Comisión Interamericana del Atún Tropical
Inter-American Tropical Tuna Commission

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Purse-Seine index of abundance and length frequency for yellowfin tuna in the EPO

2nd External review of the stock assessment of yellowfin tuna in the EPO, La Jolla, California USA, 2-8 December 2019

Data

- **Index of abundance**

  Class-6 PS vessels' catch and effort data:

  - Per-vessel data on catch (in metric tons) and effort (in days fishing)
  - Estimating fishing effort is difficult: select vessels that made >= 75% of sets on dolphin

- **Length frequency for the index of abundance**

  Class-6 PS vessels' length frequency data:

  - $5°Lat * 5°Lon * year\_month$
  - Select vessels that made >= 75% of sets on dolphin
  - Length is grouped into 10cm bins from 20 cm to 190+ cm

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Model Structure (Index of abundance)

VAST separately models encounter probability (p) and positive catch rate (λ) for each catch rate observation i:

$$\text{logit}(p_i) = \beta_1(t_i) + l_{\omega 1}\omega_1(s_i) + l_{\varepsilon 1}\varepsilon_1(s_i, t_i) + l_{\delta 1}\delta_1(v_i)$$
$$\log(\lambda_i) = \beta_2(t_i) + l_{\omega 2}\omega_2(s_i) + l_{\varepsilon 2}\varepsilon_2(s_i, t_i) + l_{\delta 2}\delta_2(v_i)$$

$\beta(t_i)$: intercept in year t_i
$\omega(s_i)$: spatial variation at location s_i; l_ω: scaling factor
$\varepsilon(s_i, t_i)$: spatiotemporal variation at location s_i in year t_i; l_ε: scaling factor
$\delta(v_i)$: vessel effects on catchability; l_δ: scaling factor

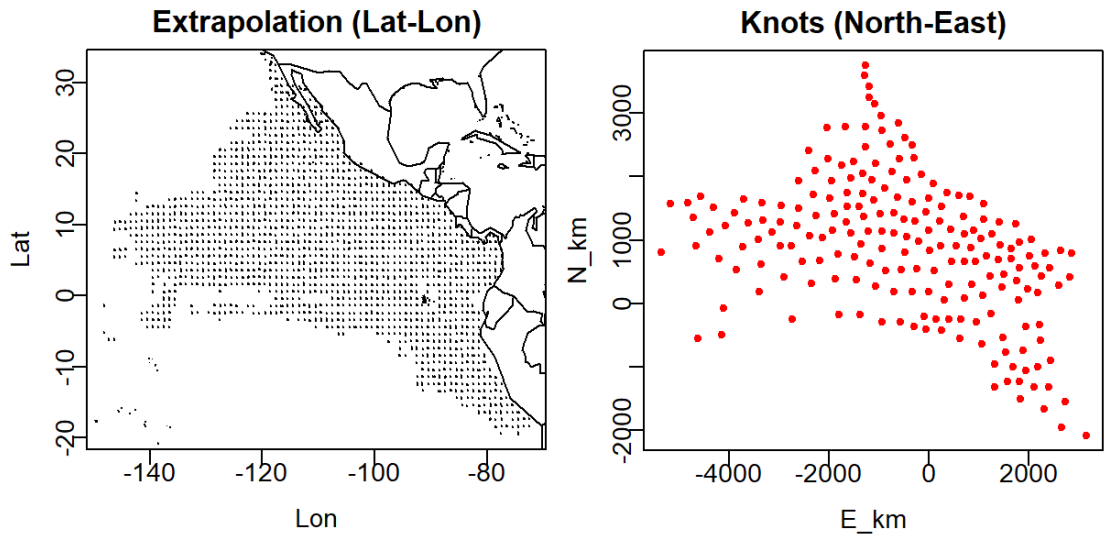
Model Structure (Index of abundance)

The probability of catch data c for sample i:

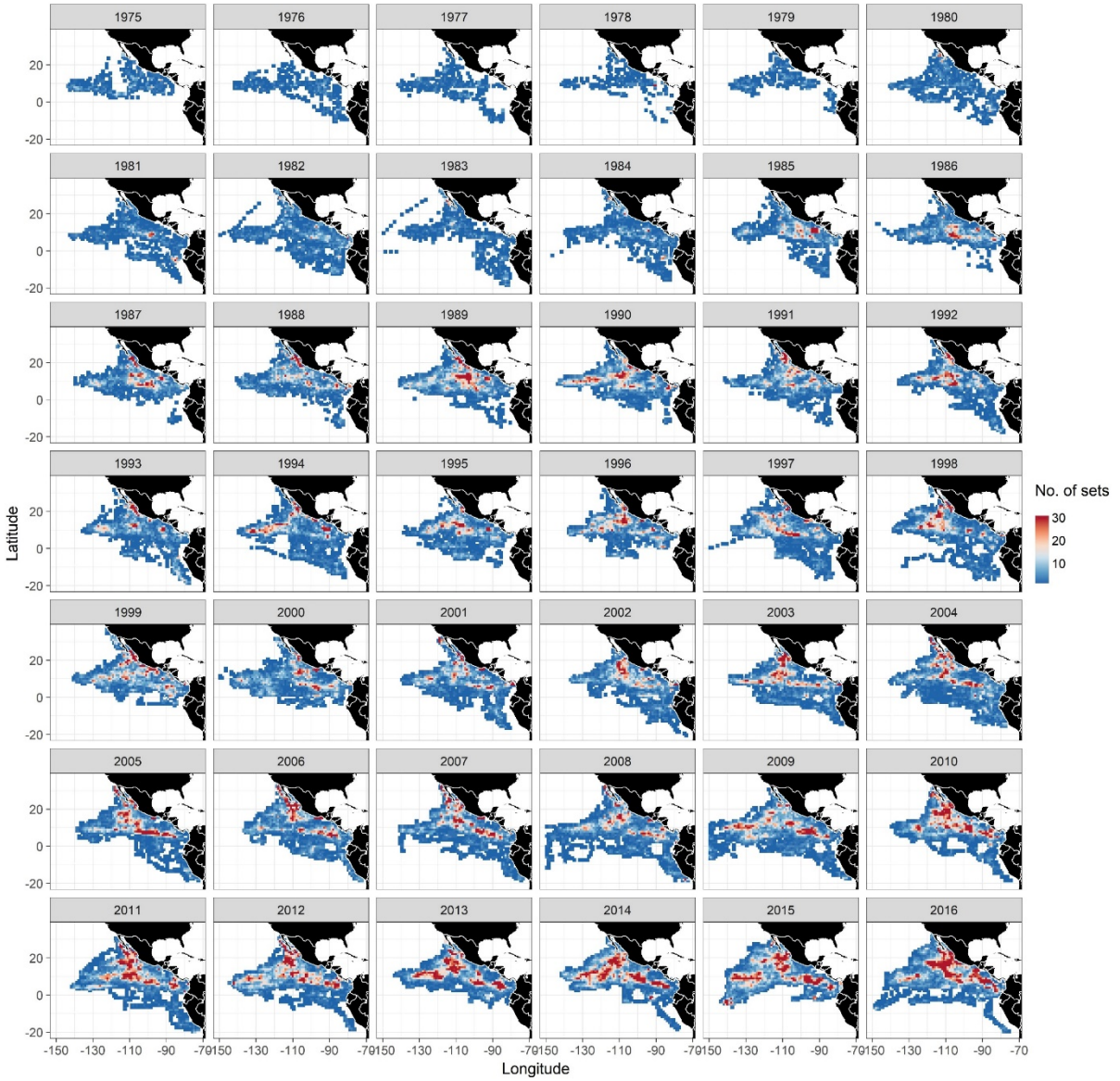
$$\Pr(c_i = c) = \begin{cases} 1 - p_i & \text{if c} = 0 \\ p_i \times \text{Lognormal}(c_i | \log(\lambda_i), \sigma_m^2) & \text{if c} > 0 \end{cases}$$

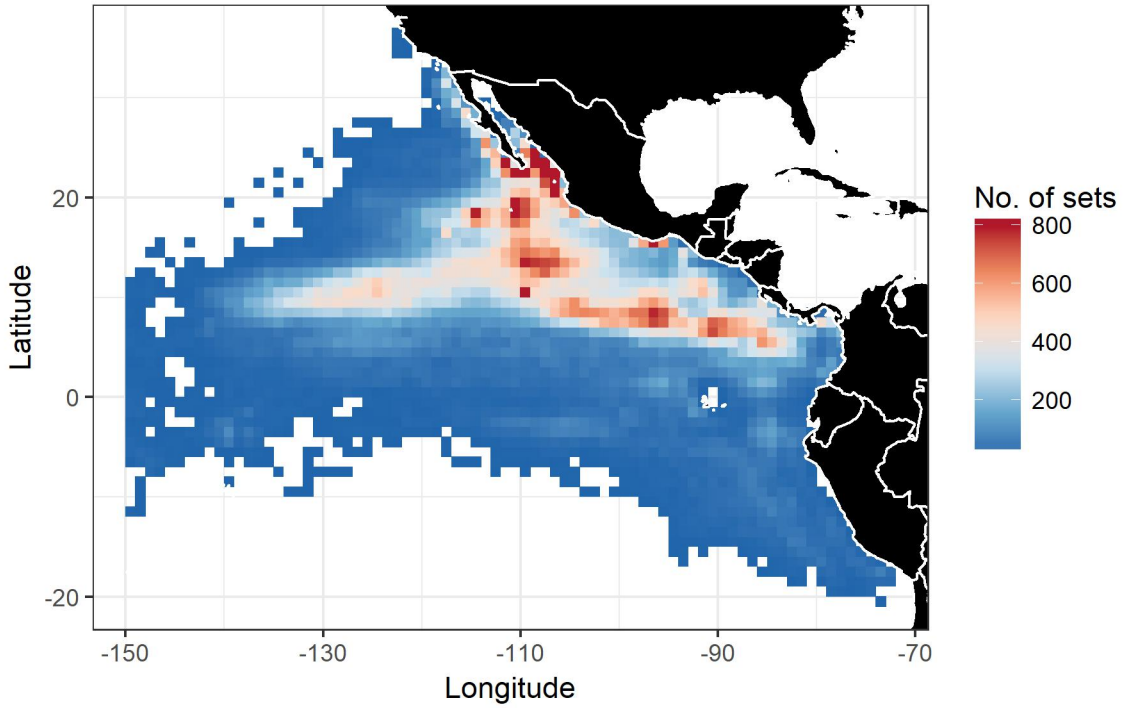
where $c_i = \frac{catch_i(in\ tons)}{effort_i(in\ days)}$

The standardized index is area-weighted: $I(t) = \sum_{k=1}^{200}(area(k) \times density(k,t))$

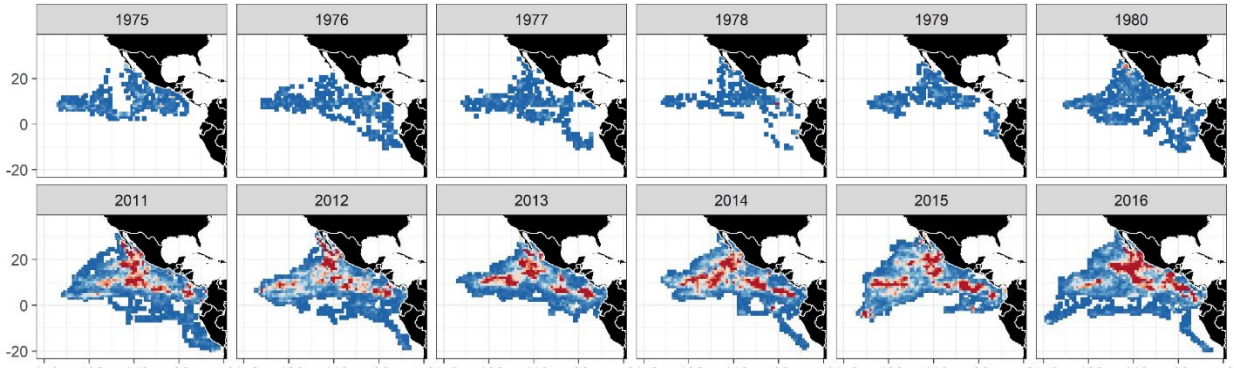


Spatiotemporal distribution of sample locations

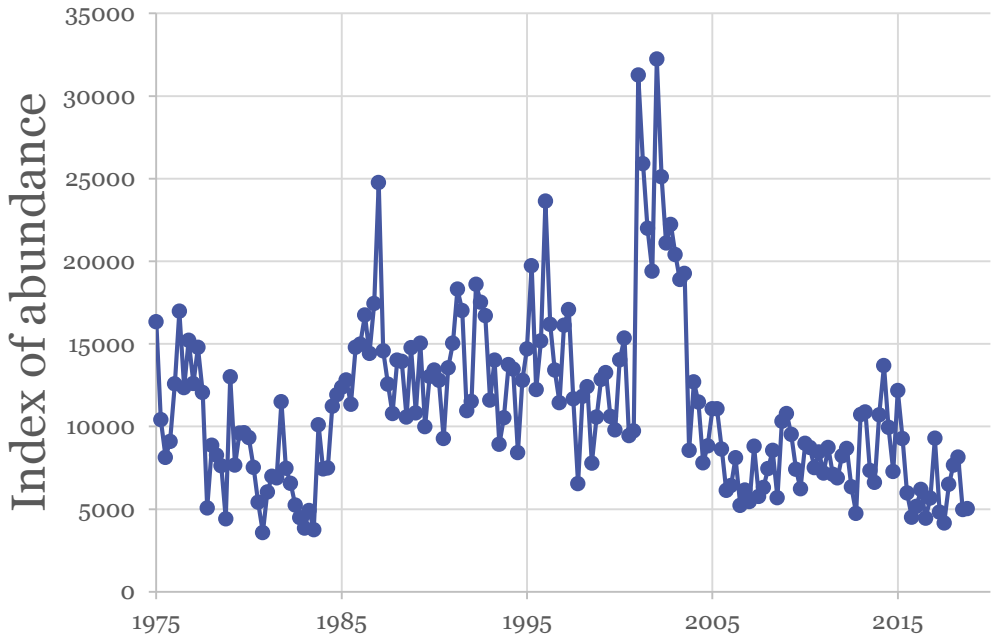


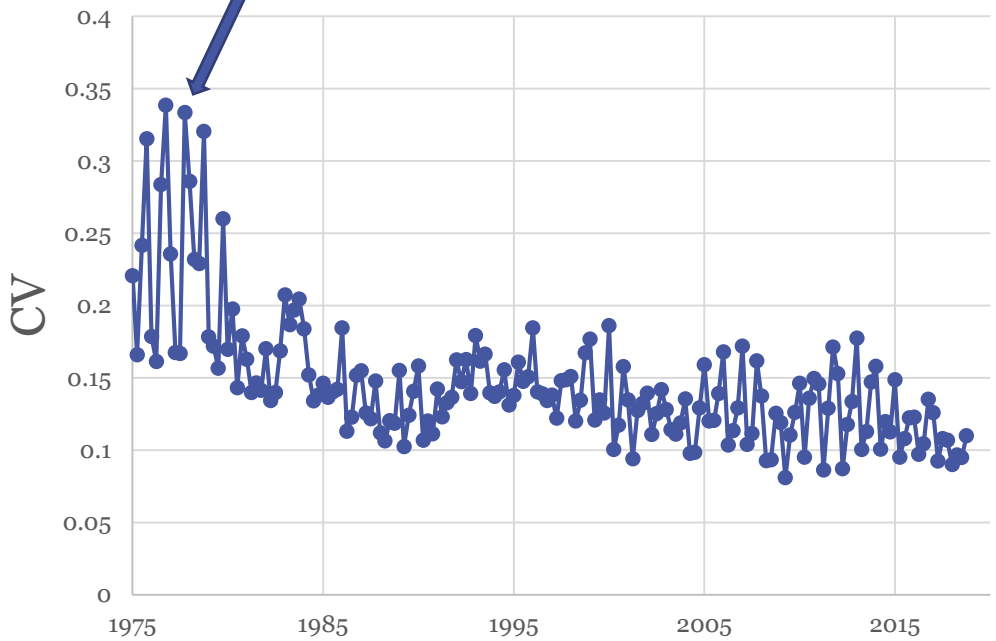


Results



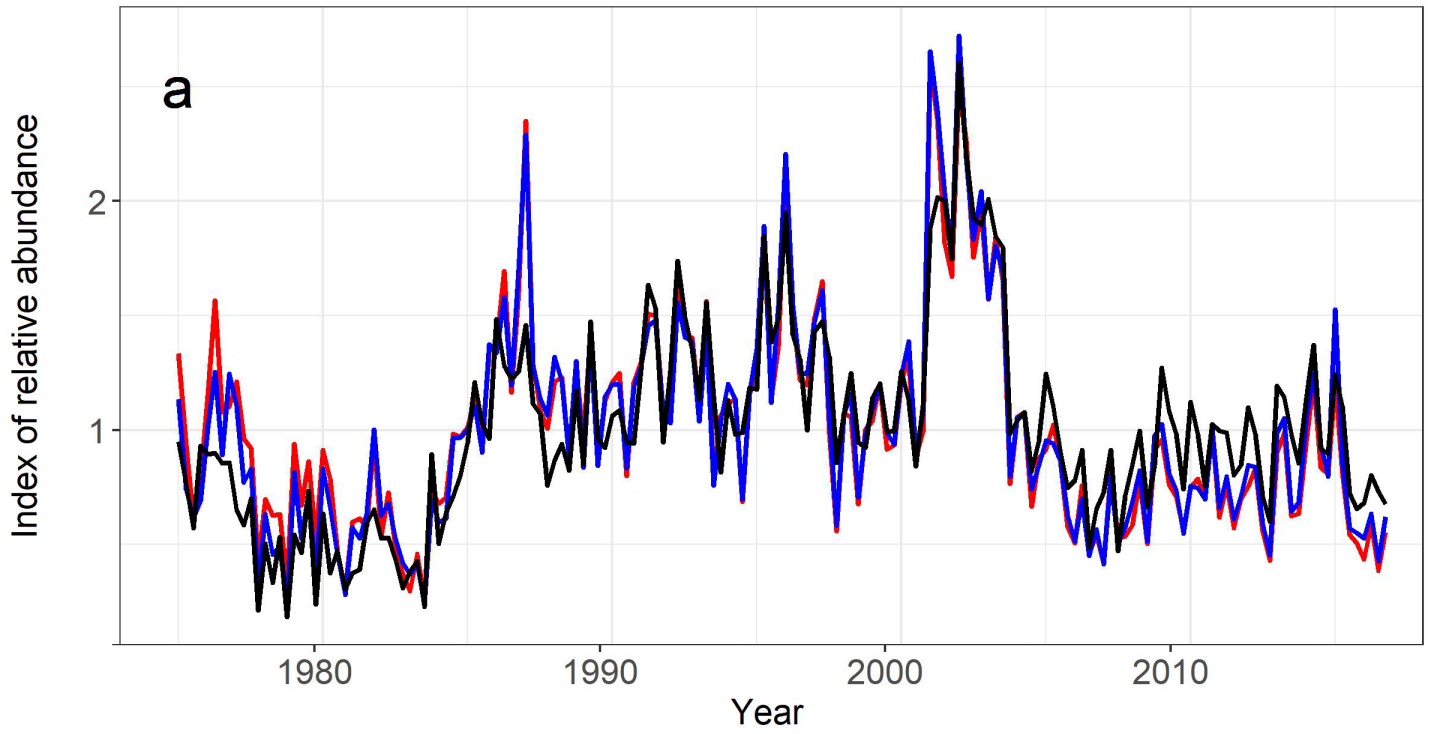
Low spatial coverage and sample size





Standardized vs. Nominal index

Red: standardized index with vessel effects
Blue: standardized index without vessel effects
Black: nominal index



- Standardized index suggests a more pessimistic population abundance trend
- Average vessel efficiency increased over time

Data

- **Index of abundance**

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  - Per-vessel data on catch (in metric tons) and effort (in days fishing)
  - Estimating fishing effort is difficult: select vessels that made >= 75% of sets on dolphin

- **Length frequency for the index of abundance**

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Model Structure (Length composition)

VAST separately models encounter probability (p) and positive catch rate (λ) for each catch rate observation i:

$$\text{logit}(p_i) = \beta_1(l_i, t_i) + \sigma_{\omega 1}(l_i)\omega_1(l_i, s_i) + \sigma_{\varepsilon 1}(l_i)\varepsilon_1(l_i, s_i, t_i)$$

$$\log(\lambda_i) = \beta_2(l_i, t_i) + \sigma_{\omega 2}(l_i)\omega_2(l_i, s_i) + \sigma_{\varepsilon 2}(l_i)\varepsilon_2(l_i, s_i, t_i)$$

$\beta(l_i, t_i)$: intercept for length l_i in year t_i
$\omega(l_i, s_i)$: spatial variation for length l_i at location s_i; $\sigma_\omega(l_i)$: scaling factor for length l_i
$\varepsilon(l_i, s_i, t_i)$: spatiotemporal variation for length l_i at location s_i in year t_i; $\sigma_\varepsilon(l_i)$: scaling factor for length l_i

*** No interaction among length bins (computationally too expensive)

Model Structure (Length composition)

The probability of catch data c for sample i:

$$\Pr(c_i = c) = \begin{cases} 1 - p_i & \text{if c} = 0 \\ p_i \times \text{Lognormal}(c_i | \log(\lambda_i), \sigma_m^2) & \text{if c} > 0 \end{cases}$$

where $c_i = \frac{length\text{–}specific\ catch_i(in\ number)}{effort_i(in\ \text{days})}$ --- CPUE by length (20, 30, 40, … , 190)

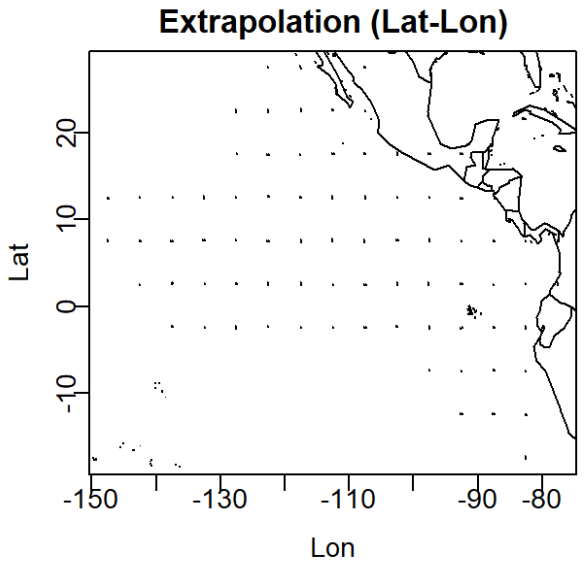
The length-specific standardized index is area-weighted:

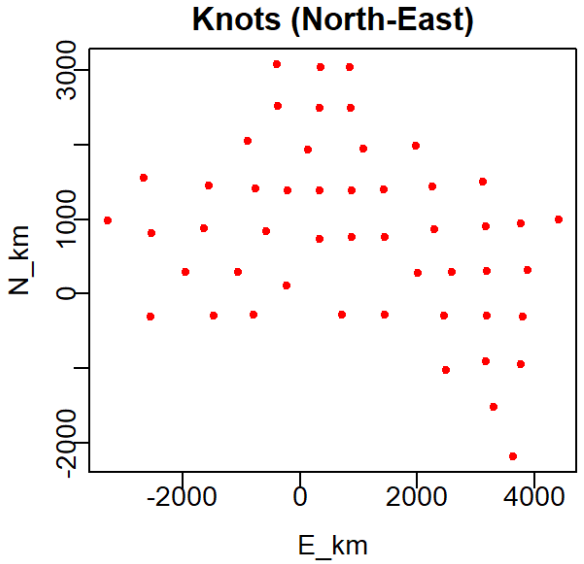
$$I(l,t) = \sum_{k=1}^{50} (area(k) \times density(l,k,t))$$

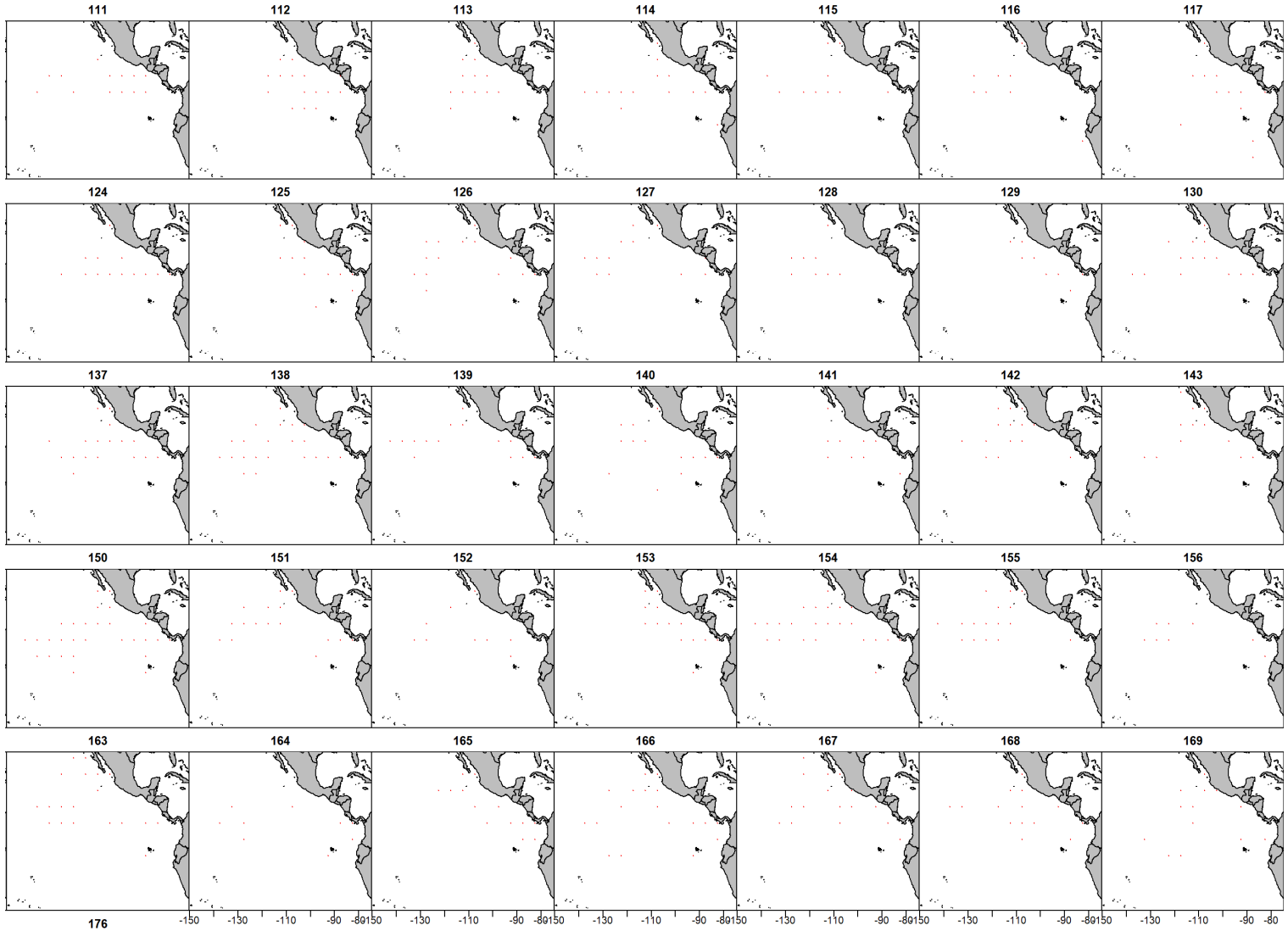
Standardized length composition:

$$P(l,t) = \frac{I(l,t)}{\sum_{l=1}^{n_l} I(l,t)}$$

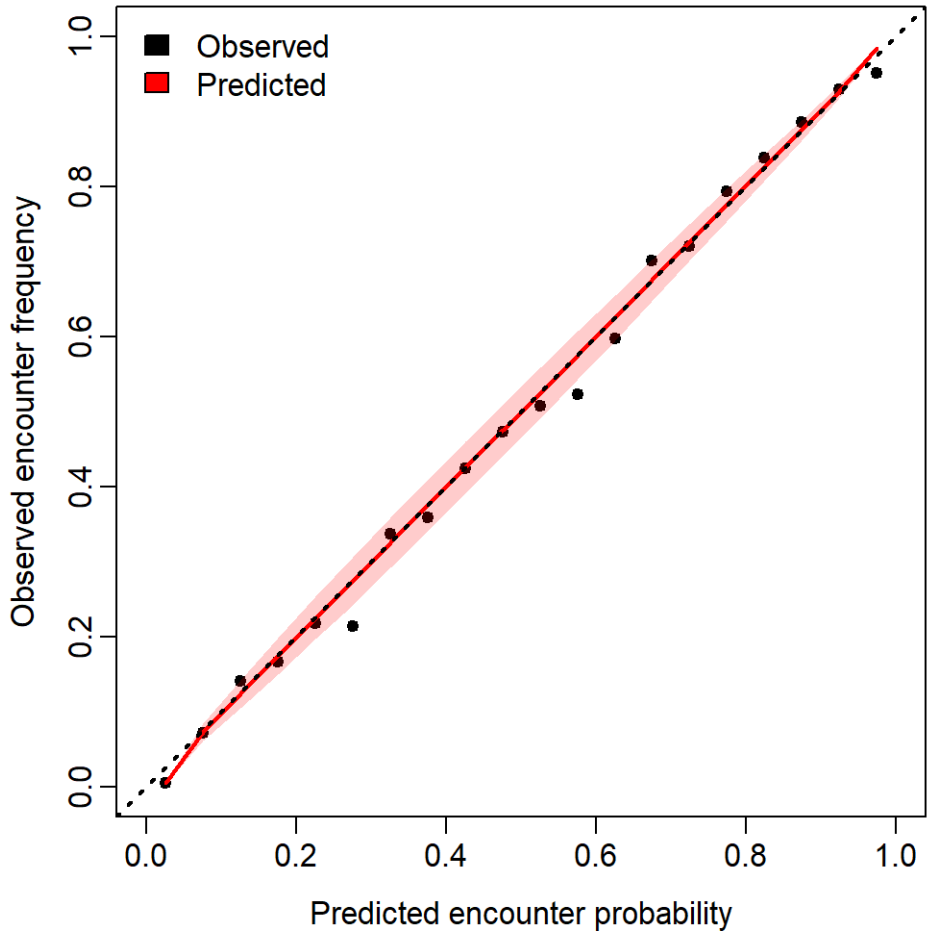
Sample distribution



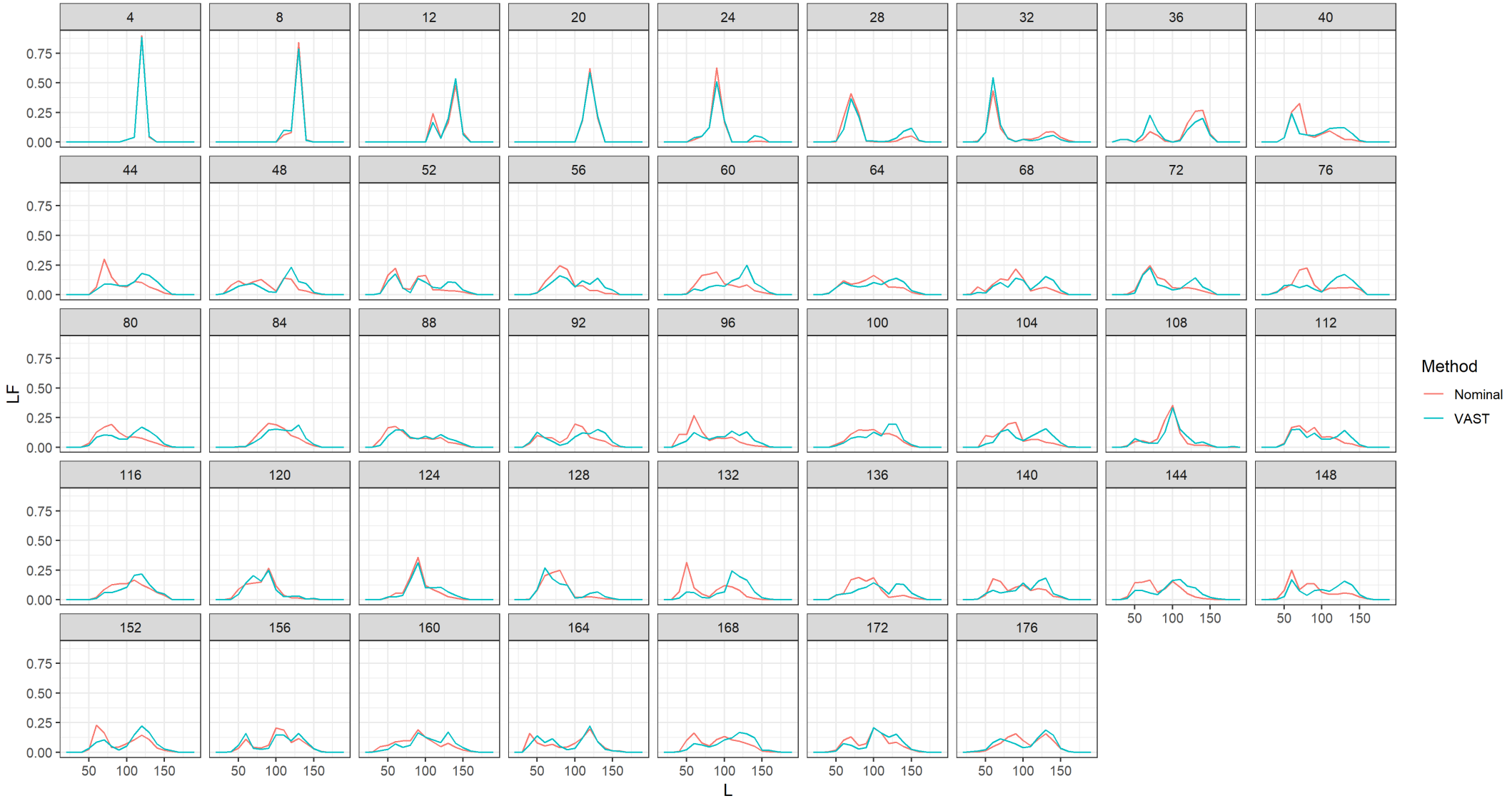




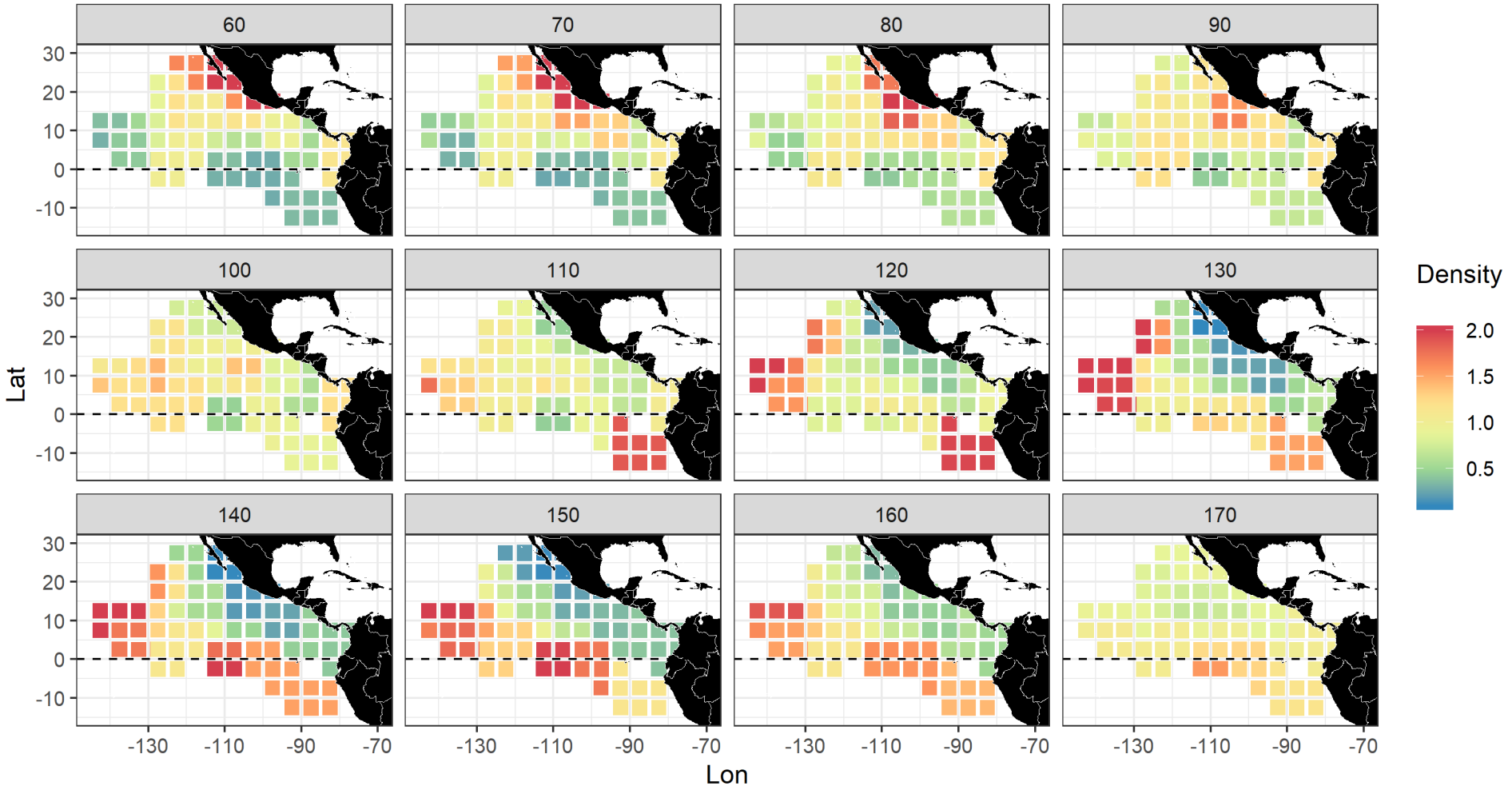
Model diagnostics



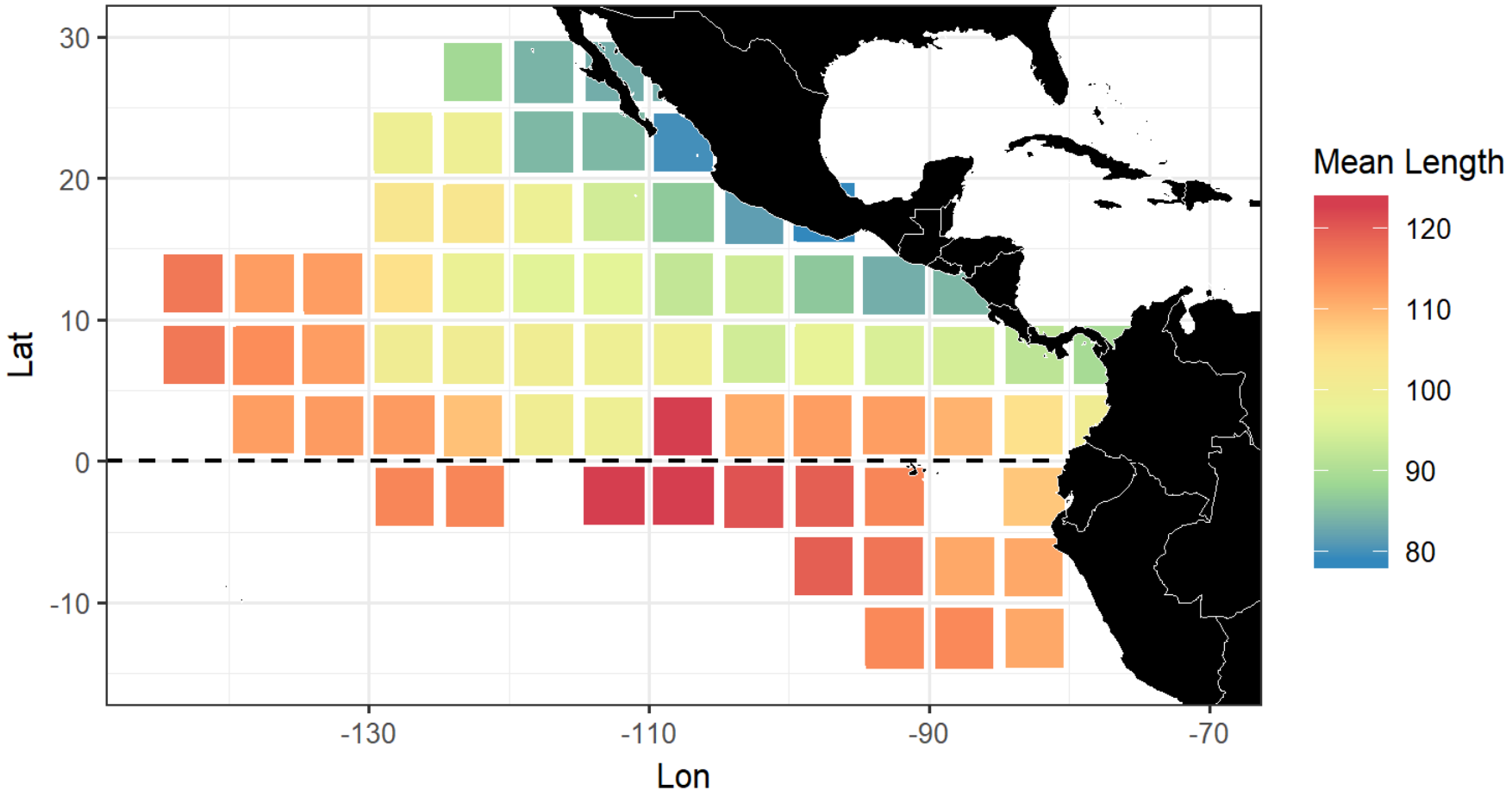
Nominal vs. Standardized Length Composition



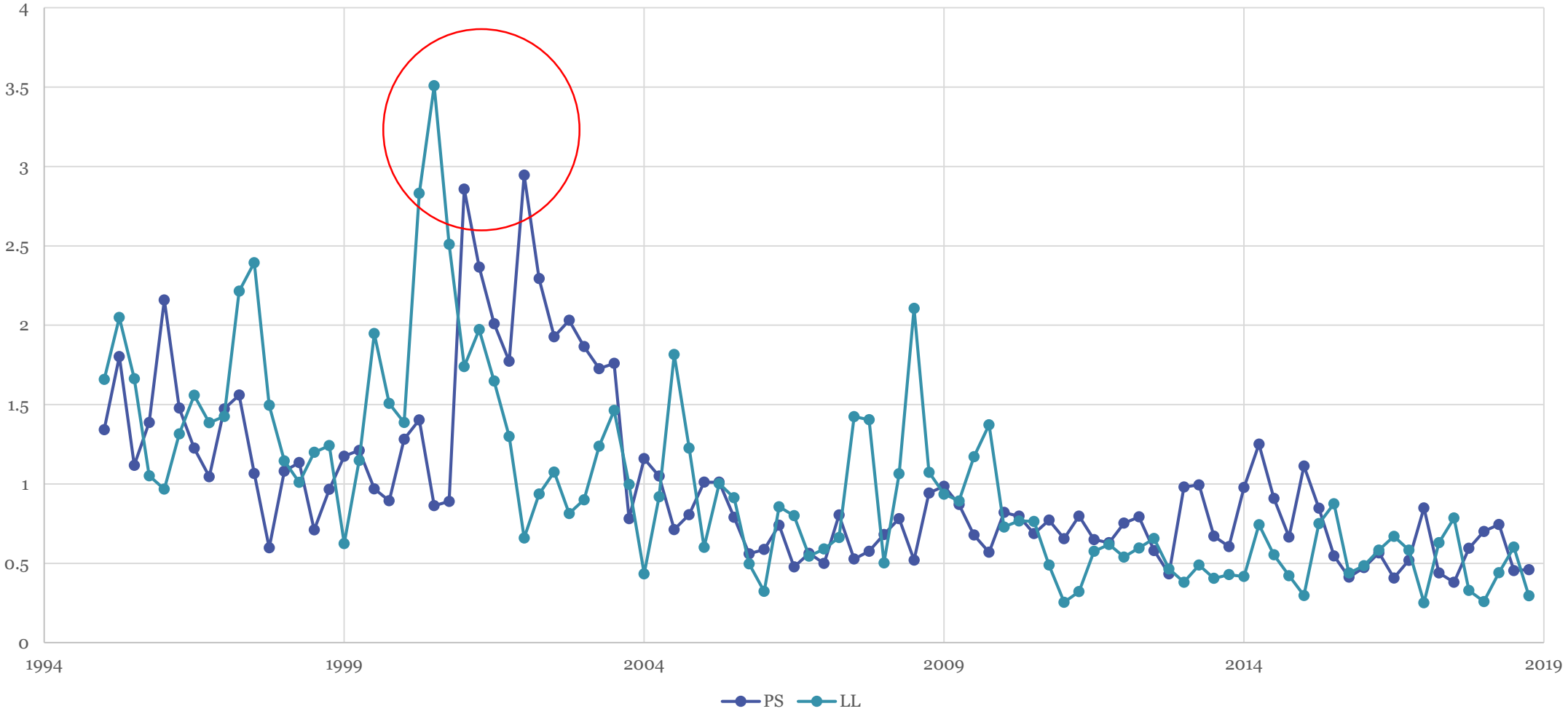
Mean YFT density by length (cm)



Mean YFT length (cm) in the fishery



Mis-match between LL and PS index of abundance



Summary

Index of abundance

- Vessel effects are included
- High CV in early years due to low sample size and low spatial coverage
- The peak is ~ 1 year after the longline peak

Length composition

- Nominal and standardized LFs are notably different (low sample size?)
- Only large bin size (10cm) is feasible in the standardization model
- A map of mean spatial catch rate by length can inform fisheries' selectivity

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Questions