Anomalous patterns in California Current pelagic micronekton distribution and abundance in 2015

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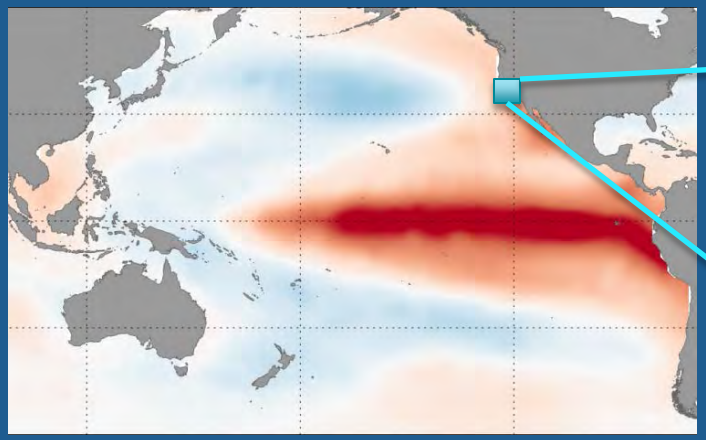
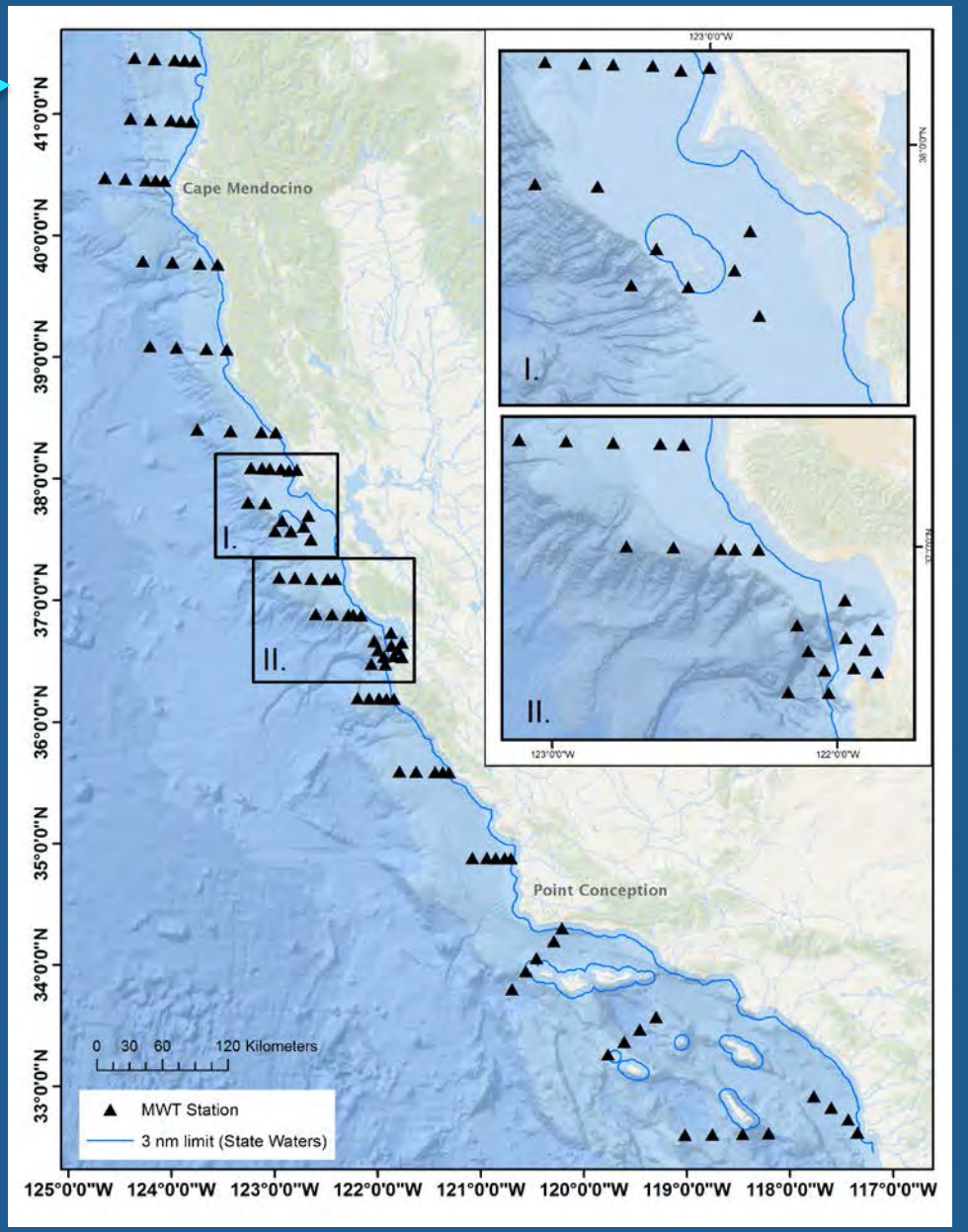
May-June midwater trawl survey in coastal waters of the California Current- primary objectives

- 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)



Time and Place

- SWC has surveyed a “core” area (central California) since 1983 (33 years time series), expanded range in 2004 from the U.S./Mexico border to Cape Mendocino
- Several others surveys cover northern regions (NWFSC), data are pooled for rockfish recruitment indices and other analyses, but not included here (shorter time series).



From 1983 through 2008 all cruises were on the R/V David Starr Jordan, since then have used 5 different vessels (including Ocean Starr, former DSJ)

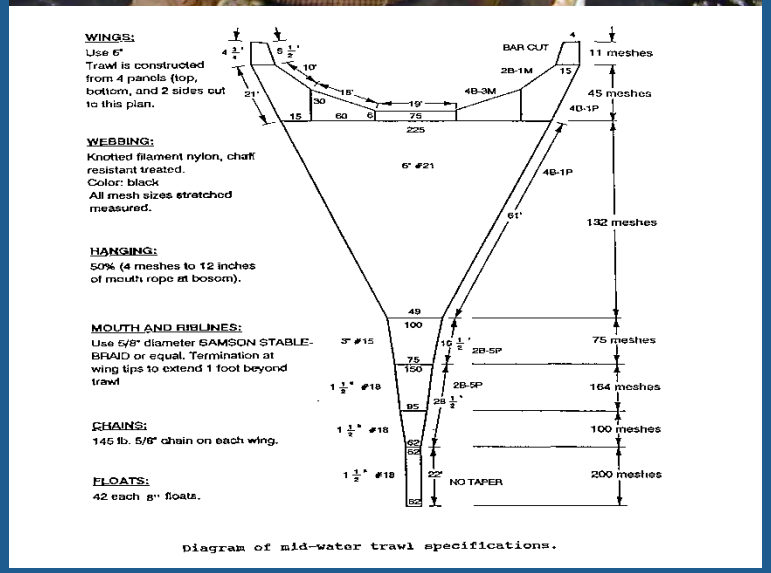


Diagram of mid-water trawl specifications.

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

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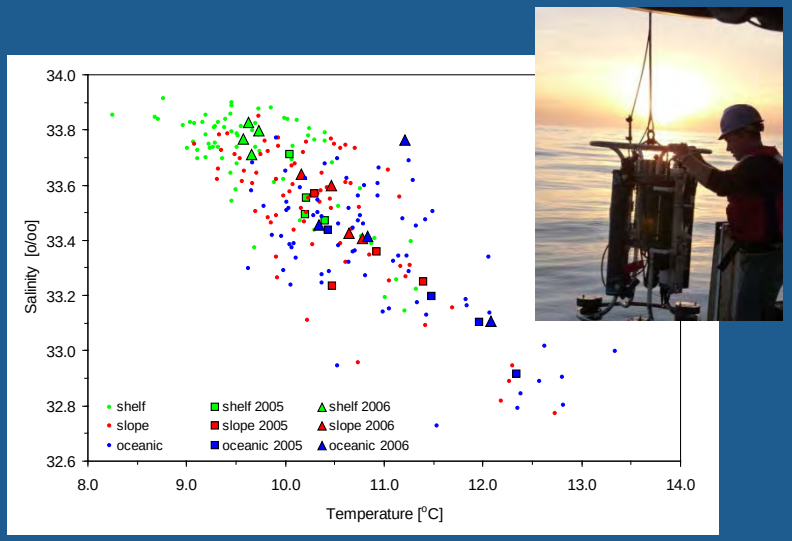
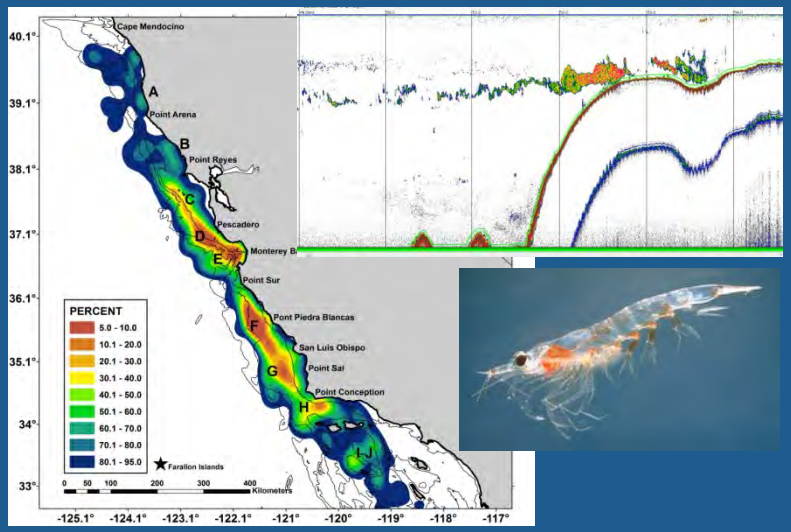
Rockfish and other species are sorted, measured and enumerated at sea

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

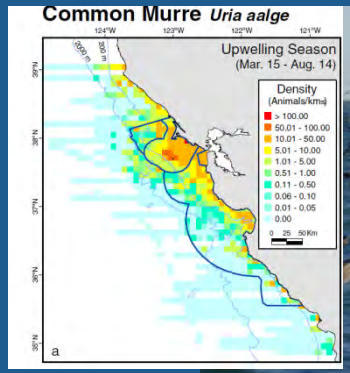


Physical Oceanography (CTD and Fluorometry), upwards of 300 casts per year, data online



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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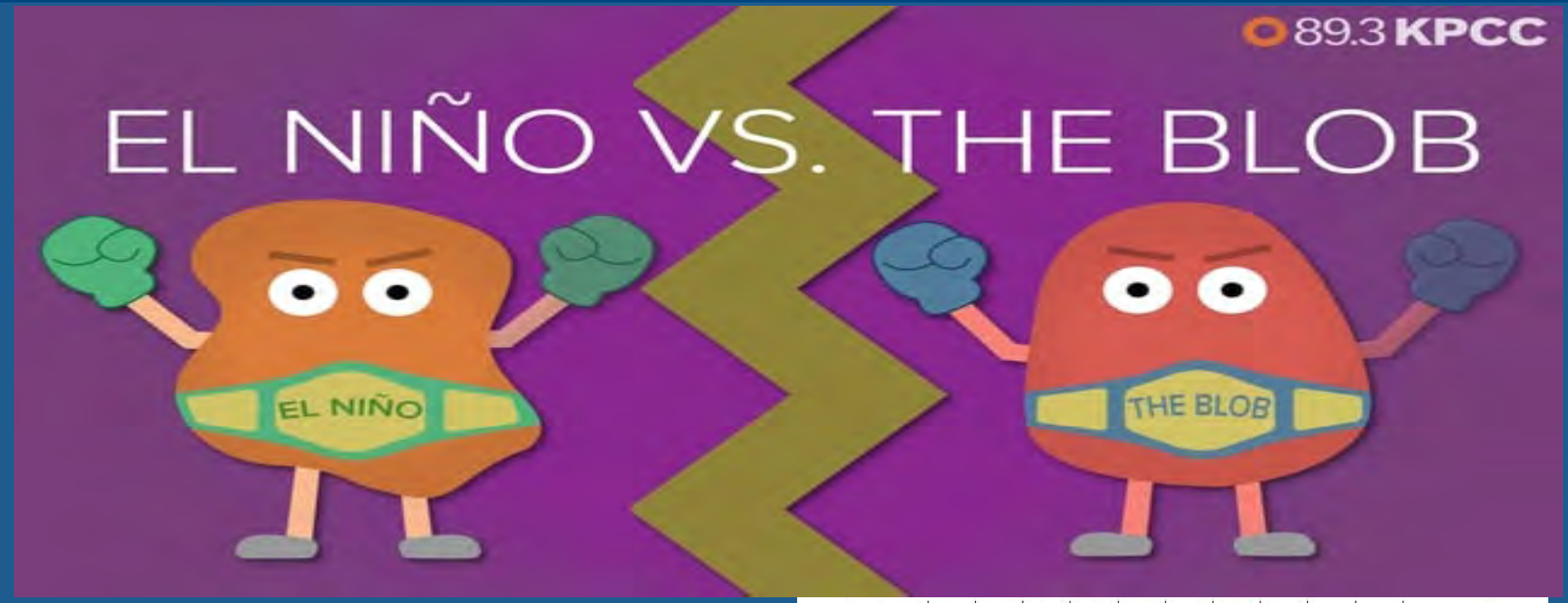
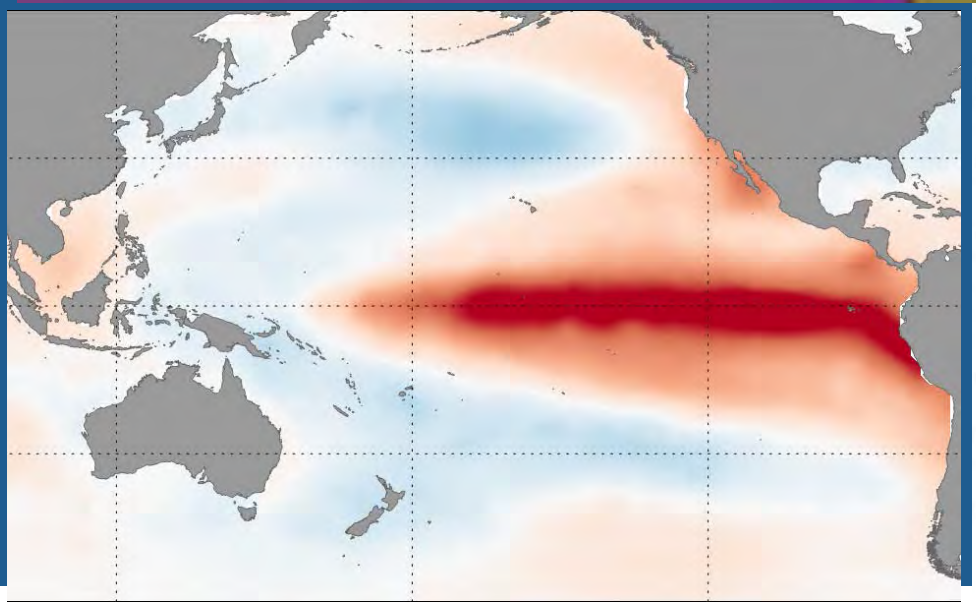
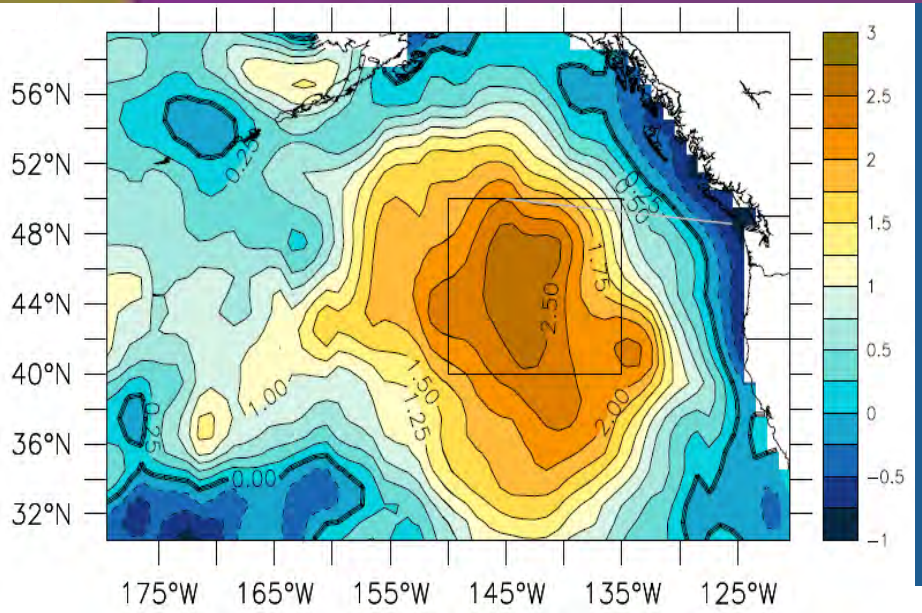
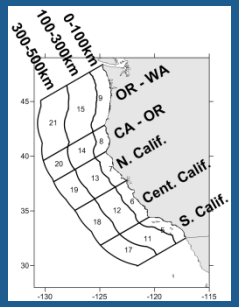

89.3 KPCC
EL NIÑO VS. THE BLOB
EL NIÑO
THE BLOB



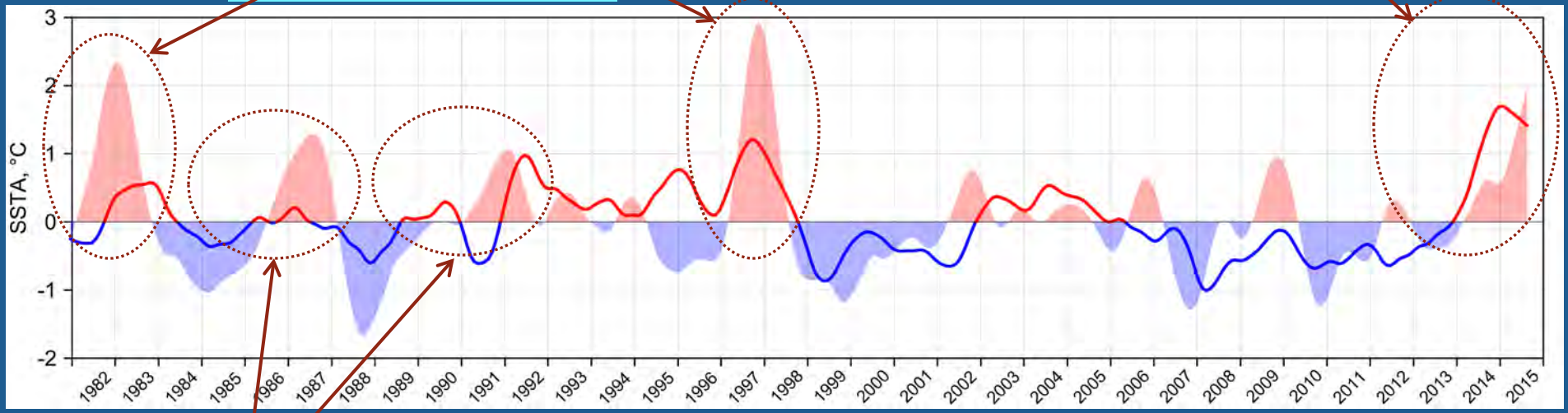

56°N
52°N
48°N
44°N
40°N
36°N
32°N
175°W
165°W
155°W
145°W
135°W
125°W
0.25
0.50
1.75
2.50
1.00
1.50
1.25
2.00
0.00
3
2.5
2
1.5
1
0.5
0
−0.5
−1

So what is the deal with ENSO and sea surface temperatures in the California Current?



"El Niño's of the century"
CCS warming, yes

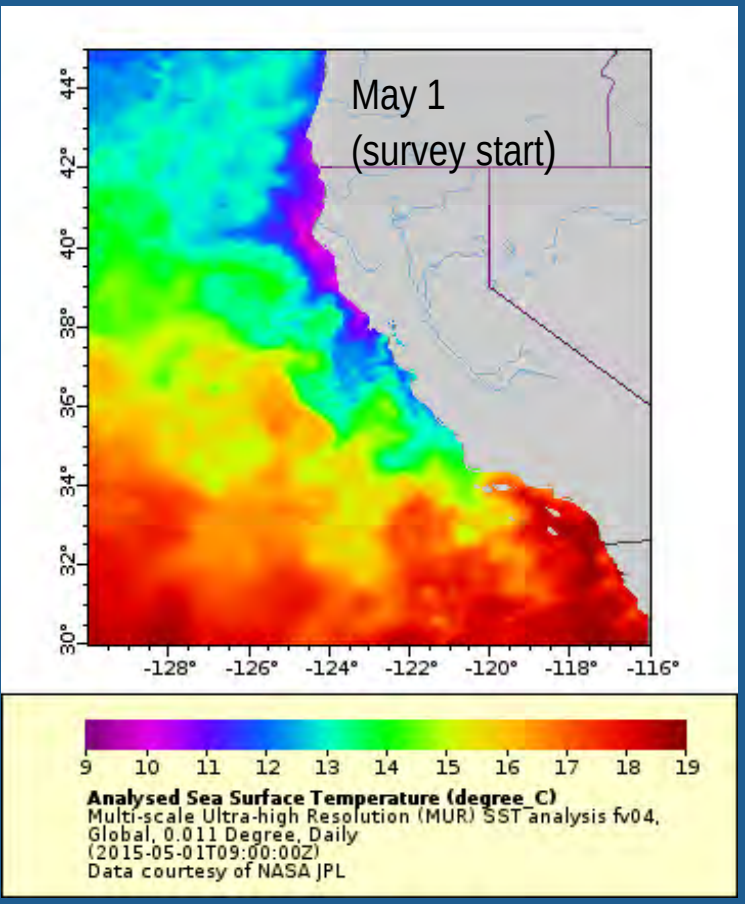
Impending "strongest El Niño ever"
preceded ~9mos by the CCS warming!

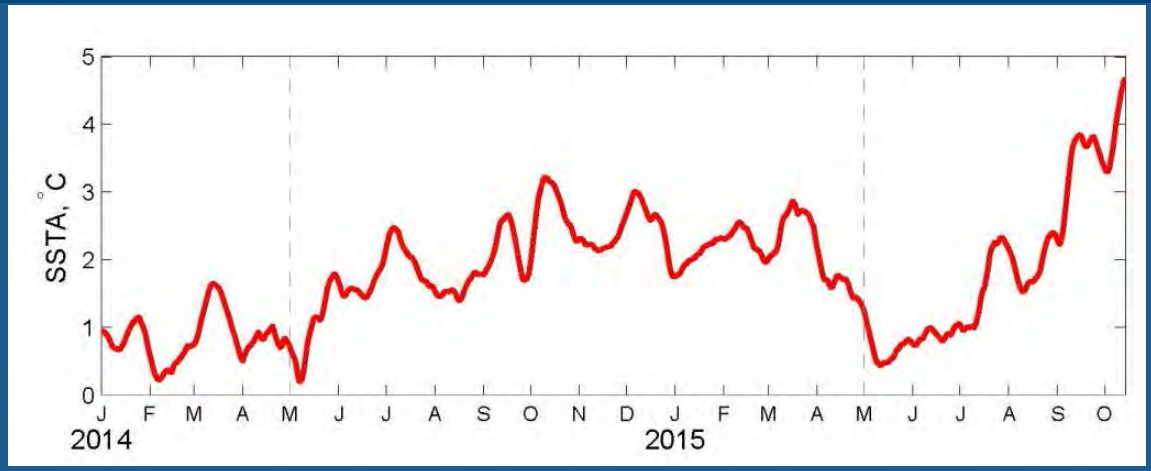


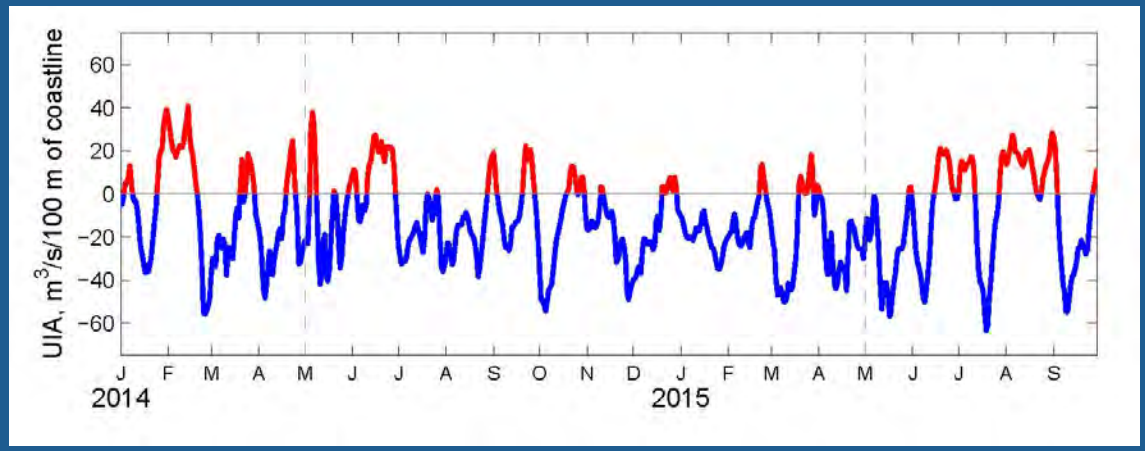
moderate El Niños
mixed story in CCS

NINO3 (5S-5N 150-90W)
California Current (U.S. west coast to 500km)
NOAA/NCEP OISST v.2

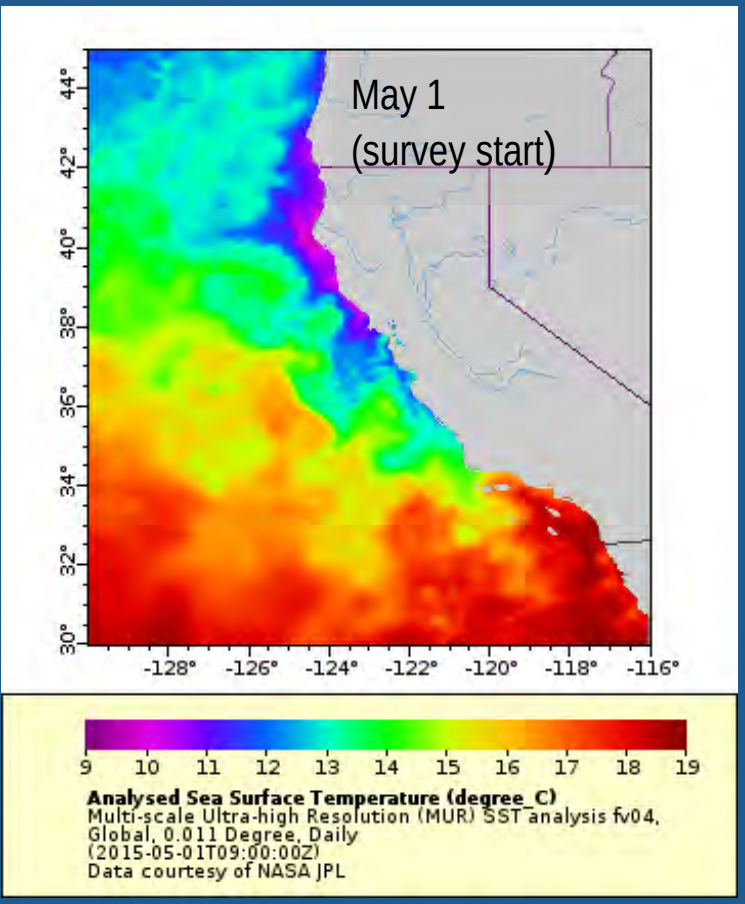
Graphic courtesy of Paul Fielder, Marine Mammal and Turtle Division, SWFSC

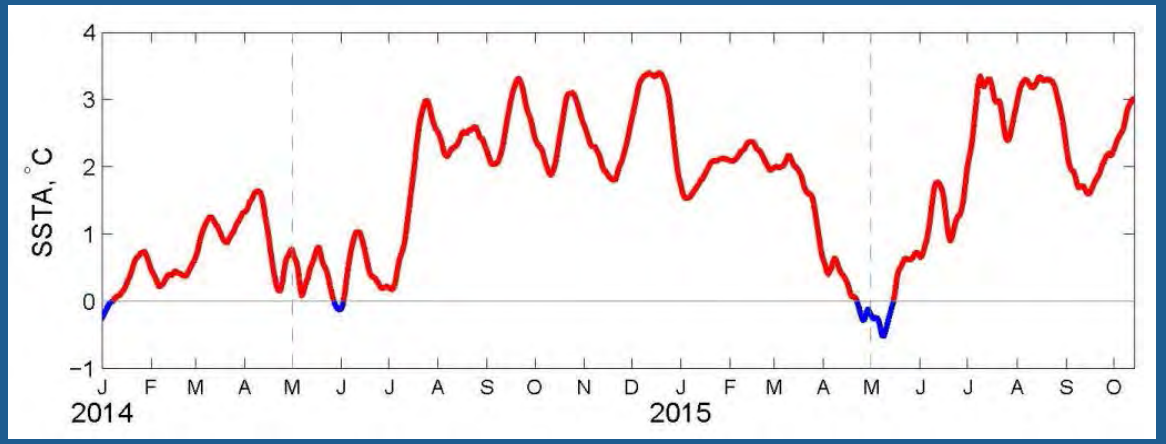


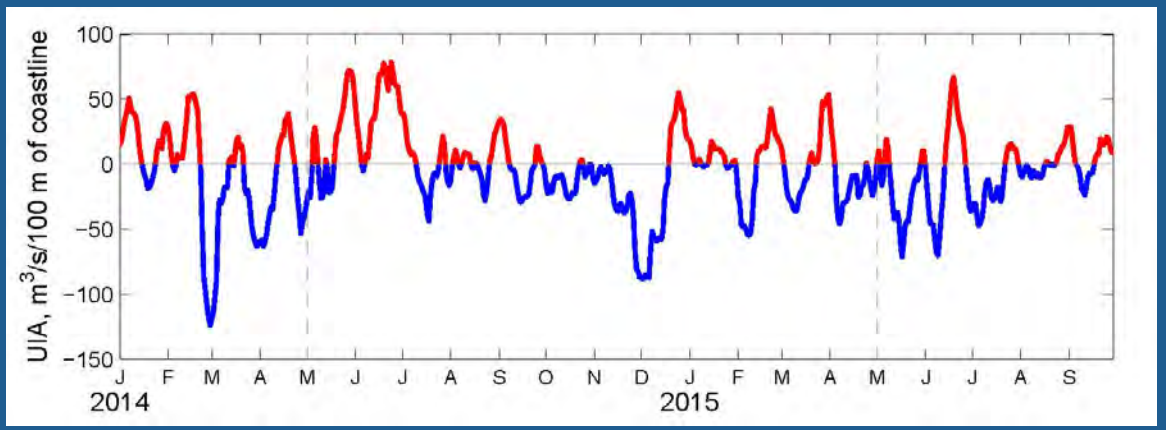




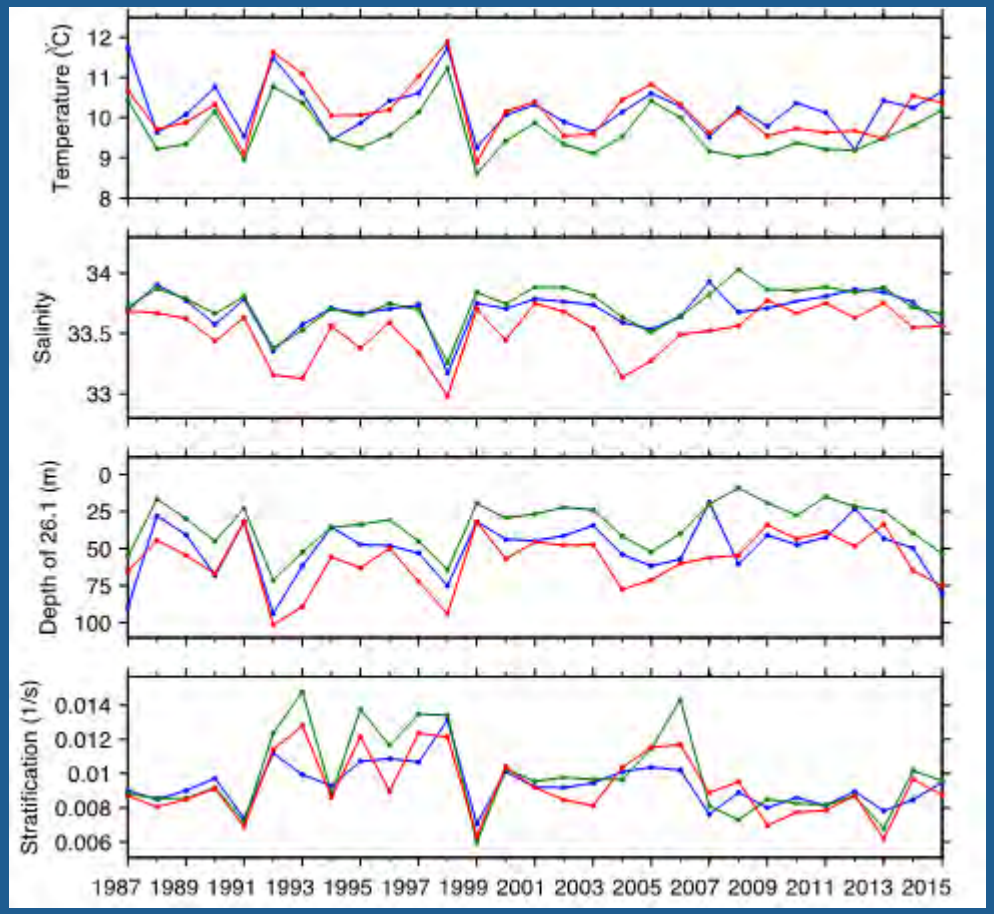
Southern California has been anomalously warm since 2014, with lower than average upwelling winds, but the real spike in SSTs came after our survey concluded. (updates from I. Schroeder, climatology 1982-2015)

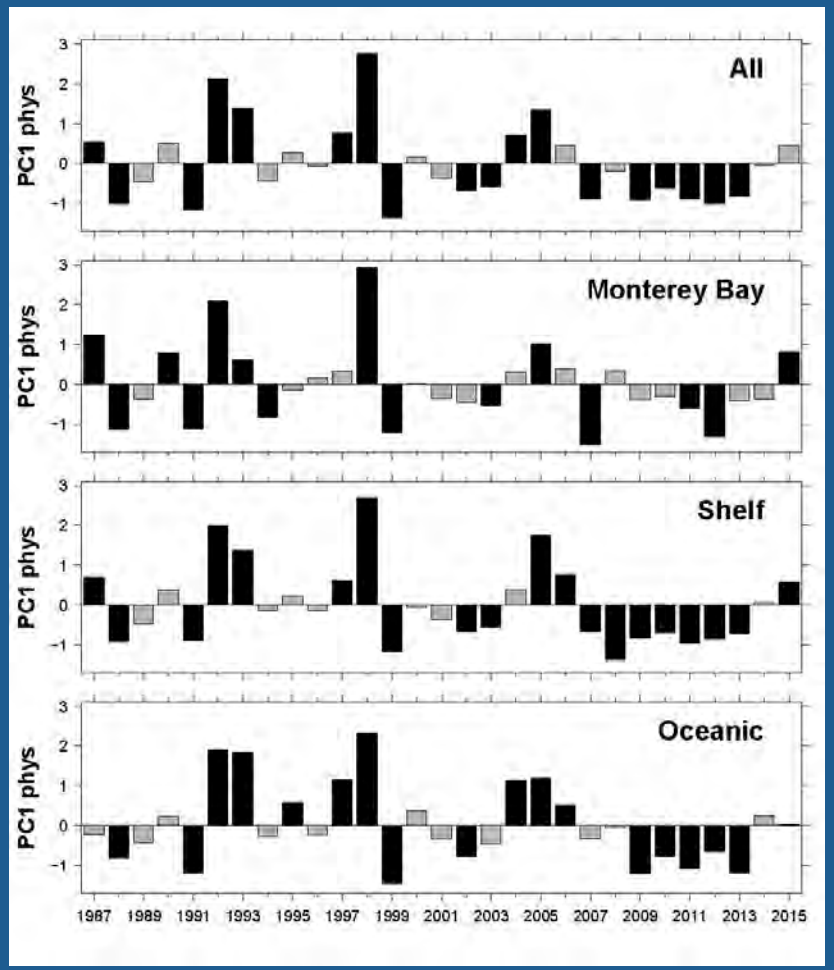






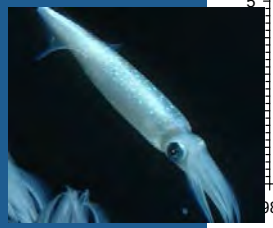
Central California was very slightly cooler than average at the start of the survey, but that cool period was sandwiched between very warm anomalies! Upwelling was generally about average (updates from I. Schroeder, climatology 1982-2015)

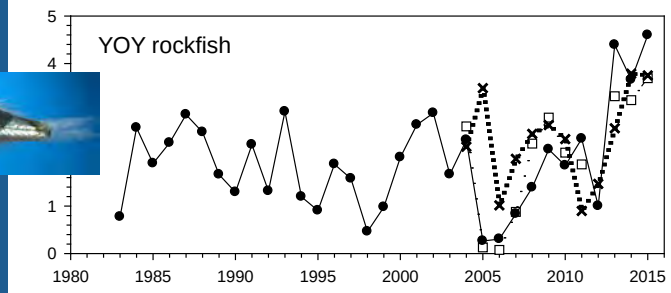


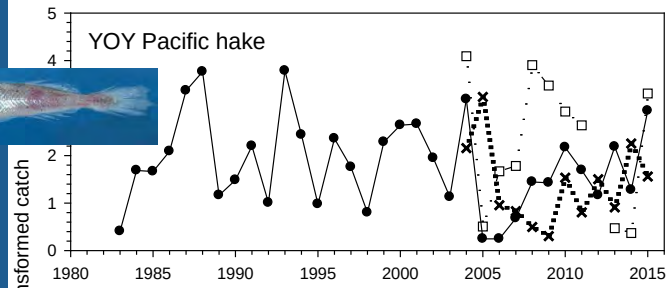


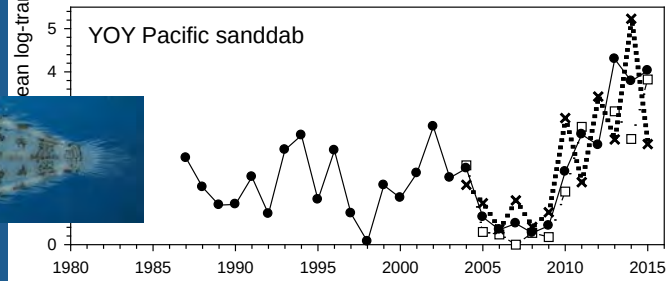
Physical conditions analyzed from CTD casts include temperature, salinity, depth of the 26.1 isopycnal and stratification- in 2015 the core area physical properties were not terribly anomalous, although conditions were more El Nino-like in the Southern California Bight (core area figures updated from Santora et al. 2014)

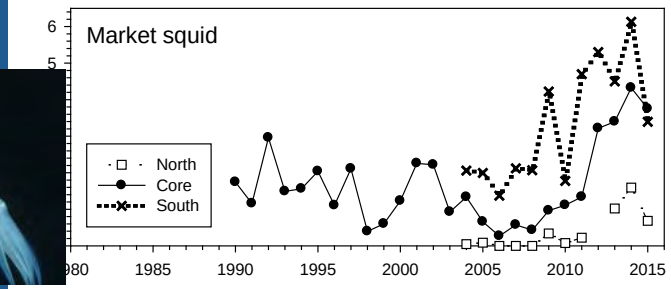
2015 catches were bizzare!! We had record catches of YOY rockfish and some other YOY groundfish, high to record catches of gelatinous organisms (salps, pyrosomes, etc.), and record catches of what have previously considered to be “El Nino” or subtropical water mass species (pelagic red crabs, lobster phyllosoma, a suite of never observed before were collected such as the slender snipefish, smalleye squaretails, pelagic stingray and the greater argonaut)

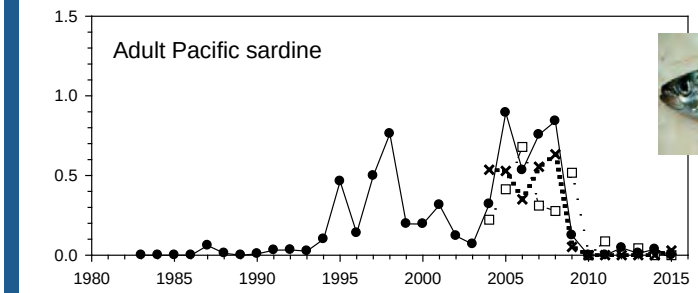


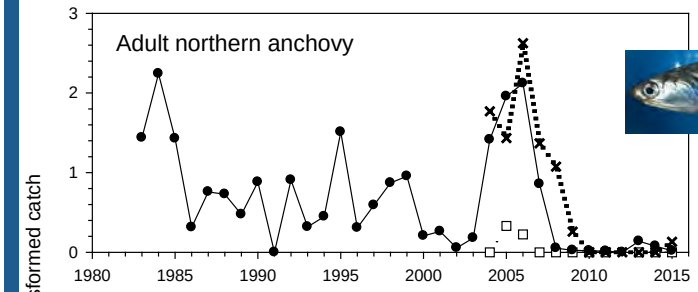

YOY rockfish
5
4
1
0
1980
1985
1990
1995
2000
2005
2010
2015

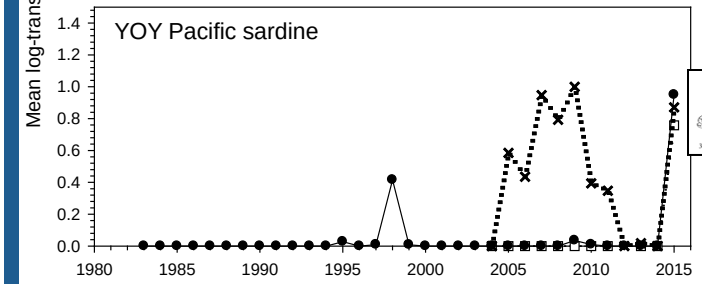

YOY Pacific hake
5
4
2
1
0
1980
1985
1990
1995
2000
2005
2010
2015

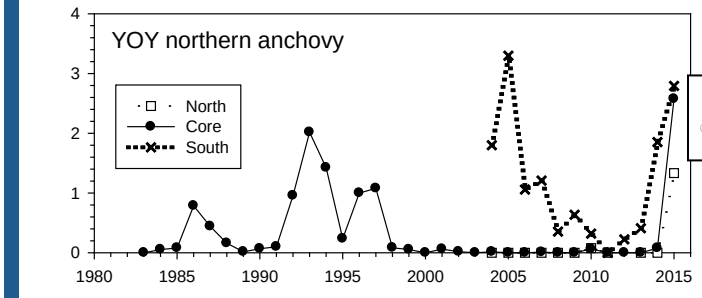

YOY Pacific sanddab
5
4
0
1980
1985
1990
1995
2000
2005
2010
2015

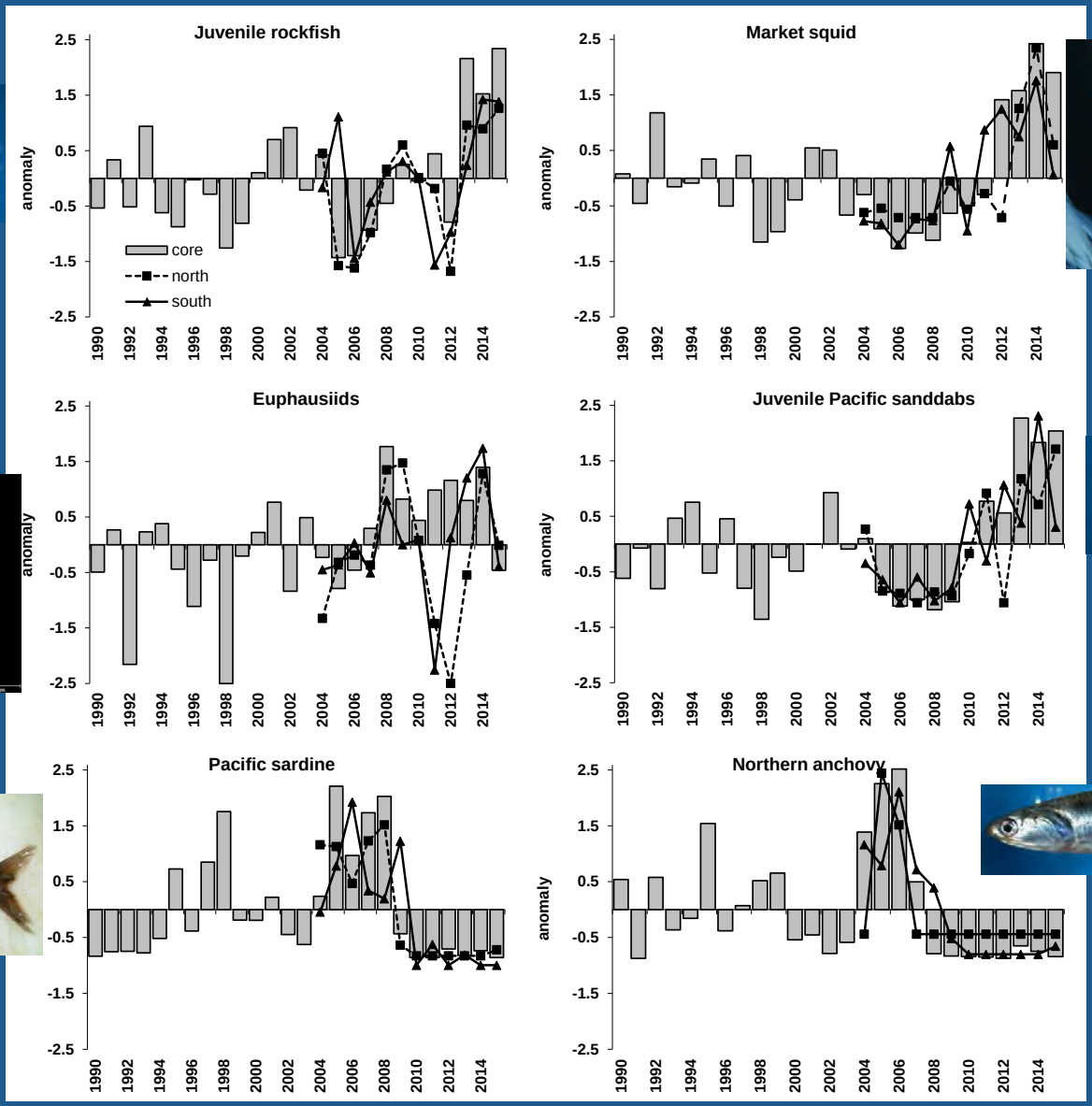

Market squid
6
5
North
Core
South
1980
1985
1990
1995
2000
2005
2010
2015
Year

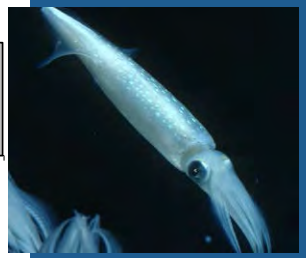

Adult Pacific sardine
1.5
1.0
0.5
0.0
1980
1985
1990
1995
2000
2005
2010
2015


Adult northern anchovy
3
2
1
0
1980
1985
1990
1995
2000
2005
2010
2015

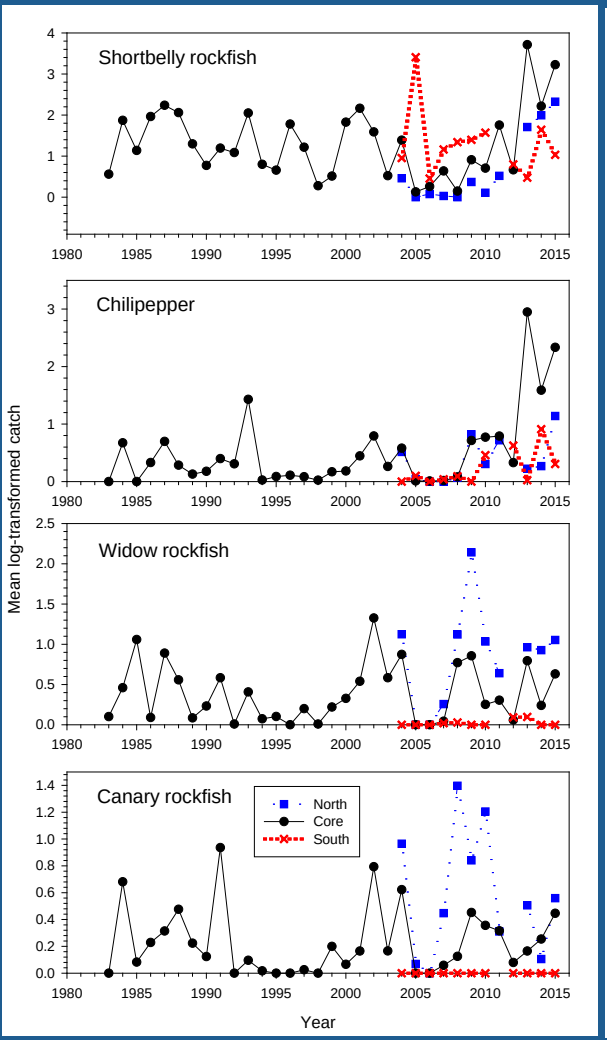

YOY Pacific sardine
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1980
1985
1990
1995
2000
2005
2010
2015

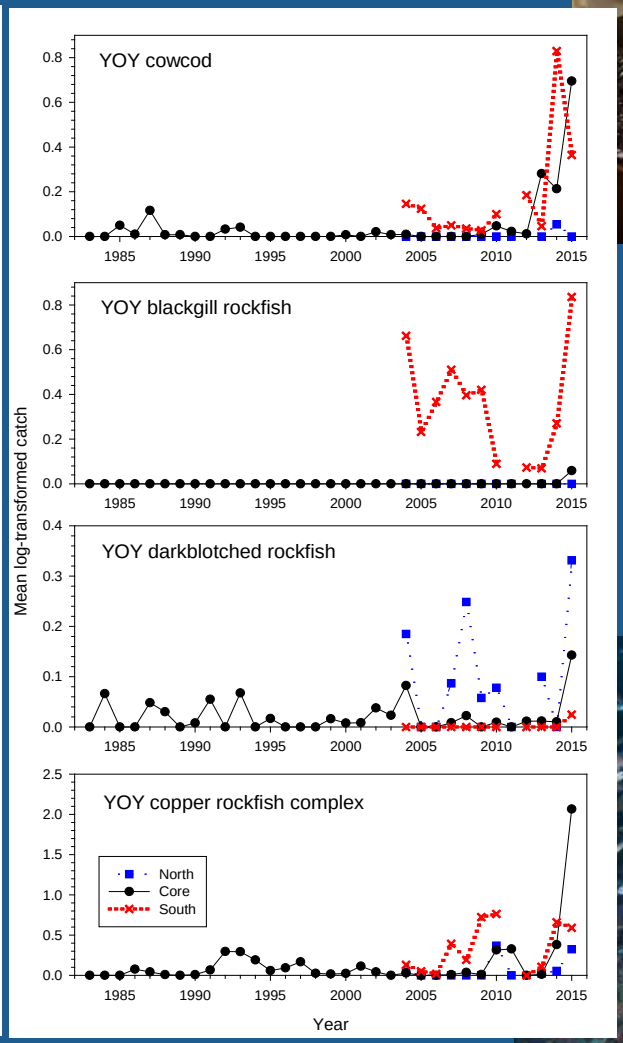

YOY northern anchovy
4
3
2
1
0
North
Core
South
1980
1985
1990
1995
2000
2005
2010
2015
Year


Juvenile rockfish
Market squid
Euphausiids
Juvenile Pacific sanddabs
Pacific sardine
Northern anchovy
anomaly
core
north
south
2.5
1.5
0.5
-0.5
-1.5
-2.5
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014



Young-of-the-year rockfish





Most at high, many at record high levels (left)- continuing a run of several strong years beginning in 2013- the 2013 year class already present in survey and fishery length and age data.

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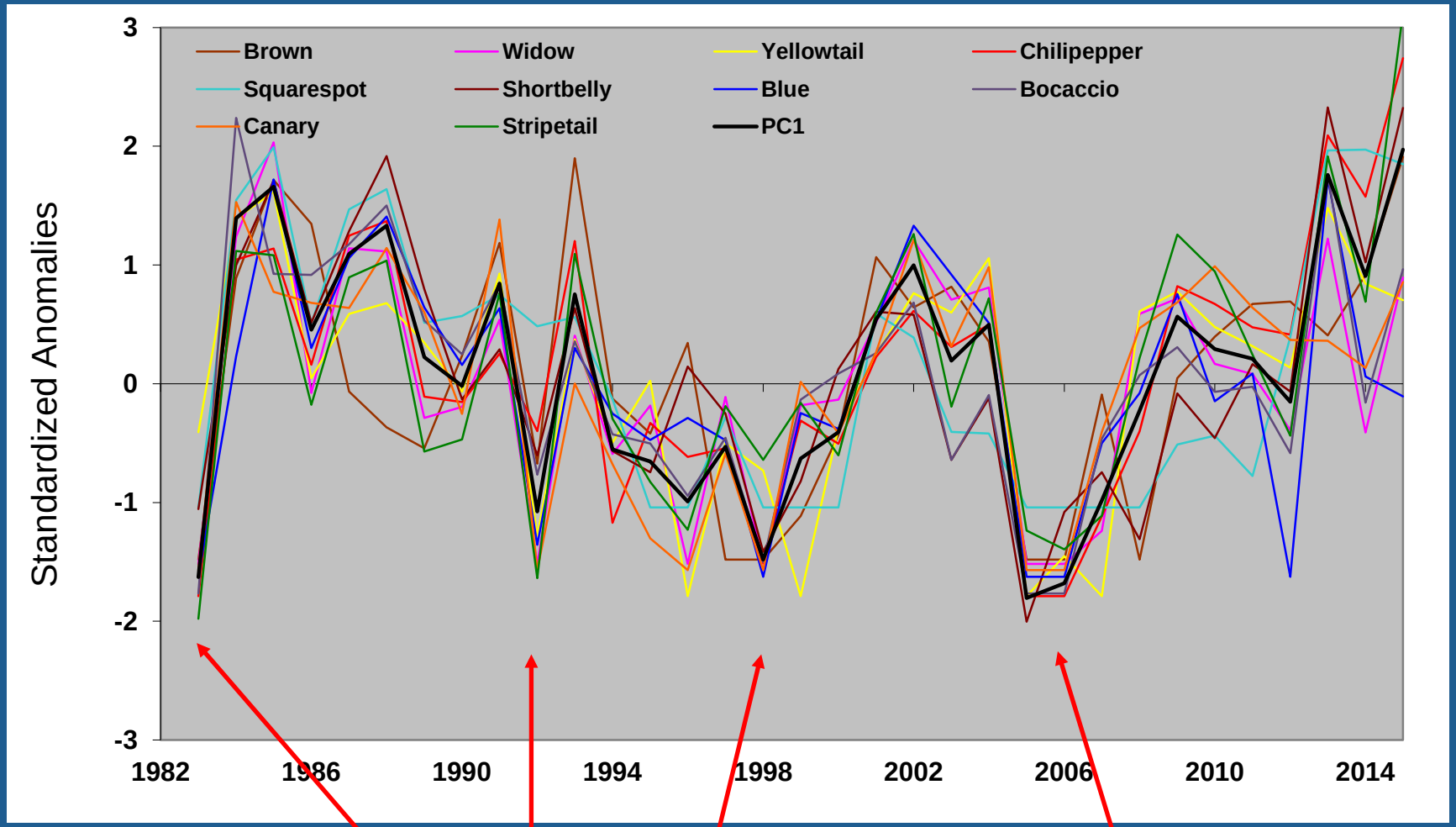
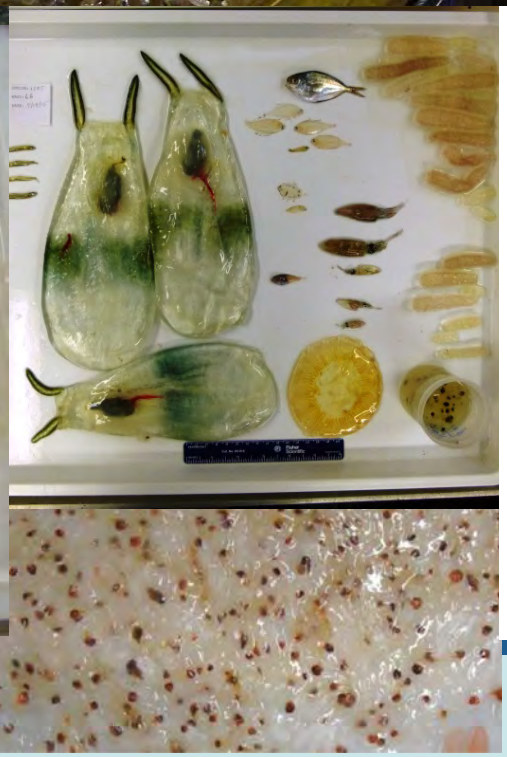
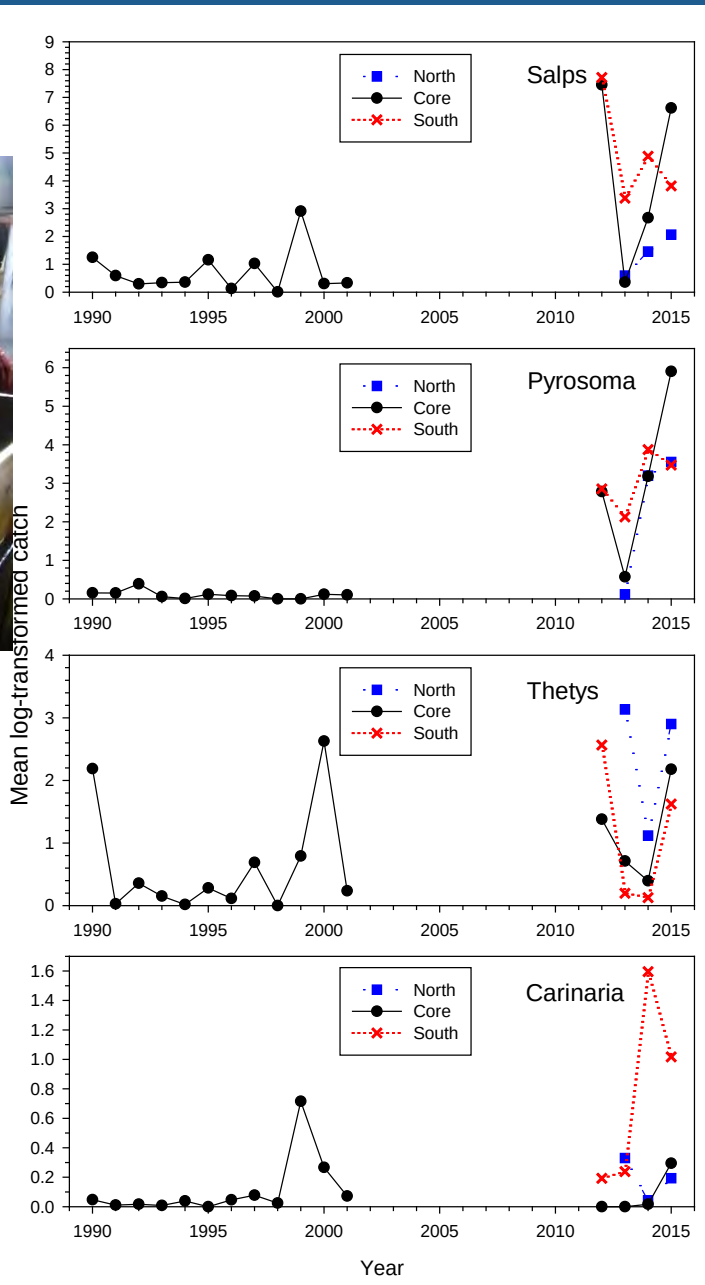
Standardized anomalies from Delta-GLM year effects for the ten most abundant species in the core area and updated PC1 from PCA (update of Ralston et al. 2013)

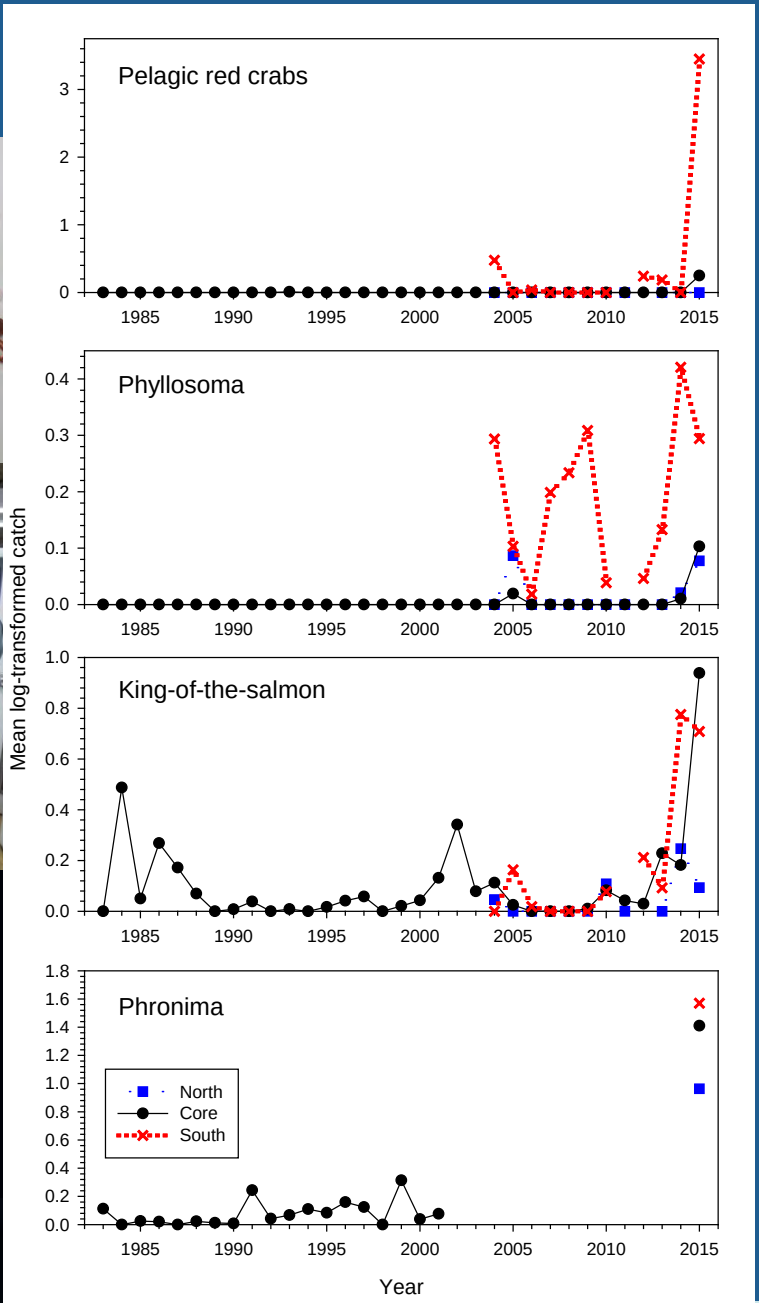


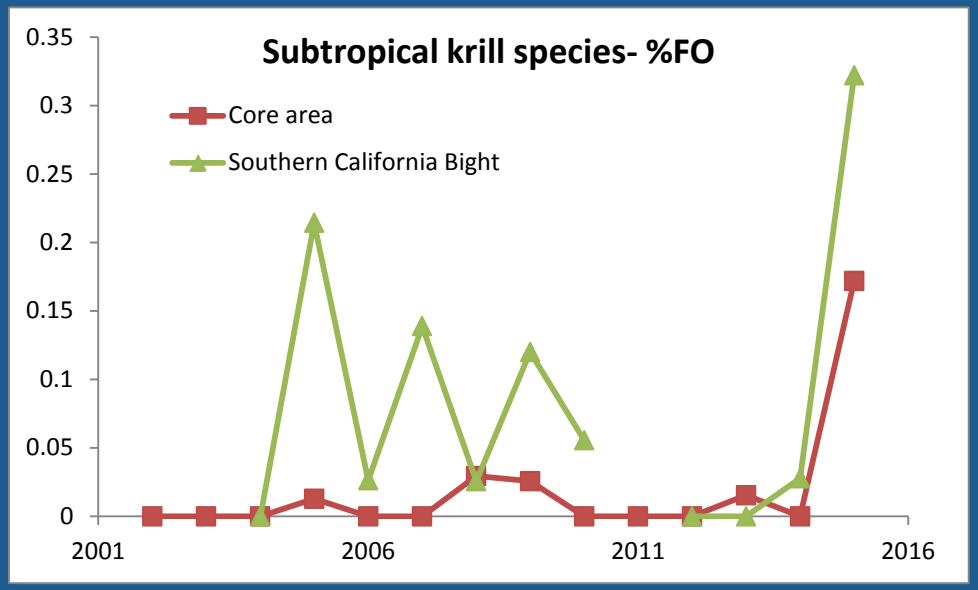
Gelatinous macrozooplankton





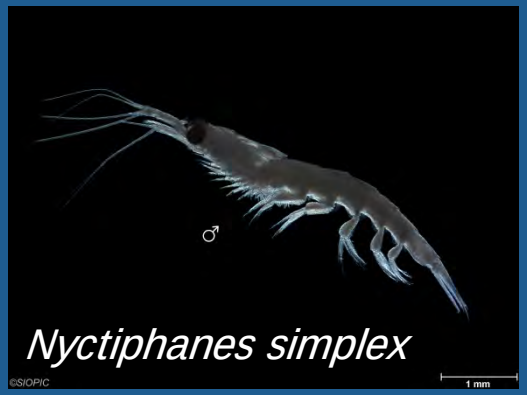
Warm water micronekton



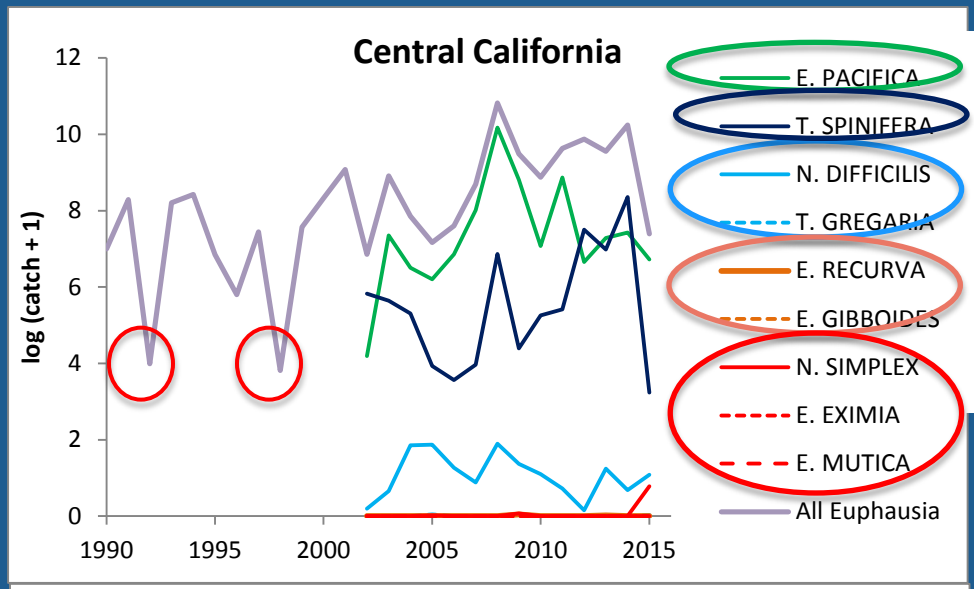


Krill

Although time series rather short, a much greater frequency of occurrence of subtropical species in 2015 (*Nyctiphanes simplex, Euphausia mutica, E. eximia,*).



Images from Scripps Institute of Oceanography Zooplankton Guide- https://scripps.ucsd.edu/zooplanktonguide/order/507



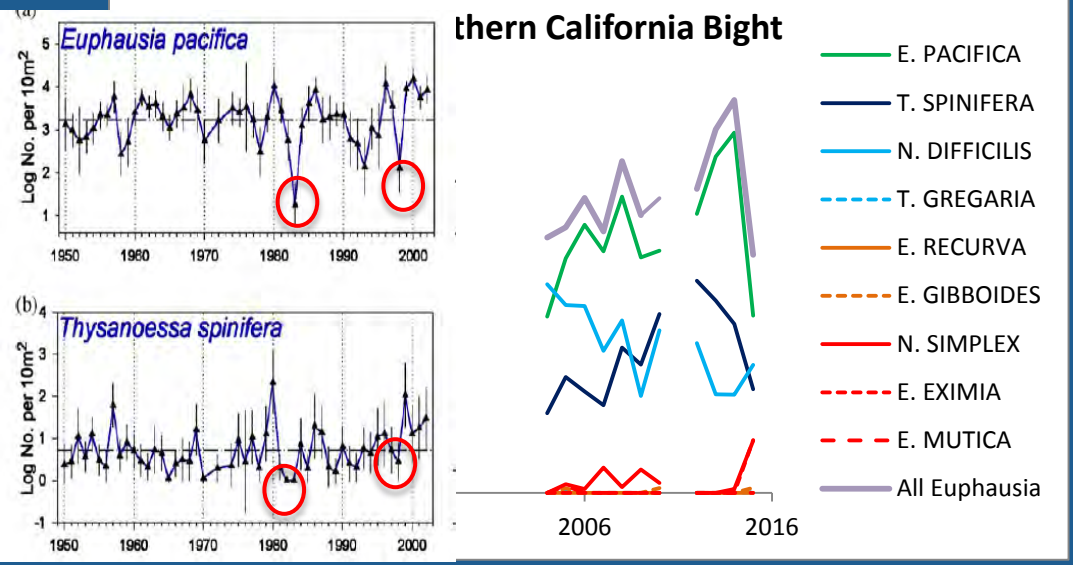
Cosmopolitan

Cold water, coastal

Transition-cool

Transition-warm

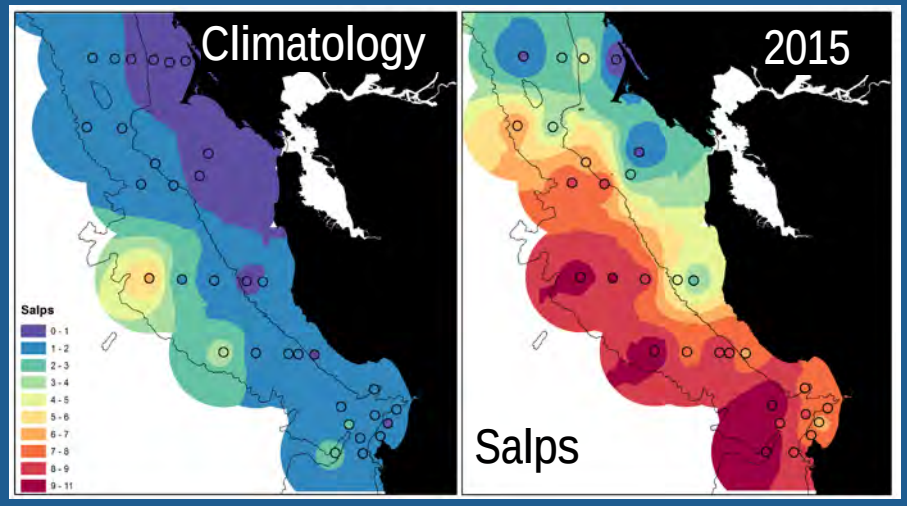
Subtropical

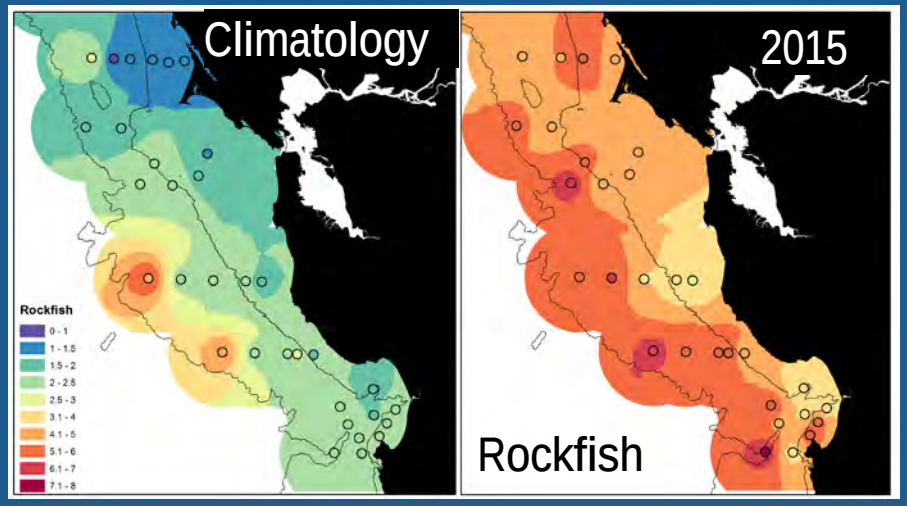


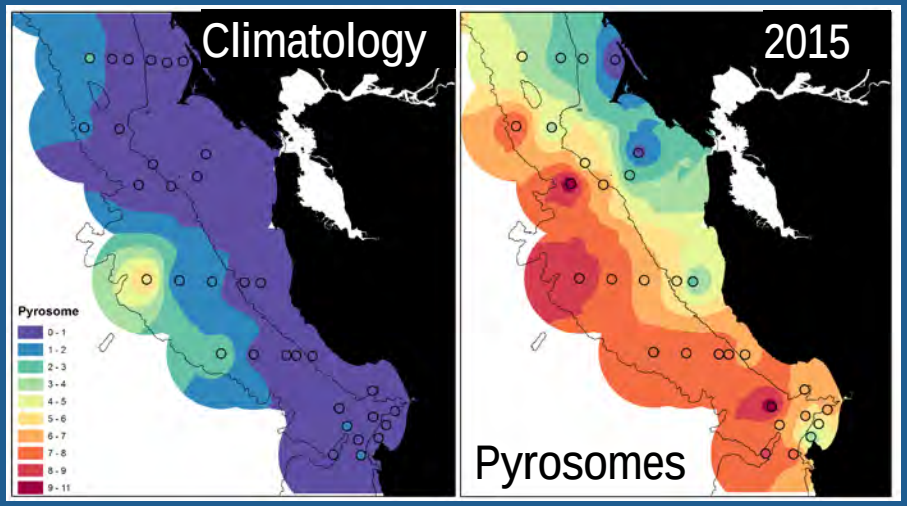
In past, the incursion of warm water species was often associated with declines in the abundance of the more abundant species (E. Pac and T. spin)- but this not *as* true in 2015, at least in the core survey area (low in south, but doesn't seem to be quite as relatively low as previous events based on Brinton and Townsend 2003).

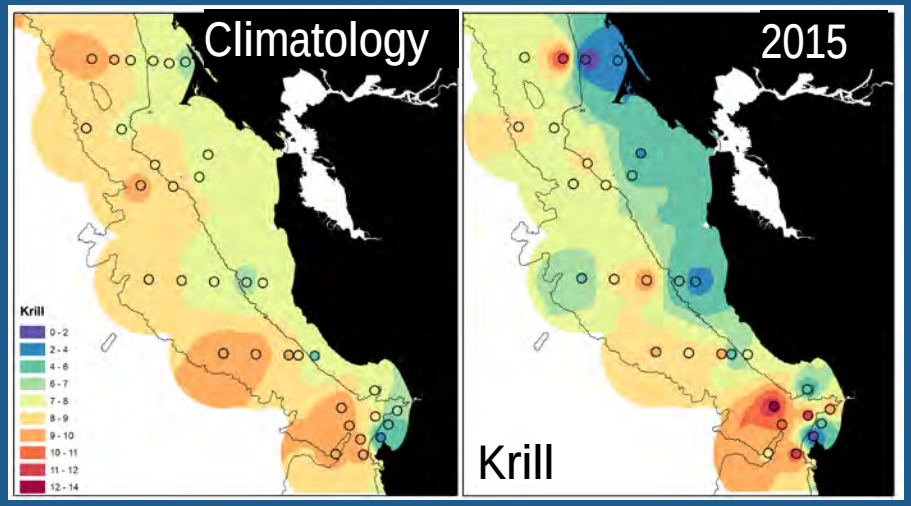
Note that 2014 and 2015 numbers still preliminary (10 ml subsample)

Spatial distribution patterns of key micronekton









Salp and Pyrosome abundance greatest offshore and at southern end of survey area, similar pattern with krill (positive spatial correlation not typical of most years)

"The Midwater Trawl Assemblage"

Twenty Taxa Occur in ≥ 10% of All Core area midwater trawls

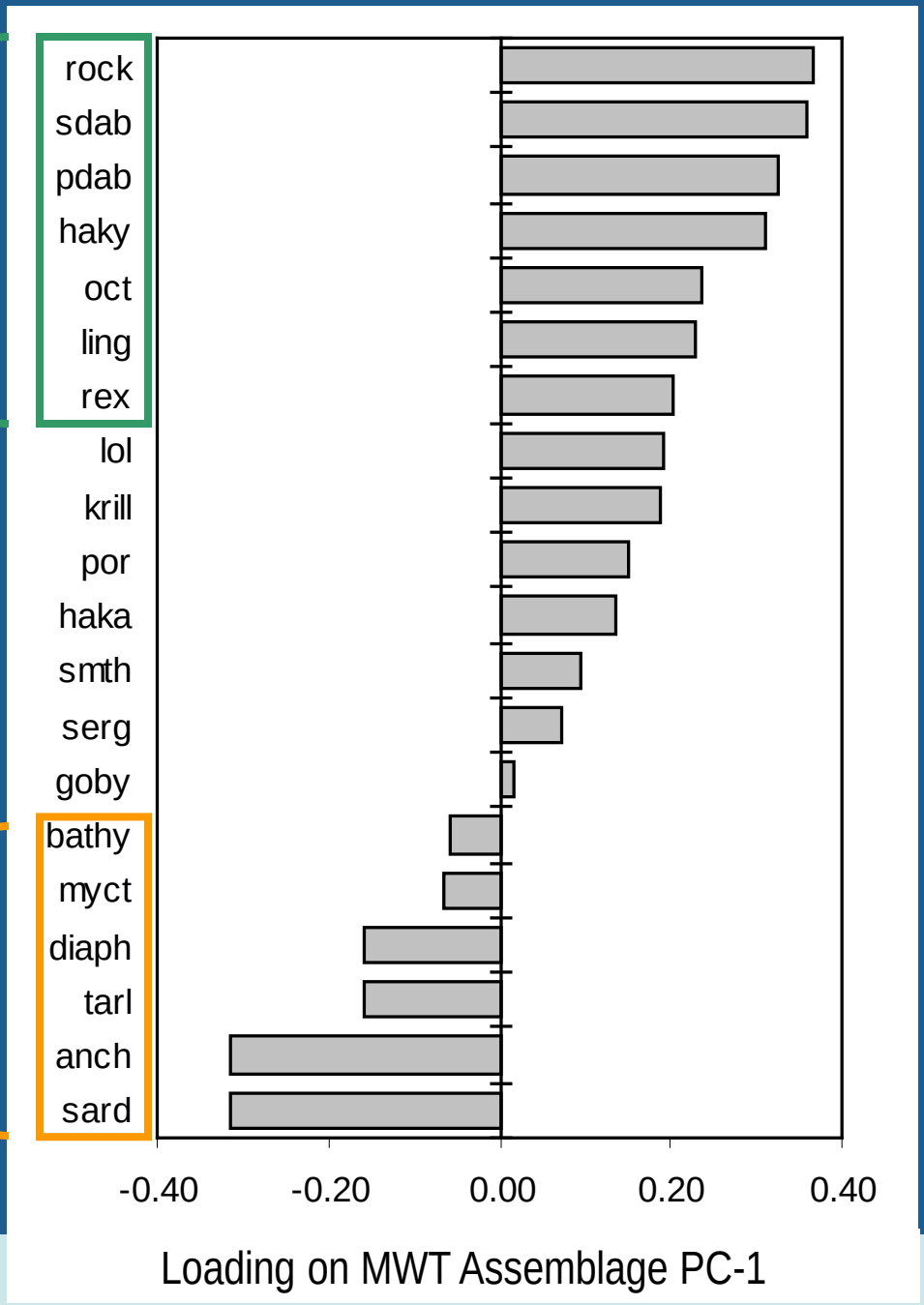
Rank	Common Name	Scientific Name	Ontogenetic Stage	Abbreviation	Frequency of Occurrence
1.	krill	Euphausiacea	U	krill	0.862
2.	rockfish	*Sebastes* spp.	Y	rock	0.719
3.	speckeled sanddab	*Citharichthys stigmaeus*	Y	sdab	0.613
4.	Pacific sanddab	*Citharichthys sordidus*	Y	pdab	0.573
5.	Pacific hake	*Merluccius productus*	Y	hakeY	0.561
6.	market squid	*Doryteuthis opalescens*	U	dory	0.489
7.	lanternfish	Mycthophidae	U	myct	0.343
8.	octopus	Octopoda	U	octo	0.268
9.	pelagic shrimp	Sergestidae	U	serg	0.252
10.	California smoothtongue	*Leuroglossus stilbius*	U	leur	0.226
11.	Pacific hake	*Merluccius productus*	A	hakeA	0.225
12.	northern anchovy	*Engraulis mordax*	A	anch	0.206
13.	rex sole	*Glyptocephalus zachirus*	Y	rex	0.191
14.	California headlightfish	*Diaphus theta*	U	diaph	0.173
15.	plainfin midshipman	*Porichthys notatus*	U	por	0.173
16.	blue lanternfish	*Tarletonbeania crenularis*	U	tarl	0.167
17.	lingcod	*Ophiodon elongatus*	Y	ling	0.165
18.	goby	Gobiidae	U	goby	0.152
19.	Pacific sardine	*Sardinops sagax*	A	sard	0.148
20.	deep-sea smelt	Bathylagidae	U	bath	0.144

Updated from Ralston et al. 2015

YOY groundfish

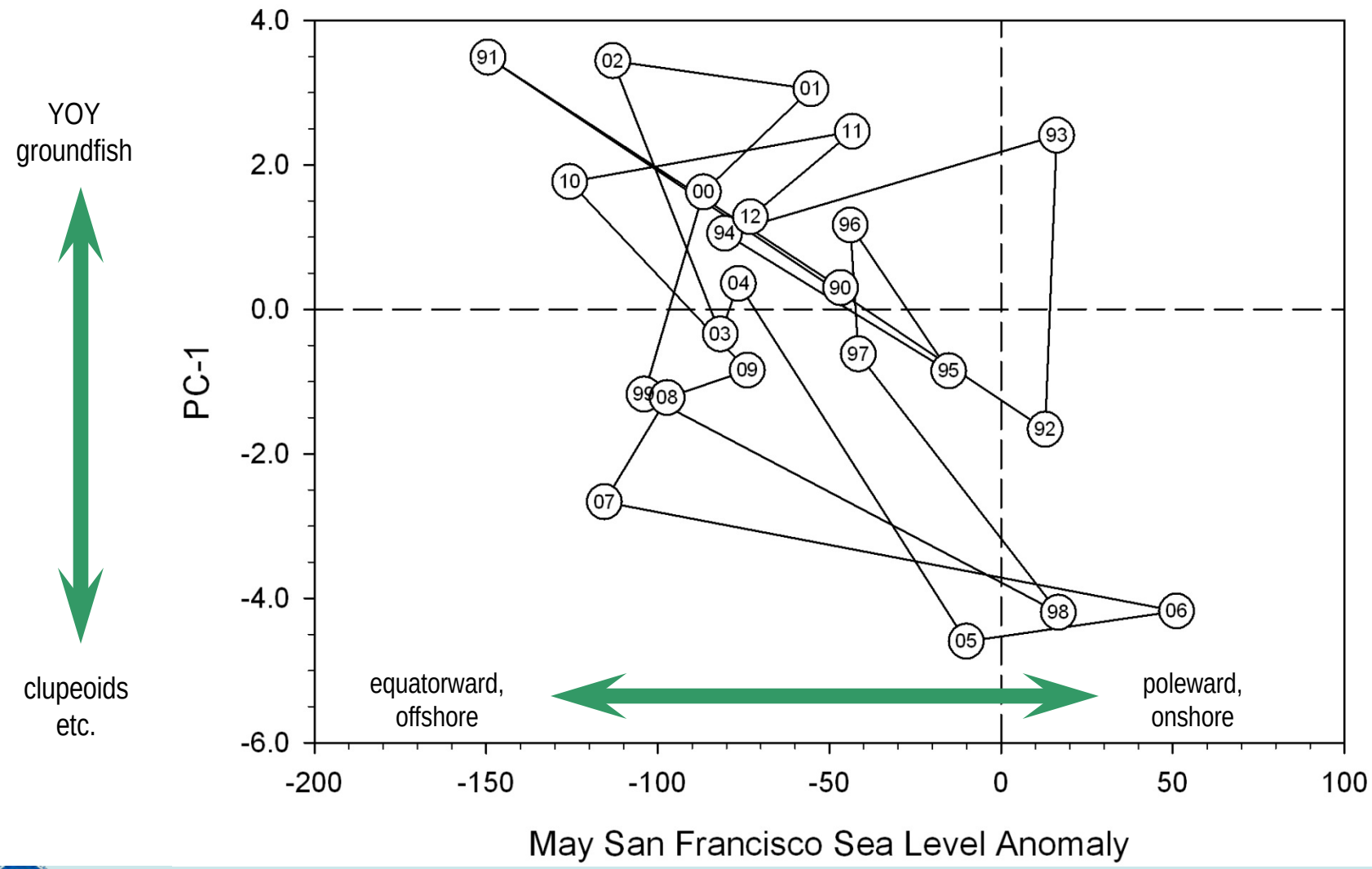
The Dominant Signal Distinguishes Two Alternative States

Scattering Layer & Clupeoids



PC	Eigenvalue	Proportion Variance	Cumulative Variance
1	5.73	29%	29%
2	3.93	20%	48%
3	2.44	12%	61%

As with the rockfish index, local sea level anomalies are related to the species composition of the forage community



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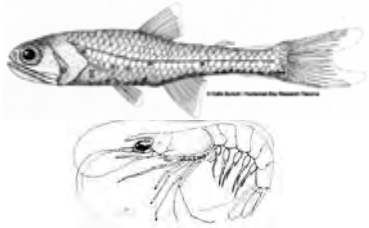
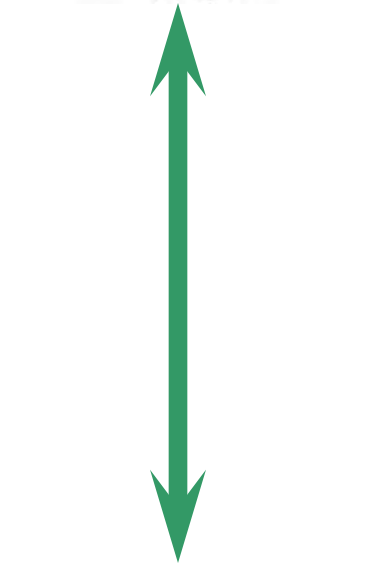
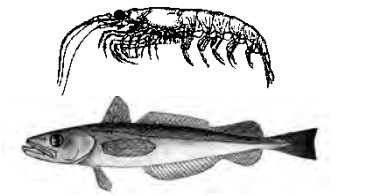
Basin-Scale processes are also important

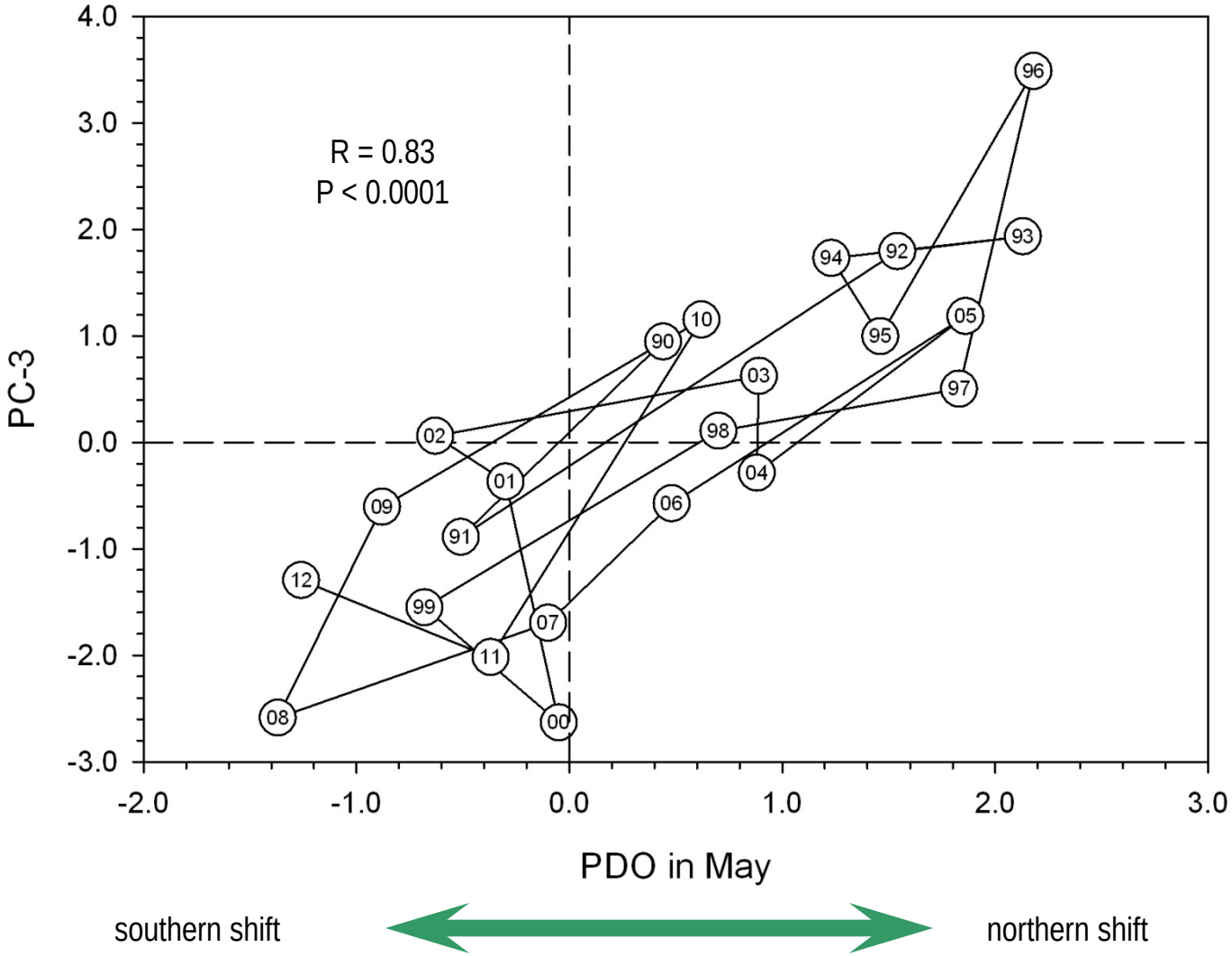
myctophids, sergestids





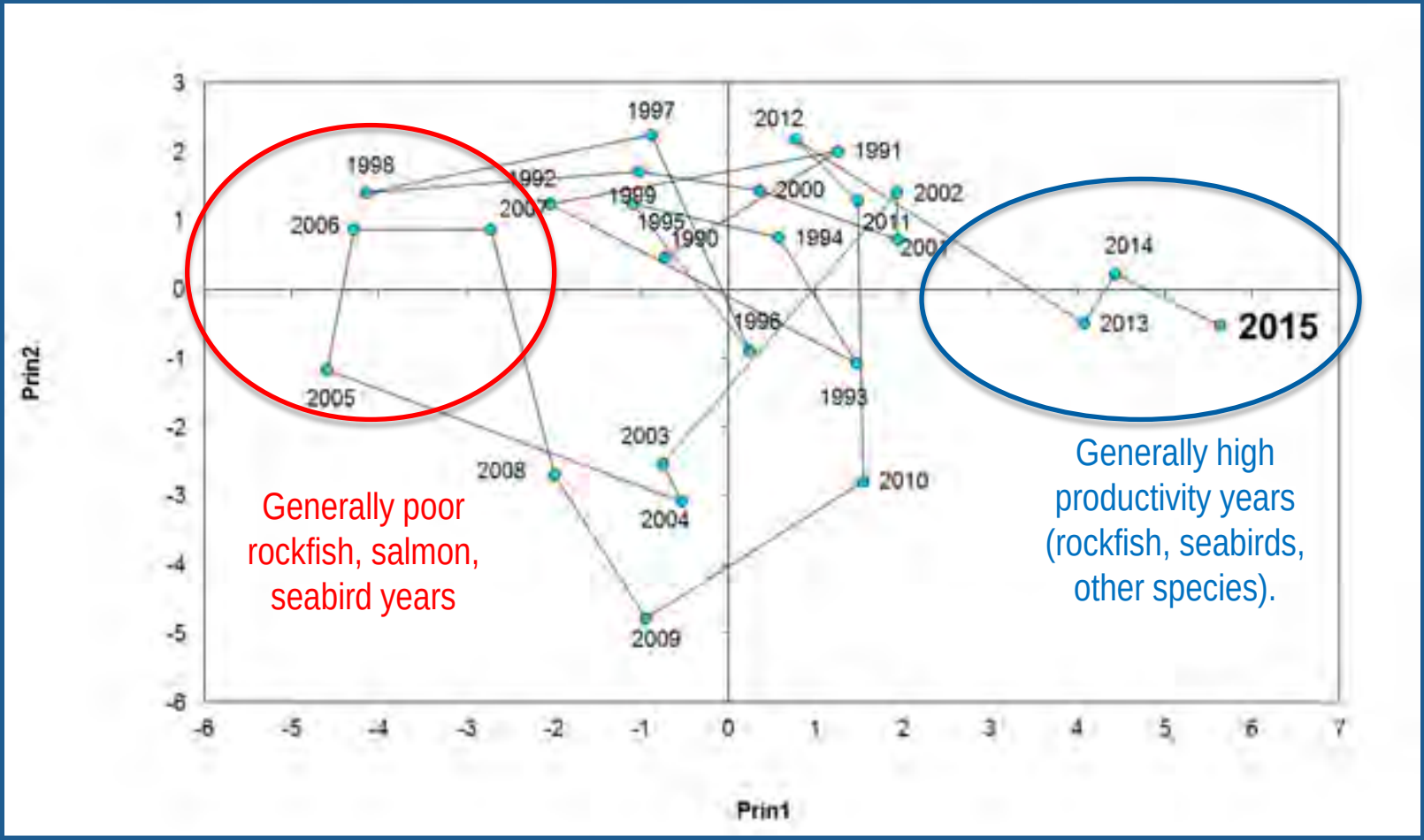


krill, adult hake

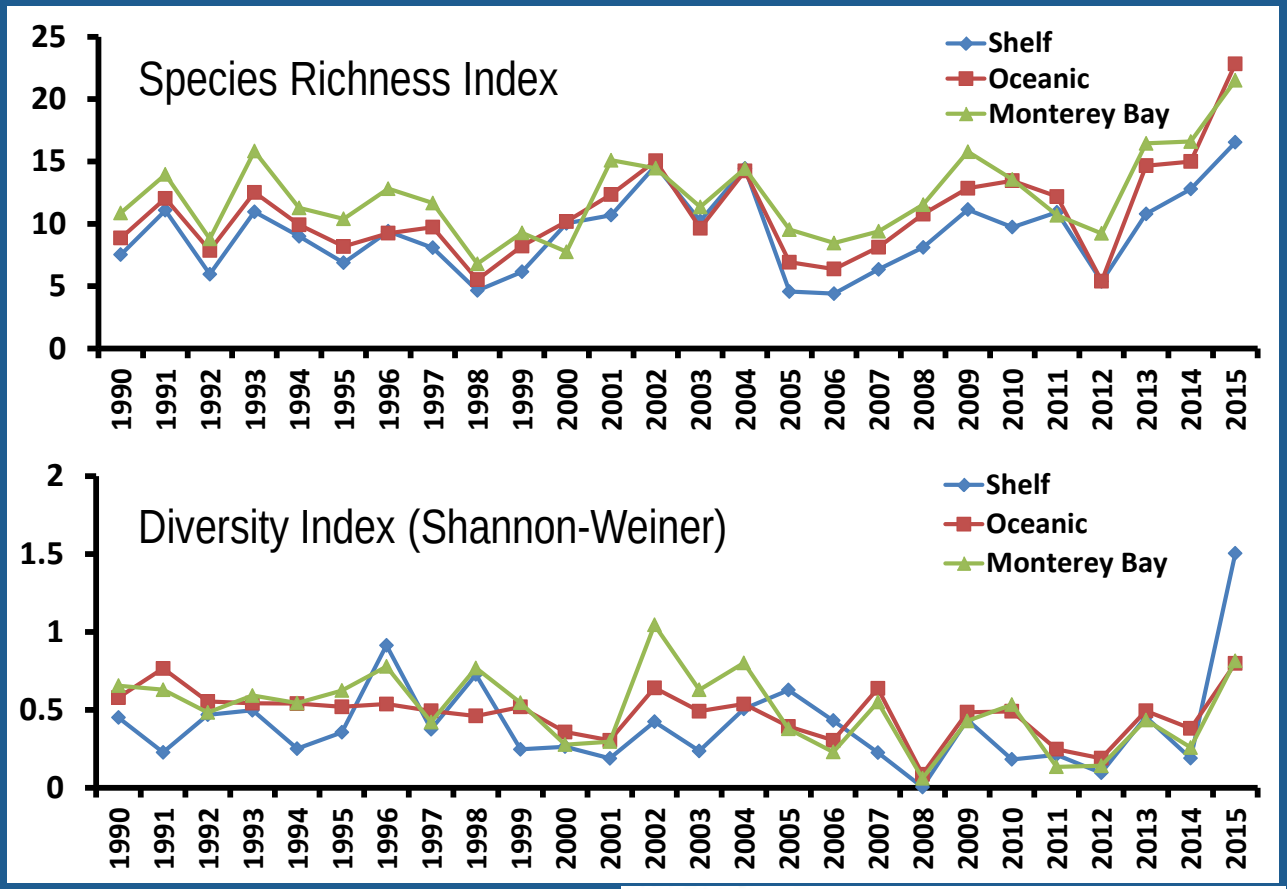


southern shift

northern shift



Strongly loading positive years on PC1 tend to be good recruitment years for rockfish and other groundfish, often with high seabird reproductive success, while strong negative loadings tend to be low productivity years for those same species.



Indices of species richness and biodiversity-

Record high levels of both observed in 2015!
Work in progress as part of a Marine Biodiversity Observation Network (MBON) effort.

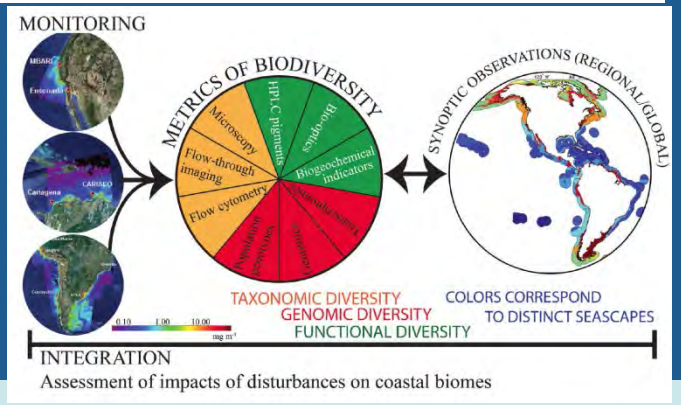


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Photo: C.Field, Marine Mammal Center

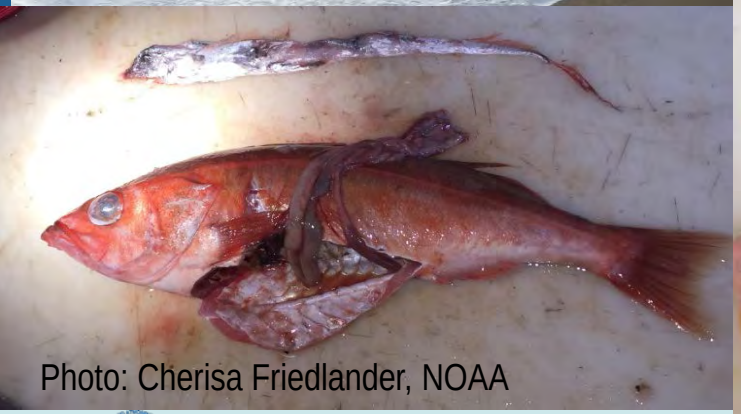

Photo: Cherisa Friedlander, NOAA

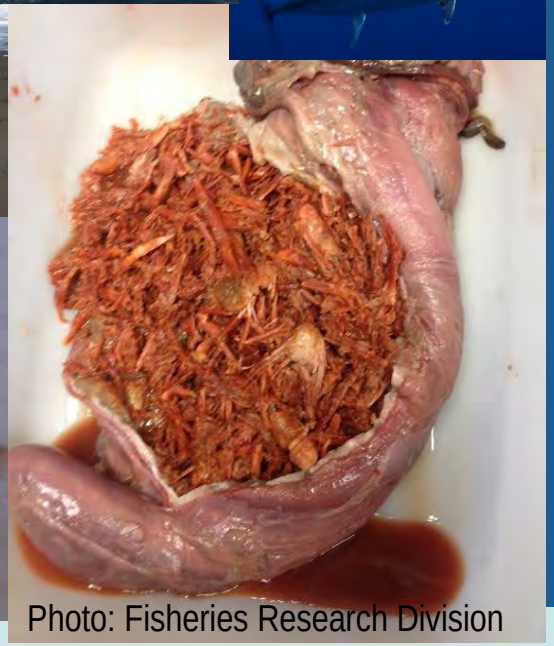

Photo: Fisheries Research Division

Although many things were abundant, forage base was either different or toxic for many predators-.

Lots of predation on atypical prey (salps, red crabs, king-of-the-salmon) by fishes, while declines in coastal pelagic species seems to be contributing to impacts on higher TL predators (over 80 stranded yearling Guadalupe fur seals, record number of California sea lion pups, with an earlier start to strandings)

Major fisheries closures (Dungeness crab, razor clam) in response to massive toxic algae (Pseudo-nitzschia) bloom, which is also implicated in record numbers of whale strandings and deaths.

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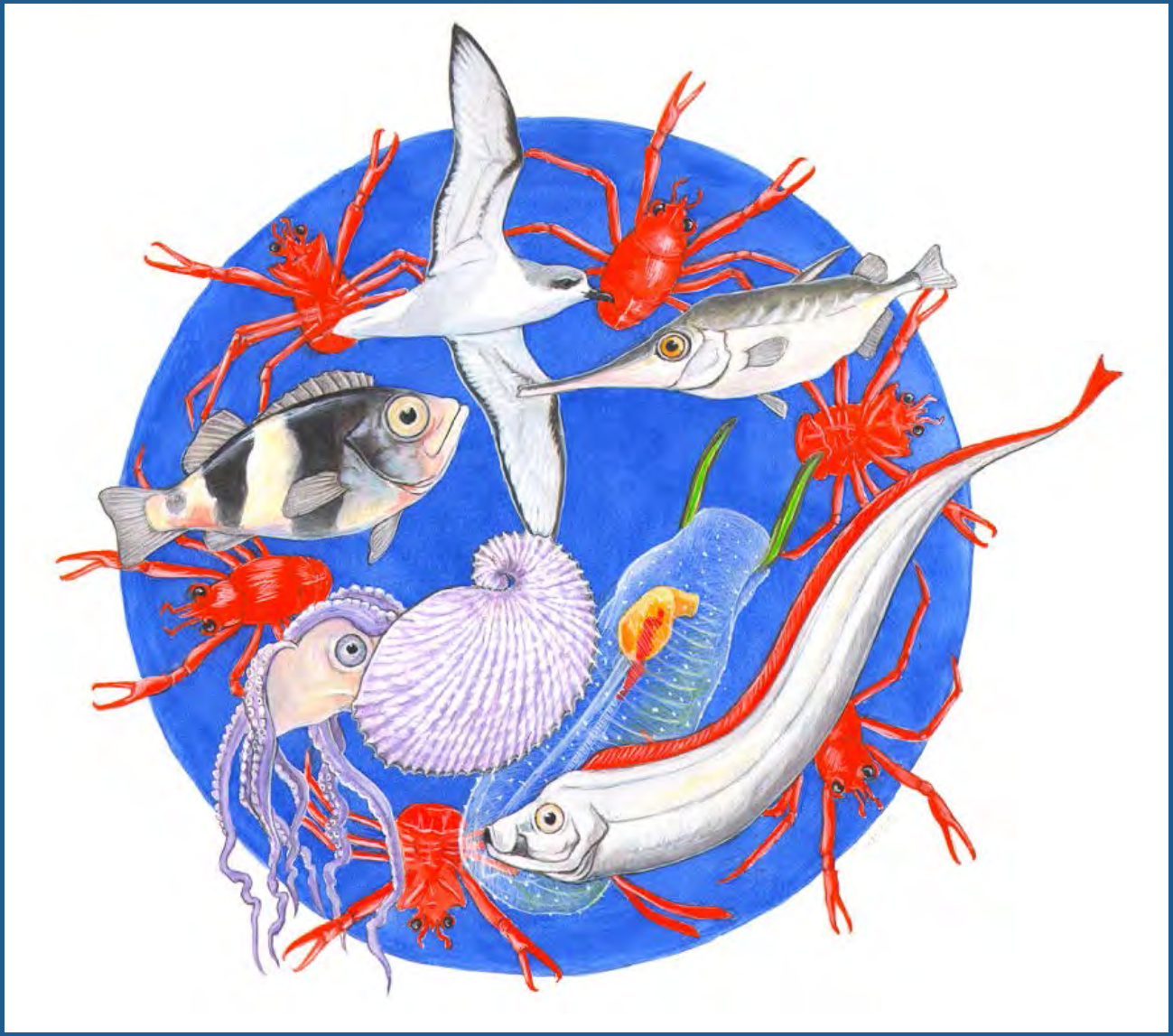
Summary

- Through sampling of past ENSO cycles, some predictable changes (and declines) are often observed, associated with a shift from equatorward to poleward transport, but despite the strong warming, impacts on productivity and abundance were not observed in 2014-15
- Instead, signature El Nino species were present along with a convergence of northern, southern, nearshore and offshore species- all at high abundance
- Some climate change predictions are for a northward shift in the distribution of upwelling centers (Rykaczewski et al. 2015), which could lead to greater declines in upwelling and productivity in the Southern California Current
- If so, 2015 food web might be a harbinger of what is to come- a complex mix of communities and food webs. This might increase diversity, but what will it do to ecosystem structure, function and productivity??



A Sophie Webb original design.