Comisión Interamericana del Atún Tropical
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Investigating vessel effects and targeting using Japanese operational data in Spatial-temporal model (VAST)

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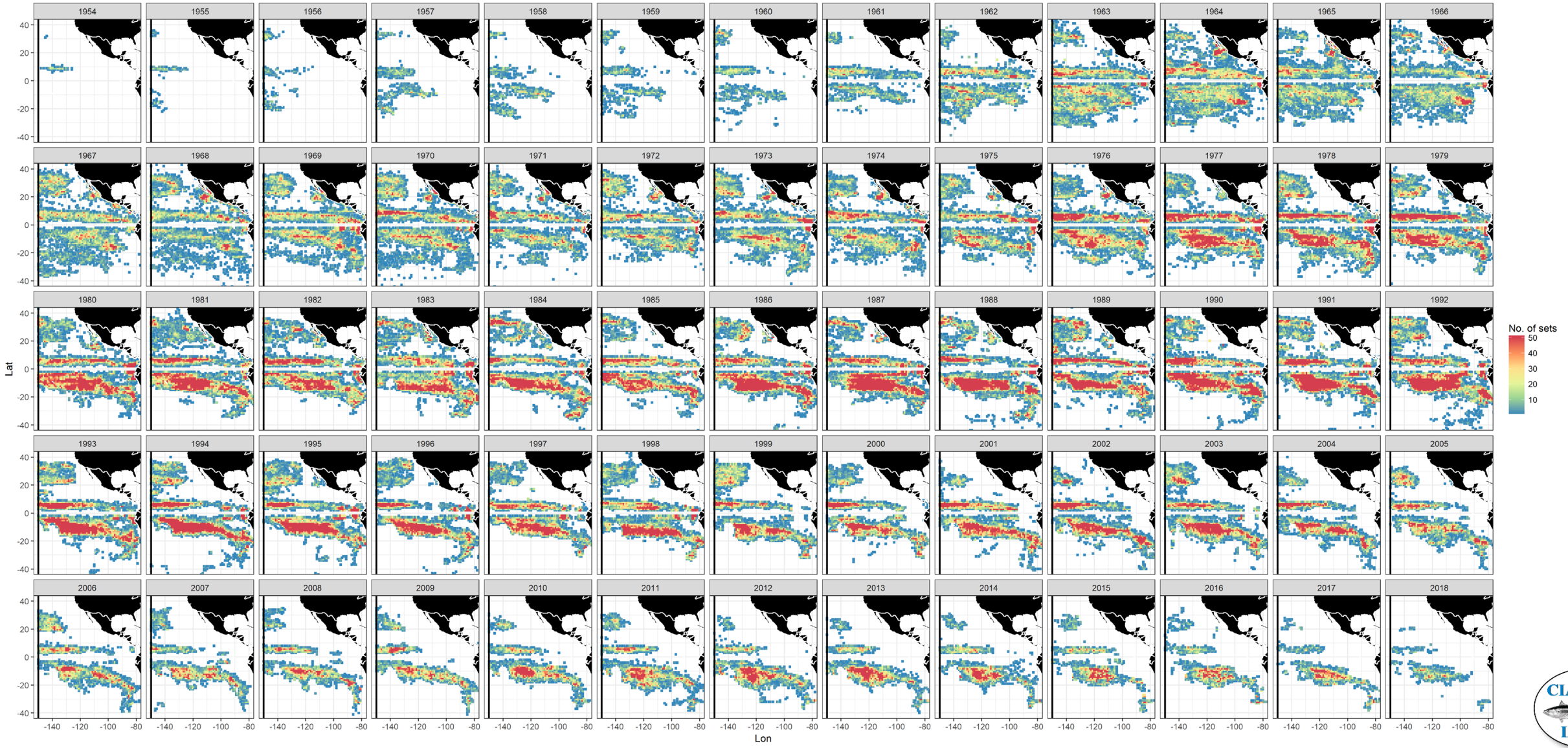
Japanese LL fishery (number of sets per year)



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Model Structure (single species)

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

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

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

$\beta(t_i)$: intercept in year t_i
$\omega(s_i)$: spatial variation at location s_i; L_ω: scaling factor (sd)
$\varepsilon(s_i, t_i)$: spatiotemporal variation at location s_i in year t_i; L_ε: scaling factor (sd)
$\delta(v_i)$: vessel/targeting effects on catchability; L_δ: 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)

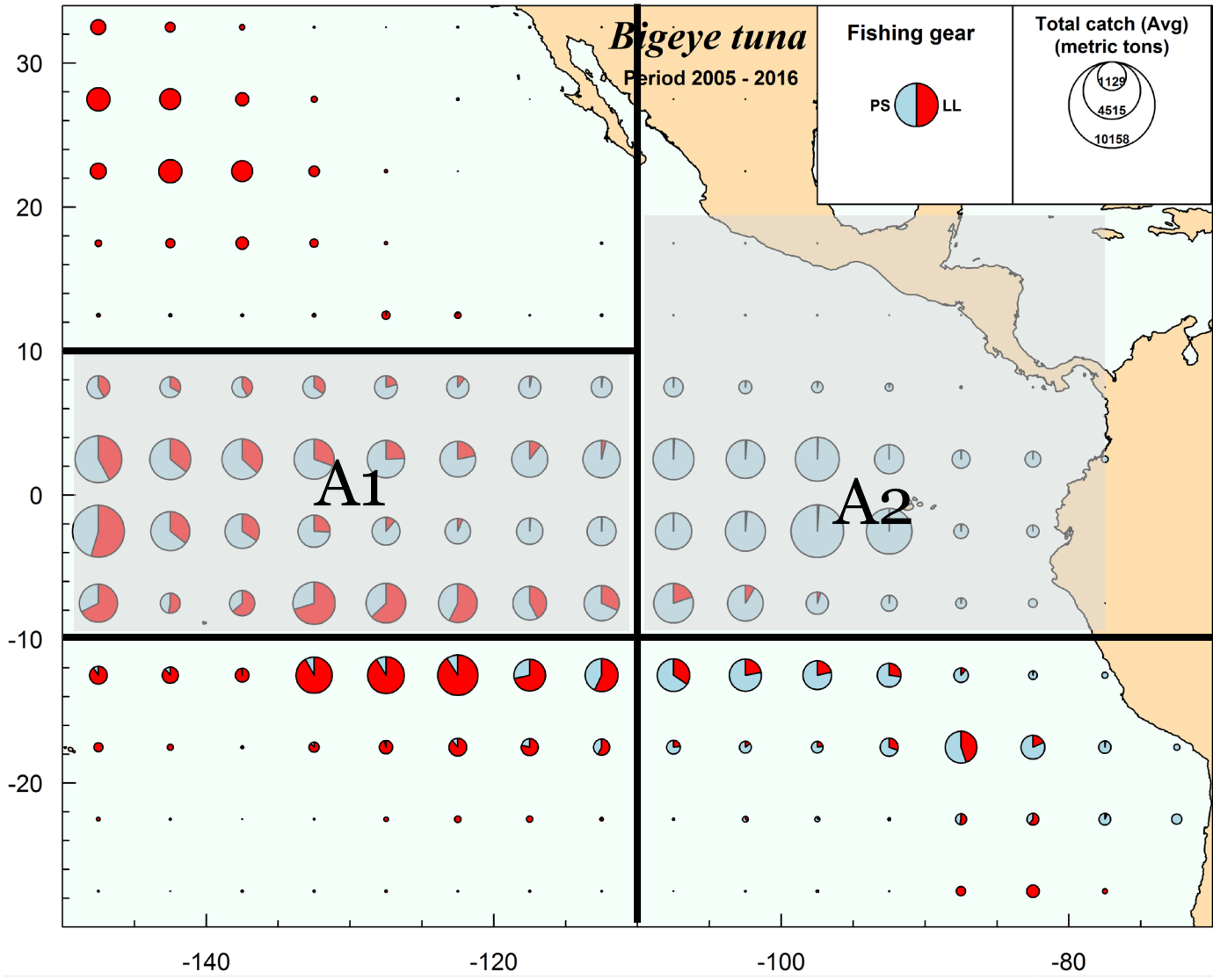
1. Vessel effects on catchability

- Why consider vessel effects in the standardization procedure?
  Different vessels can have different fishing power/efficiency

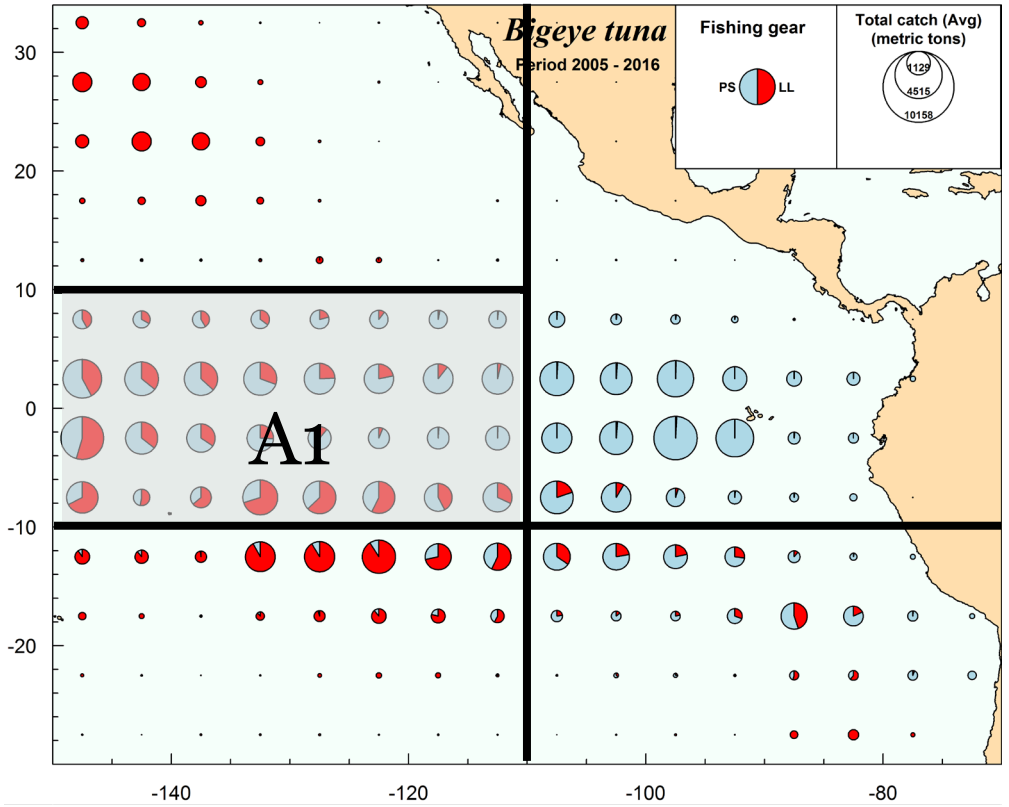
- What vessel effects can be accounted for in VAST?
  Different fishing efficiencies among vessels: larger vessels and surviving vessels are likely to have higher catchability

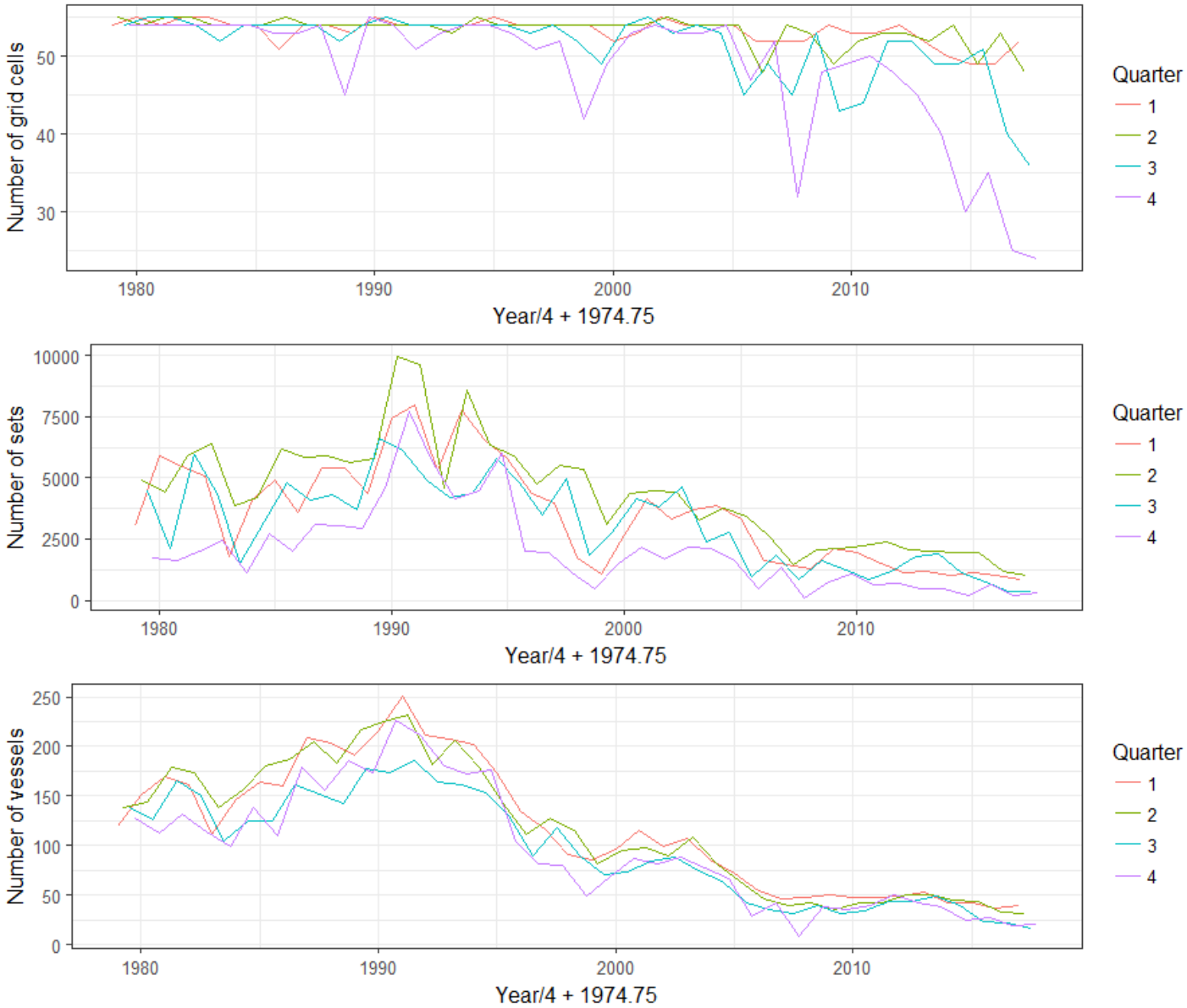
- What vessel effects cannot be accounted for in VAST?
  Changing fishing efficiency of the same vessel over time: catchability are likely to increase over time due to advanced technology and accumulated fishing experience

Two tropical areas (A1 and A2) are investigated



A1: number of vessels decreased since 1990





Four scenarios are compared for A1

1. **base**: fit VAST to aggregated data for A1 by year-quarter, lat, and lon
2. **both**: fit VAST to aggregated data for both A1 and A2 by year-quarter, lat, and lon; estimate CPUE separately for A1 and A2
3. **no_vessel**: fit VAST to aggregated data for A1 by year-quarter, lat, lon, and vessel; vessel effects are not included
4. **vessel**: fit VAST to aggregated data for A1 by year-quarter, lat, lon, and vessel; vessel effects are included

Scaled index of abundance (mean=1)

1. **base**: aggregated data for A1 by y-q, lat, and lon
2. **both**: aggregated data for both A1 and A2 by y-q, lat, and lon; index is estimated for A1
3. **no_vessel**: aggregated data for A1 by y-q, lat, lon, and vessel; vessel effects are not included
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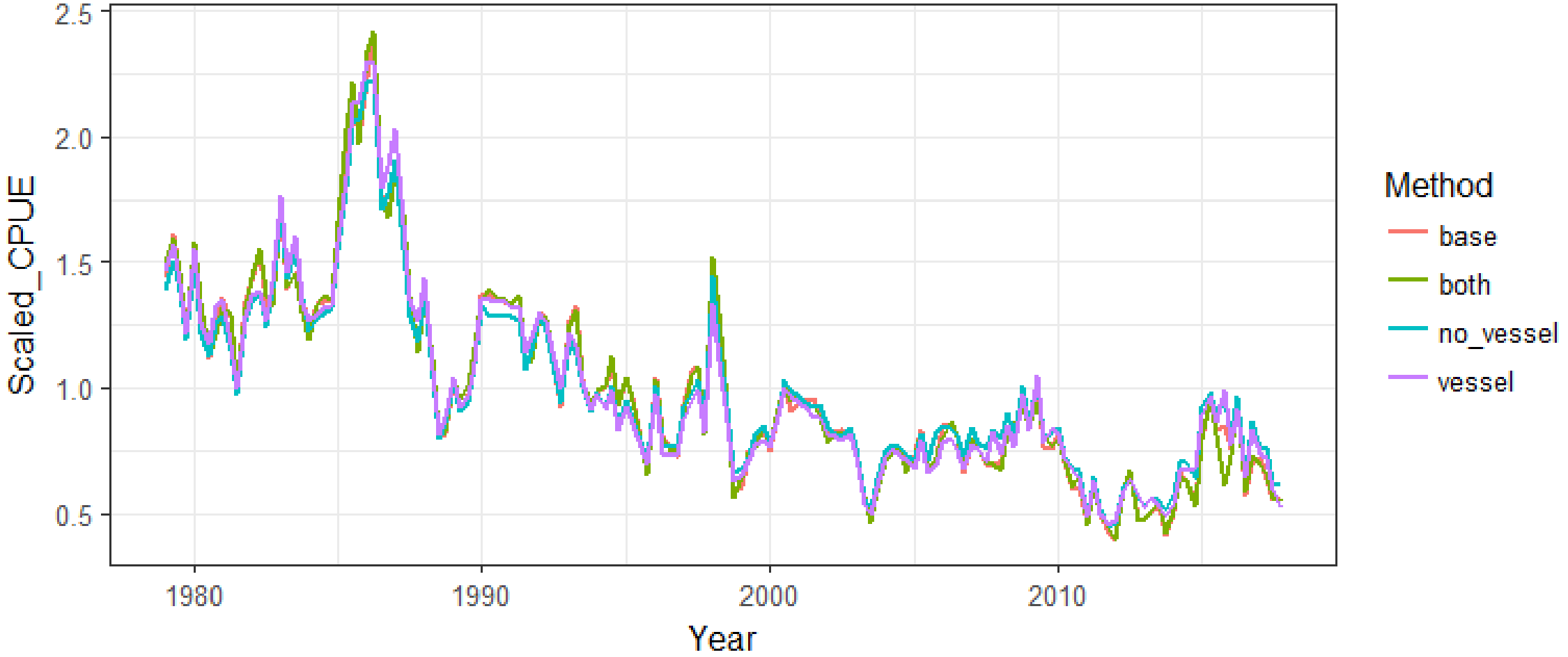
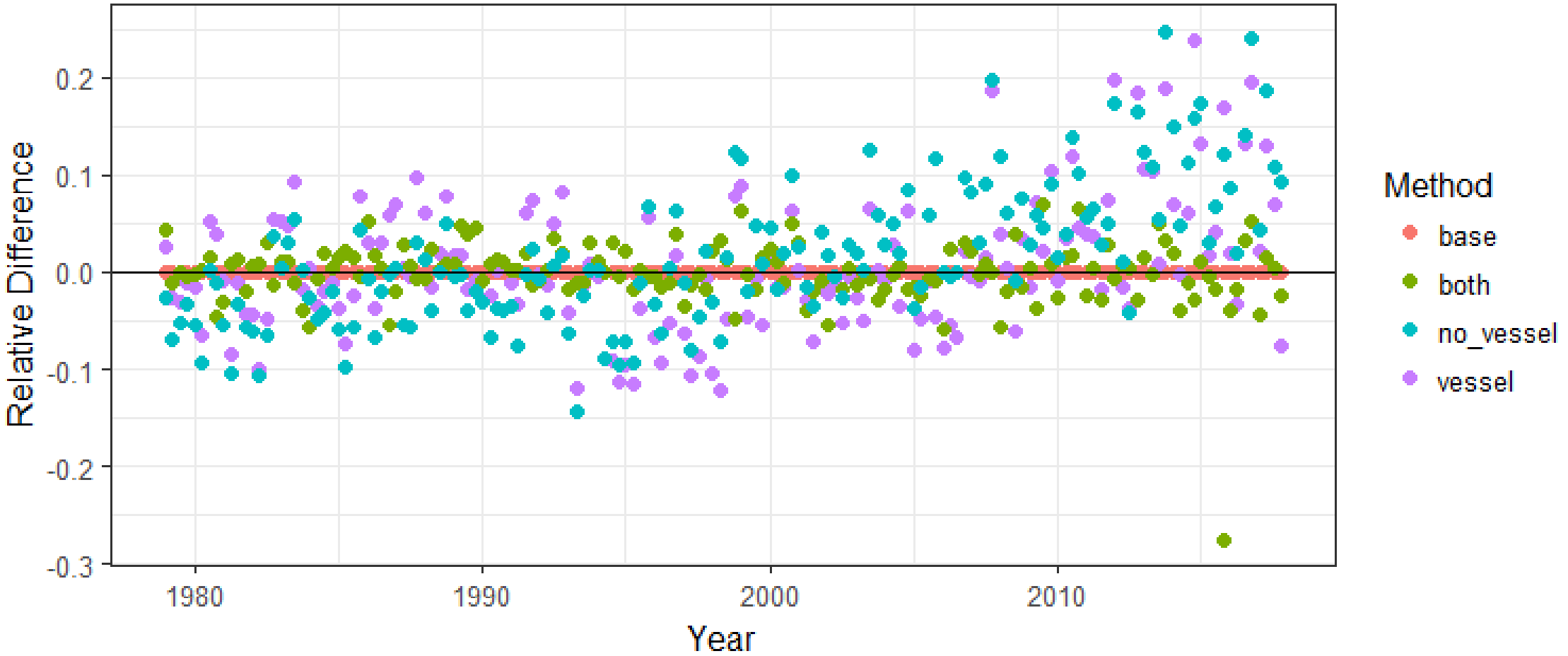


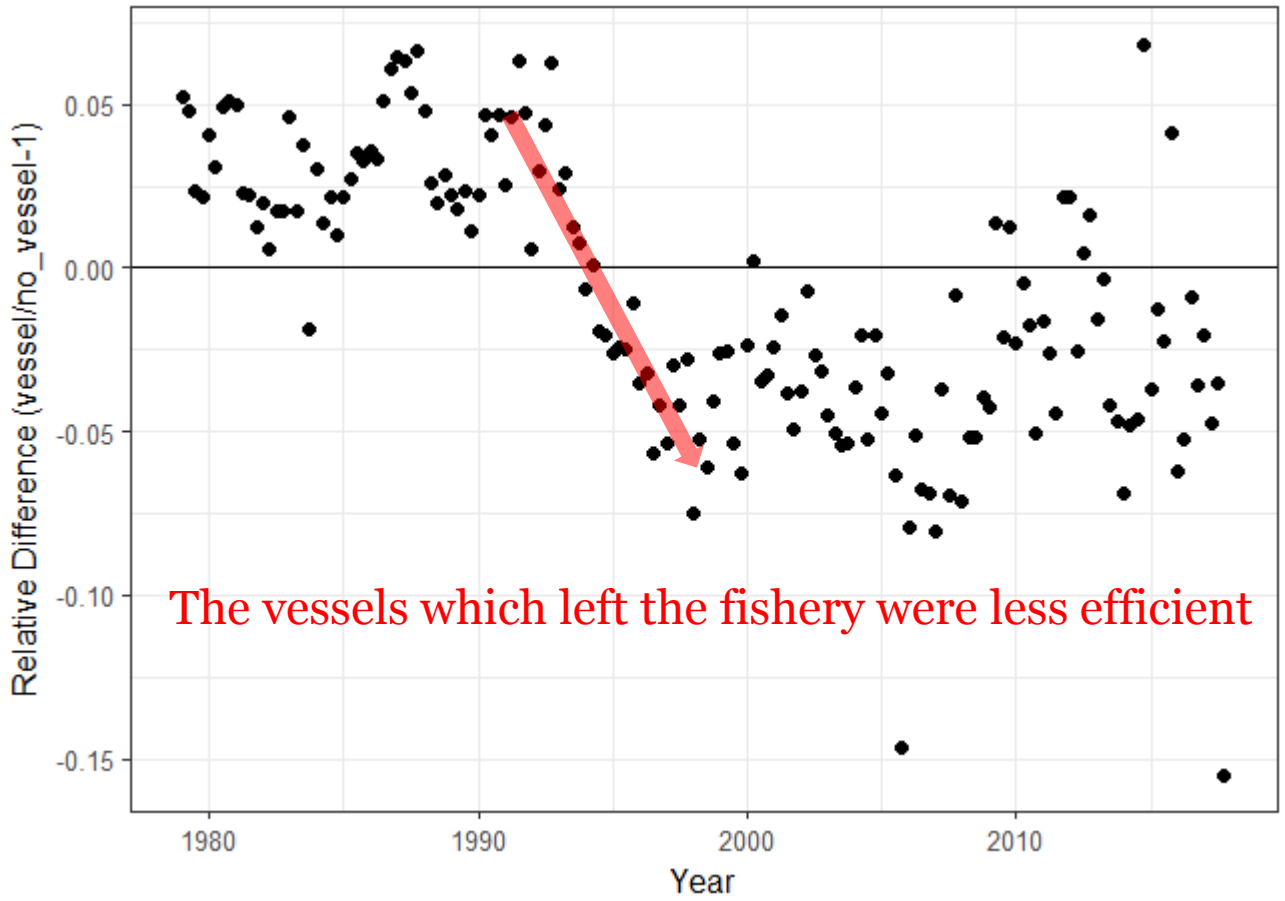
Relative difference compared to the base case

1. **How the data are aggregated (by vessel or not) is influential**
2. **Vessel effects are important**



Vessel effects on catchability are important

Relative difference between the standardized indices with and without vessel effects

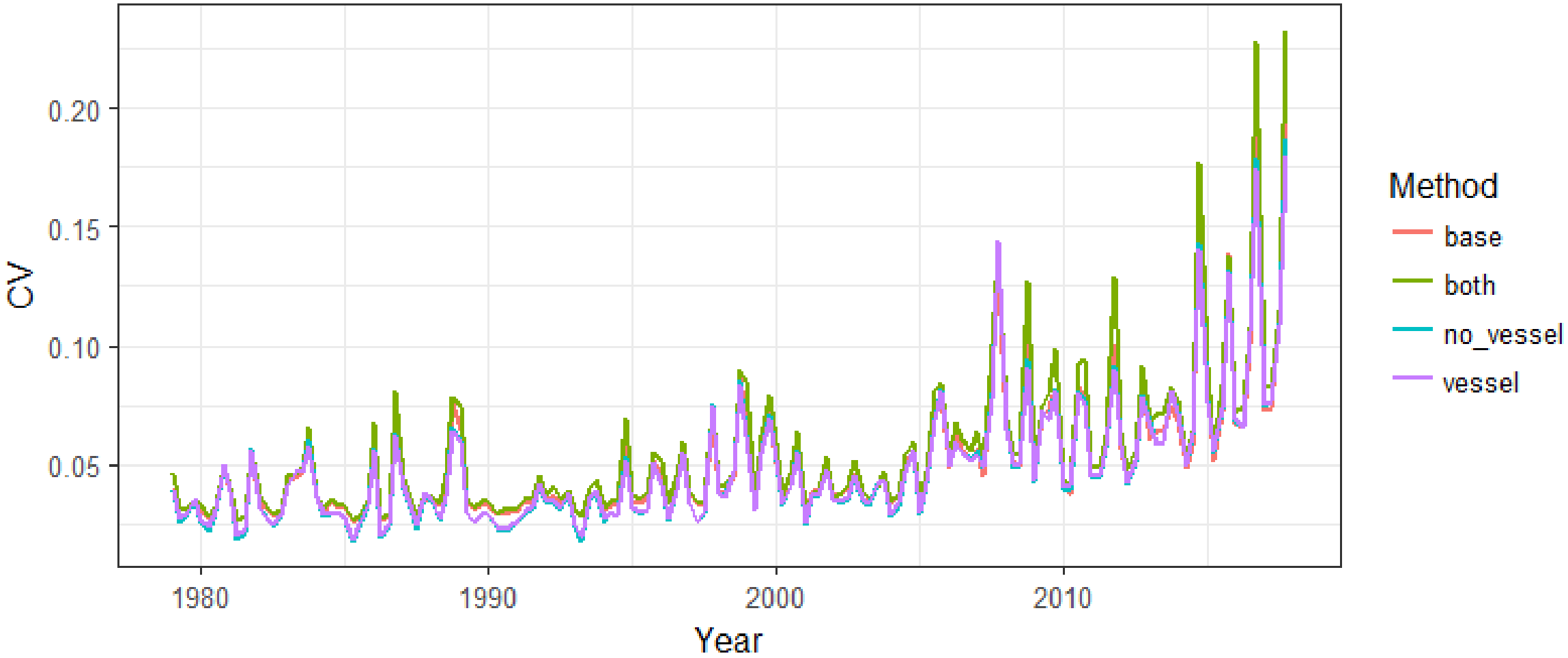


Low mean vessel efficiency

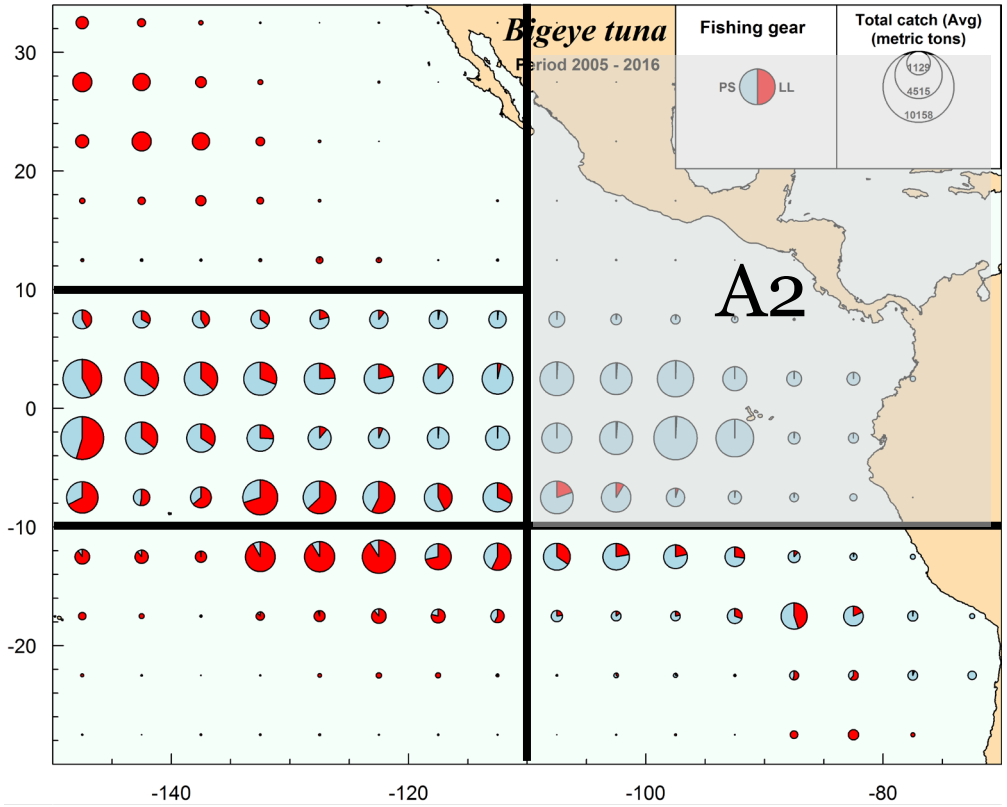
High mean vessel efficiency

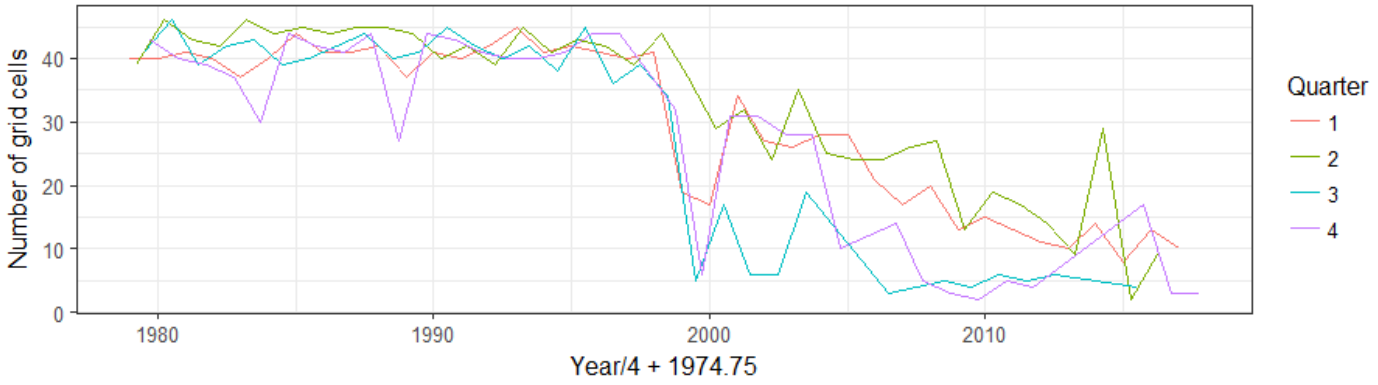
CV of the index of abundance

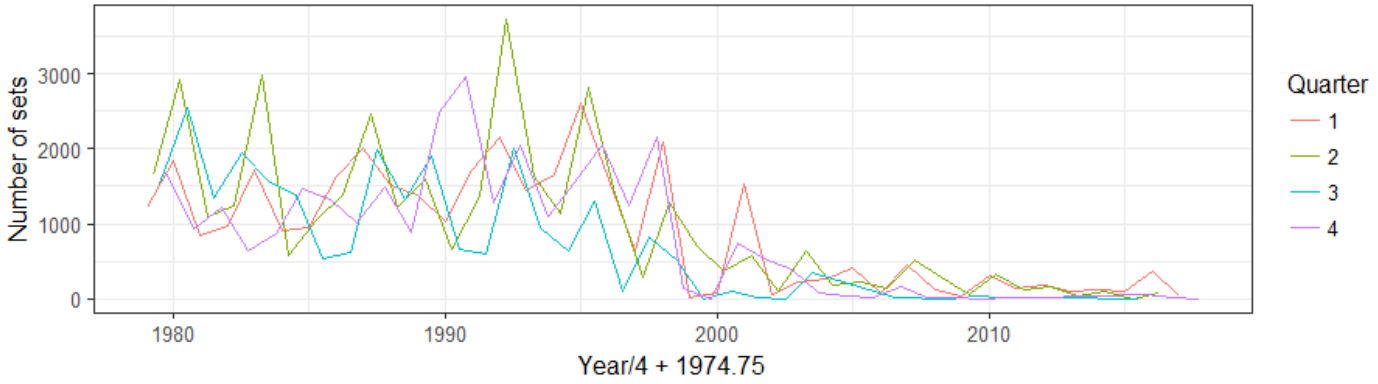
Large seasonal and interannual variations in estimated CV

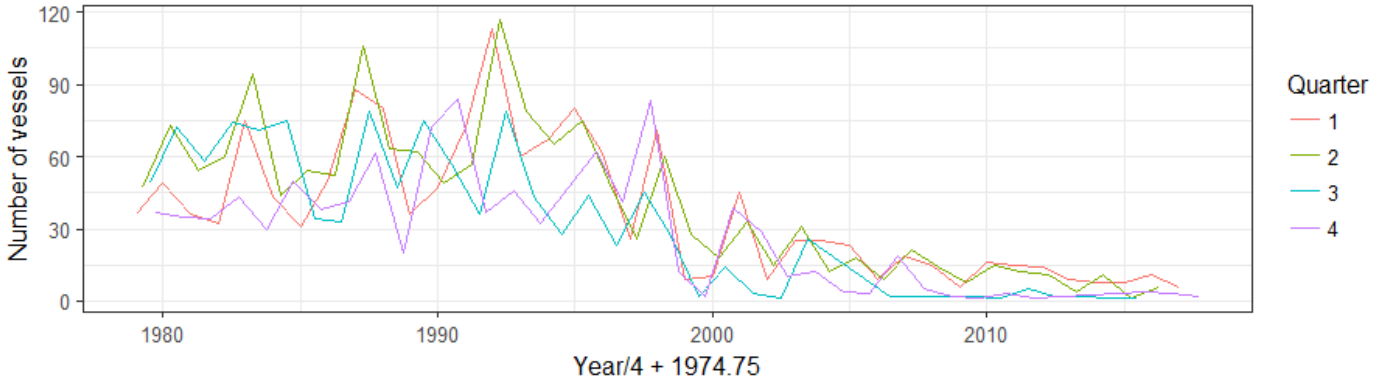


A2: number of vessels decreased since 1990









Scaled index of abundance (mean=1)

1. **base**: aggregated data for A1 by y-q, lat, and lon
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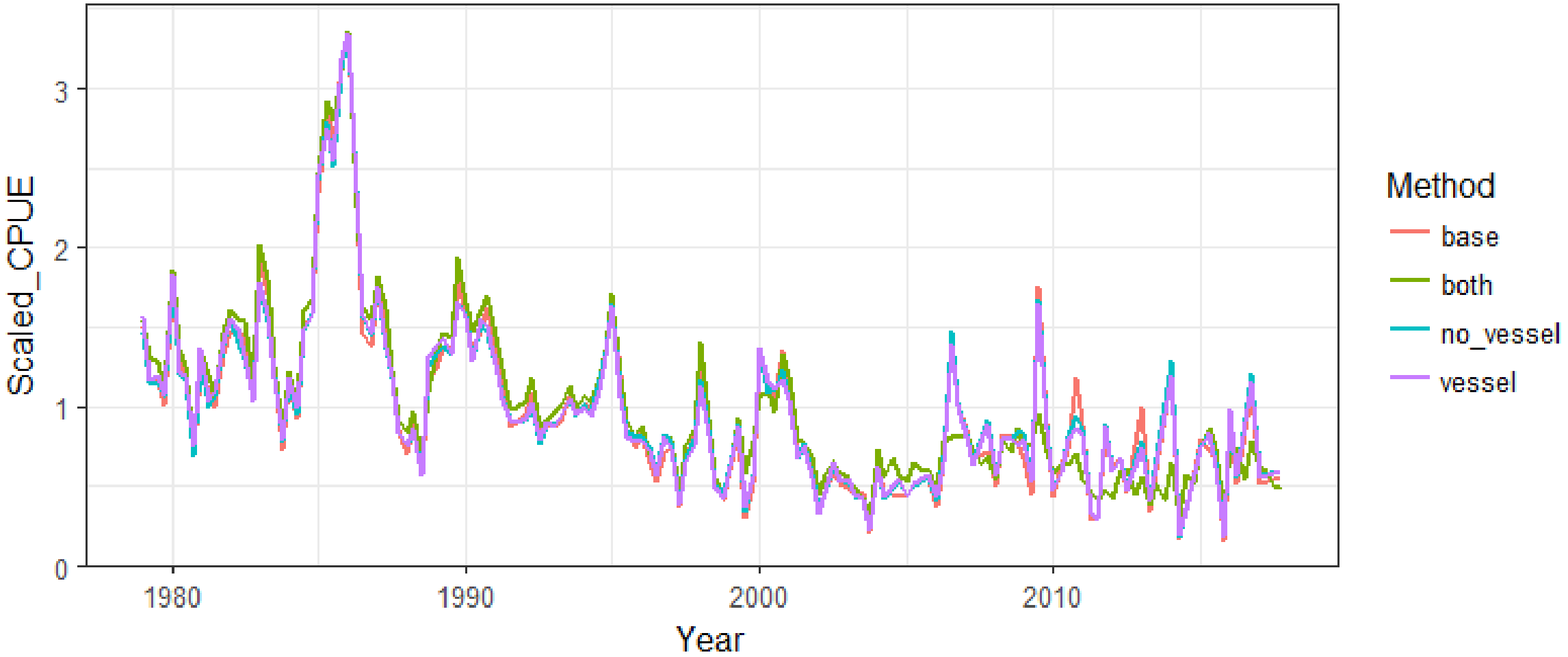
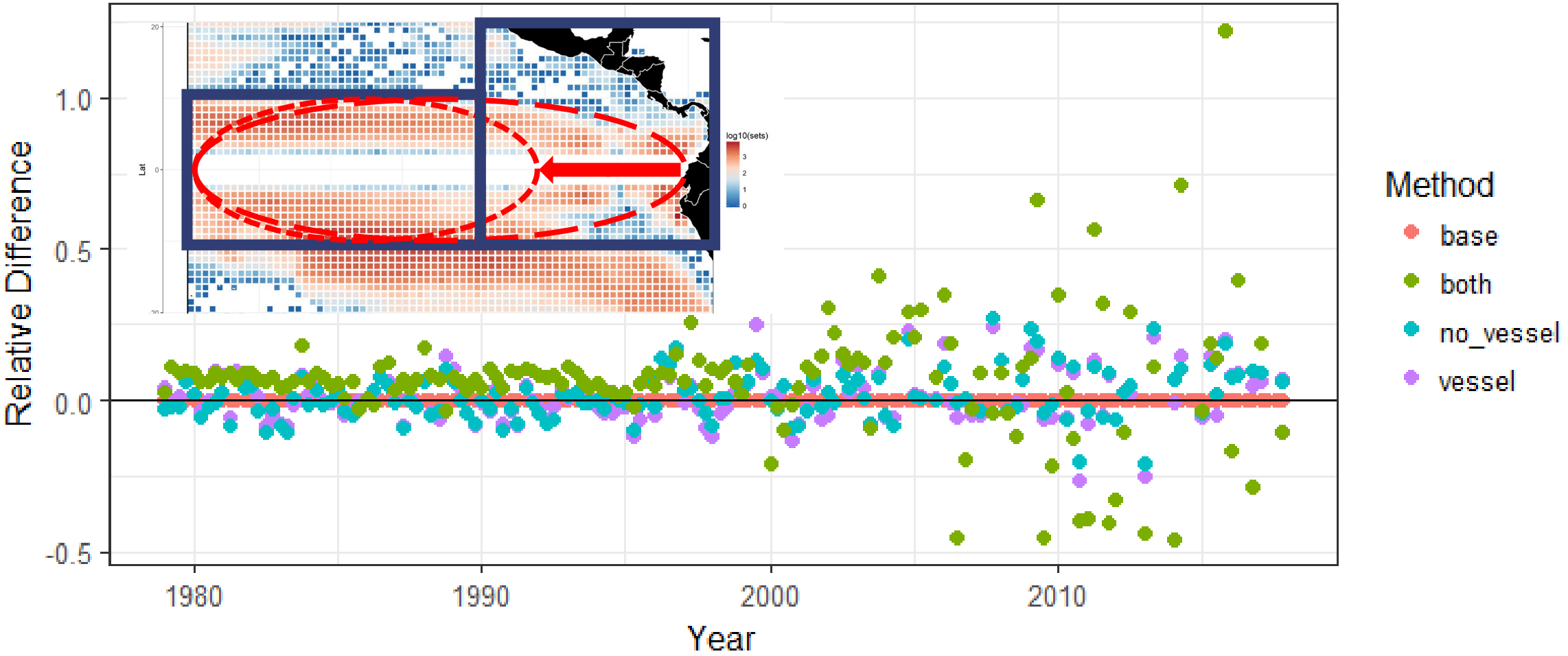


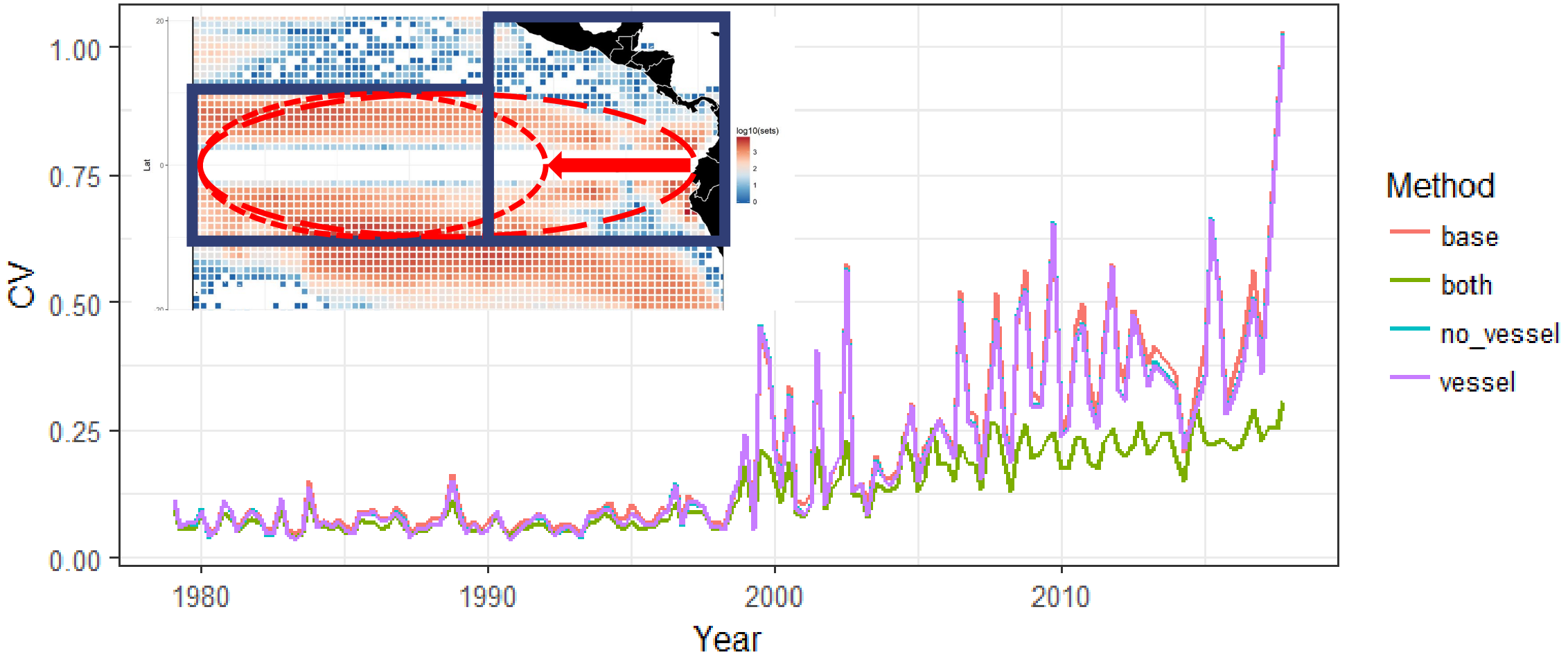
Relative difference compared to the base case

Combining the two tropical areas is very influential to the standardized index for the data-poor area



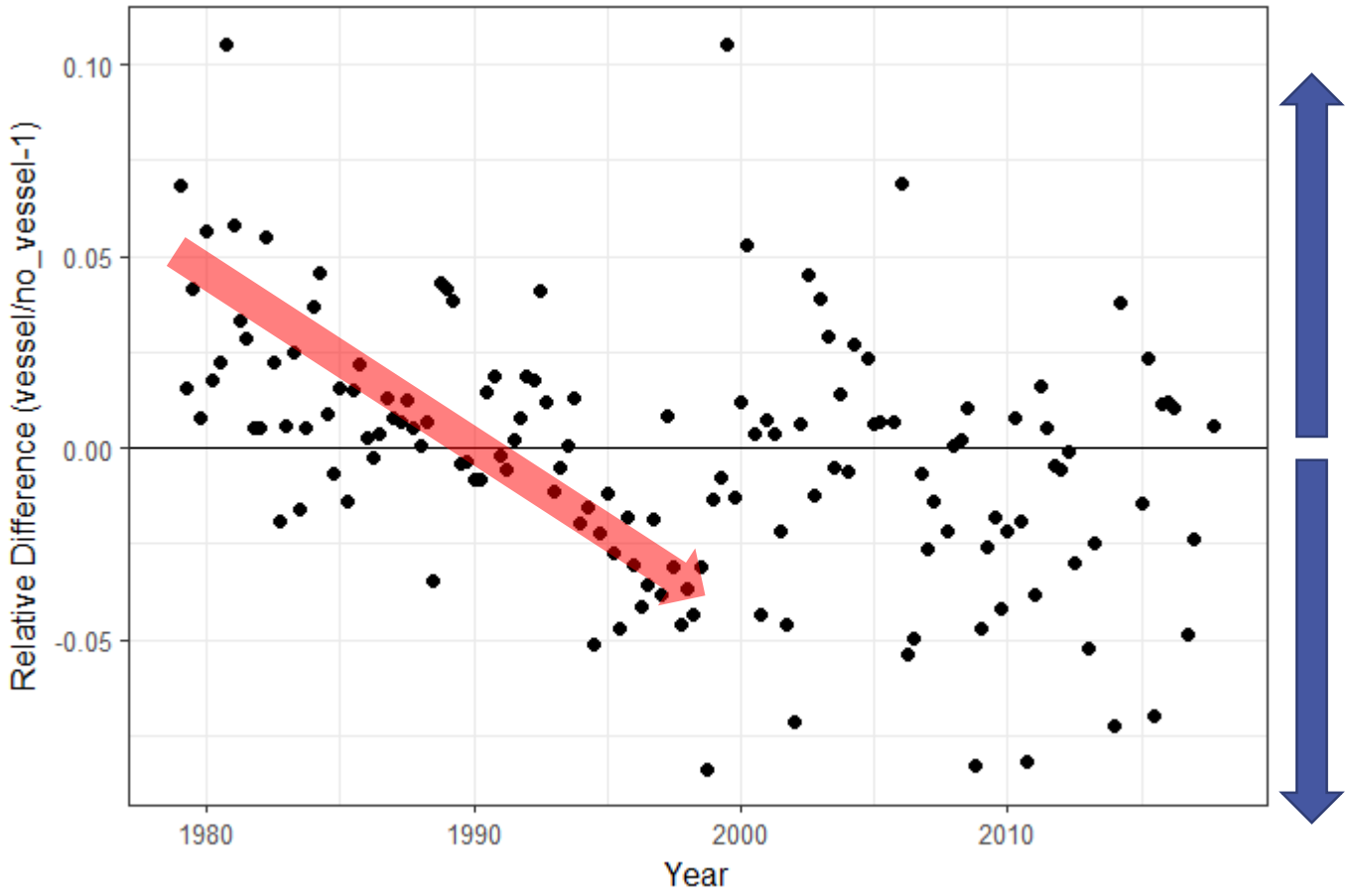
CV of the index of abundance

Combining the two tropical areas reduces the uncertainty about the standardized index for the data-poor area+period



1. Vessel effects on catchability

Relative difference between the indices with and without vessel effects



Low mean vessel efficiency

High mean vessel efficiency

2. Targeting effects on catchability

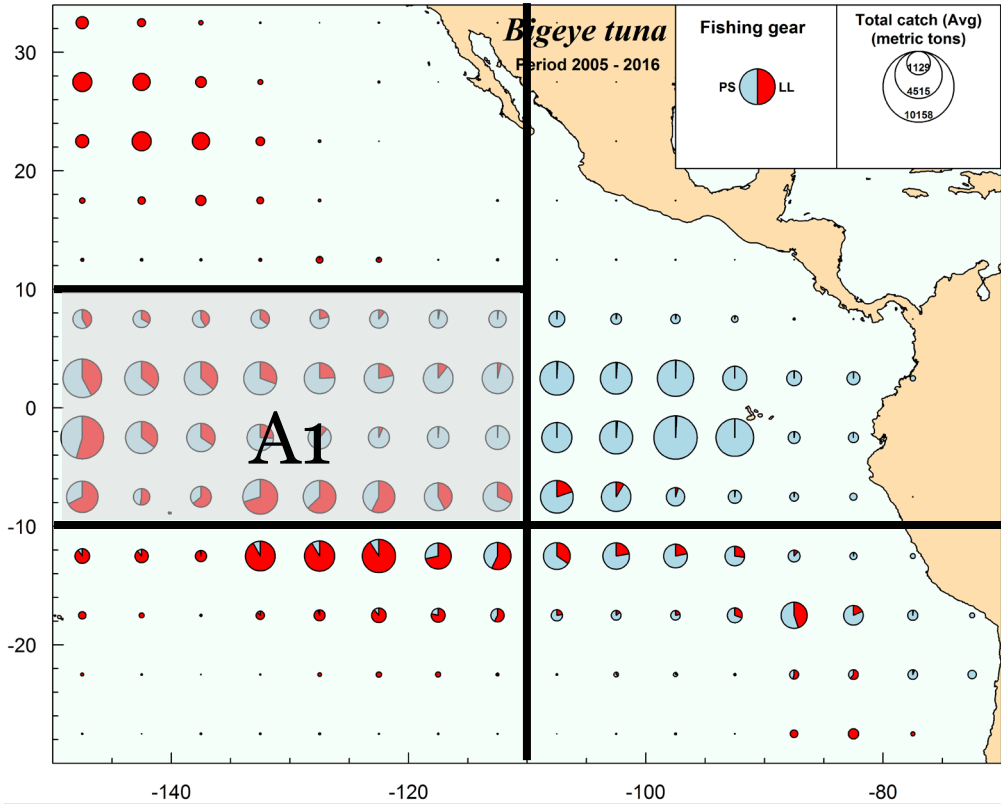
Difference between vessel effects and targeting effects:

Vessel effects: every unique vessel has a random effect on catchability

Targeting effects: every unique year-lat-lon-vessel “set” has a random effect on catchability

Data used in the targeting effect analysis

- Aggregate data by year-quarter, lat (5°), lon (5°), and vessel for A1
- Include four species: BET, SWO, and YFT
- Estimate the targeting effects on encounter probability for each yq-lat-lon-vessel “set” as random effects
- Each targeting effect is assumed to be normally distributed with a mean of zero



Model Structure (multiple species (c))

Encounter probability (p) for each catch rate observation i:

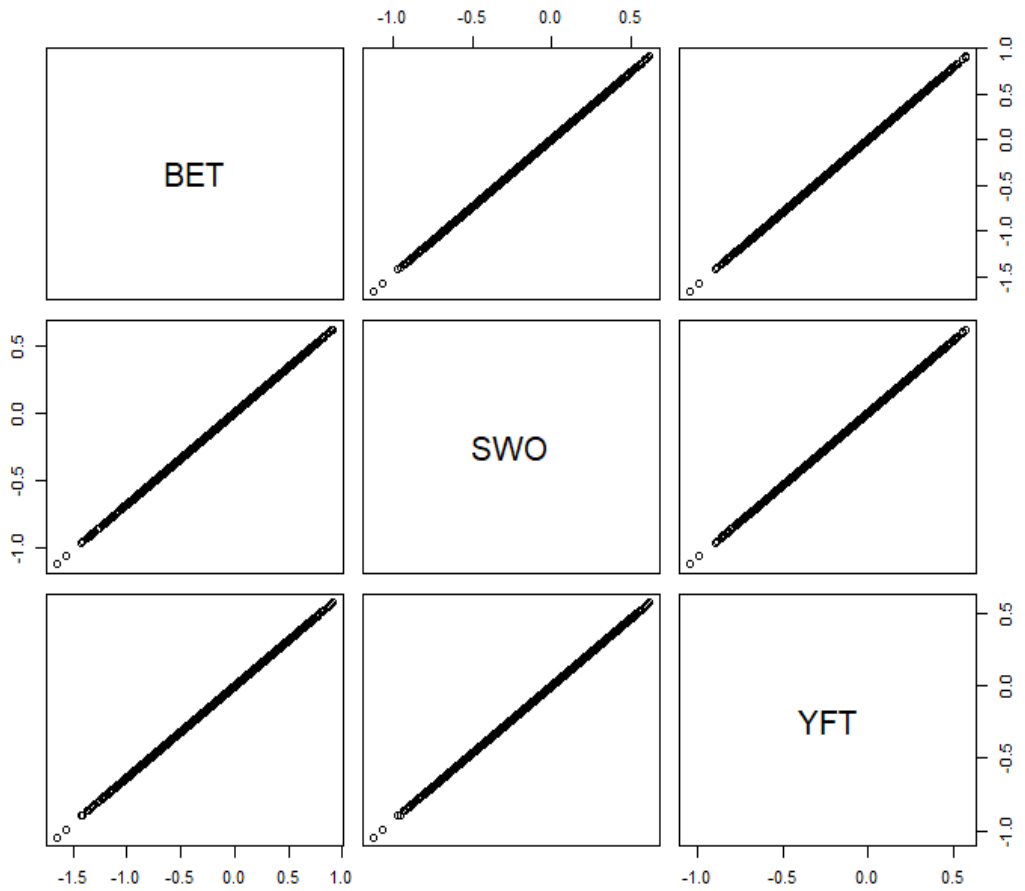
$$\begin{aligned}&\text{logit}(p_i)\\&= \beta_1(\mathrm{c}_i, t_i) + \sum_{f=1}^{n_{\omega_1}} L_{\omega 1}(c_i, f)\omega_1(s_i, f) + \sum_{f=1}^{n_{\varepsilon_1}} L_{\varepsilon 1}(c_i, f)\varepsilon_1(s_i, t_i, f)\\&+ \sum_{f=1}^{n_{\delta 1}} L_{\delta_1}(c_i, f)\delta_1(v_i, f)\end{aligned}$$

$\delta_1(v_i, f)$: targeting effects on catchability of factor f; $L_{\delta_1}(c_i, f)$: loading matrix

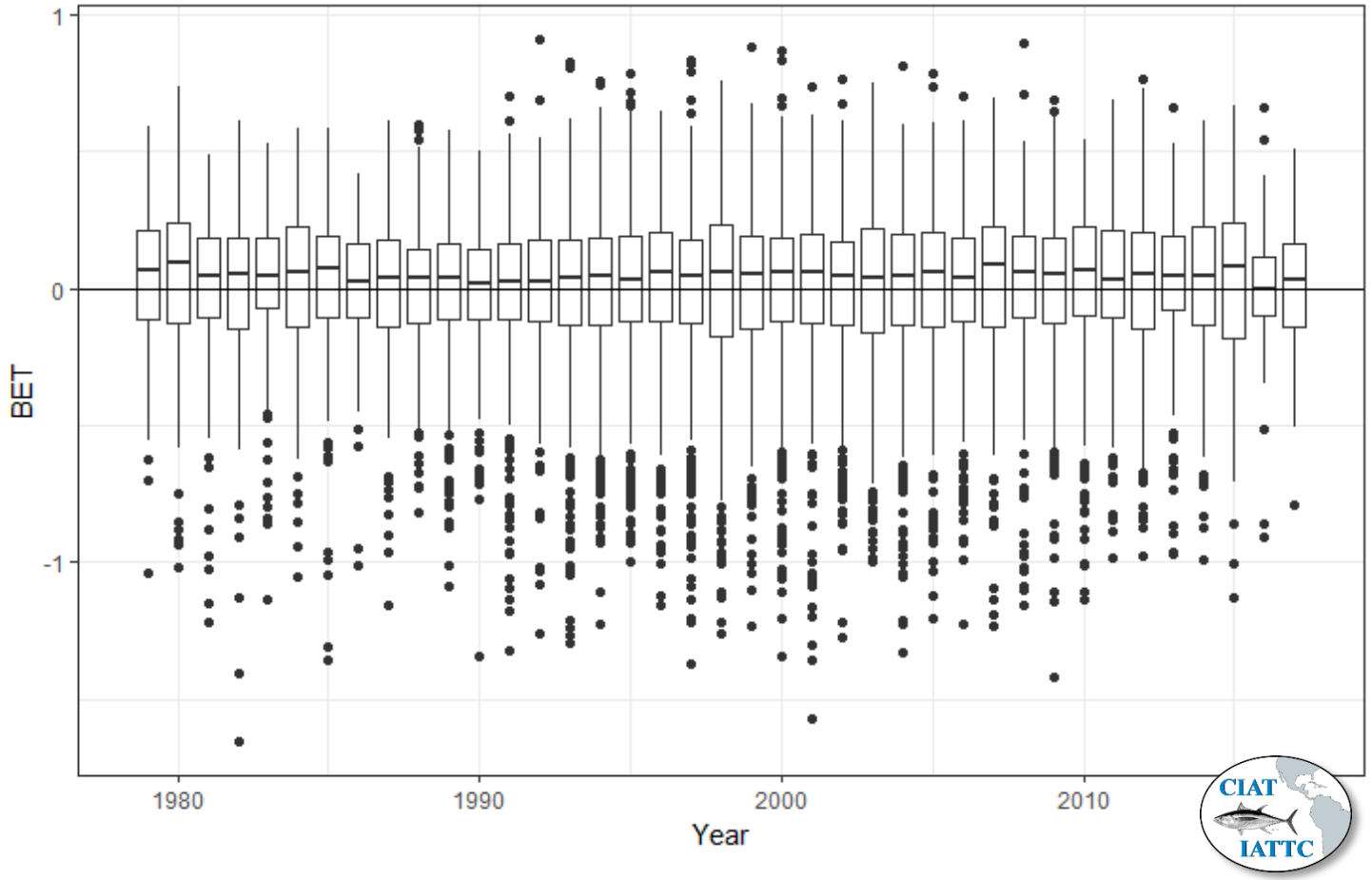
$n_{\delta 1} = 3$: the full loadings are estimated

Scatterplot of the three targeting effects

No evidence of targeting effects in A1

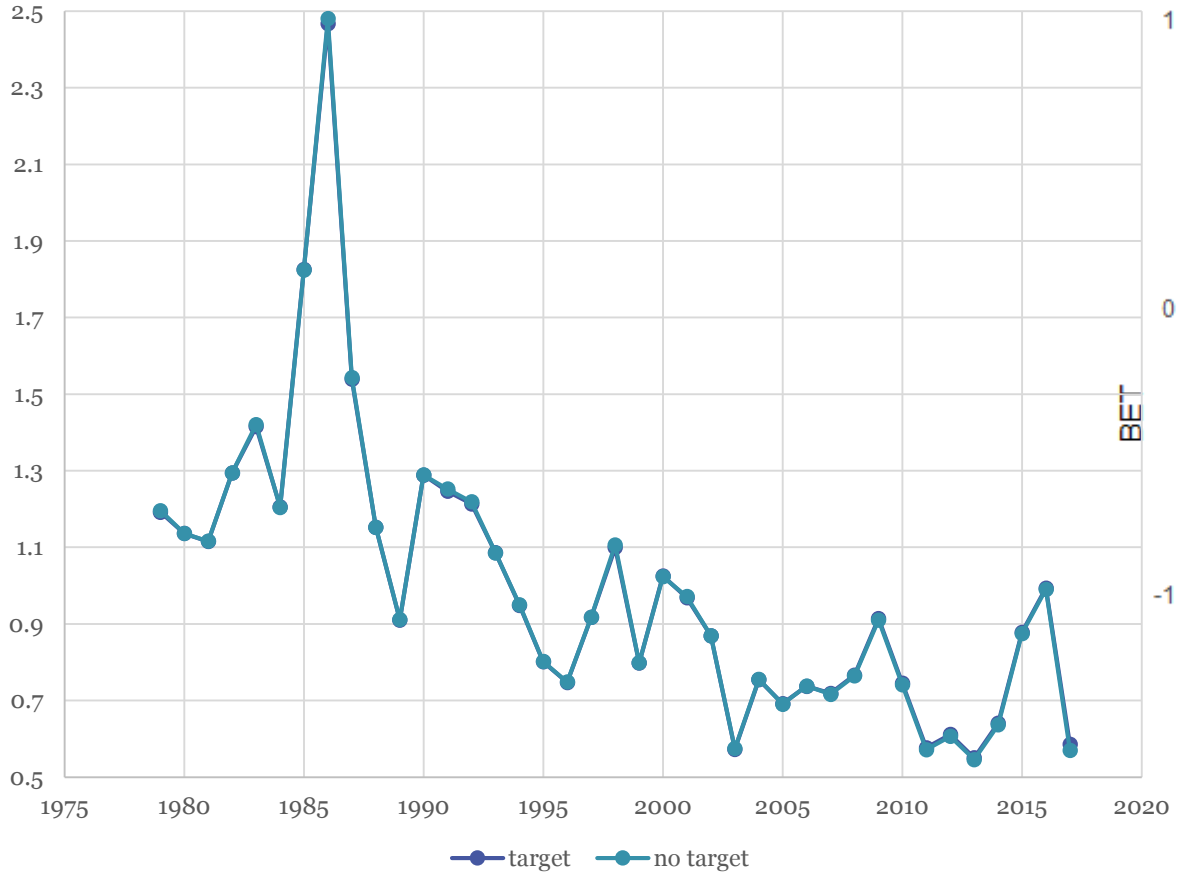


No long-term trend in BET targeting: confounded with the year effect?



Index of abundance with and without targeting effects

Negligible difference



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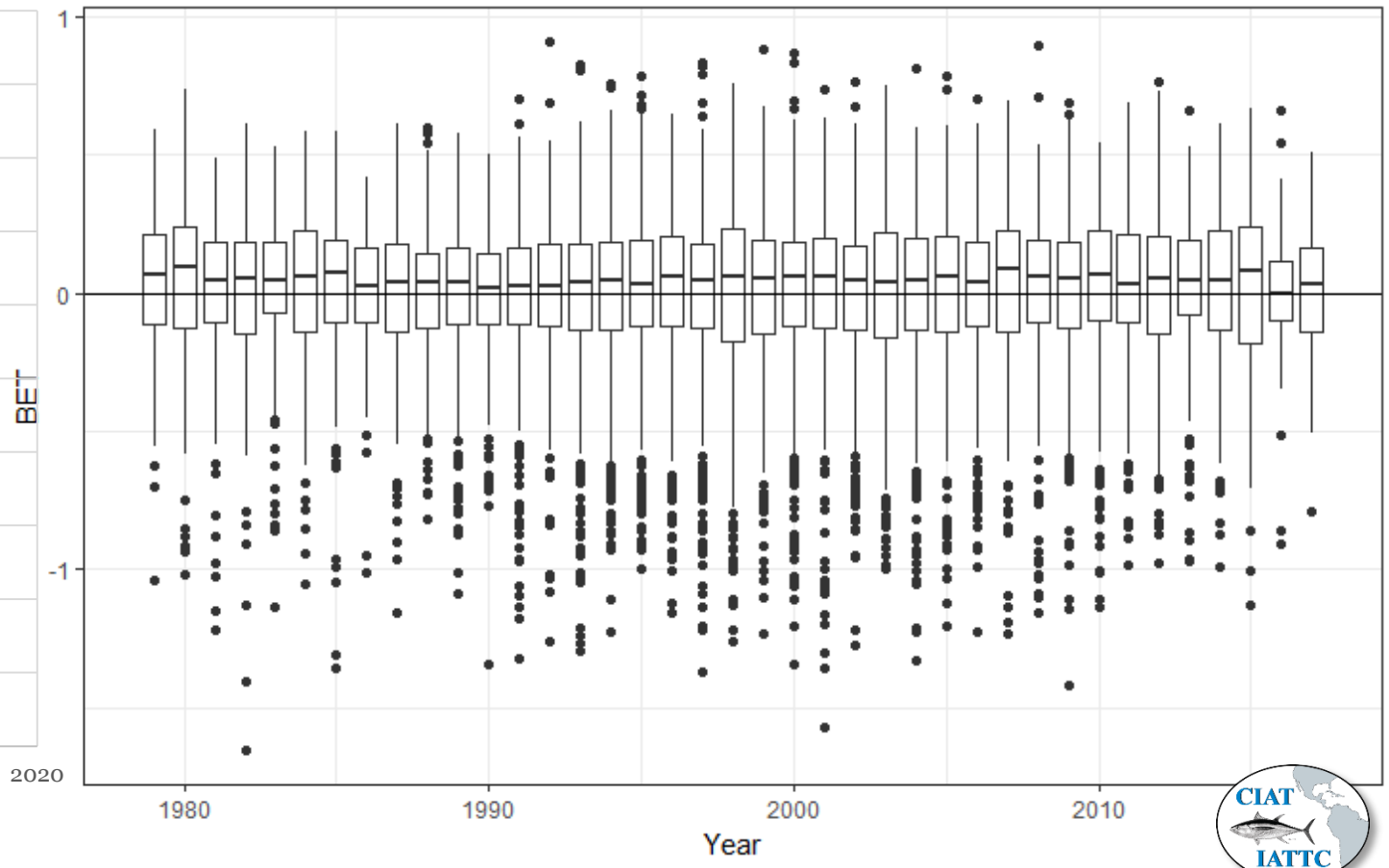
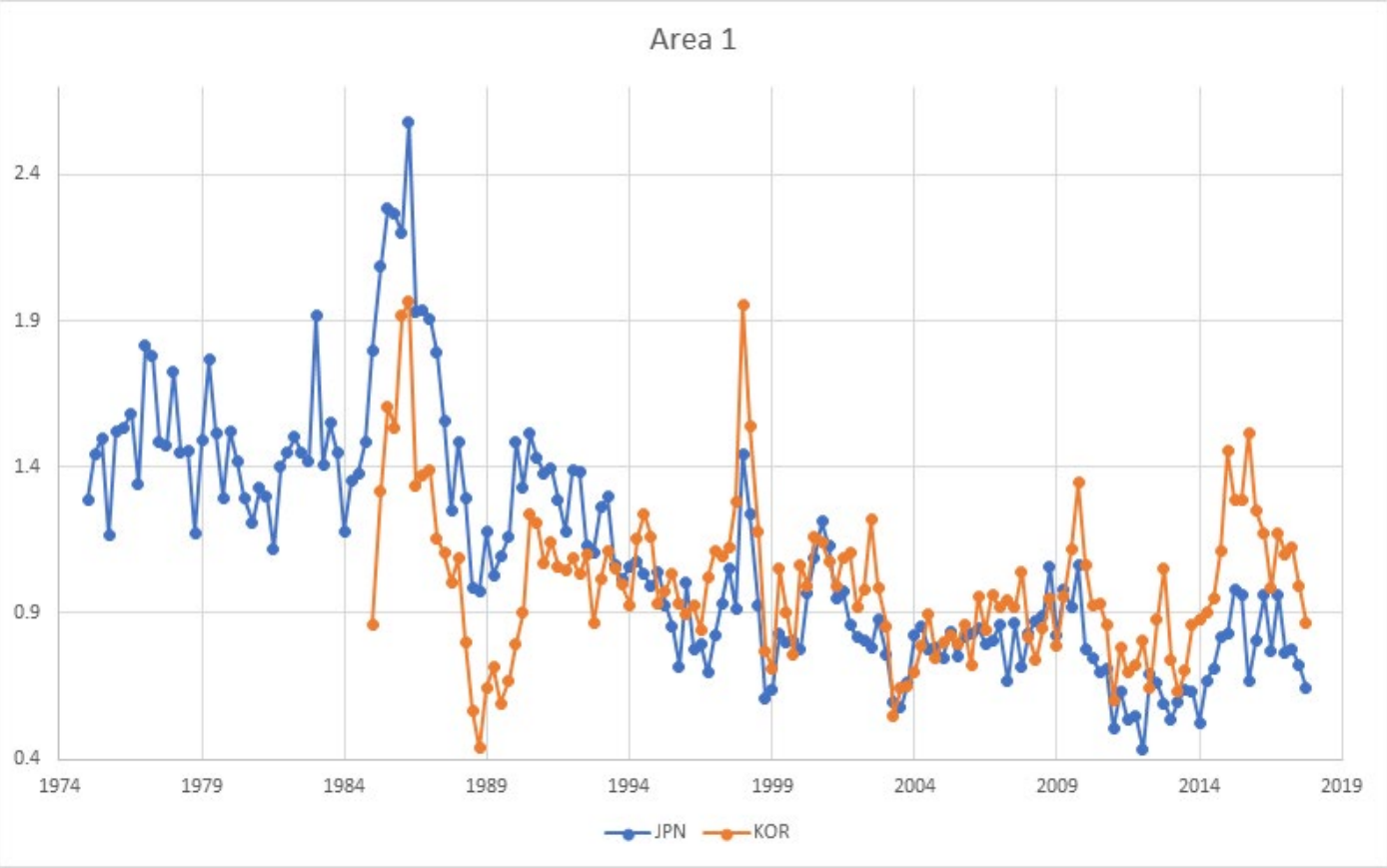
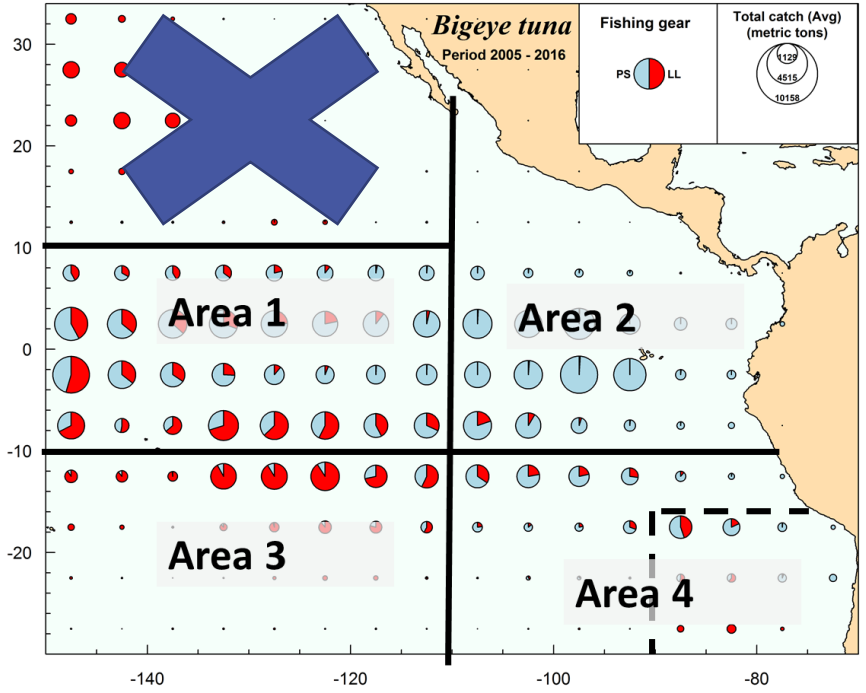


KOR CPUE vs. JPN CPUE (Area1 as an example)

Vessel effects? Targeting effects?





Discussion

- Index of abundance is sensitive to how data are weighted by vessel (aggregated by vessel or not: vessels are weighted equally or proportional to catch&effort)
- Vessel effects should be included in the standardization procedure (**more pessimistic abundance trend** with vessel effects than without) – even more pessimistic because the catchability of a vessel are likely to increased over time?
- Combining data in adjacent areas primarily impacts the estimates of index of abundance and the associated CV for **data-poor area+period**
- No targeting effect is found for BET, YFT, and SWO in A1
- Including targeting effects has a minor effect on the index of abundance when there is no trend in targeting effects over time – even when it exists, will it be absorbed into (i.e., confounded with) the year effect?

Thank you!