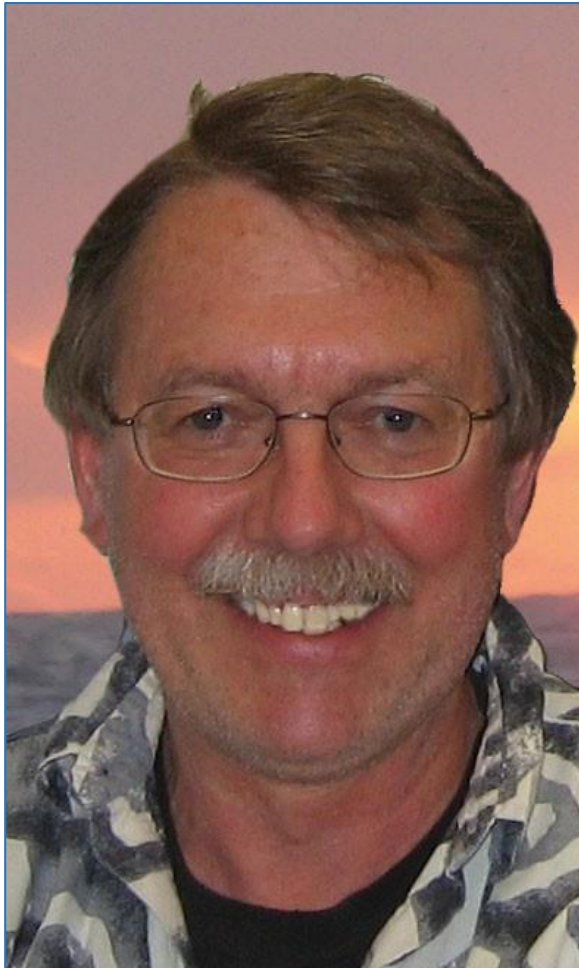


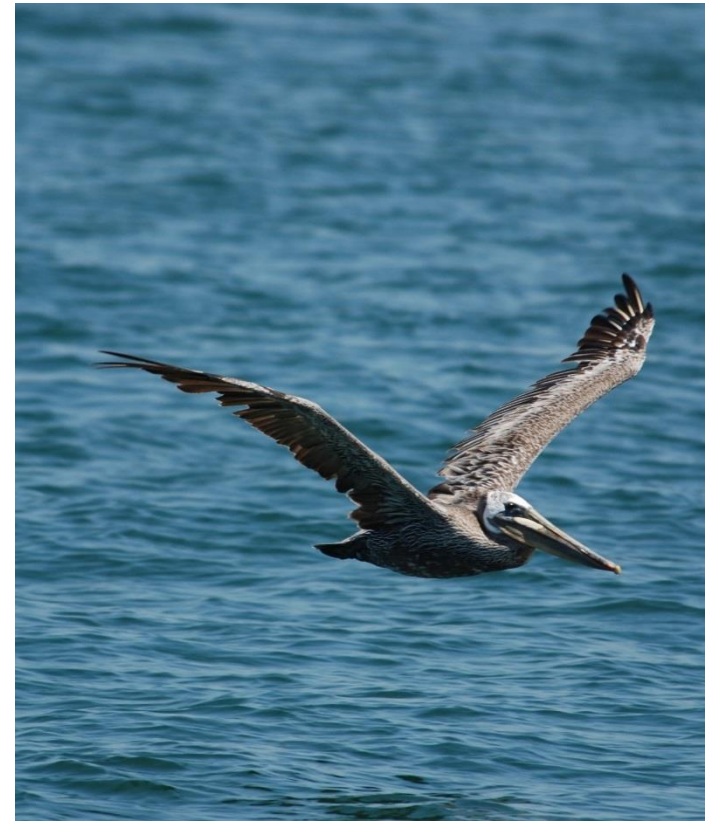
Dedication: Dr. Bill Peterson (1942–2017)



2018 California Current Ecosystem Status Report

NOAA California Current IEA Team

Presented to the Pacific Fishery Management Council
March 9, 2018, Rohnert Park, CA

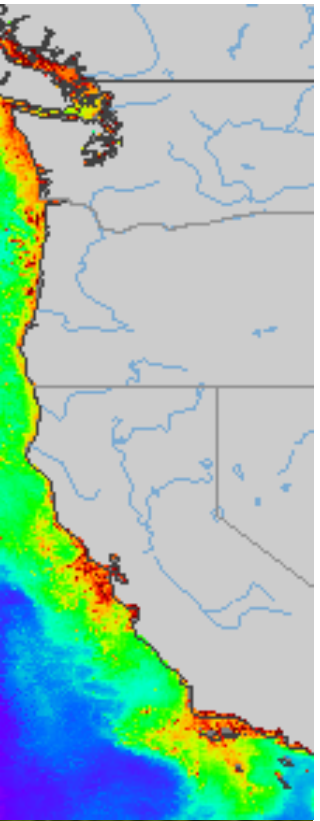


- **Climate drivers continued transition from the major warm events**
 - In 2017, PDO was neutral; ONI ranged from neutral to weak La Niña
 - Snowpack and stream flows were normal
 - Return to average conditions follows the climate “stress test” in 2014-2016 (Warm Blob, major El Niño)
- **However, some lingering effects of recent warm anomalies**
 - Subsurface warm water remained in the northern part of the system
 - Upwelling was below average in the north, above average central and south
 - Strong hypoxic event in Aug-Sept on the shelf in the northern region

- **Some ecological indicators finally shifting to more “average” values**
 - Copepod community composition off Newport
 - Sea lion pup growth on San Miguel Island
 - No productivity-related mass mortality of seabirds
 - Some upticks in key forage species in central, southern regions
- **Not all ecological and social indicators were encouraging, though**
 - Extreme numbers of pyrosomes (warm-water pelagic tunicates)
 - Poor catches of juvenile salmon off WA & OR; poor returns expected to Columbia in 2018
 - Whale entanglement reports in fixed gear remained a significant concern
 - Commercial landings and revenues continued decline through 2016

- **Emerging patterns from new analyses**

- Spatial indicator of bottom contact by trawl fleet shows areas of highest, lowest activity
- “Threshold” relationships between indicators of some pressures and species
- “Early Warning Index” analysis shows no evidence of ecosystem reorganization
- Dynamic bycatch management may increase swordfish fishing opportunities



1. Physical Conditions

Roughly average, with important exceptions

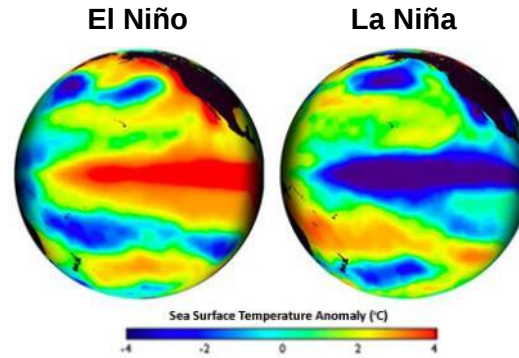


Basin-scale climate indices returning to averages

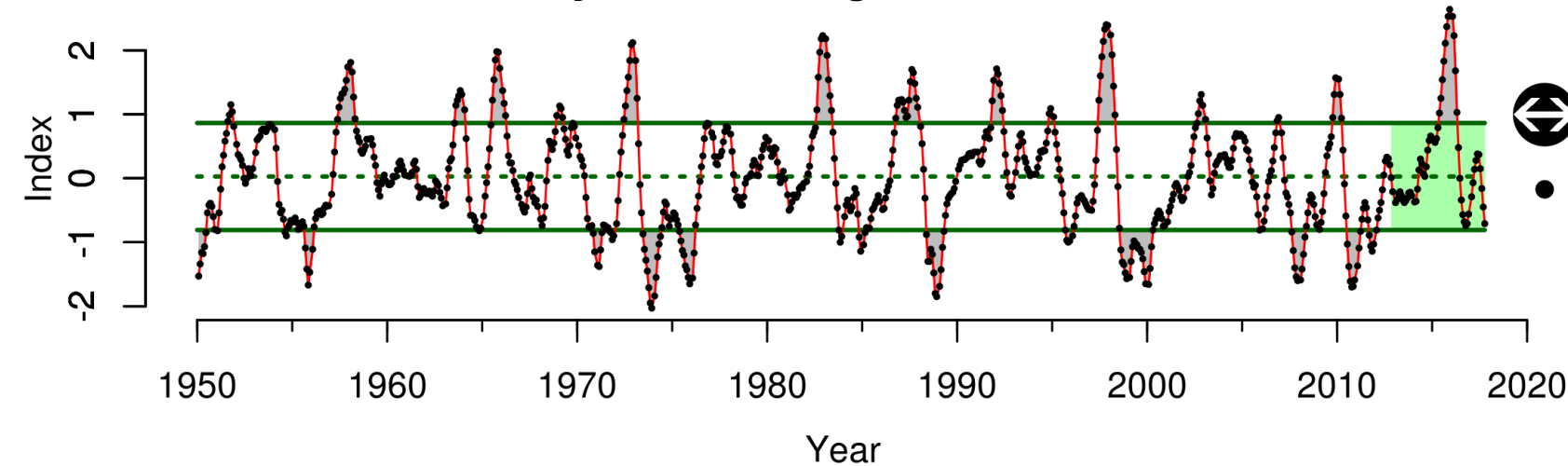
Oceanic Niño Index (ONI)

Positive ONI = El Niño conditions

Negative ONI = La Niña conditions



Monthly ONI through November, 2017

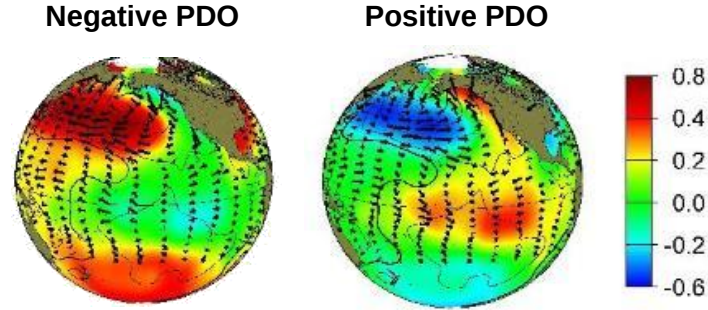


- Strongly positive (El Niño) in 2015-2016
- *Returned to neutral in late 2016 and remained neutral or negative (weak La Niña) in 2017*
- *La Niña is forecast through June 2018*

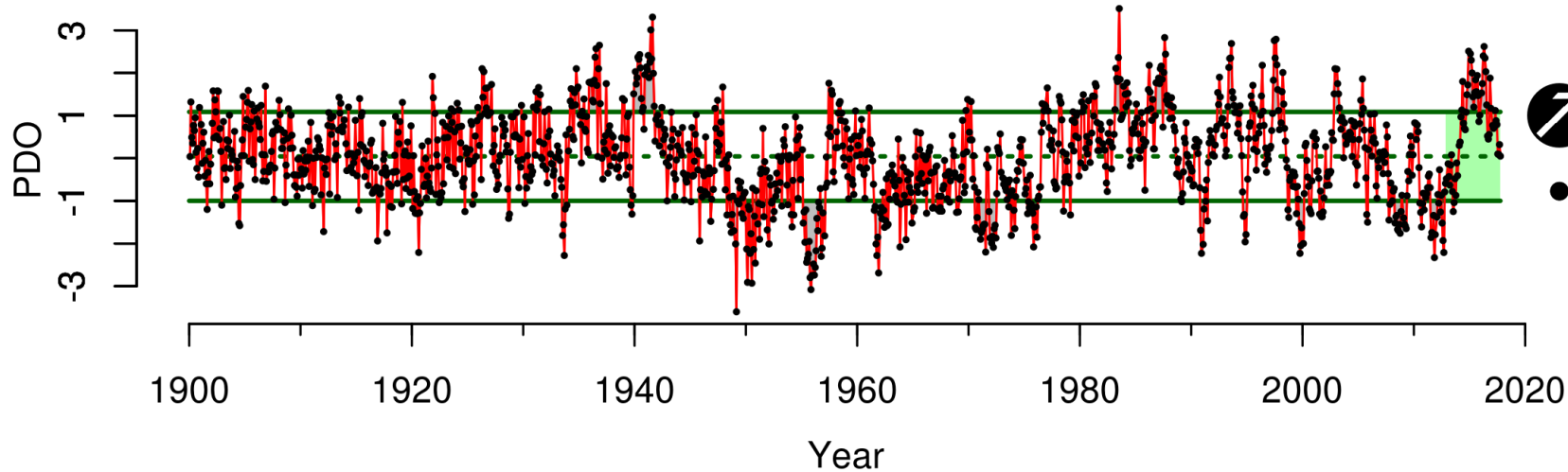
Basin-scale climate indices returning to averages

Pacific Decadal Oscillation (PDO)

Positive PDO = warm, lower productivity
Negative PDO = cool, greater productivity



Monthly PDO through December, 2017



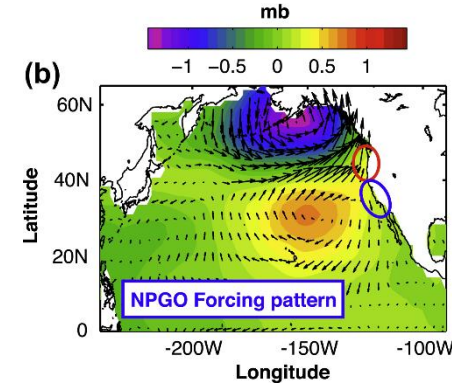
- Strongly positive from 2014-2016
- *Returned to neutral in July 2016*
- *Was neutral in nearly all of 2017*

Basin-scale climate indices returning to averages

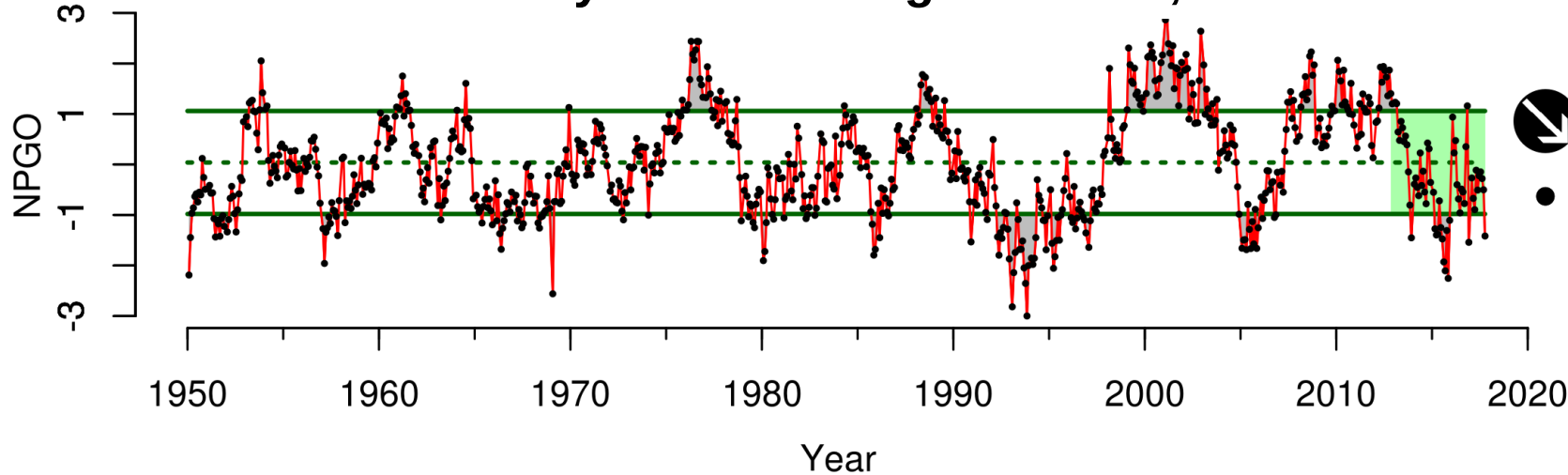
North Pacific Gyre Oscillation (NPGO)

Positive NPGO = stronger circulation, higher productivity

Negative NPGO = weaker circulation, lower productivity



Monthly NPGO through October, 2017



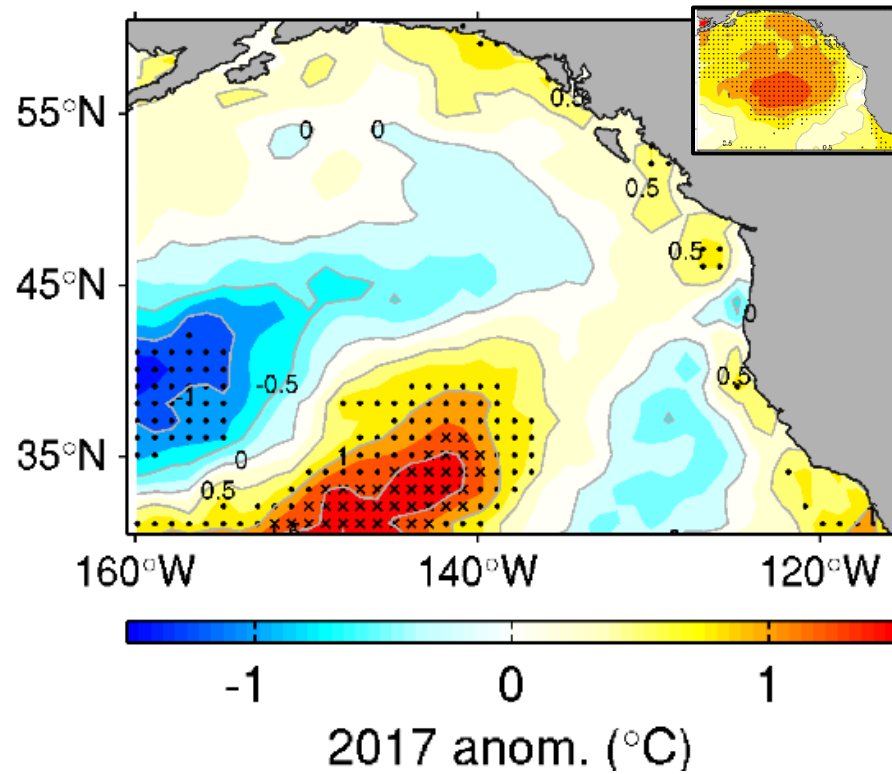
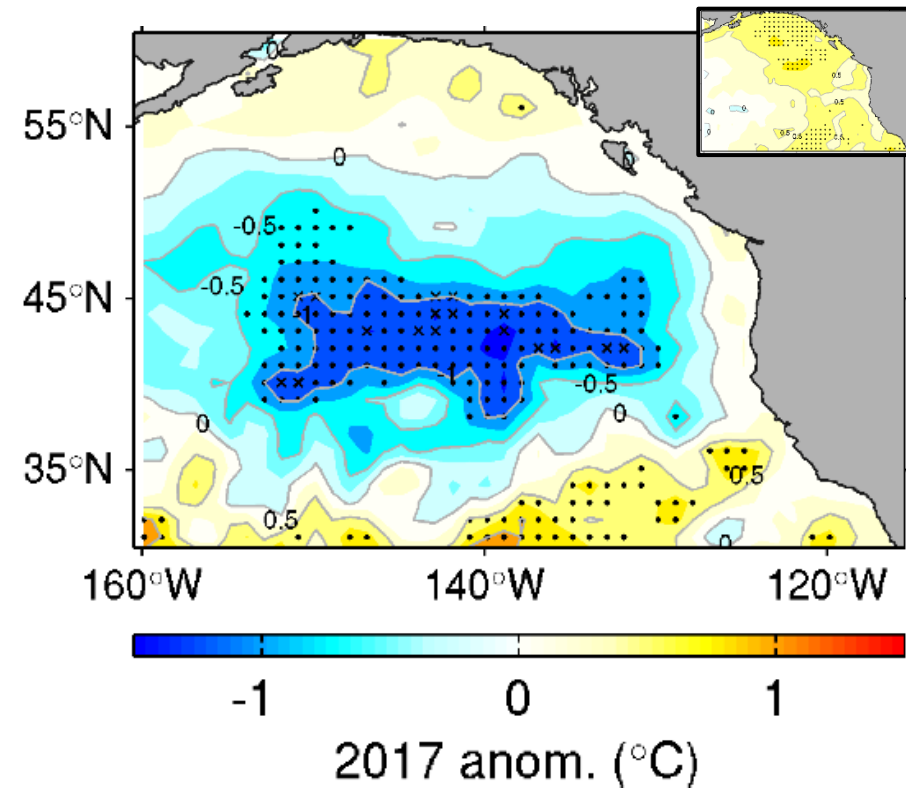
- Strongly negative in 2015
- *Mostly neutral since 2016*
- *Was neutral to negative in nearly all of 2017*

Basin-scale climate indices returning to averages

Sea surface temperature anomalies (SST_a)

Winter (Jan-Mar 2017)

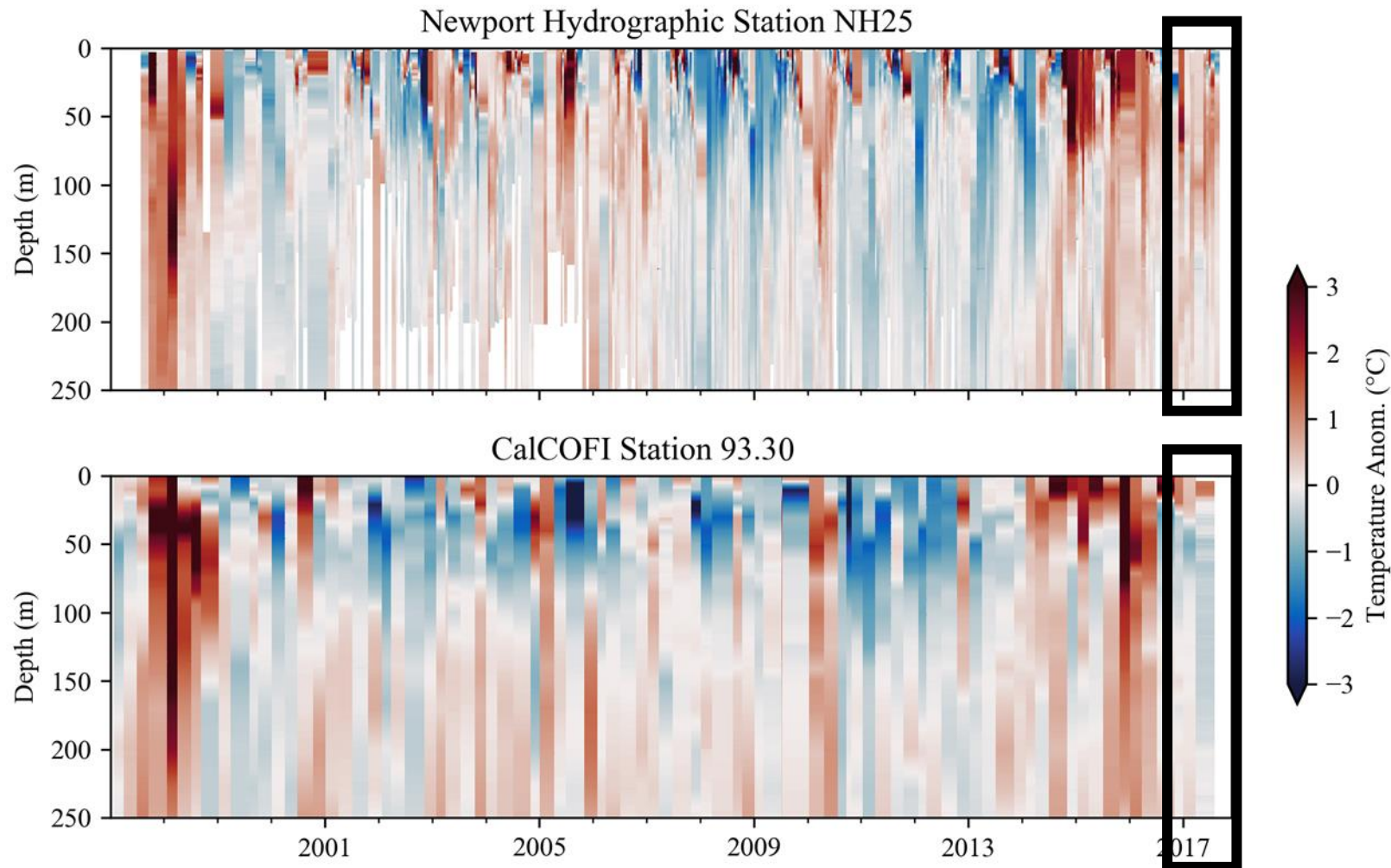
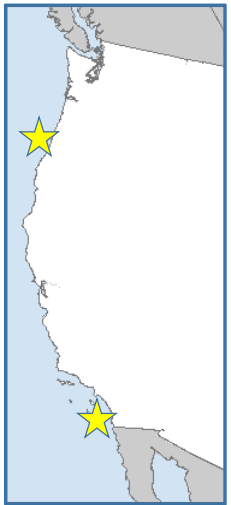
Summer (Jul-Sept 2017)



- Over last 5 years, SST_a have been well above average (*insets*)
- *In 2017, winter SST_a just slightly above average along coast*
- *Summer SST_a mostly above normal, though not as much as recent years*
- *No Blob is forecast for 2018*

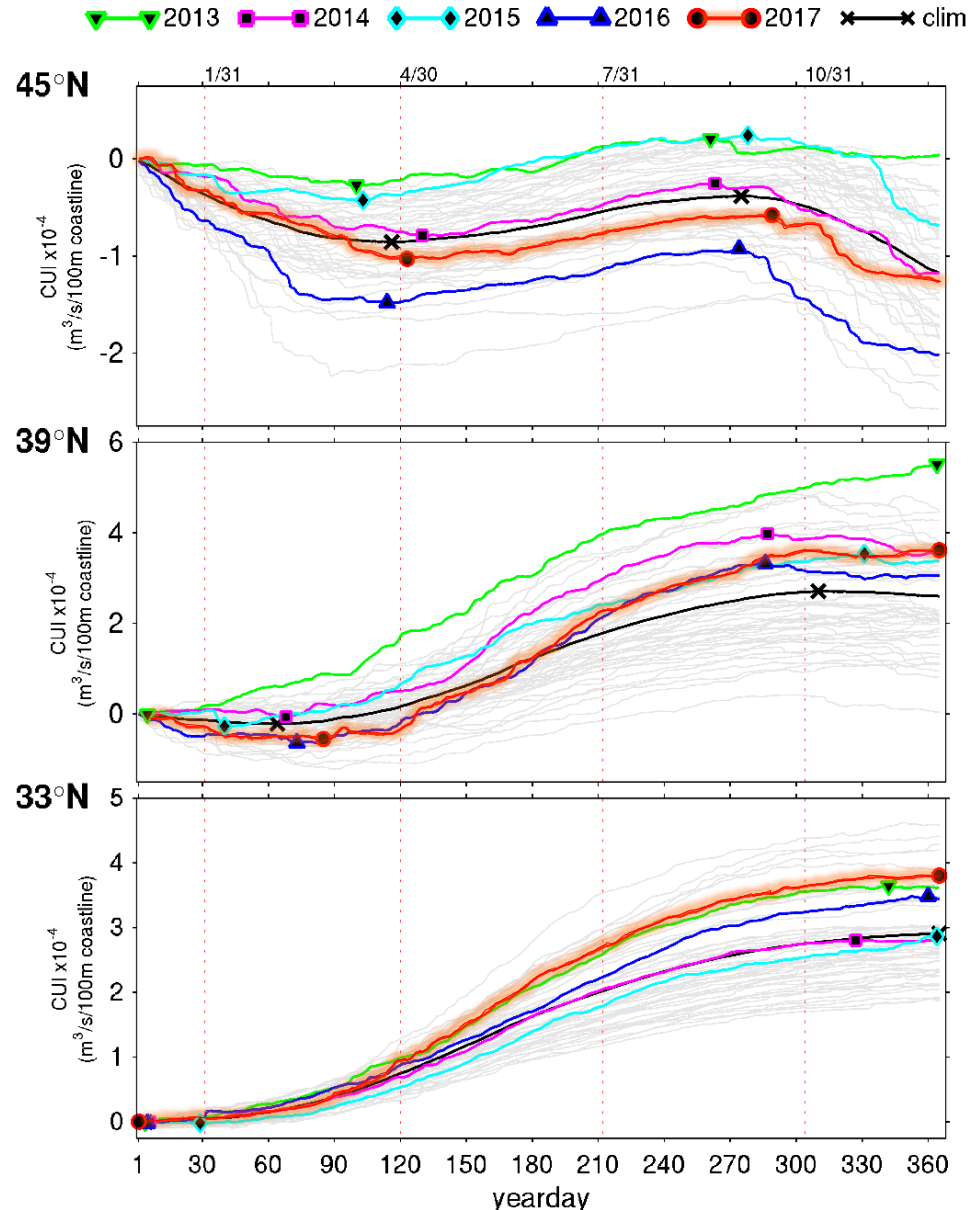
But, residual subsurface warming persists in north

Temperature anomalies at depth



- 2014-2016: very warm at surface (Blob)
- 2016: very warm at depth (El Niño)
- *In 2017, warmer than-average water remained at depth off Newport, OR*

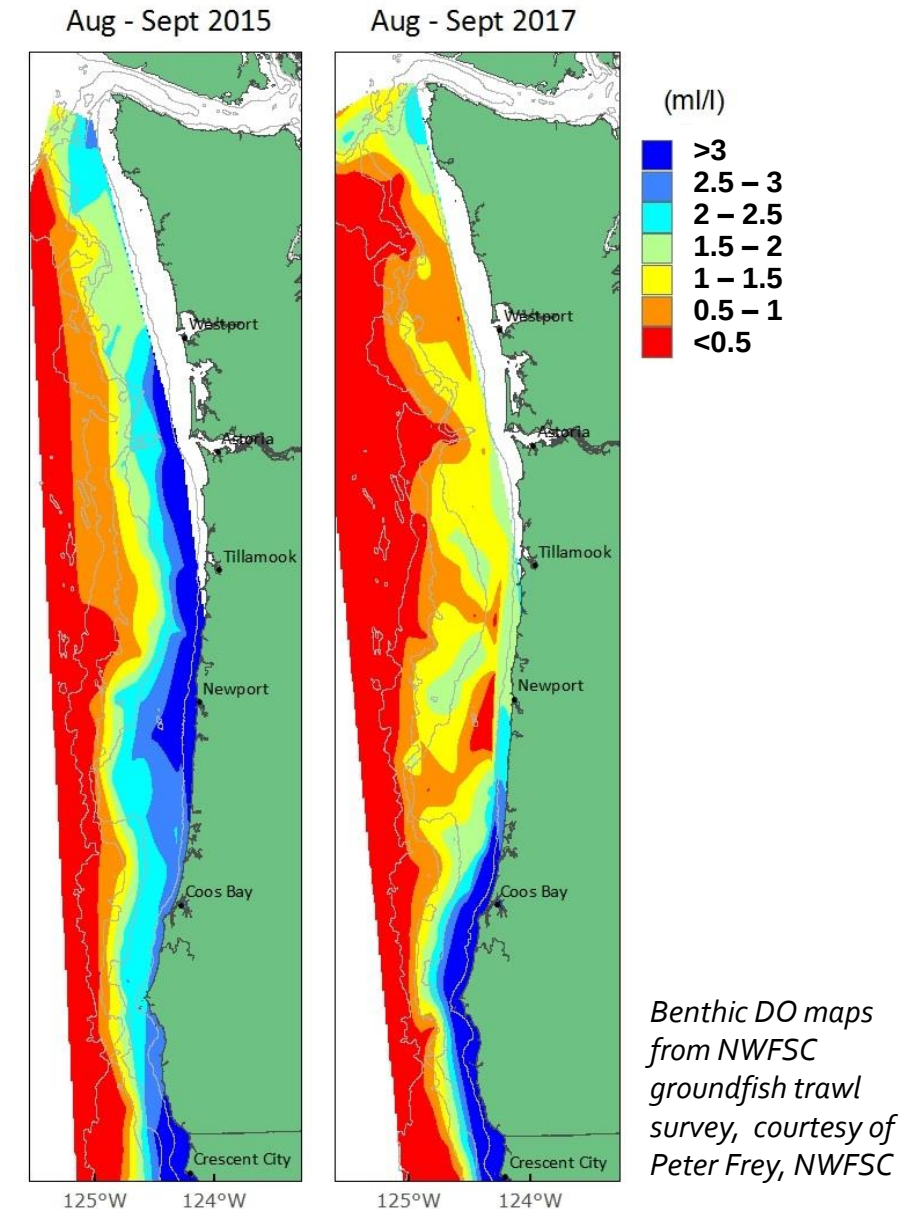
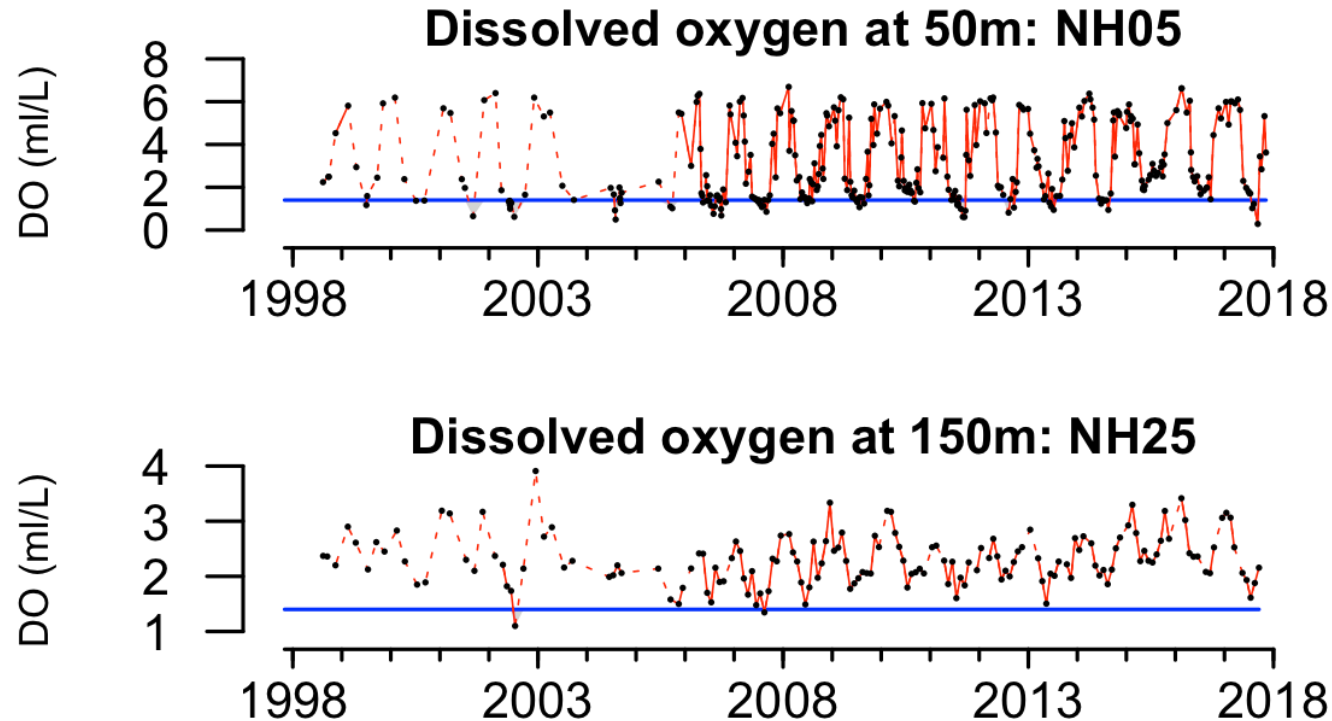
North also experienced relatively weak upwelling



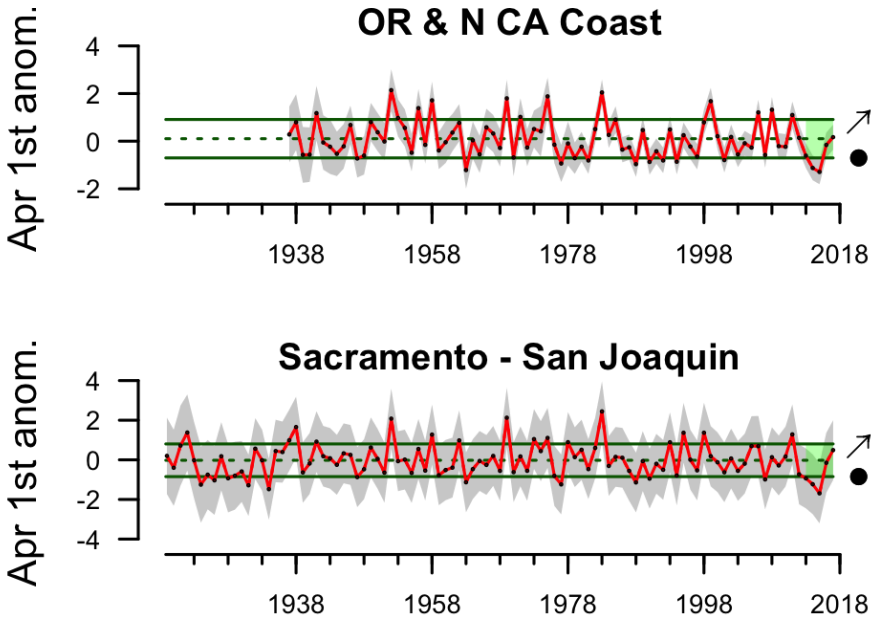
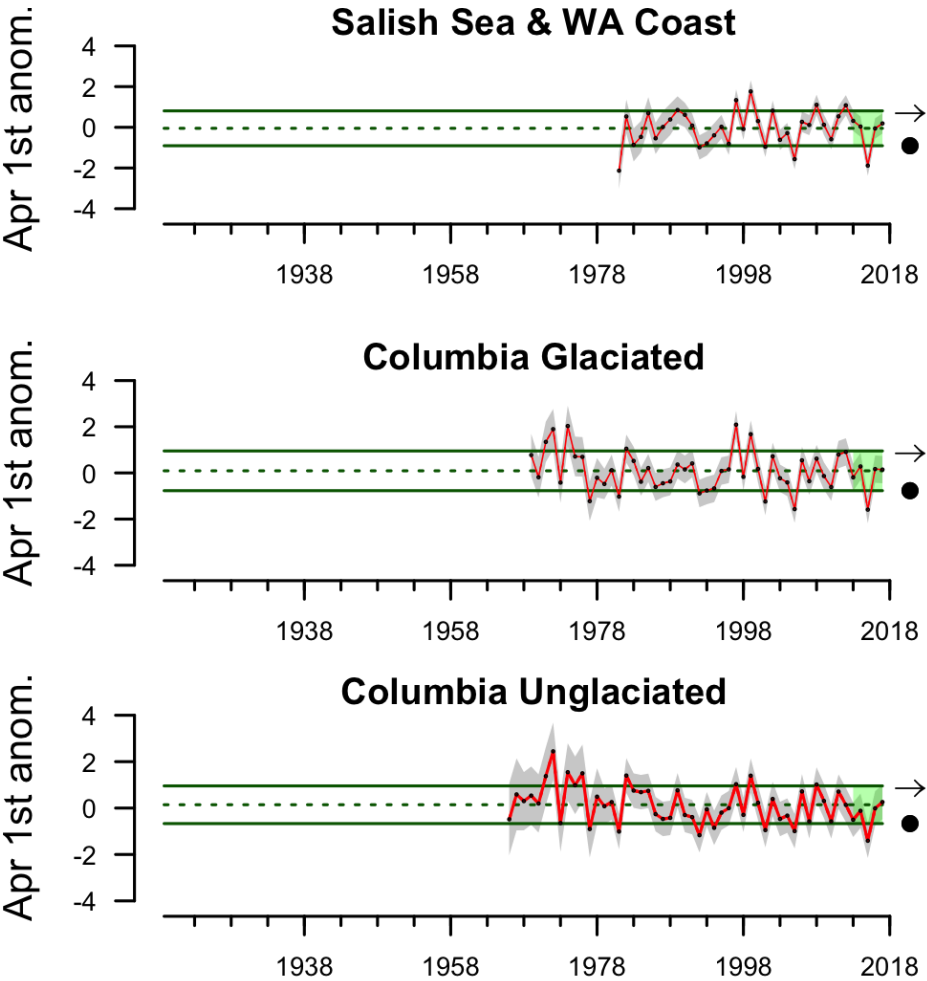
- *North: 2017 trend (red line) was better than 2016 (blue), but still below average (black)*
- *Central: 2017 below average until June and late spring transition, but strong from June-Oct*
- *South: 2017 average or above average all year*

However, north experienced major upwelling-related hypoxia

- *Values off Newport and across shelf well below hypoxia threshold for much of July-Sept*
- *Observations of invertebrate kills, displacement of groundfish*
- *Likely cause: upwelling of water with unusually low DO*



Snowpack in 2017: near average for 2nd winter in a row

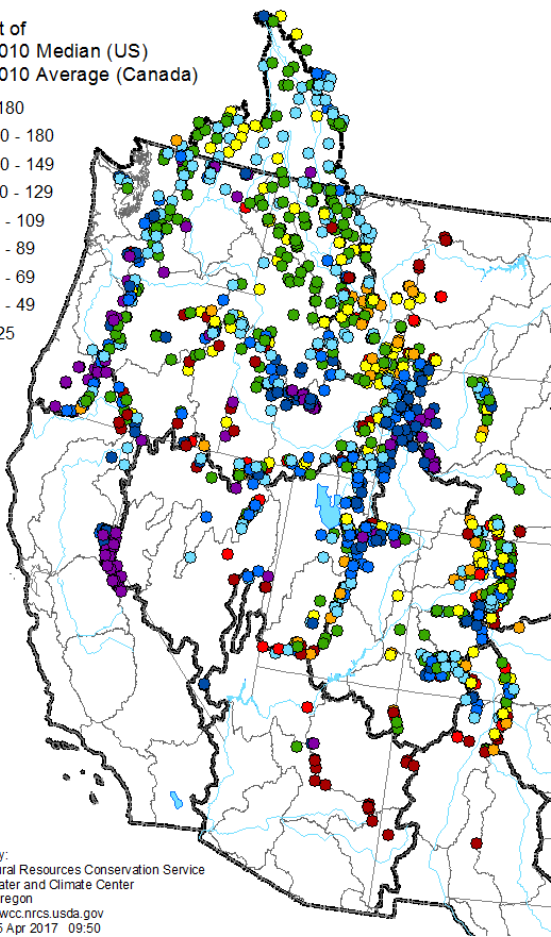


■ *As a result, stream flows were also close to long-term averages across all ecoregions in 2017*

Mountain Snowpack as of April 1, 2017

Percent of
1981-2010 Median (US)
1981-2010 Average (Canada)

- > 180
- 150 - 180
- 130 - 149
- 110 - 129
- 90 - 109
- 70 - 89
- 50 - 69
- 25 - 49
- < 25



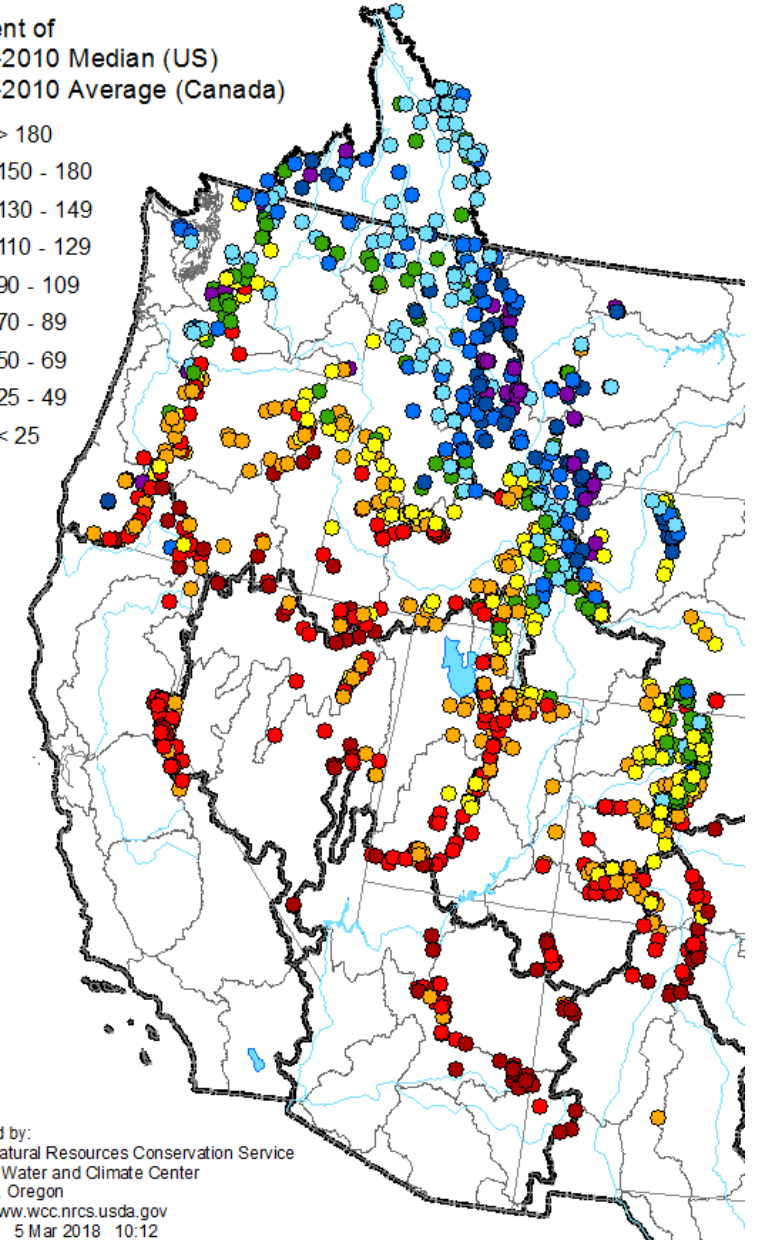
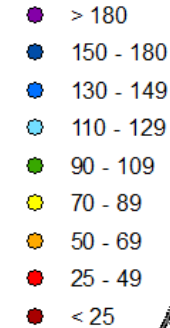
Prepared by:
USDA Natural Resources Conservation Service
National Water and Climate Center
Portland, Oregon
<http://www.wcc.nrcs.usda.gov>
Created: 5 Apr 2017 09:50

Snowpack in 2018: looks okay in north, poor in central & south

- *Data updated through March 1st, 2018*
 - *Most of CA, OR, Southern ID are well below normal*
- Official 2018 measure will be made on April 1st (approximate date of maximum snowpack)
 - Much can change between now and then; heavy snow in the northern CCE in late winter of 2017 is a good example of this
- *However, National Weather Service has forecast drought in 2018 for most of CA and interior OR*

Mountain Snowpack as of March 1, 2018

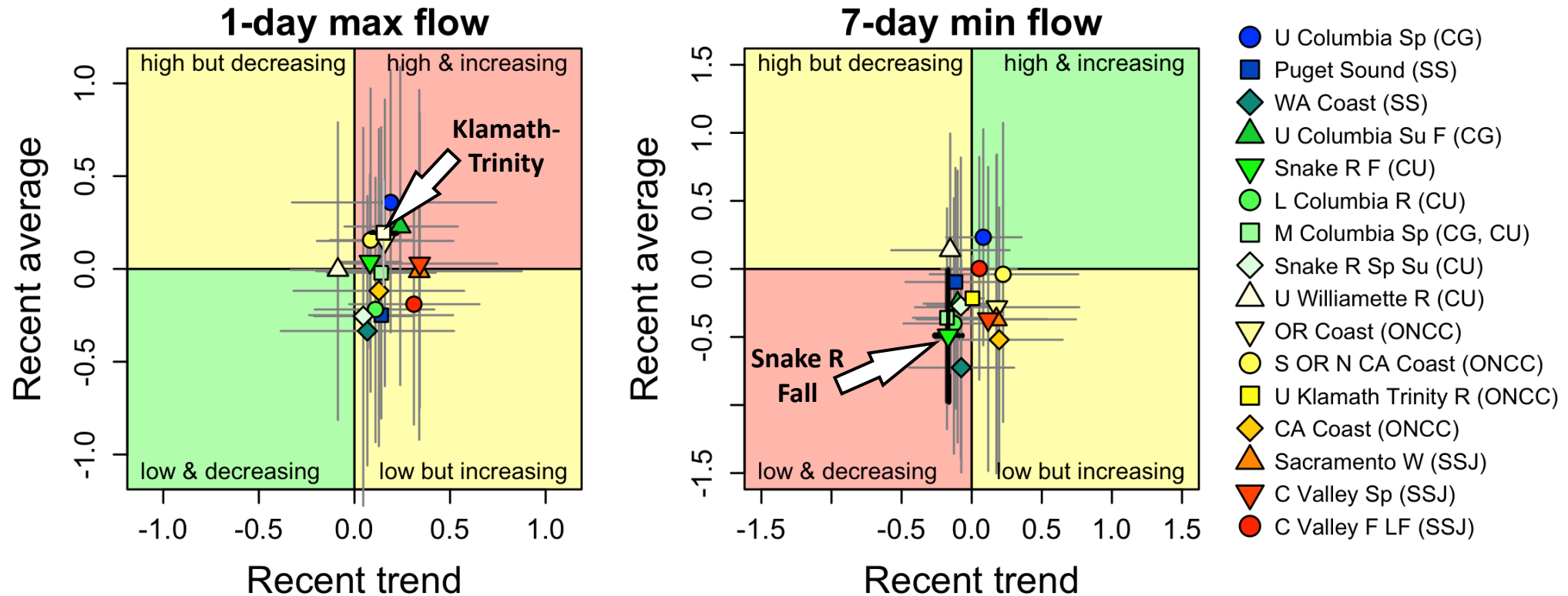
Percent of
1981-2010 Median (US)
1981-2010 Average (Canada)



Prepared by:
USDA Natural Resources Conservation Service
National Water and Climate Center
Portland, Oregon
<https://www.wcc.nrcs.usda.gov>
Created: 5 Mar 2018 10:12

Trends in stream flow for Chinook salmon ESUs

- *Only a few Chinook ESUs experiencing significant flow anomalies in last five years*
 - *Klamath-Trinity (max flow trend), Snake River Fall (min flow trend, avg)*
- *Patterns across all ESUs? (increasing max flows, below avg min flows)*



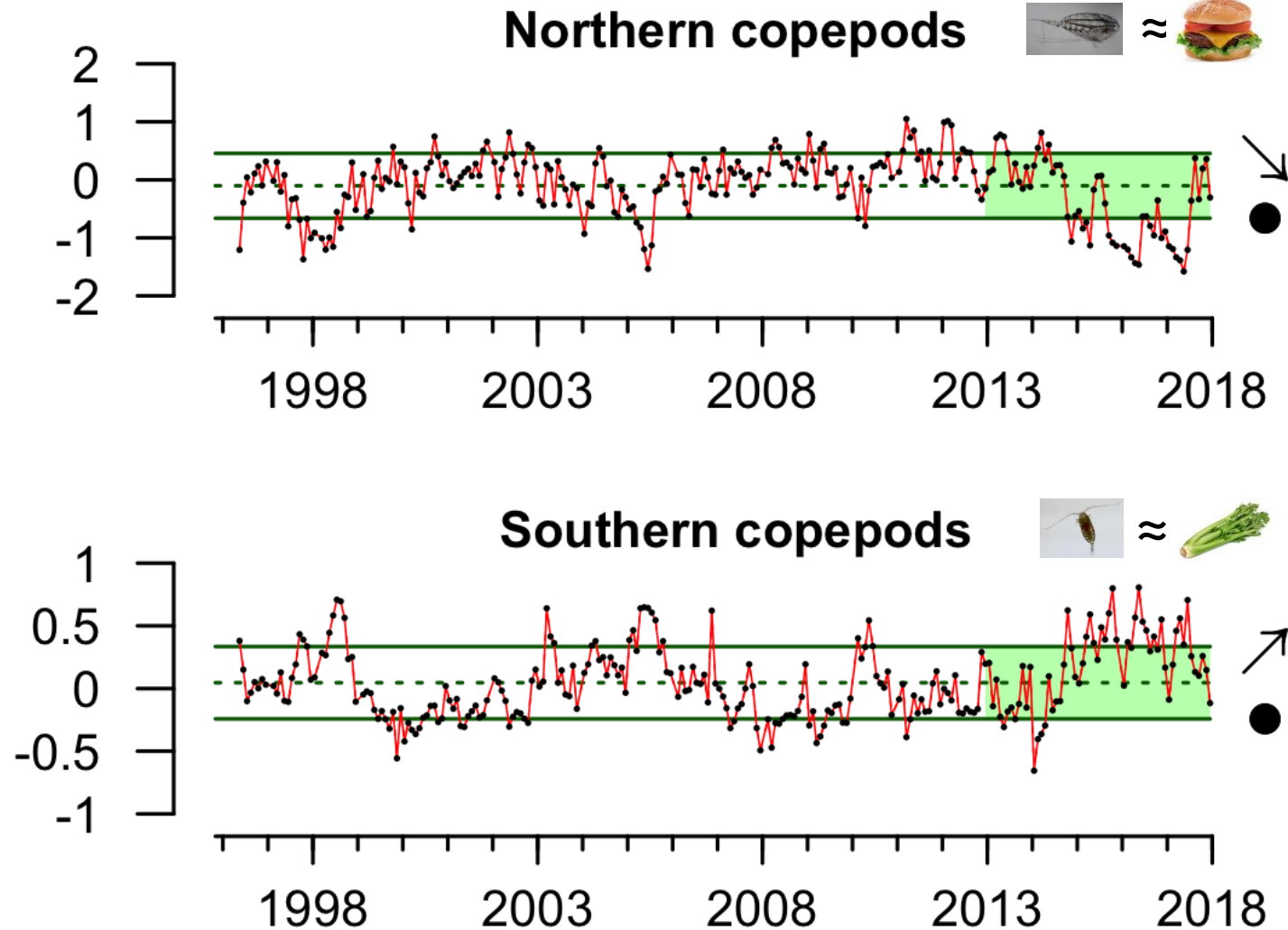
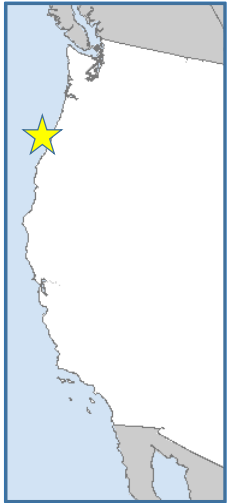


2. Ecological responses

Some improvements in productivity, but not in the north

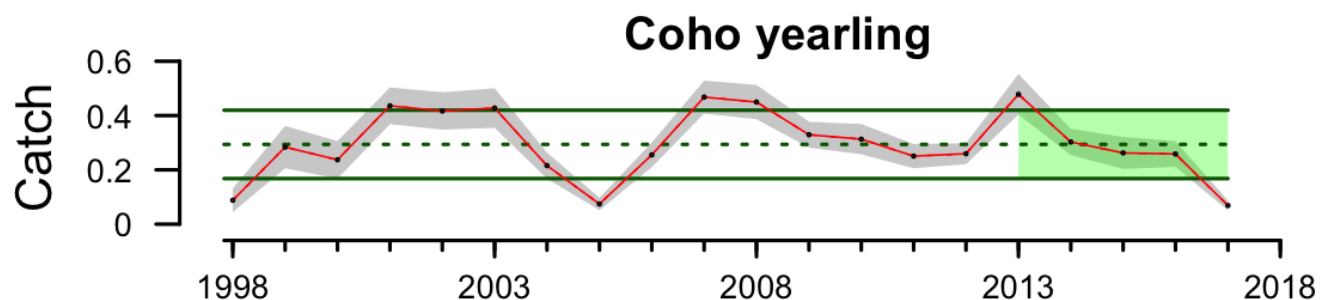
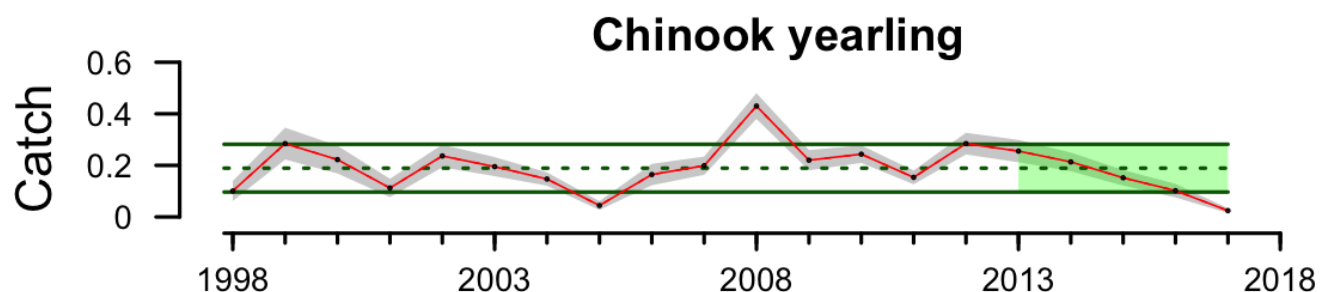
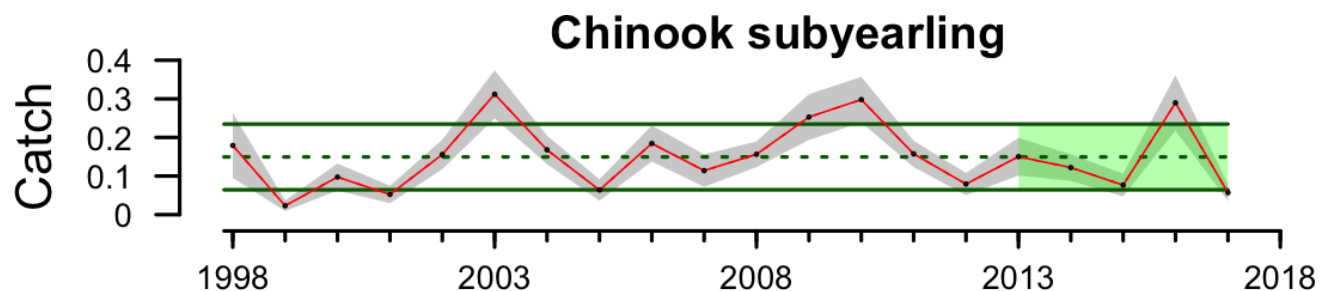
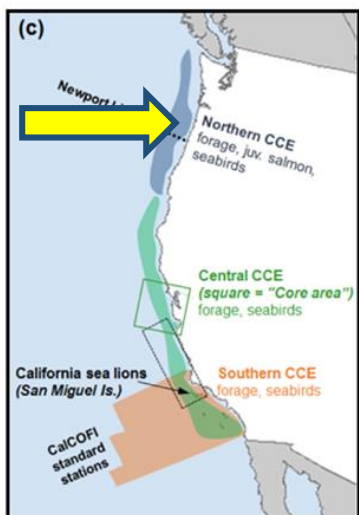


Copepods off Newport: still lagging



- Energy-rich northern copepods had very low biomasses, 2014-2016
- *By fall 2017, signs of a more “average” community, though not an unambiguous shift to a productive state*
- *Consistent with persistent warm water at depth in north*

Juvenile salmon catches off WA, OR very low in 2017



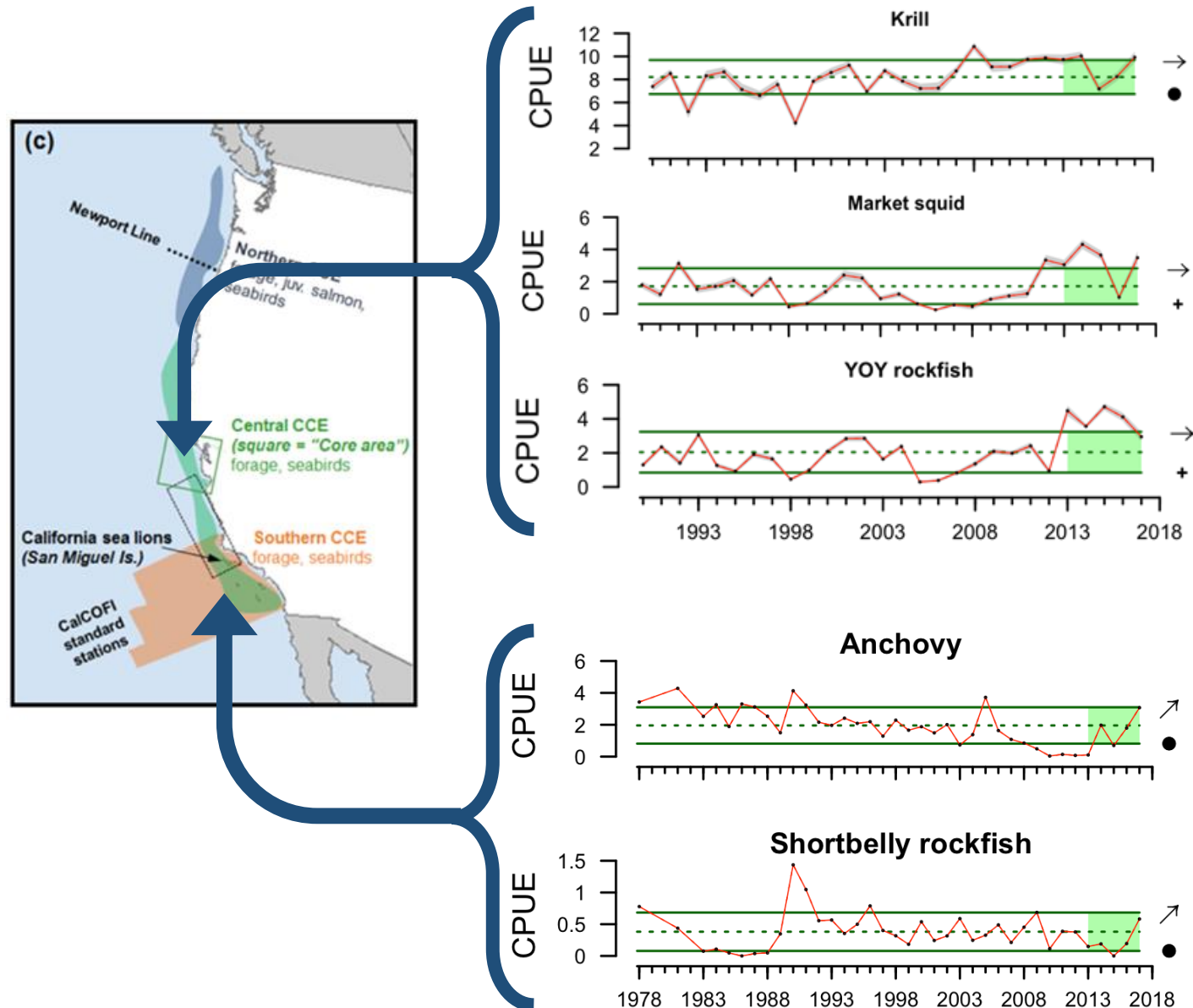
- Surface trawls from 9 transect lines (NOAA, OSU) target salmon in first year at sea
- Indicator of early ocean survival
- *2017: catches among the lowest observed in 20 years*

“Stoplight” for 2018 in Columbia R.: below average returns

Scale of indicators	Smolt year				Adult return outlook	
	2014	2015	2016	2017	Coho, 2018	Chinook, 2018
Basin-scale						
PDO (May-Sept)	◆	◆	◆	■	■	◆
ONI (Jan-Jun)	■	◆	◆	■	■	◆
Local and regional						
SST anomalies	■	◆	◆	●	●	◆
Deep water temp	◆	◆	■	◆	◆	■
Deep water salinity	◆	◆	■	◆	■	◆
Copepod biodiversity	■	◆	◆	■	■	◆
Northern copepod anomaly	●	◆	◆	◆	◆	◆
Biological spring transition	■	◆	◆	◆	◆	◆
Winter ichthyoplankton biomass	◆	●	●	●	●	●
Winter ichthyoplankton community	■	■	◆	◆	◆	◆
Juvenile Chinook catch (Jun)	■	■	◆	◆	◆	◆
Juvenile coho catch (Jun)	■	■	■	◆	◆	■

- Indicators of growing conditions for last 4 smolt years in northern CCE
- Color = rank of all years
 - Green: top third
 - Yellow: middle third
 - Red: bottom third
- ***Most conditions consistent with below-average returns to Columbia Basin***

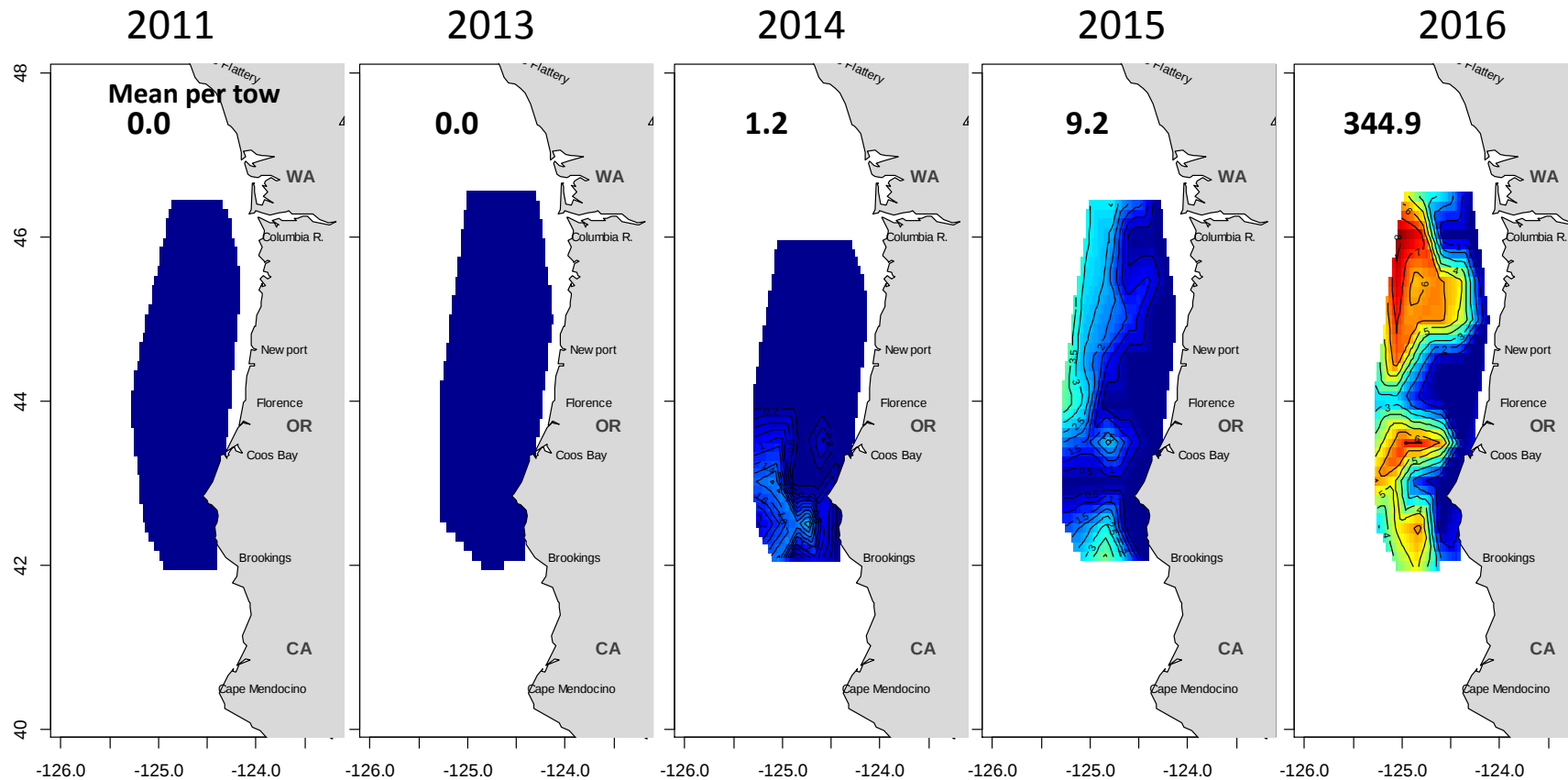
Forage: some increases in central, southern CCE



- *Northern CCE: relatively poor catches of most species (not shown)*
- *Central: more krill and squid in 2017; juv rockfish high for 5th year*
- *South: anchovy increasing, along with shortbelly rockfish (but squid decreasing; not shown)*
- *Sardine: poor catches coast-wide (not shown)*

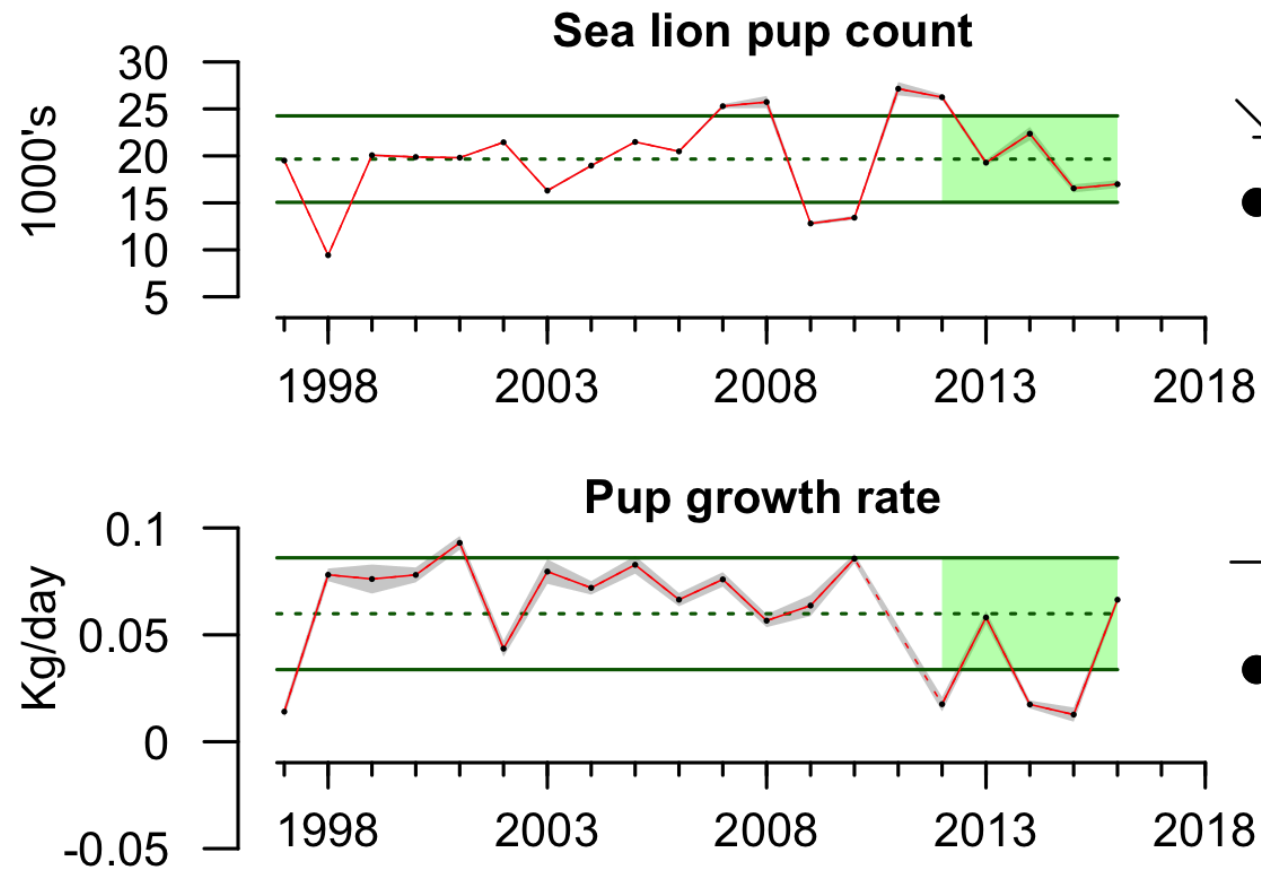
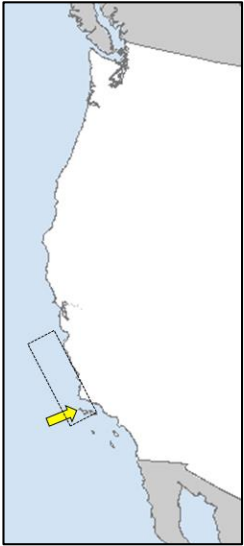
Pyrosomes had an outburst

Pyrosoma atlanticum: a warm-water species of pelagic tunicate



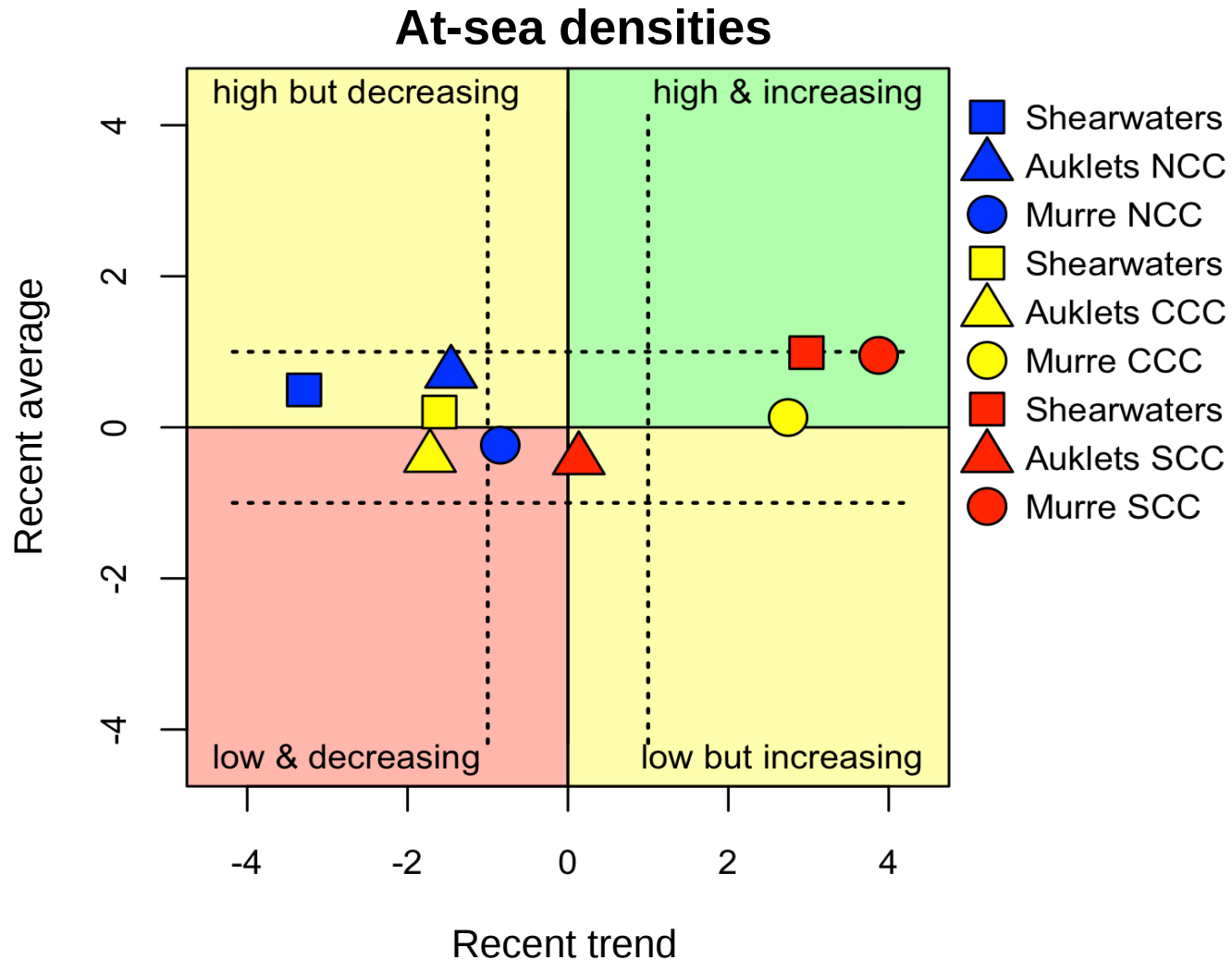
- Avg pyrosomes per tow in 2017 = **11,752!**
- Concerns: competitors for food; foul gear
- Pyrosomes already appearing in 2018

Sea lion pup growth implies better feeding conditions



- San Miguel colony
- 2016 pup count was low again; fewer reproductive females?
- But, pup growth was normal, suggesting improved foraging conditions for nursing mothers
- Preliminary data: 2017 pups had strong winter growth; maternal diet = anchovy, juv rockfish

Seabird counts also suggest North is lagging in productivity

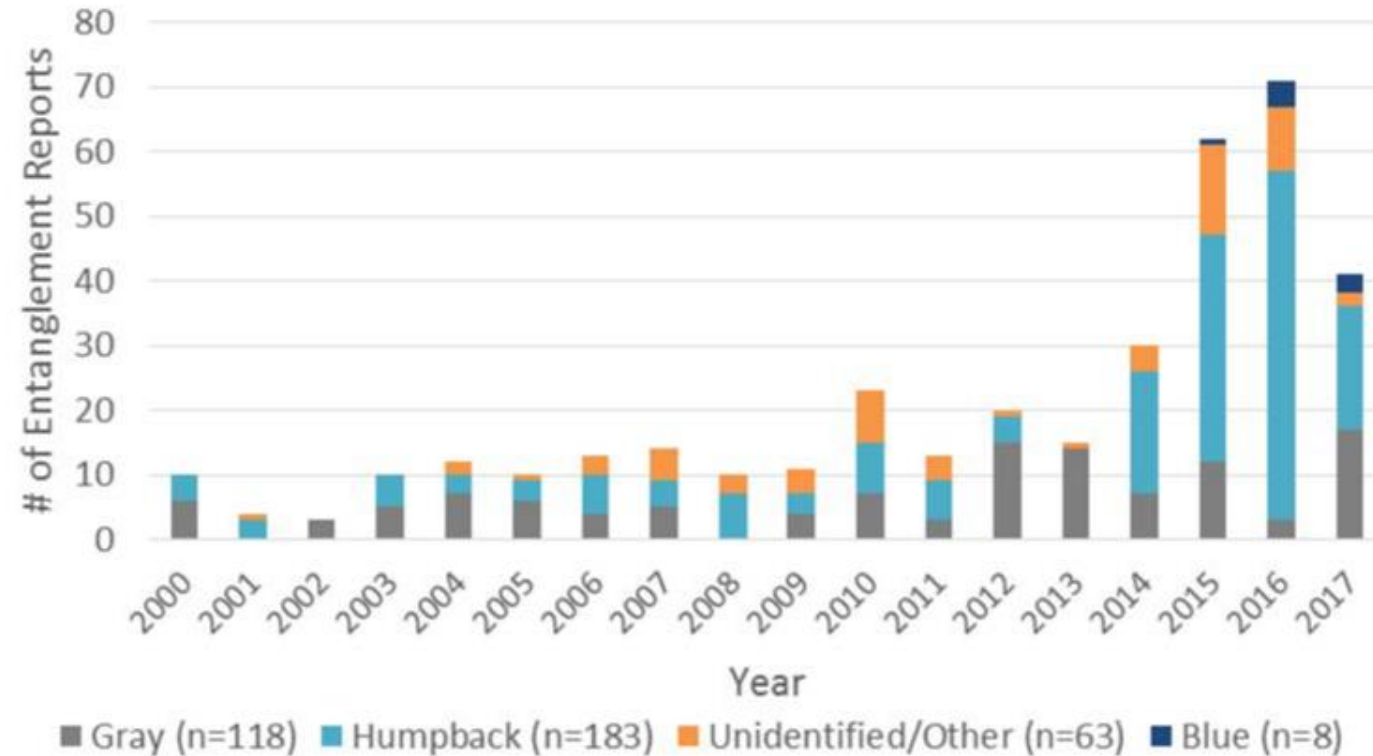


- Indicators of forage availability
 - Shearwaters and murre: small fish
 - Cassin's auklets: krill
- *At-sea counts of shearwaters high in South, murre high in South and Central; both very low in North*
- *Cassin's auklets signal more ambiguous (noisy in North, low elsewhere)*
- *No major die-offs ("wrecks") attributable to productivity in 2017*
 - *Unlike 3 preceding years*
 - *Domoic acid impacts in SoCal Bight*

Whale entanglement reports

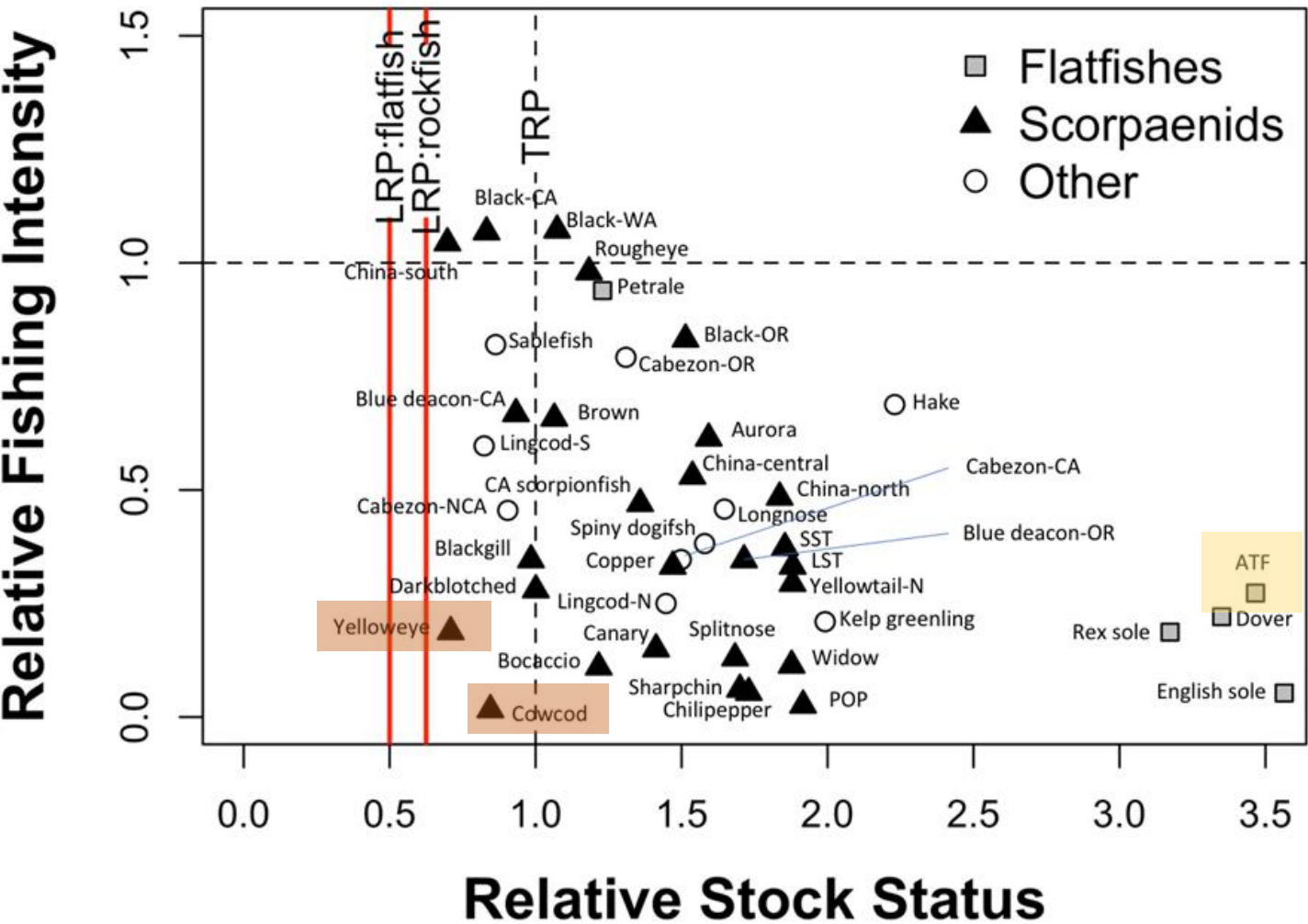


Whale Entanglements Reported by Year and Species



- *4th consecutive year: high number of reports of large whales entangled in fishing gear*
- *Most reports from CA, especially near Monterey Bay*
- *Most gear: unidentified*
- *ID'd gear mostly Dungeness crab, but sablefish gear too (2 in 2016, 1 in 2017)*
- *Cause? whales pursuing forage closer to shore x fishing patterns?*

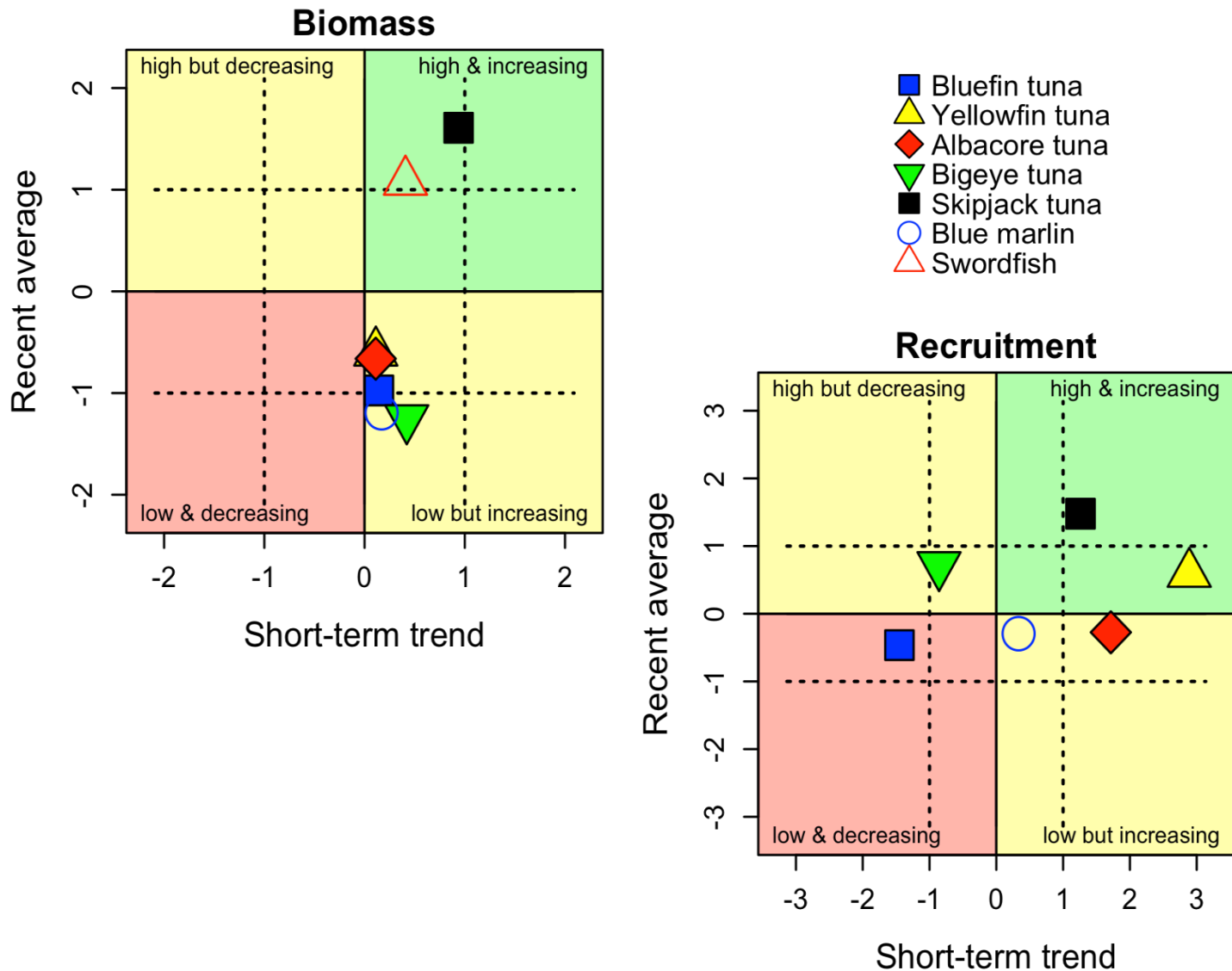
Groundfish



- *No assessed stocks “overfished”*
 - *Though yelloweye, cowcod not rebuilt*
- *3 rockfish above “overfishing” proxy*
 - *Black (CA), Black (WA), China (CA)*
 - *After tweaks to 2015 assessments*
- *Notable: substantial increase in biomass of arrowtooth flounder (important predator?)*

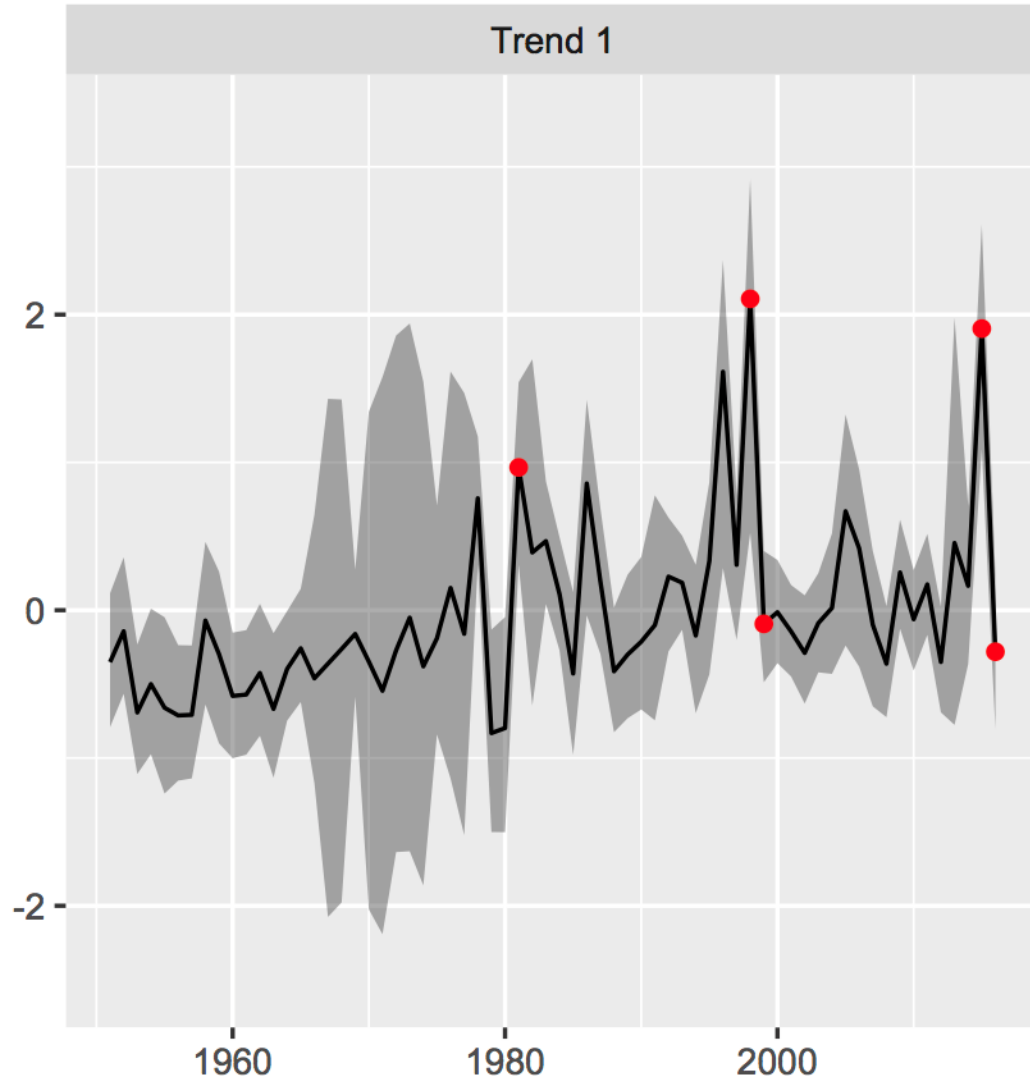
Will we soon see recruitment of all of the YOY we’ve had in the forage surveys?

HMS are now in report



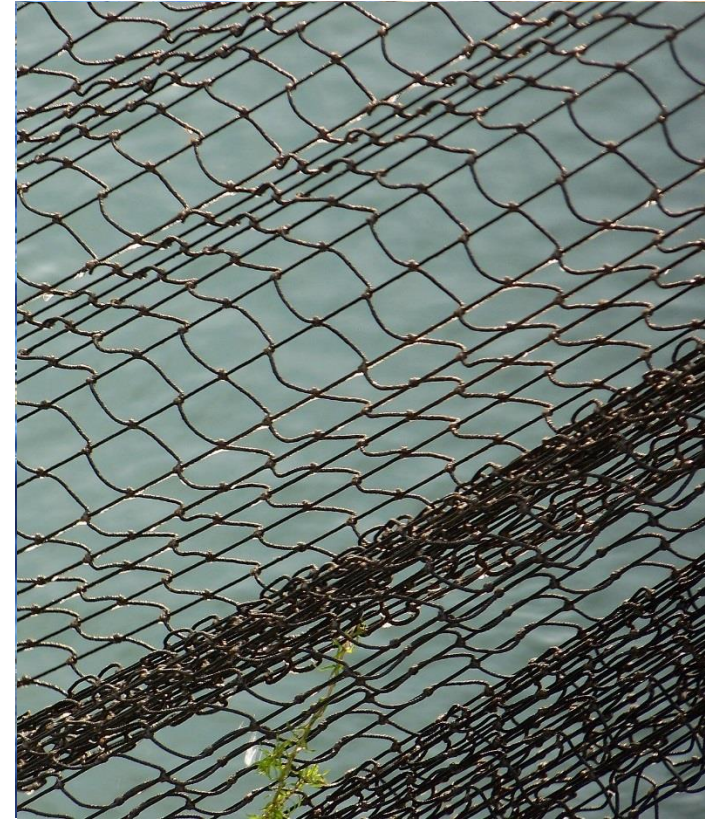
- *Biomass of eastern swordfish, skipjack is above avg; bigeye tuna biomass is below avg*
- *Recruitment of albacore, yellowfin, skipjack above avg; bluefin is below avg*
- This is our first attempt to include HMS indicators; simply drawn from recent assessments
- We are working on HMS distribution models, hope to include outputs in future reports

An “early warning signal” of major ecosystem shifts?

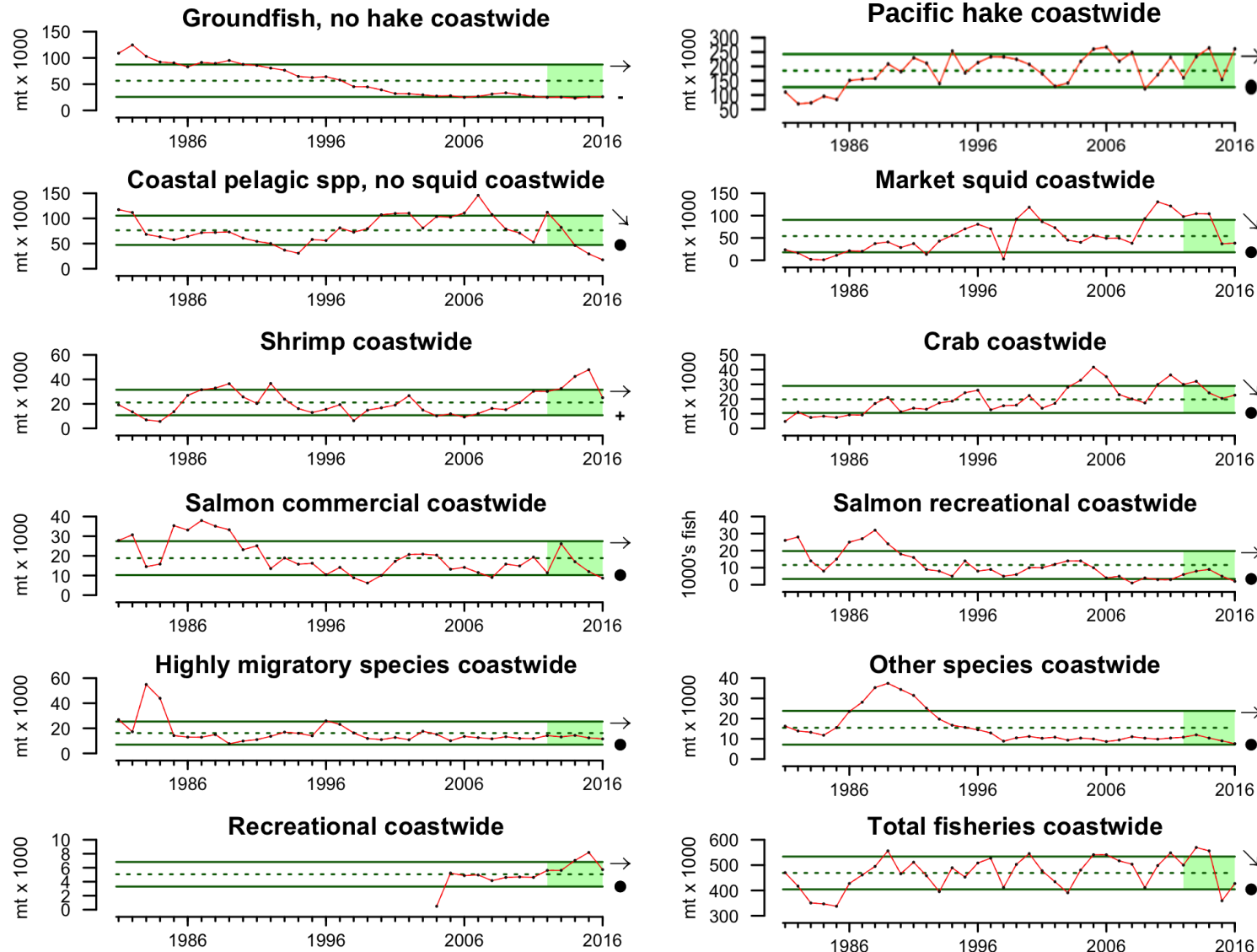


- Are there general indices of system state?
- Can we use them to anticipate pending shifts in biological regimes?
 - Example: shifts in ecosystem that have delayed recovery of Atlantic cod
- ***So far, no evidence of system reorganization after strongly anomalous years***
 - *Example at left: analysis of underlying “signals” in data for 32 species of ichthyoplankton in CalCOFI*
 - *Red dots = major annual shifts; “rare events”*
 - *The shift did not persist; quickly reverted to central tendency*

3. Human activities and wellbeing

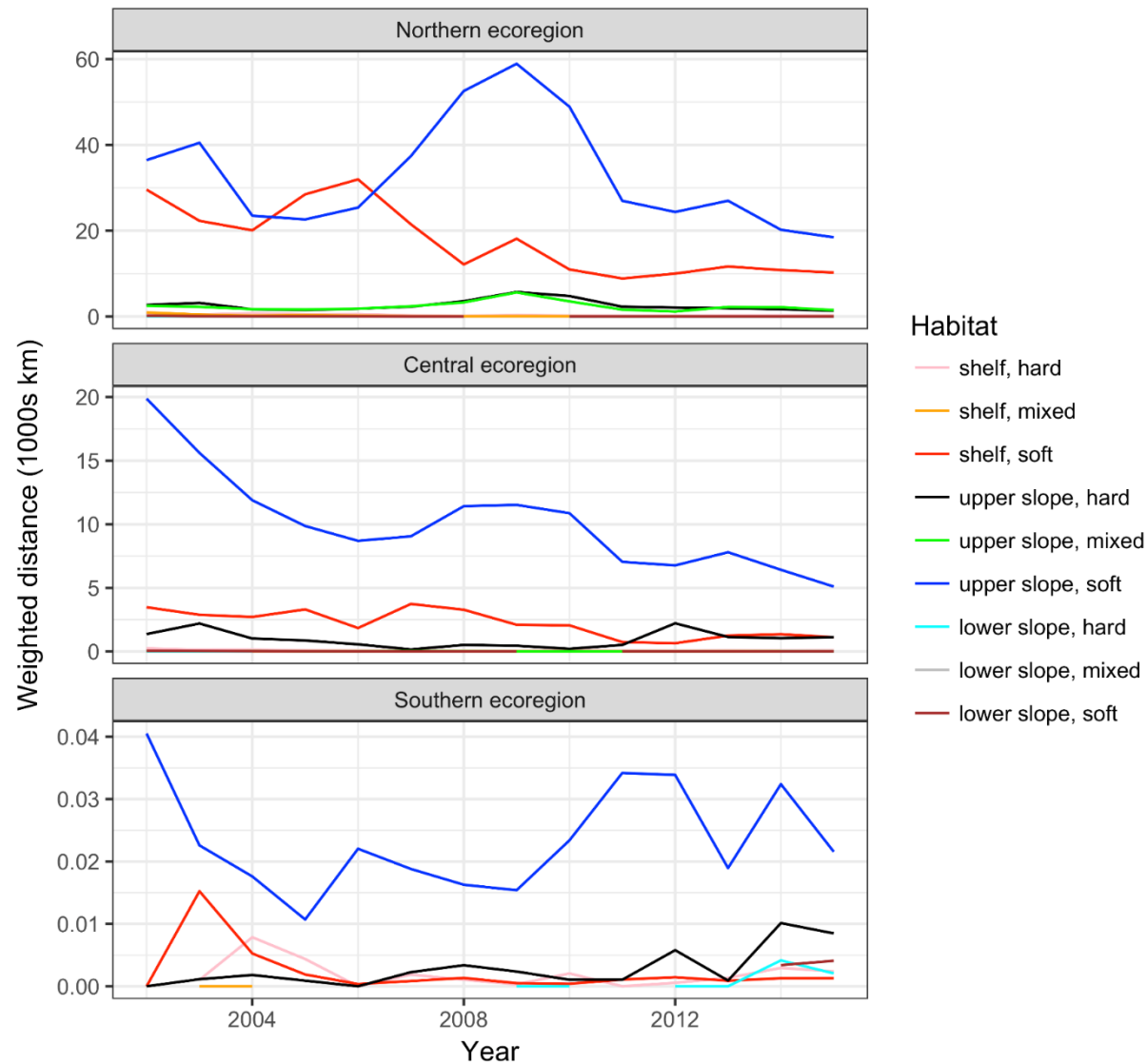


Landings through 2016



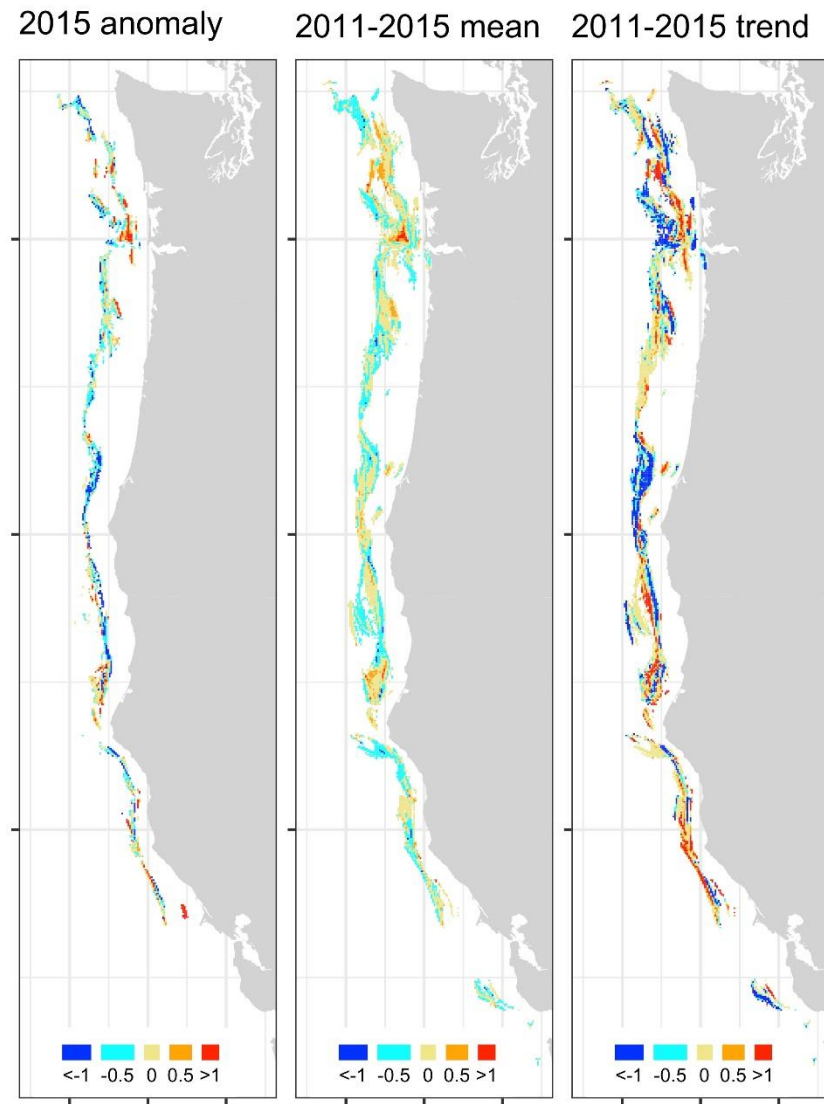
- Landings data updated through 2016
- *Landings & revenues on the whole were down in 2016, driven by CPS, shrimp*
- *Buffered a bit by large hake landings, stable crab landings*

Bottom contact gear: coastwide trend is down



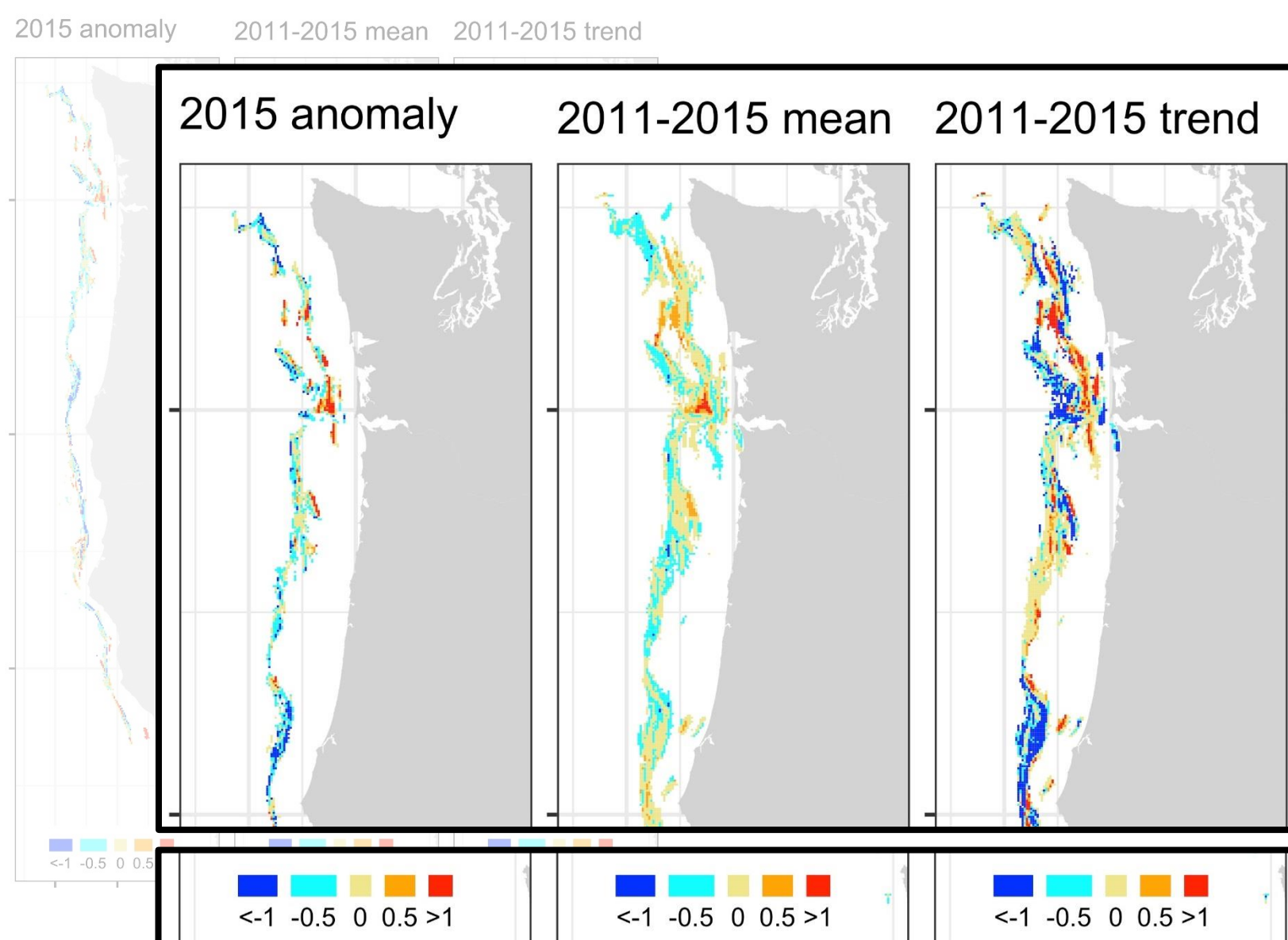
- Data from 2002-2015, both trawl and fixed gear (data availability are variable for fixed gear vessels)
- *Long-term decline in aggregate contact between gear and seafloor*
- *Trend driven by trawling on soft sediments in north and central regions*

Bottom contact gear: spatial trends provide more context



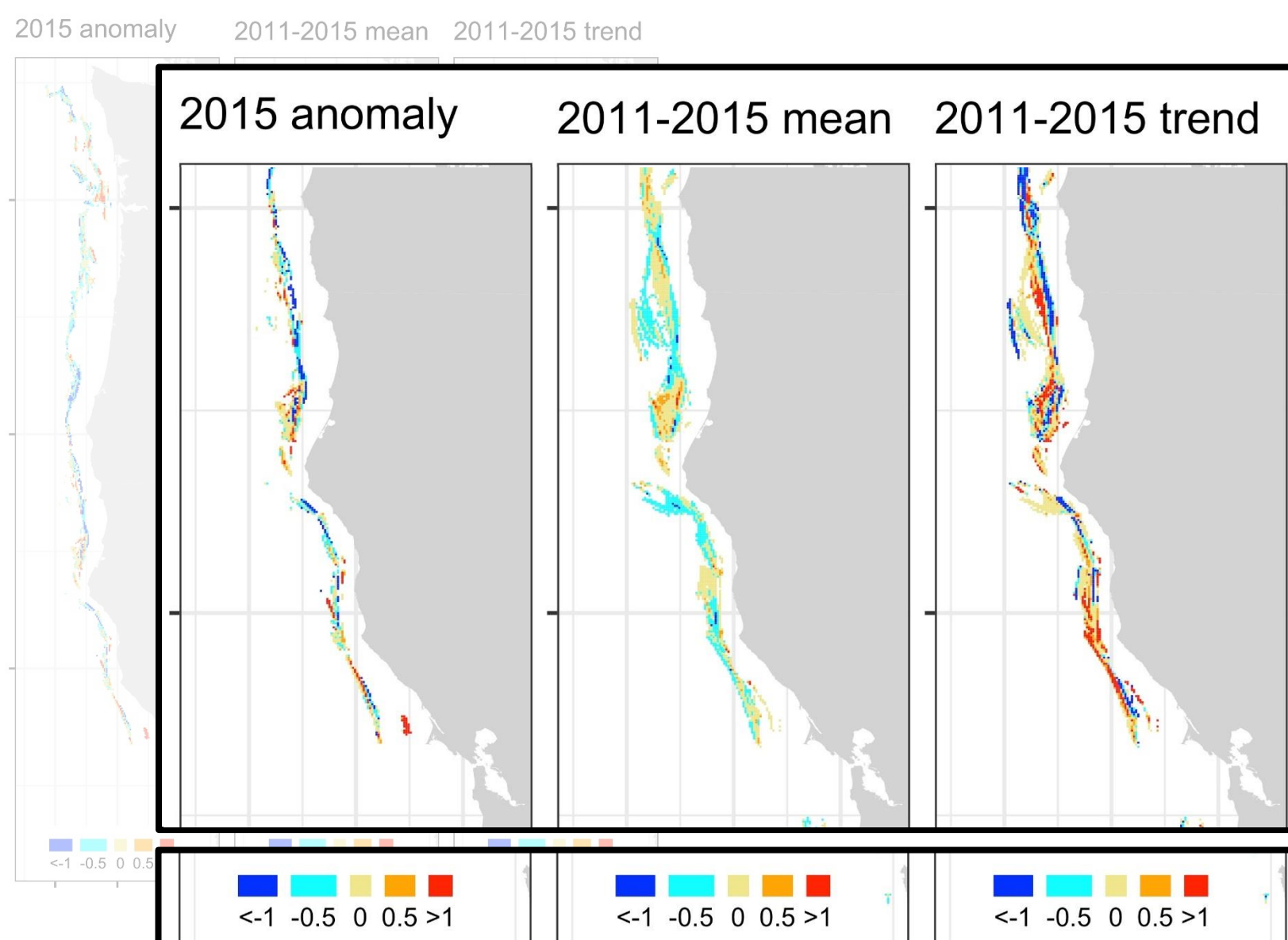
- Bottom trawl logbook data on start/stop points
 - Left: 2015 relative to mean from 2002-2015
 - Middle: 5-yr mean
 - Right: 5-yr trend

Bottom contact gear: spatial trends provide more context



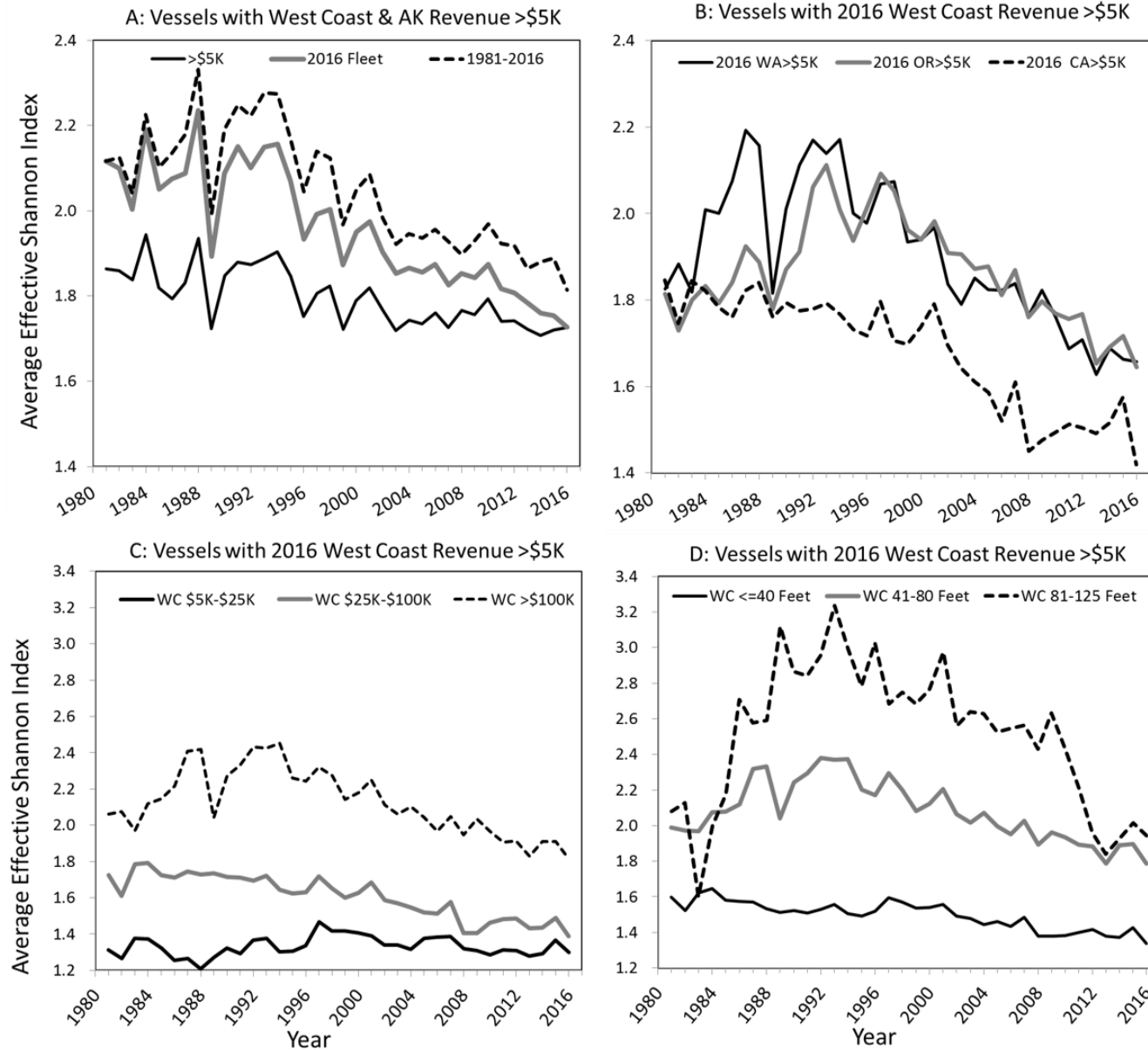
- Bottom trawl logbook data on start/stop points
 - Left: 2015 relative to mean from 2002-2015
 - Middle: 5-yr mean
 - Right: 5-yr trend
- *North: increases off Southern Washington, decreases off Cape Blanco*

Bottom contact gear: spatial trends provide more context



- Bottom trawl logbook data on start/stop points
 - Left: 2015 relative to mean from 2002-2015
 - Middle: 5-yr mean
 - Right: 5-yr trend
- *North: increases off Southern Washington, decreases off Cape Blanco*
- *Central: spottier data, but some increases north of Mendocino in 2015; below average but increasing in some bands from 2011-2015*

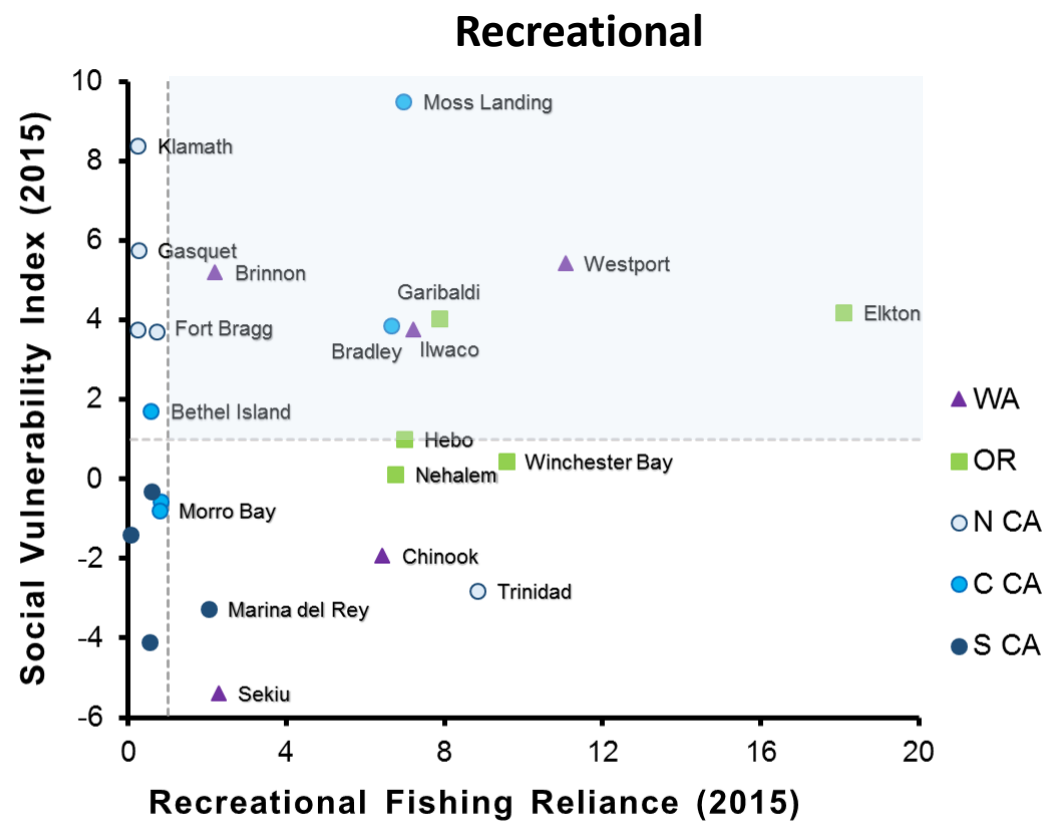
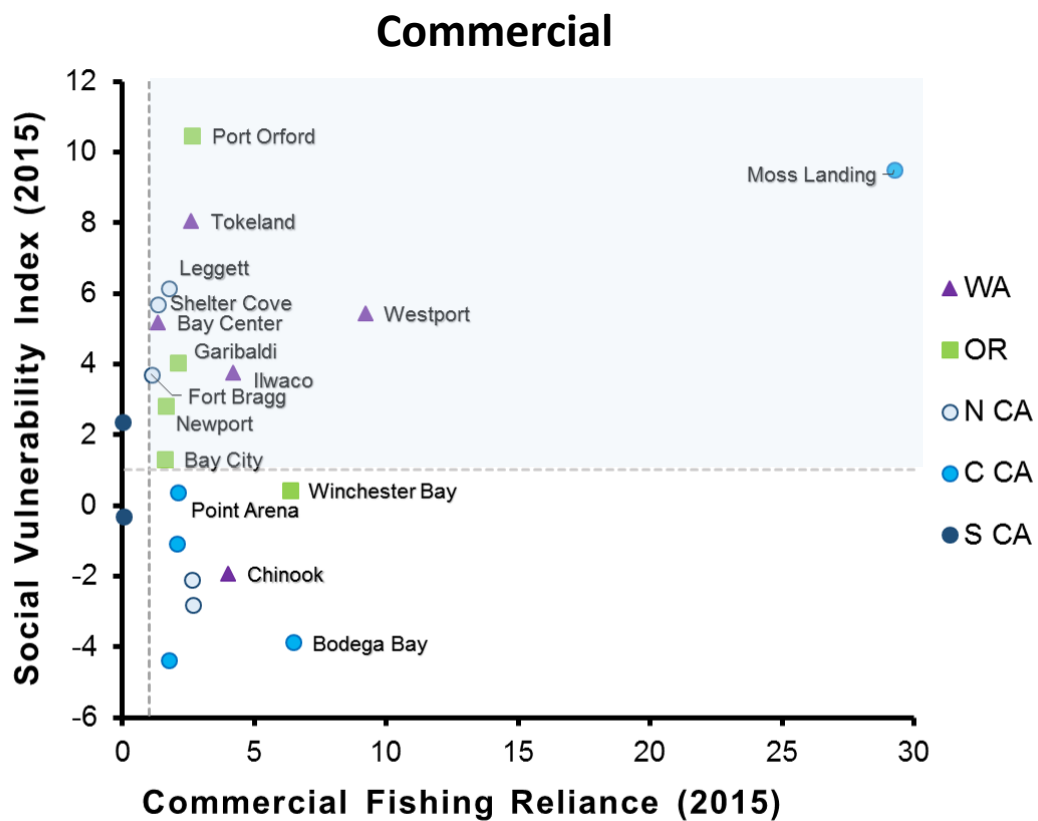
Diversity of vessel “portfolios” still decreasing



- Index of how broadly and evenly revenue is spread across different fisheries
 - Lowest score is 1; all revenue from a single fishery
- *Diversification continued declining across all classifications of West Coast vessels*
 - *Size, state, total revenue*

Social vulnerability, commercial & recreational reliance

- Social vulnerability vs. per capita “reliance” on fishing-related revenue
- Some vulnerable communities are highly reliant on both sectors (Westport, Garibaldi, Ilwaco, Moss Landing)
- There seem to be more vulnerable communities that are commercially reliant than recreationally reliant

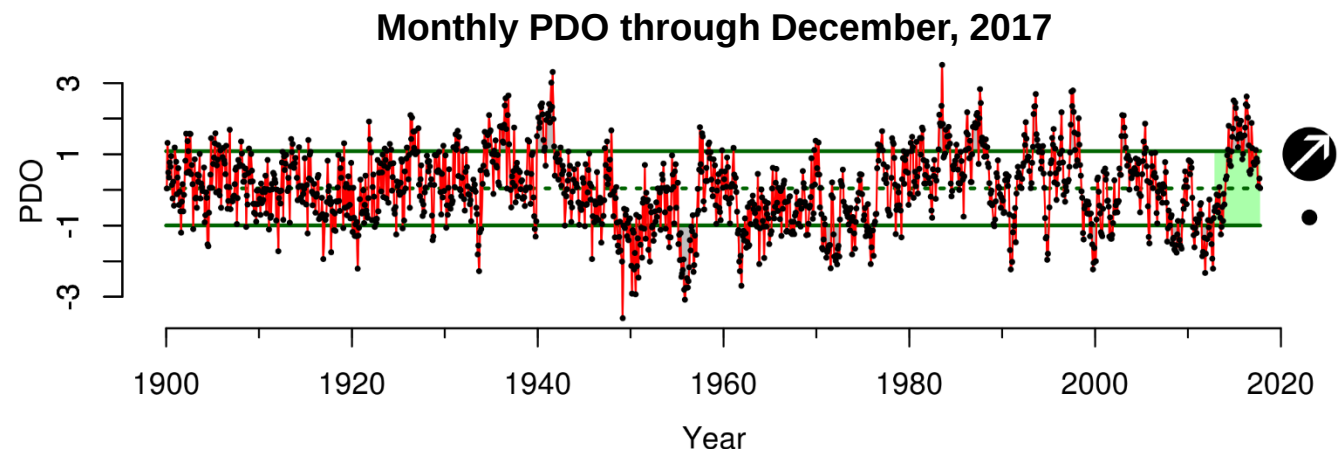
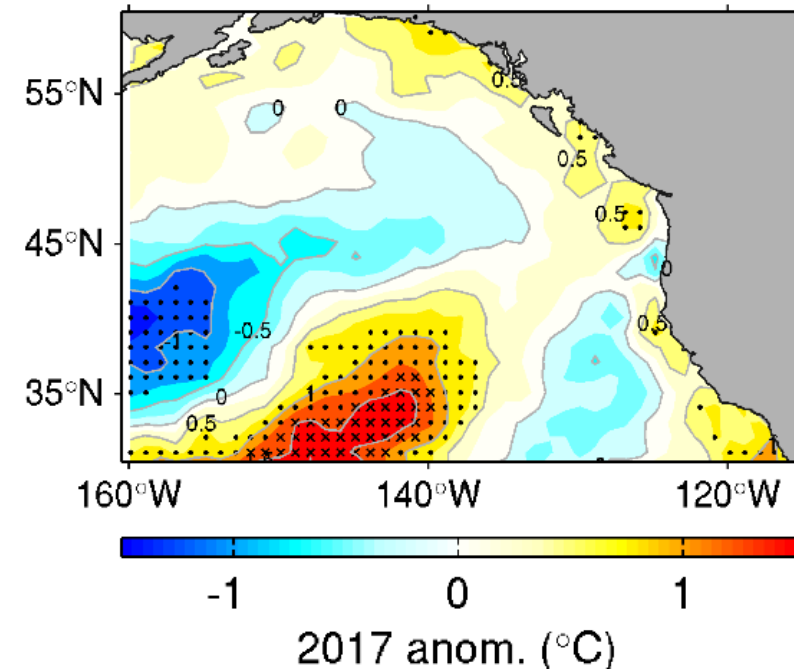


4. Synthesis

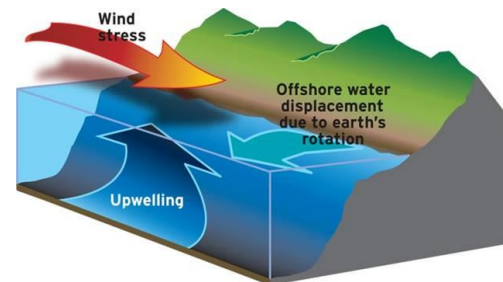
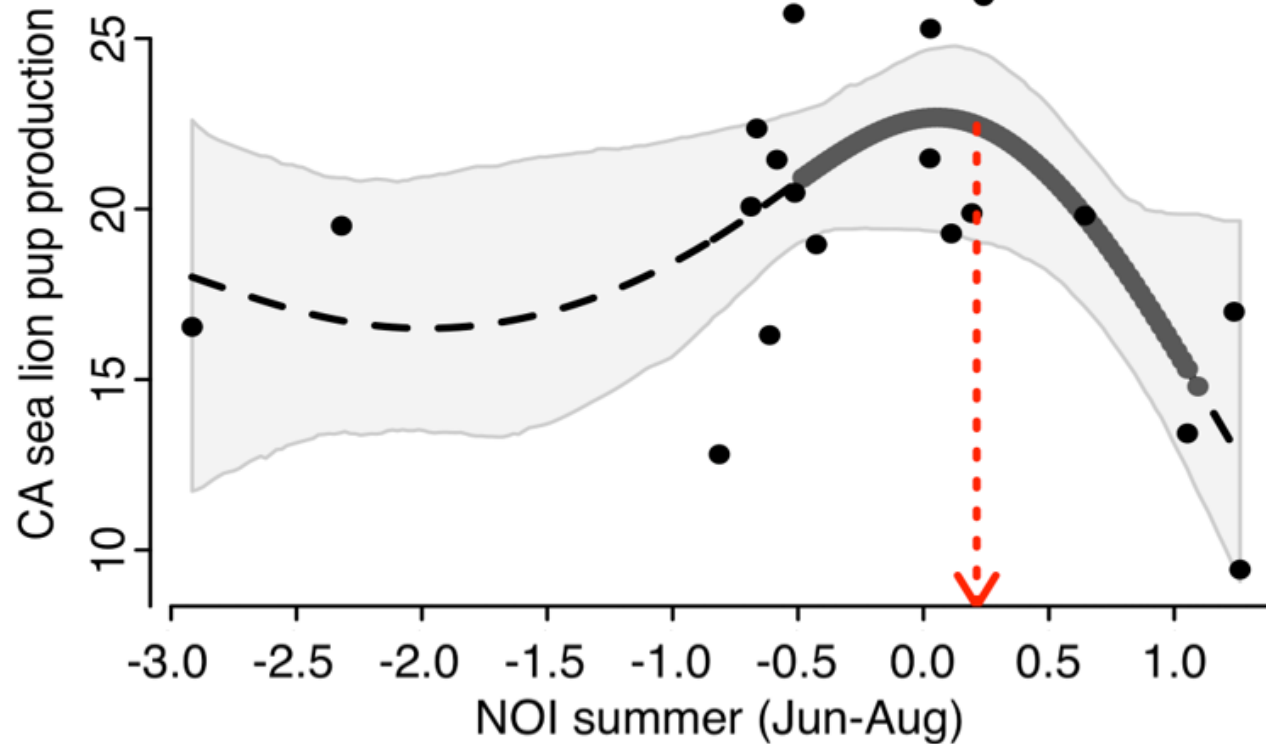


Linking physical processes to management

- We are exploring how oceanographic processes are correlated with biology in time and space
- Goal: to use indicators of drivers to identify and predict ecosystem processes that are meaningful for management
- Two examples follow
 - Ecological thresholds
 - Distributions of target and protected species

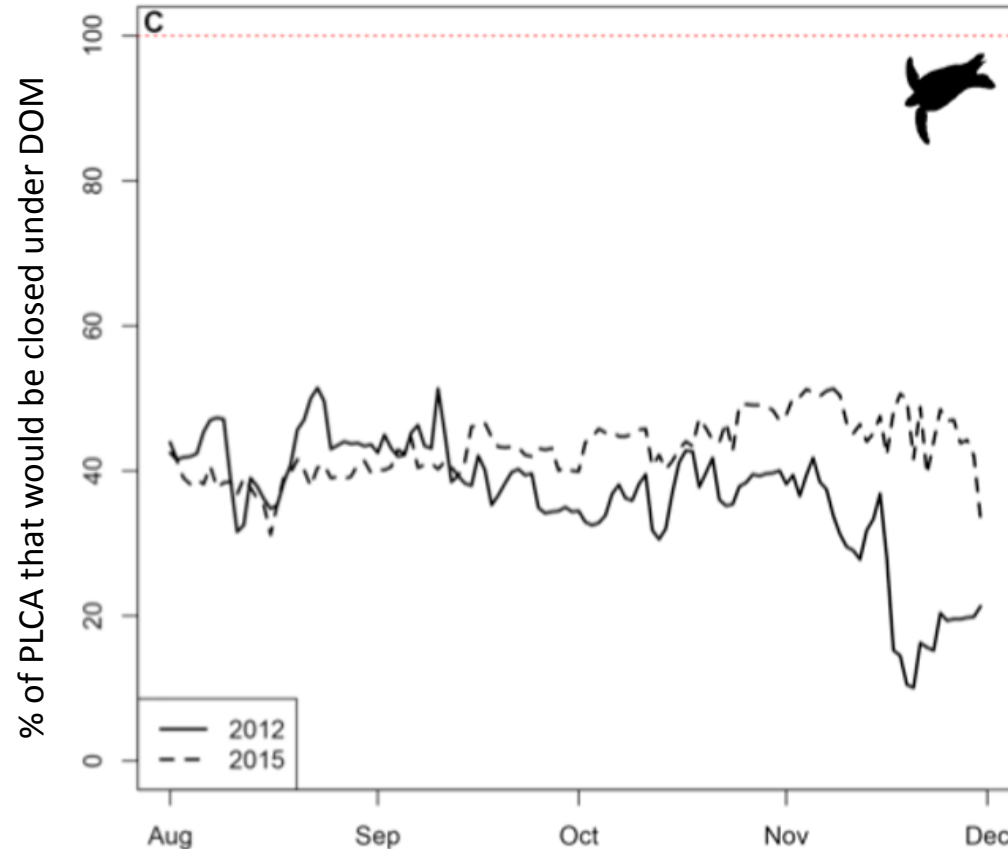
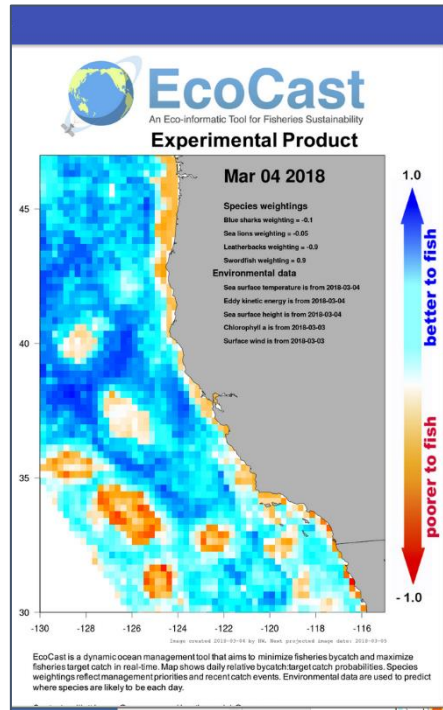


Evidence of ecosystem thresholds



- Northern Oscillation Index: a basin-scale index related to upwelling in the CCE
- *Using statistical tools, CCIEA team found threshold NOI value beyond which sea lion pup counts plunge*
- Thresholds could serve as ecosystem reference points
- We will explore this further for salmon and freshwater habitat indicators

EcoCast estimates of predator distributions related to HMS



- CCIEA team is studying HMS & PR distributions relative to oceanographic conditions
- “EcoCast” model may be useful for anglers—e.g., estimates probability of encountering a protected species in a particular location
- *May also be useful for management*
 - *Less of PLCA closed to CDGN fishery*
 - *Accounts for annual differences in environmental conditions*

- **Physical indicators near average levels**
 - Ocean conditions lagging in north; poor snowpack possible in central & south
- **Signs that feeding conditions are returning to average**
 - Most evident in central and southern waters
 - Not out of the woods yet in north
- **Near-term salmon outlook is discouraging, again**
 - Returns, feeding conditions for juveniles, possible drought

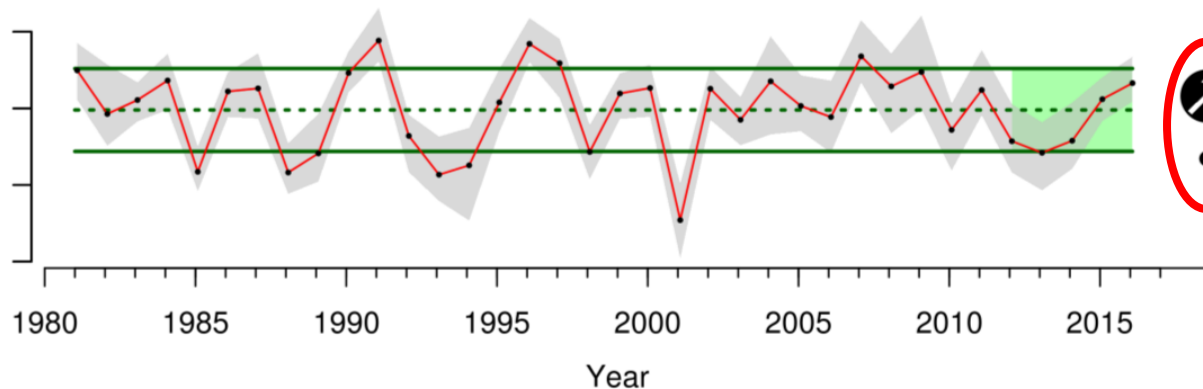
Toby.Garfield@noaa.gov, Chris.Harvey@noaa.gov

Extra Slides

Interpreting time series and quad plots

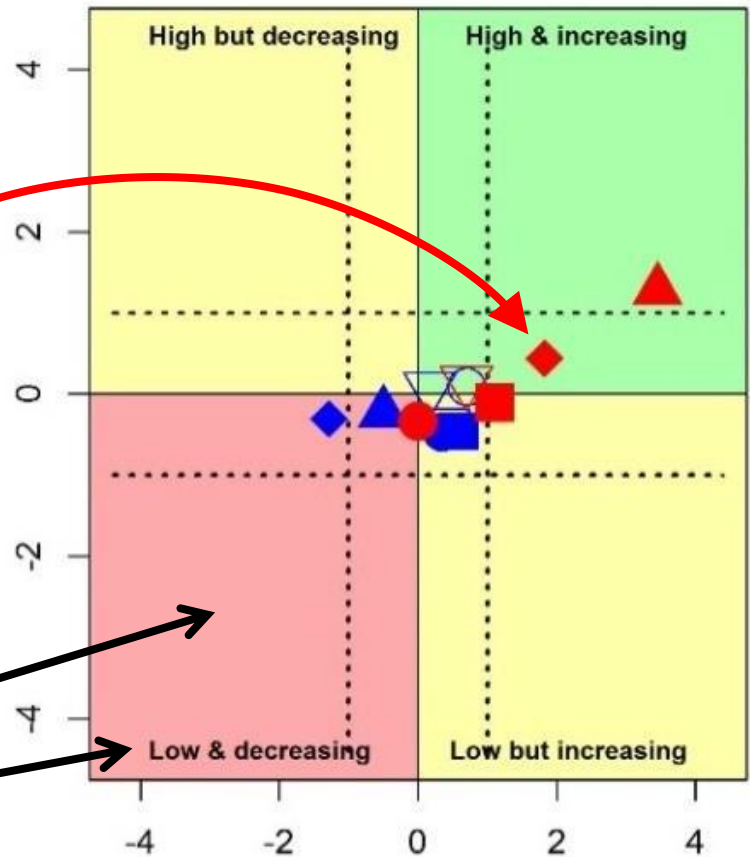
Time series show data/error relative to long-term mean (---) $\pm$ 1 standard deviation (—).

Symbols at right indicate trend ($\nearrow$, $\leftrightarrow$ or $\searrow$) and mean (+, $\bullet$ or $-$) of most recent 5 years (green area) compared to long-term data



Recent average

Each symbol represents recent status and trend of one time series (normalized to long-term data)

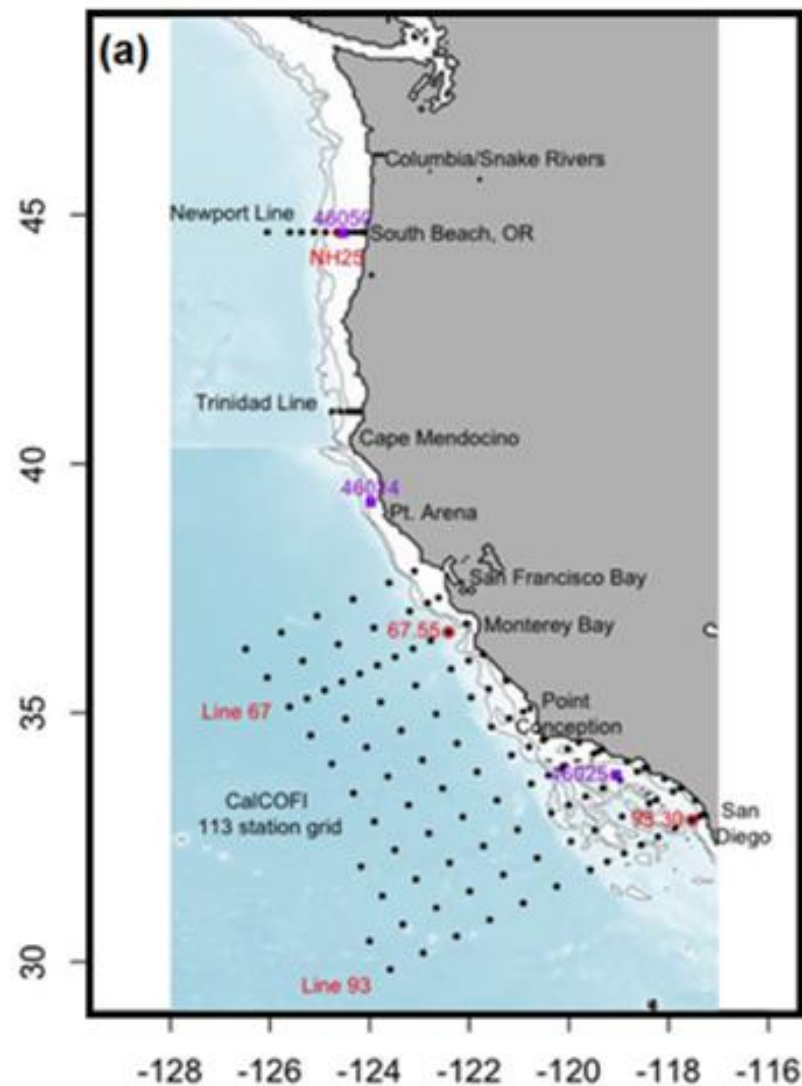


Colors and descriptions summarize status and trend for time series in each quadrant

Recent trend

Sampling areas

Oceanography



Freshwater ecoregions



Biological sampling

