Pacific Community
Communauté du Pacifique

Evolution in the CPUE standardization for WCPC assessments: From fleet-specific GLMs to spatio-temporal modelling of Pacific-wide operational data sets

Ongoing work by the Stock assessment and modelling team of the Oceanic Fisheries Programme at SPC
Including: Samuel McKechnie, Laura Tremblay-Boyer, Shelton Harley, Graham Pilling, John Hampton

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Evolution in collaborations and data access for the analysis of operational longline data

Pre-2009:

Pago Pago dataset collaboration between the US (Keith Bigelow) and SPC (Simon Hoyle) for SP albacore

2009-2013:

Collaboration between Japan and SPC (Simon Hoyle) for in-situ data analysis

2015:

***** Fleet-combined from now on (for longline indices)

Collaboration between SPC China, Chinese Taipei, Korea, Japan and the United States for CPUE analyses only for Pacific-wide bigeye assessment (+ SP albacore for some countries) (workshop at SPC with country representatives + specific staff on secure computer until August)

2017:

+ yellowfin and bigeye assessments

2018:

+ South Pacific albacore assessment

SCIENTIFIC COMMITTEE
ELEVENTH REGULAR SESSION

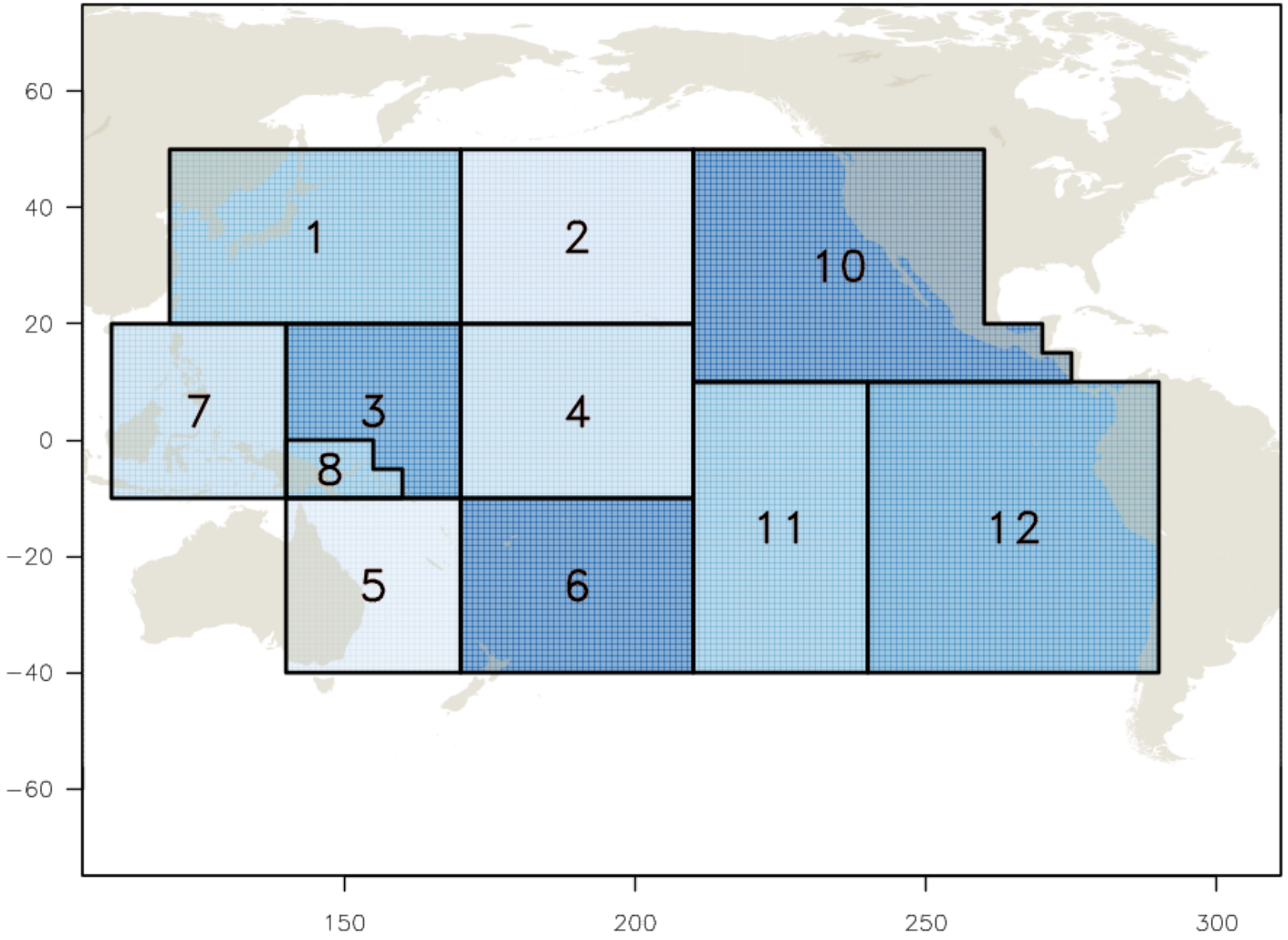
Pohnpei, Federated States of Micronesia
5-13 August 2015

Continued use of longline operational-level data provided by fishing nations to support WCPFC stock assessments

WCPFC-SC11-2015/SA WP-07

The purpose of this paper is to request consideration of the Parties to NOT require that the data be deleted, as stipulated in the Agreement, that the data be updated annually, and that the usage of the data be extended to allow it to be used for other relevant WCPFC stock assessments, as appropriate. The rationale for this request is as follows:

2015 Pacific-wide bigeye tuna assessment
(sensitivity analysis in response to 2012 review)



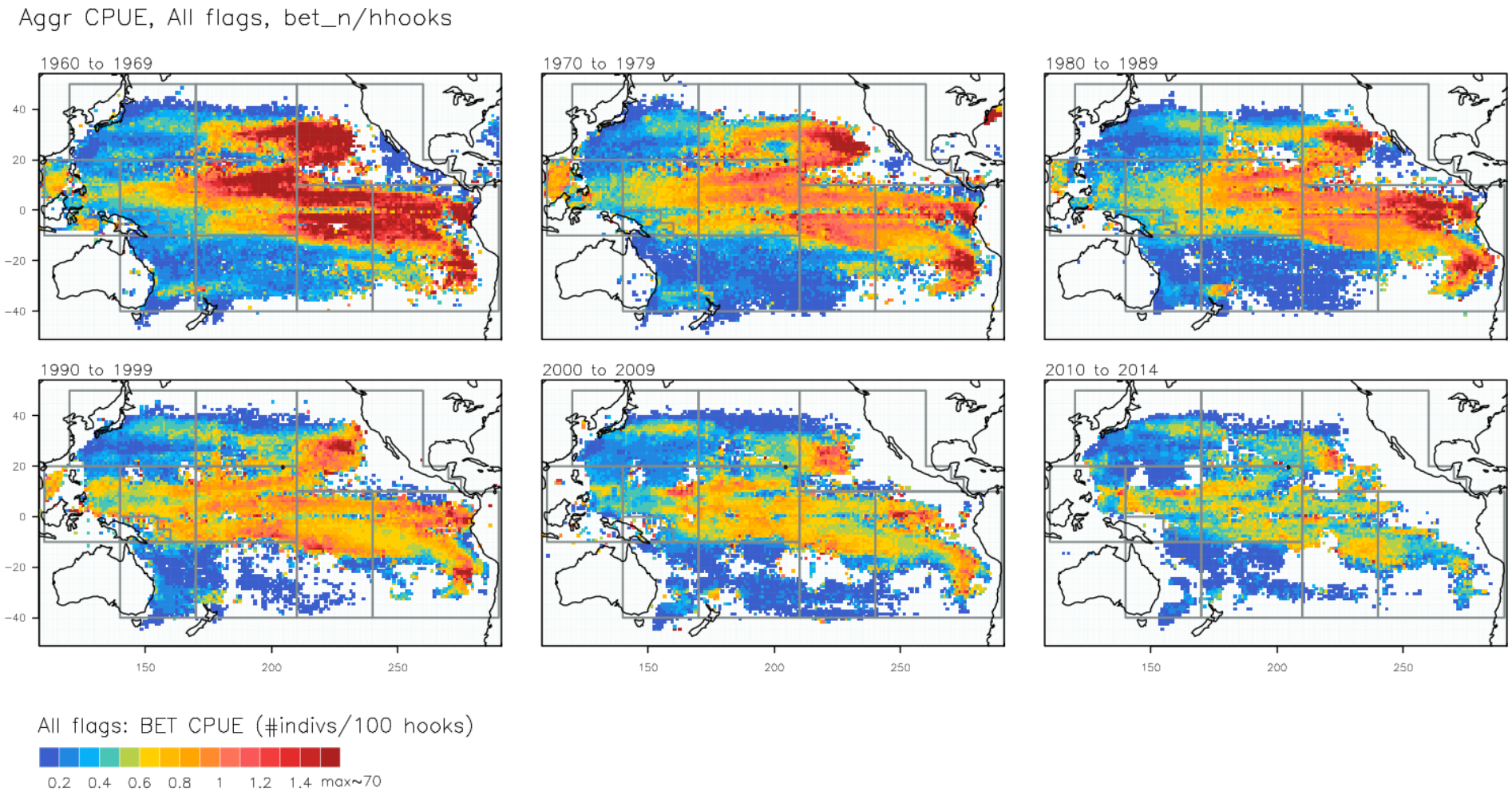
The dataset:

Logsheet longline data for domestic and distant-water fleets in the Pacific

1952-2015+ ~ 11 million longline sets

catch for ALB, BET, YFT, and SWO / effort in hooks

flag / 1x1 cell / set date / year-quarter / set time / hooks-between-floats / vessel ID



2015: CPUE indices using conventional GLM methods

2017+: … move towards spatio-temporal models

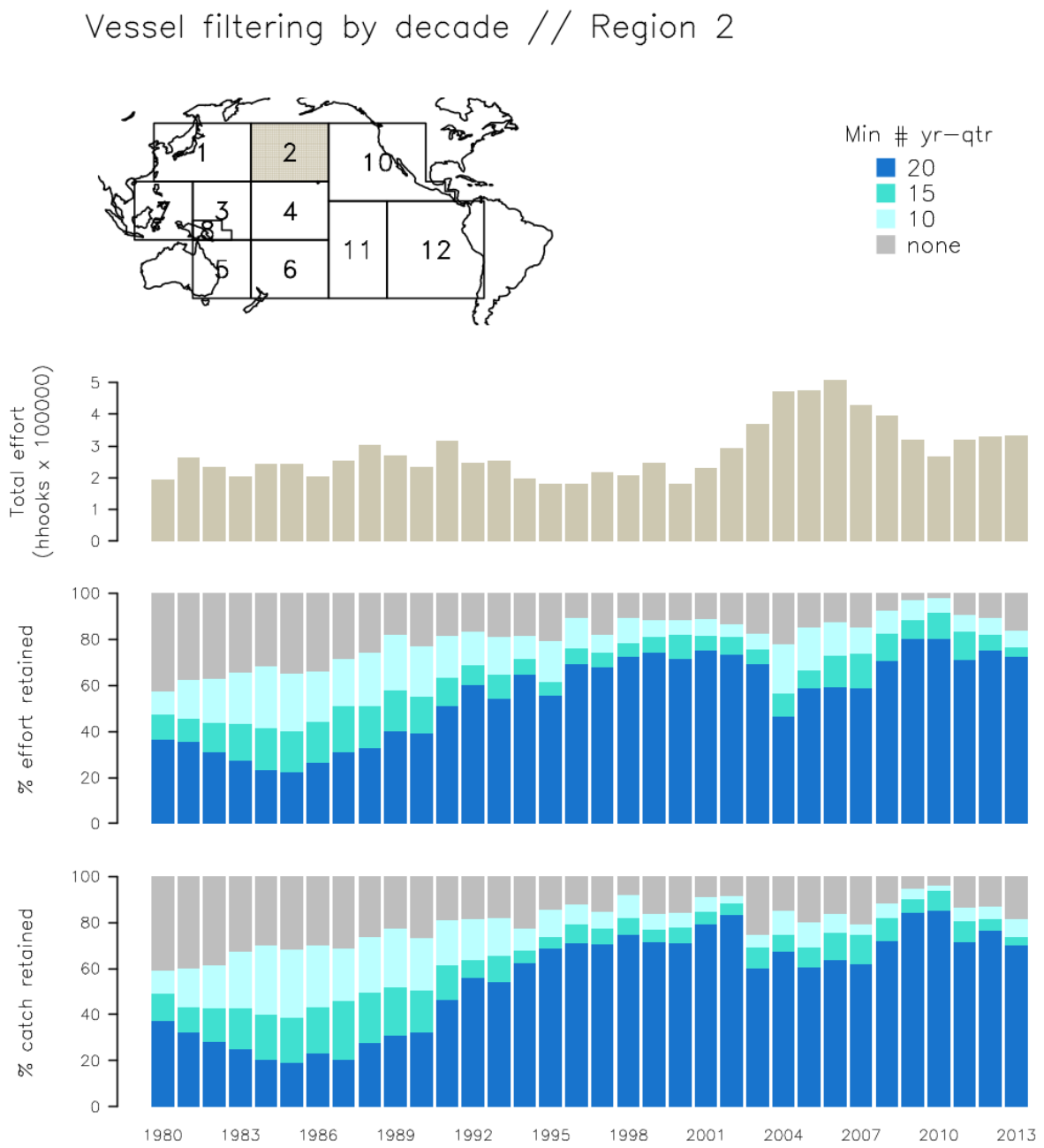
Challenges at first:

~11 million sets
region-by-region indices
switch from stats::glm() to TMB
vessel index: core fleet and missing vessel
covariates missing for part assessment span 1960-201X
targeting analysis

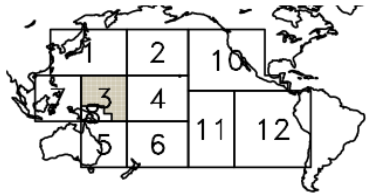
> Tried both negative binomial and delta-log normal indices

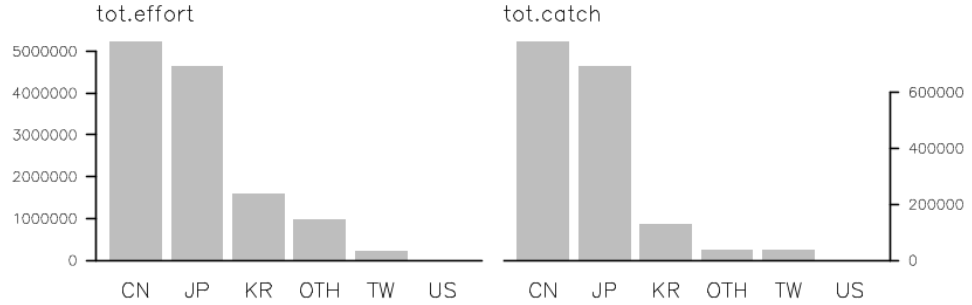
CPUE ~
year-quarter + 5degree cell + vessel + targeting.cluster

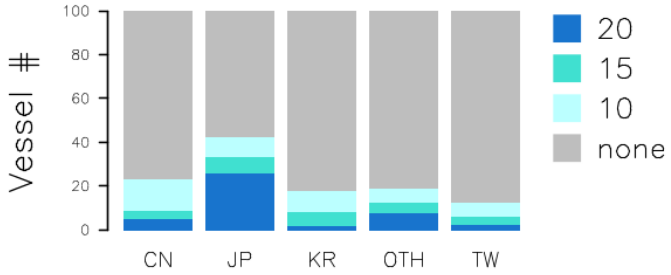
Vessel ID + subsampling: defining a core fleet

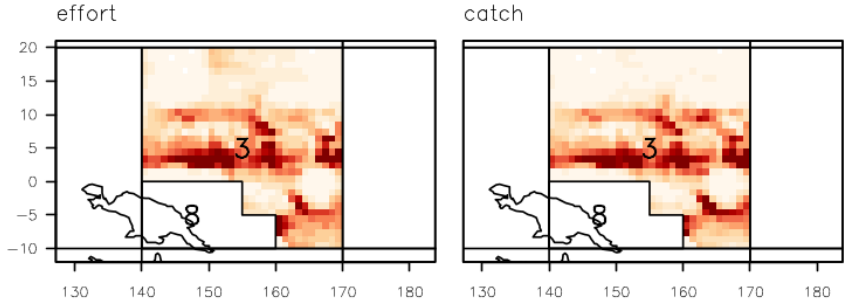


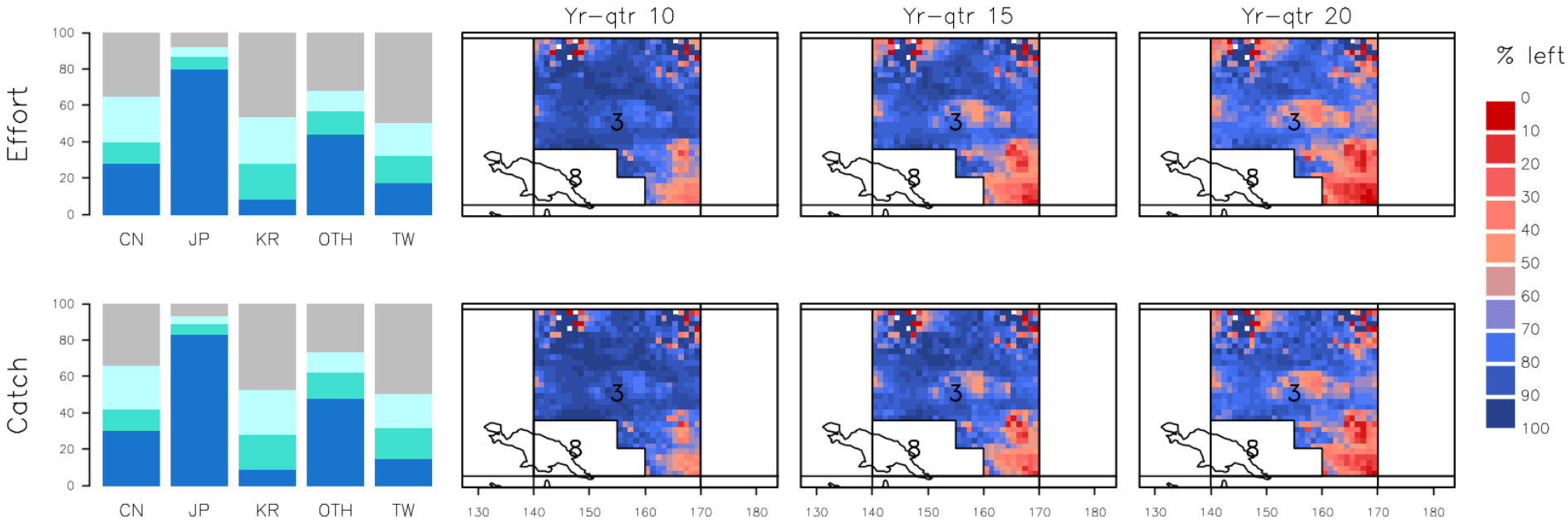
Vessel filtering // Region 3



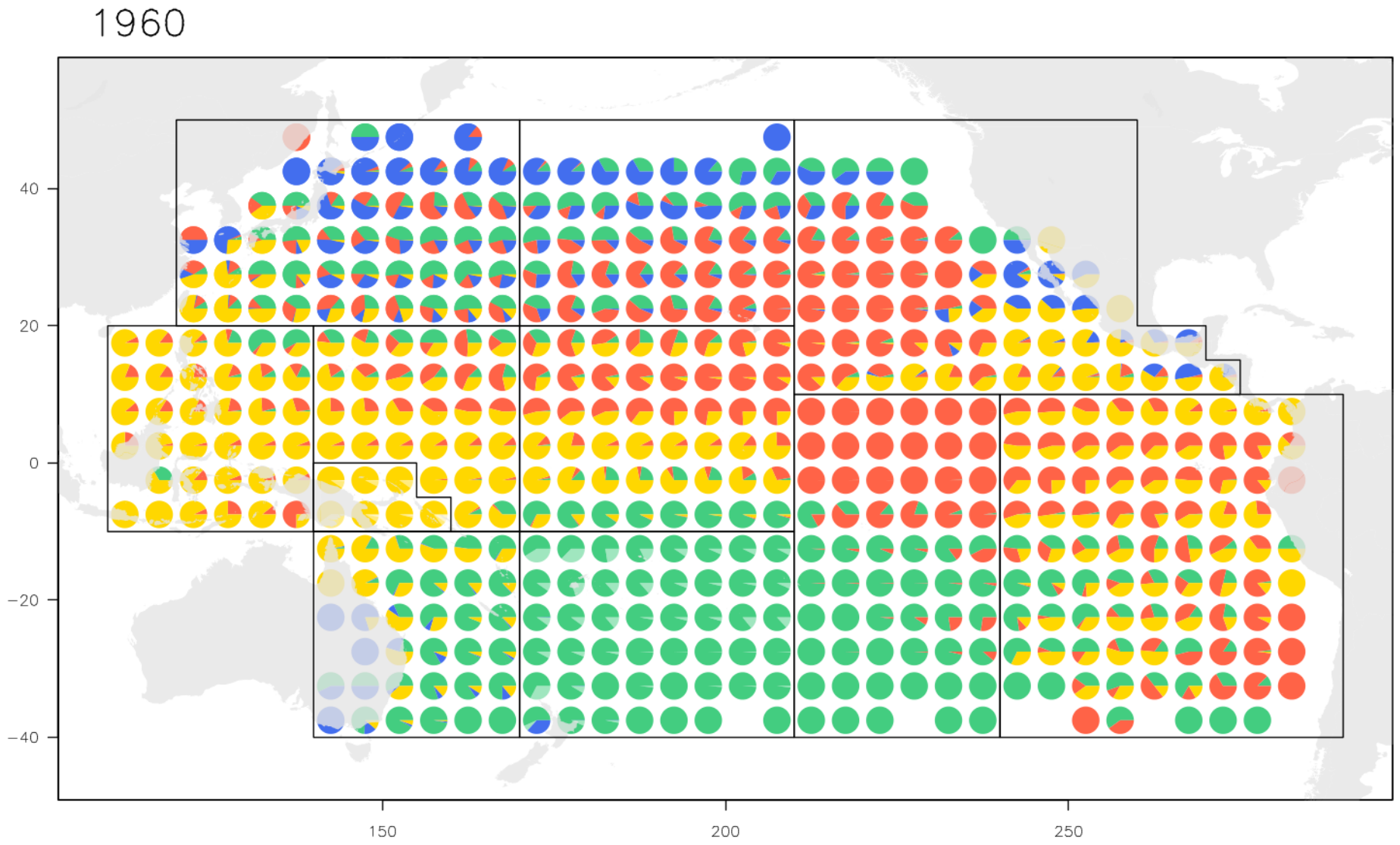




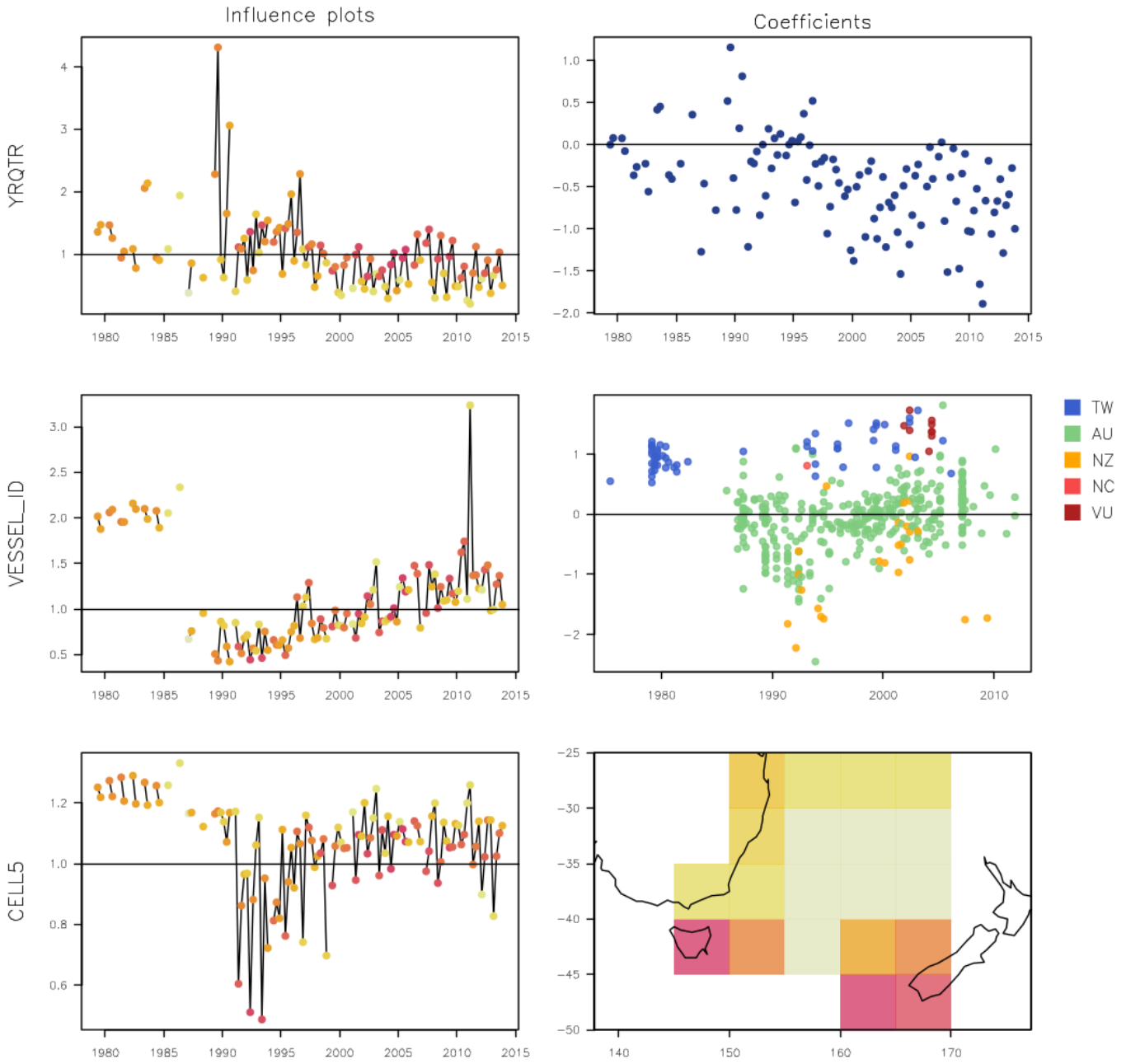




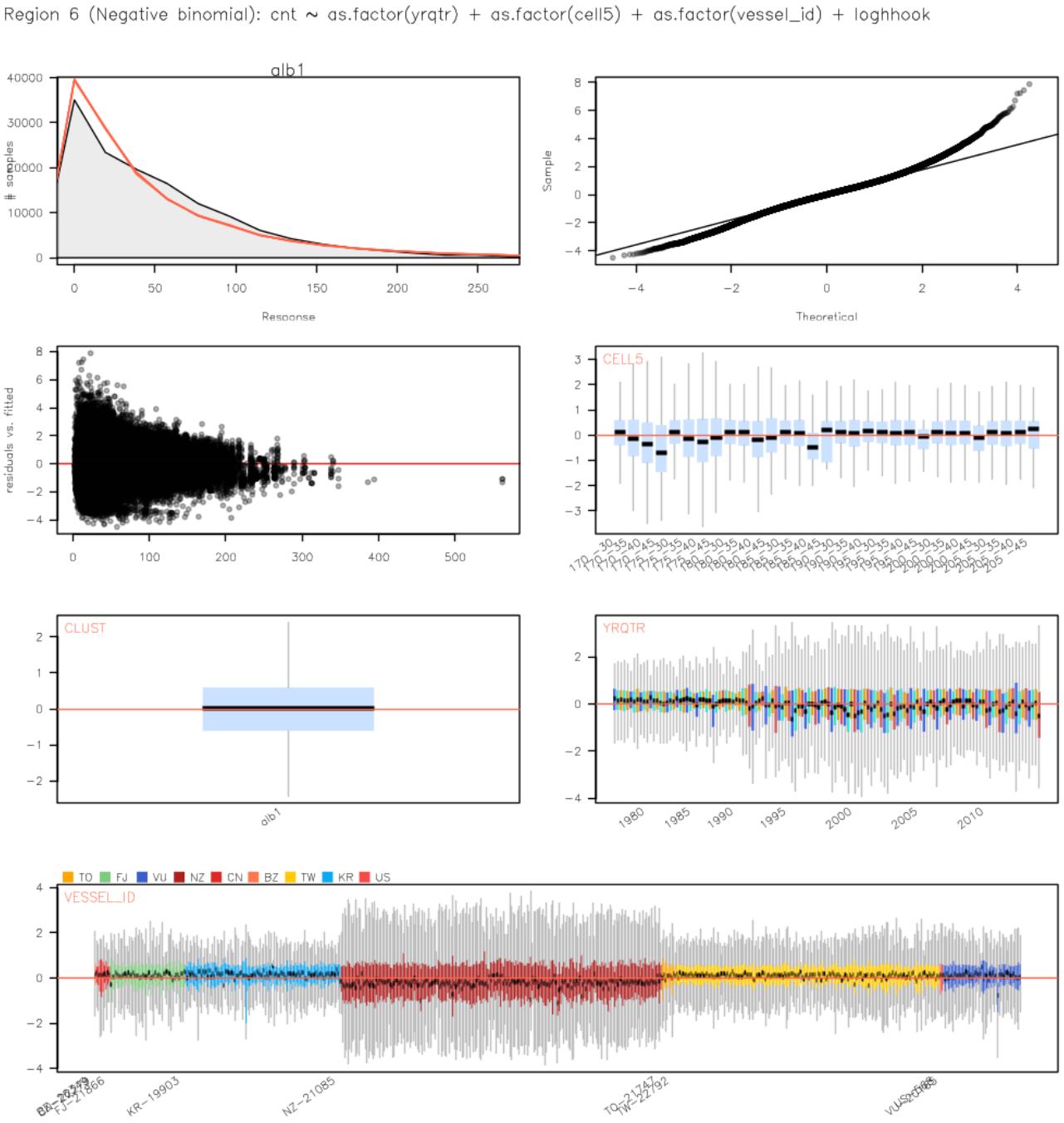
Cluster analysis to assign targeting strategy



Influence plots for region 3 of SP albacore



Diagnostics for region 6 of SP albacore



2017 onwards:

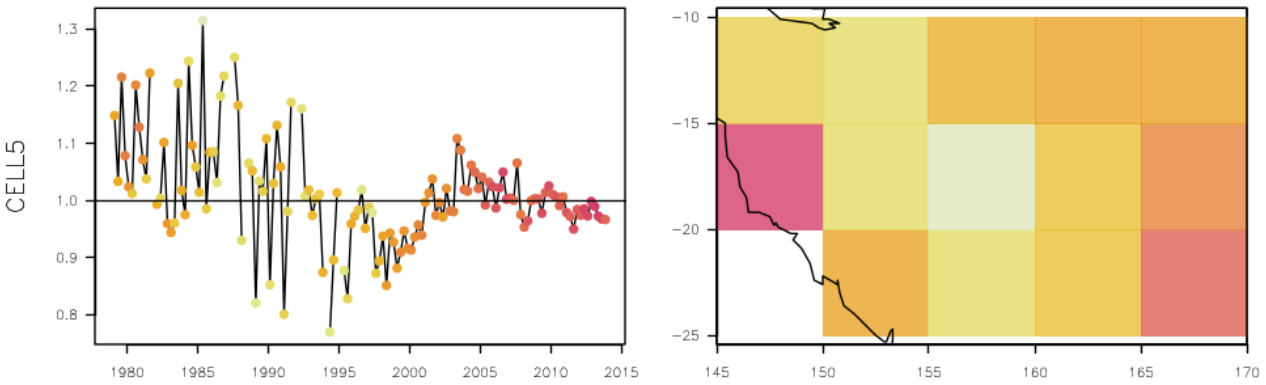
Moving towards a spatio-temporal approach to CPUE standardization

Current CPUE standardization adds cell as categorical variable to account for spatial effect:

resp ~ YrQtr + … + cell

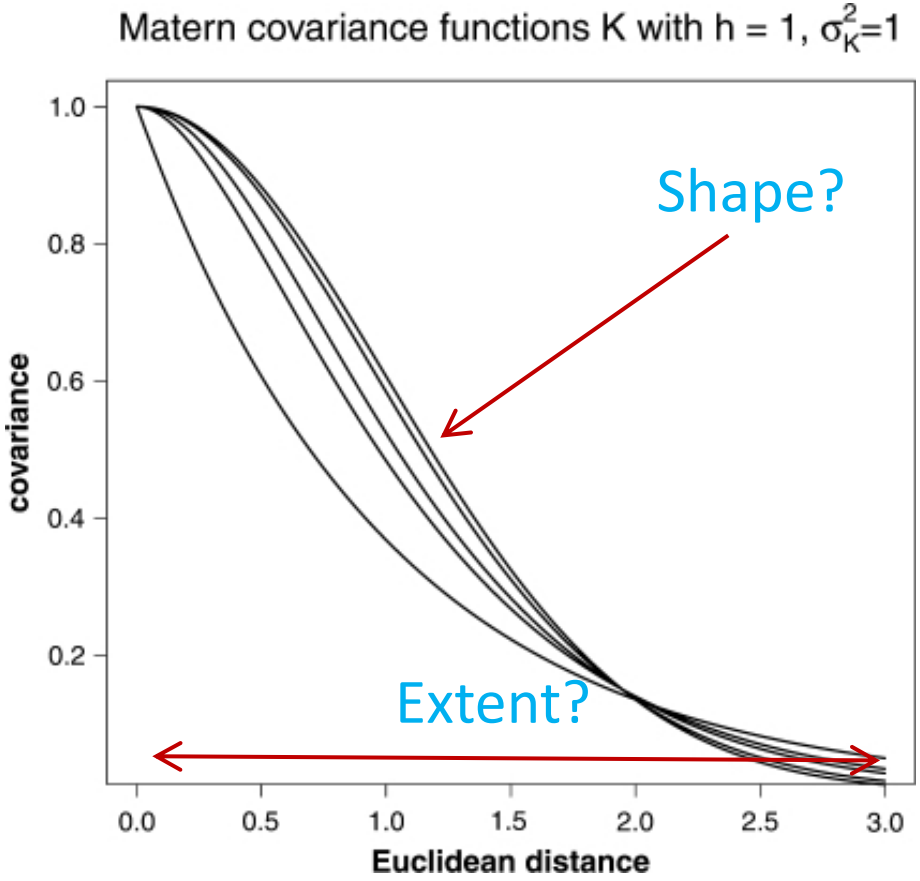
Problems:

- Does not account for spatial correlation between neighbour cells
- Challenging to included space-time interactions
- Mix-bag of spatial effect: oceanography, fleet dynamics, etc.
- Indices run individually by region



resp ~ YrQtr + … + cell

Replacing + cell by geostatistical surface with spatial auto-correlation between cells and years



Assumes points closer in distance are more correlated with each other

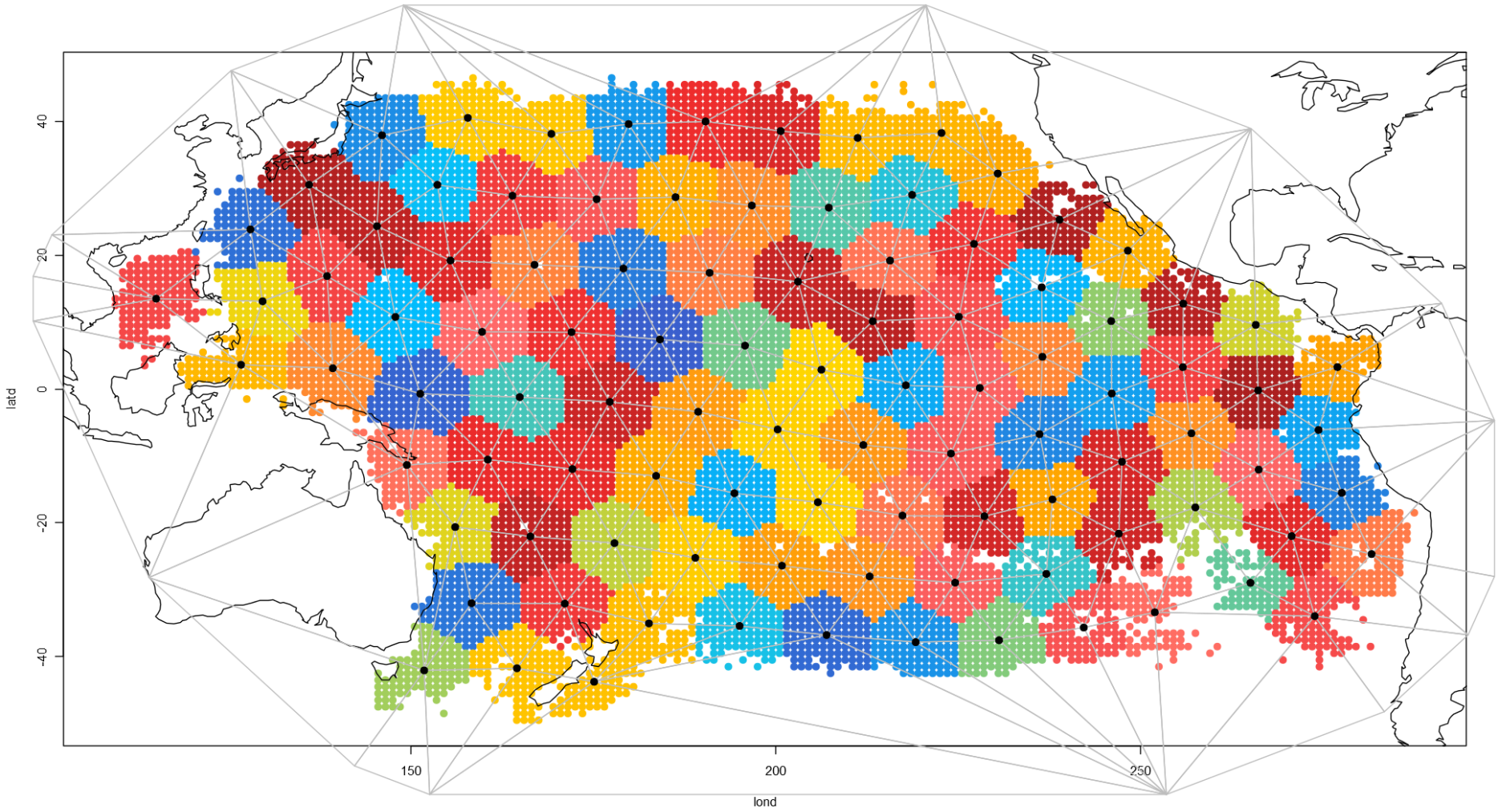
from resp ~ YrQtr + … + cell (*time)

to

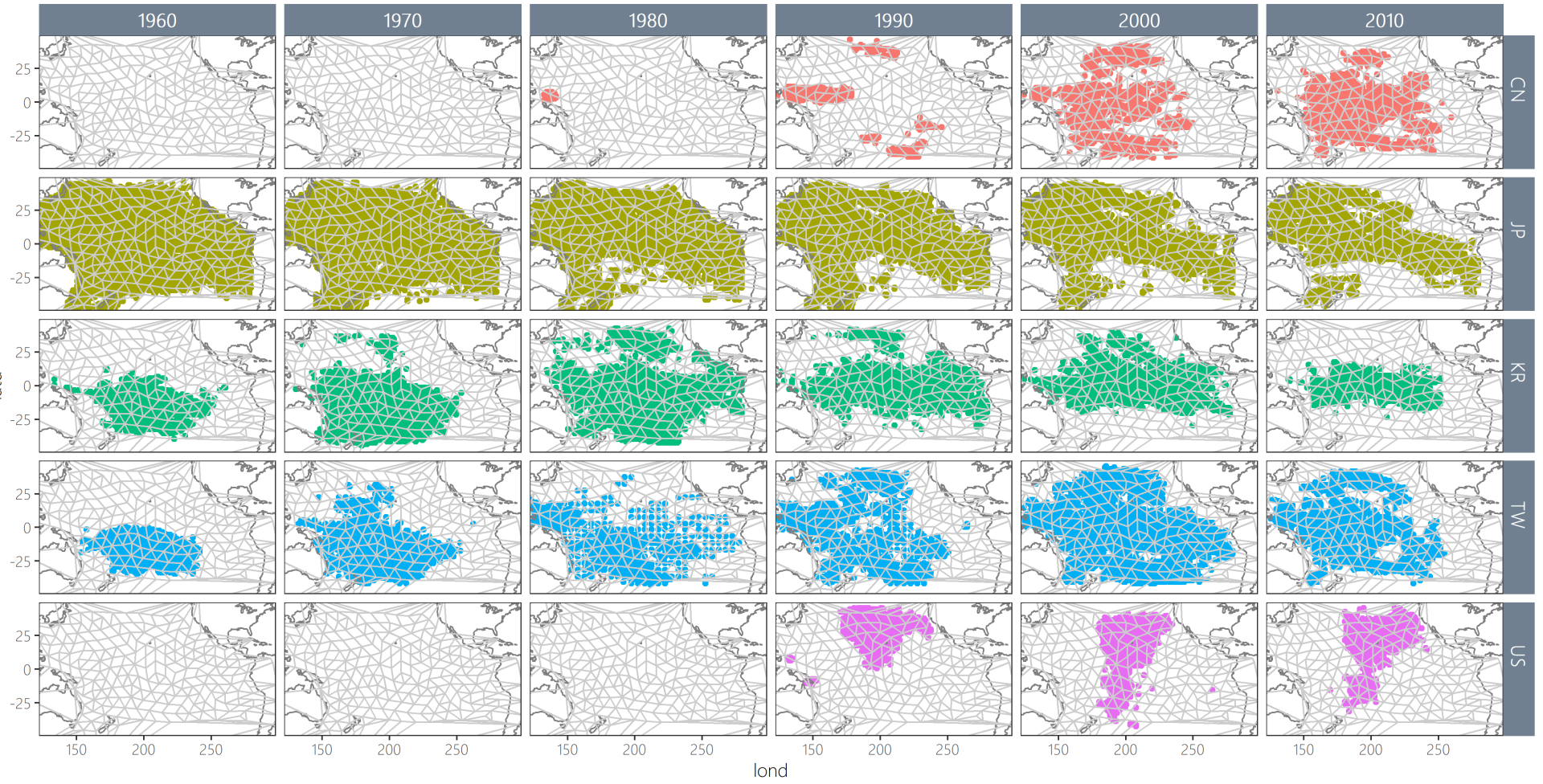
resp ~ YrQtr + … + f(knot_i) + f(knot_i,YrQtr)

[…] can be any other covariate

Error distribution: delta-log-normal

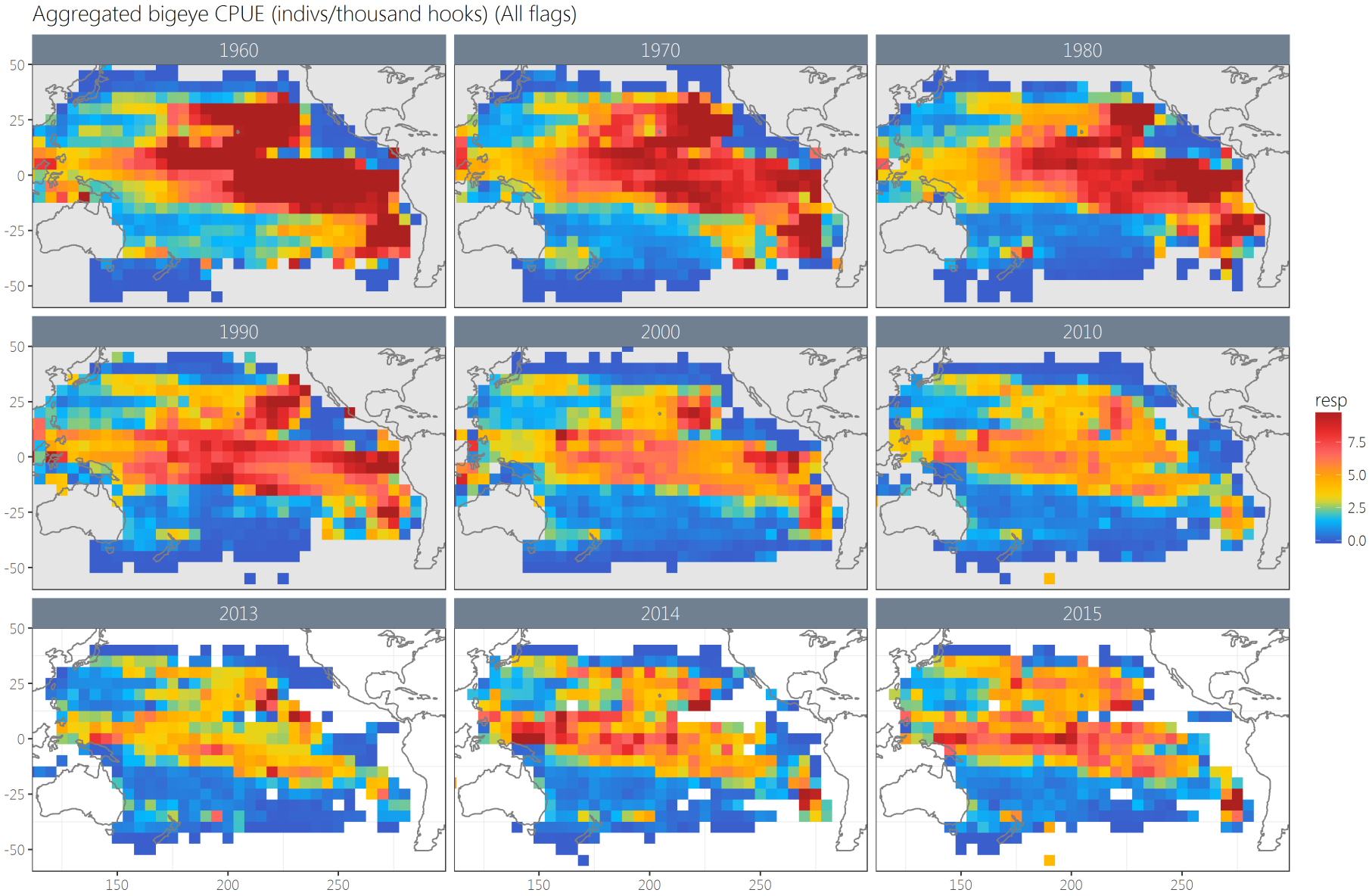


+ Domain sampled unevenly over time
+ Domain sampled unevenly by flags

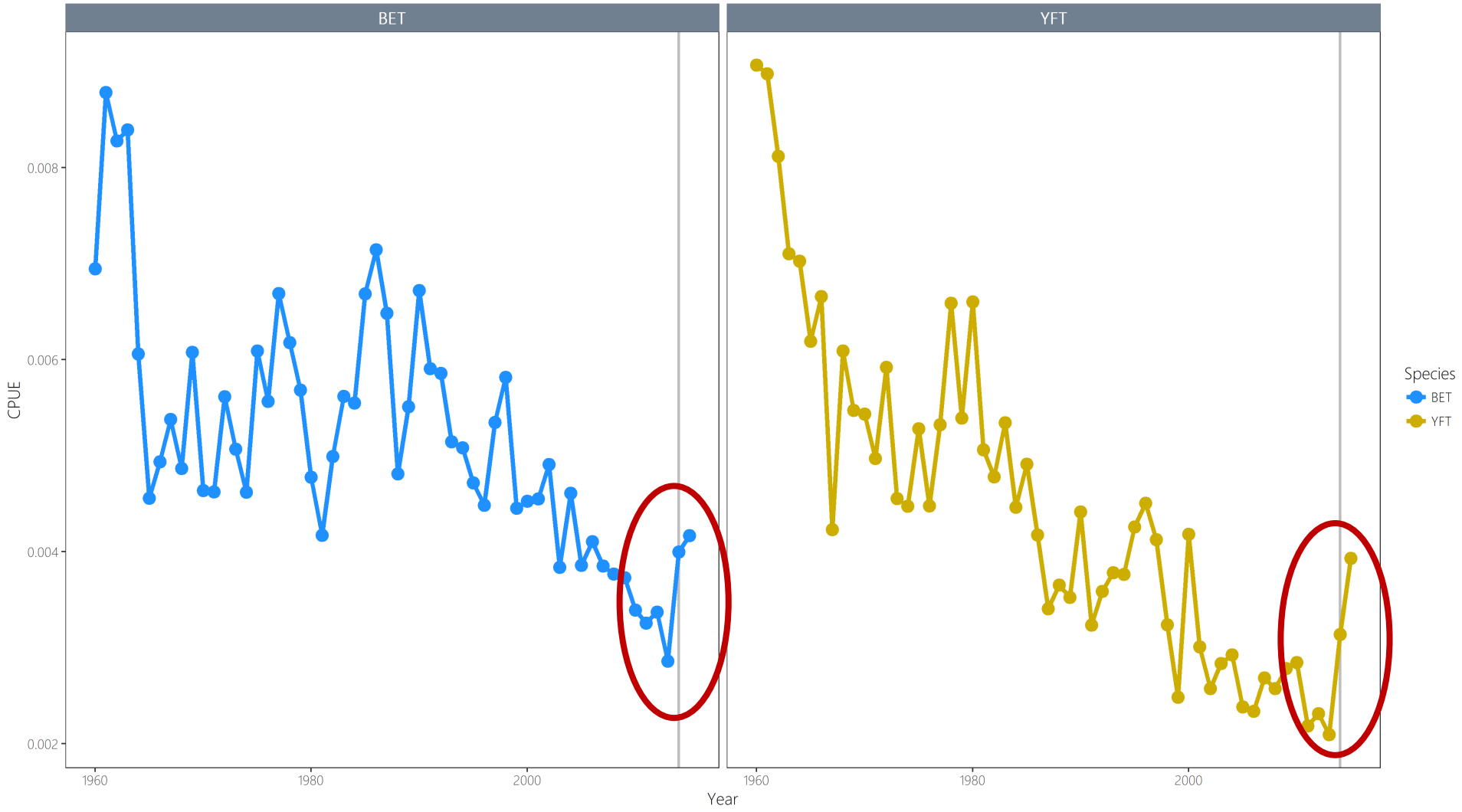


Inclusion of oceanography covariates – why?

What causes the east-west gradient in BET CPUE?



Does the recent increase spike in BET and YFT (nominal) CPUE reflect abundance?



Inclusion of oceanography covariates in CPUE standardization

catchability vs. abundance

CPUE ~ YrQtr + […] + ocn-covar

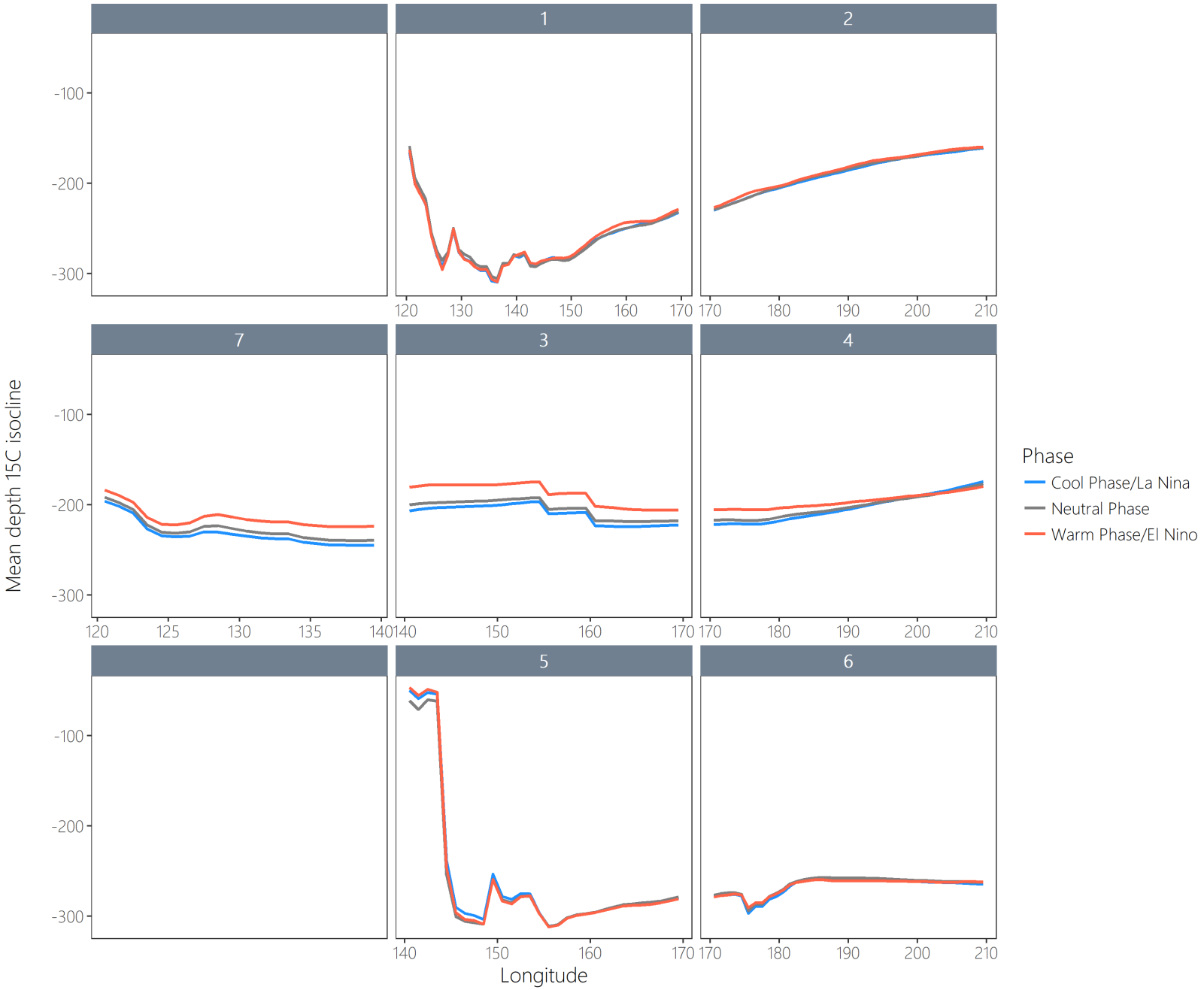
?

If the oceanography variable impacts abundance, we do not want it to be standardized against

- Collinearity between oceanography variables?

Other considerations for depth proxy:
Non-linear relationship

15C isocline by longitude and region, by ENSO phase



Abundance covariate, kept in

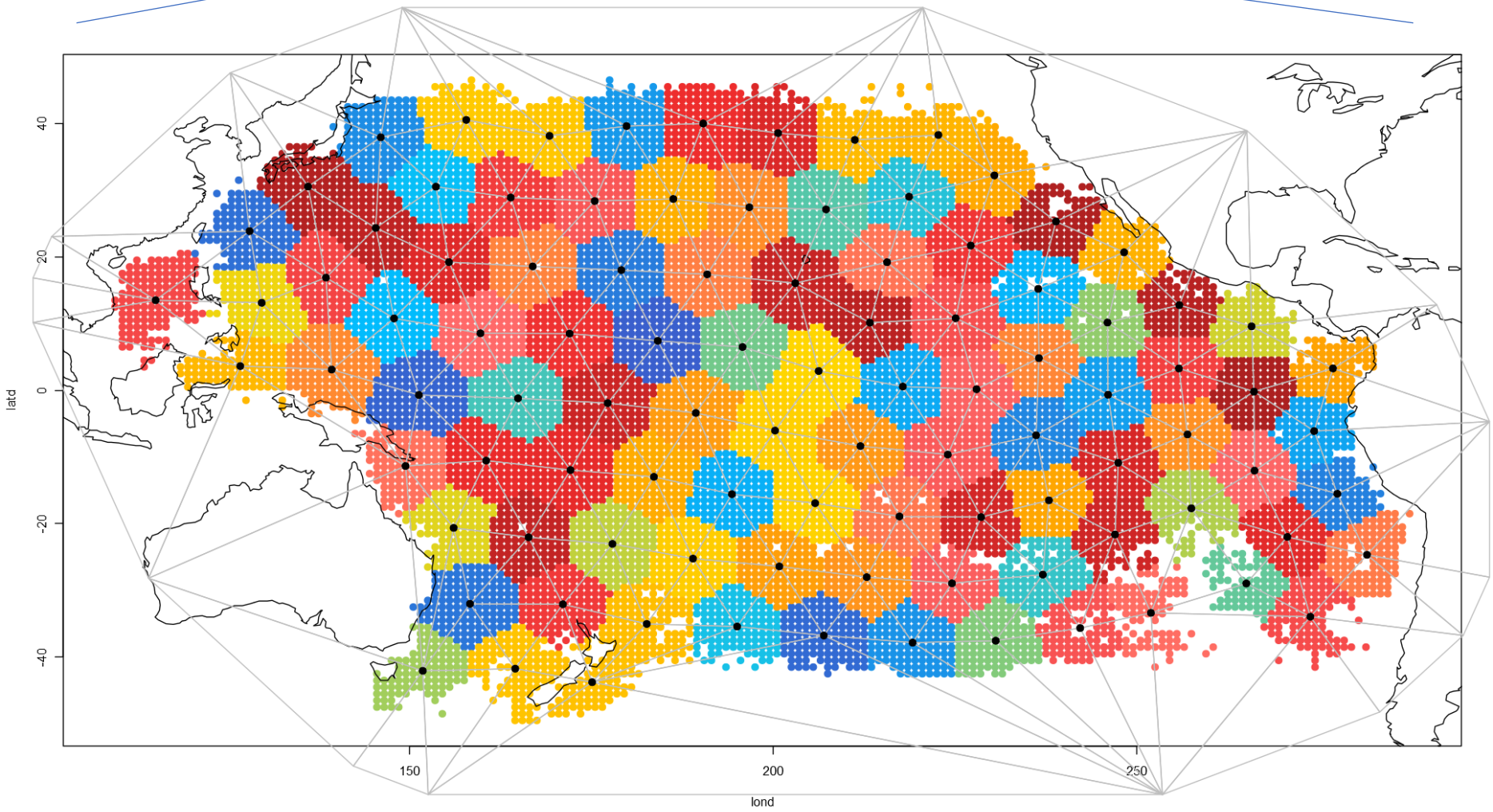
resp ~ YrQtr + … + f(SST)

Catchability covariate, standardized out

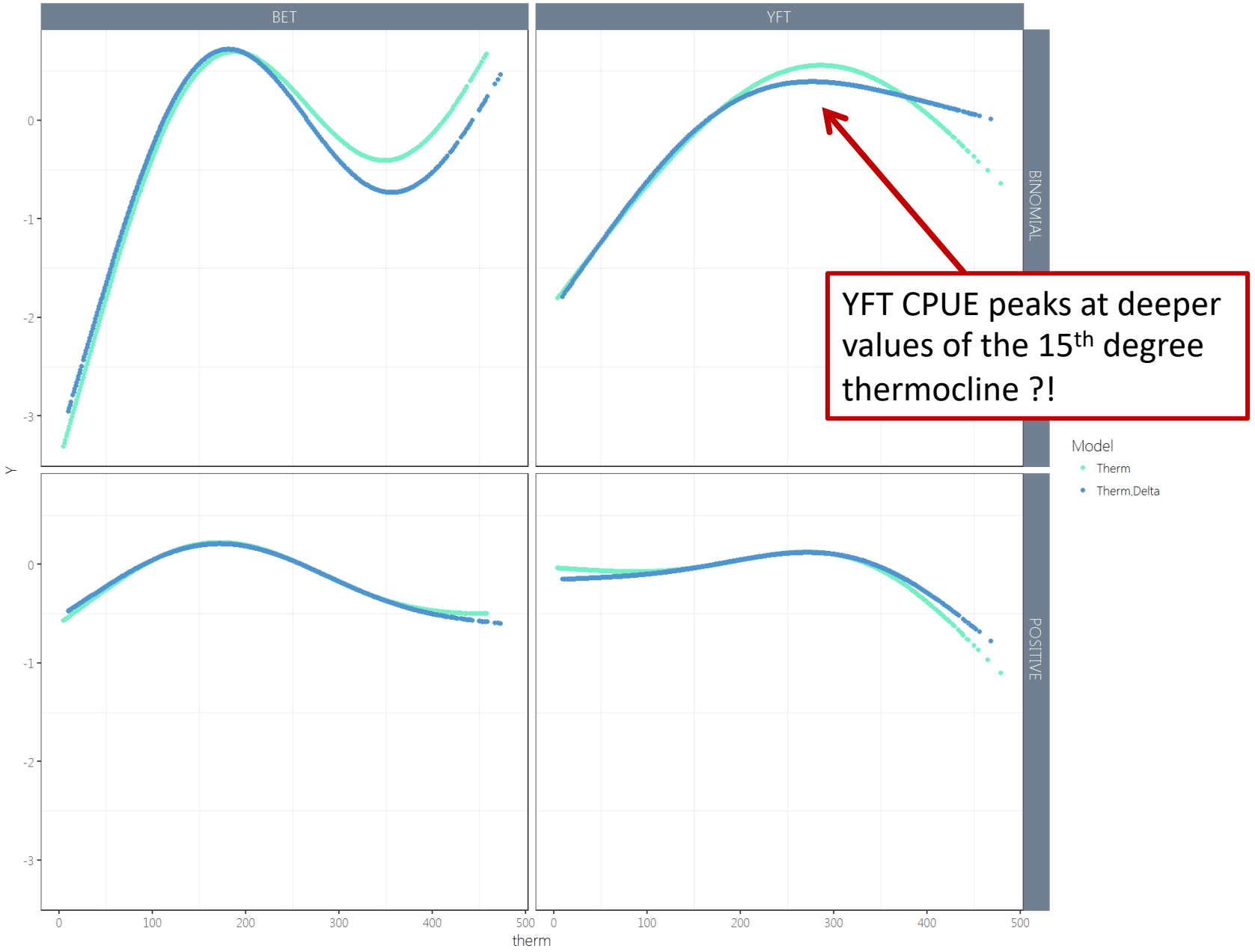
+ f(thermocline)

confounded spatial covariates?

+ f(knot_i) + f(knot_i,YrQtr)



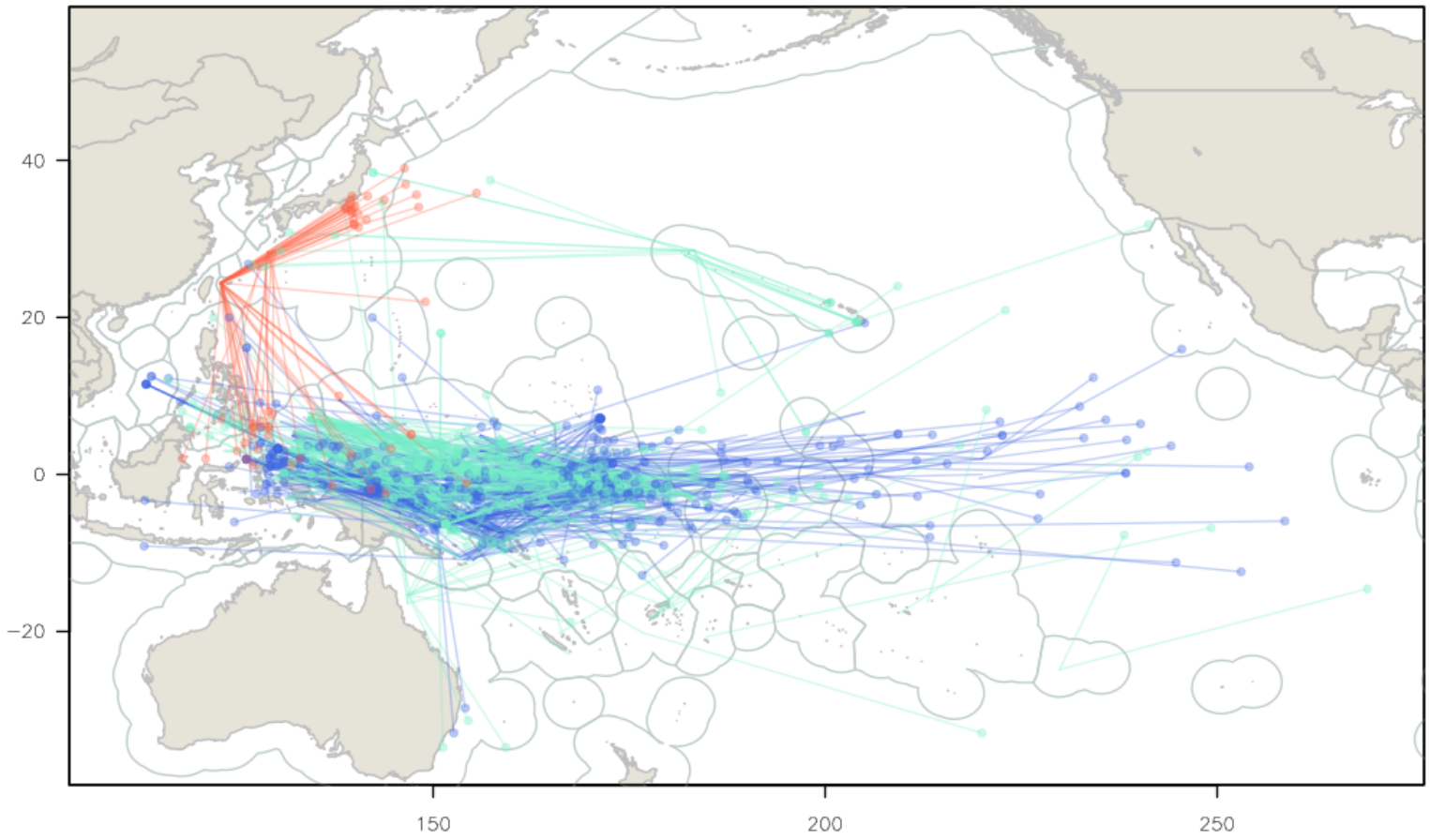
Thermocline only as a catchability covariate = uh oh.



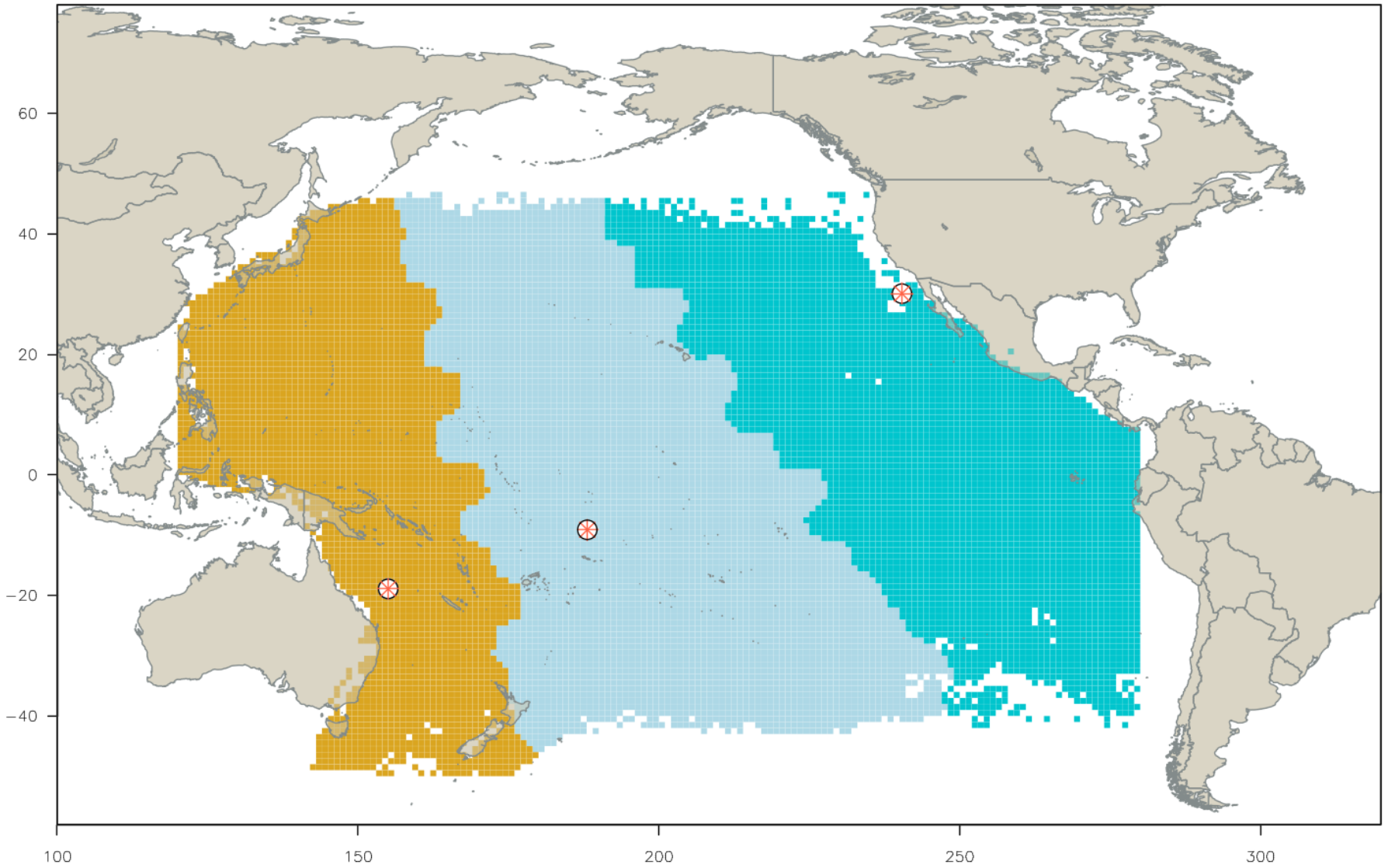
Regional or *local* abundance covariate?

SST from actual set location (local abundance effect)
vs. regional trends in SST (regional recruitment)?

Yellowfin tuna tag movements:

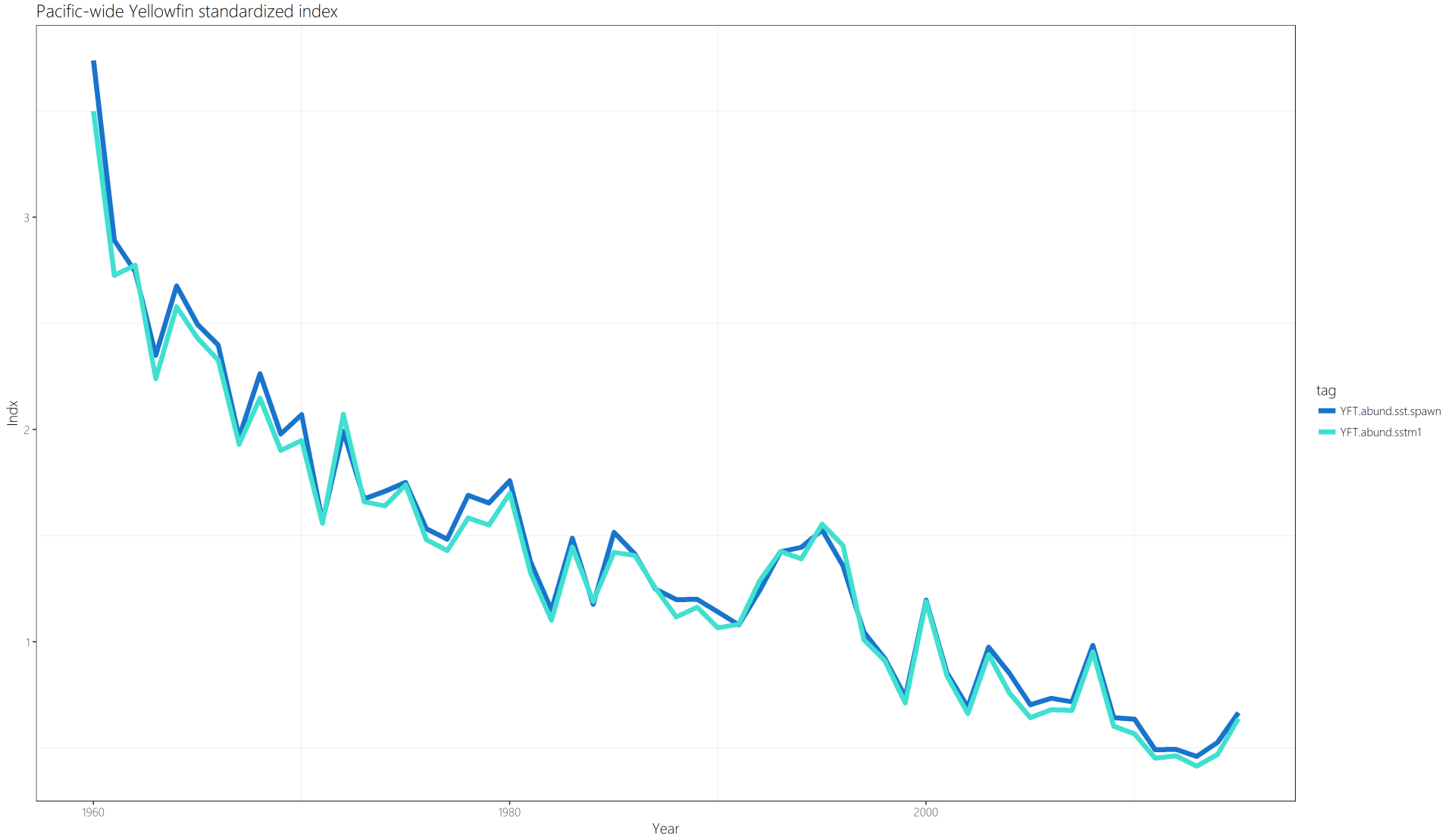


An alternative abundance covariate:
recruitment index based on the area with SST >= 27C in the previous year
Also: does fine-scale stock structure matters?



From: Grewe et al. (2015). Evidence of discrete yellowfin tuna (Thunnus albacares) populations demands rethink of management for this globally important resource. *Scientific reports*, *5*, 16916.

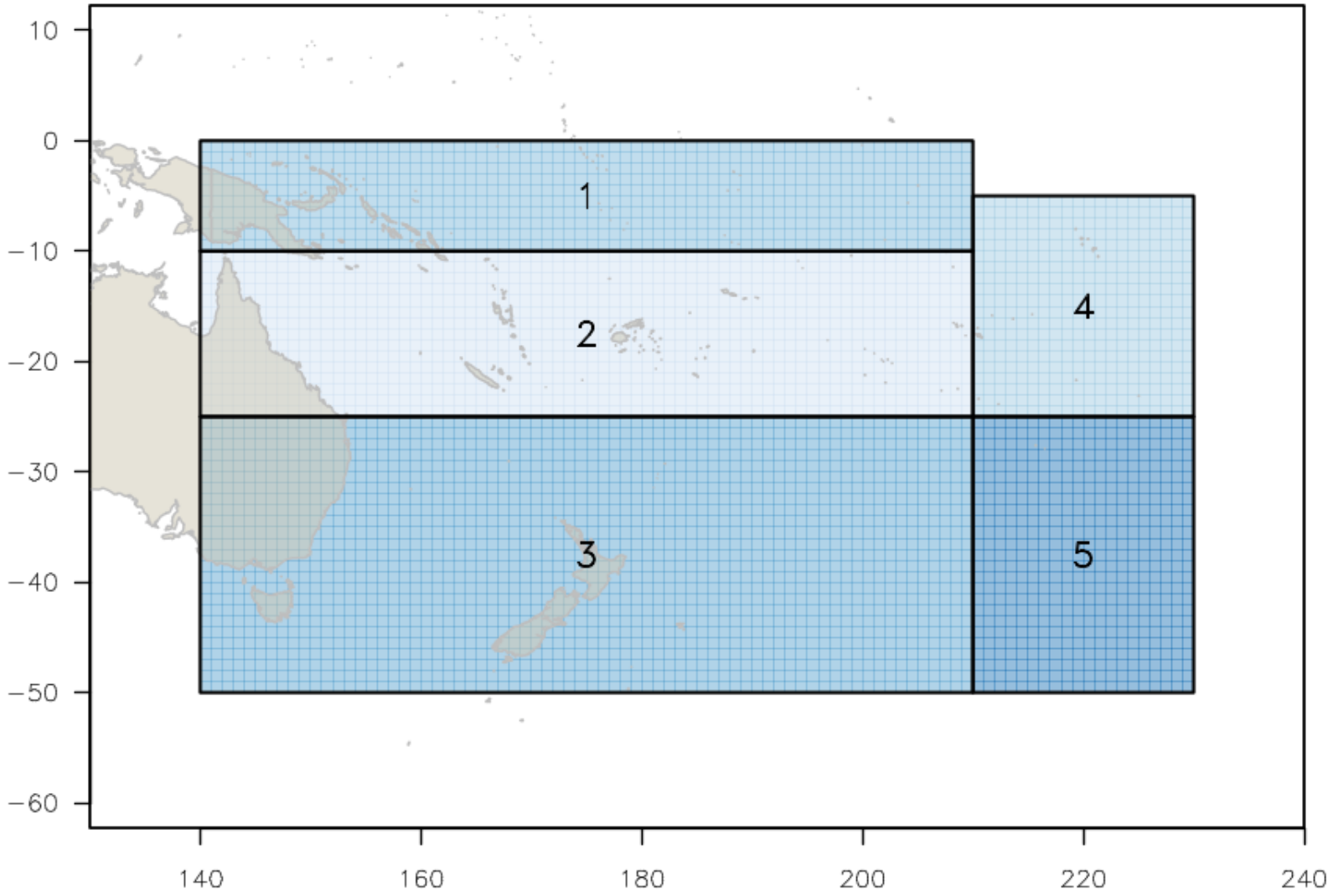
YFT: No difference in the standardized indices built from local vs. regional abundance covariates



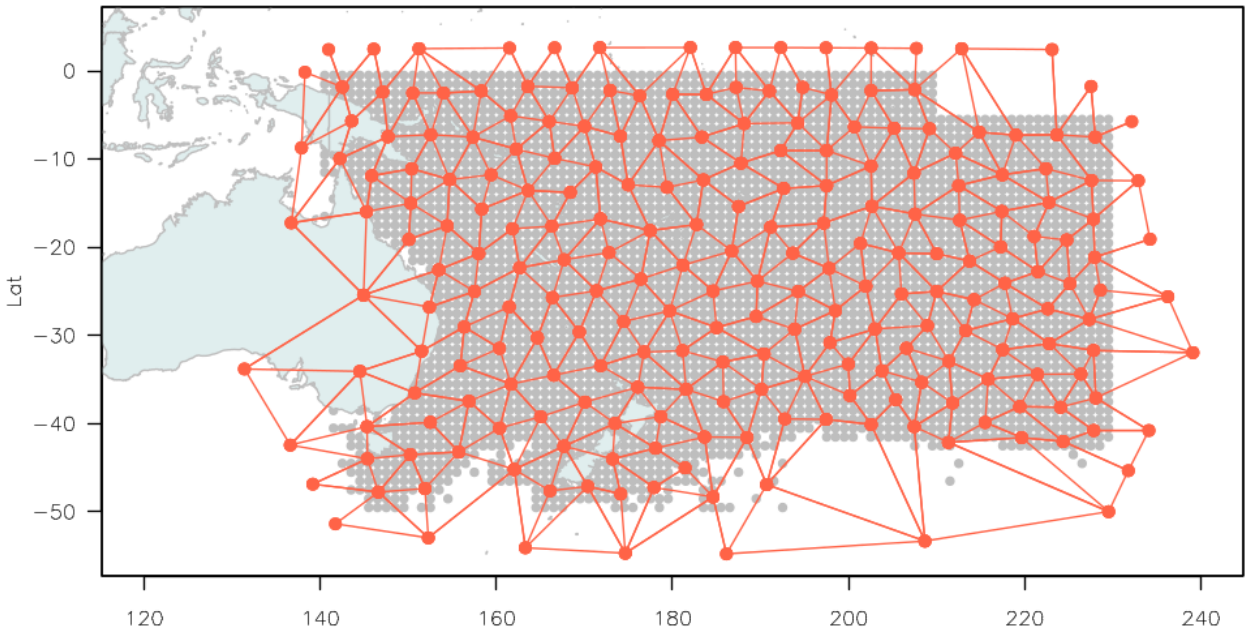
2017: index used as sensitivity scenario in bigeye and yellowfin assessments

//penguin/assessments/bet/2017/assessment/Data_Preparation/CPUE/2017UpdateNewCPUE/2017UpdatedIndicesNewCPUE.csv
vs. VAST_output/GS-CPUE-BET_YRQTR_subsmpl_200knots_465023rows_knot200_Epsilon1_wiso-3kn-ora15int_2017-07-09_wmesh2d.RData

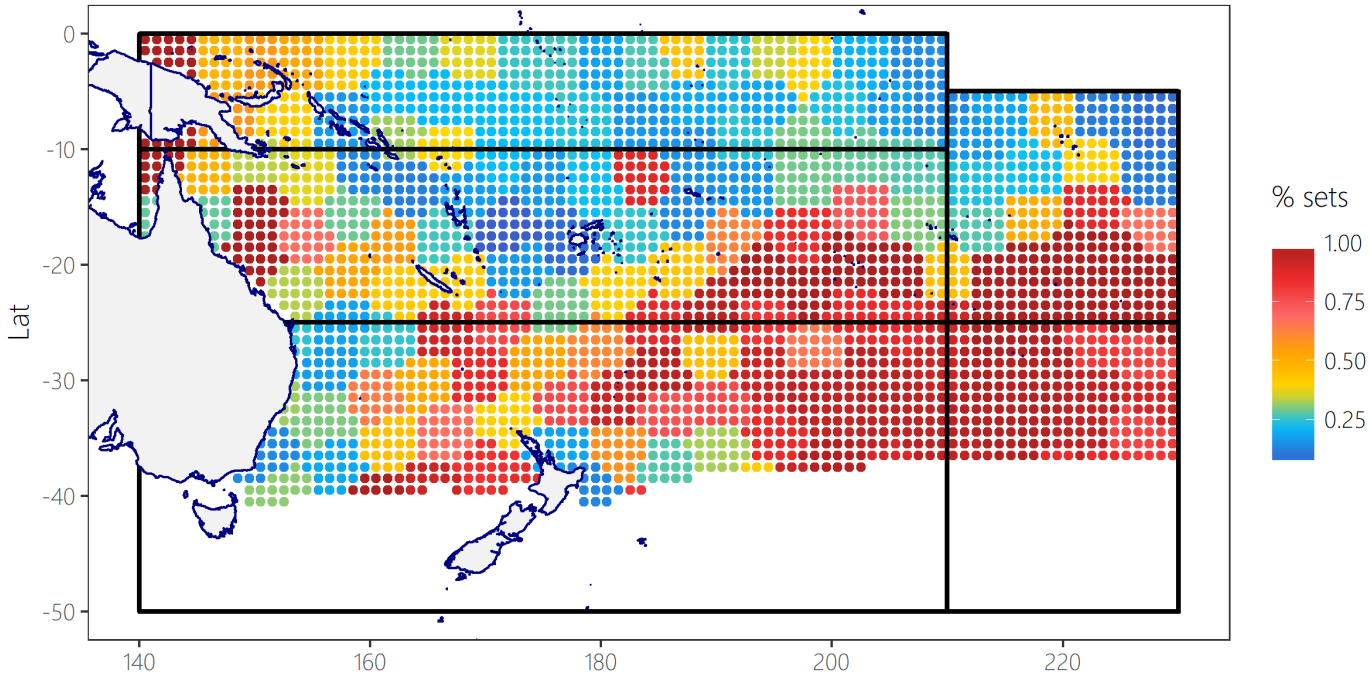
2018: South Pacific albacore



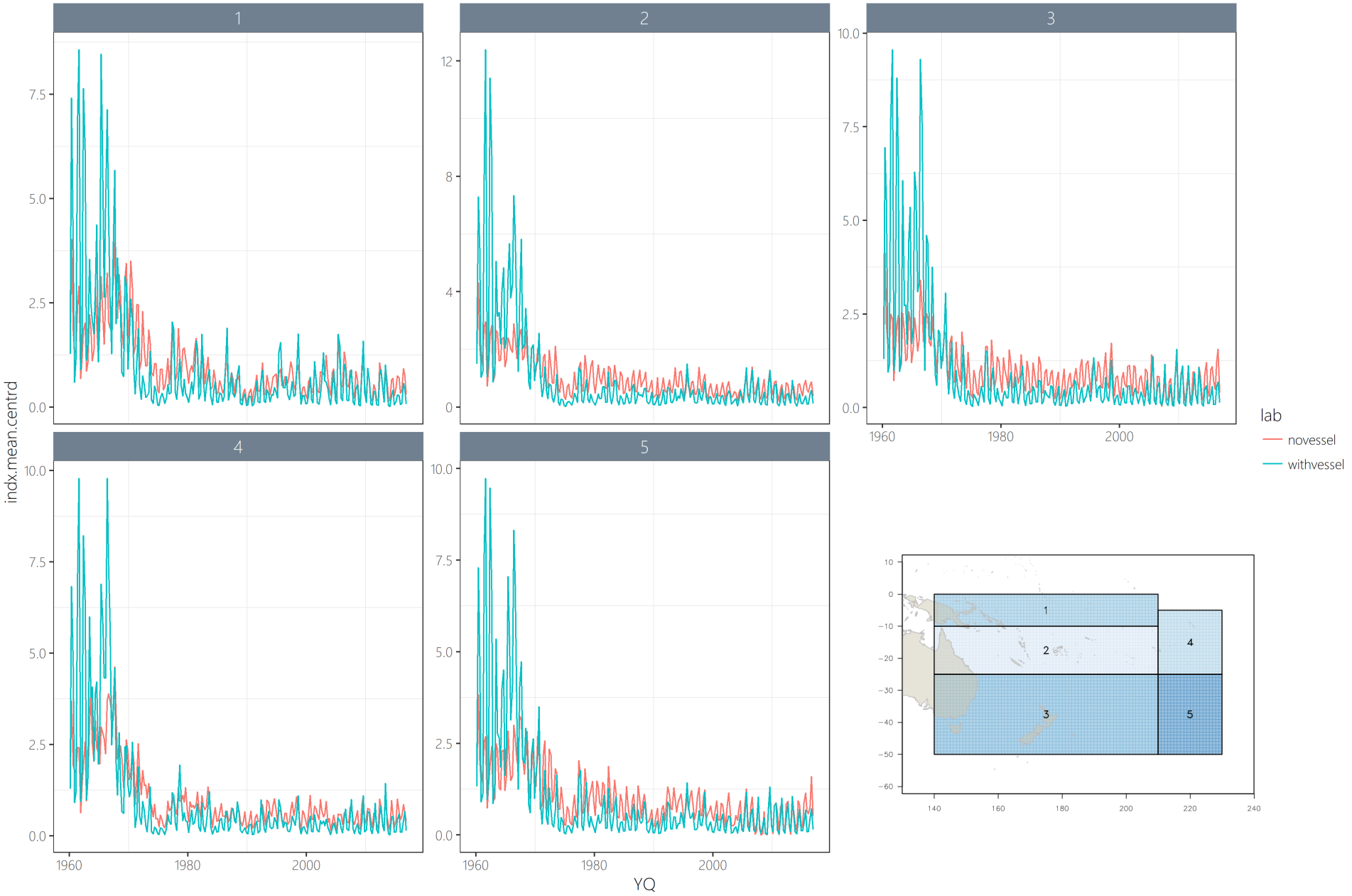
Evenly distributed mesh



Uneven sampling rate to have equal number of sets per knot

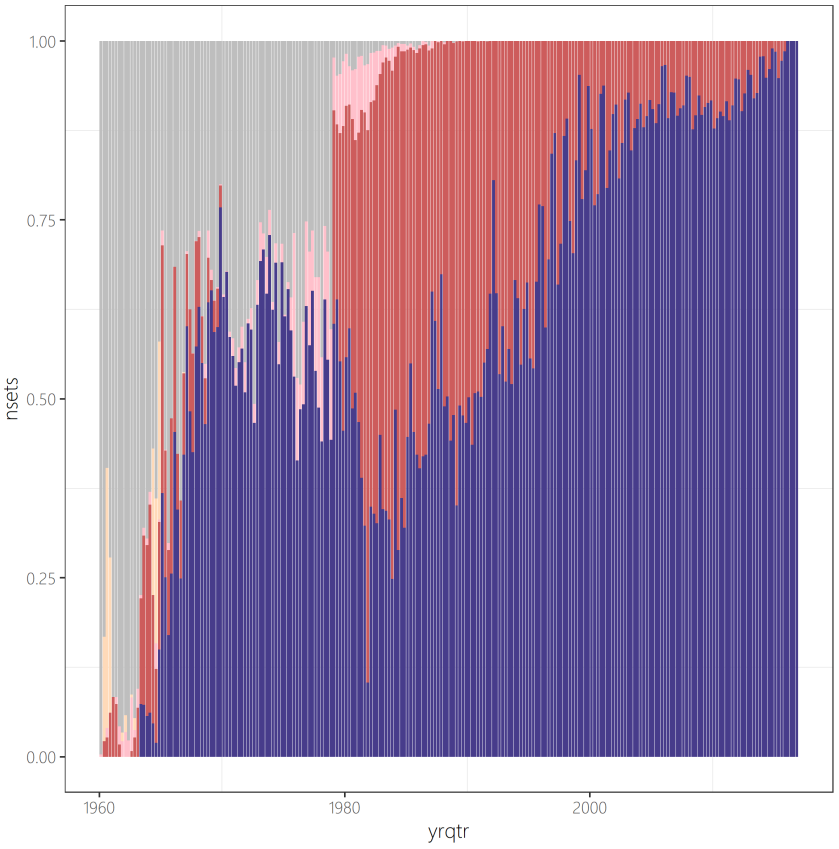


Issue: ’Missing’ vessel introduces overall bias in stock-wide CPUE

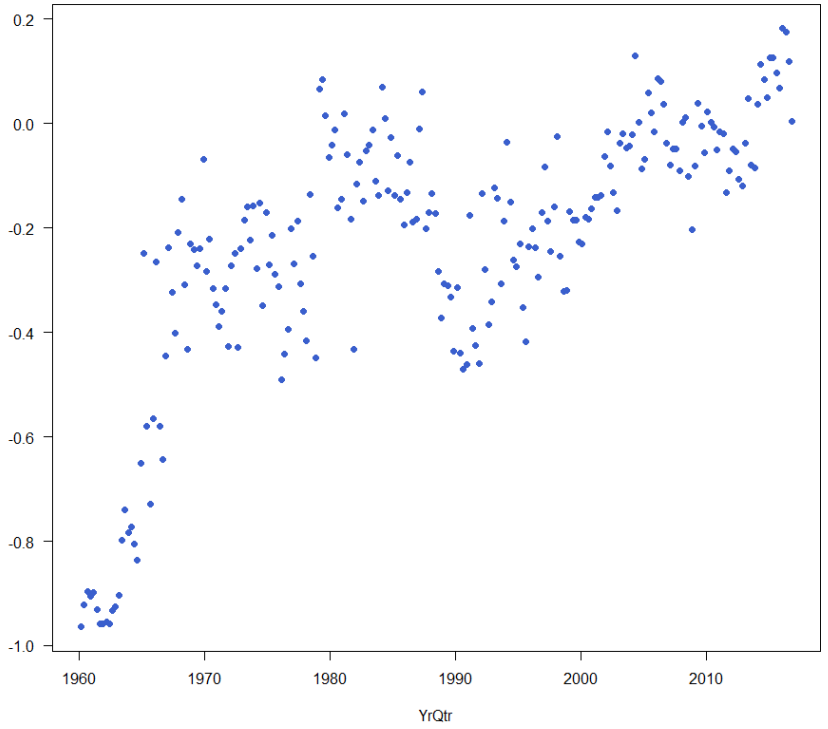


Issue: ’Missing’ vessel introduces overall bias in stock-wide CPUE

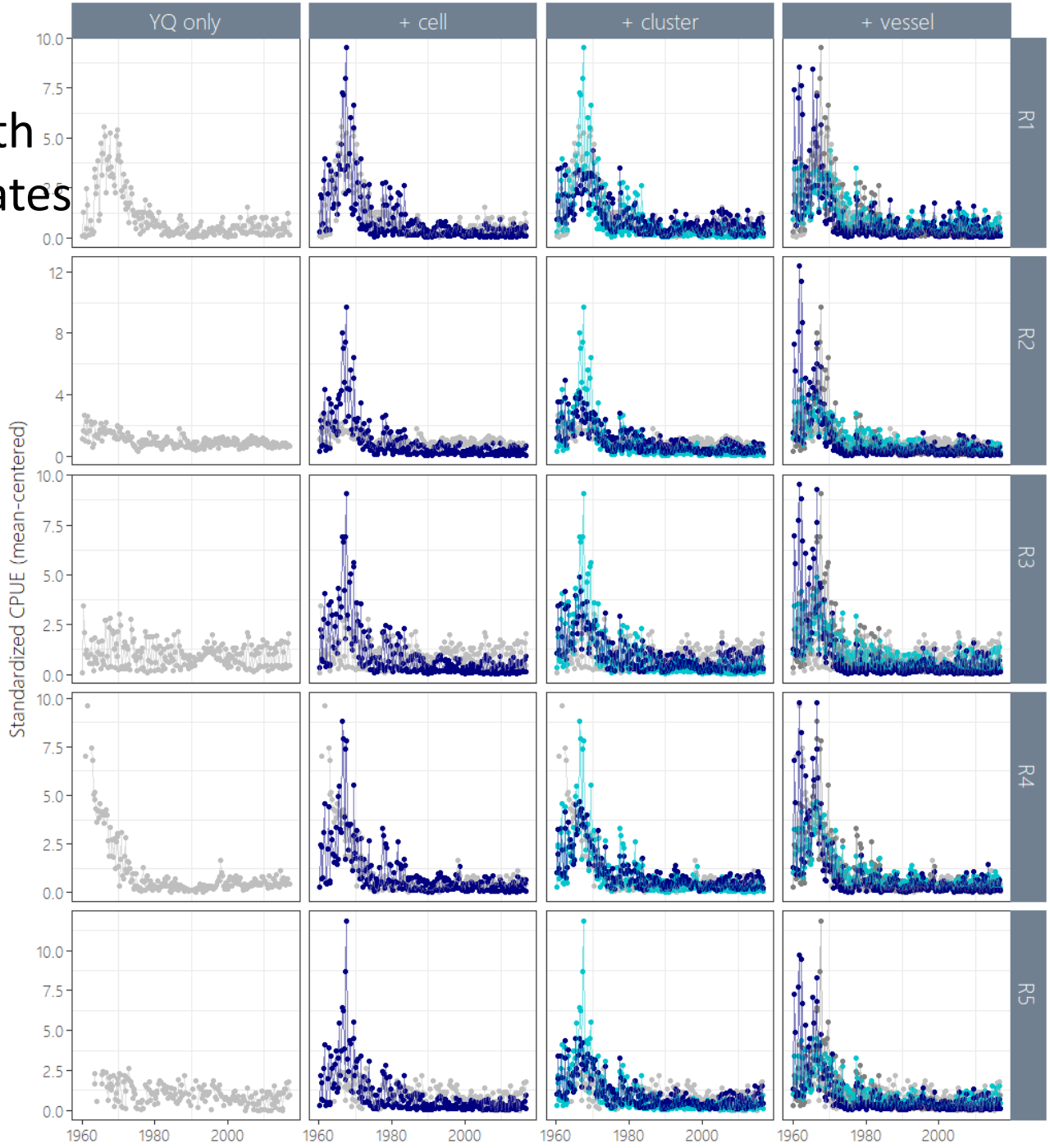
Distribution of missing vessel ID over time



Average vessel effect over time



Stepwise changes in standardized index with the addition of covariates

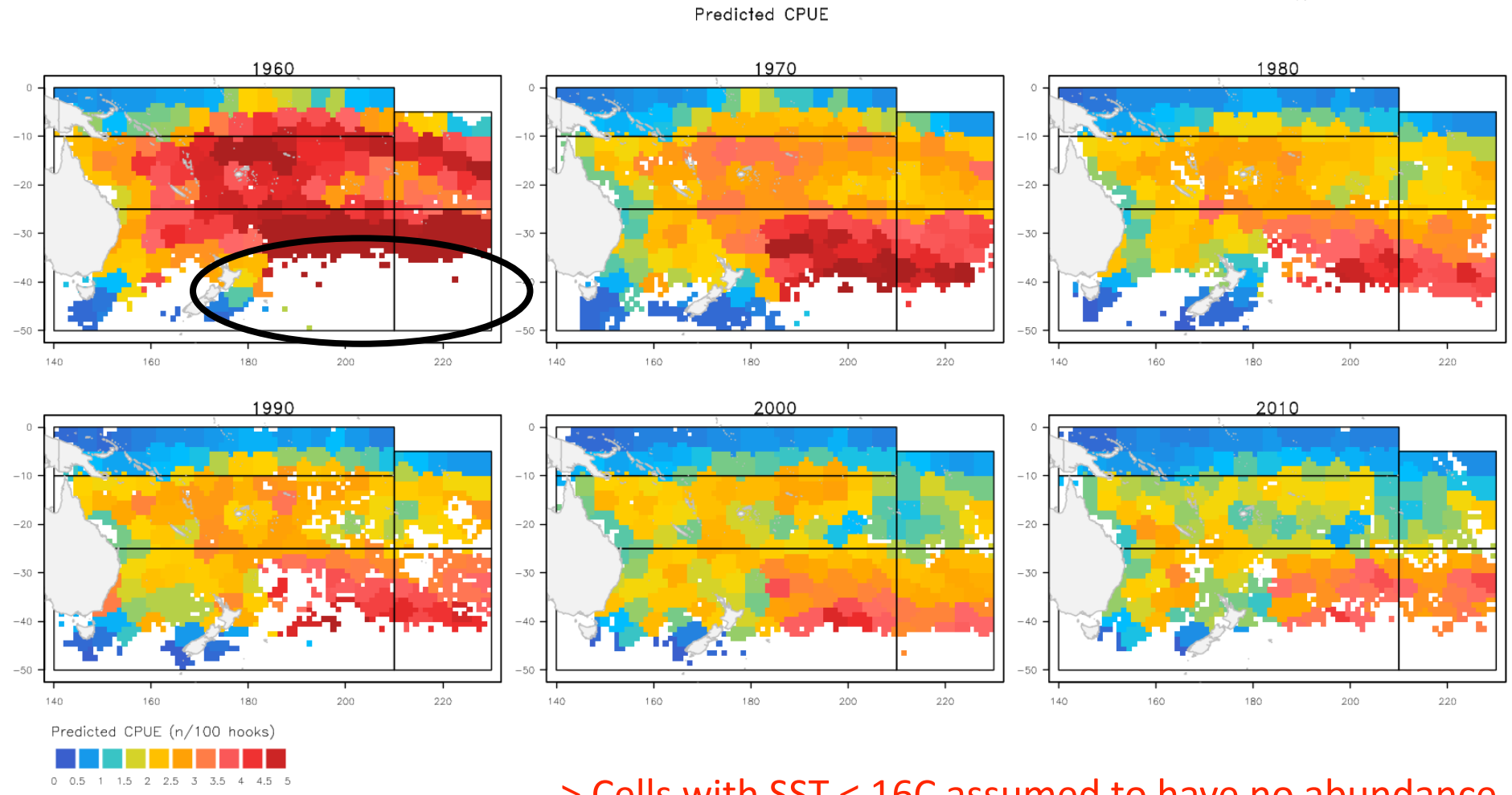


Predicted CPUE by knot for South Pacific albacore

Issue: Partial coverage for southern assessment regions

Region index at time *t*

$$I_{t,R} = \beta_t + \sum_{k=1}^{N_R} \frac{A_k \times \epsilon_{k,t}}{A_R}$$

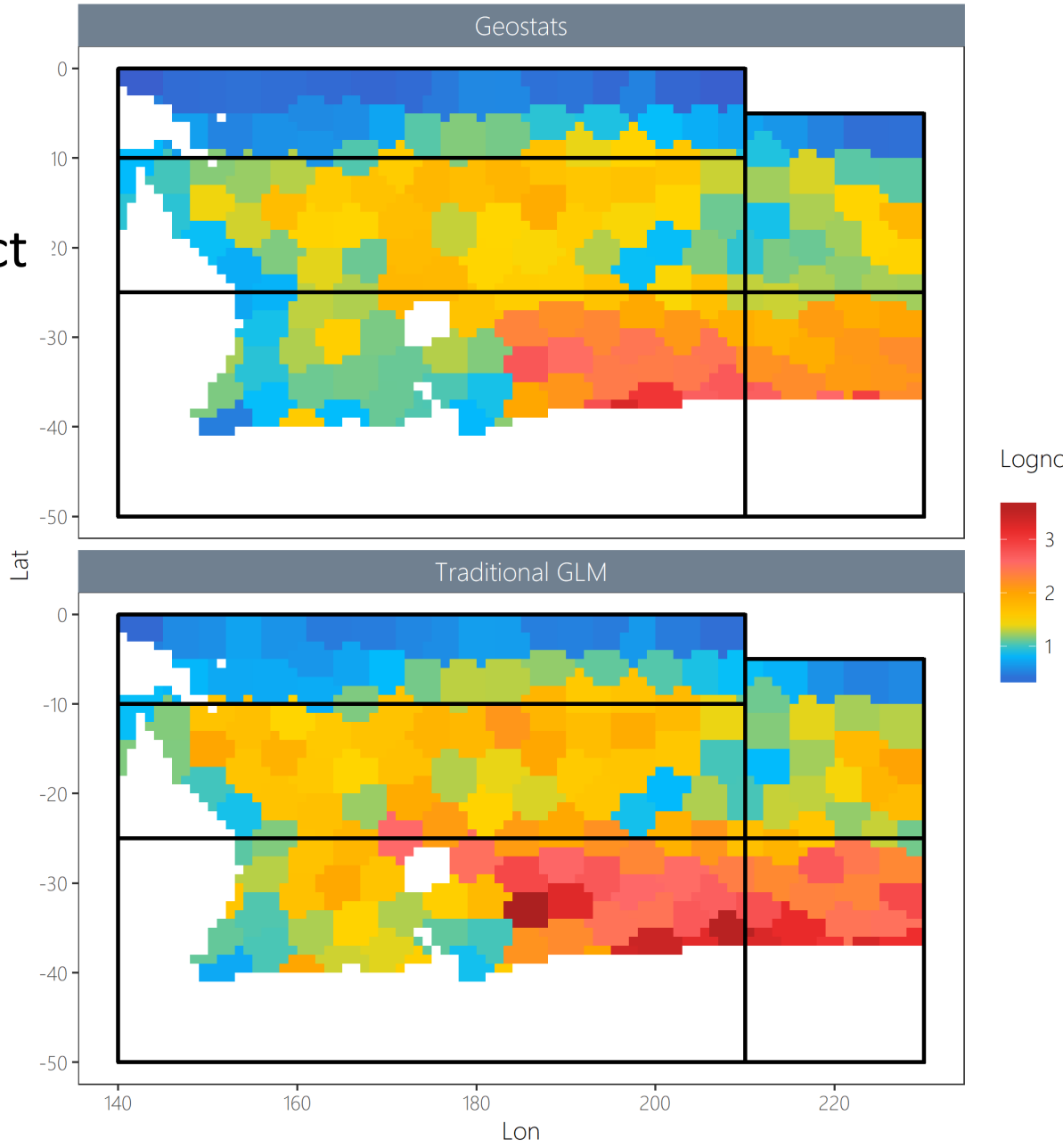


> Cells with SST < 16C assumed to have no abundance

Standardized index for South Pacific albacore by region

Geostatistical vs. Traditional

Overall knot-effect fitted via geostatistical surface
or
GLM categorical cell effect



Key working papers for recent WCPCF CPUE standardizations

> Bigelow, K. and Hoyle, S. (2008). Standardized CPUE for distant-water fleets targeting south Pacific albacore. WCPFC-SC4-2008/ME-WP-03.

> Hoyle S., Hiroshi S., Okamoto H., and Langley, A.D. (2010). Analyses of Japanese longline operational catch and effort for bigeye tuna in the WCPO. WCPFC-SC6-2010/SA-WP-02.

> Hoyle, S. D., Langley, A. D., and Campbell, R. A. (2014). Recommended approaches for standardizing CPUE data from pelagic fisheries. WCPFC-SC10-2014/SA-IP-10.

> McKechnie, S., Tremblay-Boyer, L., and Harley, S. J. (2015). Analysis of Pacific-wide operational longline CPUE data for bigeye tuna. WCPFC-SC11-2015/SA-WP-03.

> Tremblay-Boyer, L., McKechnie, S., and Harley, S. J. (2015). Standardized CPUE for south Pacific albacore tuna (Thunnus alalunga) from operational longline data. WCPFC-SC11-2015/SA-IP- 03.

> Oceanic Fisheries Programme. (2015). Continued use of longline operational-level data provided by fishing nations to support WCPFC stock assessments. WCPFC-SC11-2015/SA-WP- 07.

> McKechnie, S., Tremblay-Boyer, L., and Pilling, G. (2017). Background analyses for the 2017 stock assessments of bigeye and yellowfin tuna in the western and central Pacific Ocean. WCPFC- SC13-2017/SA-IP-06.

> Tremblay-Boyer, L., McKechnie, S., Pilling, G. M., and Hampton, J. (2017). Geostatistical analyses of operational longline CPUE data. WCPFC-SC13-2017/SA-WP-03.

> Tremblay-Boyer, L. and McKechnie, S. (2018). Background analyses for the 2018 stock assessment of South Pacific albacore tuna. WCPFC-SC14-2018/SA-IP-07.