A global stable isotope-based trophic level comparison of small pelagic fish and other nekton across ecosystems with varying levels of productivity

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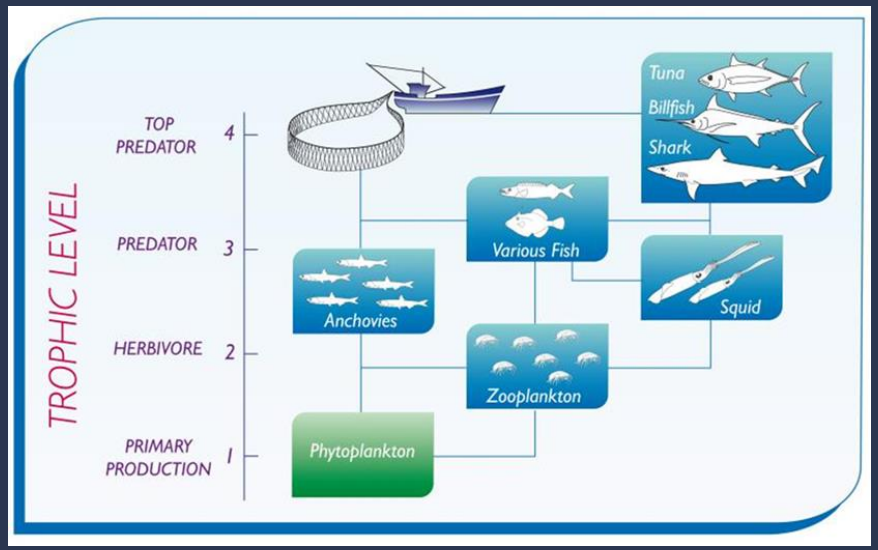
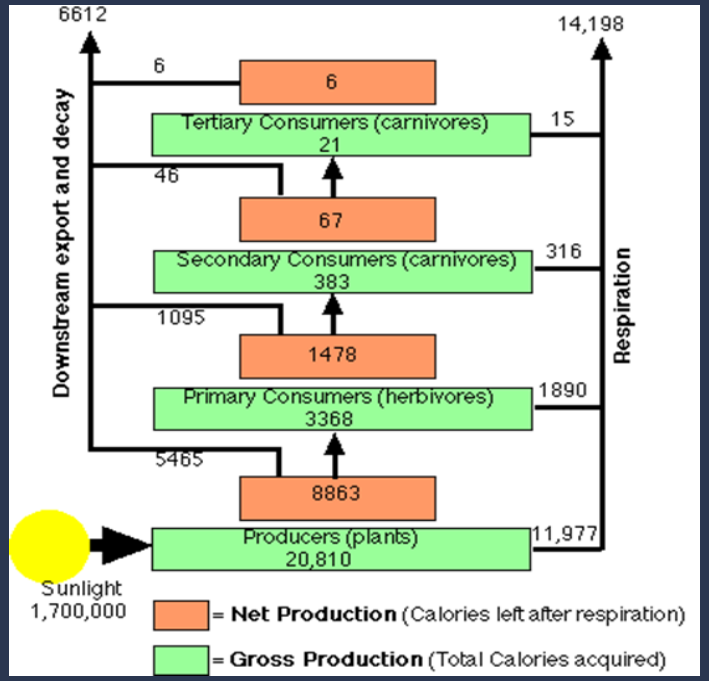
Stable isotopes and trophic levels

Why measure trophic levels?

- Mechanisms driving populations, ecosystem connectance and stability
- Ecosystem models - prediction and biomass estimation



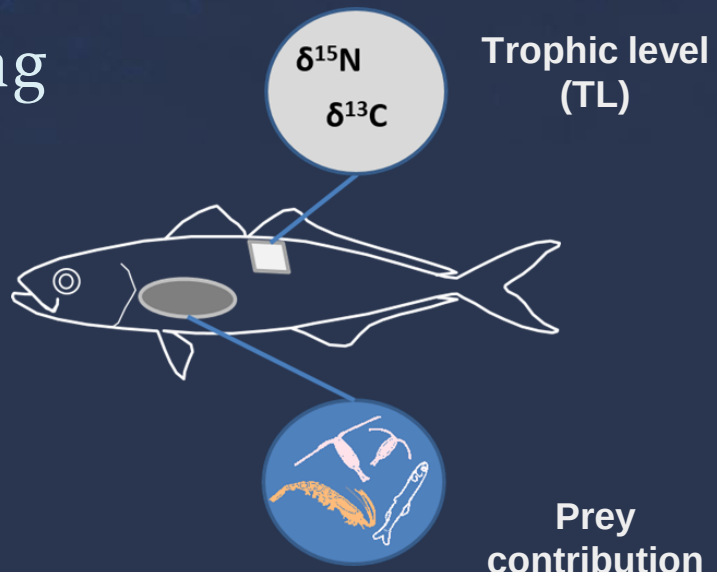


Stable isotopes and trophic levels

Measuring trophic level

Diet analysis

- Short-term 'snapshot' of feeding
- Detailed description of prey



Nitrogen stable isotopes

- Temporally integrated
- TL = $\frac{\delta^{15}N_{cons} - \delta^{15}N_{base}}{F} + \lambda$

  F= fractionation factor,

  λ=TL of base (usually primary consumer)
- Absence of prey detail

Stable isotopes and trophic levels

Stable isotope-based TL = $\frac{\delta^{15}N_{cons} - \delta^{15}N_{base}}{F} + \lambda$

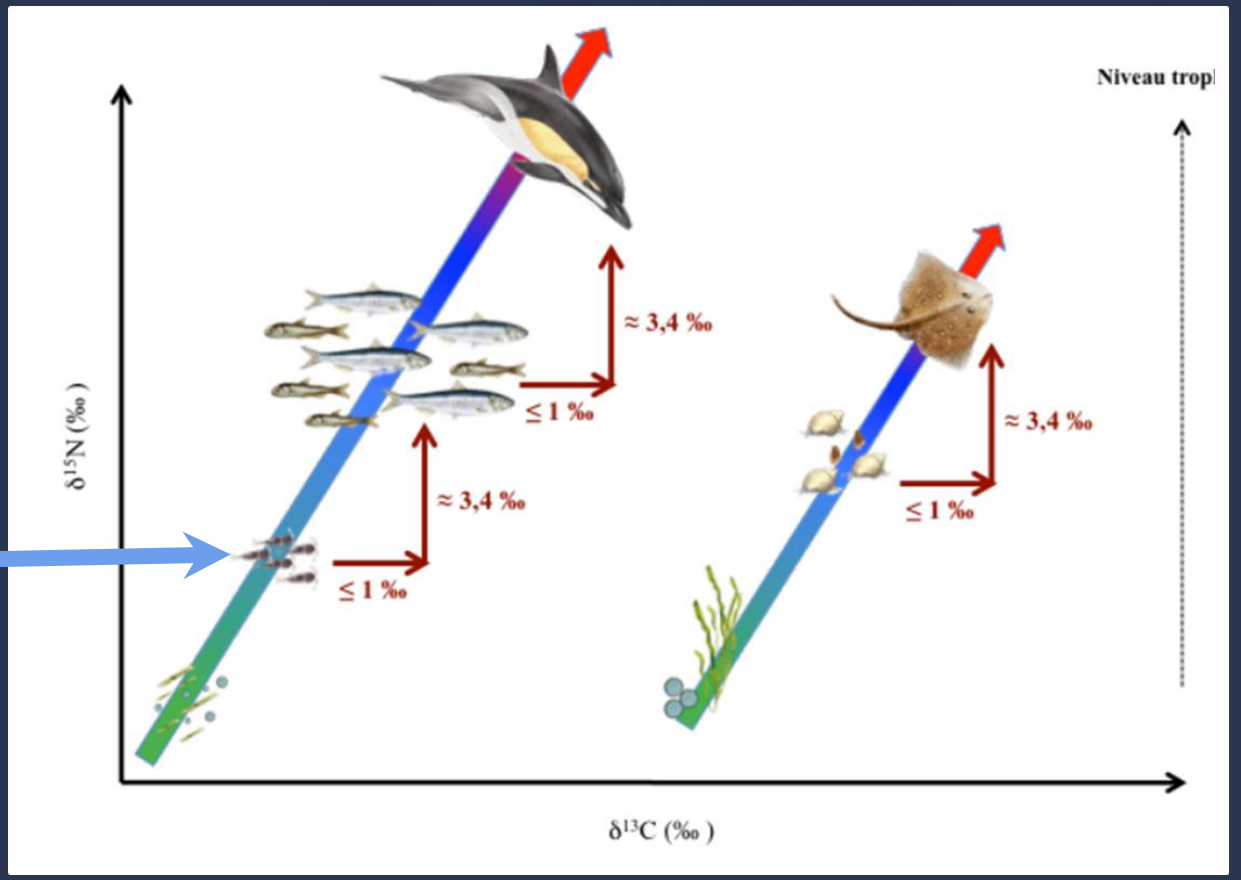
F = 3.4 (but can vary)

Copepods

1° consumer

TL(λ) = 2.0

$\delta^{15}N_{base}$



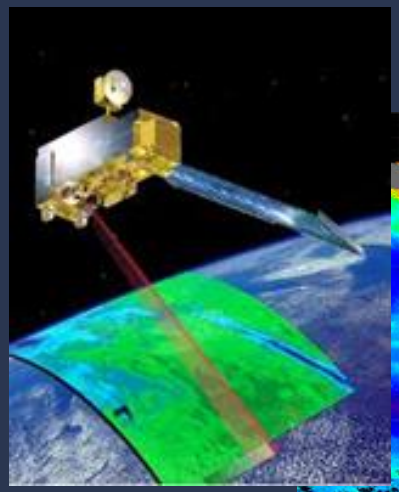
Methods

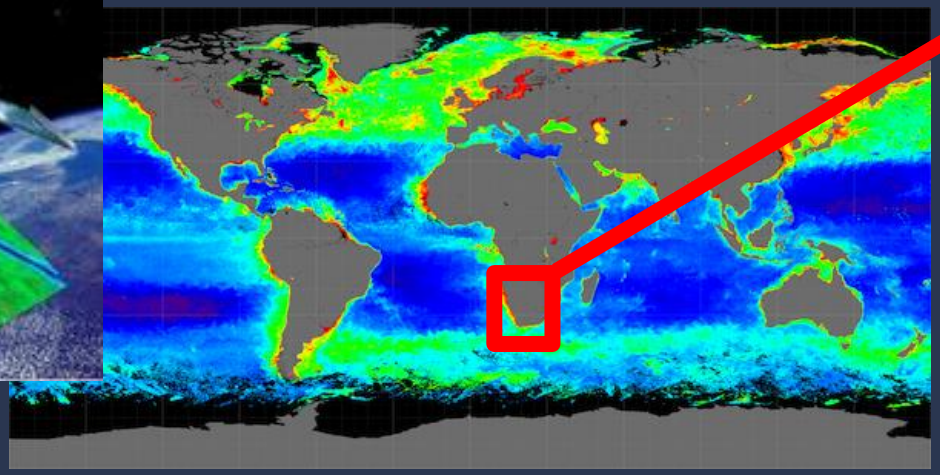
Collections, SIA and trophic level estimates

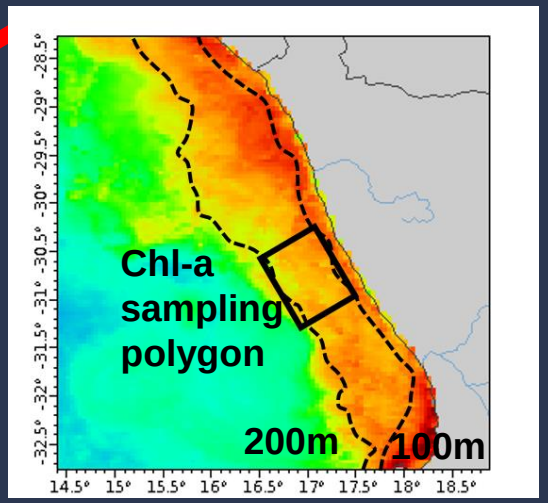
- Data available from research cruises in 15 different regions from multiple ecosystems worldwide
- $\delta^{15}N$ data for zooplankton (copepods), forage fishes (anchovies and sardines), mackerels (chub and horse mackerel) and blue shark
- Literature review from other studies to fill in gaps
- To minimize ontogenetic effects, only adult specimens (>80% of maximum size) were used in the analysis (from FishBase)
- Trophic levels (literature and our own) compared across ecosystems and within fish groups
- **Research Question:** Is pelagic trophic level influenced by ecosystem productivity?

Methods

- Ecosystem productivity from MODIS aqua chlorophyll-a through NOAA ERDDAP portal
- Global, 4 km, 2010-2020 (Monthly Composite; 10 year avg)
- Sampling polygon 100-200 m depth (marmap package), if ecosystem >or<200 m depth, selected 8x24 km polygon.

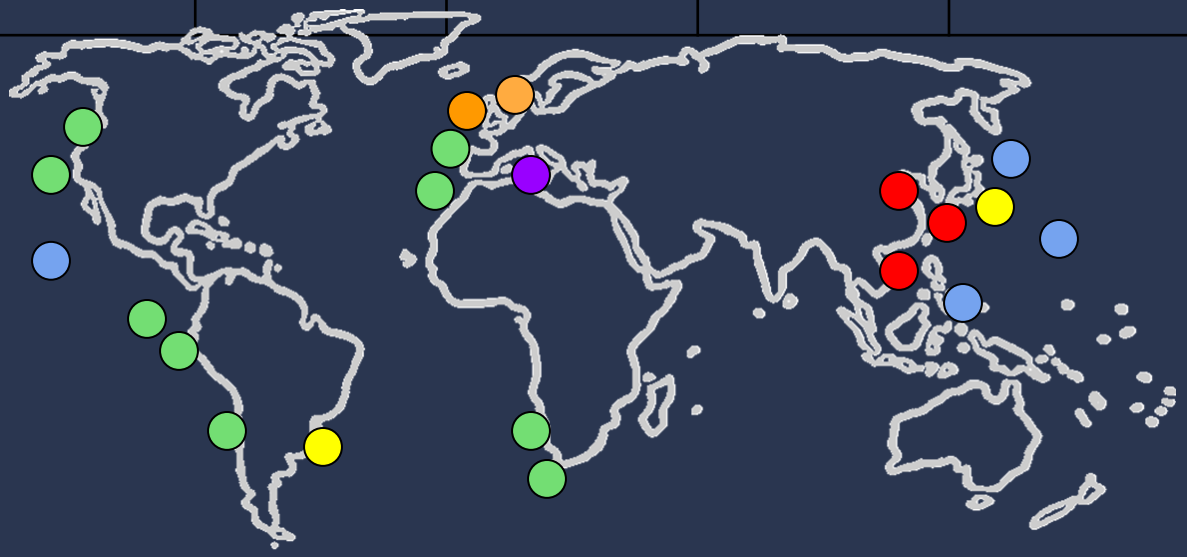






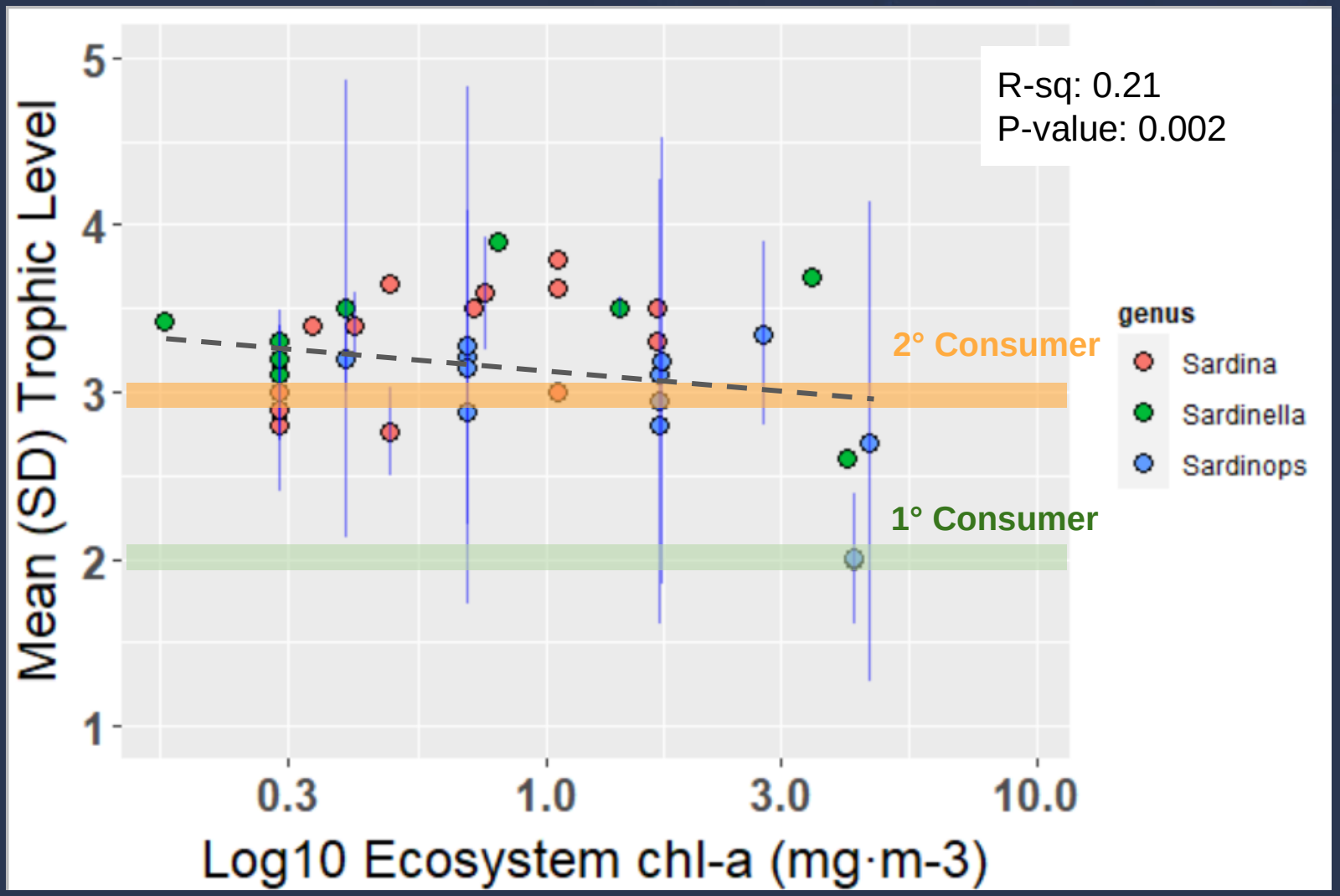
Methods

System	Number of literature-based values for isotopes (# with trophic levels in parentheses) by species and region				
	Sardines	Anchovies	Chub mackerels	Horse mackerels	Blue shark
Eastern Boundary Currents	20 (8)	19 (9)	21 (8)	24 (8)	4 (4)
Western Boundary Currents	5 (3)	4 (1)	4 (2)	5 (4)	2 (1)
Mediterranean	25 (15)	17 (10)	14 (10)	17 (11)	2 ( )
North Atlantic	6 (2)	2 (1)	8 (1)	8 (2)	
China Seas	6 (5)	12 (11)	1 (1)	1 (1)	1 (1)
Other Pacific systems			2 (2)		3 (3)



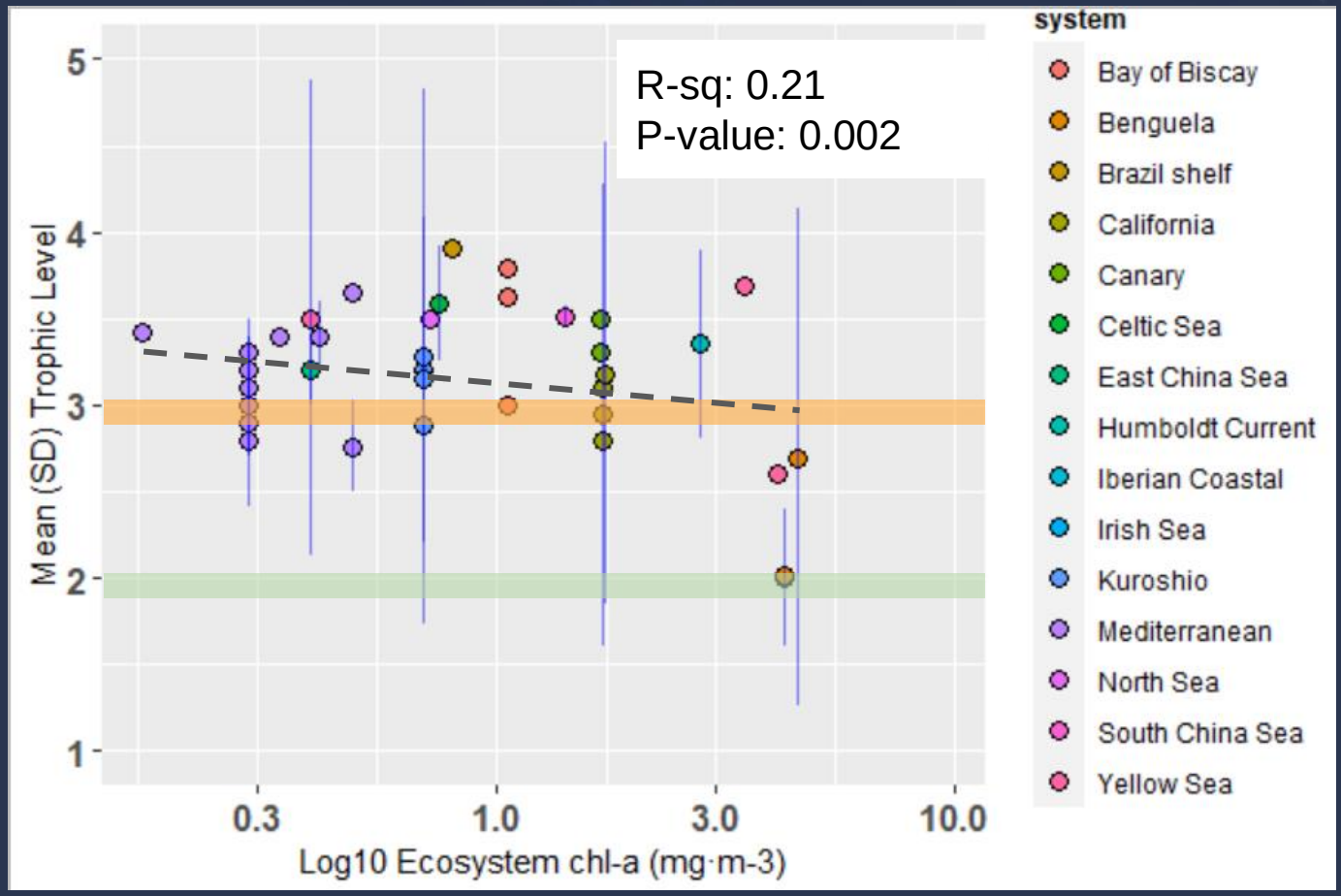
Results

Sardines (*Sardina, Sardinella, Sardinops*)



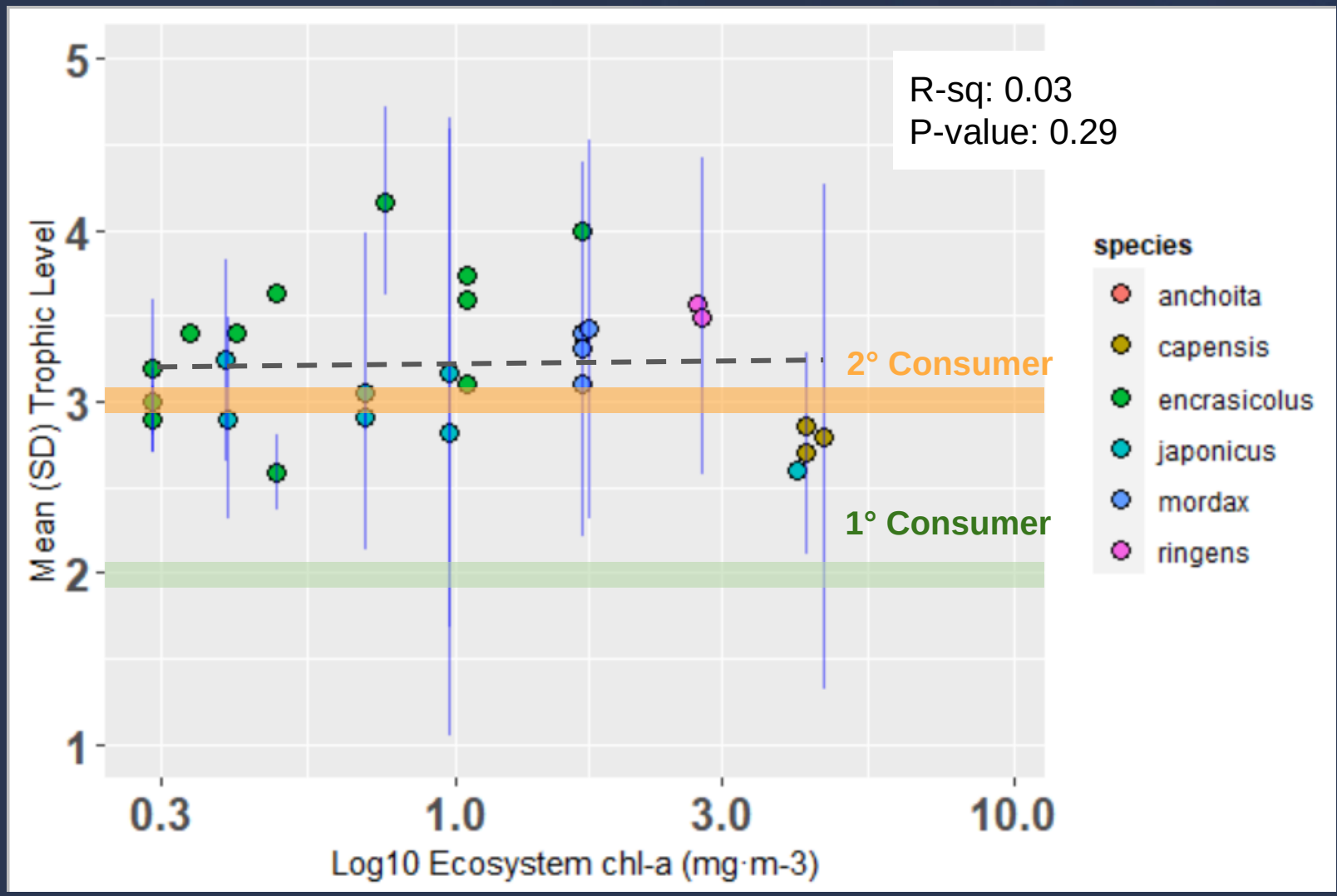
Results

Sardines by ecosystem



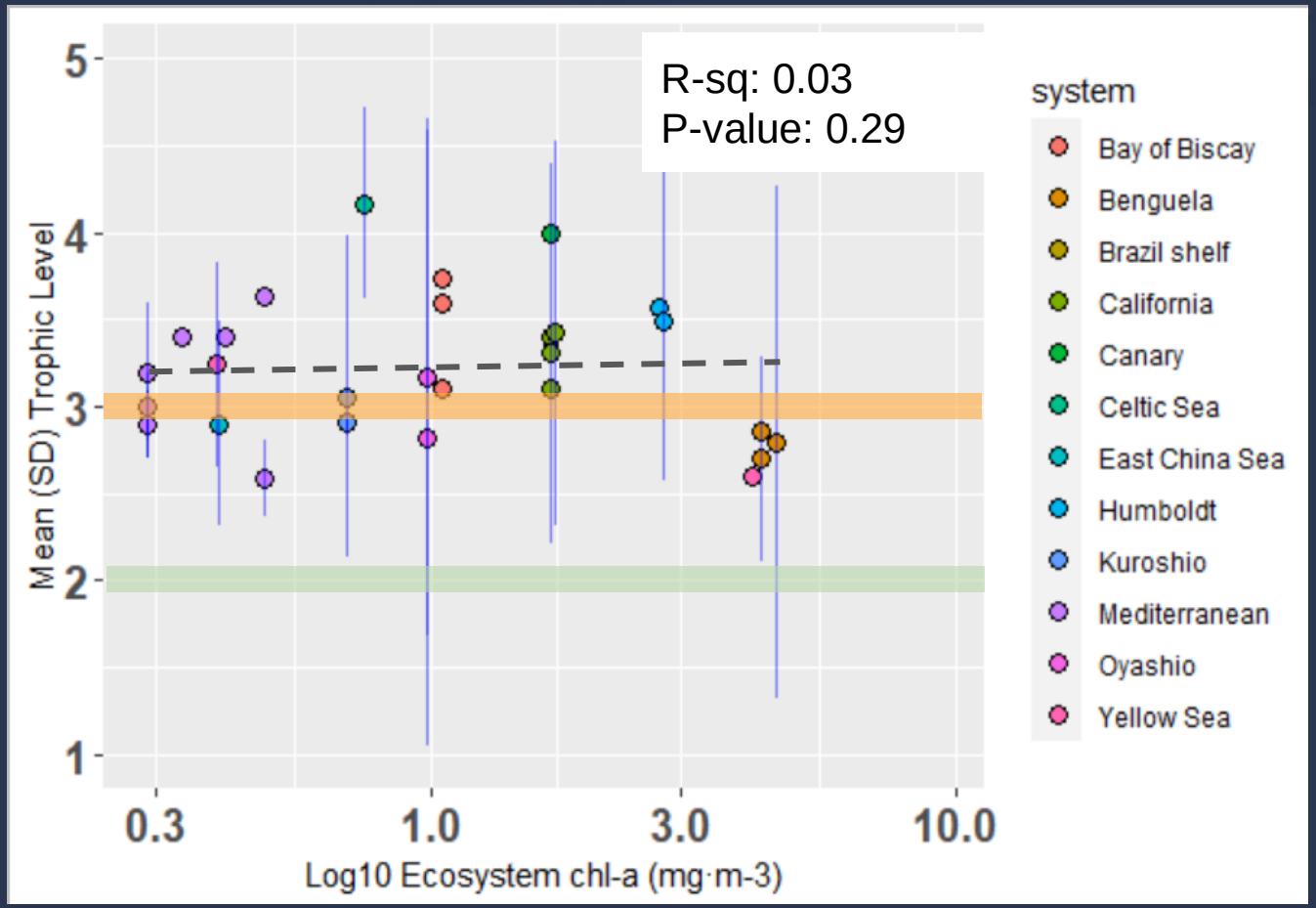
Results

Anchovy (*Engraulis* spp.) by species



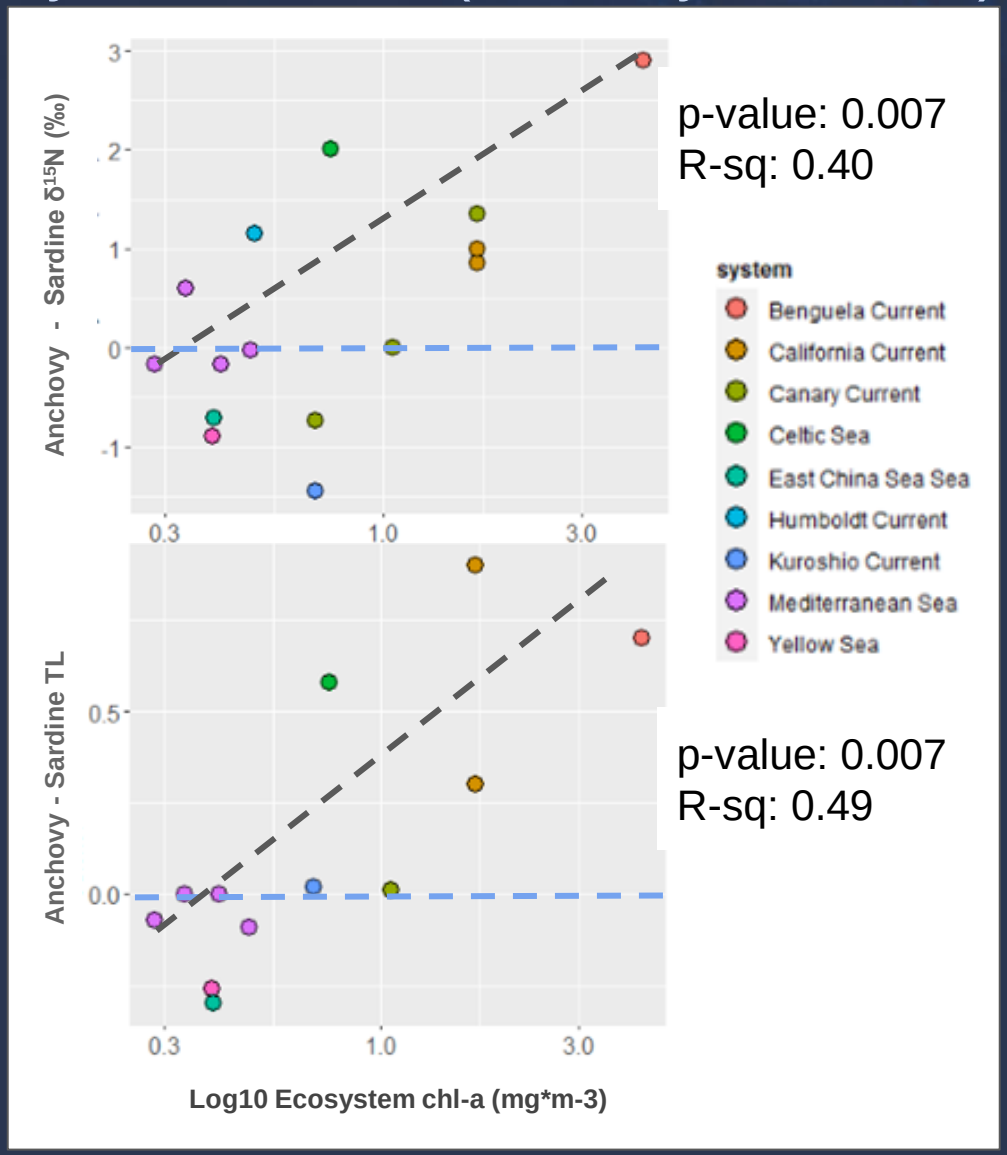
Results

Anchovy (*Engraulis* spp.) by ecosystem



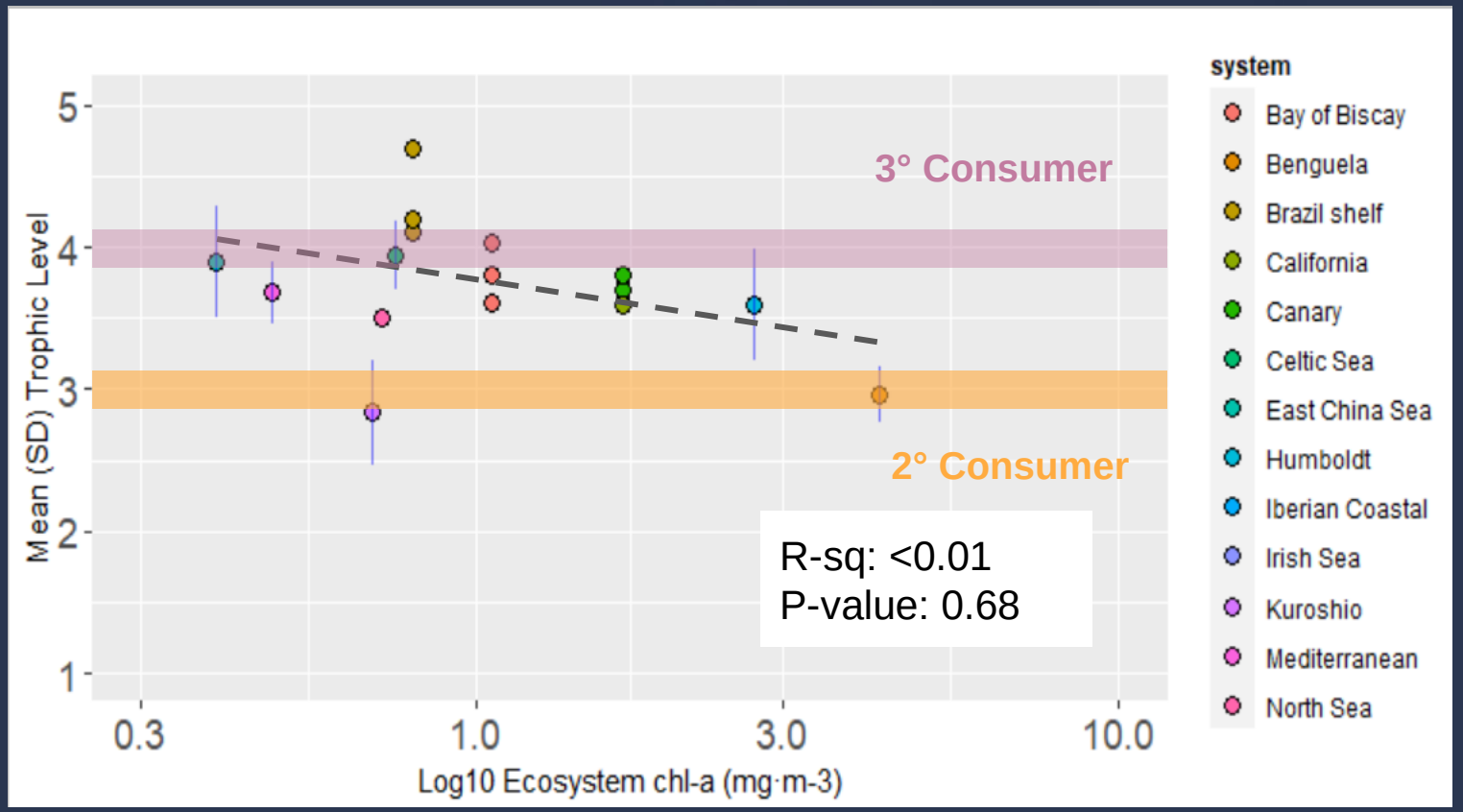
Results

Differences between anchovy and sardine (anchovy - sardine)



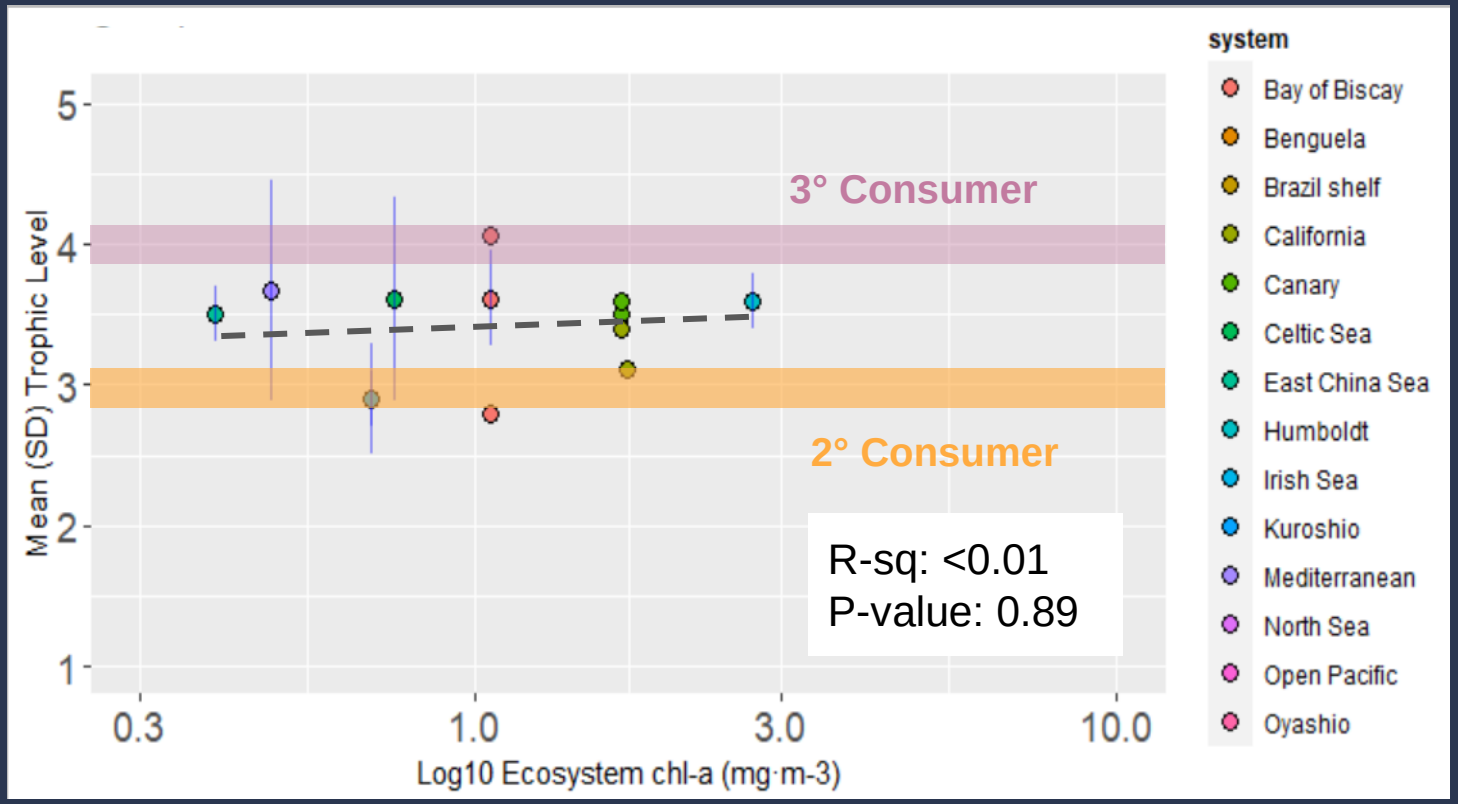
Results

Horse mackerel by ecosystem (*Trachurus* spp.)



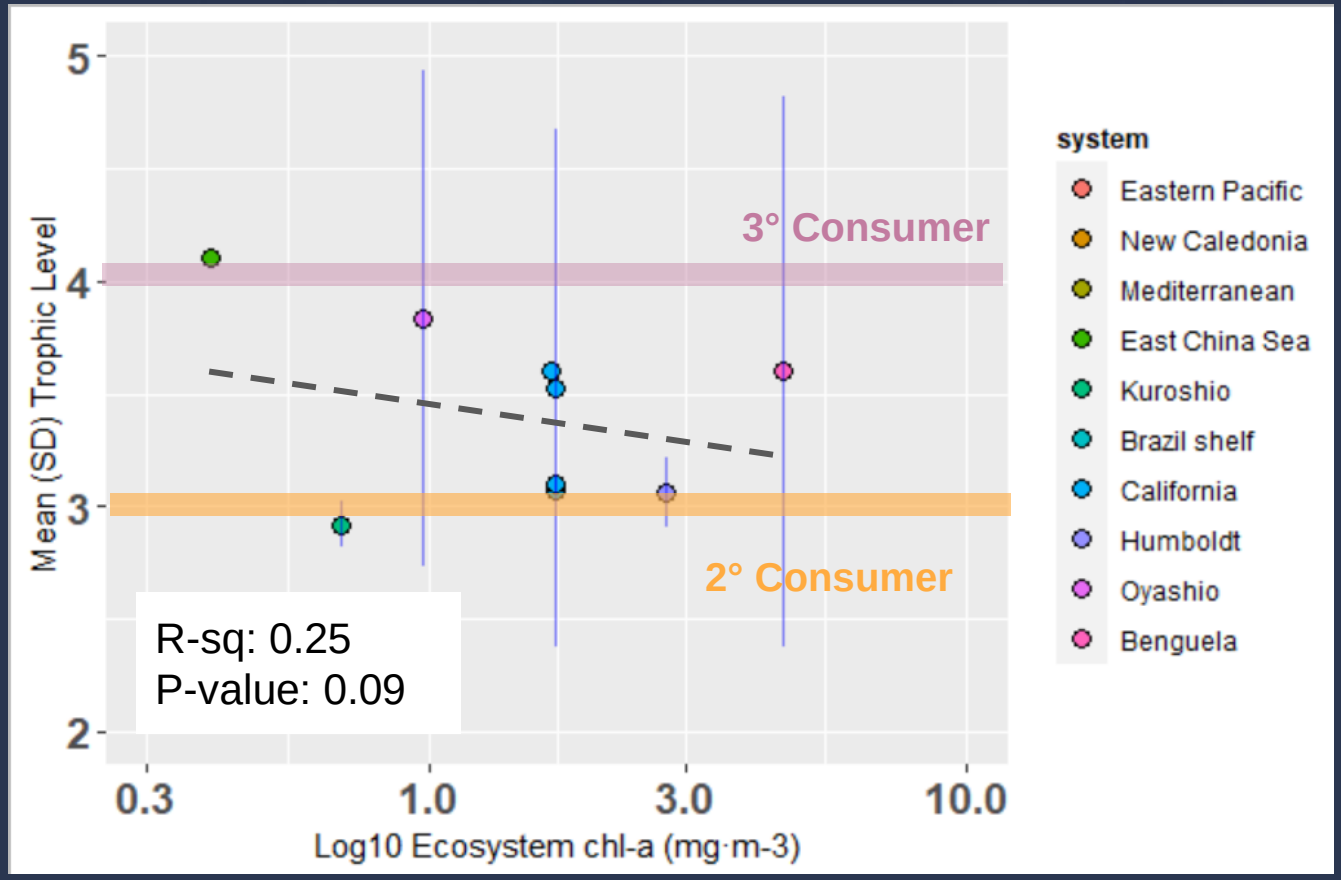
Results

Chub mackerel by ecosystem (*Scomber* spp.)



Results

Blue shark (*Prionace glauca*)



Conclusions

- Both our data and the literature review revealed considerable intraspecific variation in TLs but they still conformed to predictions, with the highest TL shown by blue sharks (TL 3.6) followed by mackerels (3.2-3.4), anchovies (3.3), and then sardines (3.2).
- Only sardine showed a significant response to chl-a. Sardine may be more responsive to lower trophic level shifts relative to other zooplanktivores such as anchovy.
- Both $\delta^{15}N$ and TL differences between sardine and anchovy are directly correlated with increasing ecosystem chl-a.
- Medium and large pelagics (mackerels and blue shark) showed no significant relationships with chl-a; however, there was a slight negative trend seen with horse mackerel and blue shark. Potential mismatch between the baseline $\delta^{15}N$ and predators in establishing TLs.

Next Steps

- Estimate primary productivity from satellite chlorophyll data concurrent to when samples were collected
- Further data collection to fill in species and area gaps and add other species when possible (e.g. herrings and tuna)
- Analyses of other factors related to trophic level including body size (ontogeny), feeding morphology, and other ecosystem characteristics
- Determine whether within-region temporal differences in productivity are related to trophic level for systems with long time series of stable isotope measurements

Acknowledgements & Affiliations

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