2.8.4 CCLME - Pinnipeds:
California sea lions: Historical diet patterns in relation to environmental changes in the southern California Current

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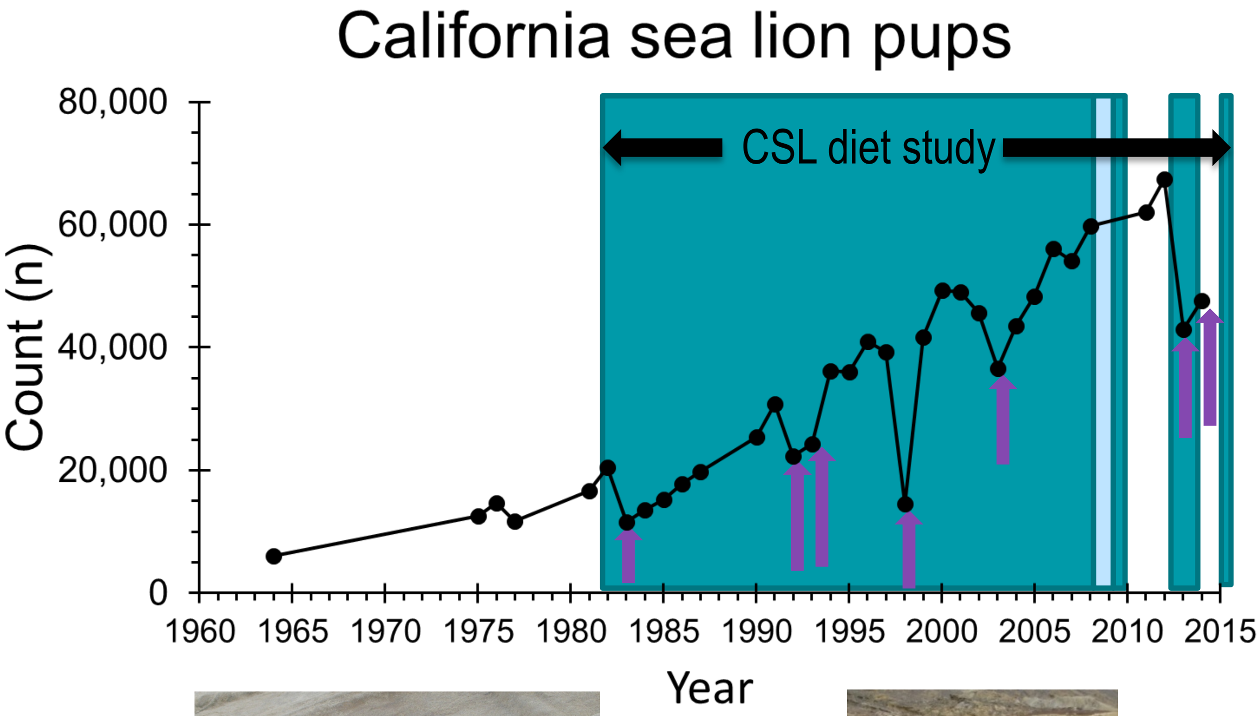
Terms of Reference Question

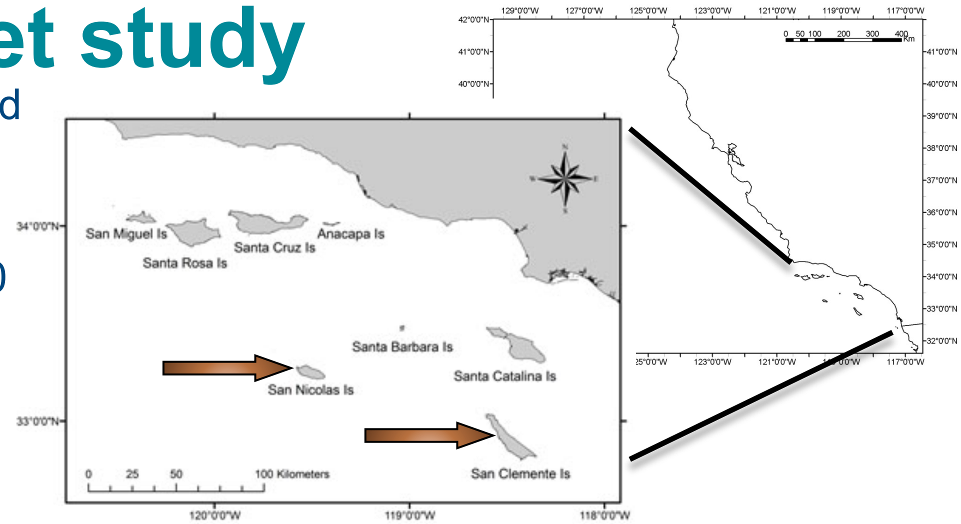
7. Ecosystem-related science program

What did sea lions in the U.S. eat while the population increased and during drops in pup production?



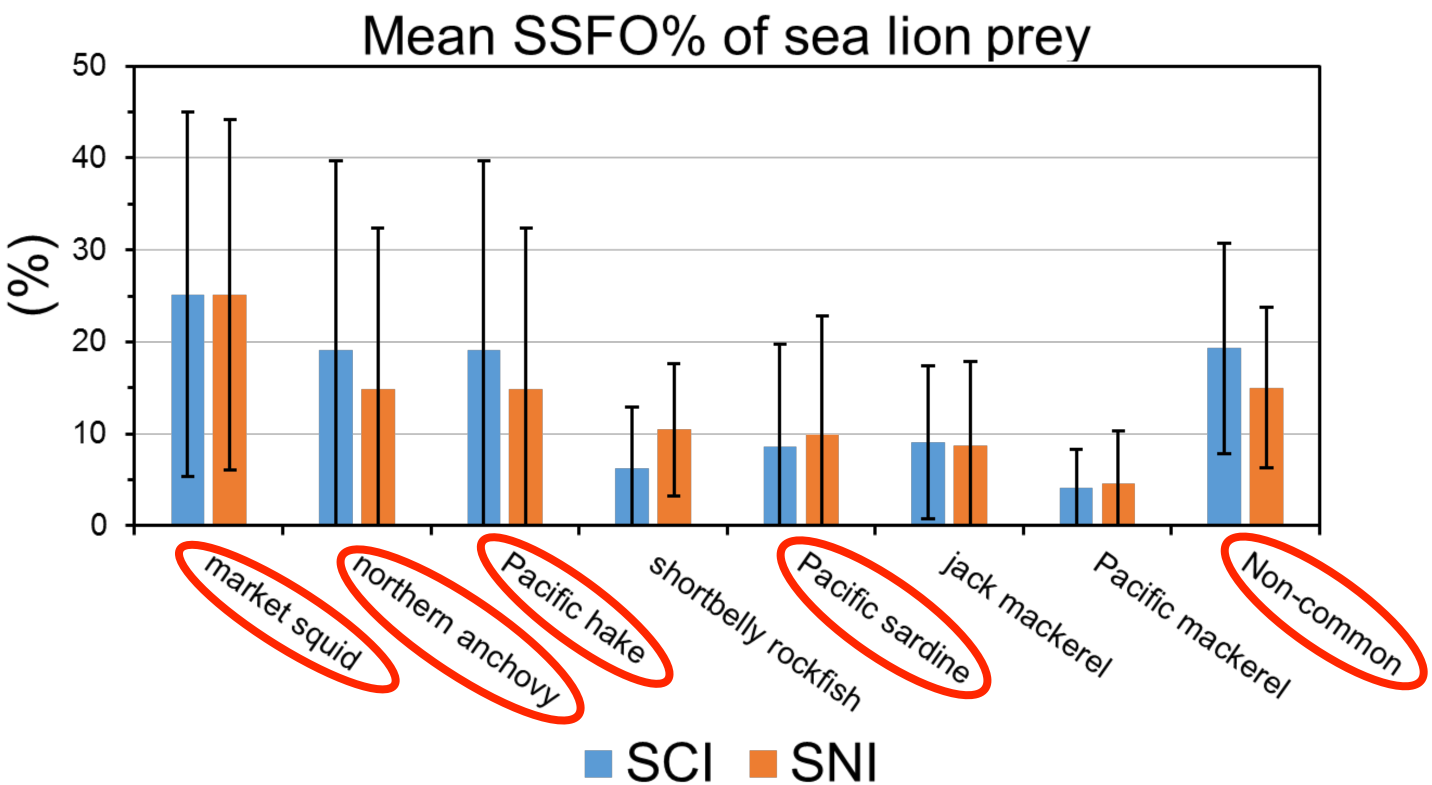
California sea lion diet study

- 1981-2015 diet study at San Clemente Island (SCI) and San Nicolas Island (SNI)
  - Seasonal scat collections
  - 16,449 scat samples processed, ~3,000 in storage.
  - 1981-2007 analyzed and 2008-2015 partially analyzed;
- Environmental variables
  - Multivariate El Niño Index (MEI)
  - Sea level height at Los Angeles harbor (SLH-LA)
- 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%.



California sea lion prey

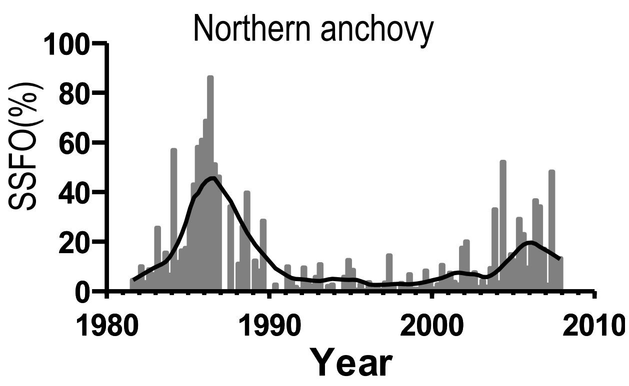
- 133 species identified
  - Fish = 103
  - Shark = 4
  - Cephalopods = 25
  - Crustacean = 1

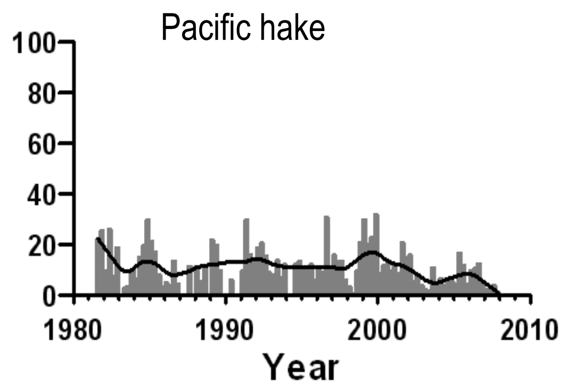


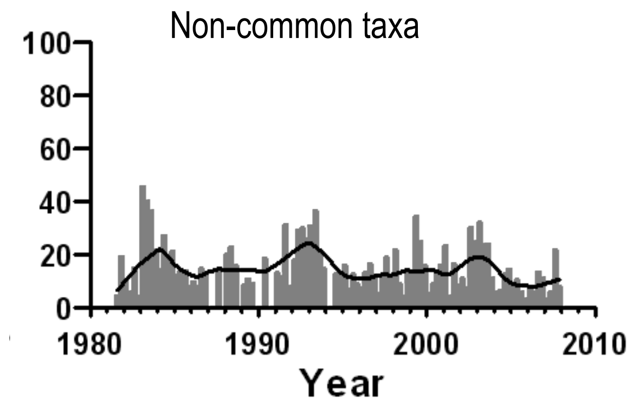
The diet story: 1981-2007

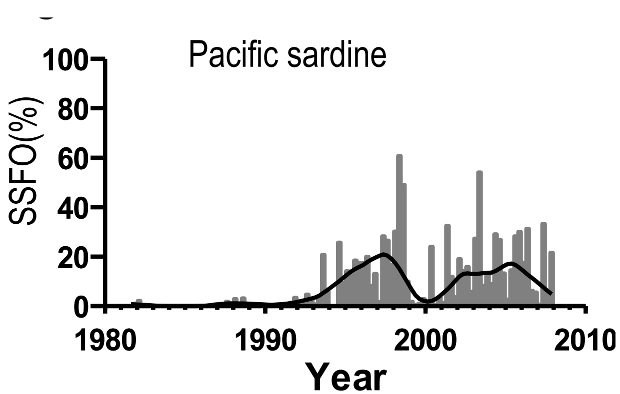
Part 1: Temporal variability in the diet

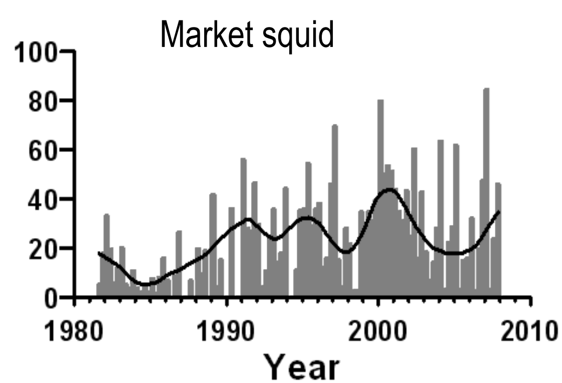
Occurrence of prey in diet, 1981-2007, San Nicolas Island









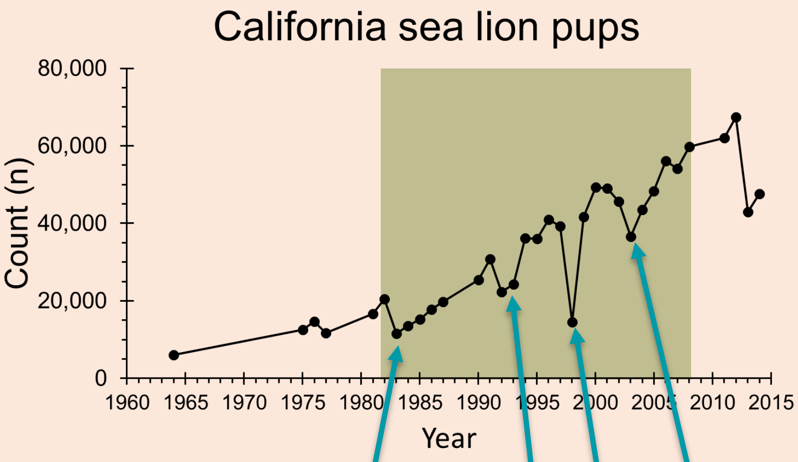


- Anchovy dominated in 1980s
- Market squid dominated in 1990s and 2000s; and increased over time.
- Appearance of sardine in early 1990s replaced anchovy.
- Hake declined over time.
- Non-common taxa increased during El Niño's and decreased in La Niña's

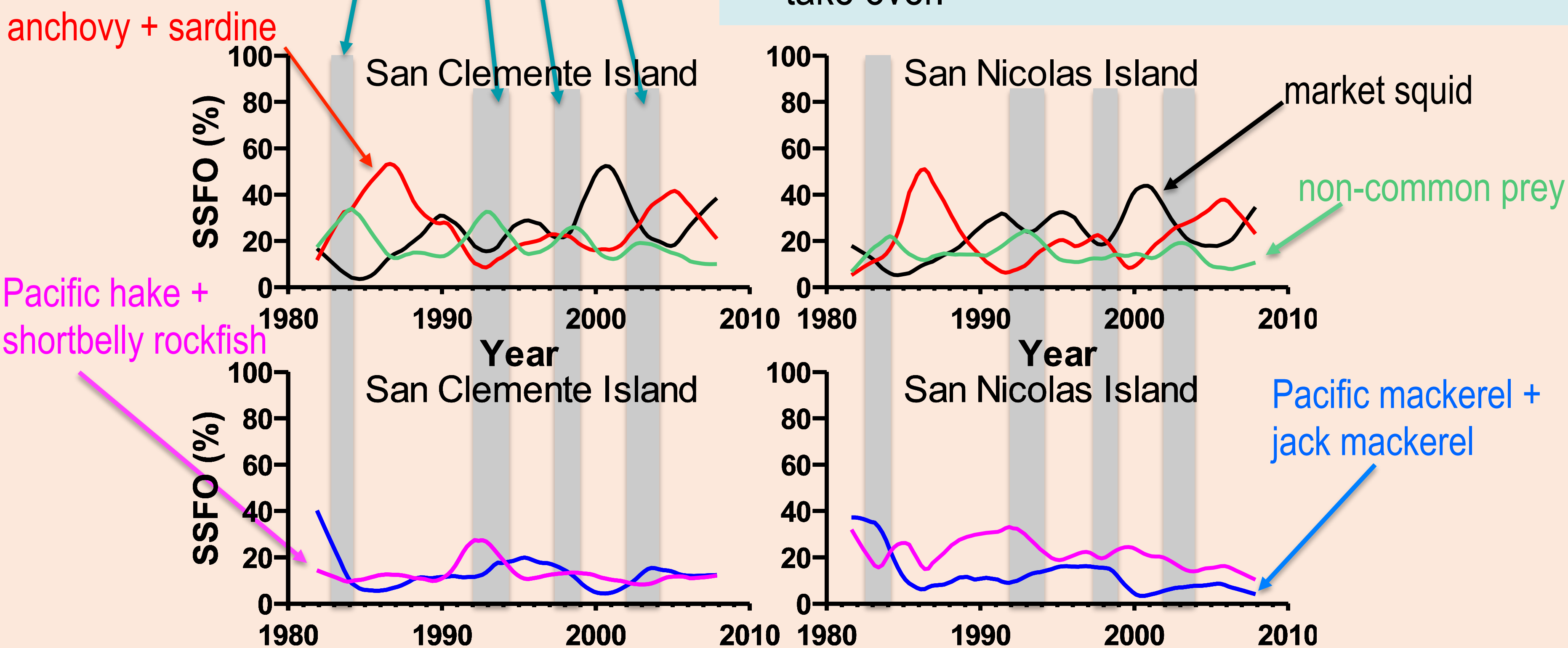
Other 1981-2007 highlights

- 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.
  - No island difference for each species.
- More non-common prey consumed in summer.
- More non-common prey consumed at San Clemente Island.
- Consumption of hake declined during El Niño's, increased in La Niña's.
  - Island difference: more hake consumed at San Nicolas Island

Prey switching



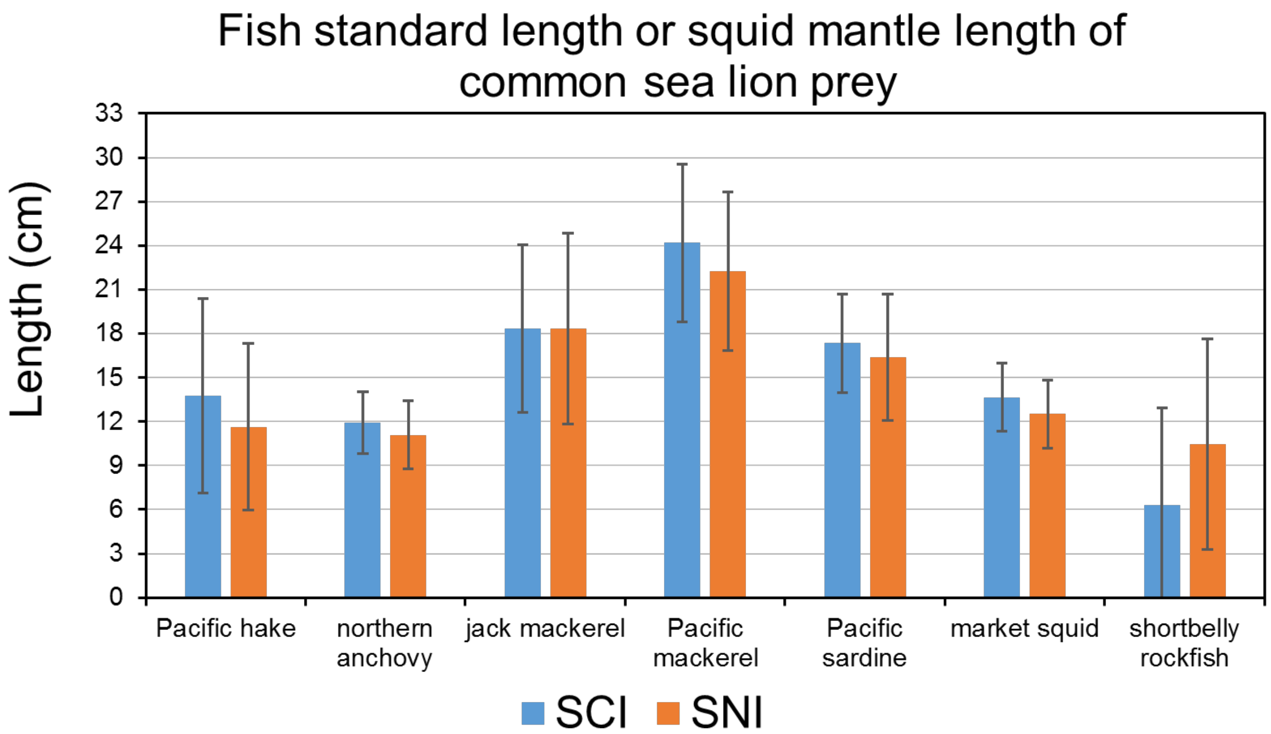
- Consumption of non-common taxa increased when pup production decreased –associated with El Niño conditions.
- When consumption of predominant prey decreased (e.g., anchovy and squid), other prey take over.



The diet story: 1981-2007

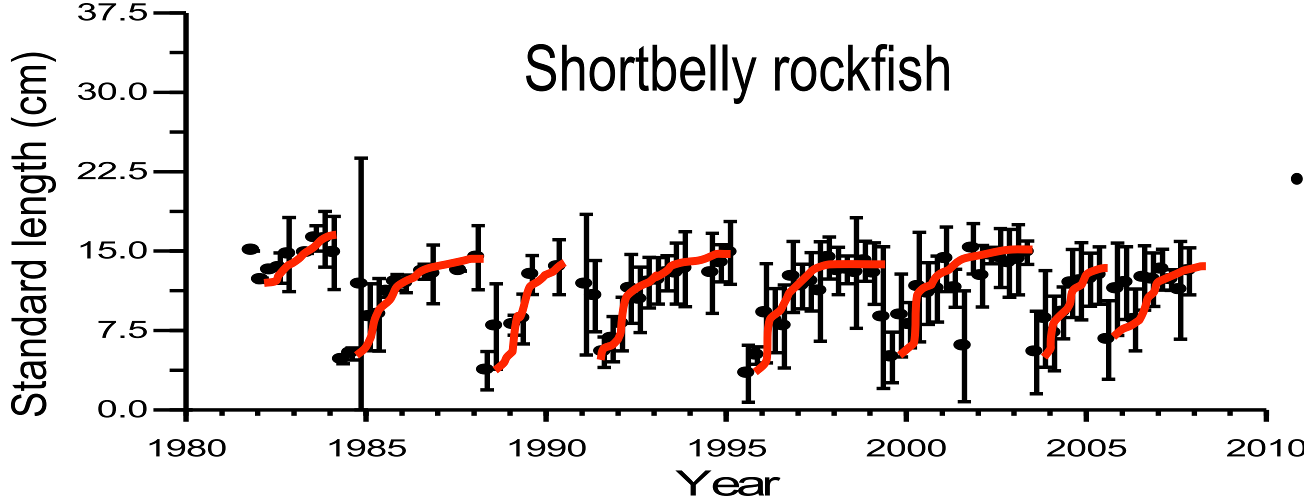
Part 2: Temporal variability in size of prey

Size of common prey

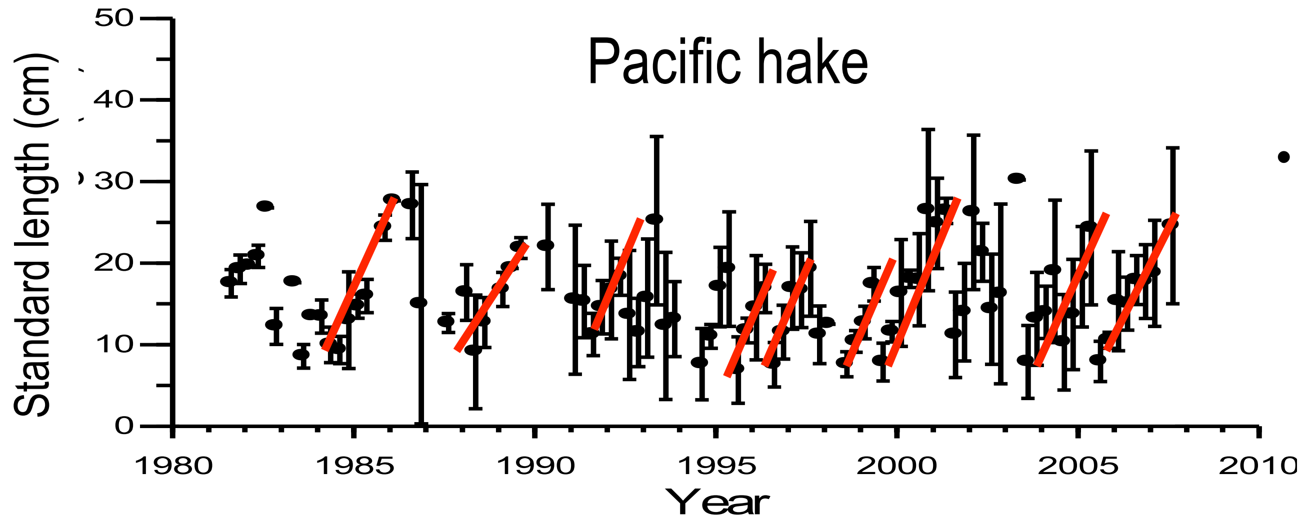


- Size of prey varies by species.
- Mackerels are their largest prey.
- Will also consume very small prey (e.g., shortbelly rockfish).

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



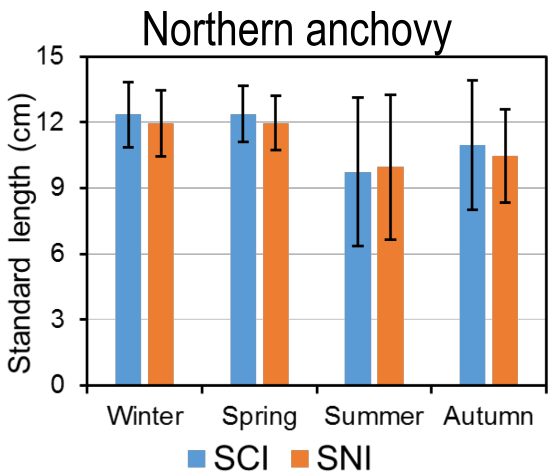
- Shortbelly rockfish cohorts: 3 to 6 years.

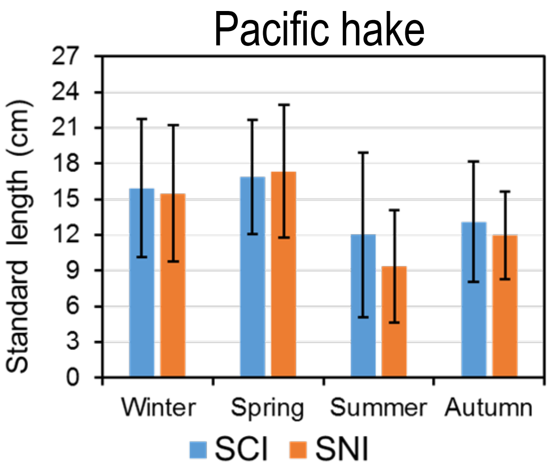


- Pacific hake cohorts: 2.5 to 3 years

Other 1981-2007 highlights

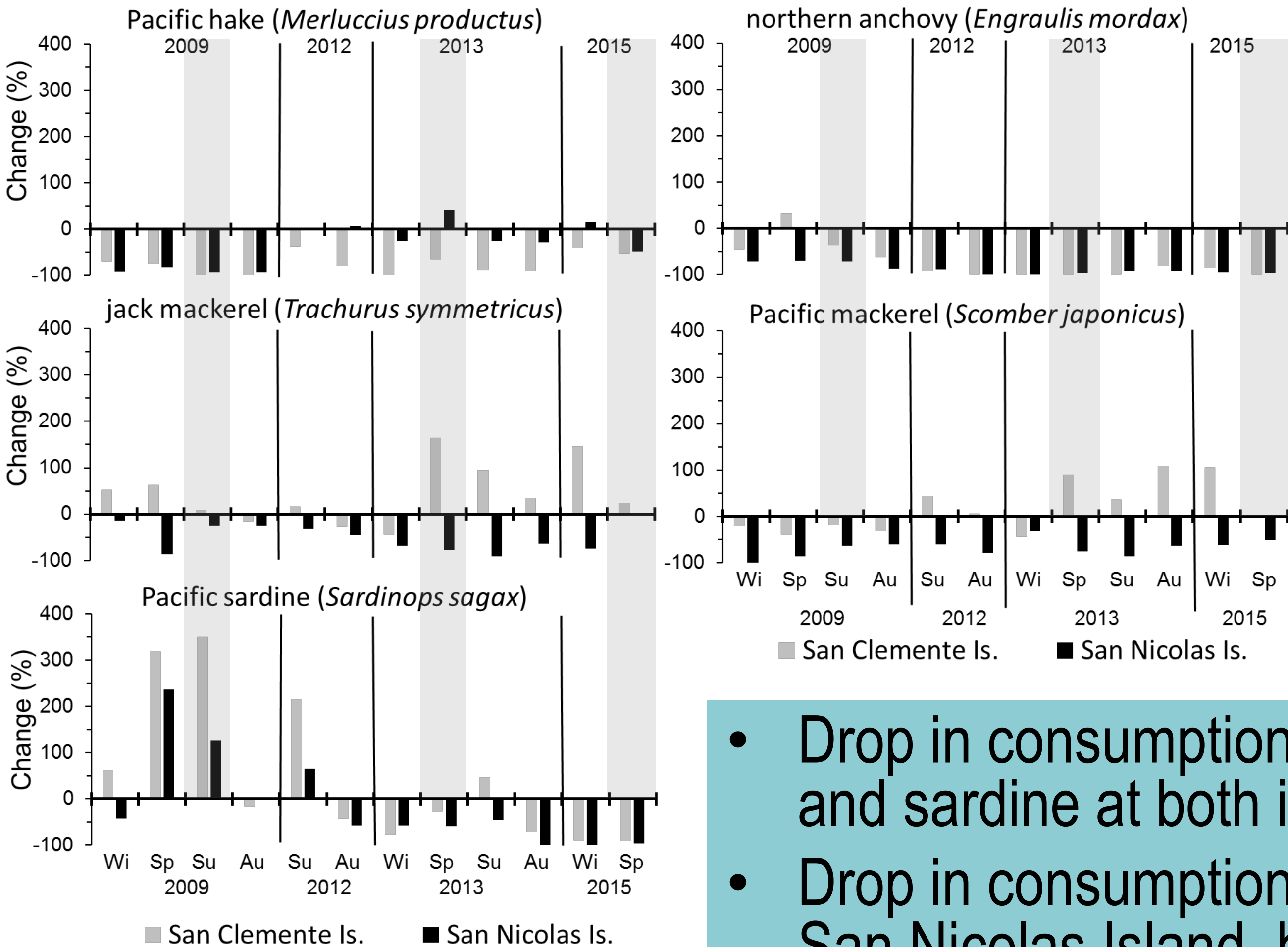
- Size of market squid and anchovy decreased through time.
- Consumed larger anchovy and hake in winter and spring, smaller in summer and autumn.





Recent unusual mortality events (UME): Anomalies from 1981-2007 seasonal mean

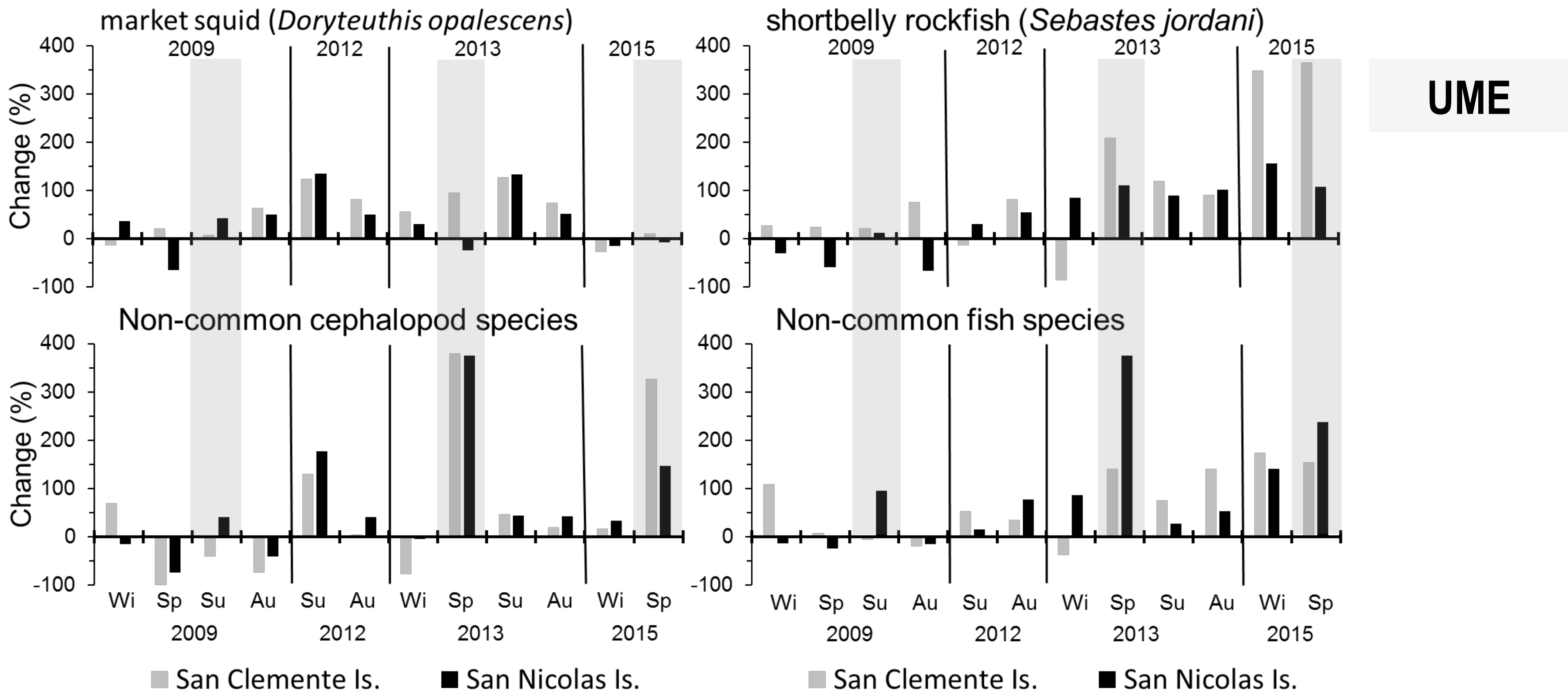
Change (%) in FO% from 1981-2007 seasonal mean



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.

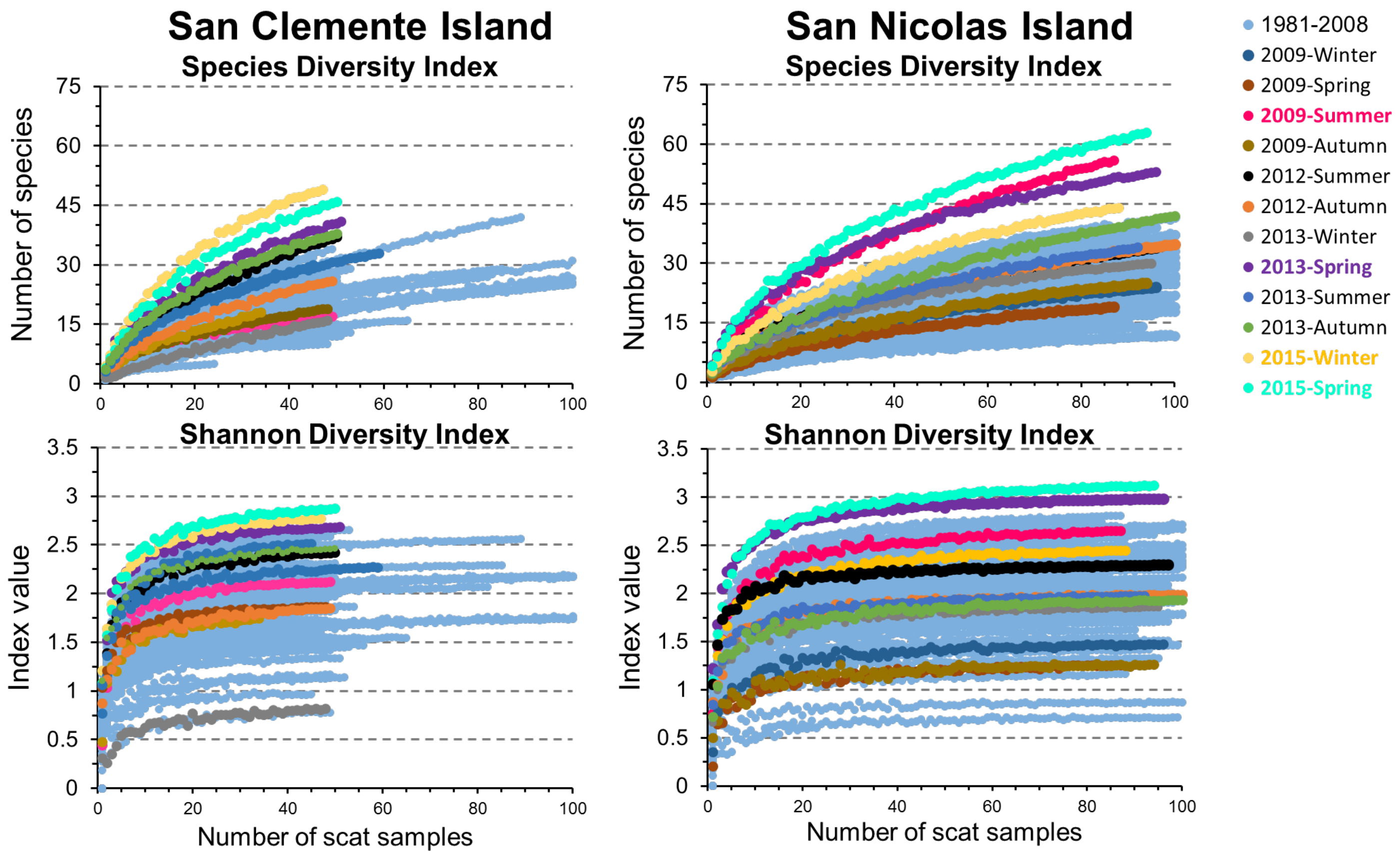
Change (%) in FO% from 1981-2007 seasonal mean



- 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 of market squid in 2012 and 2013, and average or below average consumption in 2015

Measuring diet diversity

Measures of diet diversity: 2009-2015 compared to all 1981-2008



- High diversity indices of sea lion diet were recorded in summer 2009, spring 2013, winter 2015 and spring 2015.

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.

Future Research Questions

- Explore sea lion diets as SCB ecosystem indicators
- Forecast impacts of future oceanographic changes (e.g., climate change predictions) on sea lion population dynamics via impacts of warm-water conditions on CSL feeding ecology

Strengths, Challenges, Solutions

Strengths

- Long term (35 year) data set
- High-quality dataset on foraging ecology of top marine predator
- Cost effective
- Good way to monitor ecosystem

Challenges

- Scientific:
  - Maintaining study
  - Biomass reconstruction
  - Modeling seasonal sea lion abundance
  - Consumption estimates
- Administrative:
  - Funding related challenges
  - Impending retirement of principal investigator

Solutions

- Scientific:
  - For biomass reconstruction need to derive numerical correction factors of sea lion prey from captive feeding study
- Administrative:
  - Hire more contractors
  - Convert contractors to FTEs
  - Mentor replacement for retiring principal investigator

Acknowledgements

- Doug DeMaster assigned me the project in 1981 and told me to keep it going for as long as possible.
- Jay Barlow became my supervisor in the late 1980s and allowed me to continue the project.
- U.S. Navy provided logistical support
- Many people helped collect and process scat samples.