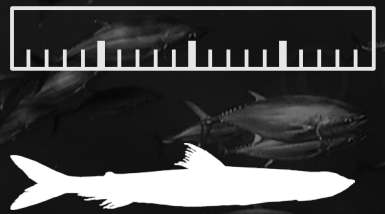
Traits-based Insights into Pelagic Food Webs under Climate Change







Project Team

Stanford University

Oregon State University Hatfield

University of Alberta

NOAA Fisheries

Scripps Institution of Oceanography, University of California Santa Cruz

Lenfest Ocean Program


Stephanie Green


Miram Gleiber


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Larry Crowder


Elliott Hazen


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Alana Krug-MacLeod


Elan Portner


Anela Choy


Travis Richards


Owyn Snodgrass


Elizabeth Daly


Brian Wells


Toby Auth


Heather Welch


Caitlin Morganson


Zachary Roote


Cindy Matuch


Iris George


Cole Brookson


Cat Nickels

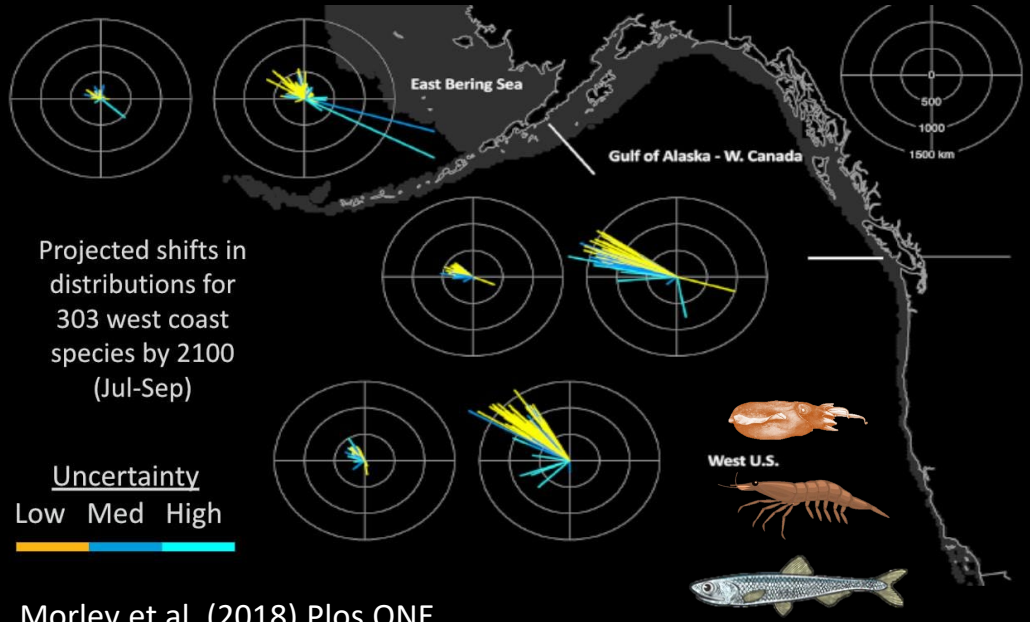

Desiree Tommasi


Ric Brodeur

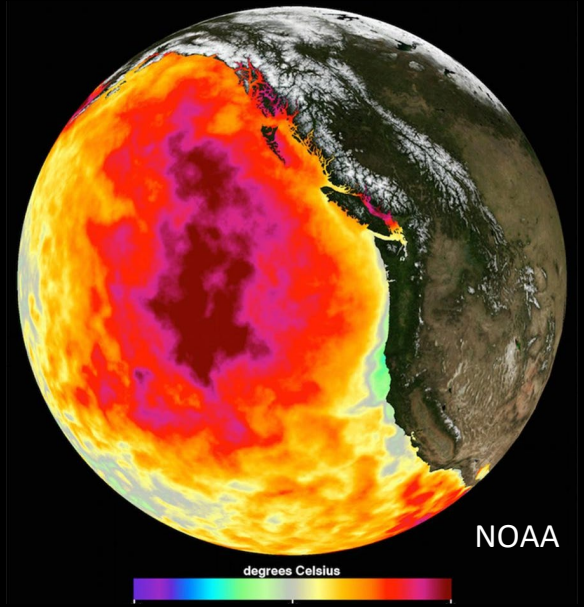

Jarrod Santora


John Field

Variable climate-driven shifts projected for NE Pacific communities

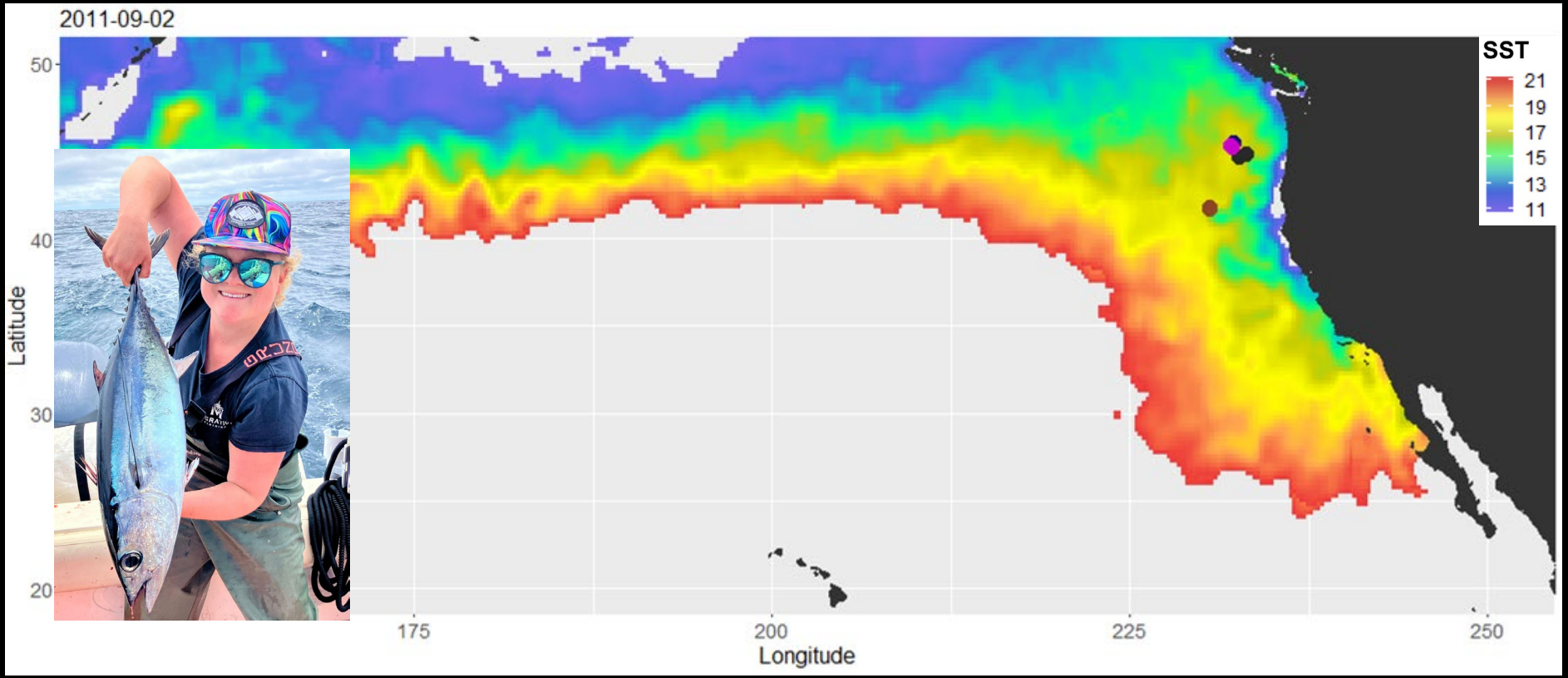


Morley et al. (2018) Plos ONE



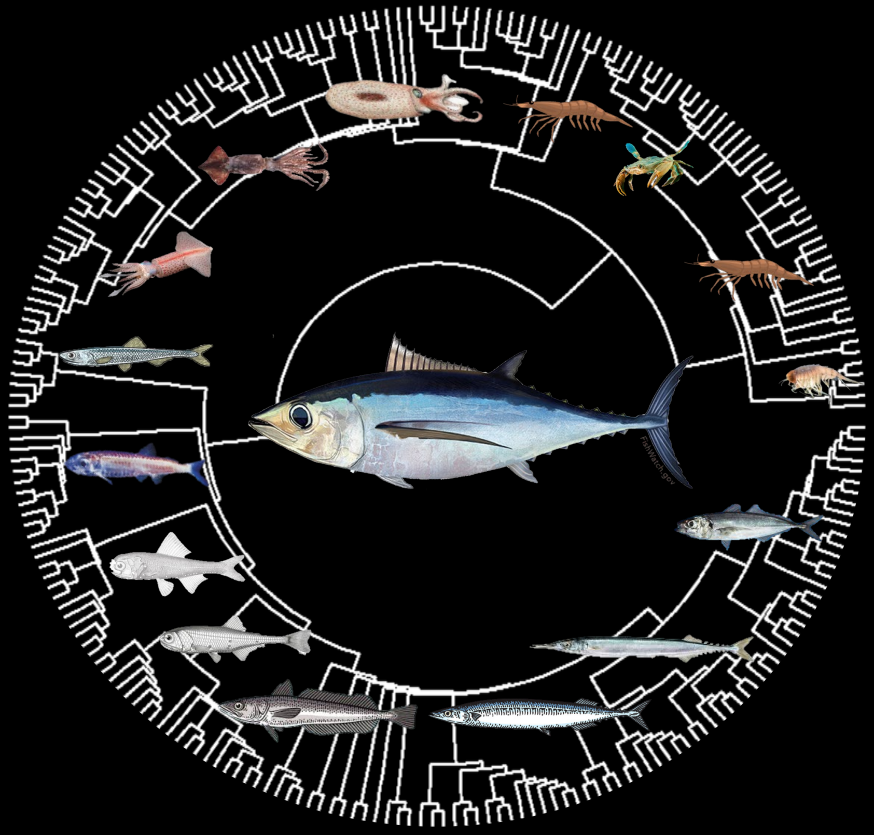
Sea Surface Temperature Anomaly

North Pacific Albacore Tuna



Courtesy of Barbara Muhling

Predator-prey interactions complex for pelagic predators

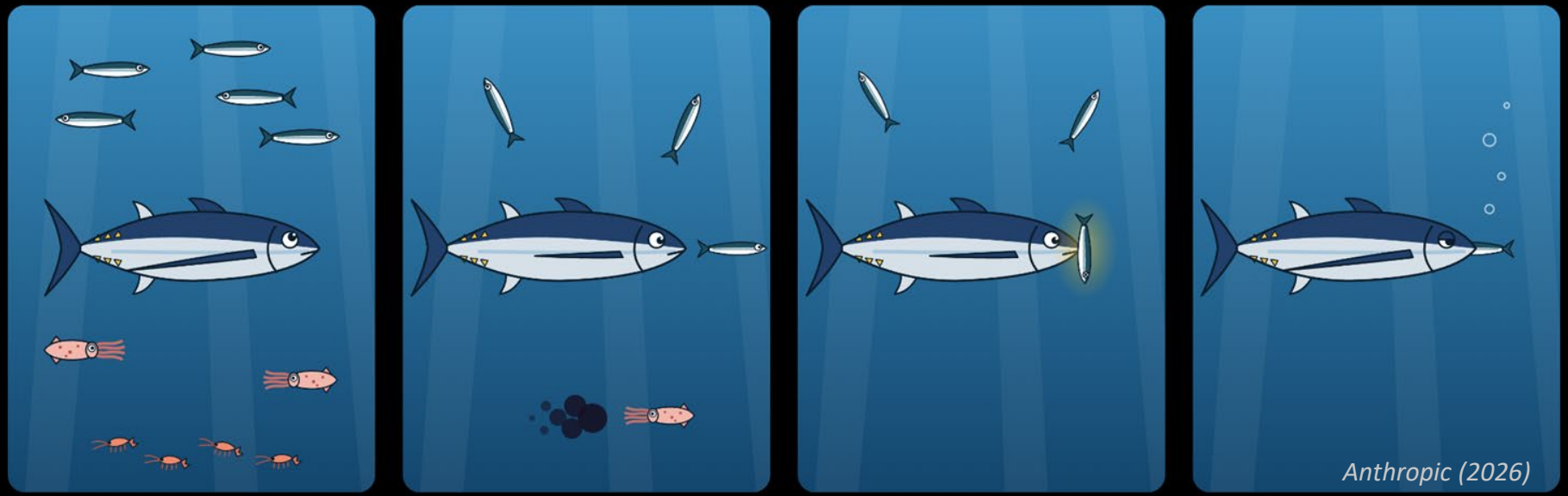


Albacore consume:

- >300 sp. globally
- >120 sp. NE Pacific

Hardy et al. (2023) *Fish & Fisheries*

Traits influence predator-prey interactions

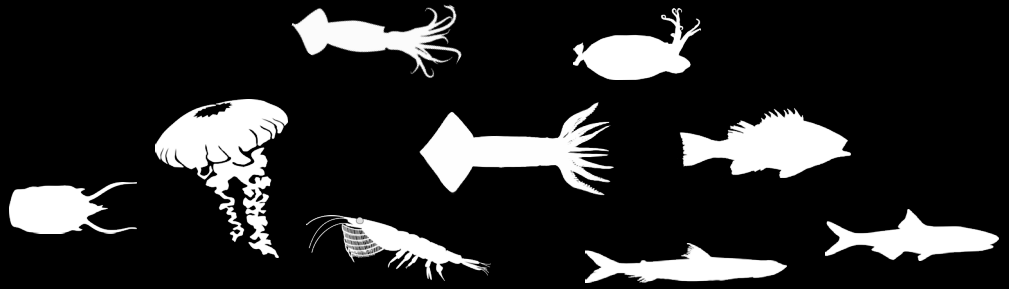


Habitat
- Horizontal
- Vertical

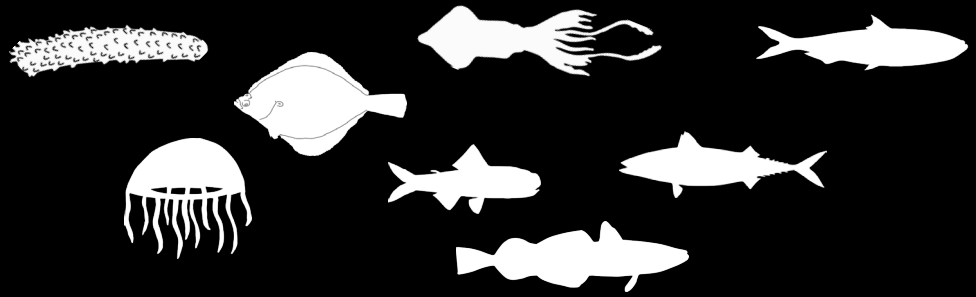
Morphology
- Countershading
- Silver
- Defenses

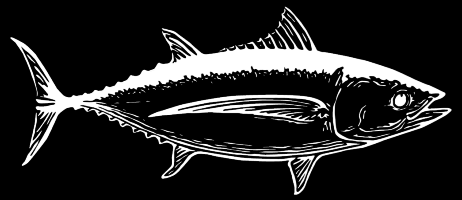
Behavior
- Schooling

Nutrition
- Fat
- Protein
- Energy



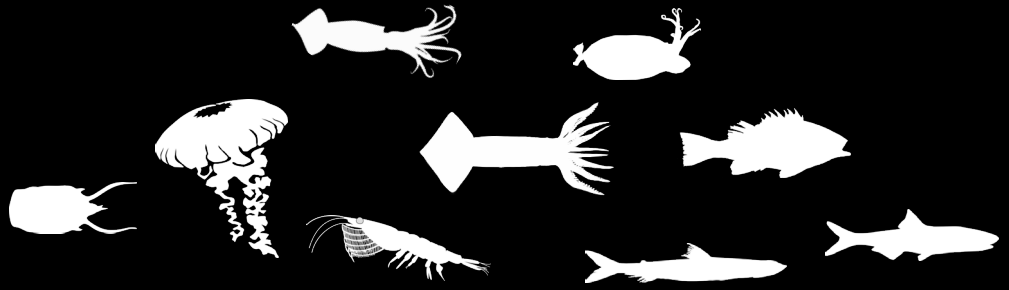
Albacore select diverse prey, but similar traits



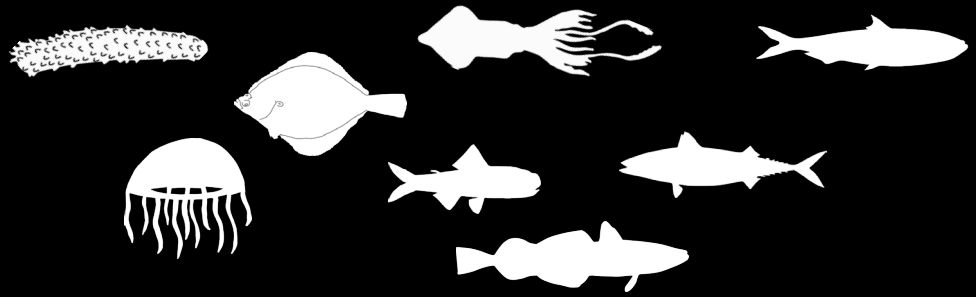


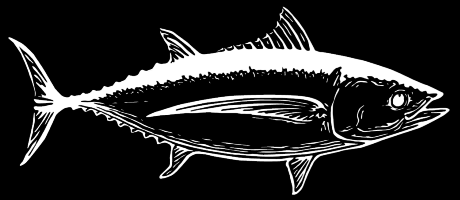
Coastal
Epi/mesopelagic
Countershaded
Silvered
Undefended
Non-transparent
Schooling
Non-diel migrants
Nutrient-rich

Gleiber et al. (2024) *Ecological Indicators*



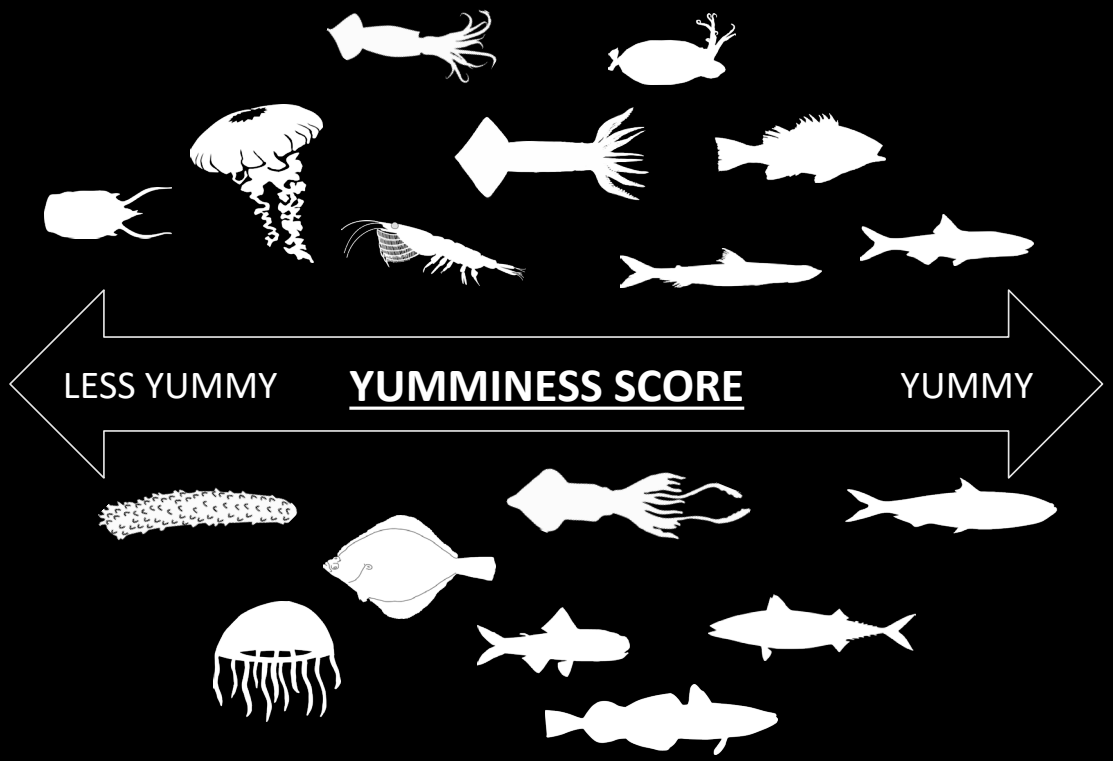
When & where are high quality prey?

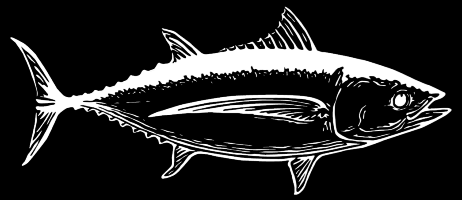




Coastal
Epi/mesopelagic
Countershaded
Silvered
Undefended
Non-transparent
Schooling
Non-diel migrants
Nutrient-rich

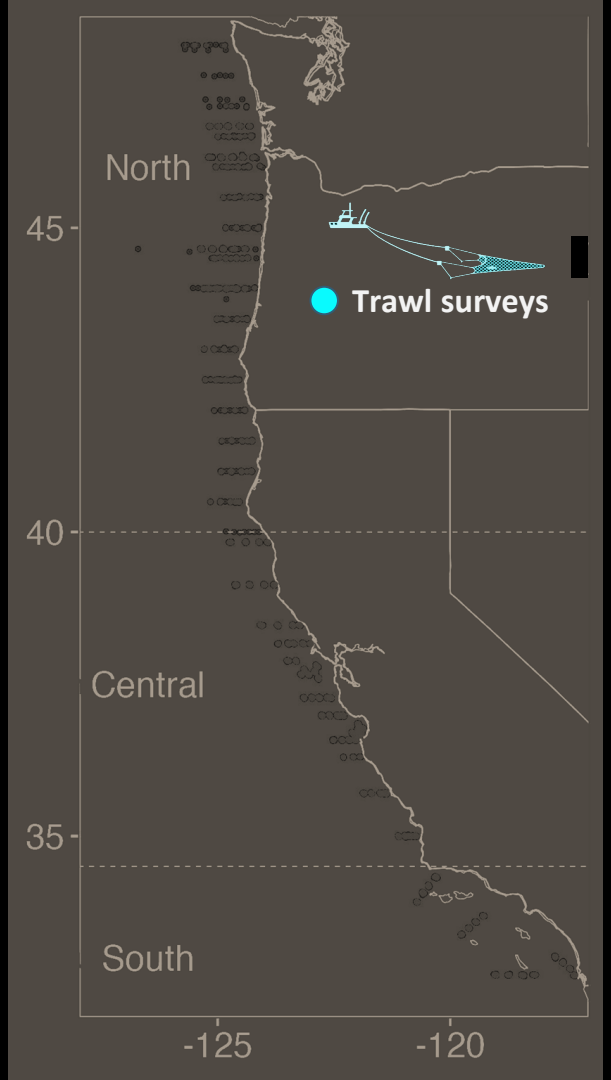
Green, Gleiber (2026) *Navigating to Solutions*





Coastal
Epi/mesopelagic
Countershaded
Silvered
Undefended
Non-transparent
Schooling
Non-diel migrants
Nutrient-rich

Green, Gleiber (2026) *Navigating to Solutions*

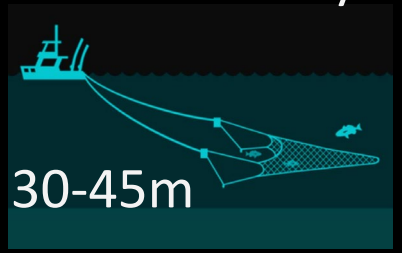


Pelagic forage assemblage sampling

Trawl Surveys (May-June)	Years
Rockfish Recruitment & Ecosystem Assessment	1990-present
Northern California Current	2011-present
Stock Assessment Improvement Program	2005-2011

NOAA FISHERIES

Annual surveys



2005 - 2024

Gleiber et al. (in preparation)

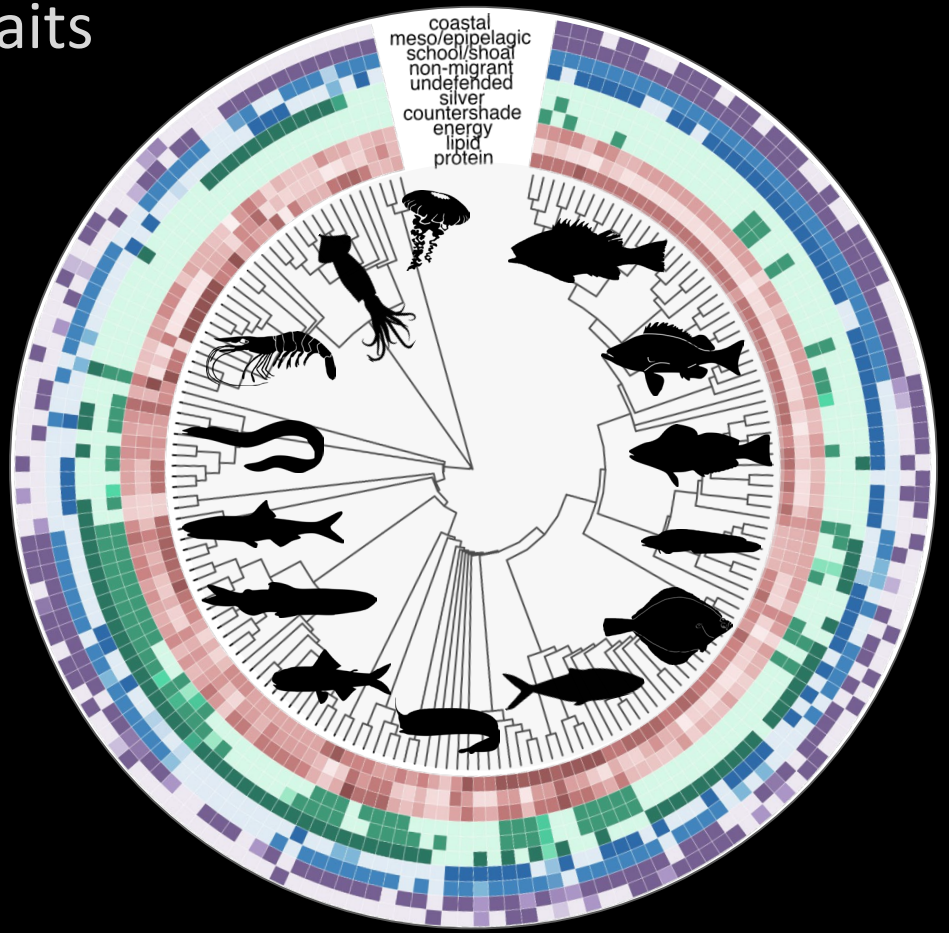
Pelagic forage assemblage traits

- 175 taxa, stage-specific

Habitat
Behavior
Morphology
Nutrition

Trait

(-) selection (+)



Gleiber et al. (in preparation)

Pelagic forage assemblage traits

- 175 taxa, stage-specific

Trait

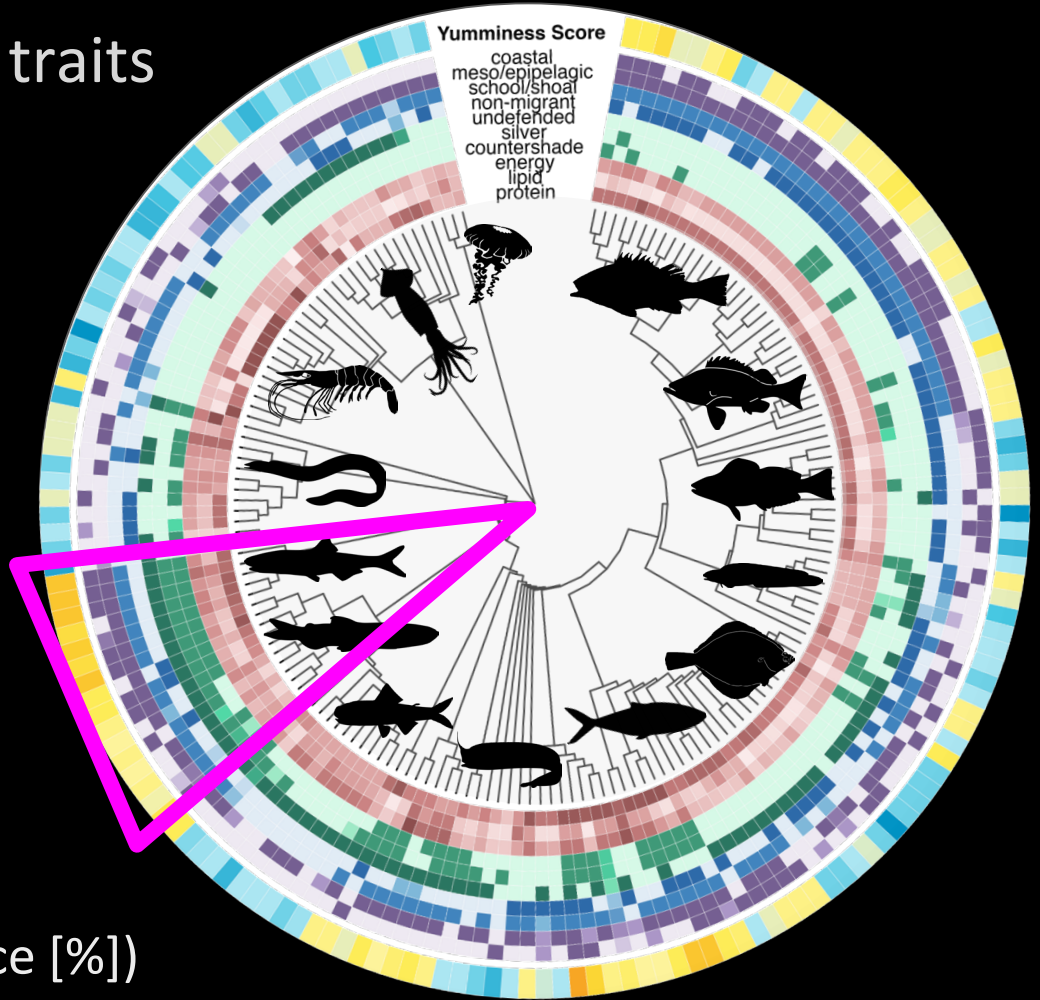
(-) selection (+)

Habitat
Behavior
Morphology
Nutrition

Yumminess Score

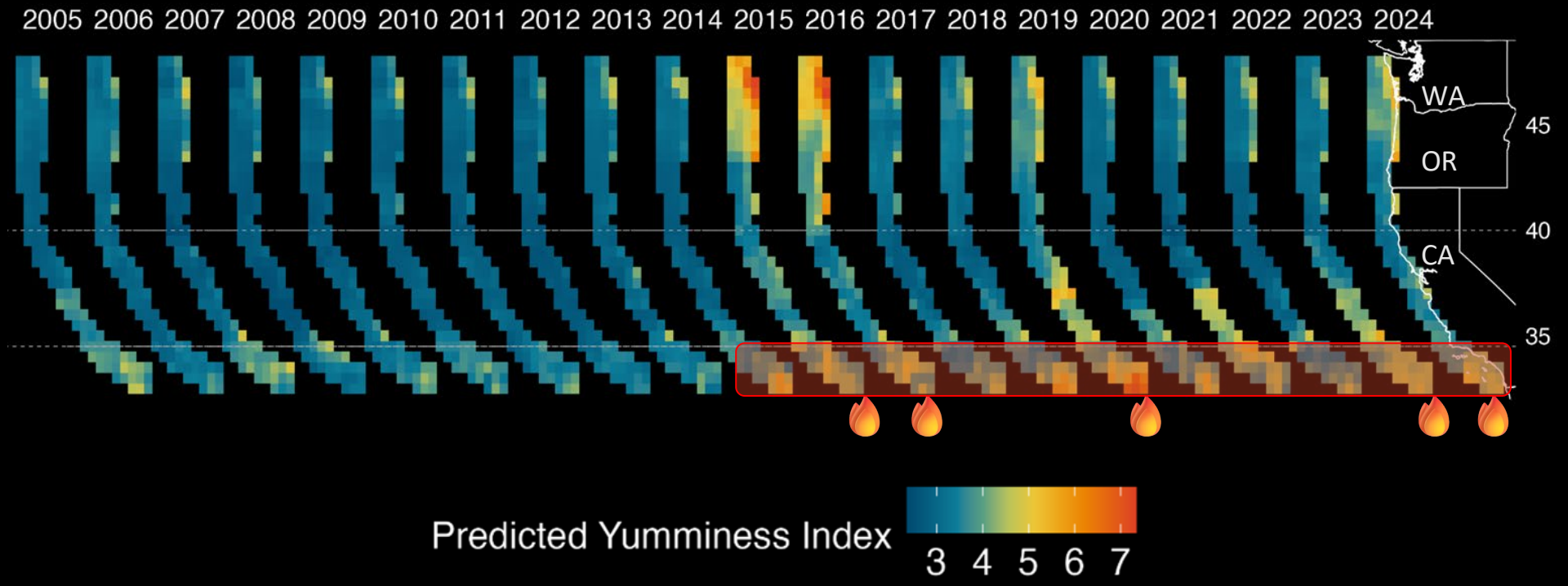
0 10

∑ (yumminess score x abundance [%])



Gleiber et al. (in preparation)

Shifts in prey quality for top predators



marine heatwaves

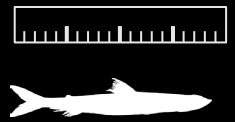
Gleiber et al. (in preparation)

Pelagic Species Trait Database

30+ traits



Habitat & behavior



Morphology



Nutrition

500+ species



adult/juvenile/larval, NE Pacific/global

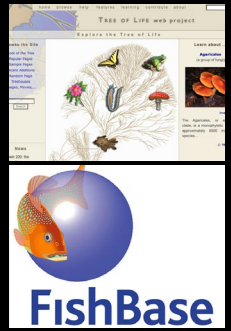
borealis

Gleiber et al (2024), *Scientific Data*

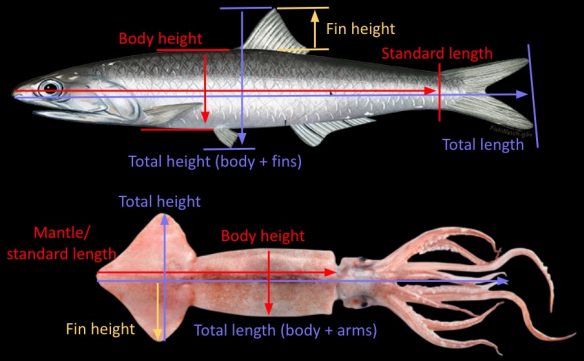
Collection Methods



Literature search

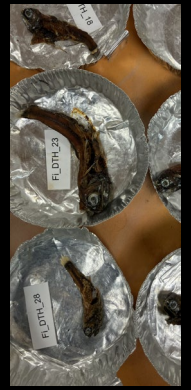


Online resources



Morphometric measurements

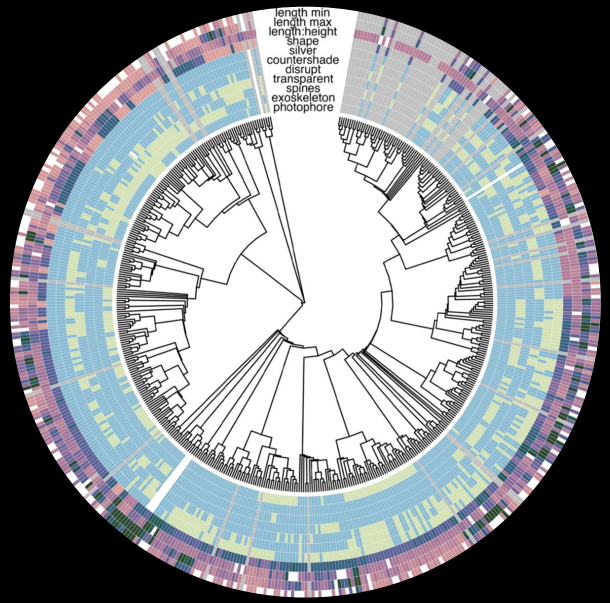




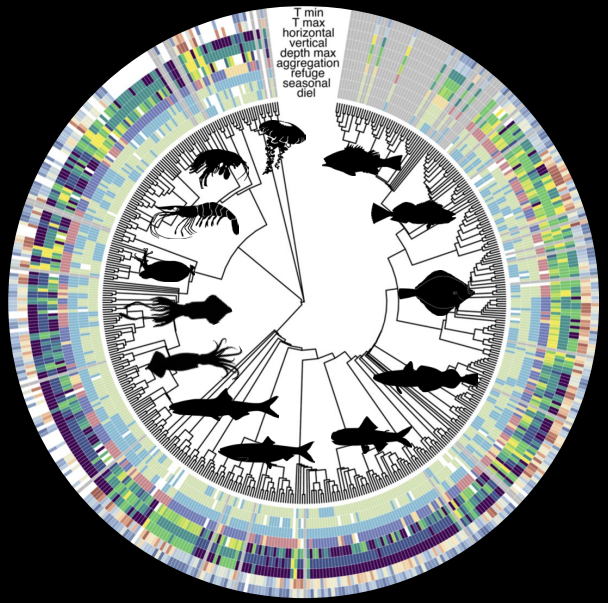
Nutritional quality analysis

Gleiber et al (2024), *Scientific Data*

Morphology



Habitat & Behavior

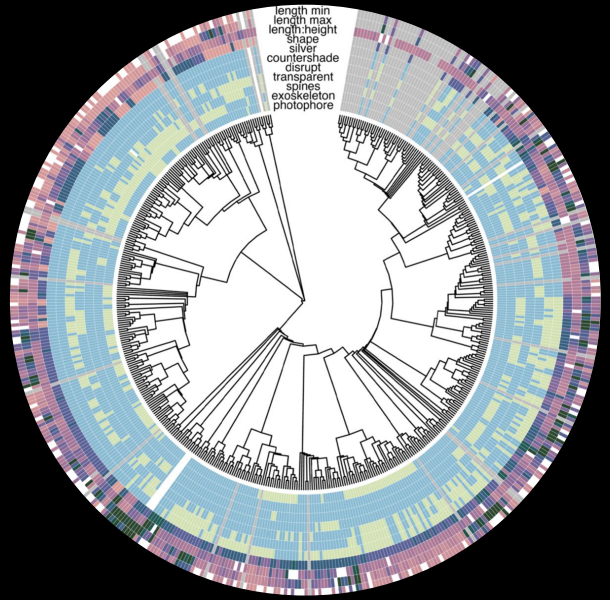


Nutrition

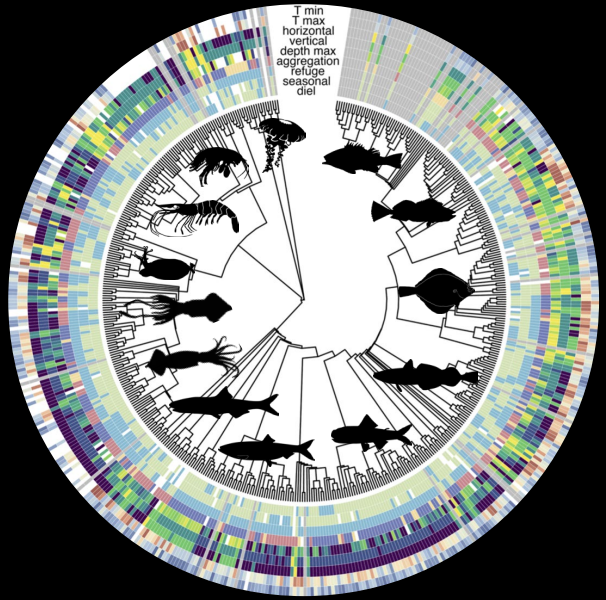


Gleiber et al (2024), *Scientific Data*

Morphology



Habitat & Behavior



Nutrition





Dr. Natasha Hardy



Caitlin Morganson



Zachary Roote



Cindy Matuch



Iris George



Zackary Tandy

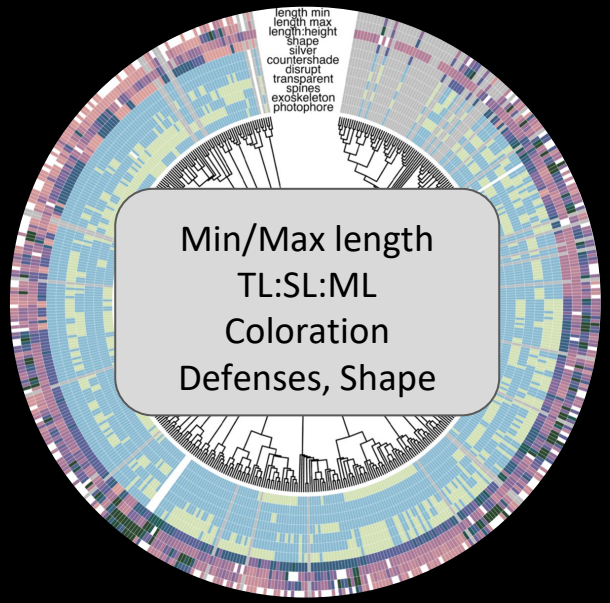


Cole Brookson



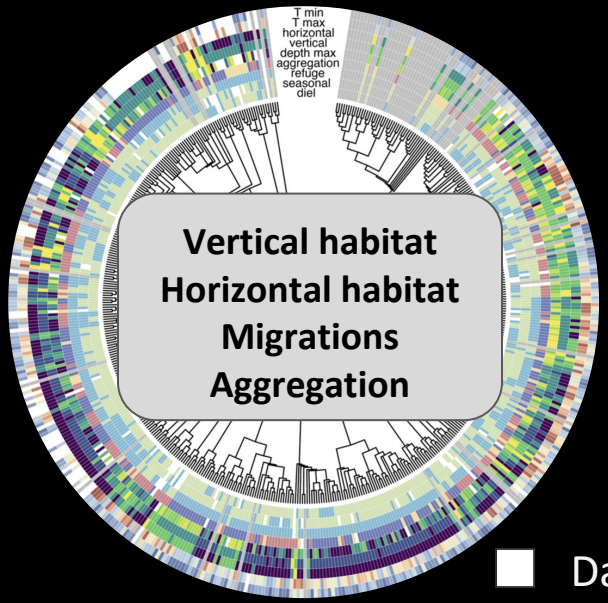
Alana Krug-MacLeod

Morphology



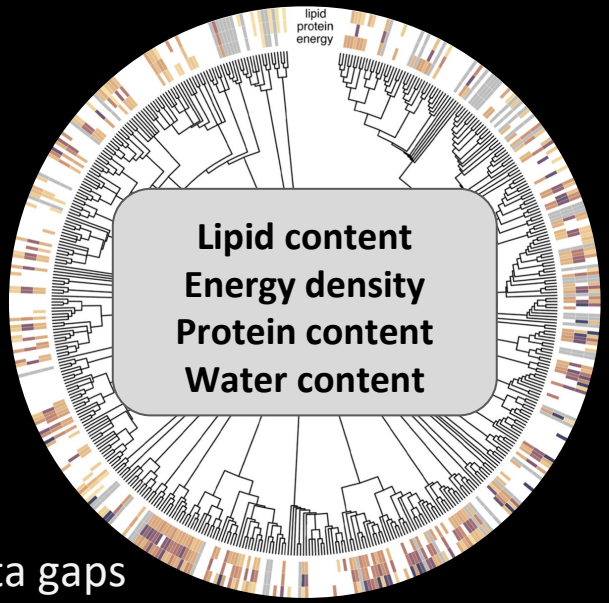
Min/Max length
TL:SL:ML
Coloration
Defenses, Shape

Habitat & Behavior



Vertical habitat
Horizontal habitat
Migrations
Aggregation

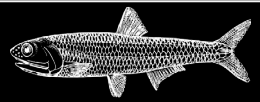
Nutrition



Lipid content
Energy density
Protein content
Water content

Data gaps

Stop by our poster tonight!





Trait applications

Explore drivers of nutritional quality



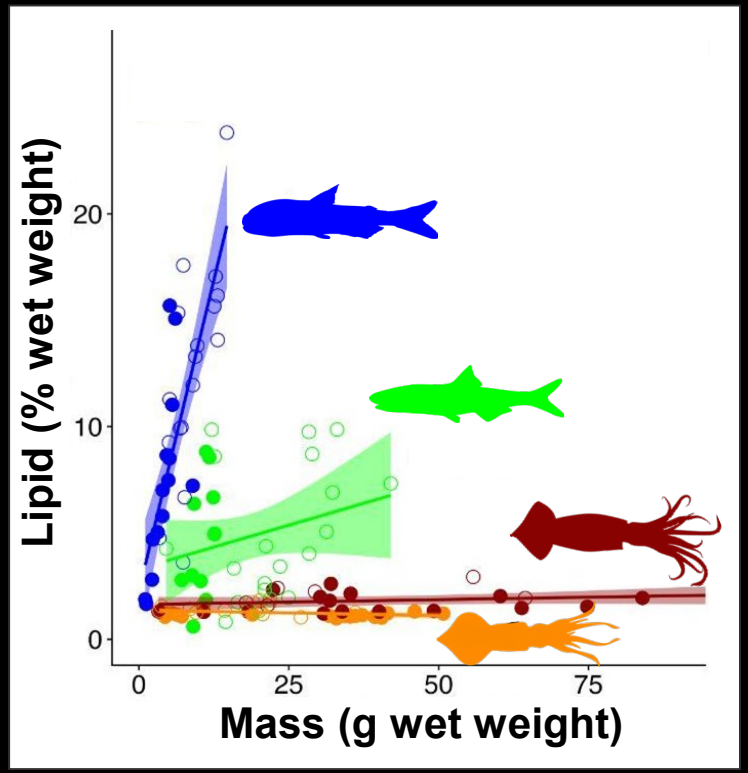
Anela Choy



Elan Portner



Elizabeth Daly





Alana Krug-MacLeod (MS student)



Northern Anchovy



California lanternfish (Myctophidae)



Market Squid



Boreal Clubhook Squid

Krug-MacLeod et al. (2026) *Fisheries Oceanography*



Anela Choy



Elan Portner



Elizabeth Daly

SCRIPPS INSTITUTION OF OCEANOGRAPHY

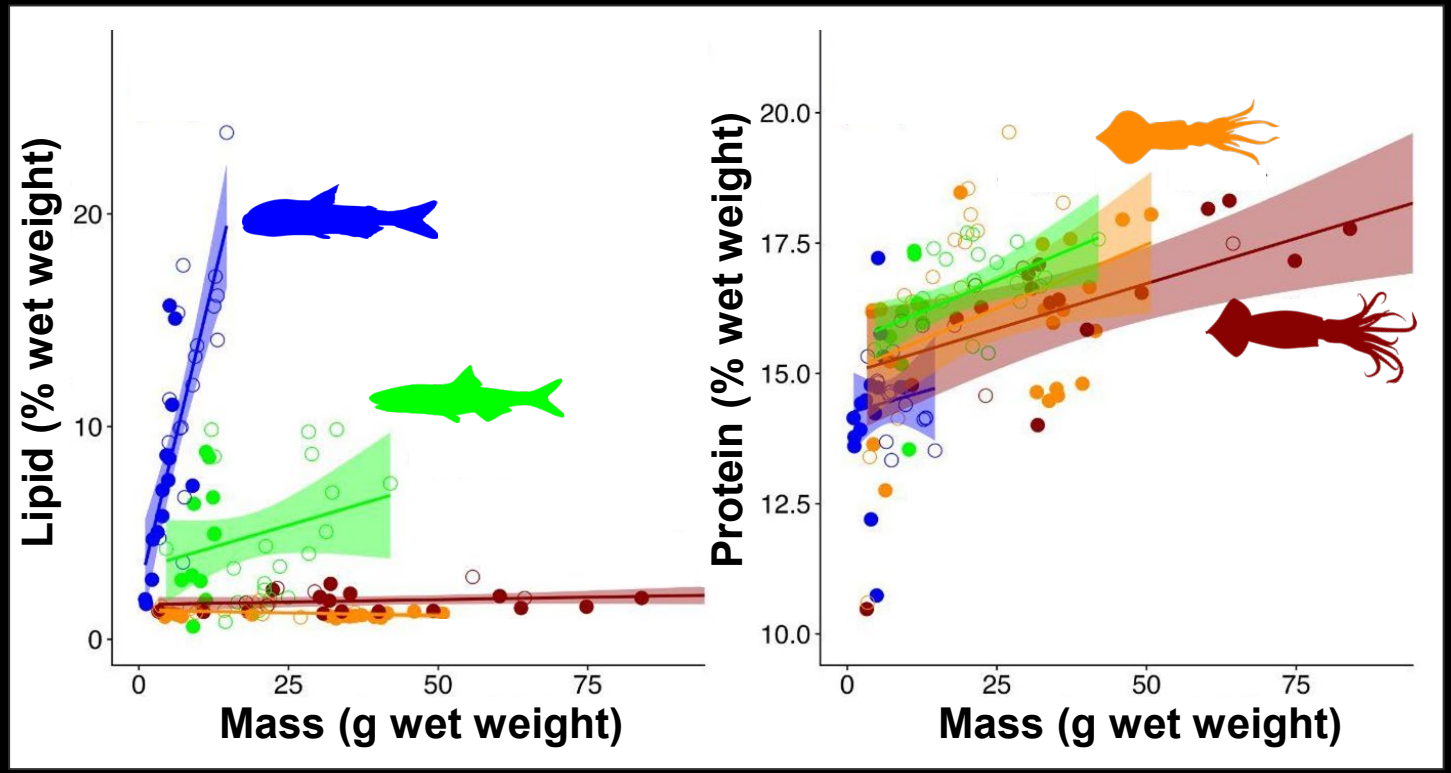
Oregon State University Hatfield

Trait applications

Explore drivers of nutritional quality



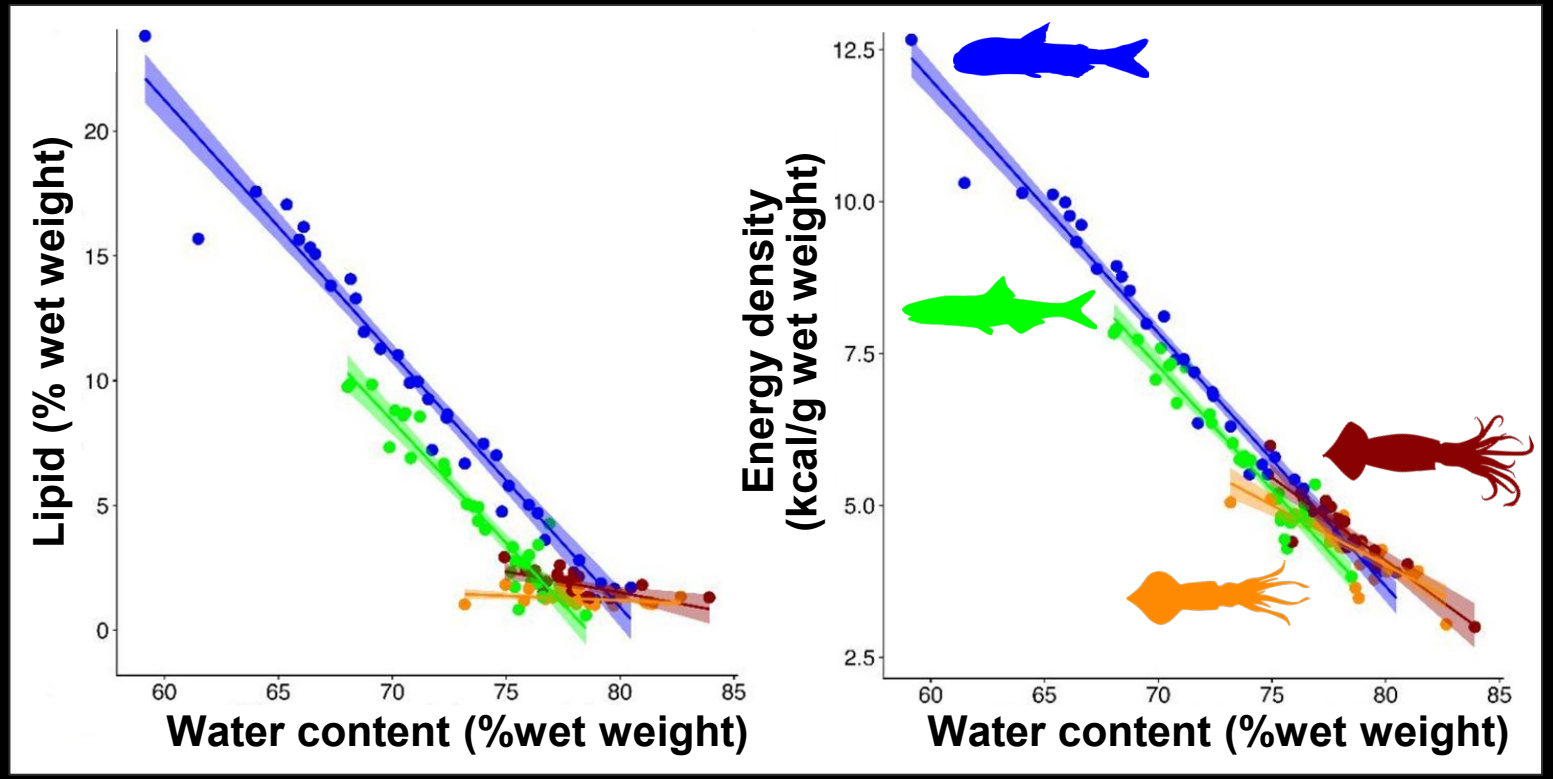
Alana Krug-MacLeod (MS student)



Krug-MacLeod et al. (2026) *Fisheries Oceanography*

Trait applications

Water is a useful proxy for nutrition!

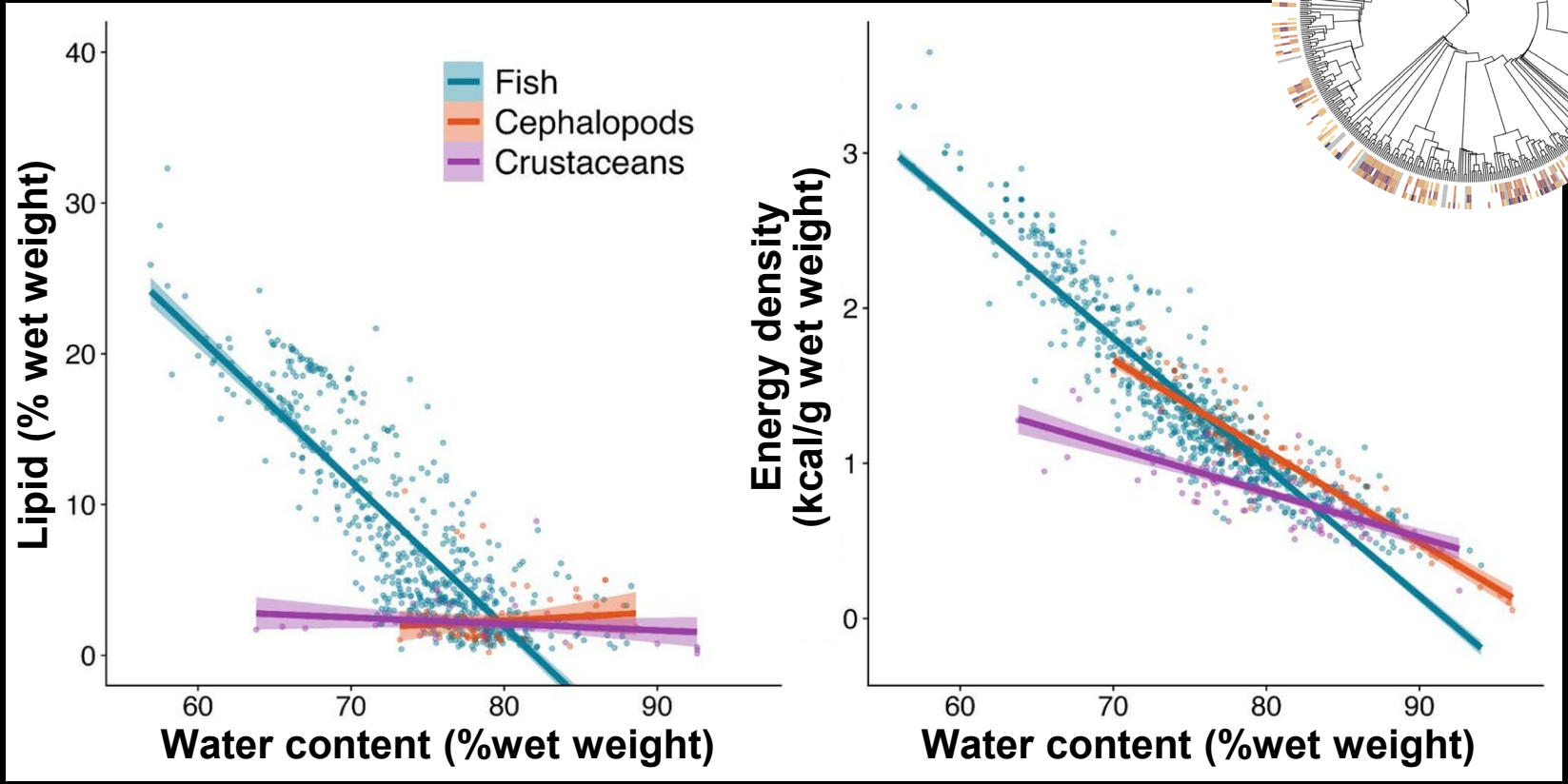


Krug-MacLeod et al. (2026) *Fisheries Oceanography*

Trait applications

Water is a useful proxy for nutrition!





Trait applications

Drivers of predator nutritional condition



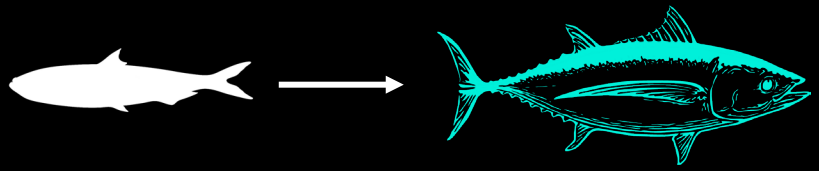
Owyn Snodgrass



Barbara Muhling



Travis Richards



Prey quality

Body quality (weeks-months)

Energy reserves





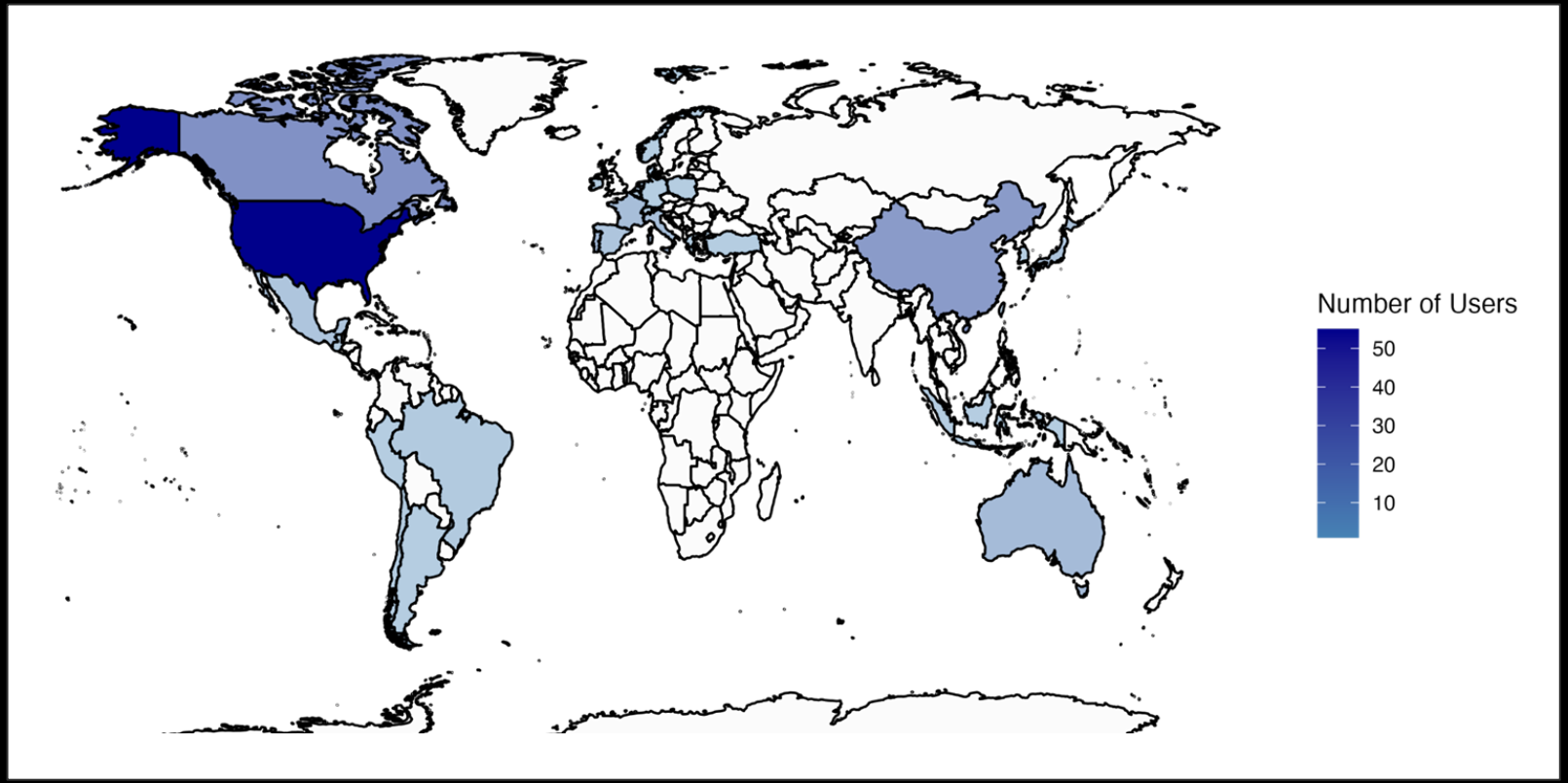
Albacore Research Foundation

DEPTH PERCEPTION CHARTERS

Cooperative fisheries sampling

Database users by country

250 users across 34 countries



Trait applications

17 published studies across 9 regions

RESEARCH ARTICLE

Journal of Animal Ecology

Resource partitioning among pelagic predators remains stable despite annual variability in diet composition

Elan J. Portner[1] | Barbara A. Muhling[2,3] | Antonella Preti[2,3] | Owyn E. Snodgrass[3] | Travis M. Richards[2,3] | Catherine F. Nickels[2,3,4] | Heidi Dewar[3] | Elliott L. Hazen[5] | C. Anela Choy[1]

Advancing Ecological Understanding and Sustainable Management of Small Pelagic Fish

Myron A. Peck[1,2] | Ignacio A. Catalán[3] | Ryan R. Rykaczewski[4] | Akinori Takasuka[5] | Susana Garrido[6] | Rebecca G. Asch[7] | Matthew R. Baker[8] | Noelle M. Bowlin[9] | Jennifer Boldt[10] | Richard D. Brodeur[11] | Cecilie Hansen[12] | Salvador E. Lluch-Cota[13] | Martin Huret[14] | Francis Juanes[15] | Isaac C. Kaplan[16] | Stefan Koenigstein[17] | Marta Moyano[18,19] | Rubén Rodríguez-Sánchez[20] | Christopher N. Rooper[8] | Dongwha Sohn[21] | Motomitsu Takahashi[22] | Desiree Tommasi[9,23] | Robert P. Wildermuth[9,23]

Climate change and its effects on the marine food web with a concentration on the pelagic fishery in the northern Arabian Sea

Imtiaz Kashani*, Sher Khan Panhwar, Kishwar Kumar Kachhi

Journal of Biogeography

RESEARCH ARTICLE | Open Access

Composition and Functional Diversity of Juvenile Groundfish Assemblages in the California Current

Ryan Gasbarro, Jarrod A. Santora, Megan Cimino, Adena Schonfeld, Steven J. Bograd, Elliott L. Hazen, Brian K. Wells, John C. Field

Home › Coral Reefs › Article

Inside the mesophotic zone: taxonomic and trait diversity of epifauna associated with black coral forests across an oceanic archipelago

Research | Published: 08 September 2025

Volume 44, pages 1683–1701, (2025) Cite this article

Trait applications

Extension to other predators

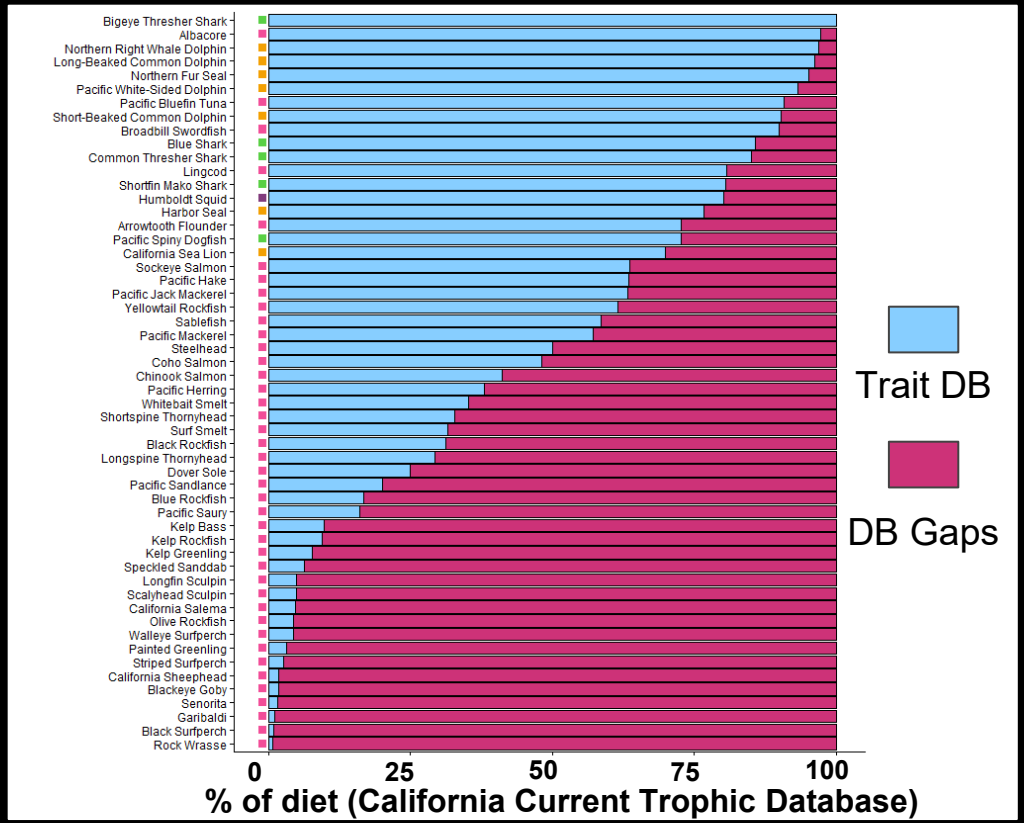








High overlap between diet composition and trait database



Bizzaro et al. (2023) *Frontiers in Marine Science;* Gleiber et al. (2024) *Scientific Data*

Thank you

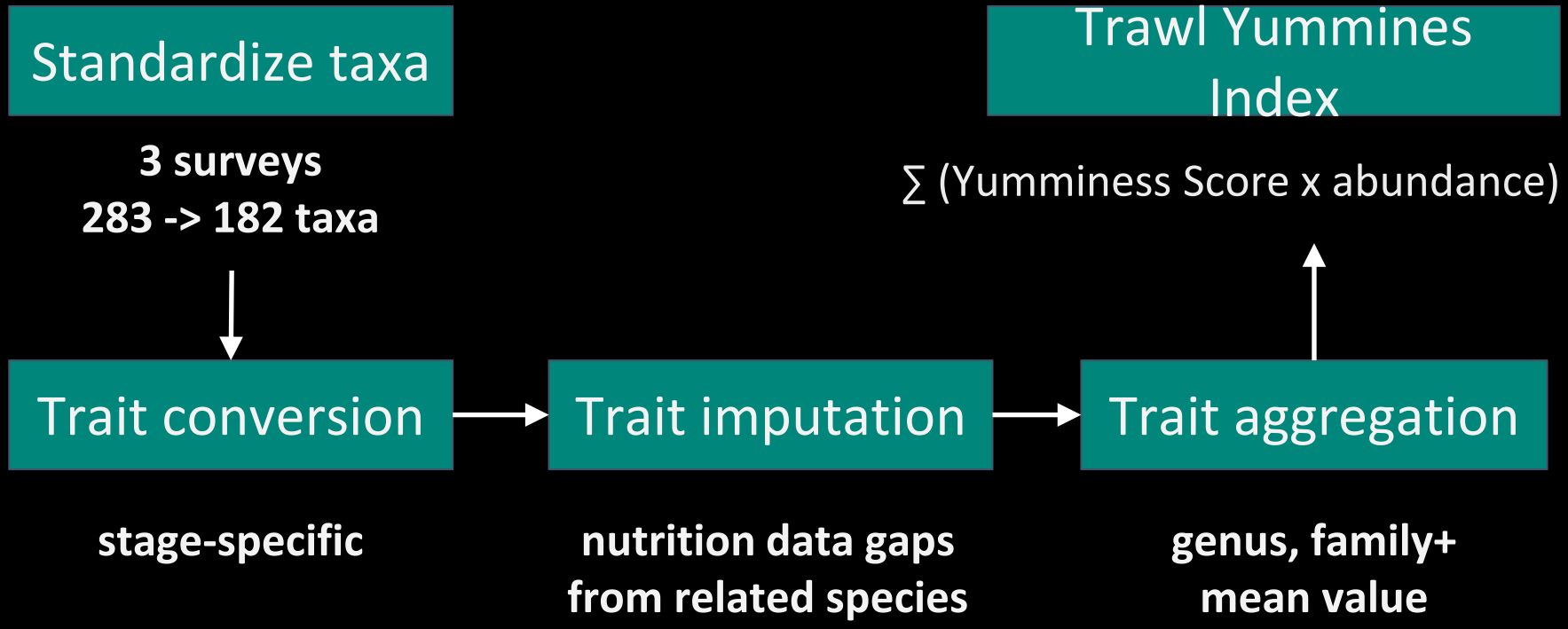
miramgleiber@gmail.com
stephanie.green@ualberta.ca

Learn more about our trait-based research

Stop by our poster tonight!

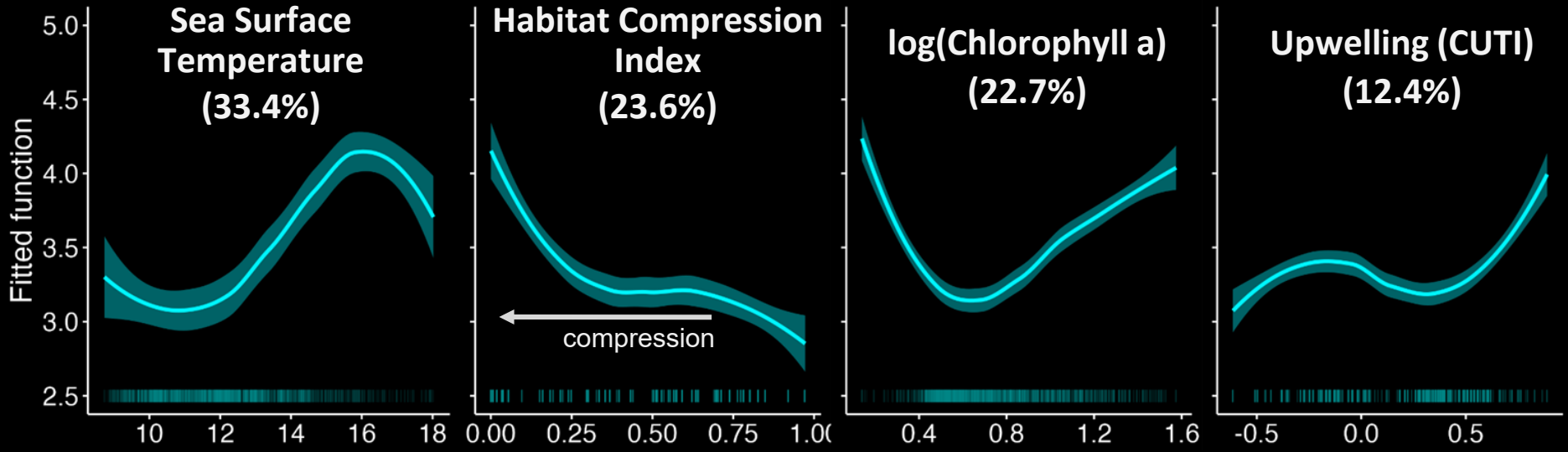


California Current forage community traits



Yumminess Index ~ SST + HCI + log(Chl a) + CUTI

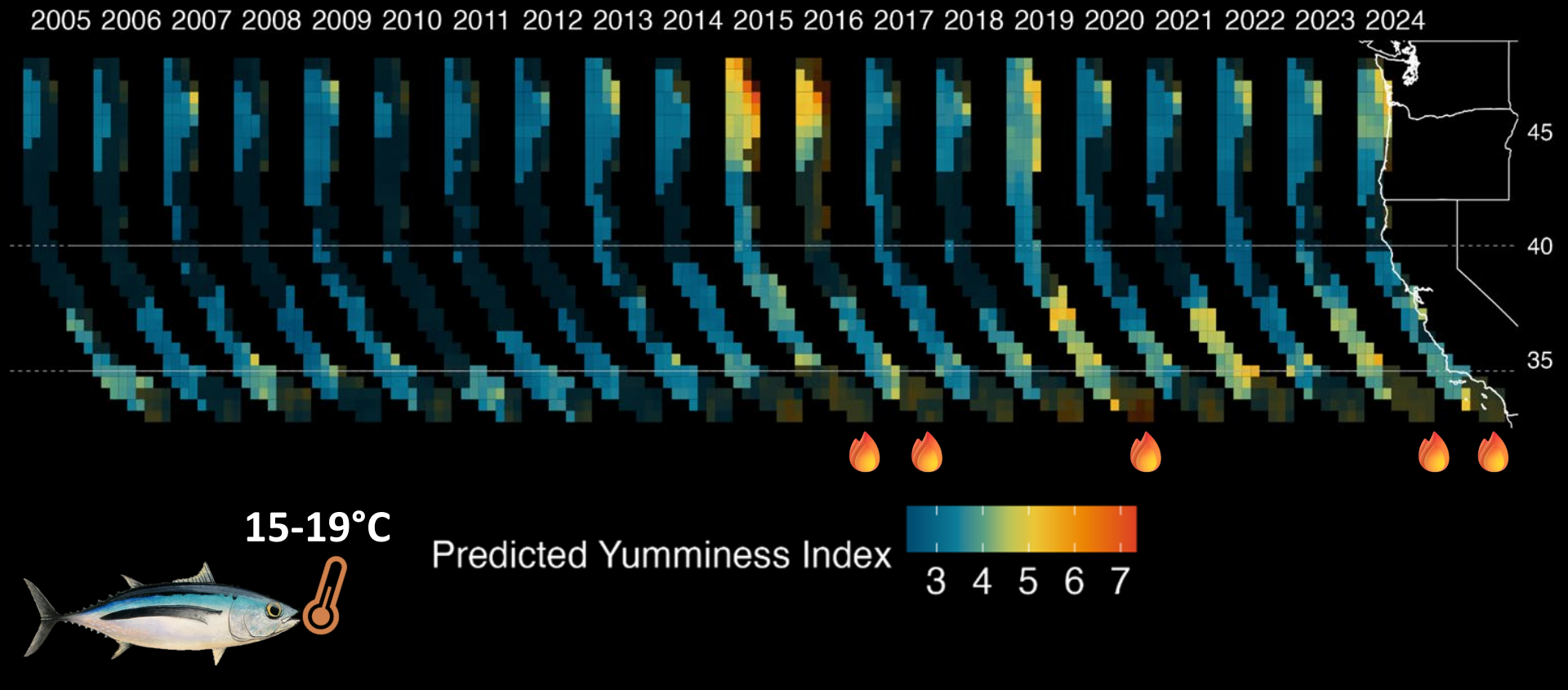
CV Dev_{test} = 0.27 Prior conditions: Nov-April mean



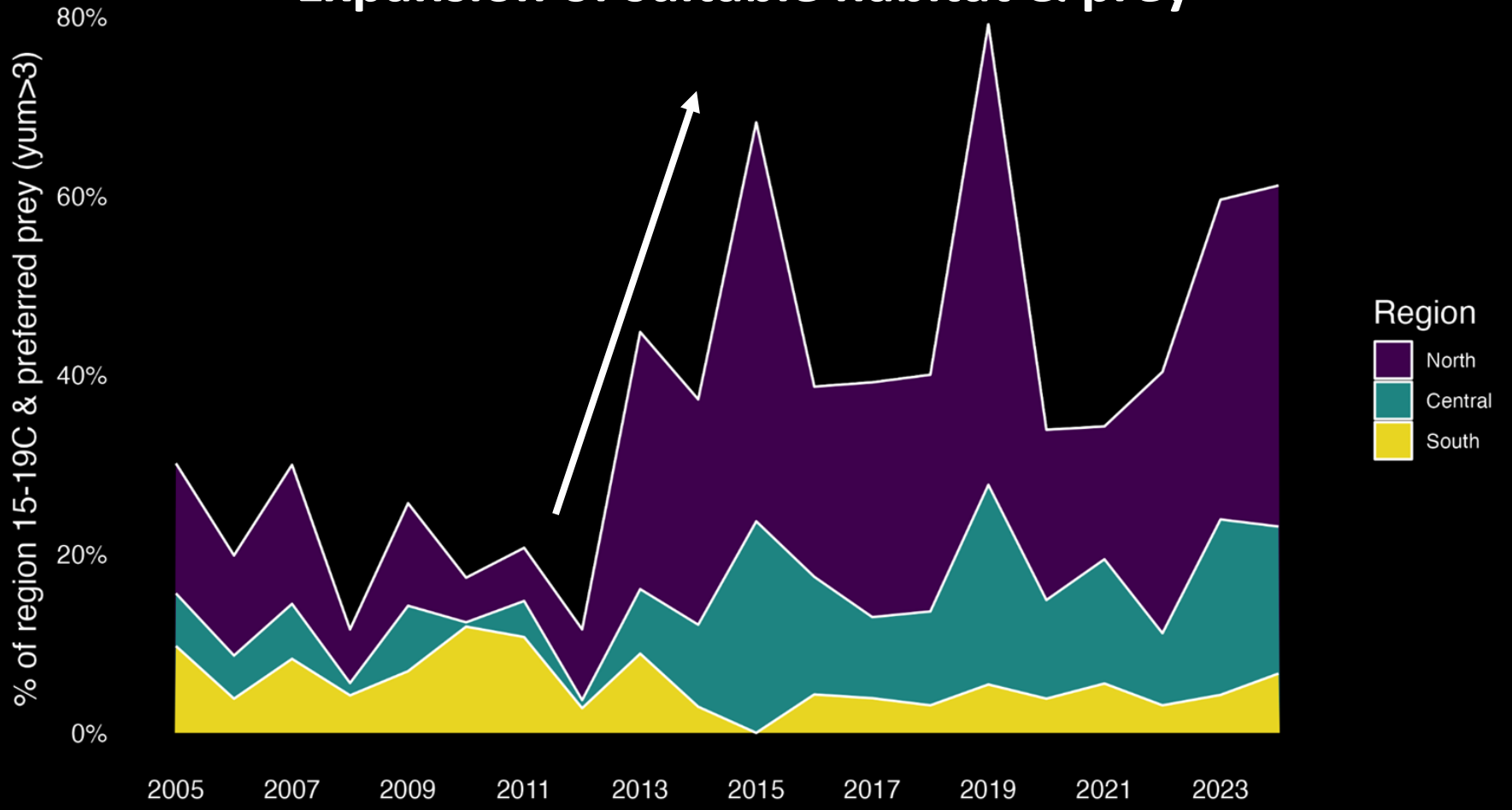
Train: 80%; Test: 20% withheld

tree complexity = 3, learning rate = 0.005, trees = 5050

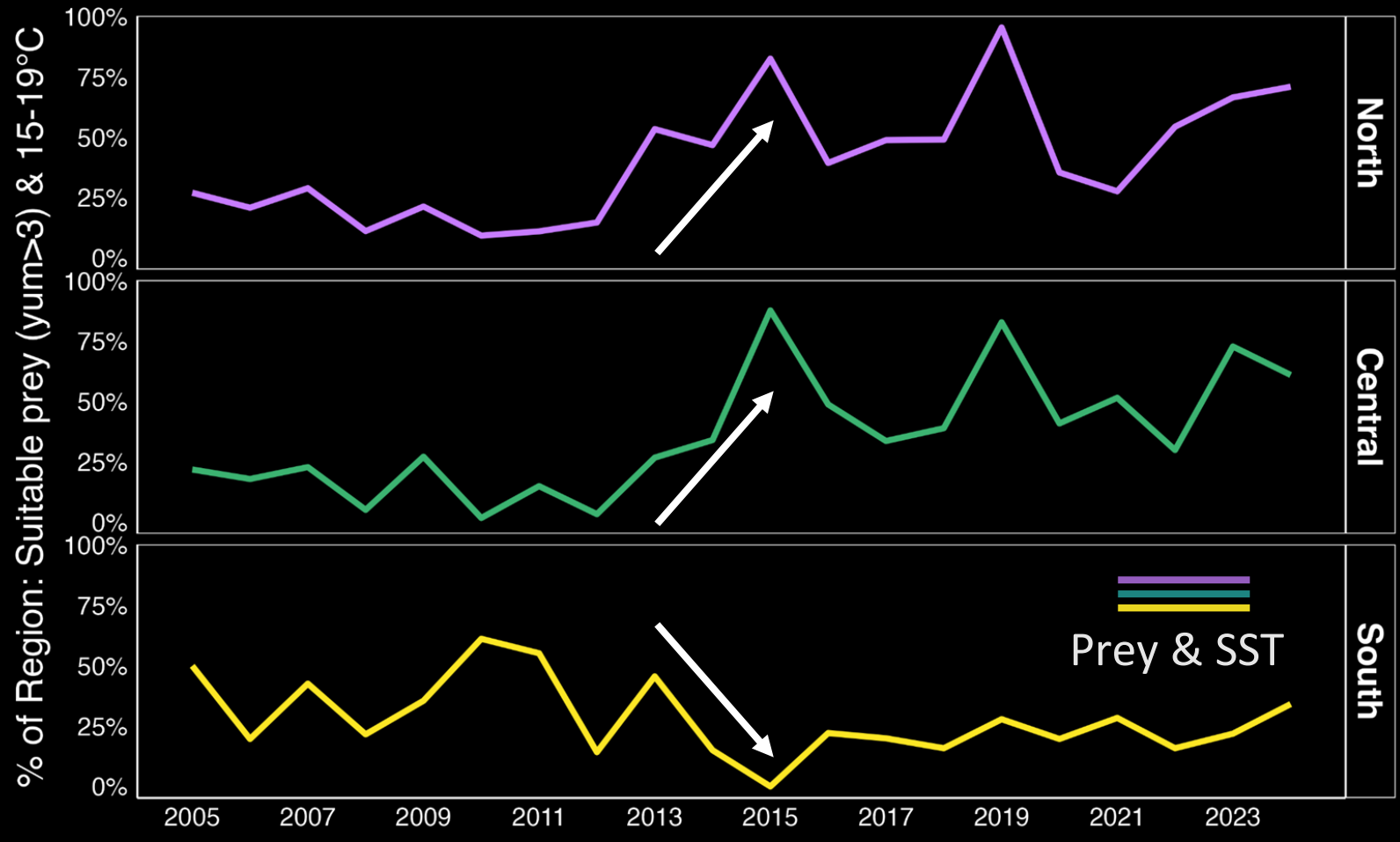
Suitable prey constrained by optimal temperature



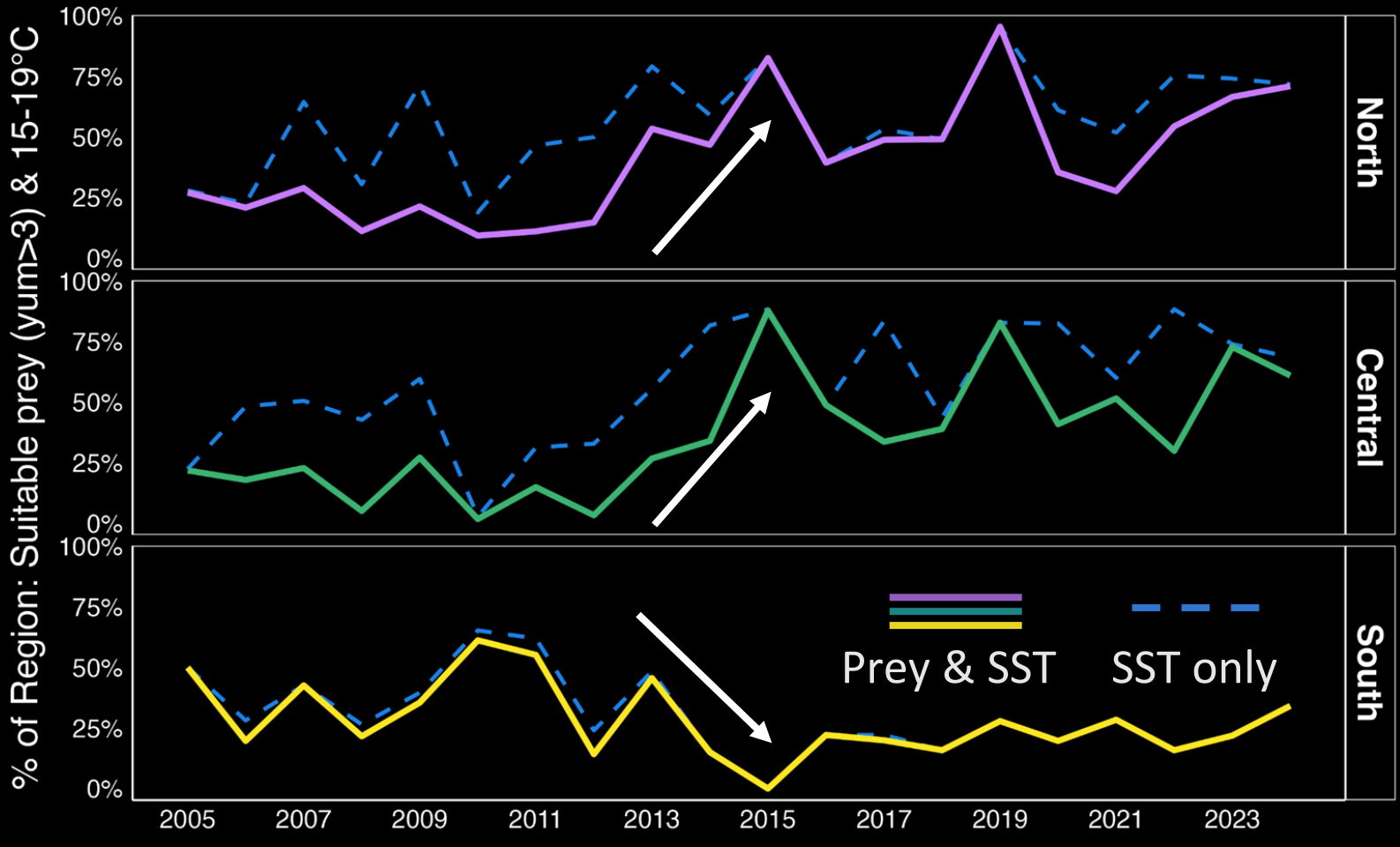
Expansion of suitable habitat & prey

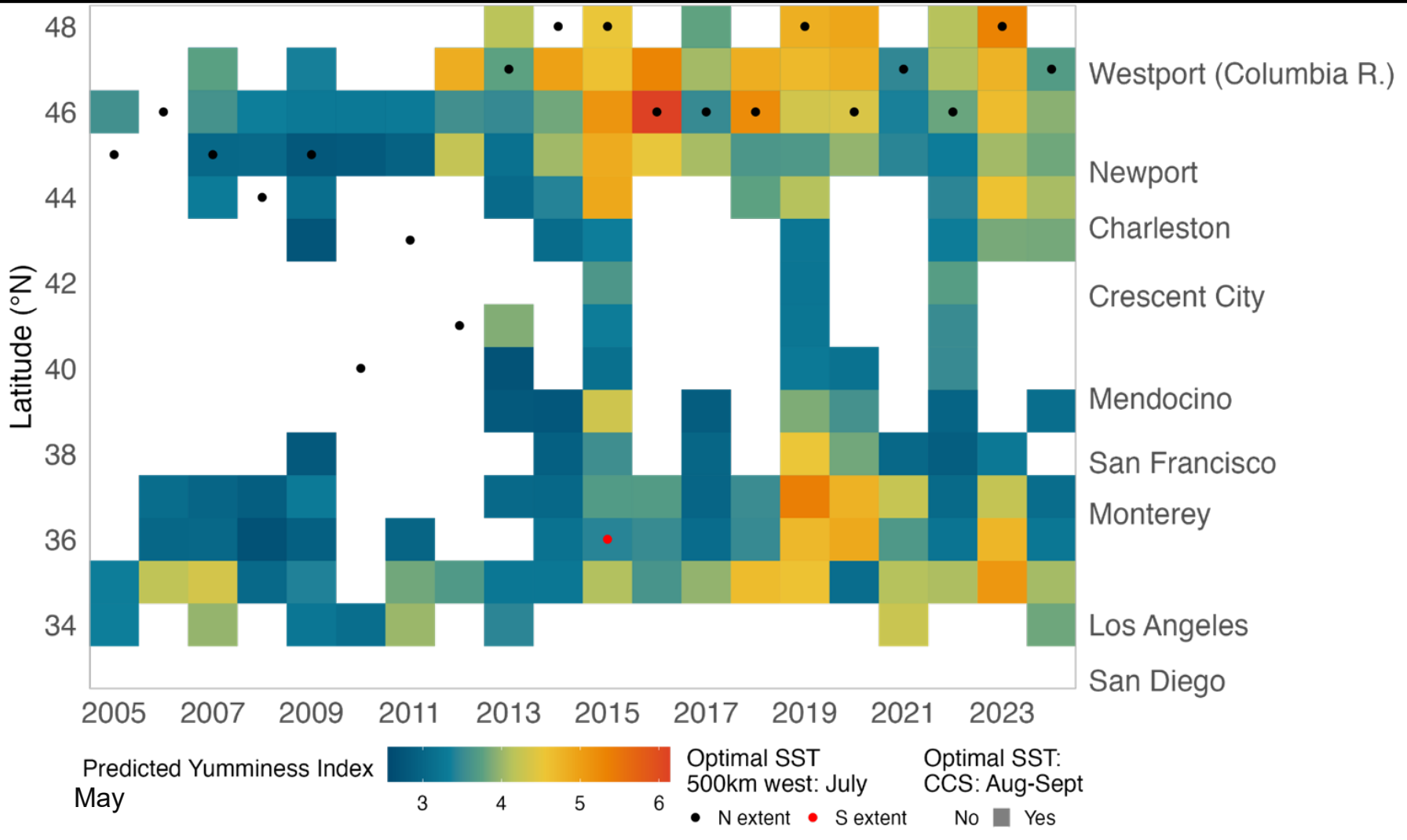


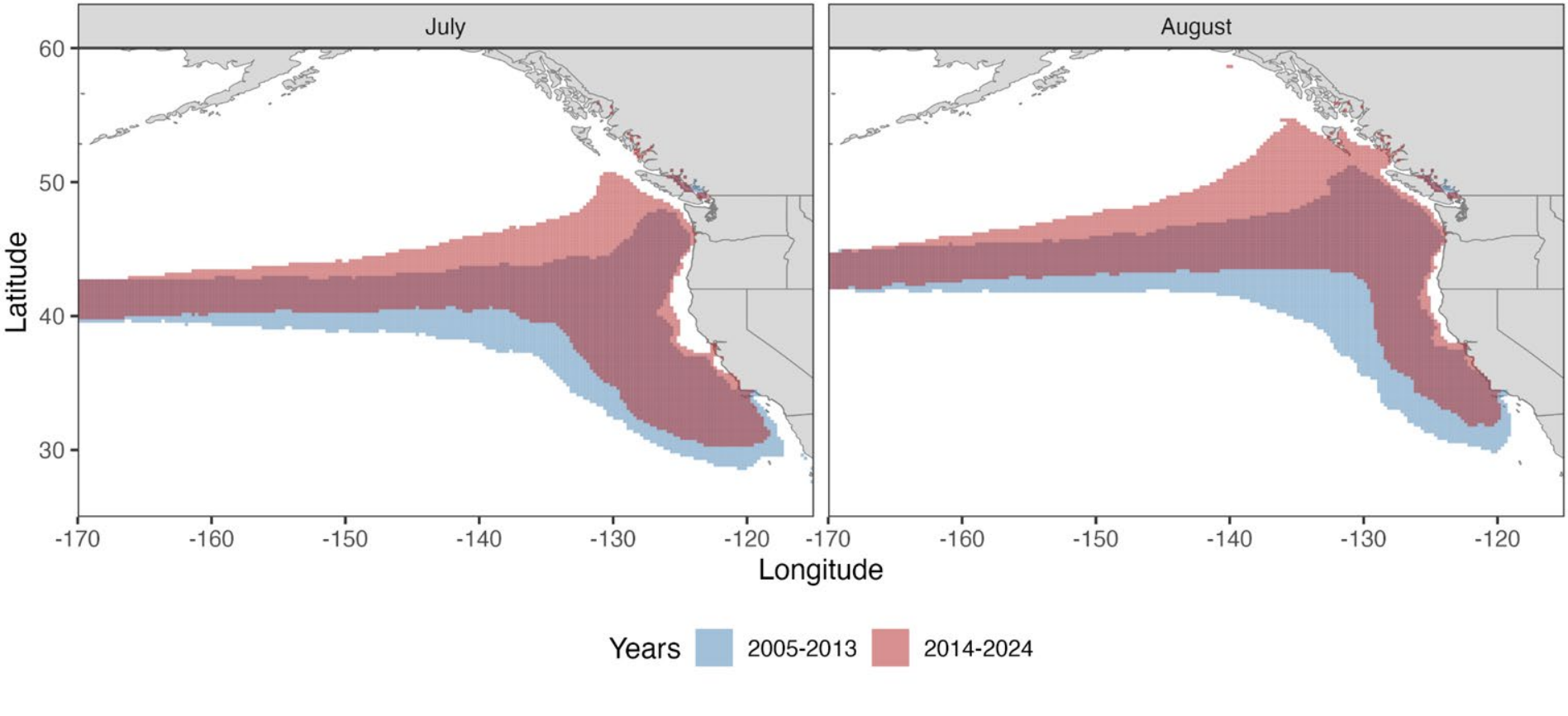
Expansion of suitable habitat in North/Central



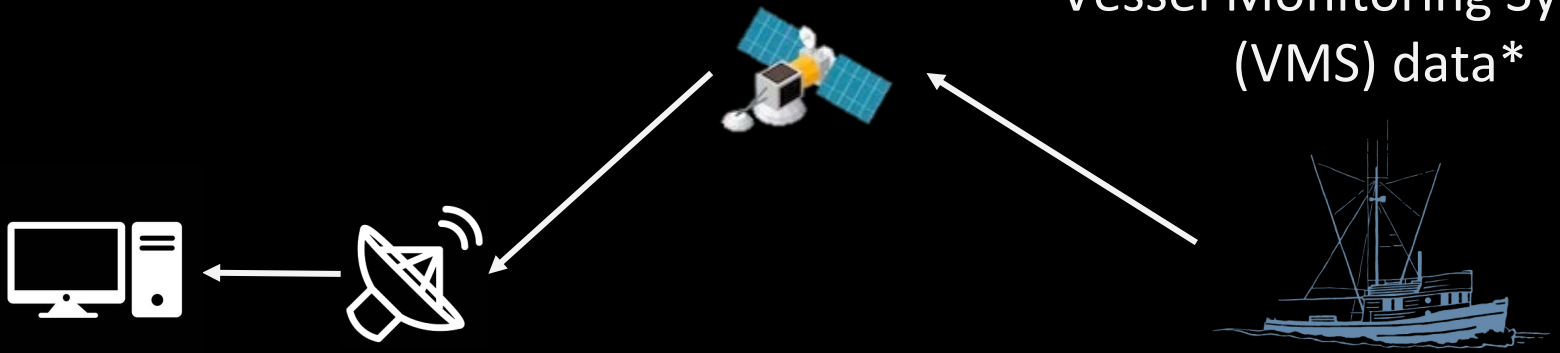
Considering prey tells us more than SST-alone




Latitude (°N)
48
46
44
42
40
38
36
34
2005
2007
2009
2011
2013
2015
2017
2019
2021
2023
Westport (Columbia R.)
Newport
Charleston
Crescent City
Mendocino
San Francisco
Monterey
Los Angeles
San Diego
Predicted Yumminess Index
May
3
4
5
6
Optimal SST
500km west: July
N extent
S extent
Optimal SST:
CCS: Aug-Sept
No
Yes


15–19°C thermal corridor
July
August
60
50
40
30
Latitude
-170
-160
-150
-140
-130
-120
Longitude
Years
2005-2013
2014-2024

Biological validation with fishery data



Vessel Monitoring Systems (VMS) data*

2010-2024

(n = 596 vessels)

* Welch et al. (2025) *PNAS*



Biological validation with fishery data

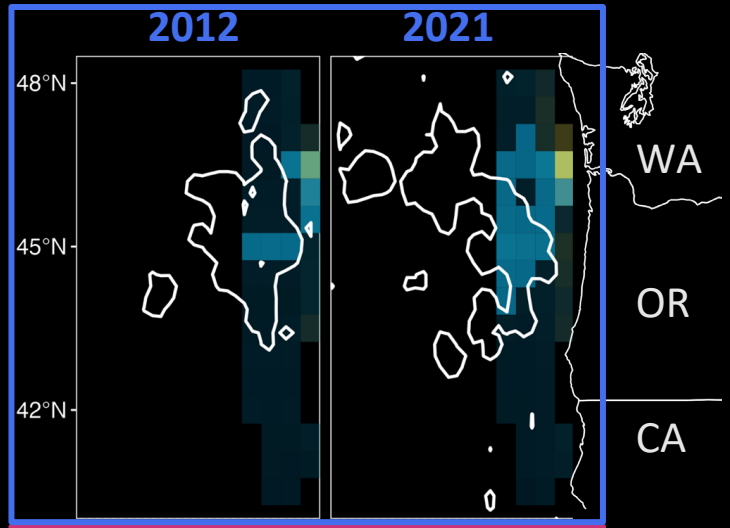
Vessel Monitoring Systems (VMS) data*

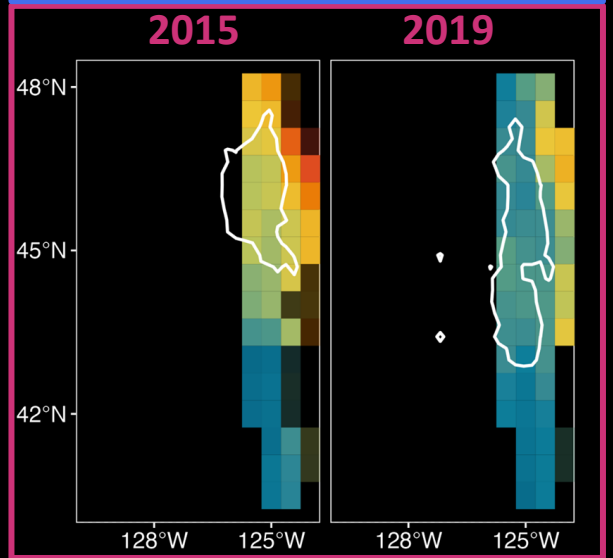




= >75% albacore fishing vessel locations

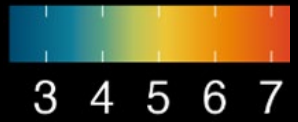
* Welch et al. (2025) *PNAS*





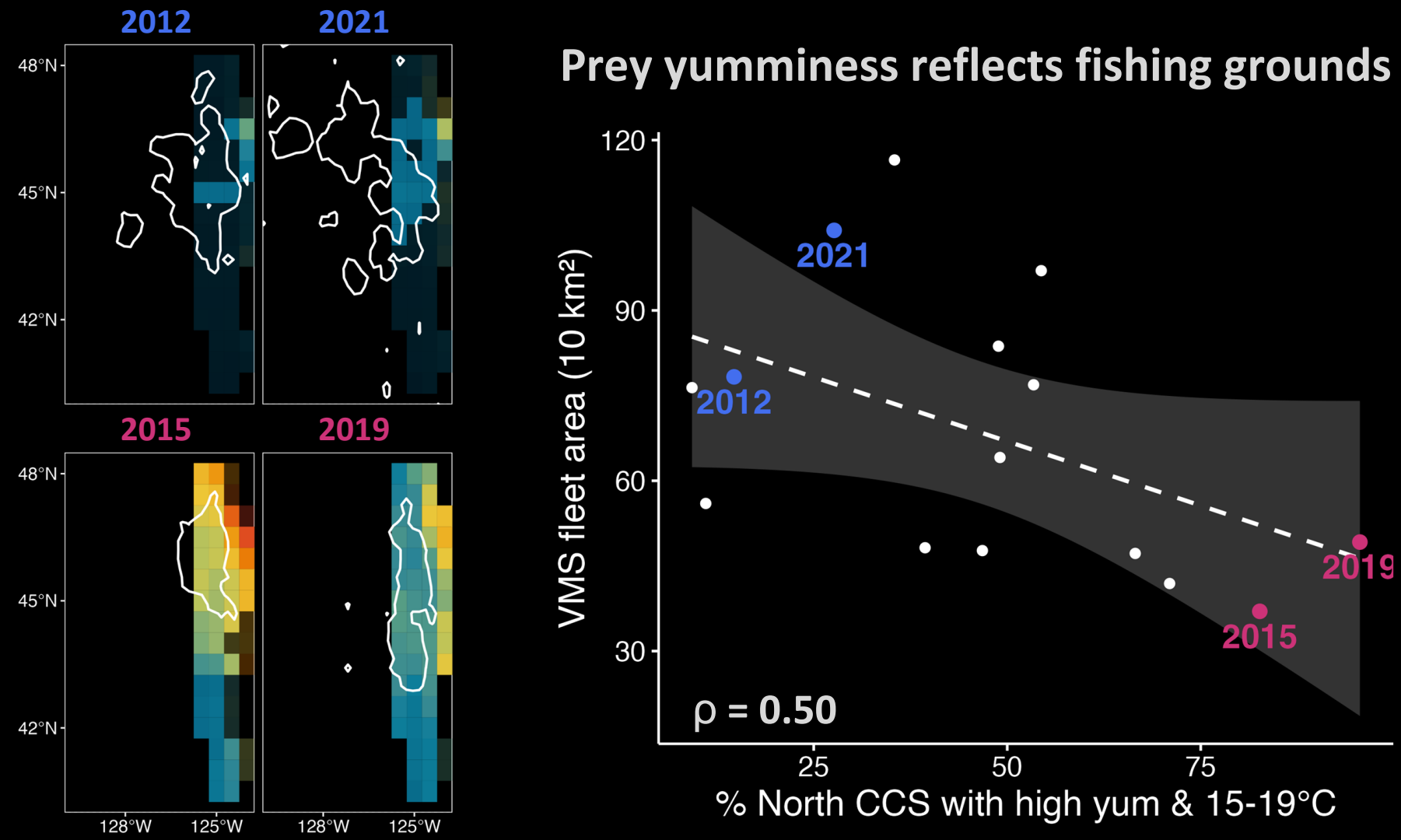
Biological validation with fishery data

Yumminess Index





= >75% albacore fishing vessel locations


2012
2021
2015
2019
48°N
45°N
42°N
128°W
125°W
Prey yumminess reflects fishing grounds
VMS fleet area (10 km²)
120
90
60
30
2021
2012
2019
2015
ρ = 0.50
25
50
75
% North CCS with high yum & 15-19°C

Albacore suitable habitat predictions: prey vs environment-only*



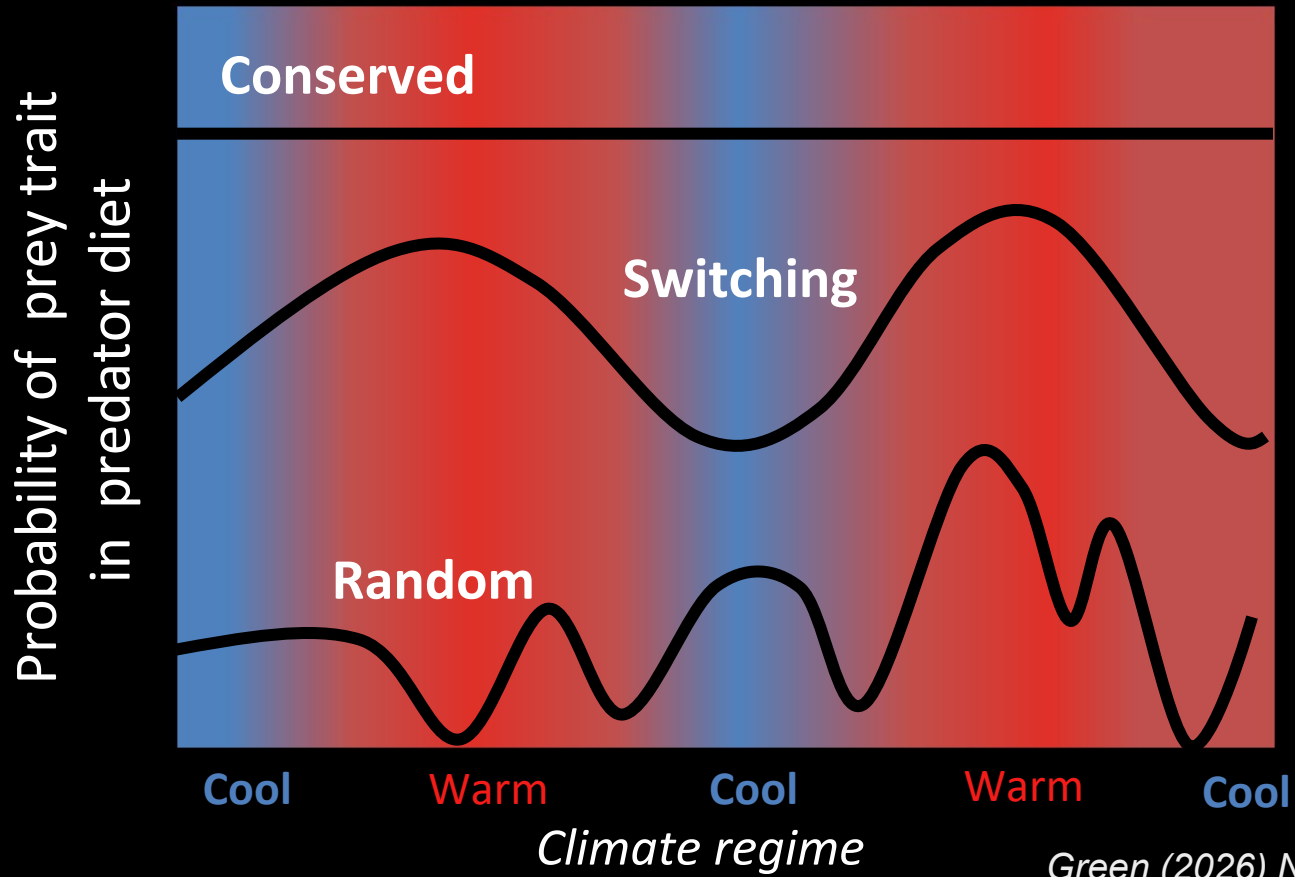


- Low correlations

- Variance: prey + sst > environment-only

* Welch et al. (2023) *Nature Comm.*

Trait-based predictions for prey tracking



Green (2026) Navigating to Solutions

NE Pacific Albacore

- Unique, sustainable fishery
  - high quality product
  - low bycatch
  - open access, flexible





Oregon Albacore Commission



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