

Dynamic humpback whale models for evaluating and mitigating entanglement risk along the U.S. West Coast



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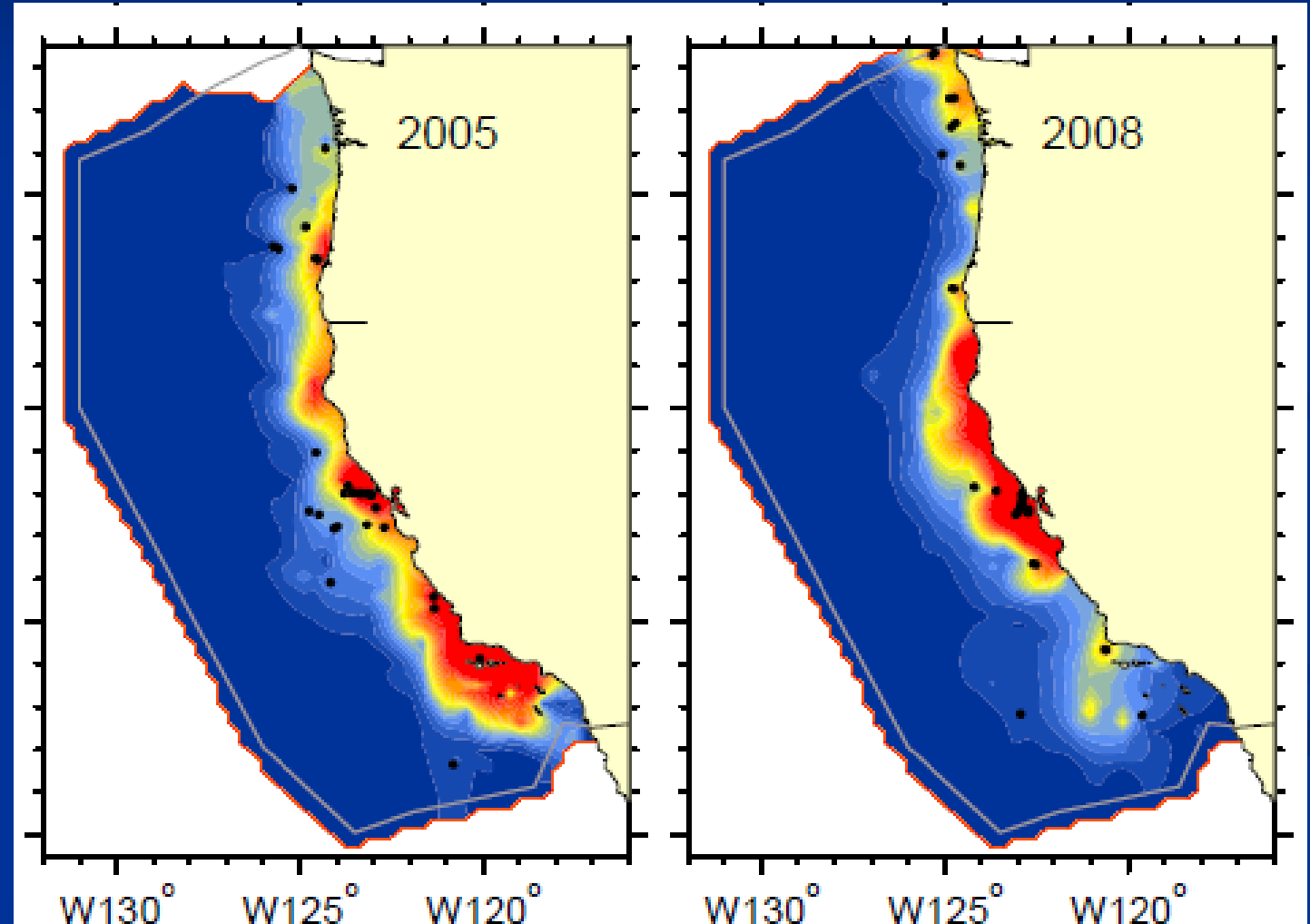
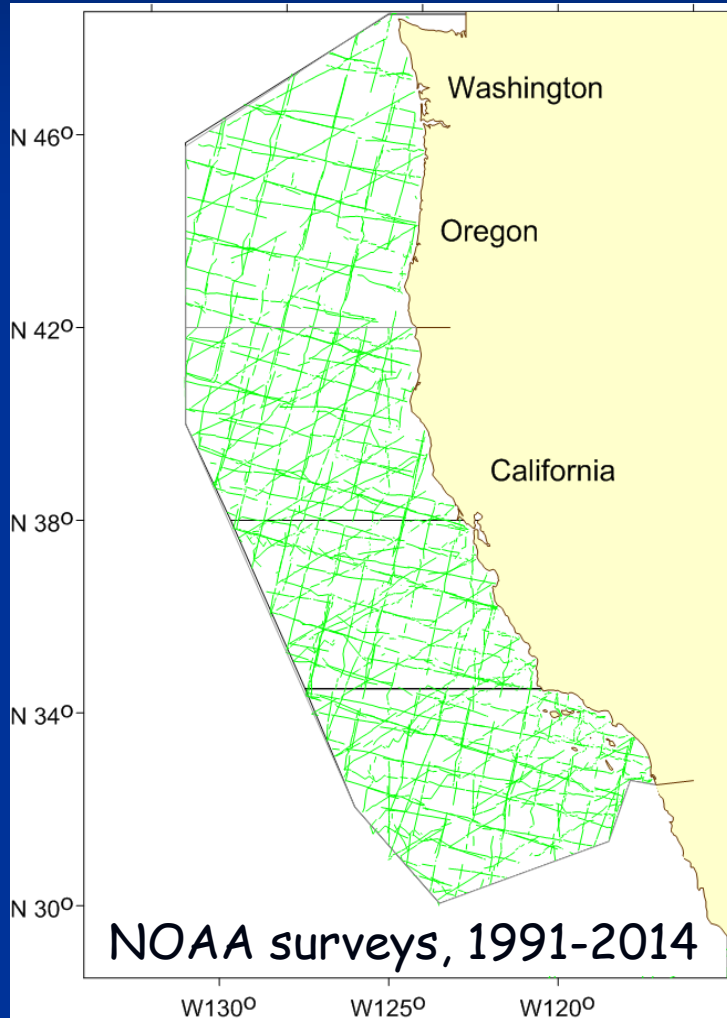
Southwest Fisheries Science Center, Northwest Fisheries Science Center, and West Coast Regional Office



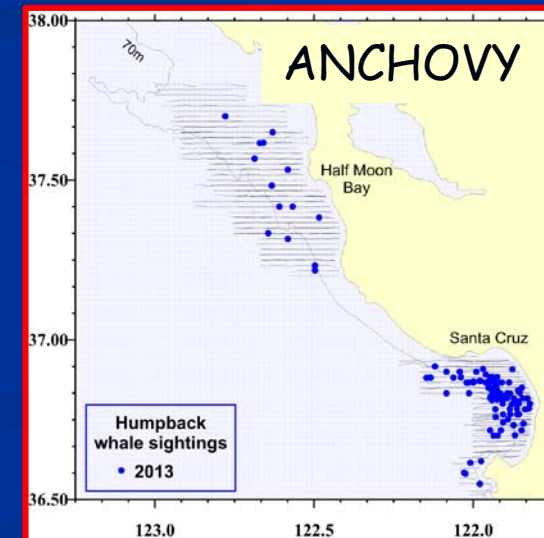
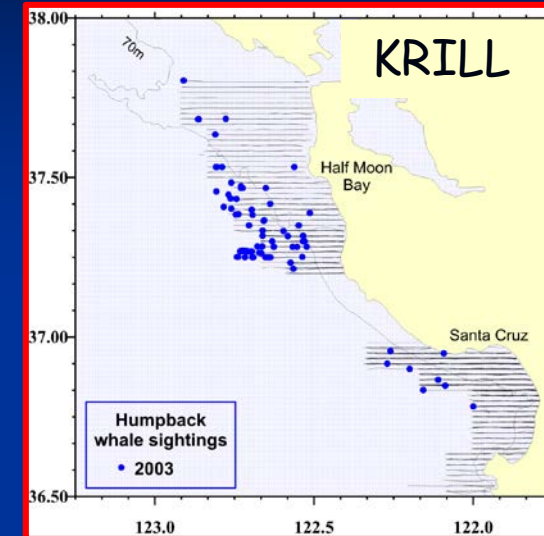
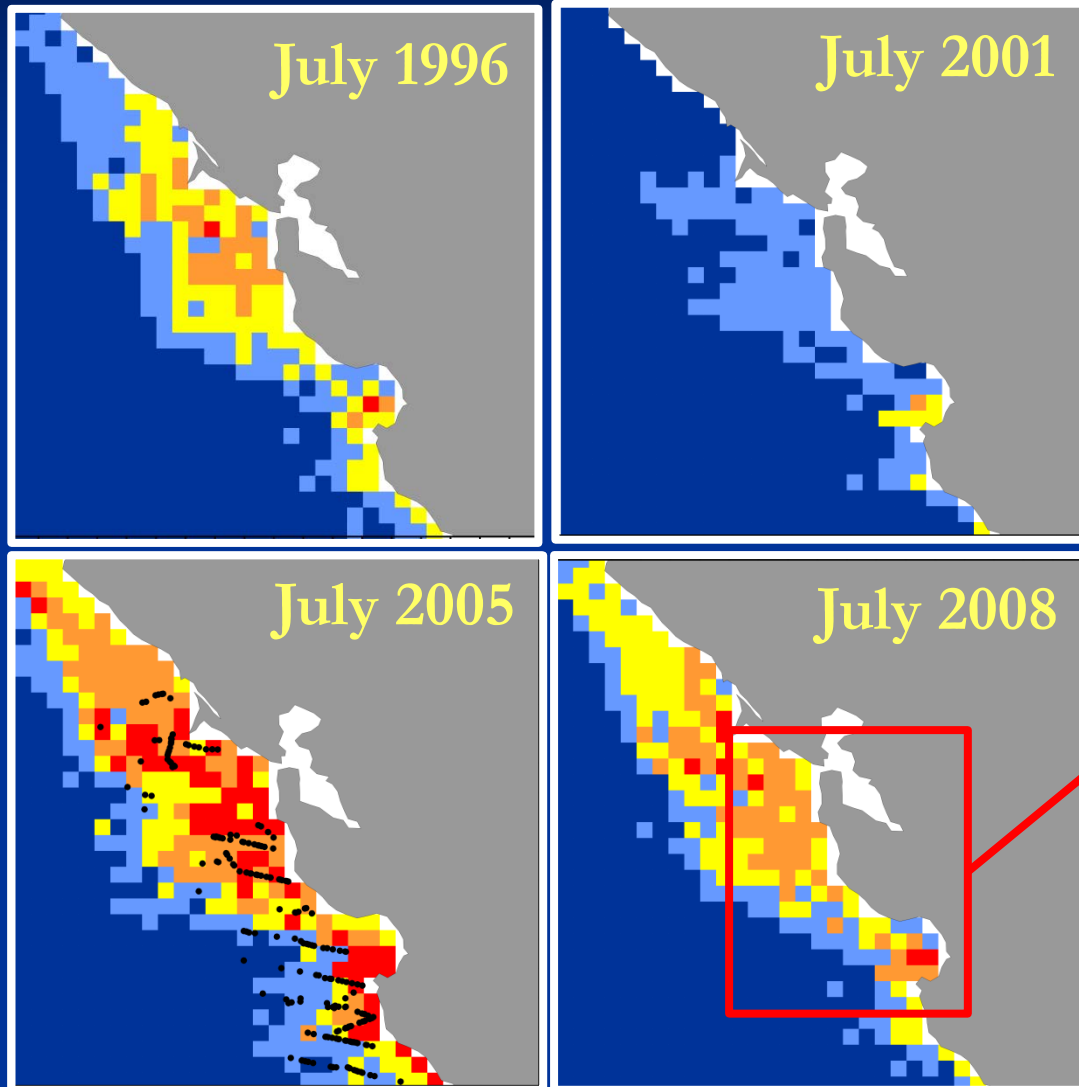
Humpback whale distribution models, 1991-2014

Becker et al. 2010, 2012, 2016, 2018

Generalized Additive Models (GAM) with dynamic habitat covariates from the Regional Ocean Circulation Model (ROMS)



Models shows interannual variation, but scale is coarse relative to humpback movement patterns and nearshore fixed-gear fishing areas



Fine-scale models to match spatial scale of fisheries

(Modified methods of Becker et al. 2016, 2018)

Model modifications:

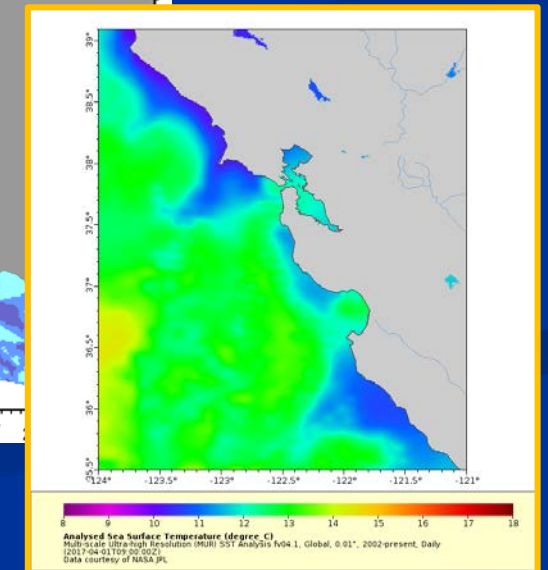
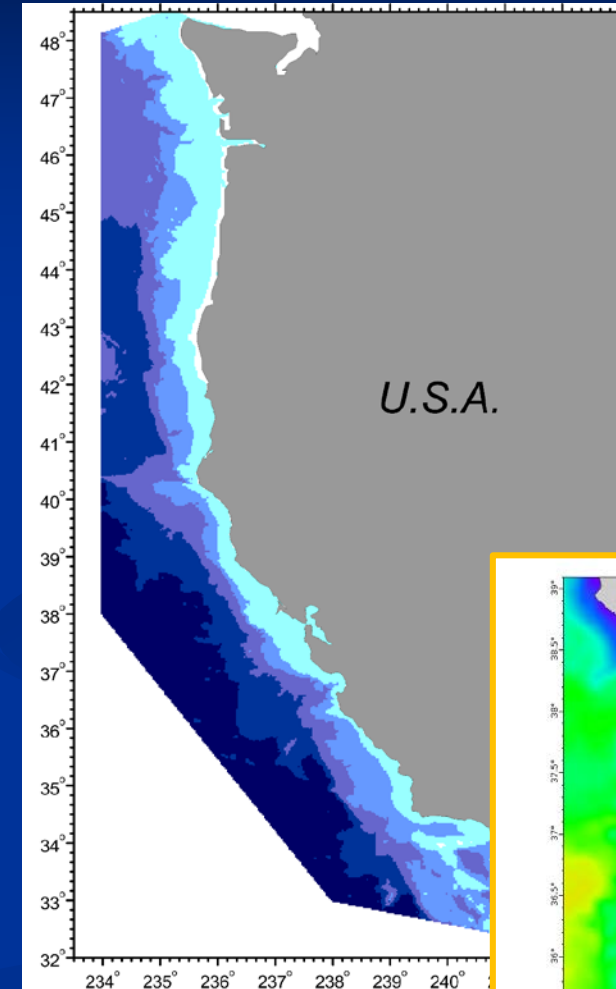
- 2005-2014 survey data (Summer/Fall)
- Excluded offshore survey effort to help resolve shelf/slope patterns
- 3-km scale (segments & prediction pixels)

Habitat predictor variables:

- SSH, MLD (and Std Dev) from ROMS; 10km
- Bathymetry from ETOPO1; 1 min scale
- Multi-spectral Ultra-high Resolution SST; 1km, no cloud gaps, and Std Dev (SST) at 9x9km and 25x25km scales

Seasonal extrapolation:

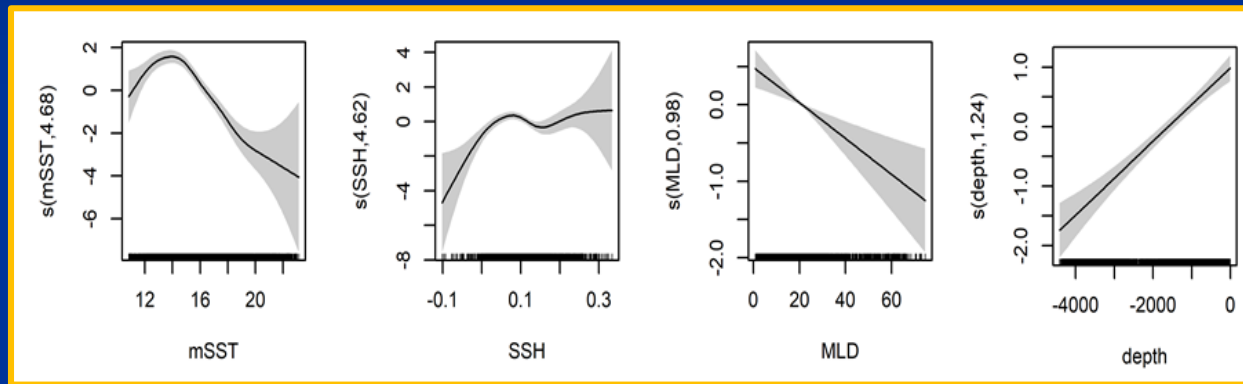
- Evaluate predictions outside of July-Nov survey period because fishery operates Nov-July



Dynamic humpback whale model

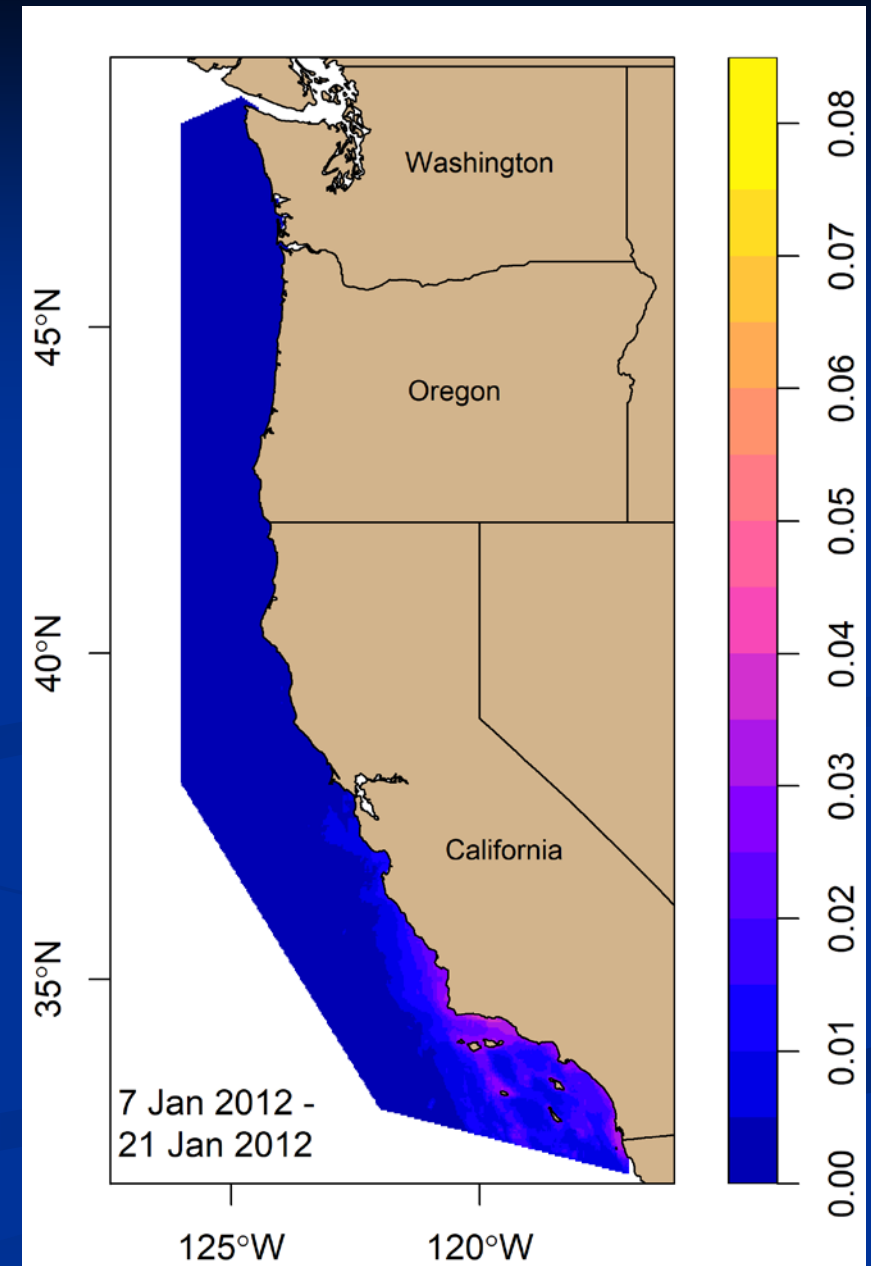
Preliminary results

- Model selected using established methods and metrics (*Becker et al. 2018*)



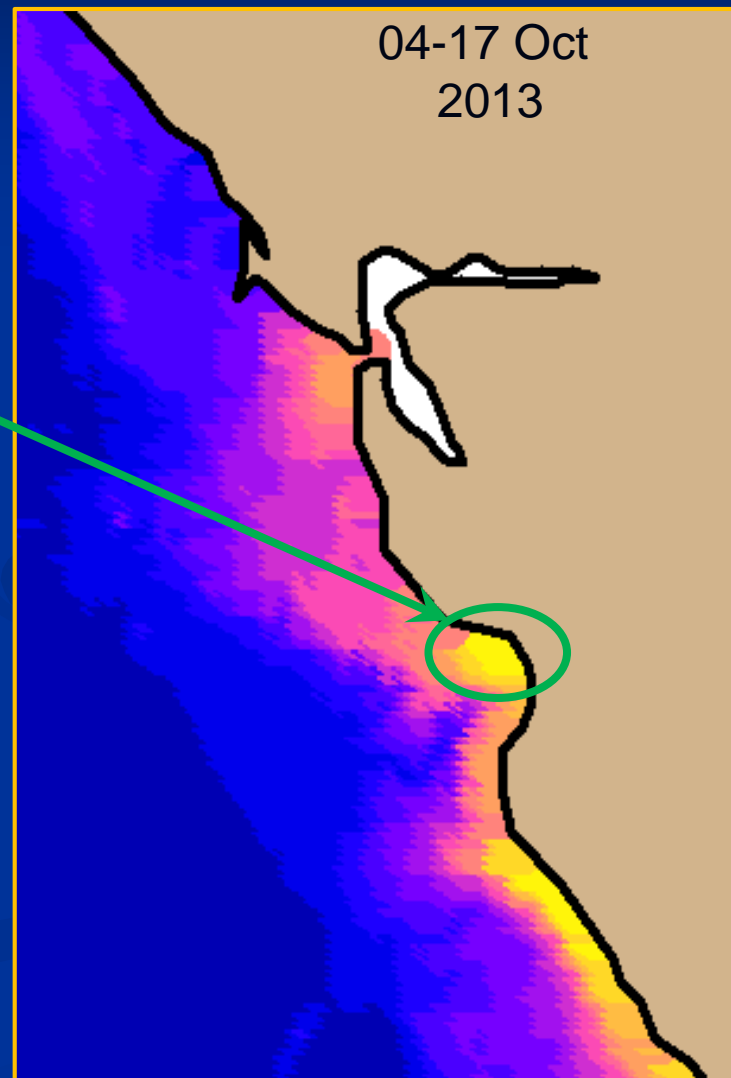
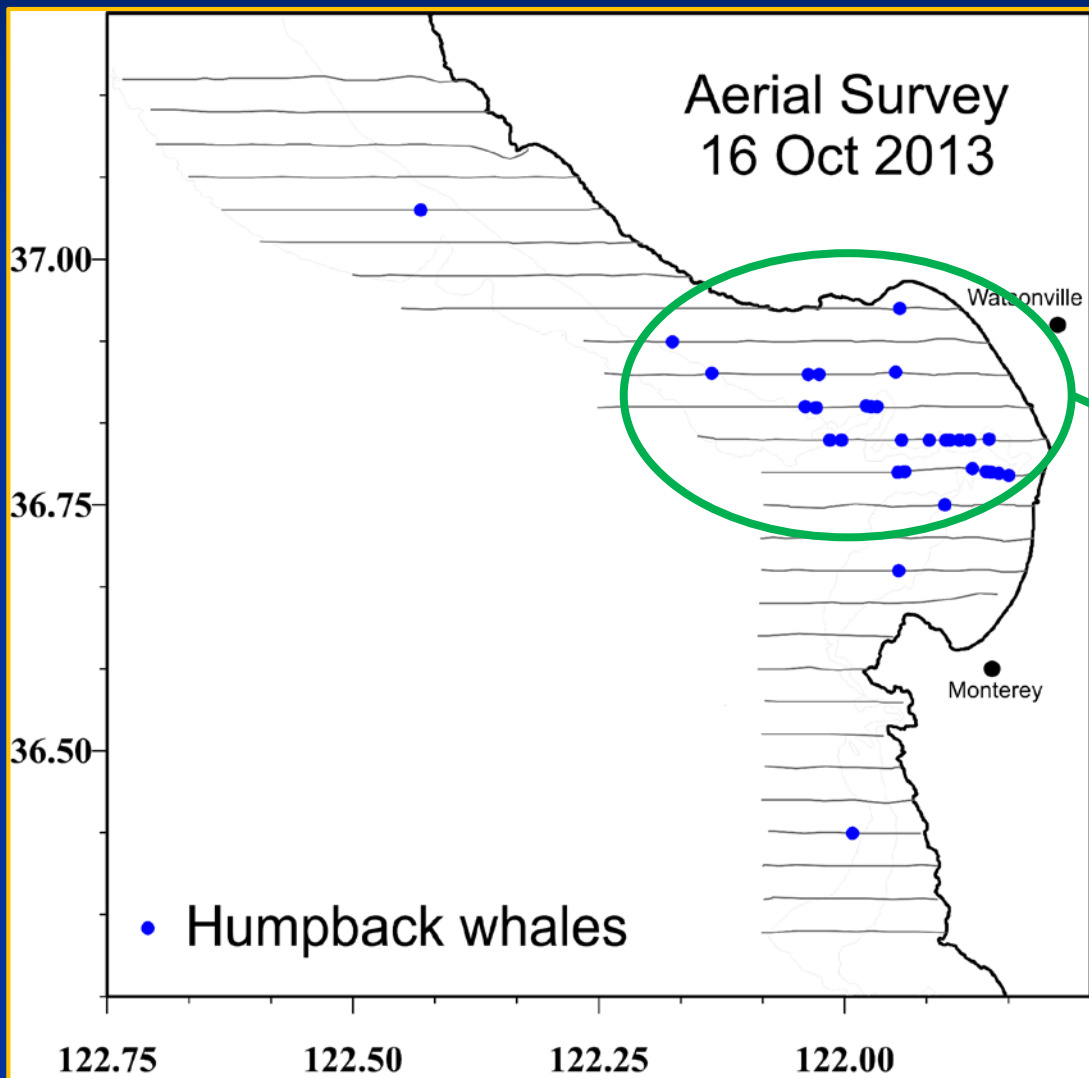
- Bi-daily predictions, averaged over 14-days and monthly
- Model captures:
 - Seasonal north-south migration
 - Varying seasonal foraging hotspots
 - Interannual variability

→ Validate using independent survey data (aerial, ship)



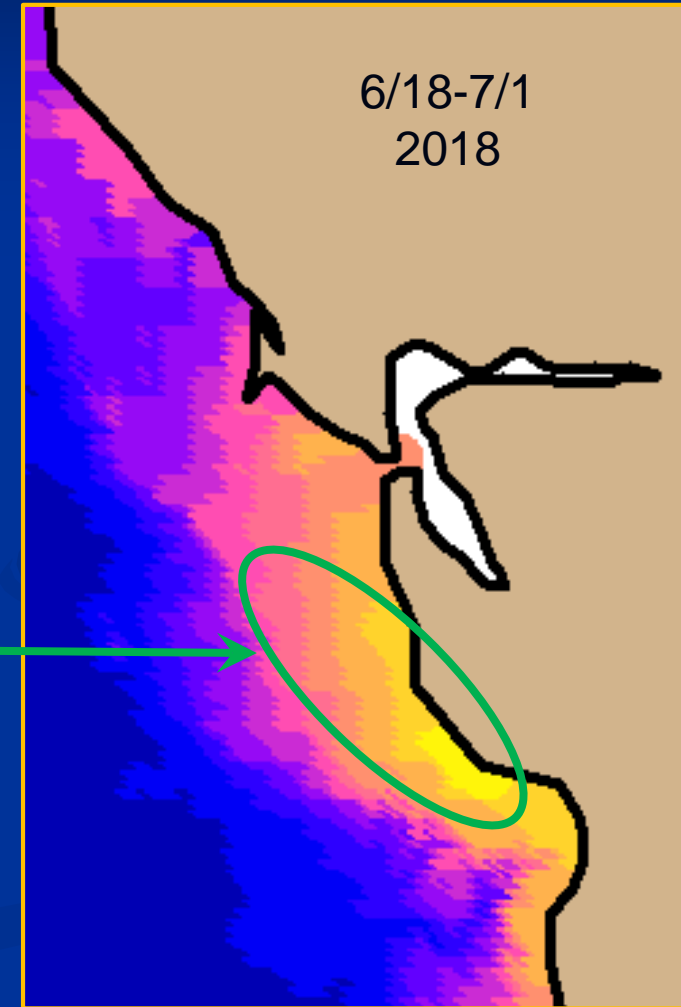
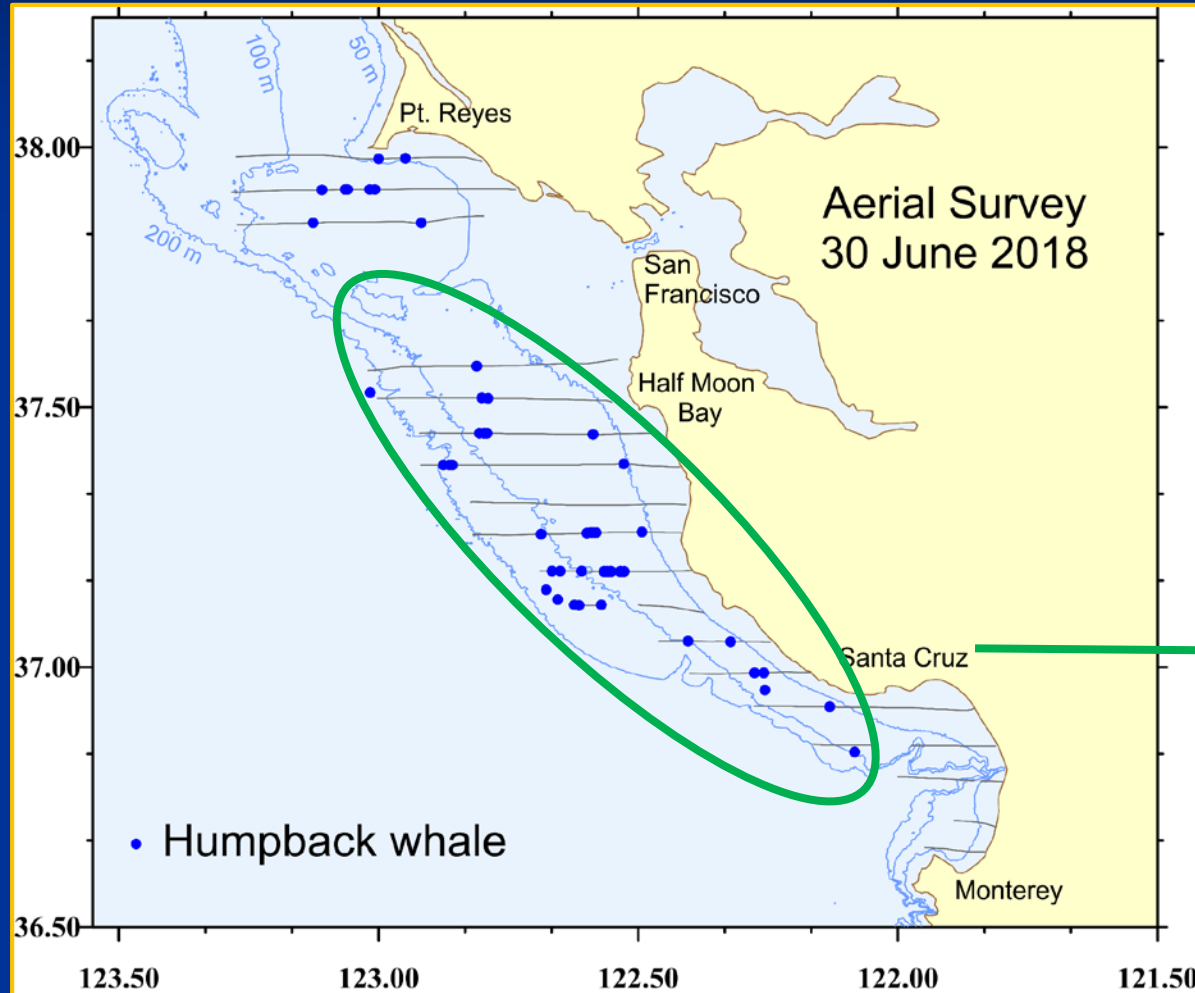
Validation Example 1:

Fine-scale hotspot in northern Monterey Bay, Oct 2013

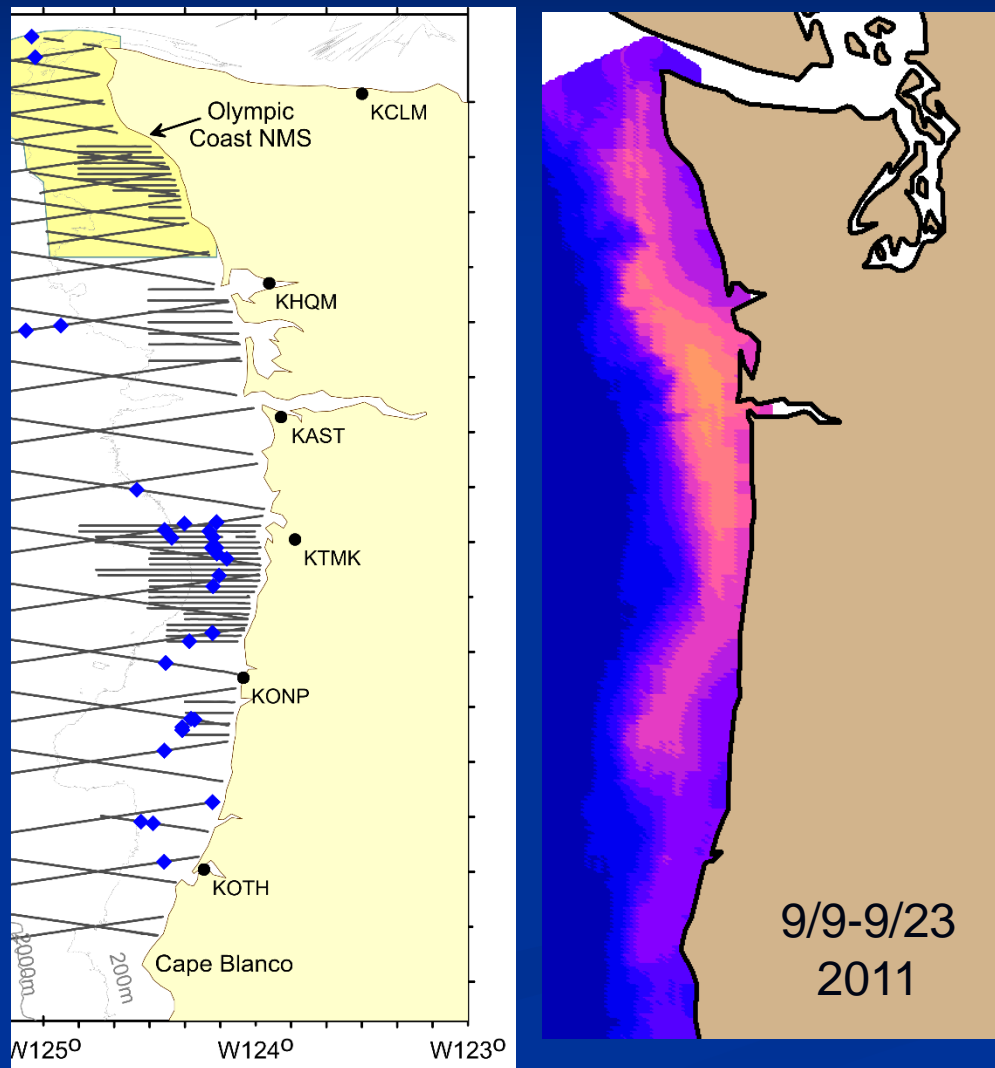


Validation Example 2:

More wide-spread distribution during June 2018

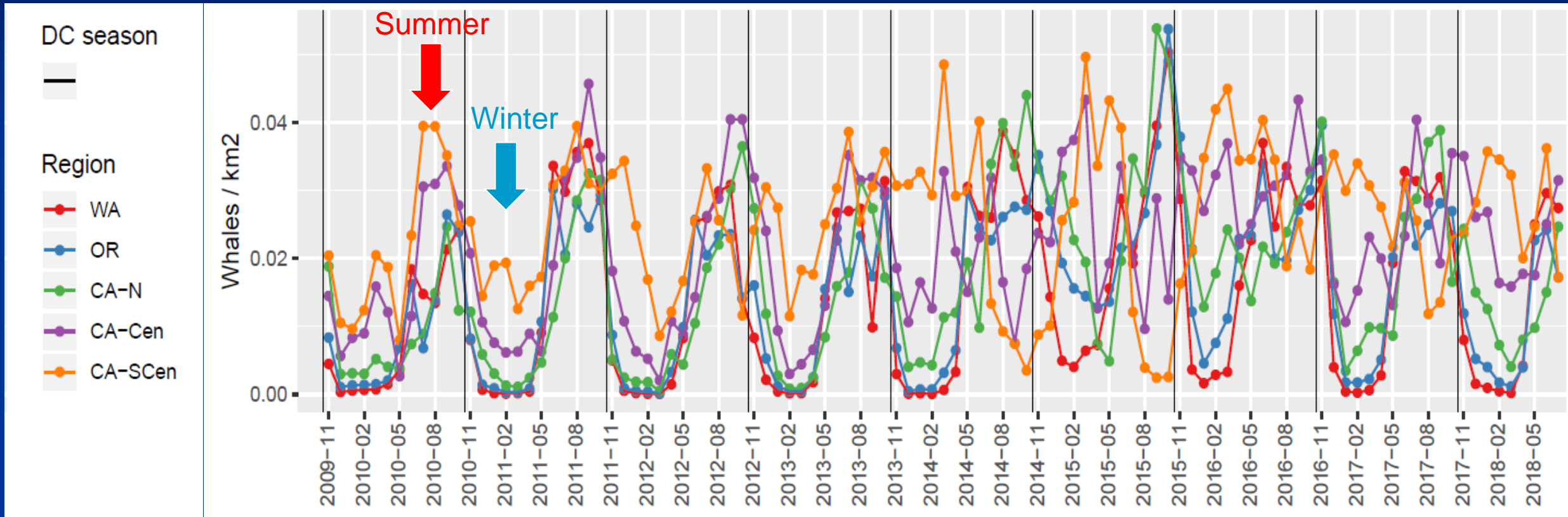


Validation Example 3: OR & WA leatherback aerial surveys, September 2011



Humpback Whale Model Validation

Seasonal cycle, 2009-2018 by region



Seasonal migration evident
(peak during summer,
mostly gone in winter)

Seasonal signal
disrupted during
Marine Heat Wave

Humpback Whale Model - What can it tell us (and what not)?

- “All models are wrong, but some are useful.” - Box 1979
 - “... for some things and not others.” - Karin Forney 2020
 - Models will not tell us exactly where the whales are at any given time
 - Models allow us to explore different scenarios to see what factors are most important for reducing entanglement risk.
 - Input for collaborative projects examining whale entanglement risk and socio-economic costs of potential management strategies (Module 5, Sep 3):
 - Redfern et al. - whale entanglement risk
 - Samhoury et al. - tradeoff analysis
 - Free et al. - HABS, Crabs and Whales Project
- Need to continue validating and improving models as we learn more

Acknowledgments

THANK YOU!

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