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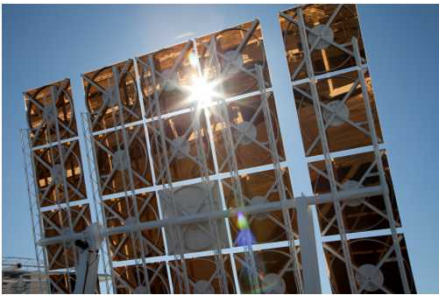

Review of Avian Mortality Studies at Concentrating Solar Power Plants

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U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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Overview

- Background and Objectives
- Avian Mortality at CSP Facilities
- Mitigation Measures
- Conclusions

Background

- Recent reports of birds being burned and killed by solar flux at CSP plants have drawn a significant amount of attention and negative publicity
  - US Fish & Wildlife released a report suggesting that birds were being killed by concentrated sunlight at a rate of one bird every two minutes
  - These reports were based on anecdotal observations of “streamers”

MacGillivray Warbler with “Grade 3” solar flux injury found at Ivanpah CSP Plant (Kagan et al., 2014)

Objectives

- Review previous avian mortality studies at CSP facilities and determine cause of “streamers”
- Assess hazardous solar flux levels
- Evaluate avian mortality from various energy sources
- Identify mitigation measures and deterrents

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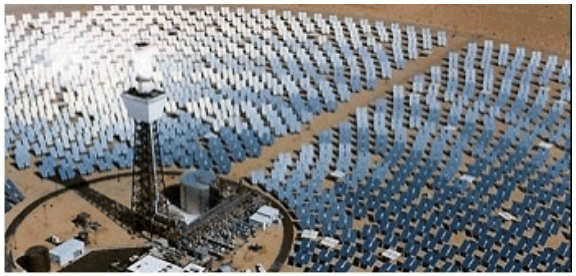
Solar One (Daggett, California)

- 10 MW_e direct-steam pilot demonstration project
- 40 weeks of study from 1982 to 1983 (McCrary et al. 1984, 1986)
  - 70 documented bird deaths
    - 81% from collisions (mainly heliostats)
    - 19% from burns
  - Impact on local bird population was considered minimal (0.6 – 0.7% per week)
  - Nearly all observed incinerations ("small flashes of light within the standby points, accompanied by a brief trail of white vapor") involved aerial insects rather than birds



Barn Swallow

White-Throated Swift

Solar Energy Development Center
(Negev Desert, Southern Israel)

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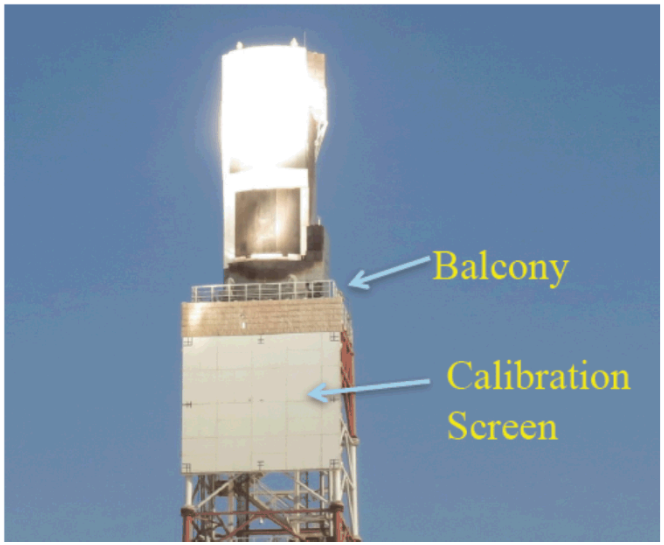
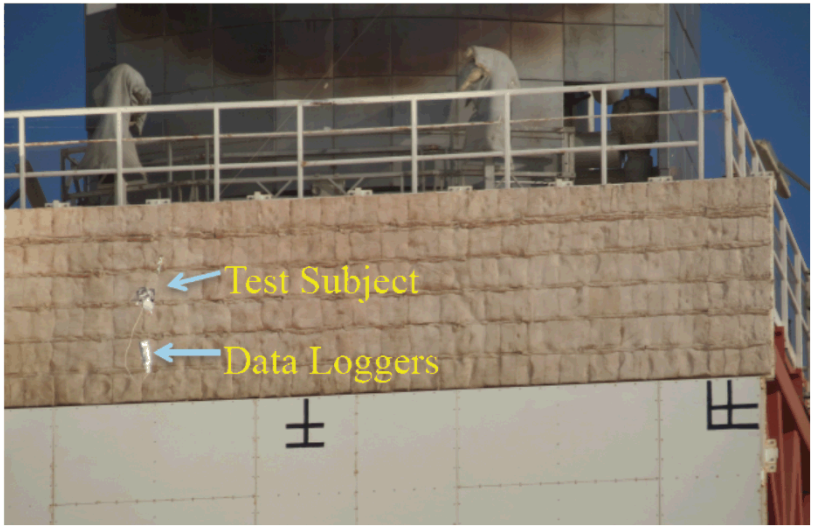
- Solar demonstration facility with a 6 MW_{th} heliostat field and power tower
- No bird singeing was reported in four years of operation while following U.S. Fish & Wildlife Service protocols of four surveys per week over 20 m transects

Solar Energy Development Center
(Negev Desert, Southern Israel)

- Tests conducted with bird carcasses exposed to different flux levels (Santolo, 2012)
  - "no observable effects on feathers or tissue were found in test birds where solar flux was below 50 kW/m^2 with exposure times of up to 30 seconds."
  - California Energy Commission analytical study found that "a threshold of safe exposure does not exist above a solar flux density of 4 kW/m^2 for a one-minute exposure"





Ivanpah Solar Electric Generating System

(Ivanpah, California)

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- 390 MW_e direct steam power-tower plant (3 towers)
- Kagan et al. (2014) found 141 bird fatalities Oct 21 – 24, 2013
  - 33% caused by solar flux
  - 67% caused by collisions or predation
- H.T. Harvey and Associates found 703 bird fatalities in first year at ISEGS
  - Study estimated 3500 bird fatalities when accounting for scavengers removing carcasses
- ISEGS has since implemented new heliostat aiming strategies and bird deterrents

	Number of Detections				
Cause	Winter	Spring	Summer	Fall	Total
Singed	27	100	42	147	316
Collision	14	15	10	45	84
Other*	5	5	2	3	15
Unknown	51	82	61	94	288
Total	**97**	**202**	**115**	**289**	**703**

* Includes detections in ACC buildings without evidence of singeing or collision effects.

H.T. Harvey and Associates, 2013 - 2014

Crescent Dunes
(Tonopah, Nevada)

- 110 MW_e molten-salt power tower
- In January 2015, 3,000 heliostats were aimed at standby points above receiver
  - 115 bird deaths in 4 hours
  - SolarReserve spread the aim points to reduce peak flux to < 4 kW/m^2
    - Reported zero bird fatalities in months following change

Figure 1 – The halo created by the reflected light of 3,000 heliostats which caused the bird mortalities.

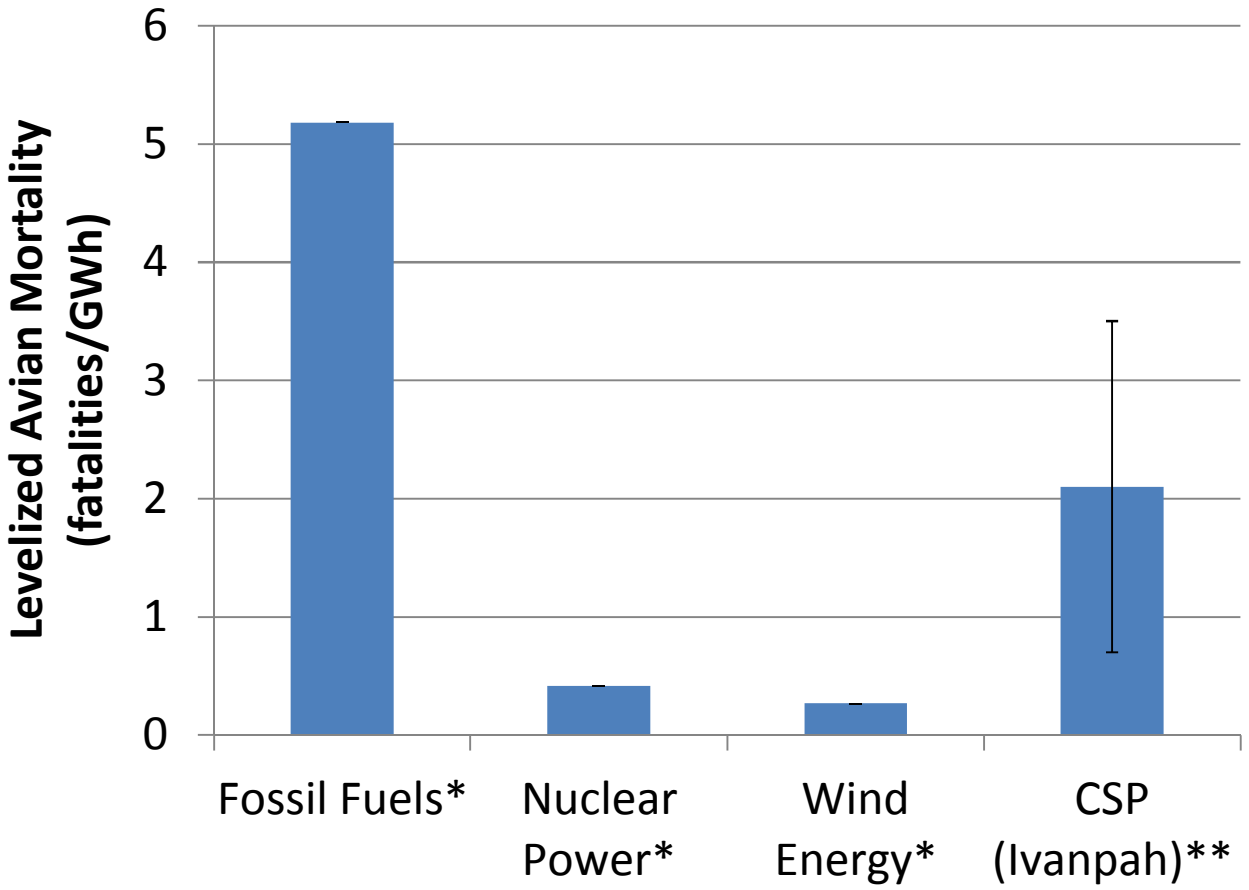
Images from http://cleantechnica.com

Gemasolar Thermosolar Plant

(Andalusia, Spain)

- 20 MW_e molten-salt power tower plant
- 14-month study revealed no avian fatalities in vicinity of tower (Dept. of Zoology, U. Granada)

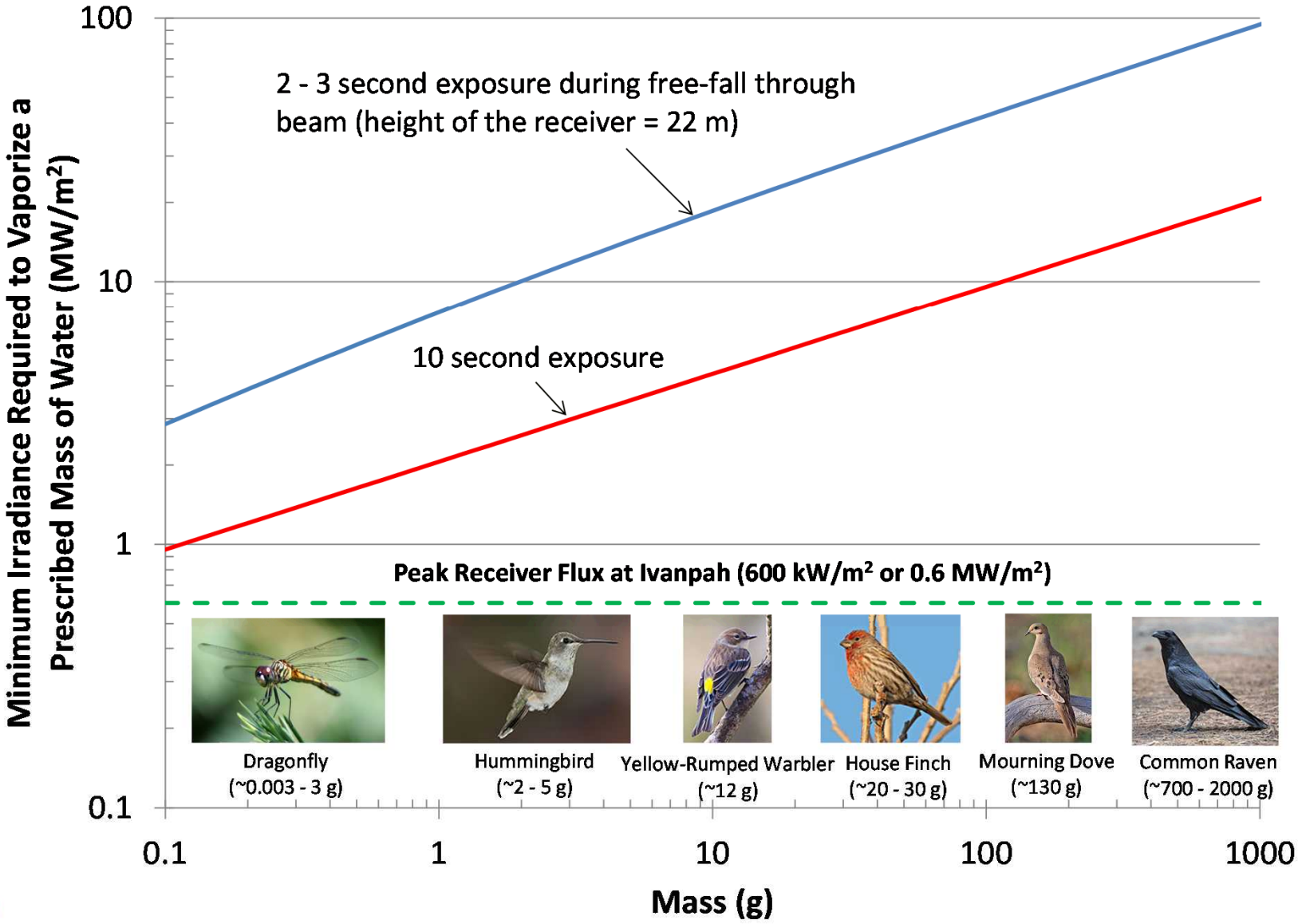
Levelized Avian Mortality for Energy (LAME)



*Sovacool (2009)

**During first year of operation at Ivanpah (2013 – 2014) before mitigation measures and deterrents were implemented

Feasibility of Bird Vaporization



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Deterrents

- Acoustic
  - Painful or predatory sounds
- Visual
  - Intense lights and decoys
- Tactile
  - Bird spikes, anti-perching devices
- Chemosensory
  - Grape-flavored powder drinks (methyl anthranilate)

- Ivanpah has implemented these deterrents and seen a ~70% reduction in bat and bird deaths (personal communication, Doug Davis, NRG, 8/3/15)

Mitigation Measures for Solar Flux

- Spread out the aim points of heliostats in standby mode to reduce the “hot spots” that birds may fly through
- Both Ivanpah and Crescent Dunes have implemented this strategy
  - Crescent Dunes reduced the flux to less than 4 kW/m^2, and they claim they have not had any reported bird deaths since then
- Need to minimize heliostat slew times to maintain operational performance

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Conclusions

- Recent reports of extreme numbers of birds being killed by concentrated sunlight at CSP plants appear to be misinformed and inflated
- The large number of “streamers,” or smoke plumes, observed and attributed to vaporization of birds is likely caused by insects flying into the concentrated flux
- Complete vaporization of birds flying into concentrated solar flux is highly improbable
- Safe irradiance levels for birds have been reported to range from 4 kW/m^2 to 50 kW/m^2
- Mitigation measures and bird deterrents can be used