Stock and fishery spatial structure considerations for future assessments of tropical tunas in the eastern Pacific Ocean

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6th Meeting of the Scientific Advisory Committee
La Jolla, 11-15 May 2015

Spatial structure in stock assessment models

- 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
- Definition of “fisheries”: areas-as-fisheries” defining fisheries by their area of operation, without setting up a spatial model per se. This allows for different selectivity and catchabilities to be estimated.

Goals of the project

- Review the history of assumed spatial stock and fishery structure in the stock assessments of tropical tunas conducted by the Inter-American Tropical Tuna Commission (IATTC);
- review the evidence for broad and fine scale distributions of stocks of tropical tunas in the eastern Pacific Ocean (EPO, east of 150°W),
- propose spatial definitions to be considered in future stock assessments of tropical tuna in EPO,
- develop stock assessment models based on the proposed spatial definitions

Results

- **YFT**
- **BET**

YFT

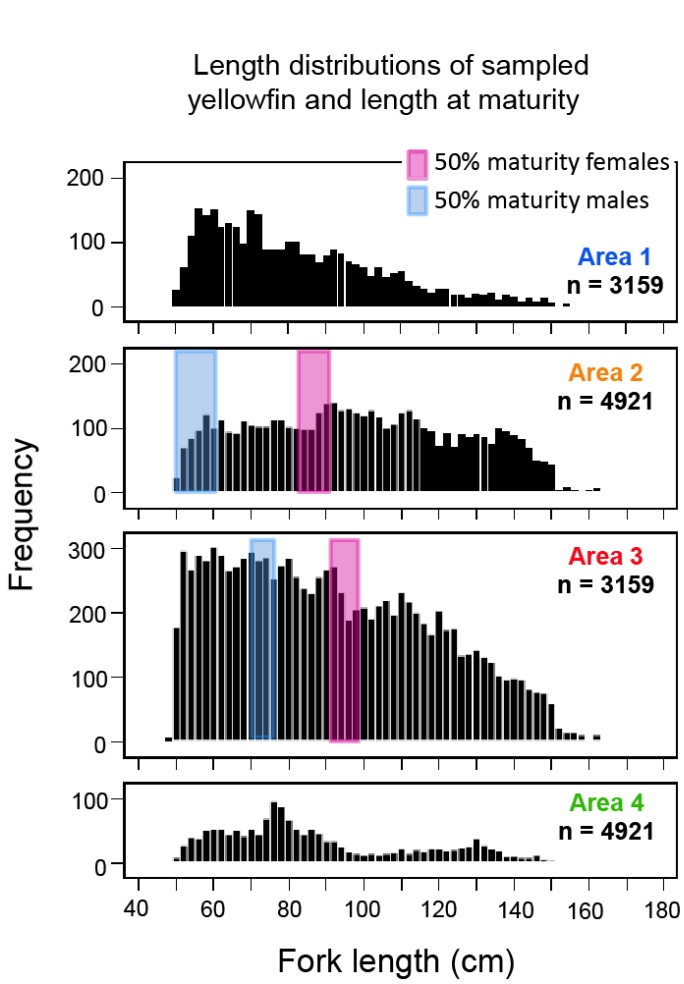
Biological evidence of stock structure

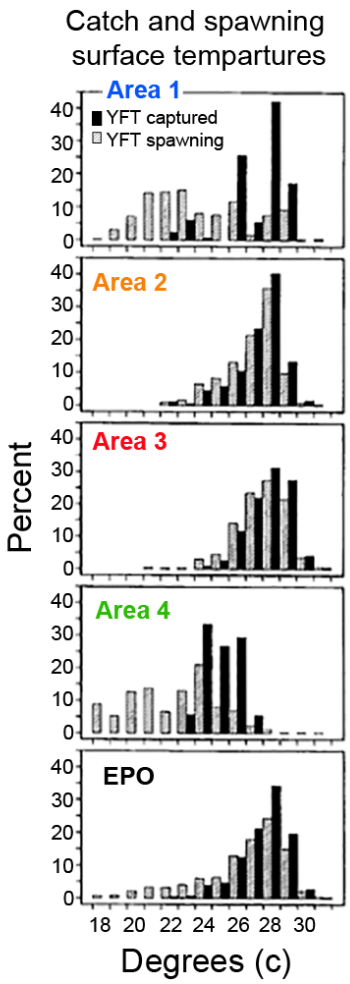
- Reproductive biology
- Morphology and meristic
- Diet
- Tagging

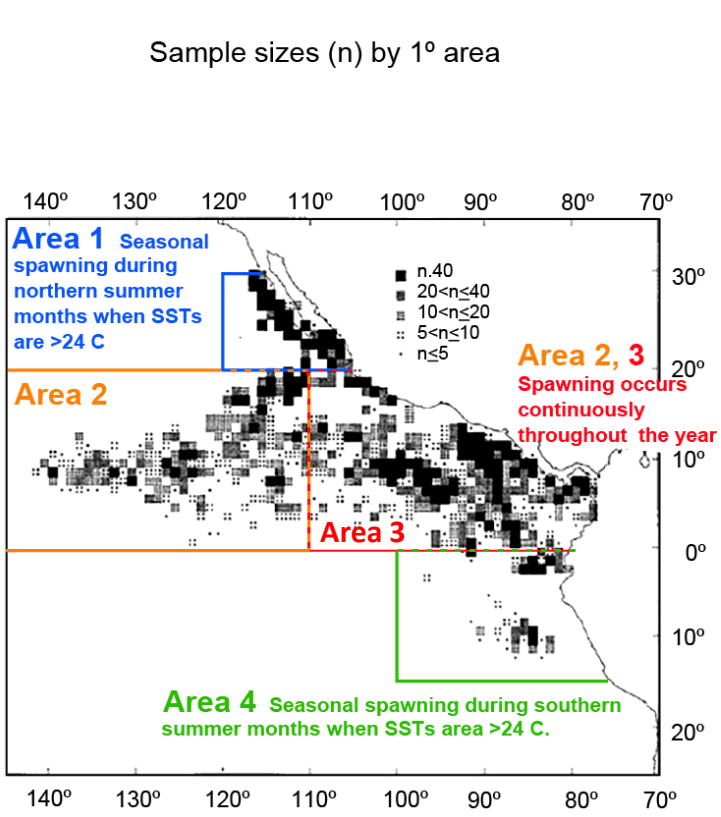
YFT

Reproductive biology

some aspects of the spatial variation in in the EPO

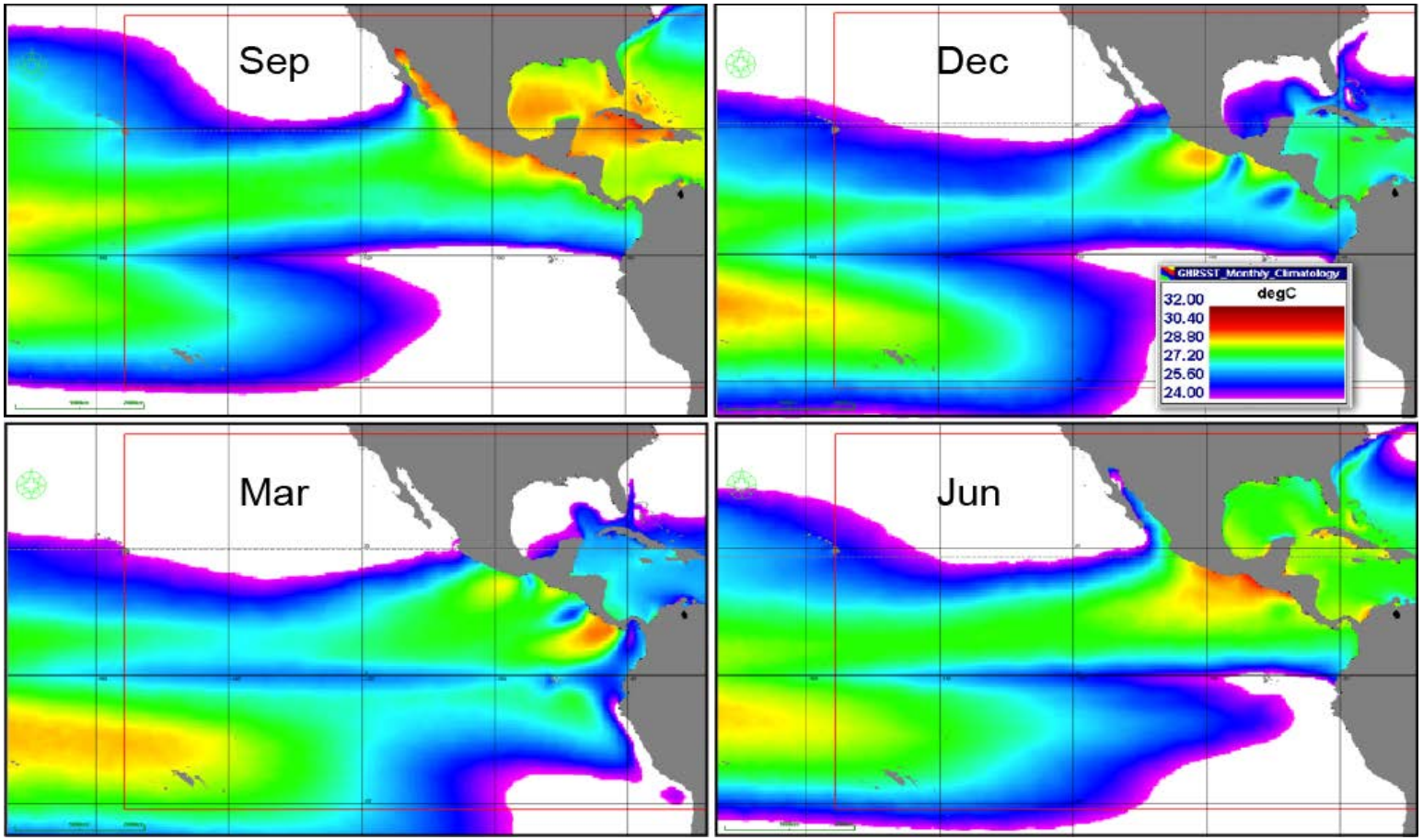






Schaefer 1998

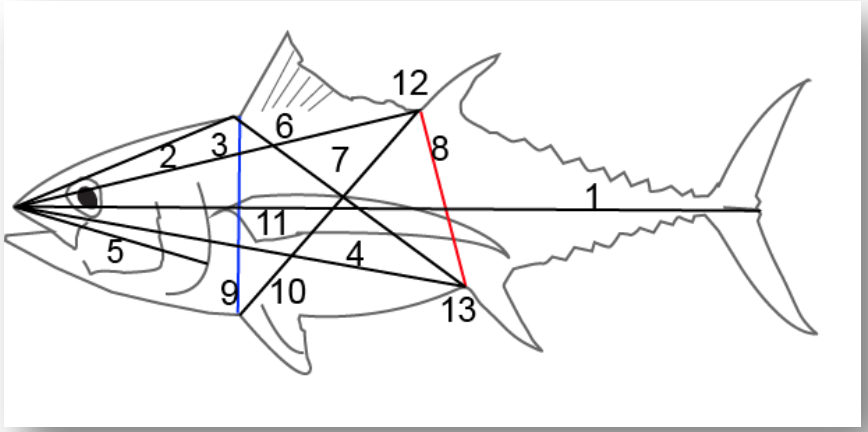
Distribution of waters of 24°C and higher



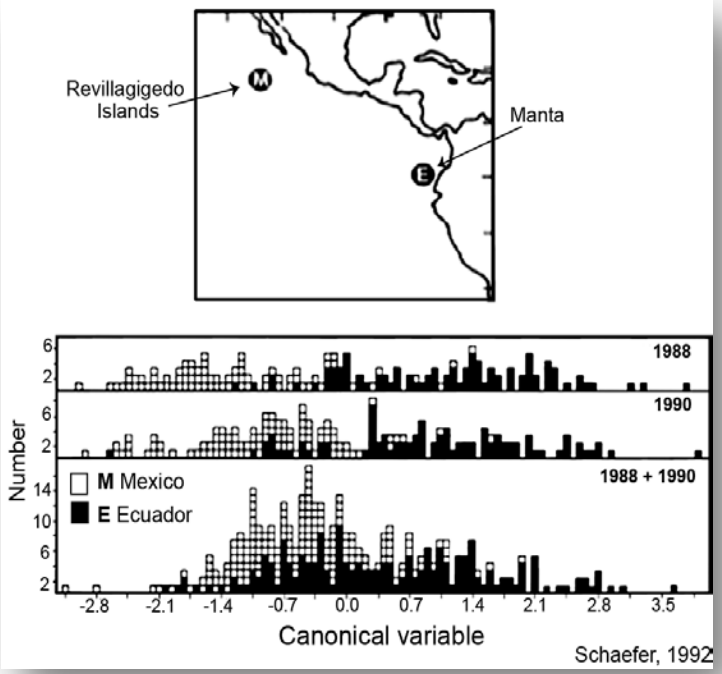
Distributions of waters of 24°C and higher in the EPO for seasonally representative months (From: Climatology, Group for High Resolution SST, https://www.ghrsst.org/)

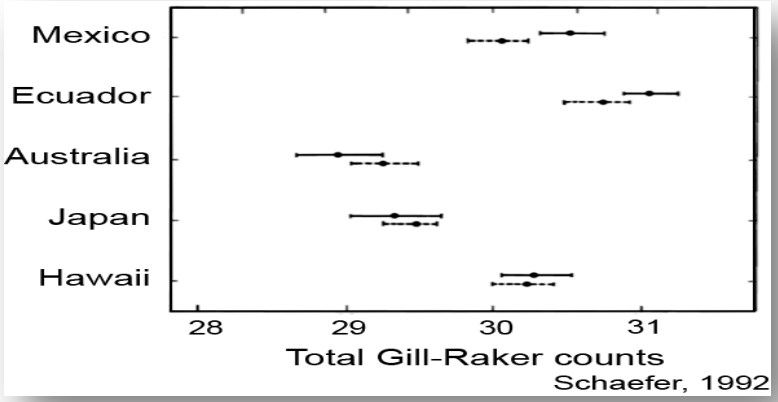
YFT

Evidence of differences in morphology and meristics



YFT from Ecuador have a deeper body than YFT from Mexico

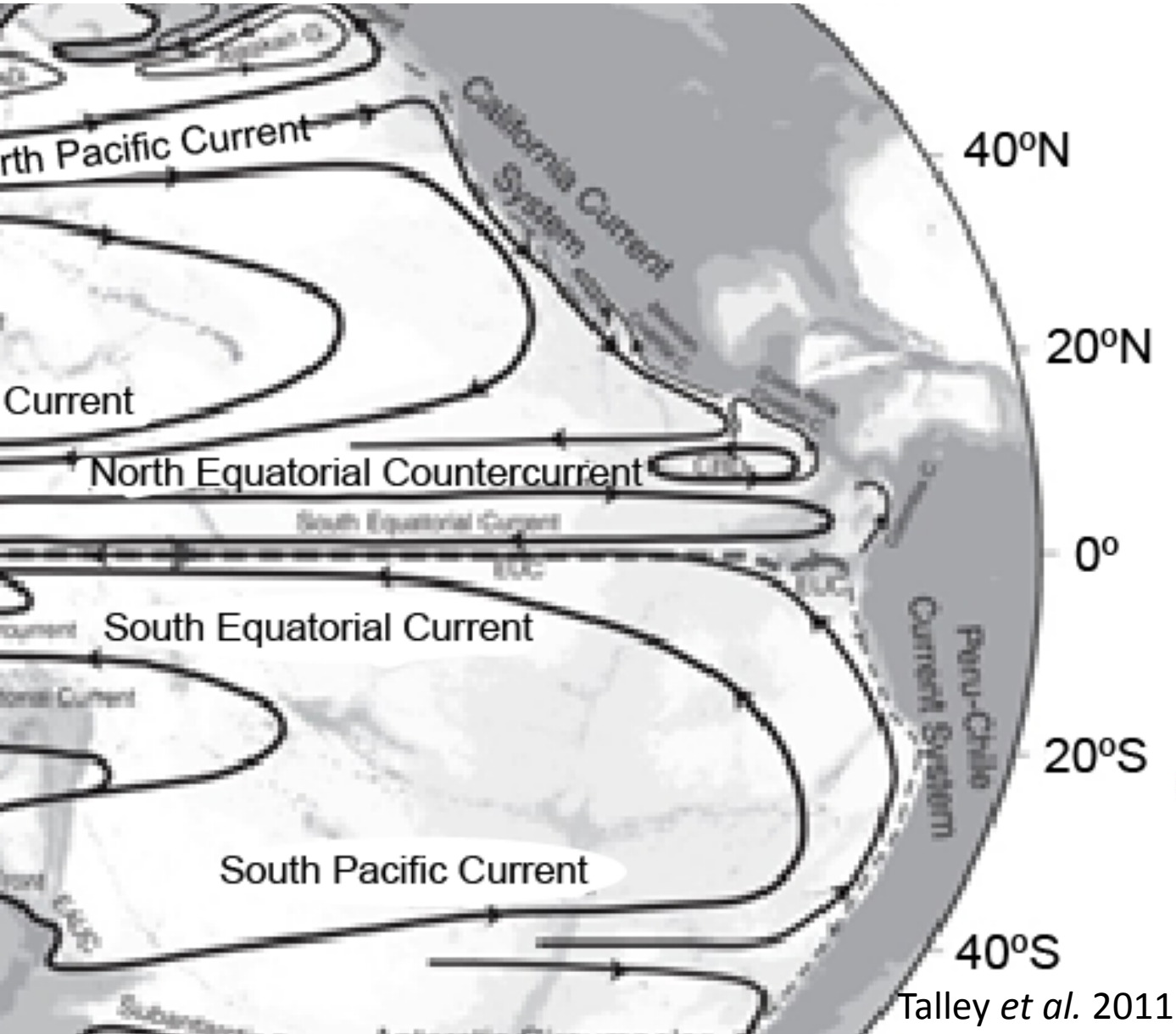




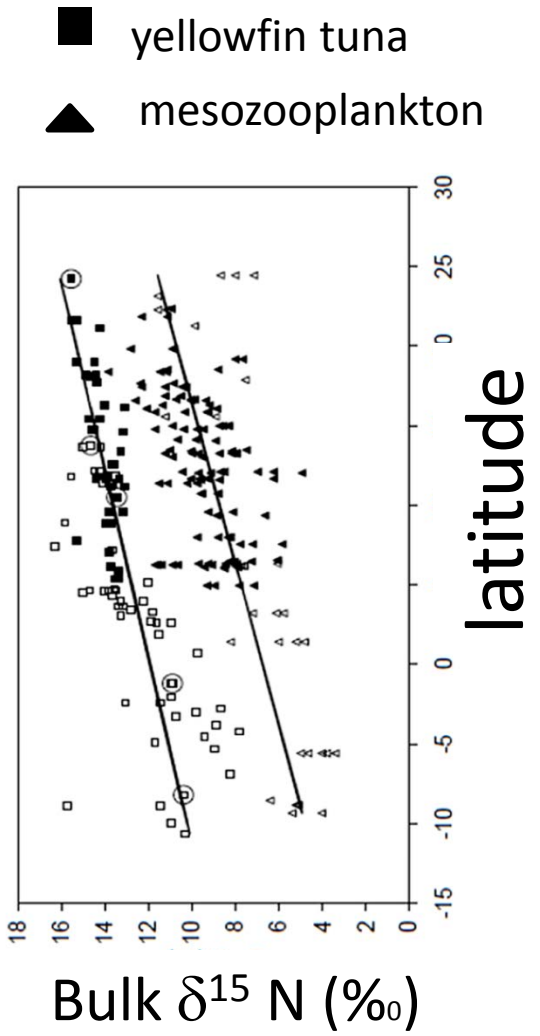
YFT from Ecuador have 1 more gill-raker on average than YFT from Mexico

Schaefer 1992

Evidence of differences in diet YFT

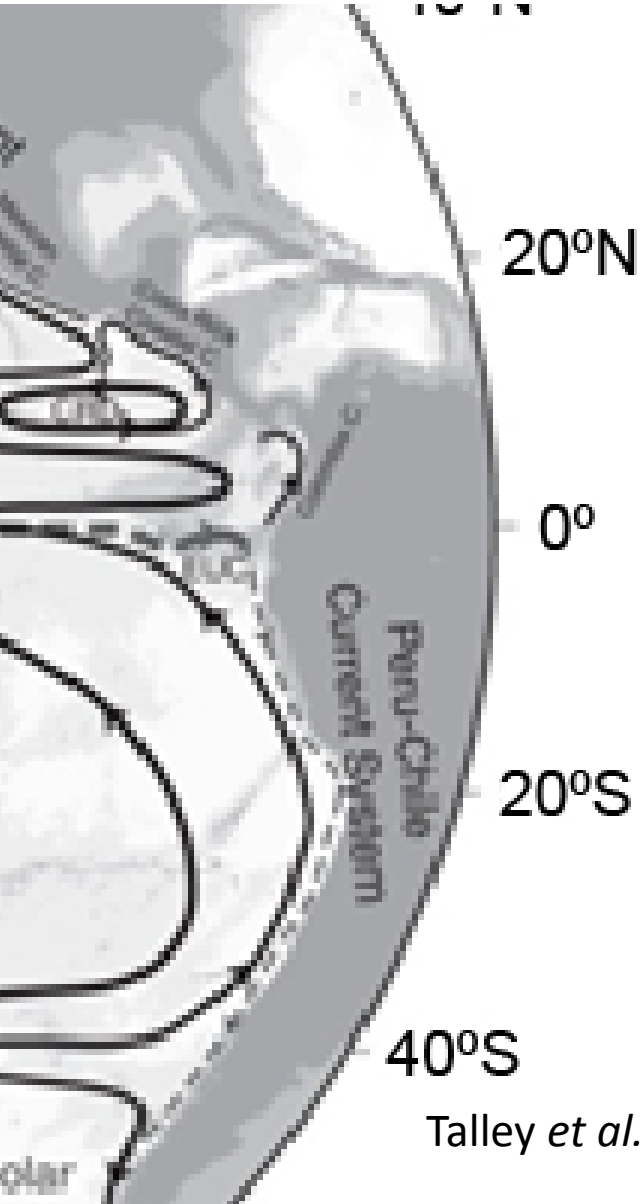


Talley *et al.* 2011

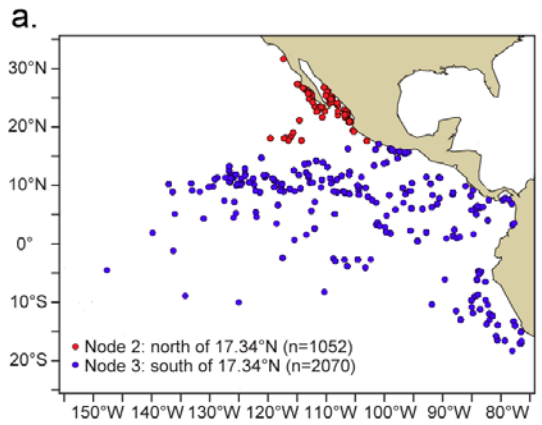


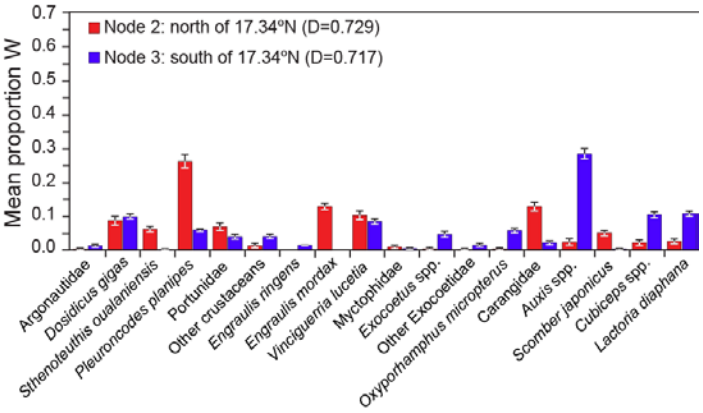
Popp *et al.* (2007)

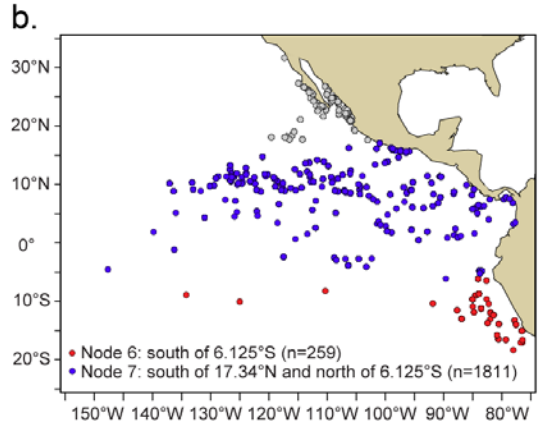
Evidence of differences in diet YFT

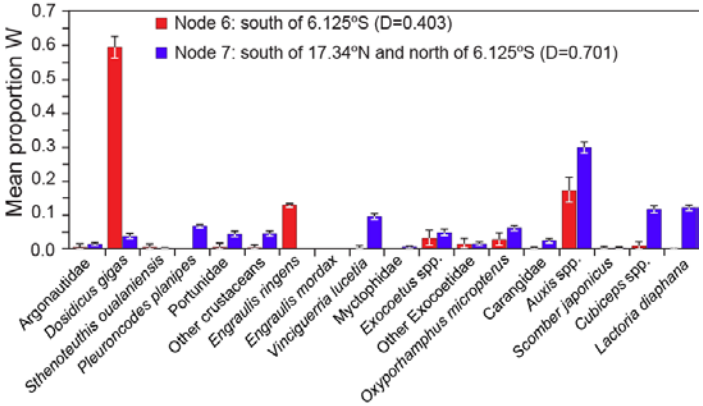


Talley *et al.* 2011





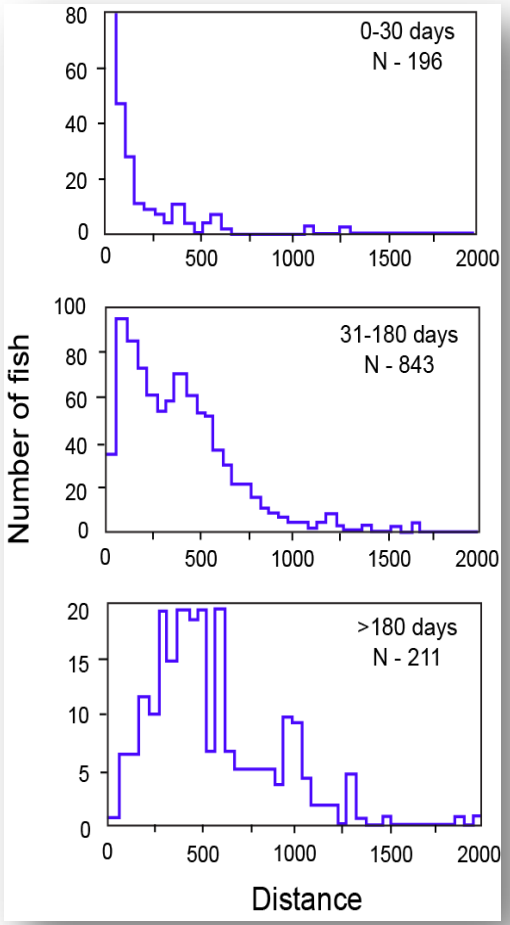




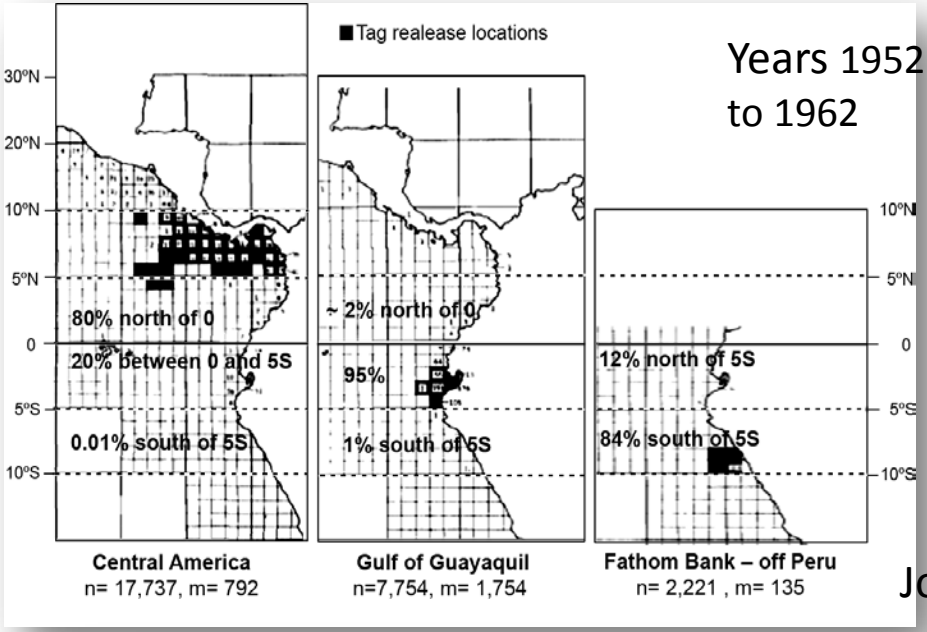
Olson *et al.* 2014

Summary of results of the conventional tagging studies

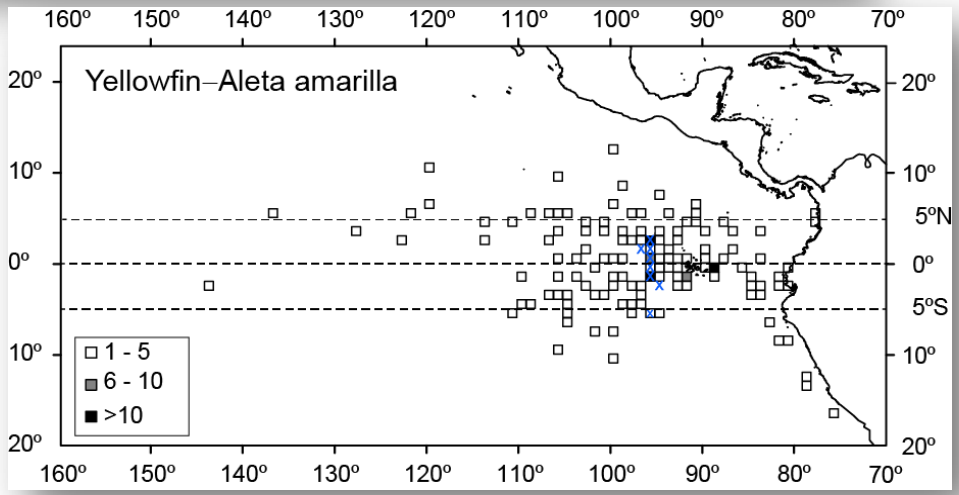
YFT



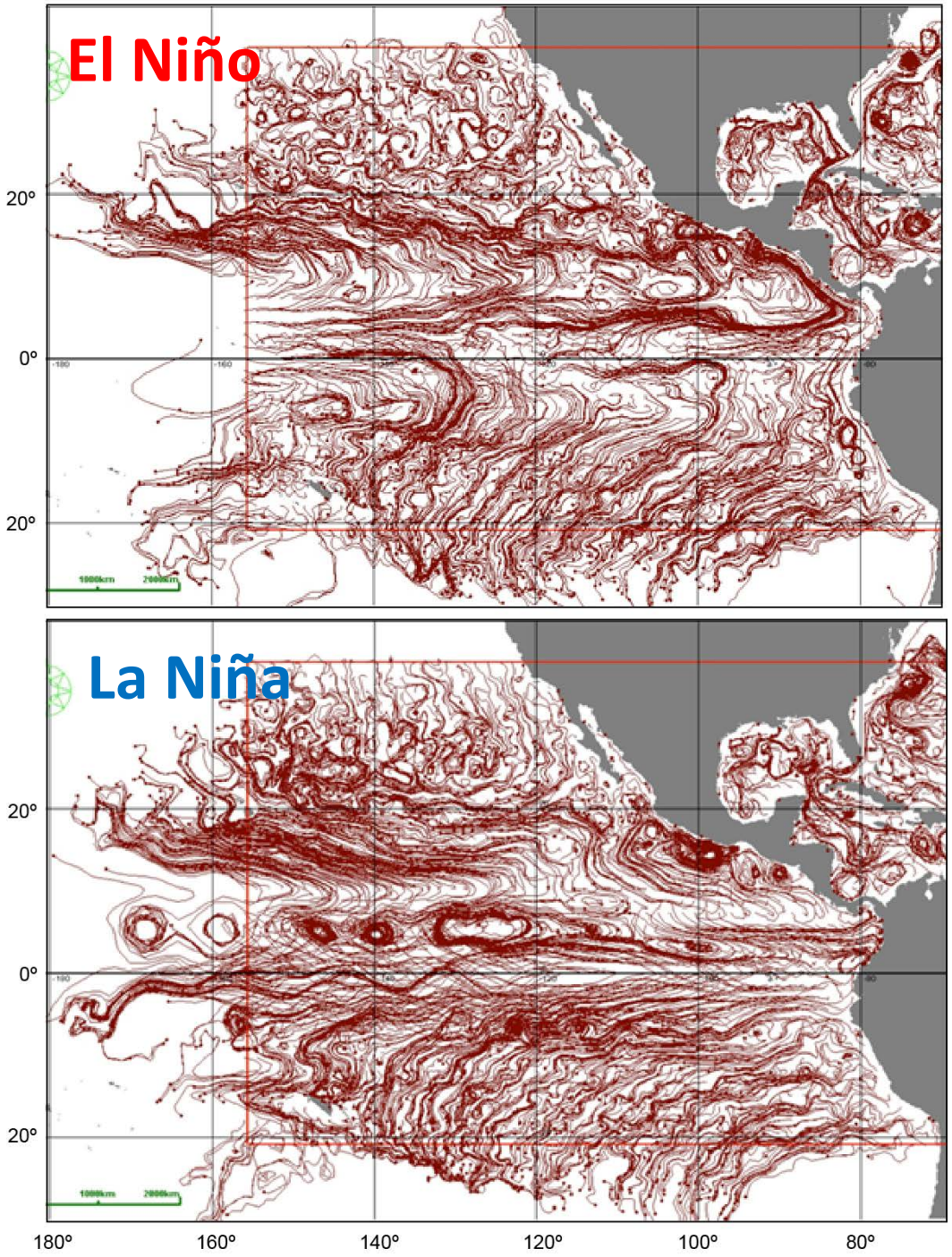
Hunter *et al.* 1986, data provided by W.H. Bayliff



Joseph *et al.* (1964)



IATTC Quarterly Report Oct-Dec 2006



Flow vector fields of surface currents in the EPO

El Niño flow clearly shows the breakdown of westward flow in the North Equatorial Current and South Equatorial Current and the absence of ring and eddy structure resulting from shear forces.

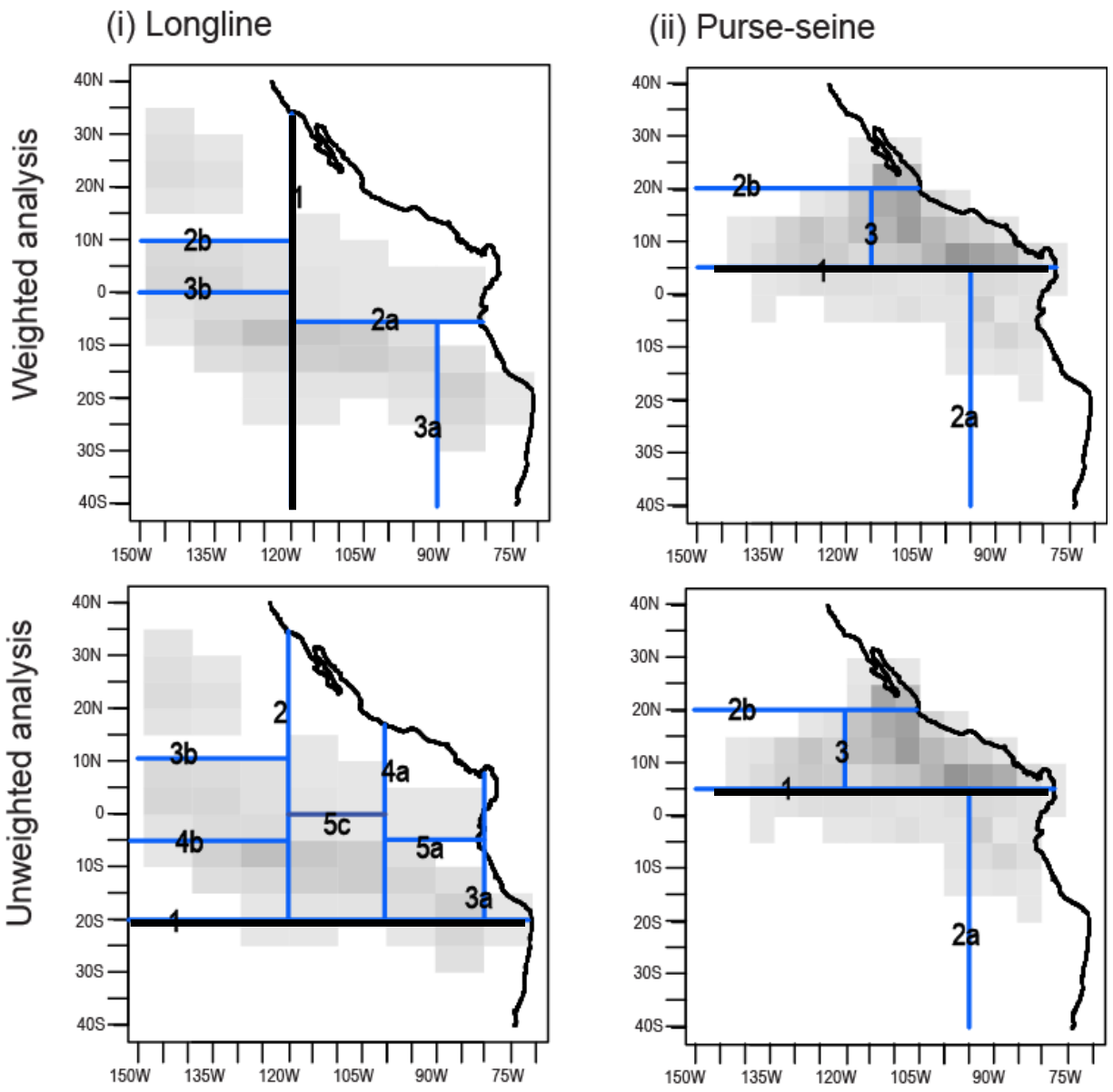
Data are from the NASA/JPL ECCO2 model, Hinton (2015)

YFT

Fishery data

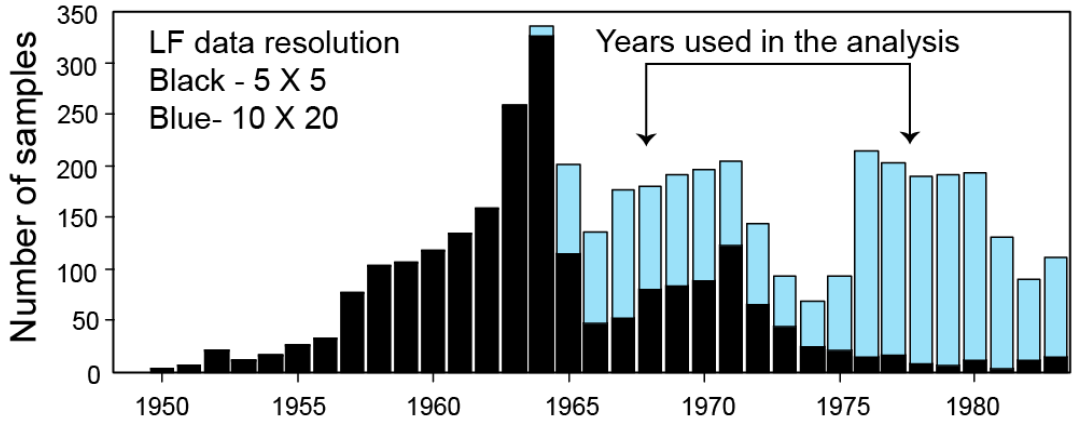
- Tree analysis on
  - PS and LL size distribution
  - LL catch rates

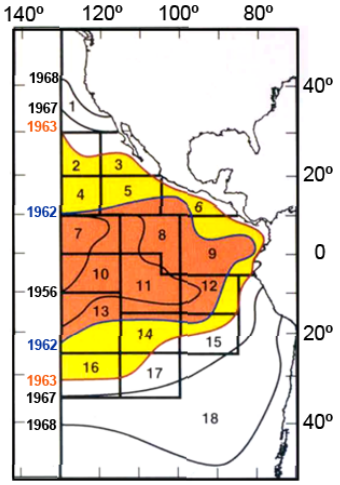
YFT



Lennert-Cody et al 2013b

YFT


LF data resolution
Black - 5 X 5
Blue- 10 X 20
Years used in the analysis
Number of samples
350
300
250
200
150
100
50
0
1950
1955
1960
1965
1970
1975
1980


140º
120º
100º
80º
40º
20º
0
20º
40º
1968
1967
1963
1962
1956
1962
1963
1967
1968
1
2
3
4
5
6
7
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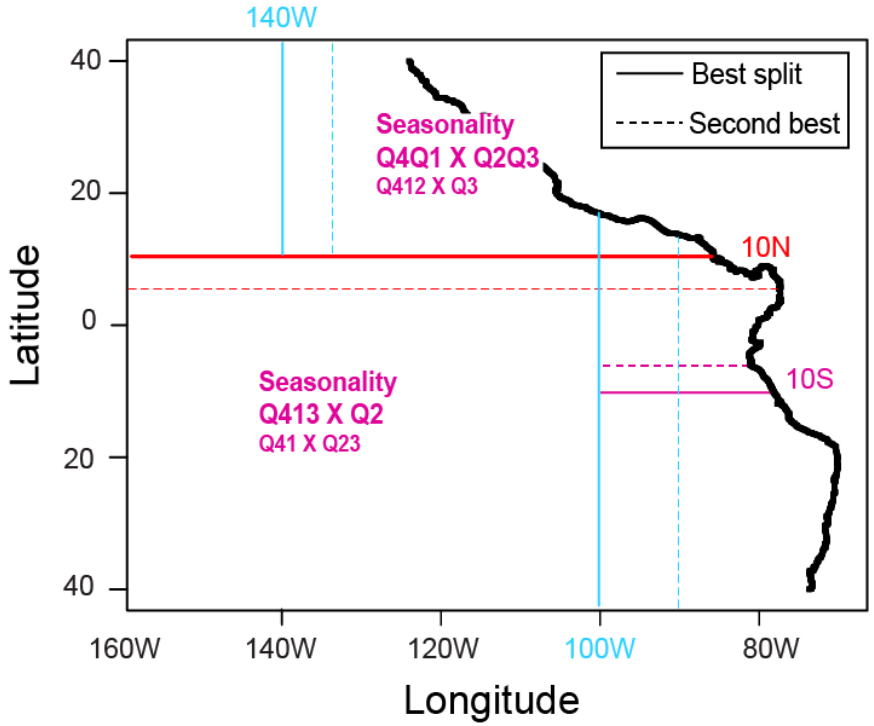
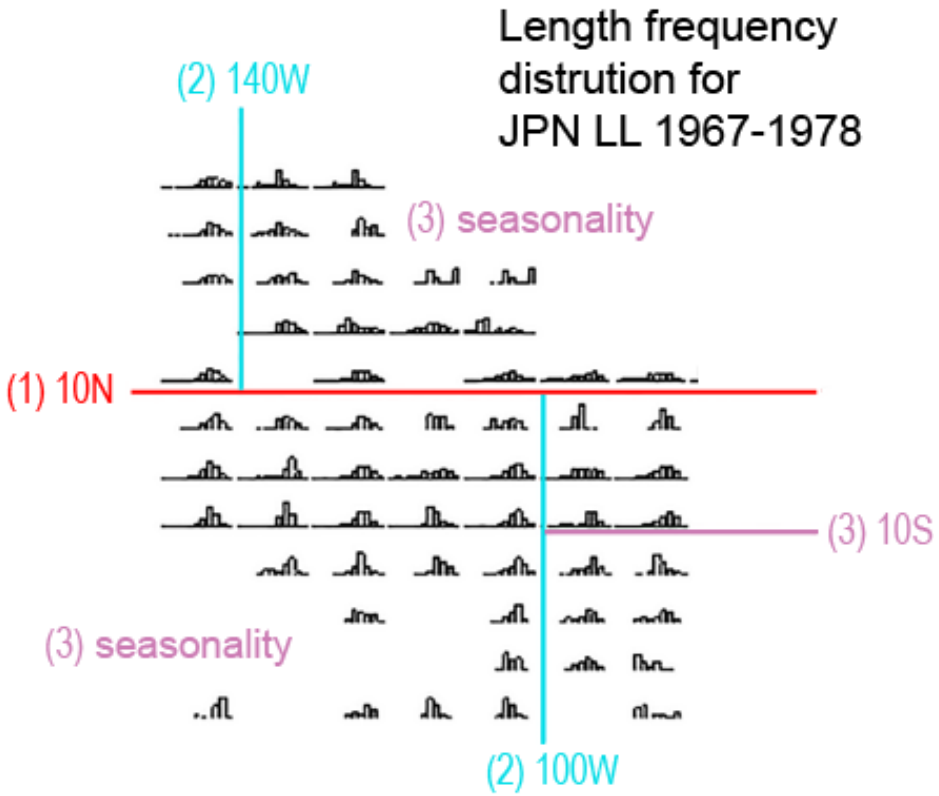
9
10
11
12
13
14
15
16
17
18


140W
Best split
Second best
Seasonality
Q4Q1 X Q2Q3
Q412 X Q3
10N
10S
Seasonality
Q413 X Q2
Q41 X Q23
Latitude
40
20
0
20
40
160W
140W
120W
100W
80W
Longitude


Length frequency
distrution for
JPN LL 1967-1978
(2) 140W
(3) seasonality
(1) 10N
(3) 10S
(3) seasonality
(2) 100W

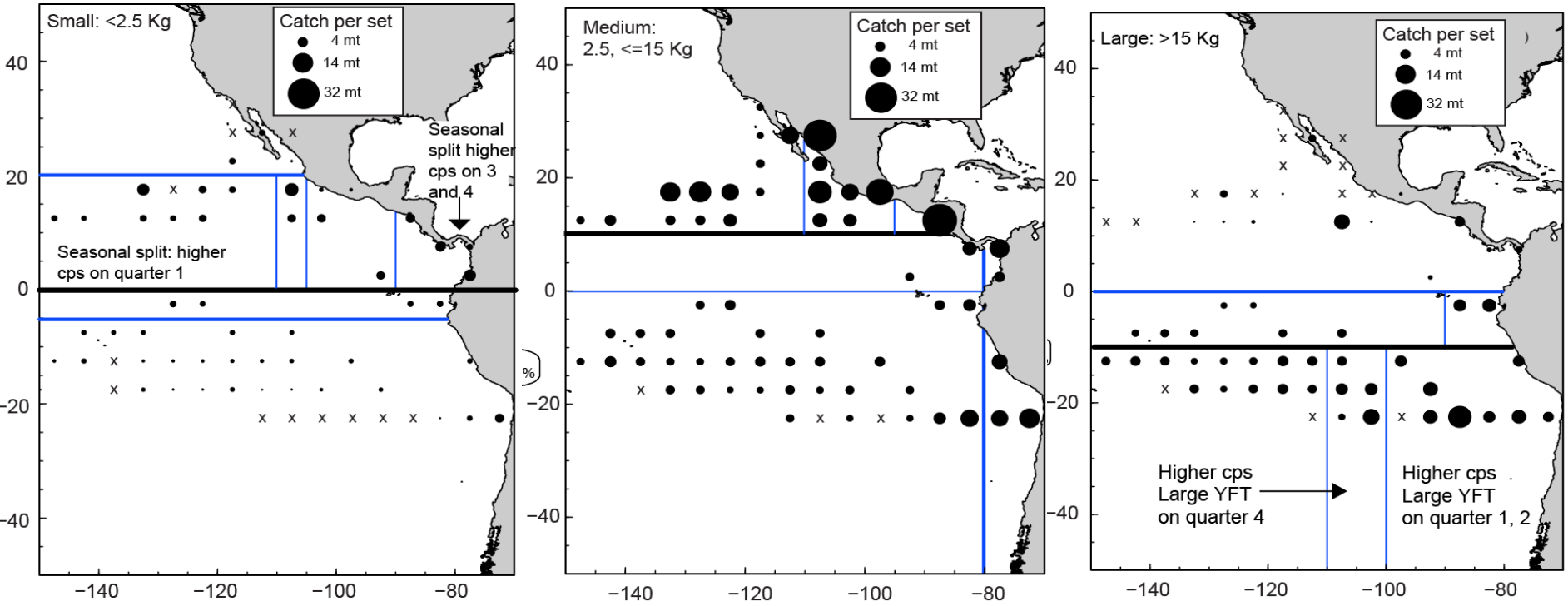
YFT

Results of regression tree analysis on catch per set of PS OBJ

Small < 2.5g

2.5kg< Medium < 15 kg

Large > 15 kg

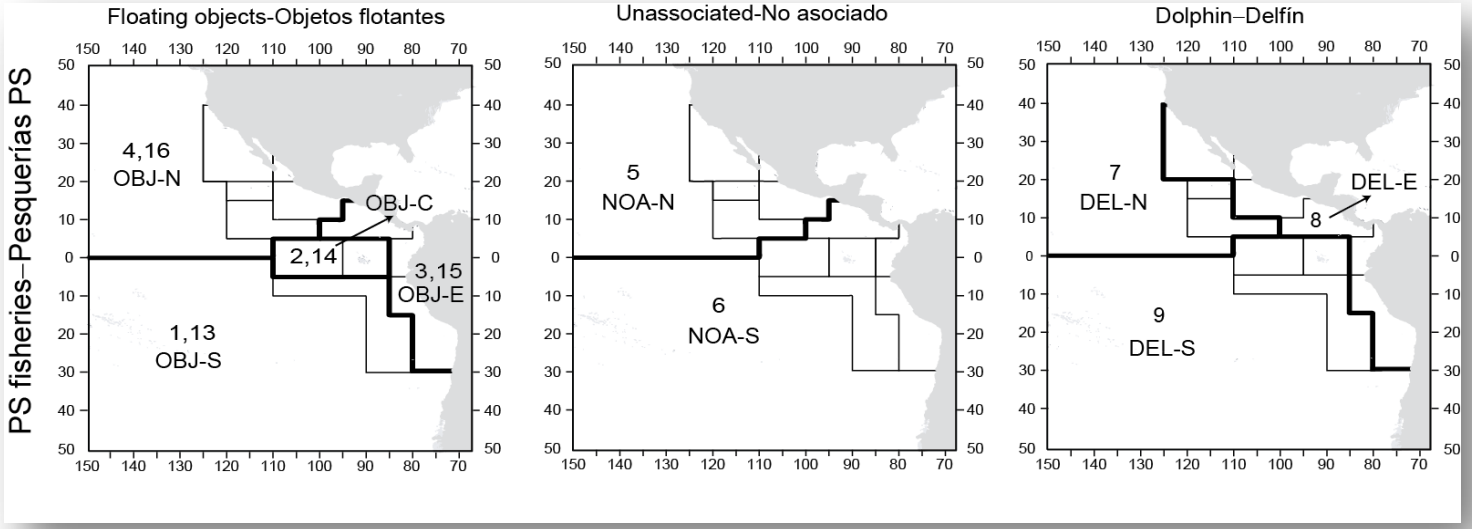


Map with the catch per set in a 5 x 5 resolution (average for years 2000-2014)

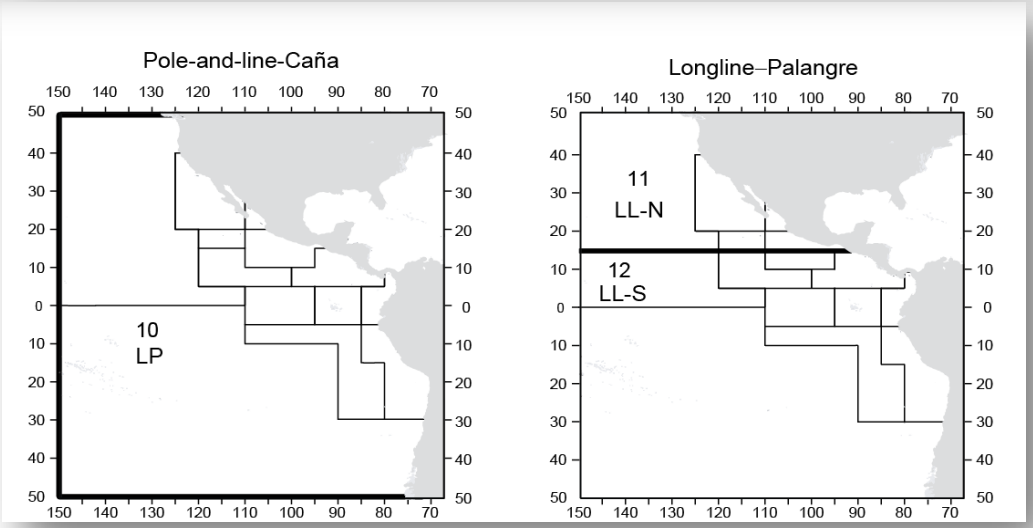
Lines: results of regression tree analysis on catch per set of PS OBJ
(data for 1993 to 2013)

YFT

Current fisheries definitions



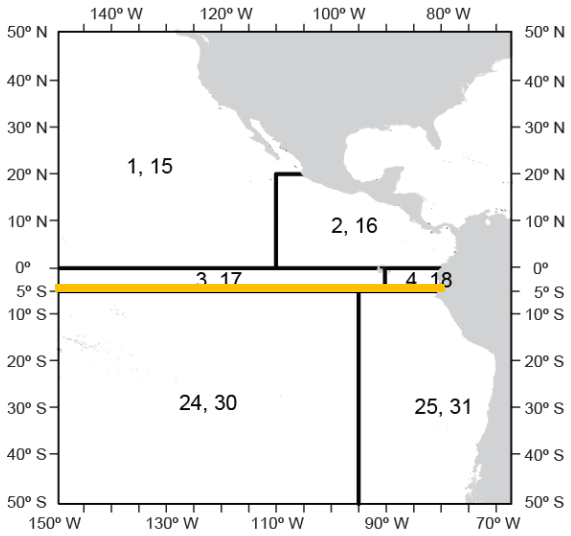
- One stock
- SS3 model
- 16 fisheries
  - ✓ Defined by gear, set type, discard
  - ✓ Spatially fisheries defined to maintain constant average size over time



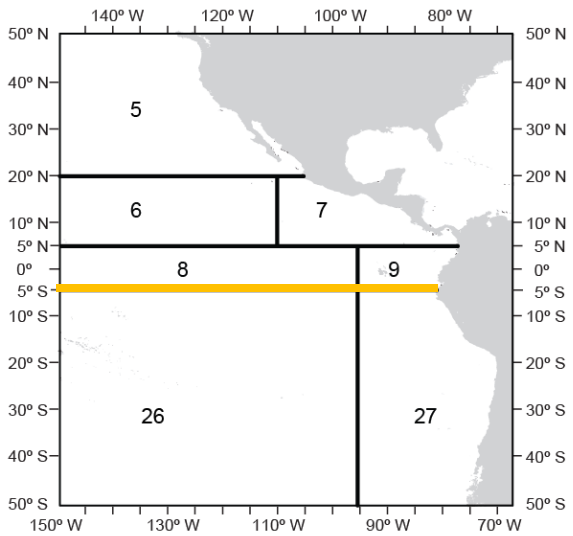
Proposal for new spatial definitions

YFT

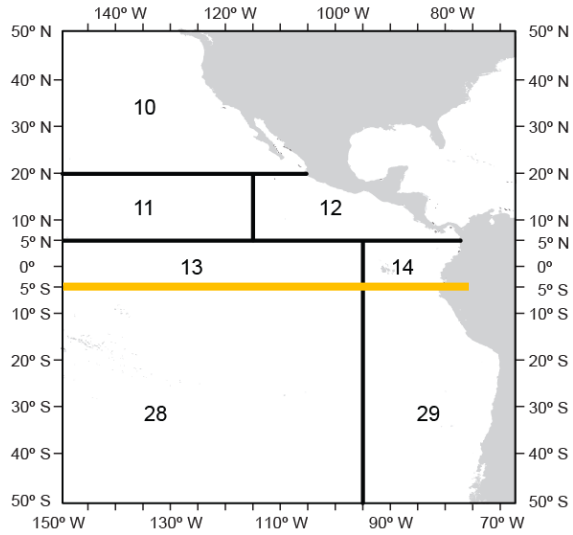
YFT - Purse-Seine Floating Objects



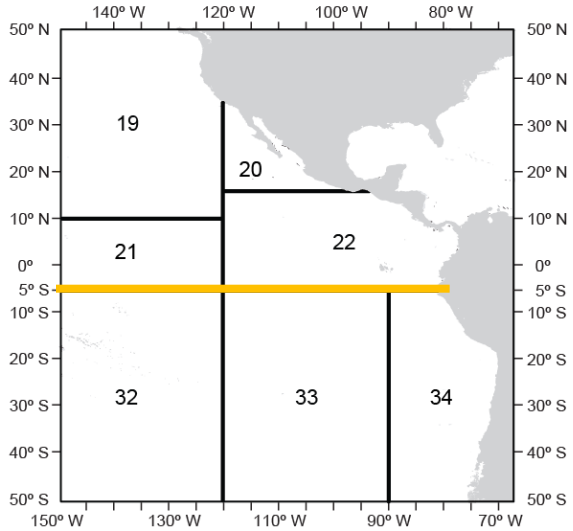
YFT - Purse-Seine Unassociated



YFT - Purse-Seine Dolphin

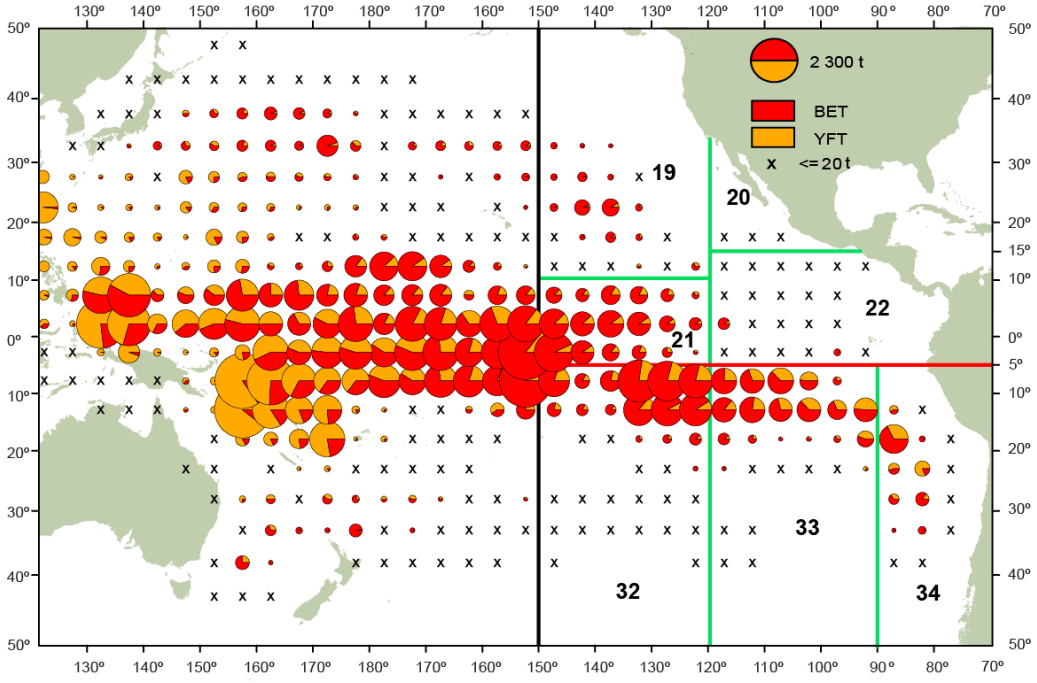


YFT - Longline

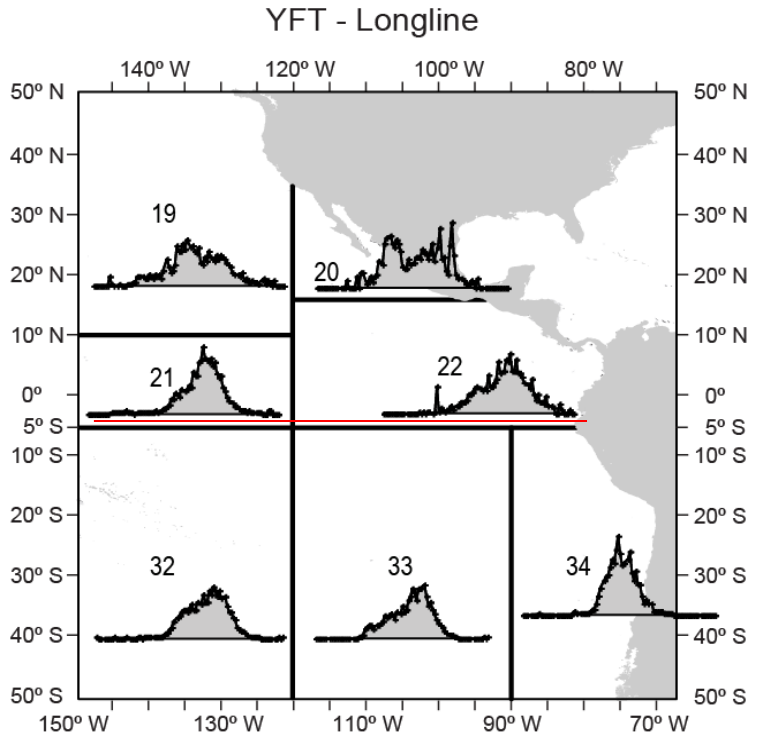


YFT Longline: proposed fishery definitions

Catches



Length-frequency



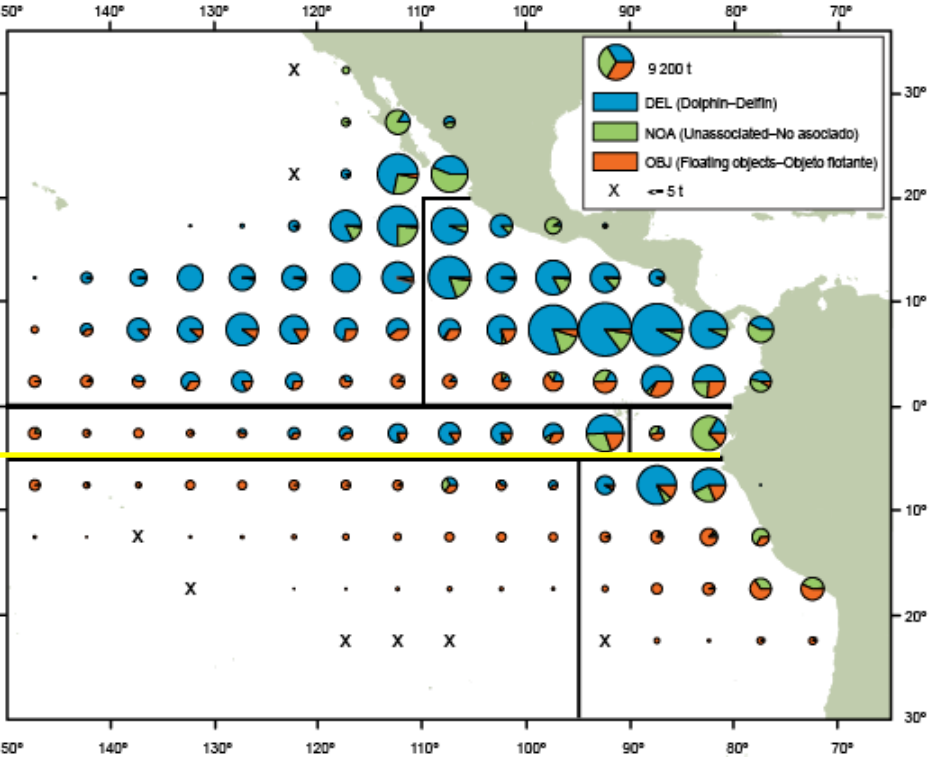
Source: JPN LL length-frequency data

Catches are averages for 2008-2012 (FSR, IATTC, 2014)

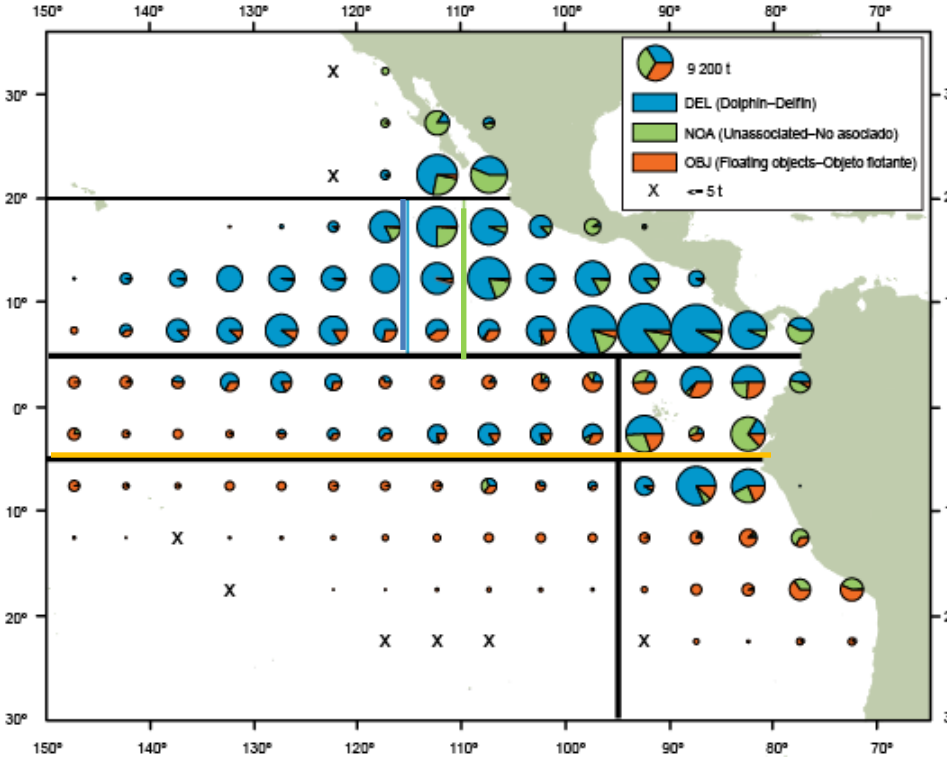
YFT

Purse seine catches by set type

PS OBJ proposed fishery definitions



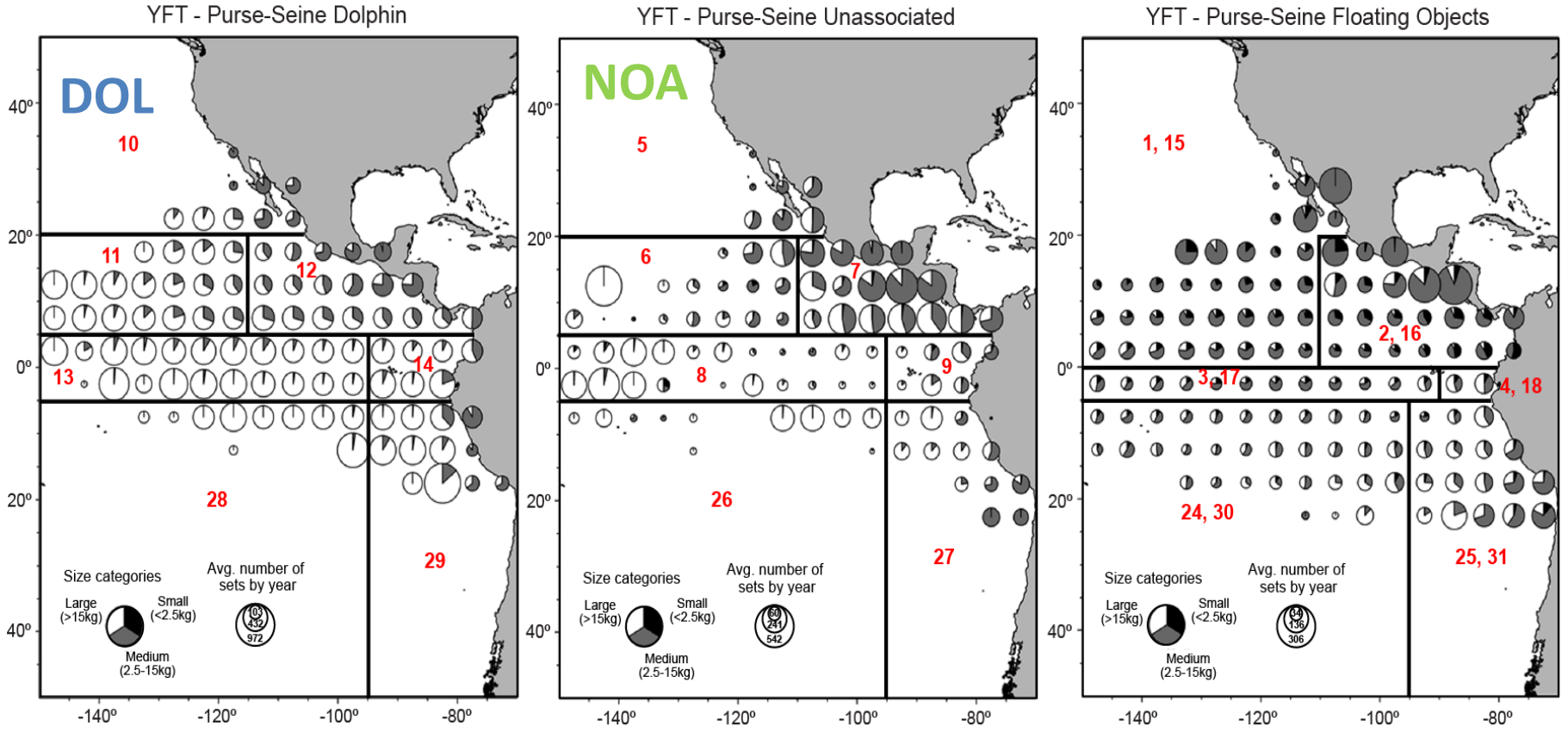
PS DOL and NOA proposed fishery definitions



Catches are averages for 2008-2012 (FSR, IATTC, 2014)

YFT

Size composition by proposed spatial definitions for PS fisheries

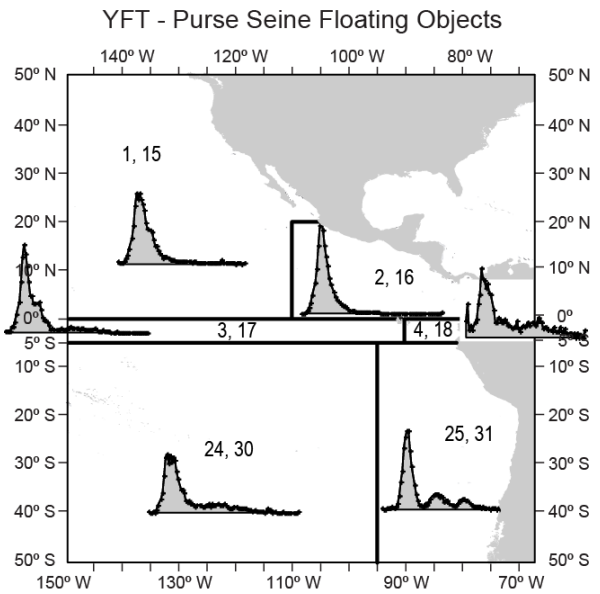


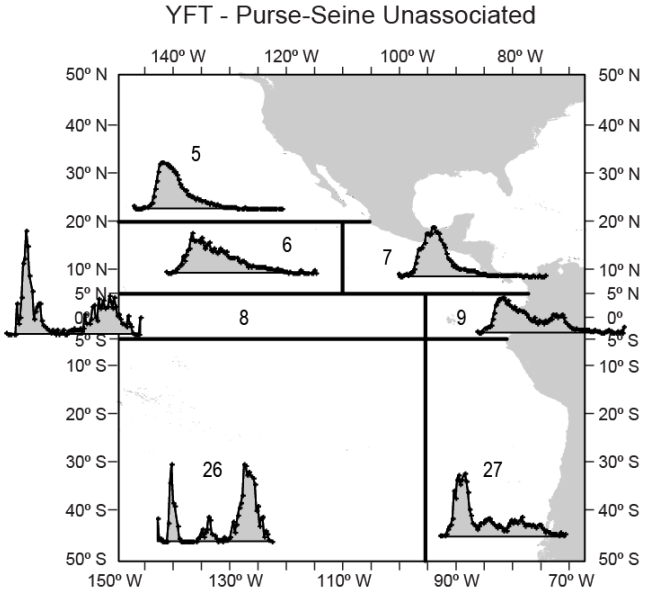
Source: IATTC observer database

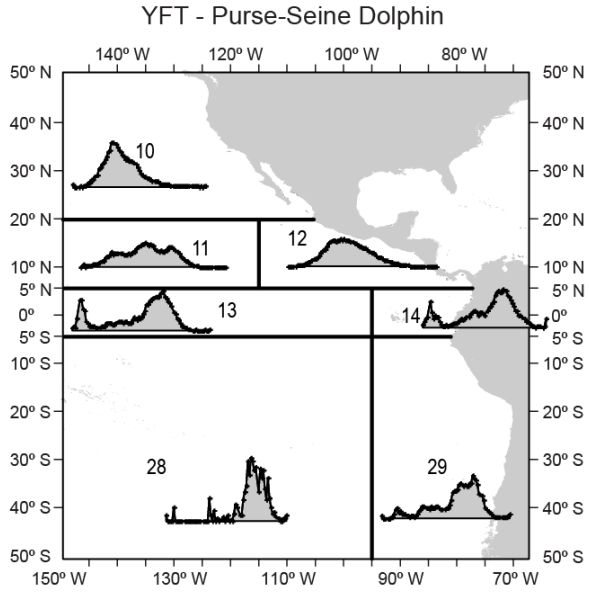
YFT

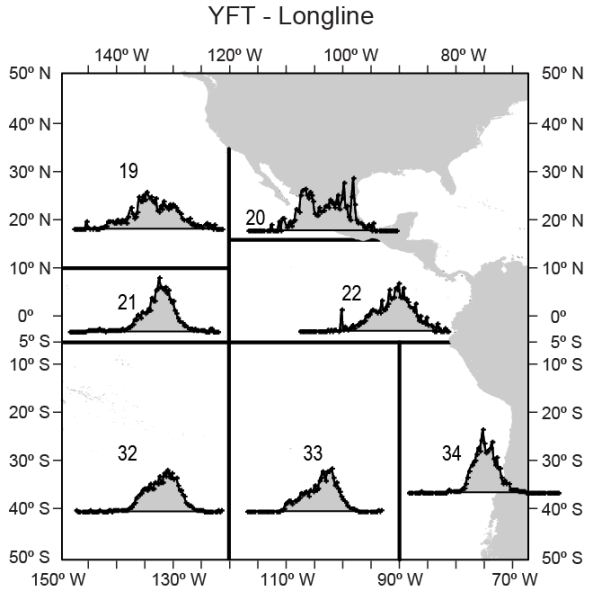
Length-frequency by proposed spatial definitions for fisheries

IATTC Port-sampling data (used to fit the models)

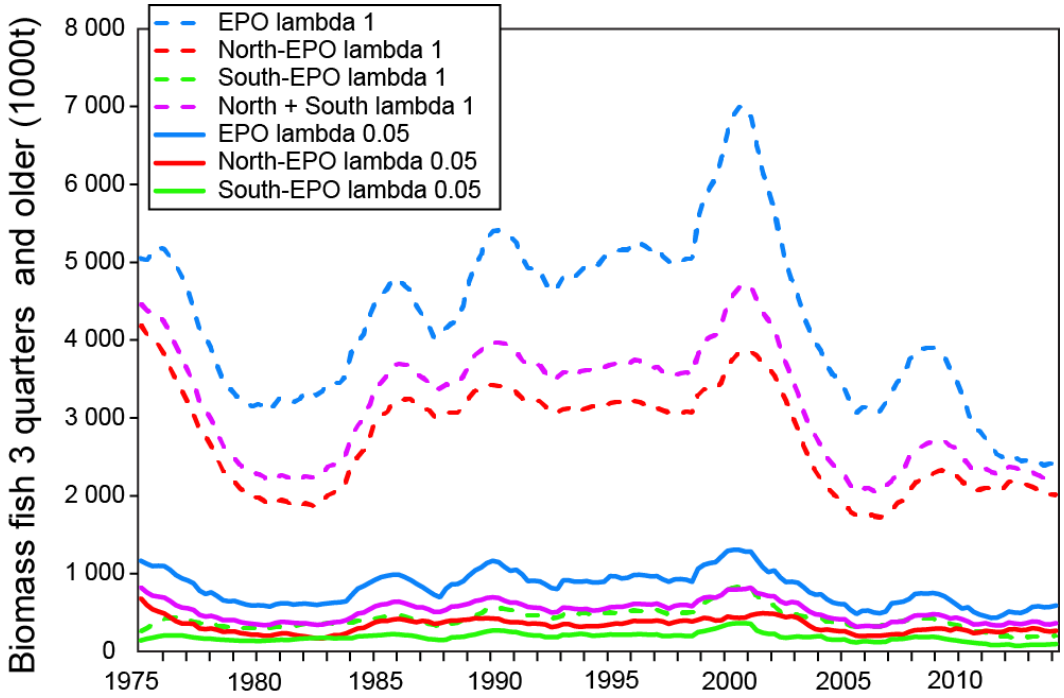


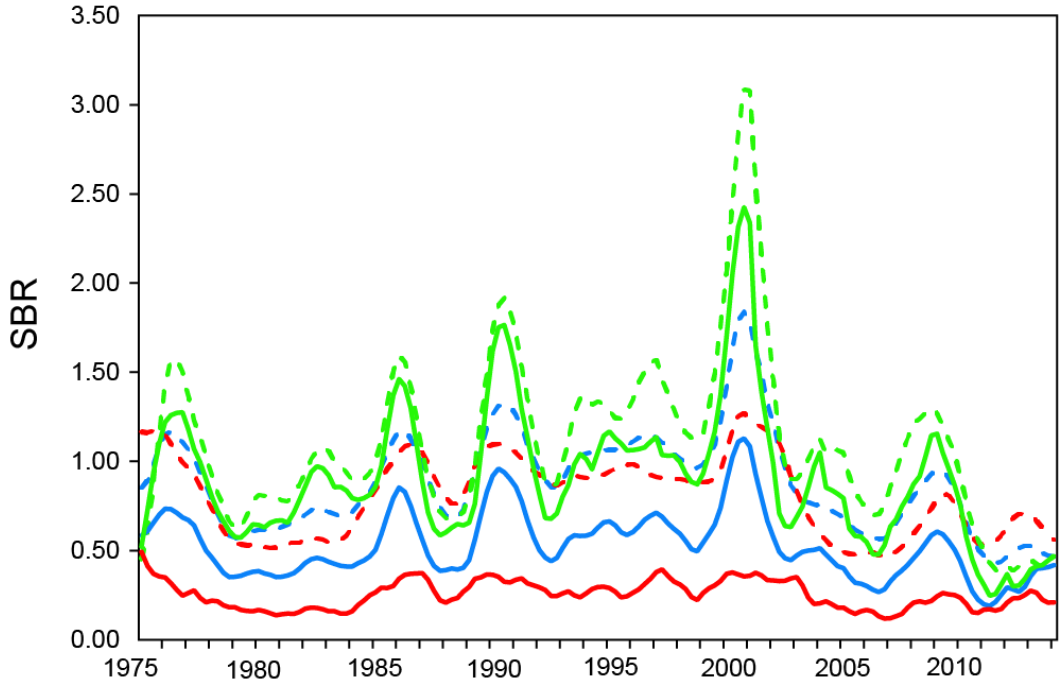






YFT

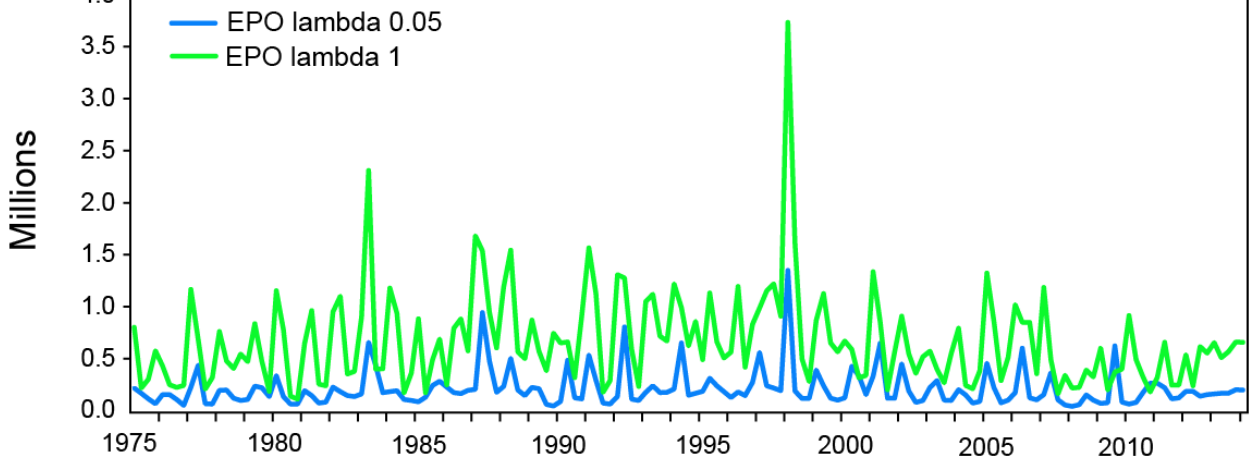


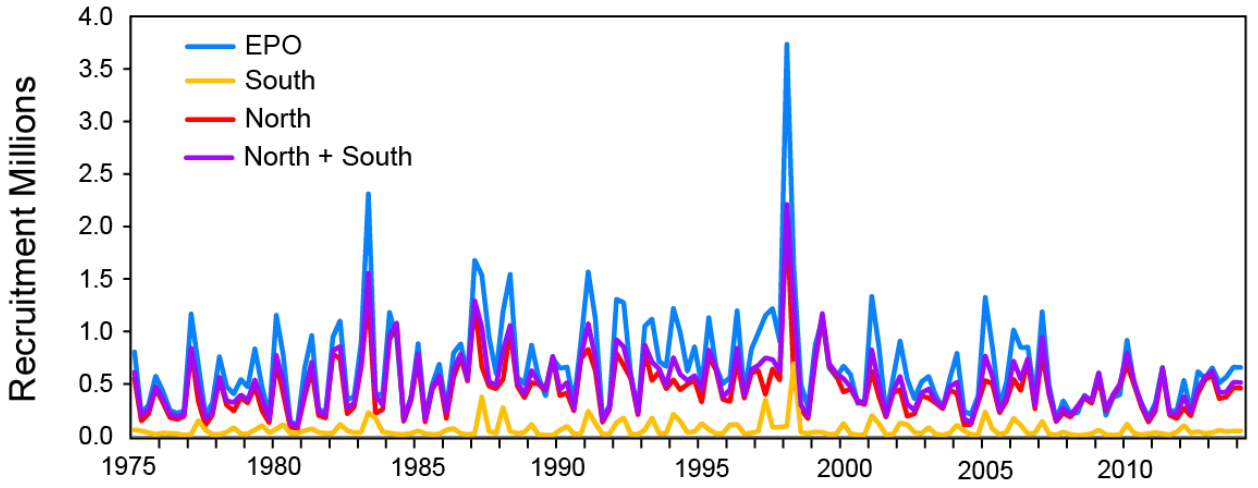


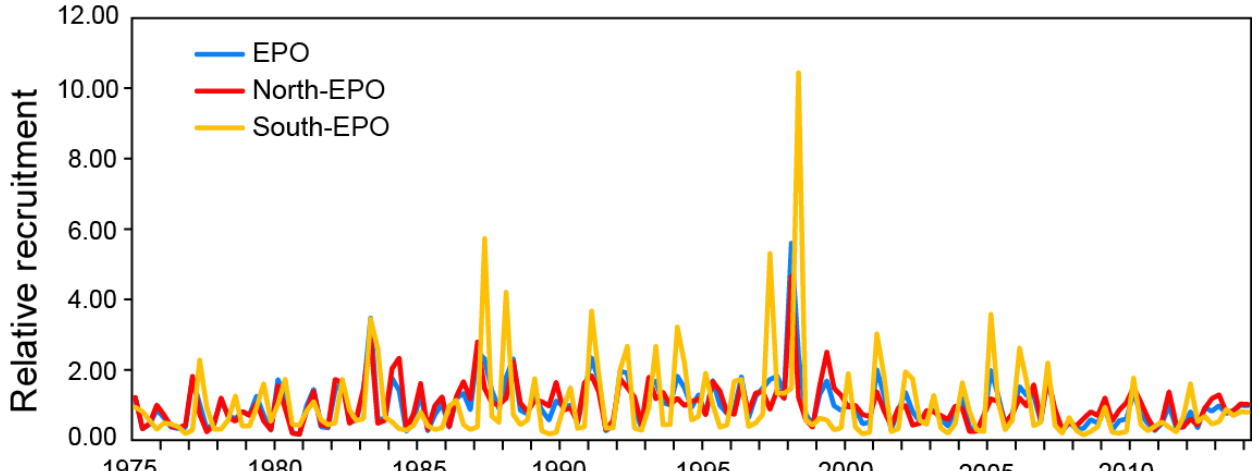
North-EPO: North of 5°S

South-EPO: South of 5°S

YFT


EPO lambda 0.05
EPO lambda 1
Millions
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
1975
1980
1985
1990
1995
2000
2005
2010

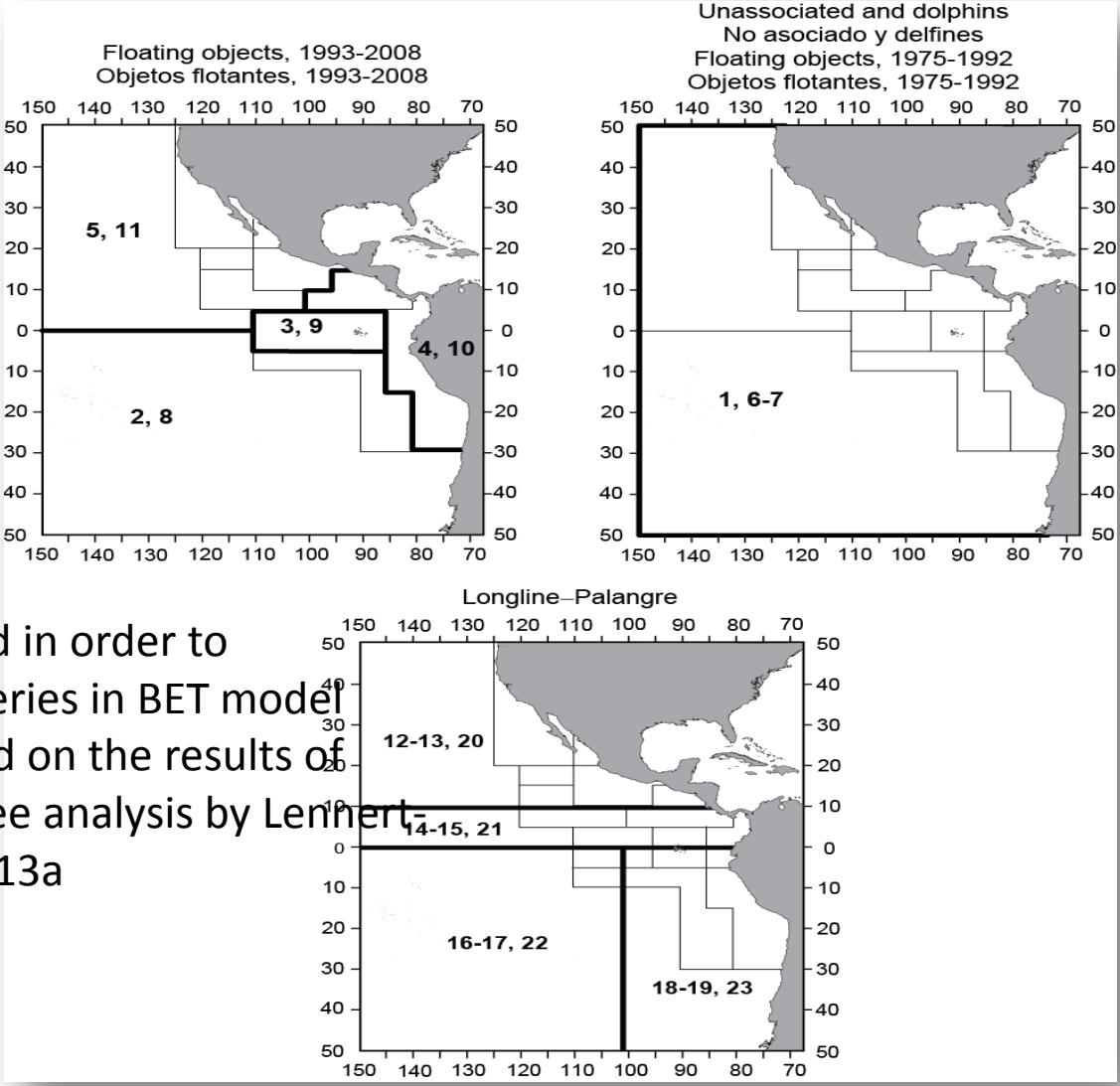

EPO
South
North
North + South
Recruitment Millions
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
1975
1980
1985
1990
1995
2000
2005
2010


EPO
North-EPO
South-EPO
Relative recruitment
0.00
2.00
4.00
6.00
8.00
10.00
12.00
1975
1980
1985
1990
1995
2000
2005
2010

Current fisheries definitions

BET

- one stock
- SS3 mode l
- 23 fisheries
  - ✓ Most defined in order to
  - ✓ Longline fisheries in BET model defined based on the results of regression tree analysis by Lennert-Cody et al 2013a



BET

Biological evidence of stock structure

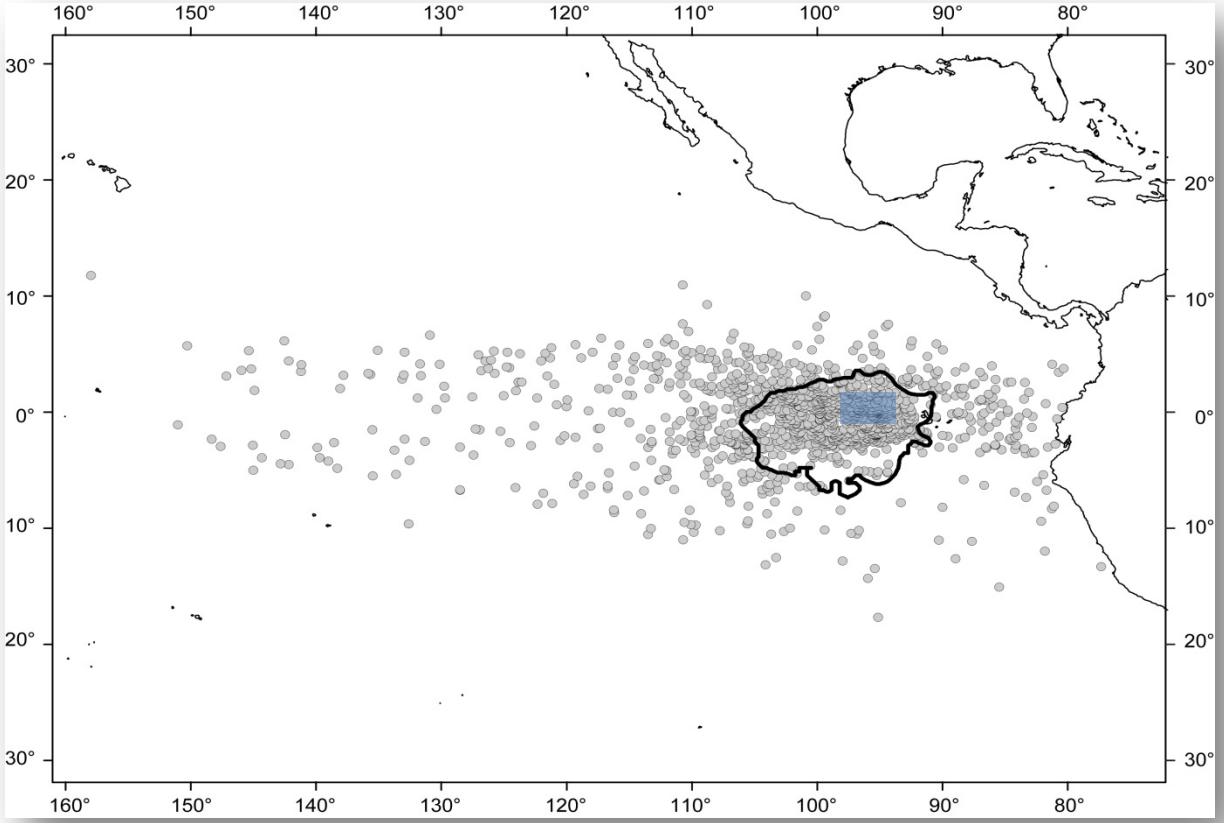
- Tagging

BET Movements and area of utilization

approximate area of release

recaptures of fish tagged with conventional and archival tags

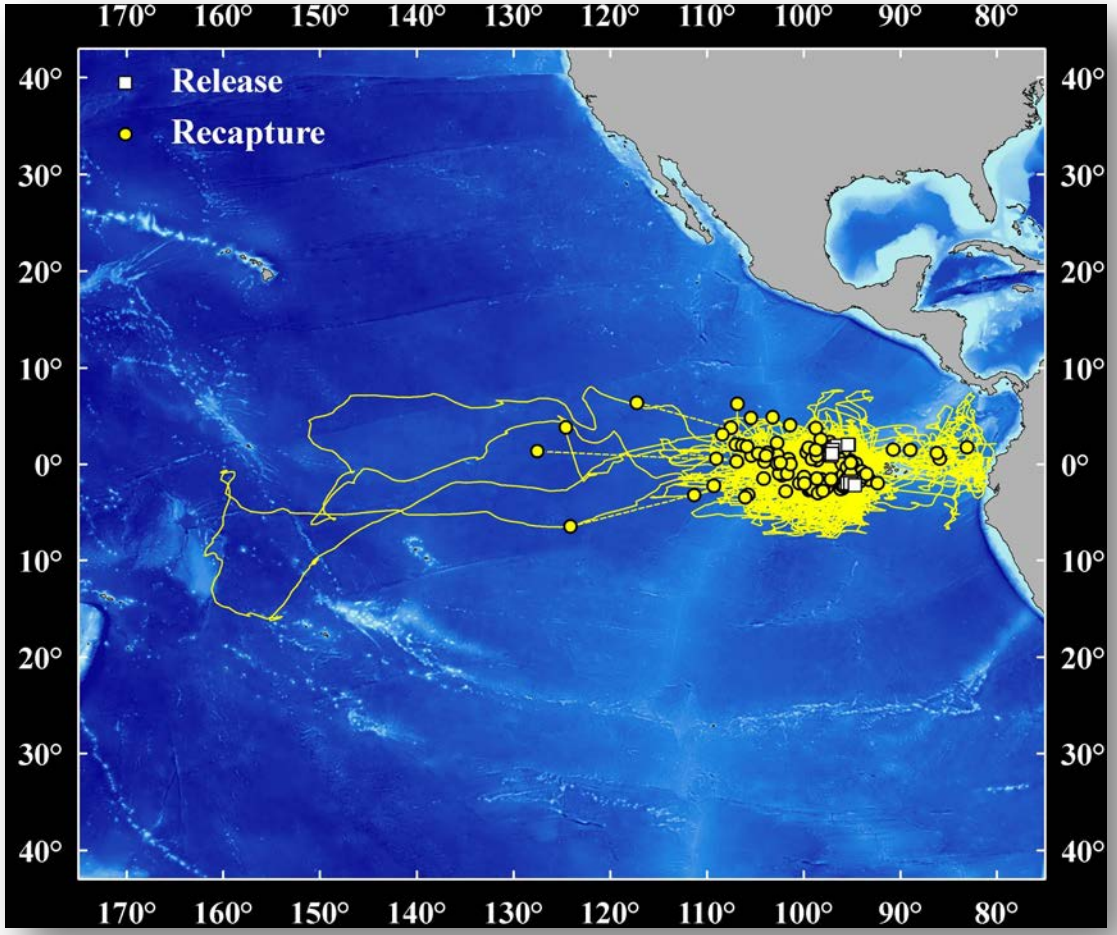
utilization distribution estimated for all fish with archival tags recovered



Schaefer and Fuller 2009

BET

Movement

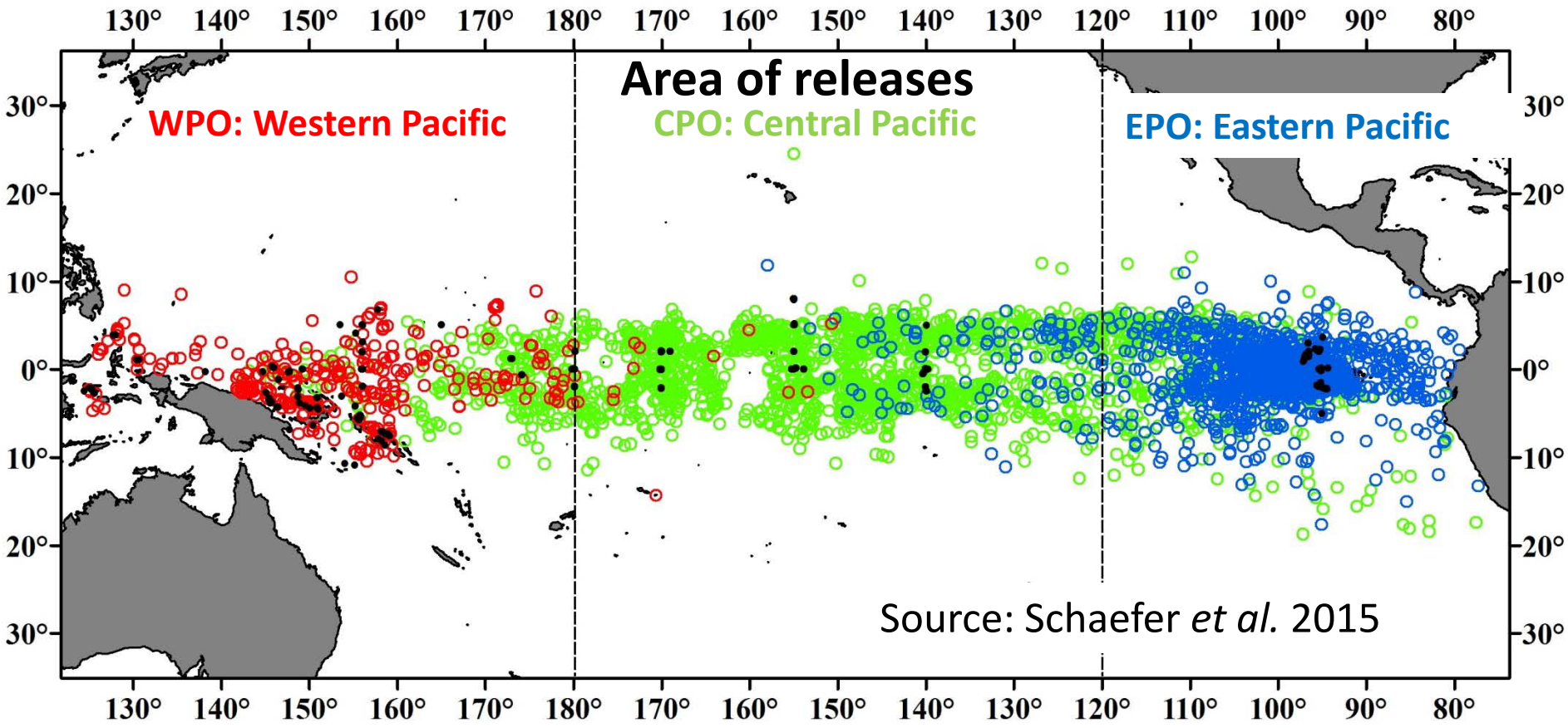


Movement paths for 96 bigeye tunas released with archival tags in the EPO

Times at Liberty: 30 to 1509 days

Schaefer and Fuller 2009

BET Dart tag recapture positions (≥ 30 days at liberty)



Descriptive statistics on dispersion and mixing among areas

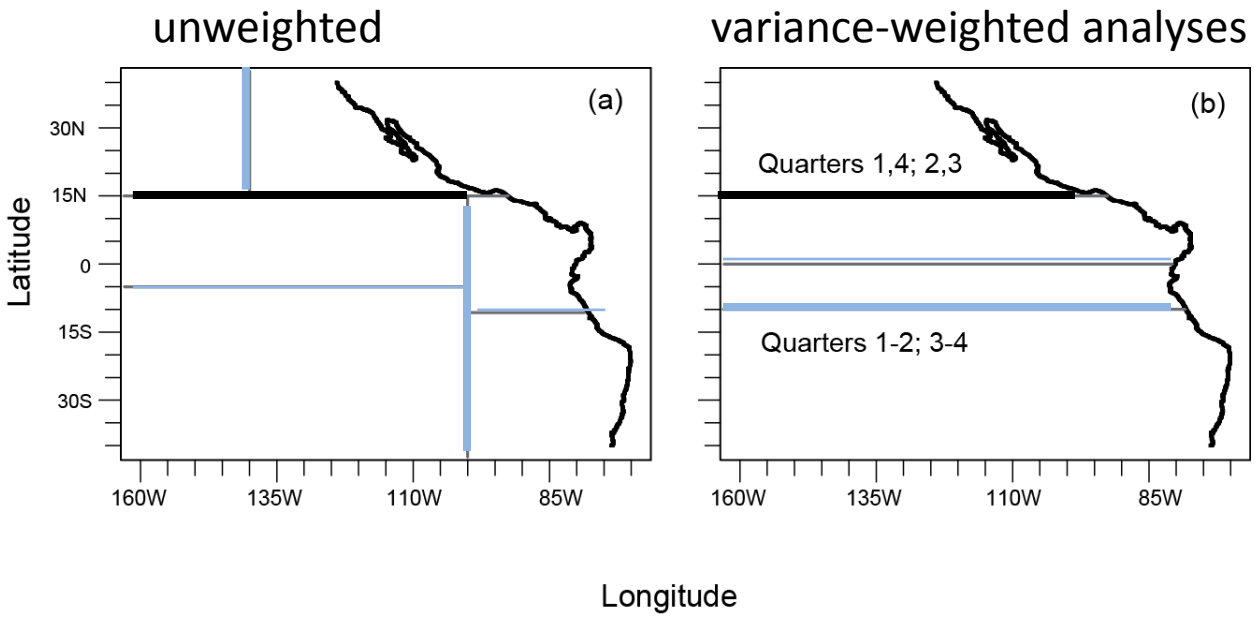
	Recoveries	CPO (120° W to 180°)	EPO (E of 120°W)	WPO (W of 180°)
CPO	5415	3311(61.1%)	1607 (29.7%)	497 (9.2%)
EPO	6692	159 (2.4%)	6533 (97.6%)	0 (0.0%)
WPO	456	20 (4.4%)	0 (0.0%)	436 (95.6%)

BET

Fishery data

BET

Longline data



LL fishery: Japanese length-frequency data for 2002-2007, catch and effort data for 1975-2007. Both data sets are used simultaneously	The main split for variance-weighted analysis is between areas north and south of 15°N, followed by a split at 10°S and another at 0°. Unweighted analysis have secondary splits at 100°W (in the south) and 140°W (in the north)

Lennert-Cody *et al.*(2013a)

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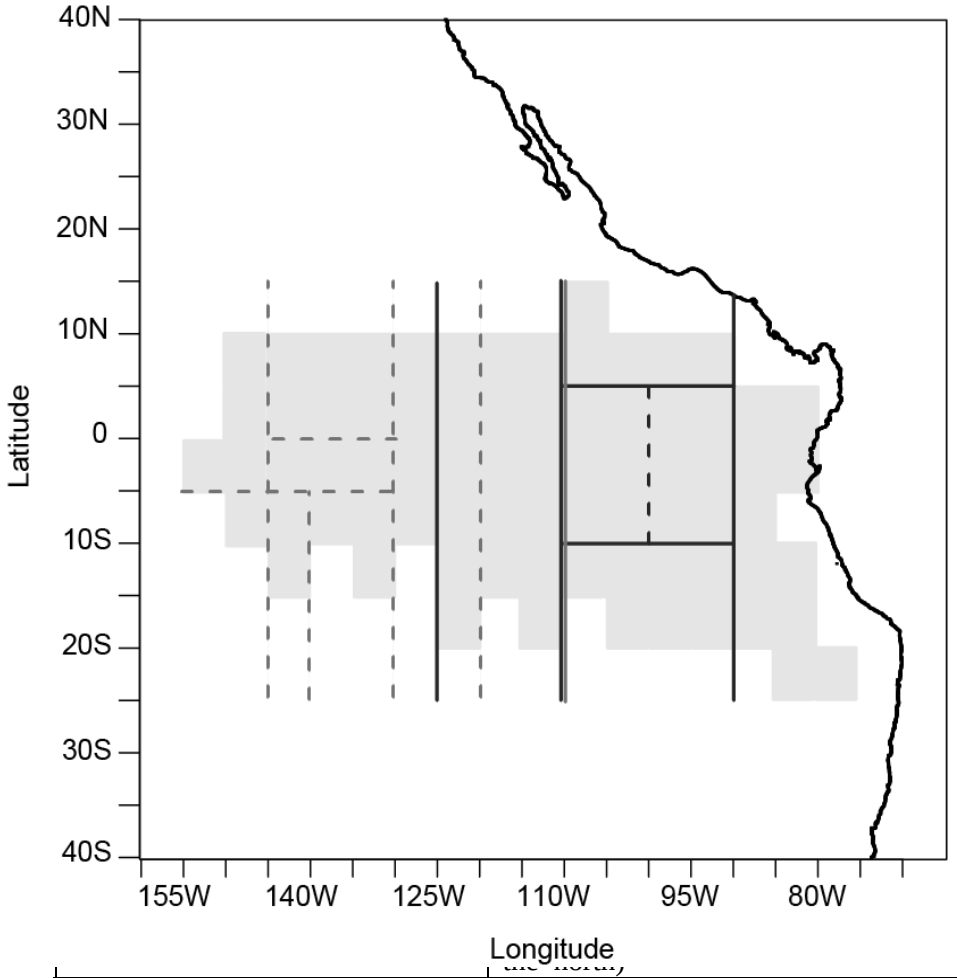
PS OBJ

Length-frequency data
1978-2008



PS OBJ Purse-seine length-frequency data for 1975-2008 from sets on floating objects	The analyses of different time periods (1975-1999 and 2000-2008) by the various tree methods showed agreement in partitioning the EPO into eastern and western regions around 100°-110°W. Finer-scale partitions were not consistent across time periods or methods.

Lennert-Cody *et al.*(2010) draft

Proposed spatial definitions for fisheries

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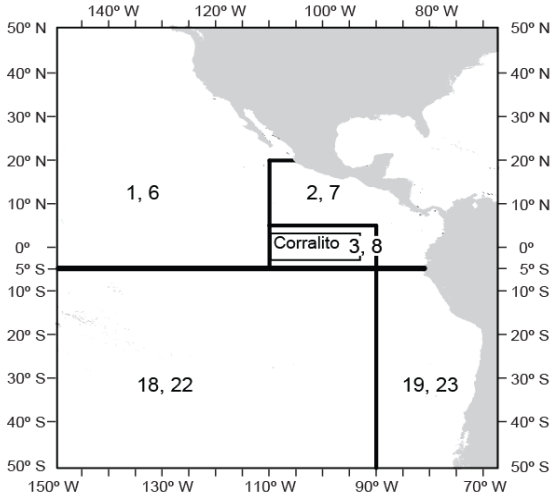
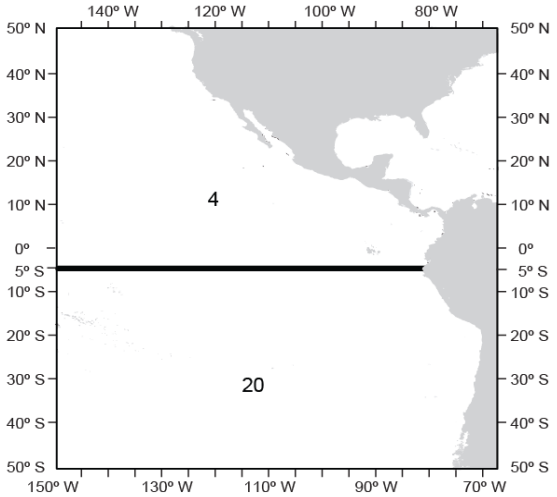
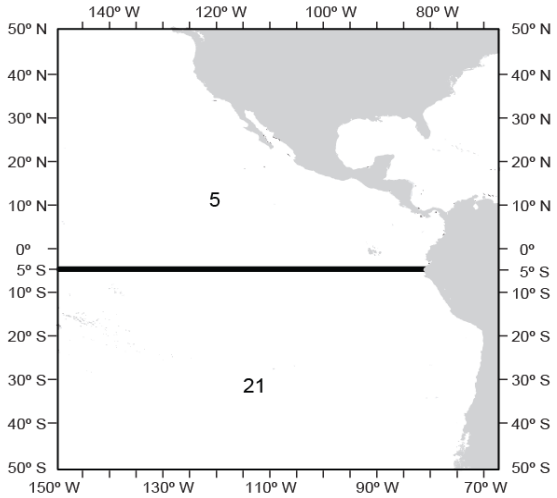
BET - Purse-Seine Floating Objects



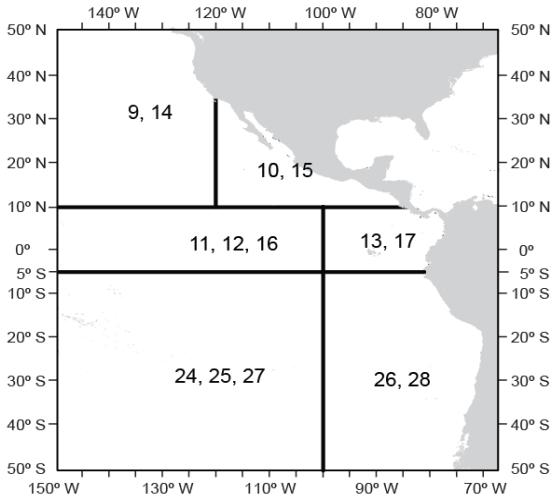
BET - Purse-Seine Unassociated



BET - Purse-Seine Dolphin



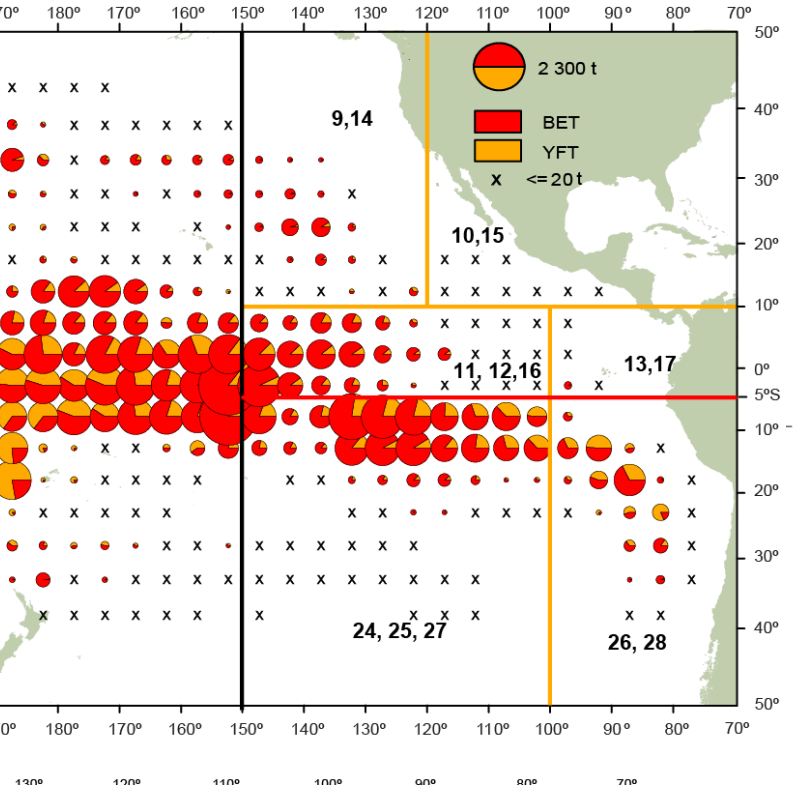
BET - Longline



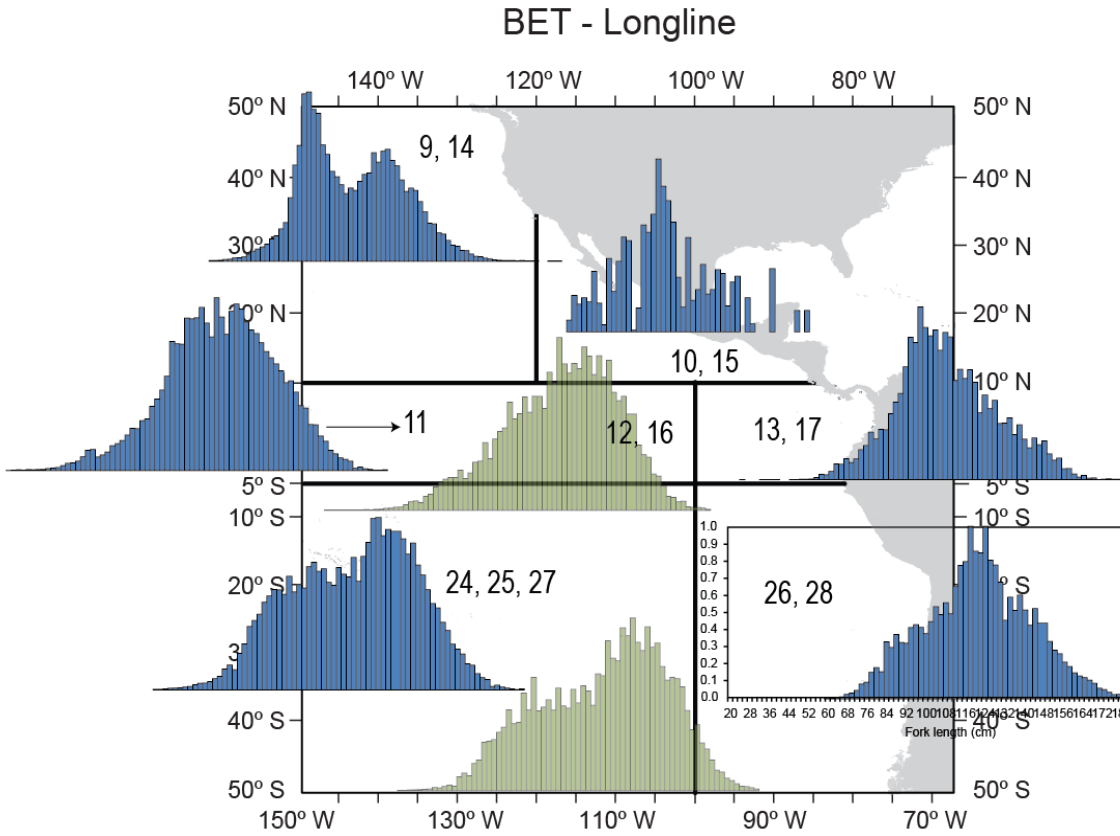
BET

Longline

Catches



Length-frequency



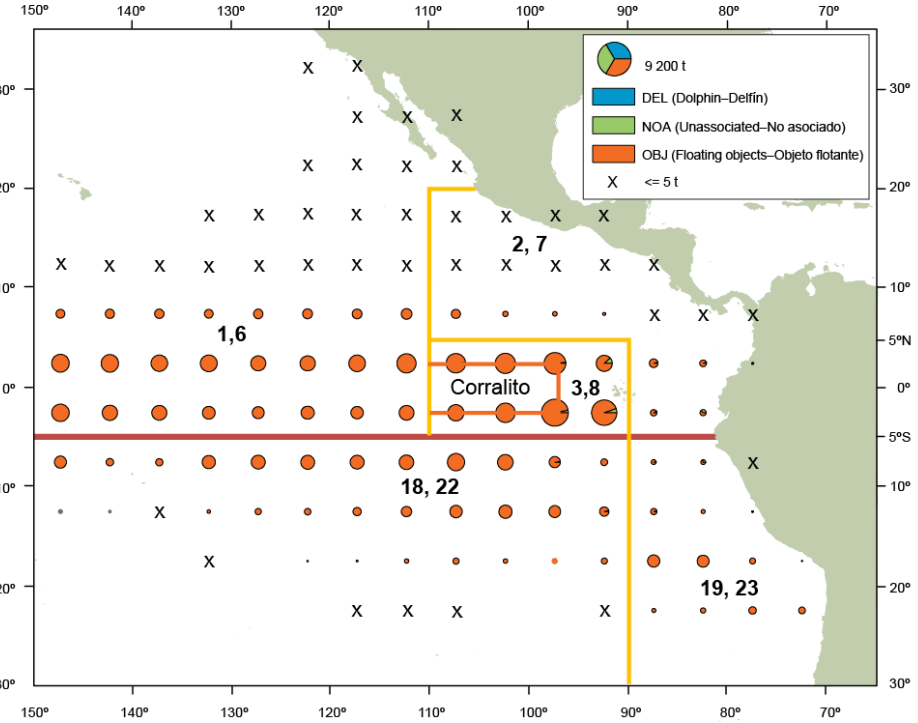
Catches are averages for 2008-2012
(FSR, IATTC, 2014)

early period (1975 to 1990)
green late period (1990 to 2013

Source: JPN LL length-frequency data

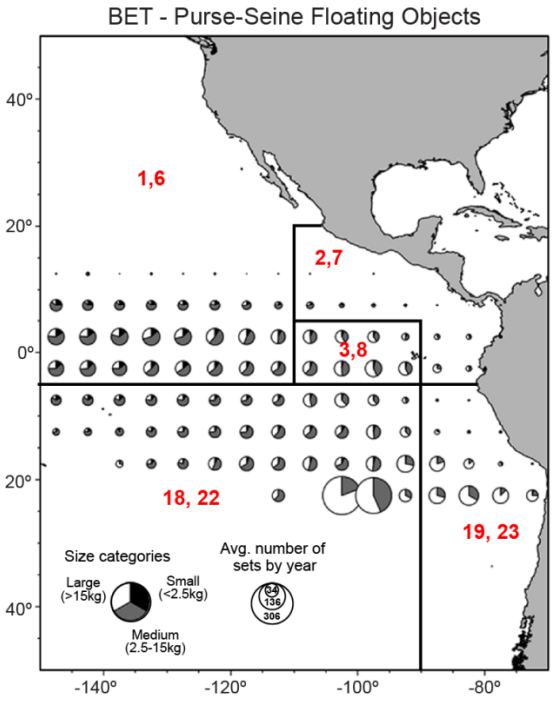
BET Purse seine

Catches

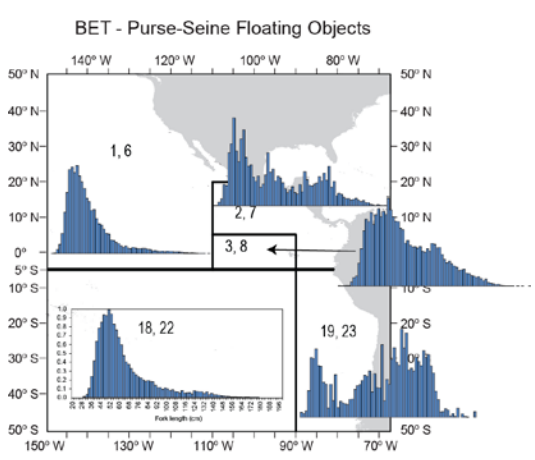


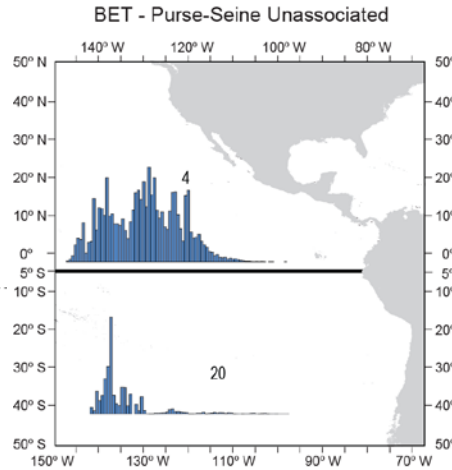
Catches are averages for 2008-2012 (FSR, IATTC, 2014)

Size composition



Source: IATTC observer data

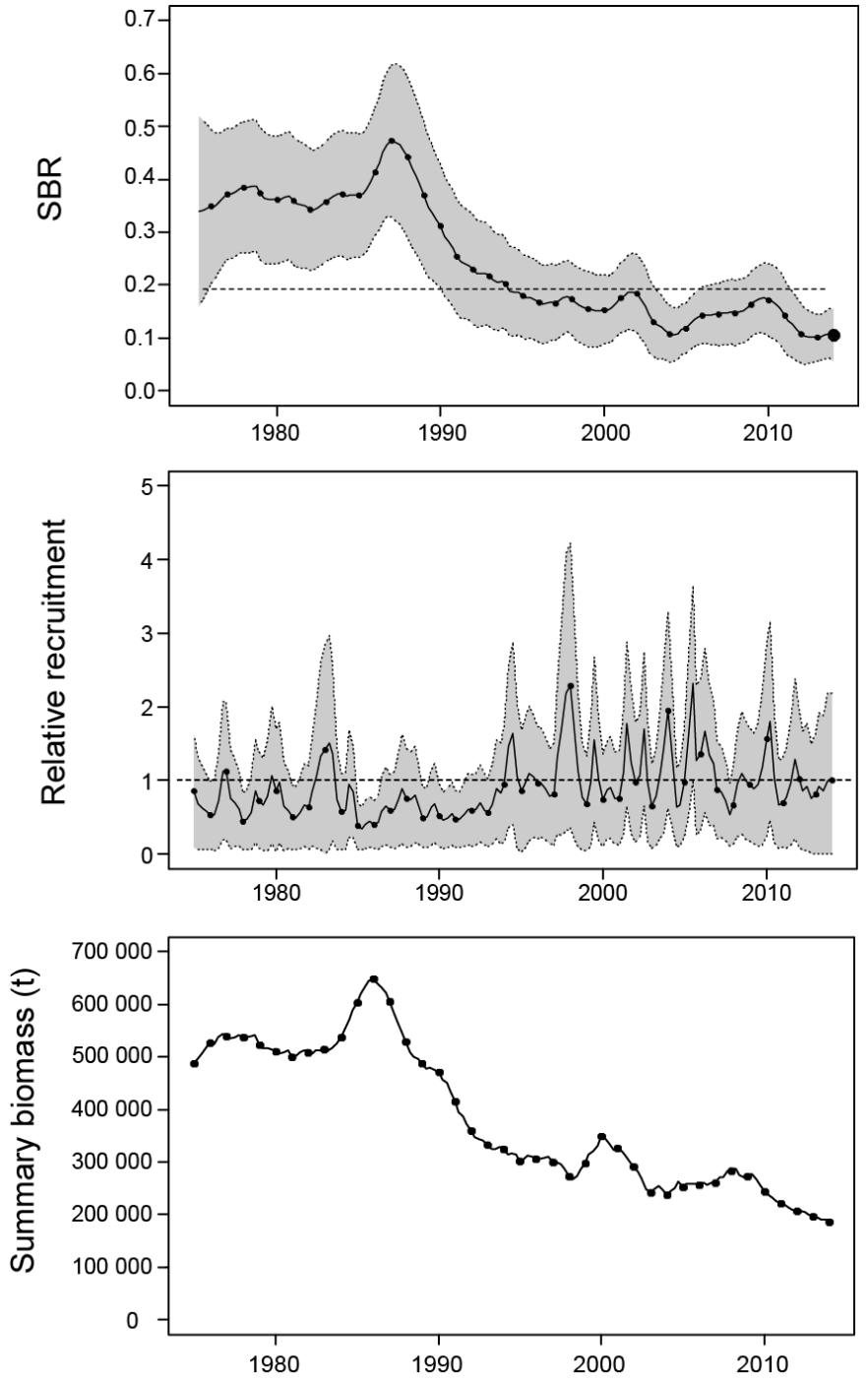




Source: IATTC Port-sampling data

BET

Example of results estimated by a stock assessment model that uses the proposed spatial definitions



Conclusions

- We proposed stock and fisheries structures for yellowfin and bigeye tuna that take into account
  - evidence reviewed here,
  - data limitations,
  - computational and practical constraints
- These are by no means the optimal stock and fisheries structures, but they have provided an exploratory analysis of alternative spatial structure.
- We conducted preliminary stock assessments based on those spatial structures:
  - The results showed differences between the north and south stocks of yellowfin tuna
  - And new and old stock and fishery structures for YFT and BET.
  - results of the stock assessment models are more dependent on the relative contribution the size composition to the fits (data-weighting) rather than assumptions on stock structure and fishery definitions

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