# Rockfish (*Sebastes*) recruitment and ecosystem indicators for the California Current, 1983-2013

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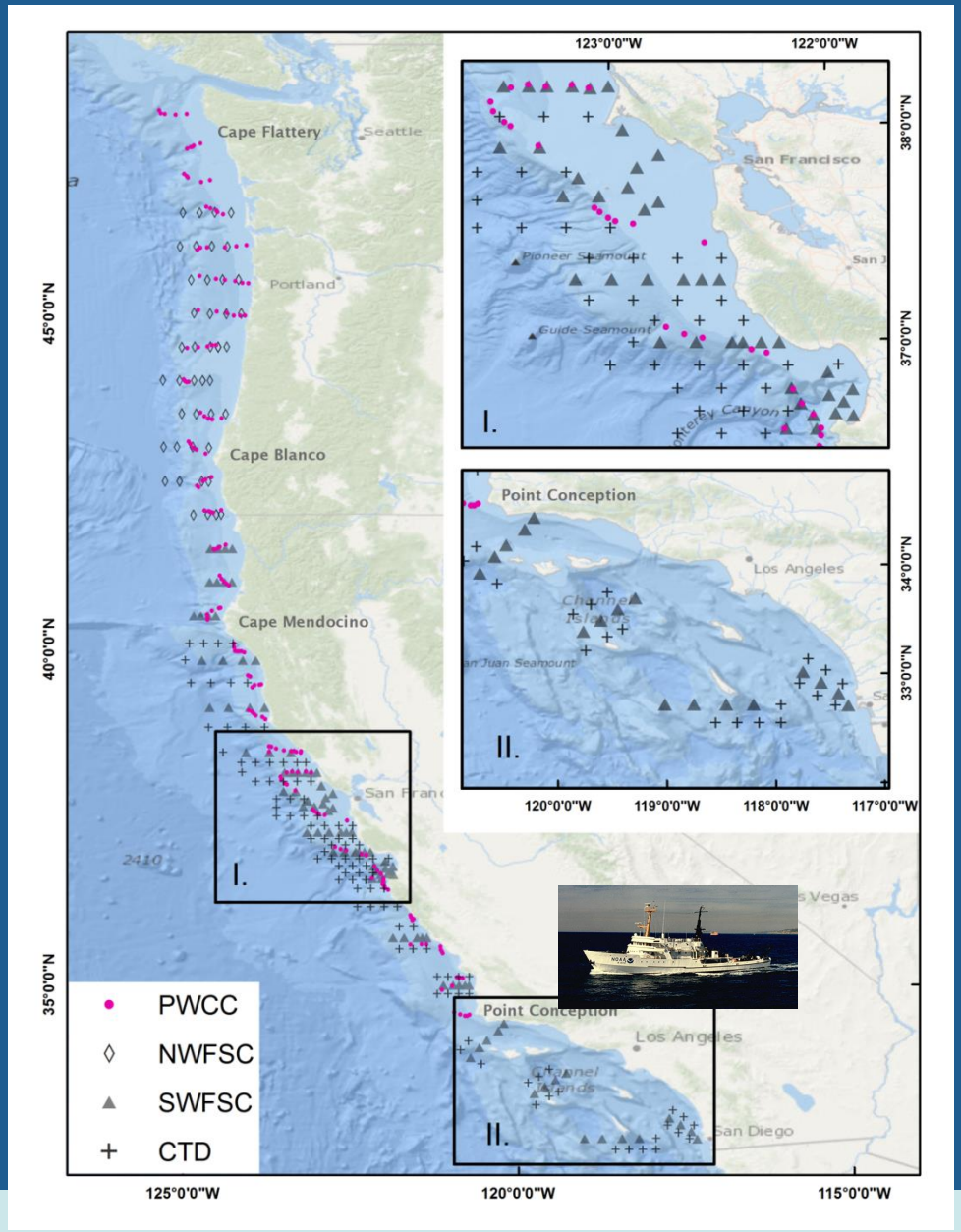
# Survey Objectives

- Develop estimates of abundance for pelagic Young-of-the-year rockfish (*Sebastes* spp.) and other groundfish for use as pre-recruit indices in stock assessments (Assessment survey)
- Improve our understand of the physical and biological ecosystem factors that lead to strong or weak year classes (Process studies)
- To improve our understanding of the spatial and temporal variability in the micronekton (forage) assemblage, including the role of YOY rockfish and other groundfish within that assemblage, particularly as related to climate variability and oceanographic conditions (Ecosystem studies)

# Area Surveyed

- The SWFSC juvenile survey has sampled a “core” area of Central California since 1983 (21 to 30 DAS), expanded range in 2004 from the U.S./Mexico border to Cape Mendocino (~45 DAS).
- A PWCC/NWFSC survey was initiated in 2001, surveyed the Pacific Northwest through Monterey Bay (single sweep south) through 2011 (~ 21 days).
- The SWC and NWC conducted a joint survey in 2013, with the goal of covering the entire coast (60 DAS), will do so again in 2014

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From 1983 through 2008 all cruises were on the R/V David Starr Jordan, since then a new ship every year (vessel effects!)

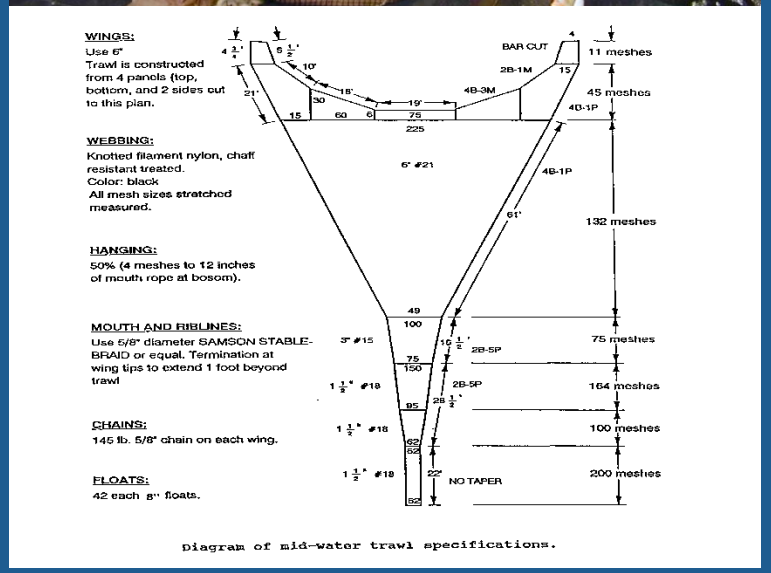


Diagram of mid-water trawl specifications.

Midwater trawling conducted at night, typically 30 m HR depth, using a modified Cobb trawl with 3/8” codend liner

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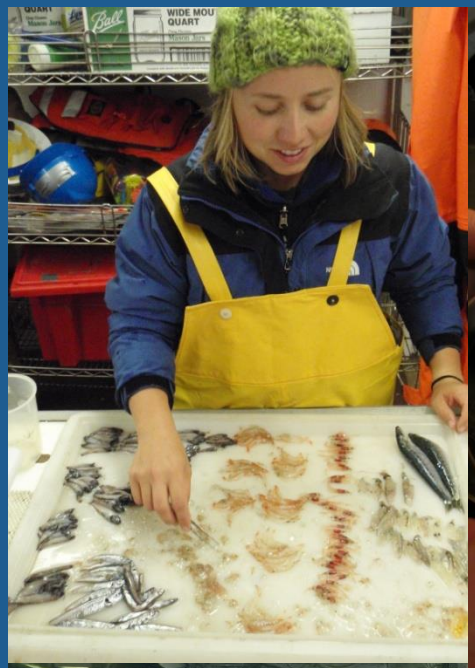
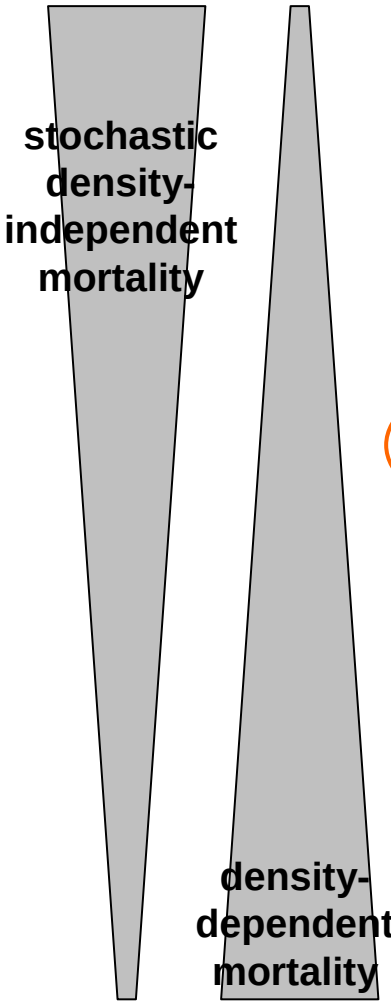
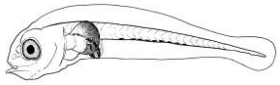


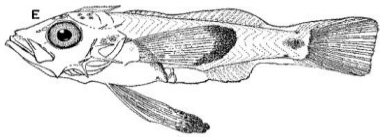


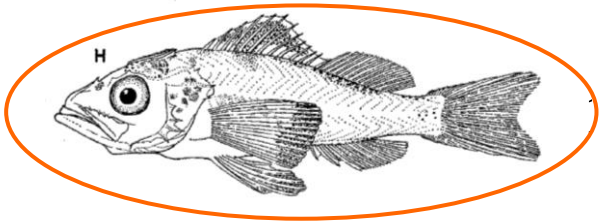
Rockfish and other species are sorted, measured and enumerated at sea

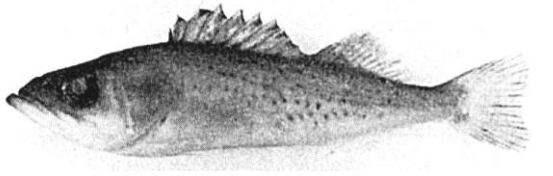
# Primary target is pelagic juvenile (age 0) rockfish, to use as recruitment indices in stock assessments

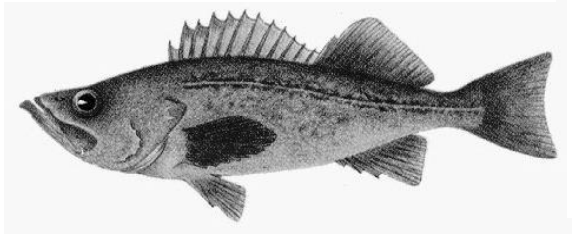








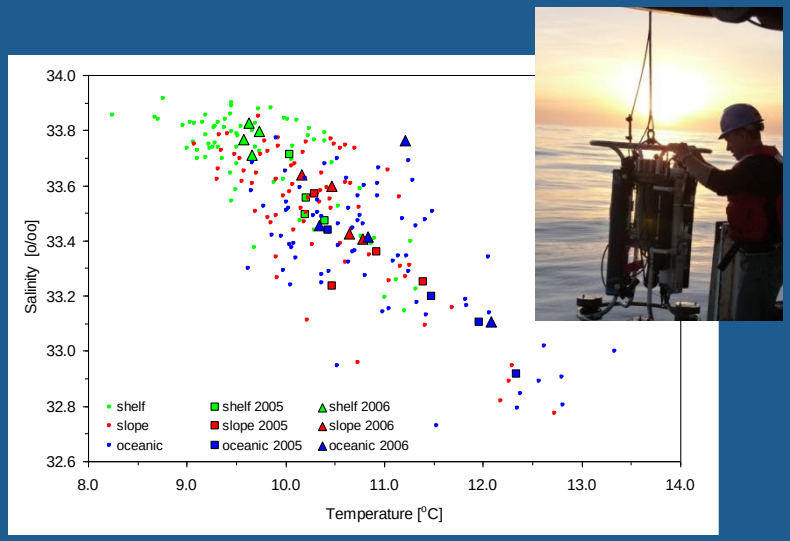


Larval abundance used as index of spawning biomass (cowcod, bocaccio, others)

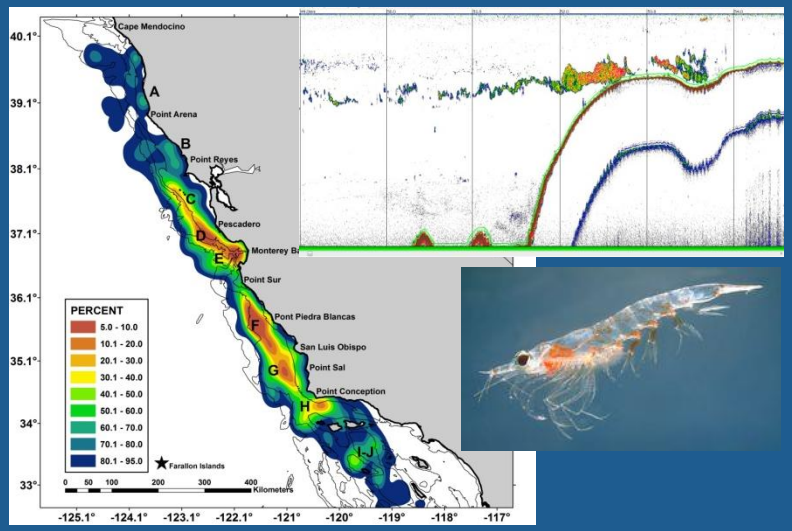
Pelagic YOY used as an Age 0 (recruitment) index (standardize to 100 days)

Fisheries and survey data used to inform abundance trends, population structure

# In addition to quantifying juvenile rockfish and other micronekton, research plan includes a suite of physical and biological observations



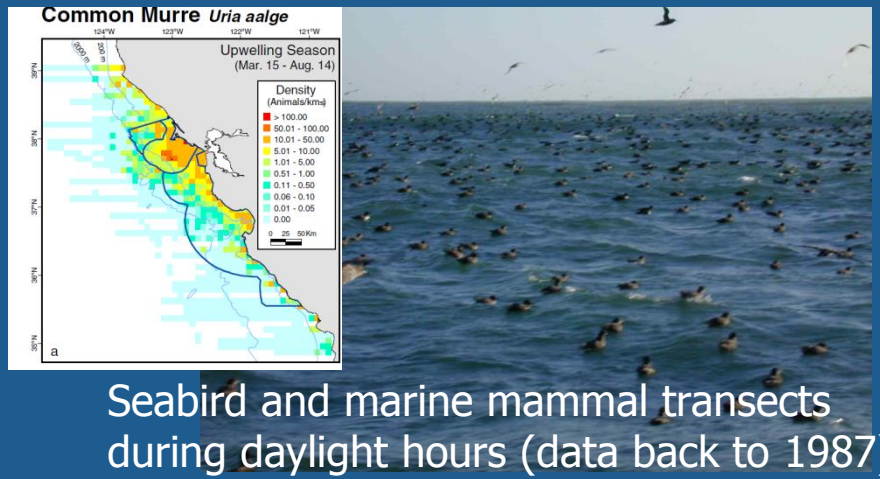

Physical Oceanography (CTD and Fluorometry), upwards of 300 casts per year, data online




Acoustic estimates of abundance and distribution of krill and other micronekton



Sampling on adult rockfish and jumbo squid for life history and food habit studies




Seabird and marine mammal transects during daylight hours (data back to 1987)

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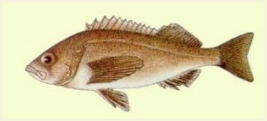
# The cast of characters





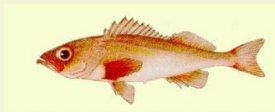


**widow rockfish**
*Sebastes entomelas*
60 yr, 59 cm max
schooling
commercial

**yellowtail rockfish**
*Sebastes flavidus*
64 yr, 66 cm max
schooling
commercial

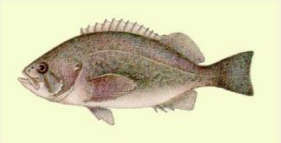
**chilipepper**
*Sebastes goodei*
35 yr, 59 cm max
schooling
commecial

**squarespot rockfish**
*Sebastes hopkinsi*
29 yr, 29 cm max
aggregate around outcrops
commercial bycatch



**shortbelly rockfish**
*Sebastes jordani*
32 yr, 35 cm max
schooling
unexploited

**brown rockfish**
*Sebastes auriculatus*
35 yr, 56 cm max
nearshore, soft bottom
sport & commercial



**blue rockfish**
*Sebastes mystinus*
44 yr, 53 cm max
Schooling, nearshore
sport

**bocaccio**
*Sebastes paucispinis*
45 yr, 91 cm max
schooling (various),
commercial, depleted

**canary rockfish**
*Sebastes pinniger*
84 yr, 76 cm max
aggregate around outcrops
commercial, depleted

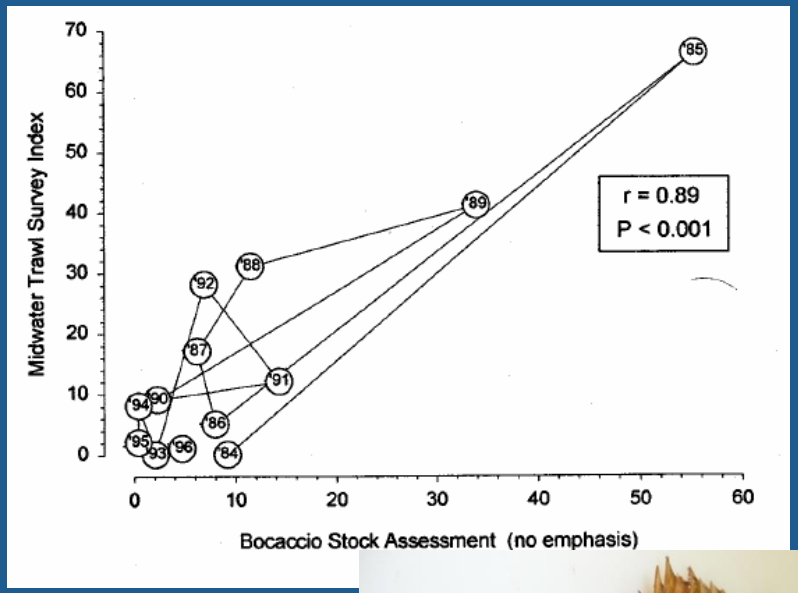
**stripetail rockfish**
*Sebastes saxicola*
38 yr, 41 cm max
solitary around mud
commercial bycatch



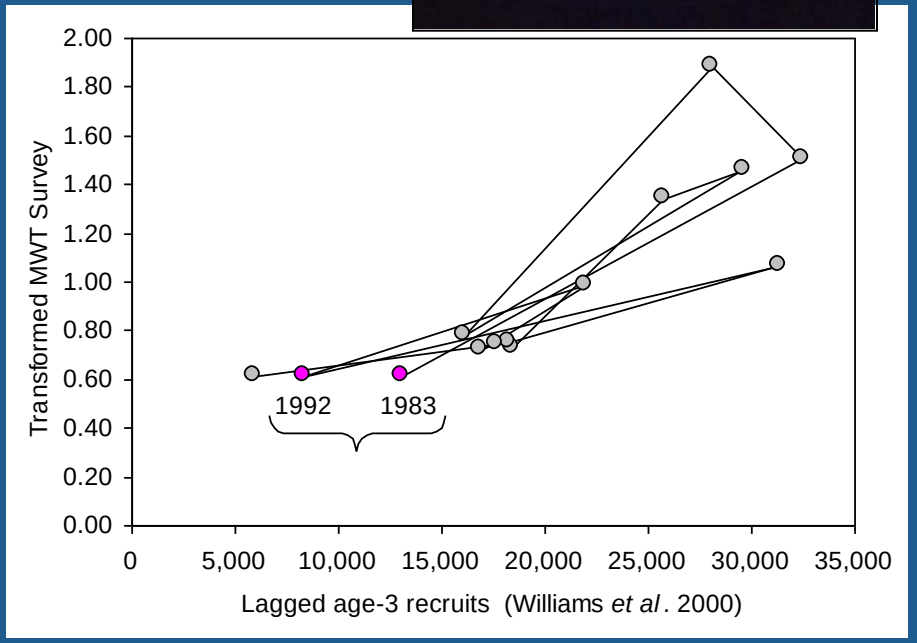


Illustrations from Eschmeyer *et al.* 1983, other information from Love *et al.* 2002

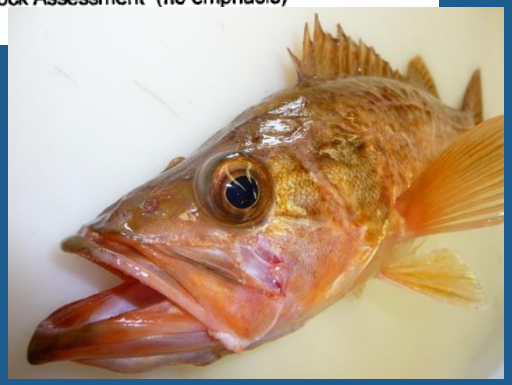
Ten winter-spawning species make up >95% of total juvenile rockfish catch, these ten have sufficient data for relative abundance indices (most others do not). These species represent about 75-80% historical CA landings rockfish.




Widow rockfish



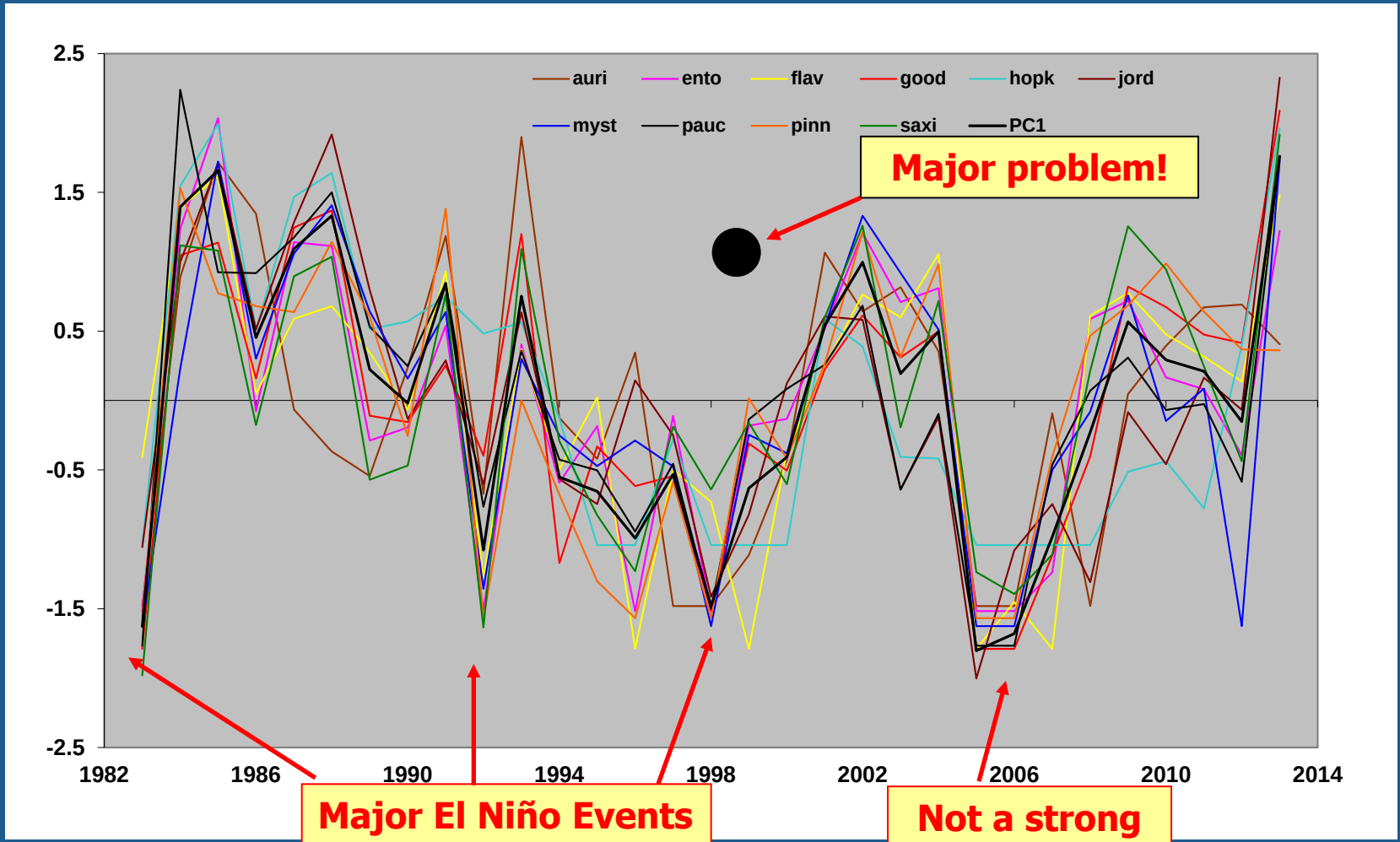

Bocaccio rockfish

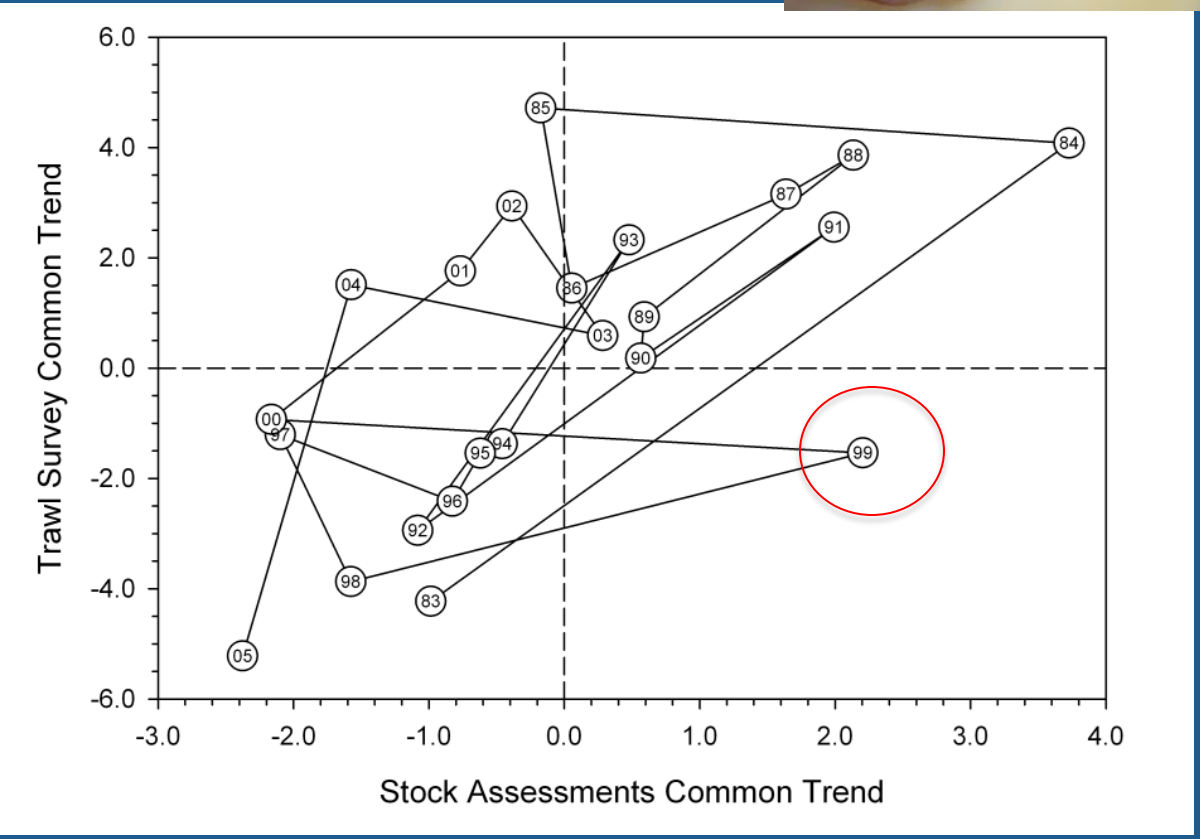


Survey has provided indices for stock assessments of eight species over time (bocaccio, widow, canary, chilipepper, black, blue, shortbelly and Pacific hake.

Prior to 1999, fits looked great…

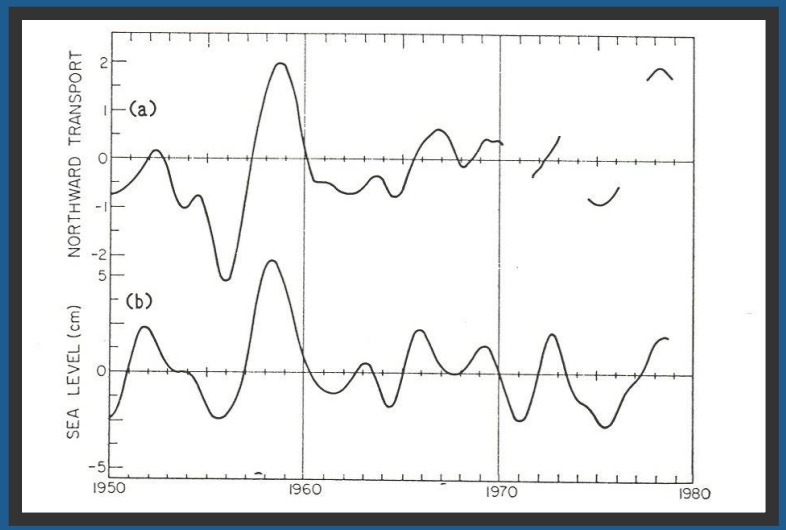
# Standardized anomalies from Delta-GLM year effects for the ten most abundant species in the core area (updated from Ralston et al. 2013)



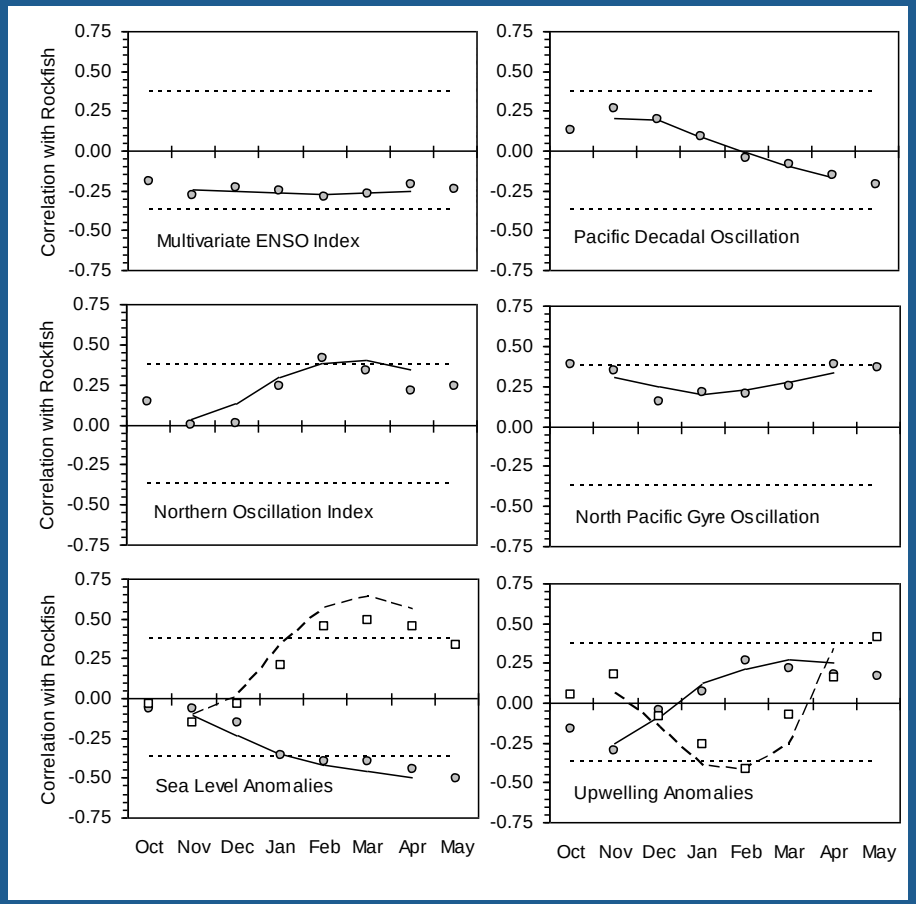



The first PC of juvenile indices from the core area compares well ($R^2$=0.39), with the first PC of a time series of recruitments for five of the assessed species for which good estimates are available.(bocaccio, chilipepper, widow, canary and shortbelly) (Ralston et al. 2013), albeit not quite well enough and 1999 is the outlier…

# Changes in sea level track geostrophic flow and productivity in the California Current, and had the strongest correlation of environmental variables to juvenile rockfish abundance

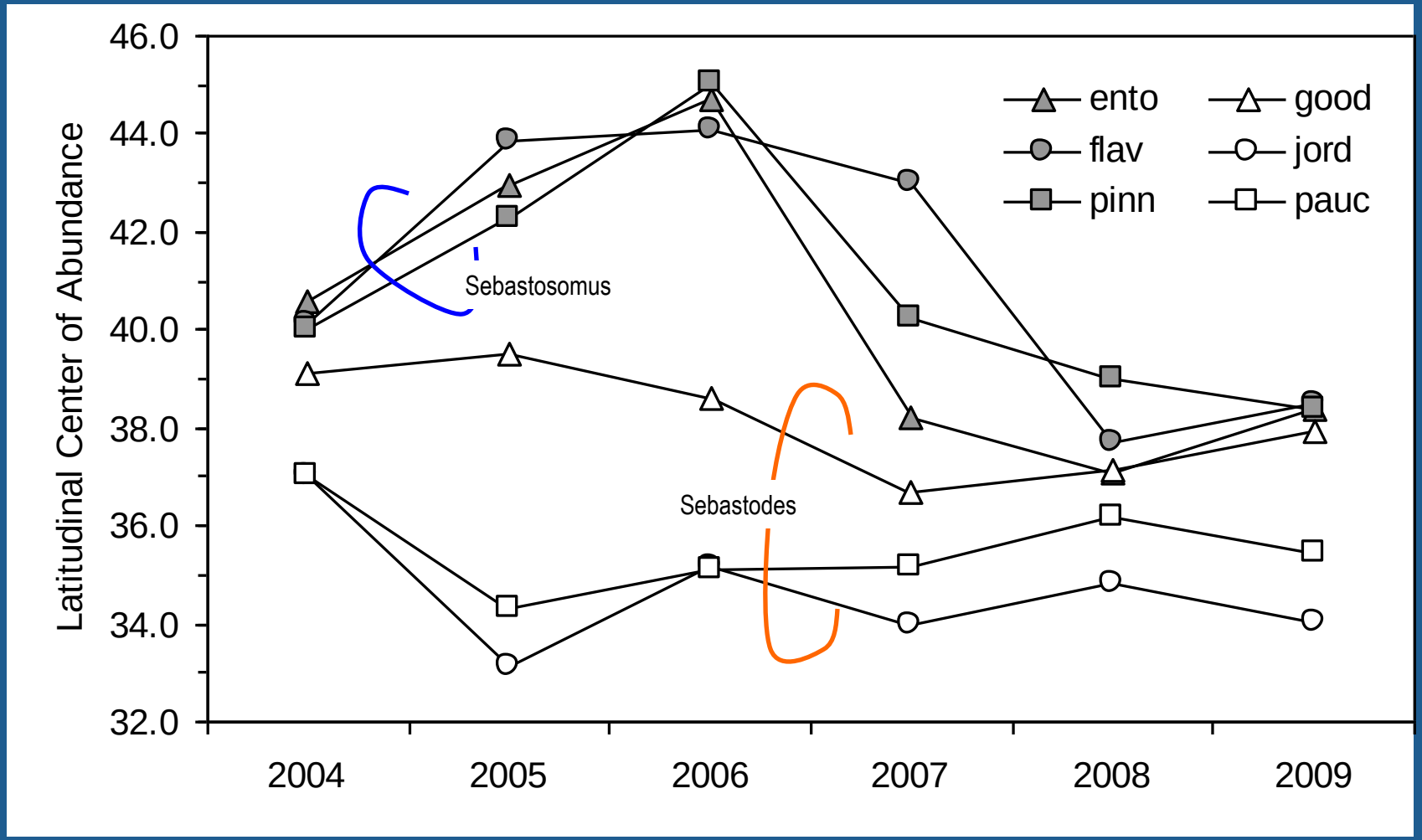



Chelton et al. 1982

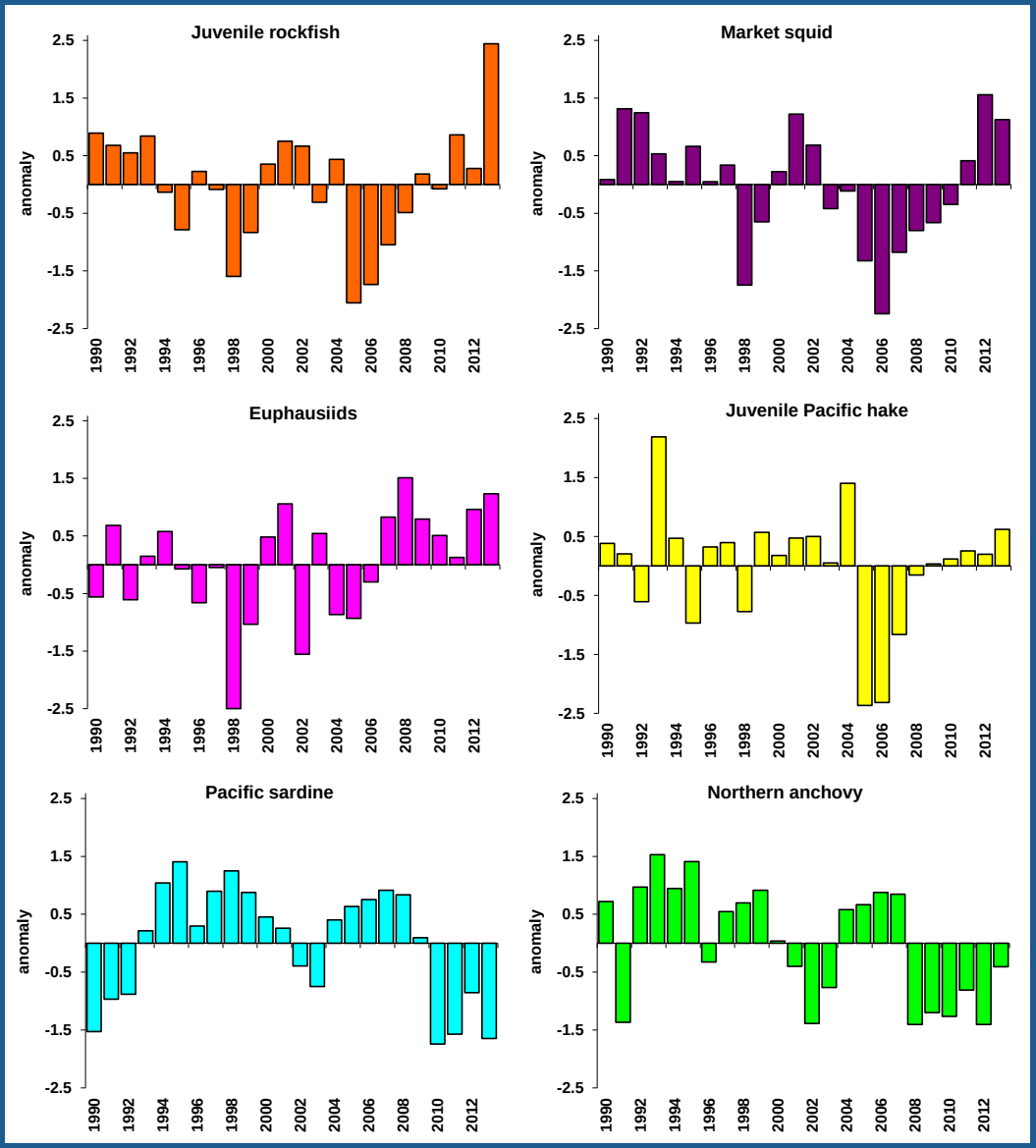



Ralston et al. 2013

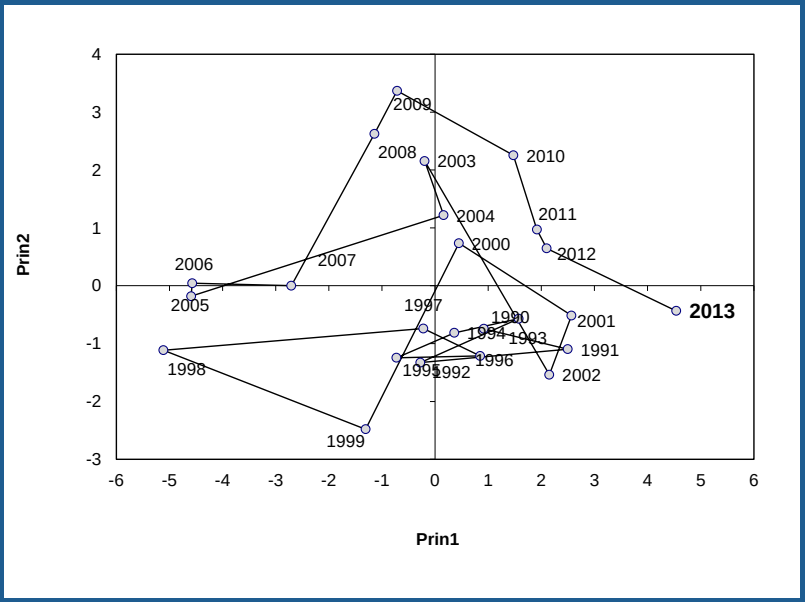
# Bifurcated Spatial Distributions in 2005-2006




Ralston and Stewart 2013




Juvenile groundfish covary in abundance with much of the other micronekton that provide the forage base for the California Current ecosystem- we have used PCA-based indices as indicators of ecosystem state

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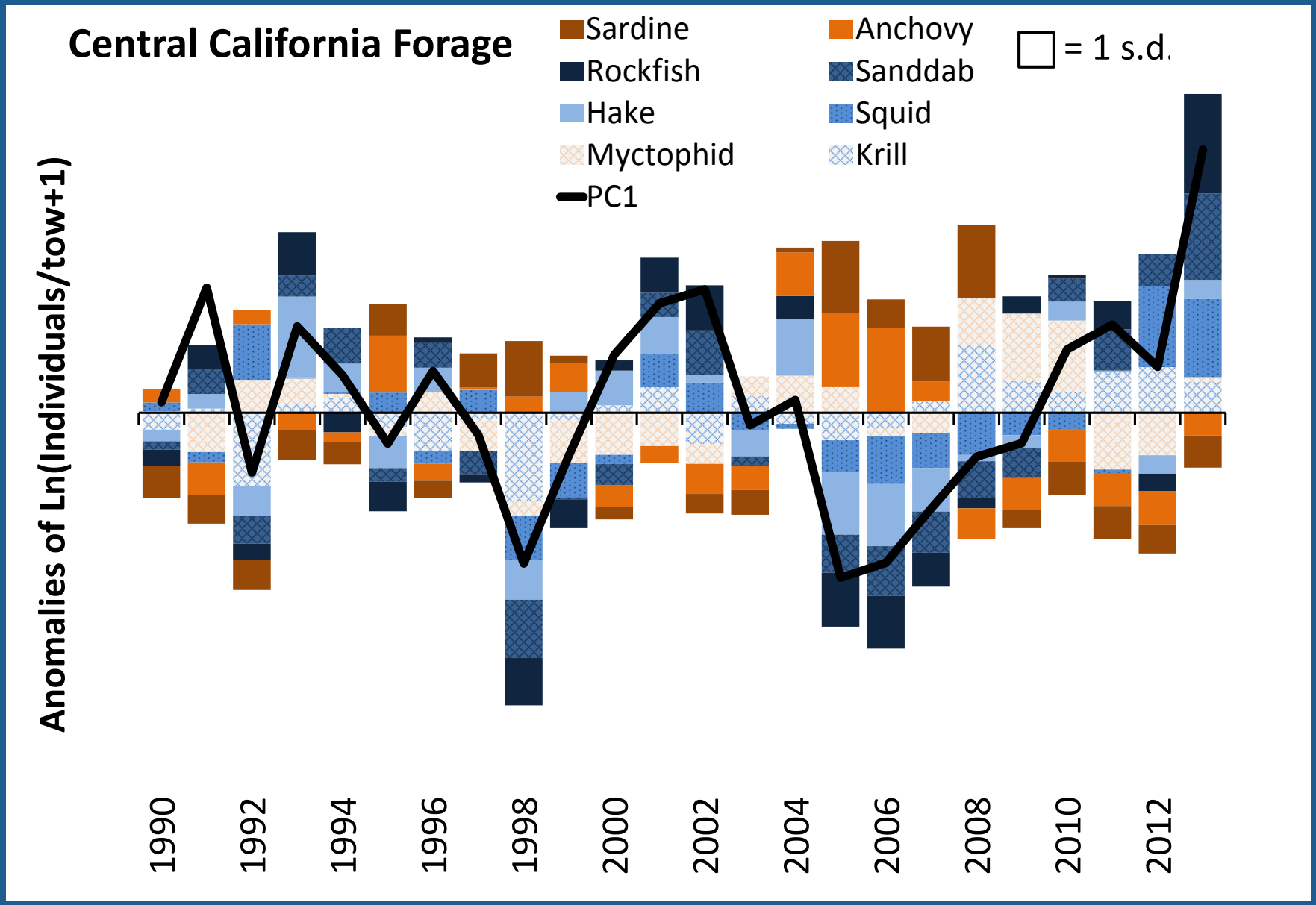
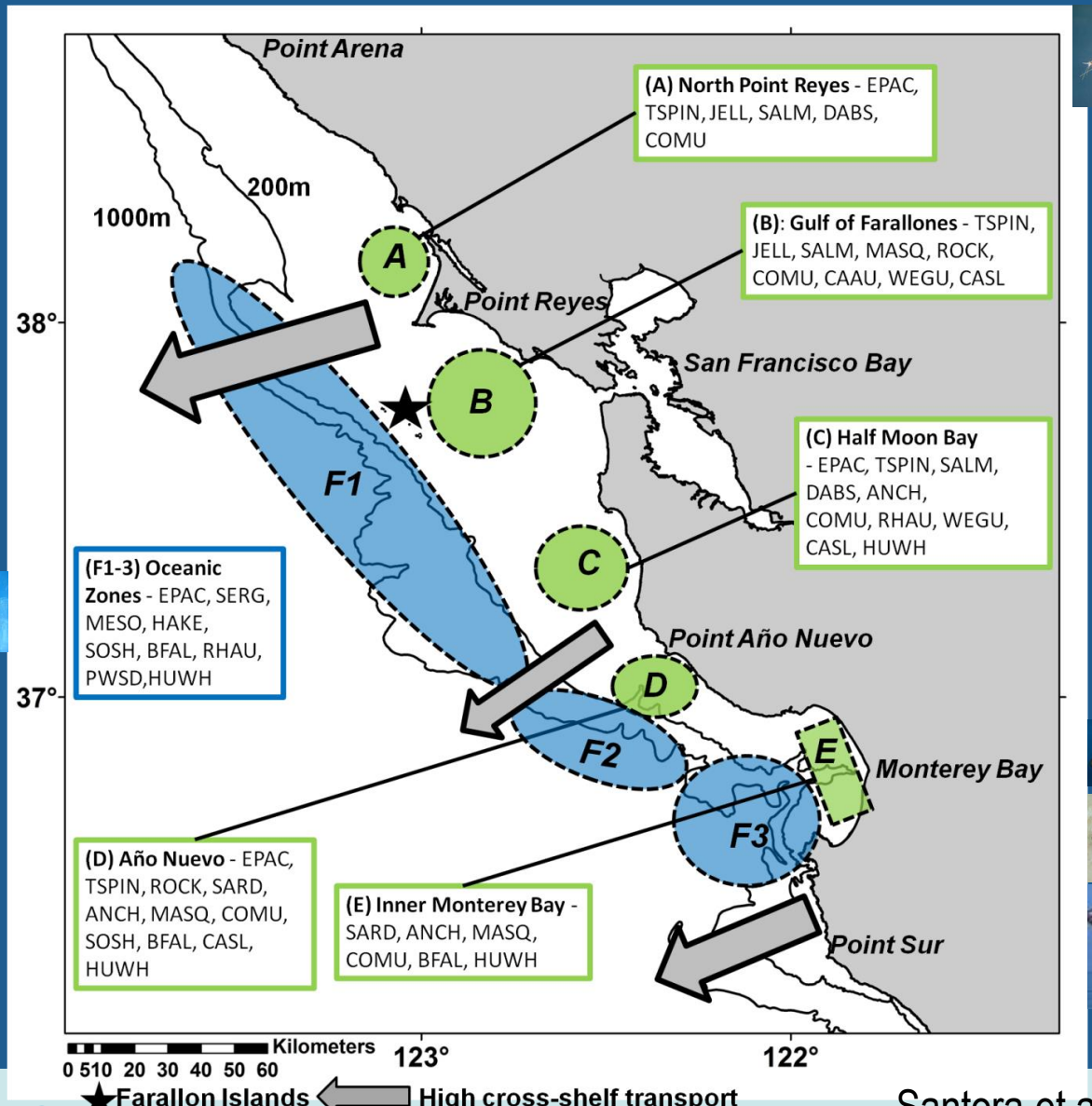

Central California Forage
Sardine
Anchovy
= 1 s.d.
Rockfish
Sanddab
Hake
Squid
Myctophid
Krill
PC1
Anomalies of Ln(Individuals/tow+1)
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012

# Spatial analysis to evaluate community structure and "ecologically important areas"

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Santora et al. 2012

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# Population dynamics of Chinook salmon *Oncorhynchus tshawytscha* relative to prey availability in the central California coastal regi

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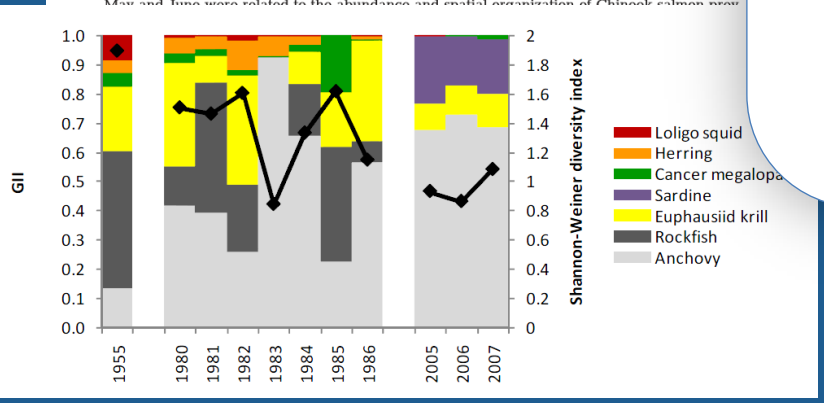
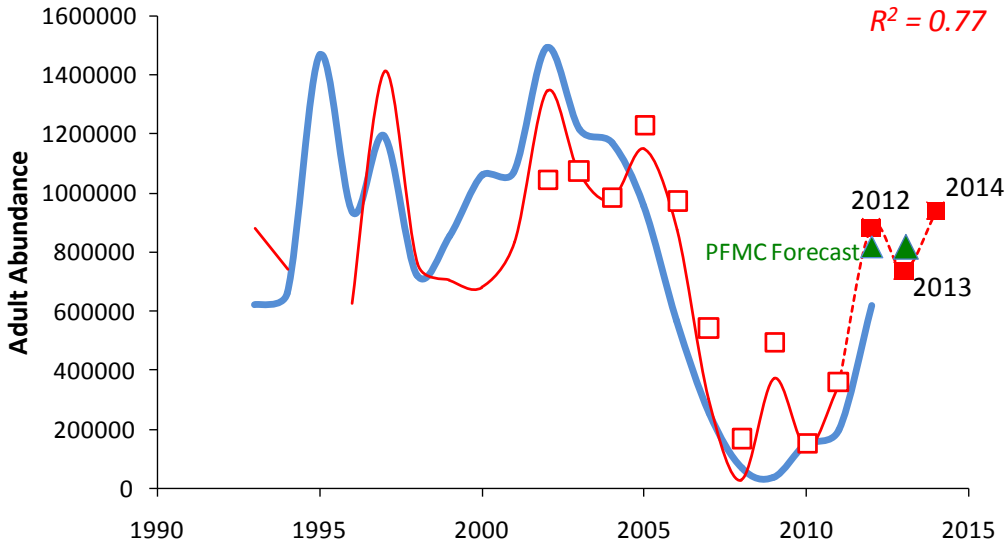
ABSTRACT: Mortality during the first period at sea is thought to be a primary determinant of salmon productivity and return rates. Here, we test this hypothesis by linking variation in prey resources during the initial phase at sea with measurements of central California Chinook salmon *Oncorhynchus tshawytscha* diet, condition, and later adult abundance. Specifically, we investigate linkages between the distribution and abundance of krill and other prey with juvenile Chinook salmon diet and body condition. Hydrographic features of the Gulf of the Farallones during

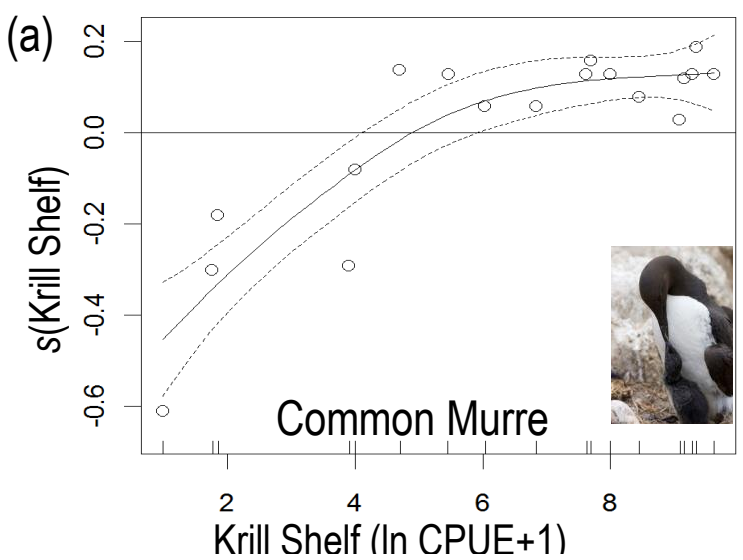


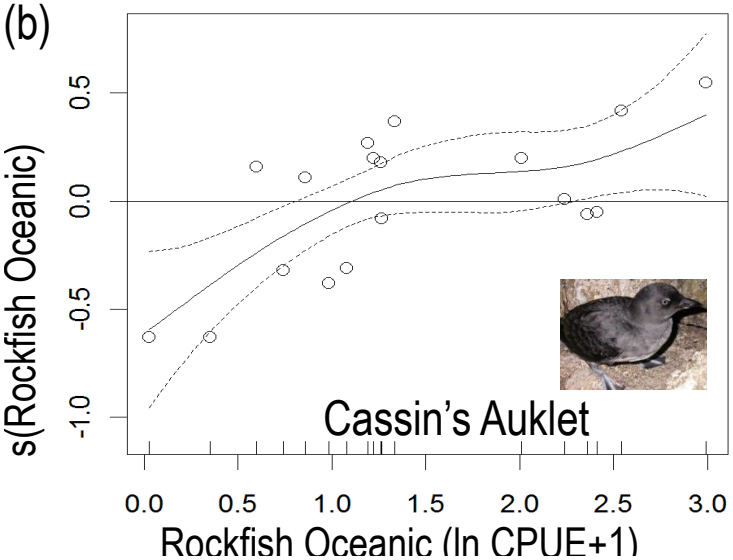



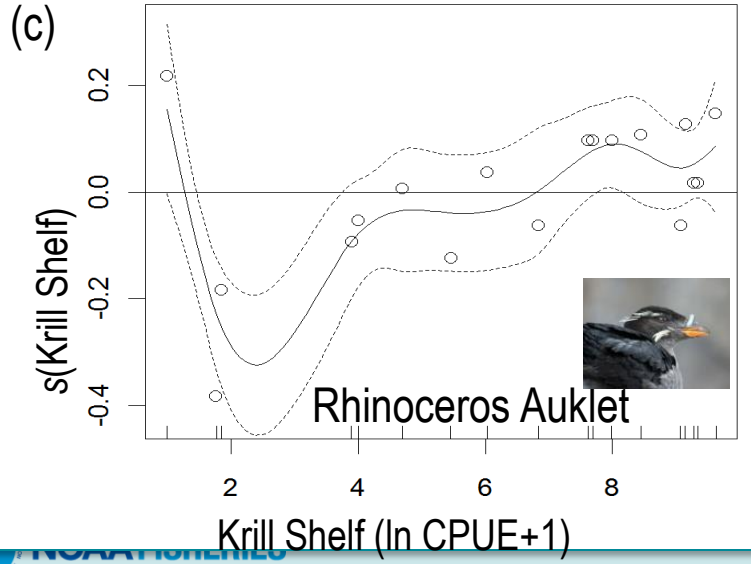

Adult Salmon Abundance (y+3)= Adult Krill (y) + SLH fall (y);
Y = year previous adult cohort comes back to spawn

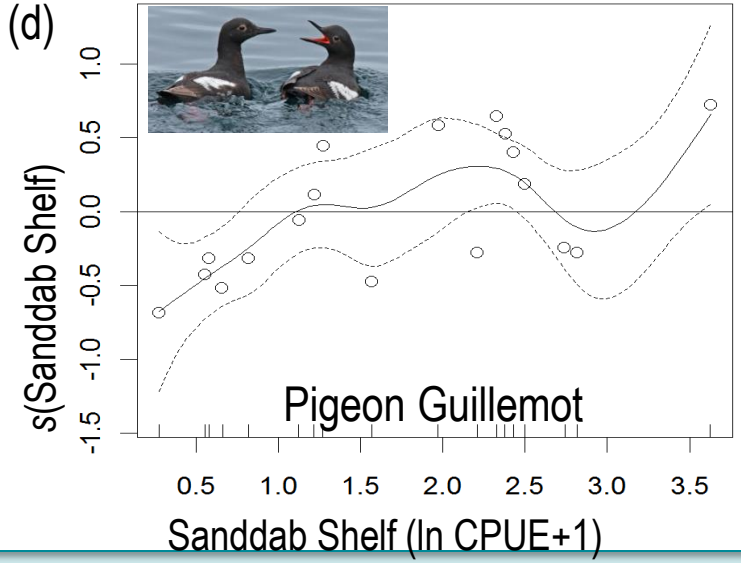
Micronekton community (particularly krill) appears to relate well to salmon survival and productivity, several large research efforts (NASA, OPC funded projects) have investigated this, some potential to inform salmon assessments

# Currently evaluating numerical response models among seabird reproductive success relative to habitat-derived prey abundance (Santora et al. in review)



# Summary

- For some stocks, we see good relationship between indices and realized recruitment (bocaccio, widow), but precision necessary to be strongly informative is historically lacking
- Anomalous oceanographic conditions likely responsible for some of the big "misses" (1999- 2005-2006), evaluating spatial and temporal covariance of coastwide trends is key next step
- Understanding of physical ocean processes driving recruitment success is improving, 2013 represents an opportunity to better understand processes driving high recruitment coastwide
- Indices of micronekton community structure suggest that much of the variation is in response to large-scale advection patterns throughout the California Current, relate well to ecosystem productivity