2017 CALIFORNIA CURRENT ECOSYSTEM STATUS REPORT

DELIVERED TO THE PACIFIC FISHERY MANAGEMENT COUNCIL, MARCH 8, 2017, VANCOUVER, WA

NOAA California Current IEA Team

SUMMARY

- **Climate drivers rebounding from the major warm events**

  - One of the largest El Niño events of the past 100 years occurred in 2015-2016; yet its impacts on the West Coast were remarkably small

  - Following the climate "stress test" of very warm water, the El Niño and low productivity, most of the large-scale climate indices for the Northeast Pacific (ONI, PDO and NPGO) returned to relatively neutral values in 2016

  - Upwelling in 2016 ranged from average (north) to above-average (south)

  - Precipitation increased from record lows and drought in 2015 to average levels last year; on pace for even greater rainfall and snowpack in 2016-2017
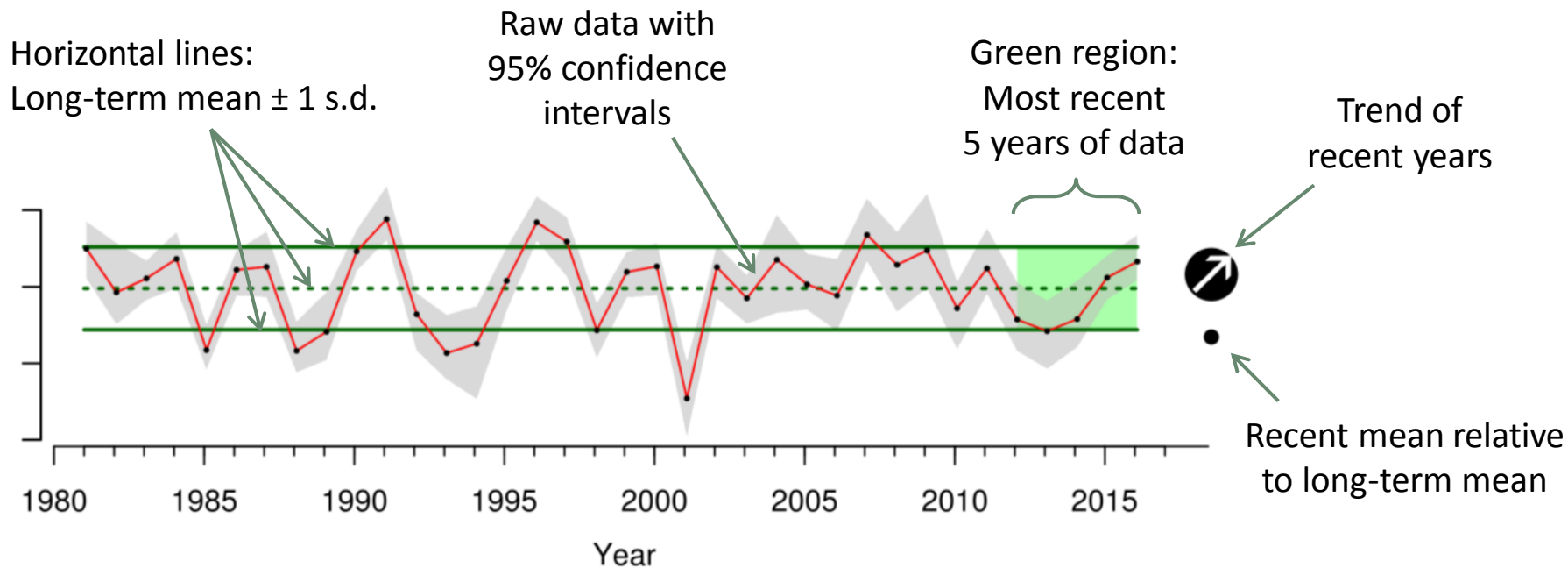
SUMMARY, CONTINUED

- **Ecology of the system lagging behind climate shifts**
  - Copepods off of Newport remain dominated by energy-poor species
  - Forage community was diverse (again) in 2016. Poor survey catches of sardine, squid, krill; large but patchy survey catches of juvenile rockfish, juvenile hake, anchovy
  - We remain concerned about environmental conditions for Chinook and coho salmon that went to sea over the past several years
  - California sea lions at San Miguel had poor foraging conditions in 2015; preliminary evidence suggests improvements in 2016
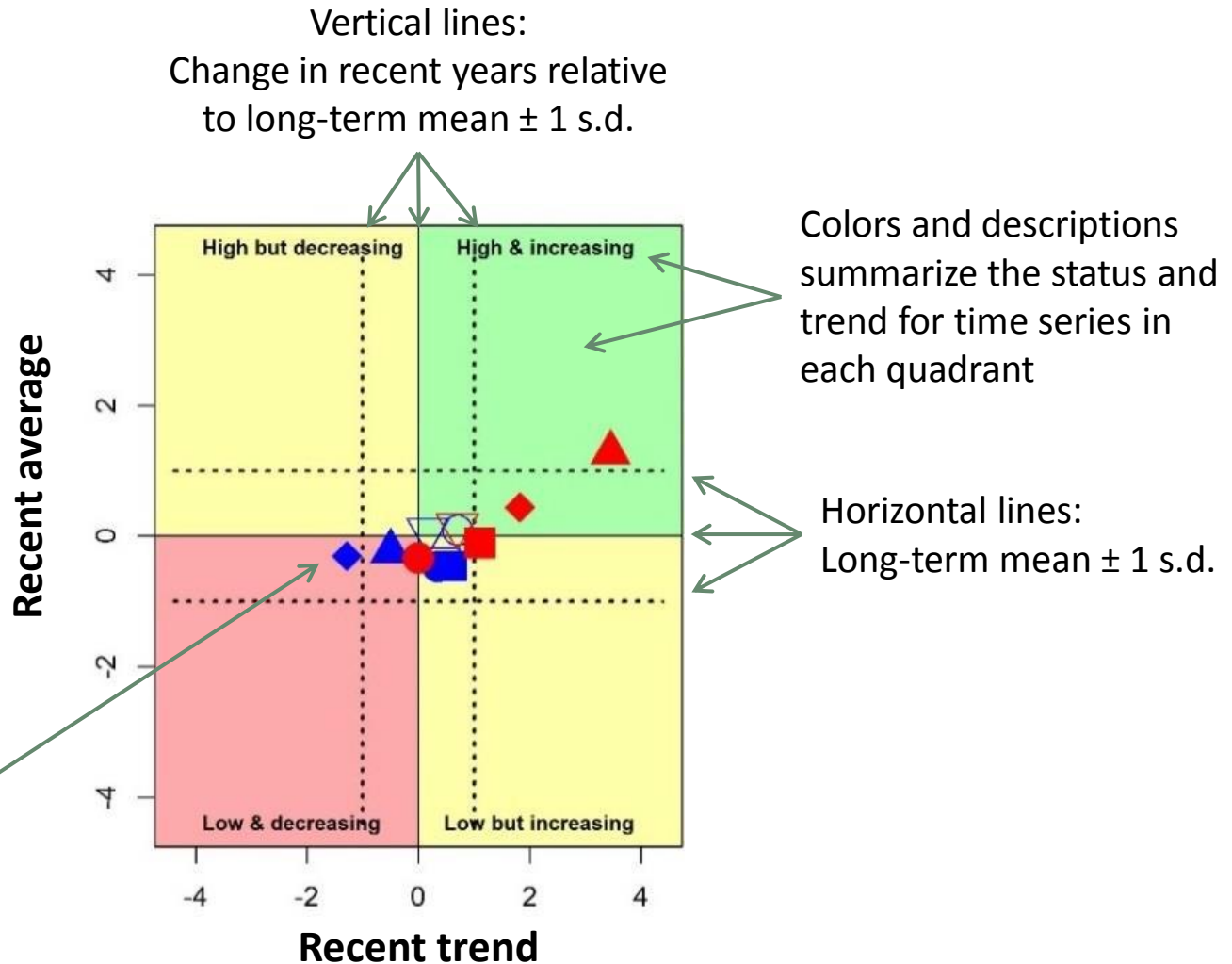
- **Changes in fisheries**
  - Commercial landings and revenues declined markedly in 2015, driven by hake, CPS, crabs*
  - Recreational removals have been near historic lows, but show signs of increasing in some areas and target species since 2008
  - Gear contact with seafloor in 2015 was historically low, due to reduced bottom trawling

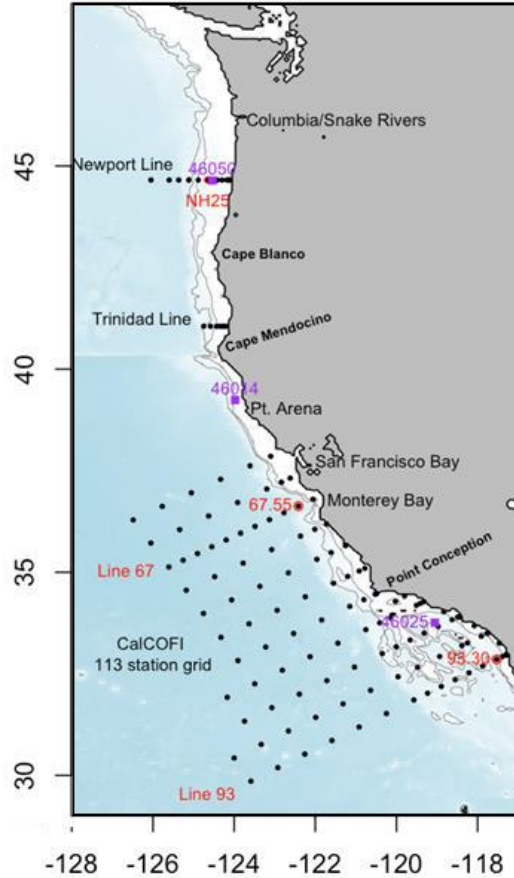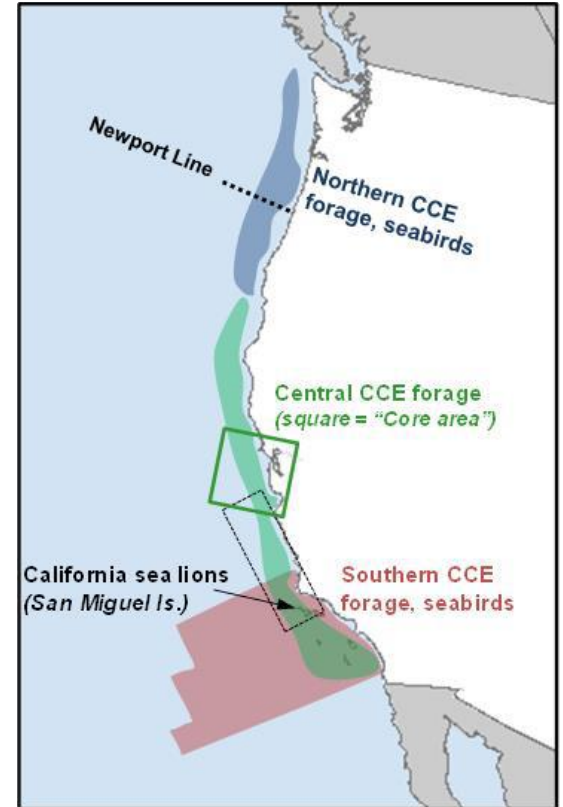# Interpreting time series plots

Horizontal lines:
Long-term mean ± 1 s.d.

Raw data with
95% confidence
intervals

Green region:
Most recent
5 years of data

Trend of
recent years

Recent mean relative
to long-term mean

Interpreting quad plots

Vertical lines:
Change in recent years relative to long-term mean ± 1 s.d.

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

Horizontal lines:
Long-term mean ± 1 s.d.

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

Sampling areas

Oceanography

Freshwater ecoregions

Biological sampling

Outline

1. **Physical Conditions**

2. **Ecological Responses**

3. **Human Activities**

4. **Human Wellbeing**

5. **Synthesis and Research Recommendations**

1. Physical Conditions:
Goodbye Blob and El Niño; Hello…?

Leslie Bell

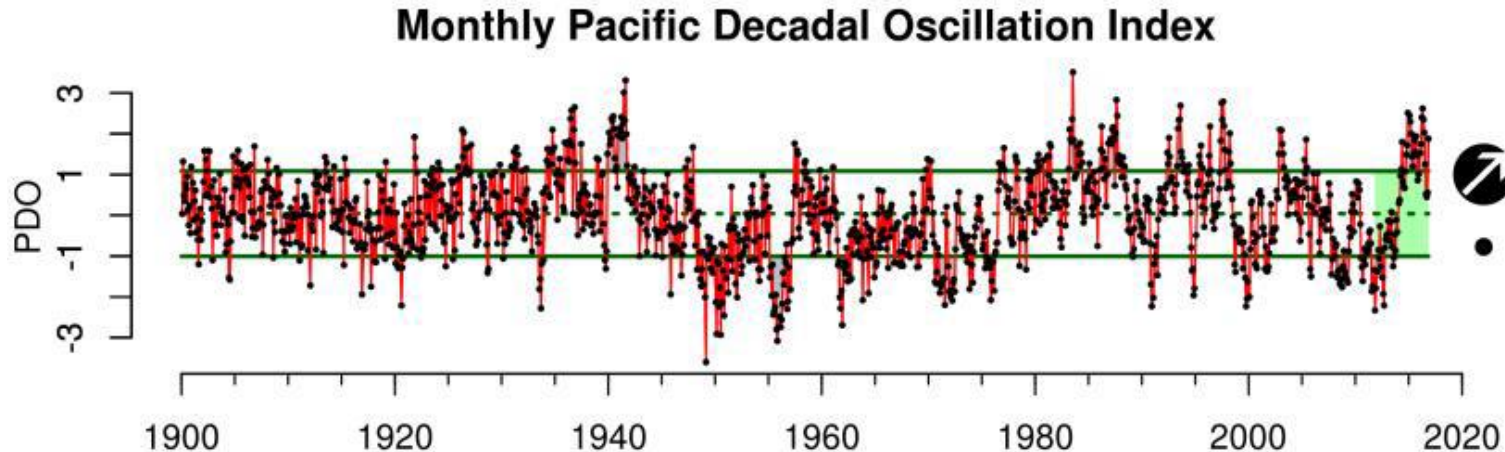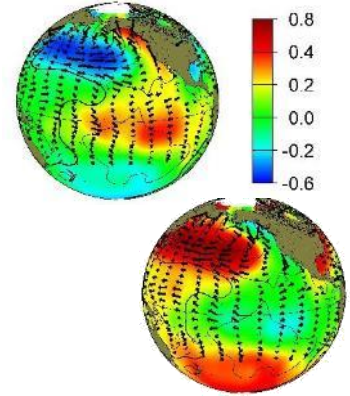# Basin-scale climate indices have shifted

Oceanic Niño Index (ONI)

- Related to upwelling, coastal currents, storm tracks
- Positive ONI = El Niño; Negative ONI = La Niña
- Became strongly positive in 2015-2016
- *Shifted to neutral or slightly negative by late 2016*

El Niño   La Niña

Sea Surface Temperature Anomaly (°C)
-4   -2   0   2   4

Monthly Oceanic Nino Index
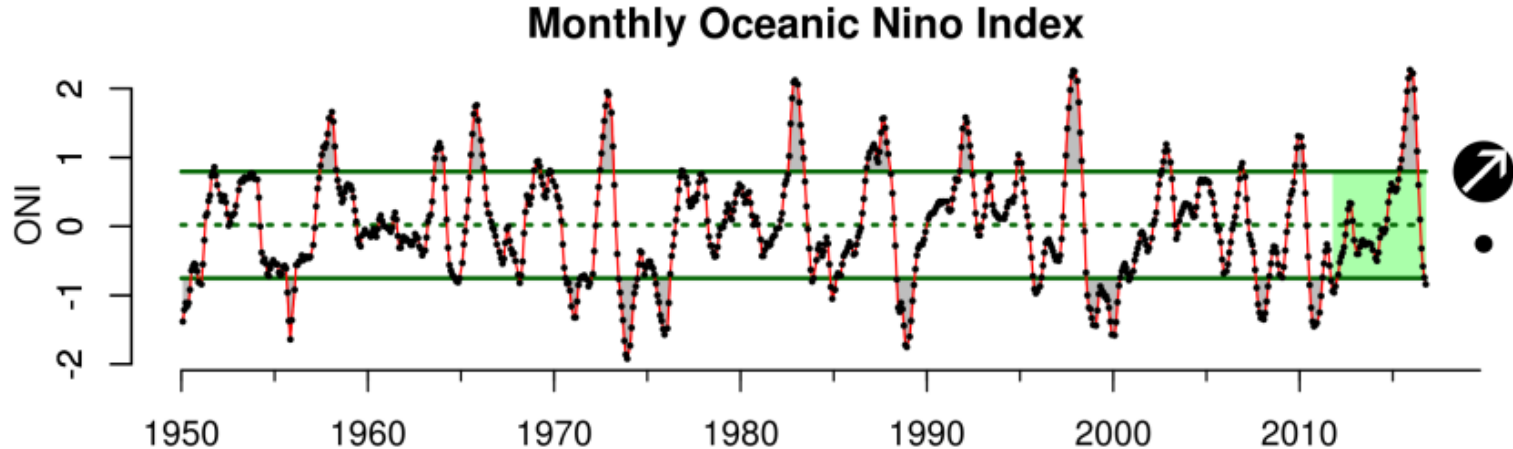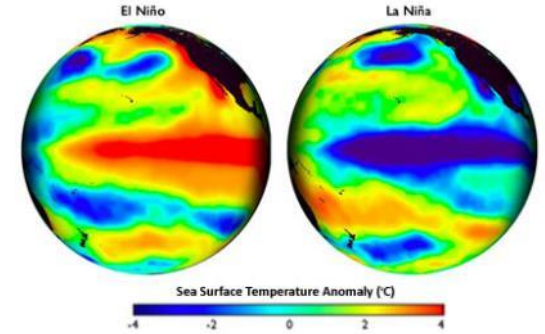
Basic-scale climate indices have shifted

## Pacific Decadal Oscillation (PDO)

- Related to sea surface temp and productivity in CCE
- Positive = warm, less productive; Negative = cool, more productive
- PDO had been strongly positive since 2014
- *Shifting between neutral and positive by late 2016*

Monthly Pacific Decadal Oscillation Index

Basin-scale climate indices have shifted
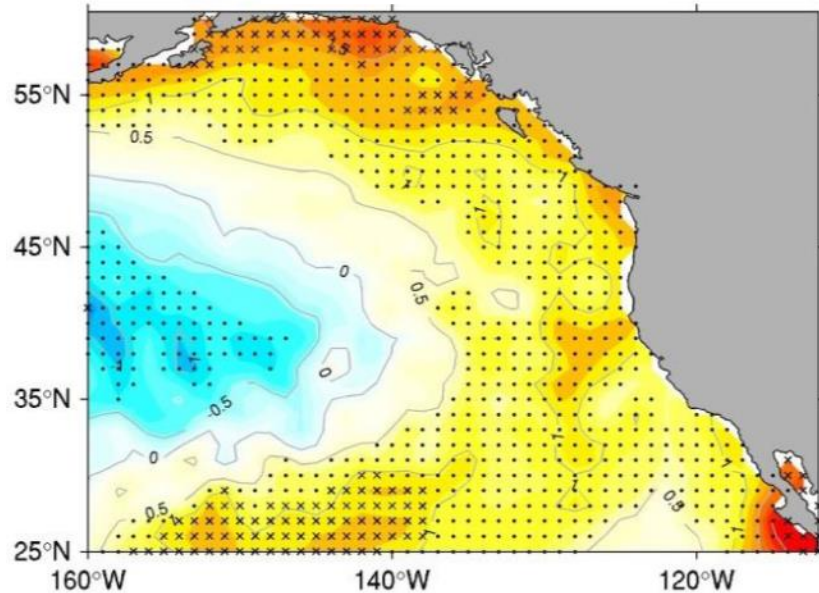
North Pacific Gyre Oscillation (NPGO)

- Related to sea surface height, circulation

- Positive = strong circulation, higher productivity; Negative = weaker, lower productivity

- Strongly negative in 2015
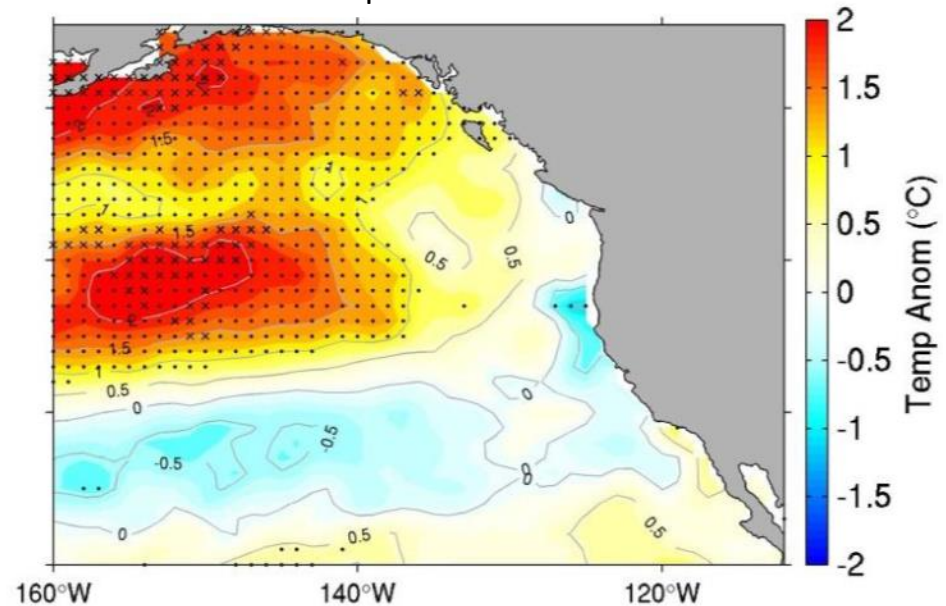
- *Shifted to neutral for much of 2016*

Monthly North Pacific Gyre Oscillation Index
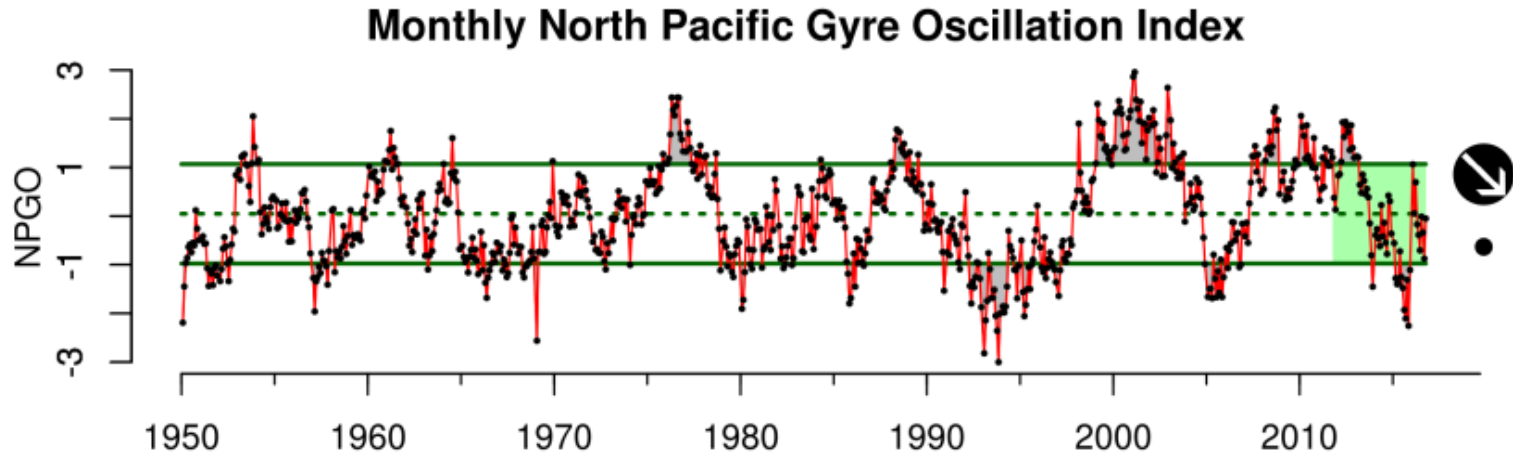
Sea surface temperatures in 2016

- *the demise of the anomalous marine heat wave*
- *no strong El Niño signal along West Coast*

Jan-Mar 2016 SST anom   Jul-Sep 2016 SST anom

SST anomalies in Winter (Jan-Mar) and Summer (Jul-Sep), 2016. Dots mark cells where the anomaly was >1 s.d. above 1982-2016 mean; x's mark cells where the anomaly was the highest of the time series.
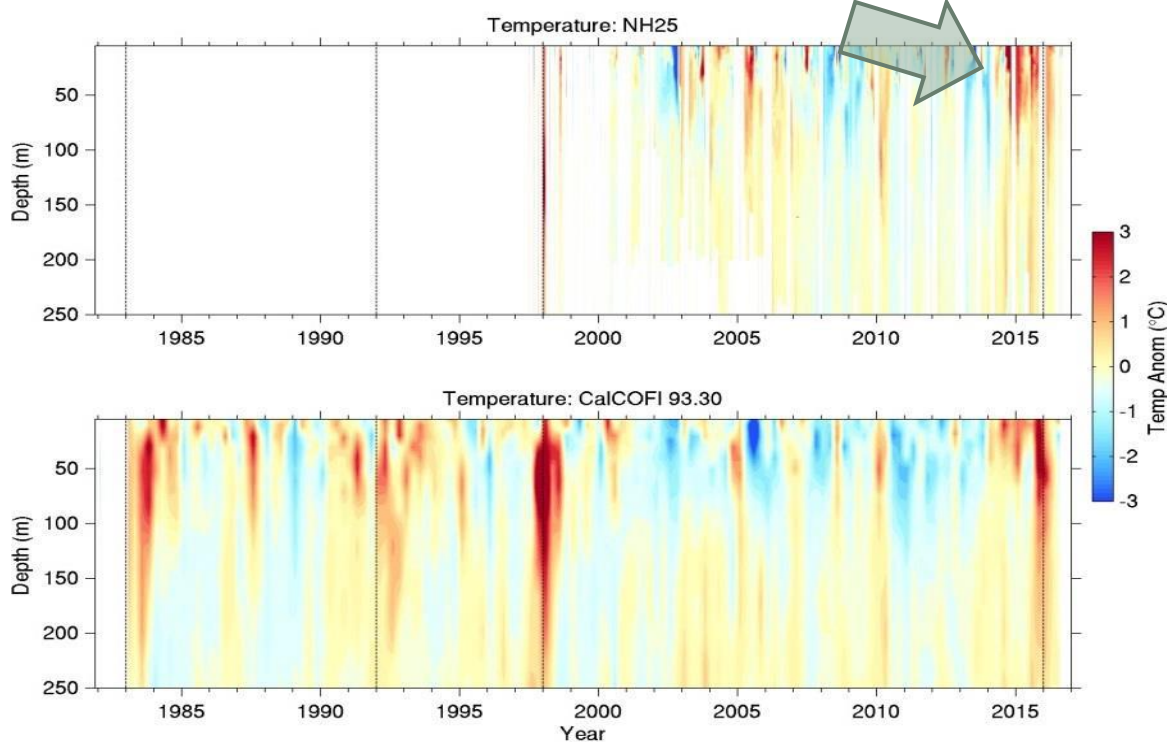
Temp at depth

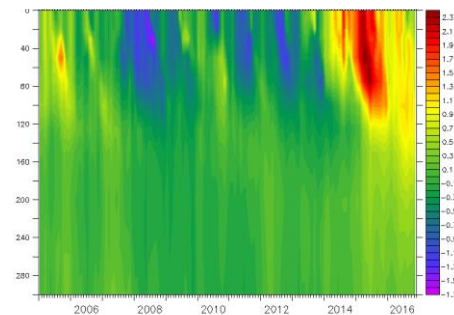Plots show temp anomalies at depth off Newport (NH25) and San Diego (CalCOFI 93.90)

El Niño years: dotted lines

2014-2015: "Blob" warm anomaly dominated at the surface

2016 El Niño penetrated deeper but was short-lived, and had little impact in North
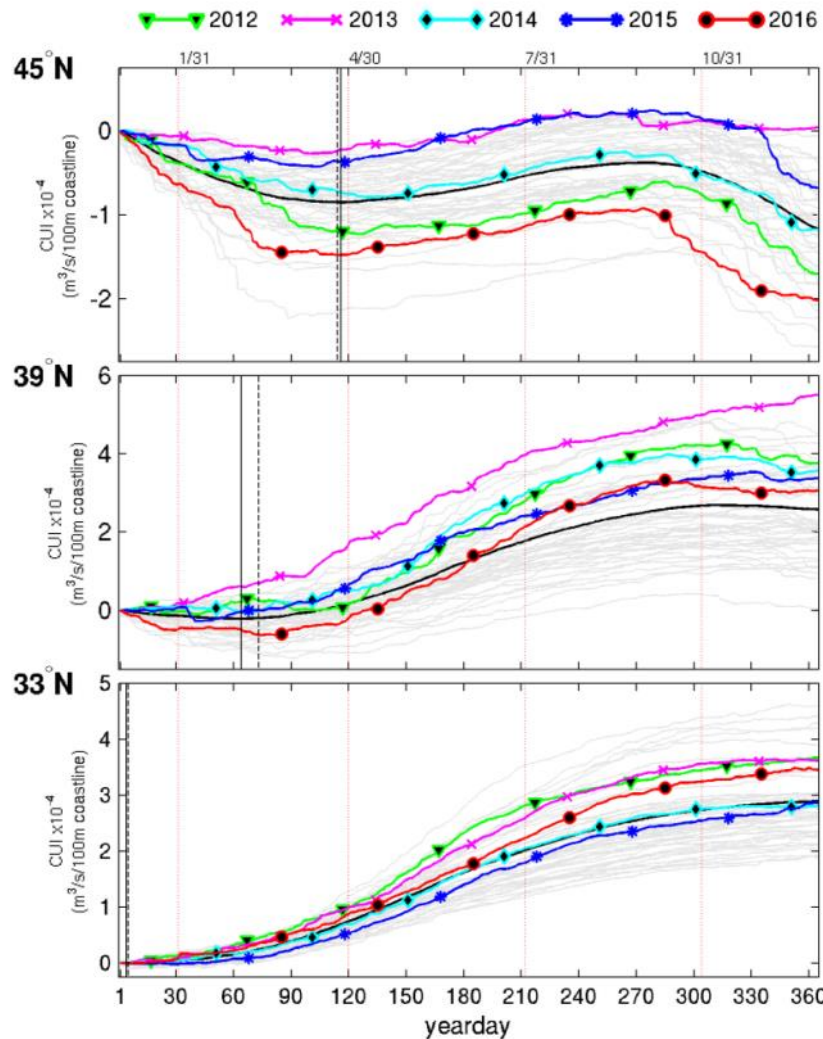
ARGO floats in the NE Pacific

Upwelling in 2016: a mixed bag

Northern region: early downwelling, then average upwelling

Central region: early downwelling, then above average upwelling

(note y-axis; this region has the strongest upwelling)

Southern region: average until summer, then above average
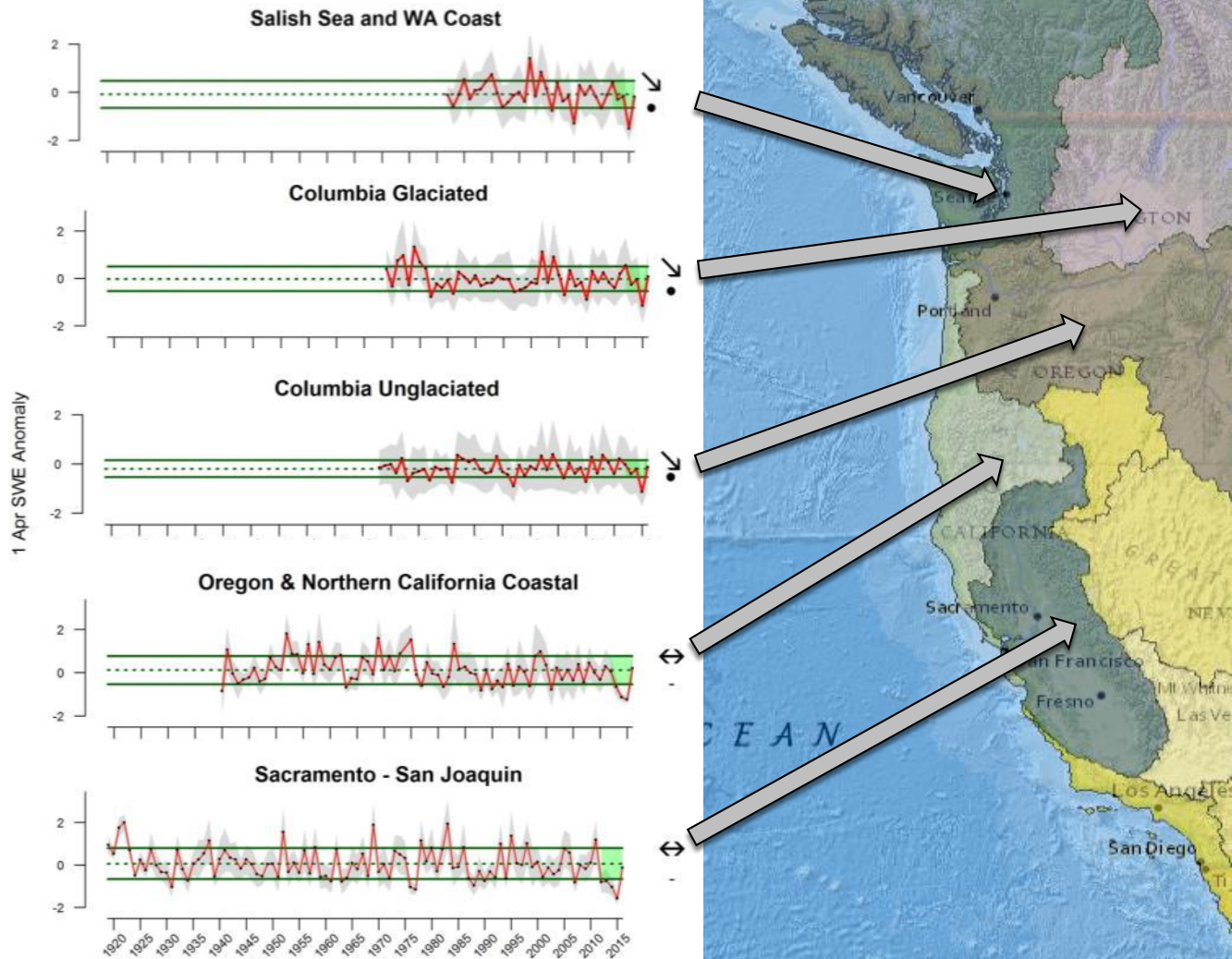
Snowpack is rebounding

2015: record poor snow-water equivalent in all freshwater ecoregions
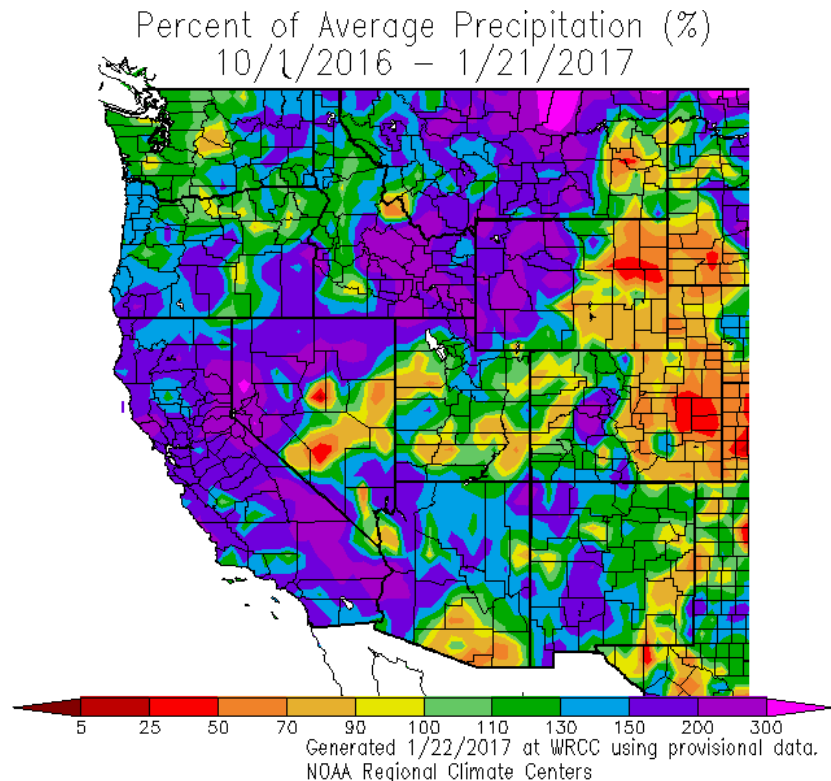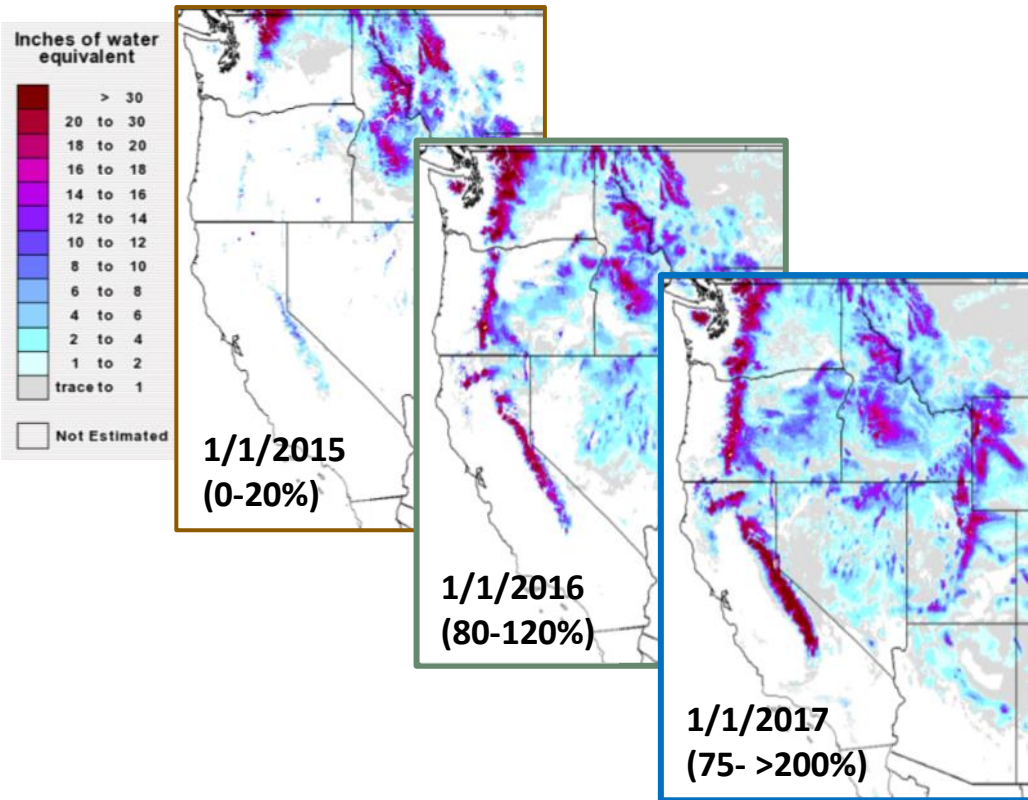
2016: SWE near long-term average coast-wide

But: warm spring and summer in 2016 caused rapid melt
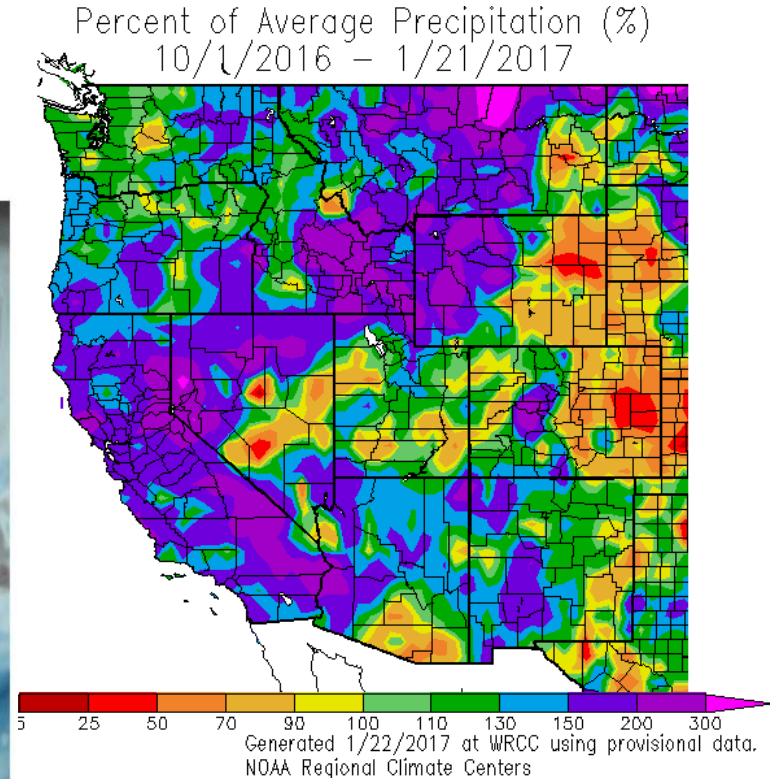
2017 is looking hopeful...

Snowpack is rebounding
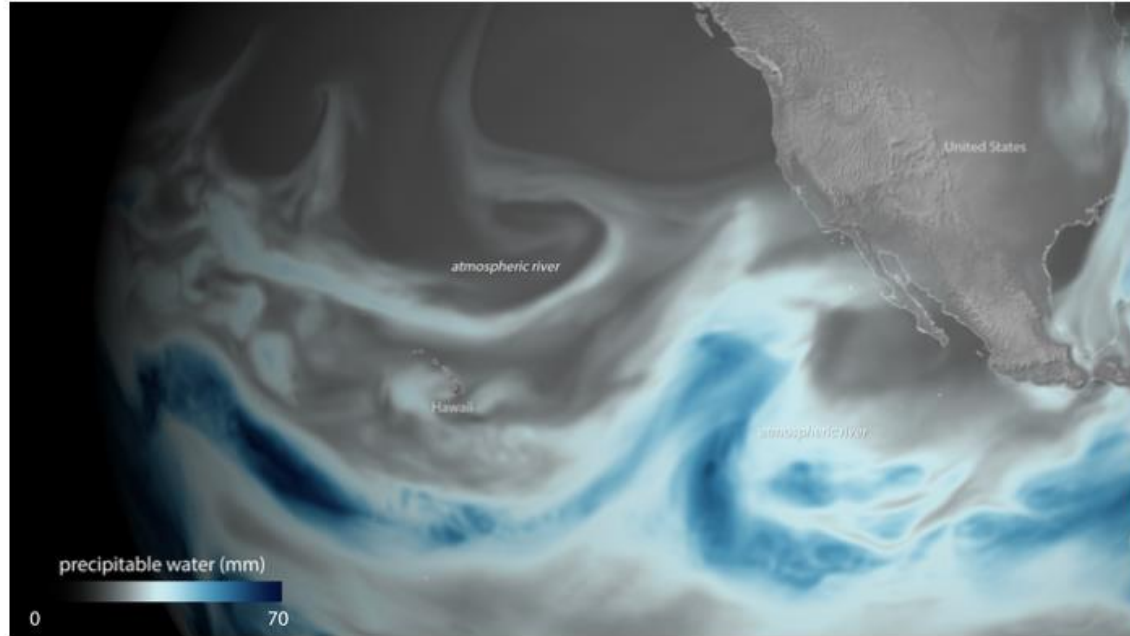

Inches of water equivalent
- > 30
- 20 to 30
- 18 to 20
- 16 to 18
- 14 to 16
- 12 to 14
- 10 to 12
- 8 to 10
- 6 to 8
- 4 to 6
- 2 to 4
- 1 to 2
- trace to 1
- Not Estimated

**1/1/2015
(0-20%)**

**1/1/2016
(80-120%)**

**1/1/2017
(75- >200%)**

Percent of Average Precipitation (%)
10/1/2016 – 1/21/2017

5 25 50 70 90 100 110 130 150 200 300

Generated 1/22/2017 at WRCC using provisional data.
NOAA Regional Climate Centers

Precipitation rebound is due to atmospheric rivers

Percent of Average Precipitation (%)
10/1/2016 – 1/21/2017

5 25 50 70 90 100 110 130 150 200 300

Generated 1/22/2017 at WRCC using provisional data.
NOAA Regional Climate Centers

precipitable water (mm)

0 70

atmospheric river

Atmospheric rivers are sinews of moisture from the tropics. The one pictured here appeared over the Northern Pacific on Jan. 3, 2017. *(NOAA)*

2. *Ecological Responses:*
Lingering and lagging effects

NOAA biologists sort pelagic red crabs, which were unusually abundant off Central California in 2015-2016 (John Field, SWFSC)

1. *Physical Conditions*
2. *Ecological Responses*
3. *Human Activities*
4. *Human Wellbeing*
5. *Synthesis and Research Recommendations*
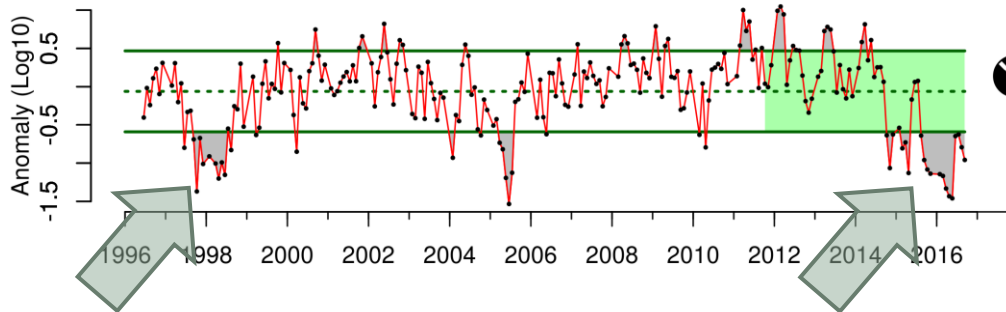
Northern copepod biomass anomaly

- "Northern" copepods are cool-water, lipid-rich species

- *Since late 2014, less-fatty "Southern" copepods have dominated, which is not ideal for forage fish and their predators*

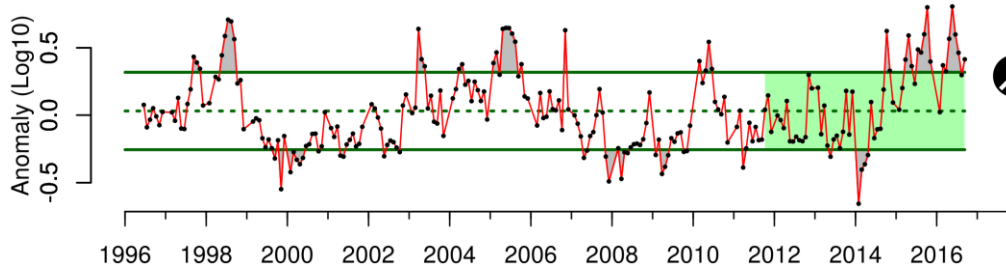- Northern copepods typically lag PDO shifts by ~6 months

Northern copepod biomass anomaly 44.6N
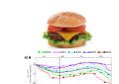

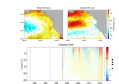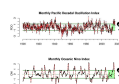Southern copepod biomass anomaly 44.6N
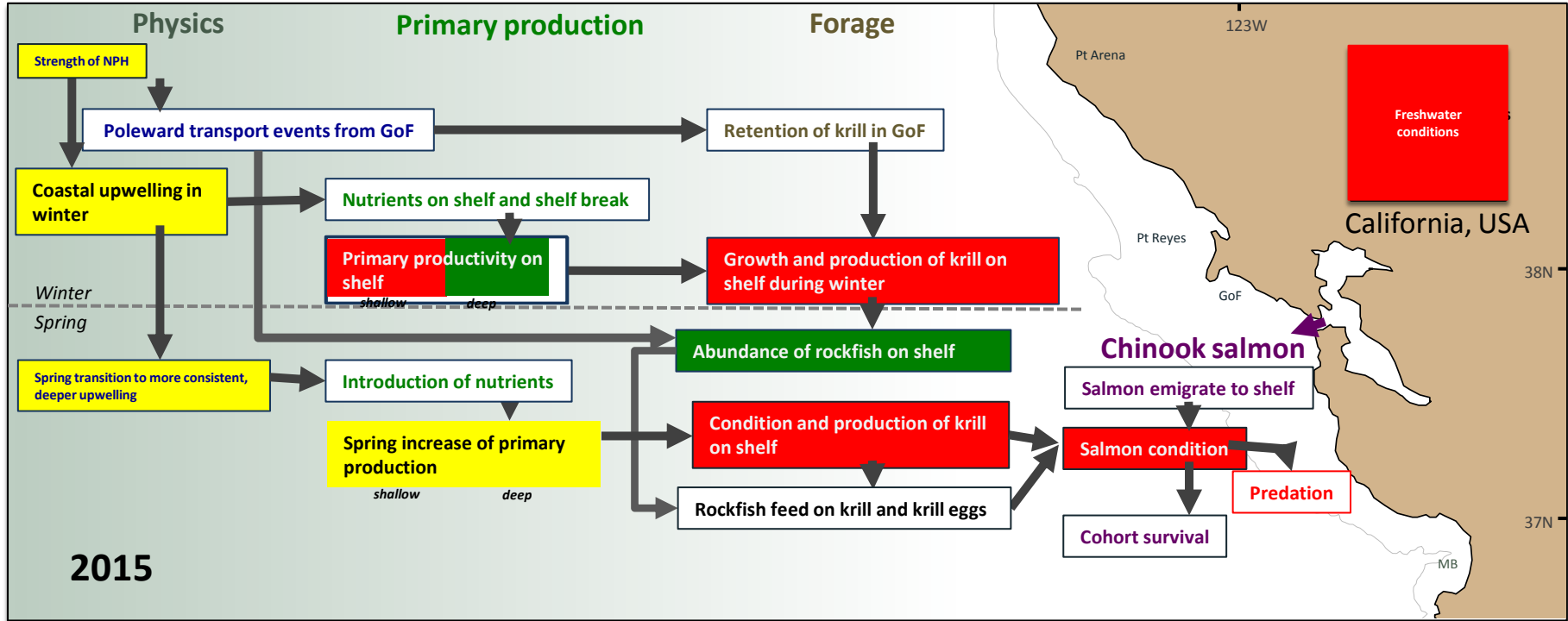
What do these indicators mean for salmon?

- Peterson (NWFSC) et al. have related indicators to conditions for coho & Chinook salmon as a "stoplight chart": Poor, intermediate, and good

- Many high-ranking CCIEA indicators included

- ***Broadly predictive for Columbia River region; outlook for 2017 returns is not good***
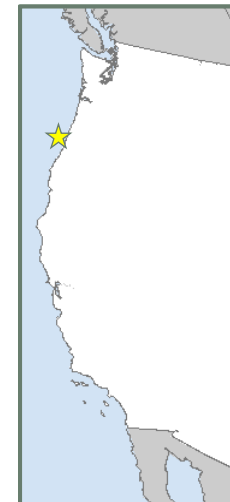
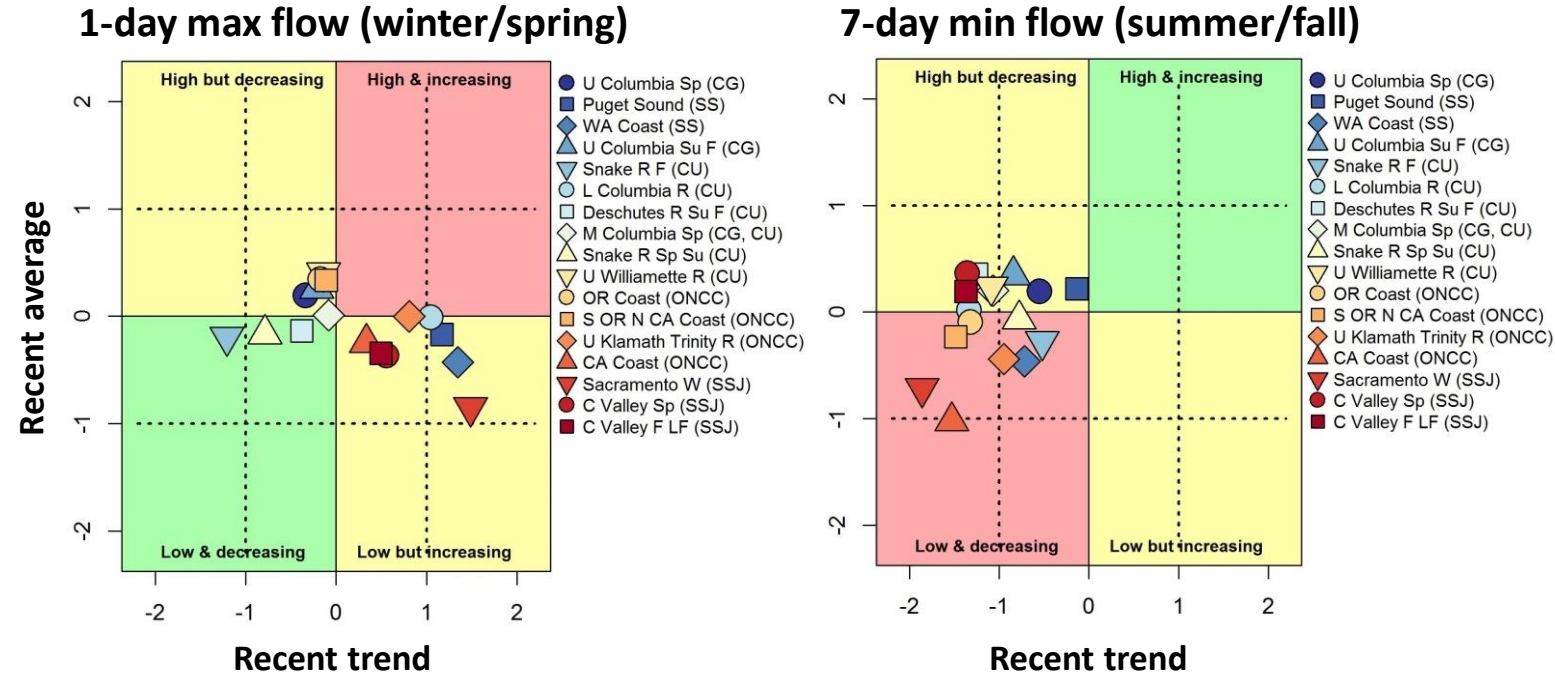| Scale of indicators	Smolt year				Adult return outlook	
	2013	**2014**	**2015**	**2016**	**Coho, 2017**	**Chinook, 2017**
Basin-scale						
PDO (May-Sept)	yellow	yellow	red	red	red	red
ONI (Jan-Jun)	yellow	yellow	red	red	red	red
Local and regional						
SST anomalies	yellow	yellow	red	red	red	red
Deep water temp	red	red	red	yellow	yellow	red
Deep water salinity	red	red	yellow	yellow	yellow	yellow
Copepod biodiversity	green	yellow	red	red	red	red
Northern copepod anomaly	green	green	red	red	red	red
Biological spring transition	green	green	red	red	red	red
Winter ichthyoplankton biomass	yellow	red	green	green	green	green
Winter ichthyoplankton community	yellow	yellow	red	red	red	red
Juvenile Chinook catch (Jun)	green	yellow	red	yellow	red	red
Juvenile coho catch (Jun)	green	yellow	yellow	yellow	yellow	yellow

What do these indicators mean for salmon?

Wells (SWFSC) et al. have taken similar "stoplight" approach for Central Valley Fall Chinook salmon, but using a conceptual model based on salmon life history

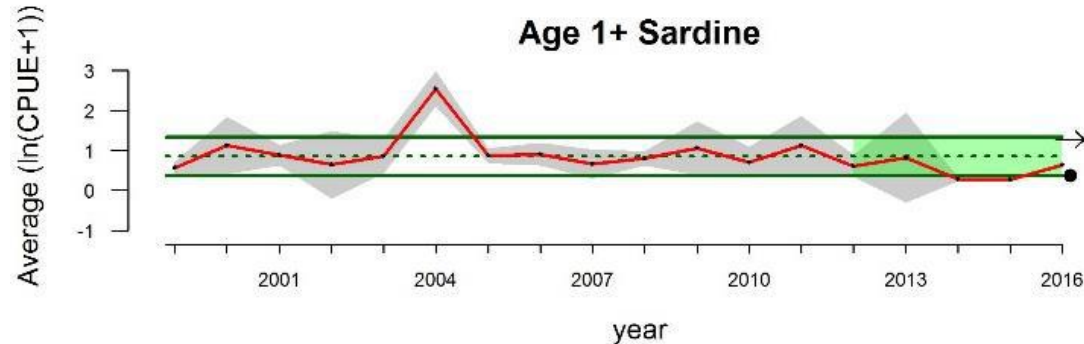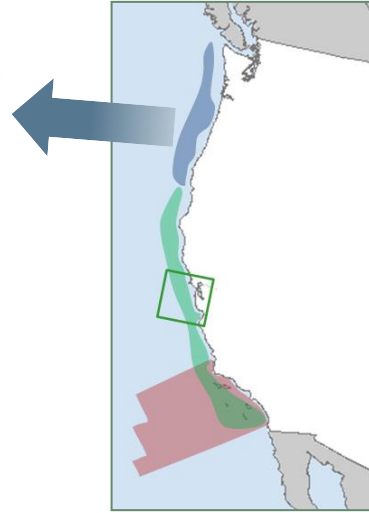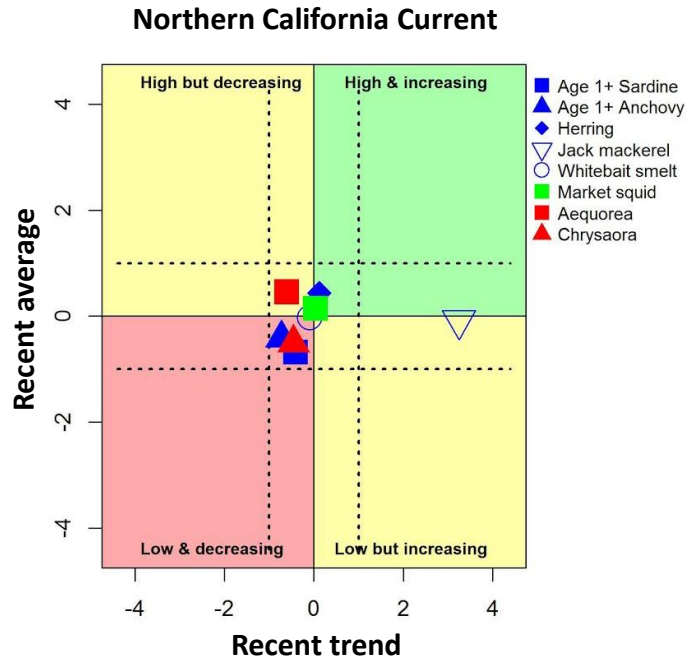# What do these indicators mean for salmon?

- Streamflow anomaly time series through 2016, at the scale of Chinook salmon ESUs
- Some ESUs experiencing increasing magnitude of spring max flow events
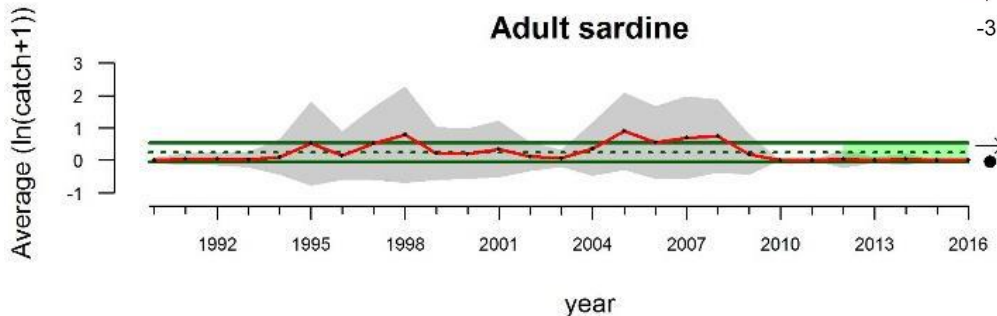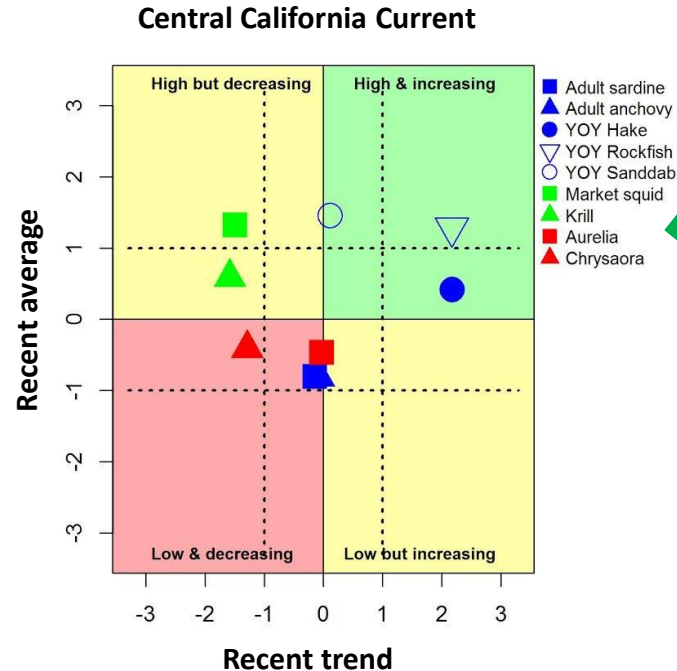- ***Many ESUs had worsening trends*** for low-flow periods in summer/fall, esp. in CA

1-day max flow (winter/spring)

7-day min flow (summer/fall)
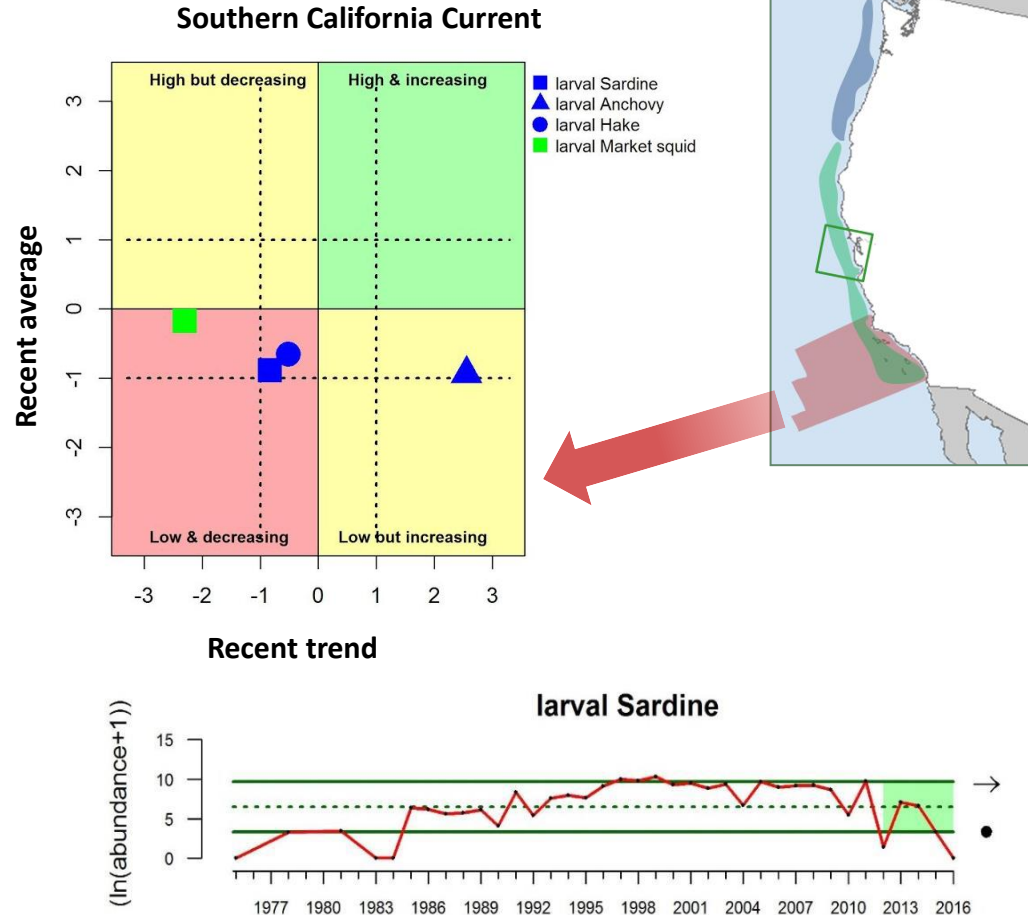
Forage through 2016

- **North:** age 1+ anchovy, sardine were very low; jack mackerel were increasing

- But, in a related survey in same region:
  - ↑ anchovy, juv rockfish, juv hake
  - ↓ krill, ↑ salps

Northern California Current

Age 1+ Sardine

Forage through 2016

- **North:** age 1+ anchovy, sardine were very low; jack mackerel were increasing

- But, in a related survey in same region:
  - ↑ anchovy, juv rockfish, juv hake
  - ↓ krill, ↑ salps

- **Central:** age 1+ anchovy, sardine very low
- ↑ juv rockfish, juv hake
- ↓ market squid, krill
- Abundant salps, pelagic red crabs

Central California Current

Legend:
- Adult sardine
- Adult anchovy
- YOY Hake
- YOY Rockfish
- YOY Sanddab
- Market squid
- Krill
- Aurelia
- Chrysaora

Adult sardine

Forage through 2016

- **North:** age 1+ anchovy, sardine were very low; jack mackerel were increasing

- But, in a related survey in same region:
  - ↑ anchovy, juv rockfish, juv hake
  - ↓ krill, ↑ salps

- **Central:** age 1+ anchovy, sardine very low
- ↑ juv rockfish, juv hake
- ↓ market squid, krill
- Abundant salps, pelagic red crabs

- **South:** Of the four species analyzed through 2016:
 - sardine and hake catches were low
  - ↑ anchovy, ↓ market squid

Southern California Current

larval Sardine
larval Anchovy
larval Hake
larval Market squid

Recent average

Recent trend

High but decreasing | High & increasing
Low & decreasing | Low but increasing

larval Sardine

2015 was another bad cohort for California sea lions

Photo: Sharon Melin, NOAA

- 2015 pup count (born in June) was down; poor growth from fall 2015 to early 2016, leading to high stranding/mortality rate

- This indicates poor foraging conditions for mothers in 2015 and early 2016

- Similar findings for other pinniped colonies in this region

- *BUT: Feb 2017 data indicate better abundance and growth for pups born in June 2016*

Sea lion pup count, San Miguel Isl.
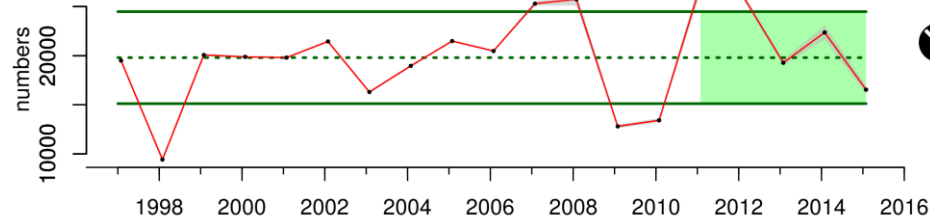
Female sea lion pup growth rate
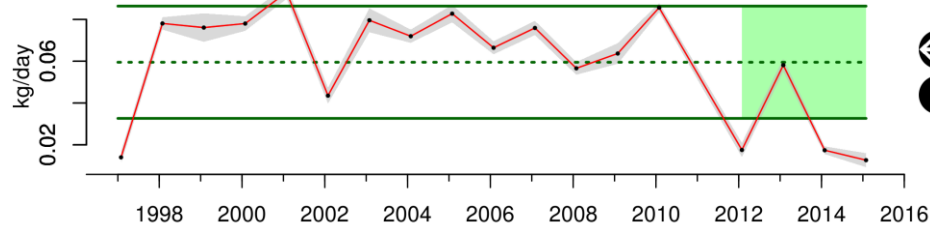
Cohort

Other indicators of ecological integrity

Vermilion rockfish (Dan Hershman)

1. Physical Conditions
2. **Ecological Responses**
3. Human Activities
4. Human Wellbeing
5. Synthesis and Research Recommendations

Chinook salmon escapement trends

- Through 2015 for CA, 2014 for WA, ID and OR

- *Most stocks near long-term averages*; Snake River Fall Chinook above average

- *Trending up:* Snake R. Fall, Snake Spr/Sum, Lower Columbia

- *Trending down:* Central Valley Winter

- *Several stocks that were trending up in last year's report are now trend-neutral*, thanks to poor escapements in 2013, 2014 and/or 2015
  - Central Valley Fall
  - Klamath Fall
  - CA Coastal
  - Northern CA/Southern OR

Chinook Escapement


A. Central Valley Fall
B. Central Valley Spr
C. Central Valley Late
D. Central Valley Win
E. California Coast
F. Klamath Fall
G. sOR-nCA Coast
H. Lower Columbia
I. Willamette Spr
J. Snake Fall
K. Snake Spr-Sum
L. Upper Columbia Spr
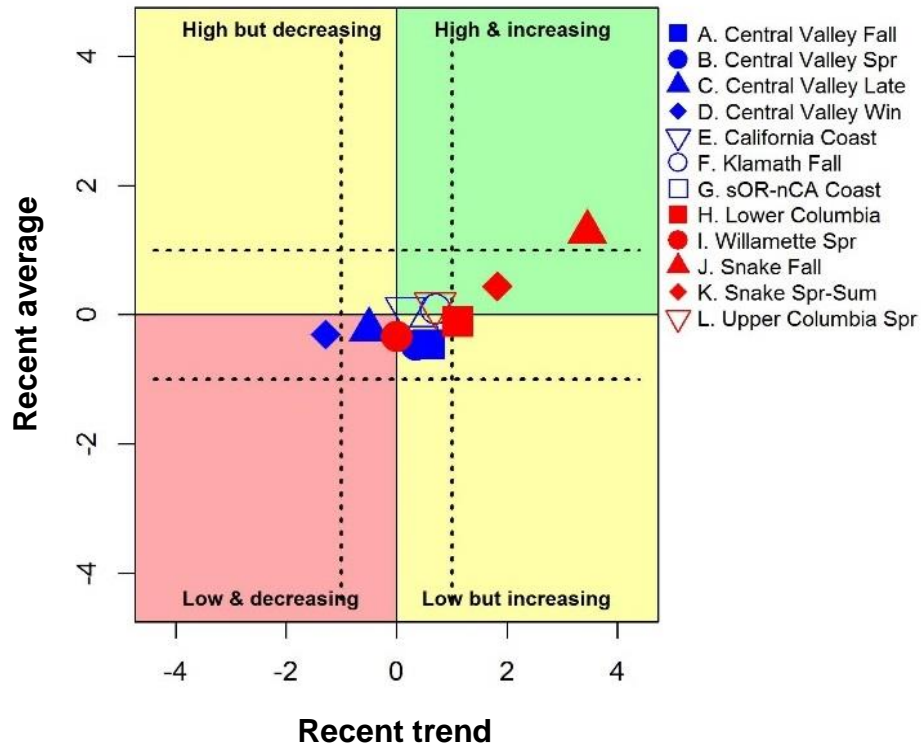
Groundfish

- No new info; new assessments coming in 2017

- Most stocks at or above biomass target, below proxy for heavy fishing mortality

- 2 overfished stocks, 3 rebuilding stocks

- Only two stocks being fished above F_{MSY} (both black rockfish)

- *2015 and 2016 may prove to be good year classes*

YOY Canary rockfish in 2016 near Olympic Peninsula (Janna Nichols, REEF)

Rockfish/thornyheads scatter plot with legend: 2007, 2009, 2011, 2013, 2015. Labeled points include Black_CA, Black_WA, China_S, Rougheye, Black_OR, Aurora, China_C, China_N, SST, LST, Yellowtail, Yelloweye, POP, Bocaccio, Darkblotched, Splitnose, Cowcod, Chilipepper, Canary, Sharpchin, Widow. Axes: $F_{terminal} / F_{MSY\ proxy}$ (y) vs $B_{terminal} / B_{MSY\ proxy}$ (x).

Other groundfish scatter plot with labeled points: Petrale, Cabezon_OR, Sablefish, Hake, Cabezon_SCA, Longnose skate, Cabezon_NCA, Lingcod_N, ATF, Kelp_greenling, Rex, Dover, English.

3. *Human activities*

Commercial albacore fishing on the F/V Her Grace off Astoria (Craig D'Angelo, NOAA)

Landings through 2015

- Total landings dropped in 2015, driven by hake, CPS, squid, crab

- Groundfish historically low

- Salmon landings highly variable, down in 2015

- HMS stable

- Shrimp continued to increase

- Recreational catches low but increasing in recent years
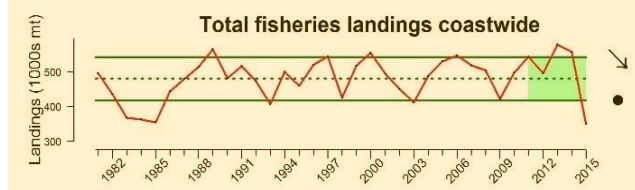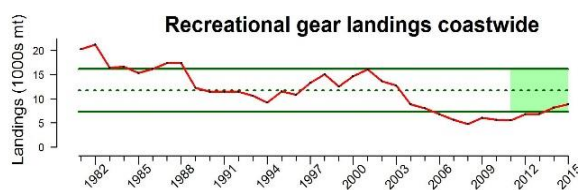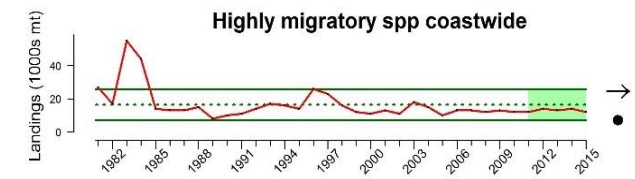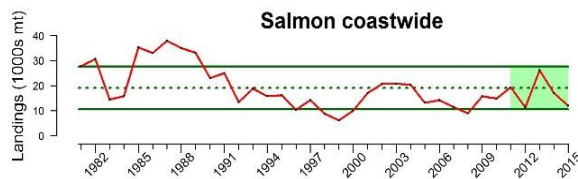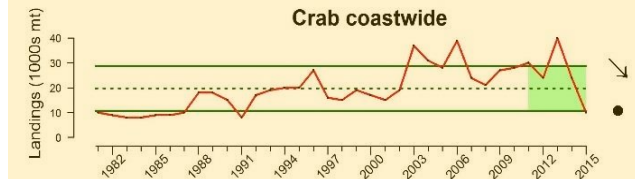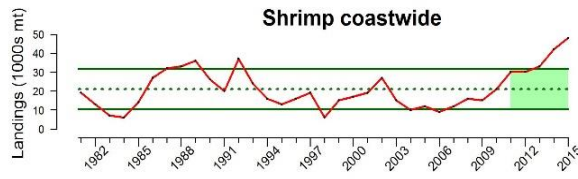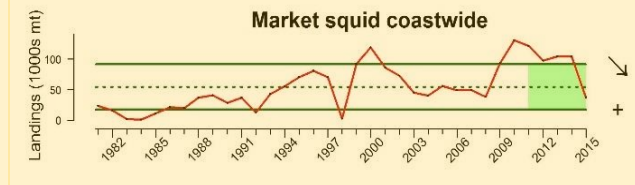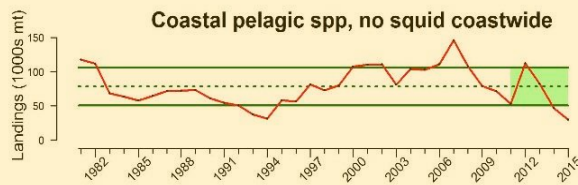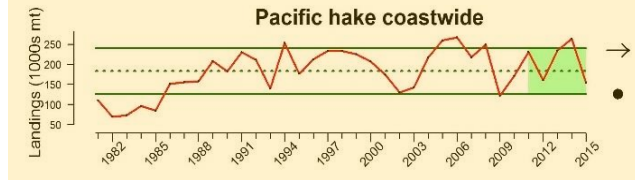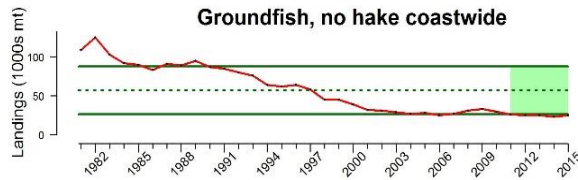
Commercial revenue

- Total revenue dropped in 2015, driven by crab, squid, hake

- CPS, salmon and HMS fairly stable over last decade, though down slightly over past few years

- Groundfish low, stable

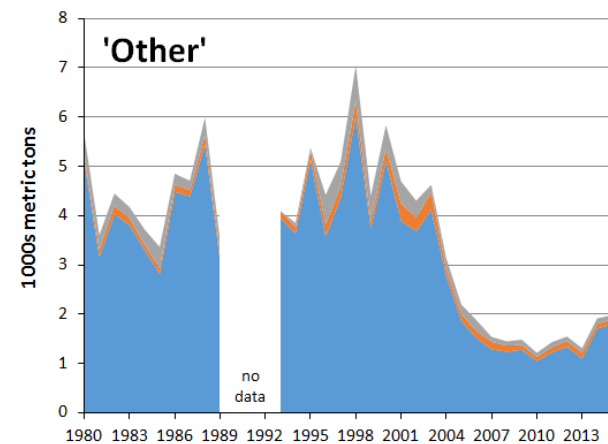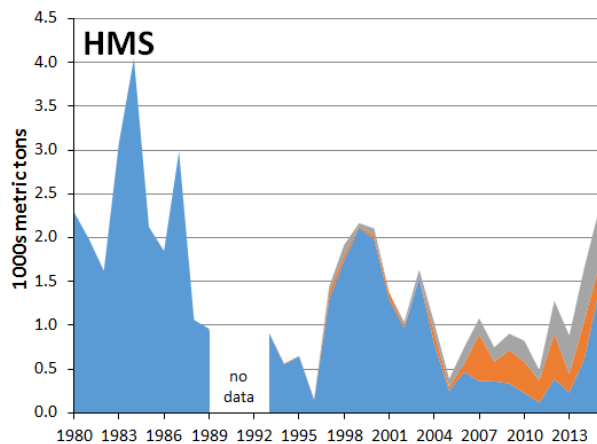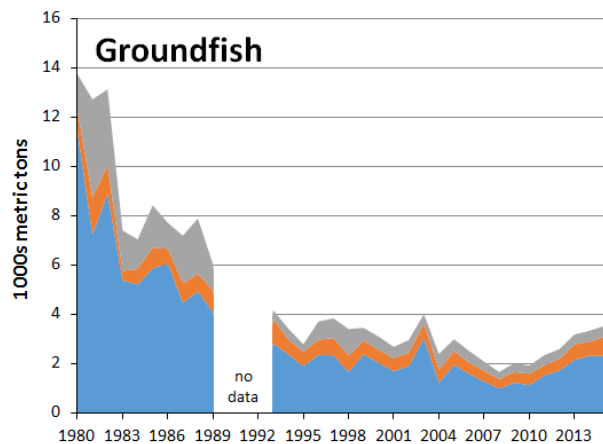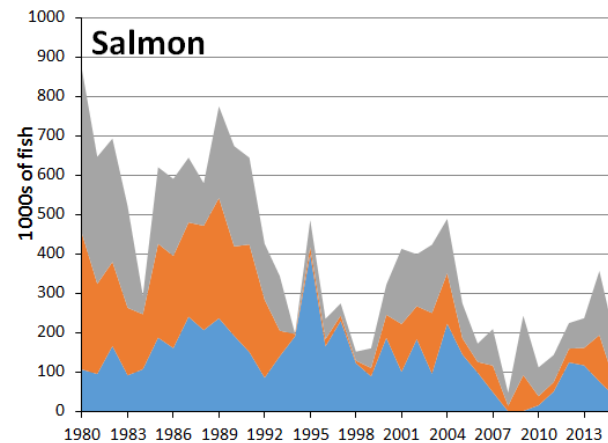- Shrimp continued to increase; shrimp + crab ≈ 40% of total commercial revenue in 2015
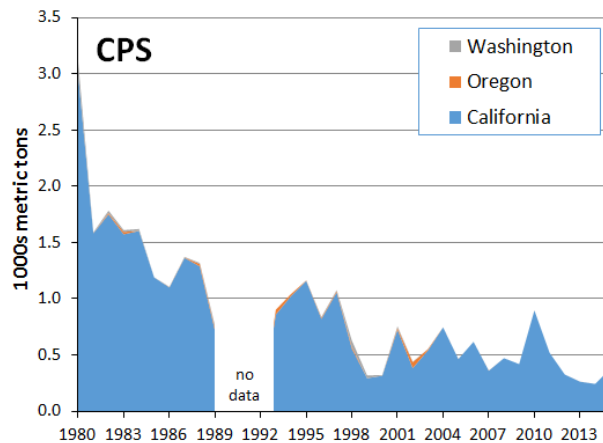
(all data adjusted to 2015 dollars)
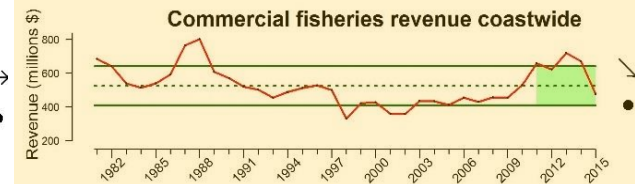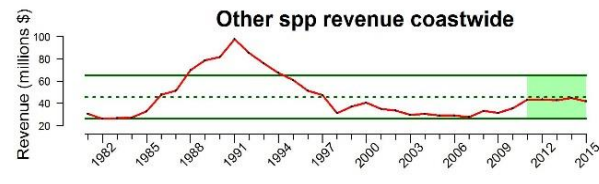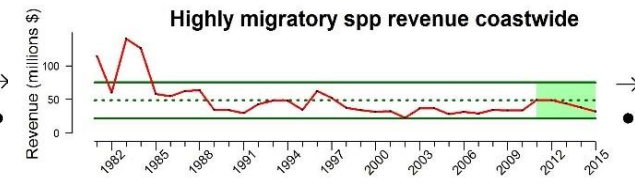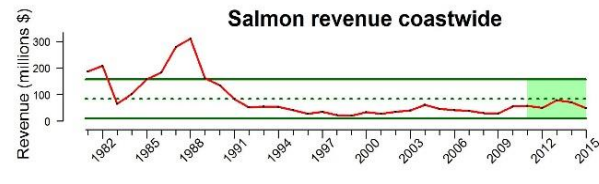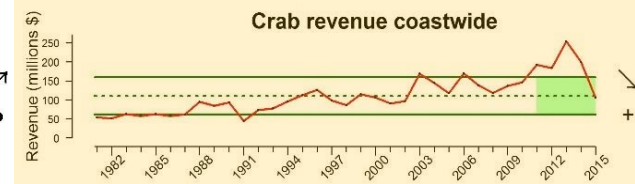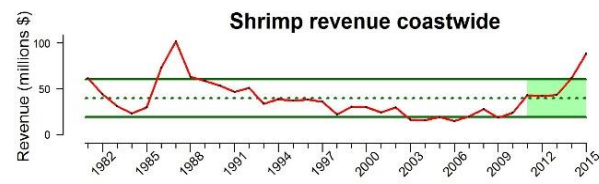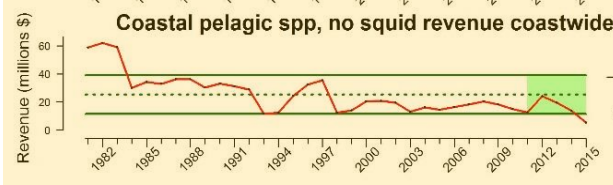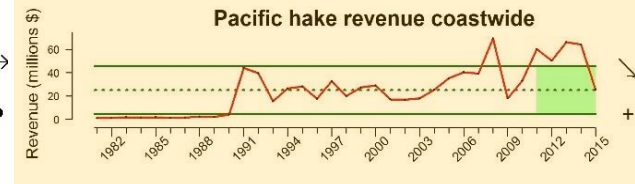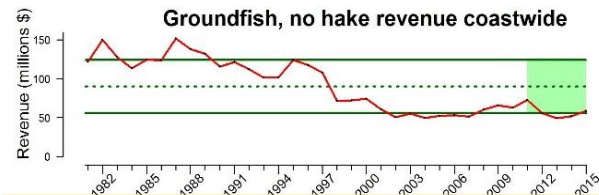
Recreational take through 2015

- Salmon corrected from briefing book (#s, not weight)

- CA accounts for most long-term rec catch, except salmon

- General decline over time, but some recent increases

Other activities

- Gear contact with seafloor has declined steadily on most shelf and slope habitat types

- The dominant signal here is the decline in bottom trawling effort on the slope and shelf, especially north of Cape Mendocino

- Shellfish aquaculture production on West Coast is at record level

- Finfish aquaculture (= Atlantic salmon) also near historic high; comparable to commercial salmon landings
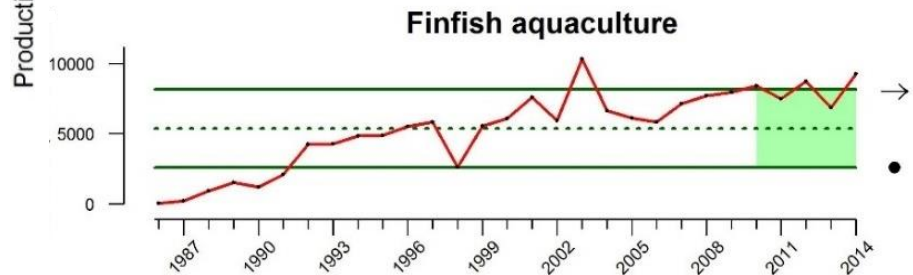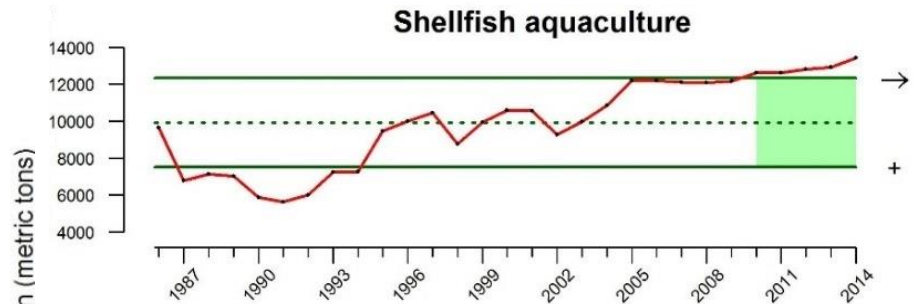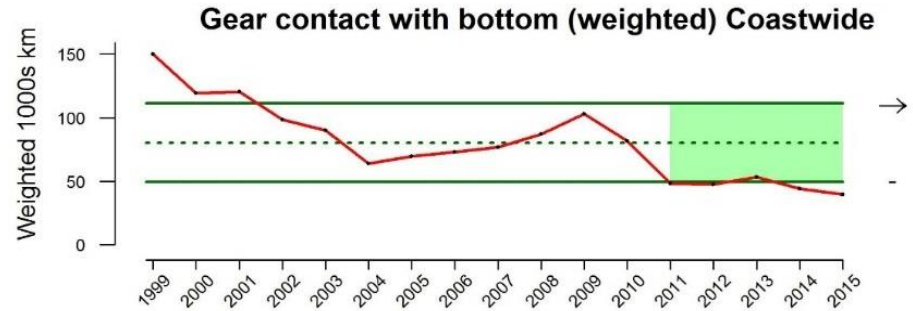
4. Human Wellbeing

Fishermen repair a trawl net
in San Francisco
(Jeremy Notch, SWFSC)

1. Physical Conditions
2. Ecological Responses
3. Human Activities
4. Human Wellbeing
5. Synthesis and Research Recommendations

Fishery diversification

- Measures how evenly revenues are distributed across fisheries in which vessels participate

- Diversification continues to decline across nearly all regions, vessel sizes, and revenue classes

- Small upticks in 2015 due in part to some non-diverse vessels opting not to fish

- *This type of information could be valuable in anticipating how fleet dynamics in response to climate or mgmt. changes*

Social vulnerability in fishery-dependent coastal communities

- Composite indexes of fishing dependence and social vulnerability for 880 coastal communities

- Top five fishing dependent communities from WA, OR, N CA, C CA and S CA are shown here, *updated through 2015*

- Gives relative idea of how changes in fishing might affect overall community wellbeing

Commercial Fishing Dependence (2014) — — — Vulnerability Index (2015)

Social vulnerability in fishery-dependent coastal communities

- Composite indexes of fishing dependence and social vulnerability for 880 coastal communities

- Top five fishing dependent communities from WA, OR, N CA, C CA and S CA are shown here, *updated through 2015*

- Gives relative idea of how changes in fishing might affect overall community wellbeing at different scales
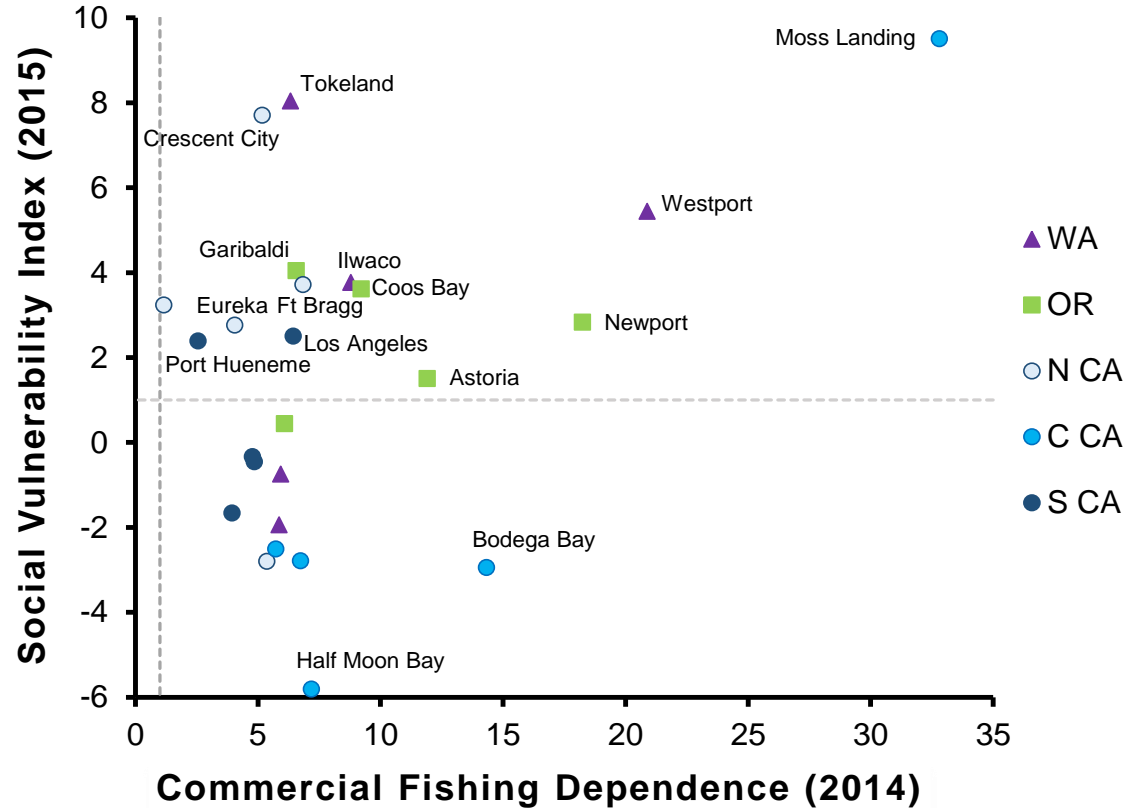
5. Synthesis and Research Recommendations

NOAA scientists and commercial fishermen sort a groundfish survey catch aboard the F/V Noah's Ark *(NWFSC/NOAA)*

1. *Physical Conditions*
2. *Ecological Responses*
3. *Human Activities*
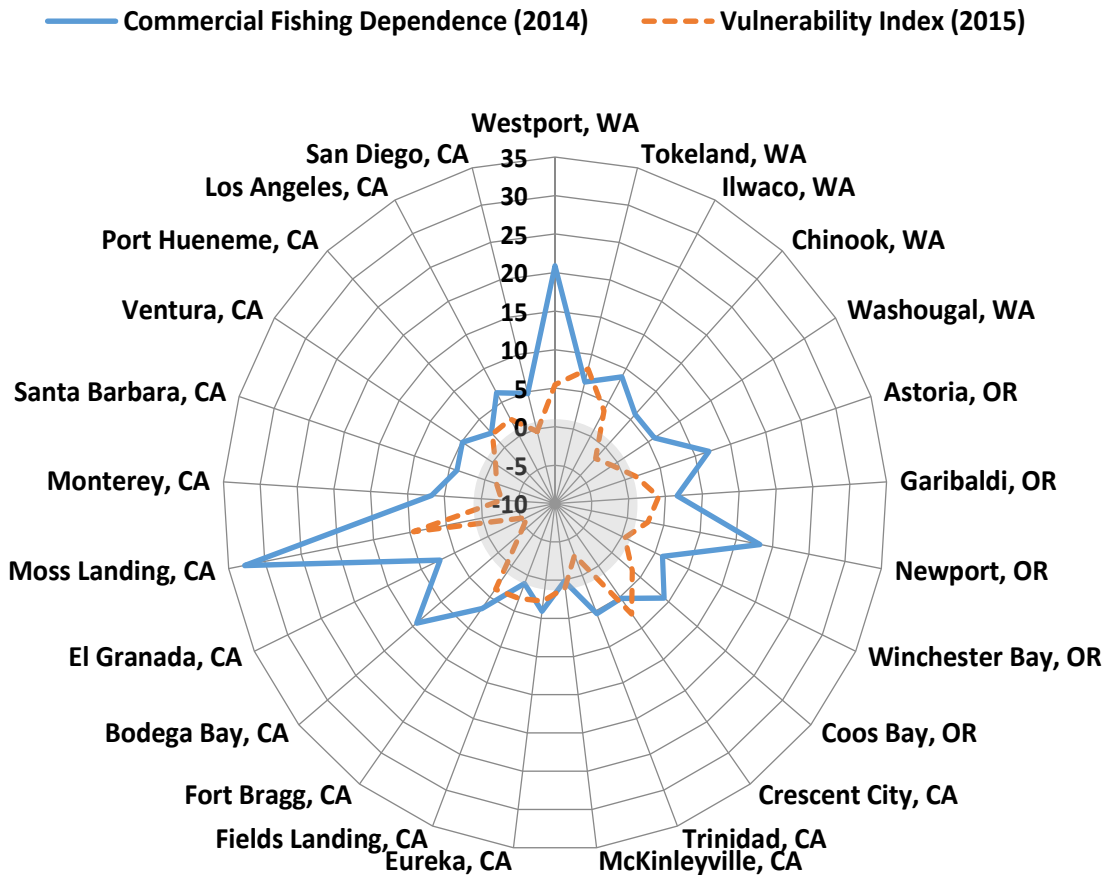4. *Human Wellbeing*
5. **Synthesis and Research Recommendations**

Research Recommendations

At the request of the PFMC Ecosystem Work Group, we developed research recommendations, many aimed at improving the power of our indicators to provide more management-ready products in the face of this uncertainty

1. *Continue the ongoing scoping process between the Council and CCIEA team*

2. *Continue making improvements to indicator analyses (FEP Initiative 2)*
   - Refining present indicators and presentation
   - Address and close gaps
   - Better indicator analyses: spatial/habitat-based analyses, modeled trends, identifying risk thresholds, early warning indexes

3. *Assess adaptations to short-term climate variability*
   - Productivity and distribution of key species (sablefish; salmon & crab; other priority species)
   - Integrated models of fishery participation choices under variable climate conditions across multiple, interacting fisheries

Sea stacks, Olympic Peninsula (NOAA)

Research Recommendations, continued

4. *Assess adaptability of fishing communities to long-term climate change*
   - Estimate climate change vulnerability of different fishery communities at sea
   - Set up panels of managers, stakeholders and scientists to analyze information and develop adaptation strategies

5. *Develop "dynamic ocean management" tools to reduce bycatch*
   - Develop bycatch risk profiles for CA drift gillnet fishery
   - Track spatiotemporal changes in risk, linked to short-term variability in ocean conditions under different mgmt alternatives

6. *Assess ecological and economic impacts of ocean acidification*
   - Drive assessment with Atlantis ecosystem model (reviewed by Council in 2015)
   - Use future climate model scenarios to estimate OA impacts on FMPs, regions, ports

Sea stacks, Olympic Peninsula (NOAA)

Synthesis

- **Climate and oceanographic indicators suggest that the climate "stress test" is over and we are returning to neutral physical conditions**

- **Species responses will lag behind the physics, from months to years; the unprecedented warm conditions of 2013-2016 leave us with considerable uncertainty as to what those responses will be**

    - Salmon indicators are discouraging for this year (at broad scale)
    - Signs of rebounds in anchovy; no such signs for sardine
    - Will copepods, krill, squid rebound?
    - Will the large numbers of juvenile rockfish become recruits in a few years?

- **People will respond as well, through choices on fishery participation and other activities; still a lot of uncertainty there too**

Sea stacks, Olympic Peninsula (NOAA)

Questions and Discussion

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Aerial view of Drake's Bay,
Point Reyes Peninsula
(Brian Cluer, NOAA)