



NOAA
FISHERIES

Time to expect the unexpected?

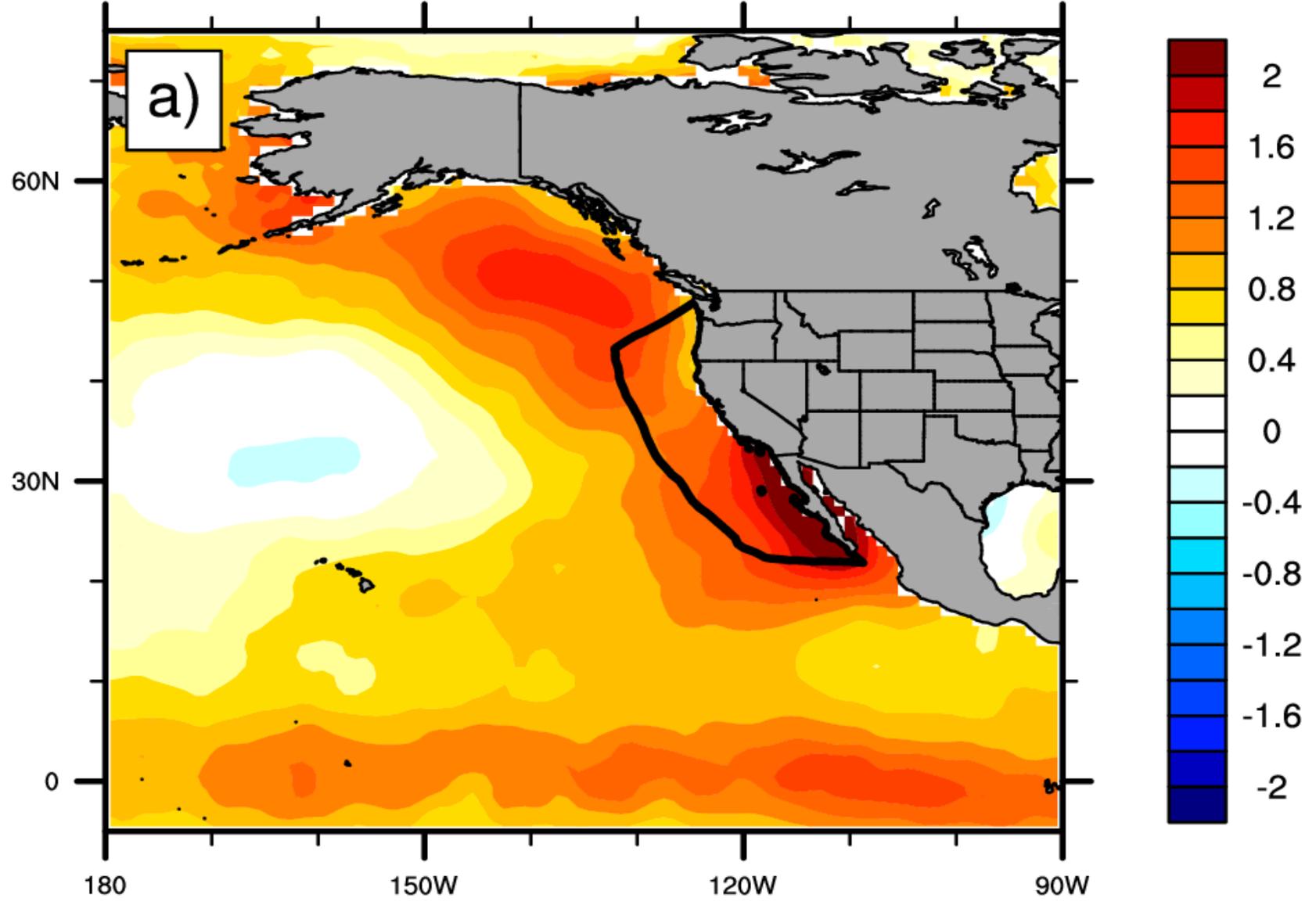
Nate Mantua

NOAA Southwest Fisheries Science Center

Fish Ecology Division

Santa Cruz, CA

Hadley SST Anom 2014-2016 (CCS boundary)



Record high SSTs in the California Current System from 2014 to 2016 were part of the broader NEP Large Marine Heatwave

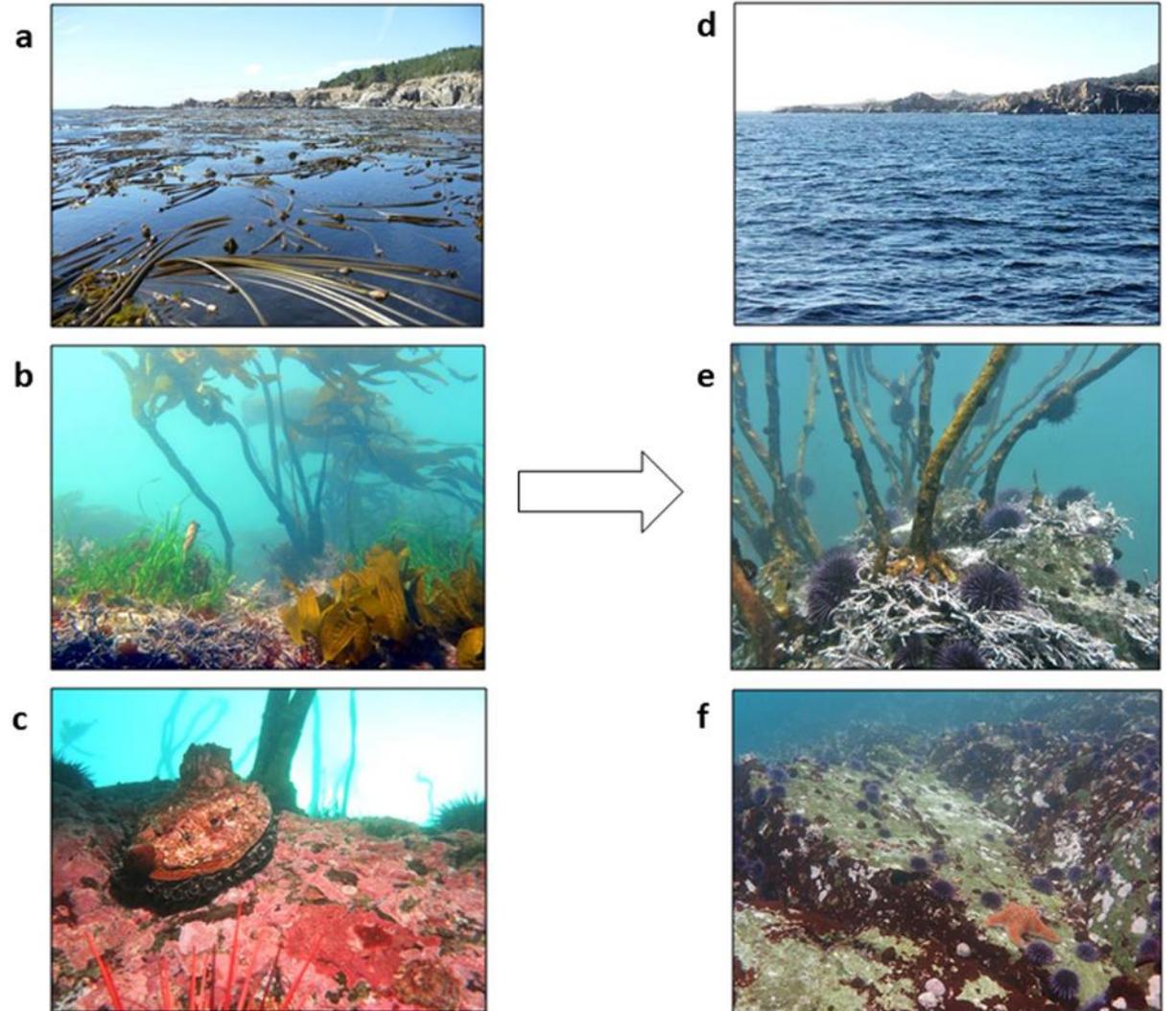
Jacox et al. (2018): Bull. Of the Am. Met. Soc.

Marine heat wave and multiple stressors tip bull kelp forest to sea urchin barrens

L. Rogers-Bennett* & C. A. Catton

2019: Sci. Rep. 9:15050

- Rapid climate-driven shift from in 2014 from a robust kelp forest to a large scale (purple) urchin barren in Northern California with Bull Kelp canopy loss > 90%
- Mass mortality of sea stars (2013-), ocean heat wave (2014-2017), urchin barrens (2015-)
- Collapse of the north coast red urchin fishery (2015 -) and sport abalone fishery (2018 -)



State of the California Current 2018-19

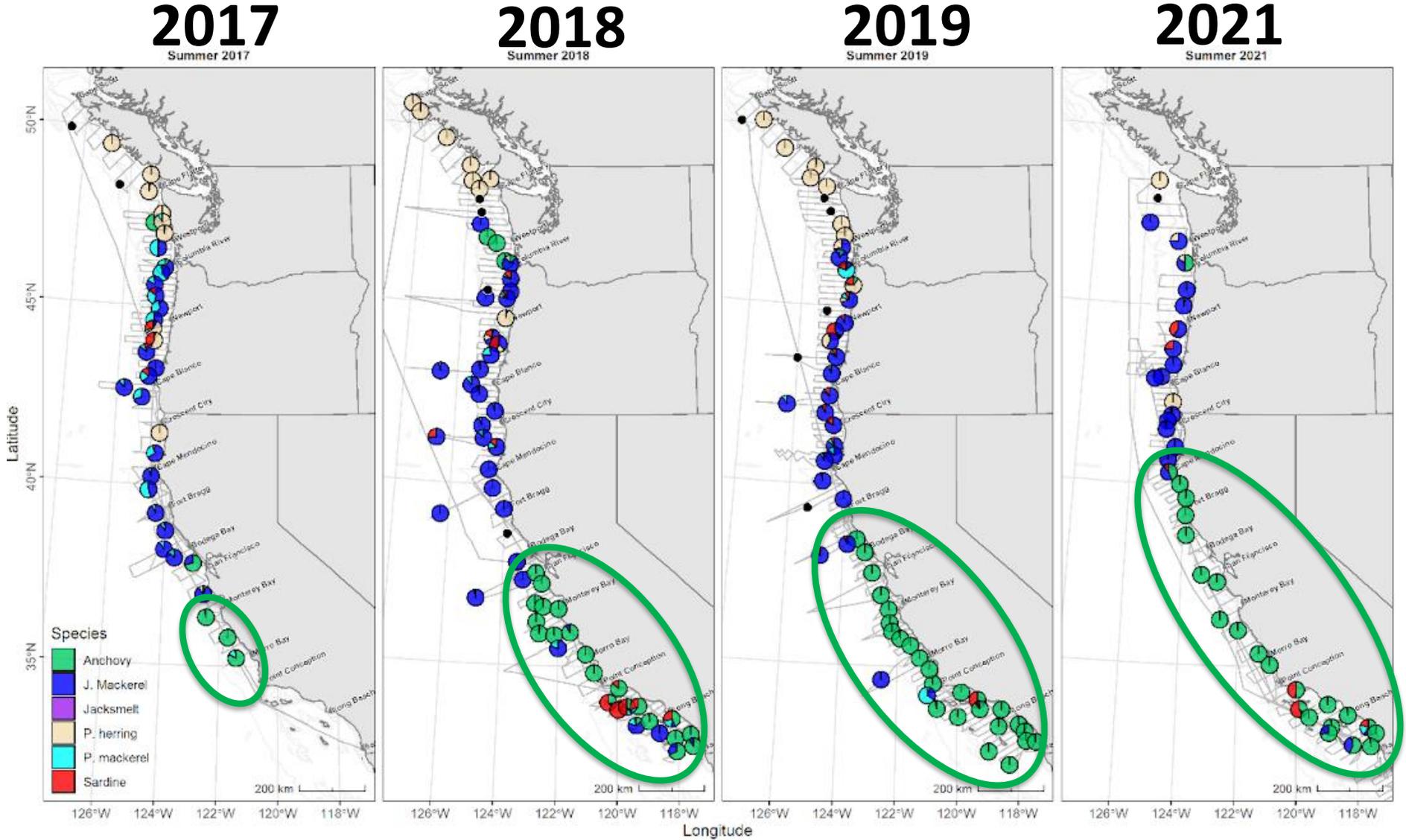
(Thompson et al. 2019, CalCOFI reports)

“In California, 2019 northern anchovy abundance from both larval and midwater surveys was the highest in recorded history while many common forage fish (e.g., juvenile rockfishes, sanddabs) and krill were very low.”



Central California
anchovy stock
biomass and north
end of their
distribution
expanded greatly
from 2017-2021
summer CPS trawl
surveys.

(NMFS Tech Memos)

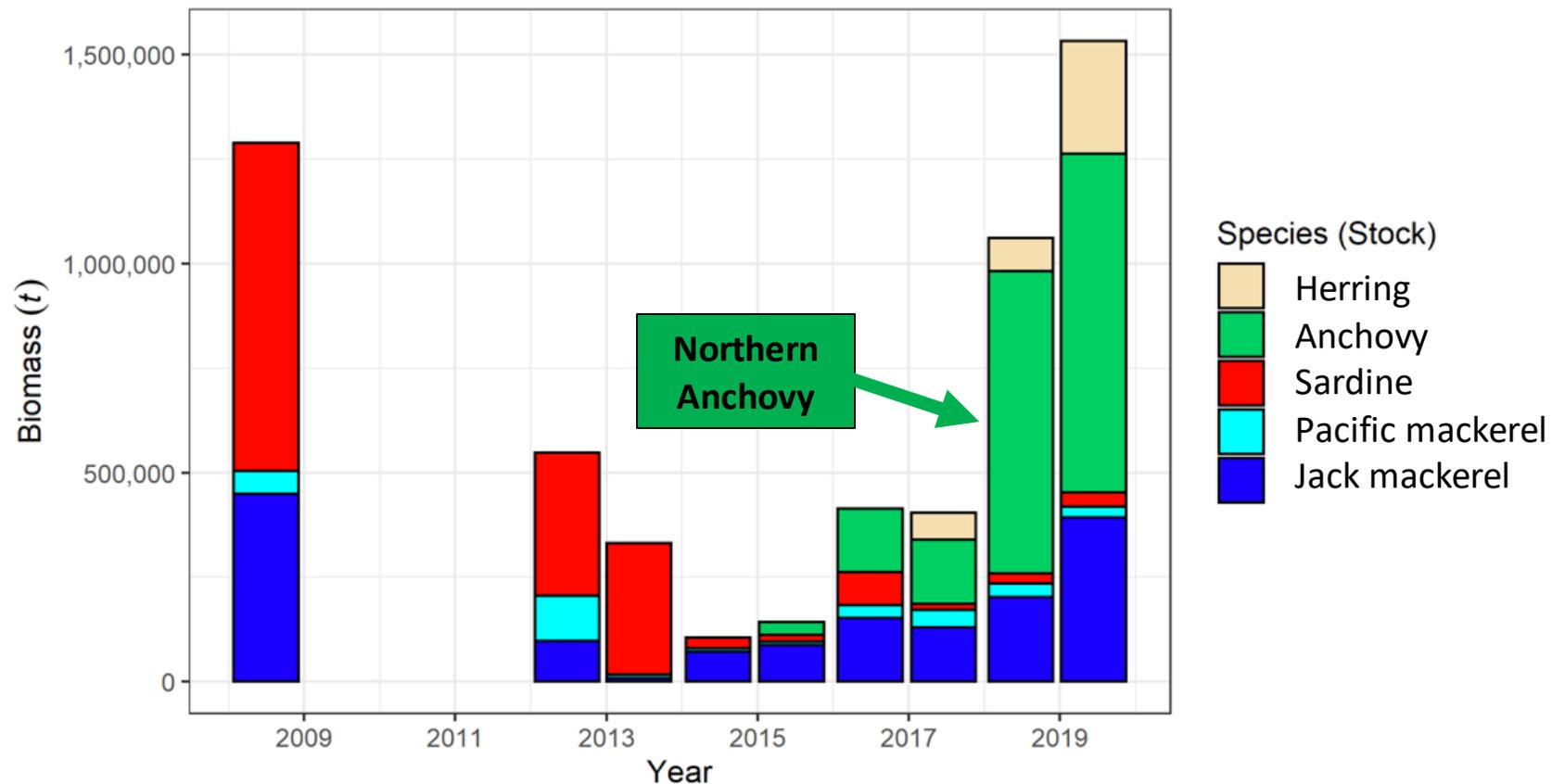


Acoustic Proportions by Cluster

Forage Fish biomass in the California Current in summer

Dominated by Pacific sardine prior to 2014, central stock of Northern Anchovy after 2015

Fig. 29 from Stieroff et al. 2020, NMFS Tech Memo

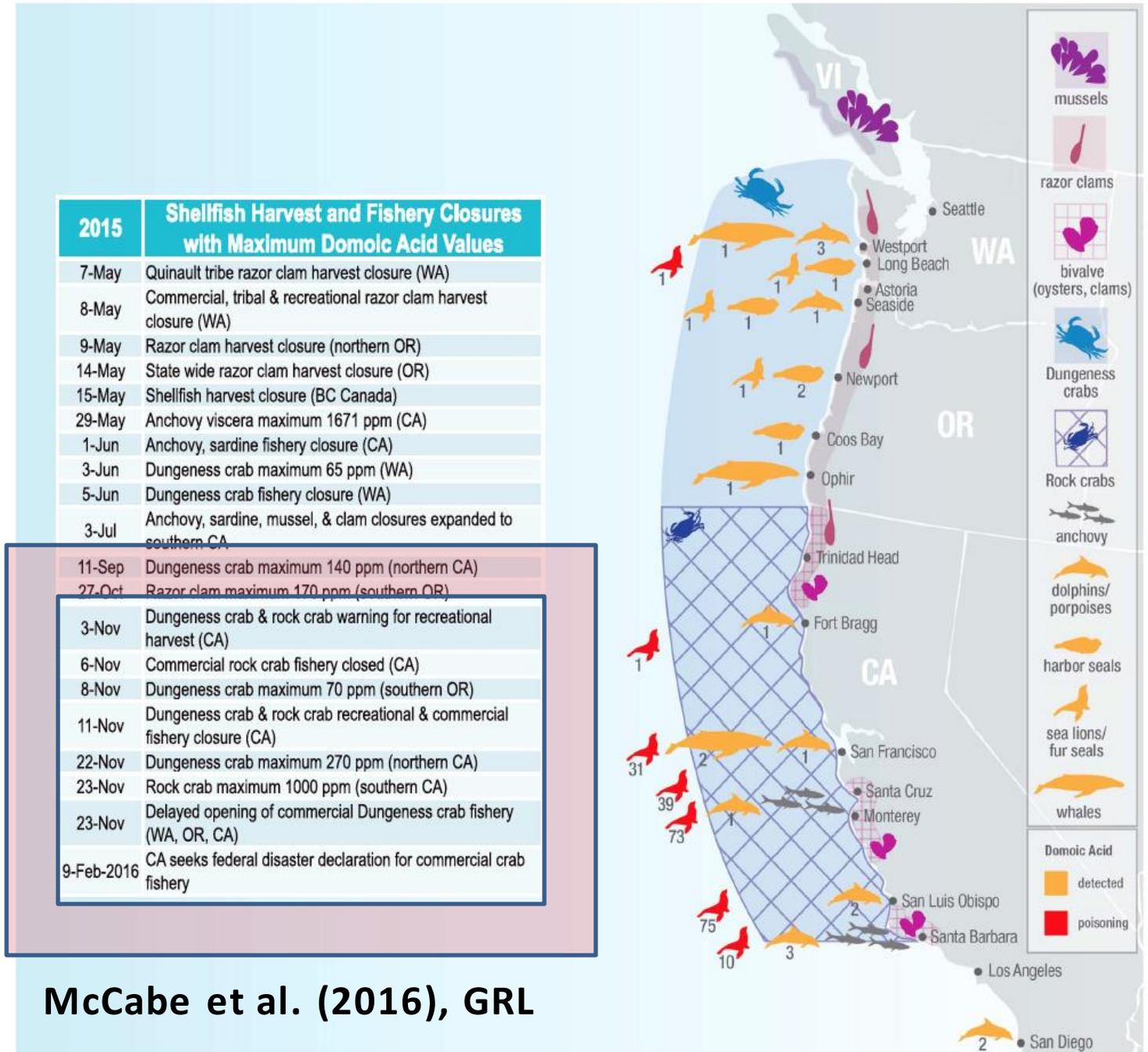


New challenges in West Coast fisheries management

- Record-breaking HAB and concentrations of domoic acid in 2015 caused unprecedented closures of commercial and recreational shellfish and finfish fisheries

2015 Shellfish Harvest and Fishery Closures with Maximum Domoic Acid Values

7-May	Quinault tribe razor clam harvest closure (WA)
8-May	Commercial, tribal & recreational razor clam harvest closure (WA)
9-May	Razor clam harvest closure (northern OR)
14-May	State wide razor clam harvest closure (OR)
15-May	Shellfish harvest closure (BC Canada)
29-May	Anchovy viscera maximum 1671 ppm (CA)
1-Jun	Anchovy, sardine fishery closure (CA)
3-Jun	Dungeness crab maximum 65 ppm (WA)
5-Jun	Dungeness crab fishery closure (WA)
3-Jul	Anchovy, sardine, mussel, & clam closures expanded to southern CA
11-Sep	Dungeness crab maximum 140 ppm (northern CA)
27-Oct	Razor clam maximum 170 ppm (southern OR)
3-Nov	Dungeness crab & rock crab warning for recreational harvest (CA)
6-Nov	Commercial rock crab fishery closed (CA)
8-Nov	Dungeness crab maximum 70 ppm (southern OR)
11-Nov	Dungeness crab & rock crab recreational & commercial fishery closure (CA)
22-Nov	Dungeness crab maximum 270 ppm (northern CA)
23-Nov	Rock crab maximum 1000 ppm (southern CA)
23-Nov	Delayed opening of commercial Dungeness crab fishery (WA, OR, CA)
9-Feb-2016	CA seeks federal disaster declaration for commercial crab fishery

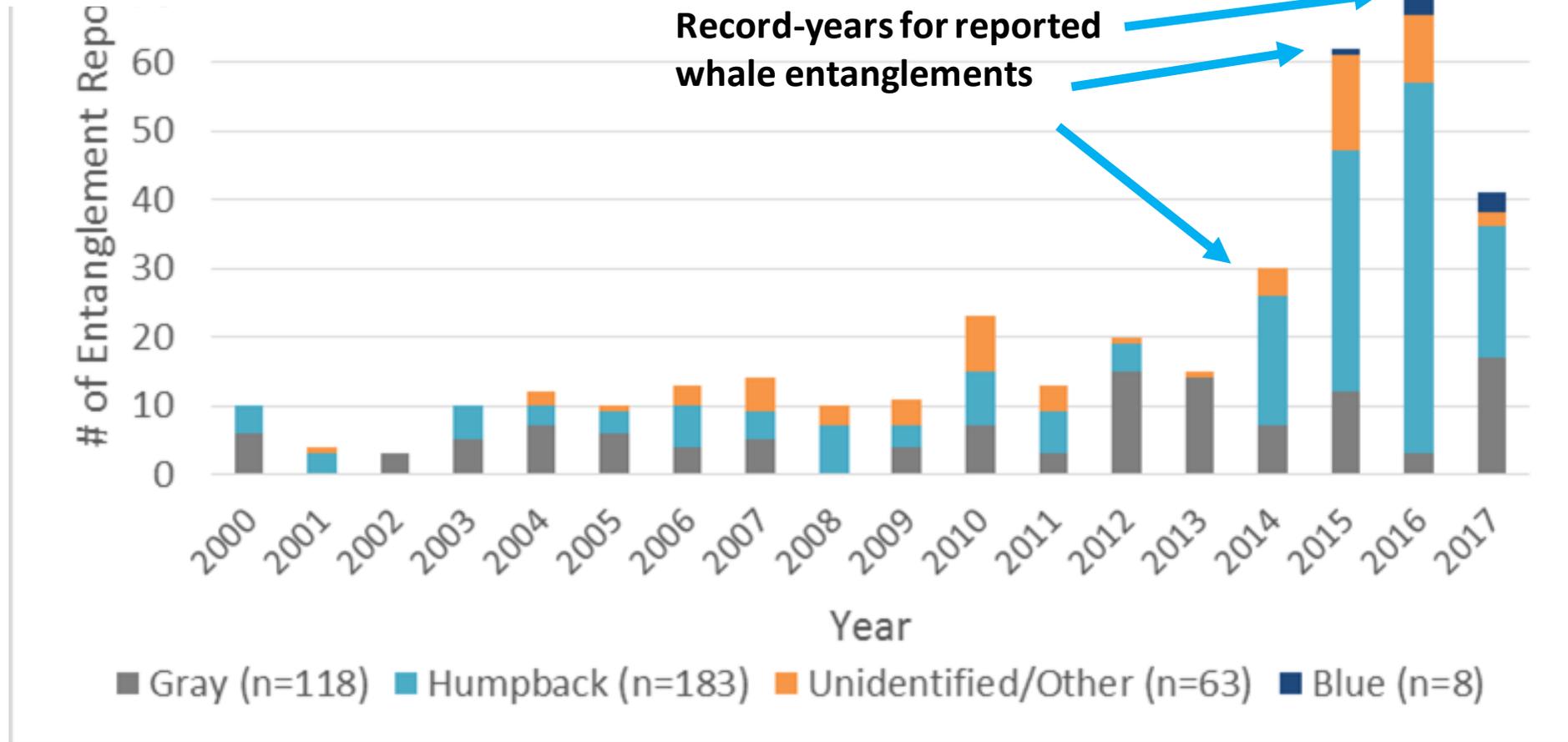


McCabe et al. (2016), GRL



Humpback whale (*Megaptera Novaeangliae*) 40-60 feet

Entanglements Reported by Year and Species



2015-16 whale entanglements

Our working hypothesis:

1. A long-term increase in whale abundance
2. LMH-driven habitat compression + prey switching:

- Persistent marine heat wave (fall 2014-2016) compressed productive habitat
- Declines in krill and increased inshore concentration of anchovy in Central CA
- Humpback whale prey-switching from shelf-break/slope krill to on-shelf anchovy

3. Amplified socio-ecological habitat compression in 2016 with the delayed opening of the crab fishery

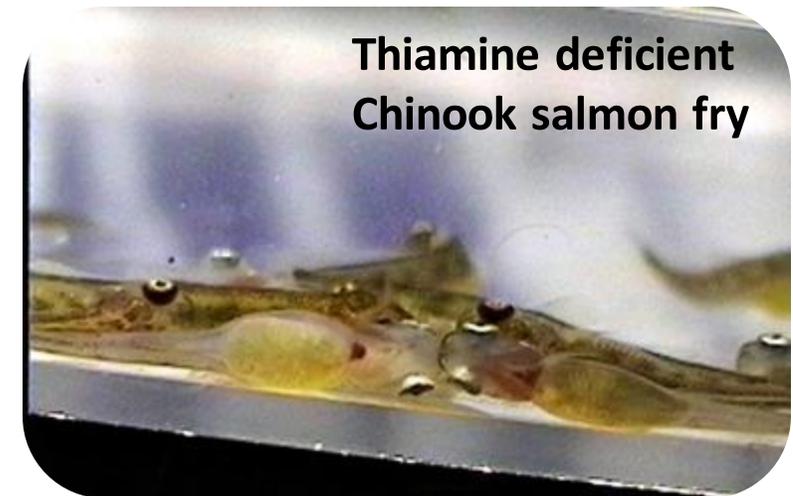
(delayed due to HAB/domoic acid contamination)

End result: consecutive years with unusually high time-space overlap of foraging whales and fishing gear



Thiamine deficiency in Central Valley Chinook salmon

- Unusually high egg-to-fry mortality rates, fry with coagulated yolks, corkscrew swimming patterns, and anorexia 2-4 weeks after ponding observed in multiple CV Chinook salmon hatcheries in 2020+21
- Scott Foott, USFWS CA-NV Fish Health Center
Memo from Jan 23, 2020:
 - FHC and UC Davis assays found “*fry loss not associated with infectious agent*”; **thiamine bath** treated fry swimming normally and feeding soon after
 - Anecdotal reports of unusually high numbers of dead fry in some Central Valley screw traps downstream of natural spawning areas in early 2020



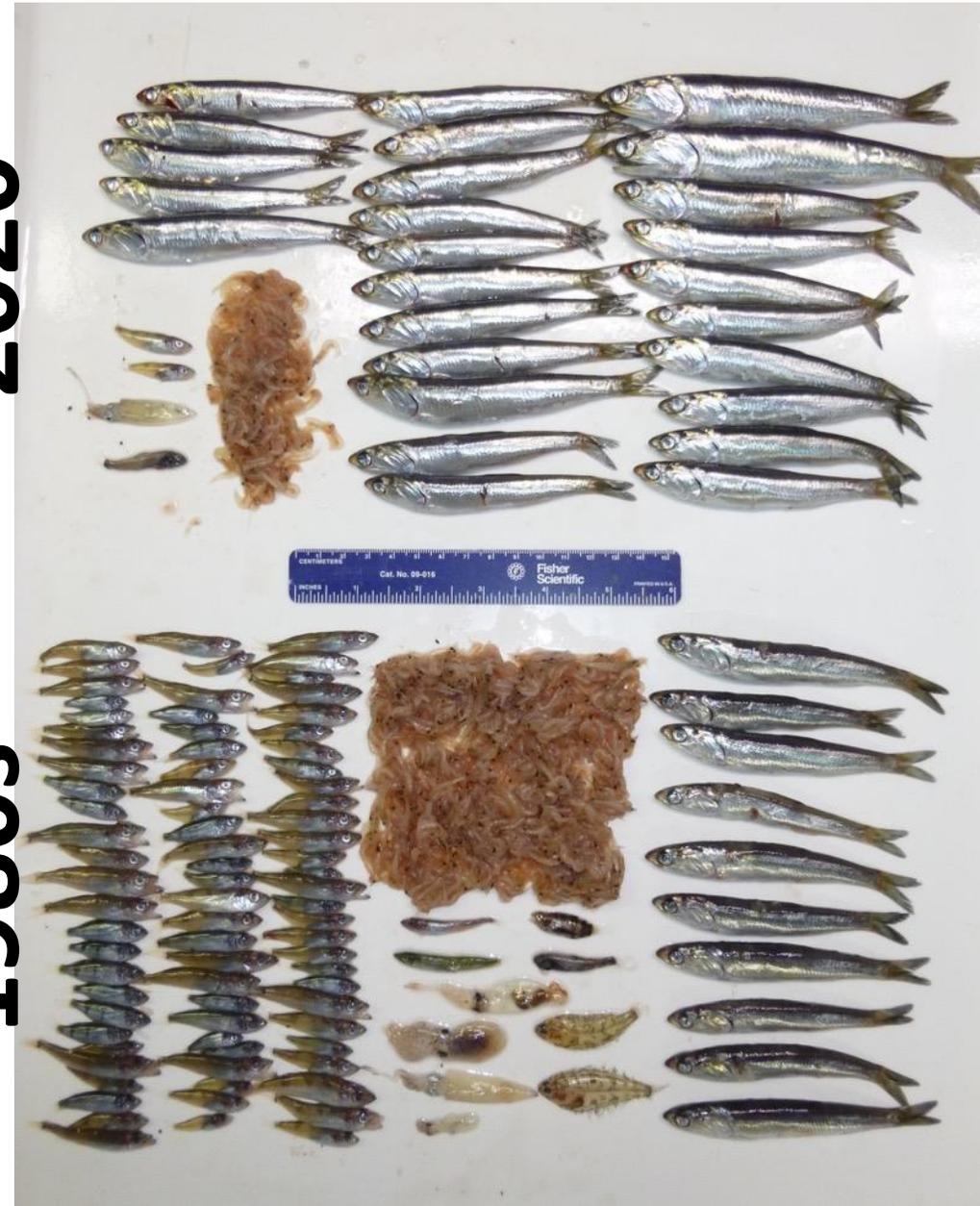
The anchovy diet hypothesis

Central Valley Chinook salmon diet was dominated by Northern anchovy in 2019-21 (perhaps to an unprecedented level?), diet shift reflects a change in the central CC forage base

- Northern anchovy, like many clupeid fish, carry an enzyme in their gut cavity that destroys thiamine in predators that eat them

2020

1980s

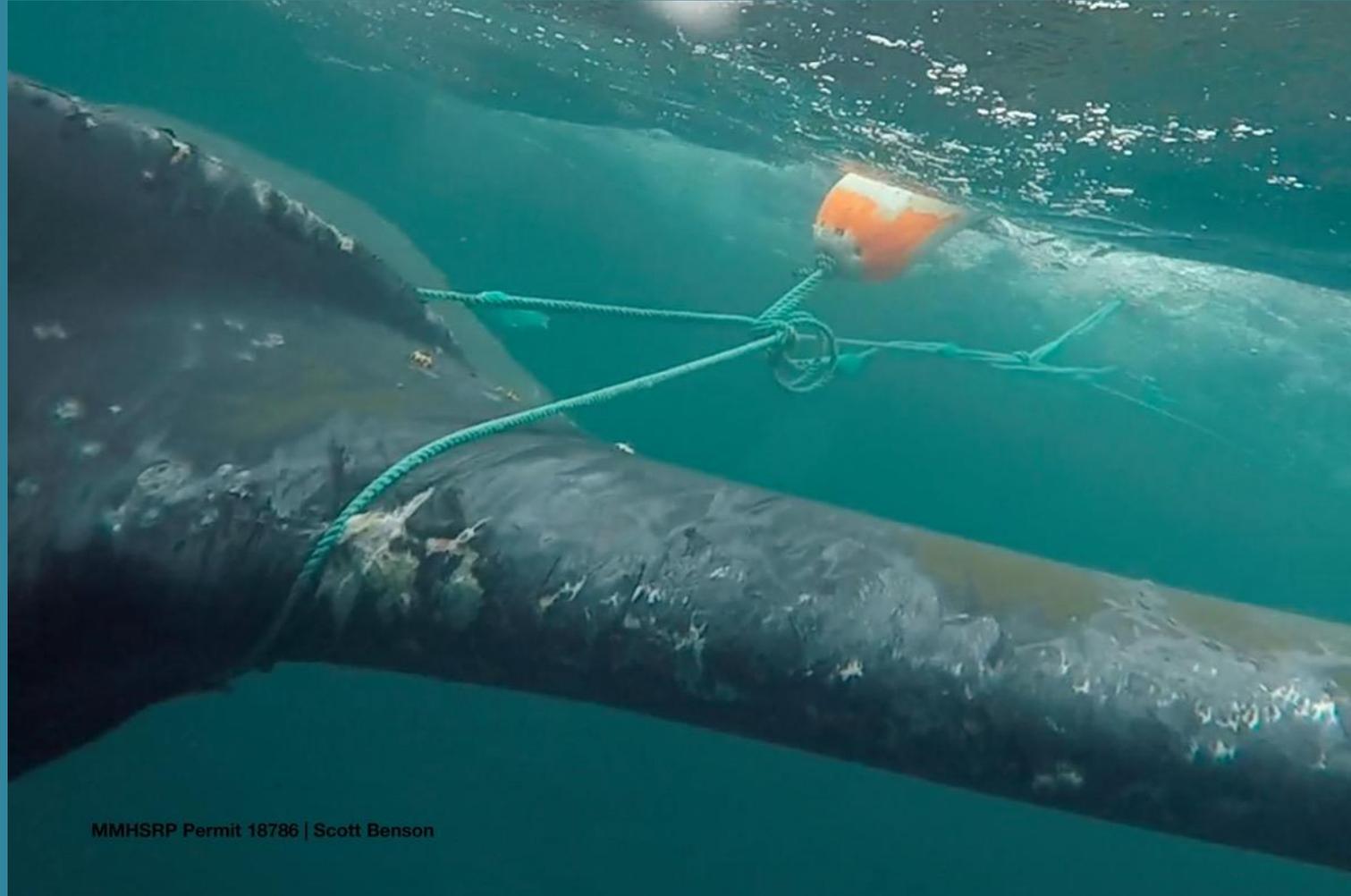


Picture from John Field, SWFSC

A nowcast and forecast

- Recent events provide a glimpse of our no-analog future as growing anthropogenic influences lead to ocean states outside historical envelopes
- These examples are compound events, where multiple factors lead to unforeseen interactions yielding ecosystem surprises
 - *Science will need to be increasingly adaptive, collaborative, and interdisciplinary*

Questions?



MMHSRP Permit 18786 | Scott Benson