YELLOWFIN TUNA STOCK ASSESSMENT: CONCEPTUAL MODEL AND EXPLORATORY ANALYSES

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1st External review of data used in stock assessments of tropical tuna in the eastern Pacific Ocean
Oct 2-6 2023

Outline

1. Background
2. Update of the conceptual model for yellowfin tuna in the EPO
3. Dynamic discrimination of stocks
4. Future directions

SAC 10 – INF - F

SAC-14-06

Background

- 2019 assessment rejected – too sensitive to the longline index of abundance
- Longline index and purse-seine indices had contradictory information
- Model misspecification due to spatial structure
- 2020 benchmark assessment used risk analysis approach

Issues

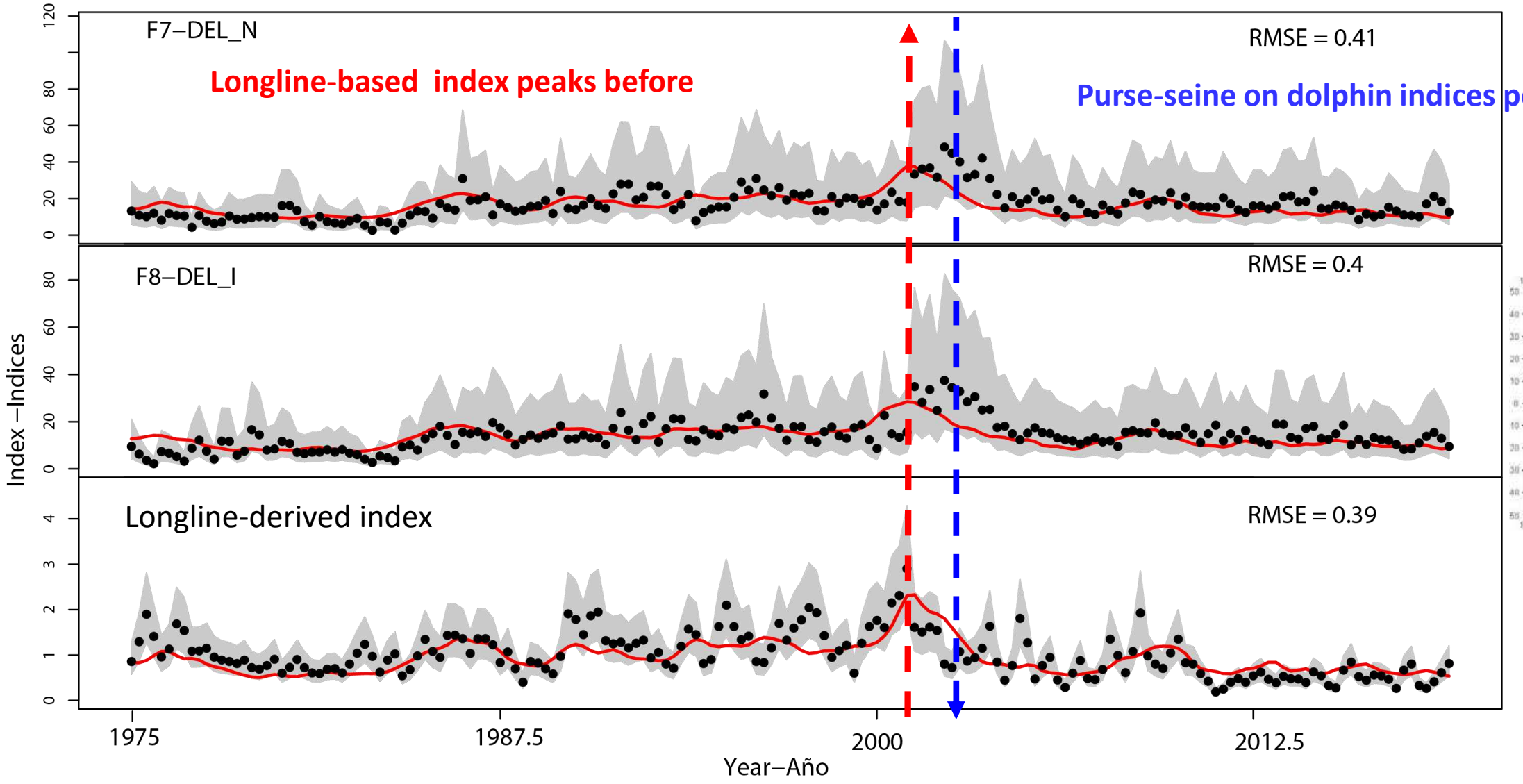
- The management quantities are sensitive to the inclusion of the 2018 data for the longline index of abundance.
- Inconsistencies between Japanese longline index and the dolphin-associated purse-seine index
- Changes in the length composition for the longline fishery

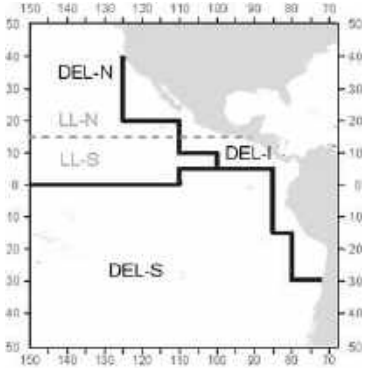
MSY and related quantities

YFT	SAC 9 Base case Caso base	SAC 10 Base case Caso base	SAC 10 Base case except update LL_S
MSY-RMS	264,283	254,975	254,872
B_{MSY}- B_{RMS}	376,696	371,787	372,247
S_{MSY}- S_{RMS}	3,634	3,638	3,642
B_{MSY}/B_0- B_{RMS}/B_0	0.31	0.31	0.31
S_{MSY}/S_0- S_{RMS}/S_0	0.27	0.27	0.27
C_{recent}/MSY- $C_{reciente}$/RMS	0.85	1.00	1.00
B_{recent}/B_{MSY}- $B_{reciente}/B_{RMS}$	1.35	0.84	1.03
S_{recent}/S_{MSY}-$S_{reciente}/S_{RMS}$	1.08	0.76	0.99
F multiplier-Multiplicador de *F*	0.99	0.89	1.00

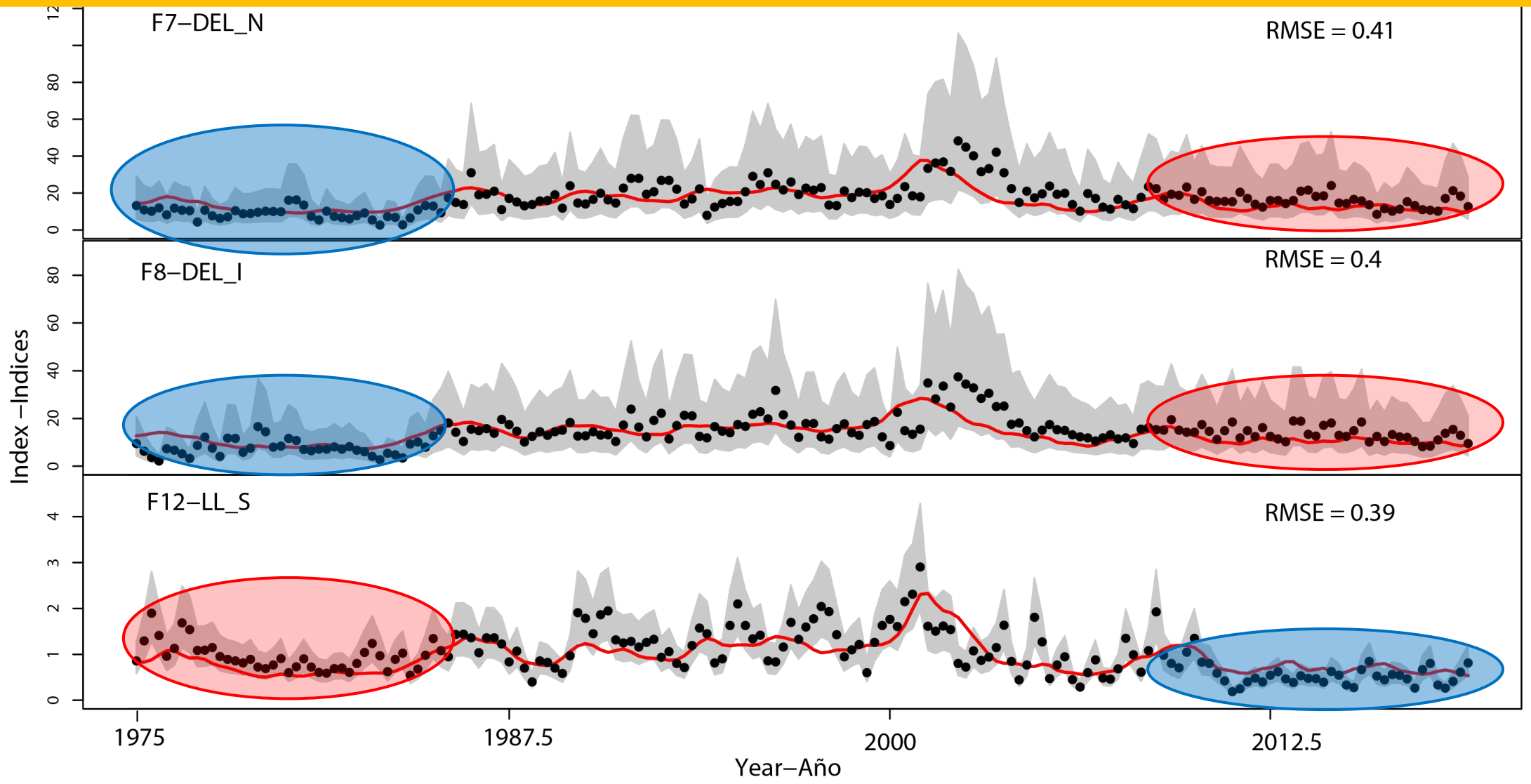
- Results driven by the update in the longline-based index of abundance
- The rest of the new (or updated) data:
  - ✓ Do not show indication of increase in fishing mortality
  - ✓ Decline in biomass not so strong

Inconsistencies among indices

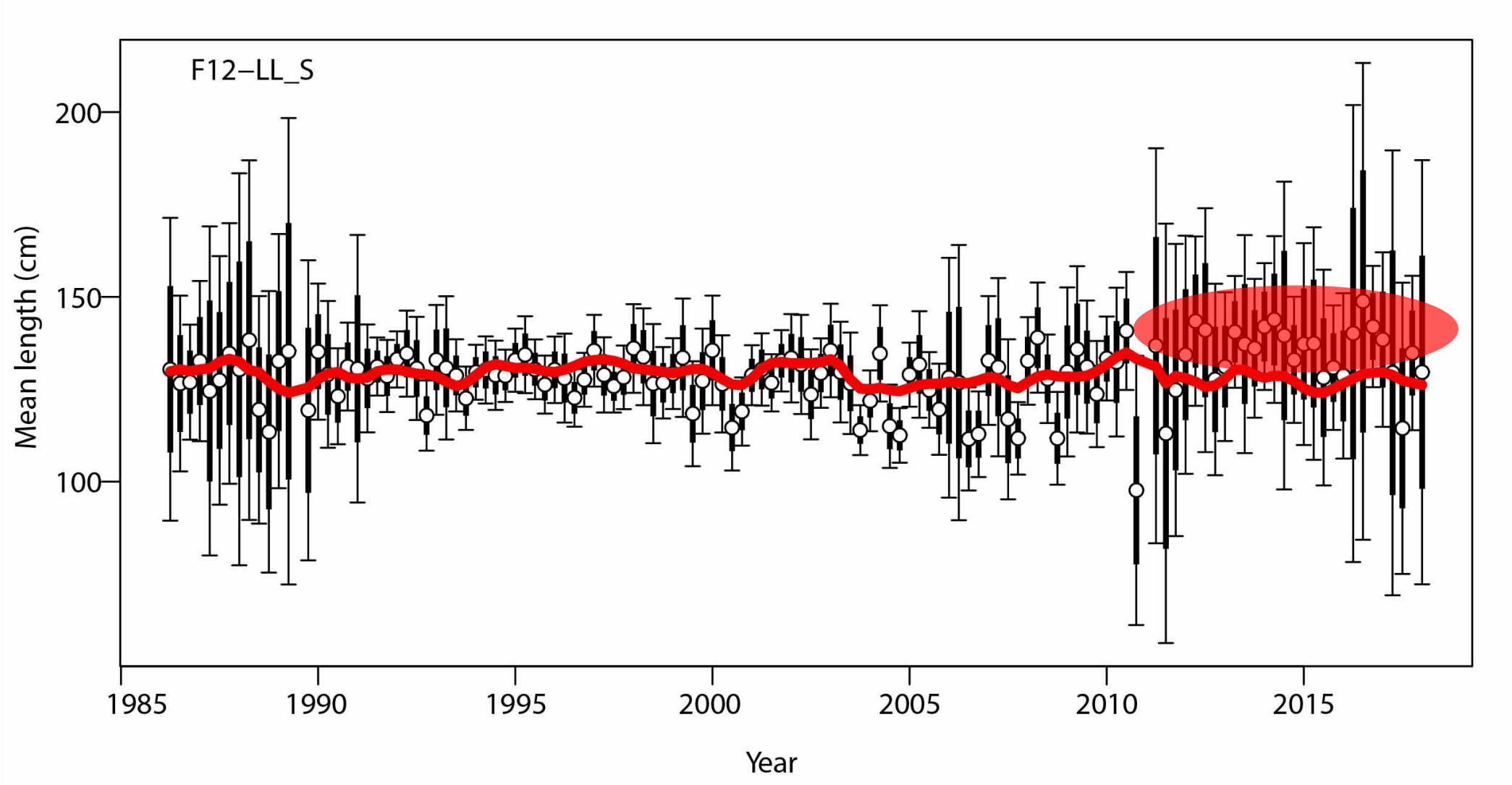




Inconsistencies among indices



Change in longline length composition



Hypotheses for index inconsistencies

- **Change in fishing behavior (e.g. targeting) by the longline fishery**
- **Mis-specified growth**
- **Inadequate consideration of spatiotemporal correlations in the indices of abundance**
- **Spatial structure in the population**

Model runs to investigate the hypotheses

- **Change in fishing behavior (e.g. targeting) by the longline fishery**

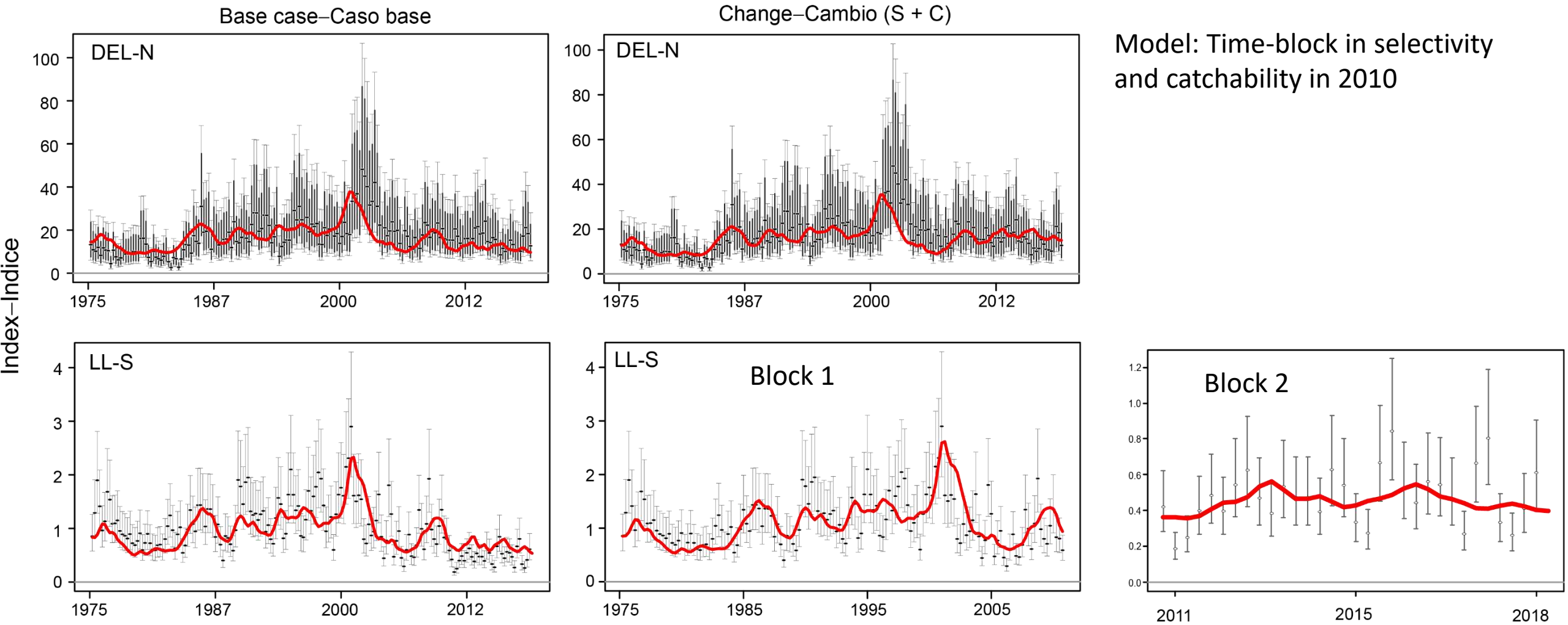
  Estimate change in selectivity and catchability in 2010

- **Mis-specified growth**

- **Inadequate consideration of spatiotemporal correlations in the indices of abundance**

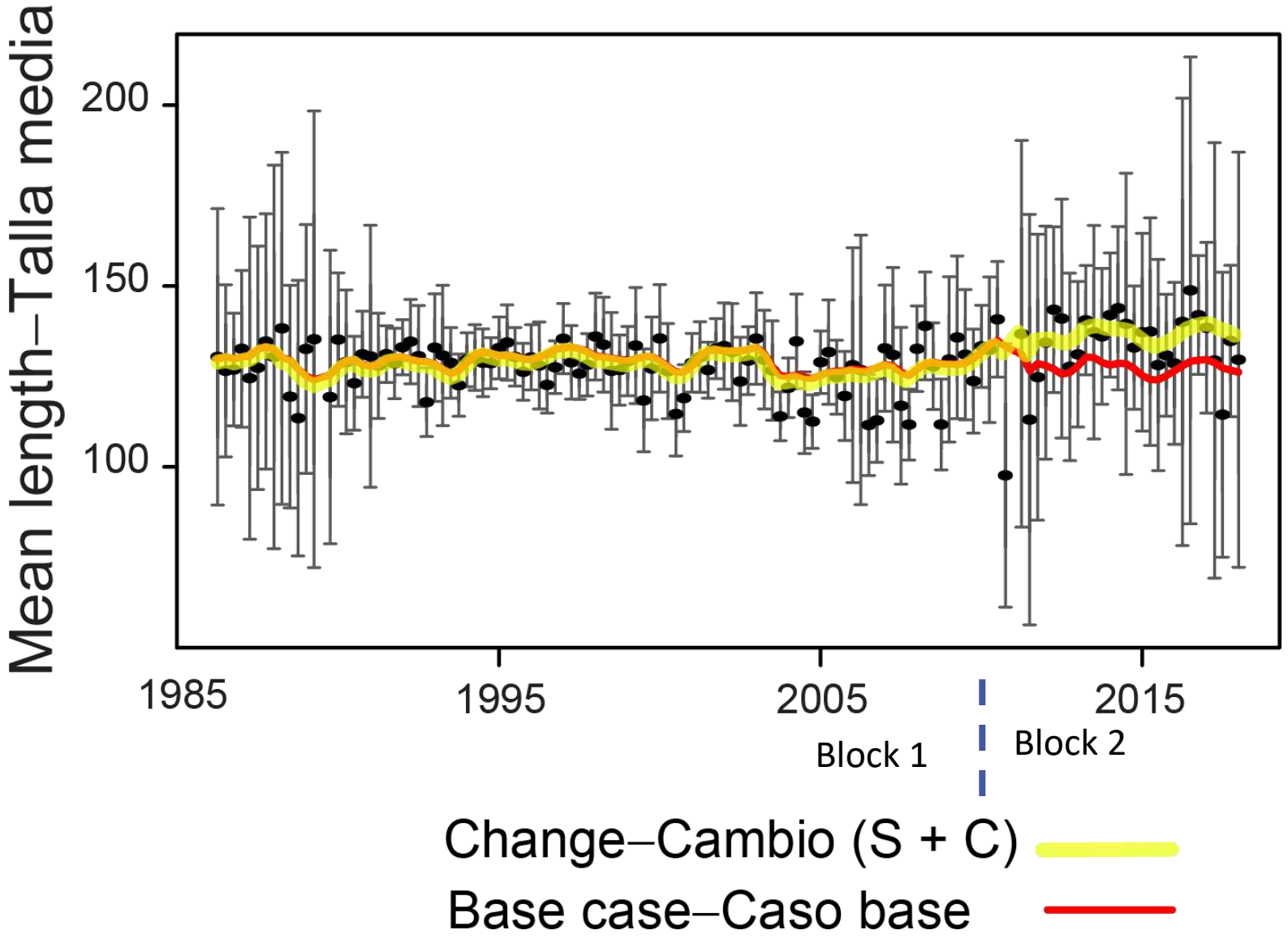
- **Spatial structure in the population**

Change in fishing behavior



Model: Time-block in selectivity and catchability in 2010

Change in fishing behavior



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  Estimate growth parameters

- **Inadequate consideration of spatiotemporal correlations in the indices of abundance**

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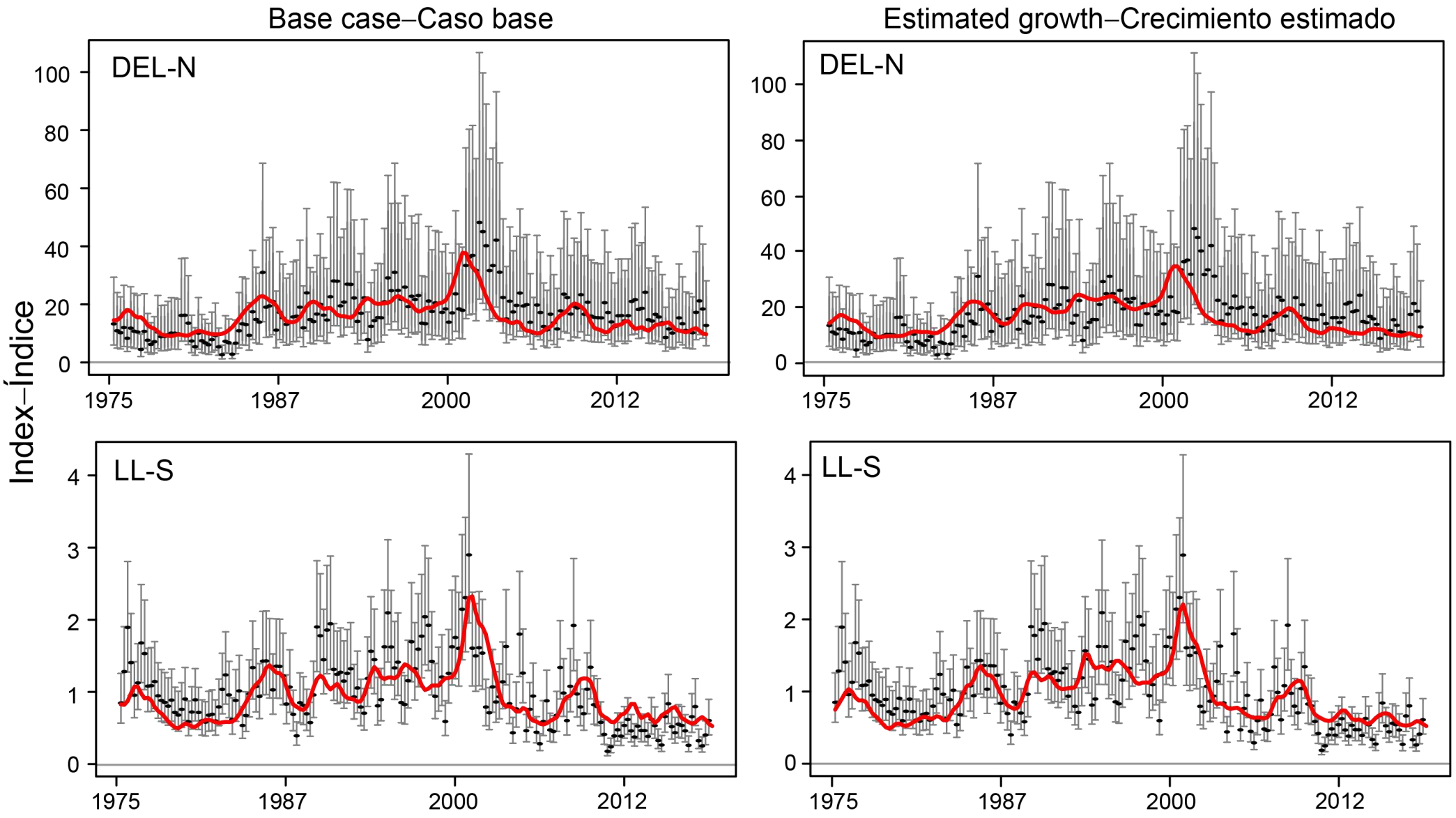
Mis-specified growth



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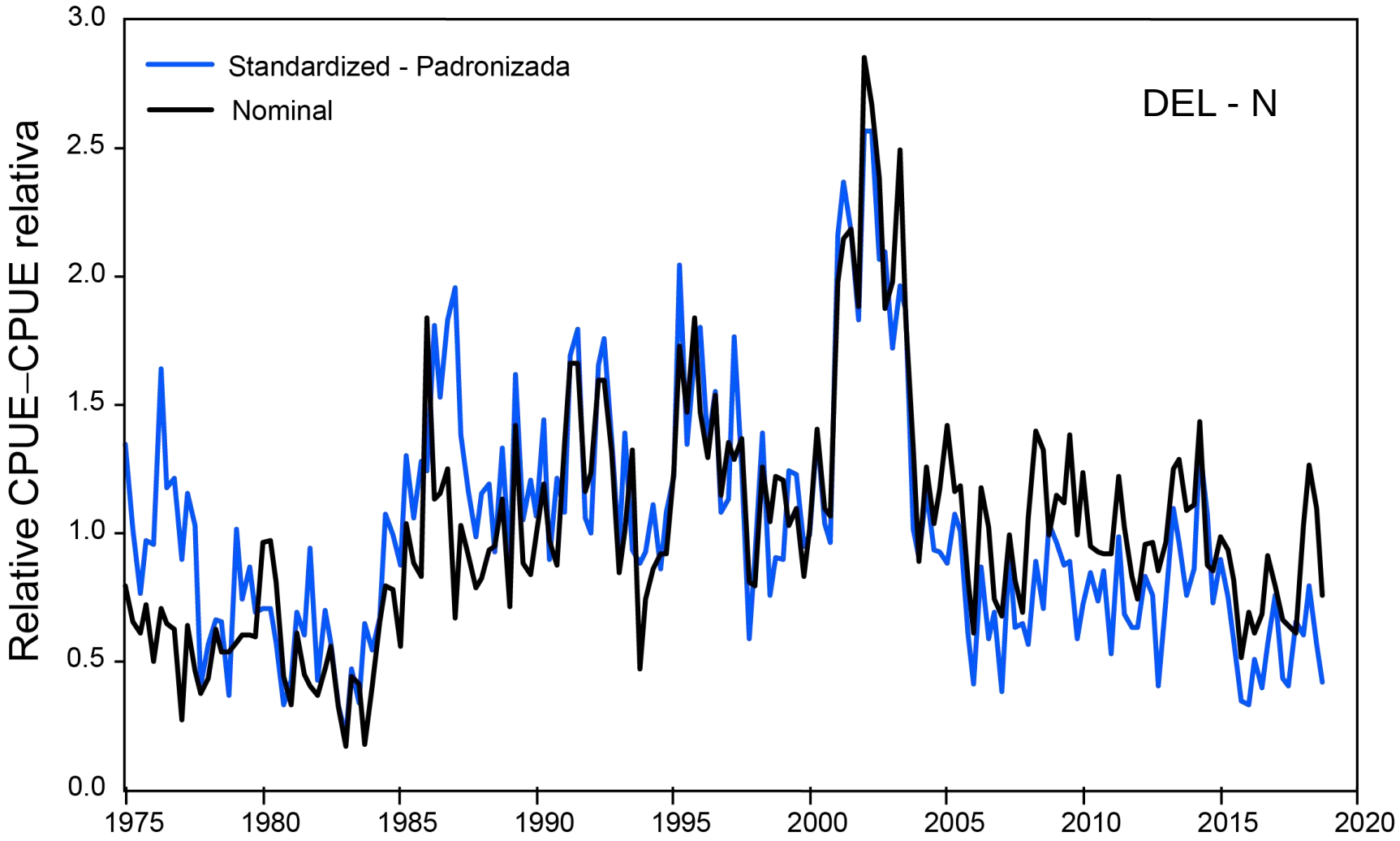
- **Inadequate consideration of spatiotemporal correlations in the indices of abundance**

  Use spatiotemporal model for dolphin associated indices

- **Spatial structure in the population**

Inadequate consideration of spatial structure in the indices of abundance



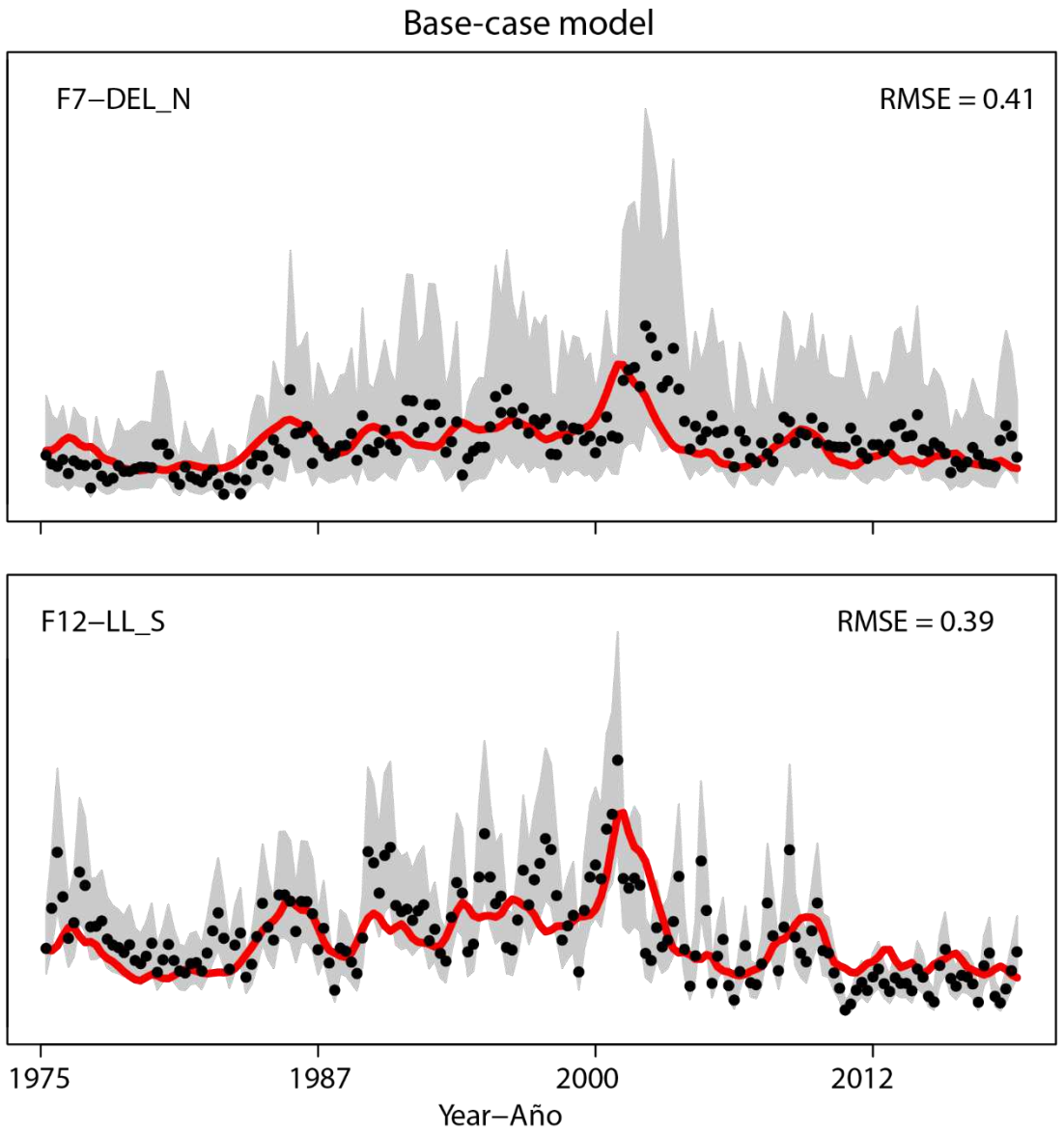
Standartization:

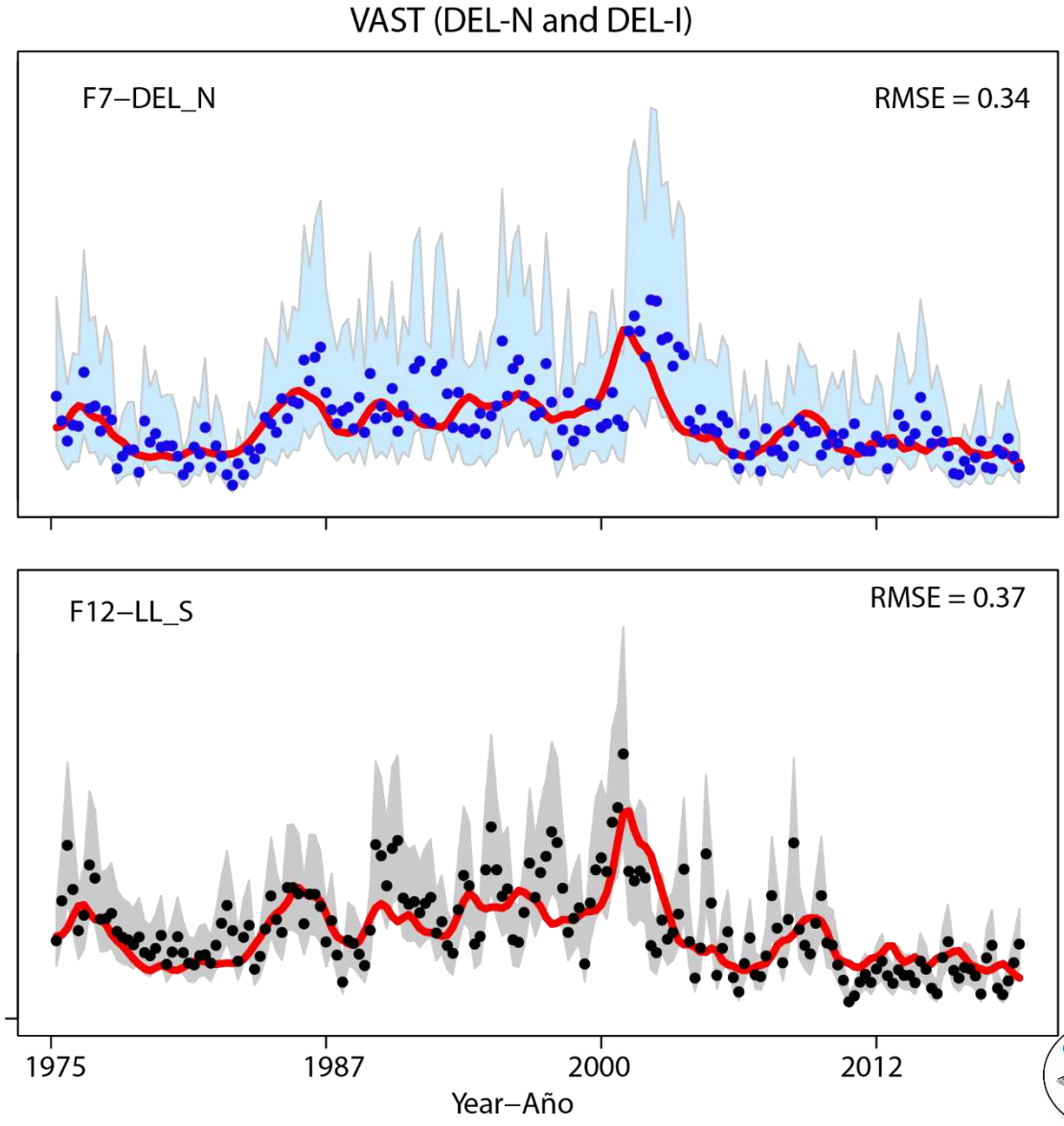
Spatiotemporal model

(Xu et al, 2019)

“VAST”

Inadequate consideration of spatial structure in the indices of abundance





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- **Mis-specified growth**

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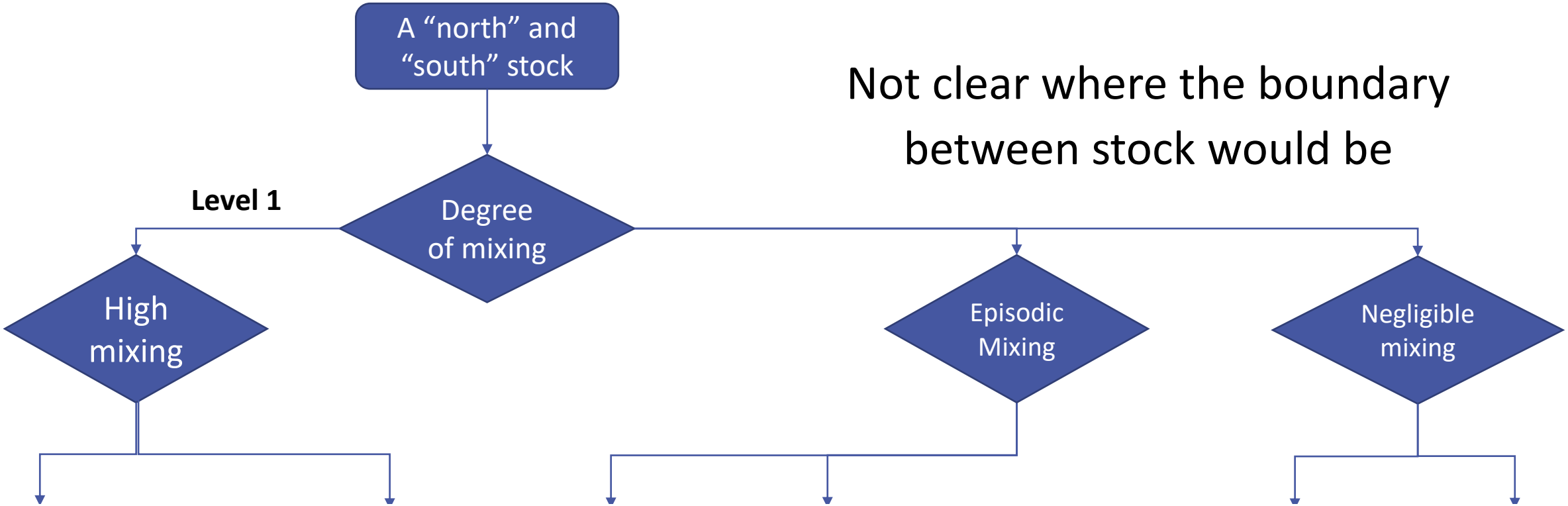
  Use spatiotemporal model for dolphin associated indices

- **Spatial structure in the population**

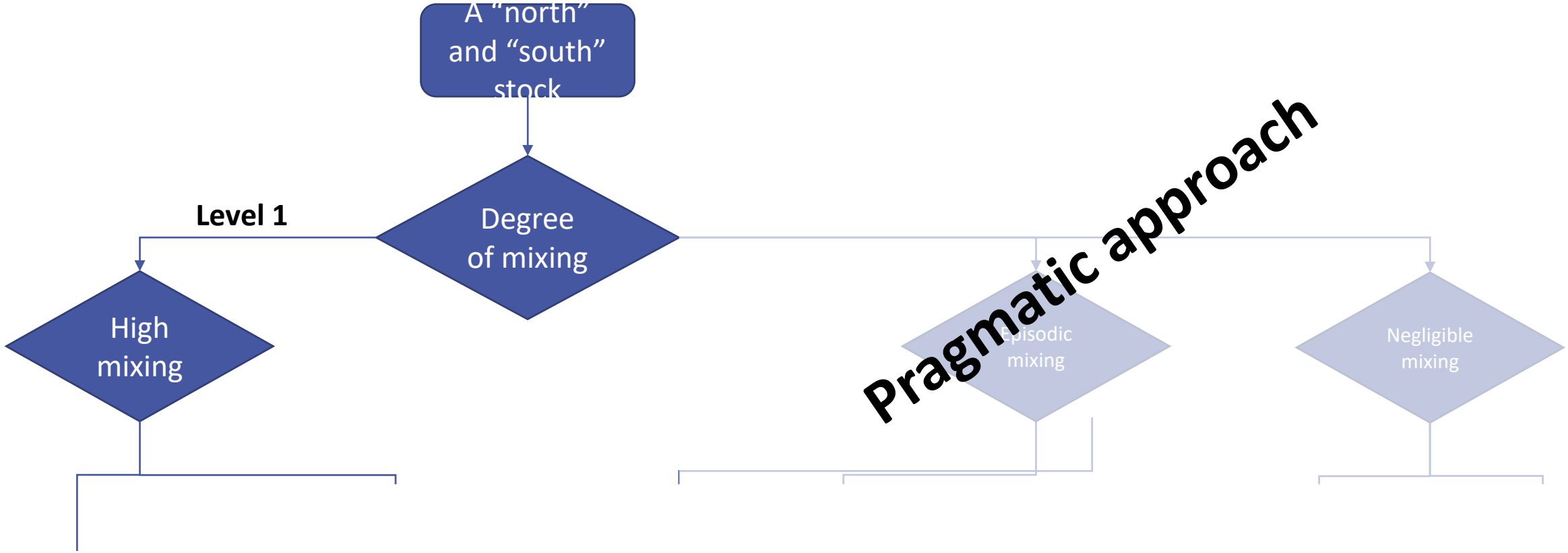
  Not investigated

2020 Conceptual model for yellowfin tuna in the EPO



Not clear where the boundary between stock would be

2020 Conceptual model for yellowfin tuna in the EPO



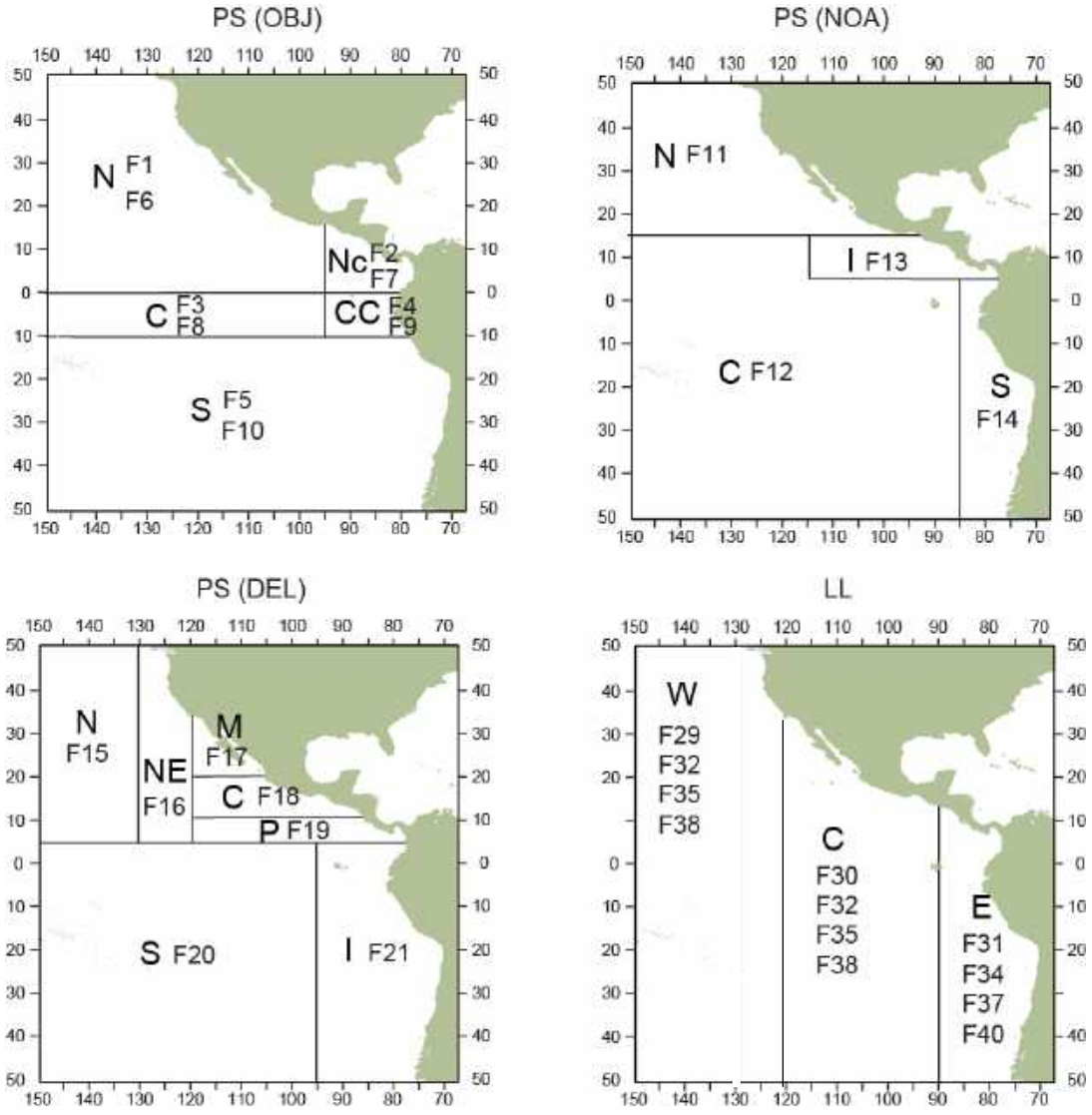
- Needed more research
- Assessment centered where the core of the catches are taken (Purse-seine index of abundance)

2020 Benchmark assessment: Fishery definitions

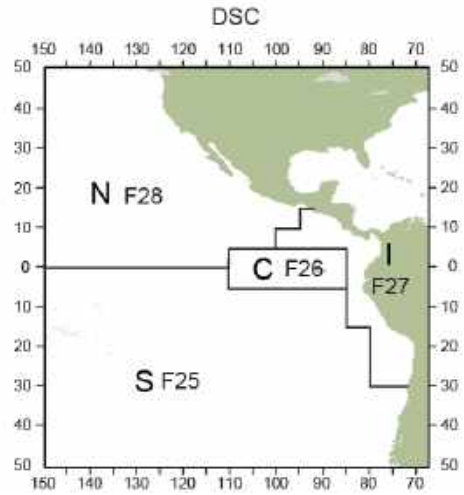
- **High mixing hypothesis**
- "Areas-as-fleets" approach
- 38 fisheries defined by gear, set type, area and quarter
- Areas and quarters grouped by similarity in the length frequency
- Floating object and longline fisheries are separated by quarter and area

  (quarters 1 and 4, quarters 2 and 3)

2020 Benchmark assessment: Fishery definitions

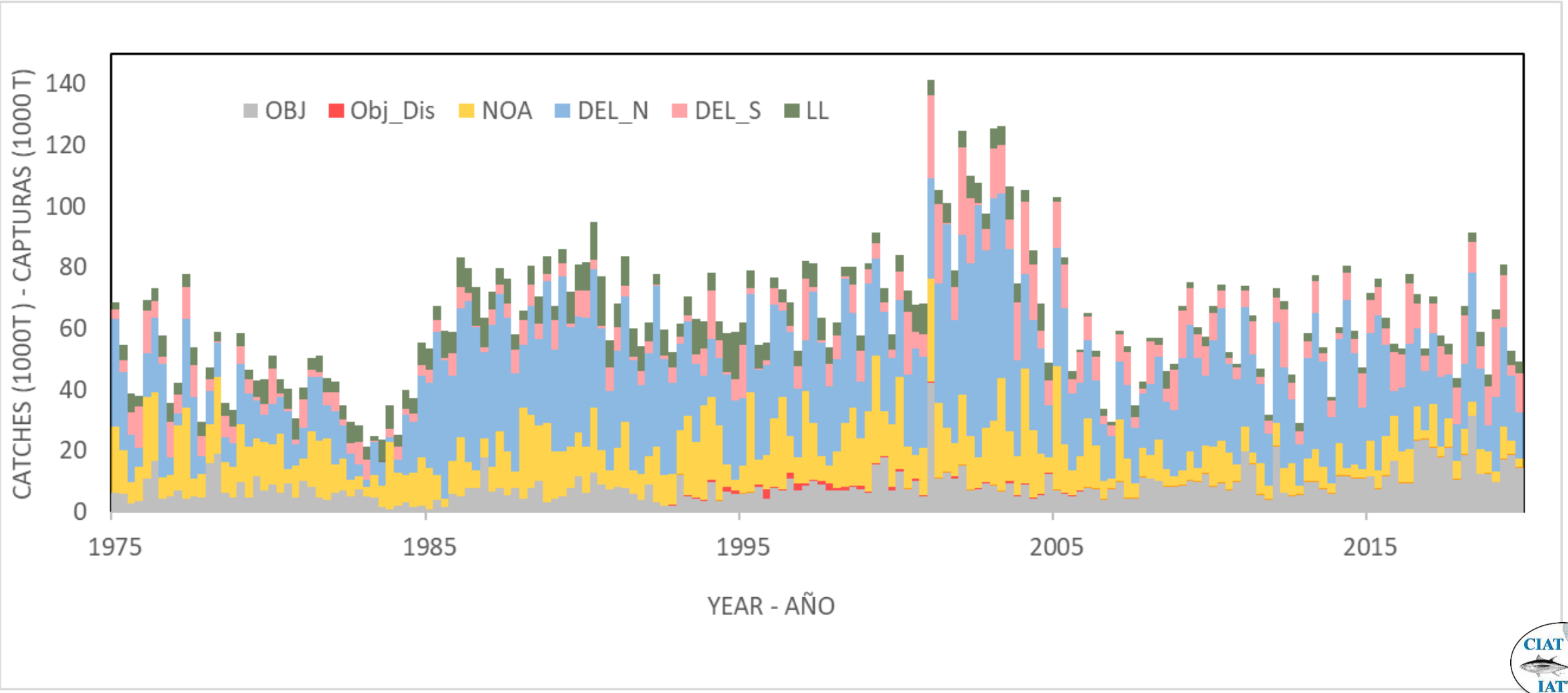


PS- Discards

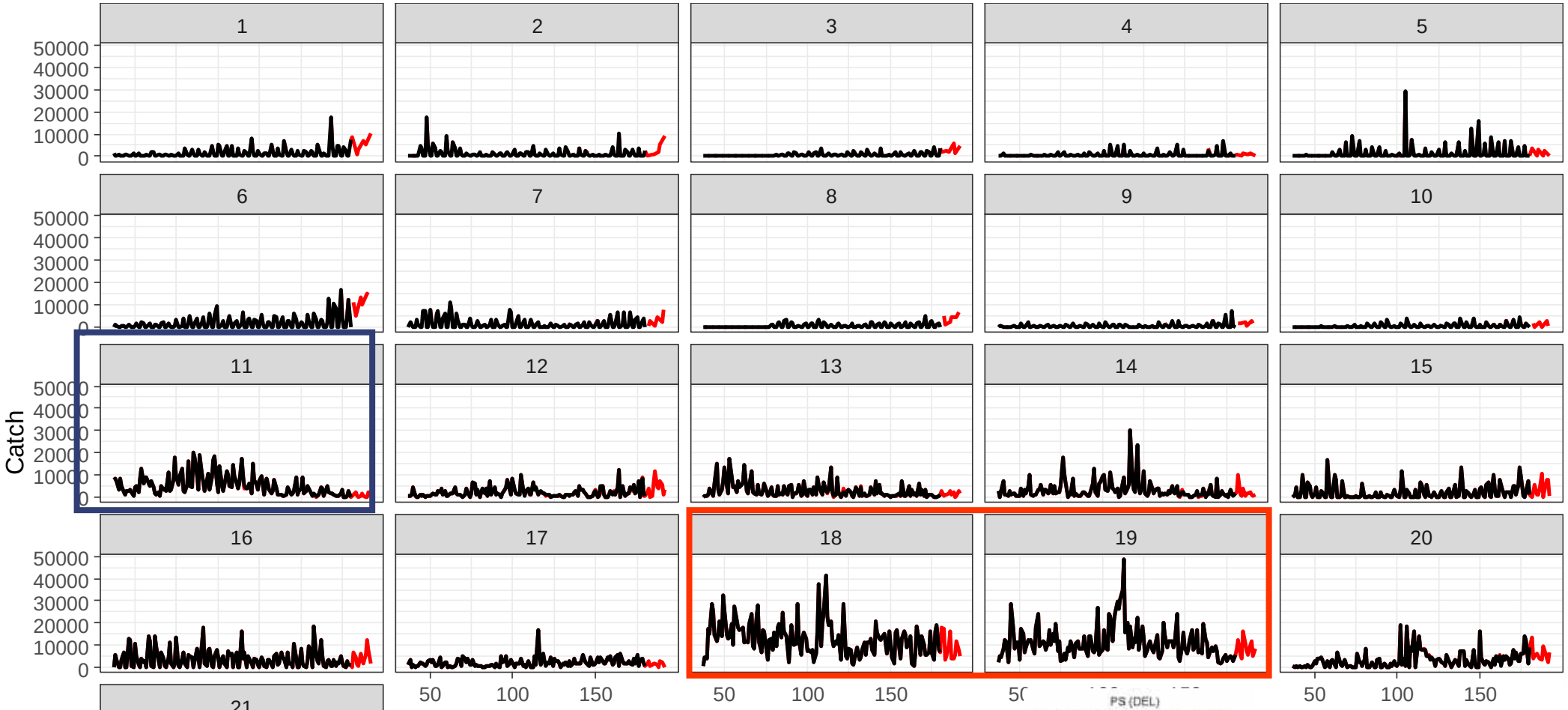


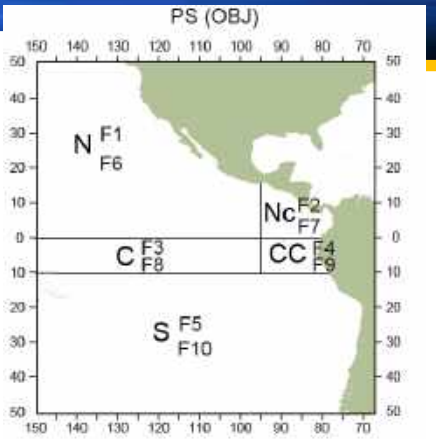
Data – catch (quarterly)

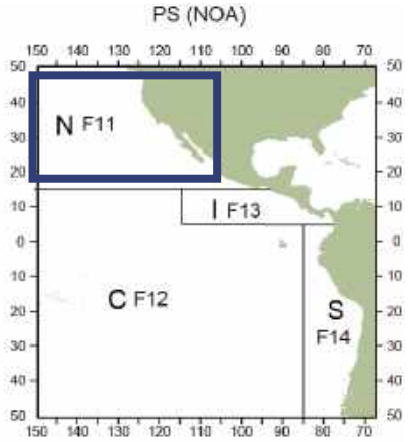
- **PS-DEL** (N and S) is the main fishery
- **PS-OBJ** has been increasing since 2015

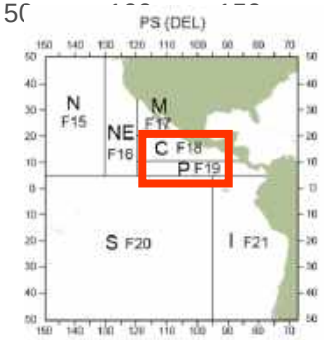


Data – purse-seine catch by fishery (annual)





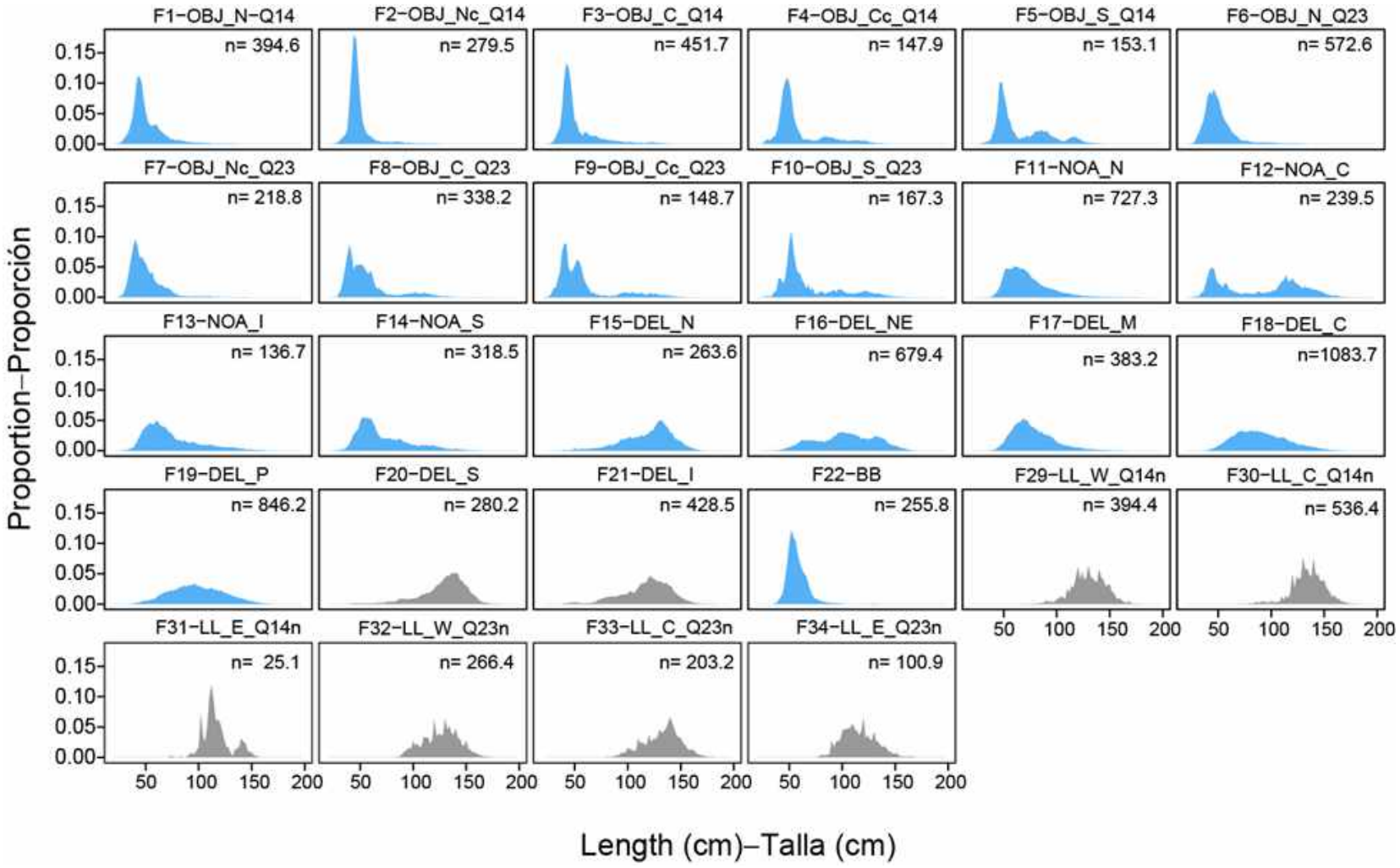




1984-2019

2020-2022

Data – size composition



Models are

fit

not fit

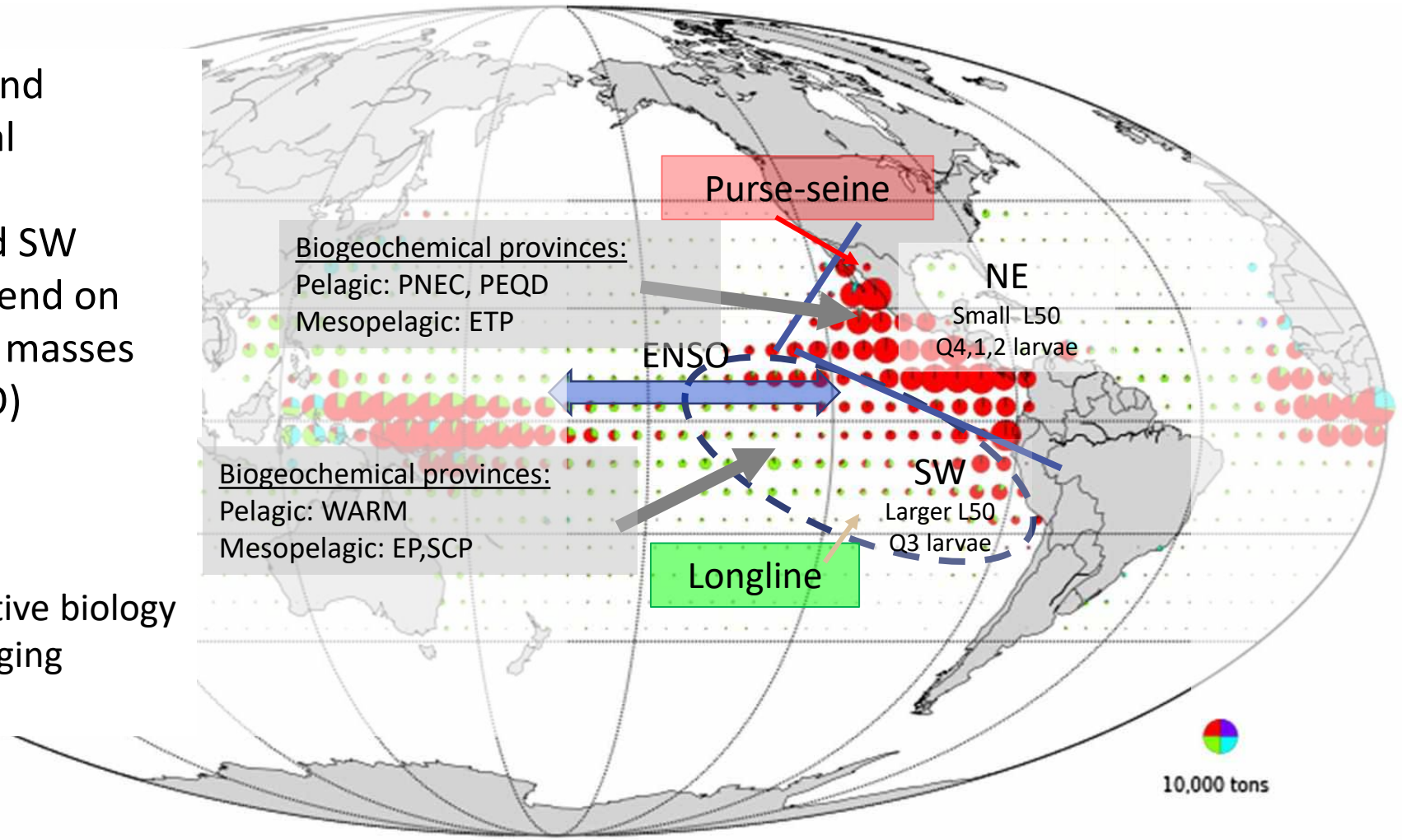
to this data

Update of the conceptual model for yellowfin tuna in the EPO

- Stocks associated with epi and mesopelagic biogeochemical provinces
- Boundaries between NE and SW stocks are dynamic and depend on the movement of the water masses (which correlates with ENSO)

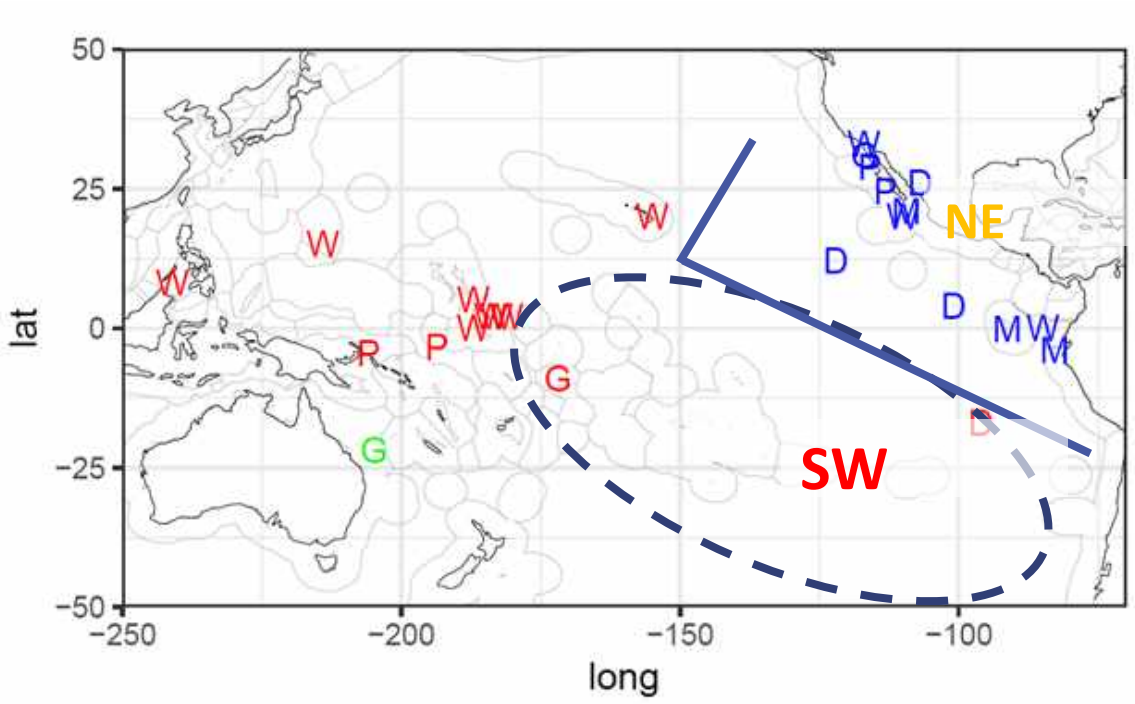
Evidence:
Genomic/ Molecular
Larval distribution/ Reproductive biology
Archival and conventional tagging
Fisheries dynamic

Two stocks in the EPO (NE and SW)



Mean annual distribution of catches of yellowfin tuna **1950-2013**
Map from Pecoraro et al 2018

Evidence: genomic/genetic data



Within each study, different color indicate genetically or genomically different, same color indicate similarity:

D D: Díaz-Jaimes and Uribe-Alcocer 2006

G G G: Grewe et al 2015

P P: Pecoraro et al 2018

M M: Muñoz-Abril et al 2022

W W: Ward et al 1997

- There may be:
  - several stocks of yellowfin tuna across the Pacific Ocean
  - 2 different stock in the EPO

Evidence: biological data

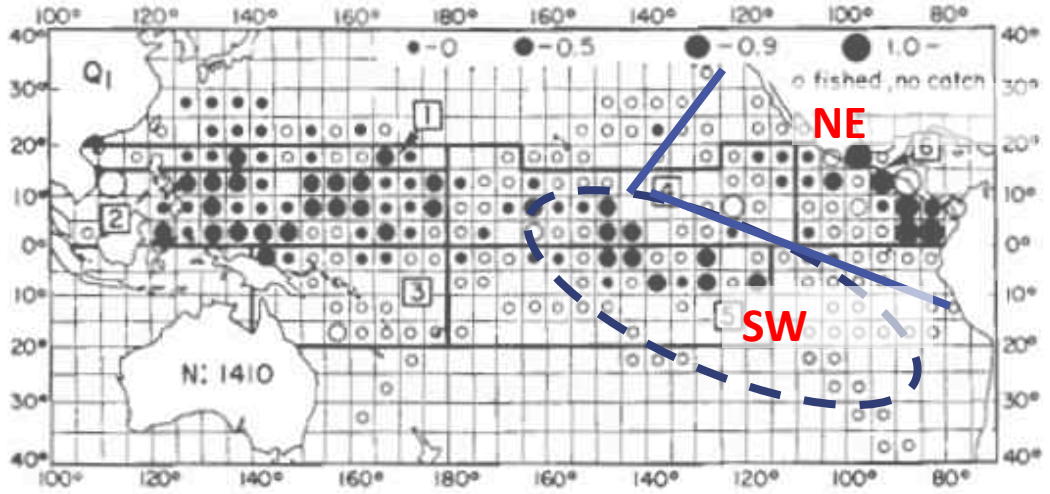
Larval distribution

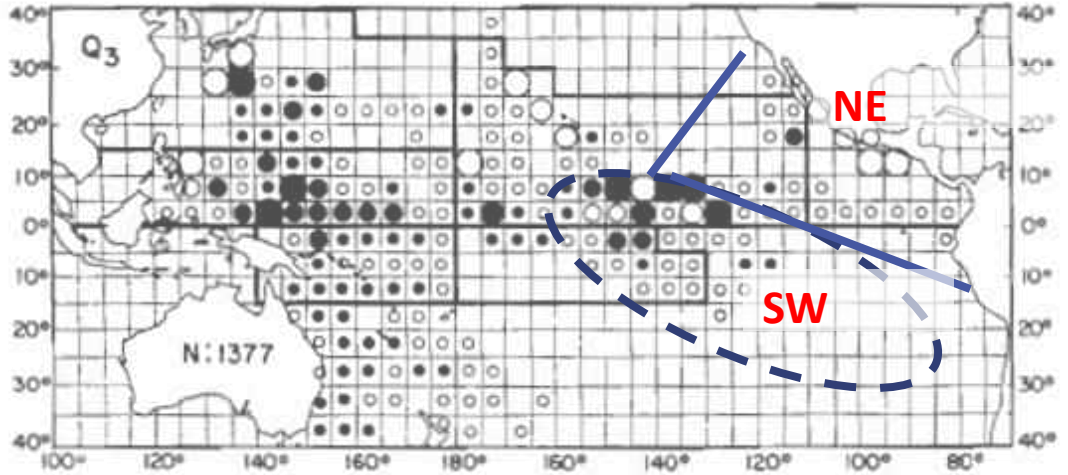
Reproductive biology

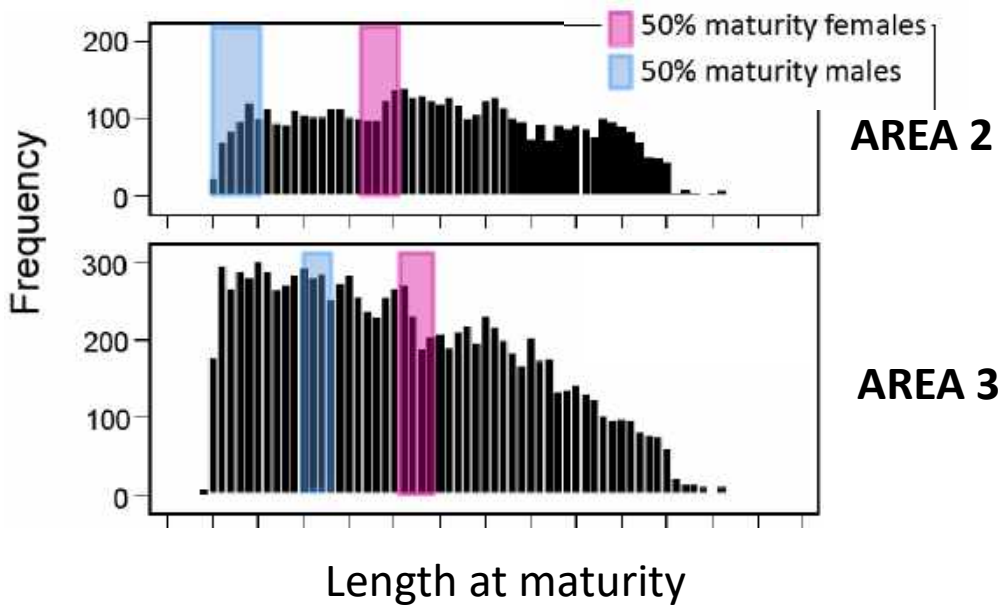
Quarter 1

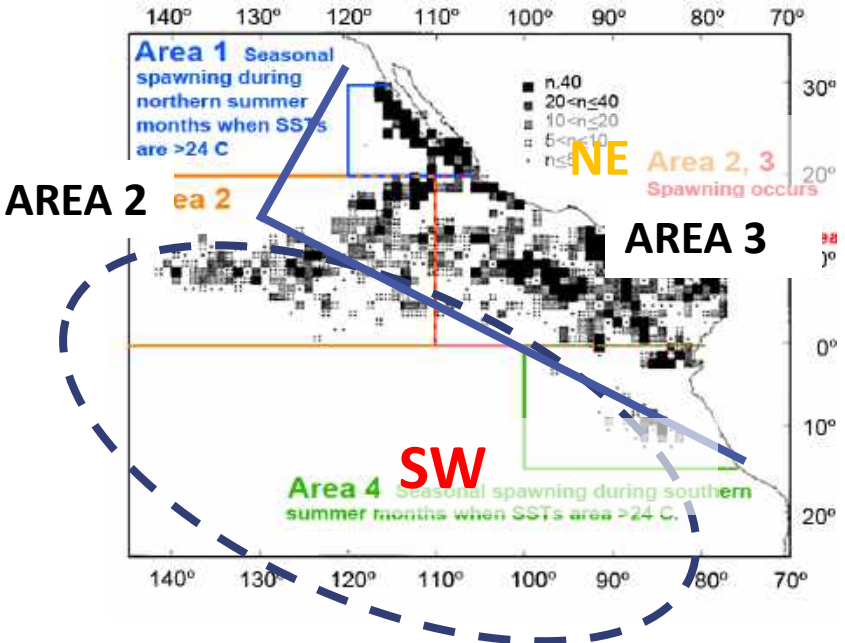
Quarter 3

Suzuki et al 1978



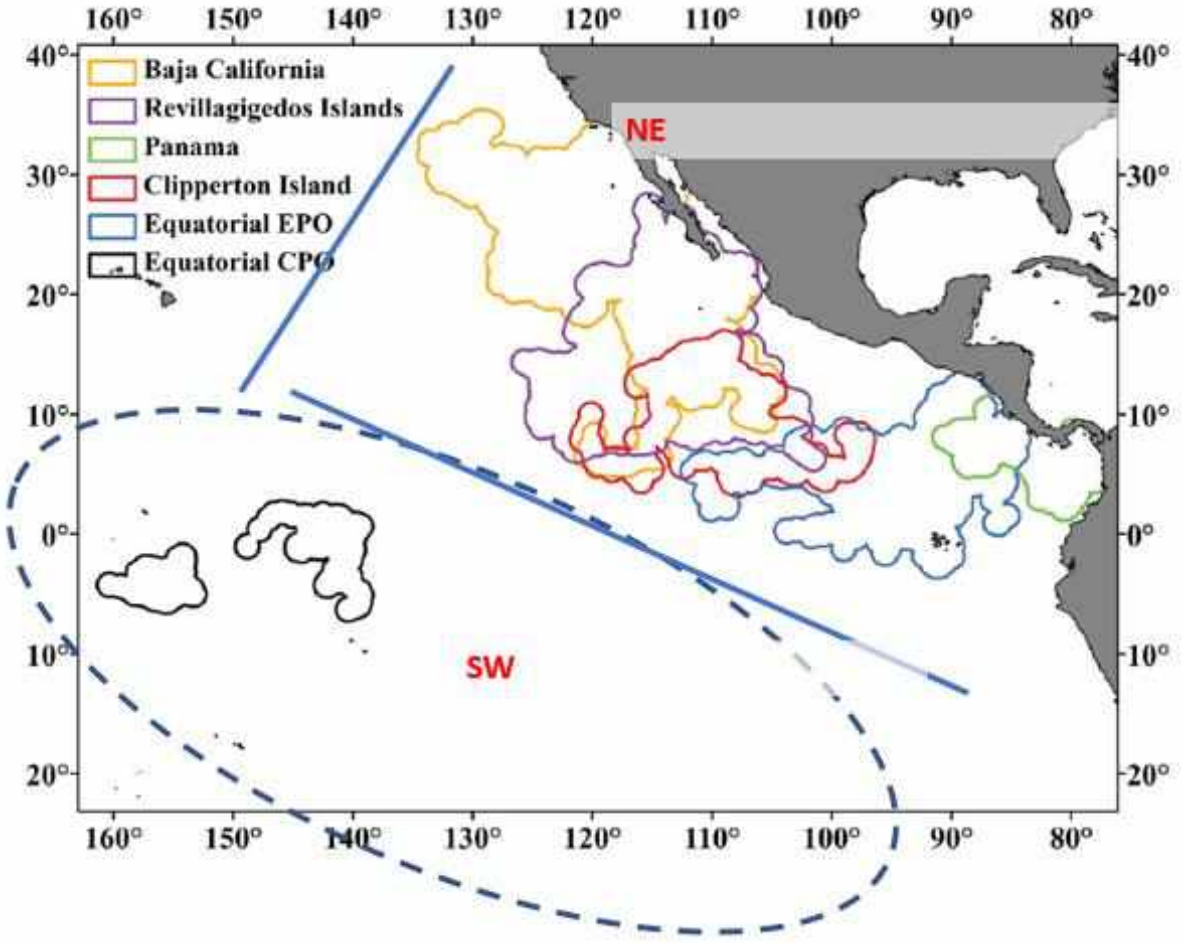


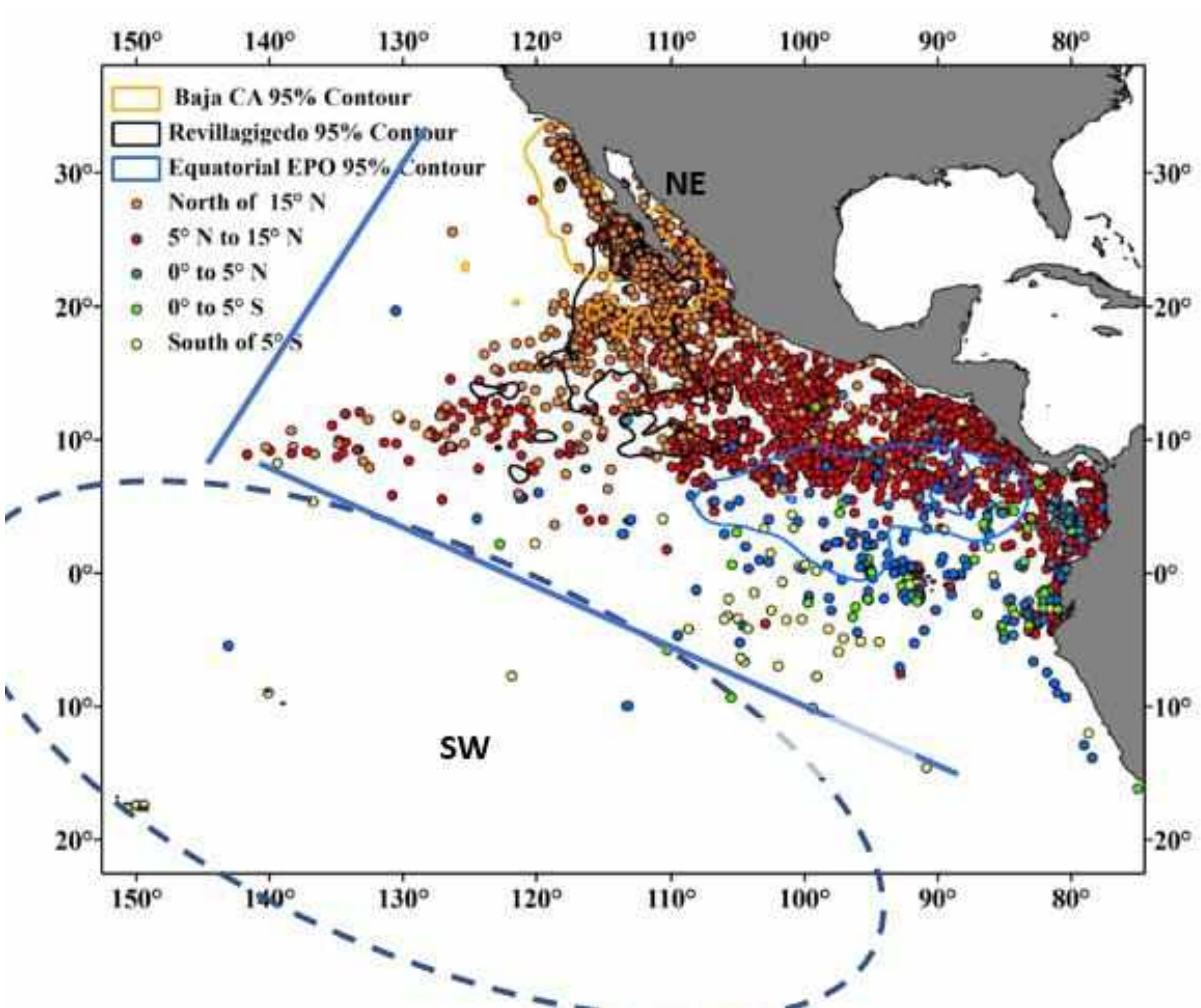




Tagging data is consistent with the conceptual model

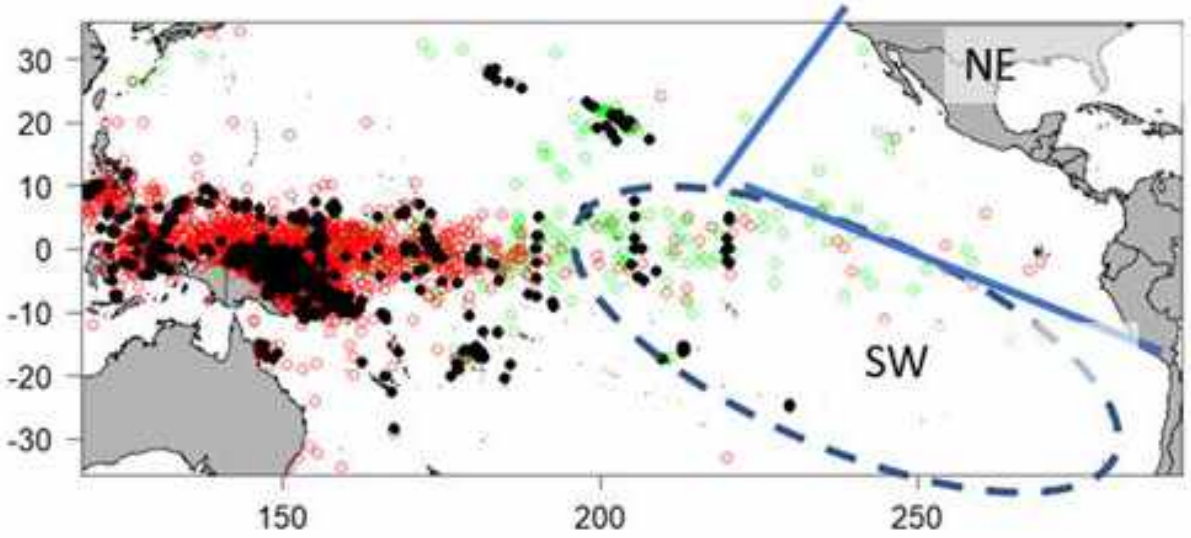
IATTC tagging data

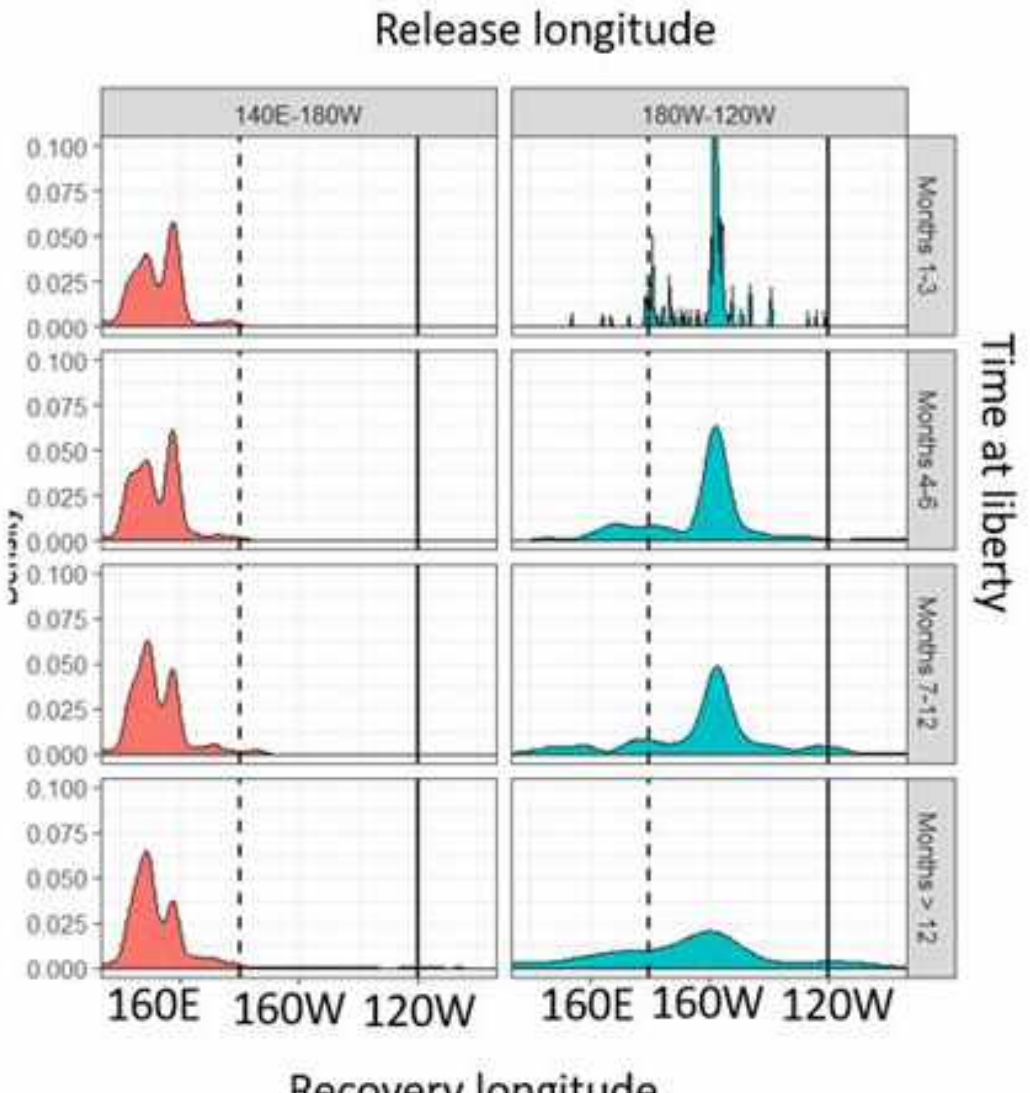




Tagging data is consistent with the conceptual model

WCPFC tagging data



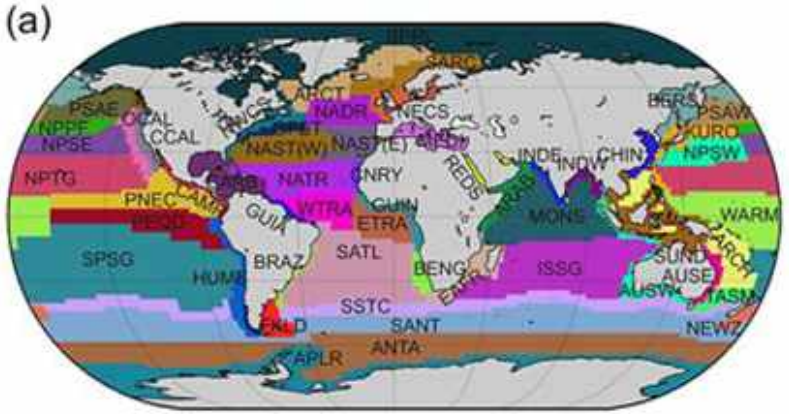


Source: SPC data, prepared by Mathew Vincent (2019) at the IATTC staff request

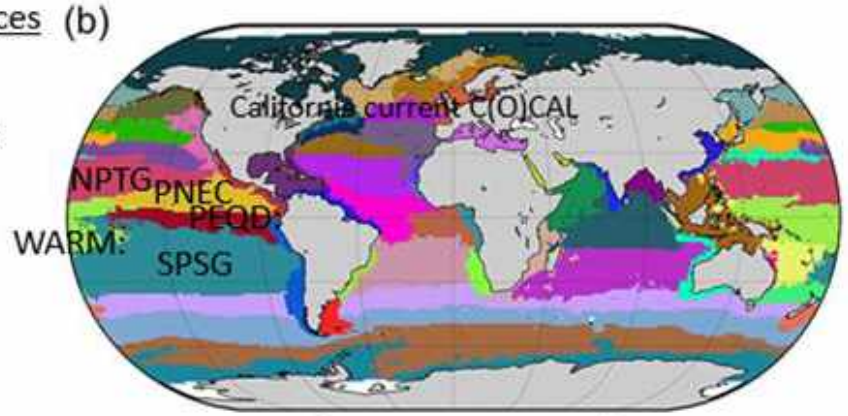
Stocks associated with biogeochemical provinces

Epipelagic

Longhurst (1995) static provinces



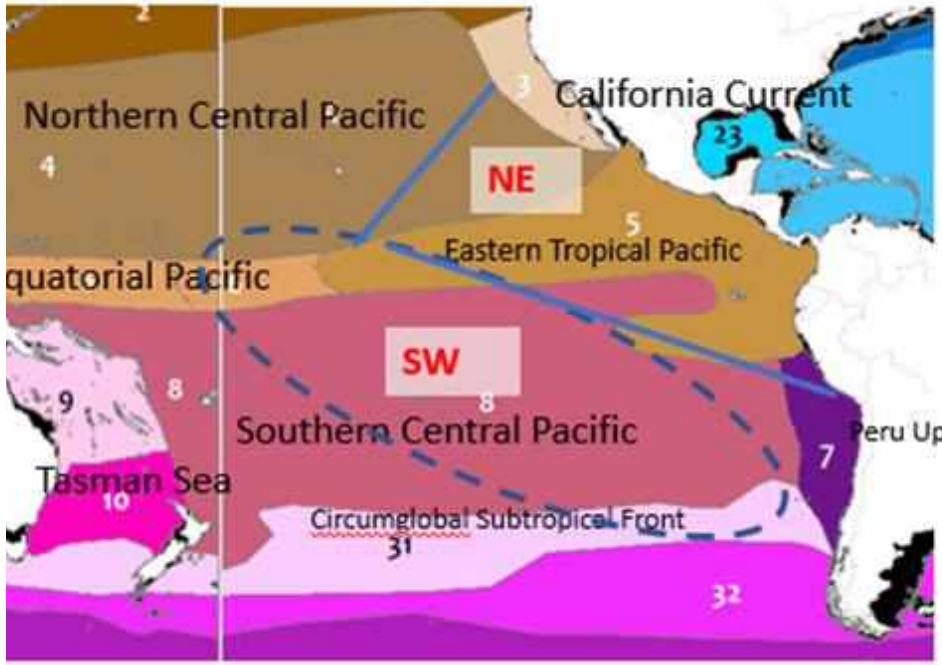
Reygondeau et al (2013) dynamic provinces



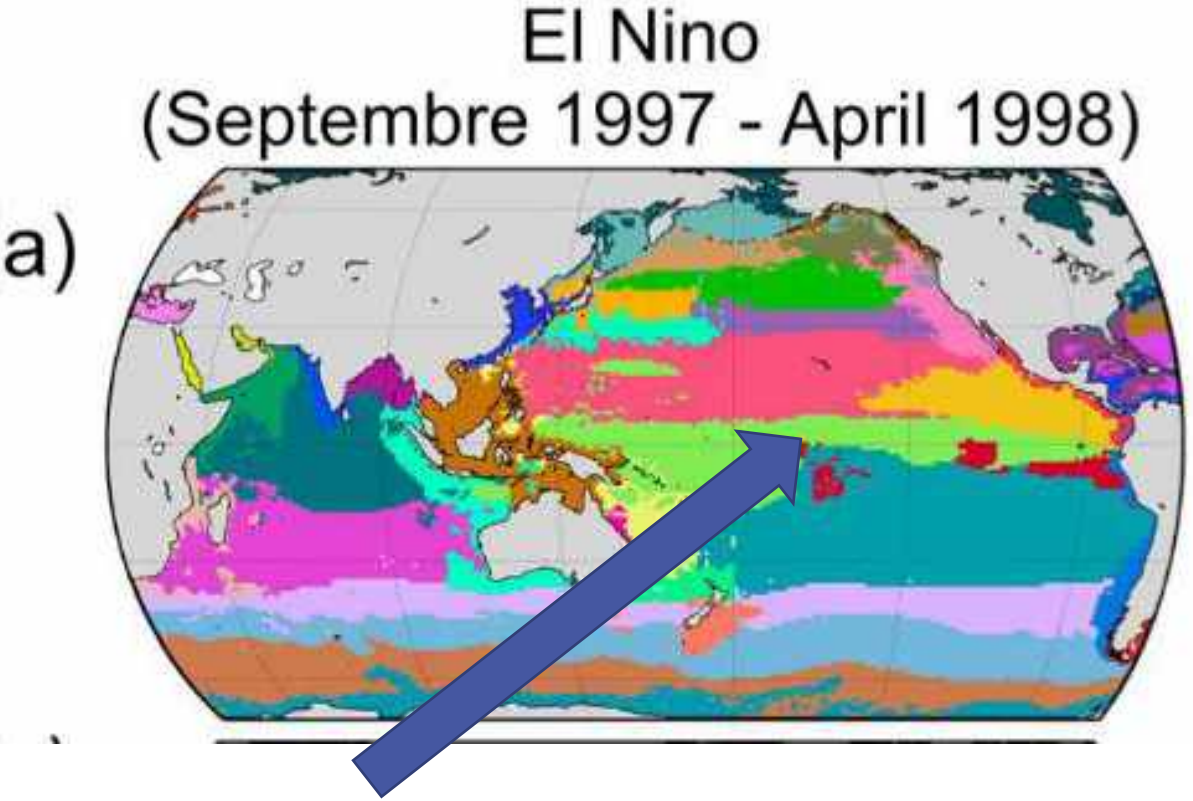
average period January 1998 to December 2007.

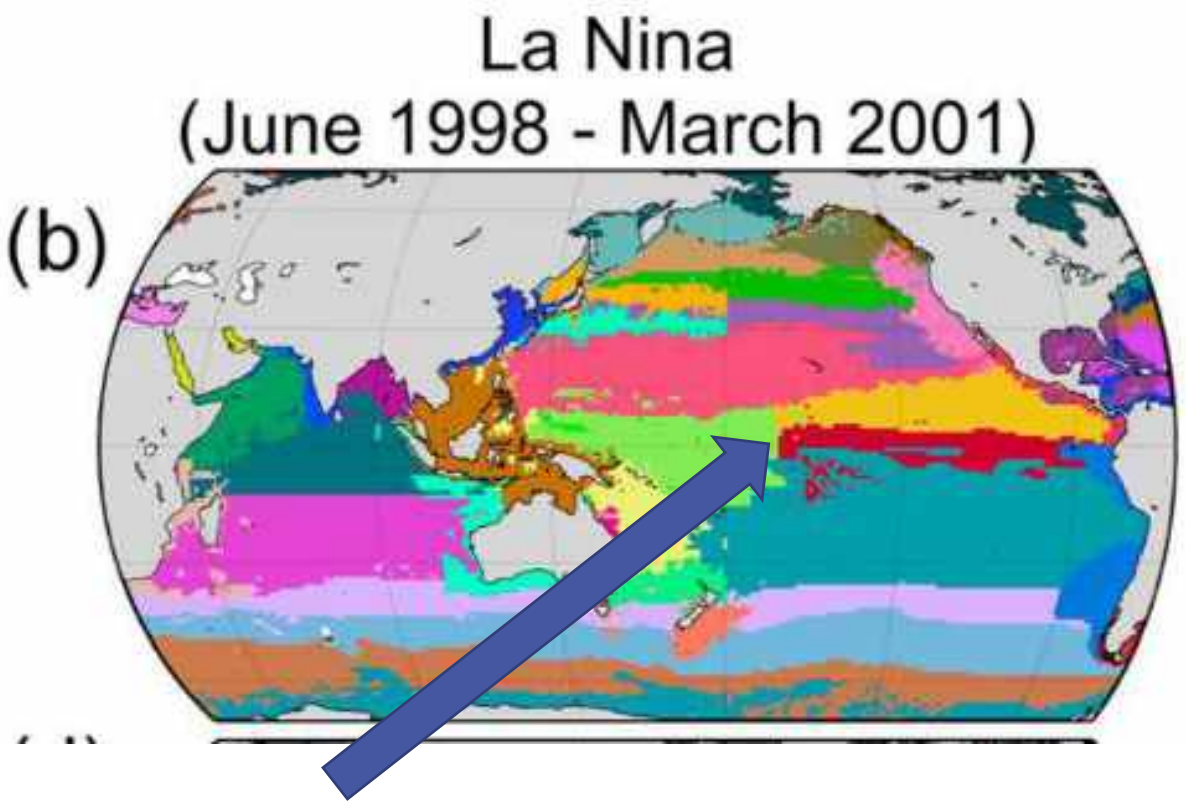
PNEC: North Pacific equatorial counter current
PEQD: Pacific equatorial divergence
NPTG: North Pacific Tropical gyre
WARM: Western Pacific warm pool
SPSG: South Pacific gyre

Mesopelagic



Biogeochemical provinces are dynamic





WARM pool expansion,
Contraction of
PNEC: North Pacific Equatorial Counter Current
PEQD: Pacific Equatorial divergence

WARM contraction,
PNEC, PEQD expansion

Principal component analysis on oceanographic variables

mixed layer depth

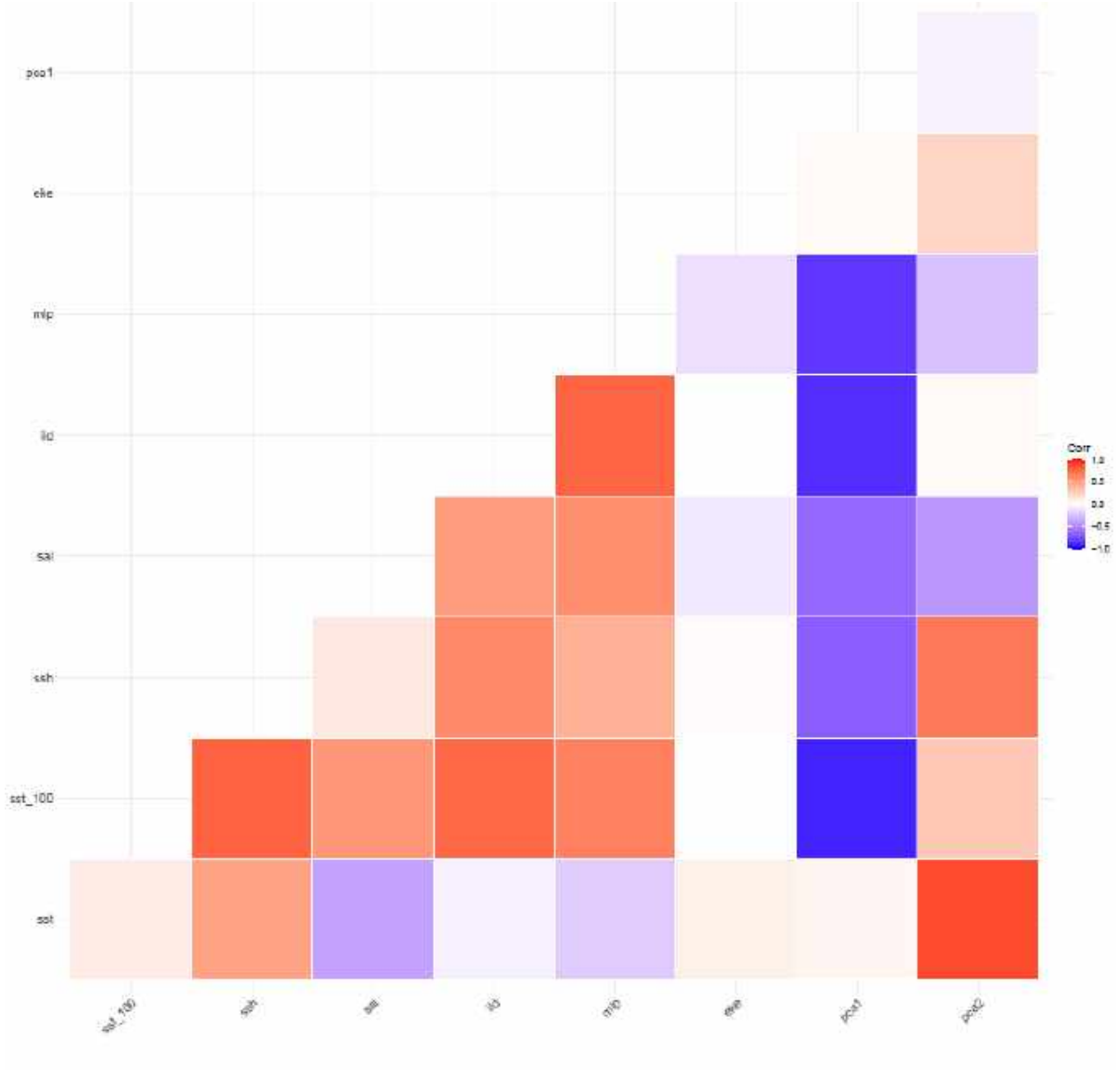
isothermal layer depth

salinity

Sea surface height

temperature at 100 meter

temperature



PC1: Gradient in water column structure

PC2: Gradient in sea Surface temperature

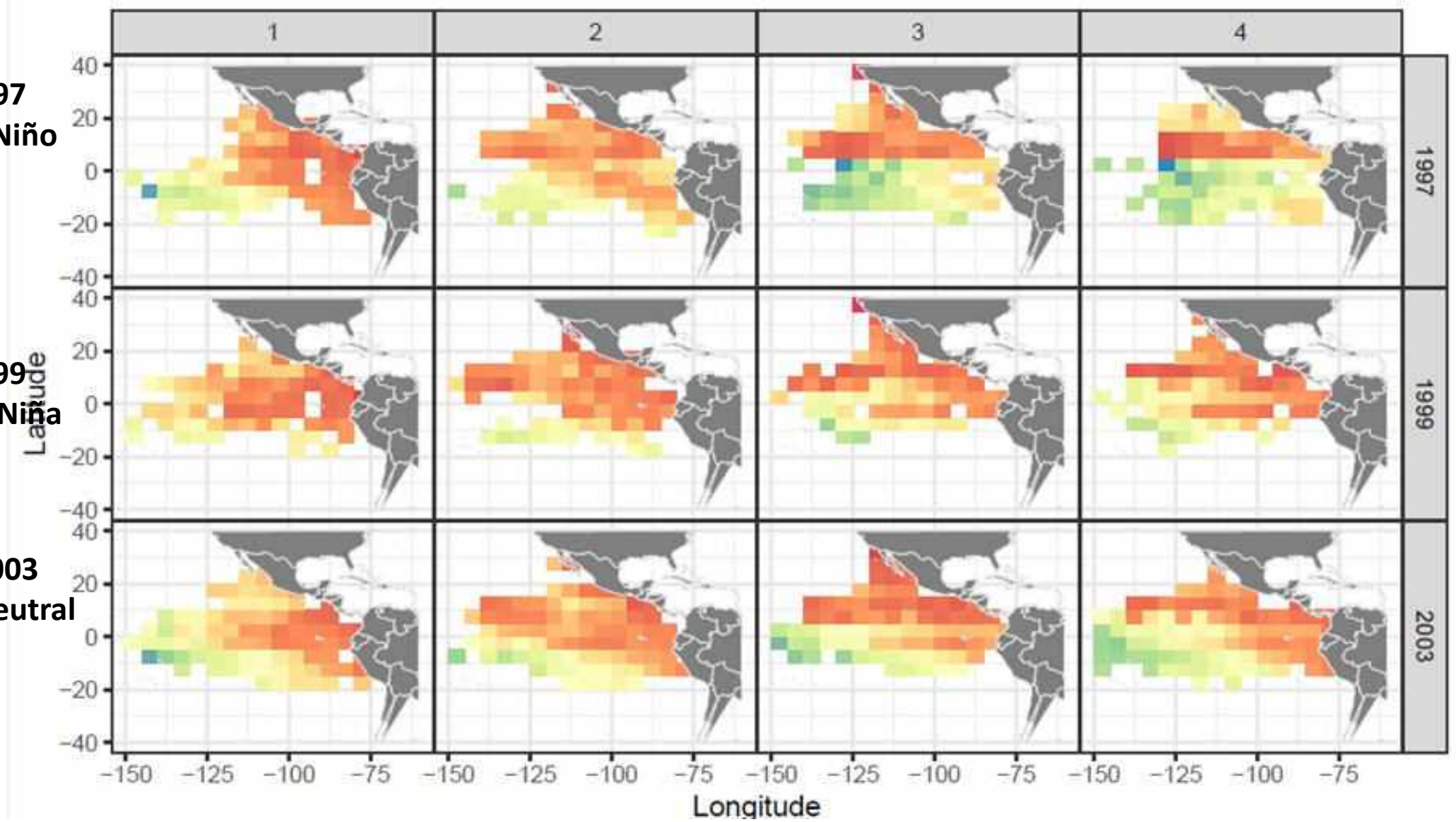
CIAT IATTC

Principal component analysis on oceanographic variables

1997
El Niño

1999
La Niña

2003
Neutral

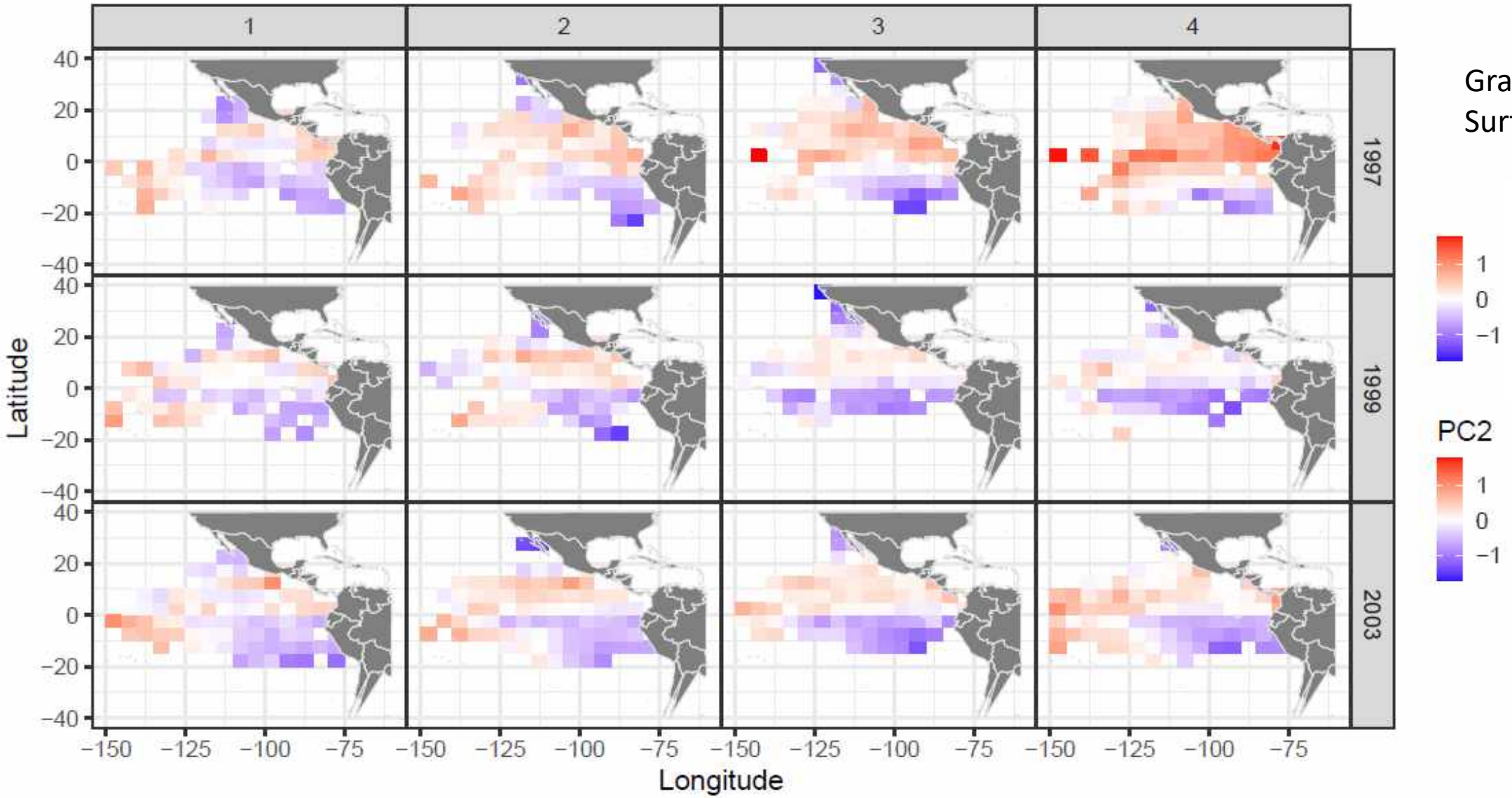


PC1

Gradient in water column structure

CIAT
IATTC

Principal component analysis on oceanographic variables



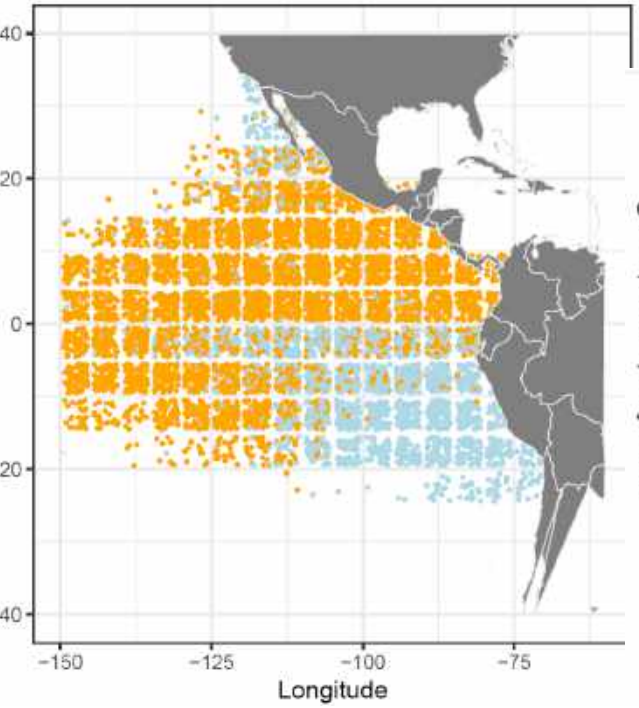
PC2

Gradient in sea Surface temperature

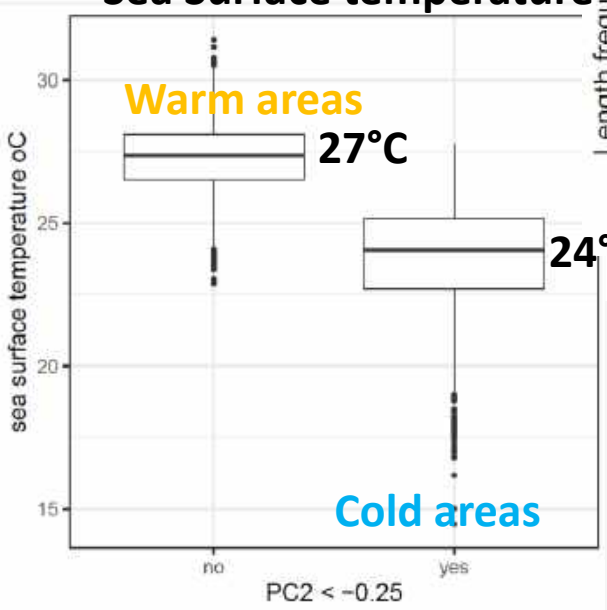
Tree analysis on length frequency using environmental gradients as explanatory variable

Floating objects set

Locations of all PS sets 1994-207

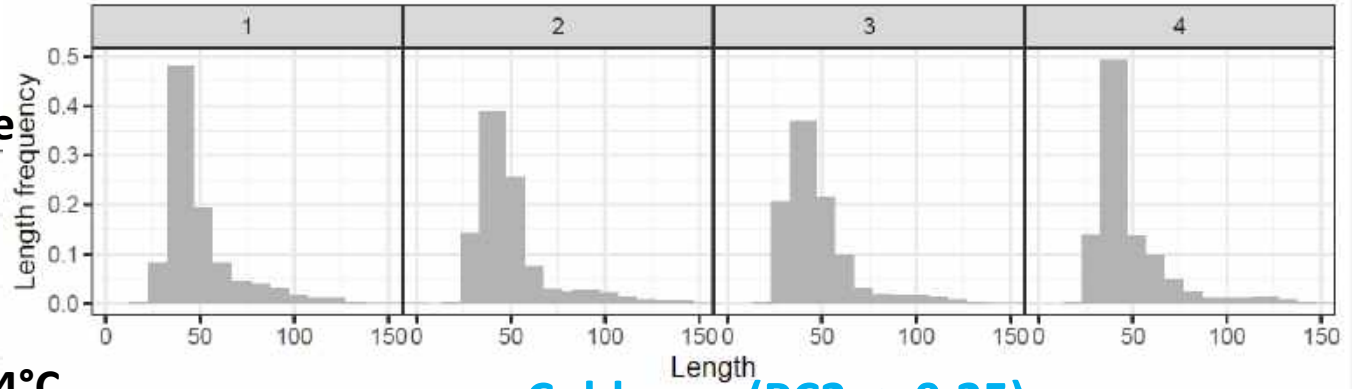


Sea Surface temperature

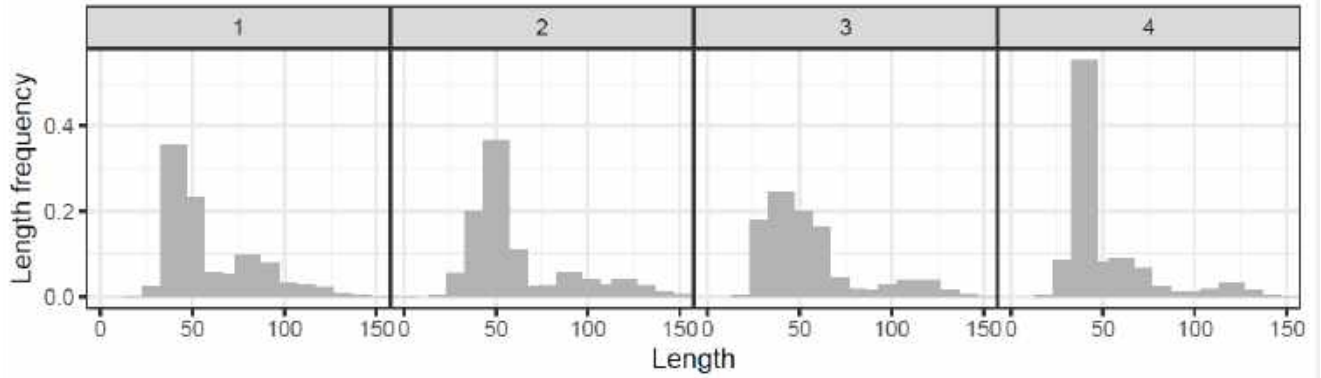


Temperature gradient

Warm area (PC2 > -0.25)

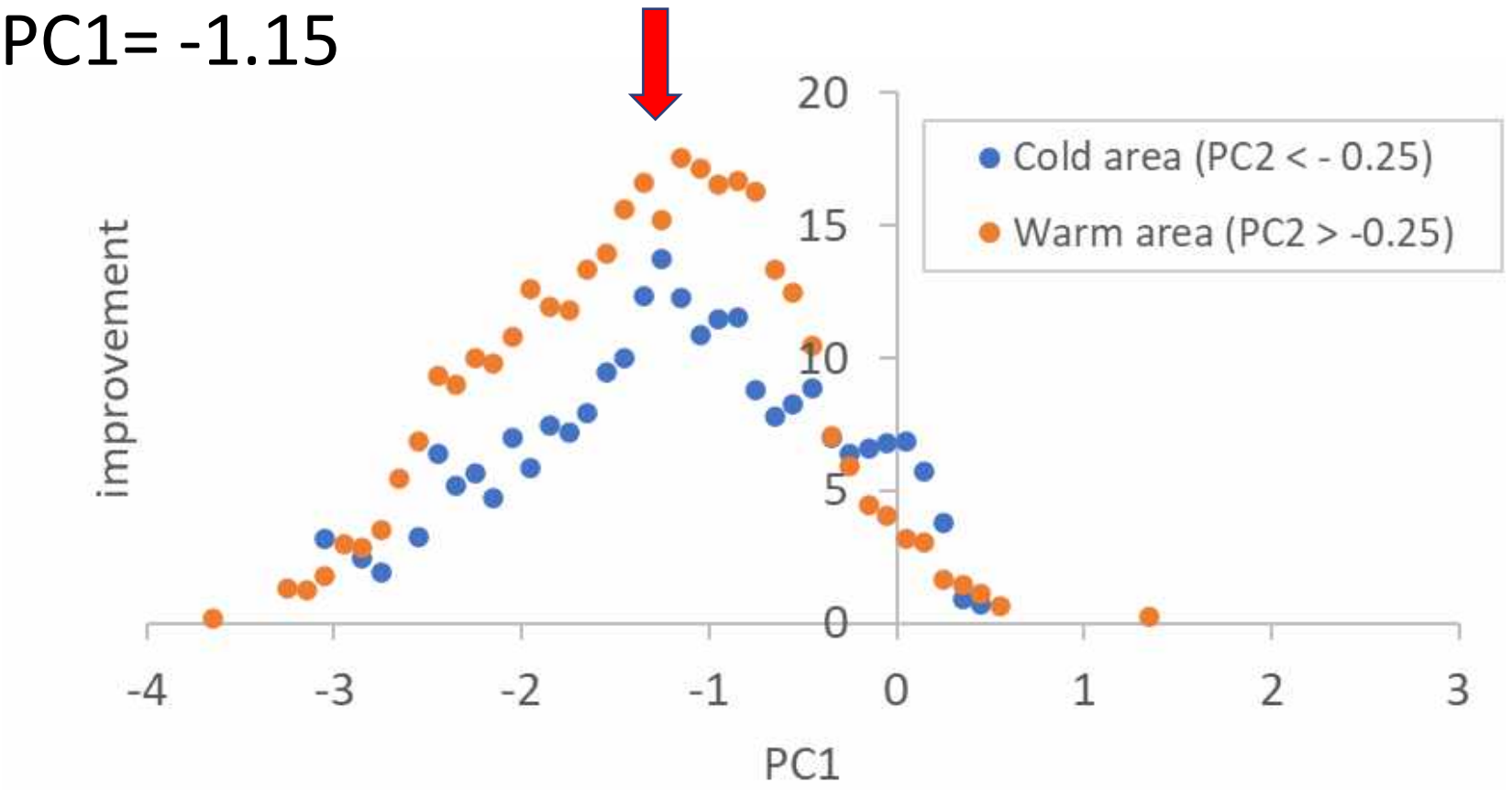


Cold area (PC2 < -0.25)



Tree analysis

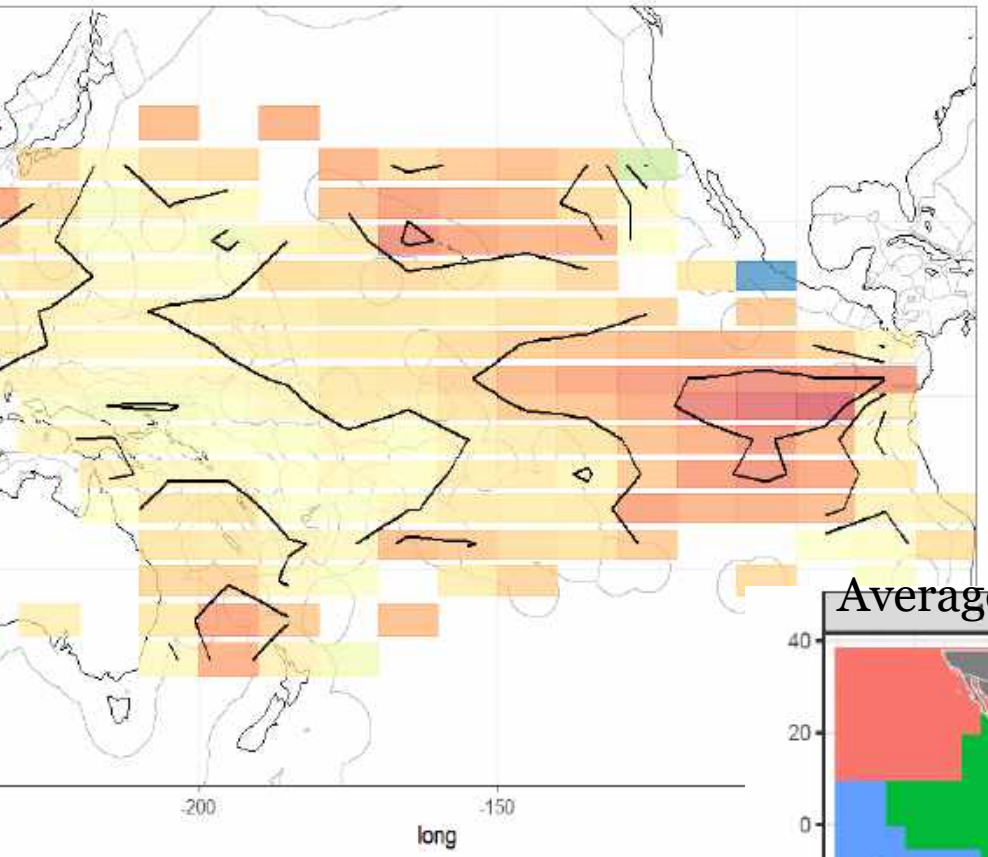
Length frequency data supports a split at PC1= -1.15



Longline size patterns

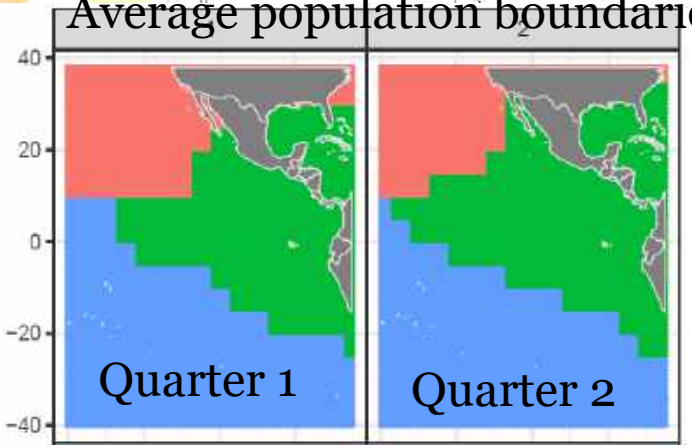
Hoyle et al in prep (1984- 2010)

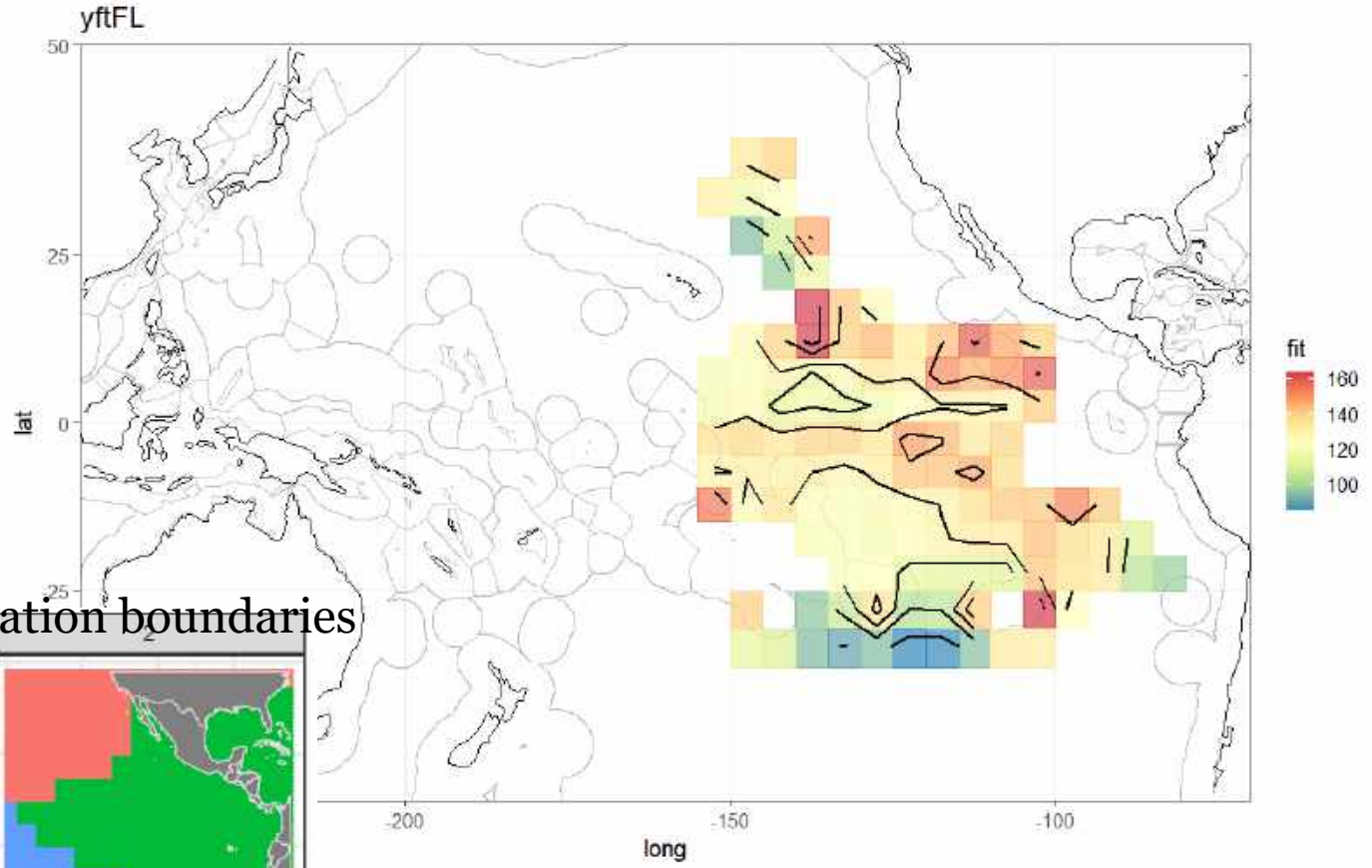
Longline observers (2013-2019)



Prediction year 2000, quarter 3

Average population boundaries





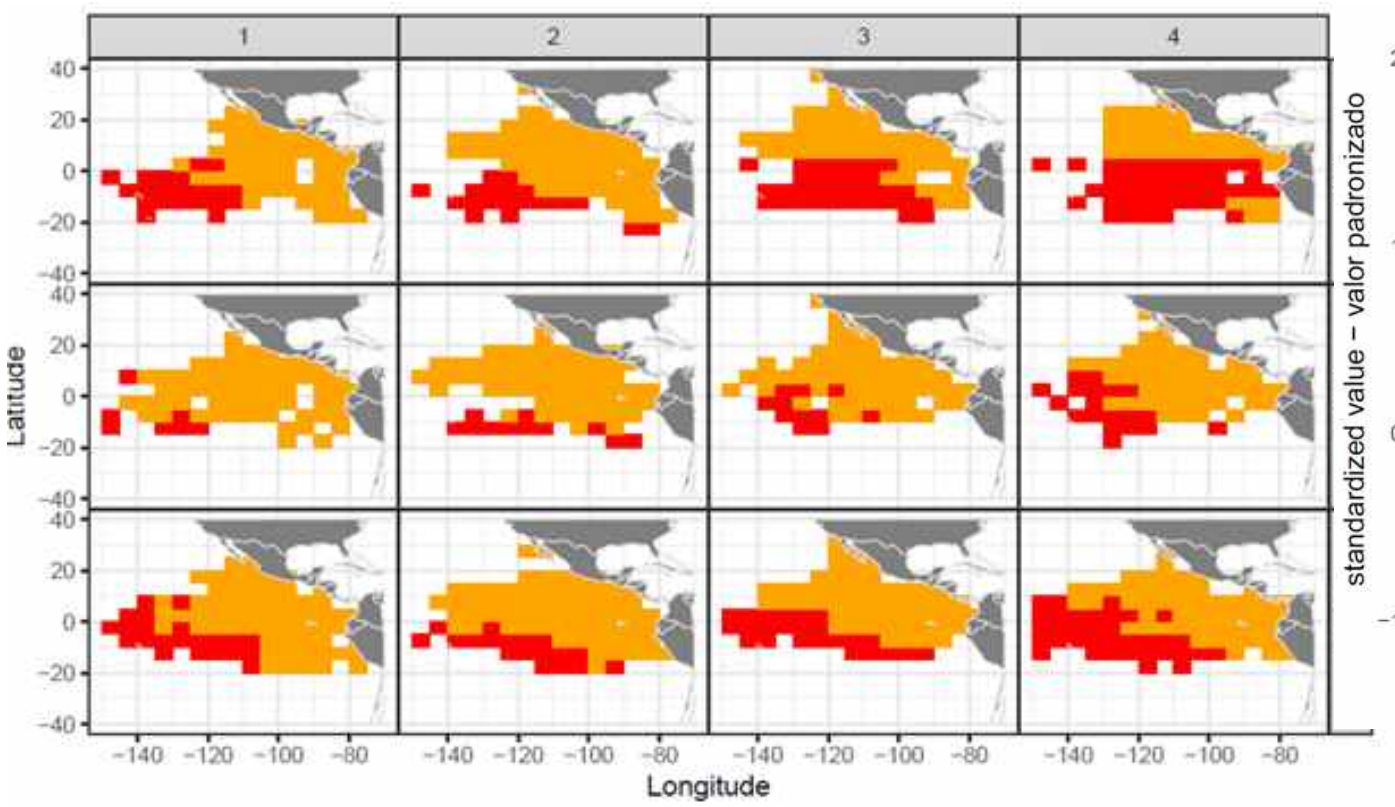
Prediction year 2018, quarter 3

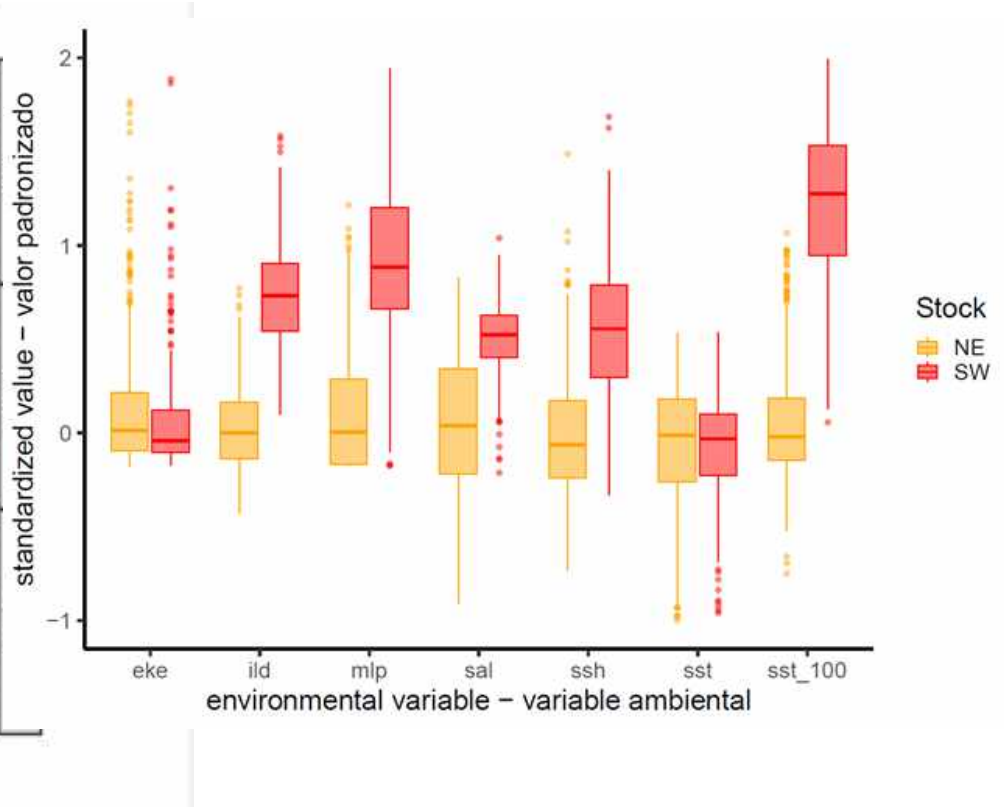
Stock separation

1997
El Niño

1999
La Niña

2003
Neutral



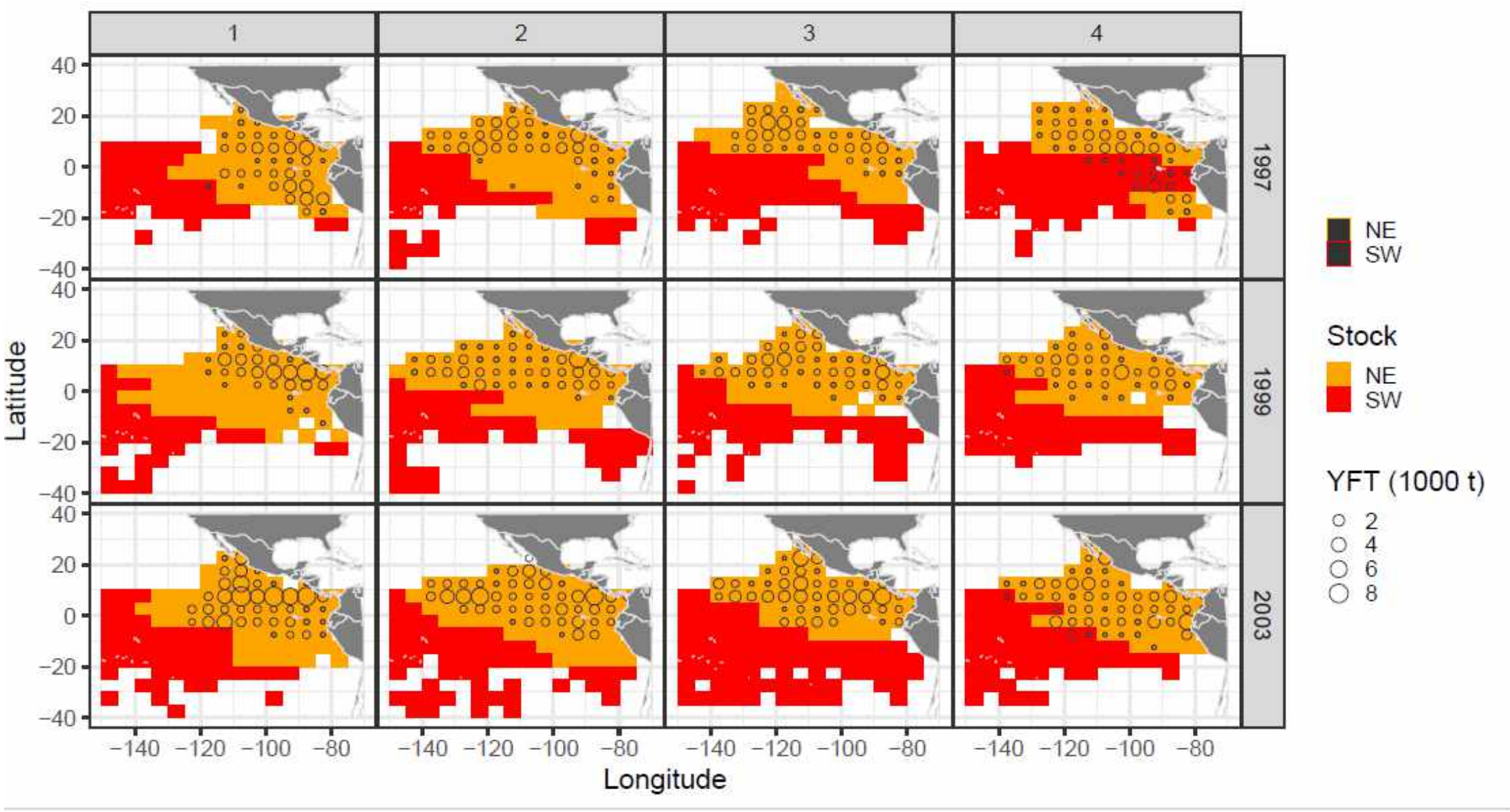


Catch distribution: dolphin sets

1997
El Niño

1999
La Niña

2003
Neutral

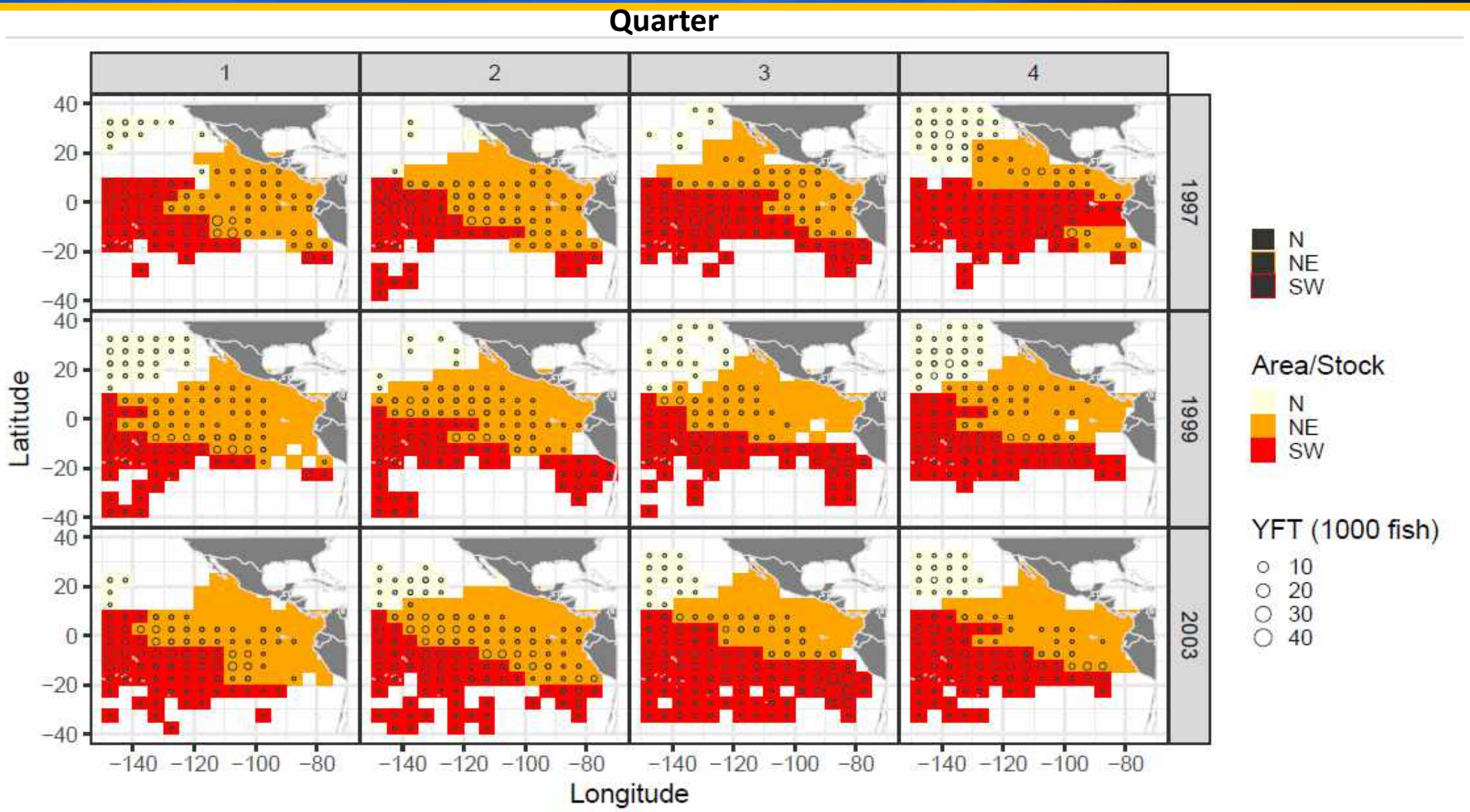


Catch distribution: longline sets

1997
El Niño

1999
La Niña

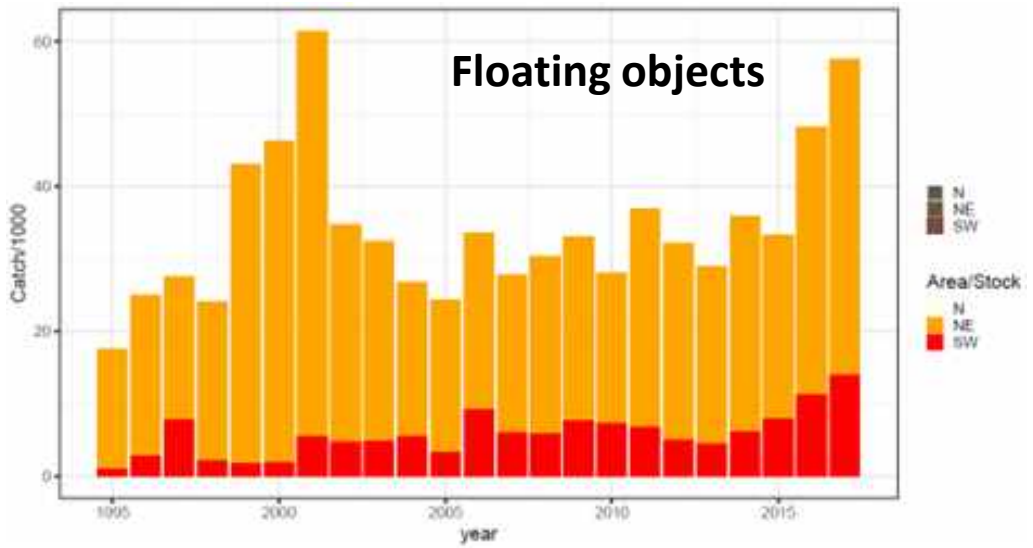
2003
Neutral

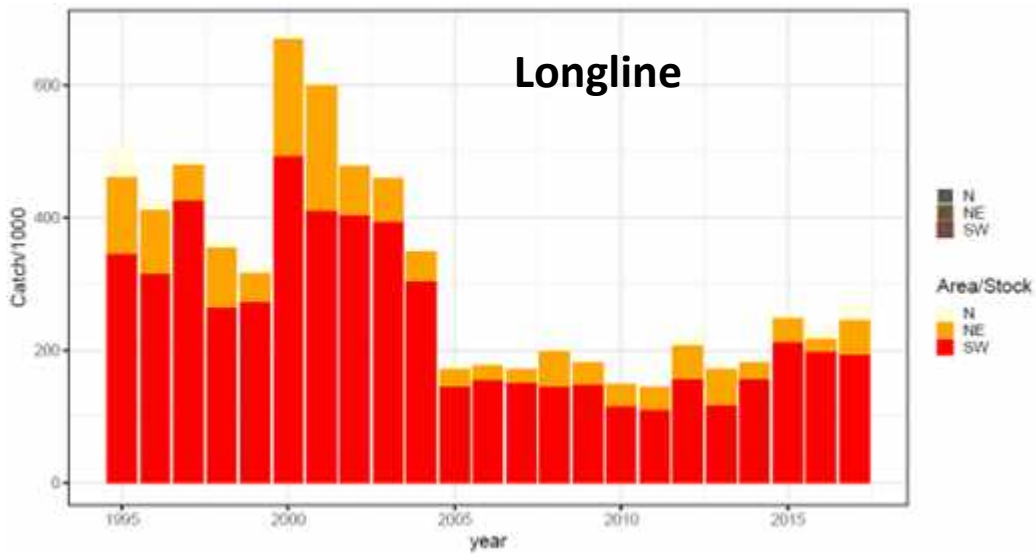


Catch distribution: proportion by area

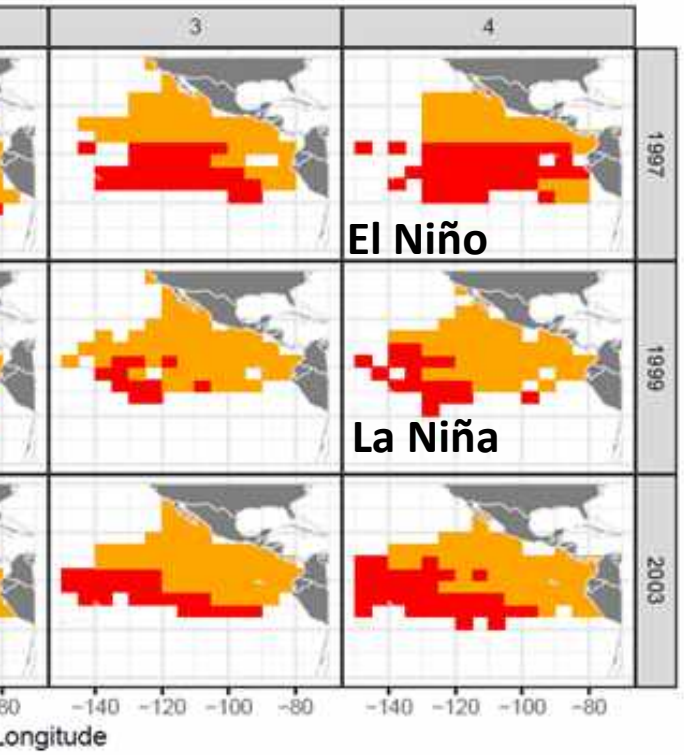
Average proportion of the catches (in weight for purse-seine and in numbers for longline) from the NE and SE putative stocks and from the north area

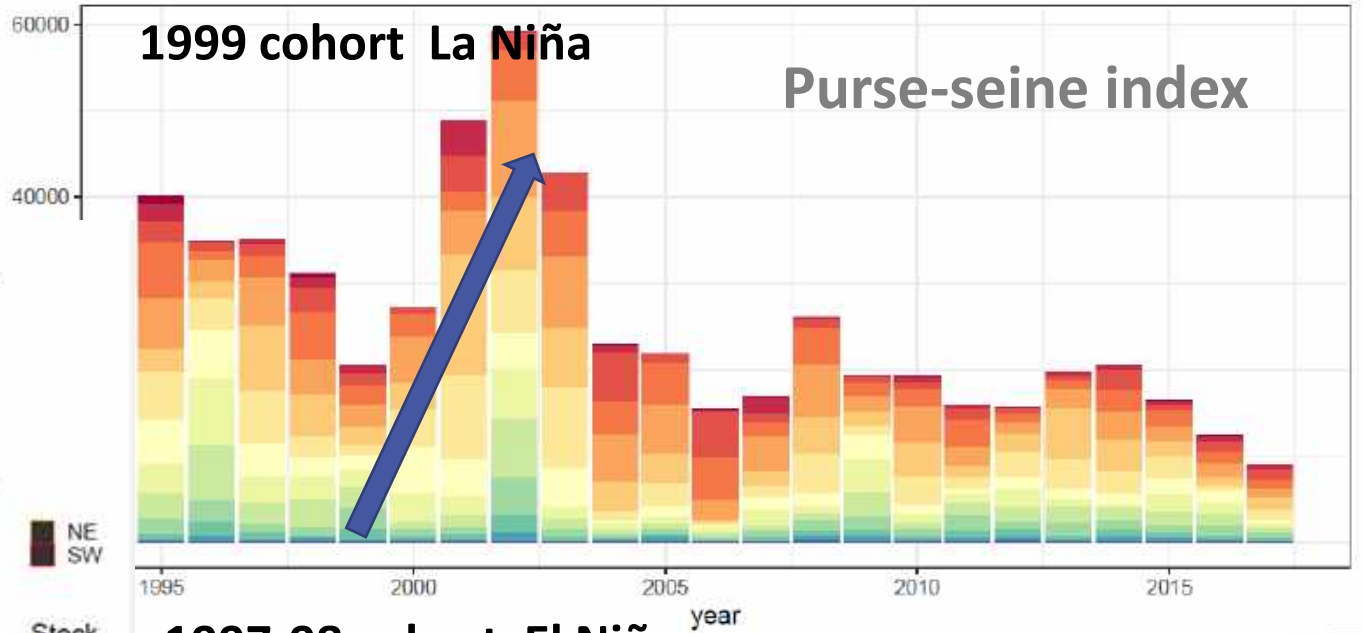
Gear	Set type	NE	SW	N
Purse-seine	Dolphin	99%	1%	1%
	Unassociated	96%	2%	2%
	Floating Objects	83%	17%	0%
Longline		17%	79%	4%



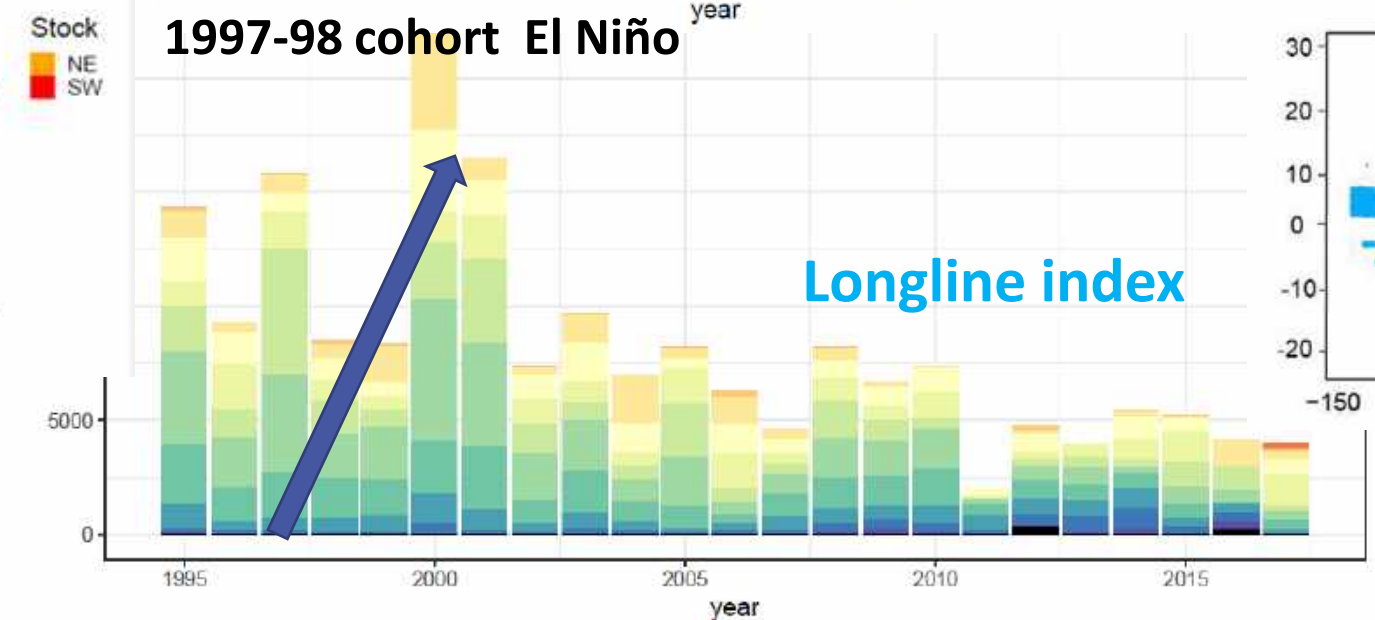


Population trends





length	age
30	0.7
40	0.9
50	1.1
60	1.4
70	1.7
80	1.9
90	2.1
100	2.5
110	2.7
120	2.9
130	3.1
140	3.6
150	4.0
160	4.5



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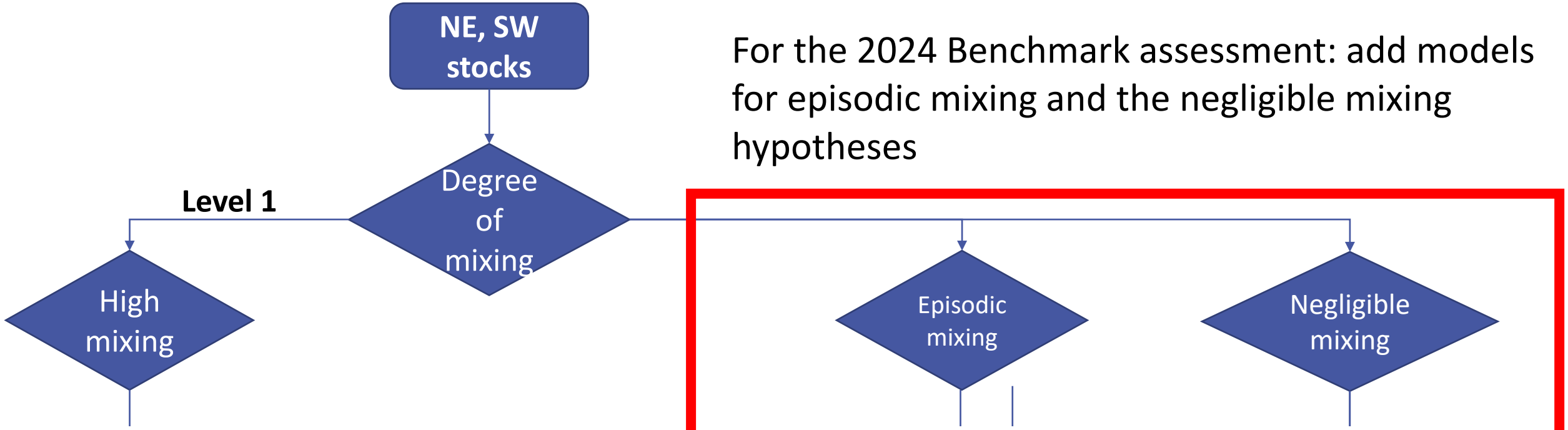
Summary

- At least two stocks of yellowfin tuna (NE,SW) in the EPO associated with biogeochemical provinces
- This conceptual model is supported by available information
- The boundary is dynamic
- The boundary was informed using environmental gradients and length composition data, this may be a viable technique to split the catches

Future directions



For the 2024 Benchmark assessment: add models for episodic mixing and the negligible mixing hypotheses

All catches
Not fit to longline data

Remove catches from "SW population"


Questions