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FALL WATERFOWL USE OF BRIDGEPORT RESERVOIR, MONO COUNTY, CALIFORNIA

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ABSTRACT: Aerial surveys from 2003 to 2019 documented the abundance of waterfowl at Bridgeport Reservoir in Mono County, California, from September through mid-November. Waterfowl totals at Bridgeport Reservoir averaged 33,106 ± 4050 (standard error) in the fall. Annual peak counts averaged 10,474 ± 1349, ranging from a low of 2583 in 2014 to the highest single-day count of 23,150 in 2005. Bridgeport Reservoir is a man-made water body in the intermountain West that waterfowl use primarily a mid-migration stopover site, with peak numbers occurring in September. The dominant waterfowl species, the Northern Shoveler (*Spatula clypeata*), Gadwall (*Mareca strepera*), Mallard (*Anas platyrhynchos*), Northern Pintail (*A. acuta*), and Green-winged Teal (*A. crecca*), showed both unimodal and bimodal migration chronologies. Regional drought, as indicated by the Palmer drought severity index, combined with a downward trend in waterfowl numbers explained 61.4% of annual variation in fall waterfowl totals. These data may allow future assessment of change in waterfowl abundance at Bridgeport Reservoir in the context of local or regional conditions, and as influenced by climate change.

Although developed for water storage to serve municipal, agricultural, or flood-control needs, reservoirs often also provide habitat for waterbirds. Designed to store water for agricultural irrigation, Bridgeport Reservoir is part of the Bridgeport Valley Important Bird Area designated by California Audubon (Cooper 2004). The reservoir lies within the intermountain West portion of the Pacific Flyway, a region where water and wetland resources carry a high value to wildlife, given their scarceness on the landscape. Despite the potential importance of the Bridgeport area, there have been few avian studies of the reservoir proper. Published data on waterfowl use are lacking, and previous data from aerial surveys of waterfowl are limited to counts in October 1996 and September 1997 (J. R. Jehl, unpubl. data).

From 2003 to 2019, I conducted aerial waterfowl surveys from September through mid-November at Bridgeport Reservoir in conjunction with waterfowl surveys of two other Mono County lakes, Mono Lake and Crowley Reservoir. These surveys contributed to the Mono Basin Waterfowl Habitat Restoration Plan (LADWP 1996), with data from Bridgeport Reservoir serv-

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ing as a basis for comparison with waterfowl numbers at Mono Lake, 29 km to the south-southeast in the same flyway. In this paper I describe the size, species composition, and migration phenology of fall waterfowl populations at Bridgeport Reservoir. I also investigated regional and local environmental factors influencing annual waterfowl abundance.

SURVEY AREA

Bridgeport Reservoir is located in Bridgeport Valley in northern Mono County, California, at an elevation of 1969 meters (Figure 1). The area has an arid continental climate (Zellmer 1977) with relatively cool, mild summers and cold, snowy winters (Sharpe et al. 2008). Annual precipitation averages 22.8 cm, mostly in the form of snow (Sharpe et al. 2008). By mid-September, average minimum temperatures drop below 0 °C (Western Regional Climate Center, https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca1075). The reservoir's surface usually freezes over in winter, with ice typically developing by mid- to late November.

Bridgeport Reservoir was completed in 1923 to provide irrigation water to Smith and Mason valleys in Nevada (Sharpe et al. 2008) and currently also supports a recreational fishery, wildlife use, and other recreational activities including birding and hunting. The reservoir is owned and operated by the Walker River Irrigation District, based in Nevada, but the California State Water Resources Control Board controls storage and releases (Horton 1996).

The reservoir covers approximately 12.5 km^2 and is rather shallow (mean depth 4.6 m, maximum depth 13.3 m; Horne 2003). When at maximum storage, approximately half of the reservoir is less than 3 m deep (Horne 2003). Because of the shallow sloping topography of the southwestern portion of the valley, the reservoir's surface area varies greatly with the water level.

Bridgeport Reservoir is part of the hydrologically closed Walker River basin, which straddles the California/Nevada border. Several creeks originating from the east slope of the Sierra Nevada drain toward Bridgeport Reservoir. Creek water is diverted for upslope irrigation of rangeland, supporting the valley's primary land use of cattle grazing. The creeks directly tributary to the reservoir are the East Walker River, Robinson Creek, and Buckeye Creek (Figure 1). Downstream of Bridgeport Reservoir Dam, the East Walker River continues into Nevada, joining the West Walker River, and ultimately discharging into the terminal Walker Lake, Nevada. In Nevada, the Walker River system supports extensive agriculture.

Flood-irrigated pastures border the gently sloping southern and southwestern portion of Bridgeport Reservoir, while Great Basin scrub is dominant along the more steeply sloped north arm and east shore. In shallow areas and creek deltas, submergent aquatic vegetation is abundant, including broad beds of water smartweed (*Persicaria amphibia* var. *stipulacea*). Marsh, dense wetlands, and woody riparian vegetation are lacking in the immediate vicinity of the reservoir and Bridgeport Valley proper. The reservoir is eutrophic because of high nutrient loading and experiences summer blooms of colonial cyanobacteria that form a dense floating scum (Horne 2003).

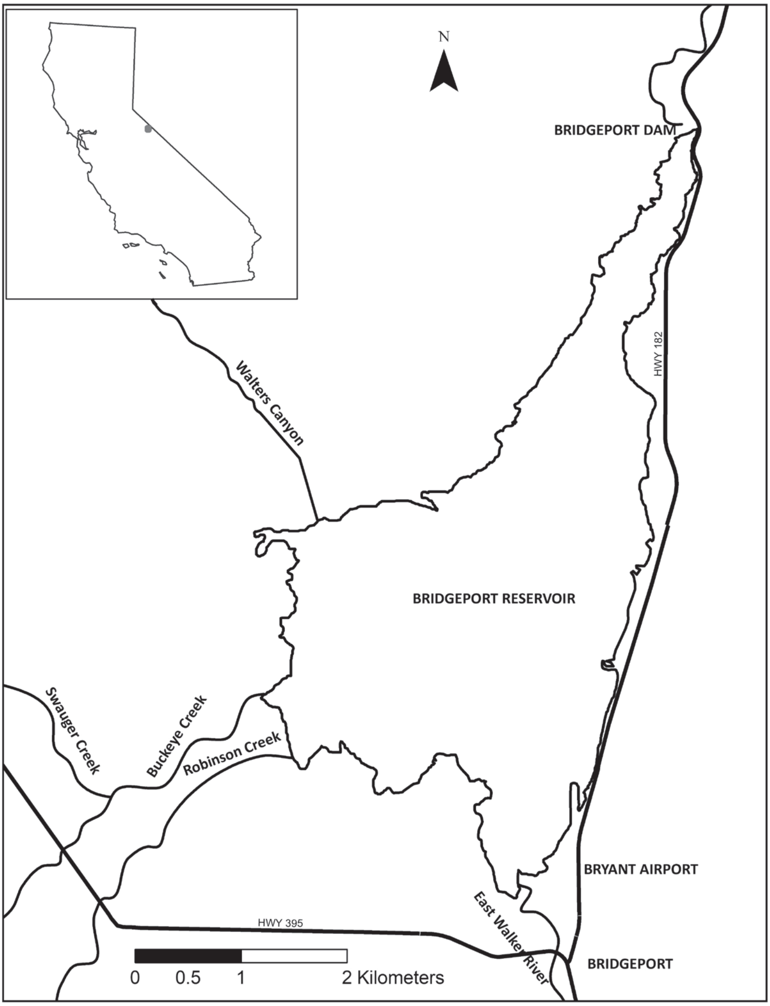

Figure 1. Location of Bridgeport Reservoir (inset), and tributary creeks.

METHODS

Waterfowl Surveys

I surveyed the waterfowl of Bridgeport Reservoir annually each fall from 2003 to 2019. Six surveys were completed at two-week intervals, starting the first week of September and ending in mid-November. A total of 102 surveys were completed over the 17-year study period.

Surveys were from a fixed-wing four-passenger airplane traveling at approximately 130 km/hr at a height of approximately 60 m above ground level. Surveys took place in the morning, generally between 10:00 and 11:00 Pacific time, and were completed in approximately 20 minutes. The entire shoreline was circumnavigated twice, with an additional transect made over the open water of the southern end of the reservoir when birds were spread out into the bay and not well viewed during the shoreline flight.

During the flights, observers used a voice recorder to record waterfowl numbers and species composition and transcribed survey data later. Waterfowl were identified to species when possible, or to the lowest identifiable category, e.g., "unidentified teal." Some closely related species difficult to identify reliably from an aircraft were combined into groups. The "Cinnamon Teal" (*Spatula cyanoptera*) may include some Blue-winged Teal (*S. discors*), a species seen in low numbers in Mono County (pers. obs.), and the "Lesser Scaup" (*Aythya affinis*) could include a few Greater Scaup (*A. marila*), a species also seen only infrequently in small numbers. Two observers were present on all flights, including one assistant besides myself. Consistency of observers has been high over the length of the study, as I was on all but one flight over the 17-year period, and there was little turnover in second observers.

DATA SUMMARY

Waterfowl Totals

The six survey periods were defined as early September (first week), mid-September, end September (includes the first week of October in some years), mid-October, end October, and mid-November. I generated totals for each survey period by summing all waterfowl (family Anatidae), including those not identified to species, then calculated total annual fall waterfowl abundance by summing the totals for the six survey periods. For each survey period, I calculated the mean, standard error, and low and high counts for the 2003–2019 study period. Descriptive statistics calculated for total fall waterfowl abundance for the duration of the study were annual mean and standard error and high and low totals for each year.

Species Composition

For each species, for the period 2003–2019, I calculated the mean by survey period, total annual mean, and standard error. In addition, I assessed community composition by grouping species into three broader categories: geese and swans, dabbling ducks, and diving ducks. The proportional abundance of each species group was calculated on the basis of totals over all surveys combined.

Migration Chronology

I assessed the intraseasonal pattern of waterfowl abundance at Bridgeport Reservoir by evaluating the mean and standard error of the totals for each survey period, 2003 to 2019, of the six most abundant ducks, the Green-winged Teal (*Anas crecca*), Gadwall (*Mareca strepera*), Mallard (*A. platyrhynchos*), Northern Pintail (*A. acuta*), Northern Shoveler (*Spatula clypeata*), and Ruddy Duck (*Oxyura jamaicensis*). I then calculated the proportion, with its standard error, of each species' total by survey period with respect to its yearly total. I used the proportion of the yearly total rather than the actual survey total to standardize for variation from year to year. To interpolate species' abundance between surveys I used a cubic spline, a polynomial function that smooths curves and estimates the values of peaks that may have occurred between surveys (Gilmer et al. 2004).

Variables Influencing Waterfowl Totals

To analyze trends in annual totals with respect to year, local conditions (the reservoir's surface area), and regional conditions (drought severity), I used multiple linear regression analysis, $\log_{10}$-transforming the numbers to fit the test's assumptions. The length of the shoreline and the availability of various depths of water vary with the reservoir's level, the exact nature of the relationships being influenced by the basin's topography. As a measure of this variation, I used the reservoir's surface area in September, estimated by linear regression with the reservoir's storage volume (km^3) the predictor variable and surface area (km^2) as the dependent variable. Data on the reservoir's storage volume were from the Department of Water Resources' California Data Exchange Center (https://cdec.water.ca.gov/dynamicapp/QueryMonthly?s=BDP). I selected the monthly value closest to the date of the satellite photo from which the volume was estimated each year. Based on imagery from the National Agriculture Imagery Program, values for surface area were obtained by mapping the shoreline in ArcGIS software by ESRI for the years 2005, 2009, 2010, 2012, 2014, 2016, 2018, and 2020 and with Google Earth's distance-measurement tool for 2006, 2013, and 2019, the years imagery was available through Google Earth. The resulting regression equation was highly predictive of the reservoir's surface area, given a particular storage volume ($r^2_{adj} = 0.976$, $p < 0.001$).

I estimated the reservoir's surface area in September of each year with the regression equation. I then included these predicted values in a multiple regression model to determine the effect of the reservoir's surface area on annual fall waterfowl totals at Bridgeport.

Regional conditions I assessed by means of the Palmer drought severity index (PDSI) for the western region (California and Nevada). The PDSI is a monthly index that incorporates both air temperature and precipitation data to evaluate the severity of hydrologic drought (Alley 1984, National Center for Atmospheric Research 2020). The combined effects of air temperature and precipitation influence evapotranspiration, which is the major factor controlling water balance in wetland habitats (Zhao and Liu 2016). Thus the PDSI may serve as a surrogate indicator of the extent or availability of wetlands in the region. The PDSI ranges from +10 (extremely wet) to −10 (extremely dry) (National Center for Atmospheric Research 2020). I averaged monthly PDSI values by water year (1 October through 30 September) for the water year immediately preceding each year's surveys.

I evaluated the model's performance by examining adjusted values of r^2 (r^2_{adj}), values of probability (p) for the model and individual variables, and the variance-inflation factor for variables.

RESULTS

Waterfowl Totals

From 2003 to 2019, the total number of waterfowl counted at Bridgeport Reservoir each fall (results of the six surveys summed) averaged 33,106 ± 4050 (SE; Table 1). Waterfowl concentrated primarily along the southwest shoreline from Walters Canyon to the East Walker River bay and offshore of the Buckeye Creek inlet (see Figure 1). Waterfowl abundance was highest in 2005 when 83,186 individuals were tallied over the six surveys. The fewest waterfowl were recorded in fall of 2014 when only 13,119 were tallied. The peak count for the year on a single survey averaged 10,474 ± 1349 and ranged from a low of 2583 in 2014 to the highest single-day count of 23,150 at the end of September in 2005.

Species Composition

Of the 23 species of waterfowl recorded at Bridgeport Reservoir in fall, geese and swans averaged 1280 per year, representing approximately 4% of all waterfowl (Table 2). The Snow Goose (*Anser caerulescens*) has been an infrequent, late-season migrant, seen in 5 of 17 years, with a peak count of 30 on 7 November 2017. The Greater White-fronted Goose (*A. albifrons*) has also been infrequent, seen between mid-September and the end of October in 3 of 17 years. The Cackling Goose (*Branta hutchinsii*) was detected only in 2016. The Canada Goose (*B. canadensis*) was the only species in this group recorded every year and averaged 1263 birds per year. The Tundra Swan (*Cygnus columbianus*) occurred as a late-season migrant in 12 of 17 years, with a high count of 85 on 14 November 2003.

Seven dabbling duck species (Table 2) averaged 29,789 annually and accounted for 90% of all waterfowl. The most abundant dabblers were the Northern Shoveler, Gadwall, Mallard, Northern Pintail and Green-winged Teal. The Northern Shoveler was the most abundant species overall, averaging 7741 ± 987 per year, constituting over 23% of all waterfowl. The Gadwall was almost equally abundant with 6369 ± 893 per year (19.2%). The yearly fall means for the Mallard, Northern Pintail, and Green-winged Teal were similar, each accounting for 10–12% of all waterfowl. The Cinnamon Teal was an early fall migrant, averaging 229 per year or approximately 1% of dabbling

Table 1 Abundance of Waterfowl at Bridgeport Reservoir, 2003–2019, All Species Pooled

Survey period	Mean	SE	High count	Low count
Early Sept	6763	899	12,160	2024
Mid-Sept	8754	1131	17,955	1962
End Sept	7078	1475	23,150	1633
Mid-Oct	4286	956	17,355	847
End Oct	3282	566	10,117	826
Mid-Nov	2943	462	6141	356
Peak count	10,475	1349	23,150	2583
Yearly total	33,106	4050	83,186	13,119

Table 2 Mean Number of Waterfowl by Survey Period, Total Annual Mean, and High Counts at Bridgeport Reservoir, 2003-2019

Species	Early Sep	Mid-Sep	End Sep	Mid-Oct	End Oct	Mid-Nov	Annual mean	SE[a]	Peak count
Geese and swans									
Snow Goose *Anser caerulescens*					<1	2	3	2	30
Greater White-fronted Goose *Anser albifrons*		1	<1		1		2	2	20
Cackling Goose *Branta hutchinsii*					1		1	1	8
Canada Goose *Branta canadensis*	253	176	197	190	154	292	1263	198	940
Tundra Swan *Cygnus columbianus*					2	10	12	5	85
Dabblers									
Cinnamon Teal *Spatula cyanoptera*	154	57	14				229	67	671
Northern Shoveler *Spatula clypeata*	2864	2560	1481	412	203	58	7741	987	8115
Gadwall *Mareca strepera*	1483	2107	1606	434	362		6369	893	5700
American Wigeon *Mareca americana*		15	22	9	8	9	66	25	220
Mallard *Anas platyrhynchos*	435	517	1102	816	782	538	4237	865	6605
Northern Pintail *Anas acuta*	154	759	993	1183	622	354	4173	699	6000
Green-winged Teal *Anas crecca*	562	614	768	473	523	658	3624	677	3600
Unidentified teal	757	1375	504	300	197	165	3352	823	5550
Divers									
Canvasback *Aythya valisineria*	<1			1	1	2	4	2	15
Redhead *Aythya americana*	4	12	19	11	19	7	72	20	155
Ring-necked Duck *Aythya collaris*	3	1	7	16	4	77	109	75	1150
Lesser Scaup *Aythya affinis*			<1	12	14	17	44	11	137
White-winged Scoter *Melanitta deglandi*						<1	<1	<1	1
Bufflehead *Bucephala albeola*	<1	1	5	16	64	105	194	50	810
Common Goldeneye *Bucephala clangula*				<1	<1	5	6	3	42
Hooded Merganser *Lophodytes cucullatus*					1		1	1	10
Common Merganser *Mergus merganser*	21	16	17	11	12	15	93	16	93
Red-breasted Merganser *Mergus serrator*					<1		<1	<1	1
Ruddy Duck *Oxyura jamaicensis*	73	228	344	227	313	326	1513	231	1600
Unidentified diving duck				2			2	2	30

[a] Standard error.

ducks. The American Wigeon (*Mareca americana*) has averaged fewer than 100 birds per year, with a peak count of 220 in 2003.

Diving ducks were the most species-rich group, but although nine species were observed (Table 2), diving ducks as a whole accounted for only 6% of all waterfowl. Their species richness was low early in the season until most species arrived in mid-October. The Ruddy Duck was most abundant of the divers, averaging 1513 ± 230 per year. The Redhead (*Aythya americana*), Ring-necked Duck (*A. collaris*), Bufflehead (*Bucephala albeola*), and Common Merganser (*Mergus merganser*) also occurred regularly but each accounted for <1% of all waterfowl over the study period. The Bufflehead was the second most numerous diver, averaging 194 ± 50 annually. Although sometimes present early in the fall season, it was most consistently recorded in higher numbers after mid-October. The high of 810 Bufflehead was recorded on 13 November 2019. The Canvasback (*A. valisineria*), Lesser Scaup, and Common Goldeneye (*B. clangula*) were detected regularly after mid-October, with high counts of the Canvasback (15) recorded on 14 November 2003, of the Lesser Scaup (137) on 27 October 2017, and of the Common Goldeneye (42) on 14 November 2018. Species detected in only one year were the White-winged Scoter (*Melanitta deglandi*; 1), Hooded Merganser (*Lophodytes cucullatus*; 10), and Red-breasted Merganser (*Mergus serrator*; 1).

Migration Chronology

From early September to mid-November, the total number of waterfowl observed at Bridgeport Reservoir rose and fell (Figure 2). Early-season (Sep-

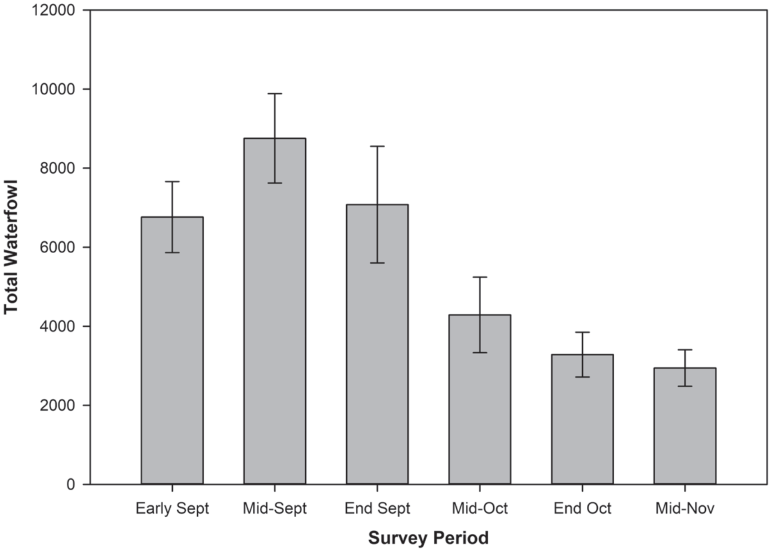

Figure 2. Mean total waterfowl (± SE) per survey period, 2003–2019. Waterfowl use in early fall (early September to end September) is significantly higher than the late fall period of mid-October through mid-November.

tember) totals were significantly higher than later in the fall (October through mid-November). Seasonal totals were typically highest in mid-September, although some of the highest counts occurred in late September. The standard errors indicate that total waterfowl counts were most variable during the mid- and end of September periods. In two of the last six years, however, seasonal counts peaked in late fall. These late fall peaks were in mid-November 2014 and the end of October 2017.

Species Chronology

The Green-winged Teal's pattern of abundance was bimodal (Figure 3a). In any one year, approximately 60% of the seasonal population had been recorded by the end of September. The long-term average count through the month of September ranged from 562 to 768. Numbers decreased in October, followed by a second smaller peak in mid-November that averaged 658 birds.

The Gadwall showed a unimodal pattern of migration early in the season (Figure 3b). By mid-September, 60% of the yearly fall population was recorded. The long-term average seasonal peak of 2107 occurred in mid-September. Numbers dropped rapidly after mid-September, and from the end of October to mid-November, Gadwall averaged 433 or fewer.

The Mallard was a mid- to late-season migrant (Figure 3c), with populations building through September to a seasonal peak averaging 1102 in mid-September. A moderate but progressive decline in use was observed following the mid-September peak such that by mid-November, numbers averaged 537. The Mallard was one of the more abundant late-season species at Bridgeport.

The Northern Pintail's pattern of abundance was unimodal, and its numbers peaked in mid-season (Figure 3d). A significant proportion of the annual fall population had often arrived by mid-September, lingering through the end of October. Peak numbers occurred from the end of September through mid-October, with the highest average number of 1183 in mid-October.

The Northern Shoveler was the most abundant early-season migrant at Bridgeport (Figure 3e). Its migration chronology was somewhat similar to the Gadwall's with numbers peaking early in the season. Most of the annual fall population was recorded by mid-September, and the highest average count, of 2864, was in early September. Given that the high count generally occurred on the first survey, it is possible that in some years the annual peak preceded the first week of September. By mid-October, average numbers dropped to 412, and by mid-November, numbers averaged fewer than 100.

The Ruddy Duck had a bimodal pattern of abundance (Figure 3f). Total numbers were low in early September, then rose to a small peak averaging 344 and approximately 20% of the annual fall population at the end of September. A second and larger annual fall peak representing almost 30% of the annual fall population occurred at the end of October.

Variables Influencing Waterfowl Totals

The estimated extent of Bridgeport Reservoir averaged 5.3 km^2, ranging from a low of 2.5 km^2 in September 2014 to a high of 10.4 km^2 in September 2017. The extent of surface water was weakly related to waterfowl totals ($r^2_{adj} = 0.252$, $p = 0.051$), but because of multicollinearity with the PDSI and the model's resulting instability, I excluded this variable from the model.

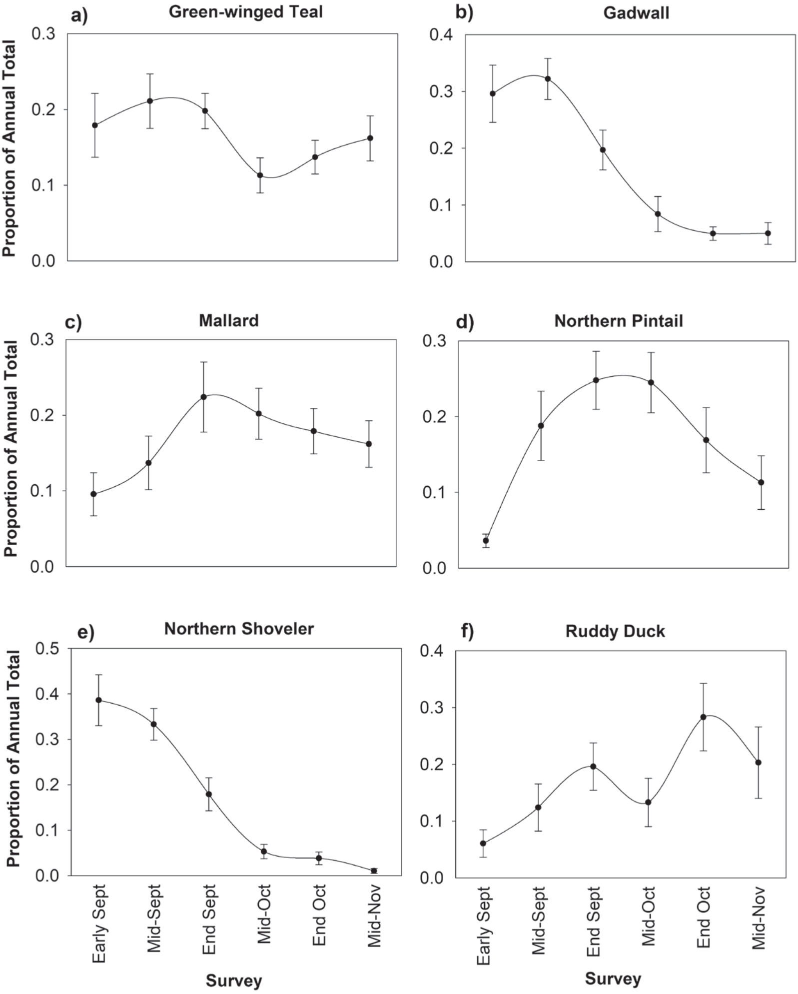

Figure 3. Migration phenology of the six most abundant species of dabbling ducks at Bridgeport Reservoir. Values represent the proportion of the species' annual fall totals present during each survey period.

The best-fit model encompassed the variables PDSI and year. These two variables combined explained 61.4% of the variability in annual waterfowl totals at Bridgeport Reservoir ($r^2_{adj} = 0.614$, $p < 0.001$).

Over the 17-year study period, the annual PDSI for California and Nevada ranged from –6.2 (extreme drought) to 2.9 (moist). The region experienced 7 years of severe to extreme drought (PDSI ≤ –3.0), two of moderate drought (PDSI –2.9 to –2.0), six normal years (PDSI –1.9 to 1.9), and two moist years (PDSI 2.0 to 2.9).

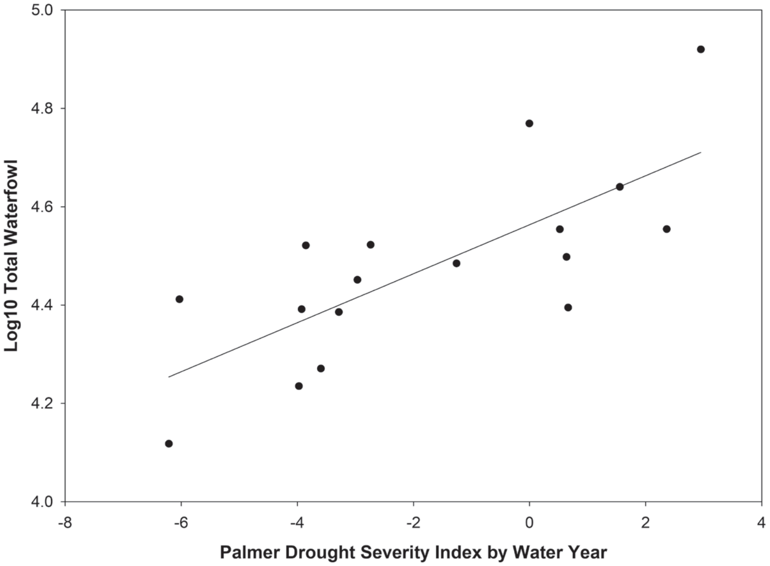

FIGURE 4. Relationship between total fall waterfowl numbers and the Palmer drought severity index.

The severity of drought, as indicated by PDSI in California and Nevada for the water year immediately prior to the survey year, influenced waterfowl totals strongly (Figure 4). This relationship was positive, indicating increased numbers as drought severity lessened and moisture conditions in the region improved, and decreased numbers during periods of drought.

Waterfowl totals were negatively correlated with year, indicating a trend of decline over the study period (Figure 5). There appears to be a cyclic pattern to annual waterfowl totals, however; since 2008, the peaks and troughs of total numbers have been lower than prior to 2008.

DISCUSSION

Bridgeport Reservoir is primarily a mid-migration stopover site for waterfowl in fall, as evidenced by high early-fall use through the month of September, followed by significantly lower numbers October through mid-November. Fall waterfowl use of Bridgeport Reservoir is unlike that at many other waterfowl sites in California in that use is highest in September. Lingering local breeders may contribute substantially to the fall numbers only in the case of the resident Canada Goose, which in some years can number several hundred in mid-summer. Otherwise, numbers of locally breeding ducks numbers appear to be insignificant compared to totals present in September (pers. obs.).

Fall waterfowl totals at Bridgeport Reservoir peak earlier than at many other sites in the intermountain West. At Lake Abert in eastern Oregon,

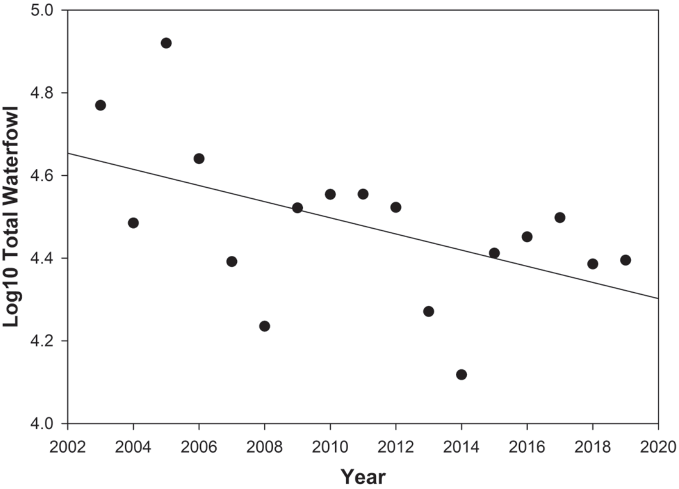

FIGURE 5. Trend in annual waterfowl totals, 2003–2019, $\log_{10}$ transformed.

Northern Shoveler numbers peak in mid- to late September, slightly later than observed at Bridgeport (East Cascade Audubon Society, http://bit.ly/2s3Kwgt). Total waterfowl numbers at Summer Lake, also in eastern Oregon, have been highest from late September through mid-October (Oregon Department of Fish and Wildlife 2020). Peak fall numbers of all ducks, as well as single-species counts for the Northern Shoveler, Gadwall, and Northern Pintail at Stillwater National Wildlife Refuge, Nevada, are in October (Bundy 2002). At Owens Lake in Inyo County, California, fall waterfowl numbers have been highest in October (Los Angeles Department of Water and Power, unpubl. data). Waterfowl use of Bridgeport in winter is much less than in early fall (pers. obs.). Although winter-hardy species such as the Mallard and Canada Goose overwinter on lakes and rivers of the intermountain West including Bridgeport Reservoir, waterfowl largely migrate out of the region with its harsh weather and freezing temperatures (Intermountain West Joint Venture 2013). The seasonal composition and abundance of waterfowl observed at Bridgeport Reservoir may reflect, in part, its location within the intermountain West and associated climate patterns including temperatures below freezing as early as September. This pattern of early fall departure may also indicate a depletion of high-energy foods sought by migrating waterfowl.

Waterfowl abundance at Bridgeport Reservoir is high relative to the size of the reservoir, and as compared to the other key waterfowl sites in Mono County—Crowley Reservoir and Mono Lake—where comparable aerial surveys were conducted over the same time period. Crowley Reservoir, which is almost twice as large as Bridgeport Reservoir at 34.2 km^2, has averaged 47,172 waterfowl annually over the same time period, or approximately 40% more waterfowl than at Bridgeport (unpubl. data). Waterfowl totals at Mono Lake, a saline lake covering 181 km^2, almost 10 times larger than Bridgeport, have averaged 24,731 (unpubl. data), or 25% less than at Bridgeport. Grant Lake Reservoir, also in Mono County and similar in size to Bridgeport Reservoir, supports few waterfowl (pers. obs., Lin and Jehl 1996).

Dabbling ducks are the most abundant waterfowl at Bridgeport Reservoir in fall, while geese, swans, and divers have constituted a small proportion of the overall numbers. Although Bridgeport Reservoir is potentially along a migration route for some portion of the western population of the Snow Goose, its use of Bridgeport has been low and sporadic. Likewise, Tundra Swan use was low and sporadic, although the western population is known to move from stopover locations in the intermountain West, including Great Salt Lake and Stillwater National Wildlife Refuge in Nevada to the north of Bridgeport, to wintering sites in California's Central Valley (Moermond and Spindler 1997), and wintering Tundra Swans are regular at Crowley Reservoir, approximately 80 km southeast of Bridgeport, arriving as early as the end of October. The majority of southbound Snow Geese and Tundra Swans wintering in the Central Valley cross west over the Sierra Nevada well to the north of Bridgeport Reservoir (F. Hall pers. comm.). Snow Geese also winter in the interior of California south of Bridgeport, including at Owens Lake (Inyo County), in Indian Wells Valley (Kern County), and in the Imperial Valley (Imperial County). The majority of waterfowl wintering in the Imperial Valley originate from central Canada and the northern Great Plains (Patten et al. 2003) and take a migratory path different from that taken by the majority of waterfowl wintering in cismontane areas of California (Bellrose 1980). Snow Geese wintering at Owens Lake and in Indian Wells Valley may originate from central Canada and the northern Great Plains as well. Thus Bridgeport Reservoir may lie outside the major migration routes Snow Geese and Tundra Swans follow, or the specific vegetation and food resources at Bridgeport may not make it attractive for a stopover.

At Bridgeport, the migration chronologies of the dominant species varied from primarily early in the season (e.g., Northern Shoveler and Gadwall) to mid-season (Northern Pintail) to mid-to-late season (Ruddy Duck and Mallard). In addition, both unimodal (Northern Shoveler, Gadwall, and Northern Pintail) and bimodal (Green-winged Teal, Mallard, and Ruddy Duck) seasonal patterns were observed. Bimodal patterns within a species may reflect different geographical source populations responsible for the early versus late pulse in numbers. The species for which bimodal patterns were observed are also typically among the most abundant species of waterfowl wintering in Mono County (pers. obs.). Early-season numbers of some species, particularly the Gadwall, presumably include small numbers of lingering local breeders.

Regional drought appears to influence waterfowl totals at Bridgeport strongly. Drought depresses waterfowl reproduction by reducing the availability of wetlands, but determining factors responsible for the effect of drought on waterfowl totals at any particular site in migration may be more complex. These factors may be influenced by the drought's severity and length at both local and regional scales, and the source population's reproductive dynamics.

With respect to migrating birds, drought has the potential to concentrate bird use in areas of suitable conditions, leading to a local increase in numbers, to decrease survival by eliminating resources along the migratory route, or to alter migration patterns, which could increase or decrease numbers. At Bridgeport Reservoir, the data do not suggest a concentration of use at this site in response to drought, as annual waterfowl use decreased as regional rainfall decreased. Drought may be influencing waterfowl use of Bridgeport Reservoir by altering migration patterns, depressing source populations, or affecting local conditions including food resources. Several studies have shown strong relationships between drought, breeding waterfowl populations, and habitat conditions (e.g., Sorenson et al. 1998, Krapu et al. 1983), thus providing a mechanism by which source populations are limited. Under the climate scenario predicted for the western U.S. of decreased precipitation, and increased temperatures reducing the effectiveness of precipitation, long-term drying is anticipated. Locally, dry periods are getting drier, and wet periods shorter (House and Honda 2018), resulting in less time for habitats and populations to recover from the consequences of dry periods. Periodic drying of wetlands can be beneficial in terms of increasing productivity, but long-term drought can lead to loss and reduction of the wetlands waterfowl use. In light of the response to regional drought, the declining trend in waterfowl numbers seen during this study could be due in part to recent changes in climate. Finally, although a relationship between reservoir level (which could influence the quantity or quality of the available habitat) and fall waterfowl numbers was not evident in this study, further investigation into the influence of reservoir level on habitat conditions may provide more insight.

Several factors are suspected to contribute to fall waterfowl abundance at Bridgeport Reservoir, including topography, available food resources, adjacent land use, and land-ownership patterns. The topography of the southern and southwestern shoreline of the reservoir results in ideal foraging conditions for dabbling ducks and geese. The gently sloping topography and the input of fresh water from the East Walker River and Robinson and Buckeye creeks combine to create extensive mudflats and shallow feeding areas along the southern and southwestern shoreline. Depending on the reservoir's level, in some years submergent and aquatic vegetation at Bridgeport is abundant, contributing to favorable foraging habitat (Fredrickson and Reid 1988). At reduced reservoir levels, the submergent vegetation, including smartweed, becomes exposed (pers. obs.), rendering seeds less available to foraging waterfowl. Similarly sized Grant Lake demonstrates how topography and surrounding land use can influence waterfowl use of a reservoir, as it is deeper, only has one perennial water source, is surrounded by upland vegetation, not irrigated pasture or meadow, and supports only small numbers of waterfowl.

Adjacent land use helps to sustain the abundance of fall waterfowl at Bridgeport Reservoir. Although cattle grazing can alter the physical structure of ecosystems, nutrient cycling, and species composition and cover (Fleischner 1994), this land use has helped to maintain open space surrounding Bridgeport Reservoir and has resulted in the persistence of meadows adjacent to it.

Fluctuating water levels at Bridgeport periodically inundate adjacent flood-irrigated pastures, and this process may be mimicking natural or managed seasonally flooded wetlands (i.e., management through maintenance of moist soil) that can result in the production of key foods for waterfowl (Nelms 2007). The abundance of water smartweed along the southern shoreline of Bridgeport Reservoir in some years attests to the functioning of this area as a moist-soil wetland. The seeds of smartweeds are widely recognized for their value as waterfowl food (Martin and Uhler 1939, Fredrickson and Reid 1988), and smartweeds also support populations of diverse invertebrates (Nelms 2007), thus enhancing the abundance of waterfowl during fall migration at Bridgeport Reservoir.

In fall, migrating waterfowl accumulate energy reserves for long-distance flight and to withstand winter conditions that may include reduced food supply or severe weather (Davidson and Rothwell 1993). The accumulation of fat is of prime importance to waterfowl in fall. At this season, waterfowl increase their use of disturbance-free refuges (Madsen 1998, Evans and Day 2002). The southern and southwest portion of Bridgeport Reservoir's shore favored by waterfowl has limited human access not only because these areas are quite muddy but because adjacent private property limits access. Likewise, waterfowl hunting pressure is low, except for the opening day and weekend of hunting season (the third Saturday in October), and, because of difficult access and limited cover, most hunting in the valley is restricted to the creeks and ditches, as opposed to the reservoir (Tim Taylor, California Department of Fish and Wildlife, pers. comm). The combined forces of land ownership and land use keep disturbance low in the areas of Bridgeport Reservoir where waterfowl concentrate to feed and rest and may contribute to waterfowl use in the fall.

Knowledge of species' movement patterns is fundamental to habitat management and conservation planning. Chronologies of waterfowl migration have been described for broad geographic areas (e.g., Bellrose 1980), but quantitative information is available only for localized areas (Baar et al. 2008).

Patterns of waterfowl migration have been observed to change over time (Lehikoinen and Jaatinen 2011, Reese and Weterings 2018), so the chronology data I present here may be useful for assessing waterfowl response to regional or local changes in conditions, including those induced by climate change.

A change in land use away from agricultural grazing lands to development is a potential threat to the nature and productivity of Bridgeport Valley. Most of the area immediately surrounding Bridgeport Reservoir and more than half of the total extent of Bridgeport Valley (19,341 hectares) are privately owned (Mono County Planning Department 2000). A small portion has been placed into conservation easements (https://www.eslt.org/preserved-lands/bridgeport-valley/). Land-use changes could alter water inputs to the reservoir, access, or the level of disturbance to wildlife including migratory waterfowl.

Changes to Bridgeport Reservoir and its habitat value for waterfowl could also occur as a result of the Walker Basin Restoration Program. The primary purpose of the Walker Basin Restoration Program is to restore and maintain Walker Lake in western Nevada, and to protect agricultural, environmental, and habitat interests in the Walker River basin (National Fish and Wildlife Foundation, https://www.nfwf.org/programs/walker-basin-restoration-program). Walker Lake is one of three desert terminal lakes in the United States that supports a fishery, but a decrease in the lake's level and a subsequent increase in total dissolved solids have resulted in significant ecological changes (Collopy and Thomas 2010). To provide more inflow to Walker Lake, rights to surface water are being acquired from willing sellers in the watershed. Ciotti et al. (2014) cited reduced reservoir levels, reduced subsurface water flow, and a loss of flow in Robinson Creek as possible effects on Bridgeport Valley as a result of water transfers. A reduction in the level of Bridgeport Reservoir could degrade waterfowl habitat by reducing the extent of shallow flooded areas along the shoreline where the birds feed, and interrupting the connectivity of flooded pastureland to wetland habitats and open water.

Because of the general aridity of the intermountain West, the value of wetlands within the region is disproportionate to their extent (McKinstry et al. 2004), and areas with appropriate conditions tend to concentrate waterfowl, particularly during migration. Water resources and wetlands of the intermountain West have been profoundly altered, and those within Bridgeport Valley are no exception. Despite these alterations, Bridgeport Reservoir has been a locally important stopover site for migratory waterfowl in fall.

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