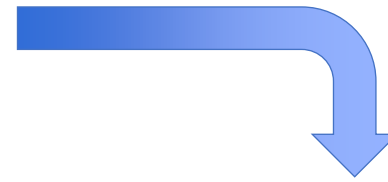


**Modeling vertical exchange processes in oceanic
ecosystems to understand forage and predator
dynamics**

***Development of Central North Pacific–EcoTran:
processes & techniques***

		consumers			
		P_1	C_1	C_2	F_1
producers	Q_{pc}				
	P_1	0	180	20	0
	C_1	0	20	35	5
	C_2	0	0	8	2
F_1	0	0	0	0	

ECOPATH food web snapshot
Consumption Matrix:
Who eats how much of what?



		producers			
		P_1	C_1	C_2	F_1
consumers	A_{cp}				
	P_1	0	0	0	0
	C_1	0.9	0.3	0	0
	C_2	0.1	0.6	0.8	0
F_1	0	0.1	0.2	0	

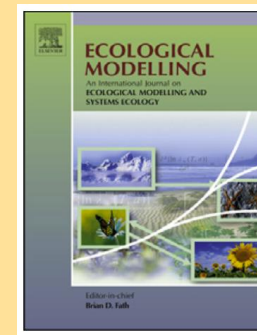
EcoTran “translation”

Trophic Matrix:

What is the fate of production?

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

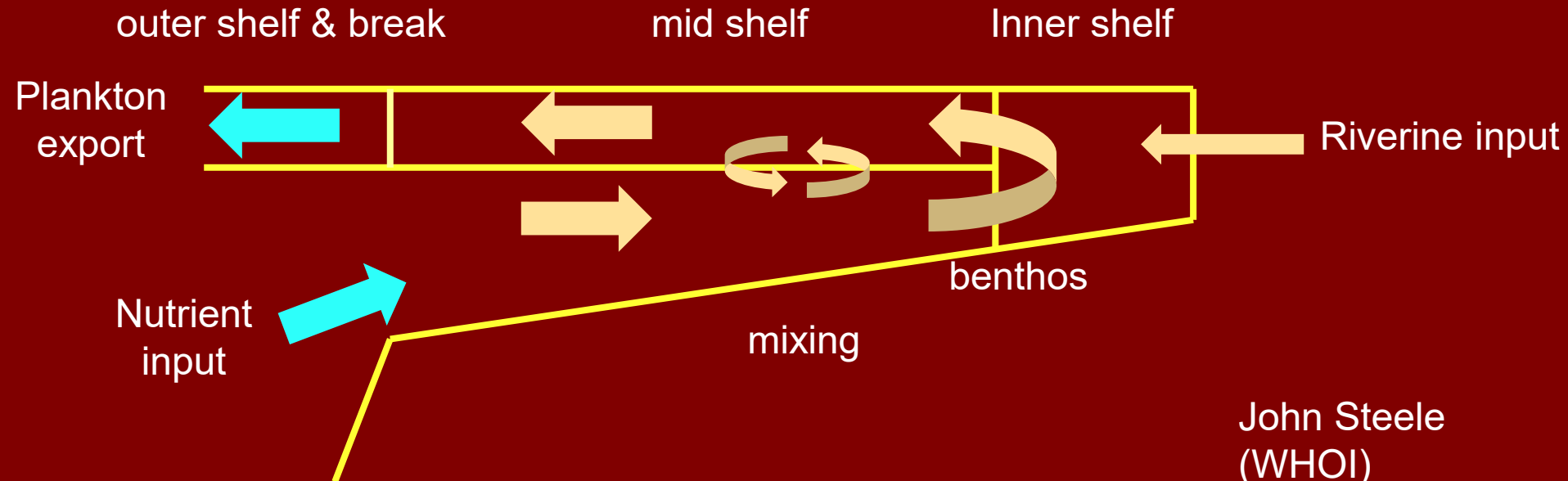
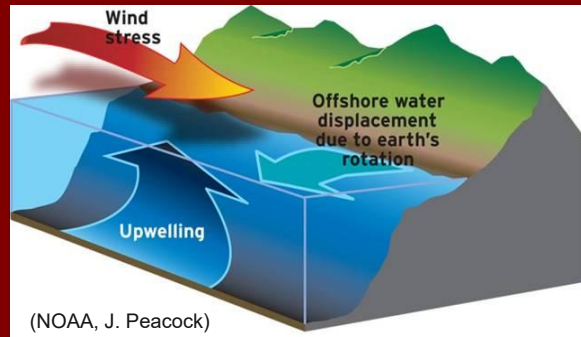
James J. Ruzicka^{a,*}, Kenneth H. Brink^b, Dian J. Gifford^c, Frank Bahr^b



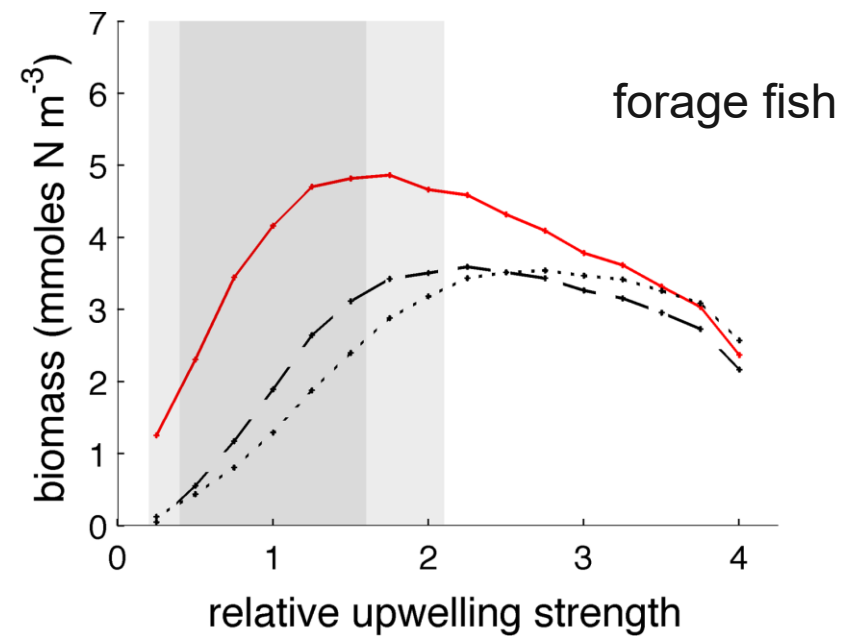
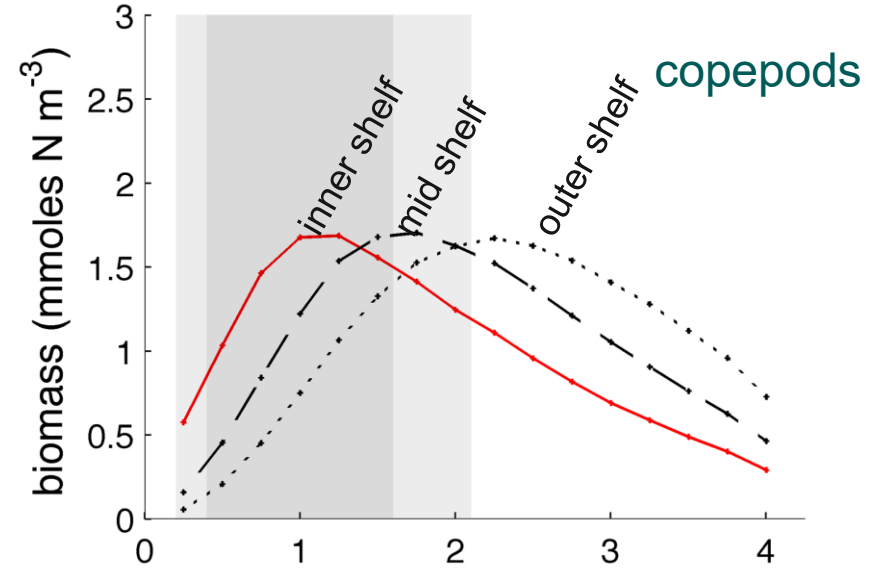
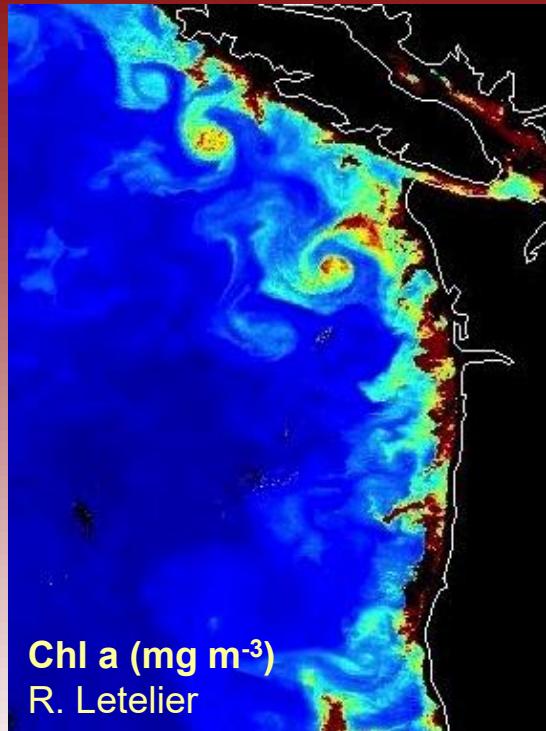
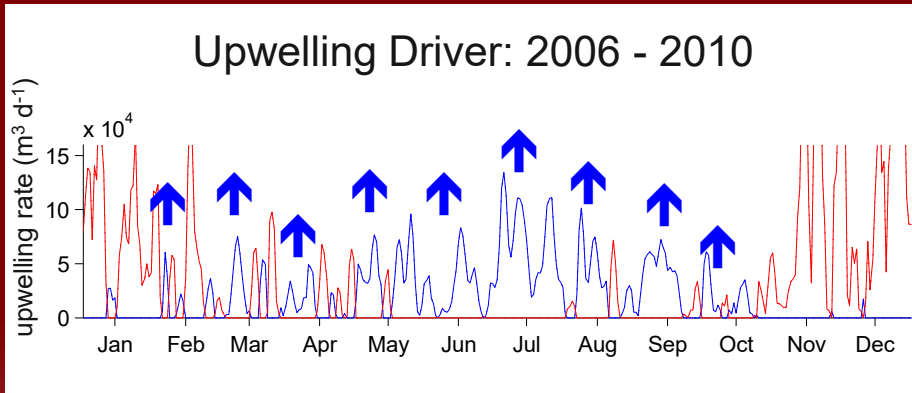
Ecological Modelling 331 (2016) 86–99

Upwelling physics in 2D:

- rate of **input** of inorganic nutrients
- **export** of planktonic production out of the system



Production Loss to Open Ocean via Upwelling Advection: event intensity



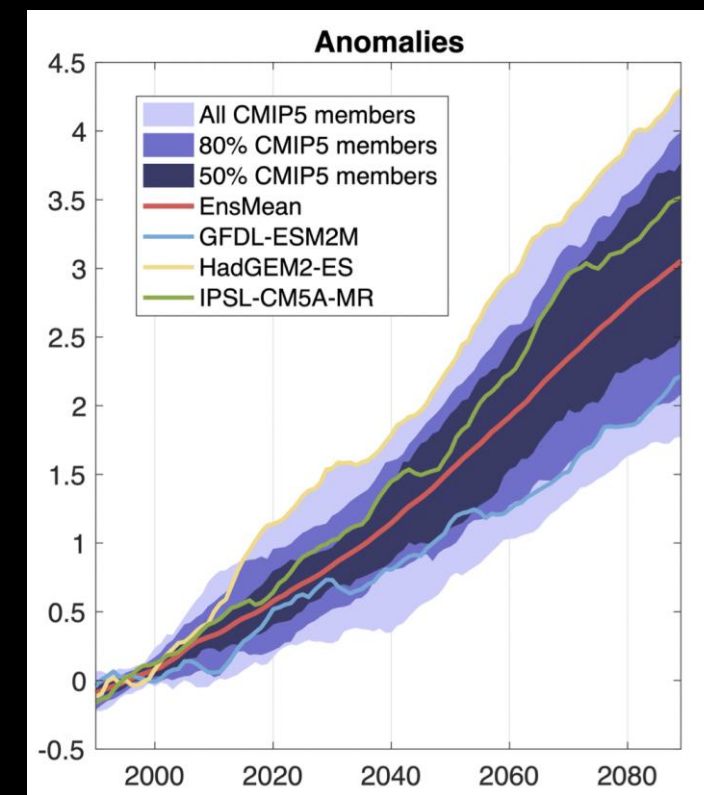
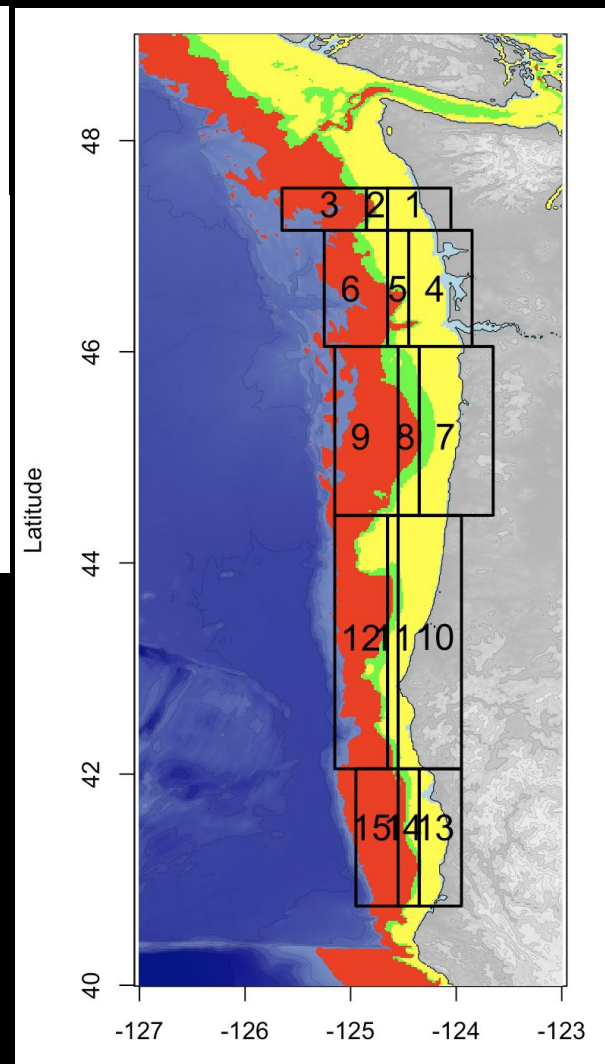
From 2D upwelling to → 3D ROMS-coupled physics w/ physiological responses to temperature

Climate change scenarios for the Northern California Current

 ORIGINAL RESEARCH
published: 07 April 2021
doi: 10.3389/fmars.2021.612874

A Dynamically Downscaled Ensemble of Future Projections for the California Current System

Mercedes Pozo Buil^{1,2*}, Michael G. Jacox^{1,2,3}, Jerome Fiechter⁴, Michael A. Alexander³, Steven J. Bograd^{1,2}, Enrique N. Curchitser⁵, Christopher A. Edwards⁴, Ryan R. Rykaczewski⁶ and Charles A. Stock⁷



ROMS-NEMUCSC (physics/BGC model)
RCP8.5 climate projection
1980-2050 (2100)



**FutureSeas NEMUCSC-
ROMS downscaled ESMs
Pozo-Buil et al. 2021 FMS**

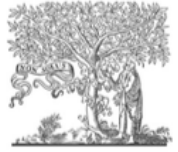
Response to Temperature: Metabolism & Ingestion

ECOLOGICAL MODELLING 202 (2007) 144-164

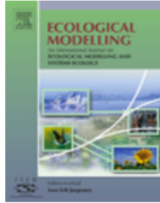
available at www.sciencedirect.com



journal homepage: www.elsevier.com/locate/ecolmodel



ELSEVIER



A bioenergetics-based population dynamics model of Pacific herring (*Clupea harengus pallasii*) coupled to a lower trophic level nutrient-phytoplankton-zooplankton model: Description, calibration, and sensitivity analysis

Bernard A. Megrey^{a,*}, Kenneth A. Rose^b, Robert A. Klumb^c, Douglas E. Hay^d, Francisco E. Werner^e, David L. Eslinger^f, S. Ian Smith^g

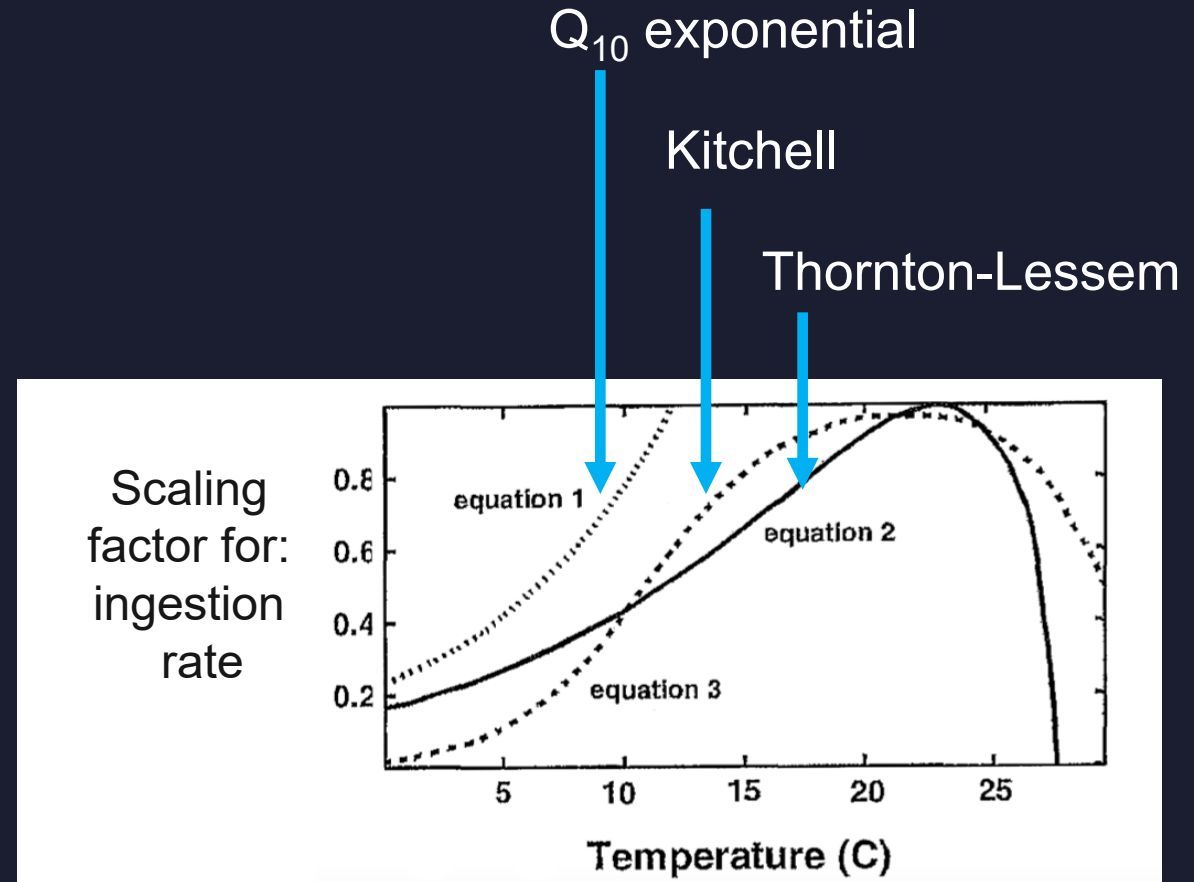
Q₁₀ exponential:
metabolic costs

Thornton-Lessem:
dome shaped
ingestion rate

$$R_2 = R_1 \times Q_{10}^{(T_2 - T_1)/10^\circ C}$$

$$gcta = \frac{(xk1 \cdot t4)}{(1.0 + xk1 \cdot (t4 - 1.0))}$$

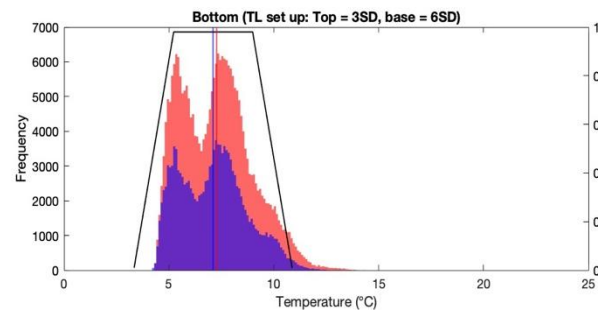
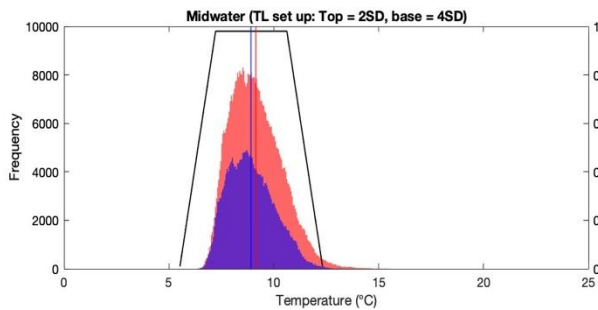
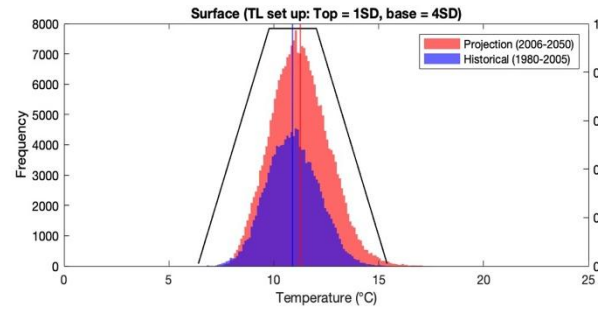
$$gctb = \frac{(xk4 \cdot t6)}{(1.0 + xk4 \cdot (t6 - 1.0))}$$



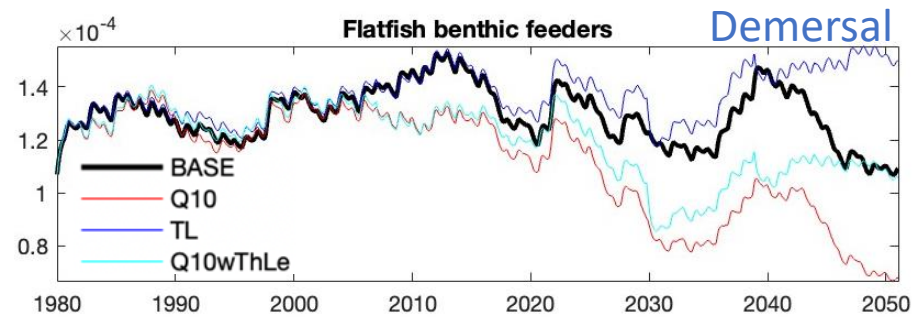
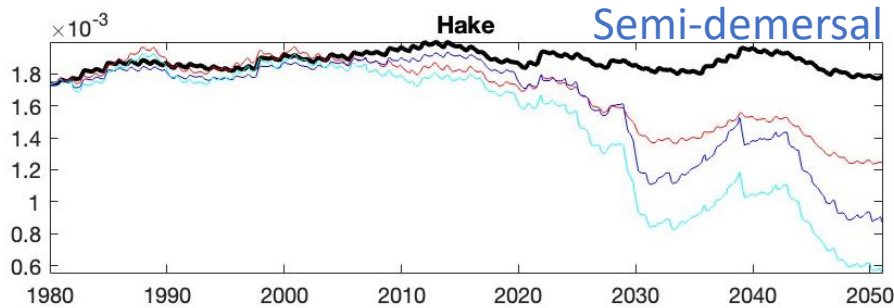
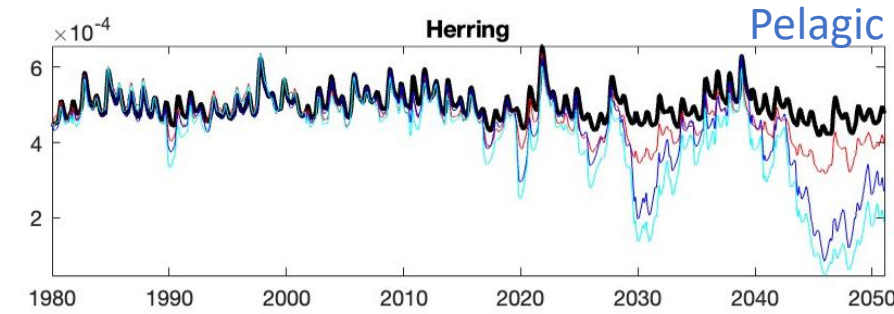
(Wisconsin Bioenergetics model - Hanson et al. 1997)

Response to temperature: Q_{10} & Thornton-Lesseem

Example: Climate Change in the Northern California Current under RCP8.5



Depth zone reference temperatures (1980-2010) to define niche



Depth-zone indicator groups to 2050 under RCP8.5

Results:

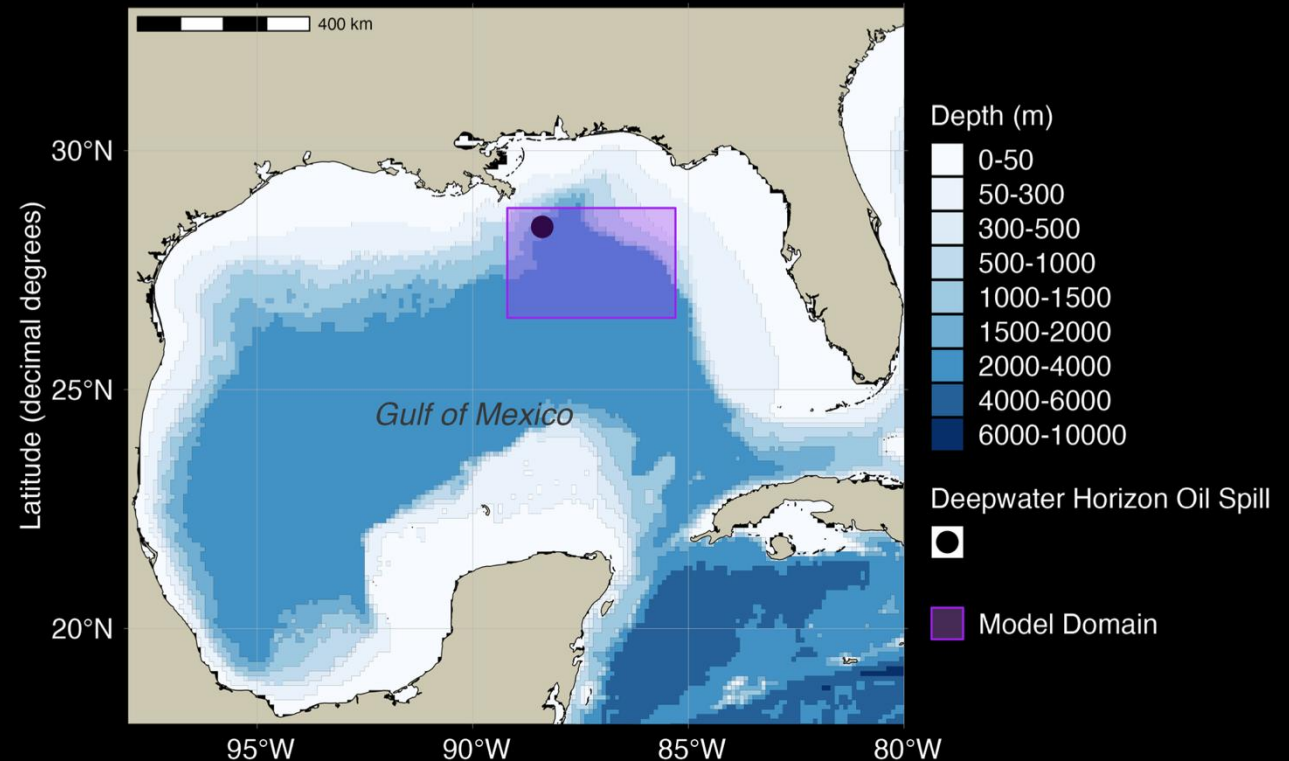
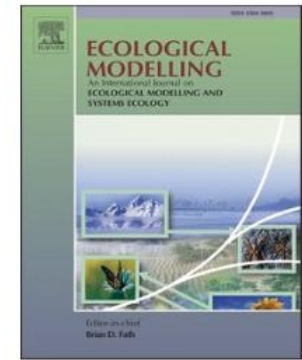
- Distinct species responses for eco-physiological scenarios given climate change scenarios
- Responses not always intuitive due to food web structural changes

Oceanic Models: Vertical Linkages

Simulating productivity changes of epipelagic, mesopelagic, and bathypelagic taxa using a depth-resolved, end-to-end food web model for the oceanic Gulf of Mexico

Stacy Calhoun-Grosch ^{a,*}, Jim J. Ruzicka ^b, Kelly L. Robinson ^a, Verena H. Wang ^c, Tracey Sutton ^d, Cameron Ainsworth ^e, Frank Hernandez ^f

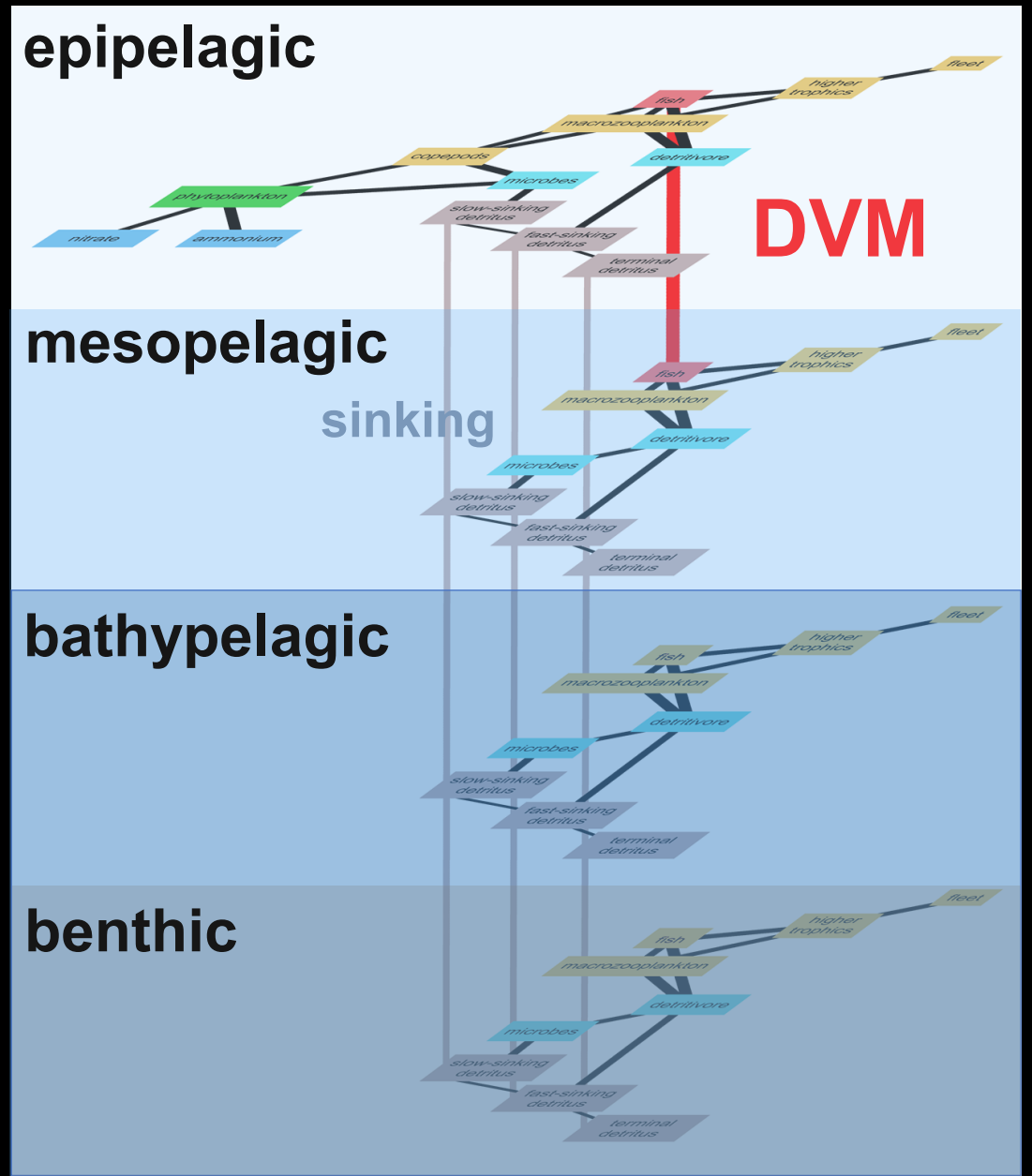
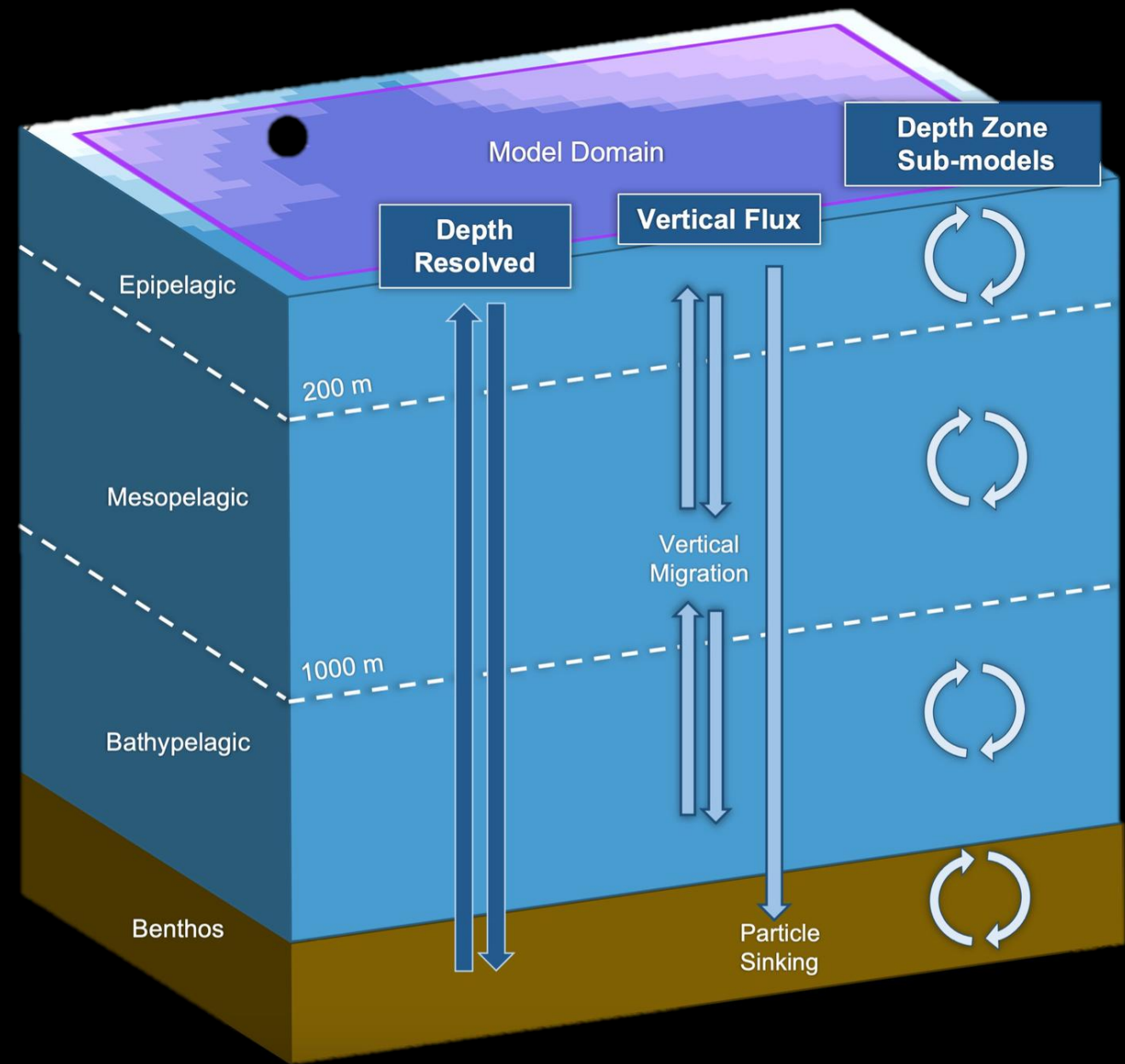
[Ecological Modelling 489 \(2024\) 110623](#)



GULF OF MEXICO
RESEARCH INITIATIVE

Grant#: G231805

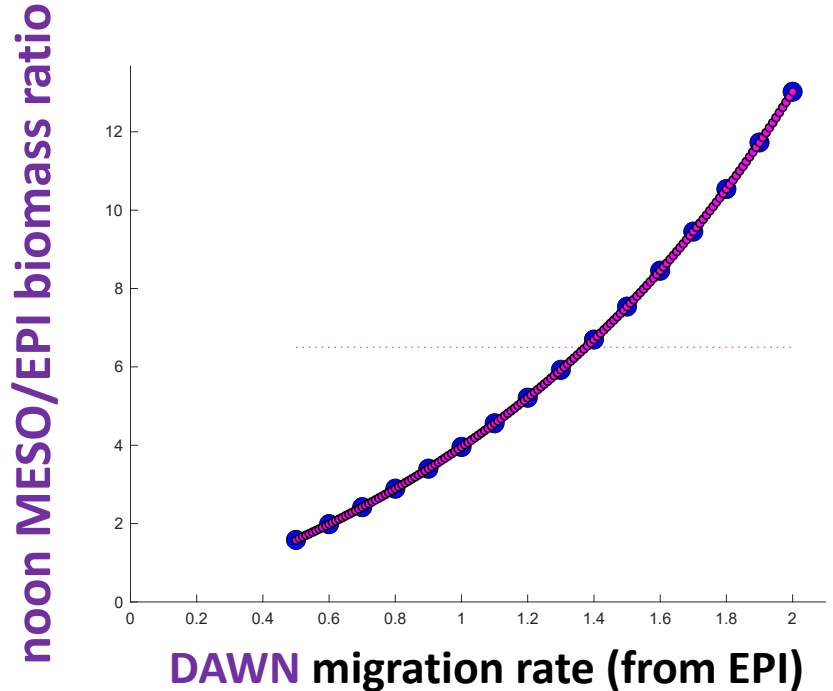
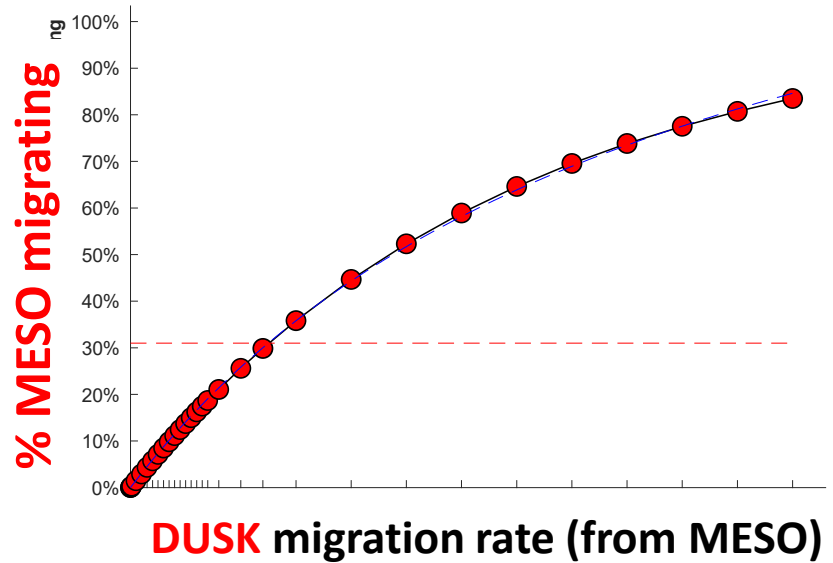
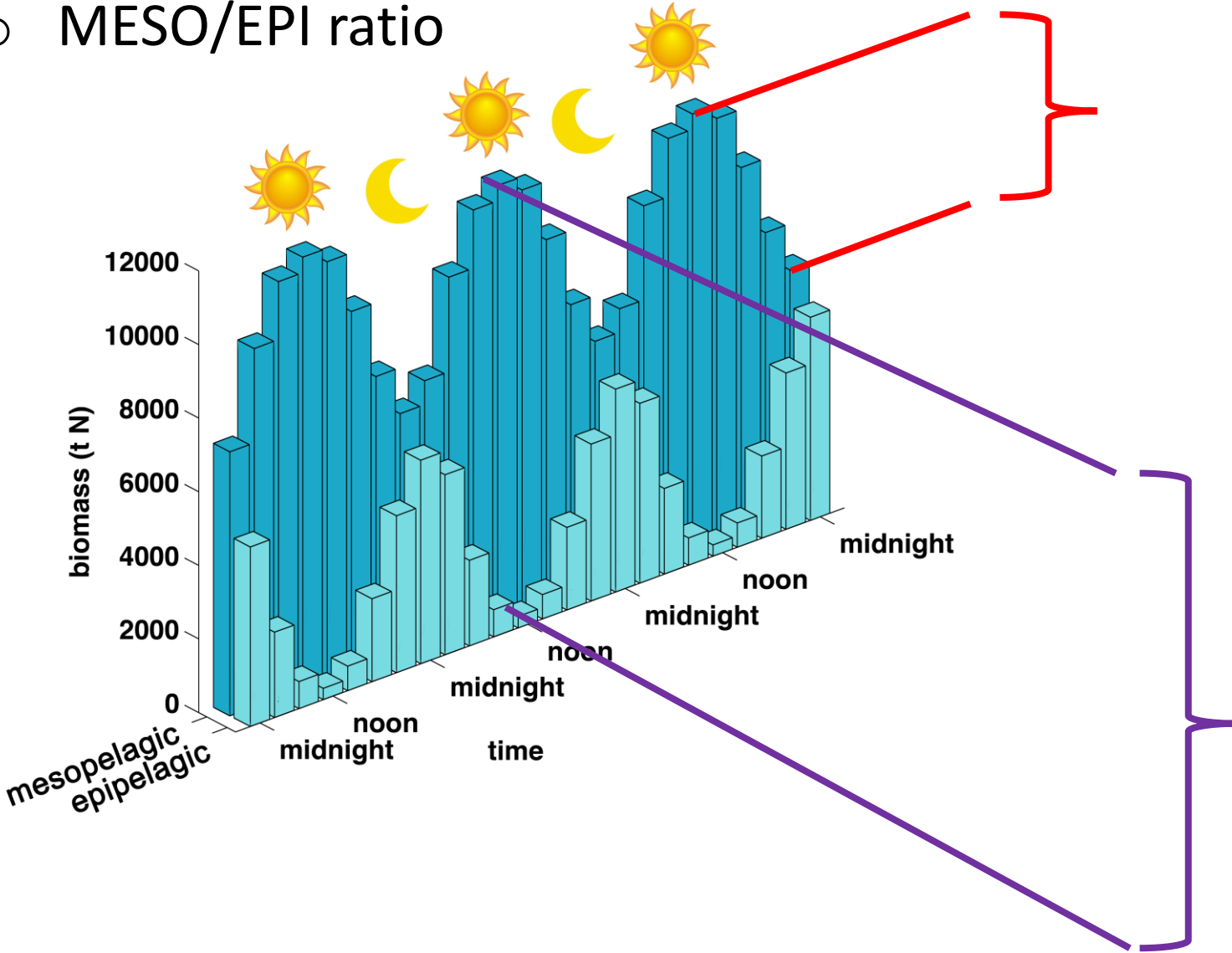


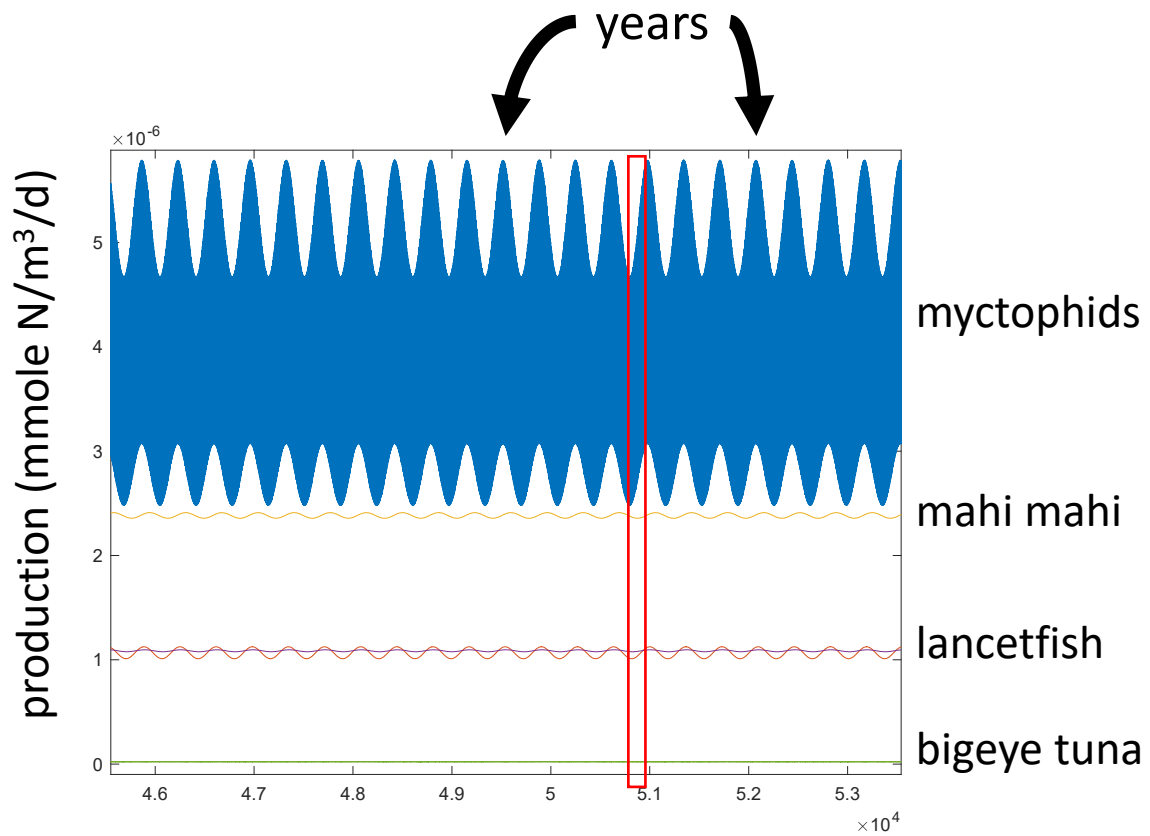


(Stacy Calhoun-Grosch)

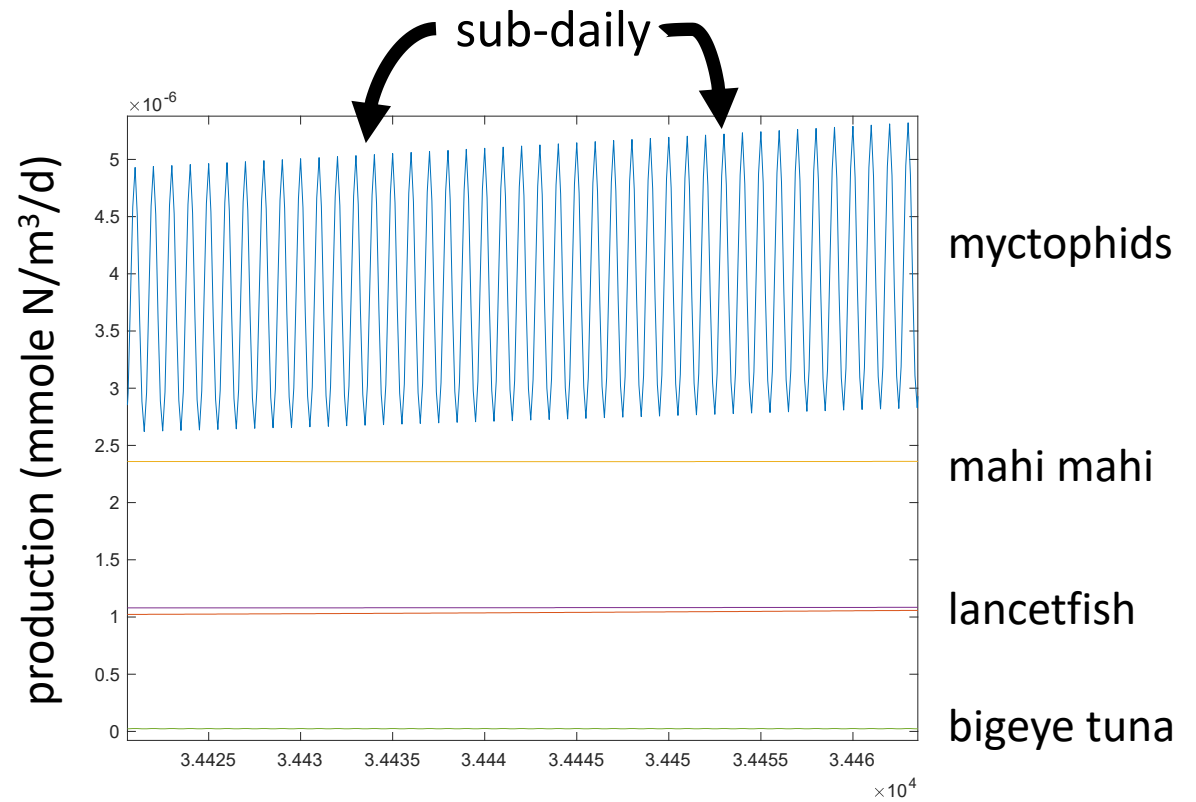
Sinusoidal Diel Vertical Migration

- % of biomass migrating
- MESO/EPI ratio



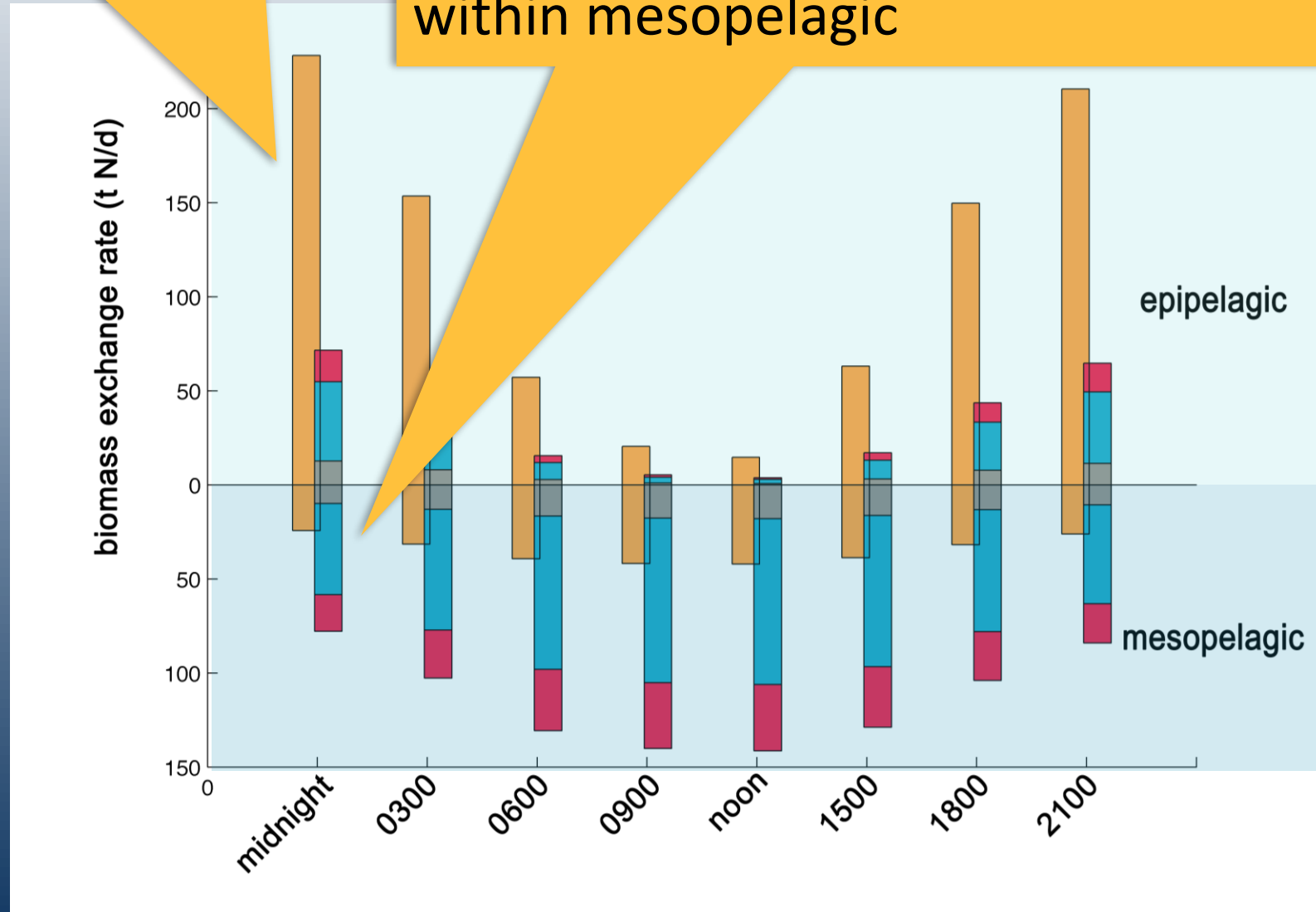
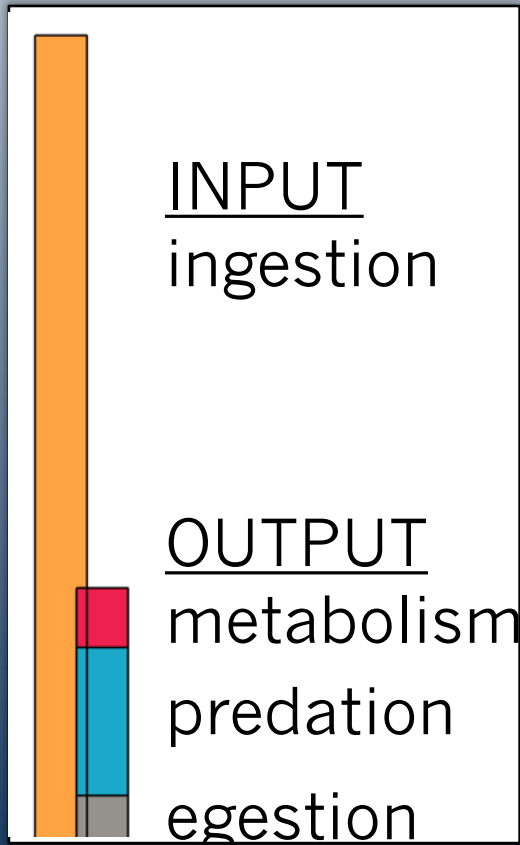


3-hour time step

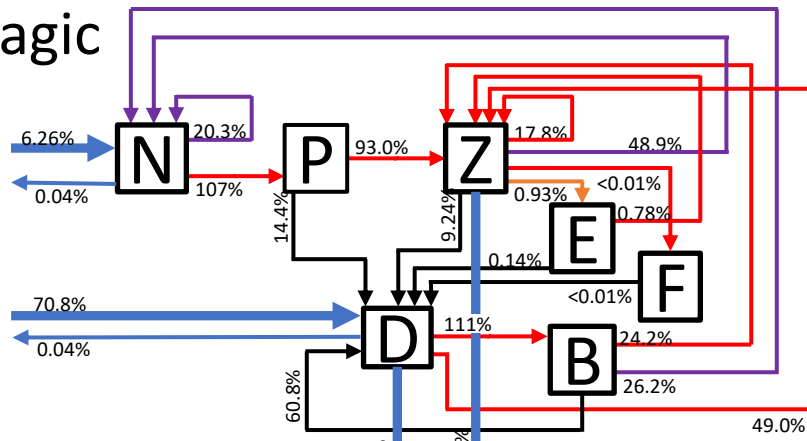


Ingestion IN vs losses OUT through the day

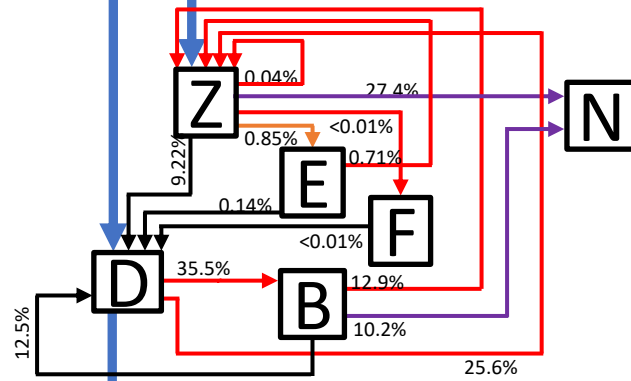
Higher metabolic & predation LOSS within mesopelagic



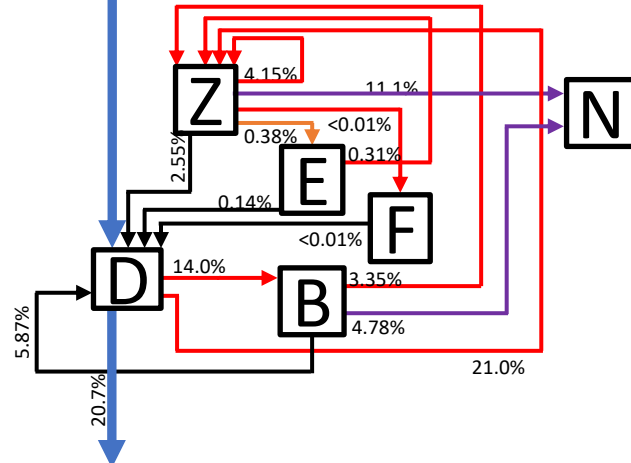
EPIpelagic



MESOpelagic

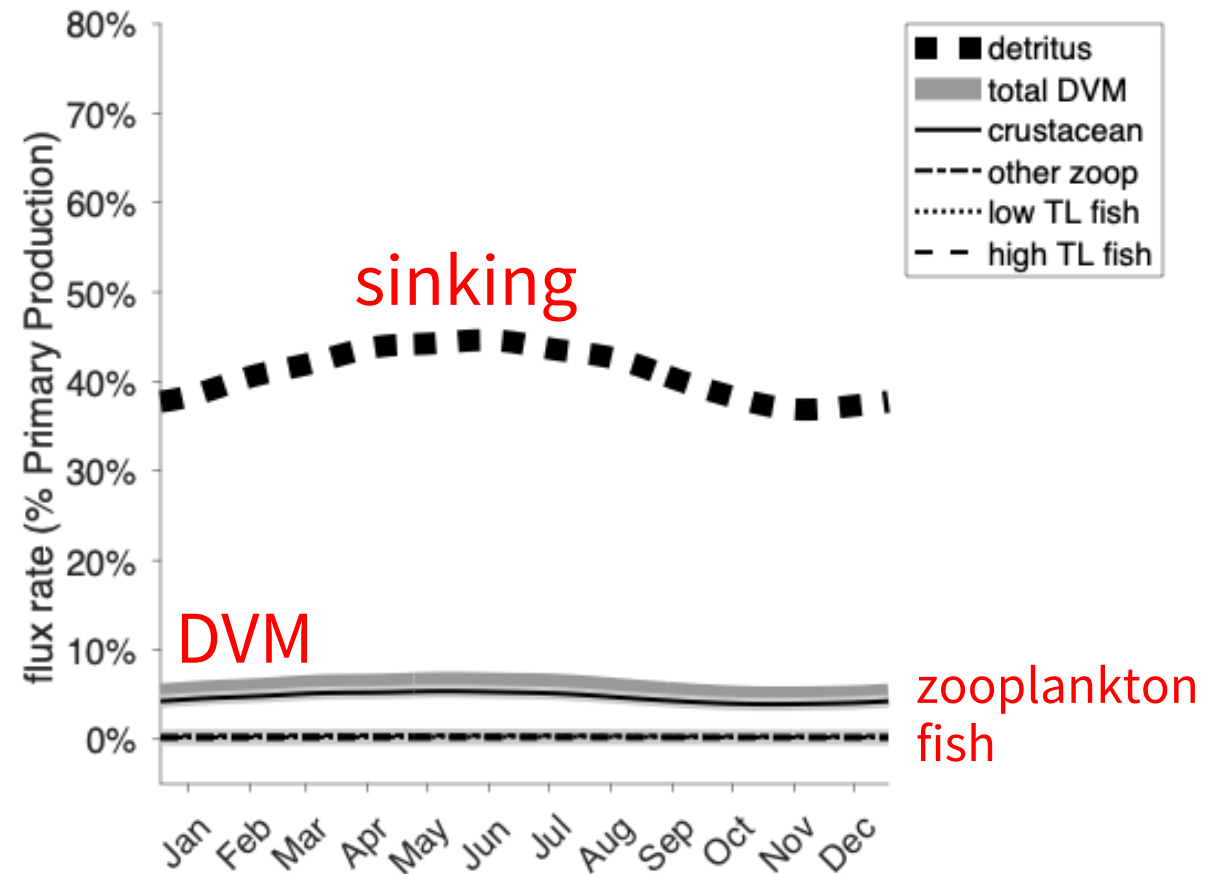


BATHYpelagic



A full accounting of biomass flux within AND between depth zones

Central North Pacific: active DVM is 12% of total Biological Carbon Pump

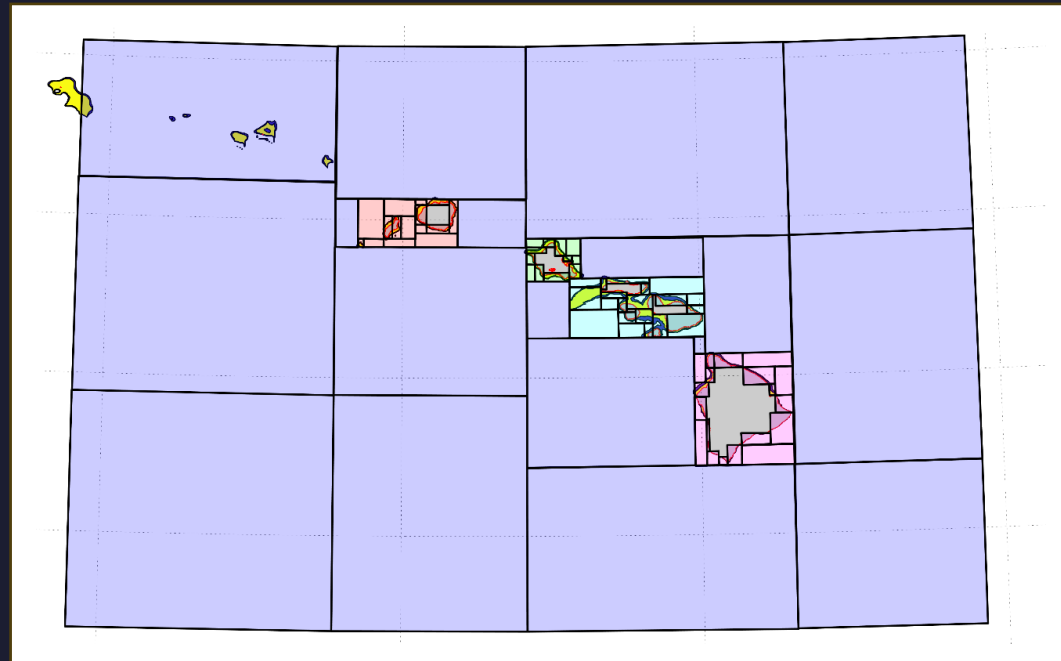
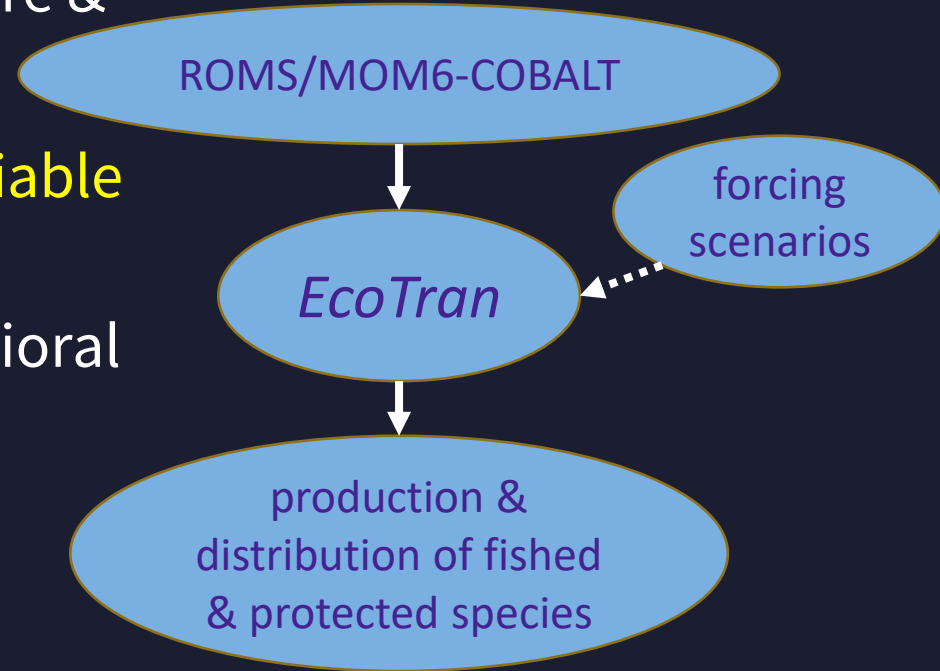


CEFI: Central North Pacific-EcoTran

End-to-end ecosystem modeling for nearshore & oceanic regions

❖ *MECHANISTIC multi-species ecosystem* model for nearshore & oceanic regions driven with ROMS & MOM6

- group productivities & spatial distributions under **variable environment & effort** by longline & small-boat fleets
- dynamics evolve from trophic, physiological, & behavioral rules defining functional groups



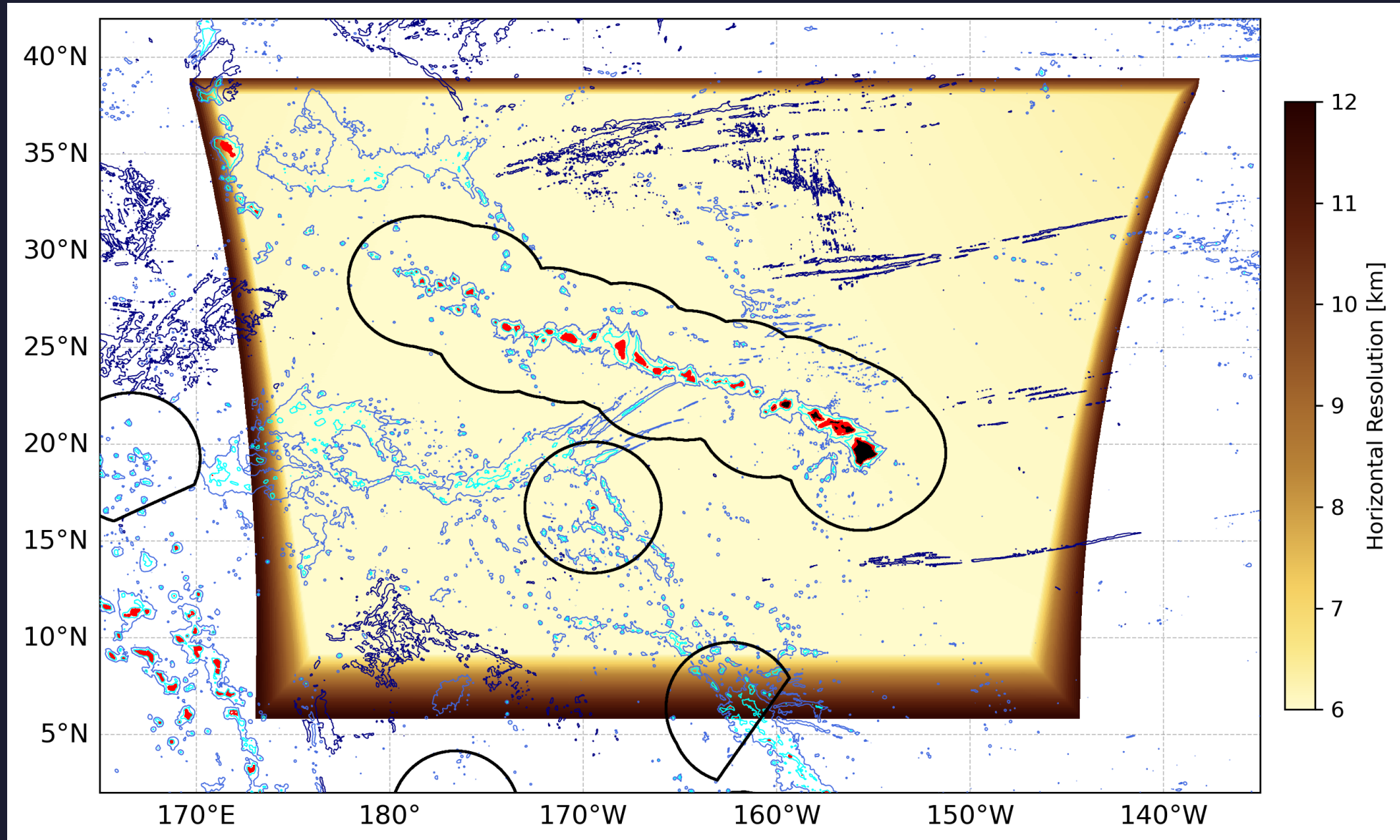
- Grid: 84 regions, 4 depth zones
 - ROMS drivers by **Tobi Friedrichs**
- Food web: from Weijerman & Choy models
 - 54 nearshore groups
 - 40 oceanic groups



Jon Whitney (PIFSC)

MOM6 Hawaiian Island Chain Oceanographic Model

Dax Matthews & Gaby Negrete



CEFI: Central North Pacific-EcoTran

Oceanic Foundation Food Web

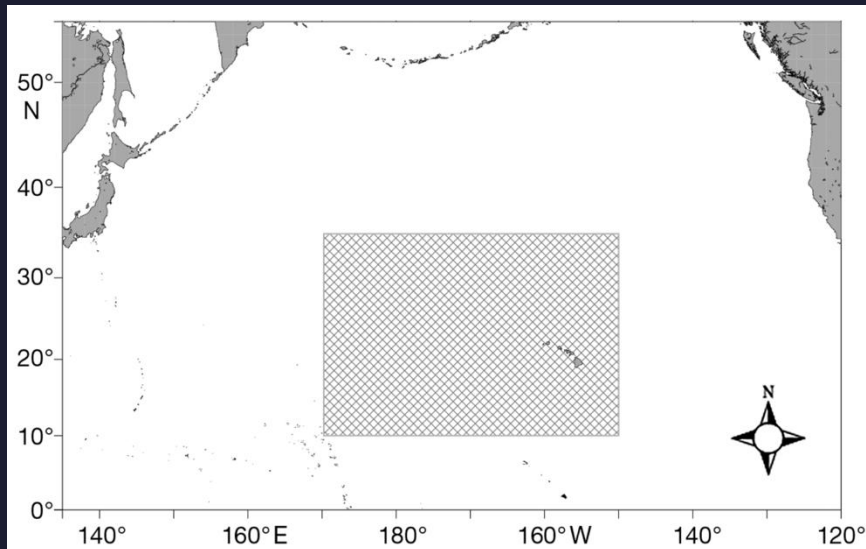
Vol. 549: 9–25, 2016
doi: 10.3354/meps11680

MARINE ECOLOGY PROGRESS SERIES
Mar Ecol Prog Ser

Published May 10

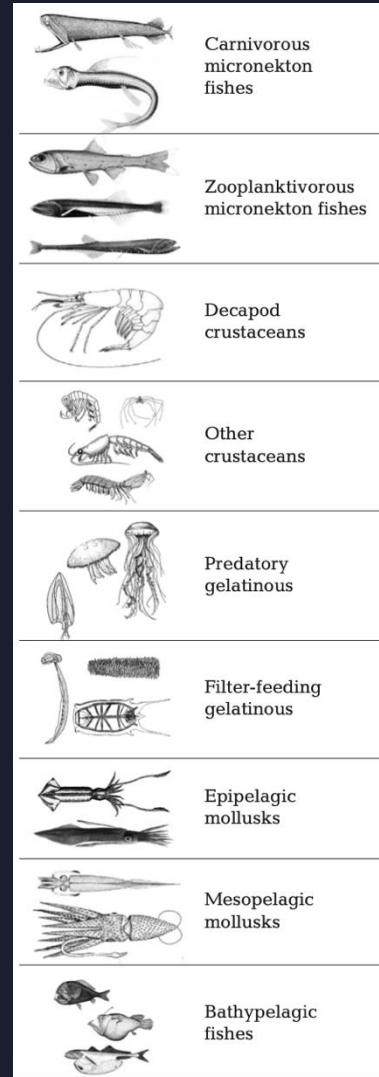
Finding the way to the top: how the composition of oceanic mid-trophic micronekton groups determines apex predator biomass in the central North Pacific

C. Anela Choy^{1,*}, Colette C. C. Wabnitz², Mariska Weijerman³,
Phoebe A. Woodworth-Jefcoats^{4,5}, Jeffrey J. Polovina⁴



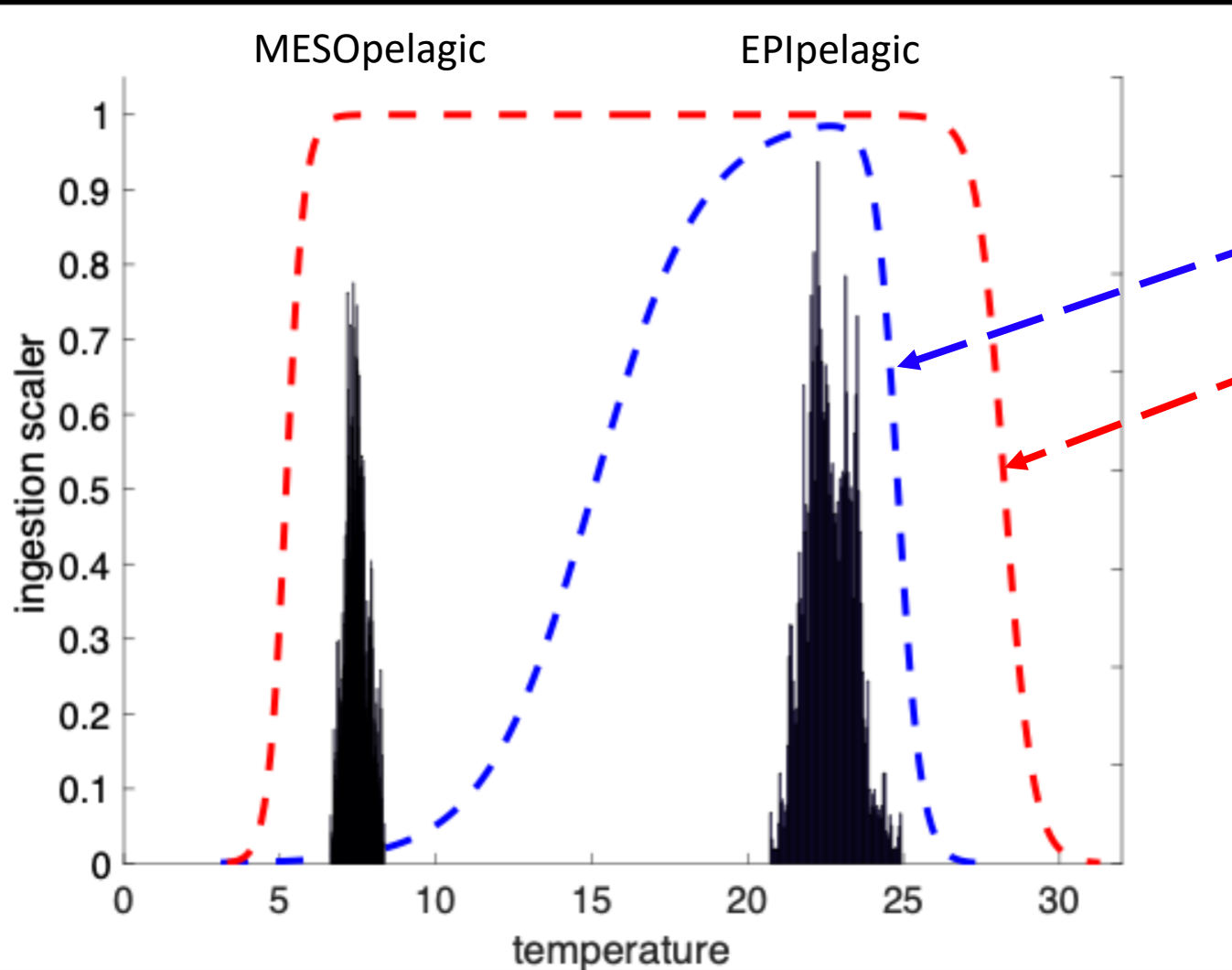
Vertically integrated w/ SPF resolution

- Depth zone resolution (EPI, MESO, BATHY, ABYSSOpelagic)
- DVM for 14 groups



Thornton-Lesseem Temperature Response Curves

Test: ingestion falls to 1% max at +/-5 stdev zone temperature



non-migrating micronekton

migrating micronekton

tuna & opah semi-homeotherms

Beware biases!

Vertical resolution

Assume EwE represents optimal ingestion

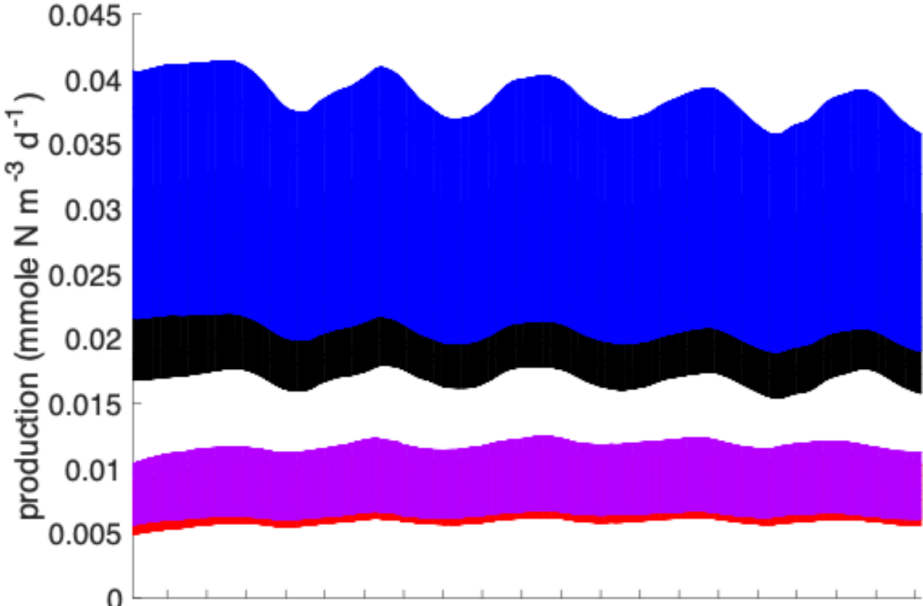
Sanity-check

(of technique only, no tuning or fitting...)

Physical model: conservation of volume across <i>EcoTran</i> grid?	YES
Biomass trends: no extinctions or explosions?	YES (trends w/ BGC)
DVM: consistent biomass in depth zones in absence of forcing?	YES
Physiological responses to temperature logical?	see next slide

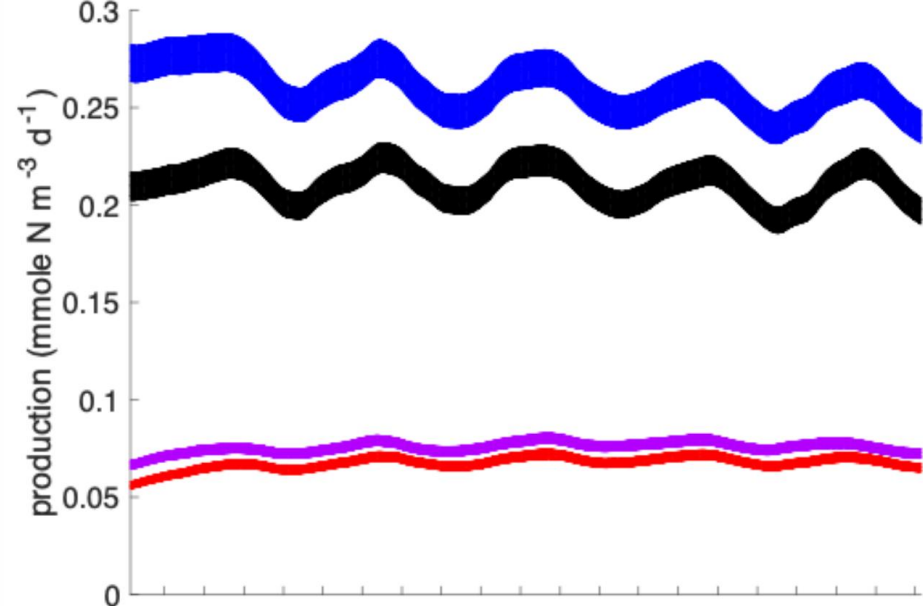
SPF Planktivores

EPIpelagic



Metabolism Response: ON +20%
Temperature Responses: OFF
Metabolism & Ingestion Responses: ON -62%
Ingestion Response: ON -65%

MESOpelagic

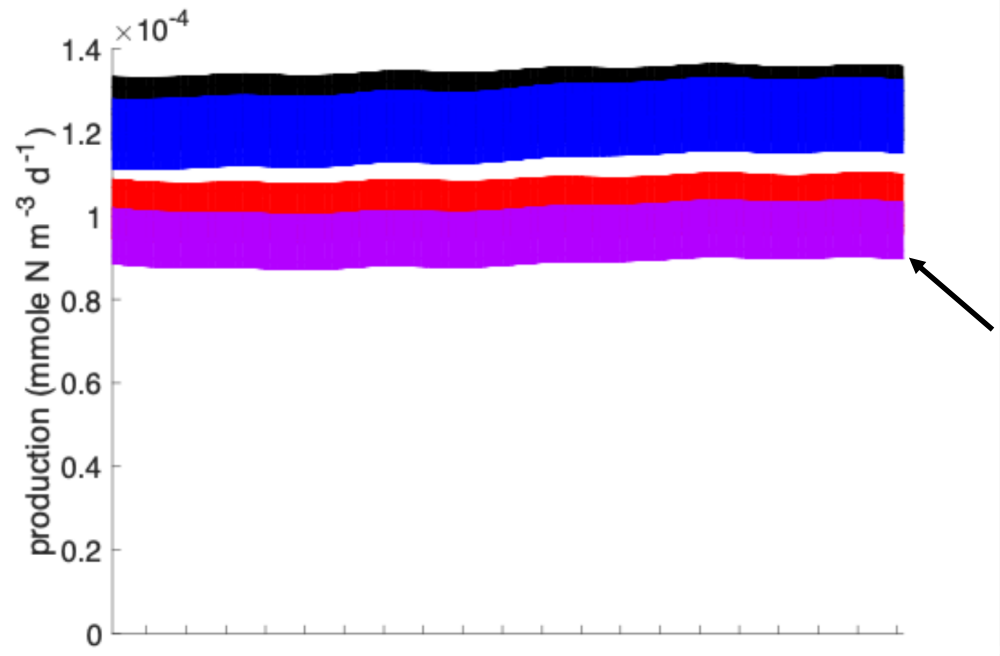


Metabolism Response: ON +22%
Temperature Responses: OFF
Metabolism & Ingestion Responses: ON -64%
Ingestion Response: ON -67%

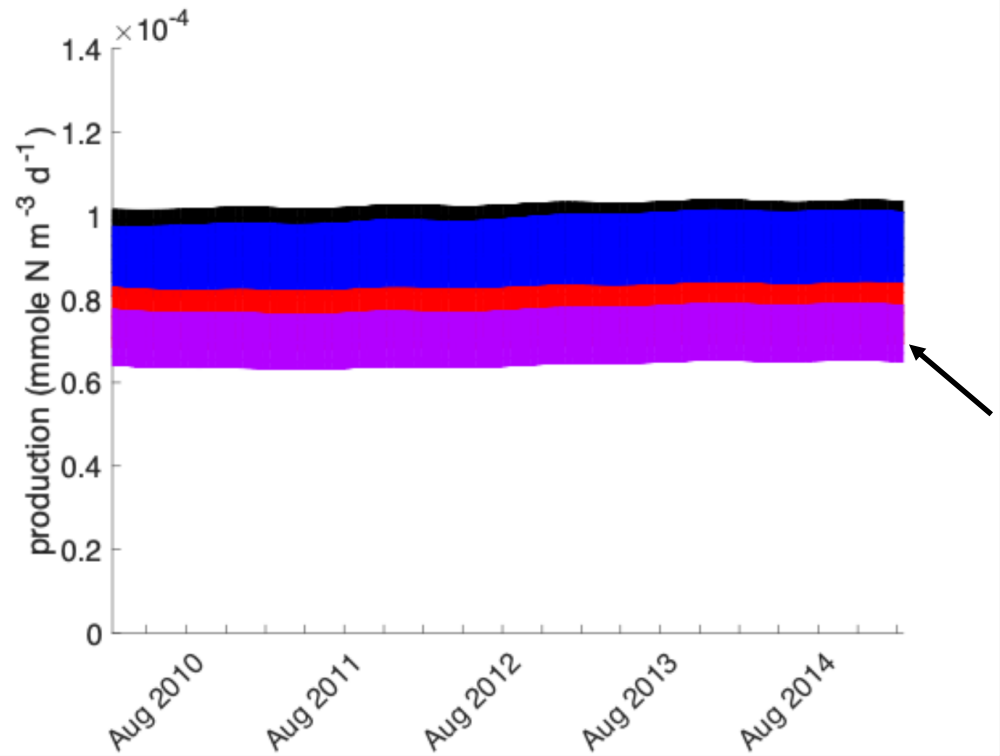
Bigeye Tuna

Temperature Responses: OFF
Metabolism Response: ON -2%
Ingestion Response: ON -19%
Metabolism & Ingestion Responses: ON -24%

EPIpelagic



MESOpelagic



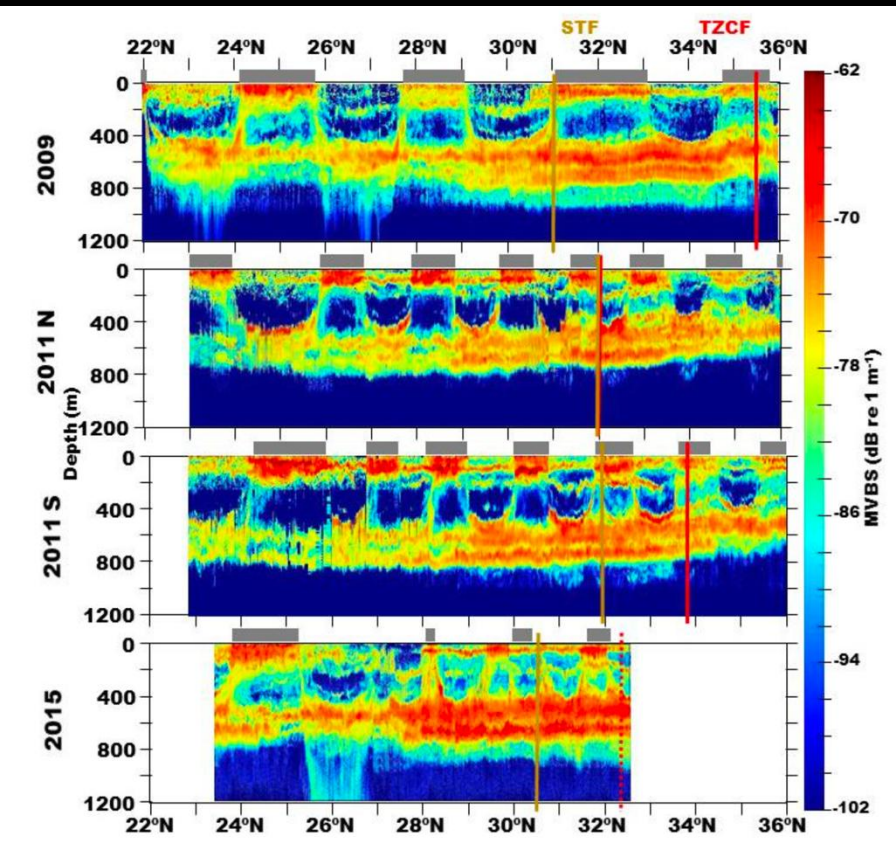
Temperature Responses: OFF
Metabolism Response: ON -2%
Ingestion Response: ON -19%
Metabolism & Ingestion Responses: ON -24%

Next steps for process modeling in the Central North Pacific

Regional changes in DVM

Spatiotemporal variability of micronekton at two central North Pacific Fronts

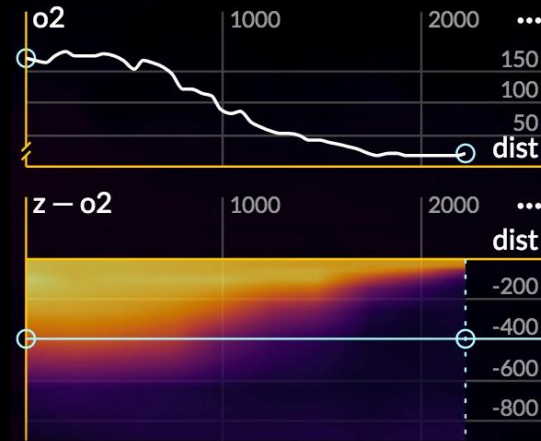
Réka Domokos *Deep-Sea Research I* 198 (2023) 104076



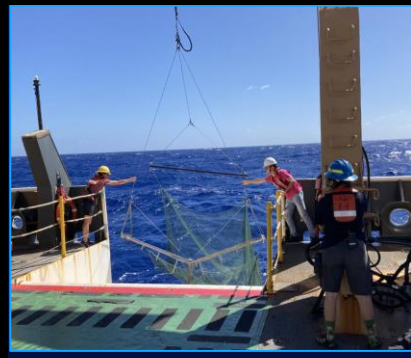
Oxygen

effects on DVM & physiology

Oxygen @ 400m-longline target (150W, 30-10N)



Copernicus: GLOBAL_MULTIYEAR_BGC_001_029

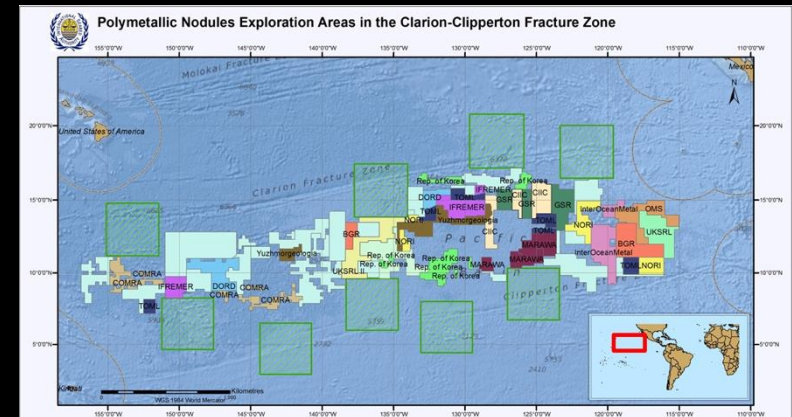
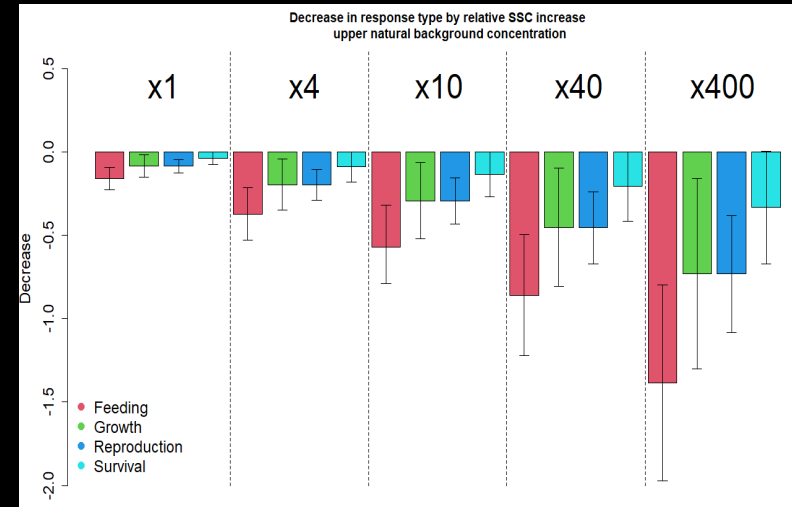


J Snyder

Deep-sea Mining Plumes

effects on physiology & grazing

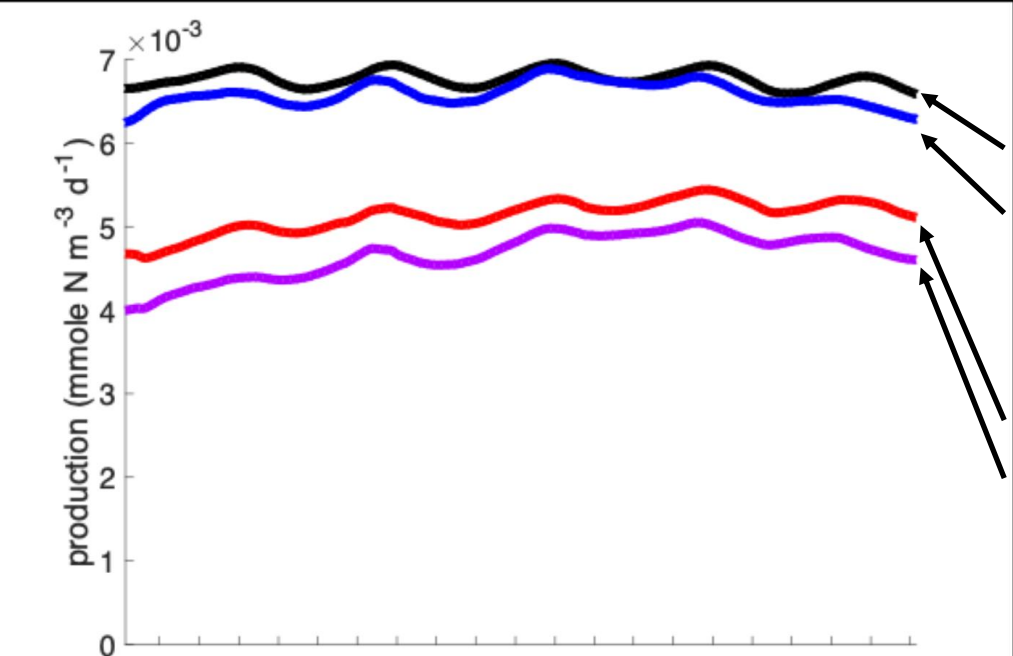
Jesse van der Grient Ph.D (UH SOEST)



ISA 2014

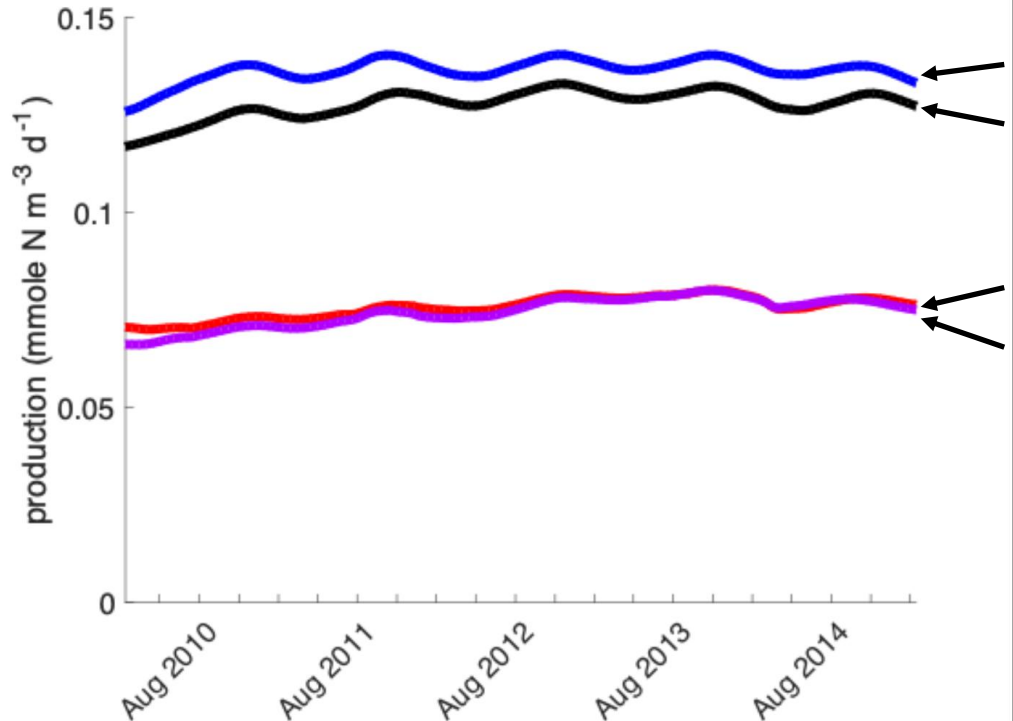
SPF Non-Migratory

EPIpelagic



- Temperature Responses: OFF
- Metabolism Response: ON -5%
- Ingestion Response: ON -22%
- Metabolism & Ingestion Responses: ON -30%

MESOpelagic



- Metabolism Response: ON +5%
- Temperature Responses: OFF
- Ingestion Response: ON -40%
- Metabolism & Ingestion Responses: ON -41%