DOCKETED	
Docket Number:	09-AFC-05C
Project Title:	Abengoa Mojave Compliance
TN #:	236353
Document Title:	Bio-17
Description:	Bird Monitoring Study First Quarterly
Filer:	Keith Winstead
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	1/19/2021 10:49:58 AM
Docketed Date:	1/19/2021

Mojave Solar LLC

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Submitted Electronically

Subject:	**09-AFC-5C**
Condition Number:	**BIO 17**
Description:	**Bird Monitoring Study First Quarterly Report_Fall2018. Revised.**
Submittal Number:	**BIO17-08-01**

August 19, 2020

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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 BIO17-08-01 Revised Bird Monitoring Study First Quarterly Report_Fall2018 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

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Attachments: Bird Monitoring Study First Quarterly Report_Fall2018.

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

BIO-17 Bird Monitoring Study
Fall 2018 Seasonal Interim Report

Submitted:
February 2019

Revised:
August 2020

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. 2018 Fall Seasonal Report. 38 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 fifth season of fatality monitoring surveys which were conducted 3 September 2018 through 1 November 2018, according to protocols established by the BIO-17 Bird Monitoring Study Plan (CH2MHill Engineers 2017). In May of 2018, after discussions with field surveyors, a proposed modification amendment to the survey design was submitted and subsequently approved by regulatory agencies (Corvus Ecological Consulting, LLC, 2018). Specifics of the modifications are discussed in detail in this report. In addition to systematic carcass searches within five (5) strata of the project, carcass persistence and searcher efficiency trials were conducted throughout the fall 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 3 September 2018 through 1 November 2018.

Coturnix quail of two sizes, Eurasian collared-doves, 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 fall 2018.Searcher efficiency was tested using fifty-two (52) specimens.

All bird and bat fatalities, both those located during systematic searches and those located incidentally, are reported for BIO-17. In fall 2018, there were eighty-five (85) incidents of fatalities or injuries, all but two (2) of which were detected within the perimeter fence of the Mojave Solar Project. Twenty-eight (28%) of all fatalities and injuries were associated with the power block cooling towers. Brown-headed Cowbird represent the species with the largest number of individuals located, with twelve (12) detections being made. All detections in the fall season were of deceased rather than injured or stranded birds.

We used the fall 2018 data alone to estimate carcass persistence. Carcass persistence was modeled using size class and a modified strata designation (the perimeter fence, evaporation ponds, and gen-tie as one and the SCF and power block as the other). The persistence times were lower for the perimeter fence strata for all size classes (8.42 days for large, 0.12 days for medium, and 0.17 days for small). For the SCF strata the estimated times were 48.47 for large, 0.7 for medium, and 0.73 for small.

Searcher efficiency results from fall 2018 were also sufficient to obtain estimates using this season's data alone. The searcher efficiency was calculated at 0.816 (90% CI of 0.708-0.891).

During the fall season of 2018, a total of eighty-one (81) carcasses of wild birds were found within the search area of the Mojave Solar Project (taking away the two outside the facility and the two found outside the surveyed area). Twenty-four (24) of these carcasses were found in the cooling tower washout pond and were not incorporated in the estimator. We ran the estimator using all the remaining carcasses found within the study area using the GenEst program. The median number of avian fatalities estimated using those carcasses was 812 (90% CI 458-1593). Eighteen (18) carcasses were suspected to be the result of predation. We also ran the estimator without these fatalities and generated a median fatality of 478 (90% CI 262-965). The cooling tower fatalities can be added back in as a raw number to obtain the final estimate of 836 or 502 for Fall 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 during fall 2018.

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

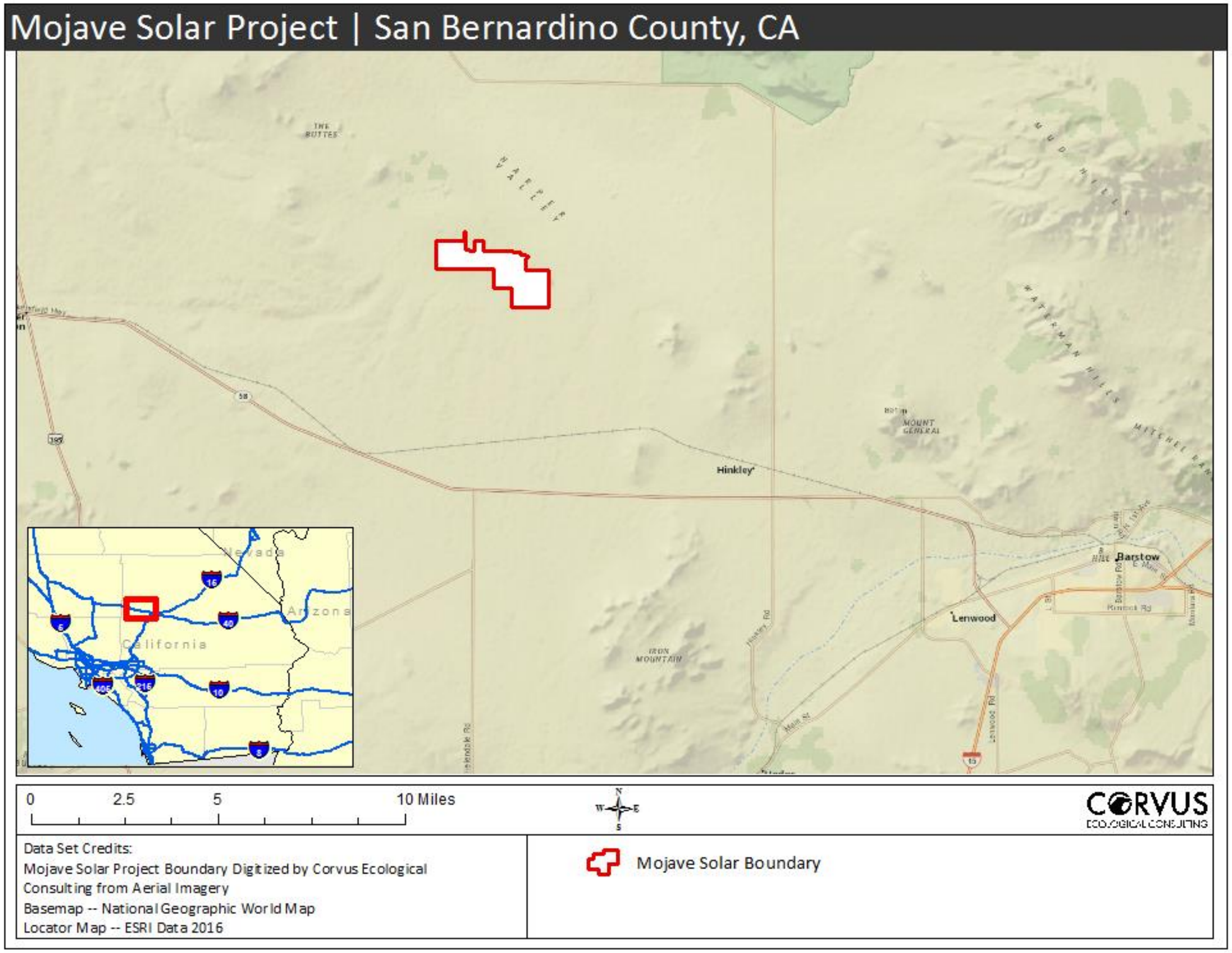

Figure 1. Project vicinity and overview.

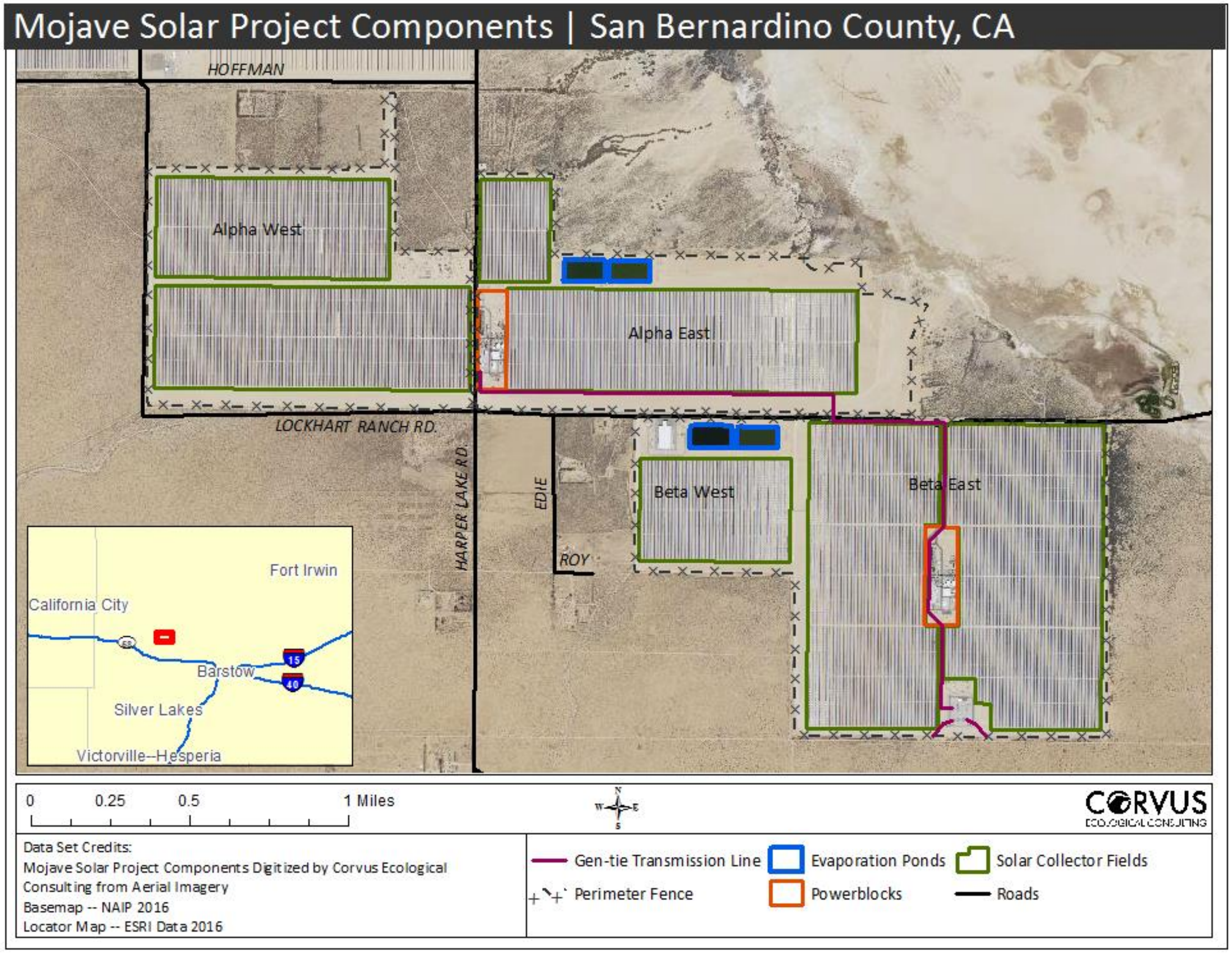

Figure 2. Mojave Solar project components.

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 fifth 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 9-week period from 3 September 2018 through 1 November 2018. The data presented in this seasonal report and in future seasonal reports are preliminary. The first annual report has been completed and submitted outlining the results from September 2017-August 2018. Once the second full year of surveys have been completed, another comprehensive annual report will include a full analysis of the two years of surveys.

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 fall season 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 49% of the total collector rows are sampled in an area. Sampling blocks assume a clear observation distance of 40 m is available when the troughs are in a horizontal position and the ground is devoid of vegetation. This is a slight modification to The Plan that was submitted in May of 2018 following discussion with field staff (Corvus

Ecological Consulting, LLC 2018). In the Plan, a 51 m observation distance was assumed and 46% of the total area was surveyed.

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 fall season began on September 3 and continued through November 1, 2018. Carcass searches were performed during daylight hours between 07:00 and 18:00.

Systematic searches routinely took place Monday through Thursday on the designated weeks. The designated search interval for fall surveys was every 7 days. There were no wind or weather closure days during the Fall of 2018.

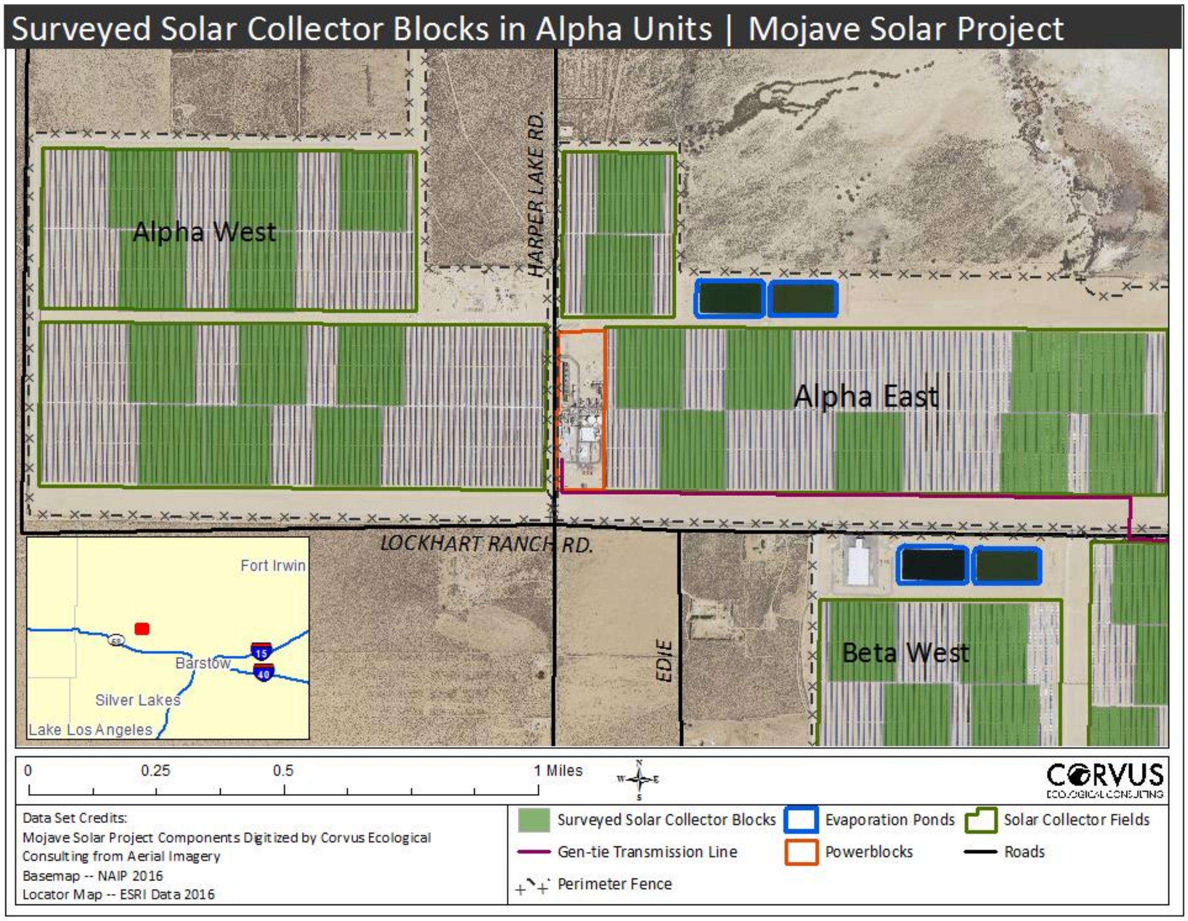

Figure 3. Solar collector blocks in Alpha units surveyed using systematic searches.

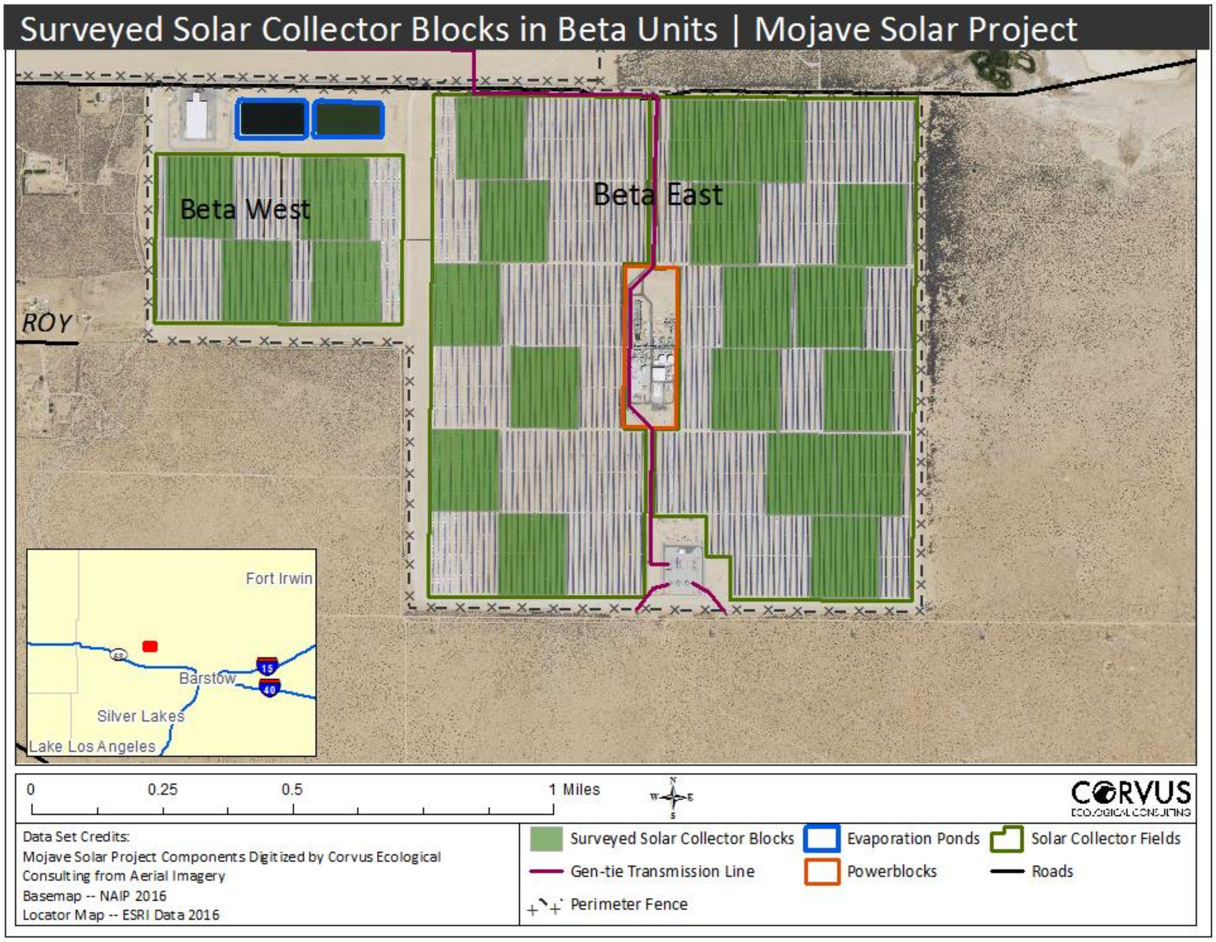

Figure 4. Solar collector blocks in Beta units surveyed using systematic searches.

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

PROJECT COMPONENT	TOTAL SIZE	UNITS	PERCENT OF COMPONENT SEARCHED
SCF	1160.00	Rows of solar troughs	45
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	476.00	Rows of solar troughs	43
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. Corvus Ecological biologists were approved by the California Energy Commission, as required by 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 three 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. This is a change from The Plan which called for two rows of driving with a greater estimated search view.

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 5 carcass persistence trials were completed during the fall 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 or Eurasian Collard Dove (*Streptopelia decaocto*), and large were domestic chickens (*Gallus gallus domesticus*).

2.2.1 Carcass Persistence Data Collection

Twelve carcasses were placed for each carcass persistence trial 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. The software will estimate two parameters of the probability density function (l = location and s = scale where the location is an expression of the horizontal shift in the graph while the scale is an estimate of the width).

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 one or both parameters of 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

Fifty-two 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. Searcher efficiency is modeled with two parameters: p = the probability that a carcass is found and k = the proportional change in searcher efficiency with each successive search. As our searchers are only given one chance to observe a carcass, we fix our k value at 0. 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. Multiple estimators have been proposed to use for such scenarios. The Huso Estimator has been shown to be superior and unbiased (Huso 2011), and this is the foundation of the USGS-developed GenEst Software Package (Dalthrop et al. 2018).

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.

To generate a confidence interval around the estimate, the software uses a parametric bootstrapping methodology. The user is allowed to specify the number of iterations to run. Because we observed a large amount of variability in the estimate, we used 100,000 iterations for this analysis.

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 found within the search area 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 fall 2018 survey efforts, eighty-five (85) detections of twenty-seven (27) identified species were recorded; including injured birds, incidental detections, and fatalities detected during systematic surveys (Table 3). The species detected in greatest abundance was Brown-headed Cowbird (*Molothrus ater*) with twelve (12) individuals. The stratum with the highest number of fatalities or injuries was the Power Block cooling tower with twenty-four [(24) 28% of total; Figures 4 and 5 and Tables 3, 4, and 5]. Sixty-five [(65) 77% of total] detections were made during systematic searches and twenty [(20) 23% of total] were the result of incidental detections.

All eighty-five detections were of deceased birds.

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

COMMON NAME	LATIN NAME	MIGRATORY BEHAVIOR*[1]	COUNT OF CARCASSES IN EACH STRATUM							
			SCF	POWER-BLOCK	COOLING TOWER	EVAP. PONDS	PERIMETER FENCE	GEN-TIE LINE	OUTSIDE STUDY AREA	TOTAL
CINNAMON TEAL	*Anas cyanoptera*	Mostly nocturnal	1			2				**3**
NORTHERN SHOVELER	*Spatula clypeata*	Both nocturnal and diurnal	1							**1**
MALLARD	*Anas platyrhynchos*	unknown				1				**1**
RUDDY DUCK	*Oxyura jamaicensis*	nocturnal					1			**1**
EARED GREBE	*Podiceps nigricollis*	nocturnal	4				2		2	**8**
WESTERN GREBE	*Aechmophorus occidentalis*	nocturnal				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	COOLING TOWER	EVAP. PONDS	PERIMETER FENCE	GEN-TIE LINE	OUTSIDE STUDY AREA	TOTAL
WHITE-FACED IBIS	*Plegadis chihi*	unknown	1							**1**
AMERICAN COOT	*Fulica americana*	nocturnal	1				2			**3**
WILSON'S SNIPE	*Gallinago delicata*	nocturnal						1		**1**
CALIFORNIA GULL	*Larus californicus*	Mostly diurnal	1							**1**
ROCK PIGEON	*Columba livia*	resident		1						**1**
MOURNING DOVE	*Zenaida macroura*	resident			1		1	1		**3**
NORTHERN FLICKER	*Colaptes auratus*	diurnal			1		3	1		**5**

COMMON NAME	LATIN NAME	MIGRATORY BEHAVIOR*[1]	COUNT OF CARCASSES IN EACH STRATUM							
			SCF	POWER-BLOCK	COOLING TOWER	EVAP. PONDS	PERIMETER FENCE	GEN-TIE LINE	OUTSIDE STUDY AREA	TOTAL
BLACK PHOEBE	*Sayornis nigricans*	resident and unknown			1					**1**
WESTERN KINGBIRD	*Tyrannus verticalis*	diurnal			1					**1**
HORNED LARK	*Eremophila alpestris*	resident		1			1	1		**3**
RUBY-CROWNED KINGLET	*Regulus calendula*	likely nocturnal						1		**1**
NORTHERN MOCKINGBIRD	*Mimus polyglottos*	resident			1					**1**
COMMON YELLOWTHROAT	*Geothlypis trichas*	nocturnal			2					**2**
YELLOW-RUMPED WARBLER	*Setophaga coronata*	nocturnal					1			**1**

COMMON NAME	LATIN NAME	MIGRATORY BEHAVIOR*[1]	COUNT OF CARCASSES IN EACH STRATUM							
			SCF	POWER-BLOCK	COOLING TOWER	EVAP. PONDS	PERIMETER FENCE	GEN-TIE LINE	OUTSIDE STUDY AREA	TOTAL
LINCOLN'S SPARROW	*Melospiza lincolnii*	nocturnal			1					**1**
GREEN-TAILED TOWHEE	*Pipilo chlorurus*	nocturnal			1					**1**
WESTERN MEADOWLARK	*Sturnella neglecta*	diurnal	1		1		2			**4**
ORIOLE SP.	*Icterus* sp.									**1**
RED-WINGED BLACKBIRD	*Agelaius phoeniceus*	diurnal/ resident			1					**1**
BROWN-HEADED COWBIRD	*Molothrus ater*	diurnal/ resident		1	11					**12**
GOLDFINCH SP.	*Spinus* sp.		1							**1**

COMMON NAME	LATIN NAME	MIGRATORY BEHAVIOR*[1]	COUNT OF CARCASSES IN EACH STRATUM							
			SCF	POWER-BLOCK	COOLING TOWER	EVAP. PONDS	PERIMETER FENCE	GEN-TIE LINE	OUTSIDE STUDY AREA	TOTAL
UNIDENTIFIED DUCK	Anatinae		4	2			1			**7**
UNIDENTIFIED SPARROW	Emberizidae						3			**3**
UNIDENTIFIED WARBLER	Parulidae				1					**1**
UNIDENTIFIED BIRD			6			4	3			**13**
TOTALS			**21**	**5**	**24**	**8**	**20**	**5**	**2**	**85**

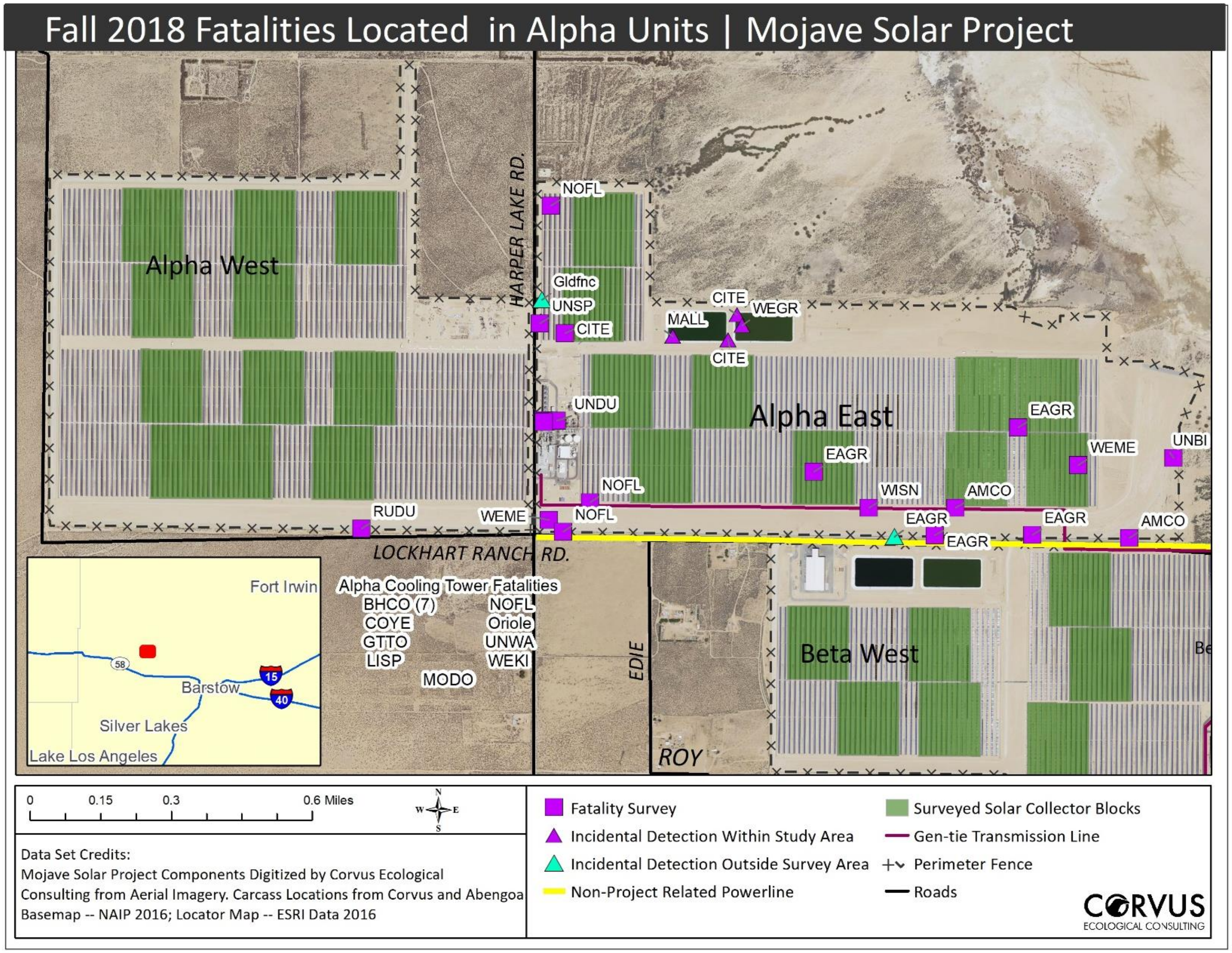

Figure 5. Locations of carcasses and injured birds found in fall 2018 on the Alpha Unit Components of the Mojave Solar Project.

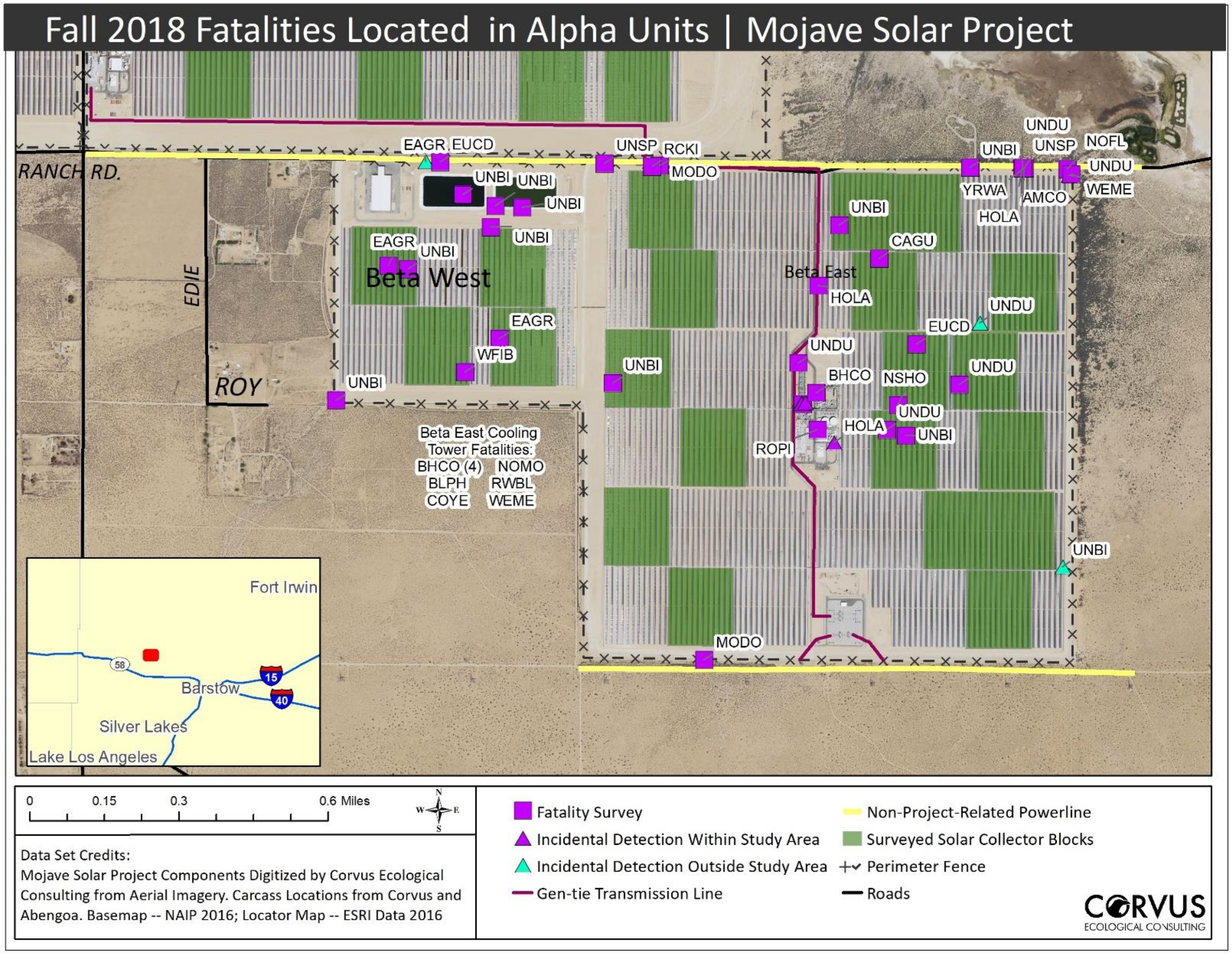

Figure 6. Locations of carcasses and injured birds found in fall 2018 on the Beta Unit Components of the Mojave Solar Project

3.1.1 Temporal Patterns of Avian Detections

The highest number of detections on a single day was seven (7), which occurred on September 19, 2018 (Figure 7). There were only two full months in this season, but overall there were 36 detections in September and 46 in October (with 1 occurring in the first days of November which fell at the end of the last search week). These numbers include totals from systematic searches and incidental detections.

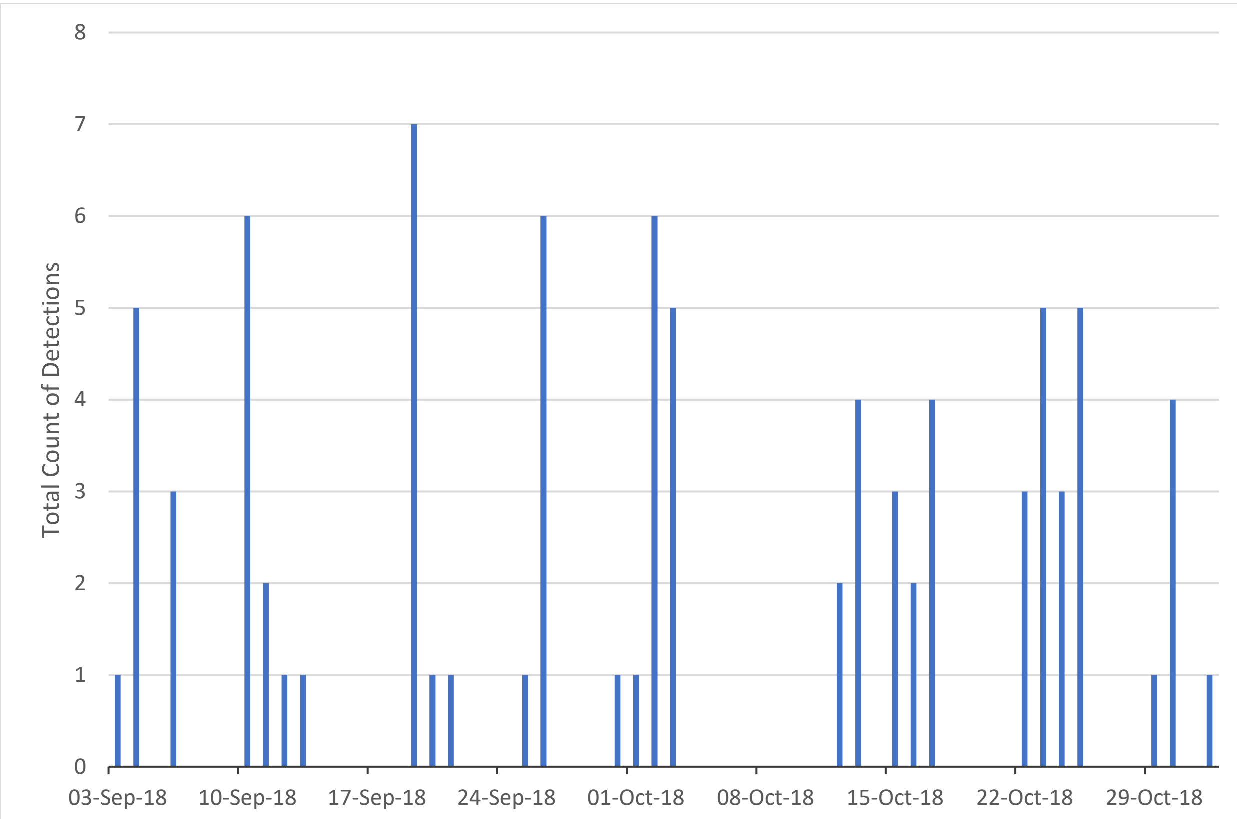

Figure 7. Total number of detections by date during fall (September 3 – November 1) 2018 at Mojave Solar Project, San Bernardino County, CA.

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). Eighty-three (83) avian mortalities were within the project's Perimeter Fence and BIO-17 survey area and two (2) were located outside the perimeter fence on Lockhart Road. Two (2) of the fatalities were located within the SCF, but outside of the surveyed area of this component. Of the 83 within the fence, the breakdown by unit is as follows: 1 in Alpha West, 36 in Alpha East, 10 in Beta West, and 36 in Beta East.

Table 4. Total detections by Project component and detection category during fall (September 3 – November 1) 2018 at Mojave Solar Project, San Bernardino County, CA.

PROJECT COMPONENT	SYSTEMATIC SEARCH	INCIDENTAL	% OF TOTAL
PERIMETER FENCE	**20**		**23.5**
OVERHEAD LINE (GEN-TIE)	**5**		**5.8**
EVAPORATION PONDS	**4**	**4**	**9.4**
POWER BLOCK			
COOLING TOWER	*12*	*12*	**28.2**
OTHER	*4*	*1*	**5.8**
SCF	**20**	**1**	**24.7**
ROADS OUTSIDE PERIMETER FENCE		**2**	**2.4**
PERCENT OF TOTAL	**76.5**	**23.5**	**100**

Table 5. Total detections (all types) by Project component and suspected cause of death during spring (September 3 – November 1) 2018 at Mojave Solar Project, San Bernardino County, CA.

PROJECT COMPONENT	SUSPECTED CAUSE OF DEATH*						% OF TOTAL
	COLLISION	DROWNED	OTHER	EXPOSURE/ DEHYDRATION	UNKNOWN -- EVIDENCE SCAVENGING OR PREDATION	UNKNOWN -- INTACT	
FENCING	2				19		**24.7**
OVERHEAD LINE	2				4		**7.1**
EVAPORATION PONDS						8	**9.4**
COOLING TOWER		24			1		**29.4**
SOLAR COLLECTOR					20	1	**24.7**
OTHER POWER BLOCK BUILDING					3	1	**4.7**
% OF TOTAL	**4.7**	**28.2**	**0**	**0**	**55.3**	**11.8**	**100**

*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 were 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 and Cause of Death

All 85 detections in fall 2018 were of dead birds. Of those, seven [(7) 8.2%] were freshly deceased; twenty-nine [(29) 34.1%] were semi-fresh with some signs of rigor mortis; one [(1) 1.2%] was mummified and forty-eight [(48) 56.5%] were scavenged or feather spots such that time since death was difficult to assess.

Section 6.6.2 of the Plan states that, "suspected cause of death will be assigned on evidence available at the detection and on the Project infrastructure, and proximity of a detection to Project infrastructure." Qualified biologists identified 18 carcasses that they determined were the result of predation by avian predators seen hunting over and adjacent to the facility. After consultation with USFWS, it was requested that the cause of death for these birds be listed as "Unknown" rather than "Predation" in absence of an eyewitness account of the deaths. (Thomas Dietsch via Ann Crisp August 4, 2020 email communication).

During the study period, no birds found at an evaporation pond were sent for necropsy. Prior to the start of BIO-17 monitoring, 16 carcasses from 5 species collected at evaporation ponds were sent to the California Animal Health and Food Safety Laboratory System. Seventy-five percent of the carcasses necropsied were determined to have died from elevated sodium ion concentrations. Absent any laboratory evidence of sodium toxicosis, birds detected during the study period were all labeled with an "Unknown" cause of death.

3.1.4 Injured or Stranded Birds

All birds located in fall 2018 were deceased.

3.2 Bat Detections

There were no bats detected during the fall 2018.

3.3 Carcass Persistence Trials

For carcass persistence trials, we analyzed the fall 2018 data alone. Due to the layout of the facility, and the small area of the evaporation ponds, power blocks, and gen-tie, we grouped the strata into those that fall mostly along the perimeter fence (perimeter fence, evaporation ponds, and gen-tie) and those that were contained within the solar collector fields (the power block and the SCF). We ran models testing for importance of this modified strata, size class, and distance to the nearest perimeter fence (a categorical designation of short, medium, and long with cutoffs at 100 meters, and 200 meters). Size class included three levels: small, medium and large carcasses. Distance to the fence was rejected as a covariate due to the low sample sizes in some of the categories, but size class and strata were both identified as important factors. 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 models tested (a total of 80 were tested, this table shows only those with a ΔAIC < 4).

Distribution	Location Formula	Scale Formula	AICc	ΔAICc
loglogistic	SizeClass + Strata	none	229.58	0
lognormal	SizeClass + Strata	none	230.86	1.28

Distribution	Location Formula	Scale Formula	AICc	ΔAICc
lognormal	**SizeClass + Strata**	**SizeClass**	**231.17**	**1.59**
loglogistic	SizeClass + Strata	SizeClass	231.72	2.14
loglogistic	SizeClass + Strata	strata	231.96	2.38
lognormal	SizeClass + Strata	strata	232.68	3.1
loglogistic	SizeClass * Strata	none	232.73	3.15

Although the model with the lowest AICc value was the loglogistic function with size class and strata covariates for the location parameter, with no covariates for the scale parameter, we opted to use the lognormal function with size class and strata as covariates for location and size class as a covariate for scale because the graph showed a slightly better fit for all combinations of size class and strata and the ΔAICc values were negligible.

Table 7. Estimates of carcass persistence. 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	STRATA	TRIALS PLACED	MEDIAN CARCASS PERSISTENCE (DAYS)	*r* PROPORTION REMAINING AFTER 7 DAYS
LARGE	Perimeter Fence-like	4	8.42	0.77
	SCF-like	6	48.47	0.97
MEDIUM	Perimeter Fence-like	6	0.12	0.11
	SCF-like	14	0.7	0.29
SMALL	Perimeter Fence-like	12	0.17	0.05
	SCF-like	18	0.73	0.25

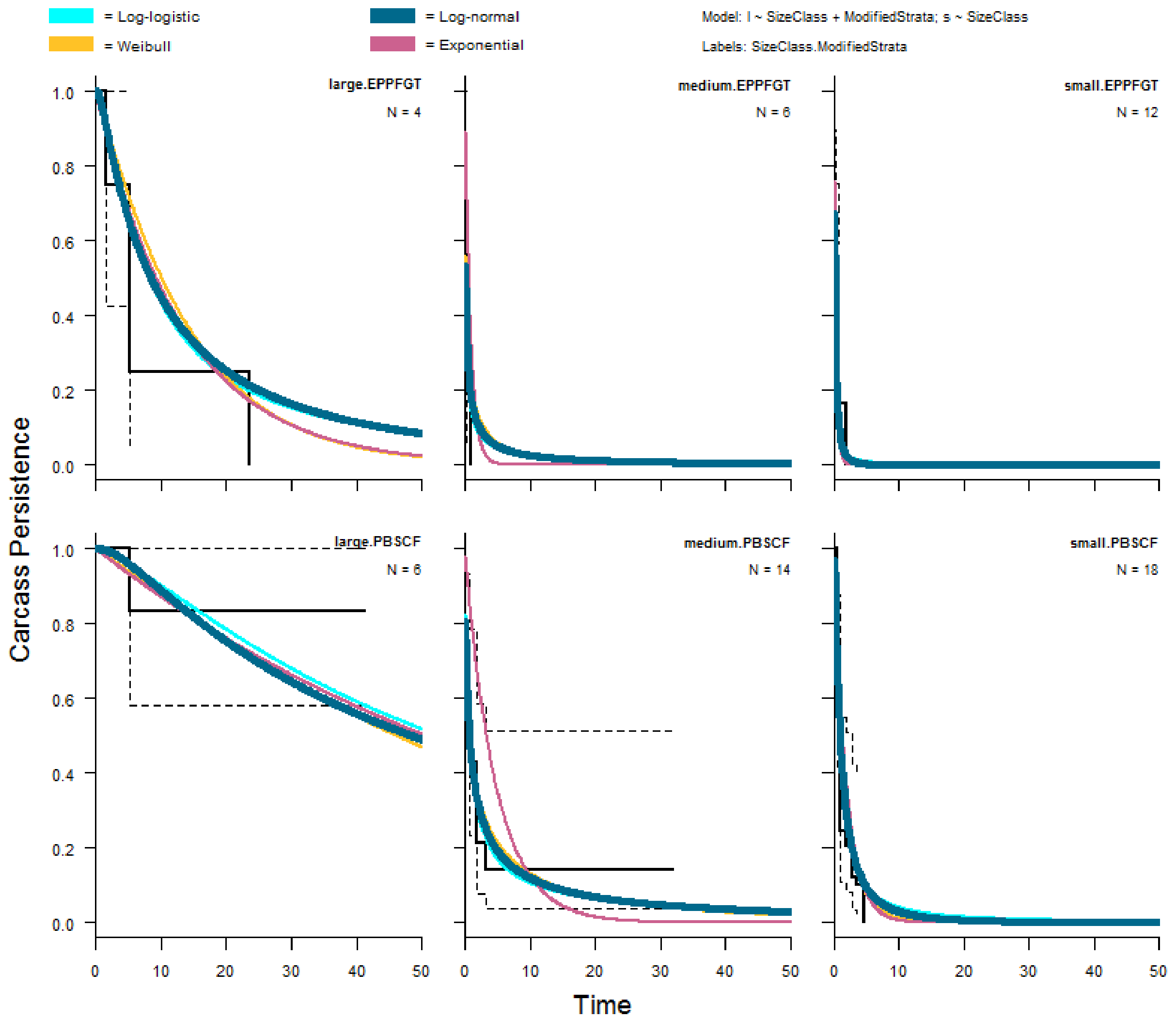

Figure 8. Carcass persistence graphs for three size classes and two strata of carcasses. Black lines denote Kaplan-Meier plots of observed data and empirical confidence limits

3.4 Searcher Efficiency Trials

We looked at searcher efficiency data for the fall season and tested models using size class, distance to transect (3 categories with cut-off values of 15 and 30 meters), and modified strata (see carcass persistence). None of the covariates produced valid results, thus searcher efficiency was estimated with p as a constant = 0.816 (90% CI of 0.708-0.891).

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 8. Carcasses of three size classes (S,M,L) placed for searcher efficiency trials in each project component of the Mojave Solar Project between September 3 2018 and November 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	1	0	0	0	0	1	1	0	1	0	0	0	1	0
GEN-TIE	1	2	0	0	0	0	1	2	0	1	1	0	0	1	0
PERIMETER FENCE	5	3	4	0	0	0	5	3	4	3	2	4	2	1	0
POWER BLOCKS	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0
SCF	19	9	6	3	0	0	16	9	6	13	8	6	3	1	0
SIZE CLASS TOTAL	26	16	10	3	0	0	23	16	10	18	12	10	5	4	0
PROJECT TOTAL			52			3			49			40			9

3.5 Fatality Estimates

We ran the estimator twice, once using all carcasses detected within the search area (with the exception of cooling tower fatalities; Table 9 and 11), and a second time removing 18 fatalities for which our field biologists felt confident were the result of avian predators (Table 10 and 12).

Estimates and confidence intervals were calculated using the GenEst package (Dalthorp et. al 2018). This package also allows us to estimate the detection probability within the categories used to build our models. In our case, we used carcass size and modified strata to estimate carcass persistence, thus we can estimate the probability of detection within each combination of these factors (Table 9 and 10).

Table 9. Average probability of detecting a carcass by location and carcass size using all carcasses located within the survey area.

SIZE CLASS	MODIFIED STRATA	AVG PROBABILITY OF DETECTING A CARCASS
LARGE	Perimeter fence- like	0.681
	SCF -like	0.918
MEDIUM	Perimeter fence- like	0.050
	SCF -like	0.211
SMALL	Perimeter fence- like	0.054
	SCF -like	0.225

Table 10. Average probability of detecting a carcass by location and carcass size using only those carcasses that were likely to be attributed to the project components.

SIZE CLASS	MODIFIED STRATA	AVG PROBABILITY OF DETECTING A CARCASS
LARGE	Perimeter fence- like	0.611
	SCF -like	0.787
MEDIUM	Perimeter fence- like	0.092
	SCF -like	0.241
SMALL	Perimeter fence- like	0.045
	SCF -like	0.205

From these tables, we see that using our carcass persistence and searcher efficiency data, the estimated probability of detecting a small or medium carcass anywhere on the facility is less than 25%.

During the fall season of 2018, using all carcass detections, an estimated 812 bird mortalities (90% CI: 458 -1593) occurred at the Mojave Solar Project (Table 11). This estimate was based on 57 observed fatalities, which excluded the 24 fatalities from the cooling tower. In fall 2018, there were 18 fatalities that our biologist felt were most likely due to avian predators rather than components of the solar farm. We re-ran the estimator excluding those fatalities (Table 12). With this subset of fatalities, the estimated number of fatalities was 478 (90% CI: 262-965).

Table 11. Fatality estimates for fall 2018 using all detections within the survey area (not including cooling tower).

	FATALITIES FOUND	ESTIMATED FATALITIES	LCL (90%)	UCL (90%)
FALL 2018				
OVERALL	57	**812**	458	1593
SIZE CLASS				
Large	5	8	5	12
Medium	35	344	176	890
Small	17	419	192	905
STRATA				
Evaporation Pond	8	79	29	199
Gen-tie	5	93	21	264
Perimeter Fence	20	492	233	1064
Power Block	5	29	9	62
SCF	19	100	57	178

Table 12. Fatality estimates for fall 2018 removing those detections suspected to be due to predation (not including cooling tower).

	FATALITIES FOUND	ESTIMATED FATALITIES	LCL (90%)	UCL (90%)
FALL 2018				
OVERALL	39	**478**	262	965
SIZE CLASS				
Large	4	6	4	11
Medium	23	232	114	608
Small	12	214	87	492
STRATA				
Evaporation Pond	8	69	24	171
Gen-tie	3	41	6	139
Perimeter Fence	11	253	100	598
Power Block	5	27	9	58
SCF	12	72	37	133

There were 24 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 836 estimated fatalities (using all detections) or 502 estimated fatalities (using the subset excluding those thought to be predated) during the fall 2018.

4.0 Discussion

The fall 2018 season was the fifth season of standardized effort for data collection in support of BIO-17 on the Mojave Solar Project. The first year of monitoring involved testing of methods and improvements to the experimental design. Our goal for this, the second year of surveys, is to maintain consistency throughout the four seasons of surveys.

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. Because of this paired trial scenario, cameras were not placed at carcasses immediately meaning that fewer removals were documented using this technology.

Due to these changes in methods, it is difficult and not meaningful to compare results from fall 2017 bias trials with those from fall 2018.

4.2 Distribution of Fatalities and Fatality Estimates

Unlike the bias trials, the methods for the systematic surveys have not been altered much between fall 2017 and fall 2018. We have changed the number of driving passes through a survey block to make up for reduced visibility within the SCF, but the timing of surveys and basic methodology has remained consistent.

In fall 2017, forty (40) detections of injured or deceased birds were made by surveyors. Nine (9) of those detections were made outside the project boundaries leaving thirty-one (31) within the facility. Of those 31 detections, nine (9) were from the cooling towers, seven (7) from the evaporation ponds, one (1) from the Gen-tie, five (5) from the perimeter fence, and nine (9) from the SCF. In fall 2018, a total of 85 detections were made with 83 falling within the facility. Of those 83, twenty-four (24) were detected within the cooling towers, five (5) were in the power block, eight (8) were in the evaporation ponds, five (5) in the Gen-tie, twenty (20) from the perimeter fence, and twenty-one (21) from the SCF (Figure 9). In fall of 2017, fatality estimates were not run by strata, so we are unable to compare fatality estimator results from the two years.

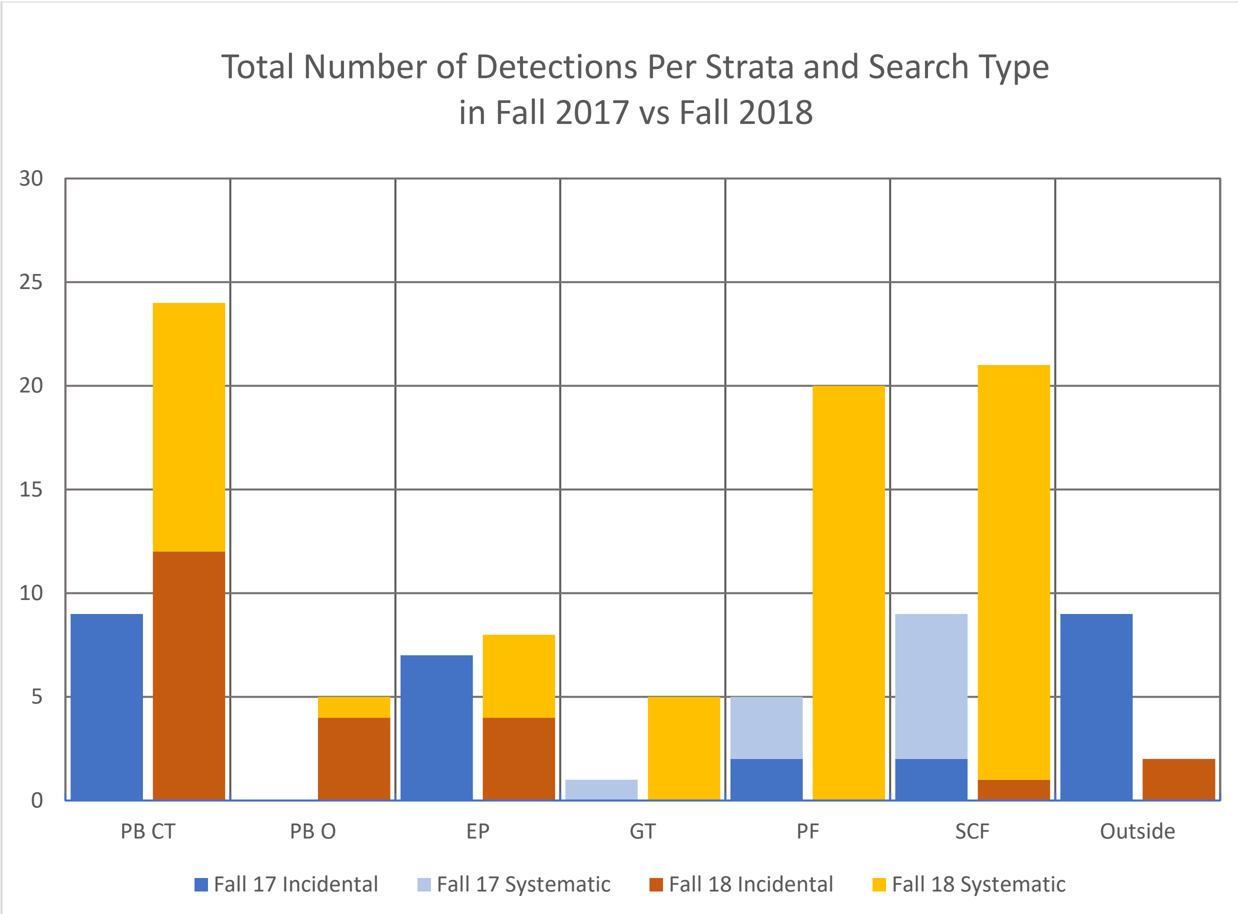

Figure 9. Comparison of fall 2017 and fall 2018 detections by strata and search type. PB CT = Power block cooling tower, PB O = Power block Other, EP = Evaporation Pond, GT = Gen-tie, PF = Perimeter Fence, SCF = Solar Collector Field.

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