California sea lions: Historical diet patterns in relation to environmental changes

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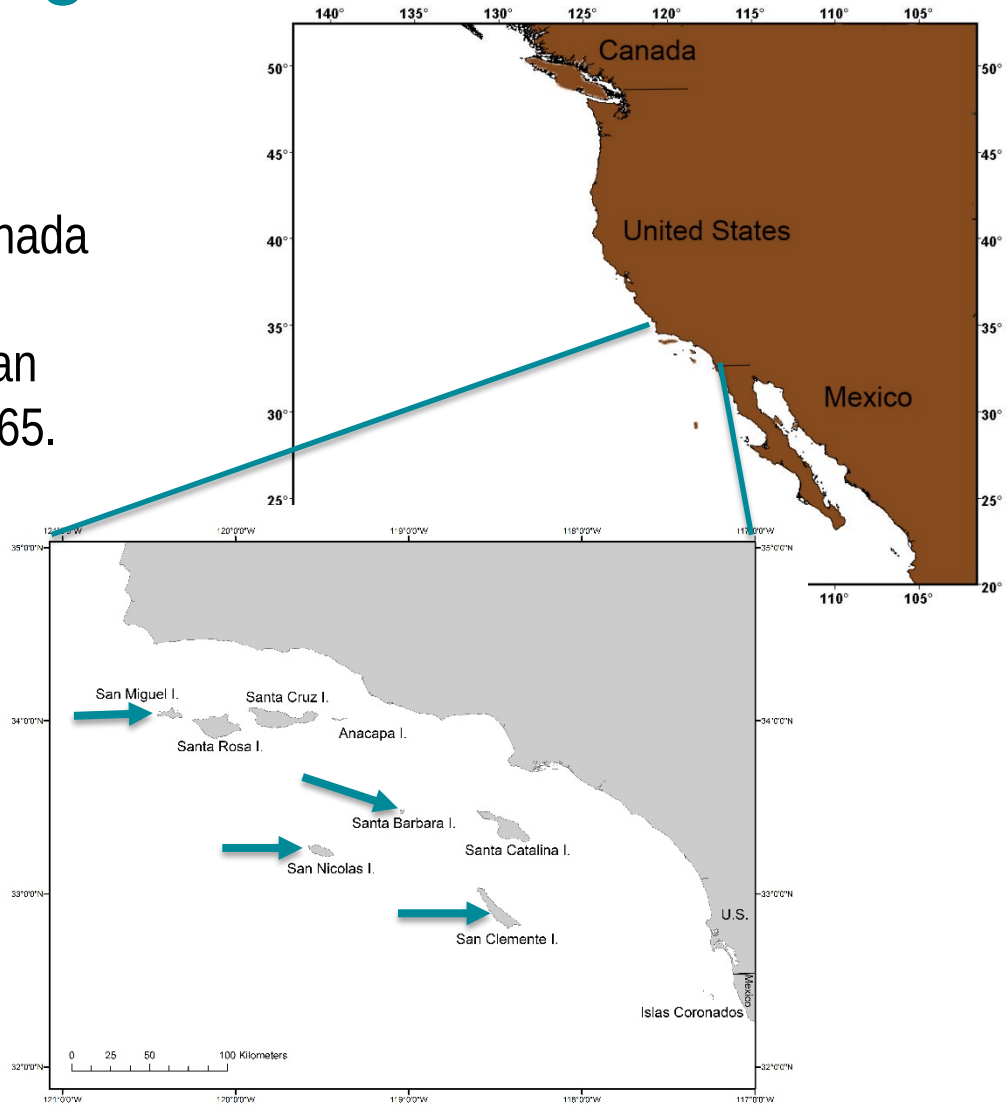
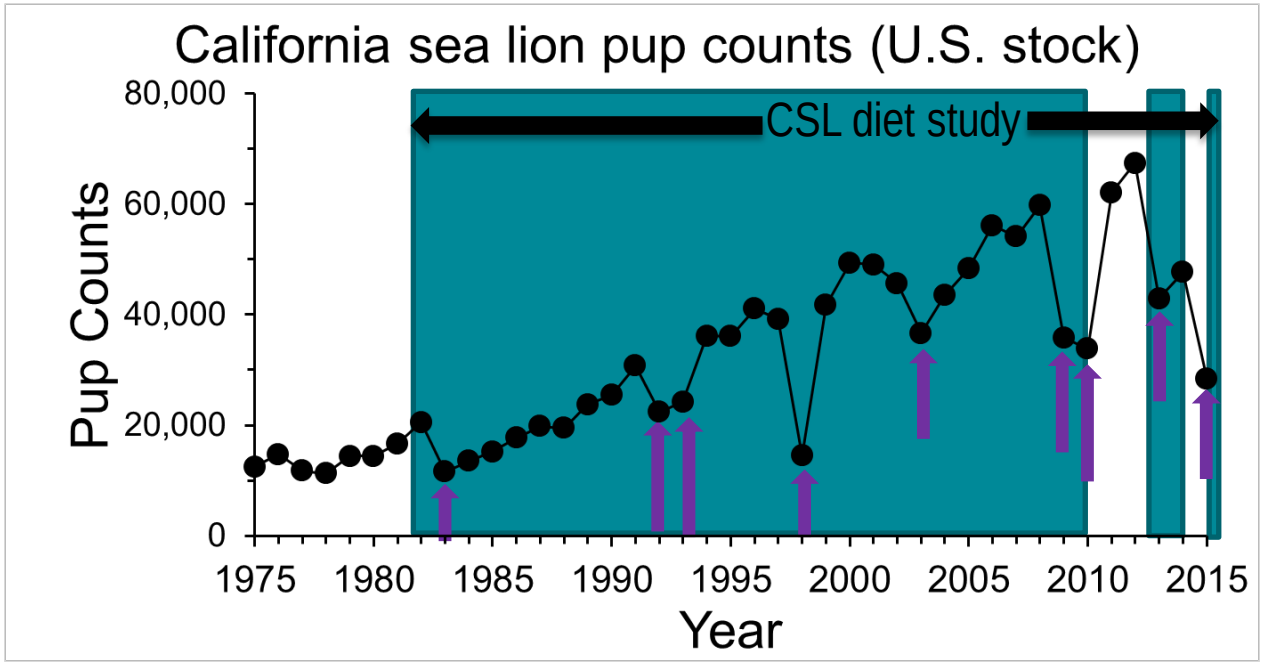
Background

- California sea lions are one of the top predators in the California Current Ecosystem
- Distributed from British Columbia, Canada to central Mexico
- U.S. population has been growing at an average annual rate of 4.1% since 1965.
- U.S. population in 2012 estimated at 340,000
  - No current estimate for population in Mexico
  - No current estimate for U.S. after 2013-2015 decline in pup production.
- 4 rookery-islands in southern California produce 99.7% of U.S. pups.



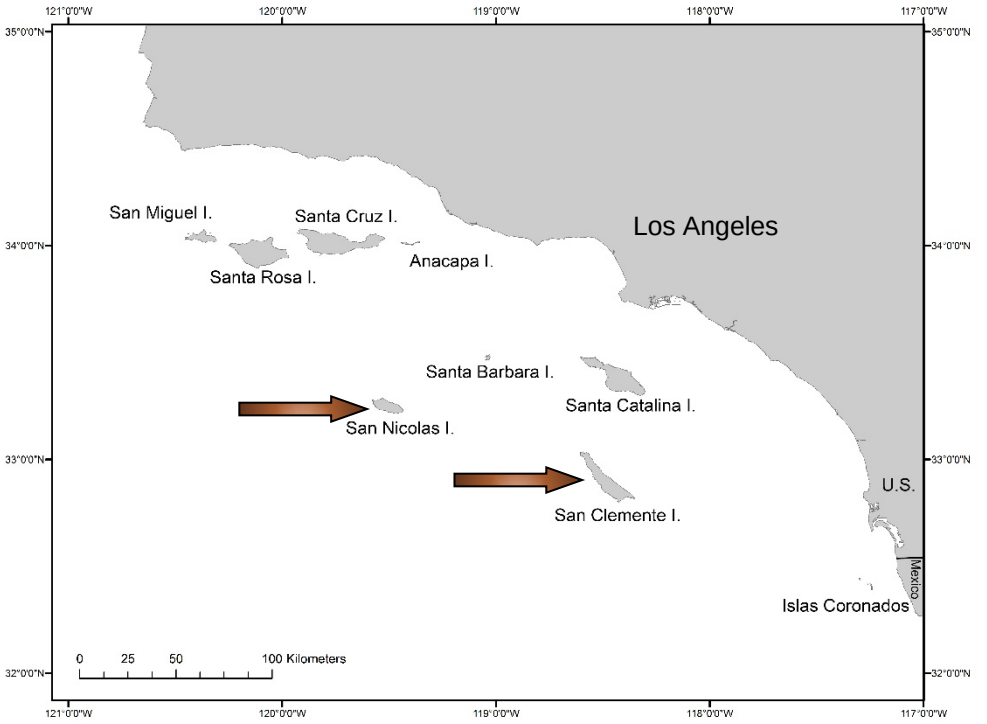
What did sea lions eat while the population increased?

What did sea lions eat while pup production decreased?



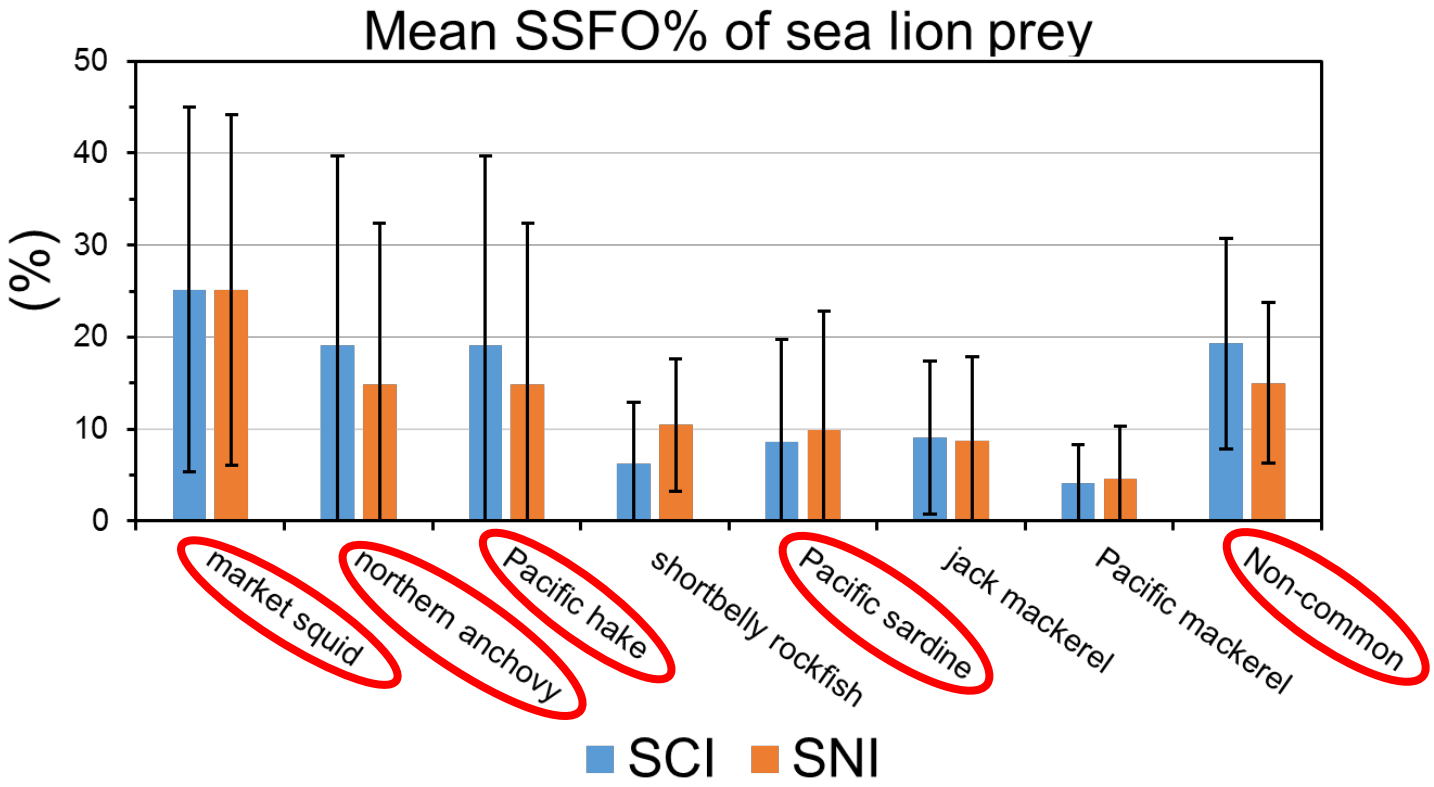
California sea lion diet study

- 1981-2015 diet study at San Clemente Island (SCI) and San Nicolas Island (SNI)
  - Seasonal scat collections
  - 16,449 scat samples processed
  - 1981-2009 analyzed and 2010-2015 partially analyzed;
- Environmental variables
  - Multivariate El Niño Index (MEI)
- Presence/ absence of prey in scat samples.
  - Frequency of occurrence (FO%)
  - Split sample frequency of occurrence (SSFO%)
- Length of prey estimated from size of cephalopod beaks and fish otoliths.
  - Otoliths size corrected for erosion
- Anomalies derived from1981-2007 seasonal mean values in FO%.
- Pup counts from literature and SWFSC surveys

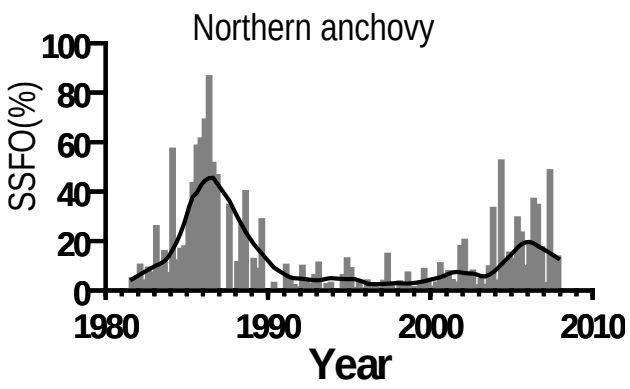


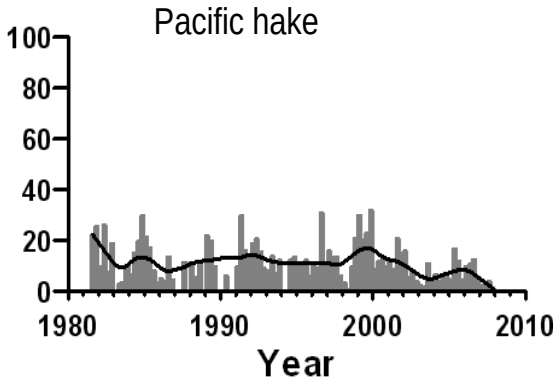
California sea lion prey

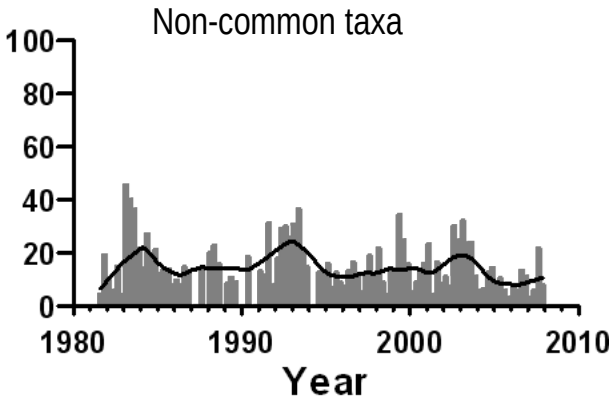
- 133 species identified
  - Fish = 103
  - Shark = 4
  - Cephalopods = 25
  - Crustacean = 1

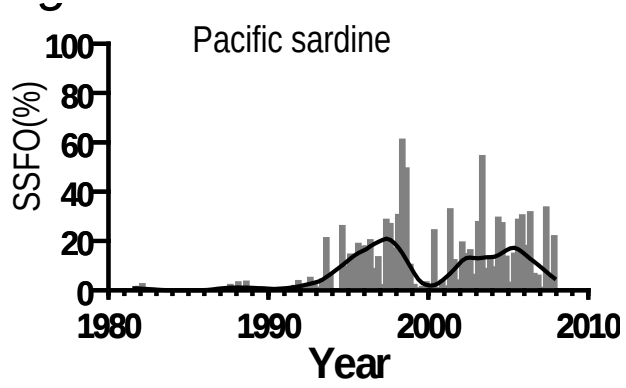


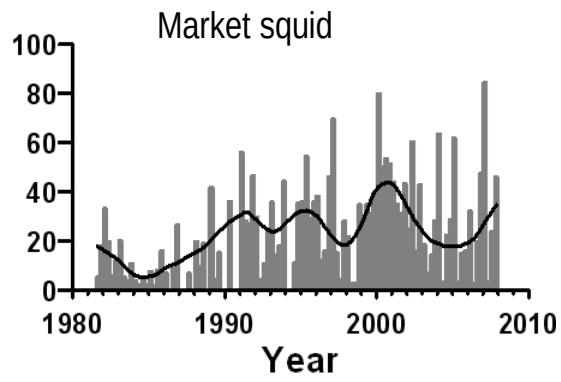
Occurrence of prey in diet, 1981-2007, San Nicolas Island









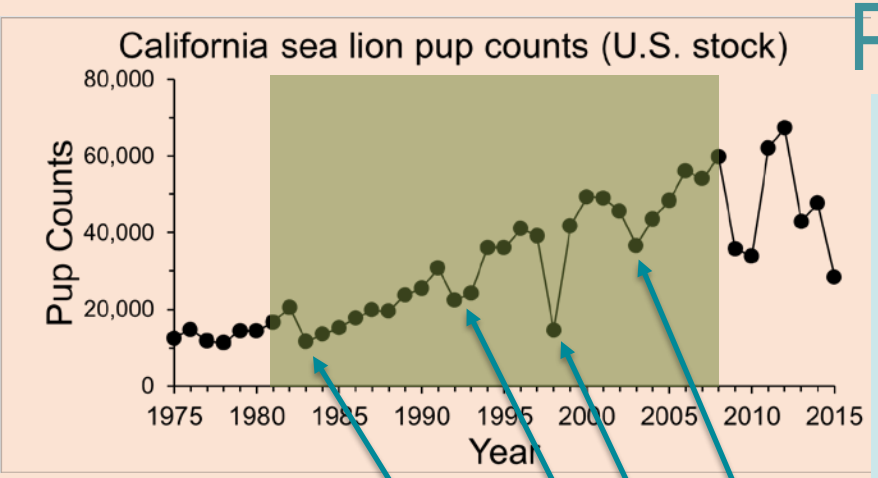


- Anchovy dominated in 1980s
- Market squid dominated in 1990s and 2000s; and increased over time.
- Appearance of sardine in early 1990s replaced anchovy.
- Hake declined over time.
- Non-common taxa increased during El Niño's and decreased in La Niña's

Other 1981-2007 highlights

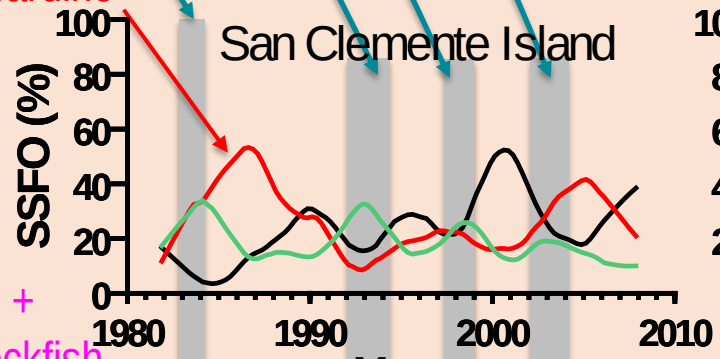
- More market squid eaten in autumn and winter than other seasons.
- During spring more anchovy consumed at San Clemente Island and more sardine consumed at San Nicolas Island.
- More non-common prey consumed in summer.
- More non-common prey consumed at San Clemente Island.
- More hake consumed at San Nicolas Island

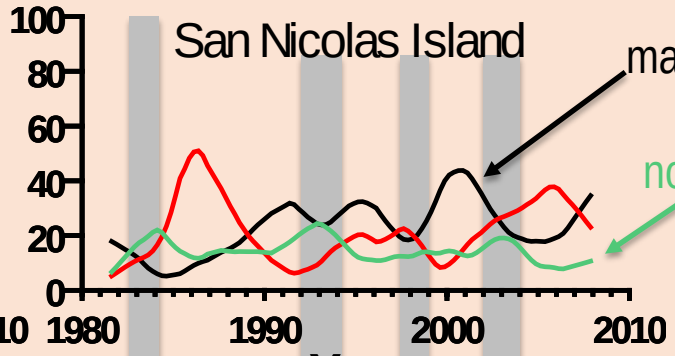
Prey switching (1981-2007)



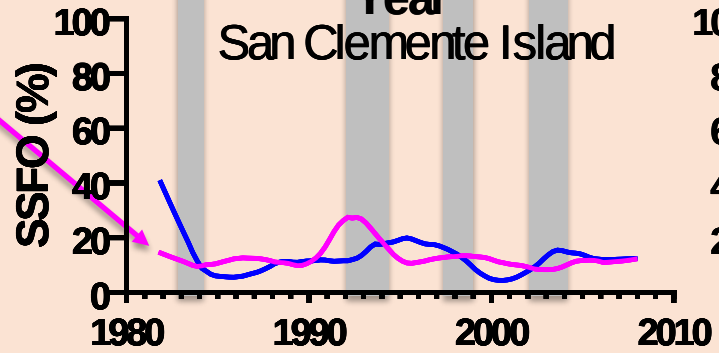
- Consumption of non-common taxa increased when pup production decreased –associated with El Niño conditions.
- When consumption of predominant prey decreased (e.g., anchovy and squid), other prey take over.

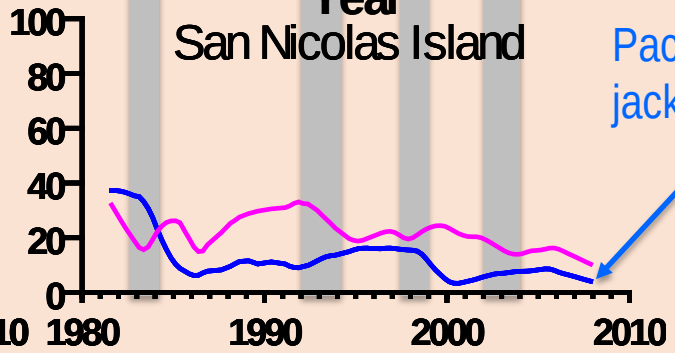
anchovy + sardine



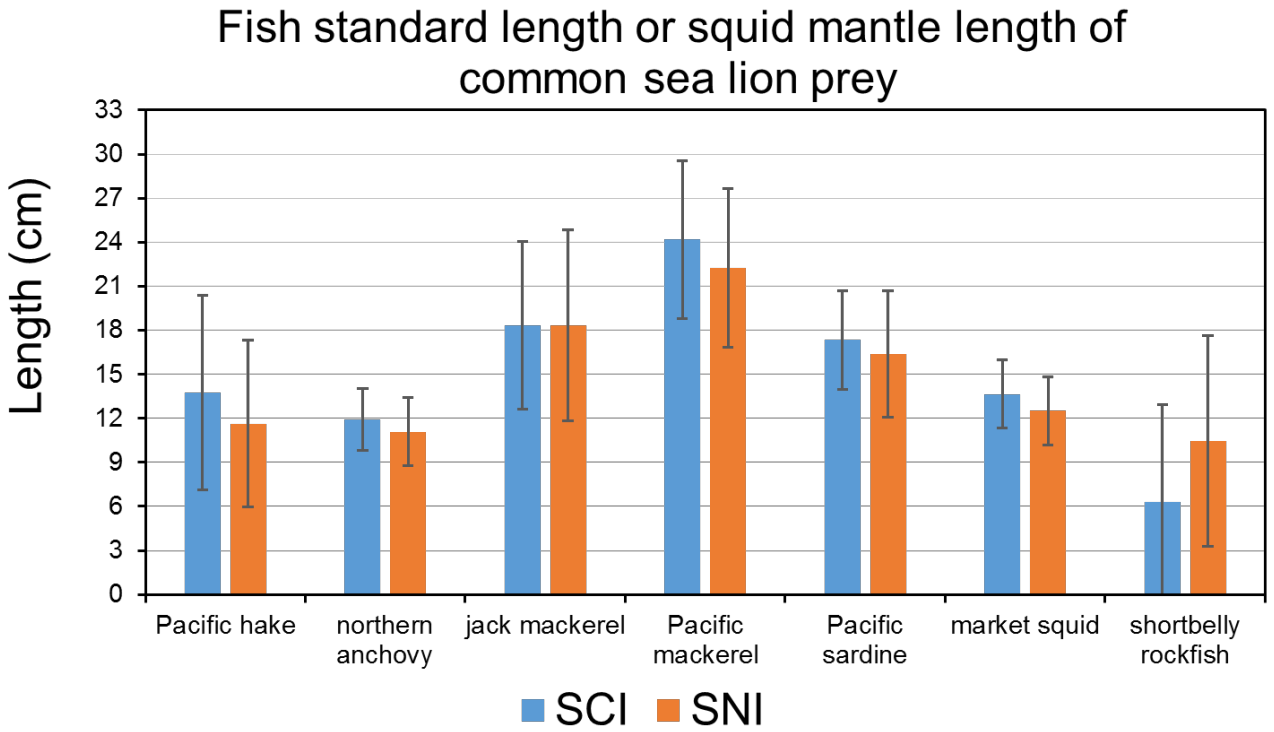


Pacific hake + shortbelly rockfish



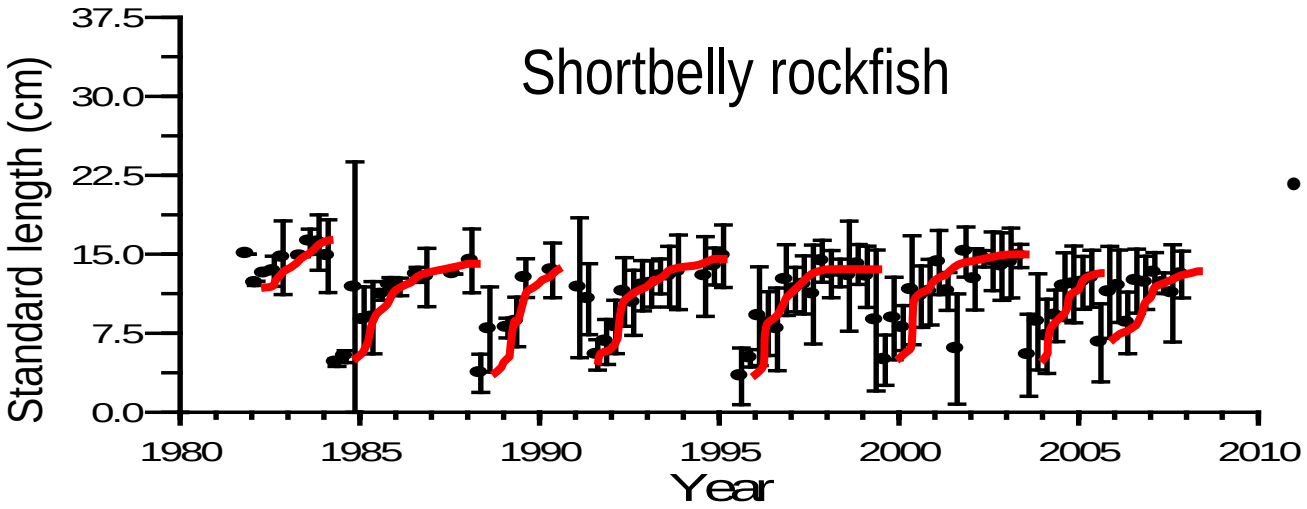


Size of common prey

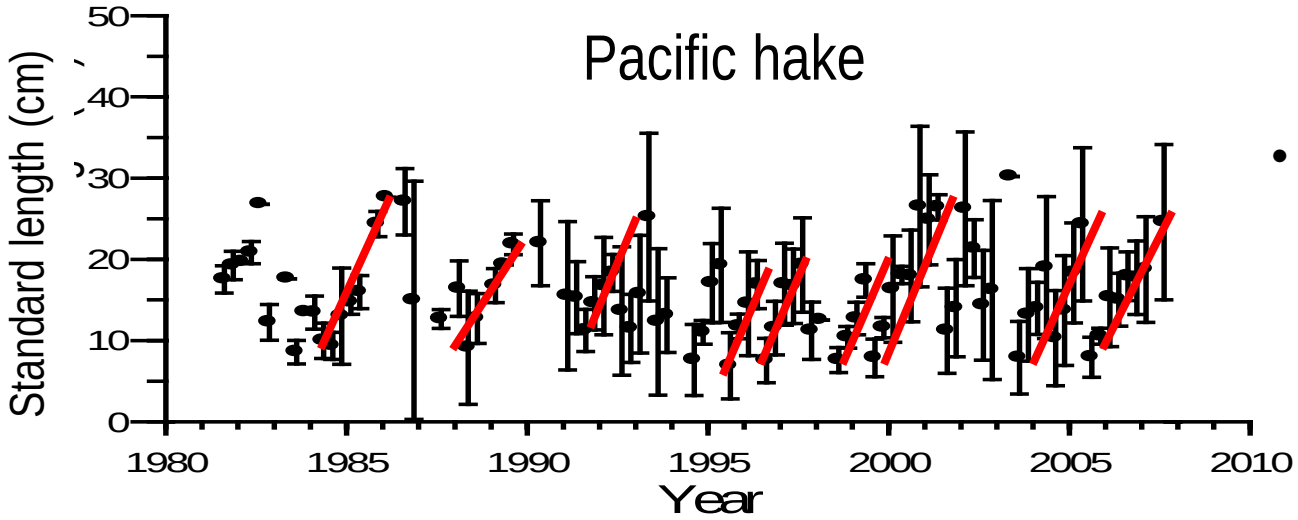


- Size of prey varies by species (Mean = 13.4 cm)
- Mackerels are their largest prey.
- Will also consume very small prey (e.g., shortbelly rockfish).

Passage of prey cohorts in sea lion diet through time, San Nicolas Island

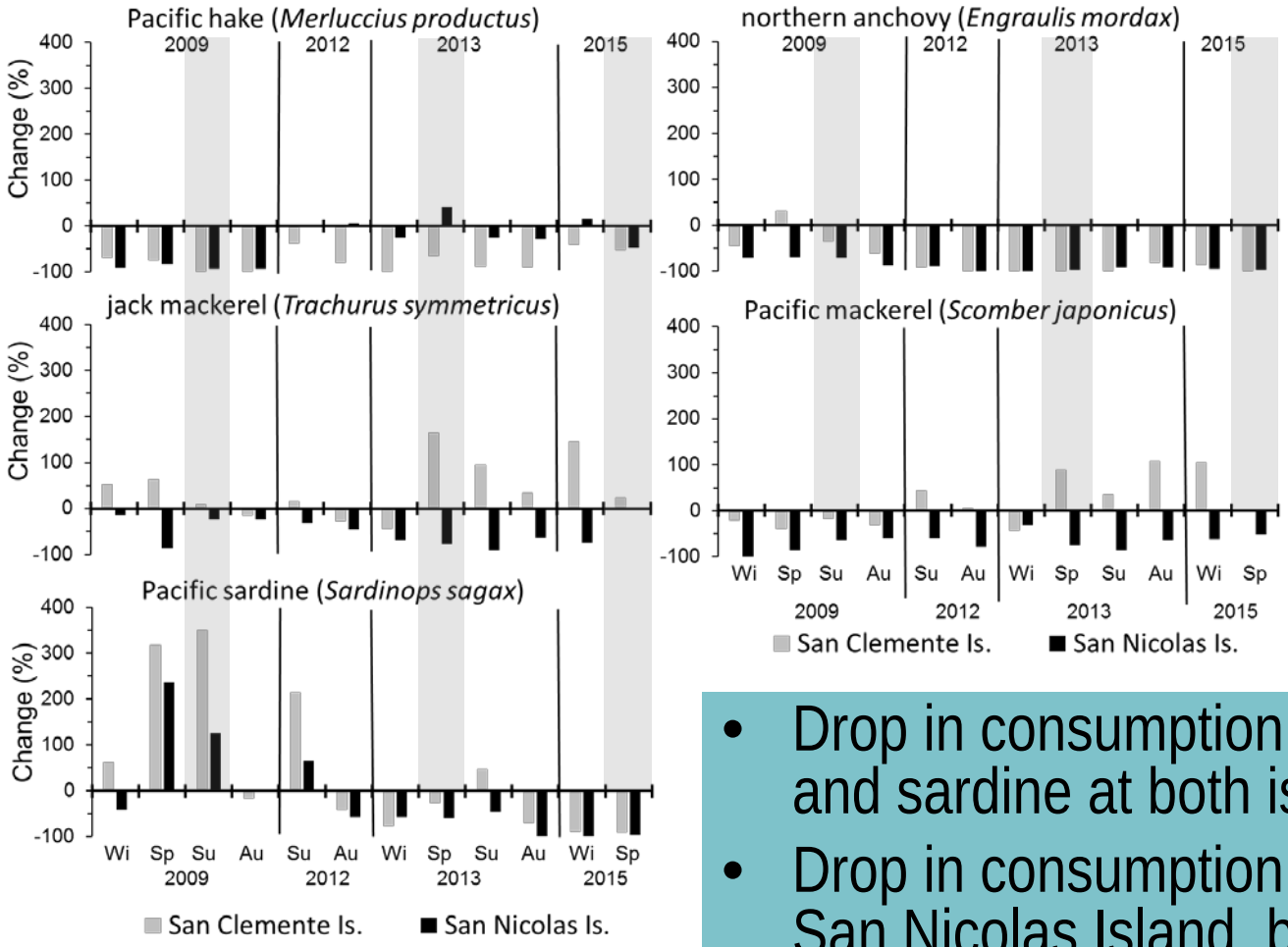


- Shortbelly rockfish cohorts: 3 to 6 years.



- Pacific hake cohorts: 2.5 to 3 years

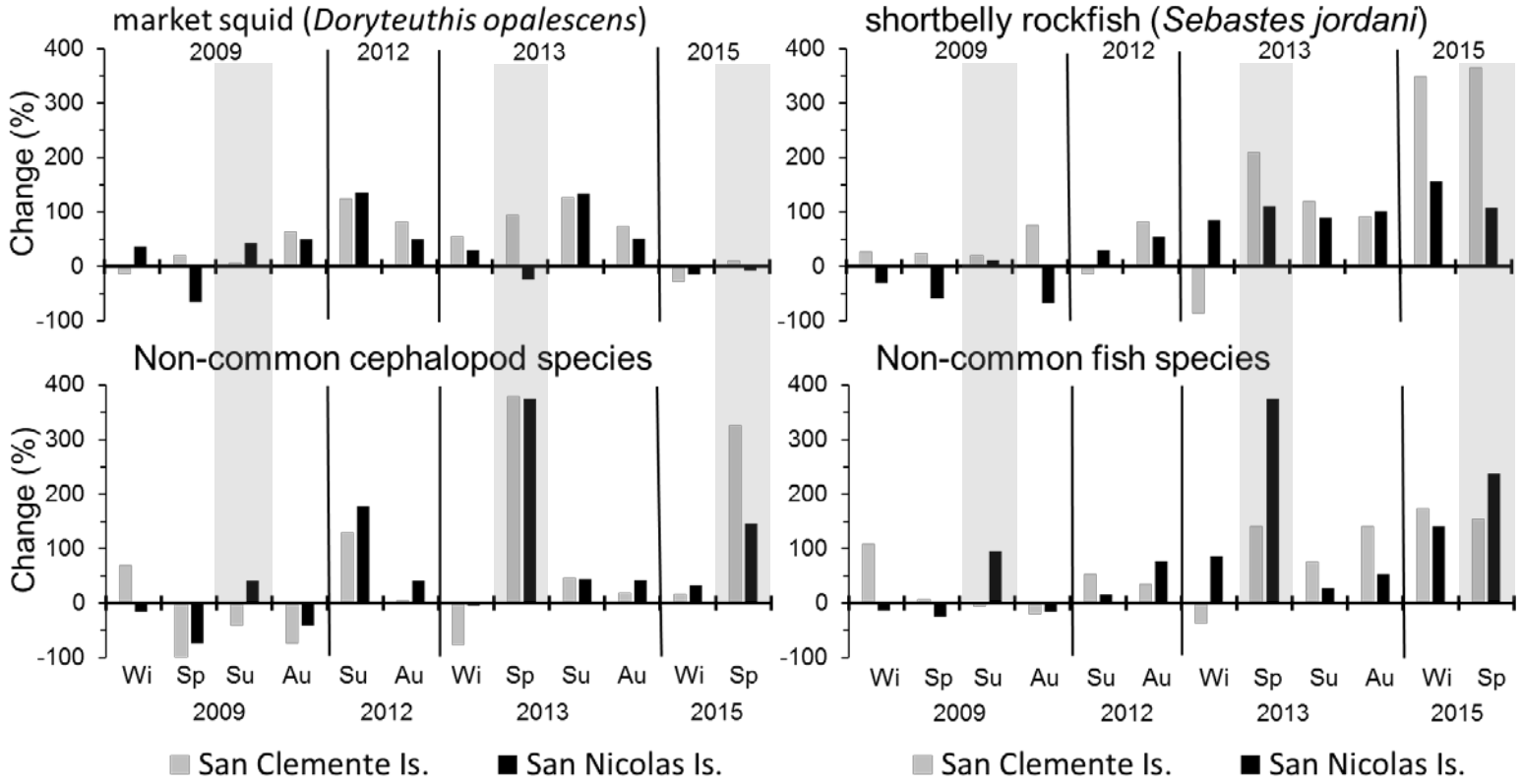
Change (%) in FO% from 1981-2007 seasonal mean



Unusual Mortality Event (UME)

- Drop in consumption of hake, anchovy, and sardine at both islands.
- Drop in consumption of mackerel at San Nicolas Island, but increase at San Clemente Island.

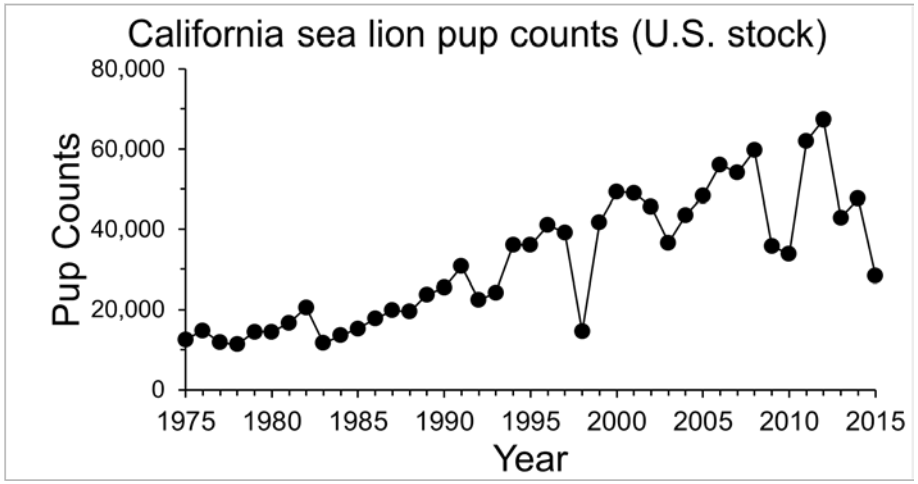
Change (%) in FO% from 1981-2007 seasonal mean

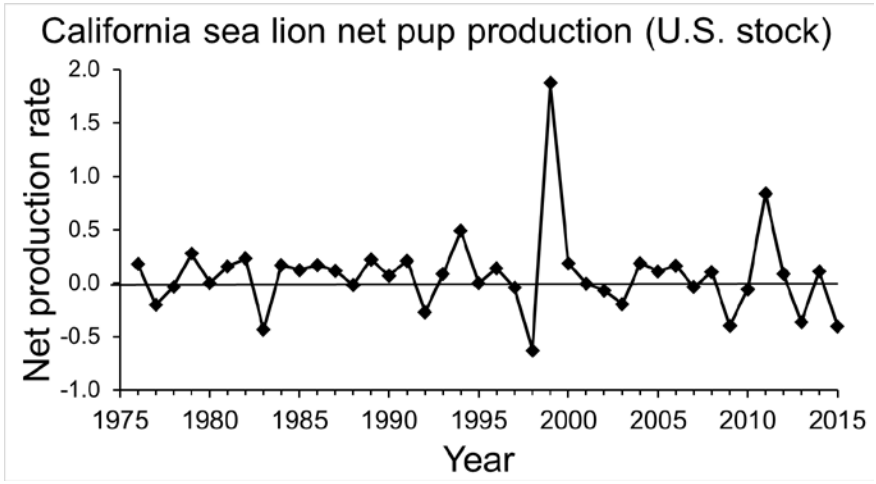


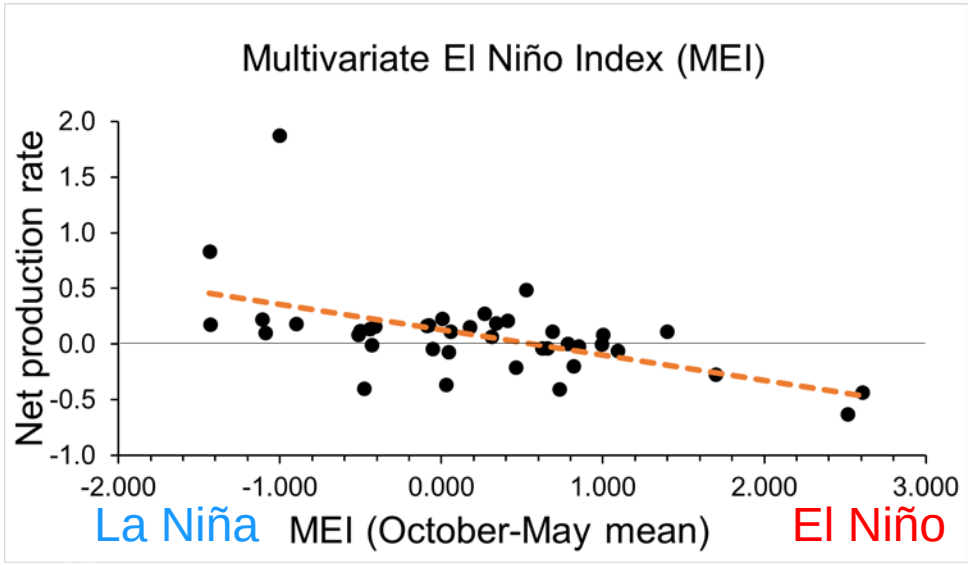
UME

- Increased consumption of non-common cephalopods and non-common fish at both islands during spring 2013 and spring 2015 UME.
- Increased consumption of shortbelly rockfish at both islands in 2013 and 2015.
- Increased consumption of market squid in 2012 and 2013, and average or below average consumption in 2015

California sea lion trends (1975-2015)

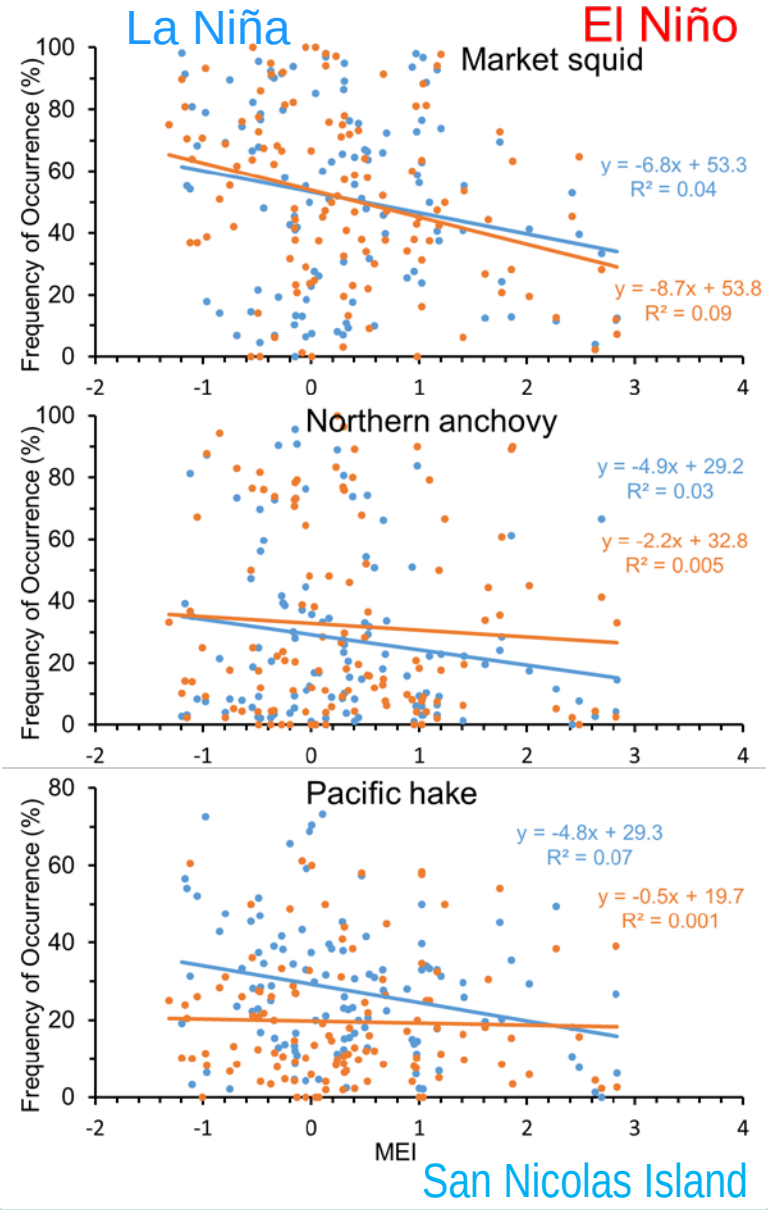


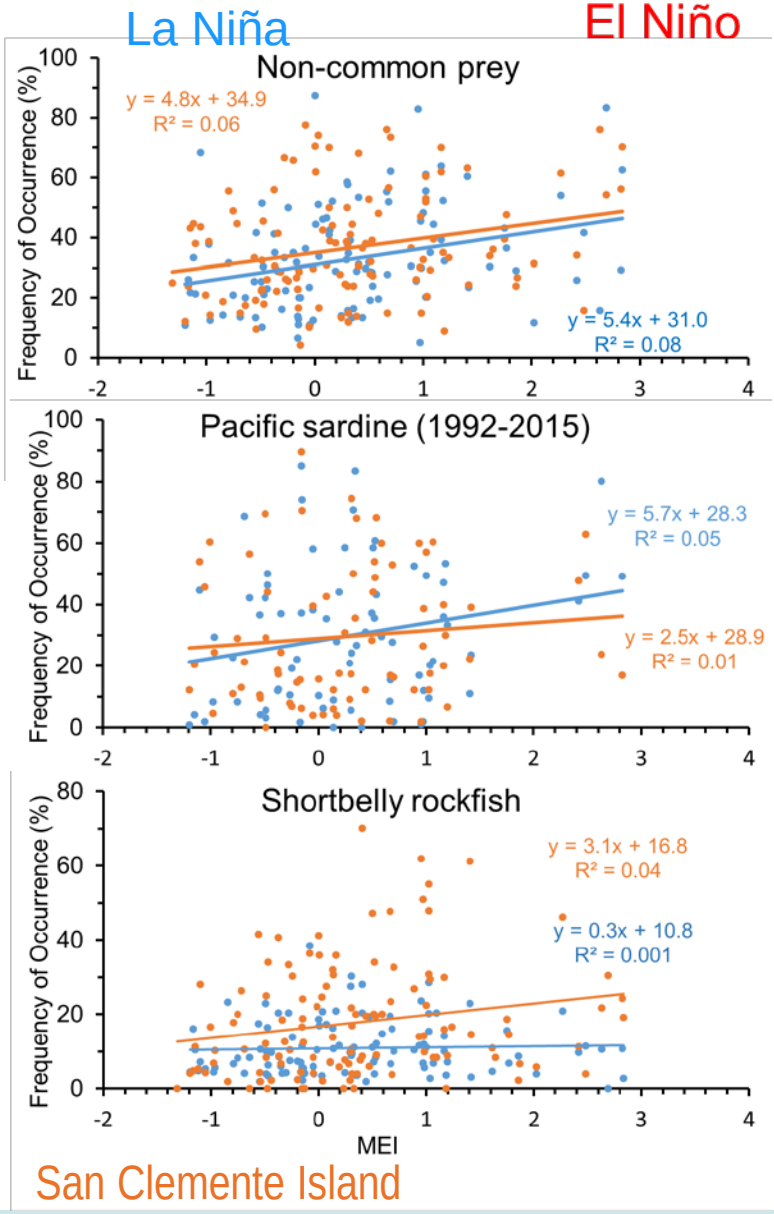




GLM Stepwise Analysis		
Effect	Coefficient	p-Value
CONSTANT	0.130	0.022
MEI	-0.228	0.000

El Niño (MEI) effect on California sea lion diet





Summary

- Diet of California sea lions is never (quite) the same.
- Diversity in their diet varies with time – sometimes less diverse, sometimes more diverse.
- ENSO cycles influence what sea lions eat and how many pups are produced.

Acknowledgements

- U.S. Navy provided logistical support
- Many people helped collect and process scat samples.