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AVIAN MORTALITY AT A SOLAR ENERGY POWER PLANT

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In 1979, the United States Department of Energy, in conjunction with the Southern California Edison Company (SCE) and the Los Angeles Department of Water and Power, initiated the construction of Solar One, the world's largest solar energy power plant (Fig. 1). Until the construction of Solar One, the use of the sun's energy to produce electrical power had not been attempted on this scale, and the environmental hazards of operation of a solar power plant were unknown. In this paper we report on bird mortality at Solar One.

STUDY AREA AND METHODS

Solar One is a 10 megawatt, central receiver solar power plant consisting of a 32-ha field of 1818, 6.9 × 6.9 m mirrors (heliostats) which concentrate sunlight on a centrally located, tower-mounted boiler, 86 m in height (Fig. 1). The reflective surface area of each heliostat is approximately 40 m^2, and the total for all heliostats is approximately 72,500 m^2. When not directed at the tower during morning startup, testing, and maintenance, some or all of the heliostats are focused on standby points, four small areas (approximate diameter = 5 m) of sky around the tower at a height of 80 m. Temperatures within the standby points vary with the number of heliostats focused on them and the reflectivity of an object placed within them, but the temperature can be high enough to burn feathers and small insects.

Solar One is located in the Mojave Desert, 4 km east of Daggett, San Bernardino County, California (34°52′N, 116°51′W). The dominant desert plant community in this area is creosote bush (*Larrea divaricata*) scrub, although abandoned and active agricultural fields (alfalfa) and extensive (53 ha) evaporation ponds (Fig. 1) are adjacent to Solar One.

We visited Solar One approximately once per week (2–3 days per visit) on 6 occasions from 3 May through 8 June 1982 and on 34 occasions from 16 September 1982 through May 1983. During each visit 1–2 observers searched the facility for any evidence of bird mortality. Although searches were not conducted in a fixed pattern, the entire facility was covered during each visit. Bird carcasses were readily found because of the sparse vegetation and level ground of Solar One. Experiments involving the placement of 19 bird carcasses of various species within and just outside (<200 m) the fenced facility were conducted in May and September 1982 to measure the rate of bird carcass removal by scavengers. These carcasses were checked periodically until removed by scavengers or decomposed.

FIGURE 1. Aerial view of Solar One: (A) heliostat field, (B) central receiver tower, (C) evaporation ponds. Tower height = 86 m, diameter of field = 765 m.

To determine the impact of bird mortality on local populations, 1–2 observers conducted surveys of relative avian abundance within an area of approximately 150 ha surrounding Solar One, concentrating on the facility grounds (32 ha), evaporation ponds, and agricultural fields. These surveys were conducted on at least 2 d per visit for 3–4 h/d.

RESULTS

Solar One related animal mortality.—During approximately 40 wks of study, we documented 70 bird fatalities involving 26 species at Solar One (Table 1). The mean rate of mortality between visits was 1.7 birds ± 1.8 SD (n = 40, range 0–7). Results of the scavenger bias experiments indicate that from 10–30% of carcasses were removed between searches, thus, the actual rate of mortality may have been from 1.9–2.2 birds. Two causes of avian mortality were identified at Solar One, colliding with structures and burning from standby points.

The most frequent form of avian mortality was from collisions with Solar One structures. We documented 57 (81%) bird deaths (20 species) from collisions (Table 1). In most cases the cause of death was determined by the presence of broken bones (usually mandibles or wings) found through external examination. From the location of birds in relation to structures, most (>75%) died from colliding with the mirrored heliostats, although a dead Blue-winged Teal (*Anas discors*) with a broken wing was found on a platform of the receiver tower. On one occasion

TABLE 1. Avian mortality from burning and collisions at Solar One, 1982–1983.

Burn fatalities		Collision fatalities	
Species	Number of individuals	Species	Number of individuals
Vaux's Swift (*Chaetura vauxi*)	1	Eared Grebe (*Podiceps nigricollis*)	11
White-throated Swift (*Aeronautes saxatalis*)	2	Blue-winged Teal (*Anas discors*)	1
Hummingbird sp.	3	American Kestrel (*Falco sparverius*)	1
Cliff Swallow (*Hirundo pyrrhonota*)	2	American Coot (*Fulica americana*)	2
Barn Swallow (*Hirundo rustica*)	1	Black-necked Stilt (*Himantopus mexicanus*)	2
Barn Swallow (*Hirundo rustica*)	1	Sandpiper sp.	1
Yellow-rumped Warbler (*Dendroica coronata*)	1	Red-necked Phalarope (*Phalaropus lobatus*)	1
Wilson's Warbler (*Wilsonia pusilla*)	1	Bonaparte's Gull (*Larus philadelphia*)	1
Sparrow sp.	1	Mourning Dove (*Zenaida macroura*)	6
		Hummingbird sp.	1
		Horned Lark (*Eremophila alpestris*)	3
		European Starling (*Sturnus vulgaris*)	4
		Yellow-rumped Warbler (*Dendroica coronata*)	1
		MacGillivray's Warbler (*Oporornis tolmiei*)	1
		Savannah Sparrow (*Passerculus sandwichensis*)	3
		White-crowned Sparrow (*Zonotrichia leucophrys*)	2
		Dark-eyed Junco (*Junco hyemalis*)	1
		Red-winged Blackbird (*Agelaius phoeniceus*)	3
		Western Meadowlark (*Sturnella neglecta*)	1
		Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)	2
		Brewer's Blackbird (*Euphagas cyanocephalus*)	5
		House Finch (*Carpodacus mexicanus*)	4
Total	13	Total	57

in May 1982 a Solar One employee observed 4 Mourning Doves (*Zenaida macroura*) die in a collision with a single heliostat.

Thirteen (19%) birds (7 species) died from burning in the standby points (Table 1). Although we never observed a bird fly through one of

the standby points, the heavily singed flight and contour feathers indicated that the birds burned to death (Fig. 2). Six (46%) of these fatalities involved aerial foragers (swifts and swallows) which are apparently more susceptible to this form of mortality because of their feeding behavior. Three of these aerial foragers died during a 2-wk period in May 1982, corresponding with the presence of the highest numbers of swifts and swallows observed (>500 per d), and an extensive period of heliostat testing when the occurrence and intensity of standby points was probably greater than at other times.

Relative avian abundance.—During 102 d from May–June 1982 (18 d) and September 1982–May 1983 (84 d), we recorded 107 bird species (daily mean = 16.7 ± 6.1 SD, n = 102) in the immediate area (150 ha) of Solar One. The mean daily count for individuals was 314 ± 203 SD (range 148–1040). Most avian species recorded at Solar One were migrants and only 15 species are year-round residents, with Horned Larks (*Eremophila alpestris*), European Starlings (*Sturnus vulgaris*), and House Finches (*Carpodacus mexicanus*) the most common breeding birds.

Of the habitats surveyed in this study, the evaporation ponds were the most heavily used by birds. Seventy percent of all species were recorded at least once at the ponds, and 45% were recorded only at the ponds; the majority of daily counts recorded mostly waterbirds.

DISCUSSION

Creosote bush scrub, which characterizes much of the undisturbed portions of the Mojave Desert near Solar One, is usually only sparsely inhabited by birds. The avian community of similar habitat in Arizona is usually less than 20 species (Tomoff, Ecology 55:396–403, 1974). However, we recorded 107 species in the vicinity of Solar One, 15 of which breed in the area. The special attraction of Solar One to birds is most likely related to the presence of a large, man-made water impoundment and irrigated agricultural fields, both of which produce an abundance of insects. Naturally occurring open water sources in the Mojave Desert are rare and usually ephemeral, while the man-made ponds near Solar One are permanent.

The most frequent form of avian mortality at Solar One during this study was from collisions with structures, primarily heliostats. Avian collisions are an inevitable by-product of almost all man-made structures (see Avery et al., FWS/OBS-80/54, 1980). Reflective surfaces are especially prone to collisions (Klem, Ph.D. thesis, Southern Illinois Univ., Carbondale, 1979), and it is not surprising that collisions with mirrored heliostats occur on a somewhat regular basis considering the reflective surface area of Solar One.

A form of avian mortality unique to solar central receiver power plants is burning in standby points. Death after being burned was infrequent in occurrence at Solar One, being in part a function of the frequent absence and variable intensity of standby points and the number of aerial foragers (swifts and swallows) in the airspace over Solar One.

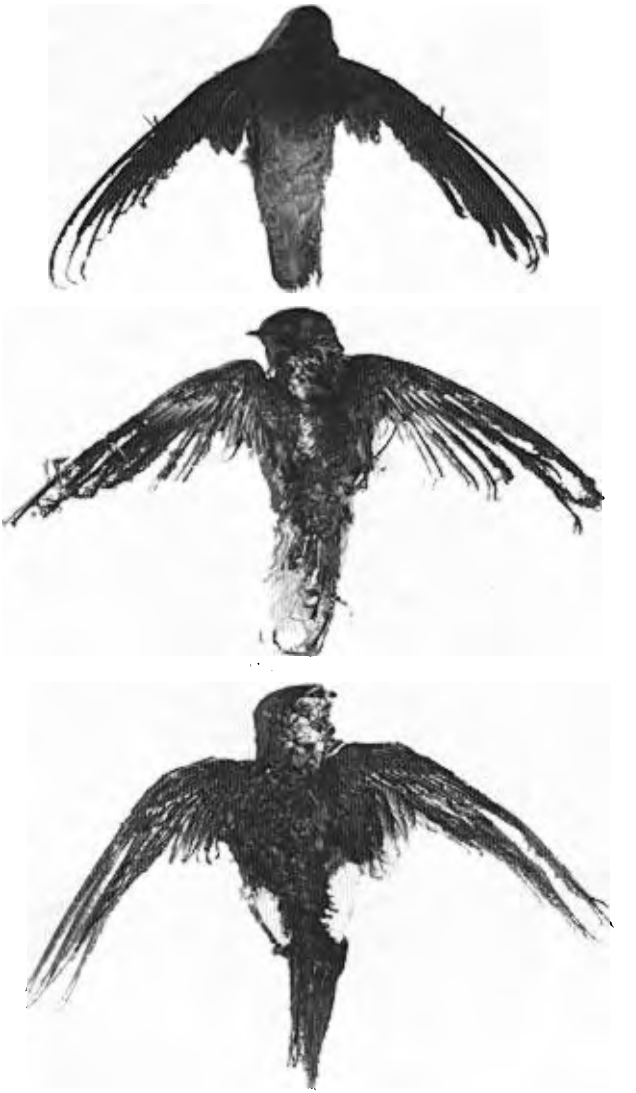

FIGURE 2. Three birds burned in standby points at Solar One. Top to bottom: Vaux's Swift (*Chaetura vauxi*), Barn Swallow (*Hirundo rustica*), and White-throated Swift (*Aeronautes saxatalis*). Note the heavily singed rectrices and remiges especially in the Barn Swallow.

Considering all known avian fatalities (70 birds) at Solar One during this study the impact of the facility on birds after construction appears minimal. Comparing the estimated rate of mortality (1.9–2.2 birds per wk) and mean relative avian abundance (314 birds per count) recorded in the vicinity of Solar One, only 0.6–0.7% of the local population present at any given time may have been affected during this study. The effect on the total population using the region in a year is obviously much less, but is unestimatable.

The results of this study suggest that, to reduce their impact on birds, future solar central receiver power plants in the Mojave Desert and other areas should not be sited in close proximity to open water or agricultural fields. The variety of species involved in avian mortality at Solar One indicates that caution should be taken when siting a solar power plant near populations of rare, threatened, or endangered species. If possible, the occurrence and intensity of standby points should be kept to a minimum. Since Solar One is only a 10 megawatt pilot facility, future projects designed to produce hundreds of megawatts will require several thousand heliostats and much taller receiver towers. The greater magnitude of these facilities may produce non-linear increases in the rate of avian mortality when compared to Solar One and extrapolations from this study should be made with caution. The removal of large tracts of desert from biological production for solar power generation and the ecological effects caused thereby should also be of concern.

SUMMARY

We studied avian mortality at an operating solar central receiver power plant in the Mojave Desert of southern California. During 40 wks of study we documented the deaths of 70 birds (26 species). The estimated mortality rate was 1.9–2.2 birds per week. Fifty-seven (81%) birds of 20 species died from collisions with Solar One structures, mainly the mirrored surfaces of heliostats. Thirteen (19%) birds (7 species) died from burns received by flying through standby points. The impact of this mortality on the local bird population is considered minimal (0.6–0.7% per wk).

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