IEA State of the California Current Ecosystem Reports:

Indicators of Ecological Components

Dense schools of fishes form over a coral and sponge community in the Cordell Bank National Marine Sanctuary. (NOAA)

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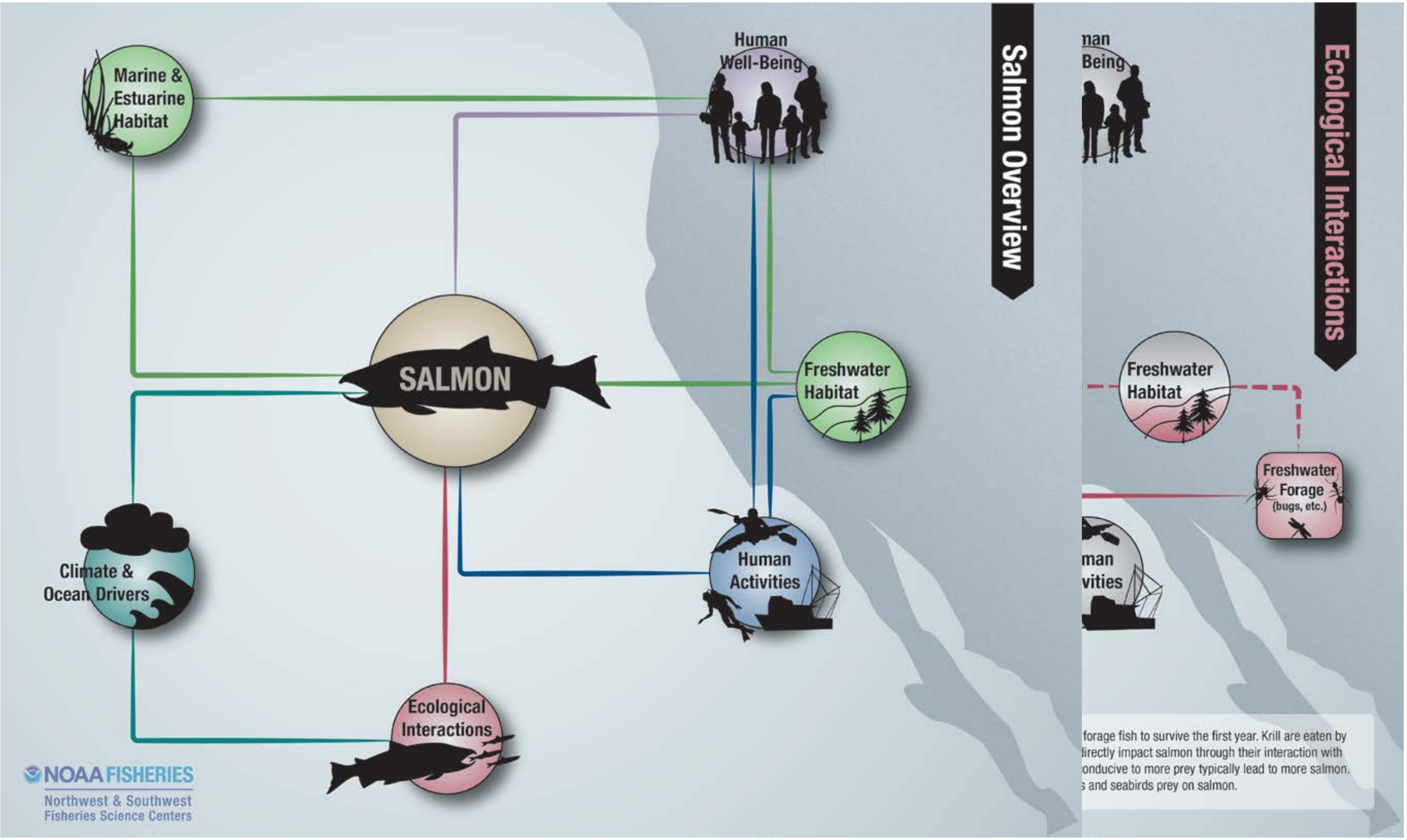
With support from the entire NOAA California Current IEA Team

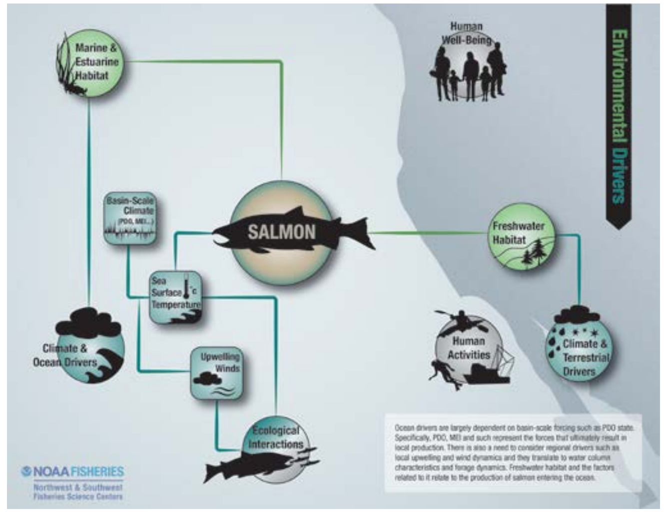
CCIEA Toolkit: Conceptual models



Credit: Su Kim, NOAA

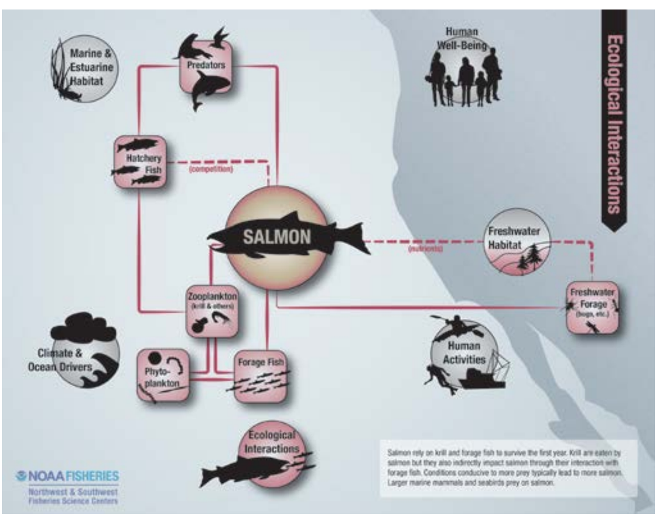
CCIEA Toolkit: Conceptual models

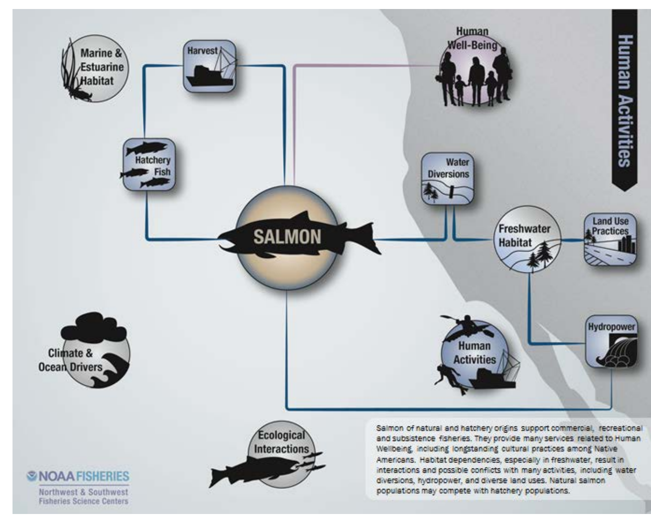
Environmental Drivers



Ecological Interactions

Human Activities





Interpreting time series plots

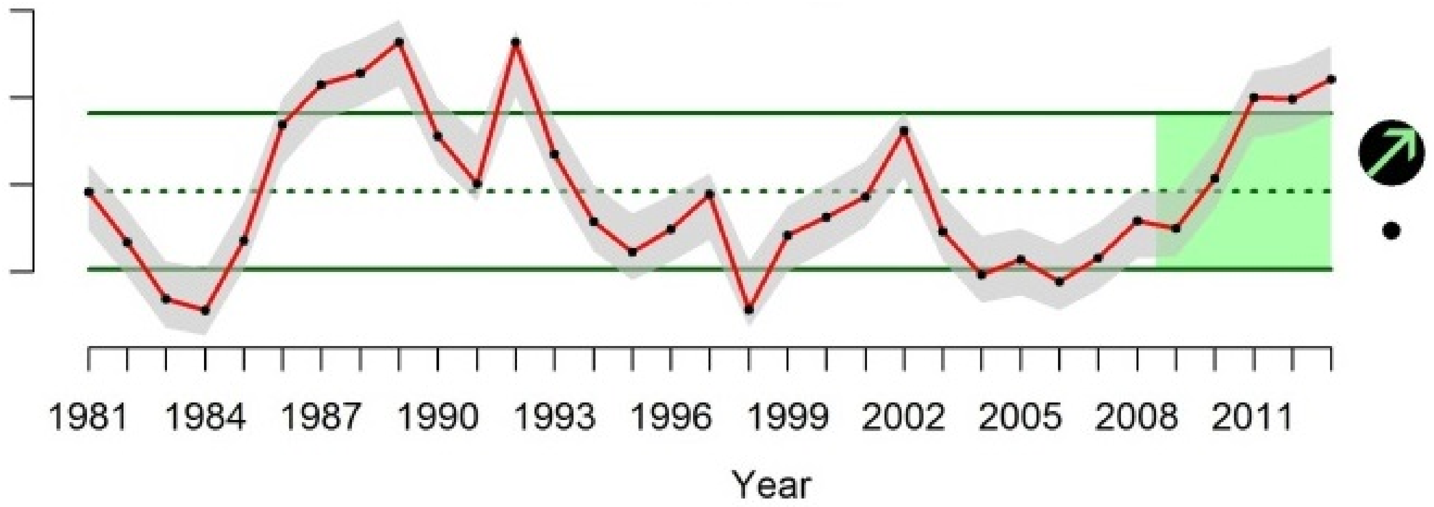
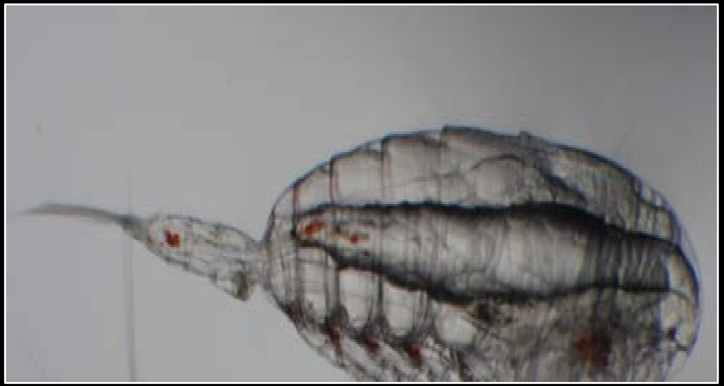


Figure 1.1: Sample time series plot. Horizontal lines show the mean (dashed line) ± 1.0 s.d. (solid lines) of the full time series. Symbol at upper right indicates whether data over the last 5 years (green shaded region) had a positive trend (↗), a negative trend (↘), or no trend (↔). Symbol at lower right indicates whether the mean over the past 5 years was greater than (+), less than (–), or within 1 s.d. (•) of the mean of the full time series. Data points are annual means with 95% confidence intervals, generated by a Multivariate Auto-Regressive State Space (MARSS) model (gray shaded region).

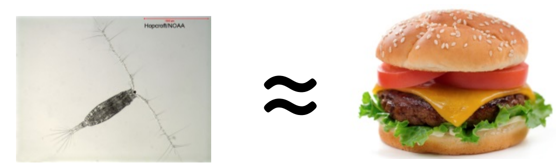


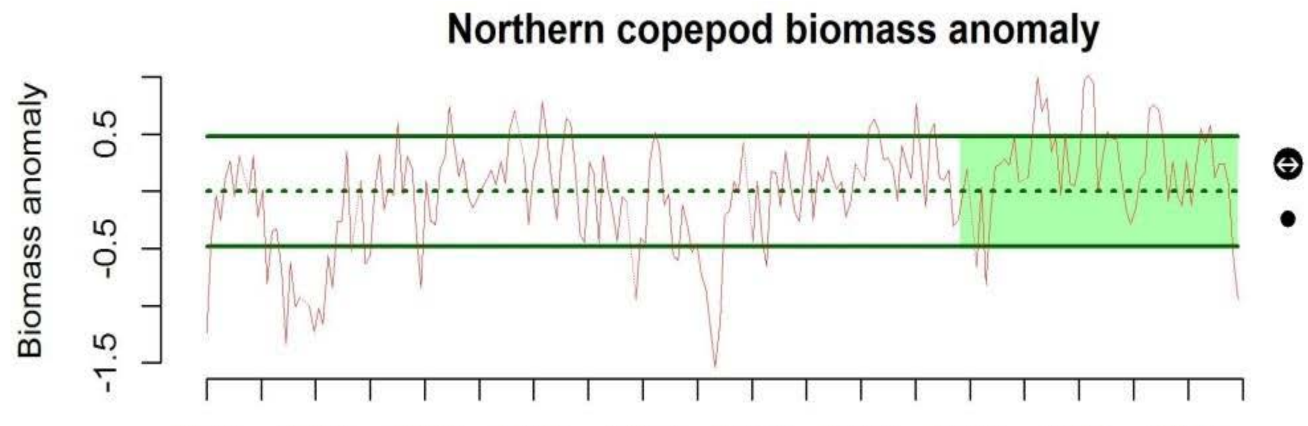
Calanus marshallae, *one of the "northern copepod" species found in the California Current. (Jennifer Fisher, NOAA)*

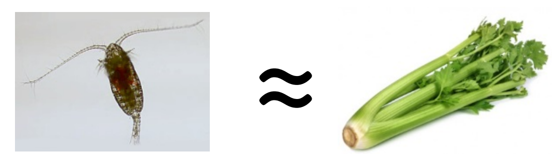
The plankton community

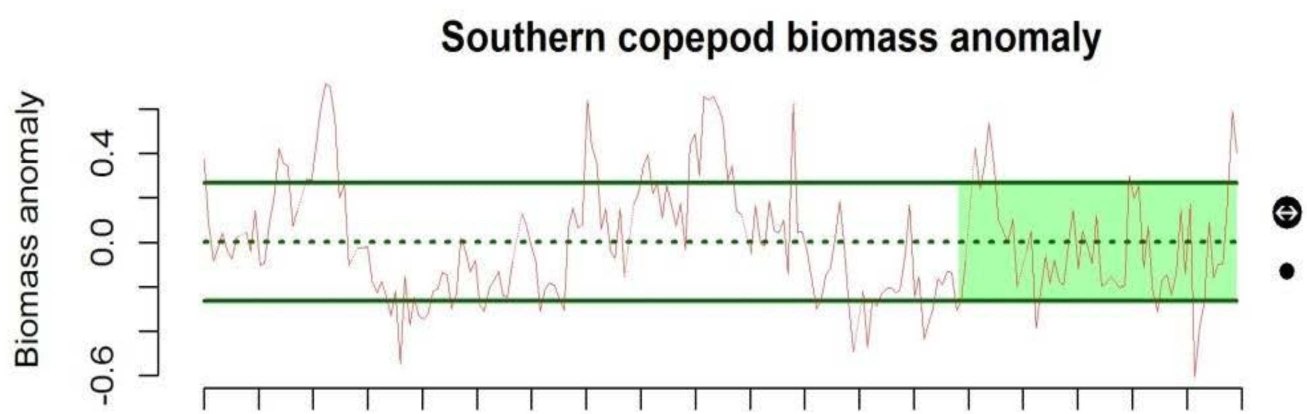
Copepod biomass anomalies

- **Depict abundance of different classes of copepods**
- **"Northern" copepods are rich in lipids; associated with cooler waters, negative PDO signal**
- ***Northern copepods are better fish prey***
- **"Southern" copepods are less fatty; associated with warmer waters**
- **Periodic major shifts consistent with regime changes (e.g., late 2014)**









Copepod biomass anomalies

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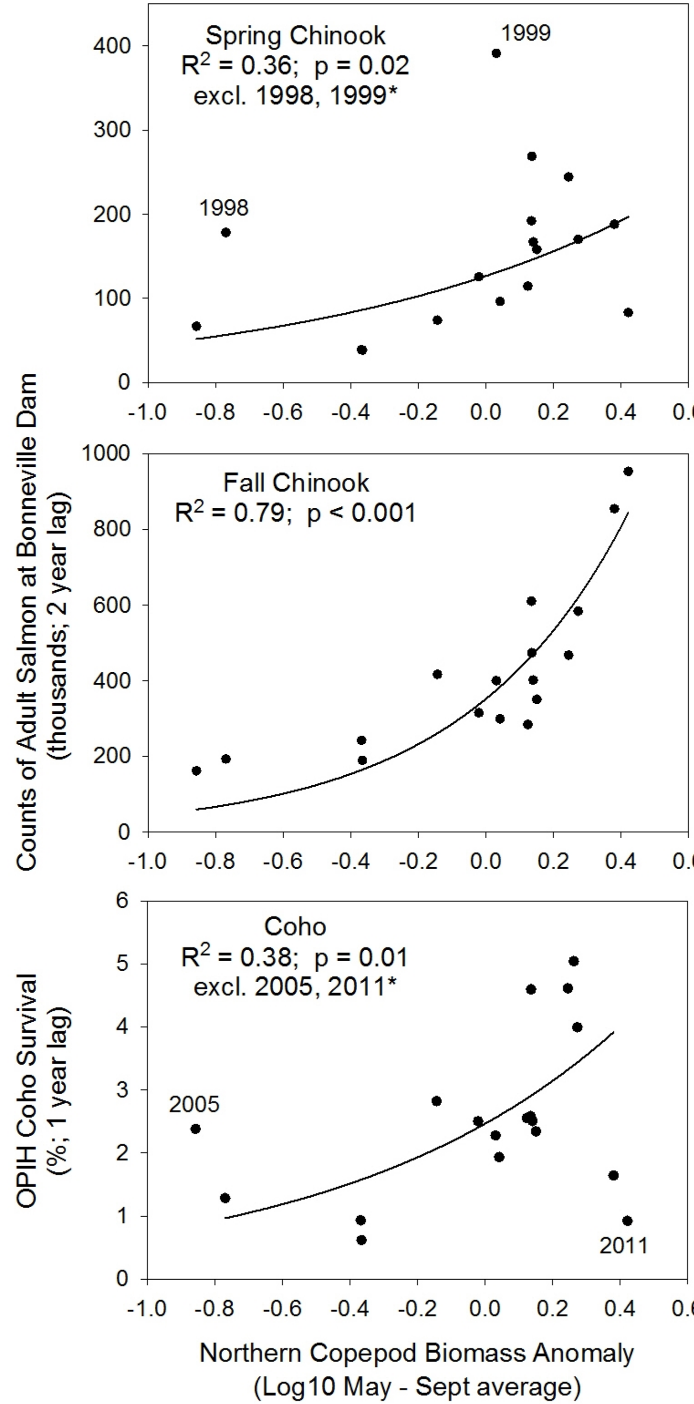
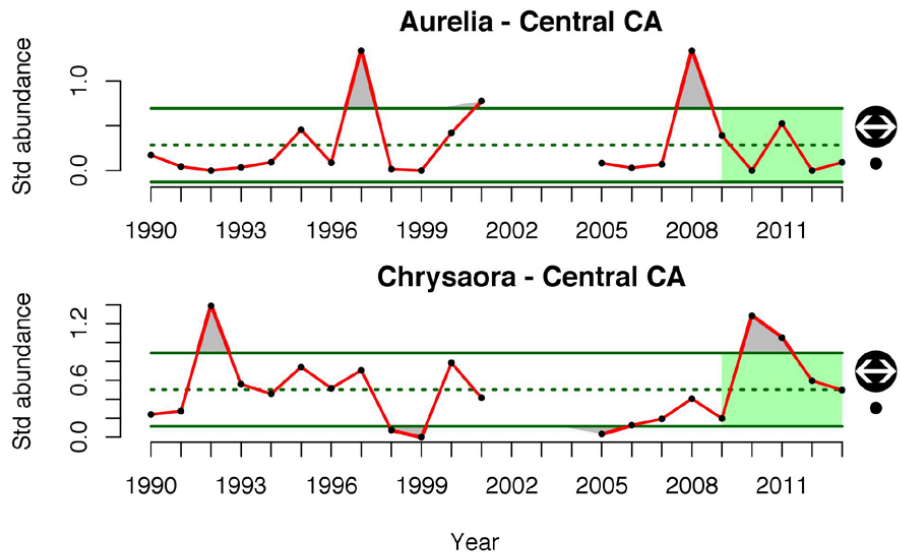
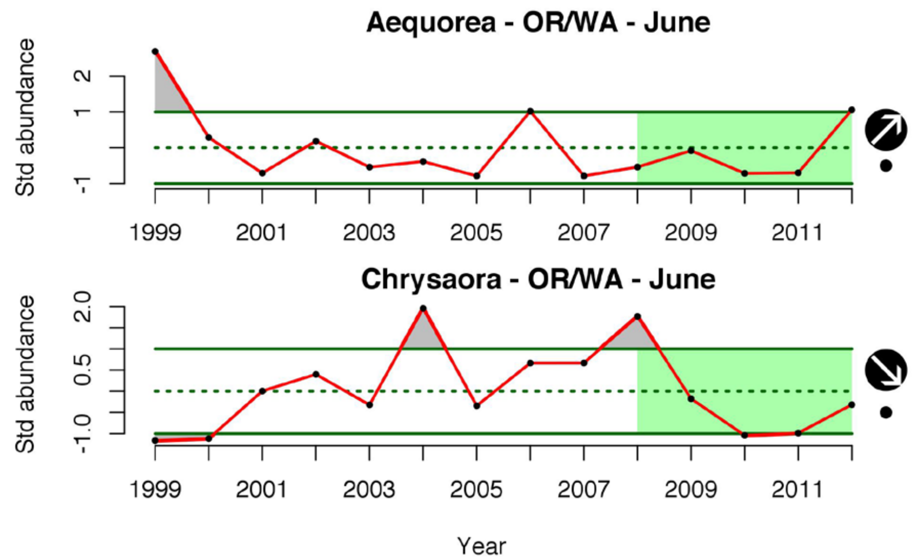
- **Value of indicator is its relationship to fish production off Newport area, e.g., to lagged salmon returns to Bonneville Dam (data from Bill Peterson, NOAA)**



Other plankton community indicator options

- Total zooplankton biomass (somewhat less info than the copepod biomass anomalies)
- Euphausiid biomass & species richness (data availability and quality are issues)
  - Maps of hotspots being evaluated
- Jellyfish abundance from CA, OR & WA
  - Longer time series from CA, with a break in the middle
  - June and September surveys from OR & WA



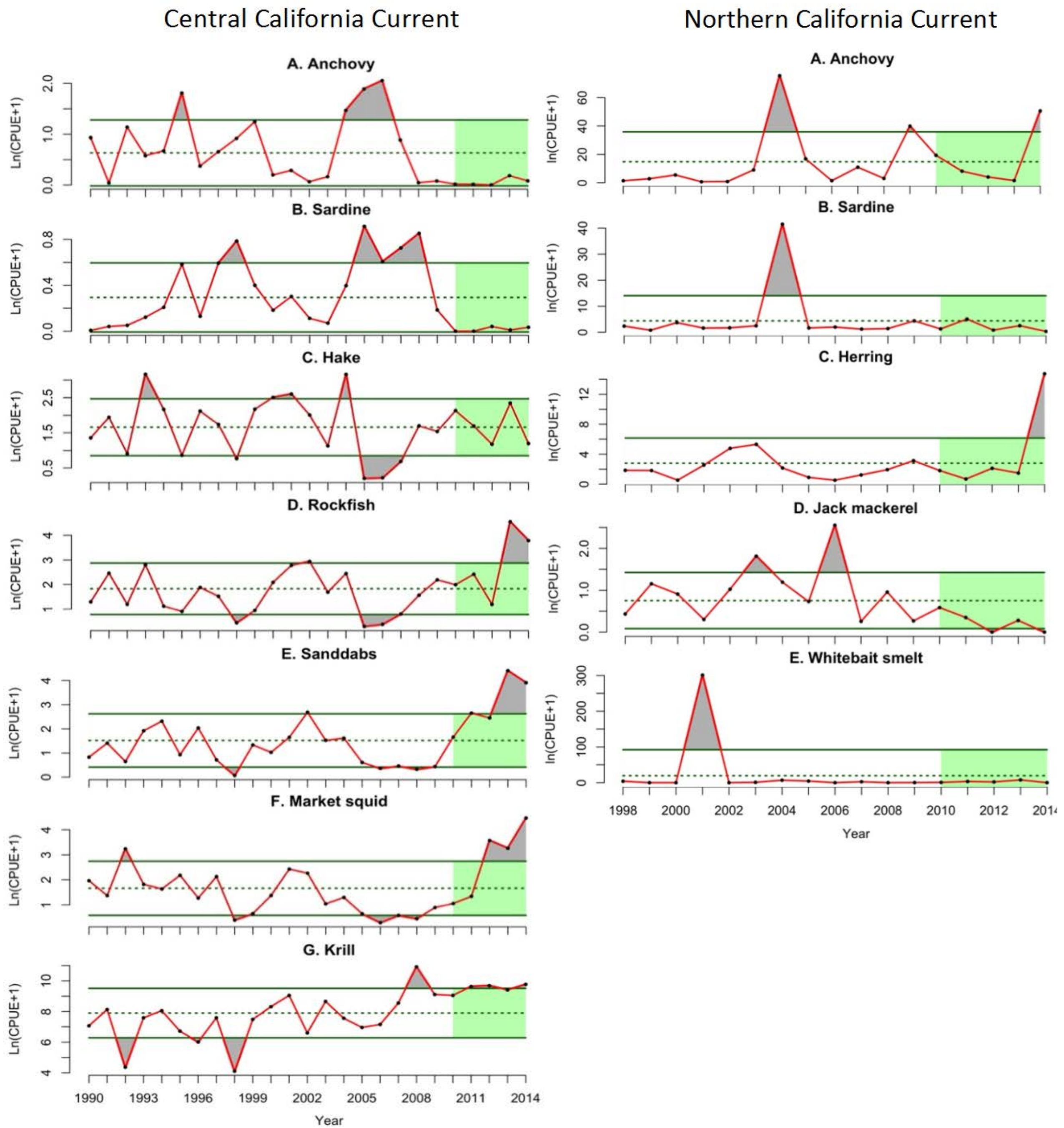


Larval market squid captured in the CalCOFI region. All individuals are less than 5 mm long. (NOAA)

The forage community

Forage availability

- NOT the same as "CPS abundance"; relative measures of CPUE, not assessment results
- This is forage available to predators
- Largely juveniles or YOY of finfish groups
- Different methods in the two regions sampled

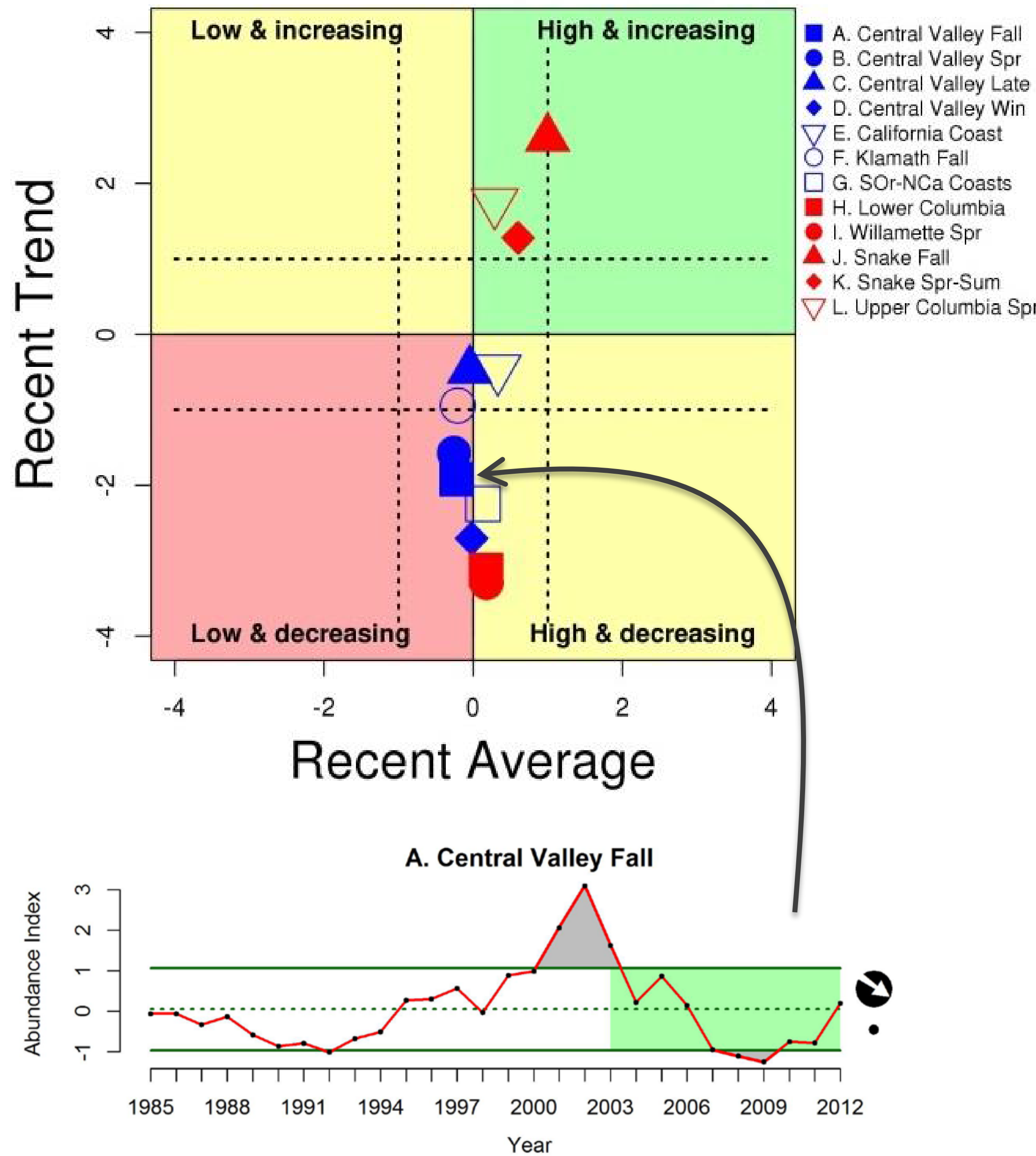


Chinook salmon on spawning grounds. (NOAA)

Salmon

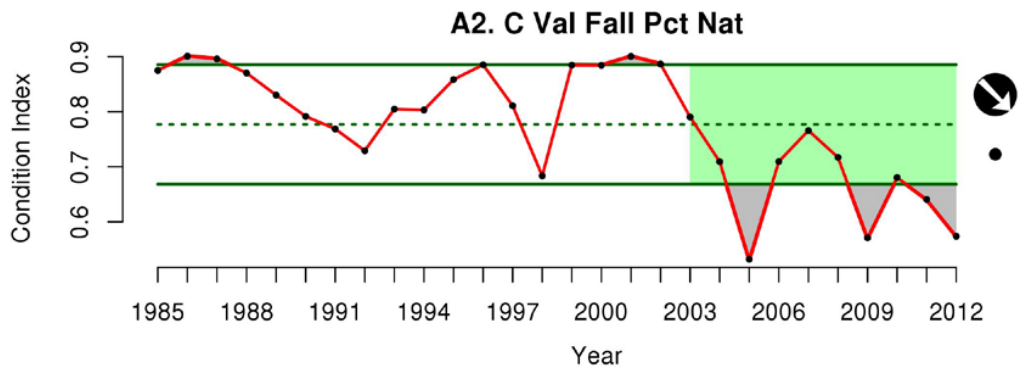
Chinook salmon escapement status and trends

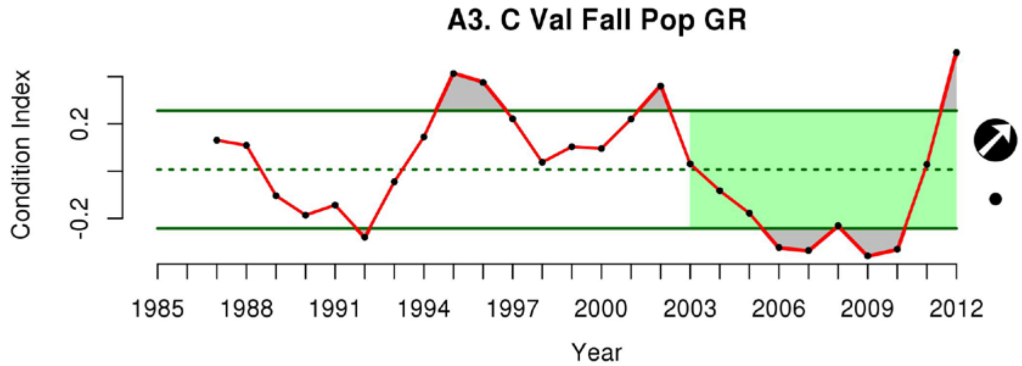
- "Quad plot" lets us summarize abundances of many populations together rather than having a long series of time series plots
- All data normalized
- Points are recent (10-yr) averages and trends, relative to long-term data
- Dotted lines represent ±1 standard deviation



Other highly rated salmon indicators

- Diversity of age structure
- % of natural spawners
- Population growth rate





- These data are patchy; not available for all populations

Bill Peterson's stop light chart

- Table of physical and biological indicators related to environmental conditions for coho and Chinook salmon in the northern California Current
- **"Poor" "intermediate" and "good" environmental conditions**
- Predictive
- Not formally vetted through CCIEA indicator screening, but we could do this
  - Many of these indicators are high-ranking indicators in the CCIEA, but not all have been tested

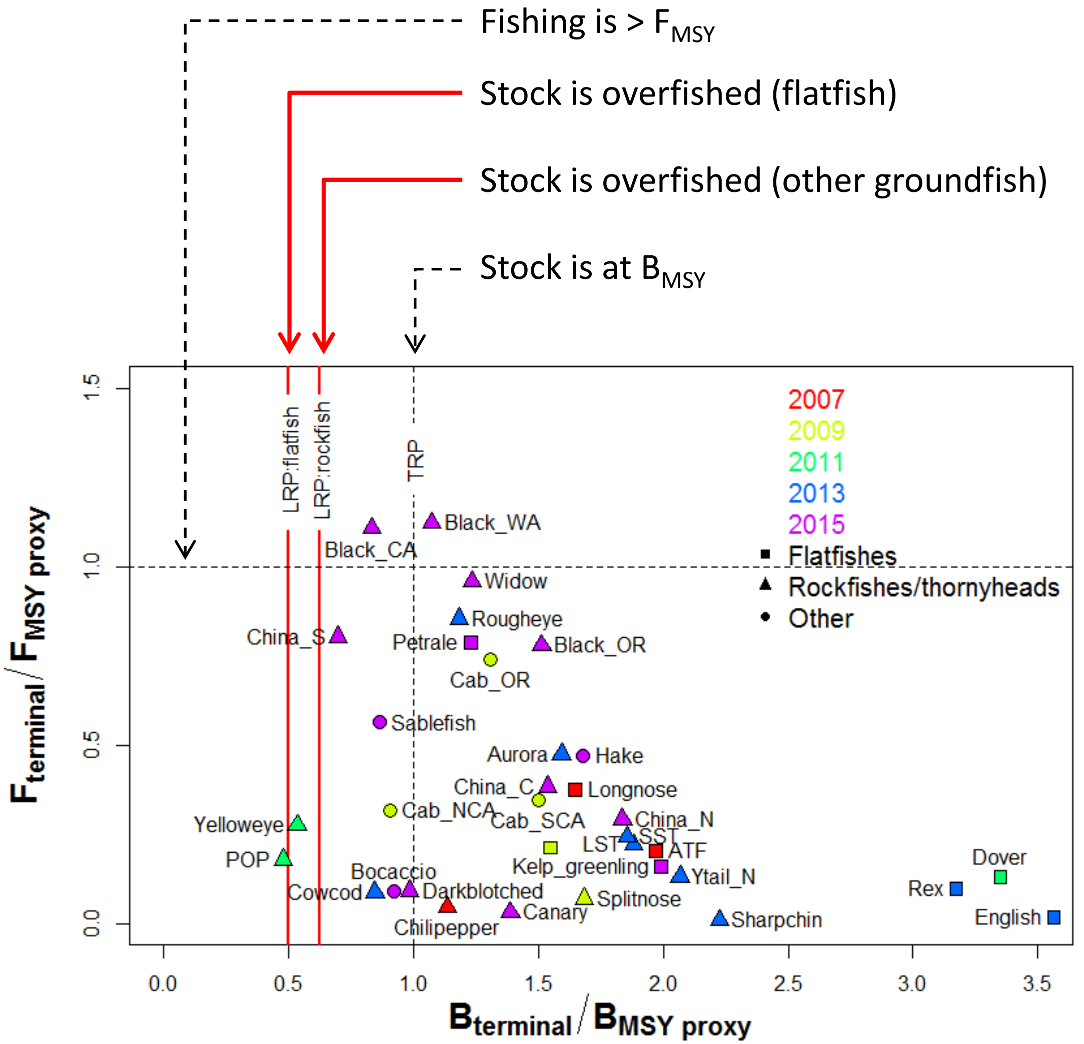
Ecosystem Indicators	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PDO (December-March)	16	6	3	12	7	17	11	15	13	9	5	1	14	4	2	8	10
PDO (May-September)	10	4	6	5	11	15	14	16	12	13	2	9	7	3	1	8	17
ONI Jan-June	17	2	1	5	13	14	12	15	7	11	3	9	16	4	5	7	9
46050 SST (May-Sept)	15	8	3	4	1	7	17	14	5	16	2	9	6	10	11	12	13
NH 05 Upper 20 m T winter prior (Nov-Mar)	17	11	8	10	6	14	15	12	13	5	1	9	16	4	3	7	2
NH 05 Upper 20 m T (May-Sept)	13	10	12	4	1	3	17	15	7	8	2	5	11	9	6	14	16
NH 05 Deep Temperature (May-Sept)	17	6	8	4	1	9	12	14	10	5	2	7	13	11	3	16	15
NH 05 Deep Salinity (May-Sept)	17	3	7	4	5	13	14	8	6	1	2	11	15	10	9	12	16
Copepod Richness Anomaly	17	2	1	7	6	13	12	16	14	11	9	10	15	4	5	3	8
N. Copepod Biomass Anomaly	16	13	9	10	3	15	12	17	14	11	6	8	7	1	2	4	5
S. Copepod Biomass Anomaly	17	2	5	4	3	13	14	16	12	10	1	7	15	9	8	6	11
Biological Transition	17	11	6	7	8	12	10	16	15	3	1	2	14	4	9	5	13
Winter Ichthyoplankton	17	8	2	4	6	15	14	10	13	12	1	9	3	11	7	5	16
Chinook Juv Catches (June)	16	4	5	14	10	12	15	17	11	8	1	6	7	13	3	2	9
Coho Juv Catches (June)	16	7	11	5	6	2	13	17	14	3	4	8	9	12	15	1	10
Mean of Ranks	15.9	6.5	5.8	6.6	5.8	11.6	13.5	14.5	11.1	8.4	2.8	7.3	11.2	7.3	5.9	7.3	11.3
RANK of the Mean Rank	17	5	2	6	2	14	15	16	11	10	1	8	12	7	4	8	13
Principle Component Scores (PC1)	6.70	-1.93	-2.55	-1.71	-1.96	1.81	2.94	4.41	1.02	-0.66	-4.70	-1.30	1.45	-1.47	-2.11	-1.35	1.42
Principle Component Scores (PC2)	-0.72	0.09	0.24	-1.10	-1.81	-1.36	2.17	-0.97	-1.20	0.38	-1.26	0.49	-1.11	1.08	0.57	1.90	2.62
Ecosystem Indicators not included in the mean of ranks or statistical analyses																	
Physical Spring Trans (UI Based)	3	6	16	13	4	10	12	17	10	1	5	2	7	9	14	8	15
Physical Spring Trans (Hydrographic)	16	3	12	7	5	11	13	17	6	8	1	8	15	3	10	2	14
Upwelling Anomaly (Apr-May)	7	1	14	3	6	11	10	17	7	2	4	5	12	14	12	9	16
Length of Upwelling Season (UI Based)	6	2	15	9	1	10	8	17	5	3	7	3	12	14	12	11	16
NH 05 SST (May-Sept)	10	6	5	4	1	3	16	14	8	12	2	15	9	7	11	13	16
Copepod Community Structure	17	5	4	8	1	13	14	16	15	10	2	6	12	9	7	3	11
Coho Juv Catches (Sept)	11	2	1	4	3	6	12	14	8	9	7	15	13	5	10	NA	NA

Yelloweye rockfish observed at Cordell Bank. (NOAA)

Groundfish

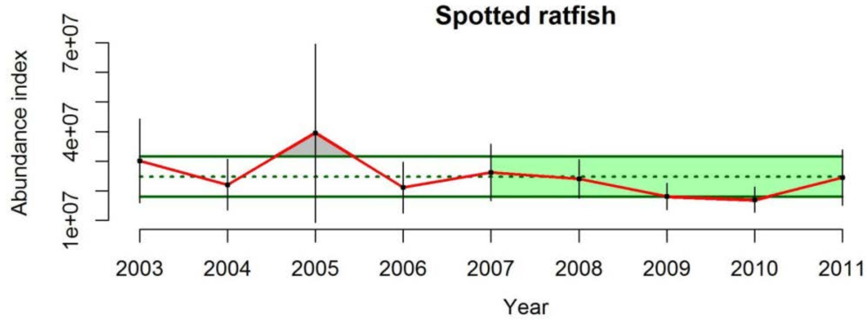
Groundfish

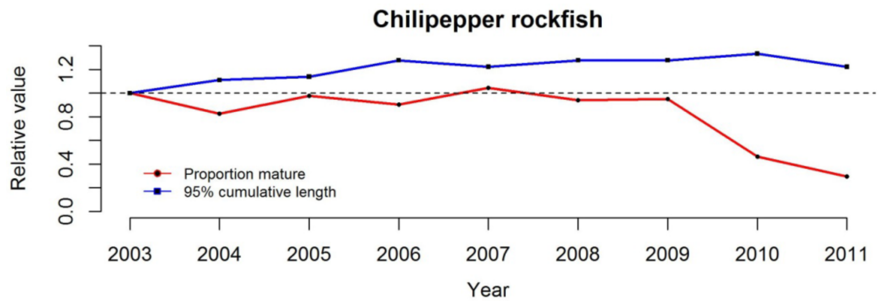
- Like salmon, we summarize multiple stocks in one plot to avoid overwhelming readers with time series plots
- Assessed species only
- X-axis is a measure of relative abundance; Y-axis is a measure of relative fishing mortality
- Lines indicate reference points
- Gives good idea of abundance and # of species of management concern

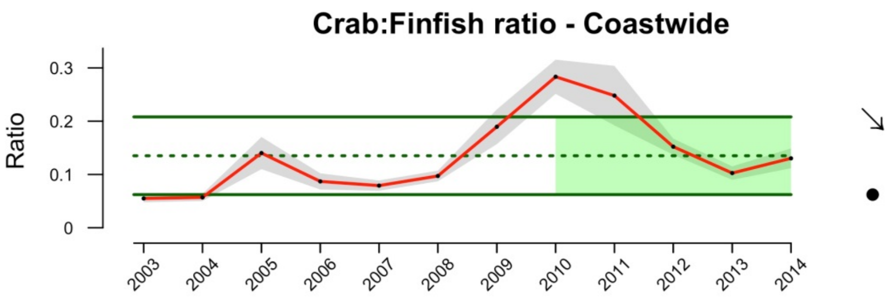


Other groundfish options, from survey data (2003-present)

- Abundance data for all groundfish, including non-target spp (2003-present)
- Age or maturity-related indicators of population condition (% mature; age- or size-structure of pop)
- Ecological integrity indicators: groundfish mean trophic level, or the biomass ratio of groundfish to large crabs
- Relative location of population centers (are distributions or communities shifting due to climate?)







California sea lions at San Miguel Island, 2011.
(Tony Orr, NOAA)

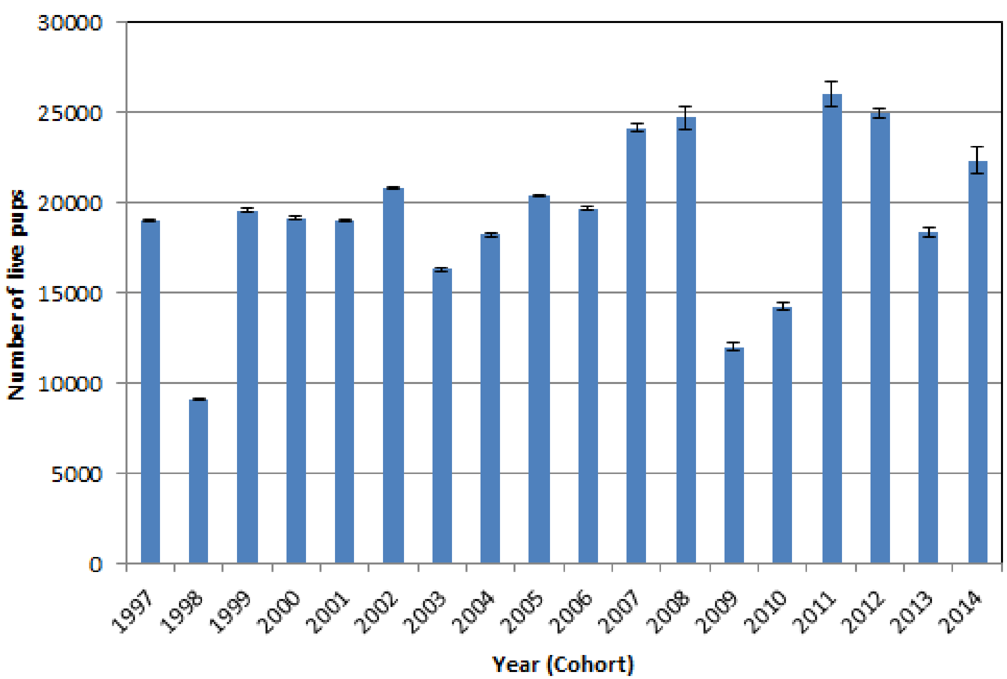
Marine mammals

California sea lion pups

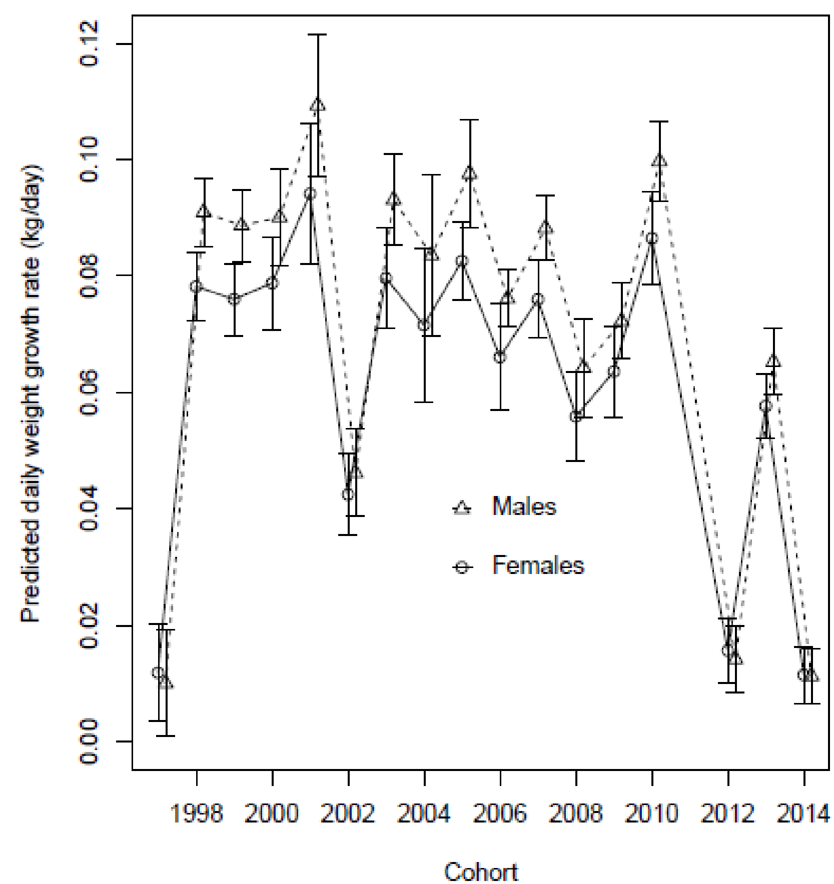
- Pup count for 2014 cohort was fairly normal
- But, pup growth is very poor and mortality likely will be ~70%
- Mothers producing poor quality milk
- 5 of last 6 cohorts are smaller than normal due to low birth rates and/or poor survival

Photo: Sharon Melin, NOAA

Pup count at San Miguel Island



Pup growth at San Miguel Island

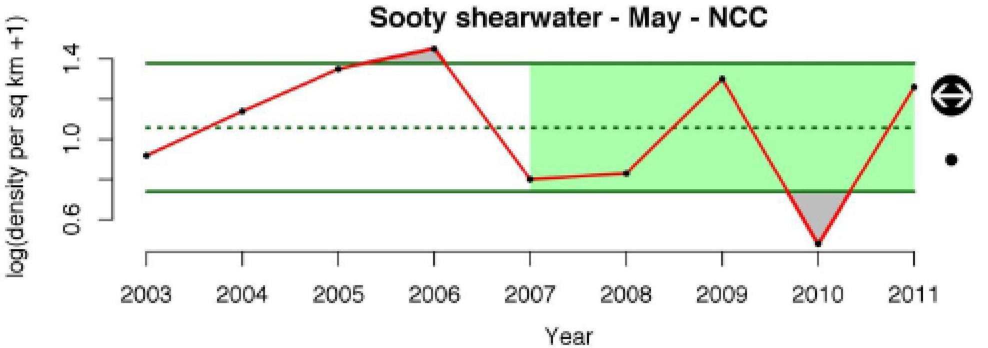


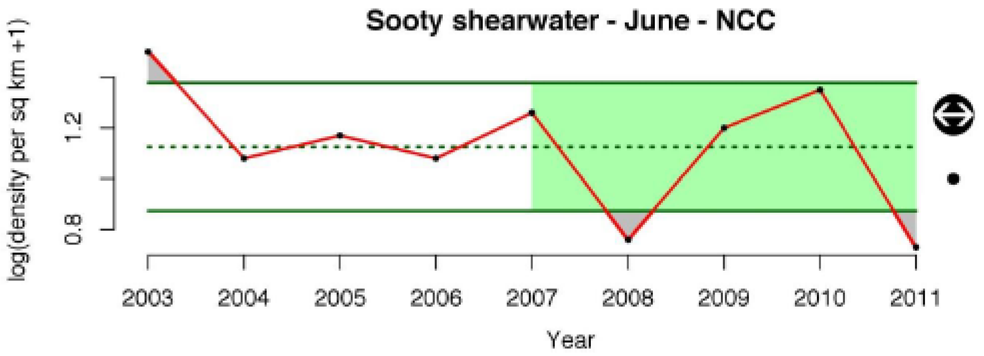
A sooty shearwater takes off near Cordell Bank. (NOAA)

Seabirds

Seabird indicators have been difficult to track

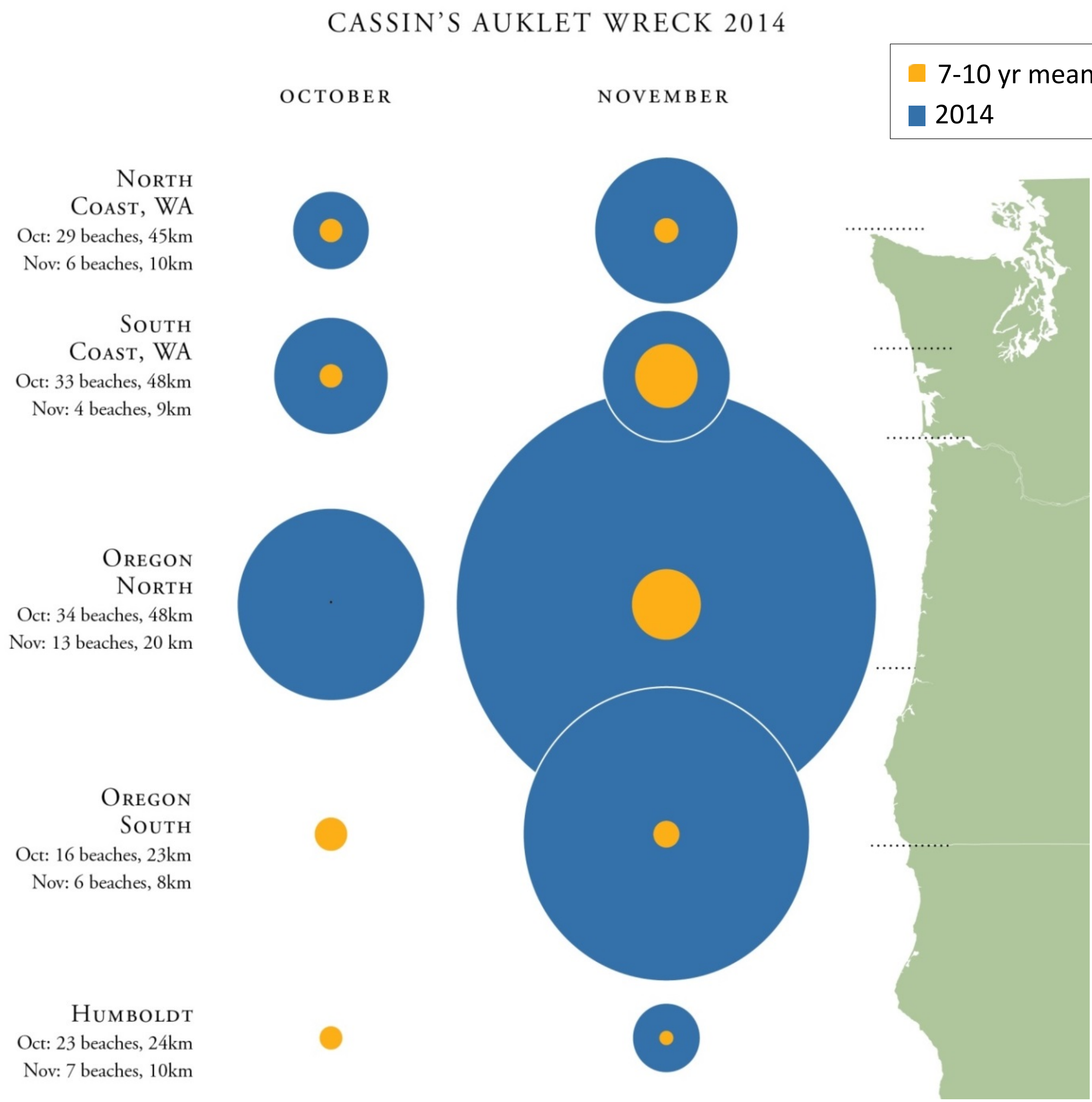
- Time series data for seabirds are often proprietary
- We have time series for sooty shearwaters, murres, and Cassin’s auklets
- No NOAA-funded, comprehensive seabird surveys on the West Coast
- The limited scope of available data may contribute to high variability and high uncertainty





Cassin's Auklet wreck, 2014-2015

- Cassin's auklets mostly eat krill
- Since 2014, mortality rates of auklets were 10 - 100 times normal
- Juvenile auklets most affected
- Cause of die-off is still undetermined



http://blogs.uw.edu/coasst/2014/12/22/cassins-auklet-wreck/

Handline fishing for albacore tuna. (NOAA)

Data gaps

Data gaps in our indicators

- **Coastal pelagic species**
  - We are just moving away from using forage availability (previous section) as a proxy for CPS
  - We could go to sardine & mackerel assessments and/or coastwide surveys where available

- **Highly migratory species**
  - No HMS indicators have been put through our screening process

- **CPS and HMS *are* focal species for IEA**
  - Both are examined in risk assessments and modeling of management alternatives
  - Just don’t have good indicators for them yet, other than total landings
  - **INDICATOR SUGGESTIONS ARE WELCOMED FROM CPSMT, CPSAS, HMSMT, HMSAS**

Discussion

Q: How might the Council "use" ecosystem indicators?
A: Actually, they already do!

1. *Establish relationship between indicator and attribute of interest*

Example: SST and sardine production (data, SSC review, etc.)

2. *Develop a decision rule based on the relationship*

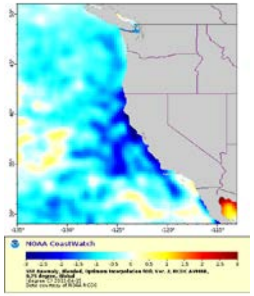
Example: sardine harvest control

$F_{MSY} = 0.248649805T^2 - 8.190043975T + 67.4558326$

where T = average 3-season SST

3. *Track the indicator(s) and incorporate into management action*

Example: track T for use in harvest control



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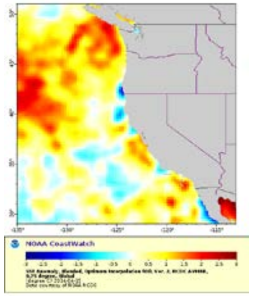

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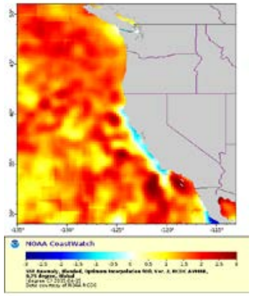


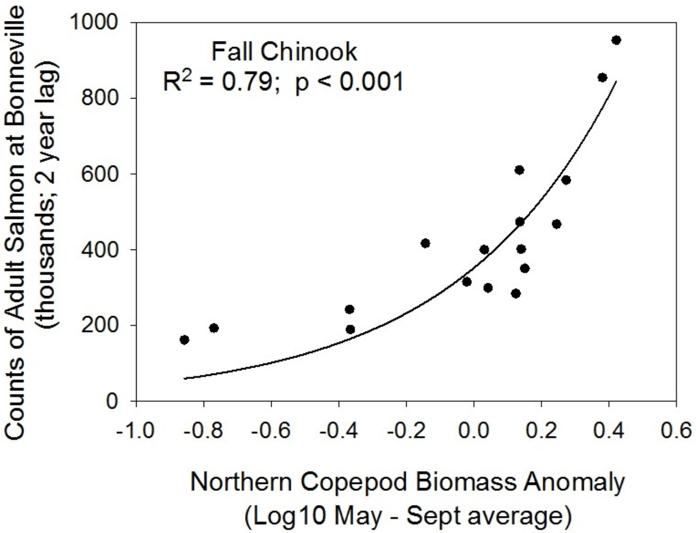
4. *Reassess periodically: does relationship hold up? Does it need adjustment?*

Example: changing from Scripps SST to CalCOFI SST

Application of indicators is a great opportunity for Council-IEA collaboration

<u>Examples include:</u>

- General context/state of system
- Management triggers
  - Northern copepod biomass anomaly and salmon production
  - Physical drivers that are correlated with protected species distribution (turtles, whales, birds) in areas where fishing is happening
- Management effectiveness: indicators should track mgmt actions in the system



If the Council has management concerns and there appear to be ecosystem factors at play, IEA can identify and screen relevant indicators