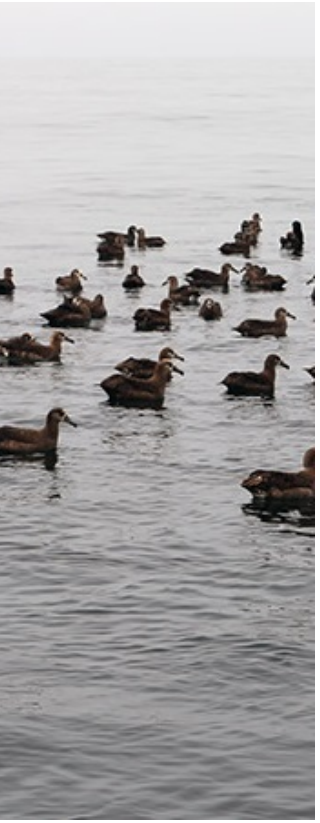


2019 California Current Ecosystem Status Report

NOAA California Current IEA Team

Presented to the Pacific Fishery Management Council
March 7, 2019, Vancouver, WA

Summary

- **Large-scale climate indices in 2018 were mixed**
  - Along the equator, weak El Niño conditions have developed
  - Negative NPGO indicates weak circulation of subarctic water into the California Current
  - PDO was neutral throughout 2018
  - No evidence (yet) of a new marine heatwave in the north Pacific

- **Regional climate and oceanography indicators also mixed**
  - Waters cooler than 2014-16, but remain average or above average, especially in the south
  - Upwelling volume and nutrient supply within historical ranges
  - Snowpack in 2018 was above average in north, generally below average elsewhere

Summary

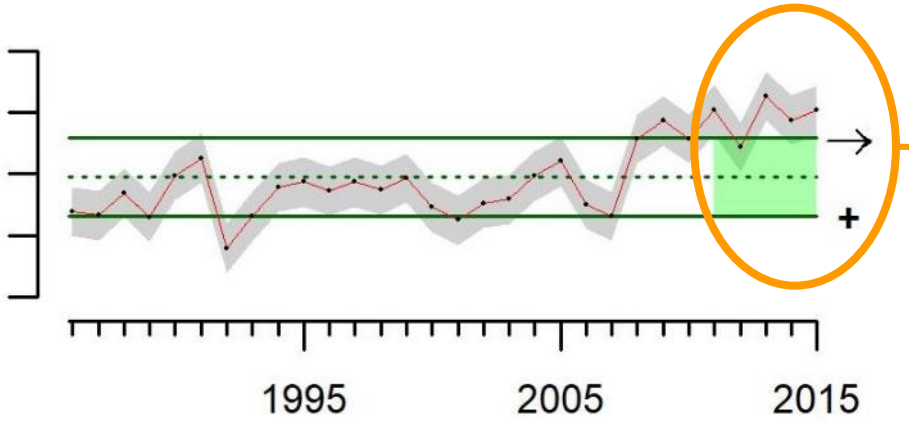
- **Many ecological indicators were average or above average**
  - Zooplankton off Newport and Trinidad Head
  - Densities of juvenile salmon off OR & WA; anchovy off CA
  - Density and growth of CA sea lion pups; densities of fish-eating seabirds
- **Not all ecological indicators were encouraging, though**
  - Still high densities of pyrosomes (warm-water tunicates)
  - Indicators suggest poor returns of Chinook salmon to the Columbia this year
  - Whale entanglements and harmful algal blooms were widespread again
- **Fisheries landings and revenue greater in 2017 than 2016**
  - Due to hake, squid, Dungeness crab

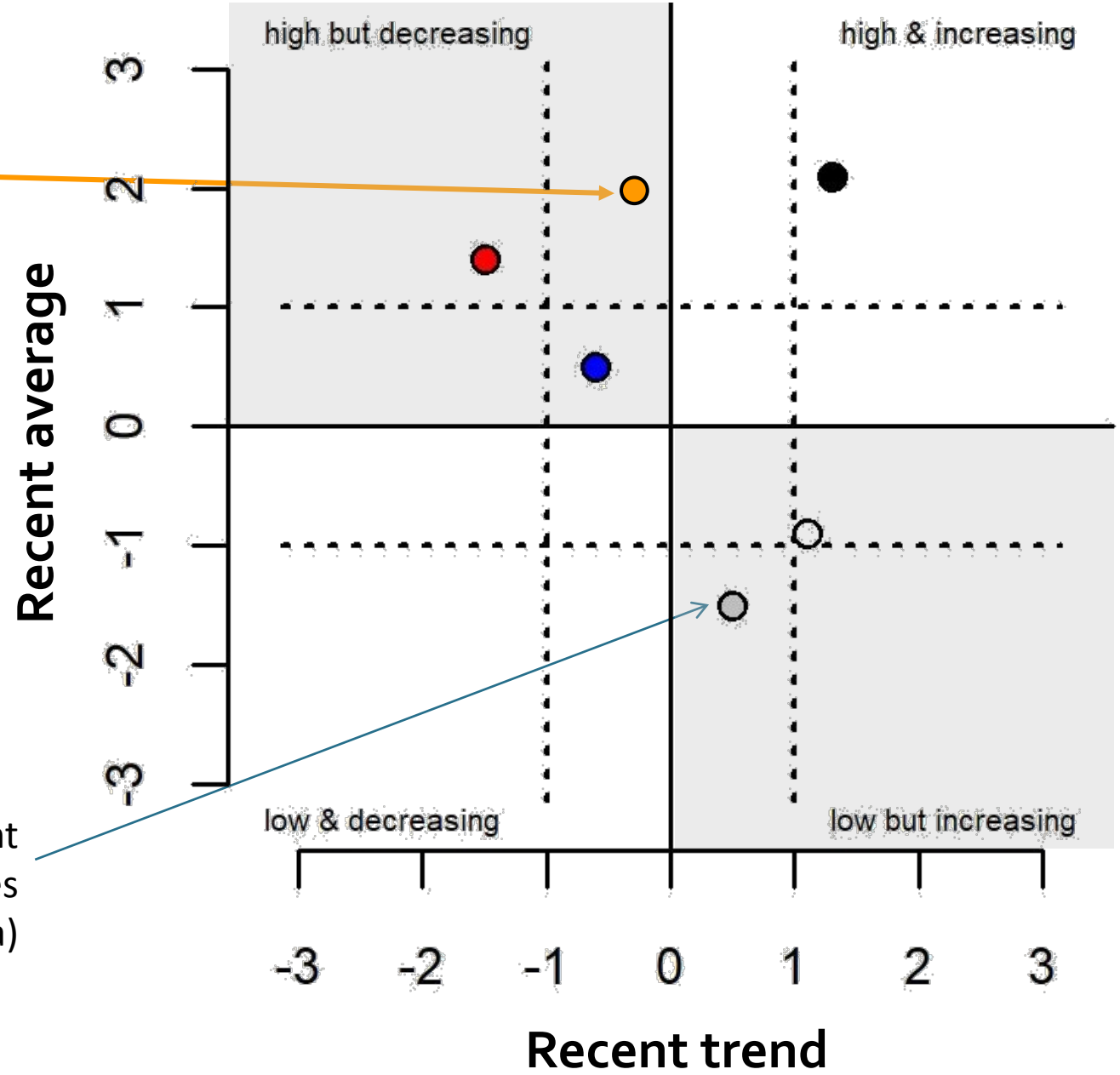
Summary

- **System is transitioning…but to *what?***
  - 2014-2016 warm anomalies seem mostly to have dissipated
  - But, climate indicators (weak El Niño, weak circulation) imply below-average productivity

- **Outlook for 2019**
  - Weak El Niño at least through spring
  - Hypoxia and acidified water off of Oregon and Washington in spring and early summer
  - Below-average returns of Chinook to Columbia; average returns of coho to Oregon coast

Time series and quad plots





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

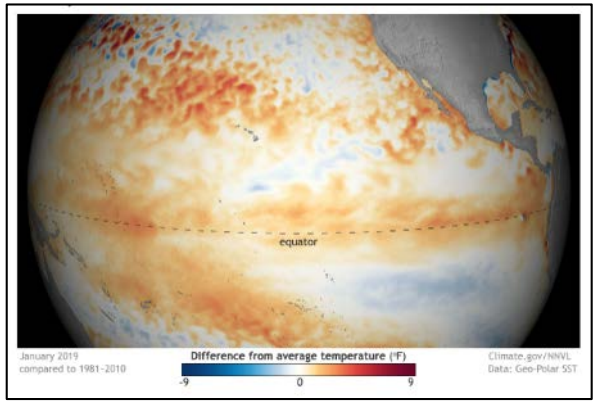
Physical Conditions

Conditions have improved, but signals are mixed

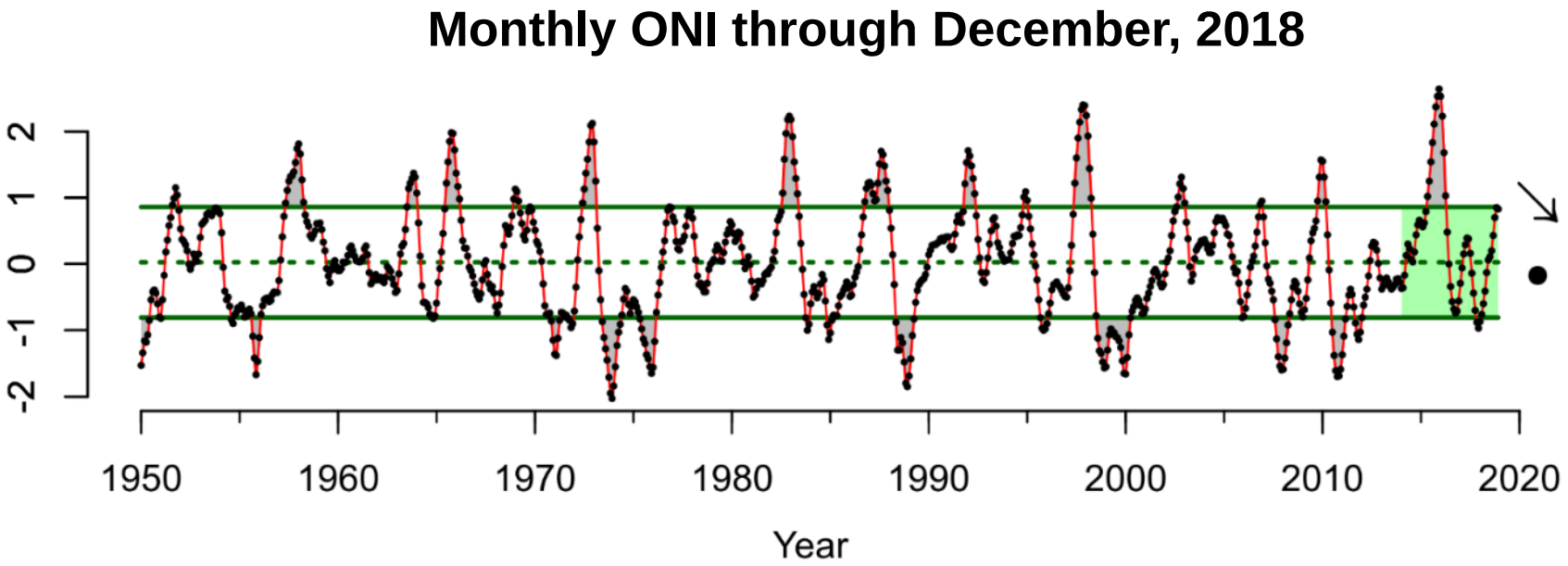
Basin-scale climate indices show mixed patterns

Oceanic Niño Index (ONI)

Positive ONI = El Niño conditions
Negative ONI = La Niña conditions



January 2019 image from Climate.gov

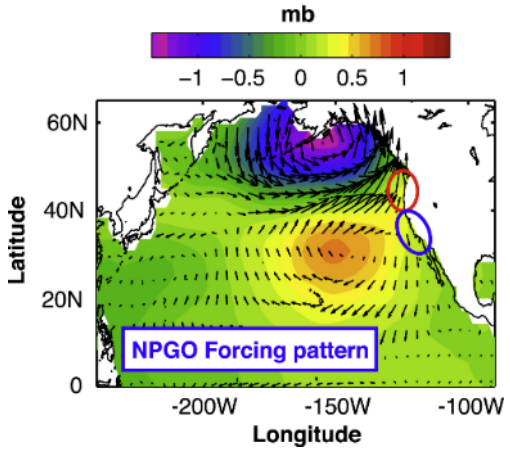


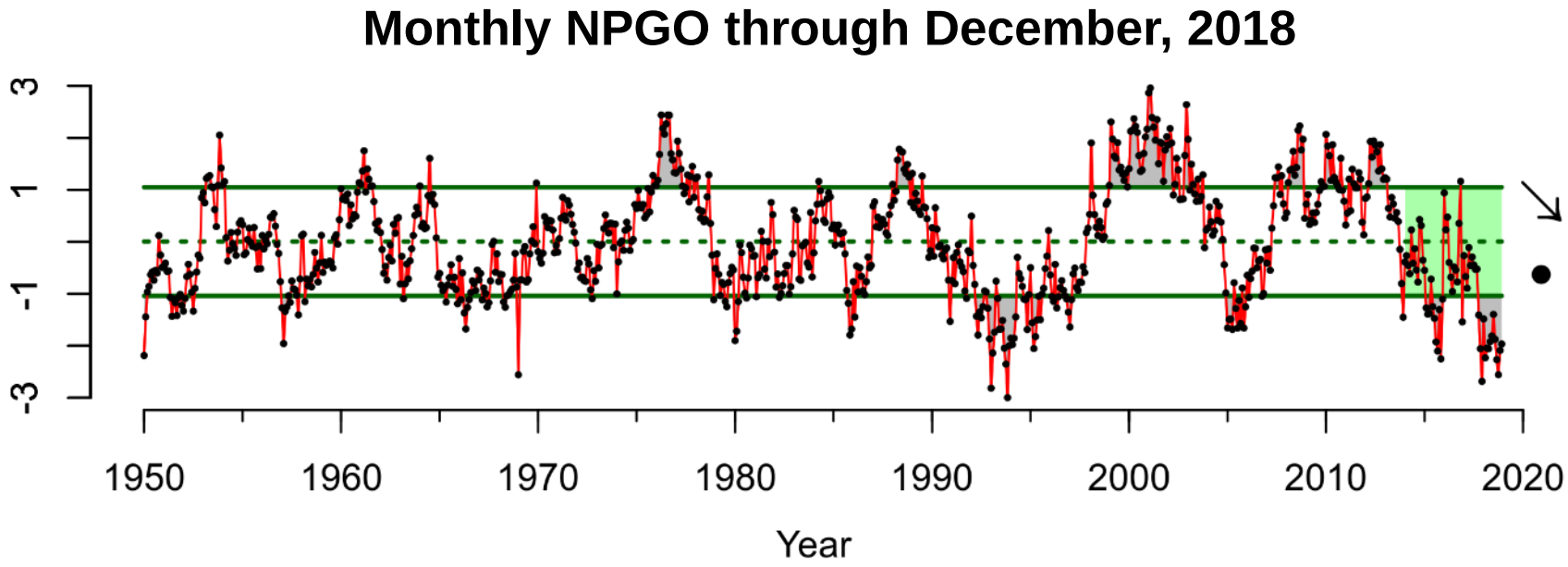
- Strong El Niño, 2015-2016
- Neutral to weak La Niña in 2017
- ***Returned to neutral and eventually positive by late 2018***
- ***Weak El Niño is present***
  - ***55% chance of persisting through Spring 2019***

Basin-scale climate indices show mixed patterns

North Pacific Gyre Oscillation (NPGO)

Positive NPGO = stronger circulation, higher productivity
Negative NPGO = weaker circulation, lower productivity



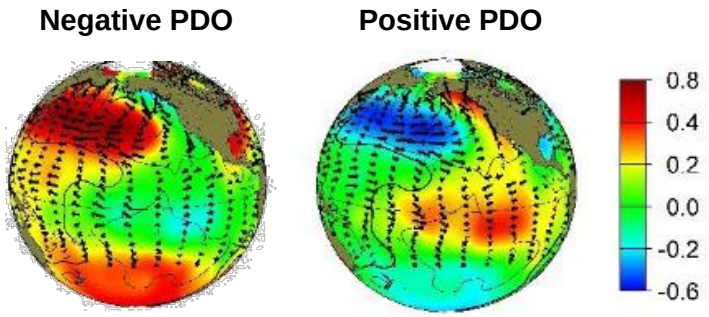


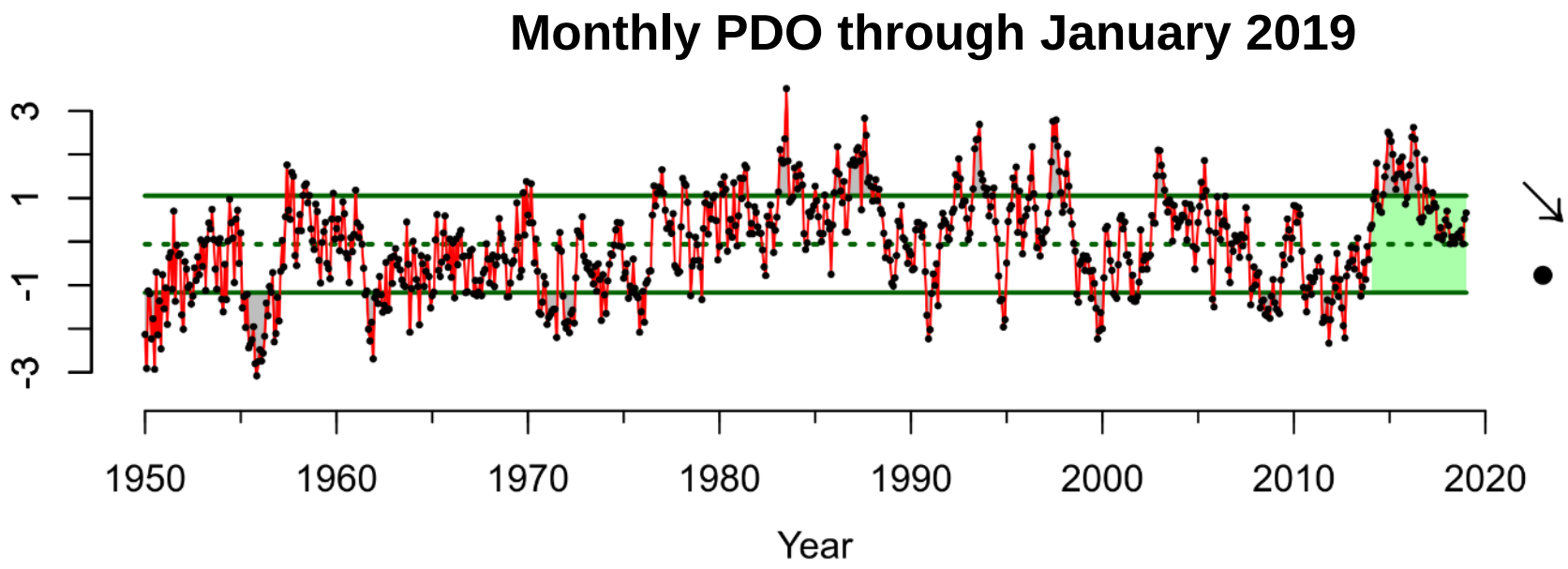
- Varied between negative and neutral from 2015-2017
- ***Strongly negative throughout 2018***

Basin-scale climate indices show mixed patterns

Pacific Decadal Oscillation (PDO)

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

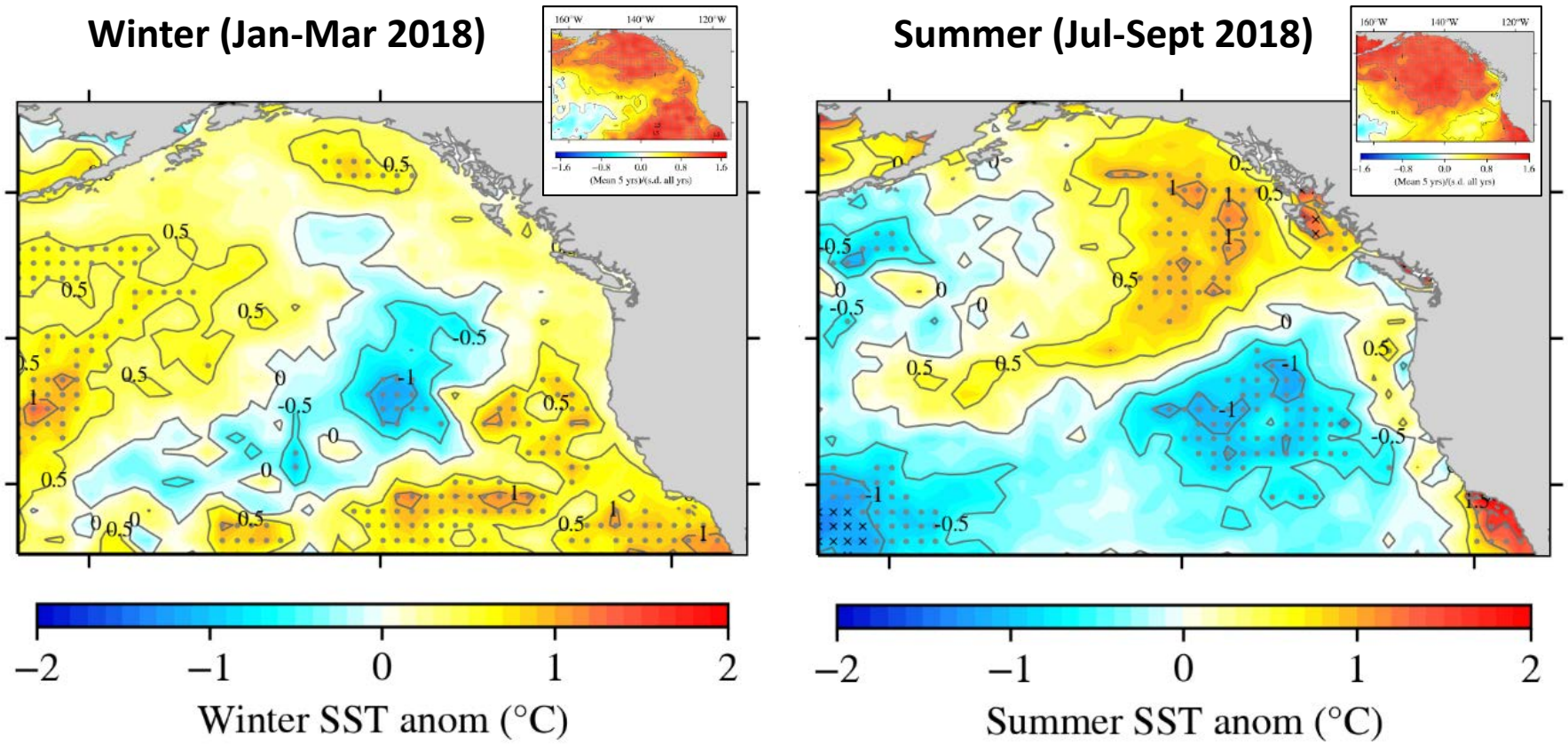




- Strongly positive from 2014-2016
- Returned to neutral in July 2016
- ***Neutral in 2018***
  - ***Ticked up in Dec 2018, Jan 2019***

California Current SSTs have cooled…but are still above average

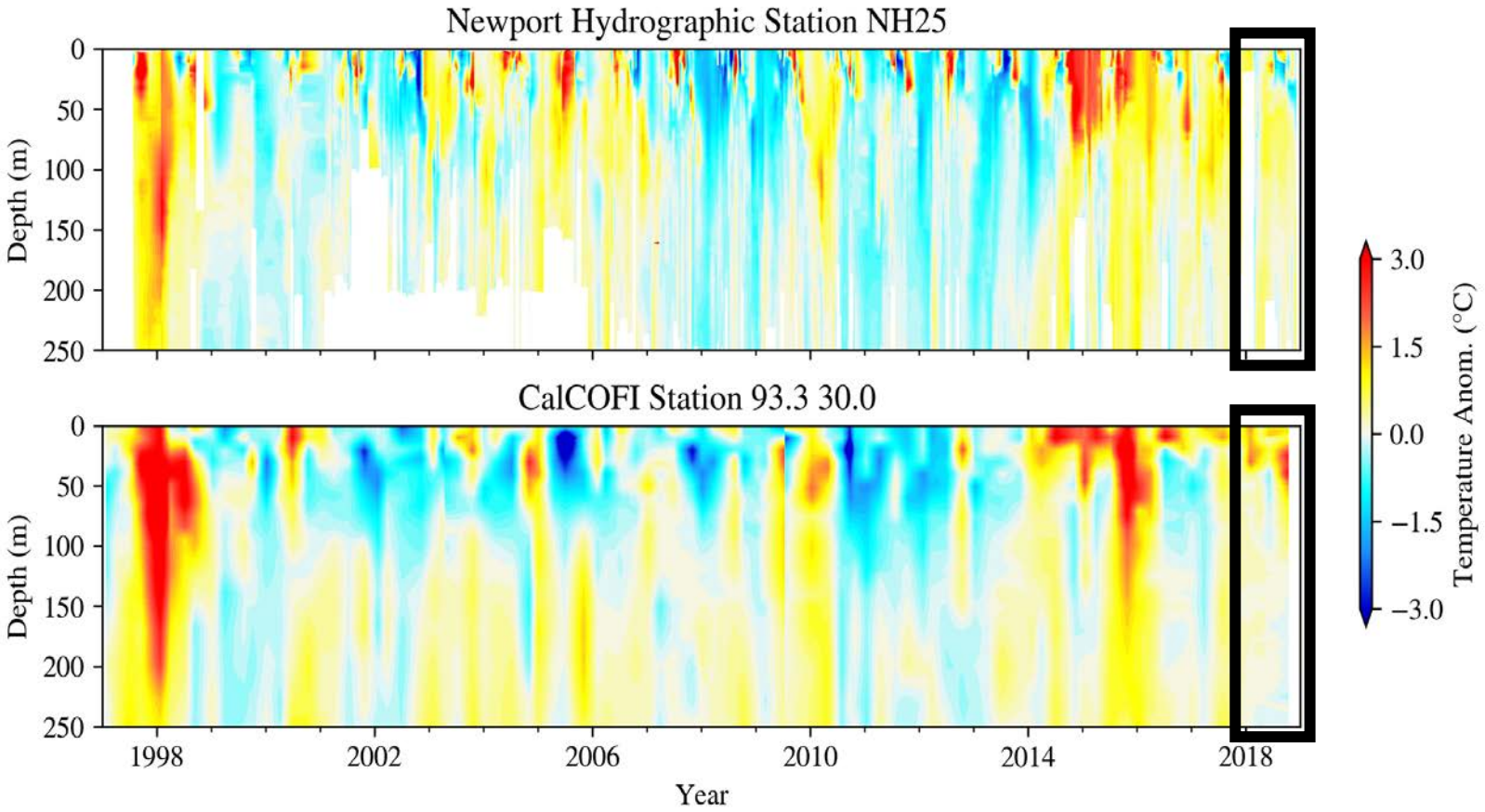
Sea surface temperature anomalies (SST_a)



- Over last 5 years, SST_a were well above average *(insets)*
- Cooling has occurred in all areas since 2014-16
- ***2018 winter SST_a still above average in California Current***
- ***Summer SST_a mixed***
  - ***Warm with patches of cool coastal water***
  - ***Well above average in Southern California Bight***

Subsurface temperatures also closer to average

Temperature anomalies at depth



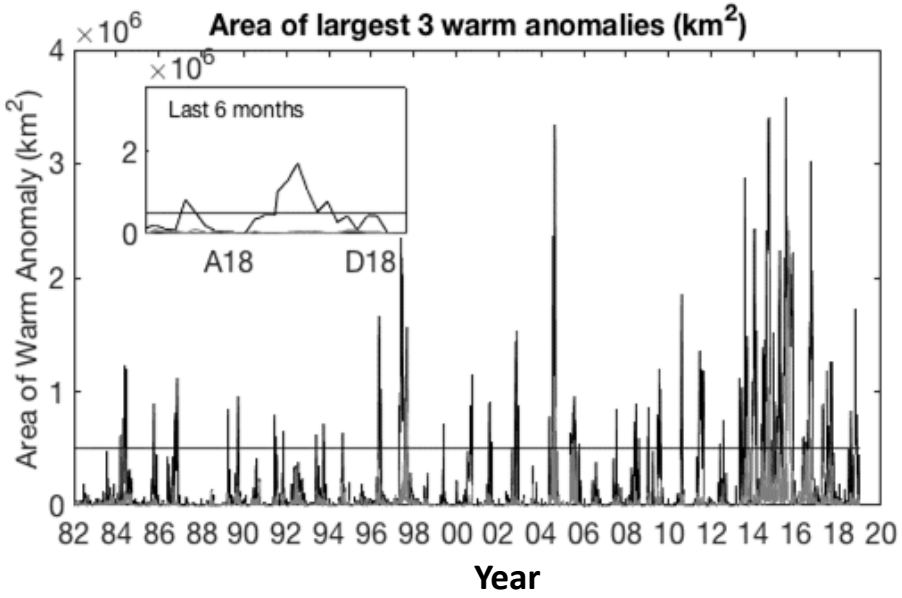
- Subsurface anomalies of 2014-2016 have subsided
- ***2018 off Newport: cooling above 50 m but still warm at depth***
- ***Off San Diego: hot at the surface, but cooling at depth***

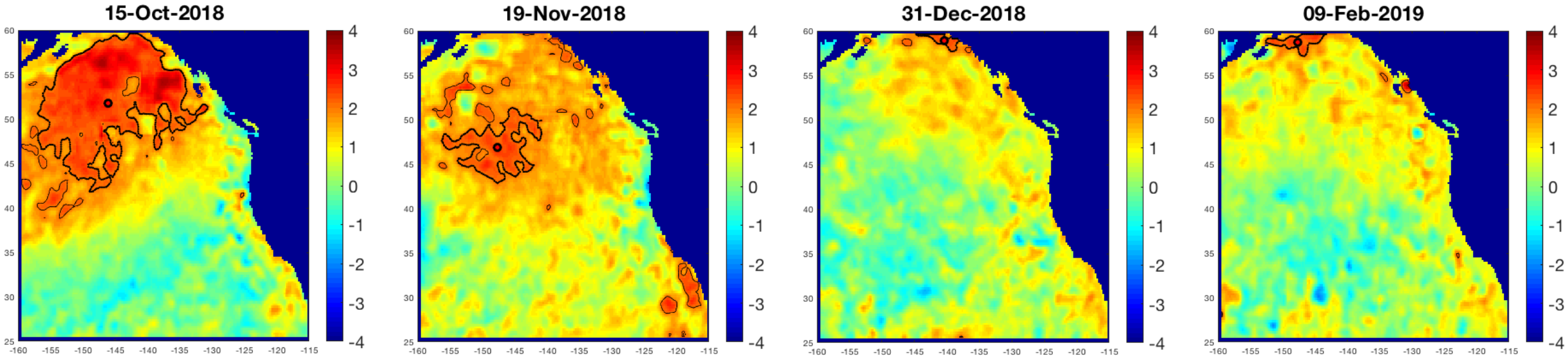
Was late 2018 another marine heatwave?

- After marine heatwave ("Blob") of 2014-2016, we developed criteria for the size, intensity and duration of SST anomalies to determine if they are marine heatwaves that influence the West Coast

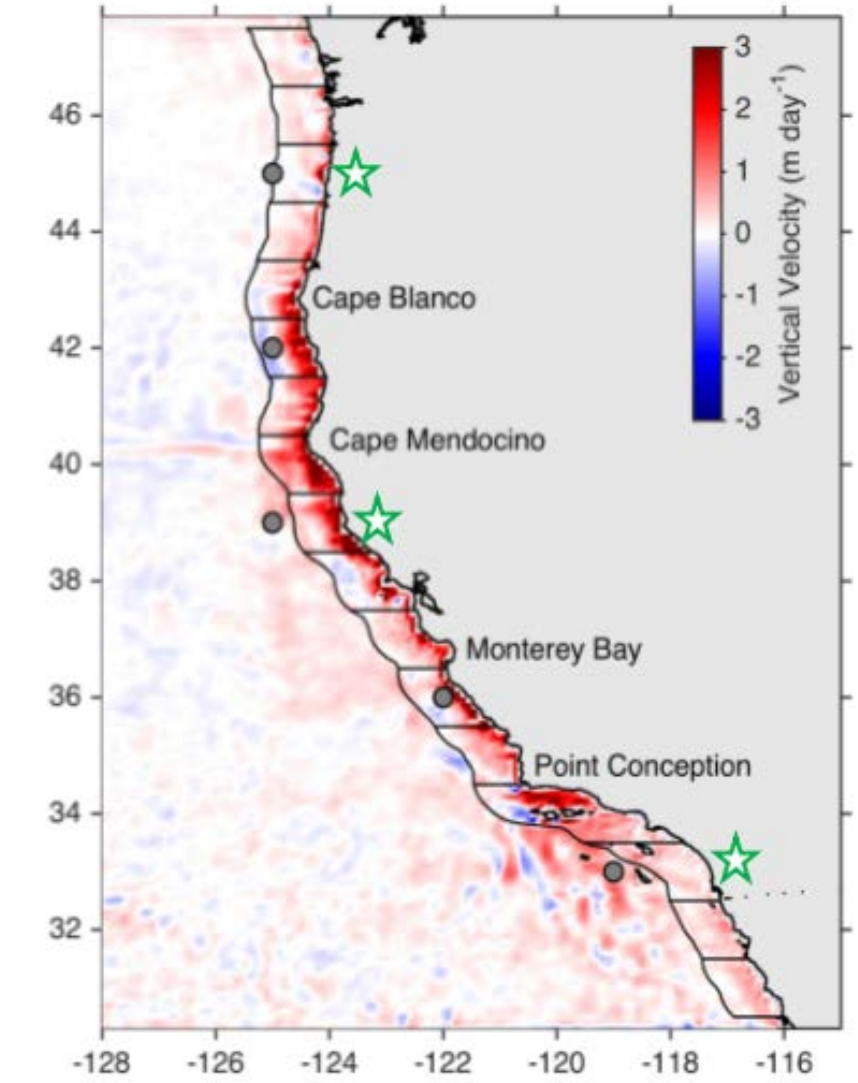
- Widespread media reports that a new marine heatwave might be forming in the North Pacific, late 2018

- ***Fall 2018 event: large and intense, but short-lived; mostly gone by December, hadn't reformed as of February 2019***



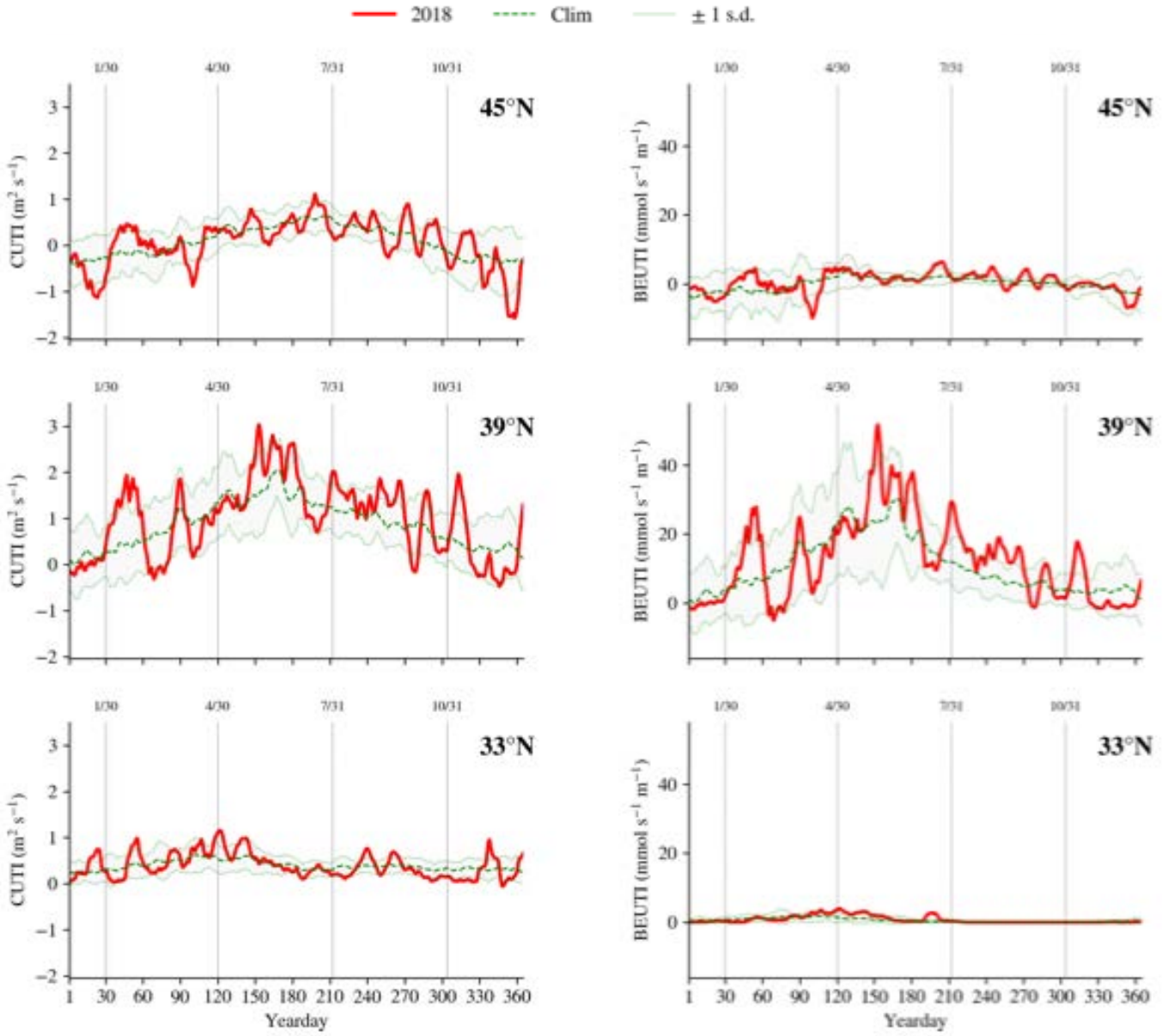


Upwelling: a new perspective



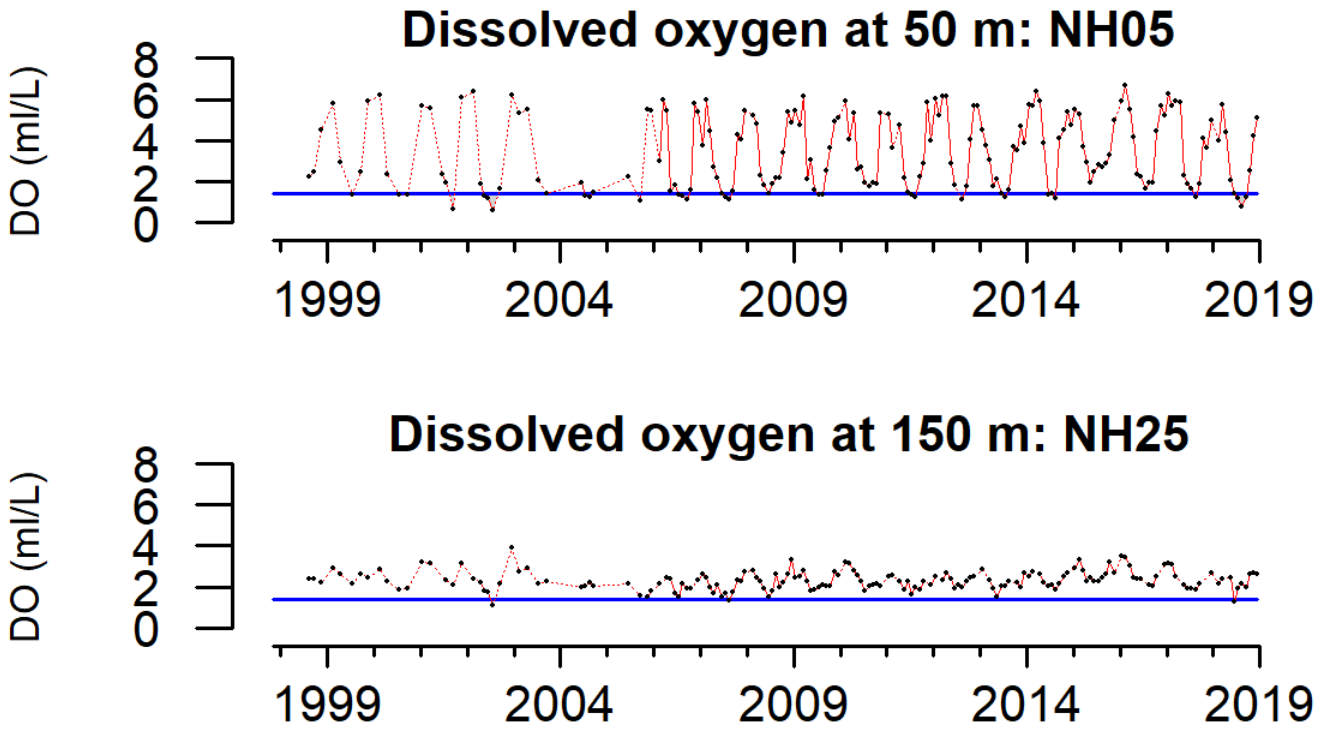
Coastal Upwelling Transport Index (CUTI)

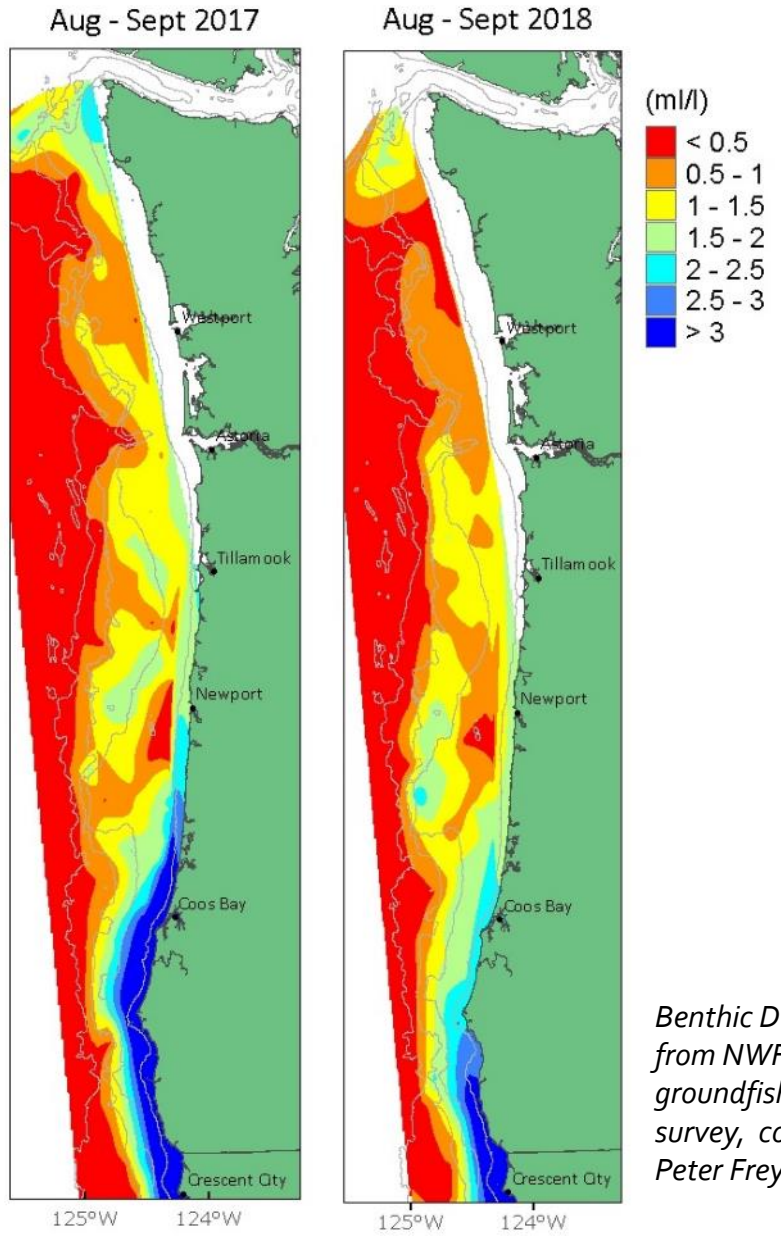
Biologically Effective Upwelling Transport Index (BEUTI)



Low dissolved oxygen, again

- Hypoxia threshold: below 1.4 ml O_2 / L
- ***DO values in the waters column off Newport in summer were the lowest observed since the early 2000s***
- ***Hypoxia on shelf bottom in summer 2018 was more extensive than in 2017 off Washington and Oregon***

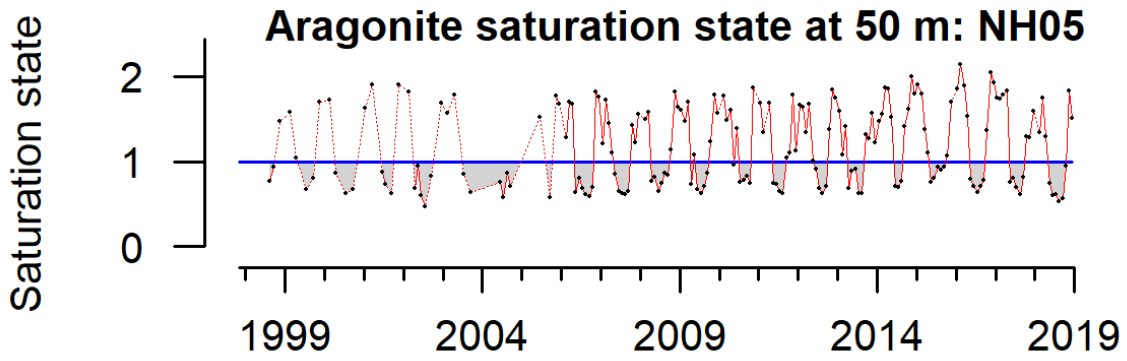


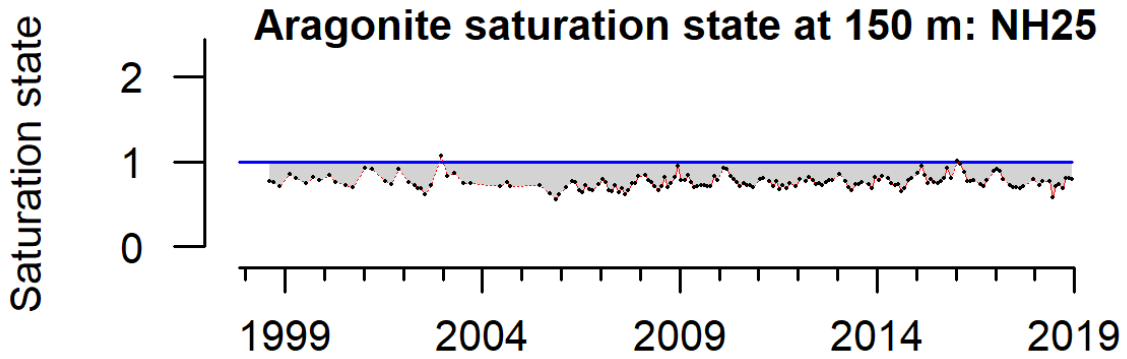


Benthic DO maps from NWFSC groundfish trawl survey, courtesy of Peter Frey, NWFSC

Ocean acidification off Newport

- Aragonite: a key structural material in many invertebrates; aragonite saturation below 1.0 indicates corrosive conditions for many species
- ***Aragonite in summer/fall 2018 was well below 1.0 at both stations; values were the lowest observed in many years***





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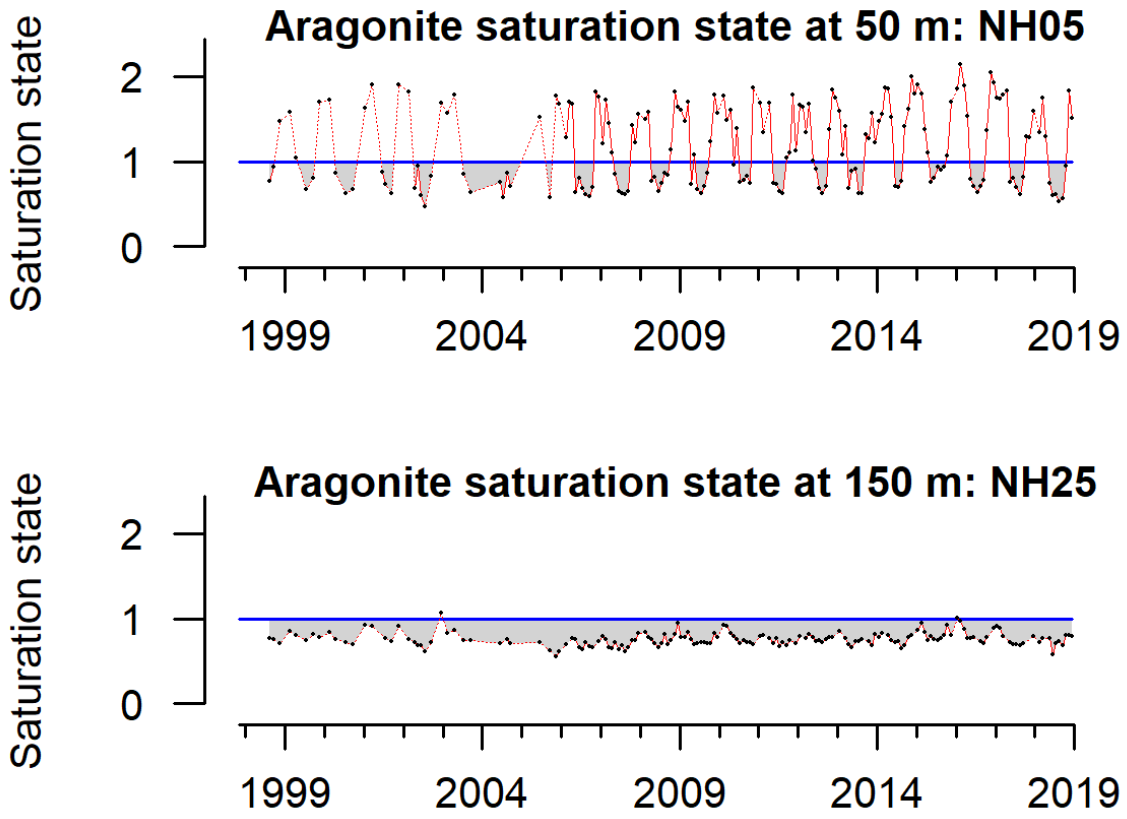
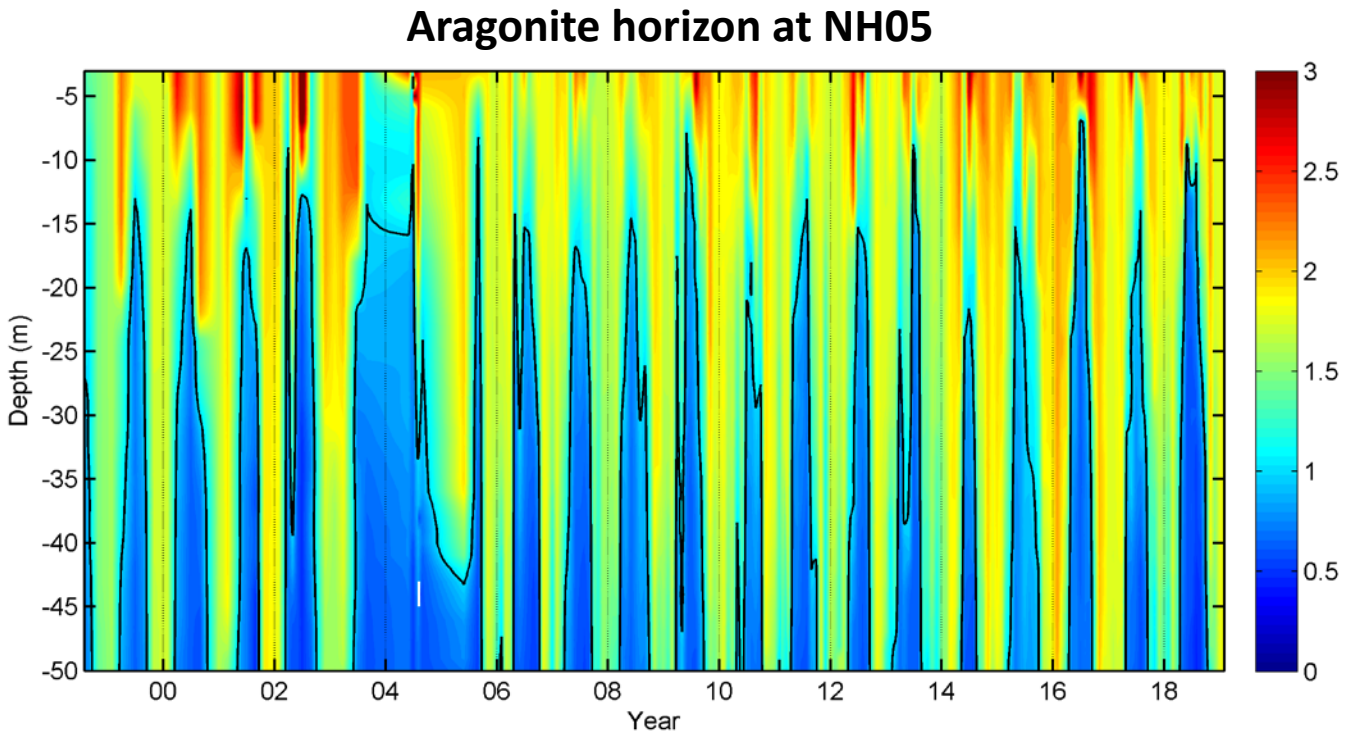
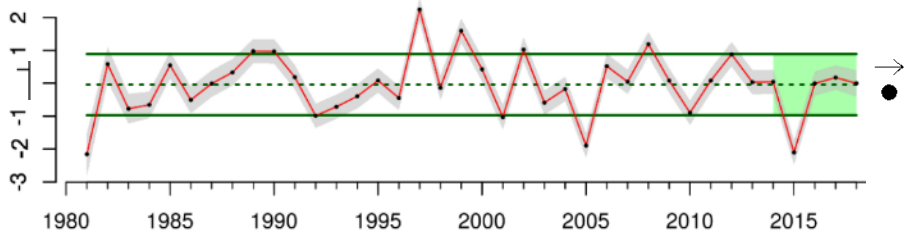




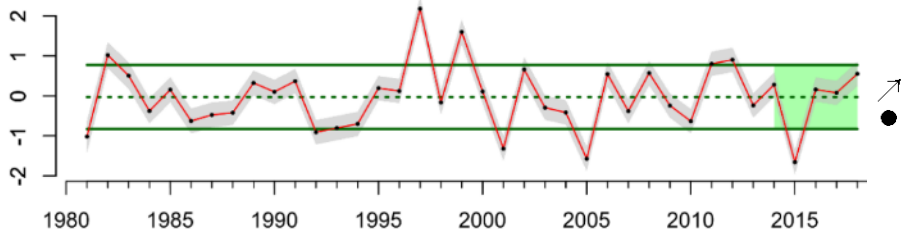
- ***60-80% of water column is corrosive over the shelf in the summer off Newport (solid line)***

Snowpack in 2018: above average in north, below average in central & south

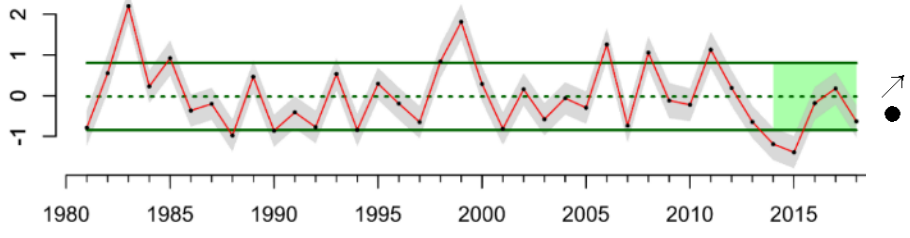
Salish Sea



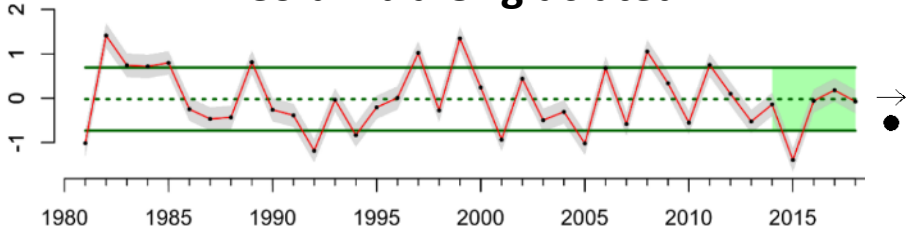
Columbia Glaciated



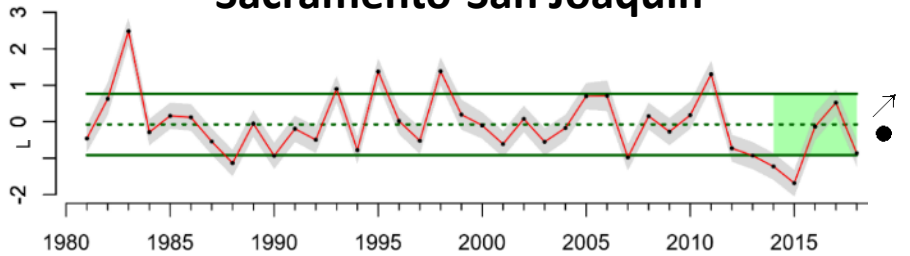
OR & N CA Coast



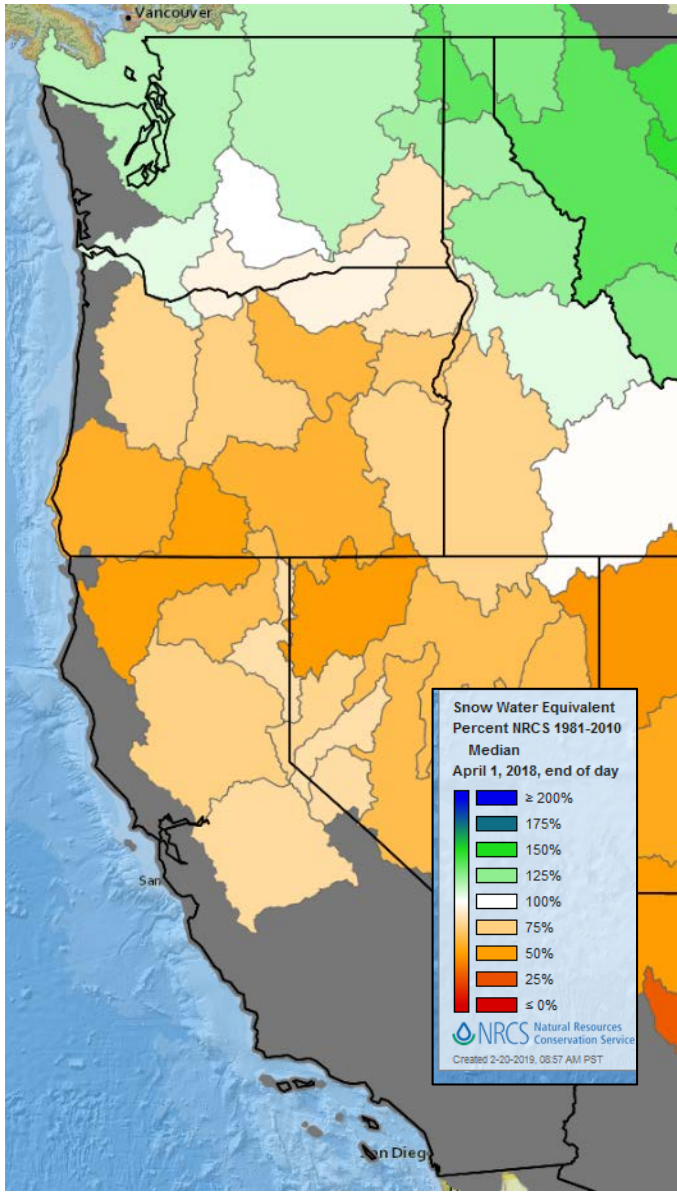
Columbia Unglaciated



Sacramento-San Joaquin

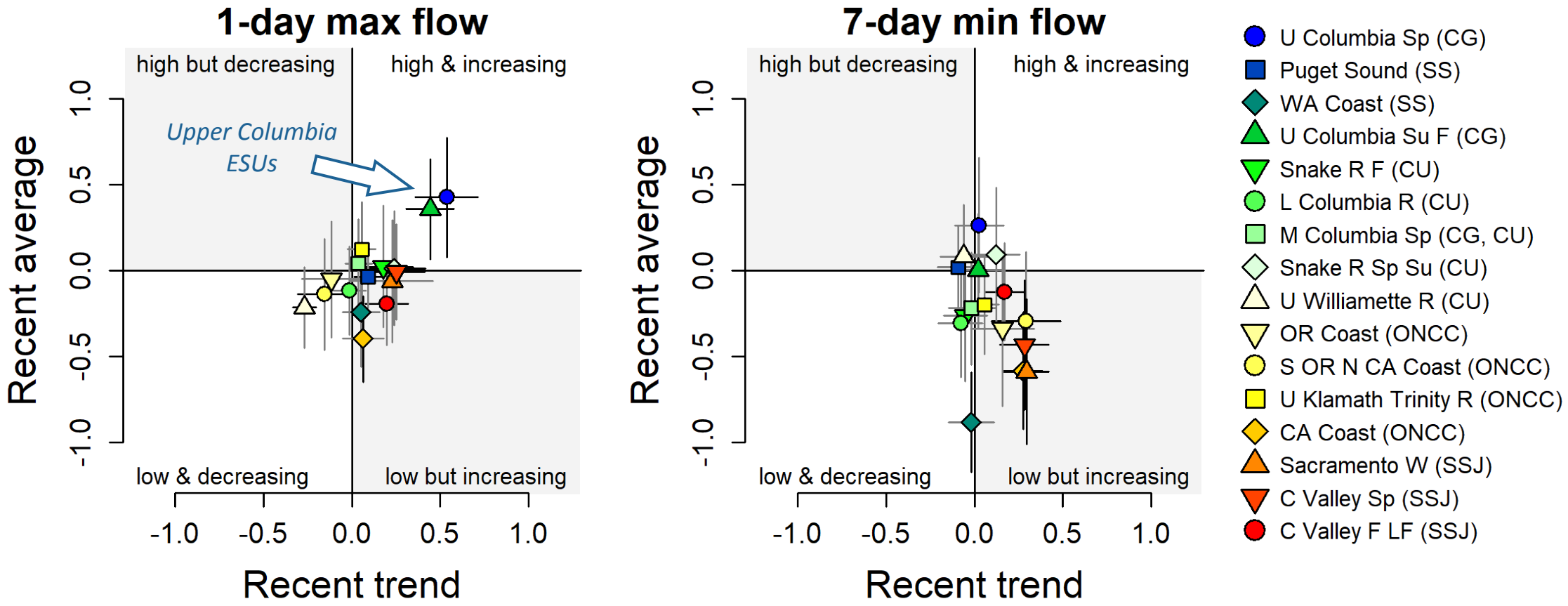


- ***This regional pattern was generally reflected in stream flows in 2018***



Stream flow for Chinook salmon ESUs, 2014-2018

- *Max flows high/increasing for Upper Columbia; no clear regional patterns elsewhere*
- *Min flows below average for many ESUs, especially coastal systems and California, though many of these have increasing trends since 2015*

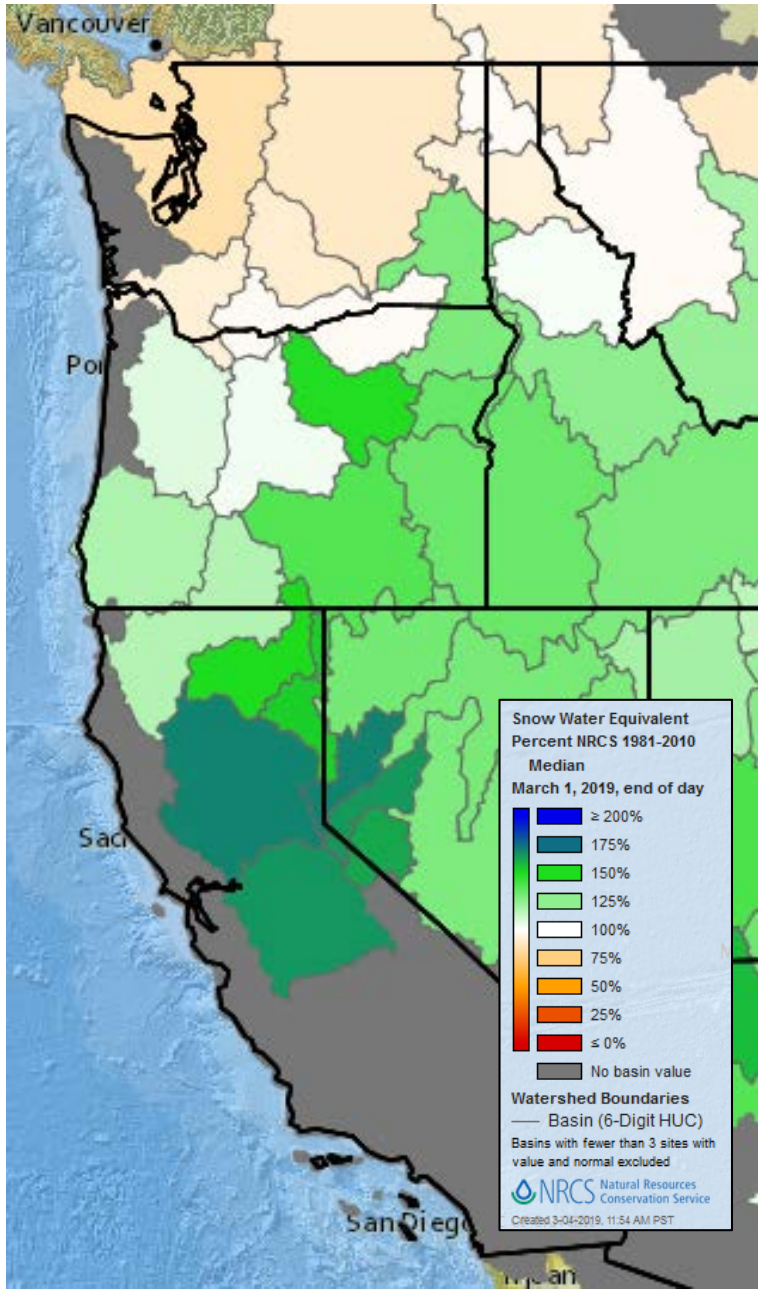


Snowpack as of March 1st, 2019

- ***California: well above median (1981-2010)***
- ***Oregon and S. Idaho: at or above median***
- ***Washington and Idaho panhandle: mostly below median***

- Official 2019 measure will be made on April 1st
  - Approximate date of maximum snow accumulation
  - Much can change between now and then

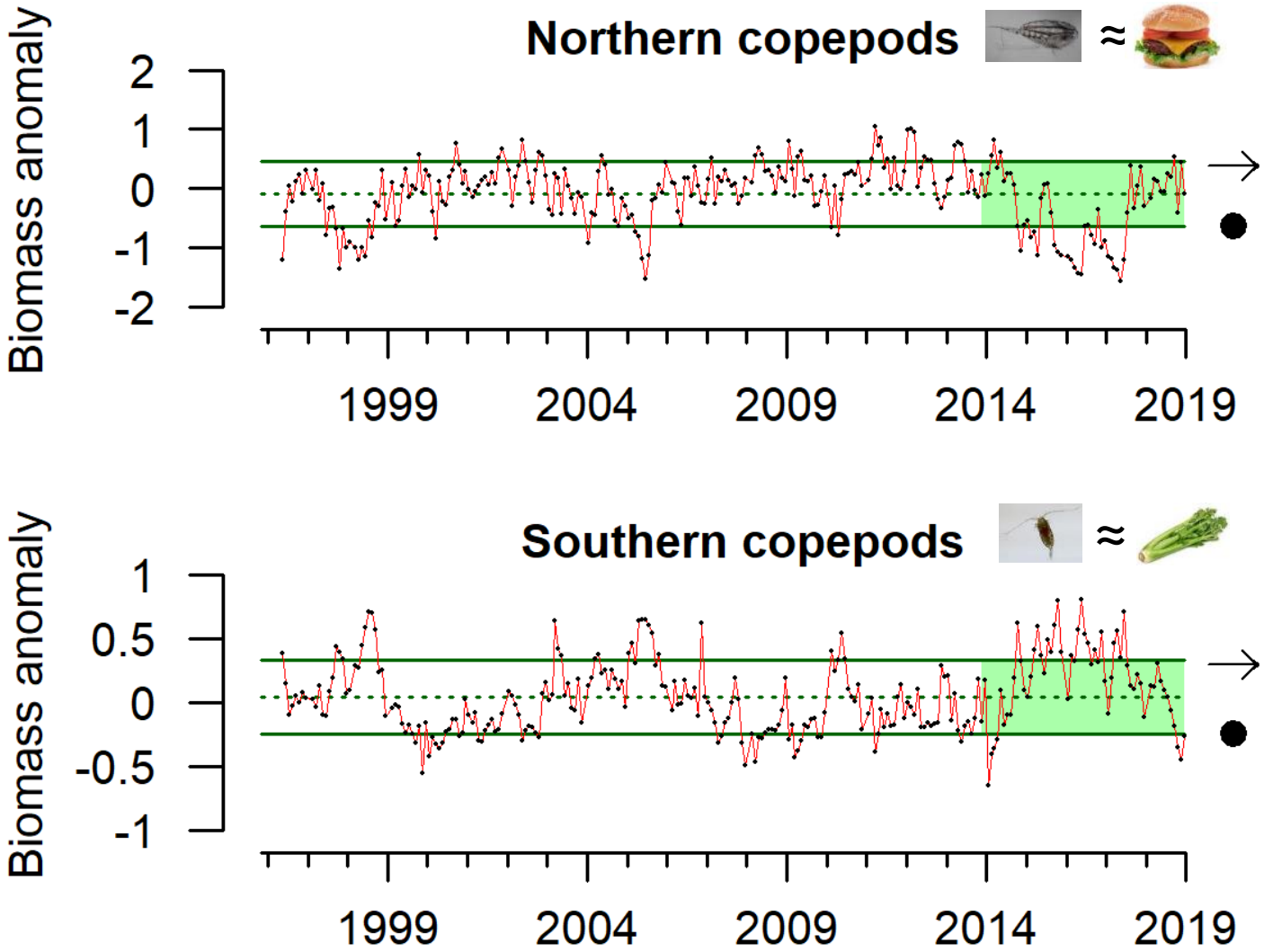
- Nat'l Weather Service Drought Forecast for Feb-May
  - Drought expected to persist in patches of central OR and WA
  - Recent atmospheric rivers reduced drought conditions in CA



Ecological responses, Part 1

Signs of improvement

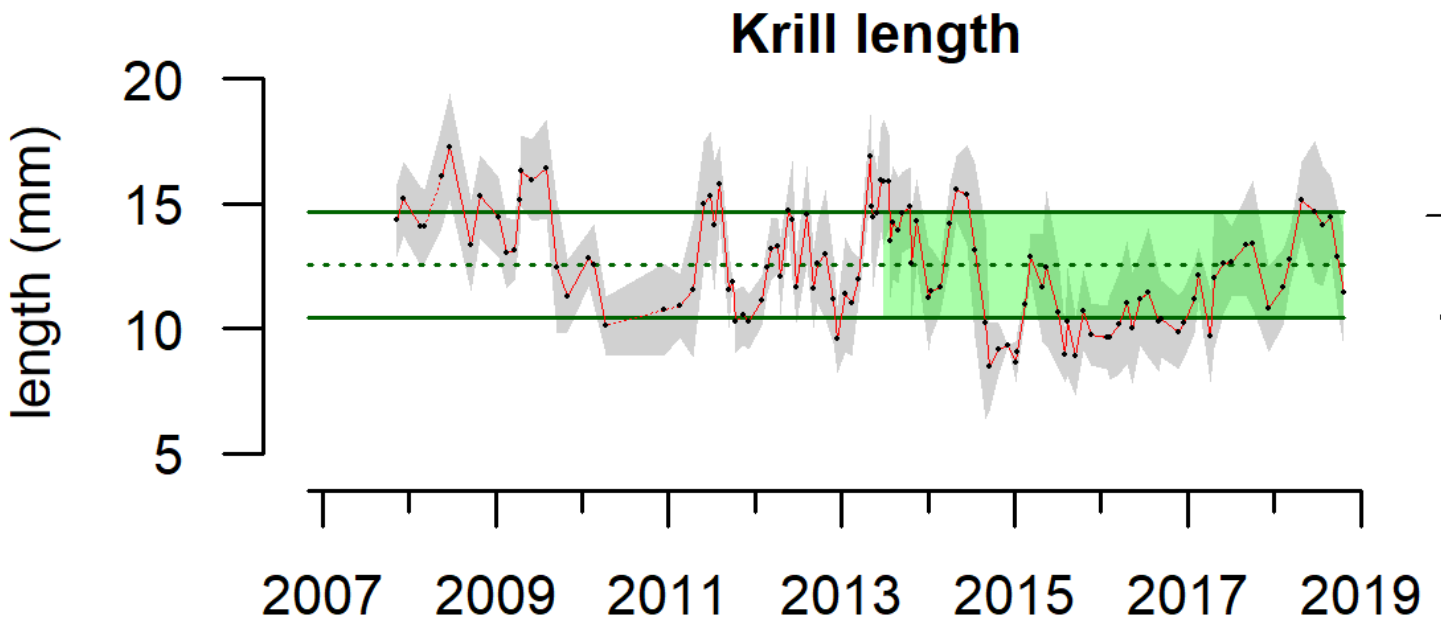
Copepods off Newport: looking better



- Energy-rich northern copepods had very low biomasses, 2014-2016
- ***Since fall of 2017, northern copepods have been hovering around average***
- ***But: energy-poor southern copepods declined pretty sharply in 2018***

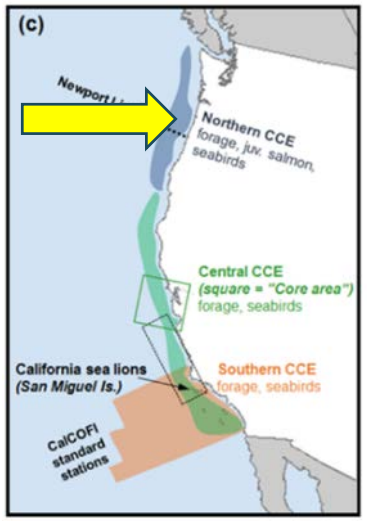
Krill off N California: bigger, more abundant

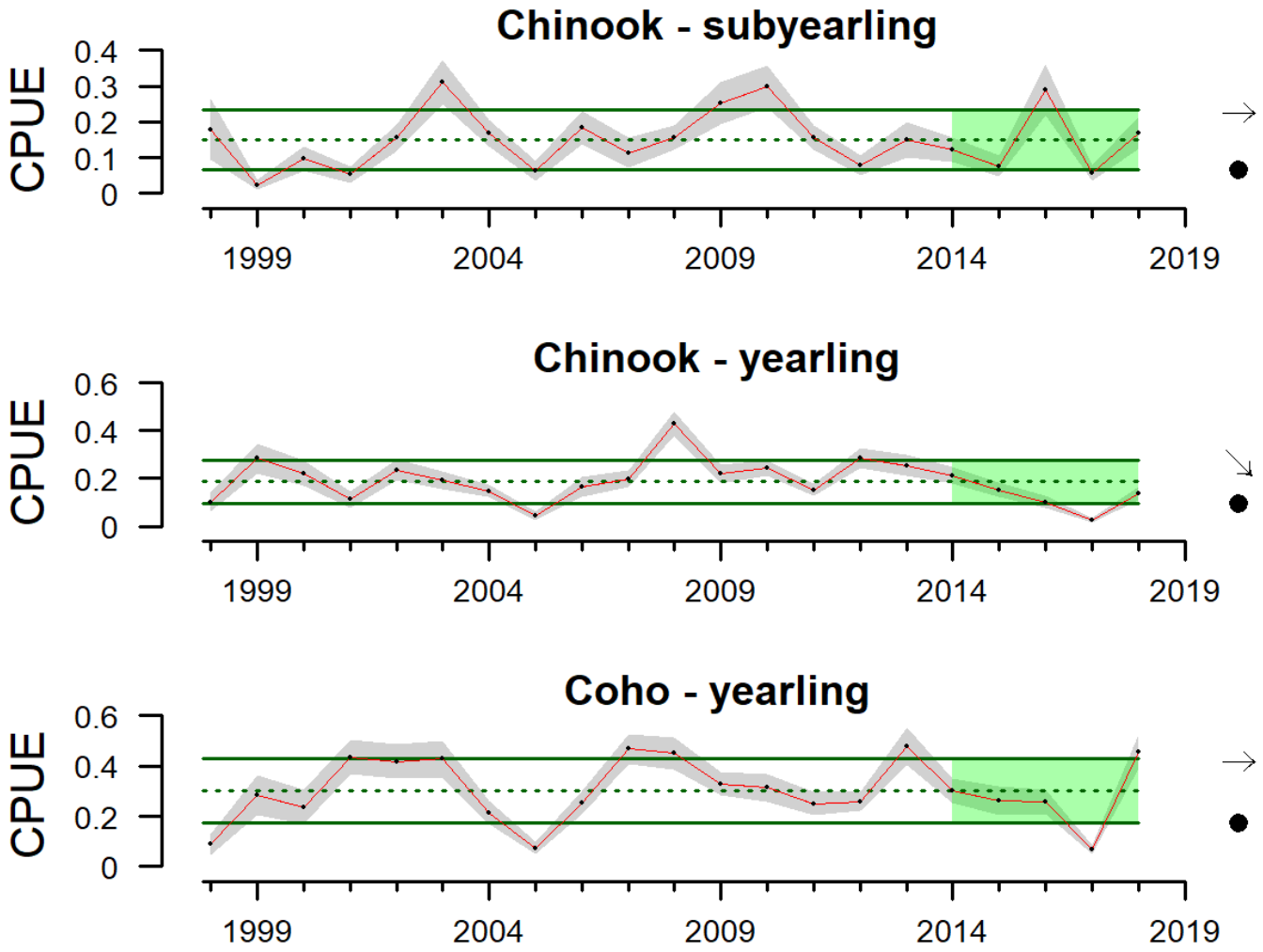
- *Euphausia pacifica*: critical prey for many fishes, market squid, birds, mammals
- Part of the 1st FEP initiative on protecting unfished forage stocks



- Krill lengths from 2014 to 2016 were lowest of the Trinidad time series
- ***Krill lengths increased in 2017 and again in 2018, within a given season***
- Krill catch rates in net sampling off cent. CA above avg in 2017, 2018

Juvenile salmon catches off WA, OR ticked back up in 2018



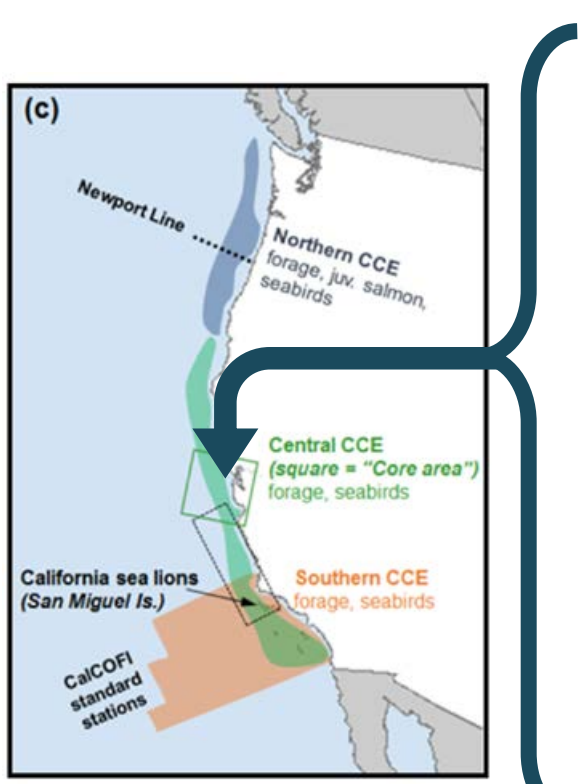


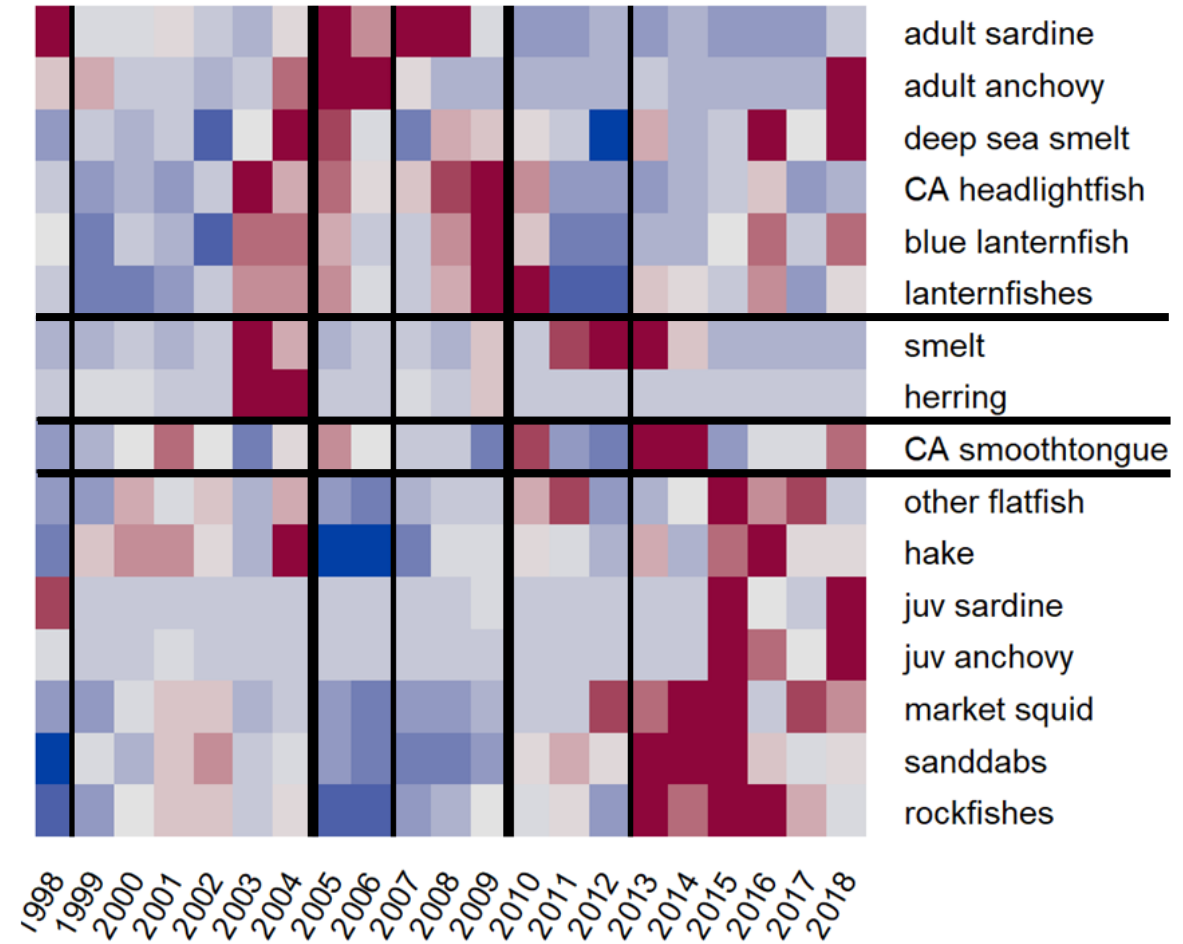
- 2017: catches among the lowest observed for all three groups
- ***2018: modest rebounds for Chinook, strong rebound for coho***

Forage community in Central region: anchovies ascendant

Vertical lines = temporal breaks; horizontal lines = co-occurring forage groups

Abundance is color coded from dark blue (very rare) to dark red (abundant)



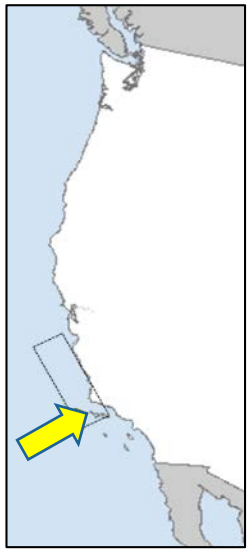


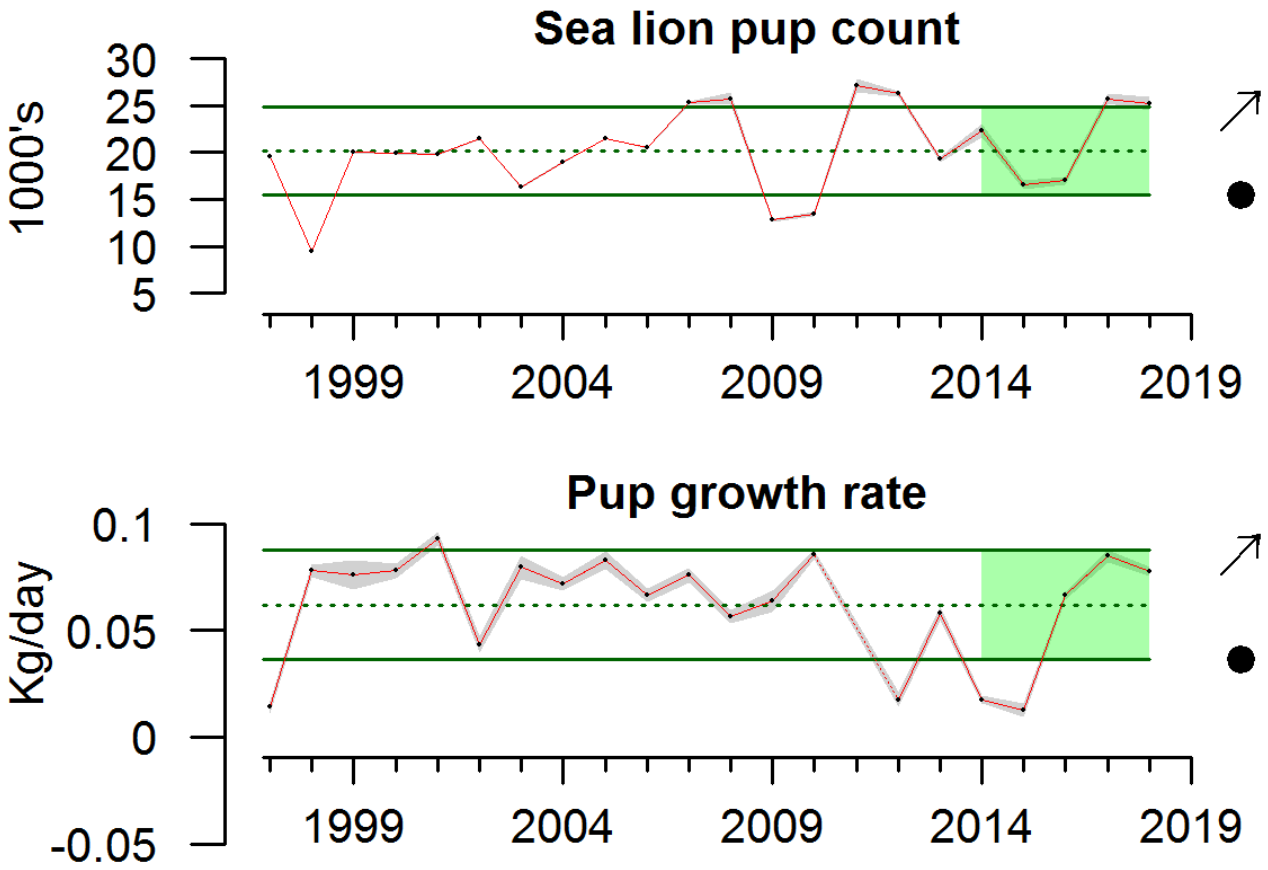
- ***Community since 2013 defined by juv. groundfish, market squid, juv. anchovy***
  - ***And occasional juv. sardine***
- ***Adult anchovy increased strongly in 2018, while some juv. groundfish dropped***
- Larval anchovy also major component of 2018 forage in Southern Cal Bight

Sea lion pups indicate better feeding conditions

San Miguel California sea lion colony (arrow on map)

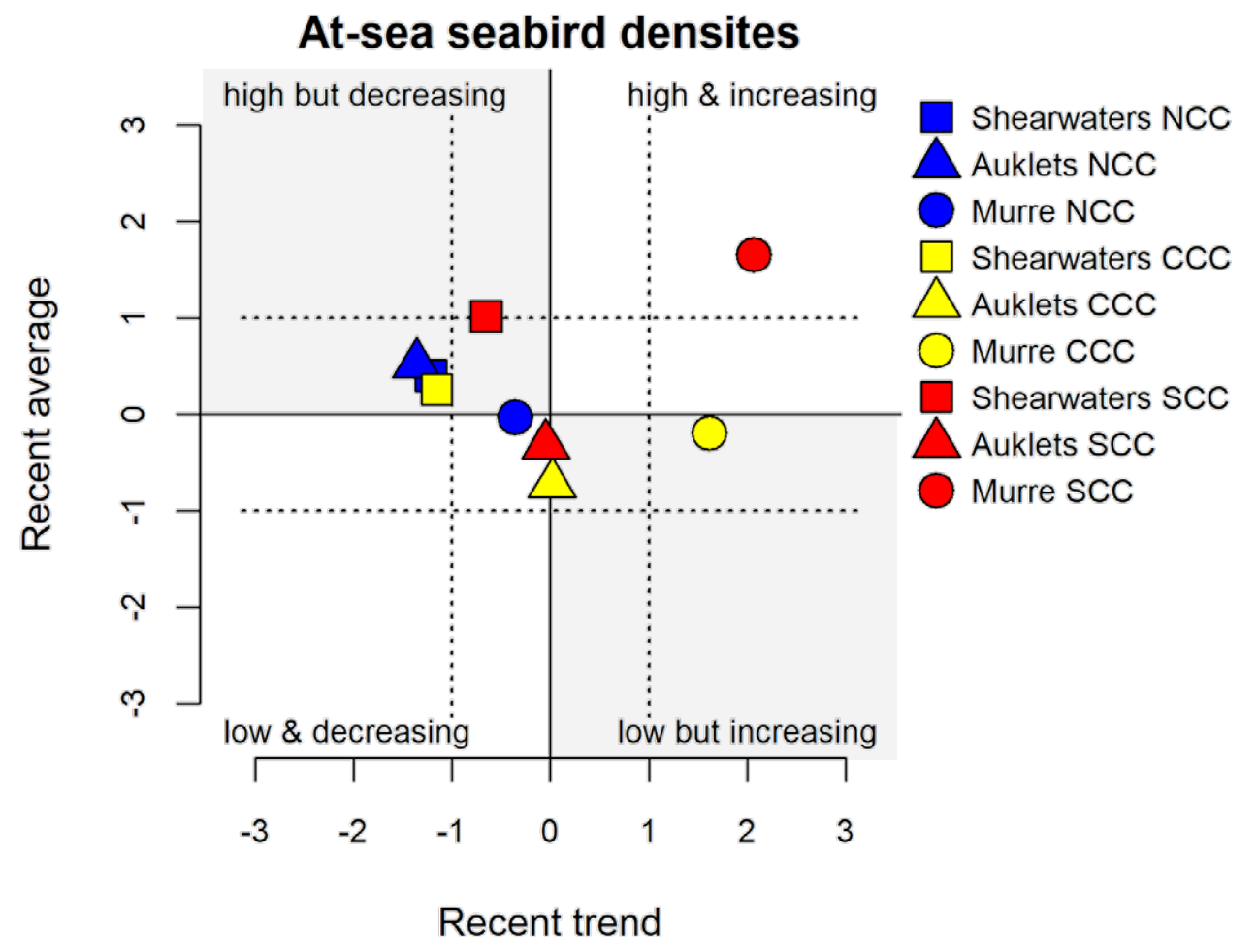
Maternal feeding grounds in southern and central California (rectangle on map)





- Indicators of forage availability
- ***2017-18 cohorts: high pup counts and above-normal winter growth***
  - ***Good feeding conditions for gestating mothers, October-June***
  - ***Good feeding conditions for nursing mothers, October-February***
- Preliminary data on recent maternal diets: anchovy, juv. hake

Seabird counts increased for some key species



- Indicators of forage availability
  - Shearwaters and murres: small fish
  - Cassin's auklets: krill
- ***Common murres increasing in central and south; highest observations ever in the south in 2018***
- ***Sooty shearwaters: variable over last 5 years, but far more abundant in 2018 than 2017***
- Cassin's auklets signal more ambiguous
- No major die-offs ("wrecks") in 2018
  - For 2nd straight year!

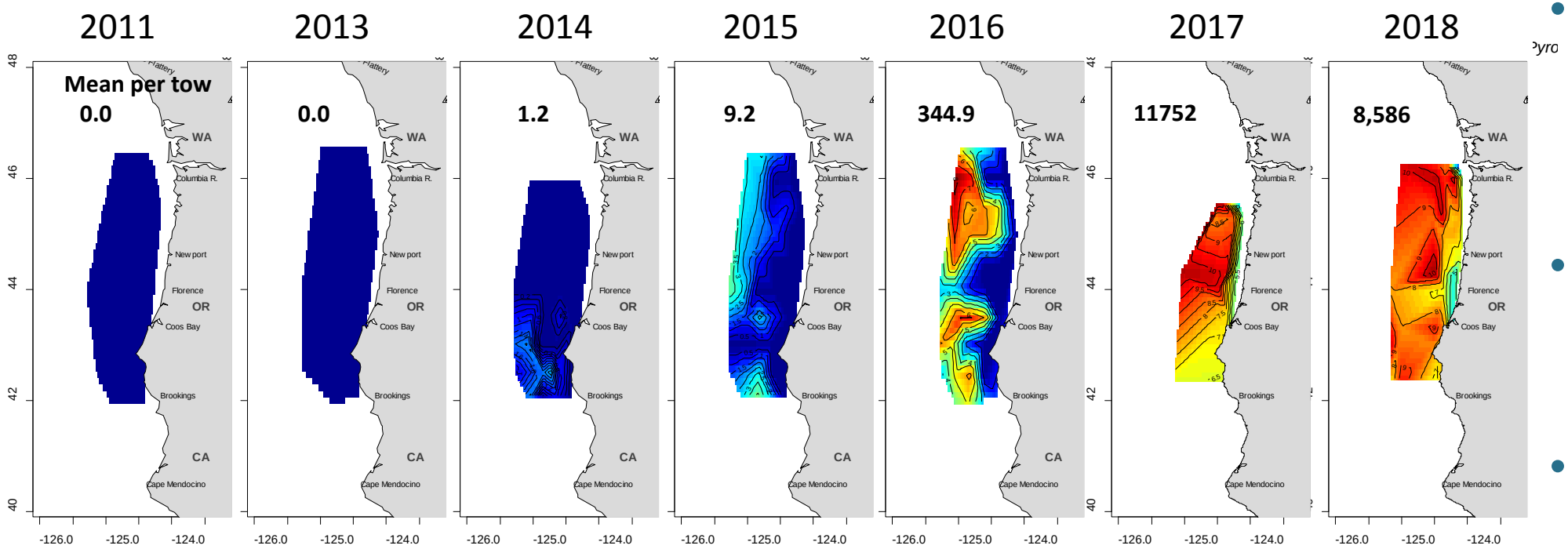
Ecological responses, Part 2

Signs of concern

Pyrosomes were still out there

Pyrosoma atlanticum: a warm-water pelagic tunicate

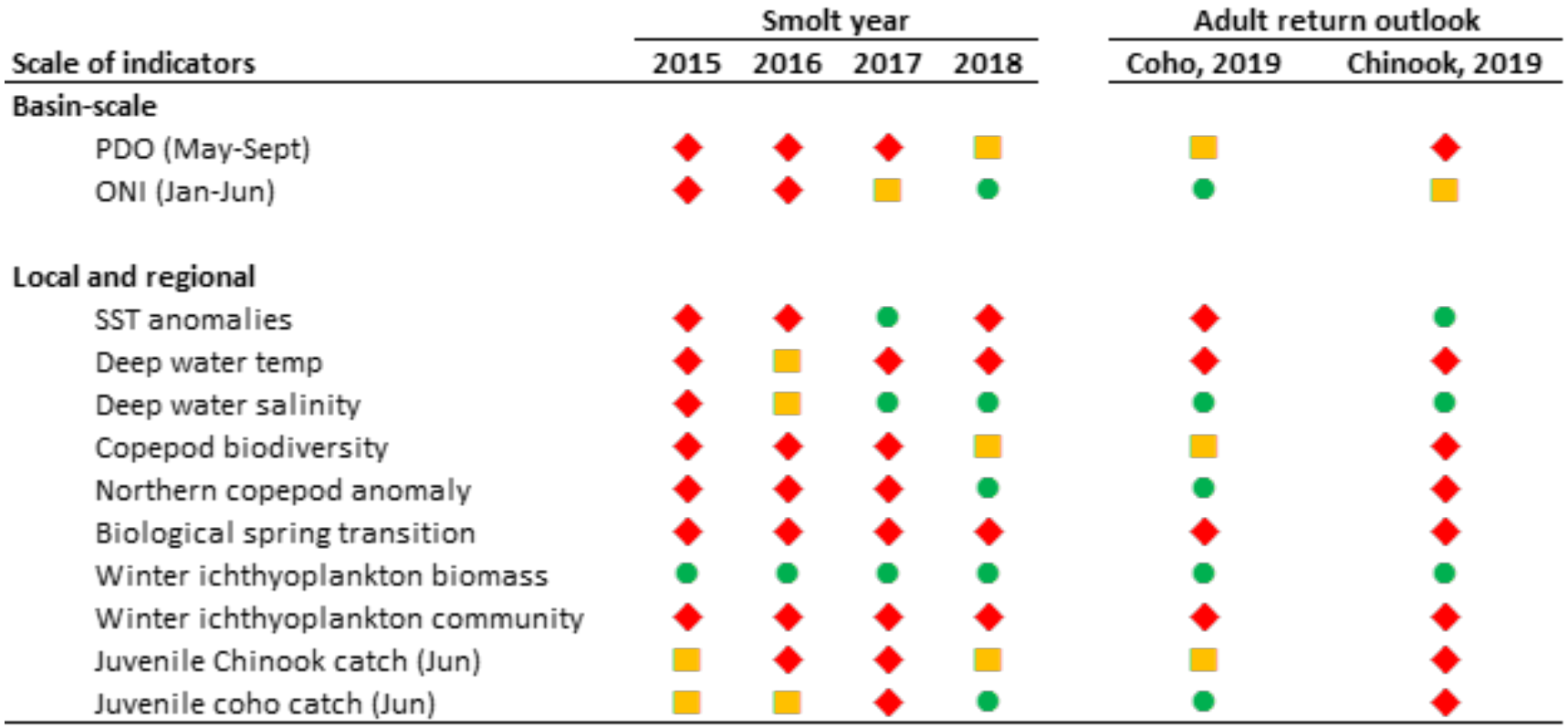
Foul fishing gear, feed on planktonic organisms



- ***Midwater off OR, pyrosomes per tow in 2018 = second highest observed***
- Densities may have declined as 2018 progressed
- Haven't been observed yet off Newport in 2019

“Stoplight” table for salmon returns in 2019: mixed bag

Chinook counts at Bonneville Dam, coho returns to Oregon coast streams

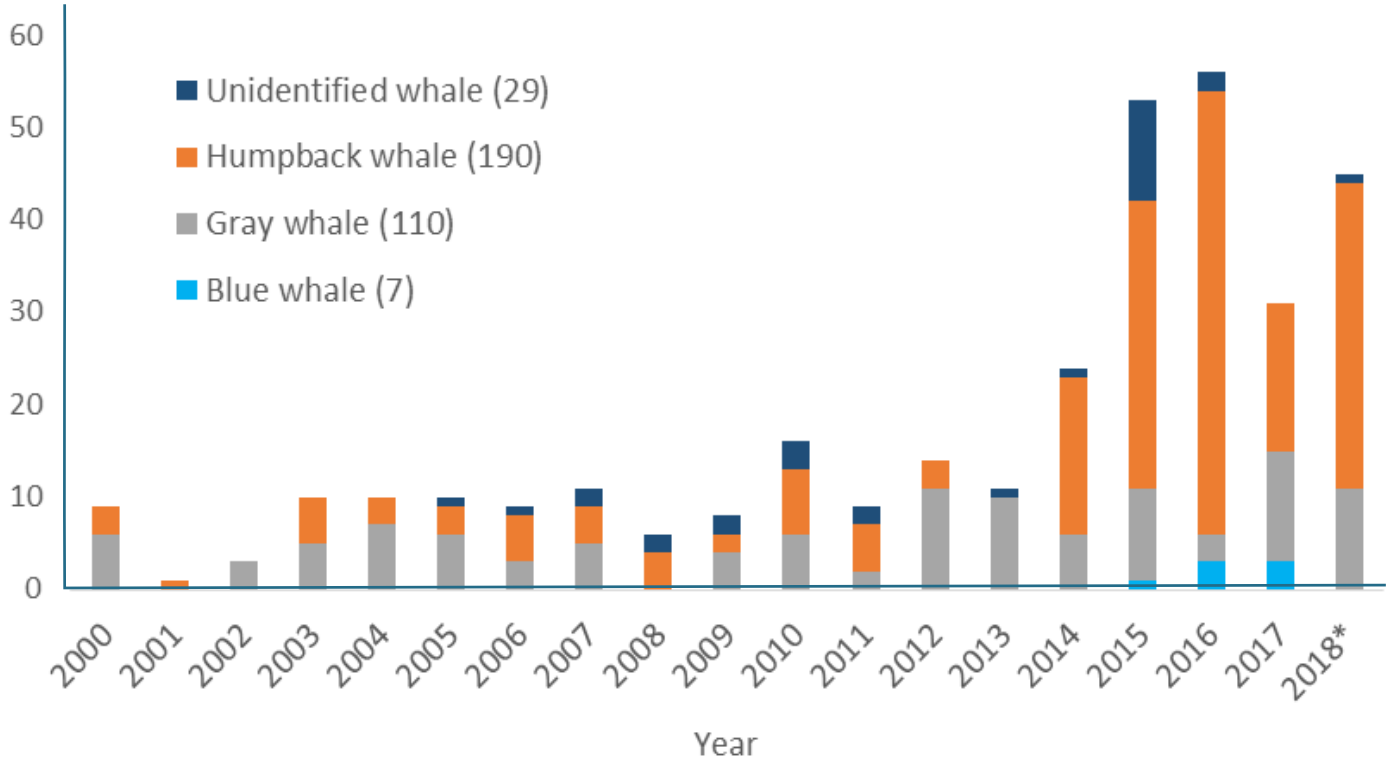


Scale of indicators	Smolt year 2015	2016	2017	2018	Adult return outlook Coho, 2019	Chinook, 2019
Basin-scale						
PDO (May-Sept)	◆	◆	◆	■	■	◆
ONI (Jan-Jun)	◆	◆	■	●	●	■
Local and regional						
SST anomalies	◆	◆	●	◆	◆	●
Deep water temp	◆	■	◆	◆	◆	◆
Deep water salinity	◆	■	●	●	●	●
Copepod biodiversity	◆	◆	◆	■	■	◆
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
- ***Consistent with below-average returns of Chinook to Columbia Basin, average returns of coho to OR coast***

Whale entanglements remain a problem

Confirmed Whale Entanglements on U.S. West Coast by Year and Species



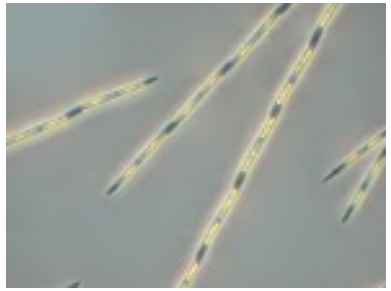
courtesy Mr. Dan Lawson, NMFS West Coast Region

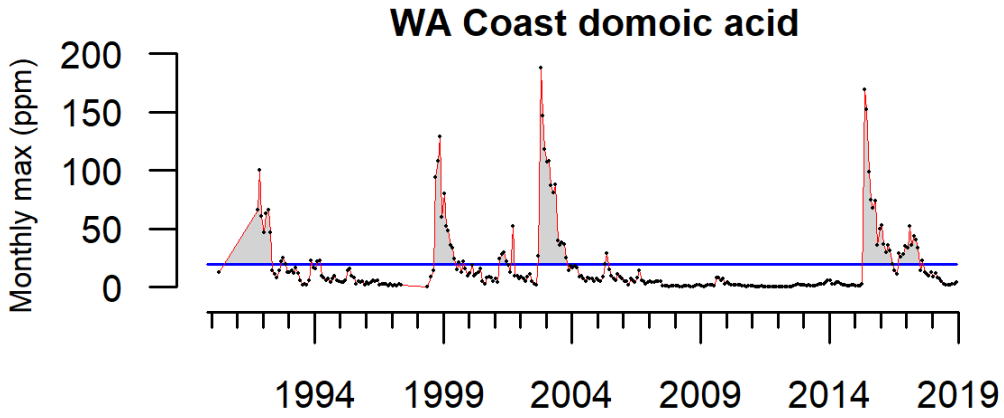
- ***Whale entanglements in fishing gear were above average again in 2018***
- ***Confirmed reports were more widely distributed along the coast, although most reports were from California***
- ***Most entanglements: humpbacks***

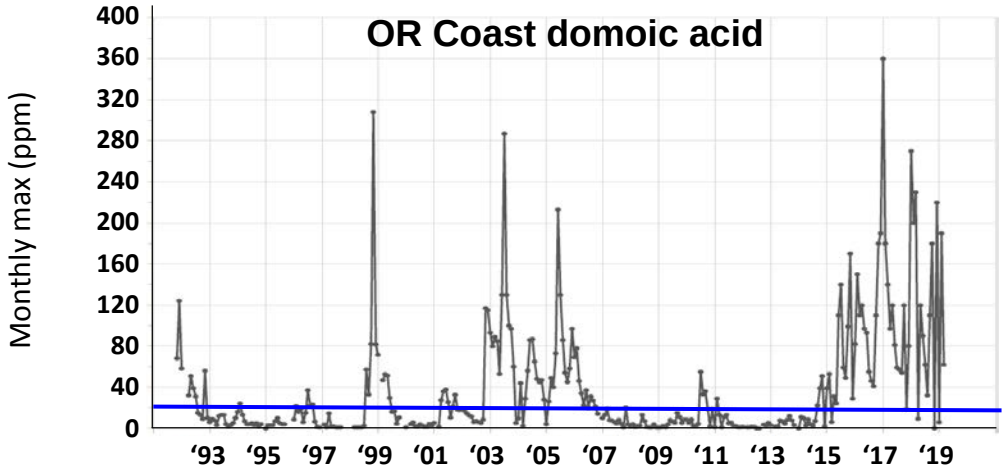
- Most gear: unidentified
- ID'd gear mostly crab
  - Sablefish gear too (2 in 2016, 1 in 2017)
  - At least 1 gillnet each year since 2012

Harmful algal blooms (HABs)

Domoic acid: toxin produced by *Pseudo-nitzschia* diatom (causes amnesic shellfish poisoning)



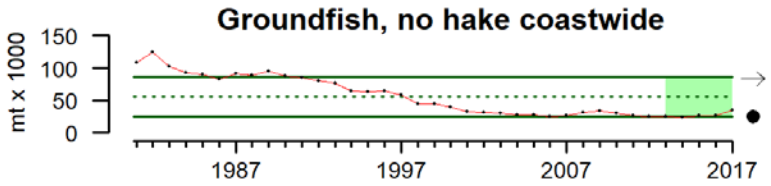


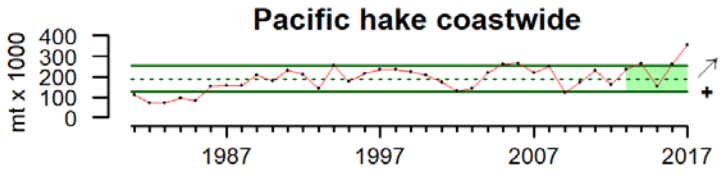


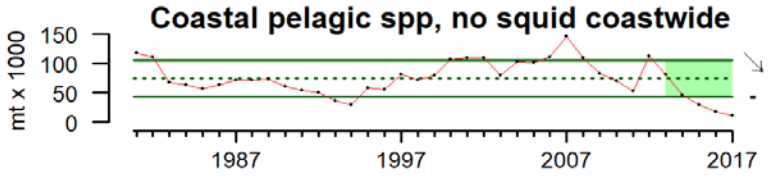
- ***Domoic acid in WA razor clams above the human health threshold (20 ppm) in most of 2015-2017, but safe in 2018***
  - Source: WA Dept of Health
- ***OR razor clams well above the safety threshold in 2015-2017, and again in 2018***
  - Source: ODFW
- ***Numerous domoic acid-related closures in 2018 in OR and CA (bivalves, crab, spiny lobster)***

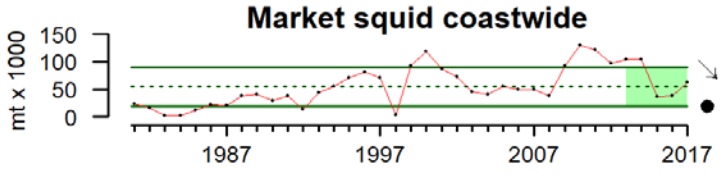
Human activities and wellbeing

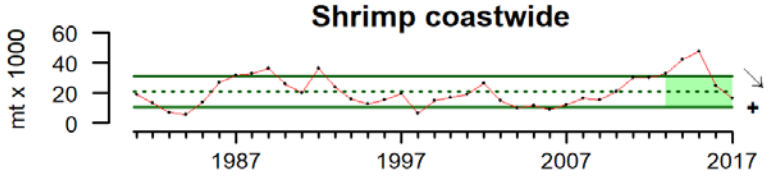
Landings through 2017: improved, but winners and losers

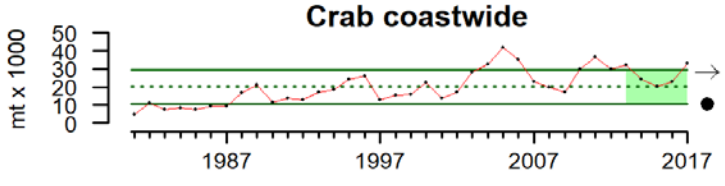


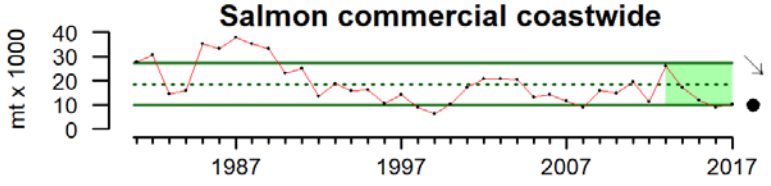


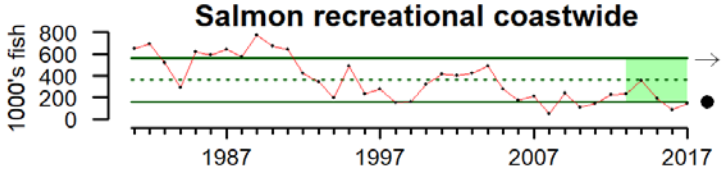


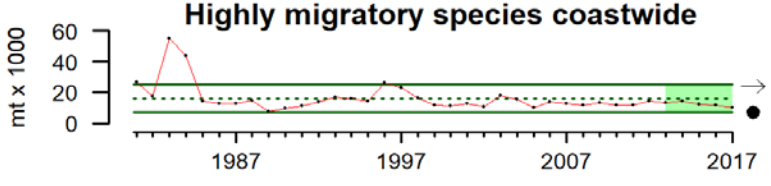


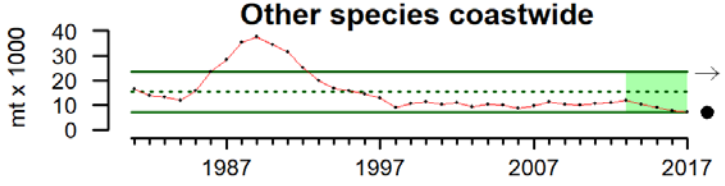


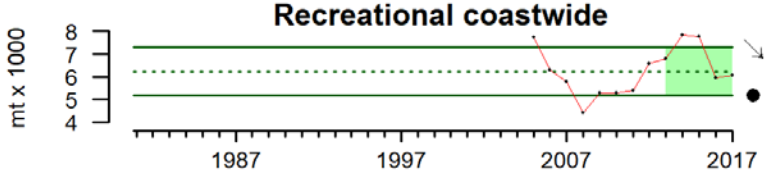


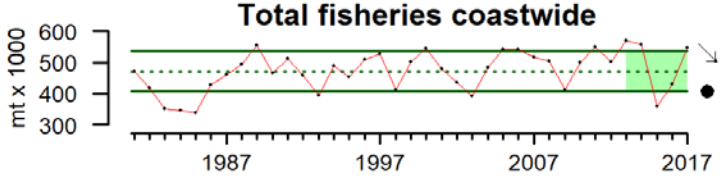








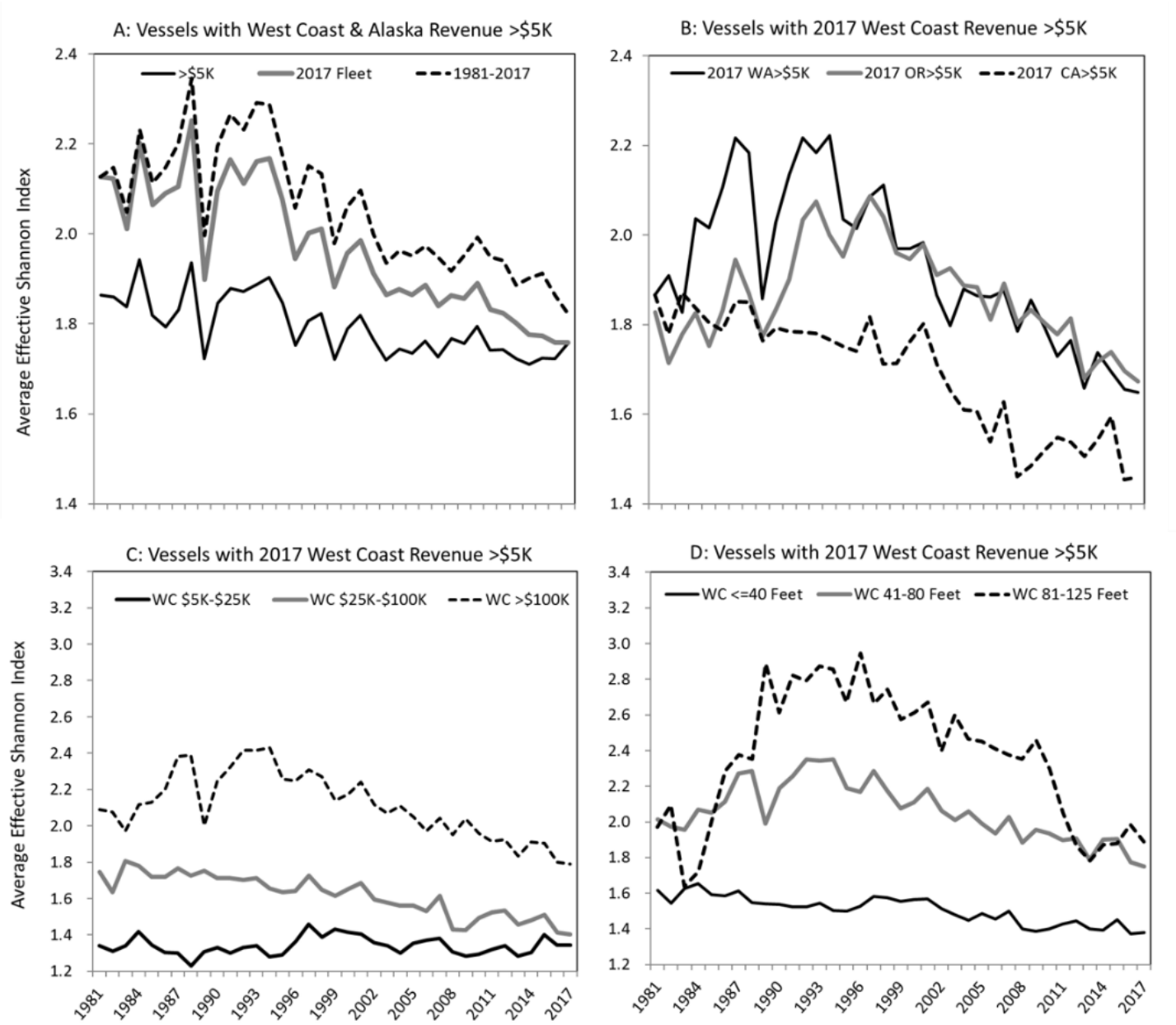




- Landings data updated through 2017
  - 2018 data compilation not quite complete as of today

- ***Landings & revenues rebounded strongly in 2017***
  - ***27.4% increase in landings, 12.3% increase in revenue relative to 2016***
  - ***Led by record hake landings, crab, and a bounce in squid***
  - ***Salmon, CPS finfish, groundfish remained very low***

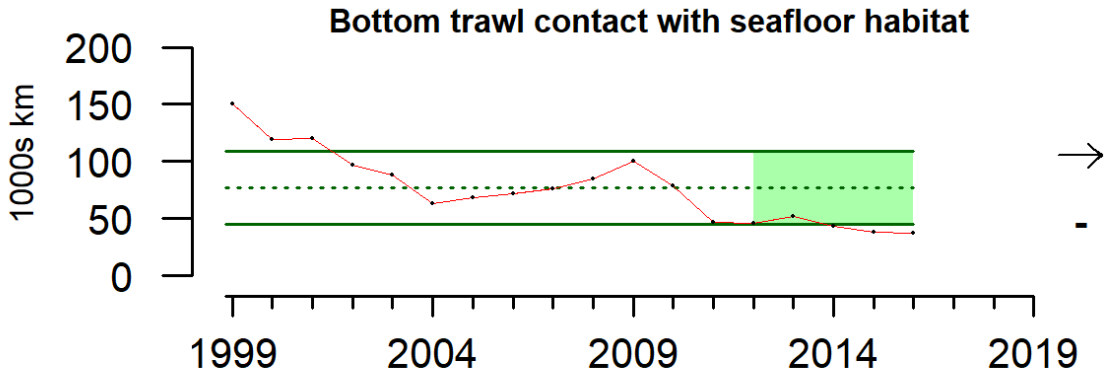
Diversity of vessel “portfolios” still decreasing



- Index of how broadly and evenly revenue is spread across different fisheries
  - Lowest score is 1 = all revenue from a single fishery

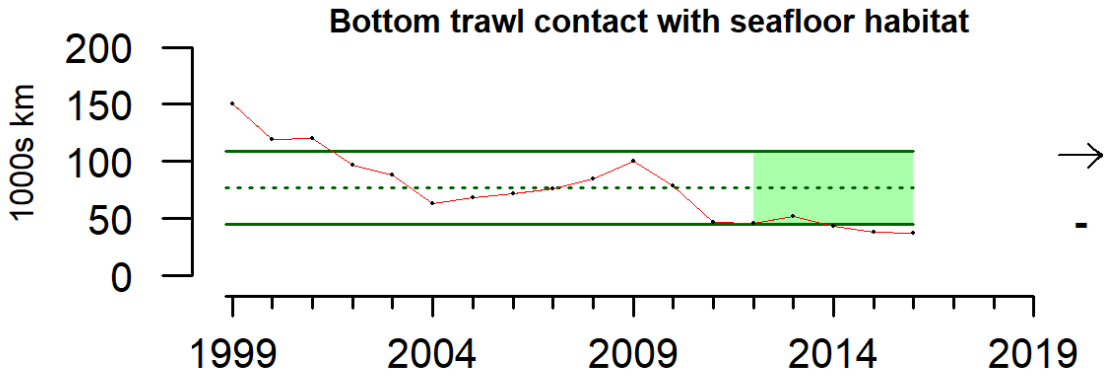
- ***Diversification remains historically low across all classifications of West Coast vessels***
  - ***Size, state, total revenue***
  - ***Little change from 2016 to 2017***

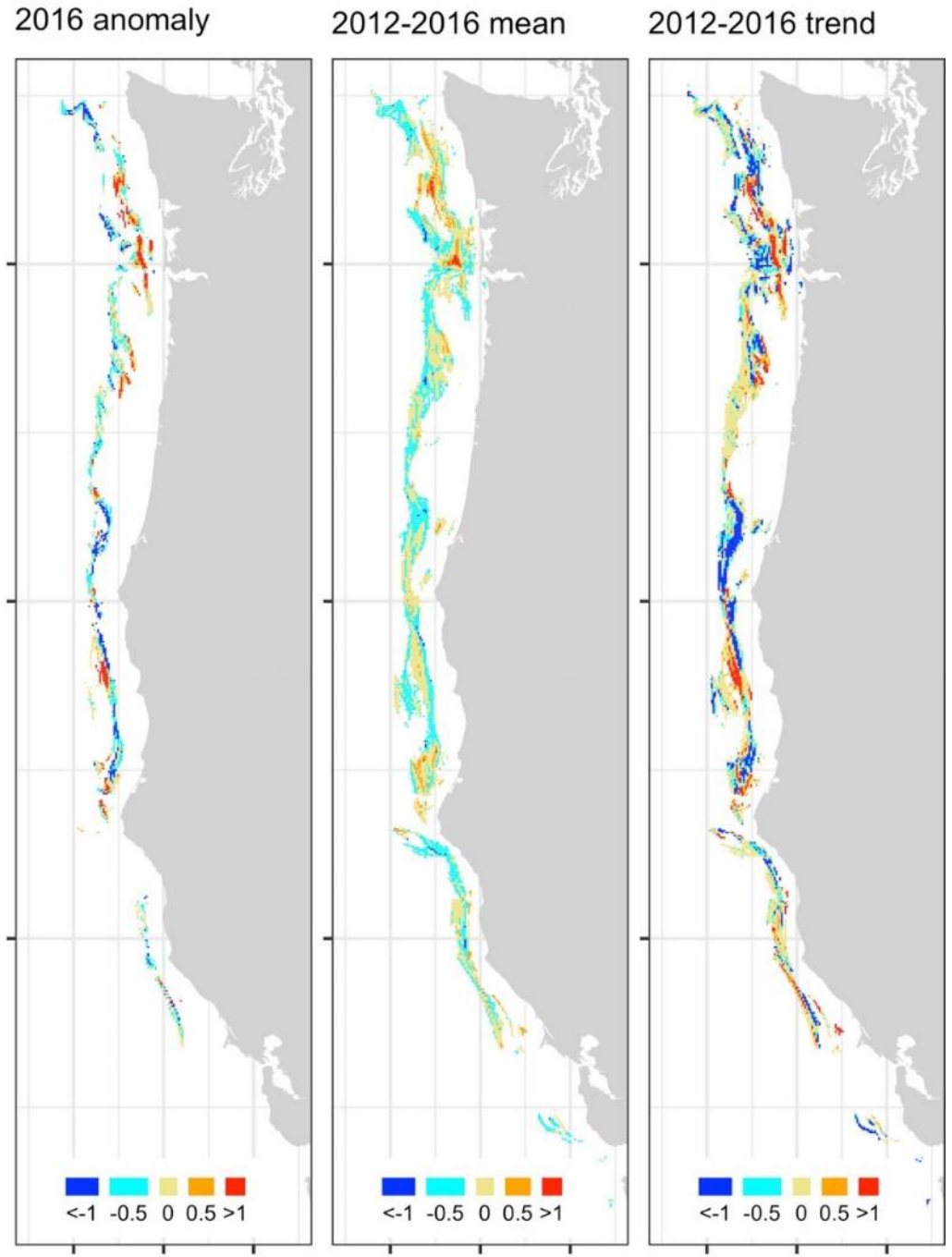
Seafloor contact: coastwide vs fine scale



- Data from 1999-2016 for trawl gear
- ***At coast-wide level, long-term decline in aggregate contact between gear and seafloor***

Seafloor contact: coastwide vs fine scale



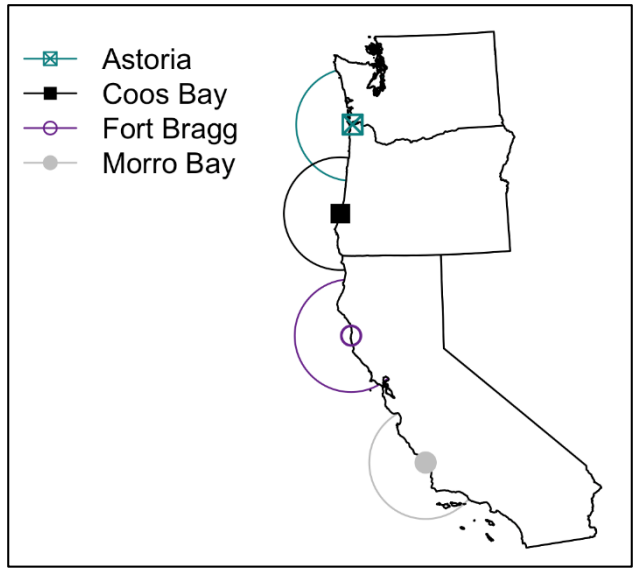


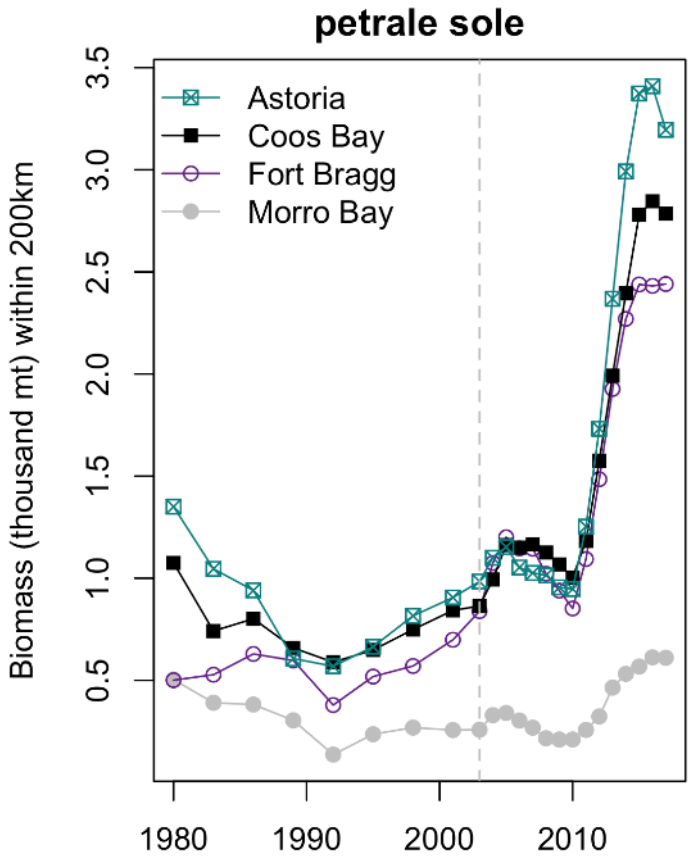
- Data from 1999-2016 for trawl gear
- ***At coast-wide level, long-term decline in aggregate contact between gear and seafloor***
- ***At finer scale, hotspots of activity:***
  - ***In 2016 (left map, red areas)***
  - ***On average over past 5 years (middle, red off WA coast)***
  - ***Increasing 5-yr trends (right map, red areas)***

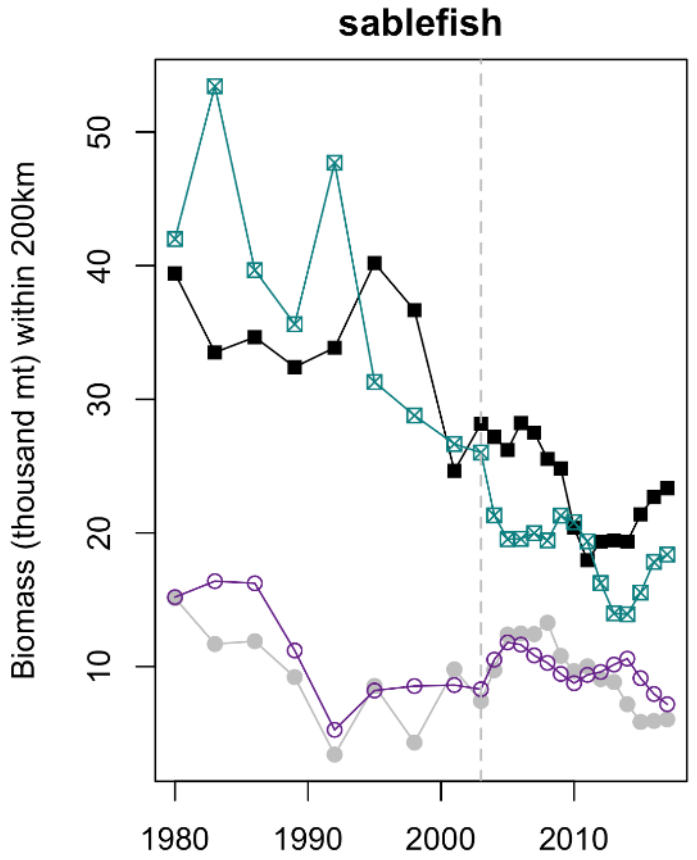
Shifting groundfish availability differs by port

Index of availability of groundfish to ports, based on changes in stock size and distribution *(from trawl survey data)*

Example: petrale sole and sablefish availability to 4 ports

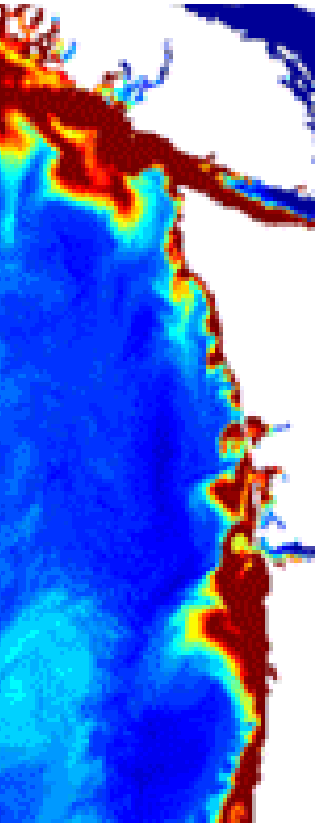






- ***Petrale sole have increased, and "center of gravity" has shifted north***
- ***Sablefish have declined, and center of gravity has shifted south***
- ***Distinct biomass patterns within 200-km radius of each port***
- Can easily be modified to account for spatial management

courtesy Dr. Rebecca Selden, Rutgers University



Outlook for 2019

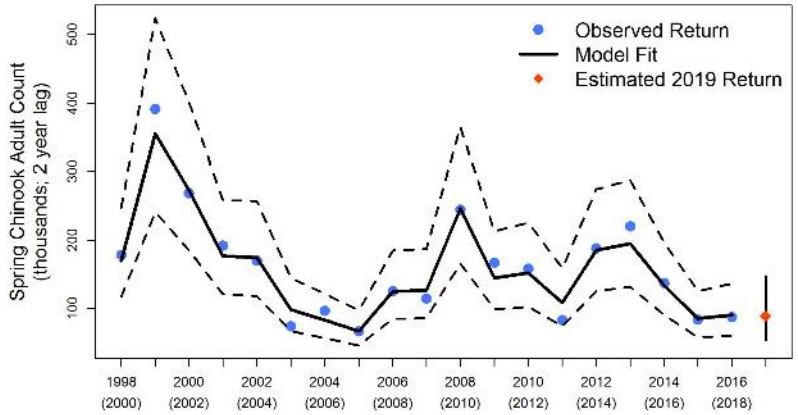
Looking ahead for 2019

- 55% chance of weak El Niño through spring

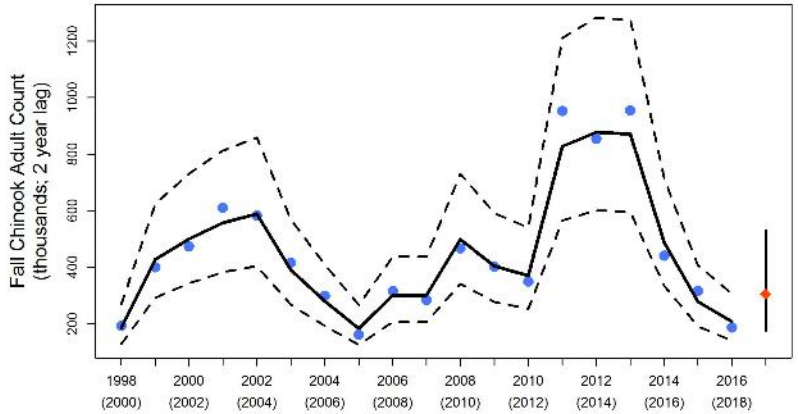
- Drought forecast through May currently limited to parts of central and eastern OR, WA

Looking ahead for 2019

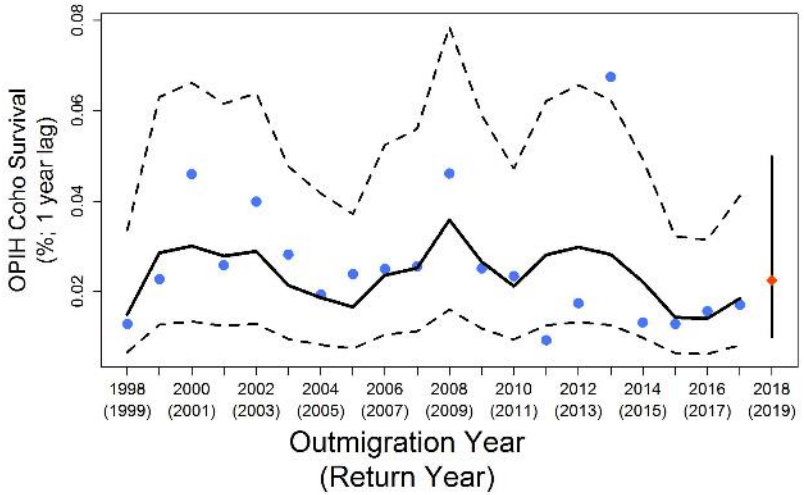
- 55% chance of weak El Niño through spring
- Drought forecast through May currently limited to parts of central and eastern OR, WA
- ***Ecosystem-based outlook for salmon***
  - ***Chinook: below-average returns to Bonneville Dam***
  - ***Coho: average returns to OR coast***
  - ***Stoplight table & related indicator-based models (B. Burke, NOAA NWFSC)***
  - ***These estimates independent of the forecasts used in Council process; intent is to inform, not replace***



Spring Chinook to Bonneville



Fall Chinook to Bonneville

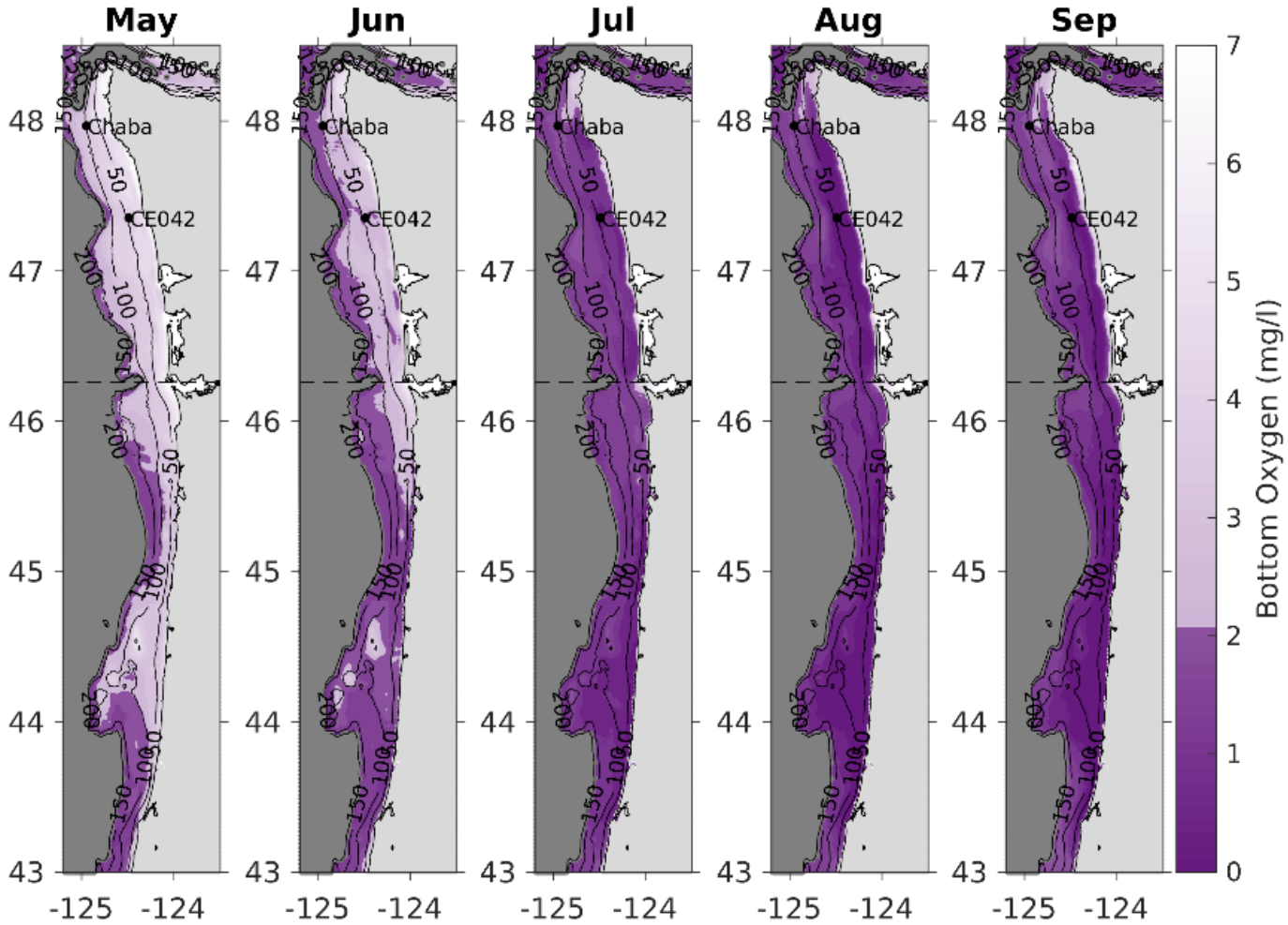


Coho to Oregon coast

J-SCOPE forecast: hypoxia off WA, OR

- J-SCOPE model system forecasts physical and biological conditions off WA, OR from Jan-Sept each year
- ***2019 forecast:***
  - ***Warmer than average temperatures***
  - ***Bottom hypoxia (dark purple) widespread by June off OR and spreading to WA by July***
  - ***Certainty of forecast is high until end of upwelling season (July-August)***

Dissolved oxygen in J-SCOPE model region



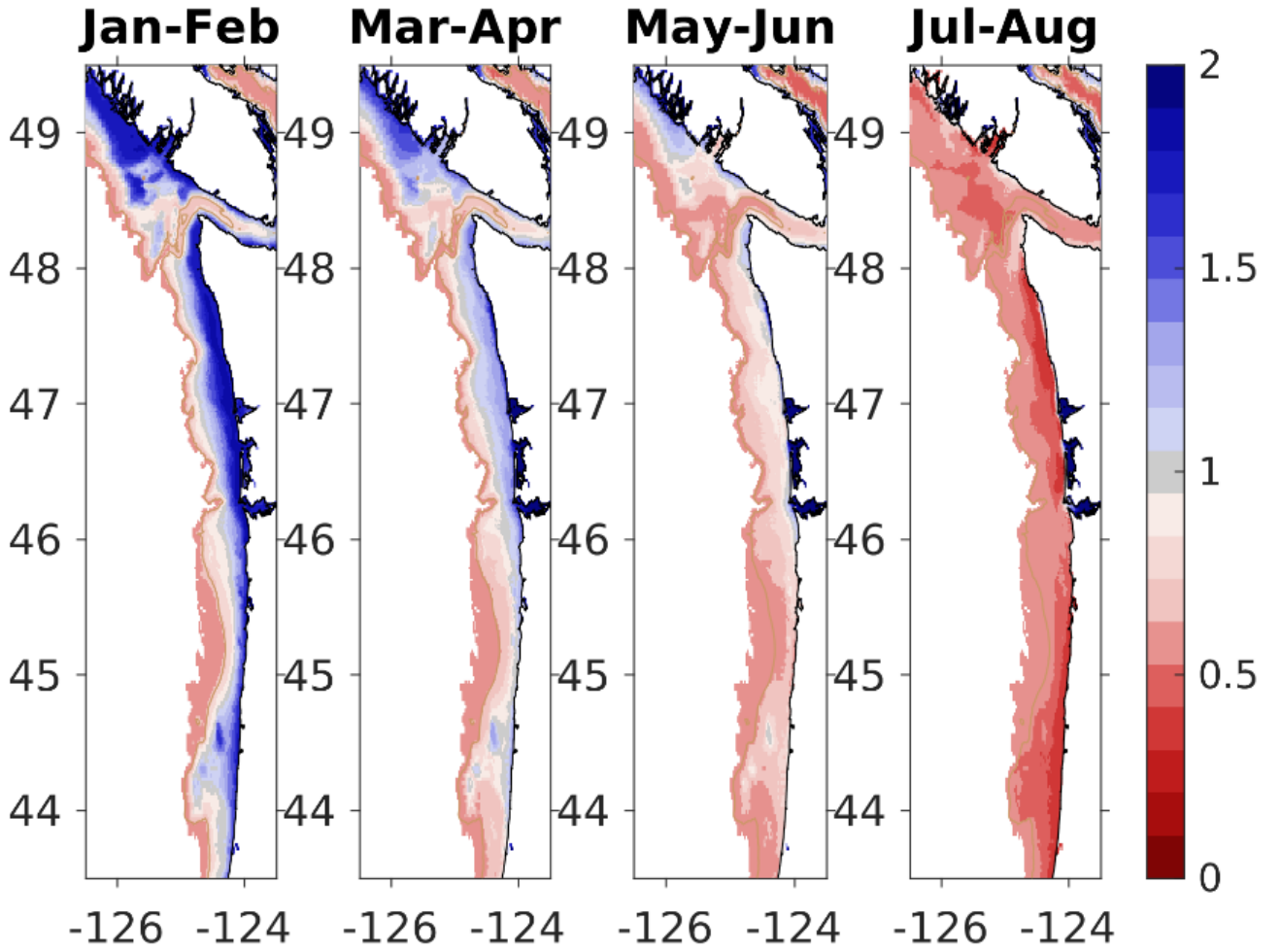
courtesy Dr. Samantha Siedlecki, University of Connecticut

J-SCOPE forecast: acidification off WA, OR

- J-SCOPE model system forecasts physical and biological conditions off WA, OR from Jan-Sept each year
- ***2019 forecast:***
  - ***Ocean acidification (values < 1.0) in bottom waters of shelf widespread throughout upwelling season***
  - ***Nearshore pockets of non-corrosive water that get smaller over course of summer***
  - ***Surface waters > 1.0 all year (not shown)***

California version in development!

Aragonite saturation in J-SCOPE model region



courtesy Dr. Samantha Siedlecki, University of Connecticut

Conclusions

Conclusions

- **The system is in transition…but to what?**
  - Climate / ocean indicators are mixed but seem to be tending toward warm and less productive conditions
  - Ecological indicators are, for the most part, better than they've been for a few years
  - Some ecological indicators still raise concerns, and we must remember to account for spatial patchiness and time lags in species responses

- **Total landings and revenues in 2017 bounced back from the "Blob" years**
  - Thanks in large part to record hake landings
  - But, landings in many FMPs remained low (salmon, groundfish, CPS finfish)

- **Indicator-based projections and analyses of shifting stock availabilities may shed further light on ecosystem dynamics and how they influence fisheries**

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