Section 5

Mono Basin Waterfowl
Habitat and Population Monitoring
RY 2012-13

APPENDIX 1

Limnology

2012 Annual Report

Mono Lake Limnology Monitoring

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INTRODUCTION

Limnological monitoring was conducted in 2012 at Mono Lake as required under the State Water Resources Control Board Order No. 98-05. The limnological monitoring program at Mono Lake is one component of the Mono Basin Waterfowl Habitat Restoration Plan (LADWP 1996). The purpose of the limnological monitoring program as it relates to waterfowl is to assess limnological and biological factors that may influence waterfowl use of lake habitat (LADWP 1996). The limnological monitoring program consists of four components: meteorological, physical/chemical, phytoplankton, and brine shrimp population data.

An intensive limnological monitoring of Mono Lake has been funded by Los Angeles Department of Water and Power (LADWP) since 1982. In past years, scientists from the Marine Science Institute (MSI), University of California, Santa Barbara, and laboratory personnel at Sierra Nevada Aquatic Research Laboratory (SNARL) have served as the principle investigators and technicians of the field sampling and laboratory analysis for this program. Beginning in 2011 and continuing in 2012, LADWP Watershed Resources staff underwent training in limnological sampling and laboratory analysis methods from the scientists and staff at MSI and SNARL. This training culminated with the transfer of responsibilities for the Mono Lake limnology monitoring program in July of 2012 from MSI to LADWP.

The Marine Science Institute was responsible for all data collection associated with the project up to July 2012, and for the transfer of all data to LADWP at the end of their contract. LADWP staff assumed all data collection responsibilities beginning in August, and was responsible for the analysis and reporting for 2012. Laboratory support for the analysis of ammonium and chlorophyll *a* from August through December 2012 was provided by Environmental Science Associates, Davis, California.

METHODS

Methodologies for both field sampling and laboratory analysis followed those specified in *Field and Laboratory Protocols for Mono Lake Limnological Monitoring (Field and Laboratory Protocols)* (Jellison, 2011). The methods described in *Field and Laboratory Protocols* are specific to the chemical and physical properties of Mono Lake and therefore may vary from standard limnological methods (e.g. Strickland and Parsons 1972). The methods and equipment used by LADWP to conduct limnological monitoring was consistent followed those identified in *Field and Laboratory Protocols* except where noted below.

Meteorology

Two meteorological stations provided weather data in 2012 - Paoha Island and Cain Ranch. The Paoha Island is located approximately 30 m from shore on the southern tip of the island. The base of the station is at 1948 m above sea level, several meters above the current surface elevation of the lake. Sensor readings are made every second and stored as either ten minute averages or hourly values in a Campbell Scientific CR 1000 datalogger. Data are downloaded to a storage module which is collected monthly during the regular sampling trips to the lake.

At the Paoha Island station, wind speed and direction (RM Young wind monitor) are measured by sensors at a height of 3 m above the surface of the island and are averaged over a 10-minute interval. During the ten minute interval, maximum wind speed is also recorded. Using wind speed and direction measurements, the 10-minute wind vector magnitude and wind vector direction are calculated. Hourly measurements of photosynthetically available radiation (PAR, 400 to 700 nm, Li-Cor 192-s), ten minute averages of relative humidity and air temperature (Vaisalia HMP35C), and total rainfall (Campbell Scientific TE525MM-L tipping bucket) are also stored. The minimum detection limit for the tipping bucket gage is 1 mm of water. The tipping bucket is not heated therefore, the instrument is less accurate during periods of freezing due to sublimation of ice and snow.

The daily mean wind speed, maximum mean wind speed, and relative humidity were calculated from 10-minute averaged data from the Paoha Island site.

The Cain Ranch meteorological station is located approximately 7 km southwest of the lake at an elevation of 2088 m. This is an automated weather station managed by LADWP that records daily minimum and maximum air temperature and precipitation.

Field Sampling

Sampling of the physical and chemical properties of the water and the phytoplankton and *Artemia* community was done at 12 bouyed stations at Mono Lake (Figure 1). The water depth at each station at a lake elevation of 1,946 meters is indicated on Figure 1. Stations 1-6 are considered western sector stations, and stations 7-12 are eastern sector stations. Surveys were generally conducted around the 15th of each month.

Physical and Chemical

Sampling of the physical and chemical properties included lake transparency, water temperature, conductivity, dissolved oxygen, and nutrients (ammonium). Lake elevation data collected bi-monthly by LADWP hydrographers will also be reported. Lake transparency was measured at all 12 stations using a Secchi disk. A high-precision conductivity temperature-depth (CTD) profiler (Idronaut,Model 316 Plus) was used to record water temperature and conductivity at nine stations (2, 3, 4, 5, 6, 7, 8, 10 and 12). The CTD is programmed to collect data at 200 millisecond intervals. The CTD was lowered to the bottom at a rate of ~0.2 meters/second, therefore data collection occurred at approximately 4 cm depth intervals.

Dissolved oxygen was measured at one centrally located station (Station 6). Dissolved oxygen concentration was measured with a Yellow Springs Instruments Rapid Pulse Dissolved Oxygen Sensor (YSI model 6562). Readings were taken at one-meter intervals throughout most of the water column, and at 0.5 meter intervals in the vicinity of the oxycline or other regions of rapid change. Data are reported for one-meter intervals only.

Monitoring of ammonium in the epilimnion was conducted using a 9-m integrated sampler at stations 1, 2, 5, 6, 7, 8, and 11. An ammonium profile was developed by sampling at station 6 from eight discrete depths (2, 8, 12, 16, 20, 24, 28, and 35 meters) using a vertical Van Dorn sampler. Samples for ammonium analyses were filtered through Gelman A/E glass-fiber filters and following collection, immediately placed onto dry ice and frozen in order to stabilize the ammonium content (Marvin and Proctor 1965). Ammonium samples were transported on dry ice back to the laboratory transfer station. The ammonium samples were stored frozen until delivered frozen to the University of California Davis Analytical Laboratory (UCDAL) located in Davis, California. Samples were stored frozen until analysis.

Phytoplankton

Chlorophyll a sampling

Monitoring of chlorophyll a in the epilimnion was conducted using a 9-m integrated sampler at stations 1, 2, 5, 6, 7, 8, and 11. A chlorophyll profile was developed by sampling at station 6 from eight discrete depths (2, 8, 12, 16, 20, 24, and 28 meters) using a vertical Van Dorn sampler. Water samples were filtered into opaque bottles through a 120 µm sieve to remove all stages of *Artemia*. Chlorophyll *a* samples were kept cold and transported on ice back to the laboratory transfer station located in Sacramento, CA.

Brine Shrimp

Artemia sampling

The *Artemia* population was sampled by one vertical net tow from each of twelve stations (Fig. 1). Samples were taken with a plankton net (0.91 m x 0.30 m diameter, 118 µm Nitex mesh) towed vertically through the water column. Samples were preserved with 5% formalin in Mono Lake water. When adults were present, an additional net tow was taken from four western sector stations (1, 2, 5 and 6) and three eastern sector stations (7, 8 and 11) to collect adult females for fecundity analysis including brood size and length. Live females collected for fecundity analysis were kept cool and in low densities during transport to LADWP laboratory in Bishop.

Laboratory Analysis

Ammonium

Nitrogen is the primary limiting macronutrient in Mono Lake as phosphate is super-abundant throughout the year (Jellison et al 1994 in Jellison 2011). External inputs are low, and vertical mixing controls much of the annual internal recycling of nitrogen. Ammonium analysis through July 2012 was conducted by laboratory personnel at SNARL and followed methodologies found in *Field and Laboratory Protocols*.

Starting in August 2012, the methodology used by UCDAL was flow injection analysis. Prior to analysis of the August 2012 samples, this method was tested on high salinity Mono Lake water and was found to give results comparable to previous years. This method has detection limits of approximately 2.8 µM. Immediately prior to analysis, frozen samples were allowed to thaw and equilibrate to room temperature, and were shaken briefly to homogenize. Samples were heated with salicylate and hypochlorite in an alkaline phosphate buffer (APHA 1998a, APHA 199b, Hofer 2003, Knepel 2003). EDTA (Ethylenediaminetetraacetic acid) was added in order to prevent precipitation of calcium and magnesium, and sodium nitroprusside was added in order to enhance sensitivity. Absorbance of the reaction product was measured at 660 nm using a Lachat Flow Injection Analyzer (FIA), QuikChem 8000, equipped with a heater module. Absorbance at 660 nm is directly proportional to the original concentration of ammonium, and ammonium concentrations were calculated based on absorbance in relation to a standard solution.

Chlorophyll a

Chlorophyll *a* is the most abundant form of chlorophyll found bound within the cells of the algae comprising the phytoplankton community at Mono Lake. Chlorophyll *a* is therefore monitored as an indicator of phytoplankton activity and abundance. Chlorophyll *a* analysis through July 2012 was conducted by laboratory personnel at SNARL and followed methodologies found in *Field and Laboratory Protocols*.

Starting in August 2012, the determination of chlorophyll *a* was done by fluorometric analysis following acetone extraction. Fluorometry was chosen, as opposed to spectrophotometry, due to higher sensitivity of the fluorometric analysis, and because data on chlorophyll *b* and other chlorophyll pigments were not needed.

At the laboratory transfer station in Sacramento, water samples (200 mL) were filtered onto Whatman GF/F glass fiber filters (nominal pore size of 0.7 µm) under vacuum. Filter pads were then stored frozen until they could be overnight mailed, on dry ice, to the University of Maryland Center for Environmental Science Chesapeake Biological Laboratory (CBL), located in Solomons, Maryland. Sample filter pads were extracted in 90% acetone and then refrigerated in the dark for 2 to 24 hours. Following refrigeration, the samples were allowed to warm to room temperature, and then centrifuged to separate the sample material from the extract. The extract for each sample was then analyzed on a fluorometer. Chlorophyll *a* concentrations were calculated based on output from the fluorometer. Throughout the process, exposure of the samples to light and heat was avoided.

The fluorometer used in support of this analysis was a Turner Designs TD700 fluorometer equipped with a daylight white lamp, 340-500 nm excitation filter and >665 nm emission filter, and a Turner Designs Trilogy fluorometer equipped with either the non-acid or the acid optical module.

Artemia Population Analysis and Biomass

A 8x to 32x stereo microscope was used for all *Artemia* analyses. Depending on the density of shrimp, counts were made of the entire sample or of a subsample made with a Folsom plankton splitter. When shrimp densities in the net tows were high, samples were split so that approximately 100-200 individuals were subsampled. Shrimp were classified as nauplii (instars 1-7), juveniles (instars 8-11), or adults (instars >12), according to Heath's classification (Heath

1924). Adults were sexed and the reproductive status of adult females was determined. Non-reproductive (non-ovigerous) females were classified as empty. Ovigerous females were classified as undifferentiated (eggs in early stage of development), oviparous (carrying cysts) or ovoviviparous (naupliar eggs present).

An instar analysis was conducted at seven of the twelve stations (Stations 1,2,5,6,7,8, and 11). Nauplii at these seven stations were further classified as to specific instar stage (1-7). Biomass was determined from the dried weight of the shrimp tows at each station. After counting, samples were rinsed with tap water and dried in aluminum tins at 50°C for at least two days. Samples are weighed on an analytical balance immediately upon removal from the oven.

Artemia Fecundity

Immediately upon return to the laboratory, ten females from each sampled station were randomly selected, isolated into individual vials, and preserved with 5% formalin. Female length was measured at 8X from the tip of the head to the end of the caudal furca (setae not included). Egg type was noted as undifferentiated, cyst, or naupliar. Undifferentiated egg mass samples were discarded. Brood size was determined by counting the number of eggs in the ovisac and any eggs dropped in the vial. Egg shape was noted as round or indented.

Artemia Population Statistics

Calculation of long-term *Artemia* population statistics followed Jellison and Rose (2011). Daily values of adult *Artemia* between sampling dates were linearly interpolated in Microsoft Excel. The mean, median, peak and centroid day (calculated center of abundance of adults) were then calculated for the time period May 1 through November 30. Long-term values were determined by calculating the mean, minimum and maximum values for these parameters for the time period 1979-2012.

RESULTS

Meteorology

Note that wind speed and relative humidity data is only available for the time period March 21-October 22, 2012. Weather data from Paoha Island prior to March was not provided to LADWP and the datalogger was damaged in October, and became nonfunctional some time after that. Air temperature and precipitation data from the weather station at Cain Ranch will be presented for the entire year.

Wind Speed and Direction

Mean daily wind-speed varied from 2.1 to 11.9 m/sec with an overall mean for this time period of 3.9 m/sec (Figure 2). The daily maximum 10-min averaged wind speeds on Paoha Island averaged three times the mean daily wind speeds. The maximum recorded 10-min reading of 25.8 m/sec occurred on the afternoon of April 26. As has been case in previous years, winds were predominantly from the south (mean 191 degrees).

Air Temperature

Daily air temperatures as recorded at Cain Ranch ranged from a low of -20.6°C on December 29, 2012 to a high of 35.6°C on August 2 (Figure 3). Winter temperature (January through February ranged from -17.8°C to 19.4°C. with an average maximum daily temperature of 10.9°C. The average maximum daily summer temperature (June through August) was 30.2°C. The difference in the minimum and maximum temperatures recorded at the Paoha Island and Cain Ranch stations was evaluated for the period for which overlap in data exists (March through October). The minimum temperatures at Cain Ranch averaged 6.1°C less than Paoha Island, while the maximum temperatures averaged 2.9°C more.

Relative Humidity and Precipitation

The mean relative humidity for the period March 21 – October 22, 2012 was 41.8% (Figure 4). Mean relative humidity was negatively correlated with both daily mean wind speed ($r = -0.294$, $p<0.01$, $n=210$), and maximum 10-minute mean wind speed ($r = -0.312$, $p<0.01$, $n=210$). Precipitation as recorded at Cain Ranch is shown in Figure 5. The total precipitation measured at Cain Ranch for 2012 was 217.7 mm. The long-term average for Cain Ranch (LADWP records) for the time period 1932-2011 is 269 mm. A large precipitation event occurred in both January and March of 2012 with 36.6 mm and 31.5 mm respectively. Several small rain events occurred in late summer (August). December was fairly wet, and began with two large events at the beginning of the month responsible for 34.5 mm and 27.7 mm of precipitation.

Physical and Chemical

Surface Elevation

The surface elevation of Mono Lake in January 2012 was 6383.3 feet. A slight increase in elevation to 6383.6 feet was observed in April. Starting in May, a steady drop in lake elevation began that continued through the end of October, before leveling off. From the 2012 high of

6386.6 feet in April, the lake dropped a total of 2.0 feet to a low of 6381.6 feet by November 20. Figure 6 shows lake elevation 1979 through 2012 and the mixing regime observed each year. As will be discussed below, Mono Lake exhibited a monomictic mixing regime in 2012.

Transparency

The lowest spring secchi depth was 0.76 m +/- 0.3 m in March (Table 1, Figure 7). Secchi depths remained shallow through mid-May at least when the transparency was 0.88 m +/- 0.05 m. As *Artemia* grazing reduced midsummer phytoplankton, lakewide transparency increased to a maximum of 5.23 m +/- 0.31 m in July. Secchi depths began to decrease through the fall, and remained between 0.75 m and 0.80 m from October through December.

Water Temperature

The available water temperature data from Station 6 indicates weak thermal stratification evident in the upper water column by mid-April (Table 2, Figure 8). By mid-July, a strong thermocline had developed at 12-13 m (as indicated by the greater than 1°C change per meter depth) and remained through mid-August. The thermocline deepened to 14-15 m by September as temperatures cooled, and showed further weakening by October. By the mid-November survey, a further deepening of the epilimniom was evident, and temperatures were fairly isothermic down to 24 meters. Holomixis occurred prior to the December 19 survey as temperature data indicate an isothermal water column with water temperatures at 6.5°C from 3 meters down to 39 meters. Note that temperature data for February-March was not provided to LADWP.

Dissolved Oxygen

Dissolved oxygen (DO) at Station 6 was at its highest concentration in the upper 6 meters of the water column in April (6.8 to 7.0 mg/l) and remained elevated (above 5.5 mg/l) into at least mid-May (Table 3, Figure 9). Dissolved oxygen concentration decreased in July and August, and reached their lowest values in the epilimnion in September. At this time, DO ranged from 2.6 to 3.0 mg/l in the upper 11 meters of the water column. DO values recovered slightly in October, but were low again in November as anoxic hypolimnetic waters were mixing through the water column. Following holomixis, DO values in December had recovered to between 4.9 and 5.6 mg/l and varied little throughout the water column. Note that dissolved oxygen data for February, March and June was not provided to LADWP.

Conductivity

No conductivity data is available for 2012. Conductivity data is used to evaluate the salinity profile of the lake however conductivity data was not provided to LADWP for the time period February through July. Furthermore a review of the August to December data indicate probable malfunction of the probe, rendering the data unreliable.

Ammonium

Ammonium levels were high in the lower portion of the water column in early 2012 (Table 4, Figure 10) as was present in December 2011 (Jellison and Rose 2011). This stratification was due to incomplete mixing of the lake in late 2011, and the resulting partial stratification. Ammonium levels in the hypolimnium in February 2012 (24 m and below) as measured at Station 6 ranged from 20.2 to 54.9 µM, indicating uptake by phytoplankton, while values in the epilimnion were low (0.8 to 1.3 µM). Commensurate with increased algal growth, ammonium levels declined throughout the water column into March, April and May. Epilimnetic ammonium levels increased July through October, as *Artemia* abundance increased and excretion of fecal pellets raised the ammonium levels in the water column. In July and August, ammonium concentrations were highest at Stations 1 and 2 in the western sector than at all other stations (Table 5). The July through October period also shows large increases in the level of ammonium in the hypolimnion below approximately 20 m (26.6 to 55.7 µM). Increases in the ammonium concentration in the hypolimnion during these months is associated with increases in algal debris and *Artemia* fecal pellets as these waste products sink to the bottom (Jellison 2011). Ammonium was well-mixed throughout the water column by mid-November and mixing remained complete through mid-December.

Phytoplankton

Seasonal changes were noted in the phytoplankton community, as measured by chlorophyll *a* concentration (Tables 6 and 7, Figure 11). On the February survey, chlorophyll levels were elevated in the water column, with higher levels at some western sector stations (Stations 5,6, and 7). Chlorophyll values increased through March and April, with peak mean lakewide value of 69.7 µg/l on April 18. Also during March and April chlolophyll values were not only high lakewide, but also throughout the water column 51.8 µg/l to 74.5 µg/l. By mid-May, there were slight declines in epilimnionic chlorophyll levels lakewide and at all depths at Station 6. Chlorophyll levels showed further declines in June, reached an average epilimnionic minimum in July of 2.3 µg/l), and remained low through September. By October, the lakewide epilimnionic average had increased to 39.6 µg/l. Chlorophyll levels increased slightly through November and December and remained at moderate levels in the eplimnion (47.1 µg/l to 48 µg/l). Data for Station 6 in November indicate fairly consistent chlorophyll levels throughout the water column.

Brine Shrimp

Artemia Population Analysis and Biomass

Artemia population data is presented in Tables 8a through 8c as lakewide and sector means and associated standard errors. As discussed in previous reports (Jellison and Rose 2011), zooplankton populations can exhibit a high degree of spatial and temporal variability. In addition, when sampling, local convergences of water masses may concentrate shrimp above overall means. For these reasons, Jellison and Rose have cautioned that the use of a single level of significant figures in presenting data is inappropriate, and that the reader should always consider the standard error associated with *Artemia* counts when making inferences from the data.

Artemia Population

Hatching of overwintering cysts had already initiated by February as the mid-February sampling detected an instar lakewide mean abundance of 12,928 +/- 1,892/m^2. The overwhelming majority (98.5%) of the instars in mid-February were instar 1. Instar abundance increased through mid-April to a peak of 40,216 +/- 17,496/m^2, while adults continued to be essentially absent. The peak *Artemia* lakewide abundance of 96,871 +/-29,541/m^2 was recorded on the May 15 survey. By May, adults comprised approximately 55% of the *Artemia* population and had also reached their peak lakewide abundance recorded for the year at 53,813 +/- 16,094/m^2. The instar analysis indicated a diverse age structure of instars 1-7 and juveniles (instars 8-11) in May. In June, females with cysts were first recorded. By July, reproduction decreased significantly, and instars and juveniles comprised only 12.7% of the population. The lowest summer adult *Artemia* abundance occurred in July (9.667+/-1,906/m^2). The adult population remained fairly constant from July through September ranging from 9,667 +/-1,906/m^2 to 13,079 +/-1,760/m^2, although a slight increase was seen after July. In mid-October, adult shrimp numbered 4,991 +/-826/m^2, dropping to 238 +/-43/m^2 in November and 98 +/-43/m^2 in December.

Instar Analysis

The instar analysis, conducted at seven stations, showed patterns similar to those shown by the lakewide and sector analysis, but provide more insight into *Artemia* reproductive cycles occurring at the lake (Table 9). Instars 1 and 2 were most abundant in February and March as overwintering cysts were hatching. In May a diverse age structure of instars was present, while adults comprised 59.3% of all *Artemia*. The number of instar 1 increased in June indicating a second generation of reproduction. Through May and June, various ages classes of instars 1-7 and juveniles were present and comprised approximately 40% of the *Artemia* population. Instar and juvenile abundance decreased July through September to approximately 9-13% of the *Artemia* population. From July through October, mean instar and juvenile abundance remained fairly steady (Table 9); the presence of late stage instars and juveniles indicates survival and recruitment into the population. Adult, juvenile and instar abundances declined considerably in November and December.

Biomass

Mean *Artemia* biomass values were low from February through April, ranging from 0.04 gm/m^2 in February to 0.25 gm/m^2 in April (Table 10). Mean lakewide *Artemia* biomass peaked at 19.95 gm/m^2 in mid-May, and remained fairly level through August, ranging from 17.25 to 18.38 gm/m^2 before declining in September. By October, mean lakewide biomass had declined to 9.01 gm/m^2, and was minimal in November and December. Biomass values differed between western and eastern sectors seasonally; as early spring (April) values were higher in the east, while early fall values (August-Sept) were higher in the west.

Reproductive Parameters and Fecundity Analysis

Table 11 and Figure 12 show the result of the fecundity analysis and lakewide reproductive parameters. In May, virtually no ovigery was detected. In June approximately 37% of females were ovigerous, with 23% oviparous (cyst-bearing), 2.5% ovoviviparous (naupliar eggs) and 11% undifferentiated eggs. From July through October, over 94% of females were ovigerous, with majority (82-94%) oviparous. Ovovivipary remained at less than 2% the remainder of the year.

The lakewide mean fecundity showed pronounced seasonal variation. The lakewide mean fecundity was initially 40.8 eggs per brood in mid-June, decreasing substantially to 18.9 eggs per brood in July (Table 11). Lakewide fecundity then began increasing in August, and reached a high of 120.9 eggs per brood in October. The majority of fecund females (93-98%) were oviparous, while ovoviviparous females with naupliar eggs constituted the remainder. Little difference was observed in fecundity between the western and eastern sectors. The minimum mean female length was 9.4 mm in July which corresponded with the smallest mean brood sizes for the year. The largest females (mean 12.2 mm) were recorded in October when mean brood size was also at its highest for the year (120.9). The number of indented cysts ranged from a low of 3% in July to 59% in August.

Artemia Population Statistics

The seasonal peak in adult *Artemia* of 53,813/m^2 was above the long-term average of 45,440/m^2 (Table 12). The mean and median were below average (16,324 vs. 19,591/m^2 and 11,302 vs 18,201/m^2). The centroid is the calculated center of abundance of adults. The centroid day of 179 in 2012 corresponds to June 27. The long-term mean centroid day for the time period 1979-2012 is 211 (July 29). A centroid day of 179 is the earliest for the period of record. Figure 13 shows daily lakewide mean adult *Artemia* values for 1982-2012. Adult *Artemia* numbers were second highest recorded for May in 2012, the lowest recorded for July, and moderate through fall.

DISCUSSION

In contrast to the foot rise in lake elevation and a return to a meromictic state in 2011, in 2012, Mono Lake saw a two foot drop in elevation, and holomixis or complete autumn mixing. Because only partial mixing had occurred at the end of 2011, some stratification was still evident early in 2012. As is common early in the season, weak thermal stratification was evident in early summer, but by July and through August, the lake was strongly stratified thermally. Temperature data from November and December 2012 indicate a deep mixing and an isothermal water column. A lack of conductivity data prevents an evaluation of the salinity gradients and changes chemical stratification in 2012. The dissolved oxygen values followed the seasonal pattern generally observed at Mono Lake. DO values were high in spring during algal blooms, but decreased through the late spring and summer. Increasing water temperatures lead to decreases in dissolved oxygen as the concentration of oxygen in solution is inversely proportional to temperature. Increases in *Artemia* populations also decrease algal populations, thereby decreasing oxygen production. As algal populations recover in fall due to decreasing shrimp numbers, dissolved oxygen values in the epilimnion increase. Stratification of the lake through the summer results in a depletion of oxygen beneath the euphotic zone. If mixing occurs, further depletion of oxygen in the water column may occur as water in the oxic zone is mixed with the anoxic zone, and consumed by biological oxygen demand in the monimolimnion (Jellison and Rose 2011). This was evident during the November sampling when oxygen values were low throughout the water column as deep mixing was occurring. Following holomixis, DO values had recovered to between 4.9 and 5.6 mg/l in December and varied little throughout the water column.

Ammonium sampling also supports the conclusion that holomixis occurred. The July through October period showed large increases in the level of ammonium in the hypolimnion below approximately 20 m, as algal debris and *Artemia* fecal pellets accumulated in the hypolimnion. Ammonium was well-mixed throughout the water column by mid-November and mixing remained complete through mid-December.

Chlorophyll levels were initially moderate from February through May, with initial decreases evident in May coincident with the increase in shrimp numbers and subsequent decreases in the algal population. As shrimp numbers declined in early fall, by mid-October, chlorophyll levels were recovering. Data for Station 6 in November indicate fairly consistent chlorophyll levels throughout the water column as mixing was occurring.

In 2012 there was an early seasonal peak in adult *Artemia* abundance followed by a steep decline. The adult *Artemia* number in May were the second highest ever recorded for this month and the centroid peak in abundance was also the earliest recorded in the last 34 years of sampling. This pattern of early, large spring first generation spring hatches shifting the temporal distribution of abundance to earlier in the year has been observed previously at Mono Lake (Jellison and Rose 2011). Large early first generation hatches have been generally followed by small second generations as food supply to the second generation is limited due to the closed-system nature of Mono Lake. High numbers early in the spring were followed by low numbers in mid-July and the lowest adult July *Artemia* values over the period of record. Although adult numbers showed a steep decline after an initial high peak, a second generation was produced, and this second generation appeared to survive as late stage instars continued to be present and adult numbers increased again later in the summer. Shrimp numbers remained steady through fall and were moderate into October as compared to long-term data. A high rate of ovigery and high brood numbers were observed in late summer through early fall. Long-term parameters indicate an above average seasonal peak in adult *Artemia*, but below average mean.

In addition to sunlight and water, the main nutrients required by phytoplankton are nitrogen and phosphorous. In Mono Lake nitrogen and its external inputs are limited but phosphorous is abundant. The majority of nitrogen, in the form of ammonium, comes from internal nutrient recycling. In November 2012, Mono Lake underwent an episode of holomixis, with some parameters showing complete mixing in mid-November, and others in December. Mono Lake most recently exhibited a monomictic regime from 2008-2010, was meromictic in 2011 when only partial mixing occurred, and again returned to monomixis in 2012. Monomixis, or annual mixing once a year, is important to the nutrient cycle at Mono Lake as it returns nutrients, most importantly, ammonium back to the epilimnion.

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Table 1. Secchi Depths (m); February – December 2012

STATION	16-Feb	21-Mar	18-Apr	15-May	13-Jun	16-Jul	30-Aug	13-Sep	15-Oct	15-Nov	19-Dec
Western sector											
1	0.95	0.65	0.80	0.60	3.00	7.60	5.00	3.60	0.70	0.70	0.70
2	0.85	0.70	0.90	0.68	2.60	6.30	5.80	2.00	0.80	0.80	0.90
3	0.80		0.82		2.50	4.90	4.80	2.60	0.70	0.80	0.60
4	0.80	0.90	0.90		3.00	4.10	3.40	2.20	0.80	0.90	0.70
5	0.72	0.75	0.90	1.00	3.00	4.60	2.90	2.00	0.70	0.80	0.60
6	0.85	0.80	0.70	0.90	3.00	3.50	2.50	1.80	0.80	0.70	0.60
AVG	0.83	0.76	0.84	0.80	2.85	5.17	4.07	2.37	0.75	0.78	0.68
SE	0.03	0.04	0.03	0.09	0.10	0.62	0.54	0.27	0.02	0.03	0.05
n	6	5	6	4	6	6	6	6	6	6	6
Eastern sector											
7	0.80	0.80	0.78	1.00	2.90	4.80	3.00	1.60	0.80	0.70	0.60
8	0.70	0.80	0.80	0.80	2.60	4.90	3.80	1.30	0.75	0.85	0.70
9	0.80	0.90	0.75	0.90	2.70	5.50	3.10	2.10	0.80	0.85	0.60
10	0.75	0.90	0.80	1.10	2.40	5.00	3.60	1.95	0.80	0.80	0.80
11	0.80	0.60	0.80	0.90	2.70	5.60	3.20	1.50	0.60	0.75	0.80
12	0.80	0.60	0.82	0.90	2.60	5.90	4.10	1.80	0.80	0.75	0.70
AVG	0.78	0.77	0.79	0.93	2.65	5.28	3.47	1.71	0.76	0.78	0.70
SE	0.02	0.06	0.01	0.04	0.07	0.18	0.18	0.12	0.03	0.02	0.04
n	6	6	6	6	6	6	6	6	6	6	6
Total Lakewide											
AVG	0.80	0.76	0.81	0.88	2.75	5.23	3.77	2.04	0.75	0.78	0.80
SE	0.02	0.03	0.02	0.05	0.06	0.31	0.28	0.17	0.02	0.02	0.03
n	12	11	12	10	12	12	12	12	12	12	12

Table 2. Temperature (°C) at Station 6, April* – December 2012

Temperature (°C) at Station 6, April - December, 2012

Depth (m)	18-Apr	15-May	17-Jul	30-Aug	13-Sep	15-Oct	15-Nov	19-Dec
0	8.9	13.7	19.2	21.1	19.9	17.0	10.8	5.8
1	-	12.8	19.3	21.1	20.3	15.8	10.6	6.7
2	7.3	11.8	19.3	21.1	20.1	15.6	10.5	6.6
3	-	11.8	19.3	21.2	20.1	15.7	10.4	6.5
4	7.0	11.5	19.2	21.1	20.1	15.7	10.4	6.5
5	-	11.4	19.2	21.1	20.1	15.7	10.5	6.5
6	6.9	11.3	19.2	21.0	20.2	15.7	10.5	6.5
7	-	11.0	19.2	21.0	20.2	15.7	10.4	6.5
8	6.2	10.7	19.2	21.0	20.1	15.7	10.4	6.5
9	-	10.6	19.2	21.0	20.0	15.7	10.4	6.5
10	6.1	10.6	19.2	21.0	19.9	15.8	10.3	6.5
11	-	10.6	19.2	20.9	19.7	15.8	10.3	6.6
12	6.1	10.2	19.2	20.1	19.5	15.6	10.3	6.5
13	-	9.8	15.4	17.8	19.2	15.5	10.3	6.5
14	5.9	9.3	14.3	16.0	18.2	15.5	10.3	6.5
15	-	8.5	13.9	14.0	15.0	14.6	10.3	6.5
16	5.7	7.4	13.7	10.9	12.6	12.9	10.3	6.5
17	-	6.9	12.6	9.9	10.6	11.0	10.3	6.5
18	5.4	6.3	11.0	9.5	10.4	10.8	10.2	6.5
19	-	6.2	8.9	9.3	10.4	10.3	10.2	6.5
20	5.2	6.0	8.3	9.1	9.4	9.8	10.2	6.5
21	-	6.0	7.7	8.9	9.4	9.8	10.2	6.5
22	5.0	5.9	7.9	8.7	8.9	9.8	10.2	6.5
23	-	5.9	7.4	8.3	8.8	9.8	10.2	6.5
24	4.9	5.7	7.4	7.9	8.3	9.8	10.1	6.5
25	-	5.7	7.2	7.7	8.2	9.8	10.1	6.5
26	4.8	5.6	7.2	7.6	8.2	9.3	10.0	6.5
27	-	5.6	6.6	7.4	8.2	9.2	9.9	6.5
28	4.5	5.5	6.5	7.2	7.7	9.2	9.9	6.5
29		5.4	6.4	7.2	7.3	9.2	9.9	6.5
30	4.5	5.4	6.2	7.0	7.1	9.2	9.9	6.5
31	-	5.2	6.1	6.8	6.9	9.4	9.8	6.5
32	4.4	-	6.1	6.8	6.9	9.5	9.8	6.5
33	4.4	-	6.1	6.7	6.9	9.5	9.7	6.5
34	4.4	-	6.1	6.6	6.8	9.4	9.7	6.5
35	-	-	6.0	6.5	6.8	8.7	9.7	6.5
36	4.4	-	5.9	6.4	6.7	8.7	9.7	6.5
37	-	-	5.9	6.4	6.6	8.5	9.6	6.5
38	4.3	-	5.8	-	-	-	-	6.5
39	-	-	5.8	-	-	-	-	6.5
40	-	-	5.7	-	-	-	-	-

*Data for Feb and March unavailable; temperature data for Feb-July is from YSI temperature-oxygen meter. Remainder of data is from CTD.

Table 3. Dissolved Oxygen (mg/l) at Station 6, April – December 2012*

Depth (m)	**18-Apr**	**15-May**	**17-Jul**	**30-Aug**	**13-Sep**	**15-Oct**	**15-Nov**	**19-Dec**
1	-	5.5	3.6	4.1	2.9	4.5	3.2	5.6
2	6.8	5.9	3.6	4.4	3.0	4.7	3.6	5.6
3	-	6.1	3.7	4.1	3.0	5.5	3.6	5.4
4	7.0	6.1	3.6	3.8	3.0	4.1	3.9	5.4
5	-	6.1	3.7	3.5	2.9	4.3	4.5	5.3
6	6.7	5.7	3.6	3.6	2.8	4.3	3.4	5.2
7	-	5.4	3.6	3.4	2.8	4.2	1.4	5.2
8	6.4	5.5	3.5	3.4	2.7	4.4	1.3	5.2
9	-	5.5	3.5	3.4	2.7	3.6	1.4	5.2
10	5.5	5.6	3.4	3.3	2.8	4.2	1.3	5.2
11	-	5.6	3.3	3.2	2.6	4.5	1.4	5.2
12	5.2	5.2	3.4	3.1	1.9	4.4	1.2	5.1
13	-	4.7	3.3	3.1	1.4	4.4	1.1	5.1
14	4.9	4.3	1.9	3.0	1.4	3.0	1.2	5.1
15	-	3.4	1.6	2.2	0.2	2.2	1.2	5.0
16	4.6	2.7	1.1	2.4	0.1	1.0	1.3	5.0
17	-	2.4	0.4	2.2	0.0	0.3	1.2	5.0
18	4.2	2.2	0.1	2.2	0.1	0.1	1.2	4.9
19	-	1.7	0.1	2.2	0.1	0.1	1.4	4.9
20	3.6	1.3	0.1	2.6	-	-	1.4	4.9
21	-	1.3	0.1	2.5	-	-	1.4	4.9
22	3.2	1.3	0.1	2.1	-	-	1.3	4.9
23	-	1.3	0.1	2.2	-	-	1.3	4.9
24	2.5	1.2	0.1	1.6	-	-	-	4.9
25	-	1.1	0.1	1.4	-	-	-	4.9
26	2.0	1.0	0.1	1.5	-	-	-	4.9
27	-	0.9	0.1	1.4	-	-	-	4.9
28	1.0	0.5	0.1	1.4	-	-	-	4.9
29	-	0.4	0.1	1.1	-	-	-	4.9
30	0.6	0.4	0.1	1.1	-	-	-	4.9
31	-	0.2	0.1	0.8	-	-	-	4.9
32	0.5	-	0.1	0.7	-	-	-	4.9
33	0.3	-	0.1	0.3	-	-	-	4.9
34	0.3	-	0.1	0.3	-	-	-	4.9
35	-	-	0.1	0.2	-	-	-	4.9
36	0.3	-	0.1	0.2	-	-	-	4.9
37	-	-	0.1	0.2	-	-	-	4.9
38	0.3	-	0.1	0.1	-	-	-	4.9
39	-	-	0.1	-	-	-	-	4.9
40	-	-	0.1	-	-	-	-	-

*Data for February and March unavailable

Table 4. Ammonium (µM) at Station 6, February through December 2012

Depth (m)	16-Feb	21-Mar	18-Apr	15-May	13-Jun	17-Jul	30-Aug	13-Sep	15-Oct	15-Nov	19-Dec
1	-	-	-	-	-	-	-	-	-	-	-
2	0.8	0.7	0.3	0.7	0.8	1.5	4.4	4.4	7.8	4.4	4.4
3	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-
12	1.0	0.7	0.3	0.5	0.7	1.1	5.0	5.0	6.7	4.4	5.0
13	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-
16	6.5	0.4	0.2	0.7	5.6	6.0	20.0	20.5	15.0	4.4	4.4
17	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-
20	9.4	3.0	0.4	3.7	12.6	5.8	29.4	31.6	33.8	4.4	6.1
21	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-
24	33.7	7.5	0.6	8.9	17.8	45.9	34.9	37.1	34.4	4.4	4.4
25	-	-	-	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	-
28	54.9	10.5	2.9	8.7	20.0	49.1	36.6	38.8	39.4	5.0	4.4
29	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	-	-
31	-	-	-	-	-	-	-	-	-	-	-
32	-	-	-	-	-	-	-	-	-	-	-
33	-	-	-	-	-	-	-	-	-	-	-
34	-	-	-	-	-	-	-	-	-	-	-
35	20.2	26.9	9.0	17.4	26.6	55.7	43.8	52.7	47.1	4.4	4.4

Table 5. 9-meter integrated values for Ammonium (µm) – February to December 2012

Station	16-Feb	21-Mar	18-Apr	15-May	13-Jun	17-Jul	30-Aug	13-Sep	15-Oct	15-Nov	19-Dec
1	1.1	1.1	0.3	1.0	0.6	5.6	6.7	5.5	7.8	4.4	3.9
2	1.1	1.0	0.4	0.7	0.8	3.3	7.2	4.4	6.7	4.4	3.9
5	1.1	0.7	0.4	0.9	0.7	2.0	5.0	4.4	6.1	4.4	5.0
6	1.2	0.7	0.4	0.6	0.7	1.5	4.4	4.4	6.7	5.0	4.4
7	1.2	0.9	0.2	0.7	0.9	1.6	5.0	4.4	6.1	5.0	5.0
8	1.0	0.9	0.0	0.5	0.9	1.2	4.4	4.4	6.7	4.4	5.0
11	1.2	0.9	0.5	0.7	0.7	1.7	5.0	4.4	6.7	4.4	5.0
Mean	1.1	0.9	0.3	0.8	0.8	2.4	5.4	4.6	6.7	4.6	4.6
SE	0.03	0.05	0.06	0.06	0.04	0.59	0.42	0.16	0.21	0.11	0.20

Table 6. Chlorophyll *a* (µg /l) at Station 6 – February through December 2012

Depth (m)	16-Feb	21-Mar	18-Apr	15-May	13-Jun	17-Jul	30-Aug	13-Sep	15-Oct	15-Nov	19-Dec
1	-	-	-	-	-	-	-	-	-	-	-
2	60.4	68.2	63.8	49.5	5.0	3.1	3.2	5.1	45.2	51.5	33.0
3	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-
8	51.9	64.9	71.3	58.0	11.4	3.5	3.7	4.5	45.5	46.1	50.4
9	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-
12	57.7	64.0	72.7	53.1	37.6	3.2	4.1	14.4	45.0	51.6	50.4
13	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-
16	42.1	65.6	74.5	57.3	47.8	42.8	27.4	23.4	37.1	48.3	54.6
17	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-
20	35.1	63.1	70.1	55.7	51.6	55.4	22.8	19.5	29.5	46.1	49.6
21	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-
24	58.2	57.6	70.2	45.1	58.9	60.4	24.6	23.4	32.0	49.2	31.8
25	-	-	-	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	-
28	60.3	51.8	61.7	50.7	52.0	66.5	24.2	20.7	34.0	48.6	48.8

Table 7. 9-meter integrated values for chlorophyll *a* (µg/l) – February to December 2012

Station	16-Feb	21-Mar	18-Apr	15-May	13-Jun	17-Jul	30-Aug	13-Sep	15-Oct	15-Nov	19-Dec
1	54.4	70.3	74.5	33.2	10.0	1.3	2.7	3.8	35.8	37.5	45.2
2	56.5	70.9	77.0	42.9	14.0	1.8	2.9	6.4	42.0	52.2	46.4
5	61.6	65.4	73.4	53.3	8.5	2.9	5.0	8.9	40.5	49.6	49.2
6	63.5	68.7	71.0	57.8	11.5	2.8	2.7	6.0	45.4	53.7	43.1
7	60.1	62.3	73.9	28.7	7.3	2.9	2.8	5.7	41.1	51.0	48.4
8	53.4	58.1	55.8	42.0	4.0	2.4	2.8	8.4	33.8	44.7	48.8
11	57.8	49.2	62.2	26.6	6.7	1.8	3.3	6.8	38.8	47.6	49.0
Mean	58.2	63.5	69.7	40.6	8.8	2.3	3.2	6.6	39.6	48.0	47.1
SE	1.42	2.96	2.93	4.52	1.25	0.24	0.32	0.65	1.47	2.08	0.88

Table 8a. *Artemia* lake and sector means, 2012

	Instars					Ad Female Ovigery Classification				
	1-7	8-11	Adult Total	Adult Males	Adult Female Total	empty	undif	cysts	naup	Total *Artemia*
Lakewide mean										
16-Feb	12,928	0	3	3	0	0	0	0	0	12,931
21-Mar	31,185	0	0	0	0	0	0	0	0	31,185
18-Apr	40,216	0	2	0	2	2	0	0	0	40,218
15-May	29,567	13,491	53,813	22,736	31,076	31,036	40	0	0	96,871
13-Jun	18,390	1,019	31,375	16,070	15,305	9,551	1,811	3,568	376	50,785
16-Jul	1,087	321	9,667	5,407	4,260	208	422	3,554	76	11,075
30-Aug	1,097	315	13,079	7,726	5,353	161	117	5,045	32	14,491
13-Sep	1,189	351	10,546	5,898	4,647	227	461	3,877	82	12,086
15-Oct	1,534	452	4,991	3,253	1,738	101	203	1,431	3	6,978
15-Nov	380	82	238	158	80	50	3	27	0	699
19-Dec	751	172	98	82	16	9	2	3	2	1,021
Western Sector mean										
16-Feb	11,797	0	7	7	0	0	0	0	0	11,804
21-Mar	23,538	0	0	0	0	0	0	0	0	23,538
18-Apr	2,834	0	0	0	0	0	0	0	0	2,834
15-May	12,777	3,561	23,199	11,026	12,173	12,093	80	0	0	39,537
13-Jun	19,665	483	29,484	15,506	13,977	8,478	1,797	3,273	429	49,631
16-Jul	1,298	492	14,343	7,890	6,453	302	580	5,420	151	16,133
30-Aug	1,676	416	17,456	10,461	6,995	277	101	6,592	25	19,548
13-Sep	1,311	492	14,343	7,890	6,453	302	580	5,420	151	16,145
15-Oct	1,304	388	3,252	2,209	1,043	63	154	819	6	4,944
15-Nov	117	19	186	98	88	57	3	28	0	321
19-Dec	132	16	6	6	0	0	0	0	0	154
Eastern Sector Mean										
16-Feb	14,058	0	0	0	0	0	0	0	0	14,058
21-Mar	38,833	0	0	0	0	0	0	0	0	38,833
18-Apr	77,599	0	3	0	3	3	0	0	0	77,602
15-May	46,358	23,421	84,427	34,447	49,980	49,980	0	0	0	154,205
13-Jun	17,116	1,556	33,266	16,633	16,633	10,624	1,824	3,863	322	51,938
16-Jul	876	151	4,991	2,924	2,067	113	265	1,689	0	6,018
30-Aug	517	214	8,703	4,991	3,712	44	132	3,497	38	9,434
13-Sep	1,044	181	5,989	3,509	2,480	136	318	2,027	0	7,214
15-Oct	1,765	517	6,730	4,298	2,432	139	252	2,042	0	9,012
15-Nov	643	145	290	217	72	44	3	25	0	1,078
19-Dec	1,371	328	189	158	32	19	3	6	3	1,887

Table 8b. Standard errors of *Artemia* sector means (Table 8a), 2012

	Instars				Adult	Ad Female Ovigery Classification				
	1-7	8-11	Adult Total	Adult Males	Female Total	empty	undif	cysts	naup	Total *Artemia*
SE of Lakewide mean										
16-Feb	1,893	0	3	3	0	0	0	0	0	1,893
21-Mar	9,225	0	0	0	0	0	0	0	0	9,225
18-Apr	17,496	0	2	0	2	2	0	0	0	17,496
15-May	9,462	4,975	16,094	6,864	9,618	9,632	40	0	0	29,541
13-Jun	2,618	244	2,204	1,091	1,241	726	237	442	118	4,243
16-Jul	198	95	1,906	1,010	982	73	104	868	39	2,120
30-Aug	248	67	1,762	1,194	668	78	45	649	17	1,970
13-Sep	187	98	1,853	967	988	78	106	883	43	2,046
15-Oct	176	75	826	512	343	20	41	306	3	932
15-Nov	140	24	43	34	16	12	2	5	0	196
19-Dec	257	77	43	35	8	6	2	2	2	365
SE of Western Sector mean										
16-Feb	2,907	0	7	7	0	0	0	0	0	2,906
21-Mar	13,940	0	0	0	0	0	0	0	0	13,940
18-Apr	890	0	0	0	0	0	0	0	0	890
15-May	855	1,064	11,220	5,369	5,911	5,936	80	0	0	12,740
13-Jun	2,428	161	3,781	1,964	1,937	668	464	727	198	5,794
16-Jul	316	153	2,428	1,285	1,377	130	172	1,278	68	2,745
30-Aug	344	110	2,106	1,528	841	144	75	834	25	2,313
13-Sep	309	153	2,428	1,285	1,377	130	172	1,278	68	2,741
15-Oct	234	95	611	548	97	22	34	69	6	759
15-Nov	23	8	36	13	26	15	3	11	0	43
19-Dec	36	6	6	6	0	0	0	0	0	35
SE Eastern Sector Mean										
16-Feb	2,610	0	0	0	0	0	0	0	0	2,610
21-Mar	12,518	0	0	0	0	0	0	0	0	12,518
18-Apr	28,054	0	3	0	3	3	0	0	0	28,053
15-May	15,136	6,974	21,404	9,980	12,589	12,589	0	0	0	41,456
13-Jun	4,859	347	2,375	1,120	1,523	1,187	180	545	144	6,717
16-Jul	233	65	1,160	611	647	58	89	541	0	1,422
30-Aug	134	60	1,247	976	422	21	55	444	26	1,226
13-Sep	198	70	724	215	610	65	88	518	0	941
15-Oct	246	119	1,190	646	561	25	73	507	0	1,261
15-Nov	242	31	77	58	23	19	3	4	0	331
19-Dec	369	127	68	56	14	12	3	4	3	534

Table 8c. Percentage in different classes for *Artemia* sector means (Table 8a), 2012

	Instars						Ad Female Ovigery Classification				
	1-7	8-11	Instar %	Adult Total	Adult Males	Adult Female Total	empty	undif	cysts	naup	Ovigerous Female%
Lakewide %											
16-Feb	100.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-Mar	100.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18-Apr	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
15-May	30.5	13.9	44.4	55.6	23.5	32.1	99.9	0.1	0.0	0.0	0.1
13-Jun	36.2	2.0	38.2	61.8	31.6	30.1	62.4	11.8	23.3	2.5	37.6
16-Jul	9.8	2.9	12.7	87.3	48.8	38.5	4.9	9.9	83.4	1.8	95.1
30-Aug	7.6	2.2	9.7	90.3	53.3	36.9	3.0	2.2	94.2	0.6	97.0
13-Sep	9.8	2.9	12.7	87.3	48.8	38.5	4.9	9.9	83.4	1.8	95.1
15-Oct	22.0	6.5	28.5	71.5	46.6	24.9	5.8	11.7	82.3	0.2	94.2
15-Nov	54.3	11.7	66.0	34.0	22.5	11.5	62.7	3.9	33.3	0.0	37.3
19-Dec	73.6	16.8	90.4	9.6	8.0	1.5	60.0	10.0	20.0	10.0	40.0
Western Sector %											
16-Feb	99.9	0.0	99.9	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
21-Mar	100.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18-Apr	100.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15-May	32.3	9.0	41.3	58.7	27.9	30.8	99.3	0.7	0.0	0.0	0.7
13-Jun	39.6	1.0	40.6	59.4	31.2	28.2	60.7	12.9	23.4	3.1	39.3
16-Jul	8.0	3.0	11.1	88.9	48.9	40.0	4.7	9.0	84.0	2.3	95.3
30-Aug	8.6	2.1	10.7	89.3	53.5	35.8	4.0	1.4	94.2	0.4	96.0
13-Sep	8.1	3.0	11.2	88.8	48.9	40.0	4.7	9.0	84.0	2.3	95.3
15-Oct	26.4	7.8	34.2	65.8	44.7	21.1	6.0	14.8	78.5	0.6	94.0
15-Nov	36.3	5.9	42.2	57.8	30.4	27.5	64.3	3.6	32.1	0.0	35.7
19-Dec	85.7	10.2	95.9	4.1	4.1	0.0	0.0	0.0	0.0	0.0	0.0
Eastern Sector %											
16-Feb	100.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-Mar	100.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18-Apr	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
15-May	30.1	15.2	45.3	54.7	22.3	32.4	100.0	0.0	0.0	0.0	0.0
13-Jun	33.0	3.0	36.0	64.0	32.0	32.0	63.9	11.0	23.2	1.9	36.1
16-Jul	14.6	2.5	17.1	82.9	48.6	34.3	5.5	12.8	81.7	0.0	94.5
30-Aug	5.5	2.3	7.7	92.3	52.9	39.3	1.2	3.6	94.2	1.0	98.8
13-Sep	14.5	2.5	17.0	83.0	48.6	34.4	5.5	12.8	81.7	0.0	94.5
15-Oct	19.6	5.7	25.3	74.7	47.7	27.0	5.7	10.4	83.9	0.0	94.3
15-Nov	59.6	13.5	73.1	26.9	20.2	6.7	60.9	4.3	34.8	0.0	39.1
19-Dec	72.6	17.4	90.0	10.0	8.3	1.7	60.0	10.0	20.0	10.0	40.0

Table 9. Lakewide *Artemia* instar analysis, 2012

	Instars									
	1	2	3	4	5	6	7	8-11	Adults	Total
Mean:										
16-Feb	14579	184	52	29	6	0	0	0	6	14855
21-Mar	30437	8364	11	0	0	0	0	0	0	38813
18-Apr	9922	20193	2552	149	0	92	0	0	0	32909
15-May	1811	4306	1932	926	2435	1690	2093	7103	32535	54829
13-Jun	9842	8738	851	1058	575	575	230	874	32308	55050
16-Jul	184	184	140	162	65	124	238	324	10209	11630
30-Aug	173	211	248	248	32	43	38	270	12731	13995
13-Sep	214	214	164	189	76	139	290	378	11910	13574
15-Oct	105	216	176	267	251	208	208	421	4238	6090
15-Nov	14	81	62	59	16	32	19	70	213	567
19-Dec	76	130	97	92	124	124	51	176	73	943
Standard error of the mean:										
16-Feb	2909	94	34	19	6	0	0	0	6	3014
21-Mar	11693	4328	11	0	0	0	0	0	0	15082
18-Apr	6274	14851	1861	90	0	92	0	0	0	23148
15-May	681	240	732	457	989	745	1039	4524	20330	27587
13-Jun	2225	2540	370	240	210	222	116	389	3218	6867
16-Jul	46	57	48	48	42	83	164	154	2977	3357
30-Aug	77	78	67	114	22	28	22	86	2076	2292
13-Sep	41	57	49	47	48	96	185	170	2890	3247
15-Oct	35	66	48	42	47	43	37	67	2890	3247
15-Nov	5	48	26	44	16	20	19	32	57	252
19-Dec	29	68	47	42	71	94	27	118	37	522
Percentage in different age classes:										
16-Feb	98.1	1.2	0.3	0.2	0.0	0.0	0.0	0.0	0.0	100.0
21-Mar	78.4	21.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
18-Apr	30.2	61.4	7.8	0.5	0.0	0.3	0.0	0.0	0.0	100.0
15-May	3.3	7.9	3.5	1.7	4.4	3.1	3.8	13.0	59.3	100.0
13-Jun	17.9	15.9	1.5	1.9	1.0	1.0	0.4	1.6	58.7	100.0
16-Jul	1.6	1.6	1.2	1.4	0.6	1.1	2.0	2.8	87.8	100.0
30-Aug	1.2	1.5	1.8	1.8	0.2	0.3	0.3	1.9	91.0	100.0
13-Sep	1.6	1.6	1.2	1.4	0.6	1.0	2.1	2.8	87.7	100.0
15-Oct	1.7	3.5	2.9	4.4	4.1	3.4	3.4	6.9	69.6	100.0
15-Nov	2.4	14.3	11.0	10.5	2.9	5.7	3.3	12.4	37.6	100.0
19-Dec	8.0	13.8	10.3	9.7	13.2	13.2	5.4	18.6	7.7	100.0

Table 10. *Artemia* biomass summary, 2012.

	Mean Biomass		
Date	Lakewide	Western Sector	Eastern Sector
16-Feb	0.04	0.04	0.04
21-Mar	0.07	0.05	0.09
18-Apr	0.25	0.01	0.49
15-May	19.95	9.33	30.57
13-Jun	17.66	17.19	18.12
16-Jul	18.38	14.37	22.39
30-Aug	17.25	21.33	13.17
13-Sep	12.63	17.08	8.17
15-Oct	9.01	5.39	12.63
15-Nov	0.36	0.29	0.44
19-Dec	0.39	0.25	0.54

Table 11. *Artemia* fecundity summary, 2012.

	#eggs/brood		%cysts	%indented	Female Length	
	mean	SE			Mean	SE
Lakewide Mean:						
13-Jun	40.8	1.72	94%	44%	10.2	0.10
16-Jul	18.9	0.92	96%	3%	9.6	0.09
30-Aug	64.6	2.32	97%	59%	11.0	0.11
13-Sep	97.9	4.42	96%	51%	11.3	0.16
15-Oct	120.9	5.10	94%	54%	12.2	0.14
Western Sector Mean:						
13-Jun	37.5	1.70	93%	53%	10.3	0.13
16-Jul	18.3	0.95	95%	0%	9.4	0.10
30-Aug	61.8	3.40	98%	30%	10.9	0.16
13-Sep	96.9	5.89	95%	58%	11.3	0.22
15-Oct	121.0	6.76	95%	50%	12.4	0.19
Eastern Sector Mean:						
13-Jun	45.3	3.16	97%	55%	10.2	0.17
16-Jul	19.7	1.73	97%	7%	9.9	0.14
30-Aug	68.2	2.90	97%	43%	11.1	0.15
13-Sep	99.2	6.81	97%	43%	11.3	0.24
15-Oct	120.7	7.93	93%	57%	12.1	0.21

Table 12. Summary Statistics of Adult *Artemia* Abundance from 1 May through 30 November, 1979-2012.

Year	Mean	Median	Peak	Centroid
1979	14,118	12,286	31,700	216
1980	14,643	10,202	40,420	236
1981	32,010	21,103	101,670	238
1982	36,643	31,457	105,245	252
1983	17,812	16,314	39,917	247
1984	17,001	19,261	40,204	212
1985	18,514	20,231	33,089	218
1986	14,667	17,305	32,977	190
1987	23,952	22,621	54,278	226
1988	27,639	25,505	71,630	207
1989	36,359	28,962	92,491	249
1990	20,005	16,775	34,930	230
1991	18,129	19,319	34,565	226
1992	19,019	19,595	34,648	215
1993	15,025	16,684	26,906	217
1994	16,602	18,816	29,408	212
1995	15,584	17,215	24,402	210
1996	17,734	17,842	34,616	216
1997	14,389	16,372	27,312	204
1998	19,429	21,235	33,968	226
1999	20,221	21,547	38,439	225
2000	10,550	9,080	22,384	210
2001	20,031	20,037	38,035	209
2002	11,569	9,955	25,533	200
2003	13,778	12,313	29,142	203
2004	32,044	36,909	75,466	180
2005	17,888	15,824	45,419	192
2006	21,518	20,316	55,748	186
2007	18,826	17,652	41,751	186
2008	11,823	12,524	27,606	189
2009	25,970	17,919	72,086	181
2010	14,921	7,447	46,237	191
2011	21,343	16,893	48,918	194
2012	16,324	11,302	53,813	179
Mean	19,591	18,201	45,440	211
Min	10,550	7,447	22,384	179
Max	36,643	36,909	105,245	252

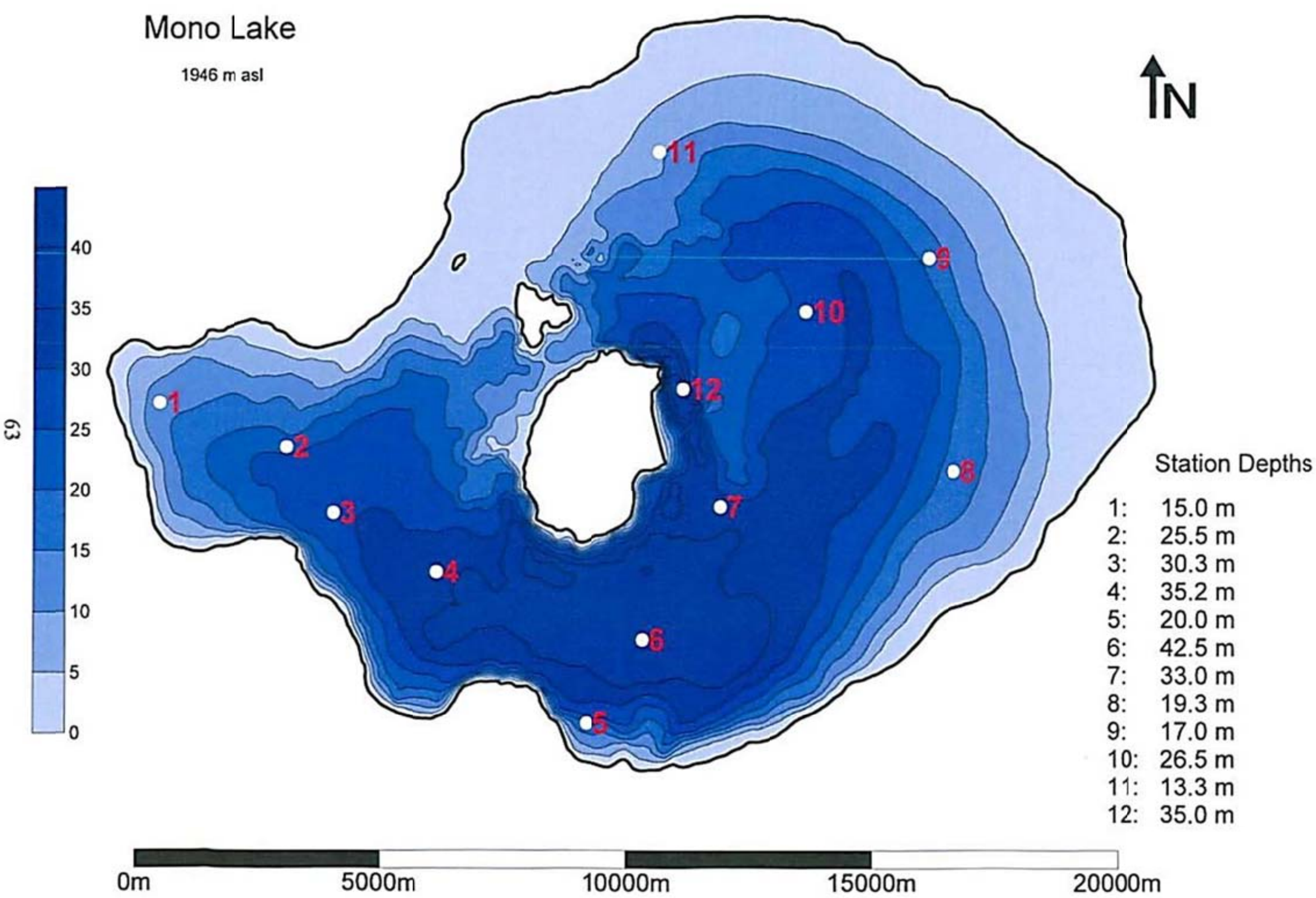

Figure 1. Sampling Stations at Mono Lake and Associated Station Depths

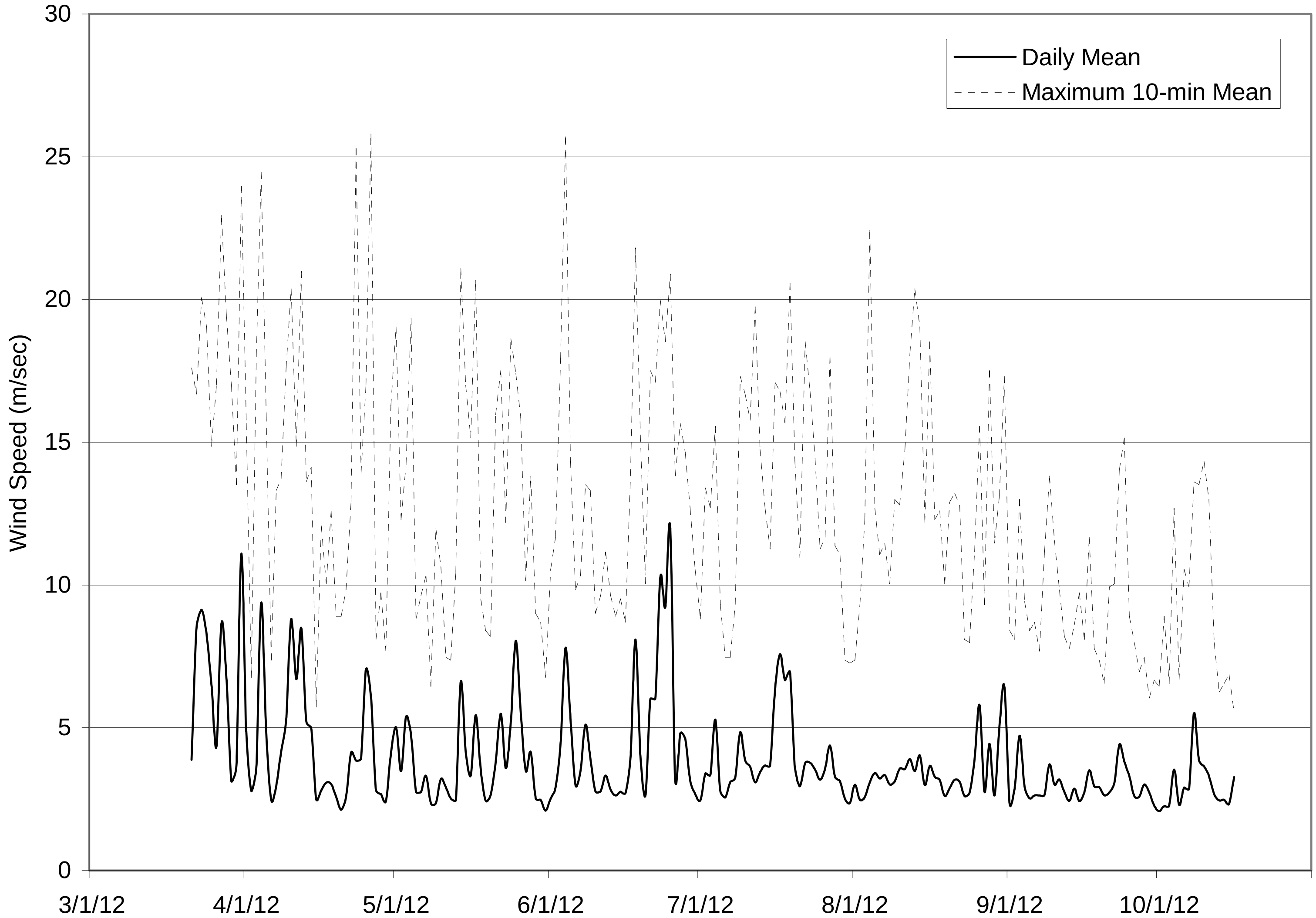

Figure 2. Mean daily wind speed and mean maximum 10-minute wind speed Paoha Island, March 21- October 22, 2012.

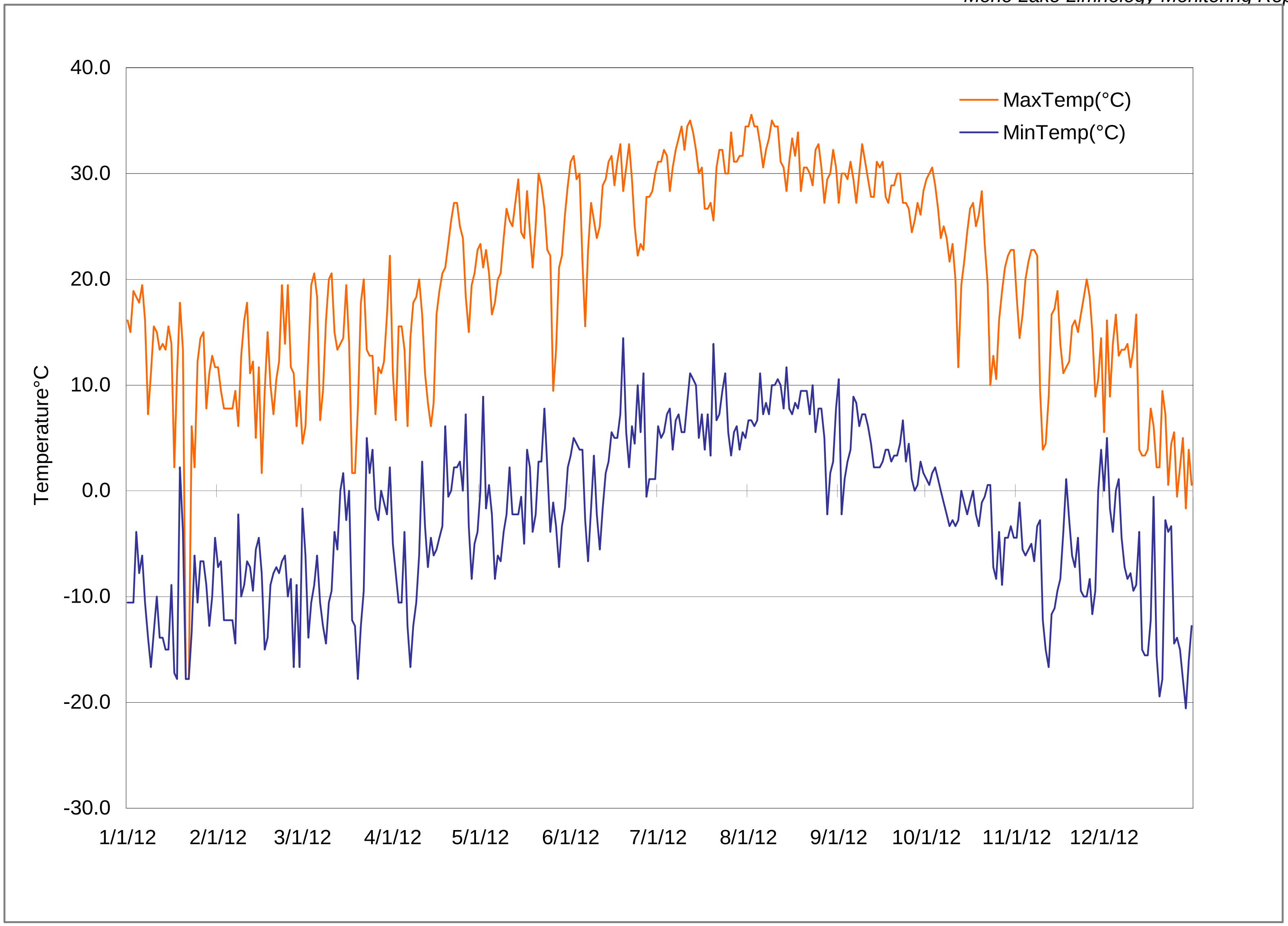

Figure 3. Minimum and maximum daily temperature (°C) as recorded at Cain Ranch.

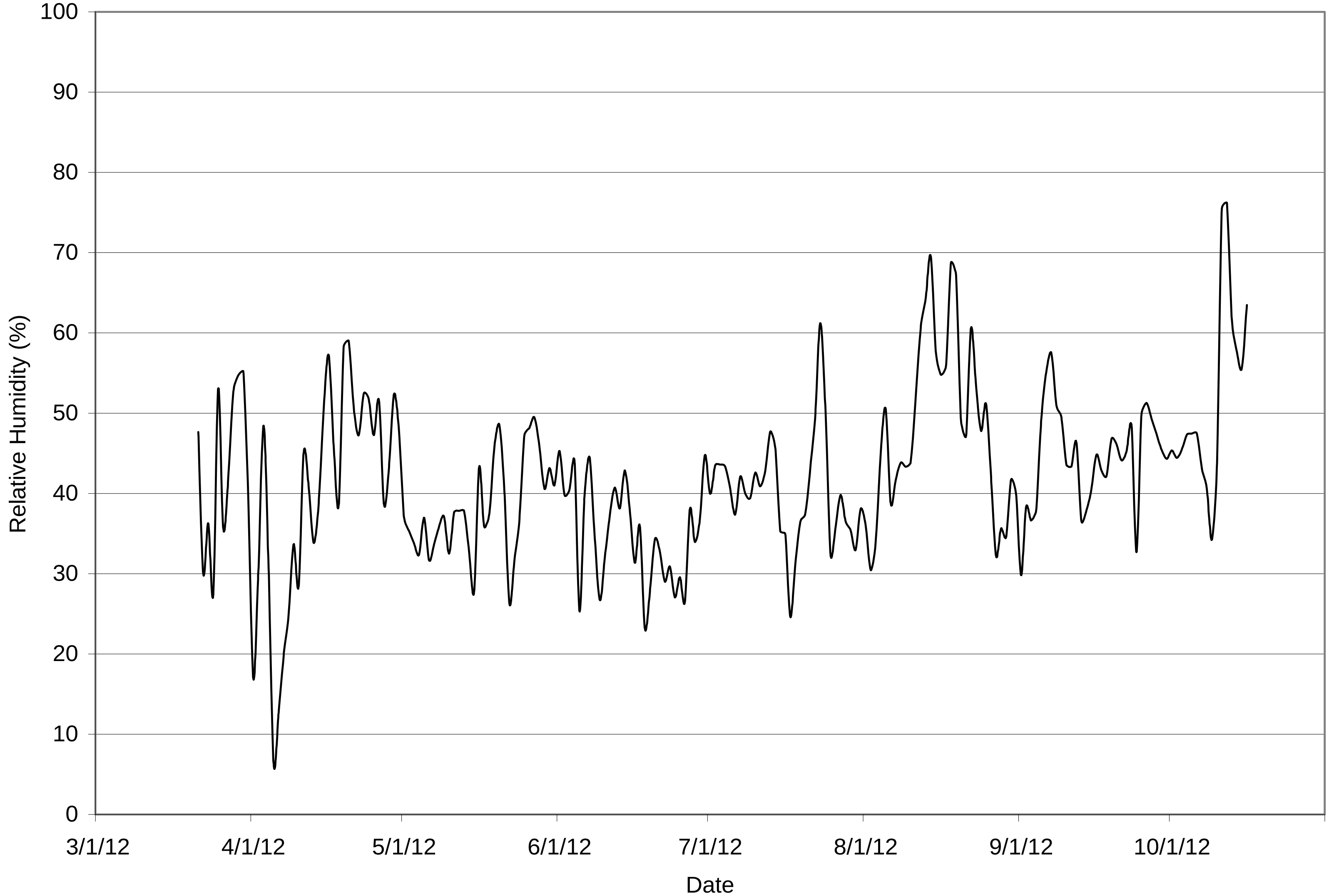

Figure 4. Mean relative humidity (%) – Paoha Island, March 21- October 22, 2012.

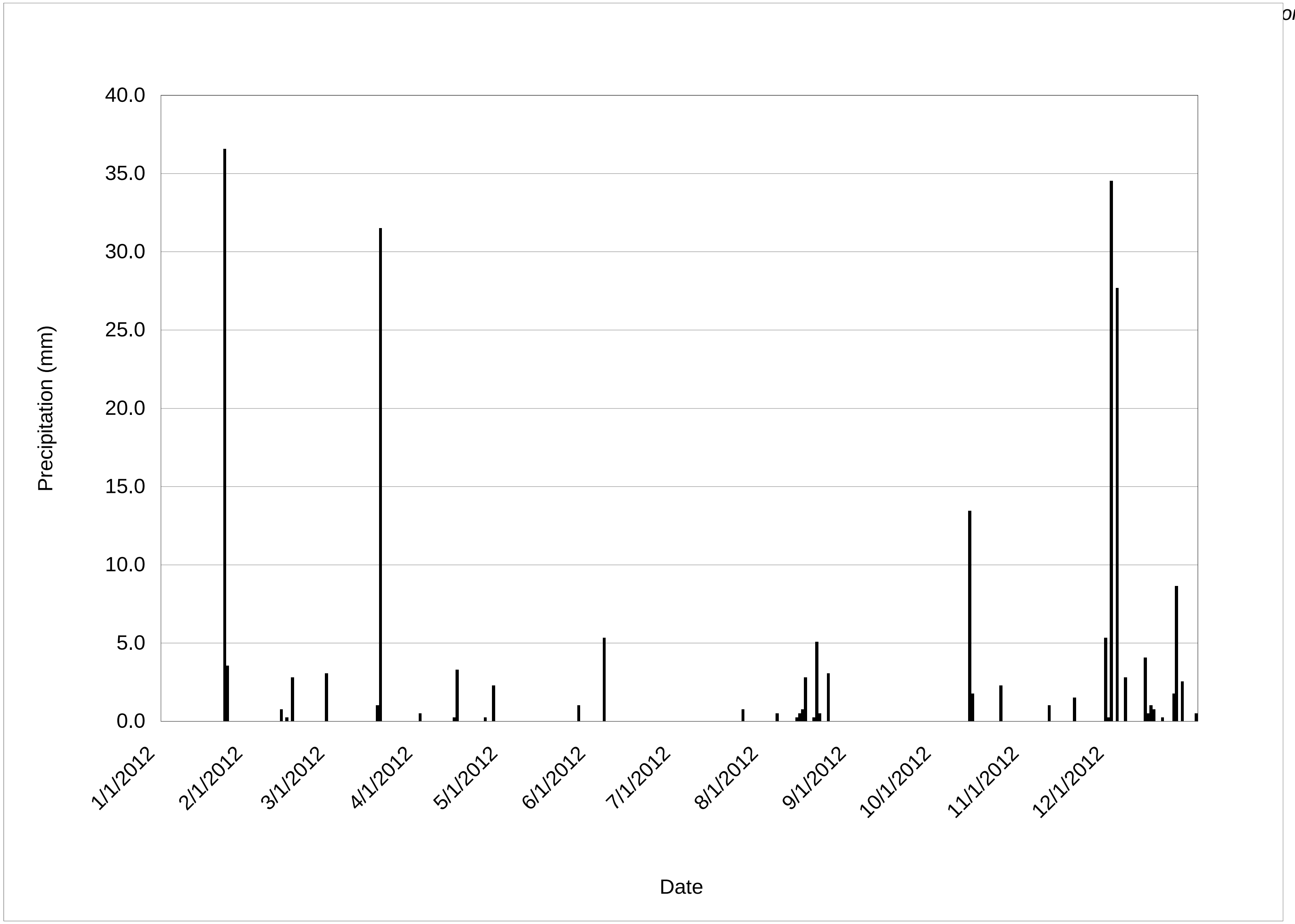

Figure 5. Precipitation (mm) at Cain Ranch, 2012.

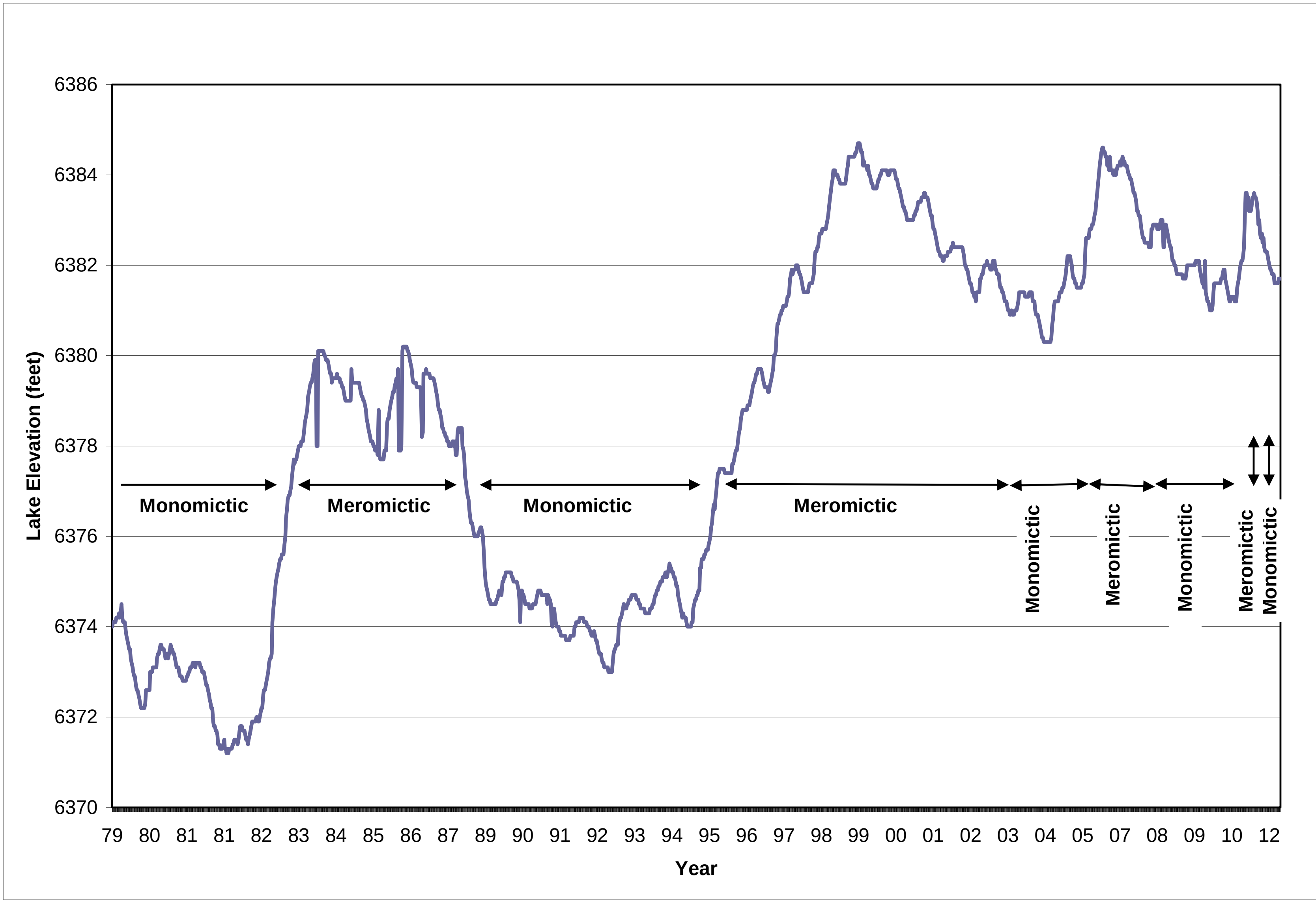

Figure 6. Surface elevation of Mono Lake and mixing regime, 1979-2012

Figure 7. Secchi depths (meters) and standard error, 2012

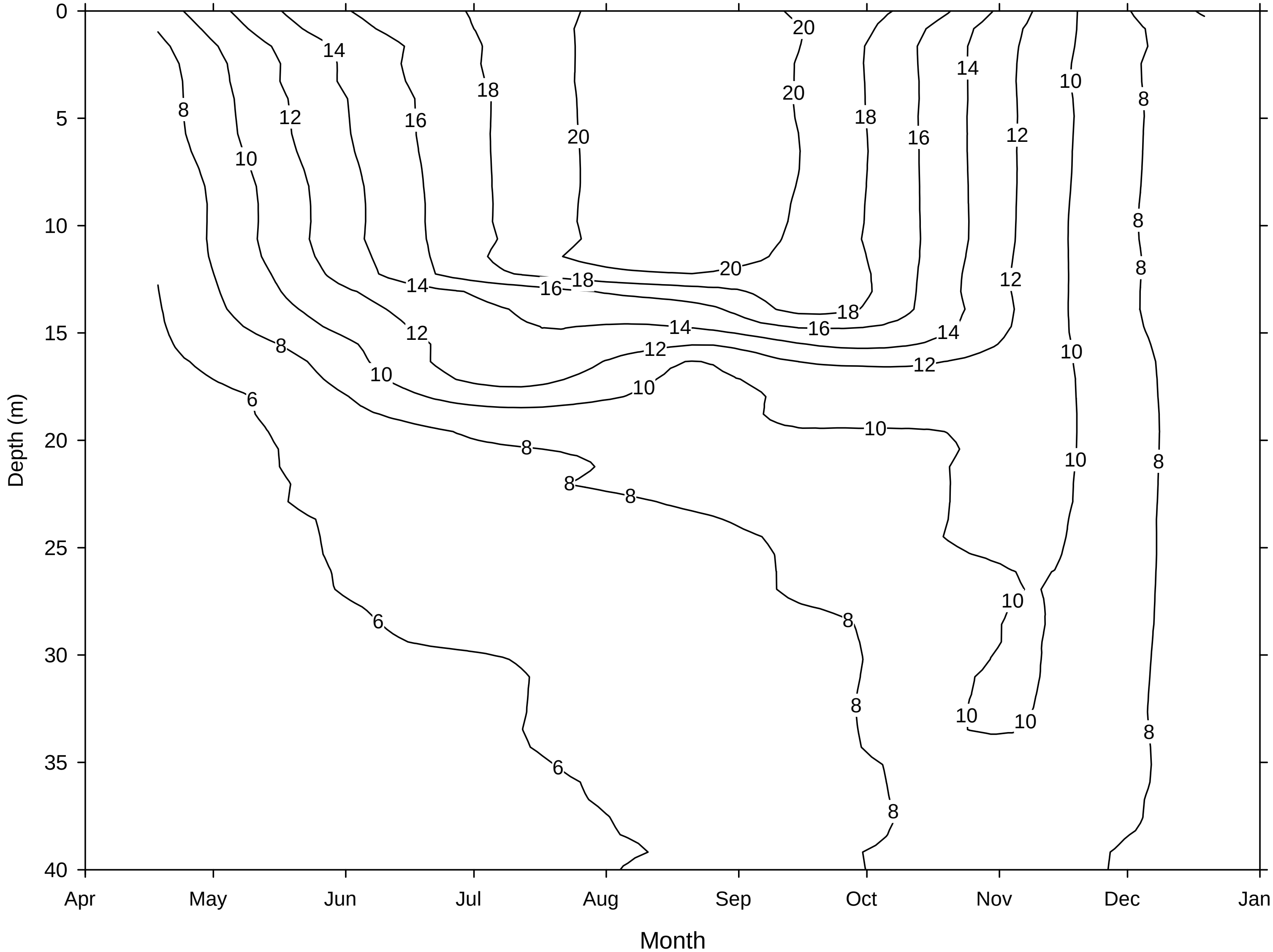

Figure 8. Temperature profiles at Station 6, April to December 2012

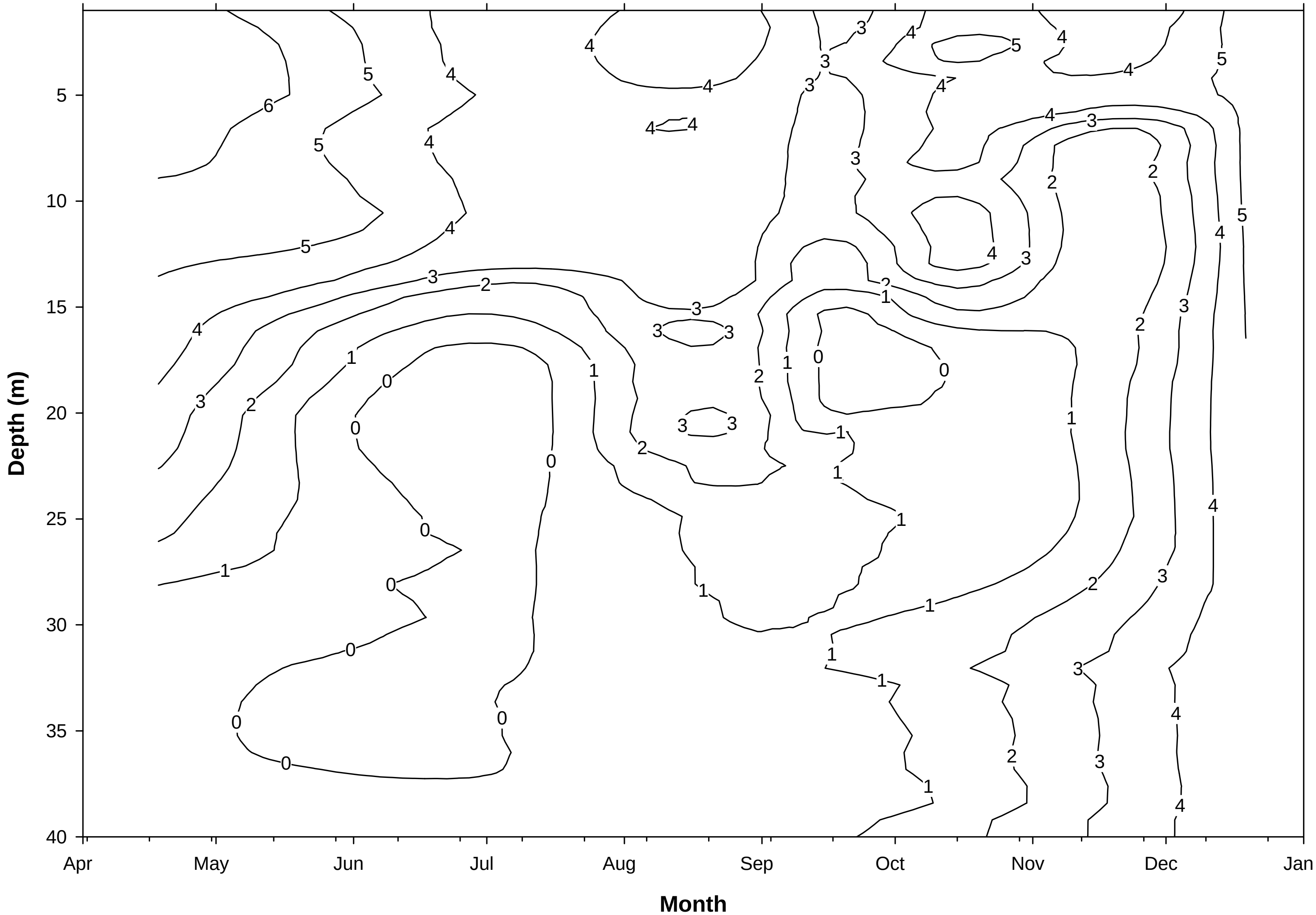

Figure 9. Dissolved oxygen profiles at Station 6, April – December 2012.

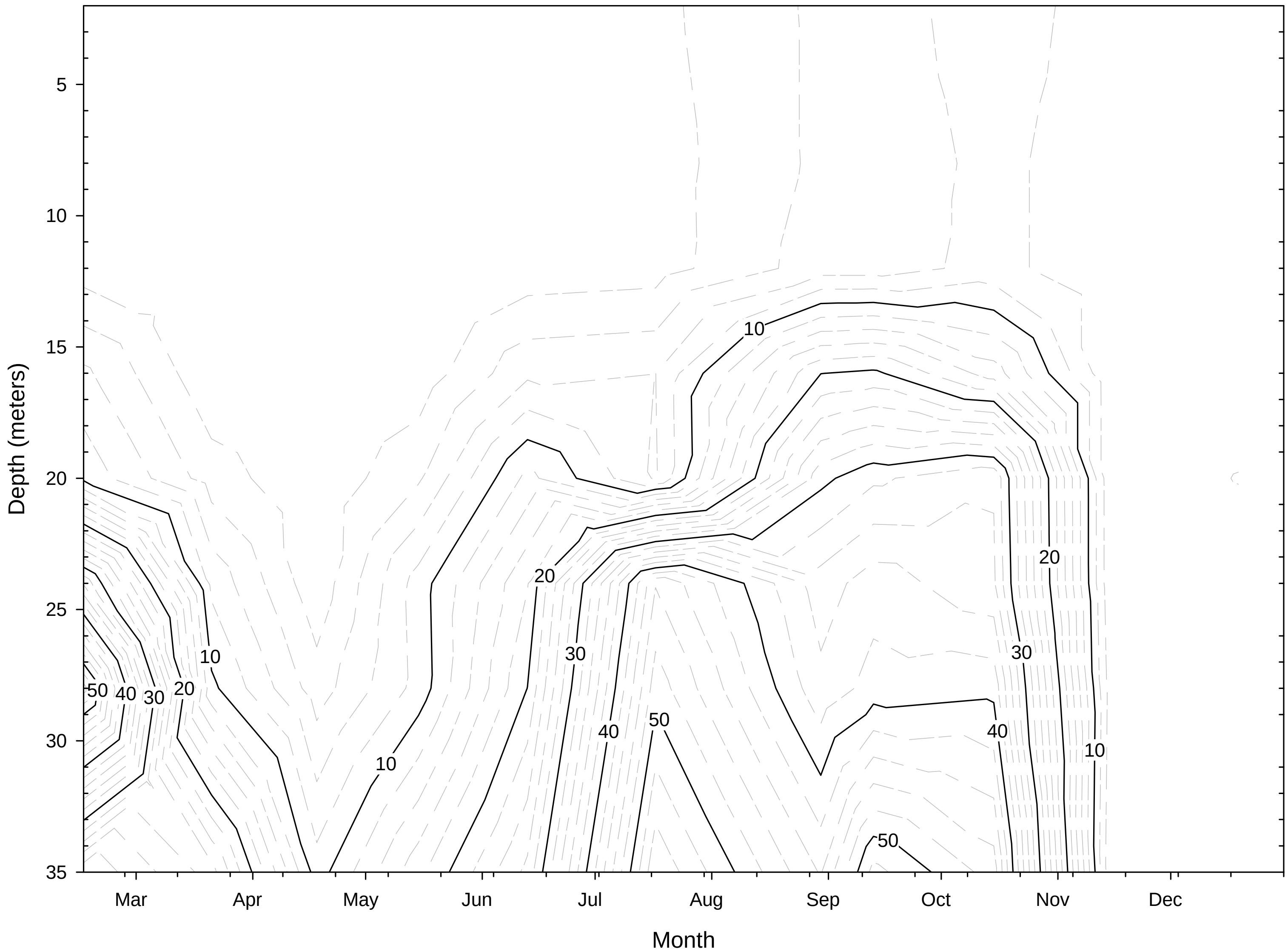

Figure 10. Ammonium profiles Station 6, March – December 2012.

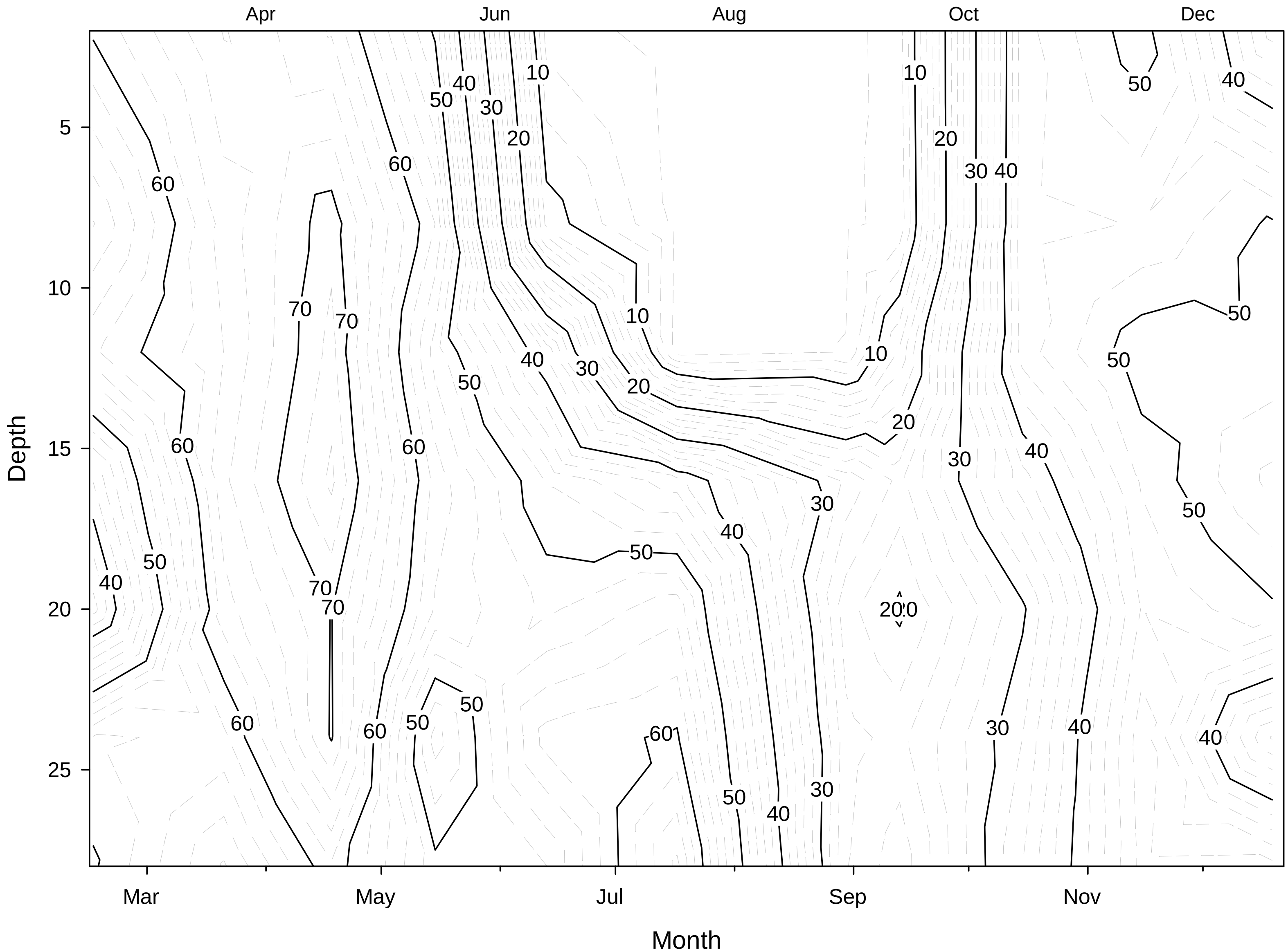

Figure 11. Chlorophyll *a* profiles at Station 6, March – December 2012.

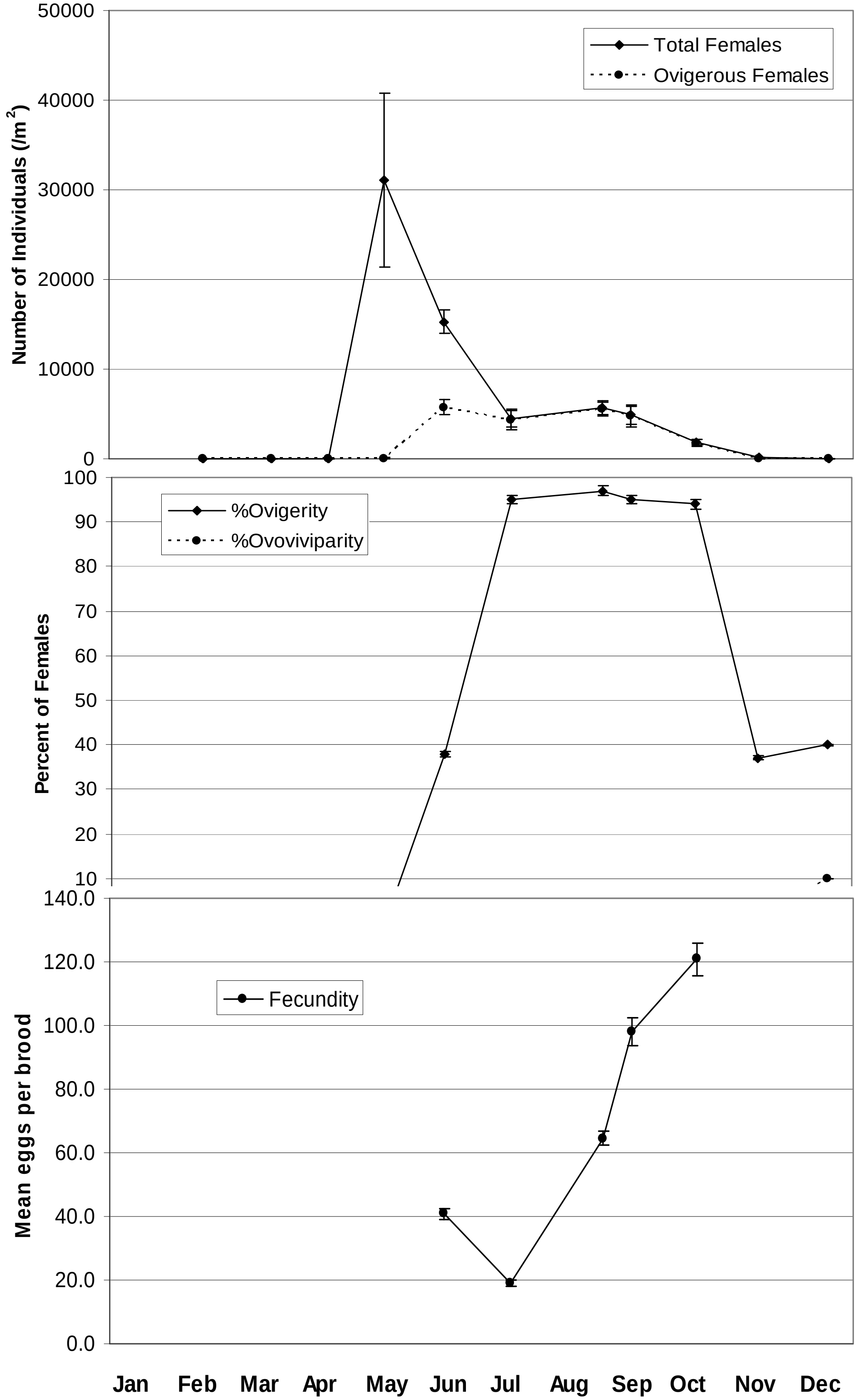

Figure 12. *Artemia* reproductive parameter and fecundity, 2012

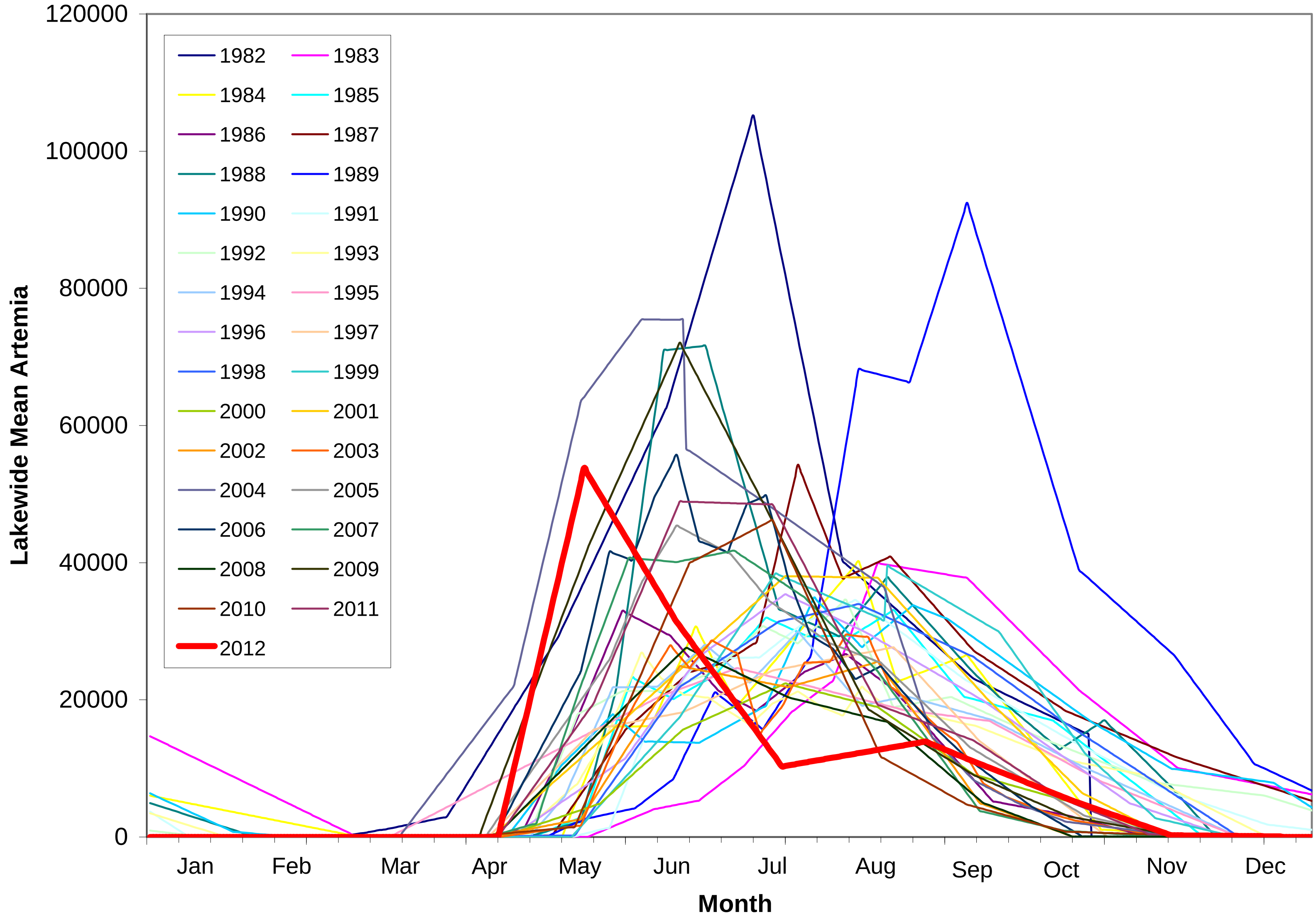

Figure 13. Mean Lakewide *Artemia* abundance 1982-2012.

APPENDIX 2

Ornithology

- Mono Lake
- Rush Creek

MONO LAKE WATERFOWL POPULATION MONITORING

2012 Annual Report

LOS ANGELES DEPARTMENT OF WATER AND POWER
PREPARED BY DEBBIE HOUSE
WATERSHED RESOURCES SPECIALIST
BISHOP, CA 93514

May 2013

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EXECUTIVE SUMMARY

Waterfowl populations were monitored in 2012 at Mono Lake, Bridgeport Reservoir, and Crowley Reservoir, as a component of the 1996 Mono Basin Waterfowl Habitat Restoration Plan. At Mono Lake, three summer ground surveys were conducted, documenting species composition, habitat use and brood production. Six fall aerial surveys were conducted at Mono Lake, Bridgeport Reservoir, and Crowley Reservoir, providing an index of waterfowl numbers using each body of water during fall migration. The fall aerial surveys of Bridgeport and Crowley Reservoirs are being conducted in order to provide data to determine whether or not long-term trends observed at Mono Lake are mirrored at other Eastern Sierra water bodies or are specific to Mono Lake.

The elevation of Mono Lake has undergone annual variations in response to runoff conditions and precipitation regimes. The 2012 runoff year in the Mono Basin was a “dry” year type with 55% of average runoff predicted. Mono Lake was at it highest level in 2012 in April at 6383.6 feet, but dropped a total of 2.0 feet during the year to a low of 6381.6 feet by mid-November.

A total of 1,075 waterfowl of nine species were recorded during summer surveys with Gadwall accounting for 56% of all detections. The four species that used the Mono Lake shoreline habitats for brooding in 2012 were Canada Goose, Gadwall, Green-winged Teal, Mallard. The number of broods detected along shoreline habitats at Mono Lake in 2012 (73) was the highest observed since 2007. The South Shore Lagoons, Sammann’s Spring and Mill Creek areas were the most heavily used areas for brooding. The primary lake-fringing habitats used in 2012 were freshwater ponds, and brackish ponds and unvegetated. A total of five Gadwall broods of were observed at the Restoration Ponds in 2012.

Fall aerial surveys of Mono Lake recorded a total of 43,258 individuals and fifteen waterfowl species. Northern Shovelers and Ruddy Ducks were the dominant species during fall migration with Northern Shovelers accounting for 62% (27,006) of all detections and Ruddy Ducks accounting for 25% (10,927) of all detections. The peak one-day count of 17,464 waterfowl occurred on the September 18 survey.

A total of 33,328 individuals and fifteen waterfowl species were recorded at Bridgeport Reservoir during fall aerial surveys. The most abundant species were Northern Shoveler, Gadwall, and Northern Pintail. The peak number of waterfowl detected at Bridgeport Reservoir was 15,582, and occurred on September 18.

A total of 33,463 individuals and 17 waterfowl species were recorded at Crowley Reservoir during the six fall surveys. The most abundant species were Northern Shoveler, Gadwall, Northern Pintail, and Ruddy Duck. The peak number detected at Crowley Reservoir was 10,464 and occurred during the September 4 survey.

There has been no correlation between total fall waterfowl detections and lake elevation in September, lake elevation change, nor between the lake level and numbers of the two most abundant species, Northern Shoveler and Ruddy Duck. There has been no trend in total waterfowl use of the lake in fall for the period 2002-2012. No correlation has been observed between the total waterfowl detected at Mono Lake and either Bridgeport or Crowley Reservoir.

Waterfowl Monitoring Compliance

This report fulfills the Mono Lake waterfowl population survey and study requirement set forth in compliance with the State Water Resources Control Board (SWRCB) Order No. 98-05. The waterfowl monitoring program consists of summer ground counts at Mono Lake, fall migration counts at Mono Lake, fall comparative counts at Bridgeport and Crowley Reservoirs, and photos of waterfowl habitats taken from the air. Three summer grounds counts and six fall aerial surveys were conducted at Mono Lake in 2012. Six comparative fall aerial counts were completed at Bridgeport and Crowley Reservoirs. Photos of shoreline habitats were taken from a helicopter on October 23, 2012.

2012 Mono Lake Waterfowl Population Monitoring
Los Angeles Department of Water and Power
Prepared by Debbie House
Watershed Resources Specialist
Bishop, CA

INTRODUCTION

In 1996, the Mono Basin Waterfowl Habitat Restoration Plan (Plan) was prepared by the Los Angeles Department of Water and Power (LADWP) for the State Water Resources Control Board (SWRCB) (LADWP 1996). This plan identified restoration objectives and potential projects in addition to land management efforts designed to mitigate for the loss of waterfowl habitat due to the lowered elevation of Mono Lake. The key components of the Plan are:

a) increasing the water surface elevation of Mono Lake to 6,392 feet,
b) rewatering Mill Creek,
c) rewatering specific distributaries in the Rush Creek bottomlands,
d) implementation of the DeChambeau Pond and County Pond Restoration Project,
e) development and implementation of a prescribed burn program, and
f) control of saltcedar in lake-fringing wetlands.

The item identified as being the restoration measure of highest importance and priority was to increase the water surface elevation of Mono Lake to 6,392 feet.

SWRCB Order WR 98-05 directed LADWP to implement the above restoration measures in the Plan and conduct monitoring to assess the success of waterfowl habitat restoration efforts. Components of the waterfowl habitat monitoring plan include the monitoring of lake levels, lake limnology and secondary producers, the mapping of riparian and lake-fringing wetland habitats, and waterfowl population surveys. The purpose of the waterfowl population survey component of the Plan is to provide information to track changes in population levels of waterfowl and assess waterfowl use of the various wetland habitats.

This report describes and discusses monitoring efforts related to evaluating waterfowl population responses to increases in Mono Lake water surface elevations. Survey data for the DeChambeau and County Restoration Ponds are also presented.

Summer ground surveys were conducted in order to determine the size of the breeding and/or summering population, species composition, spatial distribution and habitat use of waterfowl during the summer. Fall aerial surveys were conducted to provide an index of waterfowl numbers using Mono Lake during fall migration, as well as provide information on species composition and spatial distribution. Fall waterfowl surveys are also conducted at Bridgeport and Crowley Reservoirs in order to provide data to evaluate whether long-term trends observed at Mono Lake are mirrored at other Eastern Sierra water bodies or are specific to Mono Lake.

The monitoring of waterfowl populations in the Mono Basin is expected to continue until at least the year 2014, or until the targeted lake level (6,392 foot elevation) is reached and the lake cycles through a complete wet/dry cycle (LADWP 2000a).

All summer surveys were conducted by the author. Fall surveys were conducted by the author with assistance from Mr. Chris Allen, LADWP Watershed Resources Specialist.

METHODS

Summer Ground Surveys

Three ground-count surveys were conducted at Mono Lake at three-week intervals beginning in early June. All surveys were conducted as area counts, and locations were surveyed either by walking along the shoreline, along creek corridors or by making observations from a stationary point. Ground surveys of all shoreline locations were completed over four to five-days.

Shoreline locations surveyed were those identified in the Plan as current or historic waterfowl concentration areas (Figure 1), namely: South Tufa (SOTU); South Shore Lagoons (SSLA); Sammann's Spring (SASP); Warm Springs (WASP); Wilson Creek (WICR); Mill Creek (MICR); DeChambeau Creek Delta (DECR); Rush Creek Delta (RUCR); and Lee Vining Creek bottomlands and delta (LVCR). Surveys were also conducted at the restoration ponds north of the lake: DeChambeau Ponds (DEPO) and County Ponds (COPO).

Shoreline areas including SOTU, SSLA, SASP, WASP, DECR, WICR, and MICR were surveyed by traversing the entire shoreline segment on foot, following the shoreline. In RUCR and LVCR, the creeks were surveyed from the County Road to the deltas. Surveys along lower Rush Creek were conducted by walking along the southern bluff above the creek, and traversing the delta along existing sandbars. This route offered a good view of the creek while limiting wildlife disturbance and flushing of waterfowl ahead of the observer. In Lee Vining Creek, surveys of the creek channel were conducted by walking along the north bank of the main channel, which offered the best view of the channel. At the mouth of the creek, the main channel splits in two and forms two delta areas separated by a tall earthen berm-like formation. In order to obtain good views of both delta areas, it was necessary to cross the main channel and walk on top of this berm. After viewing both delta areas from the berm, the delta areas were also traversed. In both areas, birds were observed and recorded within 100 meters on either side of the deltas.

At the Restoration Ponds, observations were taken from stationary points that allowed full viewing of each pond. A minimum of five minutes was spent at each observation point at the DeChambeau and County Ponds.

All summer ground surveys began within one hour of sunrise and were completed within approximately six hours. The order in which the various sites were visited was varied in order to minimize the effect of time-of-day on survey results. Total survey time was recorded for each area. The date and time of day for each survey during 2012, are provided in Appendix 1. The common names and scientific names for species referenced in the document can be found in Appendix 2.

Surveys along the shoreline and in Rush and Lee Vining Creeks were conducted by walking at an average rate of approximately 1.5 km/hr, depending on conditions, and recording waterfowl species as they were encountered. Because waterfowl are easily flushed, and females with broods are especially wary, the shoreline was frequently scanned well ahead of the observer in order to increase the probability of detecting broods. The following was recorded for each waterfowl observation: time of the observation; the habitat type being used; and an activity code indicating how the bird; or birds were using the habitat. The activity codes used were resting, foraging, flying over, nesting, brooding, sleeping, swimming, and “other”. Shorebirds were censused in the same manner; however, shorebird data will not be presented in this document.

When a waterfowl brood was detected, the size of the brood was recorded, a GPS reading was taken (UTM, NAD 27, Zone 11, CONUS), and the location of each brood was marked on an aerial photograph while in the field. Each brood was also assigned to an age class based on its plumage and body size (Gollop and Marshall 1954). Since the summer surveys were conducted at three-week intervals, any brood assigned to Class I using the Gollop and Marshall age classification scheme (which includes subclasses Ia, Ib, and Ic), would be a brood that had hatched since the previous visit. Assigning an age class to broods allowed for the determination of the minimum number of “unique broods” using the Mono Lake wetland and shoreline habitats.

The habitat categories used, generally follow the classification system found in the report entitled 1999 Mono Basin Vegetation and Habitat Mapping (LADWP 2000b). The habitat classification system defined in that report is being used for the mapping of lakeshore vegetation and the identification of changes in lake-fringing wetlands associated with changes in lake level. The specific habitat categories used in that mapping effort (and in this project) include: marsh, wet meadow, alkaline wet meadow, dry meadow/forb, riparian scrub, Great Basin scrub, riparian forest, freshwater stream, ria, freshwater pond, brackish ponds, hypersaline ponds, and unvegetated. Salinity measurements of ponds were taken using an Extech EC400 Conductivity/TDS/Salinity probe in order to aid in the proper classification of fresh versus brackish ponds when recording habitat use. Ponds with a salinity of less than 500 ppm were classified as fresh. Ponds with vegetation present and a salinity of greater than 500 ppm were classified as brackish. Ponds which lacked vegetation and freshwater inflow were classified as hypersaline. For reference, the definition of each of these habitat types is provided in Appendix 3. Representative photos of these habitats can be found in the report entitled *Mono Lake Waterfowl Population Monitoring 2002 Annual Report* (LADWP 2003).

Two additional habitat types: open-water near-shore (within 50 meters of shore), and open-water offshore (>50 meters offshore), were added to the existing classification system in order to more completely represent areas used by waterfowl. Although a “>50 meter” category was used at the time of data collection, these observations will not be included in the final calculations unless the presence of waterfowl in the open-water offshore zone was determined to be due to observer influence (e.g., the observer sees that a female duck is leading her brood offshore and is continuing to swim away from shore).

Fall Aerial Surveys

Overview of Methodology

Aerial surveys were conducted in the fall at Mono Lake, Bridgeport Reservoir, and Crowley Reservoir using a small high-winged airplane. A total of six surveys were conducted at two-week intervals, with the first survey beginning during the first week of September, and the final fall survey occurring in the middle of November. A summary of the fall survey schedule has been provided as Appendix 4.

Each aerial survey began at Mono Lake at approximately 0900 hours. Mono Lake was surveyed in approximately one and one-half hours. Bridgeport Reservoir was surveyed next, and Crowley Reservoir was surveyed last. In all cases, surveys of all three waterbodies were completed in a single flight by 1200 hours on the day of the survey.

At Mono Lake, waterfowl and shorebirds were censused, with the primary emphasis on the censusing of waterfowl. The greater concentration and diversity of waterfowl at Bridgeport and Crowley Reservoirs prevents censusing of shorebirds at these locations. This report will only present waterfowl data. Observations were verbally recorded onto a handheld digital audio recorder and later transcribed by the observer.

A second observer was present on all six flights. At Mono Lake, the second observer sat on the same side of the plane as the primary observer during the perimeter flight and censused shorebirds. During the cross-lake transect counts, observers sat on the opposite sides of the plane and counted Ruddy Ducks and other waterfowl, and phalaropes occurring on the open water. At Bridgeport and Crowley, the second observer sat on the same side of the plane as the primary observer during the entire survey, and assisted in waterfowl counts.

Mono Lake Aerial Surveys

Aerial surveys of Mono Lake consisted of a perimeter flight of the shoreline and a set of fixed cross-lake transects. The shoreline was divided into 15 lakeshore segments (Figure 2) in order to document the spatial use patterns of fall migrant waterfowl. Coordinates forming the beginning of each segment were derived from the 2002 aerial photo of Mono Lake (2002 aerial image taken by I. K. Curtis, and processed by Air Photo, USA) and can be found in Appendix 5, along with the four-letter code for each lakeshore segment. The segment boundaries are the same as those used by Jehl (2002), except for minor adjustments made in order to provide the observer with obvious landmarks that are easily seen from the air.

The cross-lake transects covered open water areas of Mono Lake. The eight transects are spaced at one-minute (1/60 of a degree, approximately one nautical mile) intervals and correspond to those used by Boyd and Jehl (1998) for the monitoring of Eared Grebes during fall migration. The latitudinal alignment of each transect is provided in Appendix 6.

Each of the eight transects is further divided into two to four sub-segments of approximately equal length (Figure 2). The total length of each cross-lake transect was first determined from the 2002 aerial photo. These lengths were then sub-divided into the appropriate number of subsections to a total of twenty-five sub-segments, each approximately 2-km in length. This approach creates a grid-like sampling system that allows for the evaluation of the spatial distribution of species occurring offshore. The beginning and ending points for each subsection were determined using landscape features, or, when over open water, by using a stopwatch, since the survey aircraft's airspeed was carefully controlled and the approximate length of each subsection was known.

LADWP contracted with Black Mountain Air Service to conduct fixed-winged aerial counts. Black Mountain Air Service has obtained a low-altitude flight waiver from the Federal Aviation Administration in order to conduct these flights. Aerial surveys were conducted in a Cessna 180 at a speed of approximately 130 kilometers per hour, and at a height of approximately 60 meters above ground. Perimeter surveys were conducted over water while maintaining a distance of approximately 250 meters from the shoreline. When conducting aerial surveys, the perimeter flight was conducted first, and in a counterclockwise direction, starting in the Ranch Cove area. Cross-lake transects were flown immediately afterward, starting with the southernmost transect and working northwards.

In order to reduce the possibility of double-counting, only birds seen from or originating from the observer's side of the aircraft were recorded. Even though the flight path of the aircraft along the latitudinal transects effectively alternated the observer's hemisphere of observation in a North-South fashion due to the aircraft's heading on successive transects, the one-nautical-mile spacing between the transects worked in conjunction with the limited detection distance of the waterfowl (<< 0.5 nautical mile) to effectively prevent double-counting of birds on two adjacent transects.

Bridgeport Reservoir Aerial Surveys

The shoreline of Bridgeport was divided into three segments (Figure 3). Appendix 5 contains the four-letter code for each lakeshore segment and the coordinates of the beginning of each section. Survey flights started at the dam at the north end of the reservoir and proceeded counterclockwise. The distance from shore, flight speed, and height above ground were the same as employed at Mono Lake. Adjustments were made as necessary depending on lighting, lake level and waterfowl distribution. The reservoir was circumnavigated twice during each survey to allow for a second count of often large concentrations of mixed species flocks.

Crowley Reservoir Aerial Surveys

The shoreline of Crowley Reservoir was divided into seven segments (Figure 4). Coordinates forming the beginning of each segment were generated from the 2000 aerial photo of Crowley Reservoir (2000 aerial image taken by I. K. Curtis, and processed by Air Photo, USA) and can be found in Appendix 5, as well as the four-letter code used for each segment. Each survey began at the mouth of the Owens River (UPOW) and proceeded over water in a counterclockwise direction along the shoreline. The distance from shore, flight speed, and height above the water were the same as at Mono Lake during most of each flight. Temporary diversions of distance from shore or height above ground were made by the pilot as necessary to avoid direct or low flight over float-tubers or boats. Adjustments were also made as necessary depending on lighting, lake level and waterfowl distribution. The reservoir was circumnavigated twice during each survey to allow for a second count of often large concentrations of mixed species flocks.

Ground Verification Counts

Ground verification counts were conducted whenever flight conditions (e.g., lighting, background water color, etc.) did not allow the positive identification of a significant percentage of the waterfowl encountered, or to confirm the species or number of individuals present. During a ground validation count, the total number of waterfowl present in an area was recorded first, followed by a count of the number of individuals of each species present.

Photo Documentation

As required by the SWRCB Order 98-05, photo documentation of lake-fringing waterfowl habitats was completed in 2012. Photos were taken from a helicopter at all bodies of water on October 23, 2012. In 2012, shoreline conditions were also documented using a helicopter-mounted, geo-referenced video camera. Photos depicting the condition and available habitats for each shoreline segment are described under Data Summary below.

Data Summary and Analysis

2012 Summer Ground Count Data

Total detections of each species were summed by lakeshore segment for each survey. Total detections were also summed over the entire summer survey period, and the percent of total detections per lakeshore segment was calculated. Total numbers of broods per species, survey and lakeshore segment were also summed.

Chi-square goodness-of-fit analysis was used to determine if individual waterfowl species used any of the various habitats in a disproportionate manner. This analysis was done for the most abundant summering species, provided that the behavior of at least 30 individuals had been recorded. All habitat use observations except those of flyovers were included in this analysis. The waterfowl species for which habitat use data were analyzed were Canada Goose (*Branta canadensis*), Cinnamon Teal (*Anas cyanoptera)*, Gadwall (*A. strepera*), Green-winged Teal (*A. crecca*) and Mallard (*A. platyrhynchos*). For all significant goodness-of-fit tests, Bonferonni confidence intervals were calculated for each category, following Byers and Steinhorst (1984), to determine which specific habitats were used out of proportion with respect to the others.

2012 Fall Aerial Count Data

For each survey and water body, the total number of waterfowl of each species was summed by lakeshore segment and survey. The spatial distribution of waterfowl at each body of water was determined by calculating the proportion of all fall detections that occurred in each lakeshore segment or offshore (for Mono Lake). This calculation was done excluding Ruddy Duck numbers. Ruddy Ducks occur on the open water and therefore their occurrence in particular region is not expected to be tied directly to shoreline features affected by lake levels.

Trend Analysis

Although many factors likely affect waterfowl use of Mono Lake, trends in waterfowl use were analyzed relative to lake elevation, which is the primary waterfowl habitat restoration tool identified in the Plan. Pearson Product Moment Correlation (Sigma Stat 3.5) was used to evaluate the relationship between summer waterfowl abundance (each survey and total) and the total number of broods detected and lake elevation. Fall waterfowl populations at Mono Lake were also evaluated for correlations between total waterfowl detections, numbers of Northern Shoveler and Ruddy Duck and September lake elevation, and lake elevation change from previous year. To compare use of each water body by waterfowl, using the waterfowl numbers as an index, the total waterfowl detected each fall was summed for each year 2002-2012. Count data were evaluated for correlations total waterfowl use among each of the three water bodies. In addition, relative use of the three water bodies by Northern Shoveler and Ruddy Duck was also evaluated.

RESULTS

Description of Shoreline Conditions in 2012

Mono Lake

The 2012 runoff year in the Mono Basin was “Dry” year type with a predicted runoff of 55% of the 1941-1990 average runoff (see Order WR 98-05). After a slight increase in elevation in April 2012 to 6383.6 feet, the lake level steadily declined, lowering a total of 2.0 feet before stabilizing at 6381.6 in November. In early summer (June) the lake level was 6382.2 feet, or 0.2 feet lower than it had been during the same time in 2011. The lake level continued to decline through the summer and at the start of fall surveys in September, the elevation was 6382.3 feet. The decrease in lake elevation as compared to 2011 resulted in qualitative differences in lake-fringing habitats for waterfowl during the 2012 monitoring period, some of which are discussed below.

South Shoreline Areas (South Tufa, South Shore Lagoons, and Sammann’s Spring)

In the South Tufa area, the extensive brackish pond that formed along the shoreline area east of Navy Beach in 2011 was still present through summer. When present, this pond attracts waterfowl and shorebirds especially during fall migration. By October, this pond had dried (Figure 5).

The brackish pond at the extreme west end of the South Shore Lagoons area was moderately full through summer, but had contracted considerably by fall (Figure 6) . After experiencing salt-water intrusion in 2011 (LADWP 2012), a freshwater pond approximately 1.2 km farther east from this first pond (Figure 7) once again became isolated from lake water as lake levels dropped. Although small, this pond, when full, supports several waterfowl broods. At Sand Flat Spring (Figure 8), there continues to be no direct connection to the lake. The main area of waterfowl use in 2012, along the South Shore Lagoons area was the Goose Springs outflow area (Figure 9). Throughout summer and fall several small freshwater ponds and an extensive shoreline pond existed in this area. The shoreline pond varied in salinity, getting increasingly saline further west.

In the Sammann’s Spring shoreline segment, west of Sammann’s Spring faultline, a fresh water pond extended approximately 300 m along the length of the shore in early June. Declining lake levels later in the summer exposed extensive mudflats attracting many shorebirds. By October, a littoral bar had developed, retaining spring outflow water, and maintaining the pond along the shoreline in this area (Figure 10). Due to the spring flow in this region, this pond was likely fresh water, although may have varied in salinity depending on the distance from the spring source. Immediately east of the faultline, brackish shoreline ponds (Figure 11) receive moderate use by waterfowl in summer and fall.

Warm Springs and Northeast Shore

The “north pond” at Warm Springs (Figure 12) is supported by the outflow of Pebble and Twin Warm Springs. Flow to the lake was once again cut off in 2012. Throughout the summer, an extensive brackish pond was present down gradient of the north pond. This brackish pond slowly retracted in size and only remnants remained in October (see Figure 12). The south pond, supported by outflow from Warm Springs Marsh Channel, Warm B, and Bug Warm springs, held some water in 2012, and was brackish. Since 2002, this south pond has been much smaller than the northern pond and less attractive to ducks and other waterbirds. In 2012, the Northeast Shore area was dominated by barren playa (Figure 13).

Bridgeport Creek, DeChambeau Embayment and Black Point

This area of the shoreline typically consists of several small ponds with alkali meadow and/or small areas of wet alkali meadow adjacent. Small isolated ponds continued to persist in the shoreline area between Bridgeport Creek and Black Point (Figures 14 - 16). These ponds typically attract small numbers of waterfowl in the fall.

Northwest Shore (Wilson, Mill Creek and DeChambeau Creeks)

In the Wilson Creek area, the decrease in lake elevation resulted in a gradual exposure of additional shoreline (Figure 17). A small beaver dam capturing spring flow near the Wilson Creek delta was still present. In the Mill Creek delta, a fresh water pond was present at the creek mouth (Figure 18). This pond has formed behind a large sandbar that extends along much of the bay. Most of the broods found at Mill Creek were seen in this pond. Several small beaver dams exist upstream of this pond and some cutting of willows by beaver is occurring. In the DeChambeau Creek area (Figure 19), the decrease in lake elevation resulted in the formation of a narrow beach. Very small fresh water ponds exist near shore where spring outflow is retained behind small sandbars.

West Shoreline (West Shore, Lee Vining Creek, Ranch Cove and Rush Creek)

The West Shore area (Figure 20) supports primarily meadow and riparian scrub habitats, but lacks ponds. No significant changes were noted in 2012, except a slight increase in exposed shoreline. Due to the dry year conditions, there was no stream restoration flow release in Lee Vining Creek and water was confined to the mainstem. The peak flow reached in Lee Vining in 2012 was 59 cfs on April 22. A decline in lake elevation resulted in exposure of mudflats and sandbars in the Lee Vining delta (Figure 21). The Ranch Cove area (Figure 22) has limited fresh water input, and does not support ponds due to the gradient. The area continued to be dominated by sandy beach and upland vegetation. The decrease in lake elevation resulted in increased exposure of sandbars and deltaic deposits in Rush Creek delta (Figure 23). There was no stream restoration flow release in Rush Creek due to the dry year conditions. A peak flow in lower Rush Creek of 66 cfs was recorded on June 4.

Restoration Ponds

Both County Ponds were flooded in 2012. There was little open water visible at County Pond West due to the extensive growth of emergent vegetation. DeChambeau Ponds 1 and 5 were dry in 2012 while ponds 2-4 were flooded.

Bridgeport Reservoir

In September, the reservoir held 10,400 acre-feet (Department of Water Resources, California Data Exchange Center, (http://cdec.water.ca.gov/cgi-progs/queryMonthly?s=BDP&d=today), almost 58% fewer acre-feet than at the same time in 2011. As a point of reference, the storage capacity of Bridgeport Reservoir is 42,600 acre-feet. Figure 24 shows an overview of the reservoir as viewed from the south end looking north toward the dam. The south end of the reservoir, which includes the area referred to as “West Bay”, and part of the “East Shore” area, receives fresh water inflows from Buckeye and Robinson Creeks and the East Walker River, creating extensive mudflat areas adjacent to these creek inflow areas. The northern arm of the reservoir includes primarily sandy beaches bordered by upland vegetation. The decrease in elevation resulted in a notable contraction of the reservoir extent, a reduction in flooding of small inlets and bays, and the exposure of large areas of mudflats.

Crowley Reservoir

In early September, Crowley Reservoir held 75,386 acre-feet (Department of Water Resources, California Data Exchange Center, http://cdec.water.ca.gov/cgi-progs/queryMonthly?s=crw&d=today) approximately 50% fewer acre-feet than at the same time in 2011. As a point of reference, the storage capacity of Crowley Reservoir is 183,465 acre-feet. Figures 25-31 depict habitat conditions of each shoreline segment at Crowley Reservoir. Due to the low reservoir levels, an increase in exposed shore was apparent in all areas. The Upper Owens River delta area (Figure 25) includes large areas of exposed mudflats and reservoir bottom adjacent to the mouth of the Upper Owens River. Most of the length of Sandy Point area (Figure 26) is adjacent to elevated areas and upland vegetation. Small areas of meadow habitat occur in this area also. North Landing is largely bordered by dry meadows with no fresh water input (Figure 27) except near the western border. The McGee Bay area (Figure 28) supports vast mudflat areas immediately adjacent to wet meadow habitats, and receives inflow from McGee Creek. Hilton Bay (Figure 29) is surrounded by meadow habitats, and receives some fresh water input from Hilton Creek. The Chalk Cliffs area (Figure 30) lacks fresh water inflow areas and wetland habitats, and is dominated by sandy beaches adjacent to steep, sagebrush-covered slopes. Layton Springs provide some fresh water input at the southern border of this lakeshore segment. The remainder of the area is bordered by upland vegetation and a large area of sandy beach (Figure 31).

2012 Summer Ground Counts

Waterfowl abundance, distribution and brood counts

A total of 1,075 waterfowl of nine species were recorded during summer surveys (Table 1). Canada Goose, Cinnamon Teal, Gadwall, Green-winged Teal and Mallard were observed all three surveys. The most abundant species was Gadwall accounting for 56% of all detections (604/1075). The next most abundant species were Mallard (17.9%) and Canada Goose (14.1%). The total number of waterfowl using the shoreline (exclusive of dependent young) detected during summer surveys was highest (474) during Survey 1 in early June count and lowest (262) on the late July survey (Survey 3) (Table 1).

The highest proportion of detections was along the south shore in the Sammann's Spring (26.2%) and South Shore Lagoons area (22.5%) (Table 2). The fewest number of waterfowl were found in Lee Vining Creek (47; 4.4% of detections). The most ubiquitous species was

Gadwall which was found in all locations surveyed and was most numerous along the south shore. Mallard were also most numerous along the south shore, while Canada Goose were most numerous at DeChambeau Creek along the northwest shore.

Waterfowl species observed with broods in the lake-fringing wetlands and creeks at Mono Lake in 2012 were Canada Goose, Gadwall, Green-winged Teal, and Mallard (Table 3). Although Cinnamon Teal was seen throughout the summer, no broods were found. The number of broods detected in lake-fringing habitats (73) increased slightly over that observed in 2011 (68), and was the highest observed since 2007. Gadwall broods comprised the majority of broods found (45/73; 63%) while Mallard and Green-winged Teal comprised 15% of broods found (11/73). Figure 32 shows the locations of all of the broods detected in 2012. The South Shore Lagoons, Sammann's Spring and Mill Creek areas were the most heavily used for brooding as 20 and 13 and 13 broods were detected in these areas respectively.

Habitat Use

All five waterfowl species analyzed showed a disproportionate use of the various shoreline habitats in 2012 (Table 4, Figure 33). Canada Geese were observed using primarily meadow habitats and unvegetated areas, with unvegetated areas used disproportionally more than other habitats. Cinnamon Teal were only observed in fresh water ponds and brackish ponds with the overwhelming majority of observations in fresh water ponds. Gadwall were observed most frequently using fresh water ponds and brackish ponds. Fresh water ponds and brackish ponds were used significantly more than other habitats. Green-winged Teal were observed using primarily fresh water ponds which they used significantly more than other habitat types. Mallard used primarily fresh water ponds and brackish ponds which they used disproportionally to other habitat types.

2012 Fall Aerial Surveys

Fall Aerial Survey Weather Conditions

The weather was fairly mild through during the fall count period through the end of October with the first significant cold front passing through the end of October, bringing cooler temperatures and light snow to the area. By mid-November, shoreline lake-fringing ponds along the south shore of Mono Lake, and the County Ponds were frozen. Approximately one-third of Bridgeport Reservoir was covered in ice in mid-November.

Mono Lake

A total of fifteen waterfowl species and 43,258 individuals were recorded at Mono Lake during fall aerial surveys (Table 5). The peak number of waterfowl detected at Mono Lake on any single count was 17,464 and occurred on the September 18 survey (Table 5, Figure 34). While waterfowl abundance was highest September to early October, waterfowl species richness was lowest in September, but increased in October. In terms of total detections, Northern Shoveler (*Anas clypeata*) and Ruddy Duck (*Oxyura jamaicensis*) were the dominant species during fall migration with Northern Shoveler accounting for 62% (27,006), and Ruddy Duck accounting for 25% (10,927) of all detections. The peak number of Northern Shoveler (13,793) occurred on September 18, and the peak number of Ruddy Ducks (3,941) occurred on October 2.

Table 6 shows the number of waterfowl, exclusive of Ruddy Ducks, in each lakeshore segment by survey. The main shoreline areas of waterfowl use during fall 2012 were Sammann's Spring and Wilson Creek accounting for 41.6% and 36.4% of all waterfowl. Large flocks of Northern Shovelers were observed at both locations in early fall (September to early October). At Sammann's Spring, the Northern Shoveler flock was seen spread along the entire western portion of Sammann's Spring shoreline area west of the faultline, in the large shoreline pond visible in Figure 10, and just offshore. Exclusive of Ruddy Ducks, no waterfowl were observed at Northeast Shore and there was limited use of other areas namely Bridgeport Creek, Black Point and Ranch Cove. Off-shore detections of waterfowl accounted for twenty-one percent of all fall waterfowl detections, and the majority of these (9202 of 9238) were Ruddy Ducks.

Bridgeport Reservoir

A total of 15 waterfowl species and 33,328 individuals were recorded at Bridgeport Reservoir during the 2012 fall aerial surveys (Table 7). The peak number of waterfowl detected on any single count at Bridgeport Reservoir was 15,582 individuals, which occurred on September 18 (Table 7, Figure 34). Waterfowl abundance and species richness were greatest in September, and declined later in fall. The total number of waterfowl at Bridgeport declined dramatically after mid-September from the high of 15,582 on September 18 to 2,726 by October 2. The most abundant species, in terms of total detections, were Northern Shoveler (29.6%), Gadwall (24.8%), and Northern Pintail (21.4%). The peak number of Northern Shoveler and Ruddy Ducks at Bridgeport was recorded on September 4.

The West Bay was the main area of waterfowl use at Bridgeport Reservoir, accounting for over 90% of all detections (Table 8). Most of the waterfowl are generally found resting on the mudflats or on the water off shore along the southwestern part of the reservoir from Robinson and Buckeye Creek north to the ditch. Secondarily, waterfowl were found in the outflow area of the East Walker River.

Crowley Reservoir

A total of 17 waterfowl species and 33,463 individuals were detected at Crowley Reservoir during the 2012 fall aerial surveys (Table 9). The peak number of waterfowl detected on any single count at Crowley Reservoir was 10,464 individuals and occurred on September 4 (Table 9, Figure 34). Waterfowl abundance was greatest in September, and declined through fall. Species richness was variable, but the highest number of species was recorded in mid-November. The most abundant species, in terms of total detections, were Northern Shoveler (35.9%), Gadwall (15.8%), Northern Pintail (*Ana acuta*) (15.6%), and Ruddy Duck (14.1%). Peak numbers of Northern Shoveler were recorded on September 18, while peak Ruddy Duck numbers occurred on October 2 at Crowley.

McGee Bay is typically the main area of waterfowl use throughout fall, while the secondary area of use is the Upper Owens river delta (Table 10). Few waterfowl were observed in the Chalk Cliffs area in early fall, but use of this area increased in late October and November, as is typical after waterfowl hunting season opens.

Mono Lake Restoration Ponds

A total of four species and 35 waterfowl were detected at the Restoration Ponds during summer surveys (Table 11). Most of the waterfowl use was in County Pond east and the most abundant species was Gadwall. A total of five Gadwall broods were seen – all at County Pond east (Table 12). No broods were seen at DeChambeau Ponds.

A total of 150 waterfowl were detected at the DeChambeau and County Pond complexes during fall surveys (Table 13), with the majority of birds observed in County Pond east.

Trend Analysis

Summer Waterfowl

Lake elevation in both June and July have been significantly positively correlated with the number of waterfowl present on the third survey during the third week of July when the majority of broods are recorded (June: $r = 0.667$, $p = 0.0249$) (Figure 35). The number of broods detected has also been significantly, positively correlated with the lake elevation in June and July (June: $r = 0.931$, $p < 0.01$) (Figure 36).

Fall Waterfowl

There has been no correlation between total fall waterfowl detections and lake elevation in September ($r = -0.432$, $p = 0.185$) (Figure 37), lake elevation change, nor between the lake level and numbers of the two most abundant species, Northern Shoveler and Ruddy Duck. There has been no trend in total waterfowl use of the lake in fall for the period 2002-2012 ($r = 0.216$, $p = 0.515$).

Comparison Counts

The total number of waterfowl detected at Bridgeport and Crowley Reservoirs summed by year has been significantly positively correlated for the time period 2002-2012 ($r = 0.633$, $p = 0.0366$). No correlation has been observed between the total waterfowl detected at Mono Lake and either Bridgeport or Crowley Reservoir. Northern Shoveler use of Mono Lake has been statistically higher than of Crowley Reservoir, while no difference was found between Mono and Bridgeport or Bridgeport and Crowley. Use of Mono Lake by Ruddy Ducks has averaged higher than that of Bridgeport or Crowley ($p < 0.05$). Use of each of the reservoirs by Ruddy Ducks has not been significantly different.

SUMMARY

The numbers of broods seen in 2012 was the highest number seen since 2006-2007, or the last period of elevated lake level. Brood numbers increased in 2011 in response to the rise in lake elevation that occurred during the 2010-2011 runoff year. In early summer 2012, the lake was still elevated creating conditions similar to those observed in 2011, at least initially. Increases in elevation, (at least within the elevation ranges observed), result in increases in the number and extent of lake-fringing ponds, especially in the South Shore Lagoons area. The increased number of broods observed in 2011 and 2012 in response to the increase in lake elevation is consistent with patterns observed in previous years (LADWP 2011). In most shoreline areas, increases in lake elevation have been associated with changes to lake-fringing habitats that increase the quality and quantity of potential breeding habitat for waterfowl. Based on field observations, these ponds enlarge due either to increases in the groundwater table or as a result of increased spring flow. The breeding population of waterfowl at Mono Lake appears to respond positively to these changes as increases in brood production have been positively correlated with increases in lake elevation.

Summering and breeding waterfowl have shown variability with regard to the proportional use of the various lake-fringing habitats, likely in response to yearly changes in habitat availability and habitat quality. The habitats in which waterfowl at Mono Lake are encountered are ephemeral or highly variable in nature and extent on a yearly basis. In 2012, most waterfowl were observed using fresh water ponds, brackish ponds, and unvegetated areas. Fresh water ponds at Mono Lake are small, widely scattered, yet important brooding habitat. Some of the fresh water ponds at Mono Lake have been stable and present since at lease 2002, such as those that occur at the outflow of the Goose Springs complex in the South Shore Lagoons area. Others ponds are ephemeral and vary considerably in size depending on lake elevation. The extent and availability of brackish pond varies with lake elevation. Brackish ponds are most limited in extent at low lake elevations. At intermediate and elevated lake elevations, brackish ponds are much more extensive, with the areas around the lake where they occur dependent upon the specific lake elevation. The availability of the more ephemeral habitat types on a yearly or seasonal basis are being documented through field observations of conditions during the summer and annual photography of shoreline areas in the fall, but habitat conditions that may explain waterfowl use and the spatial distribution of waterfowl at Mono Lake are not readily quantified during existing vegetation mapping efforts being conducted every five years because of their ephemeral nature and small scale.

The use of Mono Lake by fall migrants is much greater than by breeding waterfowl, and is dominated by two species, Northern Shoveler and Ruddy Duck. The aquatic ecosystem of Mono Lake is also dominated by few species, which is typical of highly saline systems. Mono Lake is rich in zooplankton, phytoplankton, and benthic algae, some of which are accessible to waterfowl as a food resource. Due to the salinity of the waters, the lake does not support submerged aquatics as a food resource for waterfowl. Plant food resources such aquatic and wetland vegetation, which are an important food resource to many waterfowl species in fall, are limited to lake-fringing wetland areas, which comprise a small fraction of the total area of Mono

Lake. The Northern Shoveler, unlike other dabbling duck species in the genus *Anas*, has a bill ideally suited to strain small crustaceans from the water column. Ruddy Ducks are reported to feed primarily on aquatic insects, crustaceans, zooplankton, and other invertebrates, consuming only small amounts of aquatic vegetation and seeds (Brua, 2002). Although no diet study has been conducted on waterfowl at Mono Lake, to varying extents, these species are expected to feed on brine shrimp and alkali flies that are found in abundance at Mono Lake.

At Mono Lake, Northern Shoveler tend to be encountered in large cohesive flocks in fall. In 2012, the main areas of use by shovelers were Wilson Creek and Sammans's Spring. The Wilson Creek delta has consistently attracted a large proportion of Northern Shovelers every year while use of the south shore including Sammanns' Spring, has been more variable.

In 2012, total waterfowl numbers at Mono Lake during fall were more than observed at either Bridgeport Reservoir or Crowley Reservoir. The proportional abundance of waterfowl species at Mono Lake differs greatly from that of the nearby freshwater reservoirs as the fall waterfowl population at Mono Lake is dominated by Northern Shoveler and Ruddy Duck, while waterfowl populations at the reservoirs are much more diverse. Comparison counts between Mono Lake and the two fresh water reservoirs are of limited usefulness. The food resources of a fresh water reservoir bare little resemblance to that of Mono Lake, and thus waterfowl using Mono Lake encounter and are responding to a different set of environmental variables. The correlation between total waterfowl numbers at Bridgeport and Crowley over the time period 2002-2012 and lack of correlation with Mono Lake numbers is not surprising. In addition, the greater use of Mono Lake than the nearby reservoirs by Northern Shoveler and Ruddy Ducks is also expected.

Migratory waterfowl populations that use Mono Lake are expected to be influenced by a multitude of factors. Short-term and long-term population trends will be affected by conditions on breeding grounds, wintering grounds, and along migratory routes. Mono Lake provides abundant food resources for the limited number of waterfowl species that are able to exploit those resources. Important waterfowl habitats at Mono Lake such as brackish and freshwater ponds are ephemeral in nature as the shoreline configuration is dynamic, changing as a result of lake elevation changes and the effect of wind on the shoreline. The preliminary analysis conducted here indicates no direct and simple relationship between fall waterfowl populations and lake elevation or lake elevation changes.

Further analysis of the trend in waterfowl populations at Mono Lake, the response to changing lake elevations, and comparisons with fall counts at Bridgeport and Crowley Reservoirs will be presented in a future document.

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Table 1. Summary of 2012 Summer Ground Count Data

Species	**Survey 1**	**Survey 2**	**Survey 3**	**Total**	**Percent Detections**
Canada Goose	69	54	29	152	14.1%
Cinnamon Teal	19	12	18	49	4.6%
Gadwall	264	210	130	604	56.2%
Green-winged Teal	21	7	24	52	4.8%
Mallard	90	50	52	192	17.9%
Northern Pintail	11	5		16	1.5%
Redhead		1		1	0.1%
Red-breasted Merganser			1	1	0.1%
Ruddy Duck			8	8	0.7%
Total Waterfowl	474	339	262	1075	

Table 2. 2012 Summer Ground Count Data
Table shows the total detections of each species in each shoreline area, total waterfowl detections by area, and the percent of total detections by area.

Species	DECR	LVCR	MICR	RUCR	SASP	SOTU	SSLA	WASP	WICR	**Total**
Canada Goose	73				20	39			20	152
Cinnamon Teal				3	23		19	4		49
Gadwall	34	37	92	25	144	22	158	38	54	604
Green-winged Teal	2	2	12	9	7		13		7	52
Mallard	2	8	9	15	77		50	26	5	192
Northern Pintail			3	1	4		2	6		16
Red-breasted Merganser				1						1
Redhead								1		1
Ruddy Duck			1		7					8
Total Detections	**111**	**47**	**117**	**54**	**282**	**61**	**242**	**75**	**86**	**1075**
% of Detections	10.3%	4.4%	10.9%	5.0%	26.2%	5.7%	22.5%	7.0%	8.0%	

Table 3. 2012 Brood Data

Table shows the number of broods by species per visit in shoreline survey area.

	Shoreline Segment	DECR	LVCR	MICR	RUCR	SASP	SOTU	SSLA	WASP	WICR	**Total**
Survey 1	Canada Goose	2				2	1				**5**
	Gadwall	1									**1**
	Green-winged Teal										**0**
	Mallard				1			1			**2**
	Total Broods	3	0	0	1	2	1	1	0	0	8
Survey 2	Canada Goose										**0**
	Gadwall			2	1	5		6		3	**17**
	Green-winged Teal			1	1					1	**3**
	Mallard		1	1		1		4			**7**
	Total Broods	0	1	4	2	6	0	10	0	4	27
Survey 3	Canada Goose										**0**
	Gadwall	2	1	5	2	5		7		6	**28**
	Green-winged Teal		1	3	3			1			**8**
	Mallard			1				1			**2**
	Total Broods	2	2	9	5	5	0	9	0	6	**38**
Total	Shoreline Segment	DECR	LVCR	MICR	RUCR	SASP	SOTU	SSLA	WASP	WICR	**Total**
	Canada Goose	2				2	1				**5**
	Gadwall	3	1	7	3	10		13		9	**46**
	Green-winged Teal		1	4	4			1		1	**11**
	Mallard		1	2	1	1		6			**11**
	Total broods per area	5	3	13	8	13	1	20	0	10	73

Table 4. Chi Square Goodness-of-Fit Results for Waterfowl Habitat Use Data

Grayed categories were excluded from analysis. The results of the Bonferroni Test are indicated in the "Sign" (= significance) column. NS indicates that there was no significant difference between expected and observed use of a habitat type at the $p < 0.05$ level.

	Canada Goose				Cinnamon Teal				Gadwall				Green-winged Teal				Mallard			
Habitat	Obs	Exp	χ^2	Sign	Obs	Exp	χ^2	Sign	Obs	Exp	χ^2	Sign	Obs	Exp	χ^2	Sign	Obs	Exp	χ^2	Sign
Marsh									2	75.1	71.2	-								
Dry Meadow	27	22.8	0.8	NS																
Wet Meadow									1	75.1	73.1	-	2	7.3	3.8	-	2	32	28.1	-
Alkali Wet Meadow	36	22.8	7.6	-																
Riparian Scrub																				
Freshwater Stream									6	75.1	63.5	-	3	7.3	2.6	NS	7	32	19.5	-
Ria	4	22.8	15.5	-					59	75.1	3.5	NS	9	7.3	0.4	NS	10	32	15.2	-
Fresh Water Pond					42	24.5	12.5	+	276	75.1	537.4	+	29	7.3	64.4	+	106	32	171.2	+
Brackish Lagoon	2	22.8	19.0	-	7	24.5	12.5	-	144	75.1	63.2	+	5	7.3	0.7	NS	59	32	22.8	+
Hypersaline Lagoon																				
Unvegetated	64	22.8	74.5	+					94	75.1	4.8	NS	2	7.3	3.9	-	8	32	18	
Open Water	4	22.8	15.5	-					19	75.1	42.0	-	1	7.3	5.4	-				
Total	137		132.81		49		25		601		858.68		51				192		274.78	

Table 5. Summary of 2012 Mono Lake Fall Aerial Survey Count Data

Species	4-Sep	18-Sep	2-Oct	16-Oct	29-Oct	13-Nov	Total detections	% Total
American Wigeon			2	15			17	<0.1%
Bufflehead					5		5	<0.1%
Canada Goose			1	39	105	60	205	0.5%
Cinnamon Teal	5						5	<0.1%
Common Merganser						1	1	<0.1%
Gadwall	26	161		14	66	184	451	1.0%
Green-winged Teal	17	34	27	43	142	50	313	0.7%
Lesser Scaup					2	25	27	0.1%
Mallard	3	18	3	52	147		223	0.5%
Northern Pintail		2	3676	150	42		3870	8.9%
Northern Shoveler	9075	13793	1257	2413	468		27006	62.4%
Ruddy Duck	143	3447	3941	1941	1017	438	10927	25.3%
Snow Goose						7	7	<0.1%
Tundra Swan						2	2	<0.1%
Unidentified Teal	4	9	125	27	5	28	198	0.5%
White-winged Scoter				1			1	<0.1%
Total Waterfowl	9273	17464	9032	4695	1999	795	43258	
Species Richness	6	6	7	9	9	8		

Table 6. 2012 Fall Spatial Distribution of Waterfowl at Mono Lake

Lakeshore Segment	4-Sep	18-Sep	2-Oct	16-Oct	29-Oct	13-Nov	Segment Total	% by Segment
RUCR	81	27	400	36	395	3	942	2.9%
SOTU					6		6	0.0%
SSLA	760	61	33	9	60	68	991	3.1%
SASP	1027	11000	1075	47	186	27	13362	41.6%
WASP	14	17	7	40	115	67	260	0.8%
NESH							0	0.0%
BRCR	10			28		1	39	0.1%
DEEM	81	227	5				313	1.0%
BLPO		90					90	0.3%
WICR	6000	1800	2200	1500	99	105	11704	36.4%
MICR	900	400	1210	500	20		3030	9.4%
DECR	149	135	155	481	62	5	987	3.1%
WESH	17	170	1		2	26	216	0.7%
LVCR	3	8		112	13	55	191	0.6%
RACO	6	3			5		14	0.0%
Lakewide total	9048	13938	5086	2753	963	357	32145	

Table 7. Summary of 2012 Bridgeport Reservoir Fall Aerial Survey Count Data

Species	4-Sep	18-Sep	2-Oct	16-Oct	29-Oct	13-Nov	Total detections	% Total
Bufflehead				8	75	60	143	0.4%
Canada Goose	136	245	49	6		55	491	1.5%
Cinnamon Teal	164	1					165	0.5%
Common Merganser	3	5	8	5	7	20	48	0.1%
Gadwall	2525	5170	205	121	200	32	8253	24.8%
Greater White-fronted Goose		17					17	0.1%
Green-winged Teal	750	1193	899	25	120		2987	9.0%
Lesser Scaup						20	20	0.1%
Mallard	53	510	160	834	762	15	2334	7.0%
Northern Pintail	500	4270	692	1506	150	3	7121	21.4%
Northern Shoveler	5436	3730	452	32	221		9871	29.6%
Redhead	51						51	0.2%
Ring-necked Duck					10		10	<0.1%
Ruddy Duck	501	101	252	127	316		1297	3.9%
Tundra Swan						1	1	<0.1%
Unidentified Teal	20	340	9			150	519	1.6%
Total Waterfowl	10139	15582	2726	2664	1861	356	33328	
Species Richness	10	10	8	9	9	8		

Table 8. 2012 Fall Spatial Distribution of Waterfowl at Bridgeport Reservoir

Lakeshore Segment	4-Sep	18-Sep	2-Oct	16-Oct	29-Oct	13-Nov	Segment Total	% by Segment
NOAR	124	255	66	20	60	23	548	1.7%
WEBA	9395	14608	2237	2472	1290	276	30278	94.5%
EASH	119	618	171	45	195	57	1205	3.8%
Lakewide total	9638	15481	2474	2537	1545	356	32031	

Table 9. Summary of 2012 Crowley Reservoir Fall Aerial Survey Count Data

Species	4-Sep	18-Sep	2-Oct	16-Oct	29-Oct	13-Nov	Total detections	% Total
American Wigeon						15	15	<0.1%
Blue-winged Teal			1	2			3	<0.1%
Bufflehead		2	2	29	101	225	359	1.1%
Canada Goose	70	3	25				98	0.3%
Cinnamon Teal	72						72	0.2%
Common Merganser						13	13	<0.1%
Gadwall	3074	735	153	391	675	270	5298	15.8%
Green-winged Teal	912	310	363	293	80	120	2078	6.2%
Hooded Merganser						1	1	<0.1%
Lesser Scaup					18	2	20	0.1%
Mallard	140	238	444	490	1280	625	3217	9.6%
Northern Pintail	800	1250	594	1675	650	262	5231	15.6%
Northern Shoveler	5371	5503	185	139	802		12000	35.9%
Ring-necked Duck			1	2			3	<0.1%
Ruddy Duck	25	180	1561	1015	1292	641	4714	14.1%
Tundra Swan						7	7	<0.1%
White-winged Scoter					2		2	<0.1%
Unidentified Teal		10	22			300	332	1.0%
Total Waterfowl	10464	8231	3351	4036	4900	2481	33463	
Species Richness	8	8	10	9	9	11		

Table 10. 2012 Fall Spatial Distribution of Waterfowl at Crowley Reservoir

Lakeshore Segment	4-Sep	18-Sep	2-Oct	16-Oct	29-Oct	13-Nov	Segment Total	% by Segment
UPOW	860	1455	401	395	269	306	3686	12.8%
SAPO	0	250	0	237	27	23	537	1.9%
NOLA	0	93	40	186	28	140	487	1.7%
MCBA	9370	5413	1206	2020	2566	526	21101	73.4%
HIBA	170	150	68	65	84	173	710	2.5%
CHCL	19	200	20	76	604	600	1519	5.3%
LASP	20	490	55	42	30	72	709	2.5%

Table 11. Mono Lake Restoration Ponds - Total Summer Detections

Species	COPOE	COPOW	DEPO_1	DEPO_2	DEPO_3	DEPO_4	DEPO_5	Total
Cinnamon Teal	4					2		6
Gadwall	14					3		17
Mallard	5							5
Ruddy Duck	1				3	3		7
Pond Totals	24	0	0	0	3	8	0	35

Table 12. Mono Lake Restoration Ponds - Total Waterfowl Broods

Species	County Ponds	DeChambeau Ponds
Gadwall	5	
Total Broods	5	0

Table 13. Mono Lake Restoration Ponds - 2012 Fall Survey Counts

County Ponds	4-Sep	18-Sep	2-Oct	16-Oct	29-Oct	13-Nov	Total Fall Detections
Gadwall		50					50
Northern Shoveler	70						70
Total Waterfowl	70	50	0	0	0	0	120
DeChambeau Ponds	4-Sep	18-Sep	2-Oct	16-Oct	29-Oct	13-Nov	Total Fall Detections
Gadwall		11			4		15
Northern Shoveler	7						7
Unidentified Teal		3	5				8
Total Waterfowl	7	14	5	0	4	0	30

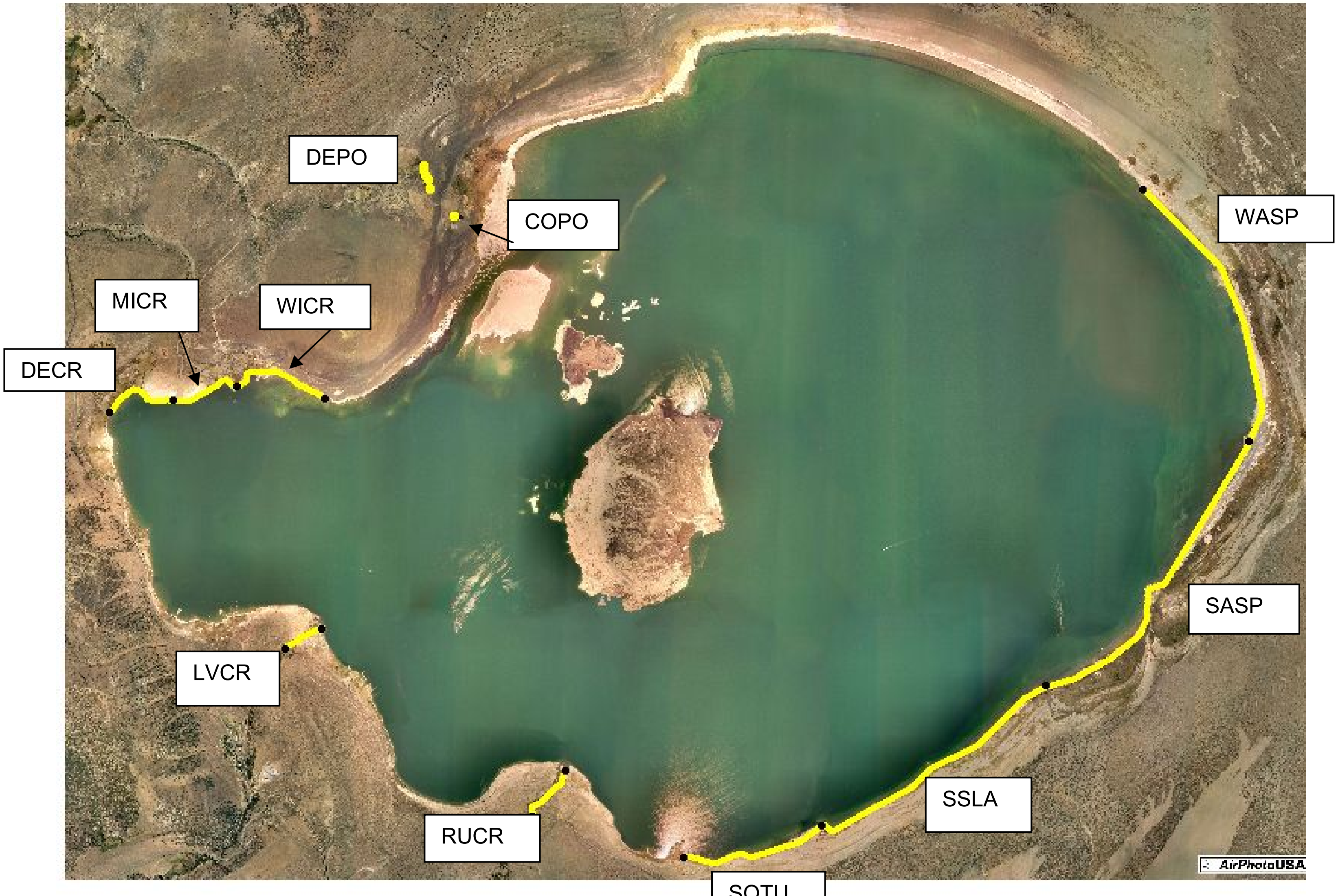


Figure 1. Summer Ground Count Survey Areas

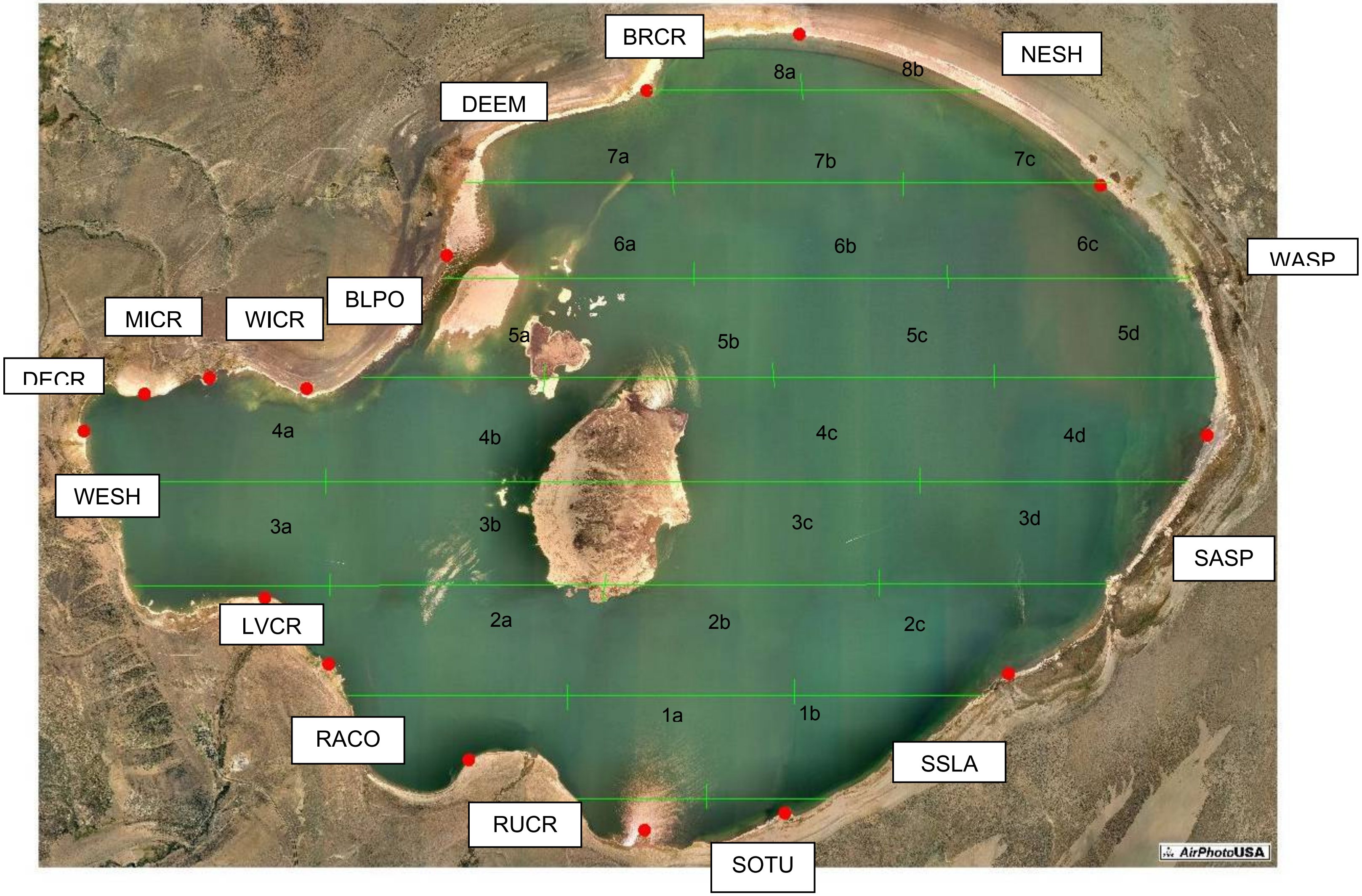


Figure 2. Mono Lake Fall Aerial Survey Lakeshore Segments, Boundaries, and Cross-Lake Transects

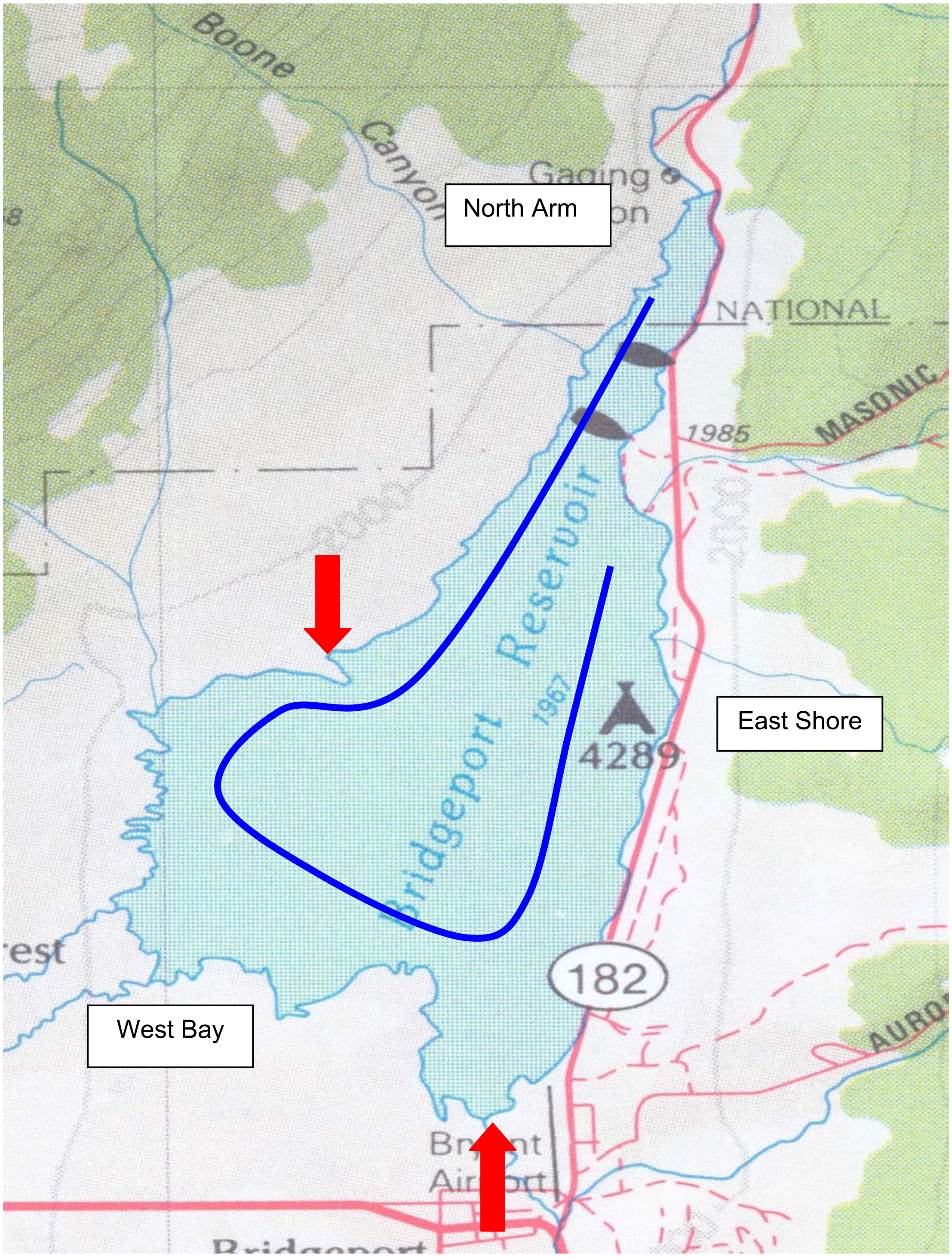


Figure 3. Bridgeport Reservoir Lakeshore Segments and Segment Boundaries

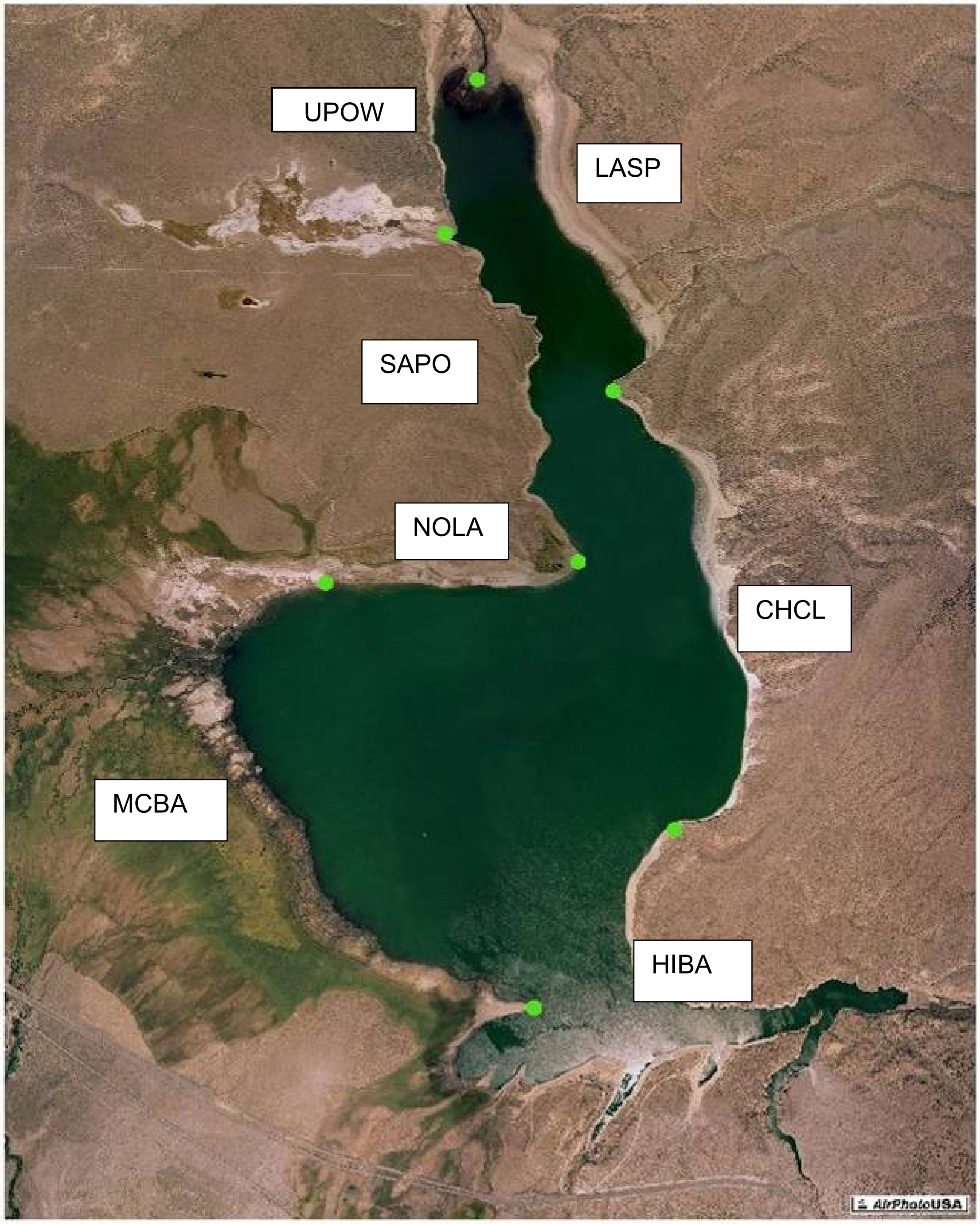


Figure 4. Crowley Reservoir Lakeshore Segments and Segment Boundaries

Figure 5. South Tufa, East of Navy Beach

Figure 6. South Shore Lagoons Area – First Pond

Figure 7. South Shoreline – Freshwater Pond

Figure 8. South Shore Lagoons – Sand Flat Spring

Figure 9. South Shore Lagoons Goose Springs Outflow Area

Figure 10. Sammann's Spring West of Tufa Grove

Figure 11. Sammann's Spring, east of Tufa grove

Figure 12. Warm Springs – North Pond

Figure 13. Northeast Shore

Figure 14. Bridgeport Creek Shoreline Area

Figure 15. DeChambeau Embayment

Figure 16. Black Point

Figure 17. Wilson Creek Shoreline Area

Figure 18. Mill Creek Delta

Figure 19. DeChambeau Creek Shoreline Area

Figure 20. West Shore

Figure 21. Lee Vining Creek Delta

Figure 22. Ranch Cove Shoreline Area

Figure 23. Rush Creek Delta

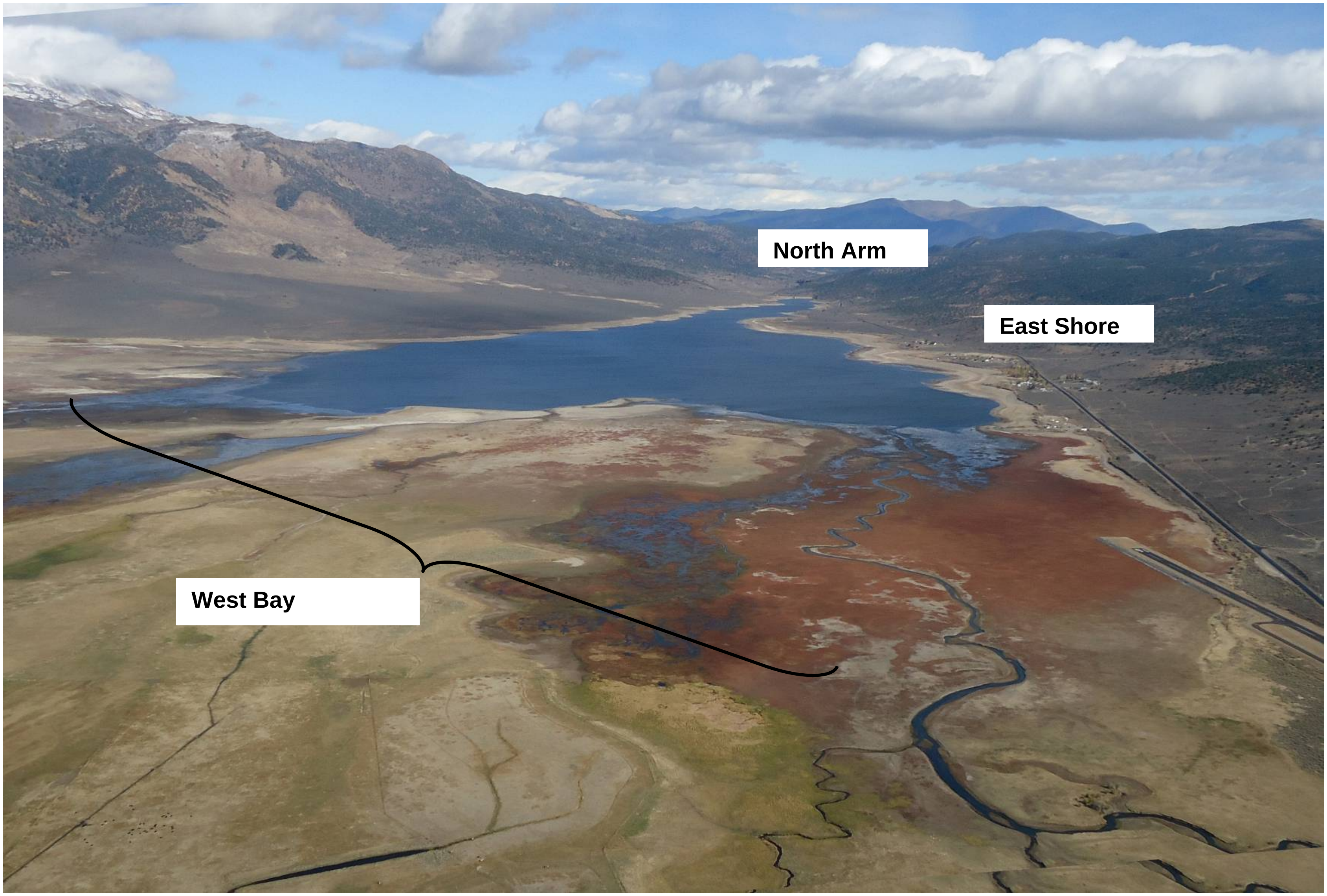


Figure 24. Photo of Bridgeport Reservoir, Looking North
Photo shows the West Bay area and the south end of the East Shore area. The majority of waterfowl that use Bridgeport Reservoir in the fall congregate in this southern end of the reservoir.

Figure 25. Upper Owens River Delta

Figure 26. Sandy Point Shoreline Area

Figure 27. North Landing Shoreline Area

Figure 28. McGee Bay

Figure 29. Hilton Bay

Figure 30. Chalk Cliffs

Figure 31. Layton Springs

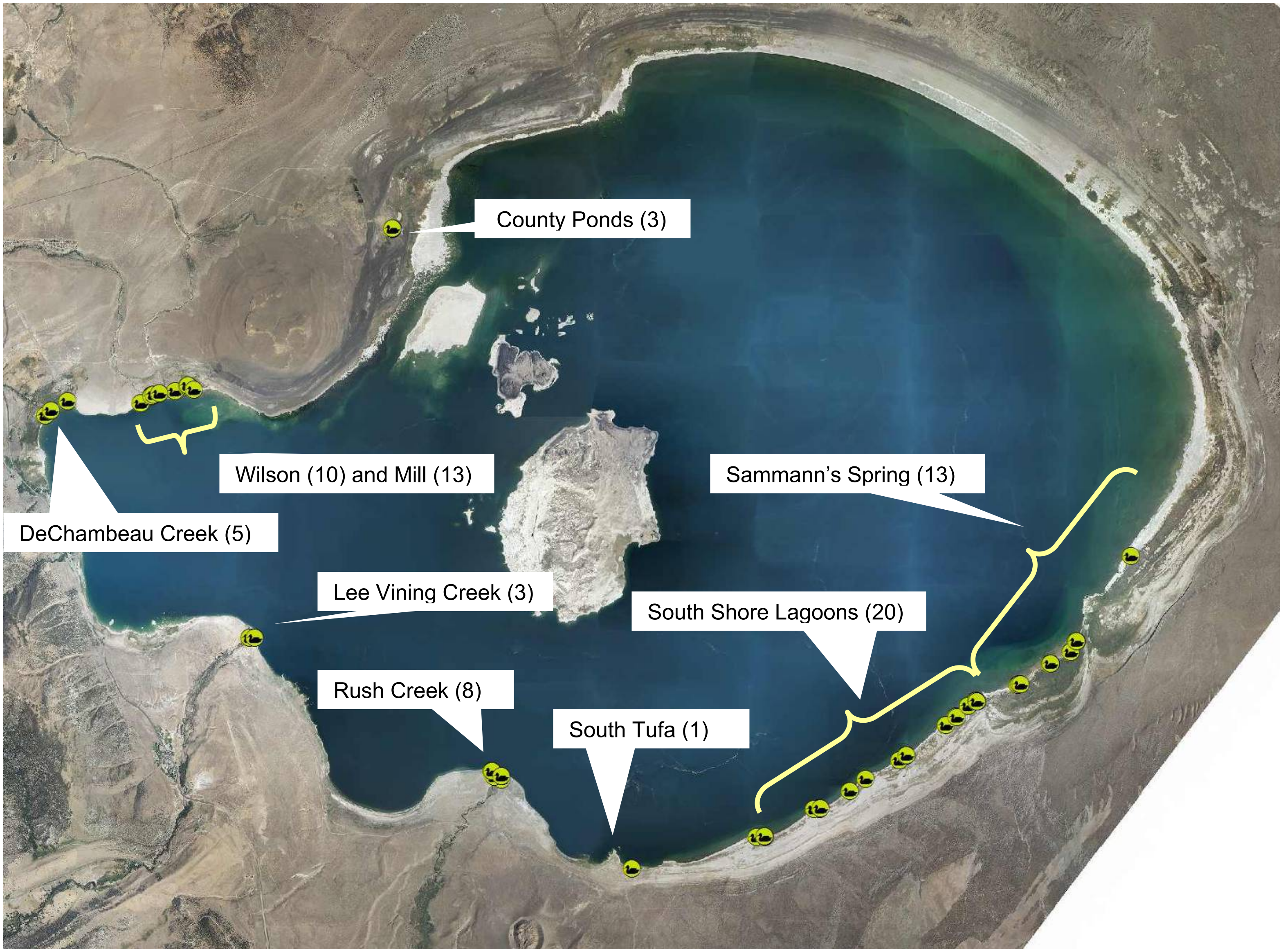


Figure 32. 2012 Brood Locations
The number in parentheses indicates the number of broods found in each area.

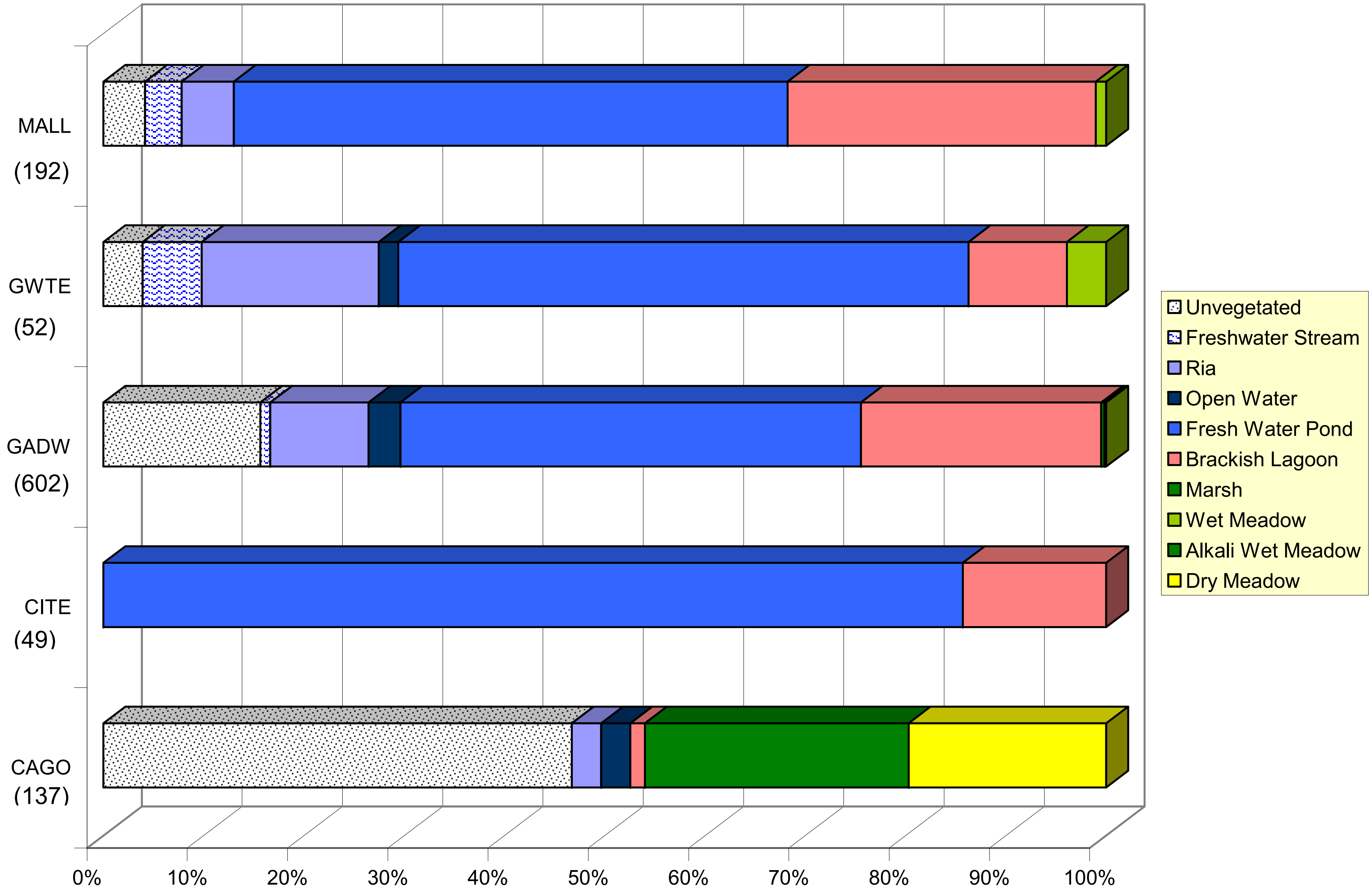


Figure 33. Waterfowl Habitat Use
The numbers in parentheses indicate sample size. The bars represent the percent of the total observations.

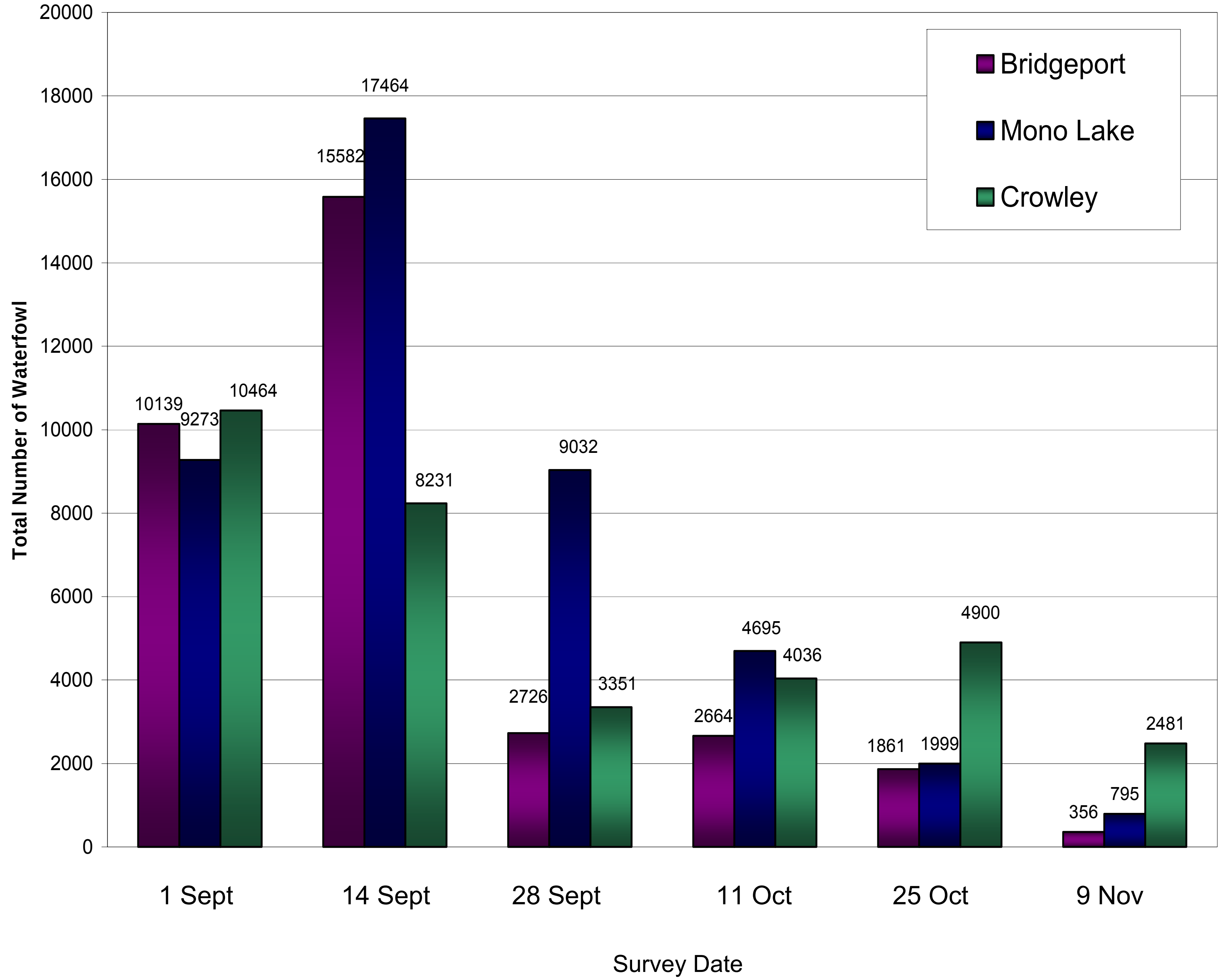


Figure 34. Total Fall Detections by Waterbody

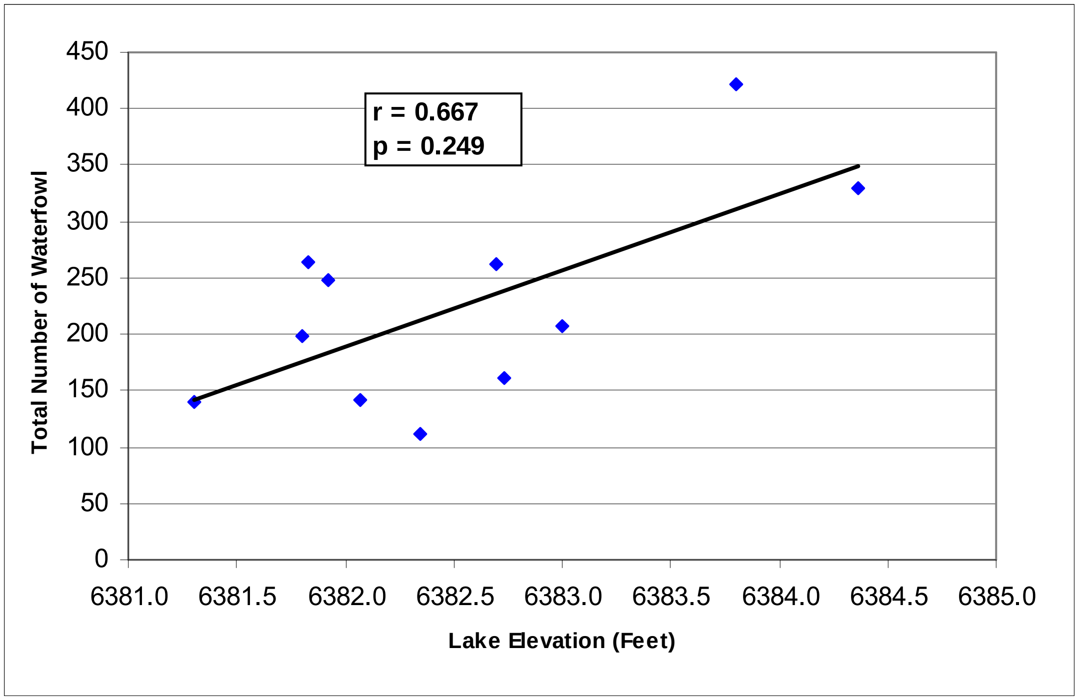


Figure 35. Relationship Between Total Waterfowl and Lake Elevation in June

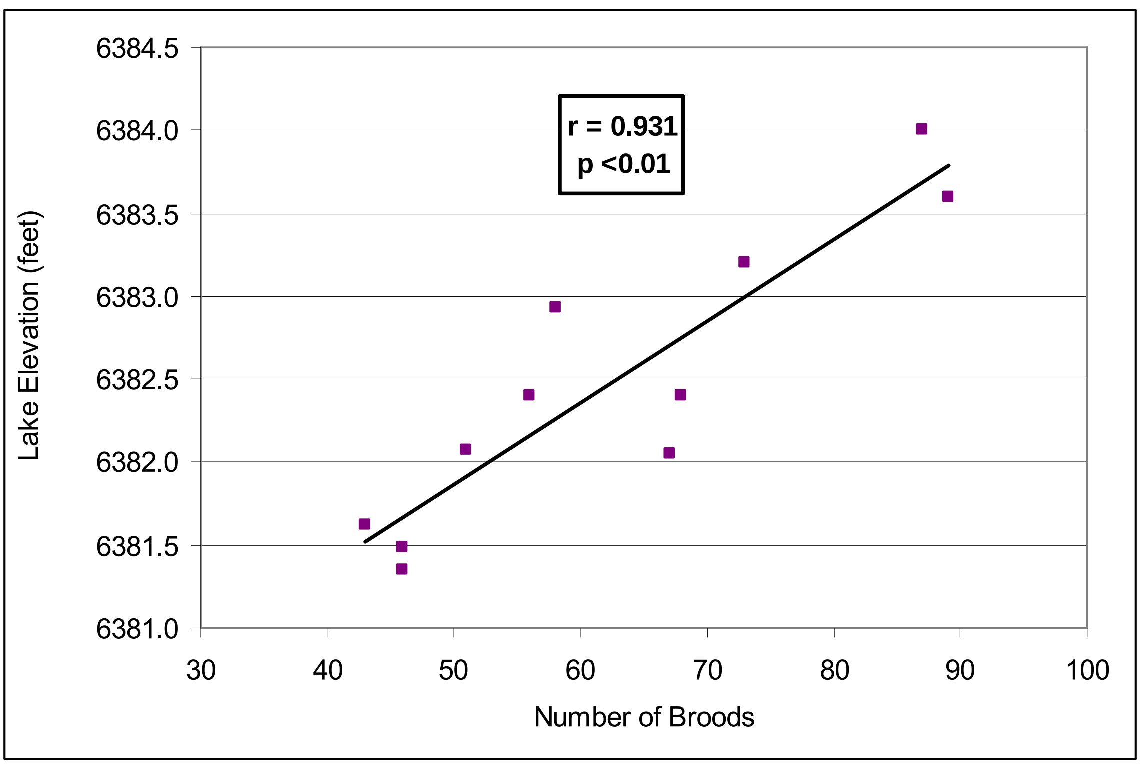


Figure 36. Number of Waterfowl Broods versus Lake Elevation in June

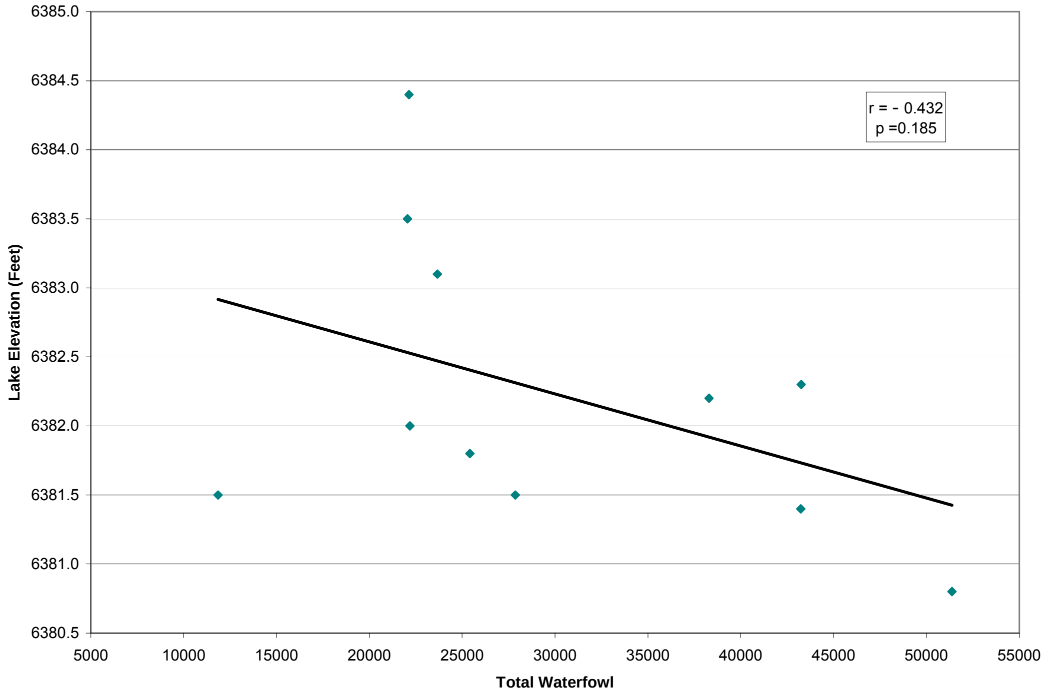


Figure 37. Total Fall Waterfowl Use of Mono Lake versus Lake Elevation in September

APPENDICES

Appendix 1. 2012 Ground Count Survey Dates and Times

Survey 1

Survey Area	Survey Date and Time			
	4-Jun	5-Jun	6-Jun	7-Jun
RUCR	0550 - 0730 hrs			
SOTU	0823 - 0942 hrs			
SSLA		1141 - 1442 hrs		
DECR		0553 - 0710 hrs		
MICR		0710 - 0836 hrs		
WICR		0836 - 0920 hrs		
LVCR	1106 - 1216 hrs			
DEPO	1307 - 1329 hrs			
COPO	1250 - 1300 hrs			
SASP			0644 - 1024 hrs	
WASP				0709 - 0900 hrs

Survey 2

Survey Area	Survey Date and Time				
	27-Jun	28-Jun	29-Jun	2-Jul	3-Jul
RUCR	1035 - 1200 hrs				
SOTU				0611 - 0720 hrs	
SSLA		0628 - 0942 hrs			
DECR	0550 - 0638 hrs				
MICR	0638 - 0737 hrs				
WICR	0738 - 0824 hrs				
LVCR				0840 - 0930 hrs	
DEPO				1045 - 1102 hrs	
COPO				1016 - 1035 hrs	
SASP			0647 - 0956 hrs		
WASP					0708 - 0840 hrs

Survey 3

Survey Area	Survey Date and Time			
	17-Jul	18-Jul	19-Jul	23-Jul
RUCR		1144 - 1321 hrs		
SOTU		1426 - 1525 hrs		
SSLA			1058 - 1440 hrs	
DECR		0607 - 0720 hrs		
MICR		0720 - 0843 hrs		
WICR		0845 - 0938 hrs		
LVCR	0626 - 0720 hrs			
DEPO	1505 - 1535 hrs			
COPO	1535 - 1543 hrs			
SASP			0657 - 1058 hrs	
WASP				0719 - 0835 hrs

Appendix 2. Common and Scientific Names for Species Referenced in the Document.

Common Name	Scientific Name
Greater White-fronted Goose	*Anser albifrons*
Snow Goose	*Chen caerulescens*
Canada Goose	*Branta canadensis*
Tundra Swan	*Cygnus columbianus*
Gadwall	*Anas strepera*
American Wigeon	*Anas americana*
Mallard	*Anas platyrhynchos*
Blue-winged Teal	*Anas discors*
Cinnamon Teal	*Anas cyanoptera*
Northern Shoveler	*Anas clypeata*
Northern Pintail	*Anas acuta*
Green-winged Teal	*Anas crecca*
Unidentified Teal	*Anas sp.*
Redhead	*Aythya americana*
Ring-necked Duck	*Aythya collaris*
Lesser Scaup	*Aythya affinis*
White-winged Scoter	*Melanitta fusca*
Bufflehead	*Bucephala albeola*
Hooded Merganser	*Lophodytes cucullatus*
Common Merganser	*Mergus merganser*
Ruddy Duck	*Oxyura jamaicensis*

Appendix 3. Habitat Categories Used for Documenting Use by Waterfowl Species (from 1999 Mono Basin Habitat and Vegetation Mapping, Los Angeles Department of Water and Power 2000).

Marsh

Areas with surface water usually present all year and dominated by tall emergent species such as hard-stem bulrush (*Scirpus acutus*), cattail (*Typhus latifolia*), three-square (*Scirpus pungens*), alkali bulrush (*Scirpus maritimus*) and beaked sedge (*Carex utriculata*).

Wet Meadow

Vegetation with seasonally or permanently wet ground dominated by lower stature herbaceous plant species, such as sedges (*Carex* spp.), rushes (*Juncus* spp.), spikerushes (*Eleocharis* spp.), and some forbs (e.g. monkey flower [*Mimulus* spp.], paintbrush [*Castilleja exilis*]). Wet meadow vegetation was in areas where alkaline or saline soils did not appear to be present. This class included the "mixed marsh" series from Jones and Stokes 1993 mapping.

Alkaline Wet Meadow

This type was similar in stature to the wet meadow class but occurred in areas clearly affected by saline or alkaline soils. Vegetation was typically dominated by dense stands of Nevada bulrush (*Scirpus nevadensis*), Baltic rush (*Juncus balticus*), and/or saltgrass (*Distichlis spicata*). The high density and lushness of the vegetation indicated that it had a relatively high water table with at least seasonal inundation and distinguished it from the dry meadow vegetation class.

Dry meadow/forb

This vegetation class included moderately dense to sparse (at least 15 percent) cover of herbaceous species, including a variety of grasses and forbs and some sedges (e.g. *Carex douglasii*). As with the alkaline wet meadow type above, comparison to vegetation series in Jones and Stokes (1993) was sometimes problematic due to difficulty in distinguishing dry meadow from wet meadow types.

Riparian and wetland scrub

Areas dominated by willows (*Salix* spp.) comprised most of the vegetation classified as riparian.wetlands scrub. Small amounts of buffalo berry (*Shepardia argentea*) and Wood's rose (*Rosa woodsii*) usually mixed with willow also were included in this class.

Great Basin scrub

Scattered to dense stands of sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus nauseosus*), and/or bitterbrush (*Purshia tridentata*) were classified as Great Basin scrub. This vegetation type included a range of soil moisture conditions, as rabbitbrush was often found in moist areas close to the lakeshore and sagebrush was typically in arid upland areas.

Riparian forest and woodland

Aspen (*Populus tremuloides*) and black cottonwood (*Populus trichocarpa*) were the two tree species most common in the riparian forest/woodland vegetation type.

Freshwater-stream

Freshwater-stream habitats are watered; freshwater channels such as exist in Rush Creek and Lee Vining Creeks.

Freshwater-ria

Freshwater-ria areas were surface water areas at the mouths of streams that likely have some salt/freshwater stratification.

Freshwater-pond

This type included ponds fed by springs within marsh areas or artificially by diversions from streams (e.g. DeChambeau/County ponds).

Ephemeral Brackish Pond

Ponds along the shoreline created by the formation of littoral bars with an extensive area of marsh or wet meadow indicating the presence of springs was present landward, were identified as ephemeral brackish ponds. In some cases, ponds were not completely cut off from lake water, but were judged to still have brackish water due to freshwater input and reduced mixing.

Ephemeral Hypersaline Pond

Ponds along the shoreline created by the formation of littoral bars, but without an extensive area of marsh or wet meadow present landward, were identified as ephemeral hypersaline ponds. These were presumed to contain concentrated brine due to evaporation.

Unvegetated

Unvegetated areas were defined as those that were barren to sparsely vegetated (<15 percent cover). This class included sandy areas, alkaline flats, tufa, and delta outwash deposits.

Appendix 4. 2012 Fall Aerial Survey Dates

Survey Number	1	2	3	4	5	6
Mono Lake	4 Sept	18 Sept	2 Oct	16 Oct	29 Oct	13 Nov
Bridgeport Reservoir	4 Sept	18 Sept	2 Oct	16 Oct	29 Oct	13 Nov
Crowley Reservoir	4 Sept	18 Sept	2 Oct	16 Oct	29 Oct	13 Nov

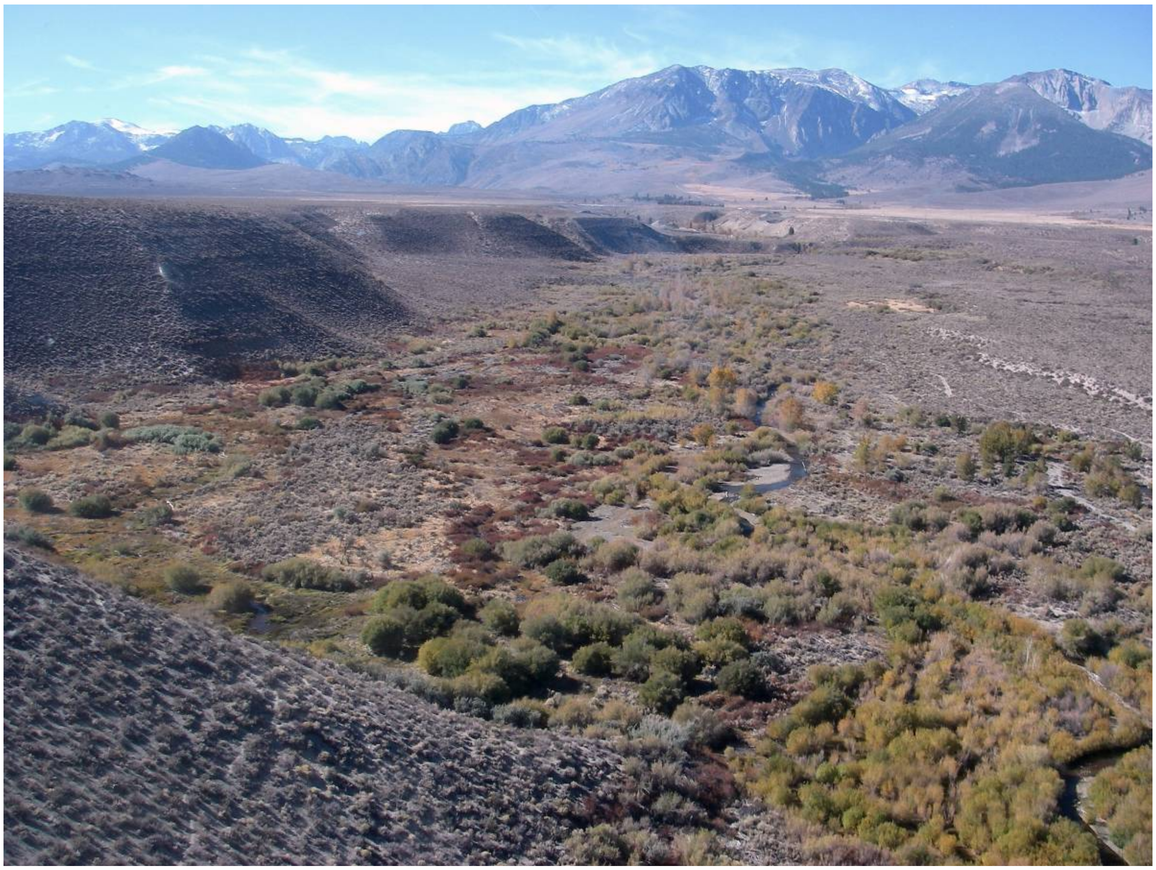
Appendix 5. Lakeshore Segment Boundaries
(UTM, Zone 11, NAD 27, CONUS)

Mono Lake	Lakeshore Segment	Code	Easting	Northing
	South Tufa	SOTU	321920	4201319
	South Shore Lagoons	SSLA	324499	4201644
	Sammann's Spring	SASP	328636	4204167
	Warm Springs	WASP	332313	4208498
	Northeast Shore	NESH	330338	4213051
	Bridgeport Creek	BRCR	324773	4215794
	DeChambeau Embayment	DEEM	321956	4214761
	Black Point	BLPT	318252	4211772
	Wilson Creek	WICR	315680	4209358
	Mill Creek	MICR	313873	4209544
	DeChambeau Creek	DECR	312681	4209246
	West Shore	WESH	315547	4208581
	Lee Vining Creek	LVCR	314901	4205535
	Ranch Cove	RACO	316077	4204337
	Rush Creek	RUCR	318664	4202603
Crowley Reservoir				
	Upper Owens	UPOW	346150	4168245
	Sandy Point	SAPO	345916	4167064
	North Landing	NOLA	346911	4164577
	McGee Bay	MCBA	345016	4164414
	Hilton Bay	HIBA	346580	4161189
	Chalk Cliff	CHCL	347632	4162545
	Layton Springs	LASP	347177	4165868
Bridgeport Reservoir				
	North Arm	NOAR	306400	4244150
	West Bay	WEBA	304100	4240600
	East Shore	EASH	305600	4237600

Appendix 6. Mono Lake Cross-Lake Transect Positions

Cross-Lake Transect Number	Latitude
1	37º 57’00”
2	37º 58’00”
3	37º 59’00”
4	38º 00’00”
5	38º 01’00”
6	38º 02’00”
7	38º 03’00”
8	38º 04’00”

Assessment of Waterfowl Habitat in the Rush Creek Bottomlands



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May 2013

Introduction

The Mono Lake Basin Water Right Decision 1631 was adopted by the State Water Resources Control Board (SWRCB) on September 28, 1994. The Decision amended water rights held by the City of Los Angeles, and limited diversions by Los Angeles Department of Water and Power (LADWP). Restrictions on the amount of water diverted from the Mono Basin were designed in part to allow the level of Mono Lake to rise to a target elevation of 6,392 feet set by the SWRCB. The SWRCB determined that since not all pre-diversion waterfowl habitat would be restored when the lake reached the established target elevation, an additional plan must be in place to mitigate for the loss of waterfowl habitat due to the diversion of water from the Mono Basin.

The Decision therefore also required LADWP to prepare stream and waterfowl habitat restoration plans for the Mono Basin. Stream Restoration and Waterfowl Habitat Restoration Plans were developed by LADWP for four tributaries to Mono Lake in the Mono Basin – Rush Creek, Lee Vining Creek, Parker Creek and Walker Creek. During development of the Waterfowl Plan, LADWP hired a panel of three waterfowl scientists to develop recommendations for restoring waterfowl habitat in the Mono Basin. A Technical Advisory Group composed of at least one individual from each of the named parties in the Decision 1631 provided input to the scientists and LADWP in preparing the report and the restoration plans. The Waterfowl Plan is based in part, on recommendations noted in the waterfowl scientists report and by the Technical Advisory Group.

The plans, approved by the State Water Resources Control Board in 1996, are currently being implemented by LADWP. The Stream Restoration Plan (LADWP 1996a) identified actions to restore, preserve and protect the streams and fisheries in the above named tributaries. The Waterfowl Habitat Restoration Plan (Waterfowl Plan) (LADWP 1996b) identified measures to enhance waterfowl habitats in the Mono Basin.

Although the action identified as highest priority for improvement of waterfowl habitats in the Mono Basin was increasing the water surface elevation of Mono Lake to 6,392 feet, additional measures to be undertaken in the tributaries were identified in order to complement rising lake levels (LADWP 1996b). Actions in the tributaries included the rewatering of Mill Creek and the opening of side channels in Rush Creek bottomlands. Side channel openings in the Rush Creek bottomlands were intended to provide small flows for restoration of waterfowl habitat in backwater depressions.

This report provides an evaluation of current waterfowl habitat conditions in the Rush Creek bottomlands. Waterfowl habitats were assessed in the Rush Creek bottomlands using the California Wildlife Habitat Relationship (CWHR) system, supplemented with site visits to document habitat conditions and waterfowl use. Current waterfowl habitat conditions were compared with a point of reference period immediately preceding habitat enhancement measures (1990). This point of reference time period was selected since a vegetation assessment and mapping was conducted at that time and aerial imagery for 1990 is available. A description of 'historic' or pre-diversion conditions is also presented from available information for perspective.

Overview of the Rush Creek System

Rush Creek, the largest stream in the Mono Basin, has primarily a snowmelt-driven hydrologic regime with peak stream flows occurring during the spring snowmelt season, and reduced flows the remainder of the year. Peak flows typically occur in June or July in any one year, but may also occur in April or May, particularly in dry years (Beschta 1994). As described by Kistler and Lajoie (*in* McBain and Trush, Ross Taylor and Associates 2010), Rush Creek cuts through glacial deposits and valley fill deposits composed of alluvial sediments, lacustrine sediments, volcanic ash and pumice. Floodplain soils are classified as Warrior-Xerofluvents Association 0-4% slope, which are well to poorly-drained, gravelly to loamy surface with boulders and cobble.

On Rush Creek downstream of Highway 395 is a channel-confining rock formation known as "The Narrows". From the Narrows to the "ford" where Rush Creek Road crosses the creek channel is the region known as the "Rush Creek bottomlands" (Figure 1). In the bottomlands area, the valley broadens, the stream gradient lessens, and there is increased stream sinuosity as compared to other sections of Rush Creek. The bottomlands area is where side-channel openings were recommended by the waterfowl scientists for the purpose of enhancing waterfowl habitat.

Figure 1. General location of the Rush Creek bottomlands

Historical Information

Pre-diversion Period (prior to 1941)

There is a long history of water diversions from creeks in the Mono Basin, dating back to the 1860's. The initial use of Rush Creek water by early inhabitants of the Mono Basin was for irrigation. The C ditch downstream of Grant Lake diverted water from Rush Creek to irrigate lands on the Cain Ranch west of Rush Creek and Highway 395. Water from Parker and Walker Creeks was likewise used to irrigate meadows on Cain Ranch. Further downstream, the A and B ditches diverted water from Rush Creek to irrigate areas in Pumice Valley, east of Rush Creek. In the bottomlands, the Indian Ditch diverted water from Rush Creek to irrigate meadows further downstream in the floodplain and along the west side of the creek. Water diversions and subsurface seepage from upstream irrigation activities resulted in the occurrence of several ponded areas alongside Rush Creek downstream of the narrows (SWRCB 1994).

Several springs were also reported to have existed in the Rush Creek bottomlands under pre-1941 conditions. Spring discharge in the bottomlands was largely supported by irrigation occurring well upstream. Most of the spring discharge in the bottomlands occurred in the "Vestal Springs" complex. Vestal Springs is just downstream of the Narrows, and west of the main creek channel. Much of the discharge from Vestal Springs was collected into a small drainage channel that fed into the Indian Ditch and thus did not flow directly into Rush Creek (Beschta 1994). Water in the Indian Ditch was used to irrigate meadow systems along the west side of the stream channel.

While irrigation practices in the area enhanced spring flow below the Narrows (McBain and Trush; Taylor and Associates 2010), flows in Rush Creek above the Narrows were severely reduced. Prior to 1941, portions of Rush Creek were intermittently dry in the fall due to irrigation upstream (Elden Vestal testimony). The portion of the stream between the B ditch and the Narrows was often dry during drought years (Brian Tillemans, pers. comm.).

Livestock grazing occurred in the bottomlands historically and resulted in severe impacts. Heavy grazing was reported to have occurred on Rush Creek up to 1941. Channel braiding and reduced streamside woody riparian vegetation bordering the creek in areas adjacent to the irrigated meadows are visible on the 1929 aerial photos.

Beschta testified that the channel braiding and reduced streamside vegetation are definitive indicators of channel instability, and that widening and shallowing are features reflective of grazing impacts. Livestock grazing in the bottomlands likely also contributed a moderate to high nutrient load into an otherwise borderline oligotrophic stream.

Beaver, first introduced by the California Department of Fish and Game near Bridgeport in 1940, occupied the bottomlands and created ponded habitat in some areas of the bottomlands.

Diversion Period (1941-1990)

Water diversion by LADWP for export out of the Mono Basin began in 1941. Rush Creek below Grant Lake was dry except in years of normal to above normal runoff. Irrigation and flows in the Indian Ditch ceased. As water from Rush, Parker and Walker Creeks was no longer being used to irrigate meadows in the Cain Ranch area and Pumice Valley, Beshta (1994) reported that essentially all of the springs in the bottomlands no longer issued water. During the period 1941-1950, Vestal reported "severe riparian vegetation encroachment" in Rush Creek after flows were even more reduced due to diversions by LADWP, impacting famed fishing conditions. In his testimony, Vestal also stated that instream habitat improvements were attempted, although specifics were not provided.

Beaver reportedly abandoned the bottomlands area by the late 1940's. Notable large runoff events occurred in 1967, 1969 and the early 1980's, causing substantial incision and scouring due to an absence of riparian vegetation to protect the banks and stabilize the soils. Incision of floodplains drained shallow ground water tables and left former side channels stranded above the newly incised main stream channel (SWRCB 1994). A straightening, widening and shifting of the main channel also occurred. Continued grazing likely contributed to further deterioration of meadow and wetland habitats.

Beginning in 1984, a court ordered year-round minimum flow of 19 cfs was reestablished to Rush Creek below Grant Lake. This flow was modified in 1989 by the courts, resulting in flows for October through February of 28 cfs, while flows from April through September were increased to 40 cfs (LADWP 1996).

In 1992 LADWP established a grazing moratorium on Rush Creek to support the recovery of riparian vegetation. This moratorium was supported by and continued under Decision 1631 and remains in effect today. Interim stream restoration began in 1994.

Impacts to Waterfowl Habitat during Diversion Period

Approximately 58 acres of bottomland habitat was considered irretrievably lost due to streambank incision, with a predicted net loss, after implementation of the Waterfowl Plan of 43 acres. The Mono Basin Water Rights Draft EIR (Jones and Stokes Associates 1993) reports that observers recalled that "the Rush Creek bottomlands once supported abundant waterfowl". Sites reported to have received heavy waterfowl use in the bottomlands were the meadow areas (SWRCB 1994). During hearings for the Mono Basin Decision, geomorphologist Dr. Scott Stine testified that "Rush Creek bottomlands were areas of duck abundance". It is unclear whether the use of the bottomlands in this instance included the Rush Creek delta area. The Rush Creek delta area was formerly the site of manmade duck ponds filled with water diverted off of the creek that attracted numerous waterfowl. Stine testified that restoration of waterfowl habitat along Rush Creek would require rewatering of abandoned channels and raising the water table of the Rush Creek bottomlands.

Bottomlands Sub-Reach Descriptions

The bottomlands area has been divided into three sub-reaches of unequal length: 4A, 4B and 4C (Figure 2). Reach 4A extends from just below the Narrows, to the beginning of the abandoned Indian Ditch. Reach 4B, the largest section, extends from the beginning of the Indian Ditch to approximately 600 feet downstream of the start of the last major meander bend above the ford where Rush Creek Road crosses the creek channel. Reach 4C extends from this point and continues downstream to the ford.

Stine et al. (1994) identified historic channels in the Rush Creek bottomlands as part of a channel rewatering feasibility study. Only a subset of all identified historic channels was selected for rewatering. In the following section, each sub-reach is described in more detail with regard to prediversion conditions and conditions during the diversion period. Aerial imagery of each sub-reach is provided for three time periods: current conditions (2008 imagery), prediversion period (1929) and the point-of-reference period

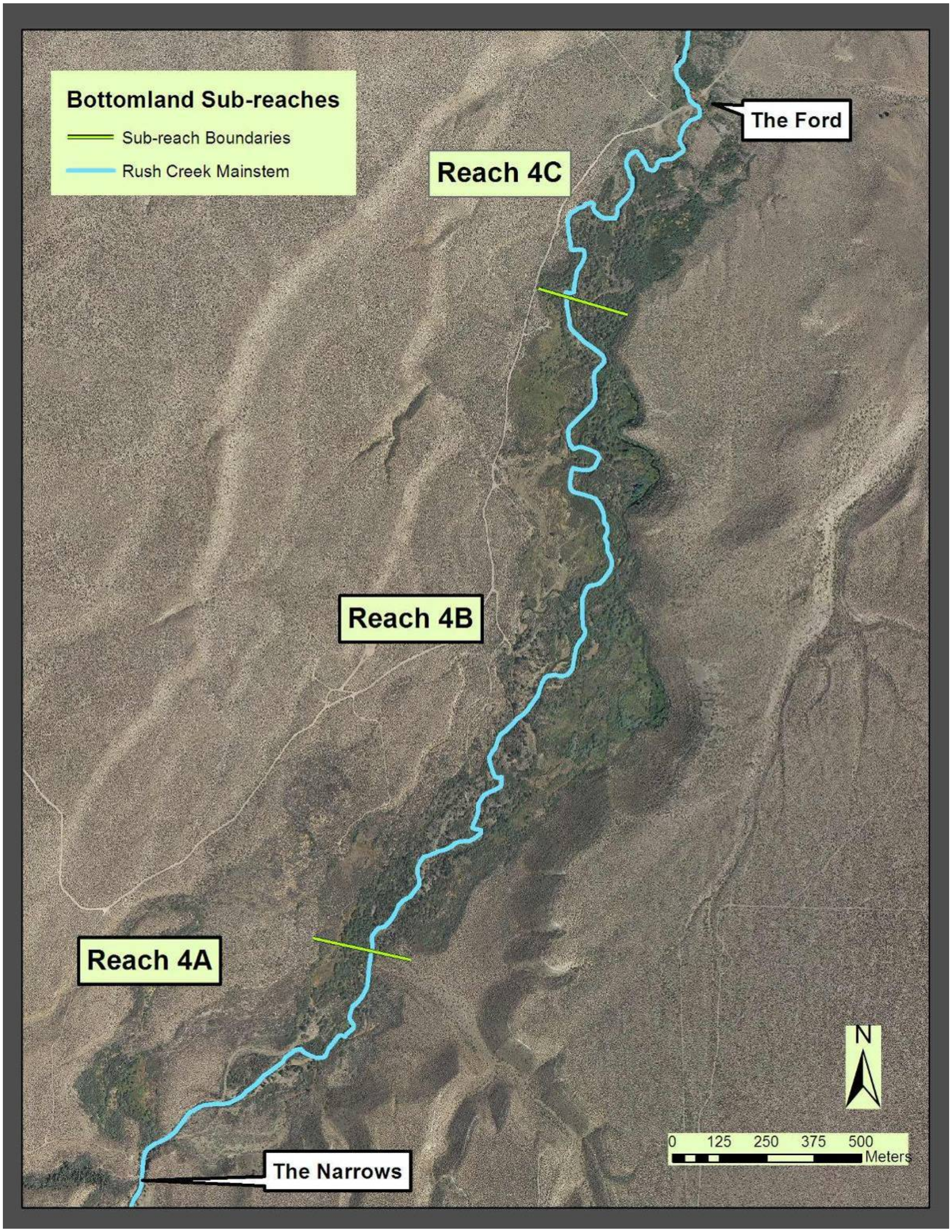

Figure 2. Subreaches of Rush Creek Bottomlands.

just prior to implementation of the stream restoration plan (1990). Historic channels and channels selected for rewatering are identified on the imagery.

Reach 4A

Figure 3 is a high-resolution aerial photograph of Reach 4A from July 2008 with physical features as discussed in the text, historic channels as mapped by Stine et al. 1994, and active channels identified for reference. The Vestal Springs complex lies to the west of the mainstem, just downstream of the Narrows. Prior to diversions, some secondary distributary channels branching off of the main channel, and also some side channels only received flow seasonally under conditions of high flow in the mainstem. The approximate locations of these channels are shown in Figure 3 and are identified as Channels 1, 1a, 1b, 2 and 3. Flow in this reach is currently confined to the mainstem. During the pre-diversion period, Channel 1a/1 was the main channel (Figure 4). Based on a review of the 1929 aerial photographs, the channel 1a/1 area appears to have been dominated by woody riparian vegetation, and thus likely did not provide much waterfowl habitat.

Black cottonwood (*Populus trichocarpa*) stands in this reach were believed to have been particularly impacted by diversions. Wet meadow areas created by the discharge of Vestal Springs are more extensive on the 1929 photos than is evident on either the 1990 or 2008 images. Major changes to this reach occurred partly as a result of the high flow event that occurred in 1967. This high flow event deposited large quantities of cobble across the floodplain, filling portions of the former main channel, and creating a new main channel. Other secondary channels were cut off due to the deposition. This event combined with desiccation, resulted in a substantial reduction in woody riparian vegetation, the drying of meadows, and a reduction in the length of the main channel as it was straightened. Figure 5 shows the condition of Reach 4A in 1990, prior to implementation of the restoration plan. The 1/1a channel was one of the channels originally considered for rewatering, but was removed from consideration because the project would cause more environmental impacts than potential benefit.

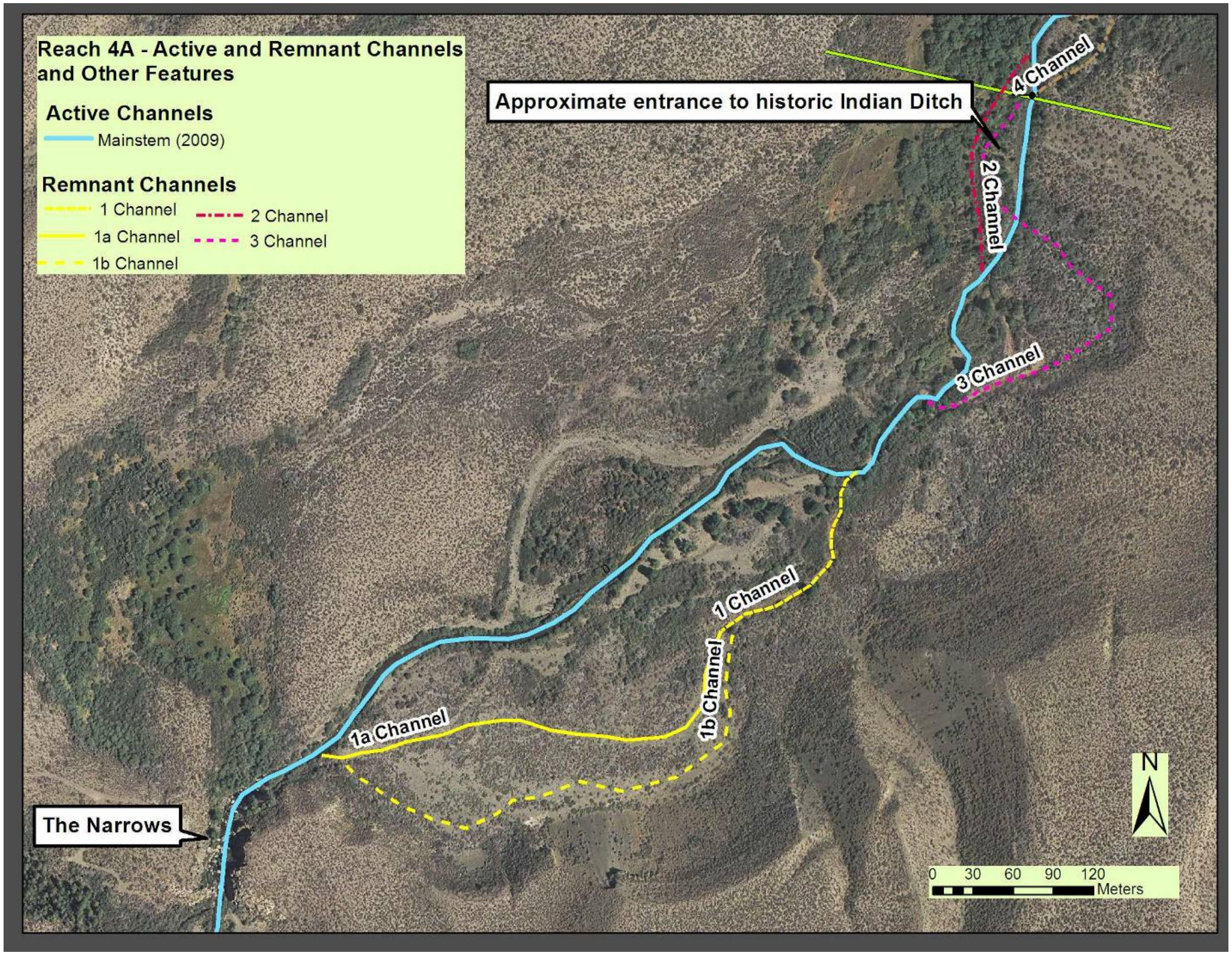

Figure 3. Reach 4A of Rush Creek bottomlands with physical features discussed in the text and historic and active channels identified. Imagery date: July 2008.

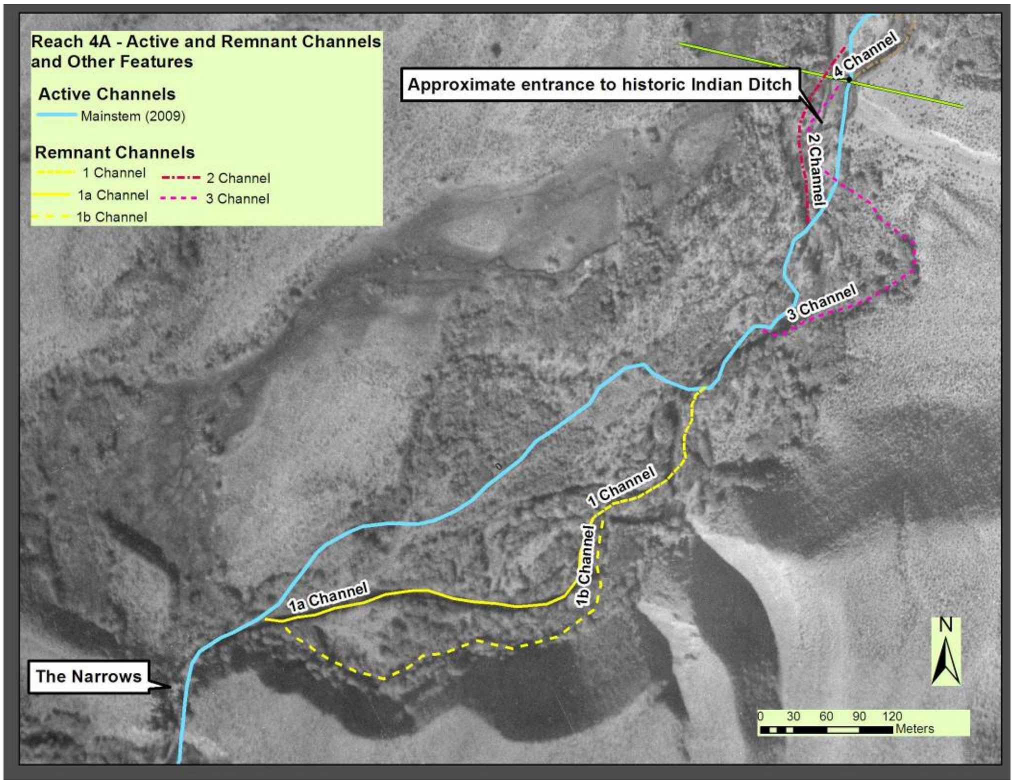

Figure 4. Aerial Imagery of Reach 4A in 1929 during the pre-diversion period.

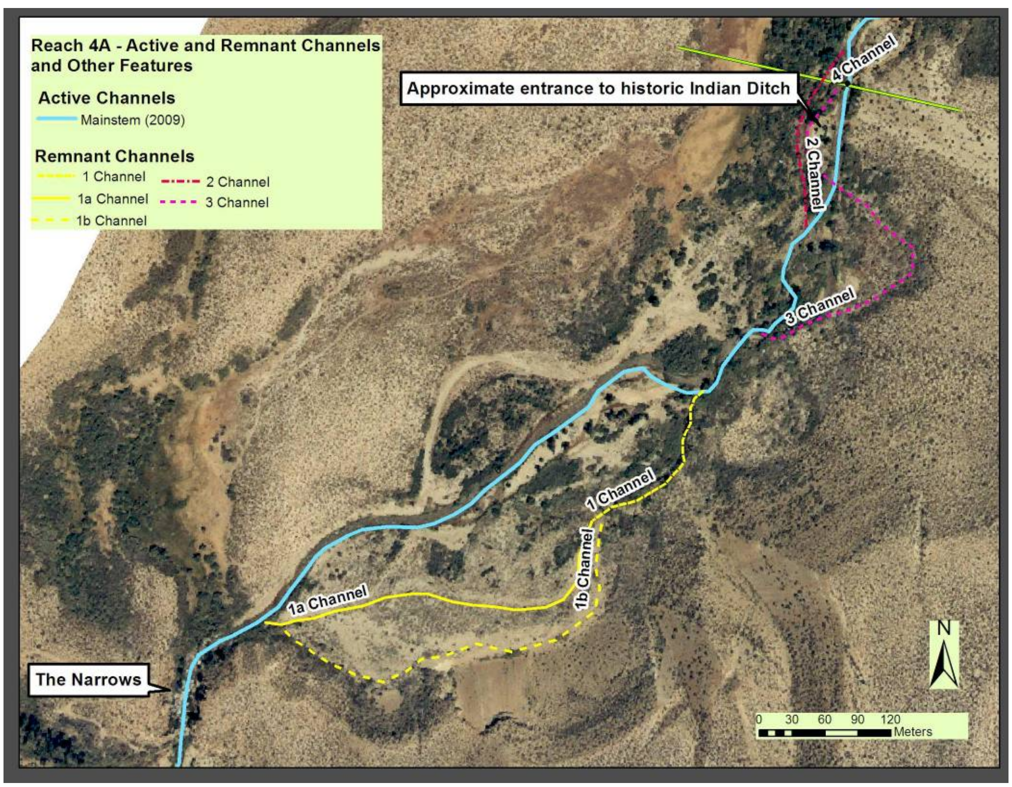

Figure 5. Reach 4A in 1990, prior to implementation of stream restoration plan.

Reach 4B

Figure 6 is a high-resolution aerial photograph of Reach 4B from July 2008. The historic Indian Ditch runs the length of this reach west of the mainstem. The reopened waterfowl channels 4Bii, 8 and 10 are in this reach. During the prediversion period, the main channel in this reach exhibited notable sinuosity. The Indian Ditch was used to provide supplemental irrigation to natural meadows that existed along the west side of the main channel, and this is apparent on the 1929 images (Figure 7). Also visible on the 1929 aerial images is channel braiding and reduced streamside woody riparian vegetation indicative of the livestock grazing impacts noted by Beschta (1994) and discussed earlier. Woody riparian vegetation was dominated by black cottonwood and willows (*Salix* spp.), with a thick understory of Wood's rose (*Rosa woodsii*) and other species in some areas. After diversions began and irrigation of upstream areas ceased, spring discharge decreased or ceased. Cobble deposition during the 1967 flood event affected primarily the upstream part of this reach, filling or blocking the main channel and some secondary channels. Most of the willows and virtually all black cottonwood was destroyed, leaving dead and decadent stands of woody riparian in the floodplain. Drying of meadows occurred as irrigation ceased and flows dropped. Downcutting also affected this reach somewhat as the elevation of Mono Lake declined. The 1990 images (Figure 8) show that creek flow was confined primarily to the mainstem.

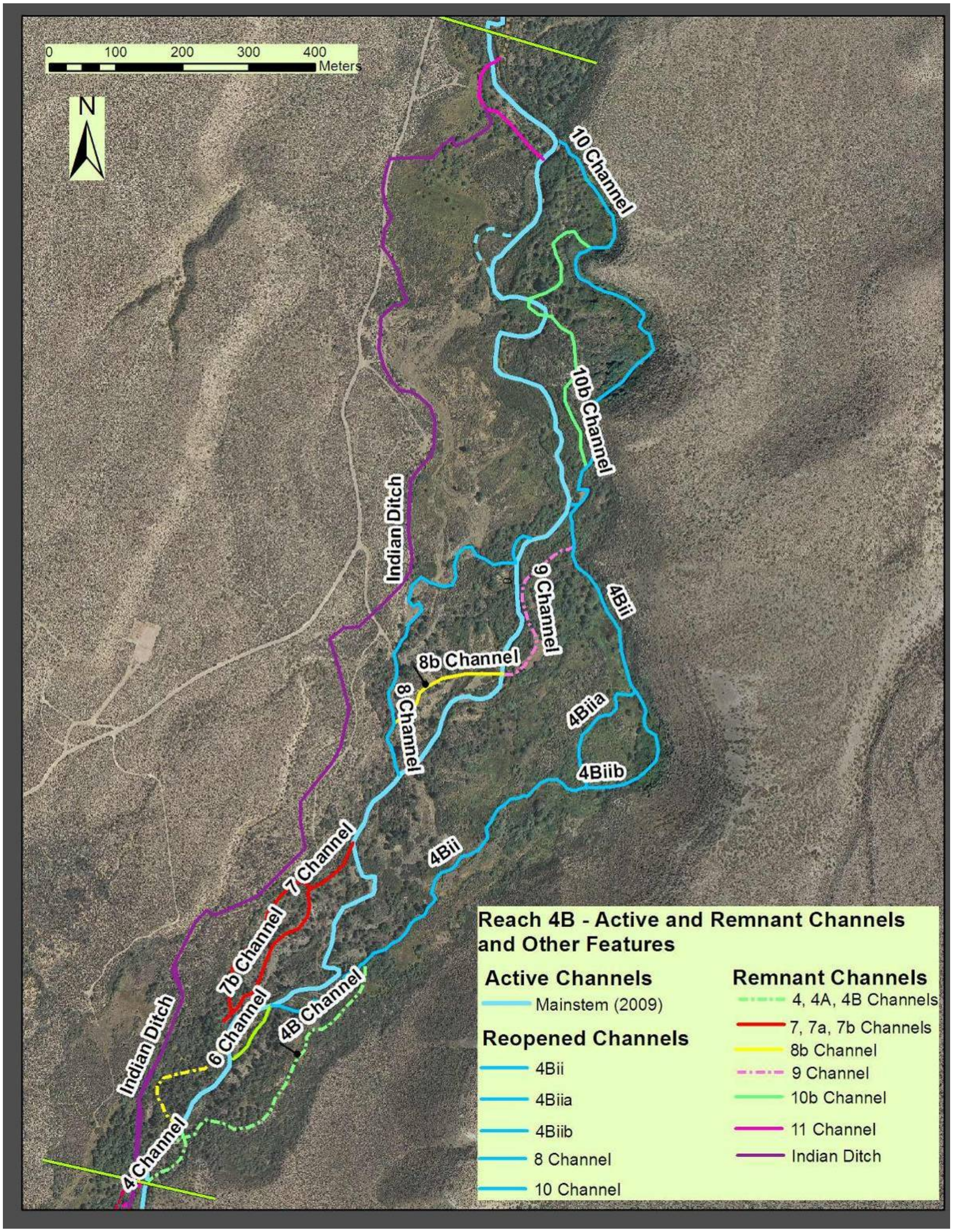

Figure 6. Reach 4B of Rush Creek bottomlands with physical features discussed in the text and historic and active channels identified. Imagery date: July 2008.

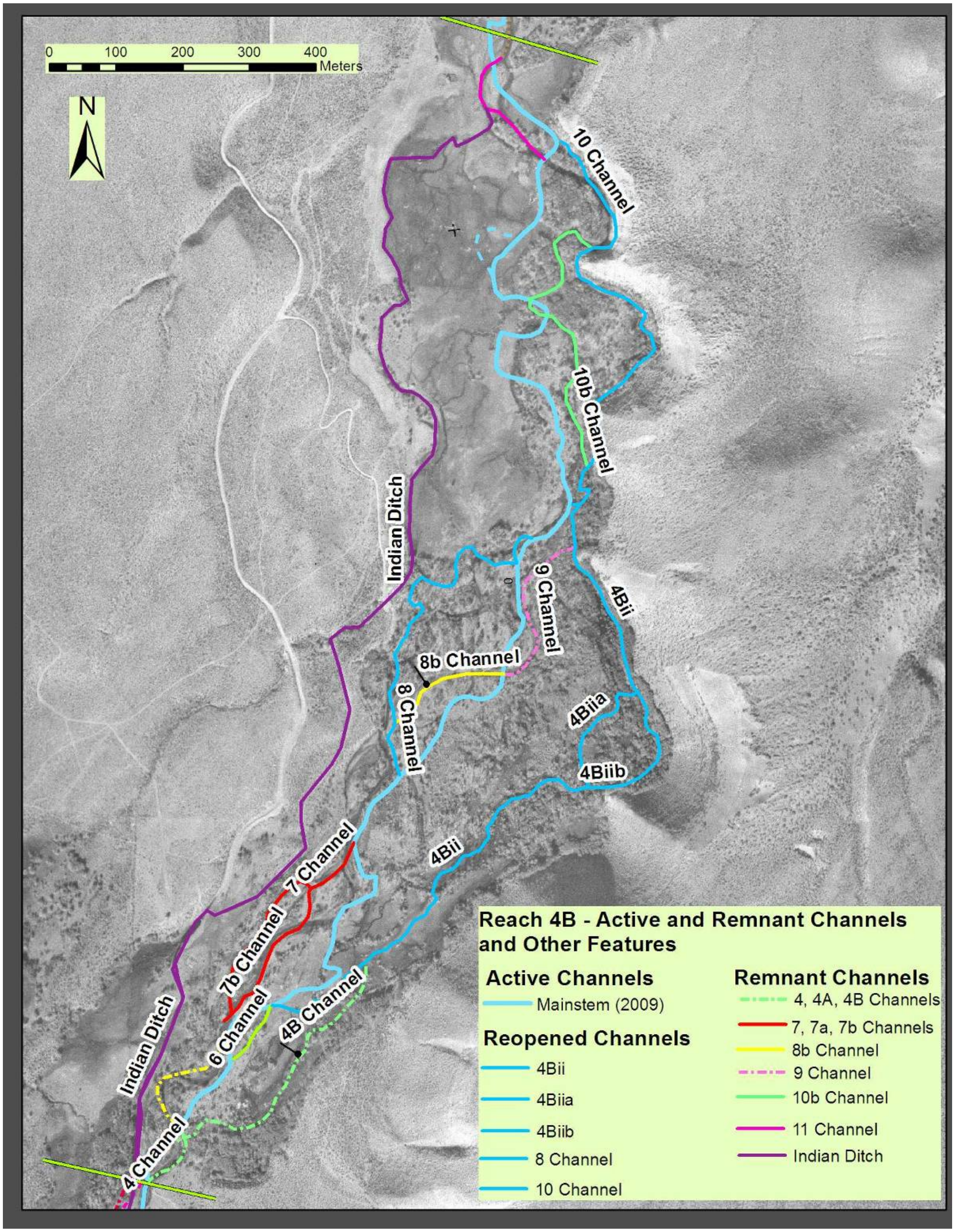

Figure 7. Aerial Imagery of Reach 4B in 1929 during the pre-diversion period.

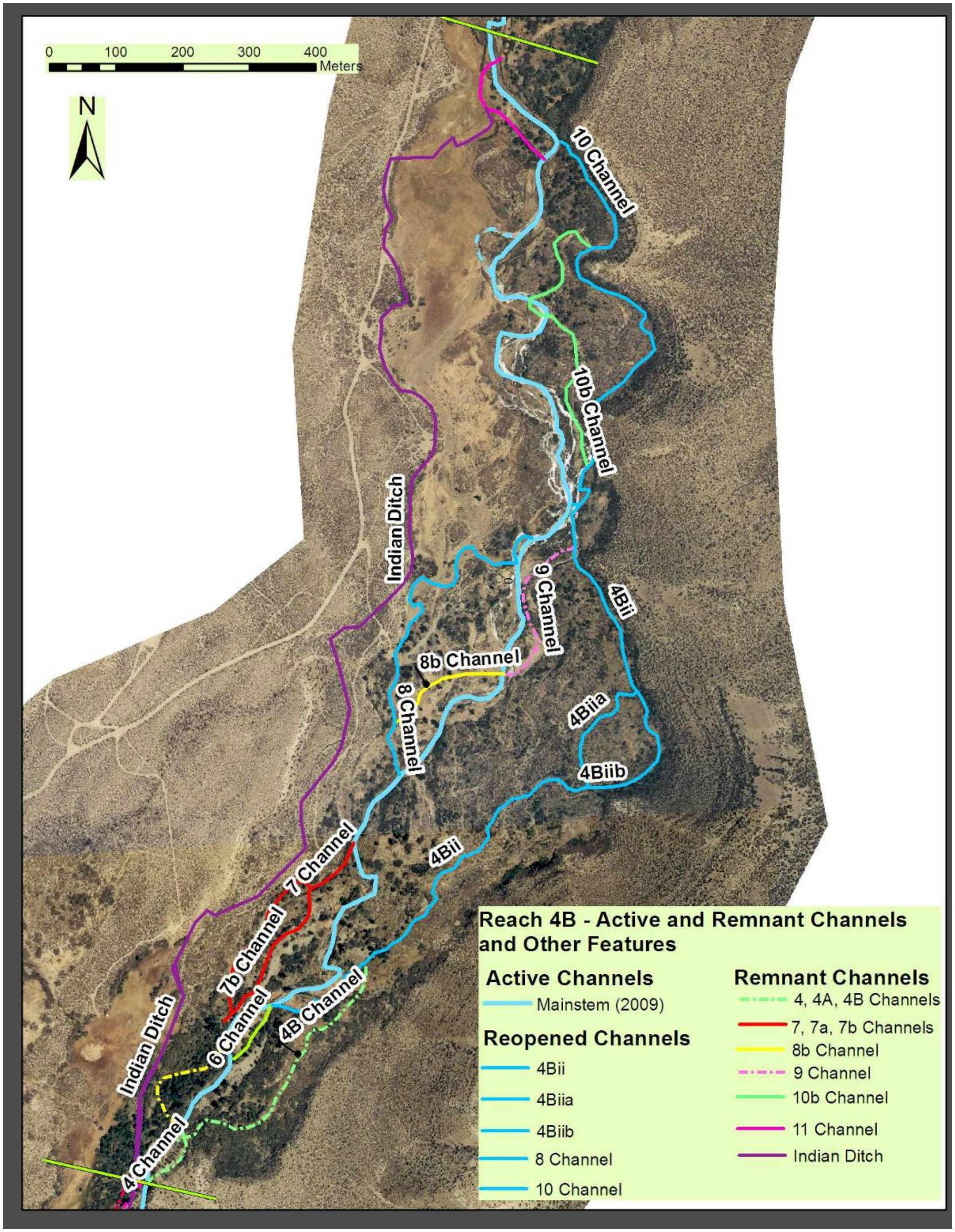

Figure 8. Reach 4B in 1990, just prior to implementation of stream restoration plan

Reach 4C

Figure 9 is a high-resolution aerial photograph of Reach 4C from July 2008. Under prediversion conditions, the channel in this area was fairly narrow, and the principal feature was a large meander bend along the right side of the floodplain, just upstream of the ford (Figure 10). This reach supported well-developed woody riparian vegetation stands. Incision associated with lowering lake levels affected this reach of the bottomlands more than the 4A or 4B. The meander bend (14 Channel) was cut off and severe loss of channel length occurred. The drop in groundwater desiccated the woody riparian vegetation, however many of the large shrub willows persisted (Figure 11). Although not waterfowl channels, the 13 Channel and 14 Channel were originally considered for rewatering. Stream incision and other floodplain changes resulted in the stream and fishery scientists recommending against attempting reactivation of these channels. This recommendation of no action was approved by SWRCB in 2008.

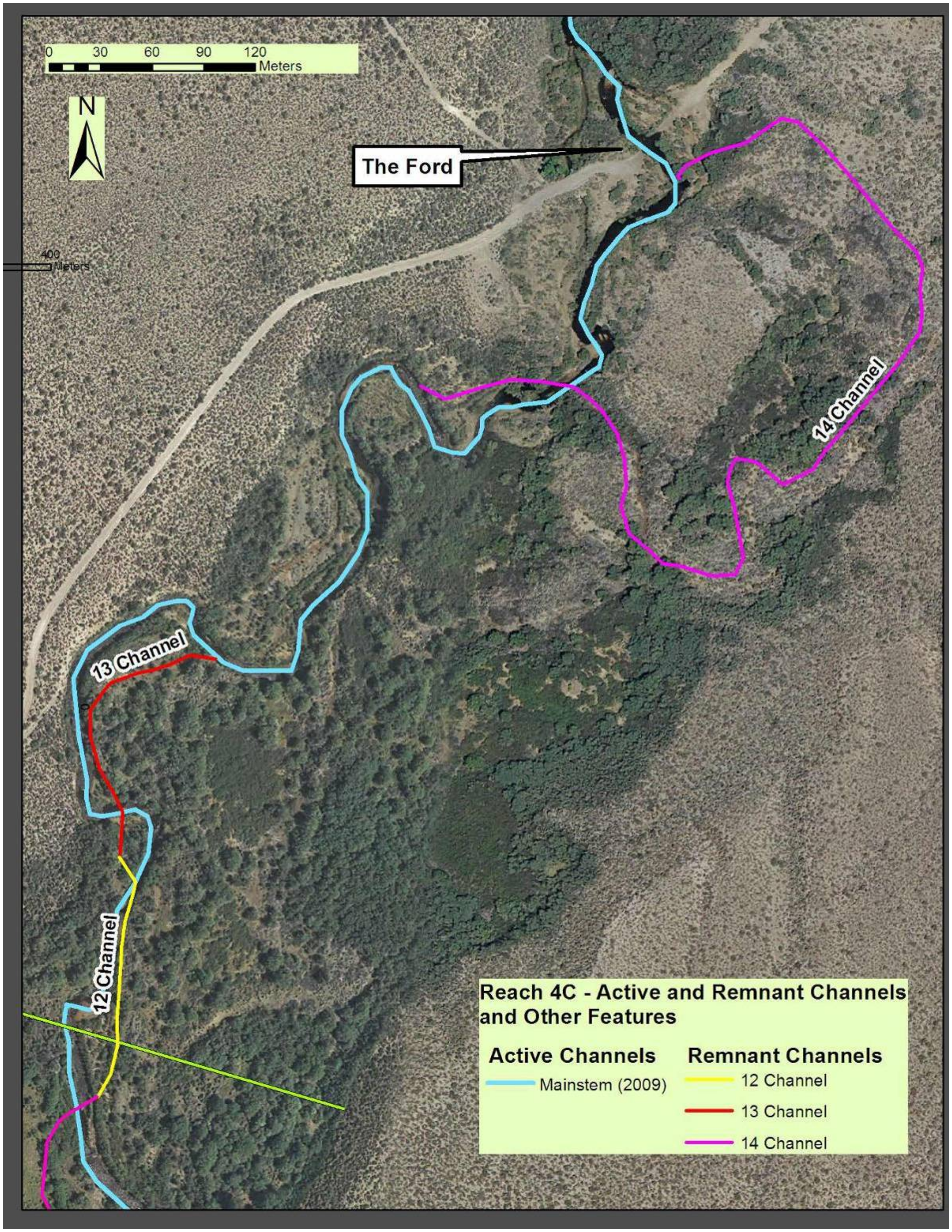

Figure 9. Reach 4C of Rush Creek bottomlands with physical features discussed in the text and historic and active channels identified. Imagery date: July 2008.

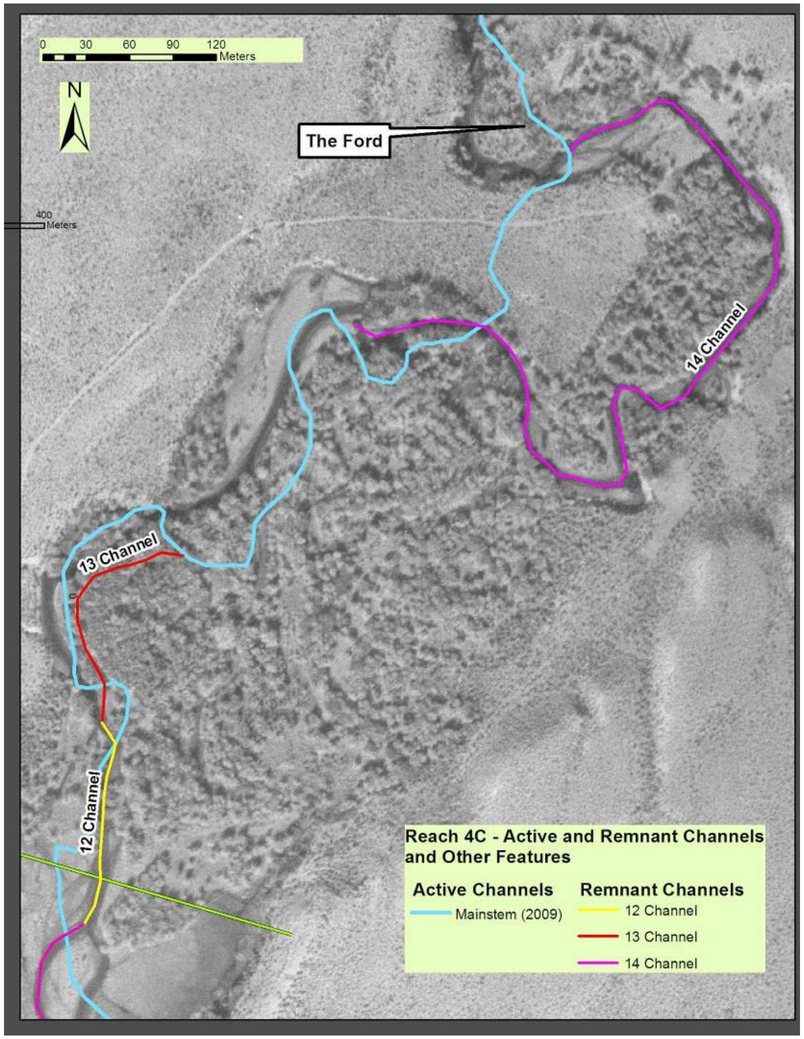

Figure 10. Aerial Imagery of Reach 4C in 1929 during the pre-diversion period.

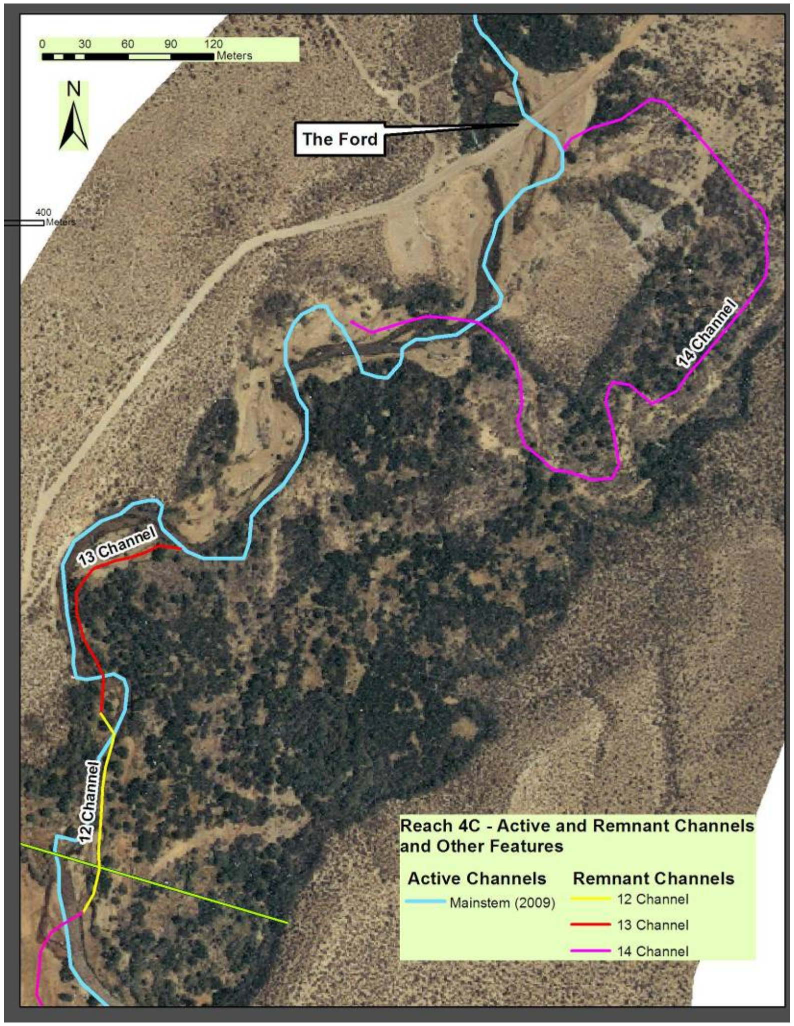

Figure 11. Reach 4A in 1990, prior to implementation of stream restoration plan.

Restoration Activities

The most important restoration effort in Rush Creek has been the establishment of perennial flow. One early project completed was known as the “Million Dollar Bend” or “Trihey’s oxbow”, and was undertaken as an emergency measure based on a recommendation by Trihey and Associates. This action blocked off flow into an oxbow, and resulted in a straightening of the channel. Future actions received more critical evaluation due to the negative impact of this project on the stream channel. In addition to an established base flow, stream restoration flows mimicking snowmelt runoff are adjusted based on runoff year predictions. Other restoration activities in the bottomlands of Rush Creek have included the placement of large woody debris, road closures, the opening of or rewatering of several side channels, and the planting of Jeffrey Pine (*Pinus jeffreyi*).

Under the initial Stream Restoration Plan, seven abandoned channels were considered for reopening to allow for perennial or seasonal flow. The seven channels initially identified were 1A (in Reach 4A), the 4Bii, channels 8 and 10 (Reach 4B), and channels 11, 13 and 14 (Reach 4C). Of these, only the 4Bii, channel 8 (unplugged lower section), the channel 10 complex, channel 11 (unplugged lower section) and the channel 13 complex were identified in the Waterfowl Plan as openings that would result in improved waterfowl habitat conditions. These were collectively referred to as “the waterfowl channels”. In 2007, Channels 11, 14 and the channel 13 complex were removed from consideration for rewatering based on recommendations by the Stream Scientists and approval by the State Water Resources Control Board. Concerns regarding floodplain drying on the opposite bank and the loss of fishery habitat led to this recommendation and eventual approval.

The three remaining and completed waterfowl channel projects are in the 4B reach (see Figure 6). The first waterfowl channel to be rewatered in the bottomlands was the 10 Channel complex. This project was completed in 1995. The 10 channel project resulted in the rewatering of 2,000 feet of historic channel. The 10 Channel flows along the toe of the east slope of the bottomlands in the downstream portion of the 4B reach. The original concept was for the 10A channel to capture approximately 10% of the entire Rush Creek flow, which at that point would equate to approximately 5 cfs. The 10

Channel has progressively captured more of the flow off of the mainstem, and as of 2008, was receiving approximately 70-80% of the total base flow (McBain and Trush, Inc. 2009). The 10 Channel sits perched 4 to 5 feet above the level of the mainstem. The checkpoint for the 10 Channel is a large waterfall at the downstream end where the 10 Channel rejoins the mainstem. This waterfall, held in place by willow roots, is known as the 10 Channel falls. The downstream portion of the 10 Channel now supports a series of glides, deep pools and beds of the submergent plant *Ranunculus aquatilis*. The channel is bordered by wet meadow vegetation, woody riparian vegetation and small isolated patches of cattails.

The 8 Channel was originally opened in 2003, with further work completed in 2008 in order to allow perennial flow. The opening was maintained until 2012 after which natural processes are allowed to occur. The historic 8 channel passed through dry upland vegetation. Where the 8 Channel rejoined the mainstem (i.e. the 8 channel return), a backwater area with an open willow canopy existed before rewatering, and attracted waterfowl. Because the 8 Channel bed is above that of the mainstem, flows in the 8 Channel are expected to be slower than in the adjacent main channel.

The 4Bii entrance was originally opened in 2007, allowing flow when Rush Creek discharges exceeded approximately 160 cfs. In March 2007, further manual work lowered the channel entrance to allow flow when Rush Creek discharge exceed 100 cfs. Perennial flow currently exists into the 4Bii. The 4Bii opening was maintained until 2012 after which natural processes are allowed to occur. Flows from the mainstem are expected to access the 4Bii channel and the 8 channel when greater than 100 cfs.

Habitat Suitability Assessment

<u>Community Classification</u>

Habitat suitability was assessed using California Wildlife Habitat Relationships system (CWHR) (California Department of Fish and Game-CIWTG, 2008). CWHR is a software system that provides habitat suitability values for wildlife species in California vegetation communities. CWHR has been integrated with BioView, an application that translates habitat suitability values for wildlife into data that can be used in a Geographic Information System. CWHR is operated and maintained by the California Department of Fish and Wildlife in cooperation with the California Interagency Wildlife Task Group

(CIWTG). Using CWHR, suitability values can be assigned to vegetation polygons based on three variables: vegetation community type, size and stage. CWHR provides a series of descriptions for vegetation communities found throughout the state, as well as community classification crosswalks for the various classification systems used. After determining the community type, the size and stage are evaluated. “Size” refers to plant height, age or vigor, diameter at breast height, or canopy diameter, depending on the vegetation community being assessed. “Stage” refers to canopy cover. Data input can be relevé, or categorical.

Subsampling of all herbaceous communities, the riverine corridor, and all woody riparian communities was conducted in June 2007. Within each of the three reaches, one-third of the total polygons (and a minimum of 3) of each habitat type with each reach were randomly-selected for visitation. Photos were taken at the centroid of each polygon in all reaches in June 2007 only. Photos were taken at all subsampling locations in the 4B reach during all visits. These photos were referenced, as needed during polygon size or stage classification. Additional photopoint locations were established along the 8 channel and the 4Bii. The UTM coordinates for all photos appearing in this document can be found as Appendix 1.

The 2009 vegetation mapping shapefile was used as the base layer for mapping waterfowl habitat. Vegetation polygons were further refined where needed to more accurately define available waterfowl habitat. For example, ponds were mapped as distinct from riffles or runs as slow-moving water is more suitable than runs or riffles for many waterfowl species. Sparsely-vegetated point bars were split from larger polygons often mapped as woody riparian and supporting dense montane riparian vegetation because waterfowl may use these sparsely vegetated areas adjacent to the creek, but avoid areas of dense shrubs or trees. All open-water areas not mapped as such, and areas subject to periodic flooding were also delineated. The 2008 high-resolution aerial imagery of the Rush Creek bottomlands was used to assign community type, size and stage classes to the 2009 vegetation mapping polygons. The resolution of the 2008 satellite imagery is 10 cm. The subsampling completed in June 2007, and knowledge of habitat conditions based on subsequent visits was used to help guide decisions made during assignment of CWHR variables. The plant communities defined by McBain and

Trush (2003) were cross-walked to corresponding CWHR habitats. The CWHR habitat type code was assigned to each vegetation polygon within ArcView.

Appendix 2 provides the crosswalk used, and a description of the size classes and stages assigned to each polygon. The Rush Creek vegetation types: rose, narrowleaf willow, yellow willow, mixed willow, Pacific/shiny willow and black cottonwood were all classified as Montane Riparian (MRI) using CWHR categories. Jeffrey Pine polygons were directly equivalent to the CWHR category Jeffrey Pine (JPN). Open aquatic and aquatic emergent were classified as either Riverine (RIV) or Lacustrine (LAC) depending on whether the area had flowing (RIV) or standing water (LAC). Barren areas adjacent to the creek channel were classified as periodically or seldom-flooded Riverine. Cattail was classified as Fresh Emergent Wetland (FEW). Great Basin grasslands polygons were assigned as either Perennial Grassland (PGS) or Wet Meadow (WTM) depending on apparent water table levels, based on site visits, flooding regime, and species composition. Mountain mahogany and sagebrush/bitterbrush polygons were classified as Bitterbrush (BBR), while sagebrush/rose, buffalo berry, sagebrush, sagebrush/Great Basin grassland, rabbitbrush, and rabbitbrush/native grassland sites were classified as Sagebrush (SGB). Areas mapped as open in upland areas and not subjected to periodic flooding were classified as Barren (BAR).

After classification of the polygons, the entire bottomlands area was clipped into the three subreaches: 4A, 4B, and 4C. The acreages of low, medium, and high suitability habitat were calculated by CWHR habitat type and indicator species by sub-reach. The total acreage of all low, medium and high suitability habitats was calculated by species and sub-reach.

BioView was used to calculate suitability values each polygon, for all species of waterfowl, excluding geese, which occur regularly in the Mono Basin. While specific habitats in the bottomlands would be considered suitable for geese under CWHR protocols, these areas are small and enclosed by tall, dense vegetation. Use of the bottomlands by geese is expected to be minimal.

The output of BioView includes a separate suitability value for foraging, cover, and nesting, and both the arithmetic mean and geometric mean of the three values. The arithmetic mean was selected for evaluation since it would demonstrate whether there was suitable habitat for foraging, cover, *or* nesting. If the geometric mean had been used, suitable habitat for foraging, cover and nesting would have to be present in order for the habitat to be suitable. Only a few of the species evaluated nest in the Mono Basin, therefore suitable nesting habitat need not be present for most species in order to be suitable. Suitability values range from 0 – 100, with "0" defined as not suitable. Low suitability is less than or equal to 33, medium suitability is 34 to 66, and high suitability values are 67-100.

The arithmetic mean of the suitability values for cover, reproduction and feeding were generated for each polygon and waterfowl species. The results were viewed using ArcMap and figures were generated displaying the suitability of each polygon as either being low, medium highly suitable, or not suitable. Wet meadow and perennial grassland polygons not adjacent to wetted channels were further evaluated in terms of distance to water. These herbaceous communities provide nesting habitat for some species, however distance to water affects the likelihood of use. If polygons were greater than a certain distance for a particular species, they were reclassified as not suitable. For Mallard (*Anas platyrhynchos*), the distance used was 150 meters, since up to 90% of nests are typically within 150 meters from water (Drilling, Titman and McKinney 2002). For Green-winged Teal (*Anas crecca*), the distance used was 30 meters as this is the average distance from water that this species nests (Bellrose 1976).

<u>Site Visits</u>

Thirteen site visits were conducted between May 2007 and January 2009. Visits were approximately every three months, and corresponded with spring, summer, fall and winter periods. The purpose of the site visits was to evaluate waterfowl use, seasonal variations in conditions, and provide photo documentation of conditions at photopoint locations. When waterfowl were encountered, the species, number of individuals, location, and habitat being used were recorded. The entire Rush Creek bottomlands area (Reaches 4A, 4B, and 4C) was walked in June 2007. Subsequent visits were to the 4B area only since this reach supports the majority of waterfowl habitat in the bottomlands.

During all site visits, photos were taken at the centroid subsampling location within polygons and at other photopoint locations, waterfowl use was recorded, and field notes made regarding environmental conditions. Photos were also taken of the locations where waterfowl were encountered. During all sites visits, the entire 8-channel, 4Bii channel and 10 Channel rewatering project areas were traversed.

Results of Habitat Suitability Assessment

<u>CWHR Community Types</u>

Table 1 shows the total acreage of each CWHR habitat by sub-reach and summed for the entire bottomlands area. The dominant vegetation type in the bottomlands is Montane Riparian which comprises more than half of the mapped bottomland area. The Montane Riparian vegetation in the bottomlands is dominated by moderately tall, dense shrub willows. The only riparian tree species present is black cottonwood. The next most common vegetation types are Sagebrush, Wet Meadow, and Perennial Grassland. Two important waterfowl habitat types, Lacustrine and Fresh Emergent Wetland, comprise <1% of the total bottomlands area, and less than one acre in total. Figure 12 shows the distribution of CWHR habitat types in each of the three reaches.

	Reach						Bottomlands Totals	
CWHR Habitat	4A	% Acreage	4B	% Acreage	4C	% Acreage	Acreage	Acreage
BAR	0.53	1.1%	1.76	1.2%	0.10	0.3%	2.39	1.0%
FEW			0.15	0.1%			0.15	0.1%
JPN		0.0%	0.02	0.0%			0.02	0.0%
LAC		0.0%	0.22	0.1%			0.22	0.1%
MRI	27.92	57.5%	72.35	49.4%	29.74	73.0%	130.02	55.1%
PGS	0.34	0.7%	0.60	0.4%	0.08	0.2%	1.02	0.4%
RIV	2.05	4.2%	9.71	6.6%	2.39	5.9%	14.16	6.0%
SGB	14.92	30.7%	44.04	30.1%	7.79	19.1%	66.74	28.3%
WTM	2.82	5.8%	17.69	12.1%	0.61	1.5%	21.12	9.0%
Total Acres	48.59		146.52		40.72		235.83	

Table 1. Acreage of CWHR habitats by bottomlands sub-reach.

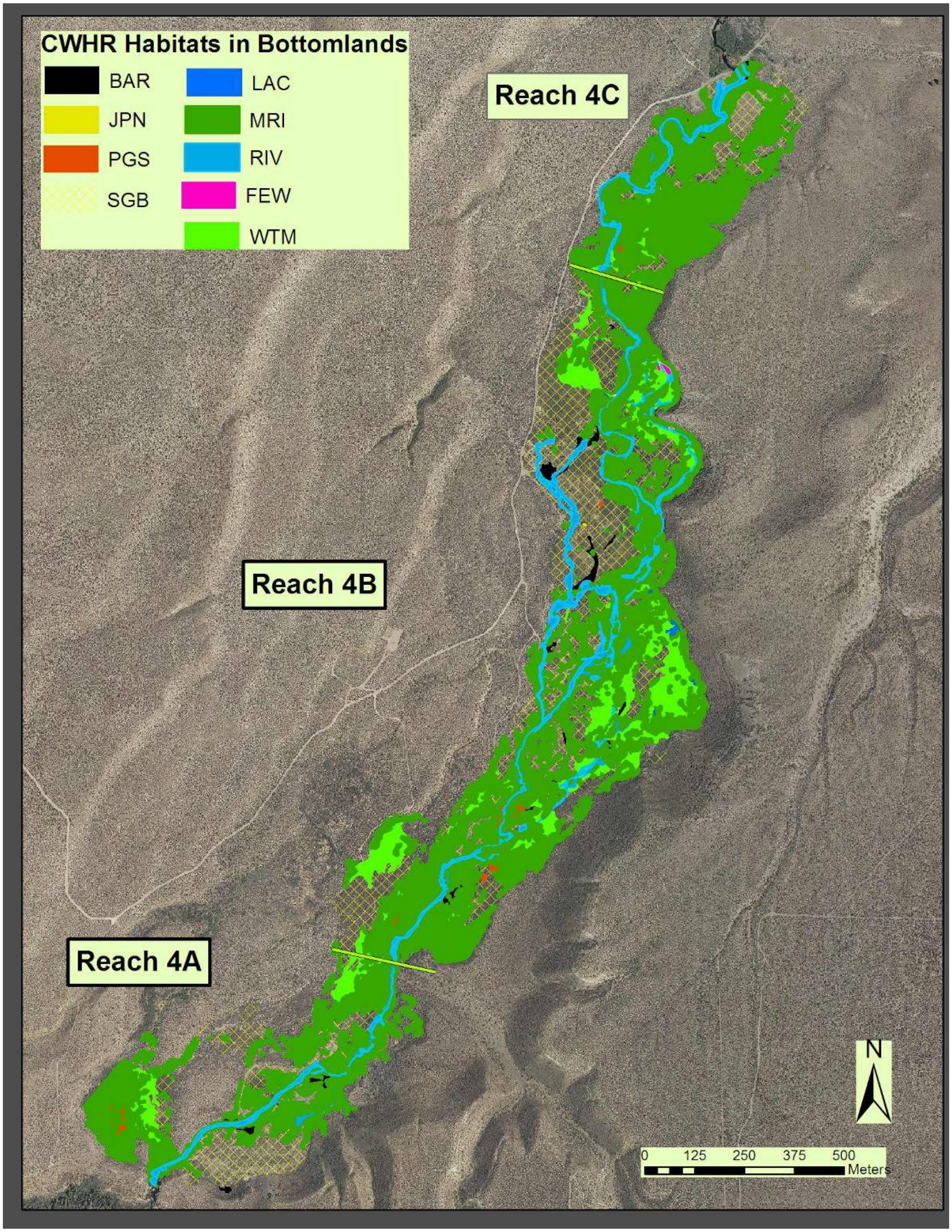

Figure 12. Map showing the distribution of CWHR habitats in the Rush Creek bottomlands

Reach 4A

Reach 4A supports primarily Montane Riparian and Sagebrush habitats. Herbaceous vegetation is found primarily in the Vestal Springs area. Figure 13 is a photo overlooking the Vestal Springs area with the Narrows in the distance, showing the Montane Riparian, Wet Meadow and Sagebrush habitats in this area. The Montane Riparian in Reach 4A is largely composed of moderate to dense (over 40% cover) narrowleaf willow and mixed willow stands. Most of the Wet Meadow acreage was classified as supporting tall (>12" high) dense (>60% cover) vegetation. Perennial Grassland sites were typically dominated by short herbaceous vegetation (<12" high) with moderate canopy cover (40-60% cover). Figure 14 is a view of the mainstem in the 4A reach. The Riverine habitats that occur along the mainstem are primarily gravel/cobble dominated, with few ponds or backwater areas. No Lacustrine sites exist in the 4A reach.

Figure 13. Vestal Springs area in Reach 4A.

Figure 14. Representative photo of the mainstem of Rush Creek in Reach 4A.

Reach 4B

The 4B reach contains the most diverse habitats within the bottomland, and while dominated by Montane Riparian, supports the highest percentage of Wet Meadow and Perennial Grassland. The 4B reach is also the only reach in the bottomlands that supports Lacustrine and Fresh Emergent Wetland vegetation (cattail and bulrush). The Montane Riparian in Reach 4B is largely composed of moderate to dense stands of mixed willow, with lesser amounts of narrowleaf willow and rose. The highest proportion of black cottonwood stands in the bottomlands is in Reach 4B. Black cottonwood stands in this reach were classified primarily as open to dense (25-100% cover), small to medium-sized trees (11 to >24" DBH, or 30 to >45 foot crown diameter), or moderate to dense stands of pole trees (6-10.9" DBH or 15-29.9 foot crown diameter). The vegetation in the wet meadow areas is tall and dense. Perennial Grassland sites were typically dominated by short, sparse to moderate herbaceous vegetation. Riverine areas of the 4B include both gravel and cobble dominated substrate, deep ponds with muddy substrate, sandy-bottomed slow moving areas, areas supporting aquatic submergent or floating-leaved plants, and periodically-flooded unvegetated or sparsely-vegetated banks. Figure 15 shows an area of the mainstem in Reach 4B. The dense scrub willow, scattered black cottonwood trees, gravel dominated substrate with occasional slower backwater areas as shown in this figure are typical components of the mainstem in this sub-reach. Lacustrine areas, present only in the 4B reach, are composed of ponds or periodically-flooded areas with muddy substrate or aquatic vegetation.

Figure 15. Representative photo of the mainstream of Rush Creek in the 4B subreach.

Current Condition of the Waterfowl Channels

<u>10 Channel</u>

The 10 channel carries most of the base flow in the 4B reach downstream of the 8 Channel return. Velocities in the 10 Channel are lower than the mainstem in part due to shallow gradient of this channel. The downstream portion of the 10 Channel is distinctly different than most other areas of the bottomlands. The best waterfowl habitat along the 10 Channel is in the downstream half of the channel where several deep pools, small backwater areas, and beds of submergent aquatic plants including *Ranunculus aquatilis* occur. The downstream area of the 10 Channel is bordered either by overhanging shrub willow (Figure 16), or dense stands of panicled bulrush (*Scirpus microcarpus*) (Figure 17) and other herbaceous species. The 10 Channel also a supports small area of broad-leaved cattail (*Typha latifolia*) which is very limited in the bottomlands (see Figure 17). Off-channel meadow habitats support tall dense herbaceous vegetation that is periodically flooded (Figure 18). Waterfowl were consistently encountered in the area of the 10 Channel shown in Figure 17. The downstream section of the 10 Channel currently is very good waterfowl habitat year-round.

Figure 16. Downstream area of the 10 Channel showing open water areas with overhanging willows used by waterfowl.

Figure 17. Downstream area of the 10 Channel where deep sandy channel with slow velocity is lined by *Scirpus microcarpus* and small stands of *Typha latifolia*.

Figure 18. Periodically-flooded wet meadow habitat bordered by overhanging willows along the 10 Channel.

4Bii

The 4Bii was the second waterfowl channel opening project completed. The channel opening of the 4Bii comes off of the mainstem downstream of its original entrance. The upstream end is narrow, and traverses various habitats including willow and cottonwood stands, Wood's Rose, and Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) with dense grass understory (Figure 19). Further downstream, the 4Bii bifurcates into the 4Biia and 4Biib, before reconverging into the 4Bii. The 4Biia/b area, especially downstream of the reconvergence of 4Biia and 4Biib is where ponded water exists, especially at higher flows. This area supports large shrub willows, emergent and herbaceous wetland vegetation, and seasonal ponds. Figure 20 shows the downstream end of the 4Bii, after reconvergence of the 4Biia and 4Biib. This area consistently attracts waterfowl when flooded, and Green-winged Teal broods have been seen here. The quality of habitat along the 4Bii varies seasonally and with groundwater and or flow conditions. When flooded, shallow open water ponds develop, creating some of the best waterfowl habitats in the bottomlands. When dry, the area still provides dense herbaceous cover that could potentially be used by waterfowl for nesting or roosting.

Figure 19. Rewatered portion of the 4Bii channel. Upstream the convergence of the 4Biia and 4Biib, the channel traverses a variety of habitats including willow and cottonwood stands, Wood's rose, and Wyoming big sagebrush grasslands.

Figure 20. Downstream of the convergence of the 4Biia and 4Biib. When flooded, this area consistently attracts waterfowl and is used for brooding.

8 Channel

The 8 Channel is the most recently-completed channel opening. Prior to rewatering, the 8 Channel area was dominated by sagebrush, with scattered Wood's rose and black cottonwood (Figures 21, 23, 25). Figures 22, 24 and 26 show the same locations after rewatering. At the lower end where the 8 channel returns to the mainstem is the 8 Channel return. Before the 8 Channel was reopened, the 8 Channel return was a small backwater area with flooded shrub willows where waterfowl were encountered (see Figure 25).

The 8 channel was opened in 2007. The bed of the 8 Channel is above the level of the mainstem, and thus water velocities are expected to be lower. Throughout most of its length, the 8 Channel is shallow and gravel-bottomed with only a few small ponds. As of 2009, herbaceous vegetation was still limited. Willow growth has filled in the 8 Channel return area somewhat since perennial flow was established, and thus may lessen use by waterfowl. The ponds and backwater areas along the 8 Channel currently provide some suitable waterfowl habitats, and conditions will likely improve over time as herbaceous cover and food resources develop.

Figure 21. Photo showing typical conditions along the 8 Channel prior to rewatering. Area was primarily sagebrush with scattered black cottonwood trees.

Figure 22. Photo of same location after rewatering

Figure 23. Preproject conditions along the 8 Channel. Area was primarily sagebrush with scattered black cottonwood trees and Wood's rose.

Figure 24. Same location after rewatering. Velocities in the 8 channel are low and the herbaceous component is increasing.

Figure 25. The 8 Channel return prior to rewatering. Waterfowl were encountered in the deep, sandy-bottomed ponds amongst the willows.

Figure 26. The 8 Channel return area after rewatering. Willow recruitment is reducing the area of open water pond.

Reach 4C

Reach 4C is dominated by Montane Riparian vegetation type, with a limited herbaceous component. The Montane Riparian vegetation is composed primarily of moderate to dense tall mixed willow and narrowleaf willow interspersed with relatively large patches of Wood's rose. Black cottonwood is essentially absent in this reach. Herbaceous vegetation is limited to small patches of dry grassland interspersed between rose and willow stands (Figure 27). The very limited wet meadow vegetation is generally short and of sparse to moderate cover. Perennial grassland sites were typically dominated by short, moderately dense herbaceous vegetation. Because of headcutting in this reach, seasonally inundated off channel areas are very limited and no Lacustrine areas exist. Figure 28 is a representative photo of the mainstem in this reach. Riverine areas of the 4C include both gravel and cobble dominated sediment and deep pools with muddy substrate. The steep embankment in the distance is an indication of the headcutting that occurred in this reach. Waterfowl habitat in this reach is limited to some deep pools and backwater areas on the mainstem, and a limited amount of shoreline, some of which is seasonally inundated.

Figure 27. The 4C reach is dominated by tall, dense shrub willows. Small openings in the canopy support dry grassland, Wood's rose or Wyoming big sagebrush.

Figure 28. Representative photo of the mainstem in the 4C reach. The steep embankment in the distance is the effect of past headcutting.

Waterfowl Habitat Suitability

Table 2 shows the suitability class [not suitable (-), low, medium, high] for each CWHR habitat in the bottomlands, and all species evaluated. Barren and Sagebrush are considered unsuitable for all species. Fresh Emergent Wetland has medium to high value for dabbling ducks, and low to medium value for diving ducks. Fresh emergent wetland plants, such as cattail, may be used by some species (such as Ruddy Duck [*Oxyura jamaicensis*]) for nesting and many other species as cover. Other fresh emergent wetlands plant species such as sedges and bulrush supply high quality waterfowl foods. Jeffrey Pine may be used by Wood Duck (*Aix sponsa*) and Bufflehead (*Bucephala albeola*), only if they are of sufficient size, contain a cavity, and are adjacent to water such that they might provide nesting opportunities. Bufflehead are not expected to nest in the Mono Basin, and while Wood Duck does not currently nest in the bottomlands, this species does nest in the Owens Valley and could potentially nest in bottomlands if appropriate habitat existed. Lacustrine habitats provide low to medium suitability habitats for all species. Montane Riparian habitats are considered suitable only for Wood Duck, Mallard, Green-winged Teal, Bufflehead and Common Merganser (*Mergus merganser*). Sparse to open canopies of Montane Riparian habitat are ranked higher quality for most of these species, while dense canopies are unsuitable for Mallard and Green-winged Teal. Perennial Grassland and Wet Meadow may be used for nesting by upland nesting species, or if seasonally-inundated, for foraging by dabbling ducks. Riverine habitat provides low to medium suitability habitat for the majority of waterfowl species.

Table 2. CWHR suitability class for habitats in the bottomlands and waterfowl species evaluated.

Suitability Class of CWHR Habitats	BAR	FEW	JPN	LAC	MRI	PGS	RIV	SGB	WTM
Wood Duck	-	Medium	Low	Low	Low	-	Low	-	-
Gadwall	-	High	-	Low	-	Medium	Low	-	Medium
American Wigeon	-	High	-	Low	-	High	Low	-	High
Mallard	-	High	-	Medium	Low	High	Medium	-	High
Blue-winged Teal	-	Medium	-	Low	-	Medium	-	-	Low
Cinnamon Teal	-	High	-	Low	-	Low	Low	-	Low
Northern Shoveler	-	High	-	Low	-	High	NS	-	Low
Northern Pintail	-	High	-	Medium	-	High	Low	-	High
Green-winged Teal	-	High	-	Low	Low	High	Low	-	High
Canvasback	-	High	-	Medium	-	-	Low	-	-
Redhead	-	High	-	Low	-	-	Low	-	-
Ring-necked Duck	-	High	-	Low	-	-	-	-	High
Lesser Scaup	-	Medium	-	Medium	-	Low	Medium	-	Low
Bufflehead	-	Low	Low	Medium	Low	-	-	-	-
Common Goldeneye	-	-	-	Low	-	-	Low	-	-
Hooded Merganser	-	Medium	-	Low	-	-	Low	-	-
Common Merganser	-	Medium	-	Medium	Low	-	Low	-	Low
Ruddy Duck	-	Medium	-	Low	-	-	-	-	-

Figure 29 shows the total acreage of low, medium and high suitability habitat for each waterfowl species evaluated. Habitats in the bottomlands are generally more suitable for dabbling ducks than diving ducks. The greatest total acreage of suitable habitat exists for Mallard and Green-winged Teal with a greater proportion of high value habitat available for Mallard than Green-winged Teal. Areas of sparse to open cover of Montane Riparian vegetation are considered suitable for waterfowl; however areas of moderate to dense cover are not suitable. Woody riparian vegetation in the bottomlands is mostly dense cover. Sparse to open cover can be found on some point bars and meander bends. High suitability habitat is also available for Gadwall (*Anas strepera*), American Wigeon (*Anas americana*) and Northern Pintail (*Anas acuta*). Habitat for Wood Duck, Blue-winged Teal (*Anas discors*), Cinnamon Teal (*Anas cyanoptera*), and Northern Shoveler (*Anas clypeatais*) is primarily composed of low suitability areas. Of the divers, the most suitable habitat is available for Lesser Scaup (*Aythya affinis*), Common Merganser and Ring-necked Duck (*Aythya collaris*). This model does not take into account landscape level factors that may affect actual use such as total area of habitat or the proximity of certain habitats to one another.

Habitat suitability maps for Mallard (Figure 30) and Green-winged Teal (Figure 31) were created based on the output from CWHR. In Reach 4A, the suitable habitat identified for Mallard includes the meadow portions of Vestal Springs, wet meadow habitat near the creek corridor, and the entire main channel of Rush Creek. Vestal Springs was considered not suitable for Green-winged Teal due to its distance from water. Suitable habitat is most abundant and widely dispersed for both species in Reach 4B and includes areas along the mainstem, 10 Channel, 4Bii, and 8 Channel. Suitable habitat in Reach 4C is primarily the mainstem, and sparsely vegetated or periodically-flooded meander bends and streambank areas adjacent to the mainstem.

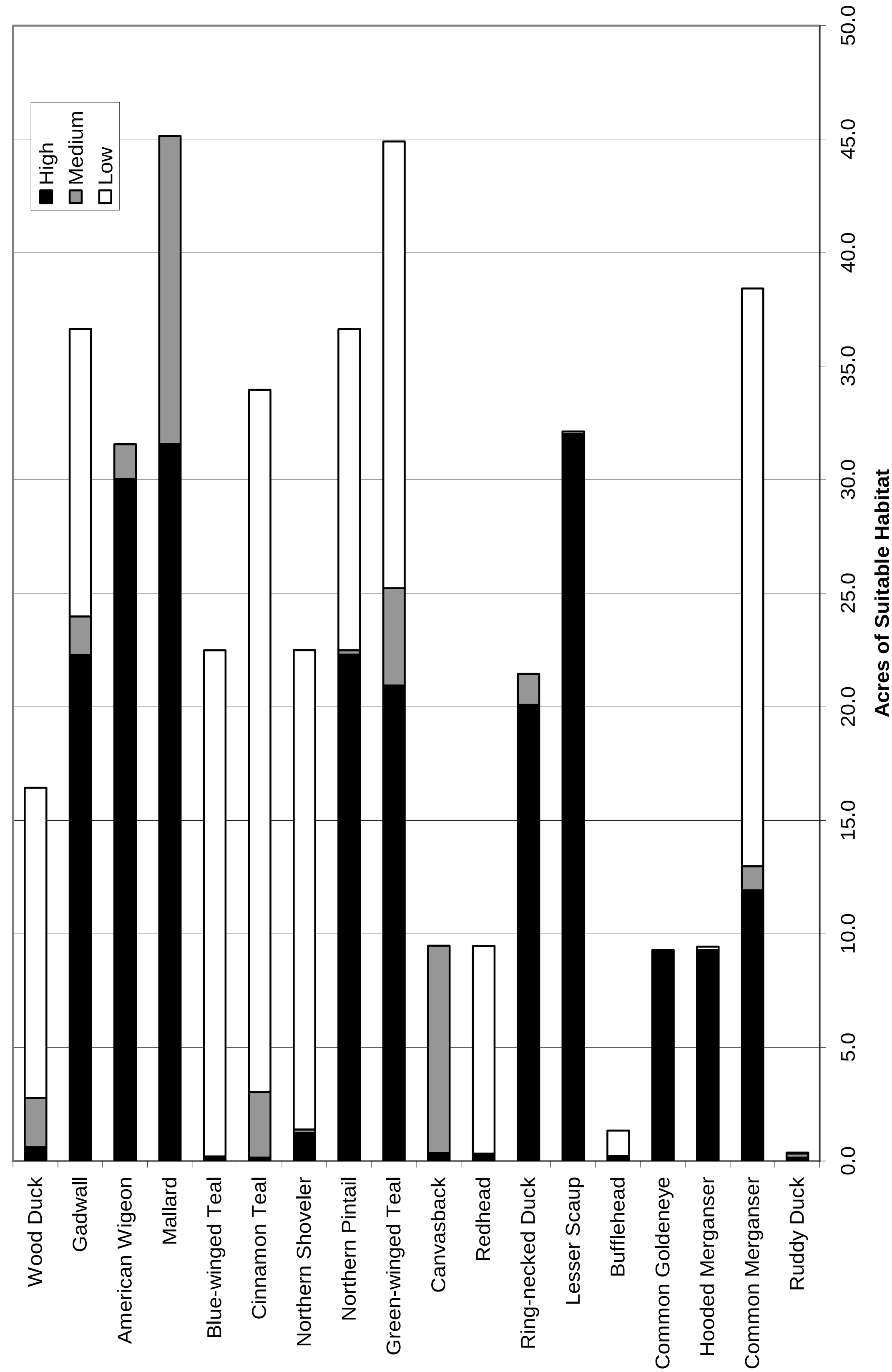

Figure 29. The acreage of low, medium and high suitability habitat for waterfowl in the bottomlands, as determined using CWHR.

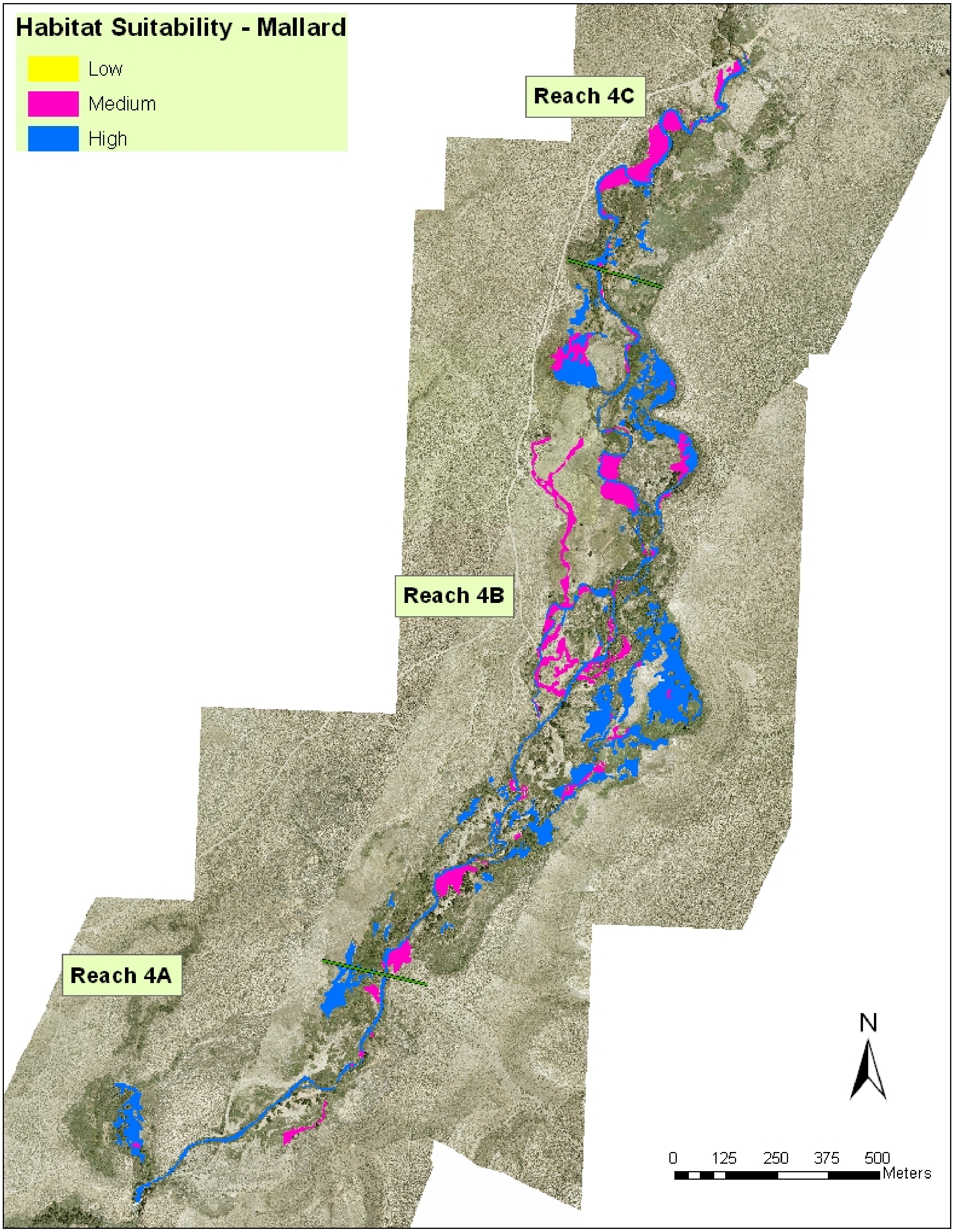

Figure 30. CWHR habitat suitability map for Mallard.

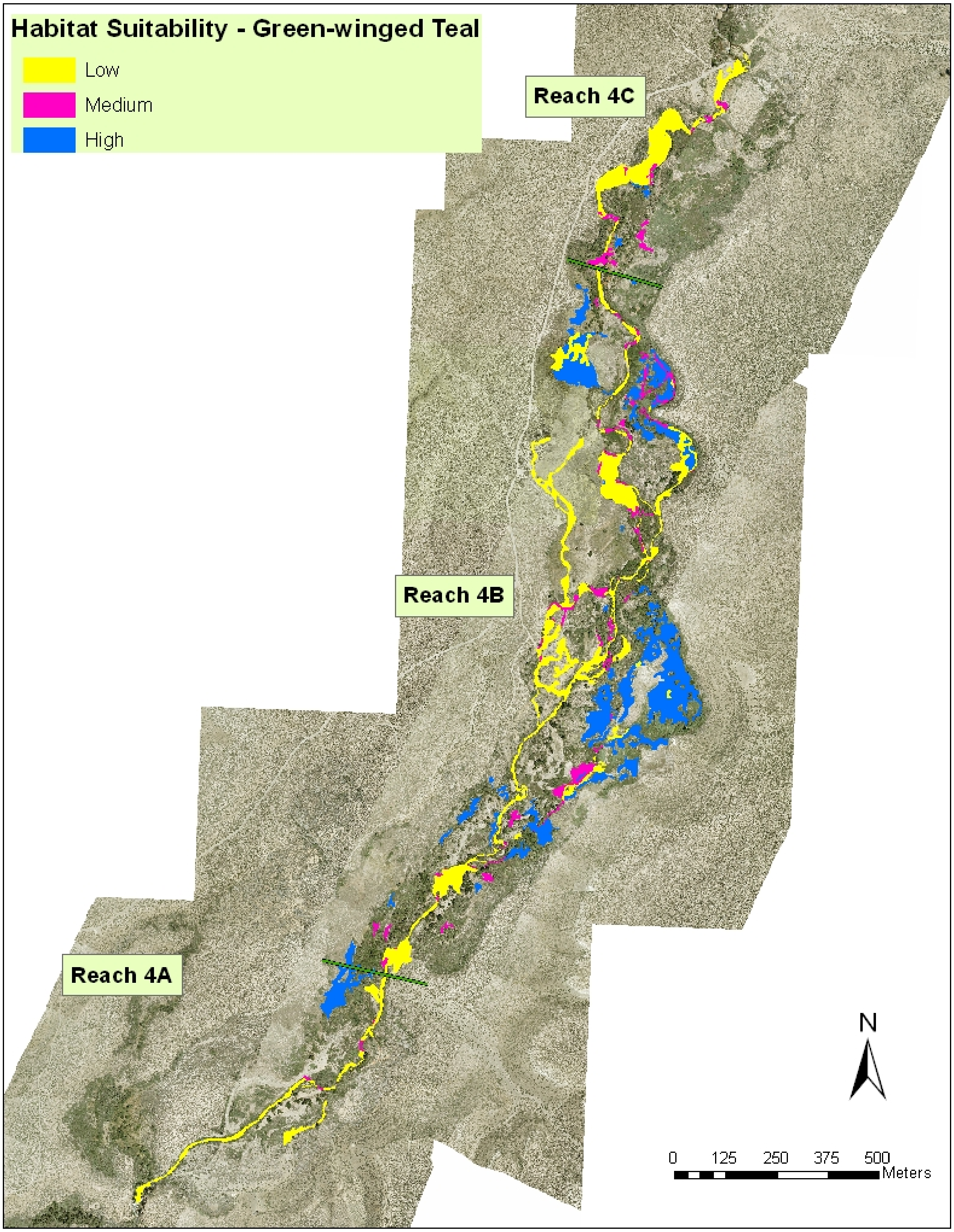

Figure 31. CWHR habitat suitability map for Green-winged Teal.

Waterfowl Use Observed in the Bottomlands

Use of the Rush Creek bottomlands by waterfowl was minimal. Only two species of waterfowl were encountered during site visits – Mallard and Green-winged Teal. More ducks were encountered during surveys in spring than at other seasons. No ducks were encountered during the January 2009 visit. The most ducks seen in any site visit was on May 1, 2007 when 14-17 ducks were encountered, including at least three Mallard pairs and two Green-winged Teal pairs. Figure 32 shows locations where waterfowl were detected by species. Waterfowl were seen primarily along the 10-channel, the 8-channel return, 4Bii channel, and the mainstem in the vicinity of the 8-channel return. No waterfowl were encountered in Reach 4A during the visit in June 2007. Waterfowl activity was minimal in Reach 4C.

Waterfowl in the bottomlands were primarily in areas of slow-moving water, flooded meadow and flooded willow, and occasionally resting along banks of the mainstem. Mallard likely nest in the bottomlands, however no nests or broods were found. Green-winged Teal nests and broods were found in the 4B reach. Figure 33 indicates one location where a Green-winged Teal nest was found on June 13, 2007, located in creeping wild rye (*Leymus cinereus*) under a small dead rubber rabbitbrush. This nest was along the mainstem east of the 8 Channel. The nest contained 6 intact eggs and two predated eggs. A partially eaten dead female Green-winged Teal was also found on the streambank nearby. Figure 34 shows another nest site, this one along the 10 Channel. A female Green-winged Teal was flushed from underneath this decadent rabbitbrush and an old Green-winged Teal nest with one remaining egg was found. It is suspected that this site was going to be reused. A male Green-winged Teal was also in this area, as was a Mallard pair that may have been nesting. Figure 35 shows a site along the extreme downstream area of 4Bii where another Green-winged Teal was suspected of nesting under a rose or willow at the edge of the wet meadow habitat. Figure 36 is the area at the downstream section of the 4Bii where Green-winged Teal broods were encountered.

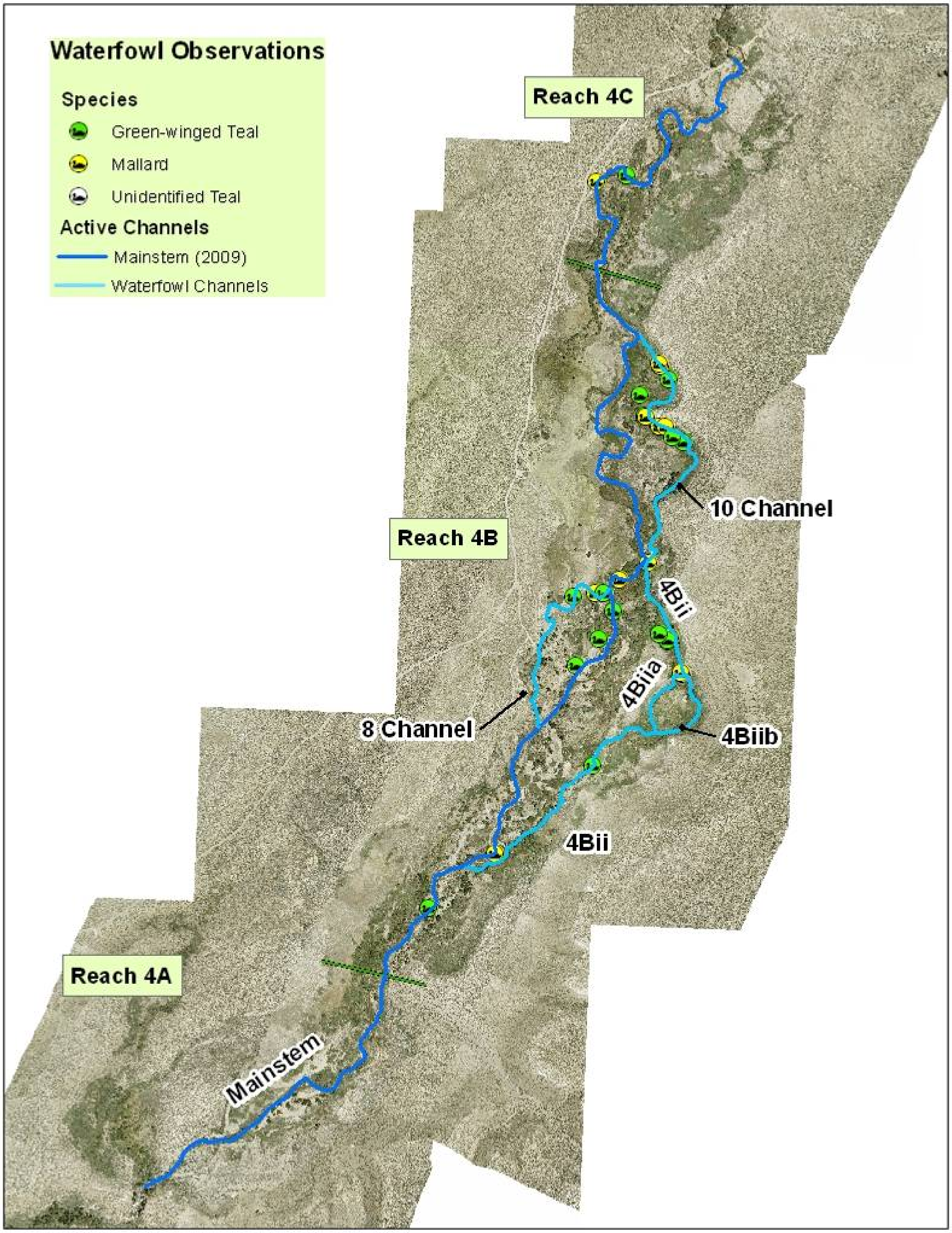

Figure 32. Locations of waterfowl detected in the bottomlands during site visits.

Figure 33. Red arrow marks location of Green-winged Teal nest along mainstem.

Figure 34. Green-winged Teal nest site along 10 Channel

Figure 35. General area of suspected Green –winged Teal Nest along the 4Bii.

Figure 36. Seasonally-flooded pond where Green-winged Teal broods and other waterfowl activity was observed.

Comparison with 1990 Conditions

As compared to 1990 conditions, habitat conditions for waterfowl have improved in general. These habitat increases are a result of the implementation of stream restoration flows and channel openings associated with the Stream Restoration Plan. Figure 37 shows the total amount of suitable acreage in 1990 as compared to 2009 conditions. Increases in suitable habitat have been greatest for dabbling duck species, and some diving duck species. Slight decreases were observed for some diving duck species for which only limited habitat exists. Increase in suitable acreage is primarily the result of increases in Wet Meadow, perennially or periodically-flooded Riverine habitat, and Lacustrine habitat.

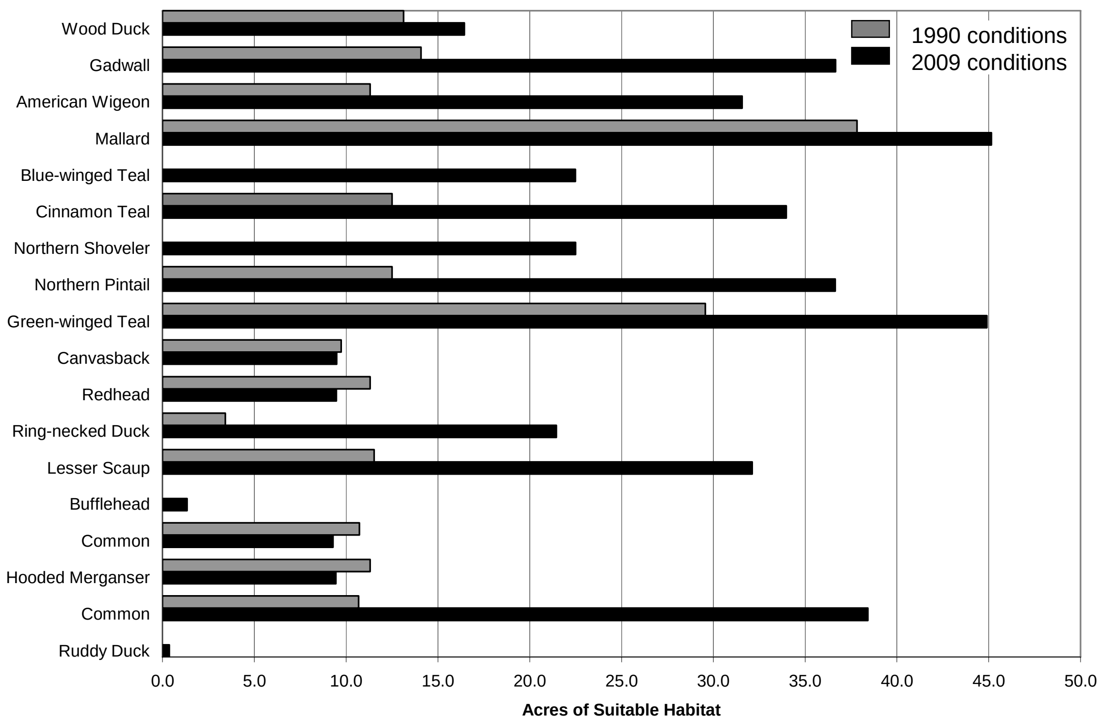

Figure 37. Comparison of acreage of suitable habitat for waterfowl in 1990 (prior to implementation of the Stream Restoration Plan) and 2008.

Discussion

The bottomlands support some of the best, and most extensive waterfowl habitat that exists along Rush Creek. However, even under pre-diversion conditions, the bottomlands were probably never a center of duck abundance in the Mono Basin. Under current conditions, and likely under pre-diversion conditions, the lake-fringing ponds and creek deltas are where waterfowl are most abundant at Mono Lake. Sometimes human perception of "abundance" is more accurately defined as frequency of encounter. Without actual waterfowl use data of the bottomlands under pre-diversion conditions, any change in waterfowl use is difficult to evaluate.

Higher waterfowl use in the bottomlands may have occurred historically than was observed during this study due to a number of factors. Until the late 1940's, beaver presence in the bottomlands would have created ponds that would have attracted waterfowl. Livestock grazing practices during that time period would have created more open meadow habitats, which when flooded, may have provided additional foraging opportunities for some species (namely Mallard). Grazing cessation has allowed the development of meadows that support tall, lush vegetation that provide potential nesting habitat, cover, and food resources in terms of plant seeds, but whose structure does not favor foraging unless flooded. The hydrologic conditions of these meadows are less predictable since they are no longer receiving supplemental irrigation from the Indian Ditch. High-quality flooded or periodically-flooded wet meadow habitat exists today in the bottomlands. Portions of the bottomlands that support this habitat type (e.g. downstream areas of the 10 Channel and the 4Bii) were areas where waterfowl were frequently encountered and observed nesting and brooding during sites visits associated with this evaluation. Under current conditions and flow regimes, it is expected that waterfowl use of the bottomlands would be less in dry years, and higher in wet years, when flooding of meadow habitats and off-river sites would be greatest.

Woody riparian vegetation has increased since implementation of the Stream Restoration Plan and portions of the Waterfowl Plan specific to Rush Creek bottomlands. Restoration activities have improved overall conditions of the riparian corridor in the bottomlands by expanding the woody riparian vegetation and wet meadow habitats. Although certain stages of Montane Riparian habitat are used by some species for nesting (e.g. Wood Duck needs moderate to large-sized trees), Montane Riparian is generally of low suitability for most waterfowl species. Since Montane Riparian is the dominant wetland plant community type in the bottomlands, its effect on overall waterfowl use should be considered when developing future expectations. Open early successional stands of Montane Riparian are most suitable for waterfowl, while tall, dense shrubby woody riparian vegetation is not expected to receive much use. Waterfowl were observed in and around tall dense willows overhanging water in both mainstem and side channel areas. Although mature riparian vegetation is less attractive to some waterfowl, over time microhabitats associated with mature riparian vegetation such as backwater areas and overhanging vegetation, may improve overall stream conditions for waterfowl in this Montane Riparian dominated system.

The rewatering of the 10 channel, 8 channel and 4bii have created areas of slow-moving water, ponds, backwater areas and other areas potentially attractive to waterfowl. The 10-channel which has had the longest time to develop, provides very good waterfowl habitat year round. The long-term stability of this area is uncertain however since the channel is 4-5 feet above the mainstem and the downstream checkpoint is a willow. The 4bii area provides excellent foraging and brooding habitat when flooded, so the quality of this area is more dependent upon precipitation year type, stream flow, and ground water levels. At the time of this study, the 8-channel was newly implemented; however, the 8-channel supports several small ponds and backwater areas that should be attractive to waterfowl.

The availability and abundance of food resources for waterfowl in the bottomlands must also be considered. Vegetation studies in the bottomlands have not documented aquatic plants, therefore information on this important waterfowl food source is limited. Additionally, plant species composition of potentially important waterfowl habitats in specific locations (e.g. 10 Channel, 4Bii) have not been documented. Plant species composition at particular sites may influence waterfowl use because specific food resources (both plant and animal) are associated with different plant communties. As Beshta remarked (1994), Rush Creek is a borderline oligotrophic stream, meaning that it is a relatively low organic system with limited nutrients and plant material. This factor too may limit overall use by waterfowl which consume aquatic and emergent plant and plant parts, and aquatic invertebrates. The dietary habitats vary between the different waterfowl groups (geese, dabbling ducks, diving ducks, etc), and also seasonally within some groups. Waterfowl generally forage in wetland habitats, consuming plant parts, aquatic or terrestrial invertebrates, crustaceans, or small fish. Dabbling ducks consume both animal and plant food material, however, the diet of many species varies seasonally. Typically, the proportion of the diet composed of animal food sources increases during the breeding season, while plant food sources are consumed in greater proportion during non-breeding periods. For dabbling ducks, seeds are the main plant part consumed.

Wetland plant communities provide both a direct or indirect source of food for waterfowl. Wetland plant community types include submergent plants (rooted plants whose vegetative material is completely underwater), floating-leaved plants (both rooted and free-floating), and emergent.

Submergent plants provide a direct source of food as waterfowl will consume tubers, leafy material, or seeds of some submergent plant species. Submergent plants also support macroinvertebrate production and therefore indirectly affect food resources. The submergent plant species that are good as a direct source of food are not necessarily the same species that support the highest populations of macroinvertebrates consumed by waterfowl. Waterfowl are known to eat the fruits of *Ranunculus aquatilis* in small quantities (Martin and Uhler 1939), and this species is abundant in some parts of the bottomlands, particularly areas of the 10 Channel.

Plant species that are part of the floating-leaved community includes rooted species, and free-floating aquatic plants. Free-floating plants can be more accessible to waterfowl than submergent species, there are only a few floating-leaved plant species that produce waterfowl food of much value (Baldasserre and Bolen 1994). Some smartweed species (*Polygonum* spp.) and a few pondweed species (especially *Potamogeton natans*) produce seeds that are of fair to good quality for waterfowl. Free-floating aquatic plants in the family Lemnaceae, including the genera *Lemma*, *Spirodela*, *Wolffiella*, and *Wolffia*, are known as duckweeds, duckmeats, or bogmats. *Lemma* was observed along small side channels in the 4B reach. Despite the common names, these plants are not important waterfowl foods. These free-floating aquatic plants do however support aquatic invertebrate production, and therefore may be consumed in small quantities as waterfowl forage for aquatic invertebrates associated with these plants.

Emergent plants provide primarily cover while some species are key food sources. Bulrushes of the leafy triangular-stemmed type such as alkali bulrush (*Schoenoplectus maritimus*) are key food producers. Other species such as hardstem bulrush (*S. acutus*), softstem bulrush (*S. tabernaemontani*), California bulrush (*S. californicus*) produce desirable nutlets. *Scirpus microcarpus* found in the 4B, especially along the 10 Channel, is a desirable food plant species for waterfowl. Cattails, (*Typha* spp.) are important for cover and nesting for some species, but are not a direct food source. Grass and sedges also occur in the emergent zone, and some species are highly valuable as waterfowl foods. Species in this group that occur in this region include sedges (*Cyperus* spp.), and spikerushes (*Eleocharis* spp.). Waterfowl may eat the seeds of rushes (Family Juncacae) when available, but these species are not considered highly valuable food resources. Saltgrass (*Distichlis spicata*) seeds may also be consumed.

In summary, habitat conditions for waterfowl in the bottomlands have improved since implementation of the Stream and Waterfowl Habitat Restoration Plans. The acreages of important waterfowl habitats such as Wet Meadow, Lacustrine and Fresh Emergent Wetland have increased as compared to 1990 conditions. The most important factor in improved habitat conditions has been the reestablishment of perennial flow in the creek. The restoration activities completed in the bottomlands have further improved conditions for waterfowl. Channel openings have created additional waterfowl habitat by providing lower velocity sites more suitable for waterfowl than higher velocities observed in the mainstem. Waterfowl habitat in the bottomlands however will continue to be restricted to relatively small patches in scattered locations in the bottomlands with the majority of the high suitability habitats in the 4B sub-reach. The dominance of woody riparian vegetation in the system limits the suitability of the habitat to a small suite of waterfowl species. Restoration habitat flows will continue to raise water tables, resulting in the flooding of additional off-channel areas, extending inundation periods, and improving waterfowl habitat quality.

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Appendix 1. UTM coordinates for photos in document. Datum is NAD 27 CONUS.

Figure Number	Photo Date	Reach	Easting	Northing	Reach/Channel
Figure 13	12-Jun-07	4A	317243	4198408	4A
Figure 14	12-Jun-07	4A	317837	4198587	4A
Figure 15	13-Jun-07	4B	317839	4198686	4B
Figure 16	14-Jun-07	4B	318484	4200022	4B/10 Channel
Figure 17	30-Sep-08	4B	318532	4200135	4B/10 Channel
Figure 18	23-Jun-08	4B	318530	4199982	4B/10 Channel
Figure 19	30-Sep-08	4B	318240	4199054	4B/4Bii
Figure 21	2-Apr-07	4B	318220	4199484	4B/8 Channel
Figure 22	30-Sep-08	4B	318220	4199484	4B/8 Channel
Figure 23	2-Apr-07	4B	318287	4199559	4B/8 Channel
Figure 24	30-Sep-08	4B	318287	4199559	4B/8 Channel
Figure 25	2-Apr-07	4B	318332	4199611	4B/8 Channel
Figure 26	30-Sep-08	4B	318332	4199611	4B/8 Channel
Figure 27	14-Jun-07	4C	318558	4200624	4C
Figure 28	14-Jun-07	4C	318557	4200771	4C
Figure 33	13-Jun-07	4B	318296	4199404	4B
Figure 34	23-Jun-08	4B	318574	4199970	4B/10 Channel
Figure 35	23-Jun-08	4B	318526	4199488	4B/4Bii
Figure 36	13-Jun-07	4B	318536	4199468	4B/4Bii

Appendix 2. Cross-walk for CWHR habitats to mapped Rush Creek vegetation communities

River		
CHWR_Habitats	**Habitat Description**	**RUCR Mapped VEG_NAME**
RIV	Riverine	Open aquatic
RIV	Riverine	Aquatic emergent
RIV	Riverine	Barren (streambank)
SIZE_CLASSES		
Code	**Descriptor**	**Description**
1	Open Water	Water greater than 2 meters in depth
2	Submerged	Area of permanent water between "open water" and shore
3	Periodically Flooded	Unvegetated areas that are periodically flooded
4	Shore	Seldom-flooded areas with < 10% vegetative cover
STAGES		
Code	**Descriptor**	**Substrate**
O	Organic	Algae, duckweed or plant material present
M	Mud	Mud substrate
S	Sand	Sandy substrate
G	Gravel/cobble	Substrate of gravel or cobble
R	Rubble/boulders	Substrate of rubble or boulders
B	Bedrock	Bedrock
Off-river wetted areas		
CHWR_Habitats	**Habitat Description**	**RUCR Mapped VEG_NAME**
LAC	Lacustrine	Open aquatic
LAC	Lacustrine	Aquatic emergent
SIZE_CLASSES		
Code	**Descriptor**	**Description**
1	Limnetic	Deep water beyond light penetration (no stage code)
2	Submerged	Ponds that are shallow enough to allow light penetration
3	Periodically Flooded	Unvegetaed areas that are periodically flooded
4	Shore	Water's edge with less than 2% vegetation
STAGES		
Code	**Descriptor**	**Substrate**
O	Organic	Algae, duckweed or plant material present
M	Mud	Mud substrate
S	Sand	Sandy substrate
G	Gravel/cobble	Substrate of gravel or cobble
R	Rubble/boulders	Substrate of rubble or boulders
B	Bedrock	Bedrock
Riparian Woody Vegetation		
CHWR_Habitats	**Habitat Description**	**RUCR Mapped VEG_NAME**
MRI	Montane Riparian	Rose
MRI	Montane Riparian	Narrowleaf willow
MRI	Montane Riparian	Yellow Willow
MRI	Montane Riparian	Mixed Willow
MRI	Montane Riparian	Pacific/shiny willow
MRI	Montane Riparian	Black Cottonwood
SIZE_CLASSES		
Code	**Descriptor**	**Crown Diameter/DBH**
1	Seeding tree	DBH < 1"
2	Sapling tree	< 15 feet; DBH 1 - 5.9"
3	Pole tree	15 - 29.9 feet; DBH 6 - 10.9"
4	Small tree	30 - 44.9 feet; DBH 11 - 23.9"
5	Med/large tree	> 45 feet; DBH > 24"
NOTE:	*Riparian shrub habitats will either be size class 1 or 2 only*	
STAGES		
Code	**Descriptor**	**Average Cover**
S	Sparse	10 - 24.9%
P	Open	25 - 39.9%
M	Moderate	40 - 59.9%
D	Dense	> 60%

Appendix 2, cont. Cross-walk for CWHR habitats

Forested Habitat		
CHWR_Habitats	**Habitat Description**	**RUCR Mapped VEG_NAME**
JPN	Jeffrey Pine	Jeffrey Pine
SIZE_CLASSES		
Code	**Descriptor**	**Crown Diameter/DBH**
1	Seeding tree	DBH < 1"
2	Sapling tree	DBH 1 - 5.9"
3	Pole tree	<12 feet; DBH 6 - 10.9"
4	Small tree	12-23.9 feet; DBH 11 - 23.9"
5	Med/large tree	> 24 feet; DBH > 24"
6	Multilayer tree	A distinct layer of size class 5 trees over a distinct layer of size 4 and/or 3 trees, and total tree canopy of layers >/=60%
STAGES		
Code	**Descriptor**	**Average Cover**
S	Sparse	10 - 24.9%
P	Open	25 - 39.9%
M	Moderate	40 - 59.9%
D	Dense	> 60%

Herbaceous Habitats		
CHWR_Habitats	**Habitat Description**	**RUCR Mapped VEG_NAME**
PGS	Perennial Grassland	Great Basin Grassland
WTM	Wet Meadow	Great Basin Grassland (high water table)
FEM	Fresh Emergent Wetland	Cattail
SIZE_CLASSES		
Code	**Descriptor**	**Description**
1	Short herb	< 12" tall at maturity
2	Tall herb	> 12.1" tall at maturity
STAGES		
Code	**Descriptor**	**Average Cover**
S	Sparse	2 - 9.9%
P	Open	10 - 39.9%
M	Moderate	40 - 59.9
D	Dense	> 60%

Shrub Habitats		
CHWR_Habitats	**Habitat Description**	**RUCR Mapped VEG_NAME**
BBR	Bitterbrush	Mountain Mahogany
BBR	Bitterbrush	Sagebrush/bitterbrush
SGB	Sagebrush	Sagebrush/rose
SGB	Sagebrush	Buffalo berry
SGB	Sagebrush	Sagebrush
SGB	Sagebrush	Rabbitbrush
SGB	Sagebrush	Sagebrush/GB grassland
SGB	Sagebrush	Rabbitbrush/native grass
SIZE_CLASSES		
Code	**Descriptor**	**Description**
1	Seedling Shrubs	Seedlings; < 3yrs old
2	Young shrub	< 1% crown decadence
3	Mature shrub	1 - 24.9 % crown decadence
4	Decadent shrub	> 25 % crown decadence
STAGES		
Code	**Descriptor**	**Average Cover**
S	Sparse	10 - 24.9%
P	Open	25 - 39.9%
M	Moderate	40 - 59.9%
D	Dense	> 60%