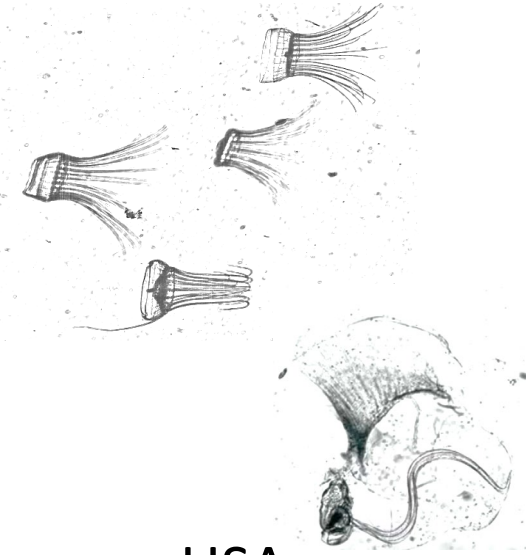
Planktonic trophodynamics in the Northern California Current - multiyear in-situ observations derived from underwater imaging



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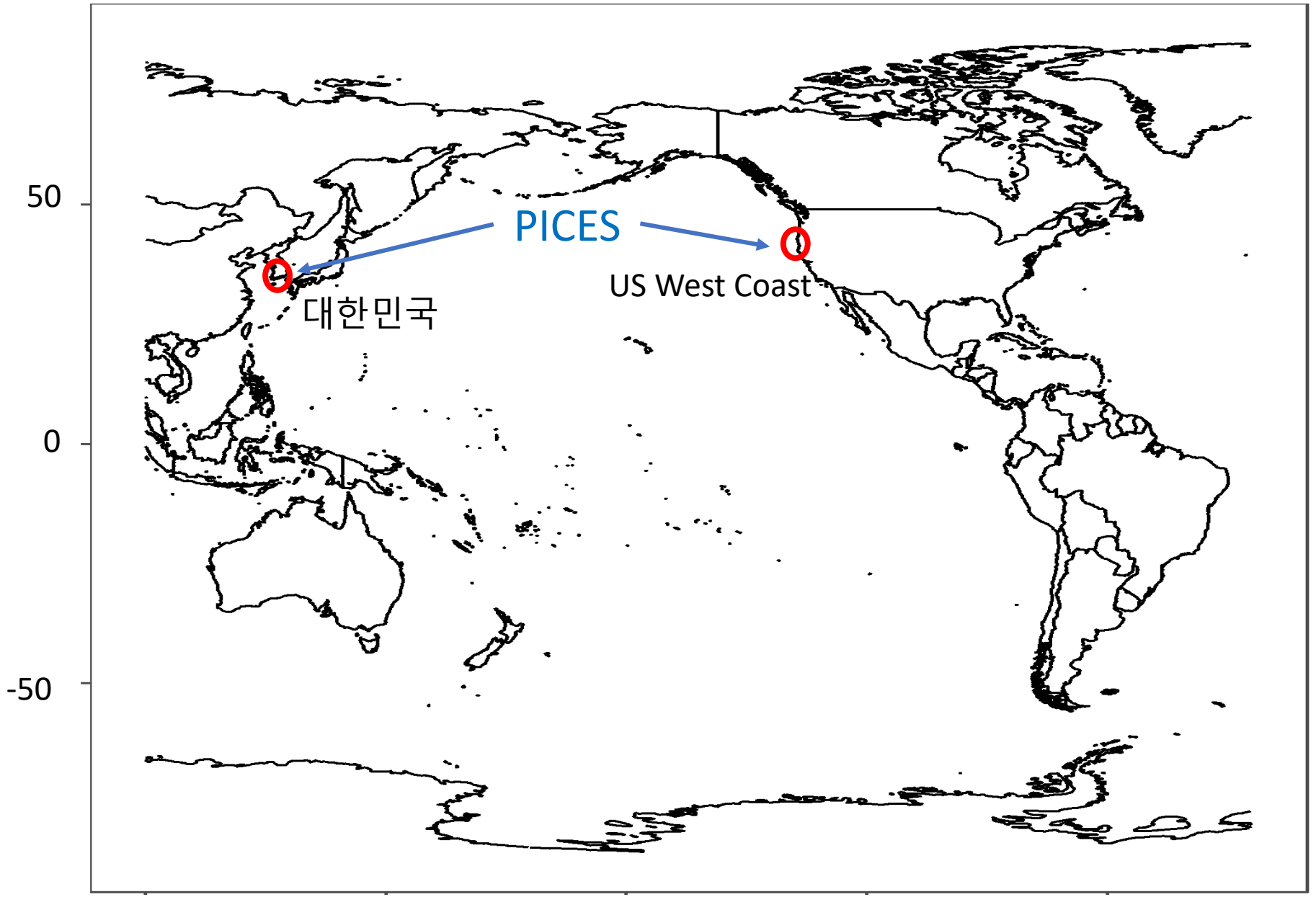
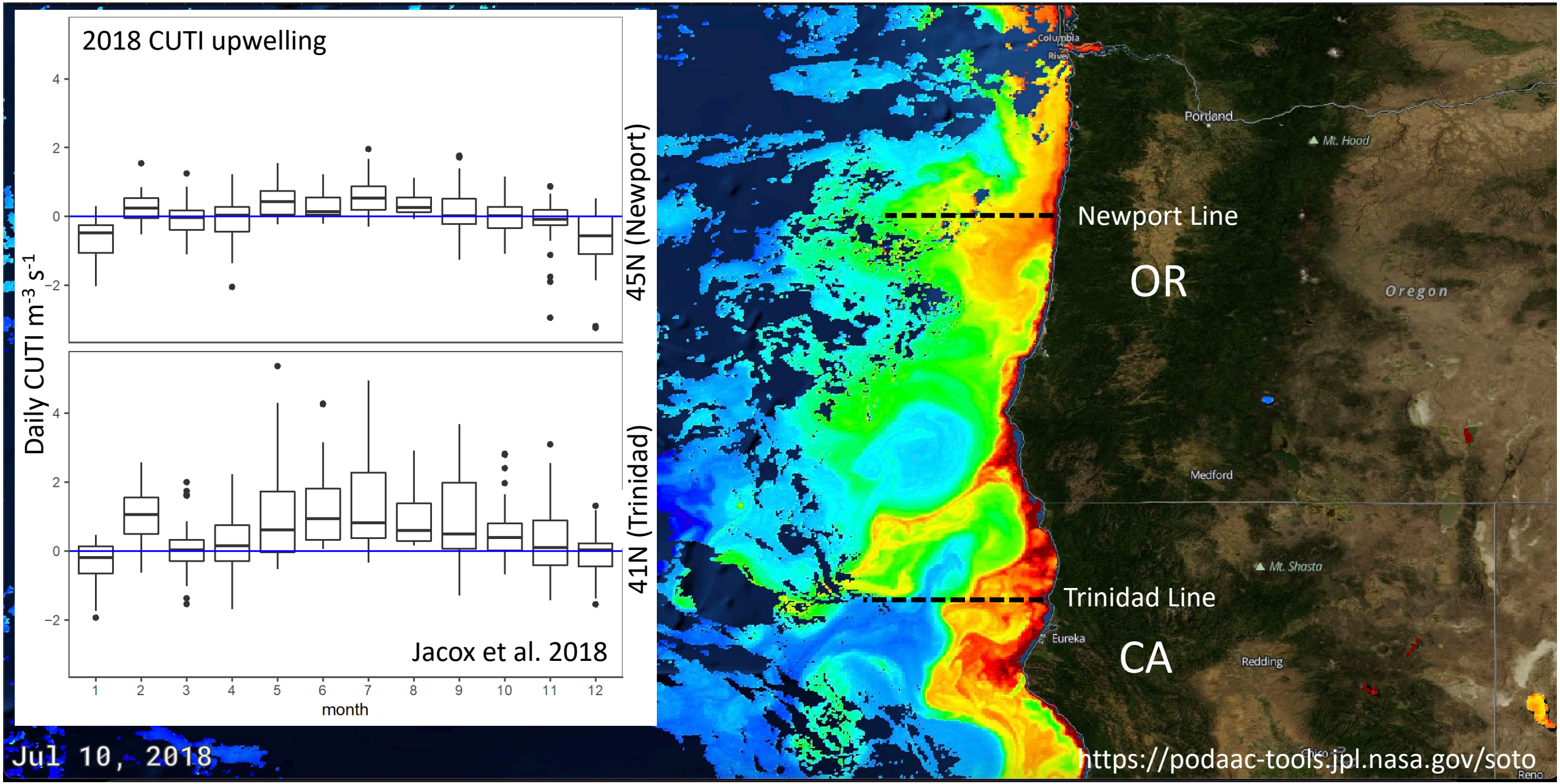
The great connector

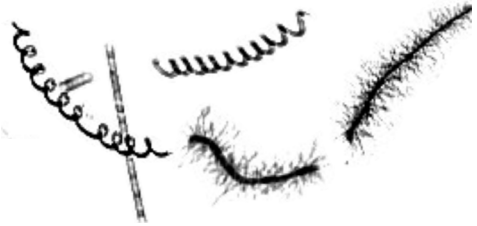


Intermittent and continuous upwelling in the NCC

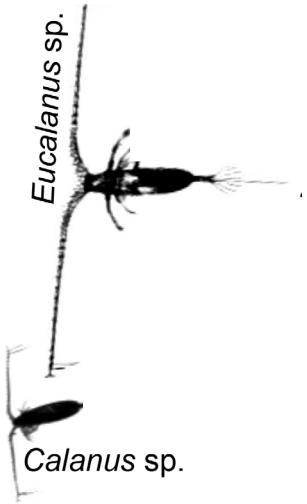


Continuous upwelling

- Short food chains starting with large diatoms
- Classic marine trophic web
- New productivity
- On avg larger plankton



Diatoms



Large copepod taxa

Intermittent upwelling

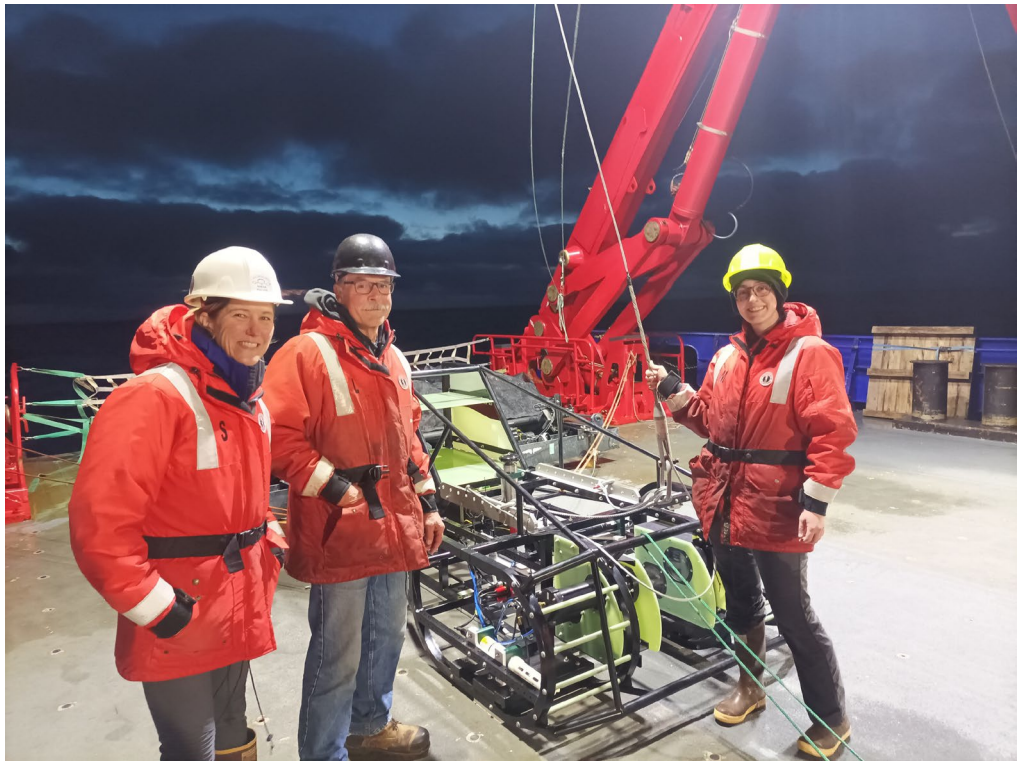
- Longer food chains with smaller phytoplankton species
- Higher activity of the microbial loop
- More recycled productivity
- On avg smaller plankton

Protists

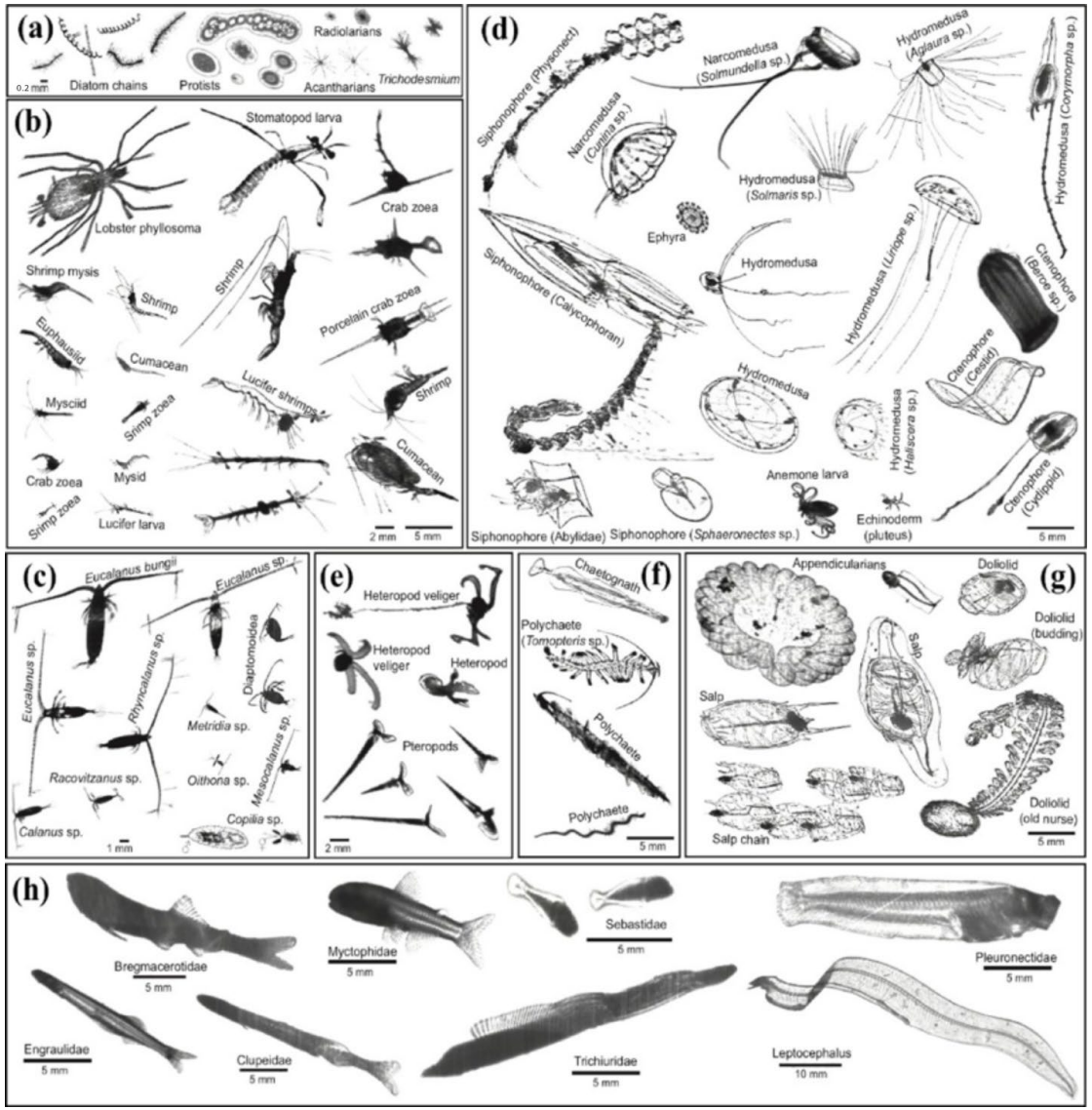
Small copepod taxa

Study the effects of continuous and intermittent upwelling on plankton communities at fine spatial scale

- In-situ imaging & machine learning



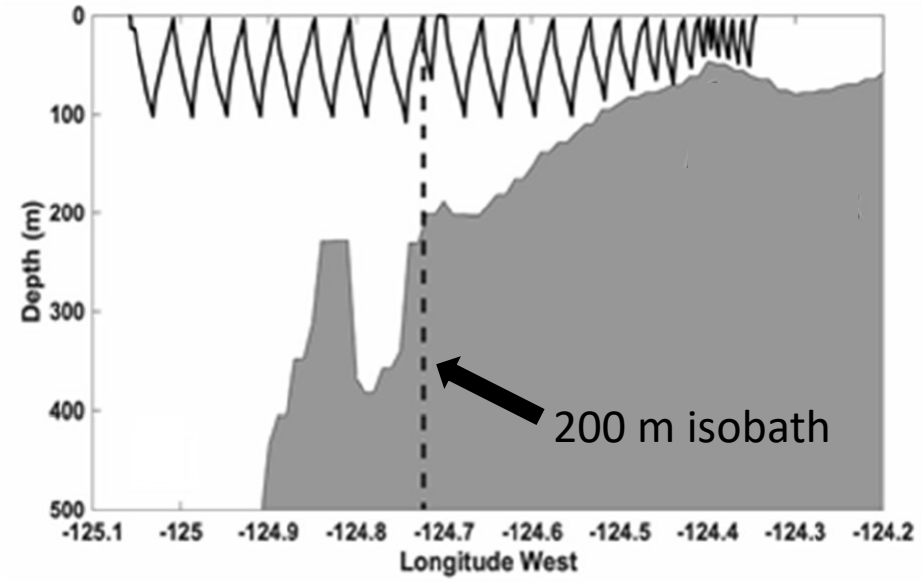
The In-situ Ichthyoplankton Imaging System (ISIIS-3)



Plankton imaged by ISIIS. 160+ classes in sCNN pipeline

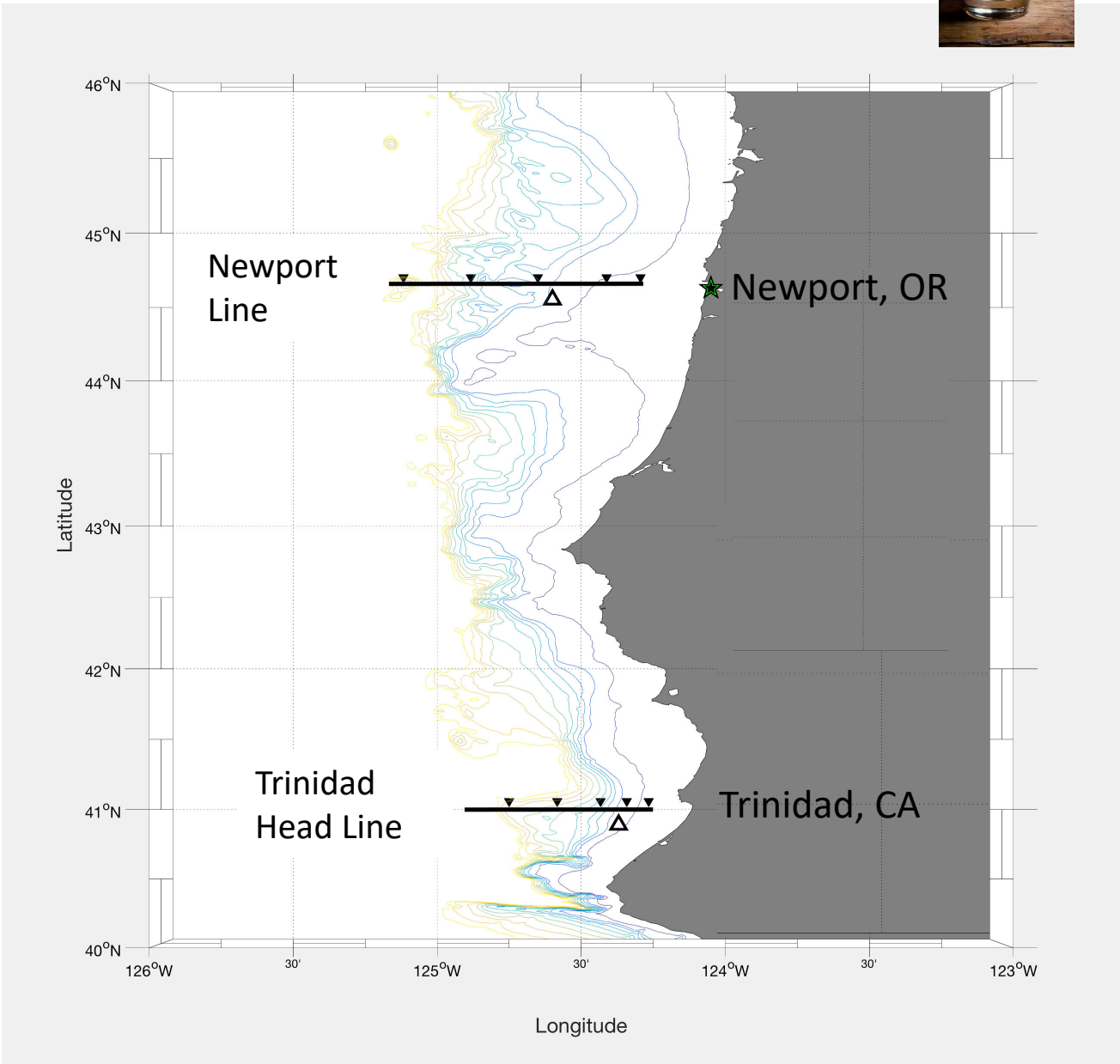
MEsoZooplankton in the Northern CALifornia Current (MEZCAL)

- 30 transects (50-75 km) in winter (Feb) and summer (July) 2018 and 2019



sCNN processing

- >1.2 billion images collected and classified (Luo et al. 2018, Schmid et al. 2021)



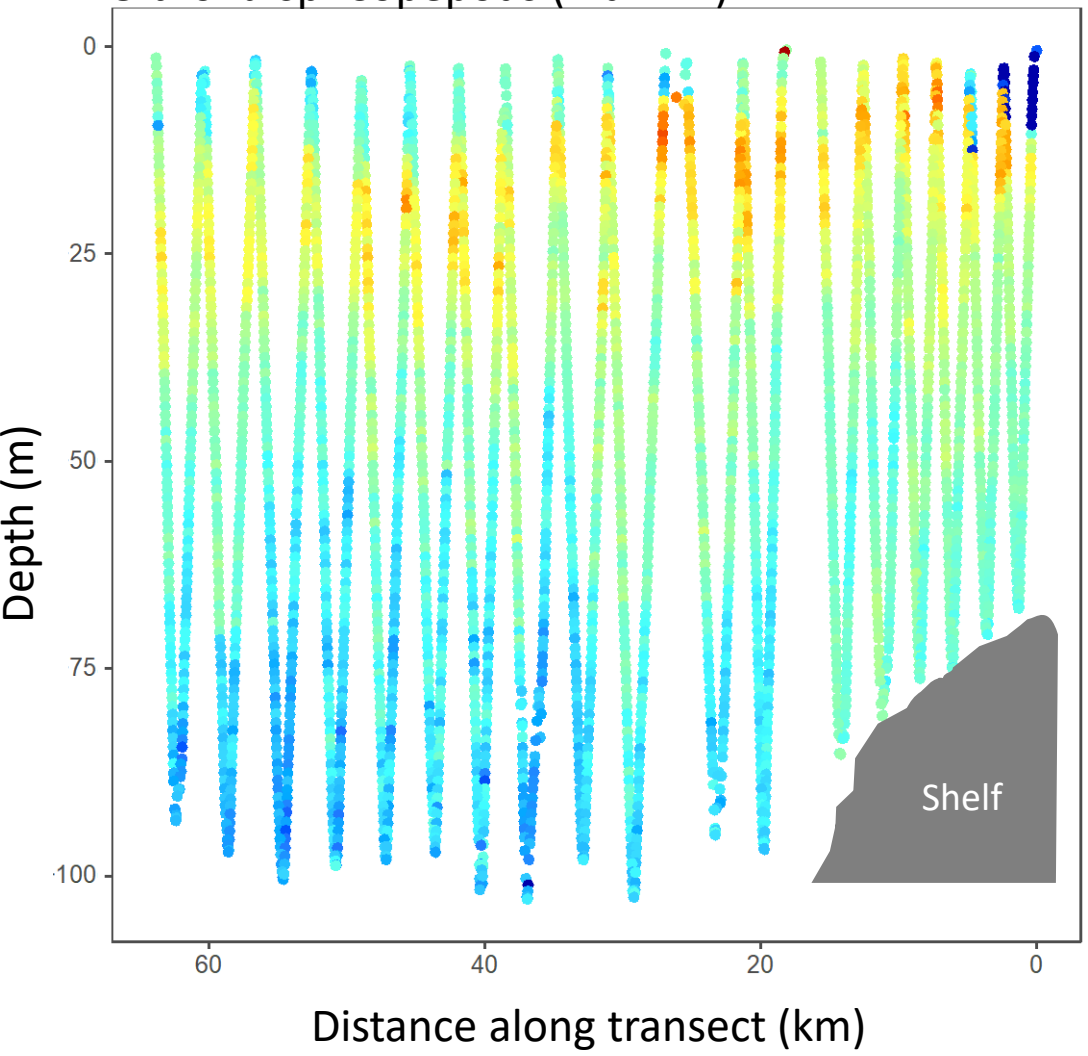
Hypotheses

a) Plankton co-occurrence, as a proxy for community structure, is affected by upwelling strength – that effect varies between continuous and intermittent upwelling regions

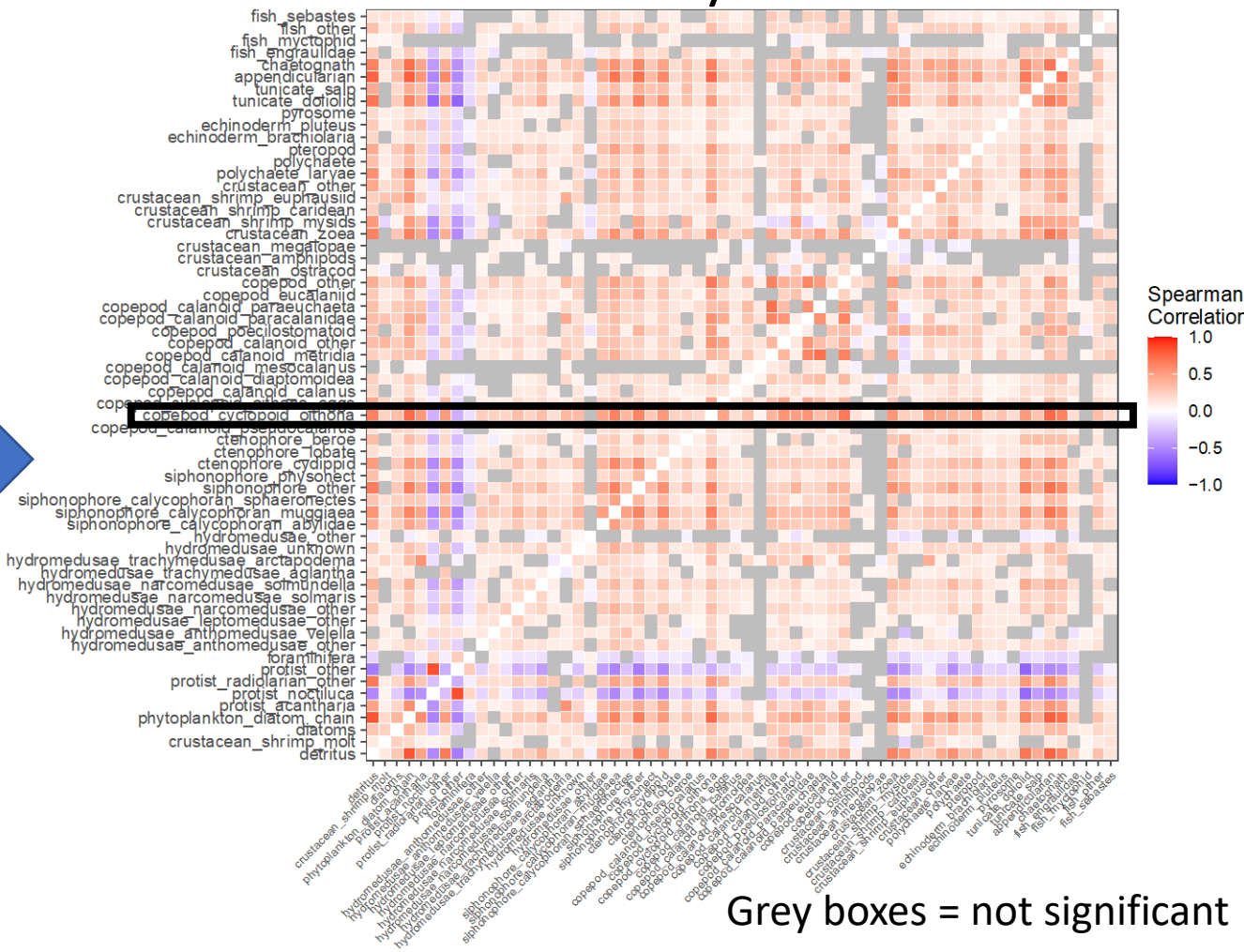
b) In intermittent upwelling, taxa associated with the microbial loop play an important role in forming taxa co-occurrence

High spatial resolution plankton distributions (< 1m scale)

Oithona sp. Copepods (ind. m^{-3})



Community structure



Grey boxes = not significant

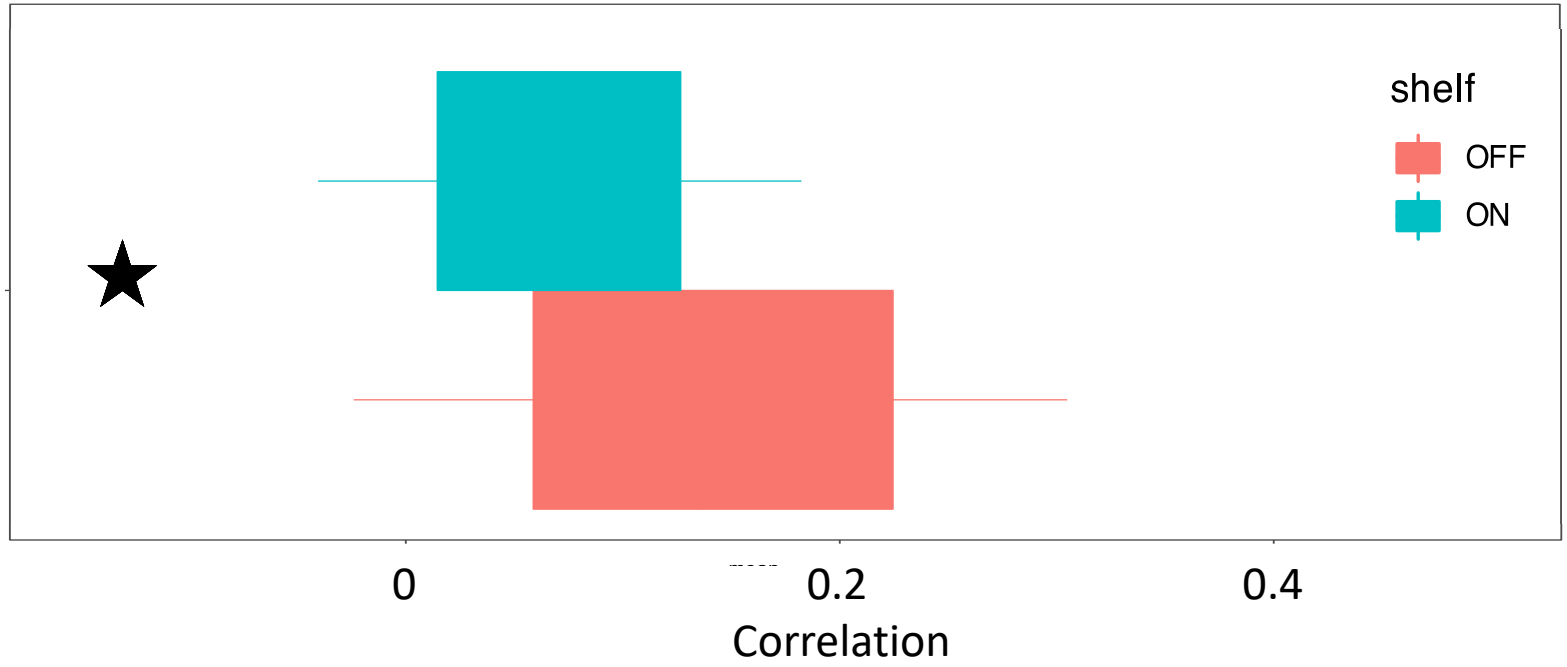
How can the plankton community as a whole be analyzed while keeping high spatial resolution information? (1950 vertical profiles)

The big picture

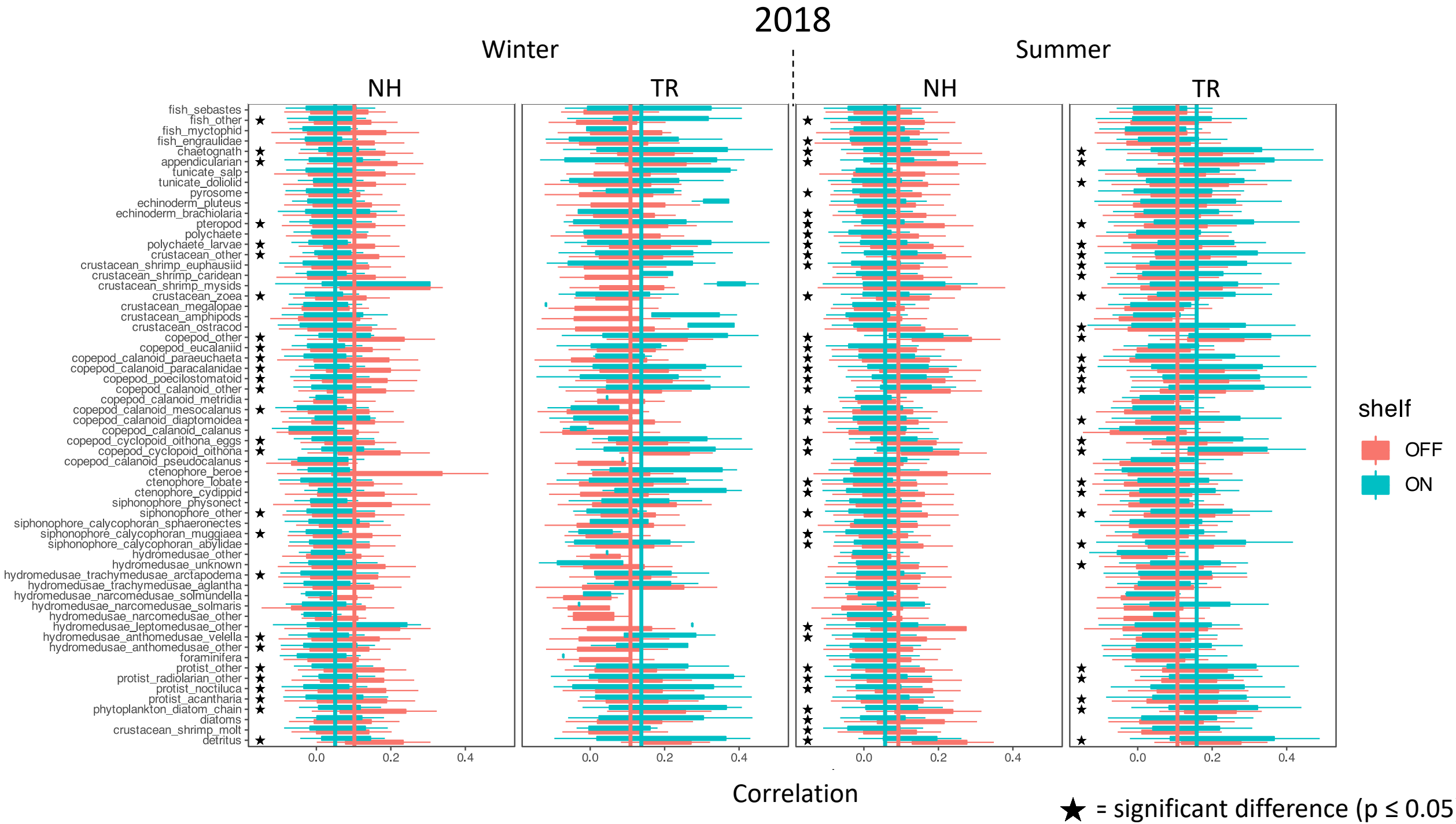
-> Combine all Newport (NH) transects, and all Trinidad Head (TR) transects

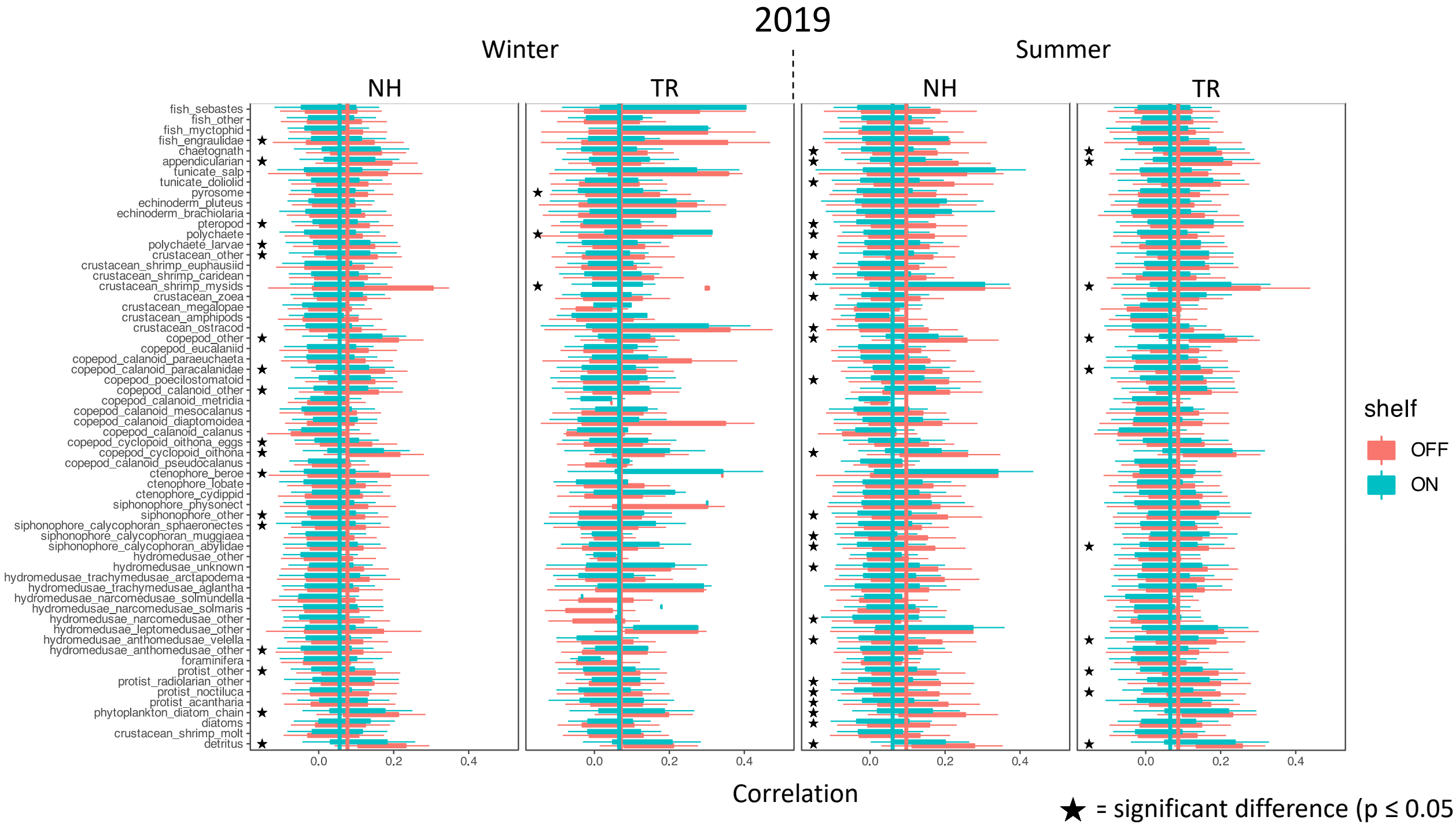
-> Stratify by on-shelf and off-shelf (200m depth)

Oithona sp.
at NH Line

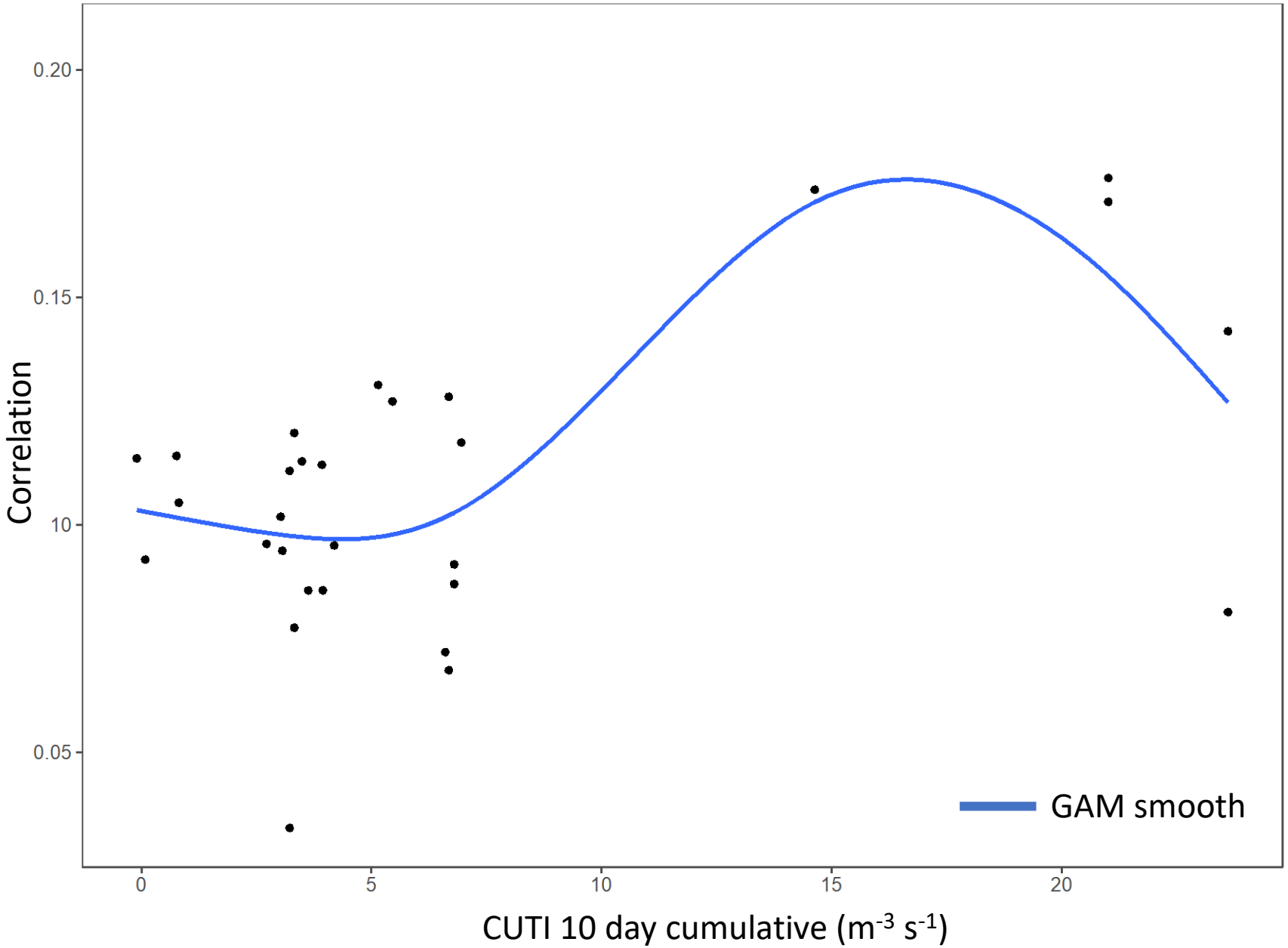


★ = significant difference ($p \leq 0.05$)


2018
Winter
Summer
NH
TR
NH
TR
fish_sebastes
fish_other
fish_myctophid
fish_engraulidae
chaetognath
appendicularian
tunicate_salp
tunicate_doliolid
pyrosome
echinoderm_pluteus
echinoderm_brachiolaria
pteropod
polychaete
polychaete_larvae
crustacean_other
crustacean_shrimp_euphausiid
crustacean_shrimp_caridean
crustacean_shrimp_mysids
crustacean_zoea
crustacean_megalopae
crustacean_amphipods
crustacean_ostracod
copepod_other
copepod_eucalaniid
copepod_calanoid_paraeuchaeta
copepod_calanoid_paracalanidae
copepod_poecilostomatoid
copepod_calanoid_other
copepod_calanoid_metridia
copepod_calanoid_mesocalanus
copepod_calanoid_diaptomoidea
copepod_calanoid_calanus
copepod_cyclopoid_oithona_eggs
copepod_cyclopoid_oithona
copepod_calanoid_pseudocalanus
ctenophore_beroe
ctenophore_lobate
ctenophore_cydippid
siphonophore_physonect
siphonophore_other
siphonophore_calycophoran_sphaeronectes
siphonophore_calycophoran_muggiaea
siphonophore_calycophoran_abylidae
hydromedusae_other
hydromedusae_unknown
hydromedusae_trachymedusae_arctapodema
hydromedusae_trachymedusae_aglantha
hydromedusae_narcomedusae_solmundella
hydromedusae_narcomedusae_solmaris
hydromedusae_narcomedusae_other
hydromedusae_leptomedusae_other
hydromedusae_anthomedusae_velella
hydromedusae_anthomedusae_other
foraminifera
protist_other
protist_radiolarian_other
protist_noctiluca
protist_acantharia
phytoplankton_diatom_chain
diatoms
crustacean_shrimp_molt
detritus
0.0
0.2
0.4
Correlation
shelf
OFF
ON
= significant difference (p ≤ 0.05)

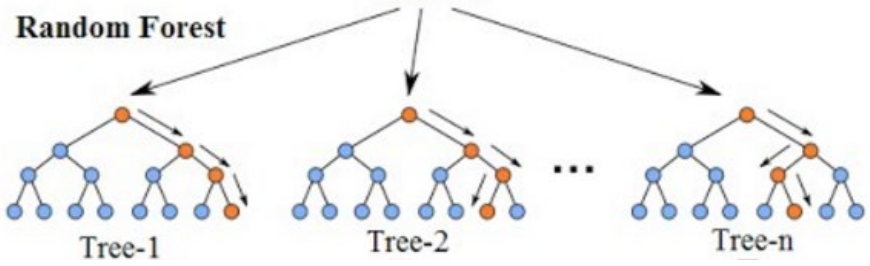

2019
Winter
Summer
NH
TR
NH
TR
fish_sebastes
fish_other
fish_myctophid
fish_engraulidae
chaetognath
appendicularian
tunicate_salp
tunicate_doliolid
pyrosome
echinoderm_pluteus
echinoderm_brachiolaria
pteropod
polychaete
polychaete_larvae
crustacean_other
crustacean_shrimp_euphausiid
crustacean_shrimp_caridean
crustacean_shrimp_mysids
crustacean_zoea
crustacean_megalopae
crustacean_amphipods
crustacean_ostracod
copepod_other
copepod_eucalaniid
copepod_calanoid_paraeuchaeta
copepod_calanoid_paracalanidae
copepod_poecilostomatoid
copepod_calanoid_other
copepod_calanoid_metridia
copepod_calanoid_mesocalanus
copepod_calanoid_diaptomoidea
copepod_calanoid_calanus
copepod_cyclopoid_oithona_eggs
copepod_cyclopoid_oithona
copepod_calanoid_pseudocalanus
ctenophore_beroe
ctenophore_lobate
ctenophore_cydippid
siphonophore_physonect
siphonophore_other
siphonophore_calycophoran_sphaeronectes
siphonophore_calycophoran_muggiaea
siphonophore_calycophoran_abylidae
hydromedusae_other
hydromedusae_unknown
hydromedusae_trachymedusae_arctapodema
hydromedusae_trachymedusae_aglantha
hydromedusae_narcomedusae_solmundella
hydromedusae_narcomedusae_solmaris
hydromedusae_narcomedusae_other
hydromedusae_leptomedusae_other
hydromedusae_anthomedusae_velella
hydromedusae_anthomedusae_other
foraminifera
protist_other
protist_radiolarian_other
protist_noctiluca
protist_acantharia
phytoplankton_diatom_chain
diatoms
crustacean_shrimp_molt
detritus
0.0
0.2
0.4
Correlation
shelf
OFF
ON
★ = significant difference (p ≤ 0.05)

How does upwelling relate to co-occurrences?



- 10 day cumulative CUTI values (Spitz & Allen 2005)
- Decreased effect at high CUTI possibly due to missing relaxation periods (Legendre and Le Fèvre 1989, Kudela and Dugdale 2000)

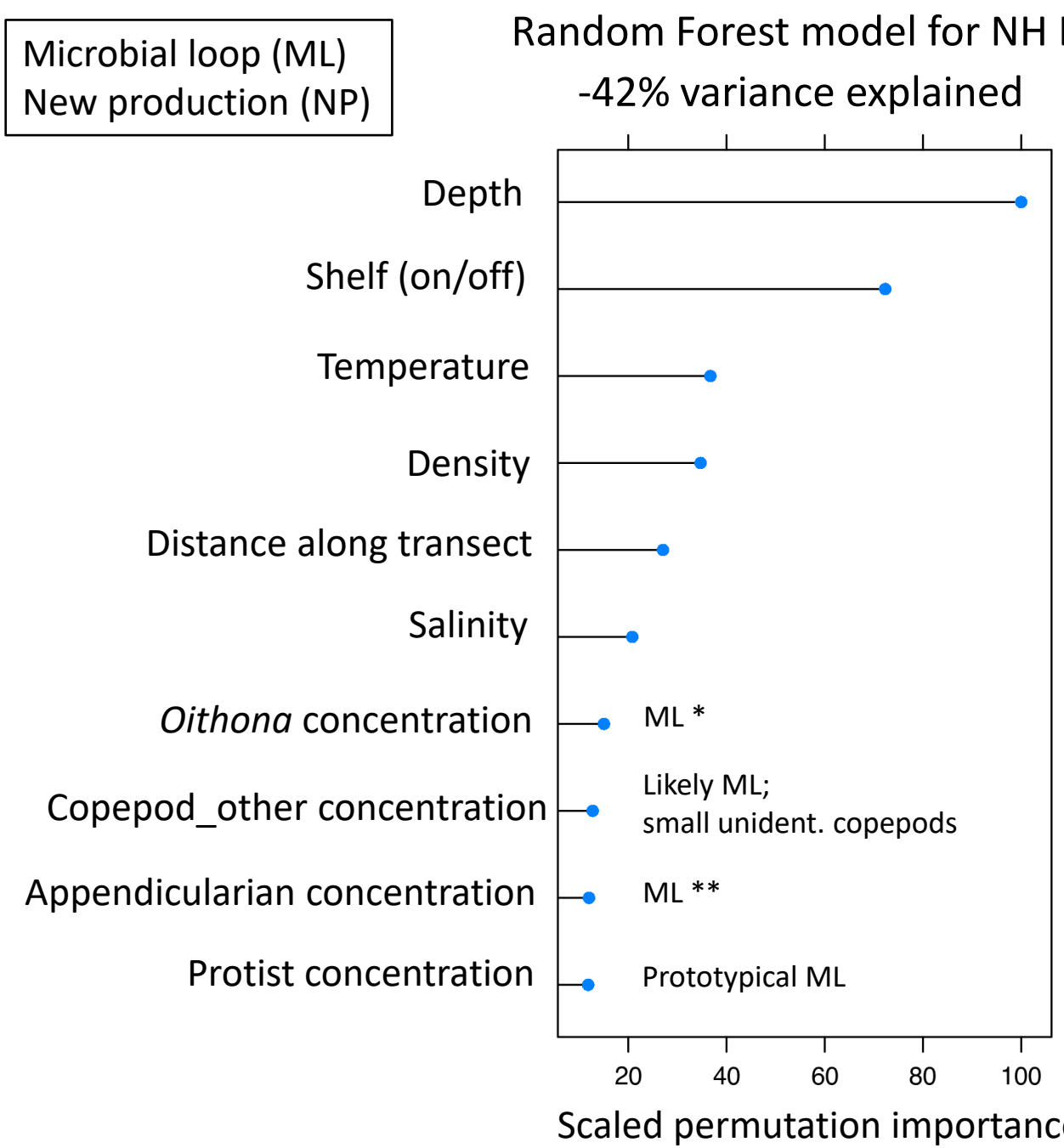
Modeling taxa correlations/co-occurrences via Random Forests

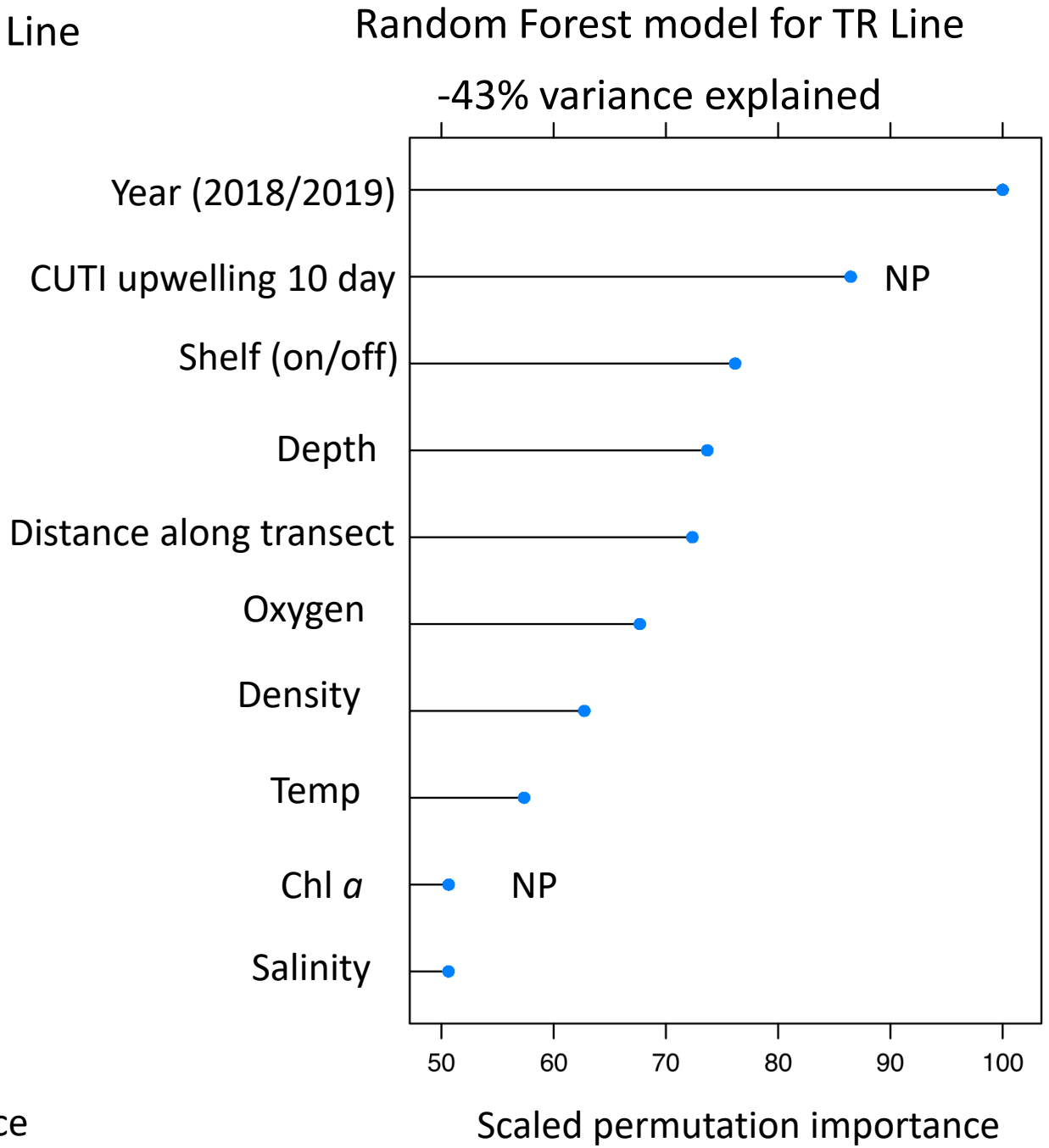


- Spatially explicit on the scale of < 1m

- 84 predictors that capture abiotic and biotic signal
  a) Taxa concentrations
  b) ISIIS sensors (e.g., Chl *a*, Oxygen, Temperature, density)
  c) Derived variables (e.g., mixed layer depth, Brunt-Vaisala frequency, geostrophic dynamic height anomaly)

Microbial loop (ML)
New production (NP)



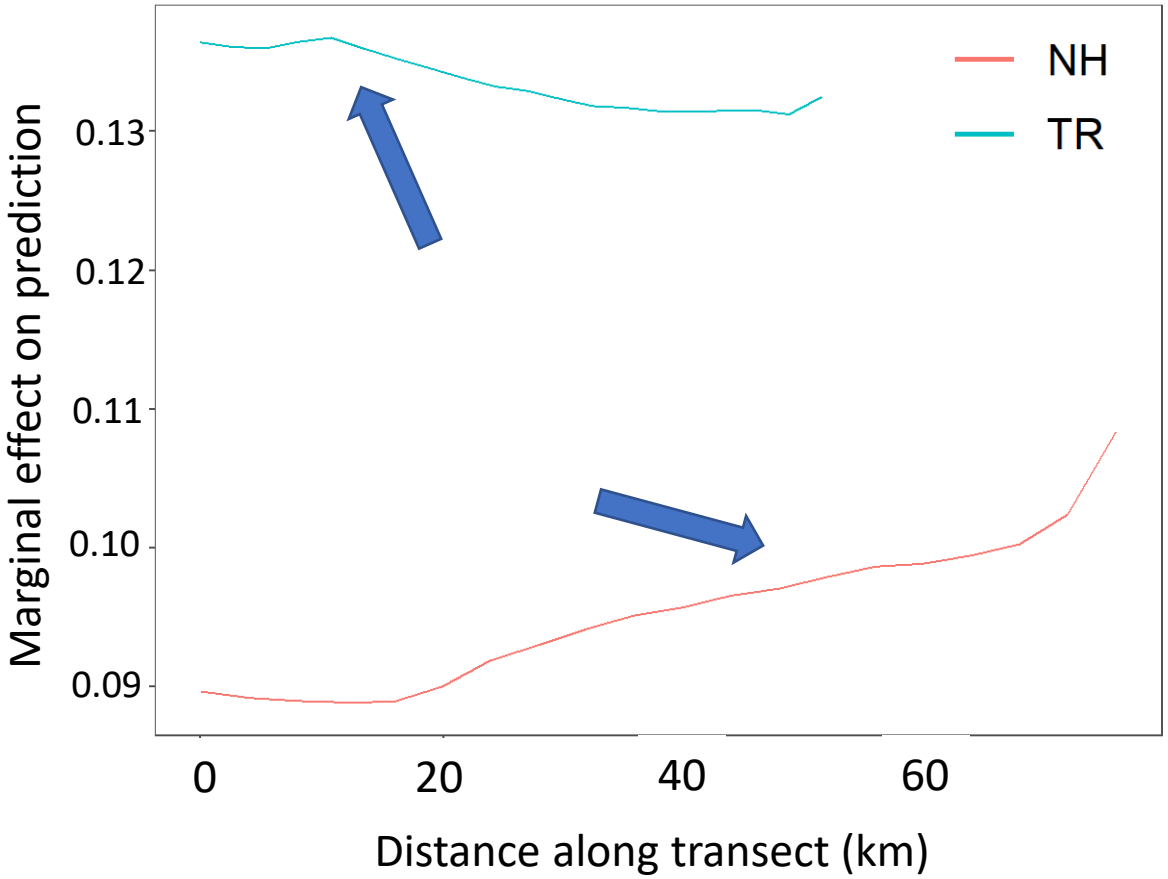


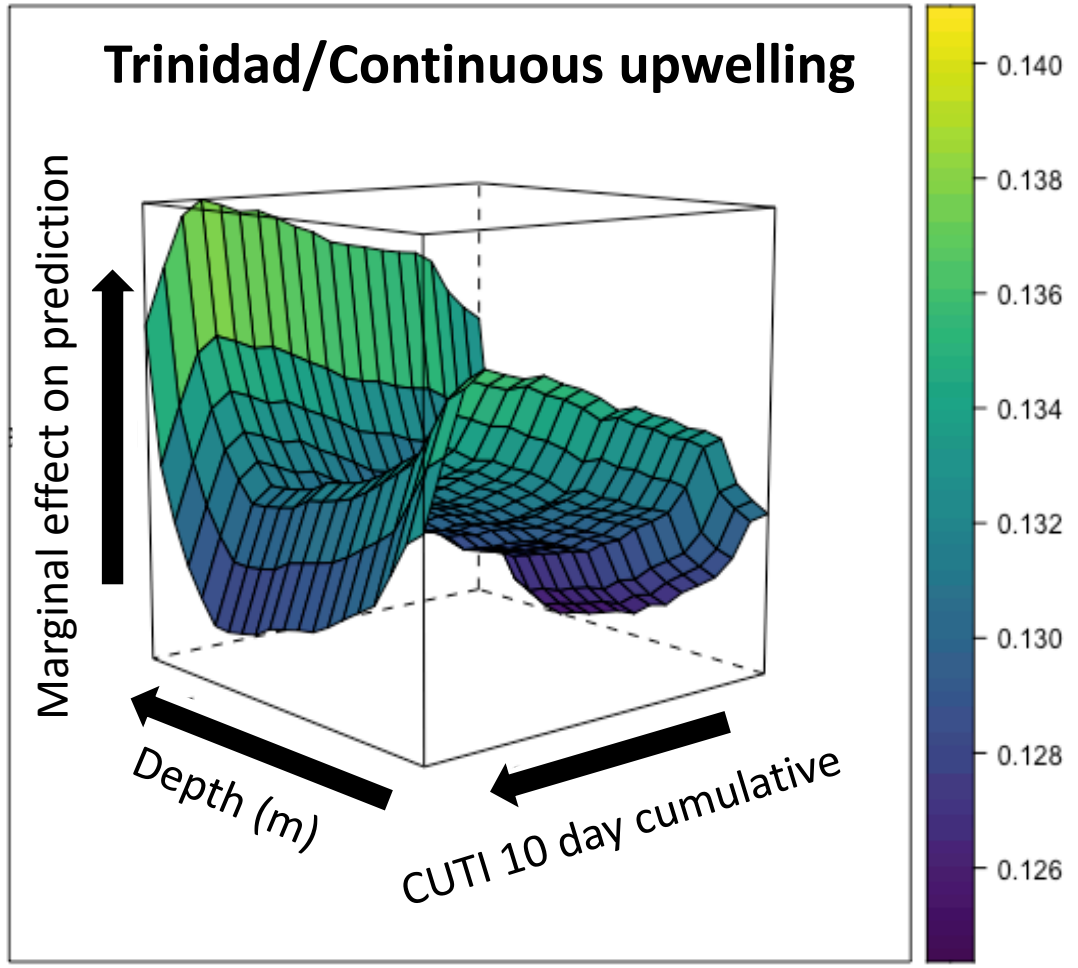
* Gonzalez et al. 1994, Nishibe et al. 2010

** Gorsky and Fenaux 1998, Sutherland and Thompson 2021

Detailed effects of variables on co-occurrences

- Partial dependence plots show the (non-linear) effects of predictors on the dependent variable





- Increase with CUTI, stronger effect shallow and deep, but drop-off at highest CUTI

Summary

- Correlation and co-occurrence as a proxy for community structure

- Distinct differences in on-shelf and off-shelf co-occurrences between intermittent and continuous upwelling regions

- Co-occurrences in intermittent upwelling were partially driven by variables attributed to the **microbial loop**, while in continuous upwelling important variables included those partial to **new production**

Conclusions

- Upwelling directly affects species co-occurrence, and more so in a continuous upwelling and narrow shelf system

- Climate change includes intensification of upwelling favorable winds (Pozo Buil et al. 2021) in the NCC -> Potential for microbial loop system ⟷ new production system. Nuanced effects on (the drivers of) species co-occurrences are likely

Acknowledgements

- Captains & crews of R/V *Sikuliaq,* R/V *Sally Ride* & R/V *Atlantis*
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- Kelsey Swieca for help with building the sCNN training library

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