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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 Third Quarterly Report_Spring2019. Revised.**
Submittal Number:	**BIO17-10-01**

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 BIO17-10-01 Revised Bird Monitoring Study Third Quarterly Report_Spring2019 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 Third Quarterly Report_Spring2019.

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

BIO-17 Bird Monitoring Study
Spring 2019 Seasonal Interim Report

Submitted:
August 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. 2019 Spring Seasonal Report. 31 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 seventh season of fatality monitoring surveys which were conducted 4 March 2019 through 1 June 2019 (spring 2019), in accordance 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 spring 2019 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 4 March 2019 through 1 June 2019.

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 spring 2019.Searcher efficiency was tested using fifty-seven (57) specimens.

All bird and bat fatalities, both those located during systematic searches and those located incidentally, are reported for BIO-17. In spring 2019, there were sixteen (16) detections of fatalities or injuries, all of which were detected within the perimeter fence of the Mojave Solar Project. Thirty-one percent (31%) of all fatalities and injuries were associated with the perimeter fence. The greatest number of detections for a single species in the spring 2019 season was 4 House Sparrows. All detections in the spring season were of deceased rather than injured or stranded birds.

During the first year of surveys, the majority of fatalities were 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. There was one fatality detected in the cooling tower washout pond in spring 2019 due to a hole in the netting surrounding the towers.

We used the spring 2019 data alone to estimate carcass persistence. Carcass persistence was modeled using size class as a covariate for the location parameter of the model. The persistence times were as follows: 43.16 days for large carcasses, 1.22 days for medium, and 0.09 days (roughly 2 hours) for small.

Searcher efficiency results from spring 2019 were also sufficient to obtain estimates using this season's data alone. The searcher efficiency was calculated for all size classes combined. The estimate was 0.93 with a 90% confidence interval of 0.85-0.96.

During the spring season 2019, a total of sixteen (16) carcasses of wild birds were found within the search area of the Mojave Solar Project. One (1) of these carcasses was found in the cooling tower washout pond and was not incorporated in the estimator. We used the calculated searcher efficiency and carcass persistence values, and the GenEst program, to obtain an estimate of 62 - 268 bird fatalities during the spring 2019 (90% CI). The cooling tower fatality can be added back in as a raw number to obtain the final estimate of 128 for spring 2019.

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 spring 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
MOJAVE SOLAR, LLC	Jose Manuel Bravo Romero	Permitting & Compliance Manager	Oversight of Mojave Solar compliance to BIO-17
ROWE ECOLOGICAL CONSULTING	Sean Rowe	Designated Biologist/Field Lead	Conduct carcass persistence and searcher efficiency bias trials

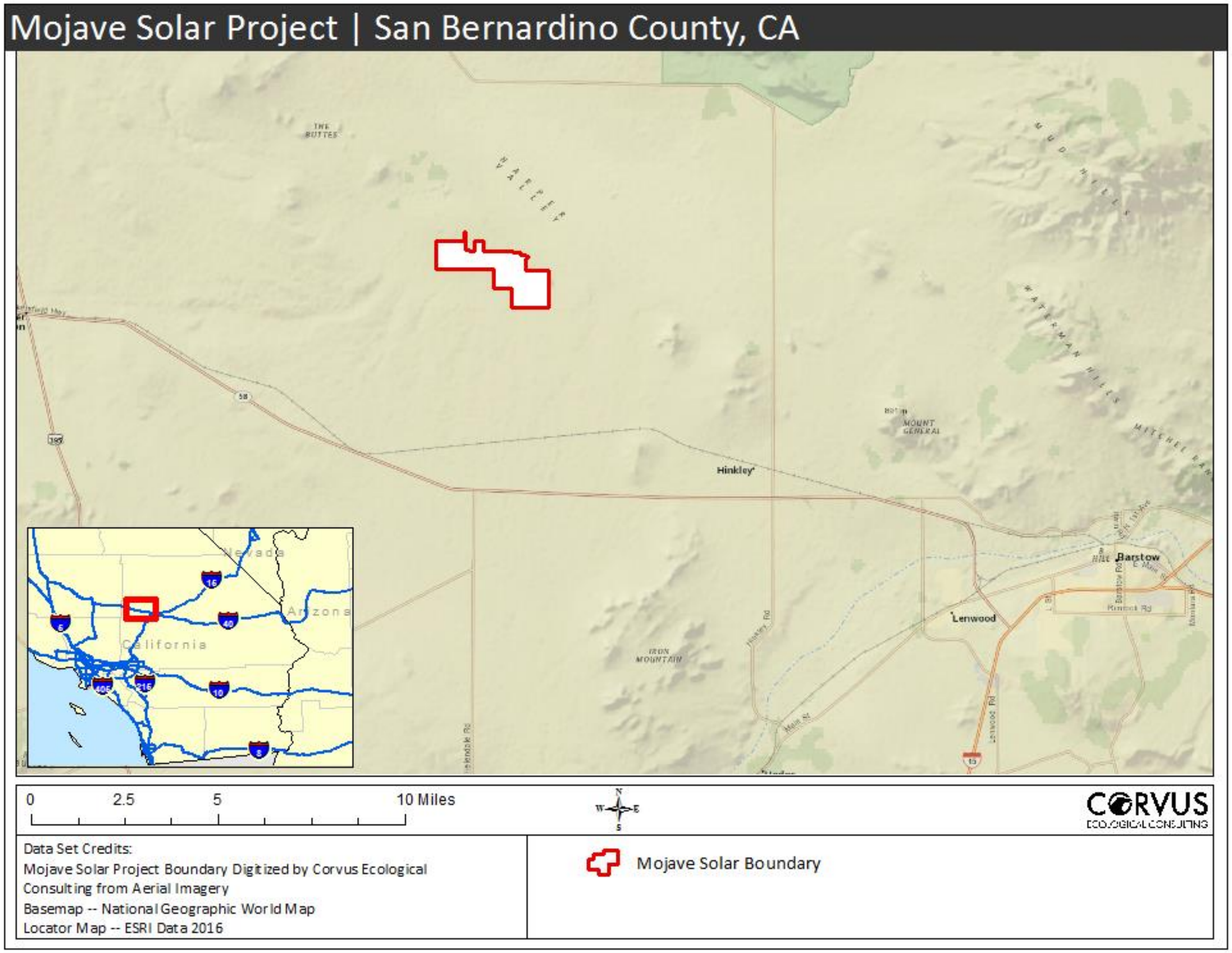

Figure 1. Project vicinity and overview.

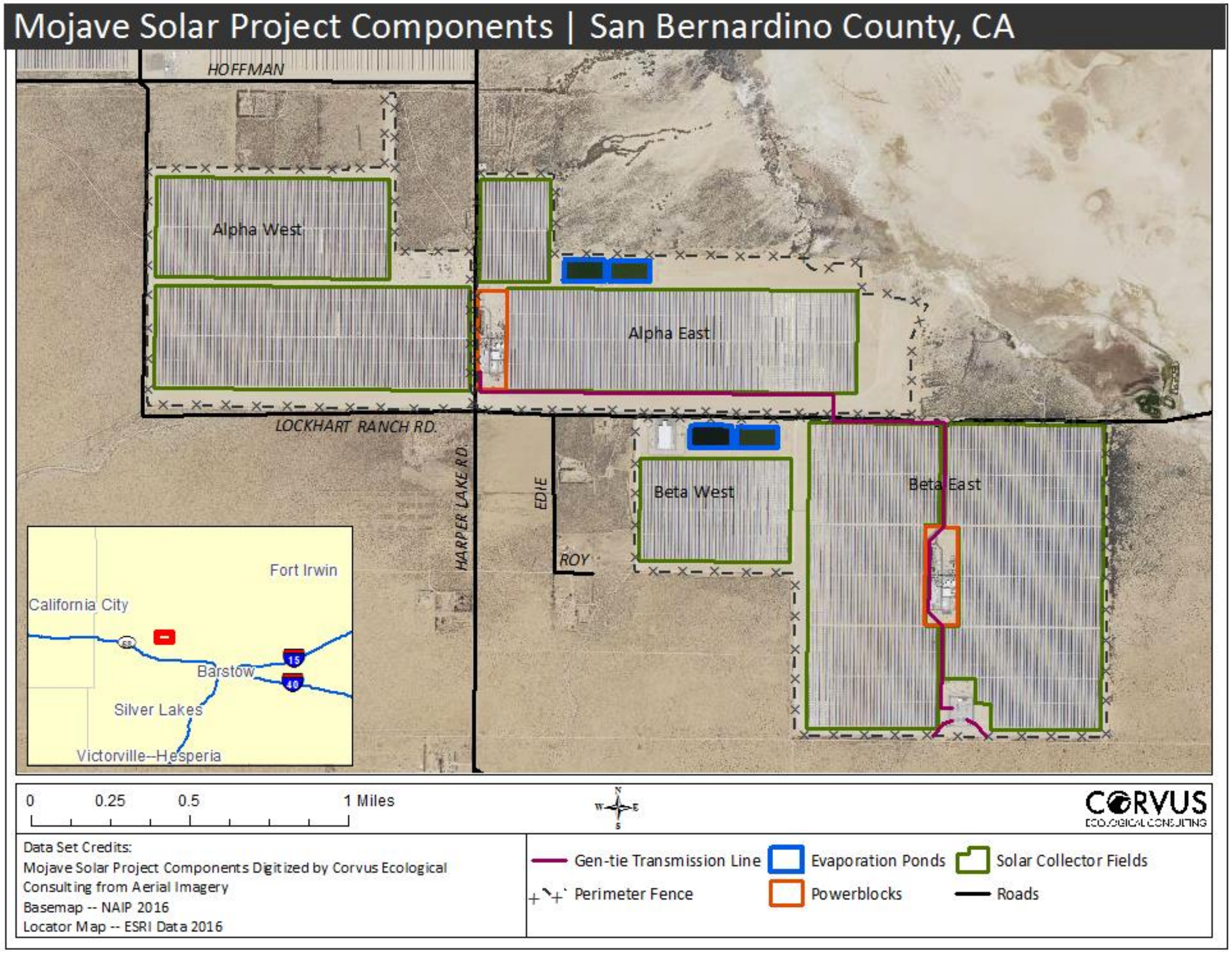

Figure 2. Mojave Solar project components.

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 seventh season of monitoring. This report summarizes the methods employed and provides preliminary results for avian and bat fatalities and injuries. The actions described in this report took place during the 13-week period from 4 March 2019 through 1 June 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 spring season 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 included in Table 2.

2.1.2 Search Frequency and Timing

The spring season began on March 4, 2019 and continued through June 1, 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 spring surveys was every 7 days. There were three days in the spring season during which the surveyor was unable to survey a portion of the SCF: on March 6 the Alpha East SCF was too wet to allow driving through the area, on April 9 a portion of Beta East was not surveyed due to high winds, and on May 21, a portion of Beta East was not surveyed again due to high winds.

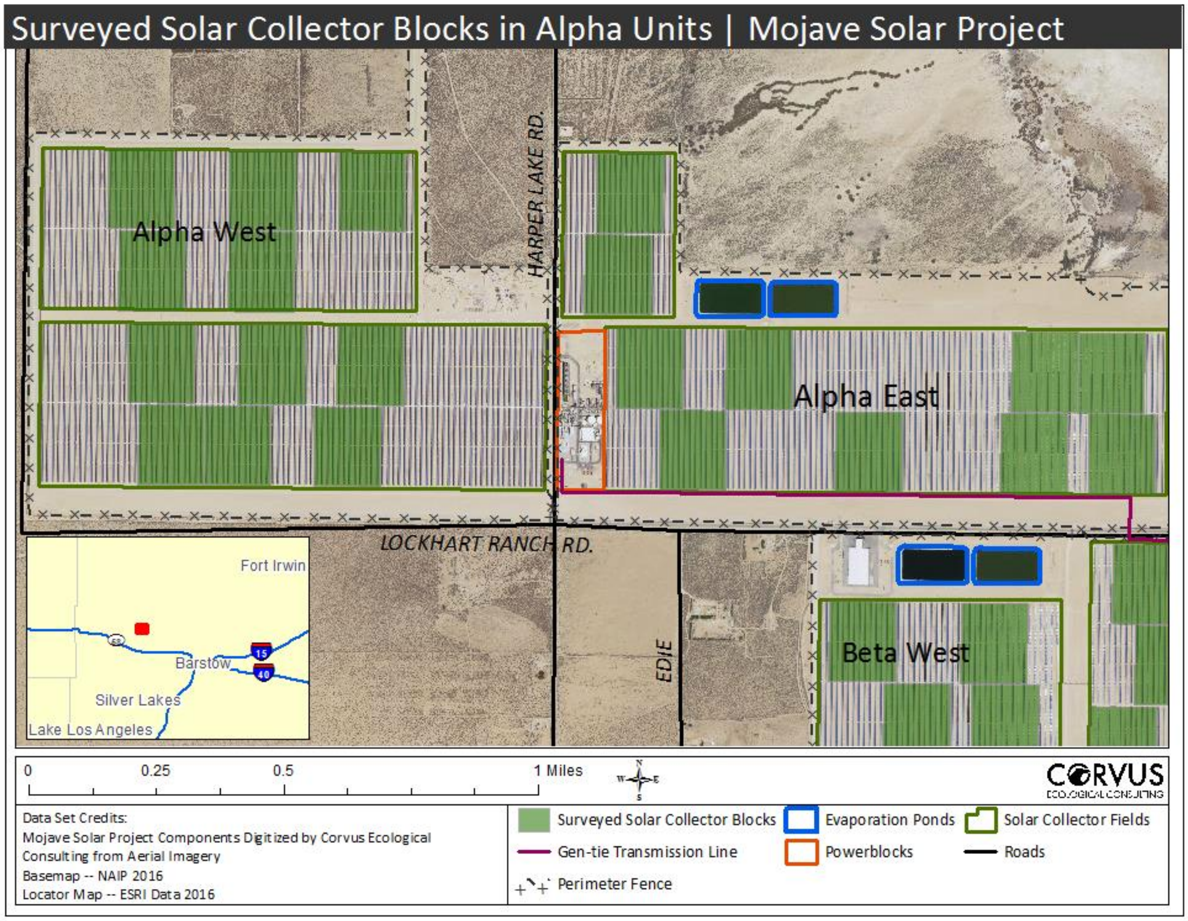

Figure 3. Solar collector blocks in Alpha units surveyed using systematic searches.

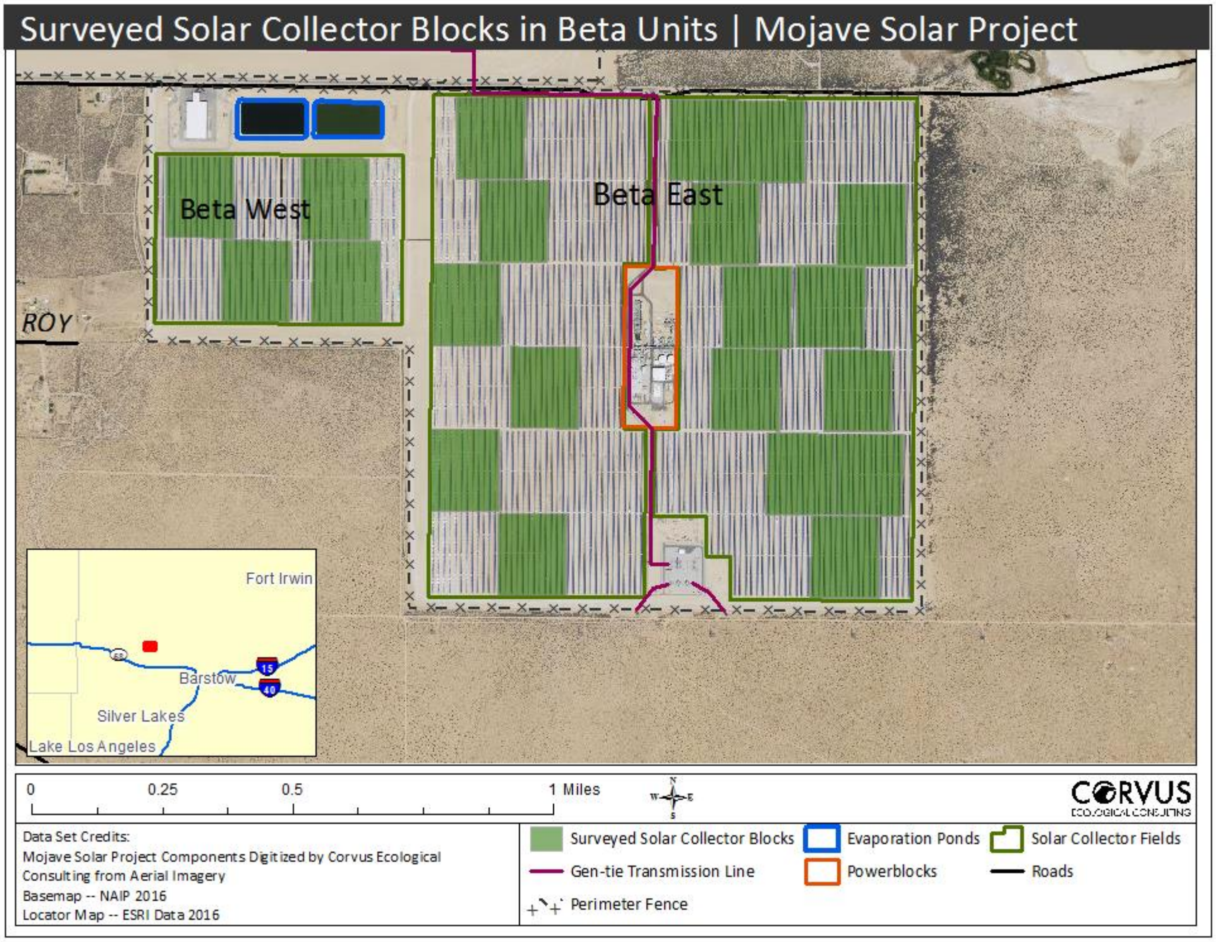

Figure 4. Solar collector blocks in Beta units surveyed using systematic searches.

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 heat-transfer-fluid 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.

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)

Prior to cooling tower netting, washout ponds were checked every day and the mortalities attributed to the cooling tower are not included in the fatality estimator. Once the cooling towers were netted, checking the washout ponds occurred a minimum of every other day.

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

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

2.2 Carcass Persistence Trials

A total of 6 carcass persistence trials were completed during the spring 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 GenEst program 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 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. One of these carcasses was removed before the searcher had a chance to detect it resulting in a sample of fifty-seven (57) 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*

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*.

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

Uncertainty in the estimator is calculated using simulated sampling distributions and subsequent back transformations of *p* and k (if used; Dalthorp et al 2018b).

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, *p* is the proportion of those persisting carcasses that the searcher will detect. In simple terms, the number of carcasses detected is equal to the actual number of fatalities times the detection probability.

The true values for carcass persistence (*r*) and proportion detected (*p*) are unknown and must be estimated from data collected during field trials and knowledge about the study area. Additionally, the relationship between the parameters of this model are all non-linear, and 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 (Huso 2011; Korner-Nievergelt et al. 2015; Wolpert 2015). For our analysis, we have chosen the USGS-developed GenEst Software Package (Dalthrop et al. 2018).

The Fatality Estimator takes data from four main sources, which each correspond to a parameter in the model: 1) the observed carcasses of wild birds (*C*), 2) Carcass Persistence (*r*), 3) searcher efficiency (estimated from field trials, and 4) the density weighted proportion (DWP) which is the relative proportion of the fatalities that occur within the area searched. It is this last parameter (DWP) that differentiates the GenEst model from other popular methods. For a more complete description of the methods and equations used in the GenEst software package see Dalthorp et al. 2018a.

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 systematic search areas were pooled with those found during searches because it was assumed that these would be found during the next scheduled search. Incidental detections made outside of the BIO-17 survey area were not included in fatality estimates. As stated above, cooling tower fatalities were also not included in fatality estimates.

3.0 Monitoring Results

3.1 Avian Fatality or Injury Detections

During spring 2019 survey efforts, sixteen (16) detections of ten (10) identified species were recorded; including injured birds, incidental detections, and fatalities detected during systematic surveys (Table 3). The highest number of detections for any one species was four (4) House Sparrows (*Passer domesticus*). The stratum with the highest number of fatalities or injuries was the perimeter fence with five [(5) 31% of total; Figures 4 and 5 and Tables 3, 4, and 5]. Ten [(10) 62.5% of total] detections were made during systematic searches and six [(6) 37.5% of total] were the result of incidental detections.

All sixteen (16) 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 spring (March 4 – June 1) 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**	**TOTAL**
COMMON LOON	*Gavia immer*	diurnal				1			**1**
CLARK'S GREBE	*Aechmophorus clarkii*	nocturnal				1			**1**
AMERICAN COOT	*Fulica americana*	nocturnal	1				1		**2**
CALIFORNIA GULL	*Larus californicus*	Mostly diurnal	1						**1**
UNIDENTIFIED SWALLOW	Hirundinidae sp.	diurnal			1				**1**
TOWNSEND'S WARBLER	*Setophaga townsendi*	likely nocturnal						1	**1**
BELL'S SPARROW	*Artemisiospiza belli*	resident					1		**1**
BLACK-HEADED GROSBEAK	*Pheucticus melanocephalus*	unknown; at least partially diurnal	1						**1**
YELLOW-HEADED BLACKBIRD	*Xanthocephalus xanthocephalus*	diurnal					1		**1**
HOUSE SPARROW	*Passer domesticus*	resident		4					**4**
UNIDENTIFIED BIRD							2		**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	TOTAL
TOTALS			**3**	**4**	**1**	**2**	**5**	**1**	**16**

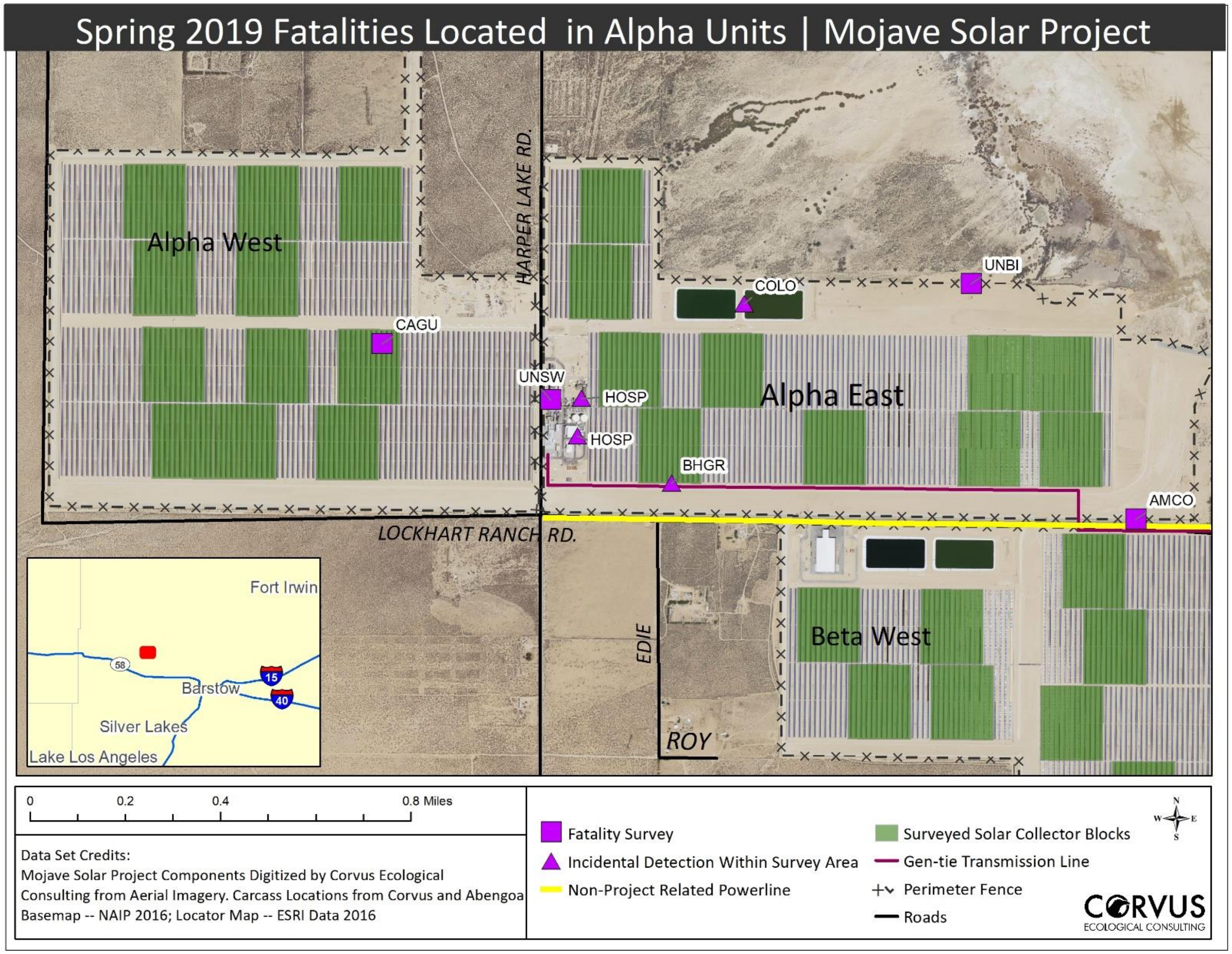

Figure 5. Locations of carcasses and injured birds found in spring 2019 on the Alpha Unit Components of the Mojave Solar Project.

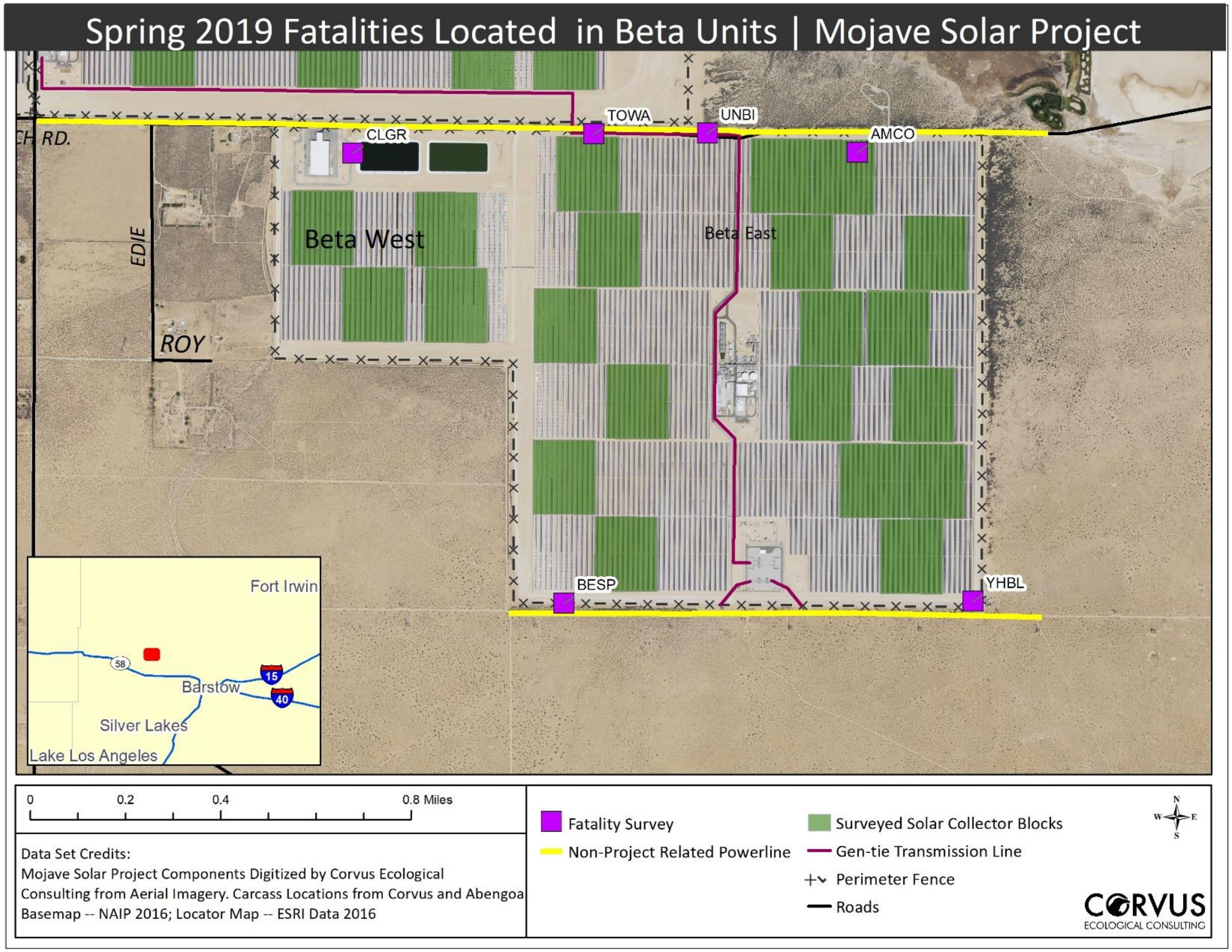

Figure 6. Locations of carcasses and injured birds found in spring 2019 on the Beta Unit Components of the Mojave Solar Project

3.1.1 Temporal Patterns of Avian Detections

The highest number of detections on a single day was three (3), which occurred on May 8, 2019 (Figure 7). There were three full months in this season. The month with the highest number of detections was May with eleven (11). The month with the second highest number of detections was April with three (3) followed by March with only two (2). These numbers include totals from systematic searches and incidental detections.

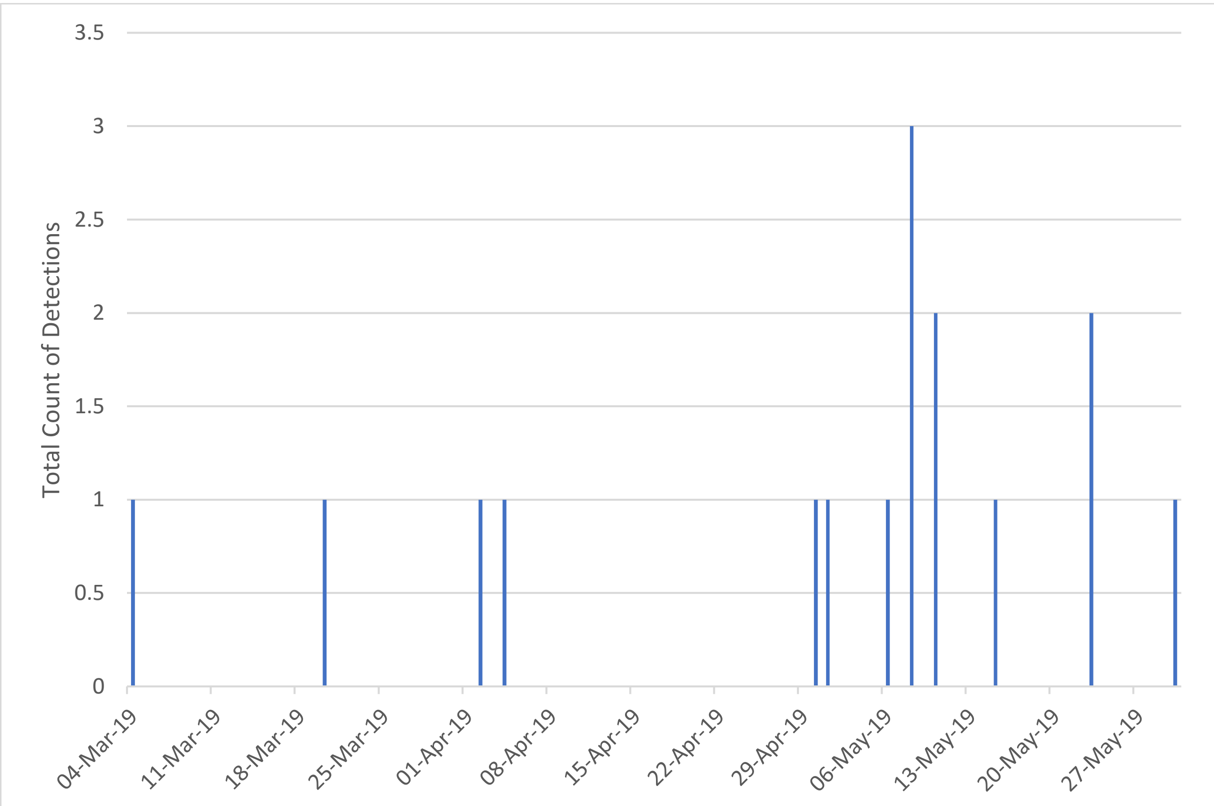

Figure 7. Total number of detections by date during spring (March 4 – June 1) 2019 at Mojave Solar Project, San Bernardino County, CA.

3.1.2 Spatial Distribution of Avian Detections

During the spring season 2019, 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. The breakdown by unit is as follows: 1 in Alpha West, 8 in Alpha East, 1 in Beta West, and 6 in Beta East.

Table 4. Total detections by strata and detection category during spring (March 4 – June 1) 2019 at Mojave Solar Project, San Bernardino County, CA.

PROJECT COMPONENT	SYSTEMATIC SEARCH	INCIDENTAL	% OF TOTAL
PERIMETER FENCE	**5**	**0**	**31.3**
OVERHEAD LINE (GEN-TIE)	**1**	**0**	**6.2**
EVAPORATION PONDS	**1**	**1**	**12.5**
POWER BLOCK	**1**	**4**	**31.3**
COOLING TOWER	*1*		
OTHER		*4*	
SCF	**2**	**1**	**18.7**
ROADS OUTSIDE PERIMETER FENCE	0	**0**	**0**
PERCENT OF TOTAL	**62.5**	**37.5**	**100**

Table 5. Total detections (all types) by Project component and suspected cause of death during spring (March 4 – June 1) 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	1				4		31.25
OVERHEAD LINE	1				1		12.5
EVAPORATION PONDS						1	6.25
COOLING TOWER		1					6.25
SOLAR COLLECTOR					2	1	18.75
OTHER POWER BLOCK BUILDING				4			25
ROAD							
% OF TOTAL	12.5	6.25	0	25	43.75	12.5	16

*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 and Cause of Death

All 16 detections in spring 2019 were of dead birds. Of those, three [(3) 18.7%] were freshly deceased; five [(5) 31.2%] were semi-fresh with some signs of rigor mortis; one [(1) 6.3%] was mummified and seven [(7) 43.7%] were scavenged or feather spots such that time since death was difficult to assess.

Two carcasses (2) were attributed to predation. While predation is almost never directly observed, biologists 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), a concentration of feathers beneath a potential perch site, 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. At the request of USFWS (Thomas Dietsch August 4, 2020 via Ann Crisp email communication), we have changed the cause of death for these two carcasses to “Unknown – Evidence of Scavenging or Predation”.

3.1.4 Injured or Stranded Birds

All birds located in spring 2019 were deceased.

3.2 Bat Detections

There were no bats detected during the spring 2019.

3.3 Carcass Persistence Trials

For carcass persistence trials, we analyzed the spring 2019 data alone. We ran models testing for importance of size class. Size class included three levels: small, medium and large carcasses. Size class was identified as a covariate for the *l* or location parameter in the best fit models, but not in the s or scale parameter. We selected the lognormal model for use in further estimation.

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

Distribution	Location Formula	Scale Formula	AICc	ΔAICc
lognormal	l~size class	s ~constant	283.29	0
loglogistic	l~size class	s ~constant	283.51	0.22

Table 7. Estimates of carcass persistence. The effective search interval was found to be seven days, and this was used to calculate r7 which is the probability that a carcass that arrives within the interval would persist until the end of the interval

SIZE CLASS	TRIALS PLACED	MEDIAN CARCASS PERSISTENCE (DAYS)	***r* 7**
LARGE	10	43.16	0.86
MEDIUM	20	1.22	0.38
SMALL	30	0.09	0.10

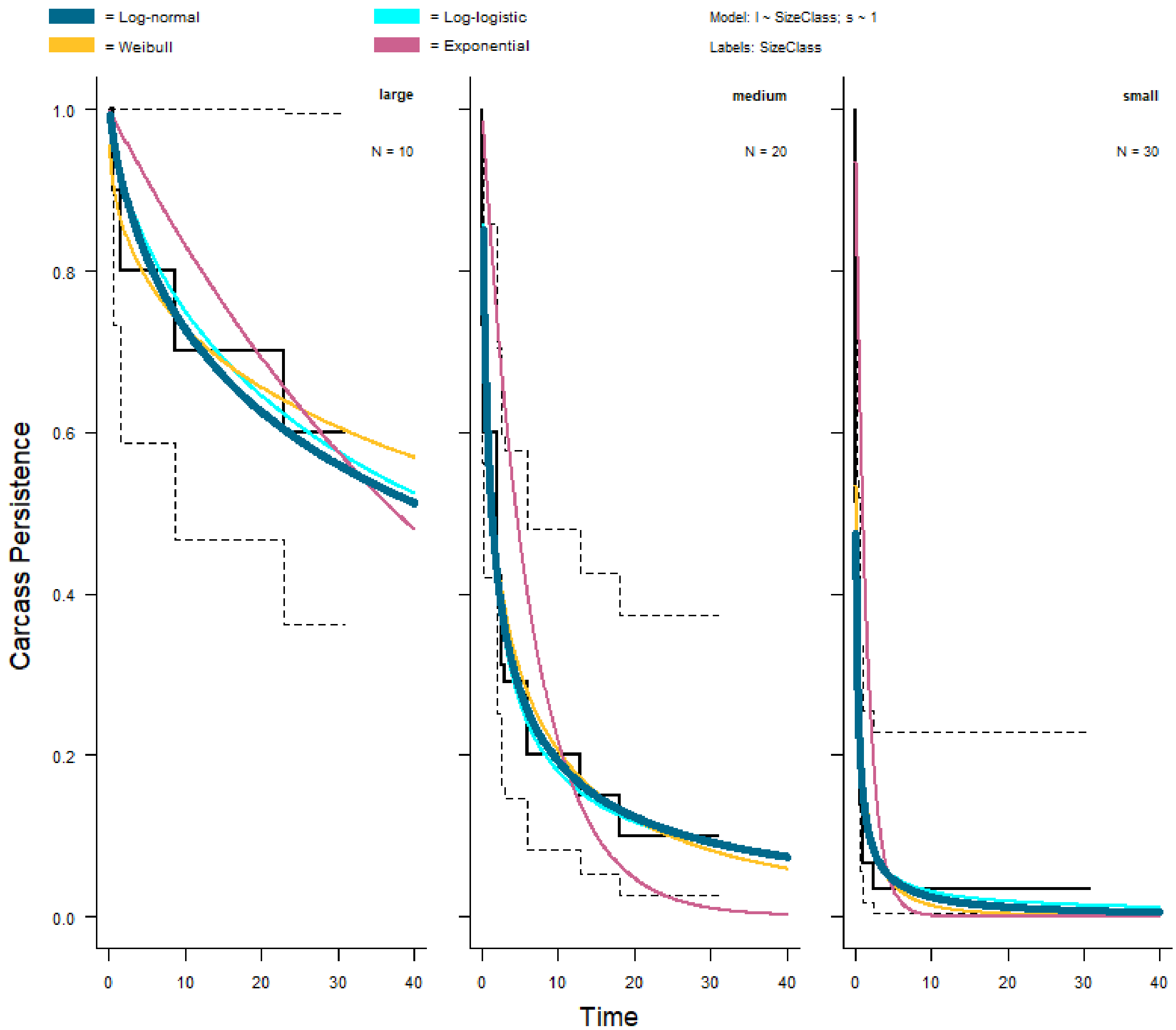

Figure 8. Carcass persistence graphs for three size classes. Black lines denote Kaplan-Meier plots of observed data and empirical confidence limits

3.4 Searcher Efficiency Trials

We looked at searcher efficiency data for the spring season and tested models using size class as a covariate. The only model to fit the data was with a constant *p* and a k fixed at 0. The overall median searcher efficiency was 0.93 with a confidence interval of 0.85 to 0.969.

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 8 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 during spring 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	2	1	0	0	0	1	2	1	1	1	1	0	1	0
GEN-TIE	1	2	0	0	0	0	1	2	0	1	2	0	0	0	0
PERIMETER FENCE	8	6	1	1	0	0	7	6	1	7	6	1	0	0	0
POWER BLOCKS	3	1	0	0	0	0	3	1	0	3	0	0	0	1	0
SCF	17	6	9	0	0	0	17	6	9	15	6	9	2	0	0
SIZE CLASS TOTAL	30	17	11	1	0	0	29	17	11	27	15	11	2	2	0
PROJECT TOTAL			58			1			57			53			4

3.5 Fatality Estimates

During the spring season of 2019, the average search interval was 7 days and the season spanned 91 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 127 bird mortalities (90% CI: 62 - 268) occurred at the Mojave Solar Project (Table 10). This estimate was based on 15 observed fatalities, which excluded the 1 fatality from the cooling tower. In spring 2019 we had 2 fatalities thought to be caused by predation, but as the overall numbers were low for this season, we have included them in the estimator. For the final report, it should be noted that these fatalities may receive alternate treatment.

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 10).

Table 9. Average probability of detecting a carcass by carcass size.

SIZE CLASS	AVG PROBABILITY OF DETECTING A CARCASS	90% CONFIDENCE INTERVAL
LARGE	0.791	0.63 – 0.894
MEDIUM	0.354	0.233 – 0.481
SMALL	0.09	0.044 – 0.16

From this table, we see that using our carcass persistence and searcher efficiency data, we estimate that the probability of detecting a small carcass anywhere on the facility is estimated to be less than 10%.

Table 10. Fatality estimates for spring 2019 (not including cooling tower fatalities).

		FATALITIES FOUND	ESTIMATED FATALITIES	LCL (90%)	UCL (90%)
SPRING 2019					
OVERALL		**15**	**127**	**62**	**268**
	STRATA				
Large	Evap Pond	2	3	2	4
	Gen-tie	0	0	0	0
	Perimeter Fence	0	0	0	0
	Power Block	0	0	0	0
	SCF	0	3	1	8
Medium	Evap Pond	0	0	0	0
	Gen-tie	0	0	0	0
	Perimeter Fence	2	6	2	14
	Power Block	0	0	0	0
	SCF	1	6	1	19
Small	Evap Pond	0	0	0	0
	Gen-tie	1	11	1	43
	Perimeter Fence	3	31	8	81
	Power Block	4	44	12	115
	SCF	1	17	1	67

This season, due to the netting on the cooling towers, we had only 1 fatality attributed to that component and that fatality was detected after a hole was discovered in the netting. We can add that back in to either estimate (with or without the suspected predated carcasses) to provide an overall estimate of 63-269 fatalities for the spring 2019 season.

4.0 Discussion

The spring 2019 season was the seventh 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

Bias estimator field methods from spring 2018 and spring 2019 were similar; however, statistical analysis from the two years has changed slightly with 2018 analyses performed using the Carcass package in R while in 2019 we have used the more current GenEst package. Even with this minor change, we can compare the results from the two years.

Table 11. Comparison of carcass persistence rates from 2018 and 2019 on Mojave Solar

SIZE CLASS	TRIALS PLACED		MEDIAN CARCASS PERSISTENCE (DAYS)		*r* 7	
	2018	2019	2018	2019	2018	2019
LARGE	10	10	5.89	43.16	0.69	0.86
MEDIUM	20	20	0.19	1.22	0.11	0.38
SMALL	30	30	0.72	0.09	0.19	0.10

In all but the small size category, the carcass persistence increased in spring 2019 over 2018.

Searcher efficiency shows a similar trend with overall efficiency increasing in 2019 over 2018. This may be expected due to an increase in experience. There have only been two surveyors in the two years of this project and the same one has been in place since spring of 2018.

Table 12. Comparison of searcher efficiency rates from 2018 and 2019 on Mojave Solar

YEAR	NUMBER CARCASSES AVAILABLE TO BE FOUND	NUMBER ACTUALLY FOUND	ESTIMATED SEARCHER EFFICIENCY	LOWER LIMIT OF 90% CI	UPPER LIMIT OF 90% CI
2018	65	51	0.78	0.68	0.88
2019	57	53	0.93	0.85	0.97

4.2 Distribution of Fatalities and Fatality Estimates

The methods for the systematic surveys have not been altered much between spring 2018 and spring 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.

Location of fatality detections should not be used to ascertain cause of death or project relationship without looking at other spatial and carcass disposition factors. Because of high scavenger rates within the project area, carcasses may have been moved from their original point of mortality to the point of detection. In spring 2018, twenty-four (24) detections of injured or deceased birds were made by surveyors. Of those 24 detections, twelve (12) were from the cooling towers, three (3) from the power block, one (1) from the evaporation ponds, one (1) from the Gen-tie, five (5) from the perimeter fence, and two (2) from the SCF. In spring 2019, a total of sixteen (16) detections were made all within the facility. Of those 16, one (1) was within the cooling towers, four (4) were in the power block, two (2) were in the evaporation ponds, one (1) in the Gen-tie, five (5) from the perimeter fence, and three (3) from the SCF (Figure 9).

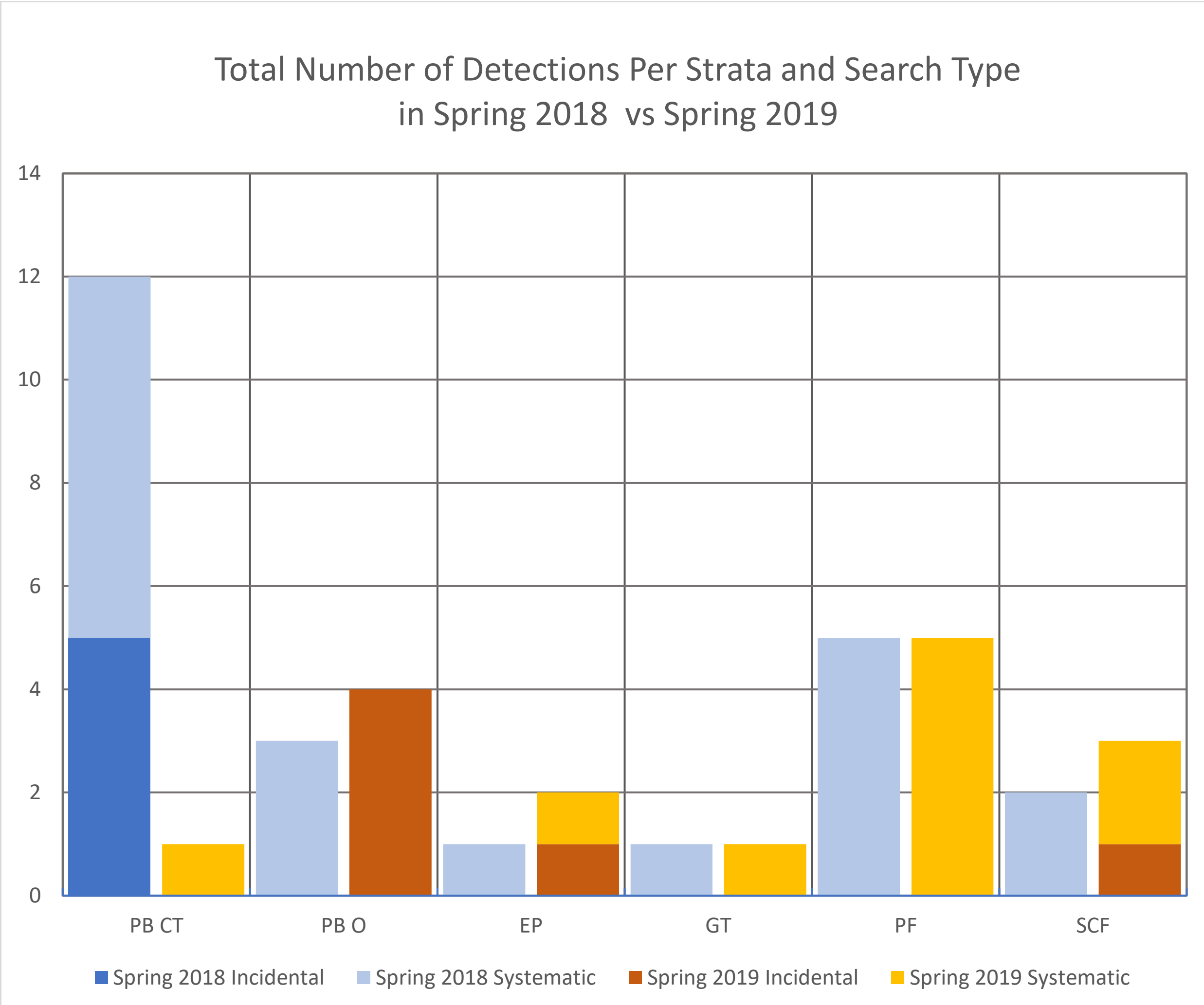

Figure 9. Comparison of spring 2018 and spring 2019 detections by strata and search type. PB CT = Power block cooling tower, PB O = Power block Other, EP = Evaporation Pond, GT = Gen-tie, PF = Perimeter Fence, SCF = Solar Collector Field.

These are just comparisons of raw data. We can also compare estimated fatalities by strata with the understanding that the statistical methods used to derive these estimates were slightly different in 2018 to 2019 (Figure 10).

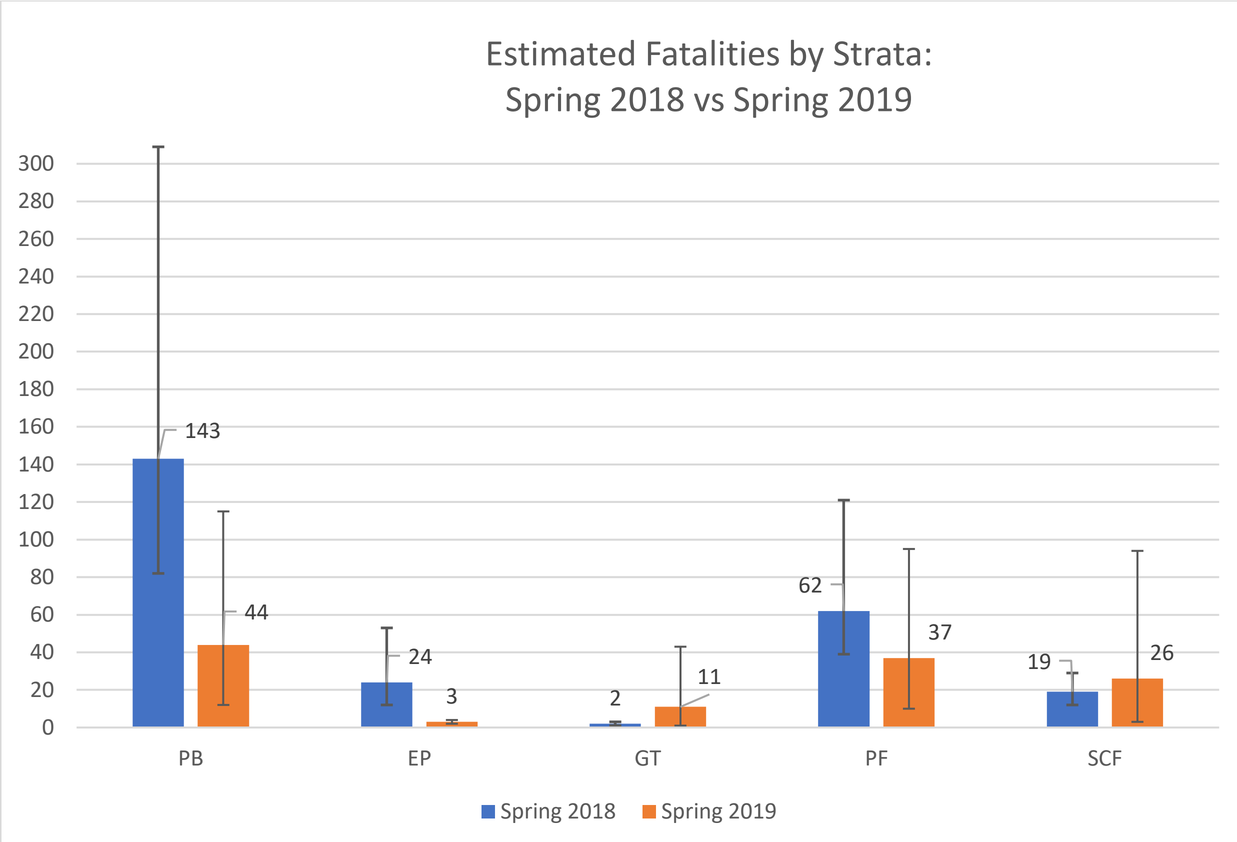

Figure 10. Comparison of spring 2018 and spring 2019 fatality estimates by strata. PB = Power block, EP = Evaporation Pond, GT = Gen-tie, PF = Perimeter Fence, SCF = Solar Collector Field. Black bars represent 90% confidence intervals.

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