SEEKING TROPHIC CLARITY: LINKING STABLE ISOTOPES AND STOMACH CONTENTS IN THE PELAGIC EASTERN PACIFIC OCEAN

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TROPHIC STRUCTURE AND TUNA MOVEMENT IN THE EQUATORIAL PACIFIC PELAGIC ECOSYSTEM

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Why seek trophic clarity?

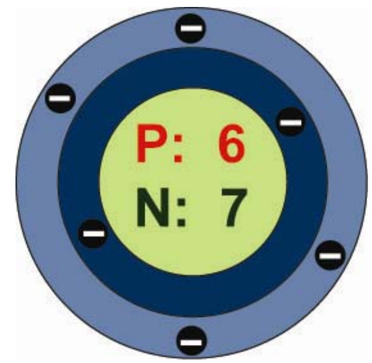
- Widespread concern that fisheries are altering the structure and function of marine ecosystems.
- Ecosystem considerations in fisheries management: “ensure conservation of not only target species, but also the other species belonging to the ecosystem.”
- Multispecies trophic models of ecosystems depend on accurate depiction of trophic links.
- Basic biological knowledge needed to underpin this approach lacking

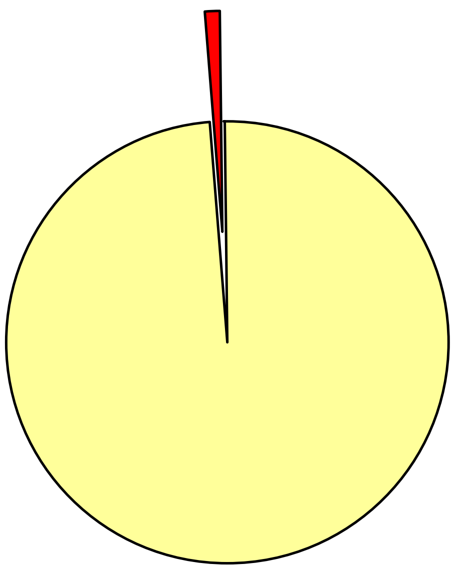
Robust methods are needed

- Traditional methods: stomach contents analysis
  - Snapshot in time – missing diet components?
- Stable isotopes integrate biochemical "signatures" of all assimilated prey components into the animal's tissues.
- Direct comparisons of diet and isotope data required for interpretation of patterns.
- Estimates of the isotopic baseline required to infer trophic structure from stable isotopes

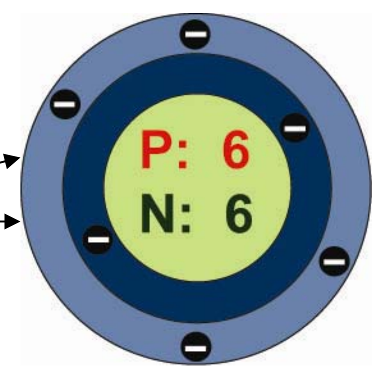
Stable Carbon Isotopes

1.1% of C atoms are ^{13}C



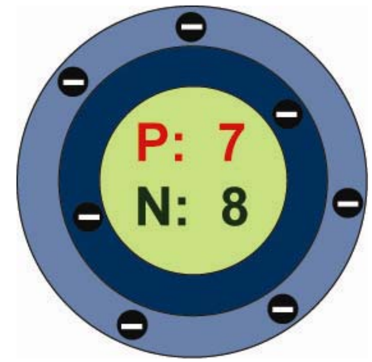


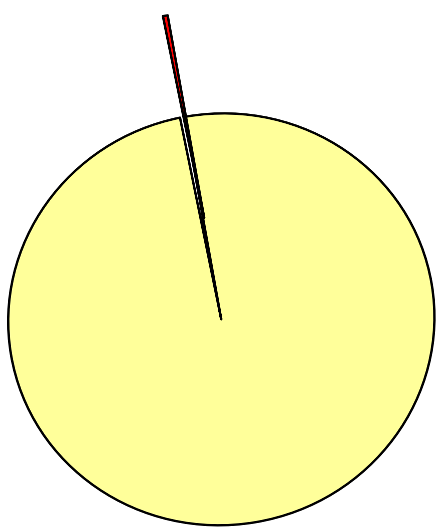
98.9% of C atoms are ^{12}C



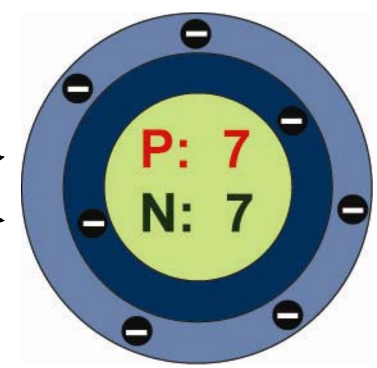
Stable Nitrogen Isotopes

0.4% of N atoms are ^{15}N



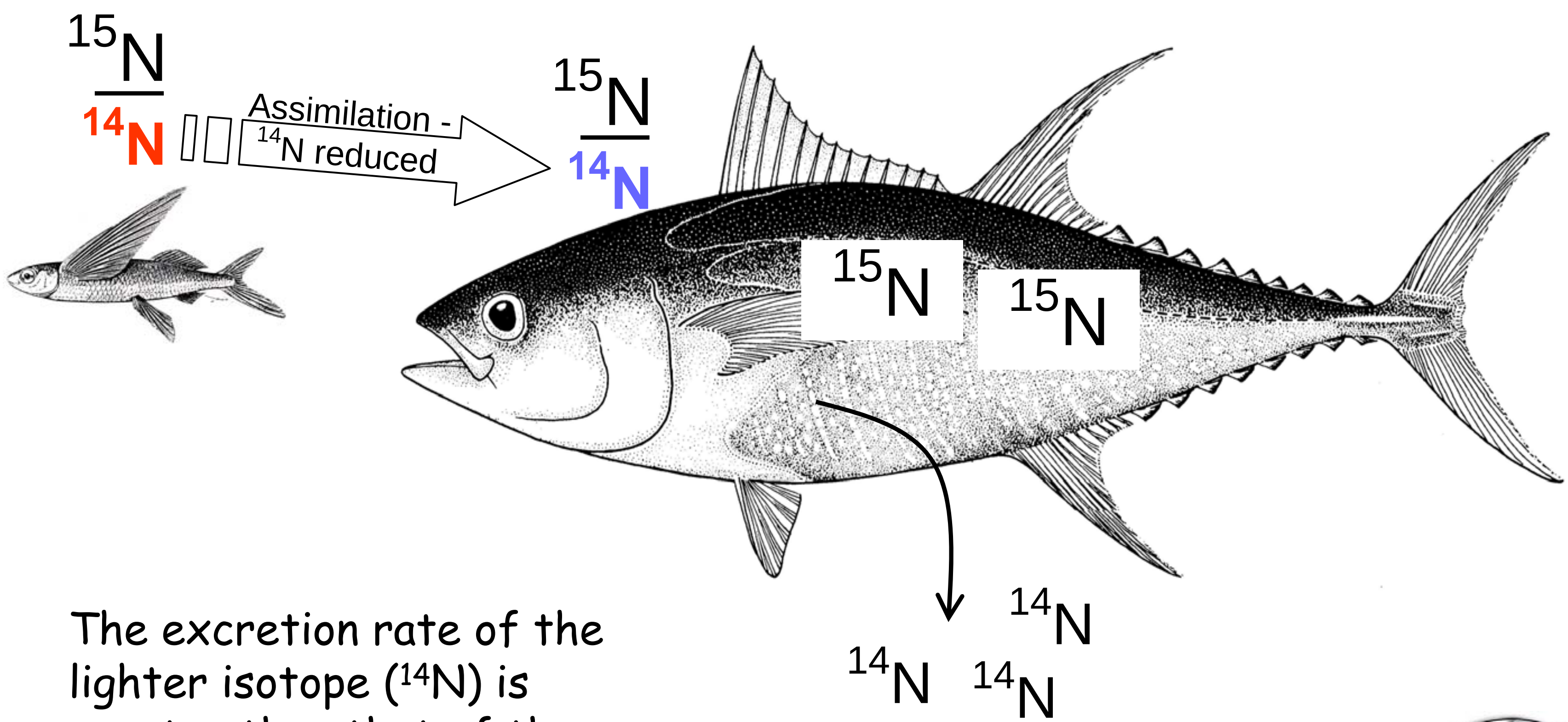


99.6% of N atoms are ^{14}N



N Isotope Fractionation

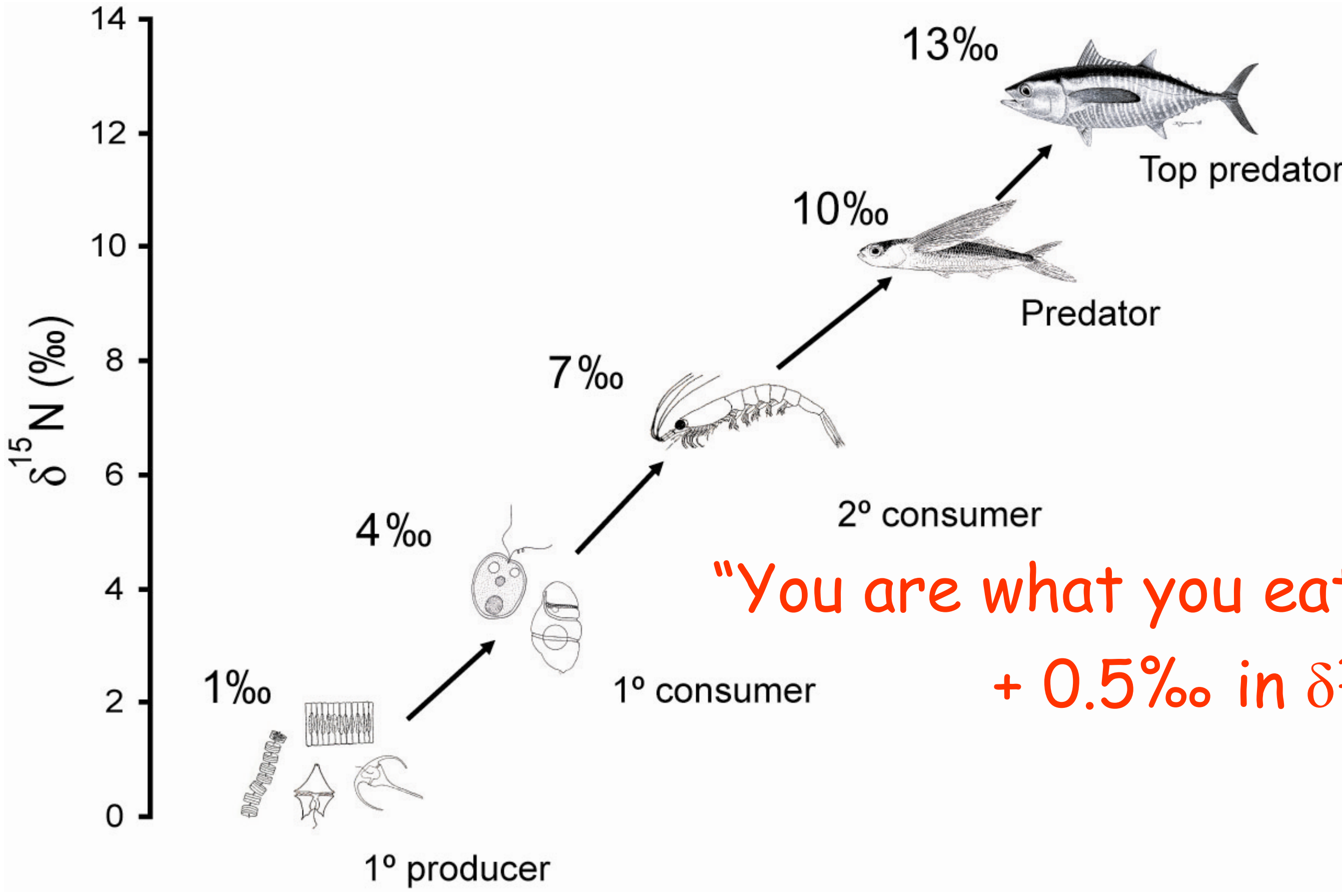
$$\delta^{15}N_{predator} = 3.0 + \delta^{15}N_{prey}\ (‰)$$



The excretion rate of the lighter isotope (^{14}N) is greater than that of the heavier isotope (^{15}N) during metabolism

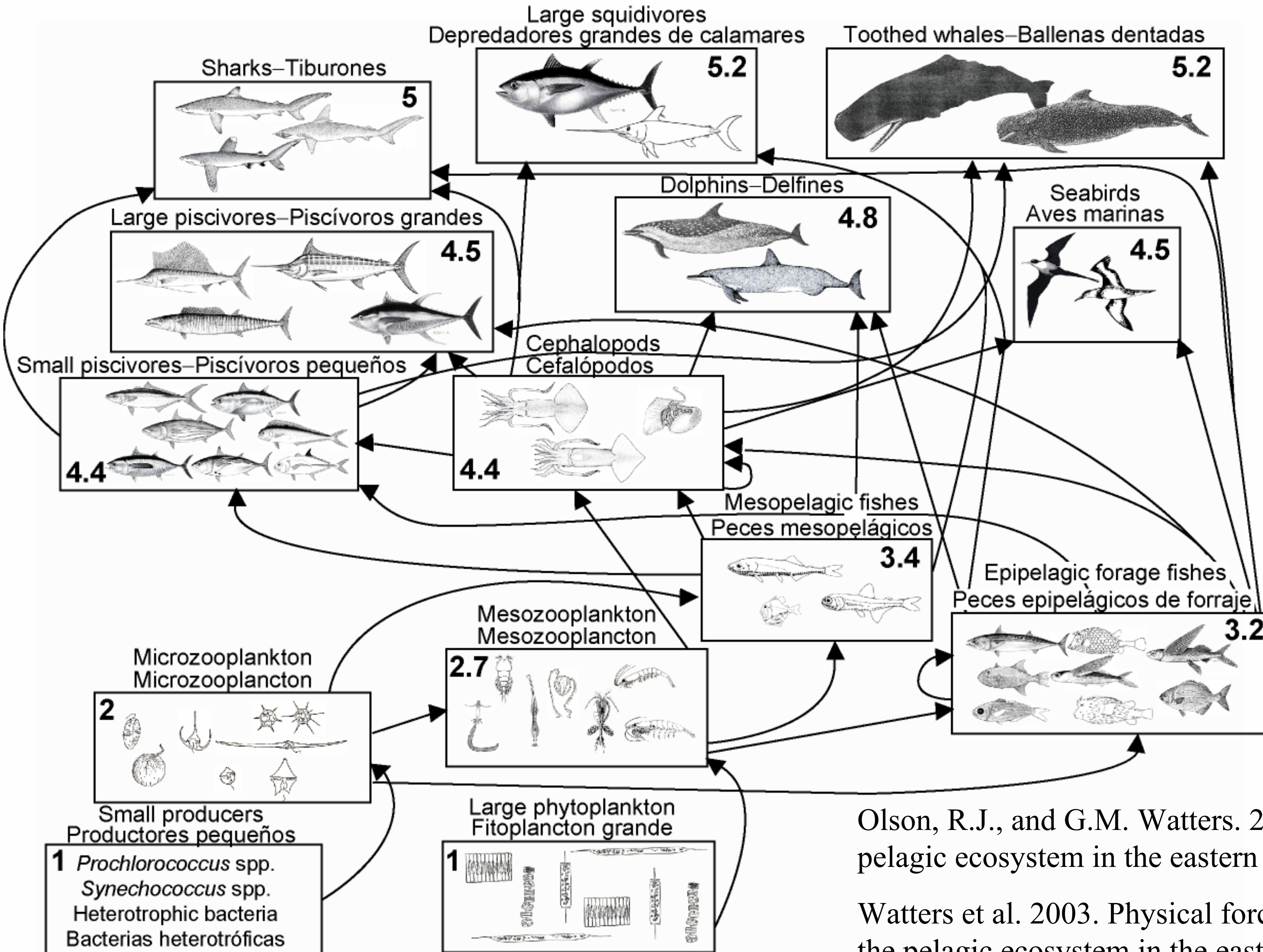
δ^{15}N Values: Trophic Position

Isotopic fractionation: lighter isotope is excreted in greater proportion than heavier isotope, leaving the animal enriched in ^{15}N and ^{13}C relative to its food source.



"You are what you eat + 3.0‰"
+ 0.5‰ in δ^{13}C

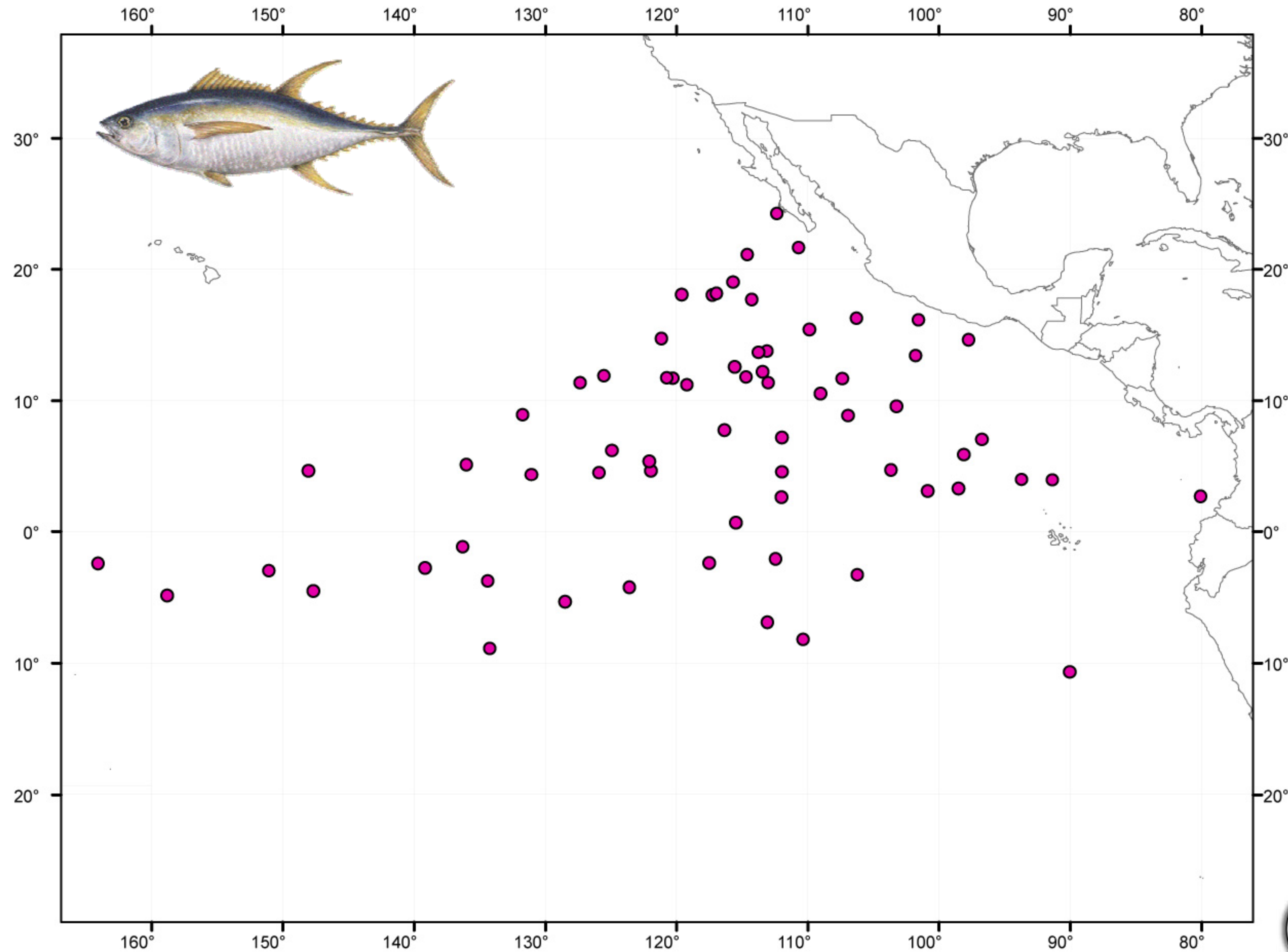
Pelagic Eastern Tropical Pacific



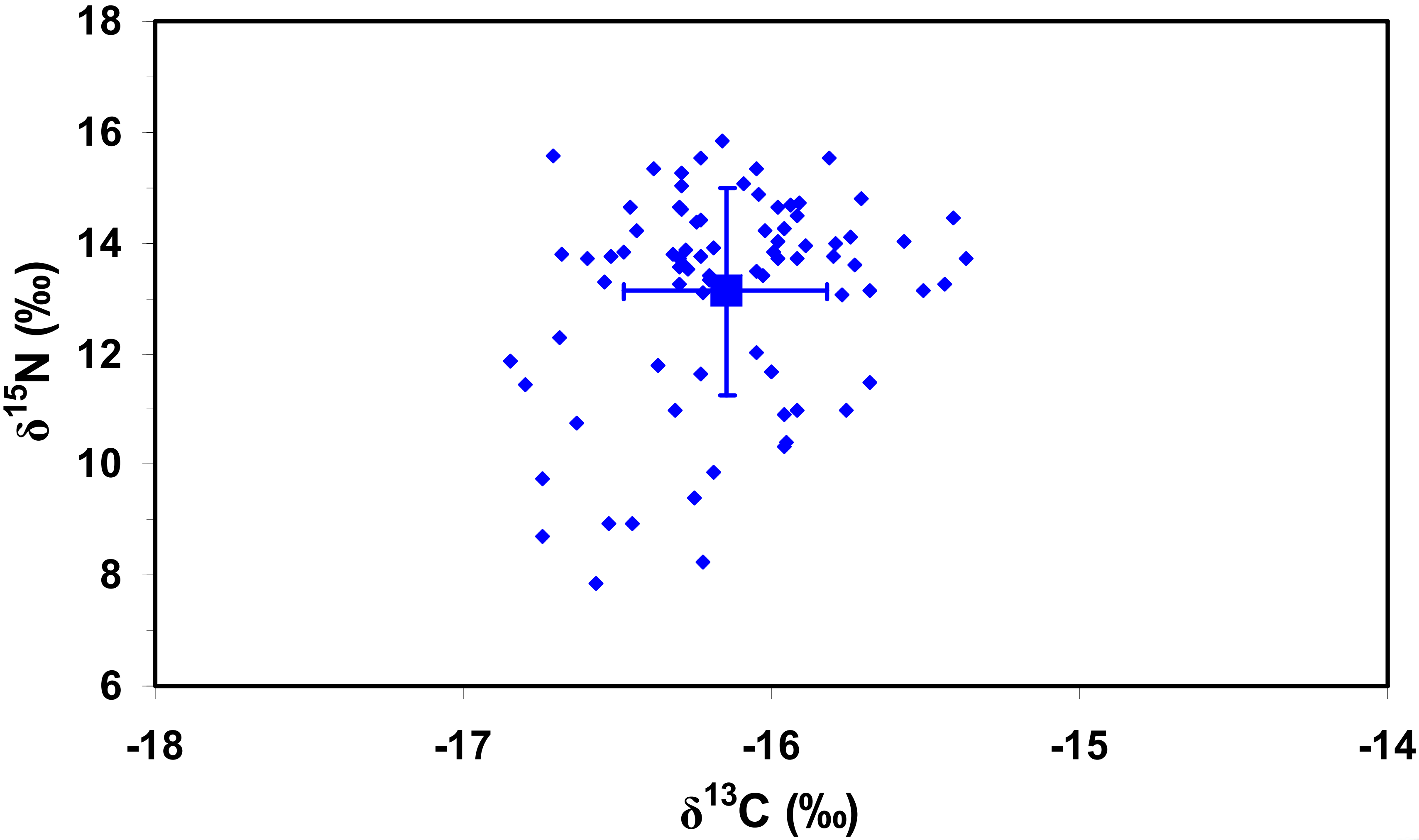
Olson, R.J., and G.M. Watters. 2003. A model of the pelagic ecosystem in the eastern tropical Pacific Ocean.

Watters et al. 2003. Physical forcing and the dynamics of the pelagic ecosystem in the eastern tropical Pacific: simulations with ENSO-scale and global-warming climate drivers.

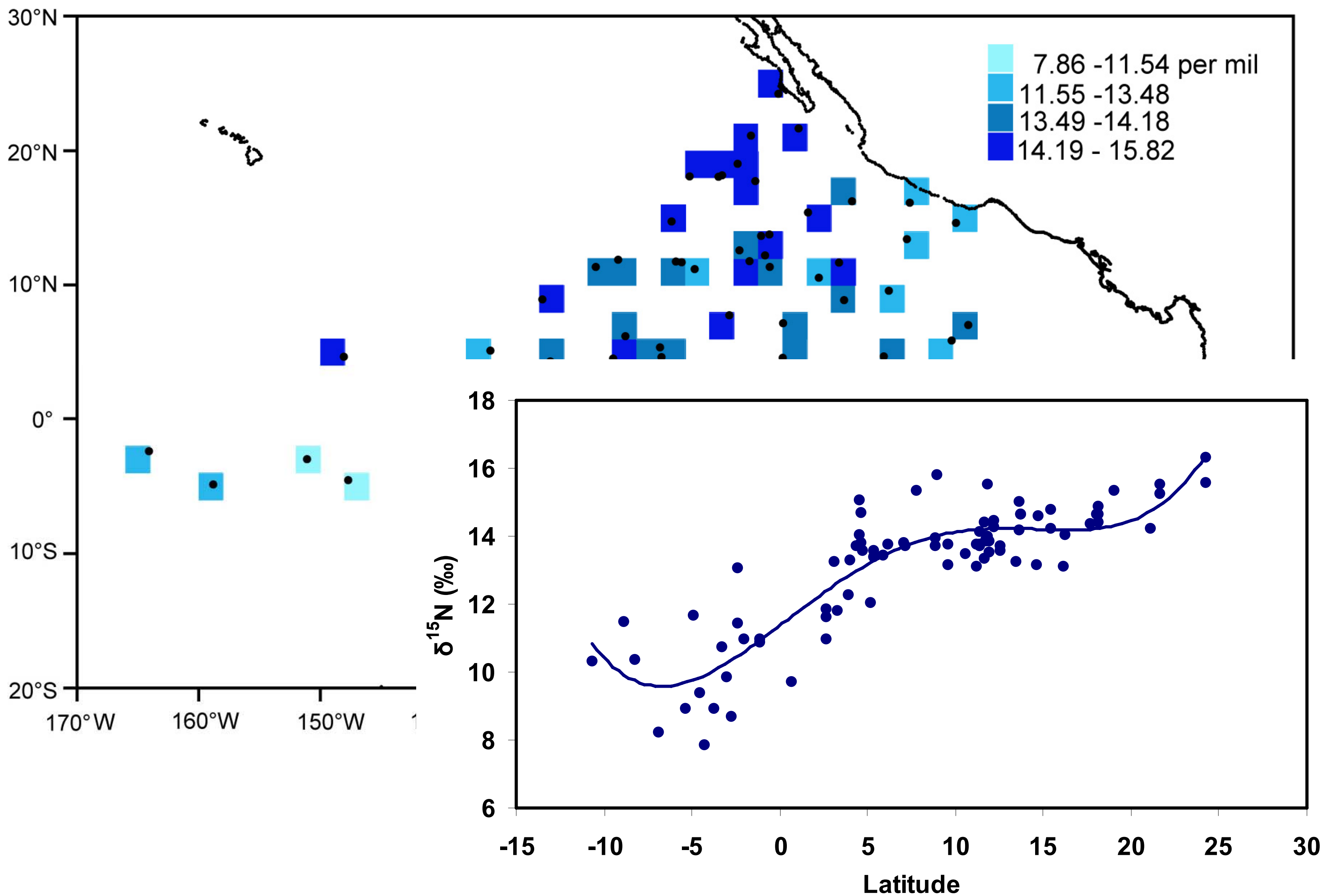
Yellowfin Tuna



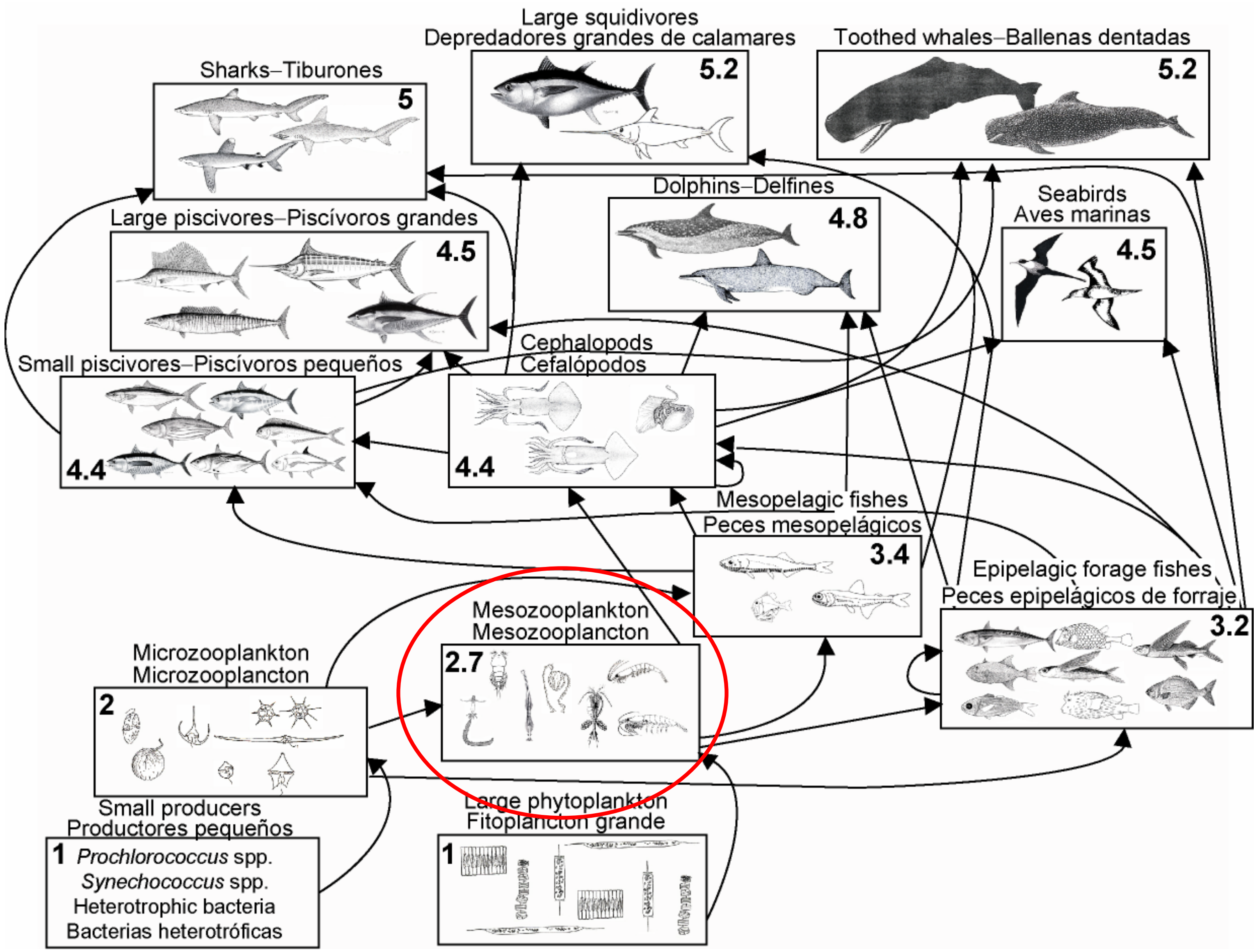
Yellowfin Stable Isotopes



Yellowfin Tuna $\delta^{15}N$



Mesozooplankton



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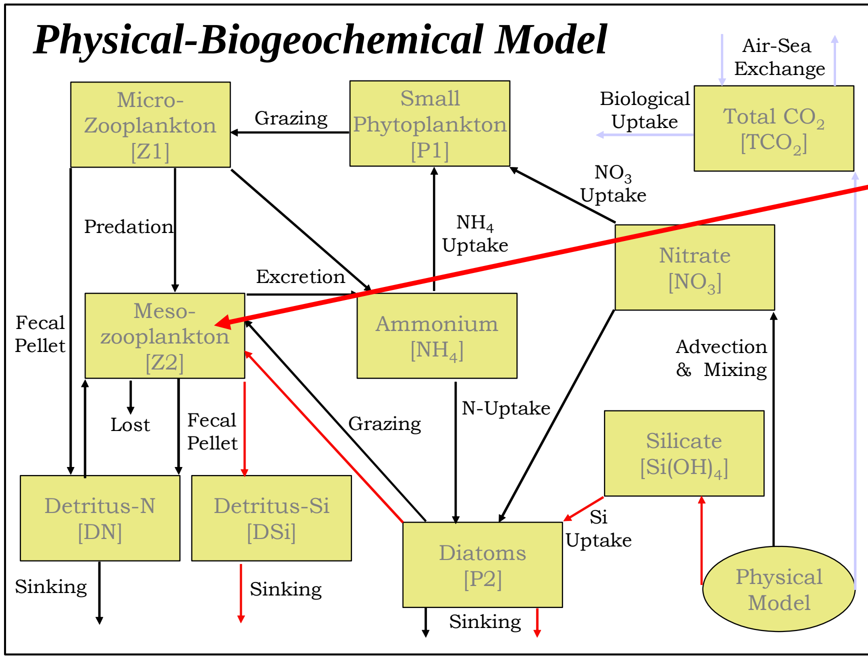
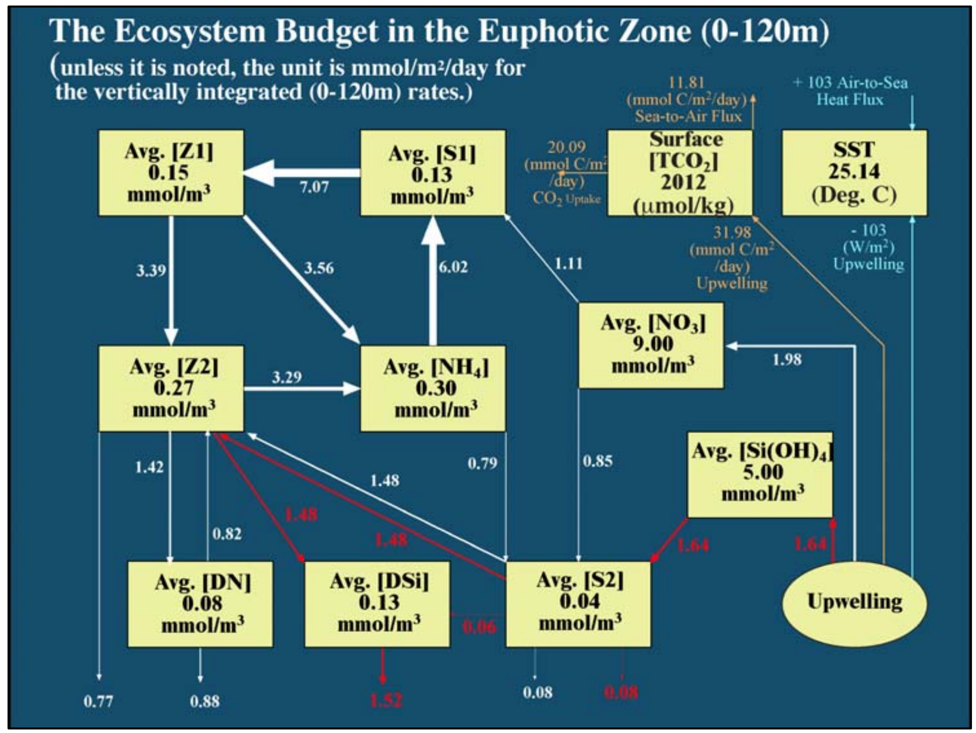
Mesozooplankton



Trophic level 2.7

Chai, F., R.C. Dugdale, T.-H. Peng, F.P. Wilkerson, and R.T. Barber. 2002. One-dimensional ecosystem model of the equatorial Pacific upwelling system. Part I: model development and silicon and nitrogen cycle. Deep-Sea Res. II 49 (13-14): 2713-2745.



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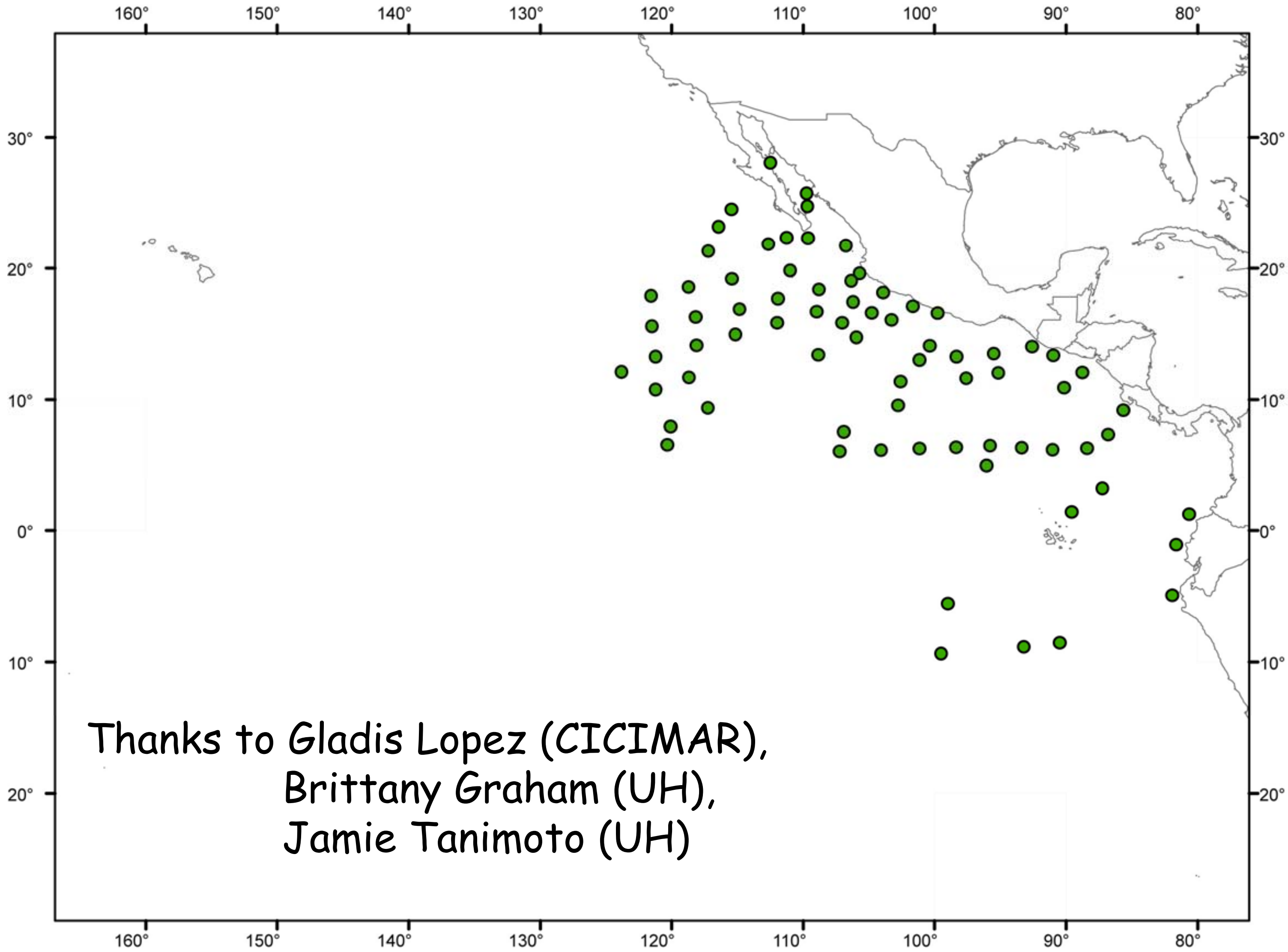

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Brittany Graham (UH),
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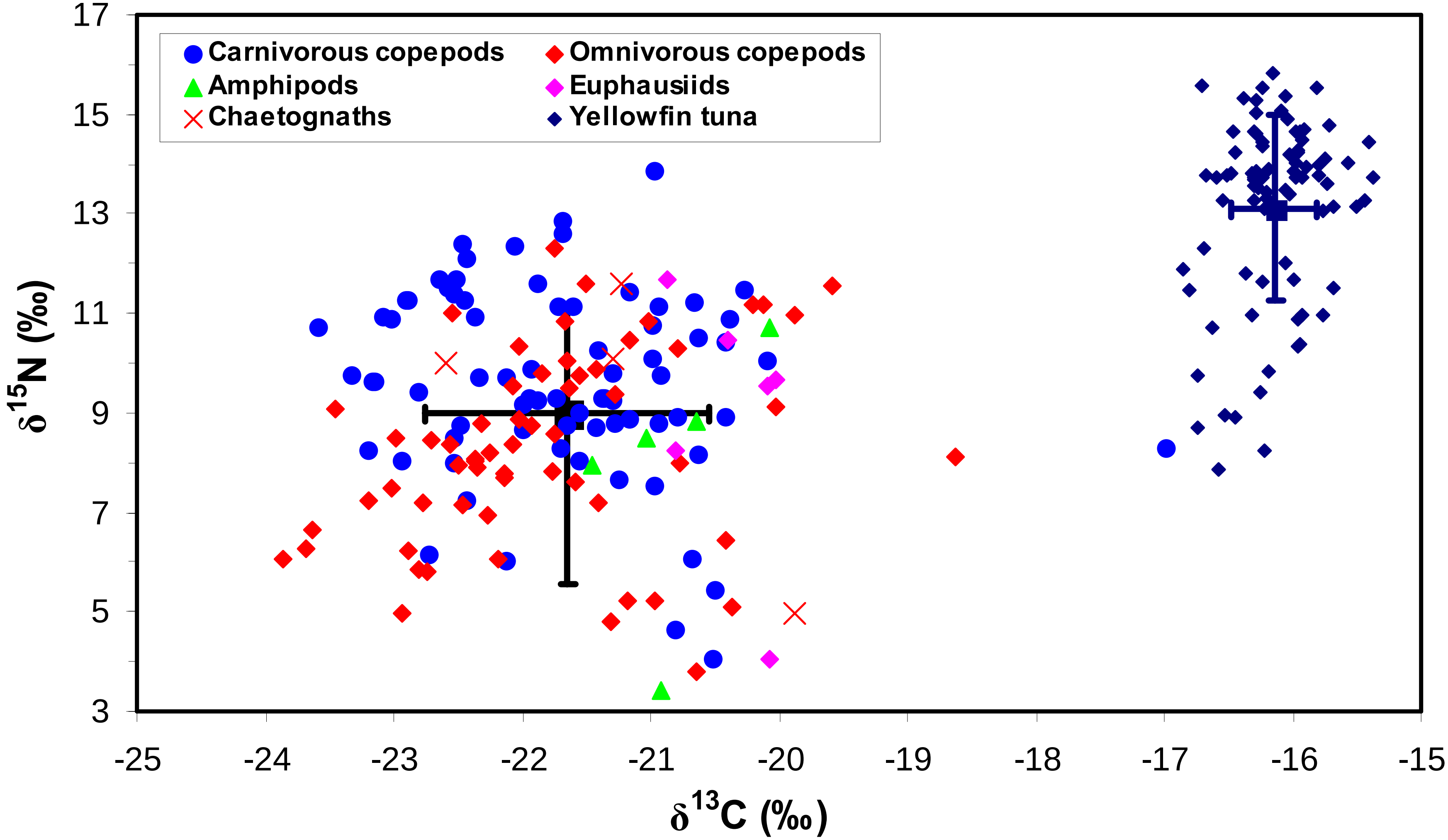
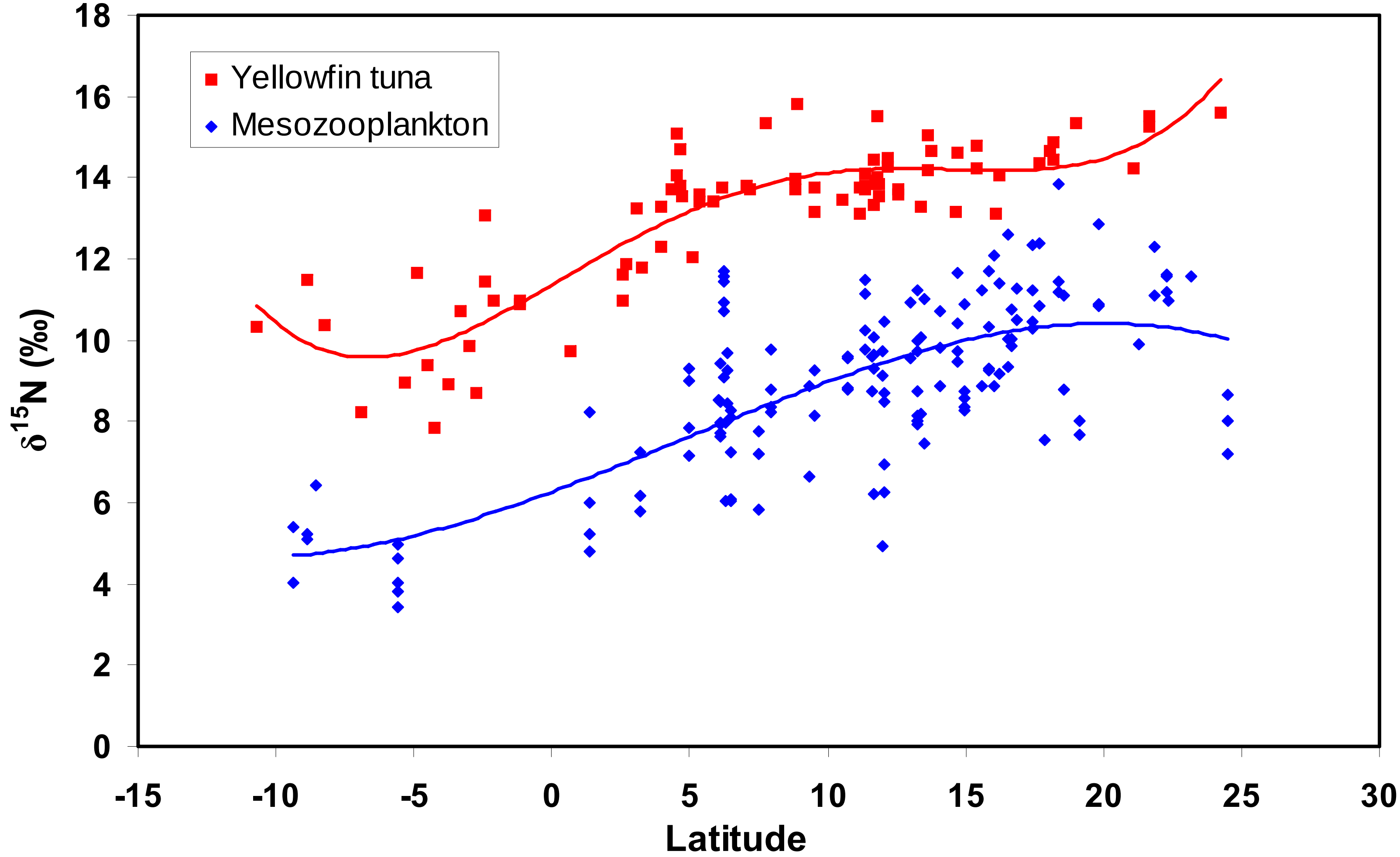
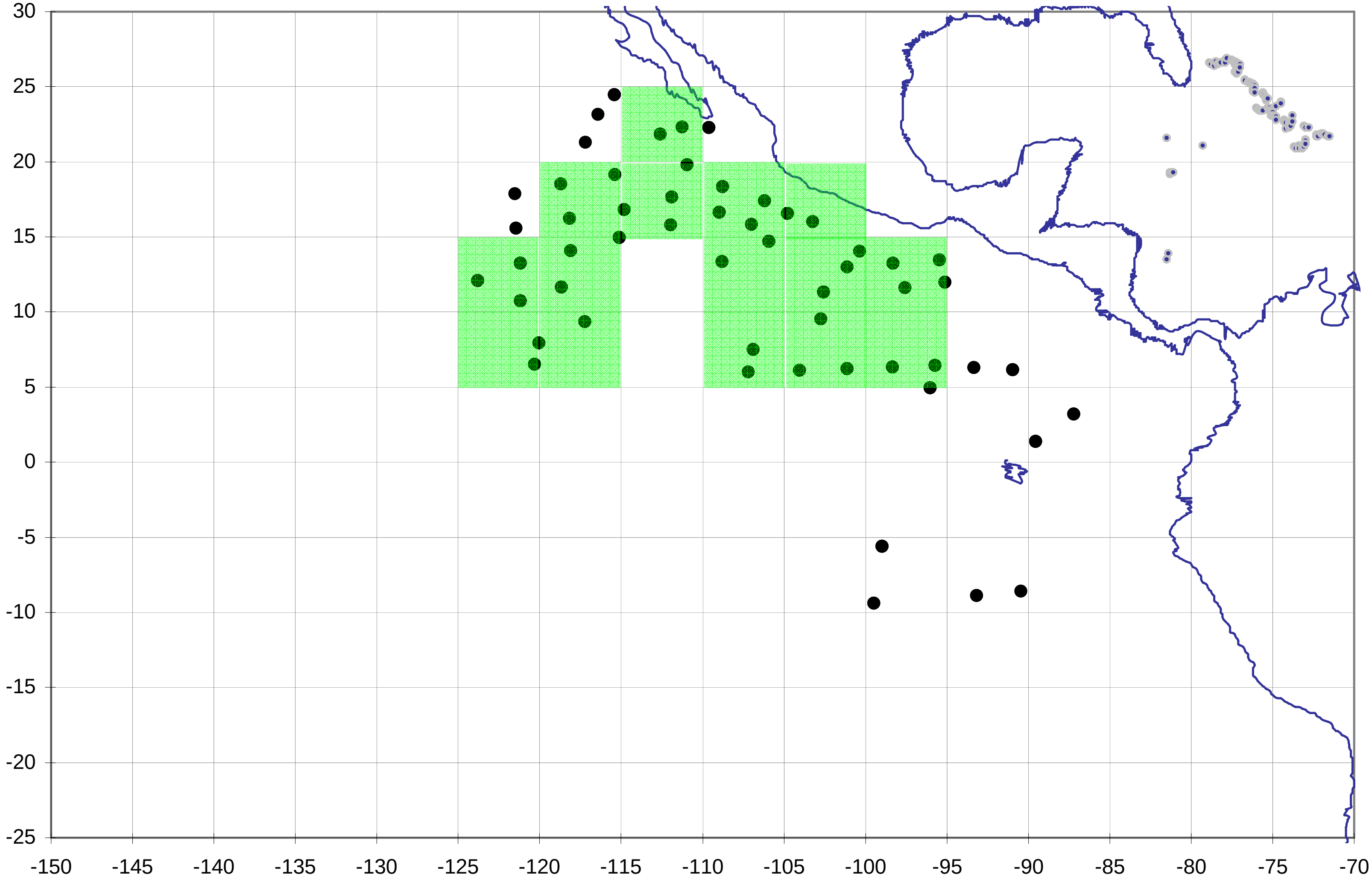
Mesozooplankton and Yellowfin Tuna



Mesozooplankton and Yellowfin Tuna



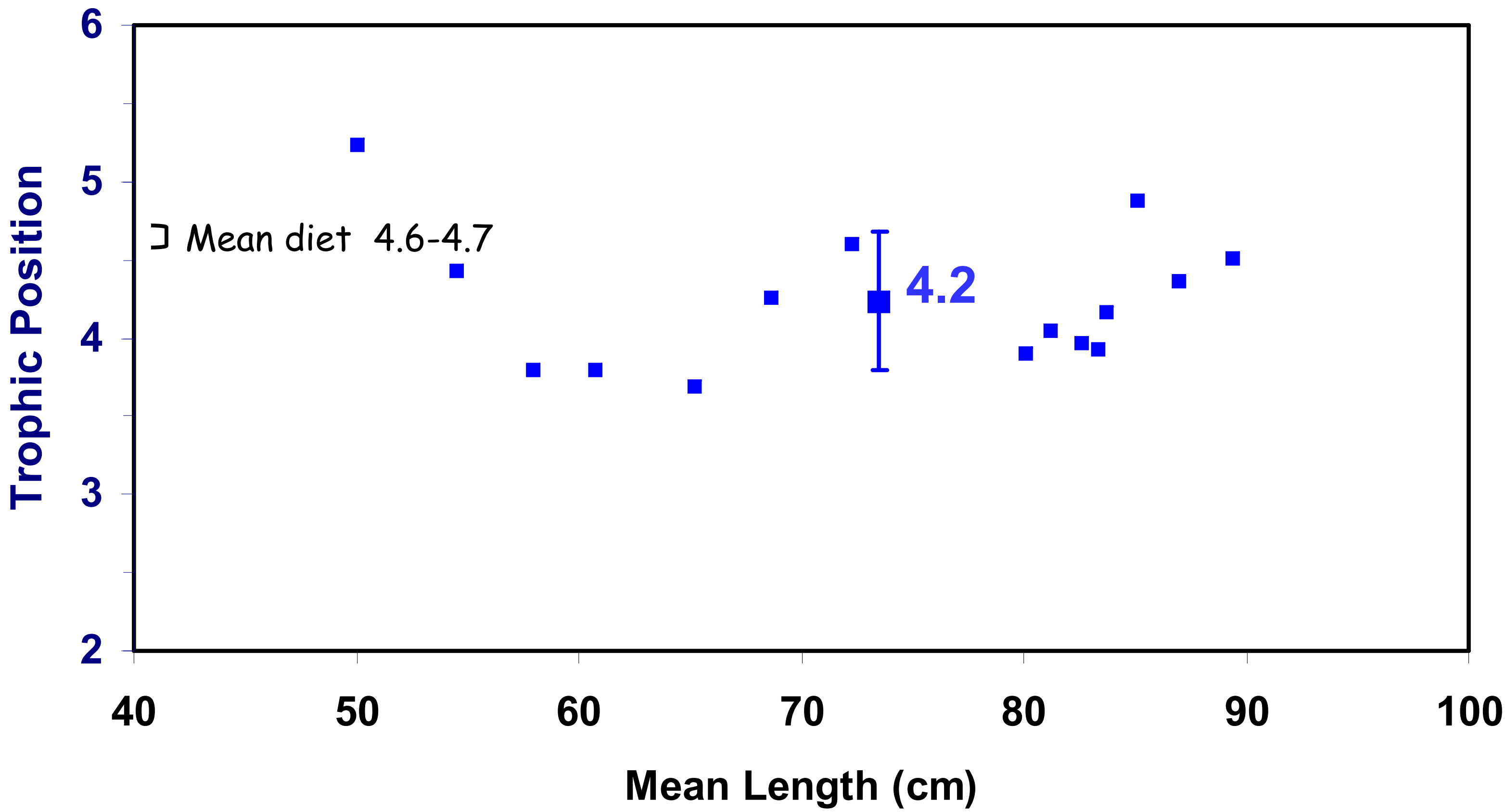
5-deg Areas: Isotope Samples of YFT and Mesozoo.



YFT Trophic Position Derived from $\delta^{15}N$ of Mesozooplankton

Assumptions : $TL_{MesoZoo}$ = 2.7 Trophic enrichment = 3.0 ‰ per TL

$$TL_{YFT} = \frac{\delta^{15}N_{YFT} - \delta^{15}N_{MesoZoo}}{3.0} + 2.7$$



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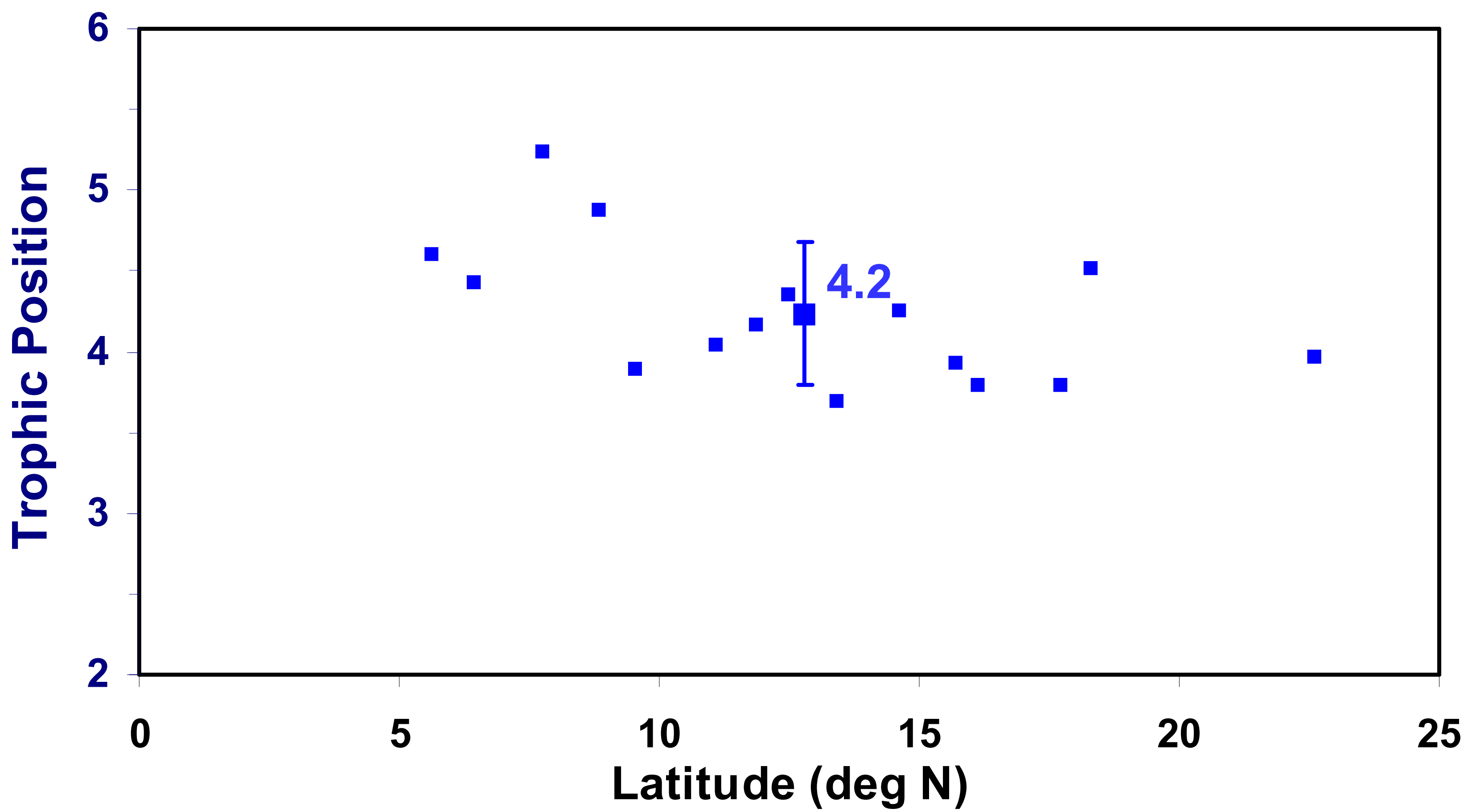
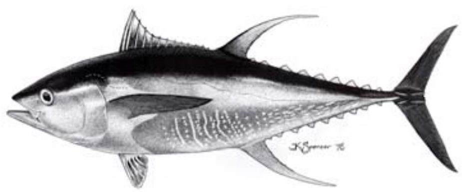


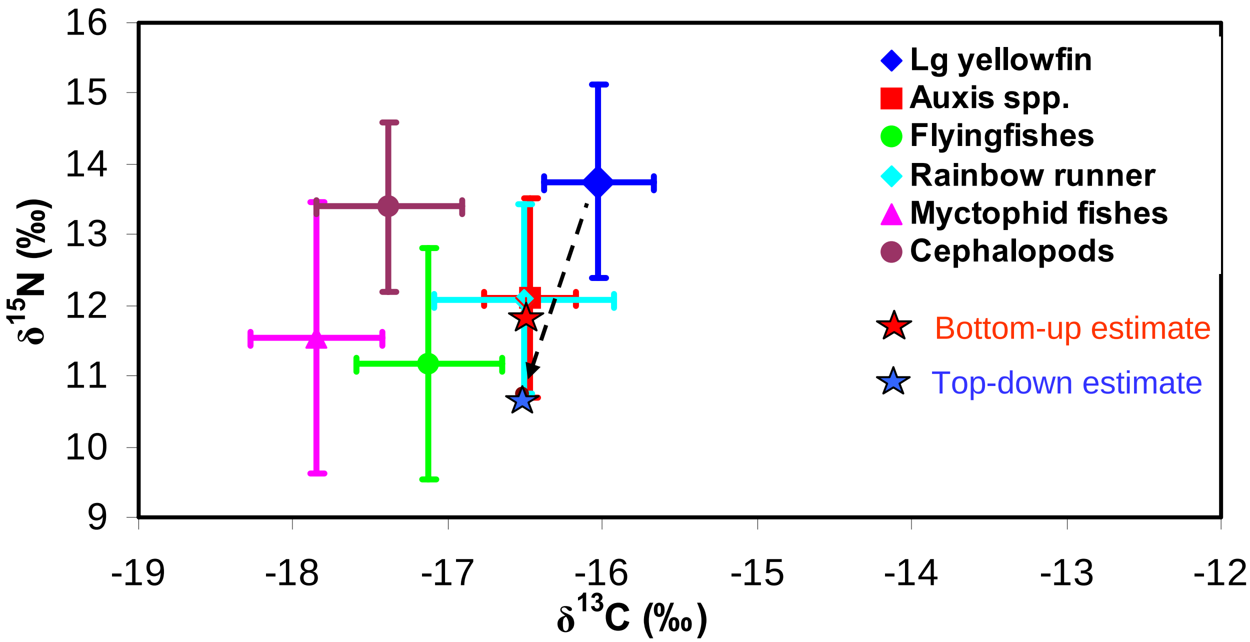


Large yellowfin tuna
(*Thunnus albacares*)
(>=90 cm)

Prey	
Taxon	**Diet % Weight**
Auxis spp.	54
Misc. epipel. fishes	29
Mesopelagic fishes	5
Flyingfishes	5
Cephalopods	4
Misc. piscivores	2
	99%

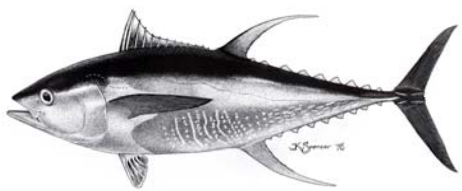
Do diet estimates differ?

Bottom-up *versus* Top-down estimates



★ Bottom-up estimate: Mean diet (calculated from prey isotopes and stomach contents.

★ Top-down estimate: Predicted mean diet (inferred from predator isotopes).



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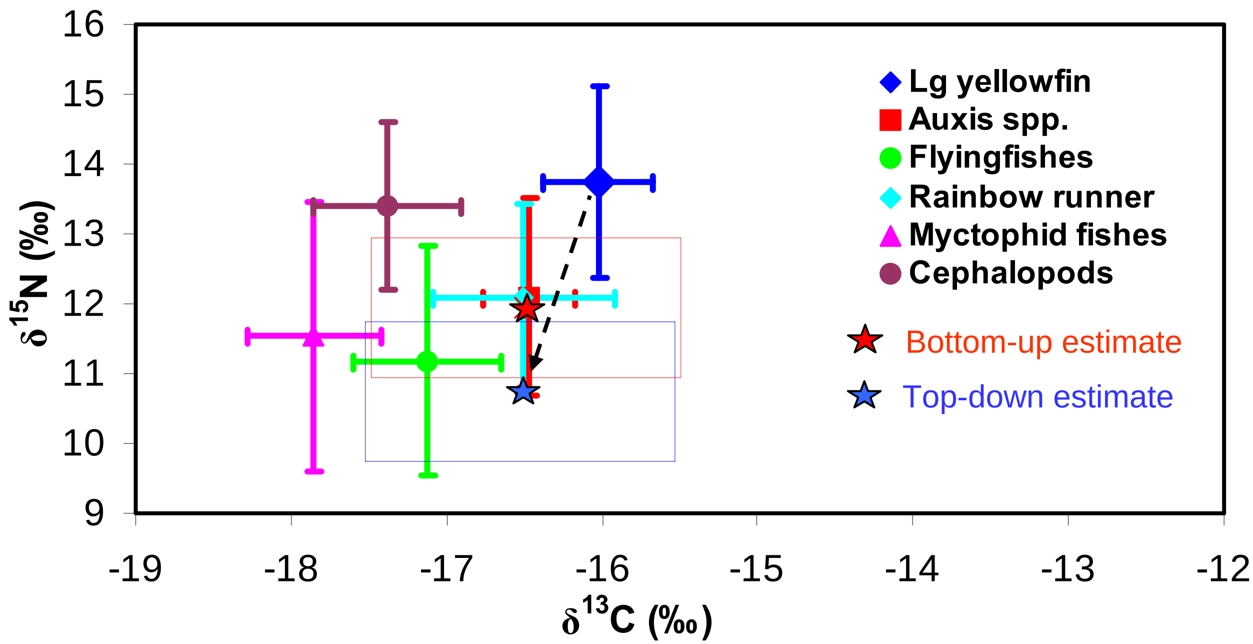
AGREE!



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Conclusions

- We now have the tools to fairly accurately measure trophic position of tunas and other key pelagic predators in nature.
- Build better trophic-based models
- With the ability to assign trophic status, it becomes feasible to consider how trophic structure may have changed over time using archived samples of predator tissues.