Purse-seine index on dolphin sets for yellowfin tuna

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

Timeline indices of abundance for yellowfin tuna

Timeline

Until 2019:

- Main index used was the longline index
  - ✓ Japanese fleet
  - ✓ Delta-lognormal model, explanatory variables: yr.qr, lat.lon, gear characteristics (hooks between floats)
- Secondary indices were the purse-seine associated with dolphins (nominal, catch per days fished)
- The purse seine and the longline indices were not compatible
- Spatial structure maybe the reason

2019:

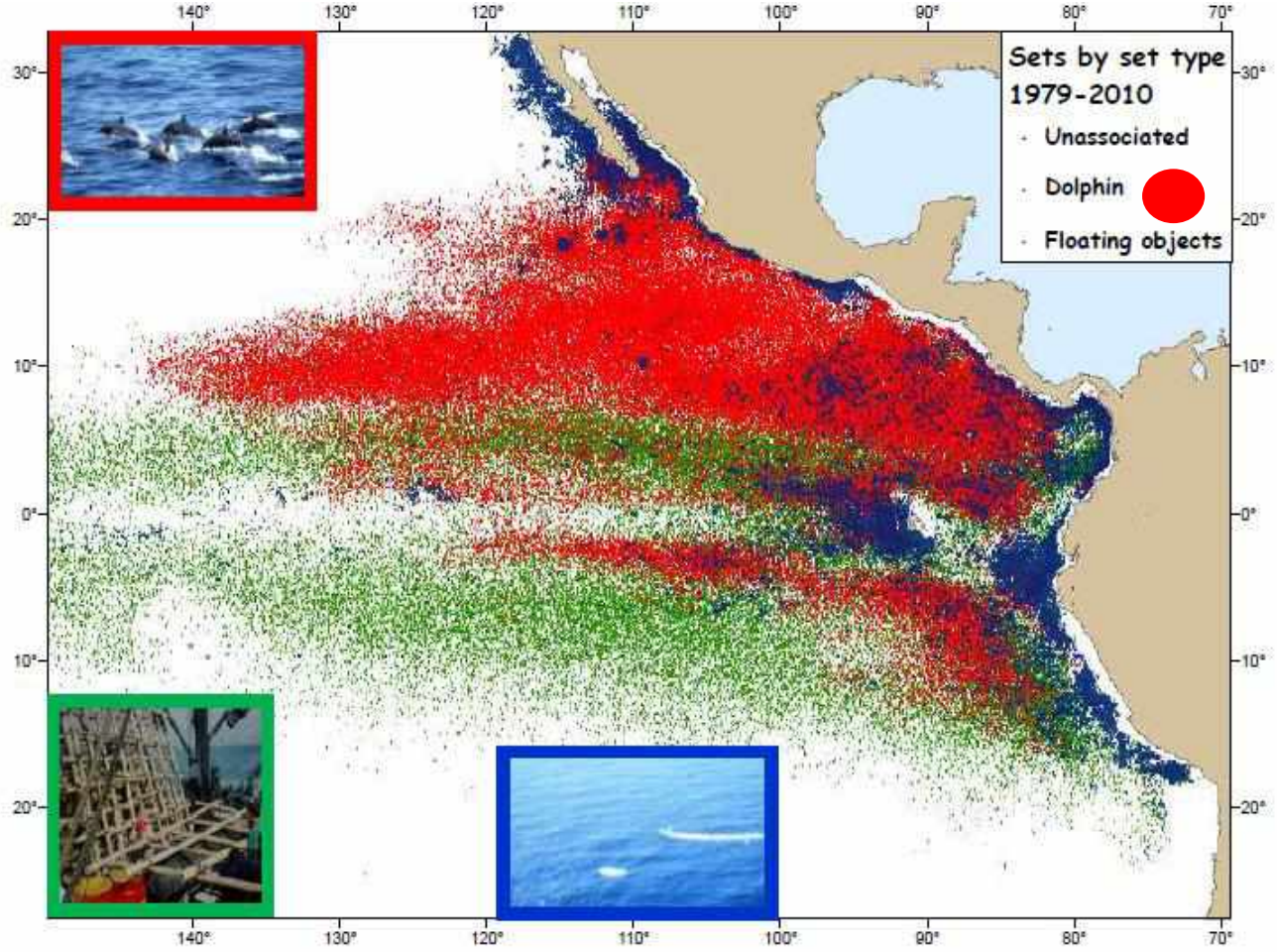
- Workshop to improve the longline indices of abundance of bigeye tuna and yellowfin tuna (OTM-30)
- Spatiotemporal models used to standardize both indices
- External review of the yellowfin tuna stock assessment (YFT-02)
- How to treat spatial structure remain the main issue, Japanese fleet continue to retract farther from the area with the core of the yellowfin catches

2020:

- Yellowfin tuna benchmark assessment
- High mixing hypothesis modelled
- But focus of the assessment in the was on the area with the core of the catches
- The purse-seine on dolphin index was deemed a better representation of the core of the catches
- Purse-seine index improved

Data

- Set by set data catch and effort data from the observer data base
- Effort as number of sets



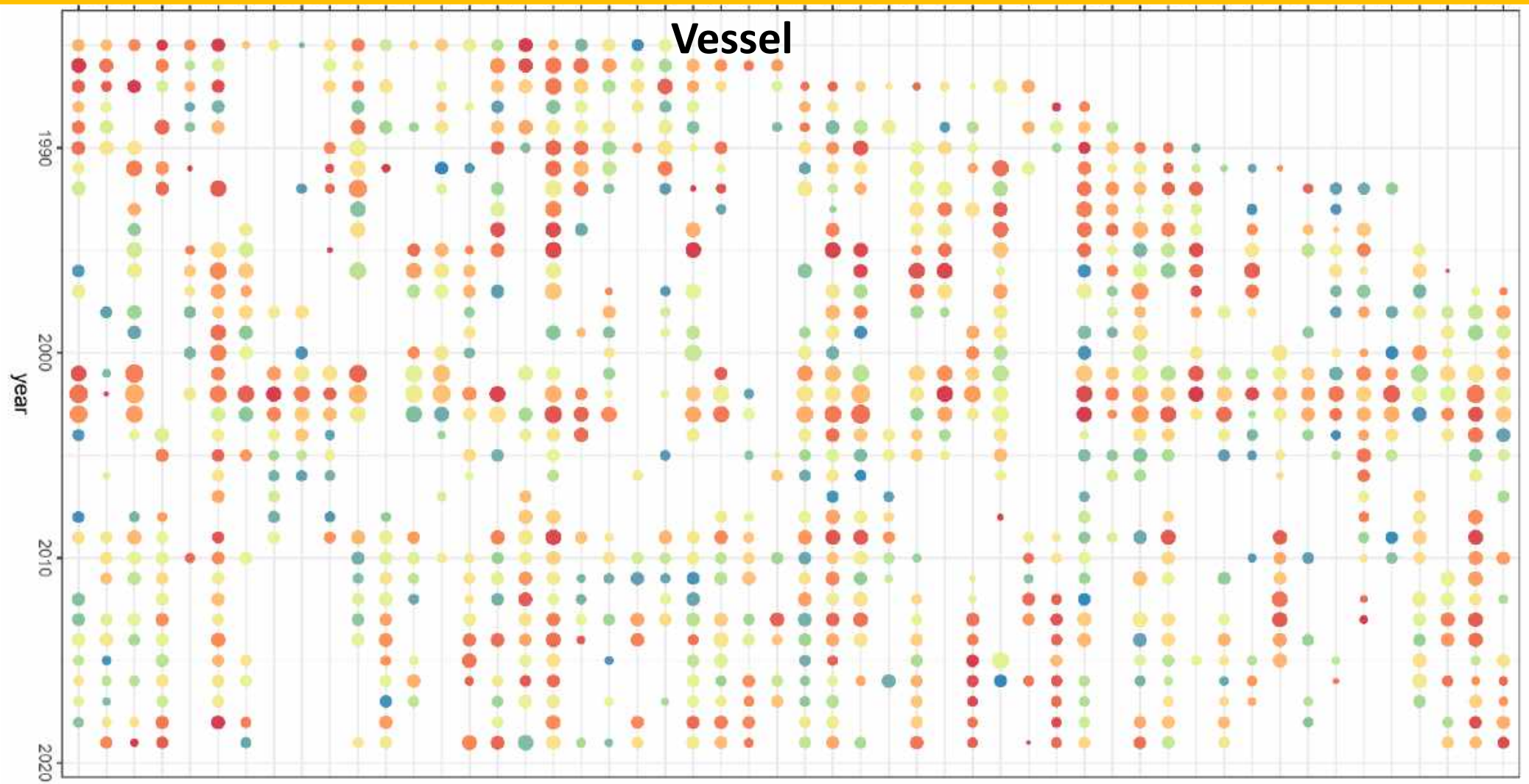
Data selection

Vessels:

- Vessels that at least 75% of the sets on dolphins on a year-quarter
- Among the vessels that meet the criterion above:
  - ✓those with at least 10 years of observation coverage and
  - ✓18 years of observation range (the difference between the first and last year of observation)

- Spatial domain:
  - ✓North of 5N
  - ✓1 by 1 cells with more than 30 years of data

Vessel selected



Proportion of sets on dolphins

Catch

Model configuration

- Spatiotemporal model that separately models encounter probability (logit link) and positive catch rate (log link)
- Implemented in the VAST R package (https://github.com/James-Thorson-NOAA/VAST)
- Spatial cells defined in a mesh
- For each spatial cell, estimation of random effects
- Random effects have correlation in space and time
- Spatial correlation may vary for different directions (anisotropy)
- Vessel effect are random

Fisheries Research 213 (2019) 121–131

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Spatiotemporal dynamics of the dolphin-associated purse-seine fishery for yellowfin tuna (*Thunnus albacares*) in the eastern Pacific Ocean

Haikun Xu*, Cleridy E. Lennert-Cody, Mark N. Maunder, Carolina V. Minte-Vera

Inter-American Tropical Tuna Commission, 8901 La Jolla Shores Drive, La Jolla, CA, 92037, USA

Model configuration

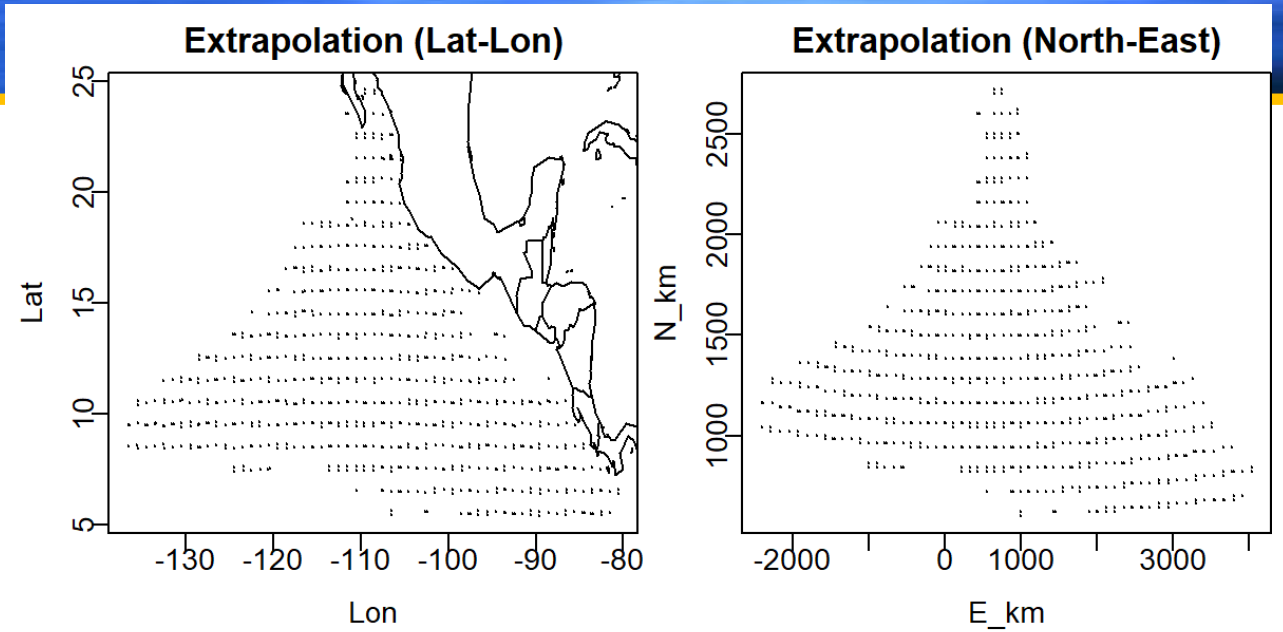
Encounter probability (p) and positive catch rate (λ) are modelled separatedly for each catch rate observation i:

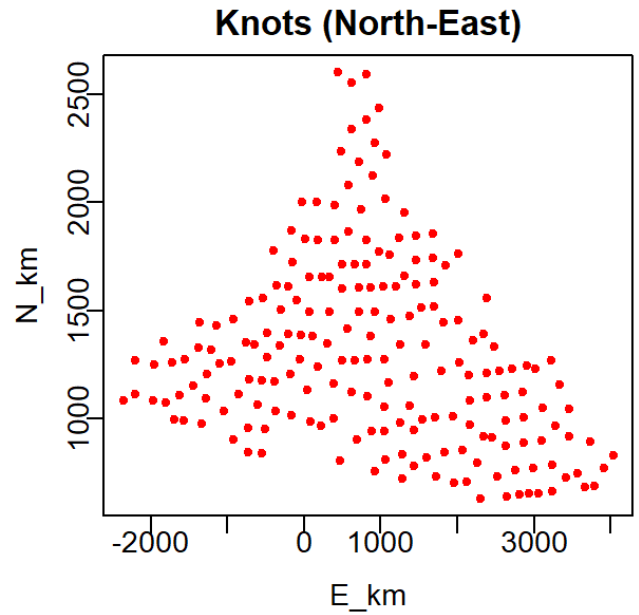
$$\text{logit}(p_i) = \boldsymbol{\beta_1(t_i)} + \boldsymbol{L_{\omega 1}\omega_1(s_i)} + \boldsymbol{L_{\varepsilon 1}\varepsilon_1(s_i, t_i)} + \boldsymbol{L_{\delta 1}\delta_1(v_i)} + \sum_{k=1}^{n_k} \lambda_1(k)Q(i,k) + \sum_{p=1}^{n_p} \gamma_1(p)X(s_i, t_i, p)$$

$$\log(\lambda_i) = \boldsymbol{\beta_2(t_i)} + \boldsymbol{L_{\omega 2}\omega_2(s_i)} + \boldsymbol{L_{\varepsilon 2}\varepsilon_2(s_i, t_i)} + \boldsymbol{L_{\delta 2}\delta_2(v_i)} + \sum_{k=1}^{n_k} \lambda_2(k)Q(i,k) + \sum_{p=1}^{n_p} \gamma_2(p)X(s_i, t_i, p)$$

$\boldsymbol{\beta(t_i)}$: intercept in year $\boldsymbol{t_i}$
$\boldsymbol{\omega(s_i)}$: spatial variation at location $\boldsymbol{s_i}$; $\boldsymbol{L_\omega}$: scaling factor (sd)
$\boldsymbol{\varepsilon(s_i, t_i)}$: spatiotemporal variation at location $\boldsymbol{s_i}$ in year $\boldsymbol{t_i}$; $\boldsymbol{L_\varepsilon}$: scaling factor (sd)
$\boldsymbol{\delta(v_i)}$: vessel/targeting effects on catchability; $\boldsymbol{L_\delta}$: scaling factor (sd)
$Q(i,k)$: catchability covariate(s); $\lambda(k)$: associated catchability parameter(s)
$X(s_i, t_i, p)$: habitat covariate(s); $\gamma(p)$: associated habitat parameter(s)

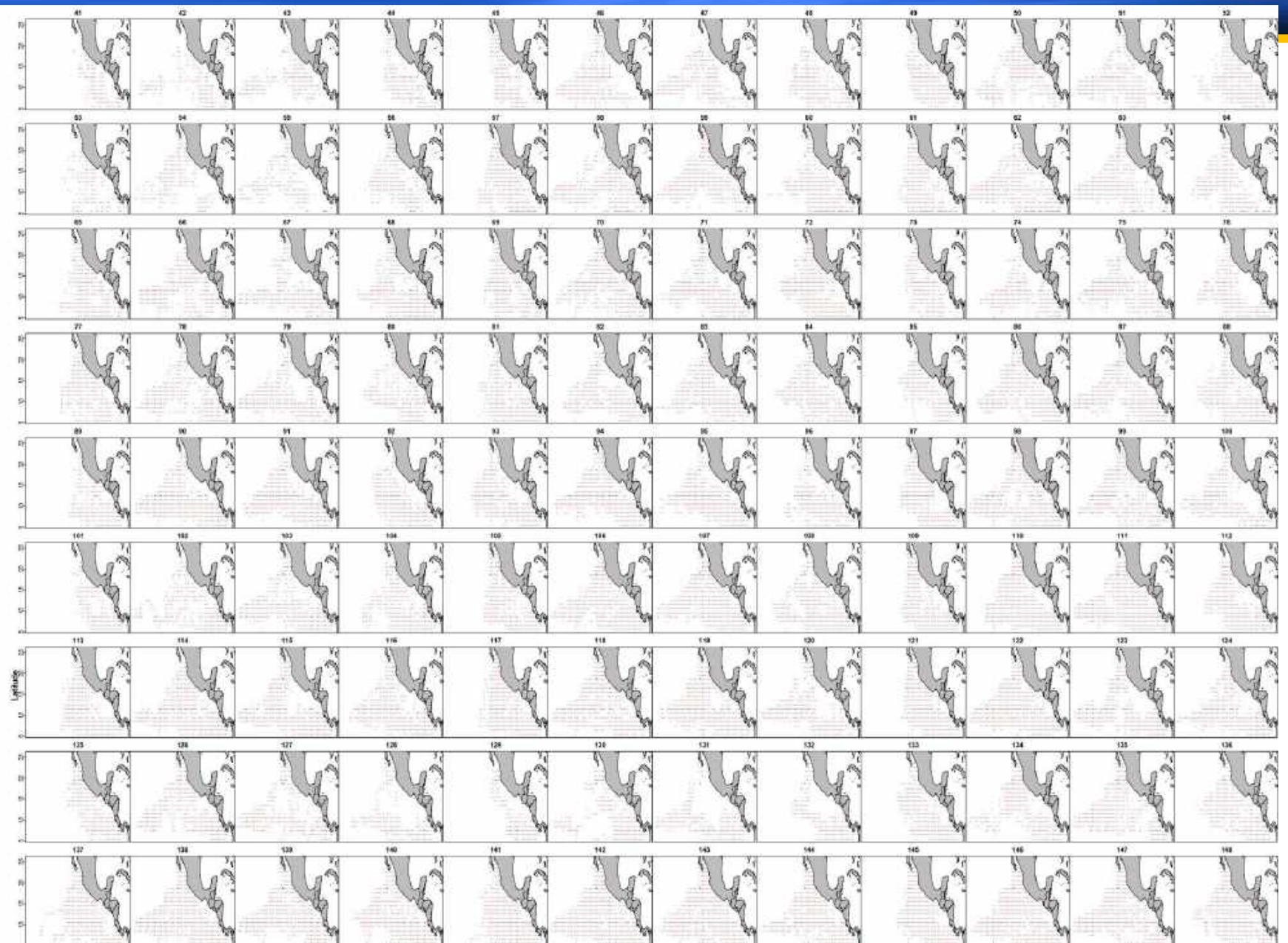
Model configuration





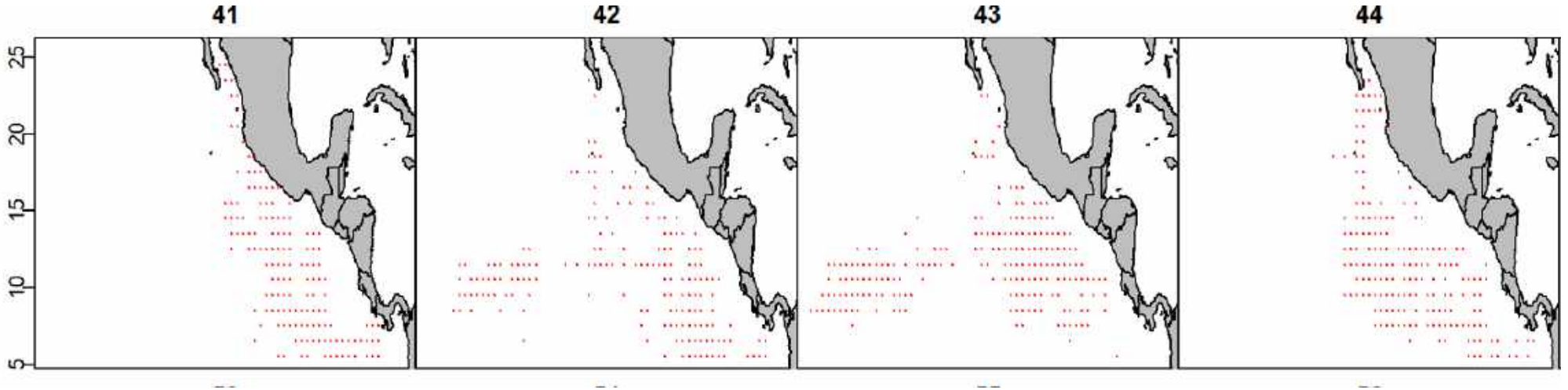
Data availability

1985 - 2022

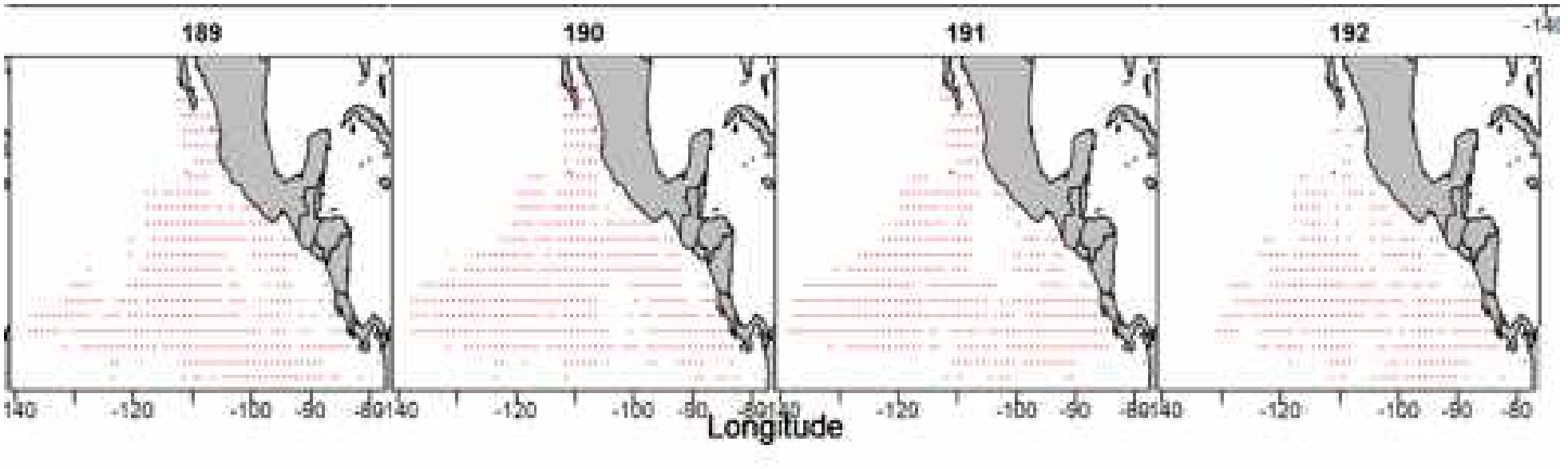


Data availability

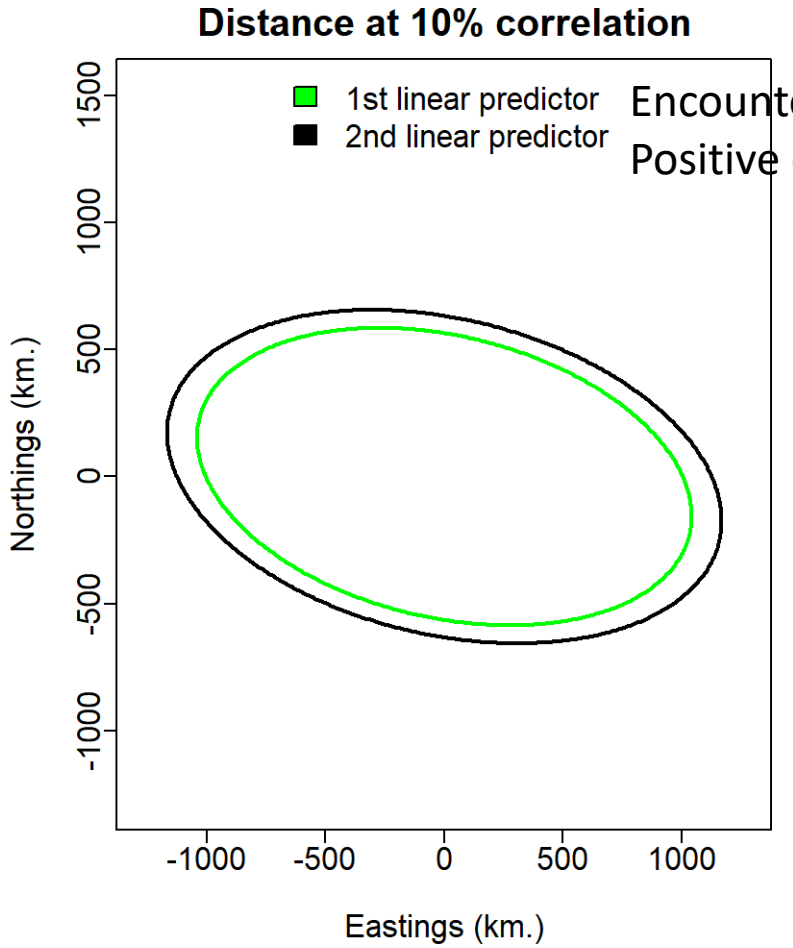
1985



2022



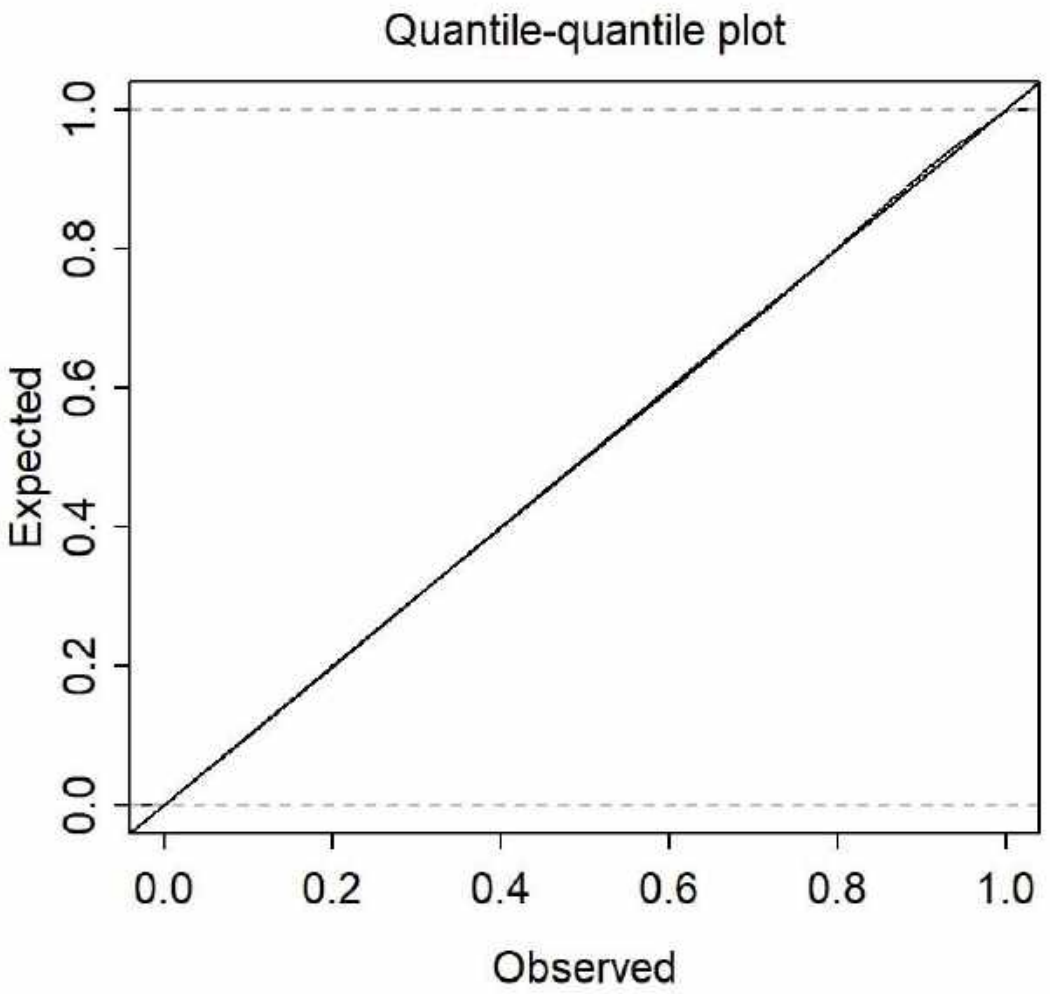
Spatial correlation

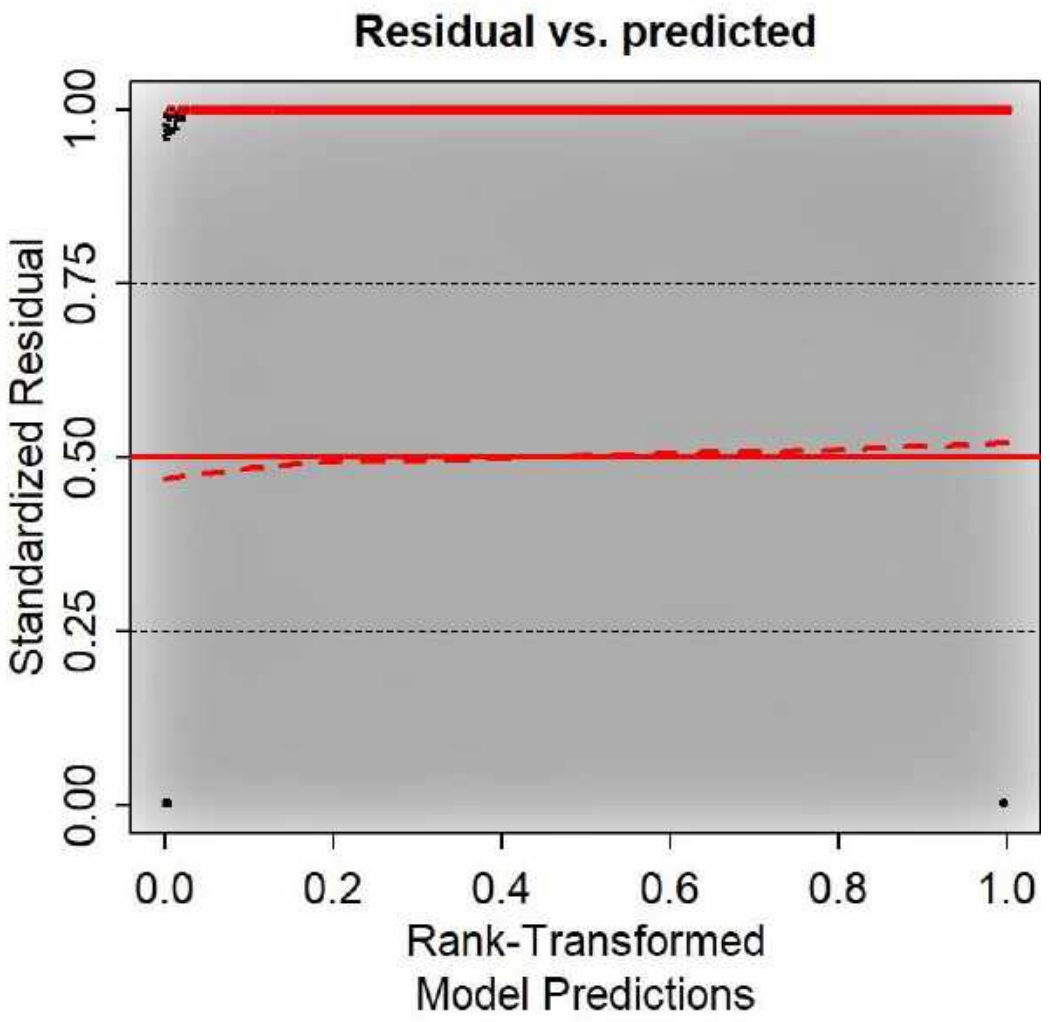


Encounter probability (p)

Positive catch rate (λ)

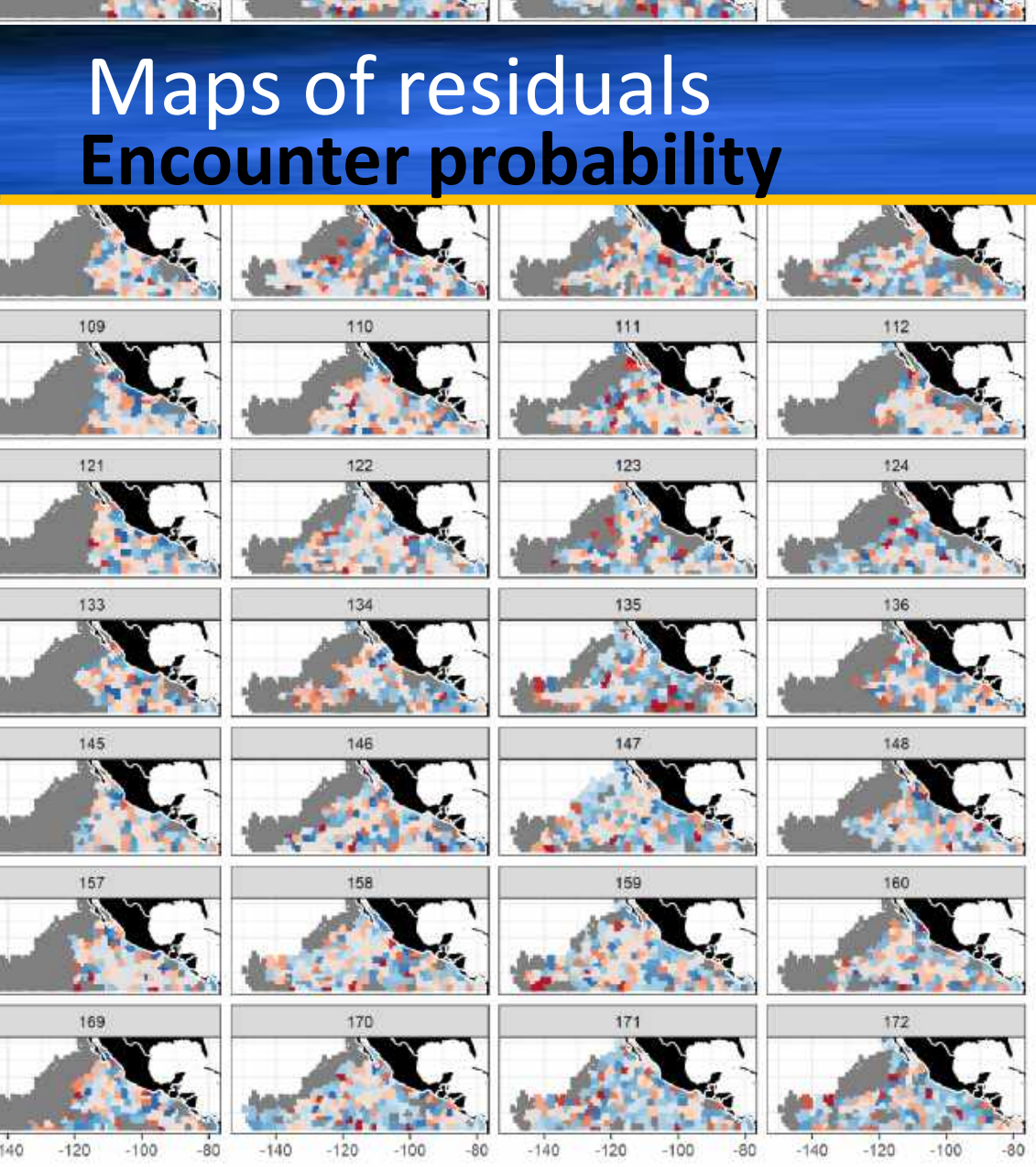
Quantile residuals



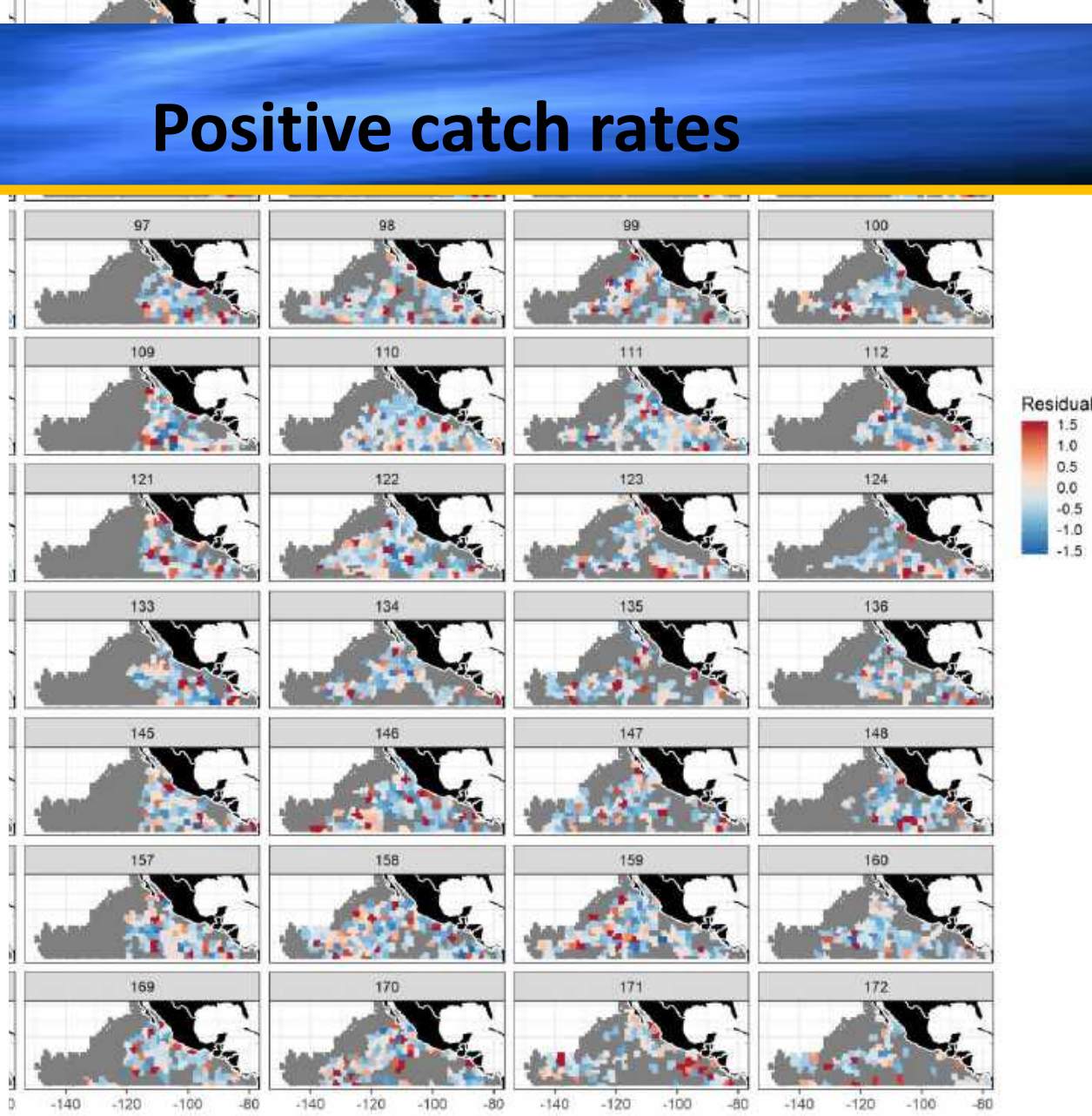


Maps of residuals

Encounter probability

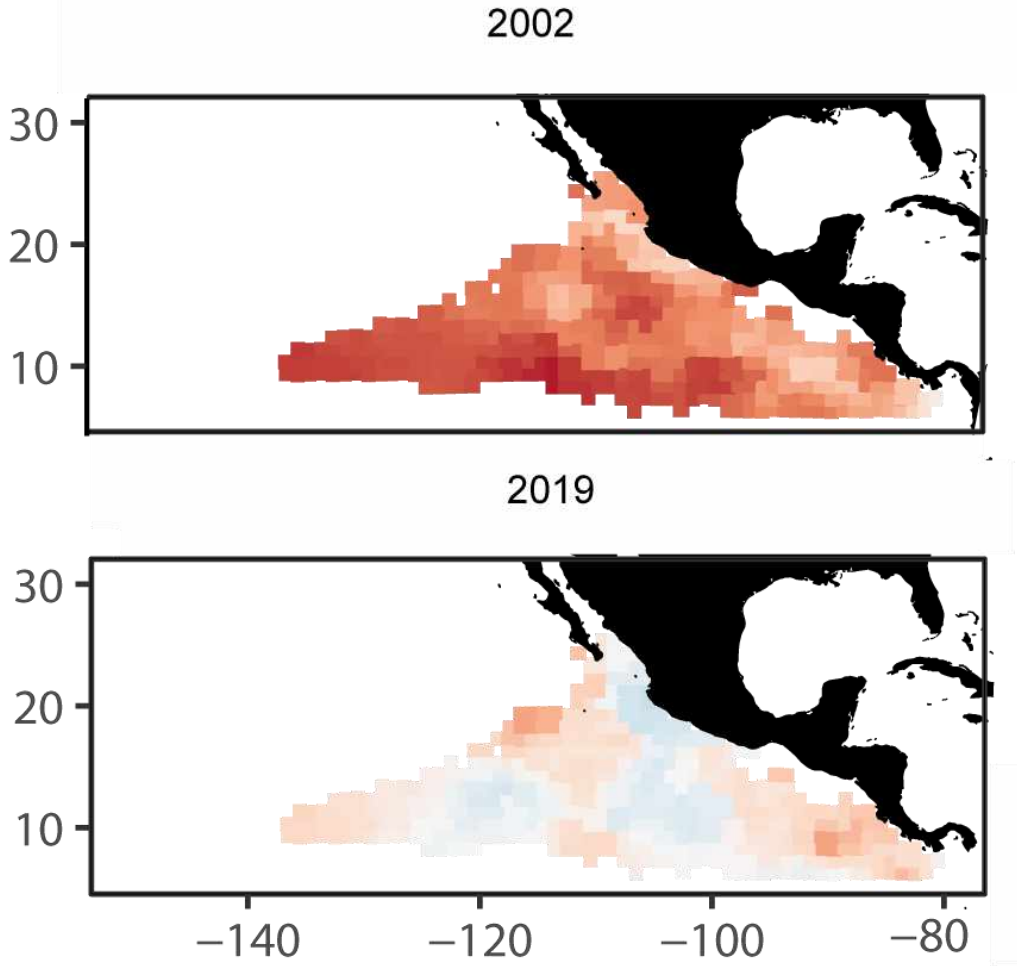


Positive catch rates

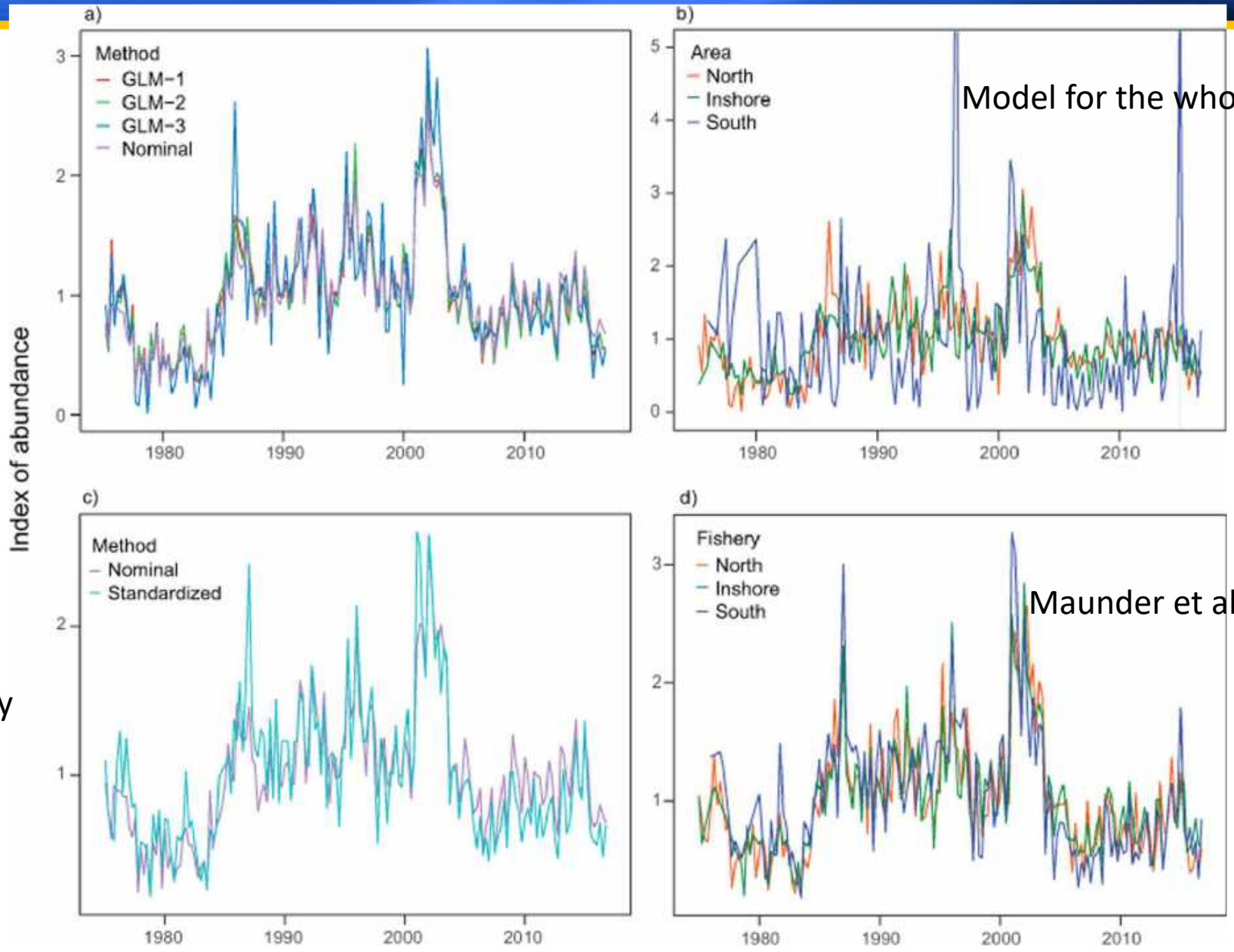


Predicted log(density)

Quarter 1



Comparisons with GLMs and nominal

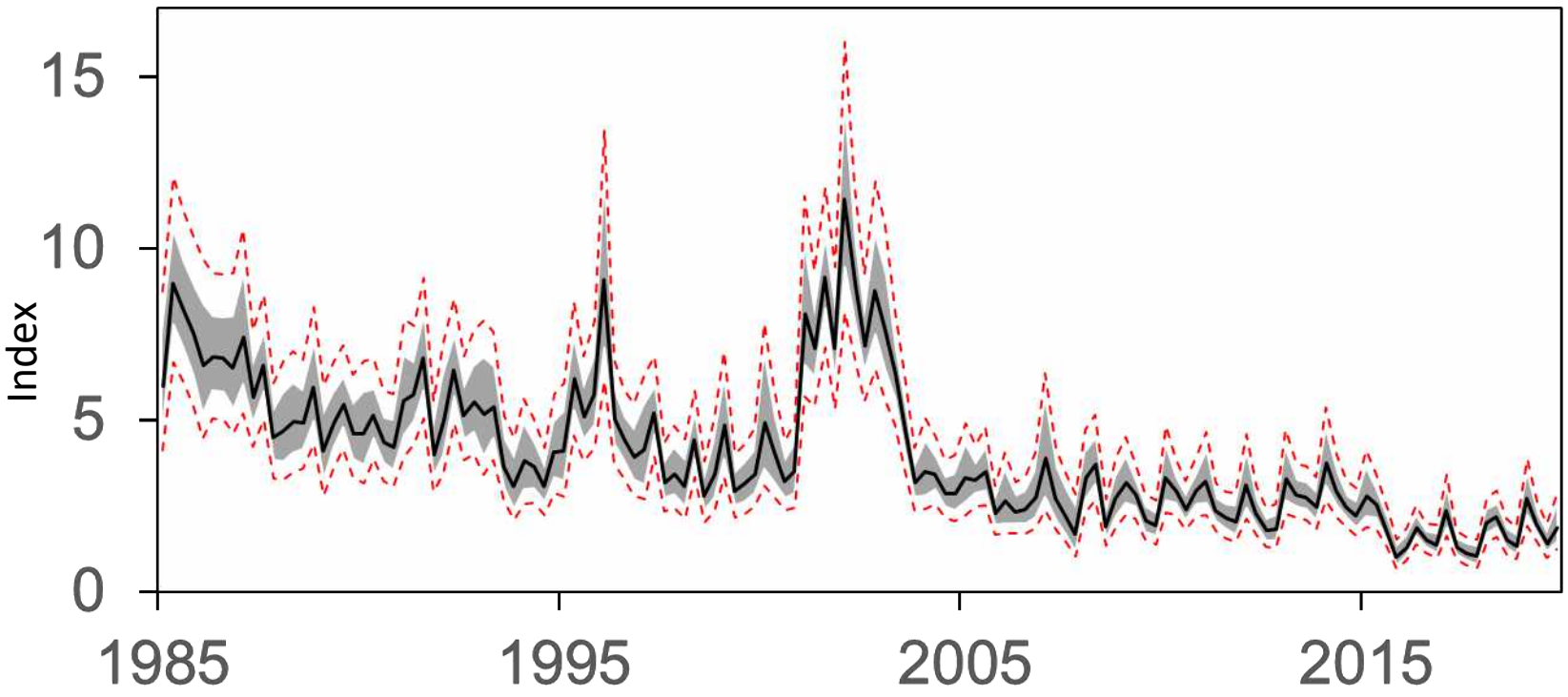


Model for the whole EPO

Spatiotemporal model:
better imputation (predictions for areas with lower sample sizes are less variable),
weights by the area, rather than by the sample size

Maunder et al (2020)

How it is treated in the assessment model



- In Stock Synthesis the abundance index is entered in the model as a “survey”, a fishery without catches but with associated size compositions

  - Several hypotheses (Level 2A) of relationship between index and abundance

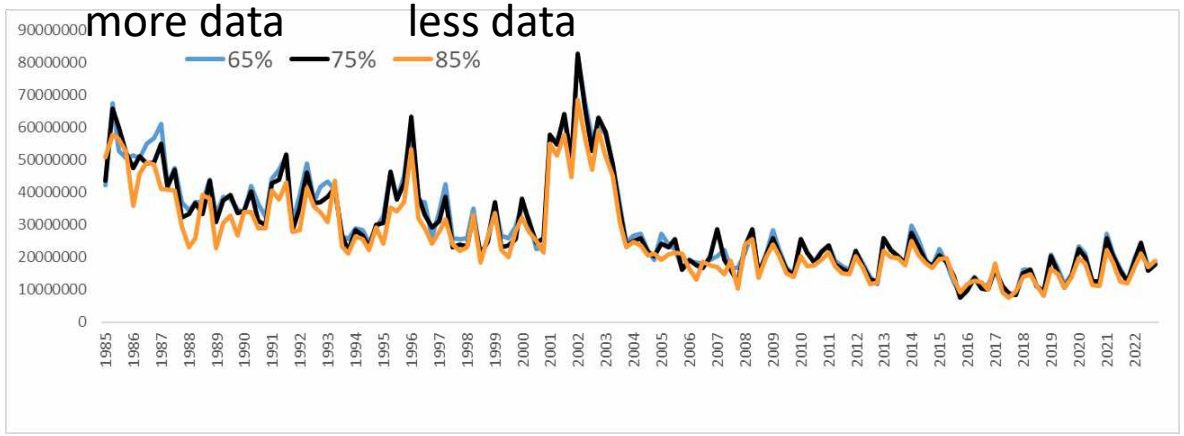
Variability:

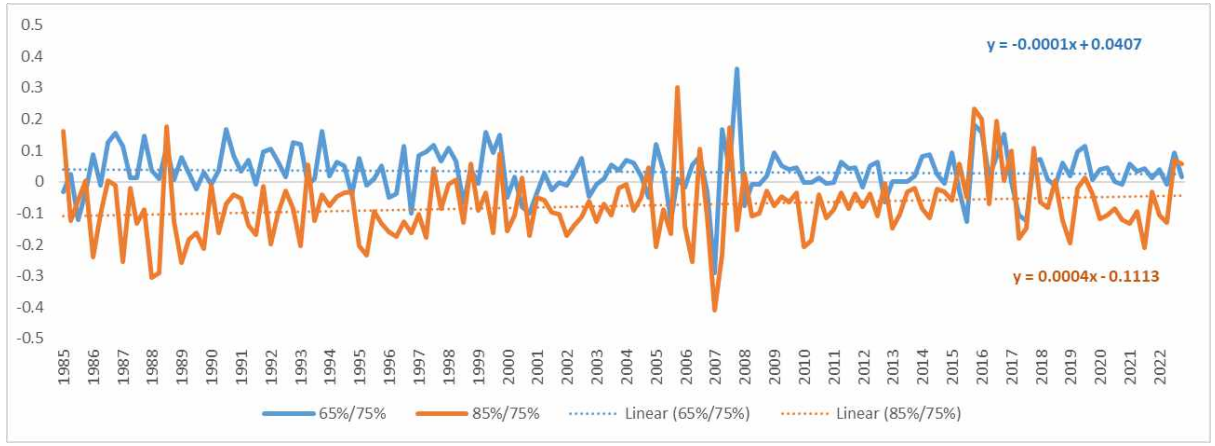
- Coefficient of variation (CV) from VAST model
- **Extra CV** added to average 0.15 over a range of years

Effect of the selection criteria: % of sets on dolphins

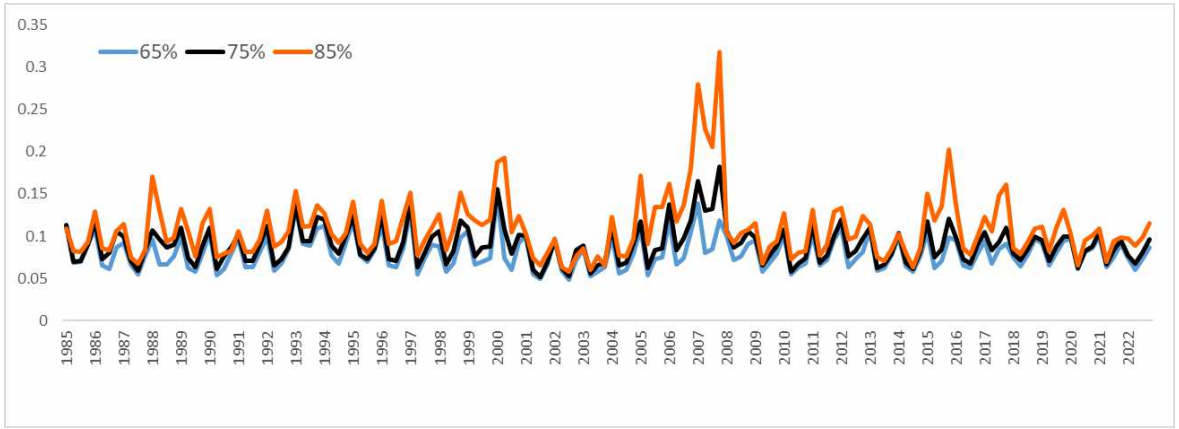
Point estimates

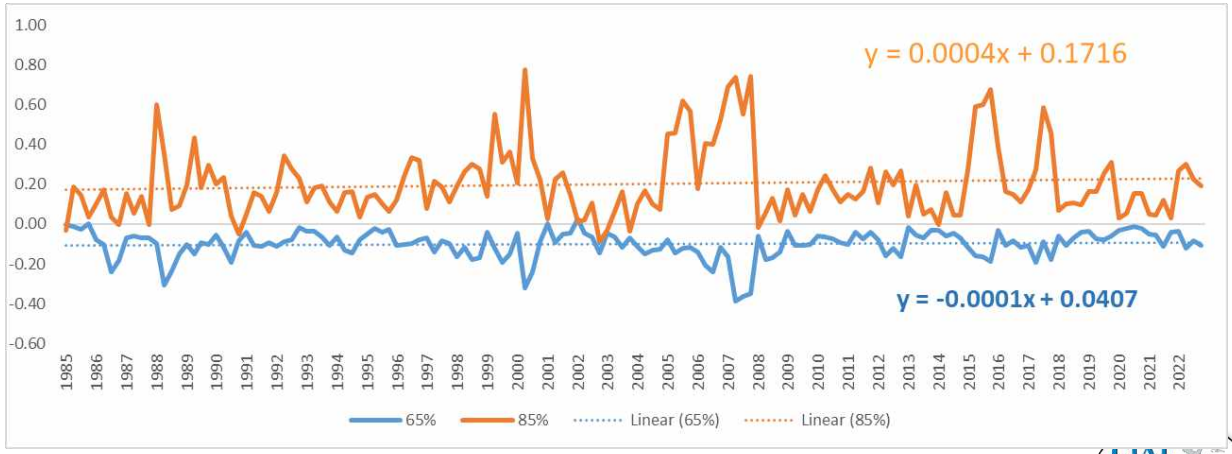
Bias X Precision tradeoff





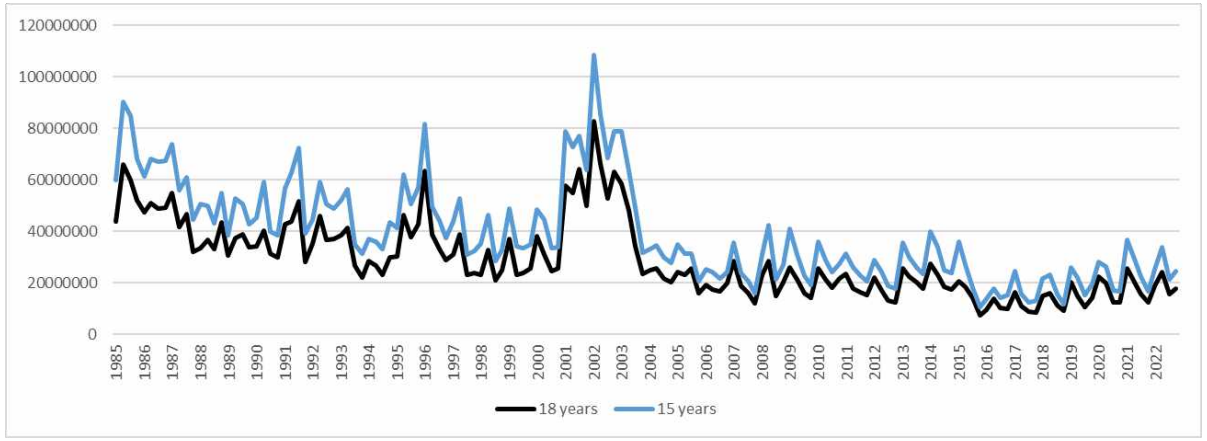
Variability (CV)

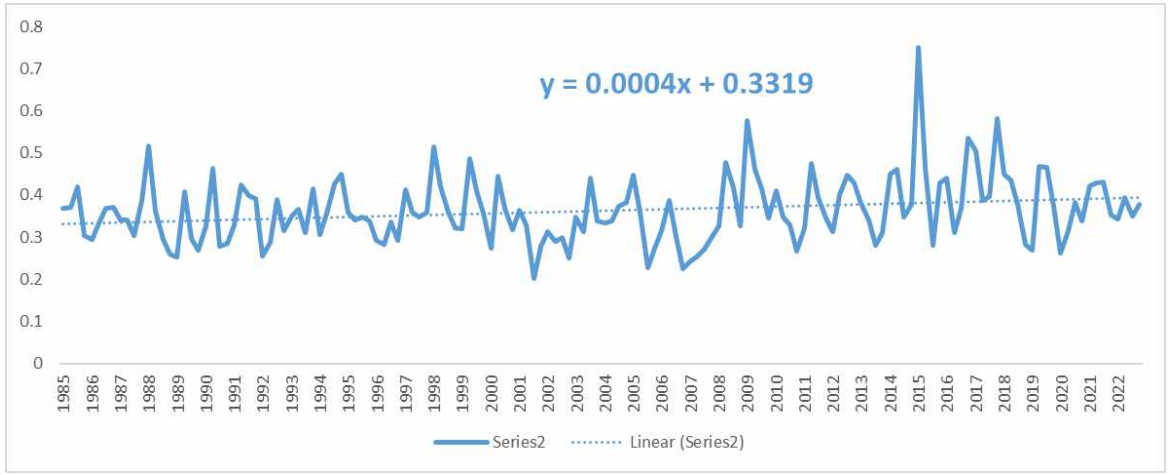




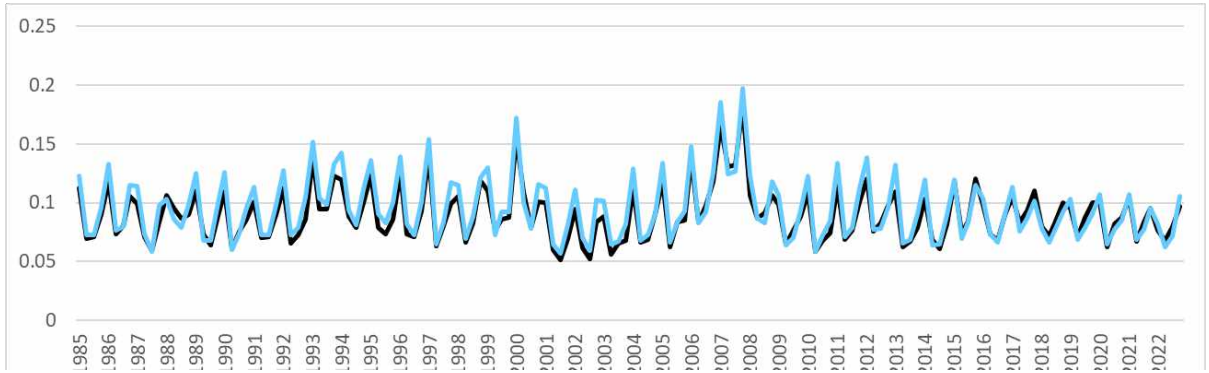
Effect of the selection criteria: cells with data

Point estimates

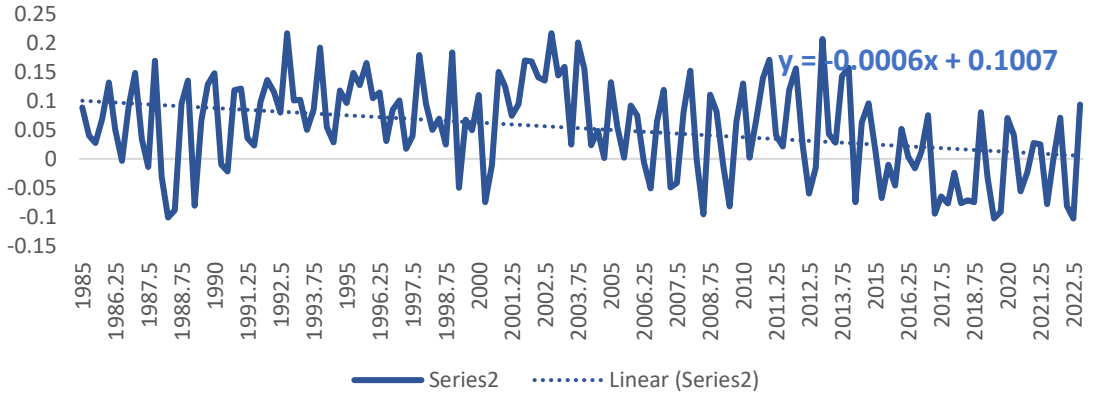




Variability



%difference



Current method: 30 years (less data)

Alternative: 15 years (more data)

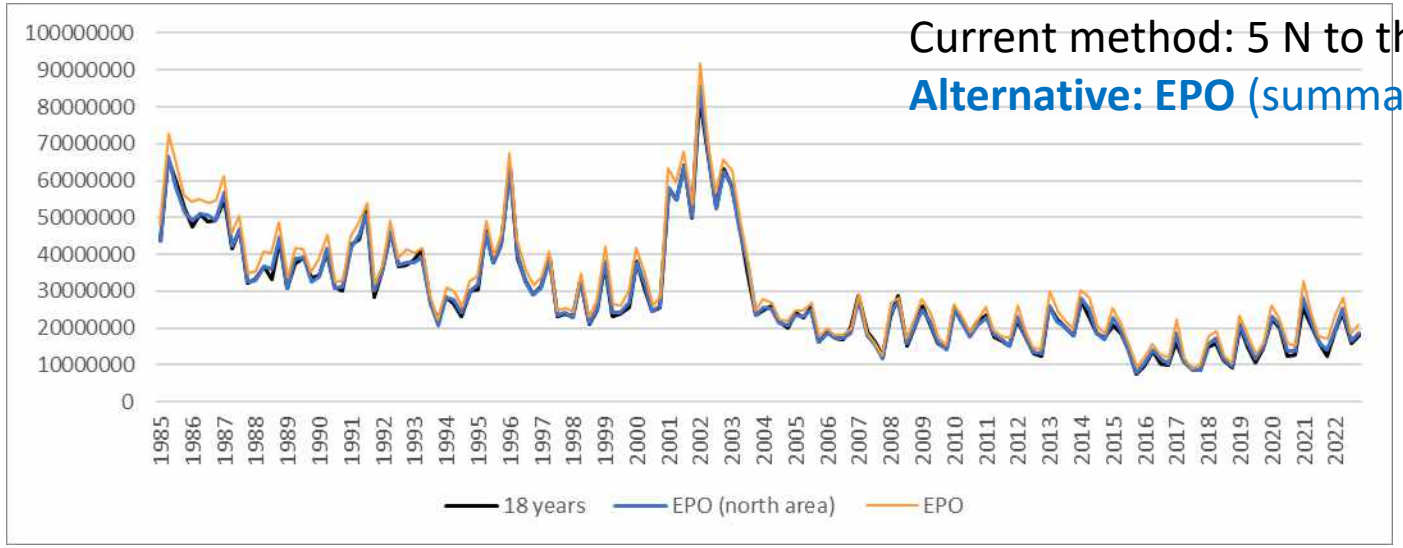
Bias X Precision tradeoff

Effect of the selection criteria: spatial domain

Point estimates

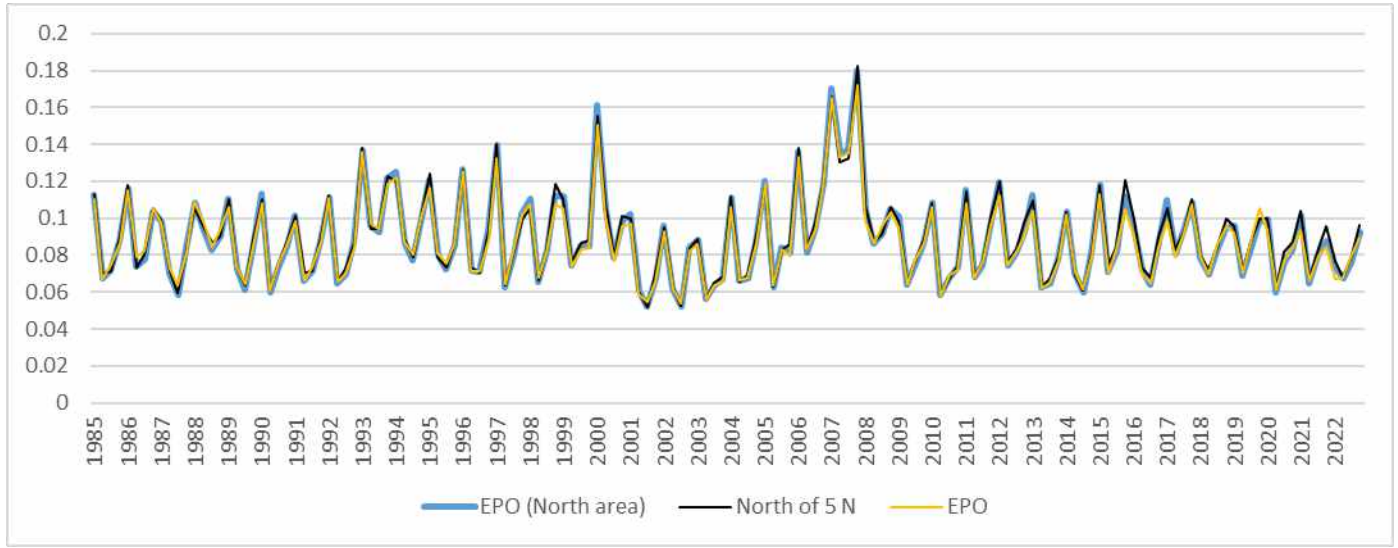
Current method: 5 N to the north

Alternative: EPO (summarize for the N)



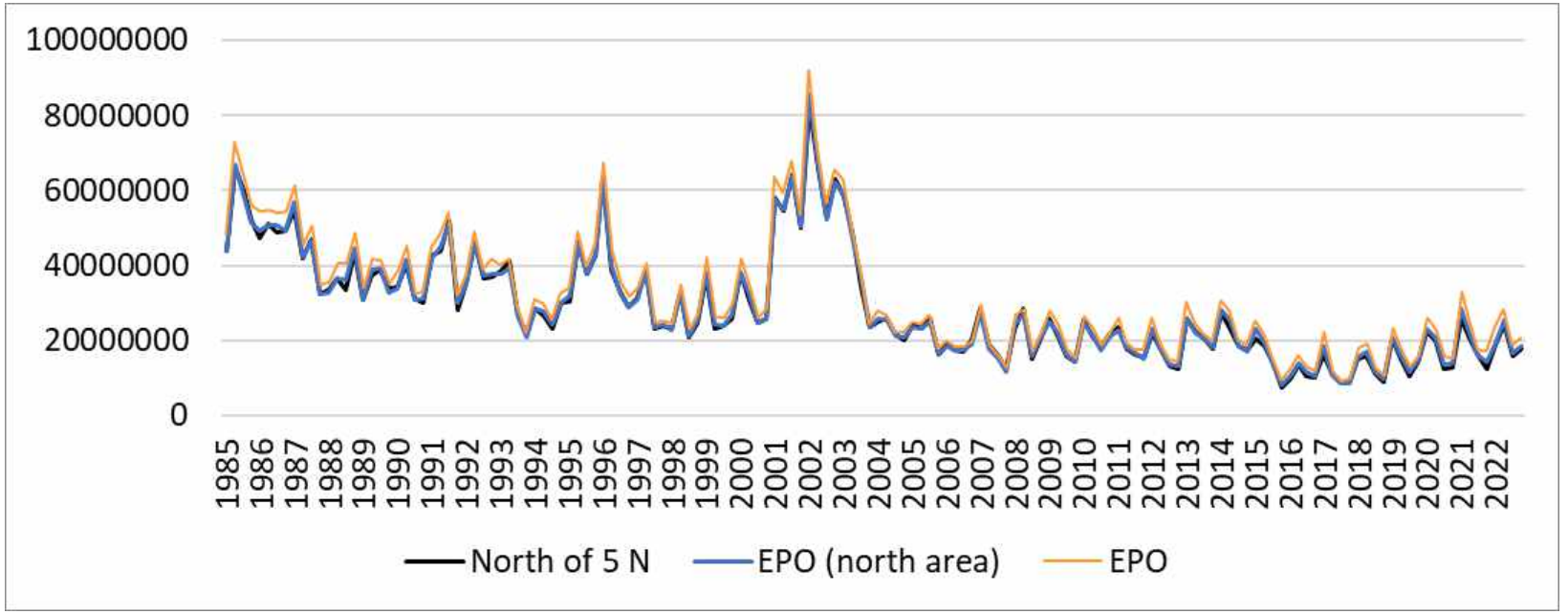
Variability

CV

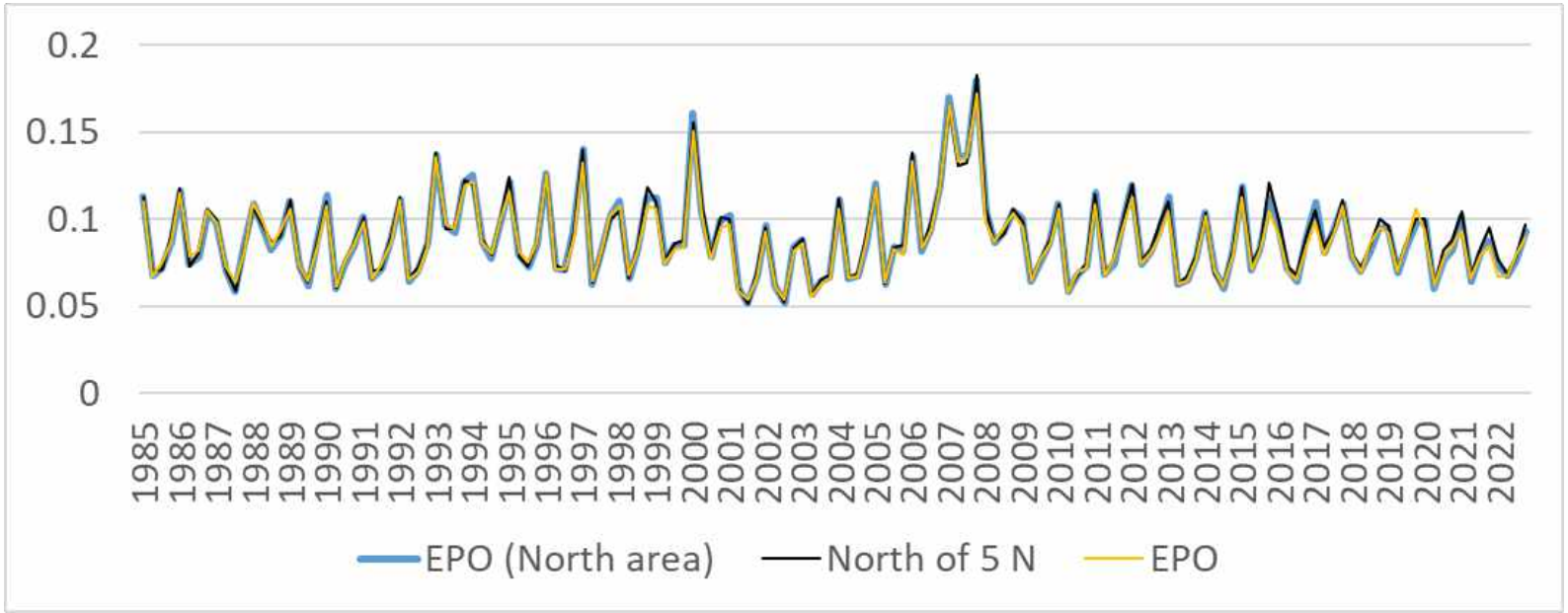


Effect of the selection criteria: spatial domain

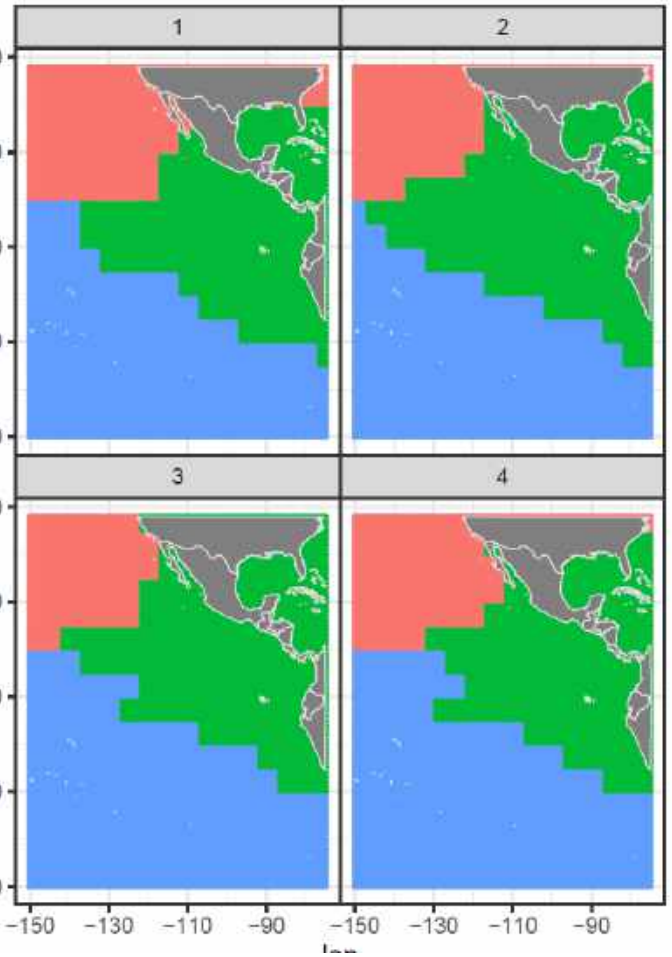
Point estimate

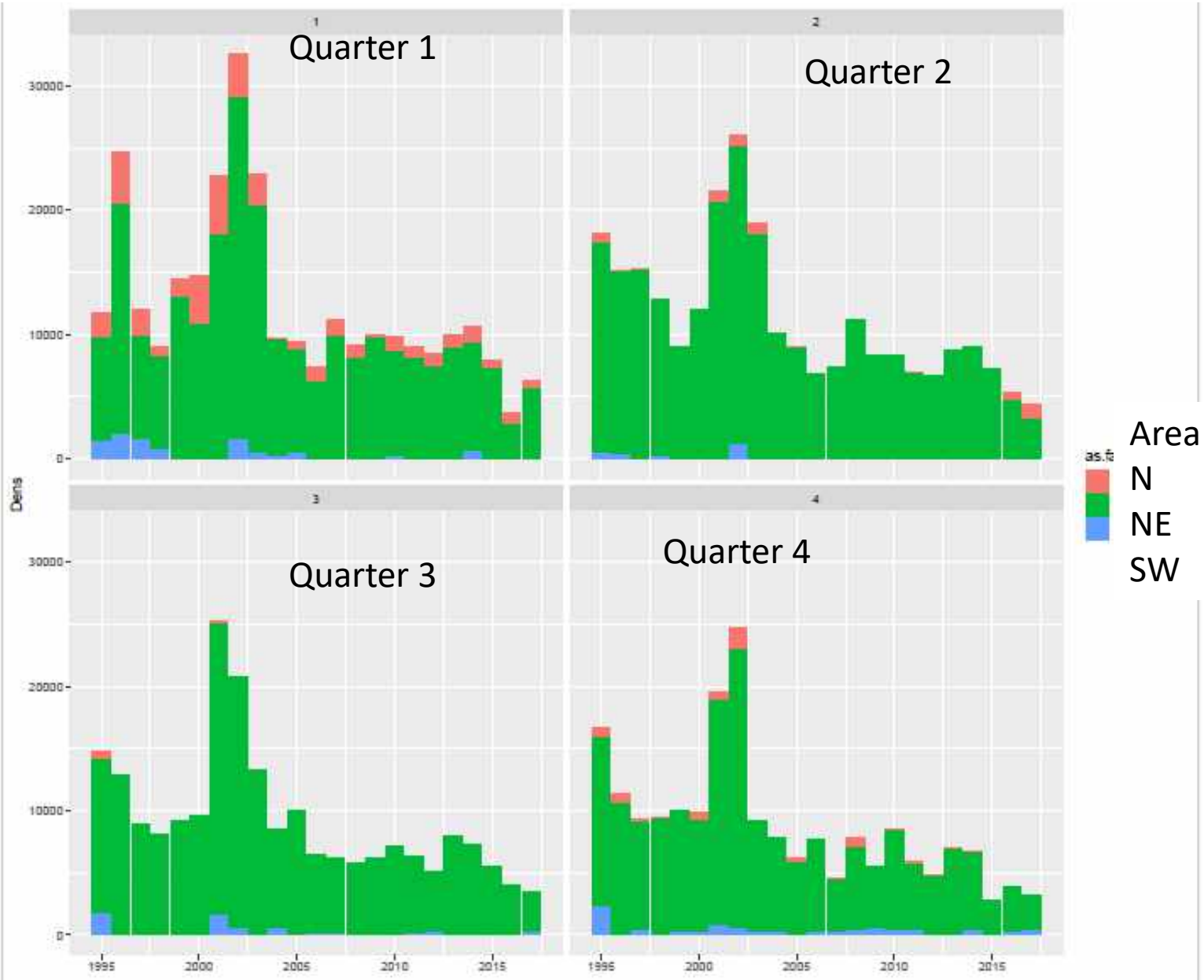


CV



Index and the new conceptual model





What are the sizes represented by the index? Standardized size compositions

The need for spatio-temporal modeling to determine catch-per-unit effort based indices of abundance and associated composition data for inclusion in stock assessment models

Mark N. Maunder[a,b,*], James T. Thorson[c], Haikun Xu[a], Ricardo Oliveros-Ramos[a], Simon D. Hoyle[d], Laura Tremblay-Boyer[e], Hui Hua Lee[f], Mikihiko Kai[g], Shui-Kai Chang[h], Toshihide Kitakado[i], Christoffer M. Albertsen[j], Carolina V. Minte-Vera[a], Cleridy E. Lennert-Cody[a], Alexandre M. Aires-da-Silva[a], Kevin R. Piner[f]

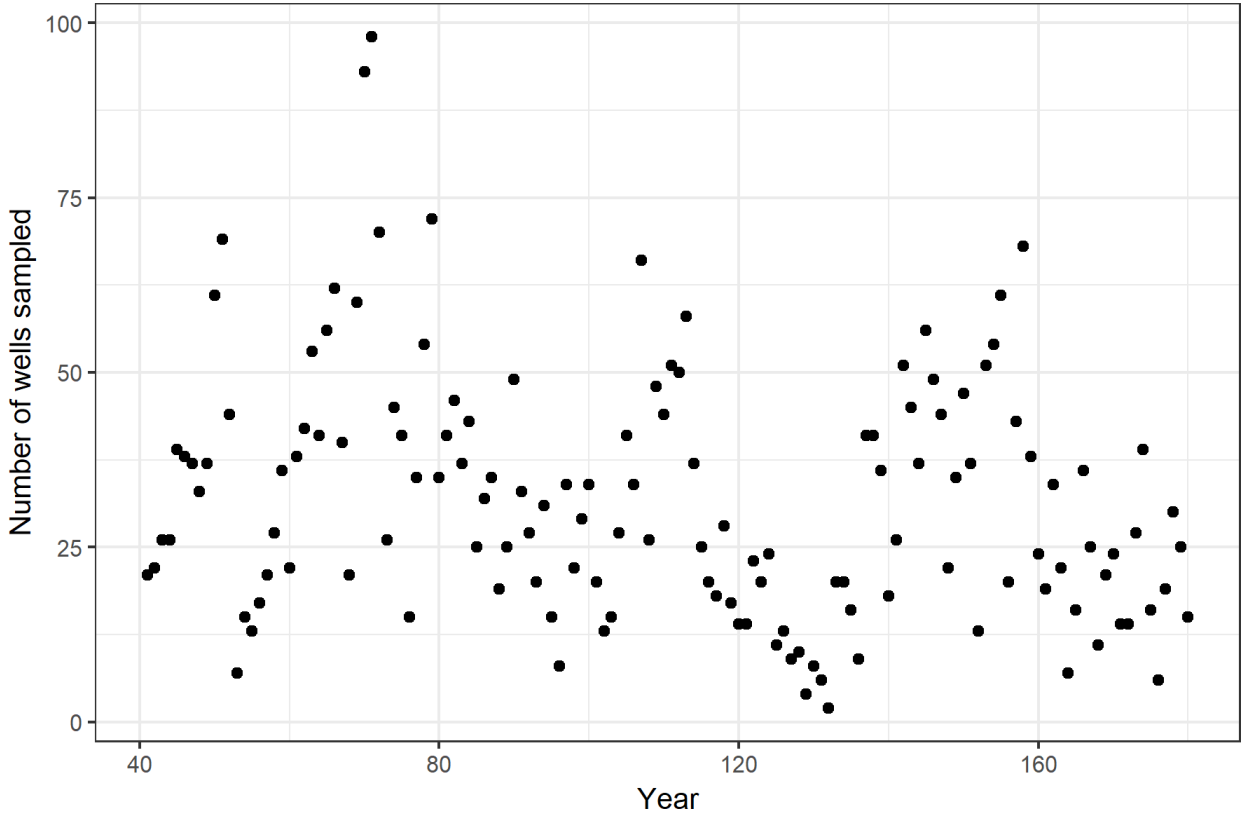
[a] Inter-American Tropical Tuna Commission, 8901 La Jolla Shores Dr., La Jolla, CA, 92037-1508, USA
[b] Center for the Advancement of Population Assessment Methodology, La Jolla, CA, USA
[c] Habitat and Ecological Processes Research program, Alaska Fisheries Science Center, NMFS, NOAA, Seattle, WA, USA
[d] National Institute of Water and Atmospheric Research Ltd (NIWA), 217 Akersten Street, Port Nelson, 7011, New Zealand
[e] Dragonfly Data Science, 158 Victoria St, Wellington, 6011, New Zealand
[f] Southwest Fisheries Science Center, National Marine Fisheries Service (NMFS), NOAA, La Jolla, CA, USA
[g] National Research Institute of Far Seas Fisheries (NRIFSF), Japan Fisheries Research and Education Agency, 5-7-1 Orido, Shimizu-ku, Shizuoka-shi, 424-8633, Japan
[h] Institute of Marine Affairs, National Sun Yat-sen University, Kaohsiung, Taiwan
[i] Tokyo University of Marine Science and Technology, 5-7, Konan 4, Minato-ku, Tokyo, 108-8477 Japan
[j] National Institute of Aquatic Resources, Technical University of Denmark, Kemitorvet 201, DK-2800, Kgs. Lyngby, Denmark

- Length frequencies associated with the index of abundance
- From port-sampling data
- Catch per day for DEL vessels
- Same selection criteria
- as for index, standardized using a **spatiotemporal model**

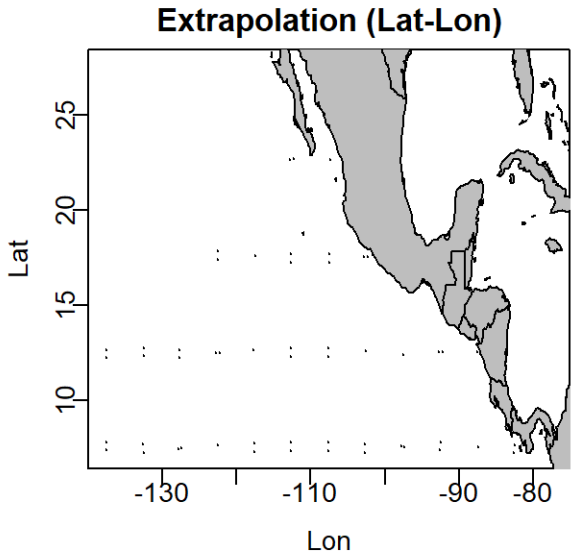
Port sampling data in number

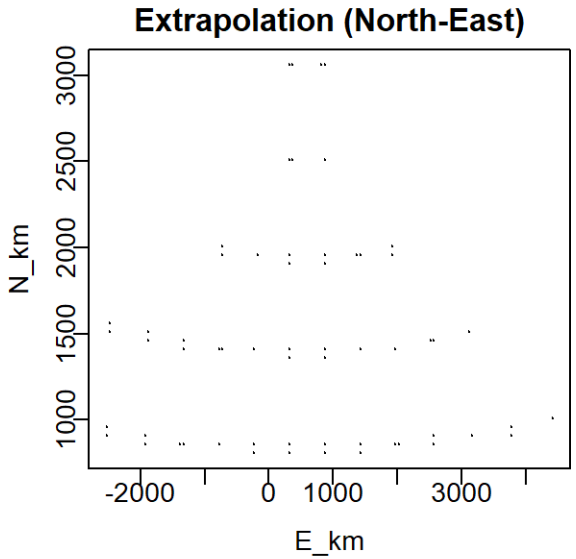
CPUE in weight

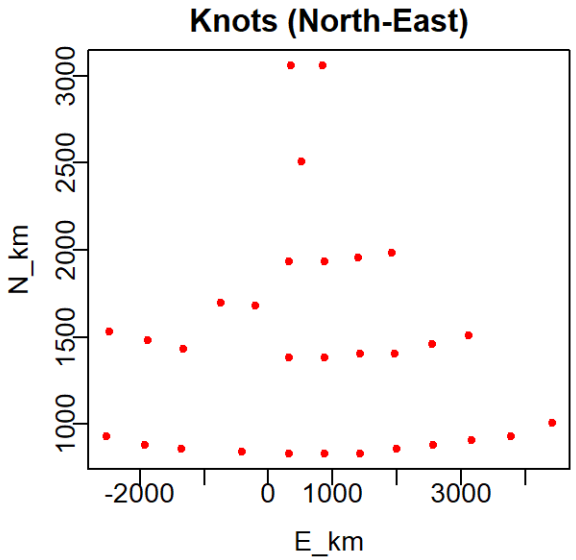
Need average weight



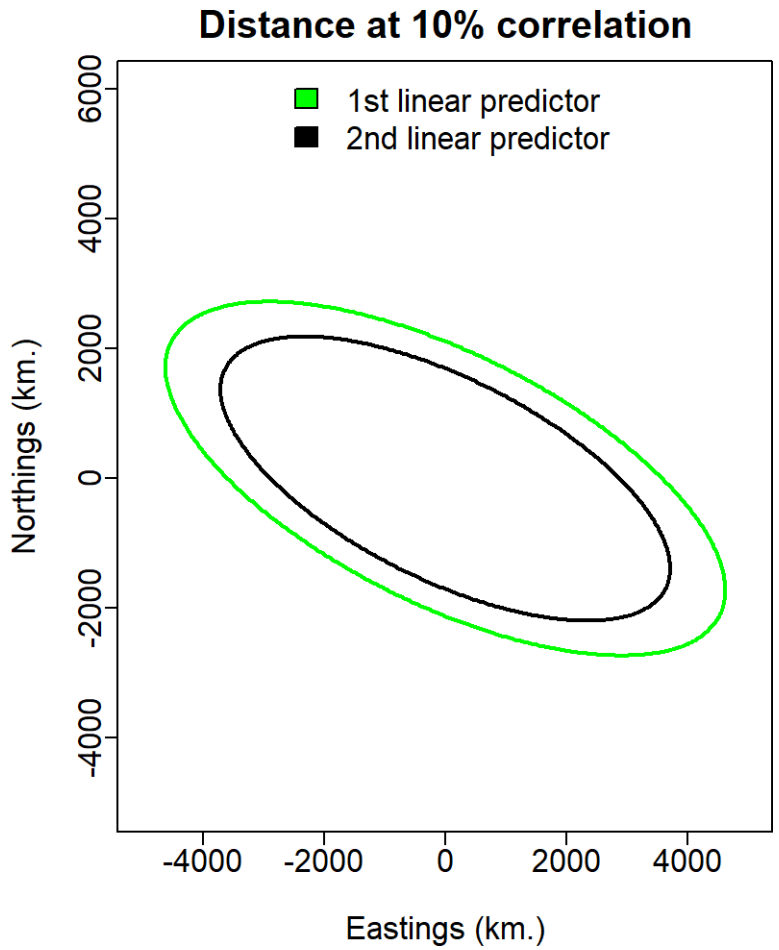
Spatial domain and number of knots



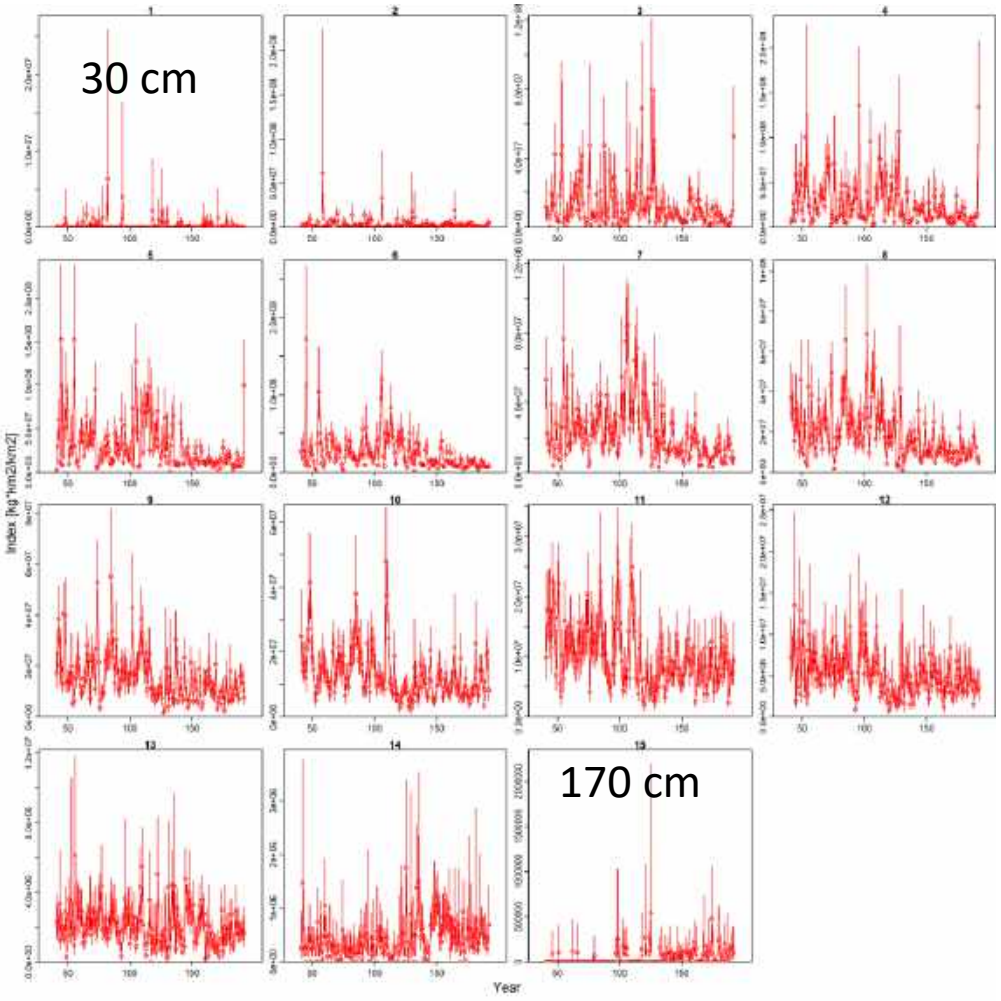


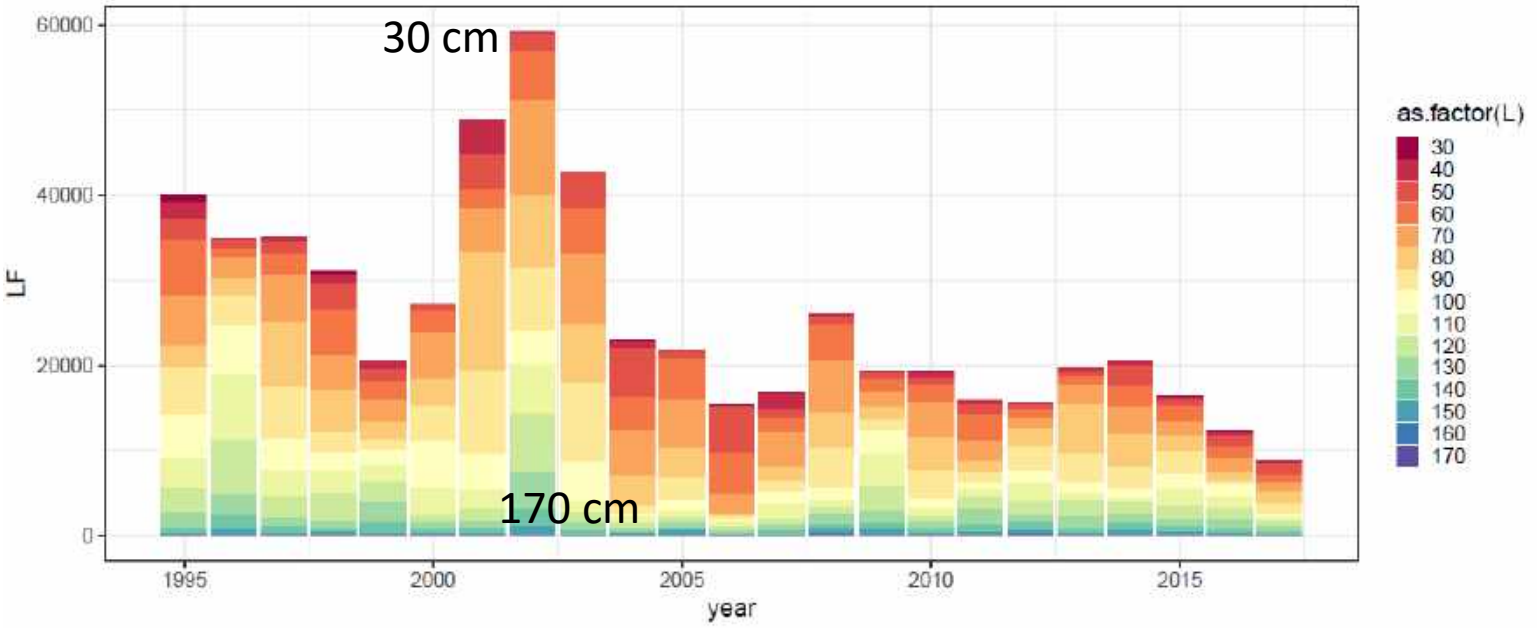


Estimated spatial correlations

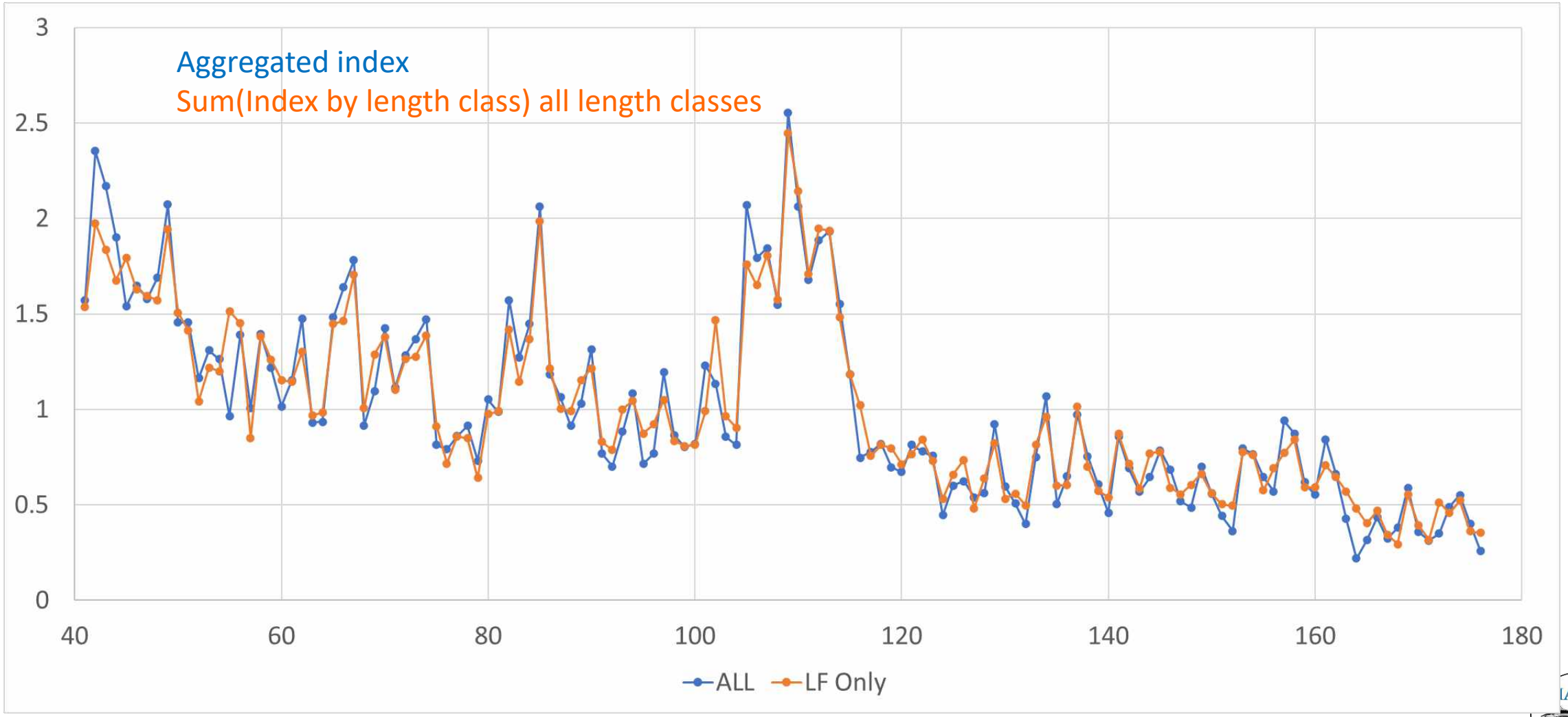


Index predicted by size class

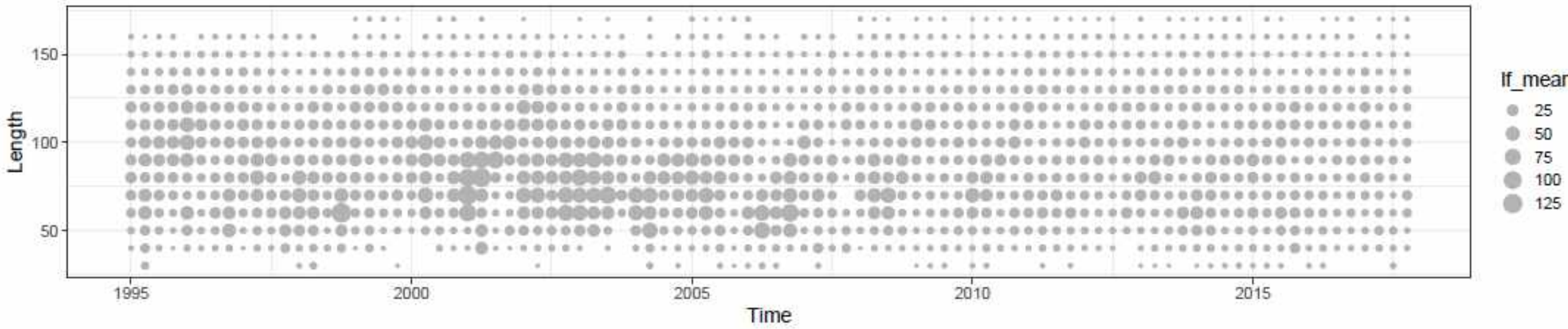




What are the sizes represented by the index? Standardized size compositions

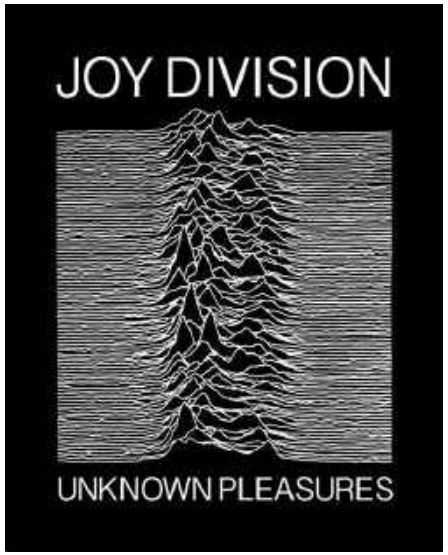


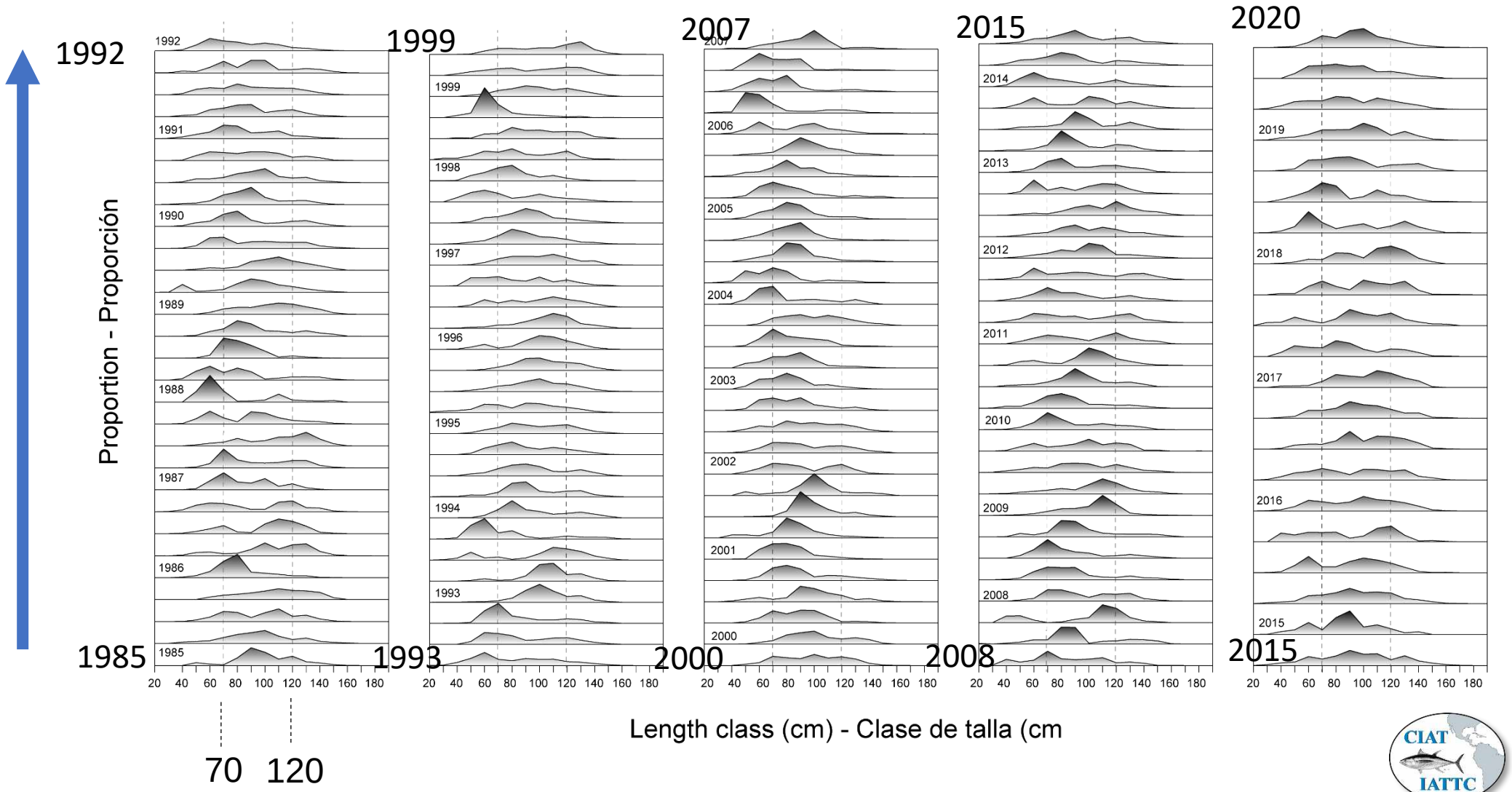
Standardized size compositions



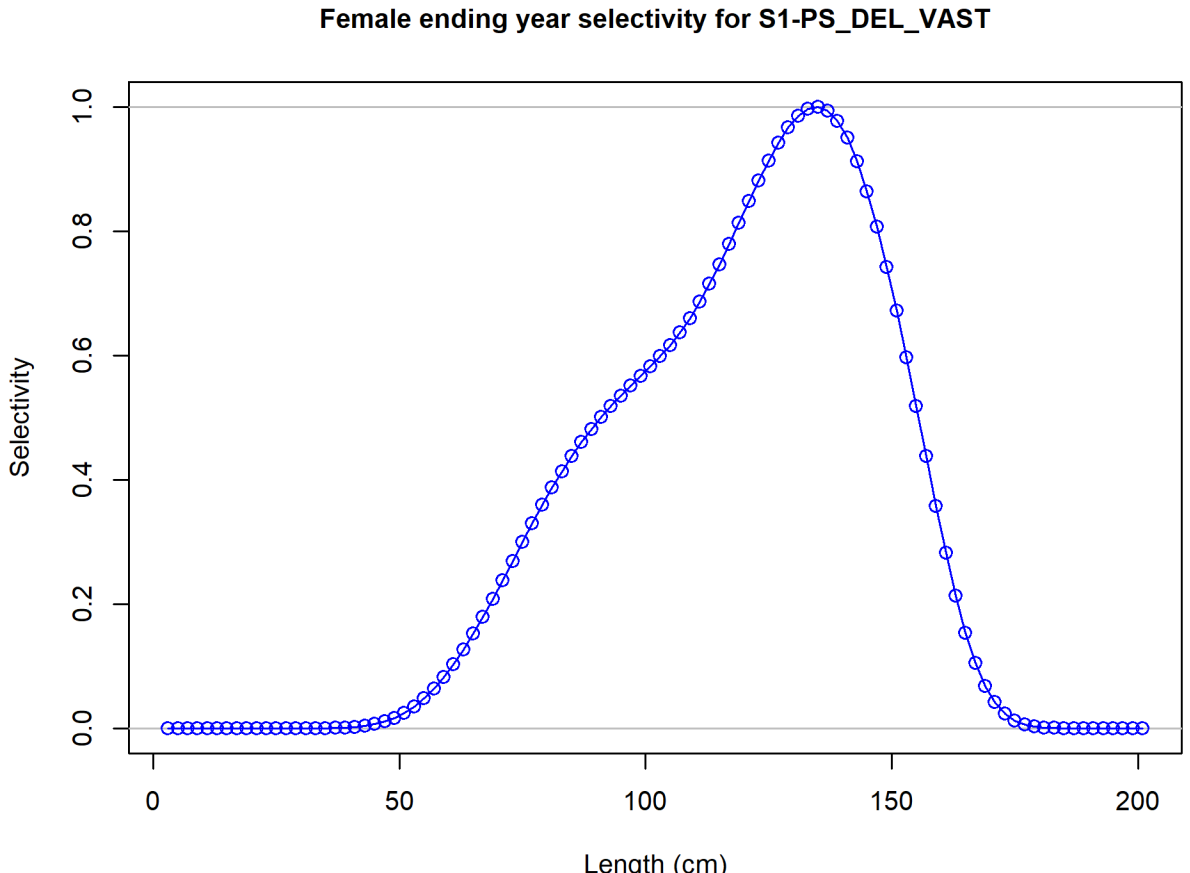
Data – standardized length frequencies

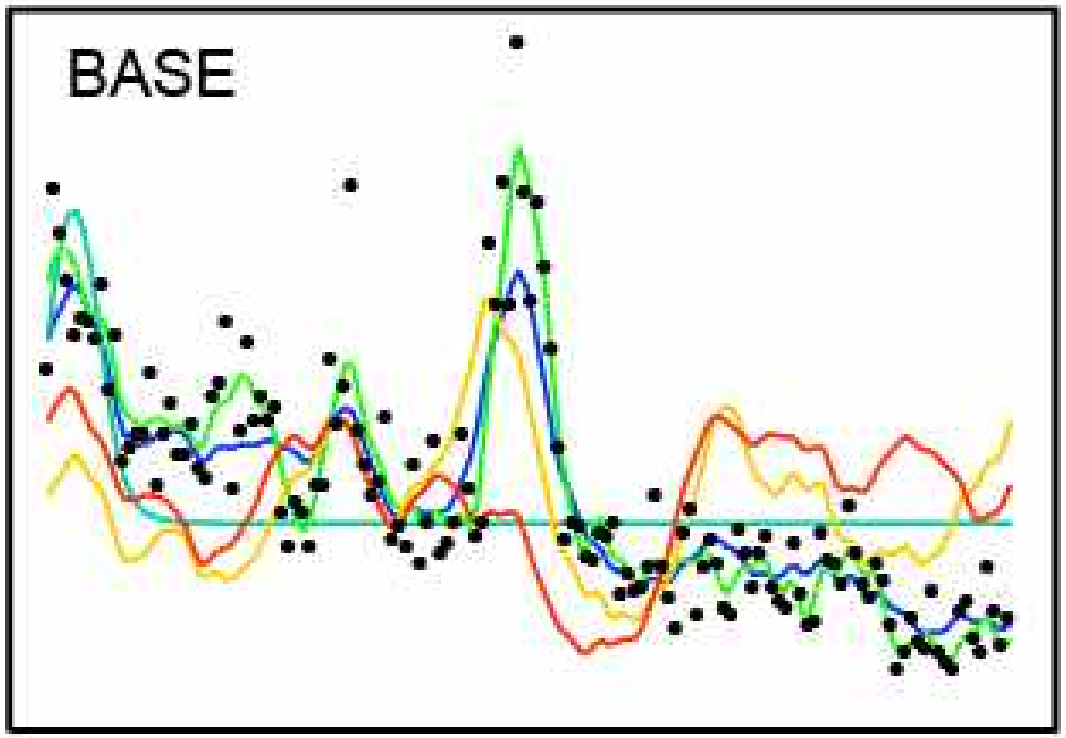
time

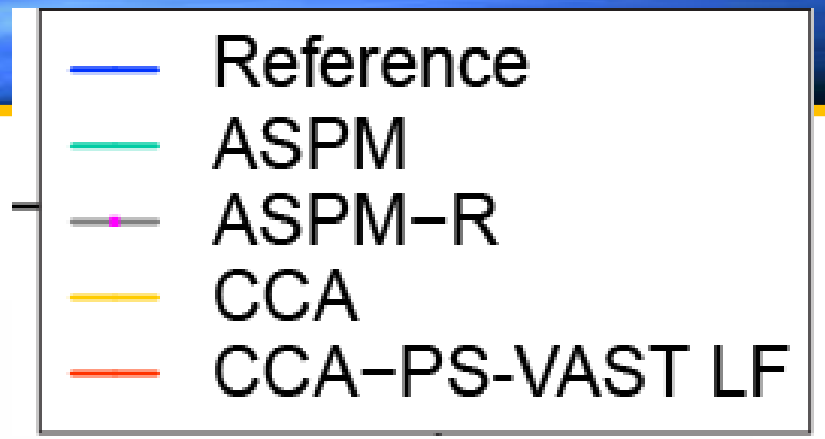




Effect on the assessment model





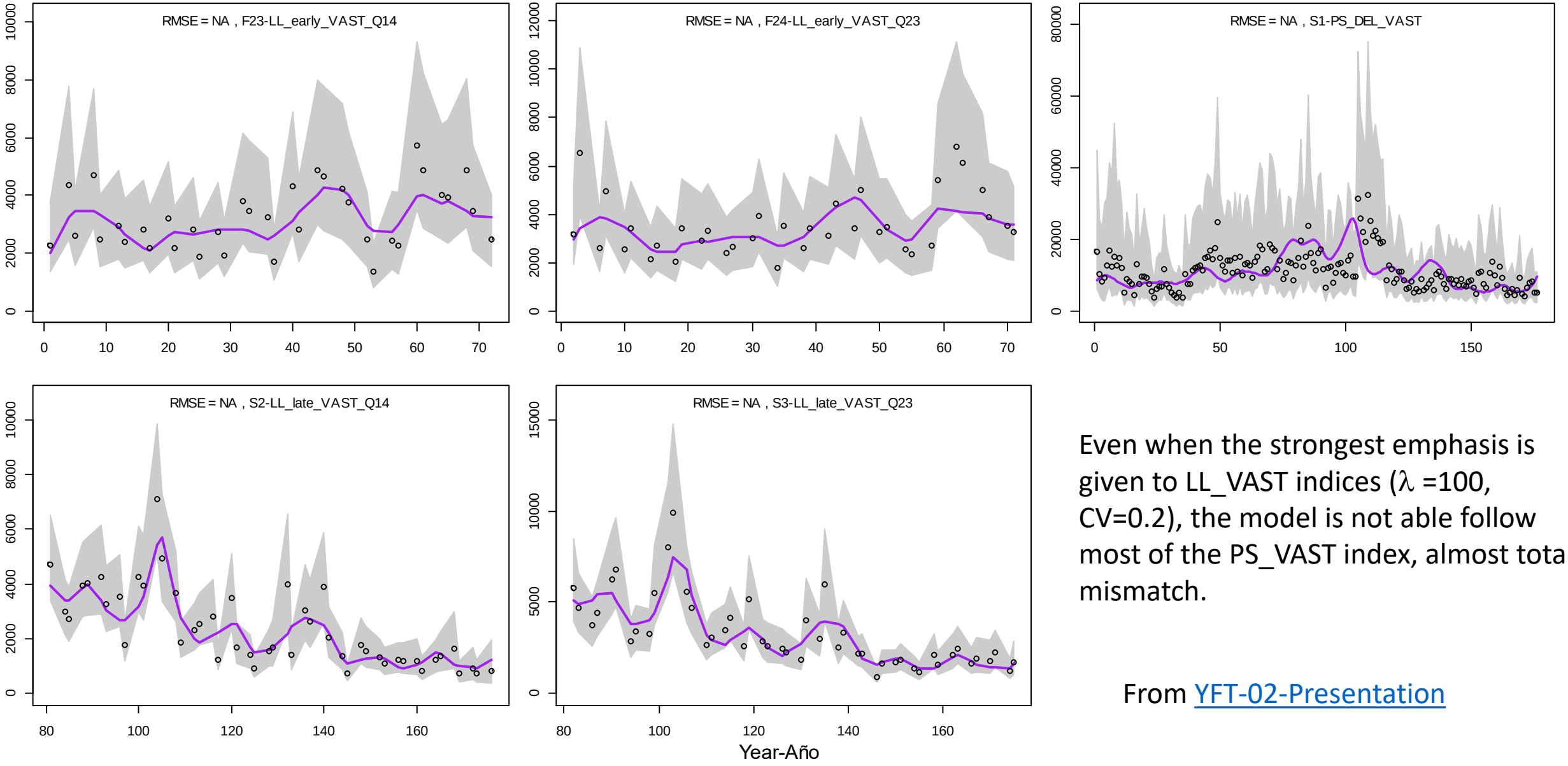


Discussion

- Vessel effects are the only covariate included
- There are other information related to the sets, used previous standardization, explore it further in spatiotemporal model?
- Length composition data are sparse in comparison with catch and effort data, use alternative methods to standardize it
- Observers collect data in broad size categories, may be used to augment the data?
- Explore seasonal changes in spatial domain using oceanographic data

Extra

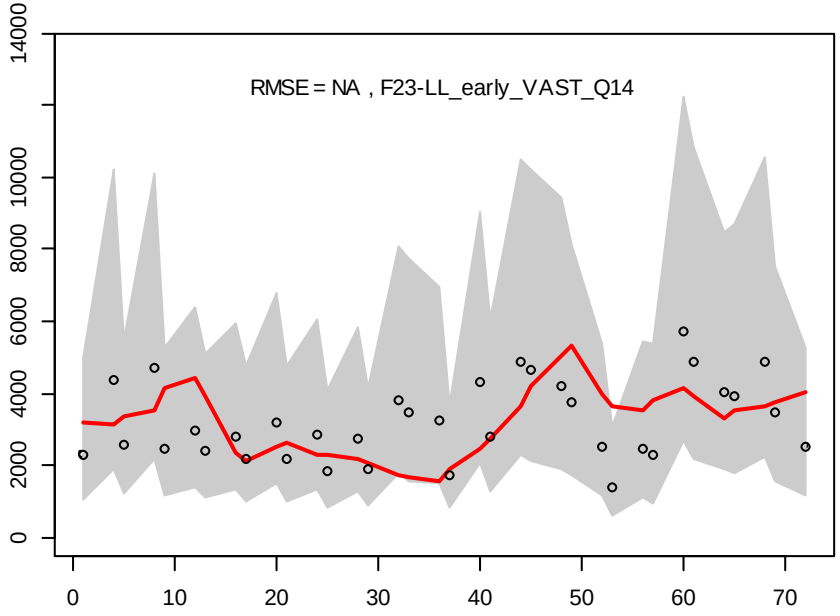
Main Index: LL_VAST X 100

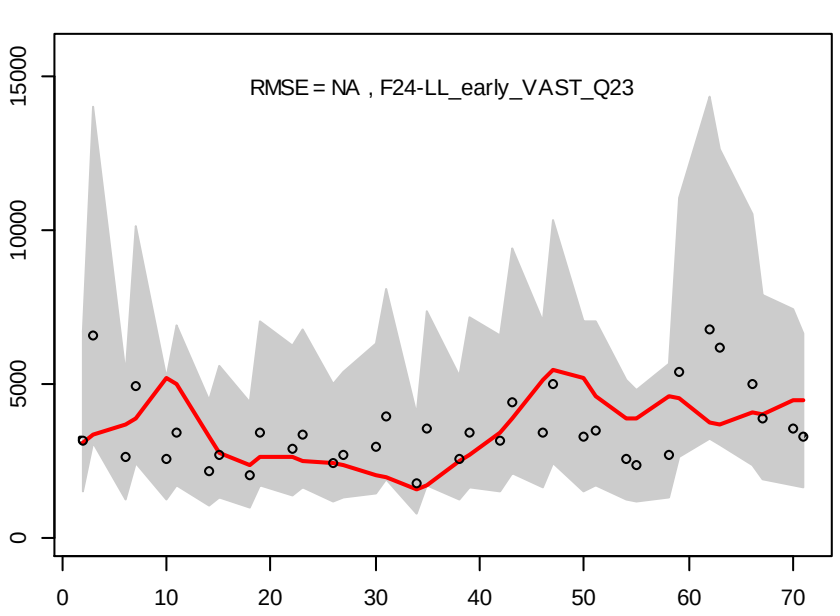


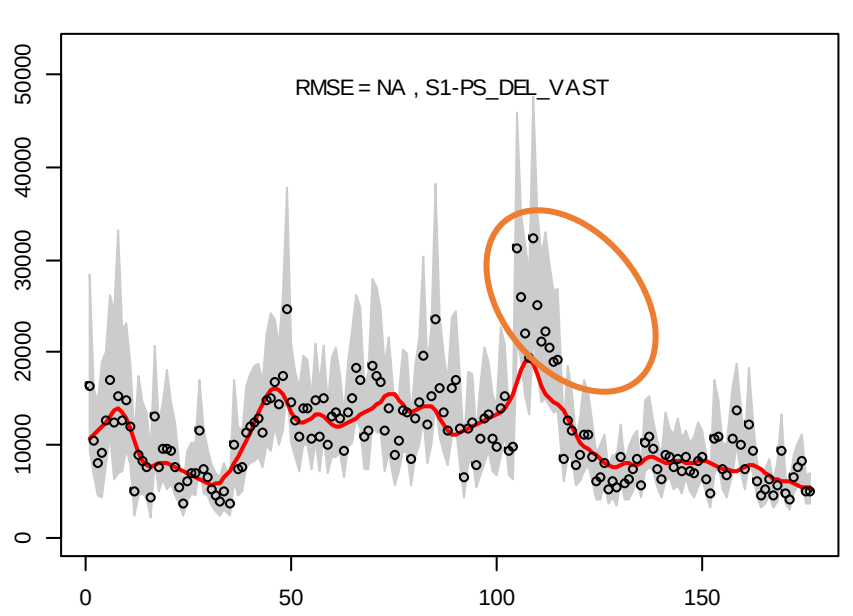
Even when the strongest emphasis is given to LL_VAST indices (λ =100, CV=0.2), the model is not able follow most of the PS_VAST index, almost total mismatch.

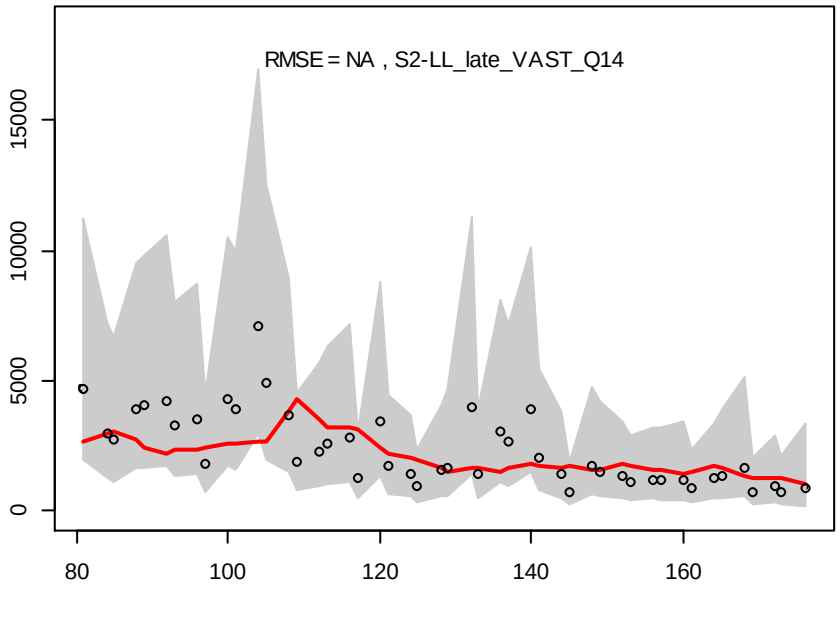
From YFT-02-Presentation

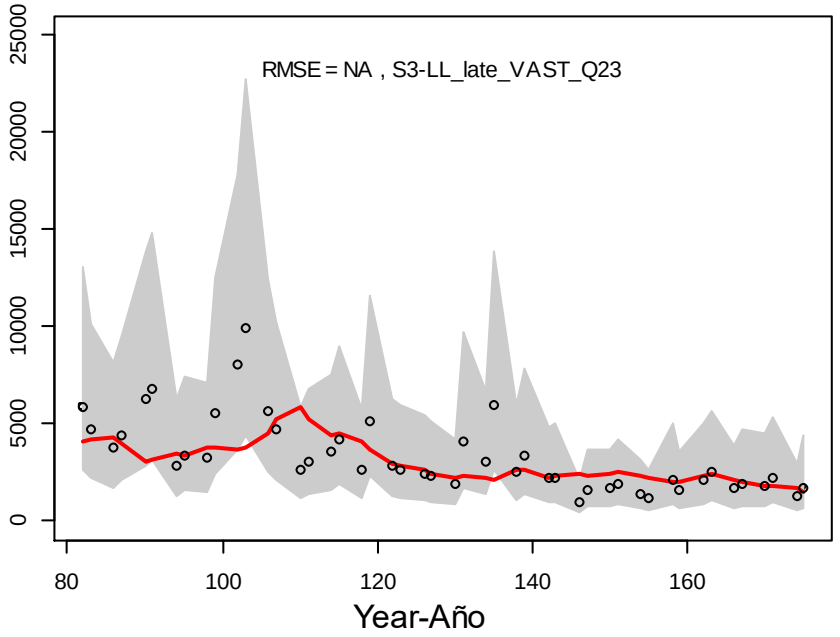
Main Index: PS_VAST X 100











Even when the strongest emphasis is given to PS_DEL_VAST (λ =100, CV=0.2), the model is not able to fit the largest values

The LL indices are not well fit

From YFT-02-Presentation

Nominal compositions