUTSIDE (WEST) OF DONUT HOLE						19.22	12.66	763		1.0	19.01	15.67	760	
13-Jul-94	H		41	53.22	121	32.22	21	22.20	6.45	829	9.30	1.0	21.55	6.58	838	9.31
13-Jul-94	B		41	53.24	121	32.17		21.82	6.76	829	9.35	1.0	21.62	6.91	832	9.34
13-Jul-94	J		41	53.22	121	32.19		24.29	6.70	822	9.37	1.0	22.24	7.42	822	9.37
13-Jul-94	G		41	53.37	121	32.04		23.73	6.87	829	9.37	1.0	22.17	8.40	813	9.40
13-Jul-94	I		41	53.37	121	32.04		23.73	6.87	829	9.37	1.0	22.17	8.40	813	9.40
13-Jul-94	K		41	53.37	121	32.06		23.73	6.87	829	9.37	1.0	22.17	8.40	813	9.40
13-Jul-94	D		41	53.26	121	32.06		23.20	7.14	811	9.40	1.0	22.10	7.93	812	9.41
13-Jul-94	F		41	53.26	121	32.05		23.20	7.14	811	9.40	1.0	22.10	7.93	812	9.41
13-Jul-94	A		41	53.20	121	32.07		24.33	6.84	816	9.37	1.0	22.47	9.20	793	9.48
13-Jul-94		WQ		53.44		31.47		23.77	7.80	820	9.53	1.0	22.56	9.17	819	9.50
13-Jul-94		WQ		53.78		31.19		23.94	12.57	759	10.09					

		STEMP °C	SDO (mg/l)	SCOND (aeS/cm)	SPH (units)	BDEPTH (m)	BTEMP °C	BDO (mg/l)	BCOND (aeS/cm)	BPH (units)
MIN		6.88	6.45	290	8.20	0.5	6.5	6.4	284.0	8.4
MAX		25.90	15.32	1030	10.09	1.5	22.6	15.7	1005.0	9.9
MEAN		18.68	8.77	767	9.31	0.9	16.7	8.9	769.0	9.3
STD DEV		4.70	2.01	190	0.35	0.1	4.1	1.7	186.0	0.4
N		127	127	127	123	132	132	132	132	128

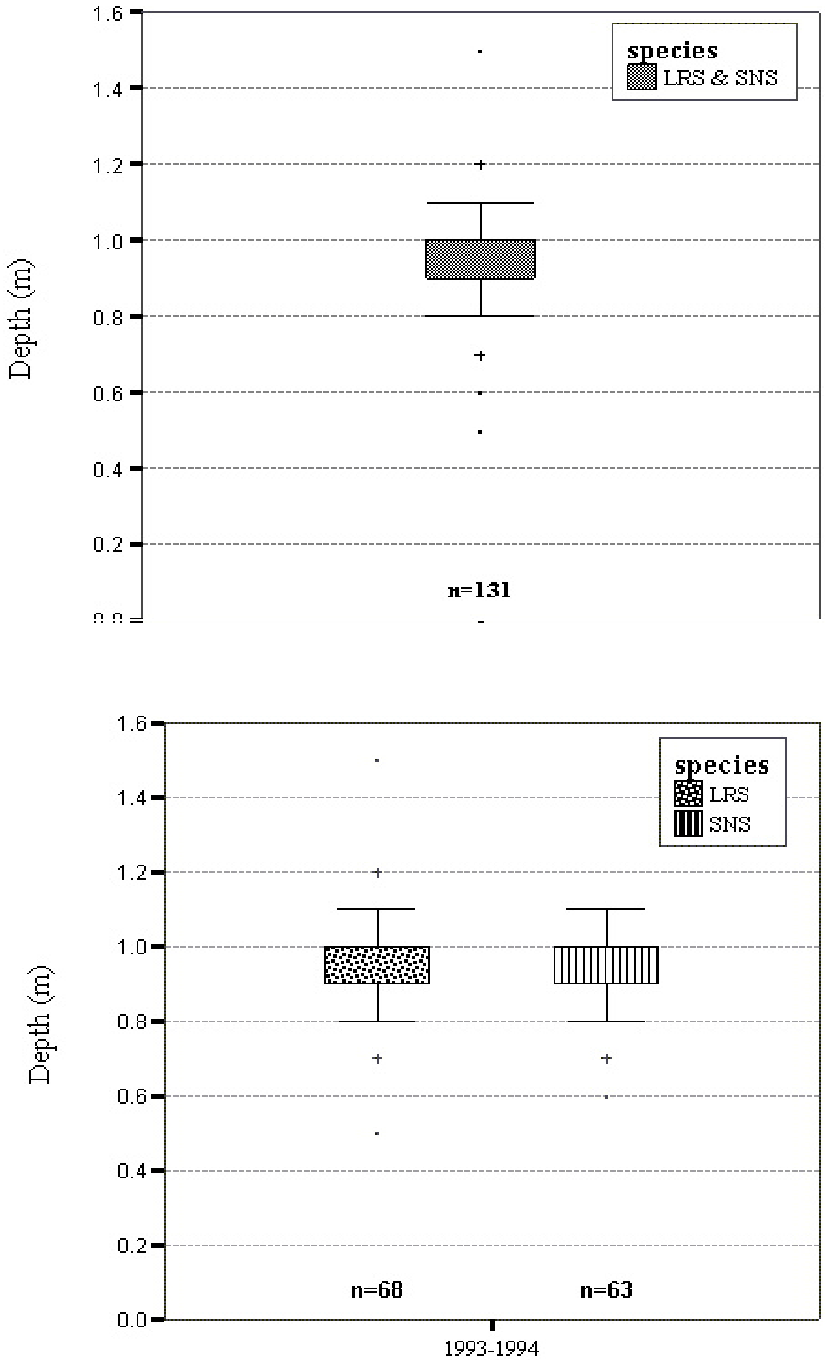
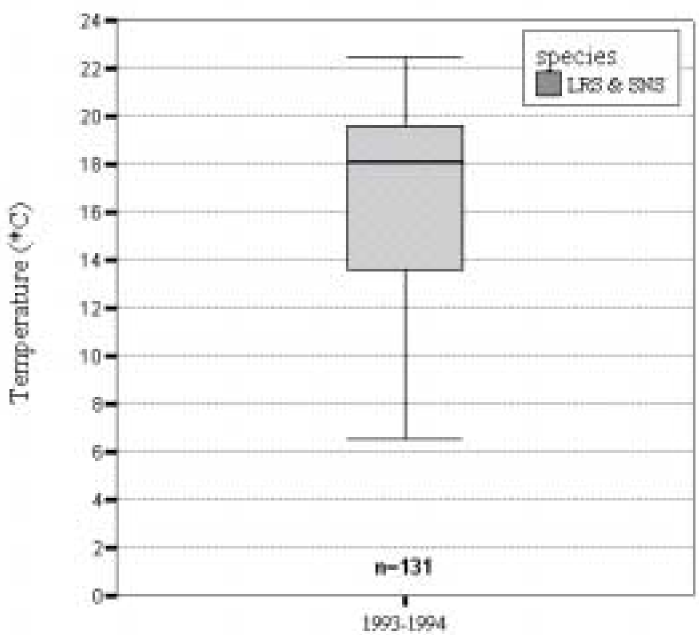


Figure 27. Near bottom water depth at sites where radio-tagged suckers were located, Tule Lake National Wildlife Refuge, California, 1993-1994.



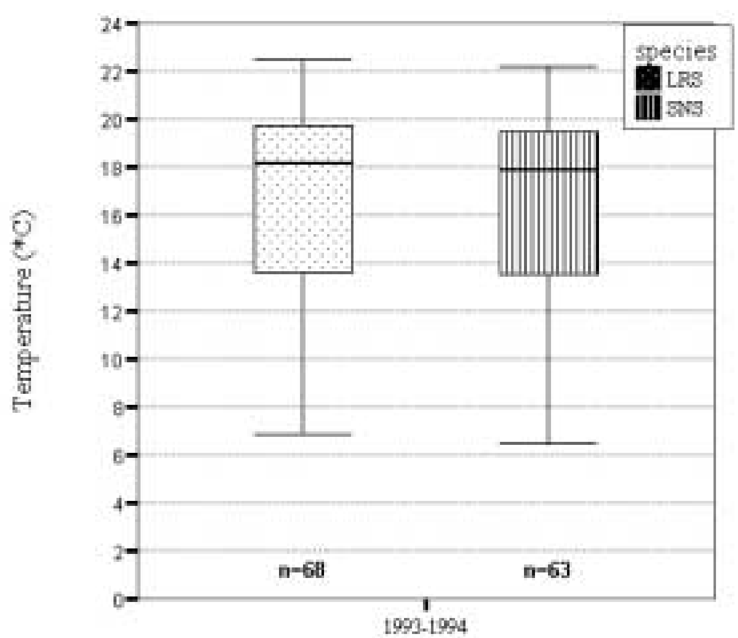


Figure 28. Near bottom temperature where radio-tagged suckers were located, Tule Lake National Wildlife Refuge, California, 1993-1994.

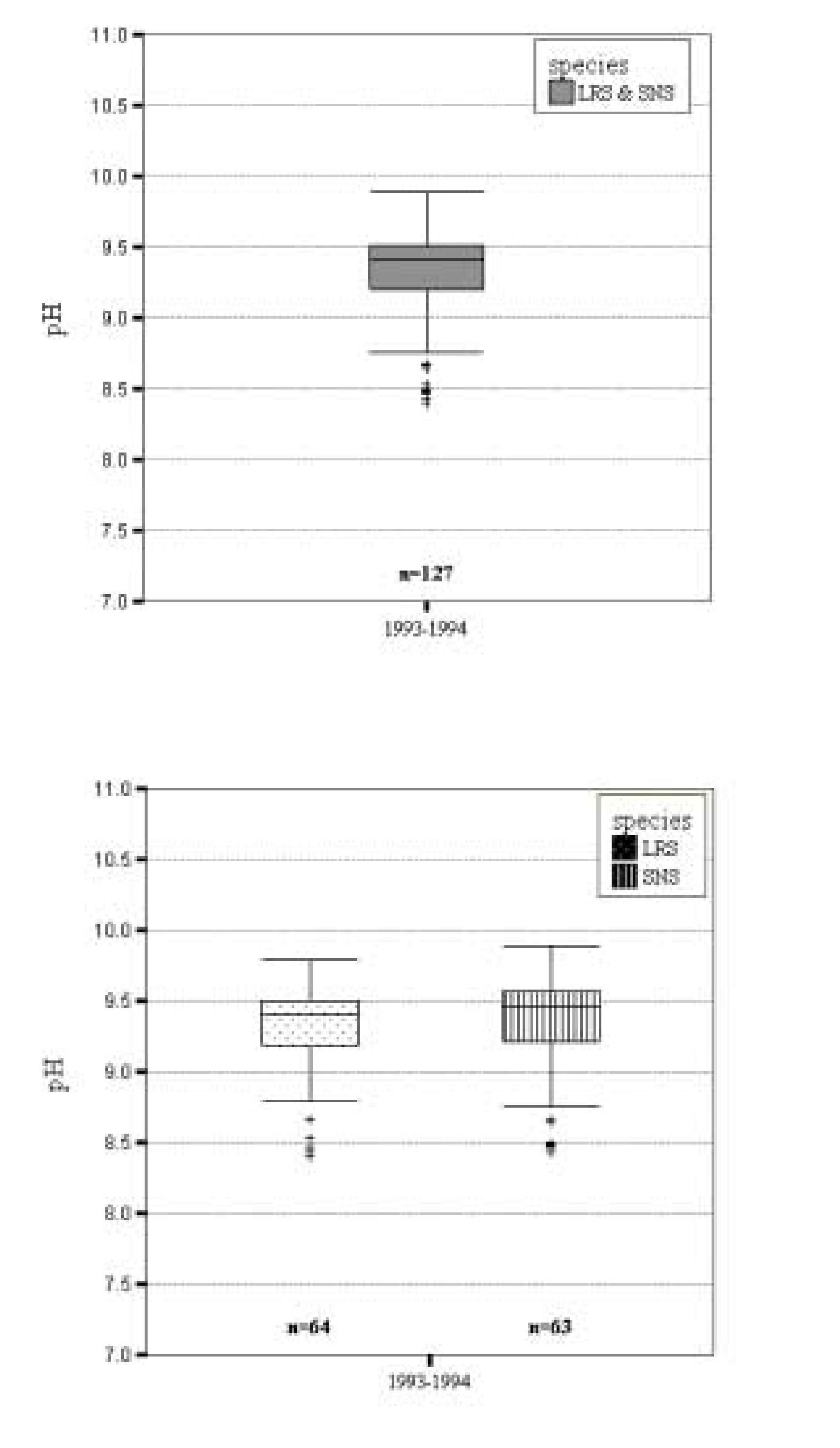


Figure 29. Near bottom pH at sites where radio-tagged suckers were located, Tule Lake National Wildlife Refuge, California, 1993-1994.

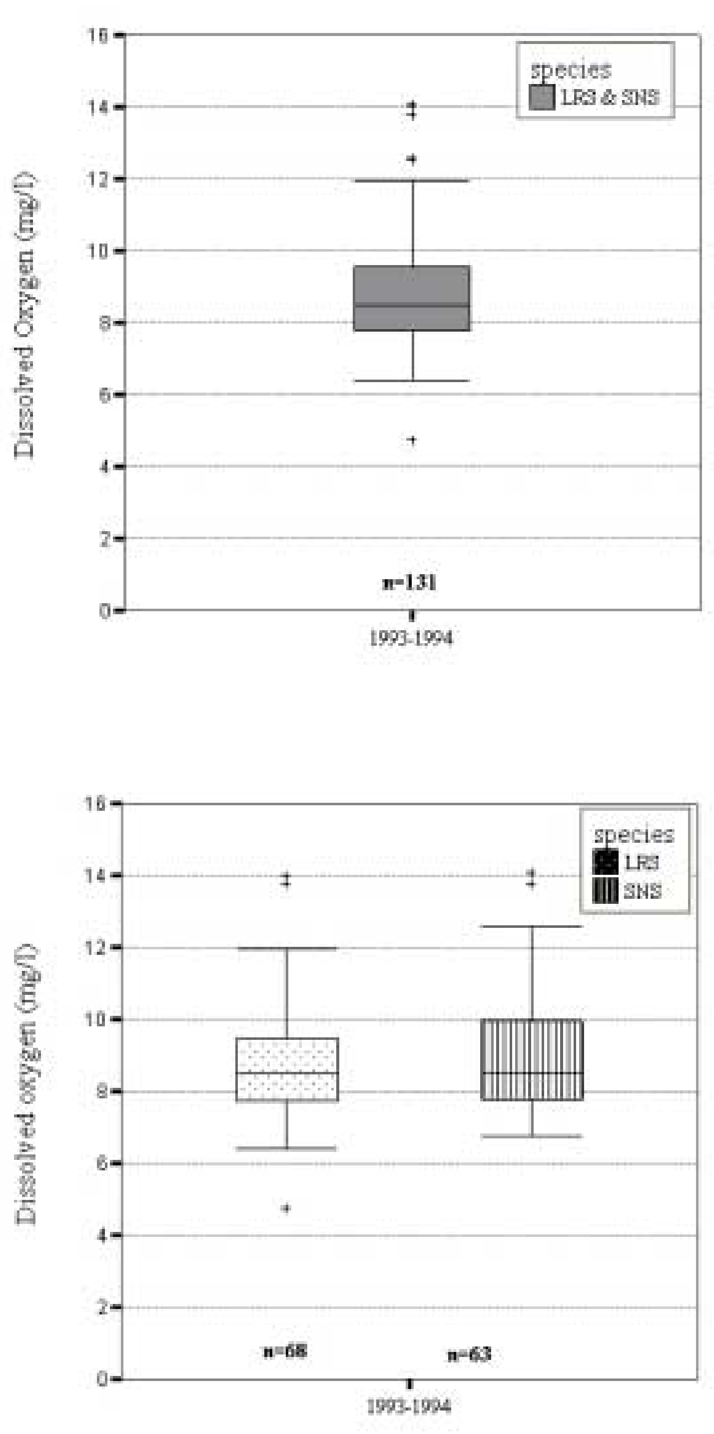


Figure 30. Near bottom dissolved oxygen at sites where radio-tagged suckers were located, Tule Lake National Wildlife Refuge, California, 1993-1994.

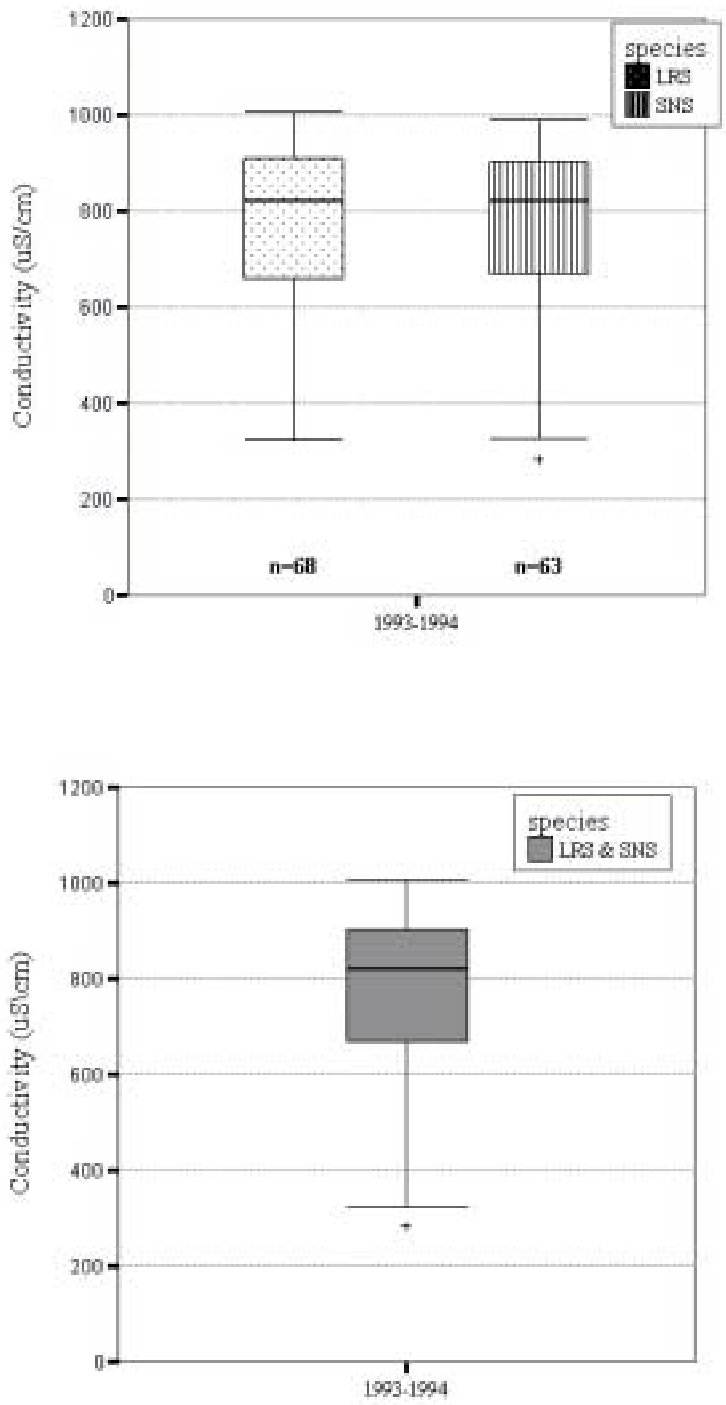


Figure 31. Near bottom specific conductance where radio-tagged suckers were located, Tule Lake National Wildlife Refuge, 1993-1994.

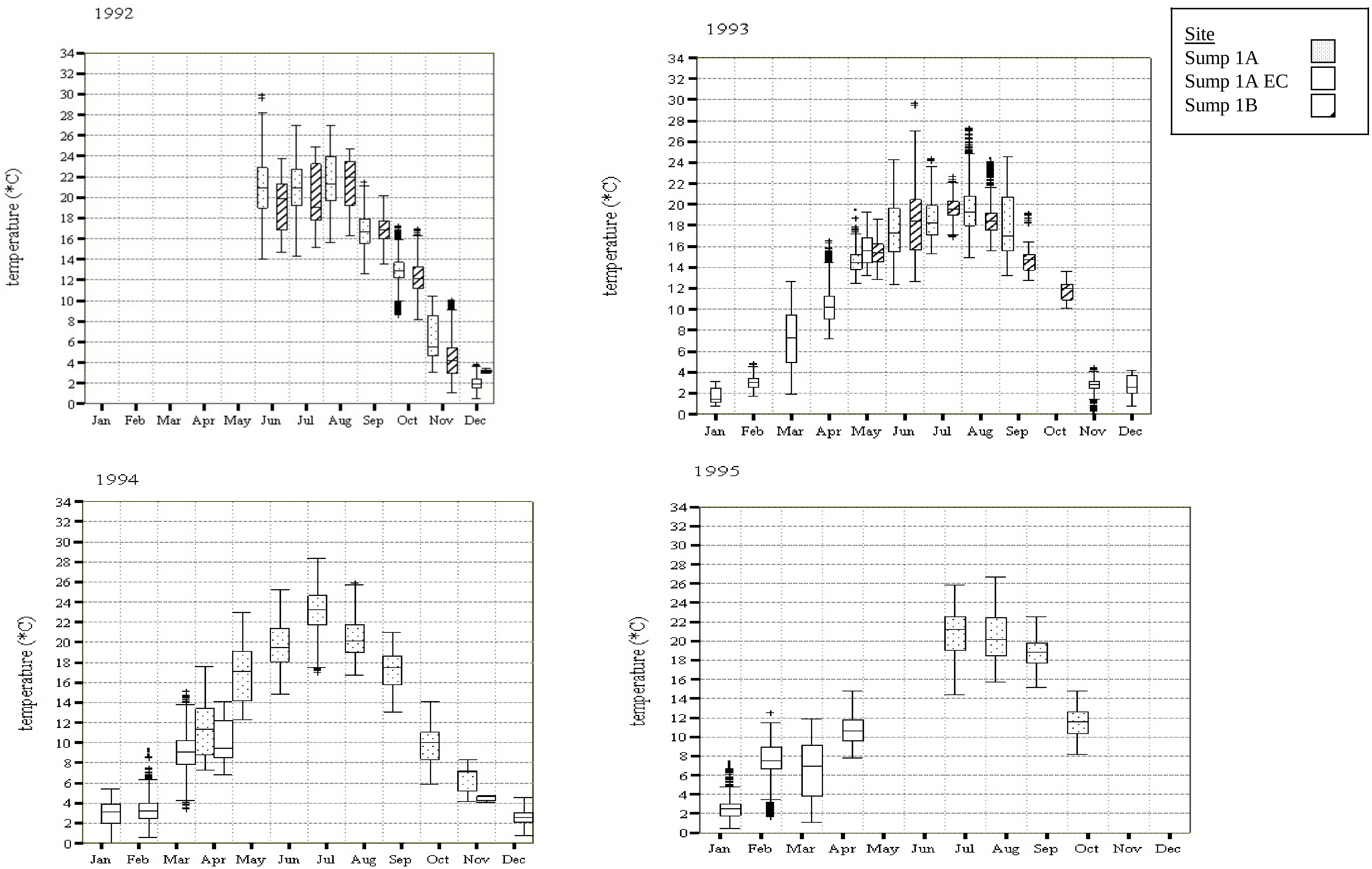


Figure 32. Continuous water temperature data collected from Sump 1A, EnglishChannel (1AEC), and Sump 1B sampling sites on Tule Lake National Wildlife Refuge, California, 1992-1995. Box and whisker plots represent the median, 25th-75th percentiles, 10th-90th percentiles, outliers, and extremes.

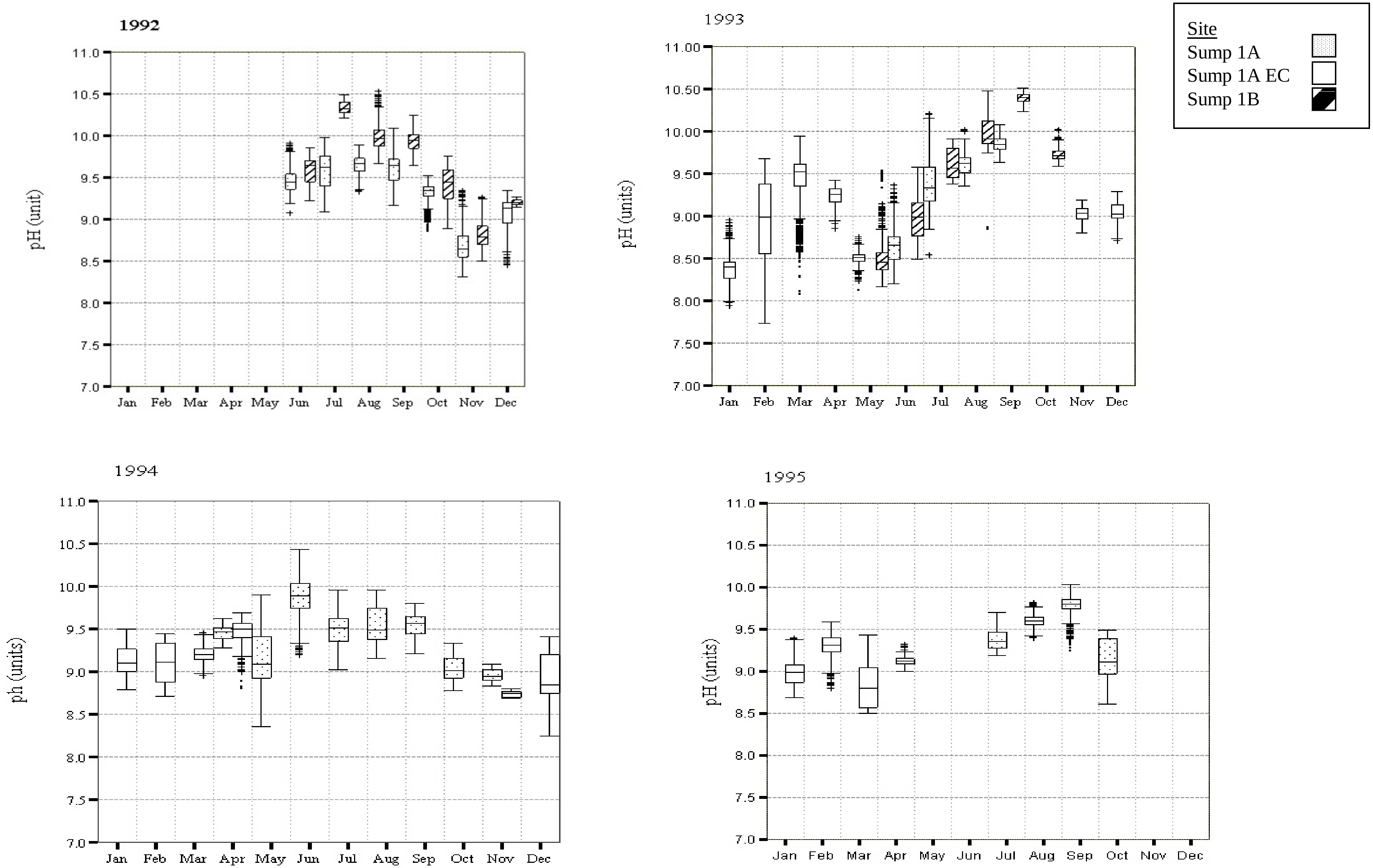


Figure 33. Continuous pH data collected from Sump 1A, English Channel (1AEC), and Sump 1B sampling sites on Tule Lake National Wildlife Refuge, California, 1992-1995. Box and whisker plots represent the median, 25th-75th percentiles, 10th-90th percentiles, outliers, and extremes.

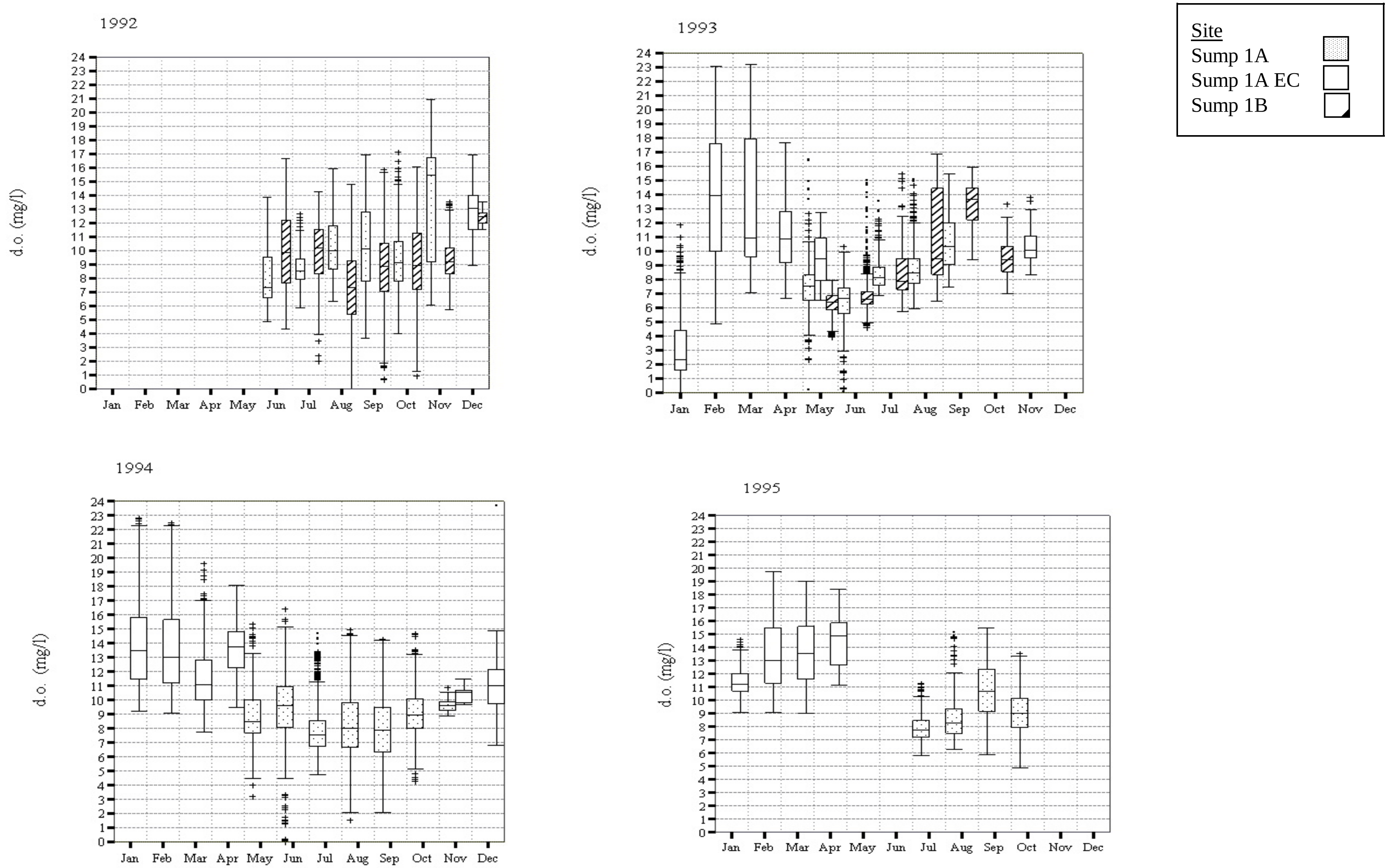


Figure 34. Continuous dissolved oxygen data collected from Sump 1A, English Channel (1AEC), and Sump 1B sampling sites on Tule Lake National Wildlife Refuge, California, 1992-1995. Box and whisker plots represent the median, 25th-75th percentiles, 10th-90th percentiles, outliers, and extremes.

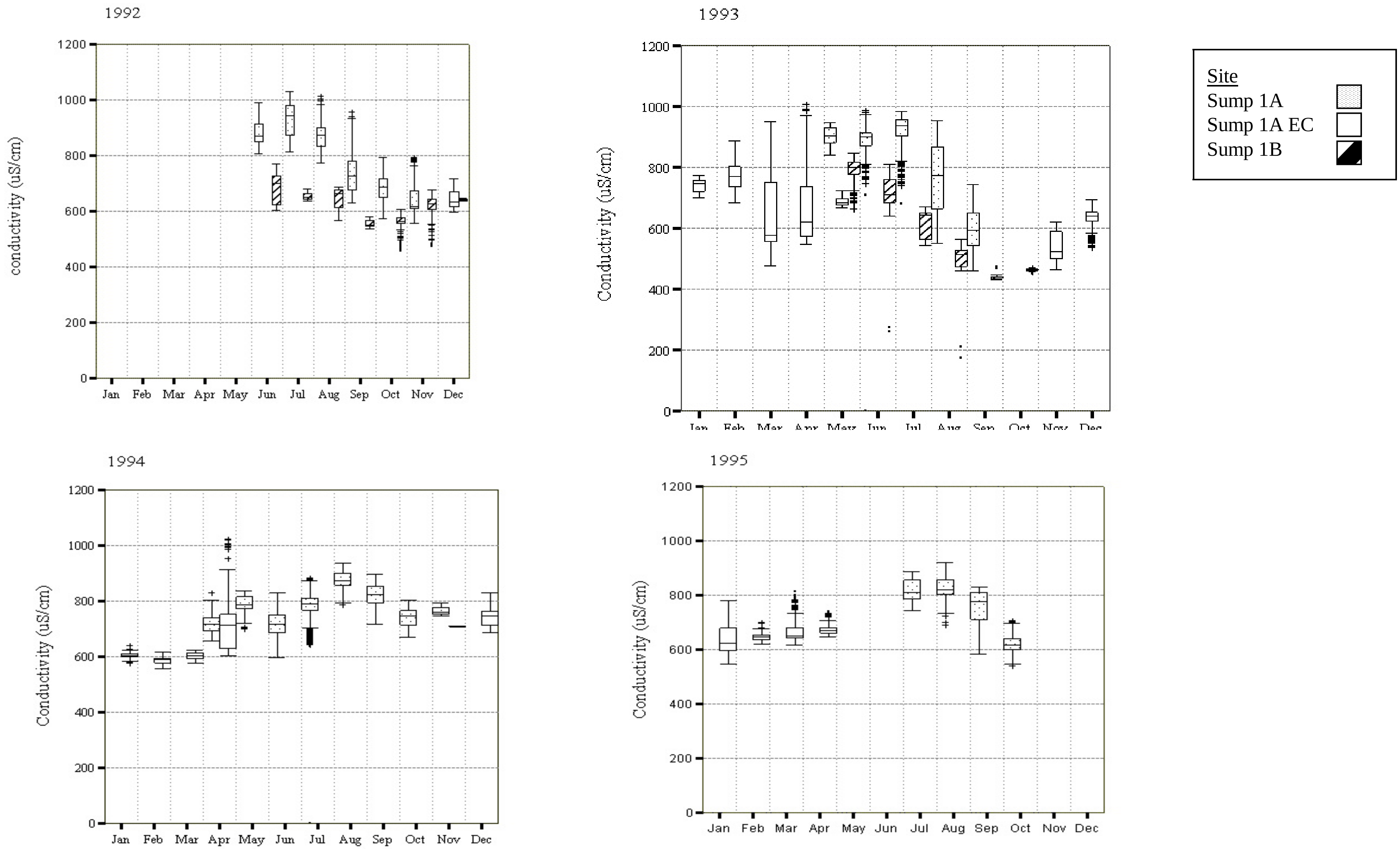


Figure 35. Continuous specific conductivity data collected from Sump 1A, English Channel (1AEC), and Sump 1B sampling sites on Tule Lake National Wildlife Refuge, California, 1992-1995. Box and whisker plots represent the median, 25th-75th percentiles, 10th-90th percentiles, outliers, and extremes.

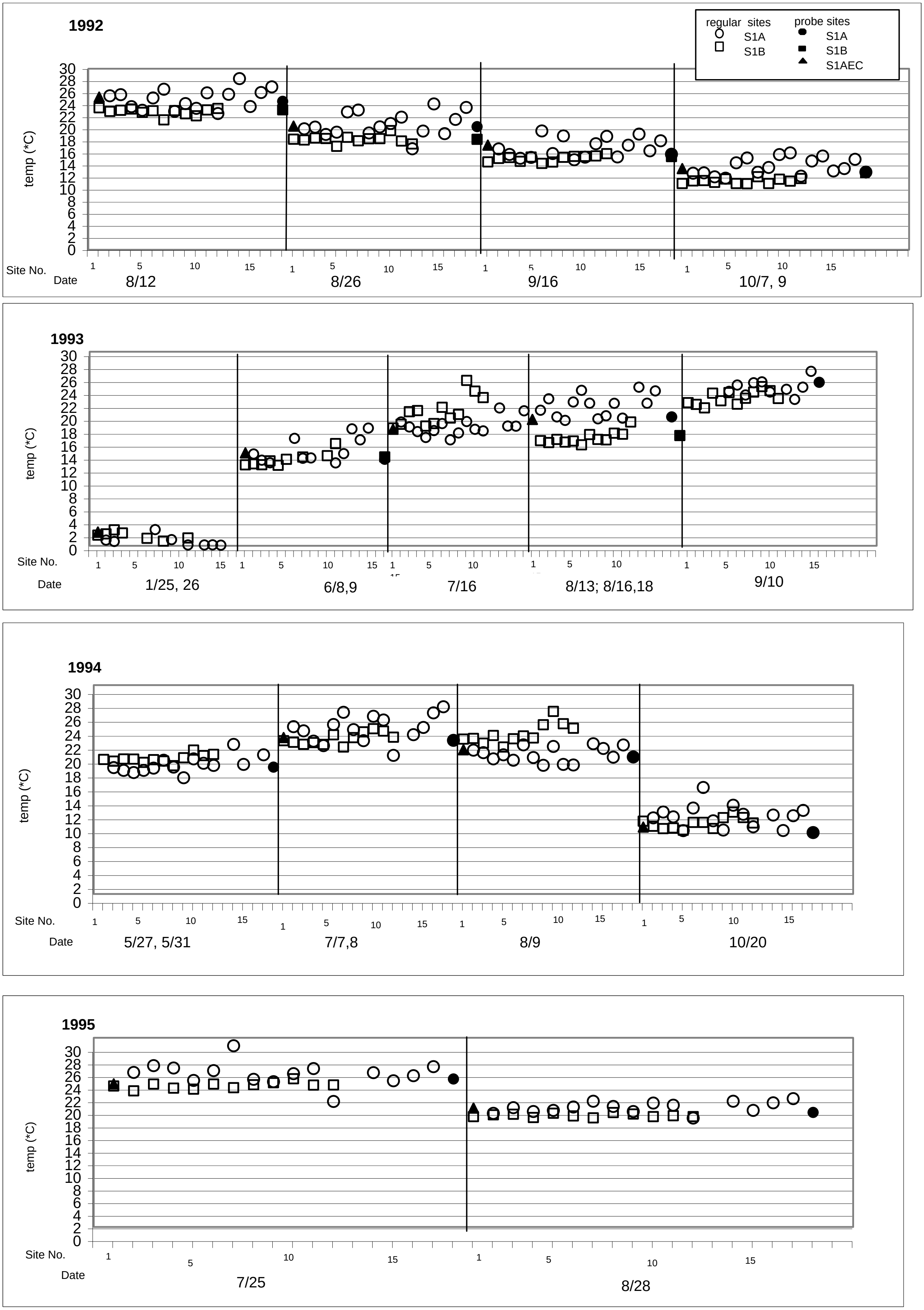


Figure 36.

Near bottom water temperature for profile sites in Sump 1A and 1B on Tule Lake National Wildlife Refuge , California, 1992-1995

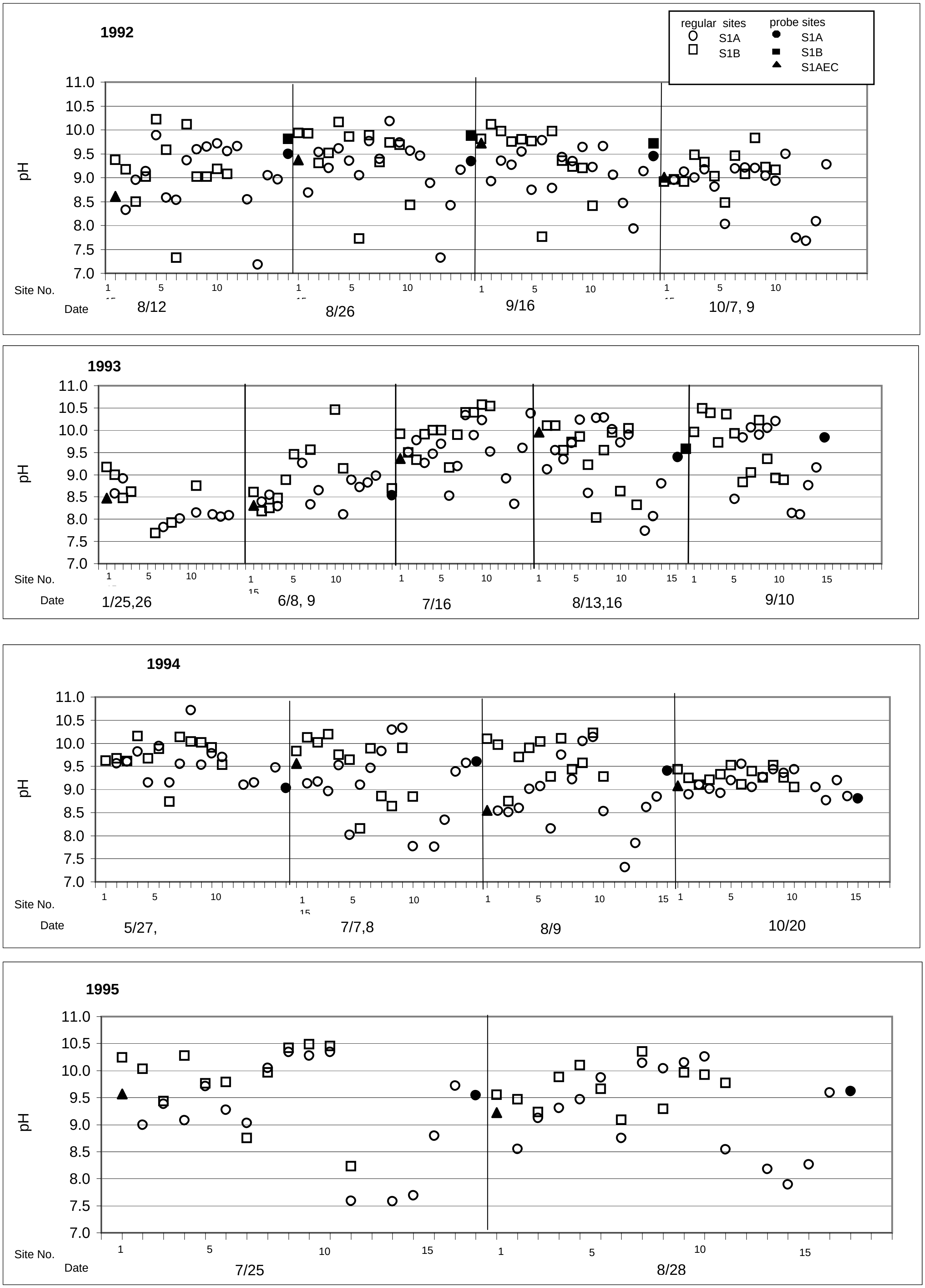


Figure 37.
Near bottom pH values for profile sites on Tule Lake National Wildlife Refuge, California, 1992-1995.

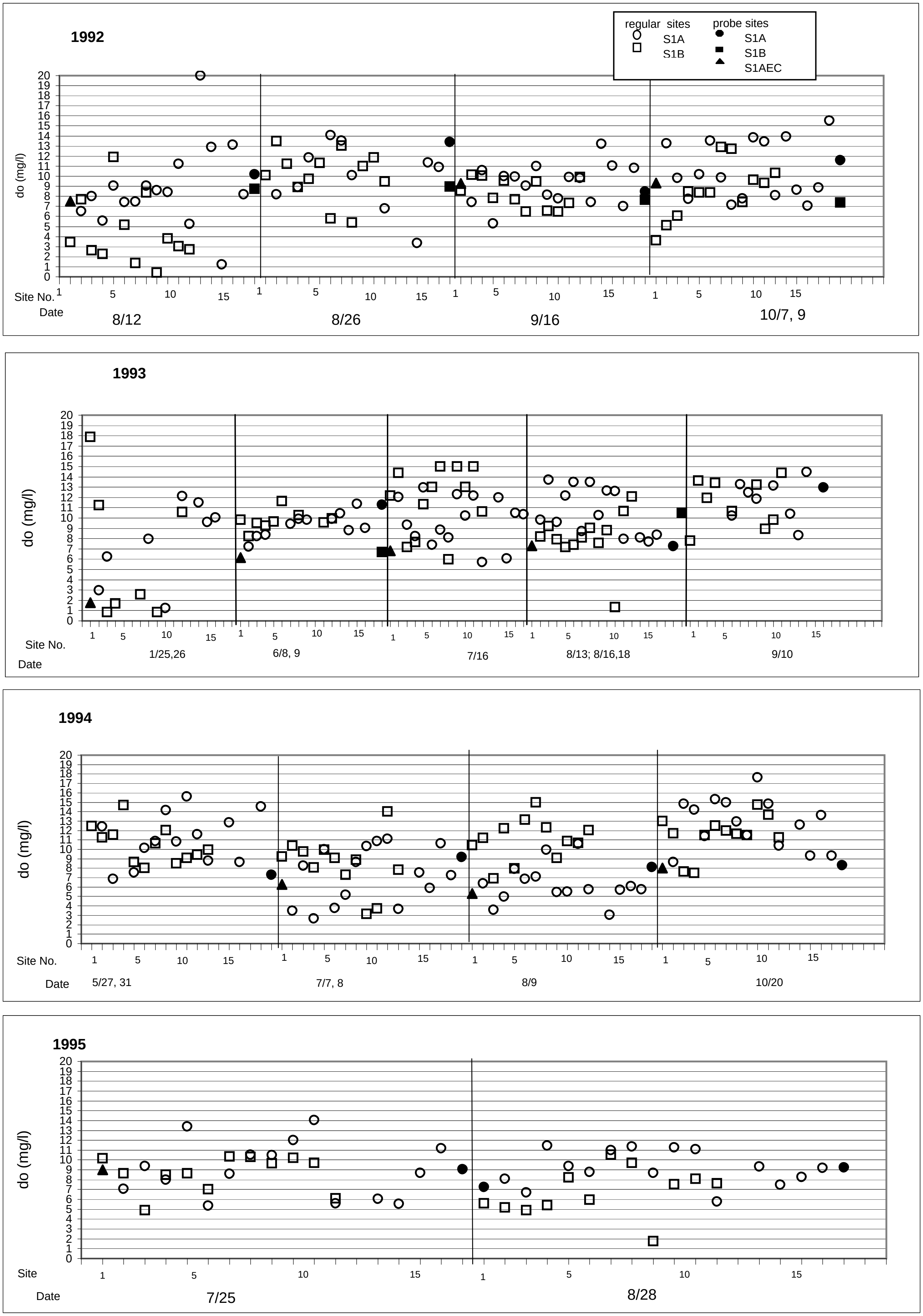


Figure 38.

Near bottom water dissolved oxygen for profile sites on Tule Lake National Wildlife Refuge, California, 1992-1995

Water Quality Monitoring
Tule Lake Sumps
Specific Conductivity (aeS/cm)

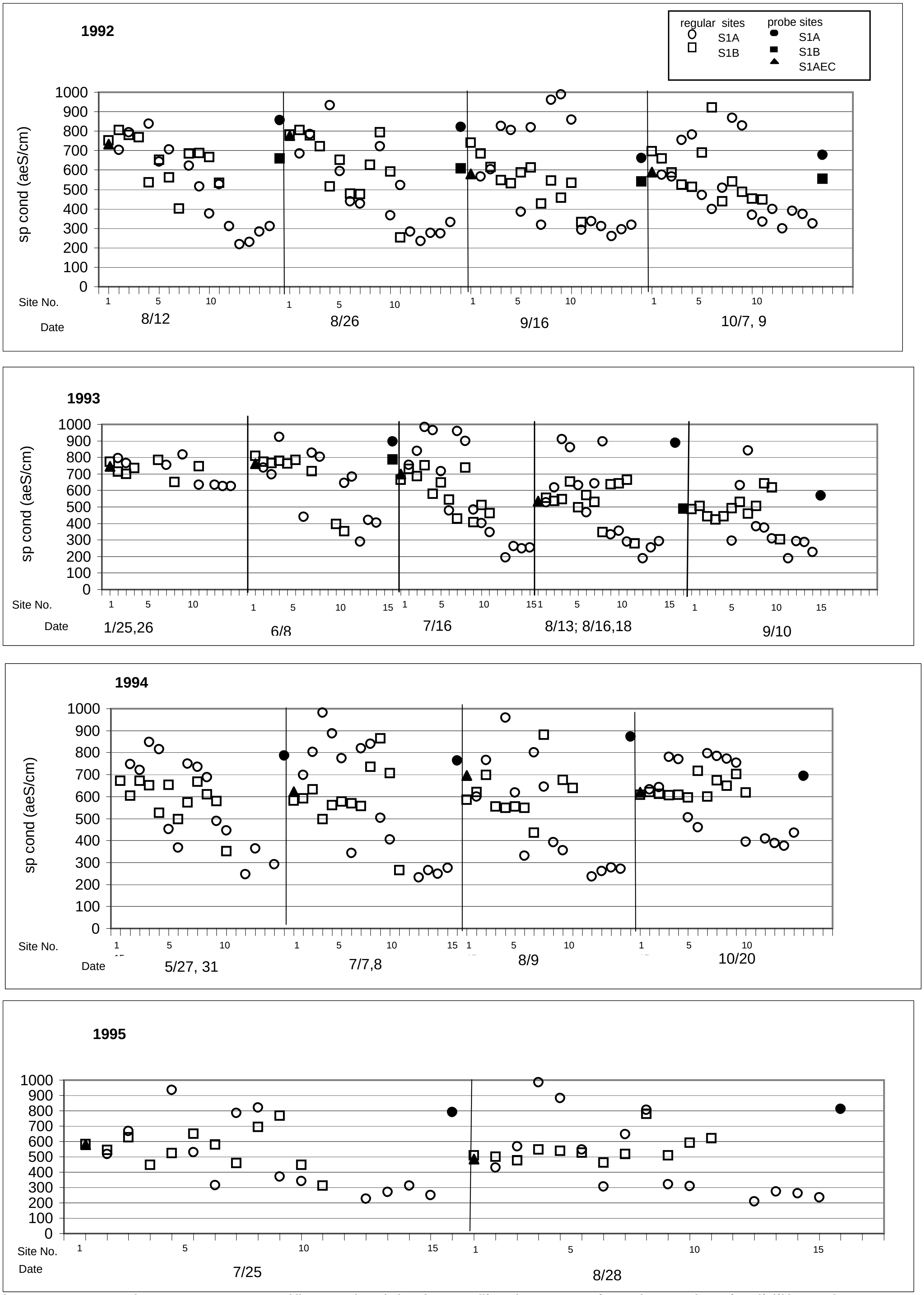


Figure 39. Near bottom water specific conductivity for profile sites on Tule Lake National Wildlife Refuge, California, 1992-1995.