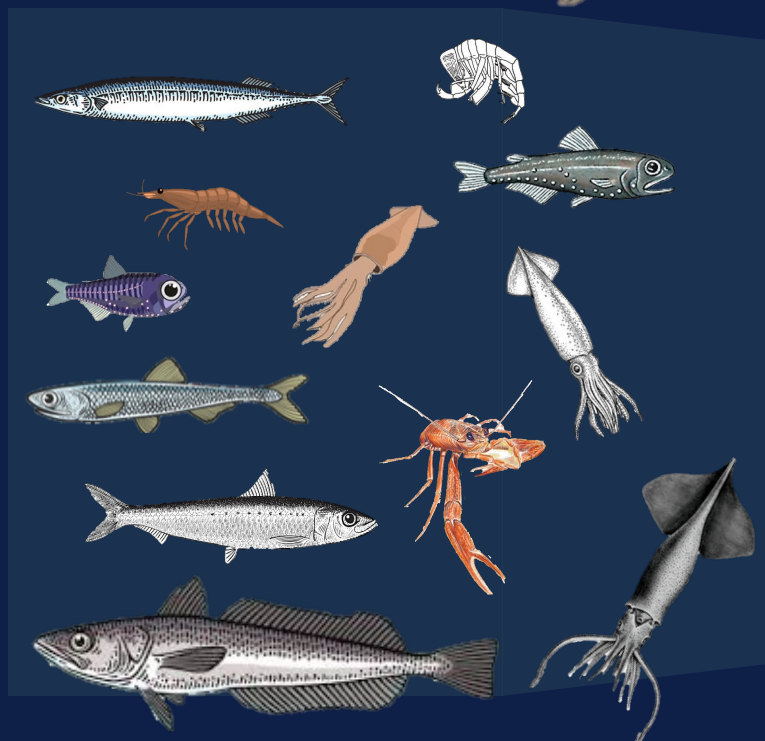
Integrating forage surveys, diet studies, and trait information to explore prey preferences of albacore tuna (*Thunnus alalunga*)

Miram Gleiber, Natasha Hardy, Caitlin Morganson, Catherine Nickels, Barbara Muhling, Jarrod Santora, Richard Brodeur, Brian Wells, Toby Auth, Dan Madigan, Elliott Hazen, Larry Crowder, Stephanie Green

How will the abundance & distribution change into the future?

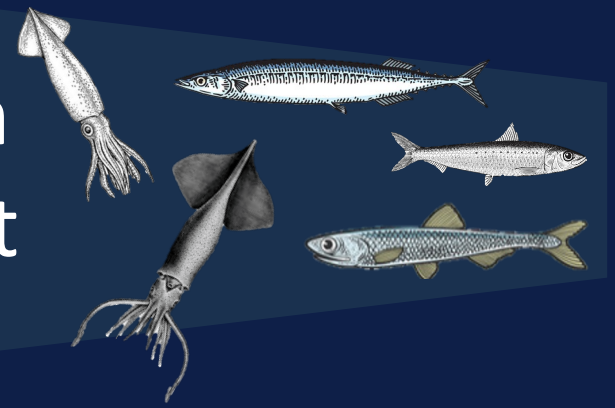
Predators are selective



Proportion prey in environment

≠

Proportion prey in diet



Aggregation behavior

Habitat position

Nutritional value

Physical defenses

Encounter → **Attack** → **Capture** → **Consume**

Activity pattern (e.g. diel migration)

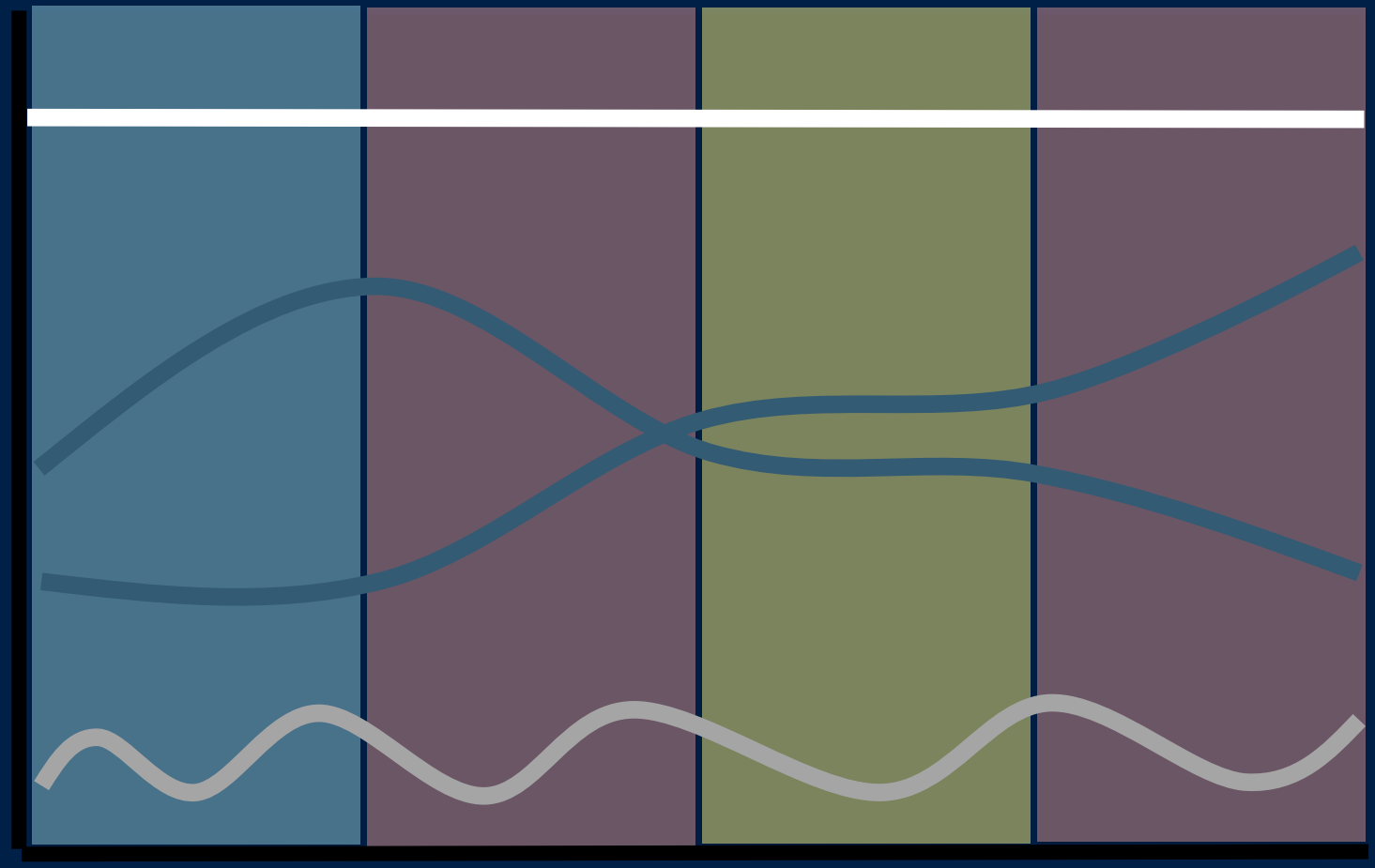
Coloration

Body shape

Body size

Lindardich, Brookson, Green (2021), Green et al (2019), Green & Côté (2014)

Trait-based predictions for future change



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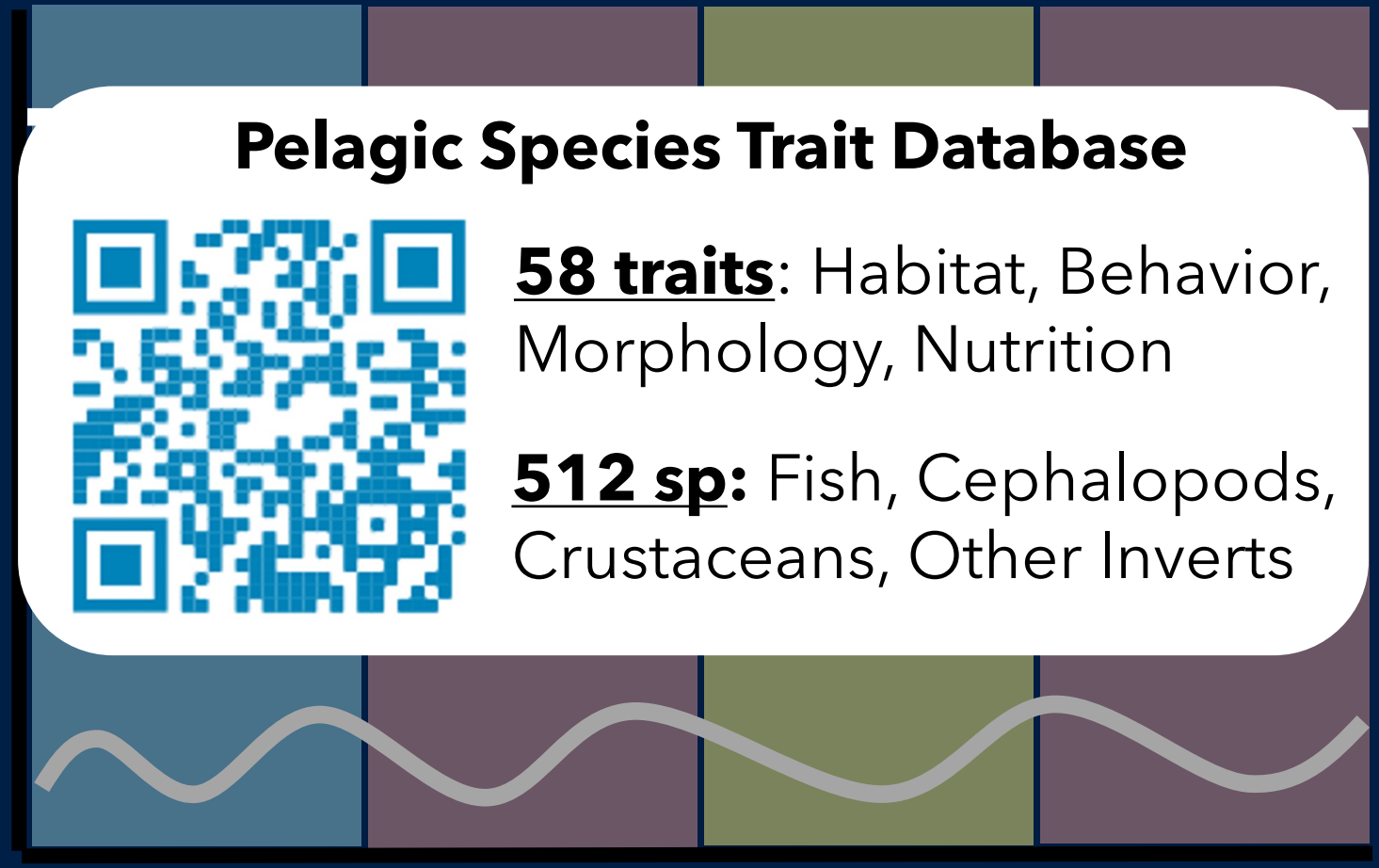
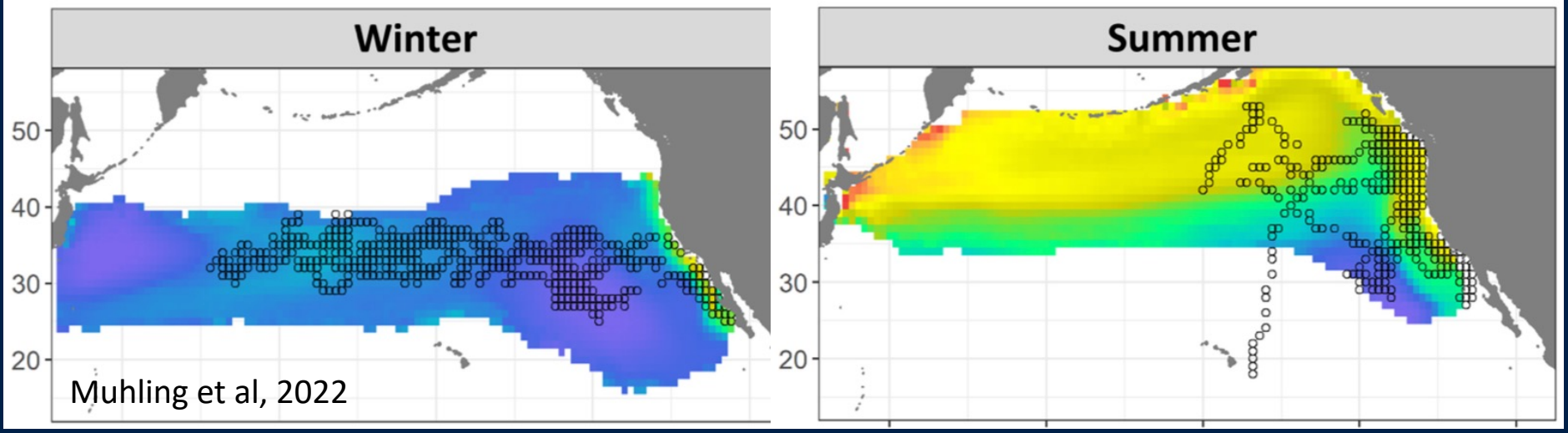


Albacore Tuna in the California Current Ecosystem (CCE)

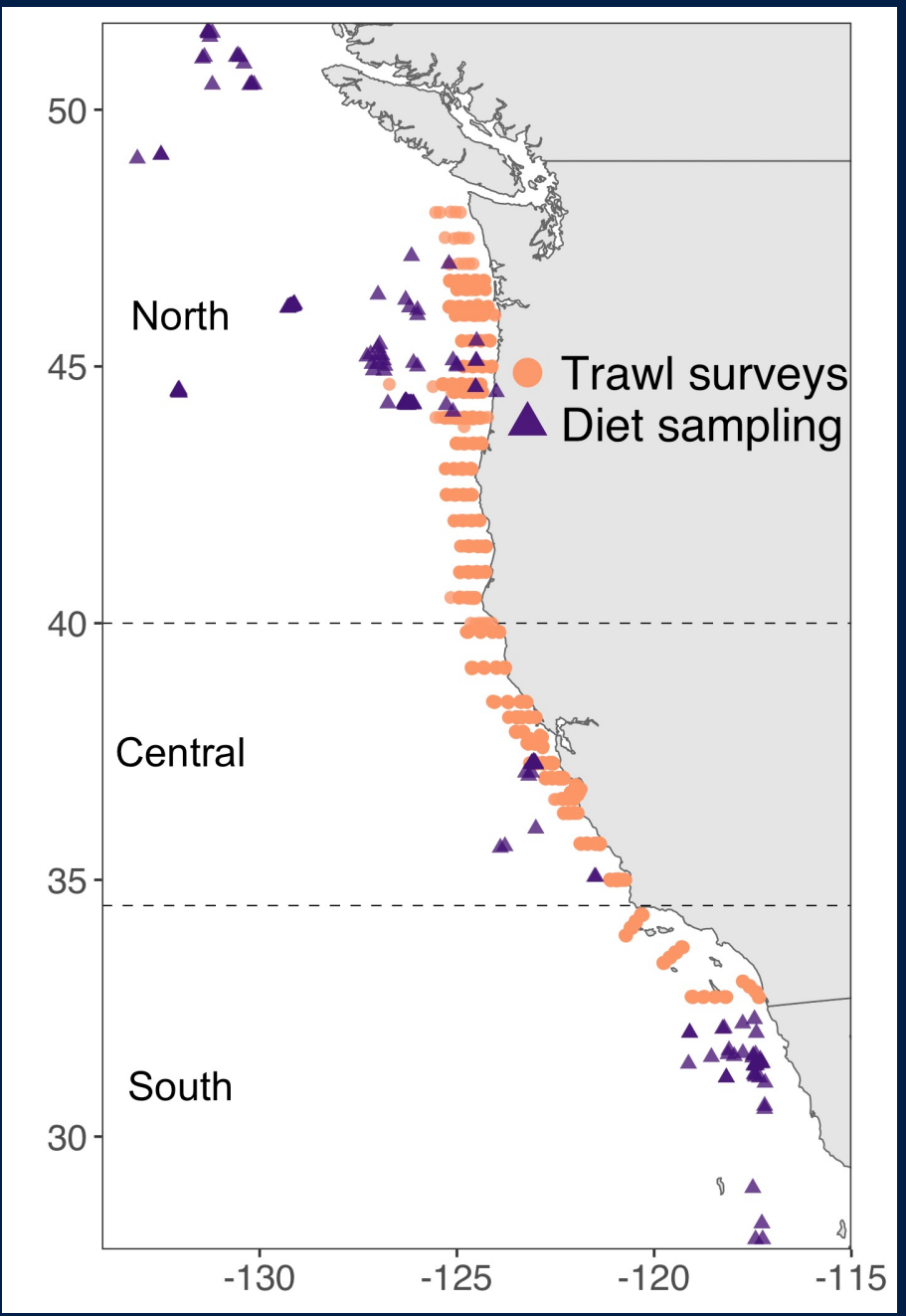


- Present June – October
- Northward distribution shift (Frawley et al, 2020)
- Diverse diet variable with environmental conditions (Nickels et al *in review*)

>100km/day
Dive >100m
Juveniles: <1m

Do albacore show selective patterns of predation across taxa and/or traits?

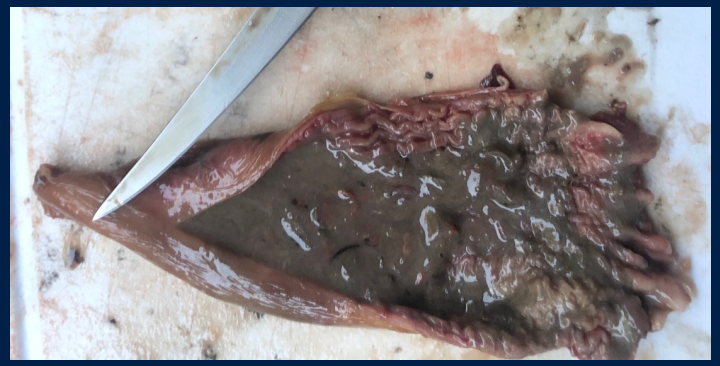
Which prey species are suitable for comparison between forage community surveys albacore diets?



Type	Dataset	Collector	Years	n
Albacore Diets	Nickels et al (*in review*)	NOAA SWFSC	2007 – 2019*	750
	Madigan et al (2015)	Dan Madigan	2008 - 2010	85
	Glaser (2010)	Sarah Glaser	2005 - 2006	371
Trawl Surveys	Rockfish Recruitment & Ecosystem Assessment Survey	NOAA SWFSC	2005 – 2018*	1684
	Stock Assessment Improvement Program	NOAA NWFSC	2005 - 2011	499
	Coastwide Cooperative Pre-Recruit Survey	NOAA NWFSC	2011 – 2019?	212

*Ongoing sampling

2005 - 2019



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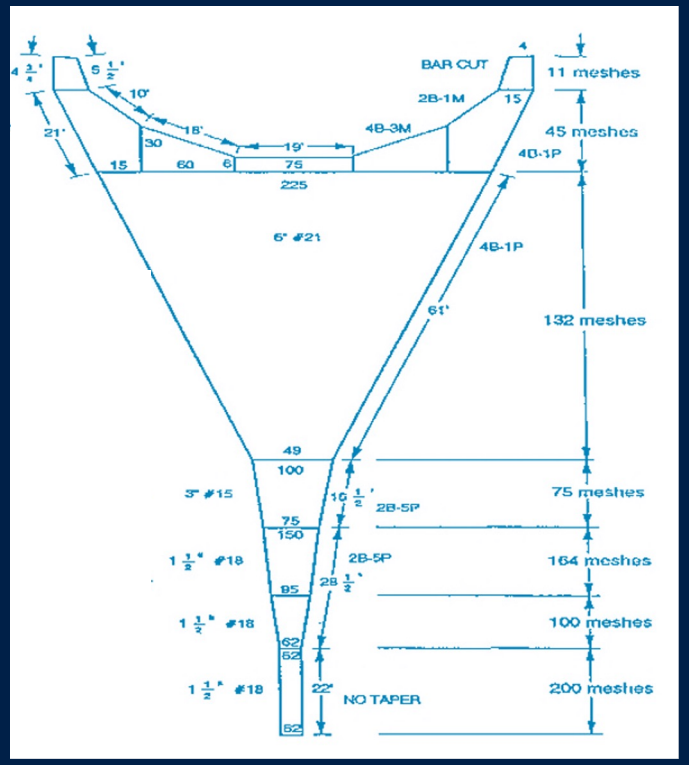
Cat Nickels

Sarah Glaser

Dan Madigan



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*Ongoing sampling

Jarrod Santora

John Field

Ric Brodeur

Brian Wells

Toby Auth

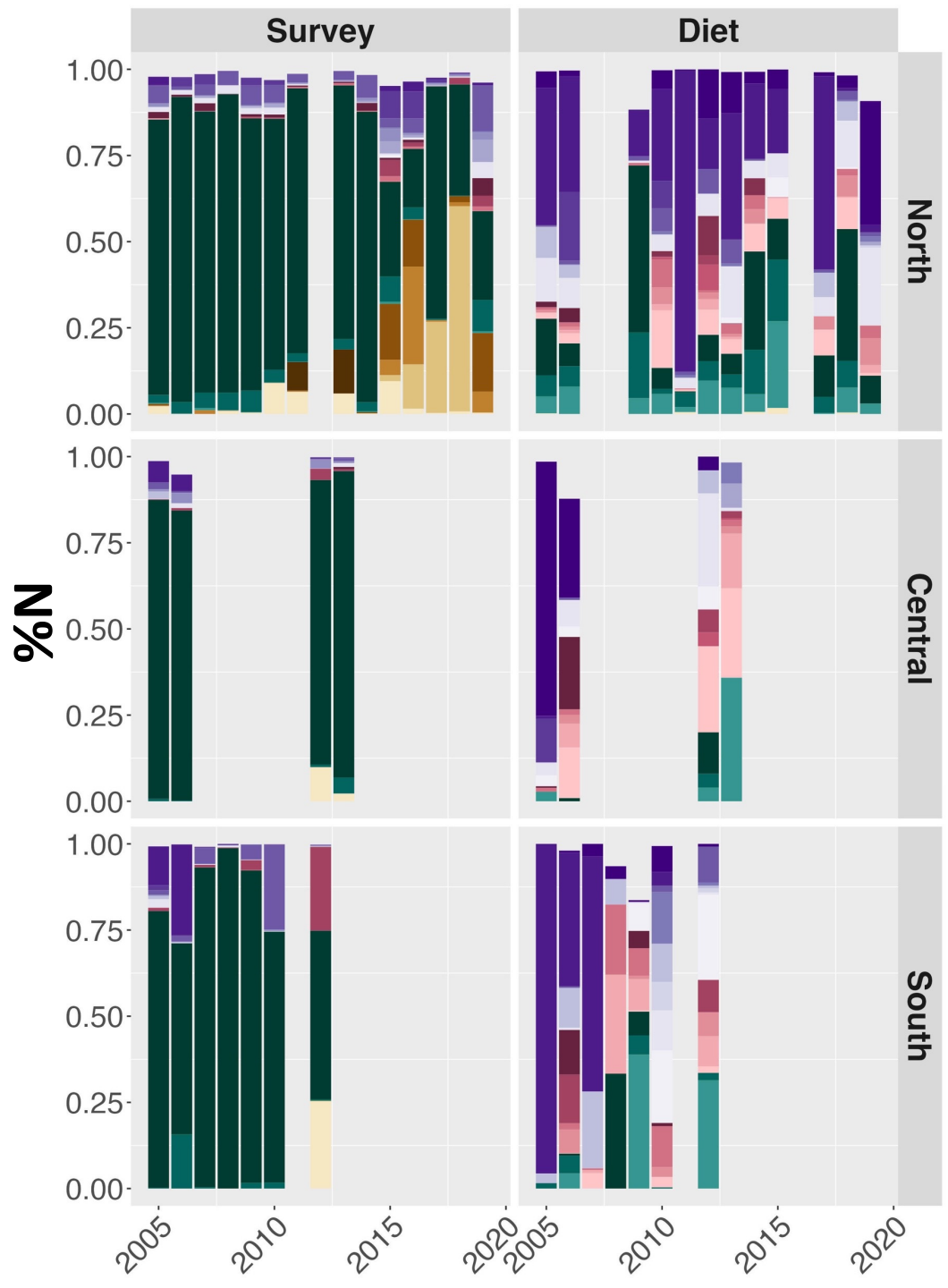
Standardizing Datasets

Use broader resolution
(E.g. decapods combined)

Proportions
p = taxon # / total #
%N = $\overline{p}$ x 100%

<1%N
158 taxa -> 32
4% diet
6% survey

*Methods follow Portner et al (2022), Nickels et al (*in review*)



Fish

- Cololabis.saira
- Engraulis.mordax
- Merluccius.productus
- Myctophidae.spp.
- Paralepididae.spp.
- Paralichthyidae.spp.
- Pleuronectidae.spp.
- Sardinops.sagax
- Scomber.japonicus
- Sebastes.spp.
- Trachurus.symmetricus

Cephalopods

- Abraliopsis.spp.
- Berryteuthis.spp.
- Doryteuthis.opalescens
- Gonatopsis.spp.
- Gonatus.spp.
- Octopoda.spp.
- Octopoteuthis.spp.
- Onychoteuthis.borealijaponica

Crustaceans

- Euphausiidae.spp.
- Decapoda.spp.
- Amphipoda.spp.

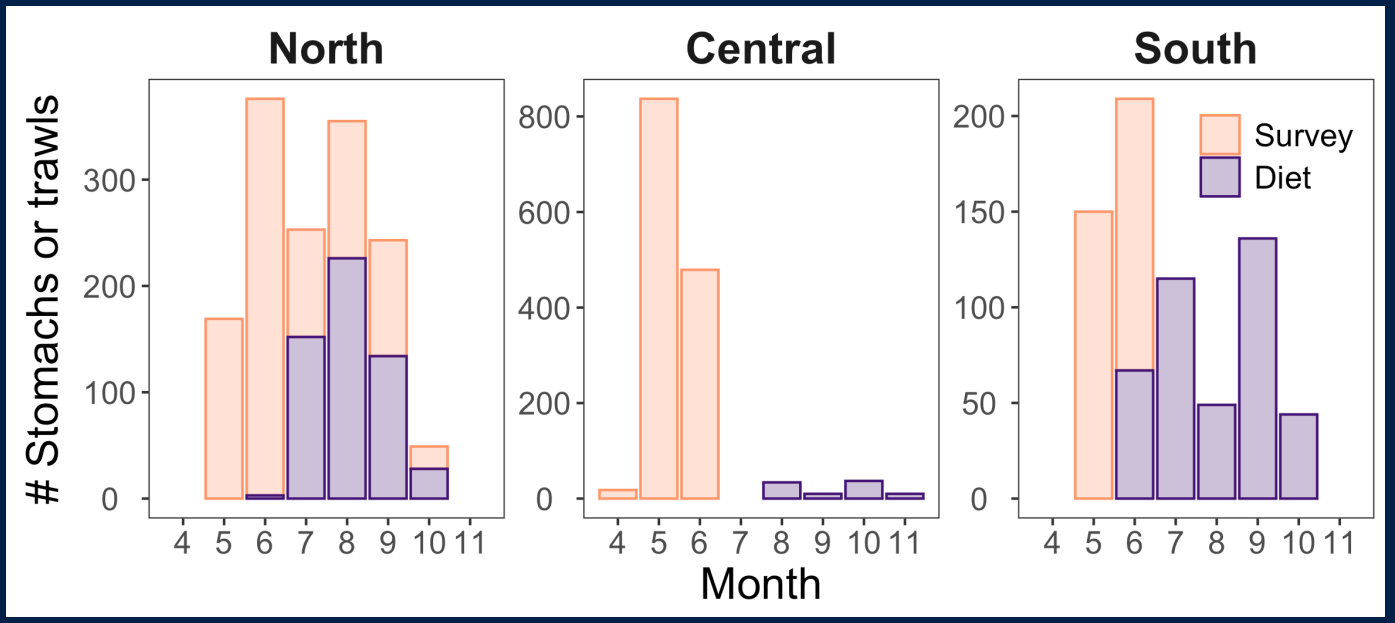
Other inverts

- Pleurobrachia.spp.
- Aequorea.spp.
- Pteropoda.spp.
- Pyrosoma.atlanticu
- Thaliacea.spp.

Interannual & regional variability

Diet & survey %N differ

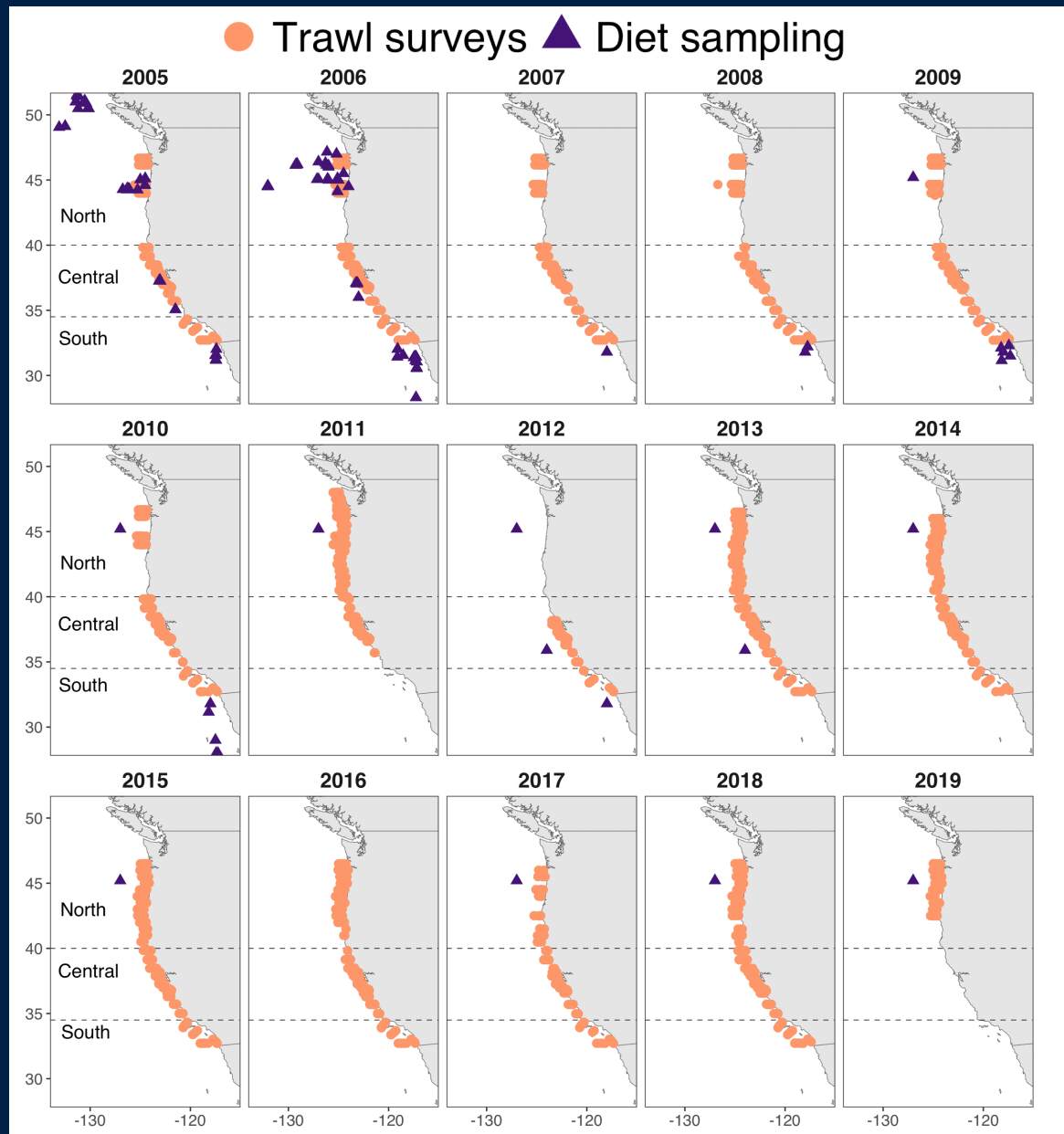
Matching data in space & time



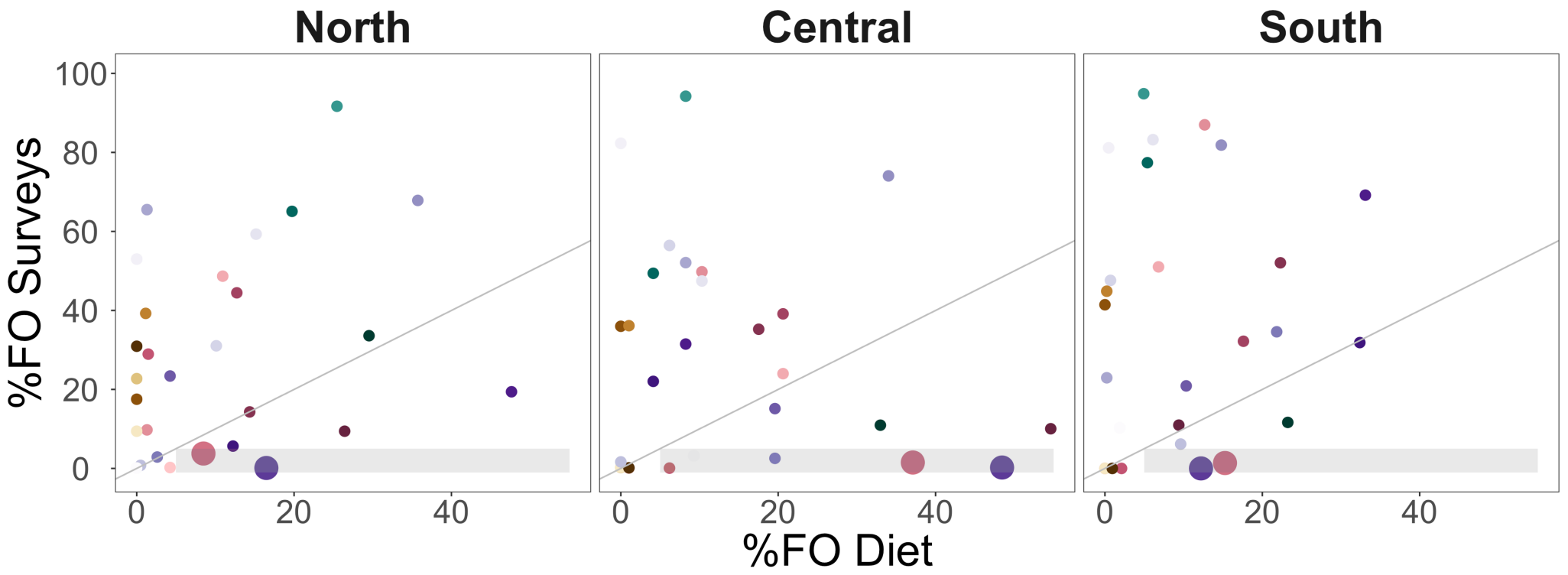
Annual-scale analyses
('State of the system' approach*)

Regions with both diet & surveys
(North & South)

*Thompson et al. (2020)



Identify species unsuitably sampled



Frequency of Occurrence (FO) =
% of stomachs or trawls a taxa is present

- Sardinops sagax
- Engraulis mordax
- Cololabis saira
- Paralepididae spp.
- Trachurus symmetricus
- Sebastes spp.
- Pleuronectidae spp.
- Scomber japonicus
- Merluccius productus
- Myctophidae spp.
- Paralichthyidae spp.
- Syngnathidae spp.

Fish

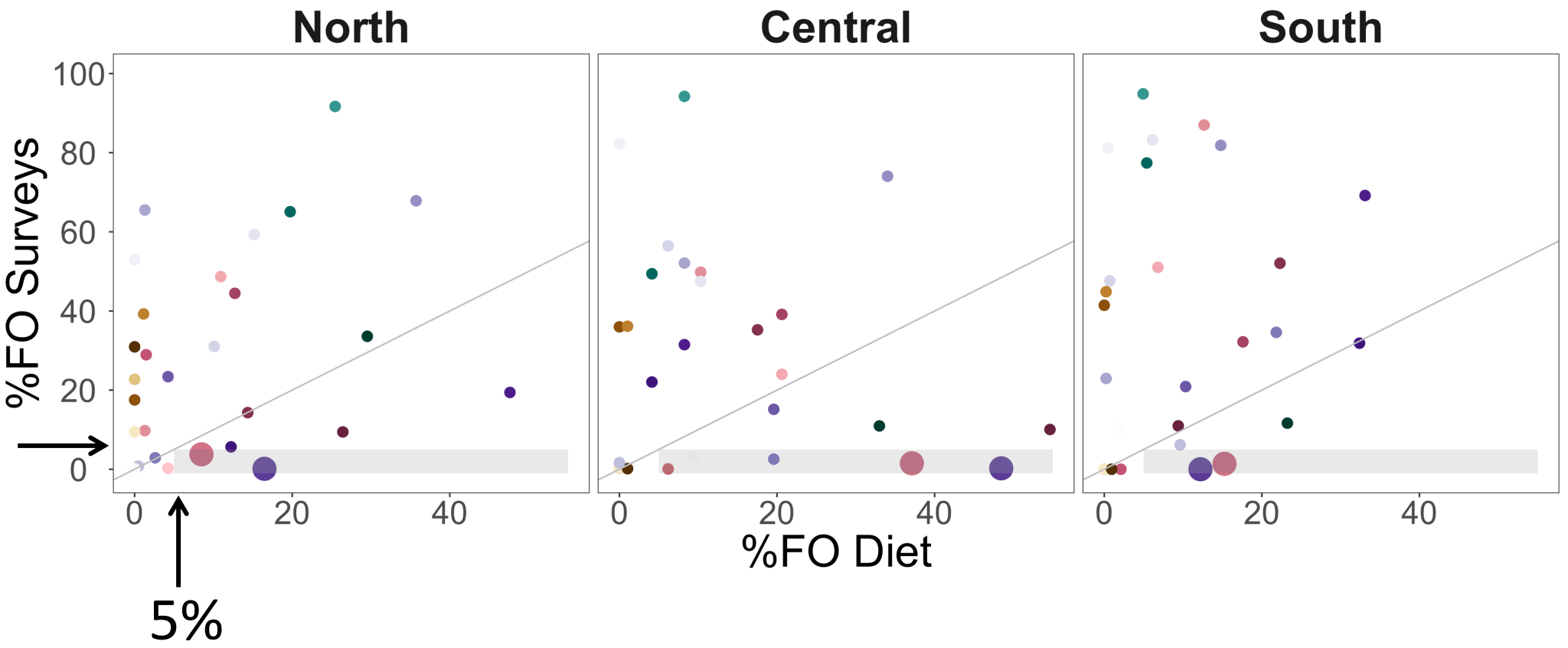
- O. borealijaponica
- Octopoda spp.
- Gonatus spp.
- Gonatopsis spp.
- Octopoteuthis spp.
- Doryteuthis opalescens
- Abraliopsis spp.
- Berryteuthis spp.

Cephalopod

- Amphipoda spp.
- Decapoda spp.
- Euphausiidae spp.
- Pteropoda spp.
- Pyrosoma atlanticum
- Thaliacea spp.
- Aequorea spp.
- Pleurobrachia spp.

Crustacean & Other inverts

Identify species unsuitably sampled



Rare in surveys

Pacific saury (*C. saira*)

Octopoteuthis spp.

Common in Diet

Fish
- Sardinops sagax
- Engraulis mordax
- Cololabis saira
- Paralepididae spp.
- Trachurus symmetricus
- Sebastes spp.
- Pleuronectidae spp.
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Albacore prey selectivity

Vanderploeg & Scavia's
Relativized Electivity (E*) Index

$$E^*_i = \frac{\alpha_i - (1/n)}{\alpha_i + (1/n)}$$

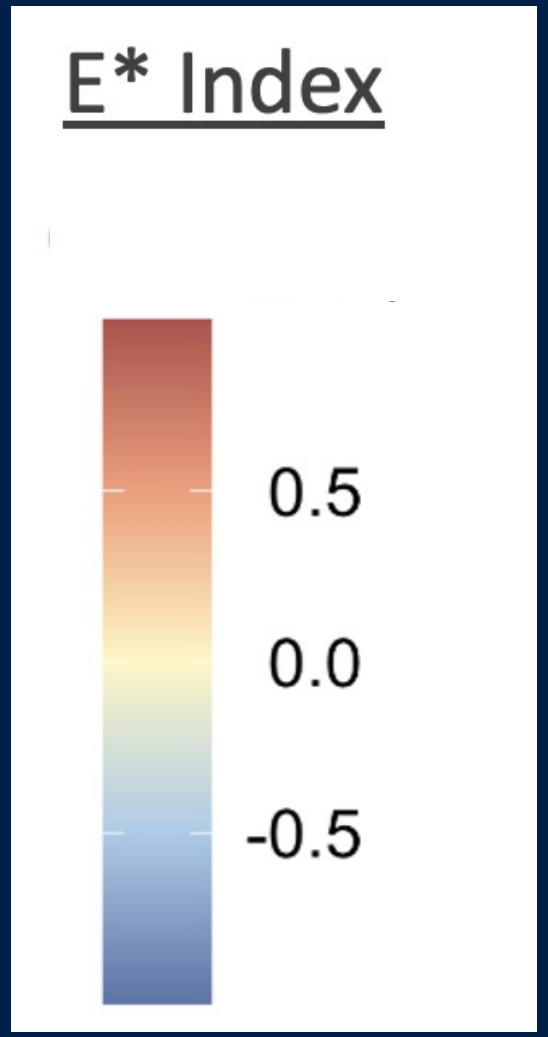
$$\text{Chesson's } \alpha_i = \frac{\%N_{diet} / \%N_{survey}}{\Sigma\ \%N_{diet} / \%N_{survey}}$$

Foraging ratio

(+) selection

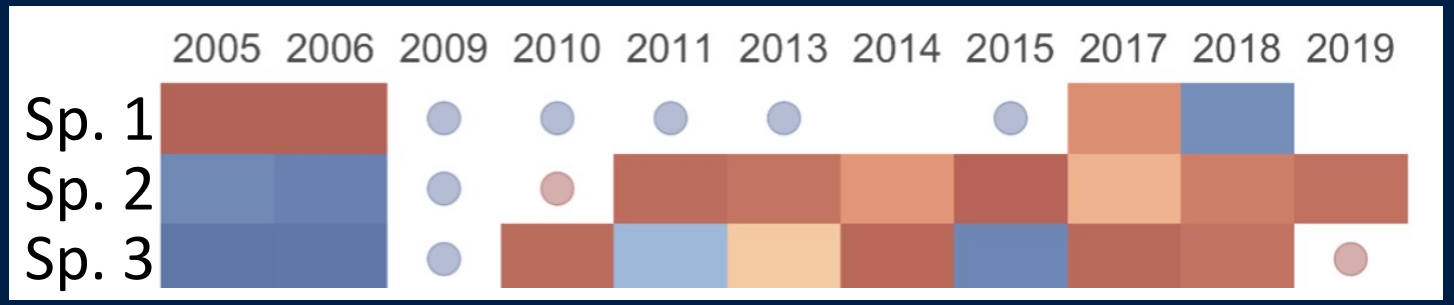
Neutral

(-) selection

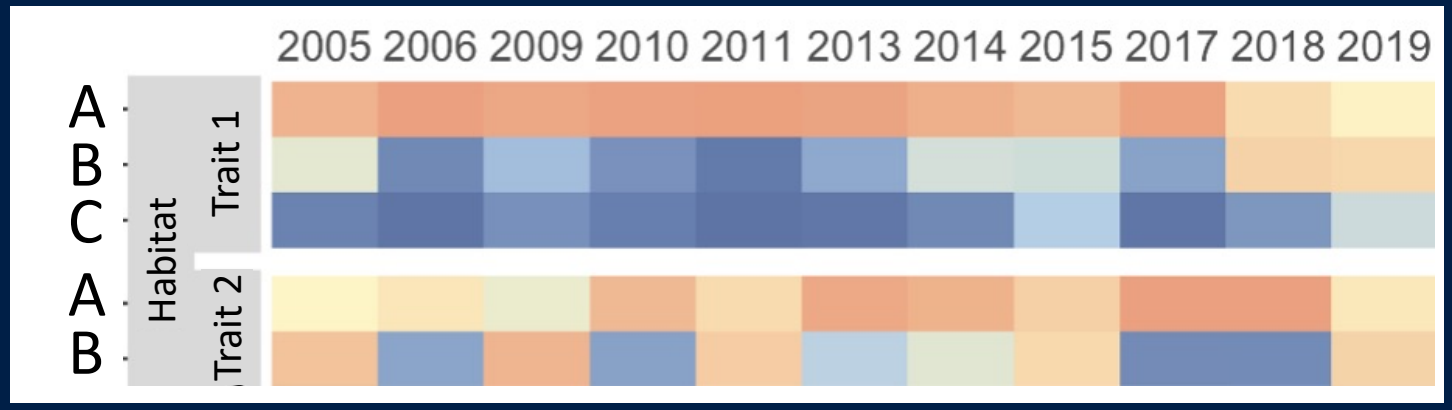


Albacore prey selectivity

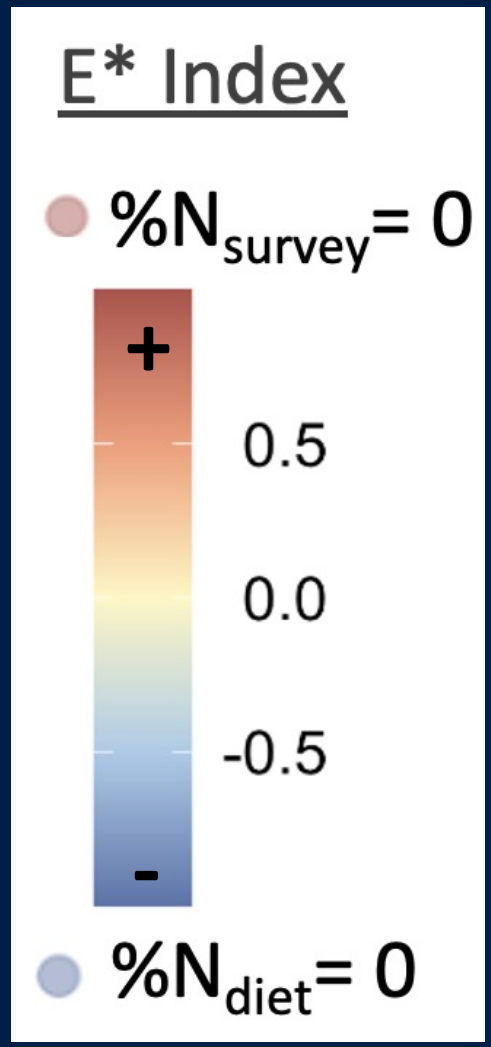
Taxa-based:



Trait-based: 13 traits

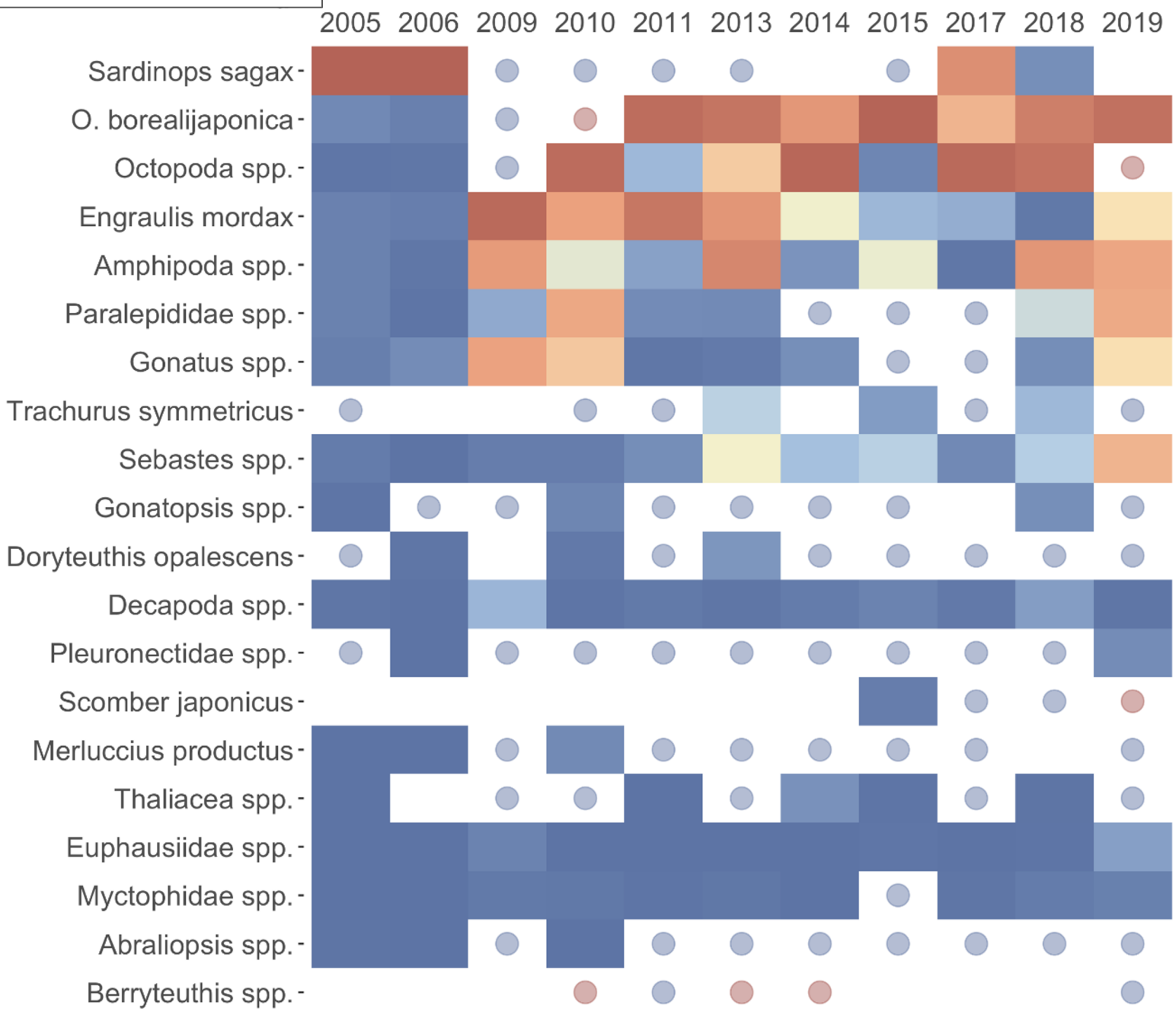


- $\%N_{taxa}$ summed across trait forms
- E* calculated separate for each trait



Taxa-based:

North



Diet > Survey (+)

8 Sardines

7 Clubhook squid

10 Octopuses

Annually variable

1 Anchovies

4 Amphipods

Barracudinas

3 Rockfishes

Survey > Diet (-)

2 Euphausiids

9 Myctophids

6 Decapods

5 Hake

Rank in $\%N_{diet}$

E* Index

$\%N_{survey} = 0$

+

0.5

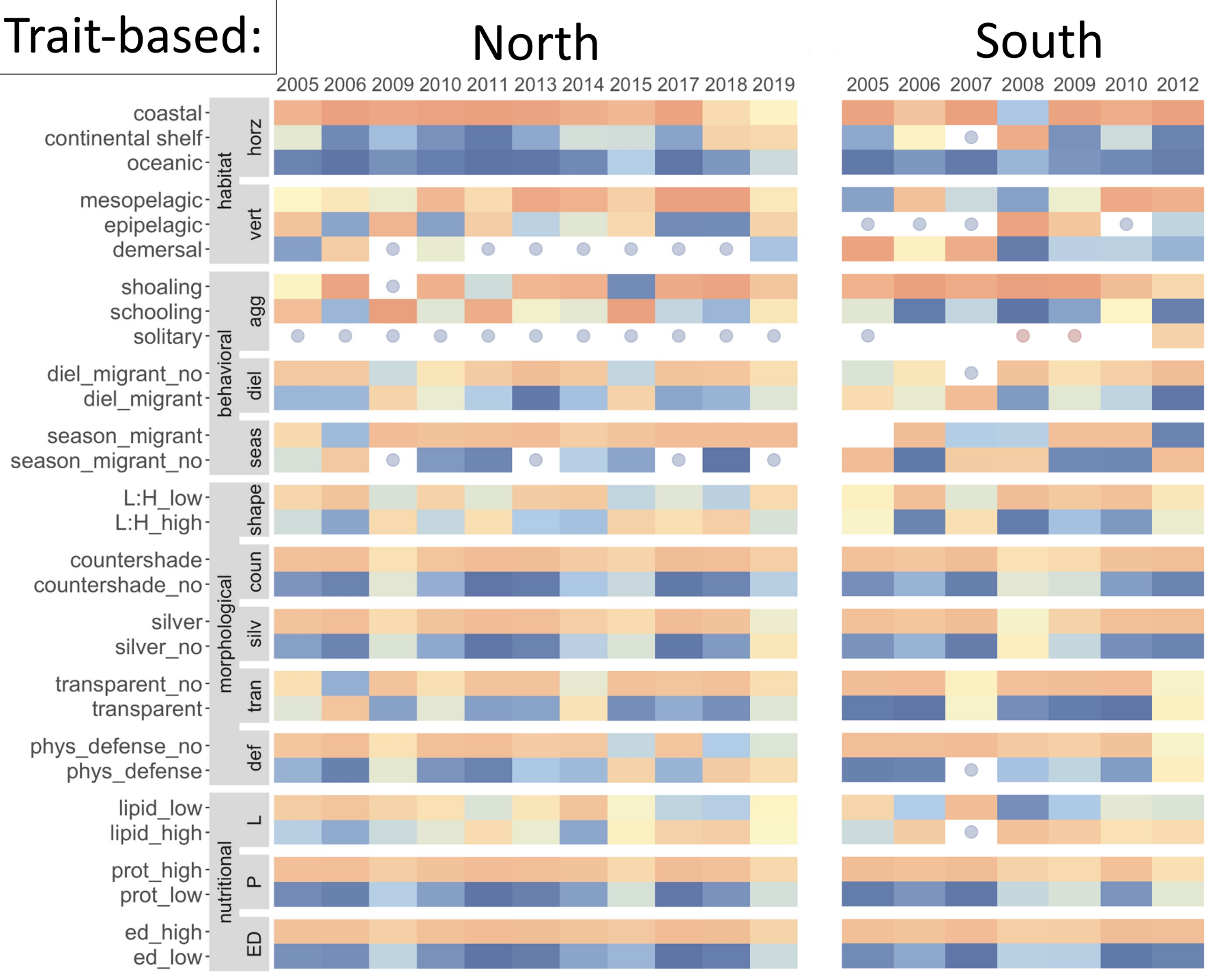
0.0

-0.5

-

$\%N_{diet} = 0$

Trait-based:

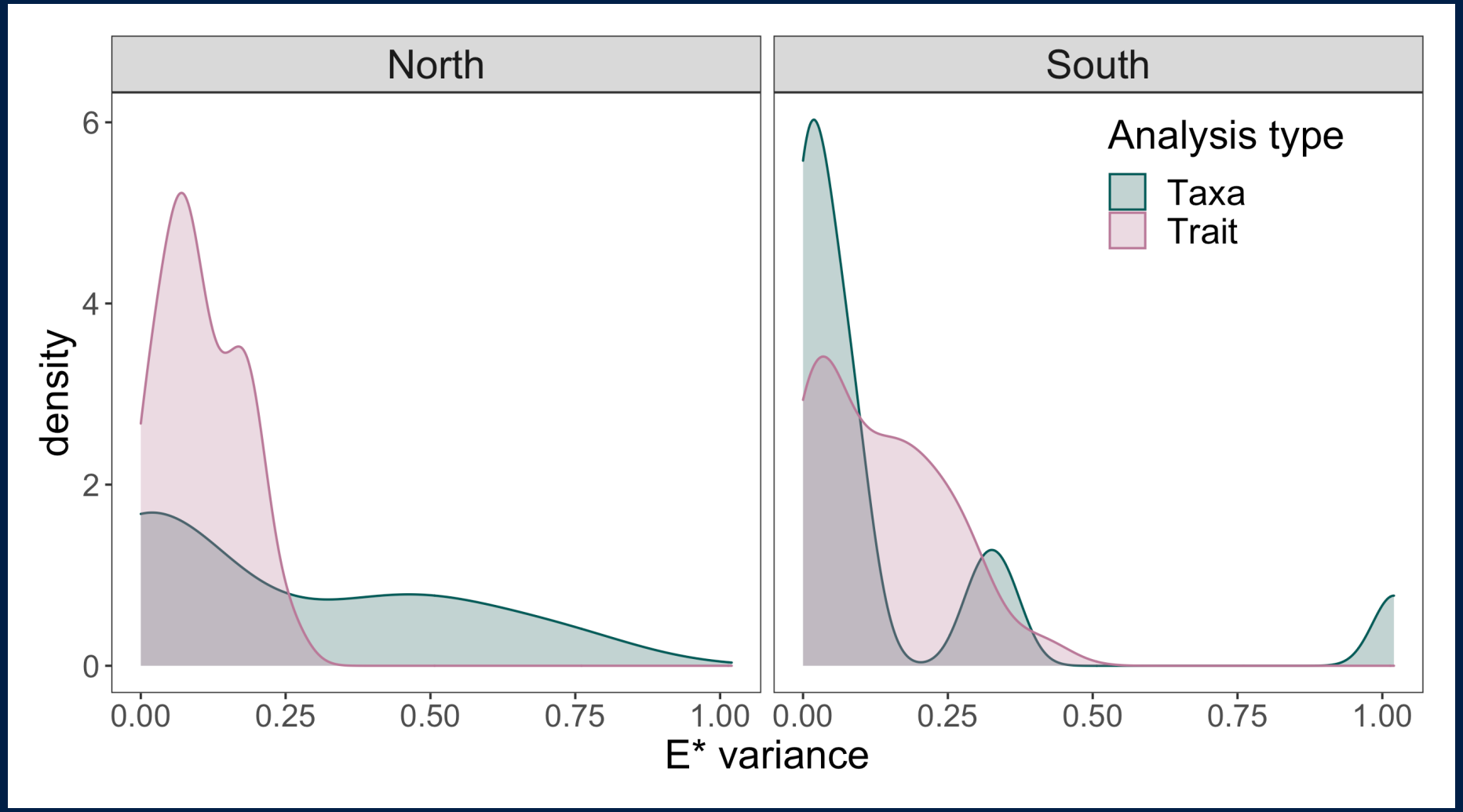


Consistent, high (+) selection

Coastal
Silvered
Countershaded
Non-diel migrants
Undefended
Non-transparent
Shoaling/Schooling
Protein-rich
Energy-rich

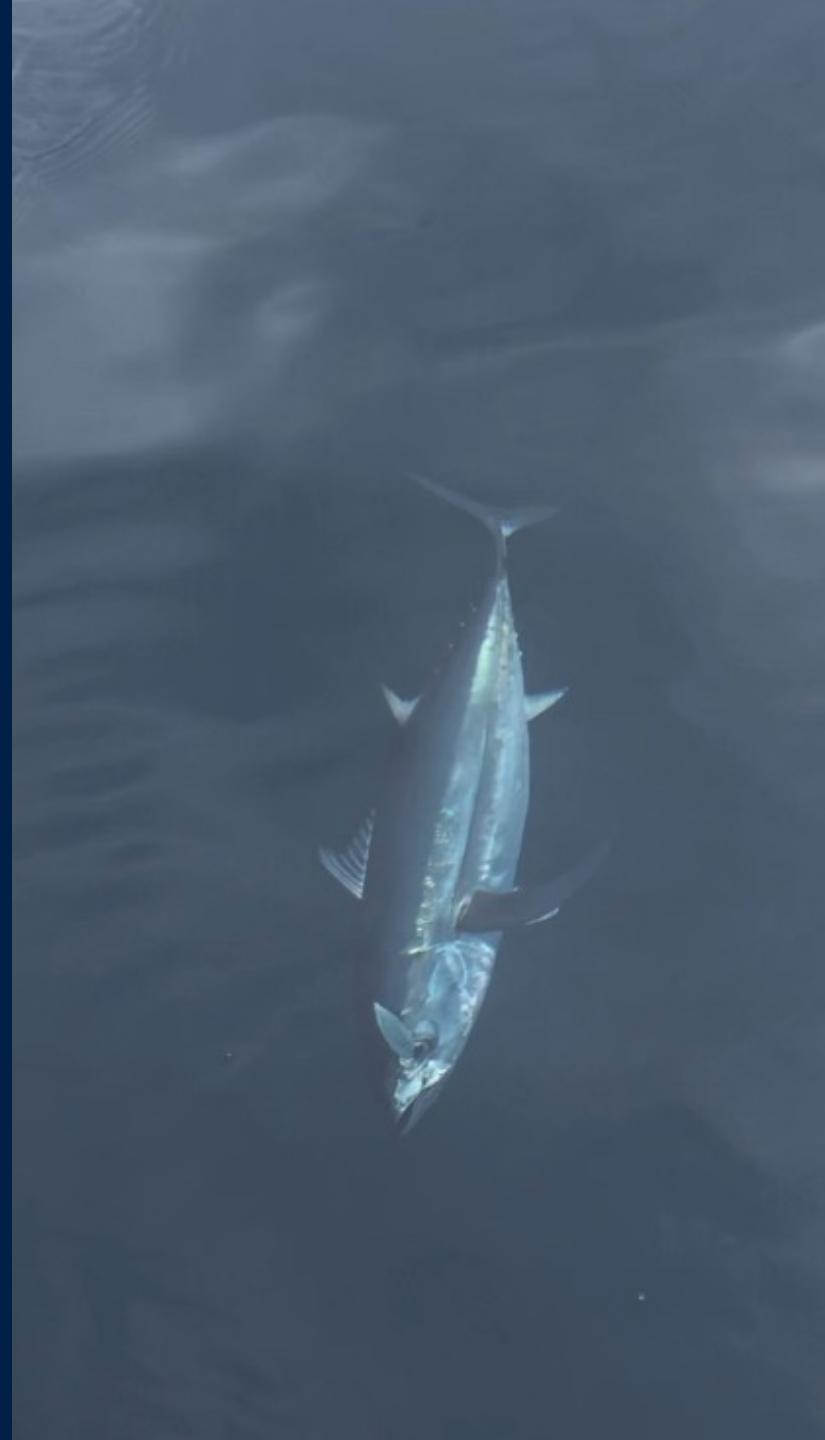
Same traits in both regions!

Selection variance minimized with trait-based approach



Conclusions

- Albacore prey selectivity provides different indicators of predator-prey interaction strength vs. only diet
- Traits minimizes variability in predator-prey relationships
- Framework for integrating trawls & diet across multiple surveys for comparative analyses



Want to learn more?
Check out these talks tomorrow from our team!

Dr. Natasha Hardy

Modelling diet shifts in a pelagic predator – albacore tuna – in relation to forage community composition and prey trait information across a 2005–2019 time series.

9:40am, Session 1, Auditorio 2

Alana Krug-MacLeod

Effect of climate state on variation in nutritional value for small pelagic species

12:00pm, Session 4, Sala 1

Acknowledgements

Trait data collection team:
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Cindy Matuch, Cole Brookson

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Elliot Hazen, Steven Bograd

Discussion & feedback:
Elan Portner (Scripps)

Dec. 1
11am PT
7pm GMT