The potential effects of photovoltaic solar farms on water birds in Aotearoa

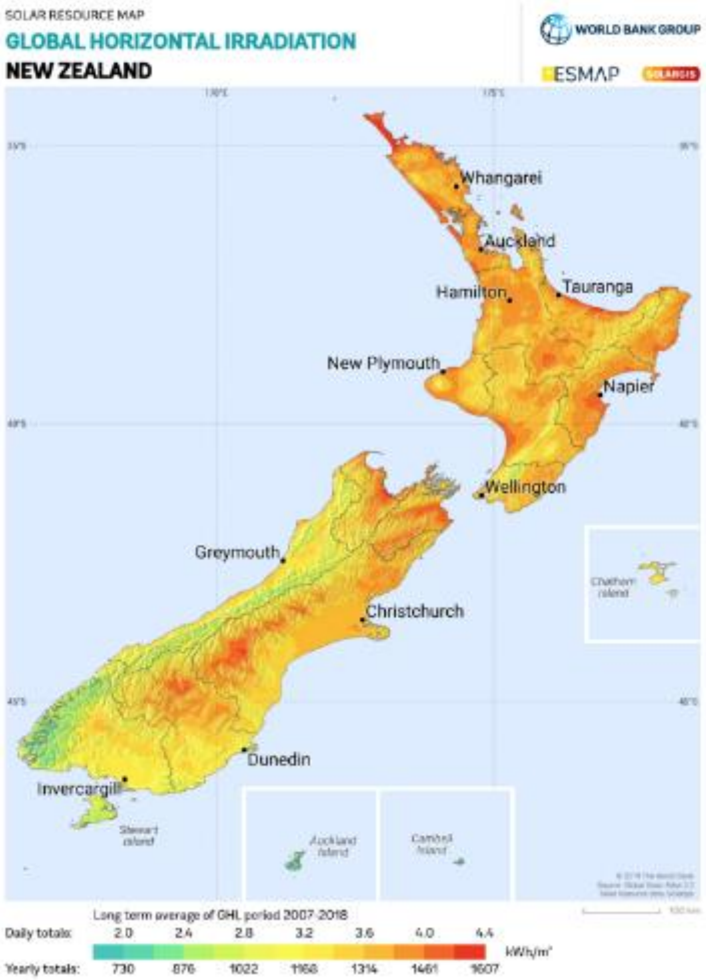
Colin O’Donnell
Department of Conservation
codonnell@doc.govt.nz

Outline

- <u>Scope:</u> Ground-based photovoltaic (PV) solar farms (SFs)
- Risks to birds from PVSFs
  - What we know from overseas studies
  - What can we infer from overseas studies in Aotearoa?
- Why important for braided river birds?

Palauig Solar Farm, Phillipines

Solar farm effects on biodiversity in Aotearoa?



https://www.lightyearssolar.co.nz/waingawa-solar-farm

Dramatic growth in PVSFs in Aotearoa

- >50 industrial scale (>50 MW) PV solar farm proposals since 2020
- If approved:
  - Would generate >8,000 MW of electricity
  - Cover >12,000 ha
  - Use >13,000,000 panels

Global guidance on biodiversity and PVSFs

- “**AMERICA’S SOLAR FARMS** have a bird problem. Utility companies have been finding bird carcasses littering the ground at their facilities for years, a strange and unexpected consequence of the national solar boom. No one was quite sure why this was happening, but it was clearly a problem for a type of energy that was billed as being environmentally friendly.”

Why Do Solar Farms Kill Birds?

"Many stakeholders became concerned when dead birds were unexpectedly discovered at some solar photovoltaic facilities in the California desert. This was surprising because there seemed to be no obvious threat to the birds from panels.......

Especially surprising was the fact that at some facilities, birds associated with water habitats, like loons and grebes, were among the casualties....."

Diehl et al. (2024) California Energy Commission

There can be benefits to birds

“Properly sited and developed ecovoltaic solar facilities in human altered landscapes can improve habitat for birds and other wildlife”

Savannah sparrow

Eurasian tree sparrow

(e.g., Jarčuška et al. 2024 J. Environ Manage 351:119902; Walston et al. 2025 J Appl. Ecology – Online only)

Overseas data on bird fatalities

- Kagan et al. (2014) - 61 carcases from one PV solar farm (Desert Sun) of which 48% were water birds
- Most monitoring data NOT in the public domain
- Largely confined to arid California

Smallwood (2020) extrapolated fatalities in California:

- >156 bird species / 2,736 fatalities
- 141,811 (95%CI = 102,227–214,593) 2019
- 125,921 (95 CI = 81,346–292,225) 2020

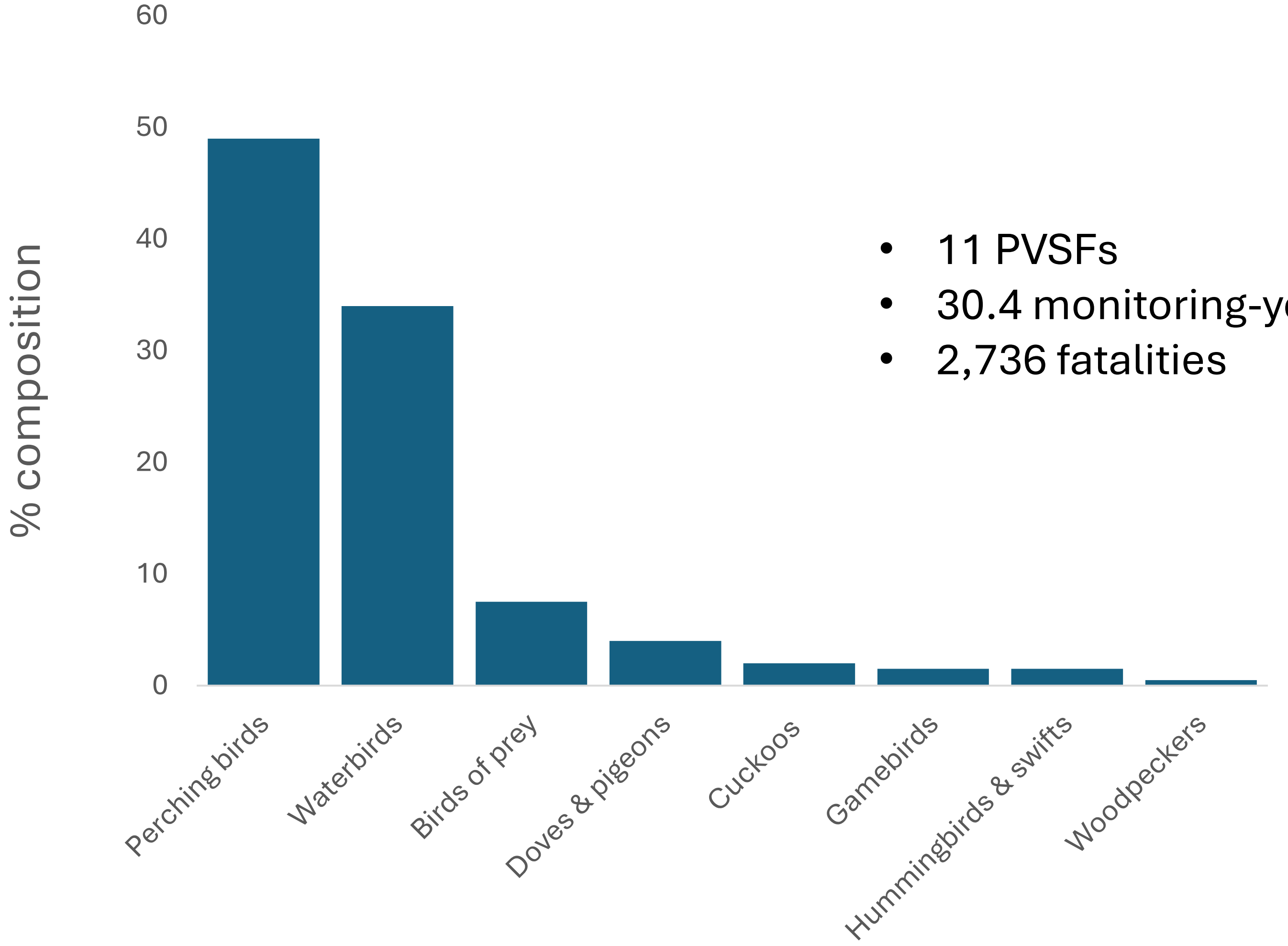
Bufflehead (duck!)

https://www.pbssocal.org/

Yuma clapper rail

Palen Solar power project

Composition of bird fatalities in California



- 11 PVSFs
- 30.4 monitoring-years
- 2,736 fatalities


Costa's hummingbird

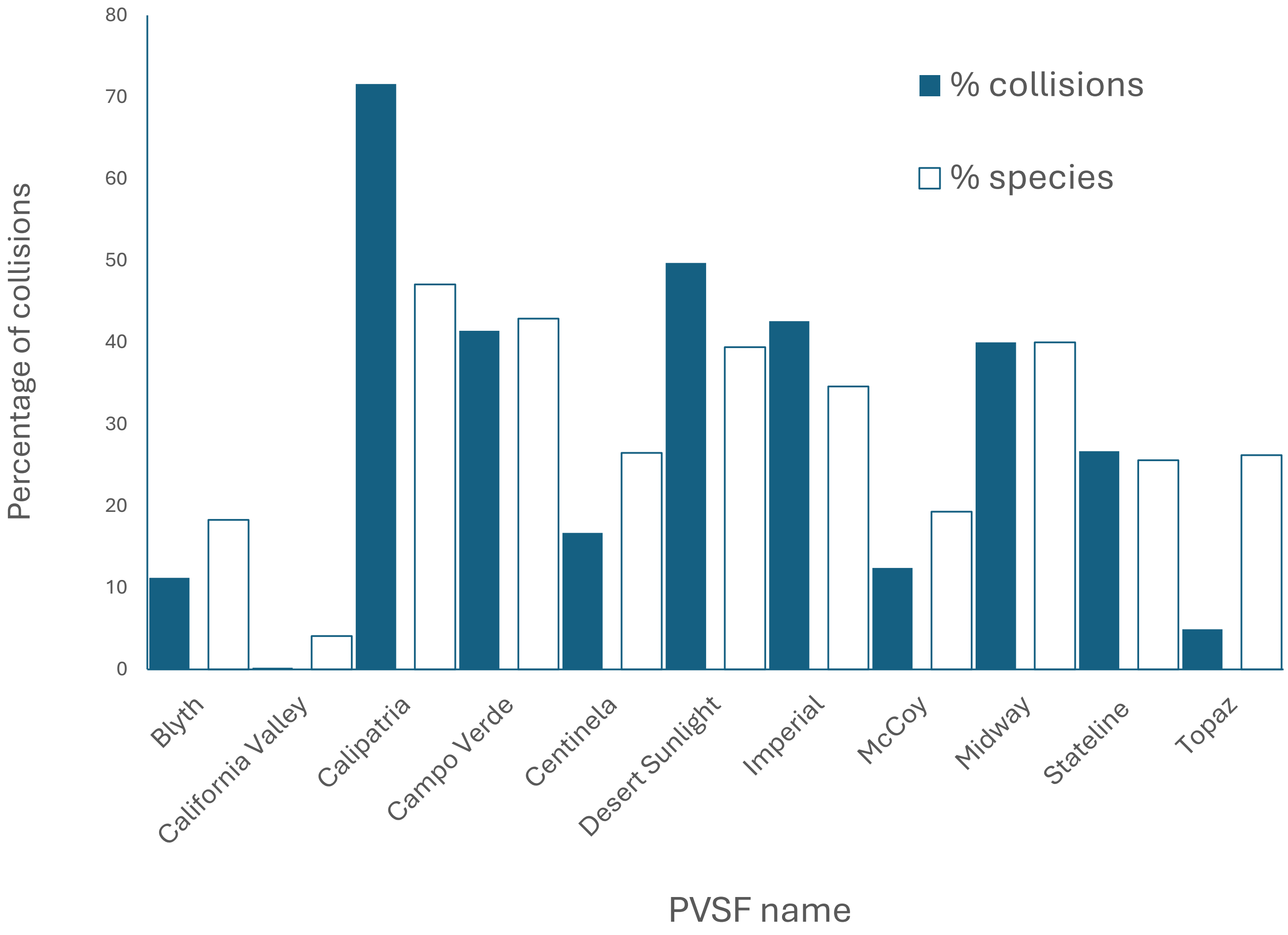

Mourning dove


Common gallinule

Wikipedia

Smallwood (2022) Journal of Wildlife Management 86: e22216
Conkling et al. (2023) PLOS ONE 18: e0295552

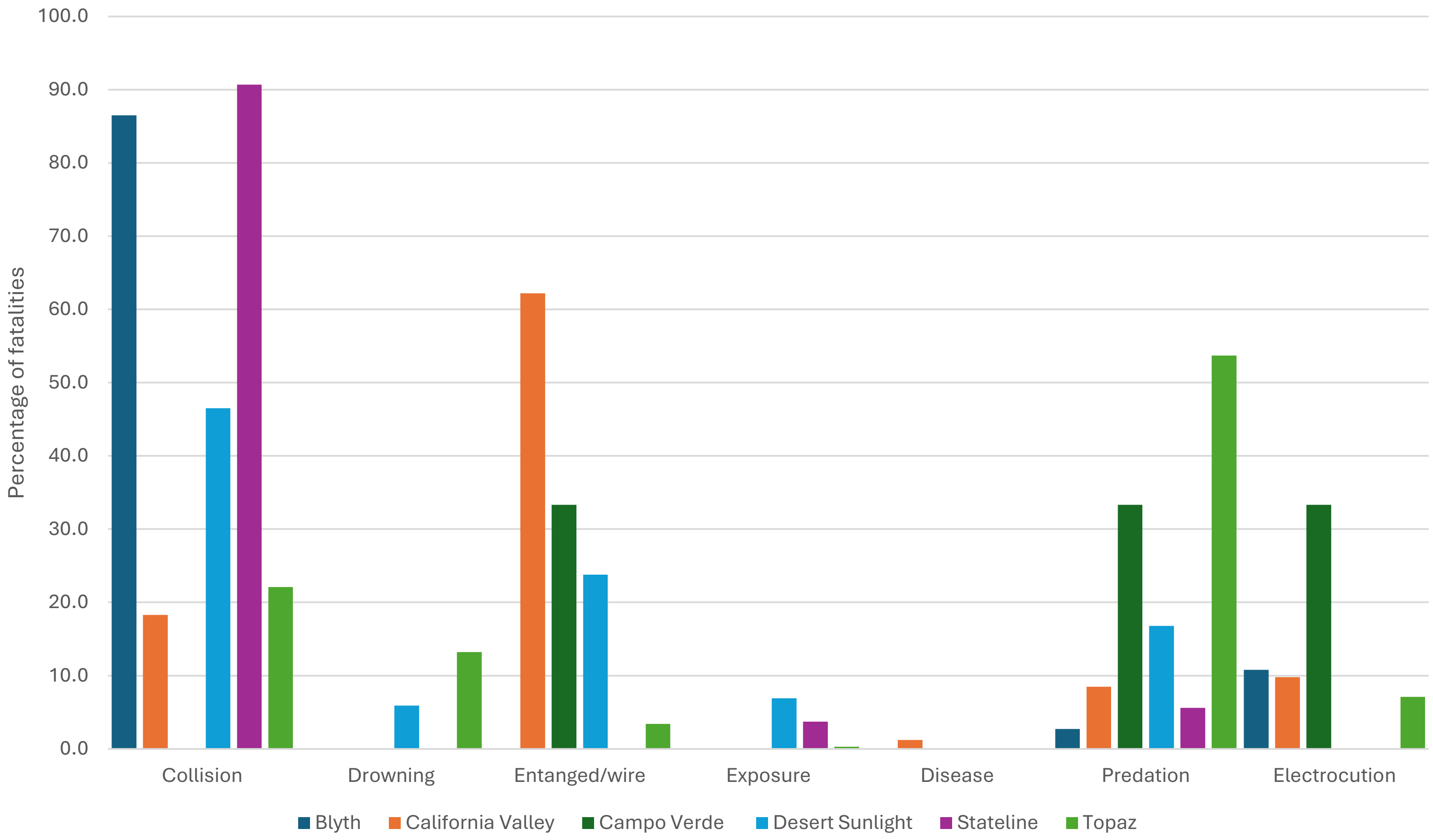
Variability in water bird fatalities (California)



Average = 30% water birds

Smallwood (2022) Journal of Wildlife Management 86: e22216

Causes of death (California)

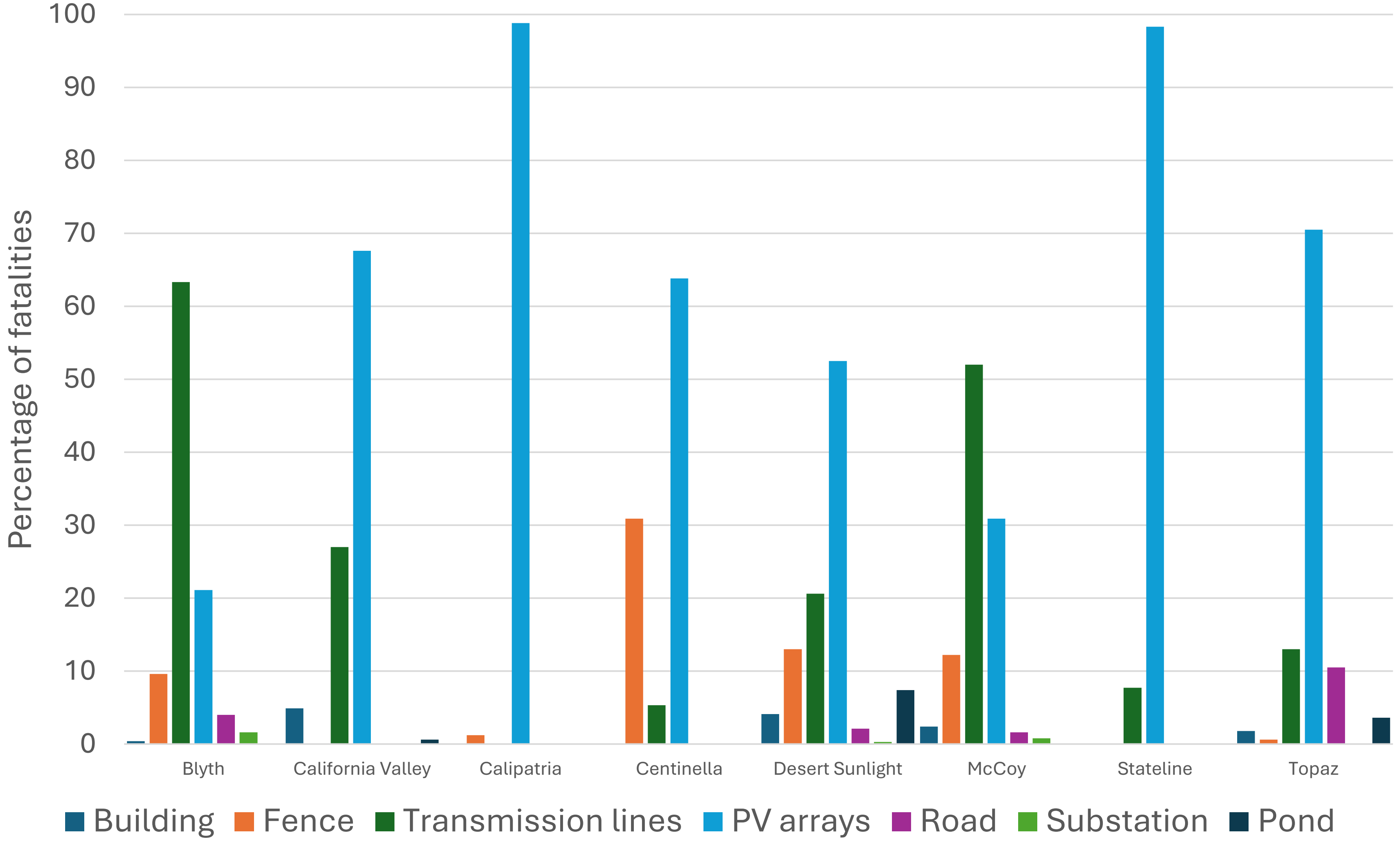


Averages:

- 44% collisions
- 21% entangled in wires/fences
- 20% predation
- 10% electrocution

6 PVSFs - Smallwood (2022) Journal of Wildlife Management 86

Which solar farm elements cause mortality?



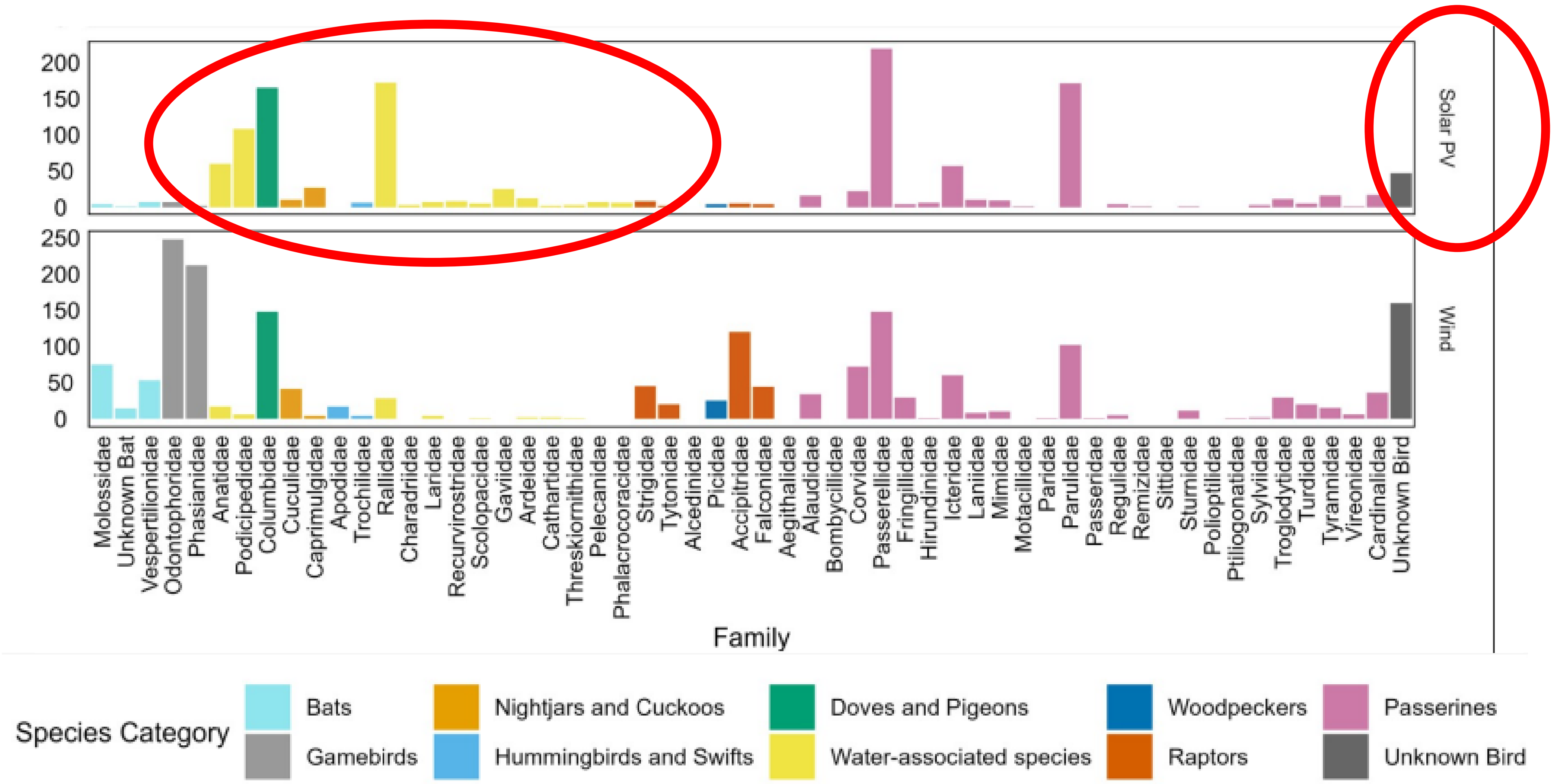
Averages:

- 63% PV arrays
- 24% transmission lines
- 9.6% fences

8 Californian PVSFs - Smallwood (2022) Journal of Wildlife Management 86

Fatalities by bird group

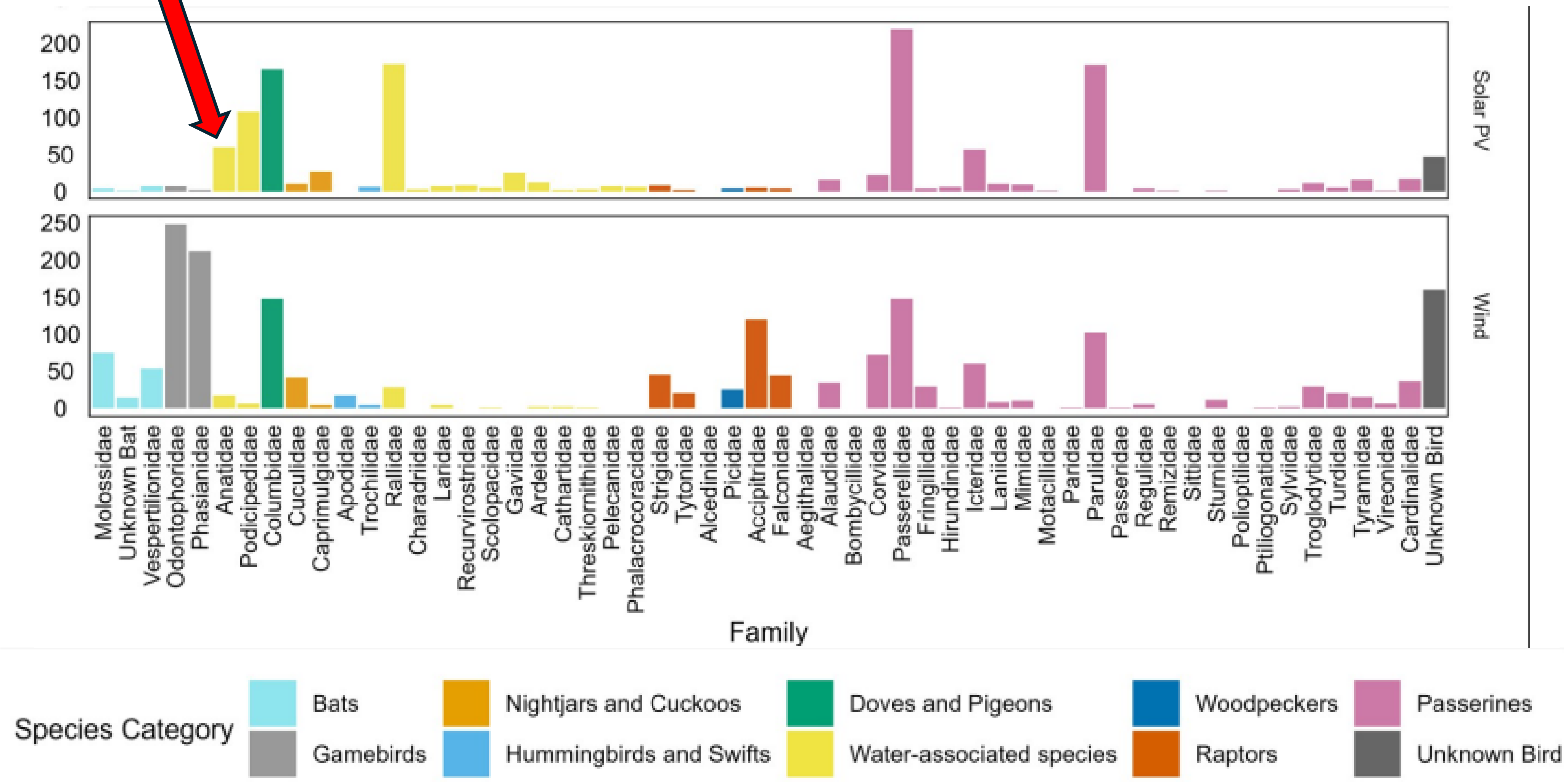
(California- from Conkling et al. 2023: PLOS ONE 18: e0295552))



Waterfowl (15 species)

Northern shoveler

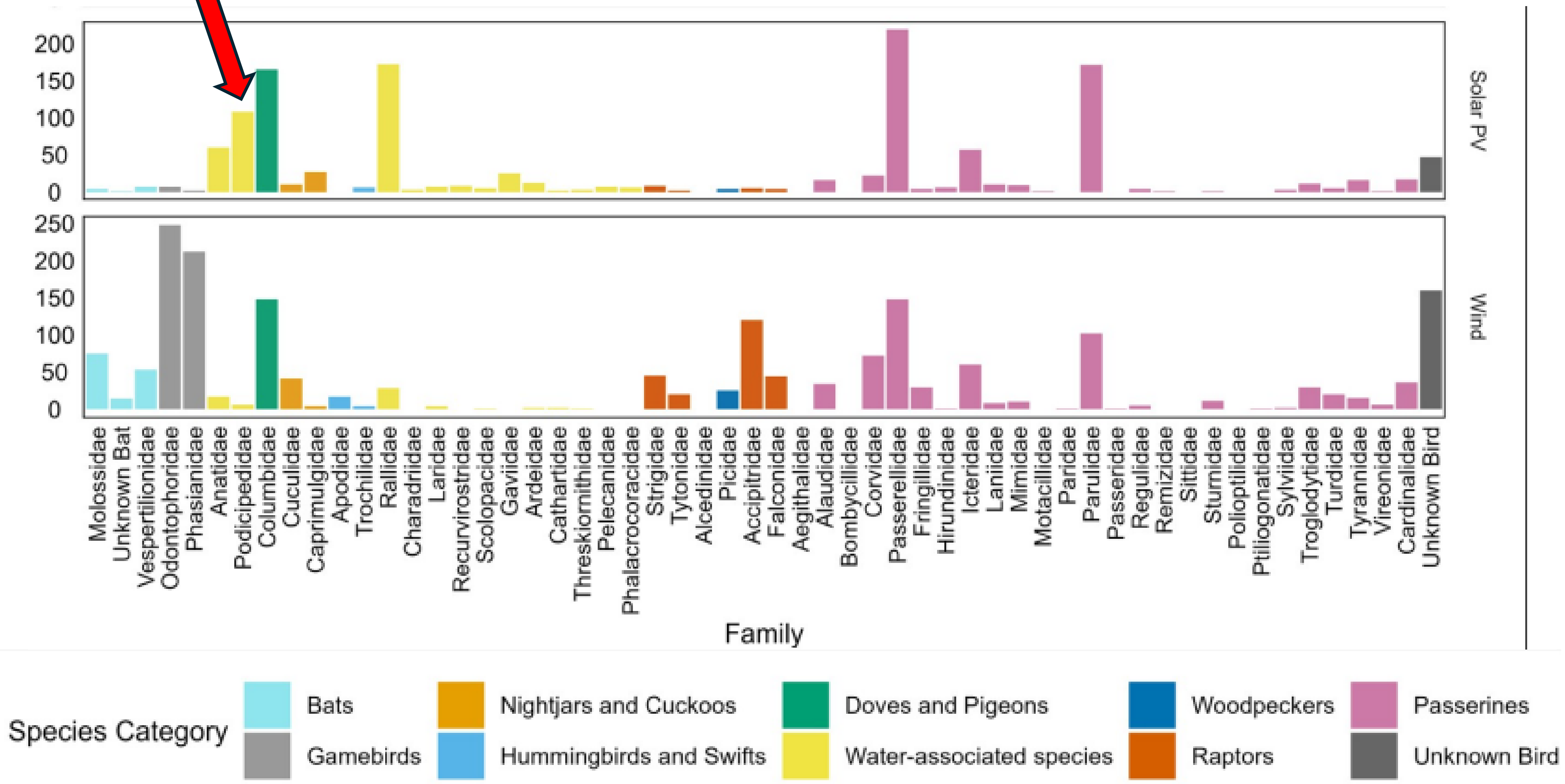
Cyril Vathelet NZ Birds Online



Grebes (5 species)

Pied-billed grebe

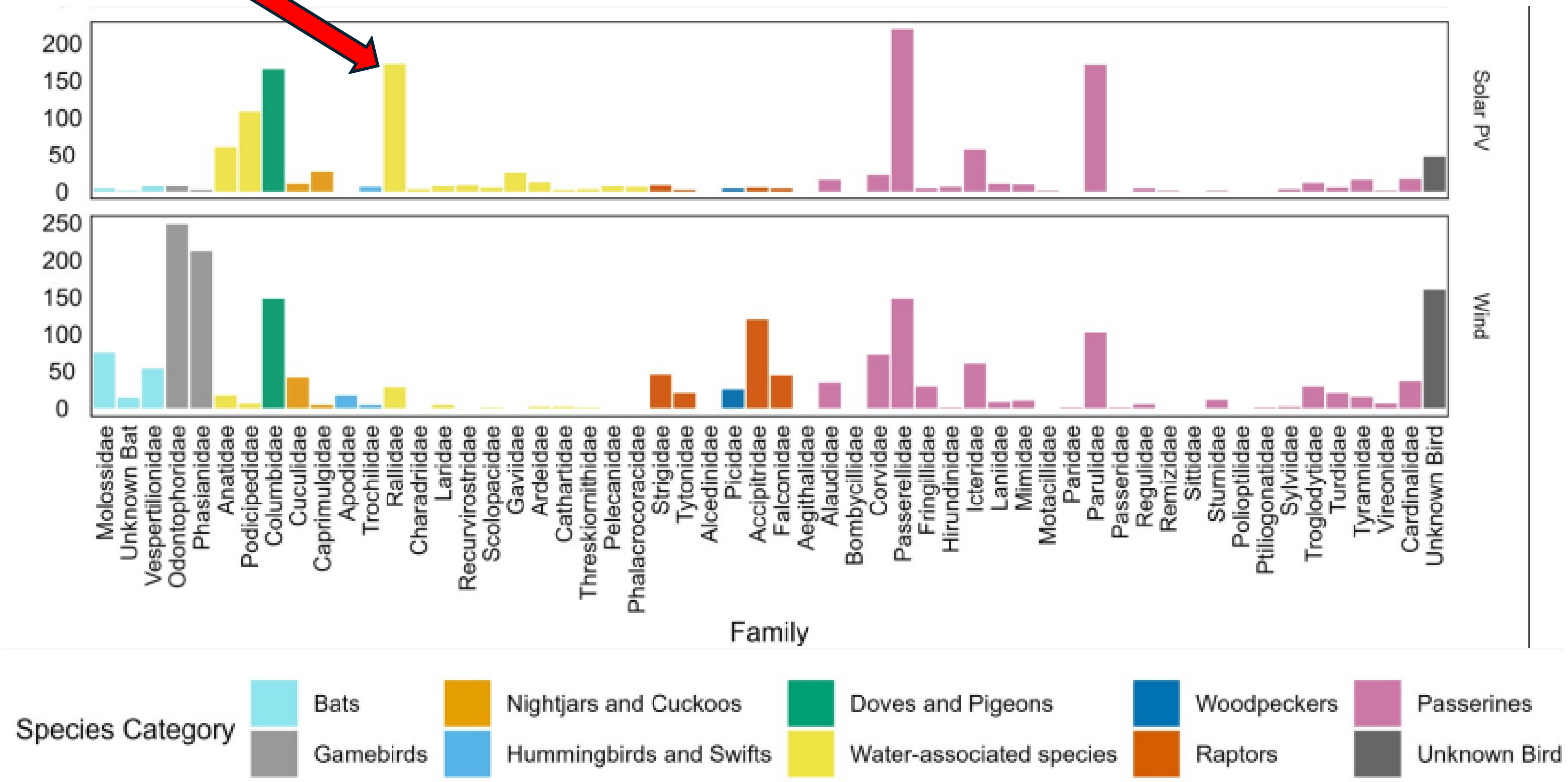
Frank Schulenburg Wikimedia Commons



Rails (6 species)

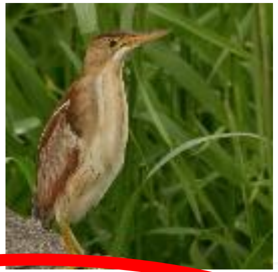
Sora (crake)

Elaine R. Wilson (Wikimedia Commons)



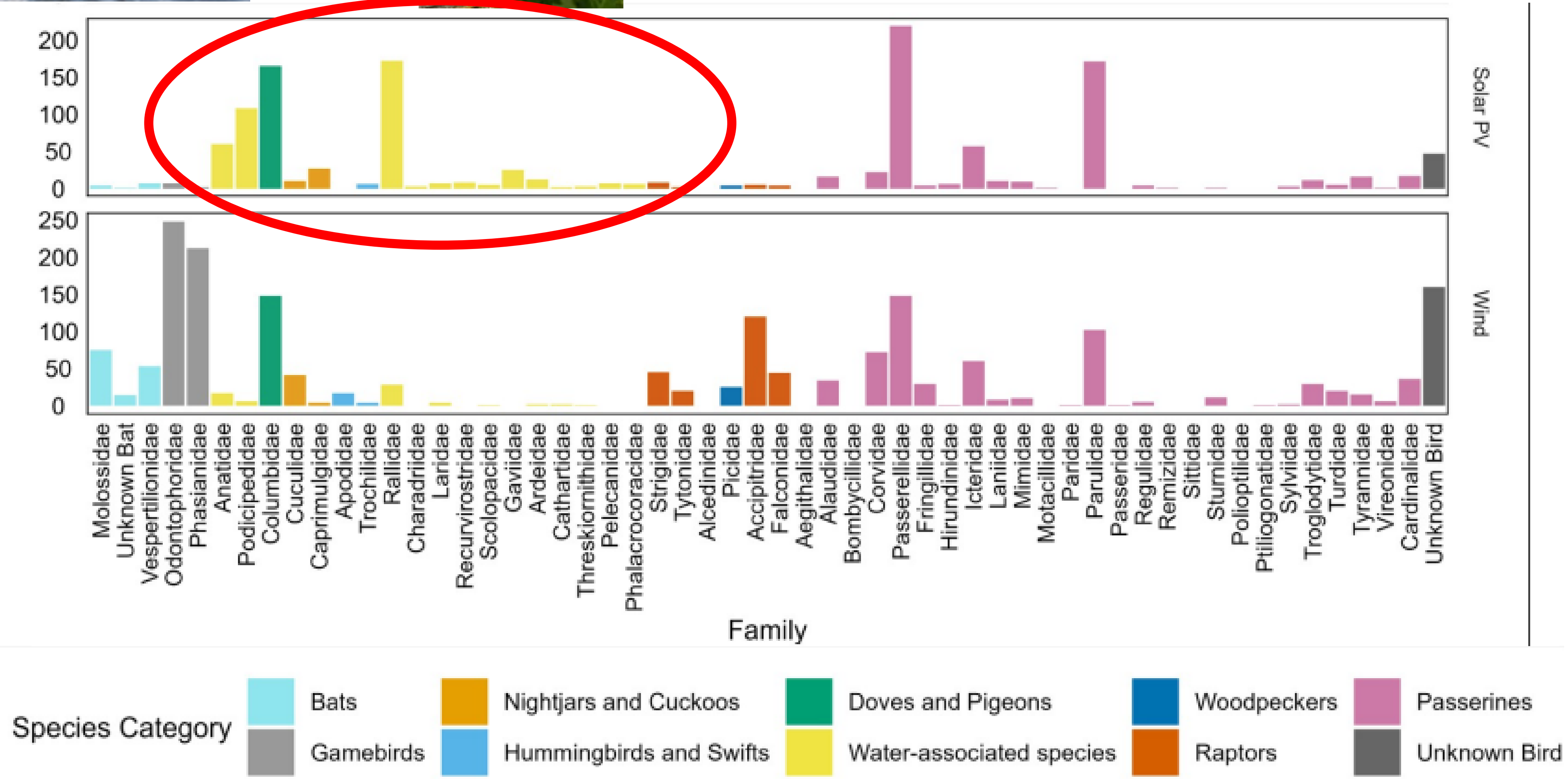
Waders (8+ spp.)

Herons (7+spp.)

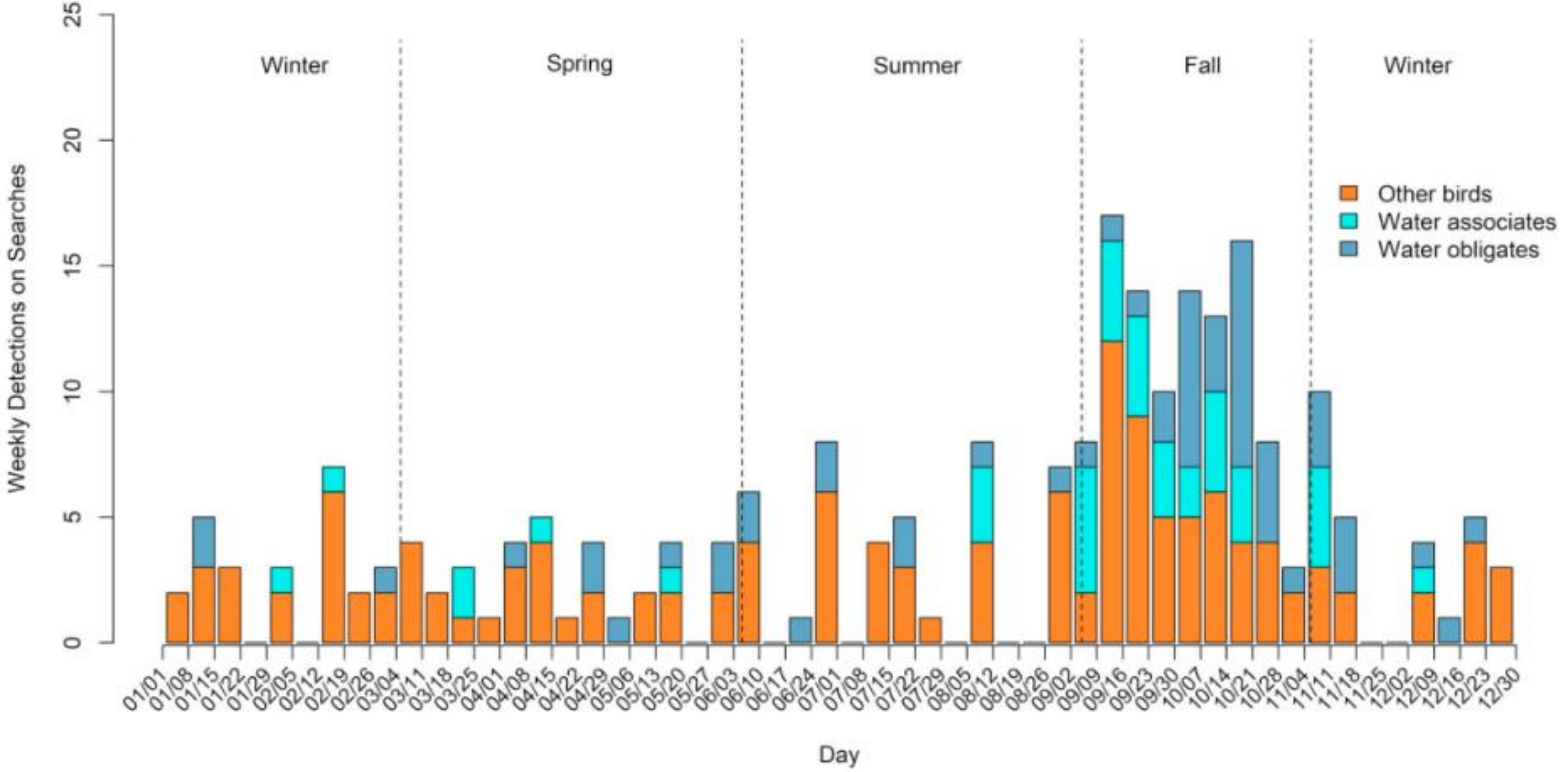


Gulls & terns (4+ spp.)

Cormorants (2 spp.)



Fatality rates through the year



Weekly detections of waterbird fatalities at 7 PV solar farms reported by Kosciuch et al. (2020 PLOS ONE 15: e0232034.) (n = 669 fatalities).

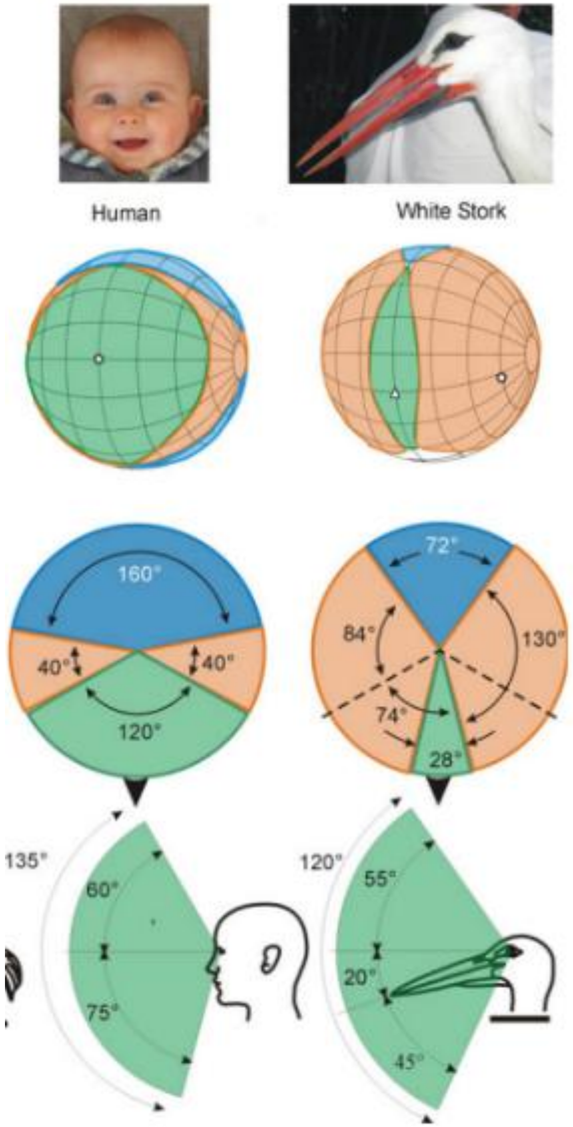
Water bird fatalities/yr in California

Species group totals	Combined solar infrastructure fatalities/yr	PV fatalities /MW/yr	Estimated total fatalities from PV/yr	Proportion of total fatalities attributed to PV (%)
Waterfowl	3,619	0.137	1,674	46
Grebes	3,165	0.084	1,161	37
Rails	11,638	0.9003	11,035	95
Waders	1,965	0.055	672	37
Gulls	246	0.006	73	30
Terns	299	0.023	281	94
Shags	244	0.02	244	100
Bitterns	209	0.017	208	100
Herons	3,556	0.273	3,336	94
Kingfishers	45	0	0	0
Swallows	9,422	0.02	244	3
Birds of prey	2,494	0.149	1,821	73
Pipits	3,631	0.01	122	3

Smallwood (2022) Supplementary data

Why do birds collide with PV infrastructure?

- Accidents (low light, startled, naïve....)?
- The 'lake-effect' hypothesis – a sensory trap?
  - Detect horizontally polarised light that mimics water
    (e.g. Diehl et al. 2024)
- Polarised light causing disorientation?
  - Mobile species use polarised light for orientation
    (e.g. Helbig & Wiltschko 1989; Moore et al. 1988)
  - Calibrate magnetic compasses
    (Muheim et al. 2016).
- Reacting to other cues?
  - UV
  - Moonlight reflectance
  - Confusion between sky and ground



Martin (2012) J. Ornithol.153 (Suppl. 1):S23–S48

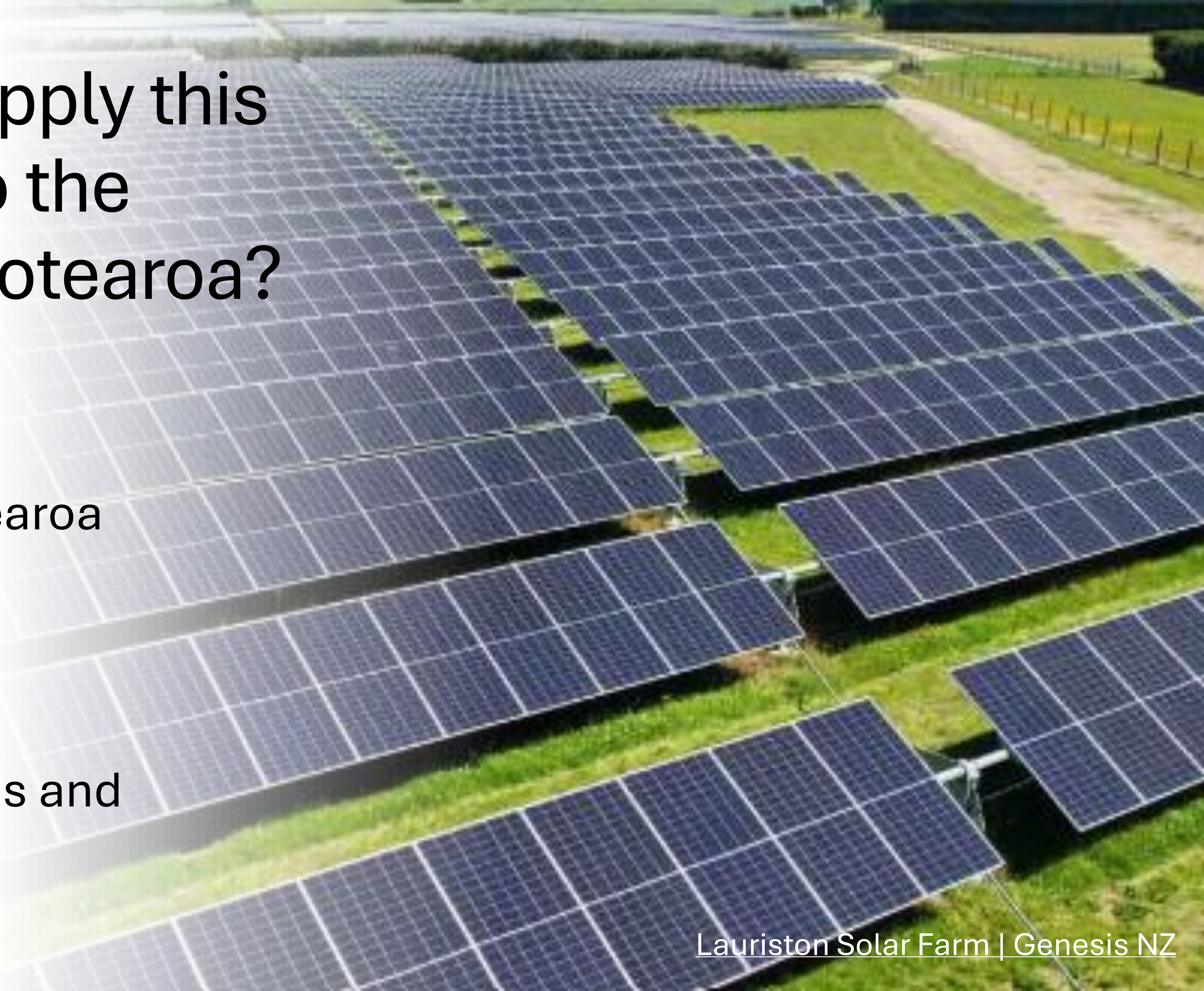
Risks of PVSFs to water birds

- Deaths and injury of birds during construction.
- Degradation and loss of local habitats following construction
  - Changed land use practices
  - Drainage
  - Disturbance
- Displacement
- Ongoing, deaths and injury through collisions with solar farm infrastructure
  - Fences
  - Cables and transmission lines
  - Solar panels
  - Electrocution

Dead western grebe, Desert Sunlight solar farm (Palen Solar power project)

How do we apply this knowledge to the situation in Aotearoa?

- Limited data from overseas
- No data from Aotearoa
- Different habitats
- Different species
- But many more threatened species and ecosystems ……..



Lauriston Solar Farm | Genesis NZ

Ecological equivalents in Aotearoa


Australasian shoveler – Neil Fitzgerald


Dabchick - Alan Tennyson


Marsh crake – Craig Martin


Banded dotterel- Ailsa Howard


NZ pipit – Neil Fitzgerald


Black cormorant – Ormond Torr

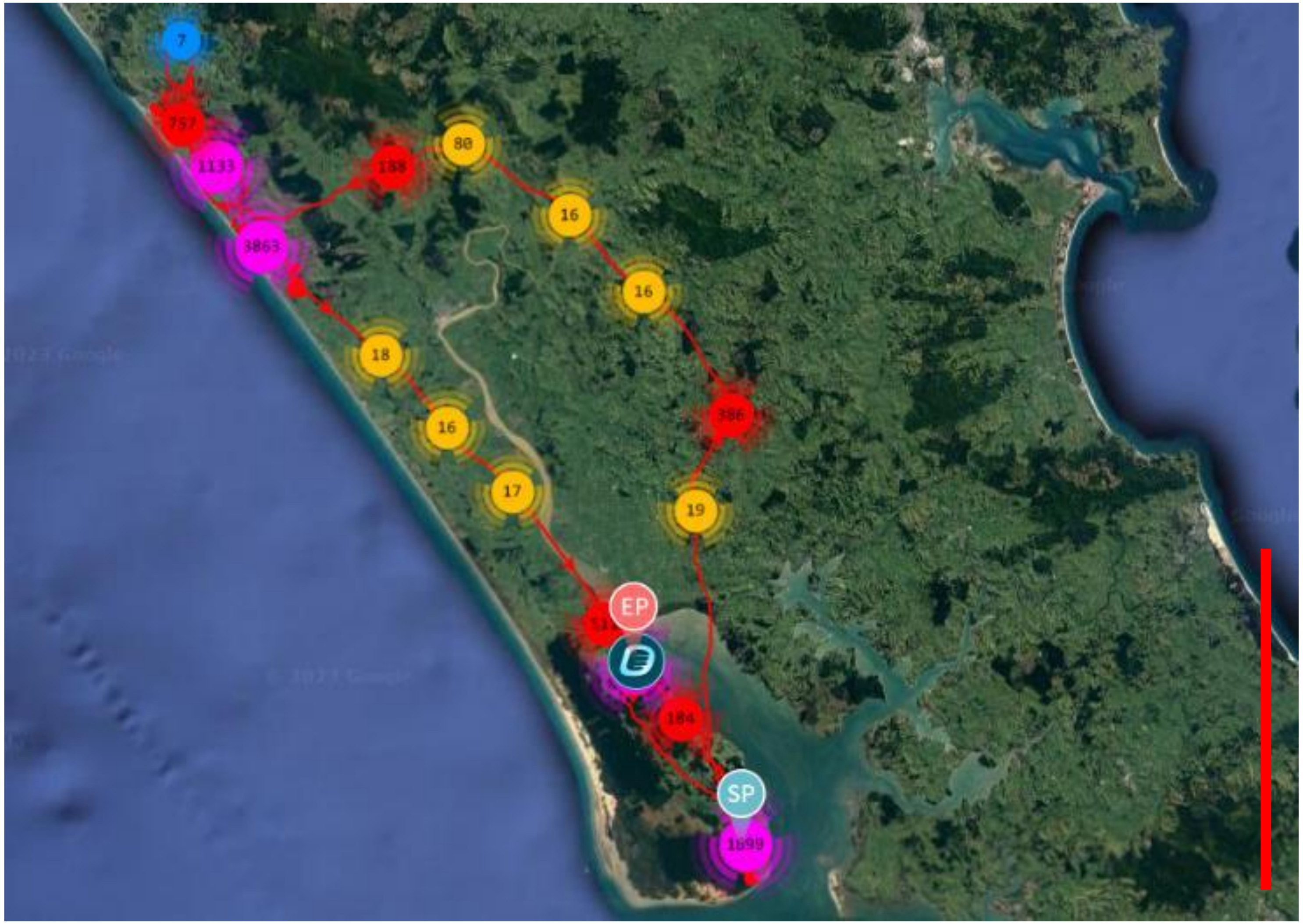

Black-fronted tern – Jack Van Hal


SI pied oystercatcher- Eugene Polkan

Birds in Aotearoa more mobile than thought

- 20 days
- 30 wetlands
- c. 200 km
- Flights at night

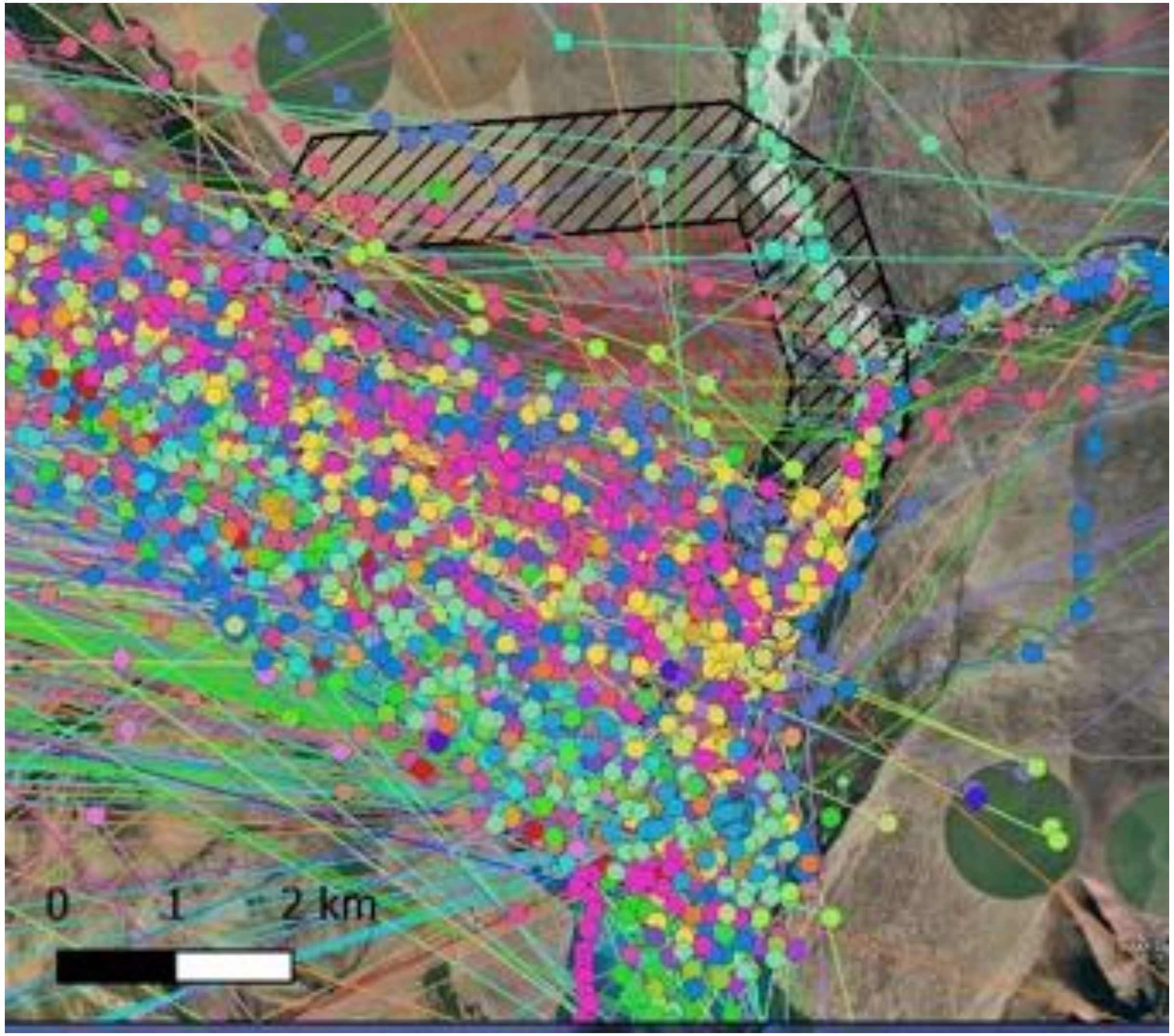
(Nov-Dec 2023)

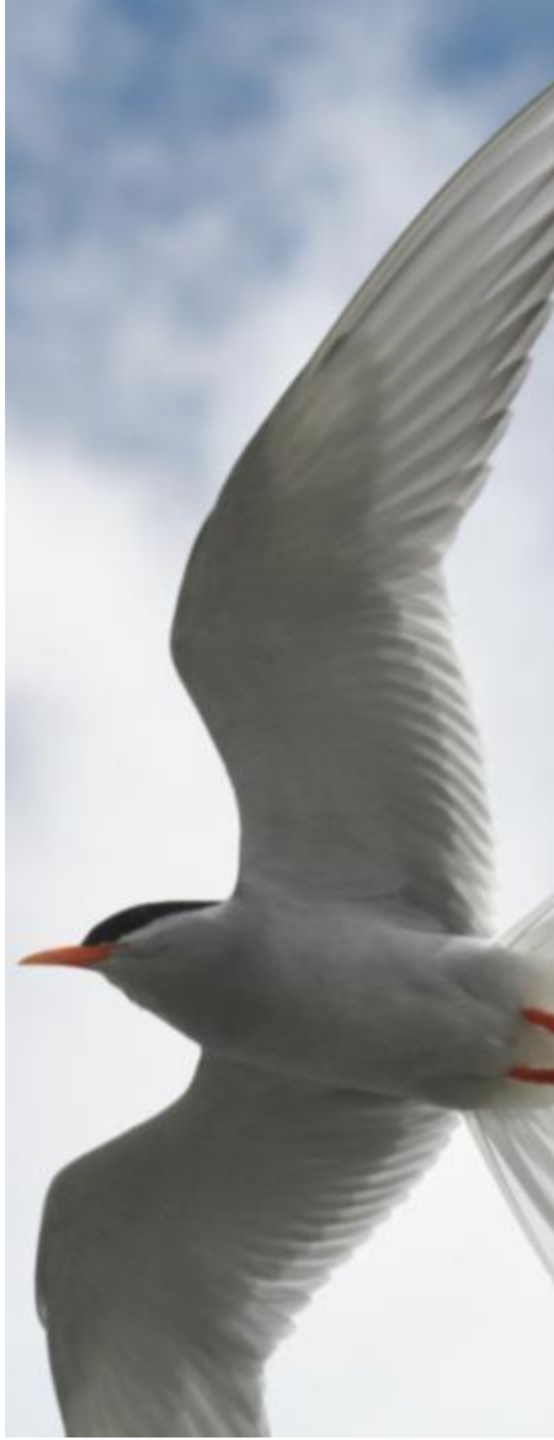


30 km

Movements overlap proposed PVSFs

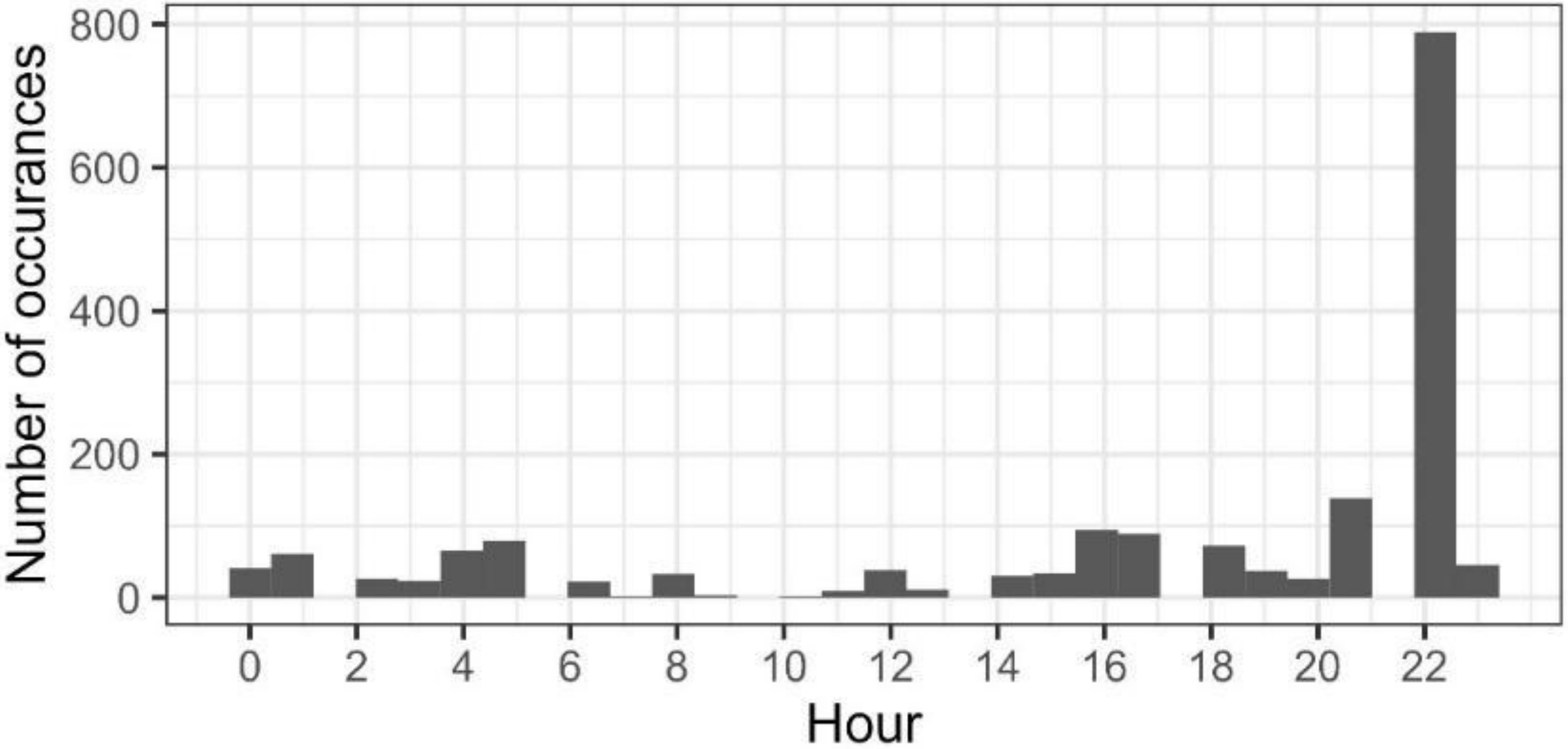
- 36 black-fronted terns
- 3,445 fixes in image
- 15 months

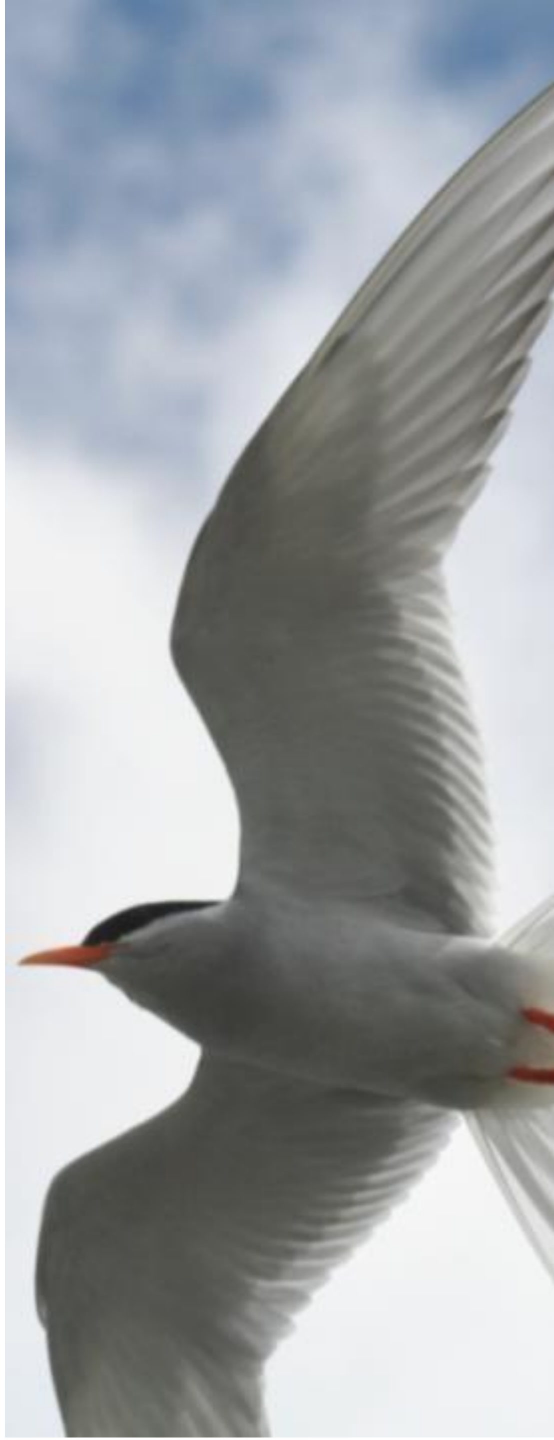




Crepuscular & nocturnal flights a norm

Black-fronted tern flights over proposed solar farm





Knowledge gaps (1)

Risks in the New Zealand context	
	Will birds collide with solar infrastructure in New Zealand?
	Which species are most likely to collide?
	Will collision rates impact population viability?

Bennun et al. 2021 IUCN Guidelines

Understanding why birds collide with solar infrastructure	
Environmental factors	Influence of location on collision risk • Habitat or land use type • Proximity to water/wetland habitats
	Influence of environmental conditions • Time of day • Time of year • Weather conditions (e.g., wind, temperature, visibility)
Biotic characteristics	Influence of species and species behaviour • Migrants and mobile species versus sedentary species • Waterbirds versus landbirds • Flight behaviours • Age, sex or other demographic characteristics • Behavioural adaptability/habituation
Physical characteristics of infrastructure	Type of solar infrastructure • Extent of panels (solar farm size) • PV panel heights • PV panel layout • Types of PV panels (including anti-reflective coatings) • PV panel orientation (operational angles including stowage angle at night) • Extent of panel polarisation
Mechanisms explaining collision risk	• Accidental collisions • 'Lake effect' hypothesis • Disorientation resulting from polarised light

Knowledge gaps (3)

Methods for reducing risks	
	Solar farm configuration • Size of blocks on PV panels • Gaps between panels • Night-time stowage angles
	Bird-sensitive anti-reflective coatings
	Insulators and having no bare wiring
	Underground cables

Conclusions (1)

- Impacts of PVSFs on birds in Aotearoa plausible but unknown
- Huge number of knowledge gaps about potential impacts
- Growth of industrial scale PVSFs outstripping our knowledge
- Disproportionate risks to water birds that breed of braided rivers likely (based on limited overseas literature)
- How we use inference from limited overseas data = challenging

Conclusions (2)

- Universal calls for more research to understand why birds collide with PVSFs
- If collision rates similar or greater than California - population scale effects on some threatened species
- Any mitigation would be experimental
- Need well-designed formal monitoring programmes
- In the meantime – exercise a precautionary approach