Traits-based tools to inform species re-distribution under climate change

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REEF/Frost Museum

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NOAA FISHERIES

FUTURE SEAS
A Physics-to-Fisheries Management Strategy Evaluation for the California Current System

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Simon Fraser U

Annabelle Brooks
Cape Eluethera Institute


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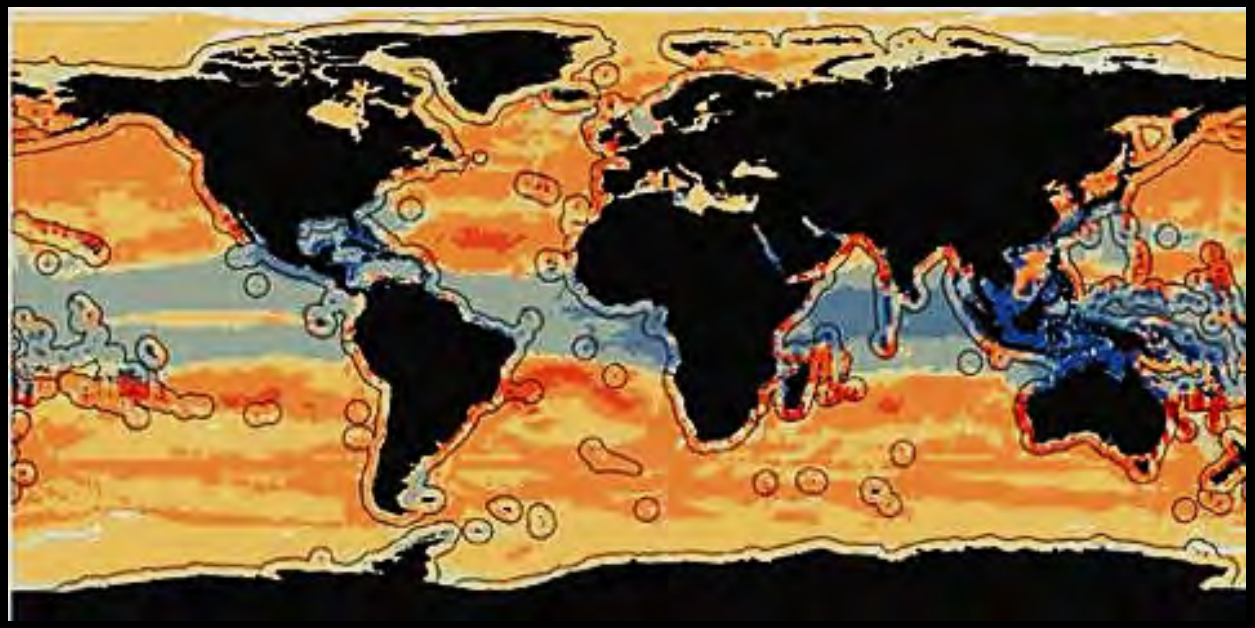
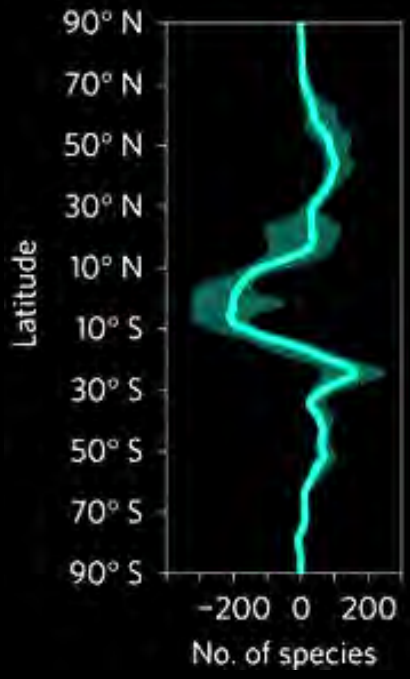
U.S. DEPARTMENT OF COMMERCE

How will ocean ecosystems respond to climate change?





Predicted change in marine species richness by 2100 under RCP8.5

Molinos et al. 2015 Nature Climate Change

Common approach to predicting species distribution

Relate past environmental conditions and species distributions

Infer future species distribution from predicted environmental change

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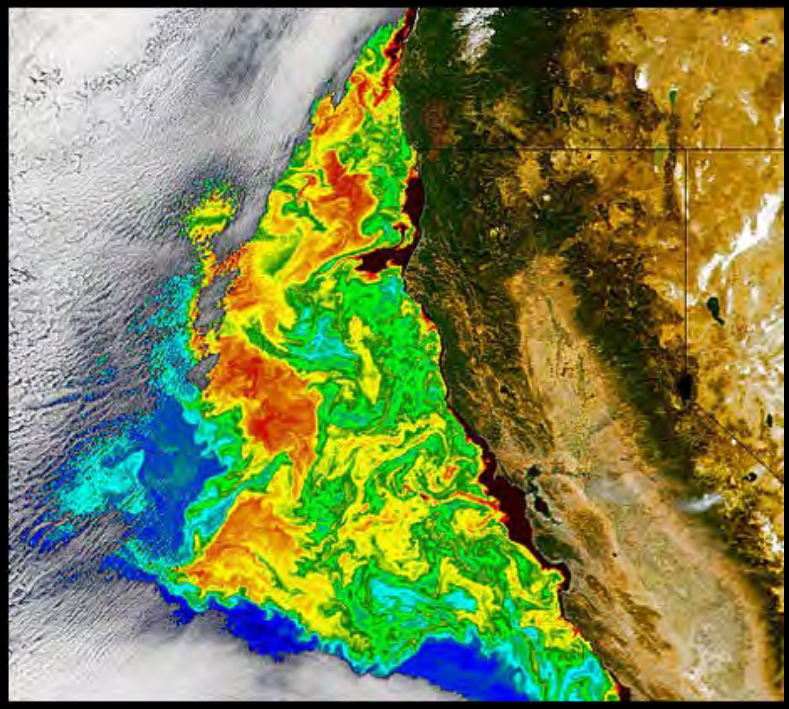
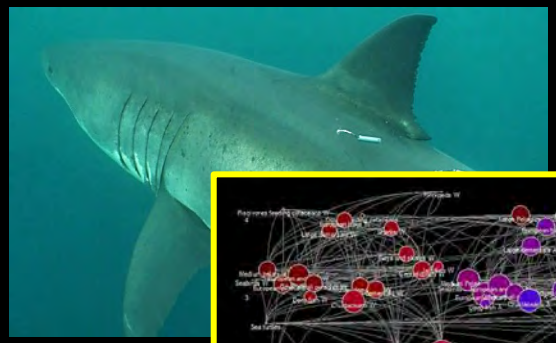
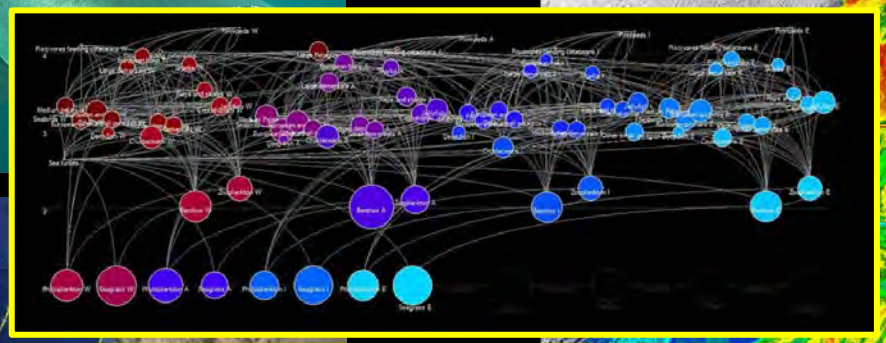


NOAA

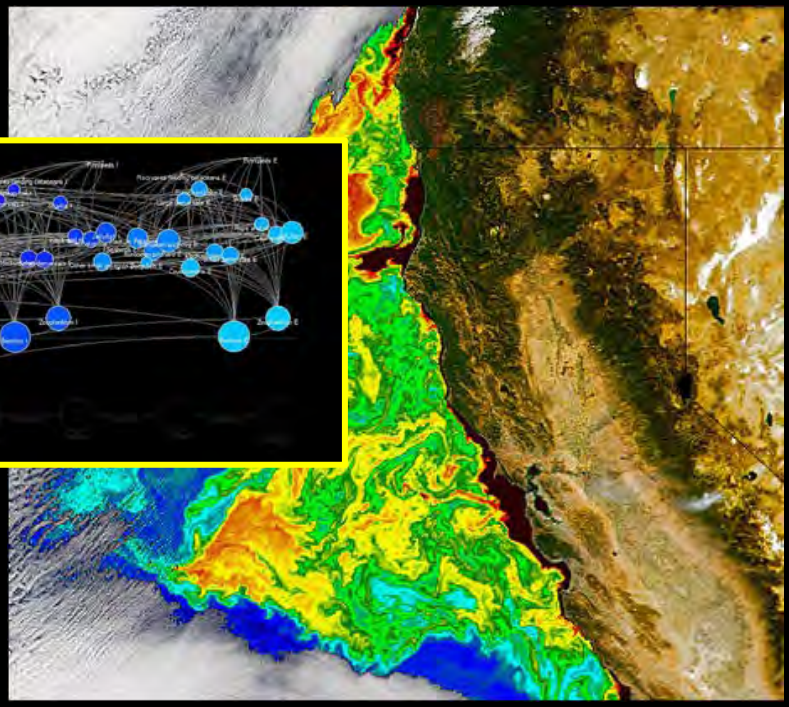
Ecosystem models offer an opportunity to incorporate predator-prey interactions

Relate past environmental conditions and species distributions → **Incorporate** effect of predator-prey interactions on abundance → **Infer** future species distribution from predicted environmental change



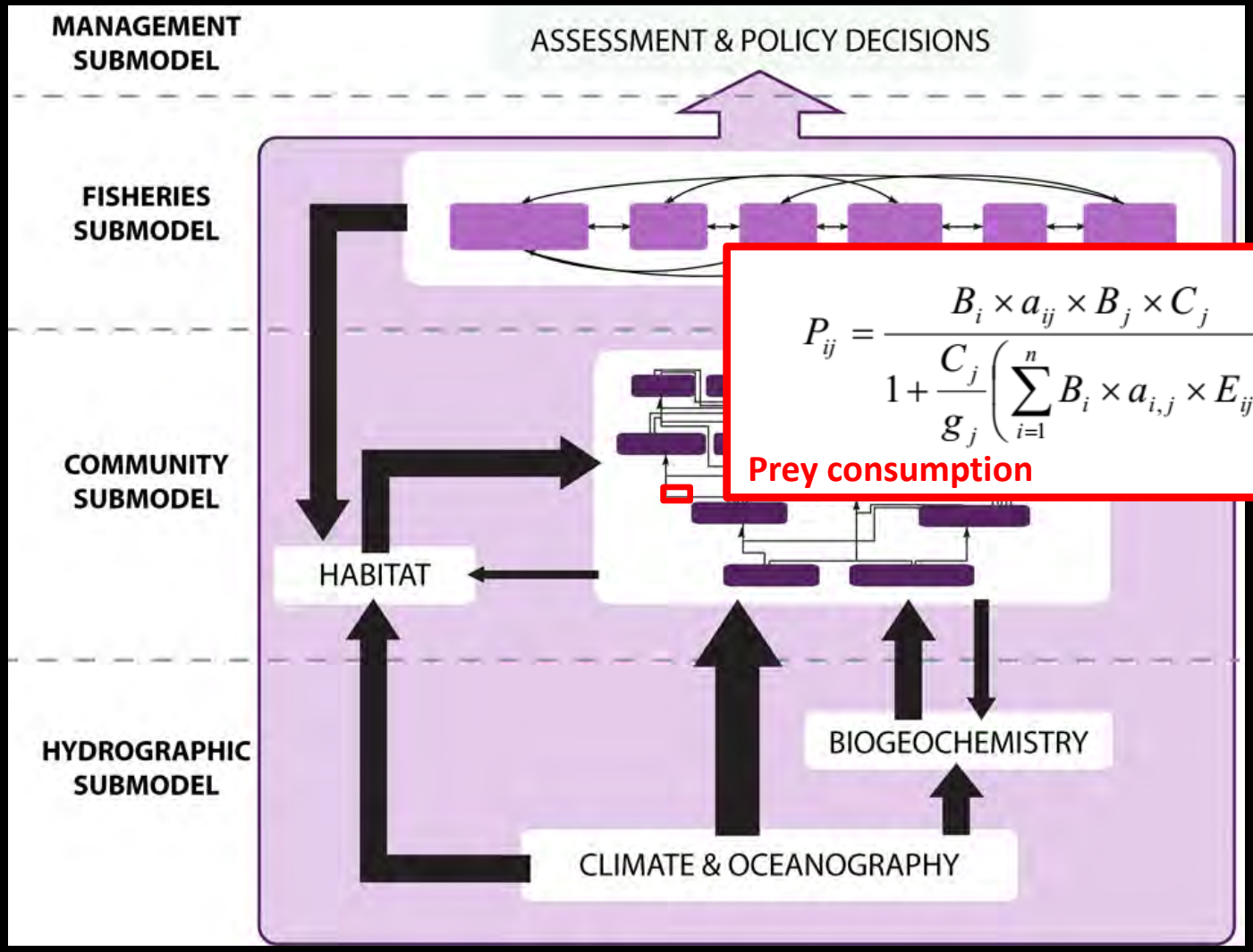


Piroddi et al. 2015



NOAA

Ecosystem models offer an opportunity to incorporate predator-prey interactions



Kaplan et al. 2016; Atlantis ecosystem model

Key challenges for inferring feeding links from stomach contents

Image: NOAA Fisheries

Image: Elan Portner

- ‘Snap shot’ of diet → disconnected in time and space
- High time and financial costs
- Characterizes prey use, not availability (are predators selective?)

Can we better account for changing feeding relationships as we predict the future distribution of ocean predators?

Lessons learned from the invasion of Indo-Pacific lionfish in the Atlantic

High variation in prey species along a regional invasion front

USGS Non-indigenous Aquatic Species Database

Insights from diet analysis

Which species are most vulnerable?

Albins and Hixon 2008
Morris and Akins 2009
Munoz et al. 2011
Jud et al. 2010
Bogdanoff et al. 2017

Green et al. 2012
Coté et al. 2012
Valdez-Moreno et al. 2012
Cure et al. 2014
Harms et al. 2016

Layman and Allgeier 20011
Barbour et al. 2010 2013
McCleery 2011
Dahl & Patterson 2016
Patterson et al. 2018

Many predators are selective

Proportion prey in diet ≠ **Proportion prey in environment**

Predicting vulnerability to predation

Encounter rate

Capture success

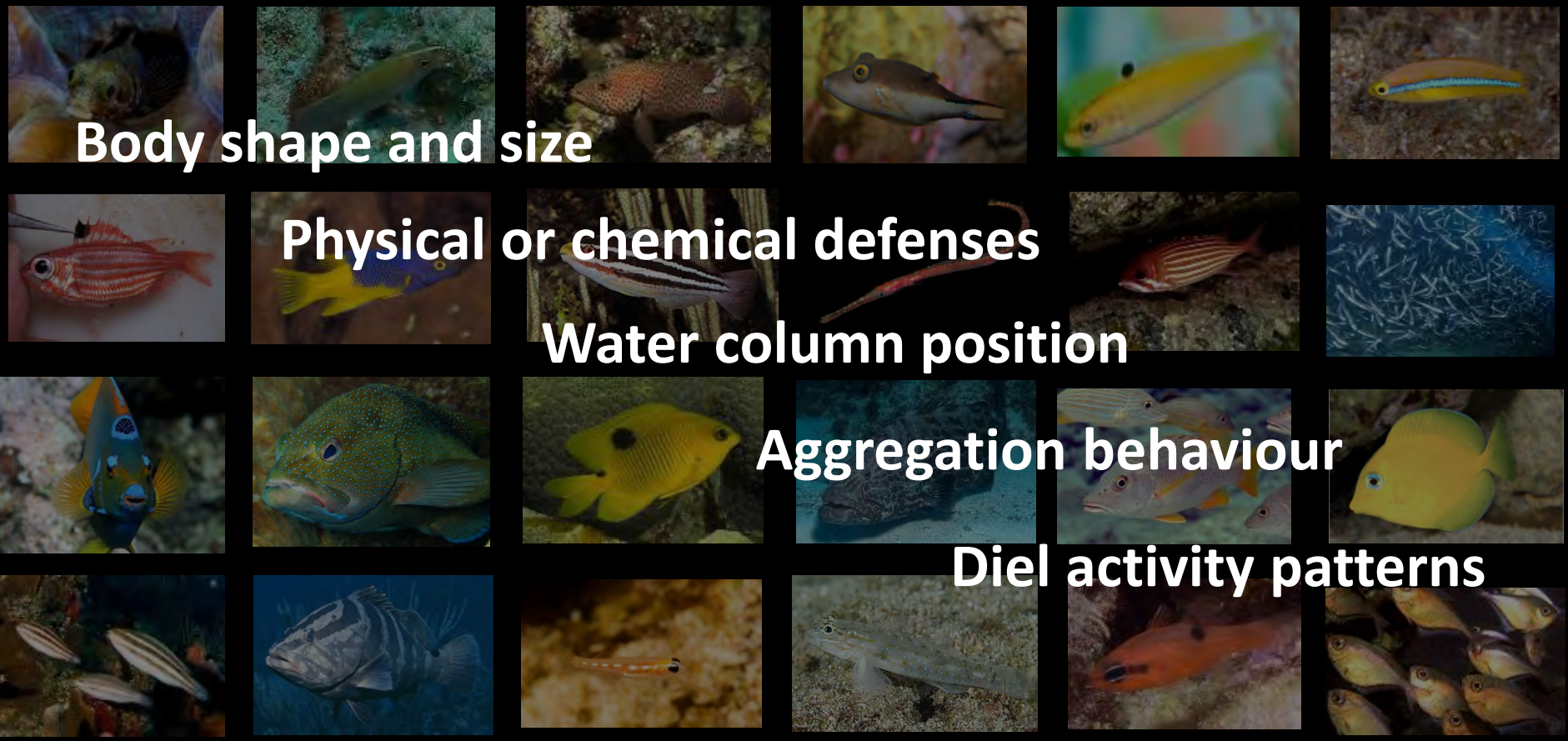
Handling time

Energetic value

behaviour & morphology

Green et al. 2015 Journal of Animal Ecology

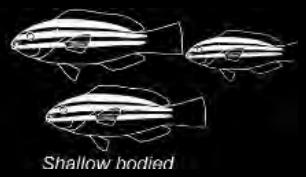
Which species are most vulnerable?

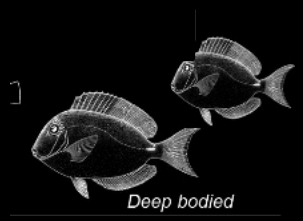


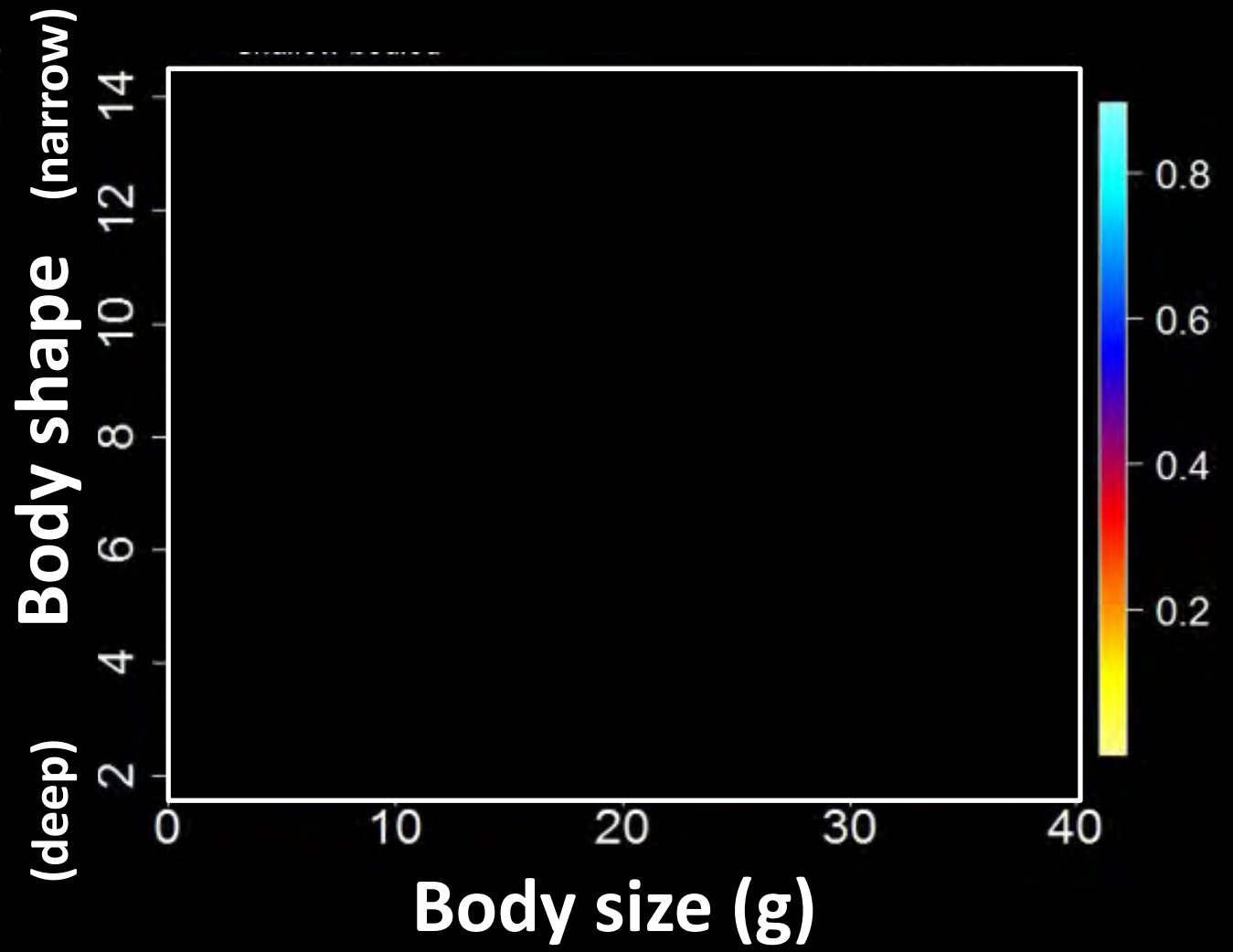
Traits are common among prey in different habitats

Green et al. 2015 Journal of Animal Ecology

Risk of predation across prey traits



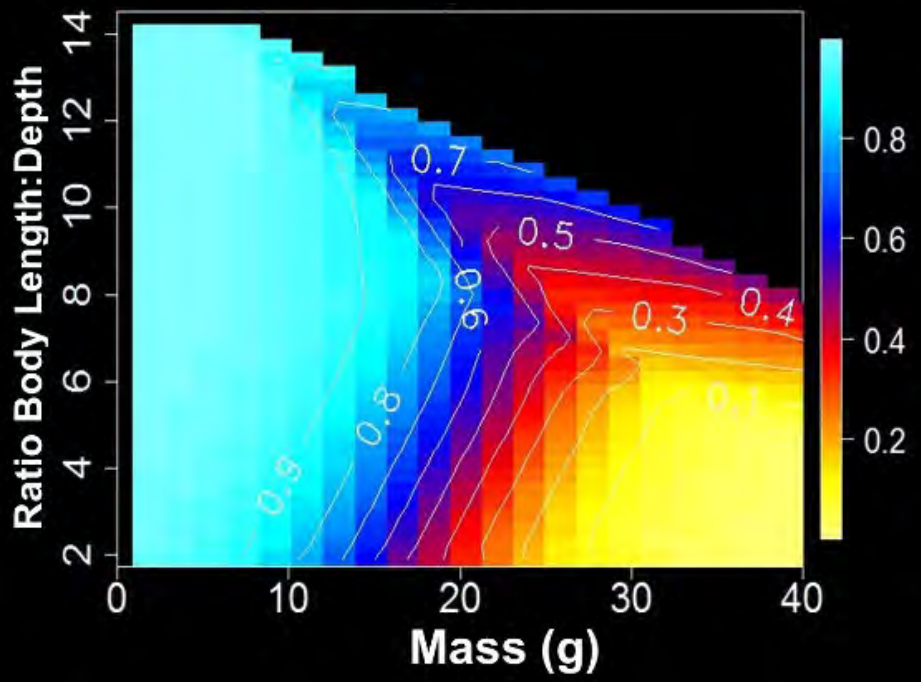




Green et al. 2015 Journal of Animal Ecology

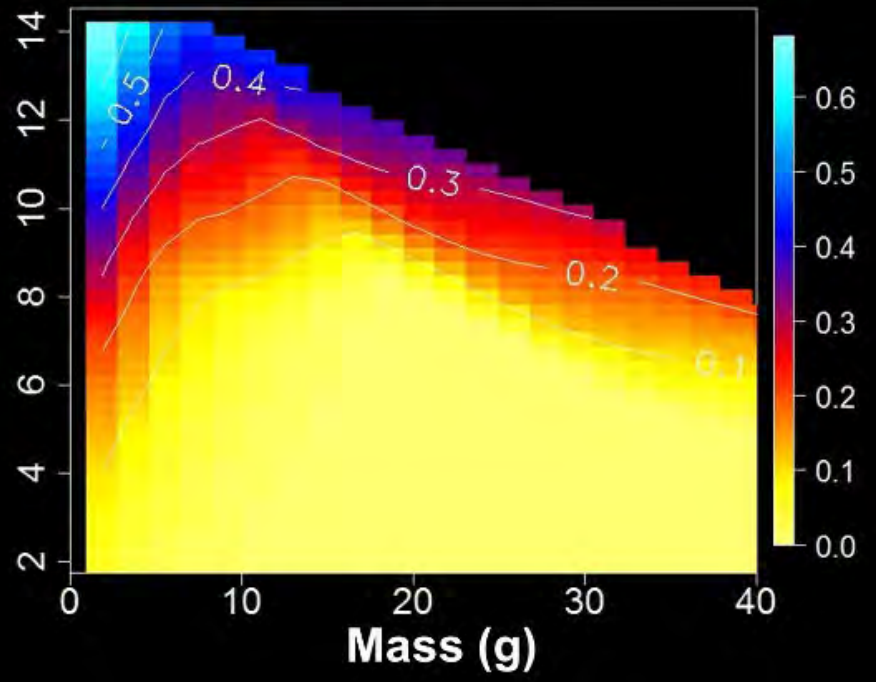
Risk of predation across prey traits

Benthic



Preferred

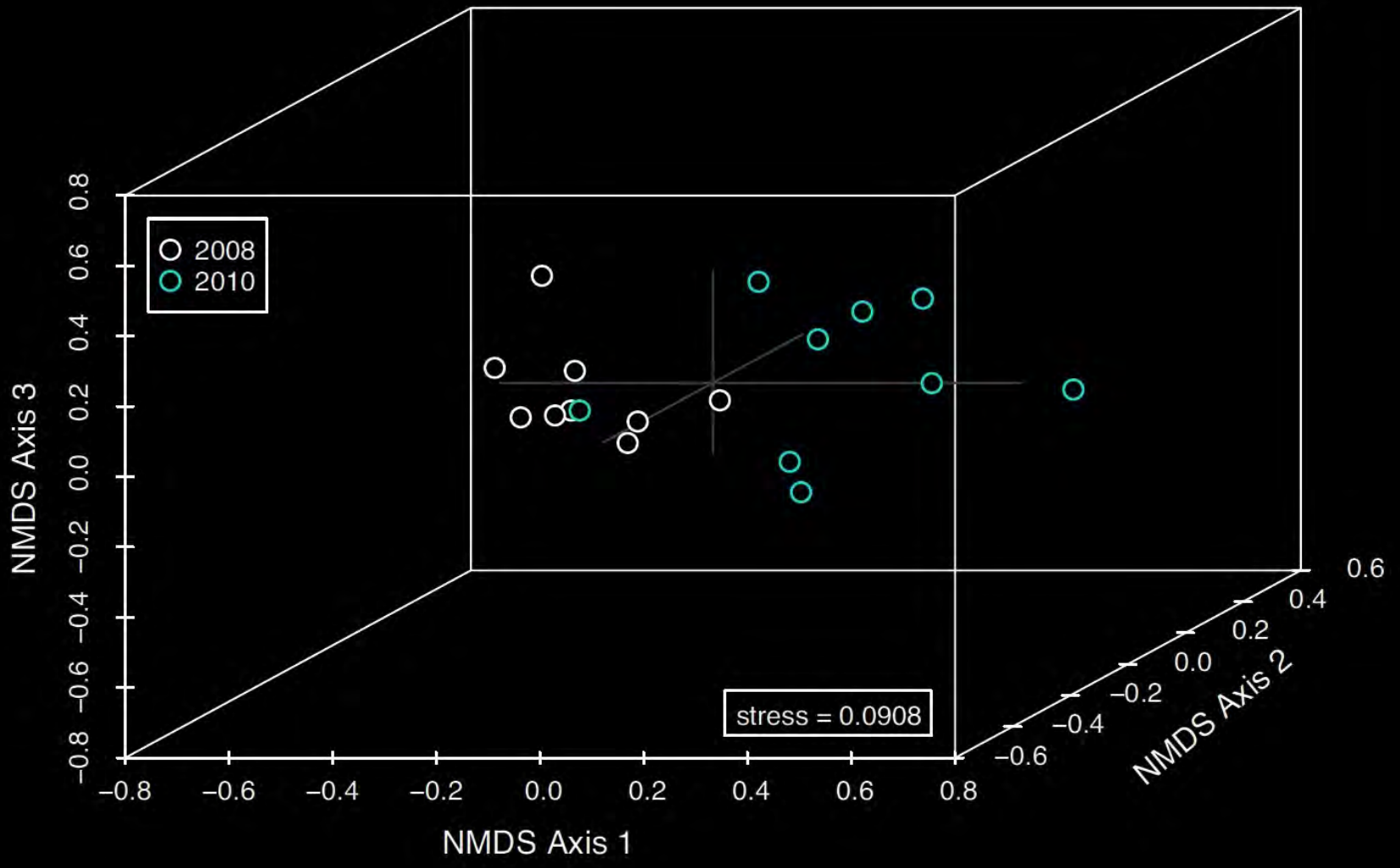
Demersal



Avoided

Green et al. 2014 Journal of Animal Ecology; Green et al. 2019 Ecopshere

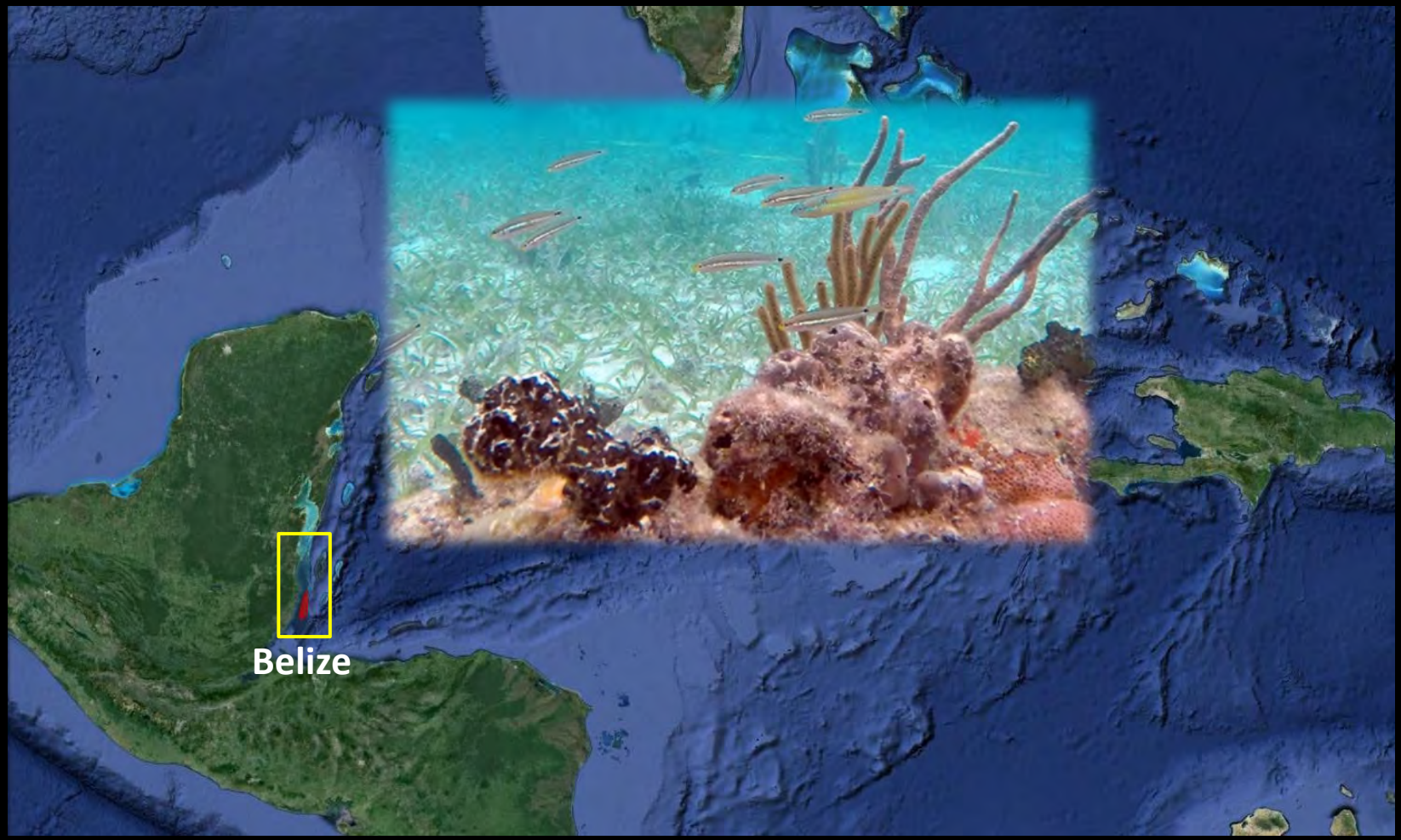
Shifts in the multivariate trait structure of invaded communities



Malpica Cruz, Green et al. 2019

Prey traits inform extinction risk

Vulnerability + Life history + Range



GLOBAL MARINE SPECIES ASSESSMENT

IUCN RED LIST SSC Species Survival Commission ODU IDEA FUSION

Linardich, Green et al. *in prep.*

Mechanistic predictions about trait-based feeding relationships to inform range and abundance change

Approach:
Trait classification

Physiological
(e.g. thermal tolerance)

Morphological
(e.g. body size)

Behavioural
(e.g. aggregation)

Life history
(i.e. life span)

Trait-based filters of distribution and abundance

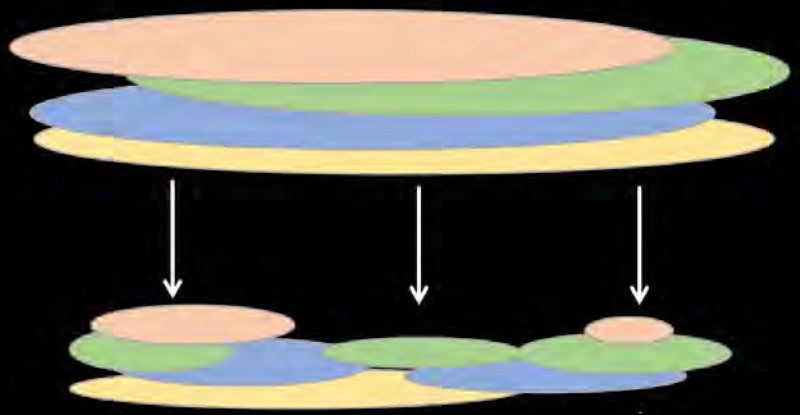
Physical
(e.g. thermal tolerance)

Trait-based filters of distribution and abundance

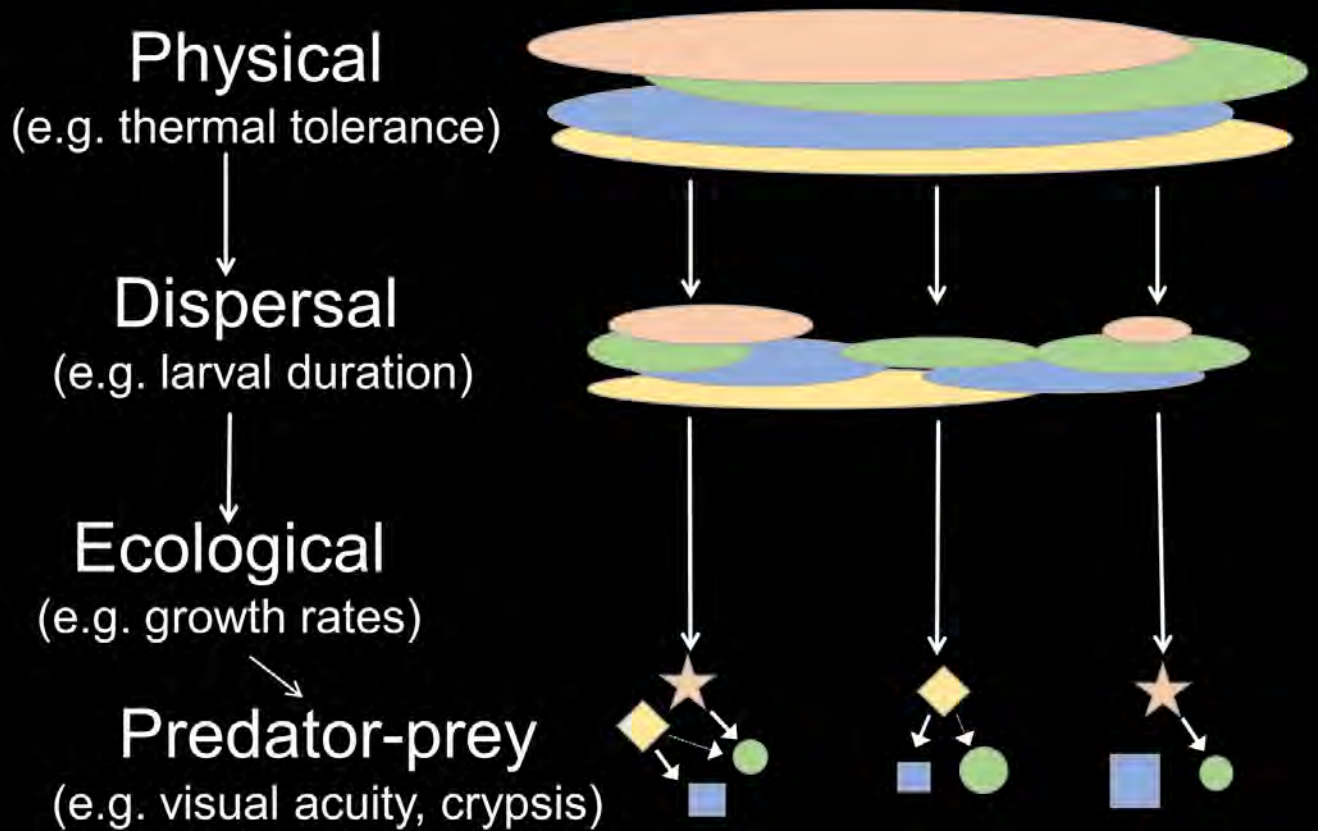
Physical
(e.g. thermal tolerance)

↓

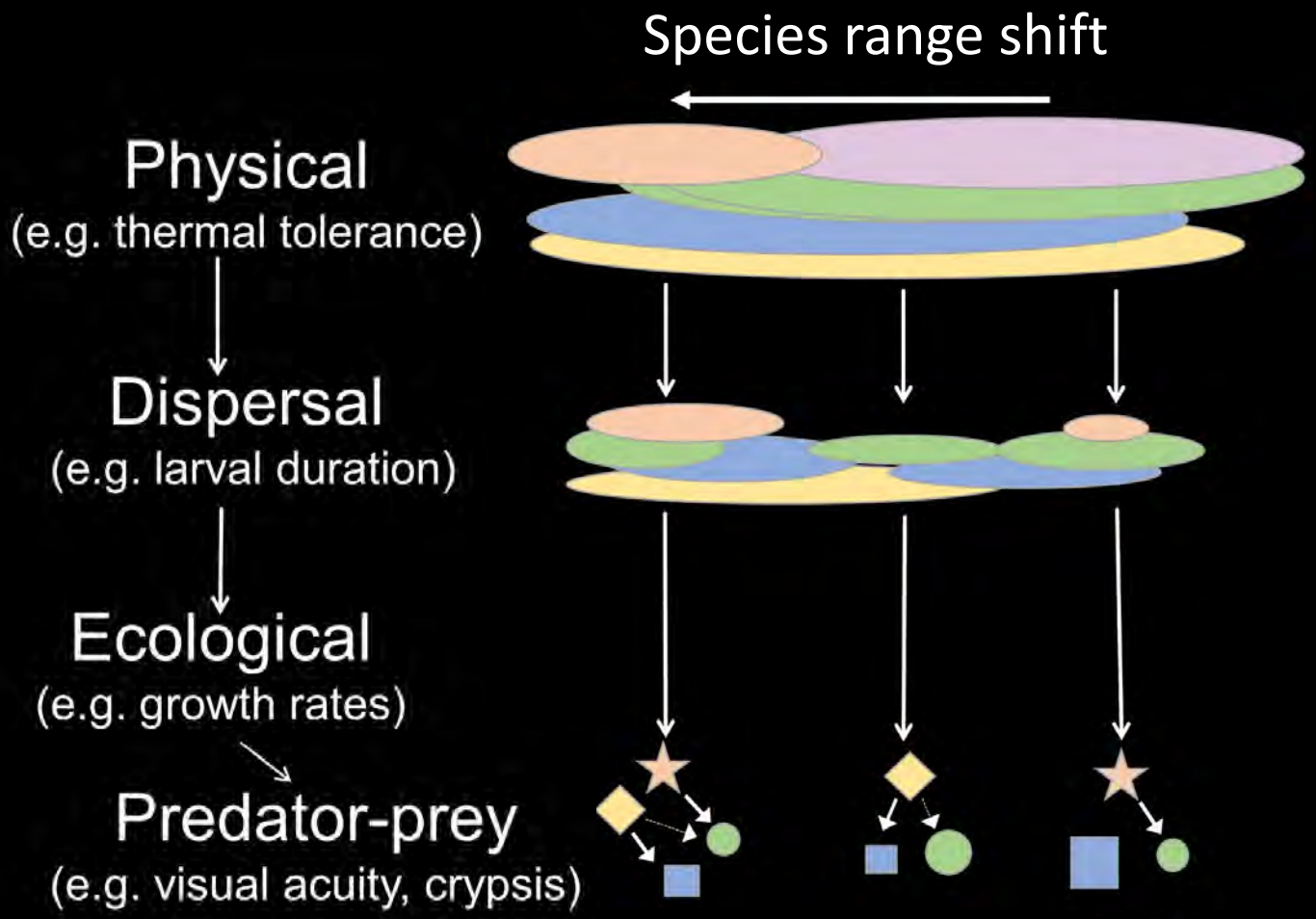
Dispersal
(e.g. larval duration)



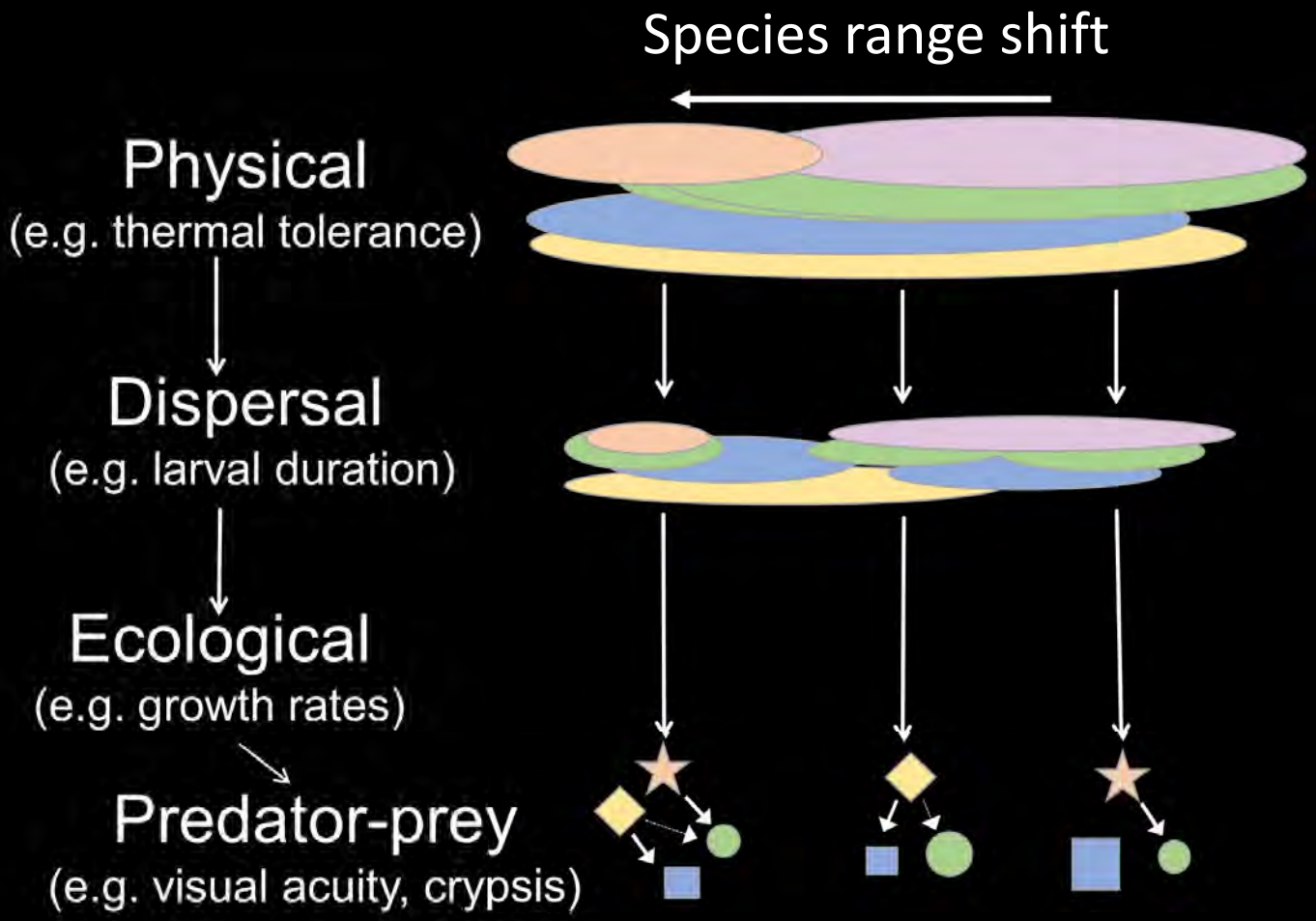
Trait-based filters of distribution and abundance



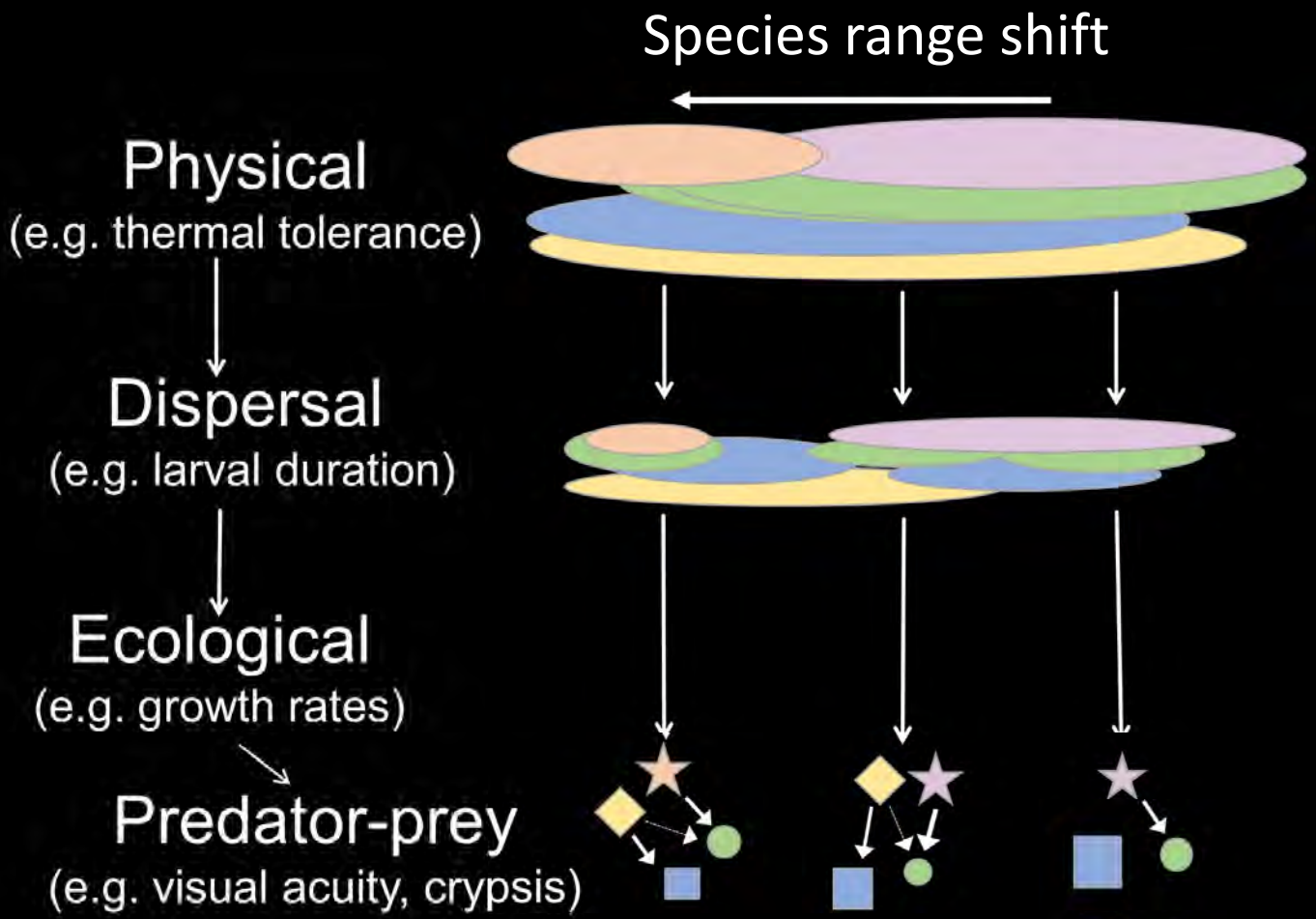
Trait-based filters of distribution and abundance



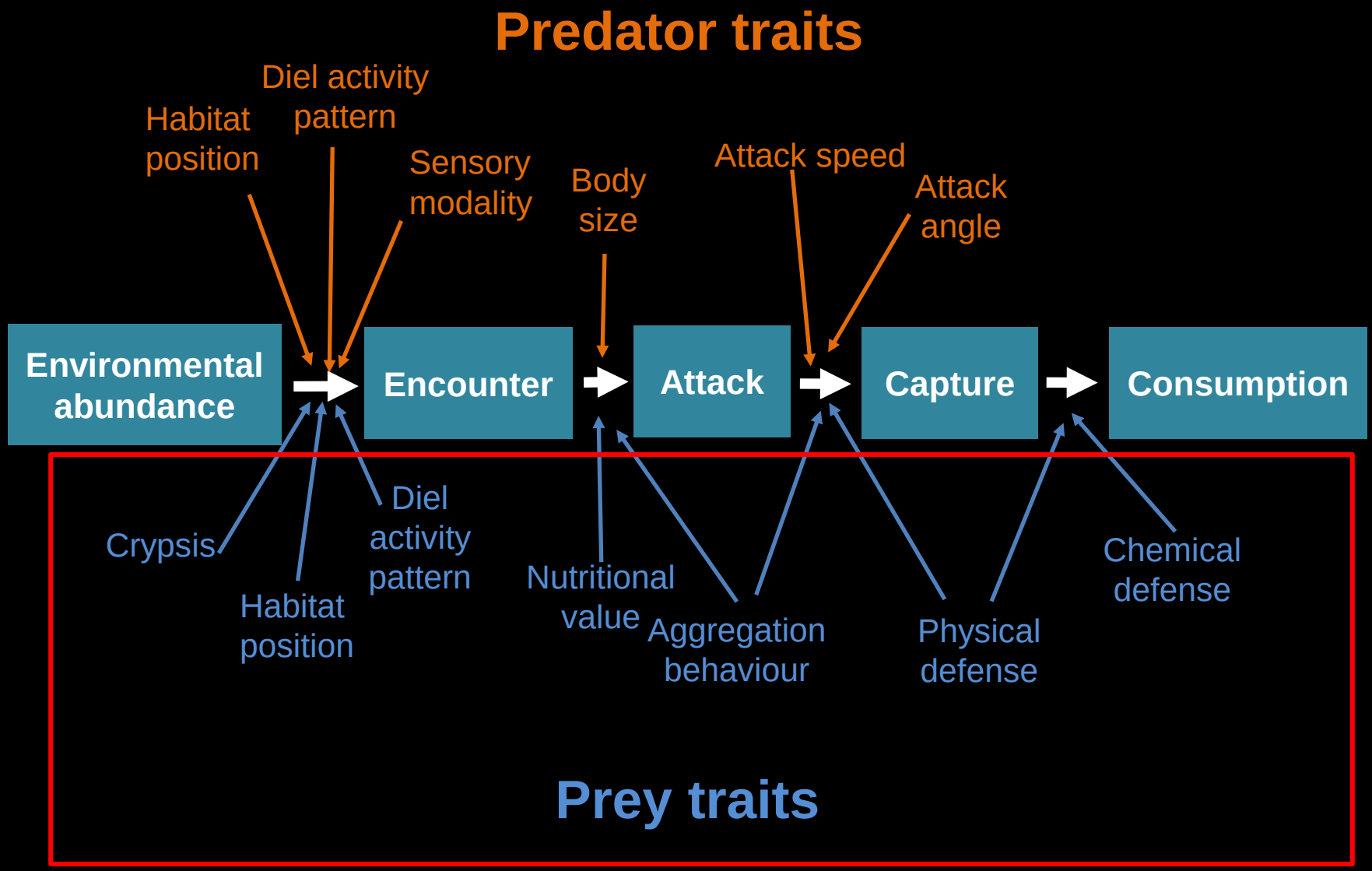
Trait-based filters of distribution and abundance



Trait-based filters of distribution and abundance



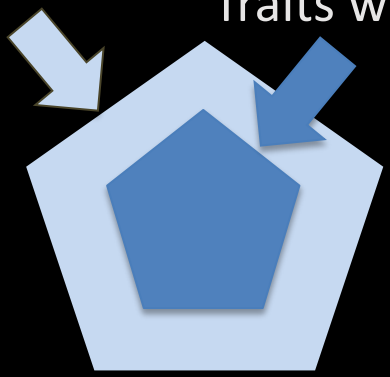
Traits influence the predation process



Effect of prey traits on patterns of diet selection

Traits of potential prey community

Traits within predator diet



Effect of prey traits on patterns of diet selection

Traits of potential prey community

Traits within predator diet

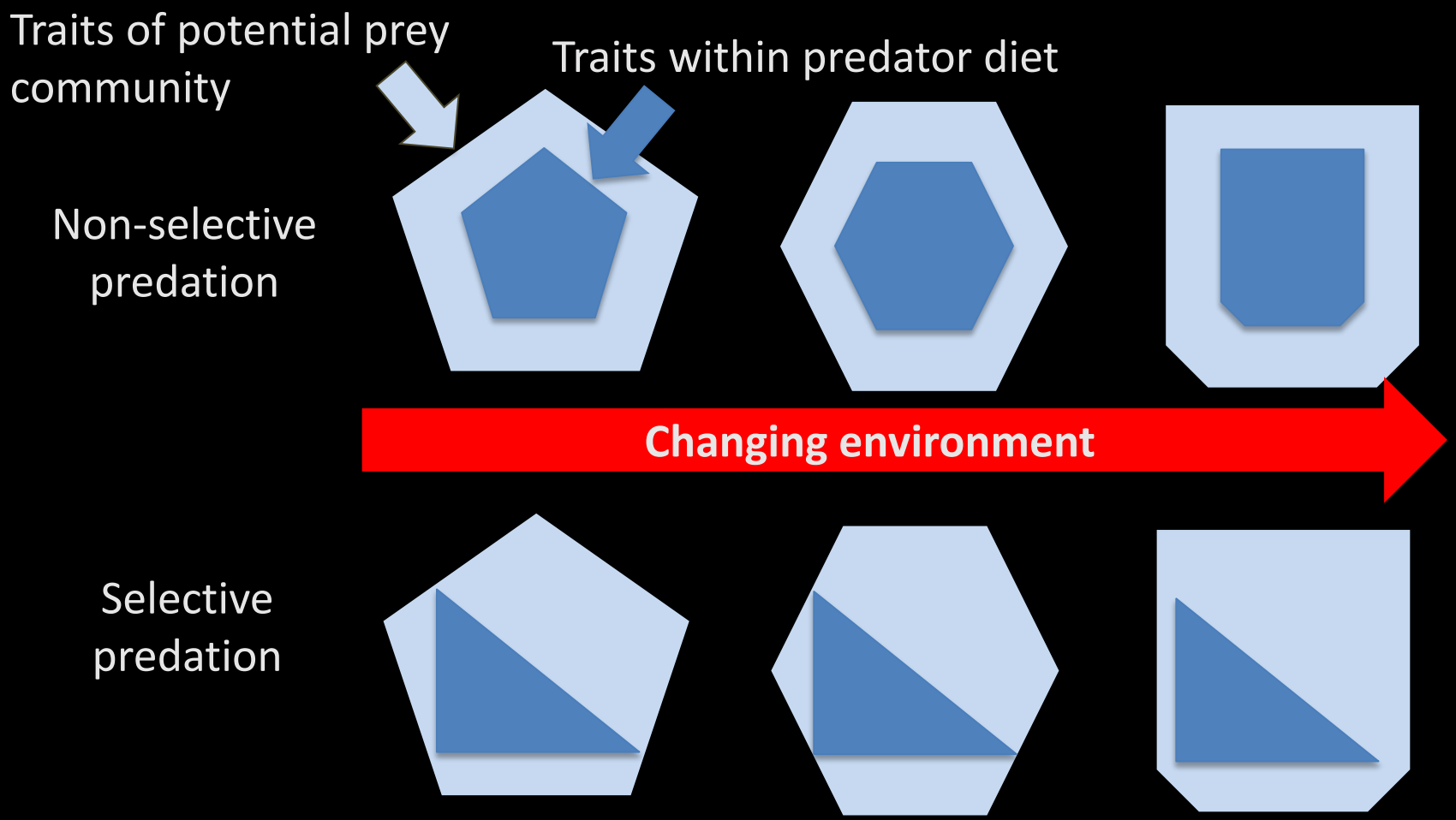
Effect of prey traits on patterns of diet selection

Traits of potential prey community

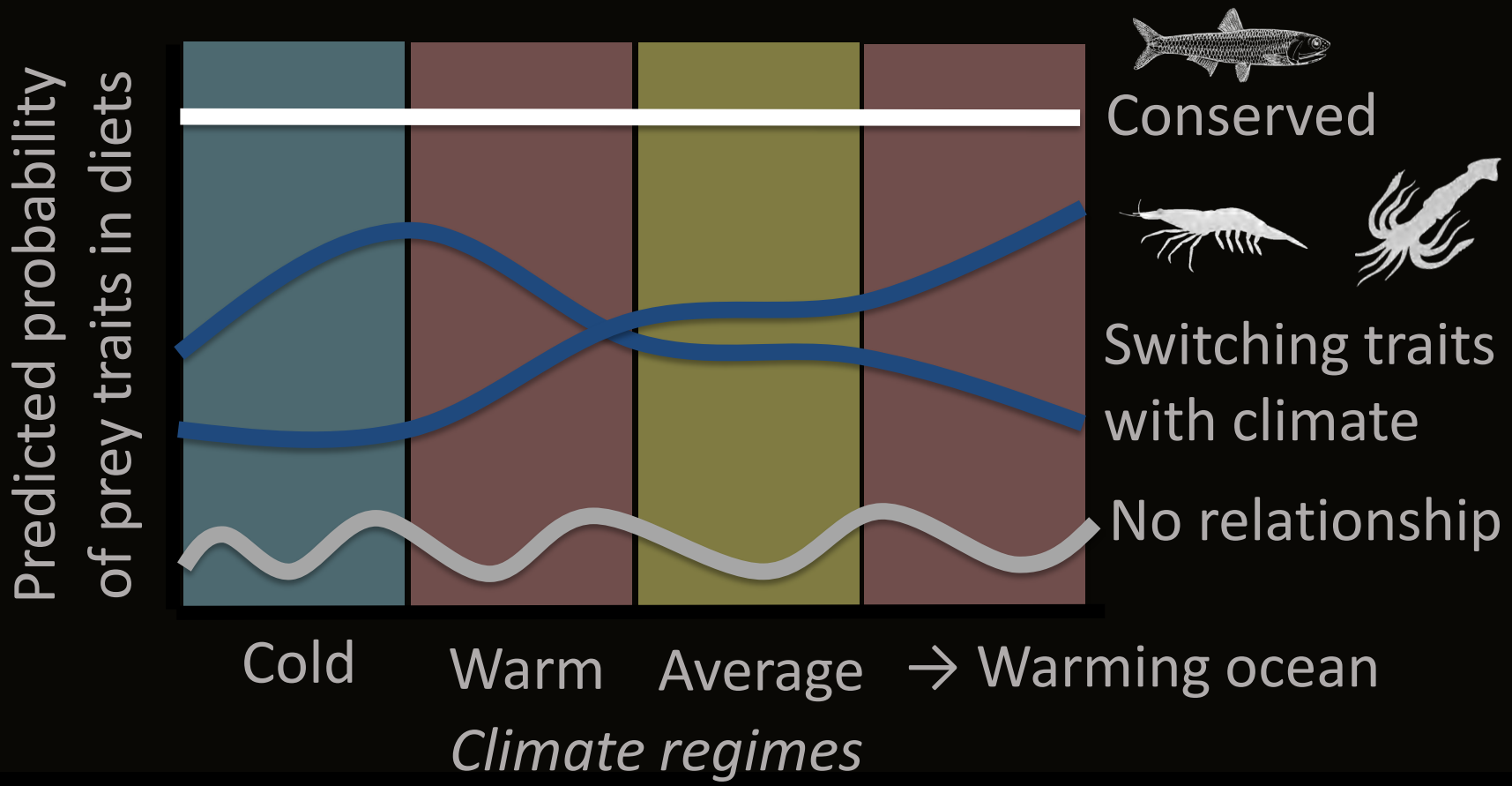
Traits within predator diet

Non-selective predation

Effect of prey traits on patterns of diet selection



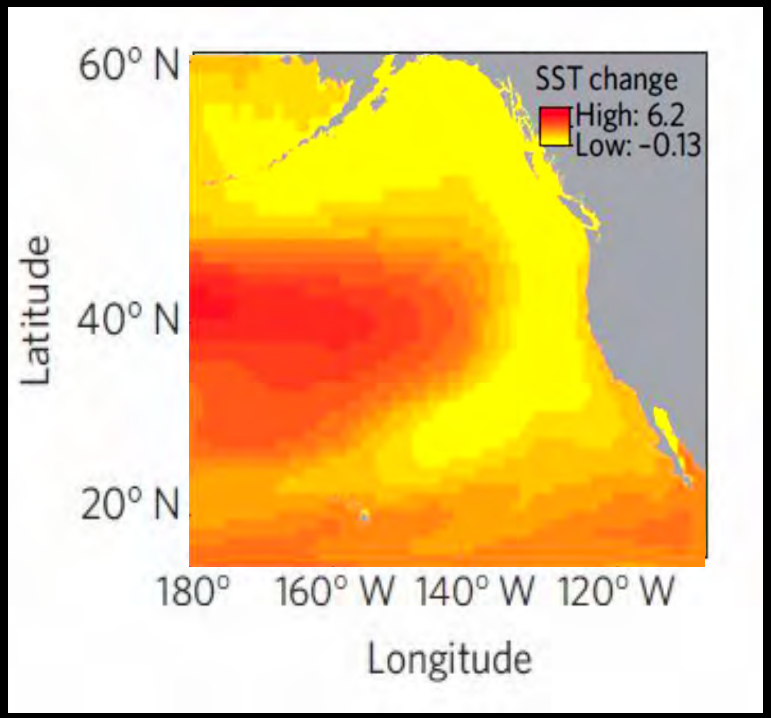
Trait-based predictions for future change

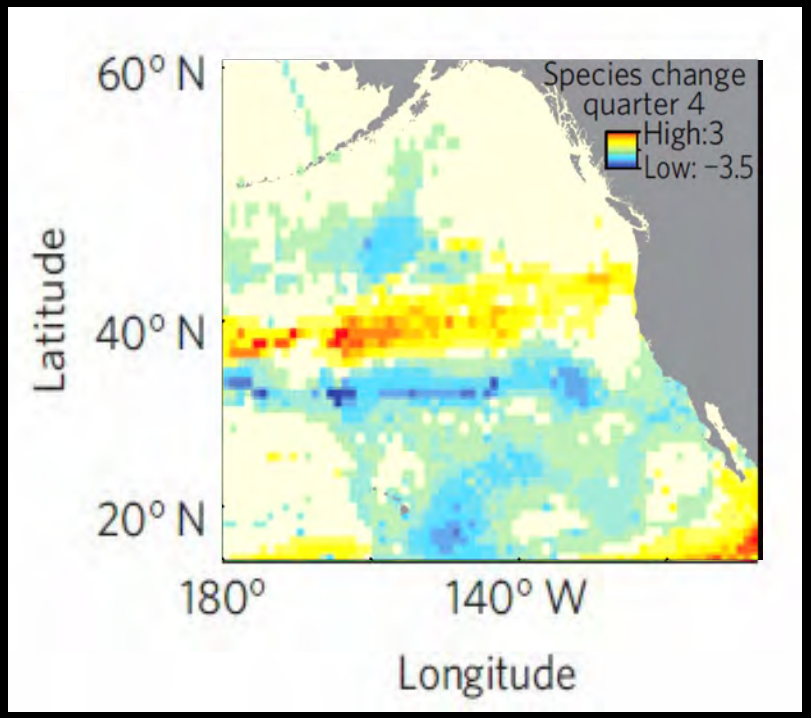


Predator response to climate change in the California Current system









Hazen et al. 2013

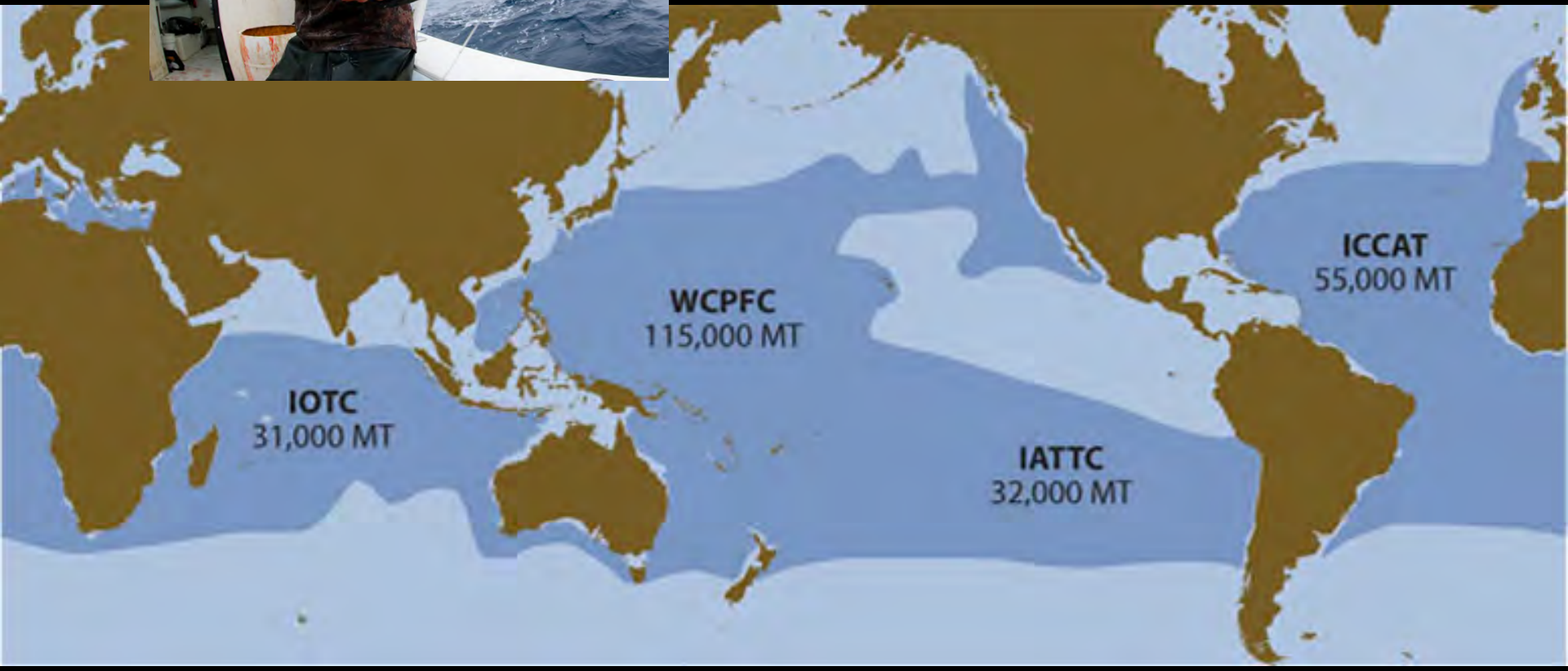
Albacore tuna *(Thunnus alalunga)*

Image: Greg Lecoeur

Image: Emerald Water Anglers

Image: Emerald Water Anglers

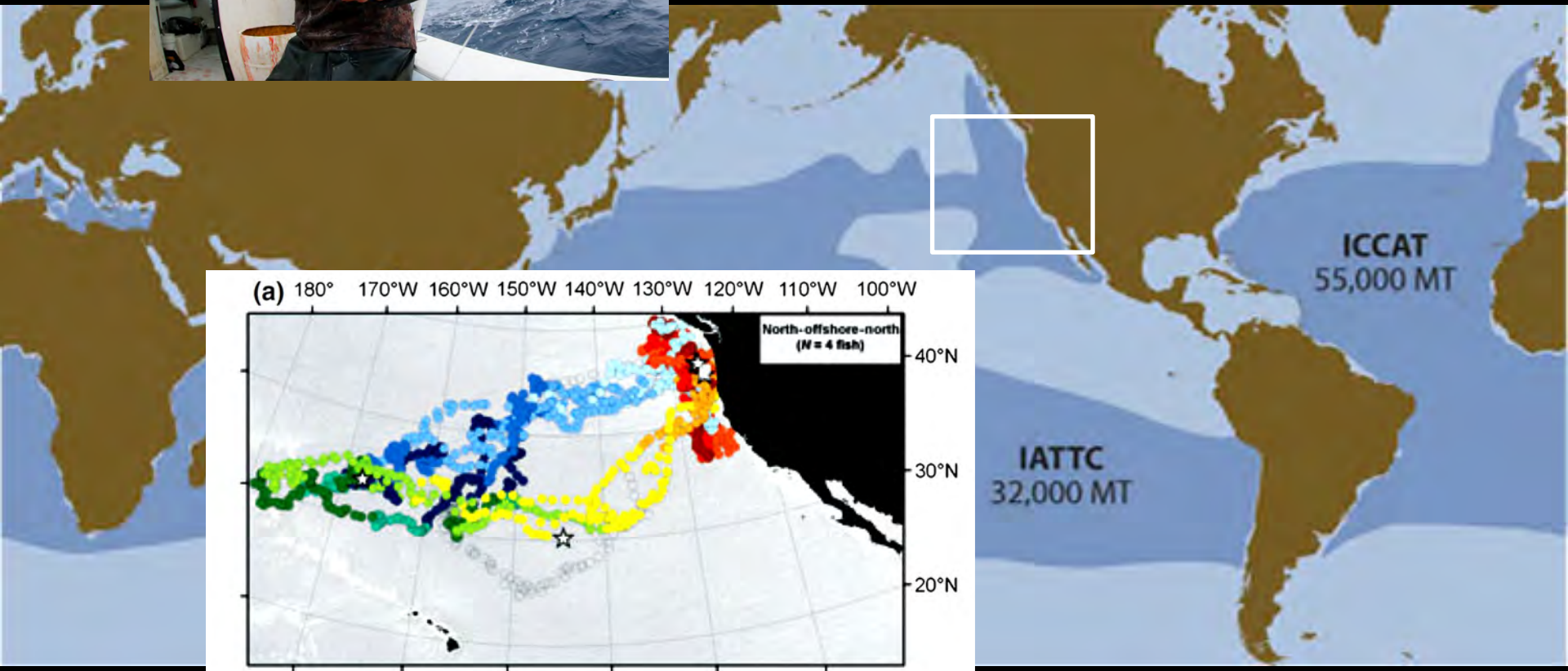
Global Albacore tuna distribution and fisheries



Pew Charitable Trust 2018

Image: Emerald Water Anglers

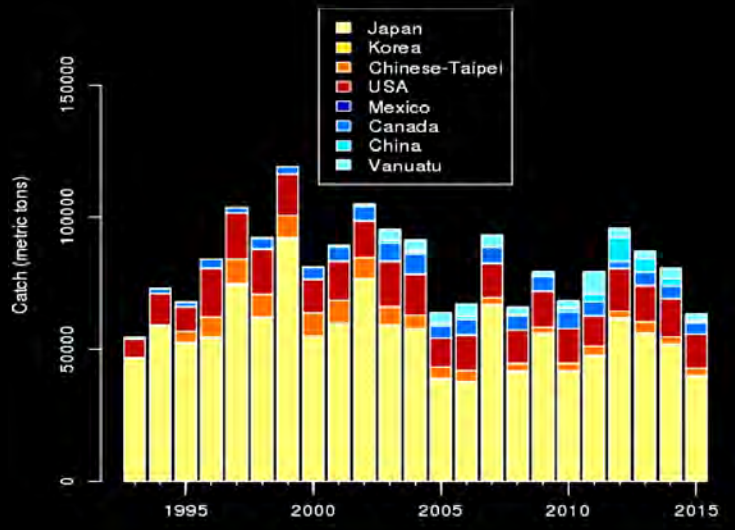
Albacore tuna in the California Current system



Childers et al. 2011

Pew Charitable Trust 2018

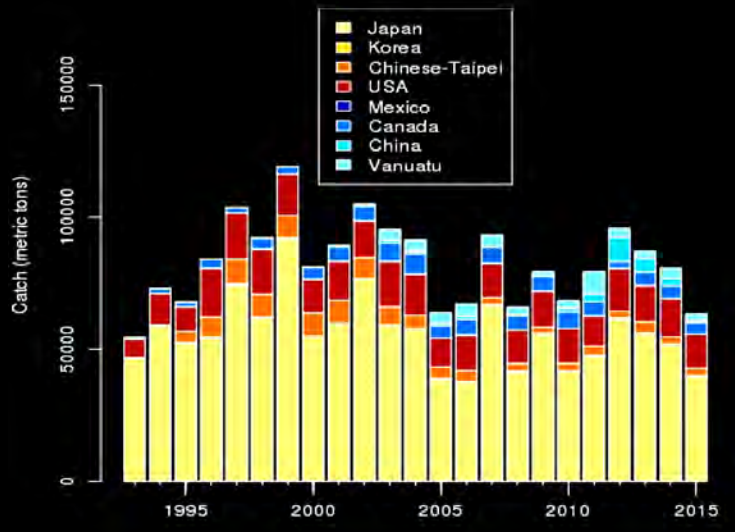
North Pacific Albacore: cross-jurisdictional management



DFO IFMP 2019-2020

Image: NOAA Fisheries

How will Albacore distribution and abundance respond to climate change?

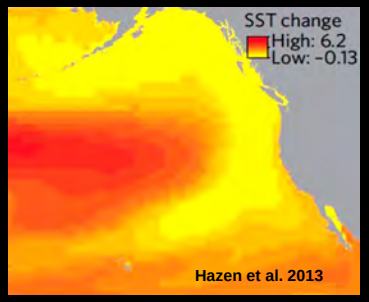


DFO IFMP 2019-2020

Image: NOAA Fisheries

Key characteristics of Albacore tuna as a case study:

- Variable diet composition



- Habitats with high climatic variability (past & future)

- Of interest for cross-jurisdictional management

Project goals & phases

1. Characterize trait-basis of foraging interactions for from past data

2. Modify food web model architecture based on traits framework

3. Test model performance & forecast possible future states

Traits-based modeling for albacore tuna predator-prey interactions in the NE Pacific

Dr. Natasha Hardy

Poster session tonight @ 6pm:

Cole Brookson

"A traits-based approach to predicting predator-prey uncoupling under climate change"

Invitation for collaboration:

How might your diet data be applied in this framework?

Postdoctoral Fellow (Mathematical Biology), Food Webs Under Climate Change

UNIVERSITY OF ALBERTA

Stanford University

LENFEST OCEAN PROGRAM

www.greenlab.ca/opportunities


Thank you
stephanie.green@ualberta.ca
@steph_j_green
www.greenlab.ca

Summary

- Opportunity to apply trait insights to predict ecological dynamics at all levels of environmental filtering

- Insights into anti-predator and foraging traits show promise for identifying strong interactions in re-assembled/data poor food webs

- Trait-based approaches can help management anticipate and adapt to environmental change (inform location and magnitude of interventions)