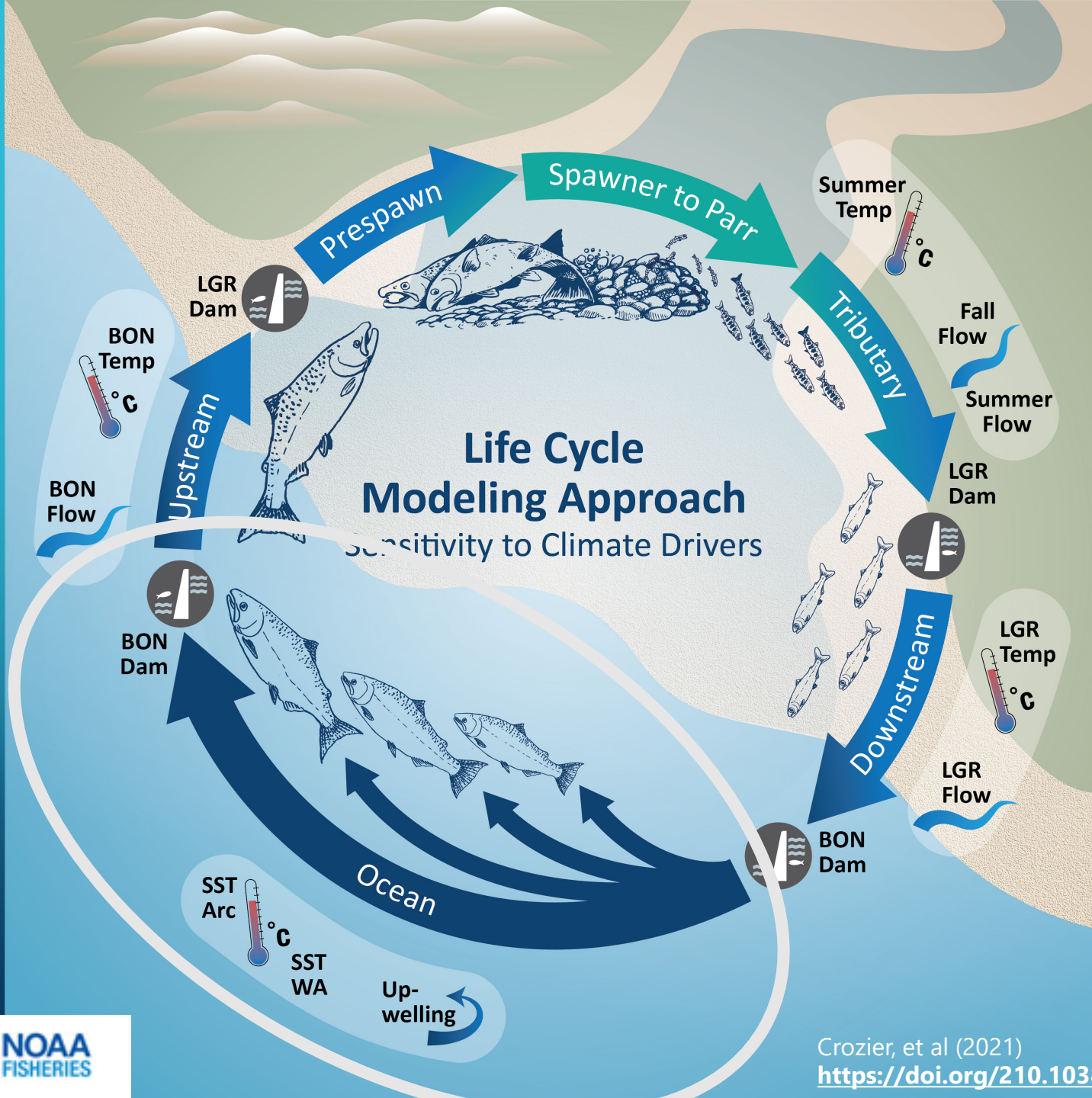


MARINE ECOSYSTEMS AND HOW THEY AFFECT SALMON:

HISTORICALLY COOL CONDITIONS,
RECENT MARINE HEATWAVES, AND
POTENTIAL FUTURES

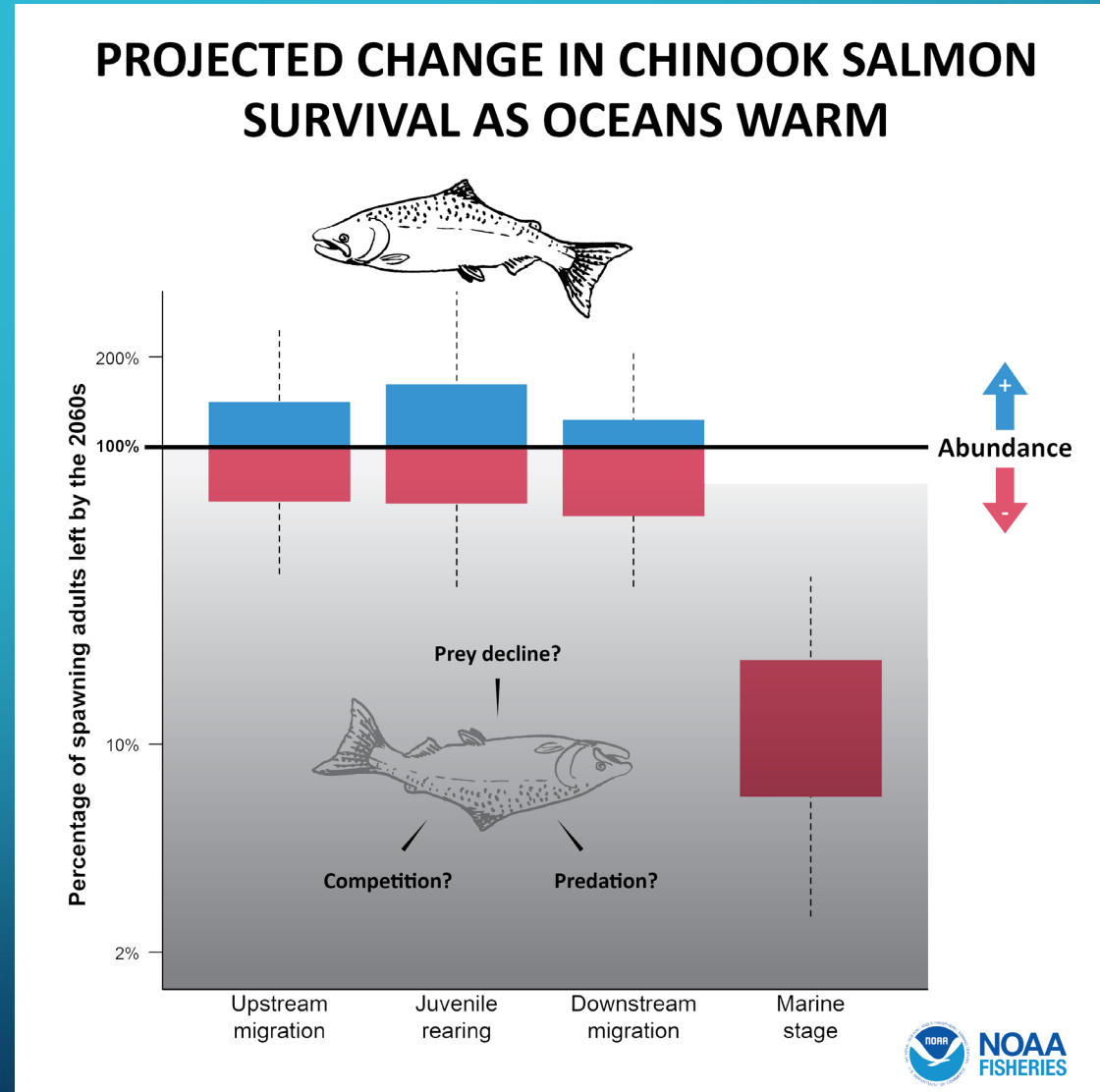
- Lisa Crozier
- Northwest Fisheries Science Center
- Ocean Forum
- Apr 4, 2024



What determines how many salmon return to freshwater, and at what age?

WHY DO WE NEED TO UNDERSTAND OCEAN ECOSYSTEMS?

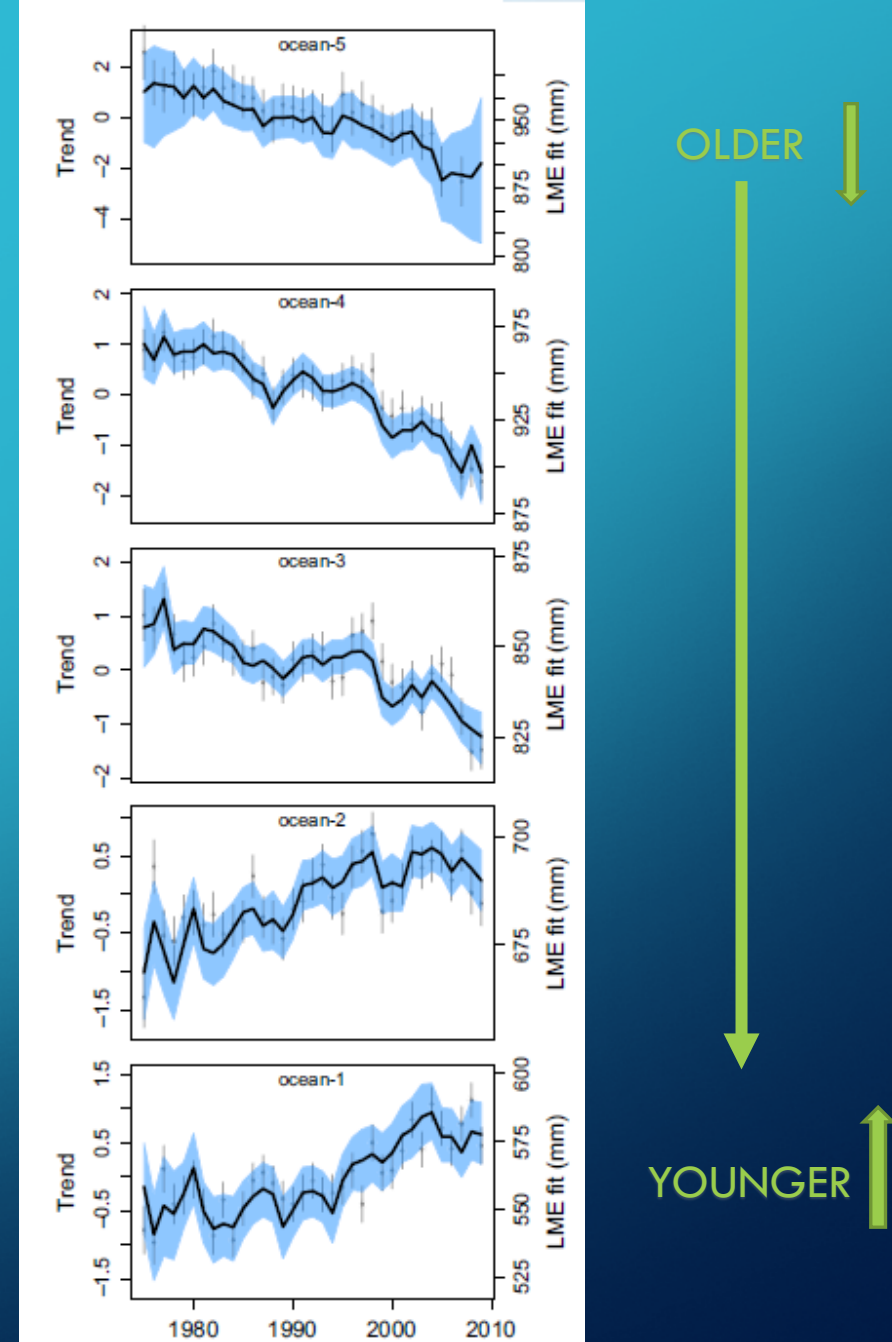
- Retrospectively and in future projections, fewer salmon return in a warmer ocean



Crozier, et al (2021). "Climate change threatens Chinook salmon throughout their life cycle." *Communications Biology* 4: 222. <https://doi.org/210.1038/s42003-42021-01734-w>

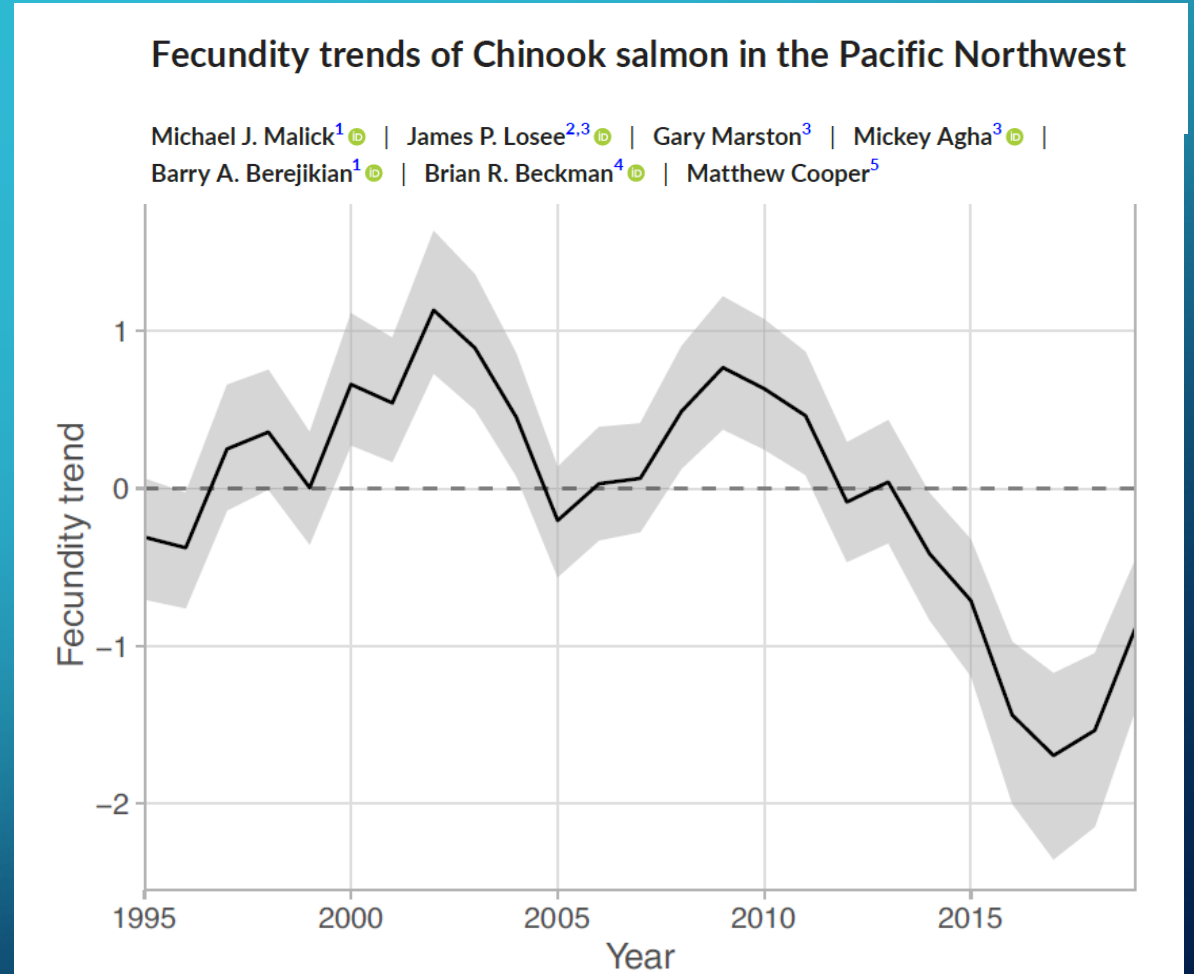
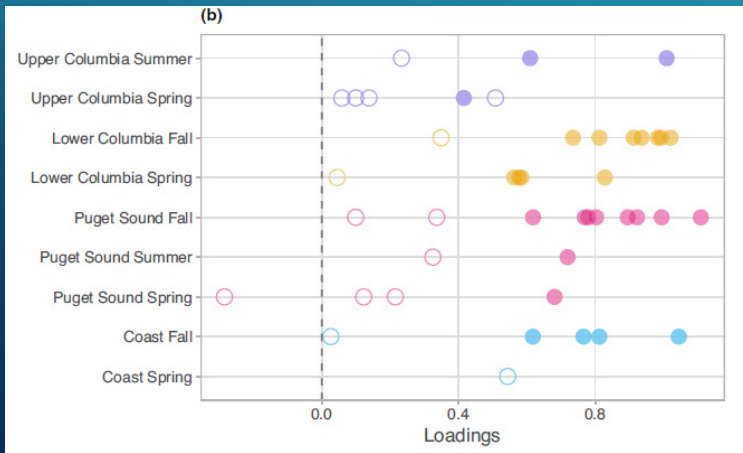
WHY DO WE NEED TO UNDERSTAND OCEAN ECOSYSTEMS?

- Retrospectively and in future projections, fewer salmon return in a warmer ocean
- Retrospectively, the salmon that do return, have gotten younger



WHY DO WE NEED TO UNDERSTAND OCEAN ECOSYSTEMS?

- Retrospectively and in future projections, fewer salmon return in a warmer ocean
- Retrospectively, the salmon that do return, have gotten younger,
- and have fewer eggs



The background is a solid teal color. In the four corners, there are decorative white line-art elements that resemble circuit traces or data paths. These lines connect to small white circles, creating a network-like pattern. The lines are thin and the circles are small, giving it a technical or digital feel.

MODELS CAN HELP US PREDICT, MANAGE, AND ADAPT
TO CLIMATE CHANGE

FRESHWATER & MARINE CONDITIONS AFFECT CHINOOK SURVIVAL

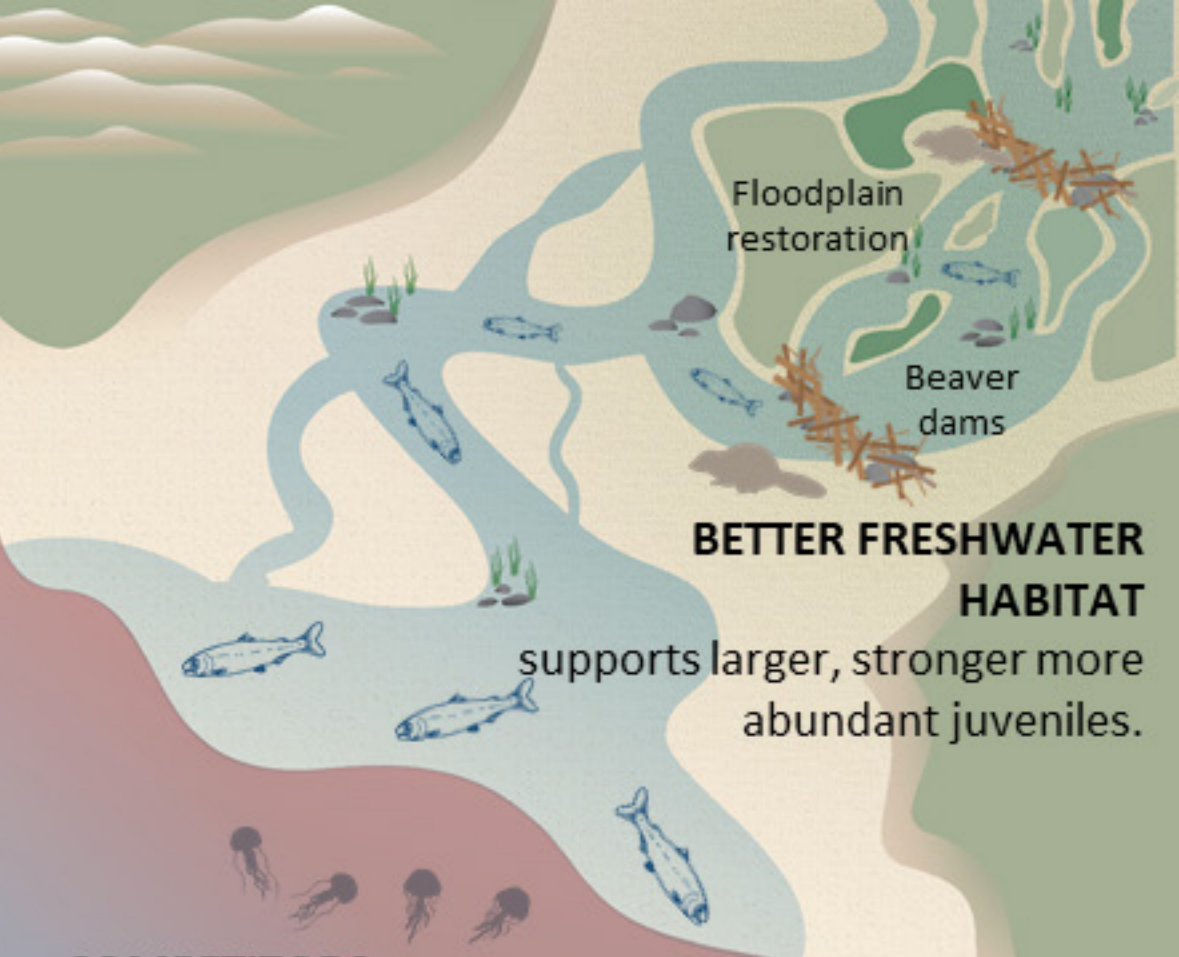


WARMER MARINE WATERS impact prey, predators and competitors & contribute to decline.

PREY
What causes decline in some prey? Is there a cost to switching to other prey?

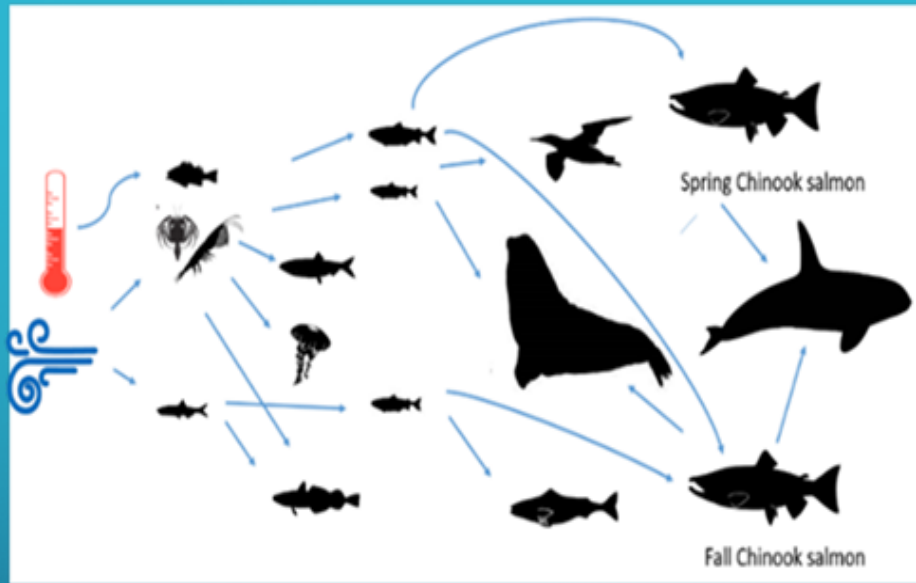
PREDATORS
Which predators increase consumption in a warm ocean?

COMPETITORS
Which competitors increase consumption in a warm ocean?



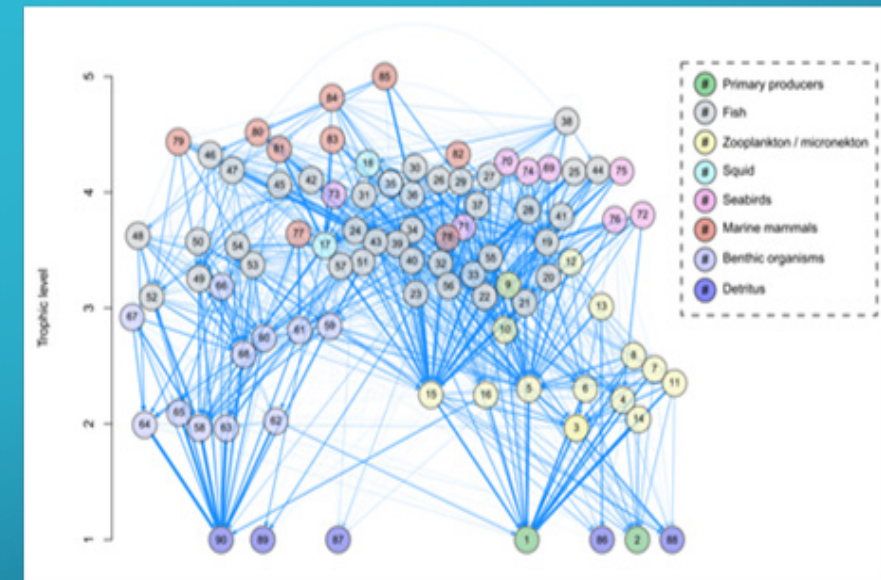
BETTER FRESHWATER HABITAT supports larger, stronger more abundant juveniles.

Two multi-species modelling approaches



Qualitative Network Analysis

Focal species and functional groups
Intermediate complexity
Exploratory



End-to-end Ecosystem Model

Maximum complexity
Data hungry, slow to run, very comprehensive
More constrained by diet data & subtle assumptions

WHAT IS QUALITATIVE NETWORK ANALYSIS?

- QNA translates any conceptual model of the food web into a matrix; explores full parameter space, given a signed impact (e.g., predator-prey or uncertain)
- Sums direct and indirect impacts on a focal species after a perturbation (e.g., warming)
- Freedom from the constraint of measured interactions
- Rapid tests of alternative conceptual models
- Helps set up and interpret quantitative models and frame research

QNA SETUP: DEFINE SPECIES CONNECTED TO SALMON

PREY



b1 larval fish




b2 zooplankton




b3 juv. anchovy


COMPETITORS



c1 forage fish




c2 jelly




c3 summer


PREDATORS




d1 bird



d2 pinniped




d3 other fish




d4 killer whale

SALMON




g1 spring adult




g3 fall adult


SMOLT



f1 yearling



f2 subyearling

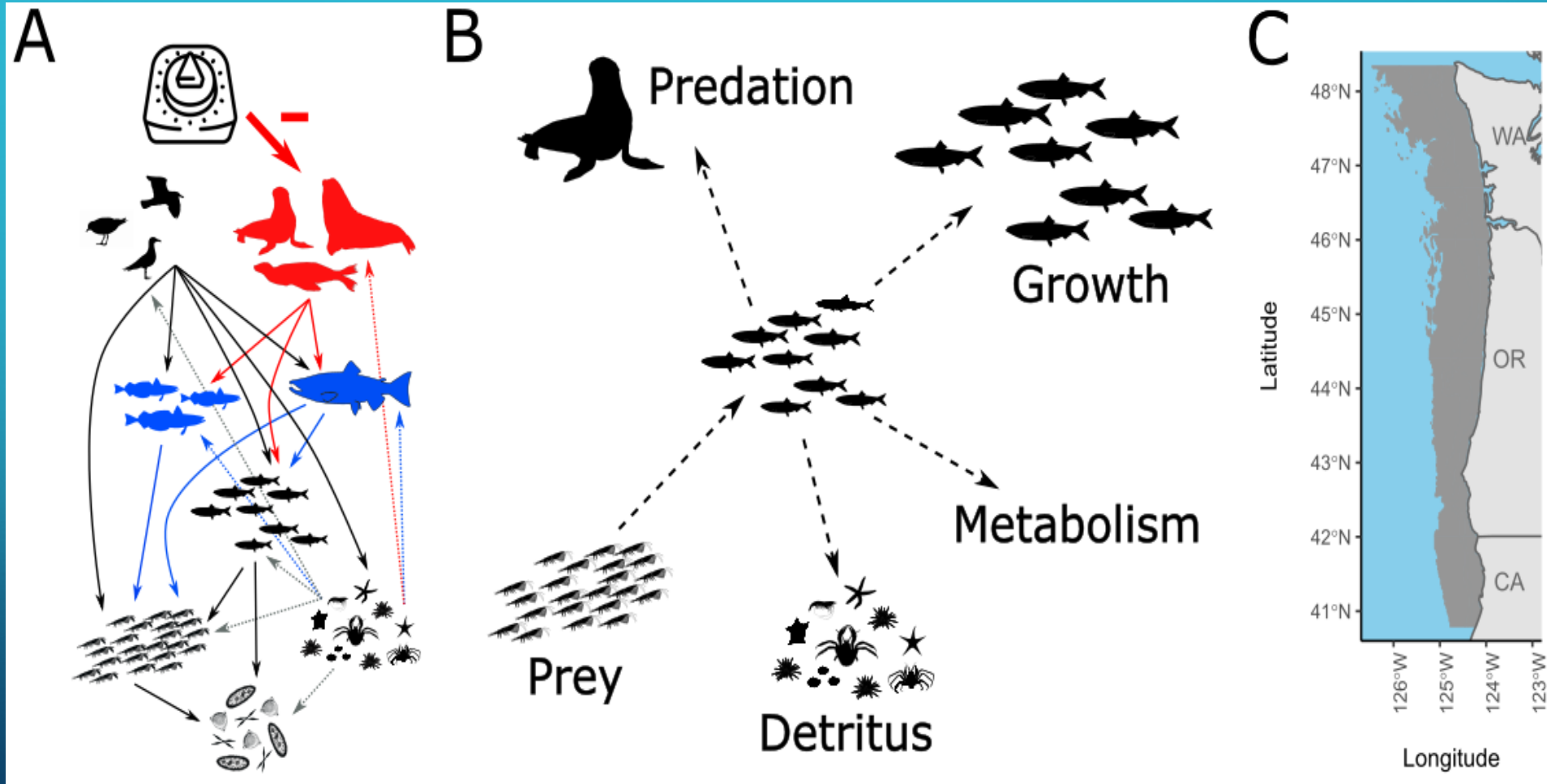


f3 summer

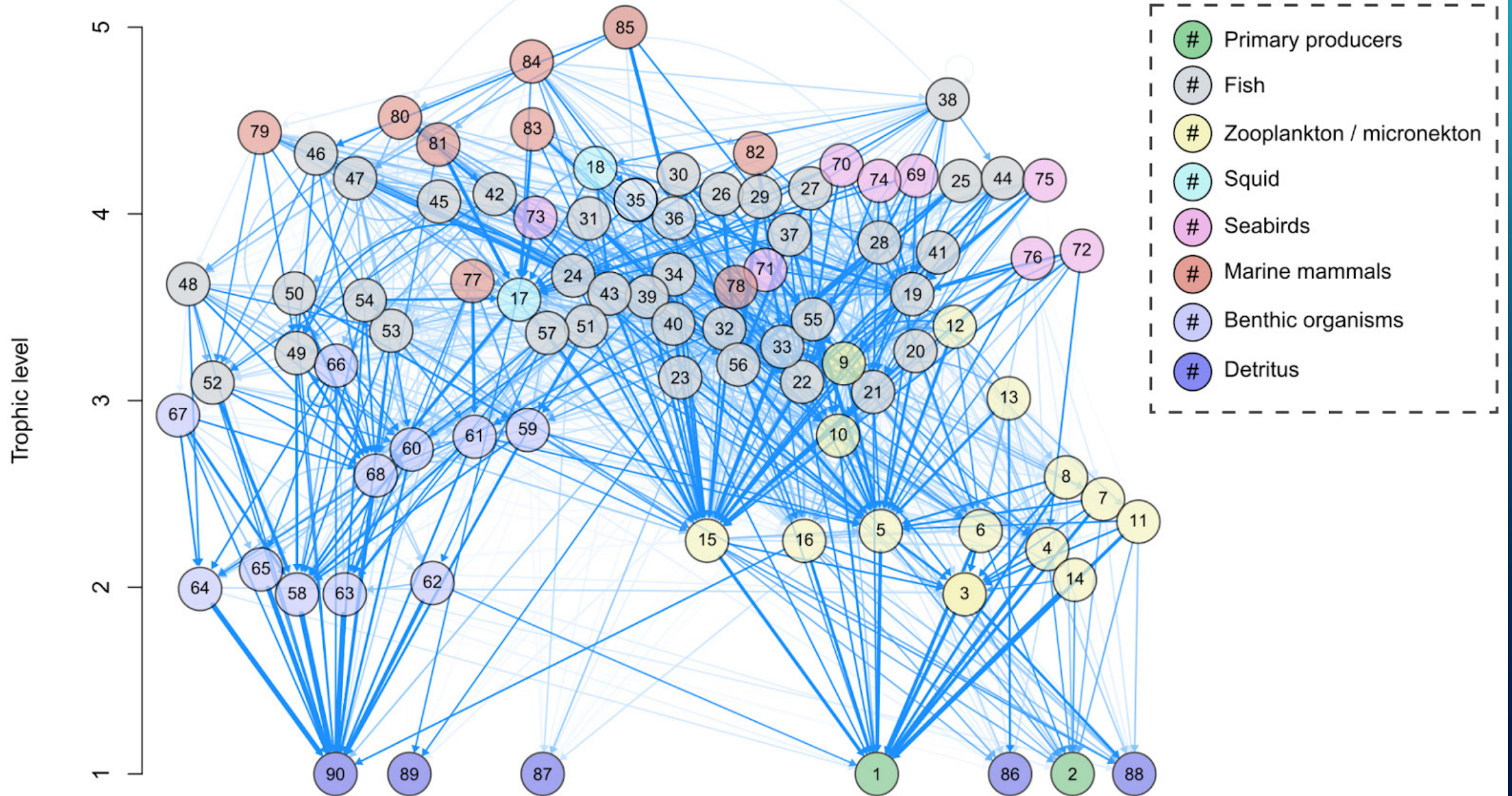
The background is a solid teal color. In the four corners, there are decorative white line-art patterns resembling circuit traces or neural network connections. These patterns consist of straight lines of varying lengths and angles, ending in small open circles. The patterns are more dense in the bottom-left and top-left corners and more sparse in the top-right and bottom-right corners.

WHAT HAPPENS WHEN WE DO EXPERIMENTS WITH A
FULL ECOSYSTEM MODEL?

ECOTRAN – AN END-TO-END ECOSYSTEM MODEL



~ 100 Functional Groups!



SUMMARY

- Qualitative network analysis showed that
 - Pressures can interact, with unexpected results
 - Risk if top-predator or competitor consumption increases, but we need to know more
 - Improving salmon condition might be our best bet, if improves spp interactions
- Ecosystem models indicated that
 - Pressures can interact, with unexpected results
 - Species with the largest biomass and most specialized diets were most influential
Fish outweighed birds and mammals
 - New competitor affected the whole food

NEXT STEPS

- Build “intermediate complexity” quantitative models
- Explore management interventions to mitigate negative impacts from climate change
- Incorporate estuary and marine survival modules into life cycle models for spring Chinook salmon & steelhead



THANK YOU,
QUESTIONS?



Photo courtesy of Morgan Bond

Bonneville
POWER ADMINISTRATION



NOAA
FISHERIES