Ecology of shortnose and Lost River suckers in Tule Lake National Wildlife Refuge, California, Progress Report, April - November 1999

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Introduction

The Lost River (*Deltistes luxatus*) and shortnose (*Chasmistes brevirostris*) suckers were federally listed as endangered species on July 18, 1988 (Federal Register 53:27130-27134). Both sucker species are relatively long-lived, have a limited geographic range, and are endemic to the Upper Klamath Basin of Northern California and Southern Oregon. Habitat degradation from water diversions and loss of riparian and wetlands habitats associated with agricultural development within their historic range is believed to be the major reason for the species decline (U.S. Fish and Wildlife Service 1993). A more detailed description on the life history, habitat requirements, and causes of decline of the species can be found in the Lost River and Shortnose Sucker Recovery Plan (U.S. Fish and Wildlife Service 1993).

Tule Lake National Wildlife Refuge (NWR), established in 1928, consists of 2 return flow sumps (Sump 1(A) and 1(B)) totaling 13,000 acres surrounded by 17,000 acres of intensively farmed lands (Fig. 1). The refuge and surrounding private agricultural lands occupy the historic lake bed of Tule Lake, a 95,000 acre lake and marsh area that was reclaimed in the early 1900's as part of the Klamath Reclamation Project. Current management of the refuge is directed by the Kuchel Act of 1964 which mandates the refuge be managed for the major purpose of waterfowl management but with optimal agricultural use that is consistent therewith. Both sumps are shallow (0.1 - 2.0 m) and consist of approximately 10,500 acres of open water with a 2,500 acre shallow (<0.1 m) emergent marsh at the northeast corner of Sump 1(A). Tule Lake has been identified as a potential refugia for both sucker species (U.S. Fish and Wildlife Service 1993).

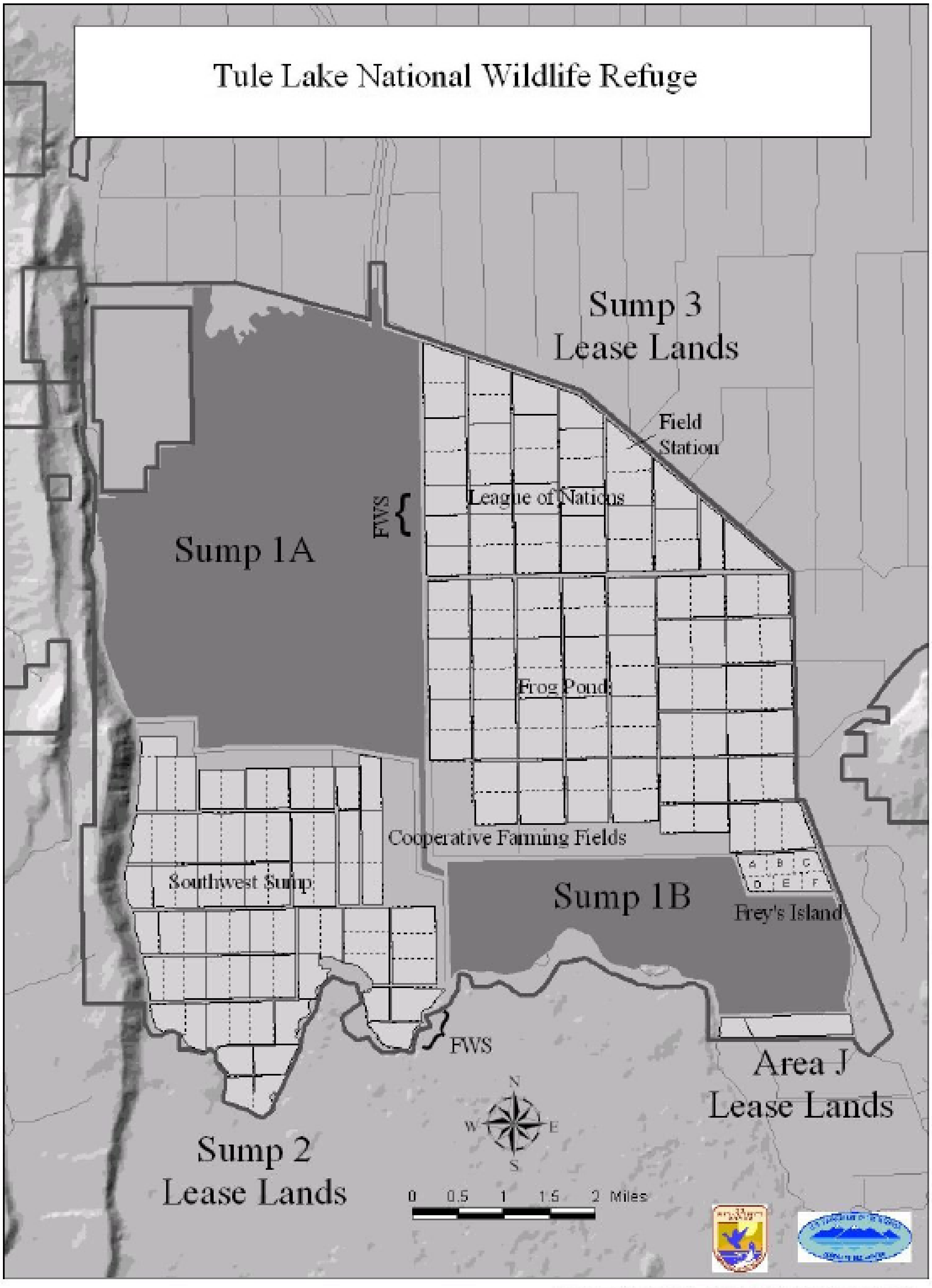


Figure 1. Tule Lake National Wildlife Refuge, California.

During winter, water within the sumps is comprised primarily of local runoff and during summer water is comprised primarily of irrigation return flows, originating from Upper Klamath Lake. Summer water quality in the sumps is similar to other water bodies within the Upper Klamath Basin and is considered hypereutrophic (Dileanis et al. 1996). Water quality problems include low dissolved oxygen (DO) and high hydrogen ion concentrations (pH) and unionized ammonia. Water quality in the Tule Lake sumps is directly affected by hypereutrophic conditions in Upper Klamath Lake (U.S. Fish and Wildlife Service 1993).

Studies conducted after publication of the Shortnose and Lost River Sucker Recovery Plan indicate that Tule Lake contains an estimated 159 (95% CI = 48-289) shortnose and 105 (95% CI = 25-175) Lost River suckers (Scoppetone and Buettner 1995). Confidence intervals for these estimates are large because of small sample sizes and low rates of recapture. Recruitment rates for the Tule Lake population via spawning below Anderson-Rose Dam is low with significant larval production occurring only in 1995 (monitoring occurred 1991-99) (M. Buettner, pers. comm). Entrainment from the irrigation system is likely the largest source of fish for Tule Lake (U.S. Bureau of Reclamation 1998). Both species of suckers in Tule lake are in good physical condition relative to fish in Clear Lake and Upper Klamath Lake with Tule Lake fish being generally heavier and exhibiting few if any problems with parasites or lamprey. (Scoppetone and Buettner 1995).

U.S. Bureau of Reclamation (Reclamation) biologists tracked 10 radio-marked suckers in Tule Lake from 1993-95. From these studies, specific use areas by time period were identified with over 99% of radio locations occurring in Sump 1(A). Of particular importance from these studies was identification of an over-summer site in the south central region of Sump 1(A) termed the ADonut Hole@ (DH).

In early 1999, the U.S. Fish and Wildlife Service (Service) proposed a wetland enhancement project on the 3,500 acre Sump 1(B). The project was designed to improve habitat for waterfowl and other associated wetland species as well as improve water quality through the conversion of Sump 1(B) from an open body of shallow water to an emergent year-round flooded wetland. The primary mechanism to create the desired habitat condition is a series of annual spring/summer drawdowns thereby creating conditions suitable for germination of desired emergent plant species. Of principal concern in developing the project was the potential effects on suckers within the sumps.

Because of the proximity of both sucker species in adjacent Sump 1(A), a project monitoring plan was developed to ascertain the potential effects of the Sump 1(B) Project on suckers and water quality. Our monitoring design benefitted from studies of water quality and sucker movements by Reclamation biologists from 1992-95. This report summarizes findings of the first year=s pre-project monitoring effort (April-December, 1999) relative to water quality and movements of radio-marked suckers.

Objectives

1. Describe seasonal distribution and movement patterns of both sucker species in Tule Lake NWR and determine if fish movements have changed since initial studies by Reclamation biologists in 1993-95.

2. Characterize water quality, in space and time, of areas used by adult suckers compared to areas which are not used.

3. Document and describe movements of radio-marked suckers to spawning areas below Anderson-Rose dam.

4. Determine whether recruitment of larvae and juvenile was occurring below Anderson-Rose Dam.

Methods

Monitoring radio-marked adult suckers

In April and May, 1999, Reclamation biologists captured 14 suckers and surgically implanted radio-transmitters (ATS, Isanti, MN) having a projected battery life of 12 months. Each transmitter had an external antennae that exited the body cavity near the lateral line of the fish. Eleven Lost River and 3 shortnose suckers were captured using trammel nets at the northwest corner of Sump 1(A) (9 fish) and immediately downstream of Anderson-Rose Dam on the Lost River (5 fish) (Table 1).

We located radio-marked fish via air thrust boats using a scanning receiver and 4-element yagi antennae. Fish were located fish 4 times/month during March and April, 2 times/month from May through September, and once per month from October through December. Fish not located via boat were located from fixed wing aircraft. We determined fish locations by moving as close as possible to undisturbed fish and recording locations with a Global Positioning System (GPS). All GPS positions consisted of 180 rover points/location and were differentially corrected via post processing software (PFinder ver. 2.11). We recorded depth information at each fish location. To determine timing and duration of the spawning migration, we monitored radio-marked fish from vehicles on the east levee of the Lost River downstream of Anderson-Rose Dam.

Table 1. Data from Lost River and shortnose suckers captured on Tule Lake National Wildlife Refuge, California and Anderson-Rose Dam, Oregon in 1999.

RADIO TAG	CAPTURE DATE	CAPTURE LOCATION	SPECIES	SEX	WEIGHT	FORK LENGTH	PIT TAG NO.
165.043	4/2/99	TULELAKE SUMP 1A	LOST RIVER	FEMALE	NO DATA	777 mm	1F3E34432C
165.063	4/2/99	TULELAKE SUMP 1A	LOST RIVER	FEMALE	NO DATA	681 mm	1F39064959
165.073	4/2/99	TULELAKE SUMP 1A	LOST RIVER	FEMALE	NO DATA	754 mm	1F4C5A6754
165.103	4/2/99	TULELAKE SUMP 1A	SHORTNOSE	MALE	NO DATA	473 mm	1F07315752
165.084	4/2/99	TULELAKE SUMP 1A	SHORTNOSE	FEMALE	NO DATA	523 mm	1F31462743
165.094	4/2/99	TULELAKE SUMP 1A	LOST RIVER	FEMALE	NO DATA	754 mm	1F4C5A6754
164.641	4/9/99	TULELAKE SUMP 1A	SHORTNOSE	FEMALE	2830 g	544 mm	1F3726750F
164.863	4/2/99	TULELAKE SUMP 1A	LOST RIVER	MALE	1040 g	440 mm	1F36490062
164.494	4/9/99	TULELAKE SUMP 1A	LOST RIVER	FEMALE	5260 g	775 mm	1F37103466
164.854	4/30/99	ANDERSON ROSE DAM	LOST RIVER	FEMALE	NO DATA	753 mm	1F390F1801
165.054	5/5/99	ANDERSON ROSE DAM	LOST RIVER	MALE	2214 g	556 mm	1F3E2A7702
164.845	5/5/99	ANDERSON ROSE DAM	LOST RIVER	MALE	1542 g	486 mm	1F36443235
164.763	5/18/99	ANDERSON ROSE DAM	LOST RIVER	MALE	2350 g	594 mm	1F30753309
164.914	5/18/99	ANDERSON ROSE DAM	LOST RIVER	FEMALE	1811 g	477 mm	1F390E6B2F

Recruitment

Reclamation biologists conducted larval and juvenile sucker surveys during May and June by sampling, visually and with dip nets, the emergent vegetation at the periphery of the Lost River downstream of Anderson-Rose Dam. Egg viability surveys were conducted in the gravel sediments immediately below the dam in May.

Water quality

We preselected water quality sampling sites (Fig. 2, Table 2) in Sump 1(A) to correspond to adult sucker use areas as determined by studies of radio-marked adult suckers conducted by Reclamation in 1993-95 (Fig. 3). We selected 2 sites in Sump 1(B) which met or exceeded the minimum depth requirement (> 3ft) for both sucker species (M. Buettner, pers. comm.) after referring to 1986 bathymetric maps. We attempted to obtain data from each site twice/month. We moved 2 sample sites (Donut Hole and Donut Hole Northwest) early in the summer and 1 site (Donut Hole West) (Fig. 2) during mid-summer to better represent summer use locations of radio-marked fish.

From May through November, we measured water quality parameters (dissolved oxygen (DO), hydrogen ion concentration (pH), and temperature (°C)) using DataSonde 3, 4 and 4a's (Hydrolab Corp., Austin, Texas) (hereafter referred to as Hydrolabs) 26 cm (12 in) above the sediment. We suspended Hydrolabs, within PVC tubes, from metal fence posts driven into the sediment. Data were collected hourly over a 96 hr period at each monitoring site. We downloaded data from Hydrolabs using the Hyperterminal software package v. 690170 to a personal computer. Unit probes were cleaned and calibrated according to Hydrolab guidelines (Hydrolab Corporation 1997) and local geographic standards.

Using the same deployment schedule as with our Hydrolabs, we sampled turbidity at each site using a Portable Turbidimeter model 2100P (Hach Corp., P.O. Box 389, Loveland, CO 80539). We collected water samples 27 cm (12 in) above the sediment at each sample site. We measured turbidity in NTUs, following the guidelines in the product manual and we measured water depth using a hand-crafted wooden pole, marked in measured increments.

We summarized water quality data using Microsoft **8** EXCEL software v. 97 SR-1 and SPSS for Windows release 9.0.0. Because of the apparent difference in summer water quality in the DH versus other sampling sites, data were summarized as DH sites and Non-DH (NDH) sites.

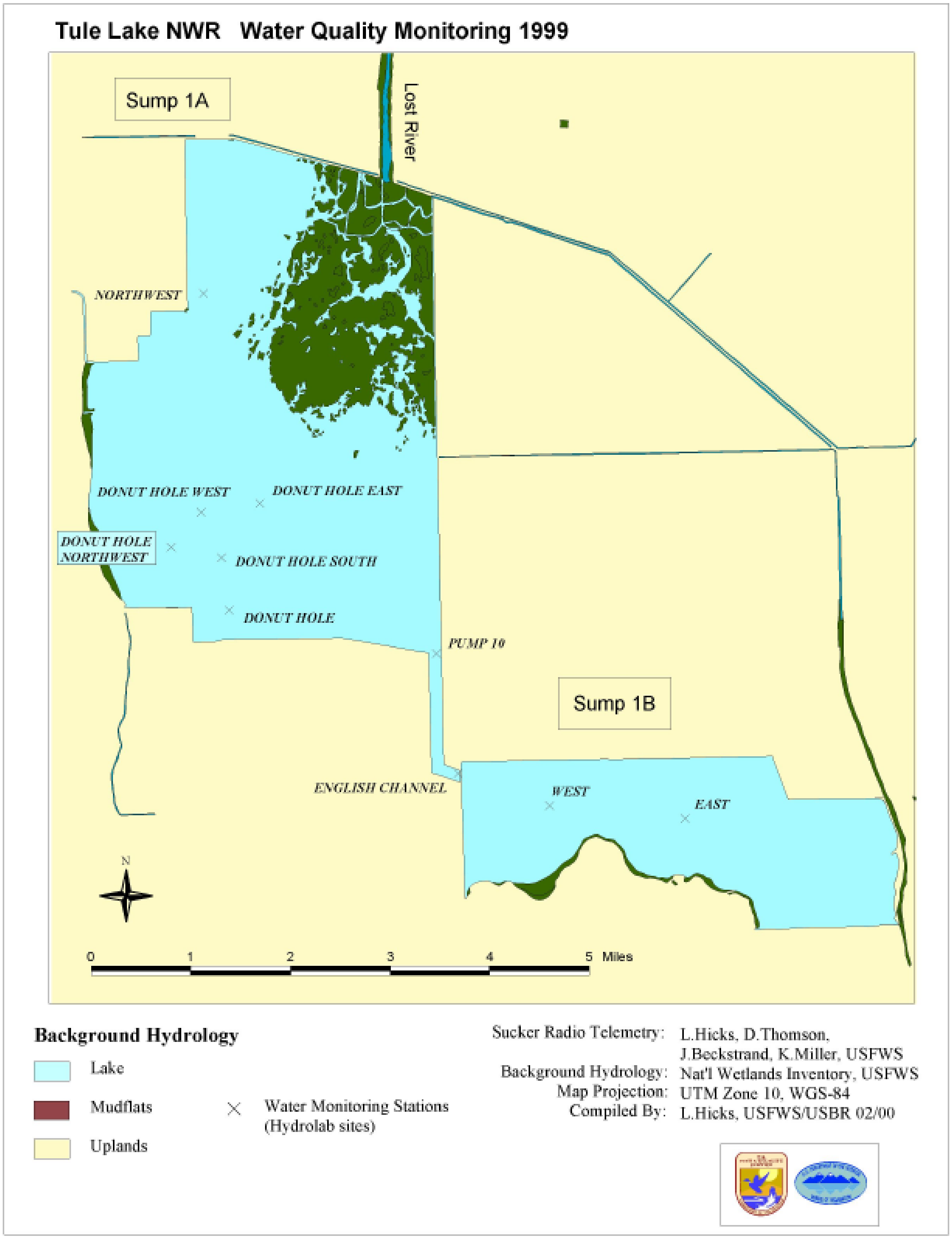


Figure 2. Water quality sample sites, Tule Lake National Wildlife Refuge, California, 1999.

Table 2. Characteristics of water quality sampling sites, Tule Lake National Wildlife Refuge, Tulelake, California, 1999.

SITE NAME	SITE ABBREVIATION	UTM_N	UTM_E	DEPTH of MONITORING SITE (m)[1]
NORTHWEST SUMP 1A	NWS1A	4642199	620803	1.2
DONUT HOLE NORTHWEST	DHNWS1A or DHNW	4638316	620542	0.9
DONUT HOLE WEST	DHWEST	4638881	321022	0.9
DONUT HOLE SOUTH	DHSOUTH	4638144	621355	0.8
DONUT HOLE	DHS1A or DH	4637299	621475	0.7
DONUT HOLE EAST	DHEAST	4639024	621971	0.8
ENGLISH CHANNEL	ECS1A or EC	4634604	625041	0.8
WEST SUMP 1B	WS1B	4634153	636647	1.0
EAST SUMP 1B	ES1B	4633948	628835	0.8
PUMP 10 SUMP 1A[2]	PMP10	4636635	624748	0.5

[1] Depth of water at deployment
[2] Pump 10 data will not be discussed in this document.

Results

Radio-marked suckers

We located fish 231 times in locations similar to those determined by Reclamation biologists in 1993-95 (Figs 3-4). Lost River and shortnose suckers did not appear to differentiate use of the sump by species; we located both species intermixed throughout the monitoring period. With the exception DH and DHNW (Fig. 2), water quality sampling sites were close to seasonal sucker use areas.

Of 14 suckers marked, mortality occurred in only 1 fish. A Lost River sucker (#X9) was tagged on 18 May at the Anderson Rose Dam; she was not located again until 23 days later on 9 June. From 9 June to 17 November, #X9 was located by signal within approximately 15 m of the original location based on the location data. It is likely that this fish died in early June within 2-3 weeks of being radio-marked. It is unknown if this mortality was related to the stress of handling and marking or some other cause.

April - May - In April-May, a period of maximum fish movements (Figs. 5-18), most suckers congregated in the AEnglish Channel@ between the sumps with a scattering of fish located between the northwest corner of Sump 1(A) and the AEnglish Channel@ (Fig. 4). Only 1 fish radio-marked in Tule Lake moved into the Lost River. This particular fish, a female shortnose sucker (#G9) was radio-marked in the northwest corner of Tule Lake on 9 April, was located in the AEnglish Channel@ on 14 April, and subsequently was located in Lost River below Anderson Rose Dam on 29 April and 6 May.

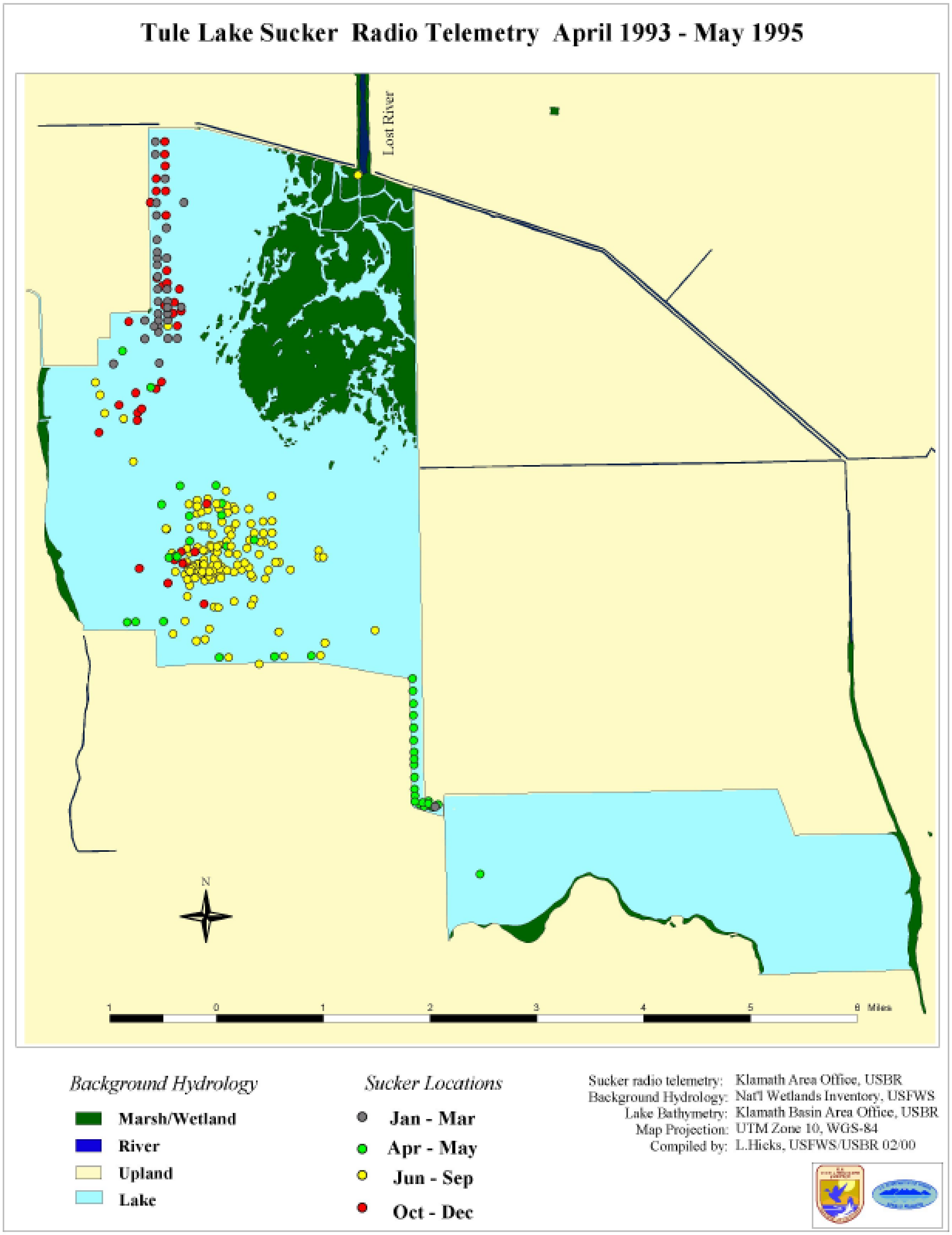


Figure 3. Locations of radio-marked suckers from studies conducted by U.S. Bureau of Reclamation, on Tule Lake National Wildlife Refuge, California, 1993-1995.

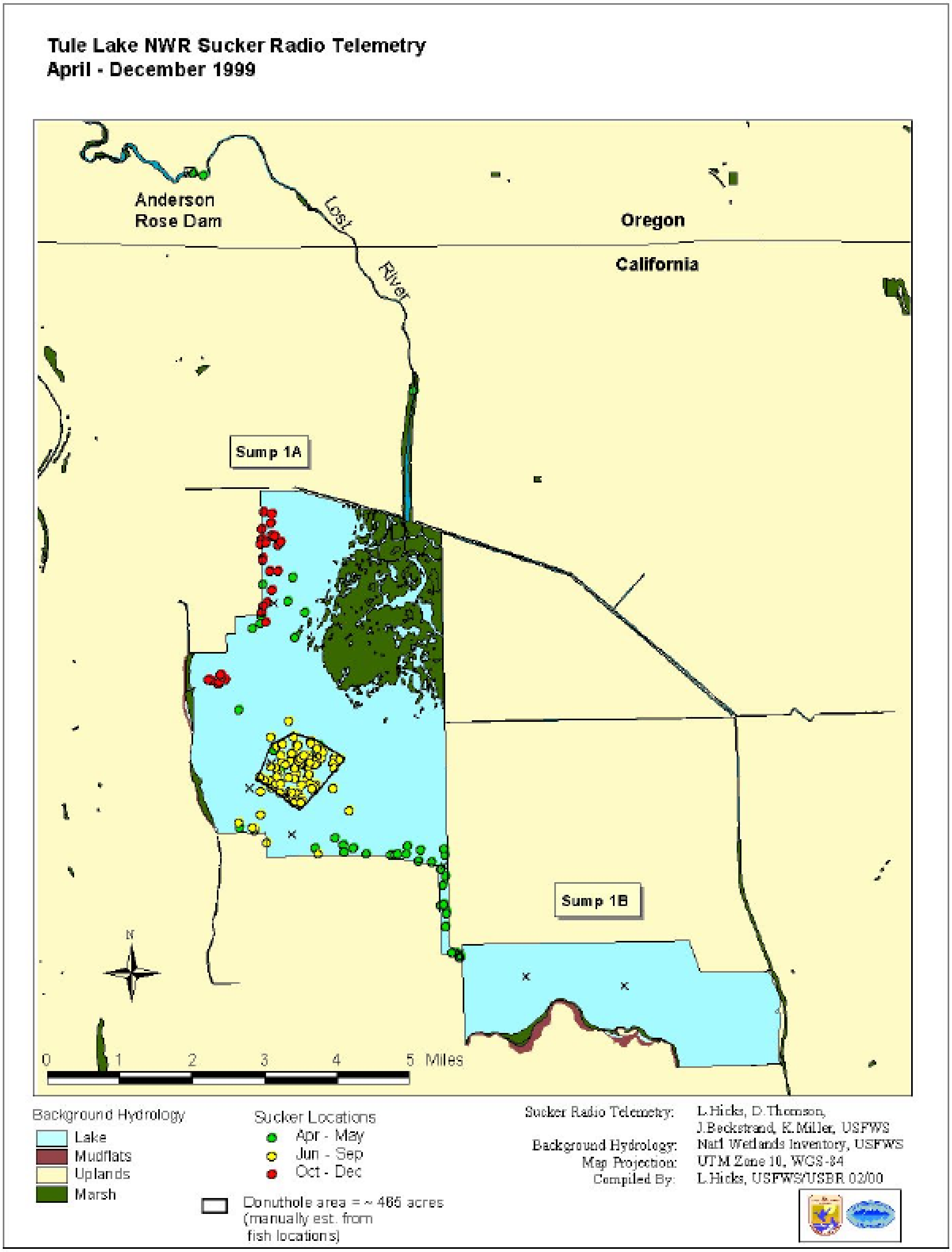


Figure 4. Locations of radio-marked suckers on Tule Lake National Wildlife Refuge, California, 1999.

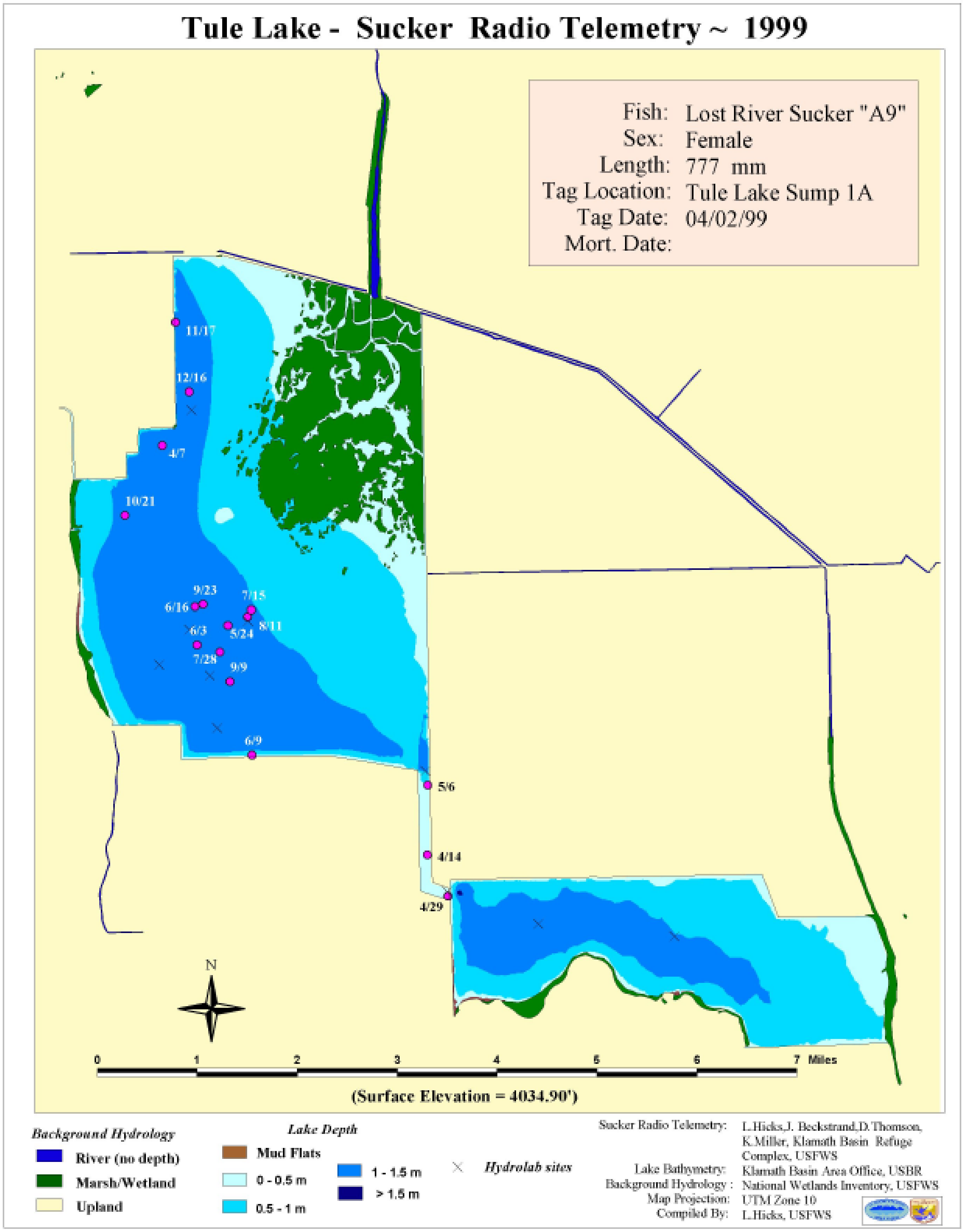


Figure 5. Movements of radio-marked sucker A9 on Tule Lake National Wildlife Refuge, California, 1999.

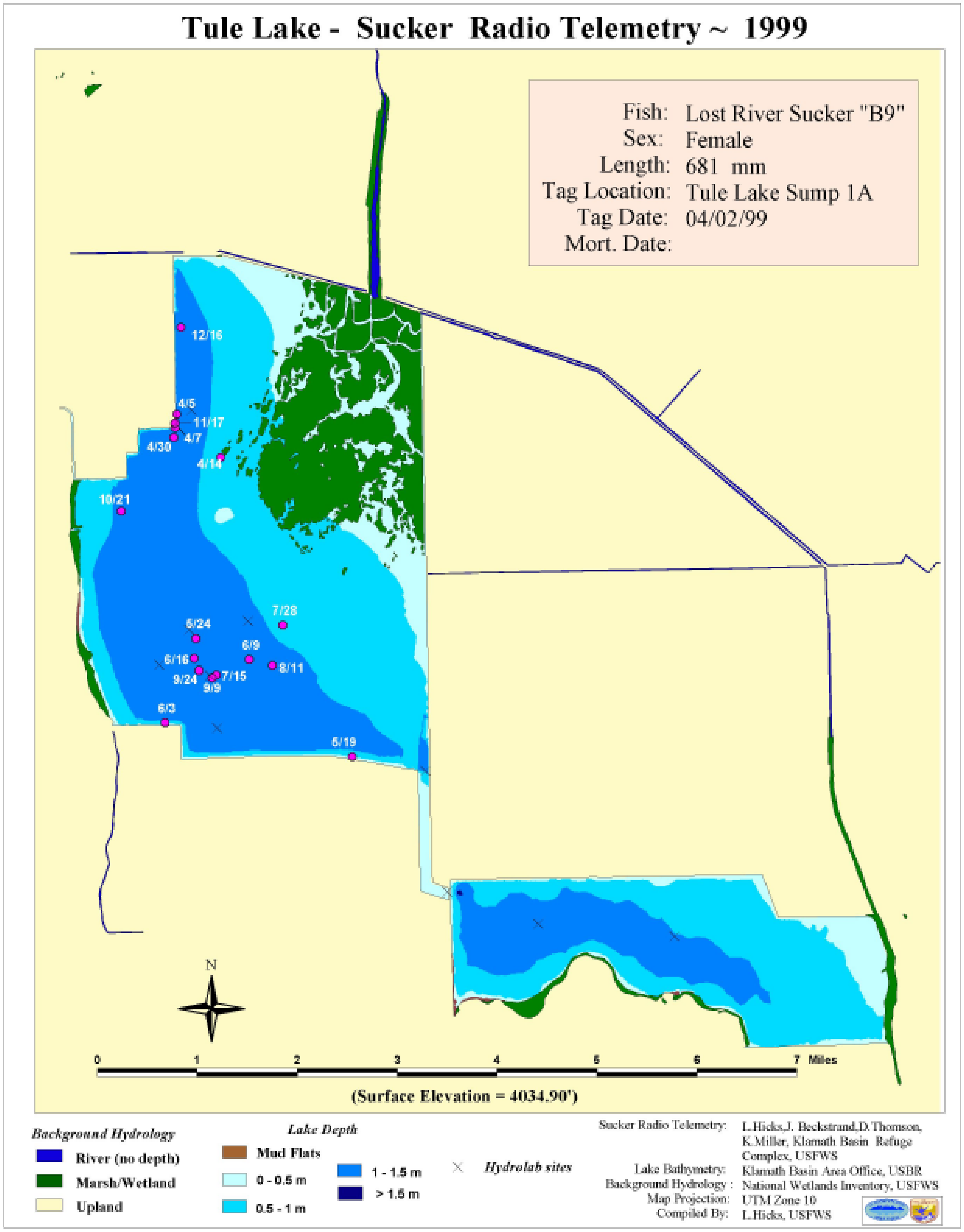


Figure 6. Movements of radio-marked sucker B9 on Tule Lake National Wildlife Refuge, California, 1999.

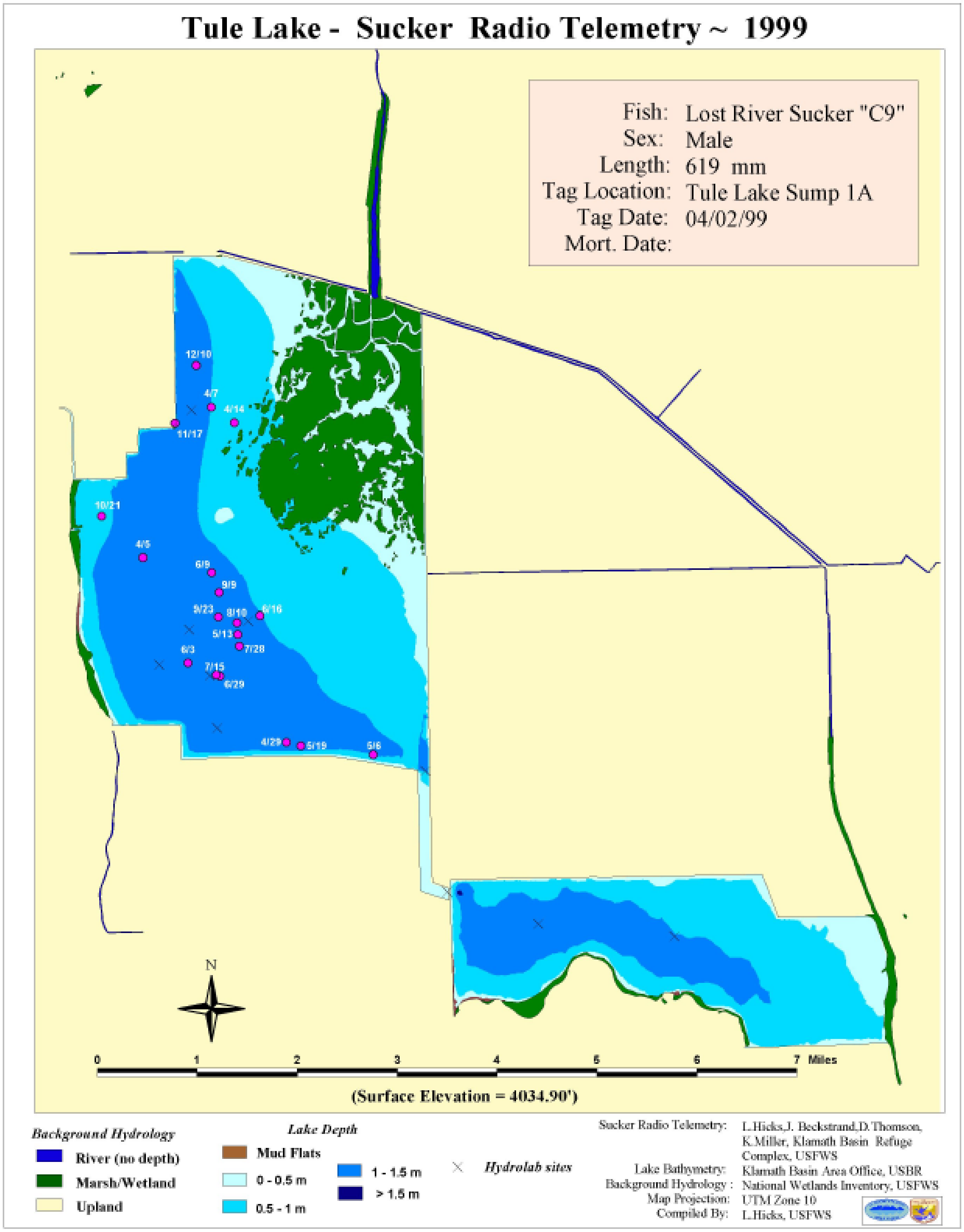


Figure 7. Movements of radio-marked sucker C9 on Tule Lake National Wildlife Refuge, California, 1999.

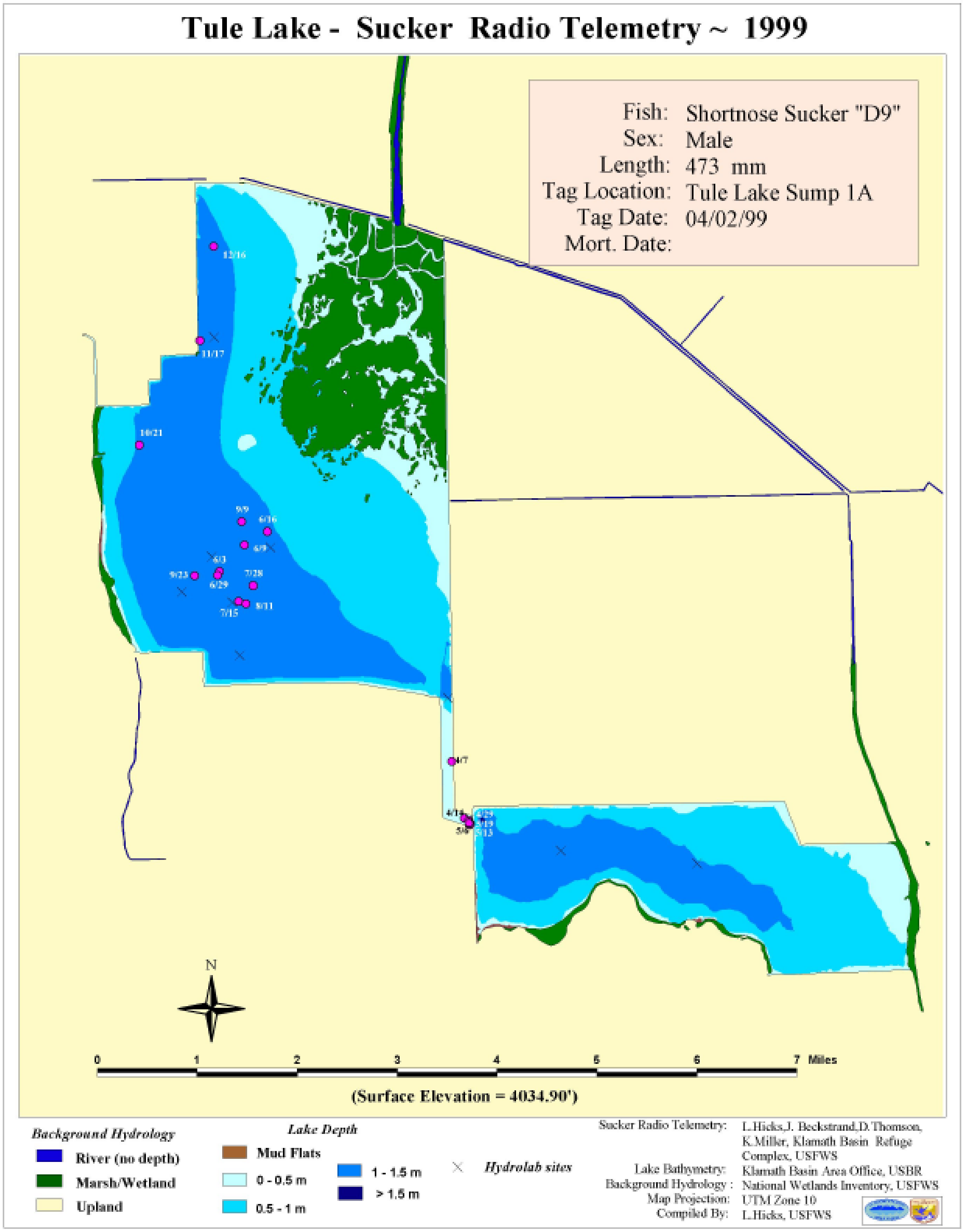


Figure 8. Movements of radio-marked sucker D9 on Tule Lake National Wildlife Refuge, California, 1999.

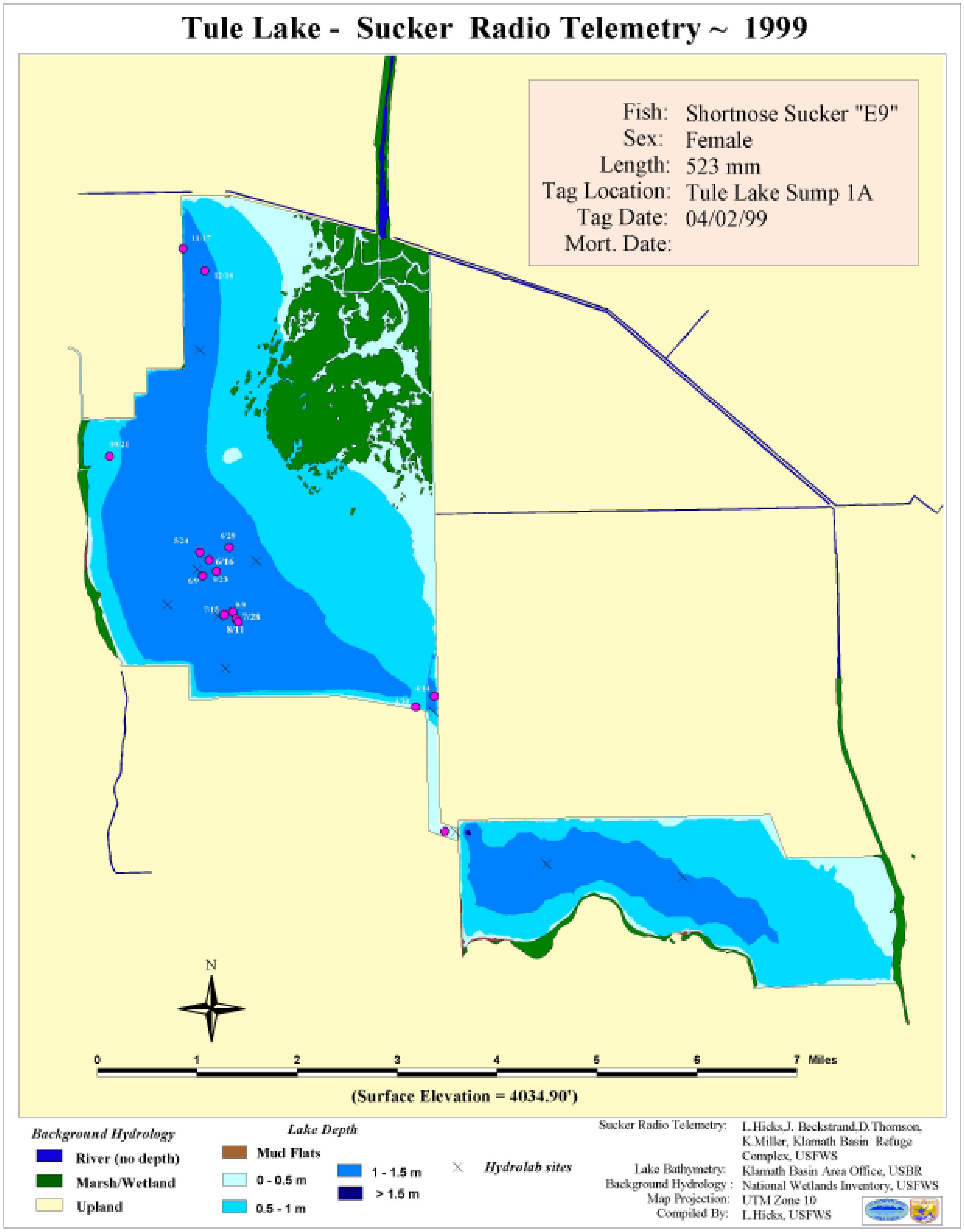


Figure 9. Movements of radio-marked sucker E9 on Tule Lake National Wildlife Refuge, California, 1999.

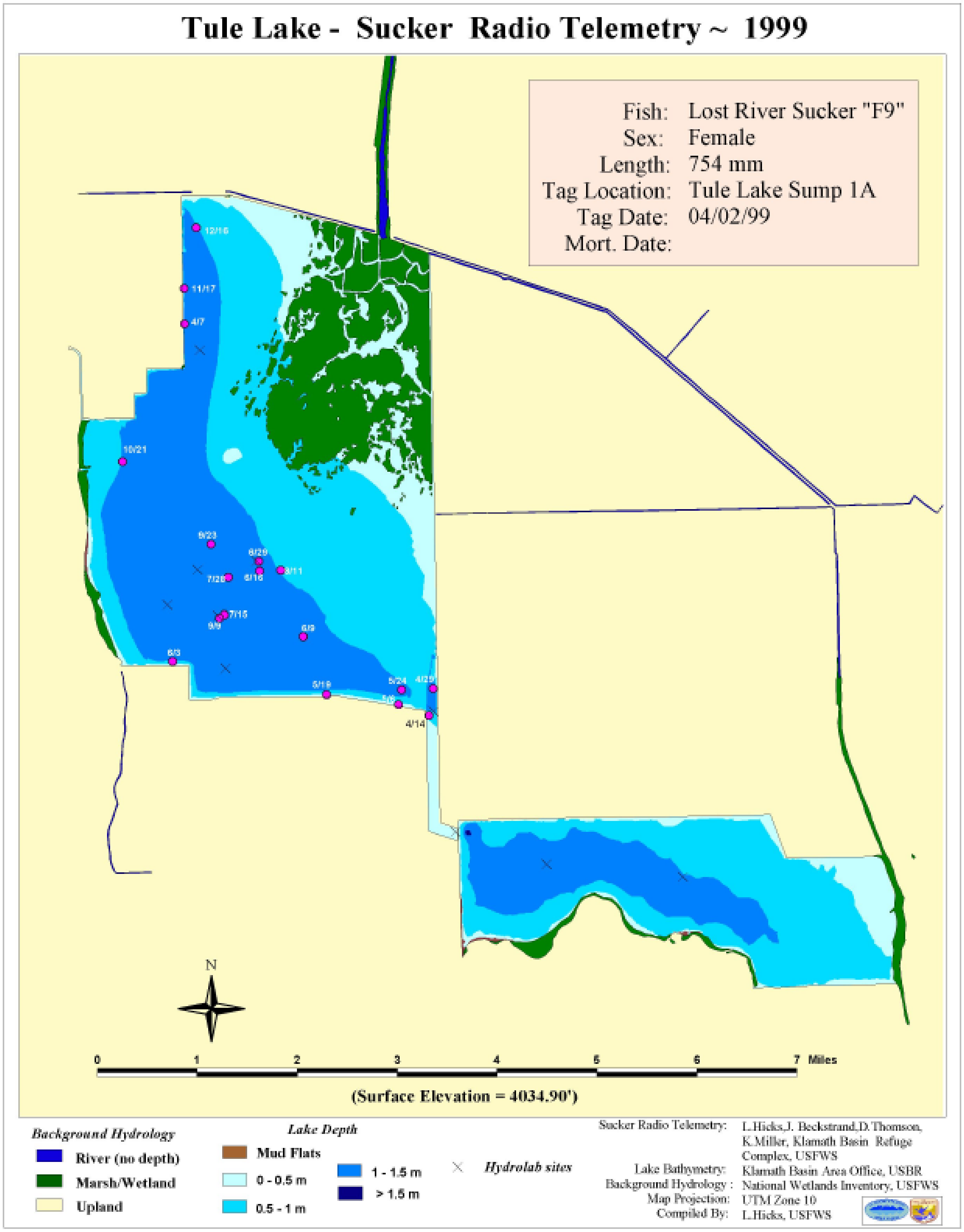


Figure 10. Movements of radio-marked sucker F9 on Tule Lake National Wildlife Refuge, California, 1999.

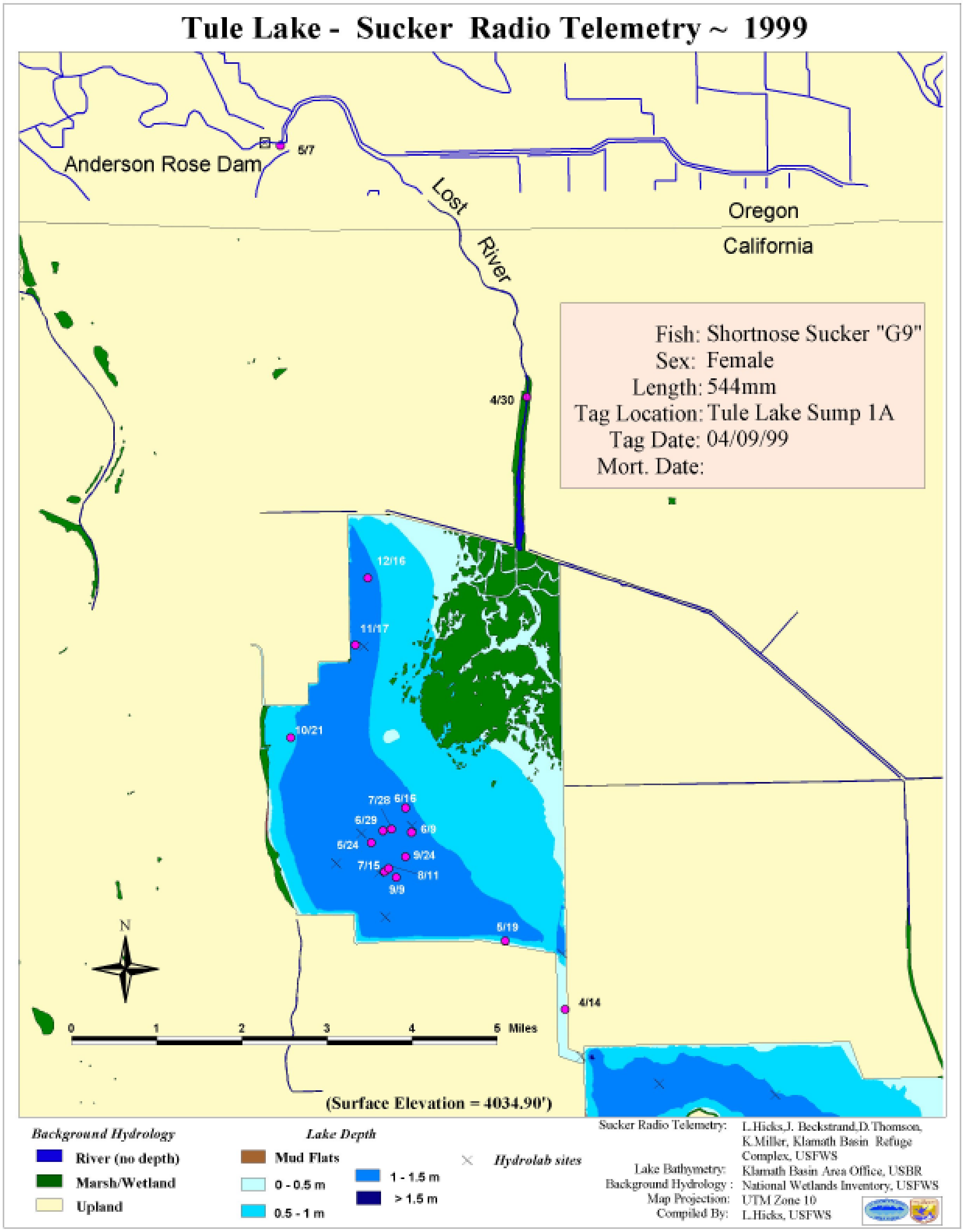


Figure 11. Movements of radio-marked sucker G9 on Tule Lake National Wildlife Refuge, California, 1999.

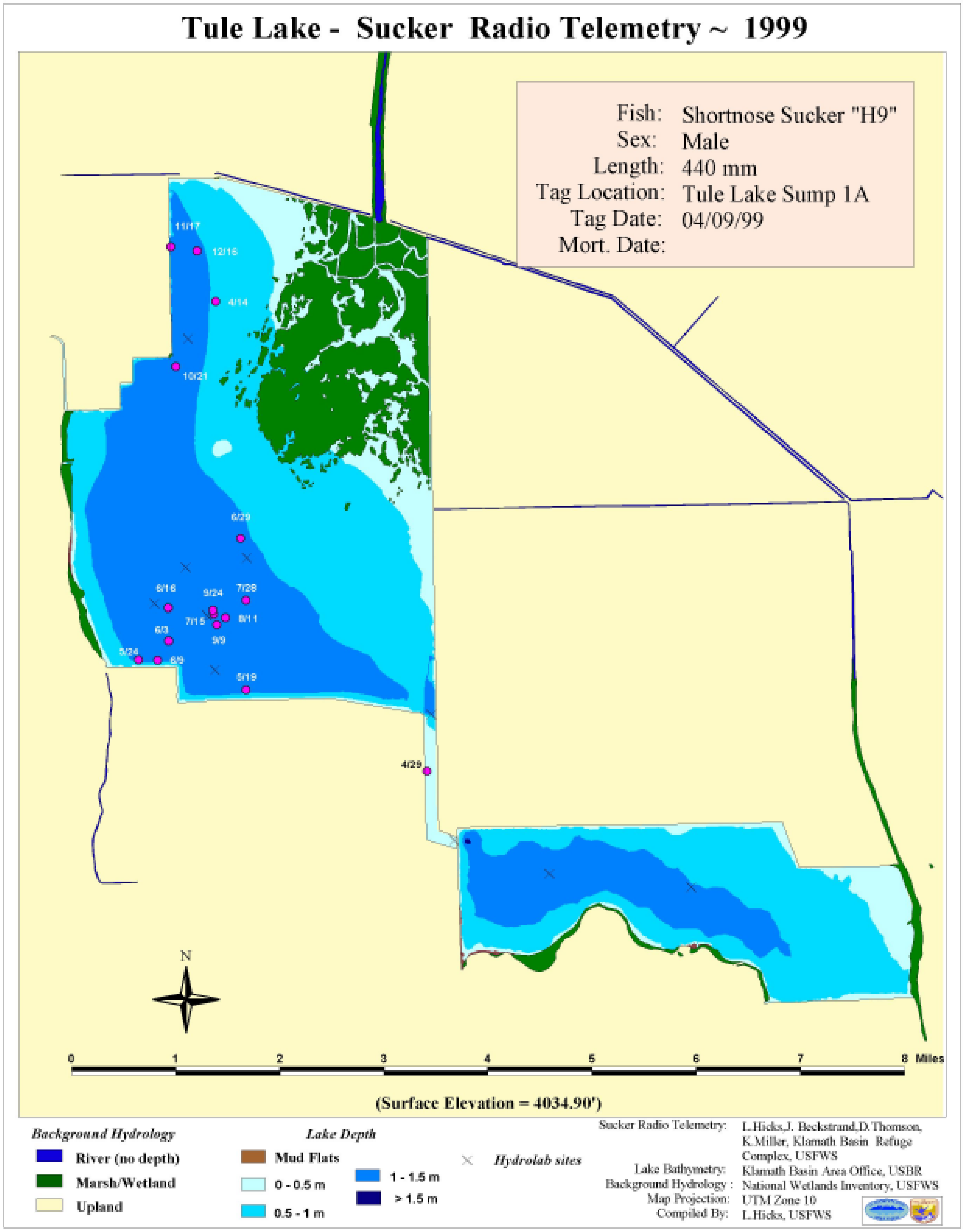


Figure 12. Movements of radio-marked sucker H9 on Tule Lake National Wildlife Refuge, California, 1999.

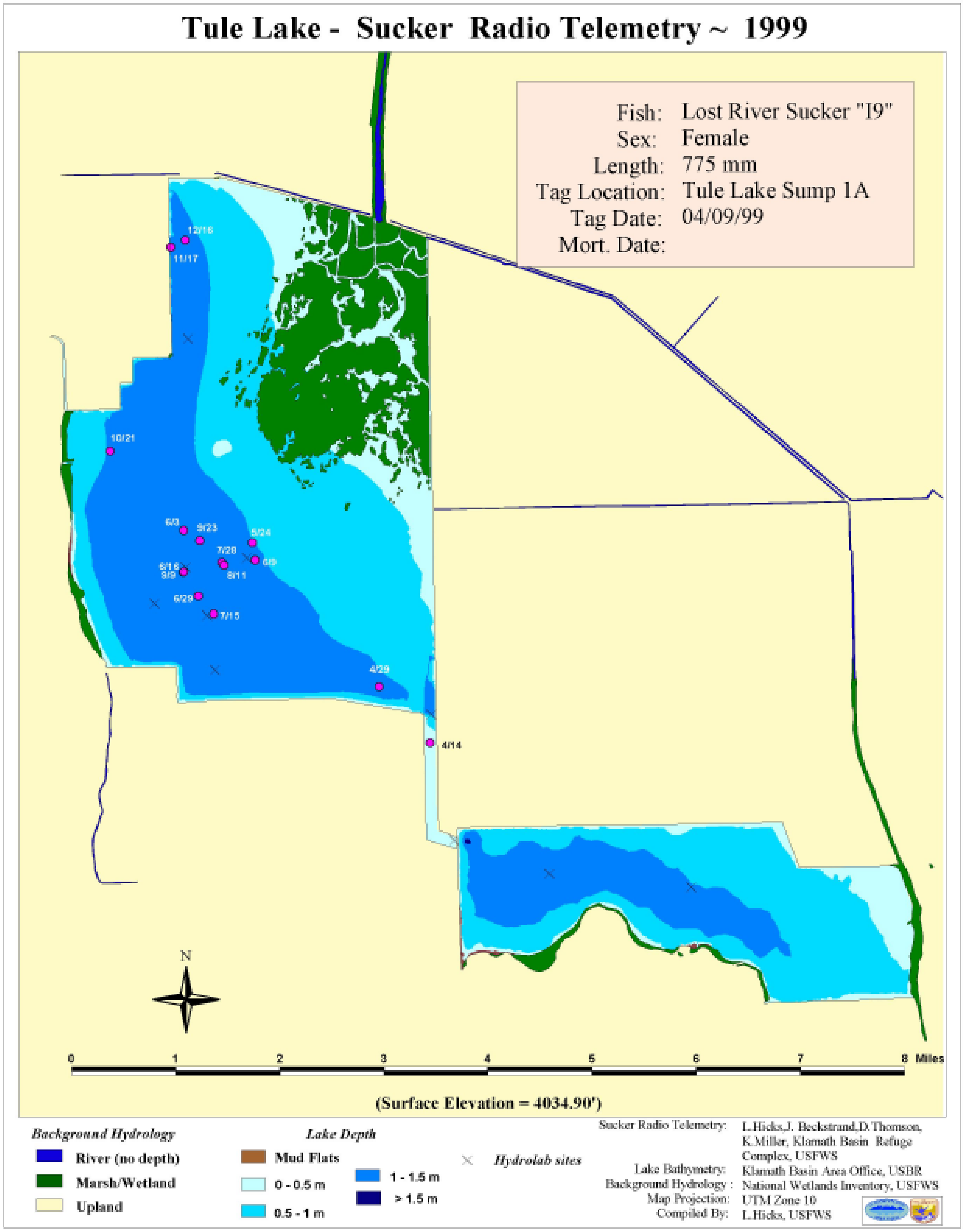


Figure 13. Movements of radio-marked sucker I9 on Tule Lake National Wildlife Refuge, California, 1999.

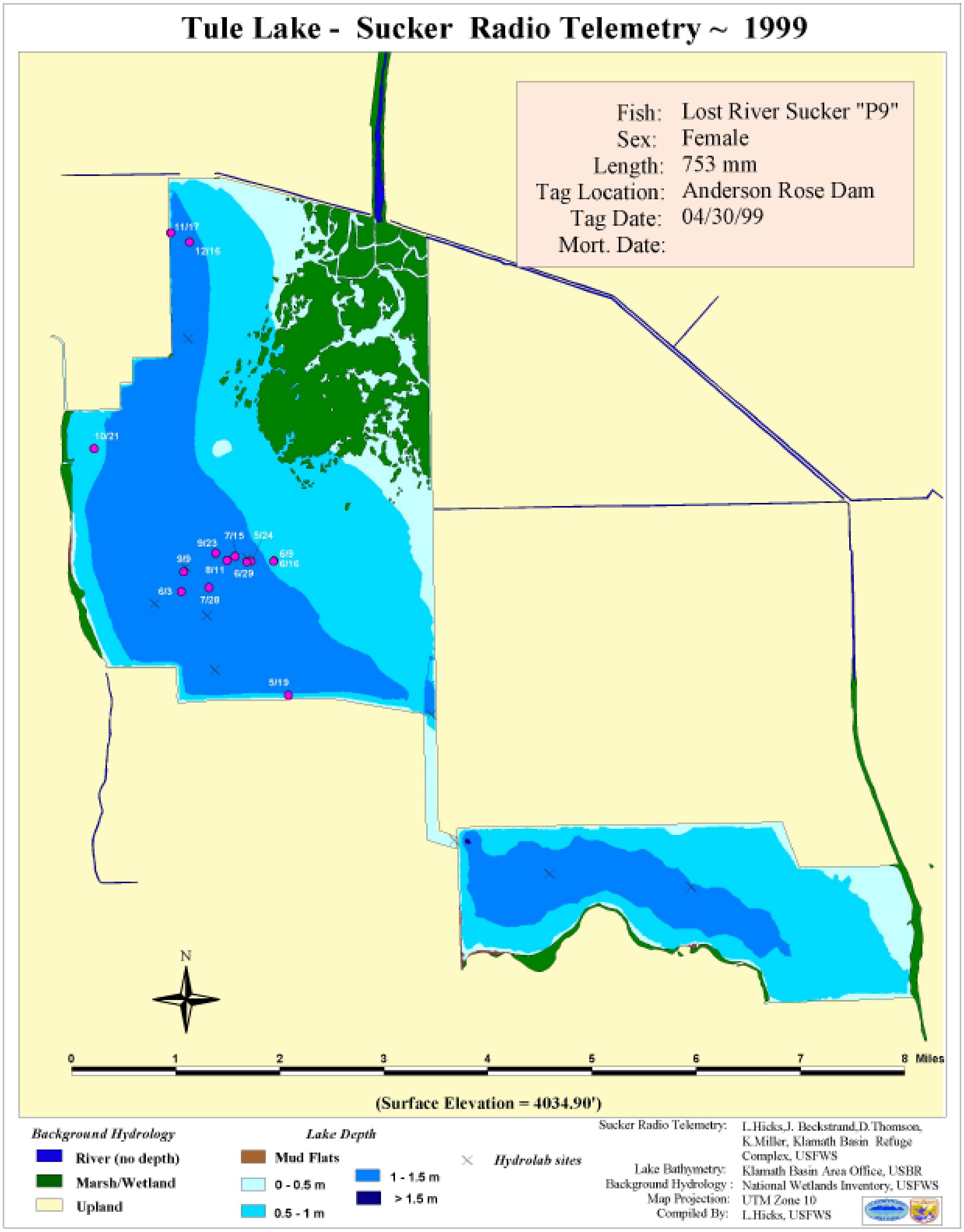


Figure 14. Movements of radio-marked sucker P9 on Tule Lake National Wildlife Refuge, California, 1999.

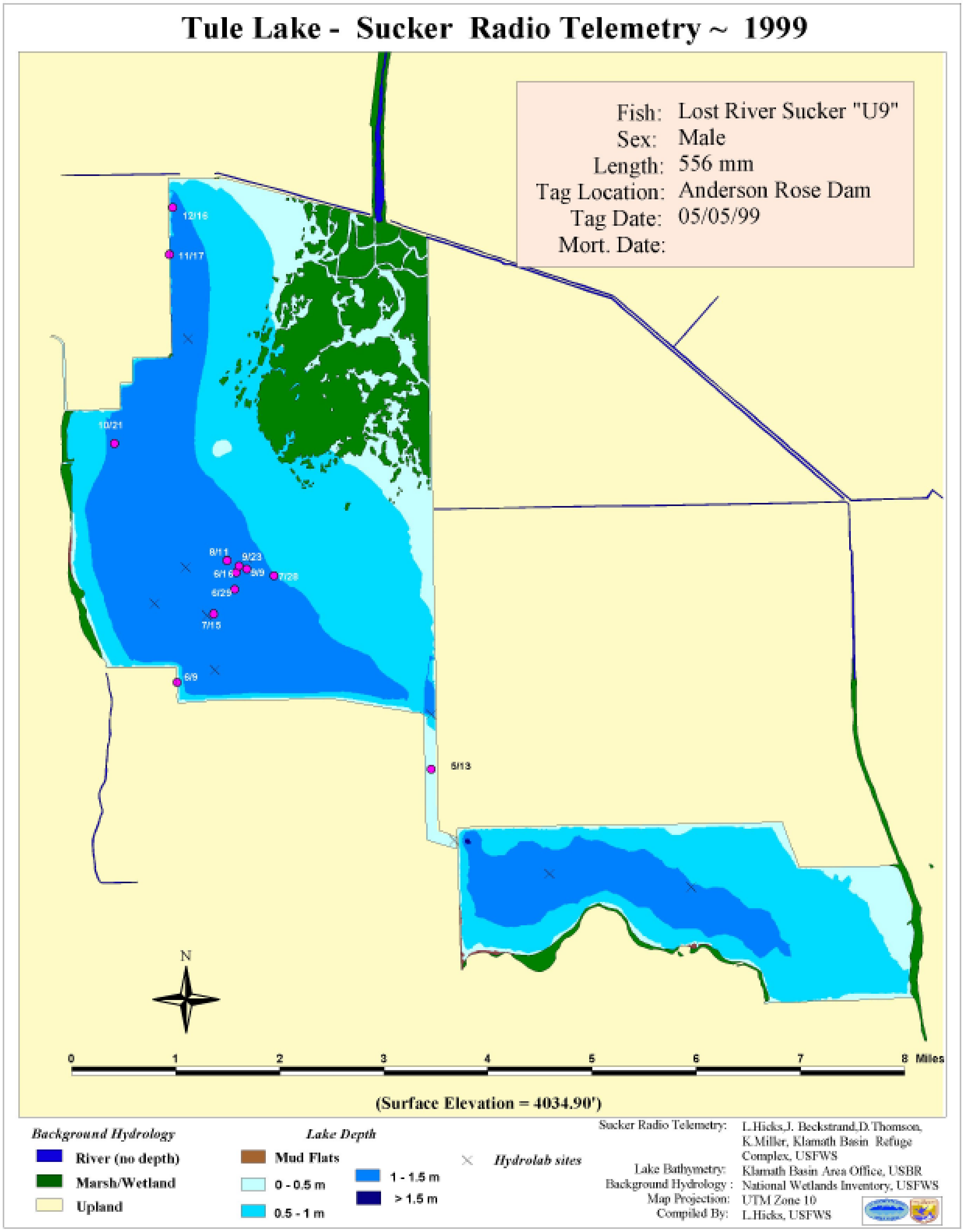


Figure 15. Movements of radio-marked sucker U9 on Tule Lake National Wildlife Refuge, California, 1999.

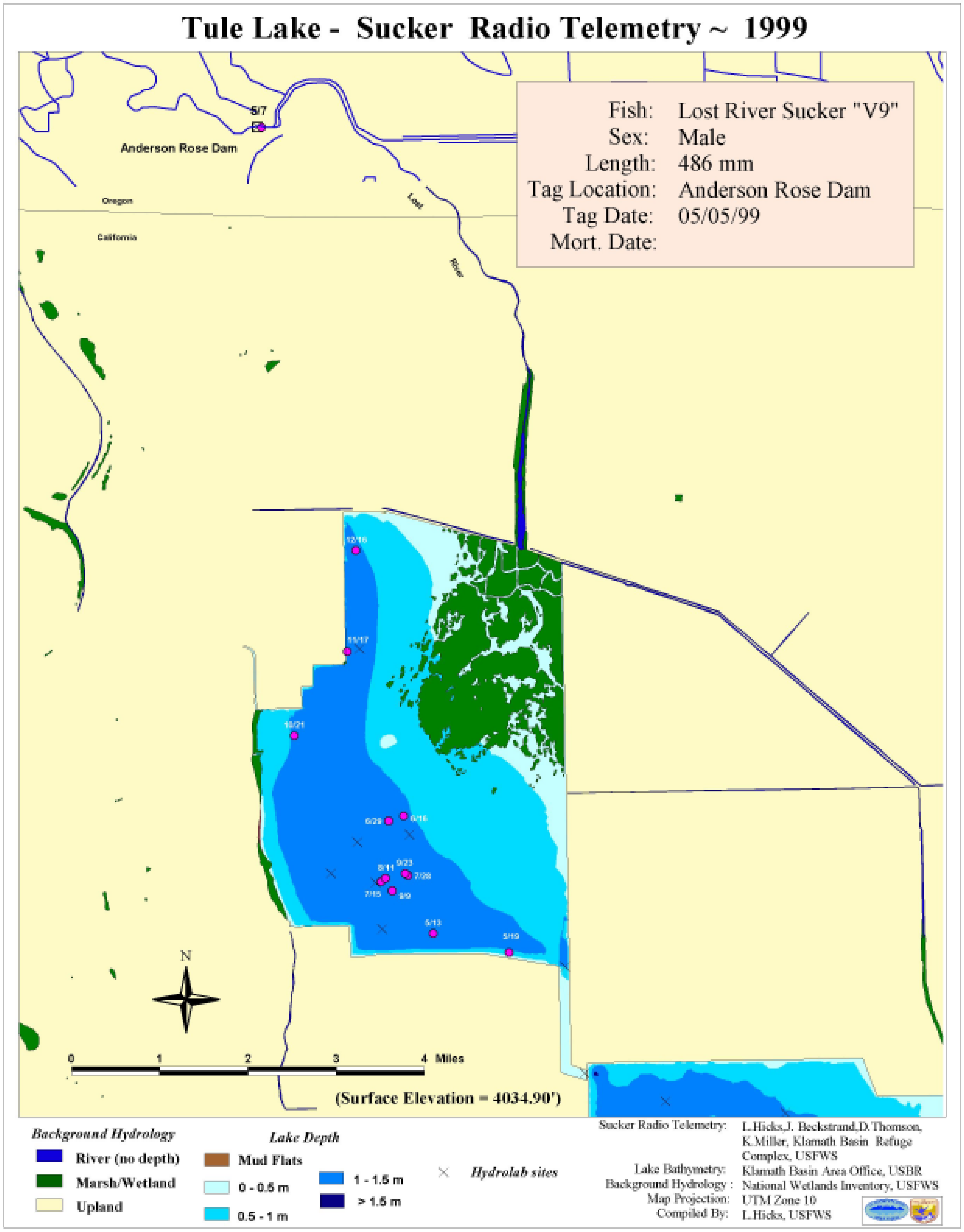


Figure 16. Movements of radio-marked sucker V9 on Tule Lake National Wildlife Refuge, California, 1999.

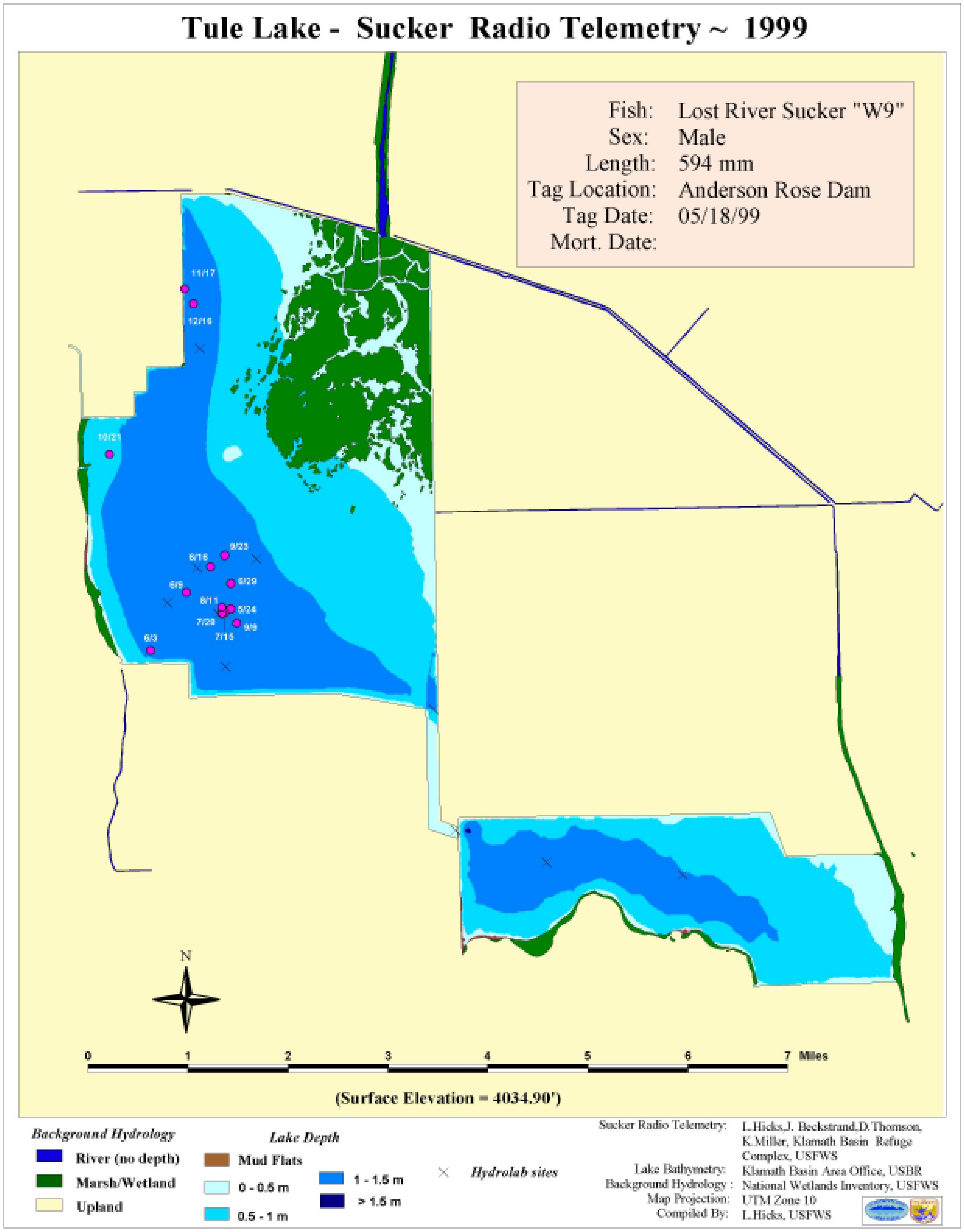


Figure 17. Movements of radio-marked sucker W9 on Tule Lake National Wildlife Refuge, California, 1999.

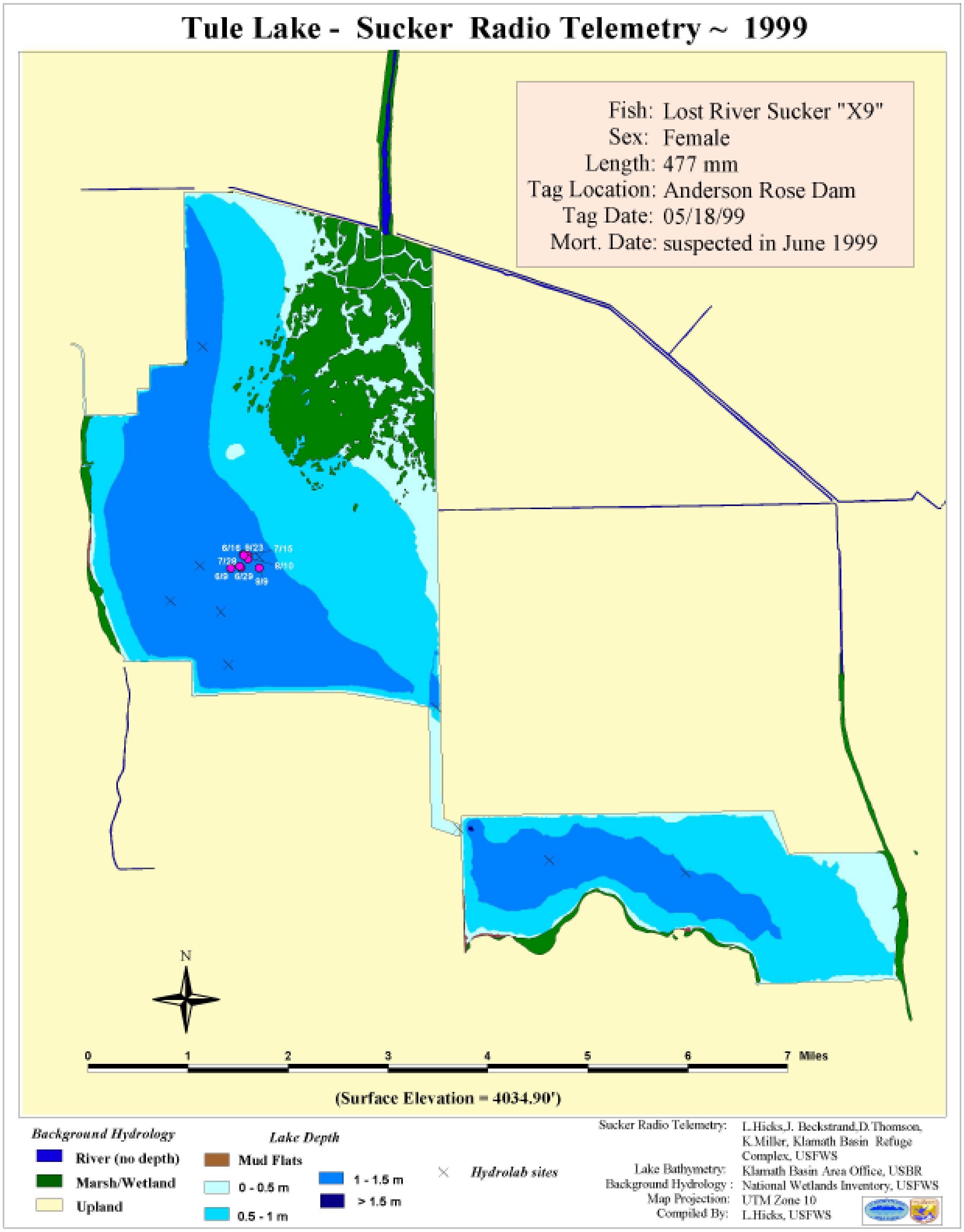


Figure 18. Movements of radio-marked sucker X9 on Tule Lake National Wildlife Refuge, California, 1999.

June - September - During this period, nearly all suckers (particularly during July and August) could be found in the DH at the south central portion of Sump 1(A) (Fig. 4). By connecting the outermost locations of approximately 90% of radio locations, the calculated area of the DH was 188 ha. Suckers using the DH were found in depths ranging from 1.0-1.3 m (39-50 in) (Fig. 19).

September - December - During this period suckers moved from the DH to the northwest corner of Sump 1(A). As of the writing of this report, (February 15, 2000) the 13 remaining fish occupy the same area.

Recruitment

Surveys by Reclamation biologists for larval and juvenile suckers in the Lost River below Anderson-Rose Dam failed to document the presence young of the year fish. Below is a summary of surveys:

Date	Result
5/25/99	Searches for eggs in gravel below Anderson-Rose Dam revealed eggs in 4 of 5 sites, some of which were viable. Larval surveys conducted at 3 sites (visual and dip net) from the dam to the wooden bridge were negative.
6/2/99	Larval surveys conducted at 5 sites including the dam, **2** and 1 mile downstream, the wooden bridge, and East-West Road were negative.
6/10/99	Larval surveys conducted at 2 sites downstream of dam were negative.

Water quality

*pH*BIn general, pH values were less variable in the DH then areas outside this region (Fig. 20). In all areas, median pH values remained below 9.5 until early June at which time values outside the DH were frequently above 10.0. pH values were particularly high (>10.0) in late June through August in ESIB and NWS1A and periodically in the EC and WS1B. pH values in the DH and areas adjacent, remained below 10.0 through September; however, there was a gradual rise in pH values in DH sites from May through September. In late September and early October, DH pH values exceeded all other sites.

*Temperature*BTemperatures in all regions reached a peak in late July through early August with no discernible difference between DH or NDH sites (Fig. 21).

*Dissolved oxygen*BDonut Hole sampling station s differed in dissolved oxygen characteristics relative to other areas of the sumps. During the June through August period DH sites ranged from 4.5 to 11.2 mg/l while areas outside this region ranged from 1.1 mg/l to 18.2 mg/l (Fig. 21). Toward November DH and NDH sites became similar DO dynamics (Fig. 21).

*<u>Turbidity</u>*B In general, turbidity values appeared greater in the DH versus areas outside, although some sites particularly in Sump 1(B) were quite variable particularly in June and July. This may have been due to the large amount of filamentous algae in Sump 1(B), potentially interfering with the measurement. Turbidity rose sharply at sites by late October and November (Fig. 23-24).

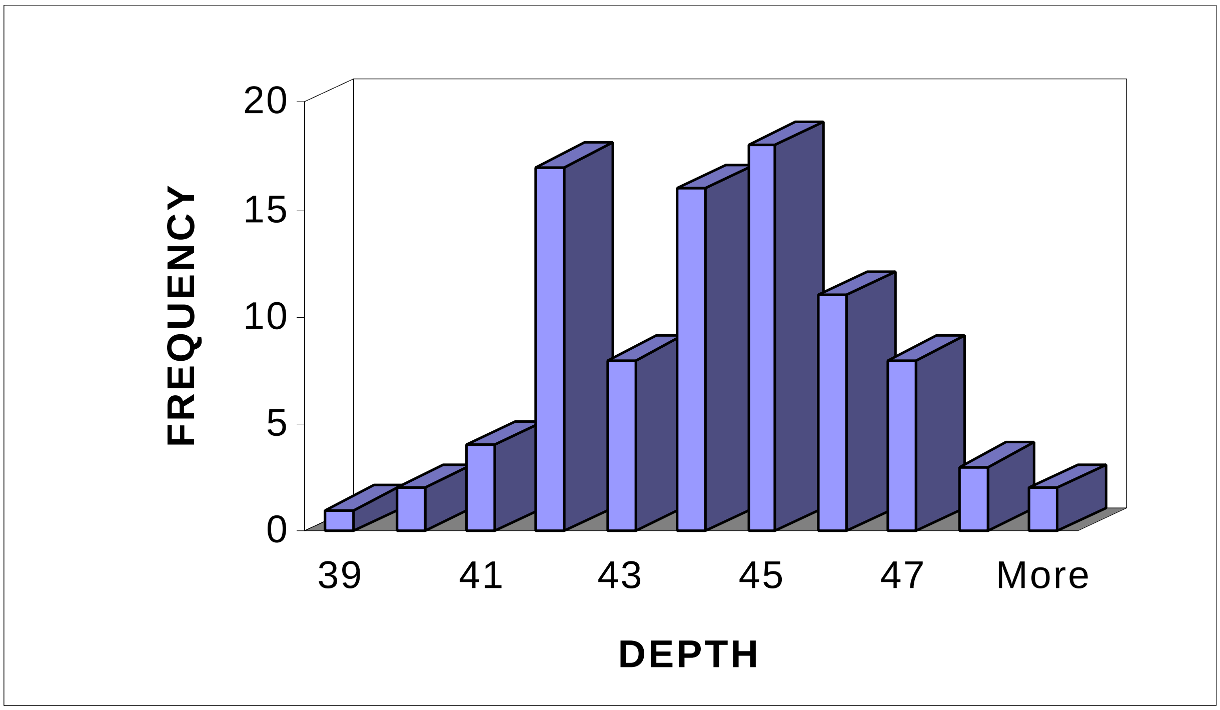
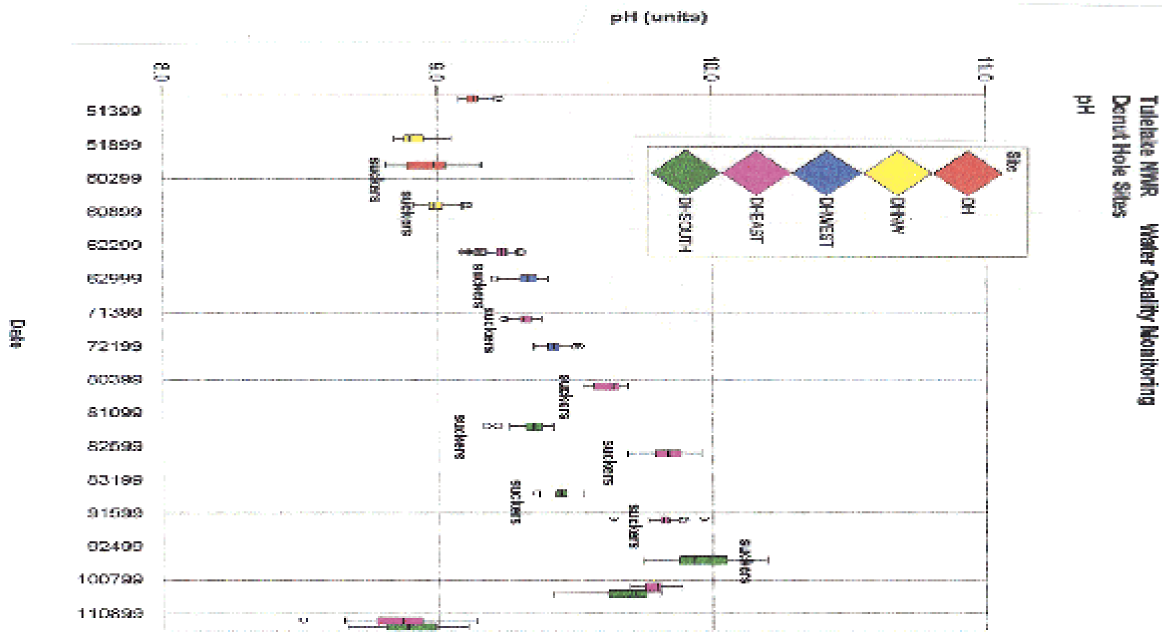


Figure 19. Water depth used by radio-marked suckers in the "Donut Hole" (June-August), Tule Lake NWR. California.



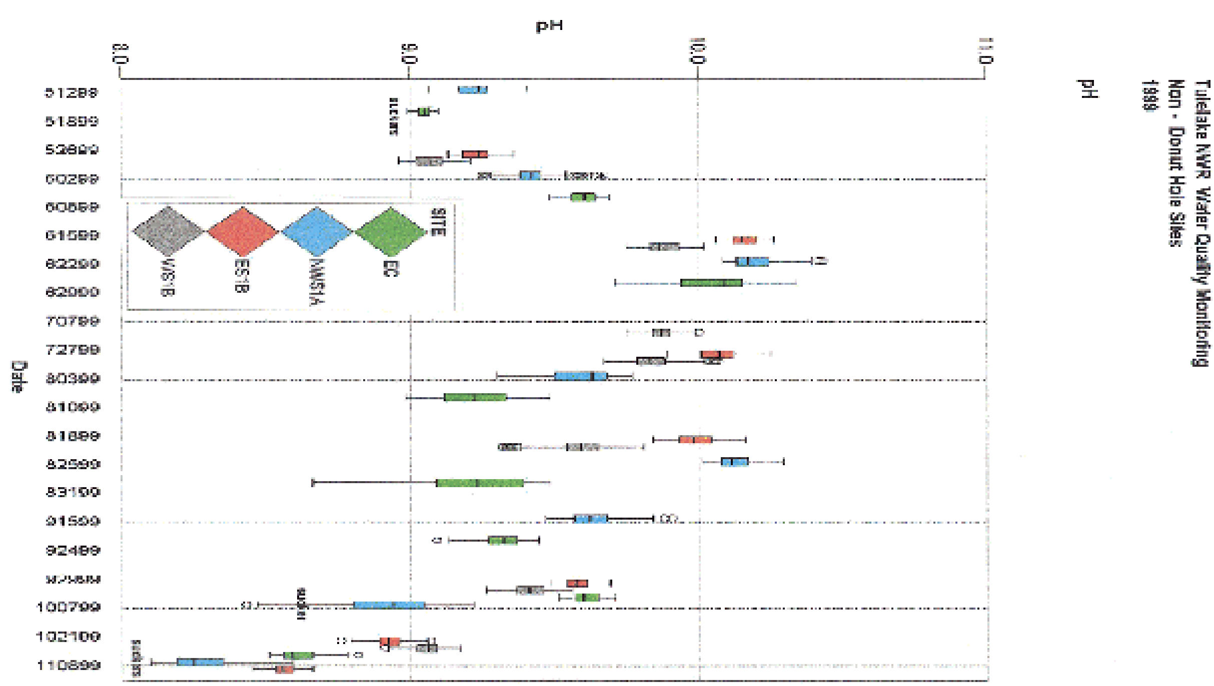
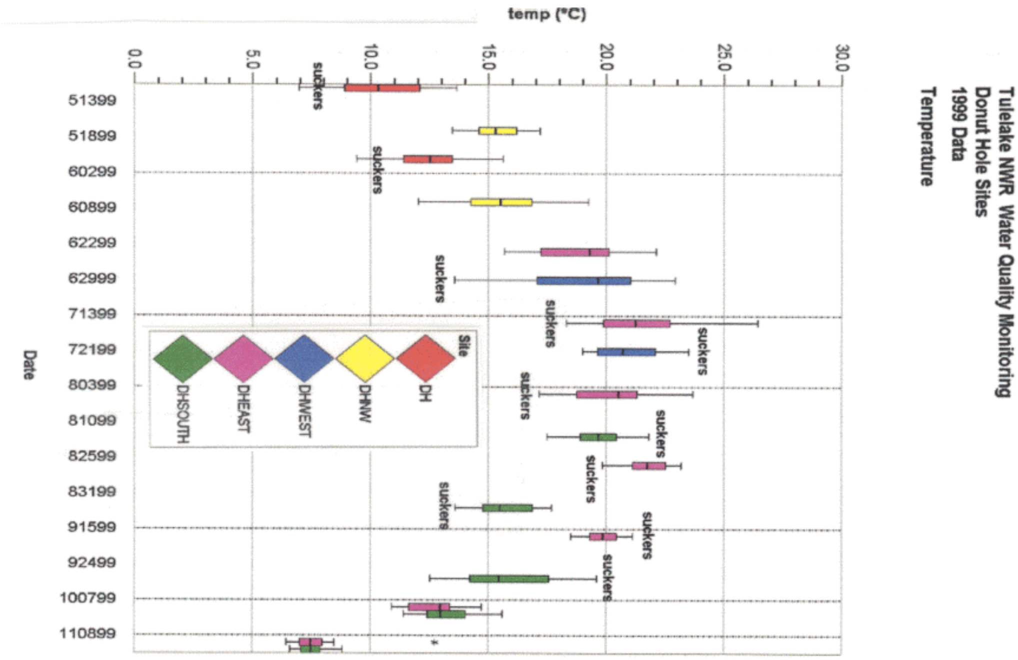


Figure 20. pH data collected from "Donut Hole" and non-Donut Hole water quality sampling sites on Tule Lake National Wildlife Refuge, California, 1999. Box and whisker plots represent the median, 25-75th and 10-90th percentiles, and outliers.



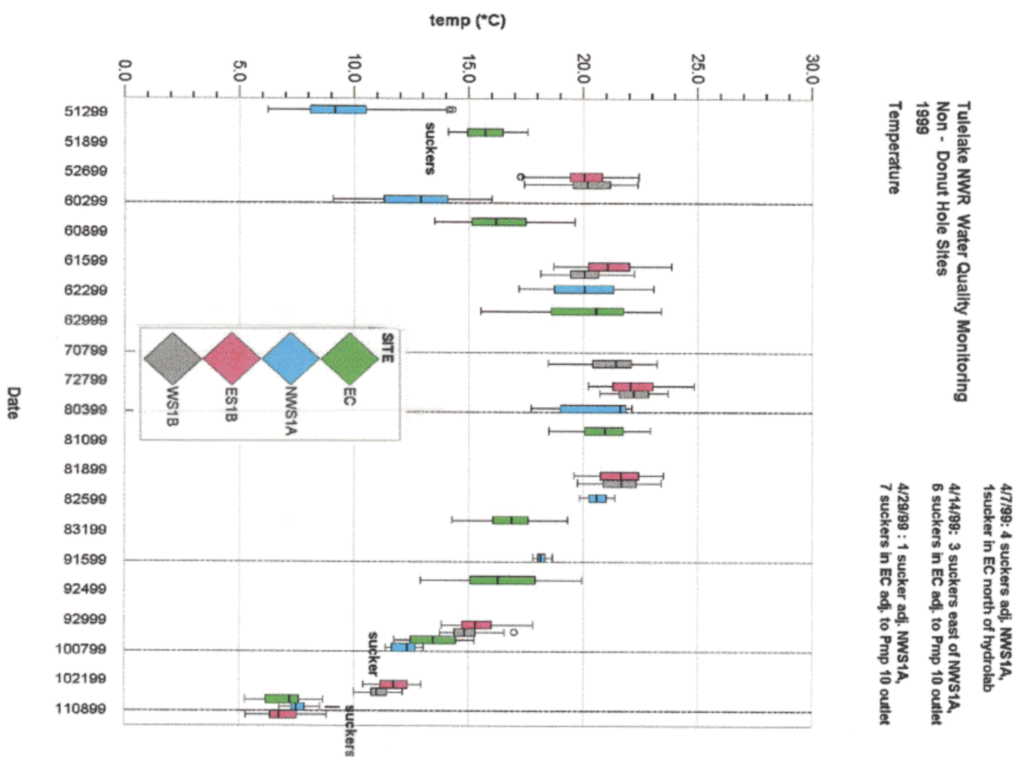
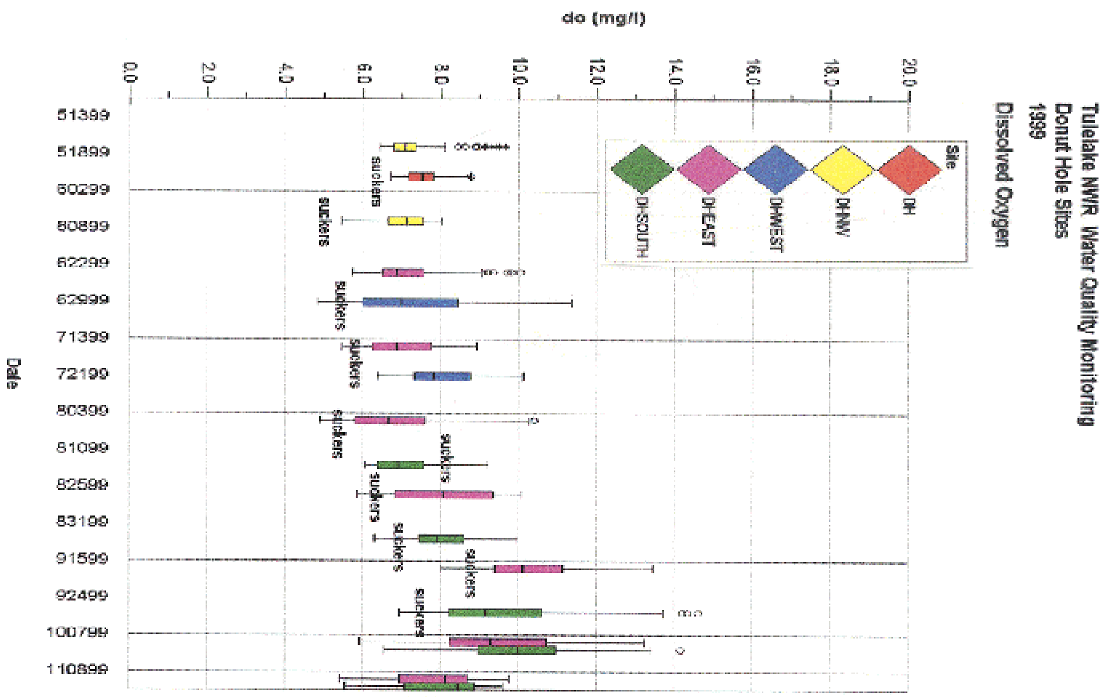


Figure 21. Water temperatures collected at "Donut Hole" and non-Donut Hole sites on Tule Lake National Wildlife Refuge, California, 1999. Box and whisker plots represent the median, 25-75th and 10-90th percentiles, and outliers.



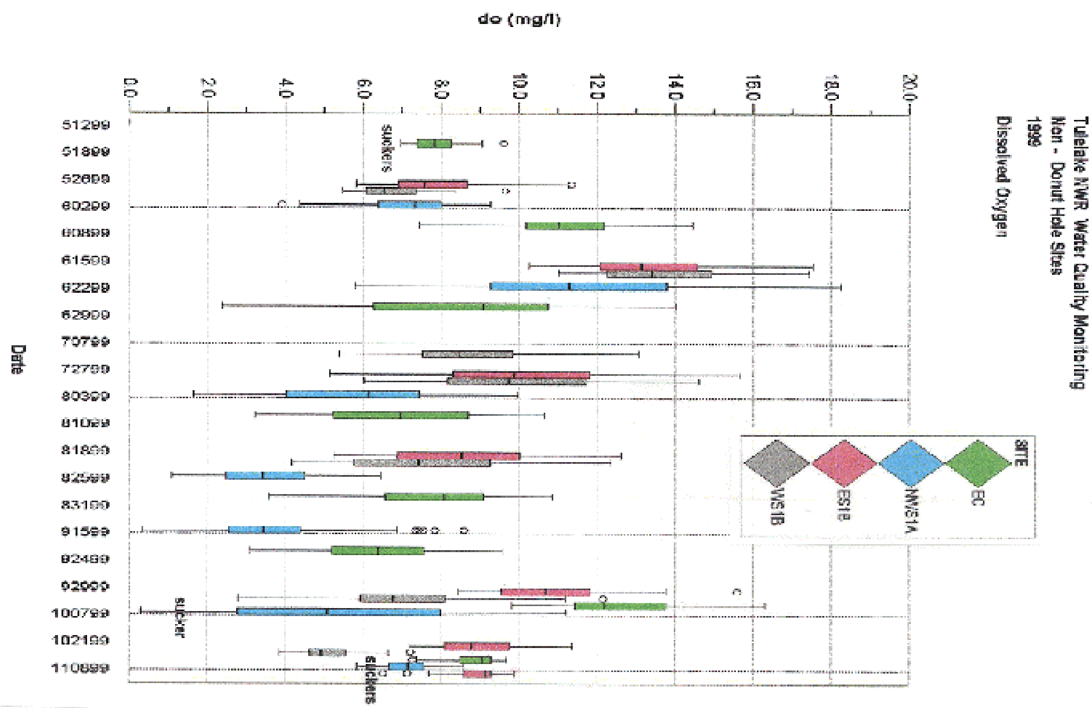
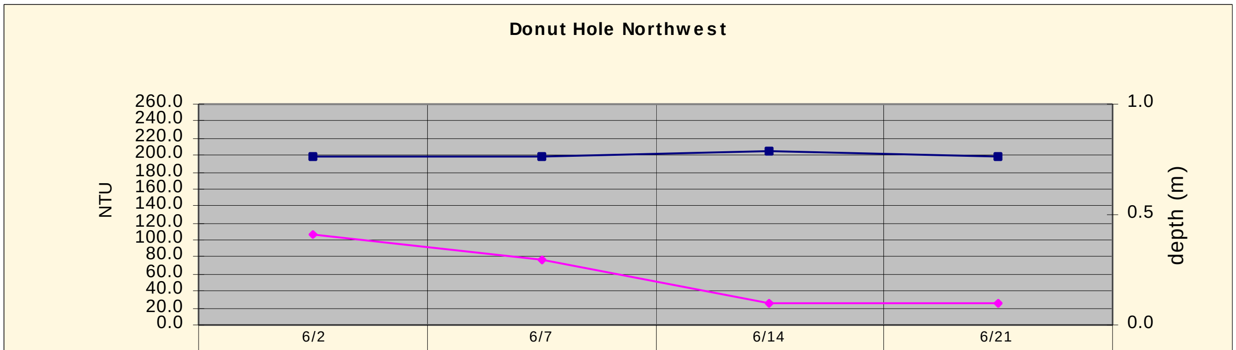
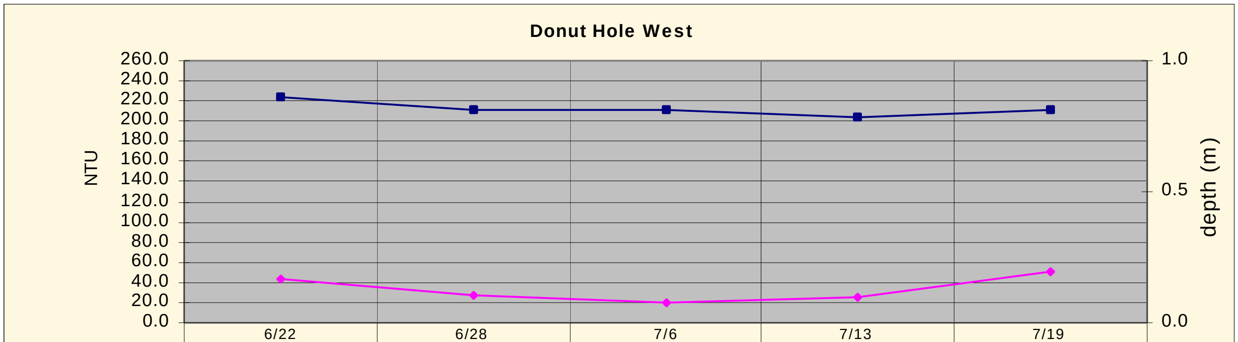


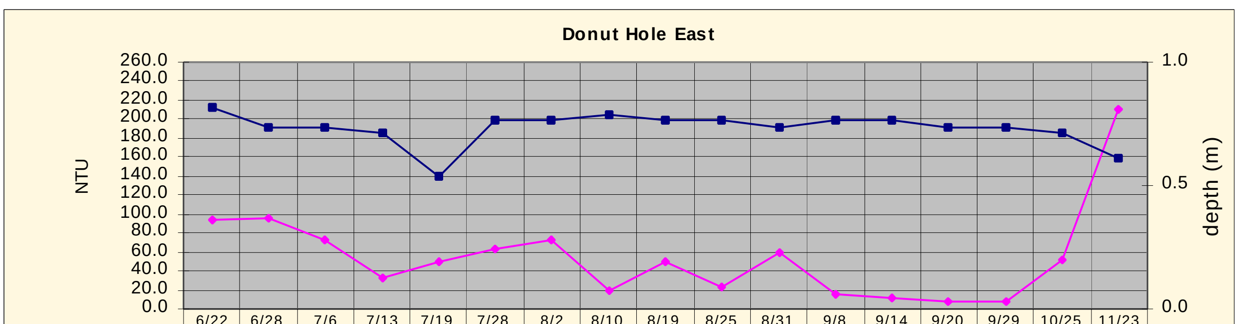
Figure 22. Dissolved oxygen concentrations at "Donut Hole" and non-Donut Hole sites on Tule Lake National Wildlife Refuge, California, 1999. Box and whisker plots represent the median, 25-75th and 10-90th percentiles, and outliers.



	6/2	6/7	6/14	6/21
NTU	107.00	77.20	25.30	24.80
Depth (m)	0.8	0.8	0.8	0.8

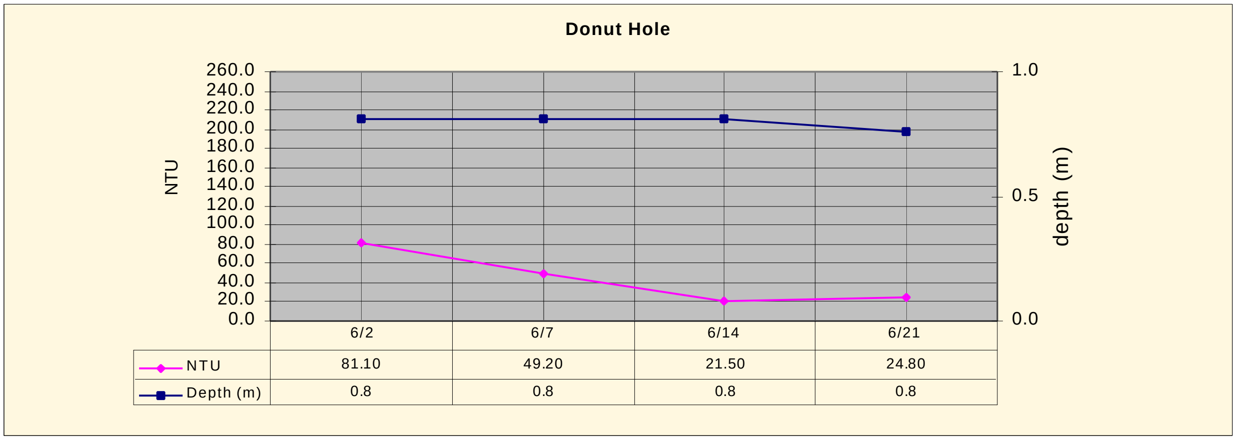


	6/22	6/28	7/6	7/13	7/19
NTU	44.00	26.60	19.90	25.70	51.40
Depth (m)	0.9	0.8	0.8	0.8	0.8



	6/22	6/28	7/6	7/13	7/19	7/28	8/2	8/10	8/19	8/25	8/31	9/8	9/14	9/20	9/29	10/25	11/23
NTU	93.70	95.40	72.70	32.30	50.20	62.50	73.30	18.55	50.20	22.20	58.67	14.38	11.03	7.00	7.80	51.00	210.00
Depth (m)	0.8	0.7	0.7	0.7	0.5	0.8	0.8	0.8	0.8	0.8	0.7	0.8	0.8	0.7	0.7	0.7	0.6

Figure 23. Turbidity at "Donut Hole" sites on Tule Lake National Wildlife Refuge, California, May to November 1999.



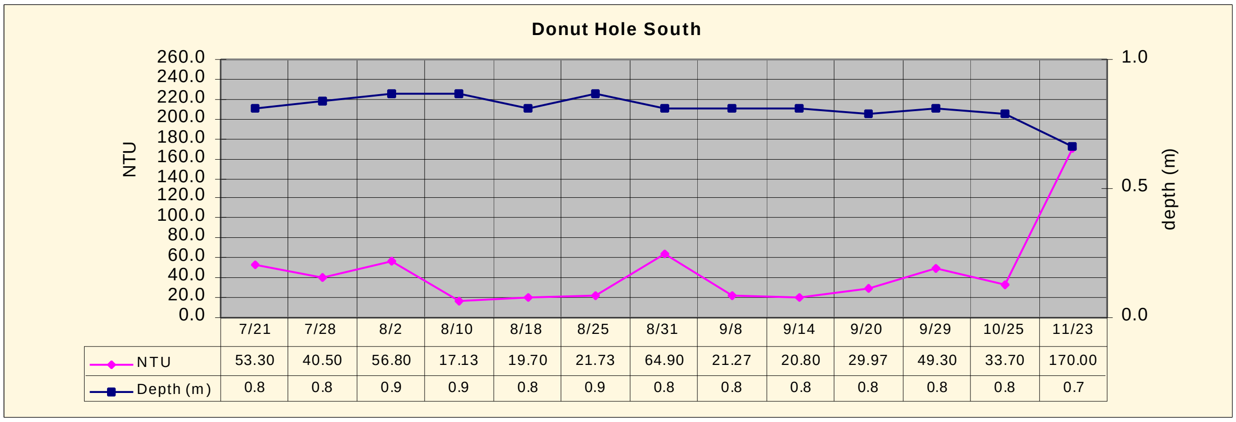
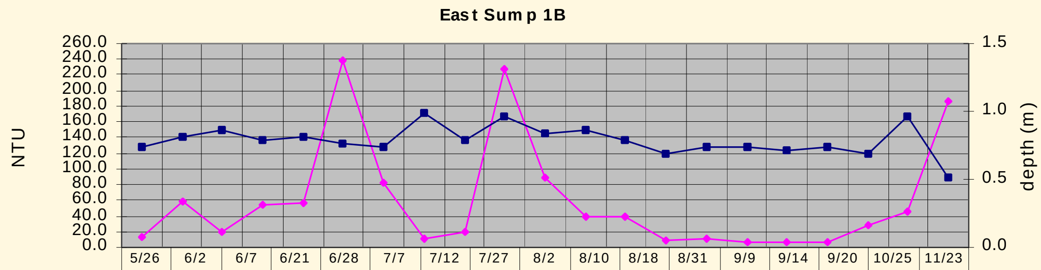
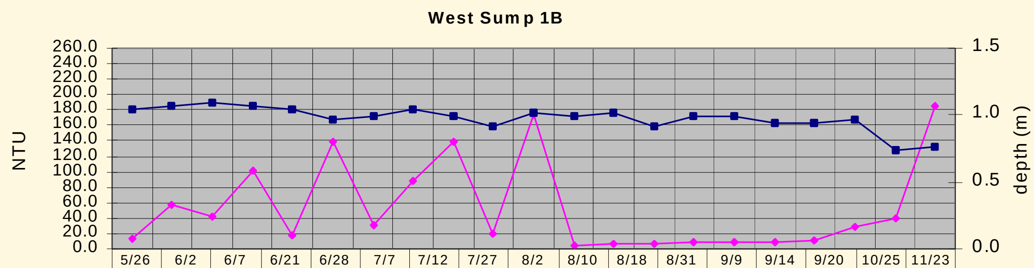


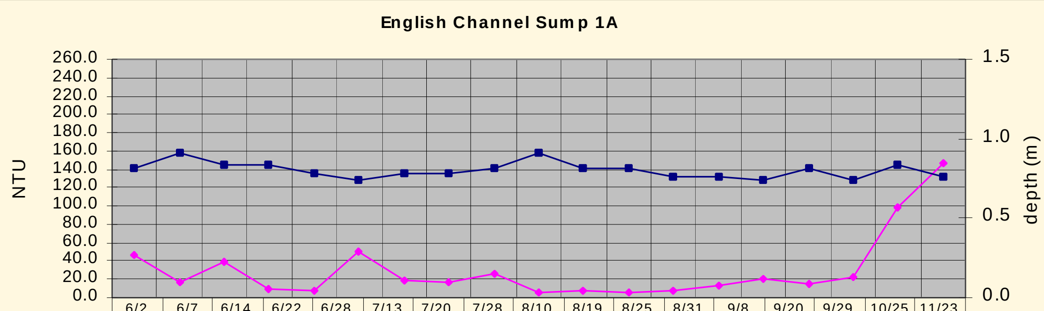
Figure 23 (cont.). Turbidity at "Donut Hole" sites on Tule Lake National Wildlife Refuge, California, May-November, 1999.



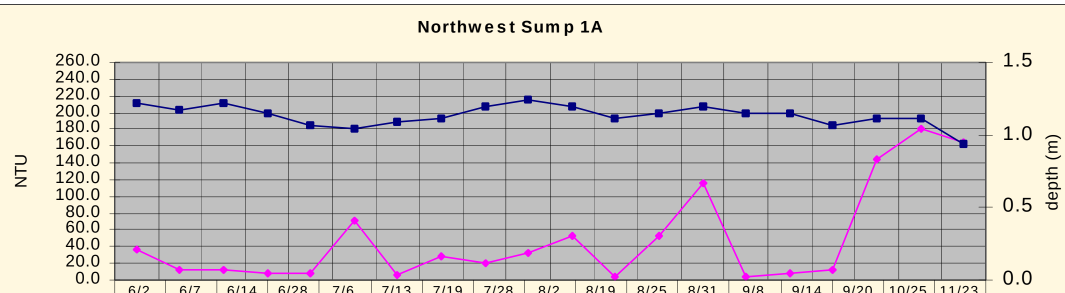
	5/26	6/2	6/7	6/21	6/28	7/7	7/12	7/27	8/2	8/10	8/18	8/31	9/9	9/14	9/20	10/25	11/23
NTU	12.30	58.70	20.30	57.40	239.00	81.70	10.40	228.00	88.00	40.00	38.17	11.30	7.00	6.17	5.83	44.80	186.00
depth (m)	0.7	0.8	0.9	0.8	0.8	0.7	1.0	1.0	0.8	0.9	0.8	0.7	0.7	0.7	0.7	1.0	0.5



	5/26	6/2	6/7	6/21	6/28	7/7	7/12	7/27	8/2	8/10	8/18	8/31	9/9	9/14	9/20	10/25	11/23
NTU	13.70	57.30	41.10	18.70	138.00	29.90	88.90	19.00	173.00	5.47	6.40	9.20	8.58	8.37	11.73	39.50	185.00
depth (m)	1.0	1.1	1.1	1.0	1.0	1.0	1.0	0.9	1.0	1.0	1.0	1.0	1.0	0.9	0.9	0.7	0.8



	6/2	6/7	6/14	6/22	6/28	7/13	7/20	7/28	8/10	8/19	8/25	8/31	9/8	9/20	9/29	10/25	11/23
NTU	46.50	16.10	39.00	9.71	6.79	17.90	17.60	26.80	4.80	7.33	6.50	7.10	13.34	15.50	22.60	98.70	146.00
Depth (m)	0.8	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.8	0.8	0.8	0.7	0.8	0.8



	6/2	6/7	6/14	6/28	7/6	7/13	7/19	7/28	8/2	8/19	8/25	8/31	9/8	9/14	9/20	10/25	11/23
NTU	36.50	12.60	13.10	7.40	71.60	5.27	28.50	20.50	32.10	4.50	52.87	115.67	4.10	7.89	12.43	180.00	164.00
Depth (m)	1.2	1.2	1.2	1.1	1.0	1.1	1.1	1.2	1.2	1.1	1.1	1.2	1.1	1.1	1.1	1.1	0.9

Figure 24. Turbidity at non-Donut Hole sites on Tule Lake National Wildlife Refuge, California, 1999.

Discussion

Water Quality

The area of the DH was delineated from plotted June through September locations of radio-marked suckers (approximately 188 ha.). The location of the DH could also be seen as an area of relatively turbid water from aerial photographs from August 1998 (Fig. 25) as well as aerial photographs taken in 1984. It is possible that the combination of 2 factors may cause the observed turbidity in the DH. First, seeps or springs may be present in the area which result in more favorable water quality during summer which attracts suckers as well as other fish species to the area. The resultant concentration of fish (suckers and chubs) may stir the sediments during feeding activities, thereby creating the observed turbidity. The additional turbidity in the DH may inhibit light penetration and the production of algae, thereby reducing photo synthetically elevated pH and the extreme minimum and maximums in DO typical of may water bodies in the Klamath Basin including Tule Lake (Dileanis et al. 1996).

The rise in turbidity at all sites in fall is likely due to the break down of rooted aquatic vegetation which then allows for wind induced wave action to stir the sediments. Other than the DH, all other sites had dense concentrations of rooted aquatic plants and/or filamentous green algae during summer.

June to September DO and pH dynamics in the DH appeared different than at NDH sites (Figs. 20 and 22). The difference was greatest in early summer with the difference becoming smaller by late summer and essentially disappearing by fall. Whether this water quality difference was a result of the more turbid waters or inflow from springs is unknown. However, attempts by Service hydrologists to model inflows, evapotranspiration, and outflows from the sumps have resulted in a positive imbalance of approximately 21,000 acre-feet of water from April through September. This positive imbalance is greatest in spring and early summer, gradually lessening by summer and essentially disappearing by fall (Tim Mayer, pers. comm.). If this inflow is occurring, it may explain differences in summer water quality between DH and NDH sites.

June to September water quality in the DH may be critical to the over summer survival of suckers in Tule Lake as pH and DO in NDH sites during summer often exceeded the tolerance limits for the fish. DO and pH levels at DH sites were less variable and did not reach the extremes that were reached in NDH sites. The lowest DO measured during June through September at DH sites were 4.83 mg/l (DHWEST) and 4.96 mg/l (DHEAST). DO and pH during summer from this study were similar to values collected by Reclamation in 1992 (Table 3). Buettner and Scoppettone (1990) found juvenile suckers only where DO was above 4.5 mg/l. It is currently believed that adult suckers become stressed at DO levels below 4.0 mg/l with mortality occurring at or below 2.0 mg/l (M. Buettner, pers. comm.). The relatively high over-summer survival of radio-marked suckers, compared to suckers radio-marked in Upper Klamath Lake (M. Buettner, pers. comm), is further evidence of suitable summer water quality conditions in the DH on Tule Lake.

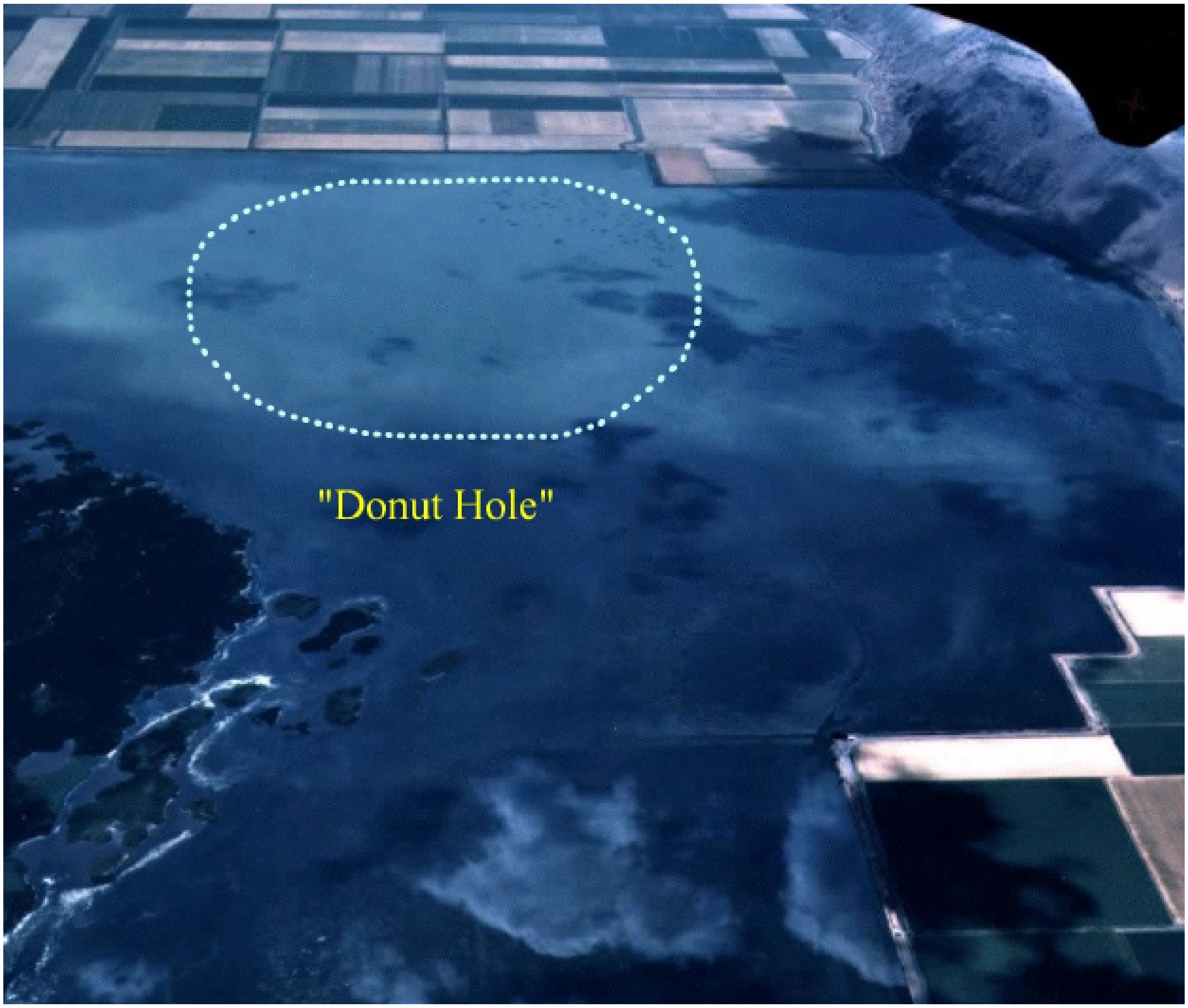


Figure 25. "Donut Hole" in Sump 1(A) of Tule Lake NWR. Note visible turbidity of area.

Table 3. Mean dissolved oxygen, pH, conductivity, and temperature on Tule Lake National Wildlife Refuge, California, July and August 1992. Data are from 2 sites; 1 site each in Sump 1(A) (within the ADonut Hole@) and 1(B). All data were from 96 hour continuous readings from Hydrolabs. Data were collected at intervals of 1-2 hours. (Data summarized from U.S. Bureau of Reclamation).

Site	Depth (M)	pH ($\pm$SD) (1200-1700 hrs)	Temp ^{o}C ($\pm$SD) (1200-1700 hrs)	Conductivity	DO[1]
Sump 1(A)	$\leq$ 0.5	9.32 $\pm$ 0.83 n=81	21.85 $\pm$ 2.84 n=81	500 $\pm$ 266 n=81	0 of 31 days
	0.51-1.5	9.22 $\pm$ 0.93 n=26	21.53 $\pm$ 2.46 n=26	598 $\pm$ 277 n=26	-
	>1.5	8.30 $\pm$ 0.71 n=10	19.90 $\pm$ 1.59 n=10	859 $\pm$ 694	-
Sump (1B)	$\leq$ 0.5	9.65 $\pm$ 0.44 n=21	22.96 $\pm$ 1.10 n=21	628 $\pm$ 148 n=21	8 of 21 days
	0.51-1.5	9.79 $\pm$ 0.45 n=7	22.11 $\pm$ 0.51 n=7	571 $\pm$ 74 n=7	-
	>1.5	No data	No data	No data	-

[1] Proportion of monitored days having a minimum dissolved oxygen level below 5 mg/l. (Data from U.S. Bureau of Reclamation)

pH levels in the DH generally remained below 10.0 whereas non DH sites frequently exceeded 10.0 (Fig. 19). Falter and Cech (1991) determined a maximum pH tolerance in shortnose suckers of 9.55$\pm$0.43 under laboratory conditions, levels generally exceeded in June - September at non DH sites and some DH sites in late summer. Buettner and Scoppettone (1990) found juvenile fish in Upper Klamath Lake largely at sites with pH < 9.0, as did Simon et al. (1996) in 1994. However, in 1995, Simon et al. (1996) found that most juvenile fish (54%) were captured in areas of higher pH (>10.0). Laboratory studies indicate significant mortality of larval and juvenile fish at high pH values (>9.55) (Falter and Cech 1991) and 9.92-10.46 (Bellerud and Saiki 1995).

Previous water quality and fish health studies on the refuge determined that water quality conditions were stressful to aquatic life and was resulting in a high (up to 37%) proportion of fish with deformities (Dileanis et al. 1996), however, studies of sucker ecology in Tule Lake have indicated that individual fish in the lake have a high condition factor and are free of external parasites (Scoppettone and Buettner 1995). Bennet (1994) recognized this apparent inconsistency, stating, A...the observation that Tule Lake suckers are in better physical condition than Upper Klamath Lake suckers indicates that certain areas of the aquatic system may be of particular importance for the recovery of those species.@ In the case of Tule Lake this Acertain area@ is likely the DH.. Suckers in Tule Lake may be in good condition because of their limited population size, the abundant food resources in this lake, and adequate water quality (in the DH) to survive the summer period.

<u>Sucker movements</u>

Although, suckers were relatively sedentary during most periods of the year, they exhibited the ability to make long distance moves in relatively short periods of time, particularly during the April spawning period. The northwest corner of Sump 1(A) receives about 90% of the inflow from the Lost River and spring winds on Tule Lake tend to move large quantities of water through the AEnglish Channel@ back and forth between Sump 1(A) and 1(B). This movement of water at both locations may explain the movement of fish observed in April and May. Suckers may be attracted to both locations when seeking spawning habitat in spring.

<u>Recruitment</u>

During the April marking period, most captured suckers appeared to be physiologically ready to spawn; however, only one fish moved into the river. Of 10 radio-marked fish monitored by Reclamation in 1993-95 no fish attempted to run the Lost River. This low proportion of fish that attempt to spawn may have one or several causes or a combination, including:

1. Stress of handling and implanting radio-transmitters so close to the spawning season may prevent fish from becoming reproductively active.

2. Under normal conditions, only a small proportion of Tule Lake suckers may attempt to spawn in any particular year.

3. Flow conditions in or at the mouth of the Lost River may be inadequate to draw the fish into the river.

4. A shallow bar (<0.3 m) of deposited silt exists between the lake and the mouth of the river which may form a physical barrier to the fish.

At the present time, a mandated flow of 30 cfs is released below Anderson-Rose Dam to provide spawning habitat at the Dam. Although this flow is intended to provide suitable spawning conditions at the Dam, these flows may be inadequate to entice fish into the river. It is likely that the historic spring flows in the Lost River were many times higher than current regulated flows. However, given that the fish are largely unsuccessful in spawning and risk additional mortality traversing the river, adult survival may be enhanced by remaining in the lake. Scoppettone and Buettner (1995) also observed no radio-marked fish from Clear Lake to move into Willow Creek during the spring spawning period. In this case the authors attributed this result to either capture stress or low stream flows during spring.

Habitat use

Although the DH is relatively shallow relative to other areas of Tule Lake, use of the DH may be mandatory to ensure over-summer survival. Although deeper waters are available to the fish, especially in the northwest corner of Sump 1(A), DO levels, in particular, likely preclude their use. Suckers did not move out of the DH until October when DO levels began to rise with cooler water temperatures. Although, Sump 1(B) contained suitable water depths and water quality conditions in fall, no suckers were located in this area. It is possible that suckers may prefer not to pass through the pipes connecting the Sumps or the proximity and flow from the Lost River in the northwest corner of Sump 1(A) may make this area more attractive as an over-winter habitat area.

The relative lack of water depth in the DH as well as other areas of the sumps is becoming of increasing concern because of the loss of water depth through sedimentation. If suckers require a minimum of 3 ft of water, as is current believed (M. Buettner, pers. comm.), current rates of sedimentation in the sumps threaten the future suitability of Tule Lake for suckers. Based on a comparison of bathymetric surveys conducted by Reclamation in1958 and again in 1986, sedimentation has been steadily reducing the water holding capacity of both sumps. Between the 1958 and 1986 surveys (28 years), Sump 1(A) has lost 22.4% of its water capacity and Sump 1(B) has lost 30.8% of its capacity due to sedimentation. This would indicate a total mean sedimentation of 11.8 inches over this time period (U.S. Bureau of Reclamation, unpubl. rep).

Over the last several years, an attempt has been made to store additional water in Tule Lake during summer by raising water levels above 4034.60 ft. This increase in water elevations (between 4034.60 and 4034.90 ft) has somewhat mitigated the loss of depth through sedimentation. However, without reinforcing and raising the levees around the sumps, there is a limit as to how high water elevations can rise. At elevation 4035.50 ft., operating regulations require breaching the sumps into overflow areas (Sump 2 or 3). Although increased summer operating levels may assist the fish, they may also increase the risk of a flood event requiring the breaching of the sumps with potentially negative impacts to the fish.

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Personnel Communications

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