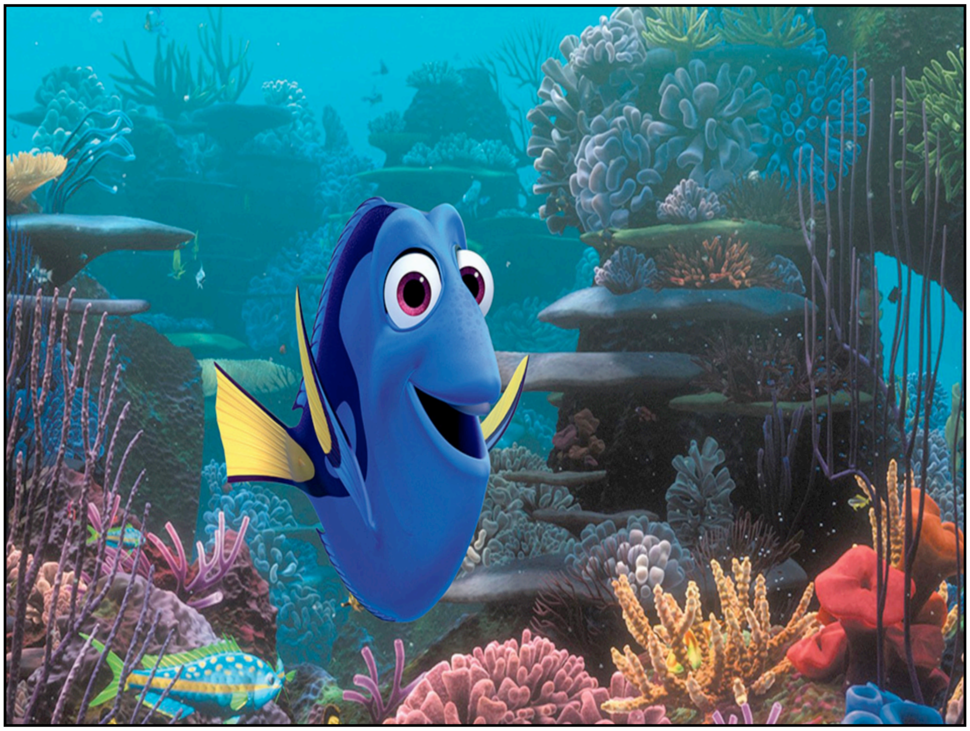
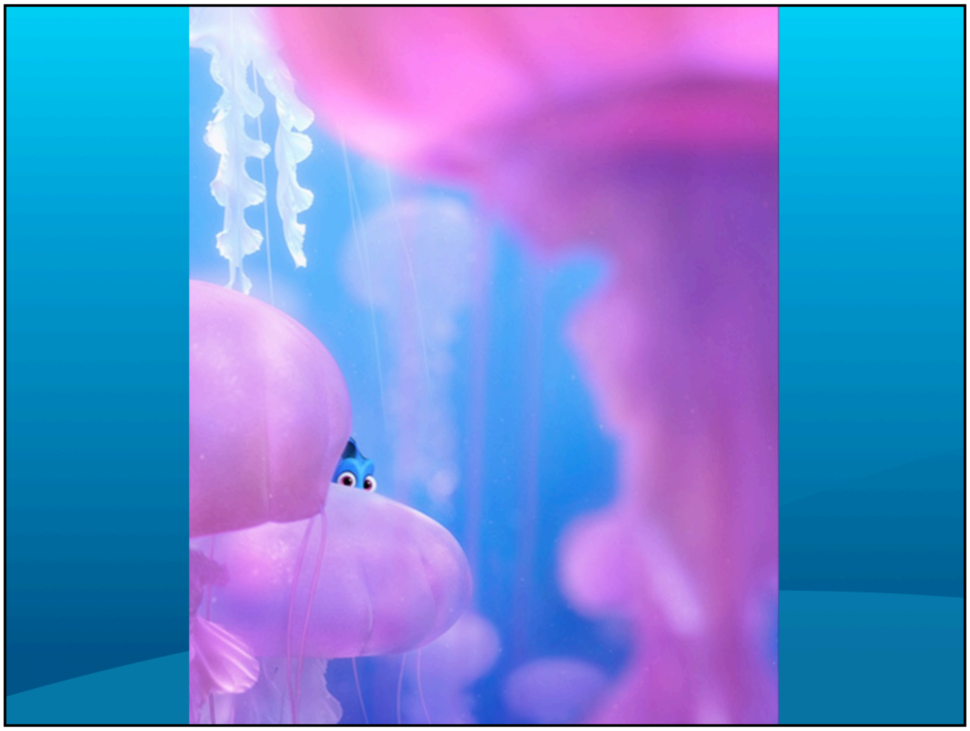


So this is a big year if your name is Dori and I hope that you won't miss the next great Pixar film

But it's my pleasure to tell you about Dori with an "i"

Unlike the title of the awesome new Pixar film "Finding Dory" we are so lucky because it was Dori who found US here at Oregon State and asked to become part of my lab in 2010.

She was a great addition to our geography program coming in with an already stellar background. After earning her M.S. in geography from SF State under Ellen Hines, she worked as a GIS Analyst for the North Atlantic Right Whale Program with the Florida Fish and Wildlife Research Institute (FWRI), where she integrated GIS methods and spatial statistical techniques to provide information to natural resource managers. And while an MS student at SF State she had already served as the assistant chair of the scientific program for the 1st Intl Marine Conservation Congress, and continued as Education and Outreach Chair for the 2011 IMCC while here at OSU.



Like the scene in Finding Nemo where Dory with a Y swims bravely through a **BLOOM** of jellyfish, Dori with an I has braved and overcome many obstacles, not the least of which was my departure for Esri in 2011 (and after her adviser at SF State did the same thing during her MS).

But true to the motto of the Pixar films — **Just keep swimming** — she has been stellar. She was a great RA on an ONR grant to **Scott Baker** and myself, served with great distinction as a campus wide GIS TA (working with **Jim Graham** another former committee member now at Humboldt State), a regular TA, and has also funded herself through this long odyssey including as a part-time researcher at the DOE National Energy Technology Laboratory in Albany.

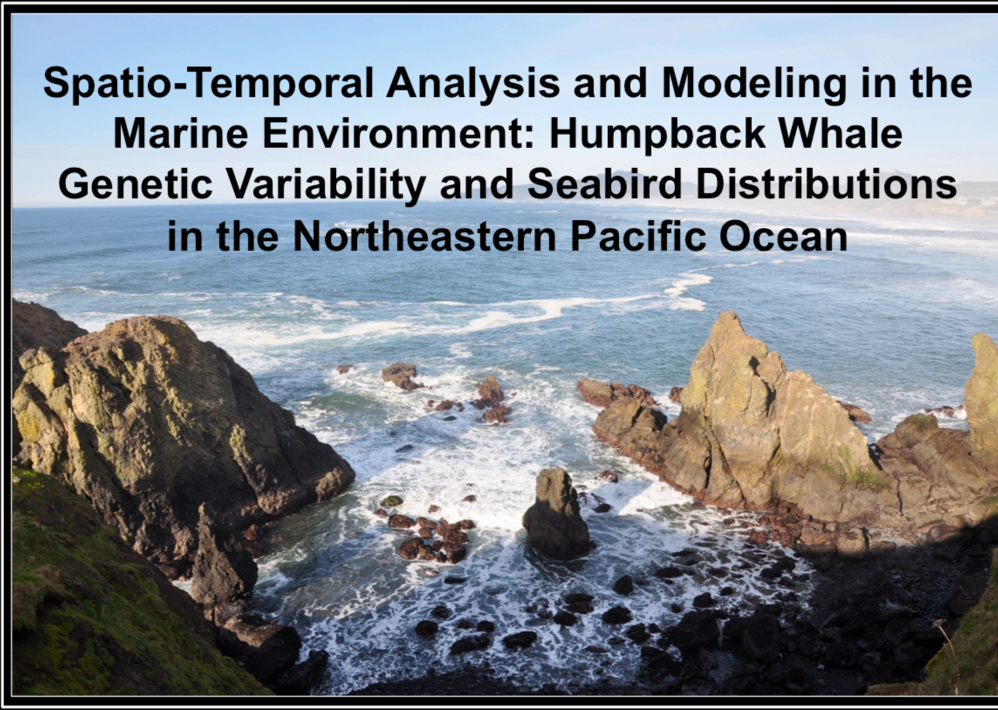
She advanced to candidacy in March of 2013.

And we continue to be proud of Dori because she was selected for the 2016 Class of NOAA Knauss Marine Policy Fellows to serve as a Protected Species Program Specialist on Climate Change in the NOAA Fisheries Office of Protected Resources (NOAA HQ, Silver Spring)

[Bailey and Piper from Finding Dory]
I'd like to introduce some of the other characters in this odyssey. You'll certainly hear about the whales and seabirds from Dori, but I'd like to acknowledge the members of Dori's current committee
Julia Jones of Geography (also Geography Program Chair) – huge role in all aspects; personal thanks from Dawn
Robert Kennedy of Geography
Susan Carozza of Public Health & Human Services, GCR
And remotely, Leigh Torres of Fisheries & Wildlife and the Marine Mammal Institute at HMSC

So without further adieu …

Spatio-Temporal Analysis and Modeling in the Marine Environment: Humpback Whale Genetic Variability and Seabird Distributions in the Northeastern Pacific Ocean



Dorothy M. Dick
Oregon State University
10 June 2016

Committee:
Dawn Wright , Advisor
Julia Jones,
Robert Kennedy,
Leigh Torres,
Susan Carozza (GCR)

Oregon State University | CEOAS

During our lifetimes, there has been a rapid, global decline in marine ecosystems and oceans are no longer considered an unlimited resource.

The impacts from resource extraction, waste disposal, shipping traffic, and climate change are well-recognized factors that have and continue to contribute to the loss of species, changes in marine communities, and losses of ecosystem functioning, goods and services.

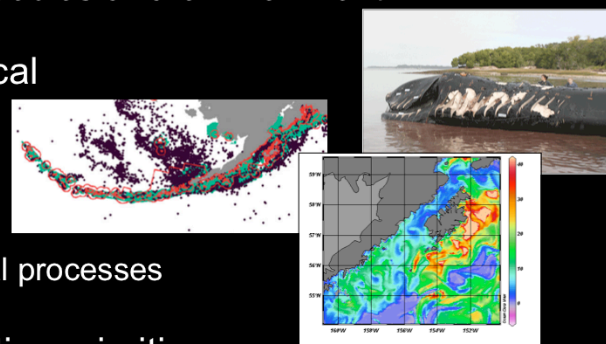
To respond to this, more holistic management approaches have developed such as marine ecosystem-based management, which considers the entire marine ecosystem, including humans, and strives to maintain a healthy, productive and resilient ecosystem into the future

Marine EBM is based on marine spatial planning, a process that that identifies the spatial distribution of ocean activities to maintain existing and emerging uses, reduce use conflicts and protect and maintain the ecosystem.

One tool of marine EBM is placed-based protection through the creation of marine protected areas. MPAs are areas of ocean designated with additional protections to enhance conservation of marine biodiversity and resources.

Marine Conservation and MPAs

- Require robust understanding of species and environment
- Spatially explicit information is critical
  - Species of interest
  - Distribution of critical habitats
  - Threats in space and time
  - Understanding physical and biological processes
- Quantitative approach to conservation priorities
- Mapping spatial data and attributes brings repeatability and scientific credibility to MPA design process



3

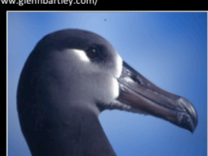
MPAs have traditionally used marine megafauna like whales and sea as ecological indicators and assumes protective measures created for such species will extend to also provide protective measures for areas of ocean productivity as well as other species dependent on that productivity.

Motivation


NOAA Stock Pictures


http://www.glennbartley.com/

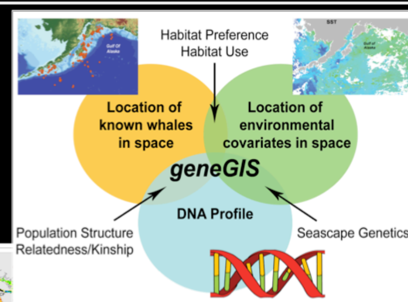

http://www.wildbirdgallery.com/images/birds/phoebastria_nigripes/nigripes_1892.jpg


Dori Dick

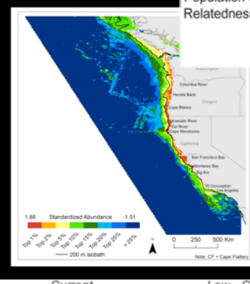
- Explore and analyze spatially explicit humpback whale and seabird data
- Inform marine spatial planning process
- Help in the design of MPAs in the North Pacific

4

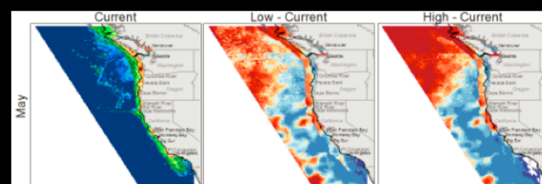
1. Develop suite of geoanalytical tools to facilitate visual exploration and spatial analyses of genetic data



2. Modeling to predict location of seabird hotspots



3. Modeling to project how hotspots will shift with climate change

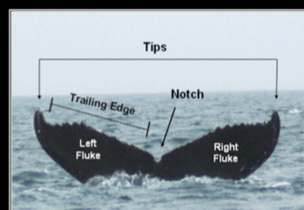


5

geneGIS: Geoanalytical Tools and Arc Marine Customization for Individual-Based Genetic Records

How can we best facilitate the exploration and visualization of *spatial* patterns of genetic variability in individual-based, long-term cetacean studies?

http://www.nationalgeographicstock.com/ngsimages/explore/explorecomp.jsf?xsys=SE&id=1231238

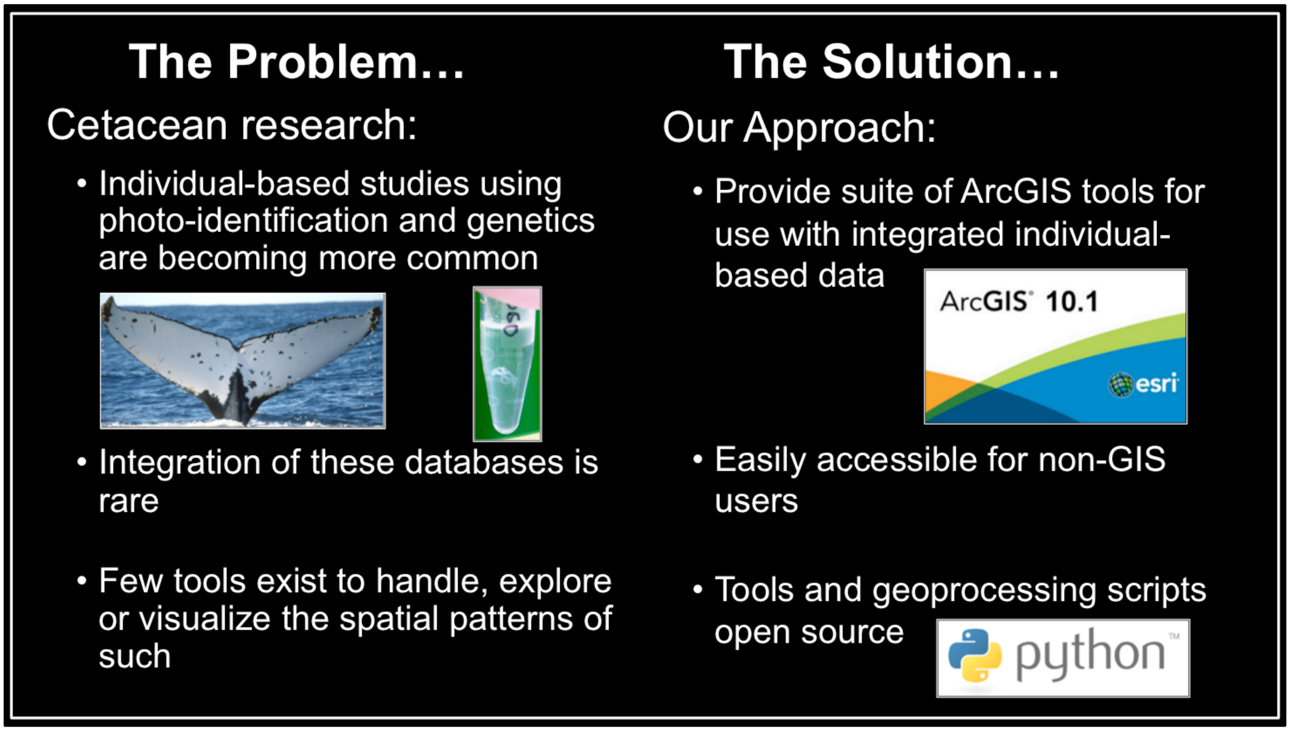


http://www.afsc.noaa.gov/ABL/Humpback/WhyPhoto.htm

Transactions in GIS 2014, 18(3):324-350

Coauthors: Shaun Walbridge, Dawn Wright, John Calambokidis, Erin Falcone, Debbie Steel, Tomas Follett, Jason Holmberg, C. Scott Baker

6

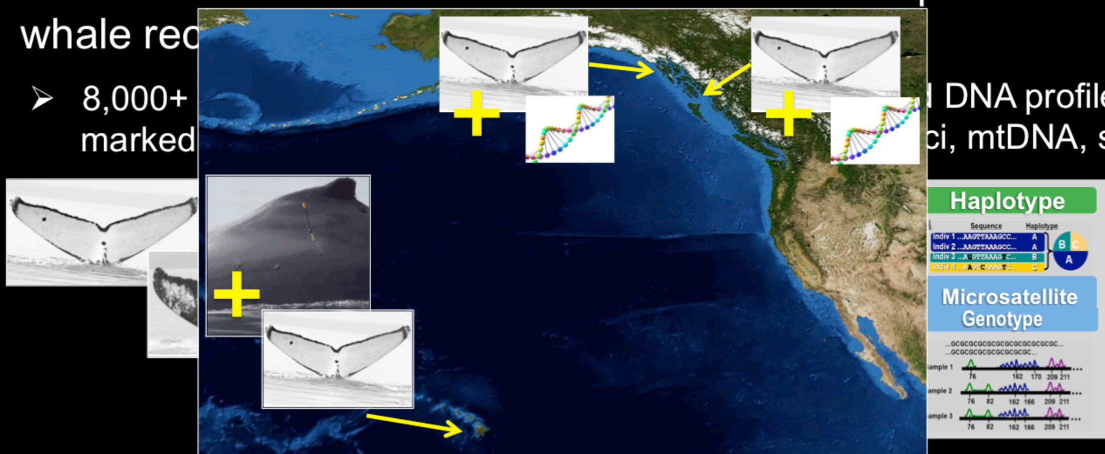


Cetacean research using individual-based techniques such as photo-identification and genetics are becoming more common.
However, integration of the two databases into one is rare.
And even when they occur as one large database, few tools exist to handle, explore or visualize the spatial patterns of such data.

With this in mind, our approach was to provide a suite of ArcGIS tools for use with integrated individual-based data that is easily accessible for non-GIS users. All tools and geoprocessing scripts are coded in the open source programming language Python, which enables the tools to be modified by a more advanced user on an as needed basis.

The Data

- *geneGIS* developed and implemented using SPLASH*, a collated & extended database of N. Pacific humpback whale rec
  - ➢ 8,000+ … DNA profiles (10 marked … ci, mtDNA, sex)



*Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific

Development Goals

- Provide suite of ArcGIS tools for researchers who want to:

  1. Visualize data on a map
  2. Spatially explore, display, and select data
  3. Export data to formats required by other genetic analyses software
  4. Extract data from environmental layers
  5. Conduct basic spatial analyses

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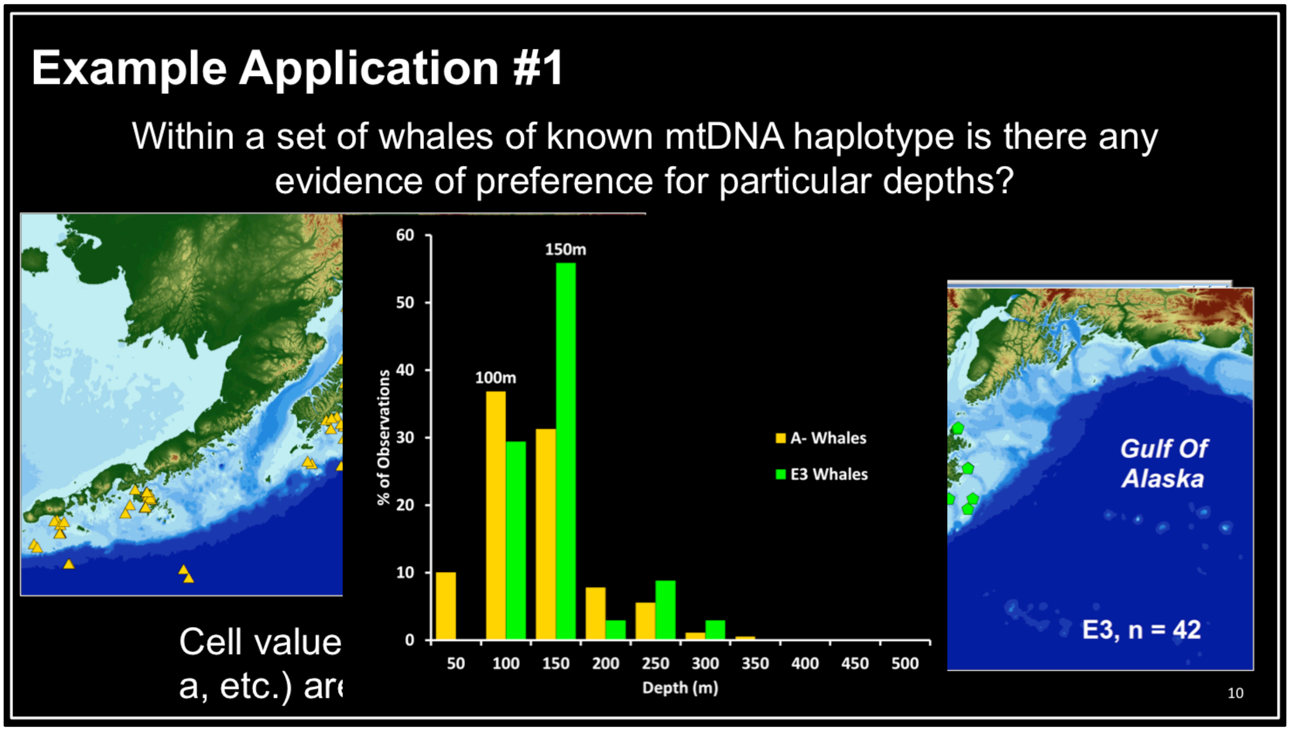
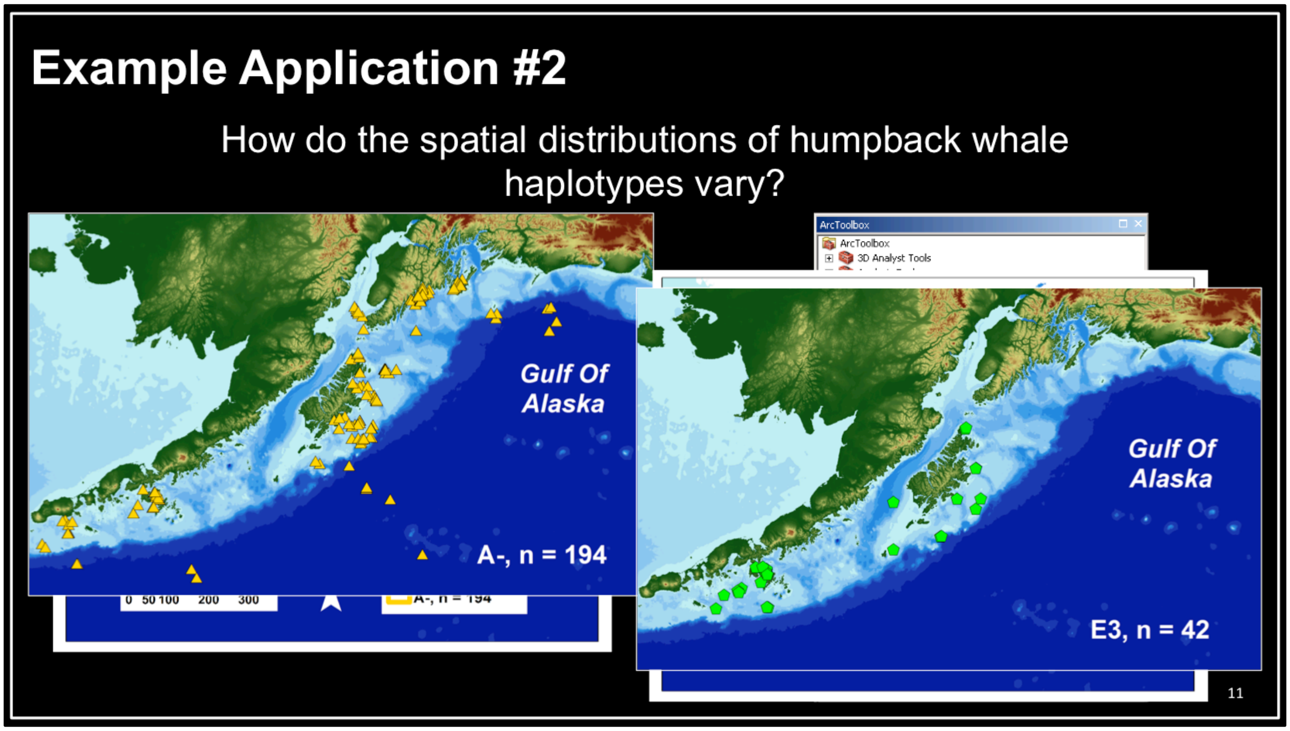


Because of the higher haplotype diversity in the Gulf of Alaska, the next 2 examples will focus on this region only to look for more fine scale patterns in the data.

To demonstrate data extraction we can ask the question: Within a set of whales of known haplotype, is there any evidence of preference for particular depths? ~~Or are whales distributed proportionally to depth?~~

From the Geographic Analysis options on the geneGIS toolbar or using the button, one can extract the raster values from various environmental layers such as bathymetry. The user can input more than 1 raster with this tool and the cell values for each point will be added to the input feature class used. This data can easily be exported to a comma separated or tab delimited format for use in Excel, R etc.

Here I have created 2 maps, showing the spatial location of encounters for two haplotypes, A- on the left and E3 on the right. Using the extracted depths values within each feature class I created a histogram of for the % of observations seen at 50m depth intervals and discover that the whales with the 2 haplotypes appear to have a preference for different depths.



Finally, to demonstrate some of the more spatial analytical capabilities of ArcGIS, we asked the question, how do the spatial distribution of humpback whale haplotypes vary?

Because the data are now in a GIS format, we can turn to and take advantage of the Standard ArcGIS toolbox to conduct more advanced spatial analyses. In this case I chose to conduct a standard deviation ellipse analysis which summarizes the central tendency, dispersion and directional trends in both the X and Y direction to visualize the different spatial distributions of the 2 haplotypes.

Using 1 standard deviation and the A- and E3 haplotype data from the previous slide, the polygons in each map represent the location where 68% of the whale encounters occurred and quickly provides the ability to visualize the different spatial distributions of the haplotypes.

Summary/Significance

www.my-photo-blog.com/breaching-humpback-whale

geneGIS provides *new quantitative* approach to *conservation priorities:*

- Map spatial data and genetic attributes of individuals
- Pose and answer questions using environmental information important to a species in geographic space
- Enhance understanding of pop^n structure, ecosystem relationships and human impact across species and ecosystems

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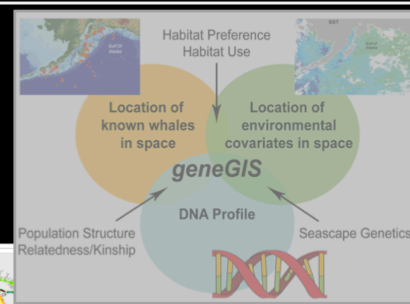
1. Develop suite of geoanalytical tools to facilitate visual exploration and spatial analyses of genetic data



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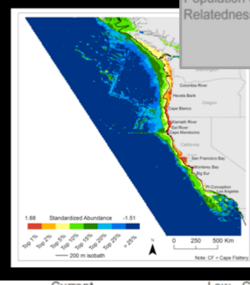

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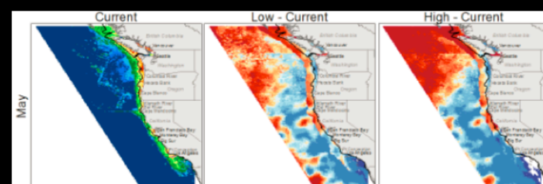

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Seabird Background

- 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

- Studies on seabirds and habitat associations important role to identify and designate MPAs

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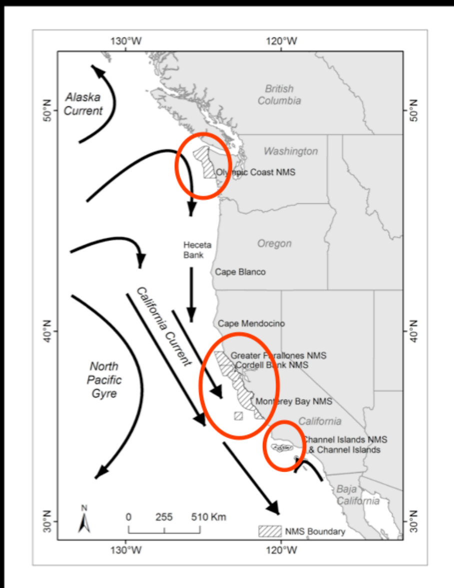
California Current System



- Eastern boundary current systems
- Spring/summer upwelling, high productivity
- Supports valuable commercial fisheries, many species including marine mammals and seabirds
- 5 federally protected national marine sanctuaries

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Mapping the Flock: Modeling Multispecies Seabird Foraging Aggregations in the California Current System

1) Across years and seasons, where are the hotspots?
2) How do hotspot locations differ across seasons?
3) How do hotspots differ among years?
4) Are there locations that were not apparent in Nur et al. (2011) that are now?
5) What are the factors that determine the location and temporal variability of hotspots?; and
6) Which factors differ in their influence among years?

Where are seabird hotspot locations and how do they vary in the California Current System?

Coauthors: Jaime Jahncke, Nadav Nur, Julie Howar, Jeannette E. Zamon, David G. Ainley, Ken Morgan, Lisa T. Ballance, and David Hyrenbach

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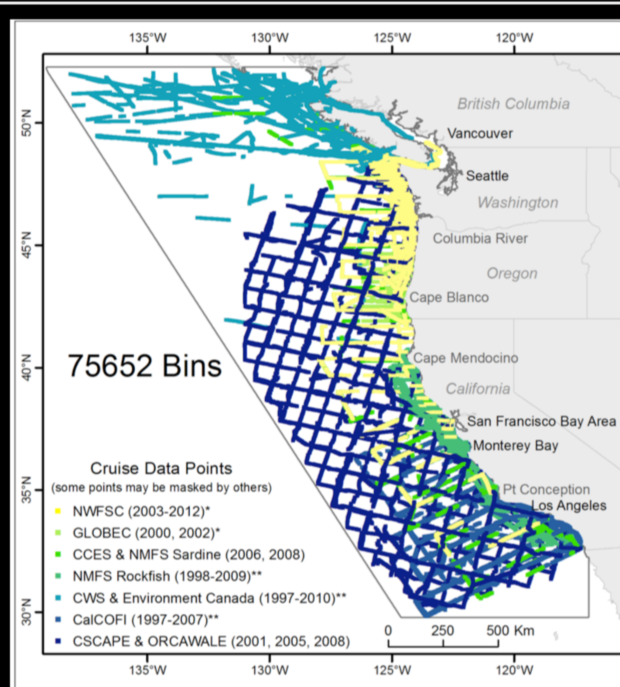
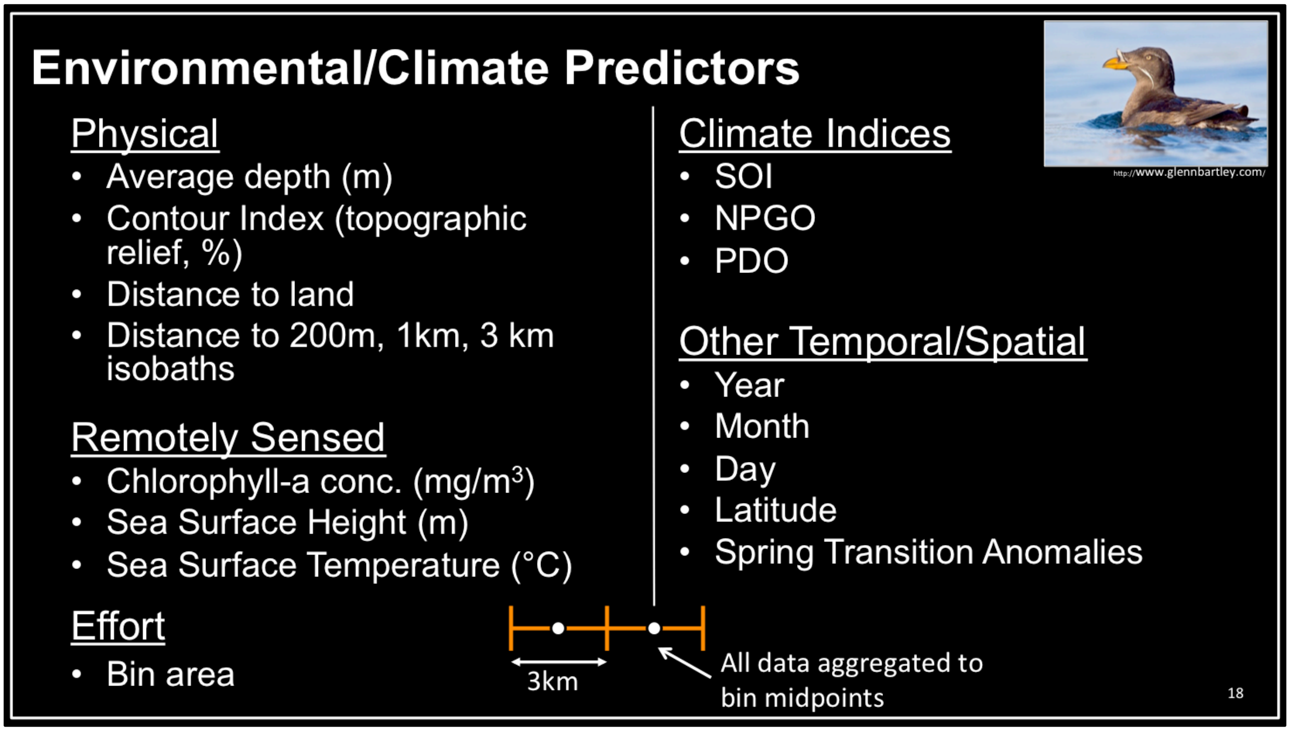
Seabird Data

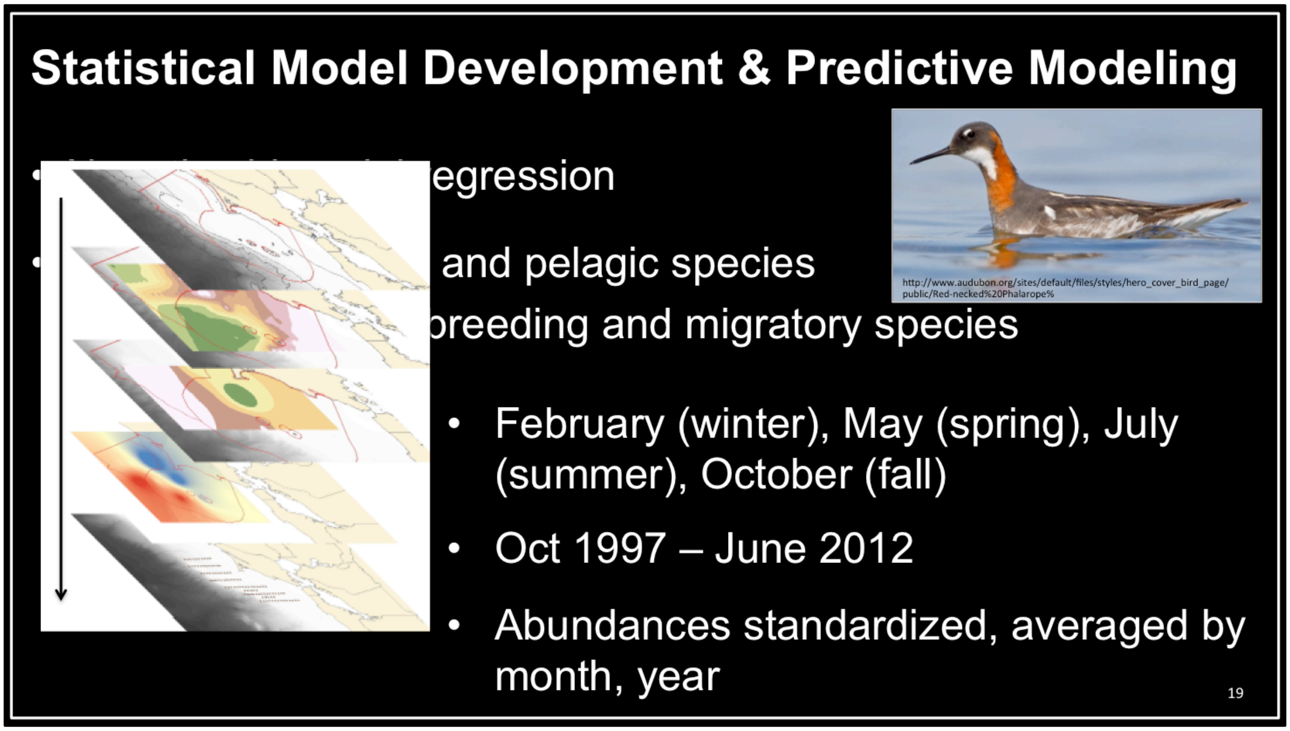
- 15 years at-sea survey data (Oct 1997 – June 2012)
- Transects divided into 3km segments (bins)
- Bin midpoints used to aggregate seabird counts by species





We included a variety of environmental and climate predictors shown here that are known to influence seabird presence and distribution

All data were extracted and aggregated to bin midpoints



Using seabird counts as the dependent variable, we used negative binomial regression models to predict the distribution and abundance of seabird species

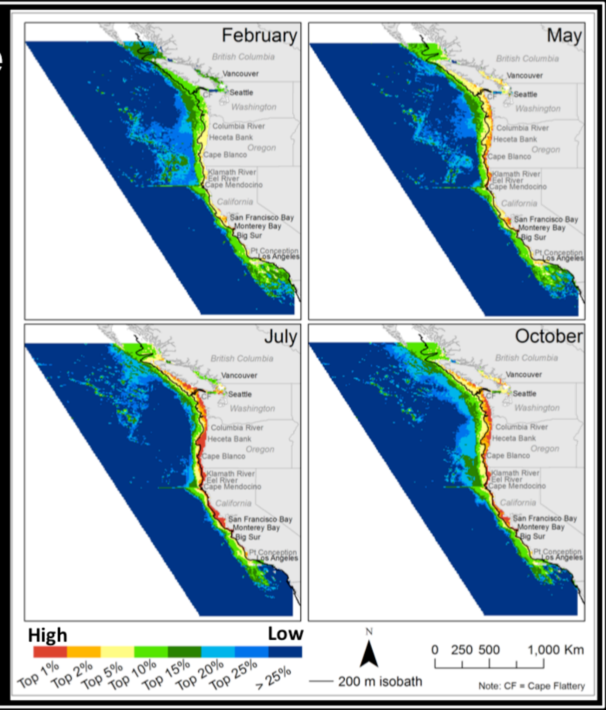
We were able to create 30 species specific models. This included both coastal and pelagic species as well as locally breeding and migratory species

We created a prediction grid for the entire study area and used the center point of each grid cell to extract predictor values to 4 focal months, February, May, July and October

We then predicted species specific distributions for the current data from 1997 – 2012

Results: Species Abundance

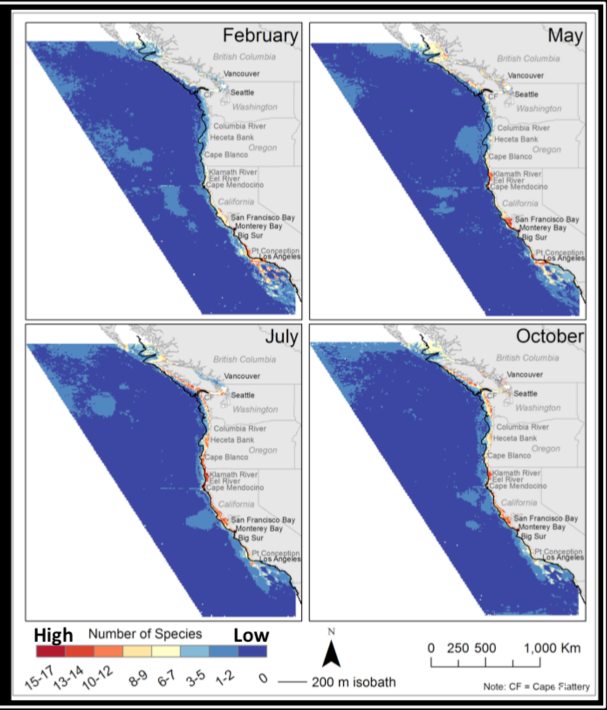
- Seasonal variation
- High abundance on along coast within 200 m isobath during upwelling
- Lower abundance during non-upwelling
- Something going on in pelagic region



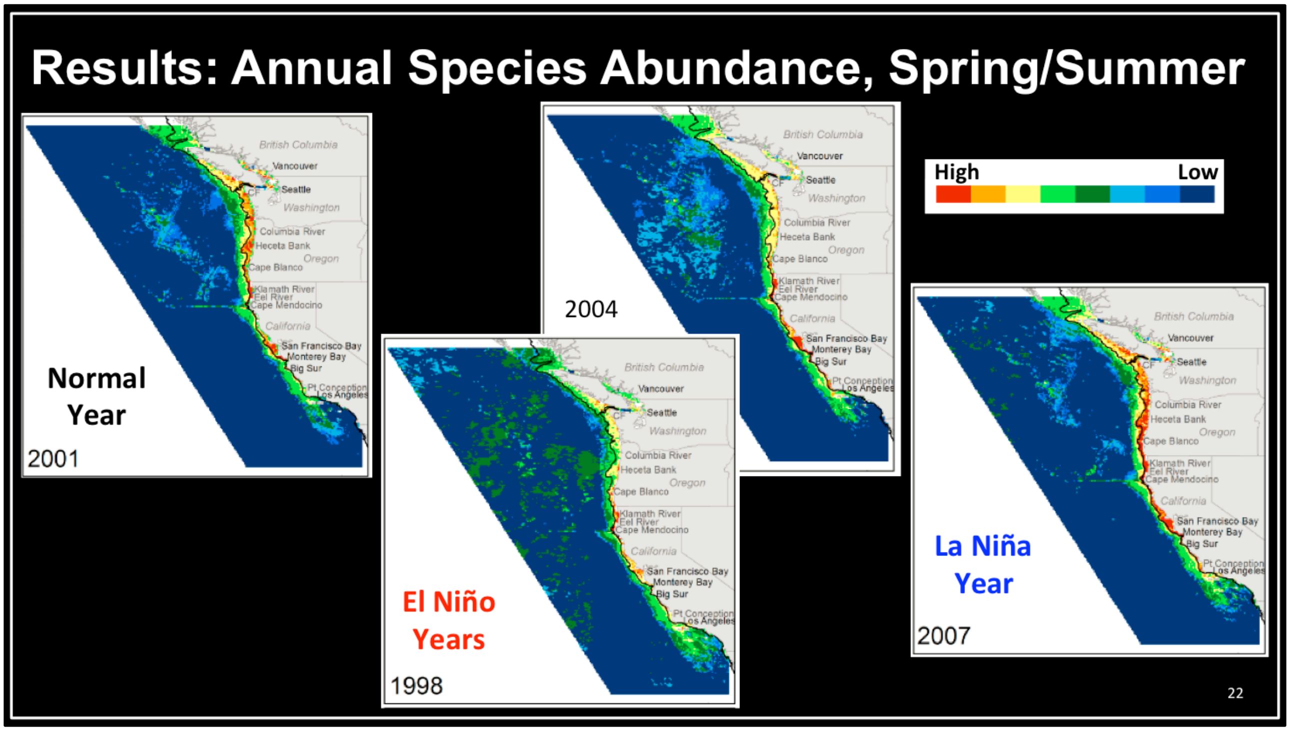
Tracks when birds are present for breeding or migrate to region for food

Results: Species Richness

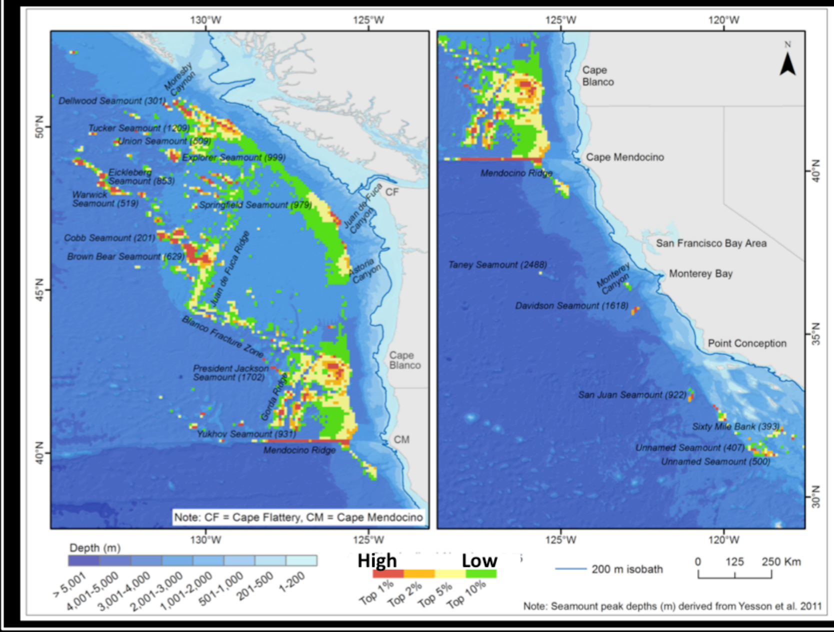
- Seasonal variation
- High number of species along coast within 200 m isobath during upwelling
- Fewer species during non-upwelling
- Not much in pelagic region



Tracks when birds are present for breeding or migrate to region for food


Results: Annual Species Abundance, Spring/Summer
High
Low
Normal Year
2001
2004
El Niño Years
1998
La Niña Year
2007
22

Results: Pelagic Species Abundance



- High abundance aligns with seamounts, ridges, and submarine canyons

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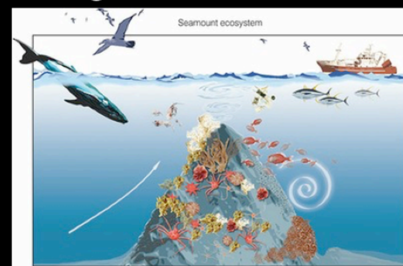
Conclusions

- When abundance high, species richness also high
- Coastal areas within 200 m isobath are most suitable
- Seamounts and ridges are important seabird habitat



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

- Using a suite of species with varying body sizes and life histories:
  - Help identify areas important for a functioning ecosystem
  - Prioritize locations for MPAs designation

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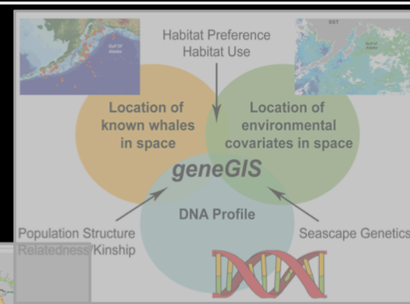
1. Develop suite of geoanalytical tools to facilitate visual exploration and spatial analyses of genetic data



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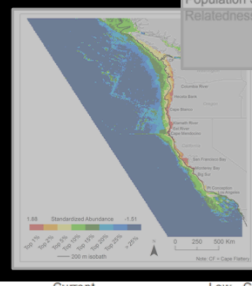

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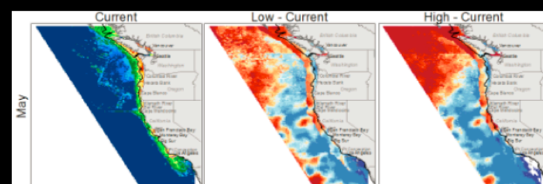

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Forecasting the Flock: Evaluating the Effects of Climate Change on Future Seabird Foraging Aggregations in the California Current System

1) How multispecies foraging aggregations shift with increasing ocean temperatures?
2) Are all species equally sensitive or are some species likely to be more sensitive to climate-related changes?
3) Do seamounts (identified as important habitat in previously) retain suitable habitat in a warming ocean?

Coauthors: Jaime Jahncke, Nadav Nur, Julie Howar, Jeannette E. Zamon, David G. Ainley, Ken Morgan, Lisa T. Ballance, and David Hyrenbach

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Data & Future Scenarios

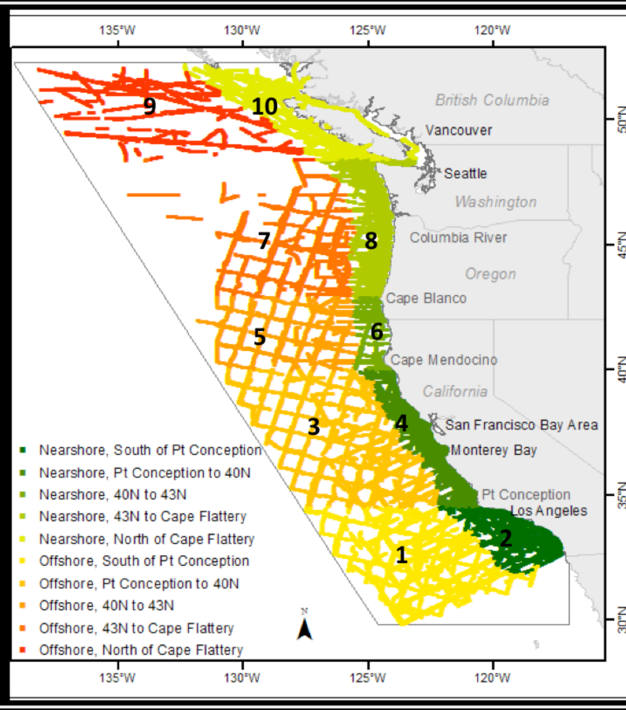
- Seabird data
- Environmental data*
- Predictive Grid
- Final species-specific models

Same as before

* EXCEPT for SST, SSH, and Chla

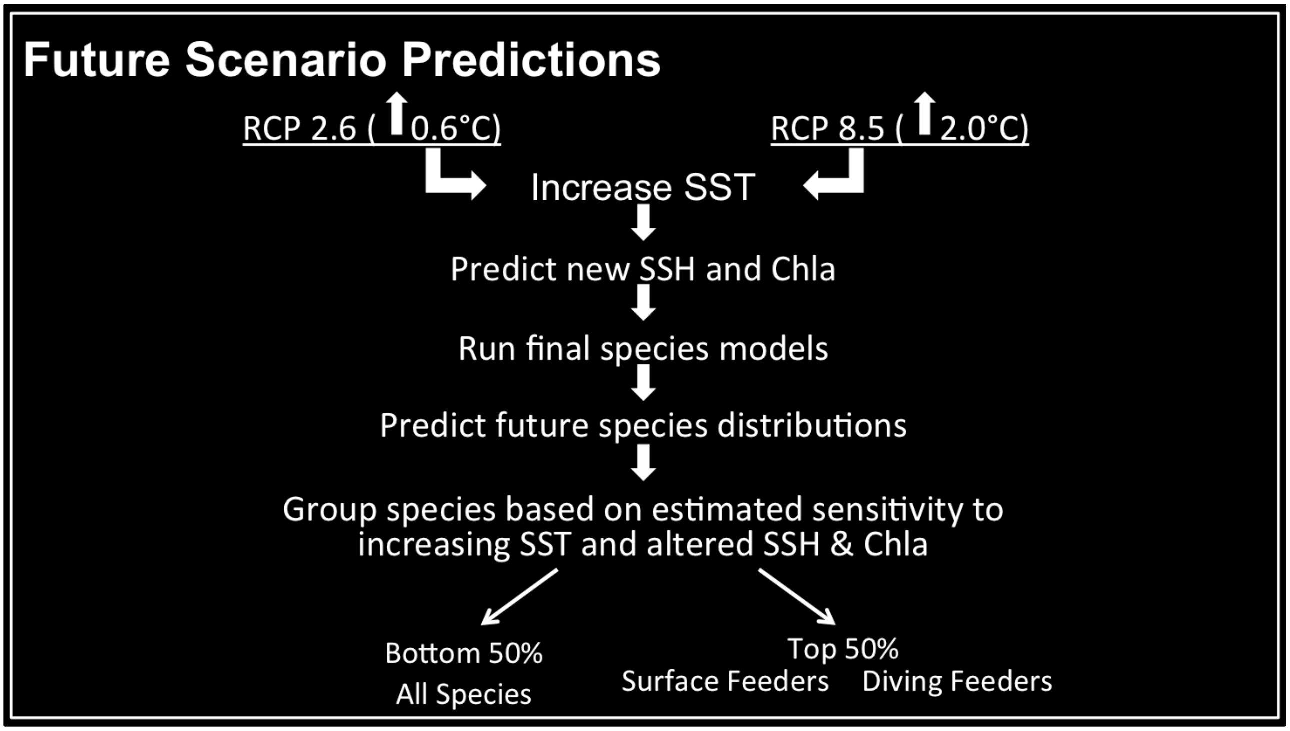
- Used current statistical relationship between SST and SSH or Chla to predict future SSH and Chla

"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*



We also divided the study area into 10 sections based on recognized differences in oceanographic properties in the CCS and re-examined those same relationships

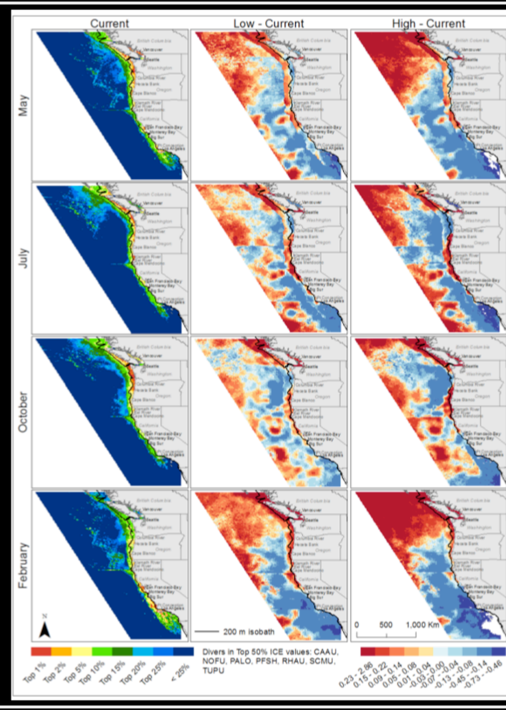
We then developed a seascape for future predictions that maintained the relationships between these variables as we increased the SST



Thus for future scenario predictions, we increased the SST, predicted new ssh and chla values, ran the species models, predicted future species distributions and then group spp based on their estimated cumulative impacts from our changing seascape

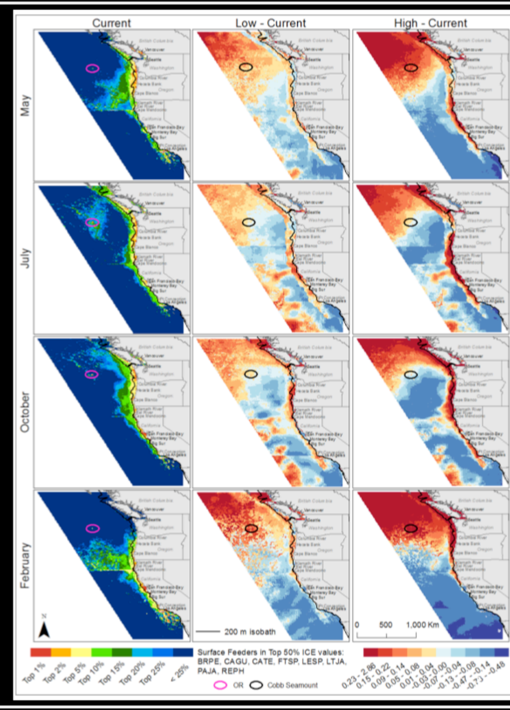
Results: Divers
(Abundance & Difference Maps)

- Suitable habitat
  - Decrease within 200 m isobath
  - Increase beyond 200 m isobath
  - Increase along west coast and north of Vancouver Island



Results: Surface Feeders (Abundance & Difference Maps)

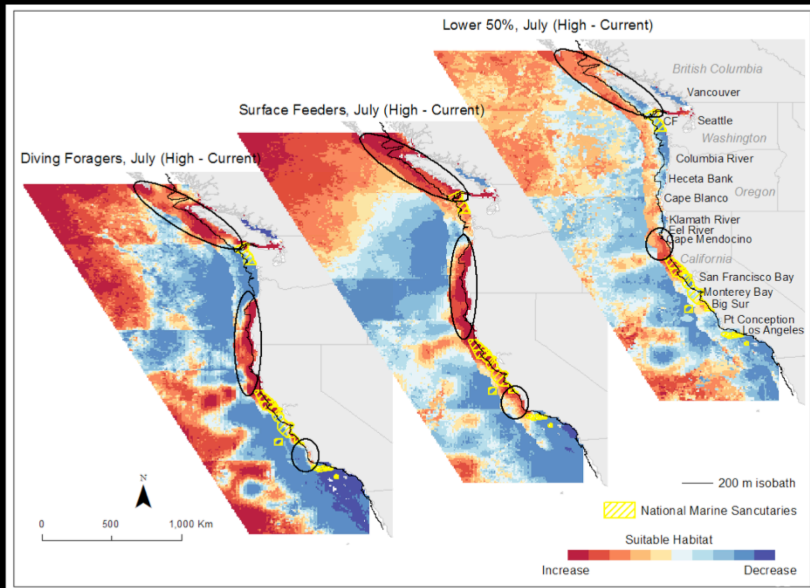
- Suitable habitat
  - ➢ Decrease within 200 m isobath
  - ➢ Increase beyond 200 m isobath
  - ➢ Increase along west coast and north of Vancouver Island
  - ➢ Cobb Seamount retains suitability



Results: Future Suitable Habitat & National Marine Sanctuaries

Projected future suitable habitat falls into 3 categories:

1. Some NMS will become less suitable
2. Some NMS will remain suitable
3. Some areas without protection will become suitable in the future



Summary

- Seabird foraging aggregation will shift offshore and north, as suitable habitat decreases within 200 m isobath

- Diving foragers and surface feeders will be most sensitive to climate related changes, esp. year-round residents and breeders

- Some seamounts (e.g. Cobb Seamount) may retain suitable habitat

Bob Whitney/BirdNote

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

32

Caveats and Conclusions

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

- 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 and seabird responses will be difficult to predict
- Initial step in understanding magnitude, direction and potential mechanism underlying projected changes in seabird habitat in California Current System

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Overall Summary

- MPA design is difficult
- Targeting areas of ocean ecologically important to top marine predators = way to prioritize MPA placement
- Requires understanding what factors influence species presence and/or genetic variability

geneGIS tools and multispecies seabird modeling results are examples of how such information can be useful to this process

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Thank You to….

My committee: Dawn Wright, Julia Jones, Jim Graham, Robert Kennedy, Scott Baker, Leigh Torres, Susan Carozza (GCR)

geneGIS:
All the researchers involved with SPLASH, my co-authors
Cascadia Research Collective for database maintenance
OSU Cetacean Conservation Genetics Lab for genetic analyses

This research was funded by ONR contract N0270A to Oregon State University awarded to CS Baker and D Wright.

Seabird Hotspots:
All researchers involved with data collection, my co-authors
Point Blue Conservation Science
Jaime Jahncke, Nadav Nur, Julie Howar, Suzanne Manugian

And *MOST* importantly, thank you to my family and friends who were always there with encouragement, support, and a good laugh!

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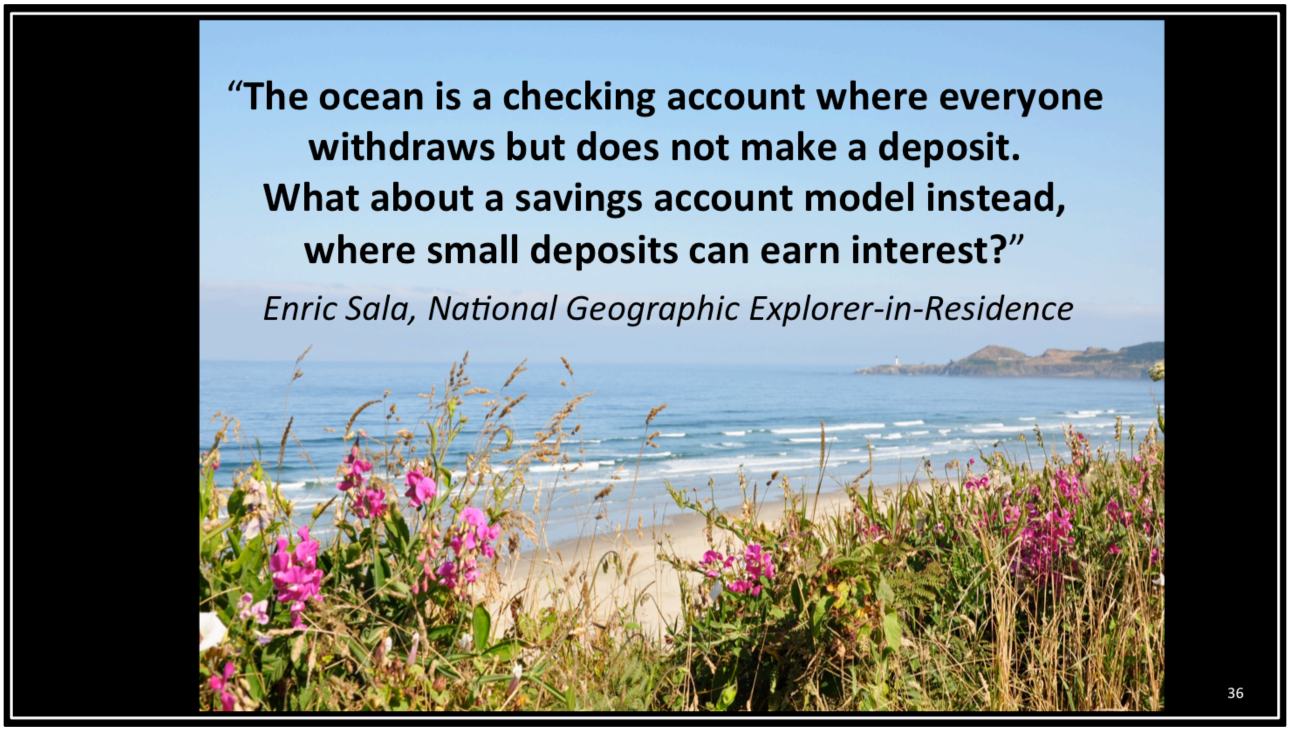
"The ocean is a checking account where everyone withdraws but does not make a deposit.
What about a savings account model instead, where small deposits can earn interest?"
Enric Sala, National Geographic Explorer-in-Residence
36

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

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This is double the number of ssp used in Nur et al so this should give us a better understanding of where mutli-spp aggreations are located