Effect of decreasing longline effort and changes in species composition on standardized CPUE for tuna in the EPO

Keisuke Satoh, Cleridy E. Lennert Cody, Carolina V. Minte-Vera, Alexandre Aires-da-Silva, Mark N. Maunder and Takayuki Matsumoto

Collaborative work between NRIFSF and IATTC

- On-going work
- No documentation for SAC8

8th Meeting of the Scientific Advisory Committee La Jolla, 8-12 May 2017

Outline

Changes of JPN LL fishery in EPO

- ✓ species composition
- ✓ gear configurations (Number of hooks between float, length of float line, and length of branch line)

Targeting effect

- ✓ Relationship between species composition and gear configuration (decision tree analysis)

The length of float line and branch lines are available since 1998. Thus, the analytical period is from 1998 to 2014.

changes of JPN LL fishery in EPO

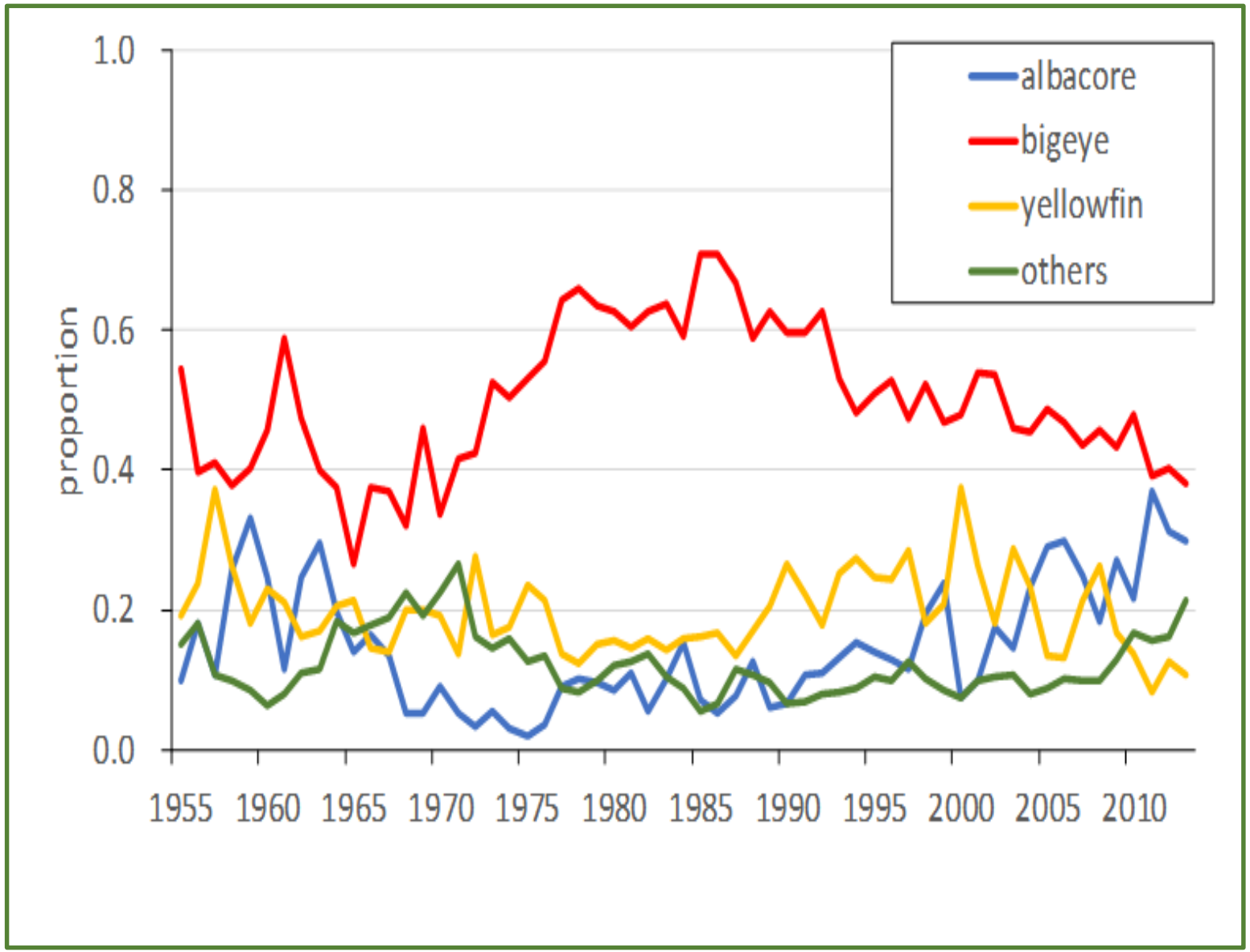


Figure 1. Species composition in number of the Japanese longline fishery in the eastern Pacific Ocean. “others” composed of swordfish and marlins.

- ✓ BET and YFT decreases, ALB and others (sword fish and marlins) increase.

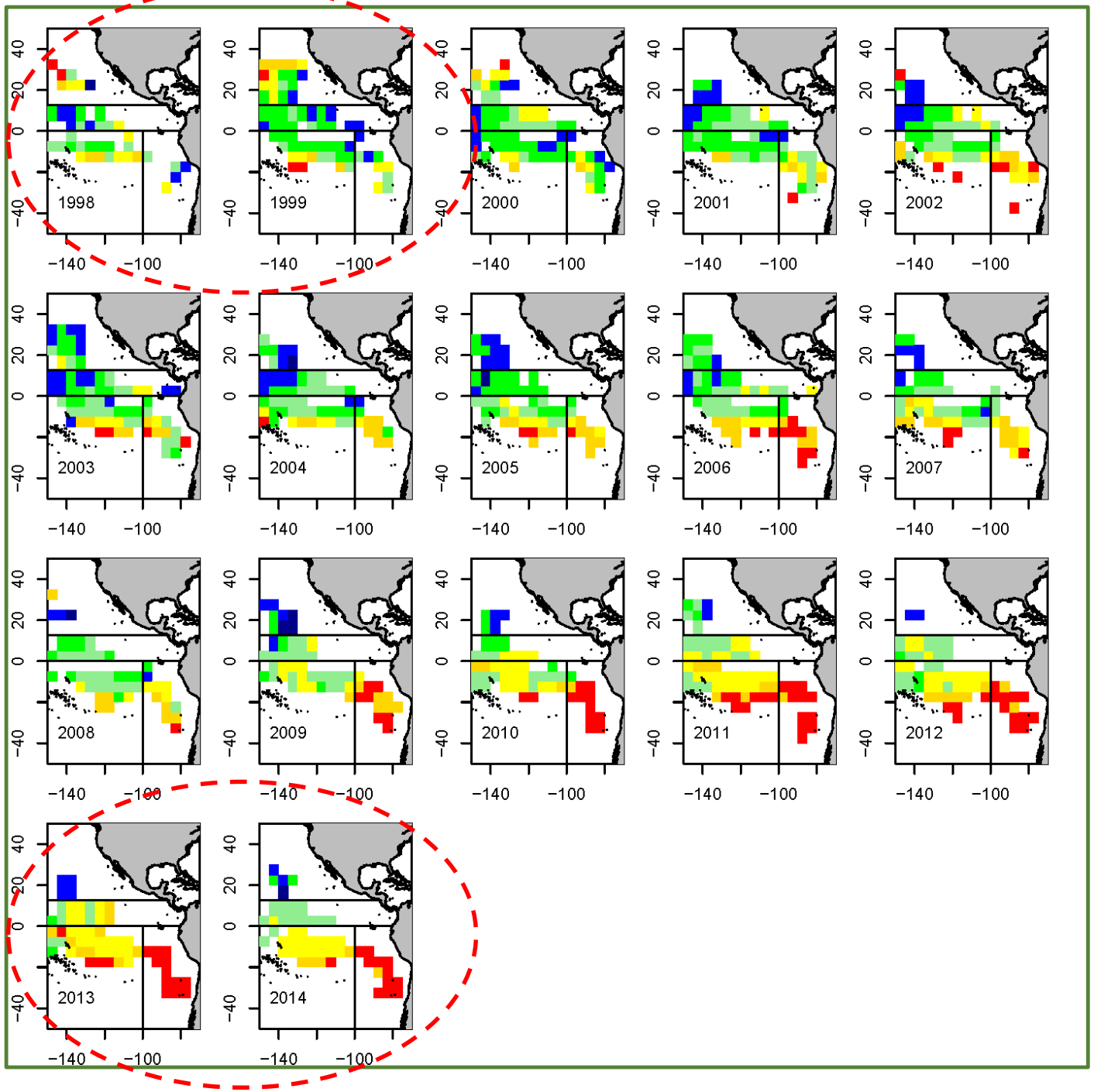


Figure. Geographical distribution by year of mean albacore ratio, albacore / (albacore + bigeye + yellowfin + sword fish + marlins). Dark blue; < 0.02, blue; < 0.08, green; < 0.15, light green; < 0.24, yellow; < 0.37, gold; < 0.62 and red; >= 0.62

The changes of the species composition and the gear configurations gradually proceeded.

For purpose of explanation, the panels of the first two and the last two years of the period were presented after that.

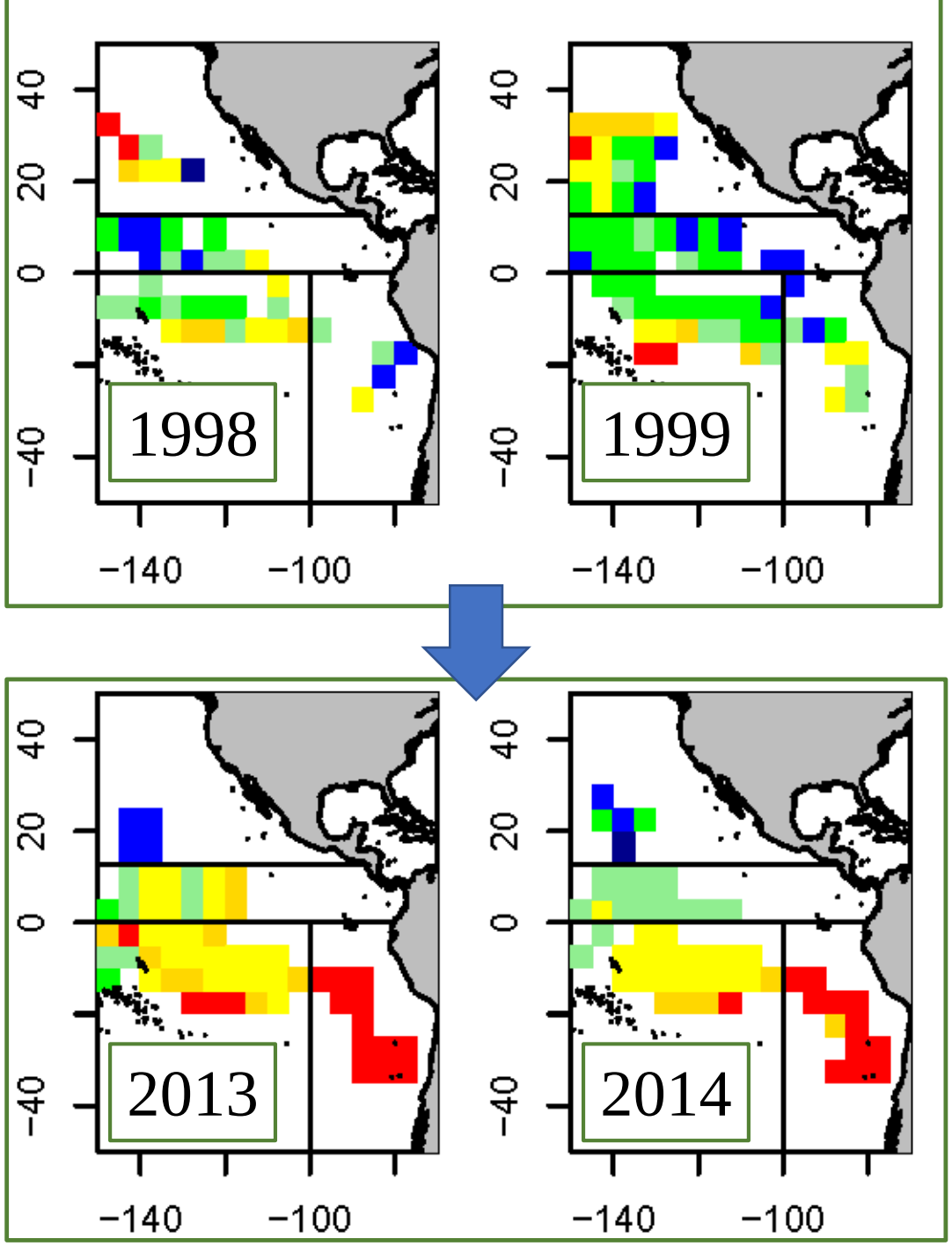


Figure 2. Geographical distribution by year of mean albacore ratio, albacore / (albacore + bigeye + yellowfin + sword fish + marlins). Dark blue; < 0.02, blue; < 0.08, green; < 0.15, light green; < 0.24, yellow; < 0.37, gold; < 0.62 and red; >= 0.62.

- ✓In the northern area (LLN), the albacore dominant area disappeared.
- ✓In tropical area (LLC + LLS), the albacore proportion gradually increased.
- ✓In most southern area (LLI), the proportion increased .

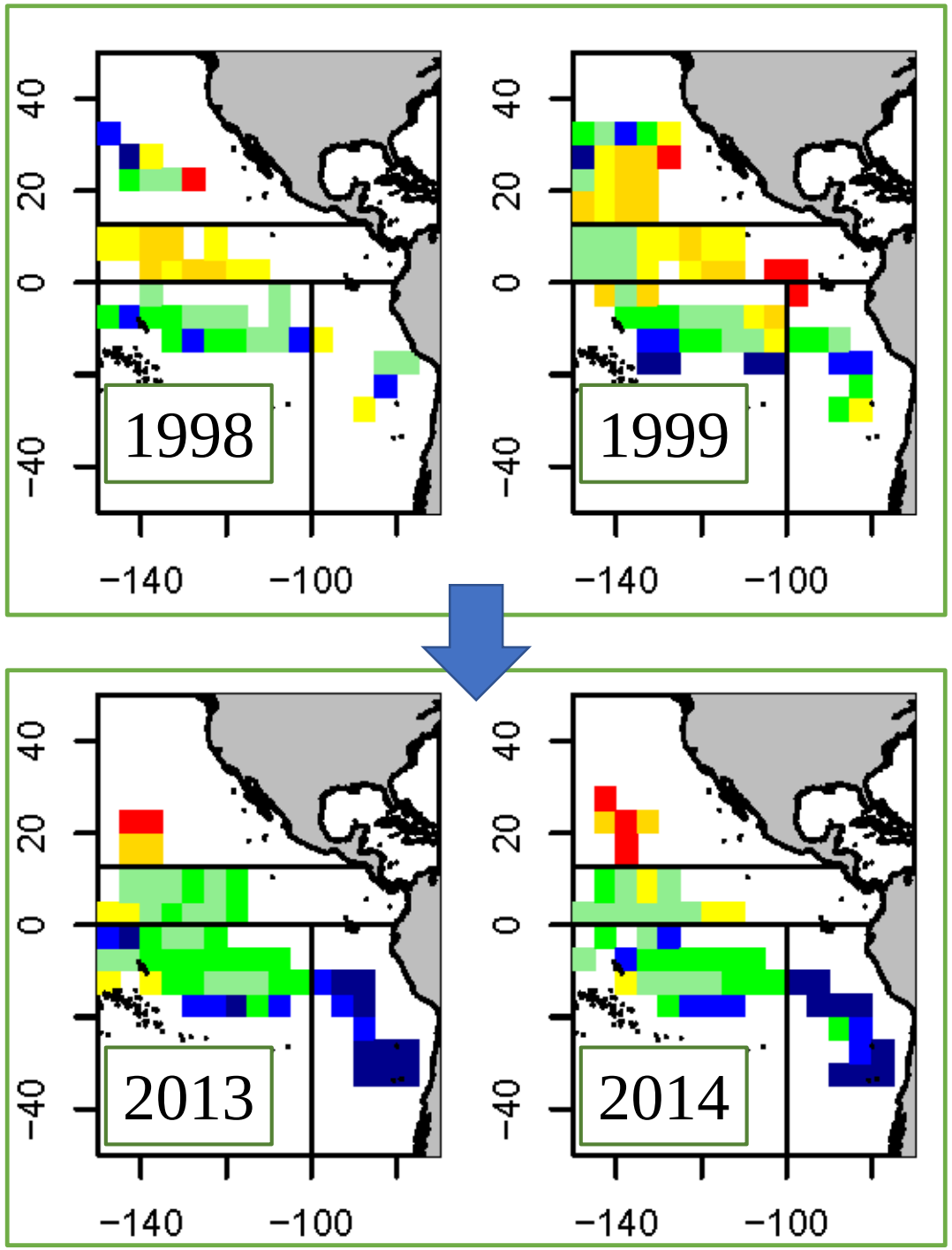


Figure 3. Geographical distribution by year of mean bigeye ratio, bigeye / (albacore + bigeye + yellowfin + sword fish + marlins). Dark blue; < 0.25, blue; < 0.41, green; < 0.53, light green; < 0.66, yellow; < 0.76, gold; < 0.90 and red; >= 0.90.

- ✓LLN: Bigeye became dominant species.
- ✓LLC + LLS: The proportion of bigeye in southern part of LLS turned to low.
- ✓LLI: The proportion of bigeye become low.

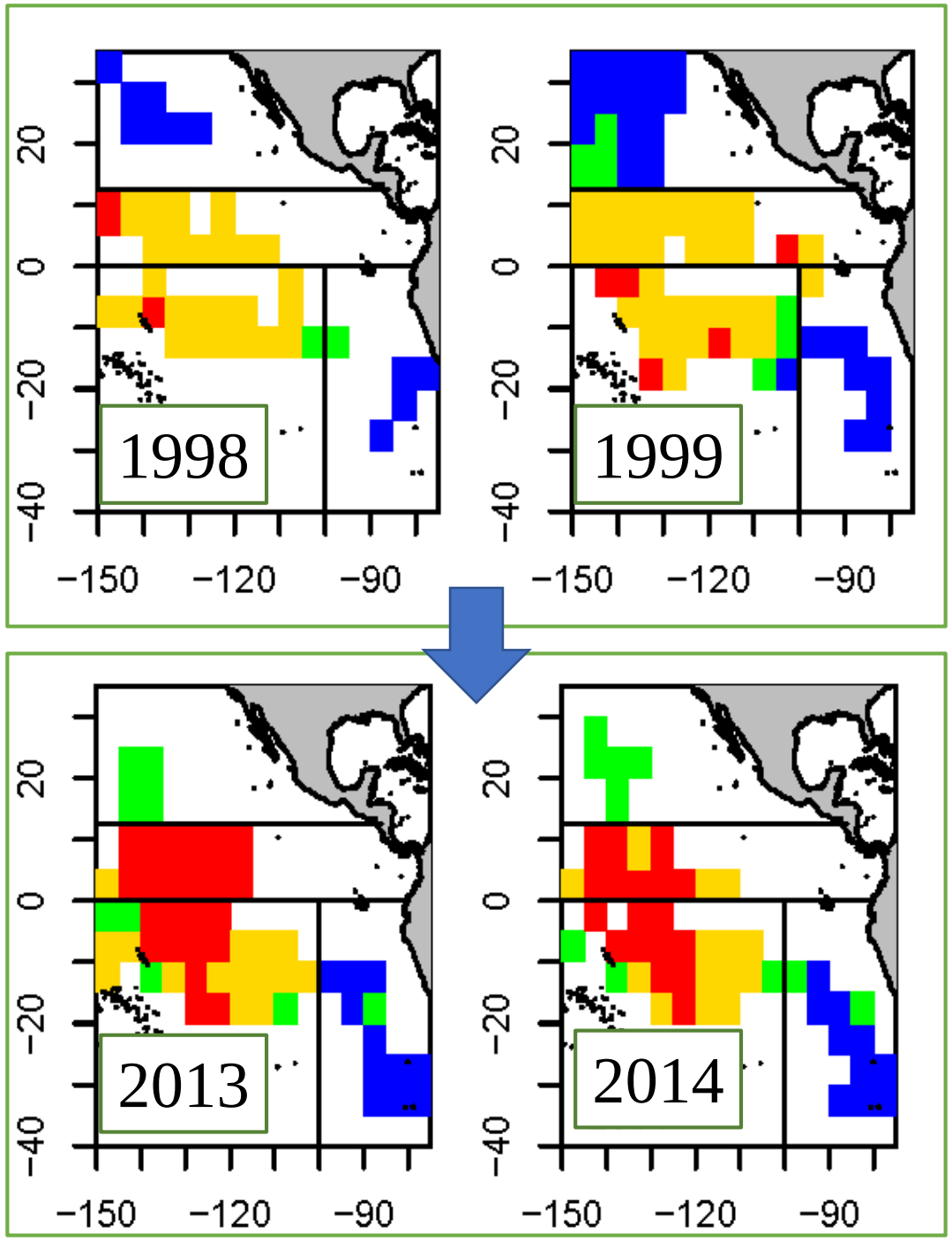


Figure 4. Geographical distribution by year of mean NHBF (number of hooks between float). Blue; < 15, green; 16, gold; 17 and red; >= 17.

- ✓LLN: NHBF became large.
- ✓LLC + LLS: NHBF became large.
- ✓LLI: There were always smaller NHBF thought the period.

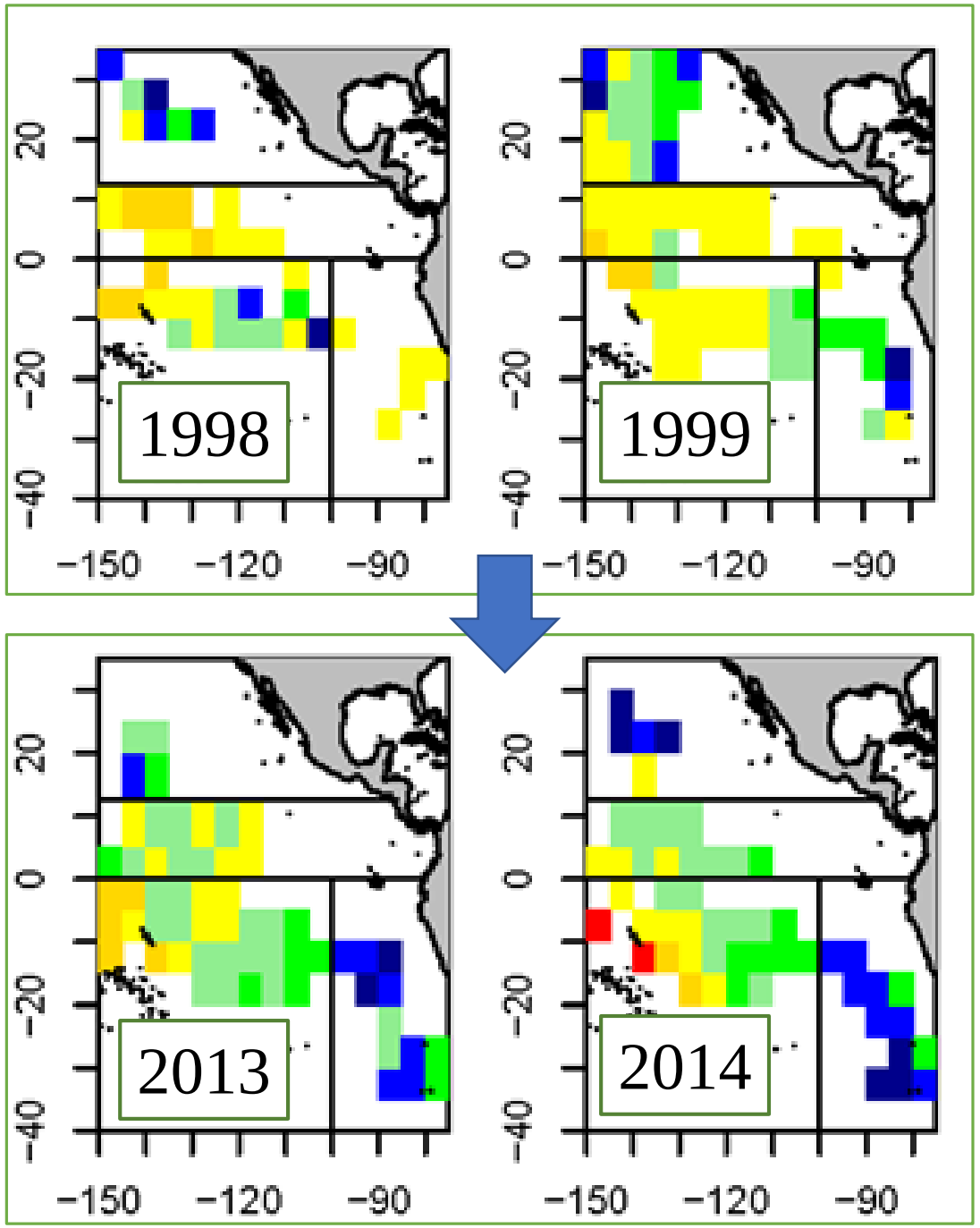


Figure 5. Geographical distribution by year of mean LF (length of float line (m)). Dark blue; < 20, blue; < 25, green; < 30, light green; < 35, yellow; < 40, gold; < 45 and red; >= 45.

✓ LLN: LF no substantial change.
✓ LLC + LLS: LF slightly became shorter.
✓ LLI: LF became shorter.

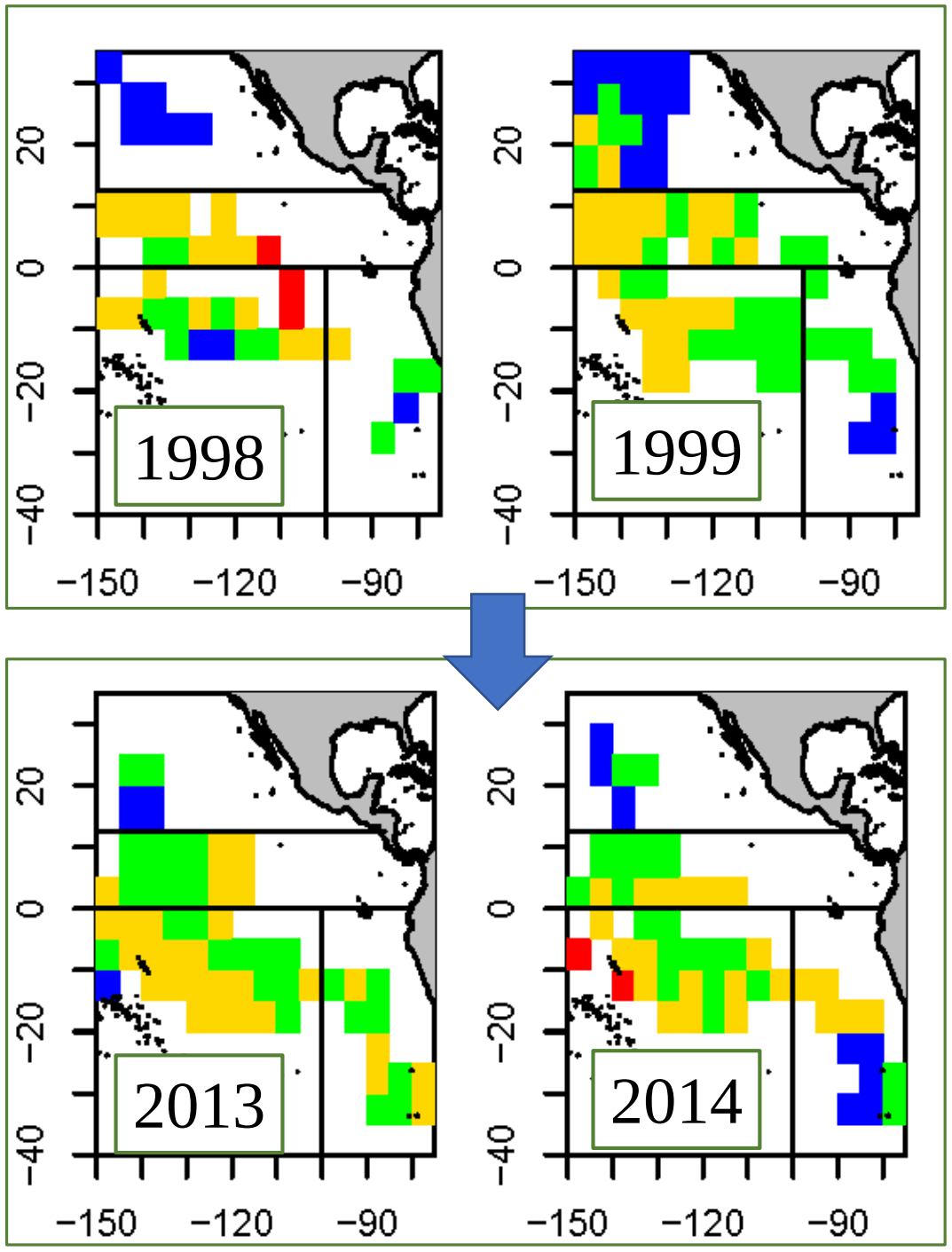


Figure 6. Geographical distribution by year of mean LB (length of branch line (m)). Blue; < 40, green; < 45, gold; < 50 and red; >= 50..

✓ LLN: LB had become longer.
✓ LLC + LLS: LB slightly became longer.
✓ LLI: LB became slightly longer.

Summary of changes of JPN LL fishery in EPO

- Species composition
  - LLN: Around 2002, albacore to bigeye
  - LLC + LLS: Around 2010, bigeye to albacore (in southern part)
  - LLI: Albacore + others was always dominate and bigeye was always low especially after 2003. Around 2010, albacore + others increased.
- Gear configurations
  - ✓ LLN: Before 2002, shallow setting (smaller NHBF + shorter LF + shorter LB). After that it became deep setting.
  - ✓ West of 110W of LLC + LLS: larger NHBF + longer LF + longer LB
  - ✓ East of 110W of LLC + LLS: smaller NHBF + shorter LF + shorter LB
  - ✓ LLI: shallowest setting. Around 2006 it became slightly deep setting.

- The changes of species composition and gear configurations seem to be related. (Shallow gear for ALB + others, Deep gear for BET)

Targeting effect

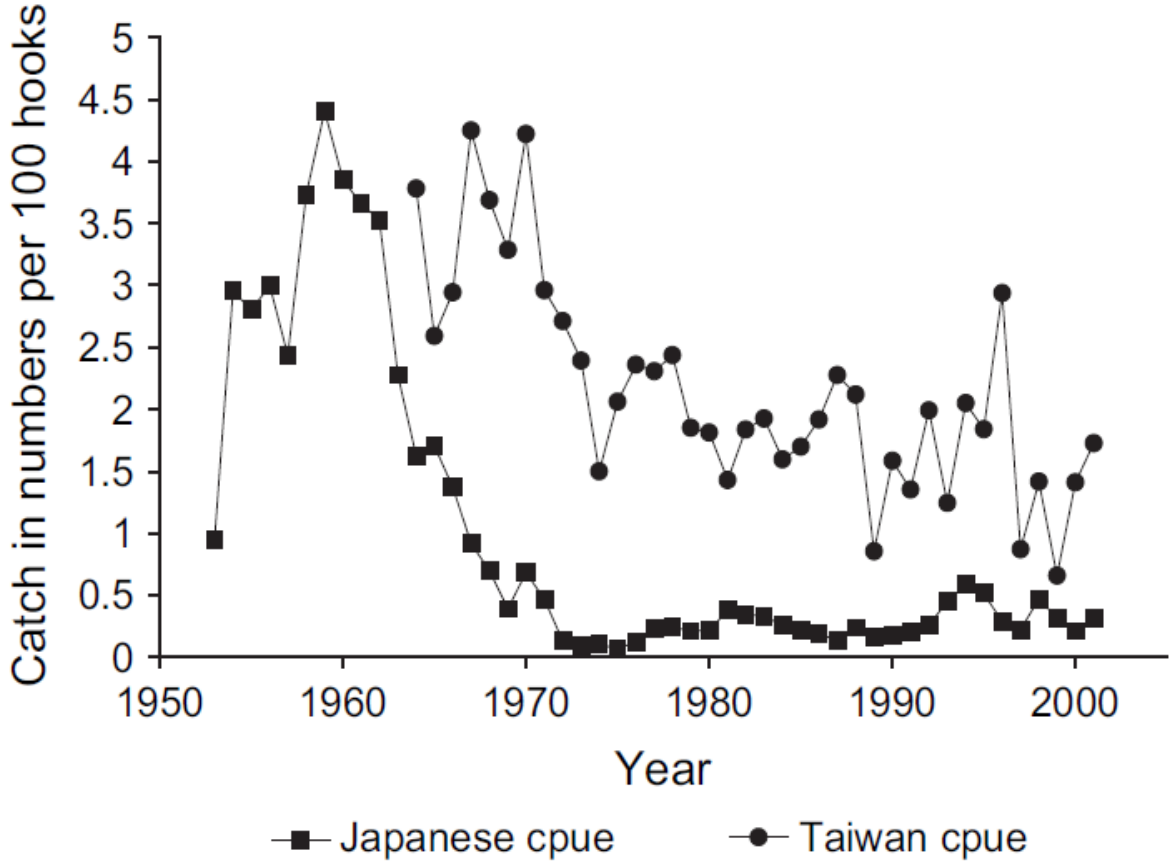


Figure 1. Comparison of albacore cpue from Japanese and Taiwanese longline vessels in Myers and Worm's (2003) area designated as the tropical Pacific Ocean (10–15°S).

From Maunder et al. 2006. ICES Journal of Marine Science, 63: 1373-1385

- ✓ If the related changes of gear configurations and species composition resulted from changing of target species of JPN LL fishery, the change should be considered in process of cpue standardization (e.g., comparison of albacore cpue between the targeted fishery (Taiwanese) and non-targeted one (Japanese)).
- ✓ The recent trends of BET and YFT cpues should be investigated from the point of view the targeting effect.

Targeting effect (previous study)

Treatments for the targeting effect in cpue standardization process in previous studies.

① Some studies simply excluded the non-target species rich region (e.g., Matsumoto et al. 2016 a, b).

② Some studies assumed that the species composition was proxy of target species and the species composition was included in the cpue standardized model as the explanatory variables (e.g., Huang 2016).

③ Other studies conducted data filtering before the cpue standardization process (Hoyle et al. 2016). The data filtering aims to omit a number of sets (certain cluster) without noticeable species composition, which is assumed to be low-target, using cluster analysis. (Or the “cluster” was included as covariant of the cpue standardization model)

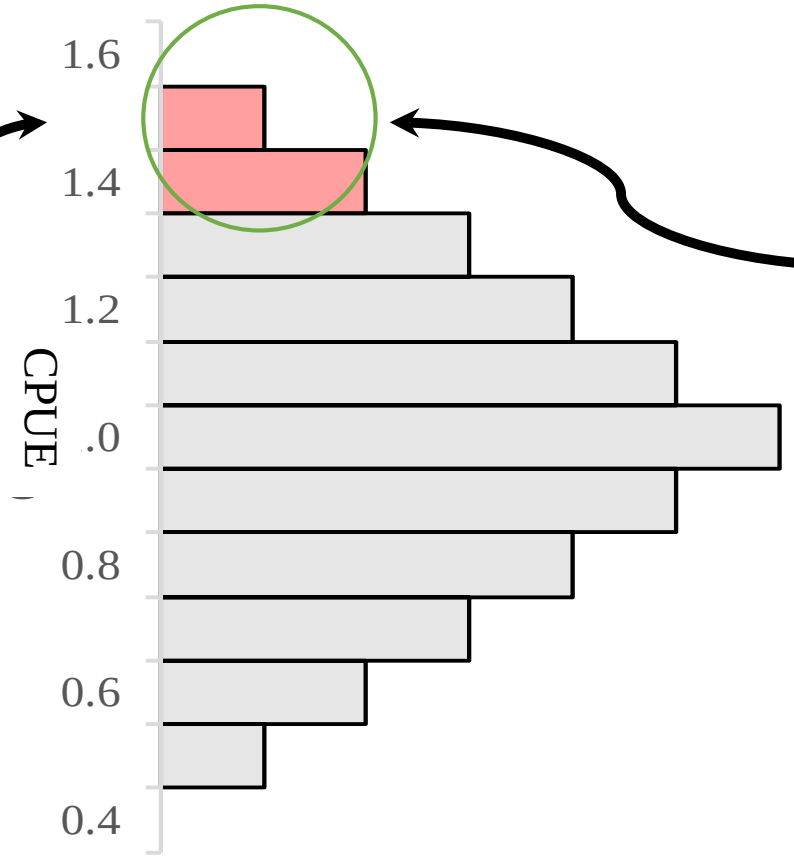
Targeting effect (previous study)

- ✓ For the first method, the selection of the region is typically fixed thorough the analytical period, thus the flexibility is needed for the case that the geographical distribution of the target species changed like the case of JPN LL in the EPO.
- ✓ The second approach might be problematic statistically as catch of interested species are used to calculate both explanatory and response variables.
- ✓ The second and third approaches used the species composition, which is inevitably affected by the stock status trends of other species.
- ✓ Development of new methodology considering target effect without species composition is needed to prevent the effect of other species stock status.

Assumption for detecting target species using sets with higher cpue

- ✓ The nominal cpue of each species are assumed to be affected by the two factors. The first one is the level of biomass in a fishing location and season, and the another one is the target effect of the fishery.

Targeting effect
(select fishing season, location and gear configuration)



High level of biomass

Separating the two factors (targeting, biomass) is essential to investigate the target effect in cpue.

Assumption of detecting target species using sets with higher cpue

- ✓ If the biomass of each species is assumed to be constant in a stratum (a year and a quarter and a 5 by 5 degrees in latitude and longitude), the nominal cpue of each species in a stratum is only affected by the target effect.

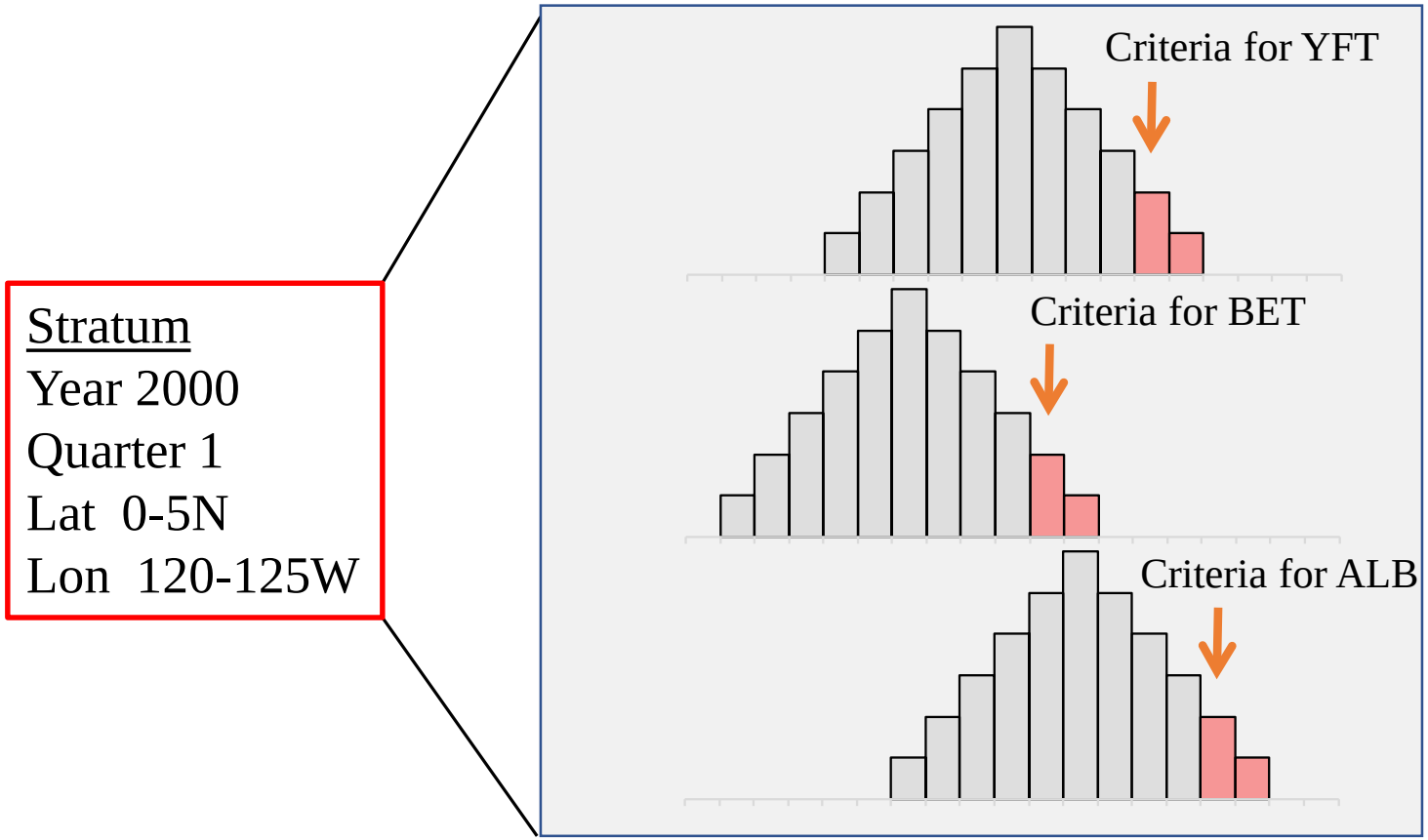
- ✓ This assumption is explicitly or implicitly applied in the previous study using cluster analysis.

- ✓ Since the time unit of stock assessment in the EPO is quarter, so the assumption for the time unit is reasonable. The assumption for the areal unit is relatively small (5 x 5 degrees), thus it may be reasonable.

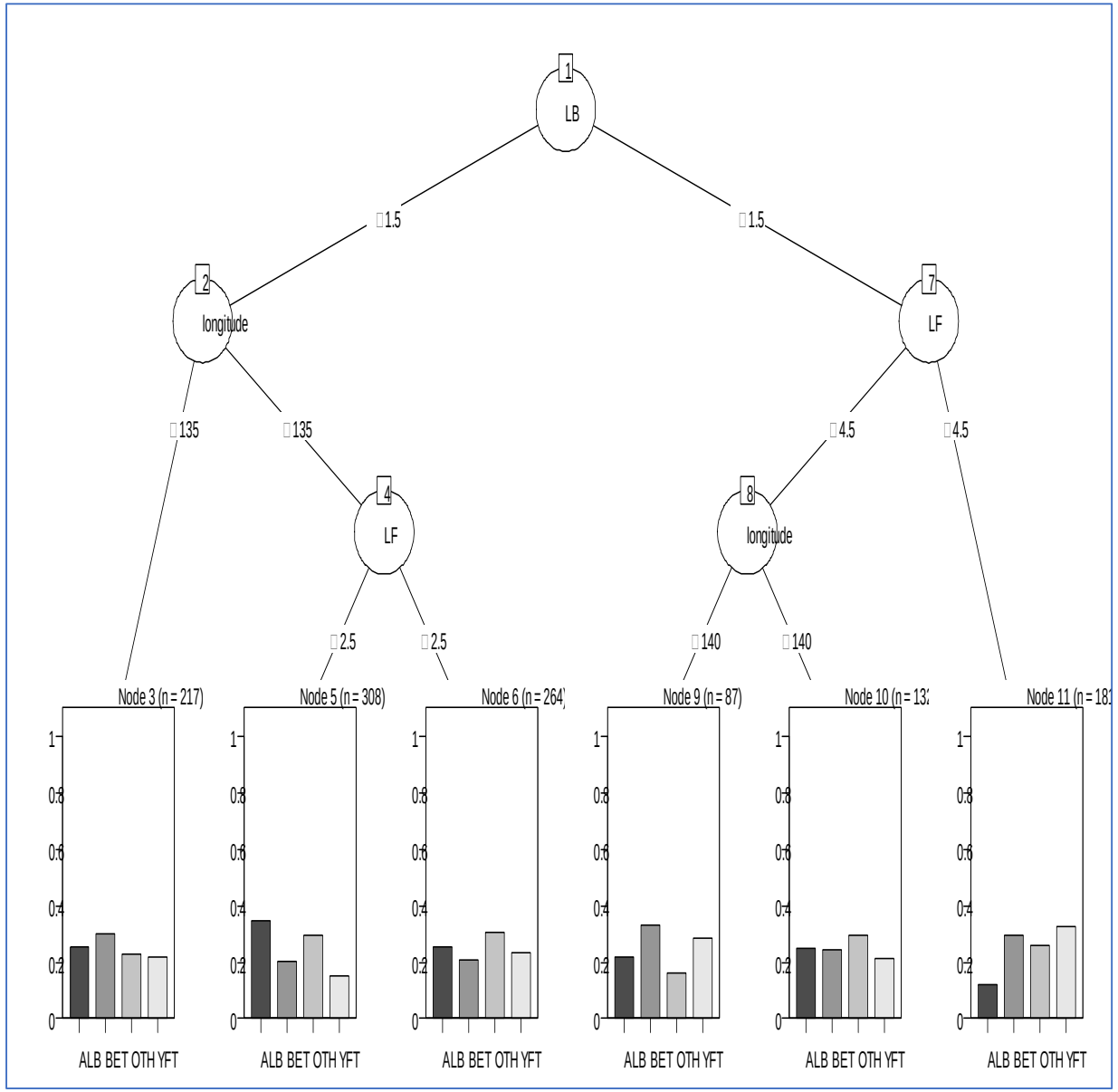
- ✓ The fishery can select their gear configurations to catch more targeted fish. Thus the target effect can be affected by the fishing location, the fishing season and the gear configurations.

To prevent the effect of other species stock status

- ✓ To prevent the effect of other species stock status, the species specific criterion is applied.
- ✓ If the cpue of a set exceed the criteria of the species, the set targeted the species. Thus, a set targeted multiple species is possible.
- ✓ The sets exceeding the criteria are assigned the target species, and it is used for further analysis.
- ✓ In this study, the target species is called as PTS (potential targeted species). The "potential" indicates that the assignment of the target species is not based on the explicit data of the target species, such as logbook.



Decision tree analysis



- The decision tree analysis is the procedure to make a number of groups which have more homogeneity of response variable (PTS) from the mother population using explanatory variables (longitude, latitude, gear configurations).

- The analysis produces a tree-like diagram composed of root and nodes with combination of number of decision rules (IF-THEN rules using explanatory variables), which are easy to understand visually for the classification.

Decision tree analysis

- The analysis was implemented by rpart package of R (ver. 3.23) (R core team 2015).
- Grid search for the complexity parameter and the minbucket (minimum number of observation in terminal node) were conducted.
- The search indicated that 5% of total number of set is appropriate for the minbucket because the setting avoid toot deep tree.
- The complexity parameter was determined by the criteria of the 10-fold cross validation with one SE rule.

Decision tree analysis

Investigation of the criteria of the “higher cpue” (robust tree is needed)

- The influence of the criteria defining higher cpue was tested. The “higher cpue” with 45 percentile to 95 percentile by 10 percentile of nominal cpue for each stratum (year, quarter, 5 x 5 degrees in latitude and longitude) of each species (yellowfin, bigeye, albacore and others (swordfish, sailfish and shortbill spearfish)) was compiled using set by set (operational) longline catch and effort data.
- Then, species name (PTS) is assigned for each set when the cpue of the set of each spices is larger than the criteria. So, each set is assigned one of the list for ALB, BET, YFT, OTH (Others), MIX, NOD. MIX means that multiple species targeted set (the set contained a number of PTS simultaneously). NOD means that the cpue of all species for the set does not exceed any criteria.
- In addition, to avoid variation of results the stratum less than 20 sets was excluded for further analysis.

Investigation of the criteria of the “higher cpue”

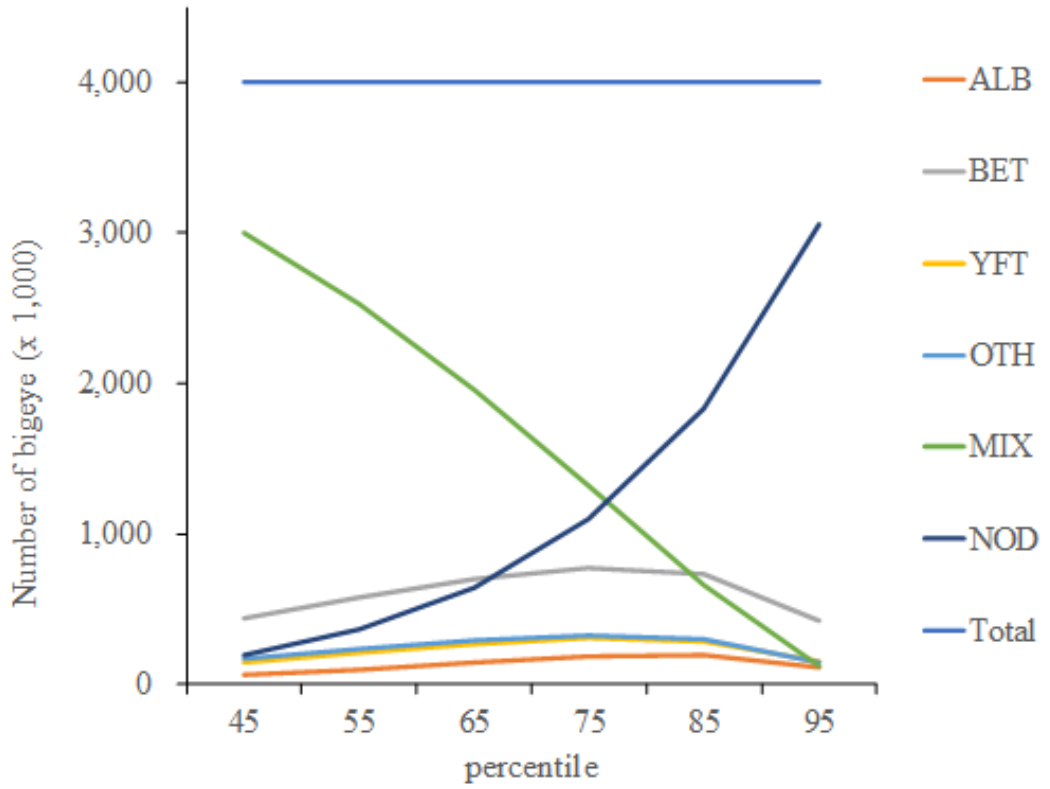


Figure 7. Number of bigeye (x 1,000) contained in each PTS for each criteria from 45 to 95 by 10 percentile.

- ✓ The highest number of bigeye of BET as PTS (gray line) are found in case of 75 percentile. The number of bigeye for BET is larger than for other PTSs.
- ✓ The number of bigeye for NOD (blue; Not detected) increased according to increase of percentile, while those of MIX (green) decreased.
- ✓ These results indicated the 75 percentile criteria included much information.

Investigation of the criteria of the “higher cpue”

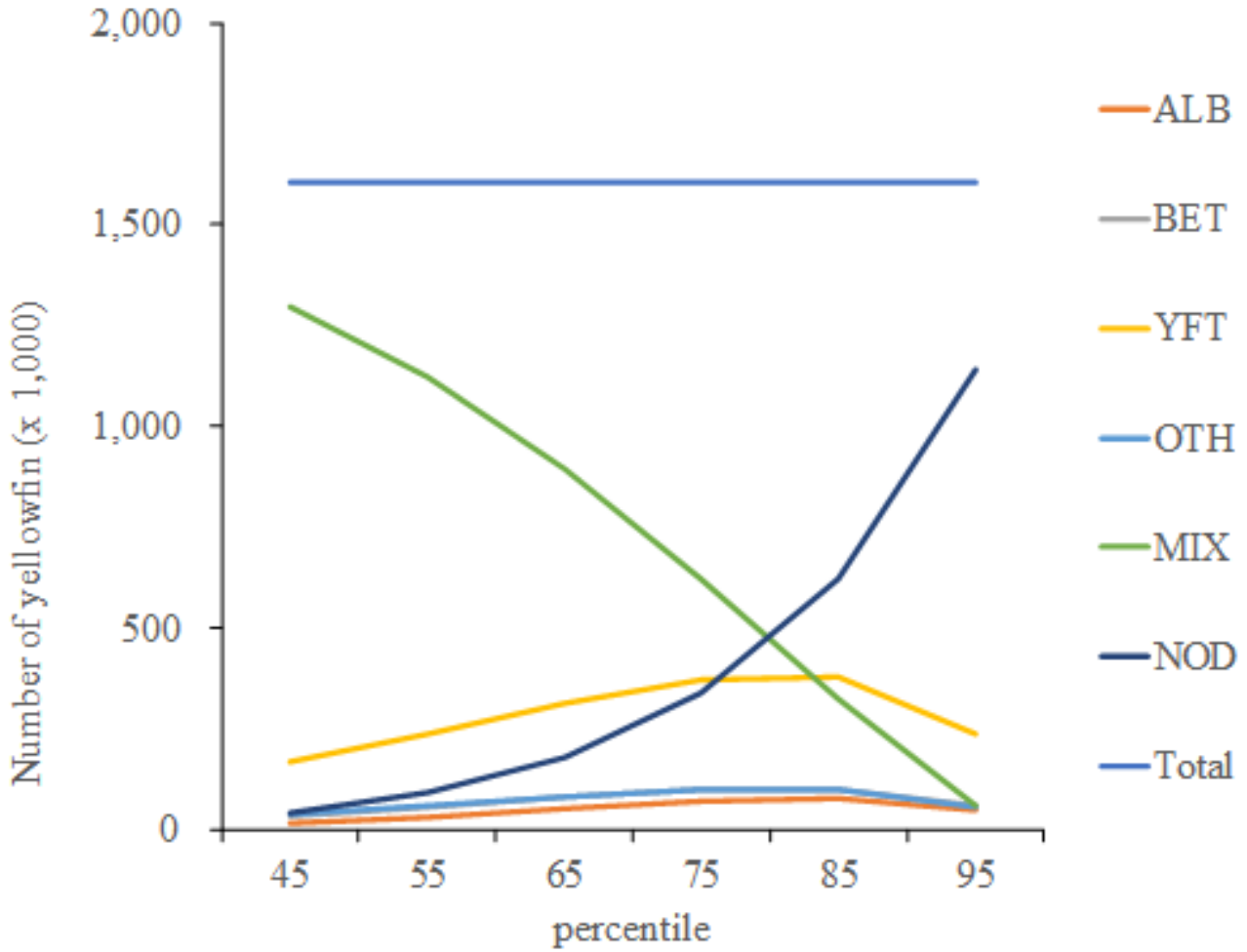


Figure 8. Number of yellowfin (x 1,000) contained in each PTS for each criteria from 45 to 95 by 10 percentile. The highest number of yellowfin were found in the case of 85 percentile.

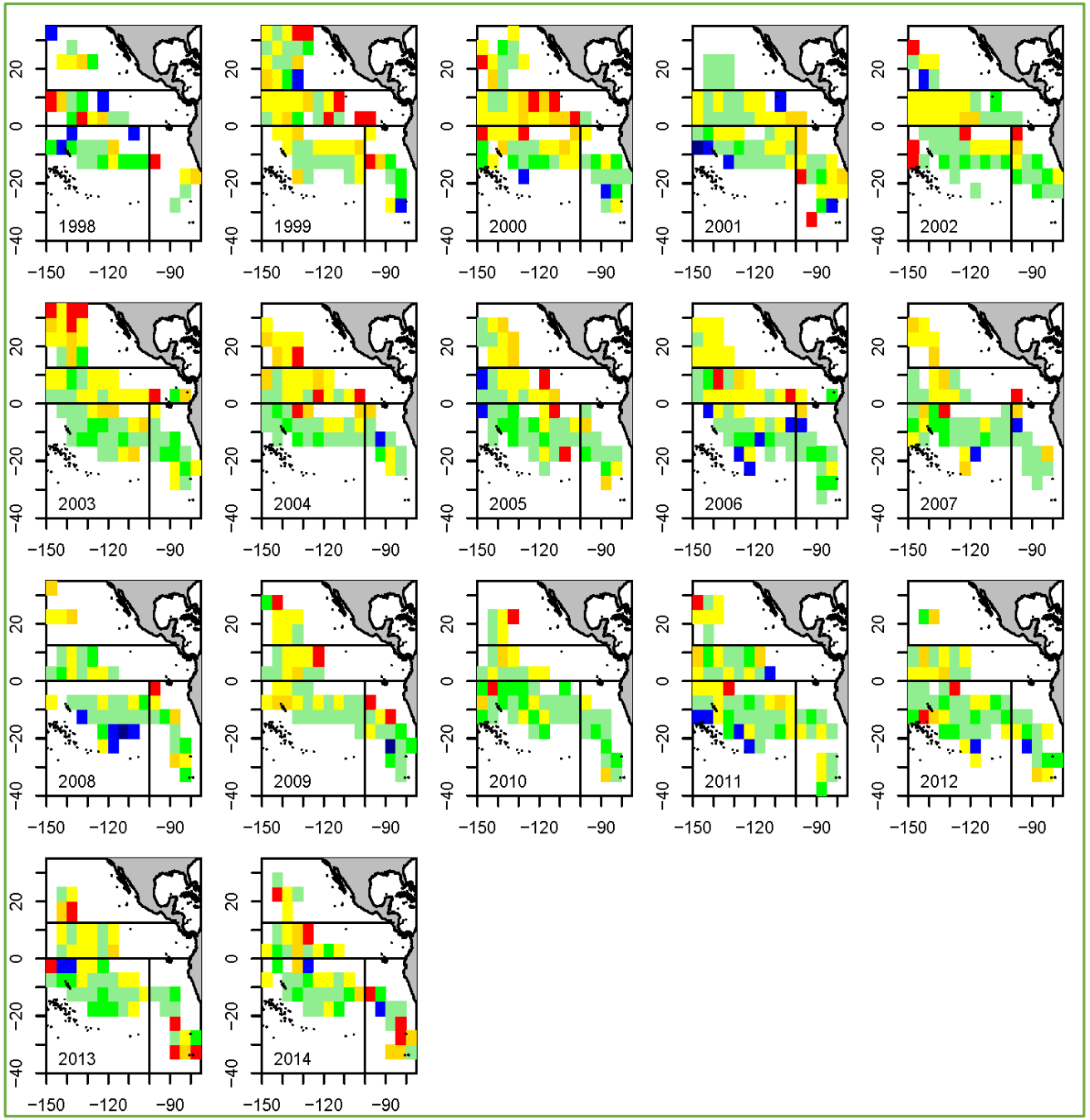
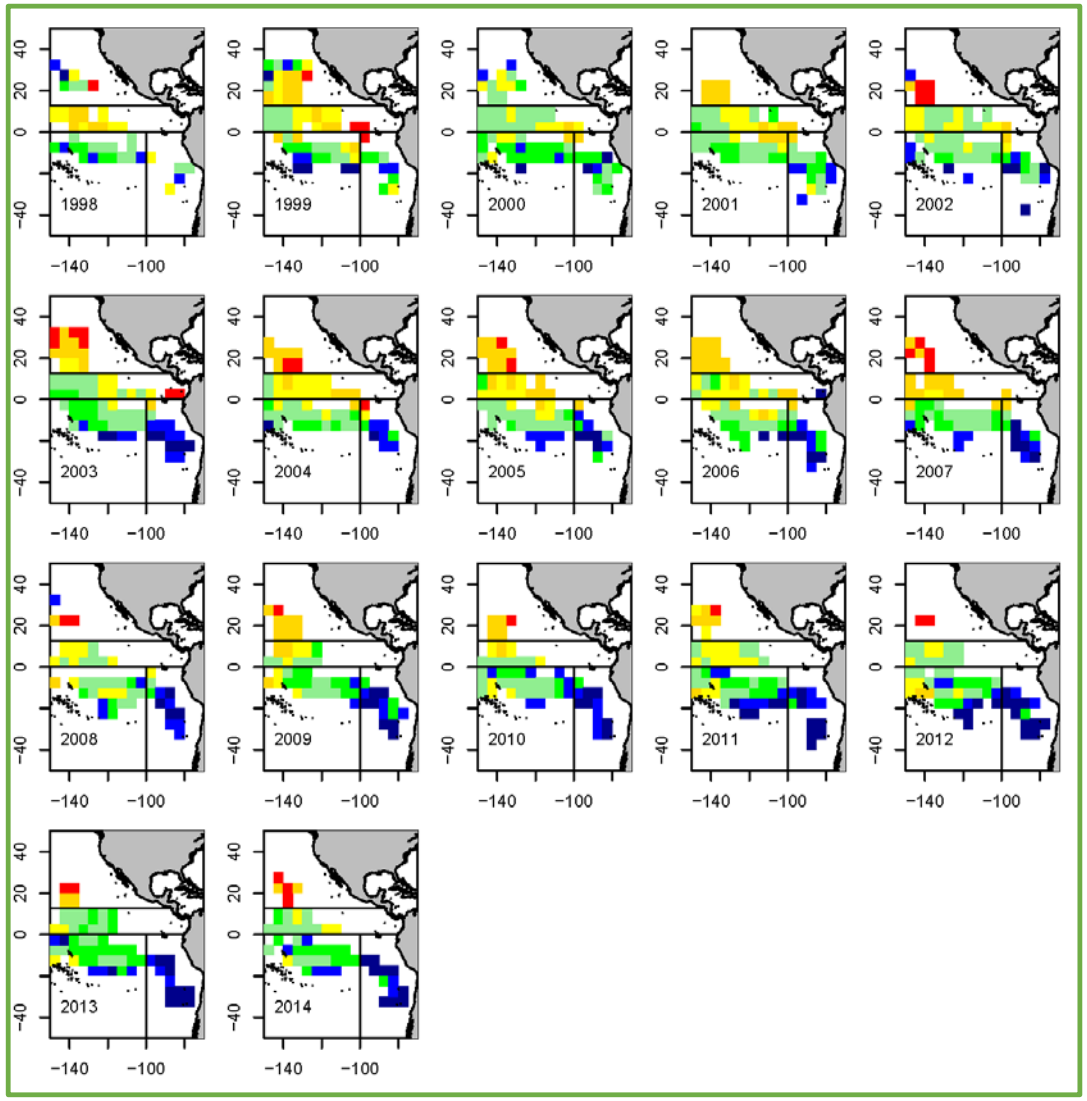
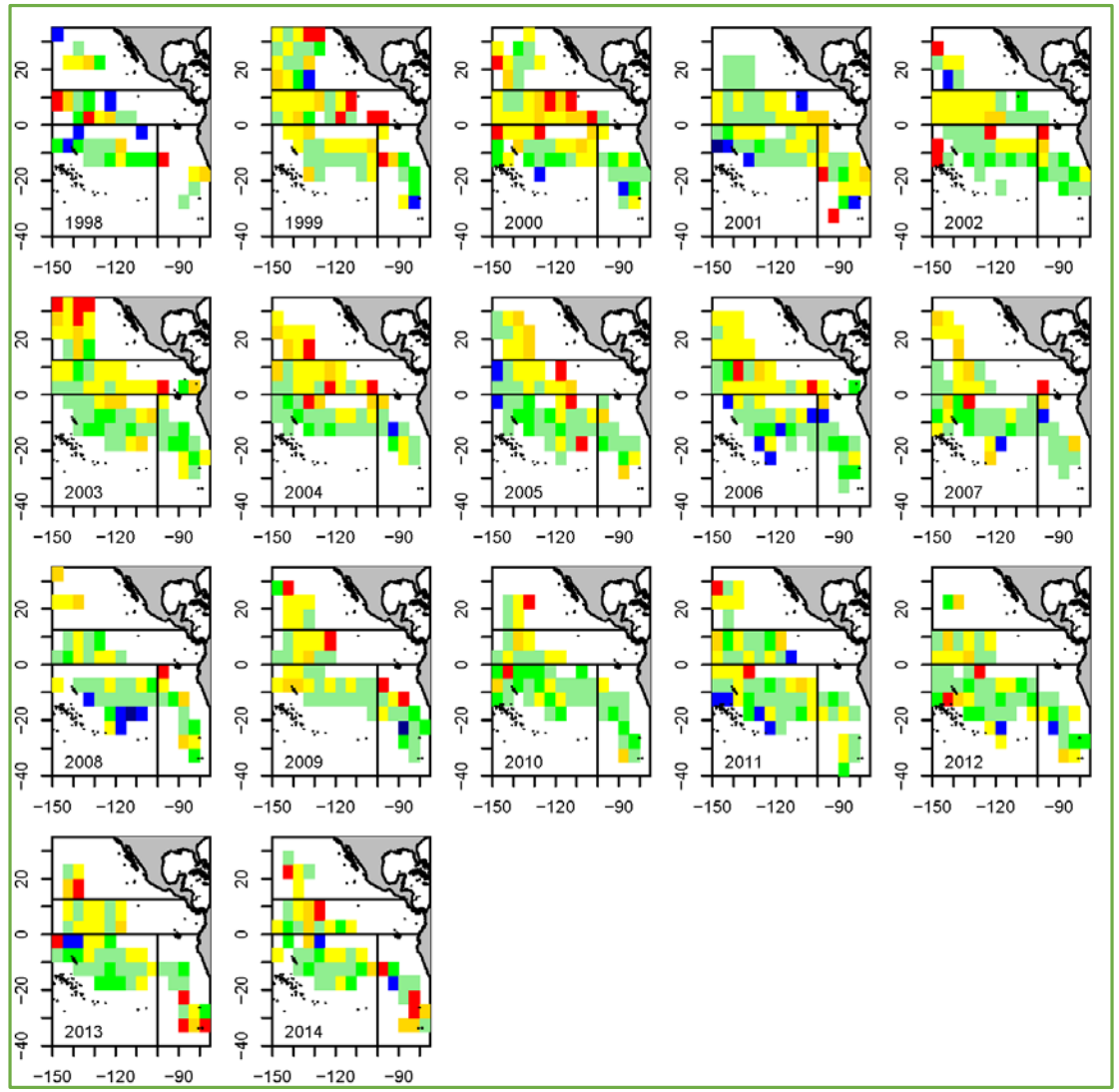


Figure 9. Geographical distribution of BET (as PTS) proportion in number of set for the criteria of 75 percentile in the EPO from 1998 to 2014. Dark blue; < 0.02, blue; < 0.05, green; < 0.08, light green; < 0.11, yellow; < 0.14, gold; < 0.16 and red; >= 0.16.

- ✓ The distribution is not necessarily similar to that of bet ratio (**Figure 3**). In LLI there is high PTS proportion of BET in recent two years.
- ✓ It indicates that the species proportion is not necessarily related to higher cpue.


1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
40
20
0
−40
−140
−100


1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
20
0
−20
−40
−150
−120
−90

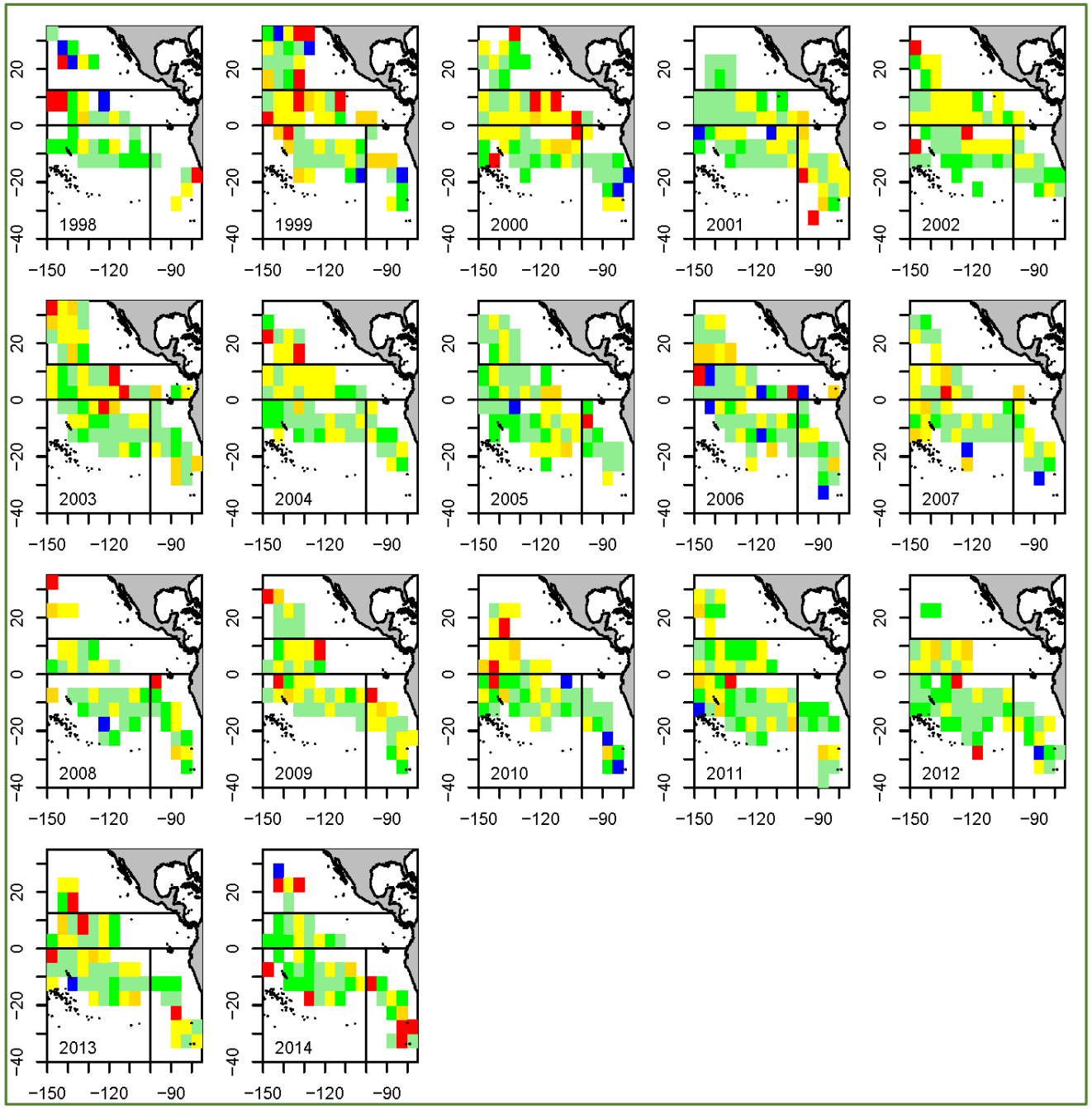


Figure 10. Geographical distribution of BET (as PTS) proportion in number of set for the criteria of 85 percentile in the EPO from 1998 to 2014. Dark blue; < 0.01, blue; < 0.04, green; < 0.07, light green; < 0.09, yellow; < 0.11, gold; < 0.12 and red; >= 0.12.

✓ The distribution is similar to that of 75 percentile.

Investigation of the criteria of the “higher cpue”

- ✓ The 75 and 85 percentile criteria included much catch and effort.
- ✓ The geographical distributions of BET (as PTS) using these criteria (75 and 85) are not necessarily similar to that of bet ratio.
- ✓ Three kinds of criteria (75, 85 and 95 percentile) were further tested for the decision tree model.

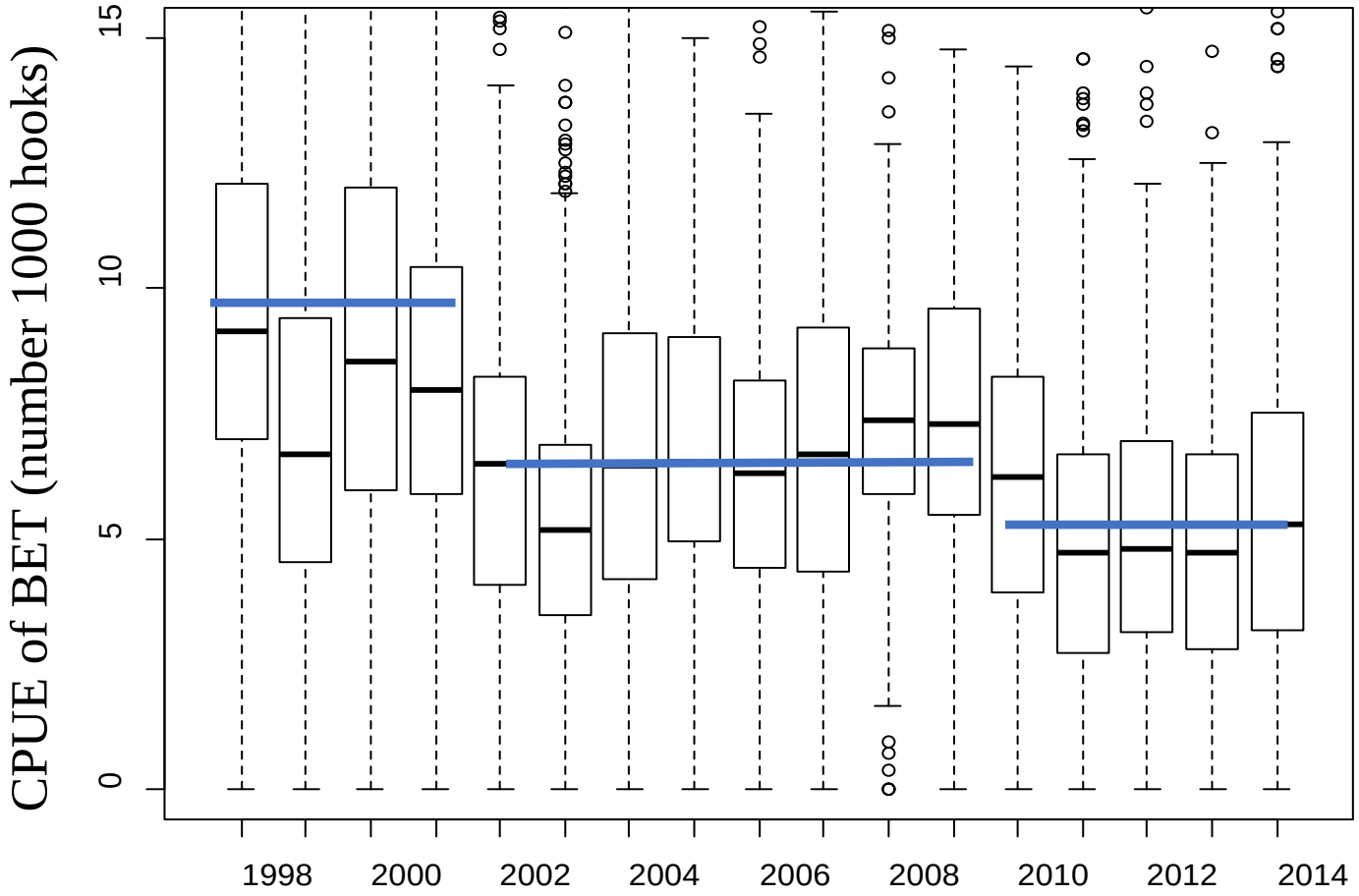


Figure. Historical changes of BET cpue in the case of 75 percentile of BET for whole EPO.

- ✓ Preliminary analysis indicated analysis using only one year occasionally fail to construct robust tree.
- ✓ Thus, 4 or 8 years are pooled according to the annual changes of nominal CPUE.
- ✓ The gear configuration is area specific, thus the tree model is applied to each area.
- ✓ In addition ,the gear configuration is categorized according to the grouping in Figures 5 to 7.

Decision tree analysis

36 runs,

Three period (1998-2001, 2002-2009, 2010-2014),

Four area (LLN, LLC, LLS and LLI) and

Three criteria (75, 85 and 95 percentile)

Deleting MIX and NOD.

Scoring

1: Same of the first splitter (both for variable and its value)

0: Other than the above

Results

75 vs 85 vs 95: 4

75 vs 85: 6

75 vs 95: 5

85 vs 95: 8

- Same first splitter thorough the settings (75, 85 and 95 percentiles) is obtained for four models.
- The similarity is highest between the trees of the 85 and 95 percentile. In this case, the first splitter are same for 8 models of total 12 models.

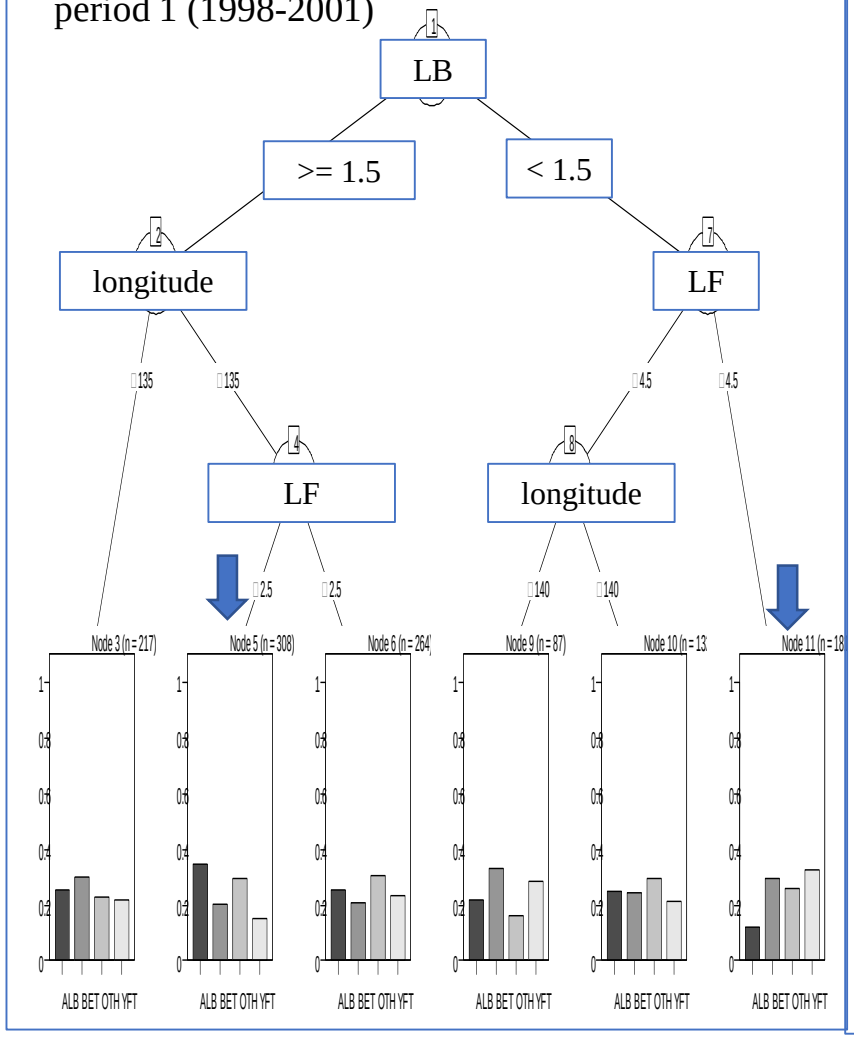
period	area	First split variable and its value		
		75	85	95
Period 1	LLN	NHBF <1.5	LB < 1.5	LB < 2.5
	LLC	LB < 3.5	LB < 3.5	LB < 3.5
	LLS	Latitude < -10	Latitude < -5	Latitude < -5
	LLI	LF < 1.5	NHBF < 2.5	NHBF < 2.5
Period 2	LLN	Longitude >=140	LB < 1.5	NHBF < 2.5
	LLC	LF < 5.5	LF < 5.5	Longitude < 140
	LLS	Latitude < -10	Latitude < -10	LF < 5.5
	LLI	LB < 1.5	LB < 1.5	LB < 1.5
Period 3	LLN	NHBF < 2.5	NHBF < 2.5	NHBF < 2.5
	LLC	LF <4.5	LF < 5.5	LF < 4.5
	LLS	Latitude < -10	LF < 4.5	LF < 4.5
	LLI	Latitude < -25	Latitude < -25	Latitude < -25

Short summary of decision tree analysis

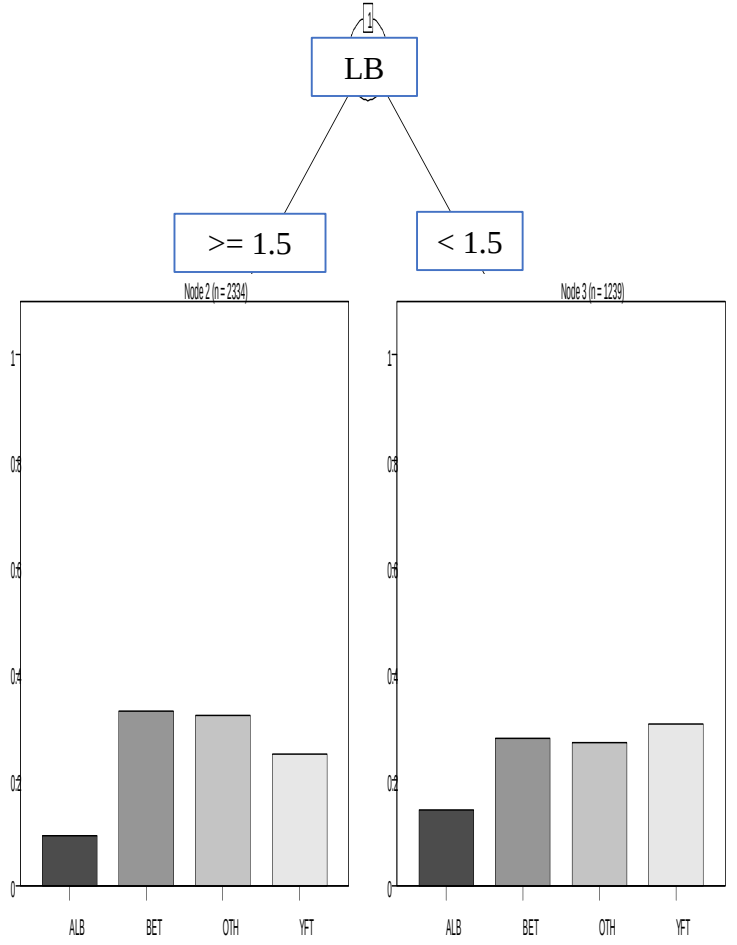
1. The 75 and 85 percentile criteria included much catch and effort.
2. The similarity of the tree models of the 85 and 95 percentile is highest. In this case, the first splitter are same for 8 models of total 12 models.
3. The 85 percentile is prefer as default setting.

Results of the 85 percentile (LLN, from period 1 to 3)

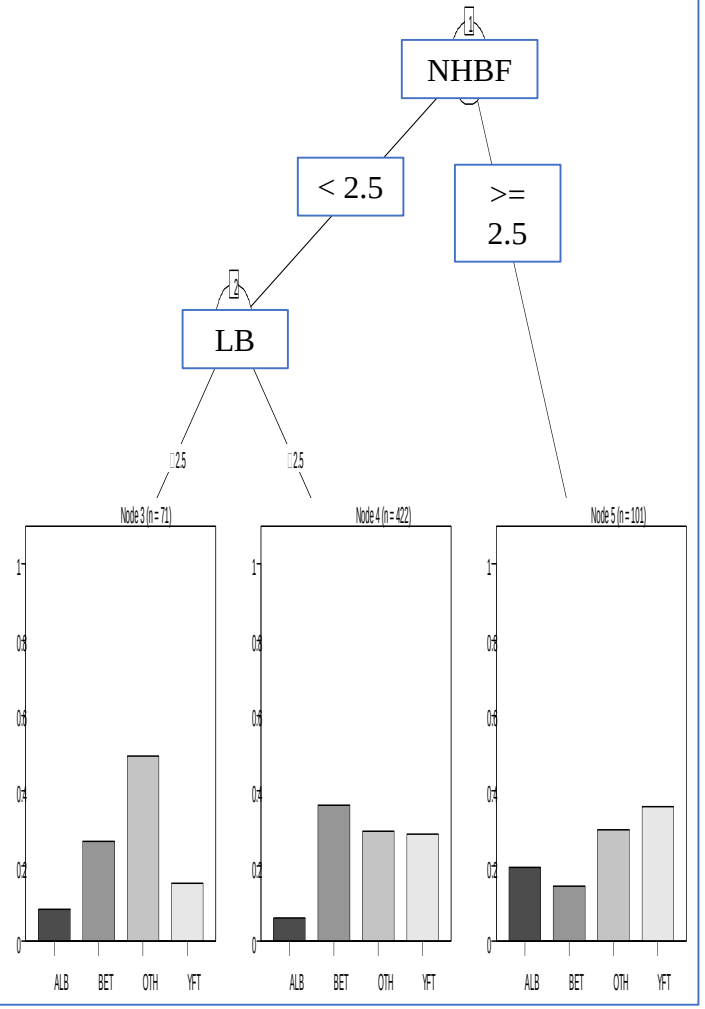
period 1 (1998-2001)



period 2 (2002-2009)

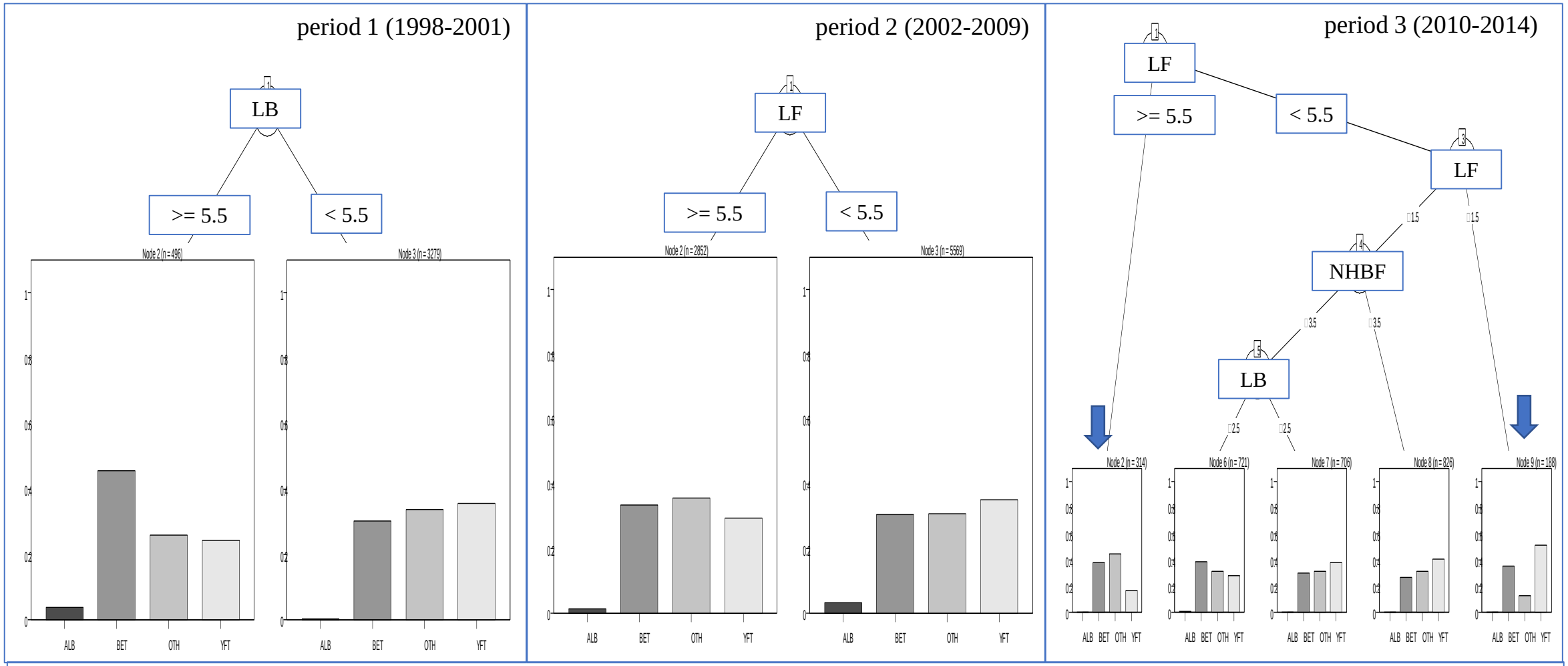


period 3 (2010-2014)



In many cases, the differences of BET proportion between nodes is not large, however, smaller proportion in YFT and ALB were detected (for eample, in nodes 5 and 11, respectively in the period 1).

Results of the 85 percentile (LLC, from period 1 to 3)

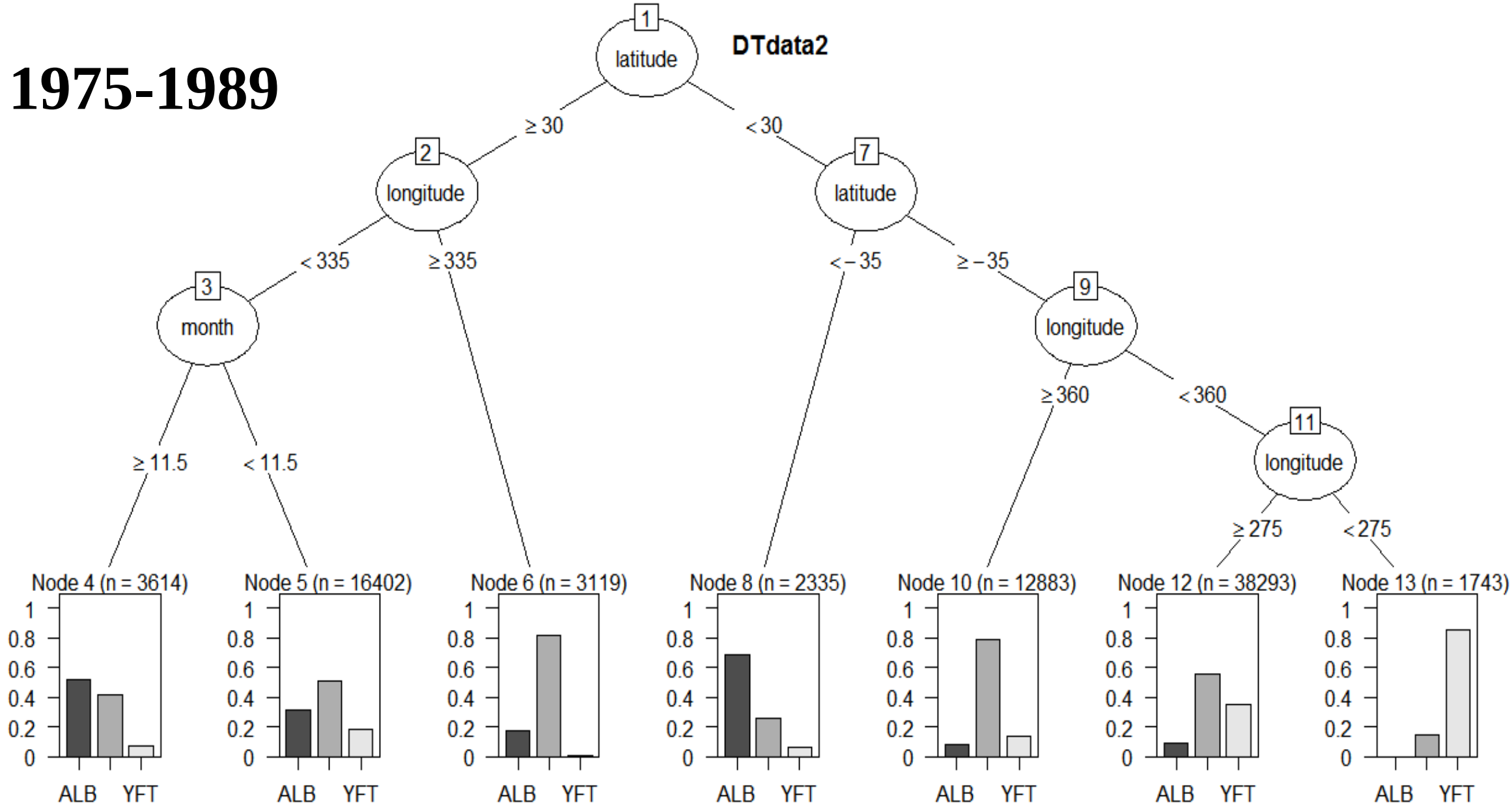


- ✓ The first splitter of period 1 and 2 periods is different.
- ✓ The difference of BET proportion between nodes is small, which indicated that BET is targeted in this area regardless the location and gear configuration.
- ✓ In the period 3, small proportion of YFT and others were detected in nodes 2 and 9, respectively.

Incorporate results of the decision tree analysis into cpue standardization process

- The relatively stable proportion of BET across node was found, which indicated bigeye is targeted regardless gear configurations and locations in many cases.
- While, in some cases, the higher proportion of some species were also detected. Thus, to explore the influence of changing species composition on cpue standardization in EPO, to compare the results with all data and without the node presenting higher proportion of ALB, YFT and other species.

1975-1989


DTdata2
1
latitude
≥ 30
< 30
2
longitude
7
latitude
< 335
≥ 335
< −35
≥ −35
3
month
9
longitude
≥ 360
< 360
≥ 11.5
< 11.5
11
longitude
≥ 275
< 275
Node 4 (n = 3614)
Node 5 (n = 16402)
Node 6 (n = 3119)
Node 8 (n = 2335)
Node 10 (n = 12883)
Node 12 (n = 38293)
Node 13 (n = 1743)
1
0.8
0.6
0.4
0.2
0
ALB
YFT

Future work

1. Discussion difference between the Atlantic Ocean and the eastern Pacific Ocean.
2. Simplified conditions (omitting “others”, simplified gear configuration) will be tested in EPO. Complicated condition will be tested for Atlantic Ocean.

3. After refinement of the decision tree analysis, cpue analysis with all data and without ALB, YFT and other species dominated node were conducted..
4. This analysis and further investigation of the JPN LL cpue standardization analysis for tropical tuna species is facilitated under the agreed conditions for collaboration on tuna research between IATTC staffs and NRIFSF staffs using set-by-set JPN LL data.