Comisión Interamericana del Atún Tropical
Inter-American Tropical Tuna Commission

Spatiotemporal dynamics of the dolphin-associated purse-seine fishery for yellowfin tuna in the Eastern Pacific Ocean (SAC-09-09)

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Outline

Spatiotemporal dynamics of the dolphin-associated purse-seine fishery for yellowfin tuna in the Eastern Pacific Ocean

- Background
- Data and Methods
- Results
- Discussion

Background

- Goal: develop a standardized purse-seine index of abundance for yellowfin tuna in the Eastern Pacific Ocean

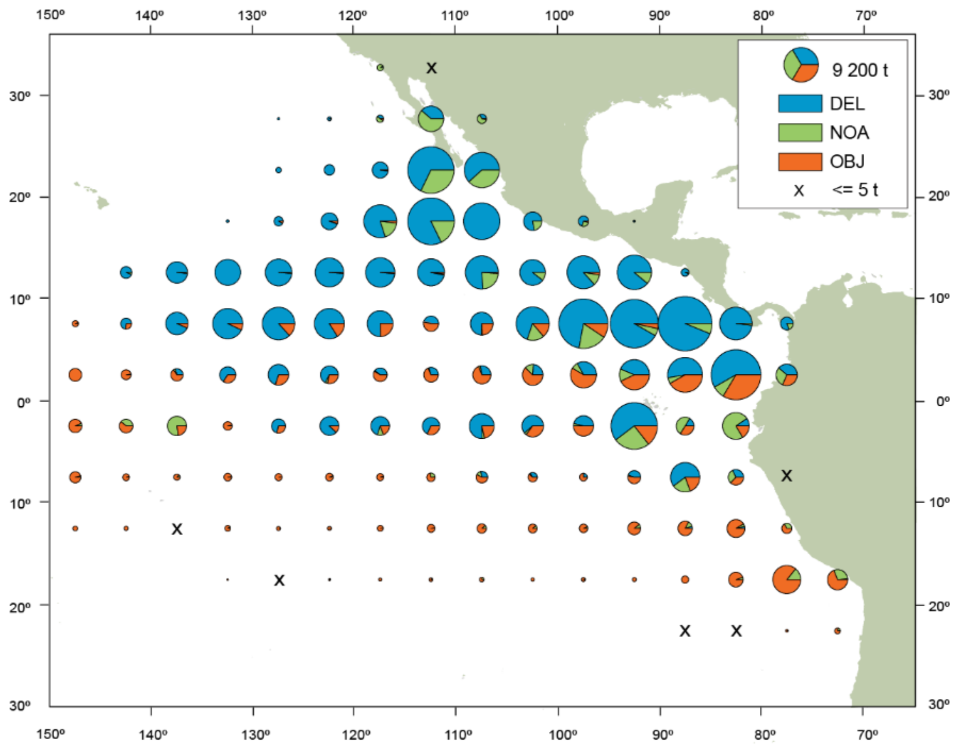
- Importance: index of abundance directly informs trend in population biomass and is a key input in the stock assessment

- Difficulties: index of abundance for yellowfin is derived solely from fishery-dependent CPUE data –> preferential sampling and sparse spatial coverage

Background

Dolphin-associated purse-seine fishery for yellowfin

- Takes the largest catch of yellowfin in the EPO
- Contributes to two of the five indices of abundance used in the stock assessment

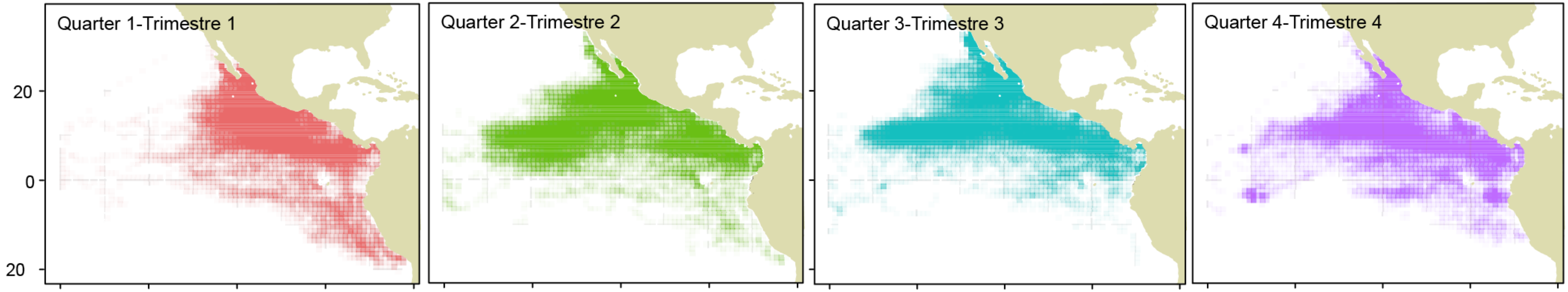


From SAC-09-03

Data

- Per-vessel catch (in metric tons) and effort (in days fishing) data from the vessels with >75% dolphin-associated sets
- Spatial resolution of 1° x 1° and temporal resolution of 1 day during 1975-2016
- Nominal CPUE = catch / effort

Spatial coverage of the dolphin-associated fishery by quarter



Methods: spatiotemporal modelling

delta-generalized linear mixed model: VAST (Thorson and Barnett, 2017)

separately models encounter probability (p) and positive catch rate (λ):

$$p_i = logit^{-1}\left(\beta_1(t_i) + L_{\omega 1}\omega_1(s_i) + L_{\varepsilon 1}\varepsilon_1(s_i, t_i) + L_{\delta 1}\delta_1(v_i)\right)$$

$$\lambda_i = \exp\left(\beta_2(t_i) + L_{\omega 2}\omega_2(s_i) + L_{\varepsilon 2}\varepsilon_2(s_i, t_i) + L_{\delta 2}\delta_2(v_i)\right)$$

$\beta_1(t_i)$ & $\beta_2(t_i)$: intercept in year t_i
$\omega_1(s_i)$ & $\omega_2(s_i)$: spatial variation at location s_i
$\varepsilon_1(s_i, t_i)$ & $\varepsilon_2(s_i, t_i)$: spatiotemporal variation at location s_i in year t_i
$\delta_1(v_i)$ & $\delta_2(v_i)$: effect of vessel v_i on catchability

Methods: spatiotemporal modelling

Autocorrelated spatial and spatiotemporal residuals:

$\omega_1 \sim \mathrm{MVN}(\mathbf{0}, \mathbf{R}_1)$

$\omega_2 \sim \mathrm{MVN}(\mathbf{0}, \mathbf{R}_2)$

$\varepsilon_1(,t) \sim \mathrm{MVN}(\mathbf{0}, \mathbf{R}_1)$

$\varepsilon_2(,t) \sim \mathrm{MVN}(\mathbf{0}, \mathbf{R}_2)$

where

$$\mathrm{R}_1(s,s') = \frac{1}{2^{\nu-1}\Gamma(n)} \times (\kappa_1|\mathbf{H}(s-s')|)^{\nu} \times K_{\nu}(\kappa_1|\mathbf{H}(s-s')|)$$

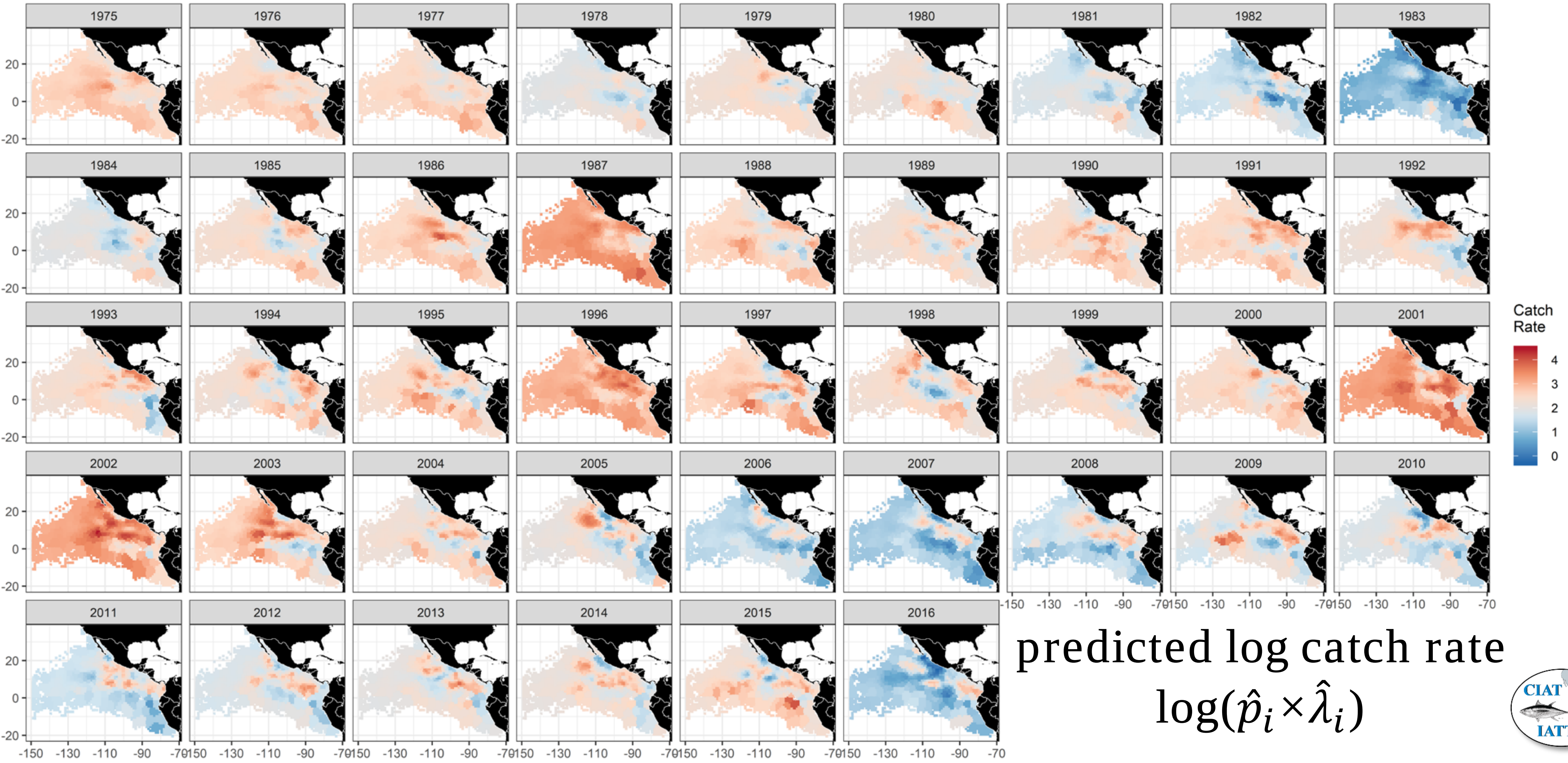
$$\mathrm{R}_2(s,s') = \frac{1}{2^{\nu-1}\Gamma(n)} \times (\kappa_2|\mathbf{H}(s-s')|)^{\nu} \times K_{\nu}(\kappa_2|\mathbf{H}(s-s')|)$$

decorrelation distance (κ_2)

geometric anisotropy ($\mathbf{H}$)

Matern smoothness (ν)

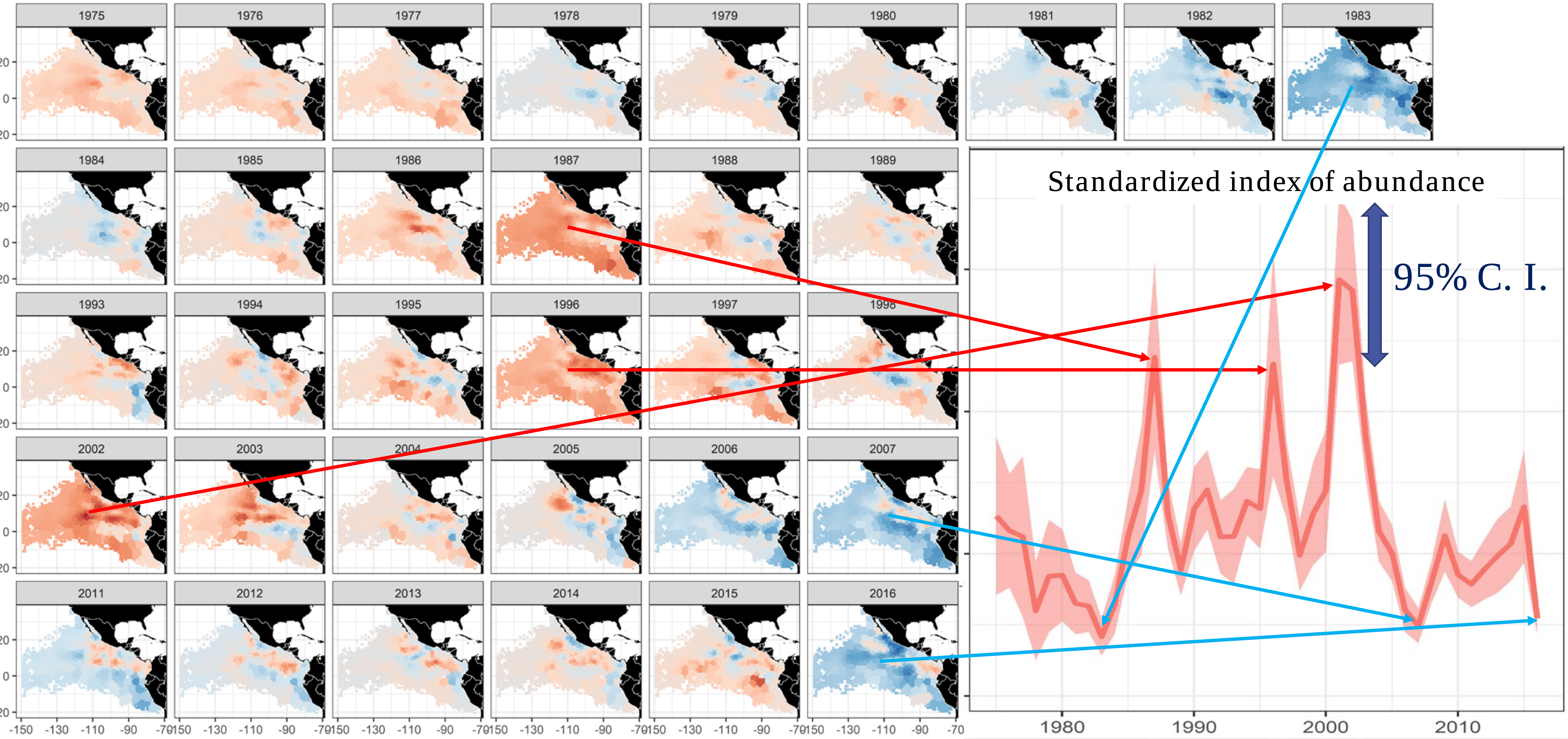
Results: quarter1 as an example



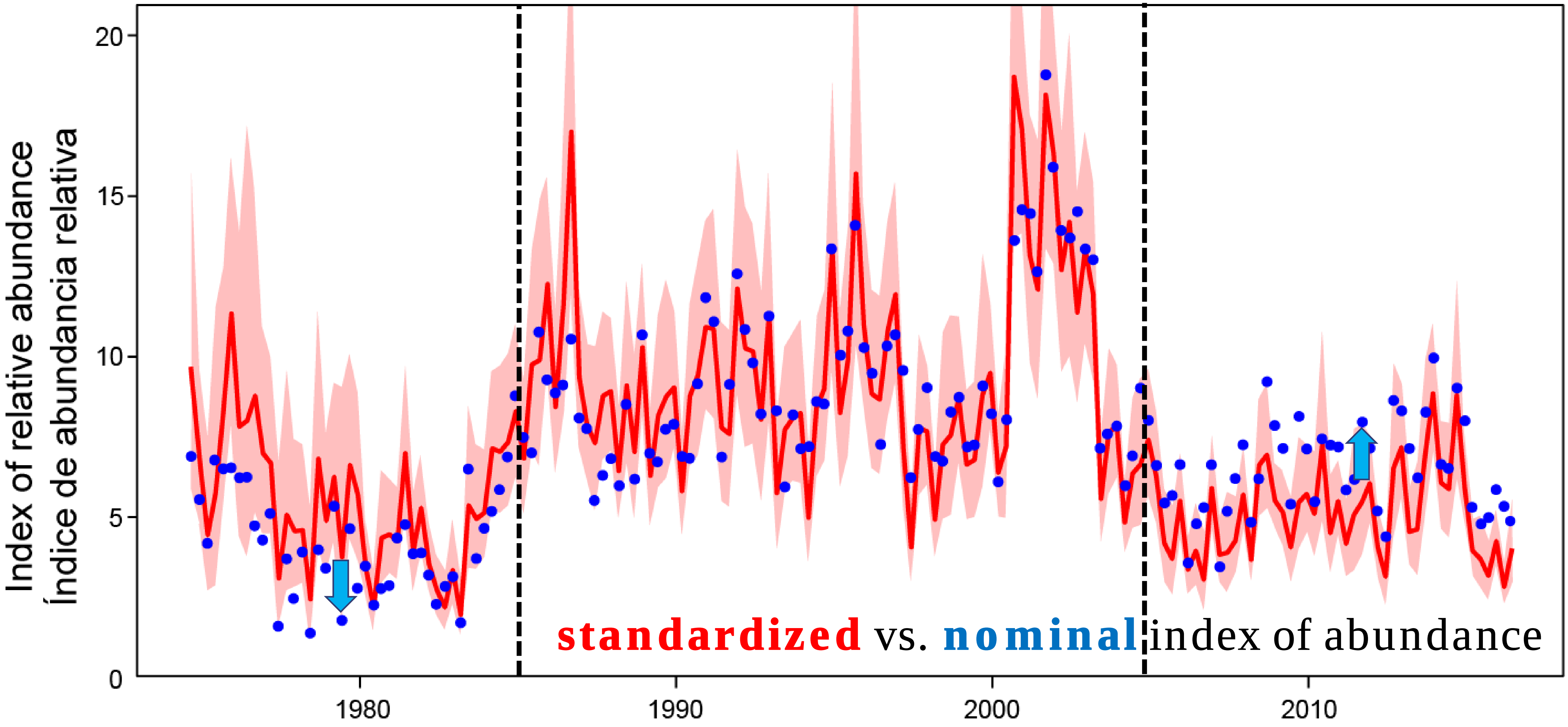
predicted log catch rate

$$\log(\hat{p}_i \times \hat{\lambda}_i)$$

Results: quarter1 as an example



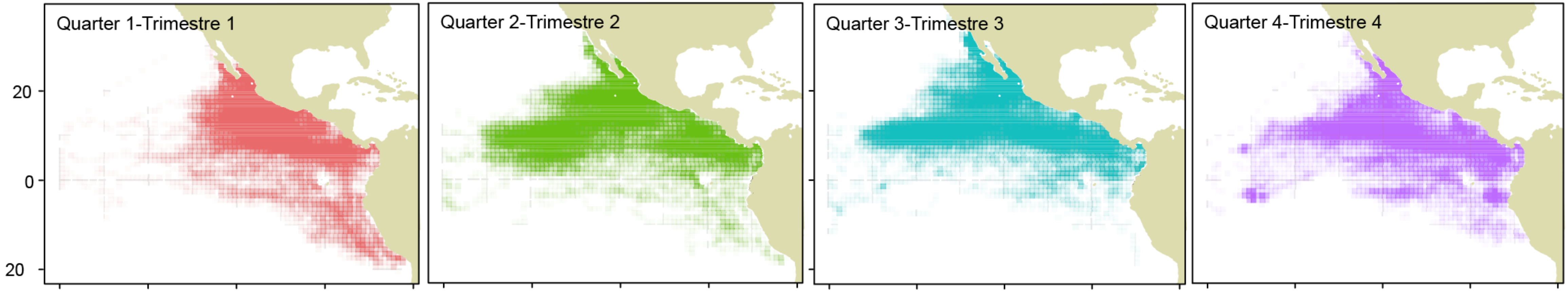
Results: combine all four quarters



Discussion: potential biases in the standardized index

Due to a large seasonal variation in fishing locations, each quarter's data were fitted to the spatiotemporal model separately.

Spatial coverage of the dolphin-associated fishery by quarter



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Discussion: potential biases in the standardized index

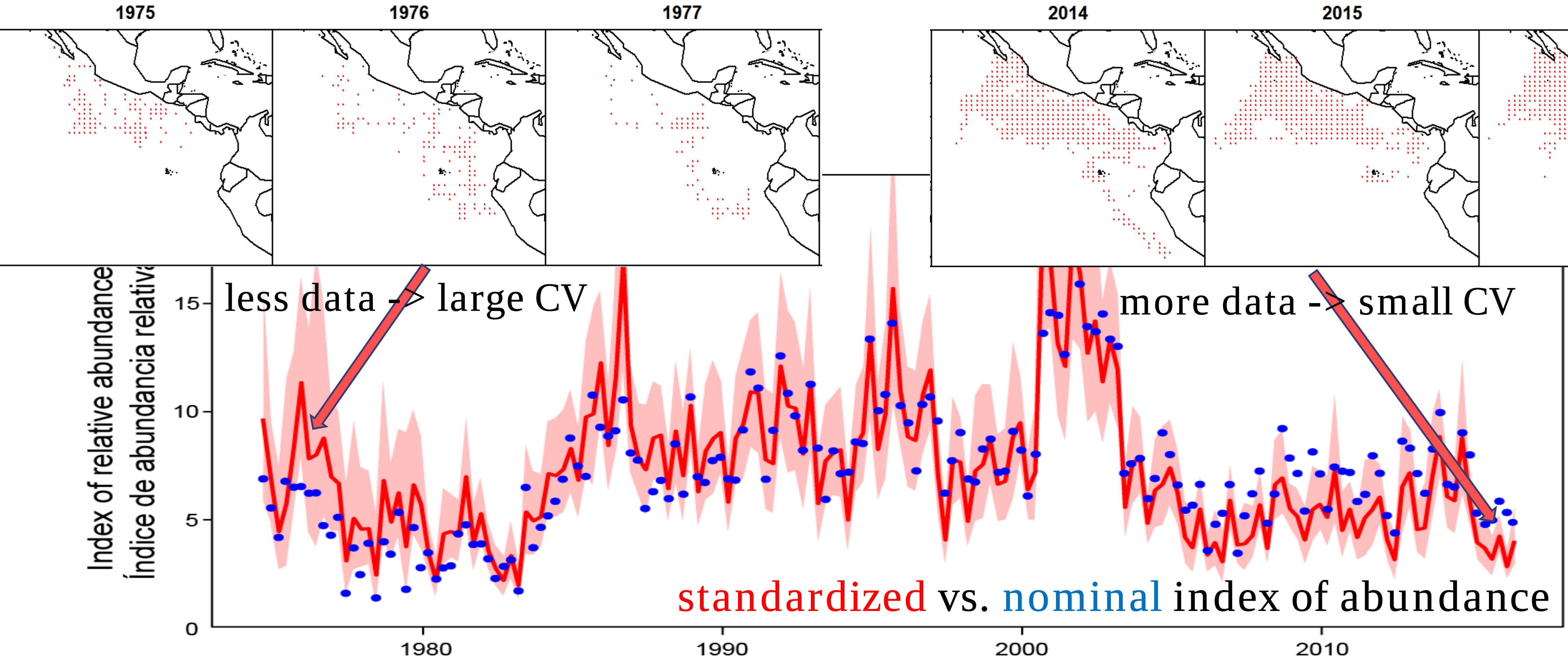
Due to a large seasonal variation in fishing locations, each quarter's data were fitted to the spatiotemporal model separately.

1. Catchability could be quarter-specific (environmental conditions vary from quarter to quarter)
2. Autocorrelations in the spatial and spatiotemporal residuals could be different (driven by different processes: static vs. dynamic)
3. Imputed catch rates for the unsampled region could be biased in different ways by quarter

Discussion: standardized index vs. nominal index

The standardized index represents an **improvement** because the approach:

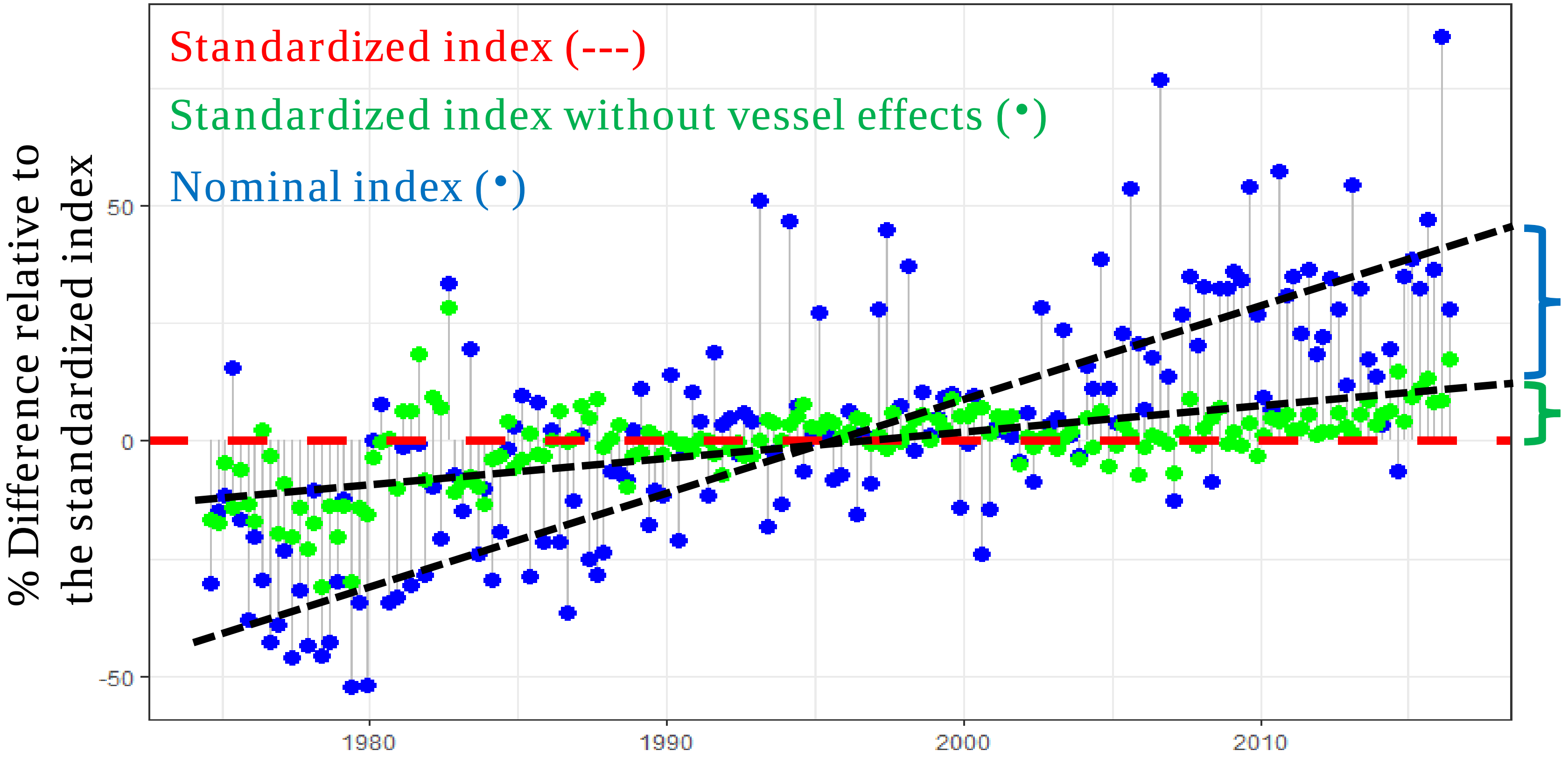
1. Estimates the coefficient of variation (CV) of the index



Discussion: standardized index vs. nominal index

The standardized index represents an **improvement** because the approach:

2. Includes vessel effects on catchability
3. Accounts for preferential sampling



Each vessel was better at finding fishing hotspots over time -> overestimating the trend in biomass

New vessels were more efficient than old vessels -> overestimating the trend in biomass

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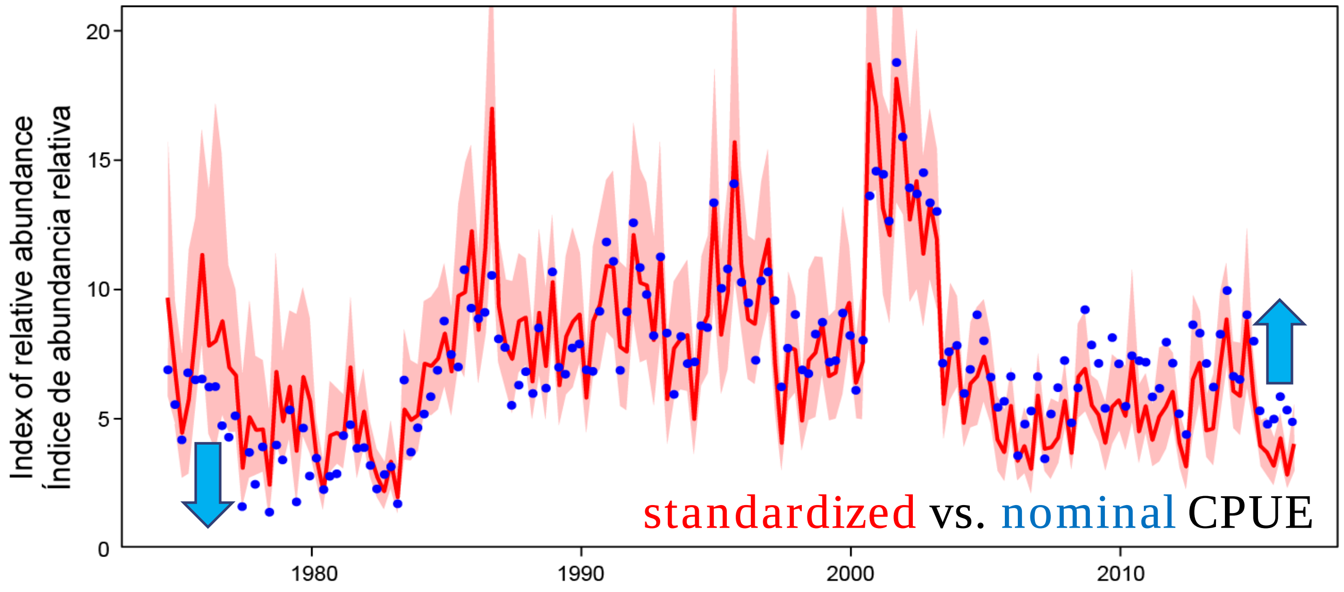
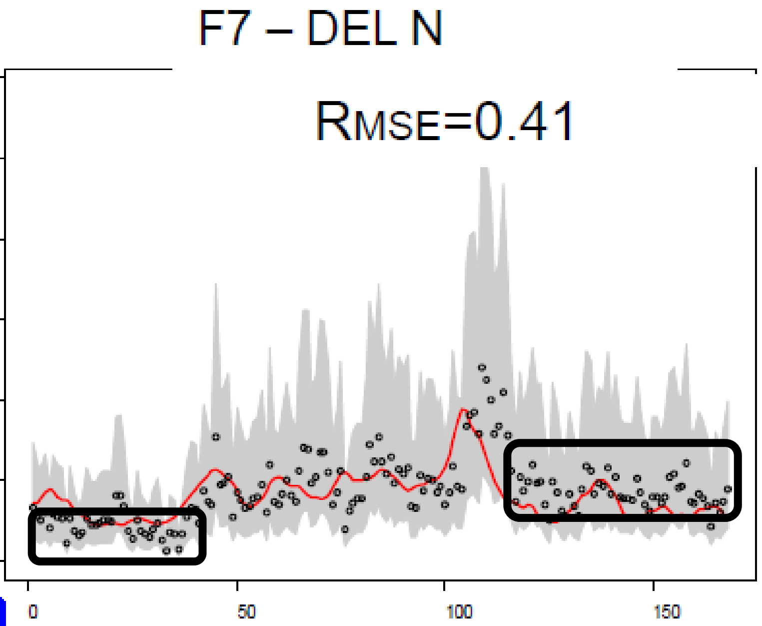
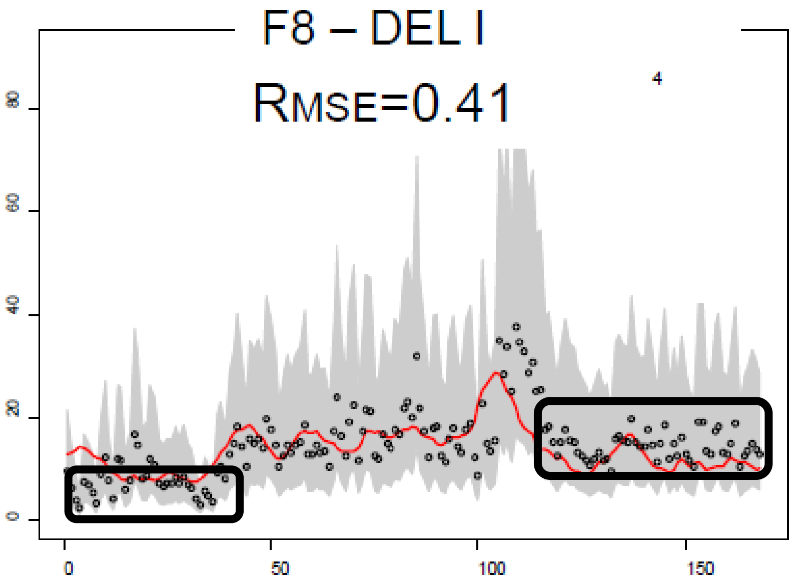
Discussion: next phase of this project

Replace the nominal CPUE by the standardized CPUE for the dolphin-associated purse-seine fishery







<- From last year's assessment report

Red line: model prediction

Black dots: nominal CPUE

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Questions