Comisión Interamericana del Atún Tropical
Inter-American Tropical Tuna Commission

Stock and spatial structure of yellowfin tuna in the Pacific Ocean

Carolina Minte-Vera,V., Xu,H., Lennert-Cody, C., Maunder, M.N., Schaefer, K. M., Fuller, D.

2nd Stock assessment Review Workshop, La Jolla, California USA, 2-6 December 2019

Outline

- Key uncertainties
- Background on general aspects of yellowfin tuna distribution and ocean biogeography
- Evidence for spatial structure
- Conclusions

Key uncertainties

Stock structure of main commercially important tuna species in the Pacific Ocean (Moore et al submitted), key uncertainties:

- the location of spawning areas;
- the degree of spawning area fidelity;
- provenance of individuals:
  - the proportional contributions of each self-replenishing population to fishery catches
  - degree of mixing of post-juvenile fish;
- linkages with stocks in adjacent oceans;
- the effects of climate change on stock structure and proportional contributions of self-replenishing population to fisheries;
- the assessment and management implications of changes in current stock assessment model assumptions that might arise from an improved knowledge of tuna stock structure.

Background

- Self-replenishing populations **should be** the basic unit of fisheries management
- In practice, stock structure: groups of fish that **have limited interaction** such that fishing on one group has a limited impact on the dynamics of the other group
- Distribution of YFT is dependent on (review on Pecoraro et al 2018b):
    - Temperature:
        - endothermic but **the temperature of the heart** (located on the ”water” side of the vascular counter-currrent heat Exchange) affects YFT movements
        - **Endothermic capability acquired during juvenile stage**
        - Larvae: yolk-sac and first feeding: **21 to 33 °C**
        - Spend most of their time within **the surface mixed layer or at the top of the thermocline (18-31°C)** where **epipelagic** preys are concentrated
        - **rapid deep dives** (**increases capability** with larger sizes)
    - Prey concentration: High degree of residency where prey densities are high (northern EPO and WCPO – Hawaii and around islands and seamounts)
    - Oxygen concentration

Vertical habitat of YFT

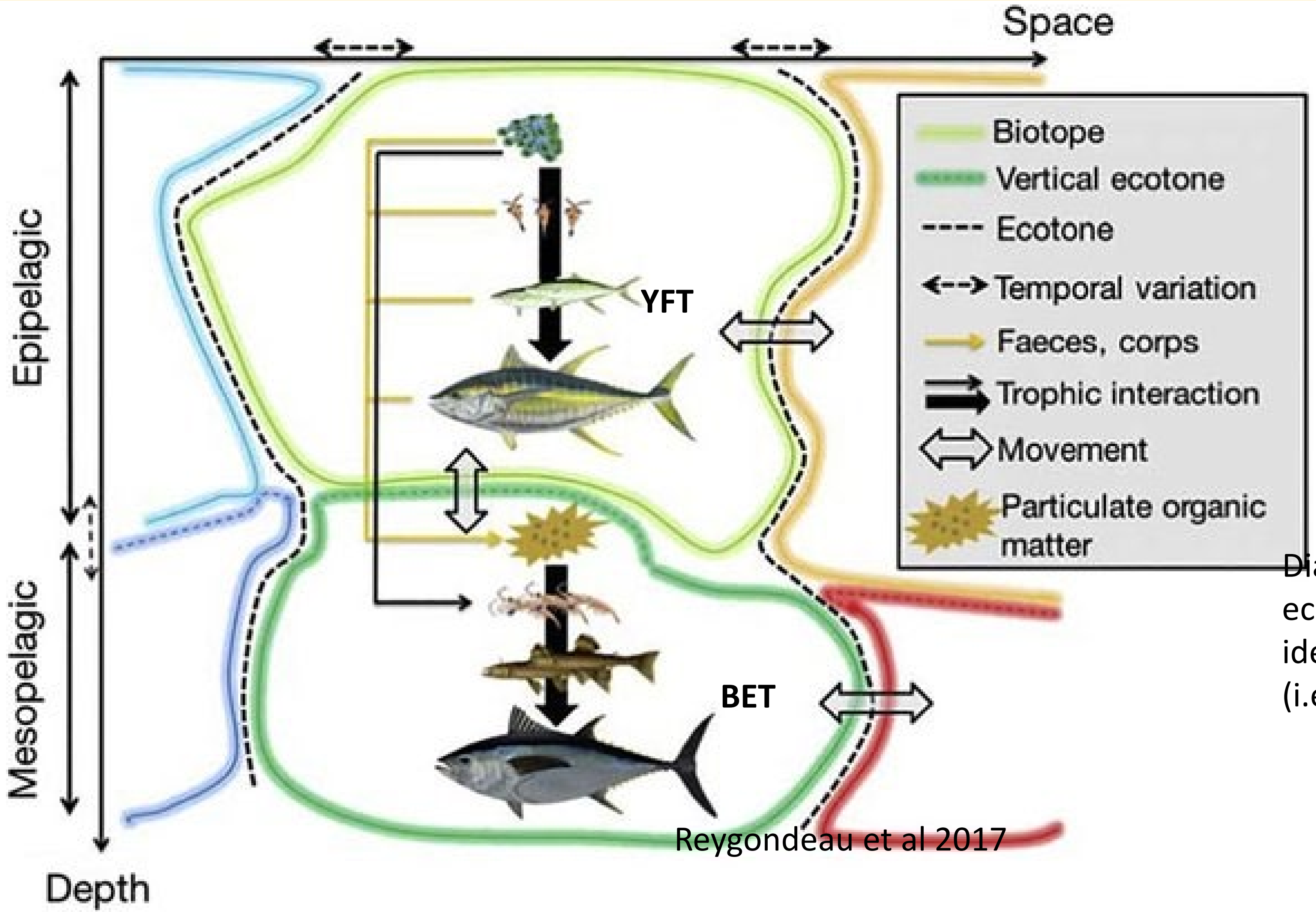


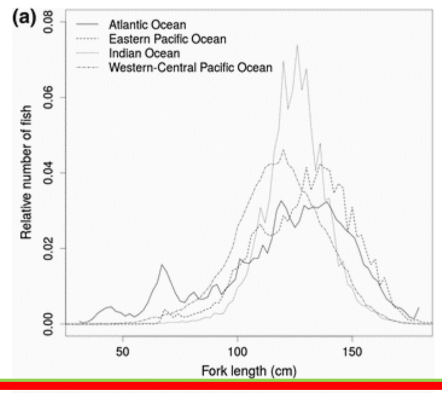
Diagram of conceptualized ecosystem within an identified ecological unit (i.e., BGCP).

Reygondeau et al 2017

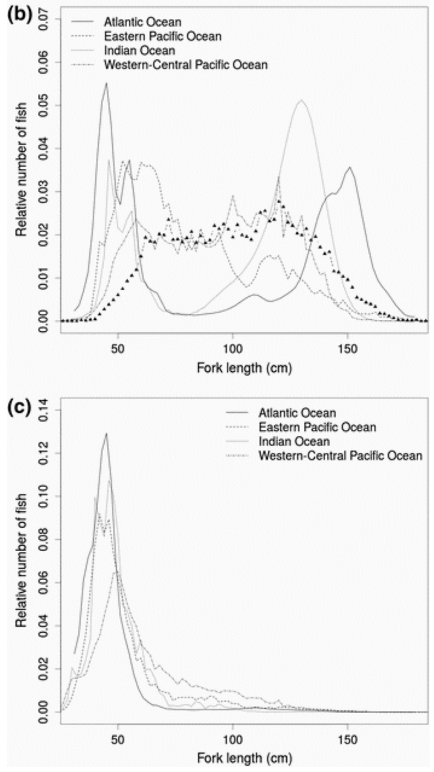
Distribution of catches

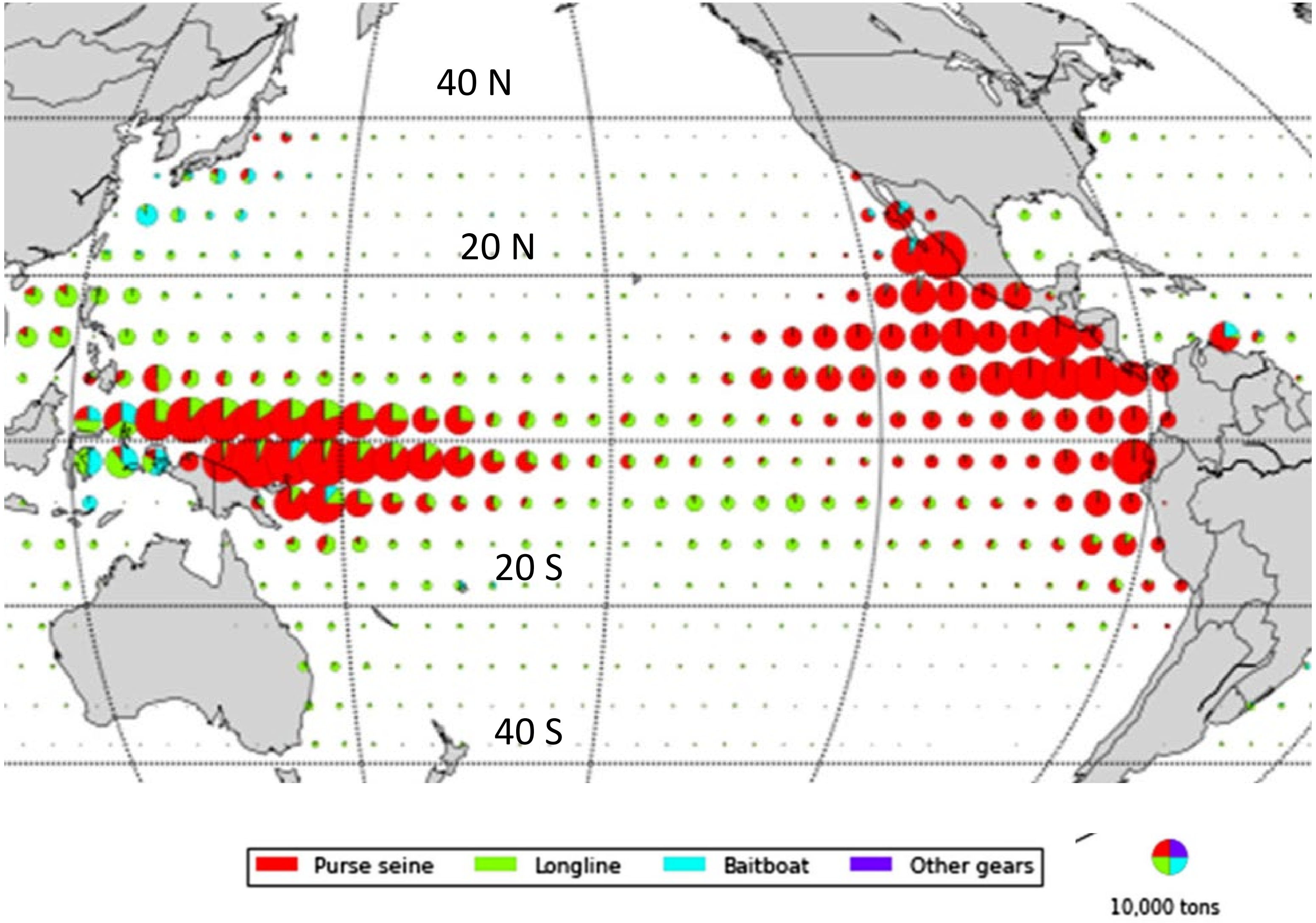
Mean annual distribution of catches **1950-2013**

Longline

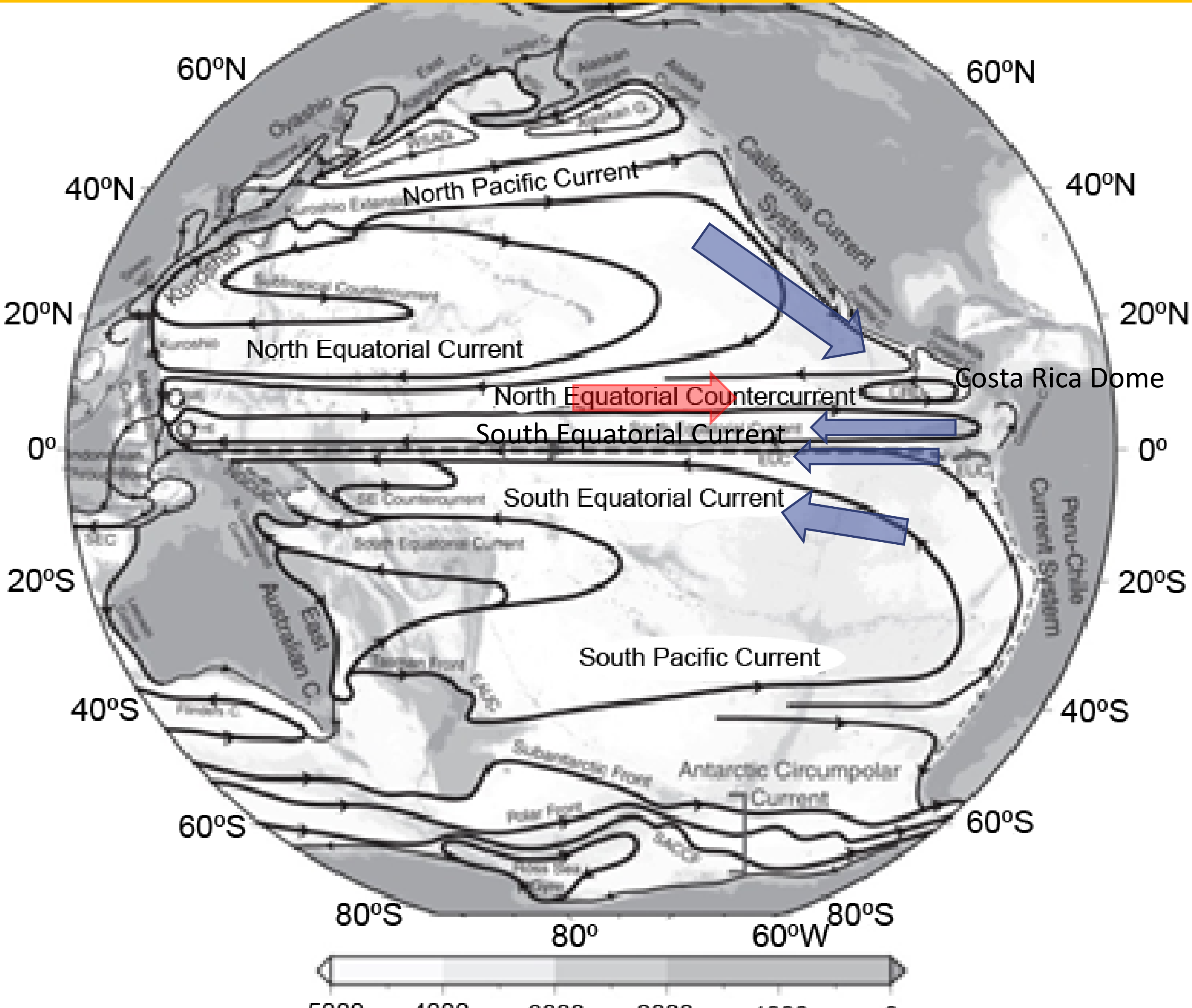


Purse-seine

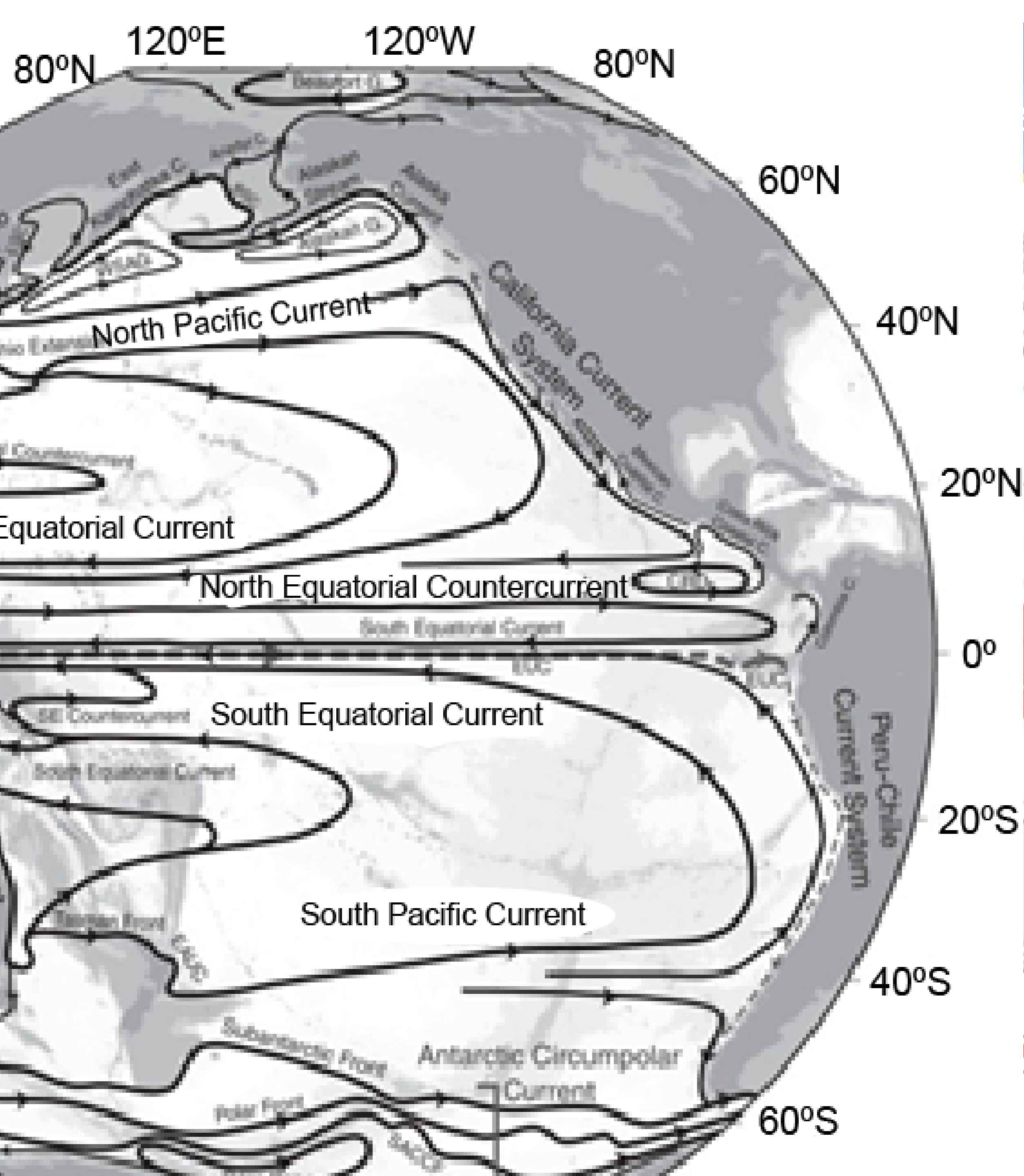




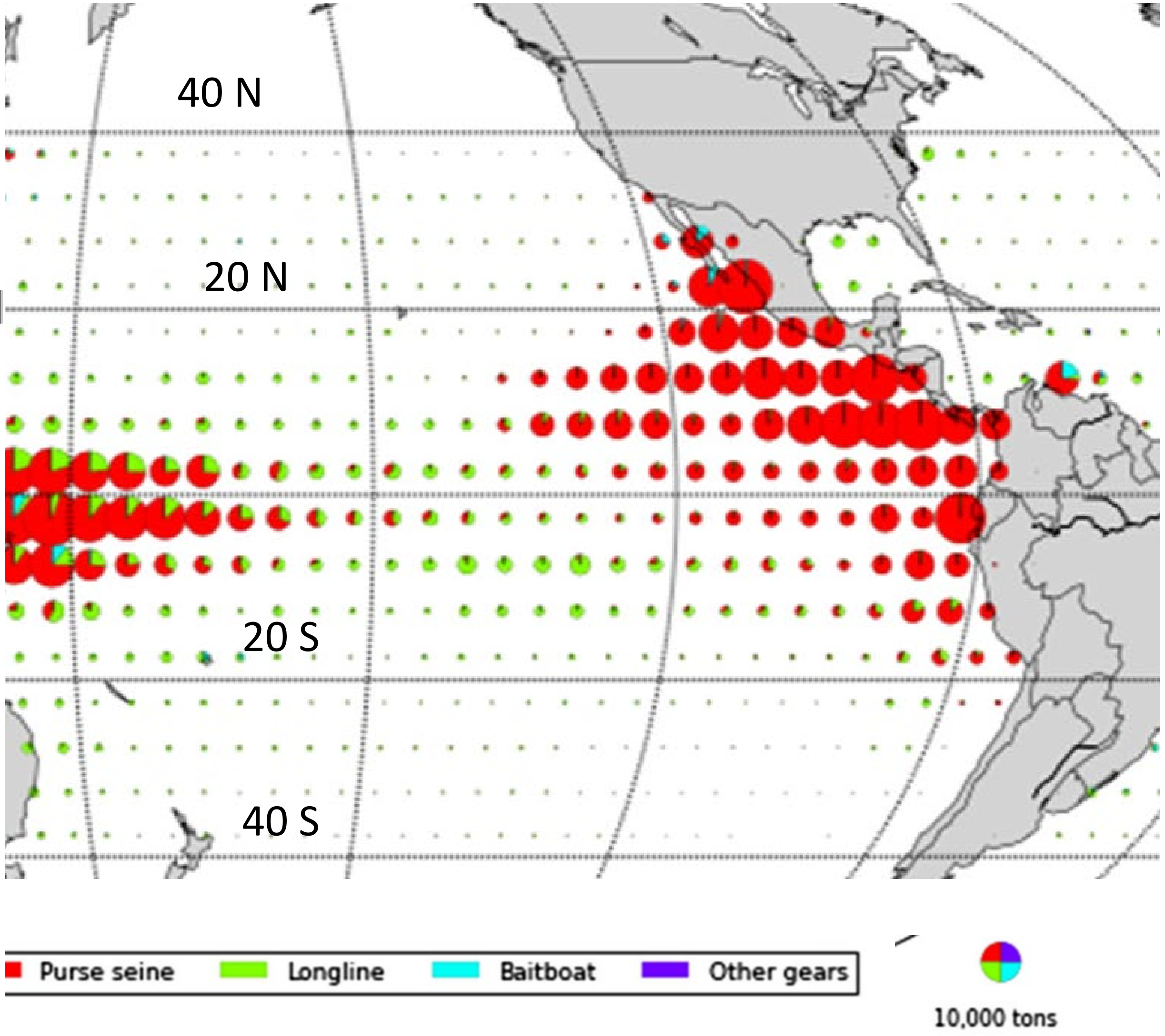
Currents Pacific Ocean



Talley *et al.* 2011



ean annual distribution of catches **1950-2013**



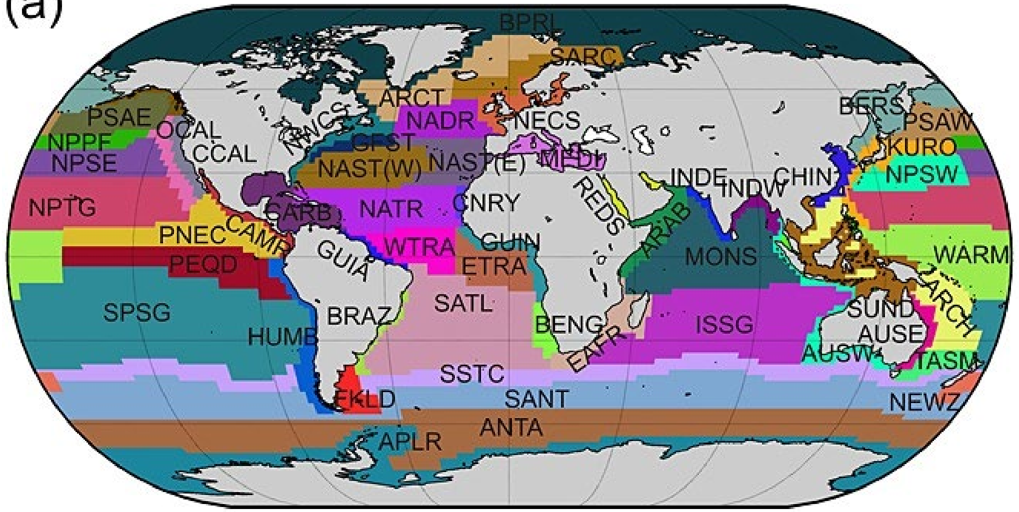
Dynamic biogeochemical provinces

average period January 1998 to December 2007.

Longhurst

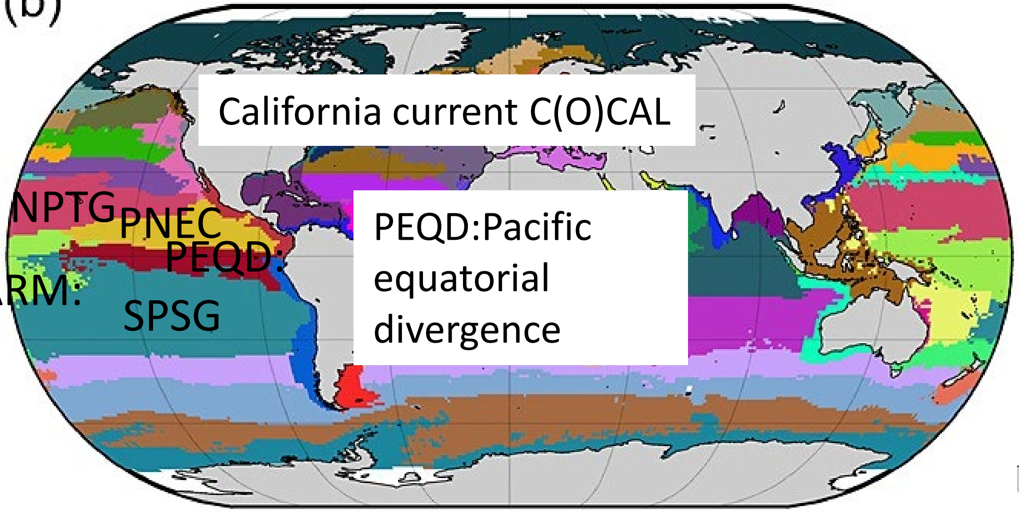
Biogeography of the global ocean

(a)



Reygondeau et al 2013

(b)



PNEC: North Pacific equatorial counter current

NPTG: North Pacific Tropical gyre

WARM:
Western Pacific warm pool

SPSG: South Pacific gyre

Table 1. Information on the Environmental Data S

Data Set	Data
Environmental data set	Sea surface temperature
	Sea surface salinity Chlorophyll *a* concentration
Biogeochemicalprovince	Bathymetry Boundary

Global Biogeochemical Cycles, Volume: 27, Issue: 4, Pages: 1046-1058, First published: 20 September 2013, DOI: (10.1002/gbc.20089)

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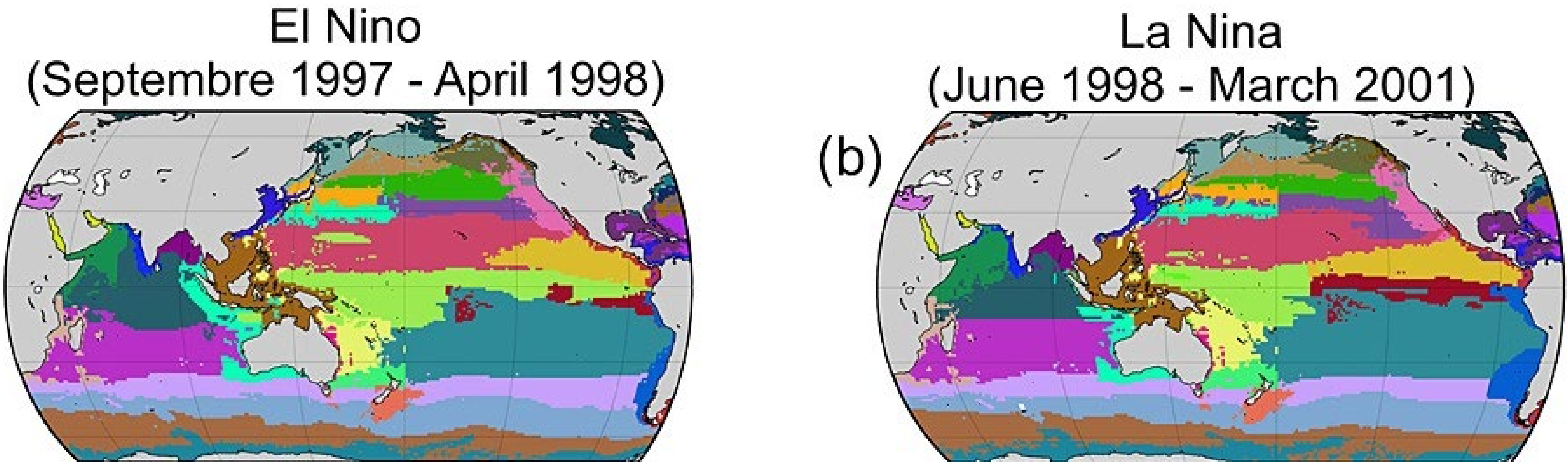
Dynamic biogeochemical provinces in the global ocean

Longhurts Provinces

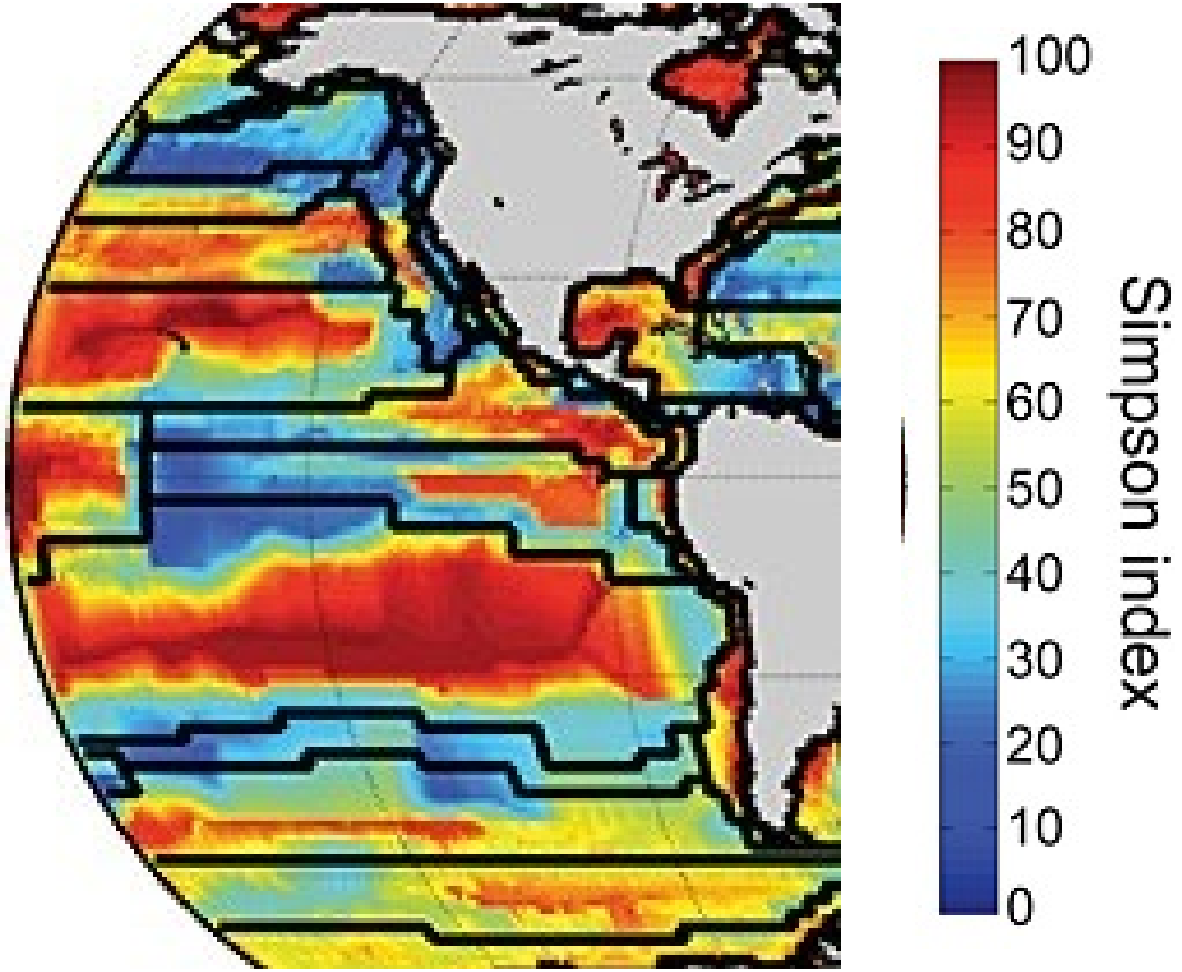


Reygondeau et al 2013

Global Biogeochemical Cycles, Volume: 27, Issue: 4, Pages: 1046-1058, First published: 20 September 2013, DOI: (10.1002/gbc.20089)

Dynamic biogeochemical provinces

Seasonal overlap between biogeochemical provinces



Province composition, belonging:

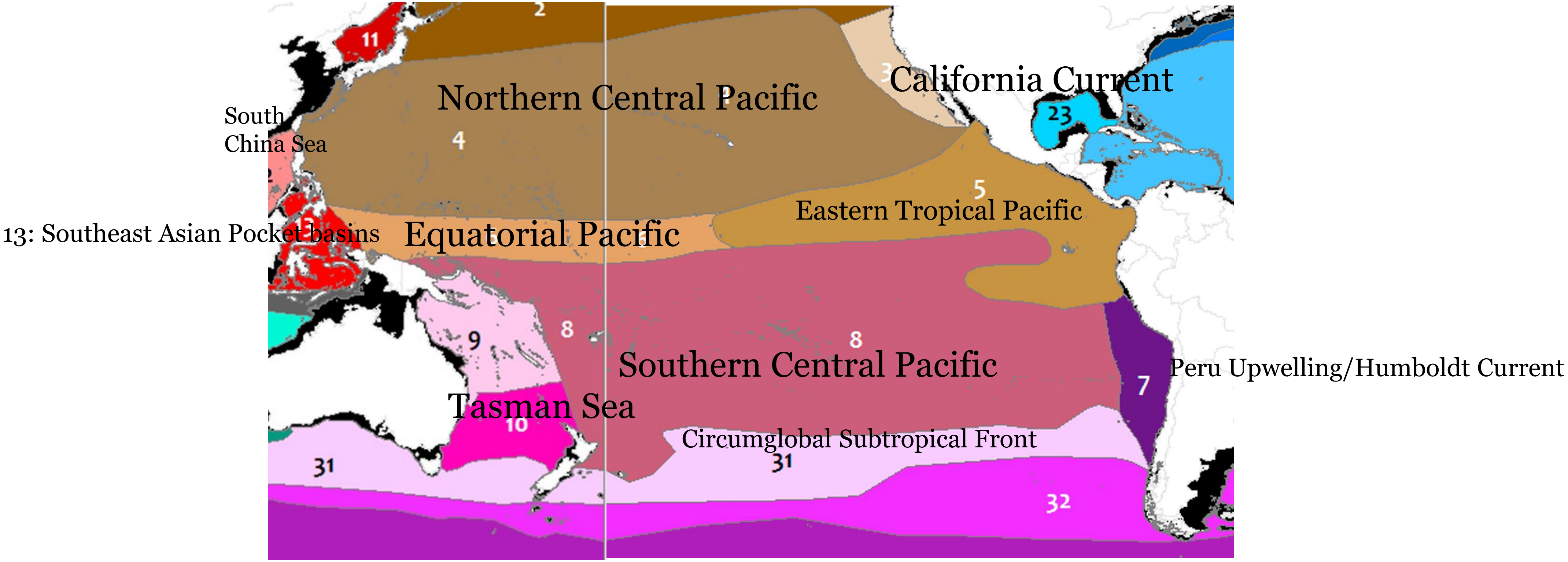
High values: more stable in time.

Low values: variable regions

Reygondeau et al 2013

Global Biogeochemical Cycles, Volume: 27, Issue: 4, Pages: 1046-1058, First published: 20 September 2013, DOI: (10.1002/gbc.20089)

Mesopelagic regions of the world



Sutton et al 2017

https://doi.org/10.1016/j.dsr.2017.05.006
https://www.sciencedirect.com/science/article/pii/S0967063717301437#f0020

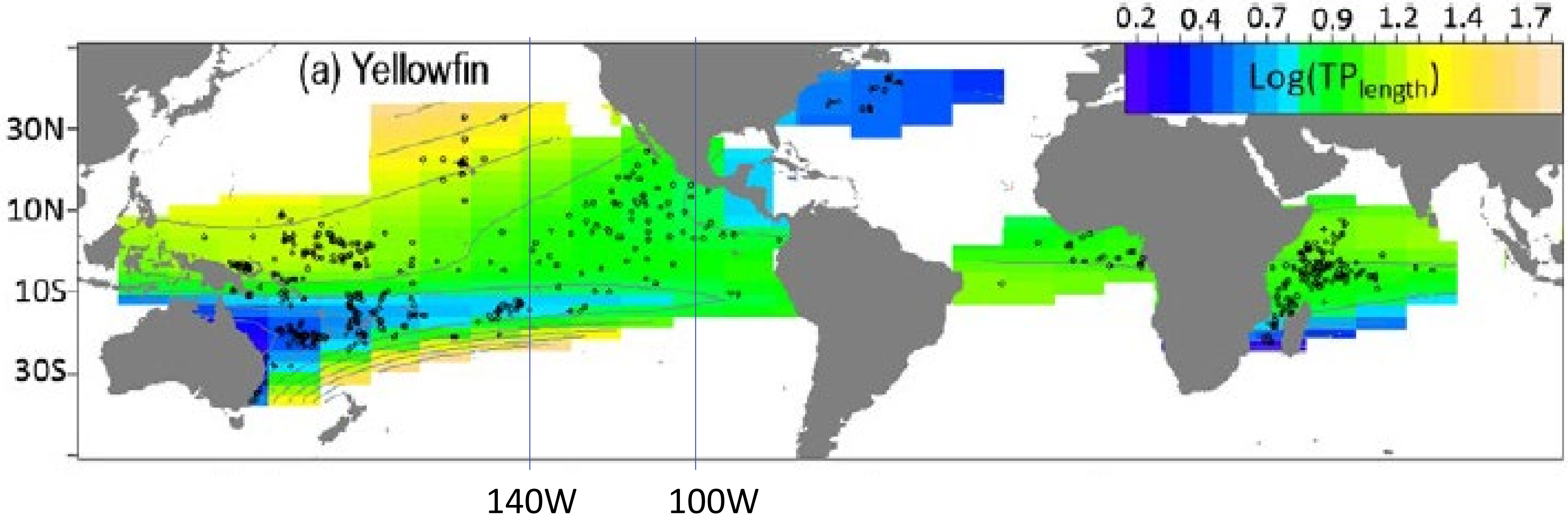
Trophic position

Received: 11 September 2017 | Revised: 29 March 2018 | Accepted: 9 April 2018
DOI: 10.1111/geb.12763

RESEARCH PAPERS

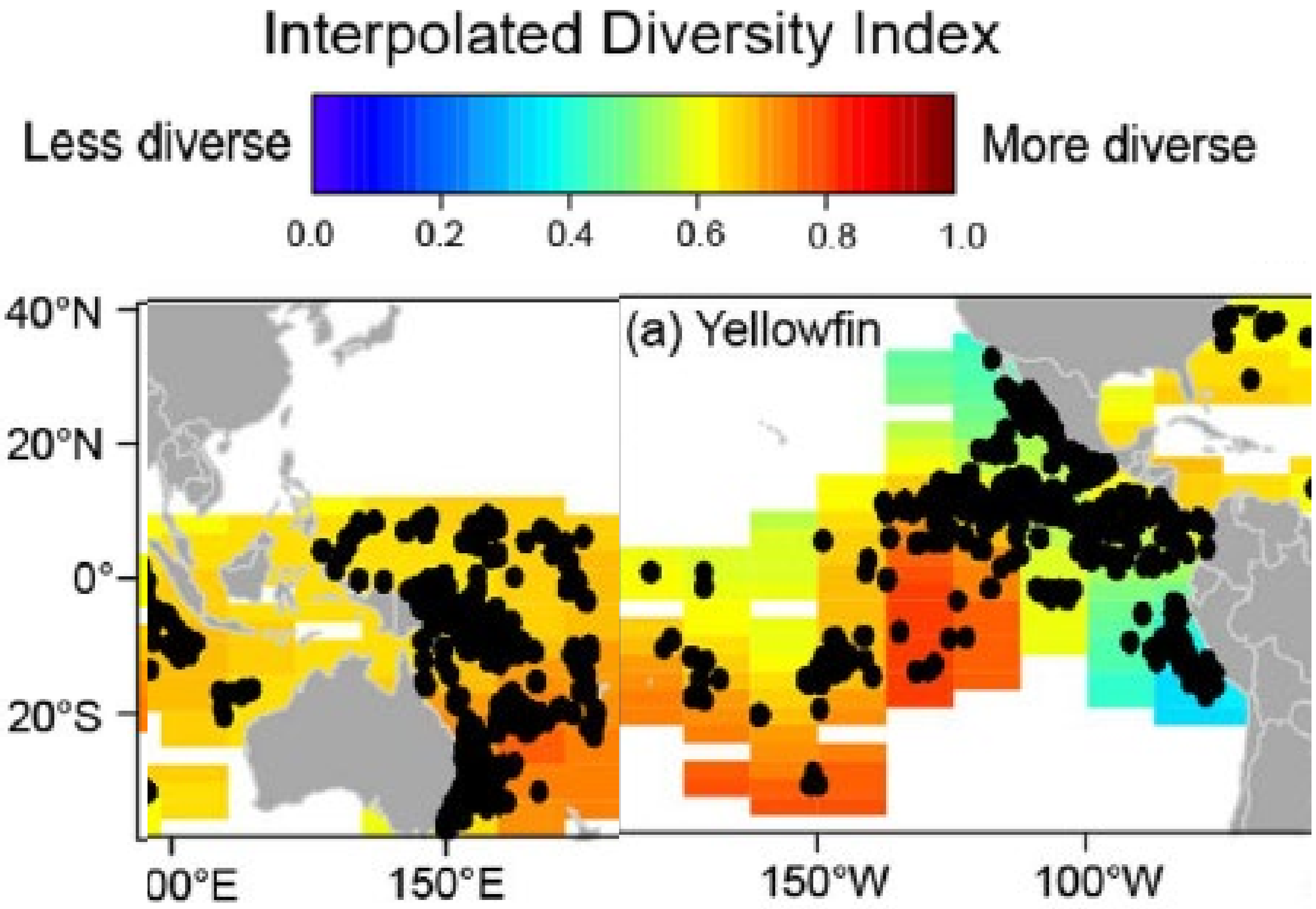
WILEY Global Ecology and Biogeography

A global meta-analysis of marine predator nitrogen stable isotopes: Relationships between trophic structure and environmental conditions



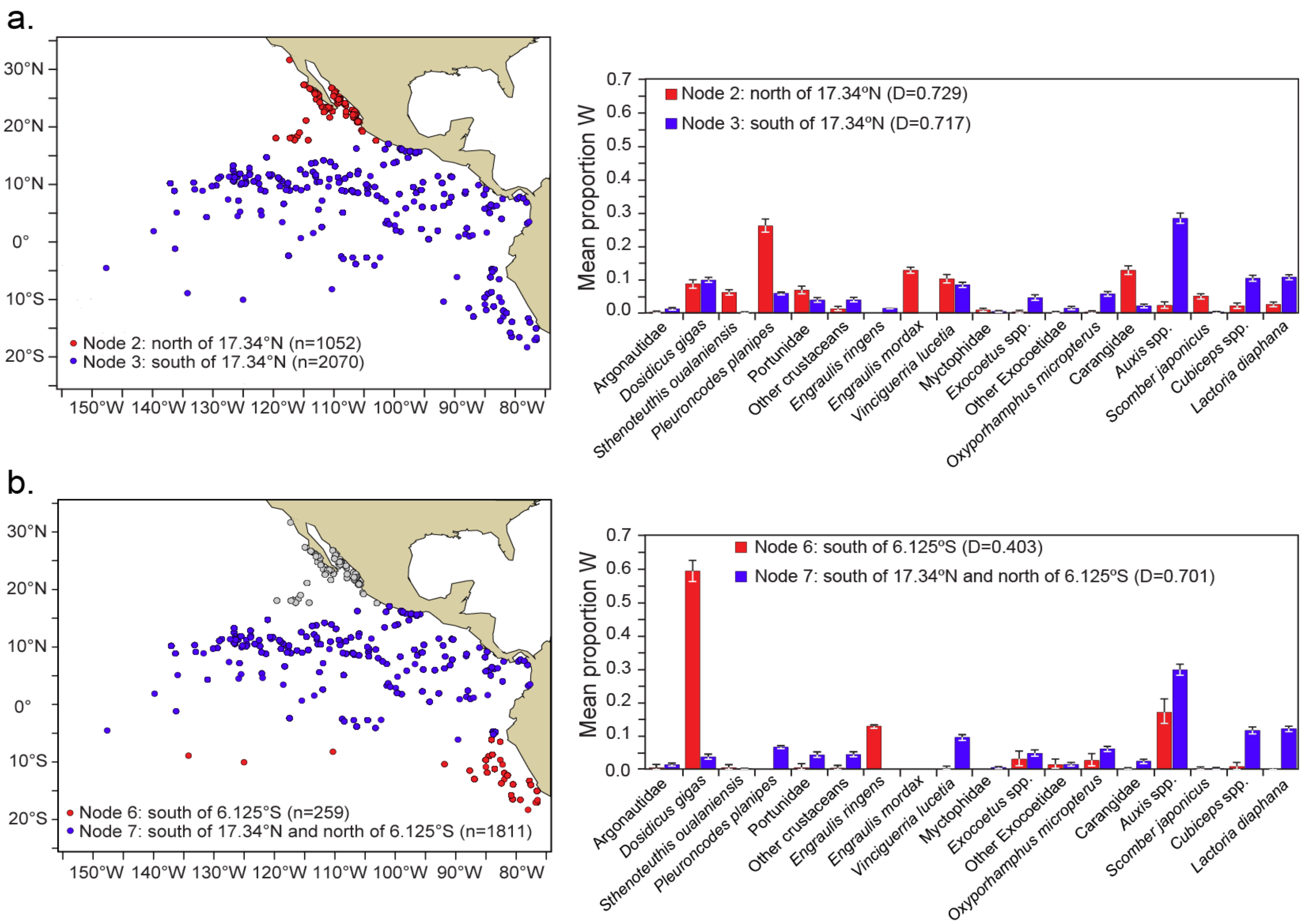
Pethybridge et al 2018

Diet composition



Duffy *et al.* 2017

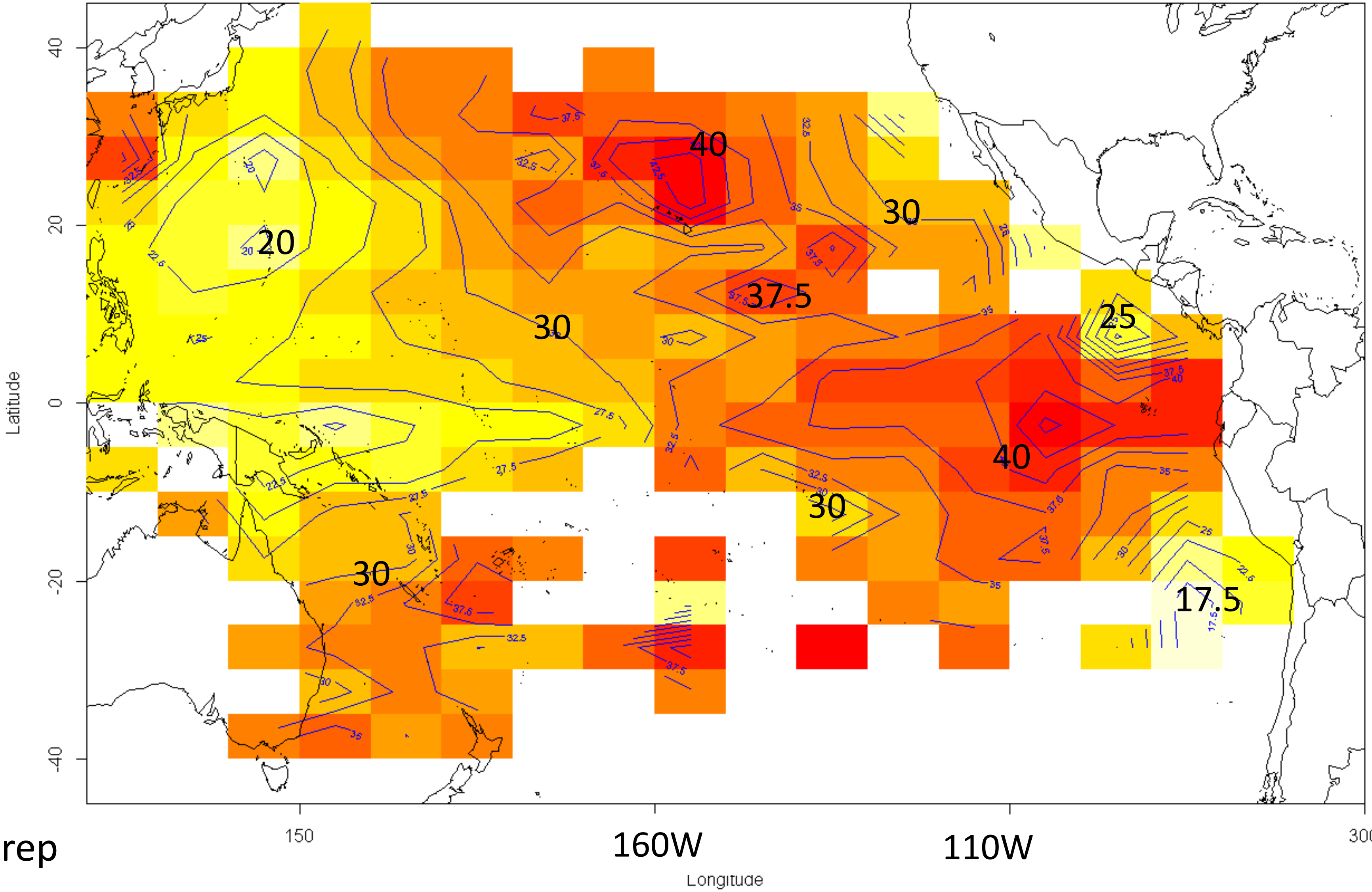
Diet composition



Olson *et al.* 2014

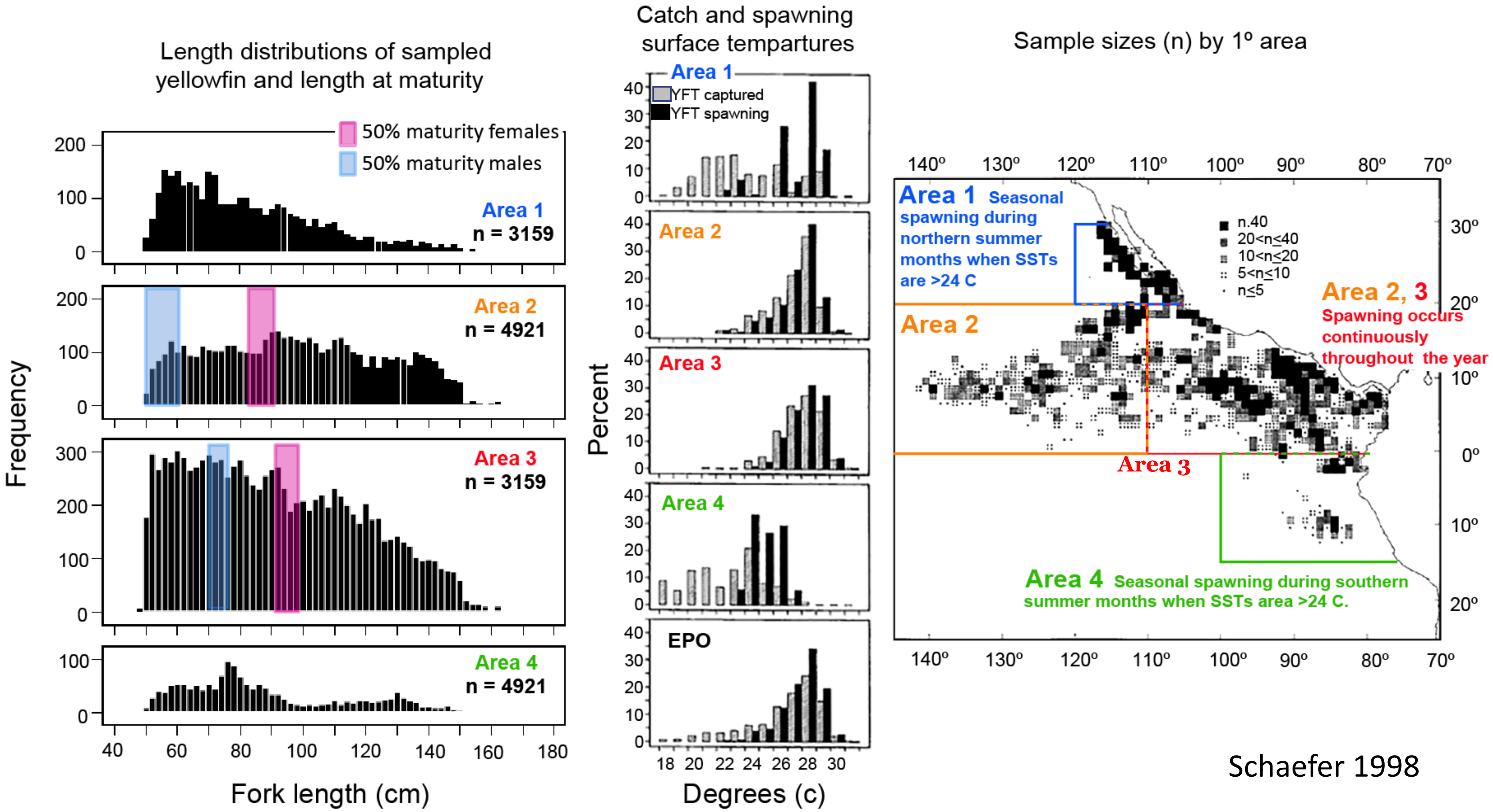
Yellowfin tuna: average weight

$$size \sim yrqtr + lat.long + flag.fleet.origin$$



Hoyle et al in prep

Reproductive biology: spatial variation in the EPO

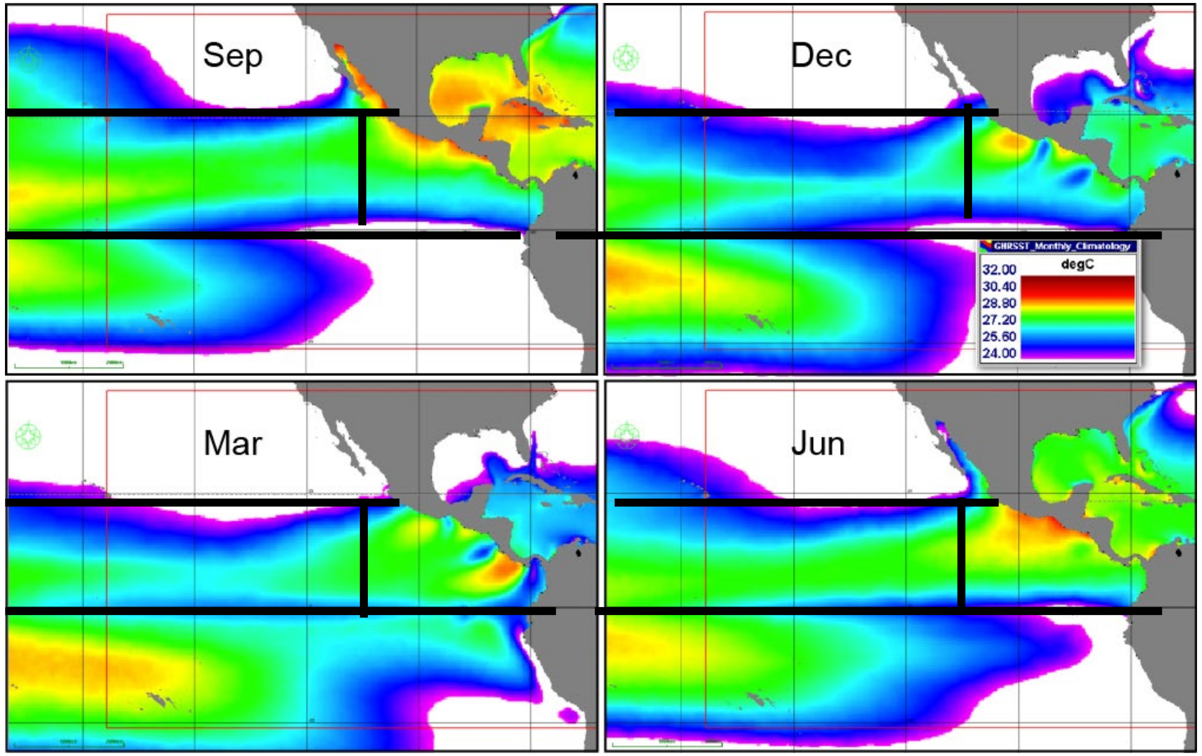


Schaefer 1998

Spawning habitat variation

Seasonal variation

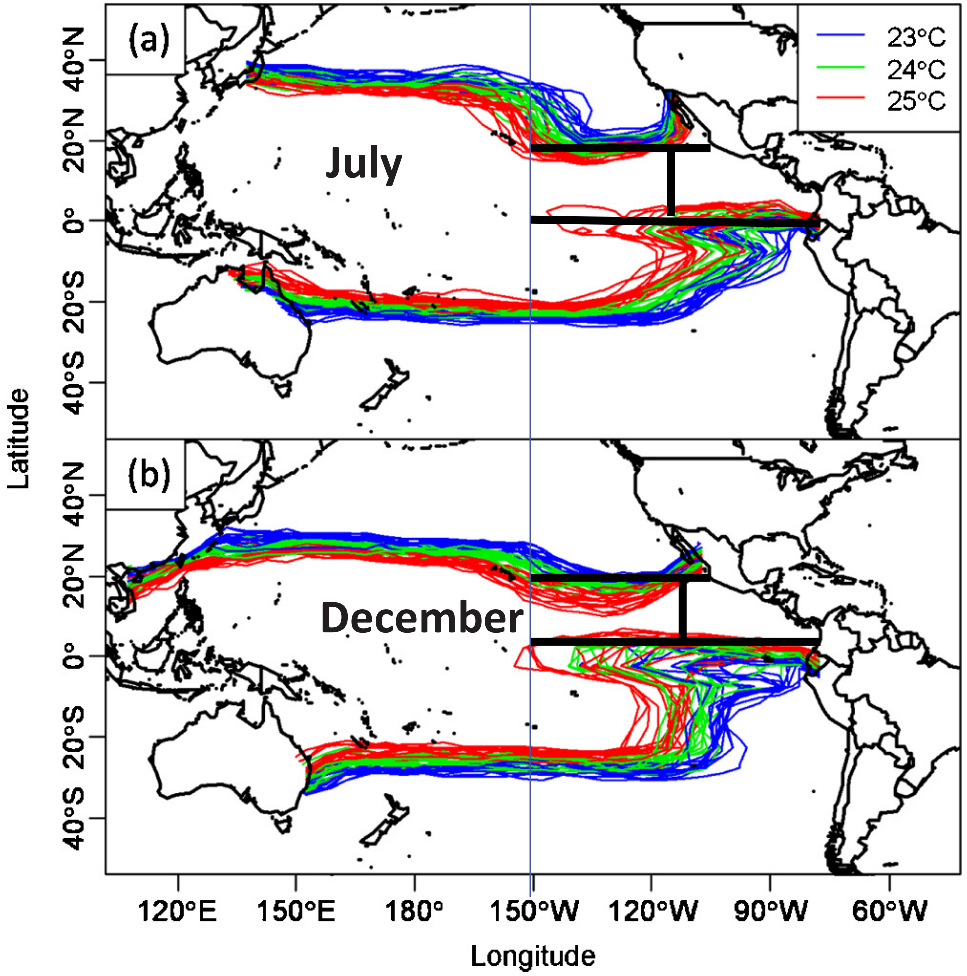
Distribution of waters of 24°C and higher



Climatology, Group for High Resolution SST,
https://www.ghrsst.org

Annual variation

SST isotherms 1998 to 2012 in the Pacific Ocean

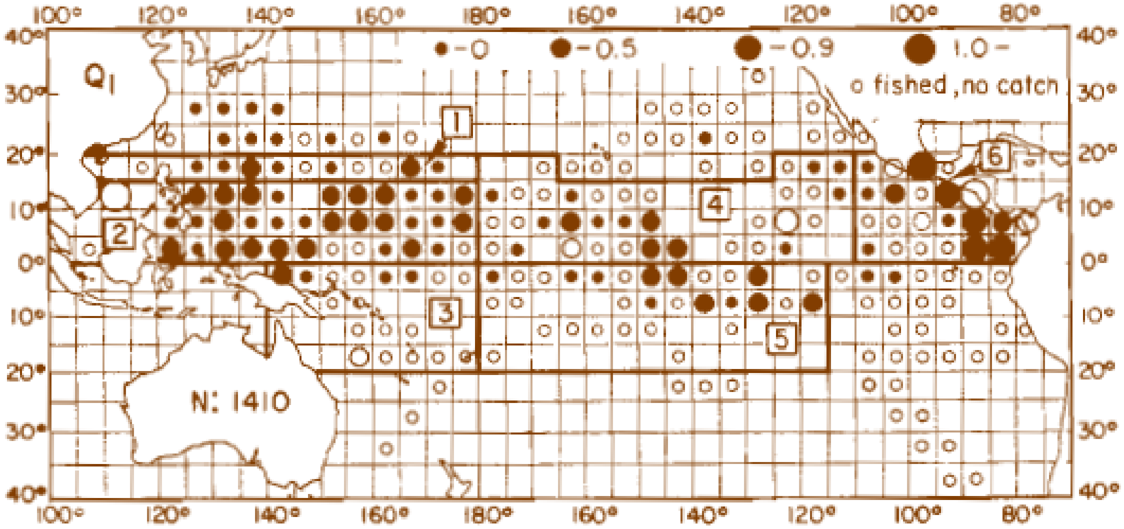


Su et al 2015

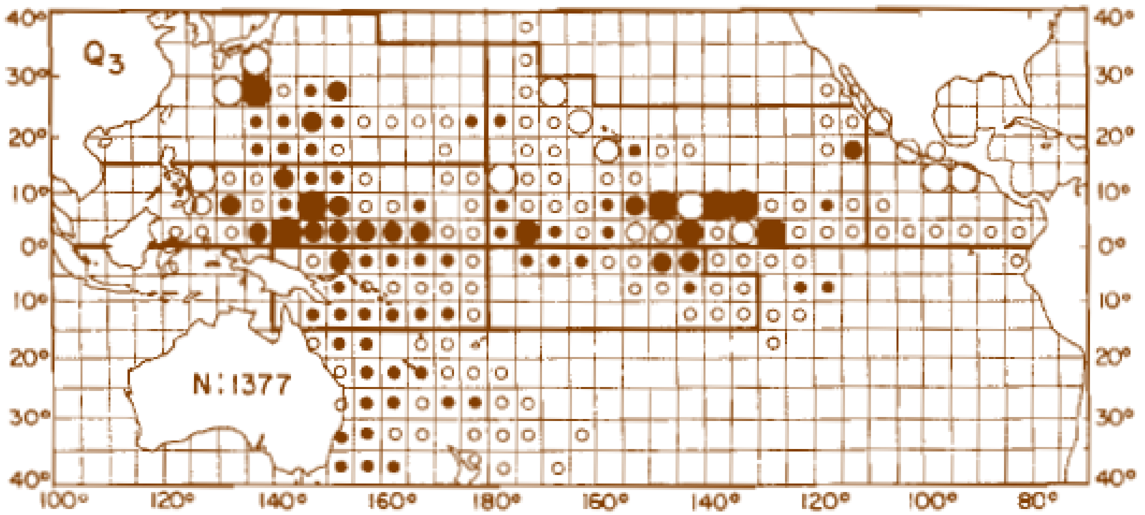
Biological data: larval distribution

Suzuki et al 1978

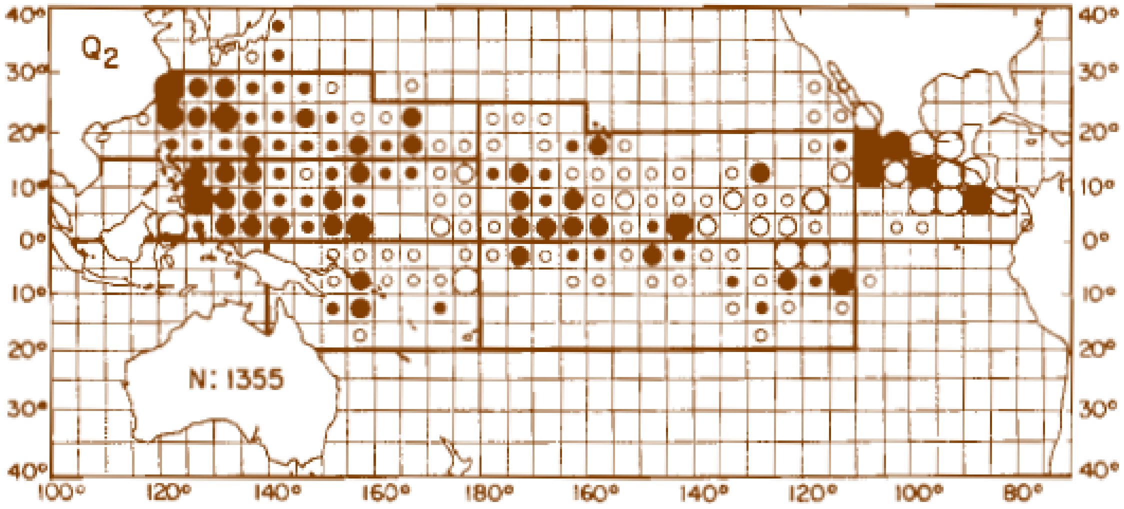
Quarter 1



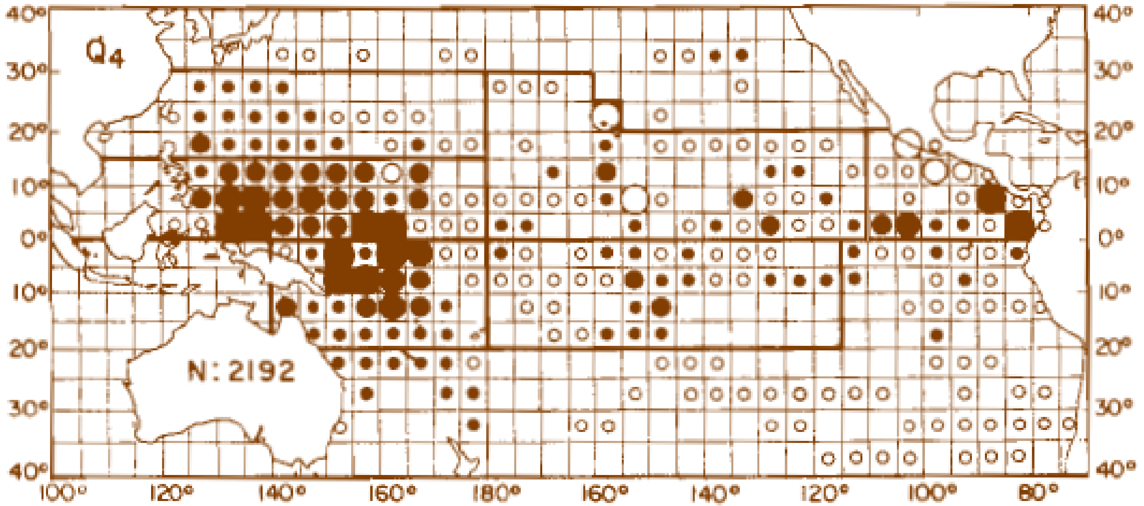
Quarter 3



Quarter 2

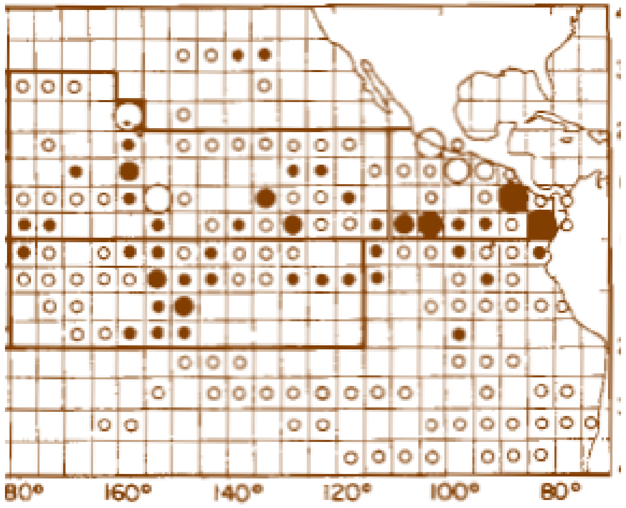


Quarter 4

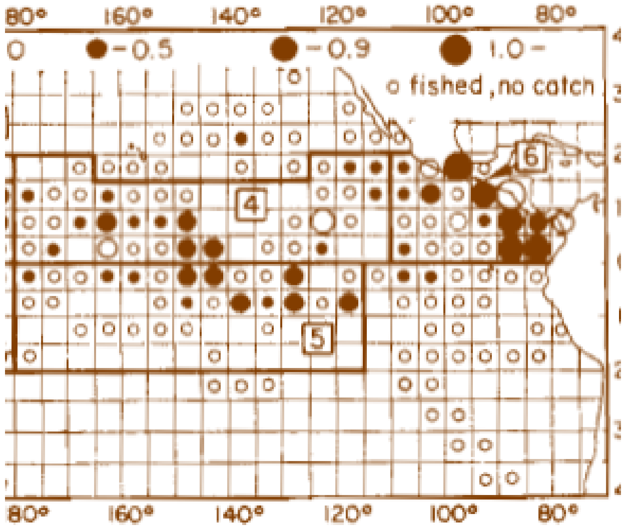


Biological data: larval distribution

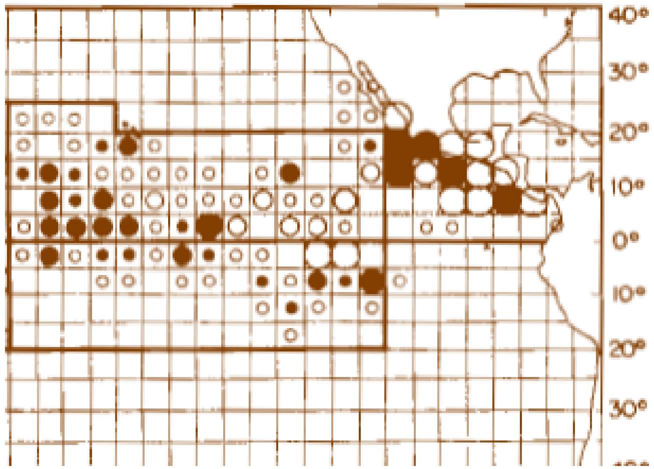
Quarter 4 – Oct - Dec



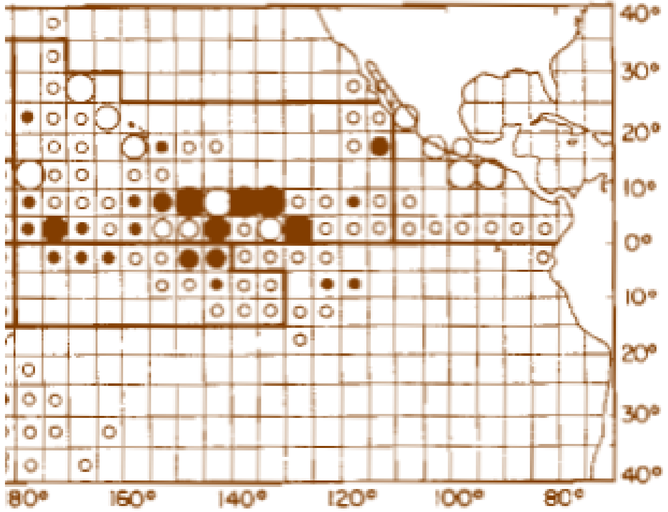
Quarter 1 –Jan -Mar



Quarter 2 – Apr - Jun



Quarter 3 Jul-Sept

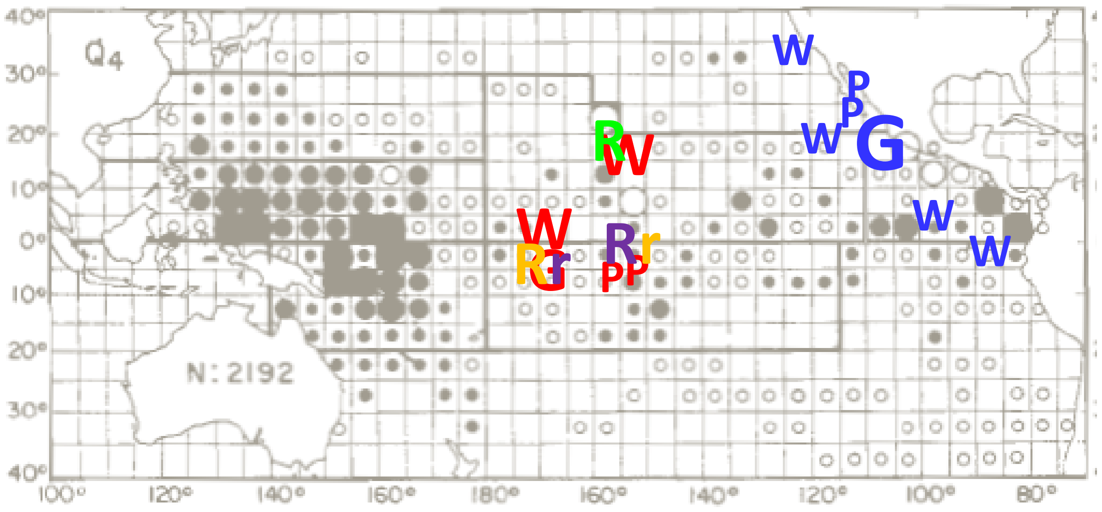


Larval dist:
Suzuki et al 1978

Molecular data

Quarter 4

Larval dist:
Suzuki et al 1978



Genetically different:
G G: Grewe et al 2015
W W: Ward et al 1997
P p: Pecoraro et al 2018

Natal origin:
R R r R r - Rooker

- There may be several stocks of yellowfin tuna across the Pacific Ocean
- Maybe 2 different stock in the EPO
- Data from the EPO needs to be processed

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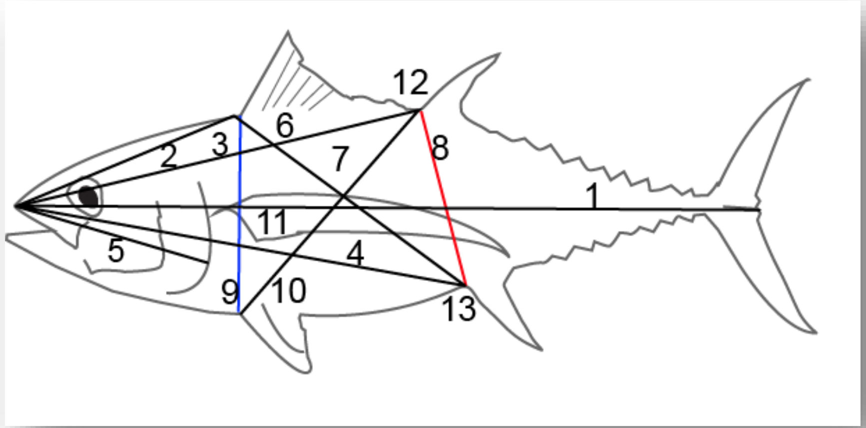
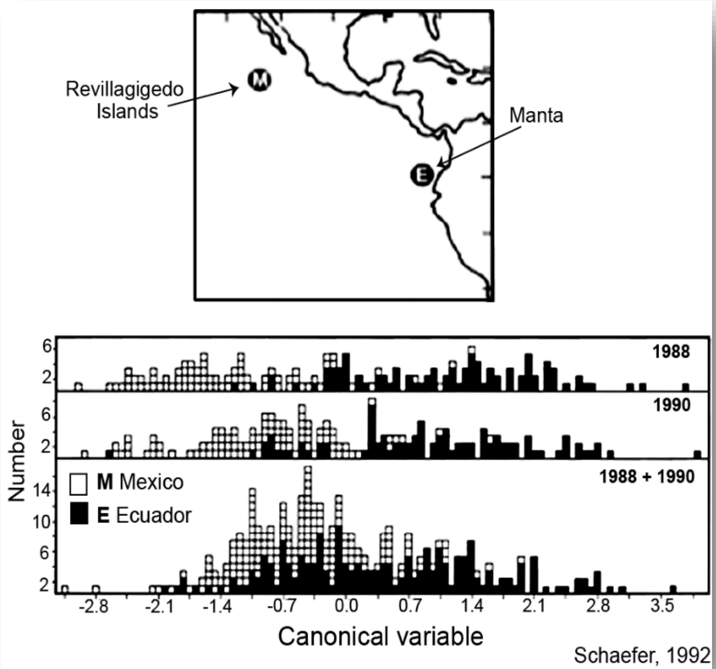
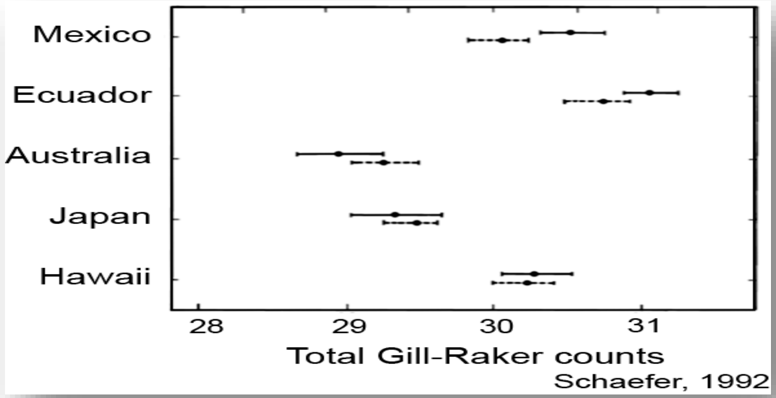
Evidence of differences in morphology and meristics



YFT from Ecuador have a deeper body than YFT from Mexico



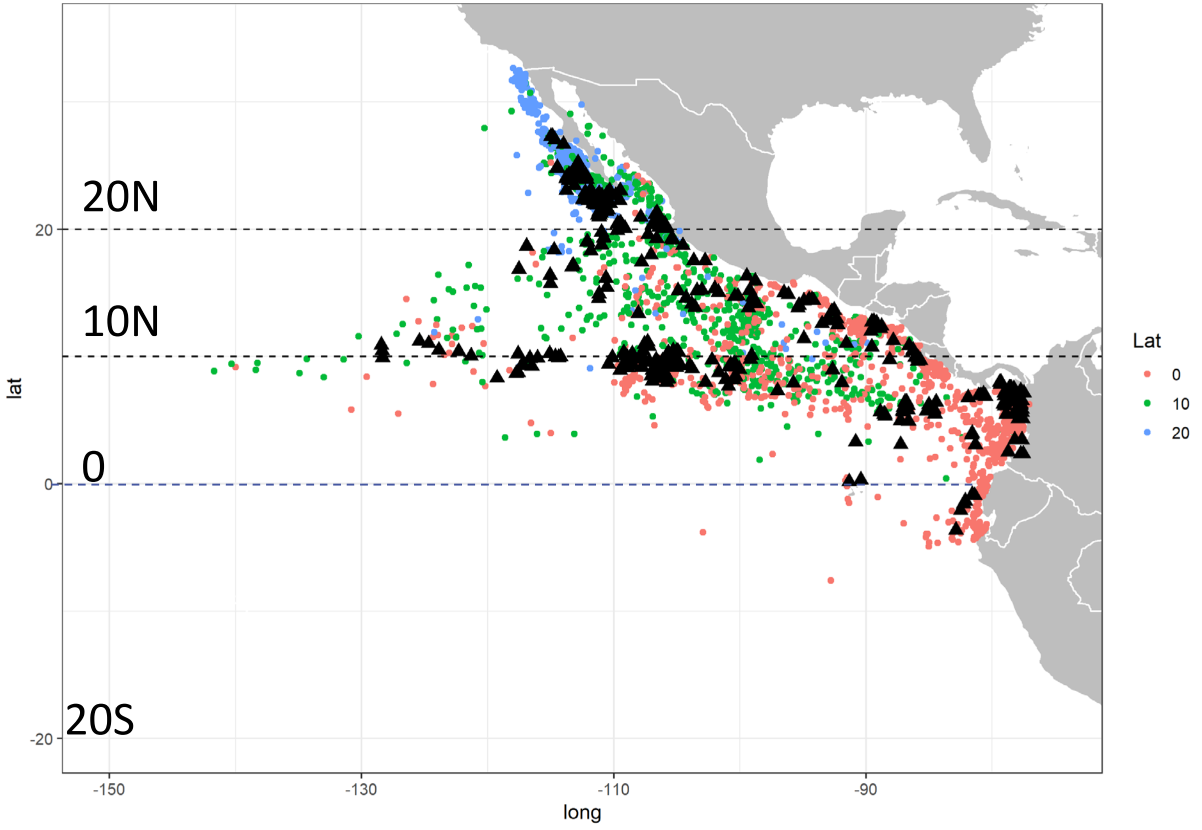


YFT from Ecuador have 1 more gill-raker on average than YFT from Mexico

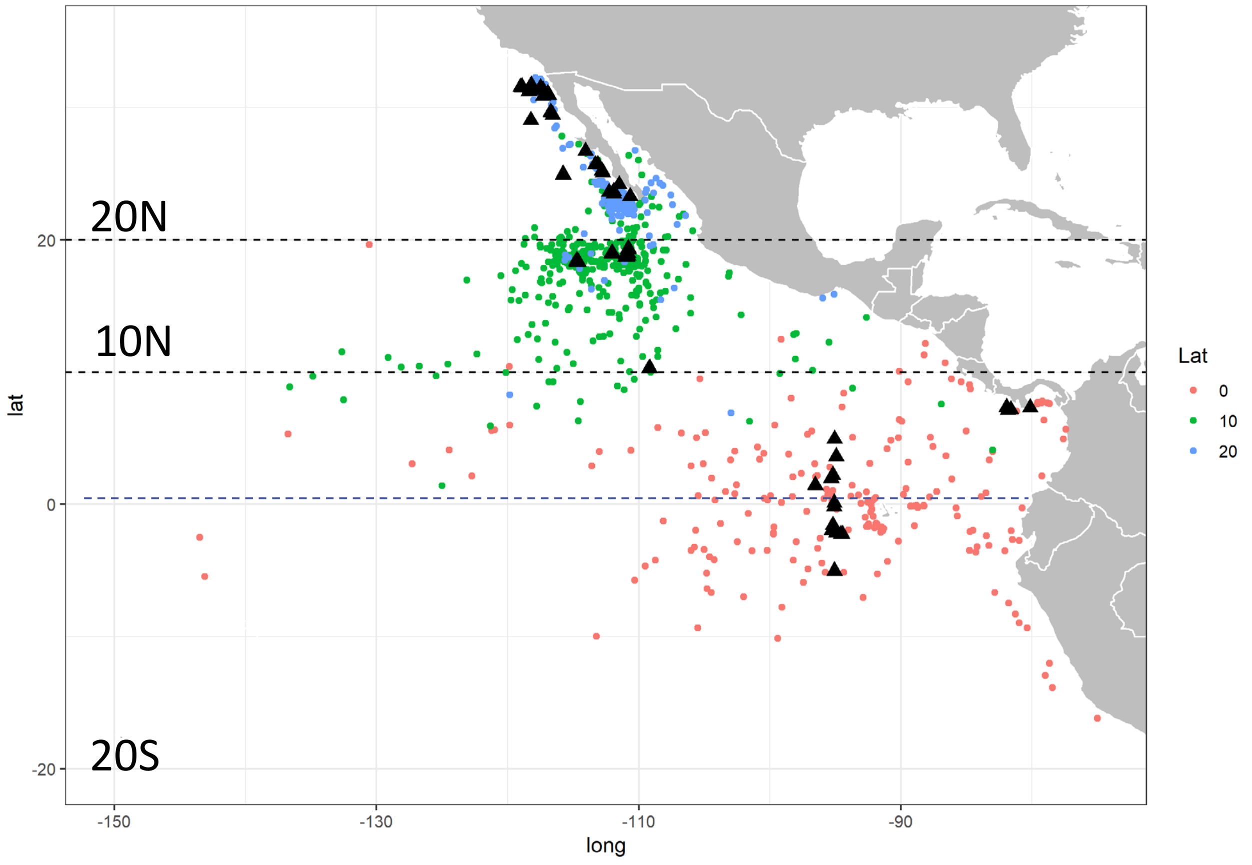
Schaefer 1992

Tagging data: EPO

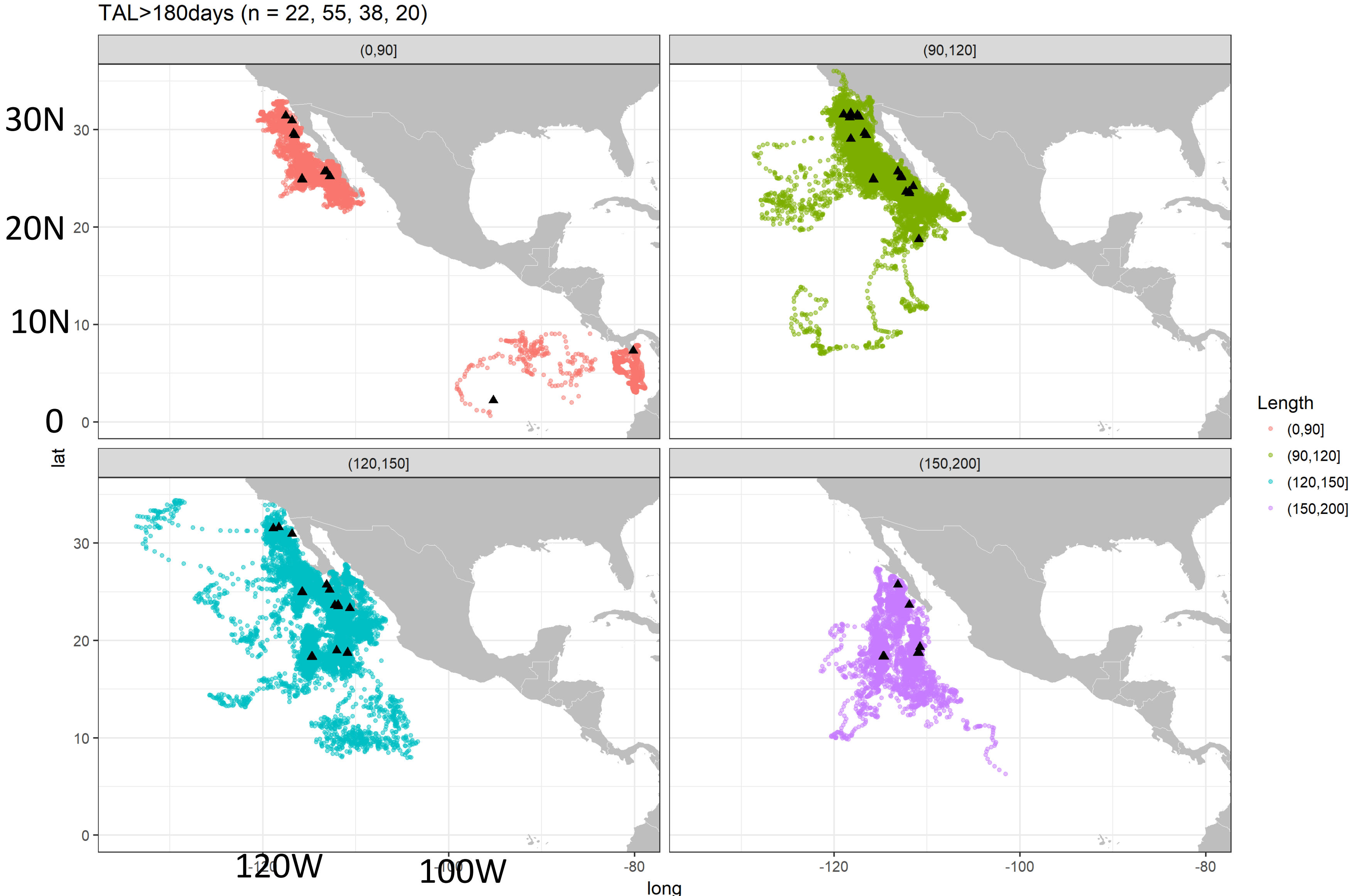
Old tagging data



New tagging data



Tagging data: EPO archival tags



Conclusions

- The yellowfin tuna population in the EPO inhabits several biogeographical provinces and current systems.
- The largest purse-seine catches are in the PNEC (North Pacific equatorial counter current province)
- The largest longline catches are in PEQD (Pacific equatorial divergence)
- The spawning habitat is seasonally available north of 20N and south of the equator
- The larvae distribution is seasonal and concentrated around the coast of central America quarters 1,3 and towards the center of the EPO in quarter 4
- Larger yellowfin in tuna (caught with longliners) are found in the EPO, the largest around Hawaii and Galapagos islands, and.
- in the EPO, the smaller yellowfin tuna (caught with longliners) are found closer to the coast
- Molecular data supports heterogeneity in the population, the eastern and western part are molecularly different
- Tagging data supports limited movement
- Although evidence exist for spatial heterogeneity, the data review does not point towards specific limits.
- The first new population model attempted followed the simplified assumption of one stock. The fisheries data, however, is more consistent with a heterogeneous structure than with a homogeneous well-mixed stock.

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