

# Whale Migrations

Helen Bailey

E-mail: [hbailey@umces.edu](mailto:hbailey@umces.edu)



University of Maryland  
CENTER FOR ENVIRONMENTAL SCIENCE  
CHESAPEAKE BIOLOGICAL LABORATORY

# Outline

- Why migrate?
- What can we learn from animal movements?
- Movement ecology initiative at CBL
- Whale movements and distribution
- New developments



# Migration

- Follow resources
  - Food
  - Suitable breeding grounds and nursery habitat

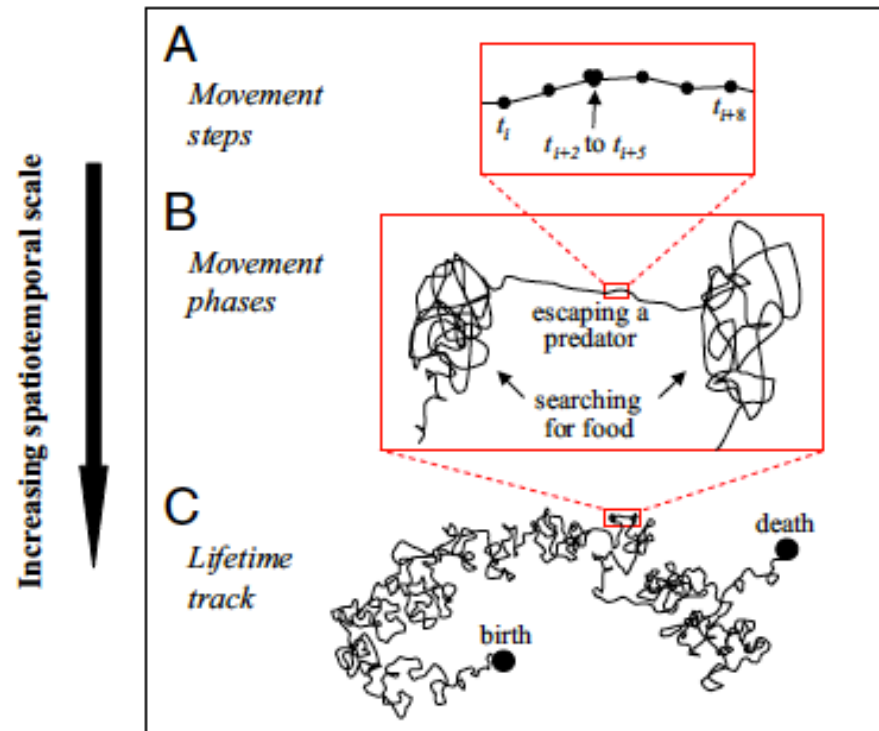


# Humpback whale



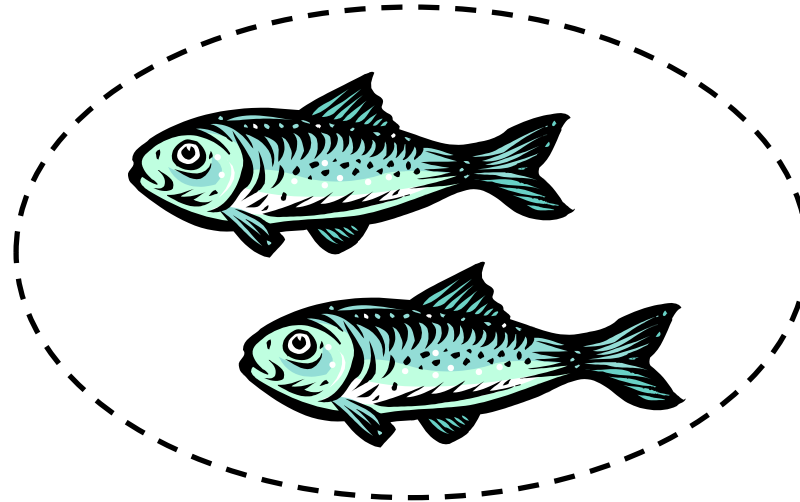
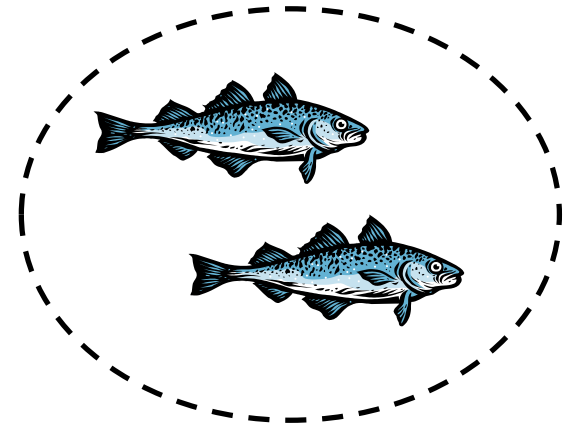
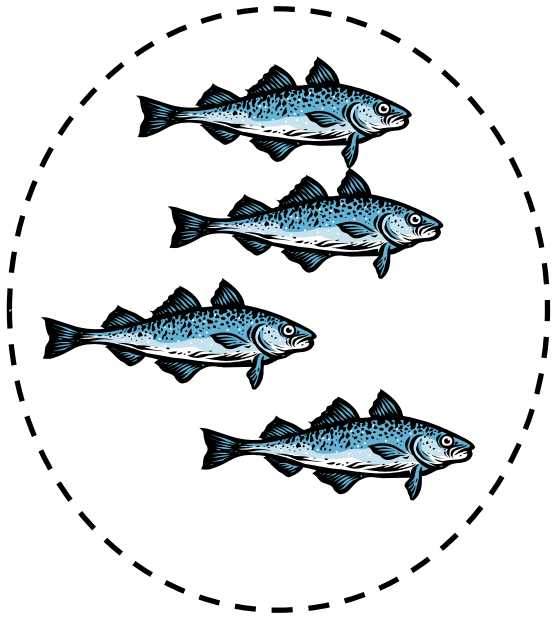
# Movement Ecology

- Understanding the causes, mechanisms, patterns, and consequences of movement phenomena
- Linking movements to specific internal traits or behaviours

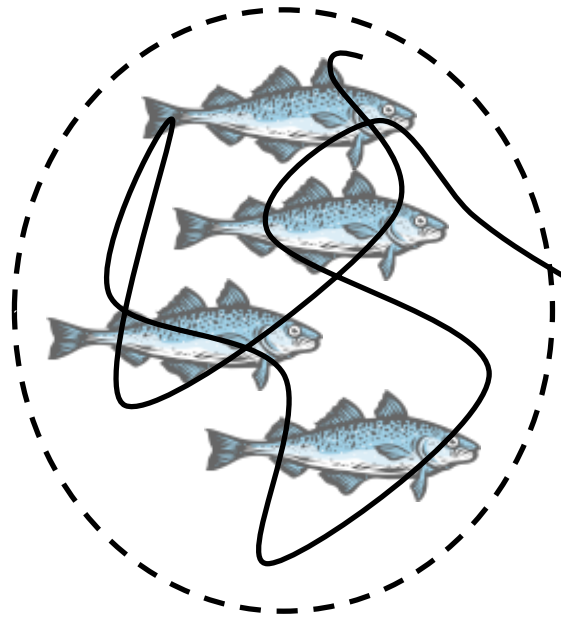


From Nathan et al. 2008

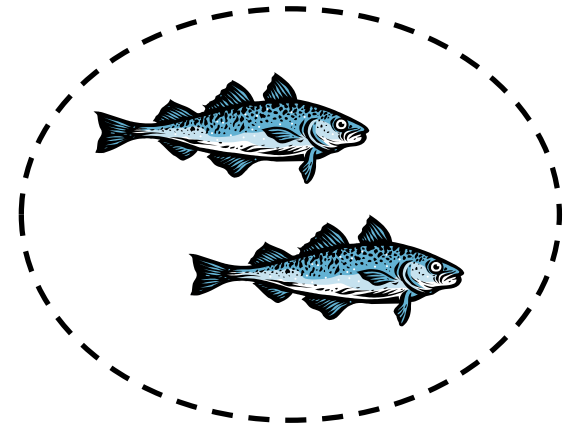
# Movement phases



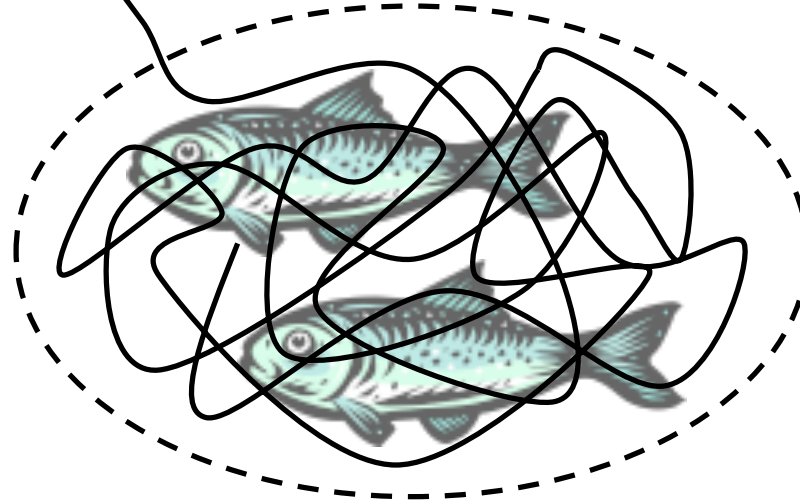
# Movement phases



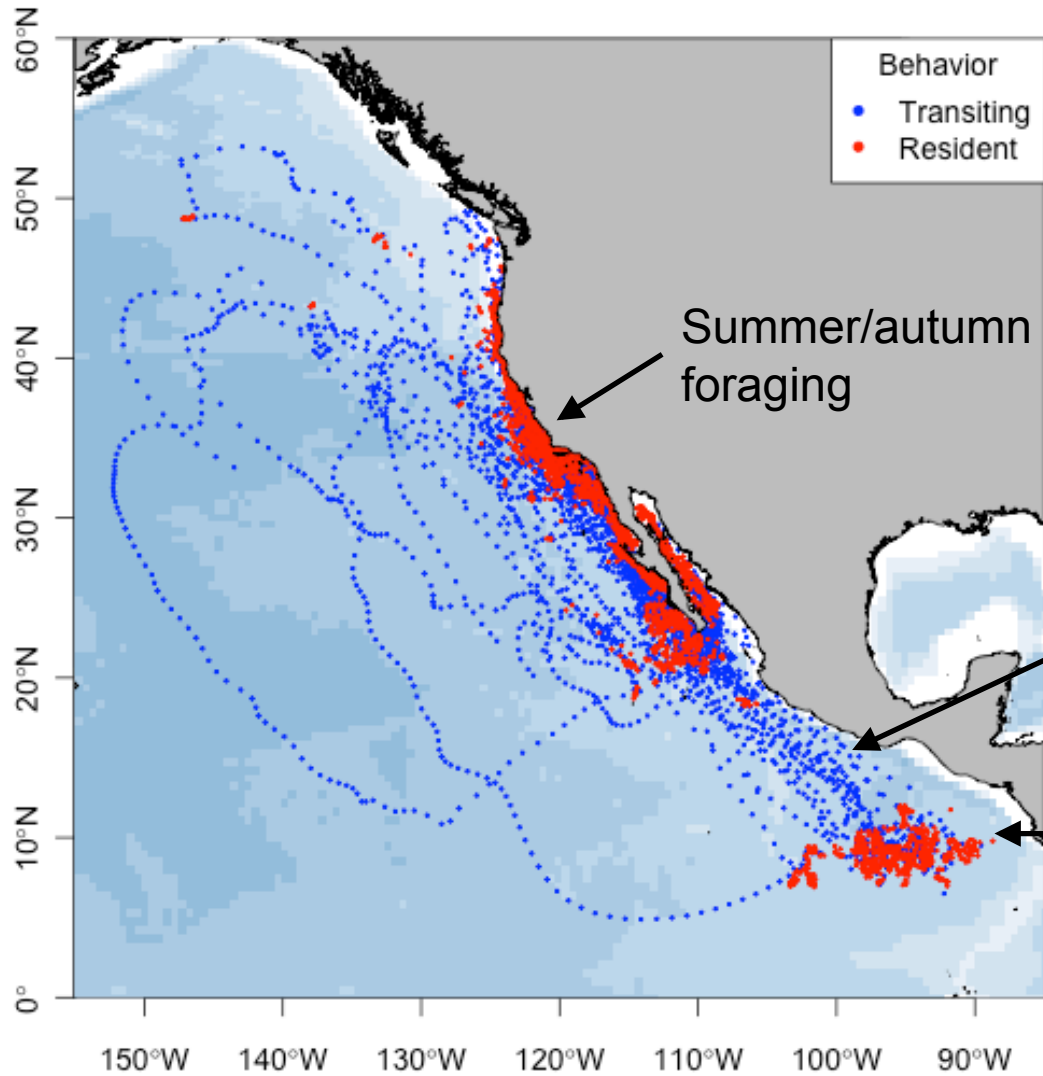
**Transit** - directed,  
rapid movement



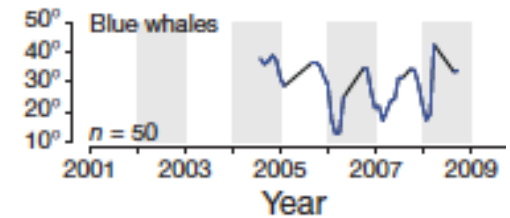
**Foraging** - higher  
turning angle and  
lower speed



# Large-scale movements



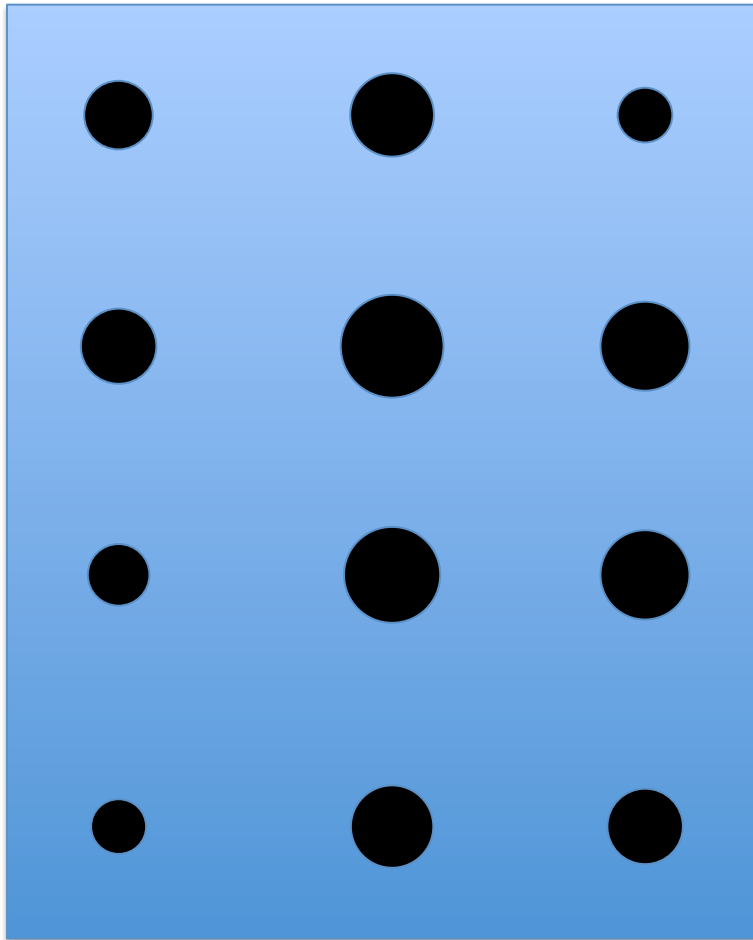
Bailey et al. 2009



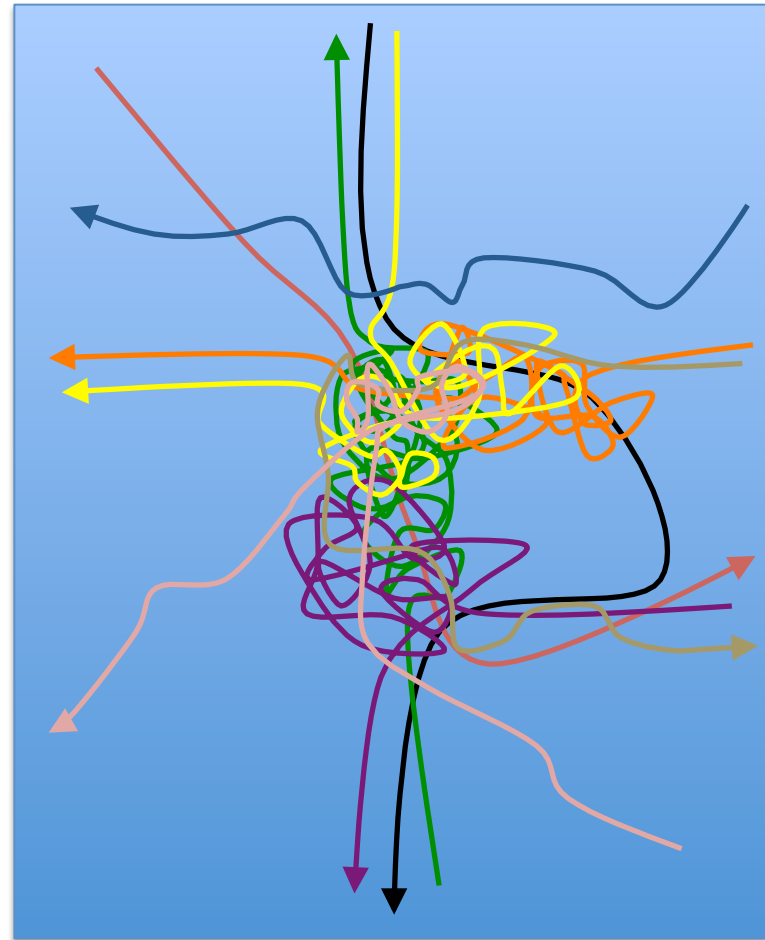
Block et al. 2011



# Survey limitations

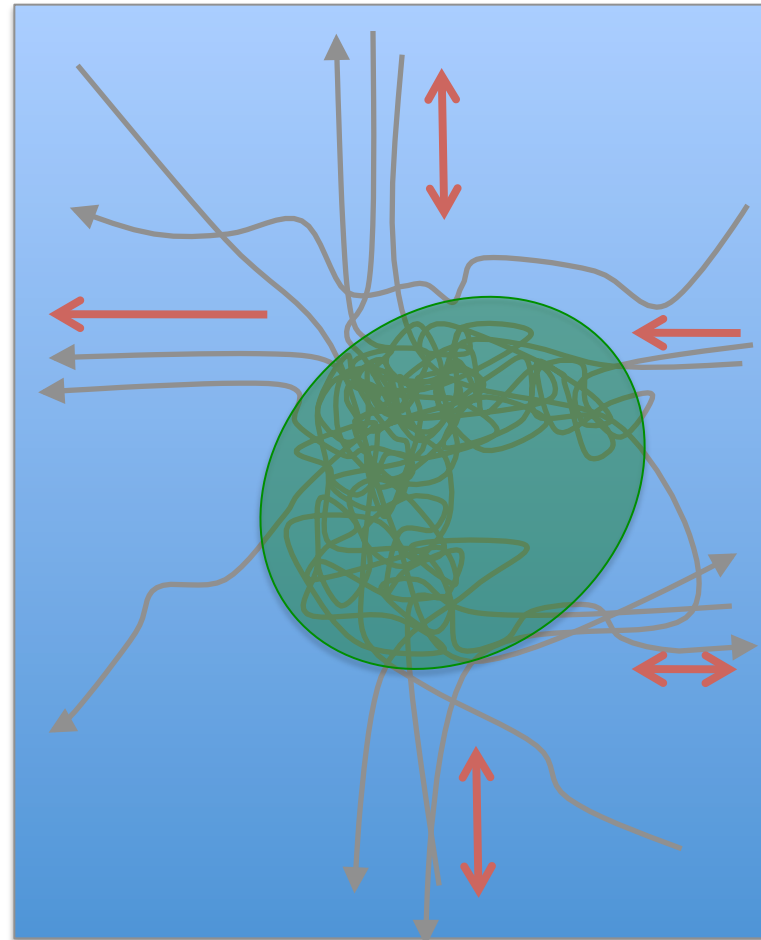
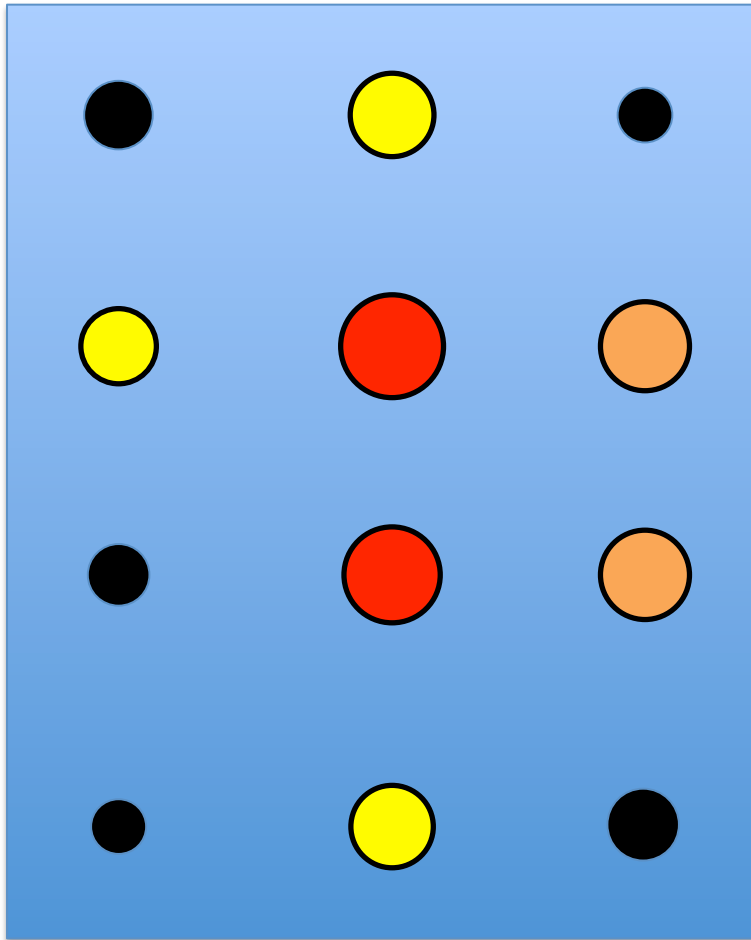


Survey catch or sightings



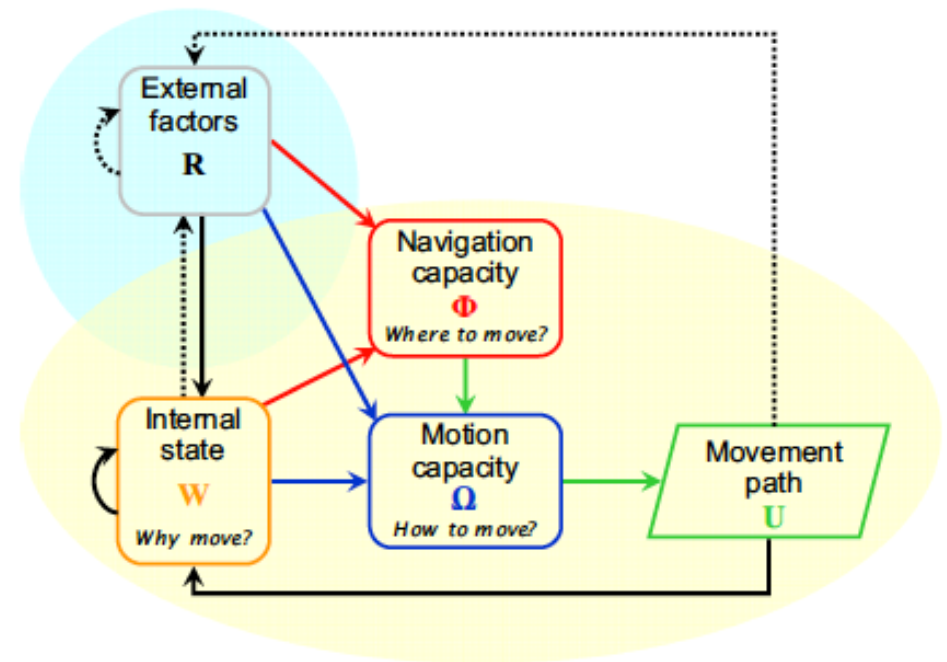
Tracks

# Survey limitations



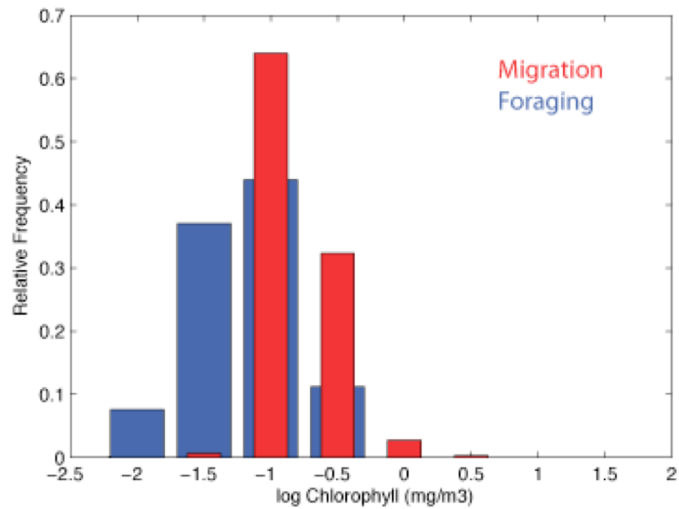
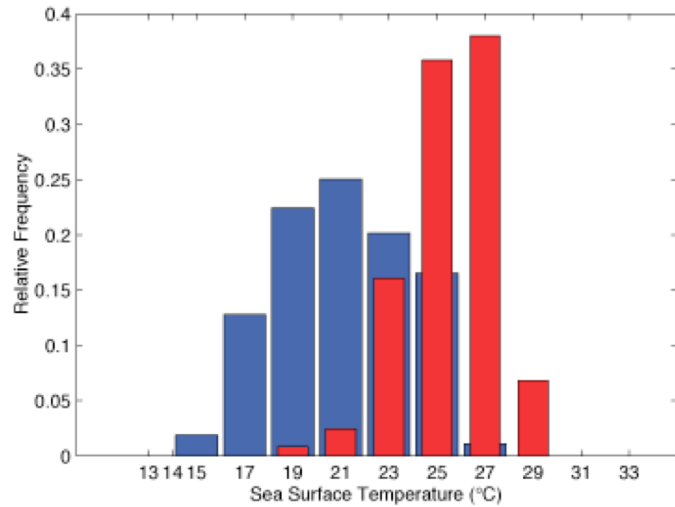
# Benefits of movement studies

- Focus on individual animals and bridge the gap with population dispersal
- Movement incorporates BOTH spatial and temporal dynamics
- Inferences can be made about behavior and functional habitat use
- Can assess fine-scale responses to events



From Nathan et al. 2008

# Functional habitat use



From Shillinger et al. 2011

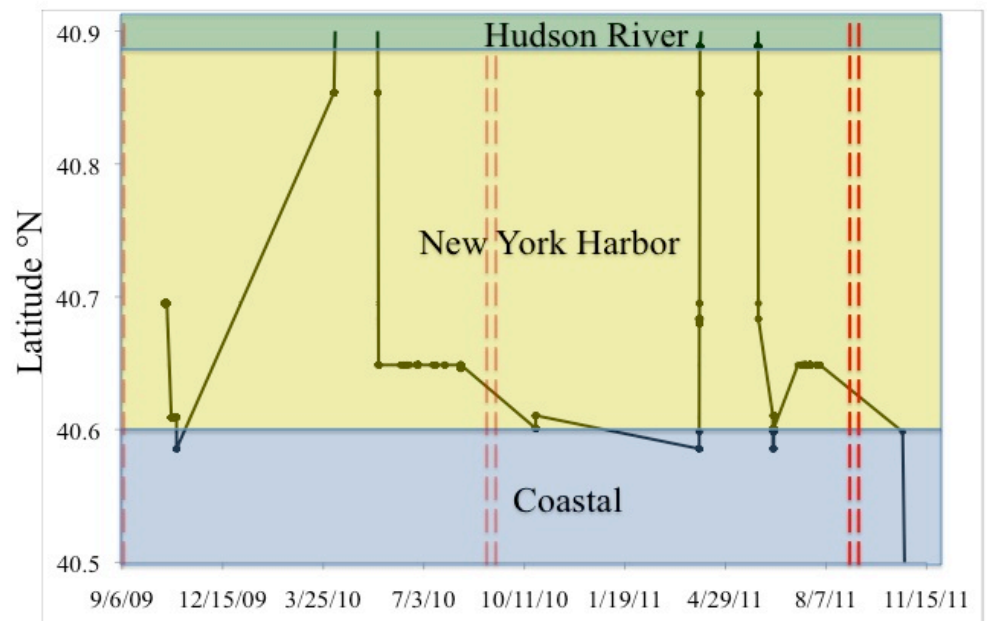
# Response to events - Storms



Reconstructing movements from acoustic tag detections.



Do storms cause displacement or other changes in movement behavior?



# WhaleWatch Goals

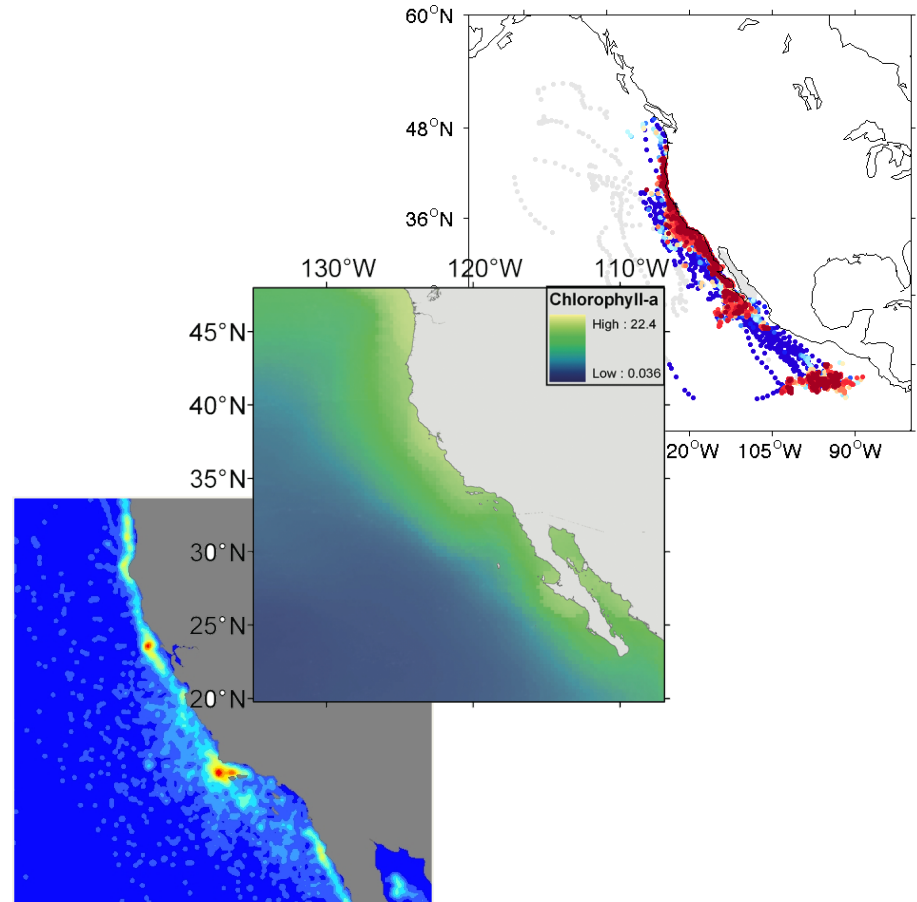


- Use satellite data to develop habitat models that will allow us to identify large whale hotspots and provide a tool for estimating occurrence and behavior in the California Current System. This will assist management efforts to mitigate against human impacts.

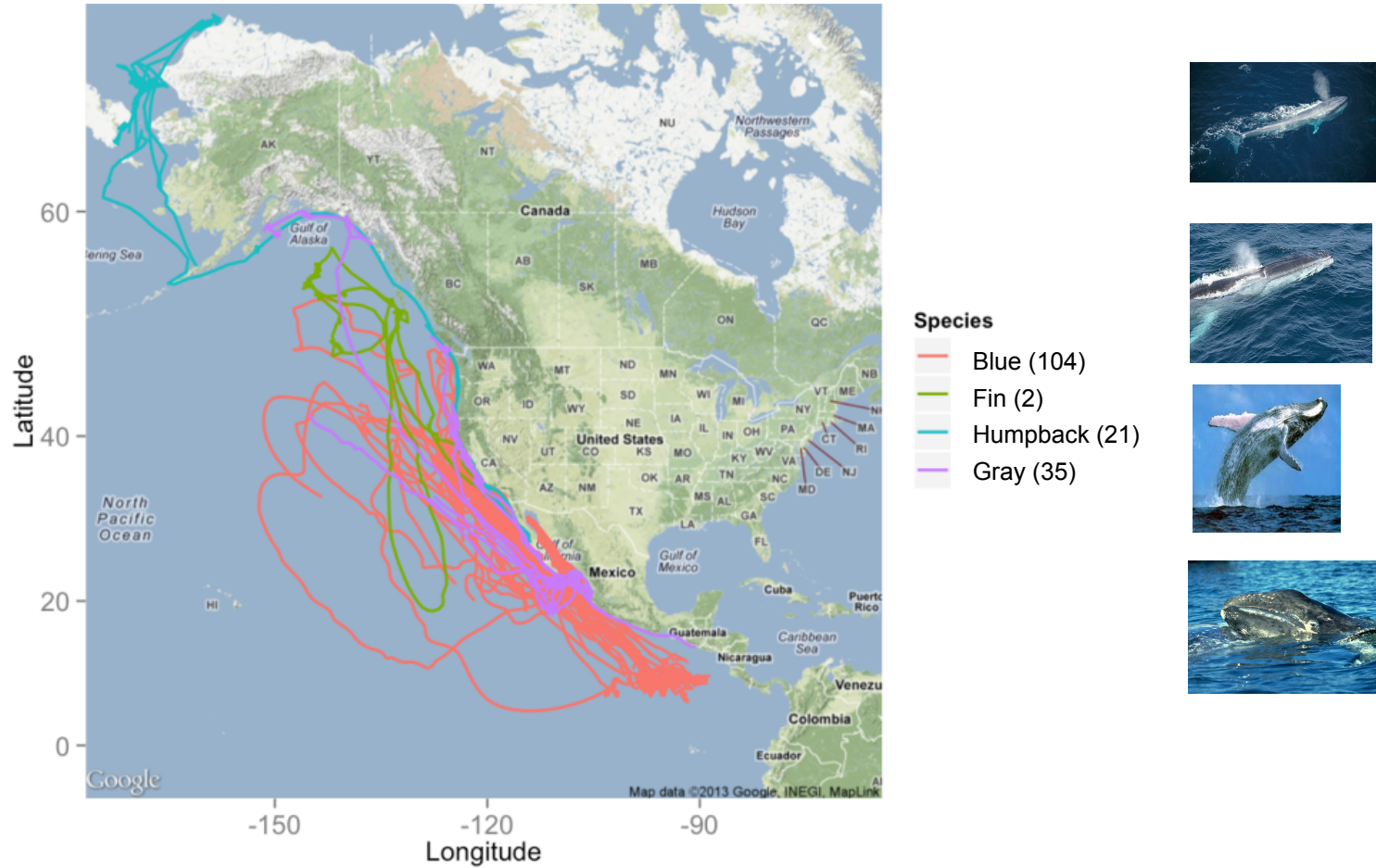


# Approach

1. Apply a state-space model to provide regularized daily positions from whale satellite telemetry data
2. Identify core area hotspots
3. Develop habitat preference models using remotely sensed environmental data
4. Develop a NOAA website with an automatically updating map predicting whale densities based on the current environmental conditions.



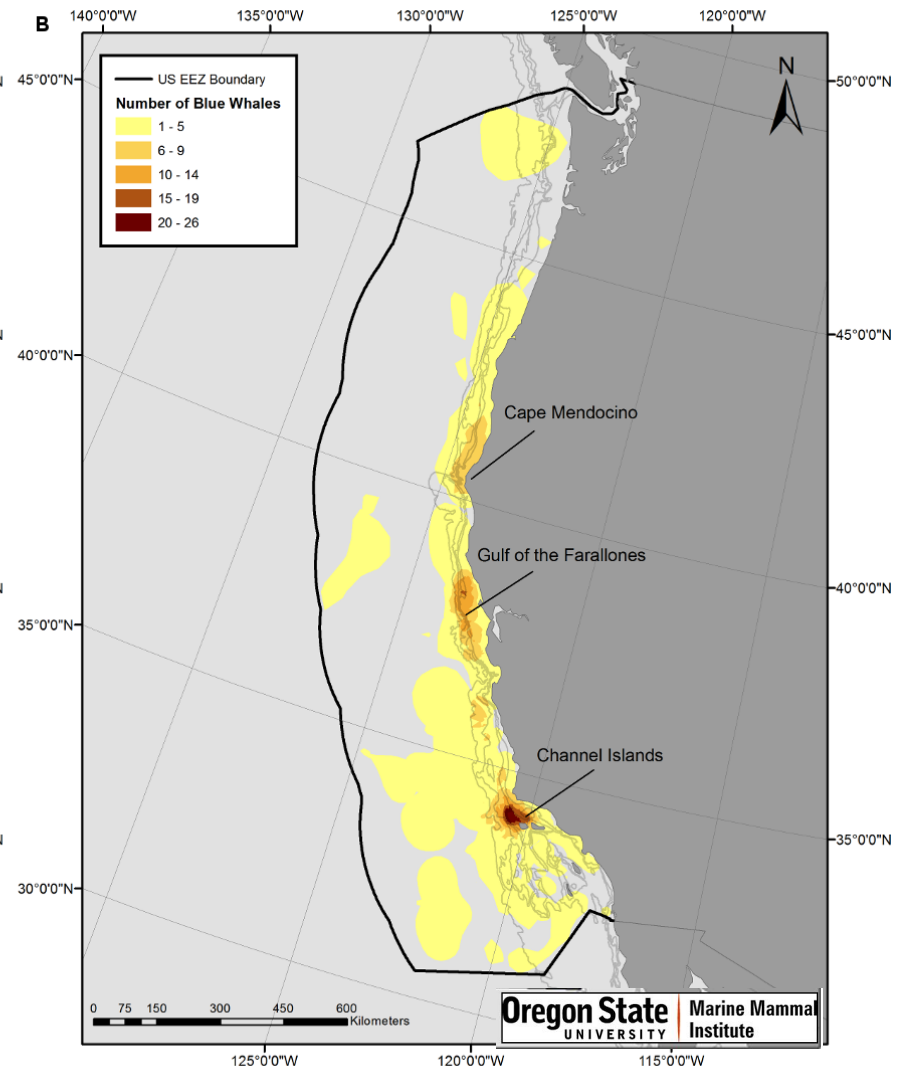
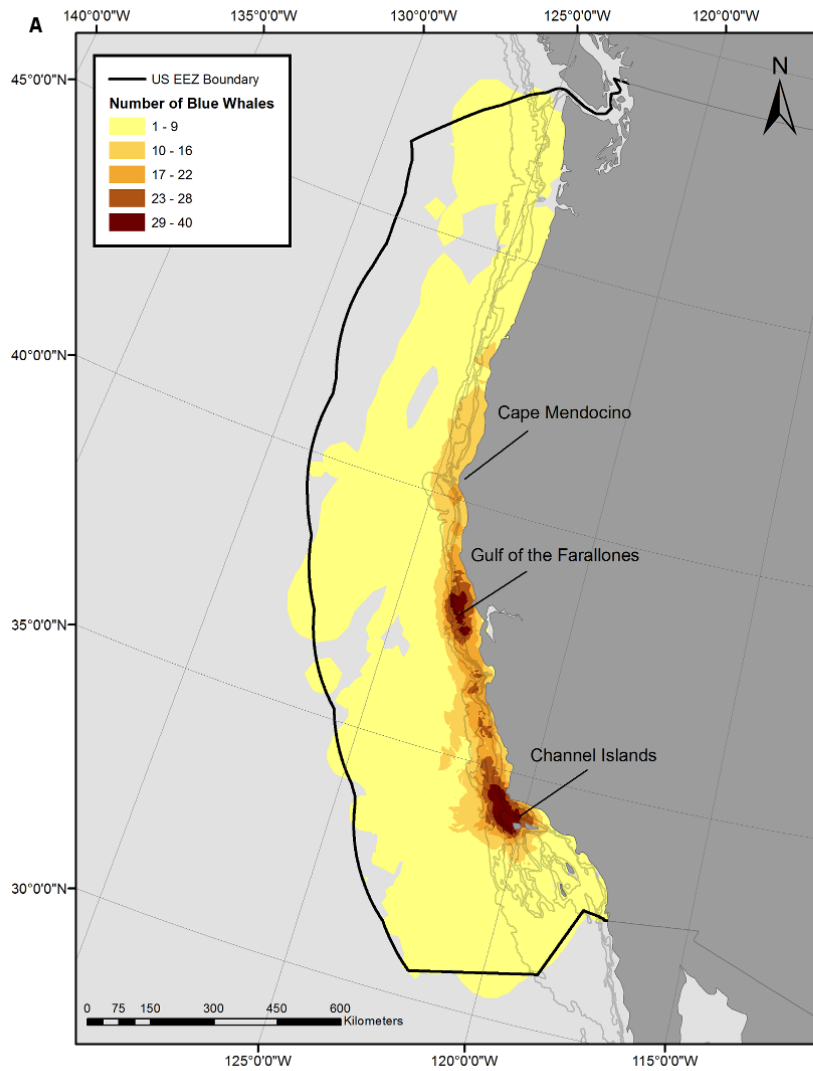
# Whale Satellite Telemetry Data



Telemetry data from: Bruce Mate, OSU Marine Mammal Institute

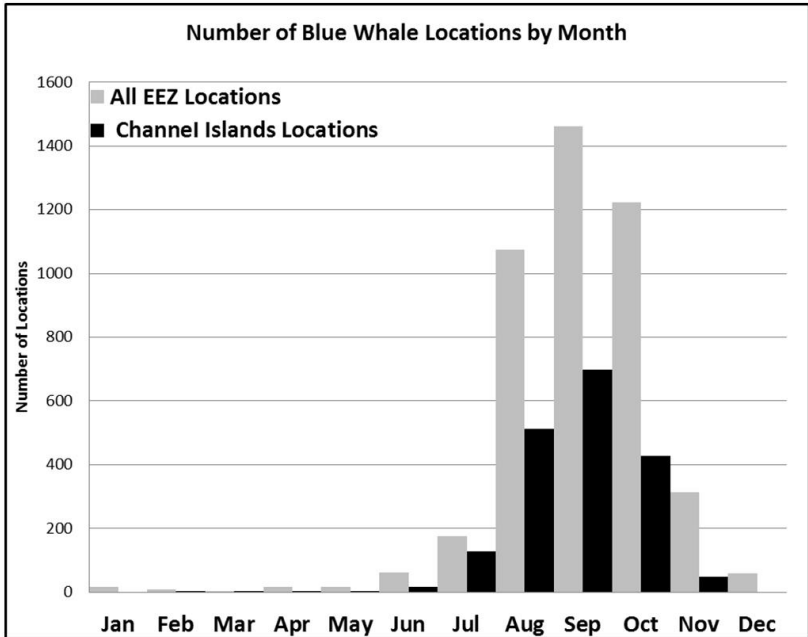
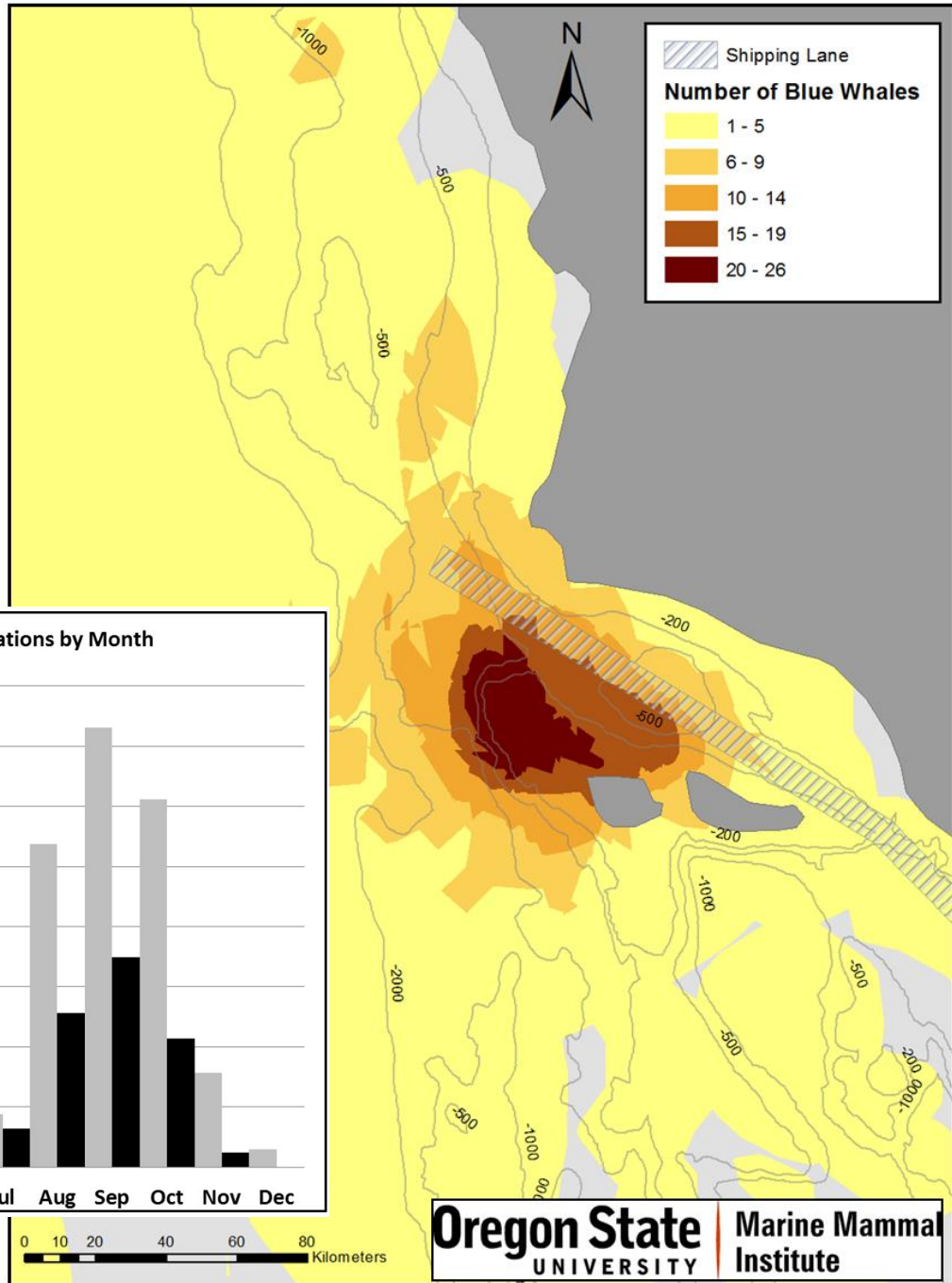


# Blue whales

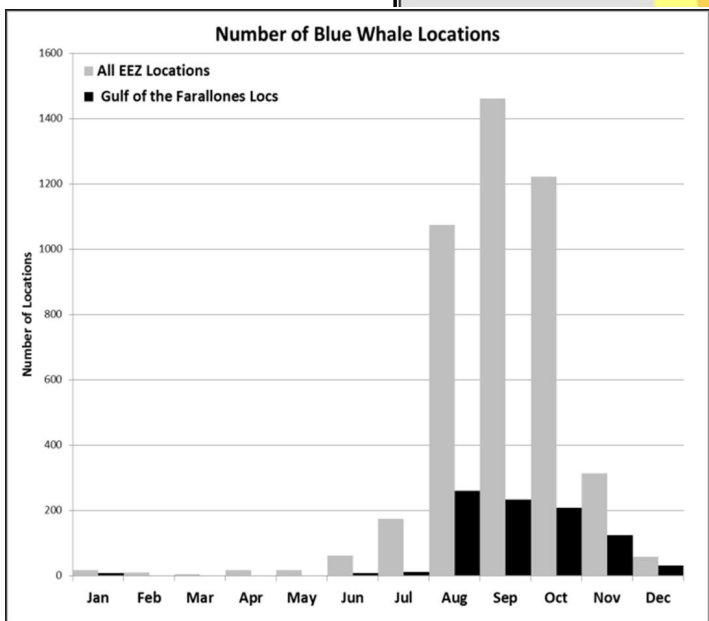
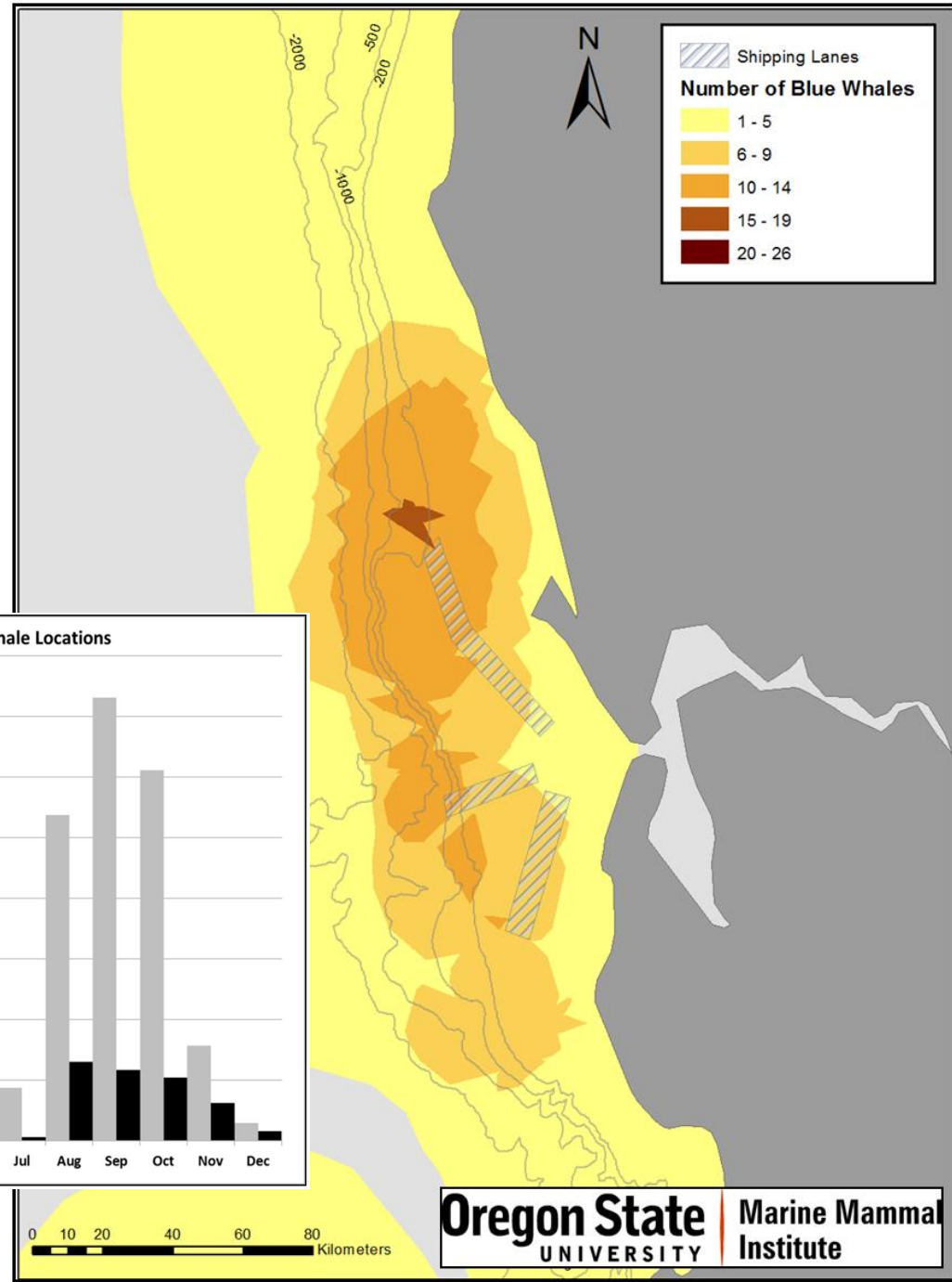


Irvine et al. Submitted

# Southern California Bight

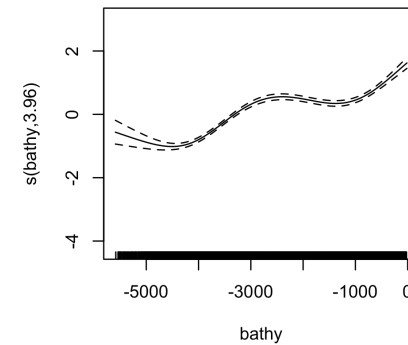
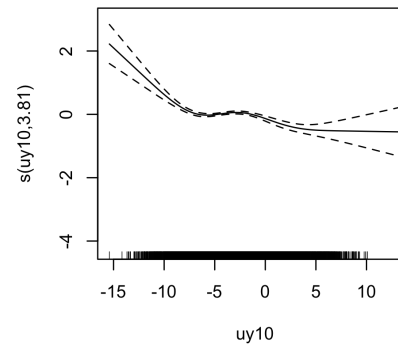
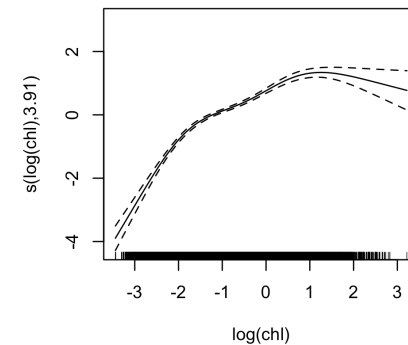
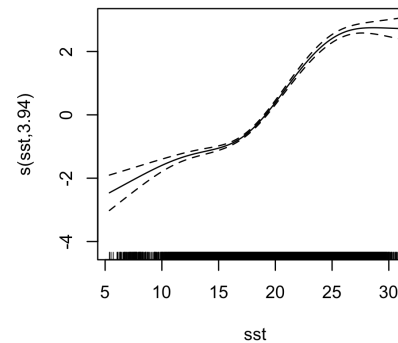
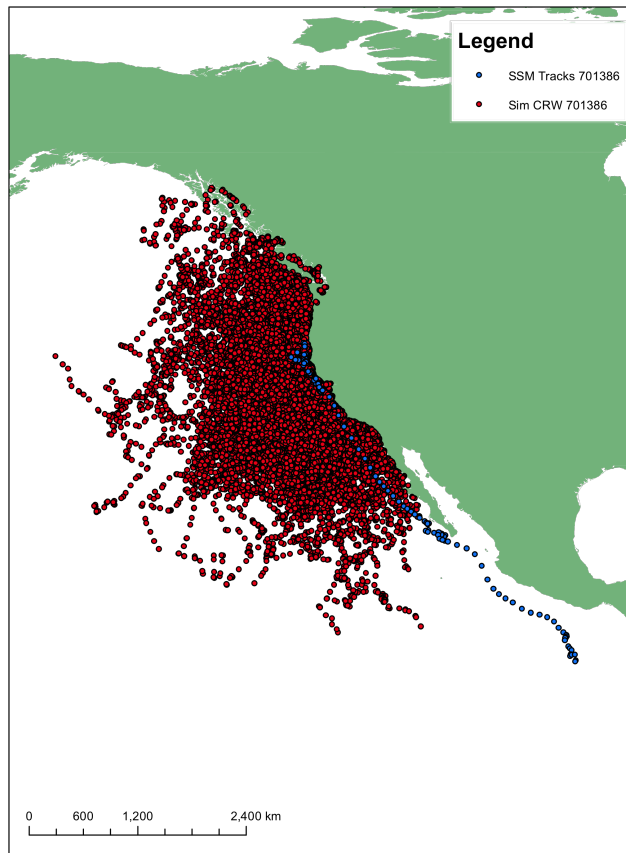


# Gulf of the Farallones



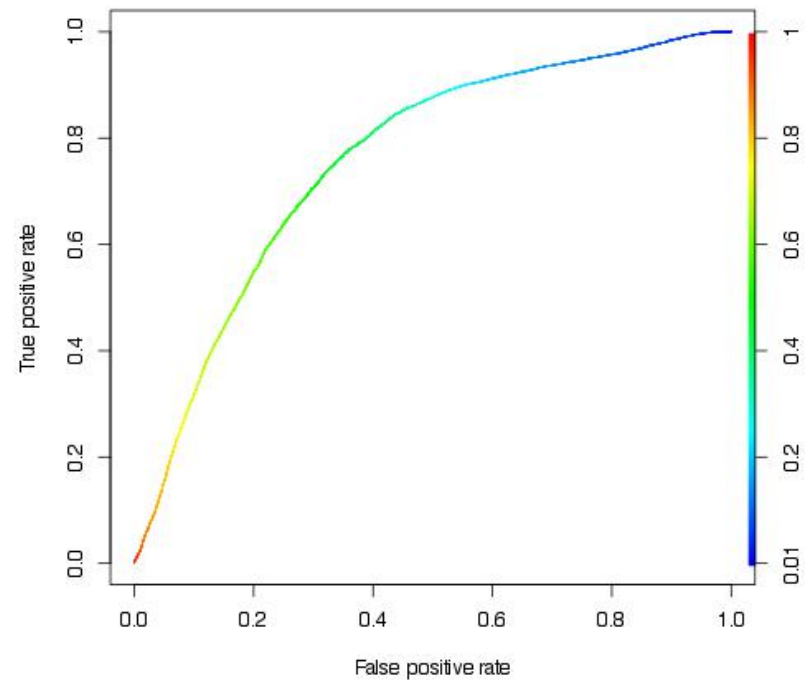
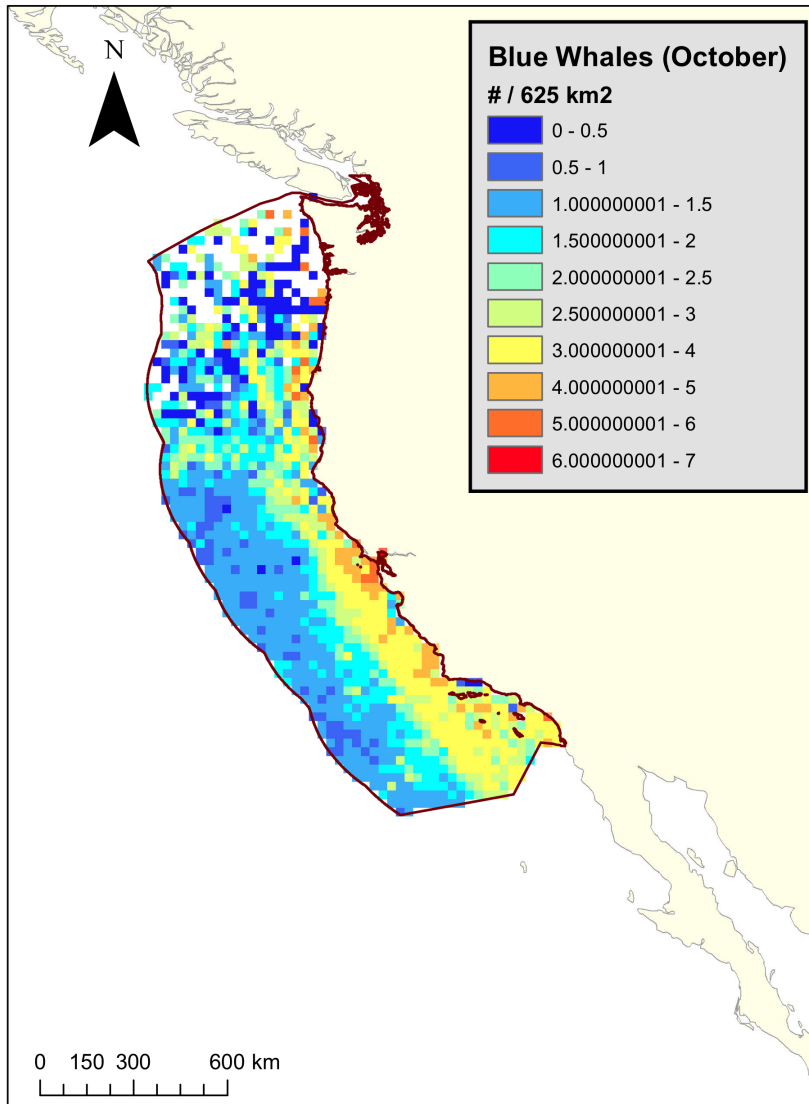
# Habitat-based model

- Generated correlated random walk (CRW) tracks to compare with real whale tracks.
- Fit a generalized additive mixed model (GAMM).



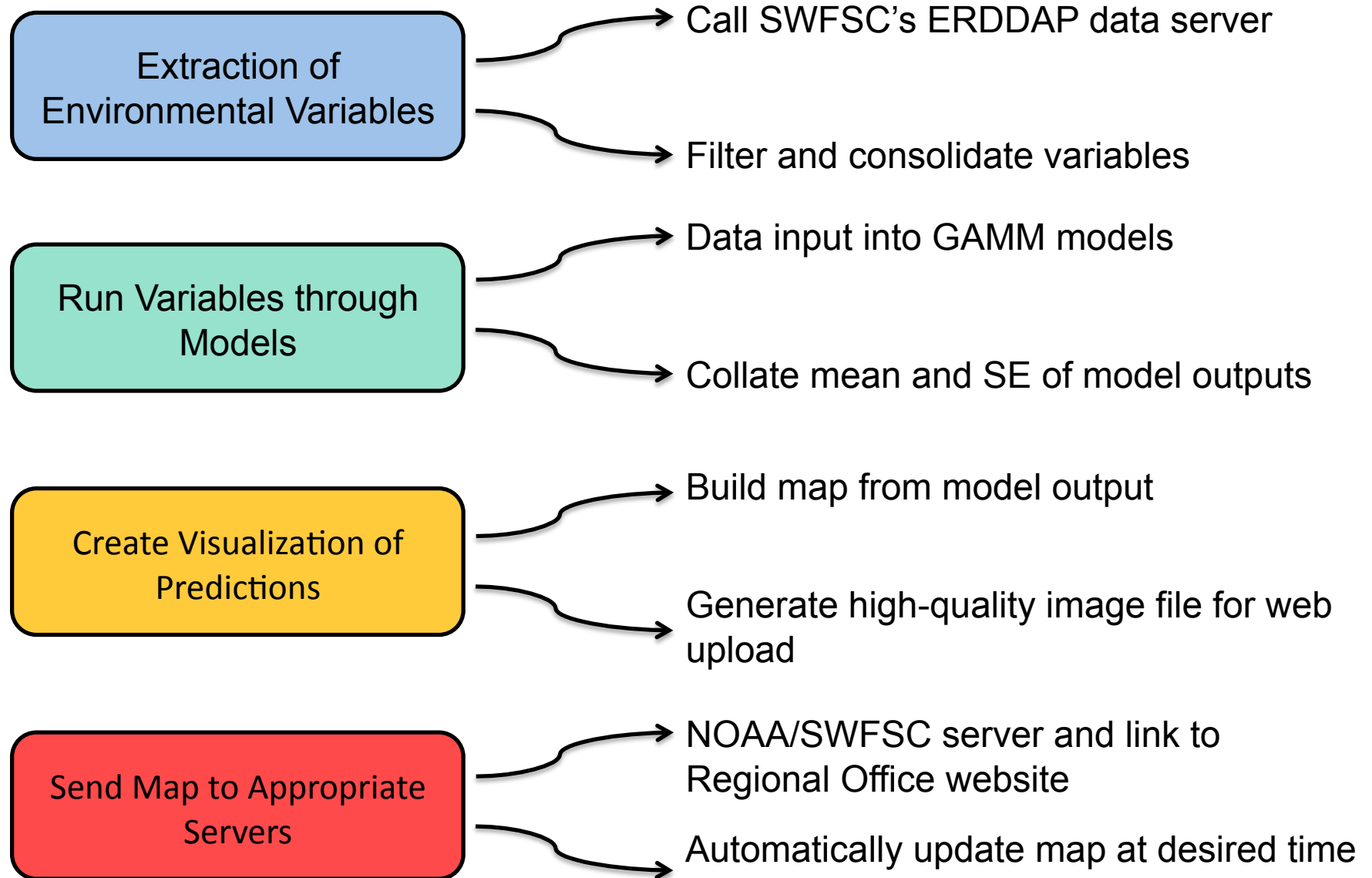
Hazen et al. in prep.

# Results

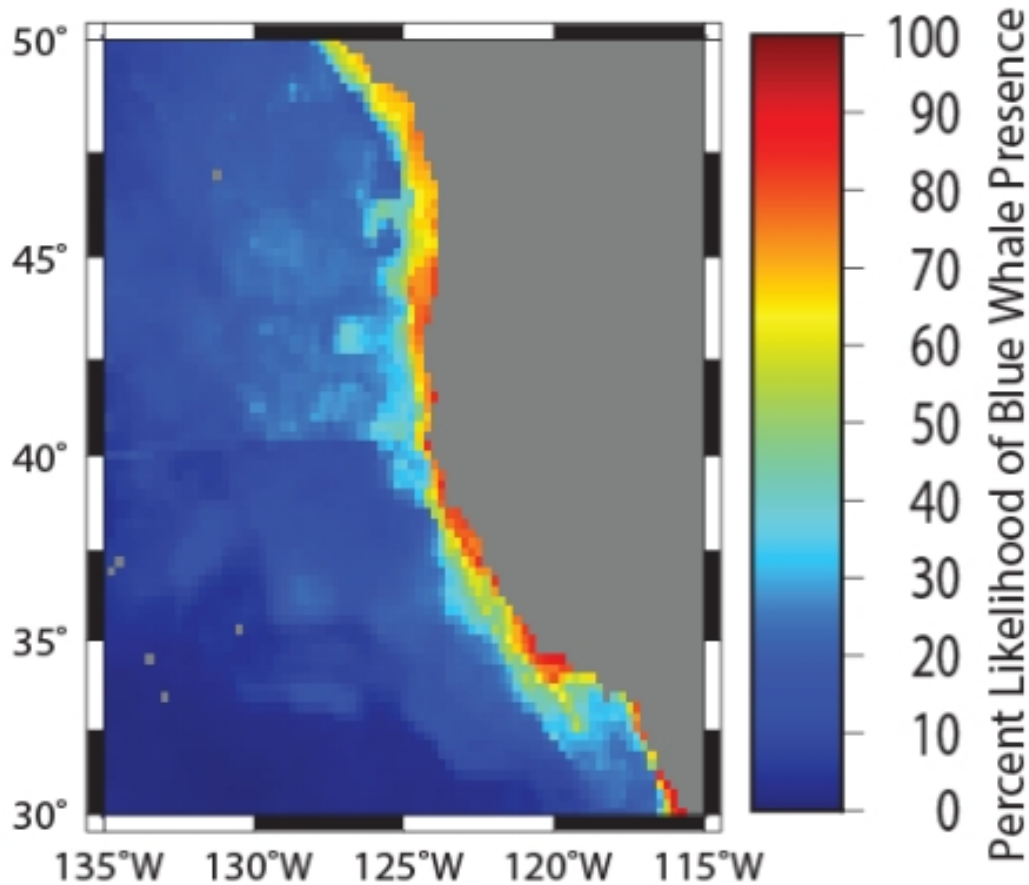


Hazen et al. in prep.

# Automated Data Processing



# Example predictions



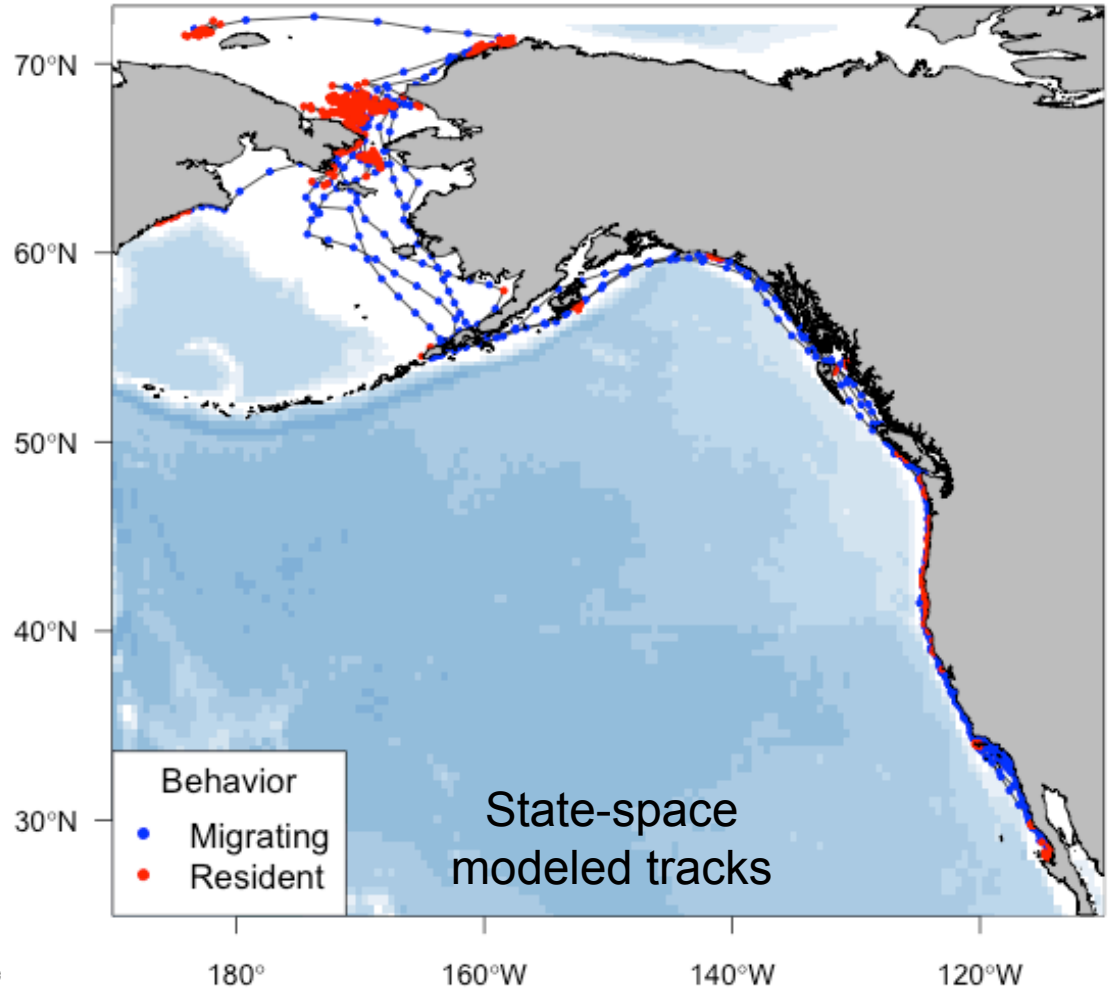
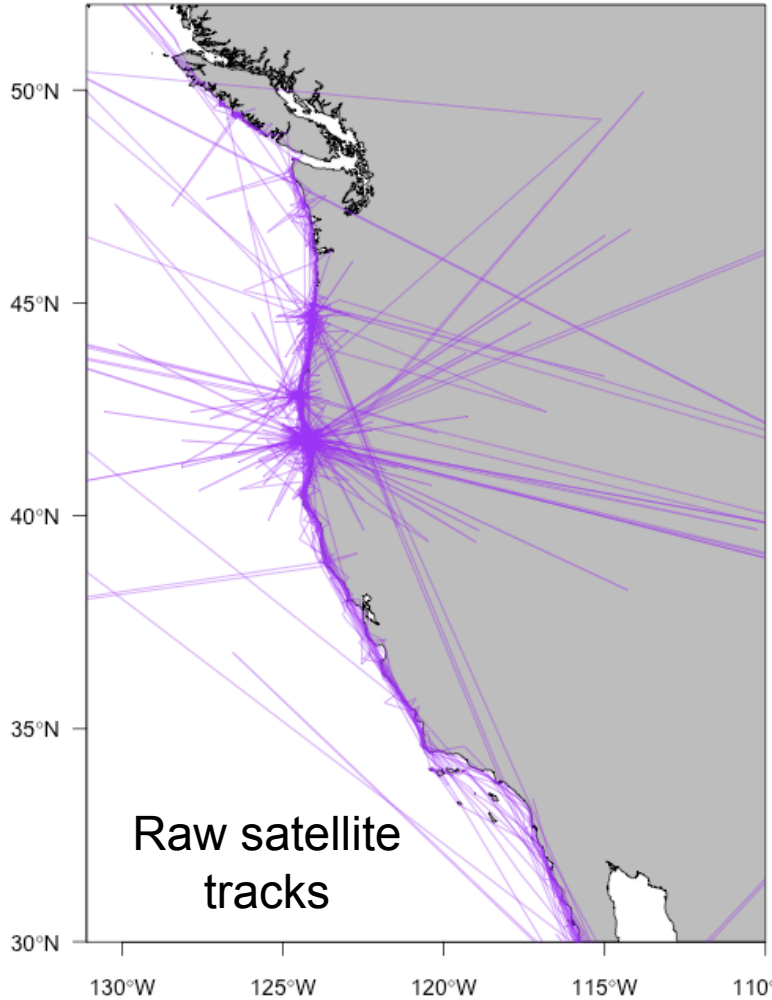
The screenshot shows the NOAA WhaleWatch Product website. At the top, there is a search bar and navigation links. The main content area features a "WhaleWatch Home" section with a navigation menu on the left and a main text block on the right. The text block includes a detailed description of the project, its goals, and the data sources used. Below the text is a smaller version of the map shown in the previous figure. At the bottom of the page, there are logos for the participating institutions: WhaleWatch, NOAA, University of Maryland Center for Environmental Science, and Oregon State University Marine Mammal Institute.

WhaleWatch is a NASA-funded project to help reduce human impacts on whales by providing near real-time information on where whales occur and hence where they may be most at risk from threats, such as ship strikes and loud underwater sounds. The WhaleWatch map provides up-to-date predictions of blue whale (*Balaenoptera musculus*) densities in the California Current System, including off the coasts of California, Oregon, and Washington. These predictions were developed from habitat-based models of whale occurrence that combine satellite tracking of whales with information on the environment. This research has been conducted by a team led by Helen Bailey (University of Maryland Center for Environmental), with the satellite telemetry data collected by Bruce Mate (Oregon State University), habitat modeling by Daniel Palacios, Elliott Hazen, Steven Bograd, Karin Forney (NOAA/NMFS Southwest Fisheries Science Center) and Ladd Irvine (OSU), and the web tool created by Evan Howell (NOAA/NMFS Pacific Islands Fisheries Science Center). This product is automatically updated based on the latest satellite-derived information on sea surface temperature, primary productivity, and ocean current conditions giving the expected number of whales based their preferred habitat. Our partner in this project is the NOAA/NMFS Southwest Regional Office as one of the priority issues for their Protected Resources Division is to reduce the number of ship strikes of large whales.

This WhaleWatch product gives the predicted number of whales within 25 x 25 km grid cells (approximately 13 x 13 nautical miles) with red colors representing higher densities and blue lower densities of blue whales. Correspondingly, human activities are likely to pose the greatest risk to whales in the high density areas and the lowest risk where whale densities are low. It should be noted that these predictions are only estimates based on the habitat-based models developed from historical data and do not represent actual recorded sightings or current densities.

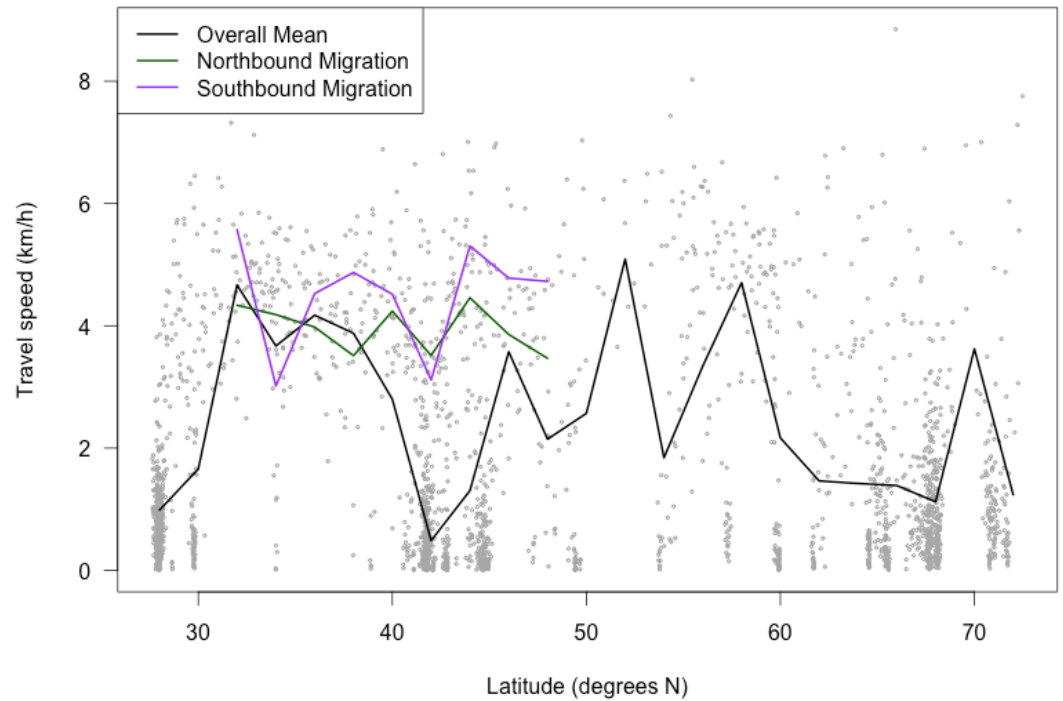
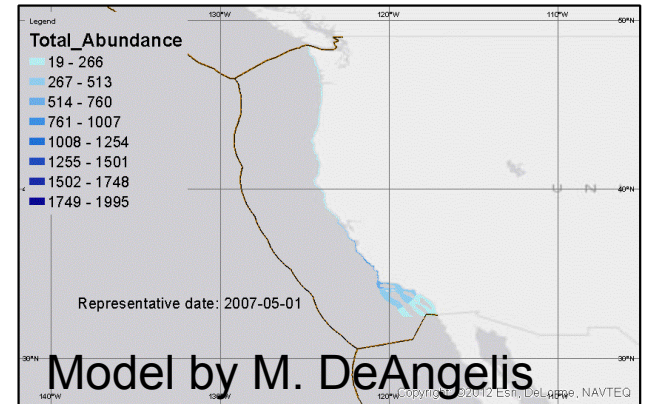
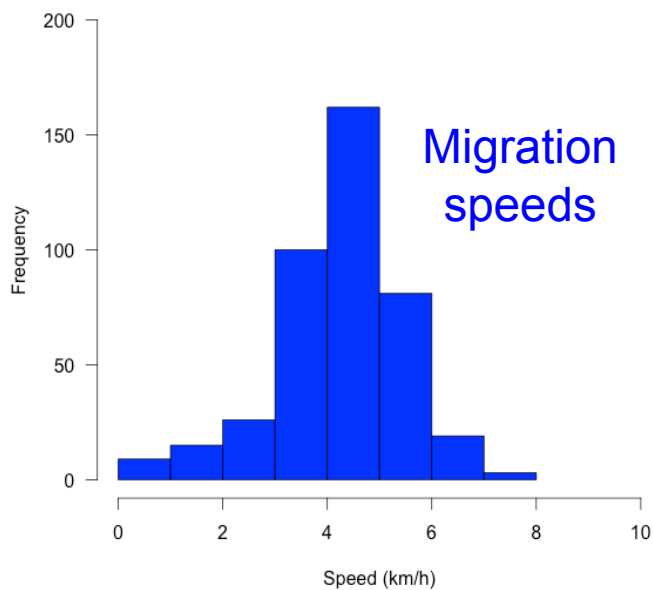
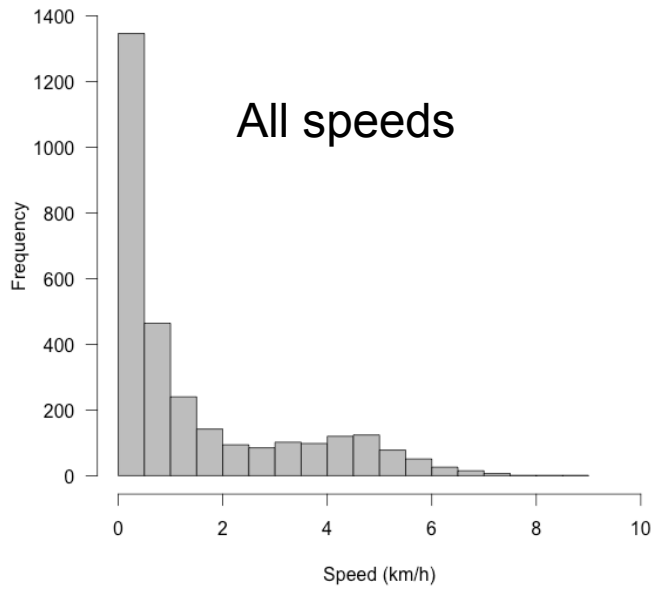
Funding for this project was provided under the interagency NASA, USGS, National Park Service, US Fish and Wildlife Service, Smithsonian Institution Climate and Biological Response program, Grant Number NNX11AP71G. Funding for whale tagging was also provided by the Office of Naval Research, the Marine Mammal Institute at OSU, and the Sloan, Packard and Moore Foundations to the Tagging of Pacific Predators Program.

# Gray whales



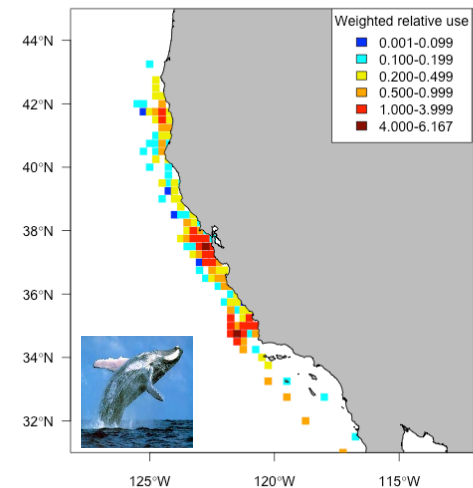
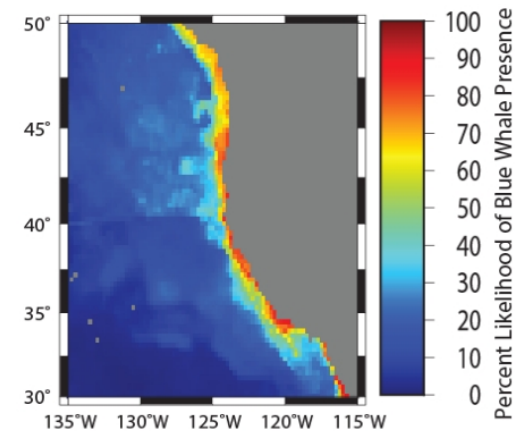


# Gray whale speeds



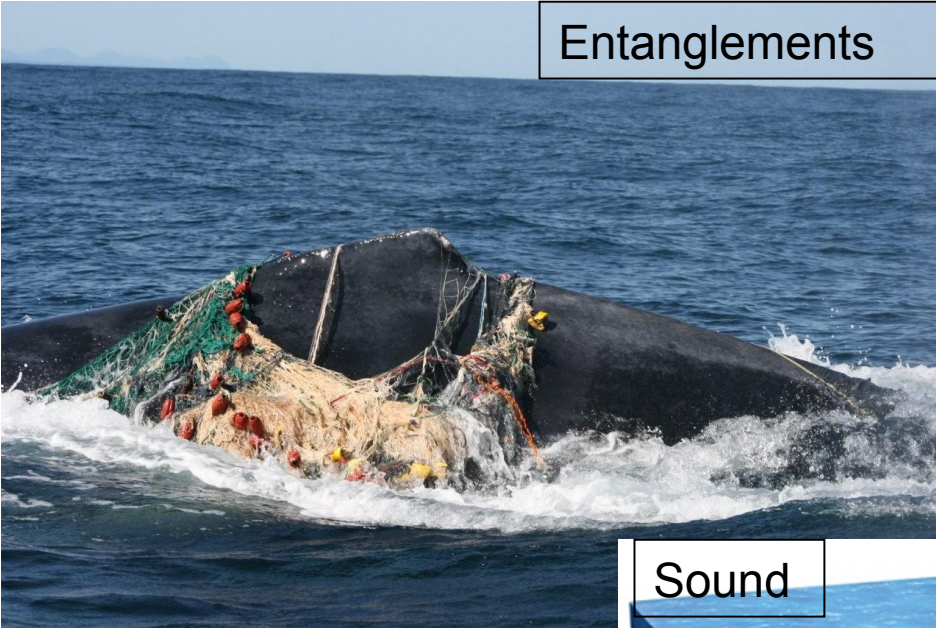
# Next steps

- Complete automated processing procedure for development of near real-time tool.
- Transitioning process:
  - Demonstrate tool and website plan to our partner, Monica DeAngelis at NOAA West Coast Regional Office.
  - Use NOAA/SWFSC server to host tool and establish publicly accessible website through NOAA Regional Office.
- Complete analysis for humpback whales and synthesis information for all 4 whale species.



# Threats

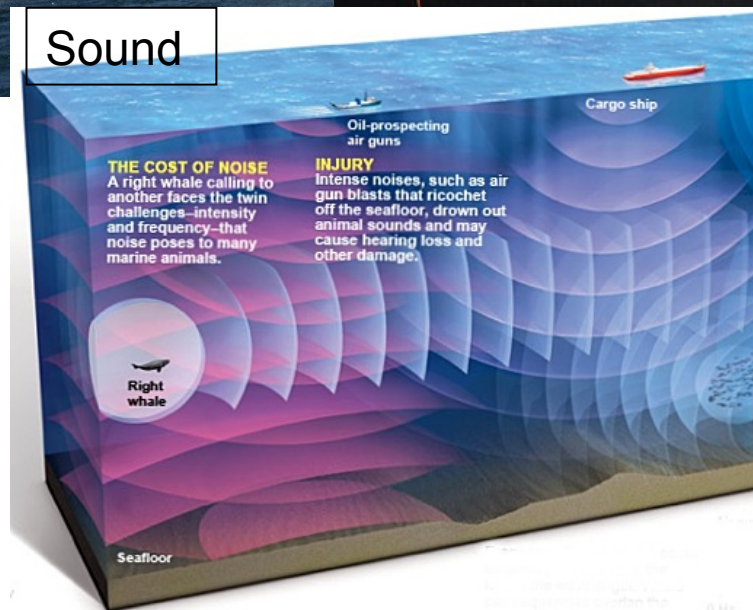
Entanglements



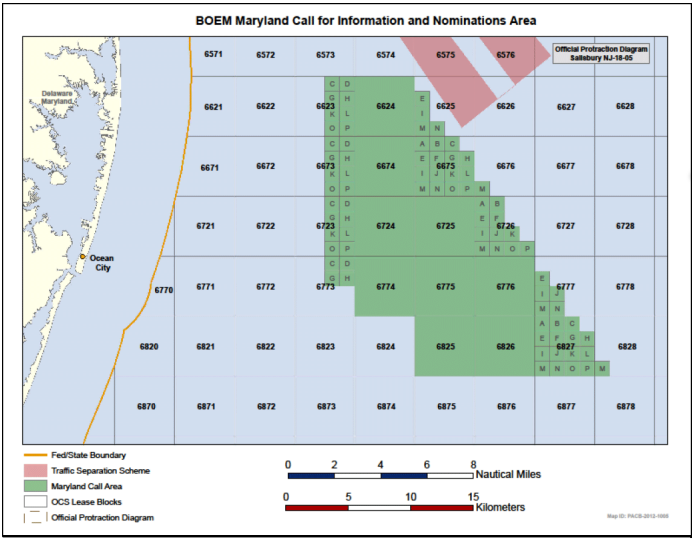
Ship strikes



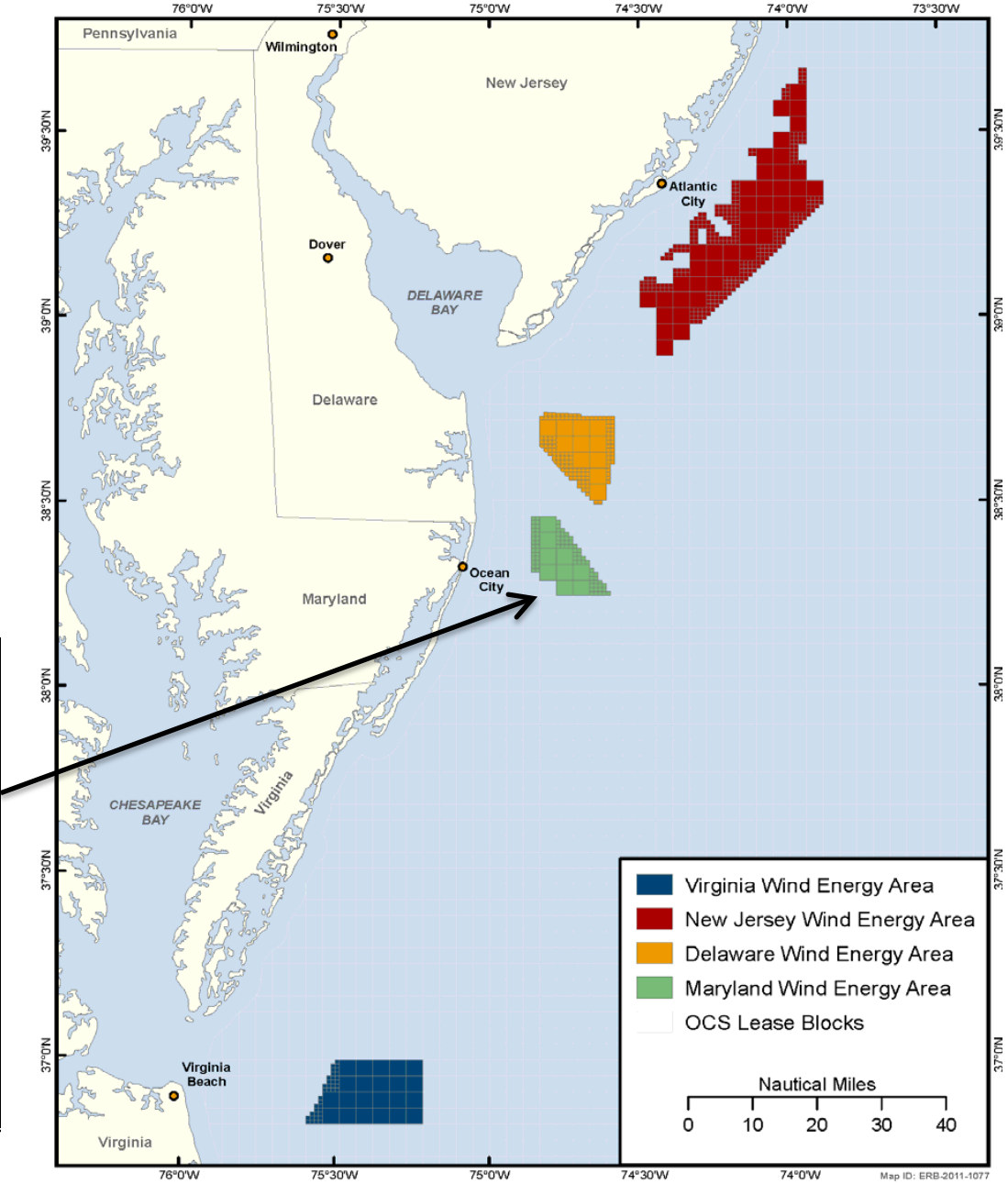
Sound



# Offshore development - wind energy areas

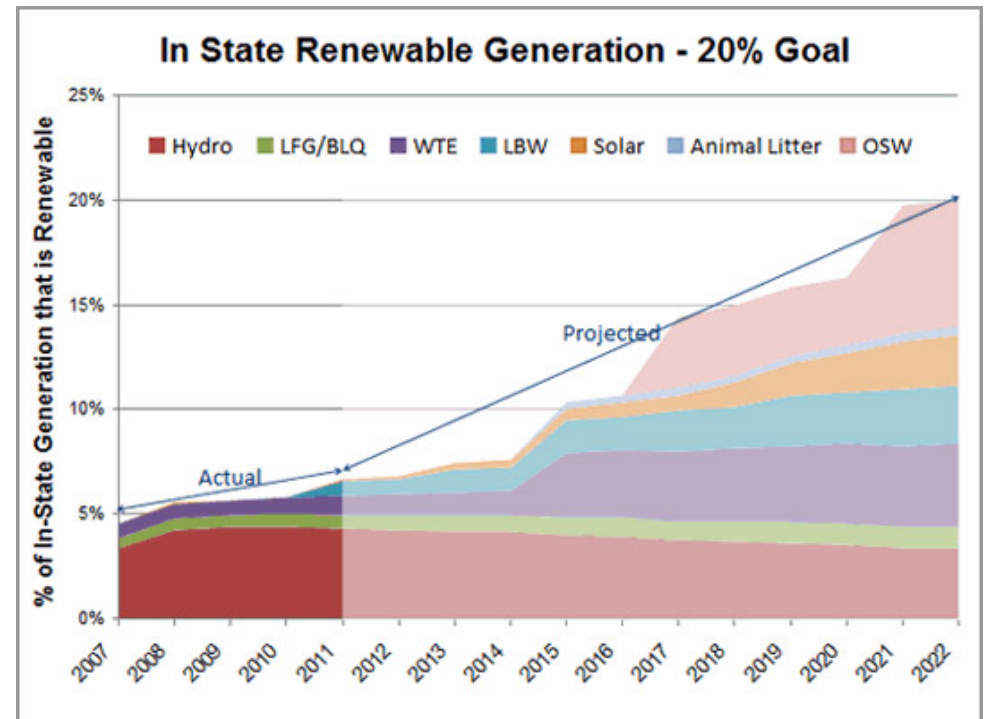


Maryland's "Wind Energy Area"



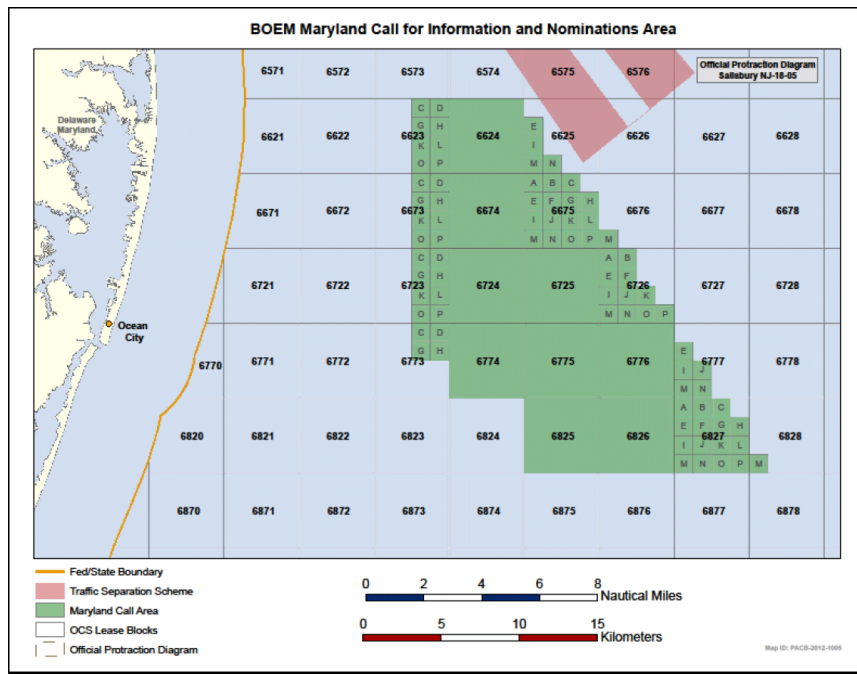
# Renewable Energy Targets

- Maryland committed to getting 20% of the State's electricity from renewable sources by 2022. Currently at about 6% (~700 MW).
- Land-based renewables (e.g. solar, wind) will only meet 36% of the goal and offshore wind can help fill the gap.



# Renewable Energy Targets

- An area 10-23 miles off the coast identified as suitable for offshore wind turbines.
- A 500 MW project would power more than half of the homes in Baltimore City.



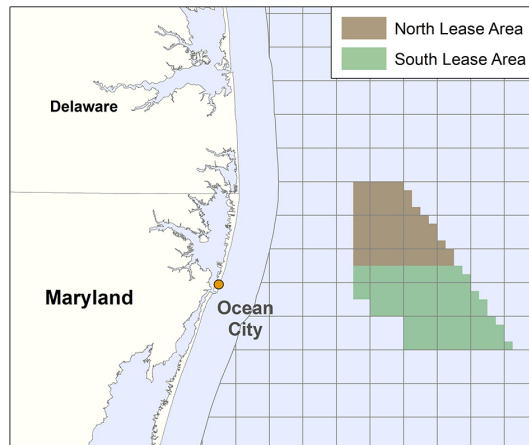
Maryland's "Wind Energy Area"

<http://www.governor.maryland.gov/wind.asp>



# Offshore Wind Energy Act

- The Maryland Offshore Wind Energy Act passed in March 2013.
- Provides \$1.7 billion in subsidies over next 20 years for Maryland offshore wind development.
- A target project of 200 MW would require the installation of about 40 turbines off the coast of Ocean City.



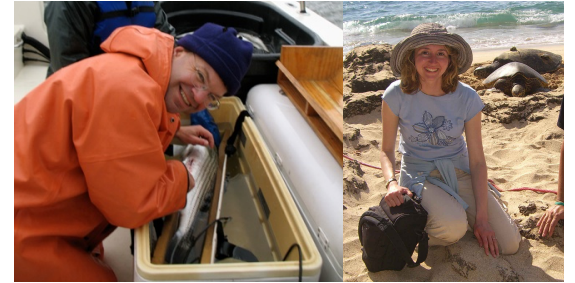
# Baseline Environmental Data

## Example: Right whales





# Conclusions



- Movement patterns can be used to identify hotspots, migratory routes and habitat use of aquatic species.
- Effective method for quantifying long-term, broad and fine-scale movements.
- Ability to infer behavior and essential habitat.
- Identify responses to events, changes in the environment, and human developments.
- Important implications for management.

# Acknowledgements

- Thanks to everyone at CBL and UMCES for their advice and support.
- Funding for WhaleWatch was provided under the interagency NASA, USGS, National Park Service, US Fish and Wildlife Service, Smithsonian Institution Climate and Biological Response program, Grant Number NNX11AP71G.
- The support of field crews was essential to the success of the whale tagging operations. Tagging was supported by private donors to the MMI Endowment at OSU, as well as the support from ONR and the Sloan, Packard and Moore foundations to the TOPP program.



# Thank you!

E-mail: [hbailey@umces.edu](mailto:hbailey@umces.edu)

Web: [www.umces.edu/cbl/faculty/hbailey](http://www.umces.edu/cbl/faculty/hbailey)

UMCES Offshore Wind Group:

<http://www.umces.edu/cbl/wind>

