Conceptual model and spatial structure for yellowfin tuna and hypotheses for risk analysis

1st External review of modelling aspects in stock assessments of tropical tuna in the eastern Pacific Ocean

6 - 10 Nov 2023 - Videoconference

Key messages and issues

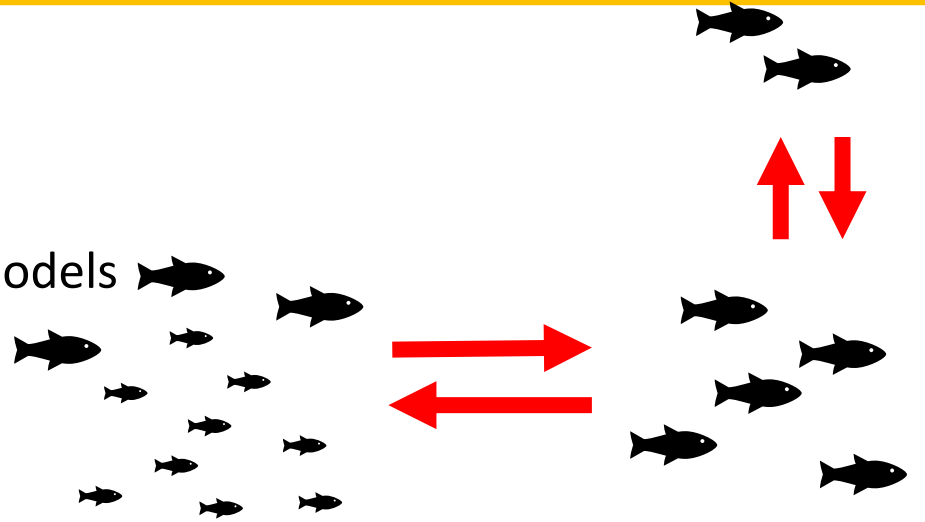
Conceptual model

- The yellowfin tuna stock in the EPO may have composed of at least two groups of fish with different dynamics
- The groups maybe be associated with major habitats and roughly located towards the NE and SW regions in the EPO, and have dynamic boundaries
- No index comprises both groups, each of the two main indices of abundance may be associated with only one group
- In 2020, assessment done with focus on the core of the catches and high mixing assumptions
- Episodic Mixing and No Mixing between groups to be modelled by splitting them based on environment

Hierarchical hypotheses for the risk analysis

- Level 1 Hypothesis: Mixing: assumed High mixing between groups, other hypotheses not modelled
- Level 2 hypotheses (data may be informative): related to index of abundance, growth and selectivity
- Level 3 hypotheses (no information in the data): steepness of the B-H stock-recruitment relationship

•Create a conceptual model



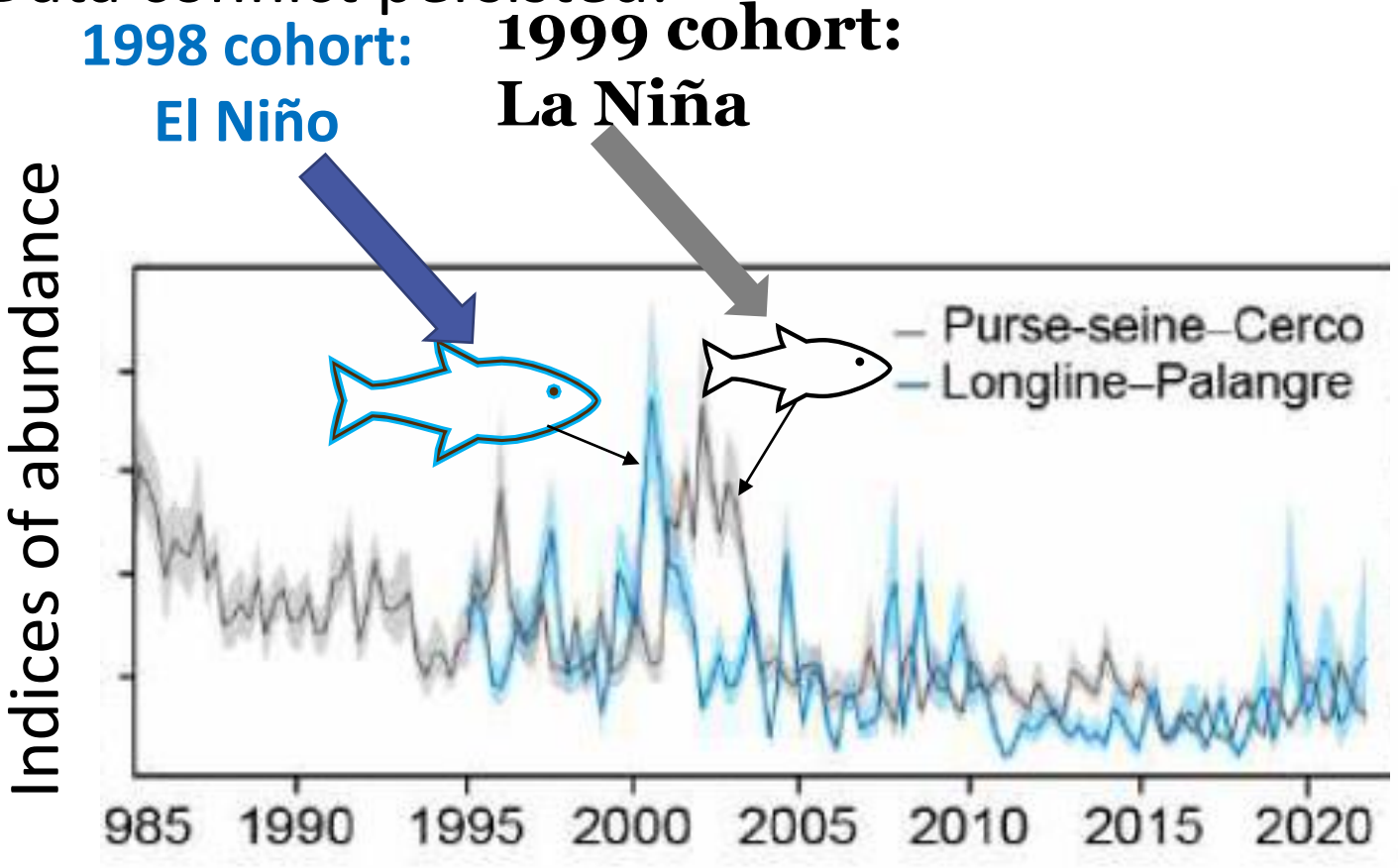
- Represent well documented spawning/feeding migrations as spatial models
- Either
  - Model isolated stocks (low interaction)
  - Using areas as fleets approach (high interaction)
- Tagging data is usually too problematic to use in integrated analyses and information on movement from length composition data is probably biased by spatial differences in growth rates
- Use analytical methods such as cluster analysis of the length composition data to identify potential fleets

2019 assessment

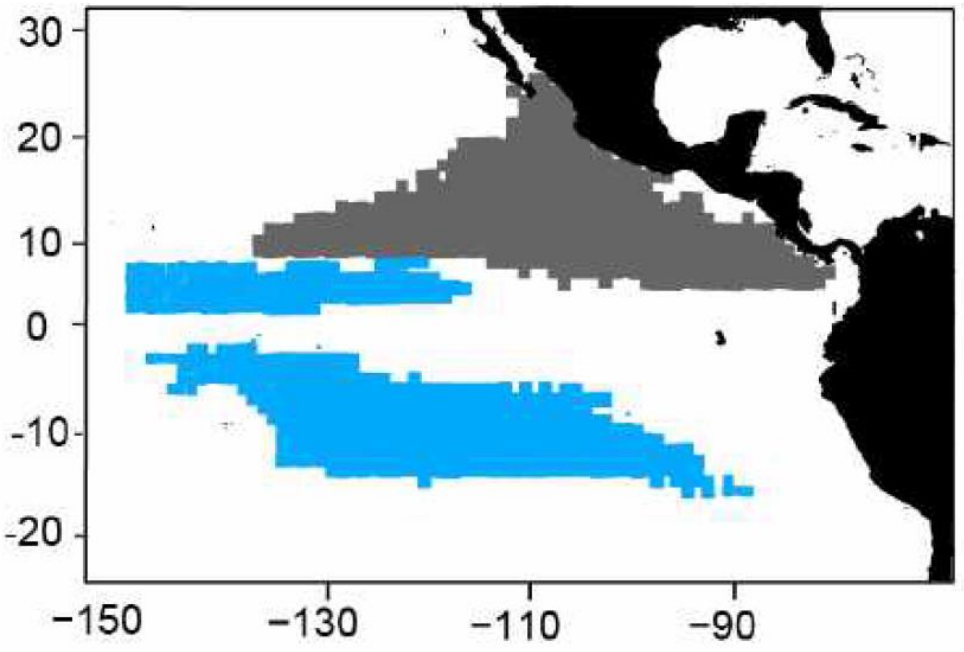
- **Rejected** due to results highly sensitive to in inclusion of recent longline index of abundance:
  - The rest of the new (or updated) data:
    - ✓ Did not show indication of increase in fishing mortality
    - ✓ Supported a weaker decline in abundance
- **Highlighted data conflicts and model misspecification:**
  - Conflicts among purse-seine indices and longline index
- Alternative hypotheses to solve the conflict were tested , did not resolve the index inconsistencies :
  - Change in fishing behavior (e.g. targeting) by the longline fishery
  - Mis-specified growth
  - Inadequate consideration of spatial structure in the indices of abundance
- **Spatial structure in the stock**
- **Multiple stocks/groups?**

2020 benchmark assessment

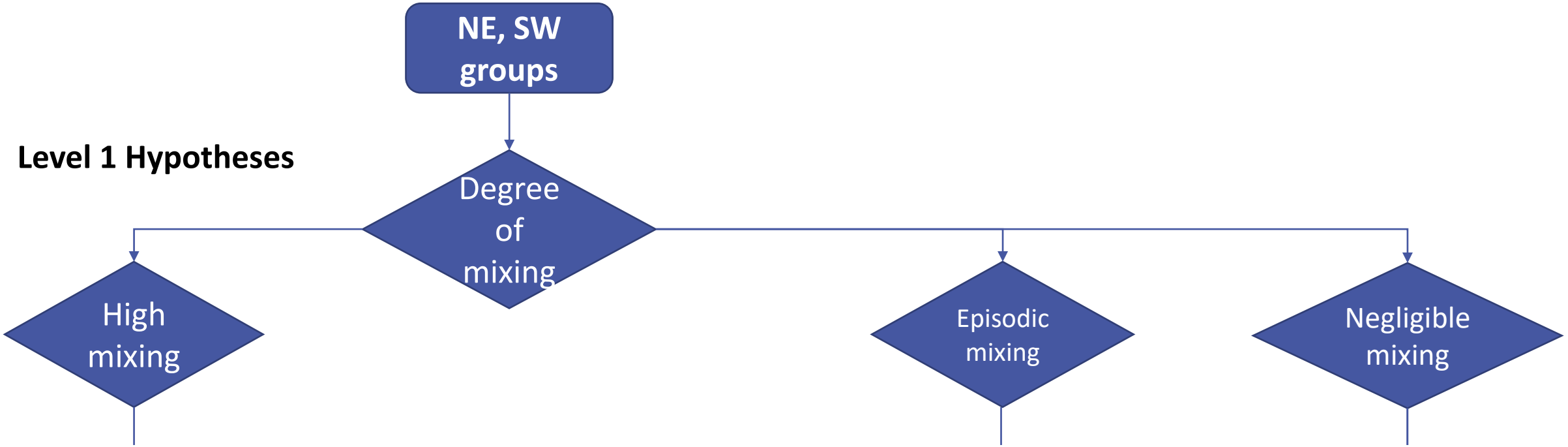
- Better purse-seine and longline indices (spatiotemporal models with size composition data associated)
- Data conflict persisted:



Spatial domain of the indices

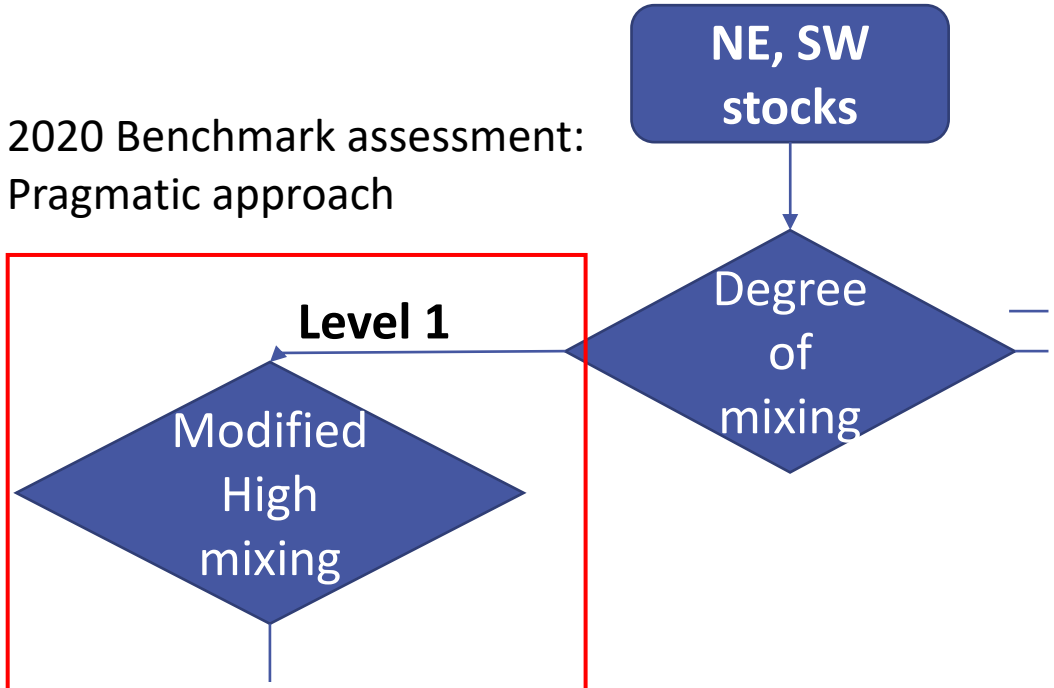


2020 Conceptual model



2020 Conceptual model

2020 Benchmark assessment:
Pragmatic approach



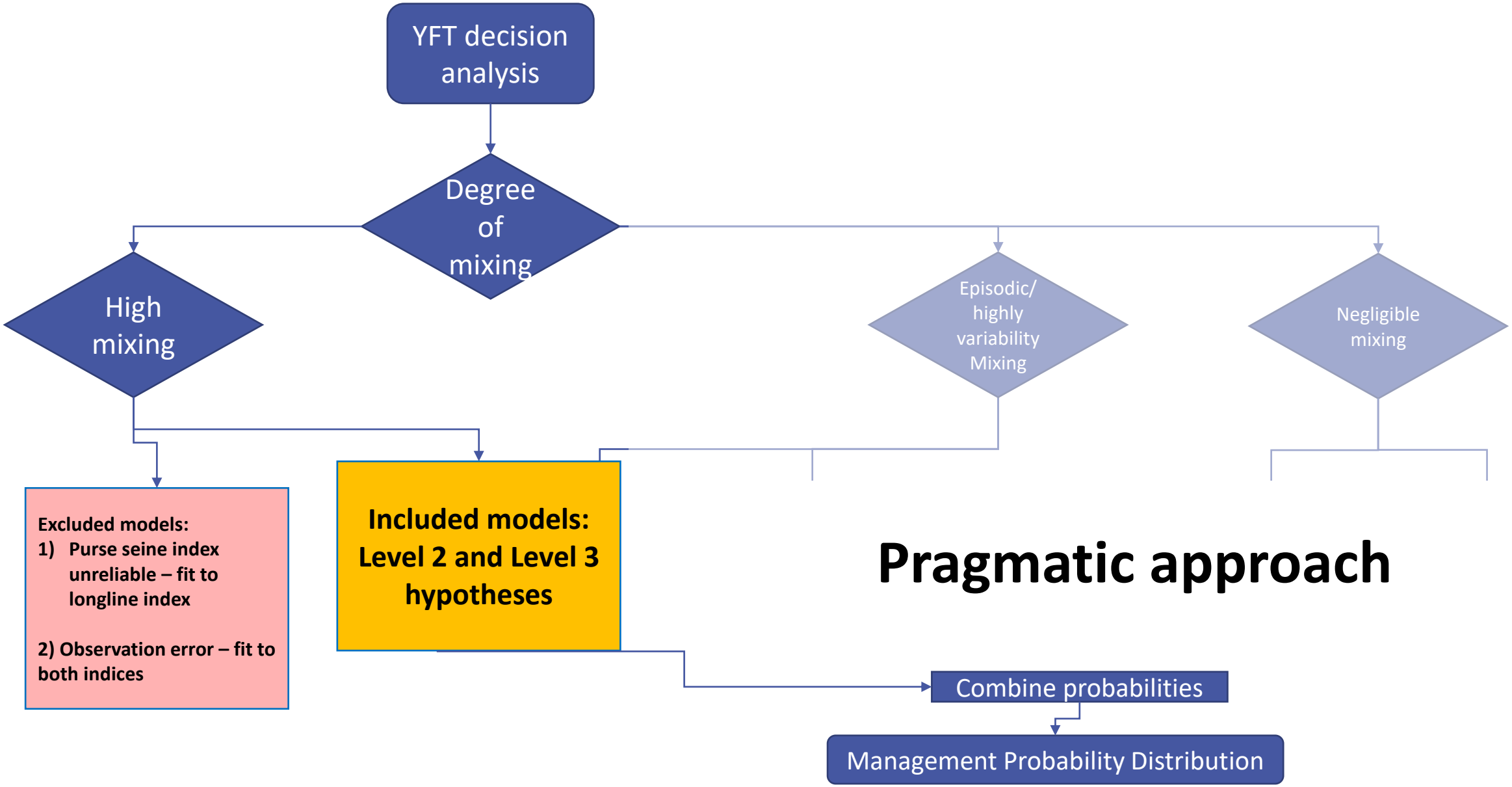
All catches
Fit to purse-seine index of abundance
Not fit to longline data and purse seine data from the "south"

Which indices to use?

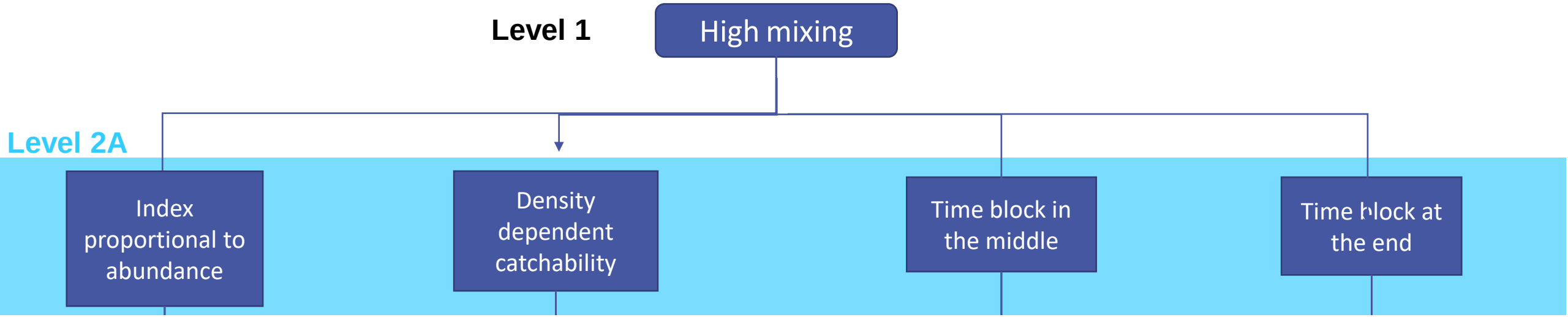
High mixing

- Both indices – observation error hypothesis
- Longline index – hypothesis of purse-seine index not representative
- Purse-seine index – hypothesis of longline index not representative

Formulation of hypotheses: YFT



Hypotheses flow chart for yellowfin



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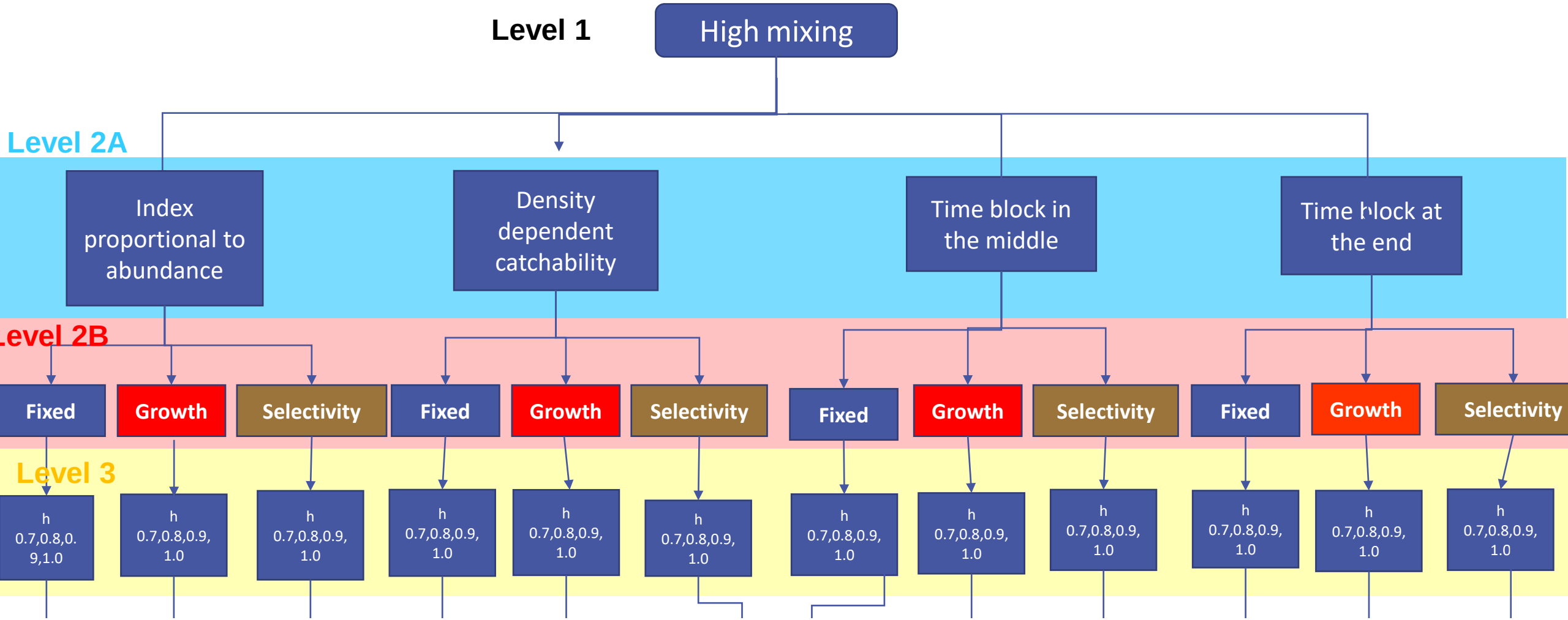

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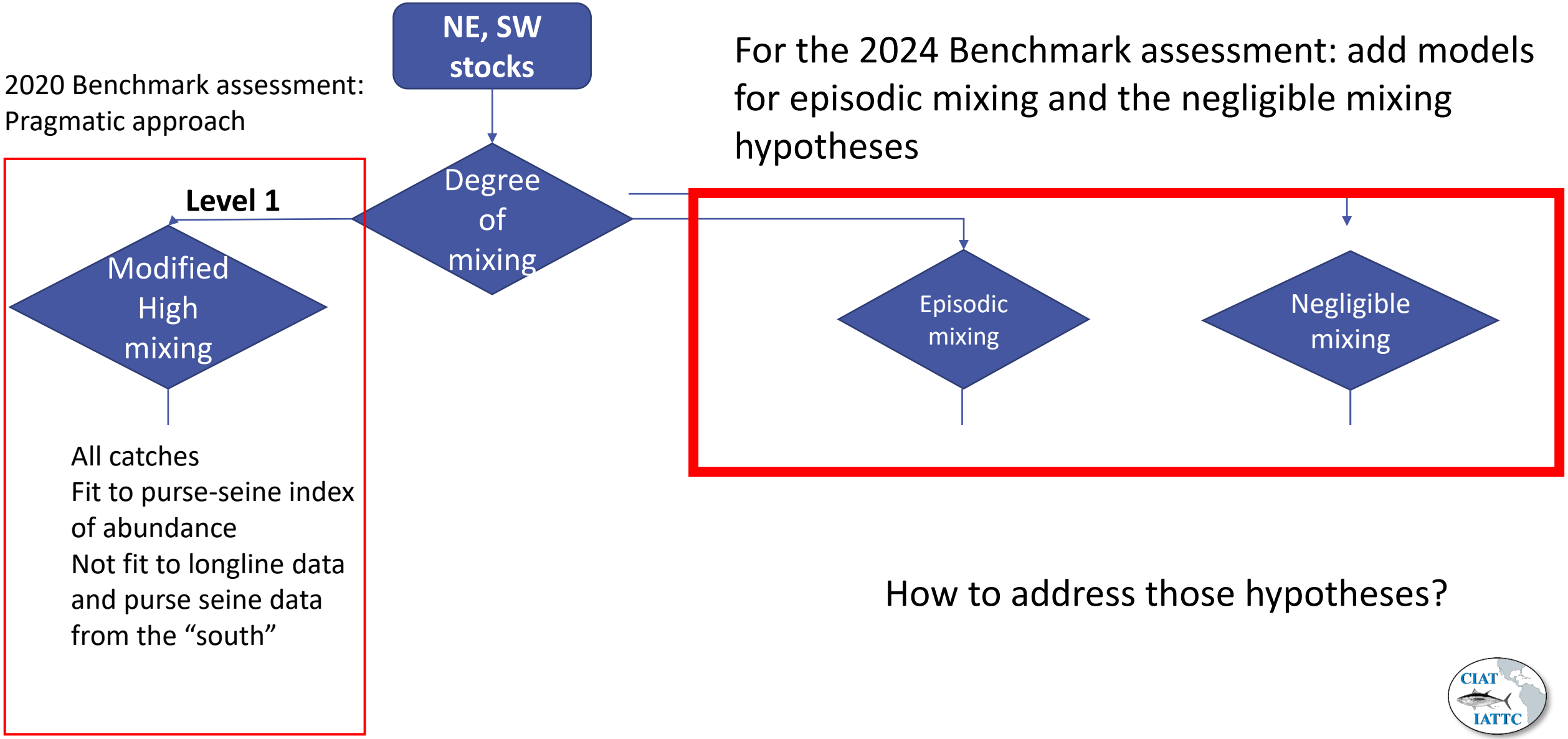
Pragmatic approach



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

How to address those hypotheses?

Improved conceptual model of YFT in the EPO

t least two groups in the EPO: dynamic boundaries based on environment

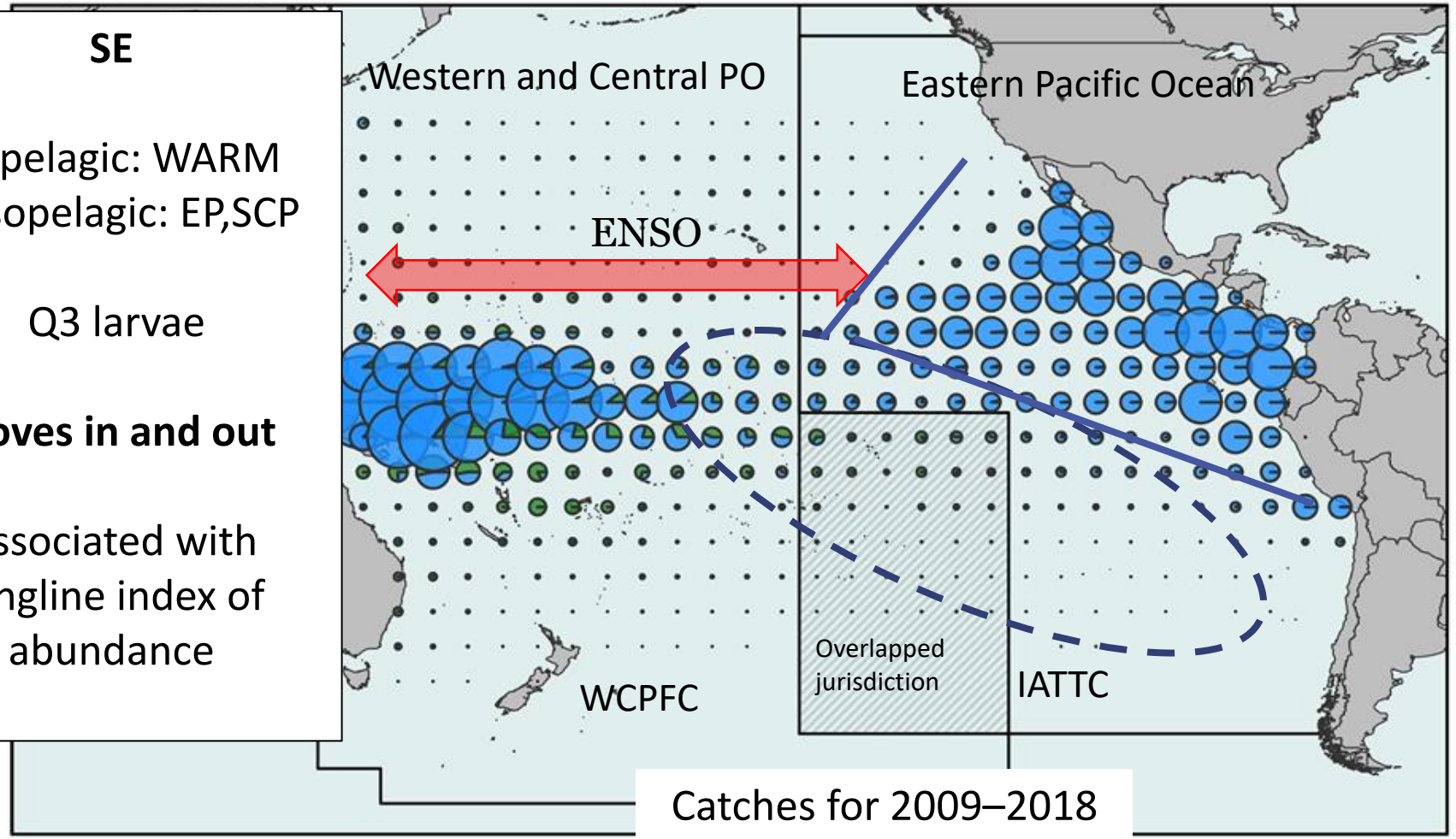
SE

Epipelagic: WARM
Mesopelagic: EP,SCP

Q3 larvae

Moves in and out

Associated with longline index of abundance



Catches for 2009–2018

NW
Epipelagic: PNEC, PEQD
Mesopelagic: ETP

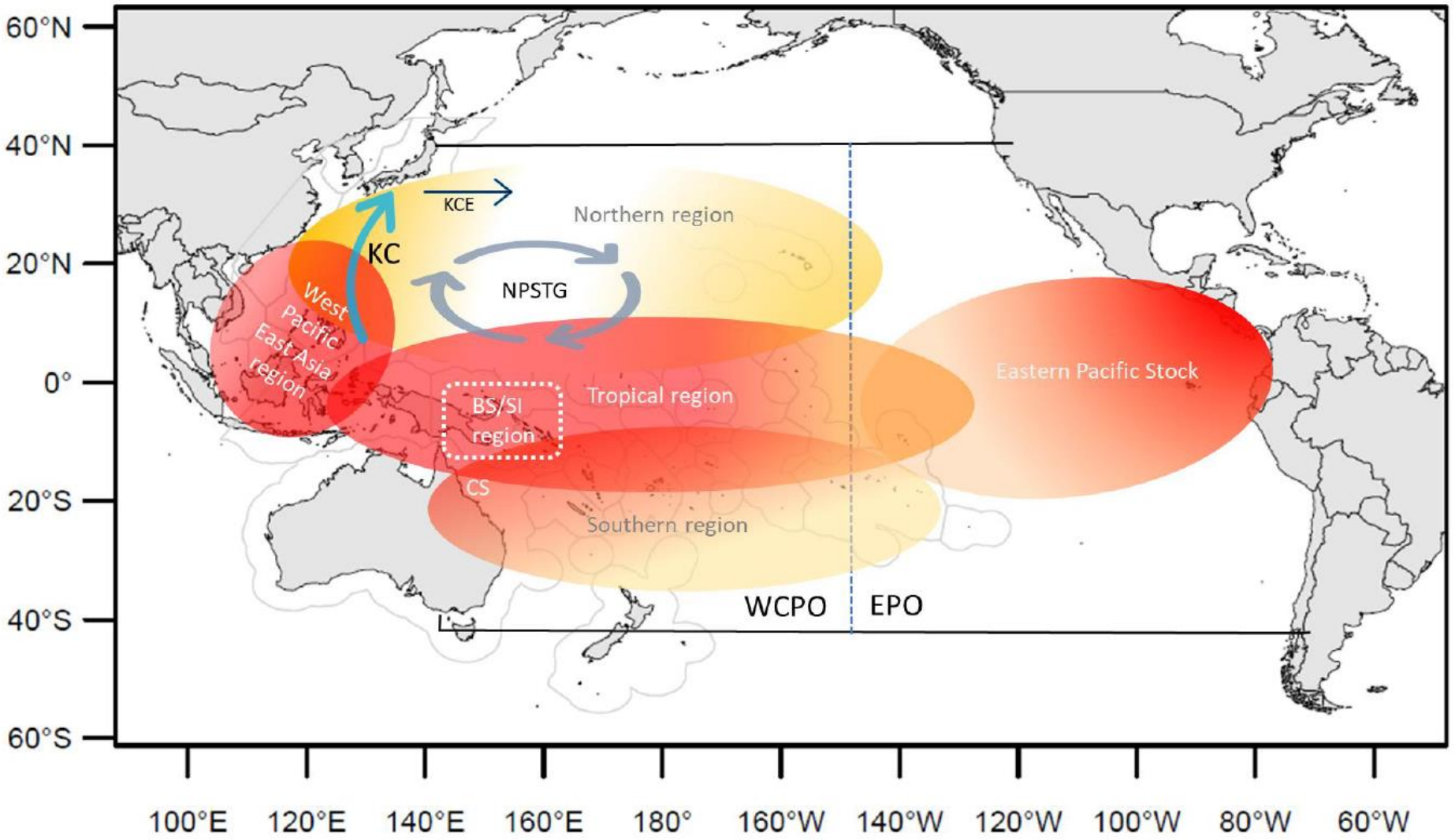
Q4,1,2 larvae

Regional fidelity

Associated with purse-seine index of abundance

Moore et al 2020

Conceptual model for WCPO



WCPFC-SC19-2023/SA-WP-02

IATTC Archival tagging data

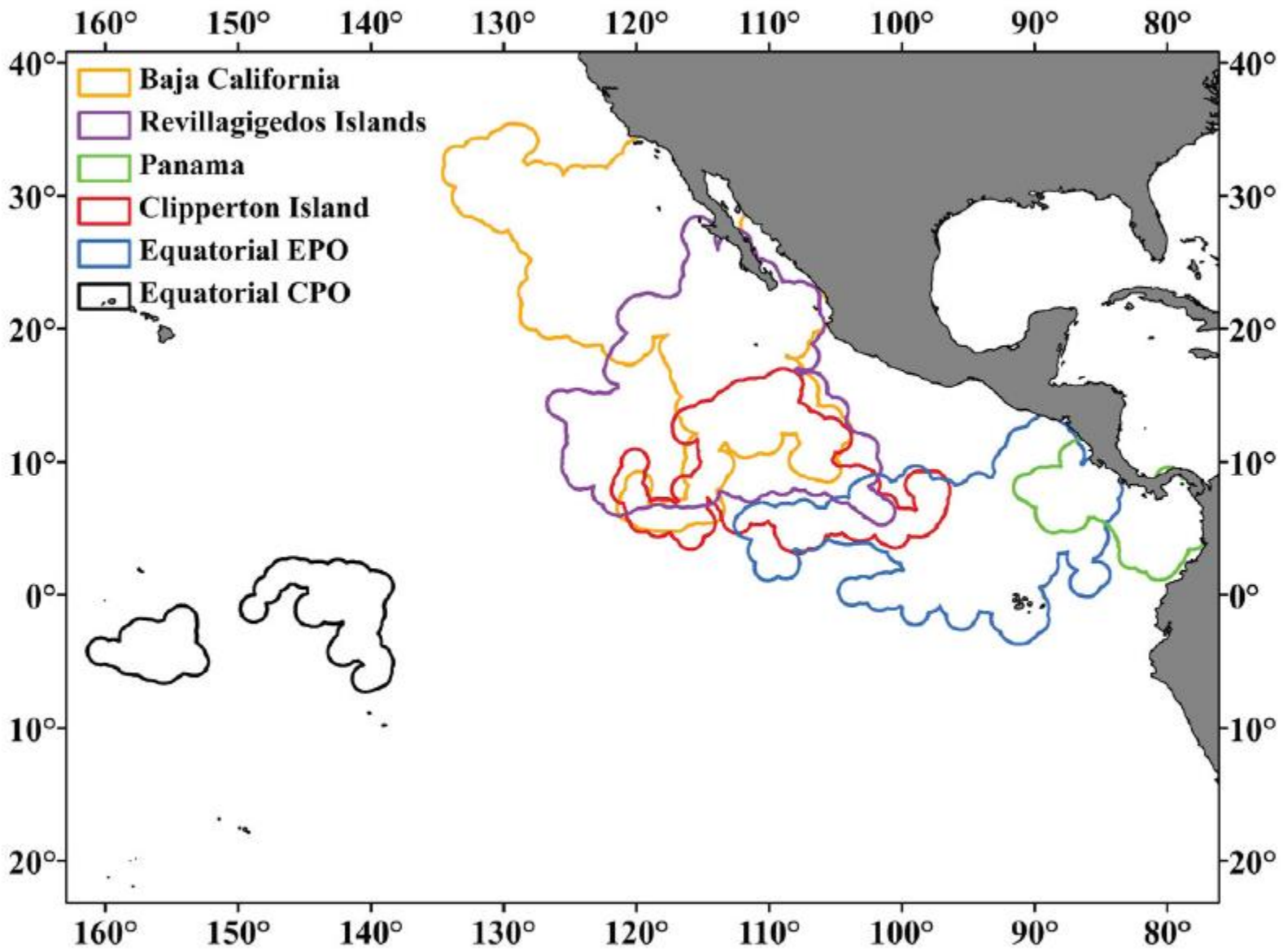
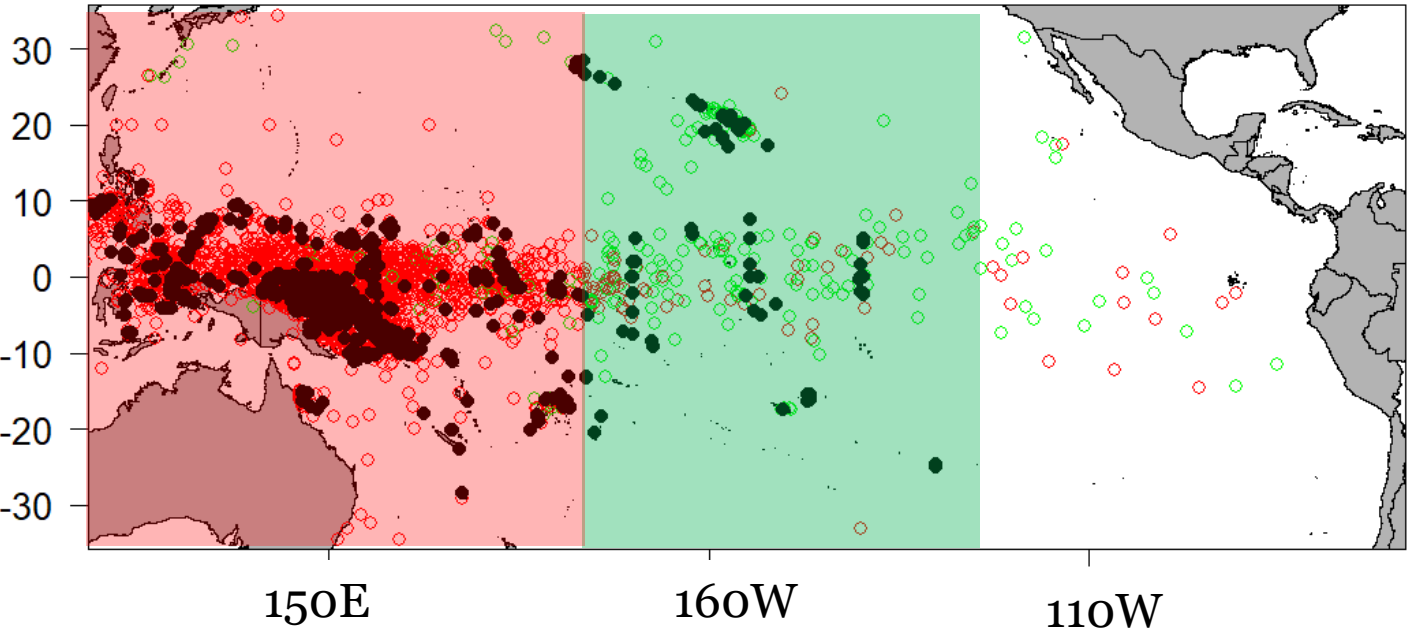


FIGURE 9 The 100% volume contours (utilization distributions) for yellowfin, derived from a kernel density estimate, using a 1°search radius and a 0.01°output cell size, for all positions along the most probable tracks of fish by release area

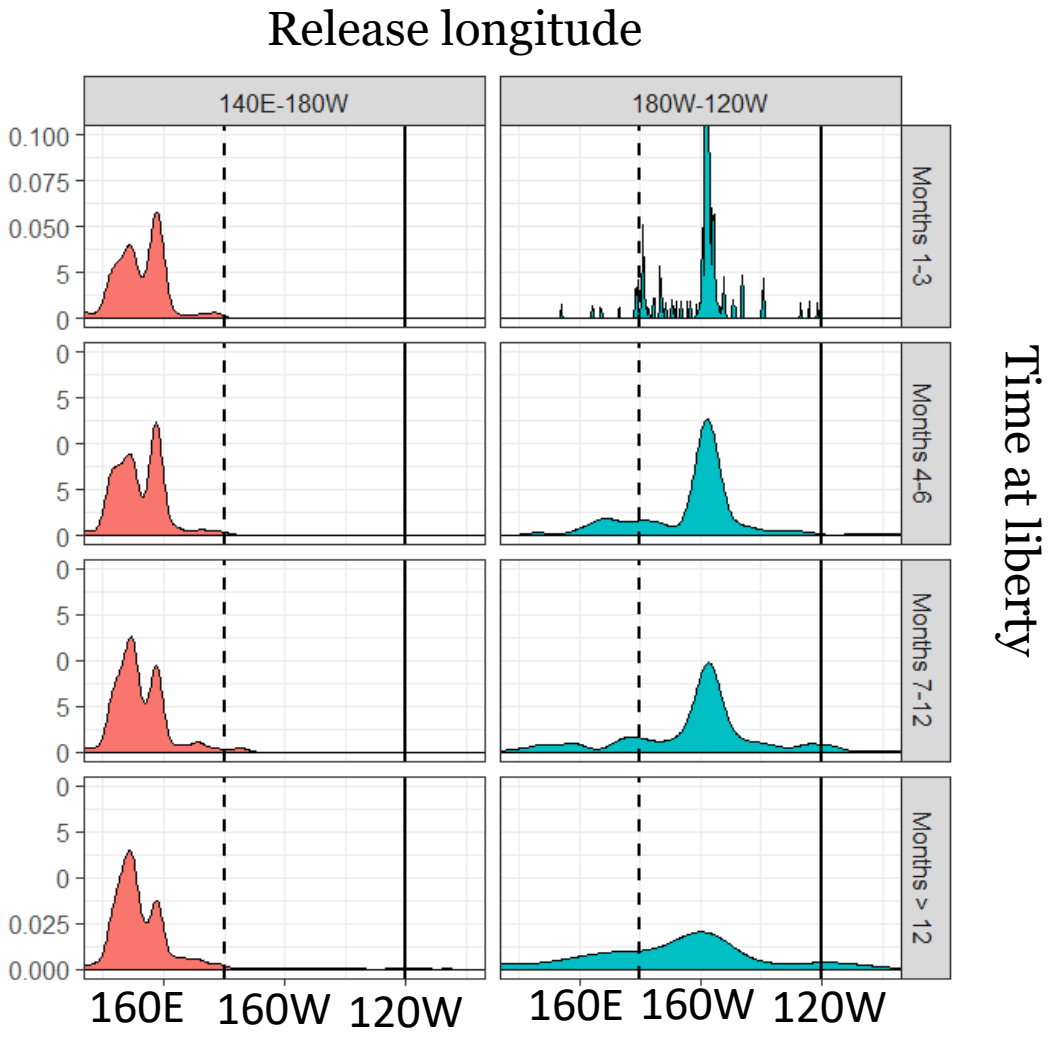
Shaeffer and Fuller 2021

Tagging data WCPO

Release locations



Data from: SPC (personal communication M. Vincent in 2019)

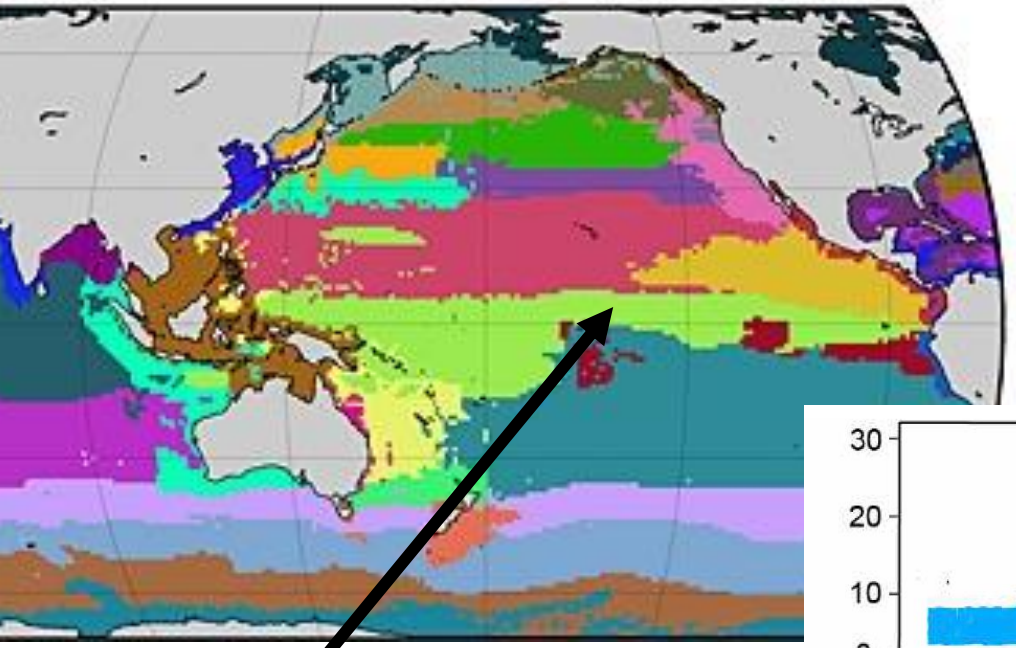


Dynamic biogeochemical epipelagic provinces in the global ocean

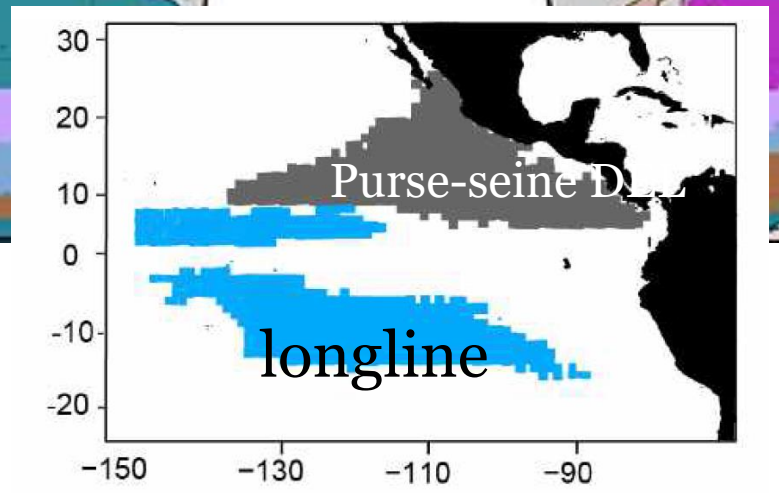
Reygondeau et al 2013

El Nino

tembre 1997 - April 1998)



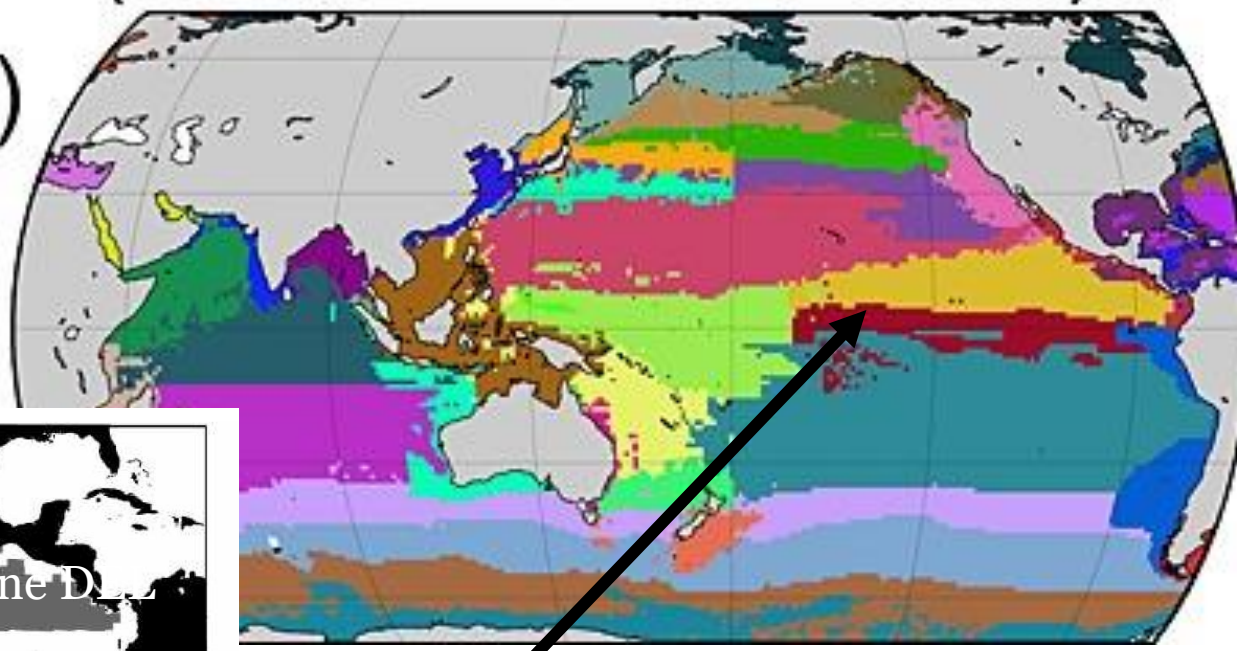
Expansion of the Warm Pool
Contraction of PNEC,PEQD



La Nina

(June 1998 - March 2001)

(b)



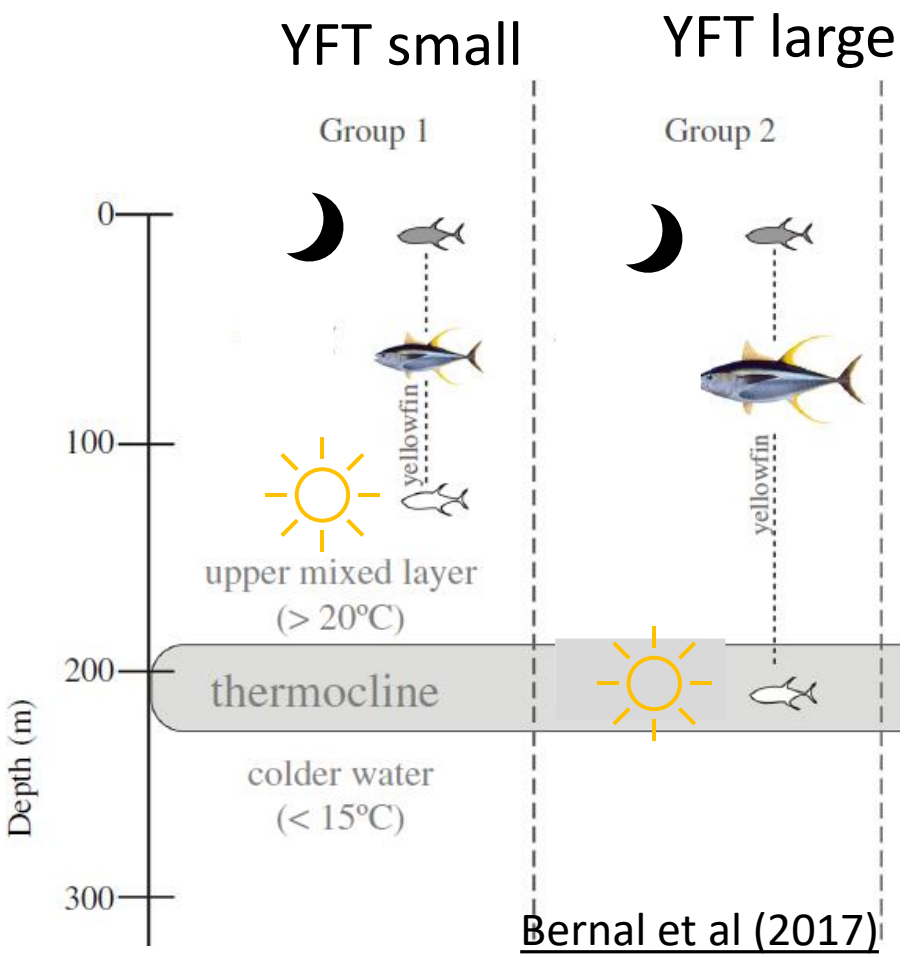
Contraction of the Warm Pool
Expansion of PNEC,PEQD

PNEC: North Pacific equatorial counter current
PEQD: Pacific equatorial divergence

Recruitment of tunas most likely linked to habitat availability

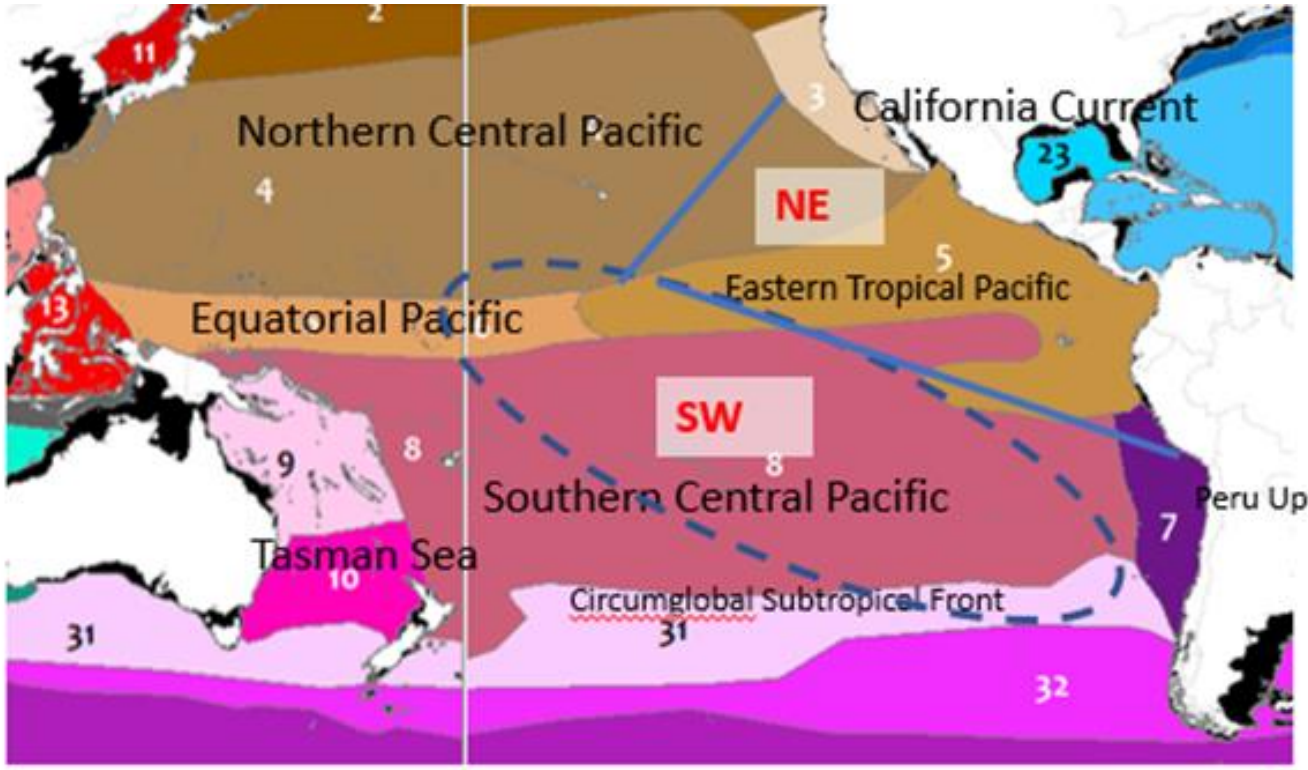
Stocks associated with biogeochemical provinces

Mesopelagic habitat important for large YFT:
Vertical movement distribution patterns by size



Bernal et al (2017)

Mesopelagic



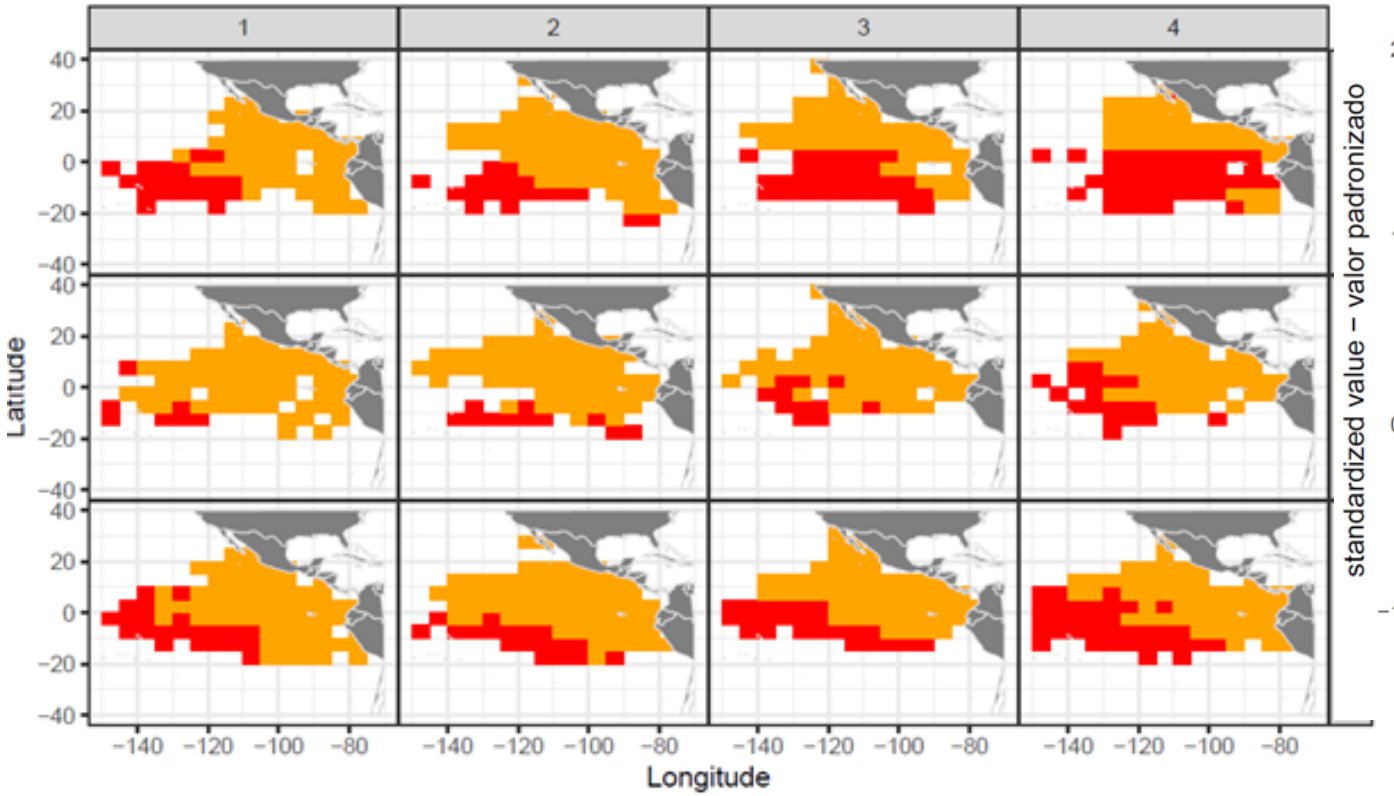
Group separation

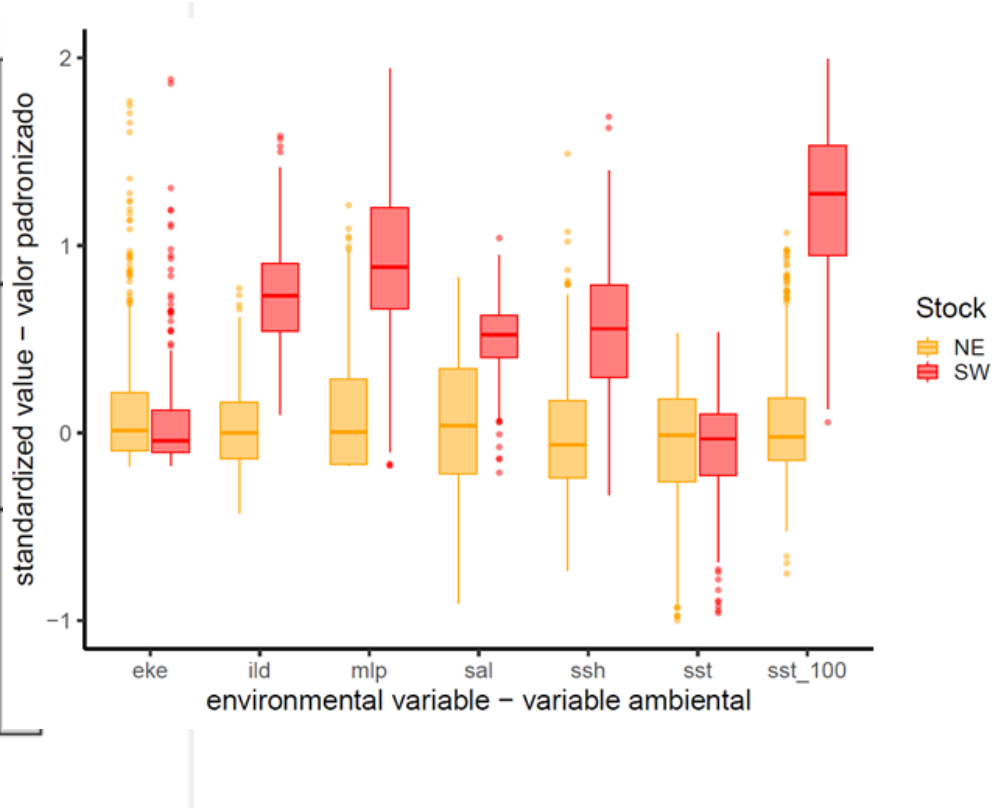
Based on environment and tree analysis of length composition data (PS-OBJ)

1997
El Niño

1999
La Niña

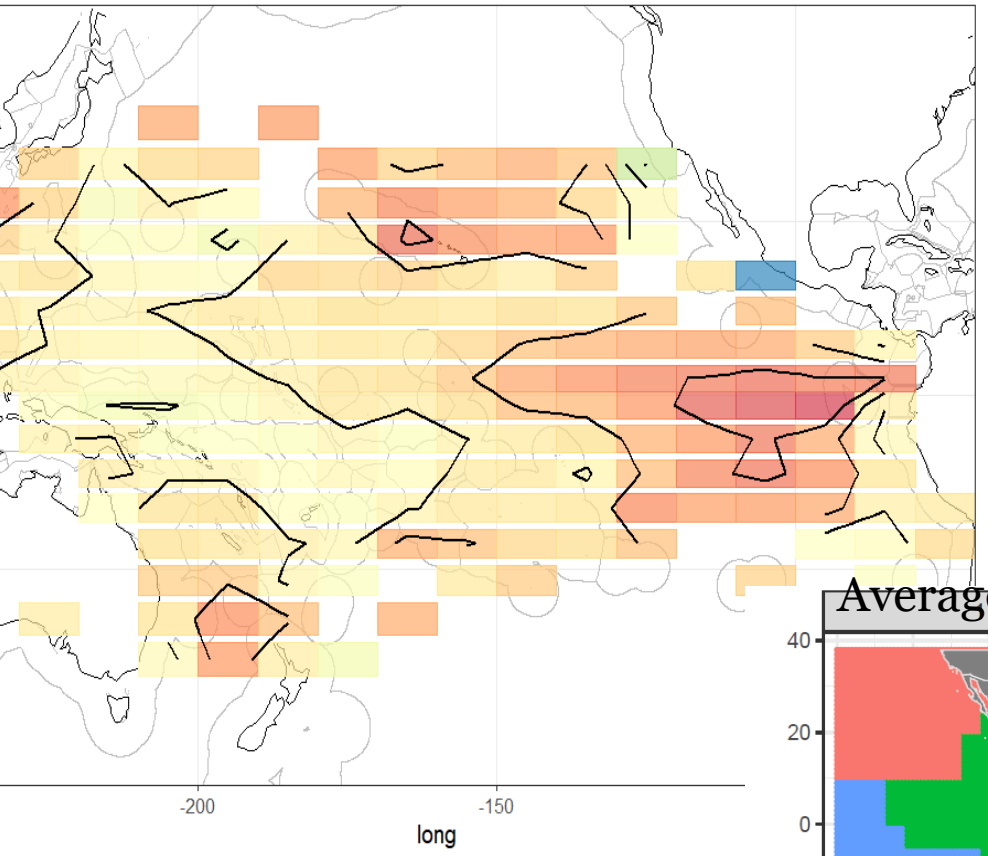
2003
Neutral





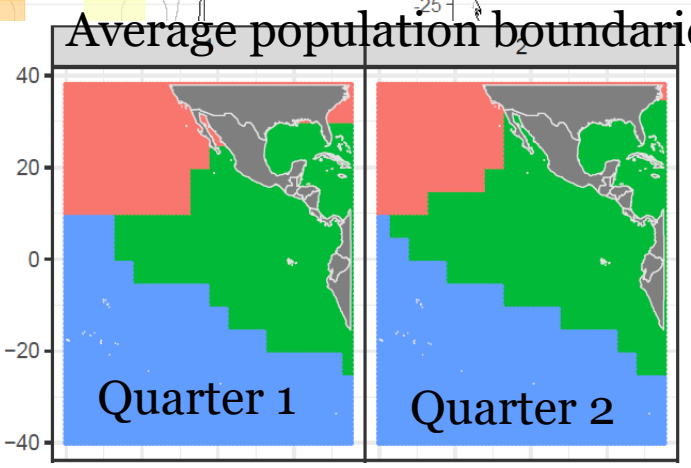
Longline fisheries: average size patterns

Hoyle et al in prep (1984- 2010)

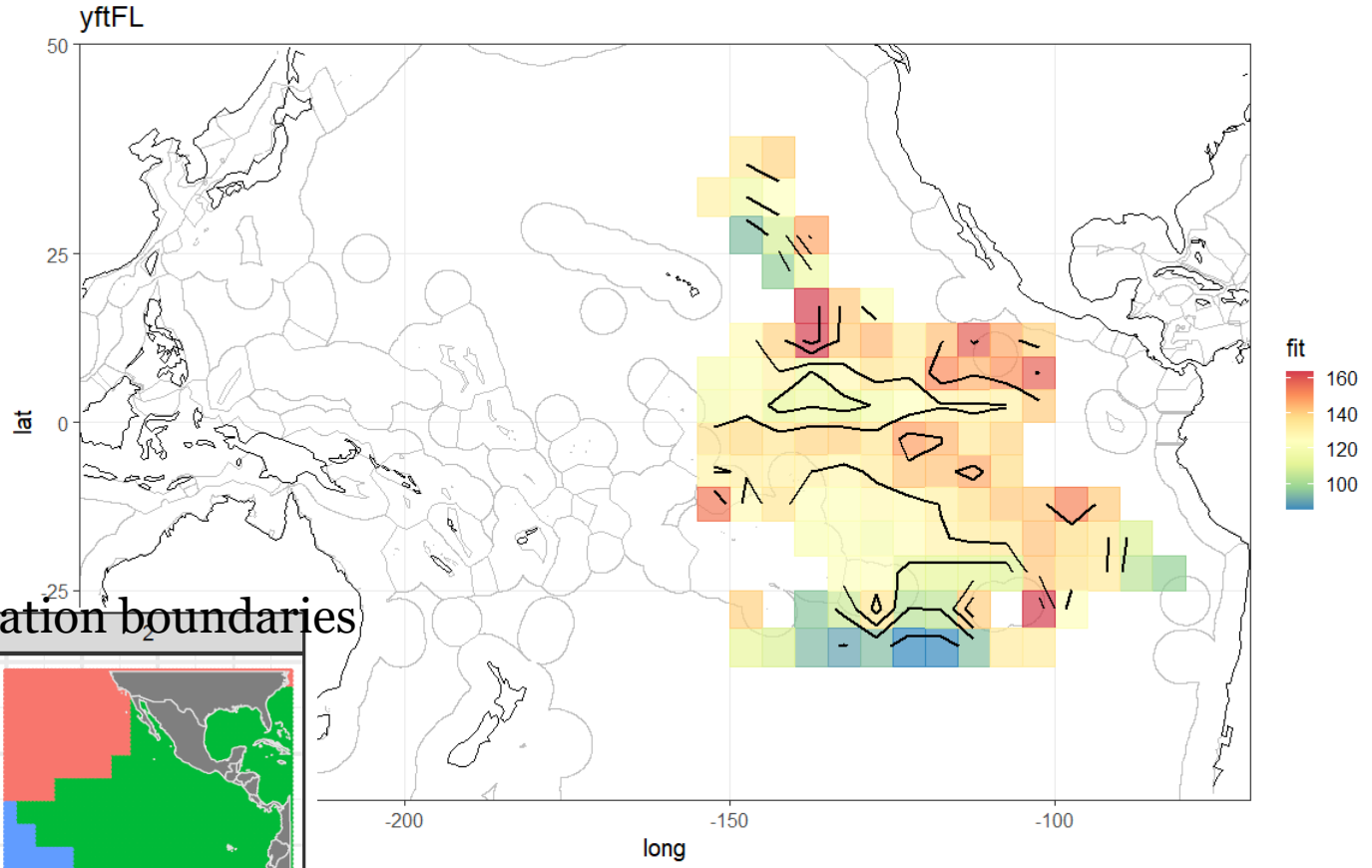


Prediction year 2000, quarter 3

Average population boundaries



Longline observers (2013-2019)



Prediction year 2018, quarter 3

Conceptual model

High mixing

Low support from data:

- Different average size over large areas
- Growth/biology vary in space
- Tagging data shows regional fidelity in the NE and mobility in the SW

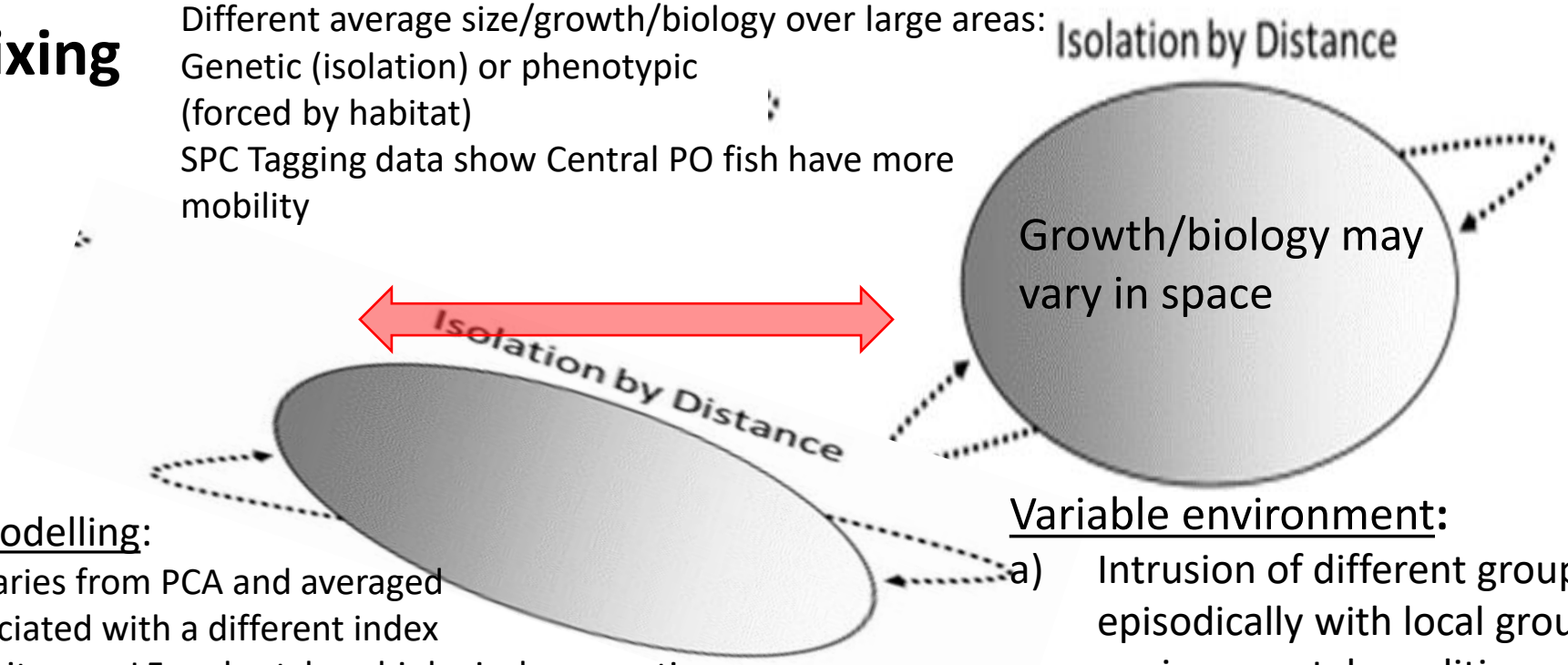
Implications for modelling:

- Differences between indices should be explained by observation error, differences in selectivity
- Large Linf may bias estimation of biomass for areas that should be low Linf
- Should it be modelled? It is robust to complex dynamics?

Conceptual model

Episodic mixing

Different average size/growth/biology over large areas:
Genetic (isolation) or phenotypic
(forced by habitat)
SPC Tagging data show Central PO fish have more mobility



Implications for modelling:

- Dynamic boundaries from PCA and averaged
- Each group associated with a different index
- Each group with its own LF and catches, biological assumption
- Indices will have more "noise" as intrusion of other fish increase local density
- Catches may increase due to intrusion of other fish
- Ideally it should be model with spatial models
- But not enough tagging data to model movement, current spatial models do not allow for different growth by area
- Areas as fleets model may be a robust approximation when movement is frequent (Results from spatial simulation experiment)
- Explore residuals of fits to indices and patterns in recruitment for "intrusions"

Variable environment:

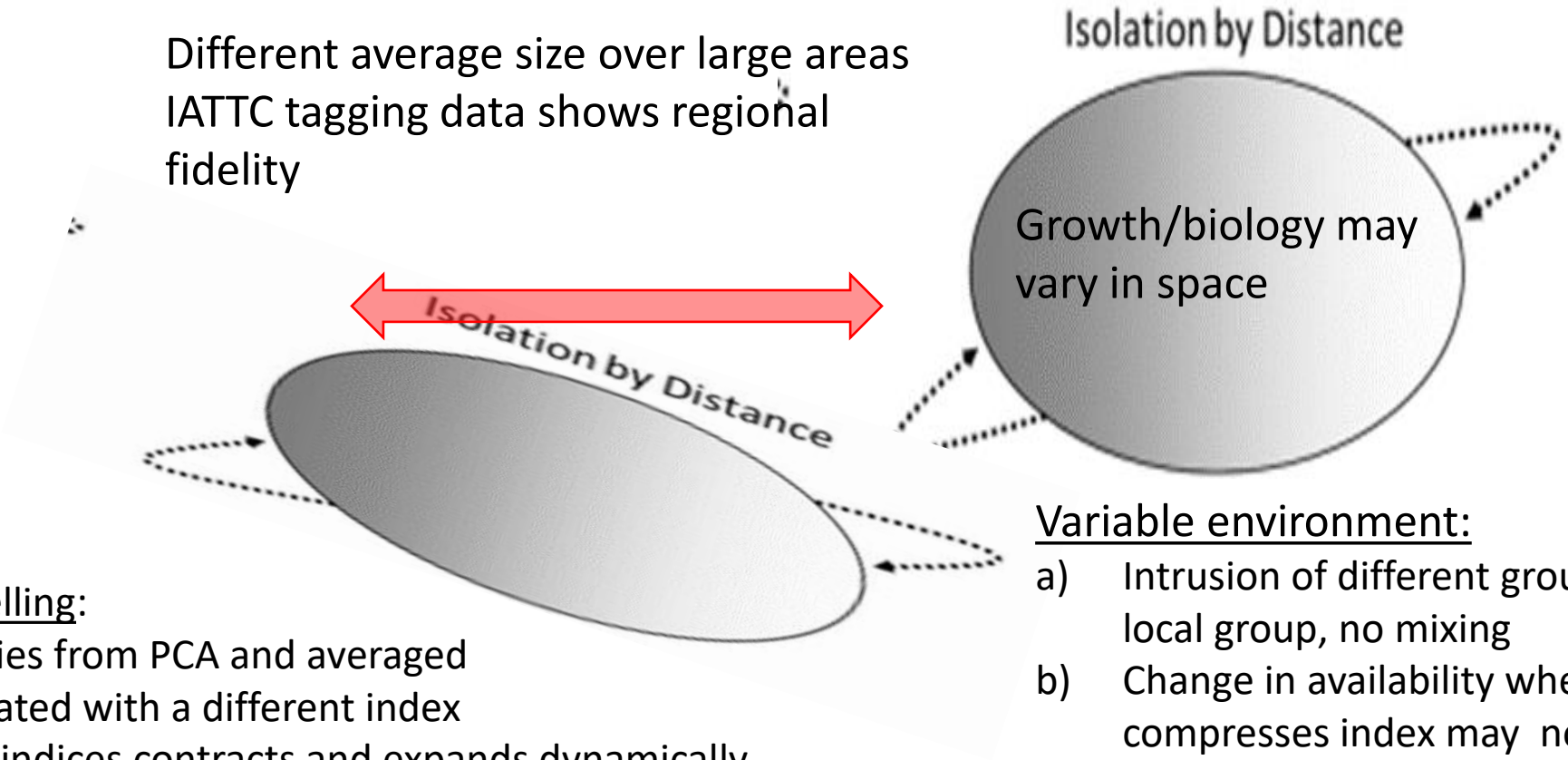
a) Intrusion of different group that mix episodically with local group when certain environmental conditions occur, this will add noise to index of abundance, effect on catches

b) Need to analyze archival tagging data to see in fish respond dynamically to environment (data review recommendation)

Conceptual model

No mixing

Different average size over large areas
IATTC tagging data shows regional fidelity



Implications for modelling:

- Dynamic boundaries from PCA and averaged
- Each group associated with a different index
- Spatial domain of indices contracts and expands dynamically
- Each group with its own LF and catches
- Modelled separated

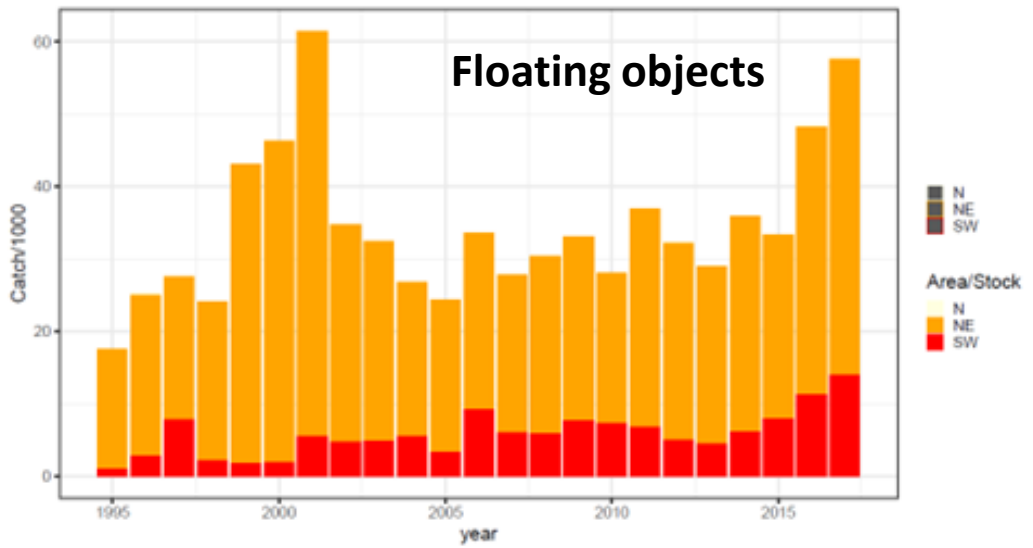
Variable environment:

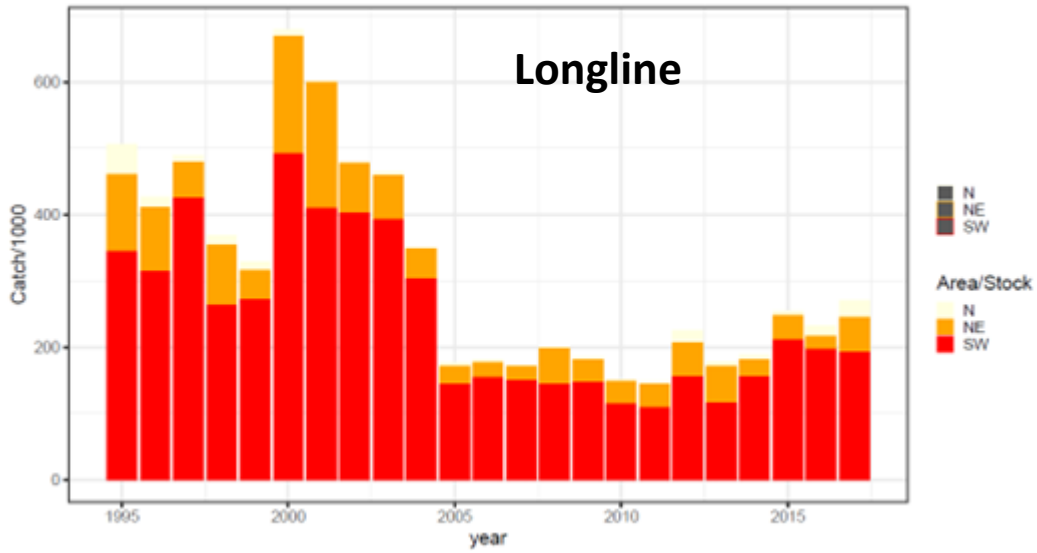
a) Intrusion of different group, compression of local group, no mixing
b) Change in availability when habitat compresses index may not be proportional to abundance

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 groups and from the north area (1995-2017)

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%





Summary

- At least two groups 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


Questions