

# Oceanography on the Wing: Black-footed Albatross use of central California National Marine Sanctuaries



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Photo courtesy of Jason  
Thompson

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# Outline

- Motivation
- Goal
- Methods
- Results
- Management Applications



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# Motivation: Conservation

- Tubenose Seabirds
  - Highly threatened
- Albatross
  - Vulnerable life-history traits
    - Greatest threat = Adult mortality (longline bycatch)



Photo courtesy: <http://news.bbc.co.uk>

# Motivation: Conservation

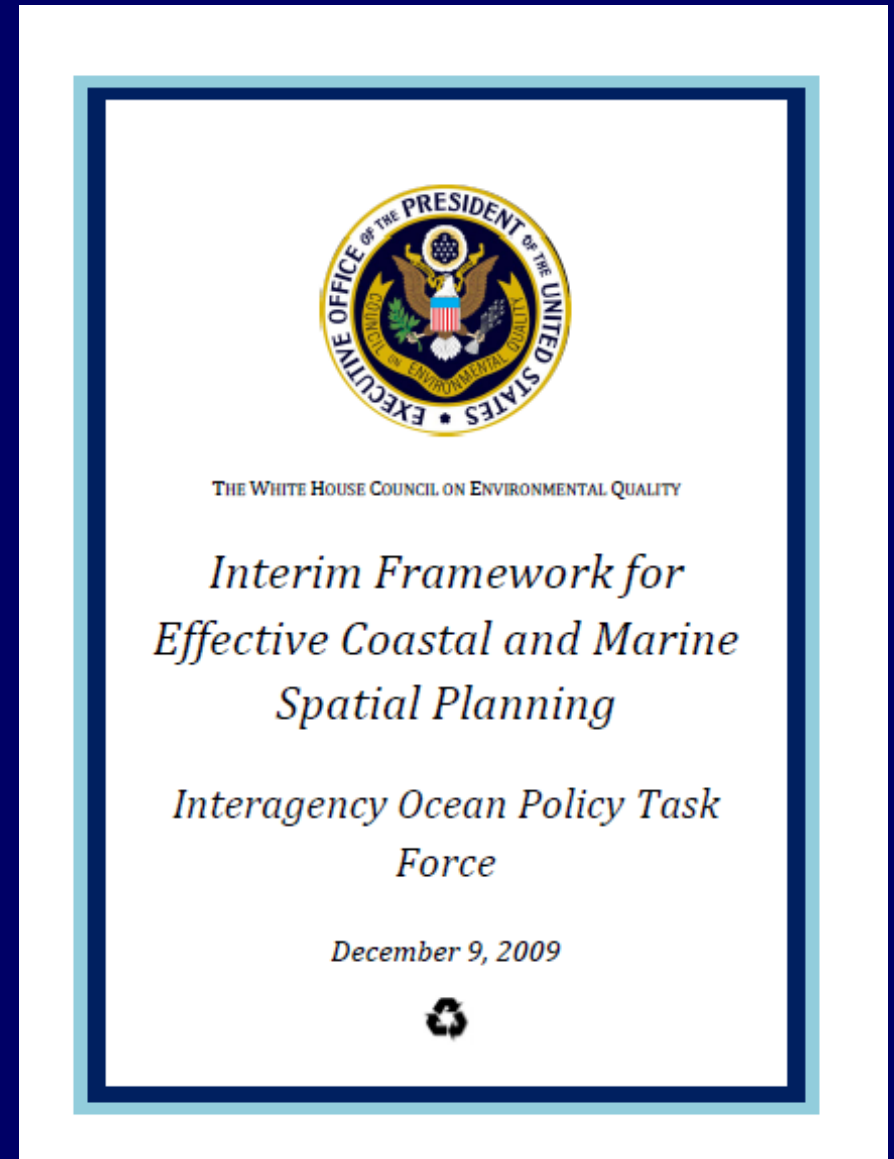
- Tubenose Seabirds
  - Highly threatened
- Albatross
  - Vulnerable life-history traits
    - Greatest threat =  
Adult mortality  
(longline bycatch)
  - Black-footed Albatross (BFAL)  
'Endangered' (IUCN, 2008)



© Photo courtesy picasaweb from Andy

# Motivation: Conservation

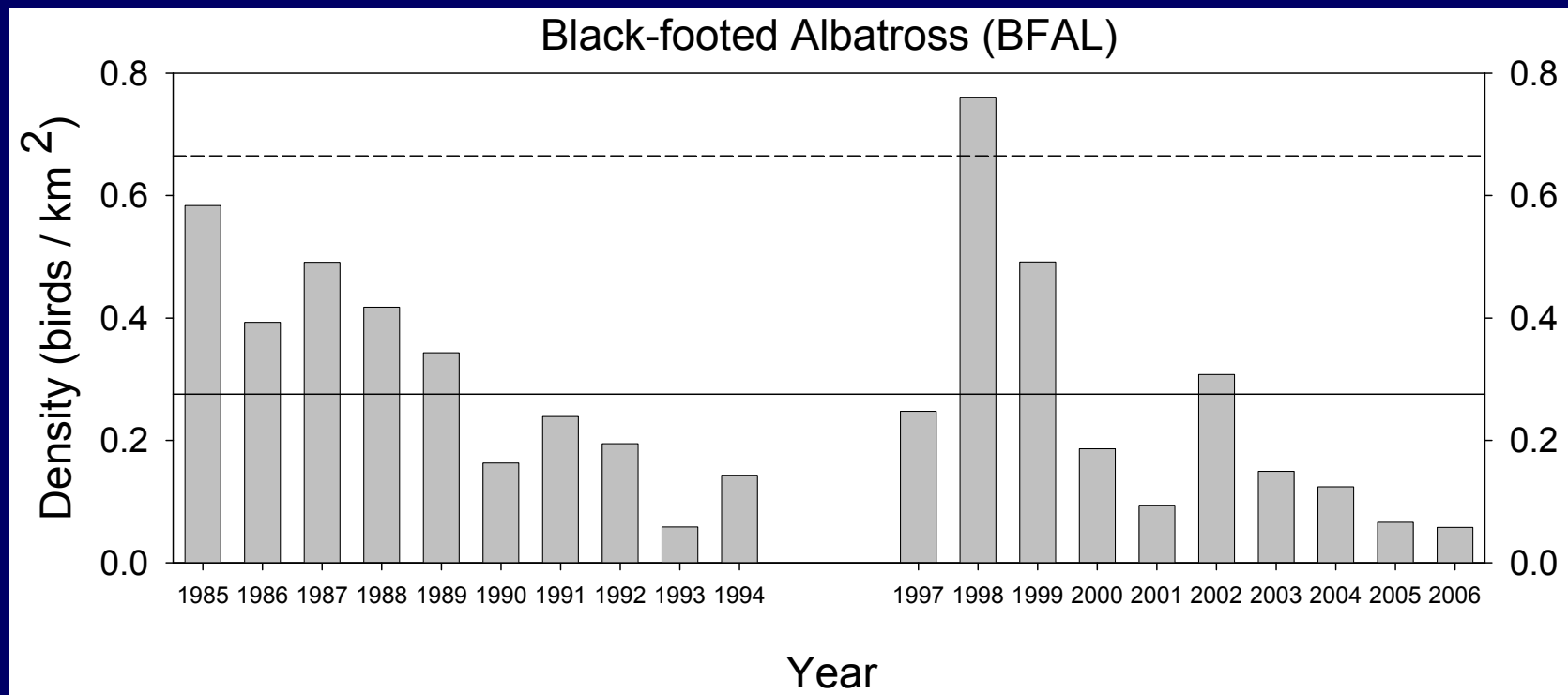
- Marine Spatial Planning
  - Define important habitats
    - Humans use and marine life
  - National Marine Sanctuaries (NMS)
    - Design and evaluation
  - Effective management within a broader context
    - Distribution and impacts



# Motivation: Conservation

## Monitoring

- Document changes in distribution and abundance



**Inter-annual changes in BFAL density off central California (1985 – 2006) (Ainley & Hyrenbach 2010)**

# General Goal:

Analyze BFAL habitat use to inform spatial management in central California waters

- Questions we addressed:
  - Does BFAL habitat use vary with season / year ?
  - Do BFAL occur more frequently near bathymetric features ?
  - Is BFAL distribution influenced by wind and water masses ?

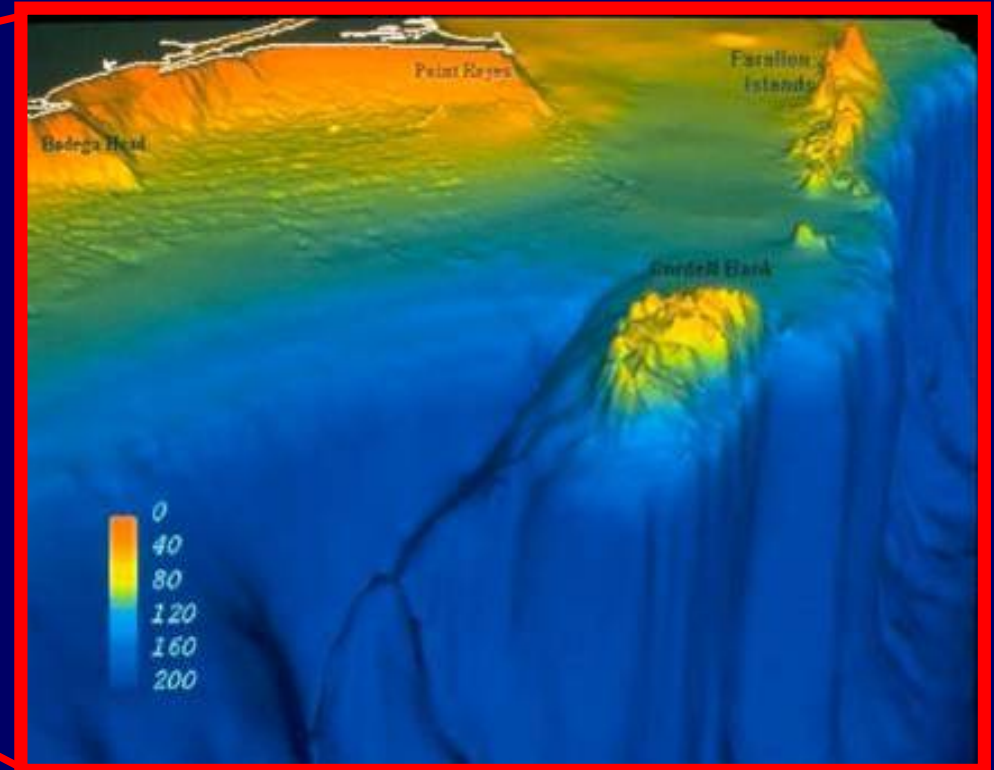


# Habitats: Bathymetry

✦ You are here



Map courtesy: [www.cordellbank.noaa.gov](http://www.cordellbank.noaa.gov)



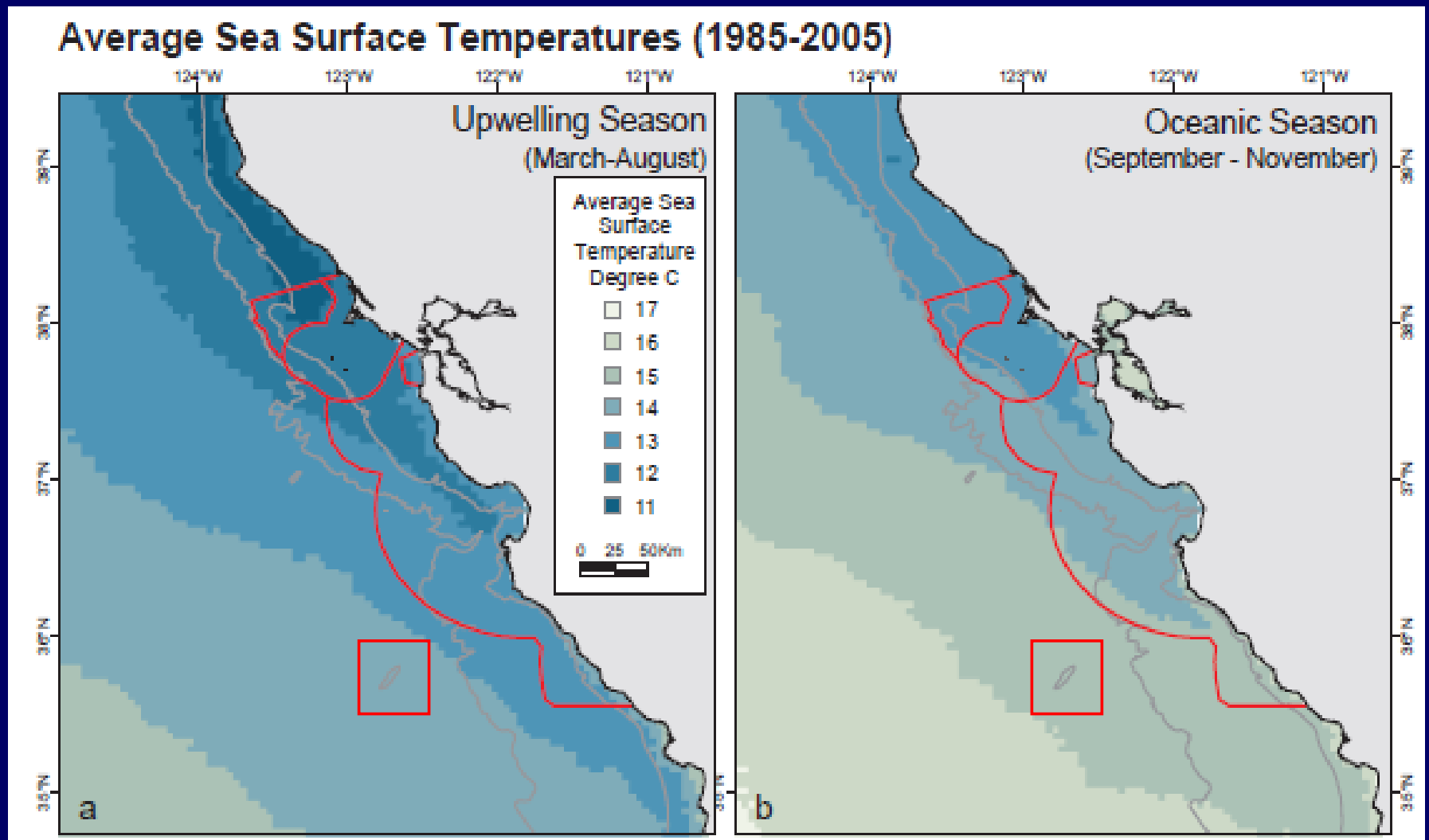
Map courtesy: [www.cordellbank.noaa.gov](http://www.cordellbank.noaa.gov)

- Static Habitats
  - Shelf-break (200 m isobath)
  - Cordell Bank
  - Rittenberg Bank

# Habitats: Hydrography

Mid-spring to late summer

Fall



# Habitats: Hydrography

## Upwelling

Atmospheric pressure → northwesterly wind →  
upwelling → cool SST & high nutrients

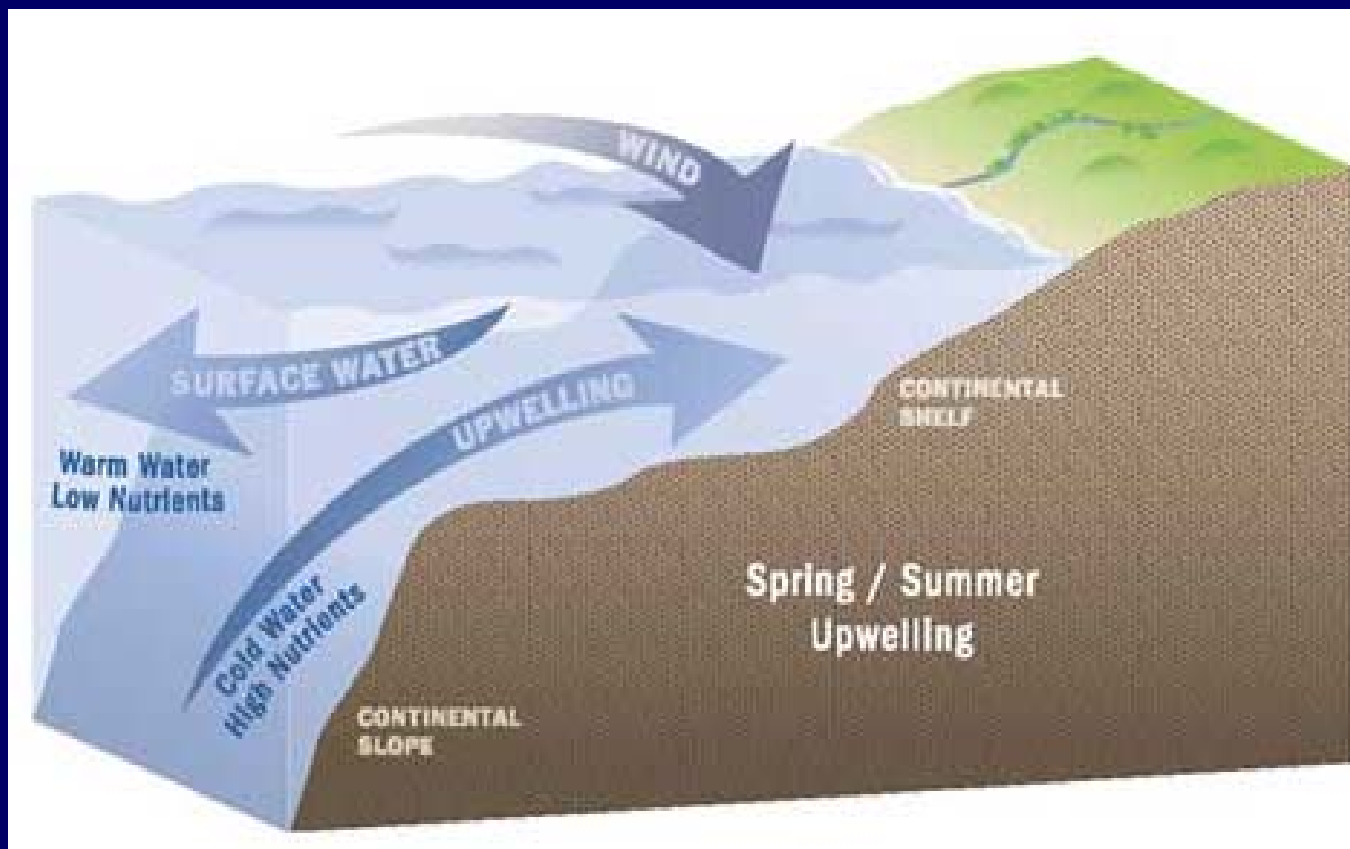


Image courtesy [cordellbank.noaa.gov](http://cordellbank.noaa.gov)

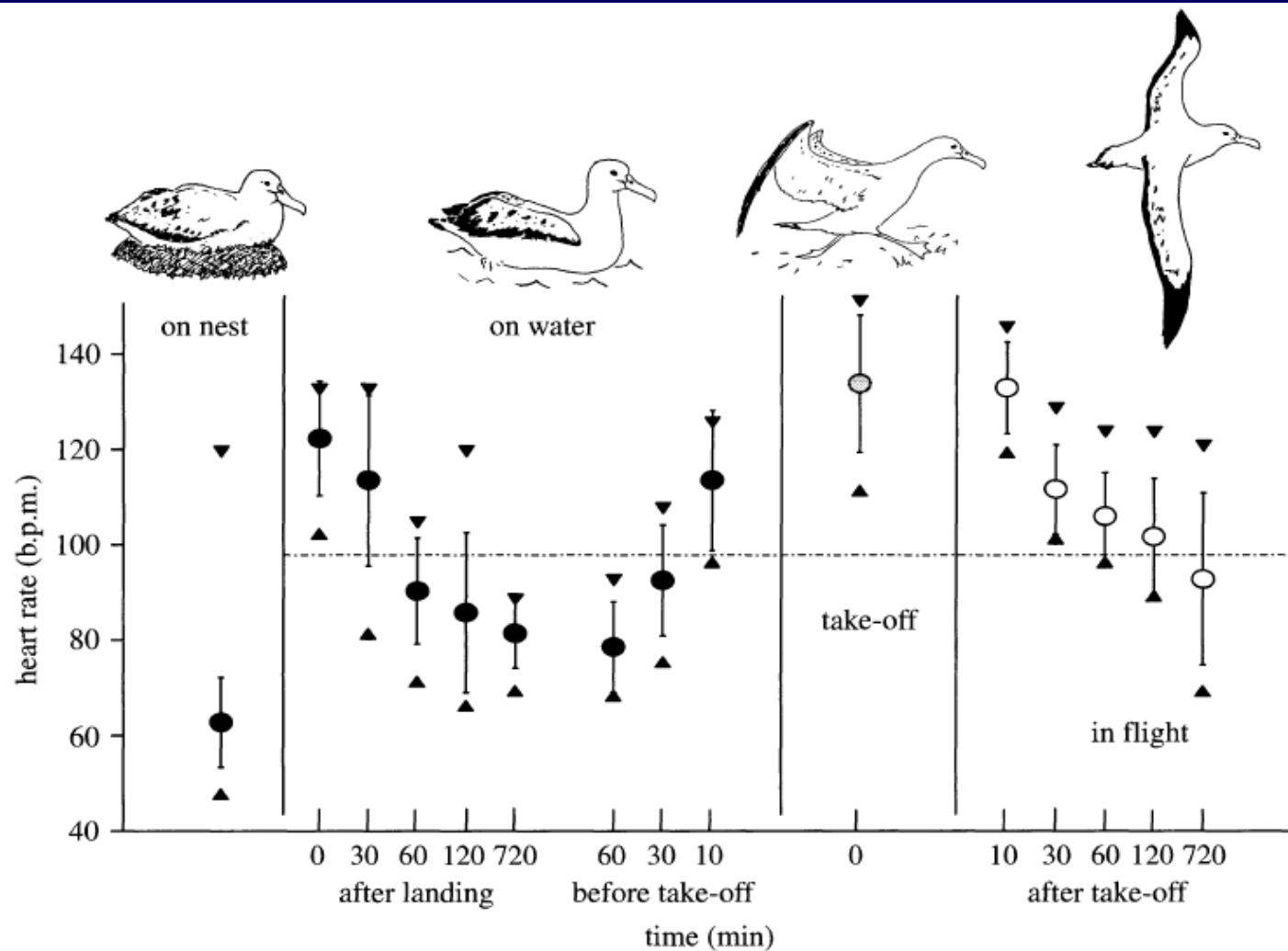
# Black-footed Albatross

(*Phoebastria nigripes*; BFAL)



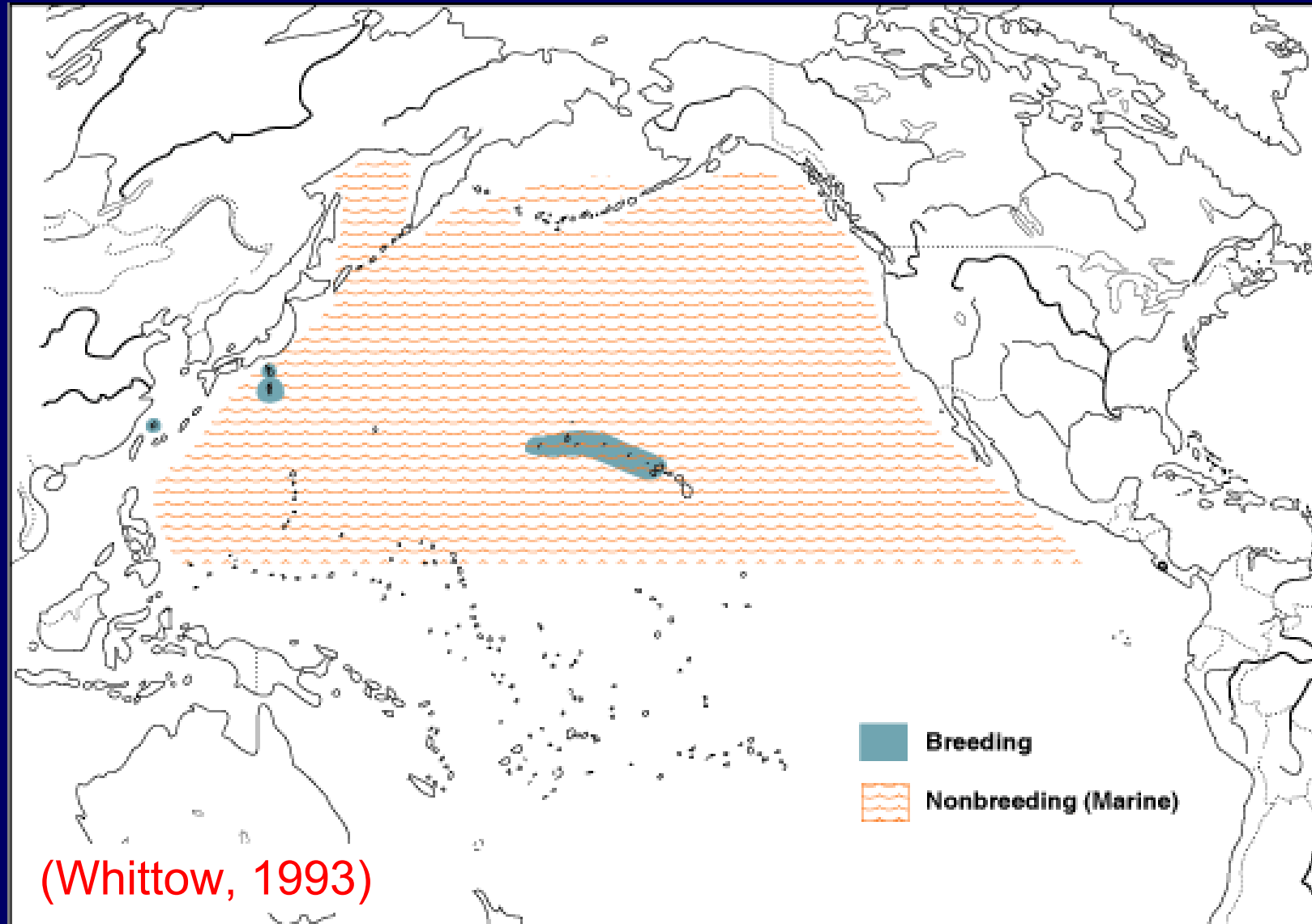
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# Albatross flight



(Weimerskirch et al., 2000)

# Black-footed Albatross Range



Vast marine range, seasonal shifts

# Black-footed Albatross Range

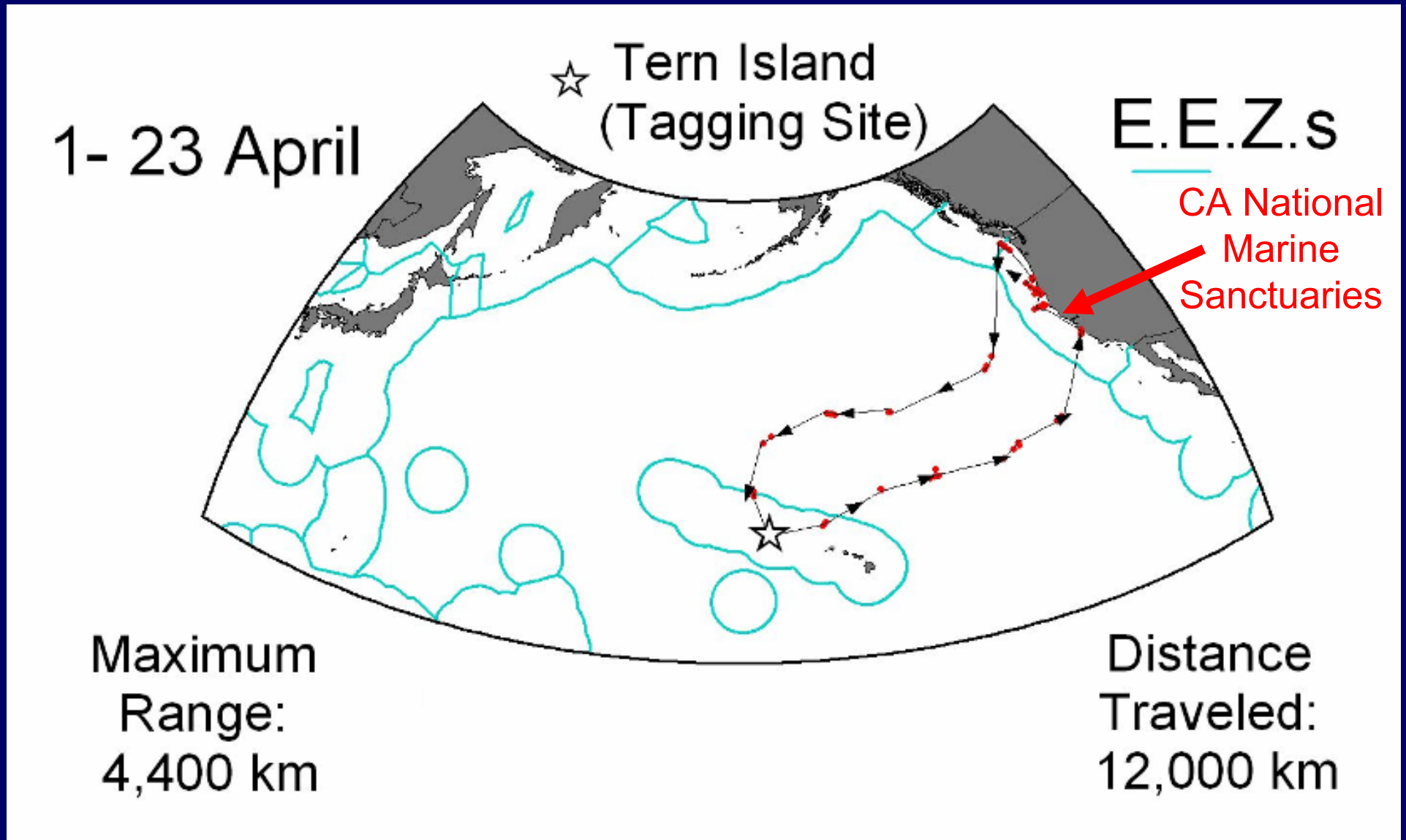


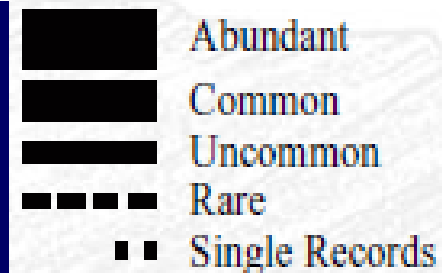
Image courtesy KD Hyrenbach

Vast marine range, seasonal shifts

# Black-footed Albatross in CBNMS

SPECIES	J	F	M	A	M	J	J	A	S	O	N	D
Shy Albatross						■			■			
Light-mantled Albatross							■					
Laysan Albatross												
Black-footed Albatross												
Short-tailed Albatross		■						■			■	

**Figure 1:** Seasonal status of albatross at Cordell Bank NMS. Adapted from Stallcup, *Amazing Seabirds of Cordell Bank National Marine Sanctuary*.



Year-round presence

More numerous in spring - summer

# Black-footed Albatross



- Previous studies of habitat use patterns
  - Range: North Pacific Basin
  - Variable distribution
    - Annual
    - Seasonal
  - Static habitats
    - Shelf-break and Slope
  - Dynamic habitats
    - Warm SST and eddies
    - Convergence zones

# Black-footed Albatross



- Limitations of previous studies
  - Emphasis on colonies during breeding season
    - post-breeding season?
  - Single year / season
    - interannual?
  - Broad-scale bathymetric domains
    - discrete features?
  - Seldom evaluation of wind speed
    - energetics?

# Goal:

Analyze BFAL habitat use to inform spatial management in central California NMS waters (Cordell Bank and Gulf of the Farallones)

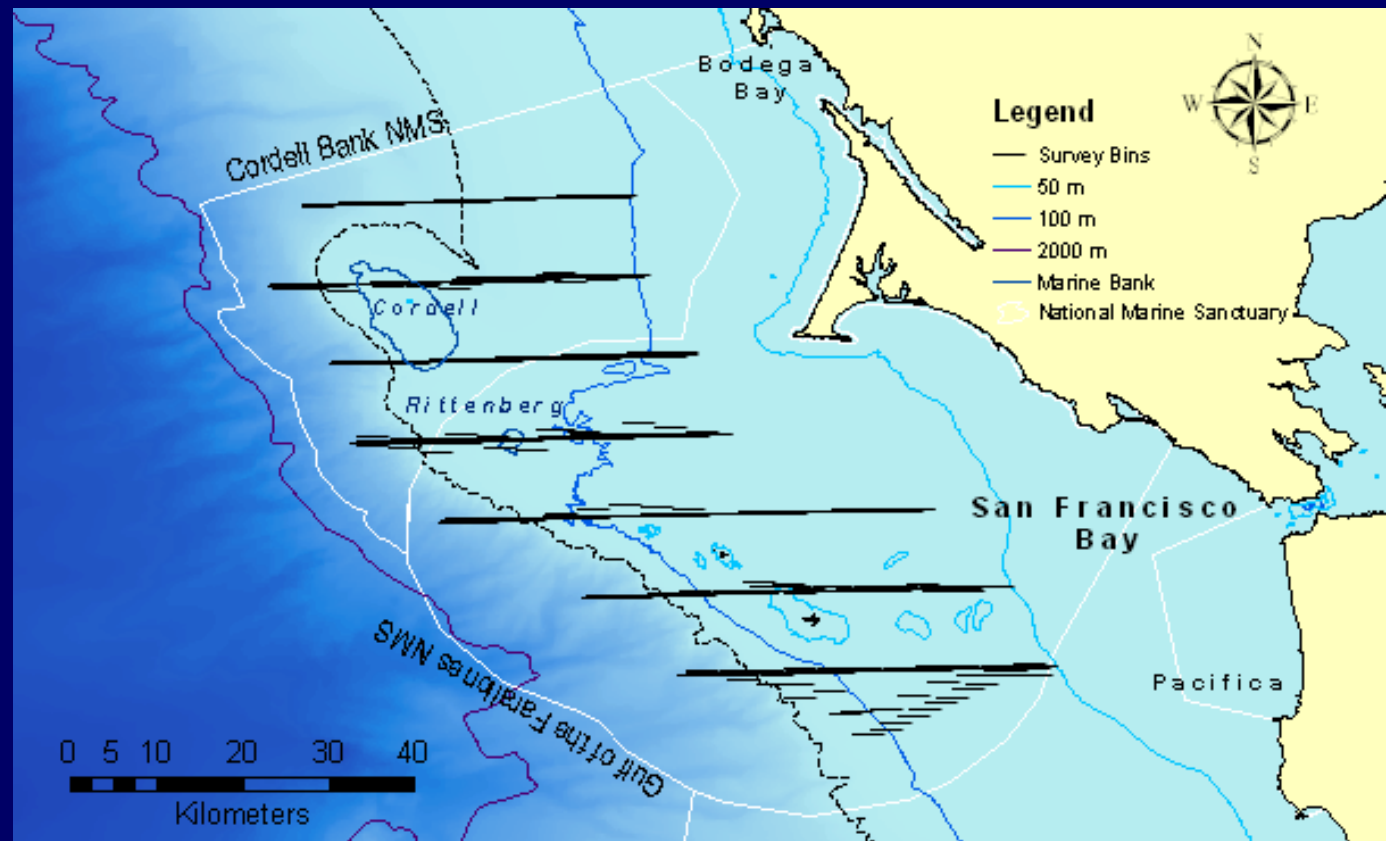
- Evaluate BFAL Habitat Use:
  - 5 years (2004-2008)
    - rearing and post-breeding seasons
  - Static features
    - Bathymetry
  - Dynamic features
    - Water masses and wind speed



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# Methods: Data Sources

- Vessel Surveys
  - Albatross presence & abundance
  - Concurrent environmental data  
SST, SSS, location (depth)



# Methods: Data Sources

- Vessel Surveys

- Albatross presence & abundance
- Concurrent environmental data  
SST, SSS, location (depth)



- Integrated variables

- Wind, atmospheric pressure, upwelling <<http://las.pfeg.noaa.gov>>



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**i** [Datasets](#) > [Model-generated and/or Blended Environmental Data](#) > [Surface Winds](#) > [NOAA Multiple-Satellite Blended 0.25 degree Sea Winds](#)  
Variable(s): **x. 6-hourly SI blended E-W sea surface wind , y. 6-hourly SI blended N-S sea surface wind (2 selected)**

# Methods: Variables

**Table 1:** Description of variables used in analyses.

Variable	Data Source	Utility
<u>Temporal</u>		
Year (cum. Julian day)	-	Inter-annual scale
Breeding Season (Julian day)	-	Intra-annual scale
Wind Modulus	Satellite/Buoy	Albatross energetics
Meridional (NS) Wind	Satellite/Buoy	Albatross energetics
Zonal (EW) Wind	Satellite/Buoy	Albatross energetics
Atmospheric Pressure	Satellite/Buoy	Movement of weather systems
$\Delta$ Atmospheric Pressure	Satellite/Buoy	Gradient of weather systems
6hr Upwelling Indices (36°N,39°N)	Interpolated surface observations	Temporally specific regional trends
Monthly Upwelling Indices (36°N,39°N)	Interpolated surface observations	Generalized regional trends

# Methods:

## BFAL Occurrence in 3km bins

- Objectives:  
Describe albatross occurrence in relation to:
  - Temporal variation  
45 models  
Year, season, interaction with other features  
EX: Year\*Average Depth
  - Static features  
91 models  
Individual features, and in combination  
EX: Average Depth + SST
  - Dynamic features  
19 models  
Individual features, and in combination

- Explanatory Power:
  - Akaike Information Criterion (AIC): Smaller = BETTER

$$\text{AIC} = -2 * \ln(\text{likelihood}) + 2 * K$$

- Akaike Weights

$$w_i = \frac{\exp(-0.5 * \Delta_i)}{\sum_{r=1}^R \exp(-0.5 * \Delta_r)}$$

# Results:

## BFAL Occurrence in 3km bins

- Temporal variation
  - BFAL occur more frequently & closer to shelf-break in rearing vs. post-breeding season
    - Shelf-break
    - Seasonal Response
      - Breeding / Oceanographic season

**Table 2 Models with (summed) Akaike weight of  $\geq 0.90$  by objective.**

Objective	Model	Coef. Direction	Akaike Weight
Temporal	Julian Day*Shelf-Break	-	1.000
Static	Shelf-Break + Monthly upwelling @ 39°N	-	0.810
Static	Shelf-Break + Monthly upwelling @ 36°N	-	0.190
Dynamic	Monthly upwelling @ 39°N	+	0.802
Dynamic	Monthly upwelling @ 36°N	+	0.198

# Results:

## BFAL Occurrence in 3km bins

- Static features
  - BFAL occur frequently near the shelf-break & in association with high monthly upwelling to the north (39N) and south (36N) of the study area
    - Importance of shelf-break
    - Response to regional variables

**Table 2 Models with (summed) Akaike weight of  $\geq 0.90$  by objective.**

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# Results:

## BFAL Occurrence in 3km bins

- Dynamic features
  - Increased BFAL occurrence related to high monthly upwelling north (39N) and south (36) of the study area
    - Moderate temporal and spatial scales

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# Management Applications

- Models developed with management in mind

Improve understanding of habitat use

→ enhanced ability to monitor and manage

- Important habitat components

- Season
- Shelf-break
- Monthly upwelling



# Management Applications

## Recommendations:

- Temporal:
  - Seasonal regulation
  - Implications for breeding birds
- Static:
  - Augmented surveys crossing shelf break outside sanctuaries
- Dynamic:
  - Monthly upwelling (seasonal)
  - Annual variation in upwelling
- Other stakeholder needs
  - Shipping lanes?
  - Recreational fishers?
  - Ecotourism?



# Next Step

- Density: where are the BFAL aggregations?

Occurrence = Range    Density = Aggregation



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© Oregon Seabirds

# Questions?

Thank you to PRBO Conservation Science, esp. Dr. J. Jahncke, for sharing their data.

Thanks to my advisor, Dr. K. D. Hyrenbach, for not leaving me at sea (yet).

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Also thanks to the NPS for allowing me to present in the beautiful Red Barn Classroom



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