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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Point Blue Conservation Science

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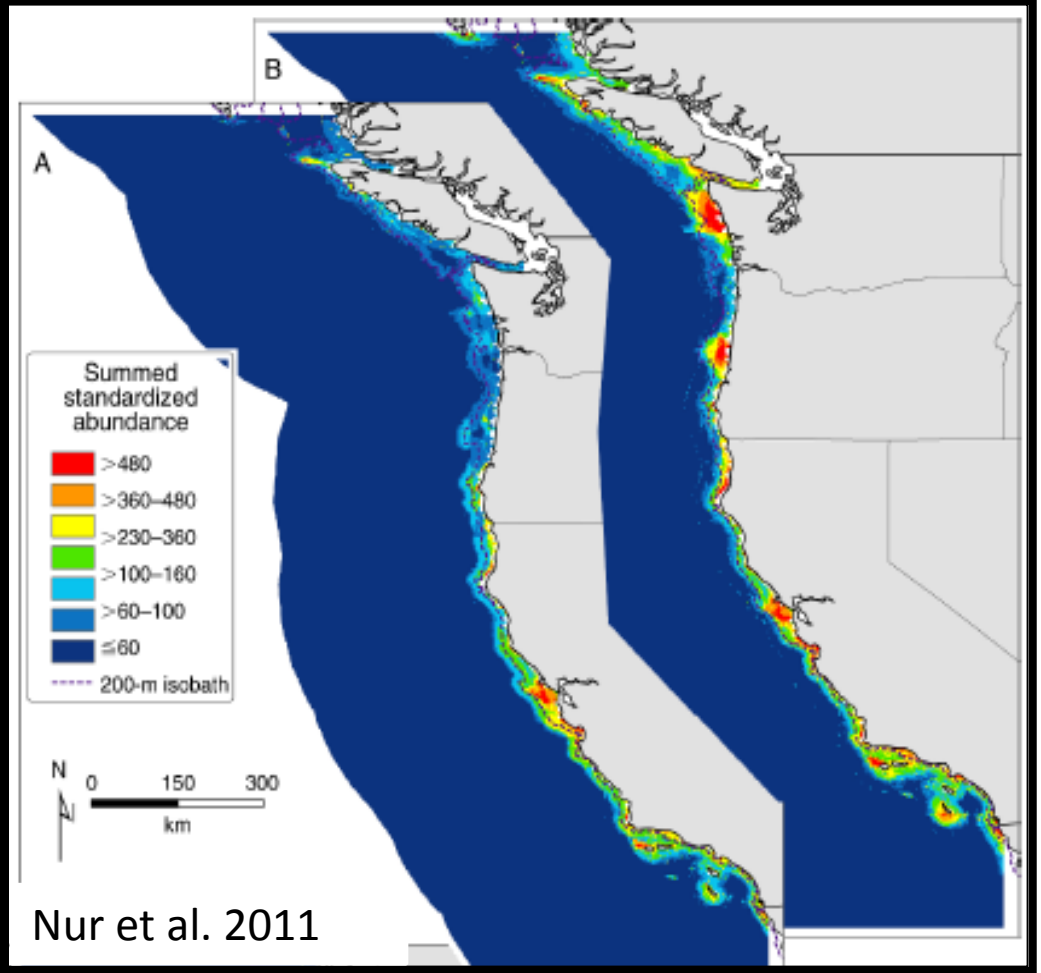
Knauss Brown Bag, NOAA Central Library

Oregon State University | CEOAS College of Earth, Ocean, and Atmospheric Sciences

Motivation for Study

- 2011 multispecies “hotspot” study

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



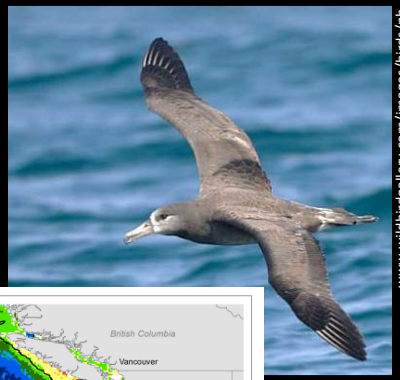
Nur et al. 2011

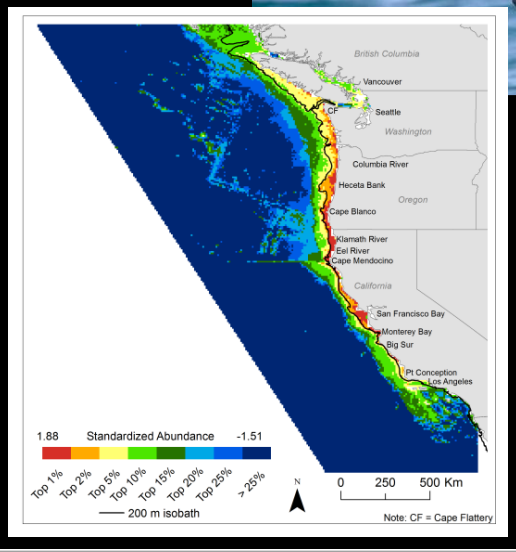
Questions

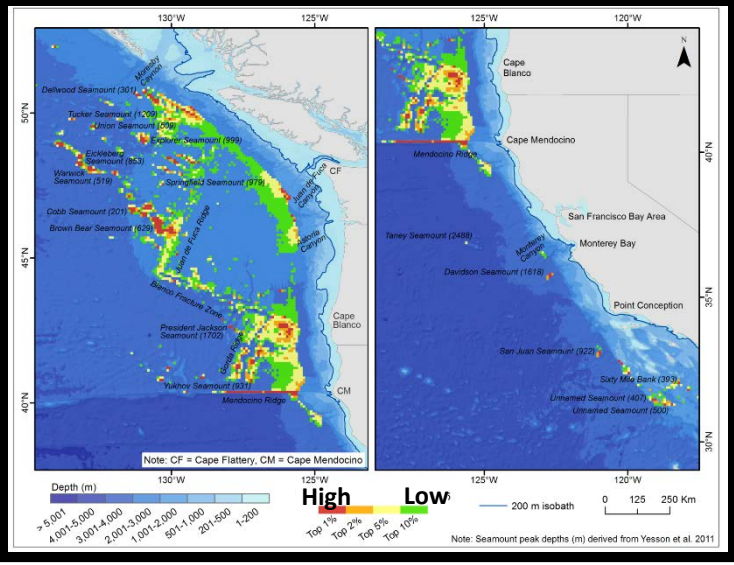
1. How do multispecies foraging aggregations (hotspots) shift with increasing ocean temperature?

2. How might different species be affected to climate-related changes?

3. Do seamounts, previously identified important habitat, retain suitable habitat in a warming ocean?







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/

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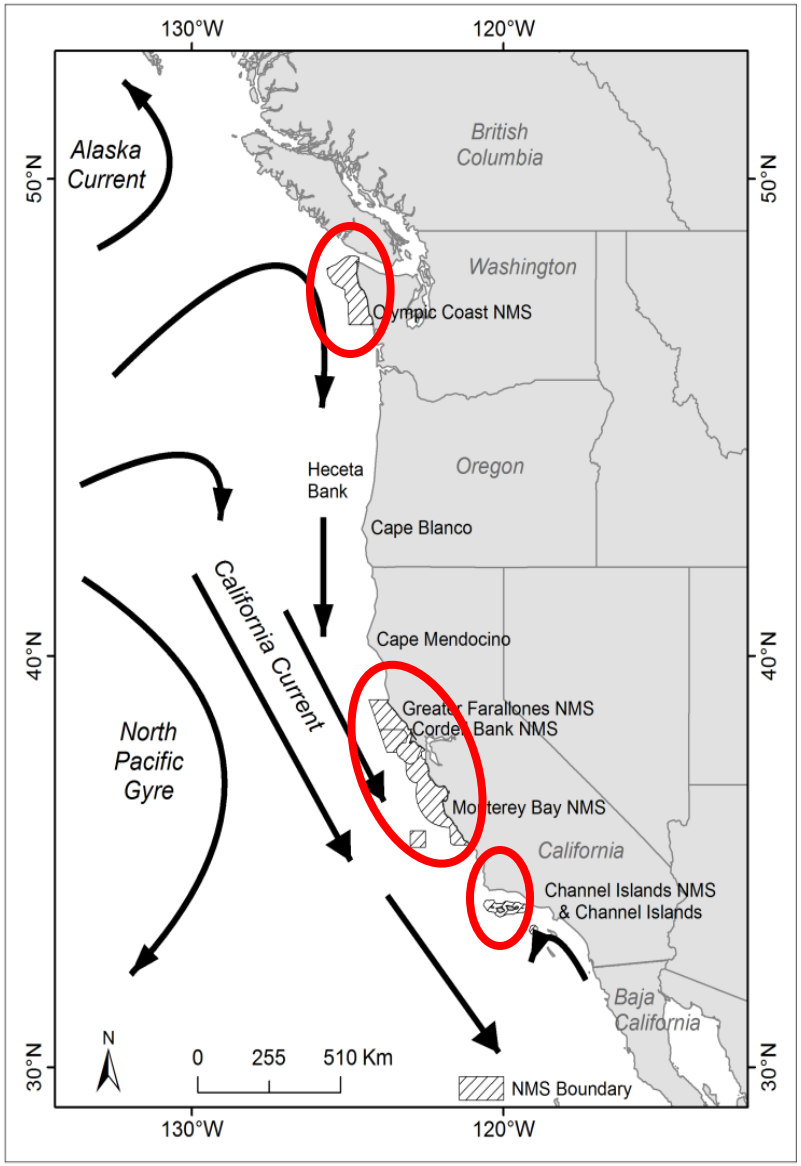
http://www.birdphotography.com/species/photos/sagu-9.jpg

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

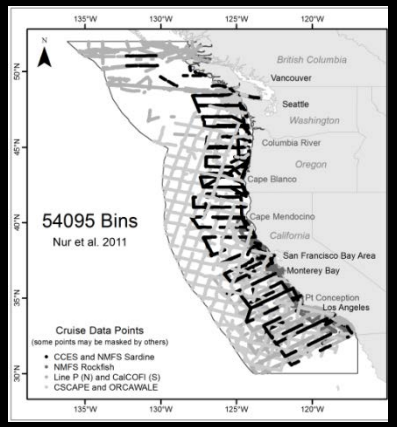
California Current System



- 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
- > 30% more data
  - bins
  - 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 (°C)

Effort

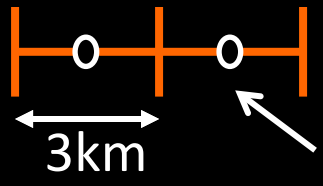
- Bin area

Climate Indices

- SOI
- NPGO
- PDO

Other Temporal/Spatial

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



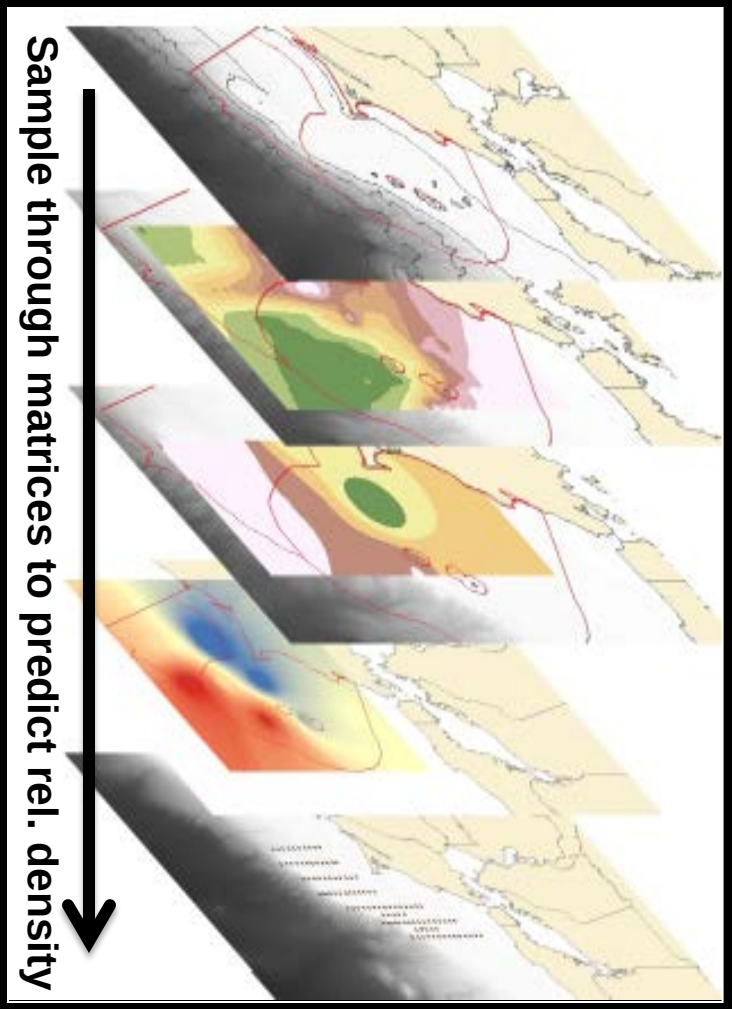
All data aggregated to bin midpoints

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%

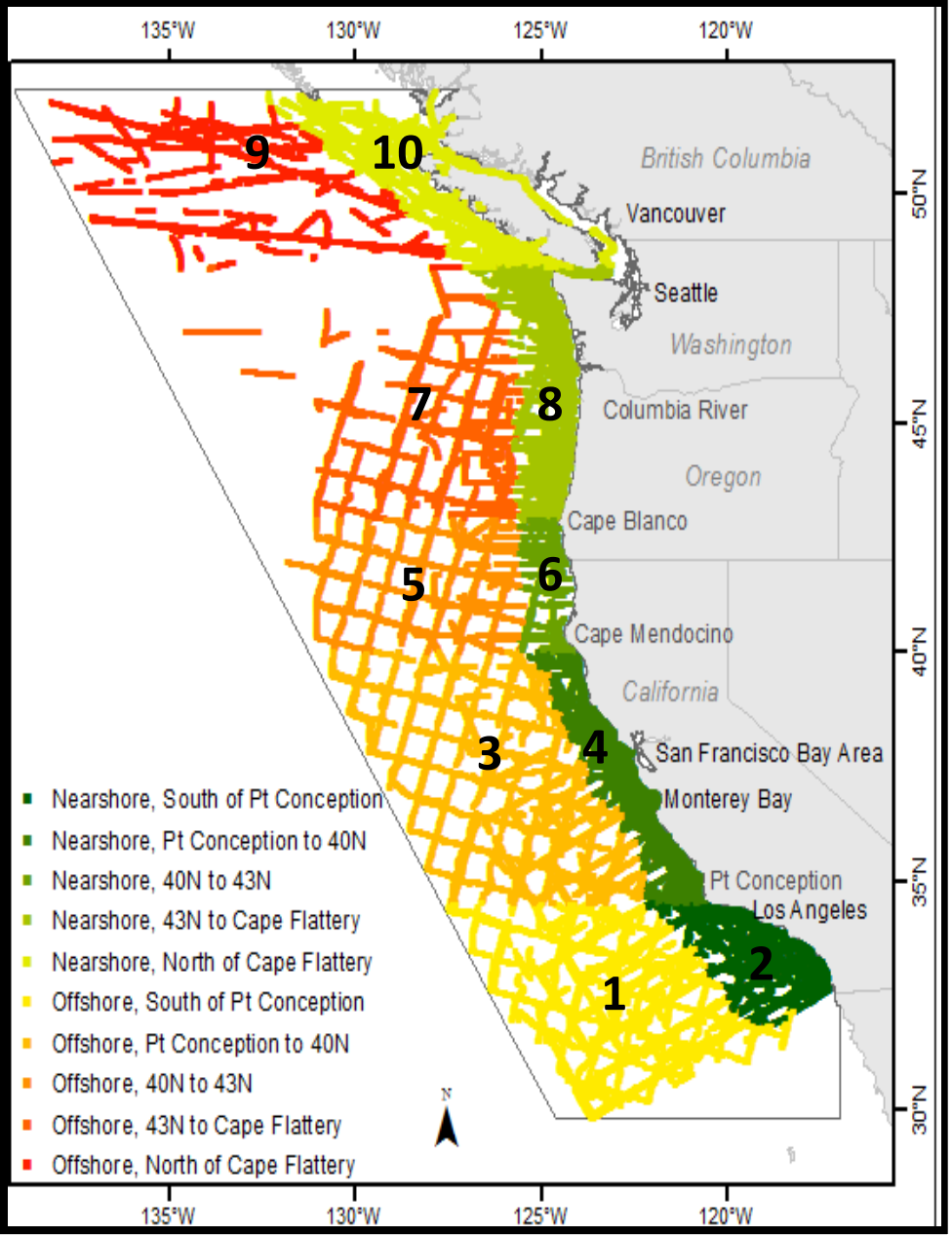
Statistical Model Development & Predictive Modeling



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

Developing Future Scenarios

- 10 regions

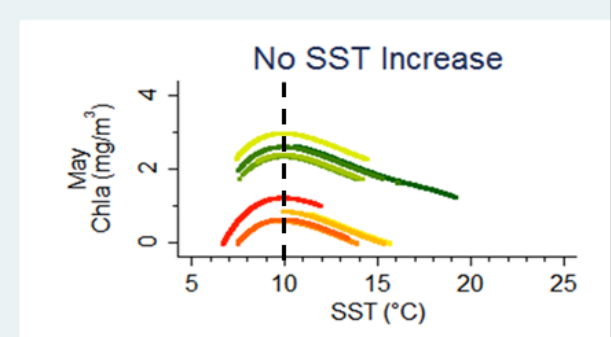


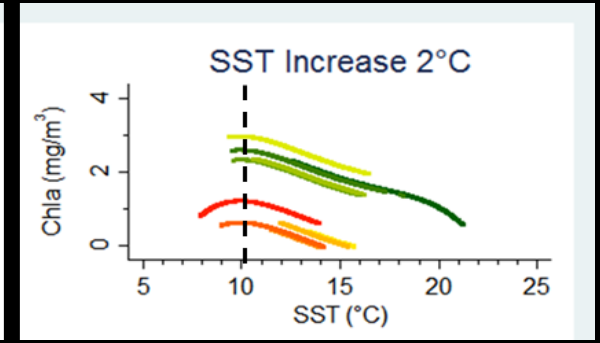
Developing Future Scenarios

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

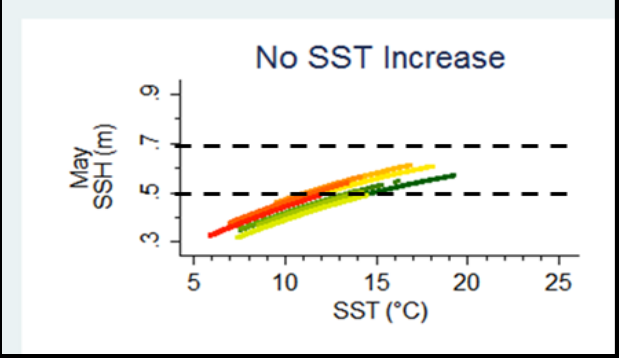
No SST Increase **2°C SST Increase**

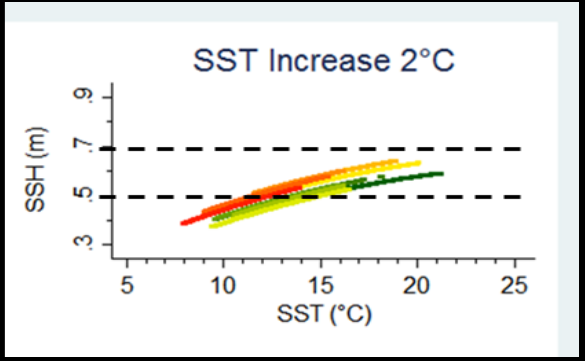
Chla





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

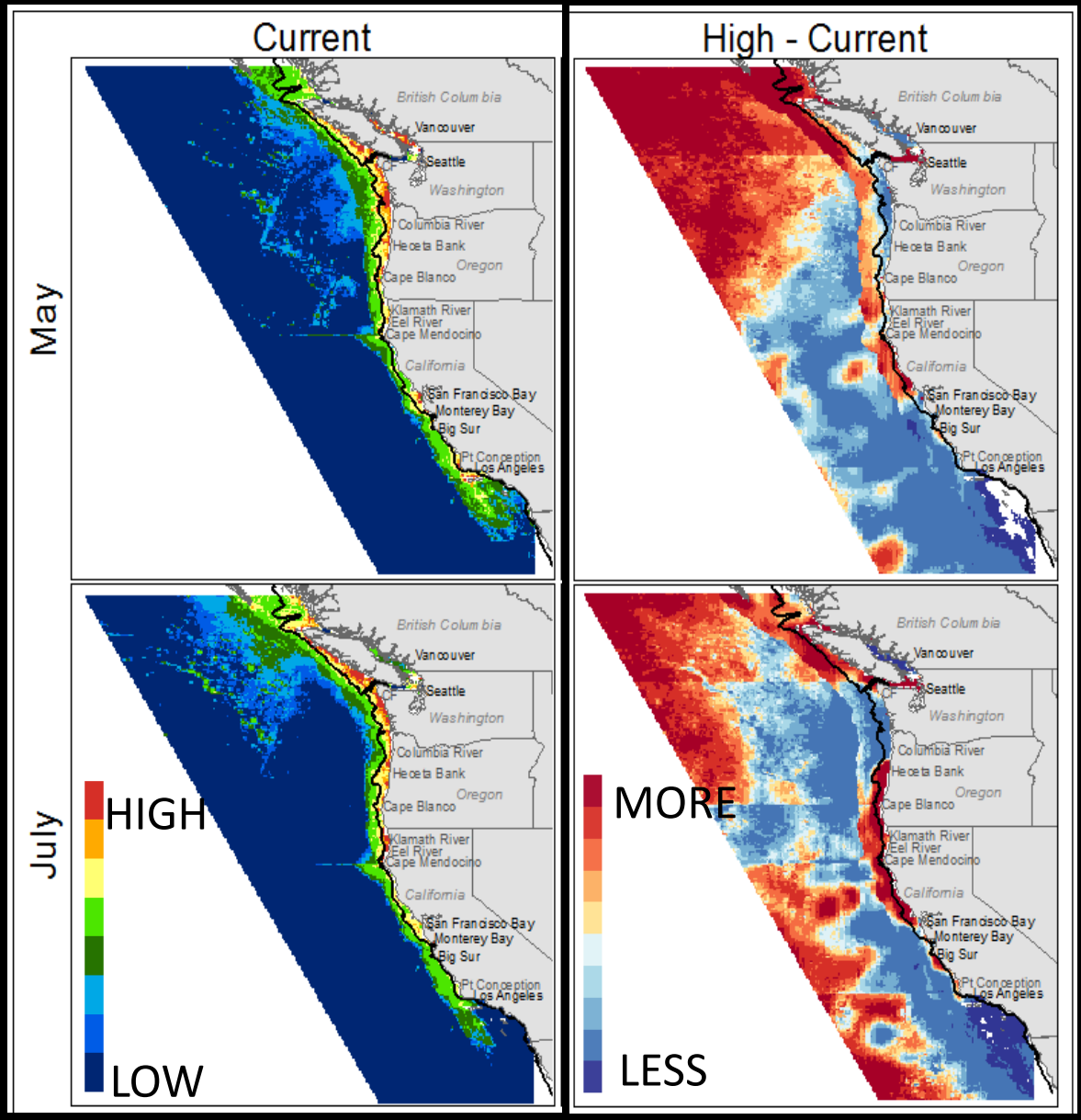
Group species based on estimated sensitivity to changing seascape

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

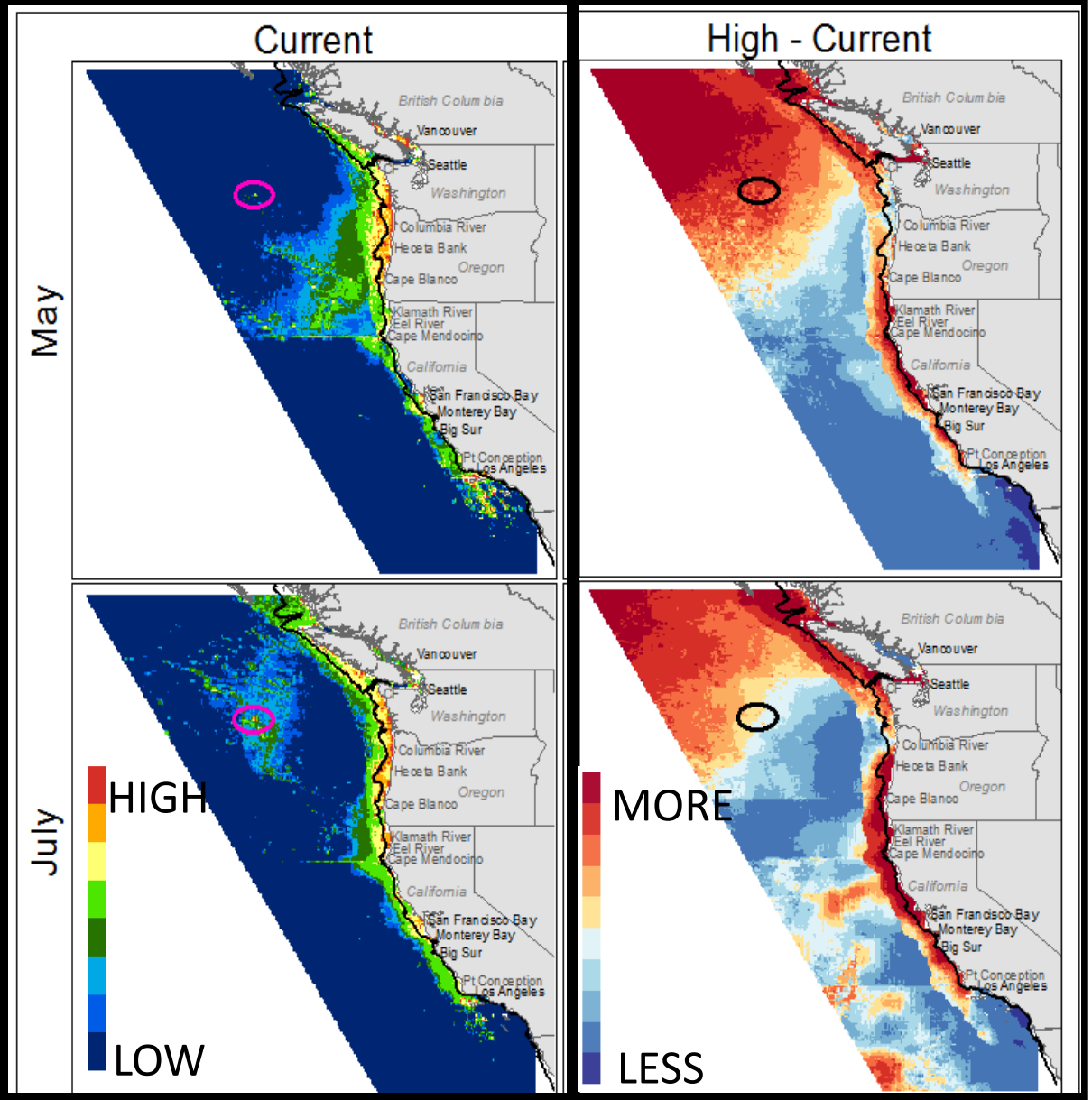


CAAU, NOFU, PALO, PFSH, SCMU, TUPU

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

Suitable habitat

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

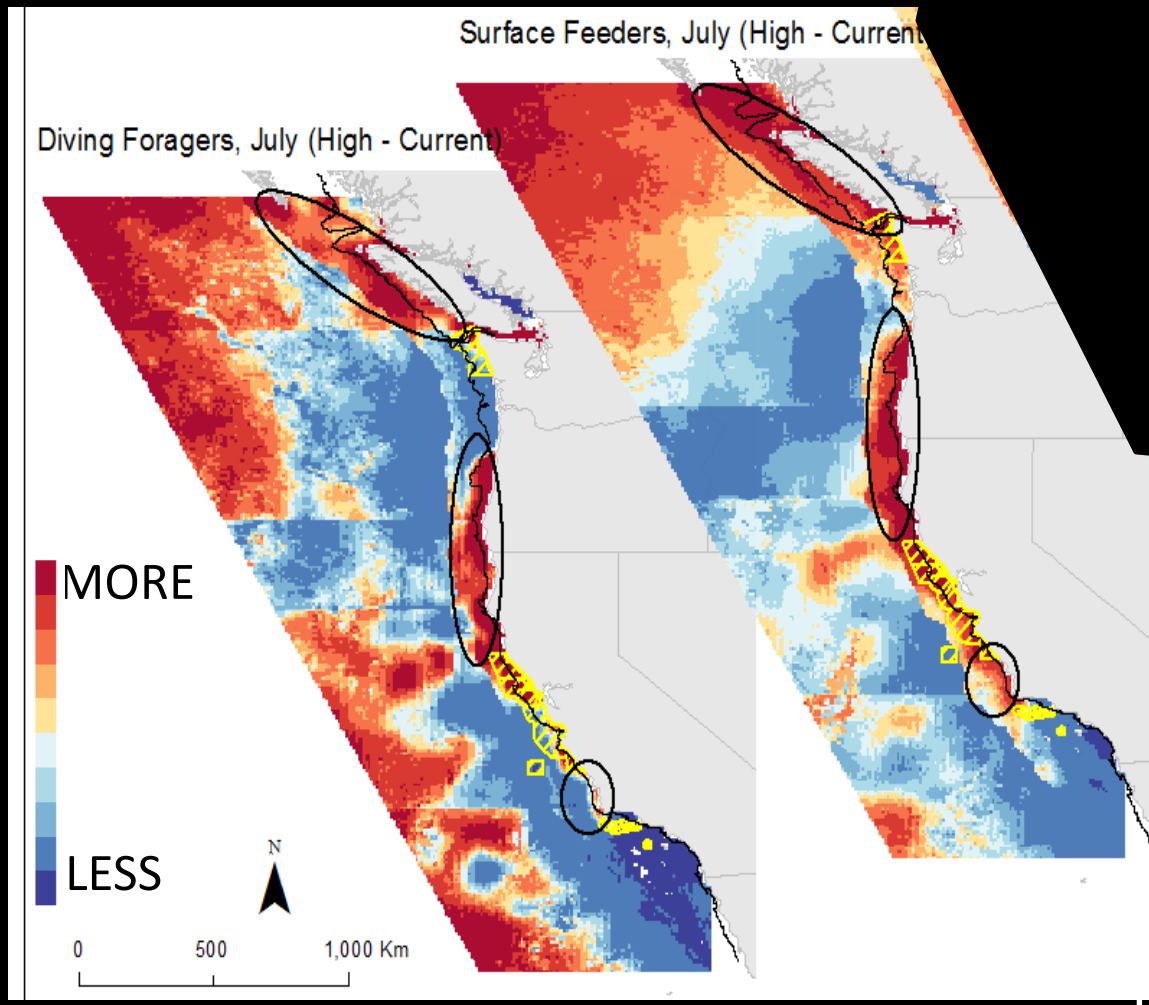


BRPE, CAGU, CATE, FTSP, LESP, LTJA, PAJA, REPH

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

How will hotspots shift?

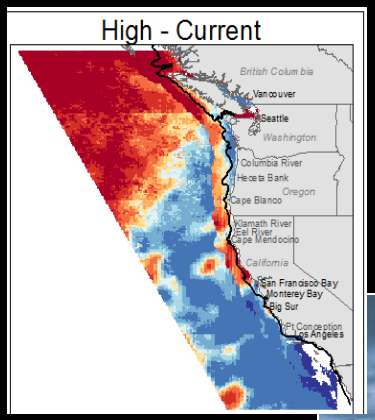
- Offshore and northward shifts
- Suitable habitat ⬇ within 200m isobath

Species differences?

- Divers and surface feeders sensitive to climate related changes, esp. year-round residents and breeders

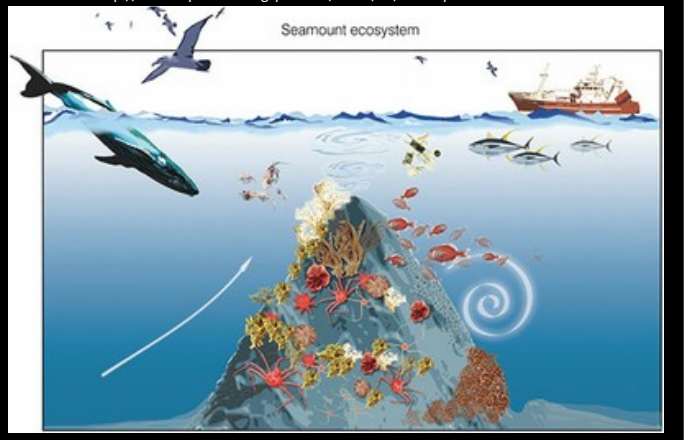
Seamounts?

- Cobb Seamount may retain suitable habitat



Bob Whitney/BirdNote

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



http://comlmaps.org/mcintyre/ch7/image_n/nfg002.jpg/image_preview

Caveats and Conclusions

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- 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

Unknown

Thank You to….

- Dawn Wright, Julia Jones
- Researchers involved with data collection
- My co-authors: J. Jahncke, N. Nur, J. Howar, J. Zamon, D. Ainley, K. Morgan, L. Ballance, and D. Hyrenbach
- Point Blue Conservation Science

Questions?

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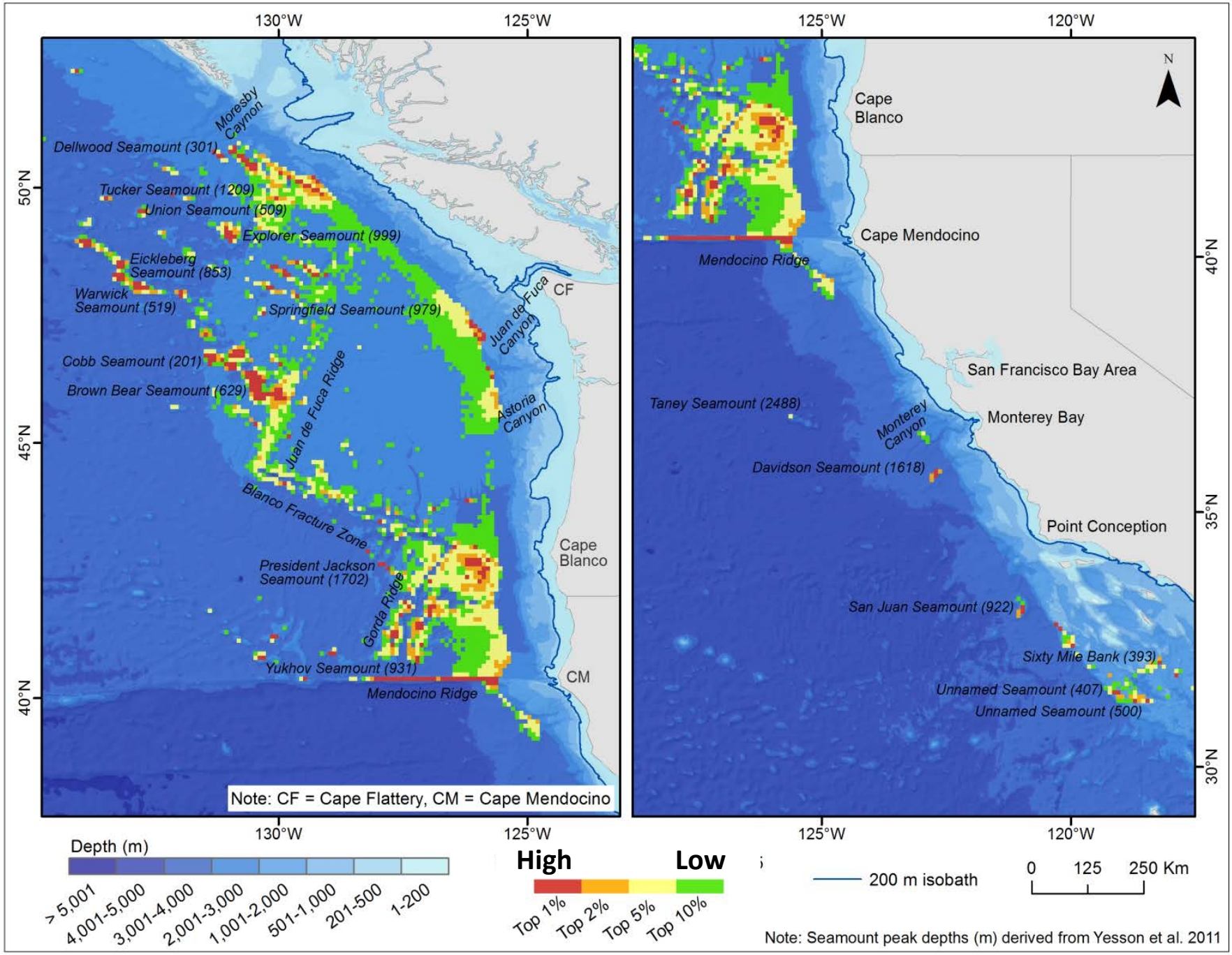
Methods – 30 Species Modeled

- **Black-footed Albatross**
- Black-legged Kittiwake
- **Bonaparte's Gull**
- **Brandt's Cormorant**
- **Brown Pelican**
- **Cassin's Auklet**
- **California Gull**
- Caspian Tern
- **Common Murre**
- **Fork-tailed Storm-Petrel**
- **Glaucous-winged Gull**
- **Heerman's Gull**
- **Herring Gull**
- Laysan Albatross
- **Leach's Storm-Petrel**
- **Long-tailed Jaeger**
- **Mew Gull**
- **Northern Fulmar**
- **Parasitic Jaeger**
- **Pacific Loon**
- **Pink-footed Shearwater**
- **Pomarine Jaeger**
- **Red Phalarope**
- **Rhinoceros Auklet**
- **Red-necked Phalarope**
- **Sabine's Gull**
- **Scripp's Murrelet (Xantus' Murrelet)**
- **Sooty Shearwater**
- **Tufted Puffin**
- **Western Gull**

Orange Font = Species modeled in Nur et al. 2011 (n = 16)


130°W
125°W
120°W
50°N
45°N
40°N
35°N
30°N
N
Moresby Caynon
Dellwood Seamount (301)
Tucker Seamount (1209)
Union Seamount (509)
Explorer Seamount (999)
Eickleberg Seamount (853)
Warwick Seamount (519)
Springfield Seamount (979)
Juan de Fuca Canyon
CF
Cobb Seamount (201)
Brown Bear Seamount (629)
Juan de Fuca Ridge
Astoria Canyon
Blanco Fracture Zone
President Jackson Seamount (1702)
Gorda Ridge
Cape Blanco
Yukhov Seamount (931)
Mendocino Ridge
CM
Note: CF = Cape Flattery, CM = Cape Mendocino
Cape Blanco
Cape Mendocino
Mendocino Ridge
San Francisco Bay Area
Taney Seamount (2488)
Monterey Canyon
Monterey Bay
Davidson Seamount (1618)
Point Conception
San Juan Seamount (922)
Sixty Mile Bank (393)
Unnamed Seamount (407)
Unnamed Seamount (500)
Depth (m)
> 5,001
4,001-5,000
3,001-4,000
2,001-3,000
1,001-2,000
501-1,000
201-500
1-200
High
Low
Top 1%
Top 2%
Top 5%
Top 10%
200 m isobath
0
125
250 Km
Note: Seamount peak depths (m) derived from Yesson et al. 2011