Modeling Pacific top predator hotspots in a changing climate

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taggingofpacificpredators.com

topp.org, www.comlsecretariat.org
Marine Top Predators

- Integrate over food-web dynamics
- Long-lived, buffer environmental variability
- Key indicators of climate variability and change
- Face serious conservation issues
Top Predators in the Pacific Ocean

- 23 species; 4,000 tags; >1 Million profiles
- Tracking, conservation, ocean observation
TOPP Synthesis: Hotspots
Topp Synthesis: Hotspots

SST structures habitat

Chl-a influences density / use
• Population effects – reproductive success / failure

• Food web effects – reduced accessibility of prey

• Phenology effects – timing of migration, reproduction

• Spatial effects – loss of habitat, range or distribution shifts
Methods: habitat models

• Generalized additive models (GAMs) were fit using bathymetry and quarterly means of remotely sensed SST and Chl-a from 2000-2009.

• We compared GFDL based habitat predictions as a scenario driven exercise:
  • 2001-2050 vs. 2051-2100
  • Monthly, yearly, and 5 year running mean time series

• Core habitat was defined as top 25% of each species potential habitat.
Methods: GFDL A2

• GFDL coupled atmosphere-ocean general circulation models (CM2.1) with a two-way coupled biogeochemistry model (TOPAZ) at 1° ocean resolution.

• A2 model representing heterogeneous energy sources and development and with CO₂ stabilizing at 836 ppm in 2100.

• GFDL-A2 Chlorophyll-a mean over the top 100m and SST were used to predict habitat changes.
Chl-a (mg \cdot m^{-3}) 2001-2010

Winter

Summer
Changes in Chl-a: 2001-2100

Winter

Summer
Changes in SST: 2001-2100

Winter

Summer
Species Richness: 2001-2010

Winter

Summer

ALL SPECIES NORMALIZED LOG SCALE
Species richness: 2001-2100

Winter

Summer
Blackfoot albatross top 25% habitat area

Model Year

2001 2011 2021 2031 2041 2051 2061 2071 2081 2091 2100

-14.3 -6.1 -1.9 2.2 6.3 10.4 14.6 18.7 22.8 27

Laysan albatross top 25% habitat area

Model Year

2001 2011 2021 2031 2041 2051 2061 2071 2081 2091 2100

-4.1 -2.7 -1.3 0.1 1.5 2.9 4.3 5.7 7.1 8.5 9.9

Albatross habitat: 2001-2100
Shark habitat: 2001-2100

Blue shark top 25% habitat area

Mako shark top 25% habitat area

White shark top 25% habitat area
Caveats

- Predictions are scenarios, not actual “habitat” – populations not species
- Coastal processes are not well resolved in most climate prediction models
- Top predators show plasticity to changing environment
- Physical variables may not be as important as previously thought

Stock et al. 2010
Conclusions and Future Directions

- Seasonal patterns in diversity gain / loss e.g. around the TZCF
- Up to 25% changes in habitat use by frequency between 2001 and 2100
- Nested / downscaled models to get a better representation of coastal processes
- We should continue to use top predators as ocean sentinels and proactively plan for adaptive management
Remote sensing data:
• Aviso/CNES (altimetry)
• NASA/GSFC (SeaWiFS ocean color)
• NOAA/NODC & JPL (SST)
• UCSD/SIO (Bathymetry)
Thank you!