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

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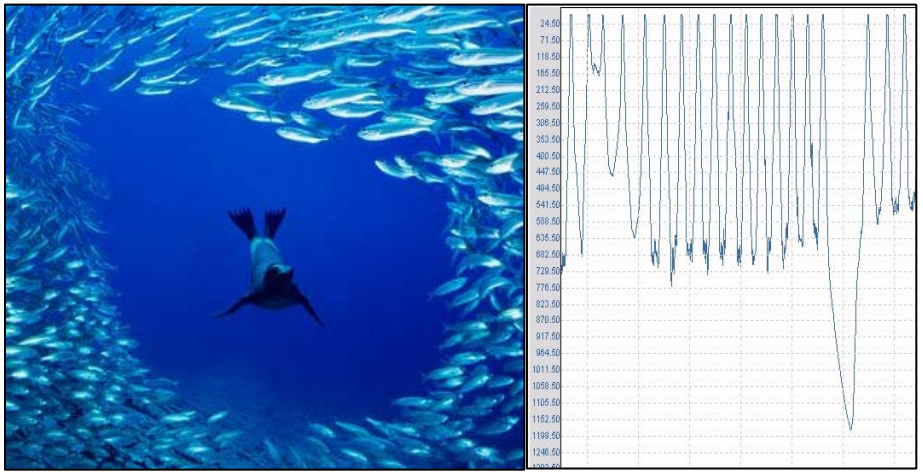
Ecological Impacts on Predators

- Changes in prey availability
- Foraging behavior
- Foraging success
- Reproductive success
- Survival

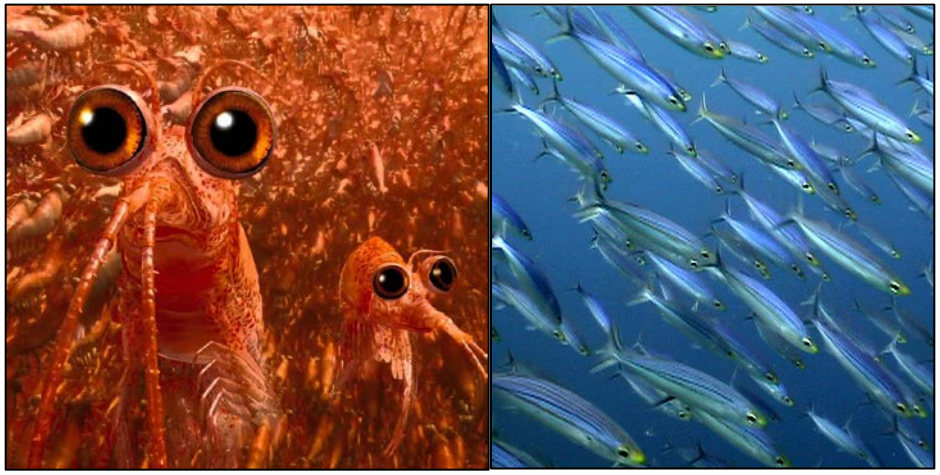
Predator Responses to Climate Variability

Change where they forage - Habitat Shifts

Change how they forage

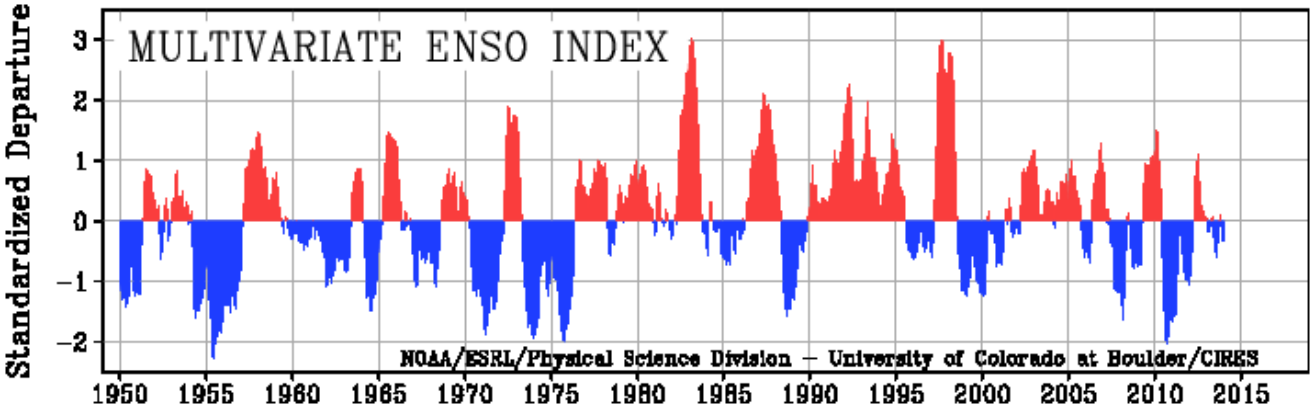


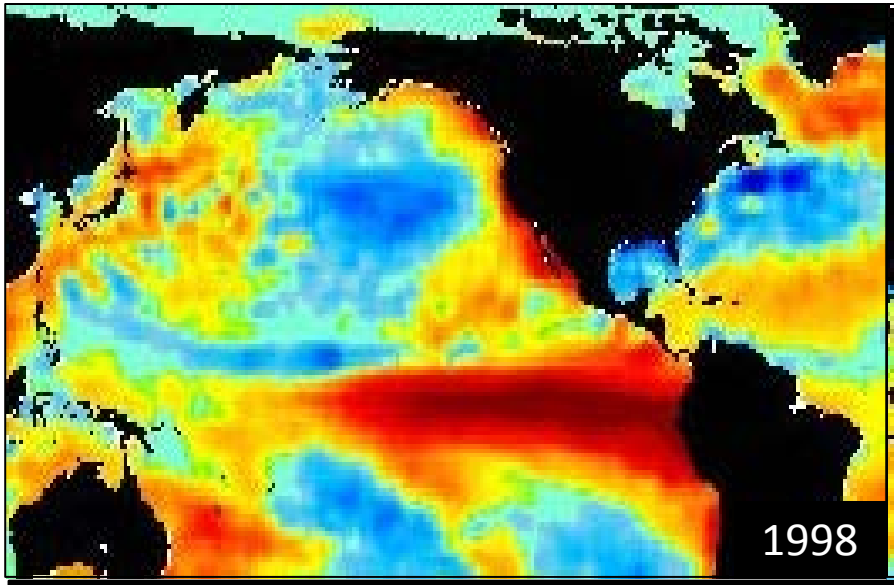
Change targeted prey



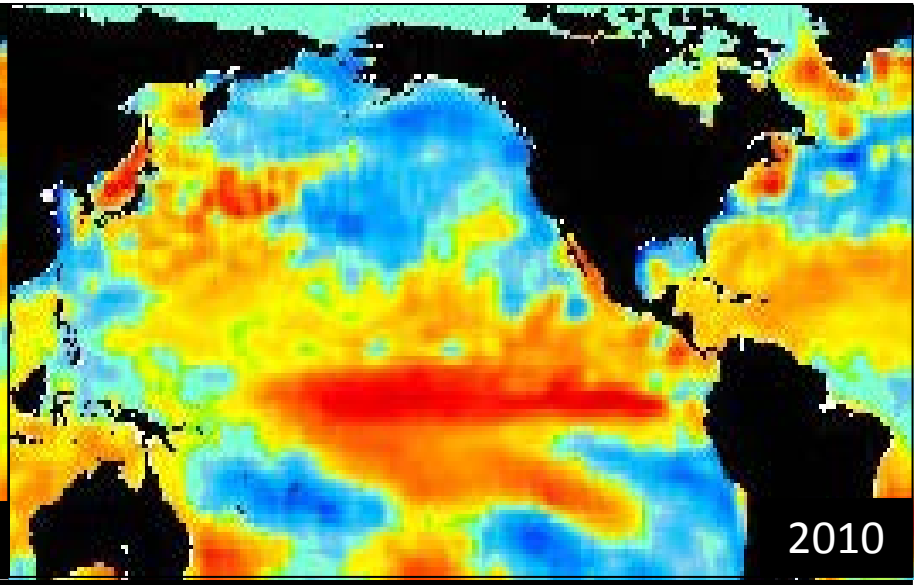
Climate Variability in the Pacific Ocean

El Niño Southern Oscillation





Eastern Pacific El Niño

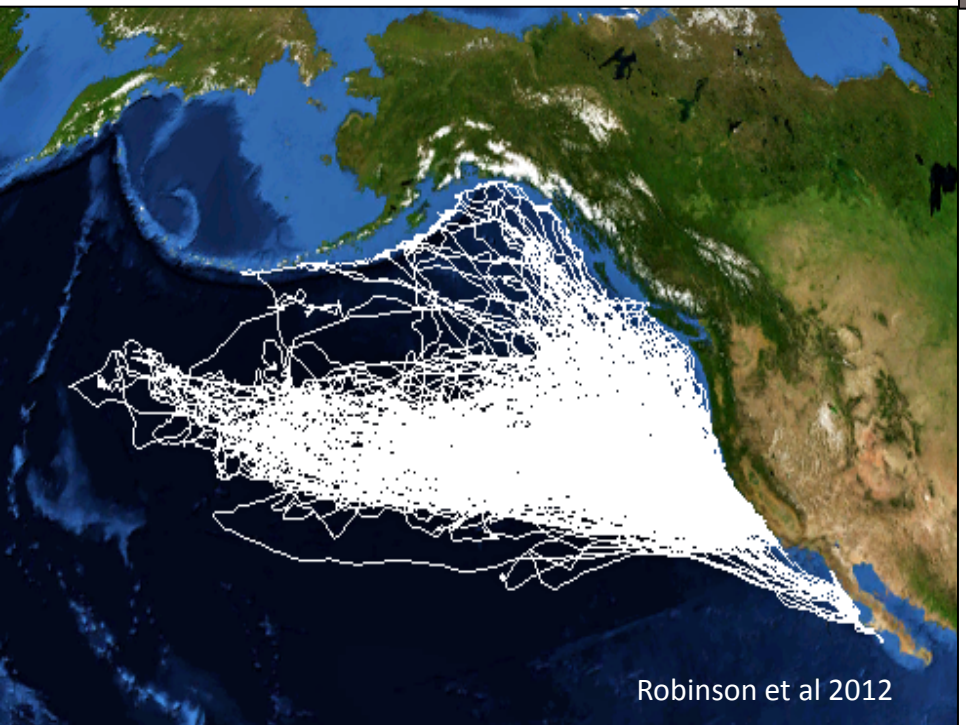


Central Pacific El Niño

Study System

Northern elephant seal
Mirounga angustirostris

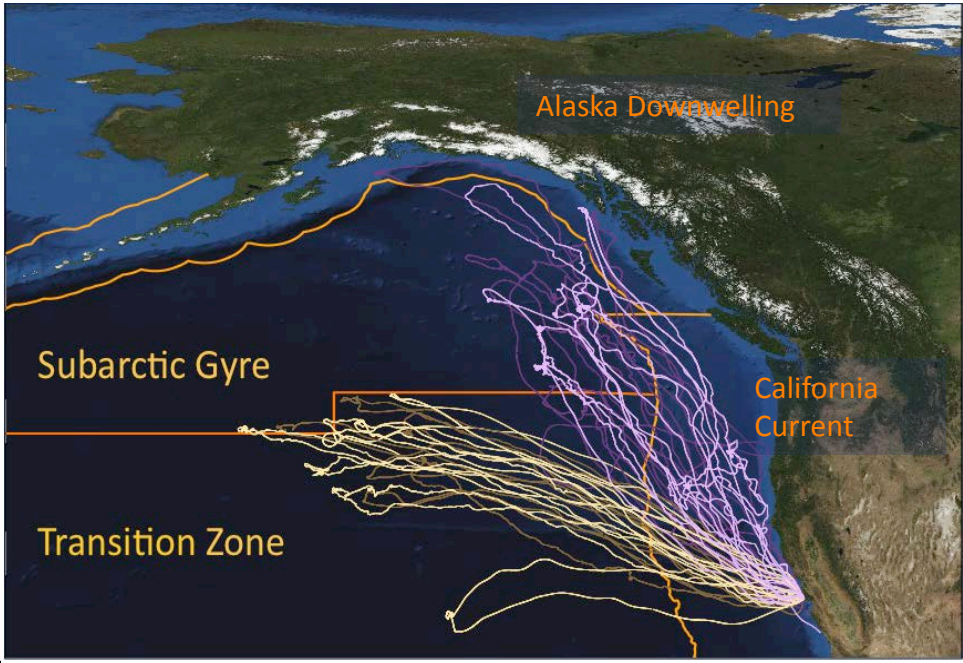
Satellite tracking and dive behavior
n = 365
2004 – 2013

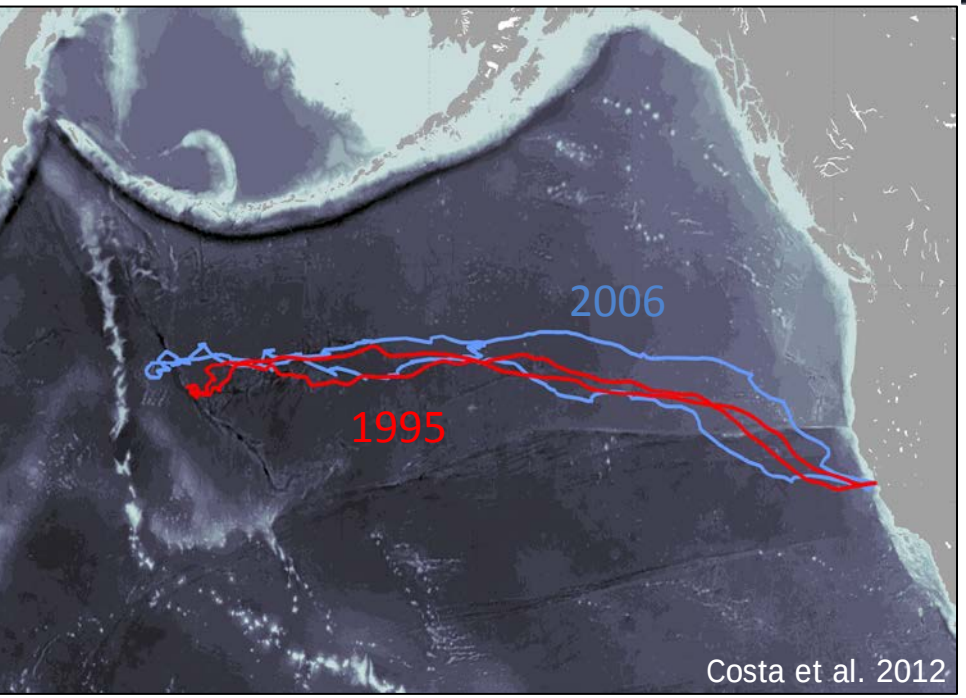


Utilize the entire northeastern Pacific Ocean

Study System

Evidence of individual foraging strategies

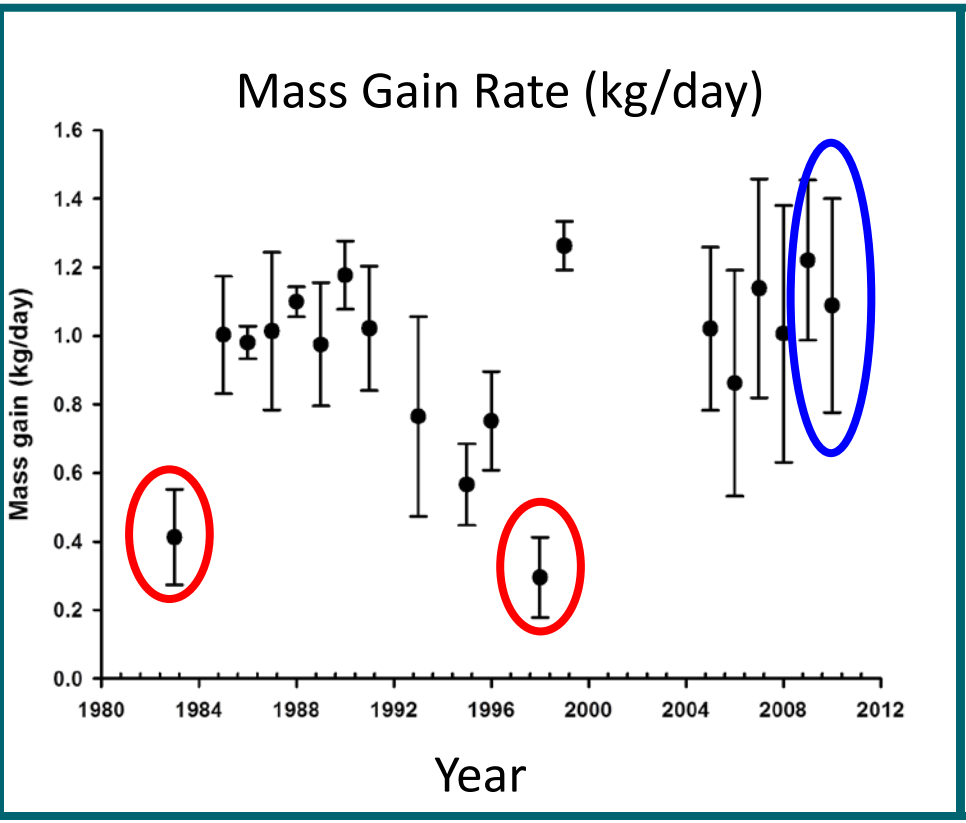


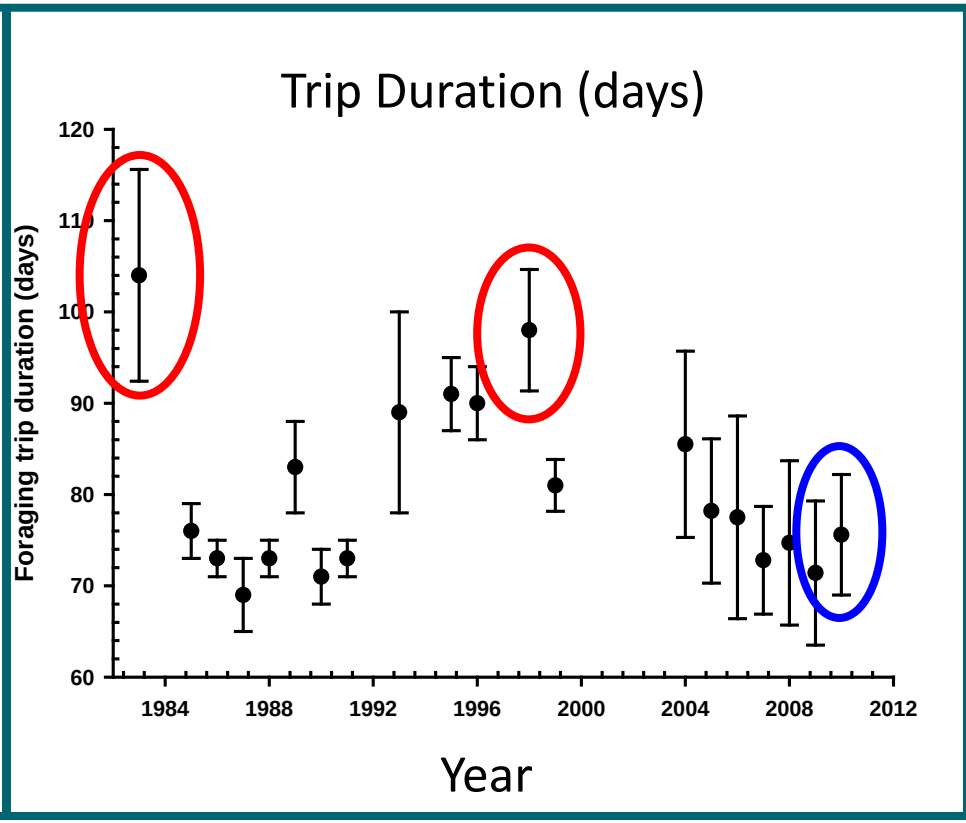


Strong year-to-year route fidelity

Climate Variability in the Pacific Ocean

Eastern Pacific El Niño Reduces Foraging Success and Increases Trip Duration





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

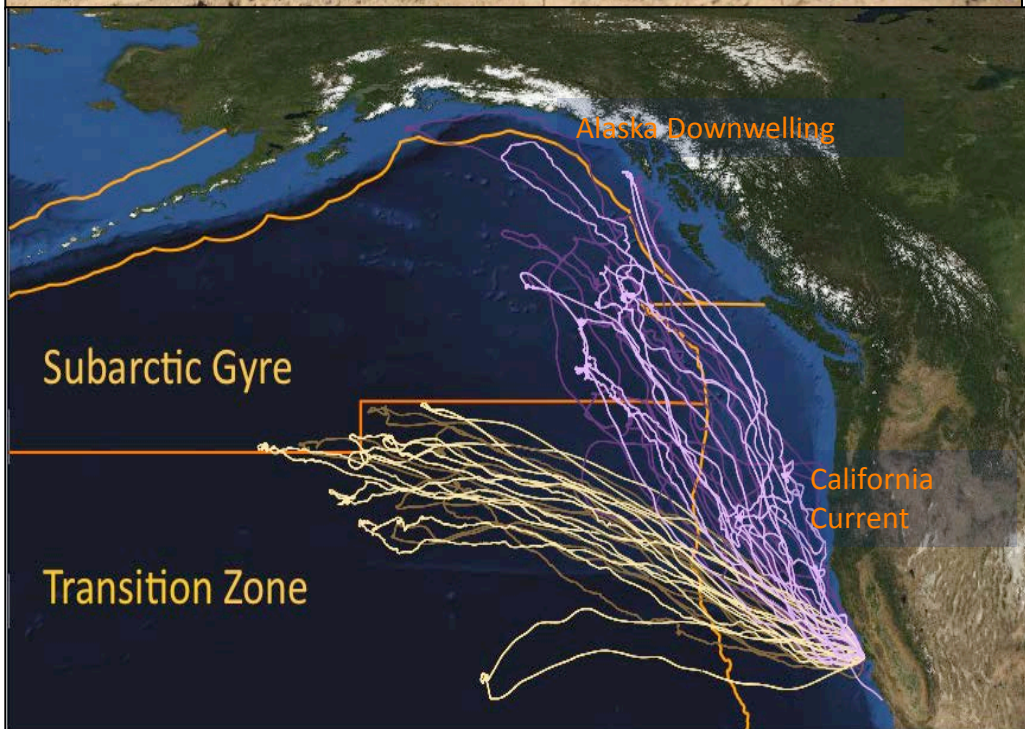
Study Site: Año Nuevo State Reserve, San Mateo County, CA

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

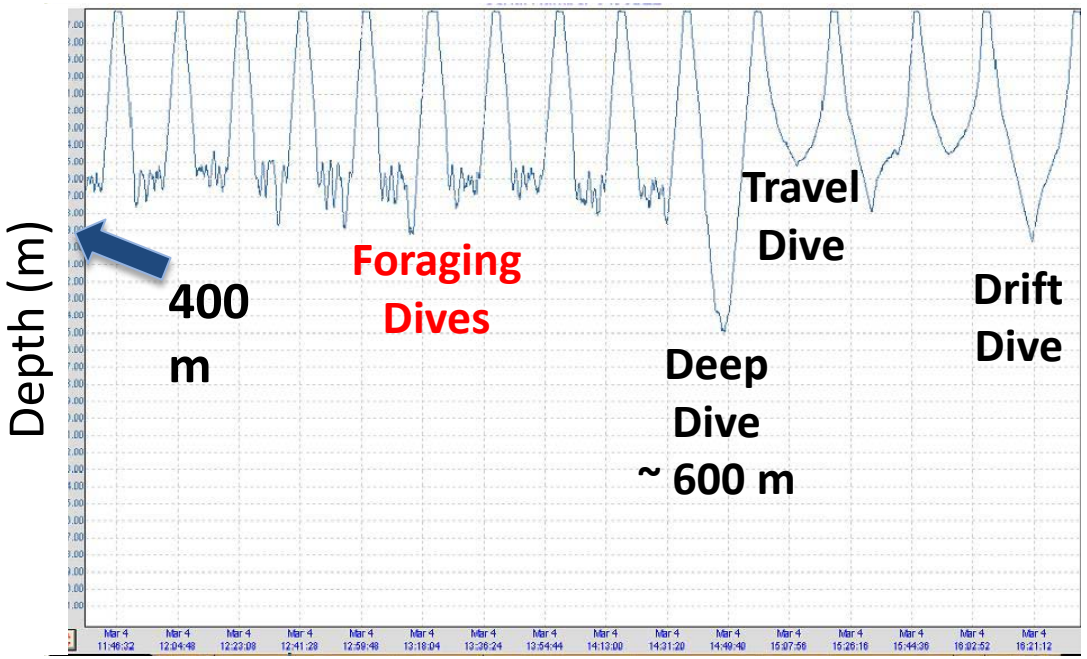
- Seals tracked did not change where they went



Methods – Foraging Behavior

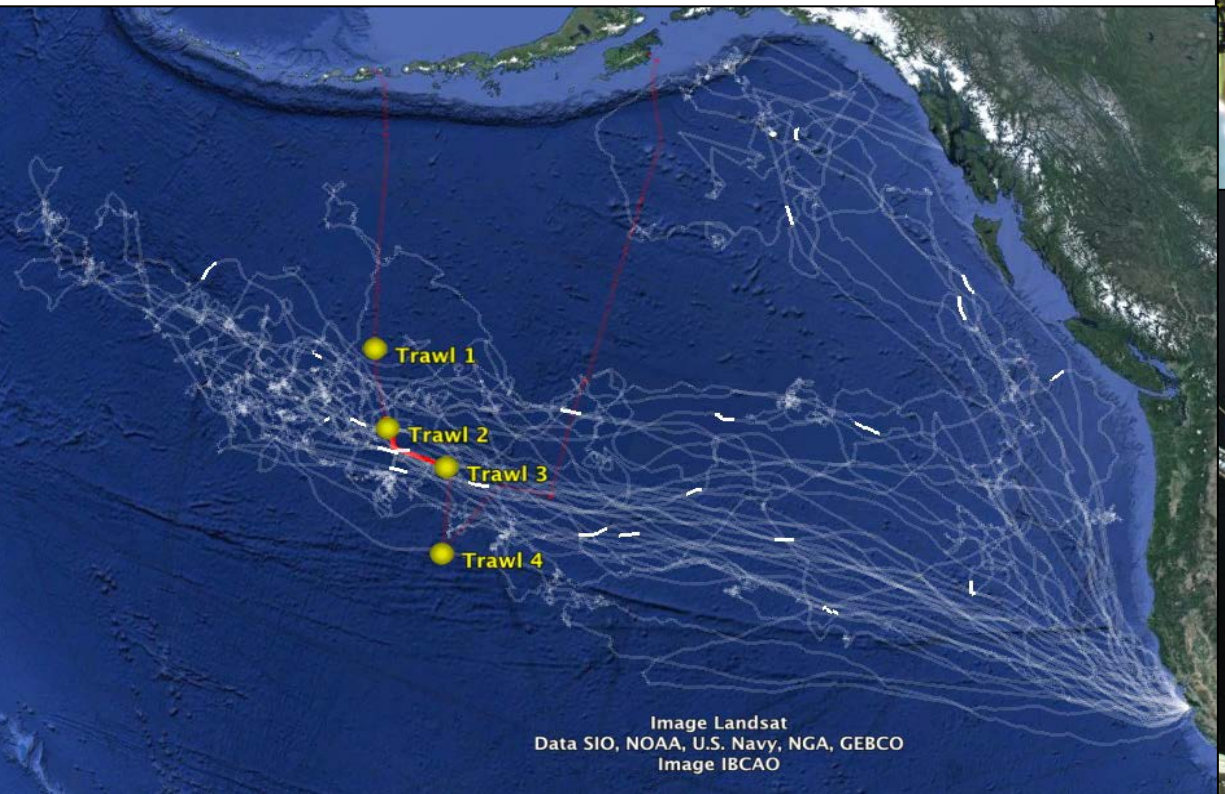
Dive Data Analysis

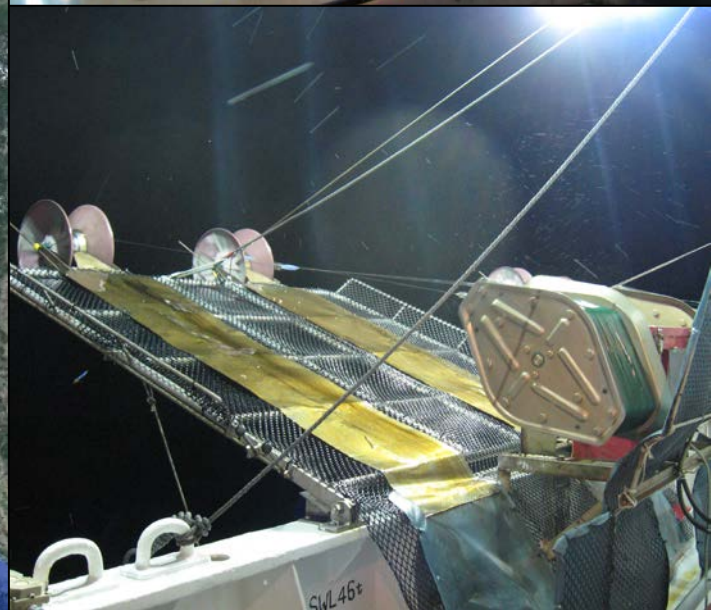
- Dive depth (m)
- Foraging Index
- Paired t-tests, $\alpha = 0.05$ (R)



Methods – Diet

- Blubber biopsies for diet
  - n = 176 (2005-2006, 2009-2012)
- North Pacific Transition Zone
- Trawl nets and squid jigs (650 – 800 m)

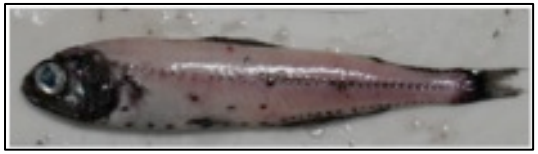




Methods – Diet

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

Myctophids



Other mesopelagic fishes

Mesopelagic squid

Methods – Diet

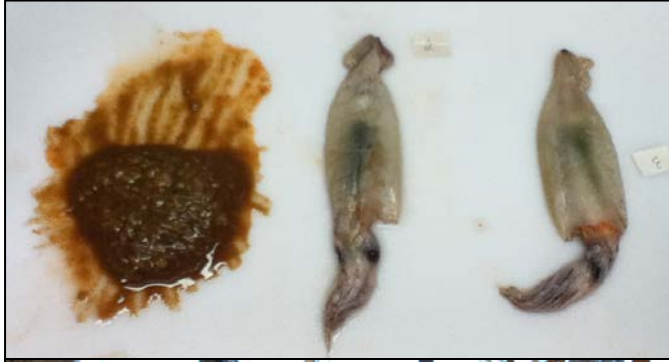
- Fatty acid profiles with gas chromatography
- Calibration coefficient
- Diets estimated with QFASA (Iverson 2004)
- Permanova, $\alpha = 0.05$ (Primer)

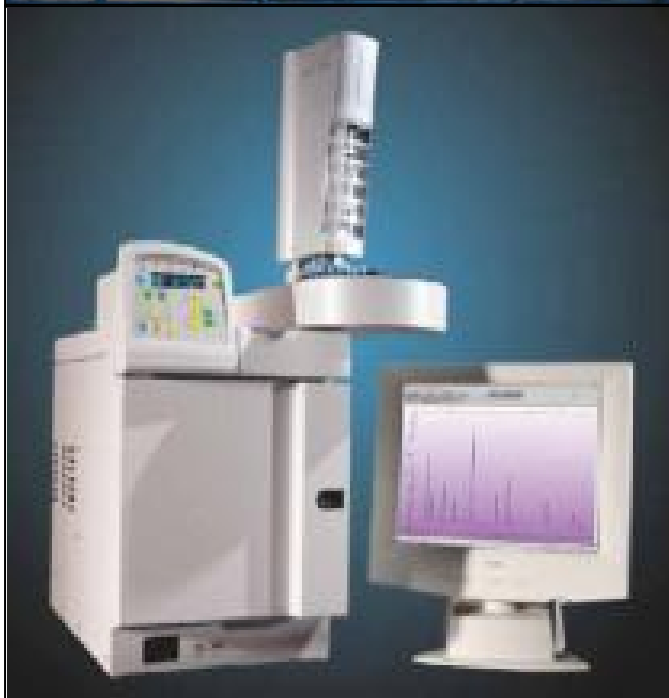
- ENSO State: Multivariate ENSO Index (MEI)
  - Positive: MEI ≥ 1.0
  - Neutral: -1.0<MEI< 1.0
  - Negative: MEI ≤ -1.0

Positive ENSO
2010 Post-breeding

Negative ENSO
2010 Post-molt
2011 Post-breeding

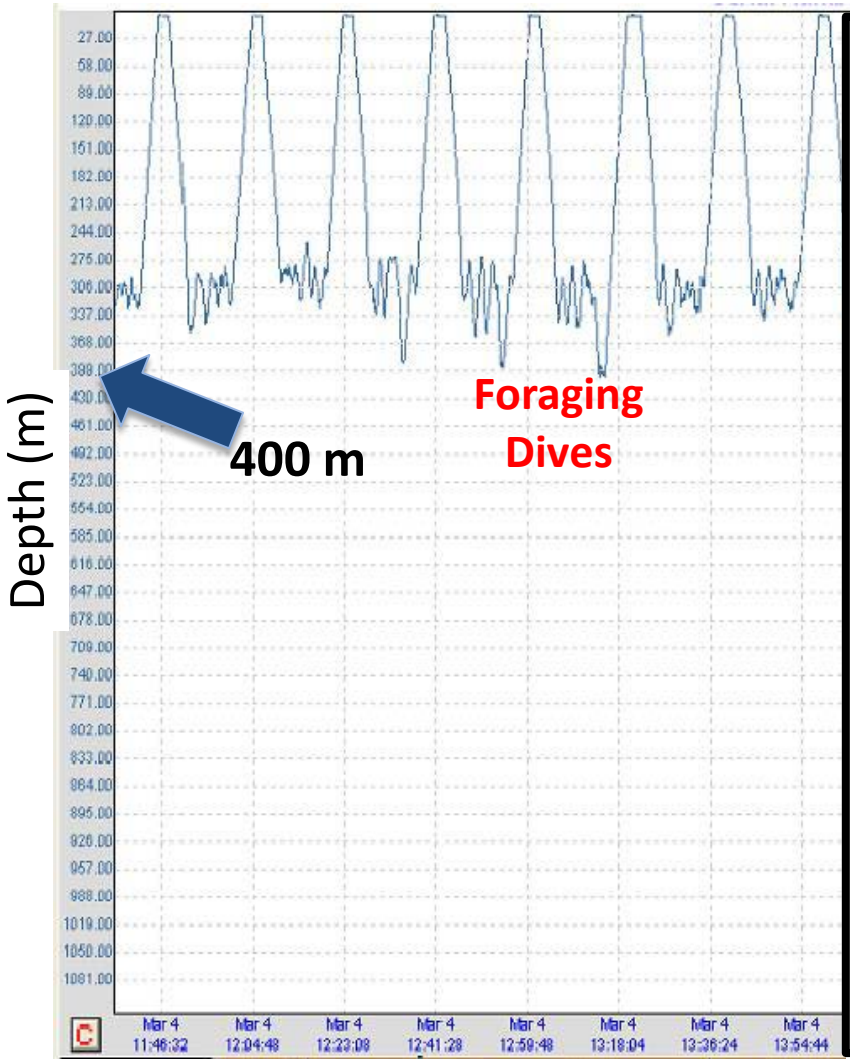
Neutral ENSO
2005 Post-breeding & Post-molt
2006 Post-breeding & Post-molt
2009 Post-molt
2011 Post-molt
2012 Post-breeding

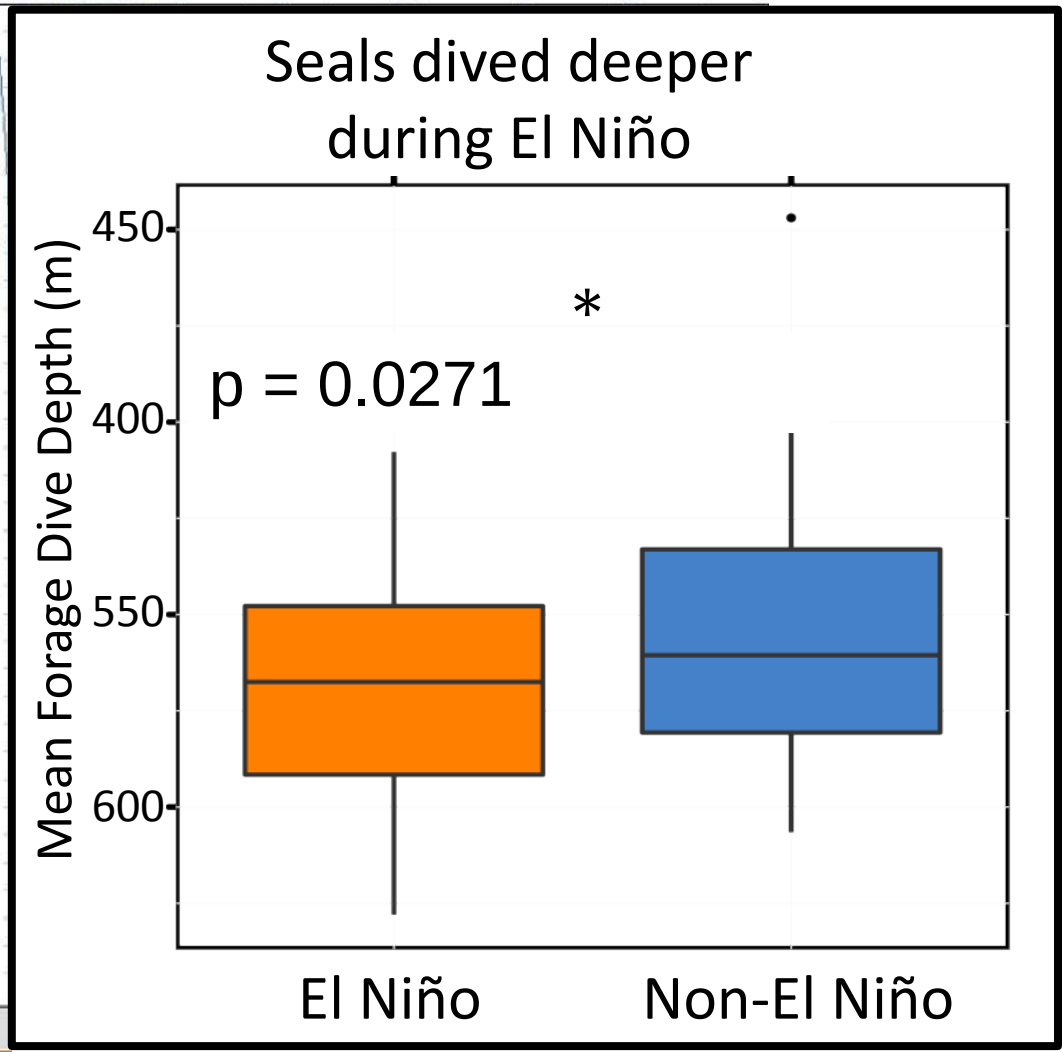




Results – Foraging behavior

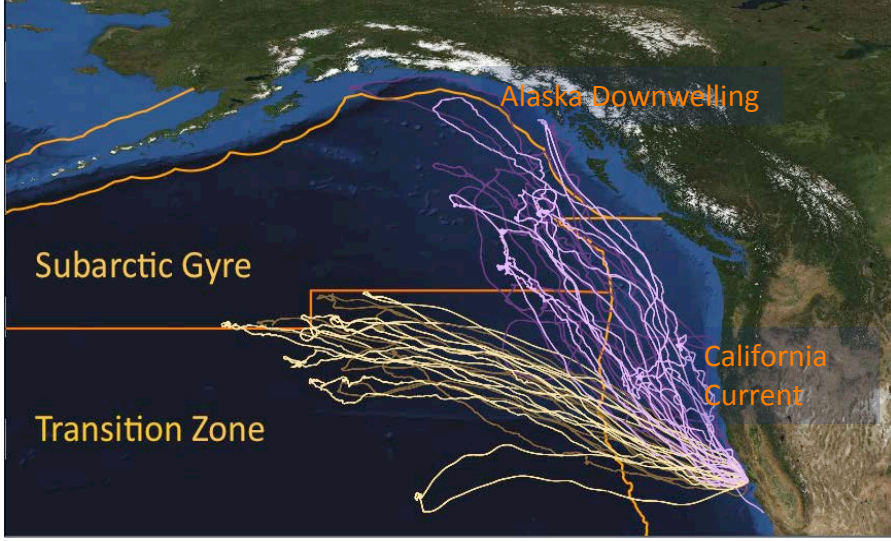
Foraging behavior changes in response to climate variability



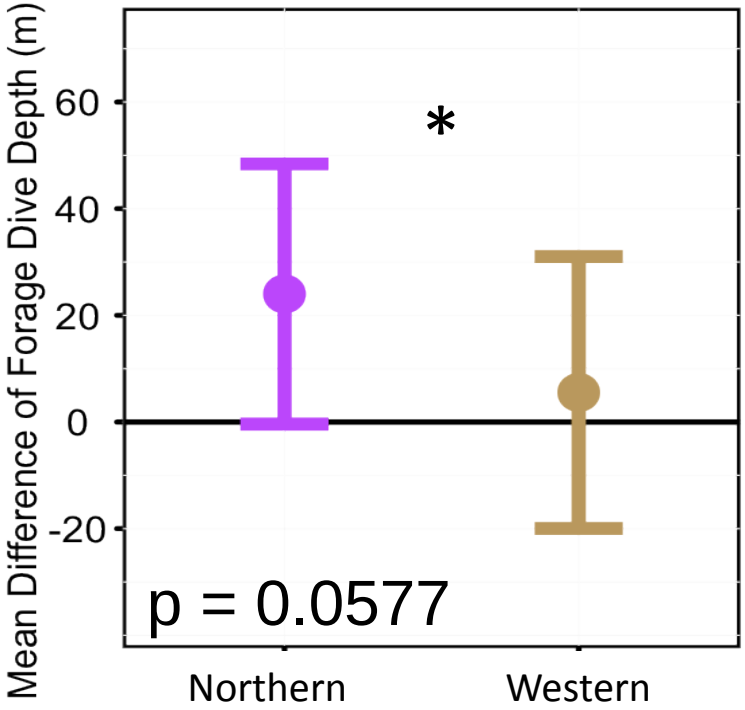


Results – Foraging behavior

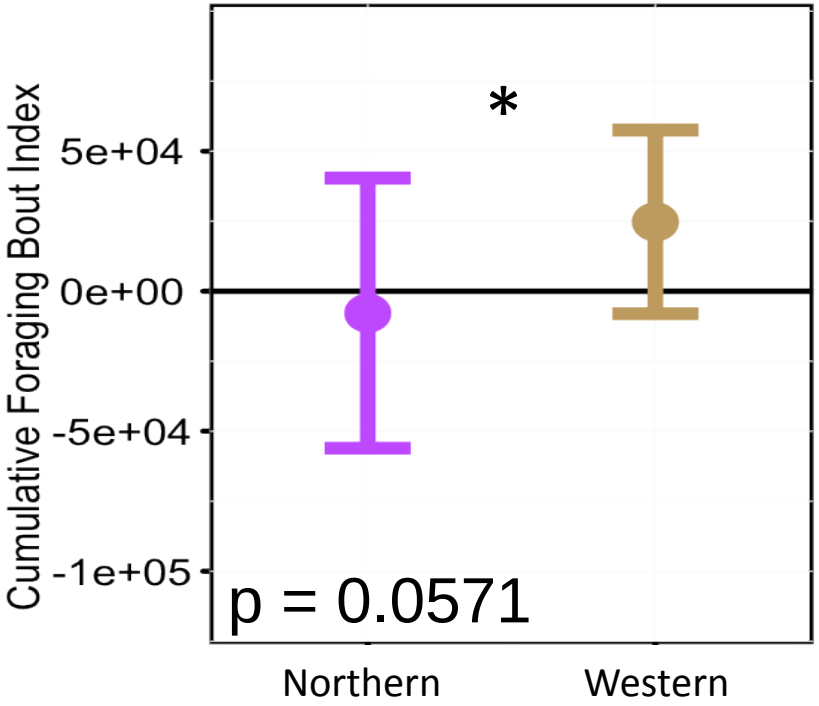
Differences between foraging areas



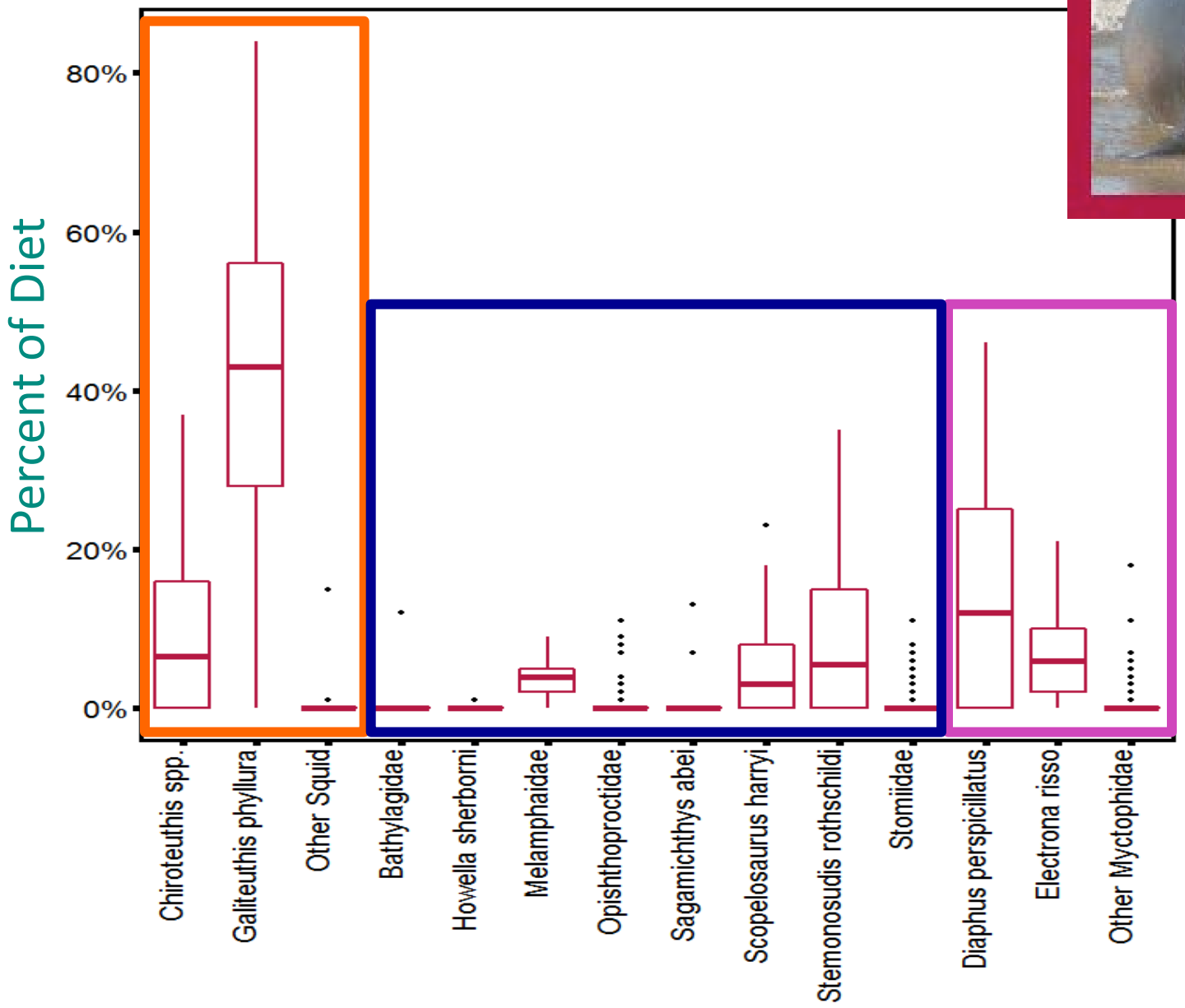
Northern seals dived deeper during El Niño



Western seals foraged more intensely in El Niño



Results – Average Diet



Squid: 51%

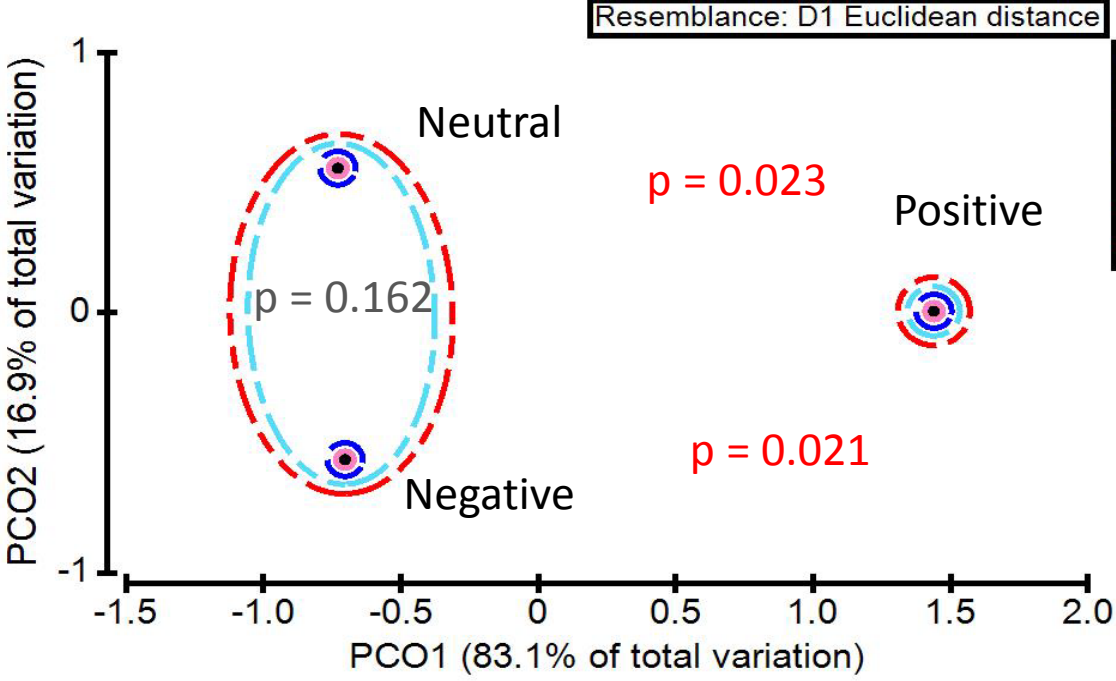
Mesopelagic Fish: 26%

Myctophid Fish: 23%

Results – Diet

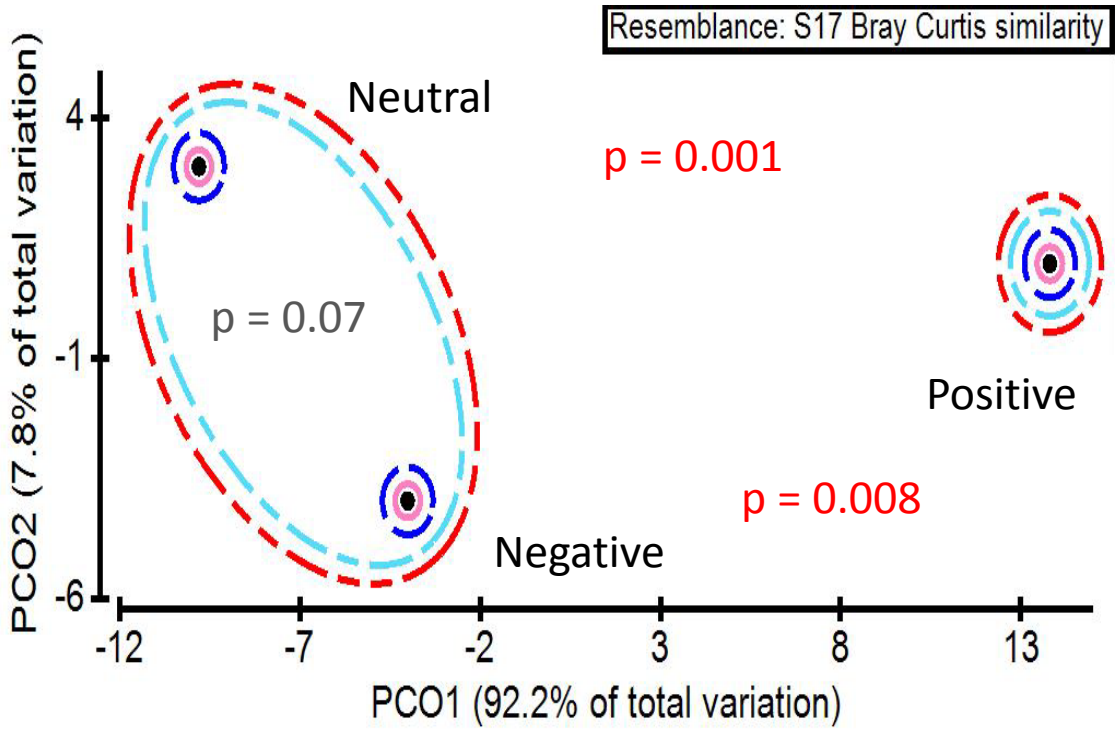
Significant difference in fatty acid profiles due to ENSO state

Permanova, p = 0.02



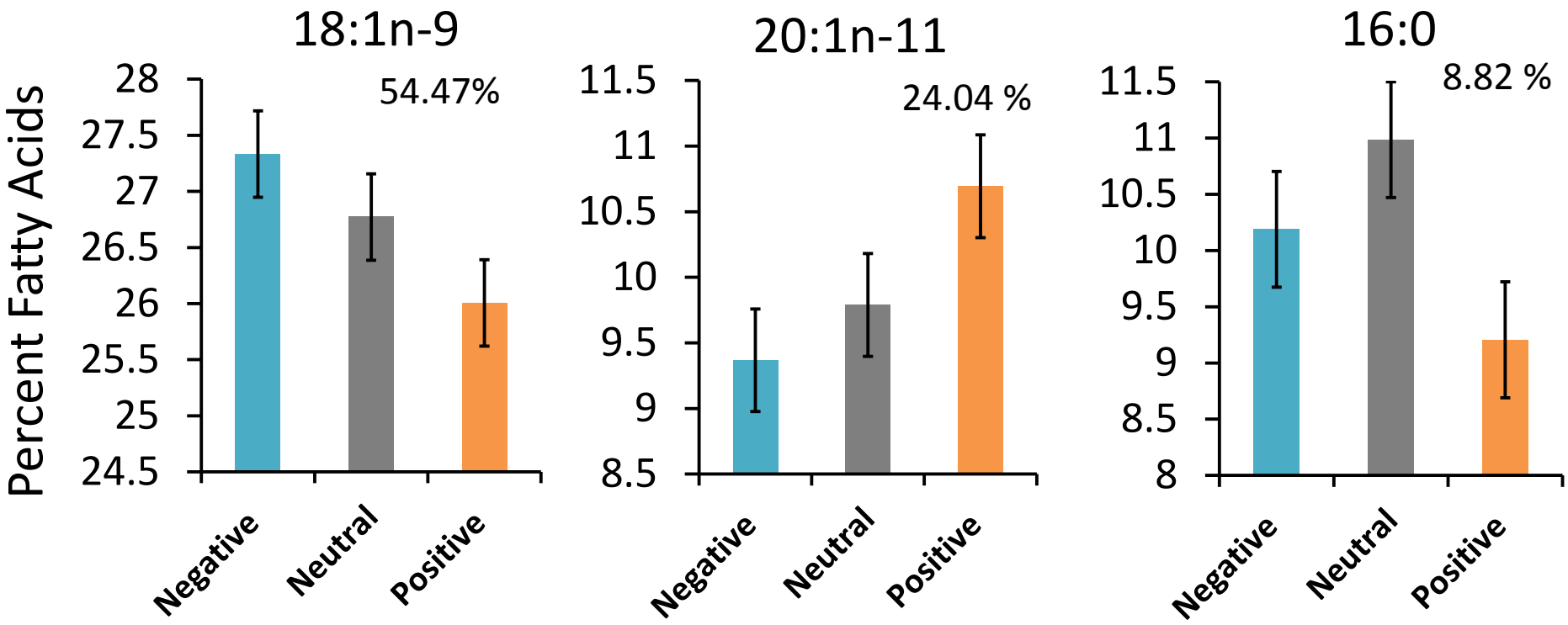
Significant difference in diet due to ENSO state

Permanova, p = 0.001



Results – Fatty Acids

Top FA Contributing to Model

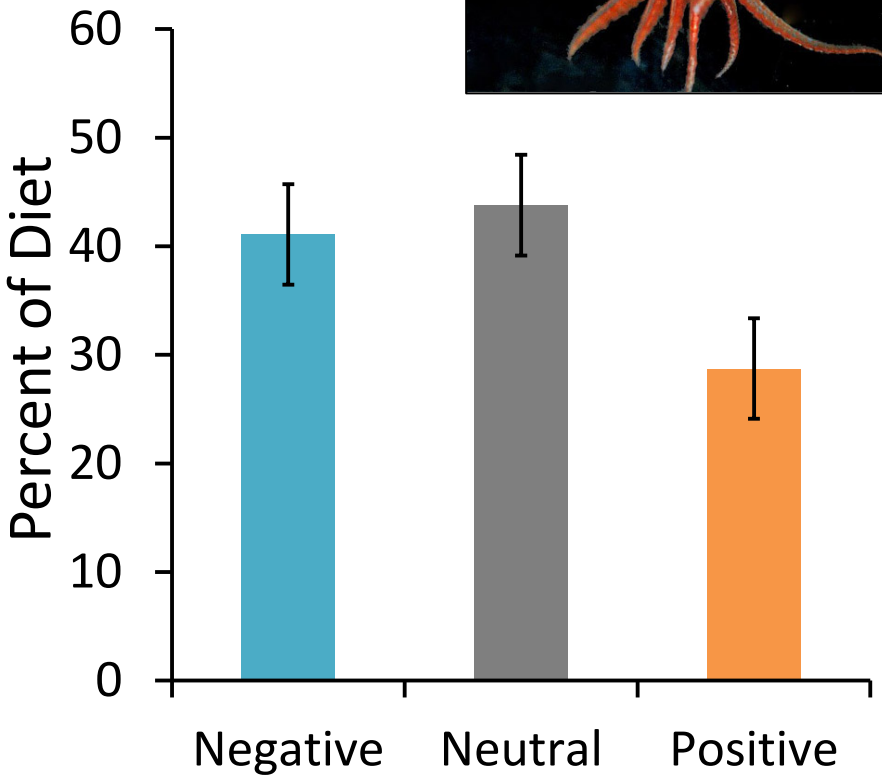


Results – Diet

Top Squid Contributing to Model

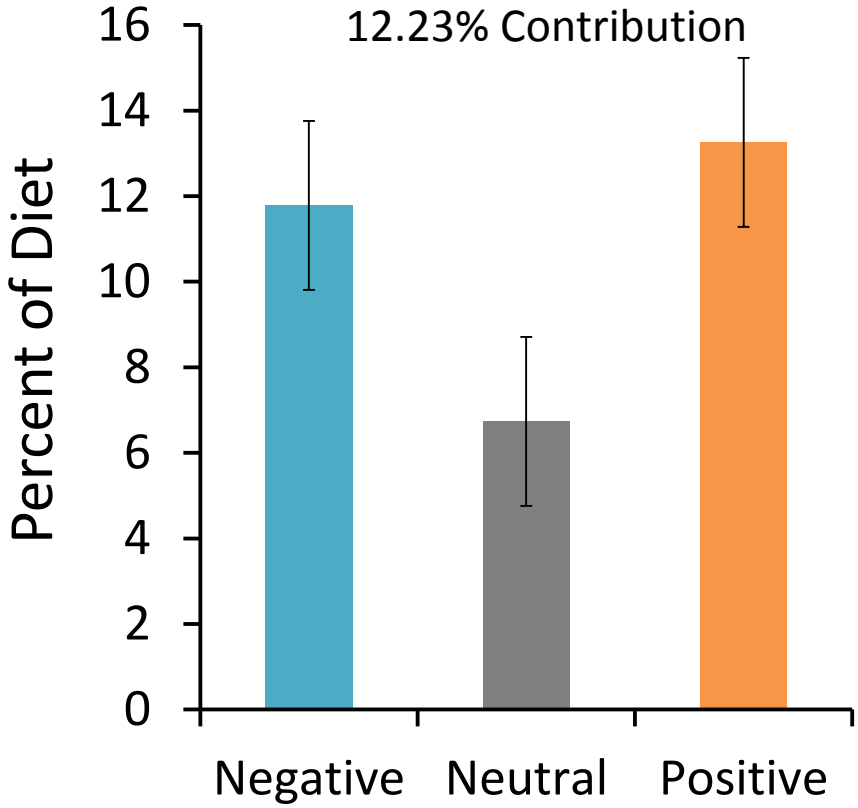
Galiteuthis phyllura

24.22% Contribution



Chiroteuthis spp.

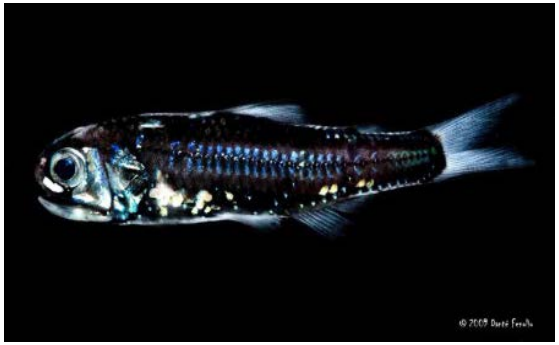
12.23% Contribution



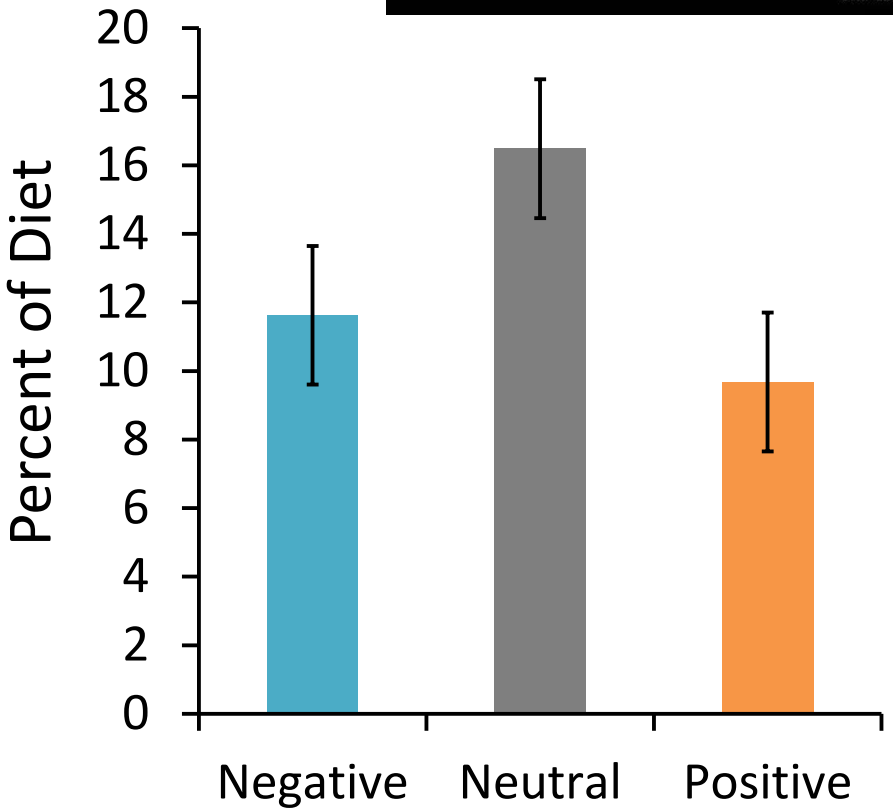
Results – Diet

Top Fish Contributing to Model

Diaphus perspicillatus

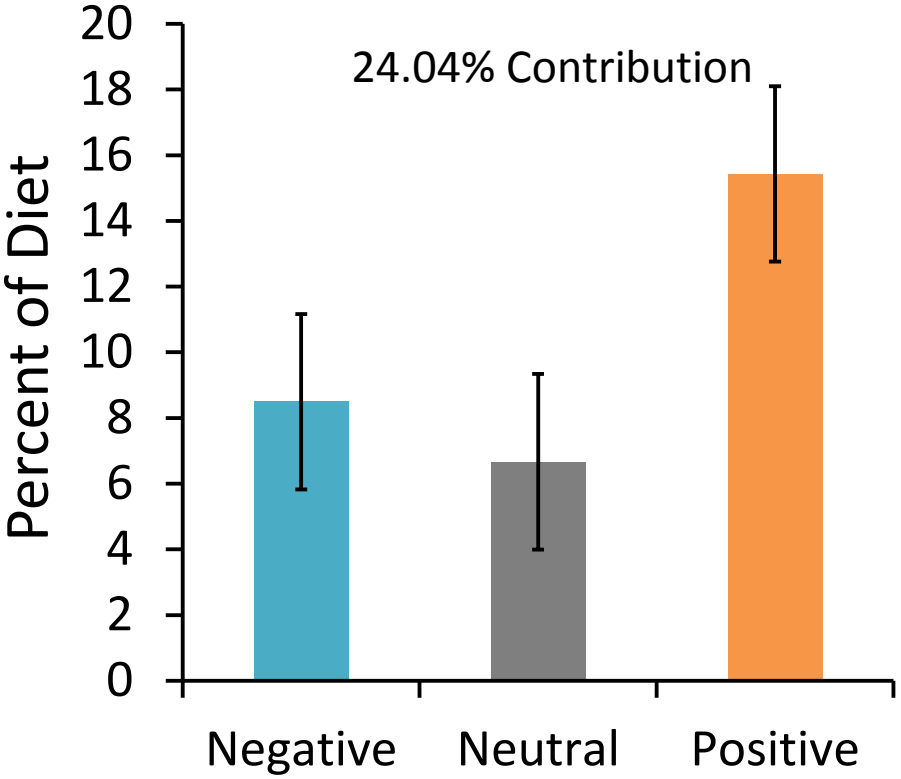


16.92% Contribution



Stemonosudis rothschildi

24.04% Contribution



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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