A stable isotope trophic assessment of upper trophic level nekton in the Northern California Current Ecosystem

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Application of stable isotopes

- C and N isotopes are used to estimate:
  - Relative trophic position ($\delta^{15}N$) increase approx. 3.4‰ with 1 Trophic Level
  - Source production (Carbon $\delta^{13}C$) – where your food comes from
- We use RELATIVE VALUES

Isotope analysis of hair

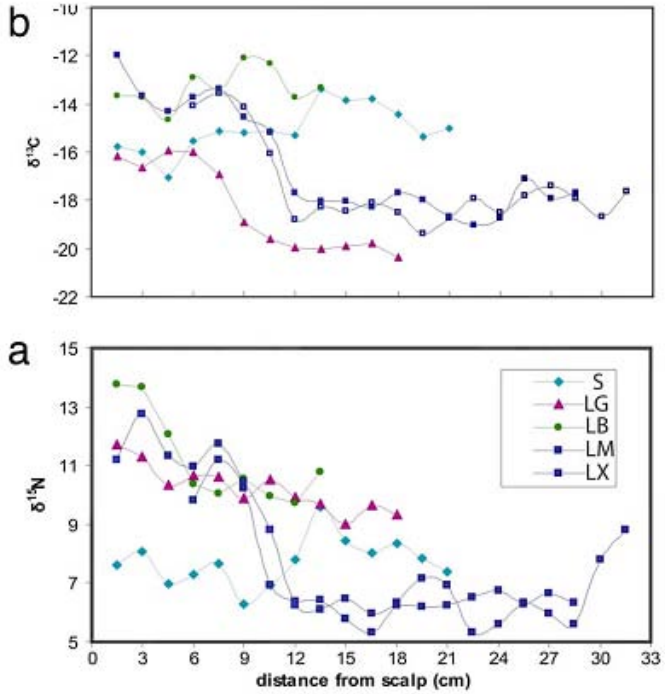

Fig. 1. Serial isotopic data from scalp hair taken from each child. S, Sara Sara Sarita; LG, Llullaillaco Lightning Girl; LB, Llullaillaco Boy; LM, Llullaillaco Maiden; LX, cut hair found with the Llullaillaco Maiden. (*a*) δ-$^{15}N_{AIR}$. (*b*) δ-$^{13}C_{V\text{-}PDB}$. (*c*) δ-$^{2}H_{V\text{-}SMOW}$. (*d*) δ-$^{18}O_{V\text{-}SMOW}$. (*e*) δ-$^{34}S_{V\text{-}CDT}$.

Stable isotope and DNA evidence for ritual sequences in Inca child sacrifice

Andrew S. Wilson[a,b], Timothy Taylor[a], Maria Constanza Ceruti[c], Jose Antonio Chavez[d], Johan Reinhard[e], Vaughan Grimes[a,f], Wolfram Meier-Augenstein[g], Larry Cartmell[h], Ben Stern[a], Michael P. Richards[f], Michael Worobey[j], Ian Barnes[j], and M. Thomas P. Gilbert[i,k]

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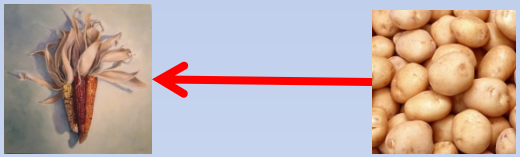
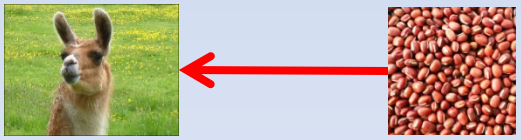
$\delta^{13}C$ - shift from potato
To corn diet



$\delta^{15}N$ - shift from plant
protein to llama



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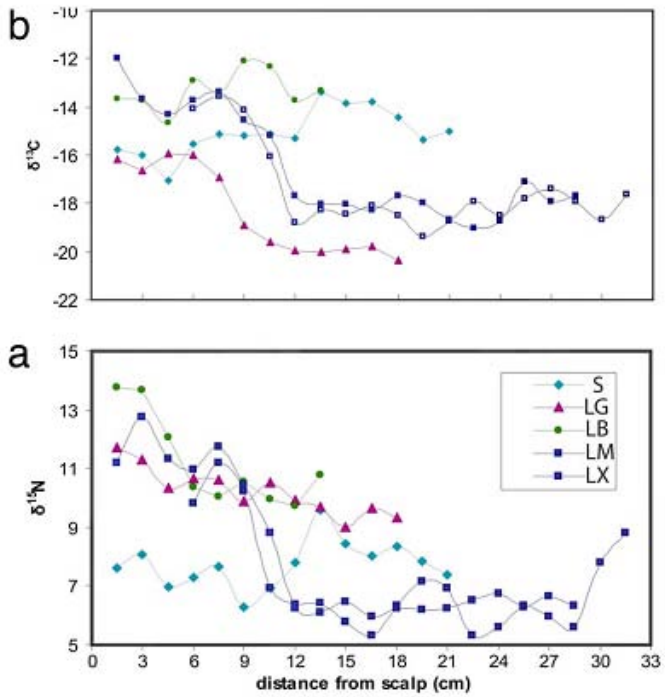

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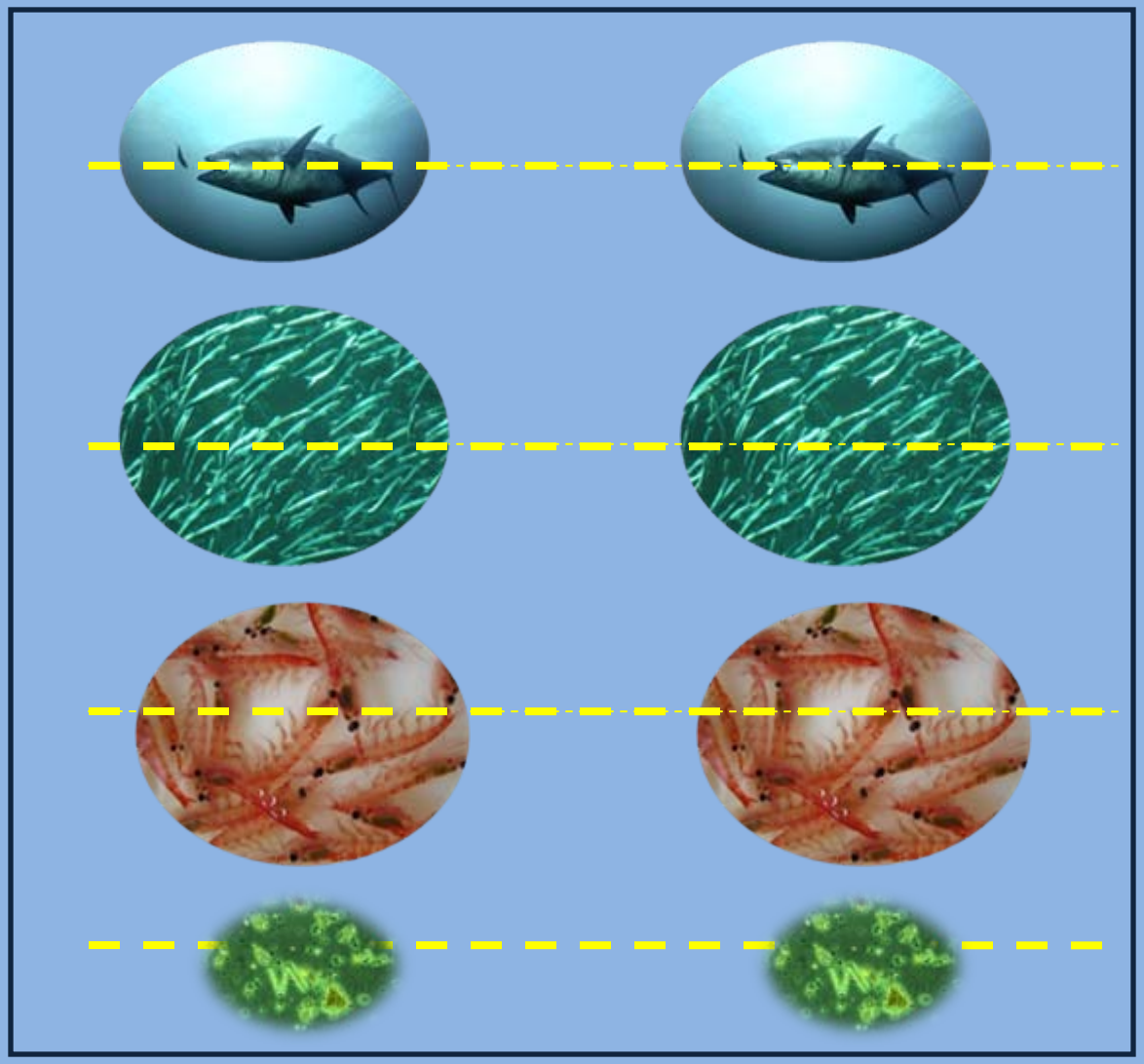
Plot of nitrogen stable isotopes used to delineate trophic level (nitrogen) and source production (carbon)



$\delta^{15}N$ (‰)

Offshore

$\delta^{13}C$ (‰)

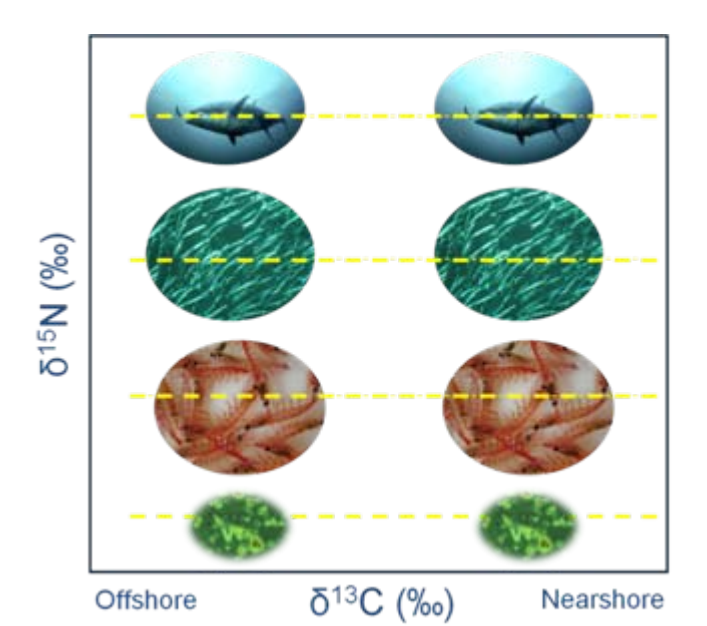
Nearshore

$\delta^{15}N$ changes approx 3.4 ‰ per trophic level and is therefore a measure of relative trophic position

1 trophic level = ~3.4 ‰

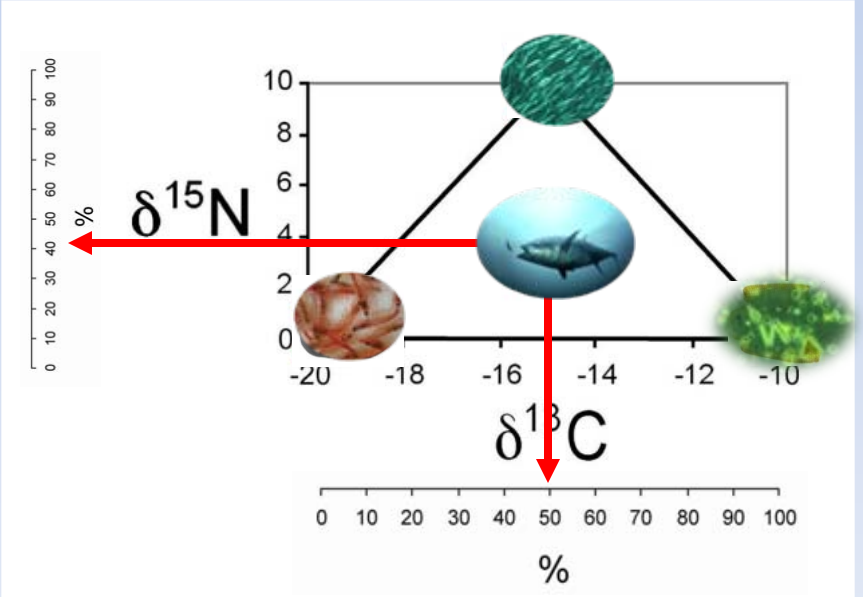
Stable isotope mixing models

- Mixing models are based on proportions contributing to a mixture
- For carbon and nitrogen the ‘isotope space’ is used at the source field to a predator ‘mixture’



Isotope mixing models

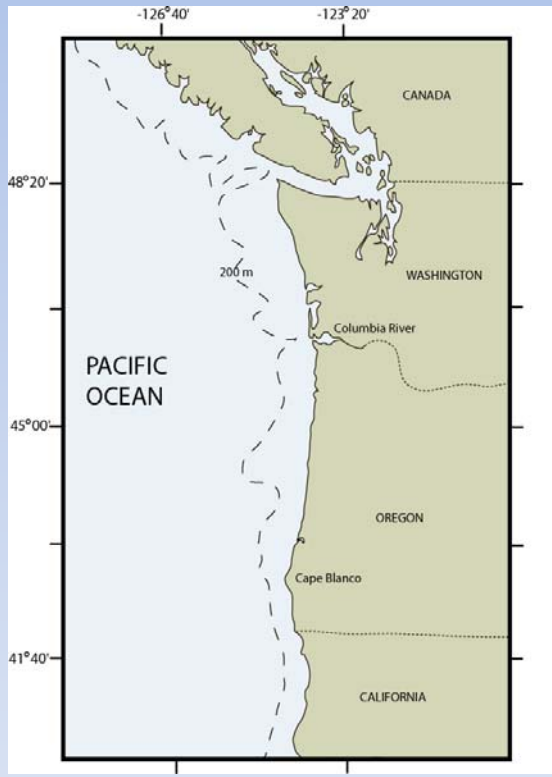
- General mixing models
- Bayesian models (Moore & Semmens 2008)



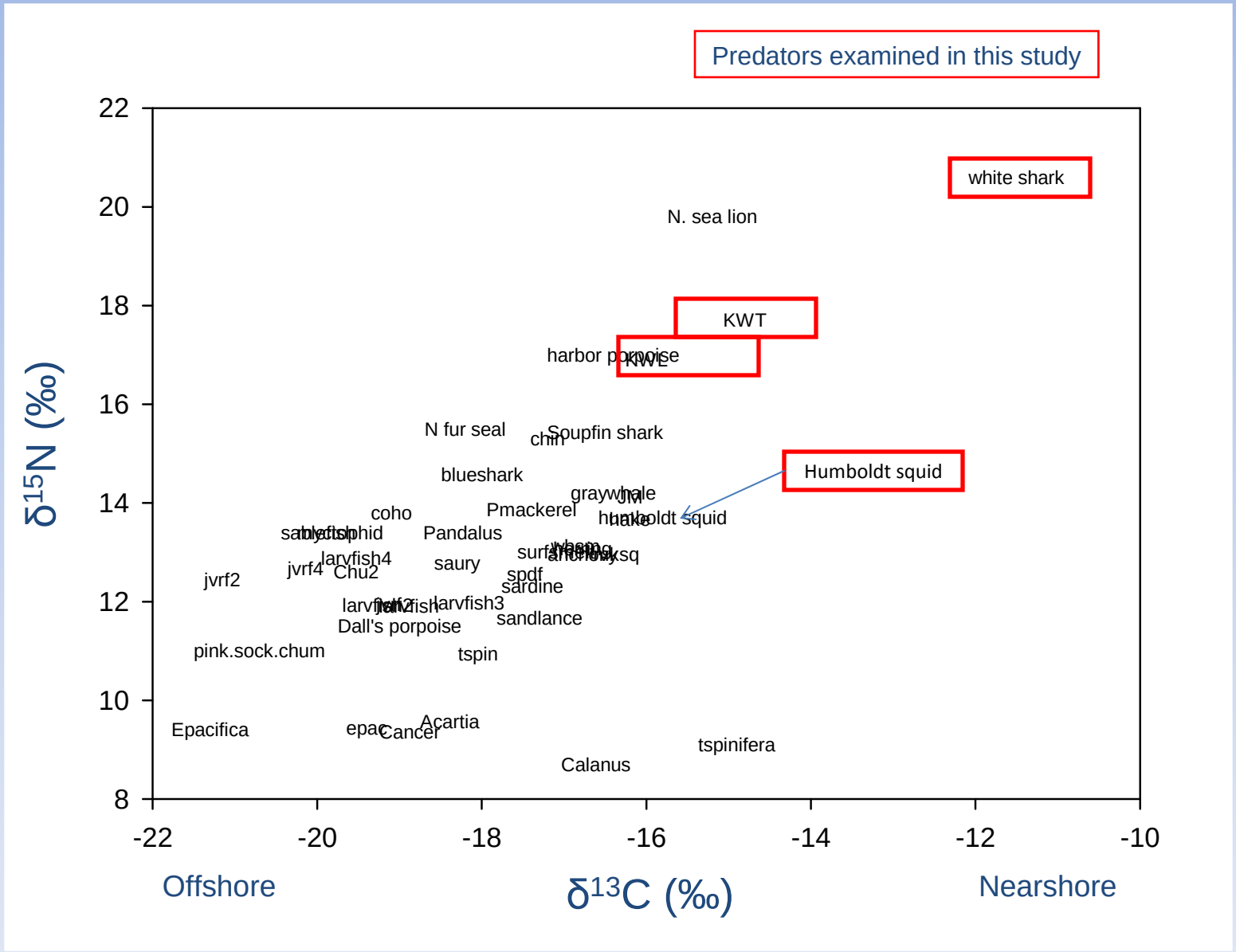
Modified from Fry (2006)

Overview and Methods – in this study we…

- Stable isotopes ~40 species (~30 we analyzed and 10 from literature)
- Examined the relative contribution of prey to several predators of interest:
  - Great white shark (collected off Oregon last year)
  - Killer whales (transient and resident) (Herman et al. (2005)
  - Humboldt squid (60 samples)
- Use of Bayesian model MIXSIR (Moore & Semmens 2008)
- We explore the reason for the food web structure observed through a comparative analyses



Untangling the Northern California food web – too many species for the mixing model!



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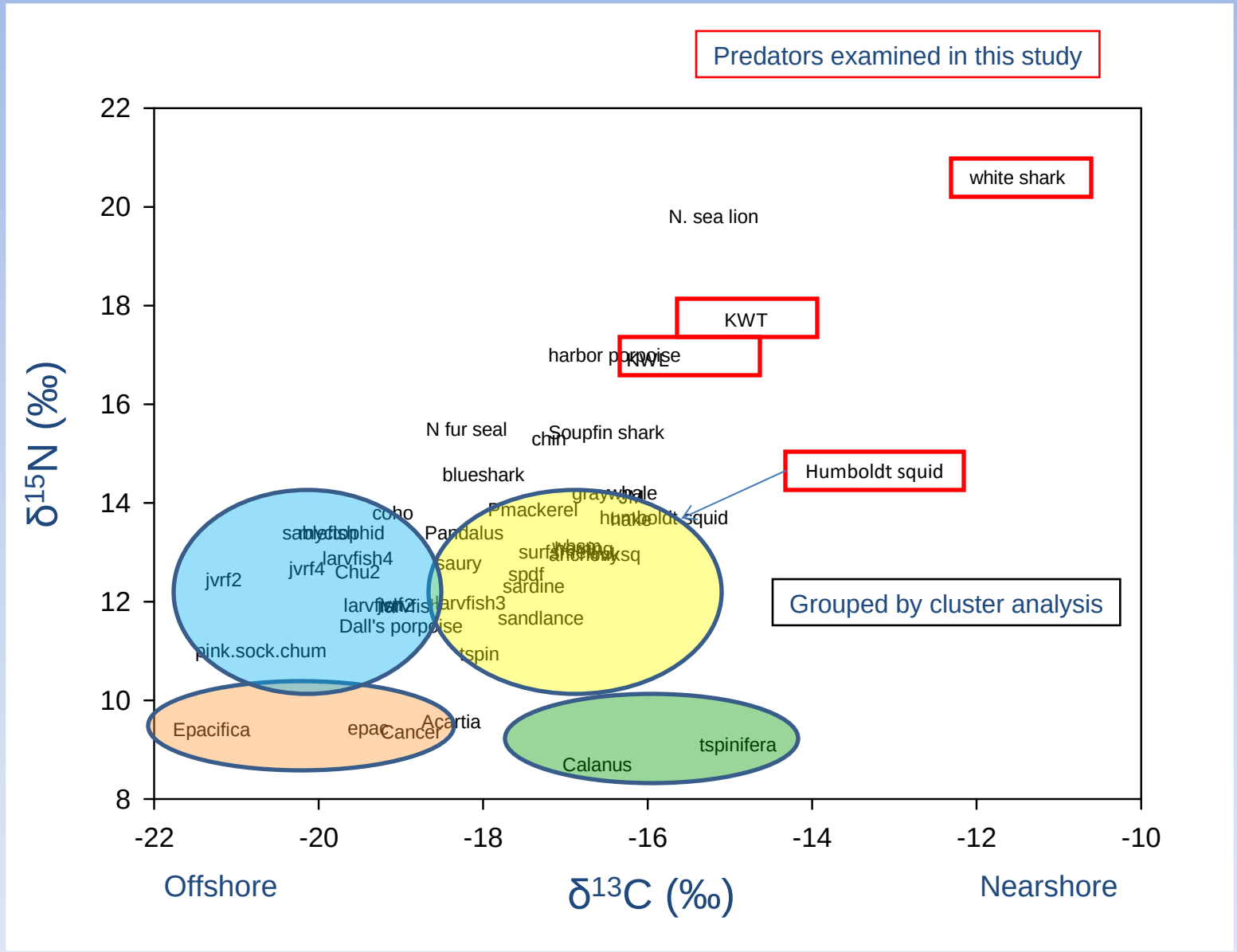
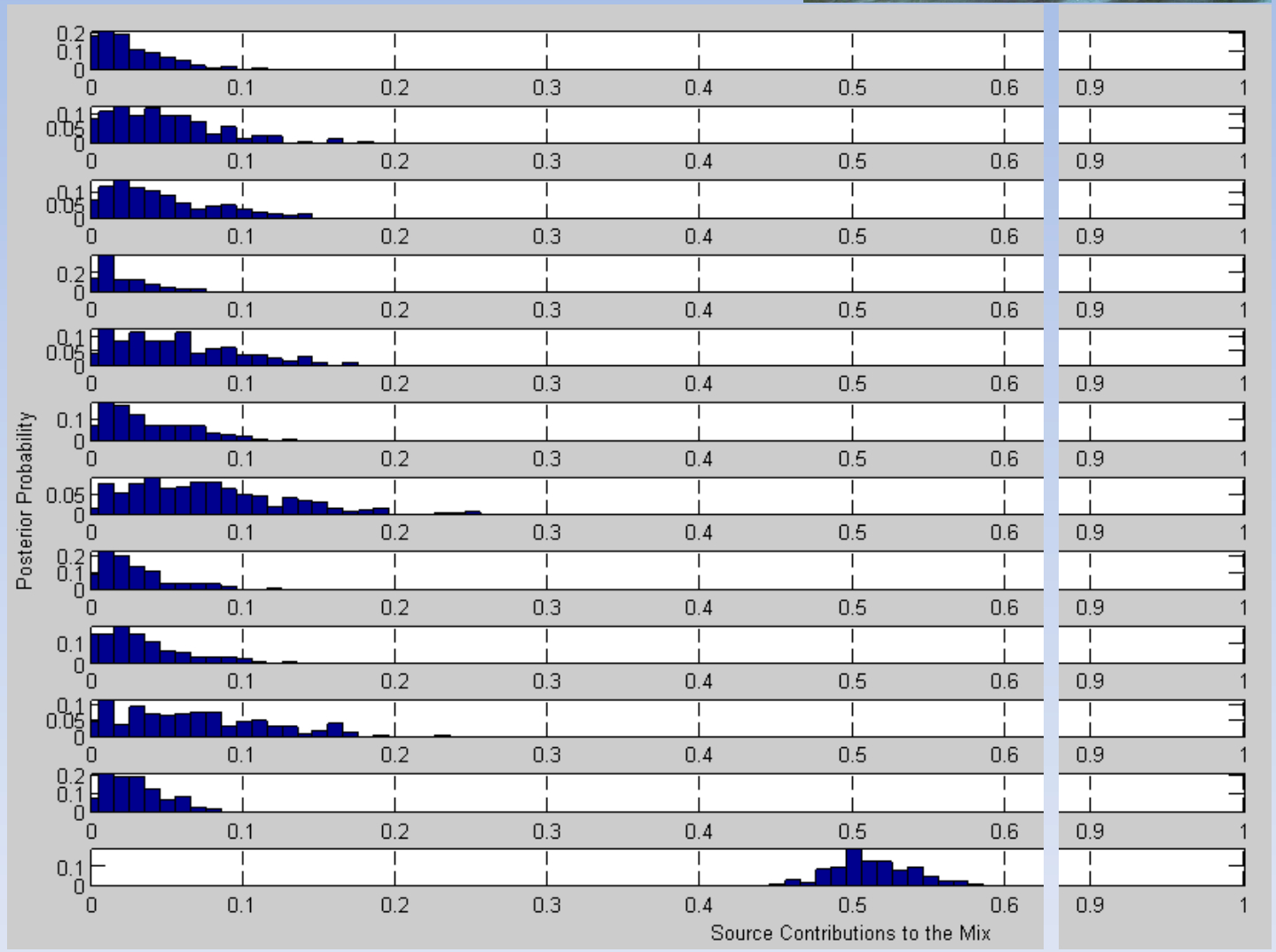


Mixing model results

Humboldt squid, *Dosidicus gigas*



Great white shark, *Carcharodon carcharias*

Grey whale

Killer whale

Harbor porpoise

Dall's porpoise

N. Fur seal

N. Sea lion

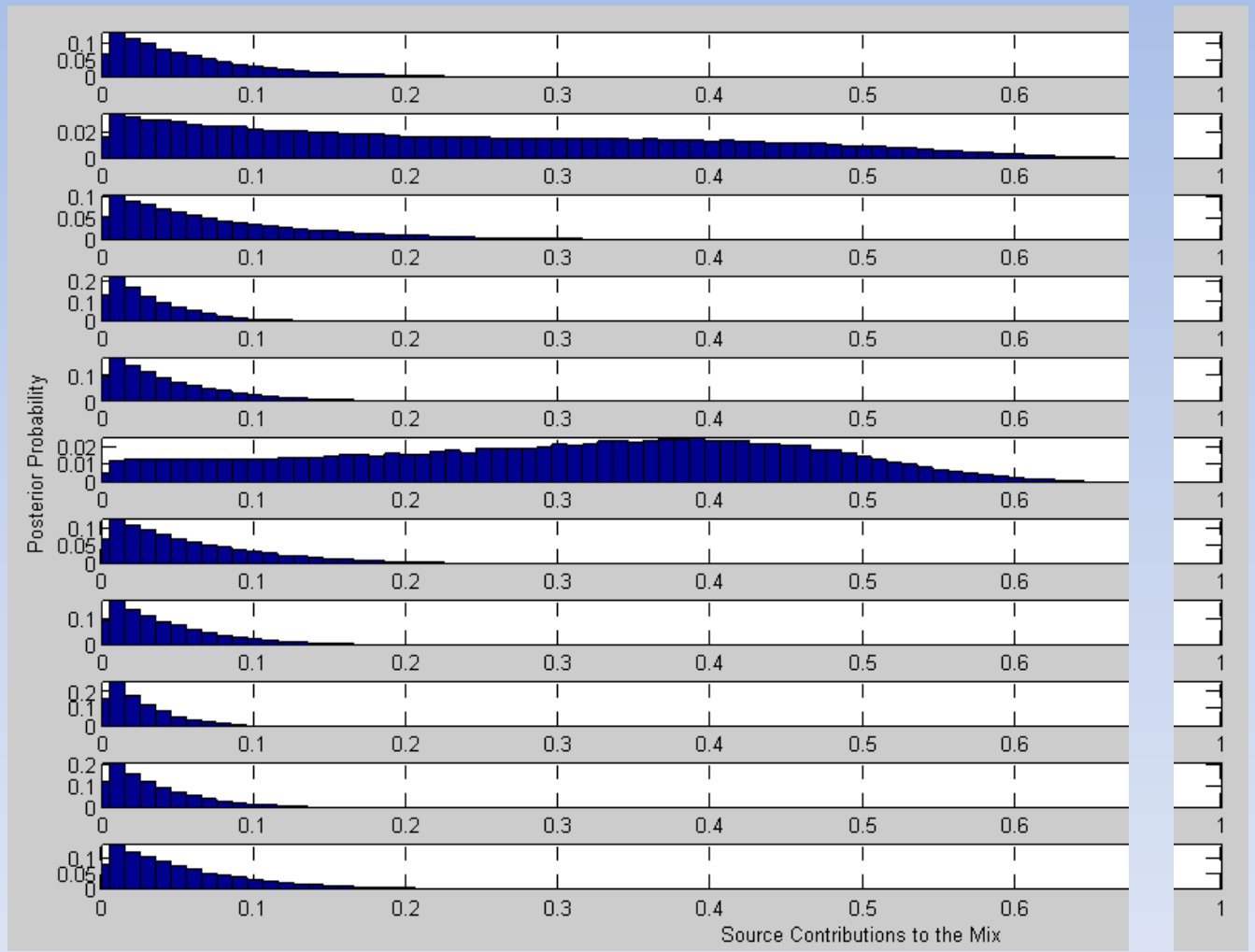
Blue shark

N. Sea lion

Pink, chum, sock salmon

Coho salmon

Chinook salmon



Surfer ?

Killer whale

(Data from Herman et al. 2005)

Transient

Pacific sardine, sand lance

Mkt squid, smelt, herring,anchovy

Hake, P. mackerel

Jack mackerel

Larval fish, juv rockfish

P. saury

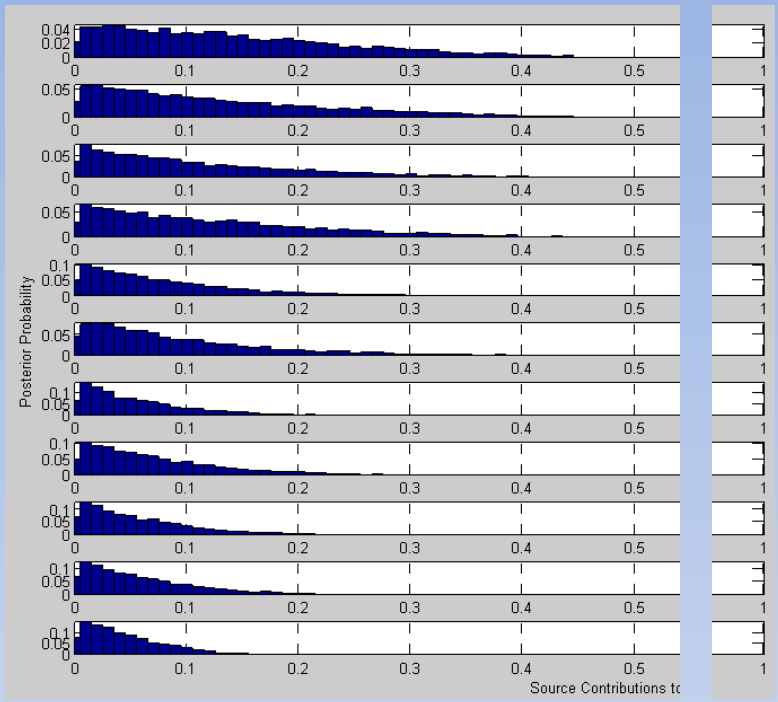
Juv sablefish

Blue shark

N. Fur seal

Harbor porpoise

N. Sea lion



Resident

Pacific sardine, sand lance

Mkt squid, smelt, herring,anchovy

Hake, P. mackerel

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Larval fish, juv rockfish

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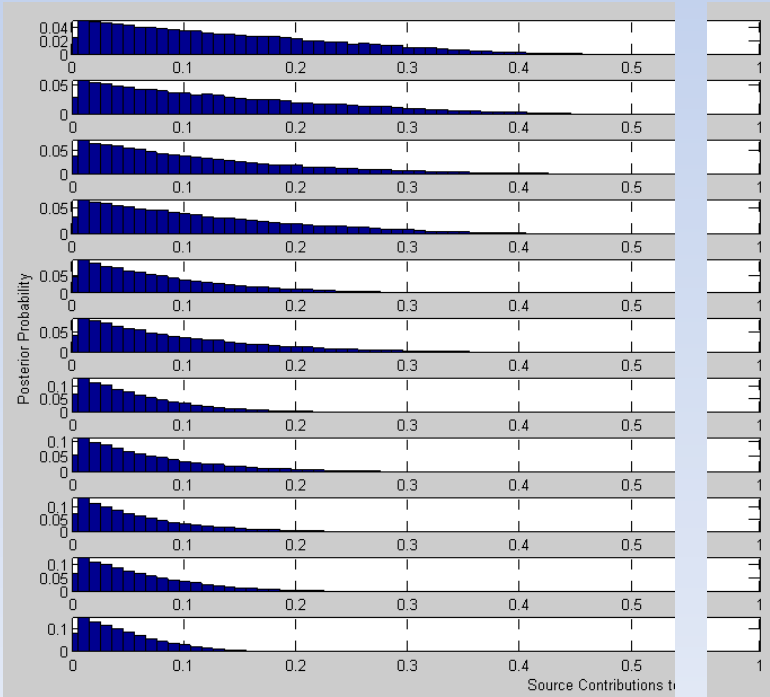
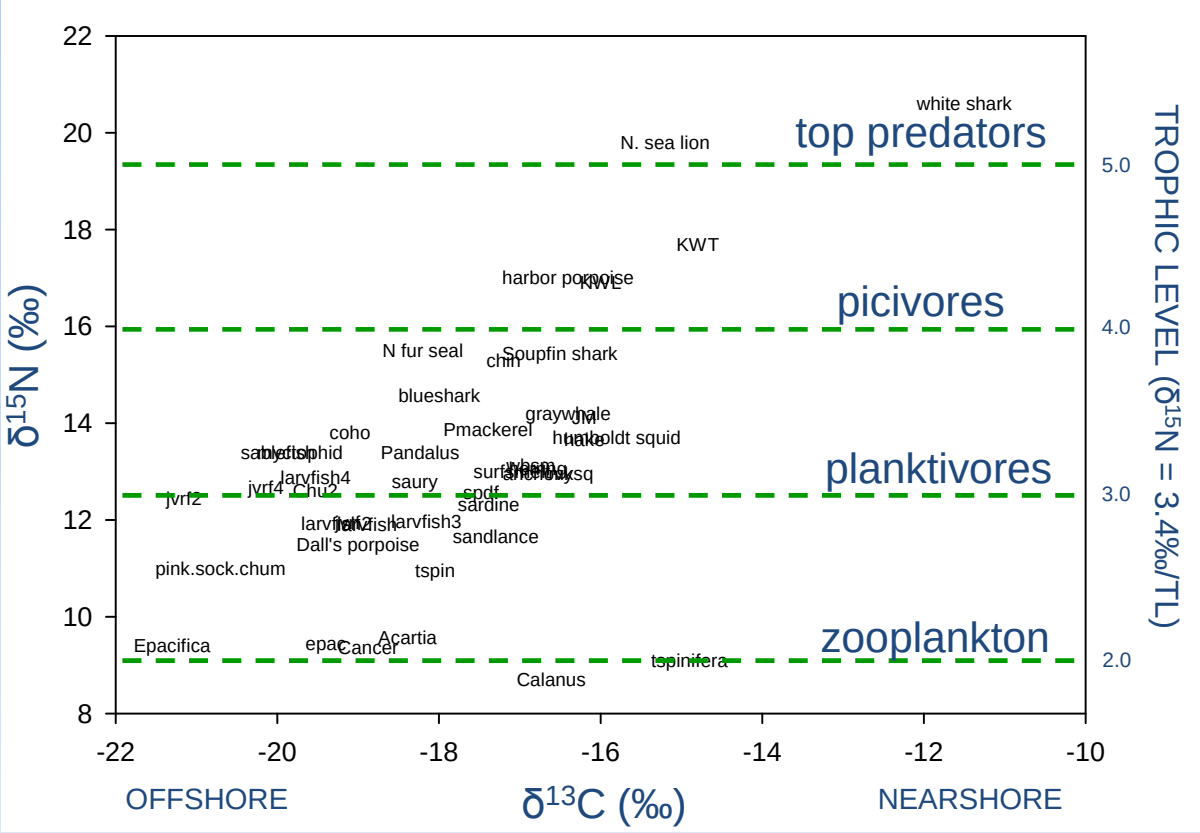


Untangling the web – from small to big scale

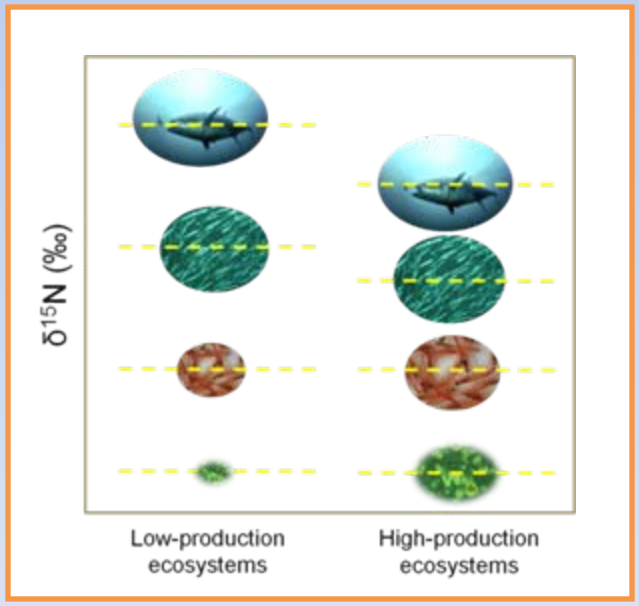
- The Northern California Current food web appears highly truncated
- This truncated structure may be due to high primary and secondary production

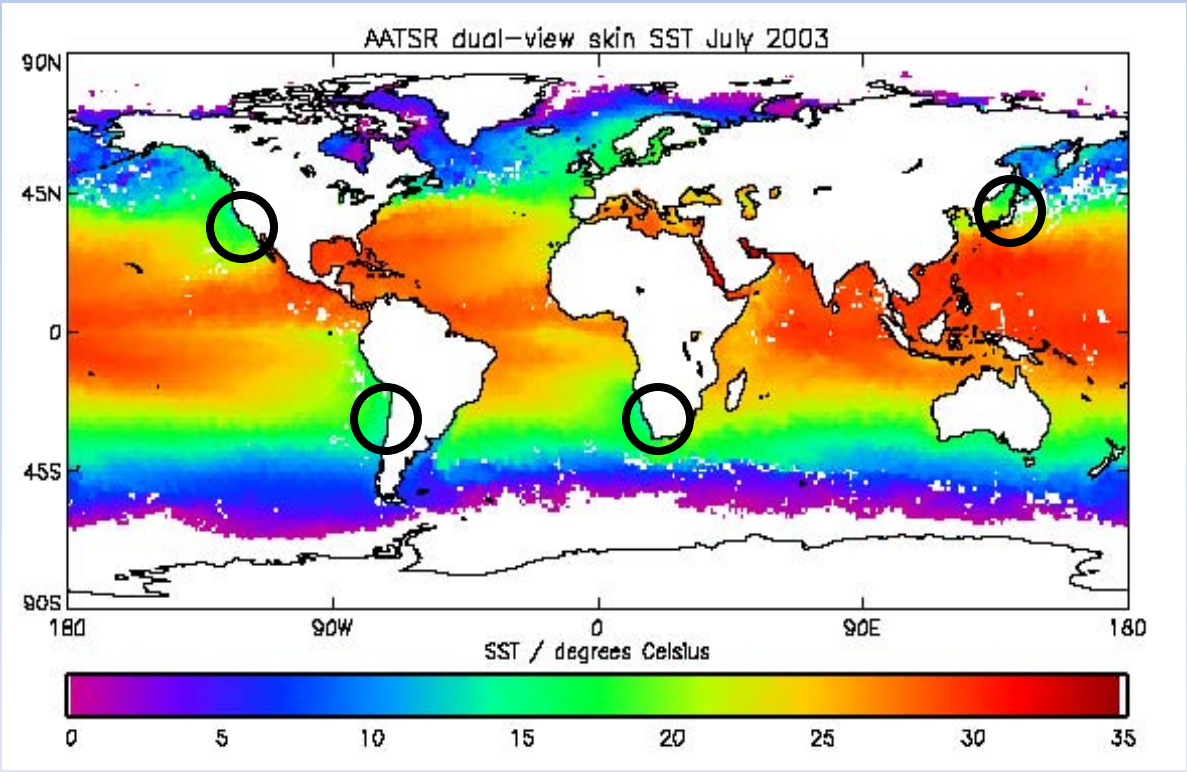
- How can we test this?



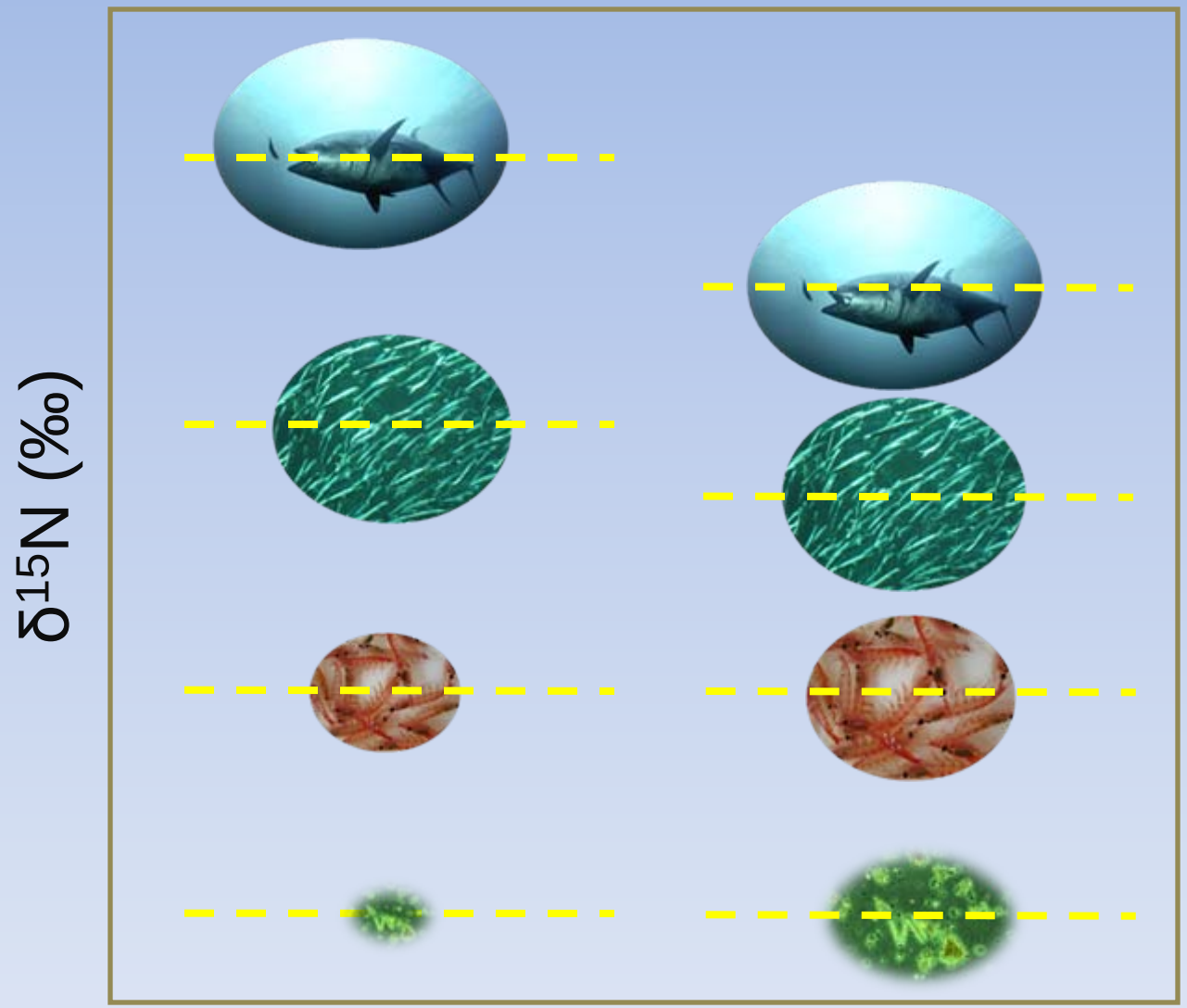
Untangling the web – from small to big scale

- Some fishes are globally distributed and they are also found in regions of relatively high and low production.
- Therefore, we can compare their RELATIVE trophic posistion to test the hypothesis that zooplankton may be shaping food web structure
- The hypothesis is – high P zones would have lower relative trophic level





Hypothesis – lower relative trophic level from high productive ecosystems



Relative trophic levels of sardine and anchovy

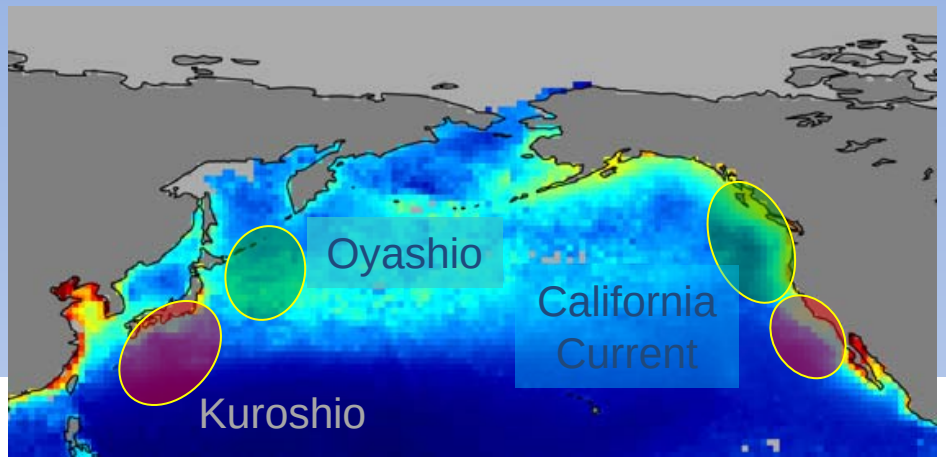
Result-

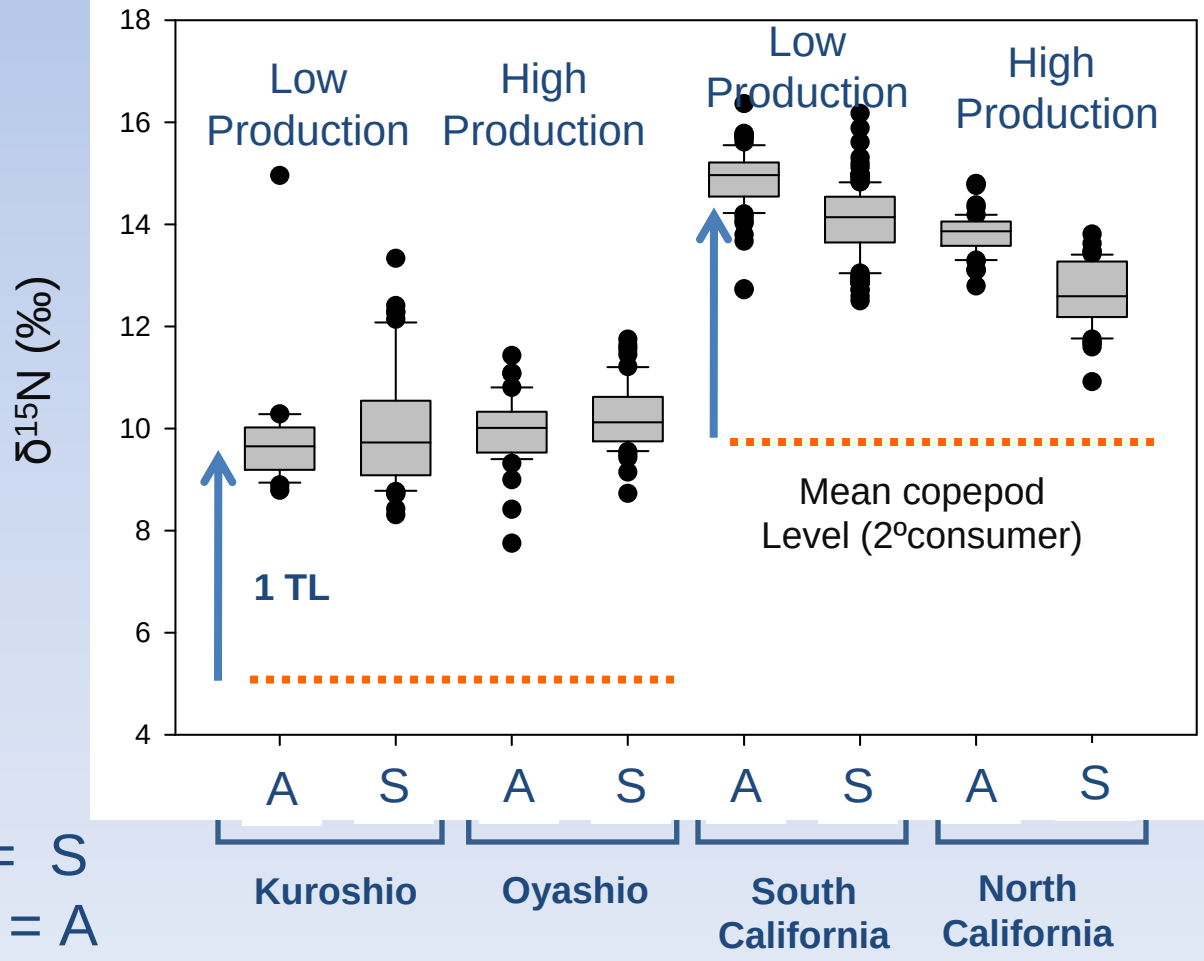
1)Northern California Current
- S and A are lower TL to S. California Current
- S lower than A

2)Kuroshio – S and A same

3)Oyashio – S and A same

4)Kuroshio vs Oyashio – S and A are higher from Oyashio



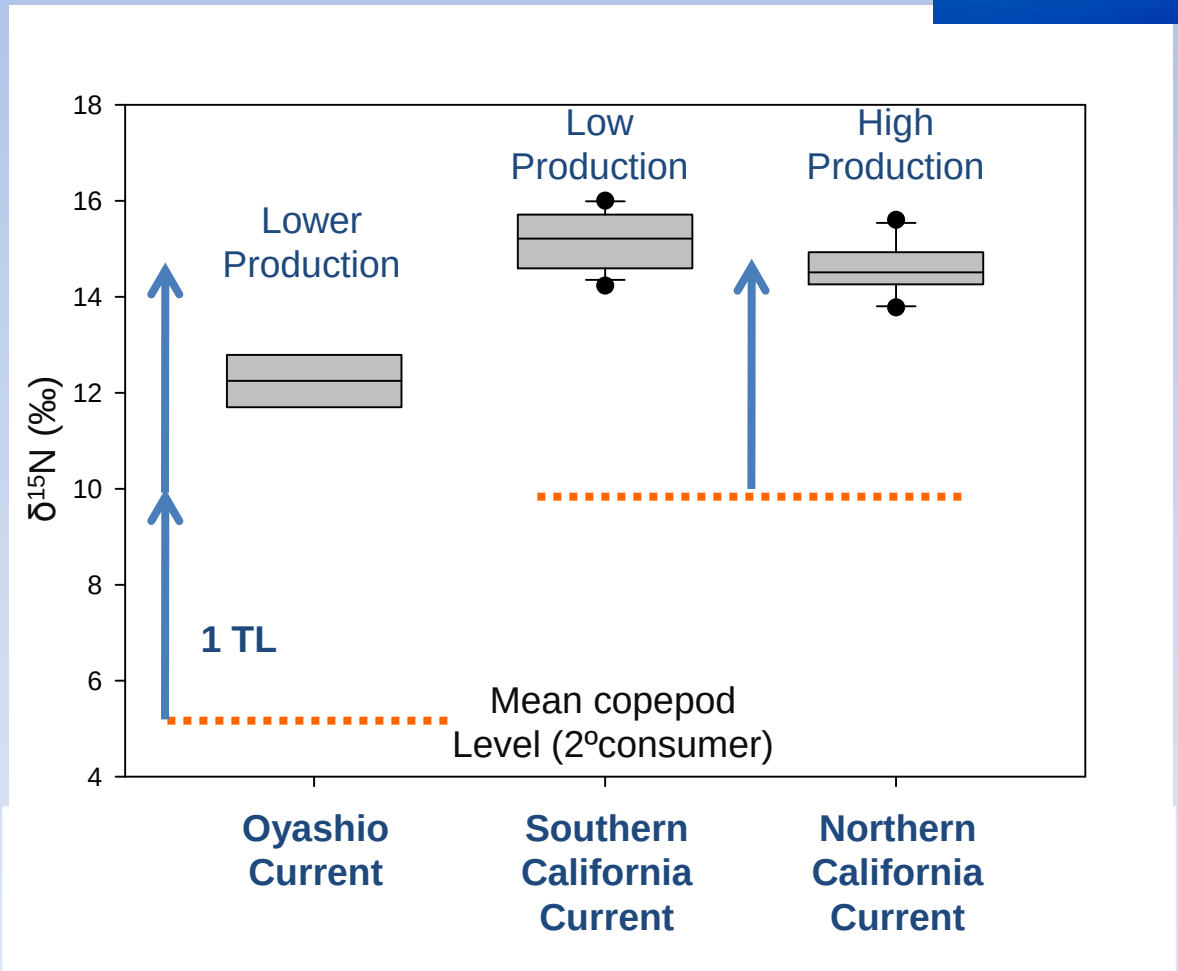


sardine = S

anchovy = A

Blue shark, *Prionace glauca*

Result – Blue shark feeds higher in the food web from regions of low production

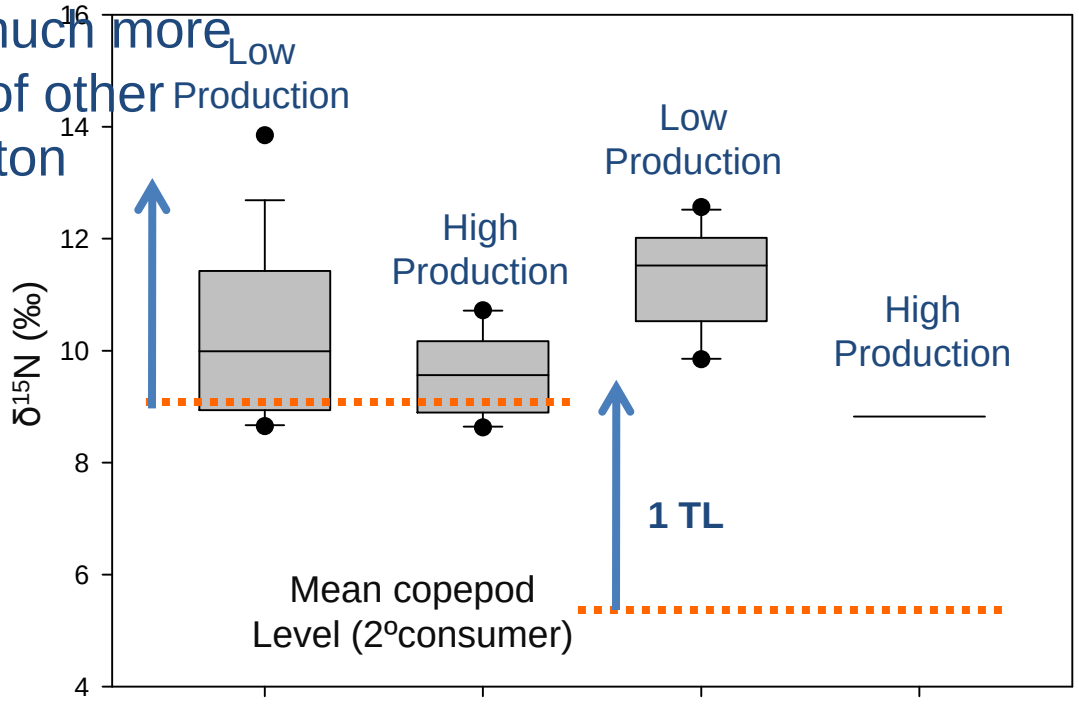


Euphausia pacifica – collected from 4 systems

Result –

East Pacific Euphausiids are almost true phytoplanktivores

West Pacific – much more consumption of other zooplankton



Major Pacific Boundary Currents

Conclusions and future research

1) **Top predators in the northern California Current ecosystem show diversity in their feeding (not suprising)**
   - **Specifically, Humboldt Squid appears to feed relatively low on the food web**
2) **Application of stable isotopes to ecosystem comparison studies show clear trophic differences**
   - **Fish showed a propensity to higher TL in lower production areas**
   - **Euphausiids (*E. pacifica*) also showed this trend**
3) **Future research –**
   - **Completed analyses from Chile, Namibia, and S. Africa**
   - **Working on connection with MODUS AQUA data to link global trends in food web characteristics to ecosystem physical/biological parameters**
   - **Expand trophic comparison on *Euphausia pacifica***
   - **FISHBASE – establish a stable isotope-based trophic level for ecosystem modelers to use and compare with diet-based trophic levels**