CLIMATE VARIABILITY IS LINKED TO DIET SWITCHING IN A MARINE PREDATOR, THE NORTHERN ELEPHANT SEAL

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Ecological Impacts on Predators

- Changes in prey availability
- Foraging behavior
- Foraging success
- Reproductive success
- Survival
Predator Responses to Climate Variability

Change where they forage - Habitat Shifts

Change how they forage

Change targeted prey
Climate Variability in the Pacific Ocean

El Niño Southern Oscillation

MULTIVARIATE ENSO INDEX

[Graph showing standardized departures from 1950 to 2015, with peaks in 1997 and 2009]

Eastern Pacific El Niño

Central Pacific El Niño

1998

2010
Northern elephant seal
*Mirounga angustirostris*

Satellite tracking and dive behavior

\[ n = 365 \]

2004 – 2013

Utilize the entire northeastern Pacific Ocean

Robinson et al 2012
Evidence of individual foraging strategies

Strong year-to-year route fidelity
Climate Variability in the Pacific Ocean

Eastern Pacific El Niño Reduces Foraging Success and Increases Trip Duration

Mass Gain Rate (kg/day)

Trip Duration (days)

Crocker et al. 2006
Questions

Q1: Do female elephant seals change their foraging behavior in response to climate variability?

Q2: Do elephant seals exhibit a diet switch in response to climate variability?
Methods – Foraging Behavior

Study Site: Año Nuevo State Reserve, San Mateo County, CA

Seal Sampling:
• Satellite tags and time-depth loggers
• Animals tagged in 2010 El Niño have a previous control track from a non-El Niño year
  • n = 16 paired tracks
• Seals tracked did not change where they went
Methods – Foraging Behavior

Dive Data Analysis

• Dive depth (m)

• Foraging Index

• Paired t-tests, $\alpha = 0.05$ (R)
Methods – Diet

• Blubber biopsies for diet
  • n = 176 (2005-2006, 2009-2012)

• North Pacific Transition Zone

• Trawl nets and squid jigs (650 – 800 m)
Methods – Diet

- 43 species of deep-sea fish
- 12 species of mesopelagic squid

Myctophids

Other mesopelagic fishes

Mesopelagic squid
Methods – Diet

• Fatty acid profiles with gas chromatography
• Calibration coefficient
• Diets estimated with QFASA (Iverson 2004)
• Permanova, $\alpha = 0.05$ (Primer)

• ENSO State: Multivariate ENSO Index (MEI)
  • Positive: MEI $\geq$ 1.0
  • Neutral: -1.0 < MEI < 1.0
  • Negative: MEI $\leq$ -1.0

Positive ENSO
2010 Post-breeding

Neutral ENSO
2005 Post-breeding & Post-molt
2006 Post-breeding & Post-molt

Negative ENSO
2010 Post-molt
2011 Post-breeding
2009 Post-molt
2011 Post-molt
2012 Post-breeding
Results – Foraging behavior

Foraging behavior changes in response to climate variability

Seals dived deeper during El Niño

\[ p = 0.0271 \]

Mean Forage Dive Depth (m)

El Niño: ~ 450 m
Non-El Niño: ~ 500 m

Foraging Dives
Results – Foraging behavior

Differences between foraging areas

Northern seals dived deeper during El Niño

Western seals foraged more intensely in El Niño

Northern

Western

Mean Difference of Forage Dive Depth (m)

Northern: 20

Western: 0

$p = 0.0577$

Cumulative Foraging Bout Index

Northern: 0

Western: 0

$p = 0.0571$
Results – Average Diet

Squid: 51%
Mesopelagic Fish: 26%
Myctophid Fish: 23%
Results – Diet

Significant difference in fatty acid profiles due to ENSO state

Permanova, $p = 0.02$

Significant difference in diet due to ENSO state

Permanova, $p = 0.001$
Results – Fatty Acids

Top FA Contributing to Model

18:1n-9
- Negative: 28.0 ± 0.5
- Neutral: 26.5 ± 0.6
- Positive: 26.0 ± 0.7

Percent: 54.47%

20:1n-11
- Negative: 10.0 ± 0.5
- Neutral: 10.5 ± 0.6
- Positive: 24.0 ± 0.7

Percent: 24.04%

16:0
- Negative: 8.5 ± 0.5
- Neutral: 9.5 ± 0.6
- Positive: 8.0 ± 0.7

Percent: 8.82%
Results – Diet

Top Squid Contributing to Model

Galiteuthis phyllura
24.22% Contribution

Chiroteuthis spp.
12.23% Contribution
Results – Diet

Top Fish Contributing to Model

*Diaphus perspicillatus*

- Contributes 16.92% to the diet.

*Stemonosudis rothschildi*

- Contributes 24.04% to the diet.
Conclusions

Foraging Behavior

• Increase forage dive depth and foraging intensity

• Increase in energy expenditure

Diet Switching

• Fatty acid profiles and QFASA diet results indicate a diet switch during El Niño

• Indication of change in prey distribution or abundance
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