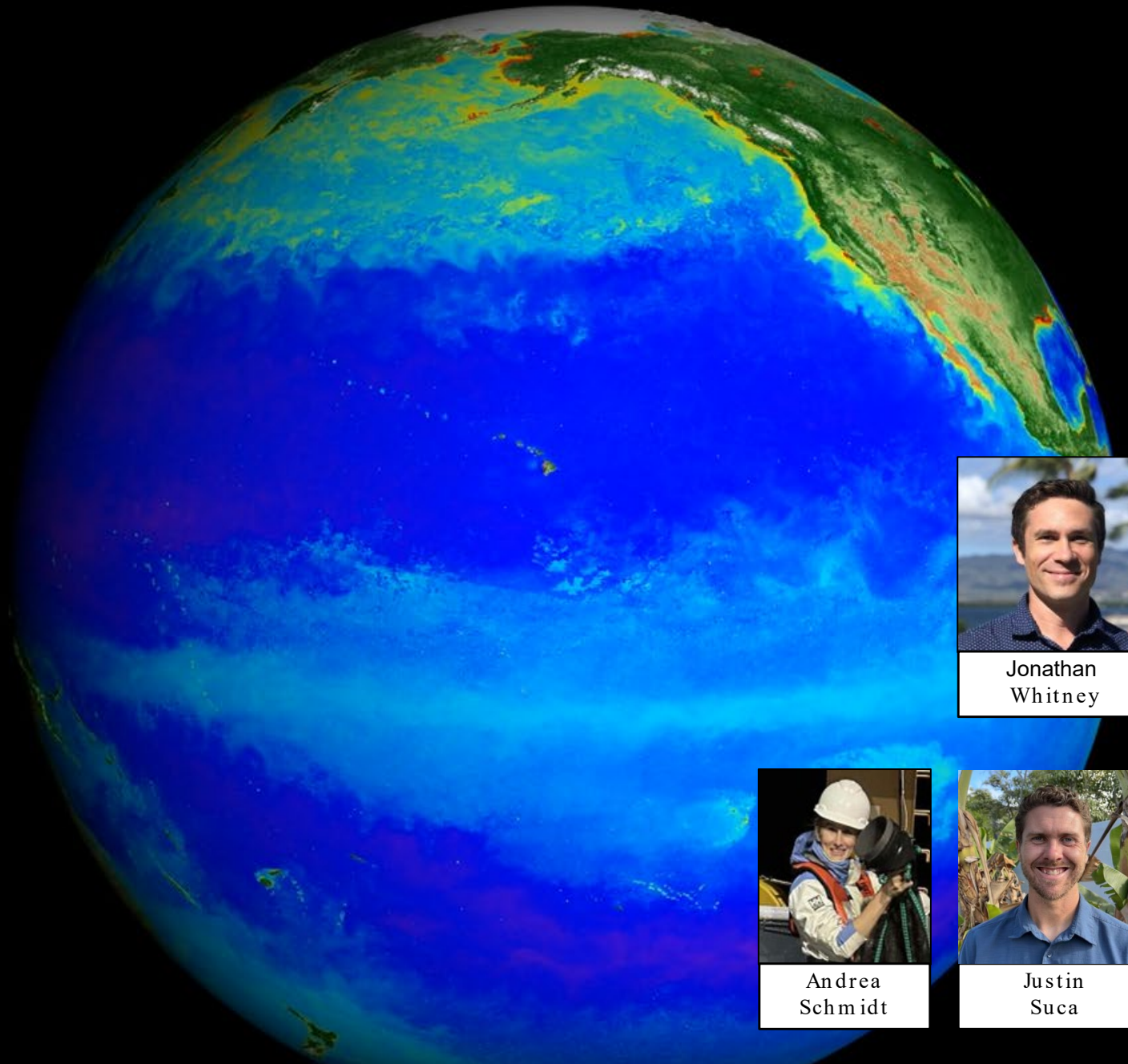
NOAA FISHERIES

Beyond boundary currents: Toward dynamic understanding of mesopelagic communities

Ryan Rykaczewski

NOAA Pacific Islands Fisheries Science Center

Honolulu, HI, USA



Thanks are due to some key collaborators on this topic:

Jonathan Whitney


Jim Ruzicka

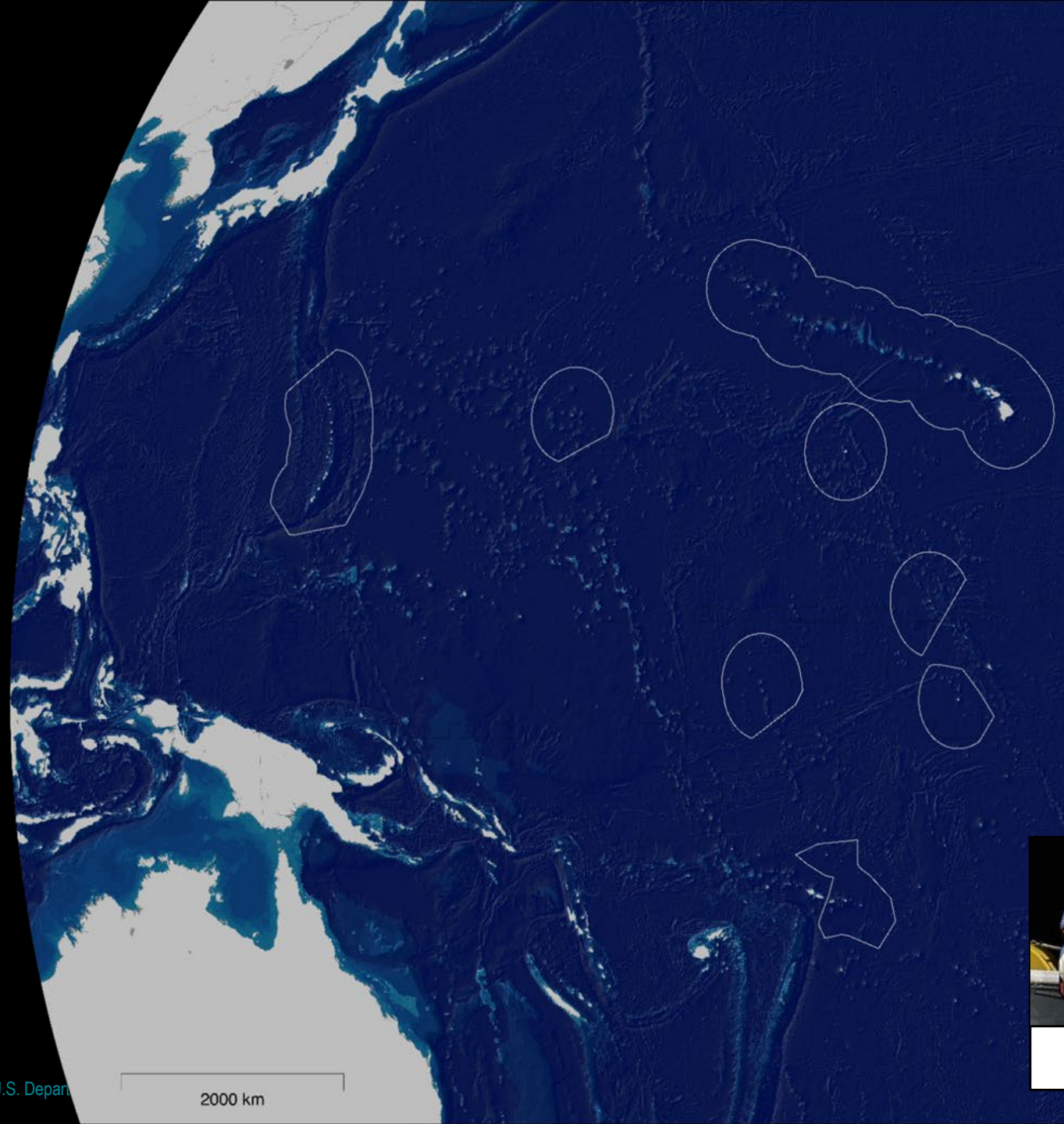

Nan Himmelsbach

Andrea Schmidt

Justin Suca


Jessie Perelman


Johanna Wren



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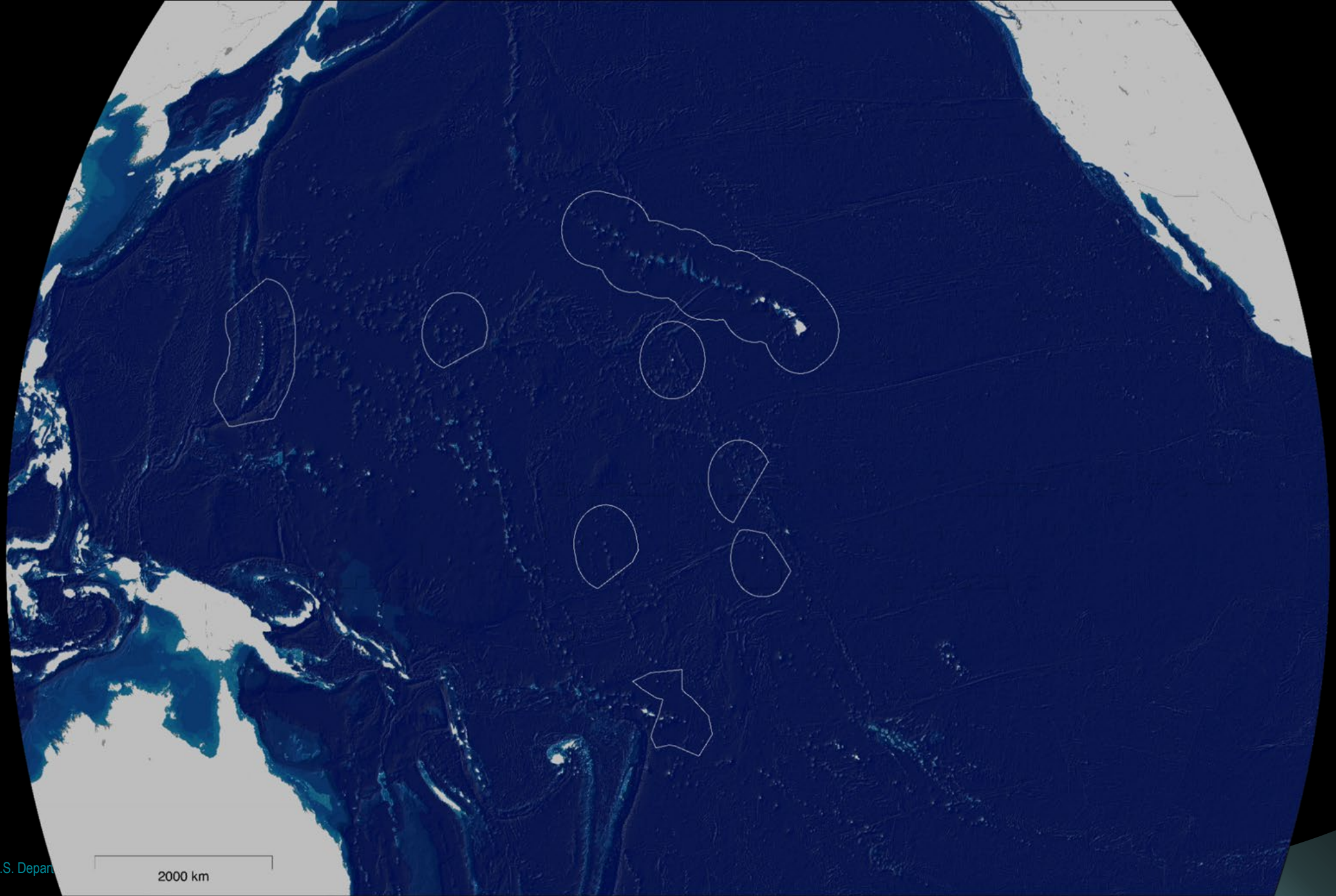

2000 km


2000 km

Longline
Purse Seine

2000 km


DON ROLO
DON RO
PL 4
MARTIN III
ELTIBURON

We are relatively blind to the dynamics of open-ocean forage communities.

Coastal and shelf forage communities

Open-ocean forage communities

Key taxa	Anchovies, sardines, herring, mackerels, capelin, spratt	Myctophids, bristlemouths, pelagic squid, and many more
Commercial landings		
Socio-economic importance		
Fisheries-independent surveys		
Sampling focus		
Density / aggregation		
Acoustic detection		
Taxonomic resolution		
Biomass certainty		

Forage research is concentrated where the biomass and habitat are not.

	Coastal and shelf forage communities	Open-ocean forage communities
		
Research effort *Symposium abstracts*		
Habitat area *Global Surface ocean*		
Standing biomass *Estimated global stocks*		
Where the field shines		

Efforts in other groups focus on understanding potential harvesting of mesopelagics and on their role in biogeochemical cycling

EU Horizon 2020

Evaluating mesopelagic biomass, sustainability of potential exploitation, and contributions to the biological carbon pump.

EU Horizon 2020

Mapping mesopelagic resources, advancing acoustic and trawl methodologies, and exploring sustainable harvest scenarios.

WHOI

Multi-disciplinary science engine combining novel platforms, eDNA, multi-ship expeditions, and the Twilight Zone Observation Network.

These efforts are advancing what we know about mesopelagic diversity and biogeochemistry.

*However, there remains a need to capture the kind of **interannual to multi-decadal variability** that has dominated coastal SPF science for decades.*

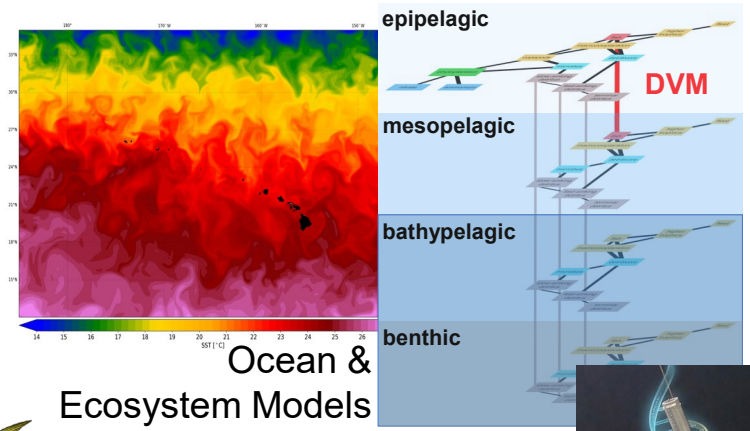
Working towards assessing temporal variability in open-ocean forage communities…

The sensitivities of the abundance, composition, distribution, and productivity of open-ocean forage communities to ocean and climate variability remain poorly described and understood.

Top predators (and our major fisheries) are dependent on a forage base we currently do not characterize.

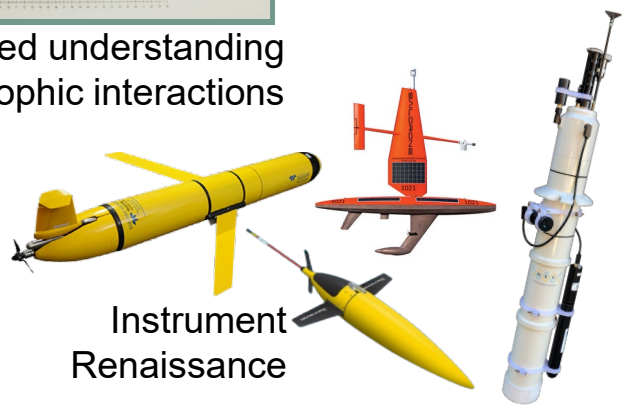
Question for all:

> *How can we leverage what we have done for coastal small pelagic populations to assess variability in open-ocean forage communities?*



Ocean & Ecosystem Models

Improved understanding of trophic interactions

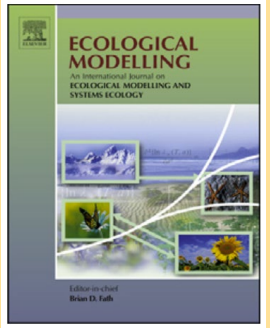


Instrument Renaissance

Coupled Trawl & eDNA Sampling

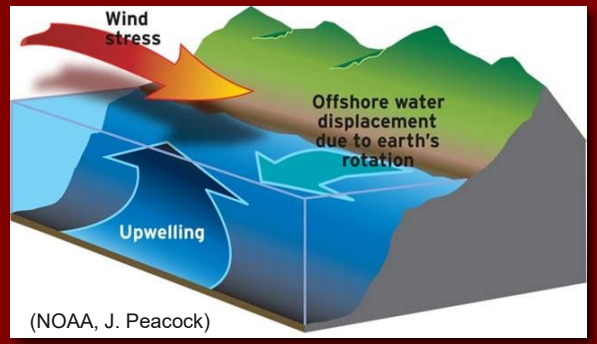
A physically coupled end-to-end model platform for coastal ecosystems: Simulating the effects of climate change and changing upwelling characteristics on the Northern California Current ecosystem

James J. Ruzicka [a,*], Kenneth H. Brink [b], Dian J. Gifford [c], Frank Bahr [b]

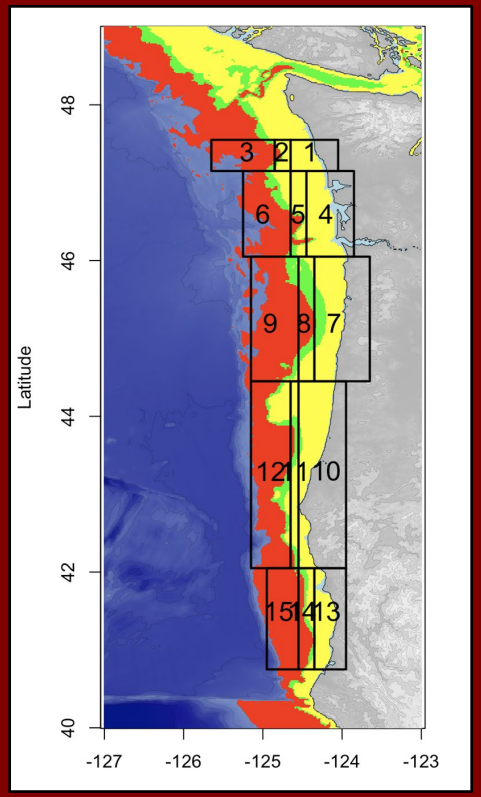


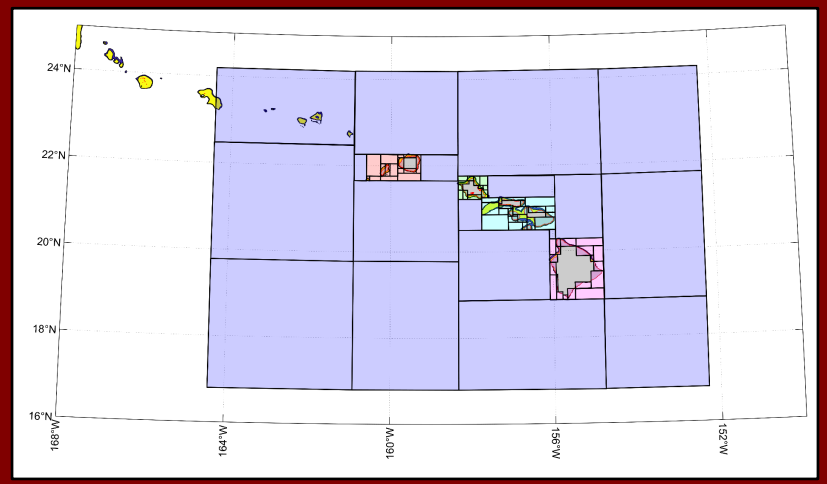
Ecological Modelling 331 (2016) 86–99

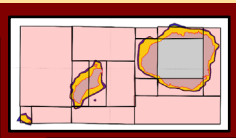
Jim Ruzicka

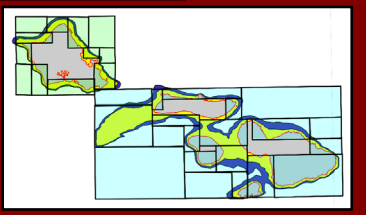


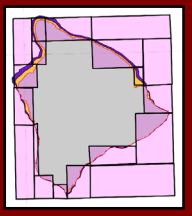
The main physical constraints on trophic fluxes:
- rate of **input** of inorganic nutrients
- **export** of planktonic production out of the system

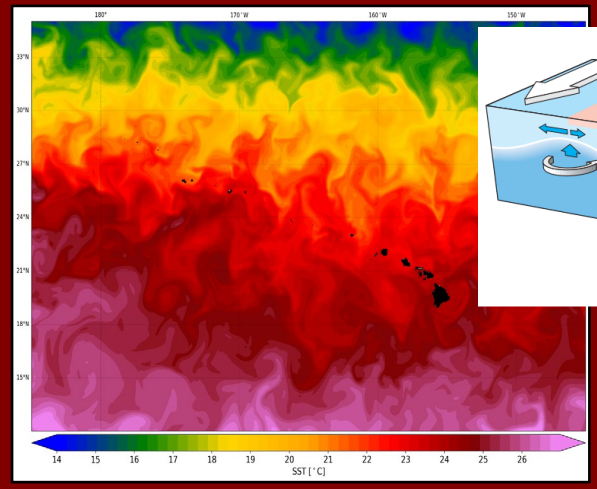


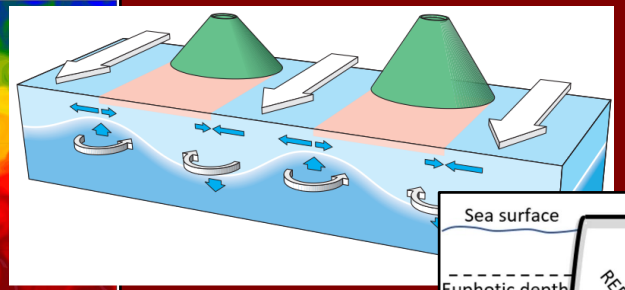


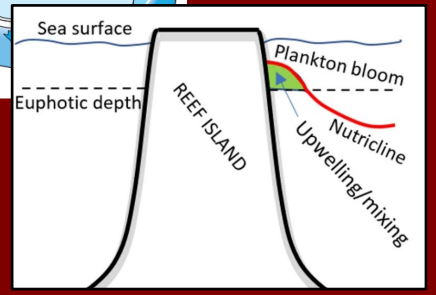








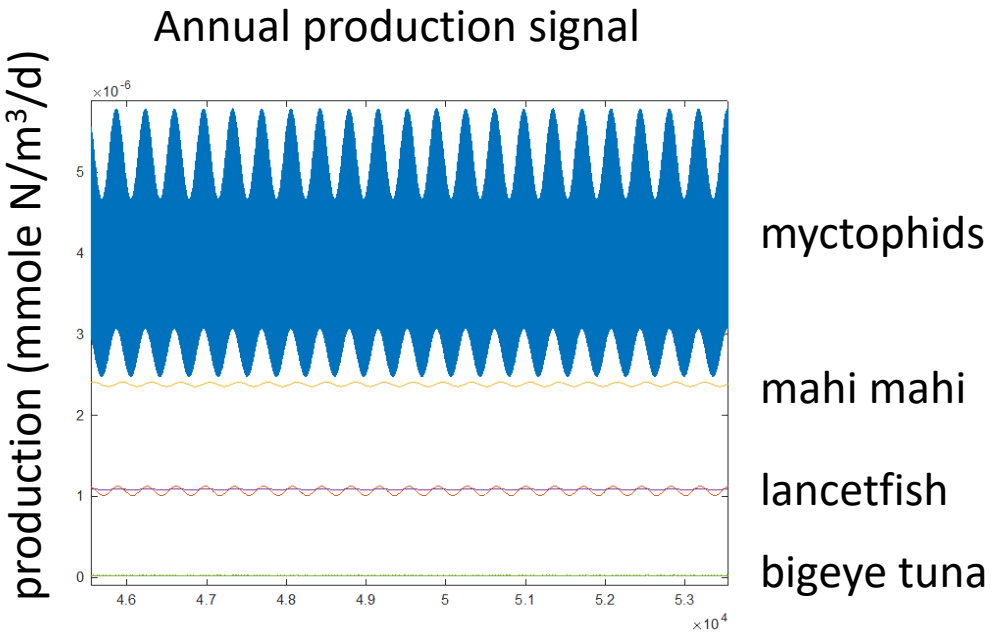




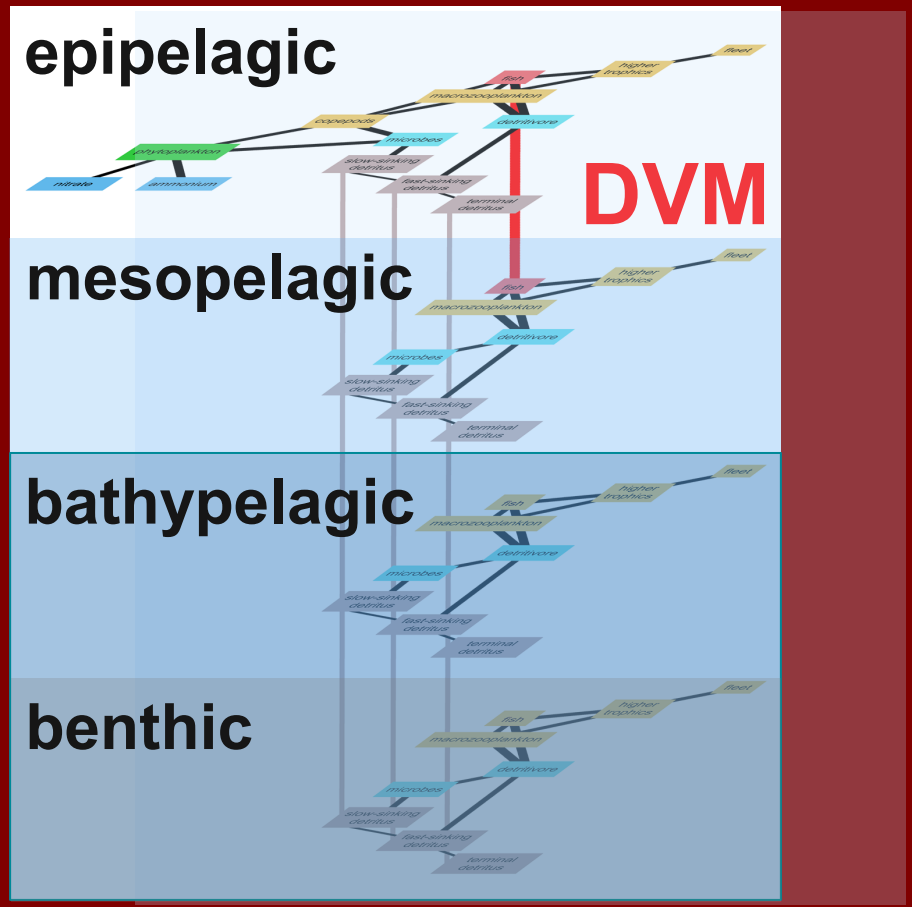
Modeling vertical exchange processes in oceanic ecosystems to understand forage and predator dynamics

Session 4

Jim Ruzicka

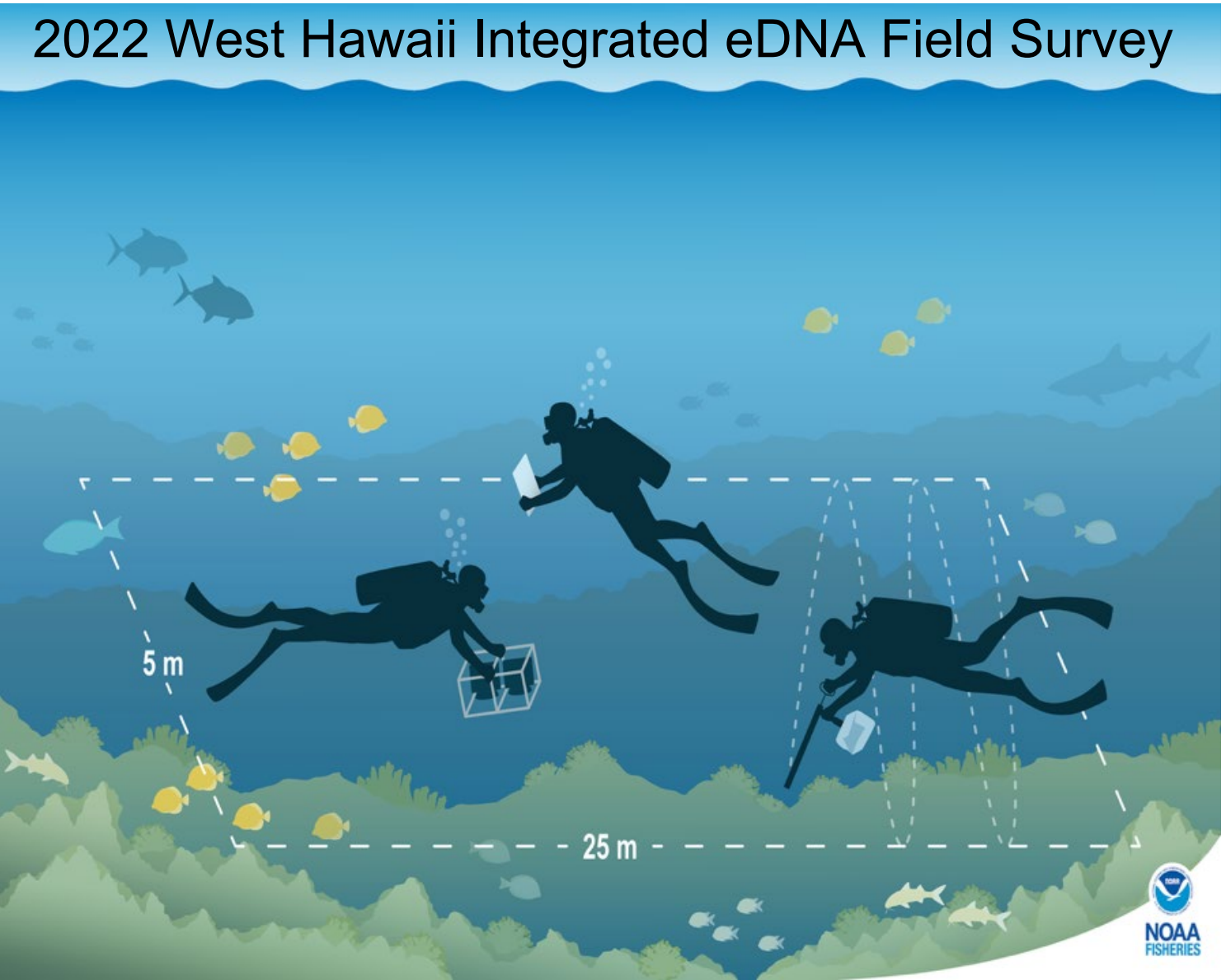


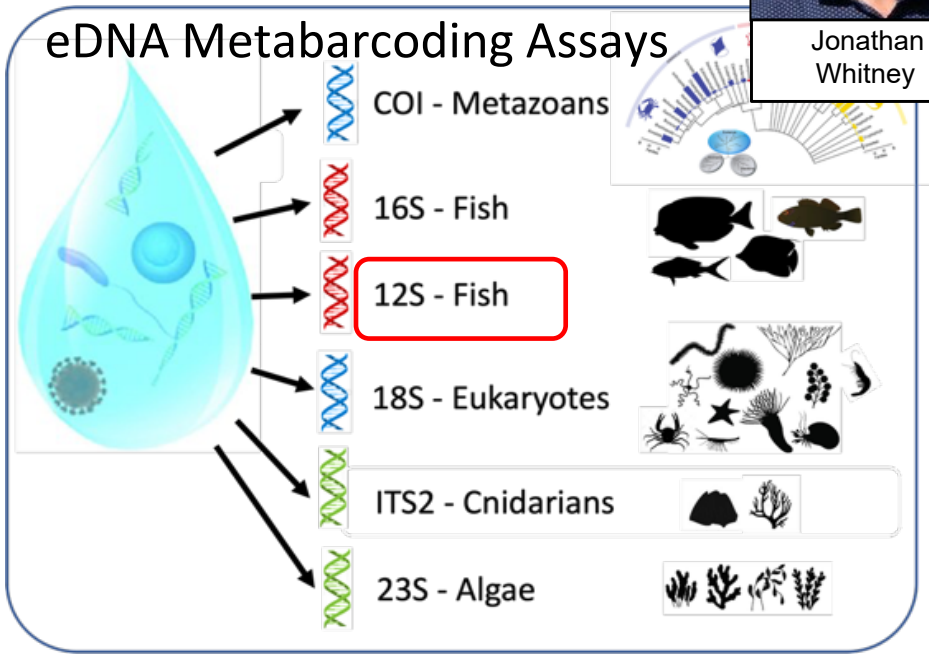
EcoTran captures vertical migration across a range of scales and accounts for the impact temperature change with depth on vital rates.



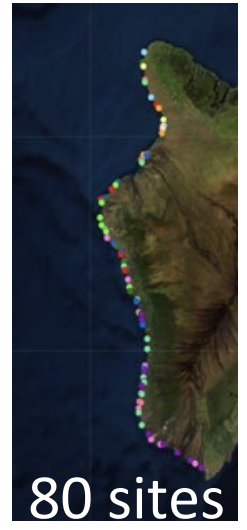
eDNA meets traditional sampling: towards quantitative metabarcoding

Jonathan Whitney





6 x 4L
replicates



eDNA meets traditional sampling: towards quantitative metabarcoding

Jonathan Whitney

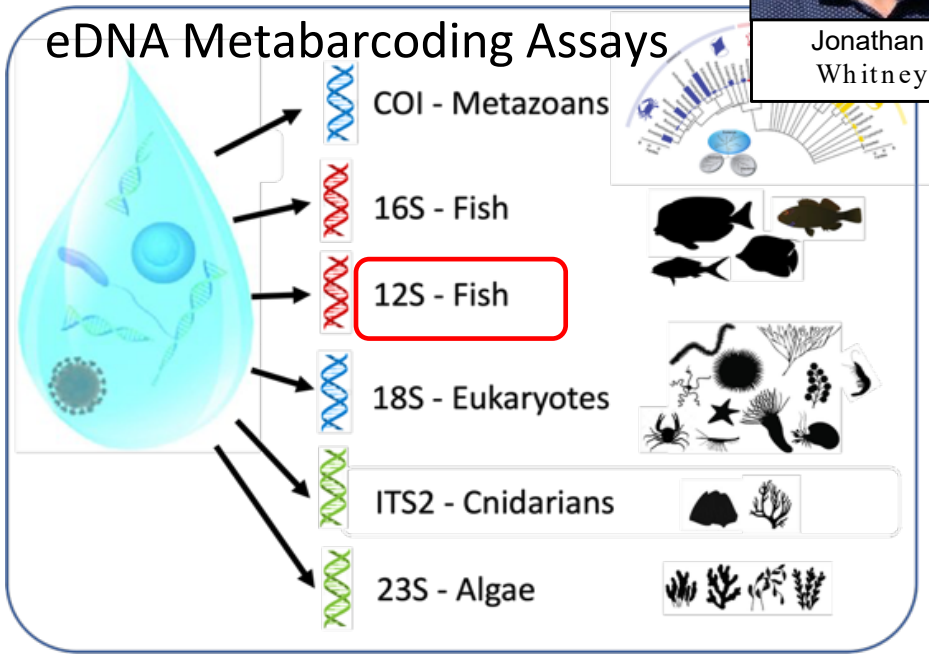
Predicted biomass

Visual Surveys

eDNA

Counts of Fish

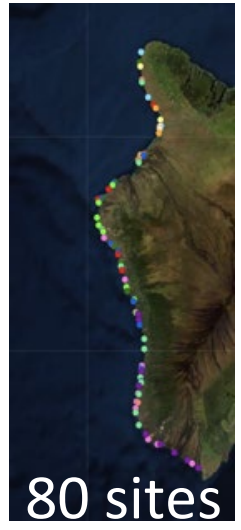
Counts of DNA



Model Covariates

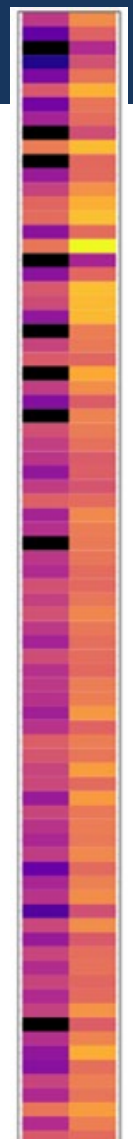
- Strata (6 GAO variables) → 1. CoralCover, 2. Rugosity-fine, 3. Rugosity-course, 4. Depth, 5. Algalcover, 6. Northing
- VRM 'complexity' SfM
- Coral Cover SfM
- Dist. 100m isobath 'slope'

6 x 4L replicates

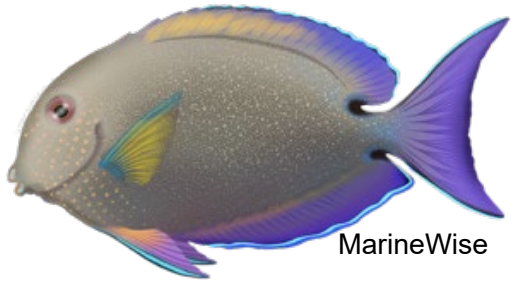


Ole Shelton
NWFSC

Highly detectable species are used to anchor the link between DNA and biomass derived from underwater visual counts

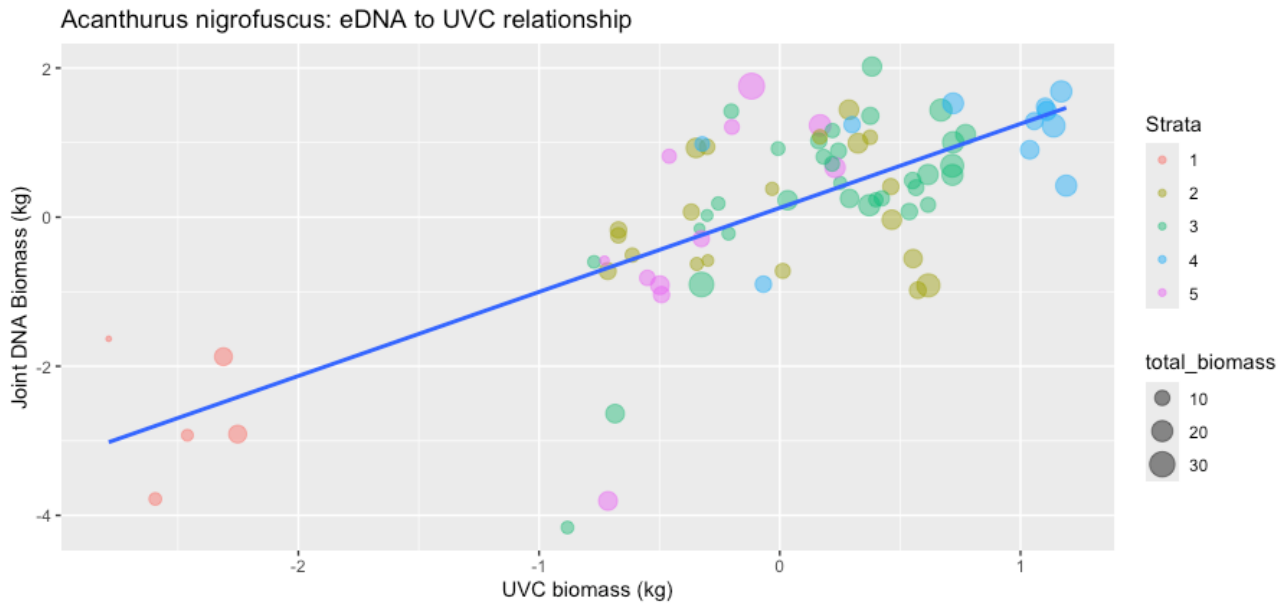


Biomass (kg)
10
1
0.1
0.01
0.001



Acanthurus nigrofuscus
lavender tang (**ma‘i‘i‘i**)


Jonathan Whitney



Offers the first fisheries-independent estimates of biomass for ʻōpelu and ʻakule at island scale

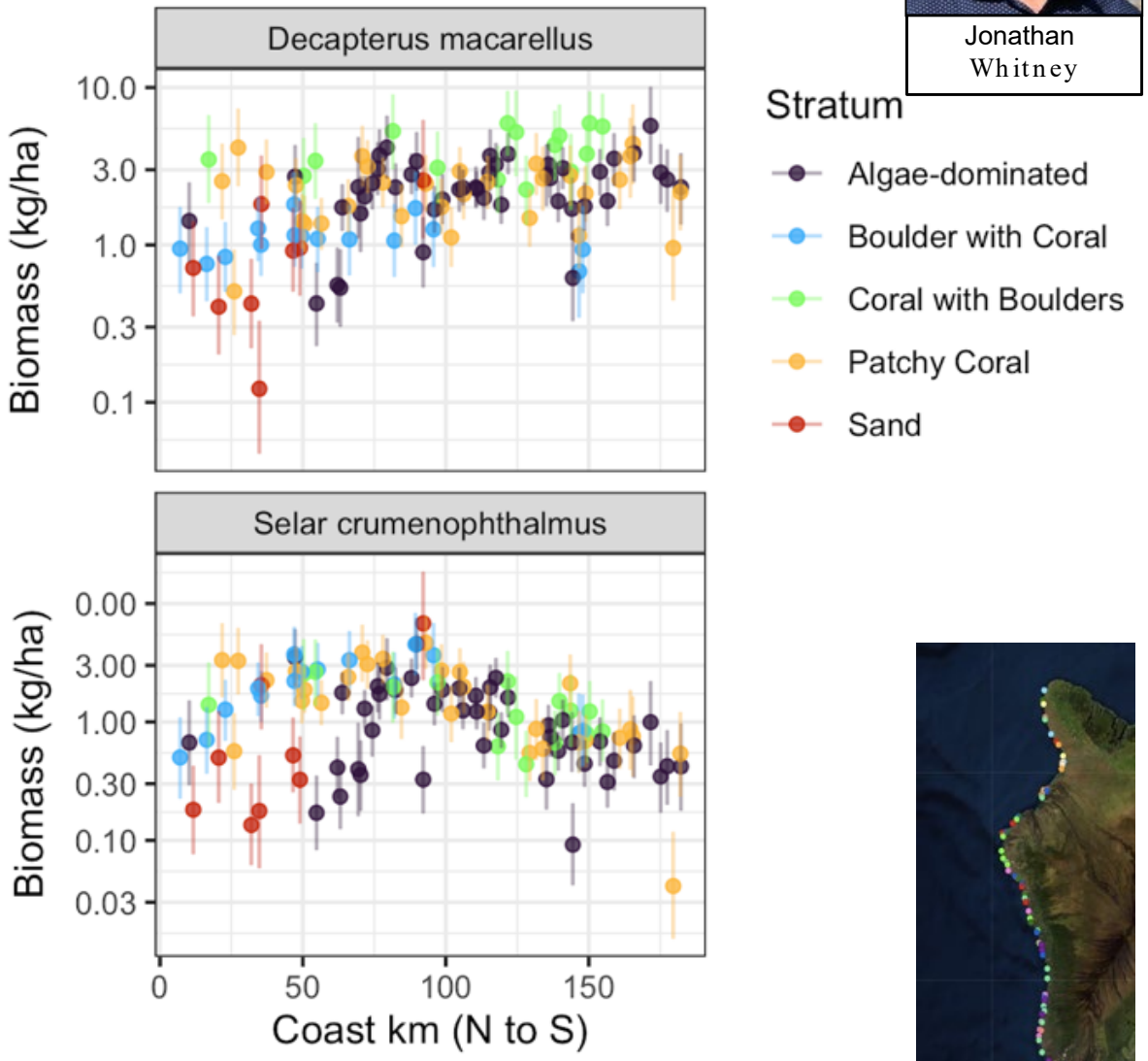
Jonathan Whitney

Biomass (kg)
10
1
0.1
0.01
0.001

ʻōpelu (mackerel scad)
Decapterus macarellus

ʻakule (bigeye scad)
Selar crumenophthalmus

Absent from visual surveys

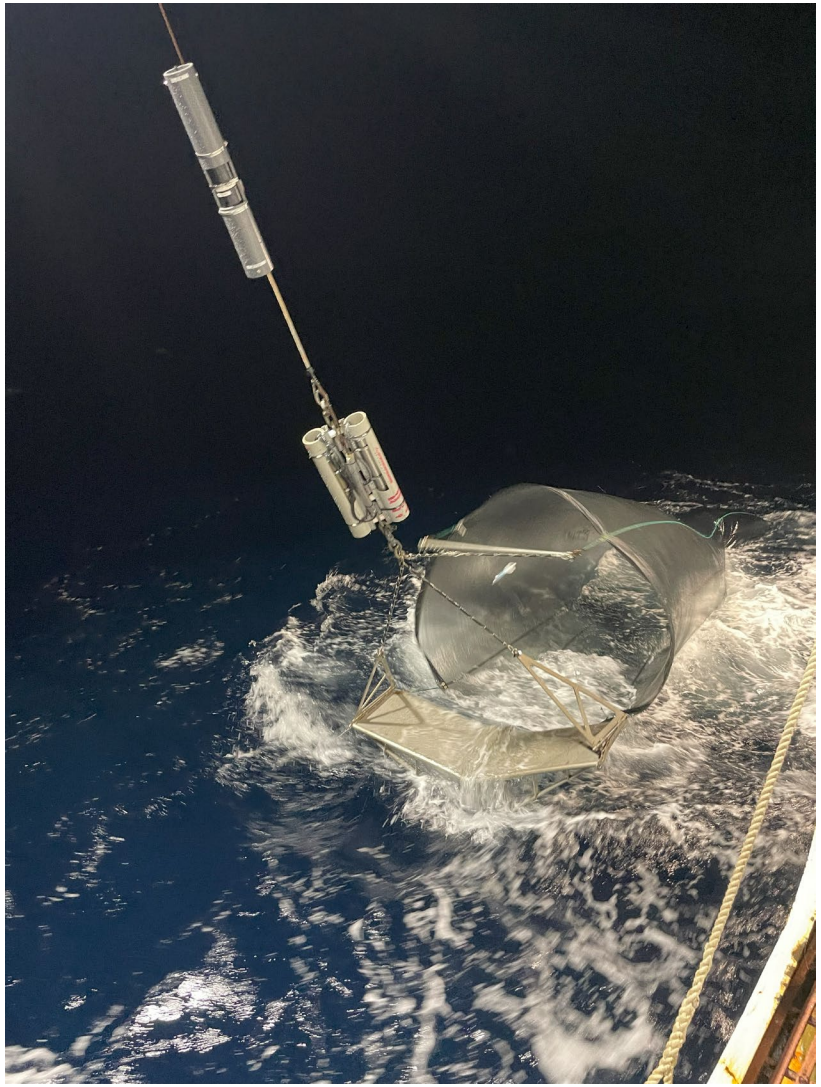


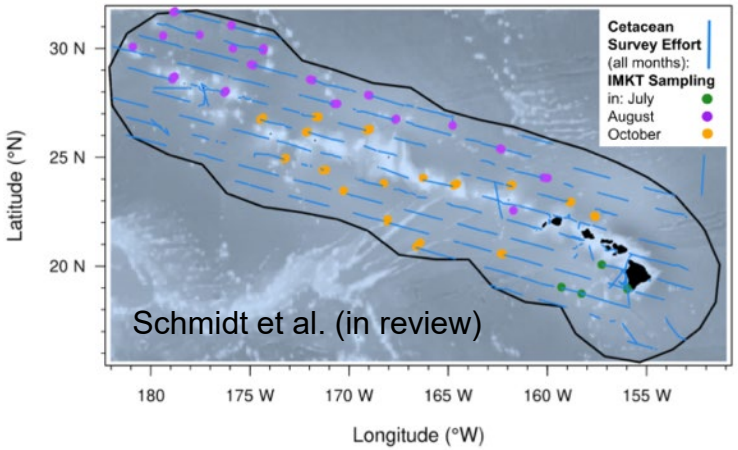
Recent effort (2023…): apply this same method to our pelagic sampling for micronekton

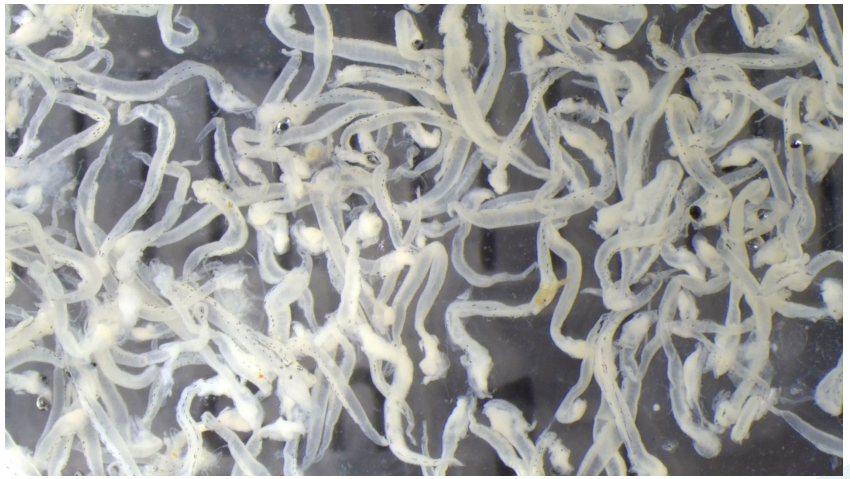
Andrea Schmidt

Justin Suca

Jessie Perelman



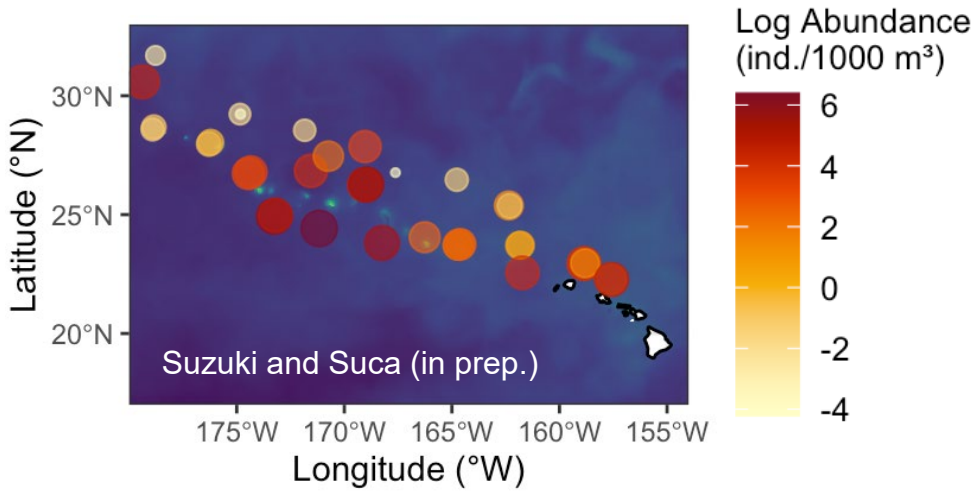




Contreras

Both methods detected a surprising biomass of nehu, or buccaneer anchovy (Encrasicholina punctifer)

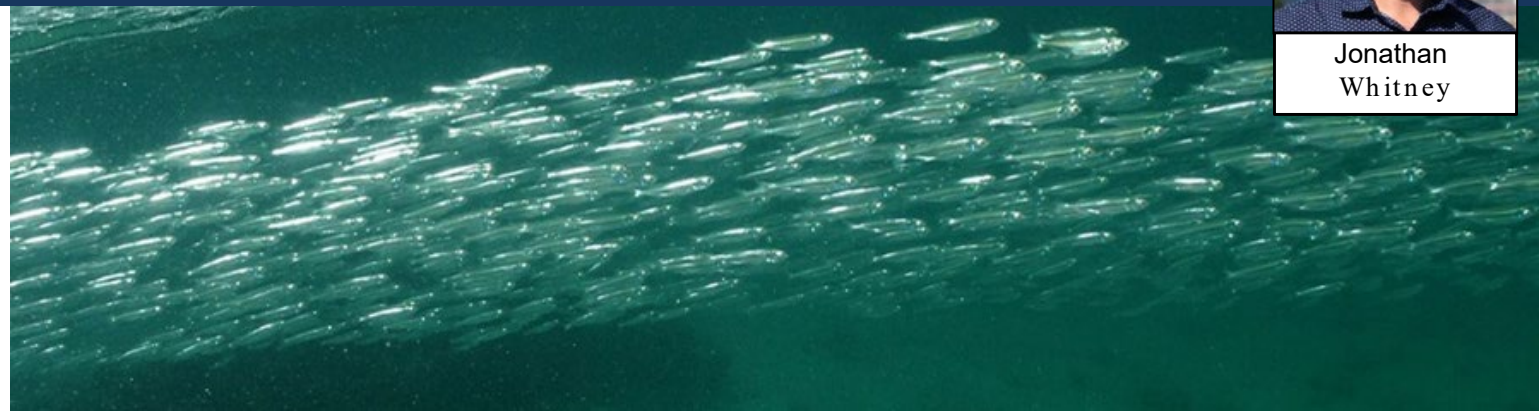
Encrasicholina punctifer

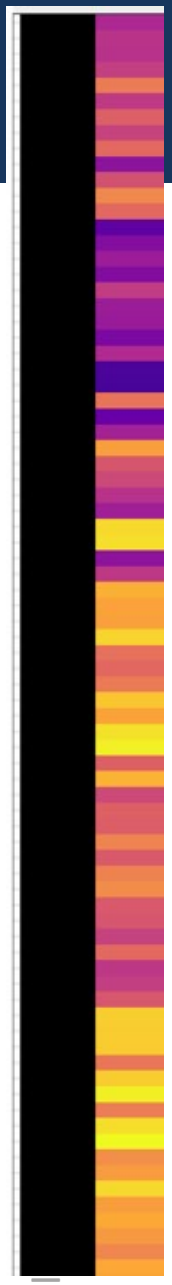


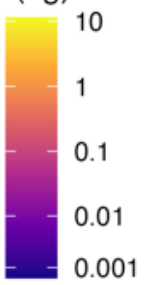
Nehu is among the dominant fishes, but almost never seen by the underwater divers

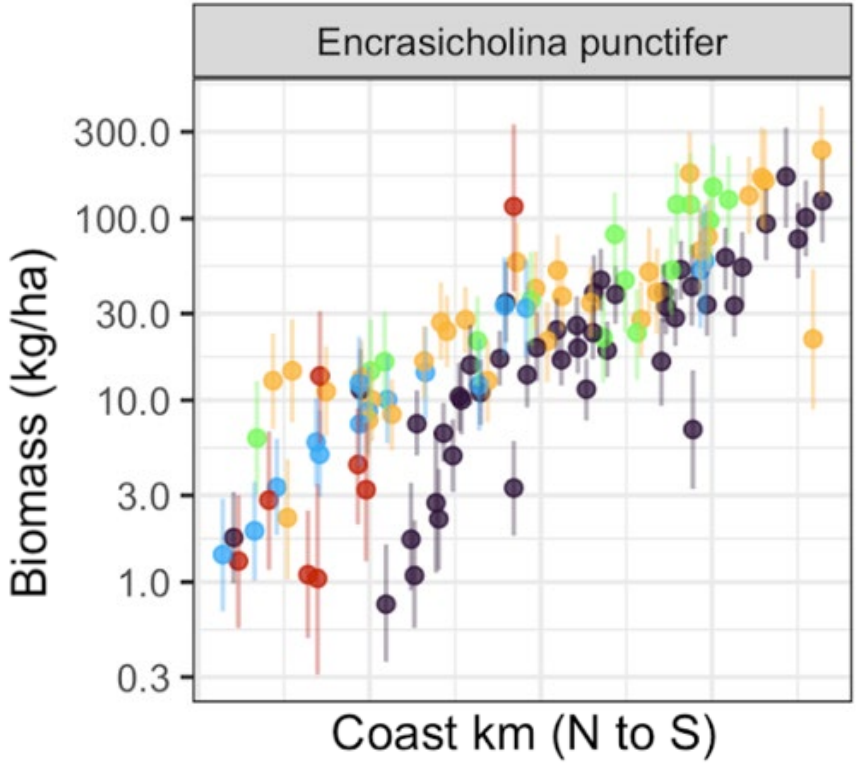
Jonathan Whitney

Encrasicholina punctifer
buccaneer anchovy (**nehu**)

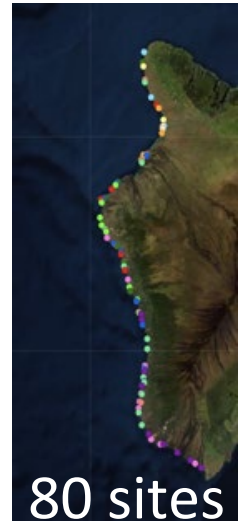








On avg. 5% of biomass per site
Strong spatial pattern



Early efforts to study forage communities are helping to shed light on changing the general consensus about critical species

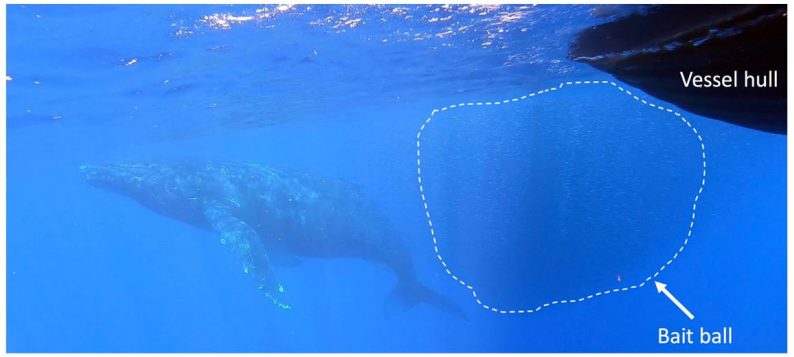
Marine Mammal Science

NOTE | Open Access

Humpback whale feeding behavior and defecation observed on the Hawaiian breeding grounds

Marc O. Lammers, Julia Zeh, Adam A. Pack, Eden Zang, Ed Lyman

First published: 04 September 2024 | https://doi.org/10.1111/mms.13177 | VIEW METRICS



Lammers et al. (2025)

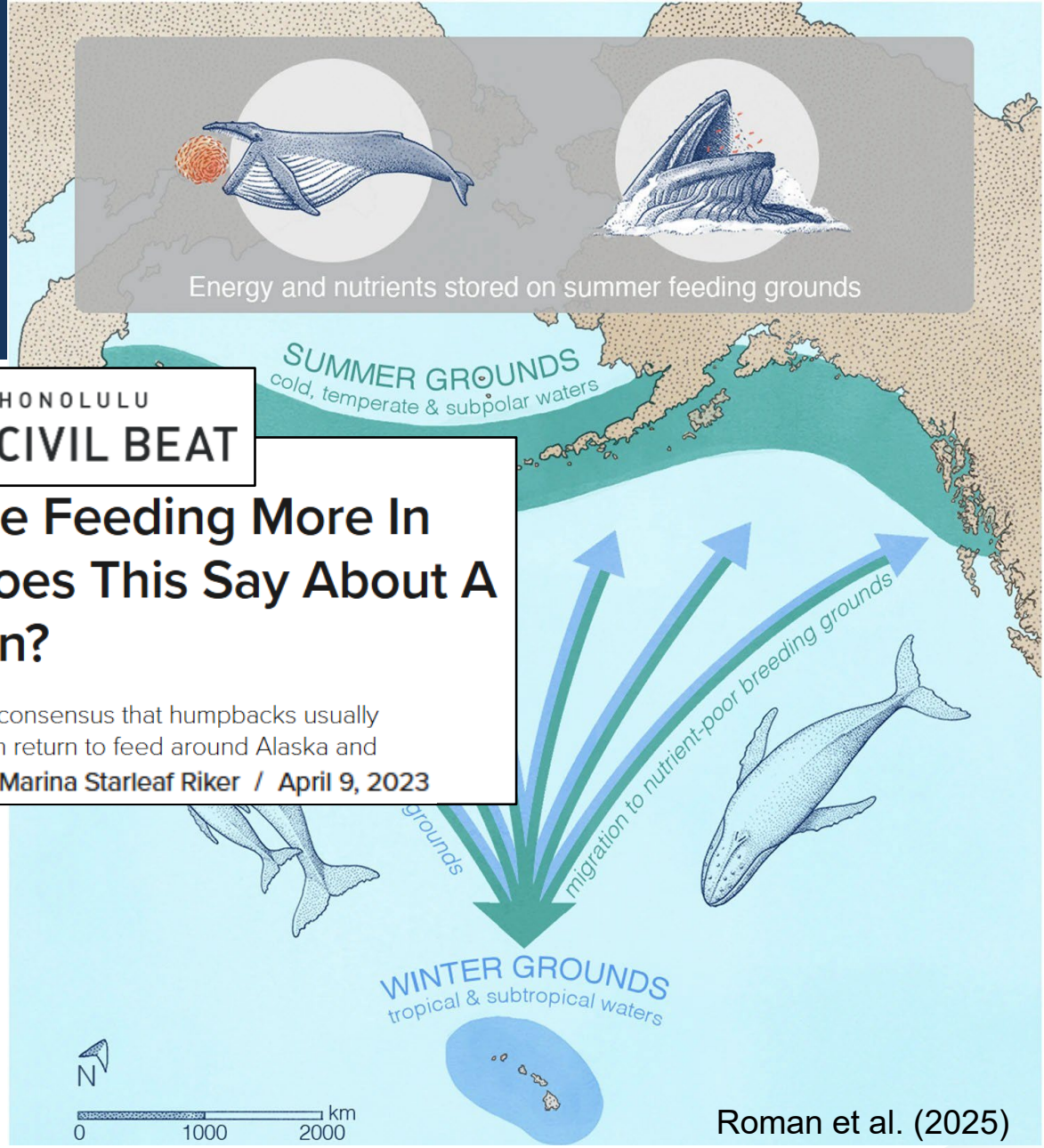
Underwater image of the whale and the bait ball off Olowalu, Maui (Photo: Eden Zang)

HONOLULU CIVIL BEAT

Stemming The Tide

Whales Might Be Feeding More In Hawaii. What Does This Say About A Changing Ocean?

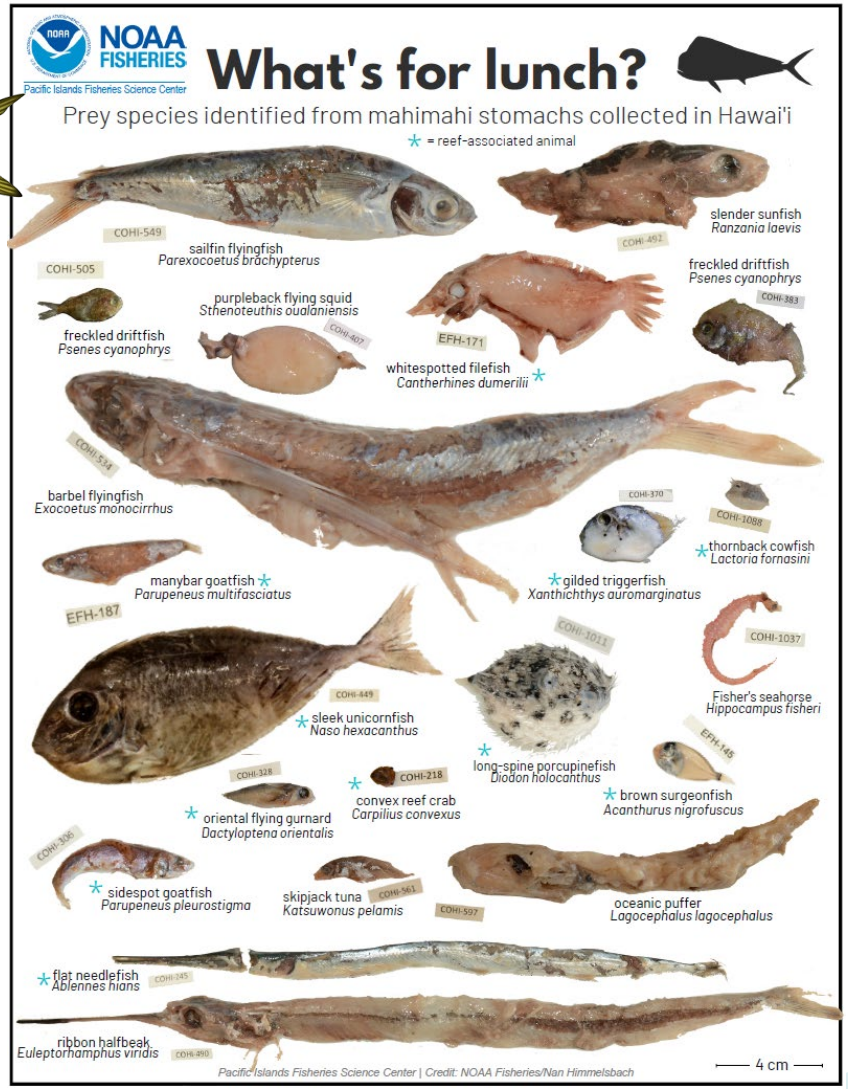
The findings contradict a general consensus that humpbacks usually just breed in Hawaiian waters then return to feed around Alaska and scientists want to know why. By Marina Starleaf Riker / April 9, 2023



Roman et al. (2025)

Progress made towards recognizing variability over space and time, but tough challenges remain

Trophic relationships are poorly resolved.
Who eats whom?



Nan Himmelsbach

Jonathan Whitney

Justin Suca

Progress made towards recognizing variability over space and time, but tough challenges remain

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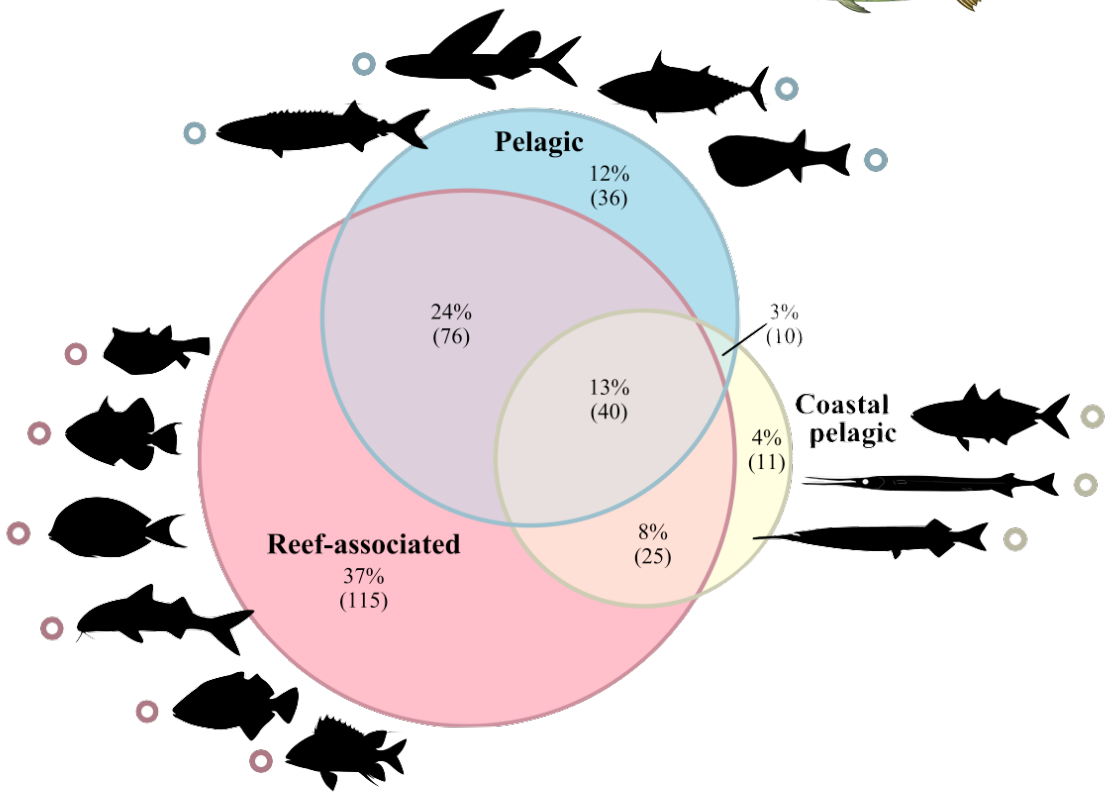
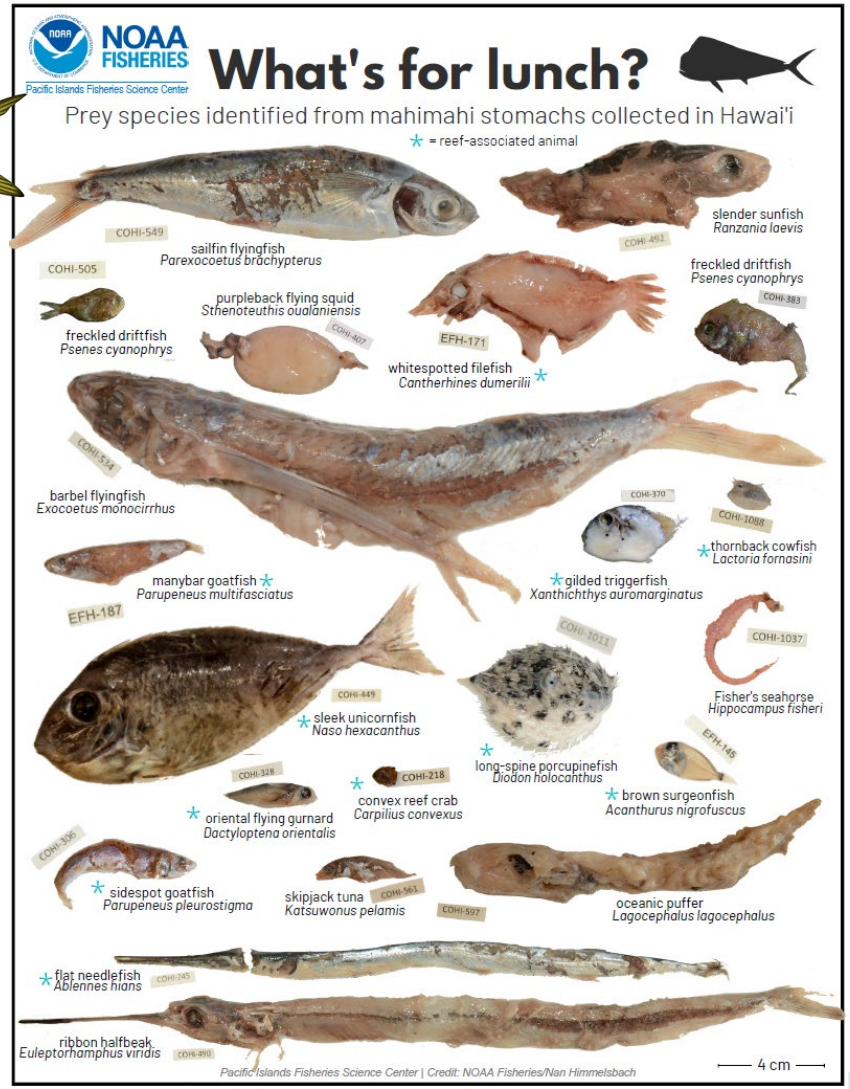




Nan Himmelsbach

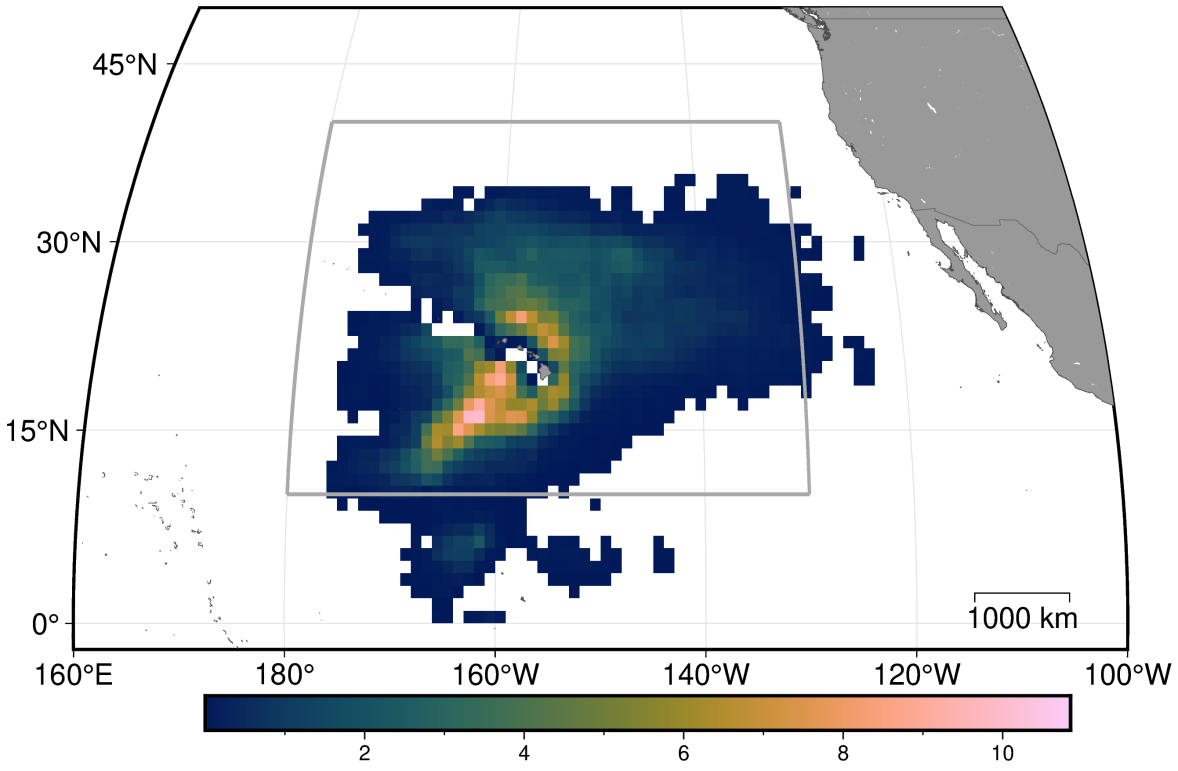
Jonathan Whitney

Justin Suca

Progress made towards recognizing variability over space and time, but tough challenges remain

The spatial scale *requires* innovative sampling platforms applied in a portfolio approach.

- ***Gliders, AUVs, satellite observations, and floats (and synthesized products derived from these observations)***
- ***Vessels of opportunity***
- ***Collaboration with fishing fleets as sampling platforms***



Effort (million hooks, 1995-2025)

A sampling of symposium abstracts addressing mesopelagic, micronekton, and/or open-ocean forage dynamics

S01 **Hill-Cruz et al.**
Competition and SPF responses to SSP scenarios, Humboldt System

S01 **Plaza-Vega et al.**
Jack mackerel fishery in the SE Pacific: interdecadal change

S03 **Camilla-Vivar et al.**
Early life history of a dominant mesopelagic fish in the South Humboldt

S03 **Vilanova et al.**
Lanternfish larvae distribution patterns in the Southwest Atlantic

S03 **Namiki et al.**
Nutritional stress in Myctophum affine larvae, SE Brazilian Bight

S04 **Loutrage et al.**
Trait-based trophic ecology of deep-pelagic fishes (invited)

S04 **Garrido et al.**
Trophic ecology of NE Atlantic micronekton via stable isotopes

S04 **Zacarias et al.**
Trophic ecology of mesopelagic fish, northern Benguela & SE Atlantic

S04 **Hunt**
Global micronekton nutritional quality and its variability

S04 **Richards et al.**
Pacific bluefin consumption of anchovy and myctophids, S. California

S04 **Ruzicka**
Modeling vertical exchange in oceanic ecosystems: forage and predators

S04 **Gleiber et al.**
Foraging traits and climate variability in NE Pacific albacore tuna

S05 **Li et al.**
NW Pacific mesopelagic fish vertical distribution and carbon export

S05 **Milles et al.**
Forage fish responses to future ocean and predator-prey redistribution

W03 **Plaza-Vega et al.**
Linking oceanographic variability and Trachurus murphyi off Chile

W06 **Titaud et al.**
Ensemble run quantifying uncertainty in the SEAPODYM LMTL component

Open-ocean forage dynamics:
Shifting from a "nice to know" to a "need to know"

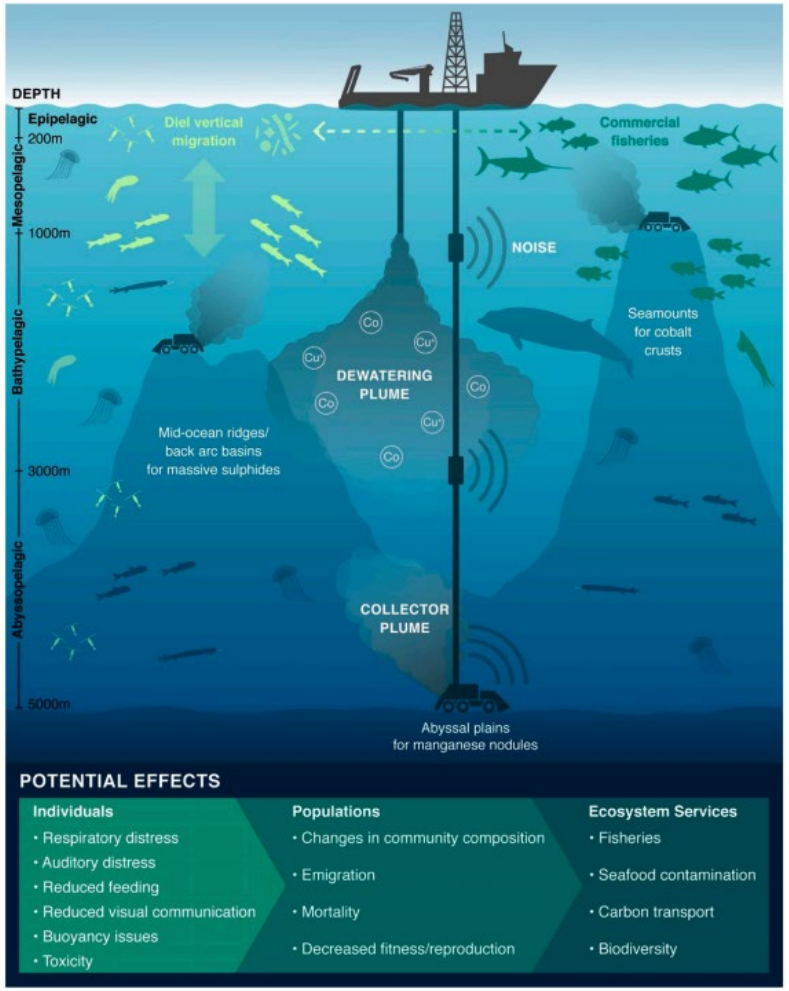


Fig. 1. Mining-generated sediment plumes and noise have a variety of possible effects on pelagic taxa. (Organisms and plume impacts are not to scale.) Image credit: Amanda Dillon (graphic artist).

Diel vertical migrators move daily through the depths where dewatering plumes may be released.

Without a baseline, we cannot distinguish natural variability from responses to new stressors. We are going to be asked to provide management-relevant science for a system we have not well measured.

This is both an opportunity and an urgency for the coastal SPF community to engage with open-ocean forage dynamics.

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