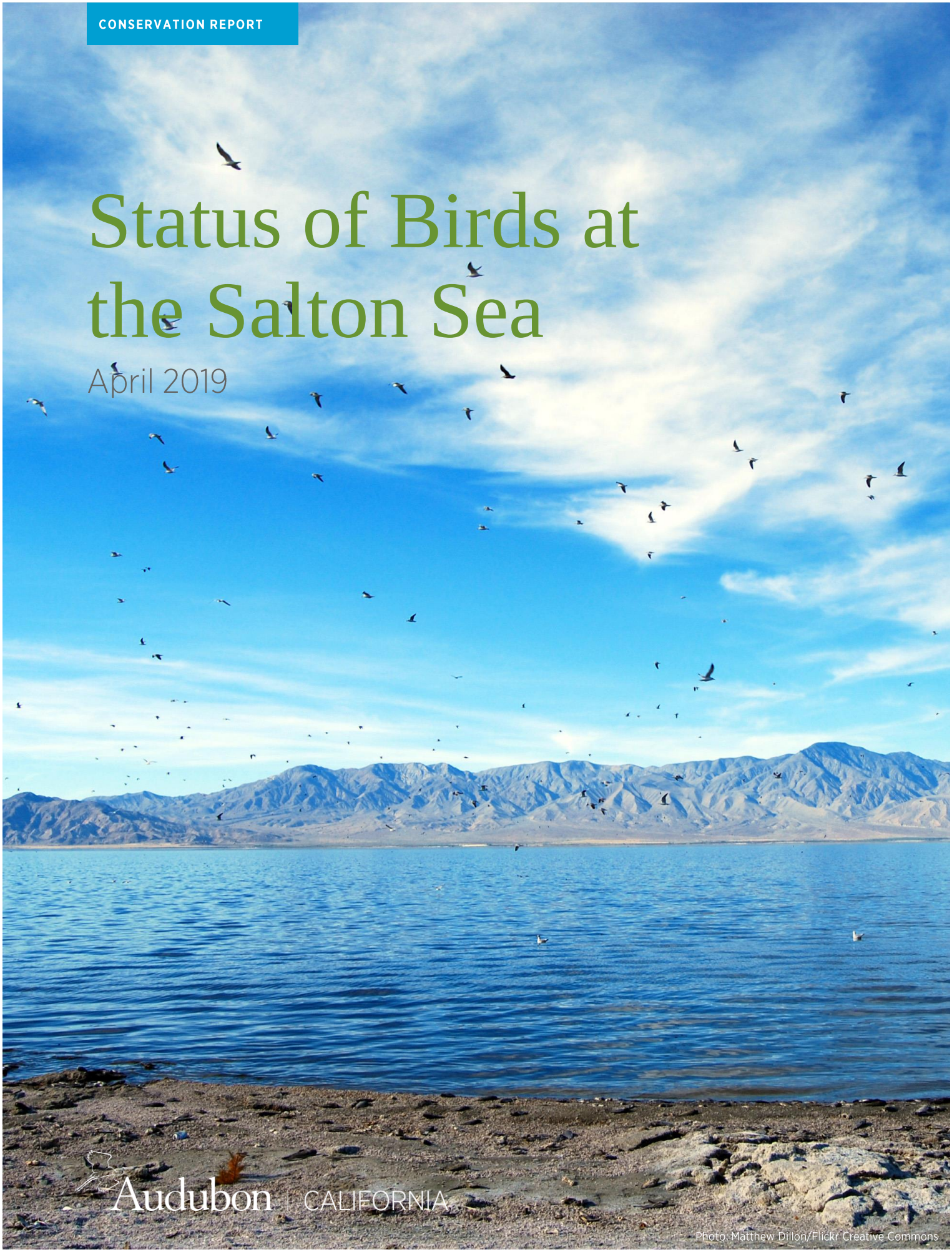
CONSERVATION REPORT

Status of Birds at the Salton Sea

April 2019



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STATUS OF BIRDS AT THE SALTON SEA

Introduction

The Salton Sea, a globally significant Important Bird Area (designated by National Audubon Society under criteria established by BirdLife International; https://www.audubon.org/important-bird-areas/salton-sea) and one of the premiere birding areas in California, is also one of the most critical inland wetland habitats for birds along the Pacific Flyway. For more than a century, the Sea has served as a major nesting, wintering, and stopover site for millions of birds. However, it is increasingly becoming one of the most imperiled.

Best considered a branch – or alternate terminus – of the larger Colorado River Delta, the Salton Sea formed and dried for eons prior to its most recent 35-mile-long incarnation, which was the result of a massive flood of water from the Colorado River just over 100 years ago. Through the 20th Century, the Sea's avifauna has been distinctly delta-like, from tiny Eared Grebes that feed in the winter far out on its surface, to American White Pelicans that roost on mudflats and fish for tilapia in its shallows, to large flocks of migratory shorebirds feeding along the muddy shorelines.

The Salton Sea is now at risk because water transfers under agreements signed in 2003 are leading to disappearing habitat and a shrinking Sea. With the reduction in the ecological value at the Sea, we are losing a vital part of the Pacific Flyway and are facing increasing dust emissions from the seabed that will likely worsen air quality for more than 650,000 residents in nearby communities. The State of California committed to mitigate these impacts, although no new significant mitigation project has been completed as of the end of 2018.

We predict that the impact of decreased water inflows on the Sea's avifauna will be profound, not just for the birds that are dependent on open water and the fish populations, but also for numerous bird species that split their time between the Sea, the shoreline marshes, and the agricultural fields that extend across thousands of acres to the south in Imperial Valley.

We are already seeing evidence that the Sea is losing birds, such as grebes, pelicans, and cormorants, which rely on fish or large invertebrates in deep water habitat. Shorebirds, however, and some waterfowl species, that can feast on insects along the shoreline, appear to still be migrating through or wintering at the Sea in large numbers.

Without the State of California or other partners building new habitats along the Sea's receding edge, the remaining Sea will become increasingly saline and less hospitable to the diversity of species that have come to rely on it.

Based on the changes already observed at the Salton Sea, Audubon and our colleagues recognized the importance of documenting recent trends and status of birds before more declines occur. This paper summarizes original research, data analysis, and observations from external organizations and agencies to understand how bird populations are responding to the dynamic environmental changes at the Sea and document the status and trends of birds at the Salton Sea.

Bird value at the Salton Sea

The Salton Sea is one of the most ecologically productive wetlands on the Pacific Flyway in the Interior West (Barnum and Johnson 2004, Shuford 2014). Upwards of 400 bird species have been recorded at the Sea and it hosts the largest populations of several duck and shorebird species in California south of the San Francisco Bay-Delta region (Shuford et al. 2004, Morrison et al. 2006). Reports from the 1990s and 2000s describe the sheer numbers and diversity of bird species at the Sea. However, some of these numbers have changed in the past few years, as described in this report.

During the winter months, the Sea has been known to support:

- An estimated 25-90% of the North American population of Eared Grebes (1 to 3 million individuals) occurred on the open water (or in nearby impoundments) in the 1980's and 1990's (Shuford et al. 2000, Patten et al. 2003);
- Approximately 50% of the Pacific Flyway population of Ruddy Ducks; (https://www.wildlife.ca.gov/Regions/6/Salton-Sea-Birds/Salton-Sea-Bird-Species).
- An estimated 30% of the North American population of American White Pelicans (Shuford et al. 2000);
- Significant interior wintering populations for Brown Pelicans and Western Grebes; and

- The largest interior wintering site for Western Snowy Plovers (Patten et al. 2004, Thomas et al. 2012).

During the summer breeding season, the Sea supports, or has supported:

- Large breeding colonies of Double-crested Cormorant (until colony abandonment – see Riesz 2014) and large waders (Molina and Strum 2004), Caspian Tern and edge-of-range populations of Gull-billed Tern and Laughing Gull (Molina 2004, Molina and Shuford 2013);
- Threatened or Endangered populations of Yuma Ridgway's Rail and the California Black Rail in wetlands around and nearby the Sea (Laymon et al. 1990, Riesz 2011); and
- A breeding population of interior Western Snowy Plovers.

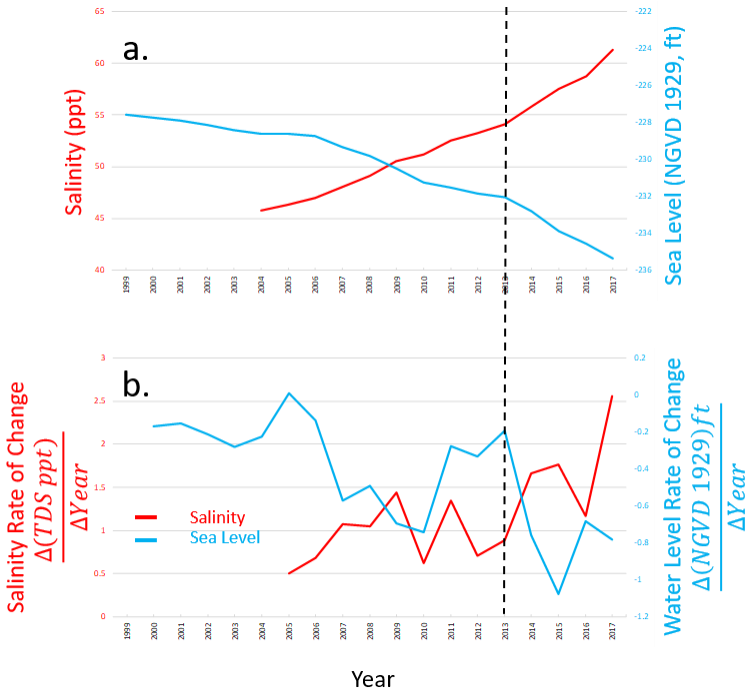

Figure 1: Salinity units are in parts per thousand (ppt) for Total Dissolved Solids (TDS) and water level units are feet relative to the National Geodetic Vertical Datum (NGVD) of 1929. (a) Yearly (x-axis) Salton Sea mean salinity (right y-axis, ppt) and sea level (NGVD 1929, ft) and (b) Yearly (x-axis) Salton Sea rate of change in salinity (right y-axis, change (Δ) in TDS ppt/change (Δ) in year) and sea level (change (Δ) in NGVD 1929 feet/change (Δ) in year) from 1999 to 2017. The black dotted line indicates the year 2013 when water drawdowns began to accelerate. *Data from the U.S. Bureau of Reclamation.*

Changes at the Salton Sea

Despite historically high bird populations at the Sea, some of these numbers have started to change in the past few years. Based on waterbird census data through 2013, no species were significantly declining since the 1980s, and many were increasing (Cooper 2015). However, recent water level drops have changed this and more recent data from 2014-onwards illustrate these trends.

The changes observed in species trends at the Sea can likely be attributed to a loss in water elevation in recent years due to water transfers. After a peak in high water in the early 2000s, the Sea's most recent elevation decline began around 2006. By 2016, the Salton Sea began experiencing a more rapid decline (Figure 1), the result of reduced freshwater inputs owing to crop-fallowing, changing agricultural practices, drought, and reduced flows from Mexico (including water conservation practices). This decline in water level has pushed salinity to 60 parts per thousand (PPT) (U.S. Department of Reclamation). This is nearly twice as saline as the ocean, which is typically around 35 ppt. Importantly, 60 PPT is the threshold widely believed to be the limit at which tilapia (the primary fish eaten by birds) could reproduce successfully (Cohen and Hyun 2006; but see Bradley and Yanega, 2017, who suggest a somewhat higher threshold). Indeed, starting in fall 2016, Audubon biologists noticed a scarcity of fish-eating birds (especially pelicans and cormorants) as well as those that feed on pile worms (especially Eared Grebes), suggesting the Salton Sea ecosystem is on the brink of major ecological change.

In 2018, water transfers required under the 2003 Quantification Settlement Agreement (QSA) to bolster water levels to compensate for water transfers, etc., came to an end. Thus began the accelerated retreat of the Sea and the resulting increasing salinity. The QSA mandated that these water transfers be mitigated by wetland restoration projects led by the State of California (California Dept. of Water Resources 2011).

In 2018, the California Natural Resources Agency released a 10-year management plan for the Sea, the Salton Sea Management Program (SSMP). This plan outlines the schedule and construction of almost 30,000

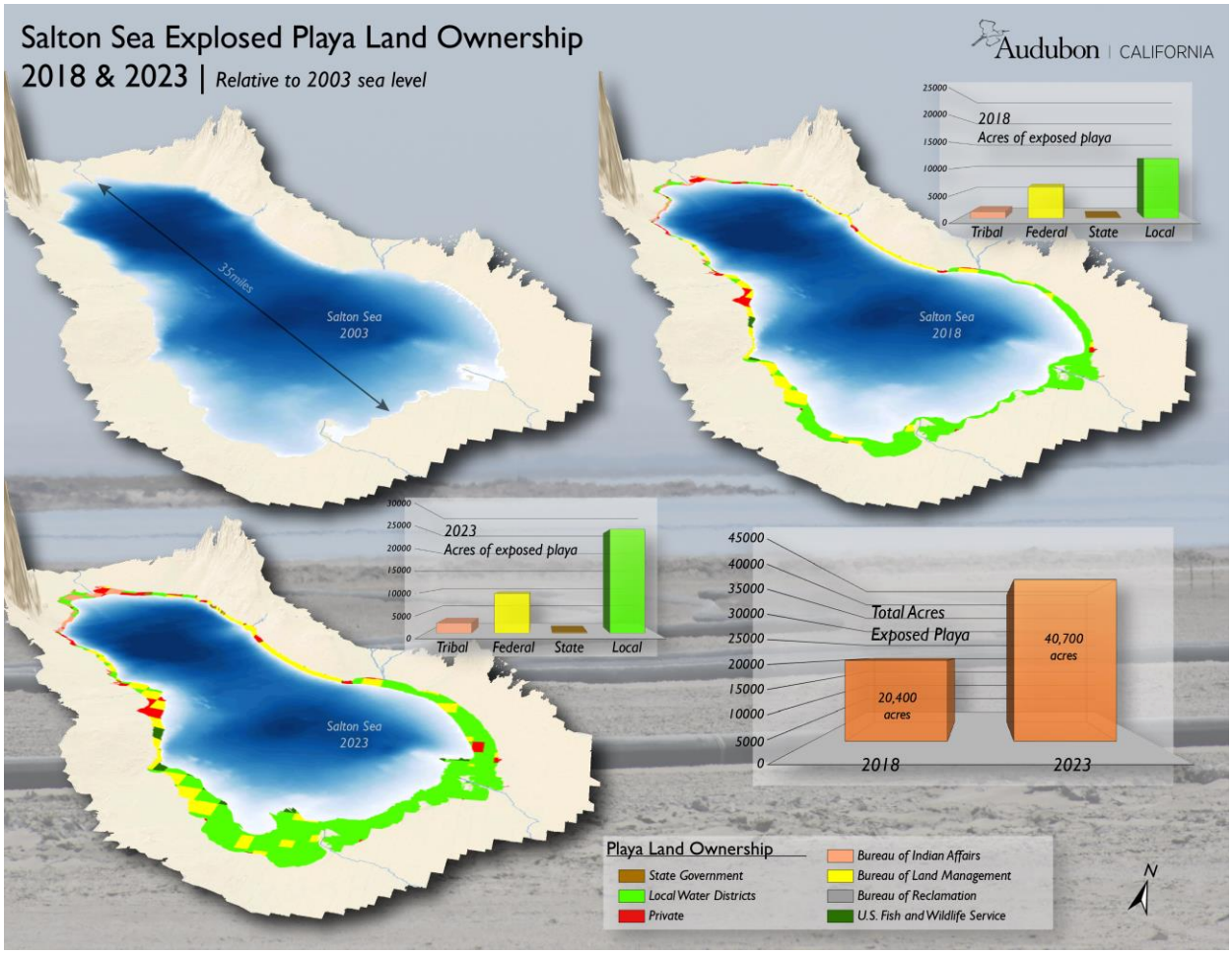

Figure 2. Graphic of exposed playa and land ownership, 2018 – 2023. Elevation values are in feet relative to the North American Vertical Datum of 1988 (NAVD88). Playa exposure is based on 2003 water levels (-227 ft. NAVD88), 2018 (-235 ft. NAVD88) are measured values (U.S. Bureau of Reclamation) and 2023 (-243 ft. NAVD88) Sea water level projections are based on the mean of the predicted values from the SALSA2 hydrologic model. Land ownership data is as defined by U.S. Bureau of Land Management, California State Office Mapping Sciences. Hillshade sources: ESRI, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatasyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community. Photo is of exposed playa at Red Hill Bay, 2018.

acres of projects through 2028, to control dust and to preserve bird and wildlife habitat (http://resources.ca.gov/wp-content/uploads/2018/10/SSMP-Phase-1-10-Year-Plan.pdf). Despite this goal, the plan provides little detail on these habitat projects, and by the end of 2018, no significant new habitat construction had been completed and the plan is behind schedule (although two projects are currently underway: 500 acres of wetlands on exposed seabed at the southeastern end at Red Hill Bay and up to 61 acres of small ponds on the North end in Torres Martinez tribal lands). However, recent analysis suggests that upwards of 60,000 acres of a mosaic of habitats are needed to offset the loss of the Sea's habitats by projected water diversions (Jones et al. 2016) and control dust on the predicted 40,700 acres of exposed playa by 2023 (Figure 2).

Bird surveys

While many studies and surveys have been conducted at the Salton Sea, few are comparable and only infrequently have Sea-wide surveys been conducted, making it challenging to compare past to current numbers. The most comprehensive, standardized bird survey of the Salton Sea was conducted in 1999 (Shuford et al. 2000), when the entire Salton Sea shoreline was divided into 19 subunits and surveyed roughly quarterly (January, April, August, November), both from shore (on foot) and from boats offshore. Other surveys and studies have been conducted by various parties, including state and federal biologists, Los Angeles Museum of Natural History, contractors, and Point Reyes Bird Observatory (now Point Blue Conservation Science) since the 1980s (T. Anderson, Sonny Bono Salton Sea National Wildlife Refuge, unpubl. data). Pacific Flyway Shorebird Surveys have been conducted by Point Blue annually in November since 2012 and Audubon's Christmas Bird Counts have been conducted annually in December or January (or almost annually) on the north and south ends of the Sea since 1965 and 1939, respectively. California Department of Fish and Wildlife (CDFW) has conducted aerial surveys from 2008 to present for piscivorous birds (S. Hayes, CDFW, unpubl. data). However, none of these surveys cover the entire Sea and all its habitats and birds.

Starting in late 2016, Audubon California initiated a 14-point Waterbird Survey along the Sea's shoreline every two months (see Cooper et al. 2018 for methods and full results), loosely modeled after much more intensive previous Sea-wide surveys. Surveys of the entire Sea by either land or boat are becoming increasingly challenging because of access issues and the receding shoreline. We selected these "rapid assessment" sites because they could provide a snapshot of bird presence at the Sea, and were relatively easy to drive/walk to and publicly accessible, ensuring consistent coverage by Audubon staff, contractors, and/or volunteers over time. Results for selected species are provided in Appendix A.

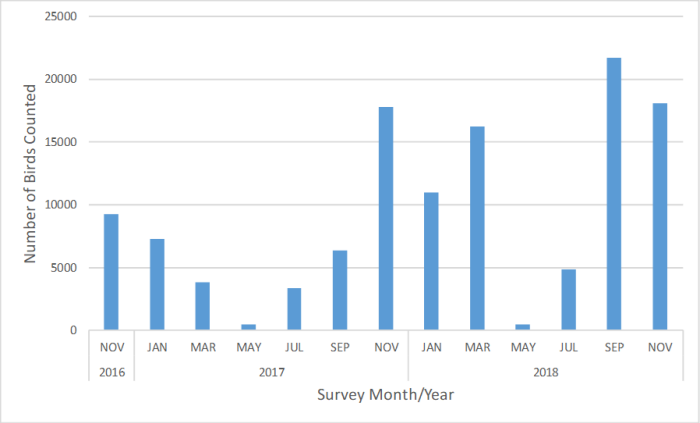

Figure 3. Total bird count in each Audubon Waterbird Survey from November 2016 through November 2018. Y-axis shows the count and x-axis shows the survev month/vear.

These surveys since late 2016 have recorded 67 species of waterbirds over 13 total visits. We found that Northern Shoveler was the most abundant species recorded, followed by Ruddy Duck. The total number of birds was highest in September through January and lowest in May (Figure 3). Fish-eating bird populations, such as pelicans and cormorants, declined during the survey period. Eared Grebe numbers were low throughout the entire survey, representing only a fraction of previous counts (Patten et al. 2003). Shorebirds, such as Least and Western sandpiper and American Avocet increased, as did some duck species – particularly Ruddy Duck and Northern Shoveler.

These data, while only representing a subsample of the Sea, indicate an increase in the overall number of individual birds since 2016. However, more survey years are needed, as different groups of species are changing in different ways. While there were increases in some migratory shorebird and duck species, other species showed declines. These data show statistically significant declines (p-value < 0.05, Table 1) in American White Pelican, Double-crested Cormorant and Eared Grebe when migratory months (those months when these species are typically observed at the Sea) sampled twice were compared. These short-term trends are somewhat supported by several longer-term data sources, as described below.

These trends may be associated with changes in reaching or surpassing the threshold of tolerance for reproduction or survival of fish species, particularly tilapia, we expect declines in food availability for piscivorous birds. Conversely, salinity conditions are

Common Name	Species Code	General Trend	Overal p-value*
American Avocet	AMAV	Increasing	0.1157
American White Pelican	AWPE	Decreasing	**0.0192**
Double-crested Cormoran	DCCO	Decreasing	**0.0037**
Eared Grebe	EAGR	Decreasing	**0.0066**
Northern Shoveler	NOSH	Increasing	**0.0395**
Least/Western Sandpiper	PEEP	Increasing	**0.0059**
Ruddy Duck	RUDU	Increasing	0.1800

Table 1. * Values were calculated using a one-tailed student's t-Test using data for migration months for each specific species, during the time period when the species is most likely found at the Salton Sea (identified using monthly data from the surveys). A p-value of less than 0.05 indicates a statistically significant trend.

Figure 4. CDFW aerial survey of Double-crested Cormorant (DCCO), Brown Pelican (BRPE), and American White Pelican (AWPE). (S. Hayes, CDFW, unpubl. data)

more favorable for halophilic invertebrates that may provide a food source for some of the migrating shorebirds and filter feeding ducks that appear to be increasing.

TRENDS IN FISH-EATING BIRDS

Wintering pelicans began using the Salton Sea in large numbers in the 1980's and 1990's (Patten et al. 2003). Brown Pelican counts peaked at around 12,000 in 2009 with lower numbers in subsequent years. White Pelicans reached a high of more than 20,000 in 2008, considered to be roughly 30% of the North American population. CDFW annual standardized aerial surveys of the Sea in both spring and fall for the past 10 years illustrate recent declines for pelicans as well as cormorants (S. Hayes, CDFW, pers. comm.) (Figure 4). While there is some annual fluctuation, 2016 to present shows a dramatic decline in pelicans and cormorants with 2016-2019 counts far below any previous count in the past 10 years.

Audubon's Waterbird Survey detected 901 White Pelicans during the 2016/2017 (Nov/Jan/Mar) winter whereas only 17 birds were counted during the same period in the 2017/2018 winter. Brown Pelicans also showed declines with 972 counted in 2017 vs. 372 counted in 2018.

Community science data from Audubon's Christmas Bird Count conducted at the north and south ends of the Salton Sea also indicate declining trends for fish eating birds and Eared Grebes over the past 10 years (ending in 2017). Trend analysis controlling for differences in effort (modified after Soykan et al. 2016) indicate average rates of decline of 24% per year for Eared Grebes, 12% per year for White Pelicans, and 10% per year for Double-crested Cormorants (Audubon, unpublished) (Figure 5). Average declines have steepened in more recent years (2014-2017): 63% in Eared Grebe, 51% for White Pelicans, and 59% for Double-crested Cormorants (Figure 5).

The collapse of the once-successful Double-crested Cormorant breeding colony at the Salton Sea (Lynch et al. 2014) further illustrates avian changes at the Salton Sea. Anecdotal reports describe Double-crested Cormorant numbers having apparently "plummeted" at the Sea in the 1970s and 1980s (Lynch et al. 2014), increased again through the 2000s with widespread breeding on Mullet Island (near Obsidian Butte at the south end of the Sea). However, they recently (as of

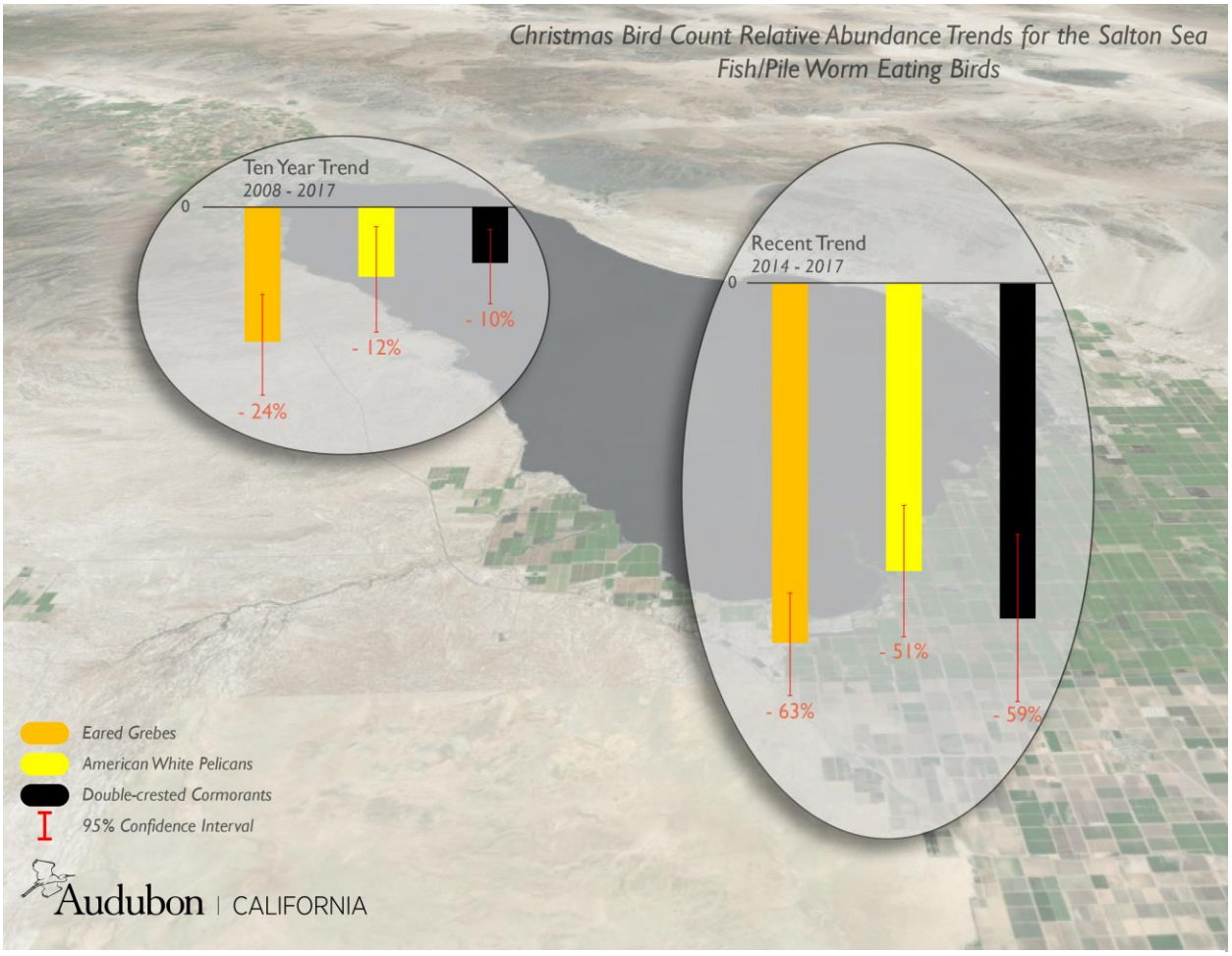

Figure 5. Graphical trend of Christmas Bird Count analyses showing trends in percent change over time (per year over the period noted). The red error bars show the 95% confidence interval for each species in each period.

2013) abandoned the Sea as a breeding site, as the water-level drop revealed a land bridge out to the island, providing access for mammalian predators (Lynch et al. 2014). The colony of more than 5,400 nesting pairs vanished and few birds have remained at the Sea, likely due to food scarcity.

Weekly bird surveys of the northern and northeastern portions of the Salton Sea by Oasis Bird Observatory (OBO) since 2014 show interesting trends in fish-eating birds that seem to justify higher temporal frequency of bird surveys. The weekly OBO surveys are intensive surveys that cover larger portions of the shorelines (McKernan and McGaugh 2018). OBO surveys include the highly productive Whitewater River mouth and other drains that are not accessible to Audubon surveyors. Their counts of Eared Grebes are much higher than what is seen in the Audubon Waterbird Surveys. While it may initially appear to contradict trends seen in Audubon surveys because they periodically detect large numbers of Eared Grebes, we believe they complement them and show the usefulness of higher temporal resolution surveys. Over the course of the OBO weekly surveys the temporal and numeric trends fluctuate, showing progressively fewer birds using the Sea over the longer late fall/winter/early spring season then in recent years showing up in large occasional pulses through the season (often in April) instead of remaining in large numbers throughout the season McKernan and McGaugh 2018).

Reports of dead birds being found with empty stomachs following these large pulses in 2016 and 2017 (Tom Anderson, U.S. Fish and Wildlife Service (USFWS), pers. comm.) may indicate that Eared Grebes arrived and left when there was not an adequate food source. While it is possible that some birds could be in the interior of the Sea and escaping detection, previous research suggests that the majority of Eared Grebes are detected within 1 km of the shoreline (Shuford et al. 2000).

Recent OBO surveys in 2019 seem to indicate Eared Grebes returning in numbers to the Salton Sea, possibly to feed on the recent hatch of water boatman (*Trichocorixa reticulata*) (Bob McKernan, OBO, pers. comm.). These aquatic insects were also detected when large numbers of grebes were detected in 2018 (McKernan and McGaugh 2018). While Eared Grebes did show up in large numbers in 2019 they declined over the winter season (November – December) to nearly absent from OBO surveys in early January only to show up again in the tens of thousands in late January 2019 (Bob McKernan, OBO, pers. comm.). While these fluctuating numbers suggest some presence of Eared Grebes using the Sea, the numbers fall far short of previous estimates from the 1980s and 1990s of more than 1 million birds. What is clear is that the Salton Sea is a dynamic and changing environment and as the environment changes and aquatic food sources change the bird species that use the Salton Sea will likely also fluctuate.

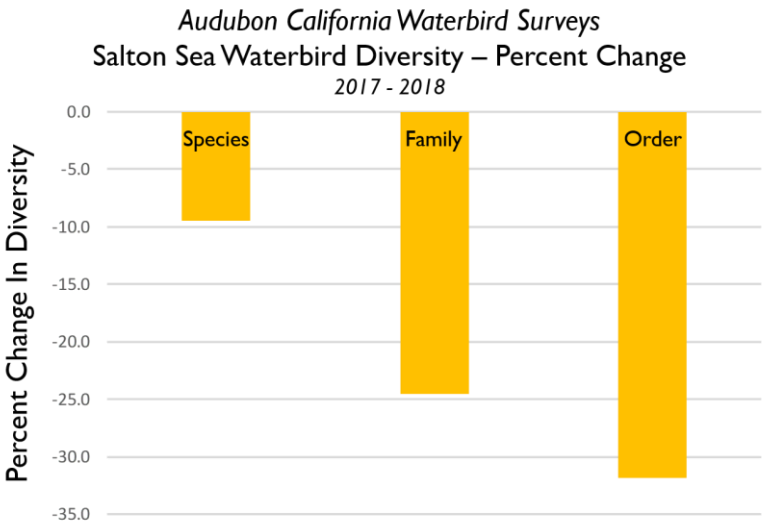

Figure 6. Percent change in diversity (Shannon Diversity Index) between the first and second year of samples from the Audubon California Waterbird Surveys. This shows the proportional change for three taxonomic levels: species, family and order.

SPECIES DIVERSITY

During the two years of Audubon's Waterbird Survey, we saw an apparent decline in species diversity and a shift from a mixture of waterfowl, fish-eating birds and shorebirds at the Sea, to a system that favors shorebirds (Appendix A, Figures 1-7). For example, in November 2016, 12% of the birds observed were shorebirds whereas in November 2018, 41% of the birds observed were shorebirds. This suggests better conditions for shorebirds but a decline in conditions for waterbirds such as pelicans, grebes, and cormorants. Overall, based on Audubon's limited dataset, there appears to be a downward trend in species diversity at the Sea over the past 2 years.

We used Shannon's diversity index (SDI) to assess trends in diversity at three taxonomic levels. Shannon diversity is a widely used index of diversity that accounts for how many species (or other specified taxonomic level) are present while also accounting for the quantity of each of those species. The declining trend in avian diversity is more negative at higher taxonomic levels. At the level of Species there was a 9.5% decrease in diversity (based on the SDI), a 24.5% decline at the level of Family and a 31.9% decline at the level of Order (Figure 6). This may indicate a declining trend in functional diversity as species grouped in higher taxonomic levels like Family and Order may fill similar ecological niches. Significant declines in Shannon Diversity at these higher levels may indicate a simplification of the ecosystem such as a reliance on a narrower variety of prey types.

Conservation Implications

Failure to properly manage the ecological changes at the Salton Sea could have serious implications for the millions of birds that rely on this habitat for survival. As the landscape and physical conditions at the Sea continue to be altered by land and water management, biological responses will be dynamic, but we predict a continued loss in species diversity. Fewer species will be able to tolerate the increasingly saline conditions and even the wet and recently exposed seabed of the receding lake will dry up, affording fewer opportunities for feeding shorebirds.

Most species, particularly special-status species that are already declining/at-risk in California, will require specific management (e.g., wetlands creation and maintenance, nesting islands, a reliable fishery) to ensure their continued presence in the Salton Sea area (Shuford and Gardali 2008).

Large scale loss of wetlands in California, and the interior west, in the 20th century has led to few alternative locations for birds to utilize. The State of California needs to build and manage a wide array of habitats at the Salton Sea to maintain the historic diversity of species rather manage for fewer habitat types and therefore a reduced avian diversity.

This should be accomplished by:

- Providing shallow-flooded and shoreline habitat for migratory shorebirds, breeding Snowy Plovers, and gulls that can adapt to eating brine tolerant invertebrates along the edges of an increasingly salty lake;
- Building habitats on the dry playa, such as wetlands and shallow ponds, to safely support species such as Ruddy Duck that need will require cleaner circulated water and food sources; and
- Building a larger impounded lake, such as the current North Lake concept, to provide fresher deeper water and habitat for fish-eating birds.

This requires the State to complete habitat projects it has promised to build. If the SSMP continues to fail meeting its goals, we will see a diminishing number of species of birds and die-offs like we saw in January 2019 from an avian cholera outbreak that killed an estimated 7,000 Ruddy Ducks and some other species of waterbirds. Birds will continue to stop at the Sea when they have no other places to go, but will be threatened by deteriorating conditions in the water and will fail to find adequate food to support them on their migration.

Summary

We hope that Audubon's Waterbird Survey, along with the other surveys mentioned in this report, will help the State understand the Sea's changing conditions and how birds are responding, and measure the success of the habitat goals set forth in the state's 10-Year Management Plan. Monitoring will be a key component of Salton Sea restoration, but given the long lead-time needed to launch such programs, these data, collected every other month (and now every month starting in January 2019), will help by providing a "snapshot" of the Sea's avifauna as more formal surveys are developed and implemented by CDFW.

By making Audubon's data publicly available (via eBird.org), Audubon and partners can access the data to assist with informing future planning for birds at this vital wetland ecosystem. Furthermore, the data can be used to update Audubon California's habitat suitability model (Jones et al., op cit.) in order better understand what local site conditions or habitat features are most favorable to birds as conditions change.

The Salton Sea is a dynamic and changing environment. As the landscape and physical conditions at the Sea continue to be altered by land and water management, biological responses will likely be dynamic. Audubon's Waterbird Surveys do not yet provide a historical context for bird trends at the Salton Sea. However, they appear to mirror contemporary trends seen in longer-term data sets. The survey data presented here has a higher temporal resolution than many of the long-term datasets currently available. Continuing these higher temporal resolution surveys will help detect potential fluctuation in species trends at the Sea as well as better establish longer-term species trends.

Next steps

Audubon plans to continue, and possibly expand, waterbird surveys for multiple years, with these goals:

- Recruit and train 10-15 local residents annually to participate in the survey; increase surveys to 1x/month and add additional survey points as needed;
- Promote Audubon's Salton Sea birding trail map (http://ca.audubon.org/node/26691) and use of eBird as an additional means to gather more location-specific data on birds at the Salton Sea;
- Coordinate surveys with Point Blue's Pacific Flyway Shorebird Survey (November/December) and collect data at each survey location on habitat conditions;
- Continue to compare data with long-term trends in the Audubon Christmas Bird Count surveys; CDFW aerial surveys of cormorants and pelicans; and weekly surveys conducted on the North end of the Sea by Oasis Bird Observatory;
- Coordinate with, and provide input, on CDFW's Salton Sea Monitoring Plan;
- Collect data, as needed, in coordination with newly constructed habitat projects, particularly with CA Department of Water Resources, USFWS, CDFW, and Imperial Irrigation District; and
- Continue to share data with CDFW, USFWS, and other interested groups.

Acknowledgements

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Appendix A. Selected species results from Audubon's Salton Sea Waterbird Surveys conducted at 14 points every 2 months, Nov. 2016 to Nov. 2018.

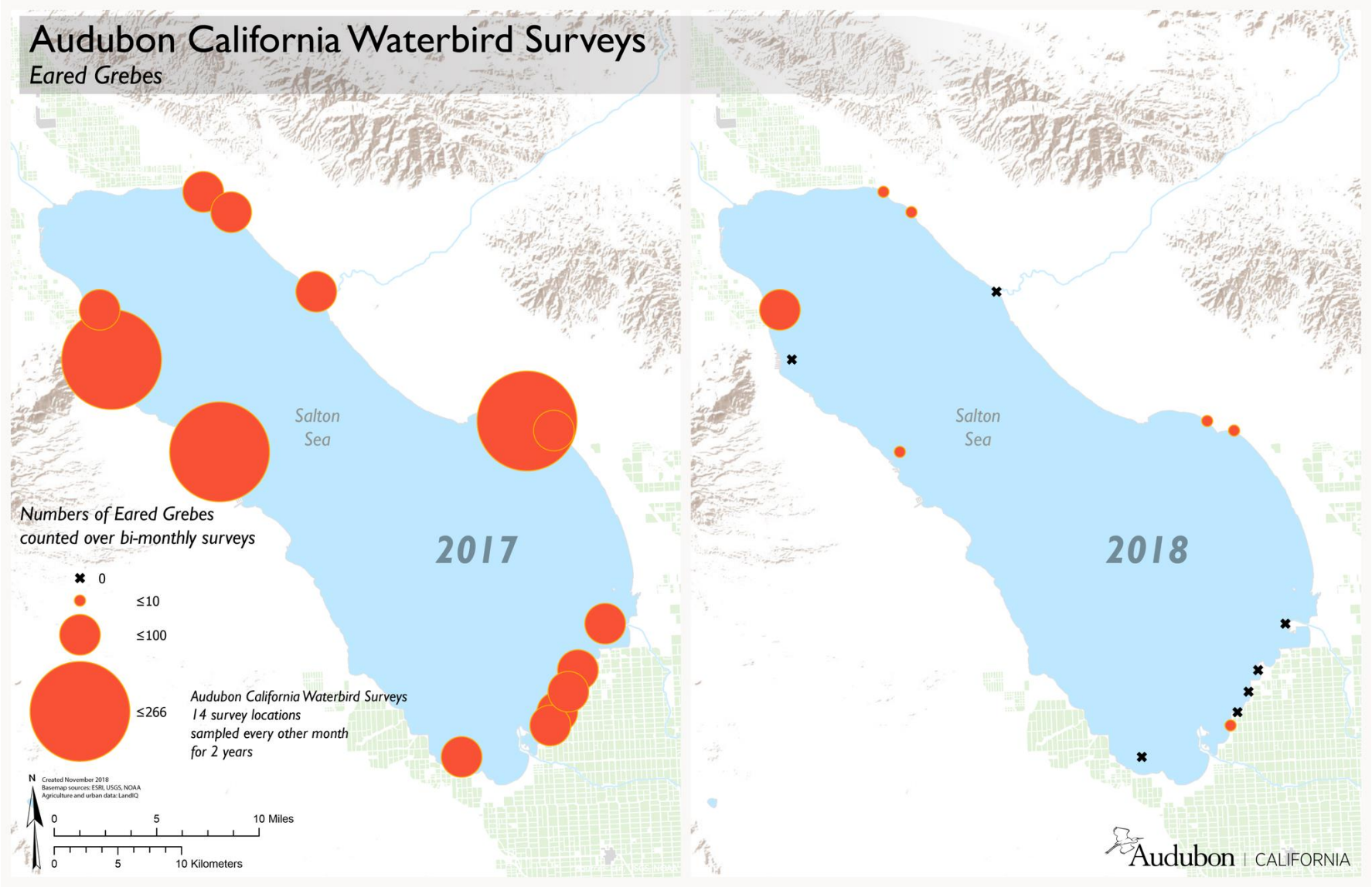

Figure 1. Eared Grebe counts from Audubon California Waterbird Surveys, 2017 vs. 2018.

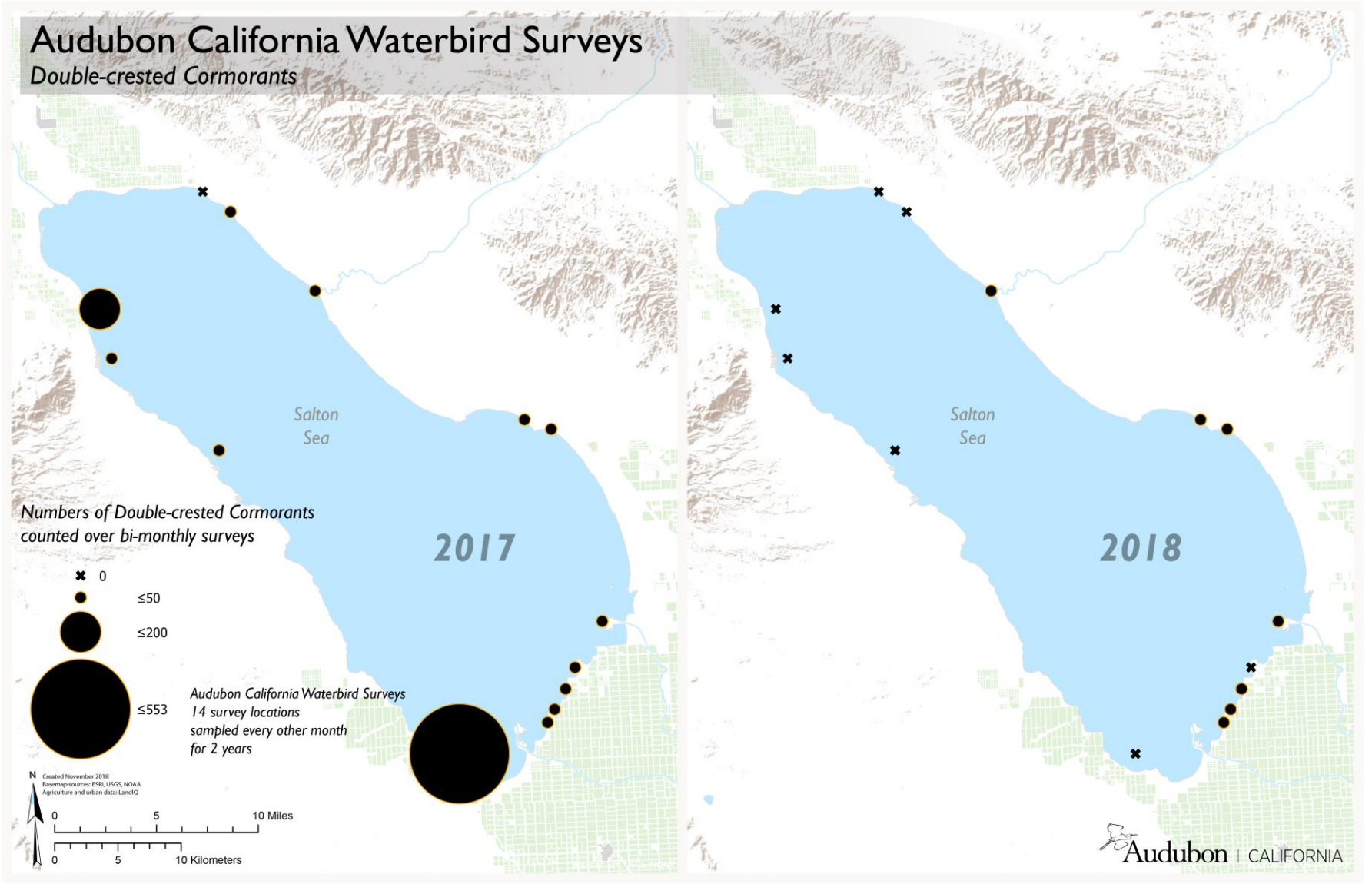

Figure 2. Double-crested Cormorant counts from Audubon California Waterbird Surveys, 2017 vs. 2018.

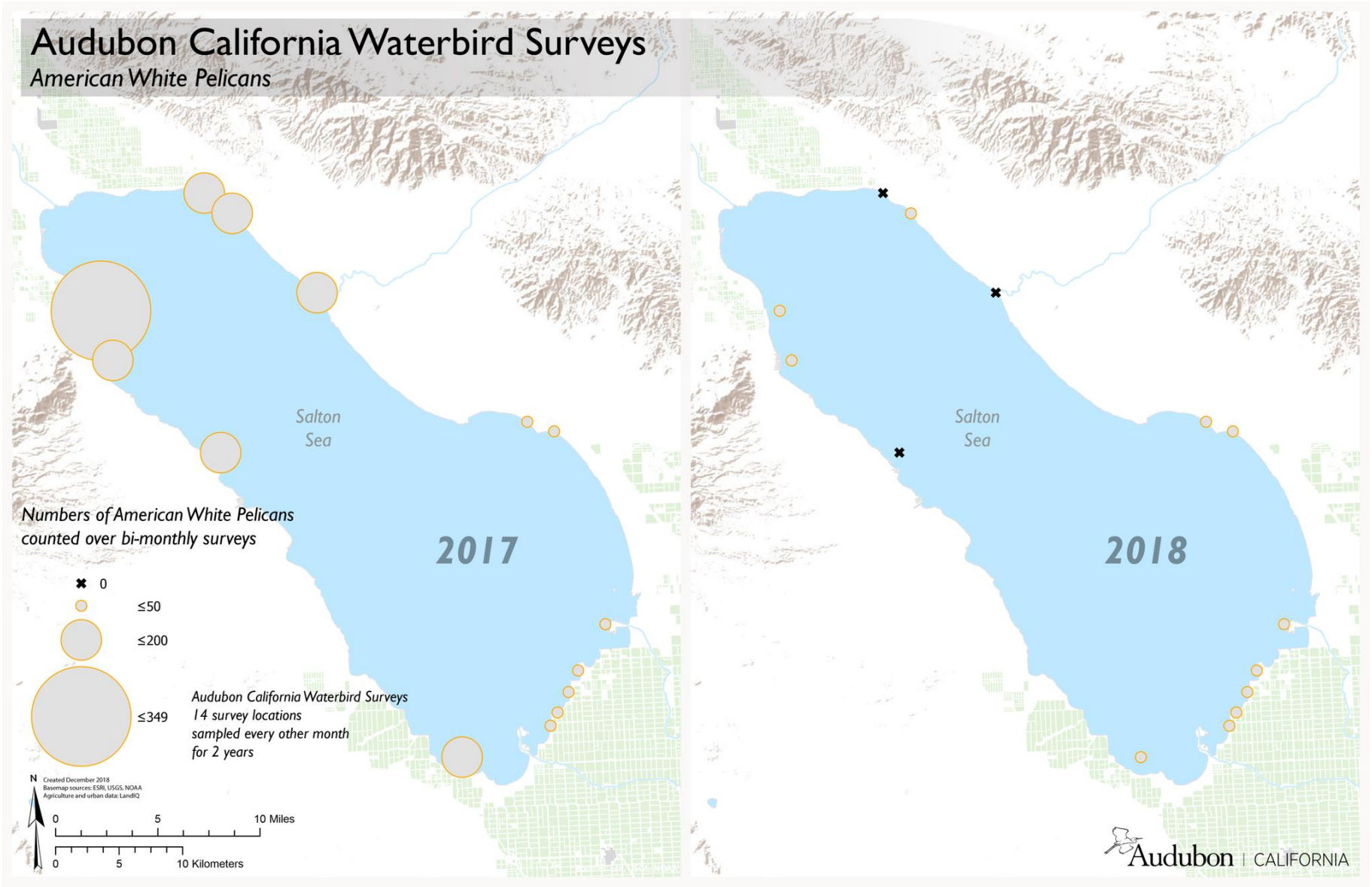

Figure 3. White Pelican counts from Audubon California Waterbird Surveys, 2017 vs. 2018.

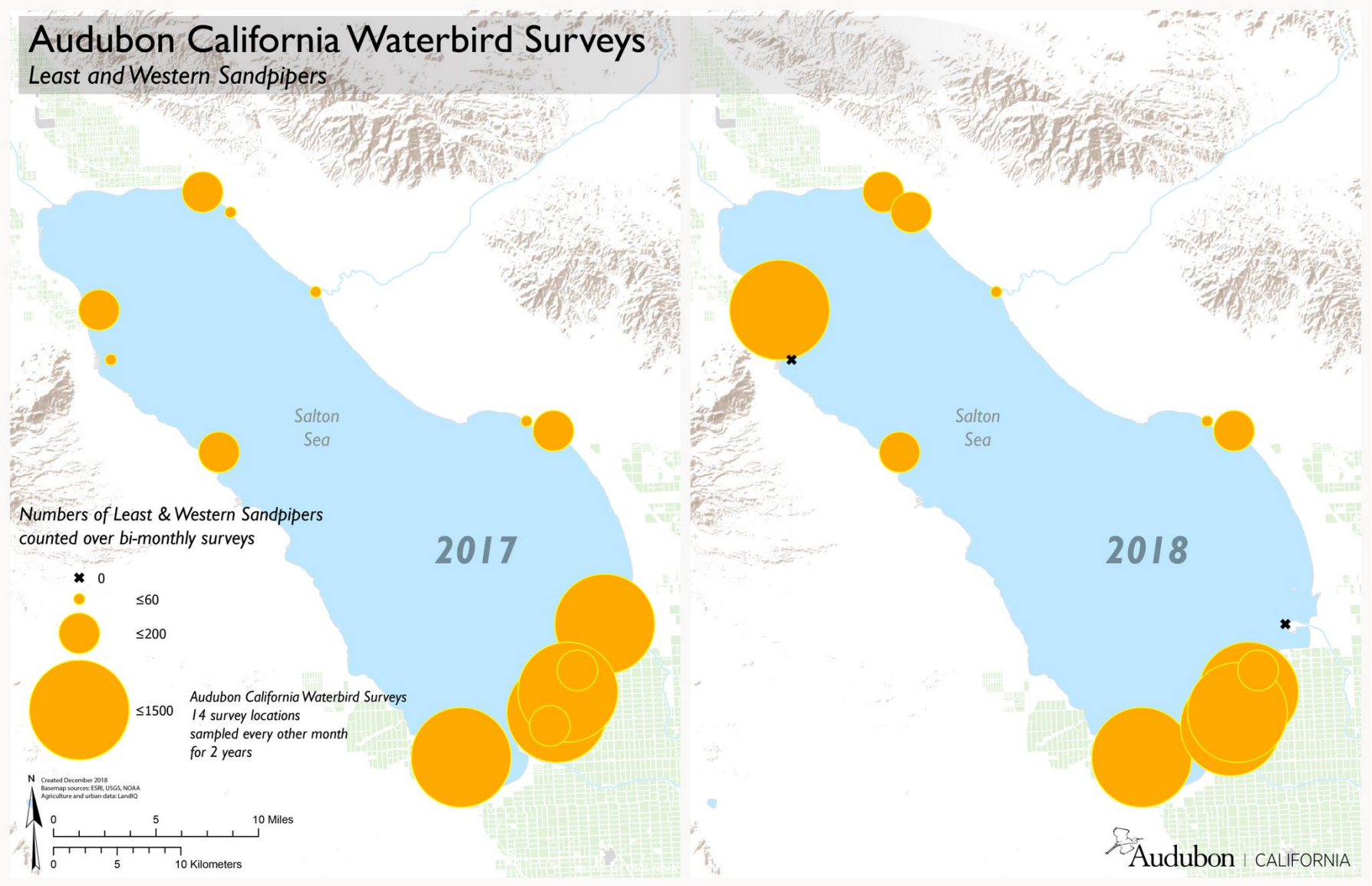

Figure 4. Least and Western Sandpiper counts from Audubon California Waterbird Surveys, 2017 vs. 2018.

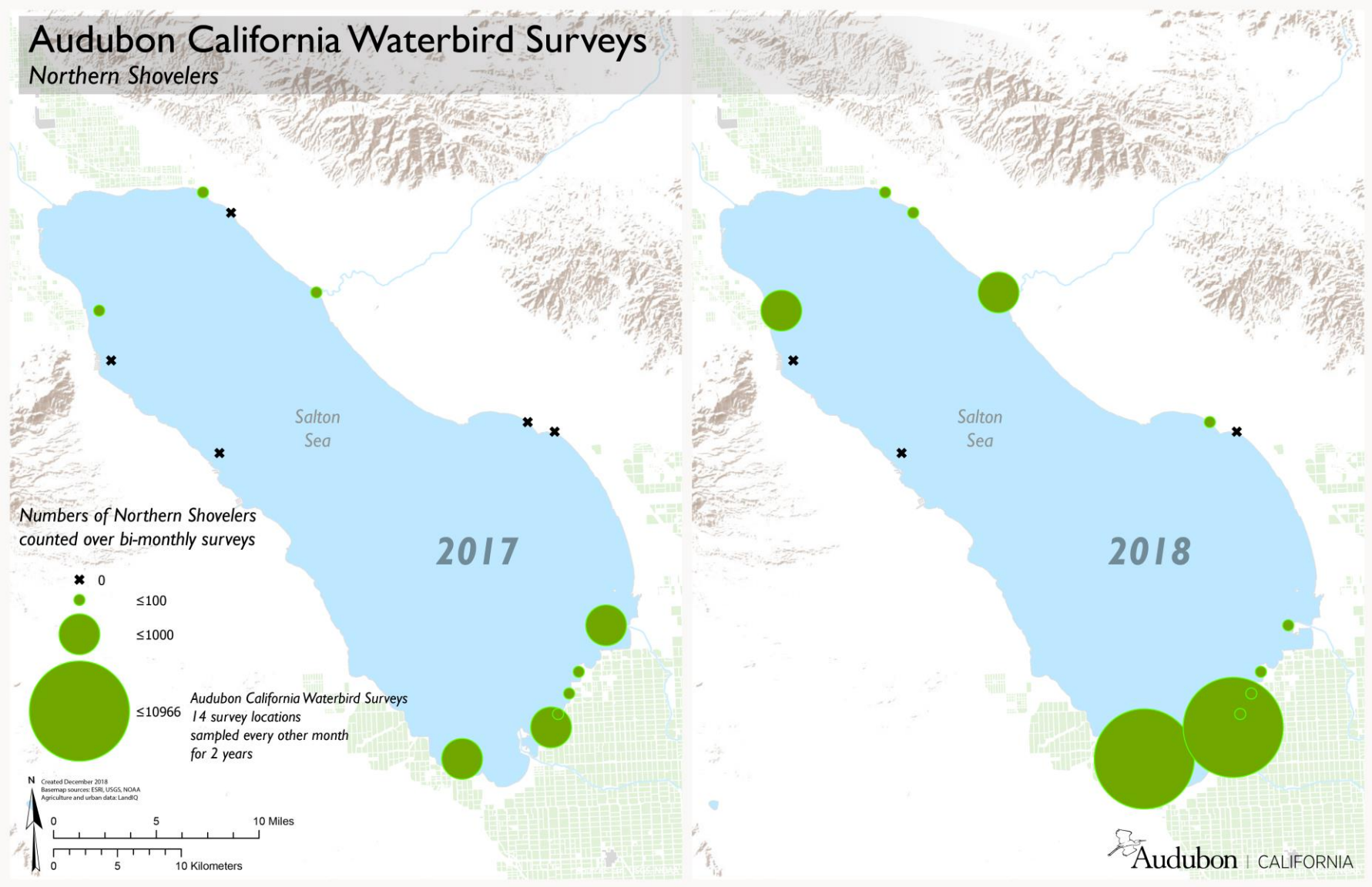

Figure 5. Northern Shoveler counts from Audubon California Waterbird Surveys, 2017 vs. 2018.

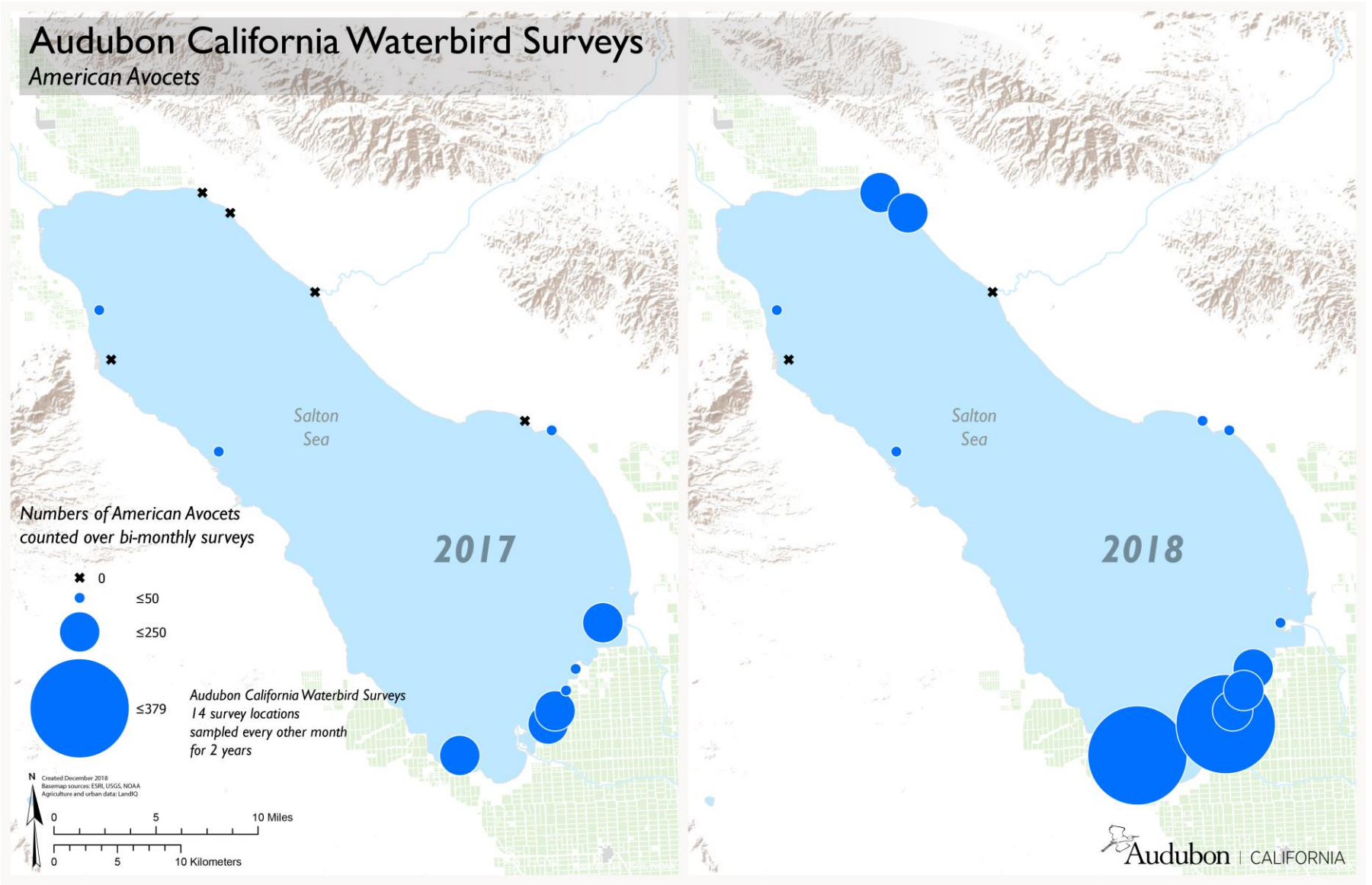

Figure 7. American Avocet counts from Audubon California Waterbird Surveys, 2017 vs. 2018.