Inventory of aquatic invasive species and water quality in lakes in the Lower Truckee River Region: 2010

by

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INTRODUCTION

The introduction and establishment of aquatic invasive species throughout the Truckee River region is of growing concern to resource managers. Recent research from the region, conducted largely within Lake Tahoe, suggests that invasive species alter the biodiversity and water quality condition of the ecosystem. For example, the recent introduction of Asian clam (*Corbicula fluminea*) is thought to facilitate increases in algal blooms in the southeastern part of the lake; and invasive plants such as water milfoil (*Myriophylum spicatum*) alter nearshore habitats and facilitate the invasion of other species such as warmwater fishes.

New invasive species to the region (e.g. dreissenid mussels at Lake Mead) are also of increasing concern to resource managers in the watershed. They have been known to significantly impact water quality, resulting in large scale economic damage by clogging water intake pipes and reducing recreational activity when they establish. Furthermore, they are capable of moving to the Truckee River region via transport on boat trailers (Whittmann et al. 2009, Umek et al. 2009). Chandra et al. (2009) suggests that adult mussels may be able to live in the ultra-oligotrophic, low calcium water of Lake Tahoe and waterways in the western Great Basin if they are transported to these ecosystems.

In order to minimize the risk of invasive species introduction to waterbodies along the Truckee River, boat inspection programs have been suggested for select waterbodies. However, prior to the full implementation of a boat inspection program, information on the current locations of invasive species is needed to determine which locations may contain species of significant concern for transport within the region.

The objective of this project was to coordinate collections by different agencies of various monitoring attributes to conduct a snap shot assessment of water quality and to monitor invasive invertebrate and plant communities in lakes and reservoirs within the Truckee River region (Donner Lake, Stampede Lake, Boca Reservoir, Prosser Reservoir, Marlette Lake, Spooner Lake, Martis Creek Lake, Pyramid Lake, Lahontan Reservoir, Rye Patch Reservoir, Independence Lake, and Webber Lake) during the 2010 season. Specifically the goals were to:

1. Develop a method to survey lake shorelines for aquatic invasive invertebrate (Dreissenid mussels, New Zealand mudsnail, Asian clam, and crayfish) and invasive plant (Hydrilla and Eurasian water milfoil) species.
2. Assess lakes for invasive invertebrate and plant species by conducting shoreline surveys at the beginning and end of the season, sampling for mussel veligers every 4-6 weeks using net hauls, and setting minnow traps at the end of the season to sample for invasive fishes and crayfish.
3. Assess water quality by conducting water quality profiles for basic parameters (temperature, dissolved oxygen, and specific conductivity) every 4-6 weeks, collect water samples from each physical strata at the beginning and end of the season for nutrient (nitrogen, phosphorus, and calcium) analysis, and collect sediment pore-water at 3 different locations in each lake at the end of the season to determine if the waterbodies can sustain mussels.

METHODS

Study lakes and agency coordination

Twelve lakes that represent the major recreational water bodies in the region were chosen for assessment (Table 1). We coordinated and compiled information collected by various agencies to obtain a larger picture of the invasion potential to the region (Table 2).

Adult invasive invertebrate and plant surveys

A protocol was developed to survey lake shoreline area for adult invasive species and invasive plants. Shoreline area sight surveys were conducted via boat or on foot, depending on feasibility, along the entire lake shoreline. When boating was required, a 14 ft rowboat was driven at a slow and constant speed around the shore. Fifteen transects were chosen in each lake for a detailed evaluation. Transect locations were chosen based on areas where invasive mussel and clam species were likely to be found (i.e., boat launches, public docks, and other hard substrates). Since lake habitat is heterogeneous, our secondary consideration was to choose transects that would be representative of habitat variability in each system. GPS coordinates were recorded for each transect when possible and the location described.

At each transect, a 5 m^2 section was closely examined for the presence of invasive species and evaluated for substrate composition. Within each section, rocks were uprooted and examined for mollusk species and sand was dug up by hand and examined for New Zealand mud snails. Unknown plants and invertebrates were collected and taken back to the laboratory for identification. At each transect, the location, substrate composition, and percent of area where invasive species were present (when applicable) was recorded. Wentworth's substrate guide (1922) was modified and used to define general substrate types present at each transect such that rock substrate includes gravel (6.4 mm) to boulder (≥ 610.0 mm), woody structure includes material with a diameter of < 20.5 mm to ≥ 50.9 mm, and fine substrates include anything smaller than gravel (sand, silt, and organic matter).

A sampling using minnow traps was conducted at the end of the season to evaluate lakes for nonnative forage fishes and crayfish. Frabill black and galvanized steel crayfish traps were set along 3 transects at various depths (specific to lake depth). Traps were baited with dry dog food contained in nylon pouches and left to fish for 24 hours. All crayfish caught were collected and taken back to the University of Nevada's Aquatic Ecosystem Analysis laboratory and processed for body condition (length, weight). Graphical representations of catch per unit effort (CPUE) and size distributions were completed in Microsoft Excel.

Quagga and zebra mussel veliger detection

Plankton tows to detect the presence of zebra and quagga mussel veligers occurred every 4-6 weeks from July to October 2010 following a standard protocol developed by California Fish and Game (CFG 2008) or a similar protocol developed by the Bureau of Reclamation for the lakes they monitored. In general samples, were sent to the California Fish and Game (CFG) laboratory for analysis within the time allotted in the CFG protocol. A 64 micron, 30 cm diameter plankton tow net was used to sample for dreissenid veligers at various locations within the lake. Sampling locations were described and their GPS coordinates recorded. Combinations of vertical and horizontal tows were used depending on water depth and sampling location. Each sample was composed of 2-3 tows from the same location and stored in a 25% by volume 95% reagent grade (non-denatured) ethanol (ETOH) solution. To prevent possible contamination between lakes, all sampling equipment was soaked in vinegar, rinsed, and dried between samplings (California Fish and Game, 2008).

Water quality profiles for lake condition (trophic status and calcium levels)

To determine the physical condition of each ecosystem at the time of sampling, water quality profiles for temperature, dissolved oxygen, and specific conductivity were completed every 4-6 weeks from July to October 2010 using a handheld YSI-85-100 meter (YSI Incorporated, Yellow Springs, Ohio). Transparency was measured at the beginning of each sampling period using a 20 cm diameter, black and white, Secchi disc. To determine the nutrient condition and calcium levels of each ecosystem, water samples were collected from each lake strata (epilimnion, metalimnion, and hypolimnion) at the beginning and end of the season. Strata were defined based on the temperature profiles at the time of sampling. Water samples were collected using a horizontal, beta Van Dorn sampler. Samples were transferred to 1 L prerinsed, plastic bottles and kept cool until processing. Samples were filtered at the University of Nevada's Aquatic Ecosystems Analysis Laboratory for calcium (Ca), total phosphorus (TP), dissolved phosphorus (DP), and ammonium (NH_4). Glass fiber filters (GFF, 0.7 um) were used to filter water for dissolved phosphorus and ammonium while 0.45 um, magna nylon filters were used to filter water for calcium analysis. Total phosphorus was measured from raw sample water. Since water column nutrients do not always indicate the nutrients available to invasive species invading benthic habitats, sediment water samples were collected from 3 different locations in each lake at the end of the season. Samples were collected using a large, modified plastic syringe apparatus and filtered for calcium analysis. Calcium samples were sent to the University of California–Davis plasma mass spectrometry center for analysis. Phosphorus and nitrogen were analyzed at the University of Nevada's Aquatic Ecosystems Analysis Laboratory using standard methods.

RESULTS

Adult invasive invertebrate and plant surveys

Aquatic invasive species were detected in each of the lakes surveyed (Table 3). Dreissenid (zebra *Dreissena polymorpha* and quagga *Dreissena rostriformis*) mussels and New Zealand mudsnail snail (*Potamopyrgus antipodarum*) were not found in any of the study lakes. Asian clams (*Corbicula fluminea*) were found in Donner Lake along the state park beach on the southeast shore. A large Asian clam shell was also found in Martis Creek Lake about 1 m out from the main boat launch/parking area on the west shore of the lake. A follow up survey was conducted and no other clams were detected (however, dense vegetation highly limited sight surveys). Crayfish (*Pacifasticus leniusculus*) were found in Boca, Prosser, Stampede, Donner, Independence, Webber, and Marlette. Crayfish catch per unit effort (CPUE) was variable across lakes ranging from 1.1 to 19.5 (Figure 1). CPUE at depth varied for each lake (Figure 2) as did size (mm) distribution (Figure 3). Eurasian watermilfoil (*Myriophyllum spicatum*) was found in Spooner and Martis Creek Lake. The invasive weed was highly concentrated in bays but was widespread throughout the entire lake in both lakes. Hydrilla (*Hydrilla verticillata*) was not found in any of the study lakes. Shoreline invasive species survey data can be found in Appendix A. The relative lake substrate composition for each lake, derived from the examined transects is presented (Figure 4).

Quagga and zebra mussel veliger detection

Veliger DNA was not detected in any of the lakes (Donner, Stampede, Boca, Prosser, Marlette, Spooner, Martis Creek L., Independence, Pyramid, Lahontan, and Rye Patch) during any sampling period in 2010 (Table 4).

Water quality profiles for lake condition (trophic status)

Water clarity, measured by Secchi depth (m) was highest in Donner lake ($\bar{x}$ = 11.17) followed by Independence ($\bar{x}$ = 10.50), Marlette ($\bar{x}$ = 6.30), Stampede ($\bar{x}$ = 5.95), Boca ($\bar{x}$ = 5.10), Webber ($\bar{x}$ = 4.85), Prosser ($\bar{x}$ = 4.80), Martis Creek L. ($\bar{x}$ = 3.60), and Spooner ($\bar{x}$ = 2.13) (Figure 5). Temperature, dissolved oxygen, and specific conductivity profiles for each lake at are found in Figure 6 (see Appendix B for actual data). All lakes typically stratify in the summer time with the exception of Martis Creek Lake. Total phosphorus (TP), dissolved phosphorus (DP), and ammonium (NH_4) concentrations for each lake are presented in Table 5. The concentrations are typical of Western water bodies with increasing concenrations of the dissolved state in hypolimnetic waters.

Calcium levels and quagga mussel invasion potential

Invasive dreissenid zebra (*Dreissena polymorpha*) and quagga (*Dreissena rostriformis bugensis*) mussels (quagga and zebra) in particular have altered the ecology of lakes and rivers by coupling pelagic and benthic trophic pathways, increasing offshore clarity, stimulating benthic production and altering biodiversity (Makarewicz et al. 1999, Bially and MacIssac 2000, Ricciardi et al. 1998). In recent years there has been a western range expansion in North America of mussels and it first appeared in western U.S. in Lake Mead, AZ-NV in early 2007 (Stokstad et al. 2007) and has subsequently been found in other major western impoundments including Lakes Powell and Mohave. The costs of the invasion are already apparent, as the Southern Nevada Water Authority has spent approximately $32 million (US dollars until 2009) to manage quagga biomass impacts on the water intake infrastructure of Lake Mead, a recently invaded reservoir in the Western U.S. (Peggy Roefer, Southern Nevada Water Authority, pers.

communication). These recent invasions have spurred efforts to determine invasion risk posed by zebra and quagga mussels in western waters.

There are a large number of dreissenid mussel establishment risk assessment approaches that have been based on European and Eastern North American invasions that may or may not be appropriate for evaluations of western water ways. Risk assessment for the western U.S. should be based on these approaches, but with careful consideration of western water body characteristics such as differences in water temperature, calcium and other nutrient concentrations as well as food availability that may determine different parameters for western waterways. Water column calcium concentration is often used as an index for determining the potential for mollusk establishment, growth, and reproduction with variable requirements depending on the species (Ramcharan et al. 1992, Sousa et al. 2008, Whittier et al. 2008). Food availability is also an important variable for mollusk establishment, and is often the cause for massive dreissenid mussel population crashes after initial population explosions (Strayer et al. 1996). Since the recent establishments in Lakes Mead, Powell and Mohave, numerous studies are underway to determine zebra and quagga mussel invasion risk to Western waterways. Based on empirical information gathered from water quality databases and modeled systems, Whittier et al. (2008) created a watershed-scale risk model for dreissenid species. This model is based on calcium requirements, primarily derived from zebra mussel due to limited experimental data on quagga mussel survival. Managers have used this model to determine the risk-potential of quagga mussel establishment from invaded water bodies such as Lake Mead. However, because quagga mussels appear to have different environmental tolerances than zebra mussels, (Baldwin et al. 2002, Stoeckmann 2003, Roe and MacIssac 1997, Zhulidov 2004), and possibly than quagga in other parts of their range (Domm et al. 1993, Antonov and Shkorbatov 1990), the potential risk of invasion of western water bodies may be underestimated by using zebra mussel-based risk assessments.

We measured calcium levels and used existing literature to determine the invasion risk of each ecosystem based on these levels using Whittier's model to suggest the risk of invasion and comparing to an adult survival study using Lake Tahoe water by Chandra et al. (2009). Since mussels live on the lake bottom we measured sediment pore water calcium as well as water column concentrations to determine if there were differences between habitats and if water column levels can be used to adequately assess the calcium levels and this invasion potential of a water body. In general lake sediments were higher than water column calcium levels (Figure 8). The epilimnion of most lakes exhibited variability over time (except Weber, Independence, and Marlette) which generally had lower levels likely due to their small watersheds and geological base. The sediment concentrations while collected only at then end of summer/ early Fall indicate variability in space (except Stampede, Independence, and Pyramid) suggesting patchiness of calcium availability along the lake bottom. As a result of the variability and to be liberal in our assessment of risk we utilized the largest of the mean values calculated for each habitat to assess risk.

Previous research suggests that in the Midwestern and eastern regions of North America, calcium can be a limiting factor for reproducing colonies of dreissenids (Cohen and Weinstein 2001). North American researchers show that the minimum calcium concentration required for establishment and reproduction is 20 $mg \cdot L^{-1}$, whereas studies conducted in European waters suggest that the calcium threshold for establishment is higher, 28 $mg \cdot L^{-1}$ (Ramcharan et al. 1992, Cohen and Weinstein 2001). Whittier et al. (2008) used literature-based calcium thresholds in create a broad scale, landscape-level approach to determine survival probability for dreissenid mussels in Western watersheds. Thresholds were established based on calcium limitations of zebra mussel, since little calcium-based survival information existed for quagga mussel. **Thus, these authors assumed that zebra and quagga mussel requirements were similar because of the genetic proximity of these two closely related taxa.** Their findings are still useful however for a 1st order estimate of the invasion potential by dreissenids. They defined risk based on calcium con- centrations as: very low (< 12 mg L–1), low (12–20 mg L–1), moderate (20–28 mg L–1), and high (> 28 mg L–1). According to their risk categories, and utilizing the highest of the mean concentrations in either habitat (sediment and epilimion) to assign this risk, the water bodies with "very low" risk include Stampede, Boca, Prosser, Pyramid, Webber, Stampede, Independence, Marlette. Lakes with "low" risk are Donner and Martis Lake and "moderate to high" risk are Lahontan and Rye Patch Reservoirs.

In contrast to the Whitter and colleagues risk assessment, we also utilized another study assessing adult survivability based on Lake Tahoe waters which contain approximately 13 ppm calcium. Chandra et al. (2009) suggests that after a 51 day exposure, quagga adults survive, exhibit positive growth, and may have the potential to release gametes. **This study did not have the funding to follow the reproductive cycle of the mussels to determine if they could produce mature veligers**. They suggest that the occurrence of veligers in the low calcium waters of Colorado lake which are similar to the Truckee Region suggest the potential for some viable production. Using this study as a benchmark and analyzing risk from another viewpoint, the following lakes could allow adult survival and growth: Lahontan Reservoir, Rye Patch, Stampede, Spooner, Martis Lake, and Donner. However, due to the variability of sediment pore water calcium and our lack of understanding on the reproductive potential for mussels in these lower calcium waters, we can not be definitive in their potential for establishment. The best way to determine their potential is to 1) conduct and experiment utilizing a range of waters from region and b) conduct a more comprehensive sediment pore water evaluation of calcium levels to assign risk based on the habitat available. One should note that calcium is not the only way to analyze risk but the food availability and other environmental variables (pH, anoxia) could prevent establishment.

Table 1. Basic morphological characteristics of the 2010 Truckee River region study lakes.

Lakes	**Max Depth (m)**	**Surface Area (ha)**	**Shoreline (km)**
Donner	70.0	390.0	12.07
Stampede	52.0	1351.7	40.2
Boca	24.0	396.6	24.14
Prosser	24.0	303.5	17.7
Martis Creek L.	6.0	23.4	Na
Webber	31.0	81.0	Na
Independence	44.0	252.9	9.3
Spooner	4.0	31.6	Na
Marlette	11.0	na	Na
Pyramid	130.0	50,000.0	160.0
Lahontan	26.0	4,409.9	96.0
Rye Patch	18.5	4,451.5	115.9

Table 2. Cooperating agencies and personnel: University of Nevada-Reno (UNR), Bureau of Reclamation (BOR), California Fish and Game (CFG), and the Nature Conservancy (TNC).

Lake	Veliger Tows	Invasive Plant and Invertebrate Surveys	Water Quality Profiles	Water Quality (N, P, Ca)	Sediment Water Quality (Ca)	Periphyton and Terrestrial Detritus	Crayfish
Donner	UNR	UNR	UNR	UNR	UNR	UNR	UNR
Stampede	BOR	UNR	BOR	UNR	UNR	UNR	UNR
Boca	BOR	UNR	BOR	UNR	UNR	UNR	UNR
Prosser	BOR	UNR	BOR	UNR	UNR	UNR	UNR
Marlette	UNR	UNR	UNR	UNR	UNR	UNR	UNR
Spooner	UNR	UNR	UNR	UNR	UNR	UNR	UNR
Martis Creek	CFG	UNR	UNR	UNR	UNR	UNR	UNR
Webber	CFG	CFG	UNR	UNR	UNR	UNR	UNR
Independence	UNR/CFG	UNR/TNC	UNR	UNR	UNR	UNR	UNR
Pyramid	BOR		BOR	UNR	UNR	UNR	
Lahontan	BOR		BOR	UNR	UNR	UNR	
Rye Patch	BOR		BOR	UNR	UNR	UNR	

Table 3. Invasive plants and adult invertebrates present in Truckee River region lakes in 2010 as determined from UNR shoreline surveys and CFG visual surveys. Species presence is denoted by "X." A blank space indicates no species were found during the surveys.

	Adult Invertebrates					Plants	
Lakes	Quagga	Zebra	NZMS	Asian Clam	Crayfish	EWM	Hydrilla
Donner				X	X		
Stampede					X		
Boca					X		
Prosser					X		
Martis Creek L.				[1]X		X	
Webber					X		
Independence					X		
Spooner						X	
Marlette					X		

[1] It is possible that the large Asian clam shell found in Martis Creek lake could have been transported by mats previously used in Marla Bay, Lake Tahoe where Asian clam presence has been well documented (Whittmann et al. 2008).

Table 4. Veliger results for invasive mussels collected every 4-6 weeks and analyzed for quagga and zebra mussel DNA by California Fish and Game Bodega Marine Laboratory for each study lake in 2010

Lake	**Sampling Agency**	**Veliger Tow Date(s)**	**Result Pos/Neg**
Donner	UNR	7-21-10 8-16-10 9-15-10	Negative
Stampede	BOR	8-21-10	Negative
Boca	BOR	8-21-10	Negative
Prosser	BOR	8-21-10	Negative
Marlette	UNR	7-24-10 8-19-10 9-22-10	Negative
Spooner	UNR	7-20-10 8-17-10 9-21-10	Negative
Martis Creek L.	CFG	8-24-10	Negative
Webber	CFG	7-7-10 8-16-10	Negative
Independence	CFG TNC UNR	8-25-10 9-na-10 10-1-10	Negative
Pyramid	BOR	8-20-10	Negative
Lahontan	BOR	8-19-10	Negative
Rye Patch	BOR	8-20-10	Negative

Table 5. Water quality nutrients (total phosphorus (TP), dissolved phosphorus (DP), and ammonium (NH_4) concentrations (ug/L) at depth for each study lake in 2010.

Lake	**Date**	**Strata**	**DP**	**TP**	**NH_4**
Donner	7/6	Epi	4.44	7.59	8.810714
		Meta	5.7	7.9	10.95357
		Hypo	3.66	7.27	9.525
	9/15	Epi	11.2	7.45	7.917857
		Meta	14.65	9.69	6.489286
		Hypo	12.97	11.6	8.810714
Stampede	7/6	Epi	7.65	12.93	7.739286
		Meta	9.79	11.05	8.632143
		Hypo	10.42	11.05	13.63214
	9/13	Epi	21.86	23.11	8.096429
		Meta	19.86	20.29	8.632143
		Hypo	23.74	21.86	9.703571
Boca	7/13	Epi	11.99	14.82	7.025
		Meta	10.73	14.5	7.025
		Hypo	10.32	20.55	9.703571
	9/13	Epi	17.78	20.29	10.95357
		Meta	18.57	21.55	10.41786
		Hypo	19.35	19.98	11.13214
Prosser	7/16	Epi	14.65	20.6	5.775
		Meta	14.02	17.22	8.632143
		Hypo	17.78	16.22	3.810714
	9/13	Epi	na	25.66	7.560714
		Meta	na	18.84	15.59643
		Hypo	na	62.83	65.41786
Spooner	7/20	Epi	11.87	18.72	13.275
		Hypo	17.16	85.49	17.91785714
	9/22	Epi	10.48	19.46	10.95357143
Martis Creek L.	7/15	Epi	14.16	17.14	17.91786
		Meta	20.88	71.4	9.525
	9/15	Epi	28.44	95.97	8.096429
		Meta	36.59	26.28	11.66786
		Hypo	61.66	45.48	3.096429
Webber	8/3	Epi	13.71	21.86	8.632143
		Meta	13.4	16.84	10.41786
		Hypo	15.59	16.84	28.63214
	9/24	Epi	5.53	10.65	6.310714
		Meta	8.41	12.56	7.382143
		Hypo	40.71	61.81	280.4179
Independence	7/27	Epi	5.53	6.49	15.06071
		Meta	3.93	20.88	11.48929
		Hypo	3.93	5.57	8.810714
	9/24	Epi	3.49	9.37	6.310714

		Meta	3.61	5.21	7.560714
		Hypo	3.77	10.01	7.025
Pyramid	7/22	Epi	66.93	109.46	10.775
		Meta	103.71	104.03	10.06071
		Hypo	107.55	106.91	24.88214
Lahontan	7/20	Epi	69.85	63.56	42.38214
		Meta	75.35	57.27	42.025
		Hypo	90.29	126.14	31.48929
	10/12	Epi	133.68	119.85	50.95357
Rye Patch	7/20	Epi	25.83	85.21	15.775
		Meta	53.5	95.75	18.81071
		Hypo	50.67	100.67	44.70357
	10/13	Epi	34.63	na	38.275
		Meta	89.5	38.09	42.38214
		Hypo	43.75	109.47	42.025
Marlette	7/23	1 m	9.95	7.44	12.38214
		3 m	6.5	16.84	11.66786
		5 m	8.07	9.95	8.632143
		7 m	7.13	10.89	8.632143
		9 m	11.36	16.84	18.63214
	9/22	1 m	19.85	38.15	10.775
		3 m	6.02	17.68	9.167857
		5 m	4.76	15.86	14.16786
		7 m	6.02	14.48	8.810714
		9 m	6.08	340.04	15.59643

Table 6. Epilimnetic calcium (Ca) concentrations (ppm) for each study lake in 2010.

Lake	**Date**	**Ca**	**Mean Ca**
Donner	7/6	7.94	6.21
	9/15	4.48	
Stampede	7/6	12.32	10.68
	9/13	9.04	
Boca	7/13	6.81	8.04
	9/13	9.26	
Prosser	7/16	5.73	4.30
	9/13	2.86	
Spooner	7/20	23.66	25.86
	9/22	28.06	
Martis Creek L.	7/15	15.74	11.80
	9/15	7.87	
Pyramid	7/22	8.32	na
Lahontan	7/20	11.85	13.64
	10/12	15.42	
Rye Patch	7/20	20.40	23.79
	10/13	27.18	
Webber	8/3	3.63	3.62
	9/24	3.60	
Independence	7/27	3.15	3.93
	9/24	4.70	
Marlette	7/23	4.58	4.88
	9/22	5.18	

Table 7. Sediment pore-water calcium (Ca) concentrations (ppm) for each study lake in 2010.

Lake	Date	#	Ca	Mean Ca
Donner	10/20	1	25.36	13.92
		2	8.13	
		3	8.28	
Stampede	10/8	1	7.21	7.26
		2	7.26	
		3	7.30	
Boca	10/8	1	13.51	10.32
		2	7.95	
		3	9.50	
Prosser	10/8	1	7.92	10.23
		2	4.69	
		3	18.06	
Spooner	10/13	1	37.13	38.48
		2	41.58	
		3	36.72	
Martis Creek L.	10/13	1	13.24	11.73
		2	12.19	
		3	9.75	
Pyramid	10/11	1	9.75	8.90
		2	8.60	
		3	8.36	
Lahontan	10/11	1	43.21	27.98
		2	23.19	
		3	17.54	
Rye Patch	10/11	1	32.79	32.76
		2	29.49	
		3	35.98	
Webber	10/21	1	3.72	3.81
		2	3.97	
		3	3.73	
Independence	10/21	1	4.83	4.47
		2	4.47	
		3	4.12	
Marlette	10/14	1	2.40	4.20
		2	4.61	
		3	5.60	

Figure 1. Lower Truckee River Region study lake locations in 2010.

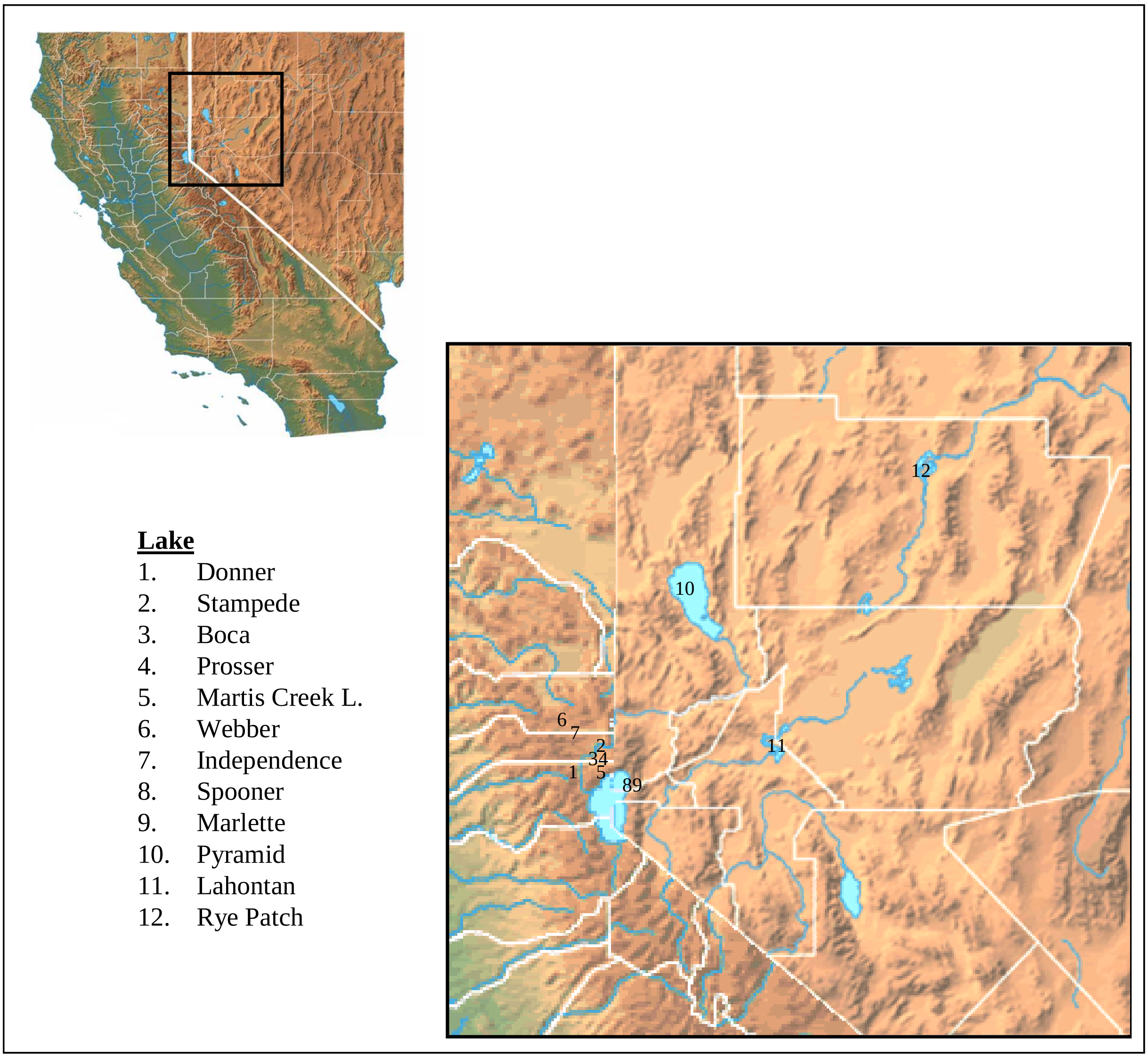


Figure 2. Total crayfish catch per unit effort (CPUE) for each study lake in 2010 where CPUE was calculated as the number of crayfish per trap per 24 hour set.

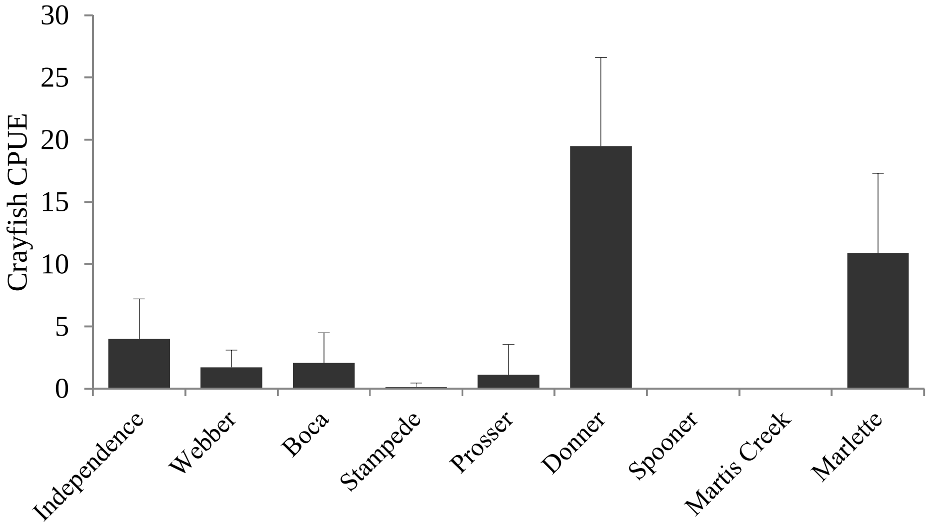


Figure 3. Crayfish CPUE by depth in each lake where crayfish were collected in 2010.

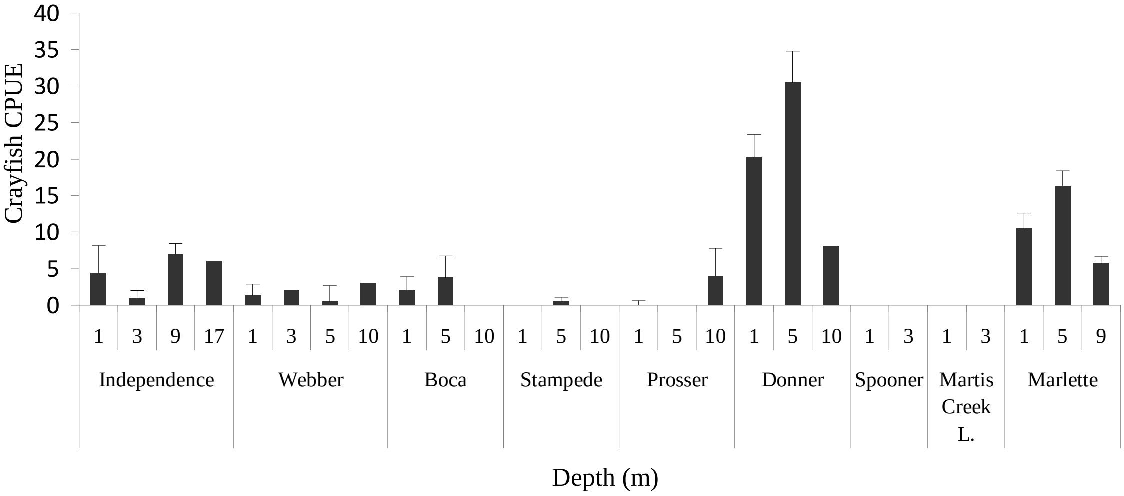


Figure 4. Crayfish size (mm) distribution in study lakes where crayfish were collected at the end of the 2010 season.

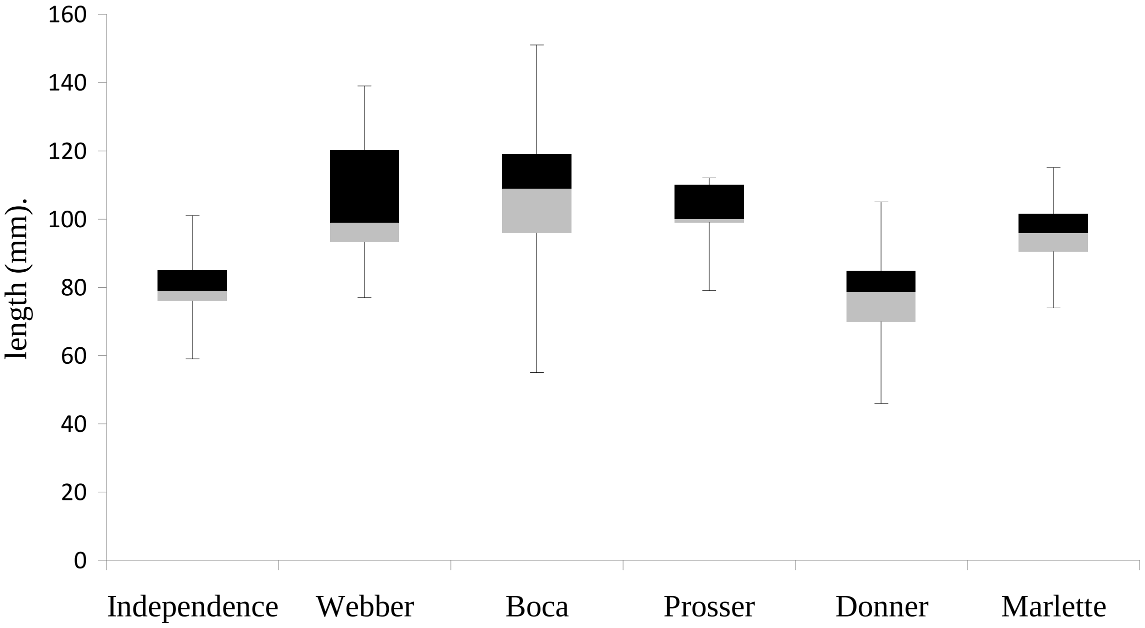


Figure 5. Relative lake substrate composition from all transects (N = 30) examined during the invasive surveys using modified categories from Wentworth’s substrate guide (1922) where rock substrate includes gravel (6.4mm) to boulder (≥ 610.0mm), woody structure includes material with a diameter of < 20.5mm - ≥ 50.9mm, and fine substrates include anything smaller than gravel (sand, silt, and organic matter).

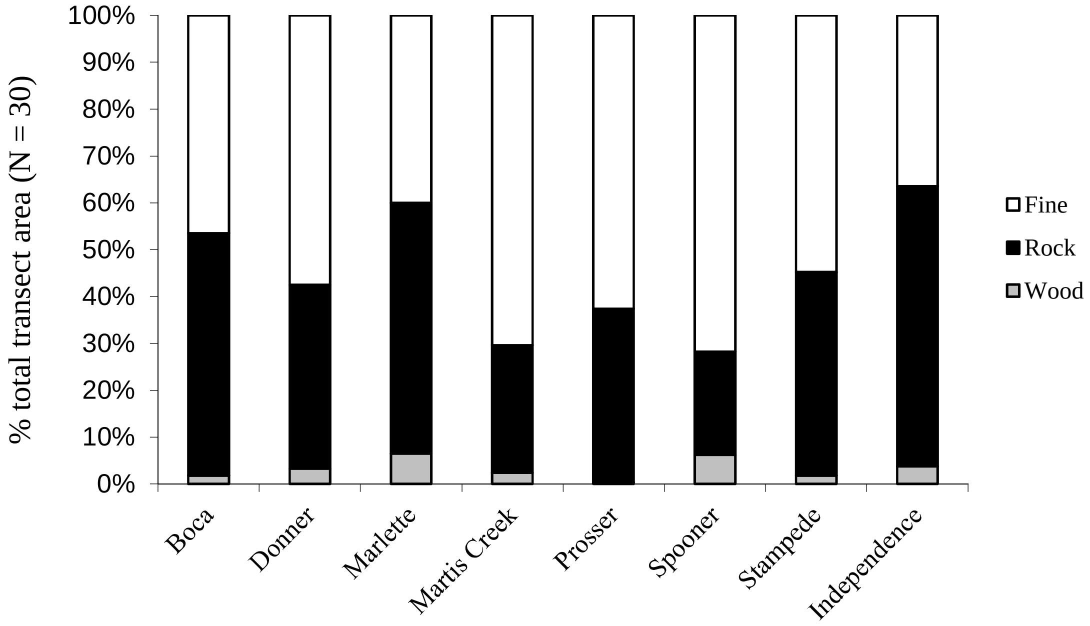


Figure 6. Water clarity measured via secchi disk for each study lake during each sampling in the 2010 season.

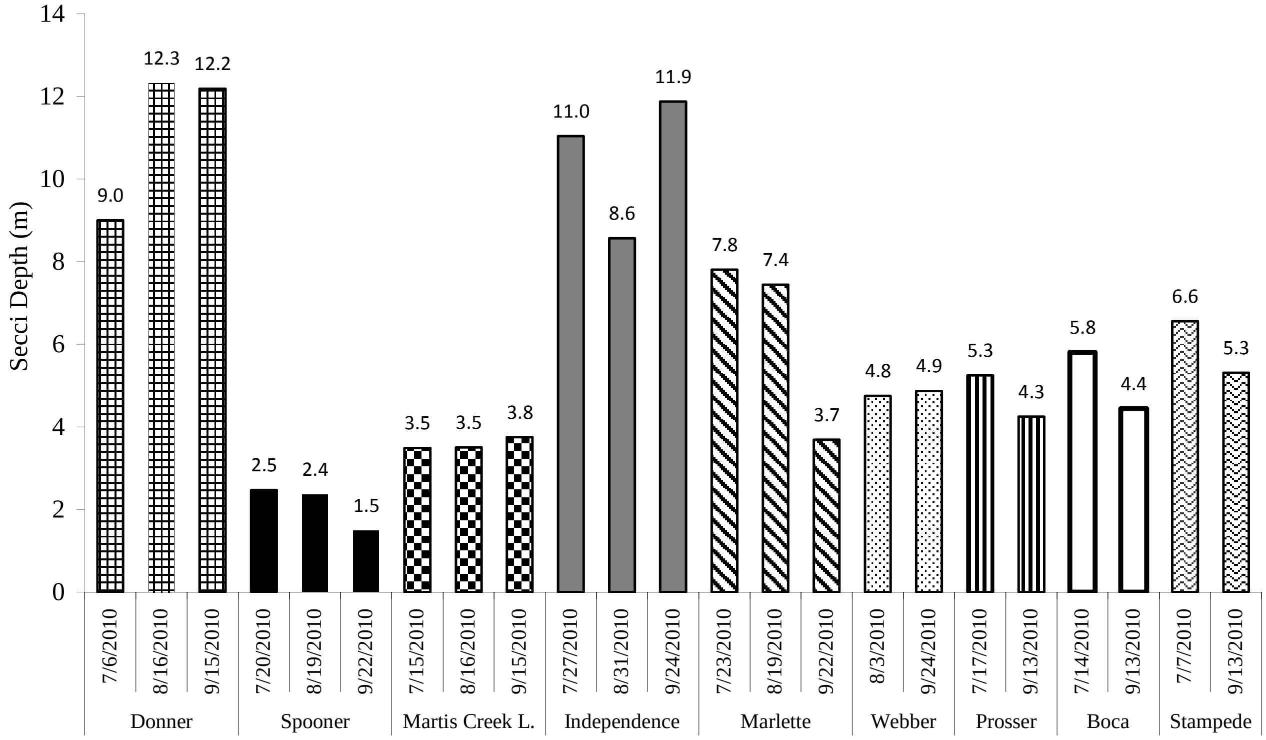
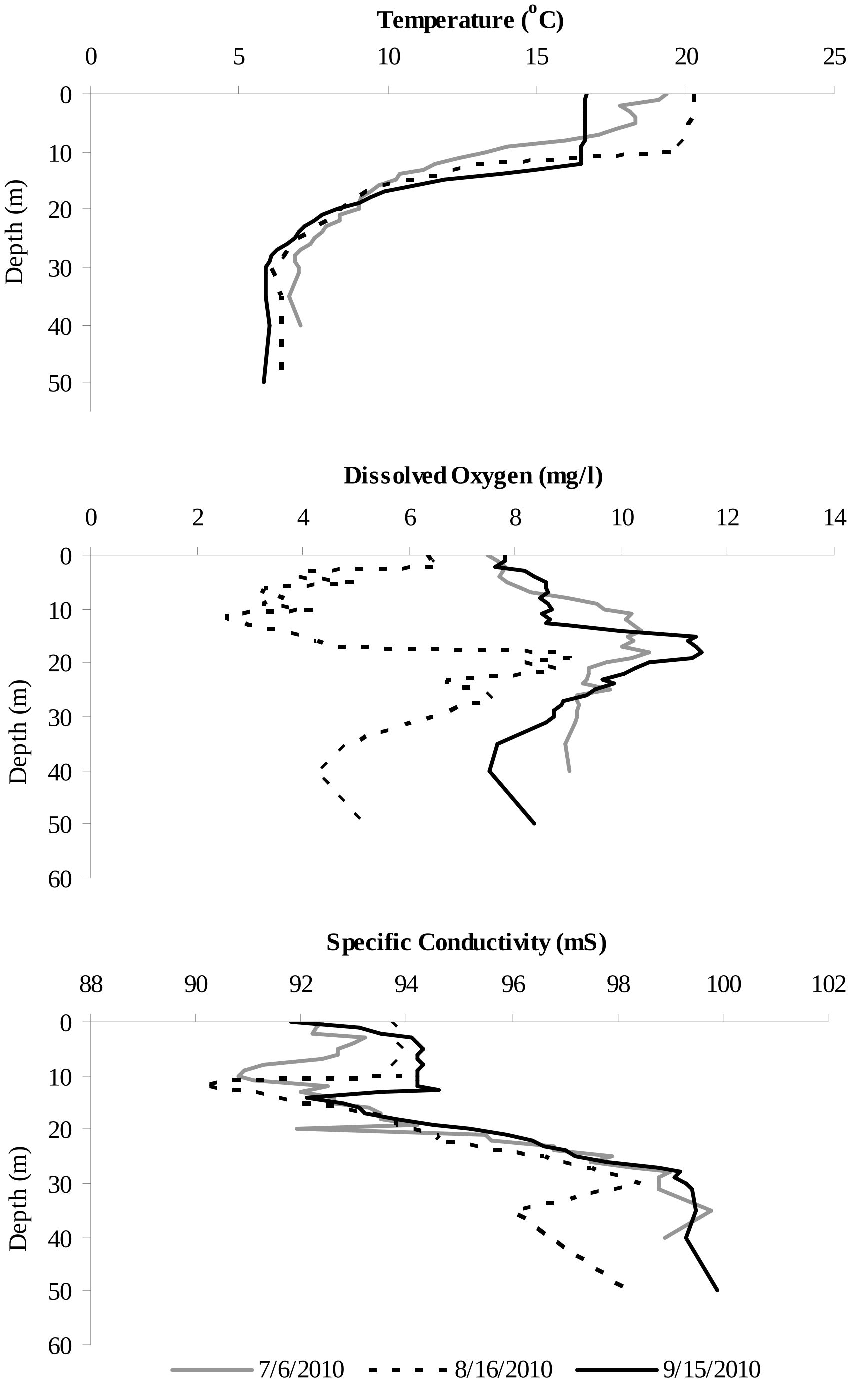
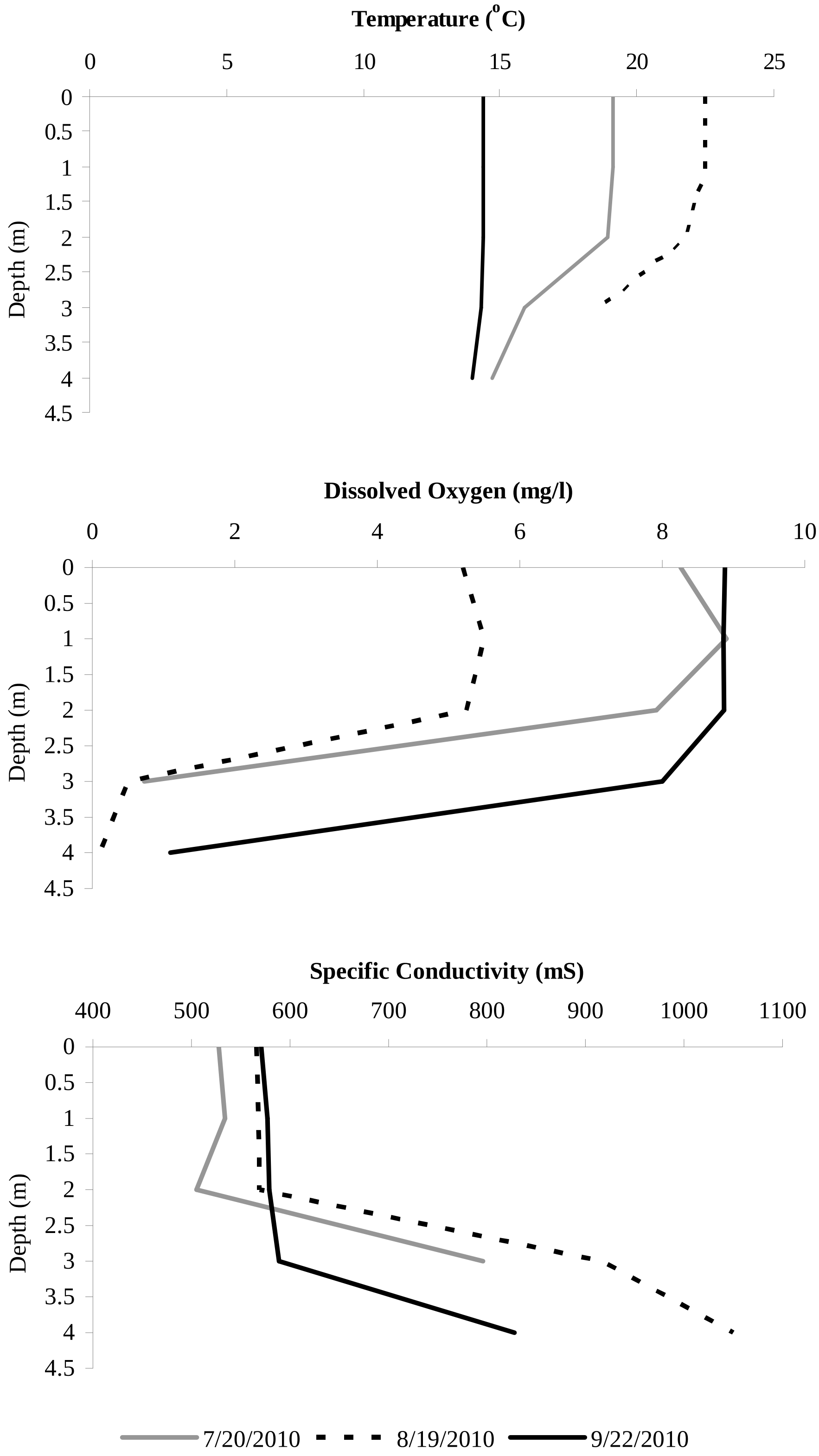


Figure 7. Water quality profiles (temperature, dissolved oxygen, and specific conductivity) for each of the Truckee River region study lakes in 2010.
a. Donner, b. Spooner, c. Martis Creek L., d. Independence, e. Marlette, f. Webber, g. Prosser, h. Boca, i. Stampede, j. Lahontan, k. Rye Patch, and l. Pyramid.

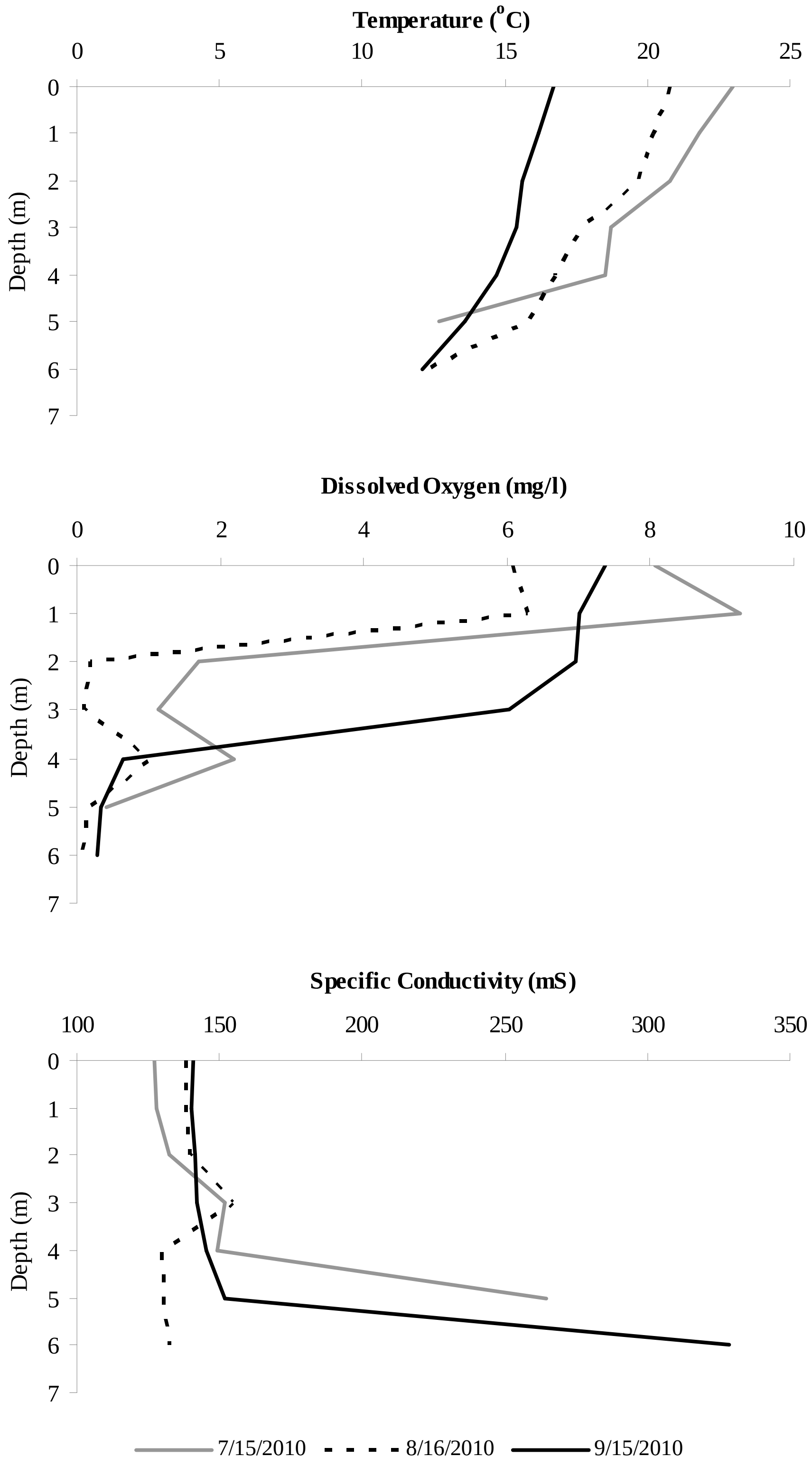
a. Donner Lake



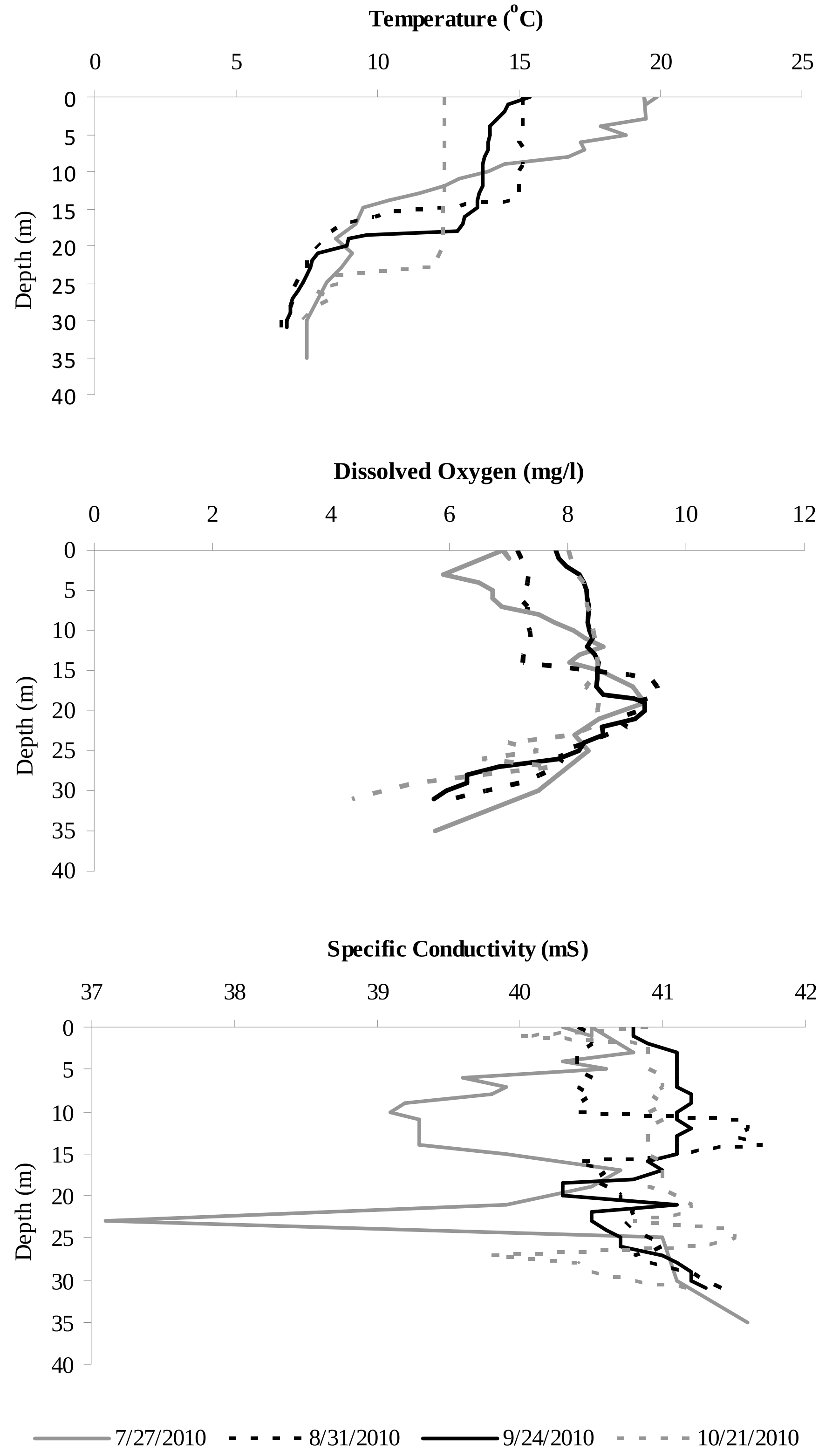
b. Spooner Lake



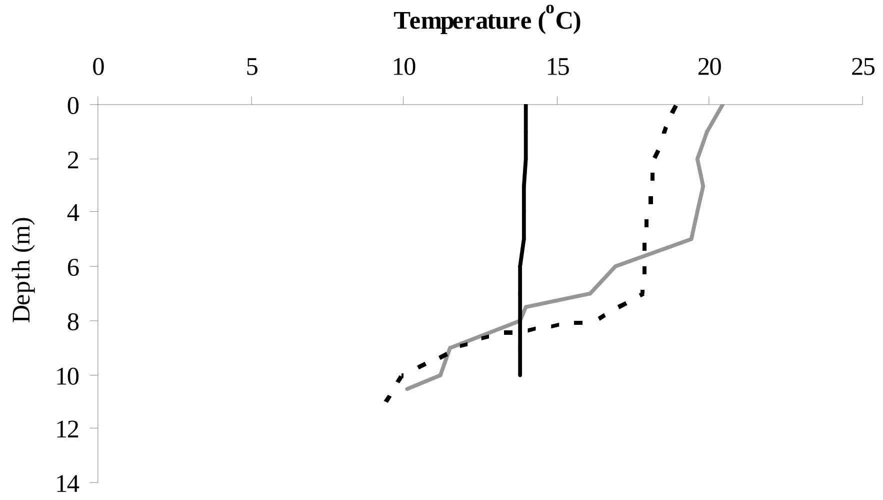
c. Martis Creek L.

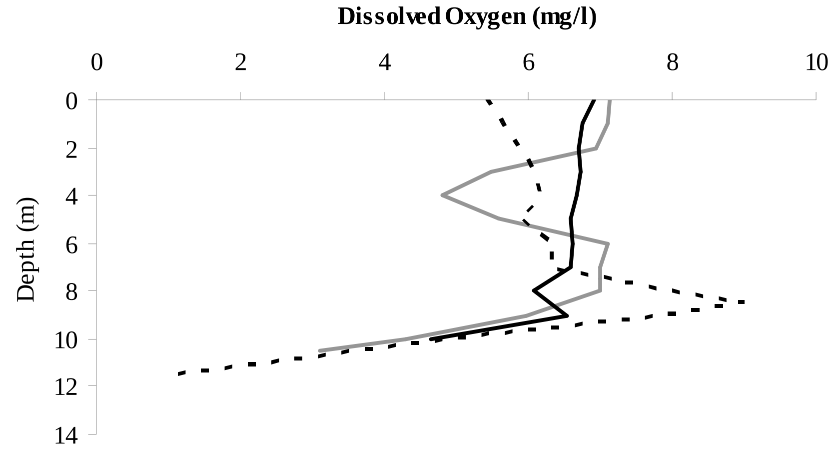


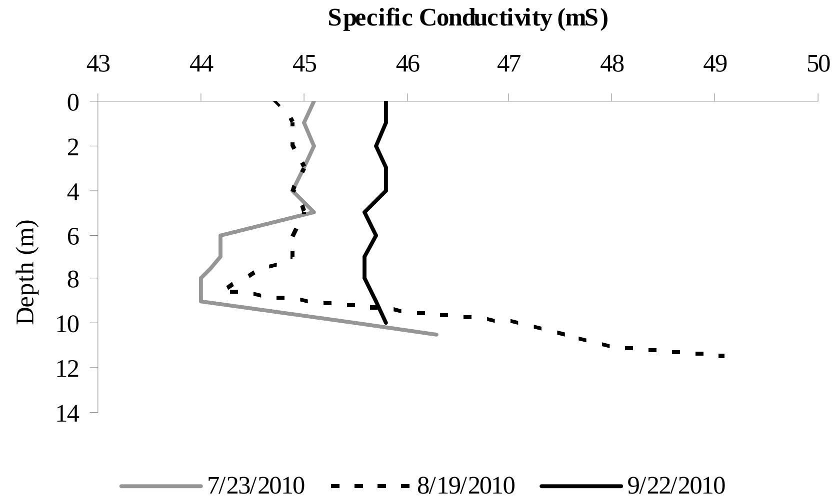
d. Independence Lake



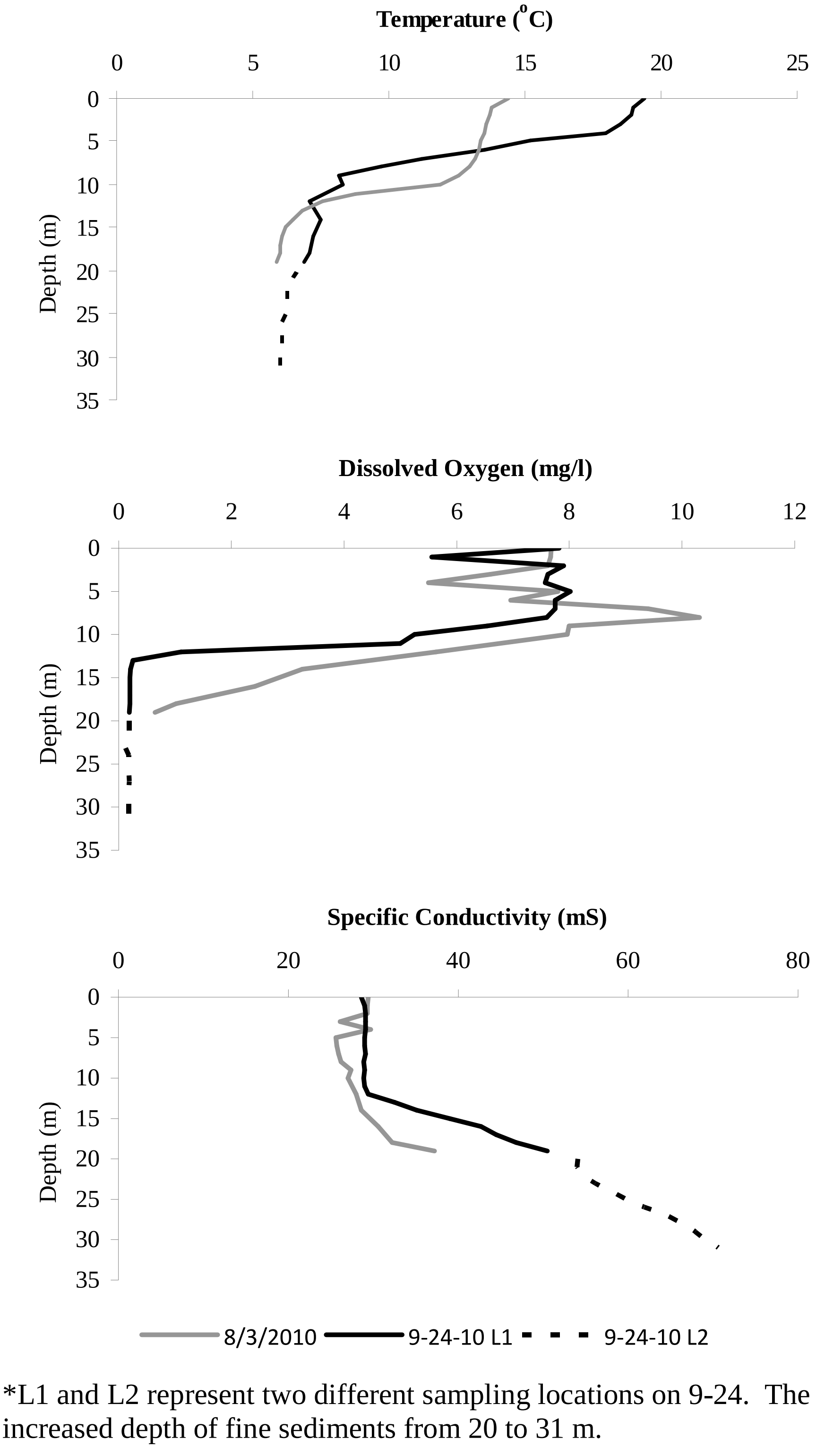
e. Marlette Lake





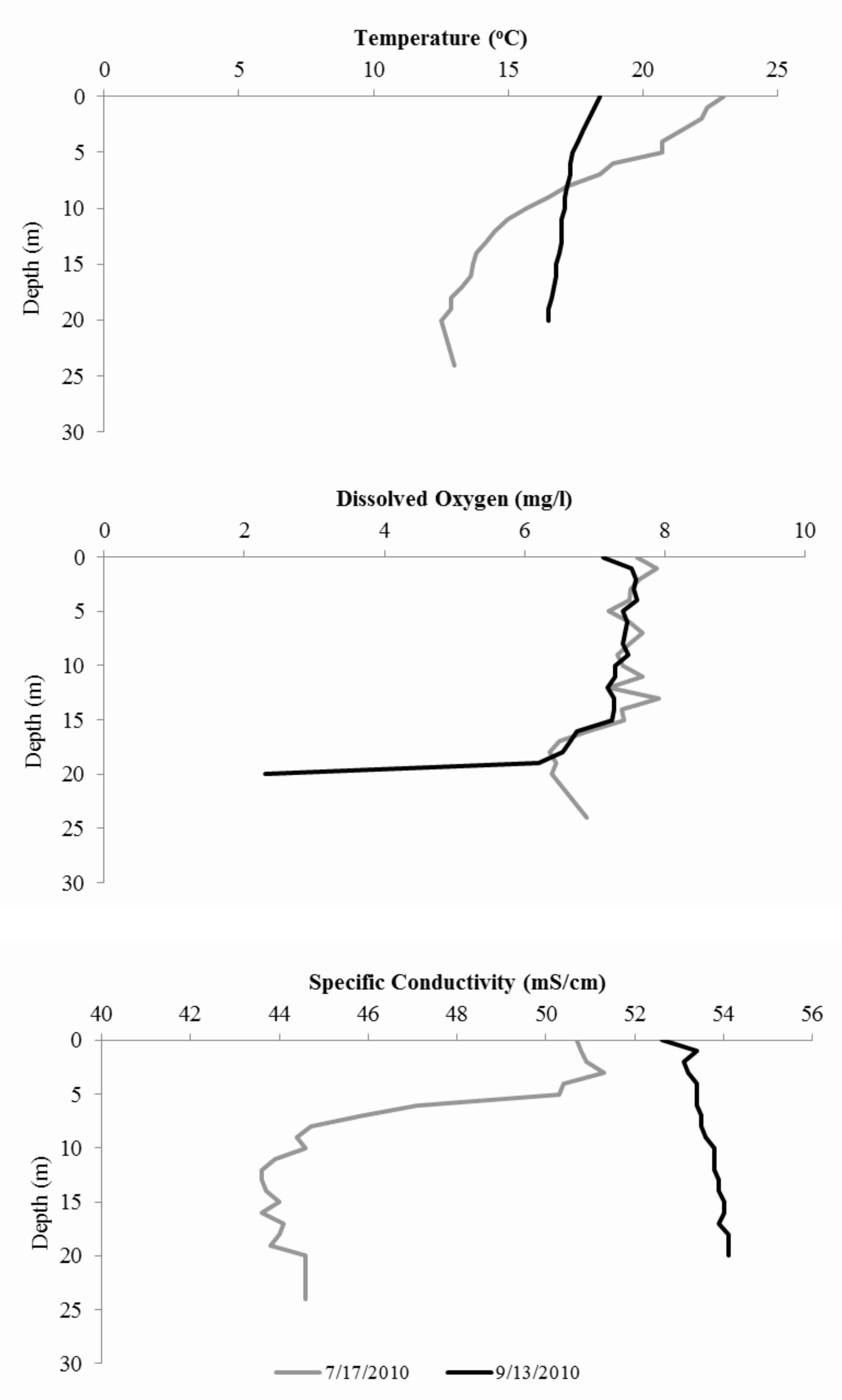


f. Webber Lake

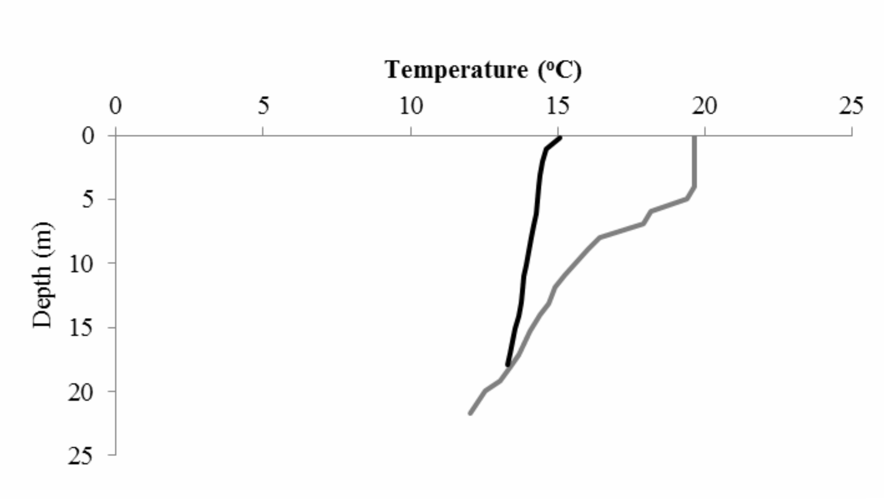


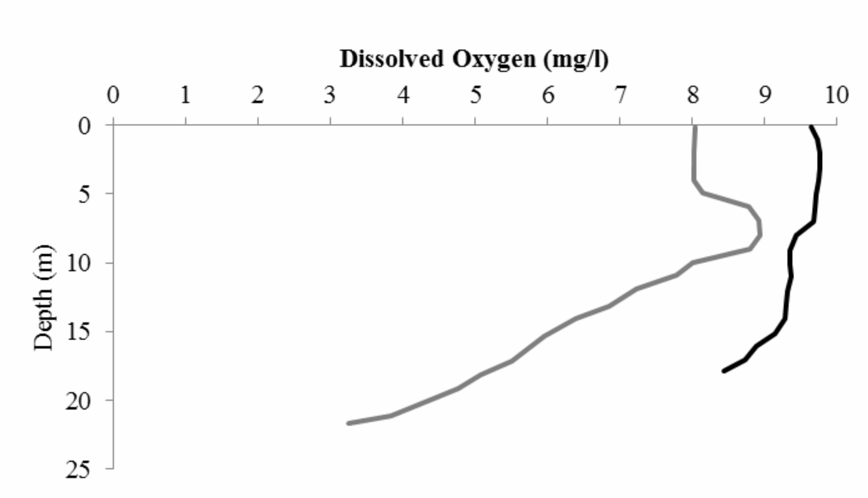
*L1 and L2 represent two different sampling locations on 9-24. The second location had an increased depth of fine sediments from 20 to 31 m.

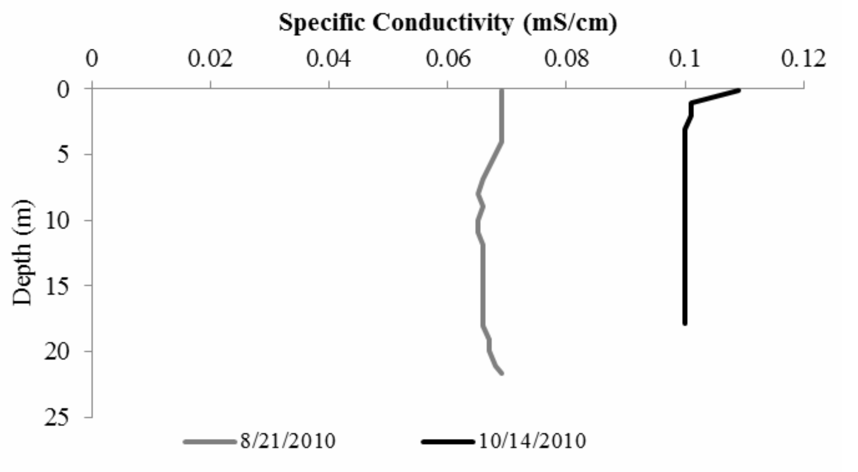
g. Prosser Reservoir



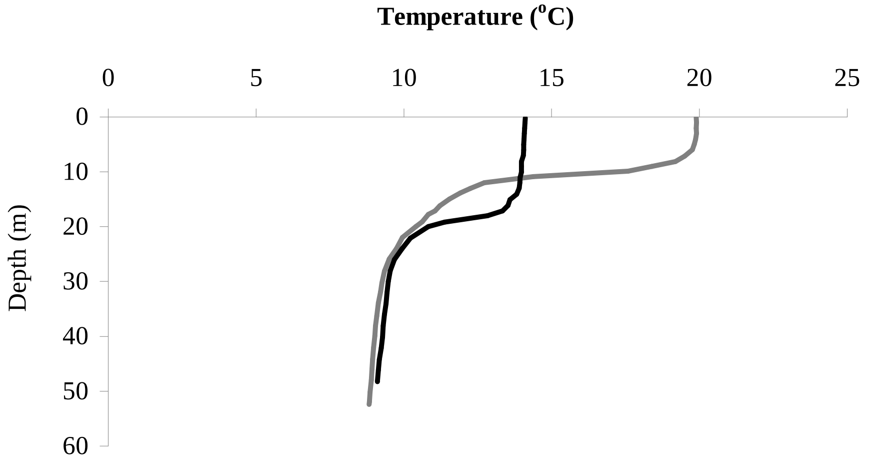
h. Boca Reservoir

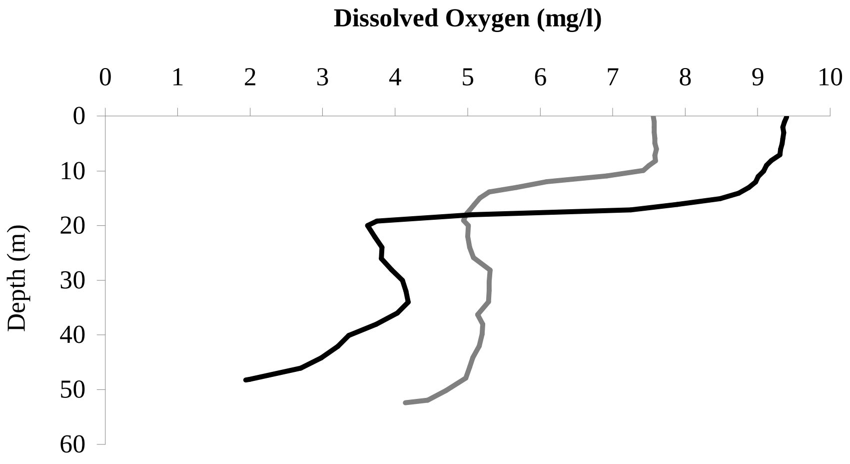


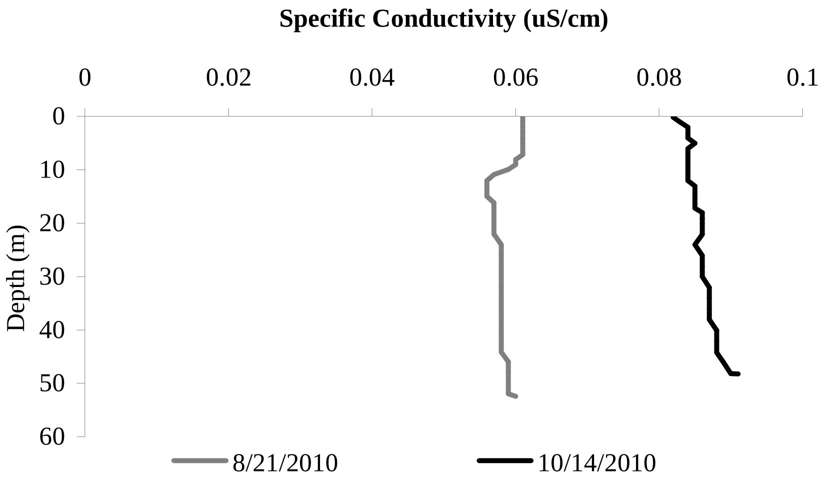




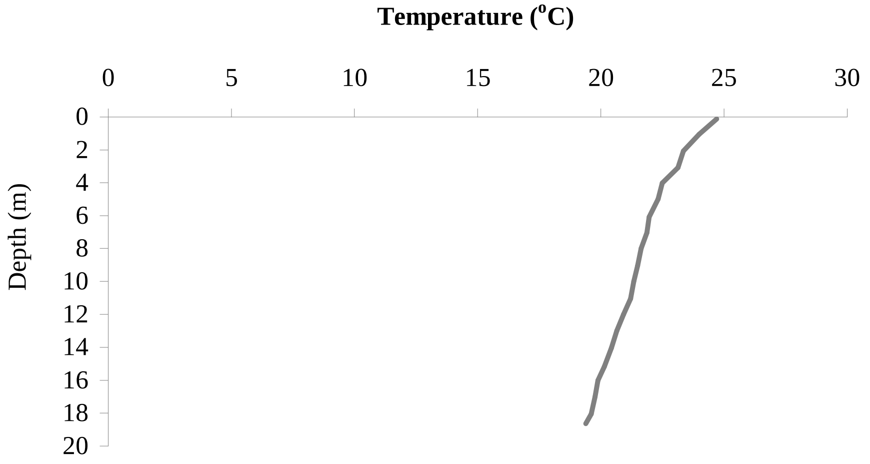
i. Stampede Reservoir

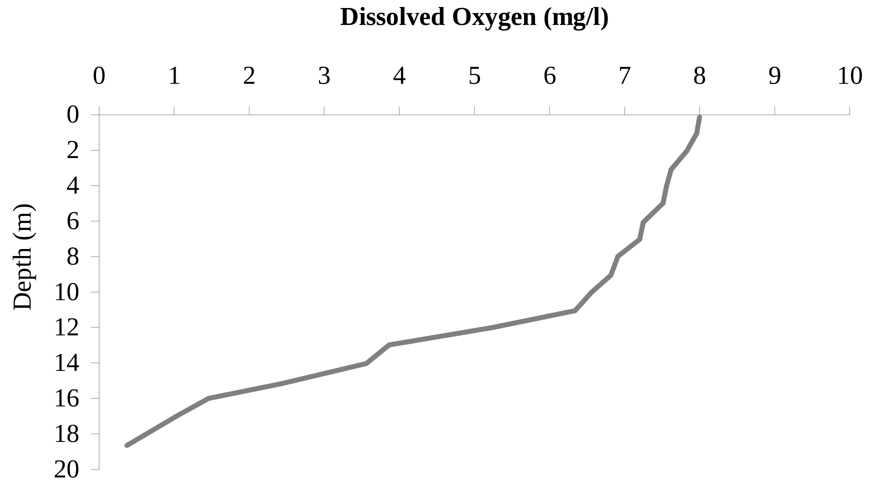


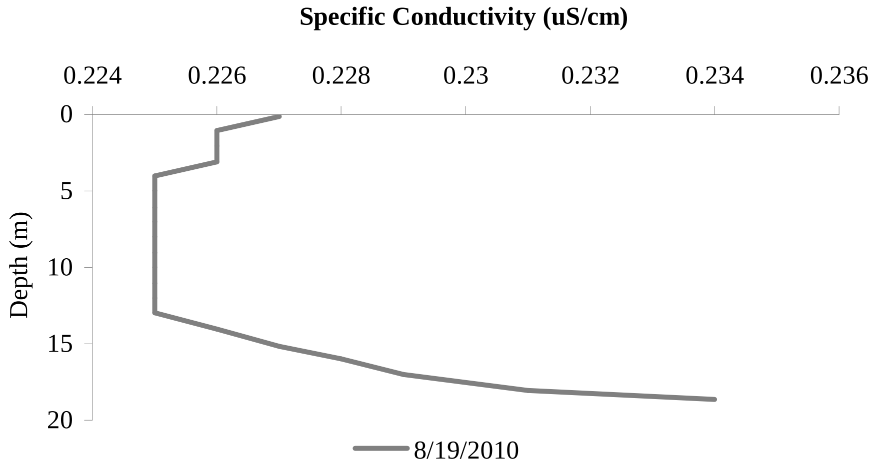




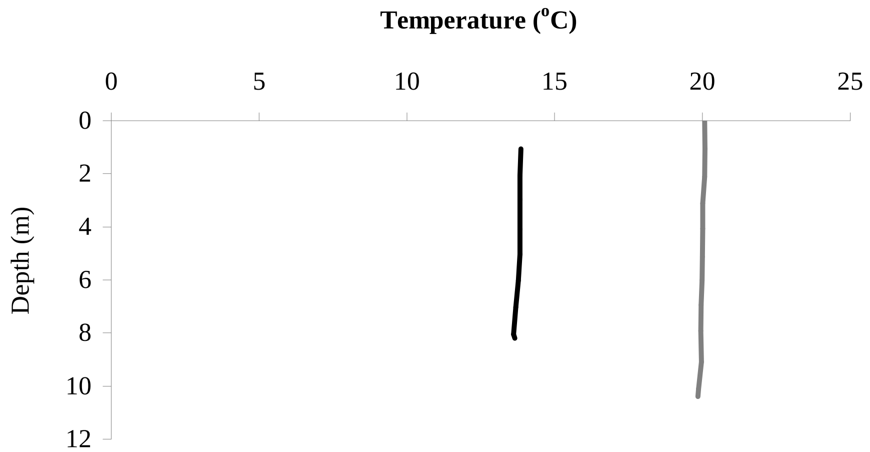
j. Lahontan Reservoir

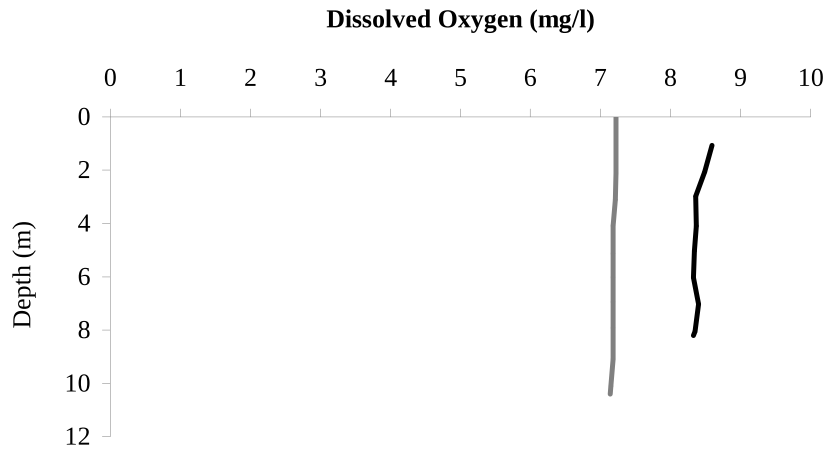


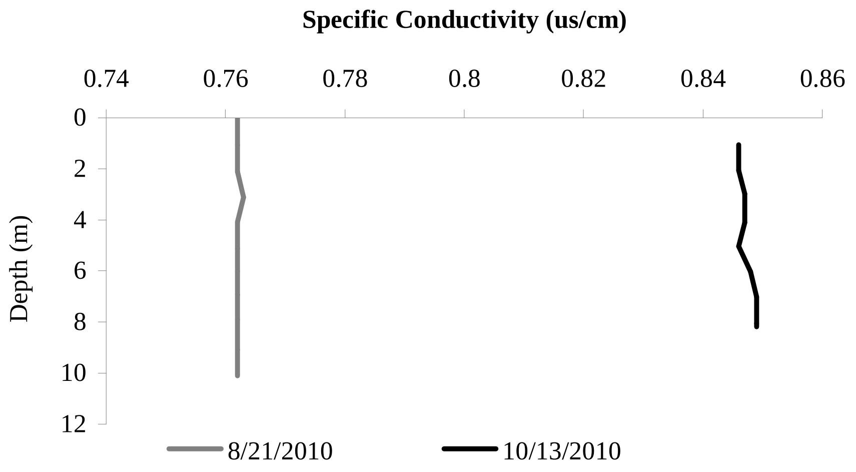




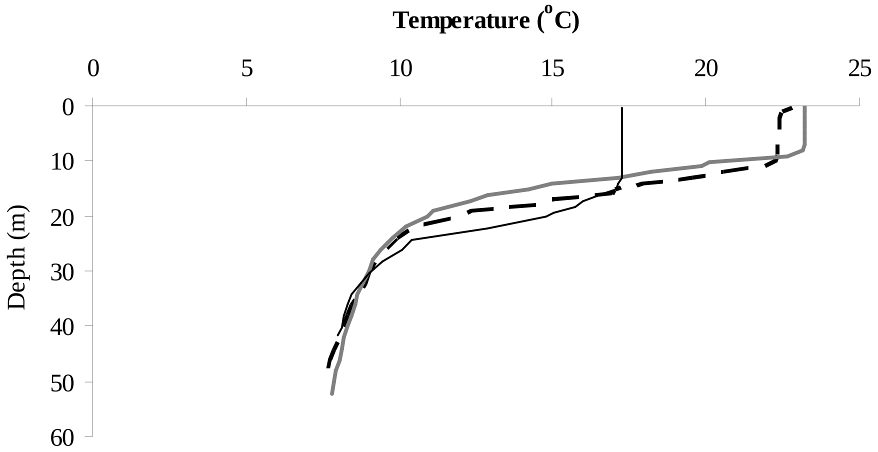
k. Rye Patch Reservoir

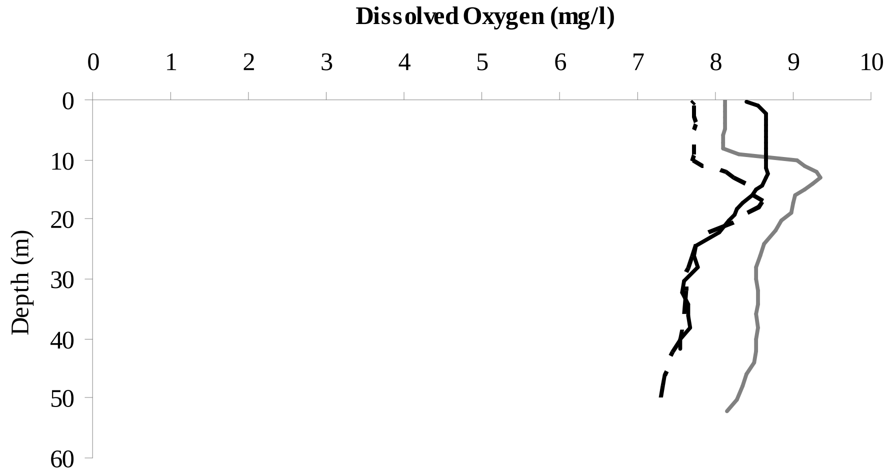






l. Pyramid Lake





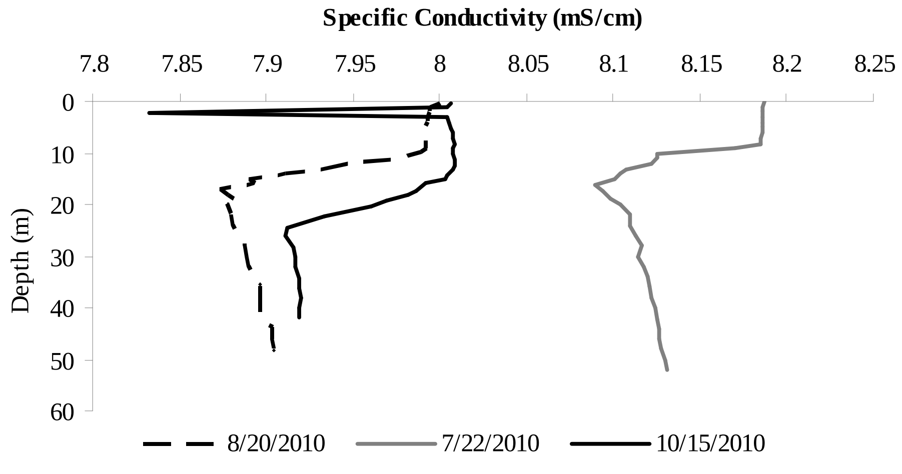
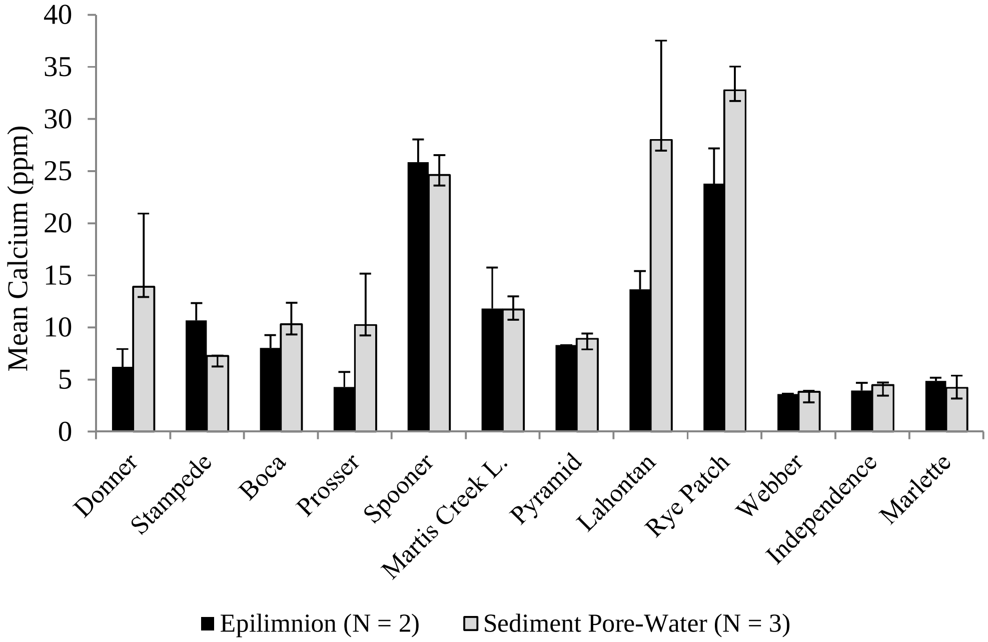


Figure 8. Mean sediment pore-water and epilimnetic calcium concentration (ppm) for the Truckee River Region study lakes in 2010.



Appendix A. Invasive species shoreline survey data (UNR) during the 2010 field season. a. Boca, b. Stampede, c. Prosser, d. Spooner, e. Marlette, f. Martis Creek L., g. Donner, and h. Independence.

a. Boca Reservoir

	LOCATION			**SUB**	**INVASIVES**				
DATE	**T**	**N**	**W**	**%Type**	**HYDRILLA**	**EWM**	**ZEBRA**	**QUAGGA**	**NZMS**
7/13/2010	1	39 24.466	120 5.498	50R 50F	0	0	0	0	0
	2	39 24.902	120 5.349	90R 10F	0	0	0	0	0
	3	39 25.233	120 5.234	80R 10W 10F	0	0	0	0	0
	4	39 25.210	120 5.350	100R	0	0	0	0	0
	5	39 25.094	120 5.845	90F 10W	0	0	0	0	0
	6	39 24.756	120 6.029	90F 10W	0	0	0	0	0
	7	39 24.432	120 6.102	90R 10F	0	0	0	0	0
	8	39 24.441	120 6.474	10W 90F	0	0	0	0	0
	9	39 24.440	120 6.515	90R 10F	0	0	0	0	0
	10	39 24.229	120 6.293	90R 10F	0	0	0	0	0
	11	39 23.907	120 6.481	50R 50F	0	0	0	0	0
	12	39 23.903	120 6.512	80F 20R	0	0	0	0	0
	13	39 23.693	120 6.167	90F 10R	0	0	0	0	0
	14	39 23.376	120 5.841	100R	0	0	0	0	0
	15	39 23.530	120 5.565	90R 10F	0	0	0	0	0
8/16/2010	1	39 23.844	120 6.402	25R 75F	0	0	0	0	0
	2	39 23.912	120 6.455	5R 95F	0	0	0	0	0
	3	39 23.911	120 6.478	10R 90F	0	0	0	0	0
	4	39 23.919	120 6.490	5R 95F	0	0	0	0	0
	5	39 23.931	120 6.470	100F	0	0	0	0	0
	6	39 23.394	120 5.869	5R 95F	0	0	0	0	0
	7	39 23.382	120 5.834	100R	0	0	0	0	0
	8	39.23.392	120 5.795	100R	0	0	0	0	0
	9	39 23.486	120 5.577	100R	0	0	0	0	0
	10	39 23.464	120 5.588	80R 20F	0	0	0	0	0
	11	39 23.766	120 5.478	90R 10F	0	0	0	0	0
	12	39 23.841	120 5.436	50R 50F	0	0	0	0	0
	13	39 24.665	120 5.475	25R 15W 60F	0	0	0	0	0
	14	39 24.911	120 5.333	95R 5F	0	0	0	0	0
	15	39 25.053	120 5.365	100F	0	0	0	0	0

b. Stampede Reservoir

	LOCATION			SUB	INVASIVES				
DATE	**T**	**N**	**W**	**%Type**	**HYDRILLA**	**EWM**	**ZEBRA**	**QUAGGA**	**NZMS**
8/6/2010	1	39 27.991	120 8.298	95F 5R	0	0	0	0	0
	2	39 27.808	120 9.308	25W 25R 50F	0	0	0	0	0
	3	39 28.199	120 9.523	75F 25R	0	0	0	0	0
	4	39 28.537	120 10.036	50F 50R	0	0	0	0	0
	5	39 28.916	120 8.700	50R 50F	0	0	0	0	0
	6	39 29.417	120 7.893	90F 10R	0	0	0	0	0
	7	39 29.396	120 7.074	95R 5F	0	0	0	0	0
	8	39 28.968	120 6.484	100R	0	0	0	0	0
	9	39 29.253	120 6.317	40R 60F	0	0	0	0	0
	10	39 29.203	120 6.174	10W 70F 20R	0	0	0	0	0
	11	39 28.617	120 6.236	20W 70F 10R	0	0	0	0	0
	12	39 28.284	120 6.587	70R 30F	0	0	0	0	0
	13	39 28.258	120 7.356	100R	0	0	0	0	0
	14	39 28.275	120 8.018	90F 10R	0	0	0	0	0
	15	39 28.275	120 8.018	80F 20R	0	0	0	0	0
9/28/2010	1	39 28.261	120 6.616	100R	0	0	0	0	0
	2	39 28.252	120 6.657	10R 90F	0	0	0	0	0
	3	39 28.332	120 6.513	75R 25F	0	0	0	0	0
	4	39 28.392	120 6.395	50R 50F	0	0	0	0	0
	5	39 28.390	120 6. 302	60R 40F	0	0	0	0	0
	6	39 28.404	120 6.312	30R 70F	0	0	0	0	0
	7	39 28.441	120 6.285	100R	0	0	0	0	0
	8	39 28.450	120 6.190	100R	0	0	0	0	0
	9	39 28.222	120 7.836	5R 95F	0	0	0	0	0
	10	39 28.263	120 8.047	100F	0	0	0	0	0
	11	39 28.264	120 8.033	10R 90F	0	0	0	0	0
	12	39 28.268	120 8.104	95F 5R	0	0	0	0	0
	13	39 27.990	120 8.275	25R 75F	0	0	0	0	0
	14	39 29.541	120 5.951	50R 50F	0	0	0	0	0
	15	39 29.519	120 5.957	50R 50F	0	0	0	0	0

c. Prosser Reservoir

	LOCATION			SUB	INVASIVES				
DATE	**T**	**N**	**W**	**%Type**	**HYDRILLA**	**EWM**	**ZEBRA**	**QUAGGA**	**NZMS**
7/16/2010	1	39 22.657	120 8.447	100R	0	0	0	0	0
	2	39 22.781	120 8.283	100R	0	0	0	0	0
	3	39 23.042	120 8.50	90R 10W	0	0	0	0	0
	4	39 23.283	120 8.757	90F 10R	0	0	0	0	0
	5	39 23.160	120 8.894	50R 50F	0	0	0	0	0
	6	39 22.974	120 8.786	90F 10R	0	0	0	0	0
	7	39 23.285	120 9.568	20R 80F	0	0	0	0	0
	8	39 23.313	120 10.442	80R 20F	0	0	0	0	0
	9	GPS dead	na	100F	0	0	0	0	0
	10	GPS dead	na	40R 60F	0	0	0	0	0
	11	GPS dead	na	90F 10R	0	0	0	0	0
	12	GPS dead	na	90F 10R	0	0	0	0	0
	13	GPS dead	na	100R	0	0	0	0	0
	14	GPS dead	na	100F	0	0	0	0	0
9/17/2010	1	39 22.388	120 9.274	50R 50F	0	0	0	0	0
	2	39 22.490	120 9.239	50R 50F	0	0	0	0	0
	3	39 22.346	120 9.280	70R 30F	0	0	0	0	0
	4	39 22.639	120 8.757	80F 20R	0	0	0	0	0
	5	39 22.666	120 8.552	95F 5R	0	0	0	0	0
	6	39 22.658	120 8.478	100F	0	0	0	0	0
	7	39 22.659	120 8.441	100R	0	0	0	0	0
	8	39 22.806	120 8.251	100R	0	0	0	0	0
	9	39 22.828	120 8.270	20R 80F	0	0	0	0	0
	10	39 23.241	120 8.752	100F	0	0	0	0	0
	11	39 23.246	120 8.805	100F	0	0	0	0	0
	12	39 23.280	120 8.792	100F	0	0	0	0	0
	13	39 23.232	120 8.718	100F	0	0	0	0	0
	14	39 23.175	120 8.698	100F	0	0	0	0	0
	15	39 23.137	120 8.670	40R 60F	0	0	0	0	0

d. Spooner Lake

	LOCATION			SUB	INVASIVES				
DATE	**T**	**N**	**W**	**%Type**	**HYDRILLA**	**EWM**	**ZEBRA**	**QUAGGA**	**NZMS**
7/10/2010	1	39 6.232	119 54.449	100F	0	0	0	0	0
	2	39 6.267	119 54.448	50W 50F	0	0	0	0	0
	3	39 6.292	119 54.464	50R 50F	0	0	0	0	0
	4	39 6.285	119 54.487	100F	0	0	0	0	0
	5	39 6.280	119 54.624	100F	0	0	0	0	0
	6	39 6.349	119 54.743	100F	0	0	0	0	0
	7	39 6.431	119 54.687	10R 90F	0	5%	0	0	0
	8	39 6.451	119 54.779	20R 80F	0	20%	0	0	0
	9	39 6.460	119 54.783	40R 10W 50F	0	15%	0	0	0
	10	39 6.468	119 54.776	90R 10F	0	5%	0	0	0
	11	39 6.489	119 54.645	40R 60F	0	95%	0	0	0
	12	39 6.655	119 54.505	100F	0	10%	0	0	0
	13	39 6.486	119 54.333	100F	0	0	0	0	0
	14	39 6.285	119 54.350	10W 90F	0	0	0	0	0
	15	39 6.233	119 54.379	100F	0	0	0	0	0
9/20/2010	1	n/a	n/a	20R 80F	0	90%	0	0	0
	2	n/a	n/a	95F 5R	0	70%	0	0	0
	3	n/a	n/a	20W 80F	0	30%	0	0	0
	4	n/a	n/a	95F 5R	0	60%	0	0	0
	5	n/a	n/a	95F 5R	0	95%	0	0	0
	6	n/a	n/a	100F	0	10%	0	0	0
	7	n/a	n/a	100F	0	80%	0	0	0
	8	39 6.455	119 54.783	20W 20R 60F	0	80%	0	0	0
	9	39 6.439	119 54.672	50R 50F	0	10%	0	0	0
	10	39.6.334	119 54.695	100F	0	15%	0	0	0
	11	39 6.287	119 54.608	100F	0	5%	0	0	0
	12	39 6.293	119 54.473	5W 5R 90F	0	0	0	0	0
	13	39 6.270	119 54.442	60W 40F	0	0	0	0	0
	14	39 6.232	119 54.386	100F	0	0	0	0	0
	15	39 6.232	119 54. 386	10W 20R 70F	0	20%	0	0	0

e. Marlette Lake

	LOCATION			**SUB**	**INVASIVES**				
DATE	**T**	**N**	**W**	**%Type**	**HYDRILLA**	**EWM**	**ZEBRA**	**QUAGGA**	**NZMS**
7/22-23/10	1	39 9.889	119 53.833	100F	0	0	0	0	0
	2	39 9.864	119 53.882	95R 5F	0	0	0	0	0
	3	39 9.675	119 53.888	5W 5R 90F	0	0	0	0	0
	4	39 9.845	119 54.075	10W 30F 60R	0	0	0	0	0
	5	39 10.366	119 54.413	50R 50F	0	0	0	0	0
	6	39 10.116	119 54.208	30F 10W 60R	0	0	0	0	0
	7	39 10.572	119 53.890	50R 50F	0	0	0	0	0
	8	39 10.589	119 54.210	50W 20F 30R	0	0	0	0	0
	9	39 10.779	119 53.934	90R 10F	0	0	0	0	0
	10	39 10.801	119 52.011	95F 5R	0	0	0	0	0
	11	39 10.797	119 54.157	95R 5W	0	0	0	0	0
	12	39 10.750	119 55.251	90R 10F	0	0	0	0	0
	13	39 10.516	119 54.417	80R 20F	0	0	0	0	0
	14	39 10.417	119 53.840	95 R 5F	0	0	0	0	0
	15	39 10.414	119 54.338	100R	0	0	0	0	0
9/22/2010	1	39 10.767	119 53.911	100F	0	0	0	0	0
	2	39 10.774	119 53.944	40R 10W 50F	0	0	0	0	0
	3	39 10.740	119 53.898	60R 40F	0	0	0	0	0
	4	39 10.712	119 53.910	75R 25F	0	0	0	0	0
	5	39 10.393	119 54.391	5W 35R 60F	0	0	0	0	0
	6	39 10.373	119 54.440	50R 50F	0	0	0	0	0
	7	39 10.380	119 54.455	25R 75F	0	0	0	0	0
	8	39 10.380	119 54.324	20W 50R 30F	0	0	0	0	0
	9	39 9.681	119 53.892	100F	0	0	0	0	0
	10	39 9.694	119 53.931	80W 10R 10F	0	0	0	0	0
	11	39 9.11	119 53.817	50R 50F	0	0	0	0	0
	12	39 9.906	119 53.865	90R 10F	0	0	0	0	0
	13	39 9.881	119 53.854	25R 75F	0	0	0	0	0
	14	39 9.867	119 53.872	90R 10F	0	0	0	0	0
	15	39 9.875	119 53.899	100R	0	0	0	0	0

f. Martis Creek Lake

	LOCATION			**SUB**	**INVASIVES**				
DATE	**T**	**N**	**W**	**%Type**	**HYDRILLA**	**EWM**	**ZEBRA**	**QUAGGA**	**NZMS**
7/9/2010	1	39 19.195	120 6.893	75R 25F	0	100%	0	0	0
	2	39 19.224	120 6.833	25R 75F	0	50%	0	0	0
	3	39 19.268	120 6.827	50R 50F	0	20%	0	0	0
	4	39 19.244	120 6.895	100F	0	100%	0	0	0
	5	39 19.301	120 6.855	80R 20F	0	100%	0	0	0
	6	39 19.458	120 6.823	10R 90F	0	60%	0	0	0
	7	39 19.503	120 6.862	50R 50F	0	5%	0	0	0
	8	39 19.034	120 7.025	60R 40F	0	50%	0	0	0
	9	39 18.892	120 7.034	20R 80F	0	100%	0	0	0
	10	39 18.925	120 7.001	50R 50F	0	95%	0	0	0
9/14/2010	1	39 19.191	120 6.898	20R 5W 75F	0	5%	0	0	0
	2	39 19. 185	120 6.902	50F 25R 25W	0	40%	0	0	0
	3	39 19.166	120 6.898	60R 40F	0	85%	0	0	0
	4	39 19.134	120 6.919	20R 80F	0	25%	0	0	0
	5	39 19.198	120 6.878	30R 70F	0	50%	0	0	0
	6	39 19.270	120 6.82	50F 50R	0	0	0	0	0
	7	39 19.266	120 6.825	40R 10W 50F	0	15%	0	0	0
	8	39 19.271	120 6.831	5R 95F	0	100%	0	0	0
	9	39 18.858	120 7.79	100F	0	0	0	0	0
	10	39 18.866	120 7.064	100F	0	0	0	0	0
	11	39 18.904	120 7.013	100F	0	0	0	0	0
	12	39 18.905	120 7.025	100F	0	90%	0	0	0
	13	39 18.896	120 7.064	100F	0	50%	0	0	0
	14	39 14.401	120 6.762	100F	0	95%	0	0	0
	15	39 19.021	120 6.970	10R 70F 20W	0	80%	0	0	0

g. Donner Lake

	LOCATION			SUB	INVASIVES				
DATE	**T**	**N**	**W**	**%Type**	**HYDRILLA**	**EWM**	**ZEBRA**	**QUAGGA**	**NZMS**
7/21/2010	1	39 19.321	120 17.368	100F	0	0	0	0	0
	2	39 19.229	120 17.417	95R 5F	0	0	0	0	0
	3	39 19.158	120 15.220	50R 50F	0	0	0	0	0
	4	39 19.485	120 16.923	10R 10W 80F	0	0	0	0	0
	5	39 19.483	120 16.577	10R 10W 80F	0	0	0	0	0
9/15/2010	1	39 19.587	120 15.918	90R 5F 5W	0	0	0	0	0
	2	39 19.479	120 17.010	70R 30F	0	0	0	0	0
	3	39 19.501	120 18.001	85R 15F	0	0	0	0	0
	4	39 19.393	120 94.706	60R 40F	0	0	0	0	0
	5	39 19.383	120 14.650	80F 10R 10W	0	0	0	0	0
	6	39 19.381	120 14.618	100F	0	0	0	0	0
	7	39 19.385	120 14.481	10W 90F	0	0	0	0	0
	8	39 19.243	120 15.126	10W 50R 40F	0	0	0	0	0
	9	39 19.194	120 15.136	100F	0	0	0	0	0
	10	39 19.162	120 15.154	100F	0	0	0	0	0
	11	39 19.225	120 17.417	40R 60F	0	0	0	0	0
	12	39 19.162	120 15.221	30R 70F	0	0	0	0	0
	13	39 19.474	120 16.802	50R 50F	0	0	0	0	0
	14	39 19.488	120 16.576	60R 40F	0	0	0	0	0
	15	39 19.492	120 16.542	75R 15F 10W	0	0	0	0	0

h. Independence Lake

	LOCATION			SUB	INVASIVES				
DATE	T	N	W	%Type	HYDRILLA	EWM	ZEBRA	QUAGGA	NZMS
8/31/2010	1	N 39 27.097	W 120 17.754	90R 10W	0	0	0	0	0
	2	N 39 26.943	W 120 18.085	5F 95R	0	0	0	0	0
	3	N 39 26.842	W 120 18.509	100R	0	0	0	0	0
	4	N 39 26.678	W120 18.923	5F 95R	0	0	0	0	0
	5	N 39 26.392	W120 19.345	20F 80R	0	0	0	0	0
	6	N 39 26.110	W120 19.646	80F 20R	0	0	0	0	0
	7	N 39 25.937	W120 19.704	100F	0	0	0	0	0
	8	N 39 25.930	W120 19.753	100F	0	0	0	0	0
	9	N39 25.890	W120 19.785	100F	0	0	0	0	0
	10	N 39 25.838	W120 18.636	100F	0	0	0	0	0
	11	N 39 26.143	W120 18.928	25W15F60R	0	0	0	0	0
	12	N 39 26.502	W120 18.037	10F 90R	0	0	0	0	0
	13	N 39 27.099	W120 17.413	20F 80R	0	0	0	0	0
	14	N 39 27.075	W120 17.457	100R	0	0	0	0	0
	15	N 39 27.024	W120 17.253	100R	0	0	0	0	0
9/29/2010	1	39 27.078	120 17.439	75R 25F	0	0	0	0	0
	2	39 27.074	120 17.461	100R	0	0	0	0	0
	3	39 27.078	120 17.548	50R 50F	0	0	0	0	0
	4	39 27.114	120 17.762	100R	0	0	0	0	0
	5	39 26.813	120 18.591	100R	0	0	0	0	0
	6	39 26.551	120 19.153	100R	0	0	0	0	0
	7	39 26.114	120 19.642	90R 10F	0	0	0	0	0
	8	39 26.005	120 19.706	10W 90F	0	0	0	0	0
	9	39 25.925	120 19.679	5W 95W	0	0	0	0	0
	10	39 25.900	120 19.674	10W 90F	0	0	0	0	0
	11	39 26.256	120 18.774	40W 20R 40F	0	0	0	0	0
	12	39 26.539	120 17.929	100R	0	0	0	0	0
	13	39 26.996	120 17.290	10W 90F	0	0	0	0	0
	14	39 26.988	120 17.263	75R 25F	0	0	0	0	0
	15	39 27.102	120 17.406	75R 25F	0	0	0	0	0

Appendix B. Truckee River Region study lakes YSI profile data.

a. Boca, b. Stampede, c. Prosser, d. Spooner, e. Marlette, f. Martis Creek L., g. Donner, h. Independence, i. Lahontan, j. Rye Patch, and k. Pyramid.

a. Boca Reservoir

Date	Depth (m)	Temp °C	DO (mg/l)	Sp. Cond (uS/cm)
8/21/2010	0.108	19.64	8.04	0.069
	1.957	19.65	8.02	0.069
	3.059	19.64	8.02	0.069
	4.015	19.63	8.02	0.069
	4.927	19.39	8.15	0.068
	5.899	18.16	8.78	0.067
	6.895	17.91	8.91	0.066
	7.957	16.41	8.93	0.065
	8.979	16.01	8.8	0.066
	9.939	15.63	8.01	0.065
	10.904	15.24	7.78	0.065
	11.883	14.9	7.22	0.066
	13.124	14.69	6.85	0.066
	14.039	14.41	6.39	0.066
	15.295	14.04	5.95	0.066
	17.12	13.68	5.51	0.066
	18.087	13.38	5.08	0.066
	19.12	13.04	4.77	0.067
	19.934	12.55	4.39	0.067
	21.133	12.18	3.84	0.068
	21.692	12.03	3.25	0.069
10/14/2010	0.148	15.06	9.64	0.109
	1.019	14.6	9.73	0.101
	2.049	14.48	9.76	0.101
	3.065	14.39	9.76	0.1
	4.013	14.37	9.75	0.1
	5.023	14.32	9.71	0.1
	6.097	14.26	9.69	0.1
	7.014	14.18	9.67	0.1
	8	14.1	9.43	0.1
	9.084	14.01	9.35	0.1
	10.136	13.93	9.35	0.1
	10.958	13.86	9.36	0.1
	12.023	13.81	9.32	0.1
	13.013	13.78	9.29	0.1
	14.056	13.69	9.28	0.1
	15.096	13.55	9.14	0.1
	16.056	13.46	8.89	0.1
	17.054	13.37	8.72	0.1
	17.882	13.3	8.44	0.1
	0.104	14.97	10.08	0.109

b. Stampede Reservoir

Date	Depth (m)	Temp °C	DO (mg/l)	Sp. Cond (uS)
8/21/2010	0.061	19.89	7.56	0.061
	1.002	19.9	7.57	0.061
	2.033	19.89	7.57	0.061
	2.983	19.9	7.57	0.061
	4.07	19.87	7.58	0.061
	4.984	19.83	7.58	0.061
	5.965	19.77	7.6	0.061
	7.151	19.5	7.58	0.061
	8.124	19.19	7.59	0.06
	9.038	18.4	7.5	0.06
	9.894	17.59	7.42	0.059
	10.921	14.38	6.92	0.057
	11.994	12.72	6.09	0.056
	13.04	12.25	5.67	0.056
	13.84	11.91	5.3	0.056
	14.97	11.54	5.17	0.056
	16.17	11.23	5.09	0.057
	17.184	11.06	5.03	0.057
	17.801	10.84	4.99	0.057
	19.105	10.63	4.94	0.057
	19.993	10.4	5.01	0.057
	22.006	9.95	5	0.057
	23.985	9.76	5.03	0.058
	25.888	9.51	5.08	0.058
	28.148	9.35	5.31	0.058
	30.271	9.26	5.3	0.058
	31.902	9.21	5.3	0.058
	33.938	9.14	5.29	0.058
	36.304	9.09	5.14	0.058
	38.06	9.05	5.21	0.058
	39.864	9.02	5.2	0.058
	42.026	8.98	5.16	0.058
	44.158	8.95	5.07	0.058
	45.952	8.93	5.03	0.059
	47.935	8.9	4.97	0.059
	50.174	8.86	4.7	0.059
	51.935	8.84	4.45	0.059
	52.401	8.82	4.14	0.06
10/14/2010	0.169	14.11	9.4	0.082
	1.097	14.1	9.37	0.083
	2.02	14.09	9.35	0.084
	3.028	14.08	9.36	0.084
	4.08	14.07	9.35	0.084
	5.032	14.06	9.34	0.085
	6.051	14.06	9.32	0.084

	7.045	14.05	9.31	0.084
	8.106	13.99	9.19	0.084
	9.018	13.98	9.12	0.084
	10.044	13.98	9.08	0.084
	11.028	13.94	9.01	0.084
	12.005	13.93	8.97	0.084
	13.034	13.9	8.88	0.085
	14.086	13.82	8.74	0.085
	15.087	13.6	8.48	0.085
	16.118	13.52	7.89	0.085
	17.17	13.34	7.25	0.085
	17.99	12.84	5.07	0.086
	19.197	11.38	3.75	0.086
	20.014	10.84	3.62	0.086
	22.086	10.23	3.72	0.086
	24.016	9.94	3.82	0.085
	26.036	9.69	3.81	0.086
	28.088	9.54	3.95	0.086
	30.011	9.48	4.1	0.086
	32.029	9.44	4.15	0.087
	34.044	9.4	4.18	0.087
	36.031	9.35	4.03	0.087
	38.044	9.31	3.74	0.087
	40.089	9.29	3.36	0.088
	42.106	9.24	3.21	0.088
	44.193	9.17	2.98	0.088
	46.121	9.14	2.7	0.089
	48.159	9.11	1.99	0.09
	48.242	9.11	1.94	0.091

c. Prosser Reservoir

Date	Depth (m)	Temp ^{o}C	DO (mg/l)	Sp. Cond (mS)
9/13/2010	0	18.4	7.12	52.6
	1	18.2	7.52	53.4
	2	18	7.59	53.1
	3	17.8	7.56	53.2
	4	17.6	7.61	53.4
	5	17.4	7.4	53.4
	6	17.3	7.47	53.4
	7	17.3	7.43	53.5
	8	17.2	7.41	53.5
	9	17.1	7.48	53.6
	10	17.1	7.29	53.8
	11	17	7.3	53.8
	12	17	7.19	53.8
	13	17	7.28	53.9
	14	16.9	7.27	53.9
	15	16.8	7.25	54
	16	16.8	6.74	54
	17	16.7	6.65	53.9
	18	16.6	6.54	54.1
	19	16.5	6.2	54.1
	20	16.5	2.3	54.1
7/17/2010	0	23	7.6	50.7
	1	22.4	7.89	50.8
	2	22.2	7.64	50.9
	3	21.5	7.51	51.3
	4	20.7	7.5	50.4
	5	20.7	7.2	50.3
	6	18.9	7.5	47.1
	7	18.4	7.68	45.9
	8	17.2	7.5	44.7
	9	16.5	7.32	44.4
	10	15.7	7.4	44.6
	11	15	7.68	43.9
	12	14.5	7.2	43.6
	13	14.2	7.91	43.6
	14	13.8	7.38	43.7
	15	13.7	7.42	44
	16	13.6	6.9	43.6
	17	13.3	6.5	44.1
	18	12.9	6.35	44
	19	12.9	6.45	43.8
	20	12.5	6.39	44.6
	24	13	6.89	44.6

d. Spooner Lake

Date	Depth (m)	Temp ^{o}C	DO (mg/l)	Sp. Cond (mS)
7/21/2010	0	22.5	8.26	528
	1	22.5	8.9	534
	2	21.8	7.92	505
	3	18.6	0.73	796
8/19/2010	0	19.1	5.2	566
	1	19.1	5.5	568
	2	18.9	5.25	569
	3	15.9	0.5	917
	4	14.7	0.1	1050
9/22/2010	0	14.4	8.88	571
	1	14.4	8.86	577
	2	14.4	8.87	579
	3	14.3	8	589
	4	14	1.1	828

e. Marlette Lake

Date	Depth (m)	Temp ^{o}C	DO (mg/l)	Sp. Cond (mS)
7/23/2010	0	20.4	7.13	45.1
	1	19.9	7.11	45
	2	19.6	6.95	45.1
	3	19.8	5.48	45
	4	19.6	4.81	44.9
	5	19.4	5.6	45.1
	6	16.9	7.12	44.2
	7	16.1	6.99	44.2
	7.5	14	6.99	44.1
	8	13.8	7	44
	9	11.5	5.96	44
	10	11.2	4.3	45.5
	10.5	10.1	3.1	46.3
8/19/2010	0	18.9	5.44	44.7
	1	18.5	5.65	44.9
	2	18.2	5.9	44.9
	3	18.1	6.07	45
	4	18	6.19	44.9
	5	17.9	5.86	45
	6	17.9	6.34	44.9
	7	17.8	6.29	44.9
	8	16.2	7.99	44.4
	8.5	13	9	44.2
	9	11.7	7.8	45.1
	10	9.9	4.82	47.1
	11	9.4	2.37	48
	11.5	9.3	1.06	49.1
9/22/2010	0	14	6.93	45.8
	1	14	6.76	45.8
	2	14	6.71	45.7
	3	13.9	6.73	45.8
	4	13.9	6.68	45.8
	5	13.9	6.6	45.6
	6	13.8	6.62	45.7
	7	13.8	6.59	45.6
	8	13.8	6.08	45.6
	9	13.8	6.54	45.7
	10	13.8	4.65	45.8

f. Martis Creek Lake

Date	**Depth (m)**	**Temp ^{o}C**	**DO (mg/l)**	**Sp. Cond (mS)**
7/16/2010	0	23	8.07	127.3
	1	21.8	9.25	127.8
	2	20.8	1.7	132.3
	3	18.7	1.13	151.9
	4	18.5	2.18	149.3
	5	12.7	0.41	264.8
8/16/2010	0	20.8	6.08	138.5
	1	20.2	6.29	137.9
	2	19.7	0.17	139.2
	3	17.7	0.11	154.4
	4	16.8	1.01	129.8
	5	15.8	0.16	130.2
	6	12.2	0.09	132.2
9/15/2010	0	16.7	7.36	140.9
	1	16.2	7	140
	2	15.6	6.97	141.5
	3	15.4	6.02	141.8
	4	14.7	0.65	145.1
	5	13.6	0.34	151.5
	6	12.1	0.29	328.6

g. Donner Lake

8/16/2010	0	20.3	6.34	93.7
	1	20.3	6.41	93.8
	2	20.3	6.6	93.8
	3	20.2	3.96	93.8
	4	20.2	3.87	93.8
	5	20.1	4.95	93.9
	6	20.1	3.27	94
	7	20	3.23	93.8
	8	19.8	3.62	93.7
	9	19.6	3.22	93.7
	10	19.7	4.17	93.9
	11	16.1	2.55	90.6
	12	13.1	2.56	90.1
	13	12.2	2.98	91.1
	14	11.9	3.58	91.5
	15	10.7	4.08	92.1
	16	9.7	4.25	92.8
	17	9.2	4.64	93.3
	18	8.9	8.99	93.8
	19	8.7	9.01	93.8
	20	8.4	8.16	94.1
	21	8.3	8.8	94.6
	22	7.9	8.3	94.5
	23	7.5	6.7	95.5
	24	7.3	6.69	95.7
	25	6.9	7.3	96.6
	26	6.8	7.48	96.9
	27	6.6	7.6	97.5
	28	6.5	6.94	97.6
	29	6.2	6.7	98.2
	30	6.1	6.4	98.4
	35	6.4	4.75	96
	40	6.4	4.26	96.7
	50	6.4	5.14	98.2
9/15/2010	0	16.7	7.79	91.8
	1	16.6	7.8	93.1
	2	16.6	7.64	93.5
	3	16.6	8.16	94.1
	4	16.6	8.37	94.2
	5	16.6	8.57	94.3
	6	16.6	8.57	94.2
	7	16.6	8.61	94.2
	8	16.6	8.46	94.3
	9	16.5	8.62	94.2
	10	16.5	8.68	94.2
	11	16.5	8.52	94.2
	12	16.5	8.66	94.2

	12.5	15.9	8.56	94.6
	13	14.9	8.98	93.5
	14	13.8	9.96	92.1
	15	11.9	11.41	92.8
	16	10.9	11.26	93.1
	17	9.9	11.39	93.2
	18	9.4	11.51	93.8
	19	9	11.33	94.5
	20	8.3	10.5	95.2
	21	7.8	10.26	95.9
	22	7.5	10.06	96.4
	23	7.2	9.64	96.6
	24	7	9.87	97
	25	6.9	9.48	97.2
	26	6.6	9.36	97.8
	27	6.3	8.89	98.8
	28	6.1	8.88	99.2
	29	6	8.73	99.1
	30	5.9	8.71	99.3
	31	5.9	8.59	99.4
	35	5.9	7.65	99.5
	40	6	7.53	99.3
	50	5.8	8.35	99.9

h. Independence Lake

Date	Depth (m)	Temp ^oC	DO (mg/l)	Sp. Cond (mS)
7/27/2010	0	19.9	6.92	40.3
	1	19.5	7.01	40.5
	2	19.4	6.9	40.5
	3	19.5	5.9	40.8
	4	17.9	6.5	40.3
	5	18.8	6.73	40.6
	6	17.2	6.73	39.6
	7	17.3	6.89	39.9
	8	16.7	7.51	39.8
	9	14.5	7.78	39.2
	10	13.9	8.1	39.1
	11	12.9	8.3	39.3
	12	12.4	8.6	39.3
	13	11.5	8.2	39.3
	14	10.4	8.03	39.3
	15	9.5	8.54	39.9
	17	9.2	9.1	40.7
	19	8.5	9.3	40.5
	21	9.1	8.53	39.9
	23	8.7	8.12	37.1
	25	8.2	8.35	41
	30	7.5	7.5	41.1
	35	7.5	5.76	41.6
8/31/2010	0	15.1	7.15	40.4
	1	15.1	7.21	40.5
	2	15.1	7.29	40.5
	3	15.1	7.34	40.4
	4	15.1	7.32	40.4
	5	15.1	7.28	40.4
	6	15	7.2	40.5
	7	15.1	7.32	40.4
	8	15	7.31	40.5
	9	15.1	7.3	40.4
	10	15	7.36	40.4
	11	15	7.38	41.6
	12	15	7.31	41.6
	13	15	7.25	41.5
	14	14.9	7.24	41.7
	14.5	13.1	7.83	41.3
	15	12.4	8.37	41.1
	15.5	10.2	9.04	41
	16	9.9	9.41	40.4
	17	8.7	9.51	40.6
	18	8.3	9.54	40.5
	19	8.1	9.1	40.6
	20	7.8	9.2	40.7

	21	7.7	8.8	40.7
	22	7.5	9	40.8
	23	7.5	8.64	40.7
	24	7.3	8.31	40.8
	25	7.1	7.85	40.9
	26	7	7.91	41
	27	7	7.83	40.8
	28	6.9	7.52	40.9
	29	6.7	7.18	41.2
	30	6.6	6.61	41.3
	31	6.6	6.02	41.4
9/24/2010	0	15.4	7.8	40.8
	1	14.6	7.85	40.8
	2	14.5	7.98	40.9
	3	14.2	8.2	41.1
	4	14	8.27	41.1
	5	14	8.32	41.1
	6	13.9	8.33	41.1
	7	13.9	8.36	41.1
	8	13.8	8.35	41.2
	9	13.7	8.34	41.2
	10	13.7	8.37	41.1
	11	13.7	8.42	41.1
	12	13.7	8.33	41.2
	13	13.6	8.46	41.1
	14	13.5	8.52	41.1
	15	13.5	8.5	41.1
	16	13.1	8.5	40.9
	17	13	8.48	41
	18	12.8	8.6	40.8
	18.5	9.6	9.12	40.3
	19	9	9.3	40.3
	20	8.9	9.3	40.3
	21	7.9	9.14	41.1
	22	7.7	8.58	40.5
	23	7.6	8.6	40.5
	24	7.5	8.27	40.6
	25	7.4	8.19	40.7
	26	7.2	7.83	40.7
	27	7	6.83	41
	28	6.9	6.3	41.1
	29	6.9	6.3	41.2
	30	6.8	5.95	41.2
	31	6.8	5.74	41.3
10/21/2010	0	12.4	8.01	40.9
	1	12.4	8.05	40
	2	12.4	8.08	40.9
	3	12.4	8.16	40.9

	4	12.4	8.27	40.9
	5	12.4	8.28	40.9
	6	12.4	8.31	41
	7	12.4	8.33	41
	8	12.4	8.41	40.9
	9	12.4	8.41	41
	10	12.4	8.43	40.9
	11	12.4	8.46	41
	12	12.4	8.47	40.9
	13	12.4	8.49	40.9
	14	12.4	8.5	40.9
	15	12.3	8.51	40.9
	16	12.3	8.42	41
	17	12.3	8.3	41
	18	12.3	8.47	41
	19	12.3	8.52	40.9
	20	12.3	8.5	41.1
	21	12.2	8.54	41.2
	22	12.1	8.4	41.2
	23	12	8.07	40.8
	24	8.5	6.99	41.5
	25	8.8	7.5	41.5
	26	7.8	6.55	41.3
	27	8.4	7.76	39.8
	28	7.8	6.52	40.4
	29	7.5	5.42	40.5
	30	7.2	4.87	40.8
	31	7.1	4.35	41.2

i. Lahontan Reservoir

Date	Depth (m)	Temp ^{o}C	DO (mg/l)	Sp. Cond (uS)
8/19/2010	0.138	24.71	8	0.227
	1.054	23.98	7.96	0.226
	2.058	23.35	7.83	0.226
	3.084	23.13	7.62	0.226
	4.019	22.49	7.56	0.225
	4.982	22.33	7.51	0.225
	6.075	21.96	7.25	0.225
	7.021	21.88	7.2	0.225
	7.987	21.63	6.91	0.225
	9.038	21.49	6.82	0.225
	10.008	21.35	6.56	0.225
	11.051	21.21	6.34	0.225
	12.005	20.93	5.23	0.225
	12.984	20.65	3.86	0.225
	14.033	20.44	3.56	0.226
	15.169	20.14	2.43	0.227
	16.001	19.88	1.46	0.228
	17.013	19.77	1.03	0.229
	18.051	19.61	0.61	0.231
	18.641	19.39	0.37	0.234

j. Rye Patch Reservoir

Date	Depth (m)	Temp °C	DO (mg/l)	Sp. Cond (uS/cm)
8/21/2010	0.016	20.07	7.22	0.762
	1.072	20.09	7.22	0.762
	2.113	20.08	7.22	0.762
	3.107	20.01	7.21	0.763
	4.08	20.01	7.18	0.762
	5.132	20	7.18	0.762
	6.016	19.99	7.18	0.762
	6.936	19.96	7.18	0.762
	7.915	19.95	7.18	0.762
	9.091	19.97	7.18	0.762
	10.102	19.87	7.15	0.762
	10.394	19.85	7.14	0.762
10/13/2010	1.066	13.86	8.59	0.846
	2.063	13.83	8.49	0.846
	2.974	13.83	8.36	0.847
	4.099	13.83	8.37	0.847
	5.037	13.83	8.34	0.846
	6.029	13.77	8.33	0.848
	7.023	13.69	8.4	0.849
	8.051	13.62	8.35	0.849
	8.197	13.66	8.33	0.849

k. Pyramid Lake

Date	Depth (m)	Temp ^oC	DO (mg/l)	Sp. Cond (uS/cm)
7/23/2010	0.114	23.24	8.13	8.187
	1.026	23.24	8.13	8.186
	2.01	23.24	8.13	8.186
	3.054	23.23	8.13	8.186
	3.965	23.23	8.13	8.186
	5.032	23.23	8.12	8.186
	5.933	23.21	8.11	8.186
	7.095	23.2	8.11	8.185
	8.17	23.16	8.11	8.185
	9.051	22.65	8.3	8.17
	10.17	20.13	9.06	8.125
	11.062	19.86	9.15	8.125
	11.926	18.24	9.29	8.122
	13.023	17.15	9.34	8.107
	13.944	14.95	9.25	8.104
	15.022	14.2	9.16	8.101
	16.087	12.91	9.03	8.089
	17.177	12.32	8.99	8.094
	19.026	11.13	8.97	8.098
	20.157	10.92	8.85	8.104
	21.968	10.21	8.78	8.11
	24.013	9.8	8.62	8.11
	26.023	9.38	8.57	8.113
	28.052	9.14	8.53	8.116
	30.025	9	8.53	8.114
	32.009	8.79	8.55	8.118
	34.089	8.65	8.54	8.12
	36.032	8.56	8.53	8.121
	38.115	8.42	8.55	8.122
	39.956	8.31	8.53	8.124
	42.126	8.2	8.53	8.125
	44.104	8.15	8.5	8.126
	46.093	8.06	8.39	8.127
	47.97	7.94	8.34	8.128
	50.154	7.88	8.28	8.13
	52.19	7.78	8.16	8.131
8/20/2010	0.21	22.76	7.68	8
	1.066	22.47	7.72	7.994
	2.066	22.42	7.73	7.994
	3.031	22.4	7.73	7.993
	3.925	22.39	7.74	7.993
	4.962	22.37	7.73	7.992
	6.085	22.36	7.73	7.993
	7.042	22.35	7.73	7.992
	7.983	22.33	7.73	7.992
	8.996	22.31	7.73	7.992

	9.996	22.26	7.71	7.989
	11.038	21.85	7.82	7.978
	12.003	20.57	8.13	7.949
	13.115	19.52	8.22	7.928
	14.003	17.92	8.37	7.911
	15.026	17.03	8.47	7.89
	15.986	16.96	8.47	7.893
	17.05	15.06	8.59	7.873
	17.978	14.38	8.55	7.877
	19.063	12.33	8.38	7.884
	20.087	11.91	8.28	7.877
	22.067	10.35	7.89	7.88
	24.083	9.91	7.74	7.881
	25.941	9.55	7.69	7.885
	27.997	9.24	7.64	7.887
	30.07	9.03	7.61	7.889
	32.087	8.88	7.62	7.89
	36.011	8.42	7.6	7.897
	37.91	8.29	7.61	7.896
	40.024	8.18	7.56	7.897
	42.132	8.06	7.46	7.898
	42.119	8.06	7.45	7.898
	43.951	7.88	7.41	7.903
	46.047	7.74	7.36	7.903
	48.057	7.68	7.33	7.904
	49.965	7.65	7.3	7.9
10/15/2010	0.301	17.24	8.39	8.006
	1.091	17.27	8.55	8.004
	2.136	17.27	8.64	7.833
	3.201	17.27	8.64	8.004
	4.325	17.27	8.65	8.005
	5.144	17.26	8.65	8.007
	6.1	17.26	8.66	8.008
	7.112	17.26	8.65	8.008
	8.119	17.25	8.65	8.009
	9.117	17.25	8.66	8.008
	10.181	17.25	8.65	8.008
	11.272	17.25	8.65	8.009
	12.269	17.24	8.67	8.009
	13.147	17.24	8.65	8.008
	14.275	17.14	8.6	8.004
	15.078	17.05	8.53	8.003
	16.027	16.68	8.48	7.992
	17.222	15.97	8.34	7.986
	18.246	15.71	8.28	7.982
	19.354	15.05	8.26	7.969
	20.19	14.77	8.18	7.961
	22.11	12.87	8.05	7.933

	24.468	10.43	7.76	7.912
	26.162	10.06	7.72	7.911
	28.159	9.45	7.78	7.916
	30.198	9.01	7.61	7.917
	32.216	8.74	7.57	7.917
	34.17	8.47	7.64	7.919
	36.161	8.32	7.65	7.919
	38.042	8.2	7.68	7.92
	40.078	8.12	7.56	7.919
	41.788	7.99	7.56	7.919

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REFERENCES

Antonov, P.I. and G.L. Shkorbatov. 1990. The ecological-physiological characteristics of *Dreissena* of lower reaches of the Dnepr River. – *In*: The Species in Its Range: Biology, Ecology and Productivity of Aquatic Invertebrates. Minks, Navuka I tehnika, publ., pp 135-141.

Baldwin, B. S., M.S. Mayer, J. Dayton, N. Pau, J. Mendilla, M. Sullivan, A. Moore, A. Ma and E.L. Mills, 2002: Comparative growth and feeding in zebra and quagga mussels (*Dreissena polymorpha* and *Dreissena bugensis*): implications for North American lakes. Canadian Journal of Fisheries and Aquatic Sciences. 59: 1159-1174.

Bially, A., H.J. MacIsaac. 2000. Fouling mussels (Dreissena spp.) colonize soft sediments in Lake Erie and facilitate benthic invertebrates. Freshwater Biology 43: 85-97.

Chandra, S, M Wittmann, A Caires, A Kolosovich, JE Reuter, G Schladow, and T Thayer. 2009. An experiment test of quagga mussel survival and reproductive status using Lake Tahoe water. Tahoe Regional Planning Agency and the Lake Tahoe Aquatic Invasive Species Working Group.

California Fish and Game and California Department of Water Resources. Zebra and quagga mussel veliger sampling protocol, vertical tow. Unpublished: 2008. https://nrmsecure.dfg.ca.gov/FileHandler.ashx?DocumentID=4954

Chandra, S. and Gerhardt, A. Invasive species in aquatic ecosystems: issue of global concern. 2008. Aquatic Invasions: Vol 3. 1:1-2.

Domm, S.R. W. McCauley and E. Kott. 1993. Physiological and taxonomic separation of two Dreissenid mussels in the Laurentian Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences. 50: 2294-2297.

Makarewicz, J.C.; T.W. Lewis, and P. Bertram. 1999. Phytoplankton composition and biomass in the offshore waters of Lake Erie: Pre- and post-Dreissena introduction (1983-1993). Journal of Great Lakes Research 25: 135-148.

Ramcharan C.W., Padilla D.K., Dodson, S.I. 1992. Models to predict potential occurrence and density of the zebra mussel Dreissena-polymorpha. Canadian Journal of Fisheries and Aquatic Sciences. 49: 2611-2620.

Roe, S.L. and H.J. MacIsaac. 1997. Deepwater population structure and reproductive state of quagga mussels (*Dreissena bugensis*) in Lake Erie. Canadian Journal of Fisheries and Aquatic Sciences. 54: 2428–2433.

Ricciardi, A; Neves, RJ; Rasmussen, JB. 1998. Impending extinctions of North American freshwater mussels (Unionoida) following the zebra mussel (Dreissena polymorpha) invasion. Journal of Animal Ecology 67: 613-61).

Sousa, R., Antunes, C., and L. Guilhermino. 2008. Ecology of the invasive Asian clam *Corbicula fluminea* (Muller, 1774) in aquatic ecosystems: an overview. Annales de Limnologie-International Journal of Limnology 44: 85-94.

Stoeckmann, A. 2003. Physiological energetics of Lake Erie Dreissenid mussels: a basis for the displacement of *Dreissena polymorpha* by *Dreissena bugensis*. Canadian Journal of Fisheries and Aquatic Sciences. 60: 126-134.

Stokstad, E. 2007. Feared Quagga mussel turns up in Western United States. Science 315:453.

Strayer, D.L., Powell, J., Ambrose, P. Smith, L.C. Pace, M.L. Fischer, D.T. 1996. Arrival, spread, and early dynamics of a zebra mussel (Dreissena polymorpha) population in the Hudson River estuary. Canadian Journal of Fisheries and Aquatic Sciences. 1144-1153.

US EPA Methods 350.1, 353.1, 365.3, and SM4500-PE

Umek, J., Chandra, S., and Brownstein, J. 2009. Limnology and food web structure of a large terminal ecosystem, Walker Lake (NV, USA). Natural Resources and Environmental Issues: Vol 15:15.

Wentworth, C.K. 1922. A scale of grade and class terms for clastic sediments. Journal of Geology 30:377-392.

Whittier, T.R., Ringold, P.L., Herlihy, A.T., and Pierson, S.M. 2008. A calcium-based invasion risk assessment for zebra and quagga mussels (*Dreissena* spp). Front Ecol Environ 6(4): 180-184.

Whittmann, M., J. Reuter, G. Schladow, S. Hackley, B Allen, S Chandra, A. Caires. Unpublished: January 2008. Asian Clam (*Corbicula fluminea)* of Lake Tahoe: Preliminary scientific findings in support of a management plan.

Zhulidov, A.V., D.F. Pavlov, T.F. Nalepa, G.H. Scherbina, D.A. Zhulidov, T. Yu. Gurtovaya. 2004. Relative Distributions of *Dreissena bugensis* and *Dreissena polymorpha* in the Lower Don River System, Russia. International Review of Hydrobiology. 89(3): 326-333.