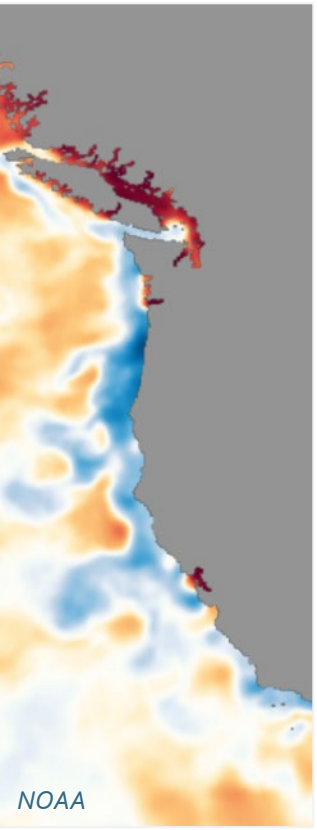
Environmental indicators used in the NOAA California Current Integrated Ecosystem Assessment (CCIEA)



Chris Harvey

NOAA Fisheries, Northwest Fisheries Science Center

Outline

Background

Some indicator examples

Online indicator data and tools

Some applications

A little background on IEAs and indicator selection

CCIEA indicator reporting

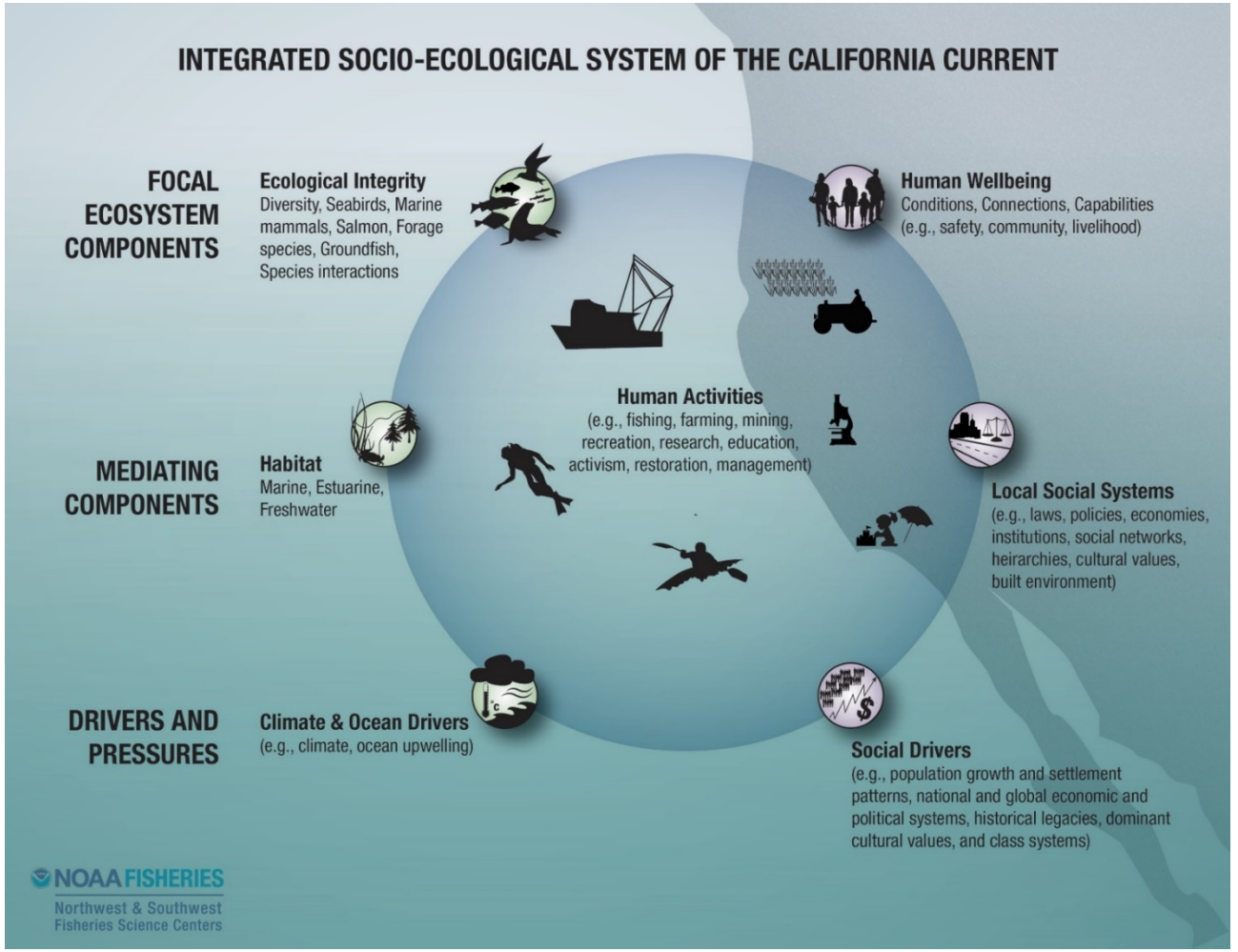
The CCIEA team compiles dozens of indicators into annual ecosystem status reports and tech memos

- *Main customers: PFMC & NMFS West Coast Region*
- *Their main request: general context*

We also maintain an online indicator data portal

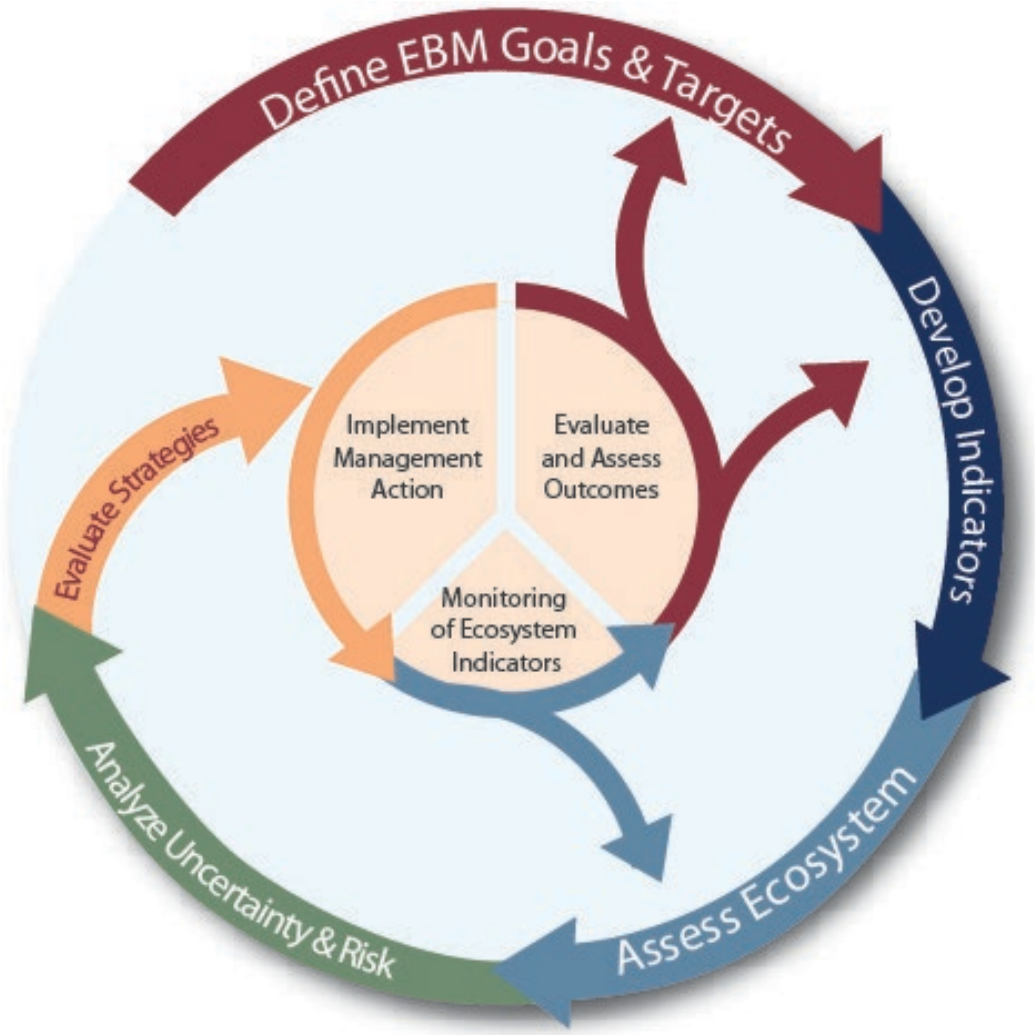
Our indicator suite includes climate, oceanographic, ecological, economic and social indicators

- *Many of them are contextualized for salmon*



From Levin et al. 2016, Coastal Management 44:397-408

The NOAA Integrated Ecosystem Assessment (IEA) Framework



In other words:

What is our goal for the ecosystem?

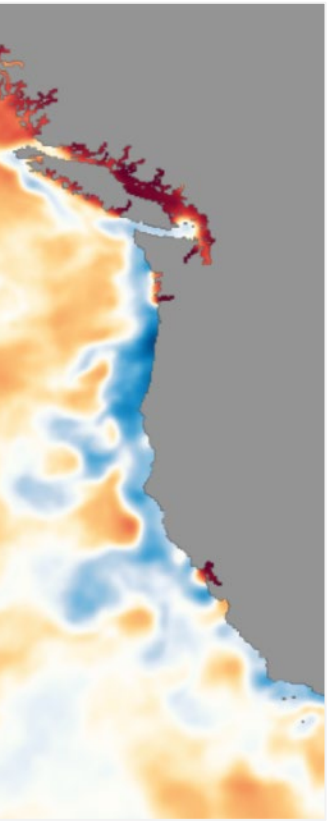
What is the status of the ecosystem now?

What pressures, risks and unknowns are between us and our goal?

What do we do about it?

(Then, continuously revisit and repeat)

For this to work, good indicators are really important.

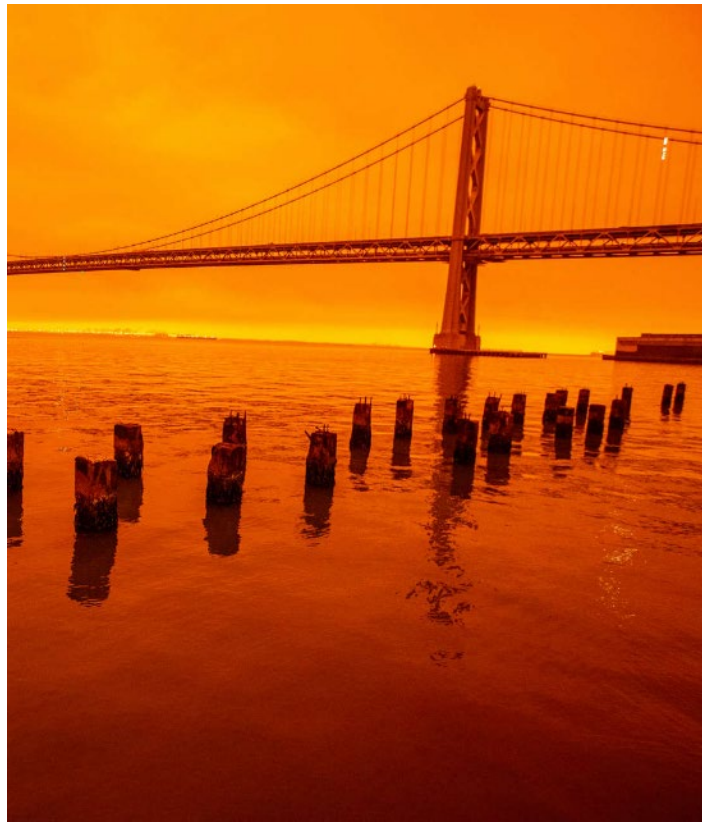


Physical Conditions

Large scale climate/ocean conditions

Regional ocean conditions

Streamflow and snowpack



Basin-scale climate and ocean indicators

Time series like these help us track large-scale variability in seasonal, annual and decadal conditions in the North Pacific

Oceanic Niño Index (ONI)

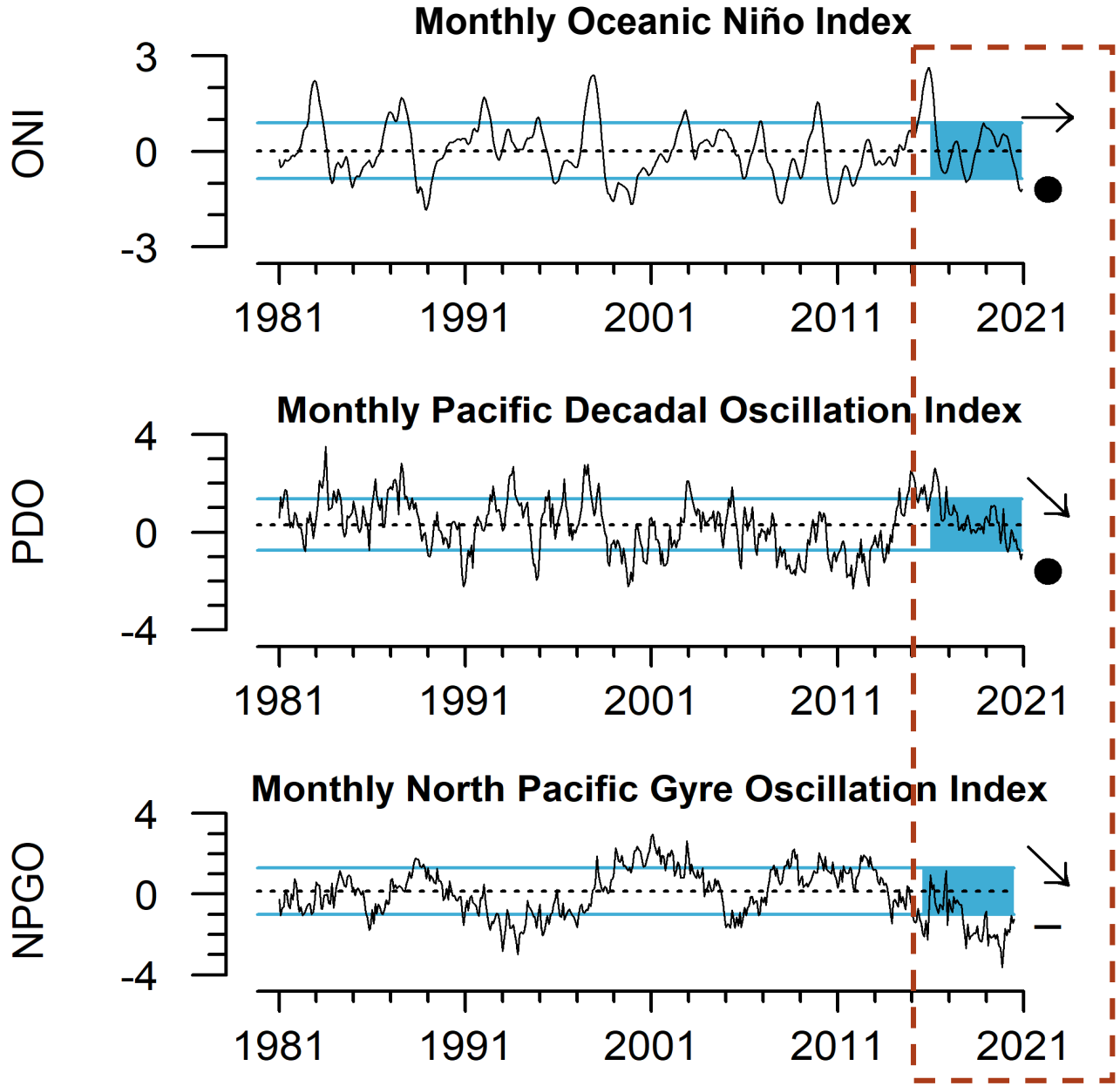
- Positive → El Niño, Negative → La Niña

Pacific Decadal Oscillation (PDO)

- Positive → warm along our coast; Negative → cool

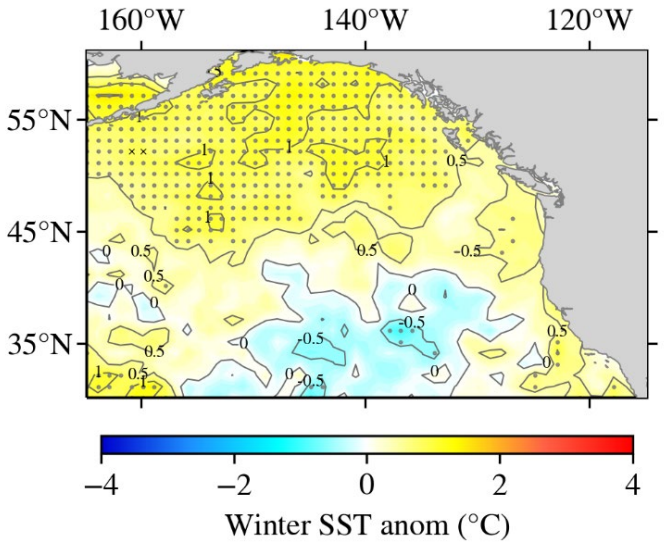
North Pacific Gyre Oscillation (NPGO)

- Positive → more water from NPG entering California Current; Negative → less

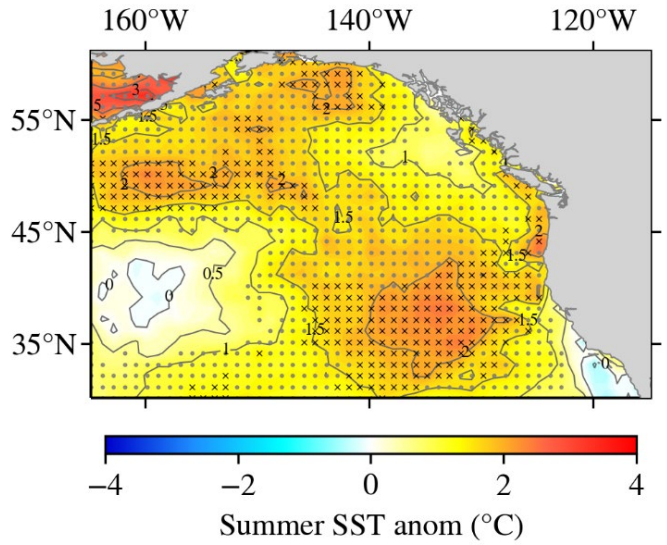


Basin-scale climate and ocean indicators

Winter (Jan-Mar 2019)

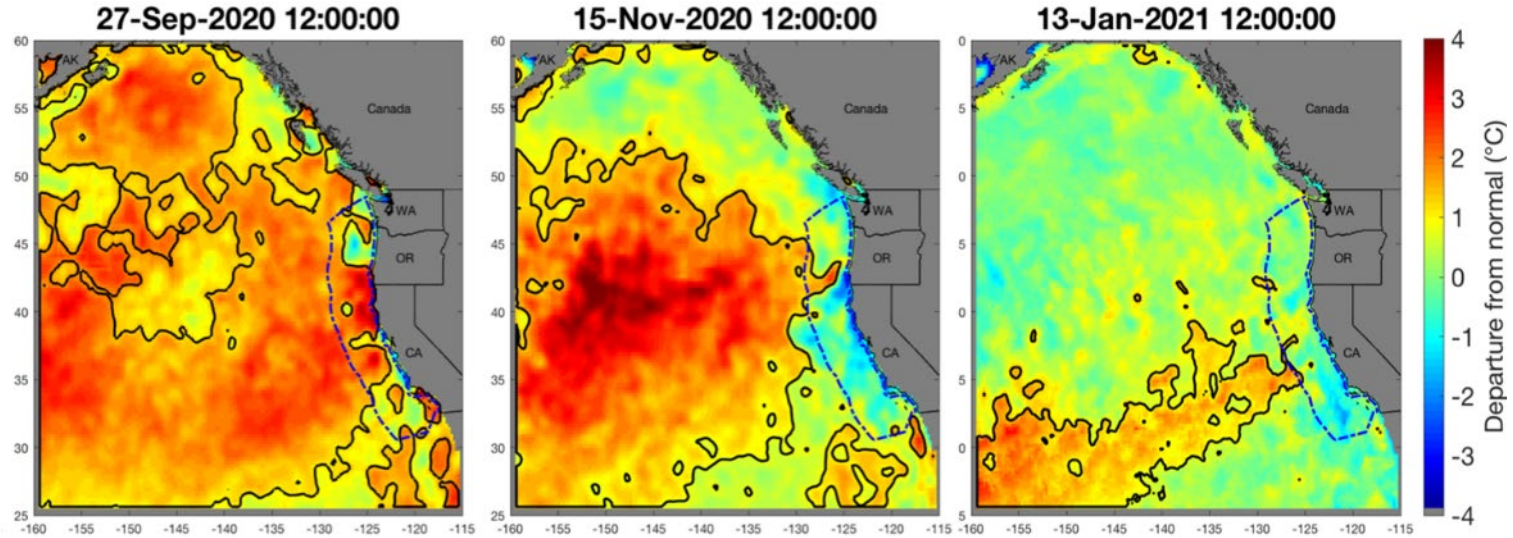


Summer (Jul-Sept 2019)



Satellite-derived sea surface temperatures, expressed as deviations ("anomalies") from the long-term average for a given location

Allows us to ask: where are hot/cool spots? Is this year warmer or colder than average? Are trends going up or down?

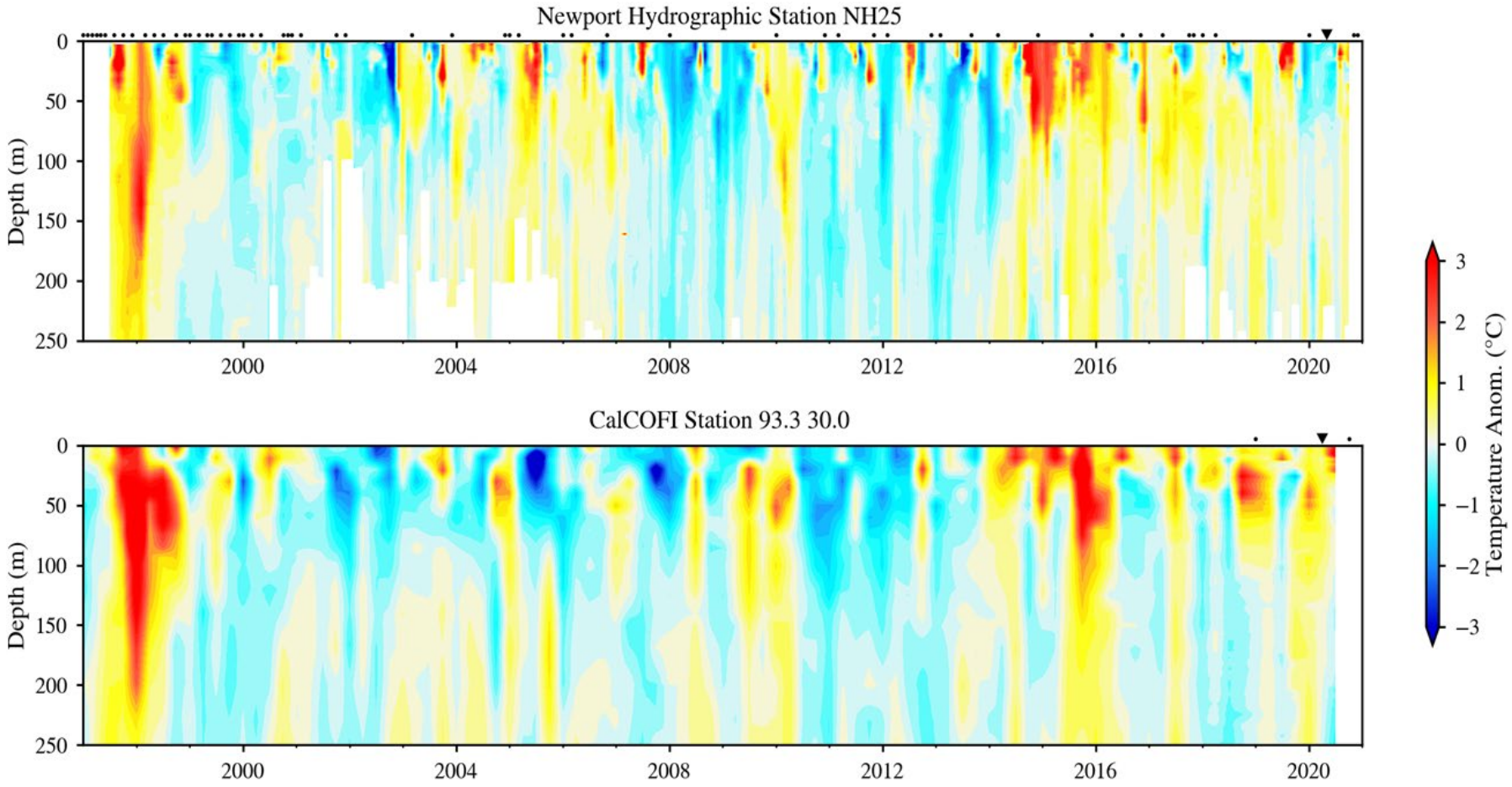


Also allows us to track the evolution of influential climate events, like marine heatwaves

Subsurface conditions

Temperature anomalies at depth from discrete points (here: off Newport, OR and San Diego)

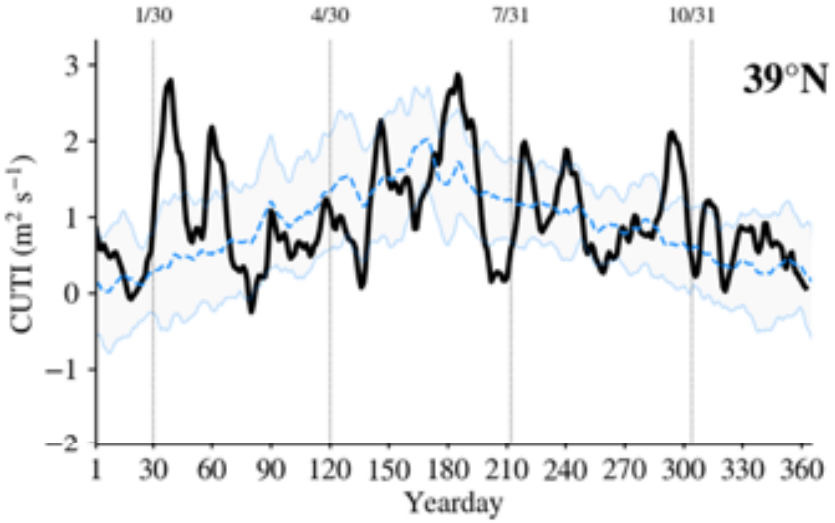
- Allows us to see how far into the water column different climate events are penetrating
- Ship-based data increasingly being replaced by autonomous samplers (“gliders”) operated by NOAA and academic partners

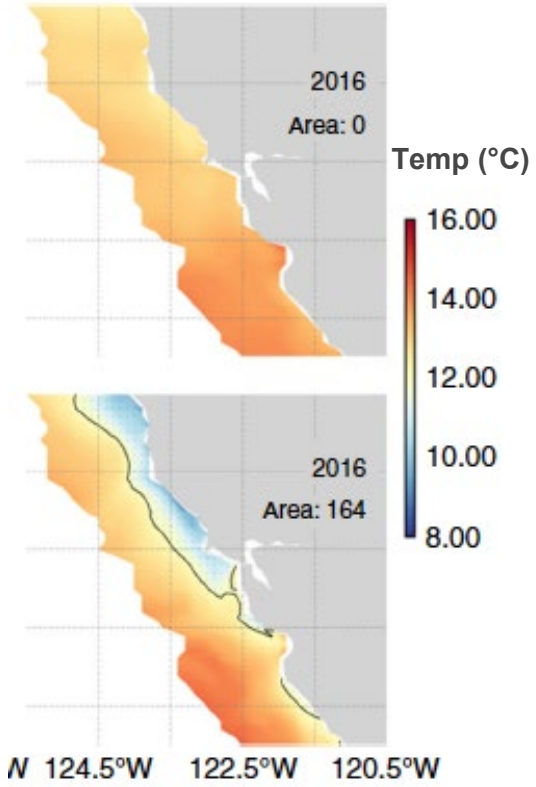


Upwelling and “habitat compression”

Circulation models estimate daily flux of upwelled water at points along the coast (Coastal Upwelling Transport Index, “CUTI”)

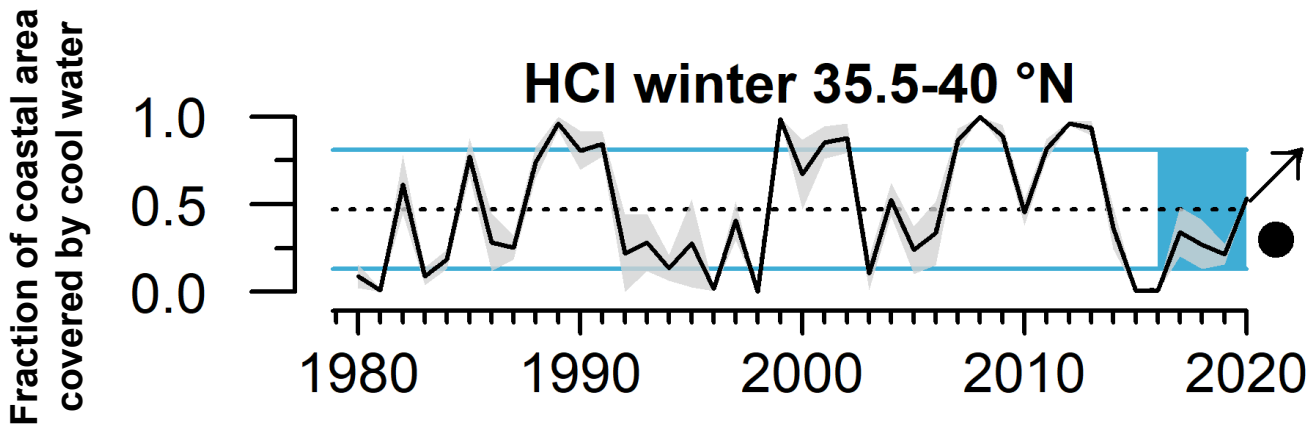
- *A related index, “BEUTI,” estimates the amount of nutrients supplied by the upwelling*
- *Jacox et al. 2018, JGR Oceans*





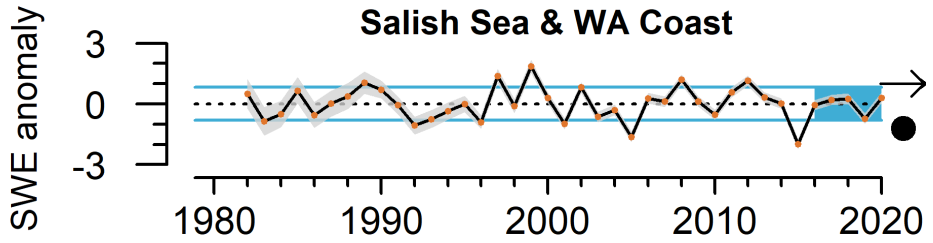
The same modeling framework can also estimate how “compressed” cool upwelled waters are against the coast

- *Food web, fisheries, bycatch effects; Santora et al. 2020 Nature Communications*

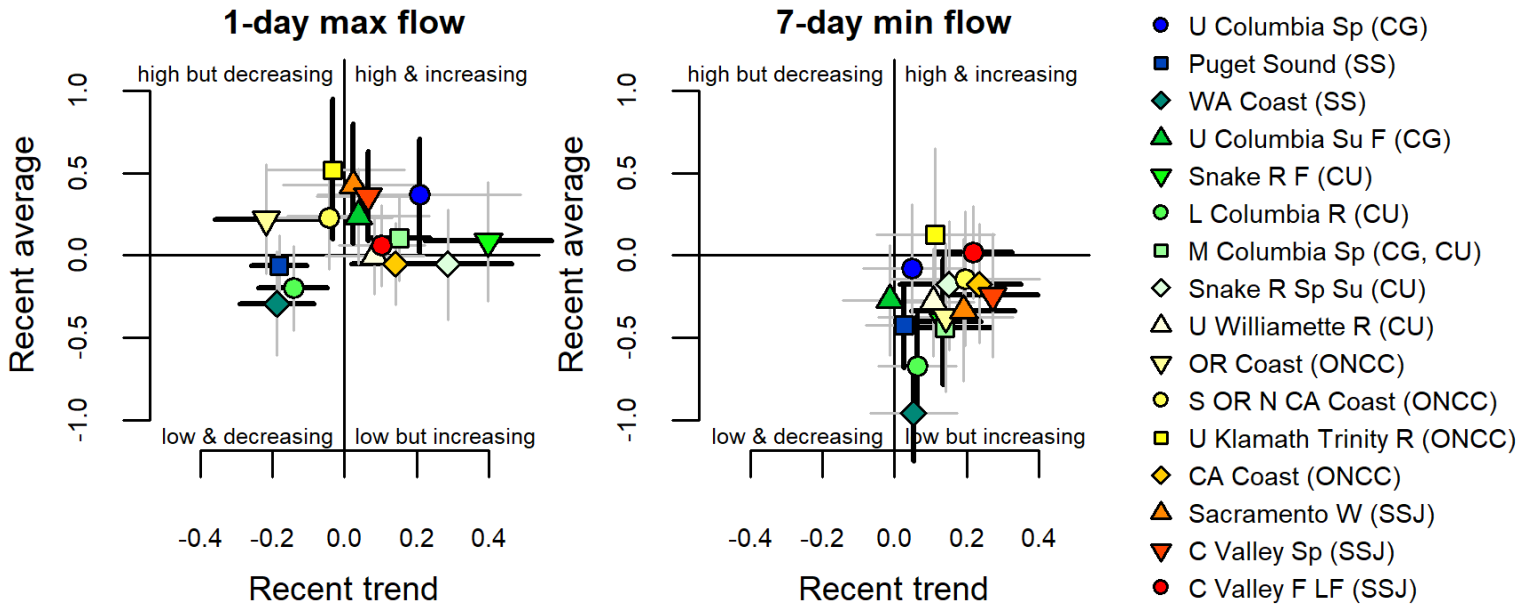


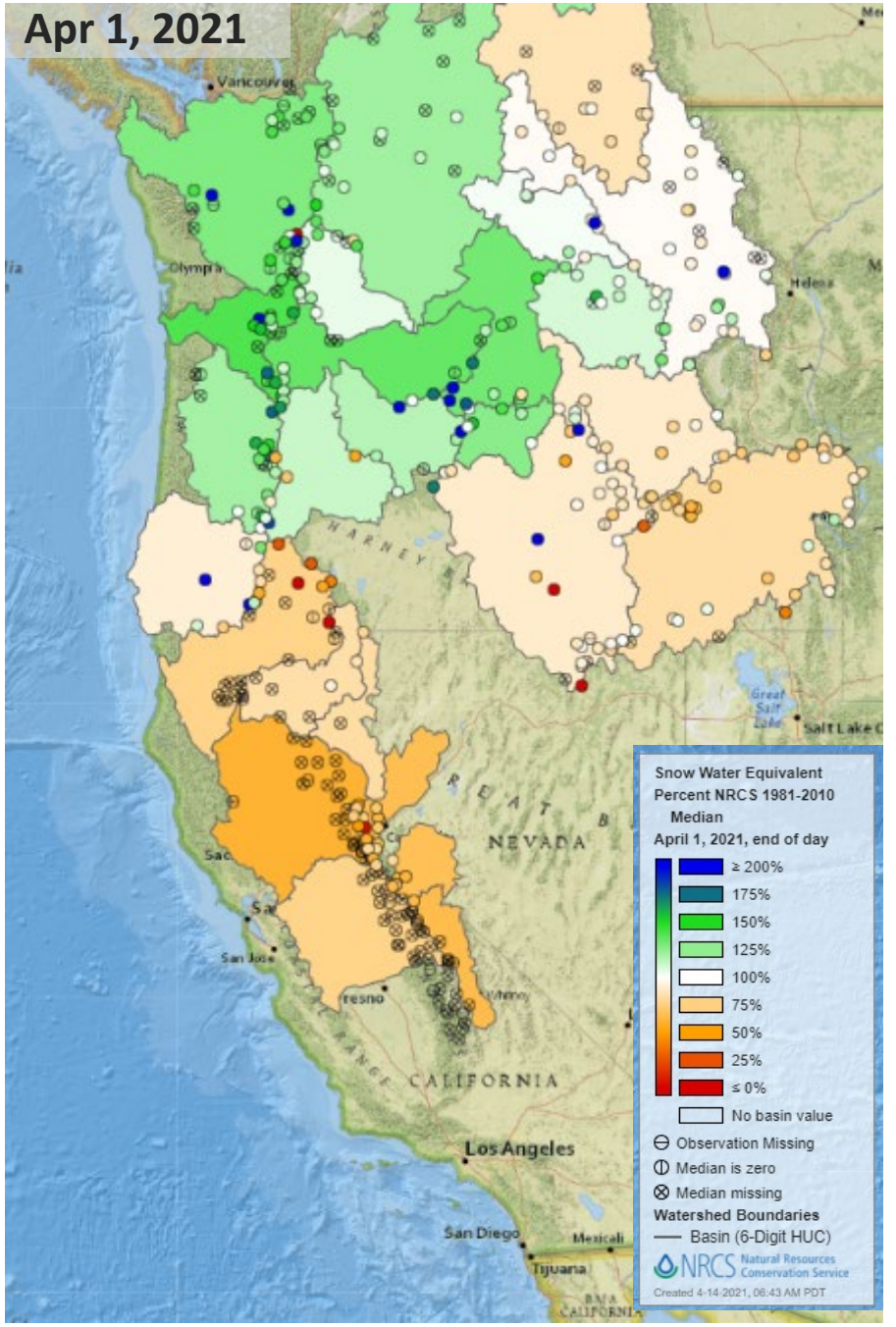
Snowpack and streamflows, summarized by ecoregions and salmon ESUs

Snow data from USDA National Water and Climate Center, summarized in both maps and time series



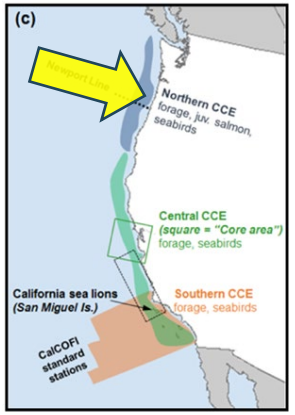
USGS streamflow data, in ESU-specific time series and "quad plots"



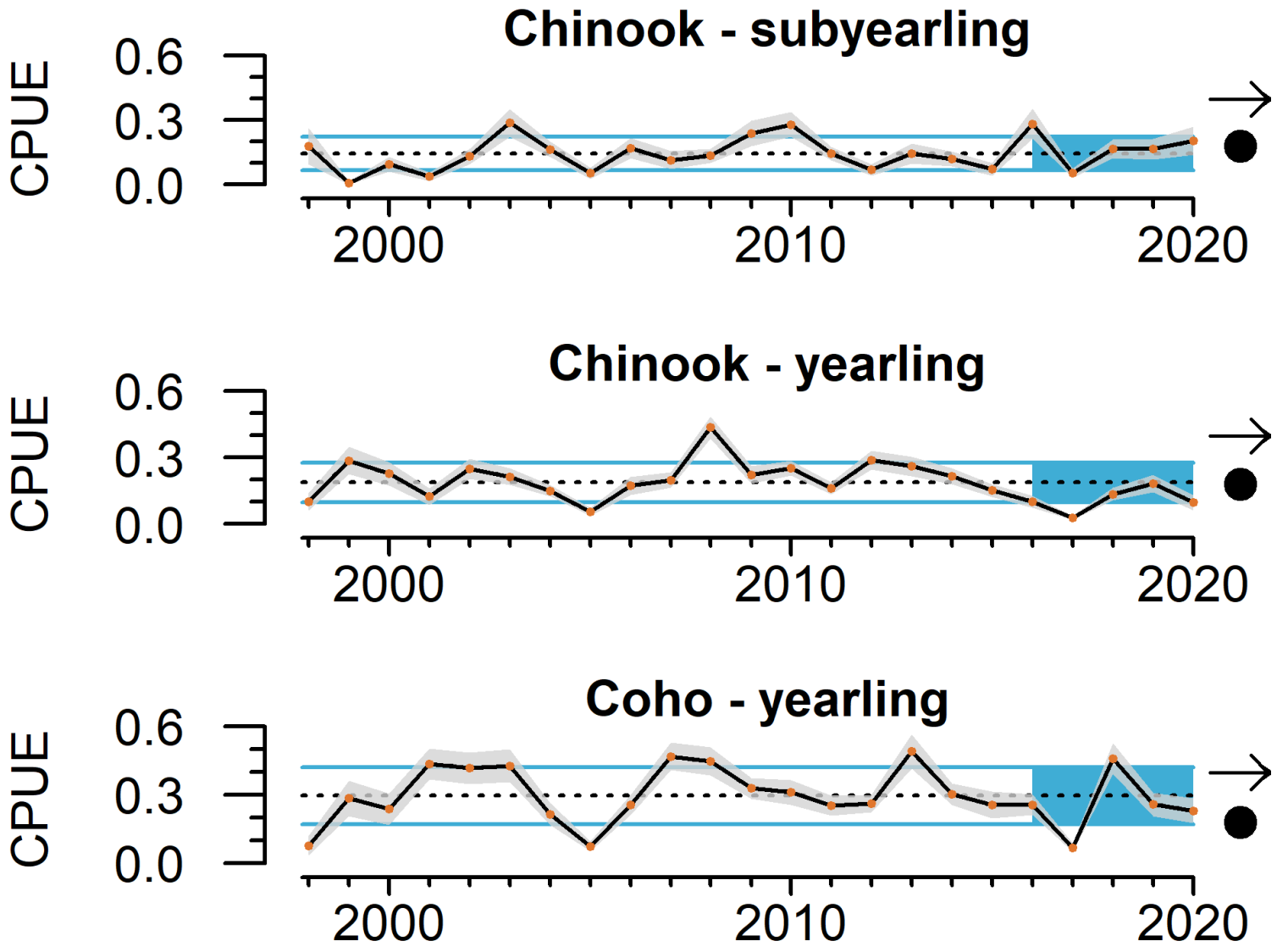


Ecological conditions and responses

Species abundances
Feeding conditions
Species distributions
Diets



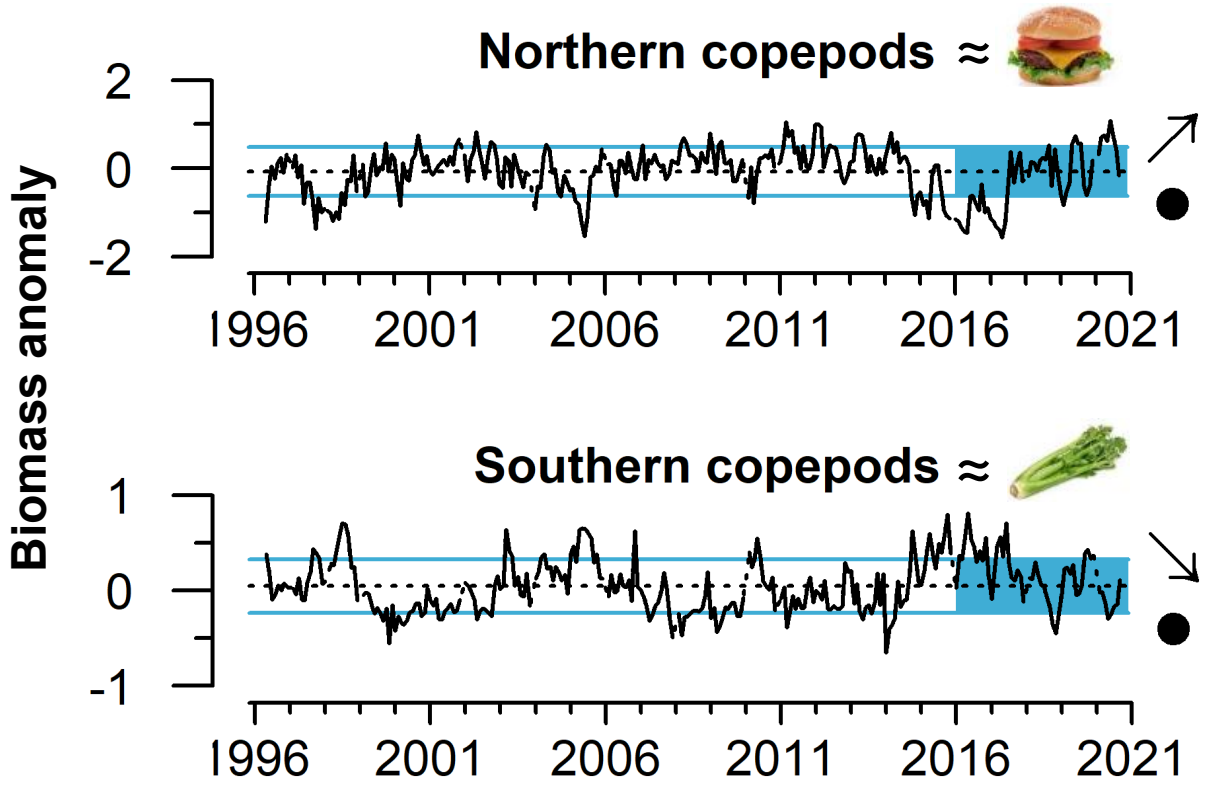
Juvenile salmon catches off WA, OR



Zooplankton off of Oregon

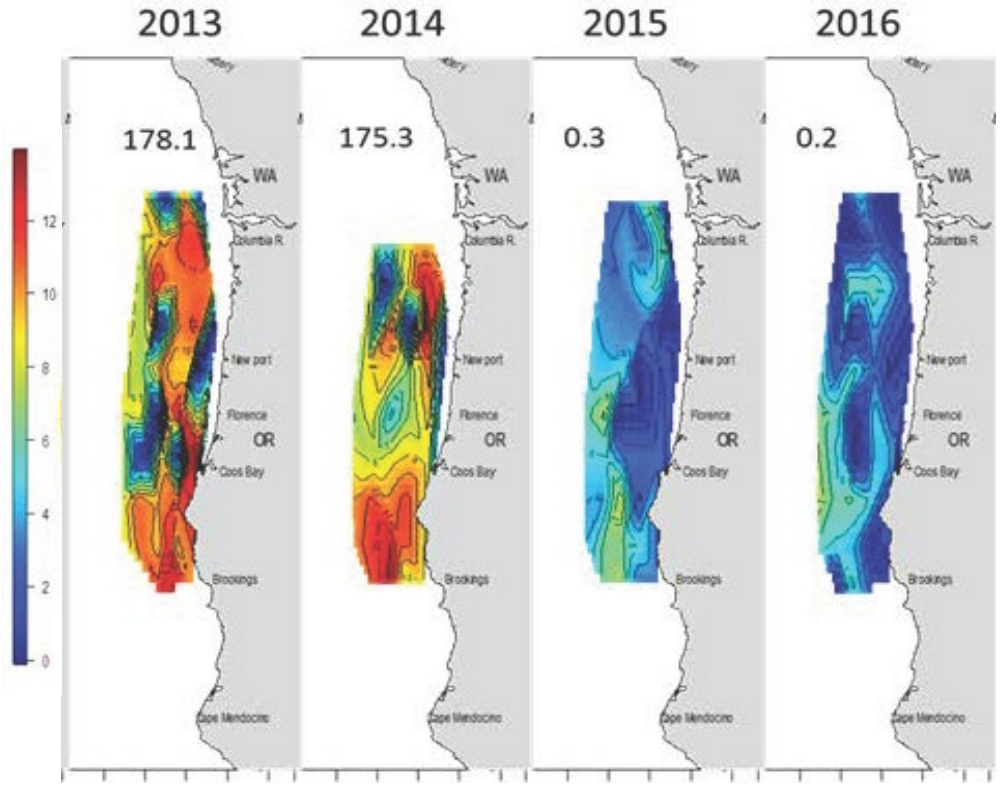
Newport Hydrographic Line:

Energy-rich northern copepods vs.
southern copepods with lower lipid content

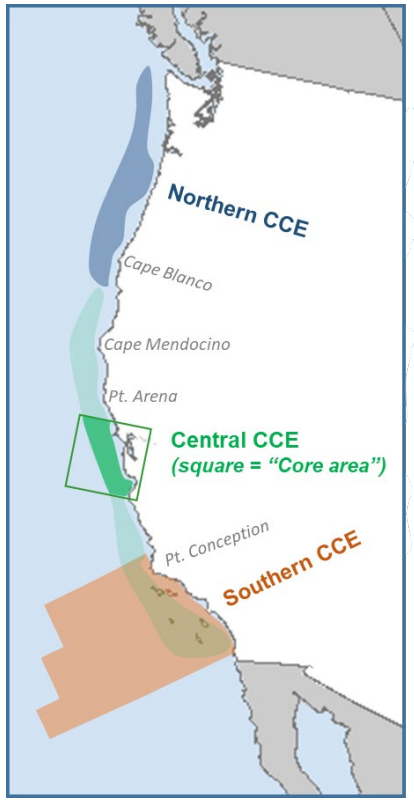


Pelagic community surveys off Oregon:

Variation in density of krill by location and by year

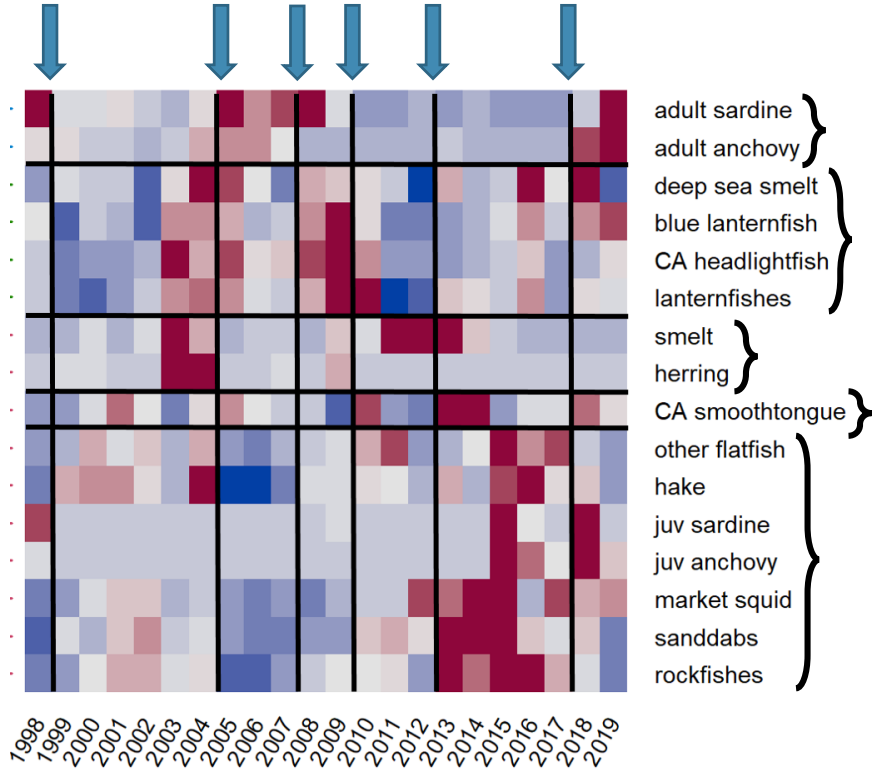


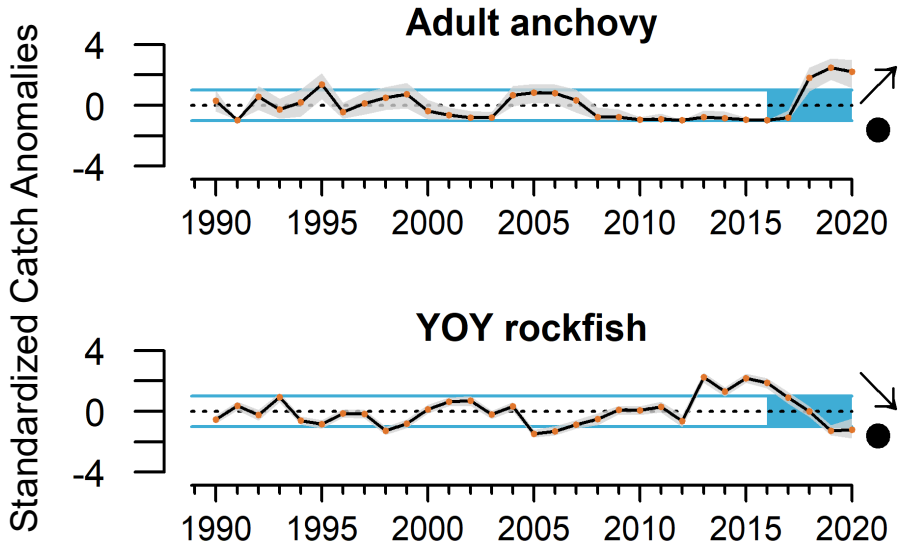
Regional “forage communities”



3 regions, 3 totally different types of survey… makes analysis and comparison difficult

Catch anomalies from “Core area” of the Central forage survey





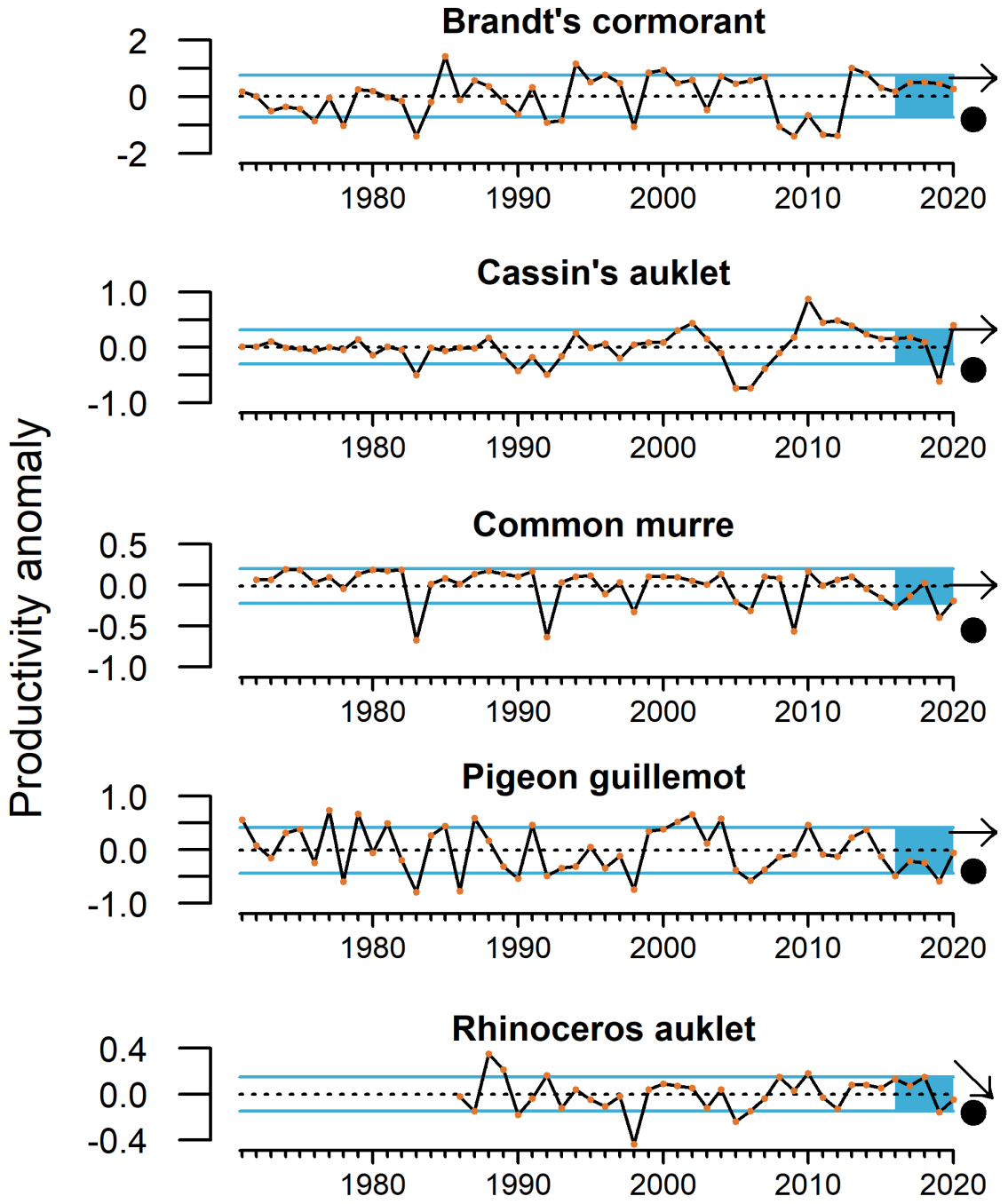
Cluster analysis of catch anomalies from “Core area” of the Central forage survey

Seabird fledglings and mass mortalities

Fledgling production for seabirds at the SE Farallon Island colony

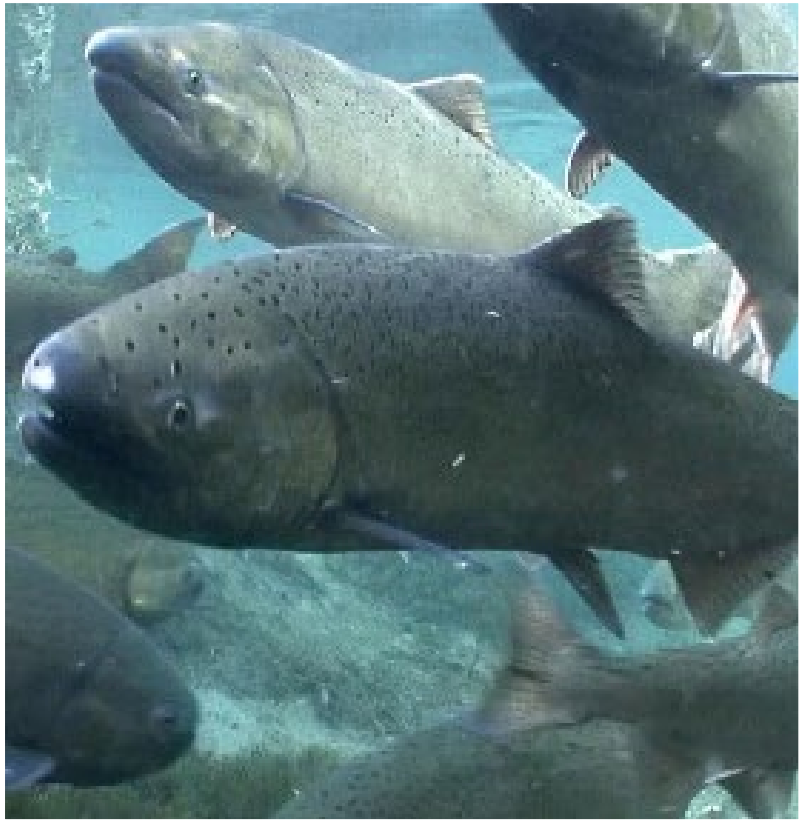
- Indicates delivery of prey to nests
- Planktivores (Cassin's auklets) and piscivores (cormorants, murres, guillemots, rhinoceros auklets)

Citizen science groups also monitor for mass mortalities ("wrecks") on West Coast beaches

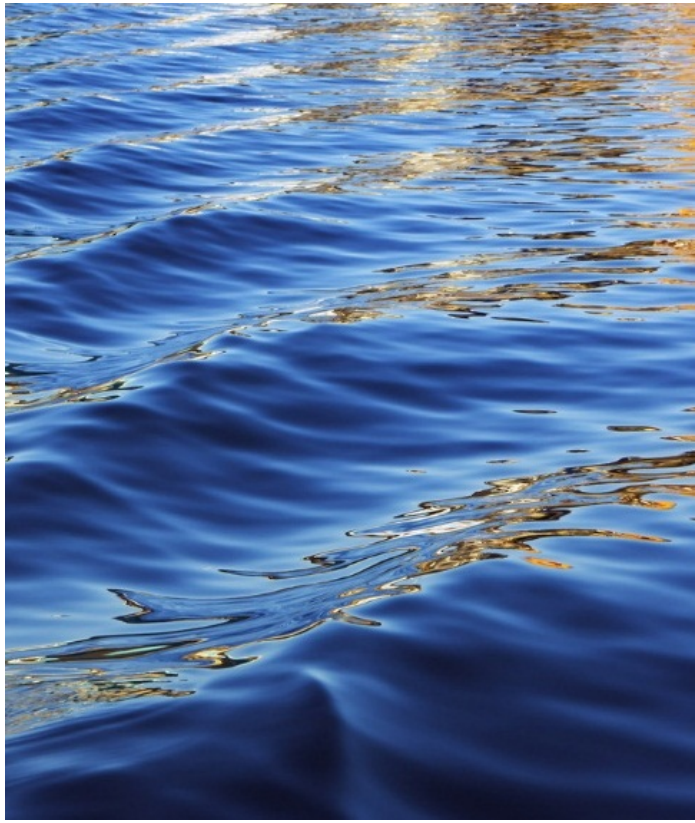


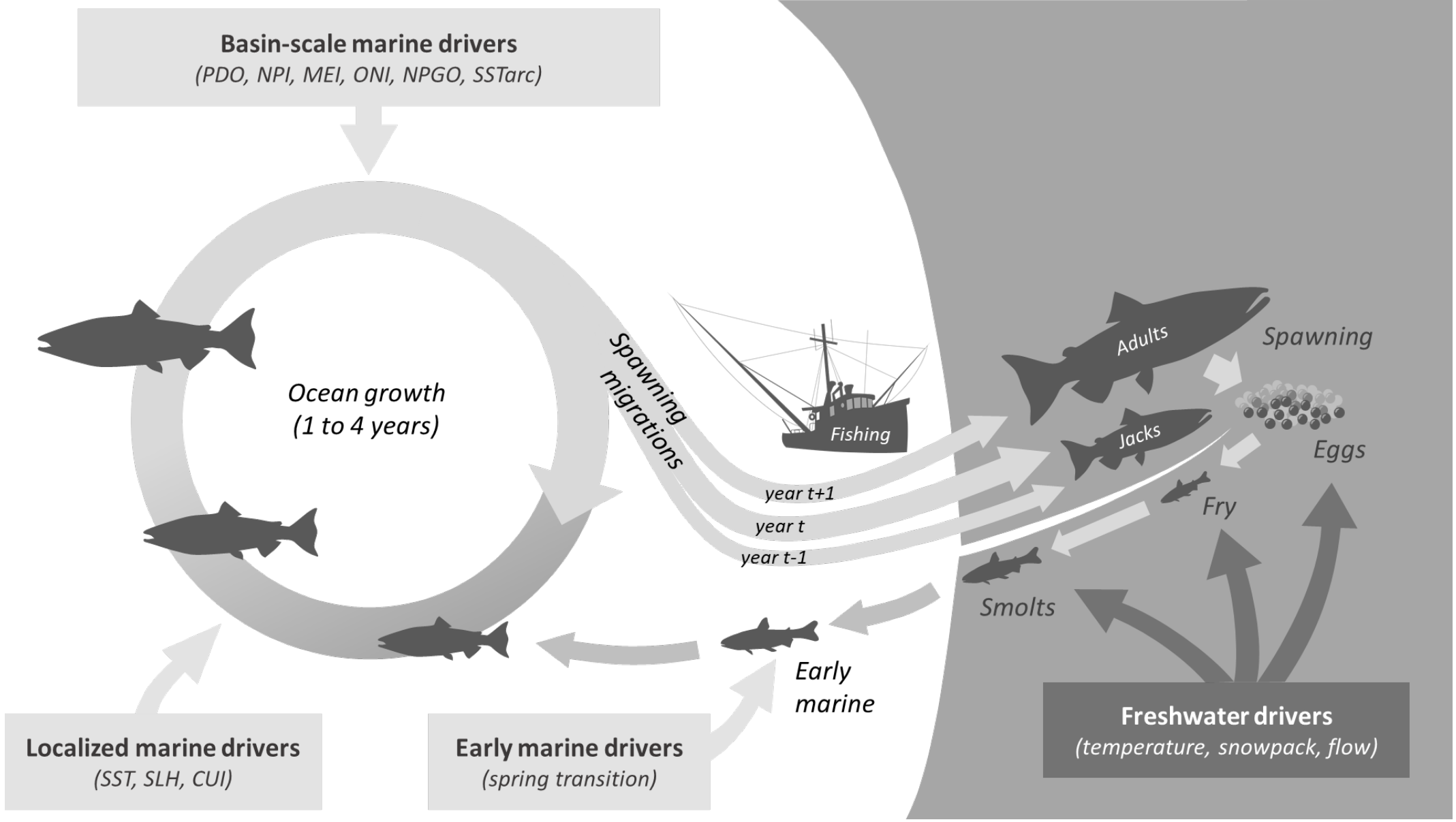
The CCIEA online indicator portal

https://www.integratedecosystemassessment.noaa.gov/regions/california-current



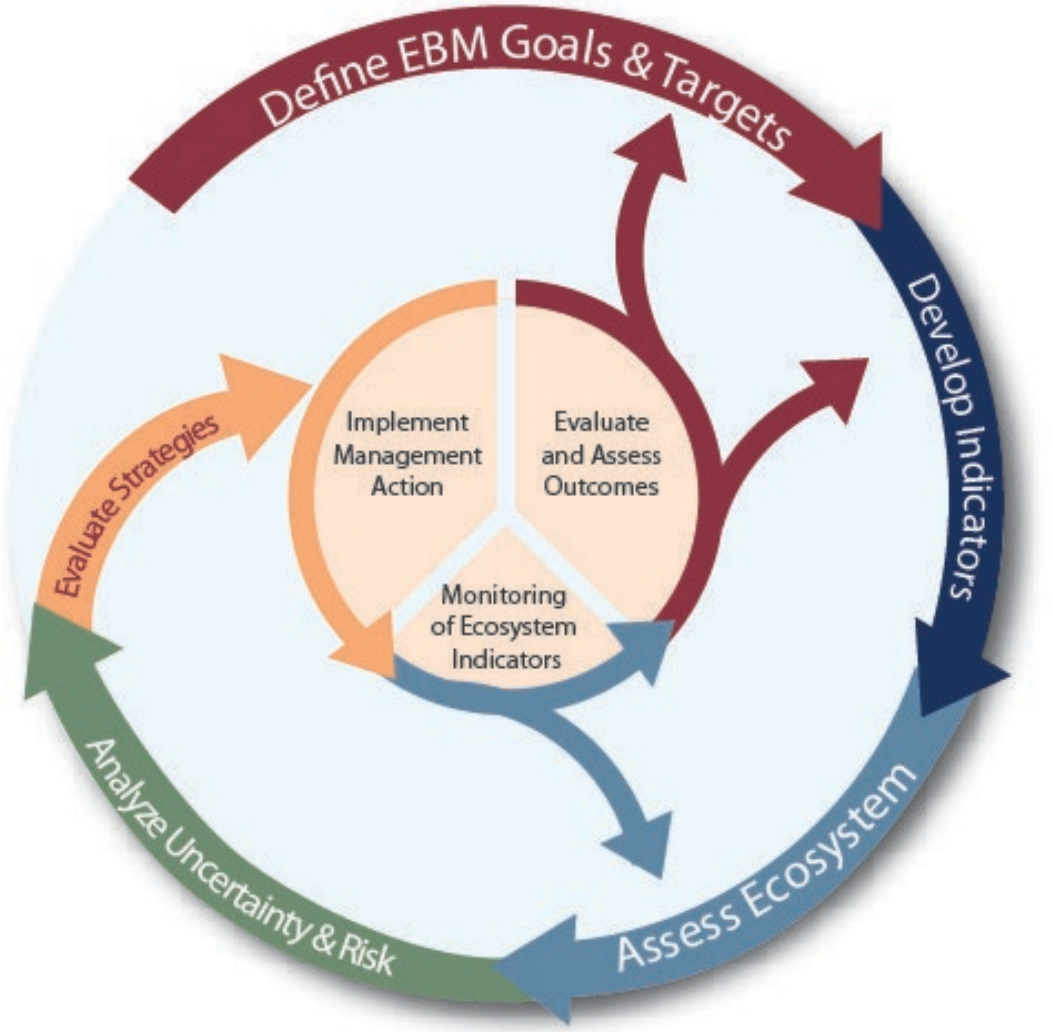
So, what do we do with all of these indicators?





From Satterthwaite et al. 2020, ICES Journal of Marine Science

The NOAA Integrated Ecosystem Assessment (IEA) Framework



In other words:

What is our goal for the ecosystem?

What is the status of the ecosystem now?

What pressures, risks and unknowns are between us and our goal?

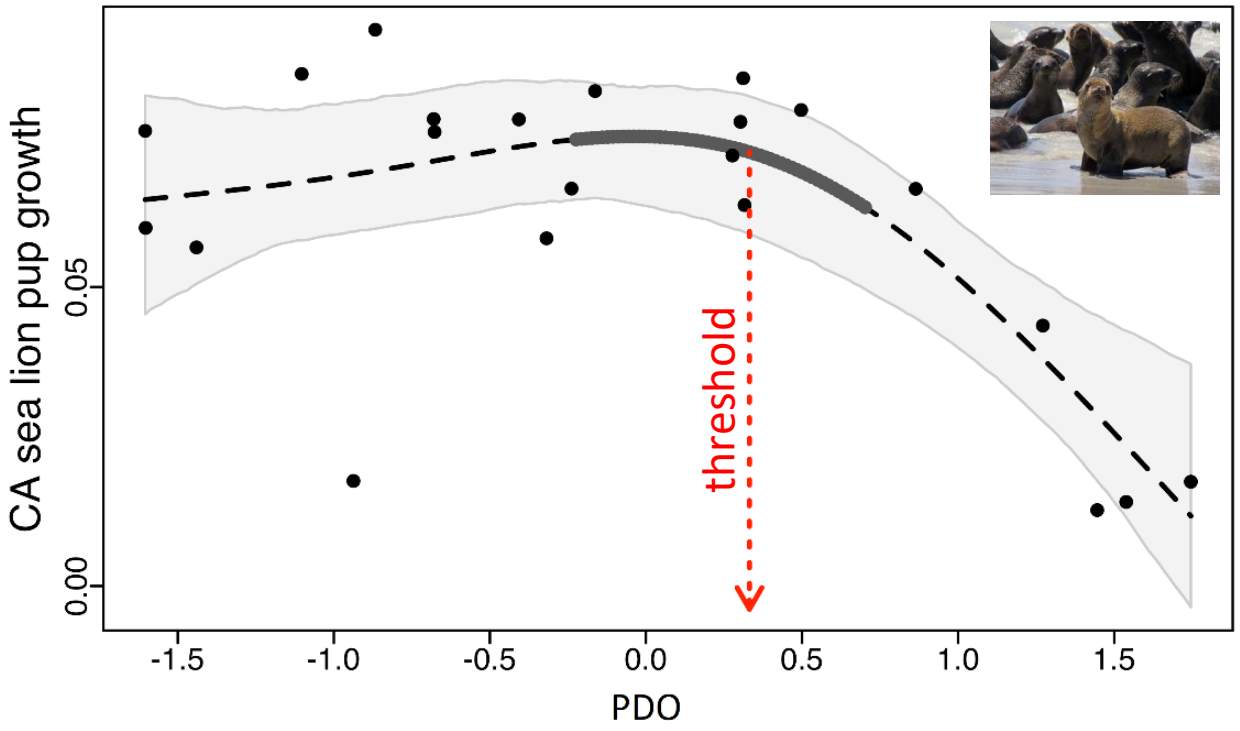
What do we do about it?

(Then, continuously revisit and repeat)

Stressor / response “thresholds” may indicate risk in ecological or management domains

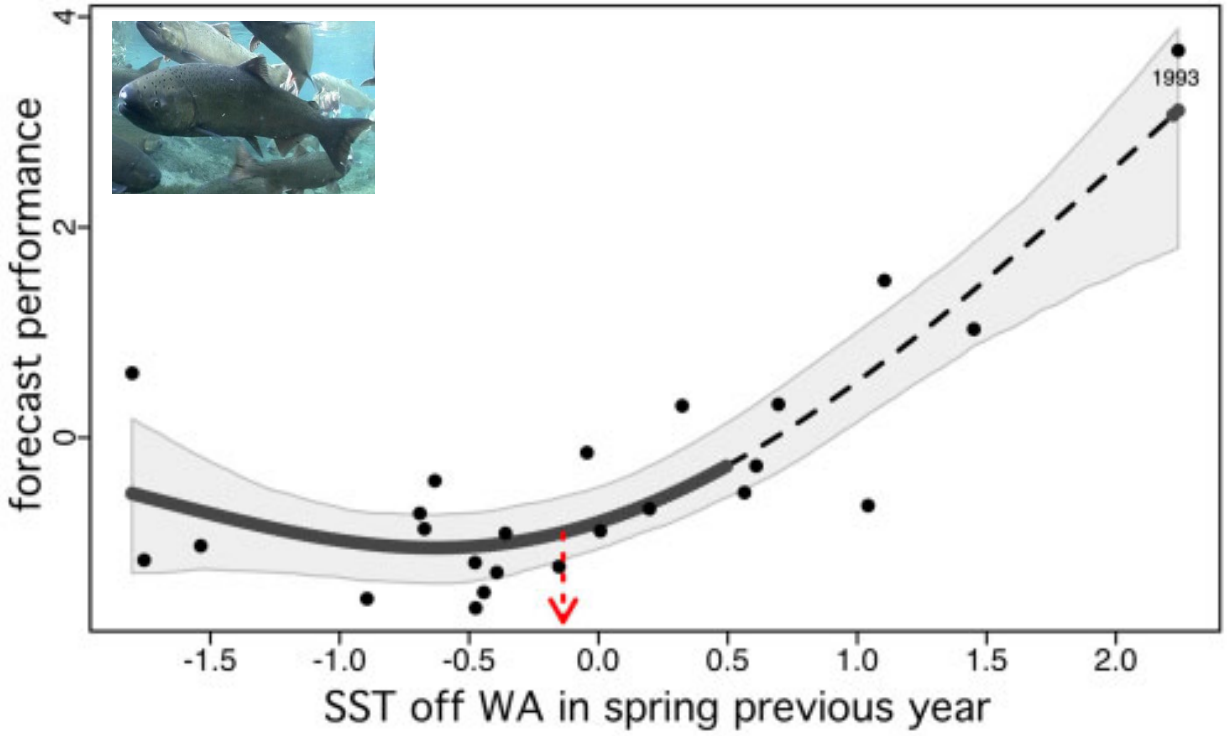
Growth and condition of California sea lion pups at San Miguel Island drops steeply when PDO > 0.4

(See Samhouri et al. 2017, Ecosphere)



Forecast models for South Puget Sound summer-fall Chinook tend to overpredict returns following a warm spring in the previous year

(See Satterthwaite et al. 2020, ICES JMS)



Closing thoughts

Lengthy and generally consistent time series are your friends

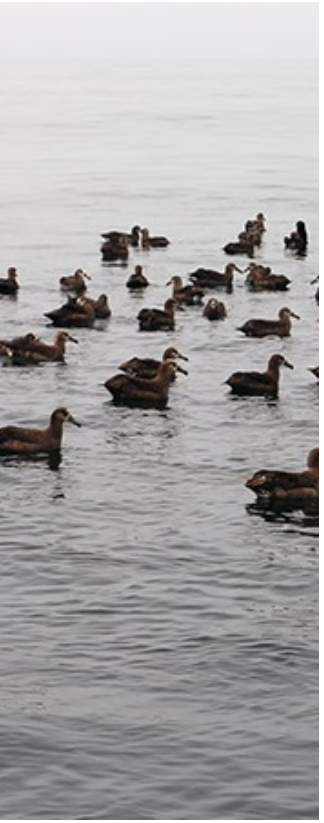
Modelers are also your friends

Know what your indicator is indicating, and revisit your assumptions from time to time

Suites of complementary indicators can really help you interpret complex ecosystem variability

CCIEA team has a pretty full plate, but we are interested in talking more with PSC about overlapping interests

- **AK IEA team may be as well!**



Thank you!

Chris.Harvey@noaa.gov

Acknowledgments

Toby Garfield, Greg Williams, Lynn Dewitt, Nick Tolimieri, Mary Hunsicker, & the NOAA California Current IEA Team

Pacific Fishery Management Council & advisory bodies

All of the survey teams and agencies that provided data

Matthew Savoca