

Forecasting the flock: using species distribution models to evaluate the effects of climate change on future seabird foraging aggregations in the California Current System

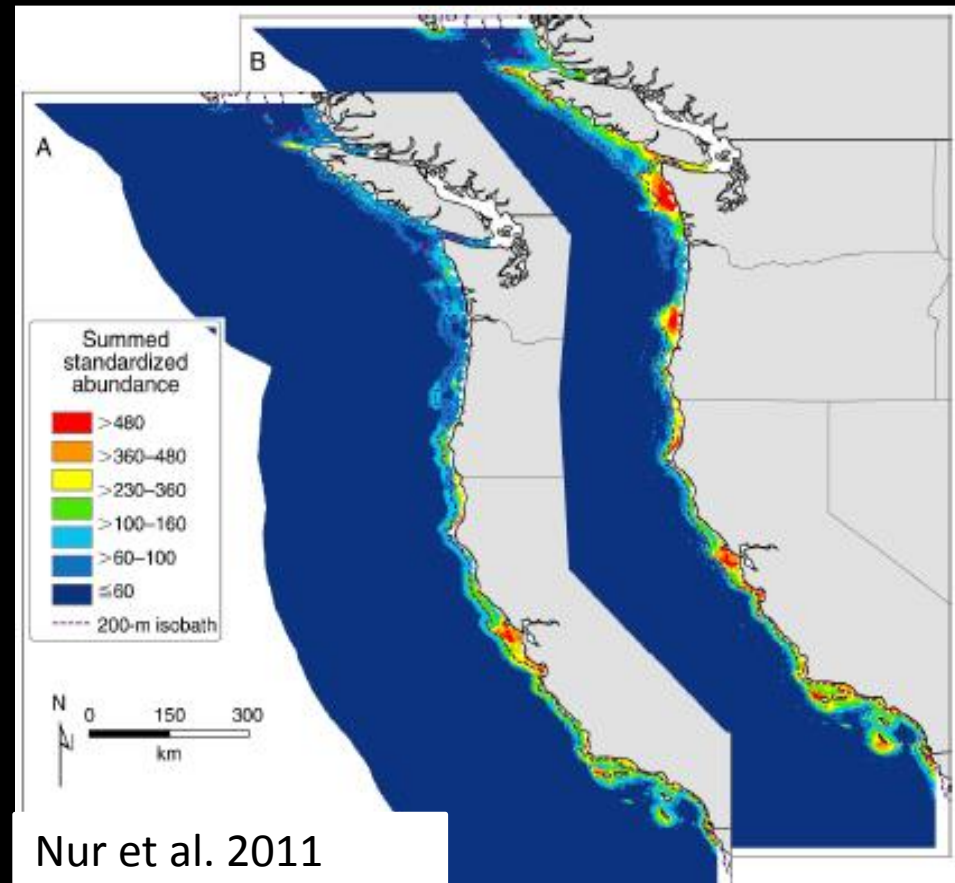
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Motivation for Study

- 2011 multispecies “hotspot” study

- Modeled 16 species, few pelagic
- Coastal hotspots, no pelagic areas
- Large data gaps, esp. OR & WA



Questions



www.wildbirdgallery.com/images/birds/phoceania_nigripes_nigripes_1892.jpg

1. How do multispecies foraging aggregations (hotspots) shift with increasing ocean temperature?
2. How might different species be affected to climate-related changes?

Seabirds

- Conspicuous marine predators
- Threatened marine group
- Important indicators of marine ecosystem status



<http://www.birdphotography.com/species/photos/caau-6.jpg>



<http://cornforthimages.com/product-category/wildlife/birds/puffins/tufted-puffin/>



Dori Dick

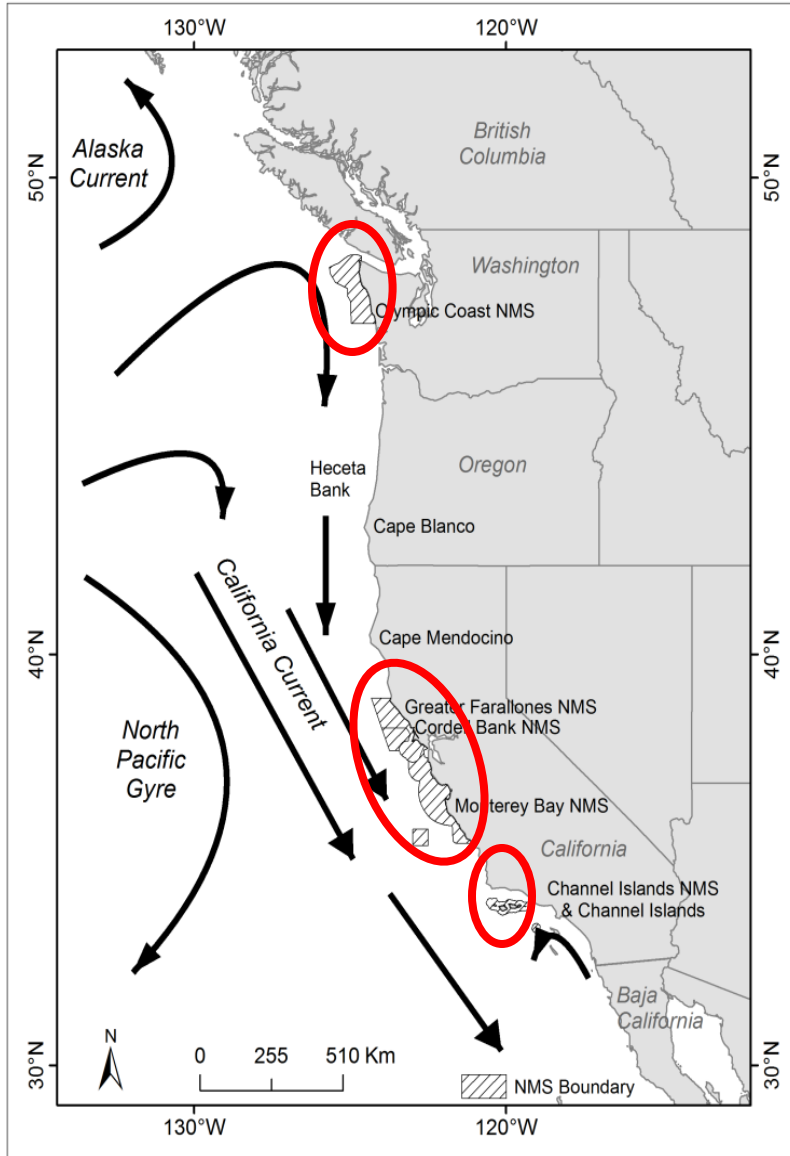


<http://www.birdphotography.com/species/photos/sagu-9.jpg>



http://s3.amazonaws.com/birdfellow-production/content/bird_photos/000/001/897/identification/Common_Murre_-32.jpg?1264519525

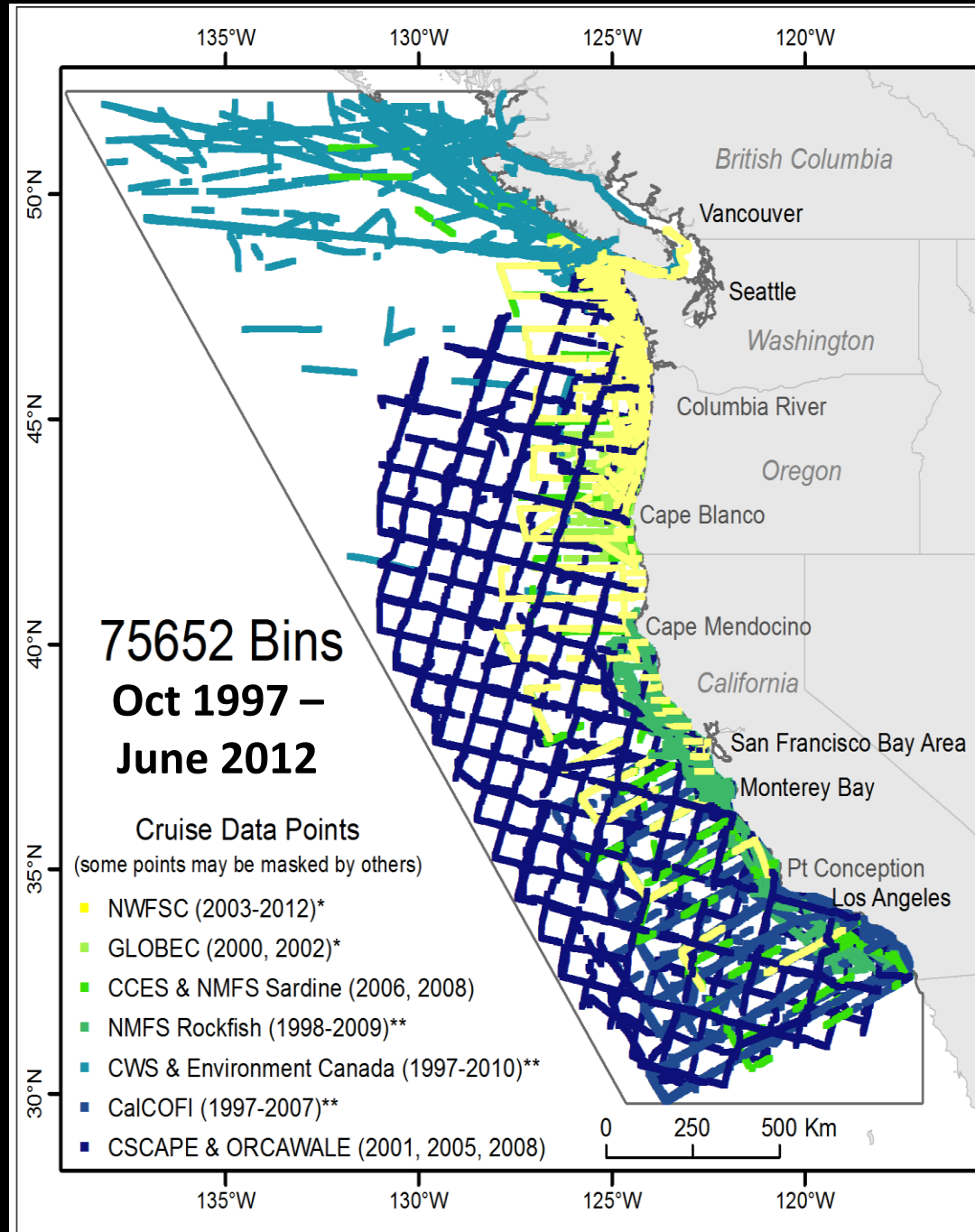
California Current System



- Eastern boundary current system
- Spring/summer upwelling, high productivity
- 5 federally protected national marine sanctuaries

Seabird Data

- At-sea transects divided into 3km segments (bins)
- Bin midpoints aggregate seabird counts by species
- Doubled data – bins and species



Environmental/Climate Predictors



<http://www.glennbartley.com/>

Physical

- Average depth (m)
- Contour Index (topographic relief, %)
- Distance to land
- Distance to 200m, 1km, 3 km isobaths

Remotely Sensed

- Chlorophyll-a conc. (mg/m^3)
- Sea Surface Height (m)
- Sea Surface Temperature ($^{\circ}\text{C}$)

Effort

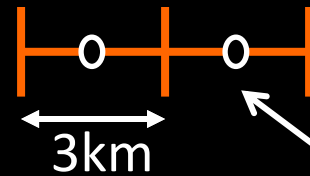
- Bin area

Climate Indices

- SOI
- NPGO
- PDO

Other Temporal/Spatial

- Year
- Month
- Day
- Latitude
- Spring Transition Anomalies



All data aggregated to bin midpoints

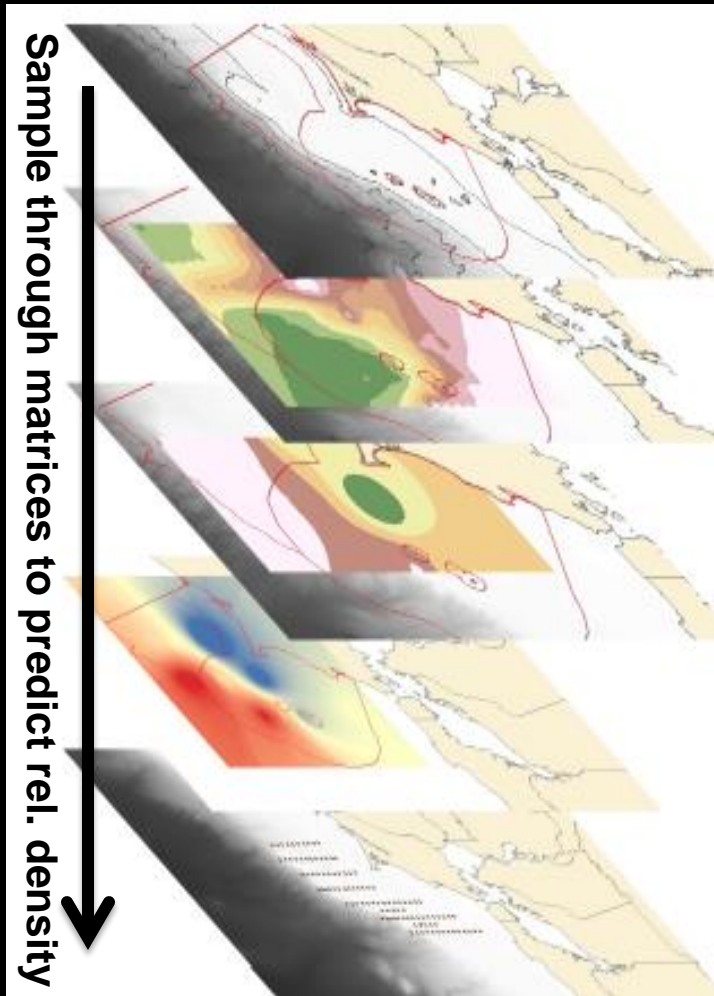
Statistical Model Development & Predictive Modeling

- Negative binomial regression
- 30 species: coastal and pelagic species locally breeding and migratory species



[http://www.audubon.org/sites/default/files/styles/hero_cover_bird_page/public/Red-necked%20Phalarope%](http://www.audubon.org/sites/default/files/styles/hero_cover_bird_page/public/Red-necked%20Phalarope%20.jpg)

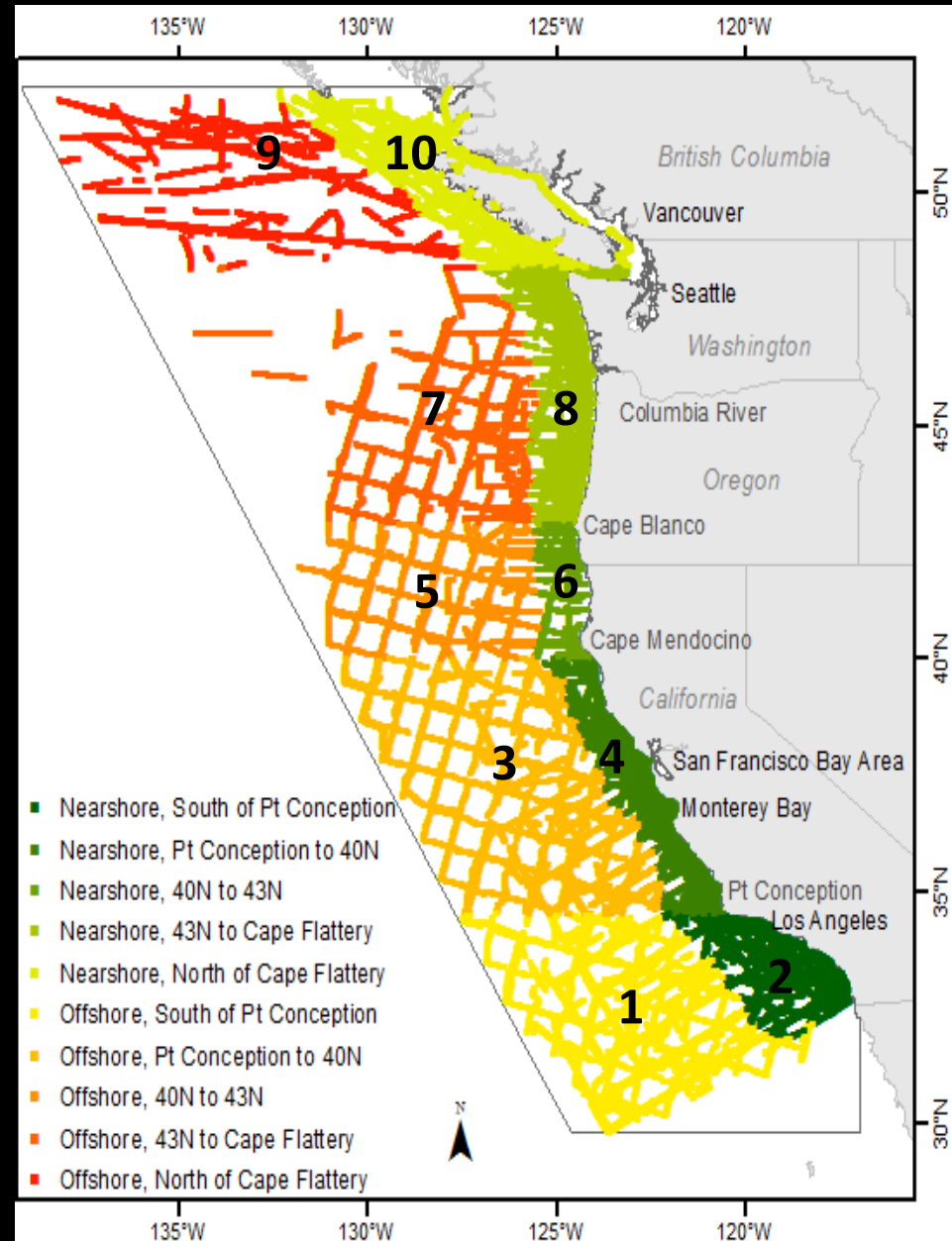
Statistical Model Development & Predictive Modeling



- February (winter), May (spring), July (summer), October (fall)
- Rel. densities standardized, averaged by month

Developing Future Scenarios

- 10 regions



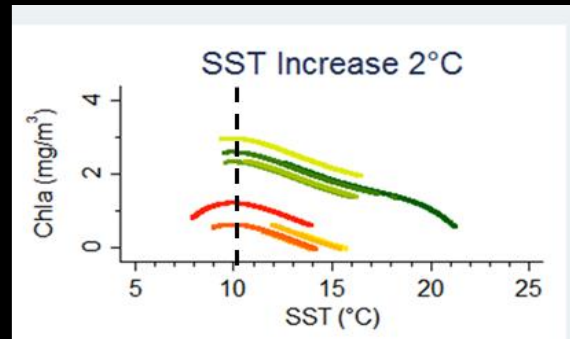
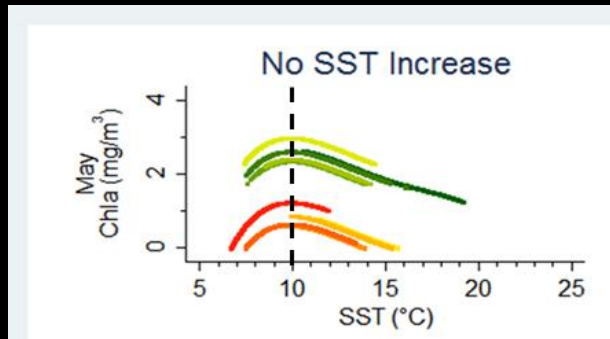
Developing Future Scenarios

- Assessed relationship between SST and SSH or Chla to predict future SSH and Chla

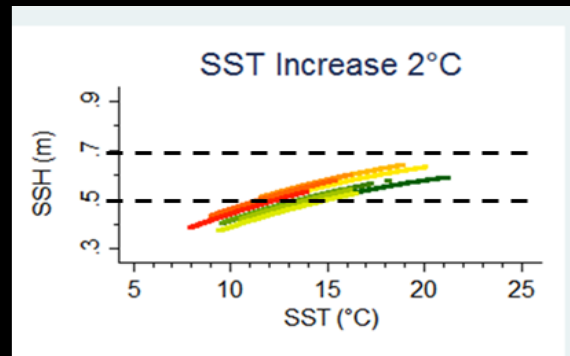
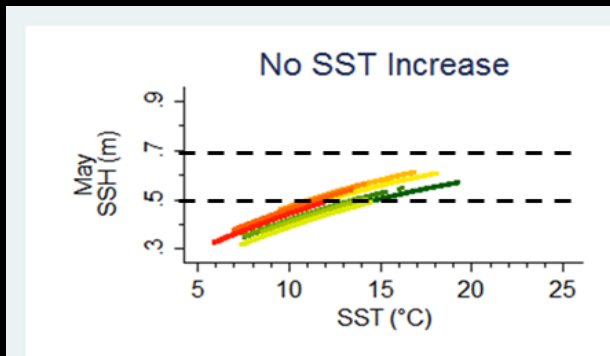
No SST Increase

2°C SST Increase

Chla



SSH



SST

“Best estimates of ocean warming in the top one hundred meters are about 0.6°C (RCP2.6) to 2.0°C (RCP8.5)”

-- IPCC AR5 report

Future Scenario Predictions

Increase SST

Predict future SSH and Chla



Predict future species distributions



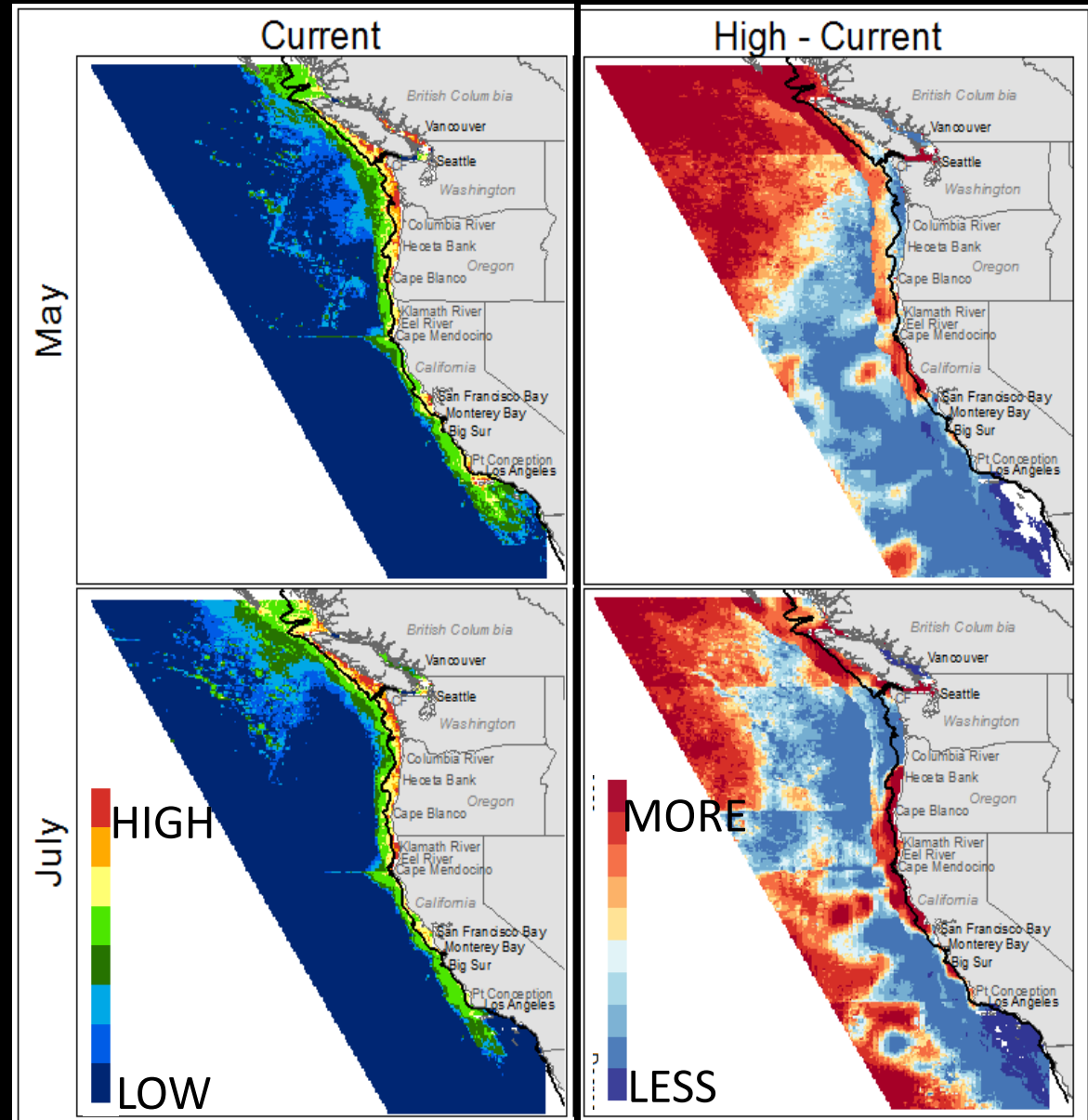
Group species based on estimated sensitivity to changing seascape

Diving vs. Surface Feeders

Results: Divers (Rel. Density & Difference Maps)

Suitable habitat

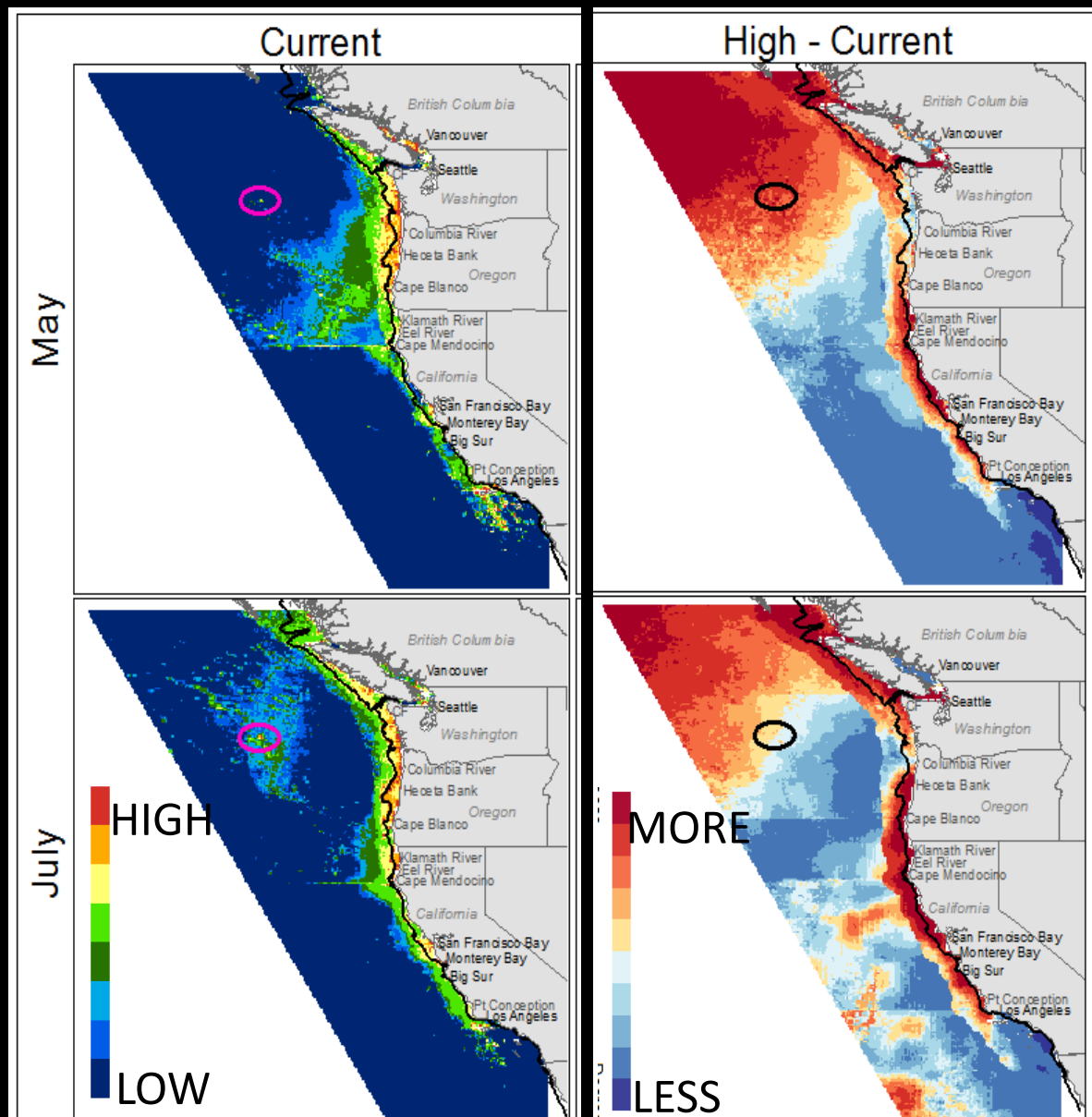
- ↓ within 200m
- ↓ in south
- ↑ beyond 200m
- ↑ along northern CA, southern OR, north of Van. Island



Results: Surface Feeders (Rel. Density & Difference Maps)

Suitable habitat

- ↑ beyond 200m
- ↑ along CA, southern OR, west of Van. Island
- Cobb Seamount retains suitability

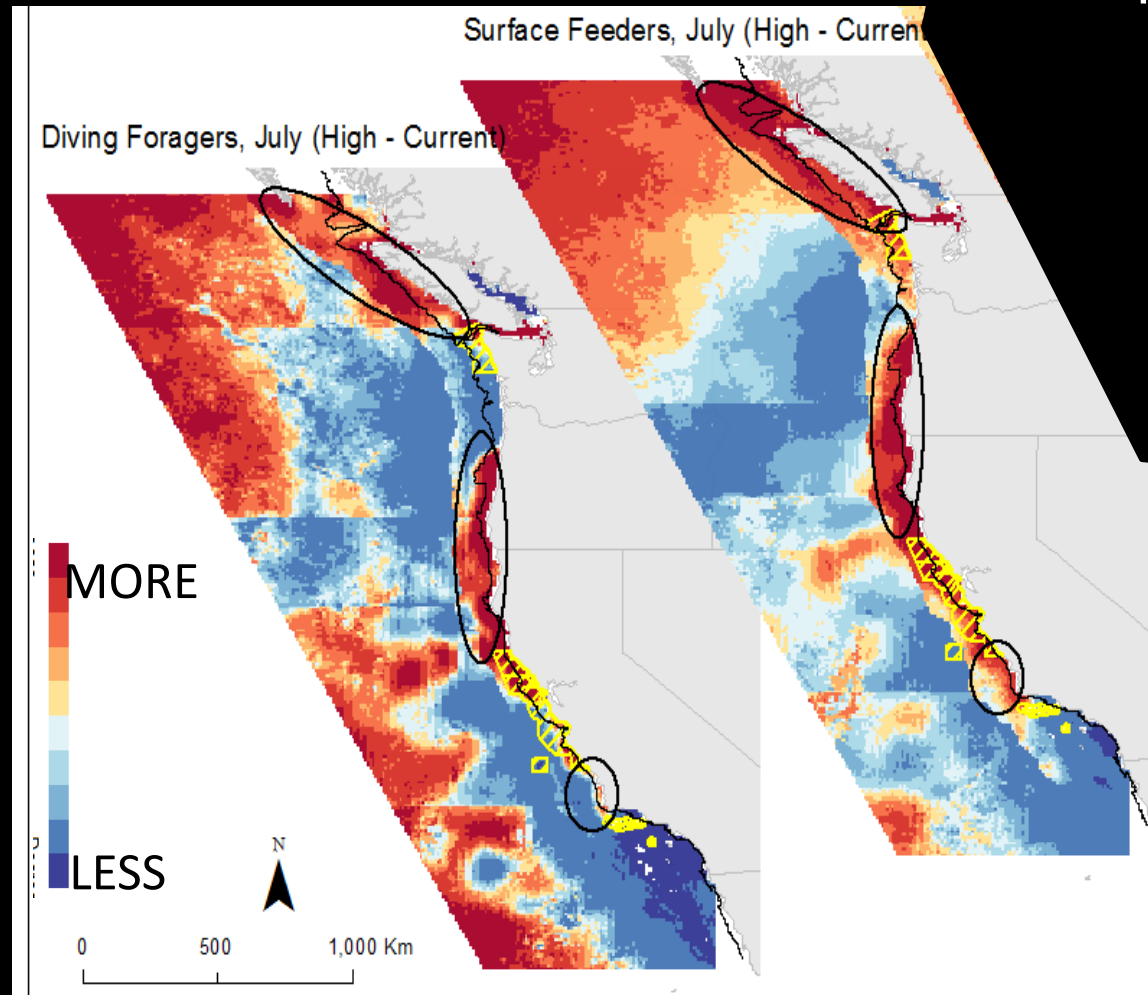


BRPE, CAGU, CATE, FTSP, LESP, LTJA, PAJA, REPH

Future Suitable Habitat & National Marine Sanctuaries

Projected future suitable habitat:

- Some NMS will remain suitable
- Some NMS will become ↓ suitable
- Some areas without protection will become ↑ suitable in the future



Summary

- Offshore and northward shifts
- Suitable habitat ↓ within 200m isobath
- Divers and surface feeders sensitive to climate related changes, esp. year-round residents and breeders
- Cobb Seamount may retain suitable habitat



Bob Whitney/BirdNote



<http://animalspartner.blogspot.com/2015/01/storm-petrel.html>

Caveats and Conclusions

- Models are representations of reality
 - Statistical correlations
 - Non-stationary relationships
 - No consideration of intra- or inter-species interactions, adaptation etc.
- Climate-related changes are leading to novel conditions, responses will be difficult to predict
- Initial step in understanding magnitude and direction underlying projected changes in seabird habitat in CCS



<http://www.fws.gov/alaska/mbsp/mbm/seabirds/images/Common-murres.jpg>

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My co-authors

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Environment and Climate Change
Canada



Questions?

