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Mojave Solar LLC

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Submitted Electronically

Subject:	**09-AFC-5C**
Condition Number:	**BIO 17**
Description:	**Bird Monitoring Study Second Quarterly Report_Winter2018-2019. Revised.**
Submittal Number:	**BIO17-09-01**

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 BIO17-09-01 Revised Bird Monitoring Study Second Quarterly Report_Winter2018
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

Mojave Solar Project Designated Biologist
Rowe Ecological Consulting
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Attachments: Bird Monitoring Study Second Quarterly Report_Winter2018.

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

BIO-17 Bird Monitoring Study
Winter 2018-2019 Seasonal Interim Report

Submitted:
May 2019

Revised:
August 2020

Prepared for:
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Suggested Reference

Corvus Ecological Consulting, LLC. 2019. BIO-17 Bird Monitoring Study at the Mojave Solar Project, San Bernardino County, California. 2018-2019 Winter Seasonal Report. 37 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 sixth season of fatality monitoring surveys which were conducted 5 November 2018 through 28 February 2019, 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 winter season.

The five strata defined in the monitoring plan include: Solar Collector Fields (SCFs), Evaporation Ponds, Perimeter Fence, Power Blocks, and Power Generation Tie-in (Gen-tie). These strata were surveyed every 7 days from 5 November 2018 through 28 February 2019 with the exception of the week of November 19-23 and the week of December 24-28 during which no surveys were conducted.

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 winter 2018-2019.Searcher efficiency was tested using fifty-six (56) specimens.

All bird and bat fatalities, both those located during systematic searches and those located incidentally, are reported for BIO-17. In winter 2018-2019, there were fifty-one (51) incidents of fatalities or injuries, all of which were detected within the perimeter fence of the Mojave Solar Project. Thirty-three percent (33%) of all fatalities and injuries were associated with the perimeter fence. Eared Grebe represent the species with the largest number of individuals located, with fourteen (14) detections being made. All detections in the winter season were of deceased rather than injured or stranded birds.

In past seasons, the majority of fatalities have been associated with the power block cooling towers. In winter 2018-2019 the facility installed nets to prevent birds from roosting on these towers at night. Since the installation of nets, there was a dramatic decrease in fatalities at the cooling towers.

We used the winter 2018-2019 data alone to estimate carcass persistence. Carcass persistence was modeled for each size class using no covariates in the model. The persistence times were as follows: 5.34 days for large carcasses, 0.94 days for medium, and 0.48 days for small.

Searcher efficiency results from winter 2018 were also sufficient to obtain estimates using this season’s data alone. The searcher efficiency was calculated for each size class. Estimates were as follows: 0.909 for large, 0.813 for medium, and 0.630 for small carcasses.

During the winter season of 2018-2019, a total of forty-nine (49) carcasses of wild birds were found within the search area of the Mojave Solar Project (taking away two found outside the surveyed strata). One (1) of these carcasses was found in the cooling tower washout pond (prior to net installation) and was not incorporated in the estimator. Another twenty (20) carcasses were the result of suspected predation and were not included in the estimator. With the twenty-eight (28) remaining carcasses, we used the calculated searcher efficiency and carcass persistence values, and the GenEst program, to obtain an estimate of the total number of bird fatalities during the winter 2018-2019 of 249 (95% CI: 157 – 405). The cooling tower fatality can be added back in as a raw number to obtain the final estimate of 250 for winter 2018-2019.

Because the actual cause of death is difficult to determine without direct observation, we also estimated the total fatalities using all the carcasses including those suspected to have been depredated. This calculation yielded an overall estimate of 367 fatalities for winter 2018-2019 (95% CI: 245-562). Again, adding the cooling tower fatality for a final estimate of 368 fatalities.

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 winter 2018-2019.

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

COMPANY	INDIVIDUAL	TITLE	ROLE IN THIS PROJECT
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

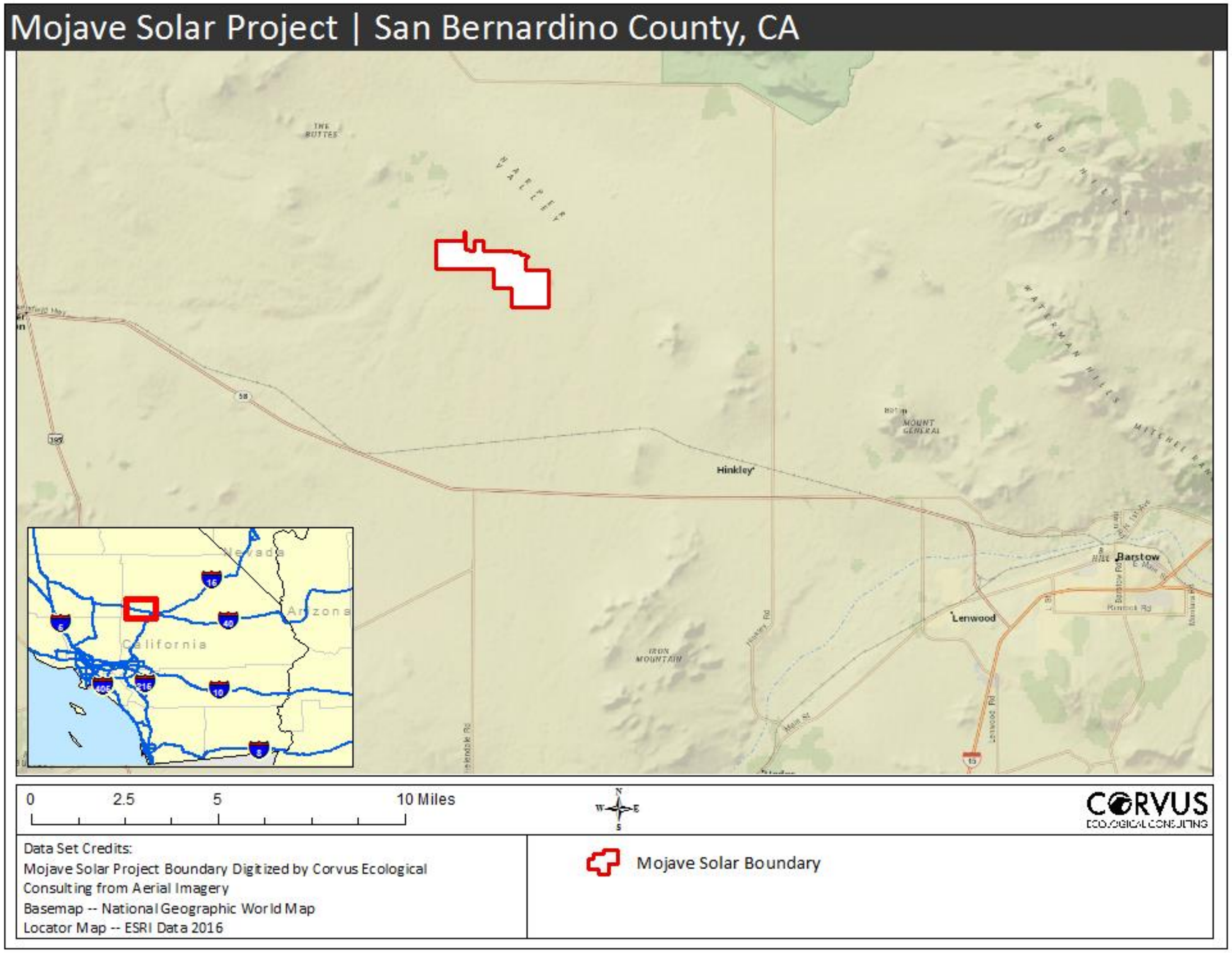

Figure 1. Project vicinity and overview.

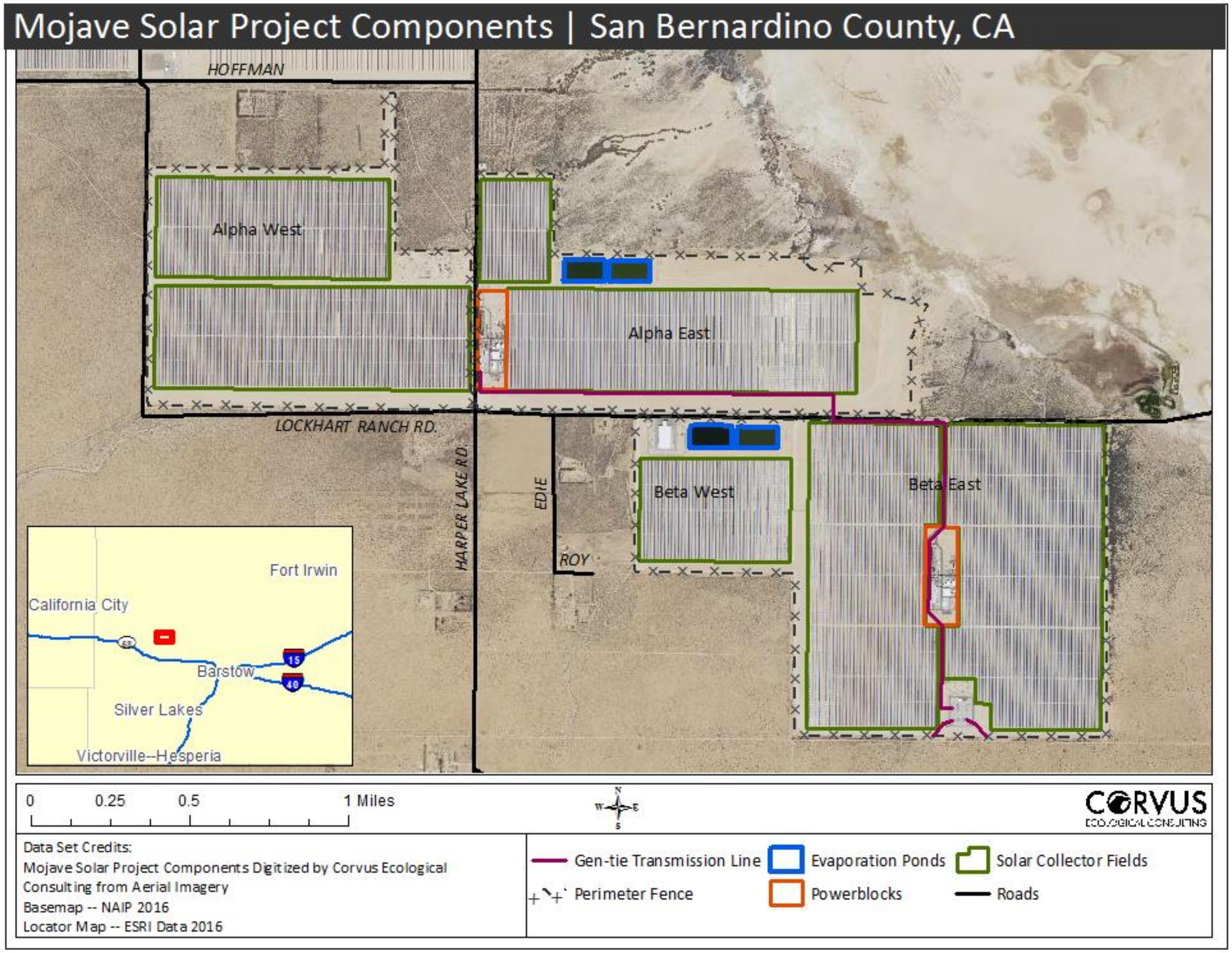

Figure 2. Mojave Solar project components.

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 sixth 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 5 November 2018 through 28 February 2019. 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 winter season 2018-2019.

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 45% 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 45% of the total rows were 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 winter season began on November 5, 2018 and continued through February 28, 2019. 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 winter surveys was every 7 days. We allowed for deviations from the survey schedule to allow for time off during the holidays. No surveys were conducted November 19-23 or December 24-28. On January 17, 2019, the Beta West facility was too wet following heavy precipitation to allow the surveyor to drive within the SCF. The rest of the survey was completed on that day, but the SCF was not surveyed until the following week.

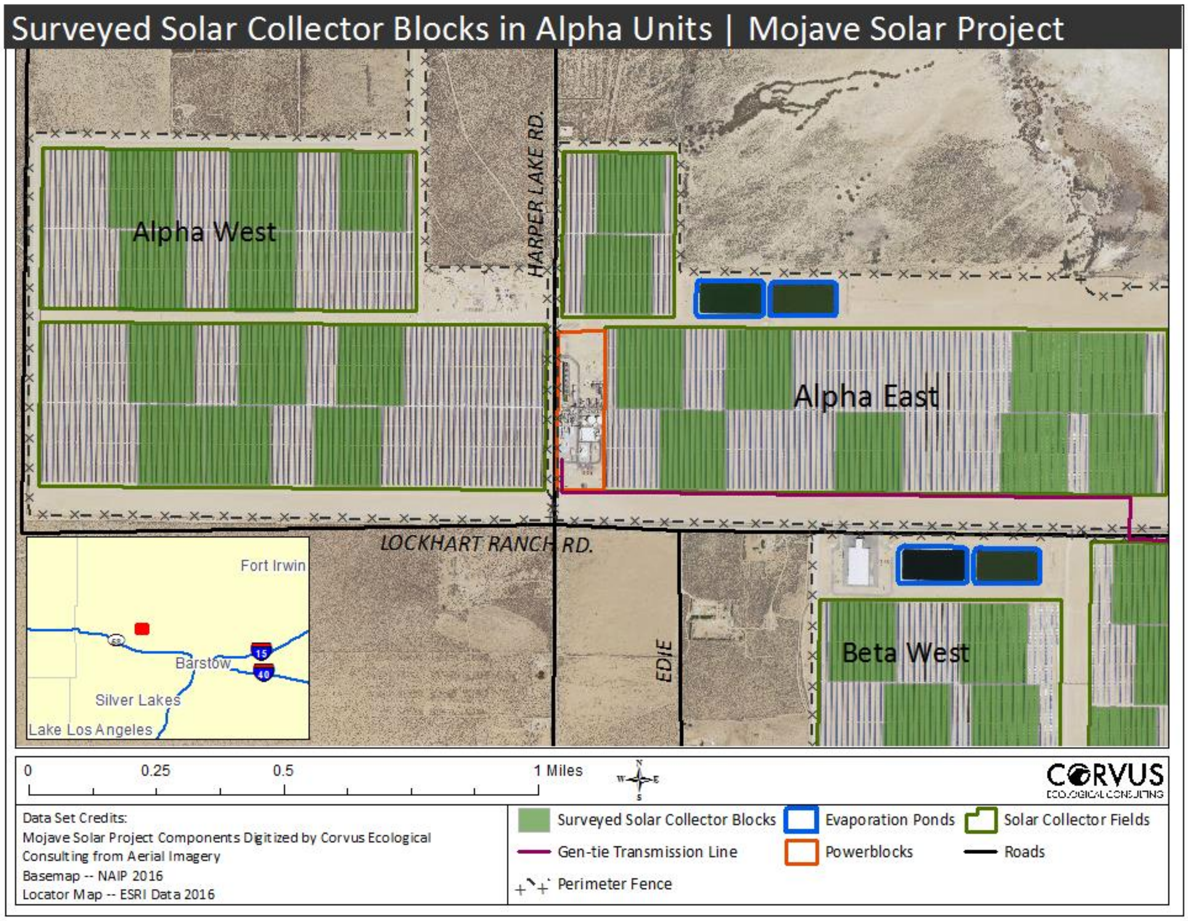

Figure 3. Solar collector blocks in Alpha units surveyed using systematic searches.

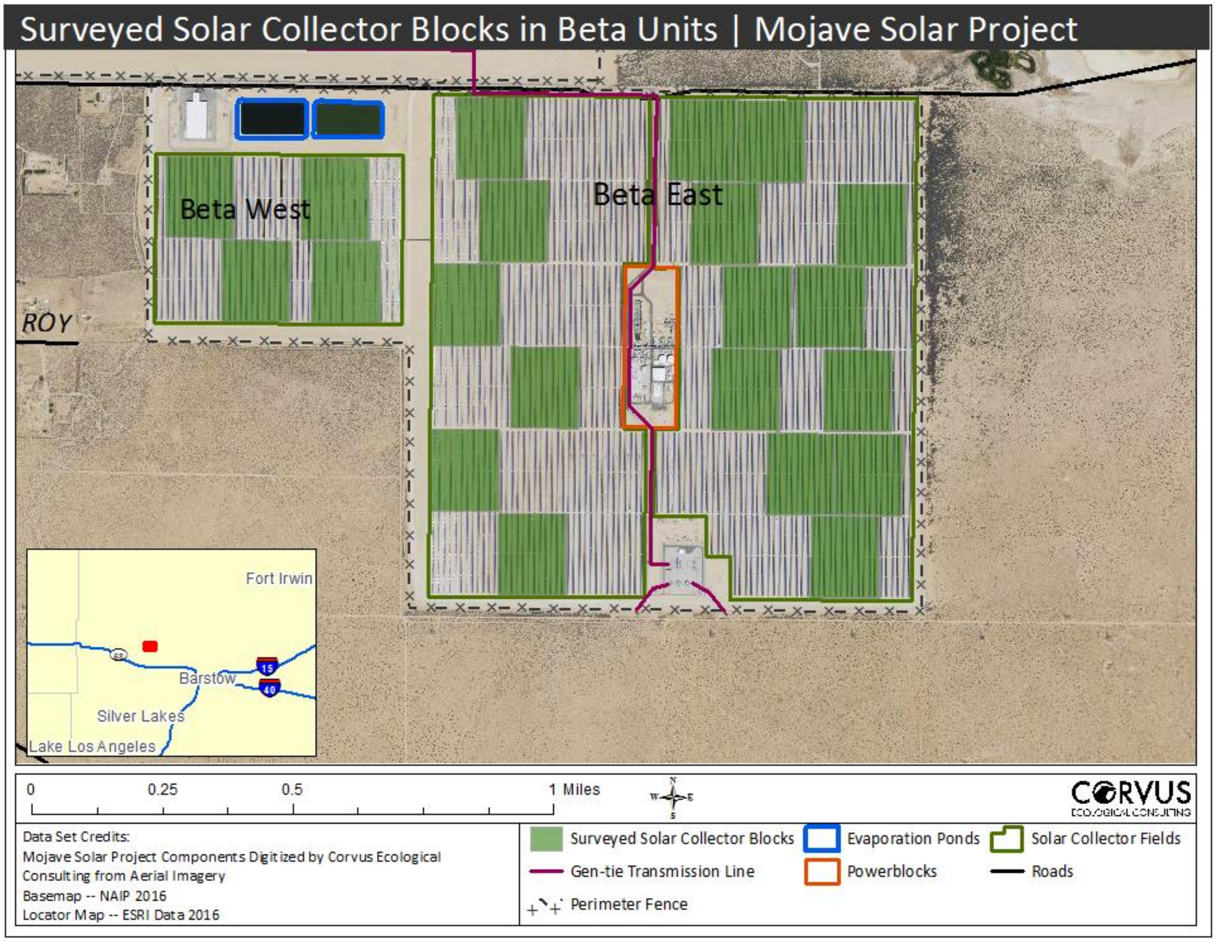

Figure 4. Solar collector blocks in Beta units surveyed using systematic searches.

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

PROJECT COMPONENT	TOTAL SIZE	UNITS	PERCENT OF COMPONENT SEARCHED
SCF	1160	Rows of solar troughs	45
ALPHA WEST	320	Rows of solar troughs	41
ALPHA EAST	244	Rows of solar troughs	49
BETA WEST	88	Rows of solar troughs	55
BETA EAST	476	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.

In winter 2018-2019, the Mojave Solar facility had maintenance requirements for the solar troughs in both Alpha and Beta units. During these maintenance operations, the troughs would remain in the stowed position making a horizontal search across multiple troughs impossible. When the surveyor encountered these conditions, he would drive up and down every row in the block rather than every other row. Eleven (11) survey days were affected: 3 in Alpha East, 2 in Alpha West, 3 in Beta West, and 3 in Beta East.

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.

During the winter 2018-2019 season, the Mojave Solar facility installed 0.75” nets around the cooling towers to prevent birds from roosting at night. Installation of nets in the Alpha block took place from November 2018 until January of 2019 and the Beta net installation began in December 2018 and finished in February of 2019 (Mojave Solar, LLC. BIO7-09-02, 2019)

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

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

2.2 Carcass Persistence Trials

A total of 6 carcass persistence trials were completed during the winter 2018-2019 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

Ten 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 winter 2018-2019 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-eight (58) carcasses were placed for searcher efficiency in all strata. Two of these carcasses were removed before the searcher had a chance to detect them resulting in a sample of fifty-six (56) carcasses. 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. 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 (90% confidence intervals). The median is taken in addition to the mean because it is much less influenced by outliers, and thus provides another useful measure of the data.

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

Estimating Detection Probability, *g*.

Recall that:

$$g = rp$$

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

2.5 Incidental Reporting

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

Any detection made outside of BIO-17 systematic search transects were considered incidental. Data on incidental detections were reported monthly in the SPUT Avian Injury and Mortality Report Forms 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 winter 2018-2019 survey efforts, fifty-one (51) detections of fifteen (15) identified species were recorded; including injured birds, incidental detections, and fatalities detected during systematic surveys (Table 3). The species detected in greatest abundance was Eared Grebe (*Podiceps nigricollis*) with fourteen (14) individuals. The stratum with the highest number of fatalities or injuries was the perimeter fence with seventeen [(17) 33% of total; Figures 4 and 5 and Tables 3, 4, and 5]. Forty-six [(46) 90% of total] detections were made during systematic searches and five [(5) 10% of total] were the result of incidental detections.

All fifty-one 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 winter (November 5 – February 28) 2018-2019 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
WOOD DUCK	*Aix sponsa*	nocturnal	1							**1**
NORTHERN SHOVELER	*Spatula clypeata*	Both nocturnal and diurnal	1							**1**
MALLARD	*Anas platyrhynchos*	unknown						1		**1**
GREEN-WINGED TEAL	*Anas crecca*	mostly nocturnal	1							**1**
UNIDENTIFIED DUCK	Anatinae		1				1	3		**5**
EARED GREBE	*Podiceps nigricollis*	nocturnal	3			9	1	1		**14**
ACCIPITER SP	*Accipiter* sp.						1			**1**
RING-BILLED GULL	*Larus delawarensis*	diurnal					1			**1**
CALIFORNIA GULL	*Larus californicus*	Mostly diurnal	1							**1**
UNIDENTIFIED LARUS GULL	*Larus sp.*		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	COOLING TOWER	EVAP. PONDS	PERIMETER FENCE	GEN-TIE LINE	OUTSIDE STUDY AREA	TOTAL
BURROWING OWL	*Athene cunicularia*						2			**2**
NORTHERN FLICKER	*Colaptes auratus*	diurnal					1			**1**
RUBY-CROWNED KINGLET	*Regulus calendula*	likely nocturnal					1			**1**
HERMIT THRUSH	*Catharus guttatus*	nocturnal	1							**1**
YELLOW-RUMPED WARBLER	*Setophaga coronata*	nocturnal					1			**1**
BROWN-HEADED COWBIRD	*Molothrus ater*	diurnal/ resident		1	1					**2**
UNIDENTIFIED SPARROW	Emberizidae						1			**1**
UNIDENTIFIED PASSERINE						1	1			**2**
UNIDENTIFIED BIRD				1		4	6			**11**
TOTALS			**11**	**2**	**1**	**14**	**17**	**6**		**51**

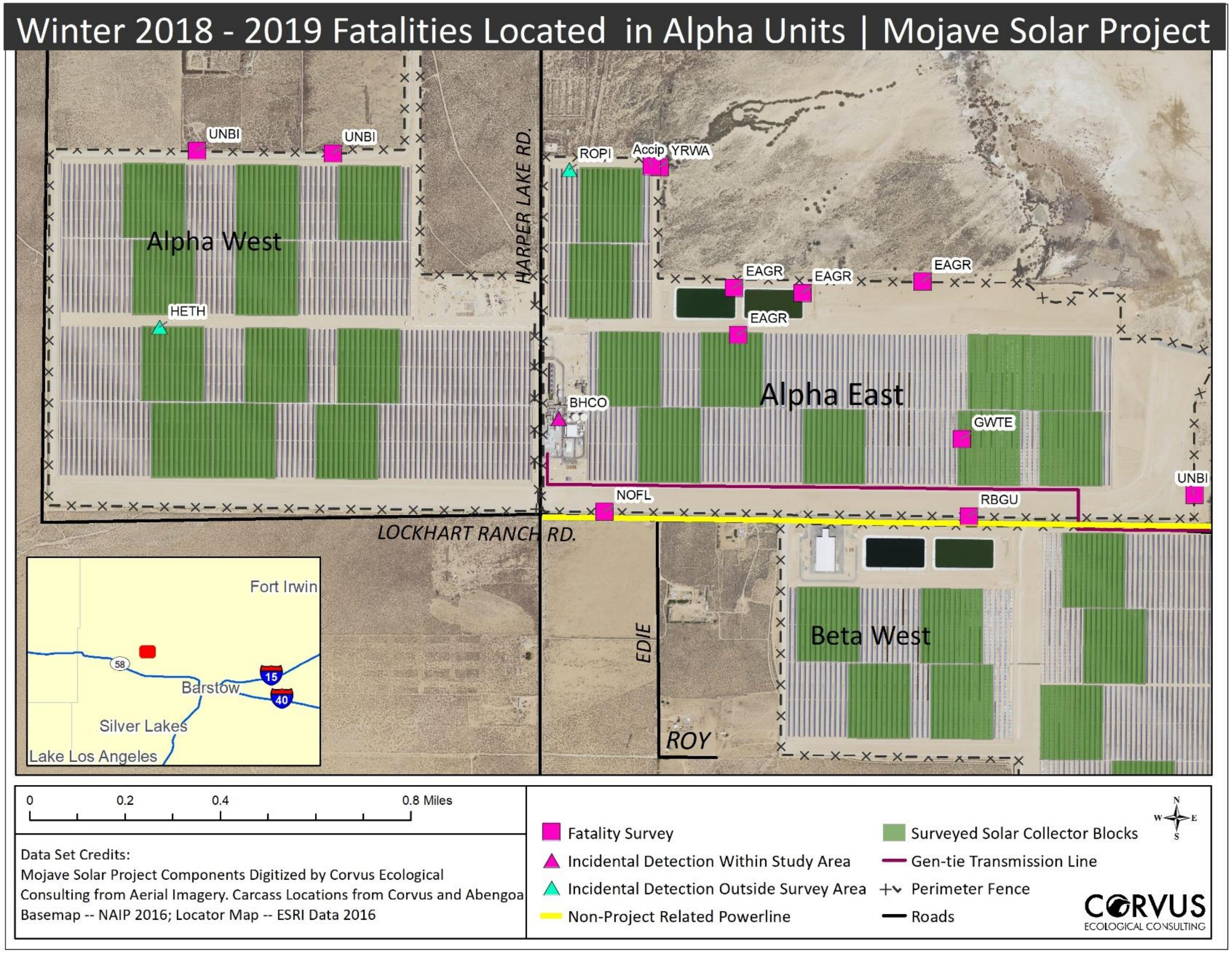

Figure 5. Locations of carcasses and injured birds found in winter 2018 on the Alpha Unit Components of the Mojave Solar Project.

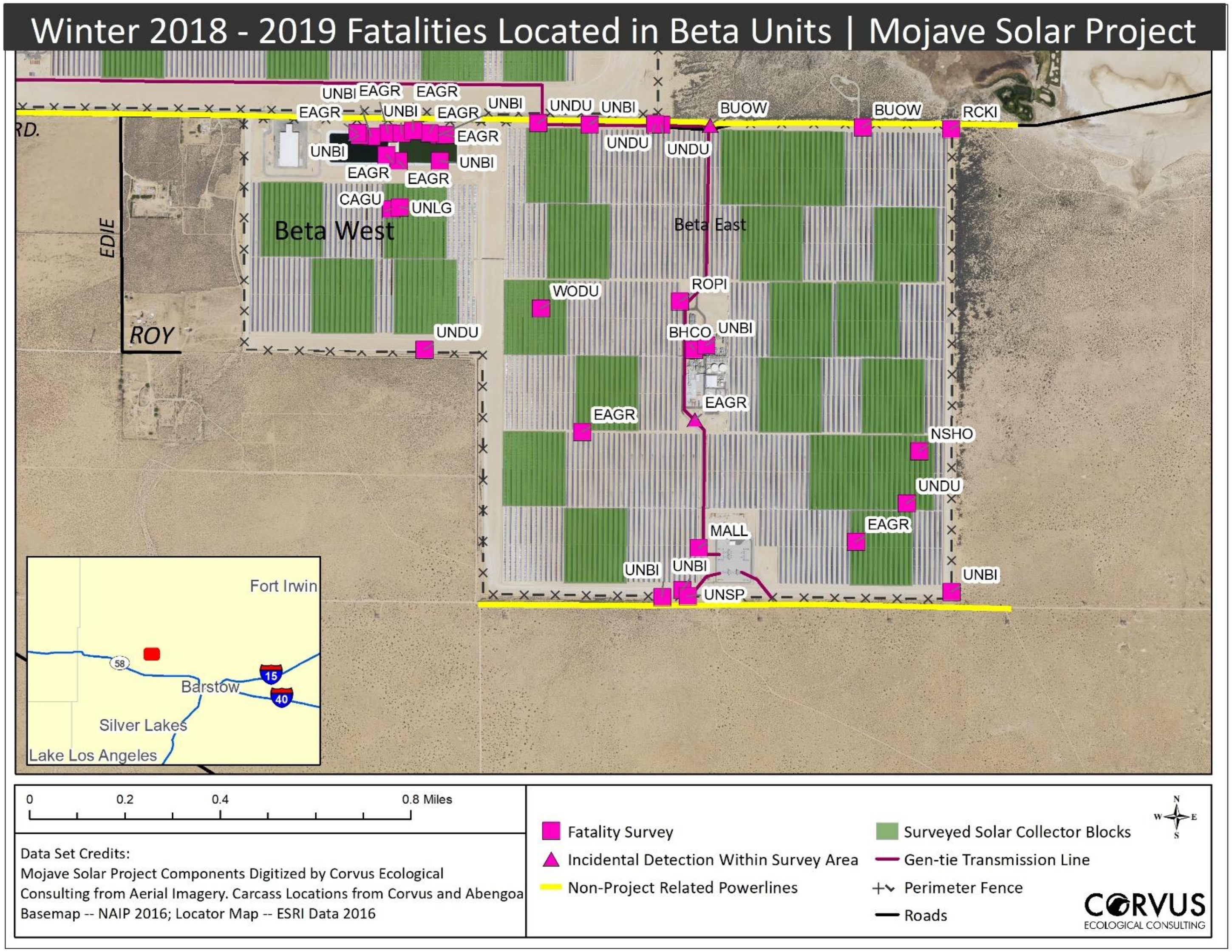

Figure 6. Locations of carcasses and injured birds found in winter 2018 on the Beta Unit Components of the Mojave Solar Project

3.1.1 Temporal Patterns of Avian Detections

The highest number of detections on a single day was six (6), which occurred on November 15, 2018 (Figure 7). There were four full months in this season. The month with the highest number of detections was November with twenty (20). This is consistent with local observations of fall migration extending into the month of November. The month with the second highest number of detections was January with fifteen (15) followed by December and February with thirteen (13) and three (3) respectively. These numbers include totals from systematic searches and incidental detections.

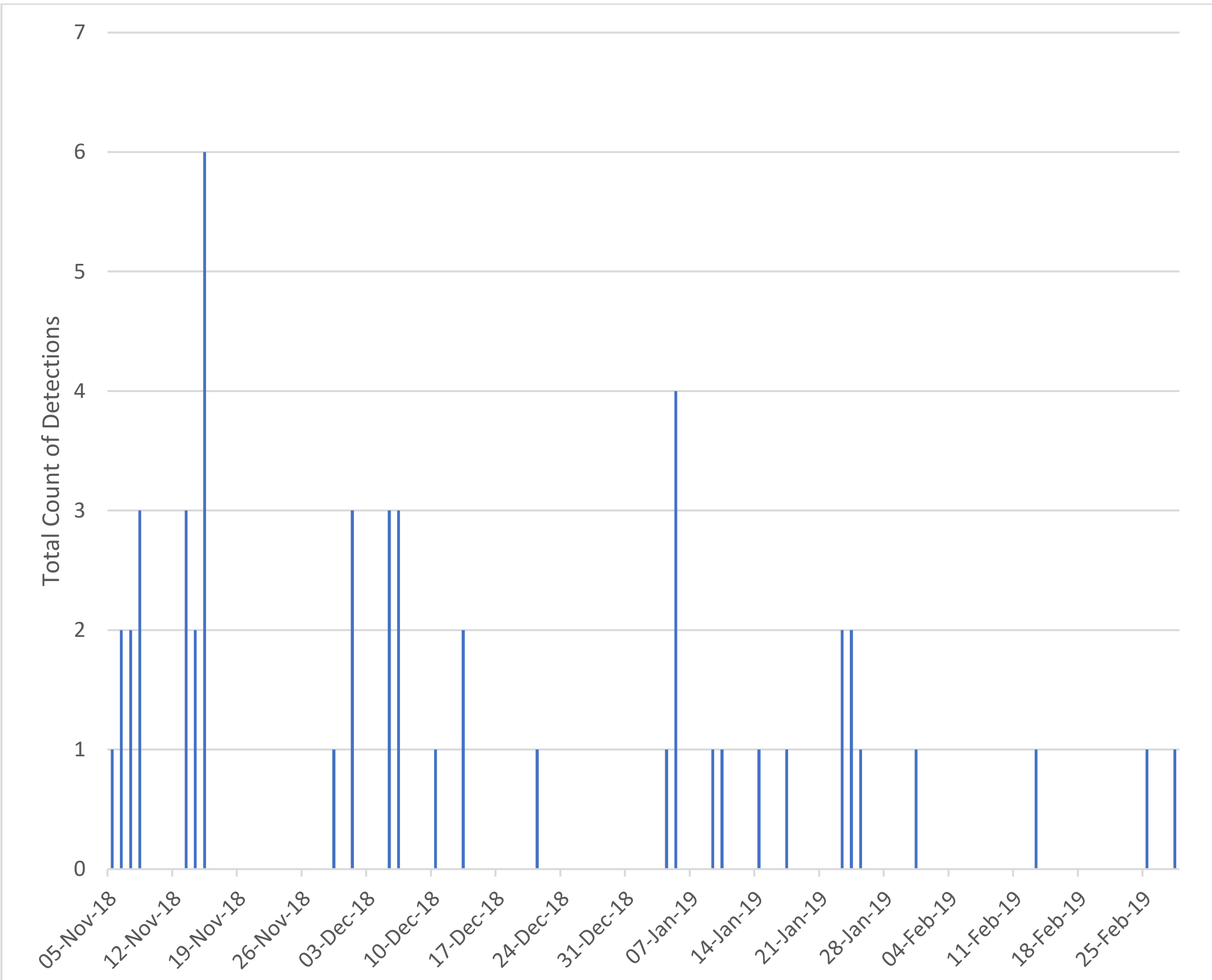

Figure 7. Total number of detections by date during winter (November 5 – February 28) 2018-2019 at Mojave Solar Project, San Bernardino County, CA.

3.1.2 Spatial Distribution of Avian Detections

During the spring season 2018, detections were made within the SCF, along the Perimeter Fence, under the Gen-tie line, within the Power Block (including the cooling tower), and in the Evaporation Ponds (Tables 3, 4, and 5). All detections were made within the project perimeter fence. Two (2) of the fatalities were located within the SCF, but outside of the surveyed area of this component. The breakdown by unit is as follows: 3 in Alpha West, 12 in Alpha East, 15 in Beta West, and 21 in Beta East.

Table 4. Total detections by strata and detection category during winter (November 5 – February 28) 2018-2019 at Mojave Solar Project, San Bernardino County, CA.

PROJECT COMPONENT	SYSTEMATIC SEARCH	INCIDENTAL	% OF TOTAL
PERIMETER FENCE	16	1	33.3
OVERHEAD LINE (GEN-TIE)	5	1	11.8
EVAPORATION PONDS	14		27.4
POWER BLOCK	2	1	5.9
COOLING TOWER	*1*		
OTHER	*1*	*1*	
SCF	9	2	21.6
ROADS OUTSIDE PERIMETER FENCE			0
PERCENT OF TOTAL	90.2	9.8	100

Table 5. Total detections (all types) by Project component and suspected cause of death during winter (November 5 – February 28) 2018-2019 at Mojave Solar Project, San Bernardino County, CA.

PROJECT COMPONENT	SUSPECTED CAUSE OF DEATH*						% OF TOTAL
	COLLISION	DROWNED	OTHER	EXPOSURE/ DEHYDRATION	UNKNOWN – EVIDENCE OF SCAVENGING OR PREDATION	UNKNOWN – INTACT BIRD	
FENCING					18	2	**39.2**
OVERHEAD LINE					2		**4.0**
EVAPORATION PONDS					1	13	**27.4**
COOLING TOWER		1					**1.95**
SOLAR COLLECTOR					11		**21.5**
OTHER POWER BLOCK BUILDING					1	1	**4.0**
ROAD					1		**1.95**
% OF TOTAL	**0**	**2**	**0**	**0**	**66.7**	**31.3**	**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 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

All 51 detections in winter 2018-2019 were of dead birds. Of those, one [(1) 2.0%] was freshly deceased; fifteen [(15) 29.4%] were semi-fresh with some signs of rigor mortis; three [(3) 5.9%] were mummified and thirty-two [(32) 62.7%] were scavenged or feather spots such that time since death was difficult to assess.

A large number of carcasses (21) were suspected to have been due to predation. While predation is almost never directly observed, biologists can use the evidence present at the carcass and the surrounding area to ascertain a cause of death. Some of the evidence used in making this determination includes: the presence of predatory birds that specialize in other birds as a main prey item (Peregrine Falcon and Merlin) observed hunting on the project site, carcasses found beneath known predator perch sites, the absence of evidence of a collision with a project feature, and the increase in mortality coinciding with an increase in predatory bird sightings within the project boundaries. Appendix A contains a description of each mortality suspected to have been due to predation and the reasons for that determination. Because predation was not directly observed it was requested by USFWS that these mortalities be labeled with an unknown cause of death for the purposes of this report (Thomas Dietsch August 4, 2020 via Ann Crisp email communication).

Similarly, mortalities associated with the evaporation pond were not sent for necropsy. Past necropsies revealed incidences of sodium ion toxicosis and it is possible that the “Unknown” mortalities in that component had similar causes (specifically those found with no evidence of predation), but in absence of laboratory evidence, they have been labeled “Unknown”.

3.1.4 Injured or Stranded Birds

All birds located in winter 2018-2019 were deceased.

3.2 Bat Detections

There were no bats detected during the winter 2018-2019.

3.3 Carcass Persistence Trials

For carcass persistence trials, we analyzed the winter 2018-2019 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 and size class. Size class included three levels: small, medium and large carcasses. Size class and strata were both identified as important factors. But running the size classes separately with no covariates resulted in a better fit with AICs less than 100.

Table 6. Model selection results displaying AICc values of models selected for each size class.

Size	Distribution	Location Formula	Scale Formula	AICc	ΔAICc
large	lognormal	constant	constant	47.68	0.91

medium	loglogistic	constant	constant	66.84	0
small	weibull	constant	constant	111.52	0

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	TRIALS PLACED	MEDIAN CARCASS PERSISTENCE (DAYS)	*r* PROPORTION REMAINING AFTER 7 DAYS
LARGE	10	5.34	0.7
MEDIUM	20	0.94	0.2
SMALL	30	0.48	0.18

Figure 8. Carcass persistence graphs for three size classes. 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 winter season and tested models using size class and modified strata (see carcass persistence). None of the covariates produced valid results. We also looked at modeling searcher efficiency separately for the three size classes in order to have estimates to use for the final estimator (Table 8)

Table 8. Searcher efficiency estimates for each size class in Winter 2018-2019

SIZE CLASS	TRIALS PLACED	EFFICIENCY ESTIMATION	AIC_C FOR MODEL
LARGE	11	0.909	9.15
MEDIUM	16	0.813	17.73
SMALL	27	0.630	37.75

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

Table 9. Carcasses of three size classes (S,M,L) placed for searcher efficiency trials in each project component of the Mojave Solar Project during winter 2018-2019. 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	3	0	0	0	0	1	3	0	0	3	0	1	0	0
GEN-TIE	2	0	2	0	0	0	2	0	2	1	0	2	1	0	0
PERIMETER FENCE	8	1	4	1	0	0	7	1	4	4	1	4	3	0	0
POWER BLOCKS	2	2	0	0	0	0	2	2	0	2	1	0	0	1	0
SCA	16	12	5	1	2	0	15	10	5	10	10	5	5	0	0
SIZE CLASS TOTAL	29	18	11	2	2	0	27	16	11	17	15	11	10	1	0
PROJECT TOTAL			58			4			54			43			11

3.5 Fatality Estimates

As was stated in the methods, our surveyor was not able to use the same search methodology for all units for all surveys due to the maintenance and the solar troughs being stowed in the down position. Typically, we would treat this altered search methodology as a different stratum, but in reviewing the data from the SCF, there were only 9 total fatalities located and 2 of them were found using the altered methodology. In total, 19% of the SCF surveys used the altered methodology and 22% of the total SCF fatalities were found using this methodology. On its surface, this did not seem to indicate that the altered survey methodology affected the detection of carcasses, although admittedly this is a small sample from which to draw conclusions.

During the winter season of 2018-2019, the average search interval was 8 days and the season spanned 120 days. Using the bias estimator trial data from this season, the estimated detection probabilities for each size class can be calculated (Table 10).

Using these data we calculate an estimated 248.78 bird mortalities (90% CI: 156.76 -405.25) occurred at the Mojave Solar Project (Table 11). This estimate was based on 28 observed fatalities, which excluded the 1 fatality from the cooling tower, 2 fatalities that were found outside the search area, and 20 were not included in the estimator due to the cause of death being predation (one predated carcass was found outside the search area and was not included for that reason). Since the cause of death is subjective, and the scavenger rates have been demonstrated to be high on this facility, we have provided another set of estimates (Table 12) that include these suspected predated carcasses.

Estimates and confidence intervals were calculated using the GenEst package (Dalthorp et. al 2018). This package also allows us to split the estimates based on additional information collected. We have chosen to split our estimates based on size class and strata (Table 11 and 12).

Table 10. Average probability of detecting a carcass by carcass size.

SIZE CLASS	AVG PROBABILITY OF DETECTING A CARCASS	95% CONFIDENCE INTERVAL
LARGE	0.585	0.395 – 0.749
MEDIUM	0.144	0.090 – 0.219
SMALL	0.102	0.061 -- 0.161

From this table, we see that using our carcass persistence and searcher efficiency data, we estimate that the probability of detecting a small or medium carcass anywhere on the facility is less than 15%.

Table 11. Fatality estimates for winter 2018-2019 (not including cooling tower or suspected predated carcasses).

		FATALITIES FOUND	ESTIMATED FATALITIES	LCL (90%)	UCL (90%)
WINTER 2018-2019					
OVERALL		**28**	**248.78**	**156.76**	**405.25**
	STRATA				
Large	Evap Pond	0	0	0	0
	Gen-tie	0	0	0	0
	Perimeter Fence	0	0	0	0
	Power Block	1	3.2	1	9.76
	SCF	2	5.11	2	11.72
Medium	Evap Pond	13	101.96	53.03	199.47
	Gen-tie	1	6.33	1	22.94
	Perimeter Fence	5	35.65	13.19	74.81
	Power Block	0	0	0	0
	SCF	1	0	0	0
Small	Evap Pond	1	9.22	1	33.44
	Gen-tie	0	0	0	0
	Perimeter Fence	4	61.25	16.77	156.87
	Power Block	1	8.77	1	29.43
	SCF	0	0	0	0

Table 12. Fatality estimates for winter 2018 (including suspected predated carcasses, but not cooling tower fatalities).

		FATALITIES FOUND	ESTIMATED FATALITIES	LCL (90%)	UCL (90%)
WINTER 2018-2019					
OVERALL		**48**	**367.33**	**245.45**	**561.93**
	STRATA				
Large	Evap Pond	0	0	0	0
	Gen-tie	2	6.28	2	16.29
	Perimeter Fence	2	6.07	2	15.19
	Power Block	1	3.09	1	9.73
	SCF	5	11.64	5.72	21.74
Medium	Evap Pond	13	103.37	54.66	194.9
	Gen-tie	4	23.5	7.5	52.14
	Perimeter Fence	8	54.04	25.89	112.1
	Power Block	0	0	0	0
	SCF	4	32.43	9.38	71.59
Small	Evap Pond	1	9.18	1	33.77
	Gen-tie	0	0	0	0
	Perimeter Fence	7	88.92	35.16	190.85
	Power Block	1	7.97	1	30.31
	SCF	0	0	0	0

This season, due to the netting on the cooling towers, we had only 1 fatality attributed to that component and that fatality was detected prior to the net being installed. We can add that back in to either estimate (with or without the suspected predated carcasses) to provide an overall estimate of 250-368 fatalities for the winter 2018-2019 season.

4.0 Discussion

The winter 2018-2019 season was the sixth 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 2017-2018, 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 remaining 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 winter 2017-2018 bias trials with those from winter 2018-2019.

When we examine the size class of fatalities and injuries detected to date on this facility, we see since the systematic surveys have started, there have been 236 avian fatality or injury detections on Mojave Solar. Roughly 46% of these detections have been of medium sized birds, 14% large birds, and 39% small birds. If we remove birds found in the cooling tower components (since the searcher efficiency and carcass persistence are different for those locations), the percentages are 57% for medium, 18% for large, and 25% for small. Our bias trials are weighted heavily toward the small carcasses as outlined in The Plan. We have almost completed two years of surveys on this facility, but if fatality monitoring is to take place on other facilities, it may be better to revise the sampling with respect to distribution of carcass size.

4.2 Distribution of Fatalities and Fatality Estimates

Unlike the bias trials, the methods for the systematic surveys have not been altered much between winter 2017-2018 and winter 2018-2019. We have changed the number of driving passes through a survey block to make up for reduced visibility (survey bias) within the SCF, but the timing of surveys and basic methodology has remained consistent.

In winter 2017-2018, seventeen (17) detections of injured or deceased birds were made by surveyors. Of those 17 detections, two (2) were from the cooling towers, two (2) from the power block, one (1) from the evaporation ponds, none (0) from the Gen-tie, seven (7) from the perimeter fence, and five (5) from the SCF. In winter 2018-2019, a total of fifty-one (51) detections were made all within the facility. Of those 51, one (1) was within the cooling towers, two (2) were in the power block, fourteen (14) were in the evaporation ponds, six (6) in the Gen-tie, seventeen (17) from the perimeter fence, and eleven (11) from the SCF (Figure 9).

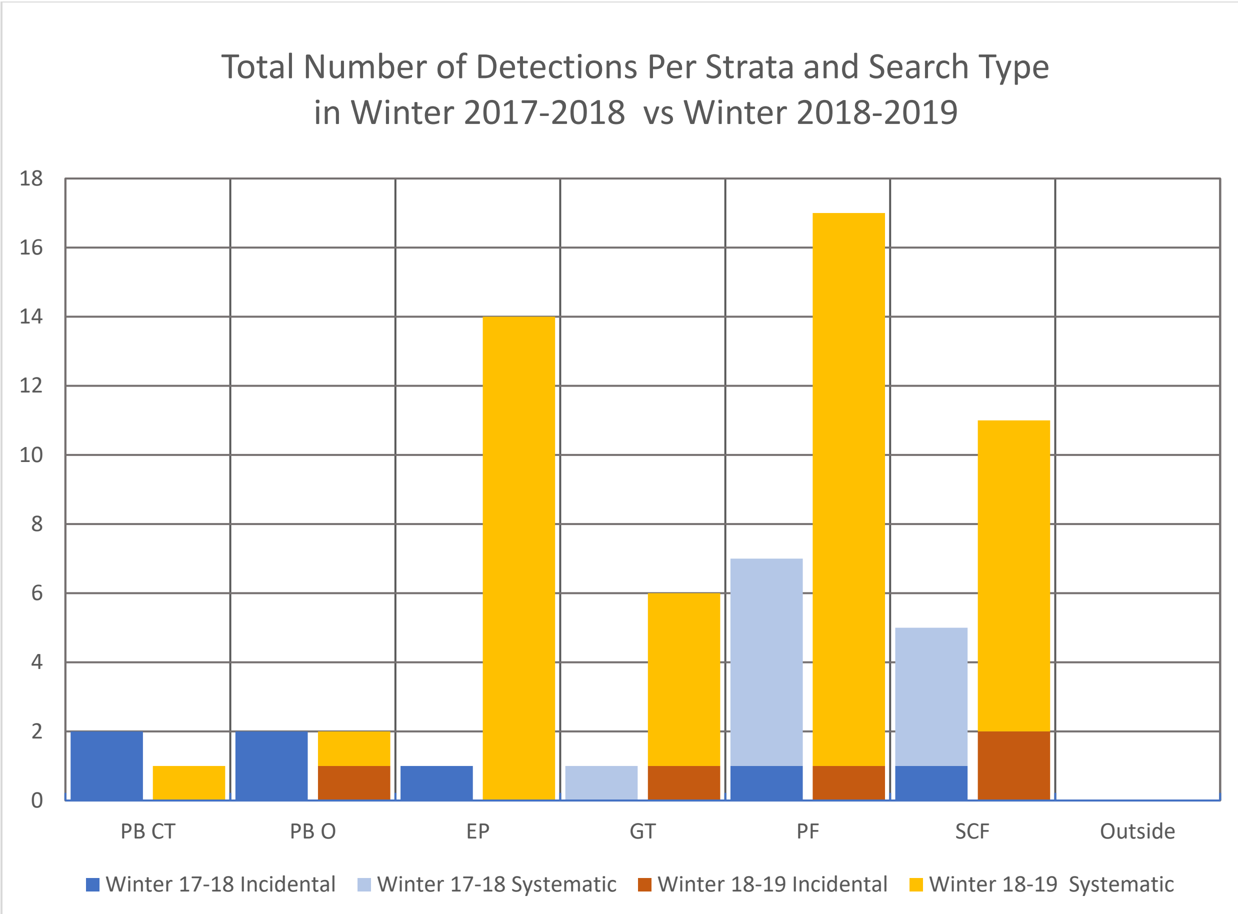

Figure 9. Comparison of winter 2017-2018 and winter 2018-2019 detections by strata and search type. PB CT = Power block cooling tower, PB O = Power block Other, EP = Evaporation Pond, GT = Gen-tie, PF = Perimeter Fence, SCF = Solar Collector Field.

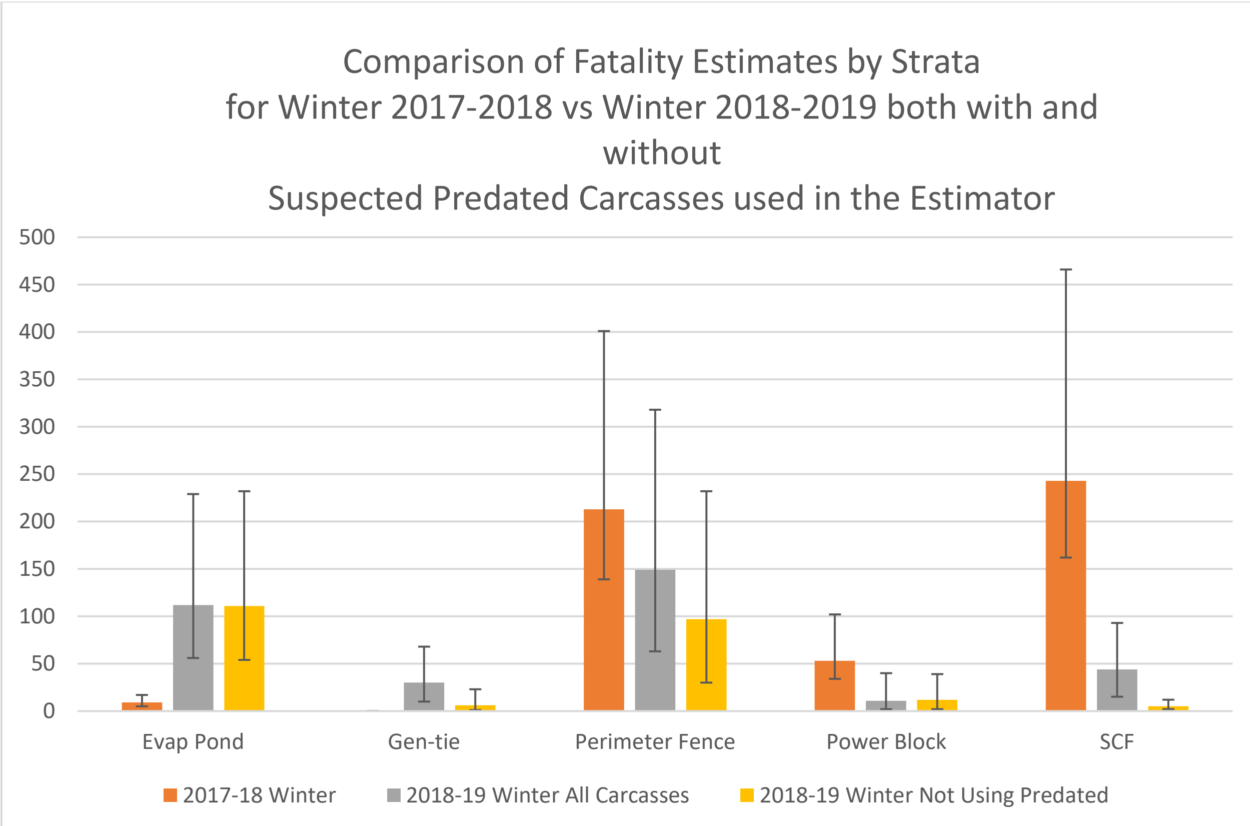

Figure 10. Comparison of fatality estimates by strata from Winter 2017-2018 vs Winter 2018-2019. For Winter 2018-2019 we compare both the estimates run using suspected predated carcasses and the estimates leaving the suspected predated carcasses out of the analysis. Black bars indicate 90% confidence intervals of the estimate.

Note that for the estimation for the SCF and Perimeter Fence, the number of fatalities detected was fewer in 2017-2018 (Figure 9), but the estimates for that strata were much higher (Figure 10). This is potentially due to the differences in statistical estimators used between years, or perhaps due to differences in estimation of carcass persistence or searcher efficiency.

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6.0 Appendix A. Suspected Predated Carcass and Explanation for Cause of Death Attribution, Mojave Solar Winter 2018-2019

COMMON NAME	DATE FOUND	TIME FOUND	SPECIMEN ID	STRATA	DESCRIPTION OF CARCASS	FULL DESCRIPTION	CAUSE OF DEATH EXPLANATION
UNIDENTIFIED BIRD	05-Nov-18	11:20	20181105-001	Perimeter Fence	Feather Spot	Attached cluster of tail feathers. Possibly a sparrow.	No other likely source of mortality nearby. Loggerhead Shrike spends time here.
EARED GREBE	06-Nov-18	13:38	20181106-002	SCA	Feather Spot	A few feathers and blood stains. Probably at least 3 days old.	No sign of contact with mirrors but looks like original fatality site based on quantity of blood. Active Peregrine area.
WOOD DUCK	13-Nov-18	11:34	20181113-003	SCA	Feather Spot	Scattered feathers and sternum and wing bones, no more than two days old	Likely Peregrine kill
EARED GREBE	13-Nov-18	8:33	20181113-001	SCA	Feather Spot	Cluster of body feathers and separate attached cluster of primaries	Peregrine hunting area
NORTHERN SHOVELER	13-Nov-18	9:02	20181113-002	SCA	Feather Spot	Two attached primaries and coverts	Peregrine hunting area
UNIDENTIFIED BIRD	15-Nov-18	11:36	20181115-005	Perimeter Fence	Feather Spot	A few body feathers and tail feathers of waterbird. No	Peregrine area

COMMON NAME	DATE FOUND	TIME FOUND	SPECIMEN ID	STRATA	DESCRIPTION OF CARCASS	FULL DESCRIPTION	CAUSE OF DEATH EXPLANATION
						more than 1 week old	
UNIDENTIFIED DUCK	15-Nov-18	11:18	20181115-004	Gen-tie	Feather Spot	An attached cluster of belly feathers and a tertial(?)	Peregrine activity area
UNIDENTIFIED DUCK	01-Dec-18	11:00	20181201-002	Gen-tie	Feather Spot	A few feathers including two small clusters of body feathers	Peregrine area
MALLARD	01-Dec-18	12:54	20181201-003	Gen-tie	Dead, semi-fresh	Traced clusters of body feathers to carcass in SCA.	Very likely a Peregrine kill. No sign of contact with troughs.
EARED GREBE	05-Dec-18	10:34	20181205-003	Perimeter Fence	Feather Spot	Attached cluster of secondaries, probably less than a week old.	Feathers likely blown to location. Peregrines active nearby.
UNIDENTIFIED BIRD	05-Dec-18	9:55	20181205-002	Perimeter Fence	Feather Spot	Attached cluster of secondaries and a few other feathers. Grebe, duck, or coot	Feathers blown to location. Peregrine perch site not far.
UNIDENTIFIED DUCK	06-Dec-18	9:50	20181206-003	Gen-tie	Feather Spot	A few clusters of body feathers. Probably less than a week old	Peregrine area
RING-BILLED GULL	04-Jan-19	9:26	20190104-001	Perimeter Fence	Feather Spot	Scattered feathers on	Peregrine still in area.

COMMON NAME	DATE FOUND	TIME FOUND	SPECIMEN ID	STRATA	DESCRIPTION OF CARCASS	FULL DESCRIPTION	CAUSE OF DEATH EXPLANATION
						upper terrace. Update: feathers scattered along south and east fences, body feathers concentrated along row 180 of SCA	
UNIDENTIFIED DUCK	05-Jan-19	8:20	20190105-001	Perimeter Fence	Feather Spot	Scattered clusters of body feathers.	Peregrine still in area
ACCIPITER SP.	09-Jan-19	8:45	20190109-001	Perimeter Fence	Feather Spot	Very fresh scattering of feathers and feather clusters centered on utility pole	Hawk processed from atop pole based on paucity of tracks and feather scatter pattern. Must have been mostly intact based on number of feathers, but probably too large for Raven to carry to pole.
UNIDENTIFIED BIRD	10-Jan-19	9:43	20190110-001	Perimeter Fence	Feather Spot	Attached primary cluster from left-wing. Not fresh. Possibly a Horned Lark	Wind-blown feathers routinely collect here. Could be collision nearby but more likely predation by falcons based on date and HOLA flight behavior.
UNIDENTIFIED DUCK	23-Jan-19	9:25	20190123-001	SCA	Feather Spot	Two small clusters of body feathers	Peregrine still in area

COMMON NAME	DATE FOUND	TIME FOUND	SPECIMEN ID	STRATA	DESCRIPTION OF CARCASS	FULL DESCRIPTION	CAUSE OF DEATH EXPLANATION
ROCK PIGEON	23-Jan-19	7:20	20190123-101	SCA – Not Surveyed Area	Feather Spot	Scattered feathers in SCA and along fenceline.	Presumed predated. Blood spots on ground. No sign of impact on mirrors.
GREEN-WINGED TEAL	24-Jan-19	13:05	20190124-002	SCA	Feather Spot	Fresh feather spot including head and some intestines	Peregrine in area. No sign of impact with solar trough
EARED GREBE	24-Jan-19	10:59	20190124-001	SCA	Feather Spot	Small feathers scattered around edge of receding rain pool. No more than three days old.	Peregrine still in area. Period of full moon.
ROCK PIGEON	31-Jan-19	11:28	20190131-001	Gen-tie	Feather Spot	Scattered body feathers within 10 m of utility pole. Original site of kill probably to north based on distribution pattern and wind. Less than a week old.	Could be collision nearby but more likely predation by PEFA based on falcon presence in area and pigeons are a popular food item