DOCKETED	
Docket Number:	09-AFC-05C
Project Title:	Abengoa Mojave Compliance
TN #:	228474
Document Title:	BIO 17 - Bird Monitoring Study Third Quarterly Report Spring 2018
Description:	N/A
Filer:	Keith Winstead
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	6/3/2019 7:30:36 AM
Docketed Date:	6/3/2019

ABENGOA
NORTH AMERICA

Mojave Solar LLC
42134 Harper Lake Road
Hinkley, California 92347
Phone: 760 308 0400

Submitted Electronically

Subject:	**09-AFC-5C**
Condition Number:	**BIO 17**
Description:	**Bird Monitoring Study Third Quarterly Report_Spring 2018**
Submittal Number:	**BIO17-05-01**

April 16, 2019

Keith Winstead, CPM
Siting, Transmission and Environmental Protection Division
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814
Dale.Rundquist@energy.ca.gov

Ann Crisp
Staff Biologist
Siting, Transmission & Environmental Protection Division
California Energy Commission
1516 Ninth Street, MS-40
Sacramento, CA 95814
Ann.Crisp@energy.ca.gov

Dear Mrs. Crisp, Mr. Winstead,

Pursuant to Condition of Certification BIO-17, enclosed for your review and approval is the BIO17-03-00 Bird Monitoring Study Third Quarterly Report_Spring_2018. Per the BIO-17 Verification for COC BIO-17, the DB is responsible for submitting all quarterly and annual reports related to this condition.

Please contact us if you need further information.

Sincerely,

Sean Rowe

Designated Biologist

ABENGOA
NORTH AMERICA
Mojave Solar LLC
42134 Harper Lake Road
Hinkley, California 92347
Phone: 760 308 0400

Project contact information:

Jose Manuel Bravo Romero
Manager. Permitting, Quality & Environment Department.

ABENGOA
NORTH AMERICA
ASI Operations LLC
42134 Harper Lake Rd
Hinkley, CA 92347

Cell: (303) 378-7302
jmanuel.bravo@abengoa.com

Attachments: Bird Monitoring Study Third Quarterly Report. Spring 2018

Mojave Solar Project
California Energy Commission (09-AFC-5C)
Condition of Certification BIO-17

BIO-17 Bird Monitoring Study
Spring 2018 Seasonal Interim Report

Submitted:
August 2018

Prepared for:
Mojave Solar LLC
42134 Harper Lake Road
Hinkley, California 92347

Prepared by:
Corvus Ecological Consulting, LLC
718 N. Humphrey's St.
Suite 202
Flagstaff AZ 86001
(928) 440-5165 (Office)
www.corvusecological.com
brooks@corvusecological.com

Table of Contents

List of Tables

List of Figures

Suggested Reference

Corvus Ecological Consulting, LLC. 2018. BIO-17 Bird Monitoring Study at the Mojave Solar Project, San Bernardino County, California. 2018 Spring Seasonal Report. 29 pp.

Executive Summary

Avian and bat fatality and injury monitoring began on the Mojave Solar Project in September of 2017. This report presents results from the third season of fatality monitoring surveys which were conducted 5 March 2018 through 1 June 2018, according to protocols established by the BIO-17 Bird Monitoring Study Plan (CH2MHill Engineers 2017). In addition to systematic carcass searches within five (5) strata of the project, carcass persistence and searcher efficiency trials were conducted throughout the spring season.

The five strata defined in the monitoring plan include: Solar Collector Fields (SCFs), Evaporation Ponds, Perimeter Fence, Power Blocks, and Power Generation Tie-in (Gen-tie). These strata were surveyed every 7 days from 5 March 2018 through 1 June 2018.

Coturnix quail of two sizes and domestic chickens were used for carcass persistence and searcher efficiency trials. A total of sixty (60) specimens were placed for carcass persistence trials during the spring 2018.Searcher efficiency was tested using eighty-eight (88) specimens.

All bird and bat fatalities, both those located during systematic searches and those located incidentally, are reported for BIO-17. In spring 2018, there were twenty-four (24) incidents of fatalities or injuries, all of which were detected within the search area for BIO-17 and within the Perimeter Fence of the Mojave Solar Project. Fifty percent (50%) of all fatalities and injuries were associated with the Power block cooling towers. The largest number of individuals located for any one species was four (4): Lincoln's Sparrow. All but one of the detections in the spring season were of deceased rather than injured or stranded birds. The one injured bird was a mourning dove that had no obvious signs of injury and was released the same day.

We were able to use the spring 2018 data alone to estimate carcass persistence. The persistence was different for each size class: 0.72 days for small, 0.20 days for medium, and 5.89 days for large carcasses. The probability that a carcass would persist for a 7-day search interval was also calculated and the results were 0.19, 0.11, and 0.69 respectively for small, medium, and large size classes.

Searcher efficiency results from spring 2018 were also sufficient to obtain estimates using this season's data alone. The searcher efficiency was calculated at 0.78 (95% CI 0.68 – 0.88).

During the spring season of 2018, a total of 24 carcasses of wild birds were found within the search area of the Mojave Solar Project. Twelve of these carcasses were found in the cooling tower washout pond and were not incorporated in the estimator. With the twelve remaining carcasses, we used the calculated searcher efficiency and carcass persistence values, and the Fatality Estimator, to obtain an estimate of the total number of bird fatalities in the spring of 2018 of 247 (95% CI: 153 – 502). The cooling tower fatalities can be added back in as a raw number to obtain the final estimate of 259 for spring 2018.

1.0 Introduction

1.1 Background and Project Overview

Mojave Solar Project (hereafter referred to in this document as the "Project") is a solar-thermal electric generating facility located in San Bernardino County, California, approximately 20 miles west of Barstow, California (Figure 1). The project sits on private property that was once occupied by crop production, cattle ranching, and dairy farming. The intent of choosing disturbed habitat for the project site was, in part, to limit impacts to natural vegetation that could provide habitat for wildlife, including avian species. The technology for solar collection in use on the Project is mirrored solar parabolic troughs used to convert water to steam. The steam is converted to electricity using a steam turbine generator. The gross electrical output is 280 MW.

The basic project layout consists of two independently operable units each with its own power block: Alpha (915 acres) and Beta (782 acres). In addition, each independent unit is further divided into subunits: East and West. The area devoted to Solar Collector Fields (SCFs) is roughly 75% of the total project area. The remaining 25% consists of 2 power blocks, drainage improvements, evaporation ponds, a substation, and other elements. The Alpha Unit is divided into Alpha West and Alpha East by Harper Lake Road, and Lockhart Ranch Road runs between Alpha and Beta fields. A combined tortoise-exclusion and security fence surrounds each of the two Alpha subunits separately while the Beta units are encompassed by a single fence. Output from each power block runs in an overhead transmission line to a substation located within the Beta sub-area (Figure 2).

1.2 Study Participants

The following individuals played key roles in BIO-17 monitoring in spring 2018.

Table 1. Participants in BIO-17 monitoring on Mojave Solar in spring 2018.

COMPANY	INDIVIDUAL	TITLE	ROLE IN THIS PROJECT
CORVUS ECOLOGICAL CONSULTING, LLC	Brooks Hart	Project Manager	Implementation of BIO-17 monitoring plan
	Marguerite Hendrie	Data Manager	Data management, and GIS support
	Peter Motyka	Statistician	Statistical analysis
	Brian Williams	Field Biologist	Systematic carcass searches
MOJAVE SOLAR, LLC	Jose Manuel Bravo Romero	Permitting & Compliance Manager	Oversight of Mojave Solar compliance to BIO-17
BIORECON	Gerald Monks	Designated Biologist/Field Lead	Oversight of project-related environmental activities
ROWE ECOLOGICAL CONSULTING	Sean Rowe	Field Lead	Conduct carcass persistence and searcher efficiency bias trials

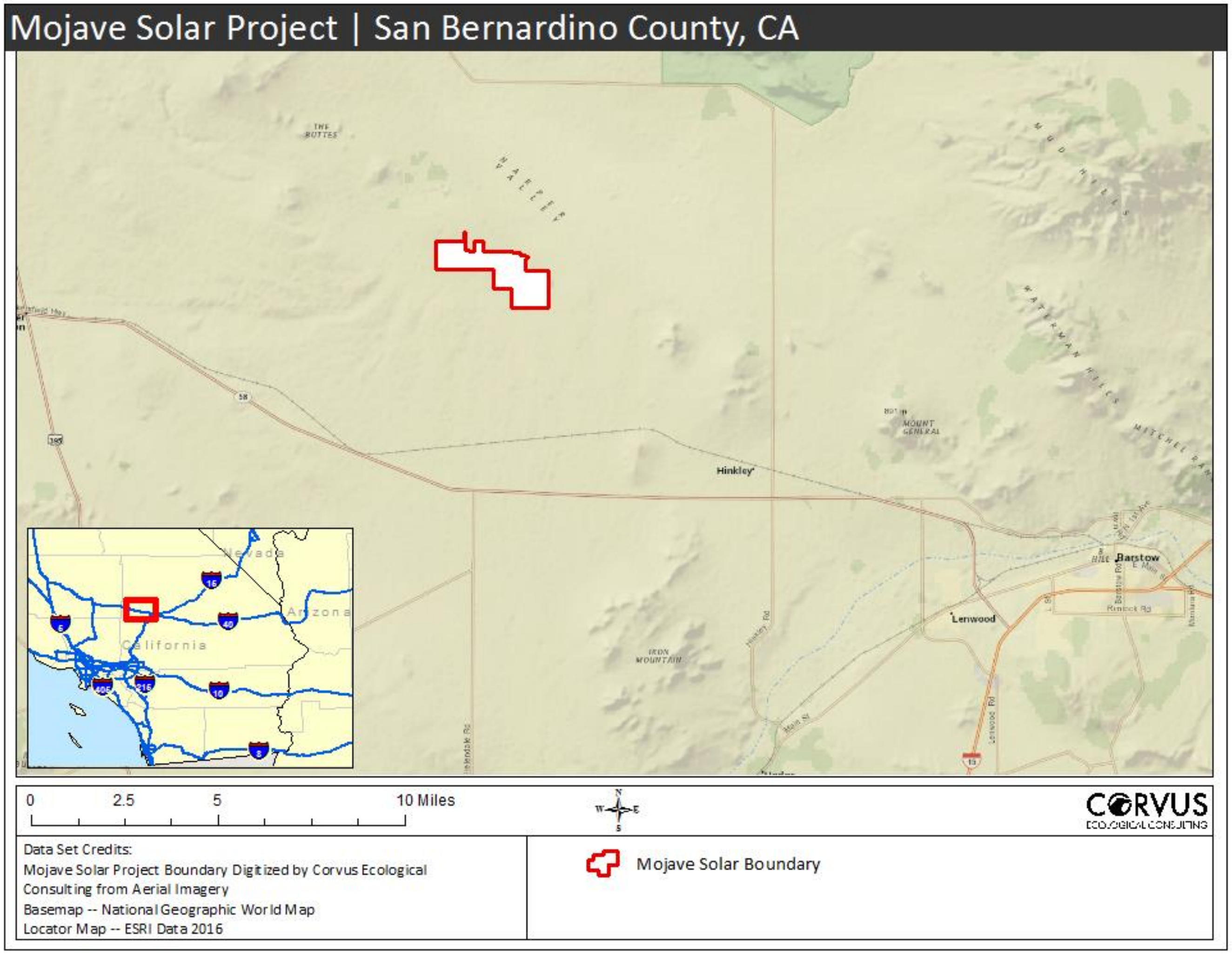

Figure 1. Project vicinity and overview.

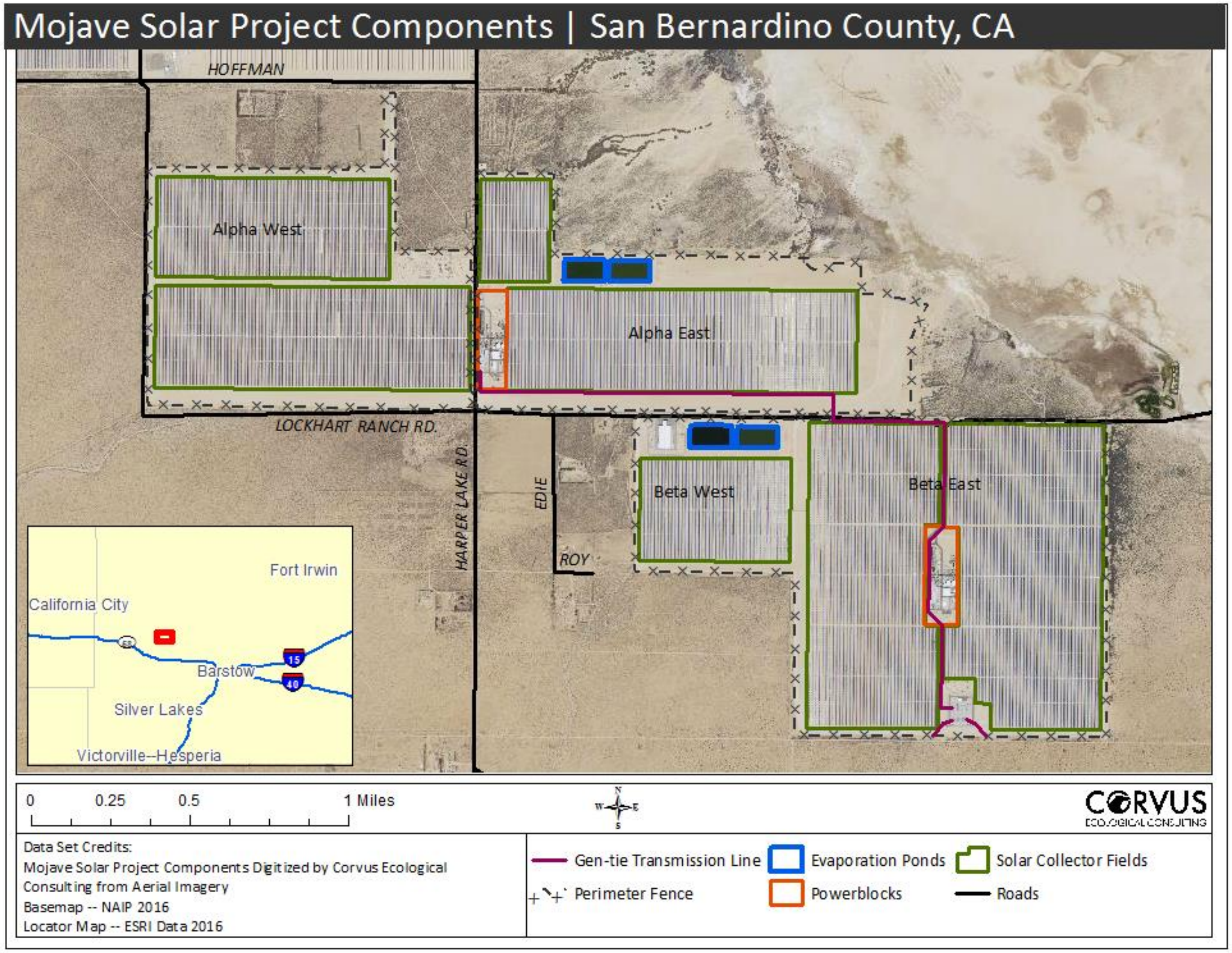

Figure 2. Mojave Solar project components.

1.3 Monitoring Plan Overview and Goals

In 2017, the BIO-17 Bird Monitoring Study Plan [CH2MHill Engineers 2017, (hereafter referred to as “the Plan”)] was submitted for approval to the California Energy Commission (CEC) pursuant to the CEC’s Condition of Certification (COC) BIO-17. The purpose of the monitoring plan was to outline the activities that would be undertaken to monitor the death and injury of birds from collisions with project features such as overhead power lines, fences, and reflective surfaces.

> **COC BIO-17:** The project owner shall prepare and implement a Bird Monitoring Study to monitor the death and injury of birds from collisions with facility features such as reflective mirror-like surfaces and from heat, and bright light from concentrating sunlight. The study design shall be approved by the CPM in consultation with CDFG [CDFW] and USFWS and shall be incorporated into the project’s BRMIMP and implemented. The Bird Monitoring Study shall include detailed specifications on data and carcass collection protocol and a rationale justifying the proposed schedule of carcass searches. The study shall also include seasonal trials to assess bias from carcass removal by scavengers as well as searcher bias.

1.4 Purpose of this Report

This report details the activities performed during the third season of monitoring. This report summarizes the methods employed and provides preliminary results for avian and bat fatalities and injuries. The actions described in this report took place during the 13-week period from 5 March 2018 through 1 June 2018. The data presented in this seasonal report and in future seasonal reports are preliminary. A full comprehensive report will be prepared after the completion of one full year of the program. Where possible, preliminary statistical analyses have been provided.

2.0 Methods

Detailed methods for all components of the study are provided in the Plan. Below is a summary of key activities performed during the spring season 2017-2018.

2.1 Systematic Carcass Searches

2.1.1 Areas Surveyed

The Plan outlined the project components to be surveyed as well as the percentage of each. Five strata were identified: Solar Collector Fields (SCFs), Evaporation Ponds, Perimeter Fence, Power Blocks, and Power Generation Tie-in (Gen-tie).

The SCFs were divided into small blocks and sampling units were created consisting of twelve (12) contiguous collector rows within a block (Figure 3 and 4). Sampling units were randomly selected such that approximately 43% of the total collector rows are sampled in an area. Sampling blocks assume a clear observation distance of 51 m is available when the troughs are in a horizontal position and the ground is devoid of vegetation.

There are two evaporation ponds each in Alpha East and Beta West subunits. Each pond was surveyed 100% using a transect at the perimeter of pond. We assume a minimum observation distance of 110 meters over the ponds on these transects.

The entirety of the perimeter fence (100%) was surveyed during each survey period. Perimeter fence surveys were for the interior of the fence only. A minimum observation distance of 50 meters in either direction from the surveyor was assumed although in most locations, the actual observation distance was much higher. Any carcasses located outside the fence were noted if present, but not counted as a survey specimen.

Each of the power blocks has a road or series of roads that travel the length and/or perimeter of this strata. The cooling towers and administrative buildings are included in this search area. Each survey period, these roads were traveled to search for carcasses. The observation distance is variable within the power block due to buildings and equipment.

The Gen-tie is wholly contained within the greater project boundary. Surveyors traveled under the Gen-tie where it did not overlap with other sampling strata. Much like in the other non-SCF strata, a minimum observation distance of 50 meters to either side of the observer is expected in areas devoid of vegetation.

The total area of each strata, as well as the percent of each component that was searched, is include in Table 2.

2.1.2 Search Frequency and Timing

The spring season began on March 5 and continued through June 1, 2018. Carcass searches were performed during daylight hours between 07:00 and 18:00.

Systematic searches took place Monday through Thursday on the designated weeks. The designated search interval for spring surveys was every 7 days. In spring 2018 the alpha and beta SCFs were closed due to high winds on 16, 17, and 19 April. The Beta SCF was also closed for maintenance on 1 May. During these closures, the position of the solar collectors makes it impossible to perform complete carcass searches.

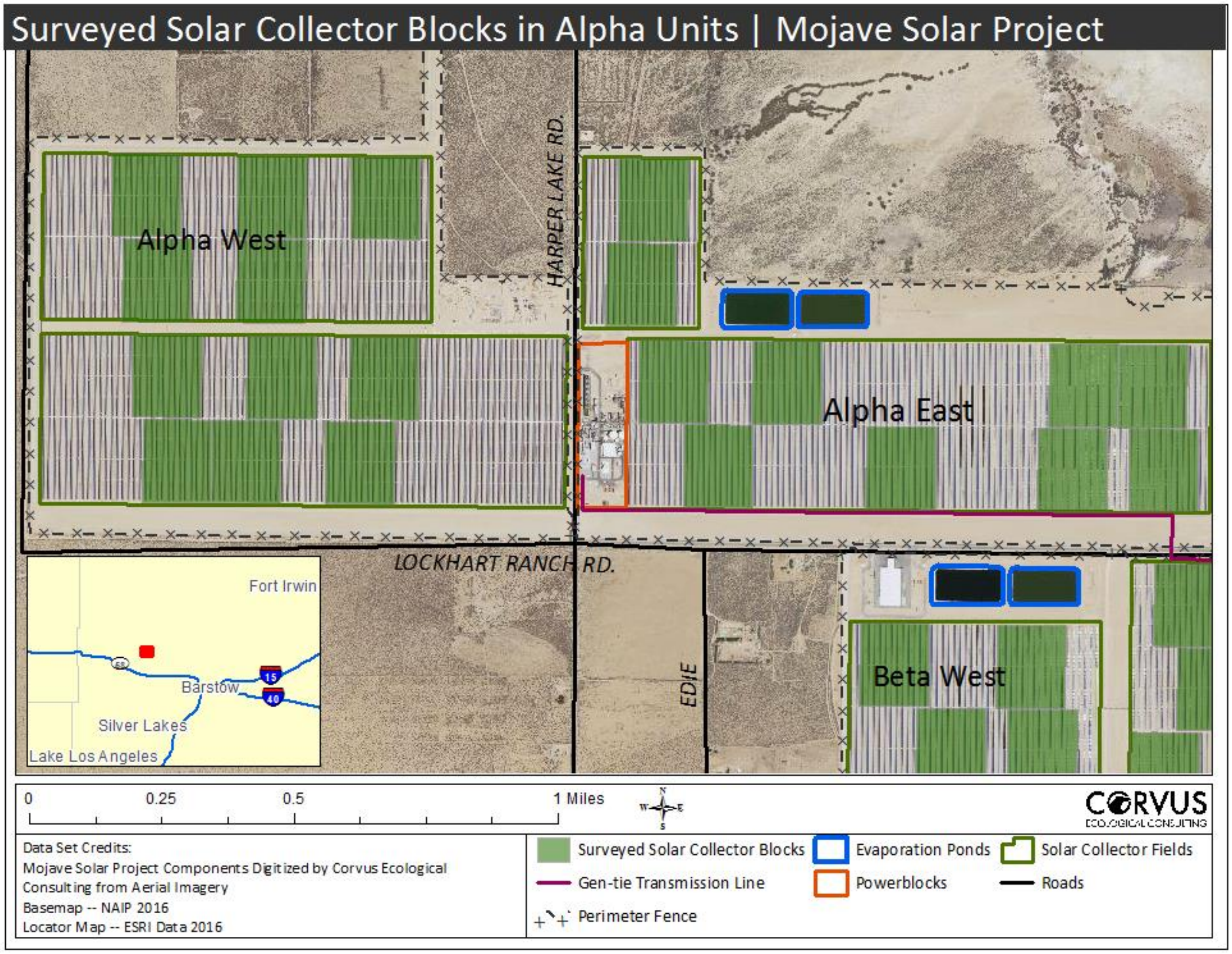

Figure 3. Solar collector blocks in Alpha units surveyed using systematic searches.

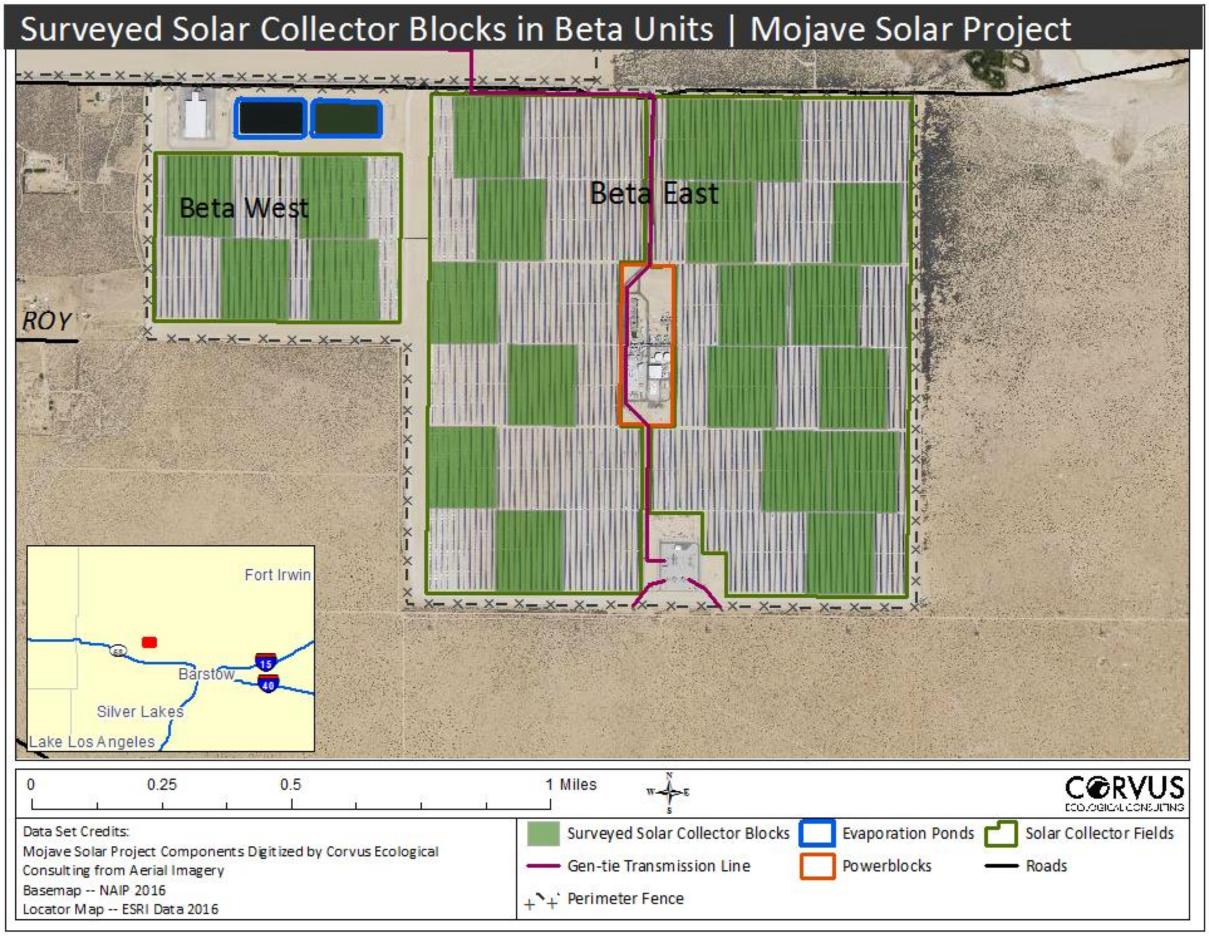

Figure 4. Solar collector blocks in Beta units surveyed using systematic searches.

Table 2. Areas included in systematic carcass searches at Mojave Solar Project during spring 2018.

PROJECT COMPONENT	TOTAL SIZE	UNITS	PERCENT OF COMPONENT SEARCHED
SCF	1160.00	Rows of solar troughs	43
ALPHA WEST	320.00	Rows of solar troughs	41
ALPHA EAST	244.00	Rows of solar troughs	49
BETA WEST	88.00	Rows of solar troughs	55
BETA EAST	508.00	Rows of solar troughs	40
POWER BLOCK	15.50	Hectares	Difficult to Measure
EVAPORATION PONDS	9.50	Hectares	100
GENERATION TIE LINE	4.20	Kilometers	100
PERIMETER FENCE	21.40	Kilometers	100 (Interior only)

[1]Due to the nature of the power block areas with buildings and machinery and the driving transect outlined in the Plan, it is difficult to fully assess how much of the Power Block is covered using this method

2.1.3 Search Methodology

Standardized systematic carcass searches were performed by Corvus Ecological Consulting (Corvus) biologists which were CEC-approved according to project protocols described in the Plan.

For the SCF strata, the timing of transects did not begin until the troughs were near parallel to ensure adequate viewing distance. Biologists drove at speeds less than 5 mph down the access roads parallel to the troughs searching ahead and to the driver's side of the vehicle for signs of bird or bat mortalities. Once the vehicle reached the steam pipe at the end of the transect, the biologist would carefully turn around and drive back up the row searching on the opposite side and ahead. Each sampling block had two rows of driving in this manner. There were 11 sampling blocks in Alpha West, 10 in Alpha East, 4 in Beta West, and 17 in Beta West.

For the evaporation ponds, the biologists would drive or walk a transect (≤ 5 mph) that encircled each pond focusing the search forward and toward the pond. Biologists would stop periodically to scan the surface of the pond with binoculars.

The perimeter fences were surveyed on foot for 100% of their length.

The power block is inherently difficult to survey due to restrictions on access and the presence of equipment and machinery blocking views. Corvus biologists followed the path outlined in the Plan and drove slowly or walked through the roads bisecting the Power Block carefully searching ahead and to either side. Casualties within the power block were more likely to be reported to the designated biologists by site personnel. Such casualties were recorded as incidental detections. Each power block contains evaporative cooling towers that were identified early on in the project as areas of special concern with respect to avian mortalities. Birds that roost in the tower structure are often washed off their perch when the water comes on and end up in the washout pond. The nature of these mortalities makes them difficult to incorporate into an estimator since both the searcher efficiency and carcass persistence have factors unique to this particular piece of equipment. For this reason, washout ponds were checked every day and the mortalities attributed to the cooling tower are not included in the fatality estimator.

The Gen-tie was surveyed using a driving transect when possible. Biologists would scan to either side of the vehicle to search for signs of injuries or mortalities.

Once a carcass was detected, the biologist would walk out to the location and record coordinates using a Global Positioning System (GPS). A range finder was used to measure the perpendicular distance from the carcass to the current transect. At times this would require the biologist to move the vehicle forward or backward, and, using the waypoint in the GPS unit, find the perpendicular location. Photographs and a comprehensive set of data were collected and recorded on provided data sheets.

2.2 Carcass Persistence Trials

A total of 6 carcass persistence trials were completed during the spring 2018 season. Carcasses were of 3 size classes: small (0-100 g), medium (101-999 g) and large (1000+ g). Small carcasses included juvenile coturnix quail (*Coturnix coturnix*), medium were adult coturnix quail, and large were domestic chickens (*Gallus gallus domesticus*).

2.2.1 Carcass Persistence Data Collection

Ten carcasses were placed for carcass persistence twice per month and remained in place for 30 days or until removed by a scavenger. Ground-based observations were made every day for the first five days post placement and then every third or fourth day afterwards. Remote game cameras were also used to monitor scavenging activity. Carcass placement was randomly determined using the sampling strata and ArcGIS randomization routines. Samples were allocated based on the percentage of total area in each stratum and the rule that each stratum must have at least 2 carcasses. During each ground-based monitoring visit, field staff recorded the condition of the carcass: present and wholly intact, evidence of scavenging, feather spot, or removed. A feather spot was defined as groups of feathers composed of at least two or more primary flight feathers, five or more tail feathers, two primaries within five meters or less of each other, or 10 or more feathers of any type within three (3) square meters. Field staff also checked remote cameras and batteries to ensure proper focus and sufficient battery power.

2.2.2 Estimating Carcass Persistence Times, *r*:

Survival analysis is a statistical method used to determine the time until an event of interest using censored data, which accounts for incomplete observations. This is ideal for analyzing carcass persistence times because most of the carcass removals are not directly observed. For example, if a carcass is removed between the survey on day 5 and the survey on day 8 (interval censored), there is no way to know exactly which day the carcass was removed. Also, some carcasses are removed before the first search survey is conducted (left censored), or they last longer than the 30-day survey period (right censored). The remote game cameras can capture the exact time of carcass removal, and these are the only data that are not censored. Survival analysis can accommodate all of these scenarios to calculate an unbiased estimate of carcass persistence.

A major step in the process of survival analyses involve determining the distribution of the data. This is important for balancing parsimony and flexibility within the model to most accurately represent the observed pattern. The Fatality Estimator tests four common distributions for the best fit to the data. These are exponential, Weibull, loglogistic, and lognormal. The exponential distribution is the most parsimonious and assumes that carcass persistence is constant across time. The other models allow for varying levels of flexibility that can capture variation in persistence across time. For example, the lognormal distribution assumes that the probability of a carcass persisting is higher immediately after it falls, then after a short period, the probability rapidly decreases. Biologically, this would mean that there is some lag time between the death of the bird, and the time when the scavenger is able to find and remove it.

Statistical methods are used to determine which distribution best fits the data, and this process is called model selection. Models are compared based on their relative quality, which is measured by the Akaike Information Criterion (AIC). This estimator measures the amount of information that is lost in a model during the process of balancing parsimony and flexibility. Therefore, the model with the lowest AIC (least information lost) is the “best” model. To account for low sample sizes, a slight modification to AIC is used, and this is called AICc.

The persistence of a carcass can be influenced by different covariates including the size of the carcass, the strata the carcass occurs in, and the season of year. Model selection with AICc is used to test if these covariates have a significant influence on the model.

The parameter, *r*, is the probability that the carcass will persist until the next search interval and this is the parameter used in the Fatality Estimator. This is different from the carcass persistence time, denoted as CP, which is an interesting and informative value, but is not directly incorporated into the final model to estimate fatality. Because *r* depends on the interval of time between searches, this interval is very important to the calculation of fatality.

2.3 Searcher Efficiency Trials

Searcher efficiency trials were conducted throughout the spring 2018 survey period. The Field Lead was provided with randomized locations for searcher efficiency. The same size classes were used as for carcass persistence.

2.3.1 Searcher Efficiency Data Collection

Eighty-eight carcasses were placed for searcher efficiency in all strata. Carcasses were placed in the morning prior to the start of systematic searches for that particular strata. Placement was done without the knowledge of the searcher.

2.3.2 Estimating Searcher Efficiency, *p*

Generalized linear mixed models with binomial error and logit link function (logistic regression) were used to estimate the probability that a carcass will be found by the searcher, given that it was available to be found. A binary response was assigned to each observation (1 if the carcass was found, 0 if it was not). Carcasses removed before the searcher survey took place were not included in these analyses. As with carcass persistence, searcher efficiency can be influenced by different covariates, but in order to be included in the model, the number of observations associated with each level of covariates must be sufficient. If no covariates are included in the model, then searcher efficiency simply equals the proportion of carcasses found, *p*.

$$p = \frac{Number\ of\ carcasses\ found}{Number\ of\ carcasses\ available\ to\ be\ found}$$

Bootstrapping is then used to calculate 95% confidence intervals.

2.4 Fatality Estimator

Estimating the number of bird fatalities at a solar farm is challenging because the fatal events are almost never observed directly, and therefore fatality estimation relies on the detection of the remaining carcasses during systematic searches. Yet, the probability of detecting these carcasses is imperfect because of two important factors: 1) the carcasses can be removed from the search area by scavengers or wind before the search, and 2) searchers can fail to detect the carcasses. An accurate and precise estimator of fatality must account for these effects by adjusting the number of carcasses that are found during searches. The general model for this fatality estimator is:

$$F = \frac{C}{rp}$$

where *F* is the total number of birds killed, *C* is the number of carcasses found during searches, *r* is the probability that the carcasses persist long enough to be detected, and *p* is the proportion of those persisting carcasses that the searcher will detect. In simple terms, this is the number of carcasses detected (*C*) divided by the probability of the carcass being detected (*g*=*rp*).

The true values for carcass persistence (*r*) and searcher efficiency (*p*) are unknown and must be estimated from data collected during field trials. Additionally, the relationship between the parameters of this model are all non-linear, and also depend on the interval of time between field trials and searches. For these reasons, the fatality estimator is actually a complex algorithm that incorporates a variety of statistical methods. Although multiple estimators have been proposed, the Huso Estimator has been shown to be superior and unbiased (Huso 2011), and this is the foundation of the USGS-developed Fatality Estimator Software (Huso et al. 2012).

The Fatality Estimator takes data from three main sources, which each correspond to a parameter in the model: 1) the observed carcasses of wild birds (C), 2) Carcass Persistence (r), and 3) Searcher Efficiency (p). When detection probability (g) is known with certainty, the Horvitz-Thompson estimator is known to be unbiased, yet it is not unbiased when g is estimated, as is the case here. Bootstrapping is a resampling method that can produce unbiased variance estimates. In this procedure, a random sample is taken from the data that is smaller than the entire dataset, and the mean and the median of this sample is recorded. This is done multiple times. For this report, 2000 bootstrap iterations were run. From those 2000 resamples, a mean and median are then available with a variance (95% confidence intervals). The median is taken in addition to the mean because it is much less influenced by outliers, and thus provides another useful measure of the data.

The Fatality Estimator also takes into account the proportion of the entire project area (or each strata) that was searched. Estimates are divided by this proportion to extrapolate estimates to the entire project area.

Estimating Detection Probability, *g*.

Recall that:

$$g = rp$$

where g is detection probability, r is carcass persistence, and p is searcher efficiency.

2.5 Incidental Reporting

Bird carcasses were located by solar farm staff not conducting systematic searches in support of BIO-17 and by designated fatality surveyors while traveling between strata or to and from transects. Incidental fatalities were also detected by biologists working on other plans, such as BIO-19. BIO-19 calls for monitoring and adaptive management of the evaporation ponds on site. Work conducted specifically under BIO-19 is not included in this report except where data collection overlaps as in the case of collection of injured and deceased birds and bats.

Any detection made outside of BIO-17 systematic search transects were considered incidental. Data on incidental detections were reported monthly in the SPUT Avian Injury and Mortality Report Forms March through May 2018 and are included in this report. Incidental detections of fatalities were pooled with those found during searches because it was assumed that these would be found during the next scheduled search. Incidental detections made outside of the BIO-17 survey area were not included in fatality estimates. As stated above, cooling tower fatalities were also not included in fatality estimates.

3.0 Monitoring Results

3.1 Avian Fatality or Injury Detections

During spring 2018 survey efforts, twenty-four (24) detections of twelve (12) identified species were recorded; including injured birds, incidental detections, and fatalities detected during systematic surveys (Table 3). The species detected in greatest abundance was Lincoln's Sparrow (*Melospiza lincolnii*) with four (4) individuals. The stratum with the highest number of fatalities or injuries was the Power Block cooling tower with twelve [(15) 63% of total; Figures 4 and 5 and Tables 3, 4, and 5]. Nineteen [(19) 79% of total] detections were made during systematic searches and five [(5) 21% of total] were the result of incidental detections.

Twenty-three (23) of the twenty-four (24) detections were of deceased birds. The one injured bird located had likely collided with the perimeter fence and was released the same day. Of the fifteen (15) power block fatalities, twelve (12) detections were located in the cooling tower washout ponds and are not included in the fatality estimate.

Table 3. Number of individual detections (systematic searches, incidental, and surveys for other project requirements), by species and component during spring (March 5 – June 1) 2018 at the Mojave Solar Project.

COMMON NAME	LATIN NAME	MIGRATORY BEHAVIOR*[1]	COUNT OF CARCASSES IN EACH STRATUM						
			SCF	POWER-BLOCK	EVAP. PONDS	PERIMETER FENCE	GEN-TIE LINE	OTHER	TOTAL
SORA	*Porzana carolina*	nocturnal				1			**1**
AMERICAN COOT	*Fulica americana*	nocturnal			1	1			**2**
ROCK PIGEON	*Columba livia*	resident		1					**1**
MOURNING DOVE	*Zenaida macroura*	resident				1			**1**
VAUX'S SWIFT	*Chaetura vauxi*	diurnal		1					**1**
COMMON RAVEN	*Corvus corax*	resident	1						**1**

[1] This information was obtained from the Birds of North America online edition. References provided in Literature Cited.

COMMON NAME	LATIN NAME	MIGRATORY BEHAVIOR*[1]	COUNT OF CARCASSES IN EACH STRATUM						
			SCF	POWER-BLOCK	EVAP. PONDS	PERIMETER FENCE	GEN-TIE LINE	OTHER	TOTAL
BEWICK'S WREN	*Thryomanes bewickii*	unknown, likely nocturnal		1					**1**
SWAINSON'S THRUSH	*Catharus ustulatus*	primarily nocturnal		1					**1**
EUROPEAN STARLING	*Sturnus vulgaris*	resident	1						**1**
COMMON YELLOWTHROAT	*Geothlypis trichas*	nocturnal		2					**2**
YELLOW-RUMPED WARBLER	*Setophaga coronata*	nocturnal		1					**1**
LINCOLN'S SPARROW	*Melospiza lincolnii*	nocturnal		4					**4**
UNKNOWN SPECIES				4		2	1		**7**

COMMON NAME	LATIN NAME	MIGRATORY BEHAVIOR*[1]	COUNT OF CARCASSES IN EACH STRATUM						
			SCF	POWER-BLOCK	EVAP. PONDS	PERIMETER FENCE	GEN-TIE LINE	OTHER	TOTAL
TOTALS			**2**	**15**	**1**	**5**	**1**	**0**	**24**

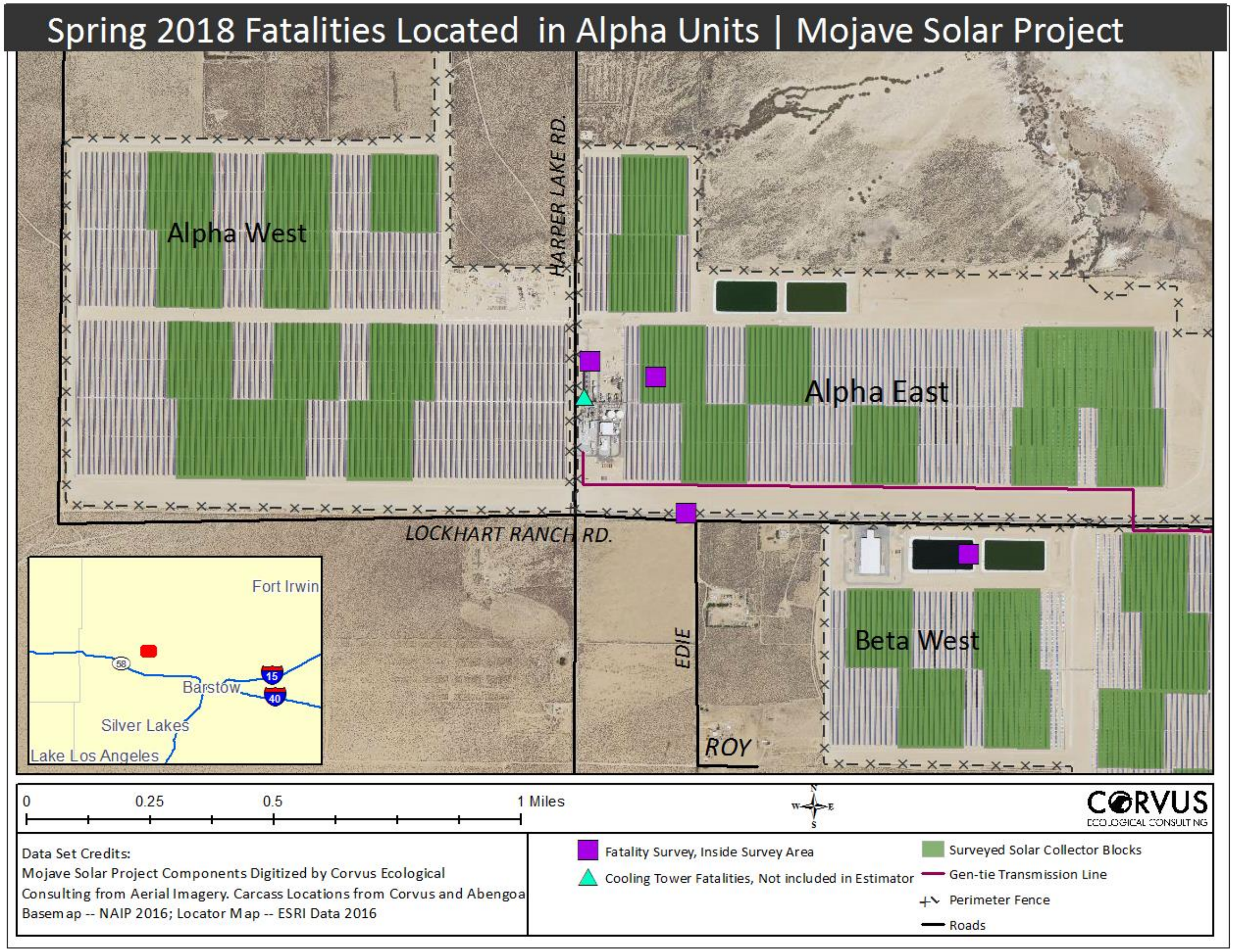

Figure 5. Locations of carcasses and injured birds found in spring 2018 on the Alpha Unit Components of the Mojave Solar Project.

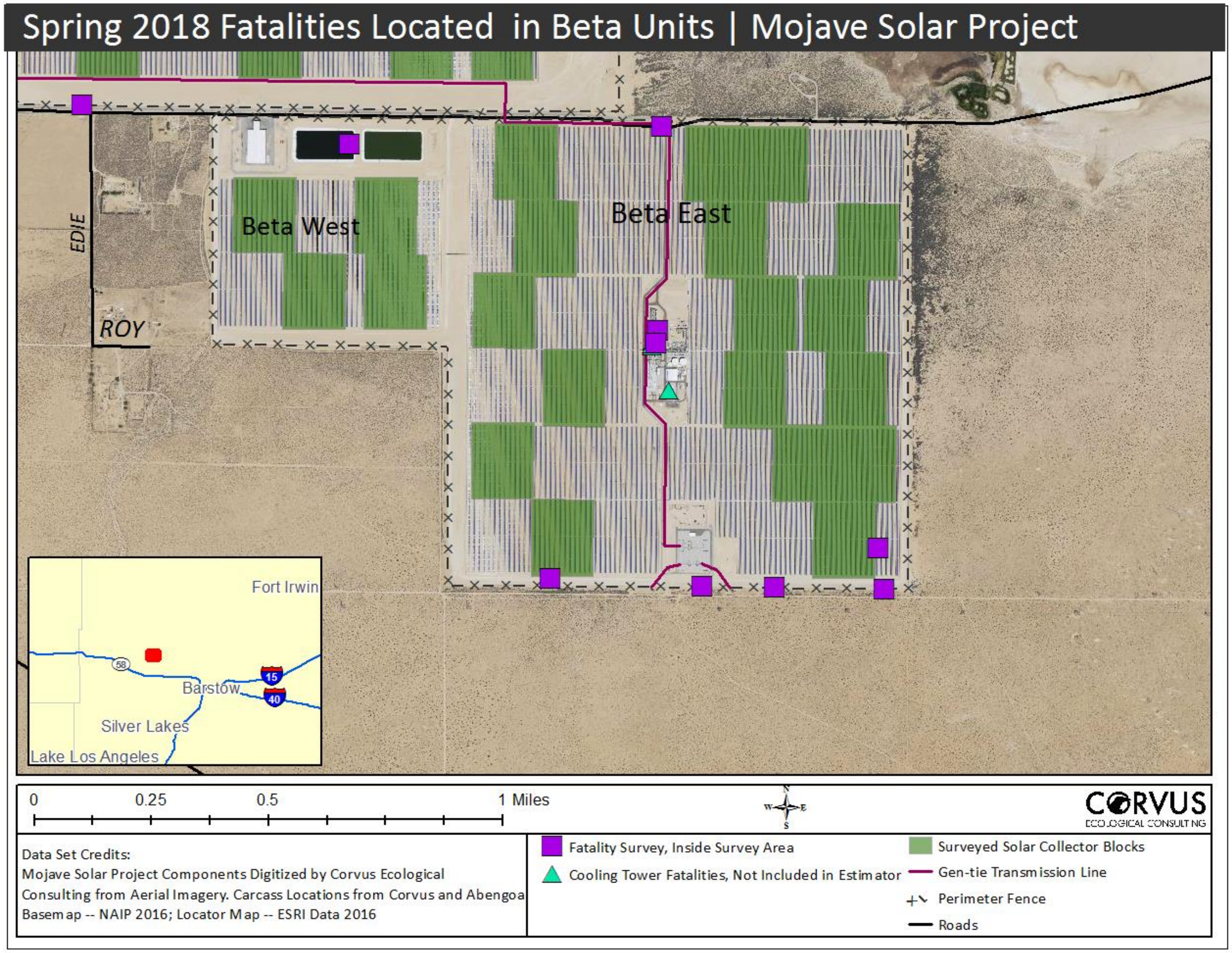

Figure 6. Locations of carcasses and injured birds found in spring 2018 on the Beta Unit Components of the Mojave Solar Project

3.1.1 Temporal Patterns of Avian Detections

The highest number of detections on a single day was five (5), which occurred on April 24, 2018 (Figure 7). Four (4) detections in March marked the fewest for any calendar month during the spring season. These numbers include totals from systematic searches and incidental detections.

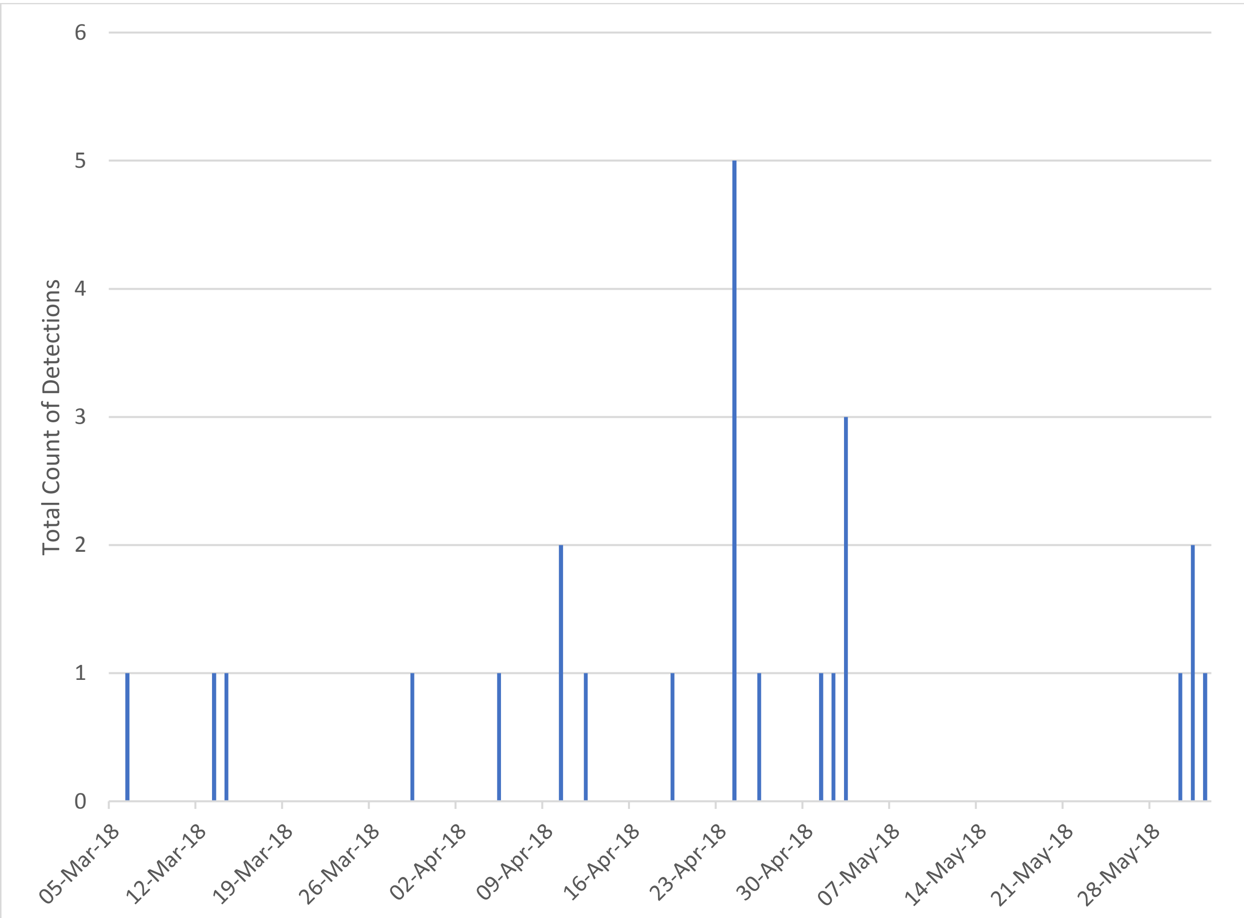

Figure 7. Total number of detections by date during spring (March 5 – June 1) 2018 at Mojave Solar Project, San Bernardino County, CA.

3.1.2 Spatial Distribution of Avian Detections

During the spring season 2018, detections were made within the SCF, along the Perimeter Fence, under the Gen-tie line, within the Power Block (including the cooling tower), and in the Evaporation Ponds (Tables 3, 4, and 5). All twenty-four (24) avian mortalities were within the project’s Perimeter Fence and BIO-17 survey area. Of the 24 within the fence, the breakdown by unit is as follows: 0 in Alpha West, 5 in Alpha East, 1 in Beta West, and 18 in Beta East.

Table 4. Total detections by Project component and detection category during spring (March 5 – June 1) 2018 at Mojave Solar Project, San Bernardino County, CA.

PROJECT COMPONENT	SYSTEMATIC SEARCH	INCIDENTAL	% OF TOTAL
PERIMETER FENCE	**5**		**20.8**
OVERHEAD LINE (GEN-TIE)	**1**		**4.2**
EVAPORATION PONDS	**1**		**4.2**
POWER BLOCK	**10**	**5**	**62.5**
COOLING TOWER	*7*	*5*	
OTHER	*3*		
SCF	**2**		**8.3**
ROADS OUTSIDE PERIMETER FENCE			
PERCENT OF TOTAL	**79.2**	**20.8**	**100.0**

Table 5. Total detections (all types) by Project component and suspected cause of death during spring (March 5 – June 1) 2018 at Mojave Solar Project, San Bernardino County, CA.

PROJECT COMPONENT	SUSPECTED CAUSE OF DEATH*						% OF TOTAL
	COLLISION	DROWNED	OTHER	EXPOSURE/ DEHYDRATION	PREDATION	UNKNOWN	
PERIMETER FENCE	4					1	**20.8**
OVERHEAD LINE						1	**4.2**
EVAPORATION PONDS		1					**4.2**
POWER BLOCK		12				3	**62.5**
SCF						2	**8.3**
ROADS							
% OF TOTAL	**16.7**	**54.2**				**29.1**	

*No necropsies were performed on the carcasses found, so cause of death is generally based on evidence available such as location in relation to infrastructure. If there was no obvious signs of injury and no further clues given the location, the cause of death was generally listed as “unknown”.

3.1.3 Characterization of Detections by Condition

Twenty-three (23) of the detections made during the spring 2018 were of dead birds. Of those, two [(2) 8.3%] were freshly deceased; four [(4) 16.7%] were semi-fresh with some signs of rigor mortis; and seventeen [(16) 70.8%] were feather spots.

3.1.4 Injured or Stranded Birds

One (1) stranded or injured bird was found during the spring 2018. The bird was a Mourning Dove found along the perimeter fence. Biologists suspected it collided with the perimeter fence and was temporarily stunned. It was taken to the nearby Harper Lake wetland and released.

3.2 Bat Detections

There were no bats detected during the spring 2018.

3.3 Carcass Persistence Trials

In previous seasonal reports, there were insufficient data from a single season alone to model carcass persistence. In spring 2018, however, there were sufficient data; thus we will present results from the spring season only. Sample size in strata other than SCF and perimeter fence were too small for strata to be considered a covariate, but we were able to use size class. Size class included three levels: small, medium and large carcasses. Model selection found that the lognormal model with carcass size as a covariate was the best model to estimate carcass persistence (Table 6).

Table 6. Model selection results displaying AICc values of 8 models tested. The model with the lowest AICc value was chosen as the best model

DISTRIBUTION	COVARIATES	
	None	Size Class
WEIBULL	193.25	167.5
EXPONENTIAL	240.93	175.48
LOGLOGISTIC	186.4	159.25
LOGNORMAL	187.13	**158.76**

Table 7. Estimates of carcass persistence with 95% confidence intervals (LCL, UCL). The effective search interval was found to be seven days, and this was used to calculate the proportion of carcasses remaining to the next search (r).

SIZE CLASS	TRIALS PLACED	MEDIAN CARCASS PERSISTENCE (DAYS)	MEAN CARCASS PERSISTENCE (DAYS	CP LCL (95%)	CP UCL (95%)	*r* PROPORTION REMAINING AFTER 7 DAYS	*r* LCL (95%)	*r* UCL (95%)
LARGE	10	5.86	5.89	2.9	12.96	0.69	0.5	0.86
MEDIUM	20	0.20	0.19	0.09	0.38	0.11	0.09	0.18
SMALL	30	0.72	0.72	0.46	1.15	0.19	0.14	0.29

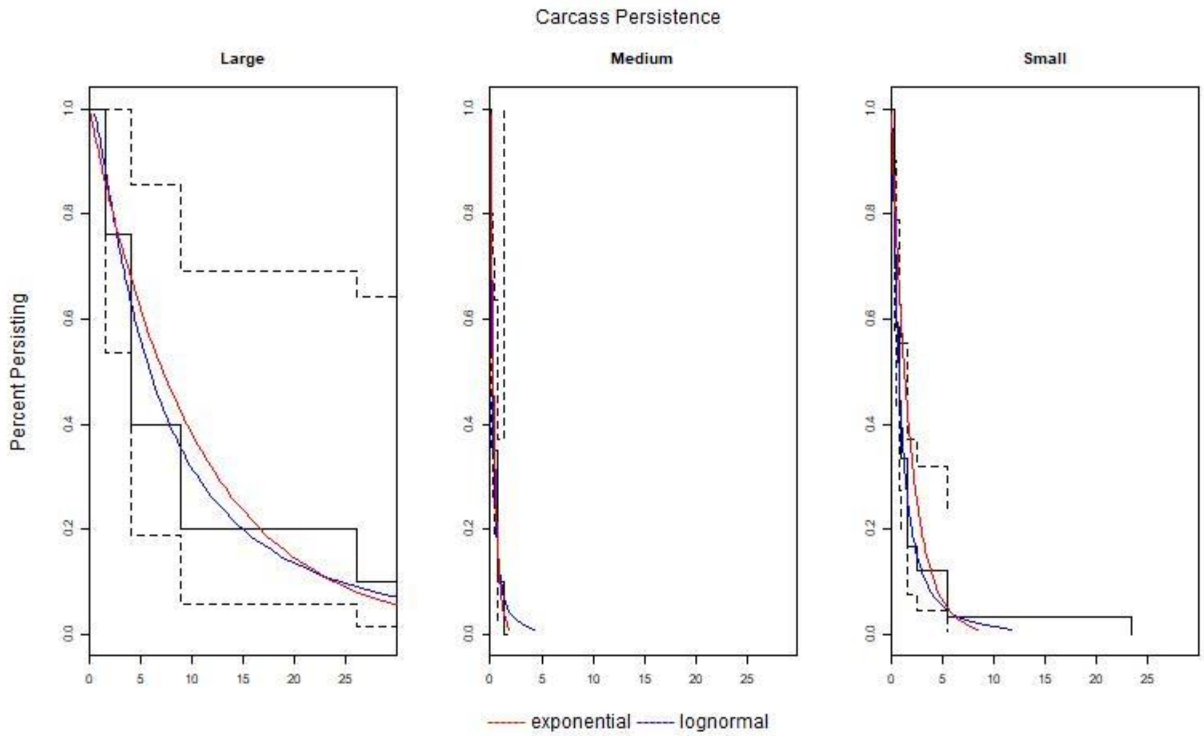

Figure 8. Carcass persistence graphs for three size classes of carcasses. Black lines denote the parametric estimation of CP with 95% confidence intervals (dashed line) using the Kaplan-Meier model. Red lines denote the non-parametric estimation using the fitted exponential distribution, and blue lines denote non-parametric estimation using the fitted lognormal distribution, which was chosen as the best model.

3.4 Searcher Efficiency Trials

As with the carcass persistence, we had sufficient data from the spring season alone to run models, although the limited data from strata other than SCF or perimeter fence inhibiting considering strata as a covariate.

Table 8. Model selection results for searcher efficiency displaying AICc values of 2 models tested. The model with the lowest AICc value was chosen as the best model

	COVARIATES	
	None	Size Class
AICc	**69.79**	72.35

The model with no covariates was chosen over using size class as a covariate.

Some searcher efficiency trial specimens were removed by scavengers and other environmental factors before they were encountered by the searcher, making them unavailable for trial purposes. Table 9 details trial specimen availability and searcher detection rates.

Table 9. Carcasses of three size classes (S,M,L) placed for searcher efficiency trials in each project component of the Mojave Solar Project between March 5, 2018 and June 1, 2018. Carcasses removed by scavengers or wind before the survey was conducted were not able to be detected by the searcher.

PROJECT COMPONENT	PLACED			REMOVED			AVAILABLE TO BE DETECTED			DETECTED			NOT DETECTED		
	CARCASS SIZE														
	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L
EVAPORATION PONDS	1	2	0	0	1	0	1	1	0	1	1	0	0	0	0
GEN-TIE	0	2	2	0	2	0	0	0	2	0	0	2	0	0	0
PERIMETER FENCE	11	7	5	3	2	0	8	5	5	6	4	5	2	1	0
POWER BLOCKS	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0
SCA	32	16	9	11	4	0	21	12	9	15	11	5	6	1	4
SIZE CLASS TOTAL	45	27	16	14	9	0	31	18	16	23	16	12	8	2	4
PROJECT TOTAL			88			23			65			51			14

With 51 out of 65 specimen located in spring 2018, searcher efficiency was 0.78 (95% CI: 0.68 – 0.88).

3.5 Fatality Estimates

During the Spring season of 2018, an estimated 247 bird mortalities (95% CI: 153 -502) occurred at the Mojave Solar Project (Table 10). This estimate was based on 12 observed fatalities, which excluded the 12 fatalities from the cooling tower. Estimates and confidence intervals were calculated using the Huso (2012, 2018) Fatality Estimator Model. Whereas in previous reports, data was pooled across seasons, this report includes only data from the

Spring season because data was sufficient to do so. The only limitation this presented was that SE and CP trials in strata other than the SCA and the perimeter fence were insufficient to test differences across these strata. Searcher efficiency was much improved for the Spring season at 0.78 (95% CI: 0.68 – 0.88). For carcass persistence, large carcasses persisted significantly longer than medium and small carcasses. Carcass persistence for medium carcasses was the lowest with and mean of 0.19 days (95% CI: 0.09 – 0.38), and because almost half of fatalities (5 out of 12) were medium sized carcasses, this explains the high estimate and wide confidence intervals.

Table 10. Fatality estimates for spring 2018 (not including cooling tower).

	FATALITIES FOUND	ESTIMATED FATALITIES	LCL (95%)	UCL (95%)
SPRING 2018				
OVERALL	12	**247**	153	502
SIZE CLASS				
Large	3	8	5	11
Medium	5	202	111	456
Small	4	38	24	65
STRATA				
Evap Pond	1	24	12	53
Perimeter Fence	5	62	39	121
Gen-tie	1	2	1	3
Power Block	3	143	82	309
SCA	2	19	12	29

There were 12 fatalities found in the cooling tower washout ponds that were not included in the estimator. Since this element of the project was checked daily for fatalities, and scavenging of the washout pond seems unlikely, we can add this number into the estimated fatalities for a total of 259 estimated fatalities in spring 2018.

4.0 Discussion

The spring 2018 season was the third season of standardized effort for data collection in support of BIO-17 on the Mojave Solar Project. Using the experiences from fall 2017 through spring 2018 we are able to refine and improve our methods and analyses.

4.1 Carcass Persistence and Searcher Efficiency Trials

In fall 2017 and subsequently winter 2017, we attempted to reduce the problem of "scavenger swamping" by running carcass persistence and searcher efficiency concurrently using the same carcasses. Due to the fast removal time, and the length of time taken to survey the entire facility, this technique resulted in too few carcasses available for searchers to detect. Starting in spring 2018, we began conducting searcher efficiency trials with a separate set of specimens that were placed on the same day as the search effort. This change in methodology likely contributed to higher rates of searcher efficiency. Other changes included more information collected on the part of the field lead with respect to the presence of the searcher efficiency carcasses at the end of the day on which they were placed which has resulted in a more accurate accounting of the number of carcasses removed before the searcher has a chance to find them.

4.2 Distribution of Fatalities and Fatality Estimates

Additional data will allow the testing and application of more flexible and robust modeling techniques. The Plan calls for collection of data to perform distance sampling on the carcasses collected during systematic surveys and thus have another possible model for estimating overall fatalities. We hope to investigate this method for the final annual report.

As seasons vary, we expect avian visitation of the project site to be dynamic and subsequently fatality and injury rates will change. During the spring 2018, we saw the number of fatalities ramp up in April corresponding with the height of spring migration and then fall back down again with a small spike toward the end of May. We will continue to monitor throughout the seasons with the survey frequency outlined in the Plan. All strata will be sampled during each systematic survey in an effort to tease apart differences in fatality rates based on project components.

4.3 Cooling Tower Mitigation

Mitigation efforts for specific project components (e.g. evaporation ponds and cooling towers) are not specifically part of the BIO-17 plan although the outcomes will likely affect the mortality estimation for the project as a whole. Mojave Solar is working on providing a feasibility study for netting/ screening the Cooling Towers. The feasibility study will be a separate submittal. The preliminary study is positive, and the nets will be installed pending final approval from Atlantica Yield's Engineering Department.

5.0 Literature Cited

Ammon, E.M. 1995. Lincoln's Sparrow. The Birds of North America (A. Poole, Ed.) Ithaca: Cornell Laboratory of Ornithology; Retrieved August 22, 2018, from The Birds of North America: https://birdsna.org/Species-Account/bna/species/linspa/introduction

Boarman, W.I. and Bernd Heinrick. 1999. Common Raven. The Birds of North America (A. Poole, Ed.) Ithaca: Cornell Laboratory of Ornithology; Retrieved August 22, 2018, from The Birds of North America: https://birdsna.org/Species-Account/bna/species/comrav/introduction

Brisbin Jr., I. Lehr and Thomas B. Mowbray. 2002. American Coot. The Birds of North America (A. Poole, Ed.) Ithaca: Cornell Laboratory of Ornithology; Retrieved February 12, 2018, from The Birds of North America: https://birdsna.org/Species-Account/bna/species/y00475/introduction

Bull, E.L. and Charles T. Collins. 2007. Vaux's Swift. The Birds of North America (A. Poole, Ed.) Ithaca: Cornell Laboratory of Ornithology; Retrieved August 22, 2018, from The Birds of North America: https://birdsna.org/Species-Account/bna/species/vauswi/introduction

Cabe, P.R. 1993. European Starling. The Birds of North America (A. Poole, Ed.) Ithaca: Cornell Laboratory of Ornithology; Retrieved August 22, 2018, from The Birds of North America: https://birdsna.org/Species-Account/bna/species/eursta/introduction

CH2MHill Engineers, Inc. and Western Ecosystems Technology, Inc. 2017. BIO-17 Bird Monitoring Study. Mojave Solar Project San Bernardino County, California. 51 pp.

Guzy, M.J. and Gary Ritchison. 1999. Common Yellowthroat. The Birds of North America (A. Poole, Ed.) Ithaca: Cornell Laboratory of Ornithology; Retrieved August 22, 2018, from The Birds of North America: https://birdsna.org/Species-Account/bna/species/comyel/introduction

Hunt, Pamela D. and David J. Flaspohler. 1998. Yellow-rumped Warbler. The Birds of North America (A. Poole, Ed.) Ithaca: Cornell Laboratory of Ornithology; Retrieved February 12, 2018, from The Birds of North America: https://birdsna.org/Species-Account/bna/species/yerwar/introduction

Huso, M.M., 2011. An estimator of wildlife fatality from observed carcasses. Environmetrics, 22(3), pp.318-329.

Huso, M.M., Som, N. and Ladd, L., 2012. Fatality estimator user's guide (No. 729). US Geological Survey.

Johnston, Richard F. and Peter E. Lowther. 2014. Rock Pigeon. The Birds of North America (A. Poole, Ed.) Ithaca: Cornell Laboratory of Ornithology; Retrieved February 12, 2018, from The Birds of North America: https://birdsna.org/Species-Account/bna/species/rocpig/introduction

Kennedy, E.D. and Douglas W. White. 2013. Bewick's Wren. The Birds of North America (A. Poole, Ed.) Ithaca: Cornell Laboratory of Ornithology; Retrieved August 22, 2018, from

The Birds of North America: https://birdsna.org/Species-Account/bna/species/bewwre/introduction

Korner-Nievergelt, F., Behr, O., Brinkmann, R., Etterson, M.A., Huso, M.M., Dalthorp, D., Korner-Nievergelt, P., Roth, T. and Niermann, I., 2015. Mortality estimation from carcass searches using the R-package carcass—a tutorial. *Wildlife Biology*, *21*(1), pp.30-43.

Mack, D.E. and Wang Yong. 2000. Swainson’s Thrush. The Birds of North America (A. Poole, Ed.) Ithaca: Cornell Laboratory of Ornithology; Retrieved August 22, 2018, from The Birds of North America: https://birdsna.org/Species-Account/bna/species/swathr/introduction

Melvin, S.M. and James P. Gibbs. 2012. Sora. The Birds of North America (A. Poole, Ed.) Ithaca: Cornell Laboratory of Ornithology; Retrieved August 22, 2018, from The Birds of North America: https://birdsna.org/Species-Account/bna/species/sora/introduction

Otis, D.L., J.H. Schulz, D. Miller, R.E. Mirachi, and T.S. Baskett. 2008. Mourning Dove. The Birds of North America (A. Poole, Ed.) Ithaca: Cornell Laboratory of Ornithology; Retrieved August 22, 2018, from The Birds of North America: https://birdsna.org/Species-Account/bna/species/moudov/introduction

R Core Team. 2018. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.