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Submitted Electronically

Subject:	**09-AFC-5C**
Condition Number:	**BIO 17**
Description:	**Bird Monitoring Study Second Quarterly Report_Winter2017_2018**
Submittal Number:	**BIO17-04-01**

April 16, 2019

Keith Winstead, CPM
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Ann Crisp
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Siting, Transmission & Environmental Protection Division
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Dear Mrs. Crisp, and Mr. Winstead,

Pursuant to Condition of Certification BIO-17, enclosed for your review and approval is the BIO17-03-00 Bird Monitoring Study Second Quarterly Report_Winter2017_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

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Attachments: Bird Monitoring Study Second Quarterly Report. Winter 2017-2018

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

BIO-17 Bird Monitoring Study
Winter 2017-2018 Seasonal Interim Report

Submitted:
May 2018

Prepared for:
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Suggested Reference

Corvus Ecological Consulting, LLC. 2018. BIO-17 Bird Monitoring Study at the Mojave Solar Project, San Bernardino County, California. 2017-2018 Winter Seasonal Report. 30 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 second season of fatality monitoring surveys which were conducted 6 November 2017 through 2 March 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 winter season.

The five strata defined in the monitoring plan includes: Solar Collector Fields (SCFs), Evaporation Ponds, Perimeter Fence, Power Blocks, and Power Generation Tie-in (Gen-tie). These strata were surveyed every 21 days from 6 November 2017 through 2 March 2018.

Coturnix quail of two sizes and domestic chickens were used for carcass persistence and searcher efficiency trials. A total of eighty (80) specimens were placed for carcass persistence trials during the winter 2017-2018. Twenty (20) of these were placed concurrently with systematic searches and were designed to also serve as trial specimens to test searcher efficiency. An additional 10 specimens were placed for searcher efficiency alone.

All bird and bat fatalities, both those located during systematic searches and those located incidentally, are reported for BIO-17. In winter 2017-2018, there were seventeen (17) incidents of fatalities or injuries, fifteen (15) of which were detected within the search area for BIO-17 and within the Perimeter Fence of the Mojave Solar Project. Forty-one percent (41%) of all fatalities and injuries were associated with the perimeter fence. The largest number of individuals located for any one species was two (2): Green-winged Teal, American Coot, and Rock Pigeon. One (1) of the detections was an injured or stranded bird rather than deceased.

We pooled carcass persistence data from fall 2017 and winter 2017-2018 to obtain estimates of the average number of days a carcass would persist before being removed by a scavenger. The persistence was different for each size class: 0.84 days for small, 1.28 days for medium, and 2.71 days for large carcasses. The probability that a carcass would persist for a 7-day search interval was also calculated and the results were 0.21, 0.3, and 0.48 respectively for small, medium, and large size classes.

Searcher efficiency results were also pooled from fall 2017 and winter 2017-2018, but still the sample size was too low for model selection. The searcher efficiency was calculated at 0.43 (95% CI 0.25 – 0.61).

During the winter season of 2017-2018, a total of 15 carcasses of wild birds were found within the search area of the Mojave Solar Project. Using the calculated searcher efficiency and carcass persistence values, and the Fatality Estimator, the total number of bird fatalities in the winter of 2017-2018 was estimated to be 515 (95% CI: 342 – 954).

Study Participants

***Corvus* Ecological Consulting, LLC**

Brooks Hart	Project Manager
Marguerite Hendrie	Data Manager
Peter Motyka	Statistician
Frank Treadway	Field Biologist
Brian Sandstrom	Field Biologist
Brian Williams	Field Biologist

Mojave Solar LLC

Jose Manuel Bravo Romero	Permitting & Compliance Manager

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Gerald Monks	Designated Biologist/Field Lead

Rowe Ecological Consulting

Sean Rowe	Field Lead

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).

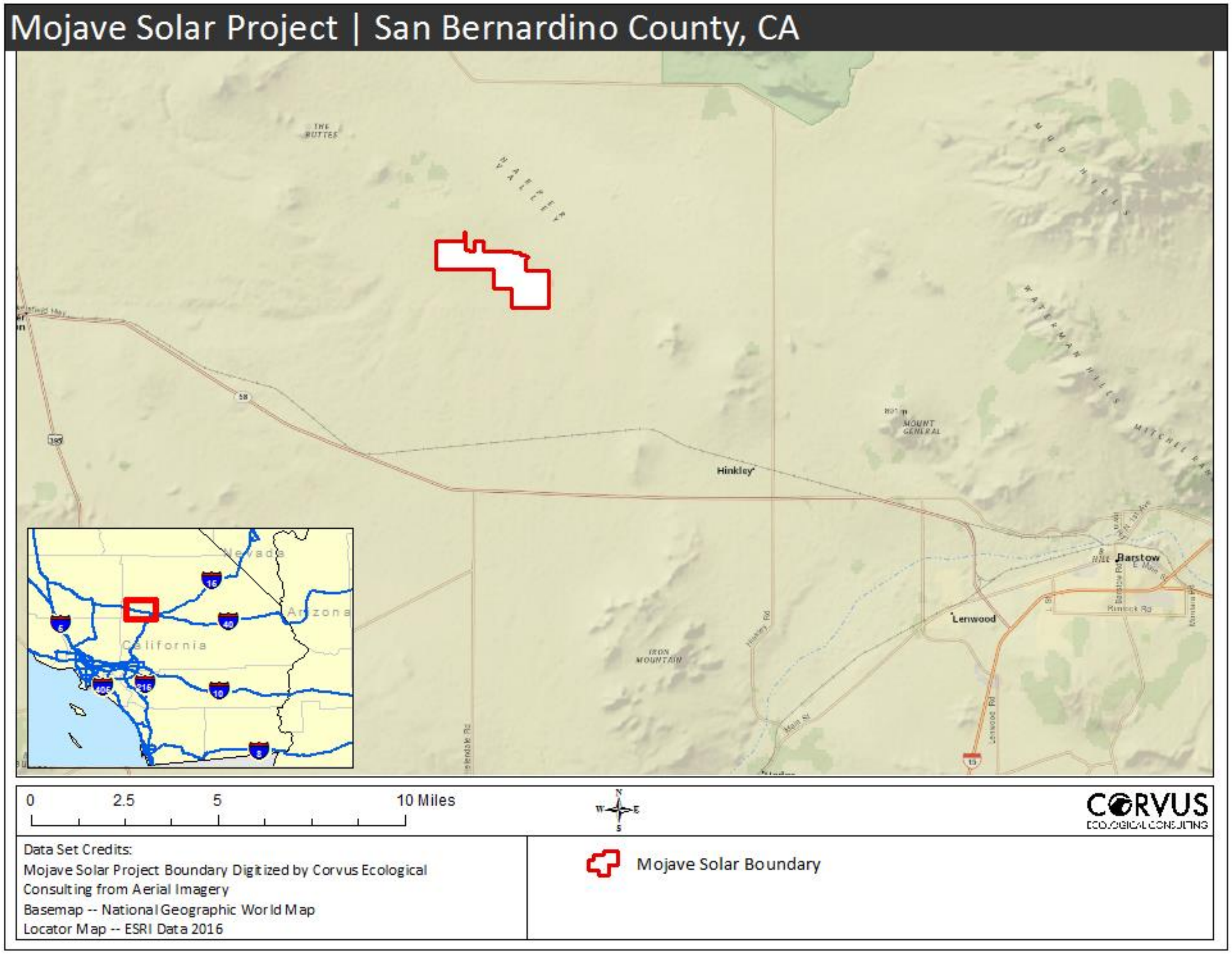

Figure 1. Project vicinity and overview.

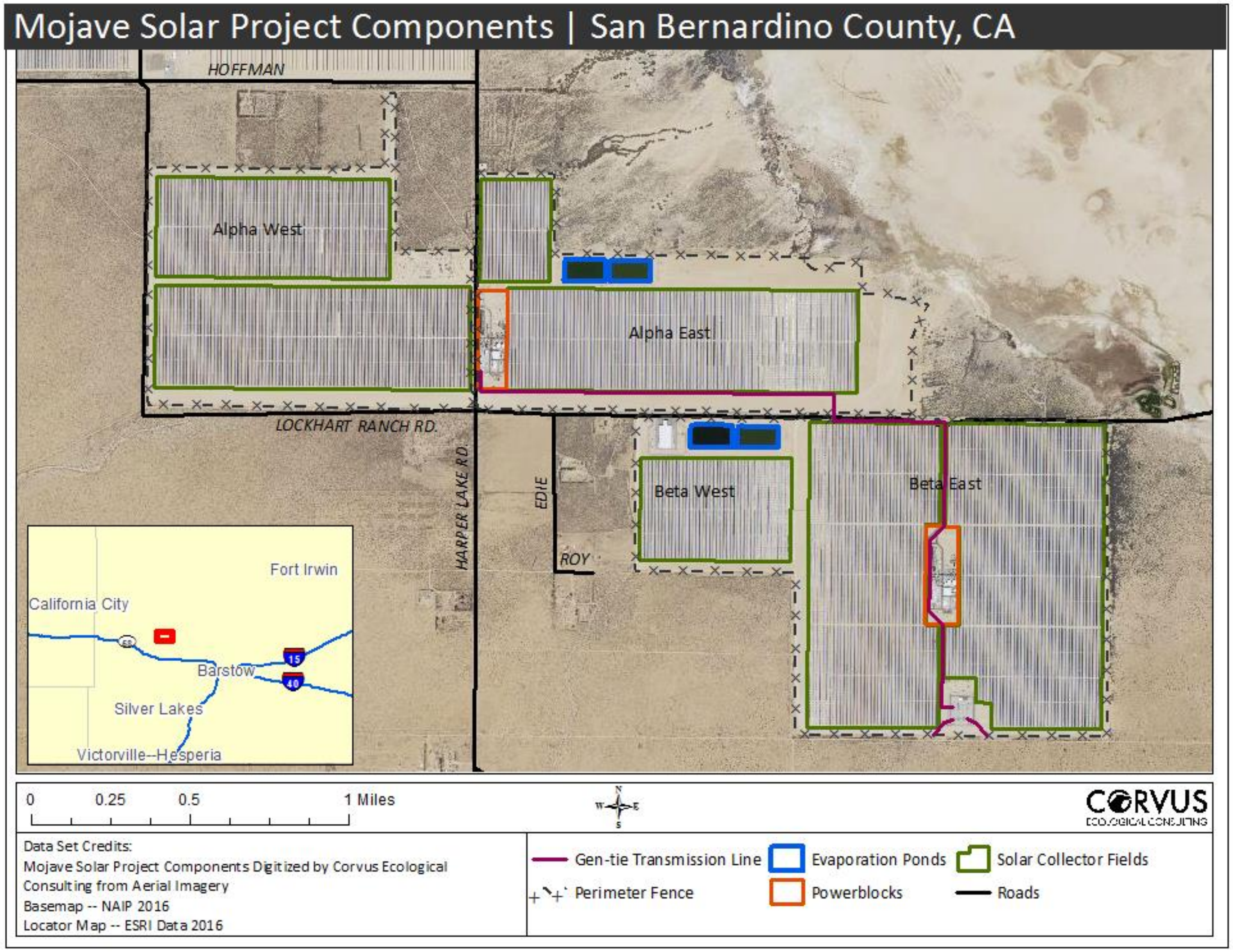

Figure 2. Mojave Solar project components.

1.2 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.

1.3 Purpose of this Report

This report details the activities performed during the second 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 17-week period from 6 November 2017 through 2 March 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, but small sample sizes inhibited the ability to perform a thorough or complete analyses at this early stage.

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 winter 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 1.

2.1.2 Search Frequency and Timing

The winter season began on November 6 and continued through March 2, 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 winter surveys was every 21 days. In Winter 2017-2018 there were no closures of the solar facility that interfered with the systematic searches.

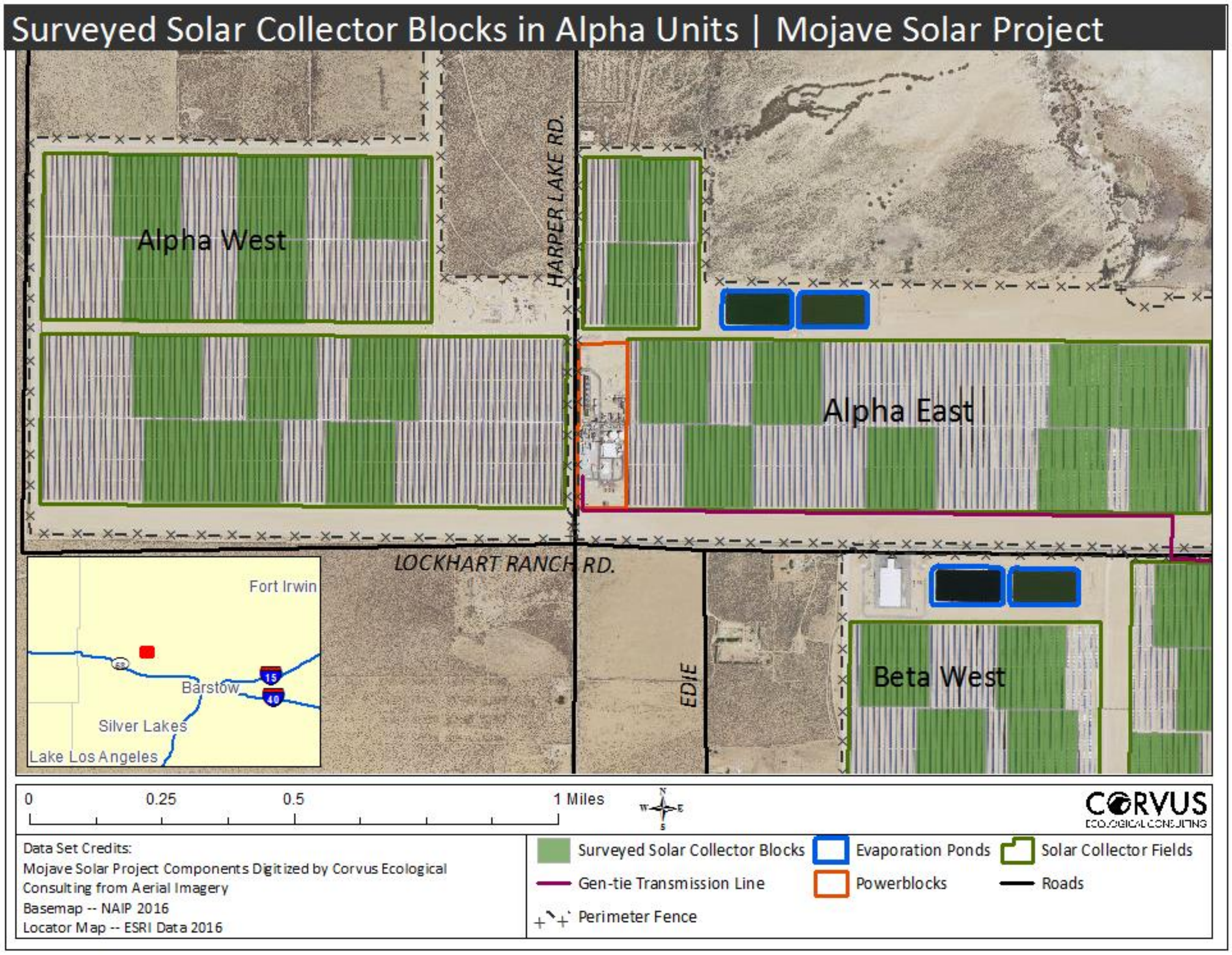

Figure 3. Solar collector blocks in Alpha units surveyed using systematic searches.

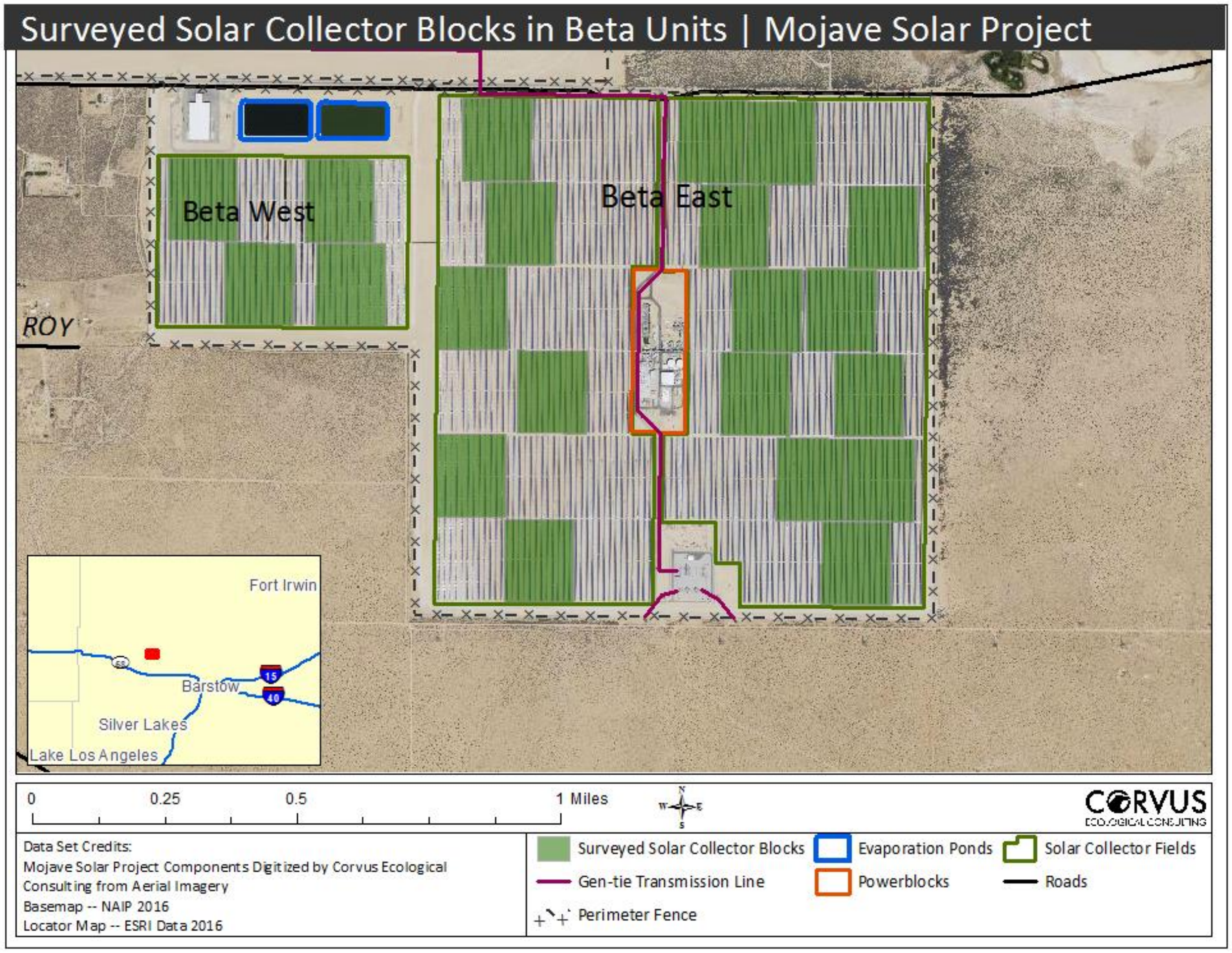

Figure 4. Solar collector blocks in Beta units surveyed using systematic searches.

Table 1. Areas included in systematic carcass searches at Mojave Solar Project during winter 2017-2018.

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 from a vehicle (≤ 5 mph) where possible. Where driving along the fence became difficult or unsafe, the biologist would walk the sections.

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 7 carcass persistence trials were completed during the winter 2017-2018 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

For the majority of the winter 2017-2018 monitoring period, searcher efficiency trials were conducted in conjunction with carcass persistence trials. The Field Lead was provided with randomized locations for carcass persistence specimens, and when the timing corresponded with a systematic search, was instructed to not place cameras until the searcher had a chance to survey the area where the trial specimen was located. The same size classes were used as for carcass persistence. Upon review of the data from fall 2017, we altered the methodology for the February survey so that searcher efficiency specimens were separate from carcass persistence specimens.

2.3.1 Searcher Efficiency Data Collection

Twenty (20) carcasses were placed with the intention of having them be used for both searcher efficiency and carcass persistence. These locations were chosen randomly (see Carcass Persistence Data Collection) in all strata. Carcasses were placed in the morning of the first day of surveys prior to the searcher beginning systematic searches. Placement was done without the knowledge of the searcher. Nine (9) carcasses were placed in February for searcher efficiency trials only. These carcasses were placed in the morning that the particular strata would be surveyed and collected after the searcher was finished for the day.

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 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 November 2017 – February 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 winter 2017-2018 survey efforts, seventeen (17) detections of ten (10) identified species were recorded; including injured birds, incidental detections, and fatalities detected during systematic surveys (Table 2). The species detected in greatest abundance were American Coot (*Fulica americana*) Green-winged Teal (*Anas crecca*), and Rock Pigeon (*Columba livia)* all with two (2) individuals. The stratum with the highest number of fatalities or injuries was the perimeter fence with seven [(7) 41% of total; Figures 4 and 5 and Tables 2, 3, and 4]. Ten [(10) 59% of total] detections were made during systematic searches and seven [(7) 41% of total] were the result of incidental detections.

Sixteen (16) of the birds detected in this quarter were deceased with one (1) found unable to fly with no signs of physical trauma. Two (2) incidental detections were made in the cooling tower washout ponds and not included in the fatality estimate.

Table 2. Number of individual detections (systematic searches, incidental, and surveys for other project requirements), by species and component during winter (November 6 – March 2) 2017-2018 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
GREATER WHITE-FRONTED GOOSE	*Anser albifrons*	nocturnal and diurnal	1						**1**
GREEN-WINGED TEAL	*Anas crecca*	mostly nocturnal	1			1			**2**
PIED-BILLED GREBE	*Podilymbus podiceps*	nocturnal		1					**1**
AMERICAN COOT	*Fulica americana*	nocturnal				2			**2**
UNIDENTIFIED *LARUS* GULL	*Larus sp.*	diurnal				1			**1**
ROCK PIGEON	*Columba livia*	resident	1			1			**2**

[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
PEREGRINE FALCON	*Falco peregrinus*	diurnal			1				**1**
HORNED LARK	*Eremophila alpestris*	resident	1						**1**
YELLOW-RUMPED WARBLER	*Setophaga coronata*	nocturnal		1					**1**
DARK-EYED JUNCO	*Junco hyemalis*	nocturnal		1					**1**
RED-WINGED BLACKBIRD	*Agelaius phoeniceus*	diurnal/resident		1					**1**
UNKNOWN SPECIES			1			2			**3**
TOTALS			**5**	**4**	**1**	**7**	**0**	**0**	**17**

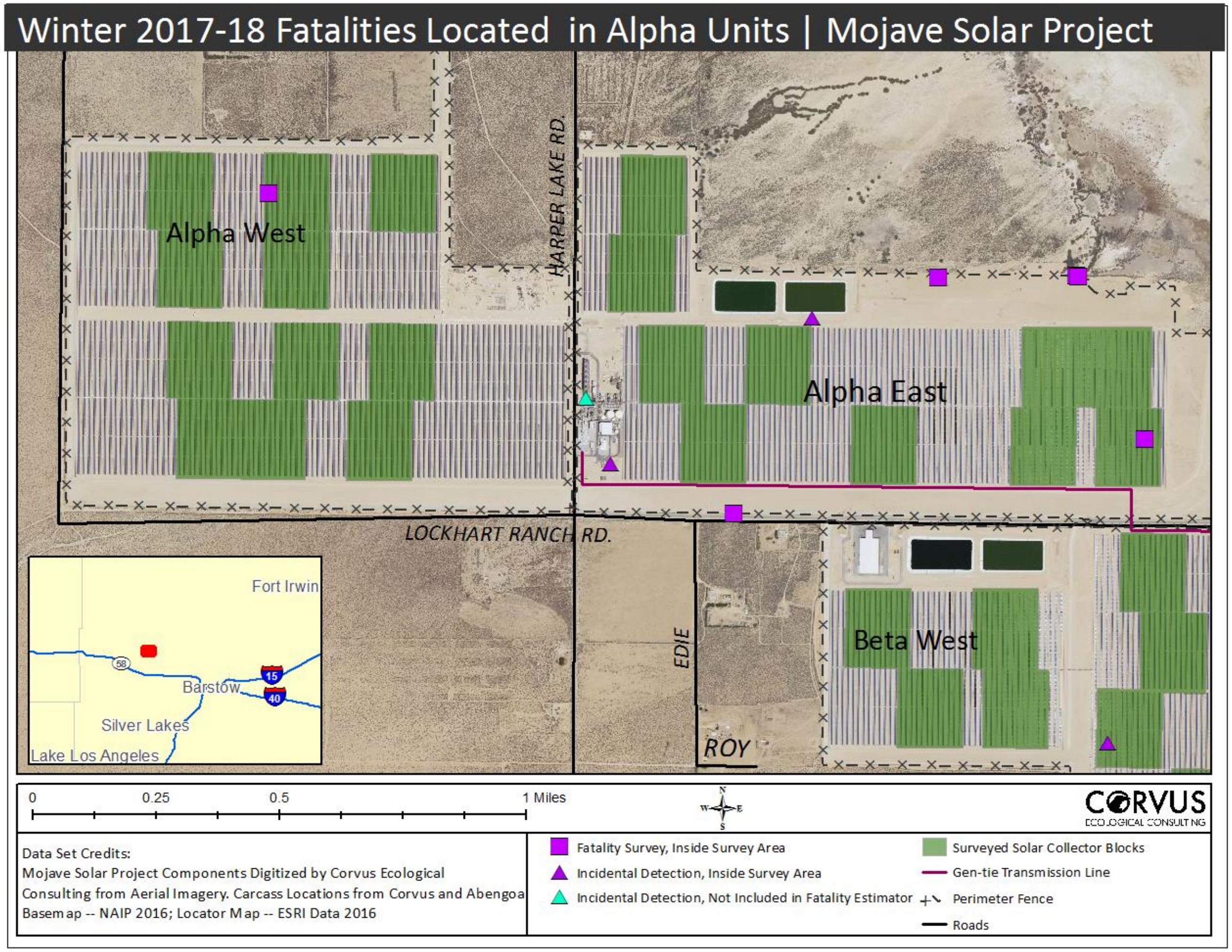

Figure 5. Locations of carcasses and injured birds found in winter 2017-2018 on the Alpha Unit Components of the Mojave Solar Project.

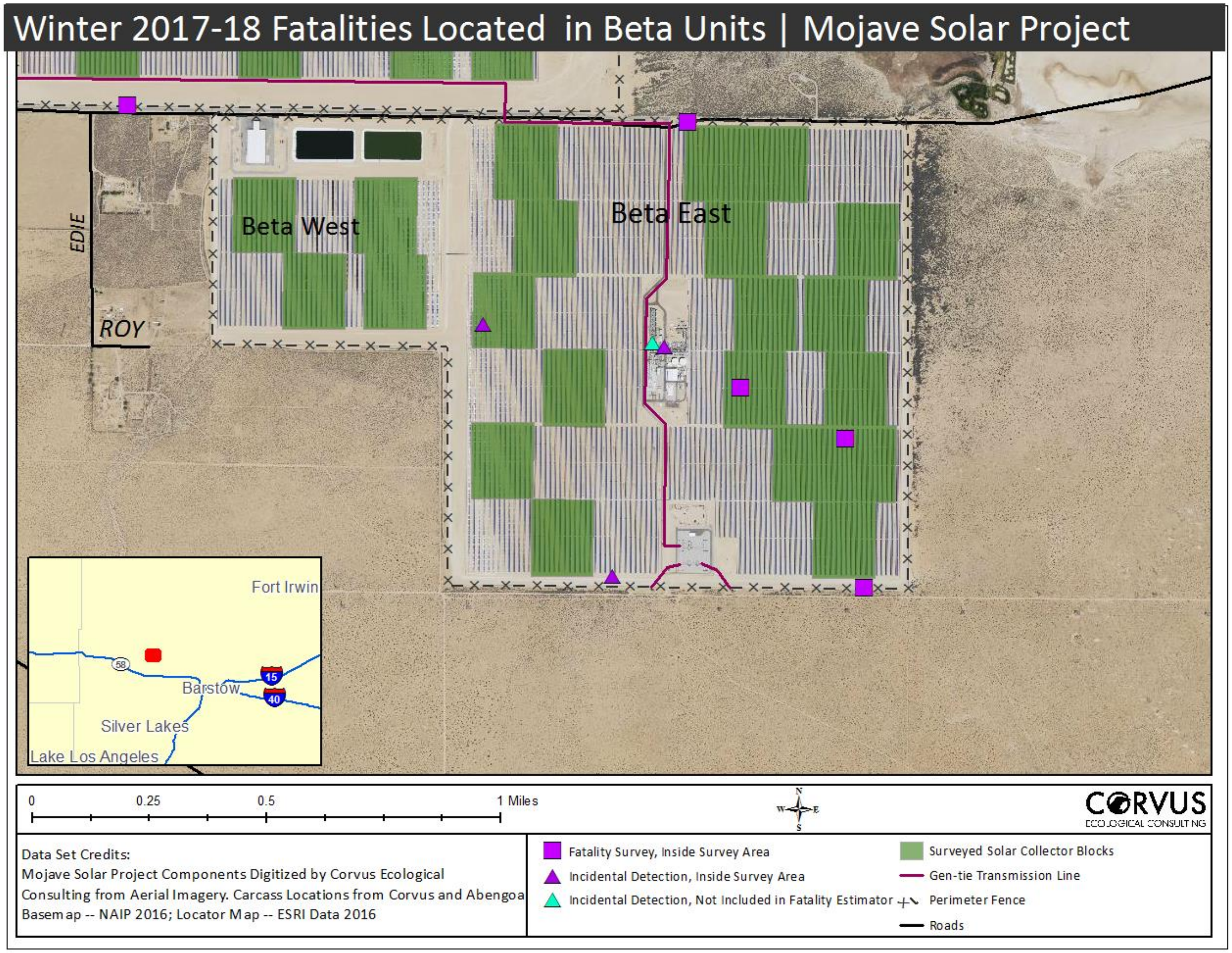

Figure 6. Locations of carcasses and injured birds found in winter 2017-2018 on the Beta Unit Components of the Mojave Solar Project

3.1.1 Temporal Patterns of Avian Detections

The highest number of detections on a single day was three (3), which occurred on February 12, 2018 (Figure 7). Two (2) detections in January marked the fewest for any calendar month during the winter season. These numbers include totals from systematic searches and incidental detections.

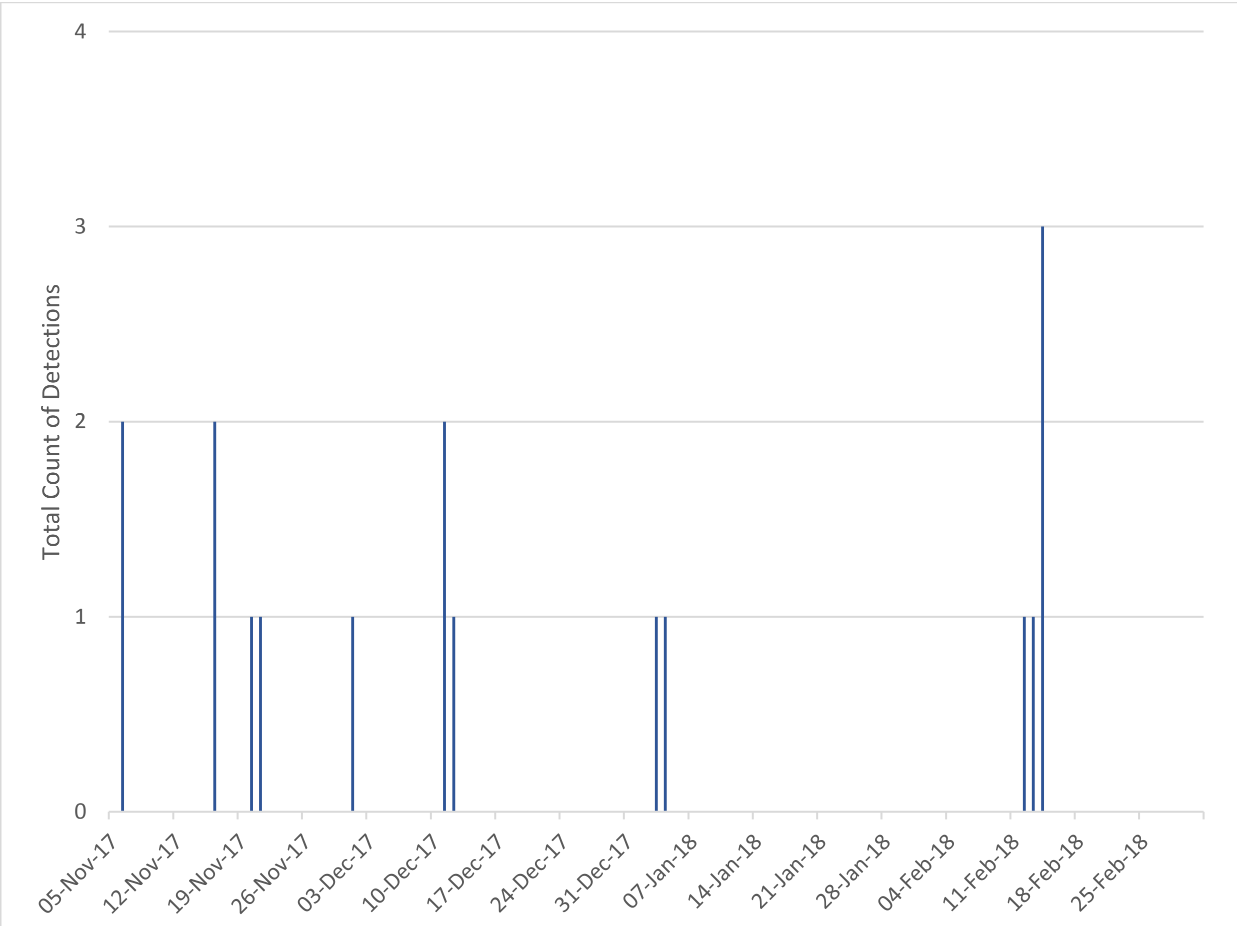

Figure 7. Total number of detections by date during winter (November 6 – March 2) 2017-2018 at Mojave Solar Project, San Bernardino County, CA.

3.1.2 Spatial Distribution of Avian Detections

During the winter season 2017-2018, detections were made within the SCF, along the Perimeter Fence, within the Power Block (including the cooling tower), and in the Evaporation Ponds (Tables 2, 3, and 4). All seventeen (17) avian injuries and mortalities were within the project's Perimeter Fence and BIO-17 survey area. Of the 17 within the fence, the breakdown by unit is as follows: 1 in Alpha West, 8 in Alpha East, 0 in Beta West, and 8 in Beta East.

Table 3. Total detections by Project component and detection category during winter (November 6- March 2) 2017-2018 at Mojave Solar Project, San Bernardino County, CA. Table 3 totals include only those detections used in fatality estimates.

PROJECT COMPONENT	SYSTEMATIC SEARCH	INCIDENTAL	% OF TOTAL
PERIMETER FENCE	**6**	**1**	**41.2**
OVERHEAD LINE (GEN-TIE)			**0**
EVAPORATION PONDS		**1**	**5.9**
POWER BLOCK		**4**	**23.5**
COOLING TOWER		*2*	
OTHER		*2*	
SCF	**4**	**1**	**29.4**
ROADS OUTSIDE PERIMETER FENCE			
PERCENT OF TOTAL	**58.8**	**41.2**	**100.0**

Table 4. Total detections (all types) by Project component and suspected cause of death during winter (November 6- March 2) 2017-2018 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					1	6	**41.2**
OVERHEAD LINE							
EVAPORATION PONDS				1			**5.9**
POWER BLOCK		2	1	1			**23.5**
SCF						5	**29.4**
ROADS							
% OF TOTAL		**11.75**	**5.9**	**11.75**	**5.9**	**64.7**	

*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

Sixteen (16) of the detections made during the winter 2017-2018 were of dead birds. Of those, two [(2) 11.8%] were freshly deceased; four [(4) 23.5%] were semi-fresh with some signs of rigor mortis; four [(4) 23.5%] had sign of scavenging; and six [(6) 35.3%] were feather spots.

3.1.4 Injured or Stranded Birds

One (1) stranded or injured bird was found during the winter 2017-2018. The bird was a Pied-billed Grebe found in the power block. Biologists suspected it landed on wet pavement and couldn't take off. It was taken to the nearby Harper Lake wetland and released.

3.2 Bat Detections

There were no bats detected during the winter 2017-2018.

3.3 Carcass Persistence Trials

Data from fall 2017 and winter 2017-2018 CP trails were pooled. Candidate models included the four common distributions and four sets of covariates (including none). Size Class included three levels: small, medium and large carcasses; Strata included two levels: SCA and all other strata pooled; and season included two levels: fall 2017 and winter 2017-2018. Model selection found that the lognormal model with carcass size as a covariate was the best model to estimate carcass persistence (Table 5).

Table 5. Model selection results displaying AICc values of 12 models tested. The model with the lowest AICc value was chosen as the best model

DISTRIBUTION	COVARIATES			
	None	Size Class	Strata	Season
WEIBULL	340.34	335.59	339.83	337.62
EXPONENTIAL	346.91	338.36	346.58	340.58
LOGLOGISTIC	340.93	332.06	331.98	340.67
LOGNORMAL	339.09	**331.00**	332.40	338.17

Table 6. 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	MEAN CARCASS PERSISTENCE (DAYS)	CP LCL (95%)	CP UCL (95%)	*R* PROPORTION REMAINING AFTER 7 DAYS	*R* LCL (95%)	*R* UCL (95%)
LARGE	19	2.71	1.68	4.29	0.48	0.35	0.61
MEDIUM	35	1.28	0.86	1.81	0.3	0.22	0.37
SMALL	56	0.84	0.55	1.24	0.21	0.15	0.28

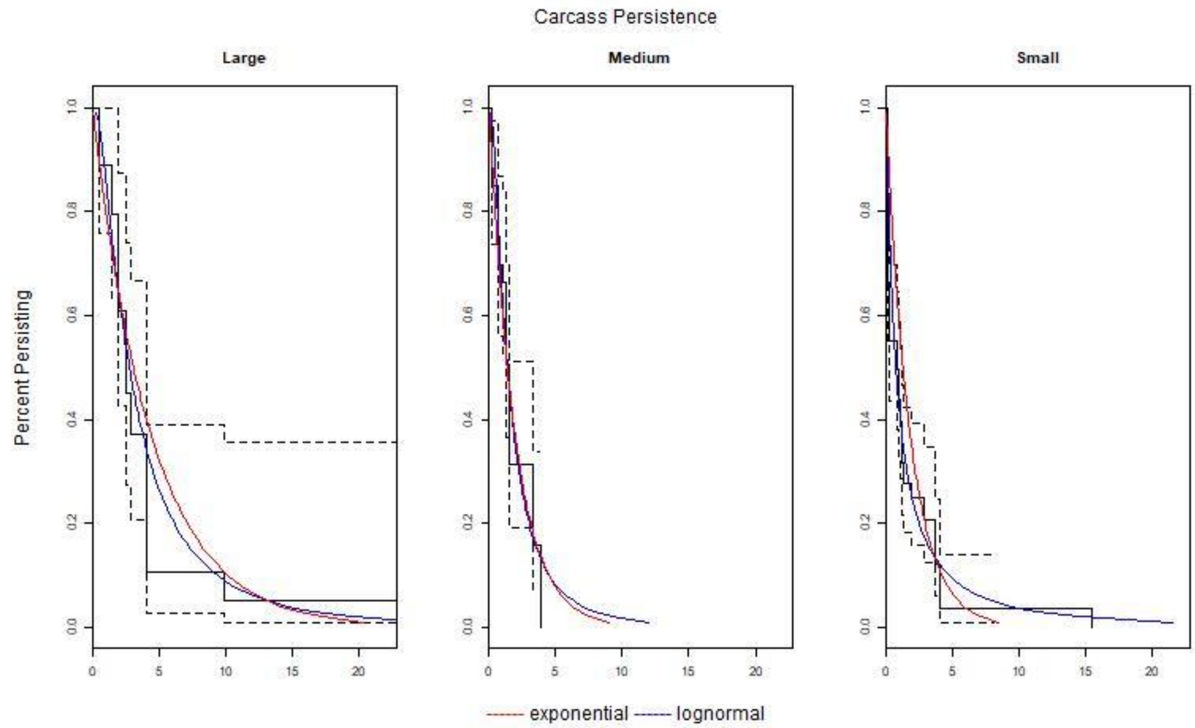

Figure 8. Carcass persistence graphs for three size classes of carcasses. Black lines denote the parametric estimation of CP with 95% confidence intervals (dashed line) using the Kaplan-Meier model. Red lines denote the non-parametric estimation using the fitted exponential distribution, and blue lines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

3.4 Searcher Efficiency Trials

Data from fall 2017 and winter 2017-2018 CP trails were pooled. A total of 12 carcasses were found out of 28 that were available to be found. These sample sizes were not sufficient to consider covariates, therefore no model selection was conducted. This produced an estimated SE of 0.43 (95% CI 0.25 – 0.61).

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 7 details trial specimen availability and searcher detection rates.

Table 7. Carcasses of three size classes (S,M,L) placed for searcher efficiency trials in each project component of the Mojave Solar Project between November 6, 2017 and March 2, 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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GEN-TIE	2	0	0	0	0	0	2	0	0	1	0	0	1	0	0
PERIMETER FENCE	6	2	1	6	1	0	0	1	1	0	0	0	0	1	1
POWER BLOCKS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SCA	6	9	3	5	1	0	1	8	3	0	1	2	1	7	1
SIZE CLASS TOTAL	14	11	4	11	2	0	3	9	4	1	1	2	2	8	2
PROJECT TOTAL			29			13			16			4			12

3.5 Fatality Estimates

During the winter season of 2017-2018, a total of 15 carcasses of wild birds were found within the search area of the Mojave Solar Project. Searcher efficiency was 0.43 (95% CI: 0.25 – 0.61) and mean carcass persistence was 0.84 days (95% CI: 0.56 -1.23) for small carcasses, 1.28 days (95% CI: 0.86 – 1.81) for medium carcasses, and 2.71 days (95% CI: 1.68 – 4.29) for large carcasses. Using the Fatality Estimator, the total number of birds impacted during the winter of 2017-2018 was 515 (95% CI: 342 – 954).

Table 8. Fatality estimates for winter 2017-2018 and for fall and winter 2017-2018 pooled.

	FATALITIES FOUND	ESTIMATED FATALITIES	LCL (95%)	UCL (95%)
WINTER 2017-2018				
OVERALL	15	**515**	345	972
SIZE CLASS				
Large	3	68	39	141
Medium	8	250	158	470
Small	4	198	116	401
STRATA				
Evap Pond	1	9	5	17
Perimeter Fence	7	213	139	401
Power Block	2	53	34	102
SCA	5	243	162	466
FALL 2017 AND WINTER 2017-2018				
OVERALL	36	**745**	502	1388
SEASON				
Fall 2017	21	230	156	420
Winter 2017-2018	15	515	342	954
SIZE CLASS				
Large	6	80	47	163
Medium	18	349	217	660
Small	12	317	191	620
STRATA				
Evap Pond	8	57	38	103
Gen-tie	1	10	6	19
Perimeter Fence	12	249	164	467
Power Block	2	53	33	99
SCA	13	378	255	696

4.0 Discussion

The winter 2017-2018 season was the second season of standardized effort for data collection in support of BIO-17 on the Mojave Solar Project. Using the experiences from fall 2017 and winter 2017-2018 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. There will likely still be some carcasses removed by scavengers before they are subjected to the searcher, but we hope this method will increase our available sample size for searcher efficiency trials. In addition, by having two sets of carcasses for each type of trial, we can place carcass persistence specimens outside of the search area to get a more accurate assessment of removal throughout the entire project area. Further, game cameras can be placed before or concurrently with carcass persistence trial specimen placement to gather a more complete set of pictures.

There is very little vegetation on this project, and little reason to assume that searcher efficiency will vary seasonally. Searcher efficiency is most likely impacted by the sandy substrate of the project, debris (both natural and anthropogenic) reducing visibility, as well as the basic construction and site preparation within the SCFs. The mirrors are placed in rows and each pair of rows is connected via piping. The ground in the aisle between two connected rows is depressed in relation to the neighboring drivable row. This means that the visibility of a carcass is not uniform across the proposed 51 m transect width, but in fact, every 17 meters or so, the visibility will be reduced (Figure 8).

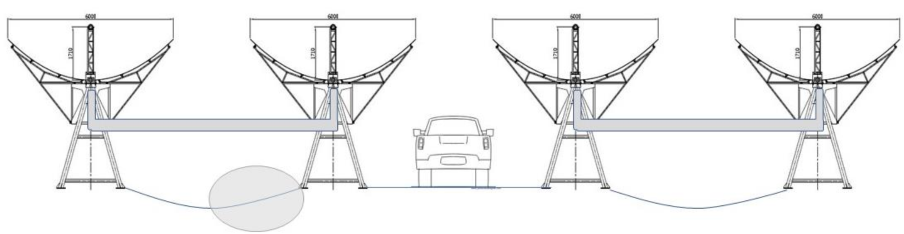

Figure 9. Diagram showing a view looking down rows of mirrors in the SCF and the visibility issues created by the site preparation.

Carcass removal rates, however, will likely vary temporally as different cohorts of scavengers visit the site seasonally and other natural food sources come available. The SCF comprises the majority of the project area (75%) and will likely be the site of the majority of carcass placement. Since the Gen-tie is wholly contained within the project area, running very close to the SCFs, there will likely be very little difference in removal rates between the two. In addition, the perimeter fence is typically less than 200 meters from the SCF, and the evaporation ponds are all along perimeter fences so even with a greater sample size, strata may not be much of a factor in removal rates. It may be better to analyze removal times with respect to distance from project edge which we hope to investigate in future reports.

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. Thus far, however, with only 21 carcasses detected during systematic surveys in both fall and winter surveys, we had insufficient data for valid model selection and subsequent estimation. Distance sampling may also prove problematic based on obstructions to the observer view as discussed above.

As seasons vary, we expect avian visitation of the project site to be dynamic and subsequently fatality and injury rates will change. During the winter season 2017-2018, the calendar month with the highest number of fatalities was November (n=6), which corresponds with fall migration. The calendar months with the fewest mortalities were December (n=4) and January (n=2), a period of time when migratory bird activity is minimal. 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.

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