Ichthyoplankton Response to Environmental Change in the NE Pacific Ocean

Microstomus pacificus

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Tetragonurus cuvieri

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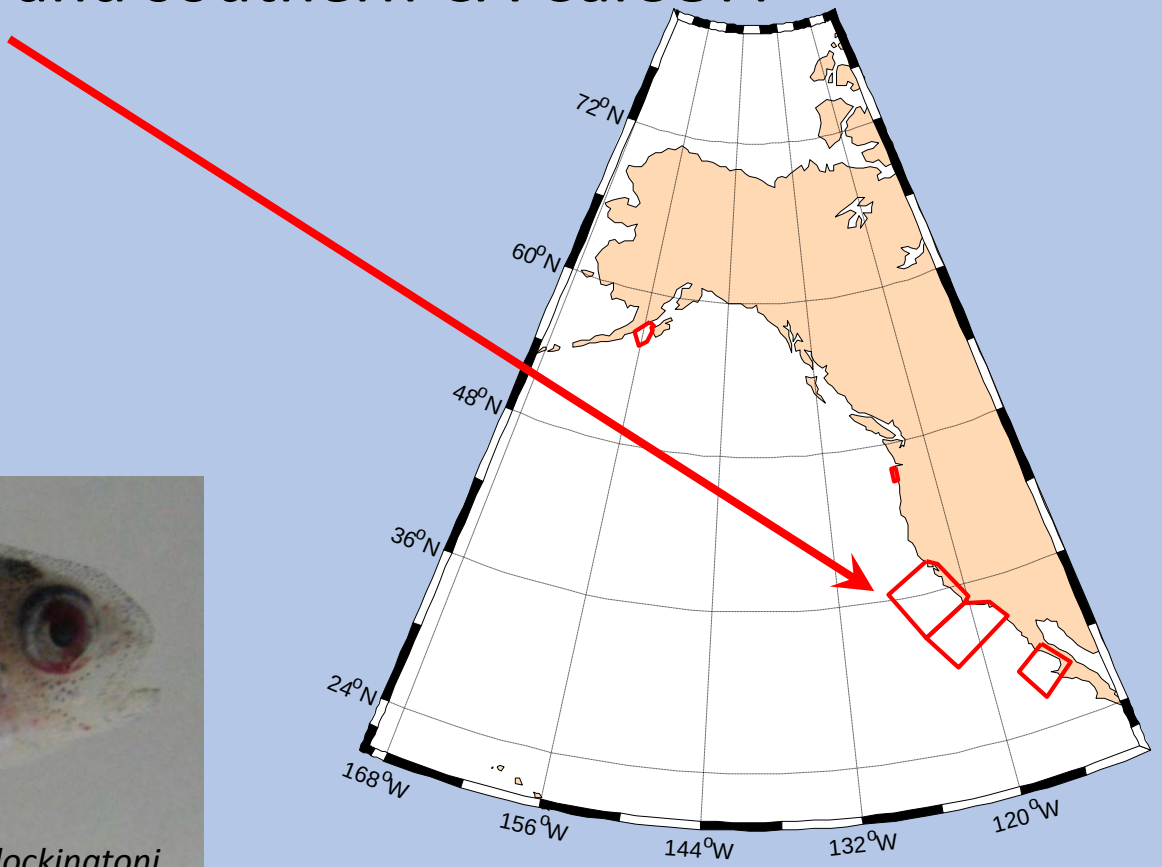
Goals

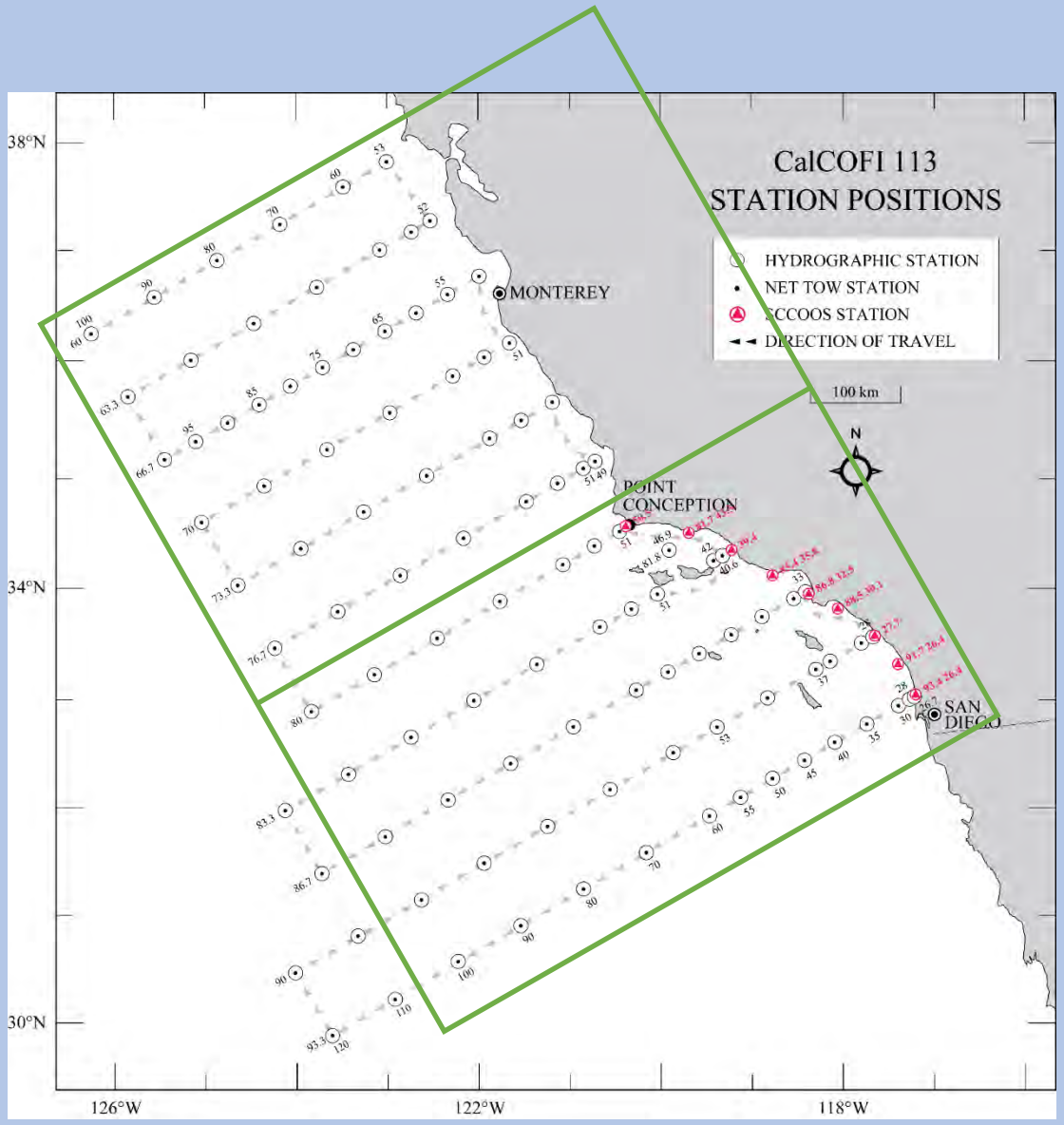
- Look for large-scale coherence in ichthyoplankton with environmental indices along North American west coast
- Focus here on central and southern CA CalCOFI time series
- Focus here on PC1's

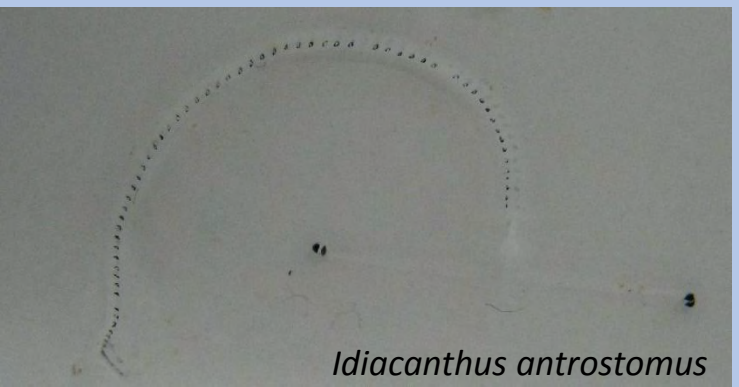
Icichthys lockingtoni



Study Area

- 1951-2015
- Spring cruises





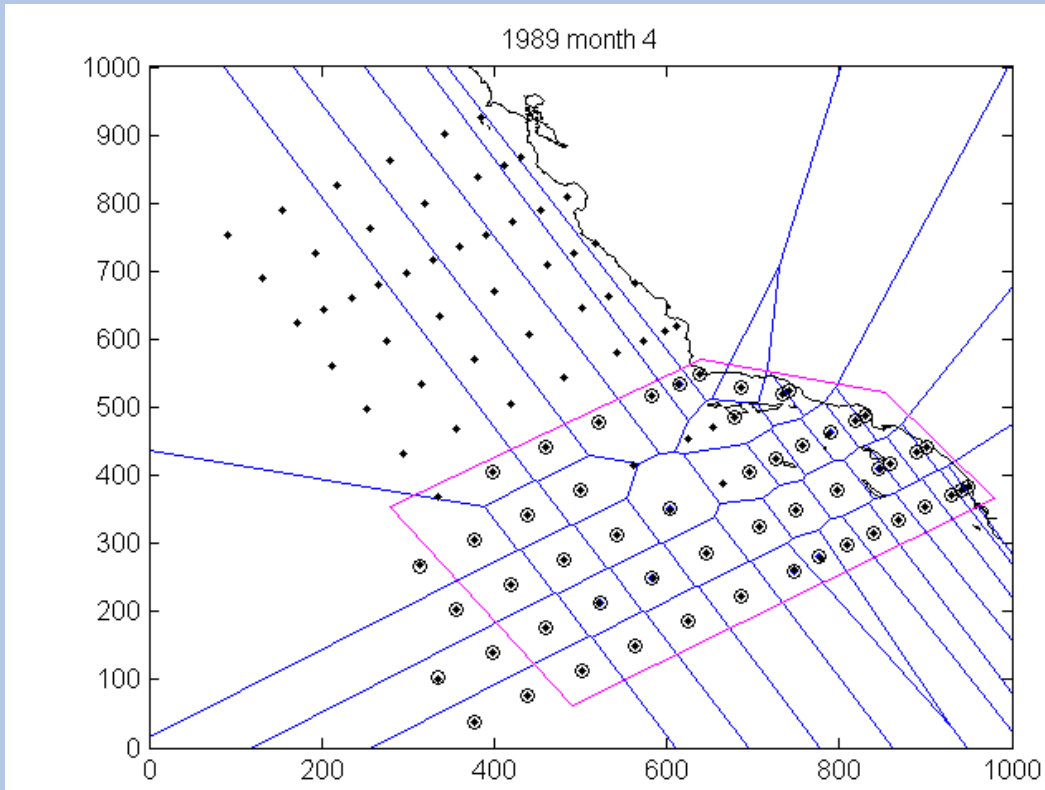
Idiacanthus antrostomus

Methods

- Included only “species” present >50% y
- PCA
- Annual environmental variable indices
- Spatial correction (Voronoi tessellation)


Liparis fucensis


Rhinogobiops nicholsii



Where we left off…

- Koslow et al. 2011, 2013, 2015
  - 1951-2008
  - S. CA only
- PC1 strongly linked to deep oxygen
- Commonality between PC2 and Power Plant Intake time series
  - 6/7 most abund. species

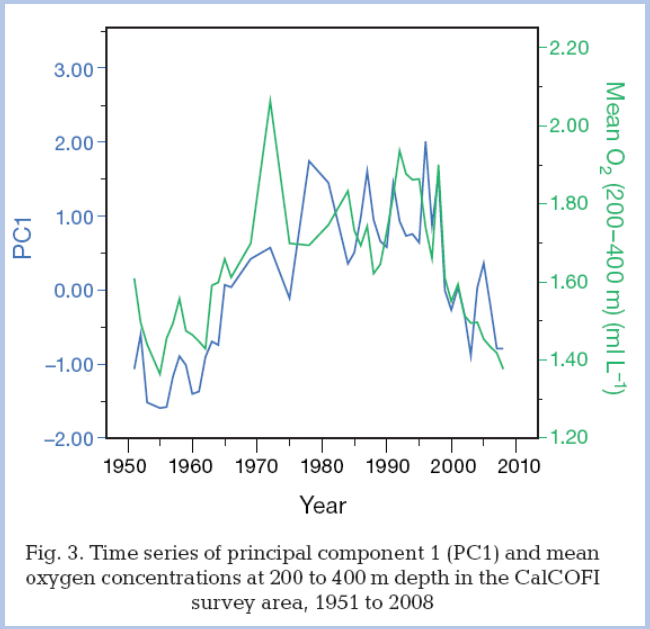
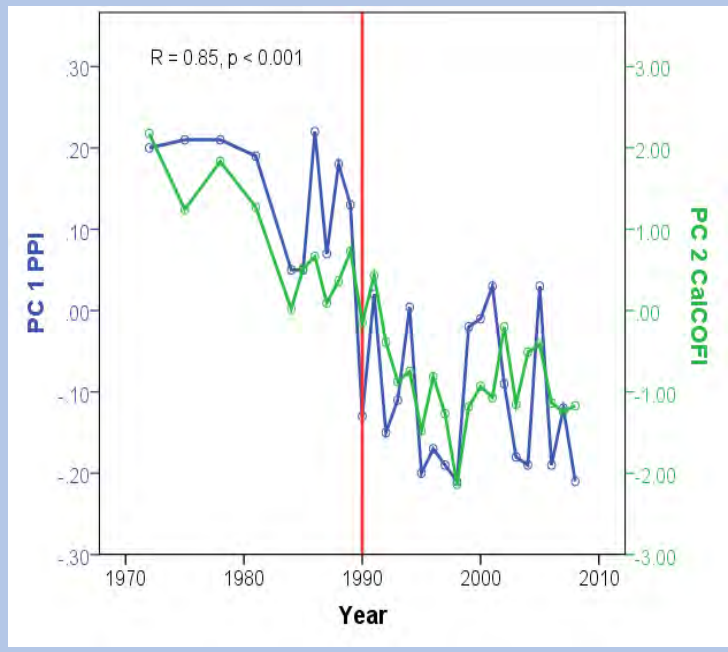
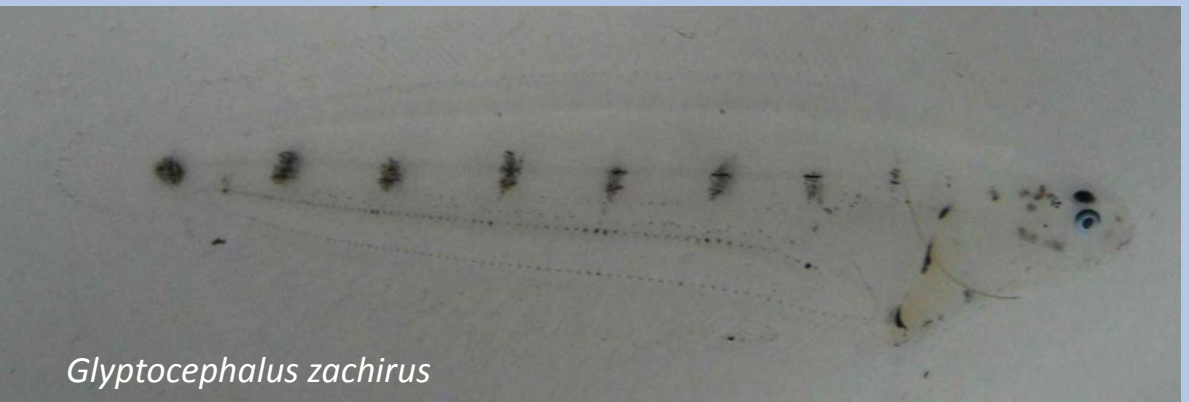


Fig. 3. Time series of principal component 1 (PC1) and mean oxygen concentrations at 200 to 400 m depth in the CalCOFI survey area, 1951 to 2008

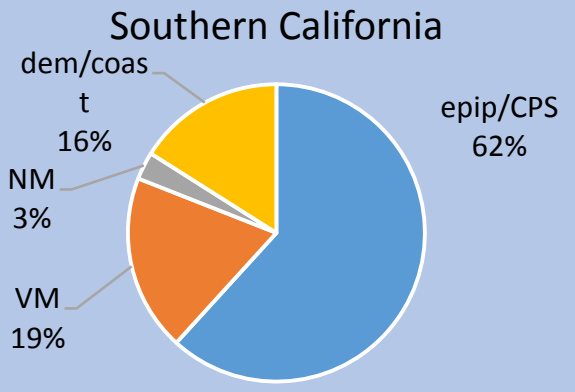


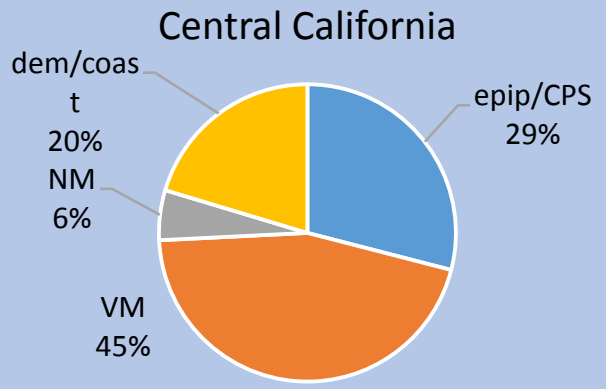


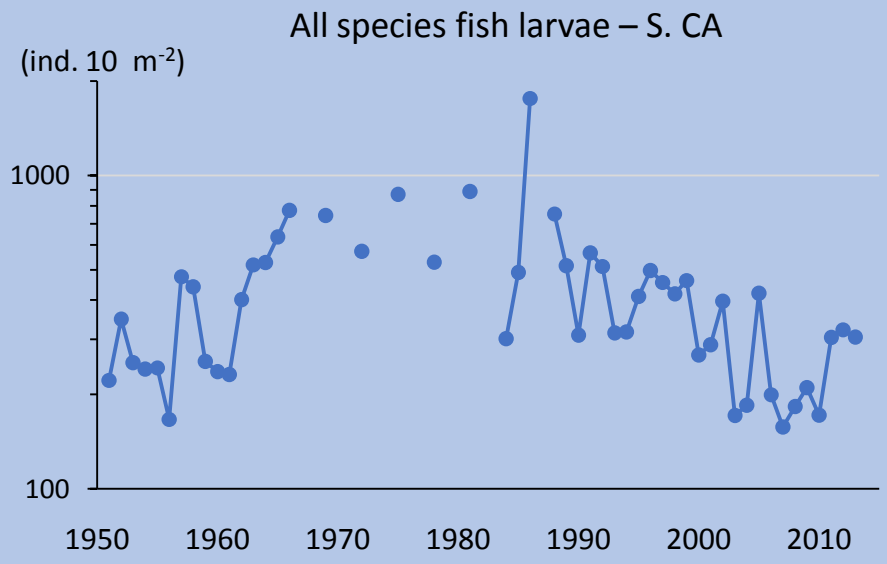
Glyptocephalus zachirus

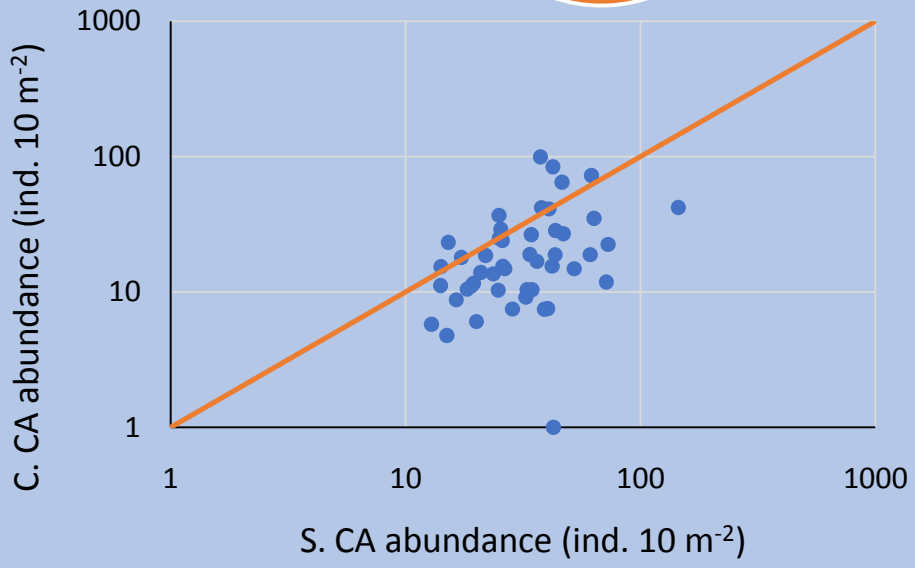
Overall Abundance

- CPS dominant off S. CA
- Mesopelagics dominant off C. CA
- Fewer species off C. CA (205:281)
- Lower abundance off C. CA



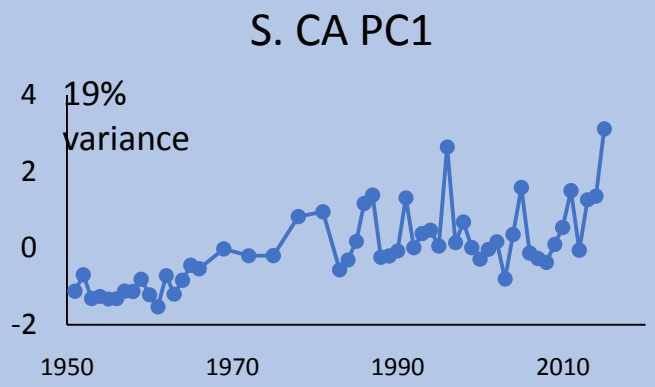


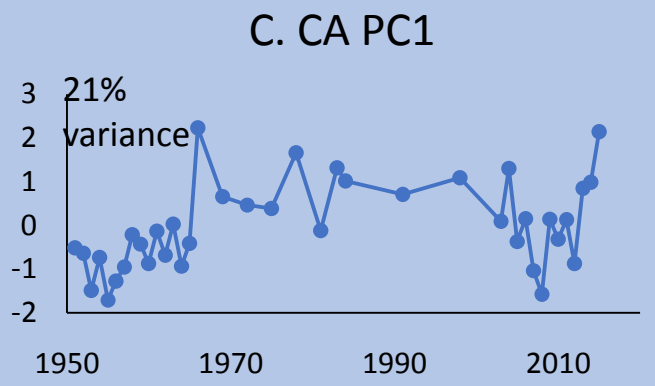


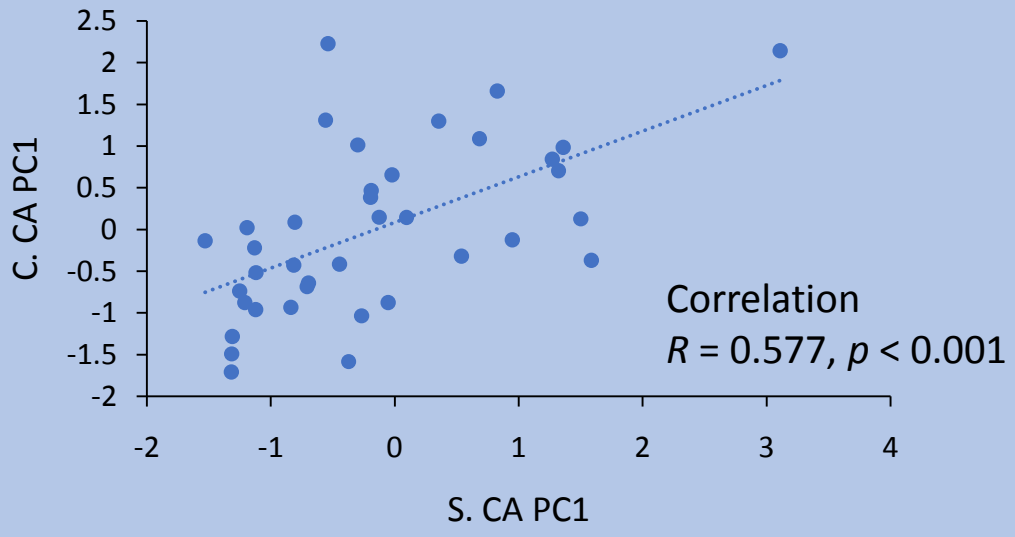


PC1

- S. CA significant loadings
  - Most demersal and mesopelagic species
  - Warm water affiliated species
- C. CA significant loadings
  - Most demersal and mesopelagic species







PC1

Changes from 1951-2008 analysis (Koslow et al. 2011)

S. CA

	PC1
MEI	0.339*
PDO	0.438*
NPGO	-0.222
temp	0.208
sal	-0.321*
deep O2	0.159

*$p < 0.05$

C. CA seems to be holding to the "old pattern"

C. CA

	PC1
MEI	0.562*
PDO	0.544*
NPGO	-0.272
temp	0.343*
sal	-0.506*
deep O2	0.416*

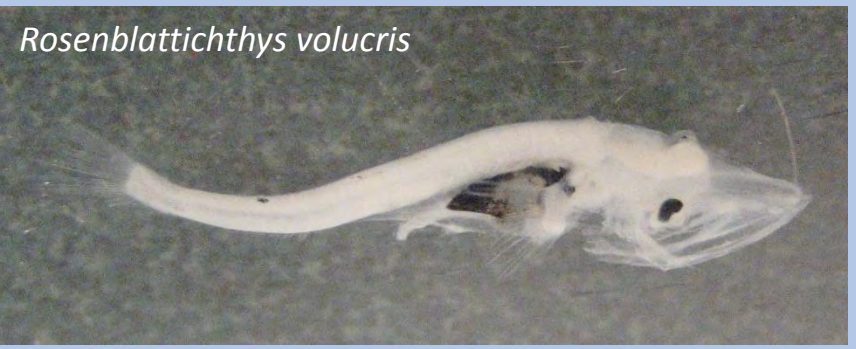
*$p < 0.05$

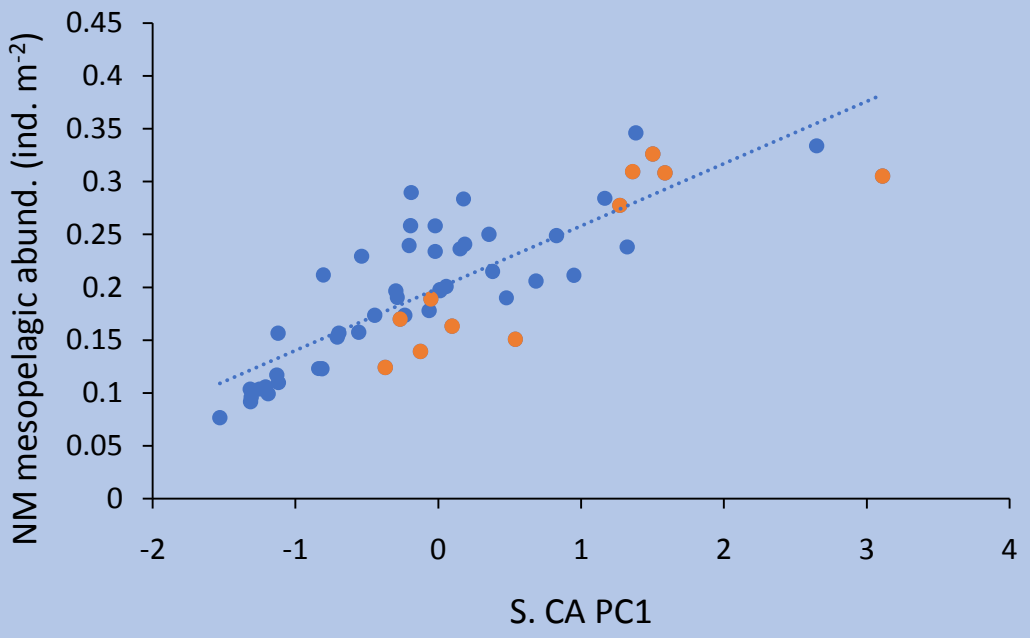
Arctozenus risso

PC1

Ecological group	Abund. Corr. To PC1
All larvae	0.14
Epipelagic/CPS	0.02
Demersal/coastal	0.07
VM mesopelagic	0.35*
NM mesopelagic	0.83*

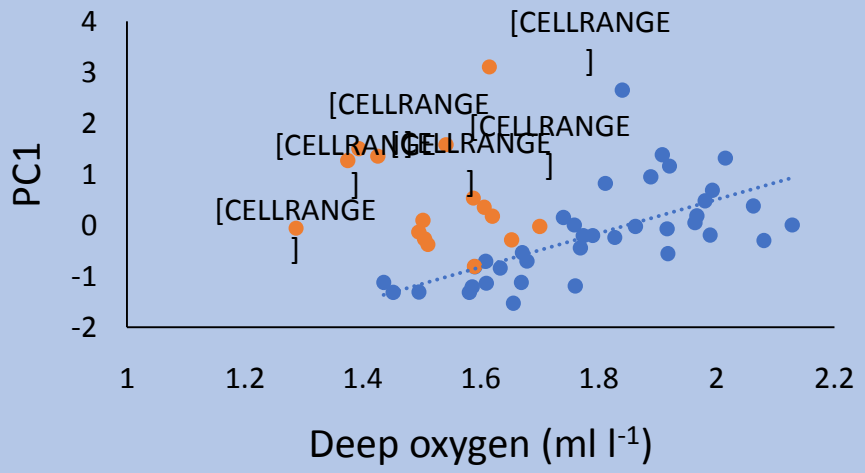
*$p < 0.05$

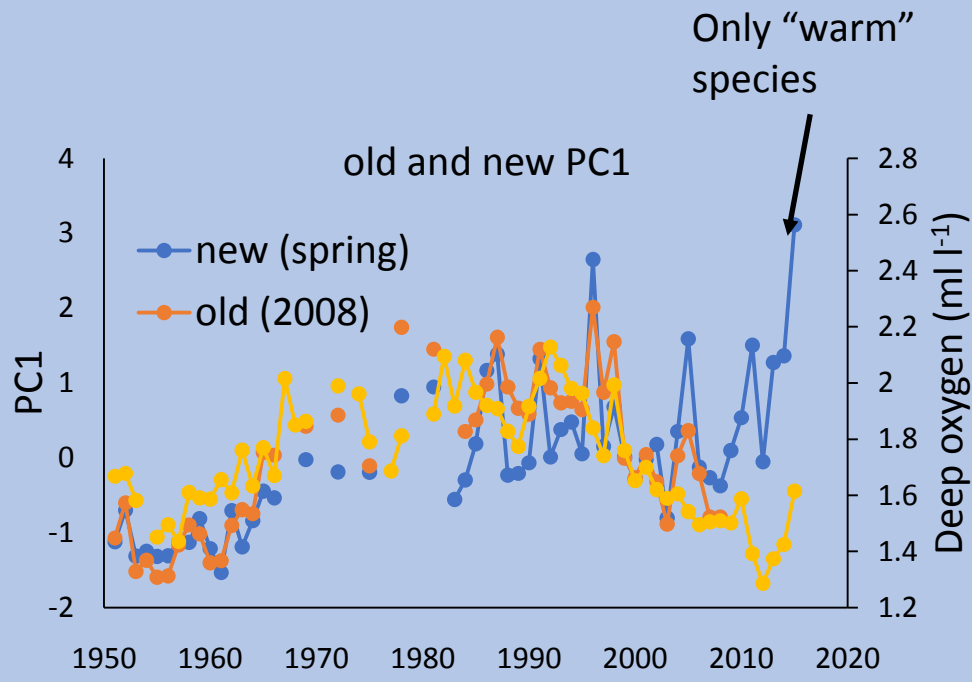




What happened with oxygen and PC1?

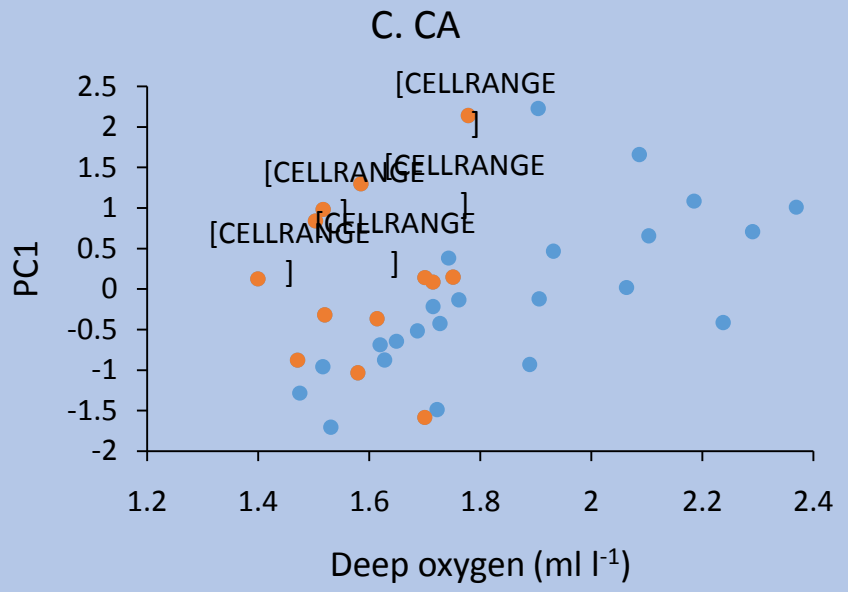
- Koslow et al. : high correlation between PC1 and oxygen
  - 18/20 Koslow et al. (2011) PC1 species sig. load on PC1 here
  - Koslow et al. and new PC1 are sig. correlated ($R = 0.84$, $p < 0.001$)

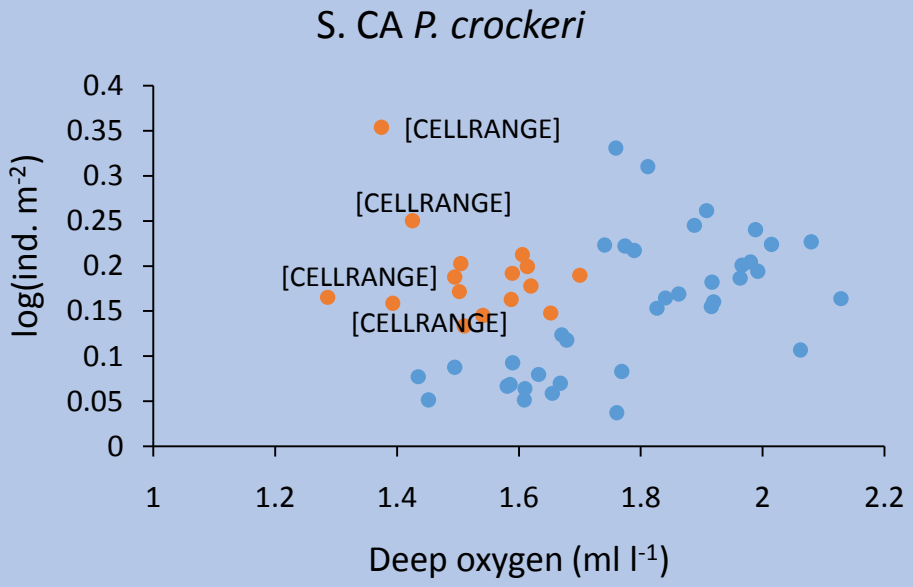


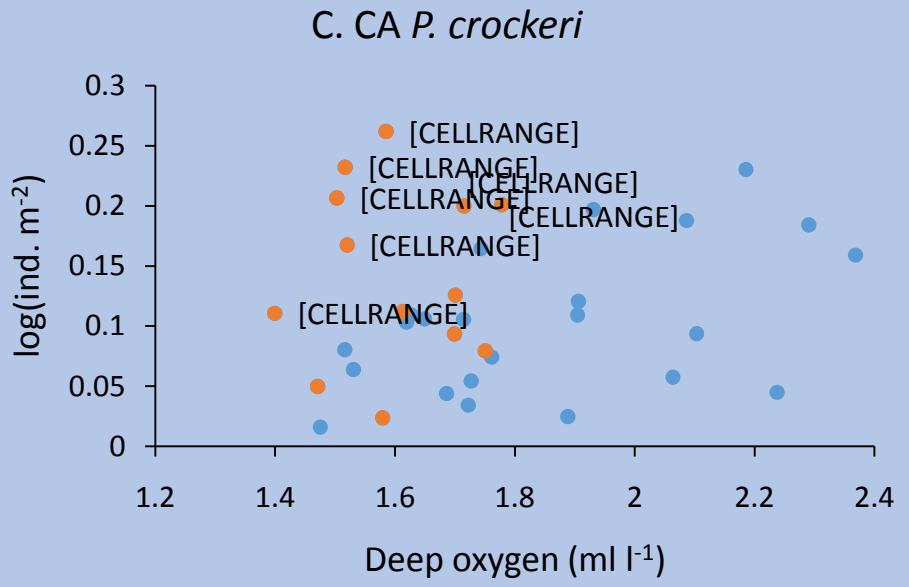


Similar divergence off C. CA

- Pattern seen across many species
- Stronger to south
- May be lagged to north

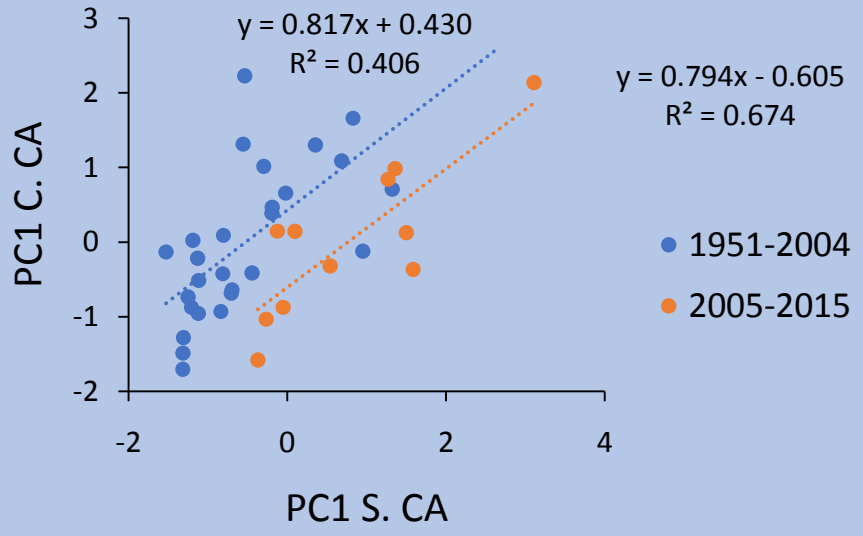


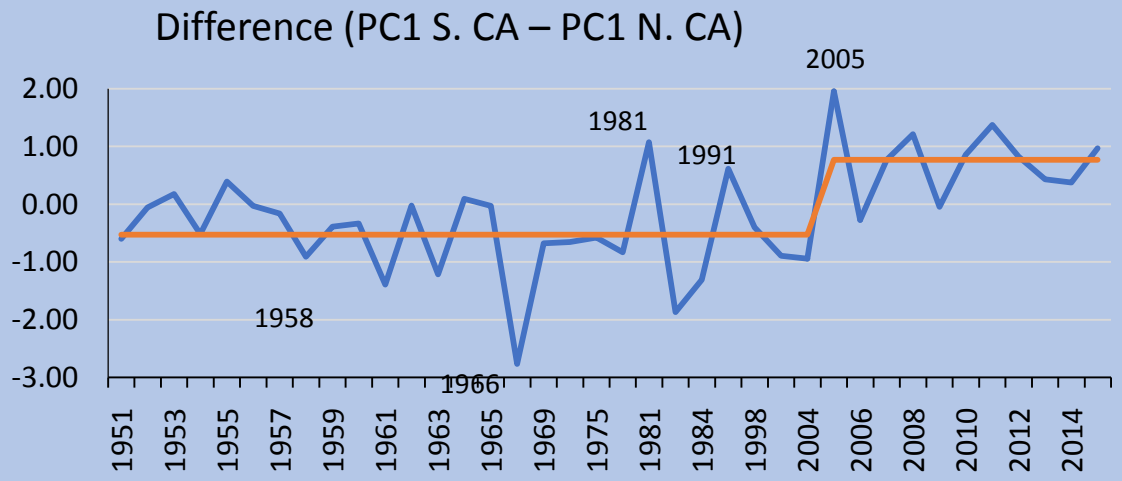




Relationship between S. CA and N. CA changed ~2005

- Slope the same (p = 0.94)
- Intercepts differ (p = 0.001)

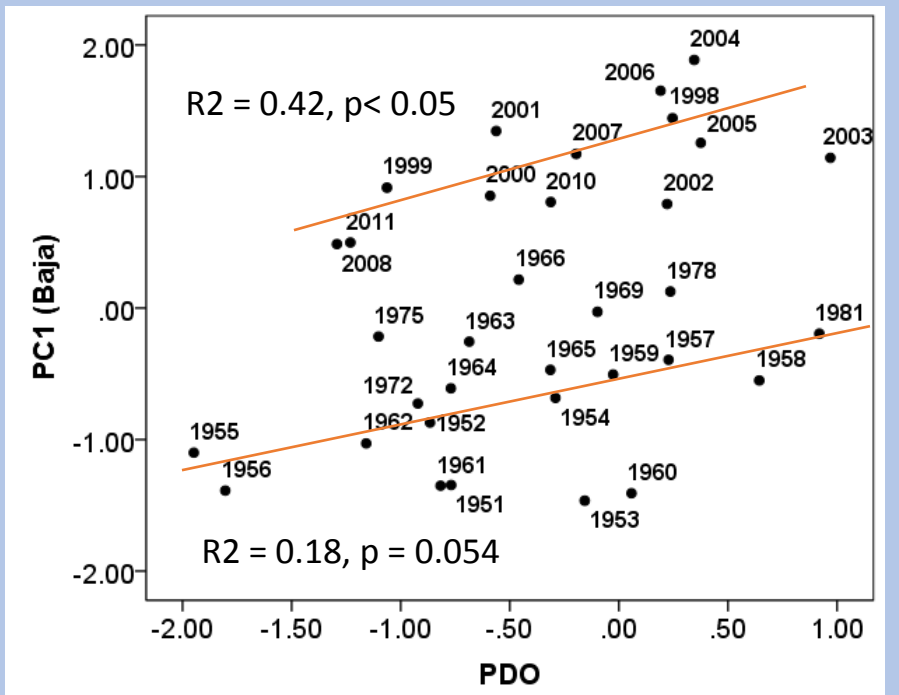


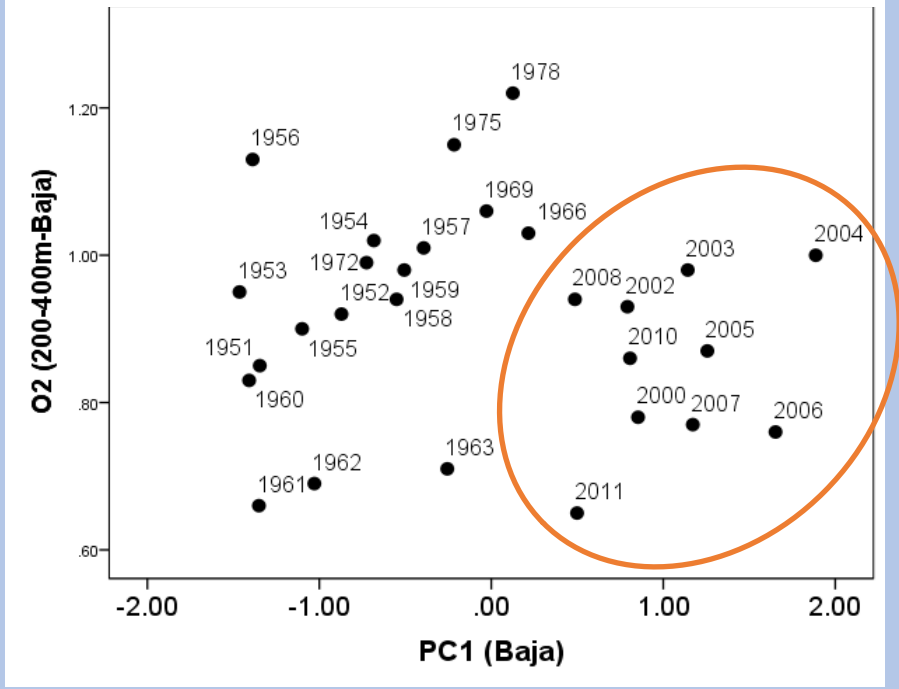


Baja CA

- Similar changes off Baja CA
  - Earlier (≤ 1998)

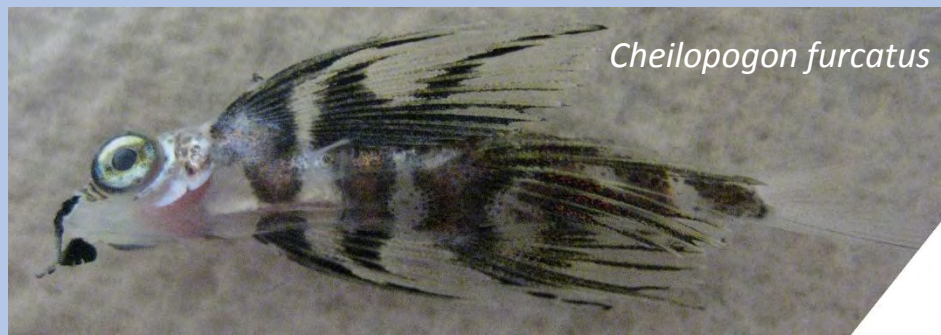
Psenes pellucidus





Preliminary Conclusions

- A formerly highly-significant relationship between ichthyoplankton abundance and oxygen appears to have changed ~2005-2010
  - Other relationships seem to have changed at the same time
  - Suggestion that “state change” may be moving south-north
- Species most strongly linked to PC1 are warm-water mesopelagics
  - Cause uncertain
  - Response to regime change ~2000?
  - Influence of Blob/El Nino in 2015 uptick
  - Release from competition or reduced larval predation by collapsed CPS stocks?


Cheilopogon furcatus

Next steps

- More env./ecological variables
  - Includes CalCOFI euphausiid time series
- More regional fish time series
- Objective test of state change
- Use GAM to identify most important variables
- Other numerical techniques

Symbolophorus californiensis

Naucrates ductor

The National Academies of
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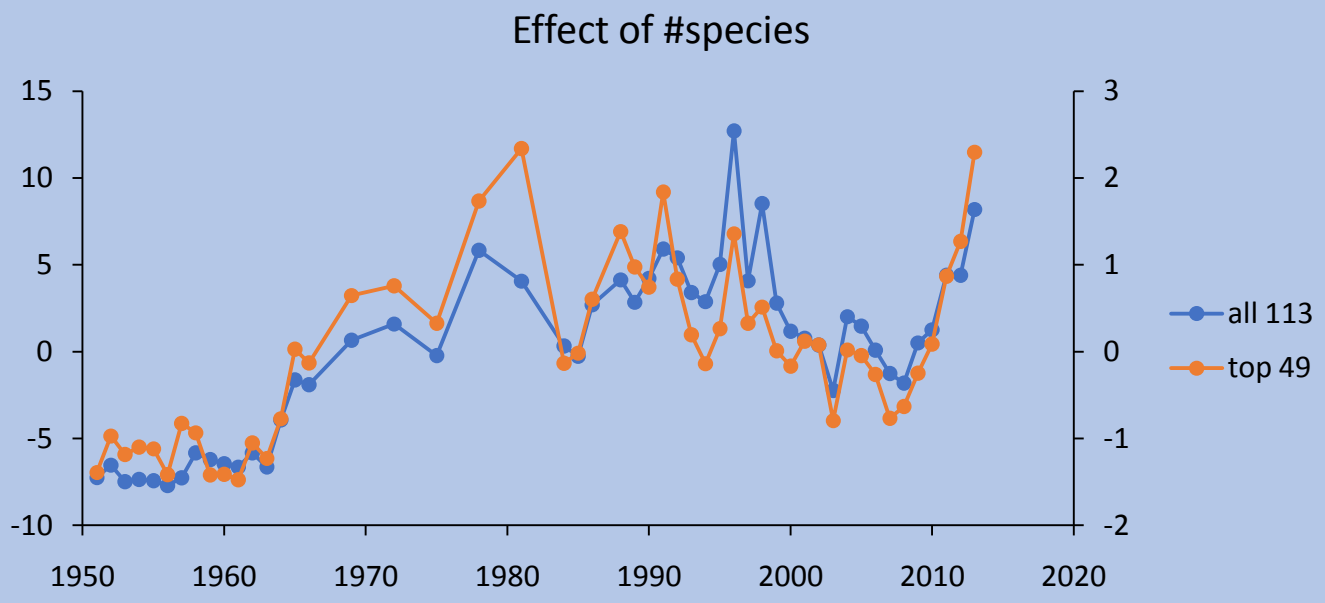
Support:
National Research Council
CalCOFI
Scripps Institution of Oceanography
NOAA

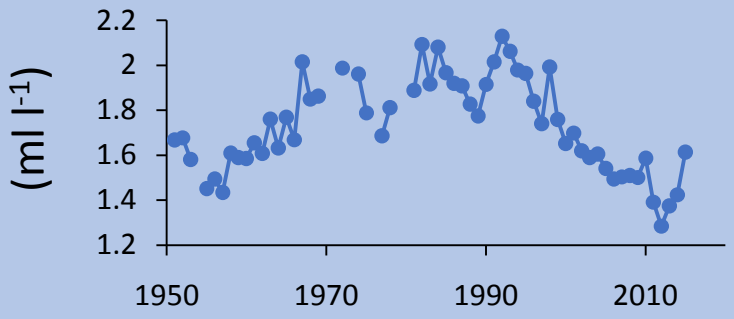
PC1 with more variables than years



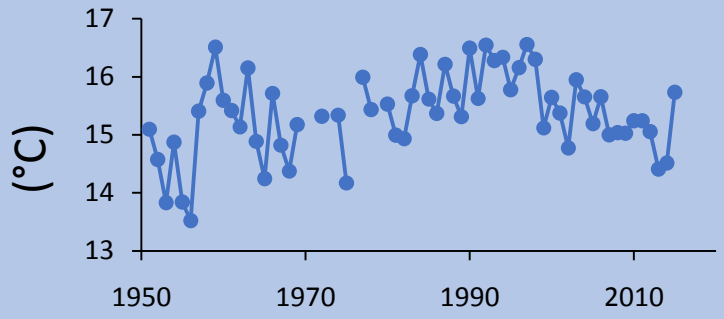
Tactostoma macropus

S. CA annual averages

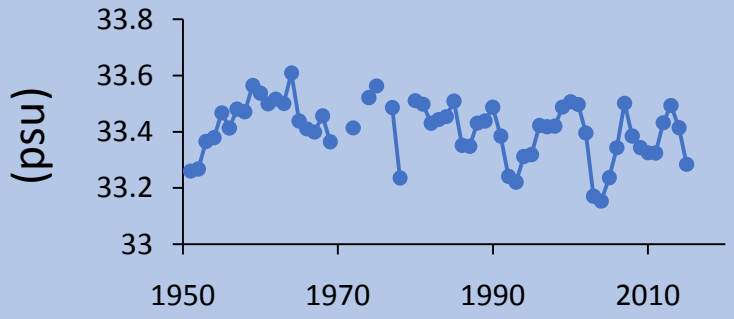
Deep oxygen (200-400 m)



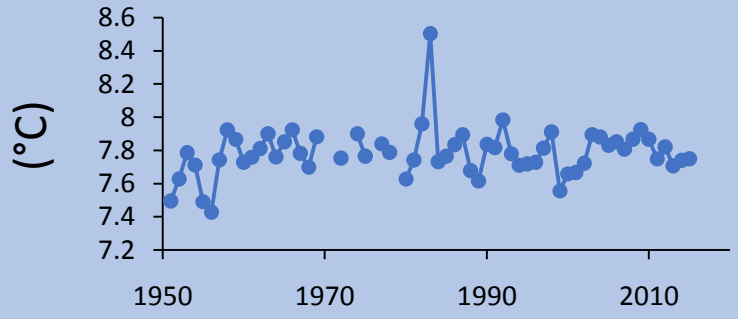
Temperature (10 m)



Salinity (10 m)

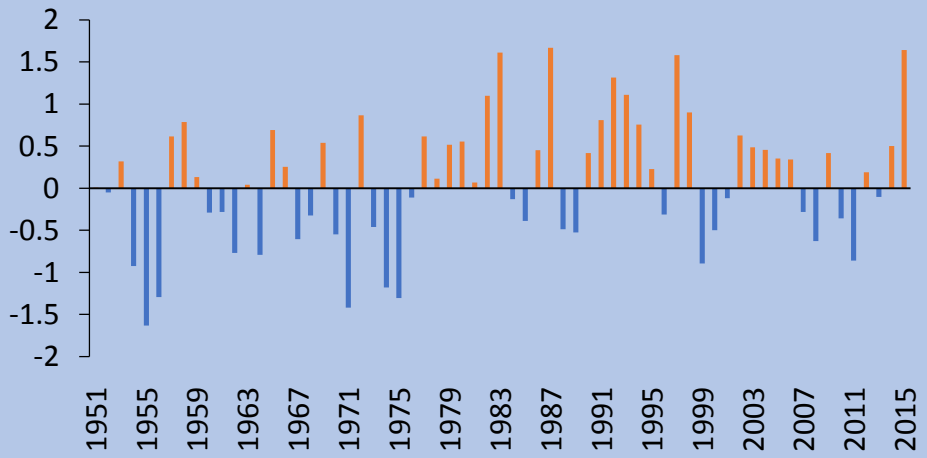


Deep temperature (200-400 m)

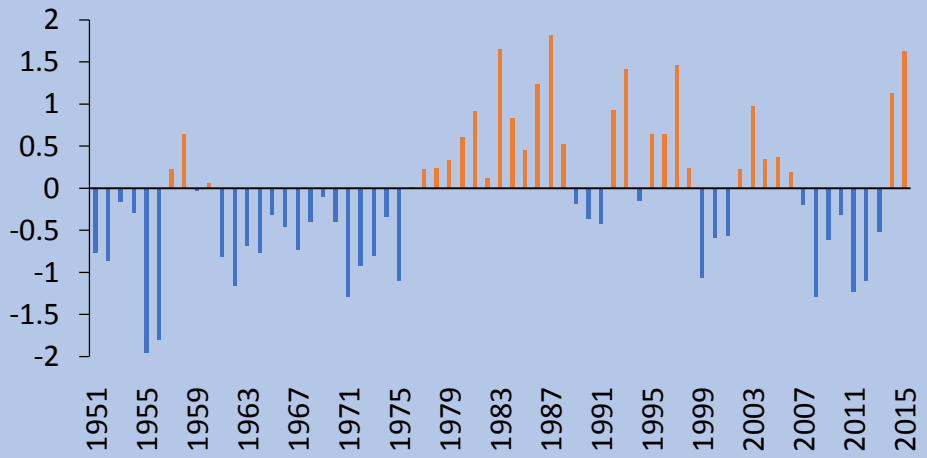



Diplospinus multistriatus

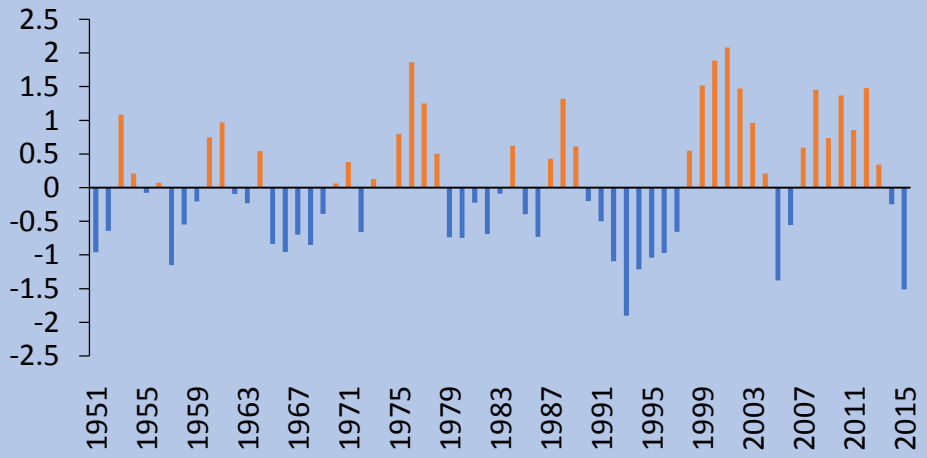
MEI



PDO



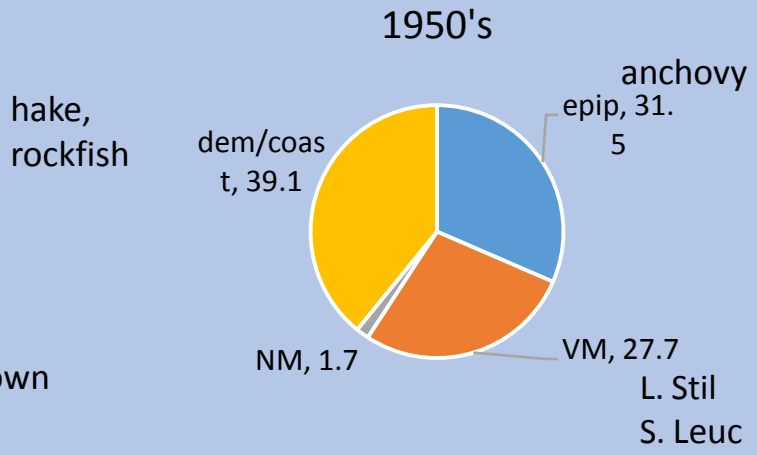
NPGO



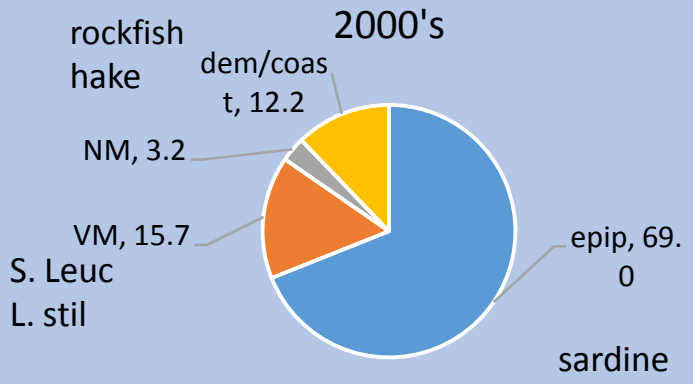
Bathylagoides wesethi

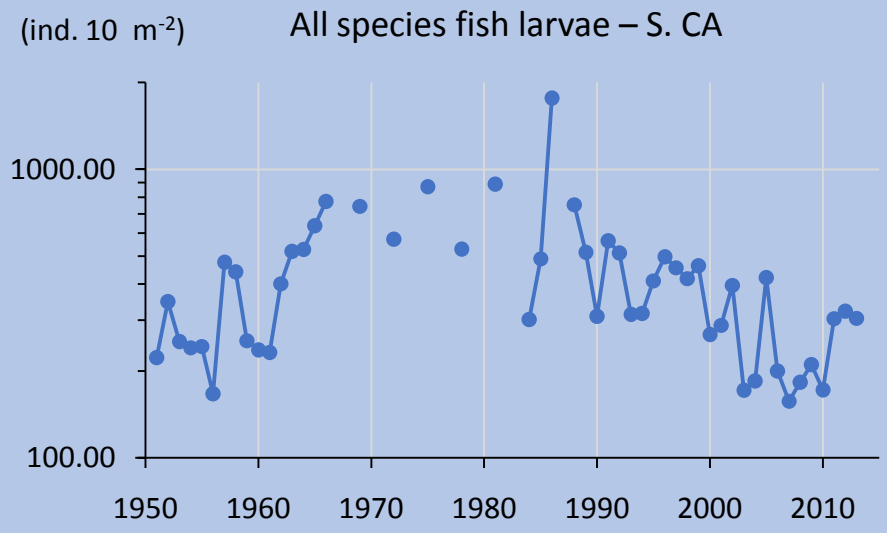
Are the 1950's similar to the 2000's?

- S. CA overall abundance similar
- CPS similar
- PC1 similar
- Oxygen similar

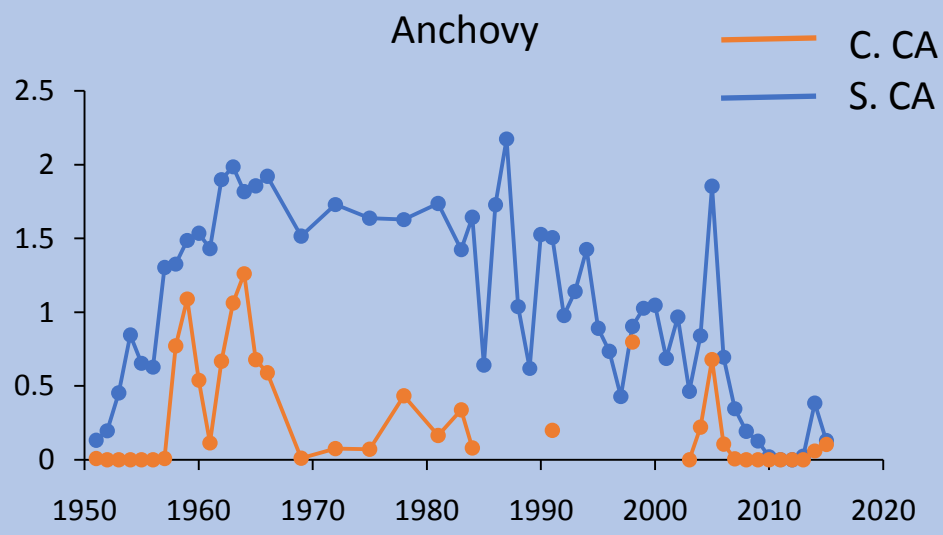


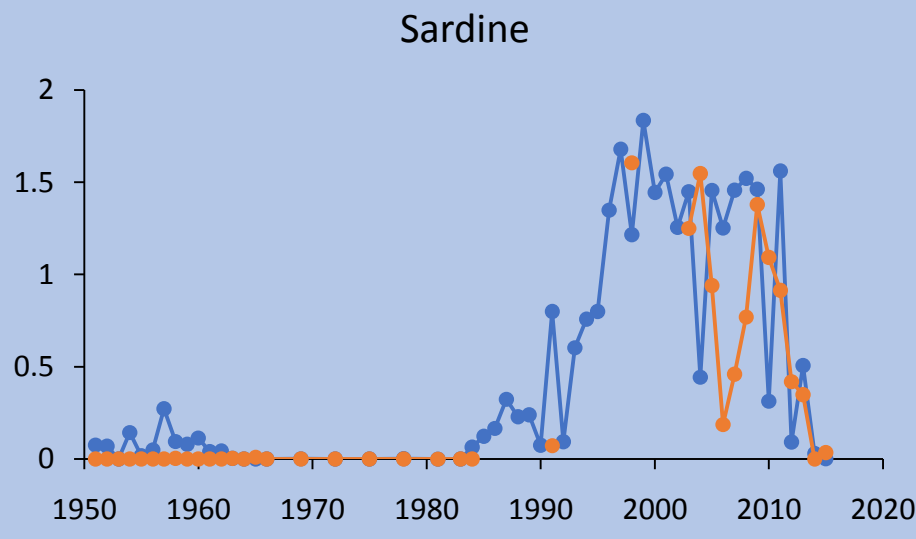
Sardine up
Hake, L. stil, S. leuc down

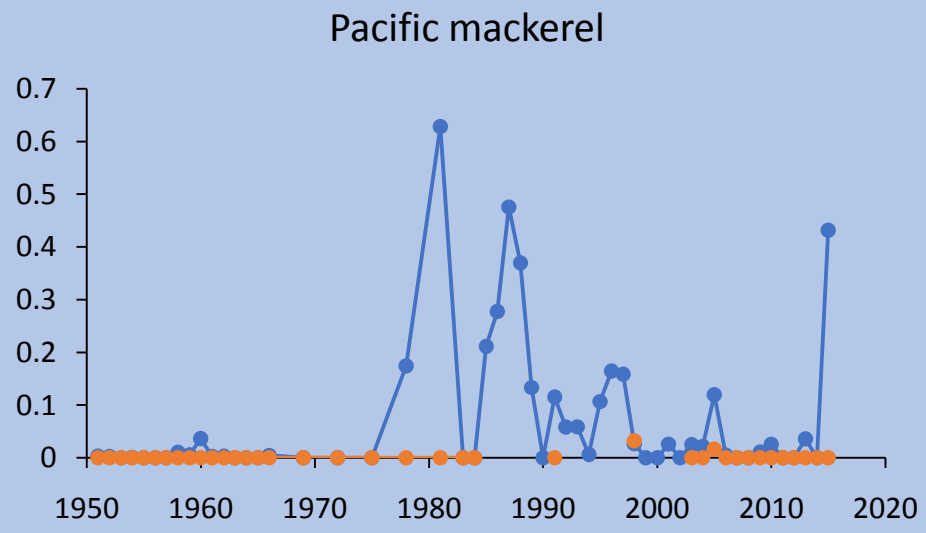


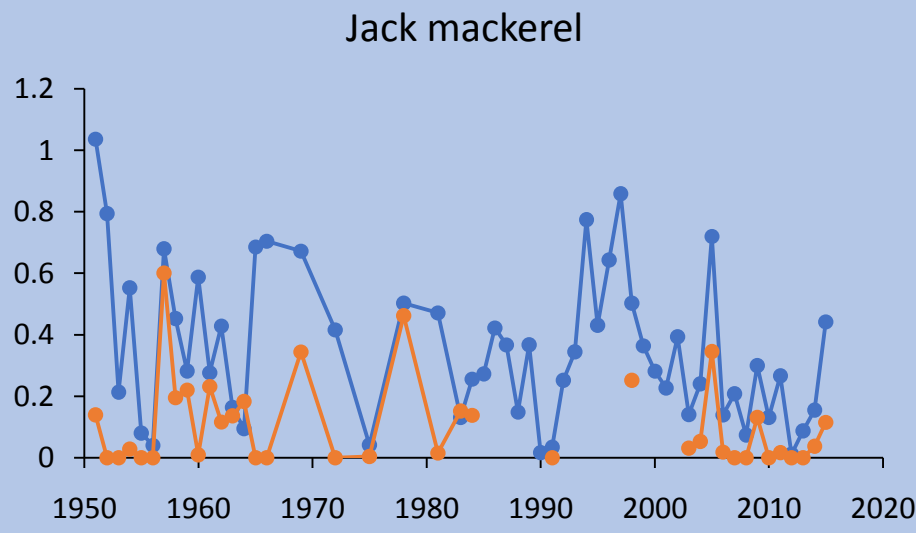


Coastal Pelagic Species (log_{10}(ind. m^{-2}))









Three PC's

S. CA

	PC1	PC2	PC3
MEI	0.339*	-0.121	0.233
PDO	0.438*	-0.270*	0.210
NPGO	-0.222	0.334*	-0.495*
temp	0.208	-0.198	-0.030
sal	-0.321*	0.053	0.036
deep O2	0.159	0.021	0.333*

C. CA

	PC1	PC2	PC3
MEI	0.562*	-0.207	0.012
PDO	0.544*	-0.341*	-0.047
NPGO	-0.272	-0.240	-0.299
temp	0.343*	-0.429*	-0.137
sal	-0.506*	0.127	-0.023
deep O2	0.416*	-0.159	0.390*