Marine birds of the California Current and studies to inform offshore renewable energy

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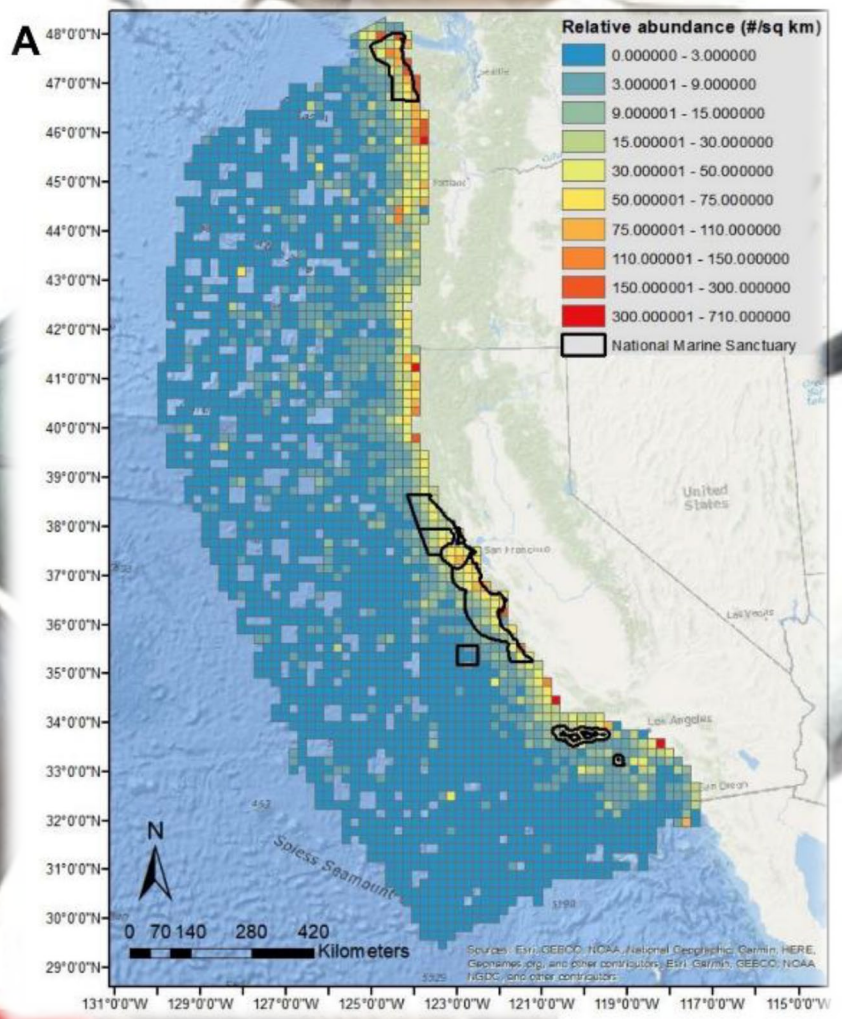
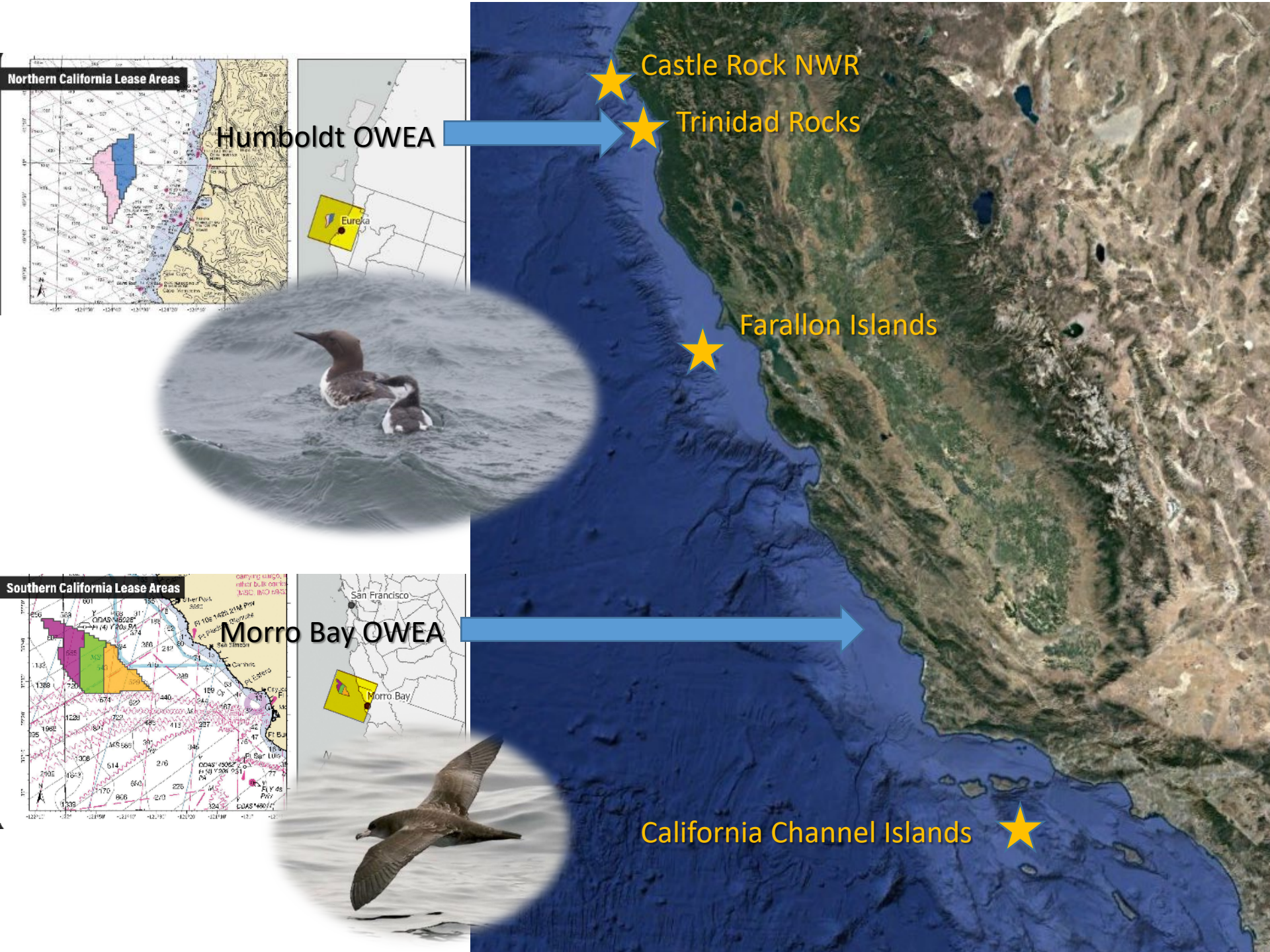
Diversity and abundance of seabirds in the California Current Ecosystem

- One of the most productive ocean regions on Earth
- Diversity of ocean habitats
- Subduction plate boundary with paucity of offshore islands
- Large, localized nesting populations (~21 species), >600,000 individuals)
- Including marine birds and seasonal migrants, species richness increases to >80 species with total numbers in the millions of individuals

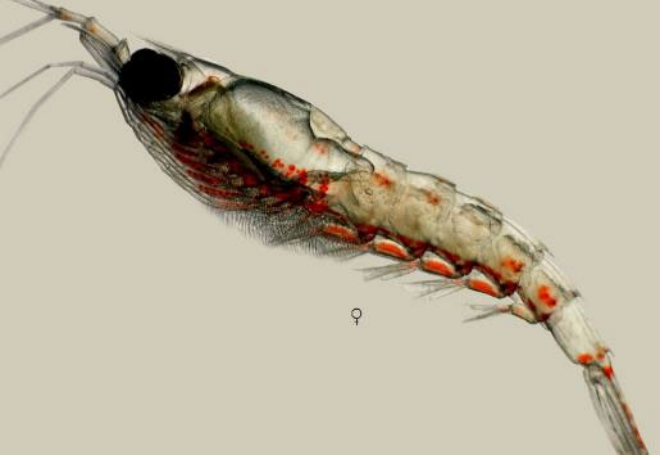


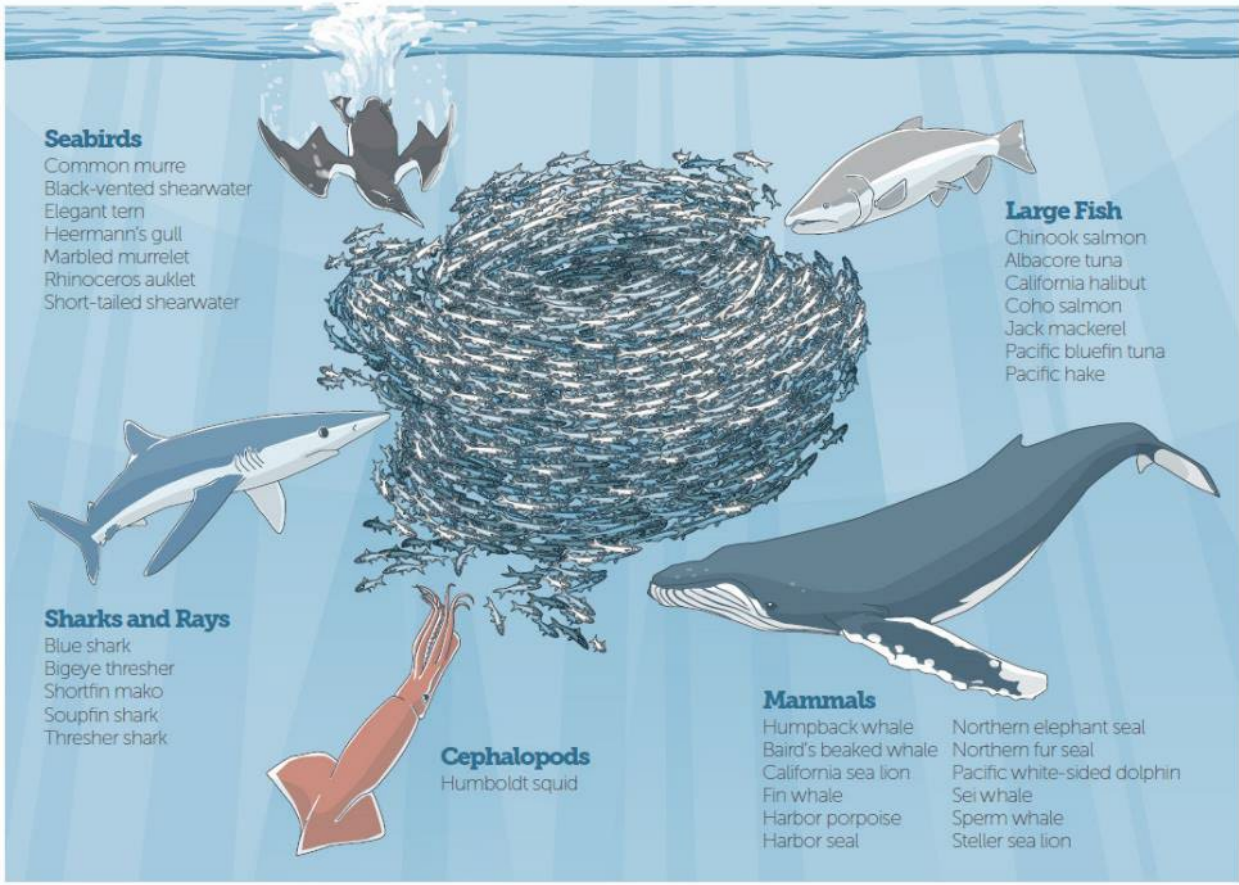
Map: Russel *et al.* 2023, *Journal of Marine Systems*

Illustration: Sophie Webb

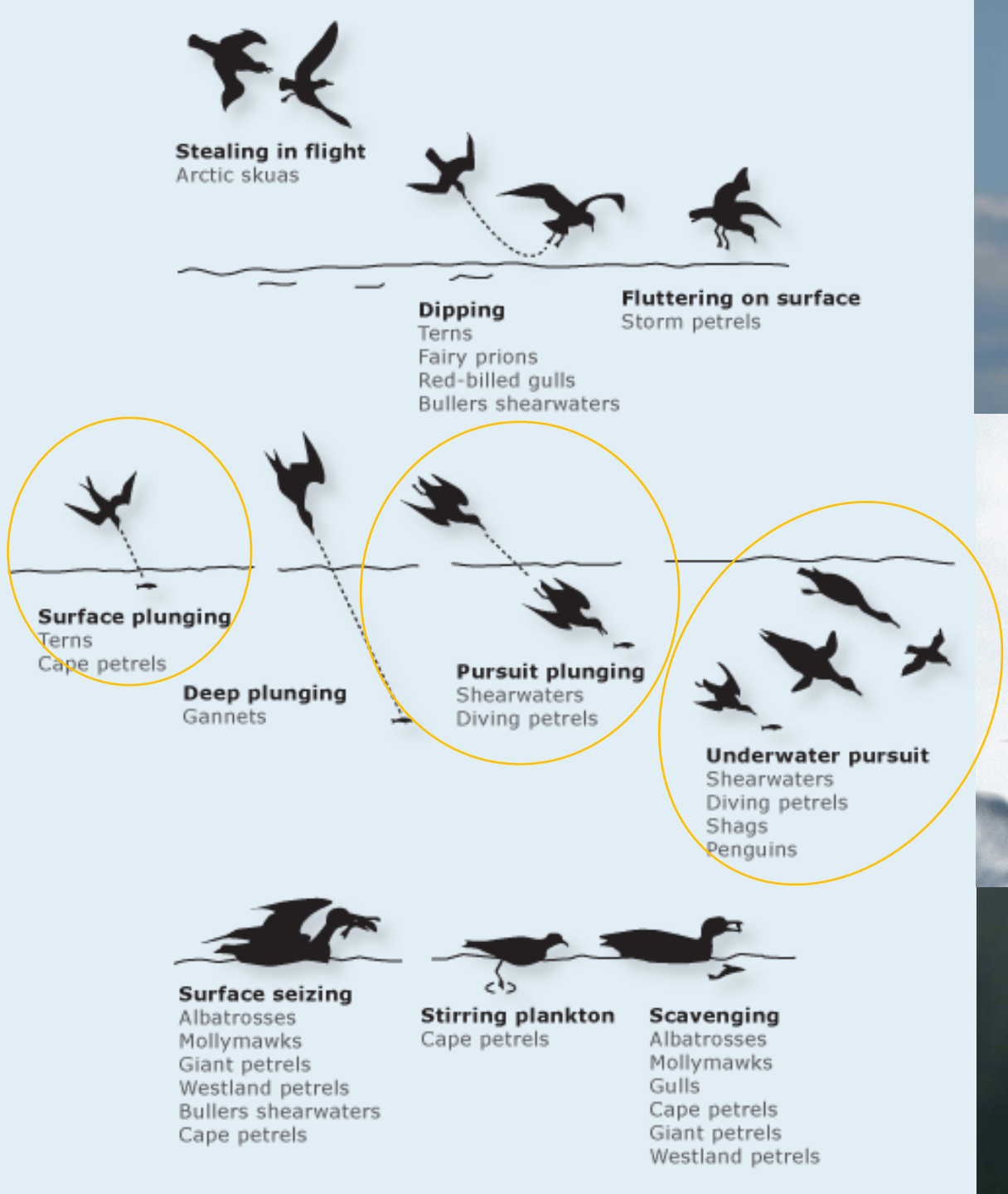

Northern California Lease Areas
Humboldt OWEA
Eureka
Castle Rock NWR
Trinidad Rocks
Farallon Islands
Southern California Lease Areas
San Francisco
Morro Bay OWEA
Morro Bay
California Channel Islands

Forage species and feeding ecology





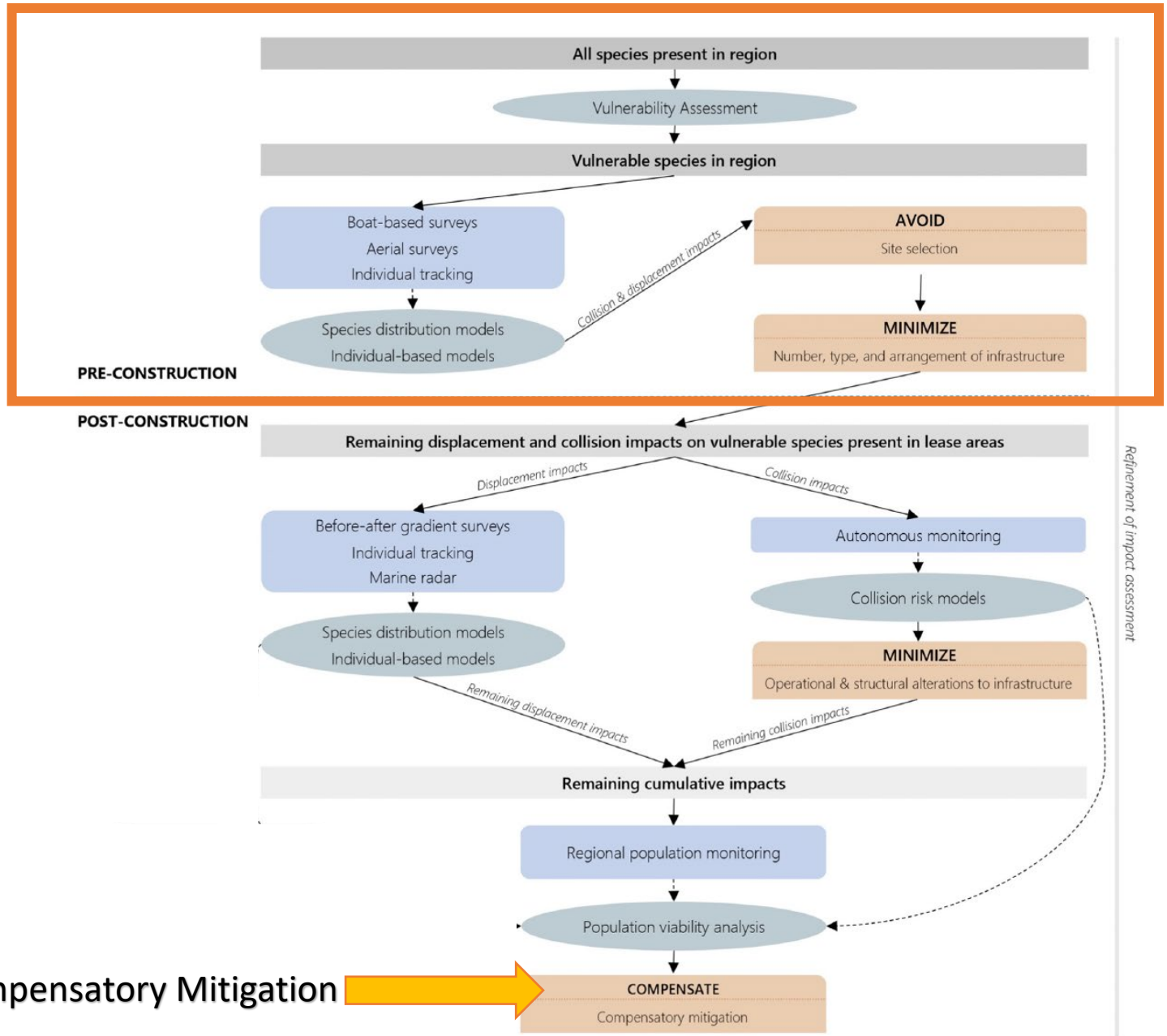
Source: Thayer *et al.* (2013) "California Current Predator Diet Database: Predators on Forage Species."




Stephen Ingraham


ScienceAdvances


L'Aurora Borealis



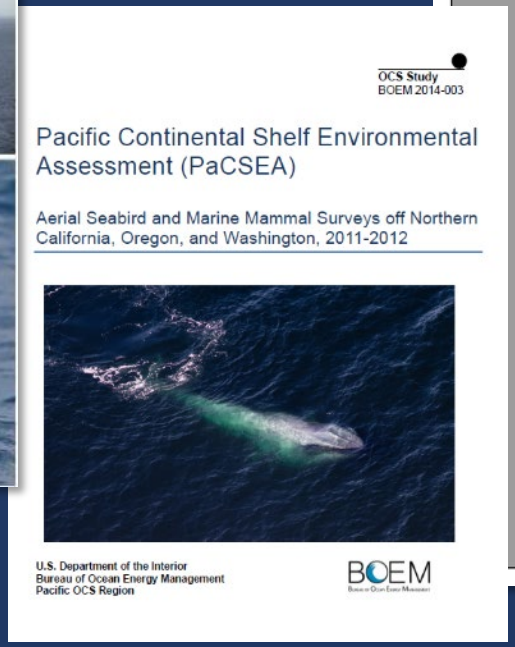
Compensatory Mitigation

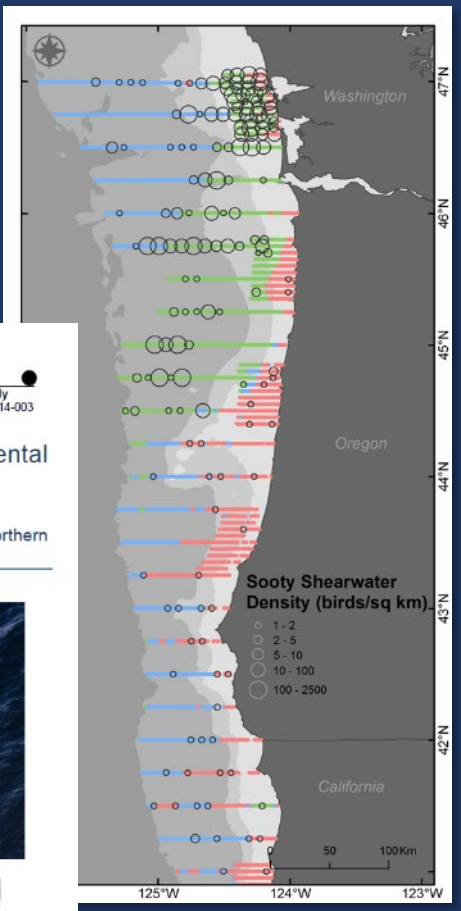
Croll *et al.* 2022, Framework for assessing and mitigating the impacts of offshore wind energy development on marine birds, *Biological Conservation*

California Current regional aerial surveys

broad-scale environmental assessments every 15-20 yrs (since mid 1970s)

- Northern and Southern California (1983-1992)
- Southern California (1999-2002)
- Northern California Current (2011-2012)
- Central – Southern California (2018-2022)





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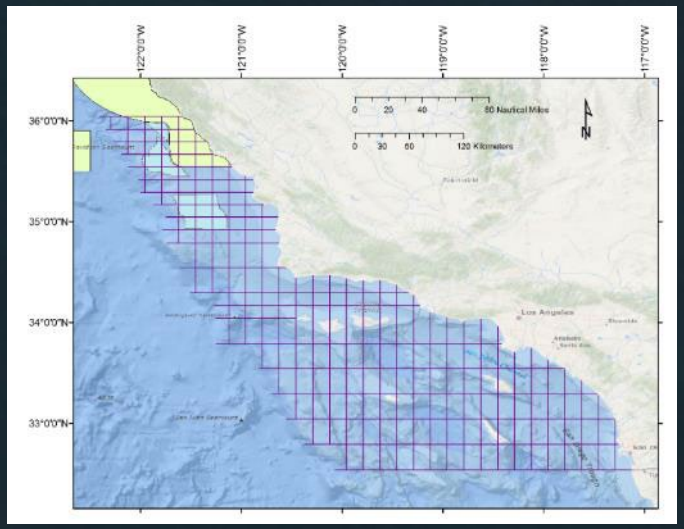
Digital aerial photographic surveys off central and southern California (2018-2022)

Aerial Surveys Flown 2018 – 2021

- 2x Winter, Summer, Fall, and Spring/Fall Migration
- ~800,000 high resolution jpg images

Machine Learning Methods Development

- Image Quality Metrics (pixel color, glint, blur)
- Active Learning Pipeline and Transfer Learning process
- Preliminary training and test datasets
- Candidate model evaluation Spring 2021
- Best model applied to complete dataset Summer 2021
- Annotation tool deployment and species level identifications



https://www.usgs.gov/centers/werc/science/aerial-seabird-and-marine-mammal-surveys

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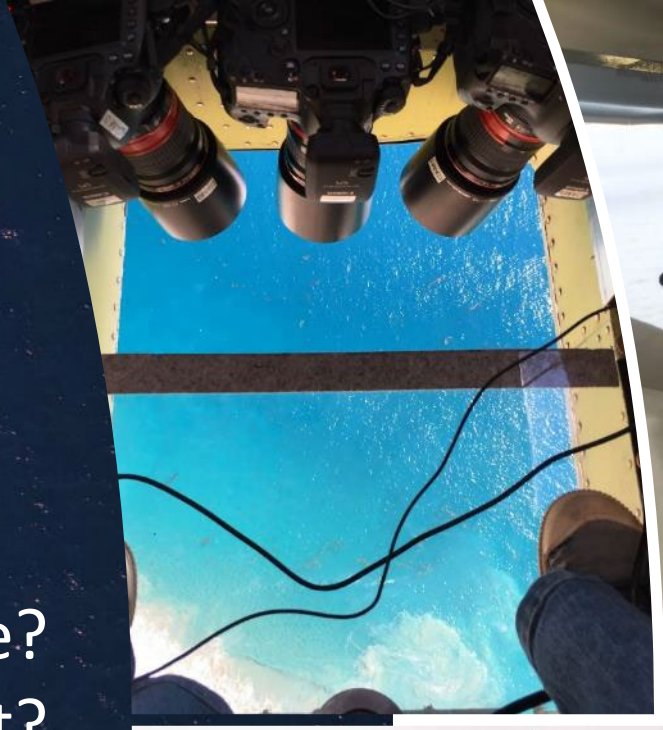
Conservation Metrics Improving conservation through better monitoring

Machine Learning: Object Detection



Localization – Where?
Classification – What?

Shearwater

Shearwater

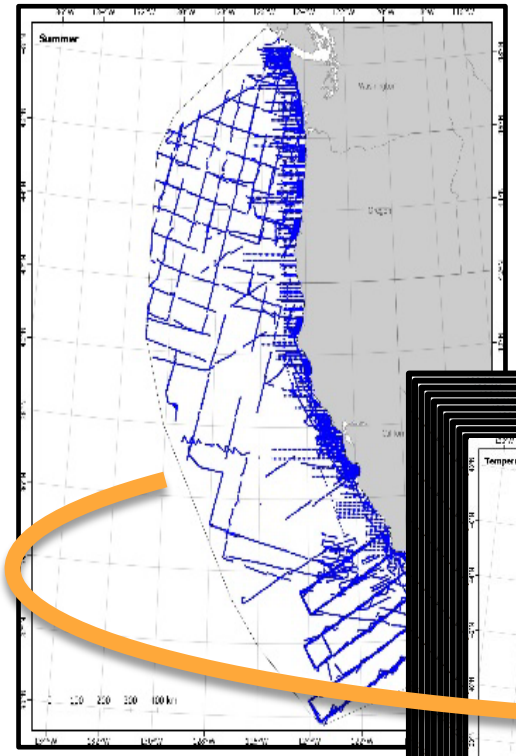
Shearwater

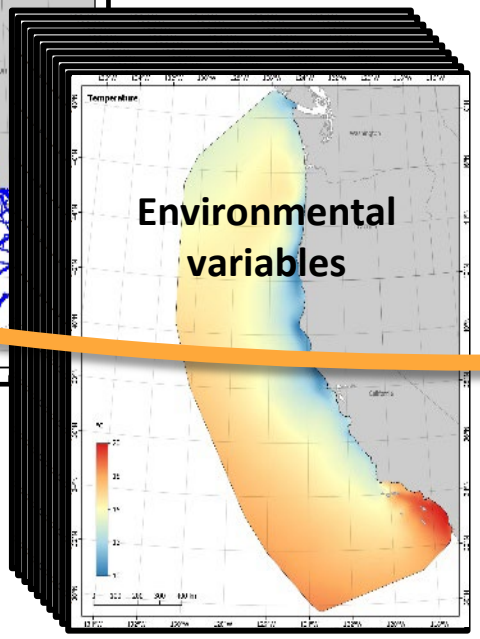
Pinniped

Species Distribution Modeling: 50 yrs of legacy data

- Long-term average spatial patterns of relative density for marine birds throughout the CCS
- 135 species/group-season combinations during spring, summer, fall, winter when present in sufficient numbers

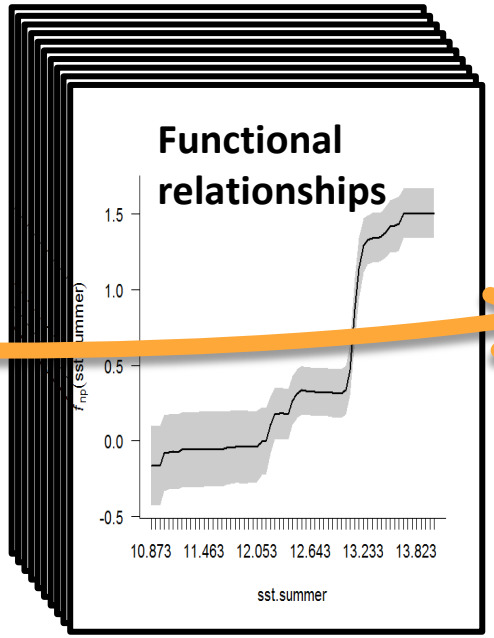
Observed counts



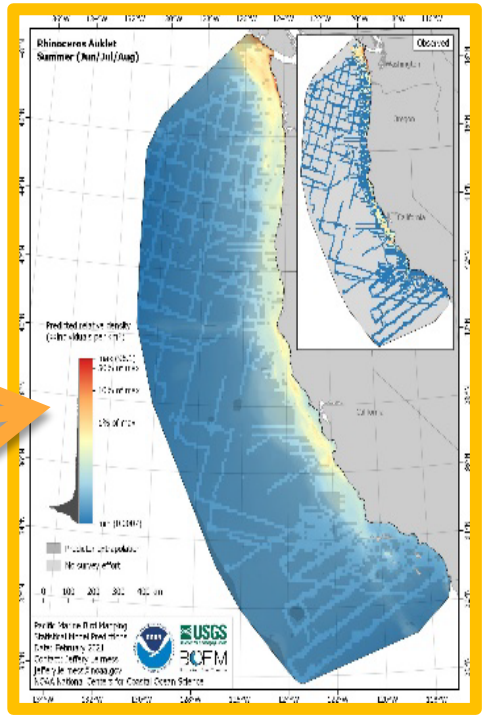


Environmental variables

Functional relationships

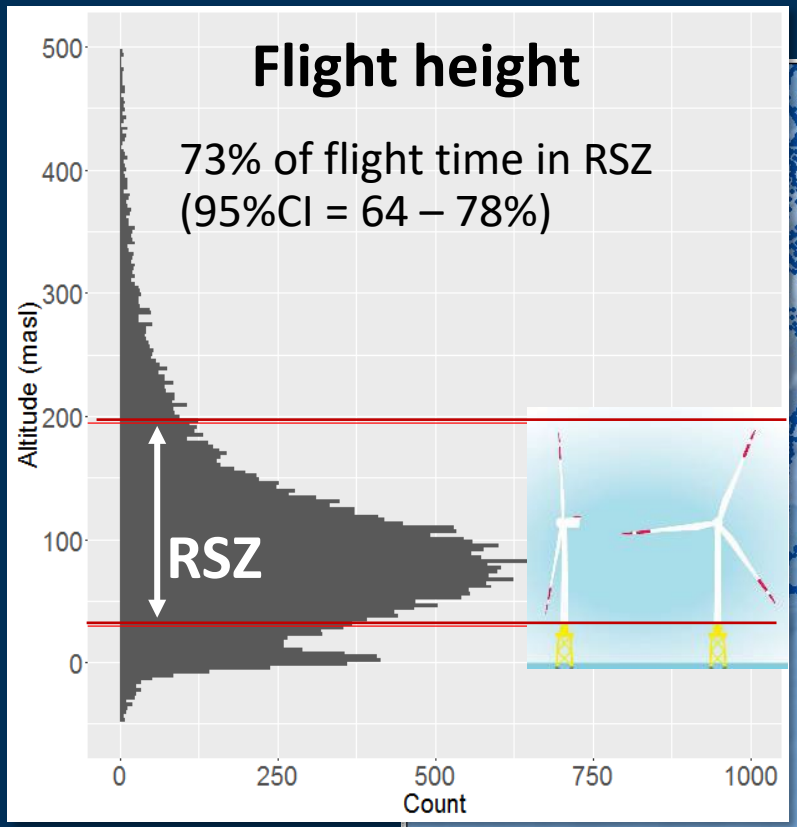


Predicted density

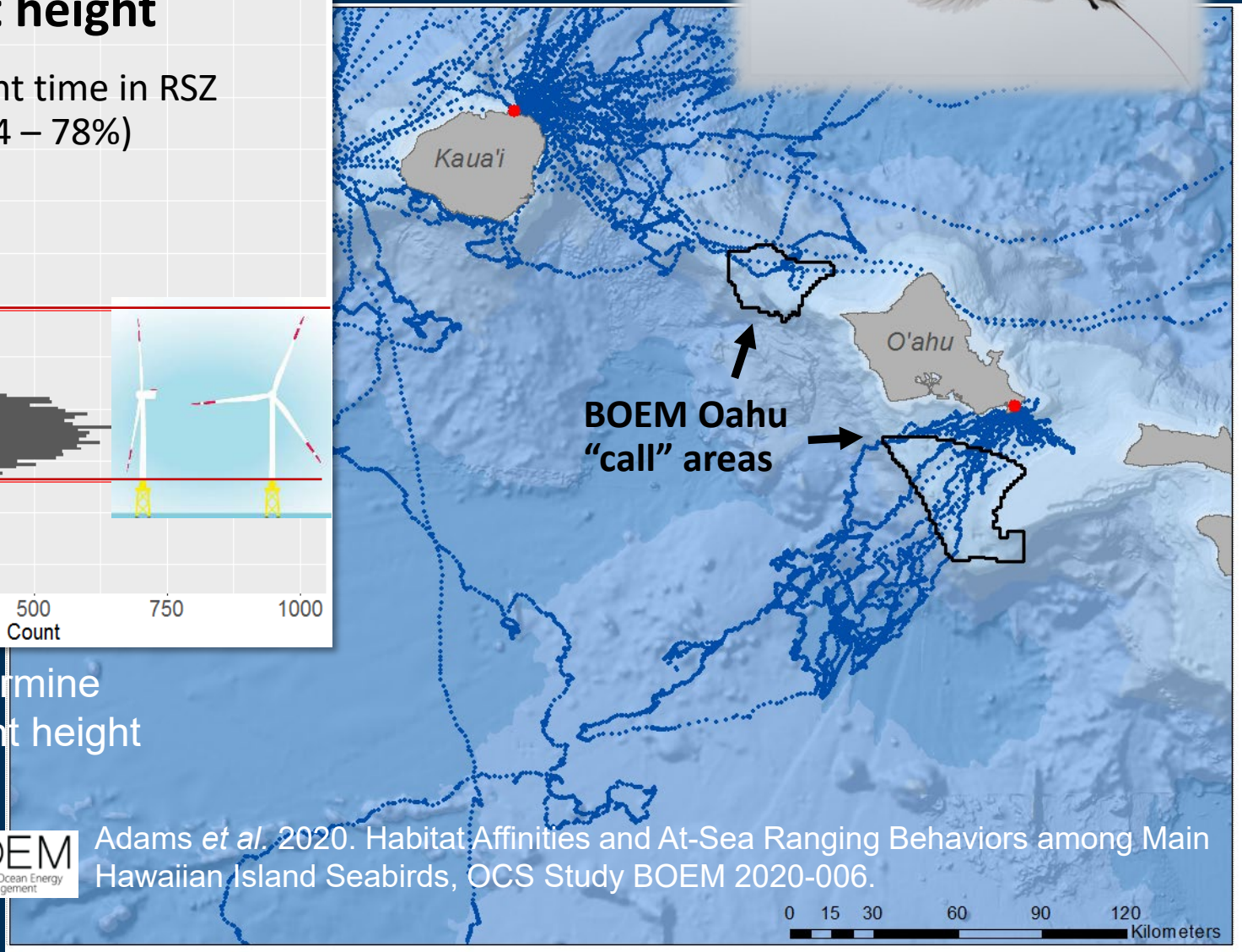


Leirness *et al.* 2020, BOEM OCS Study Report

Tracking to assess displacement and collision risk (Pre-construction)



GPS data to determine behavior and flight height



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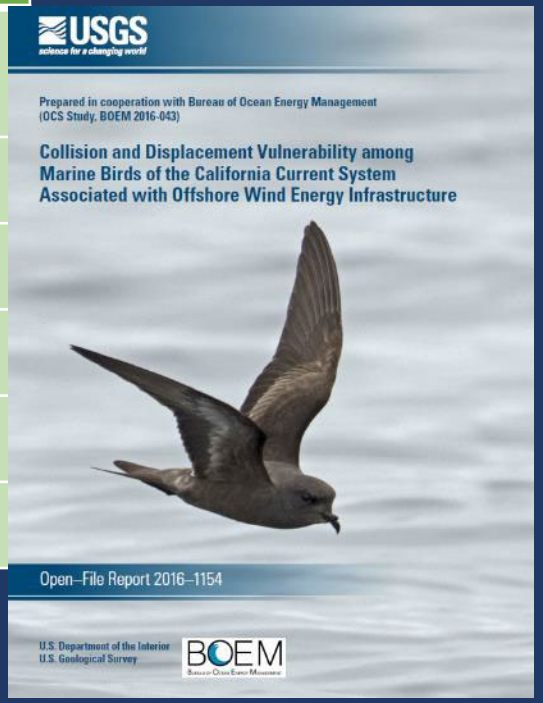
Adams *et al.* 2020. Habitat Affinities and At-Sea Ranging Behaviors among Main Hawaiian Island Seabirds, OCS Study BOEM 2020-006.

Seabird vulnerability to OWEI in the CCS (Pre-construction)

(81 marine bird species; REVISION IS FORTHCOMMING!)

Population Vuln		Collision Vuln		Displacement Vuln	
POP	Global Population Size	AO	Annual Occurrence (hrs. in CCS)	MA	Macro-Avoidance of Wind Turbines
CCSpop	Proportion of Pop in CCS	NFA	Nocturnal Flight Activity	HF	Habitat Flexibility
TR	Threat Status	DFA	Diurnal Flight Activity	AO	Annual Occurrence (hrs. in CCS)
AS	Adult Survival	RSZt	Percent Time in RSZ	BR	Breeding and Feeding time in CCS
		MA	Macro-Avoidance of Wind Turbines		
		BR	Breeding & Feeding time in CCS		



[e.g.] *Collision Vulnerability* =

$$AO \times \frac{(NFA \pm NFAu) + (DFA \pm DFAu)}{(RSZt \pm RSZtu)} \times ((MA \pm MAu) \times BR)$$

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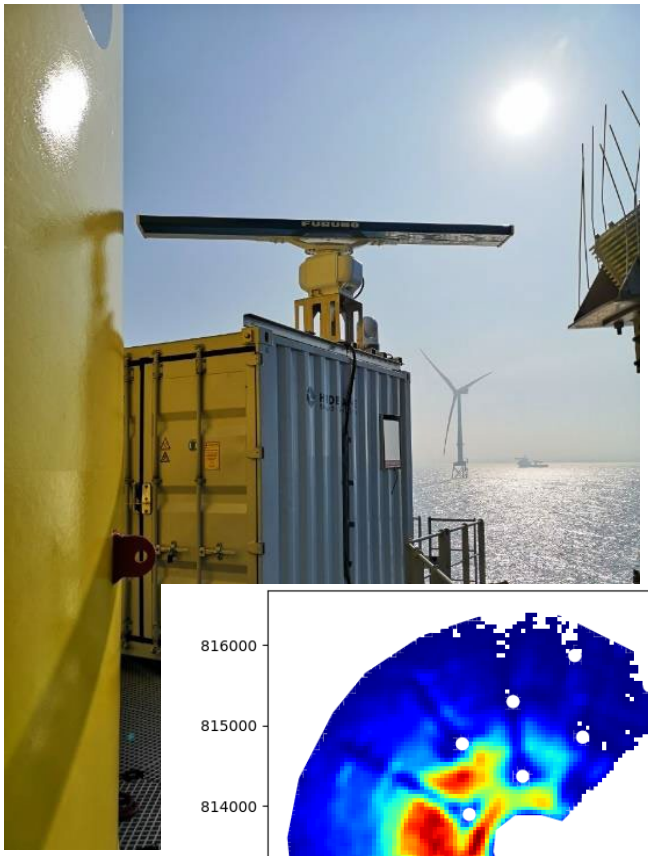
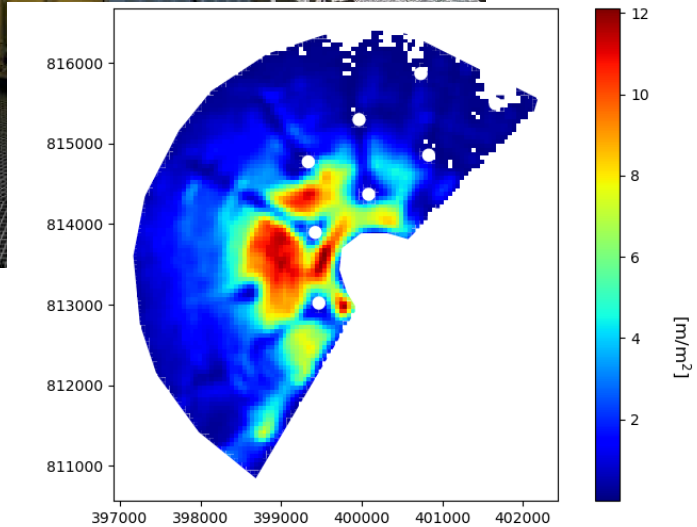
Adams et al. 2016, Kelsey et al. 2018 *Journal of Environmental Management*

Collision vulnerability (Post-construction)

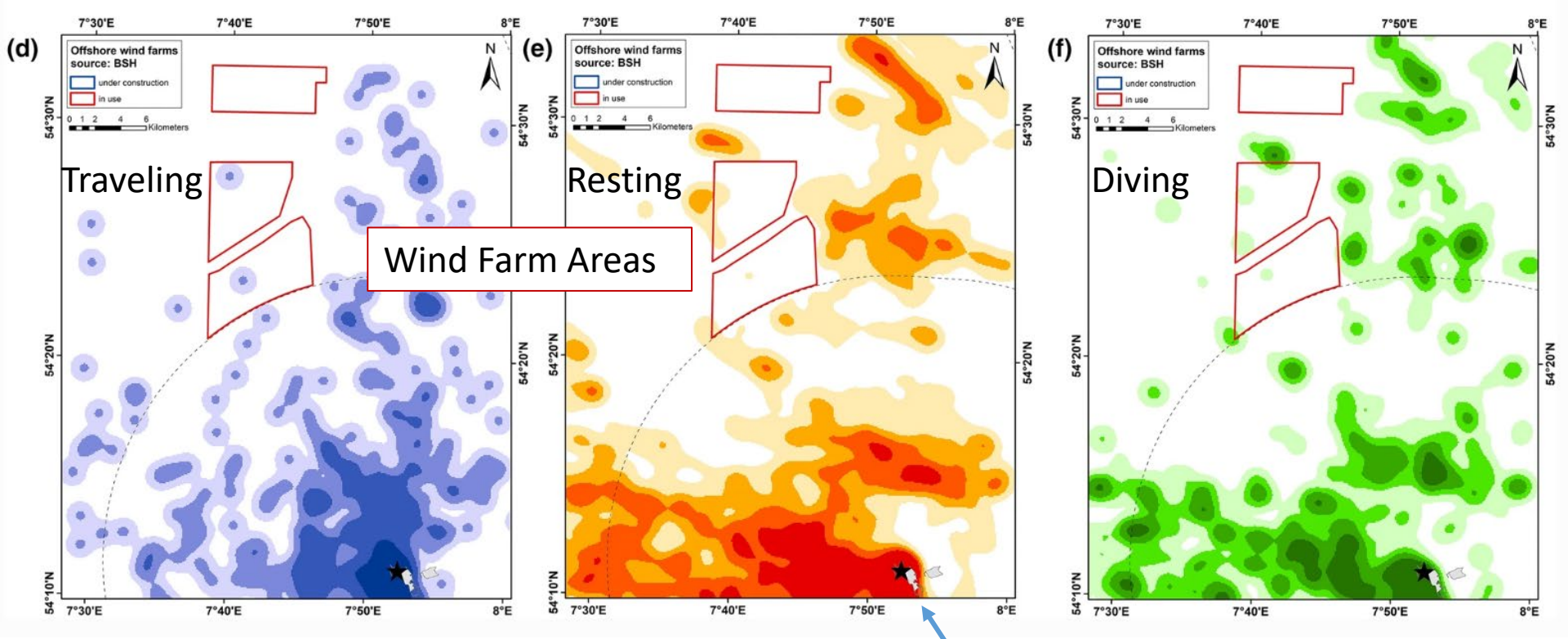




- gannets, kittiwakes, large gulls
- diurnal flight activity during breeding/post-breeding in 2020 and 2021
- meso-avoidance: 50-70% (windfarm footprint area)
- micro-avoidance: >96% (w/in 10m of RSZ)
- low risk of collision during day (no collisions or narrow escapes observed) – less known about night and inclement weather

Cox & Larsen 2023, Resolving Key Uncertainties of Seabird Flight and Avoidance Behaviours at Offshore Wind Farms

Displacement vulnerability (Post-construction)



Murre colony, island of Helgoland, North Sea

Peschko *et al.* 2020, *Marine Biology*

Existing data gaps moving forward

- OWE Infrastructure and its distribution at sea?
  - Number turbines, spacing, rotor sweep zone, blade height ASL, base architecture (roosting)?
  - Lighted activities at sea during construction, maintenance, and operation
  - Instrumentation/systems for monitoring infrastructure and wildlife
- At-sea surveys to inform seabird abundance changes (site-specific BAG designs) and monitoring for demographic rates/pop trends

WindFloat Atlantic
Horns Rev 2 Denmark Bob Strong Reuters
Block Island Wind Farm near Rhode Island (Ørsted)

Adams *et al.* 2019. Synopsis of Research Programs that can Provide Baseline and Monitoring Information for Offshore Energy Activities in the Pacific Region, BOEM OCS Study BOEM 2019-042.

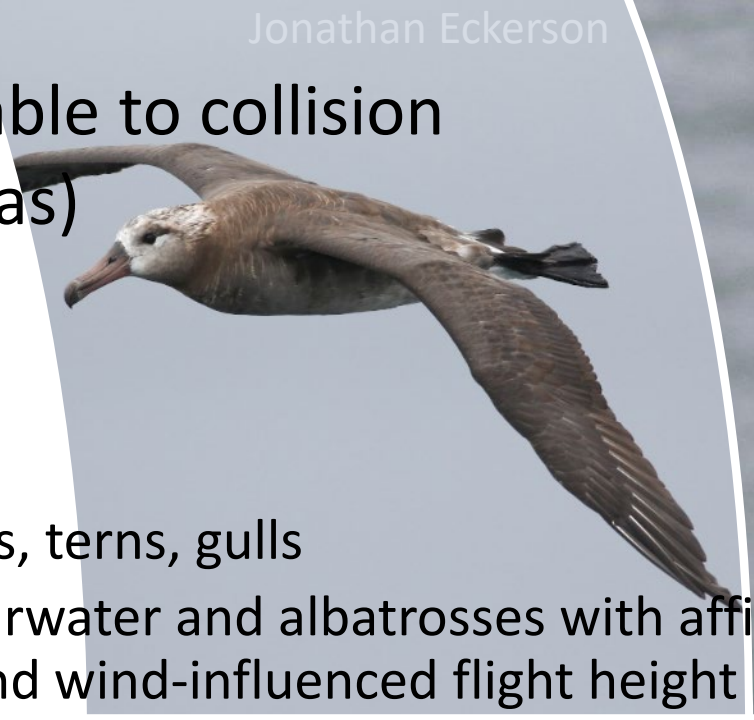
Species vulnerable to displacement (specific to lease area)

Ian Davies

Existing data gaps moving forward

- Three southern murrelet species in winter (Scripps's, Guadalupe, Craveri's)
- Endemic Ashy Storm-Petrel (esp. southern area)
- Breeding Leach's Storm-Petrel (northern lease area)
- Breeding Common Murre (northern lease area)

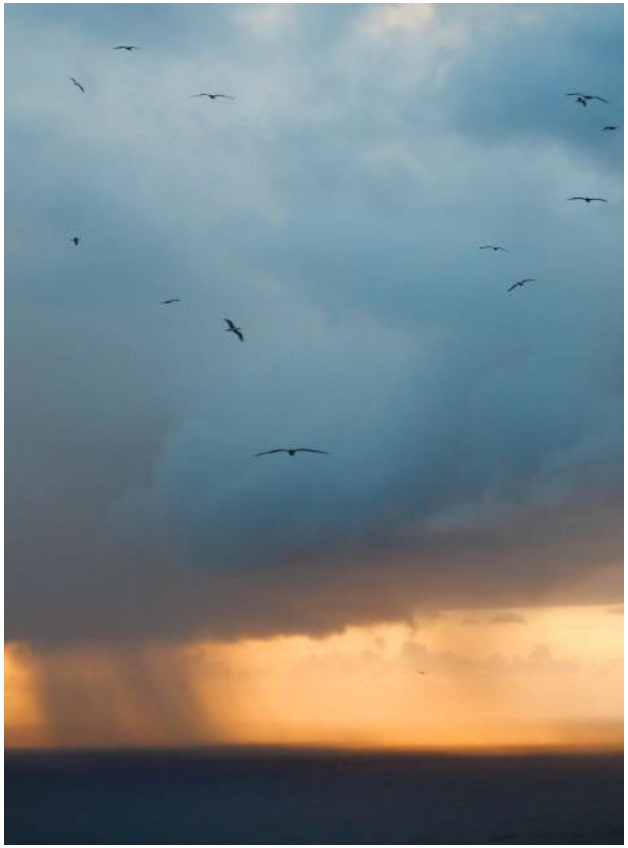
Species vulnerable to collision (both lease areas)



- Migratory jaegers, terns, gulls
- Pink-footed Shearwater and albatrosses with affinities for outer shelf and wind-influenced flight height

Existing data gaps moving forward

Thank you!



Happy to share ideas and answer questions!