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TROPICAL TUNA BIOMASS INDICATORS FROM ECHOSOUNDER BUOYS IN THE EPO (2012-2021)

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Introduction

Index of abundance of juvenile skipjack tuna in the Eastern Pacific Ocean derived from echosounder buoys (2012-2021)

Indices of abundance from acoustic buoys?

ICCAT

2015: Towards a Tropical Tuna Buoy-derived Abundance Index (TT-BAI)

2019: A novel index of abundance of juvenile yellowfin tuna in the Atlantic ocean derived from echosounder buoys ------- YFT Assessment

2021: Index of abundance of juvenile bigeye tuna in the Atlantic ocean derived from echosounder buoys ------- BET Assessment

2022: Index of abundance of skipjack tuna in the Atlantic Ocean derived from echosounder buoys (2010-2020) ------- SKJ Assessment

IOTC

2019: A novel index of abundance of juvenile yellowfin tuna in the Atlantic ocean derived from echosounder buoys

2020: A novel index of abundance of skipjack in the Indian Ocean derived from echosounder buoys

IATTC

2021: Informational paper TROPICAL TUNA BIOMASS INDICATORS FROM ECHOSOUNDER BUOYS IN THE EPO (2012-2020)

2020-2022: Agreement between the IATTC and AZTI for the development and implementation of a project on “developing alternative buoy-derived tuna biomass indexes”

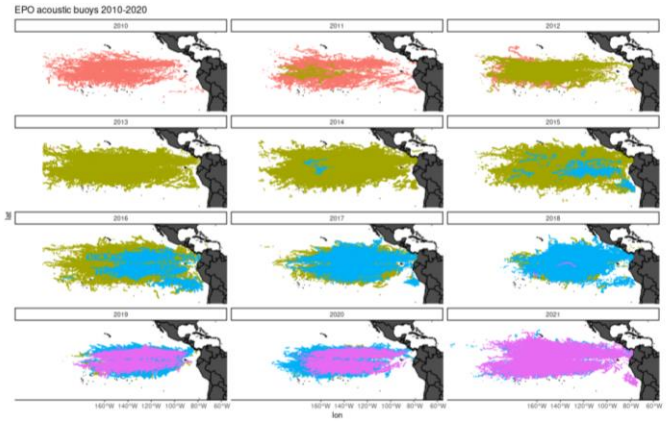
Joint t-RFMO FAD Working Group meeting
2017: Buoy derived abundance indices of tropical tunas in the Indian ocean
2019: Treatment of acoustic data obtained from echosounder buoys for tuna biomass estimates
2019: A novel approach to obtain indices of abundance of tropical tunas from echosounder buoys

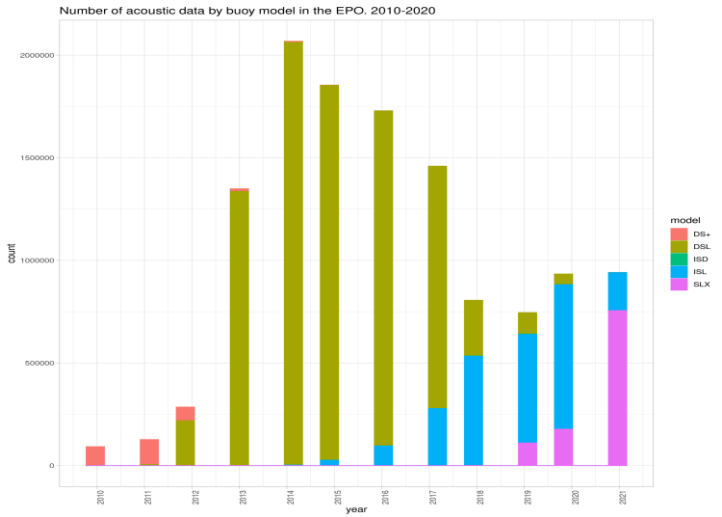
CECOFAD-1
CECOFAD-2
RECOLAPE

Satellite linked echo-sounder buoys

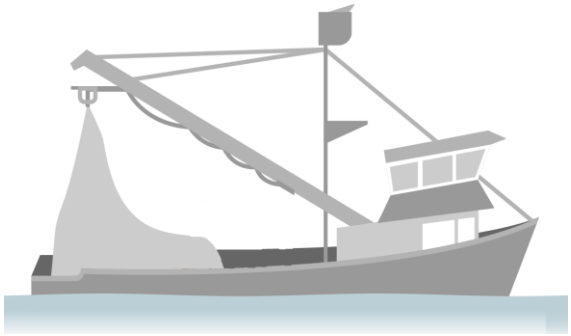
The framework of collaborative work between the Inter-American Tropical Tuna Commission (IATTC) and AZTI Foundation, together with echosounder buoy providers and tropical tuna purse seiner fishing companies operating in the eastern Pacific Ocean (EPO) (companies integrated in OPAGAC and Cape Fisheries) has facilitated the recovery of information from echosounder buoys (2010-2021).

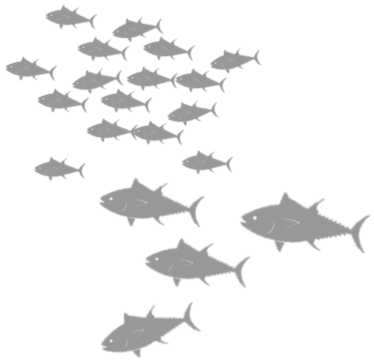
~12.39 million acoustic records [SATLINK]

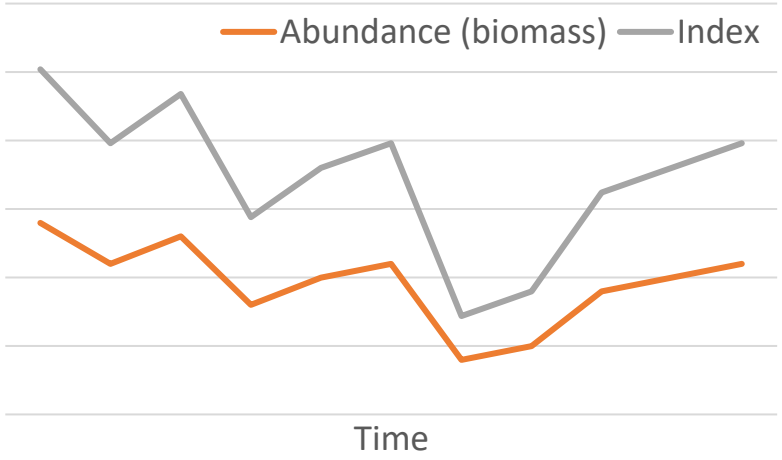


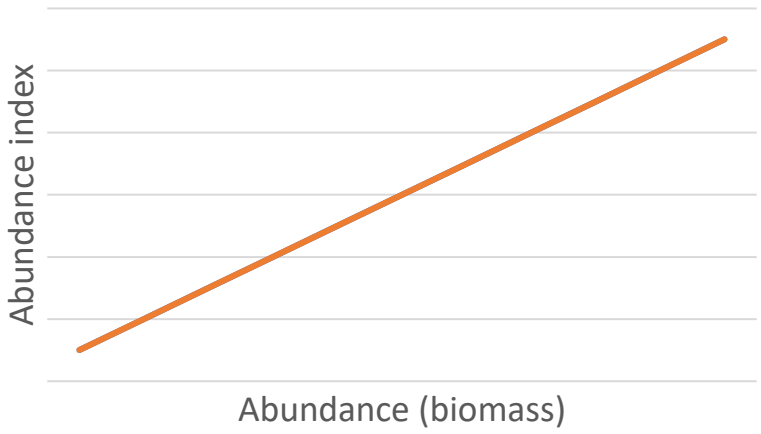


CPUE



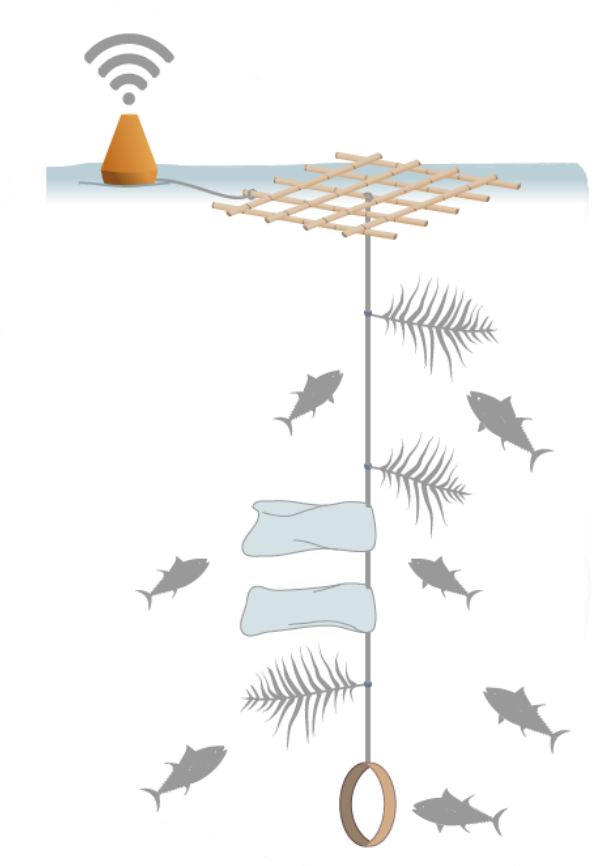






$$CPUE = q \cdot biomass$$

BAI



$$BAI = \lambda \cdot biomass$$

Key assumptions:

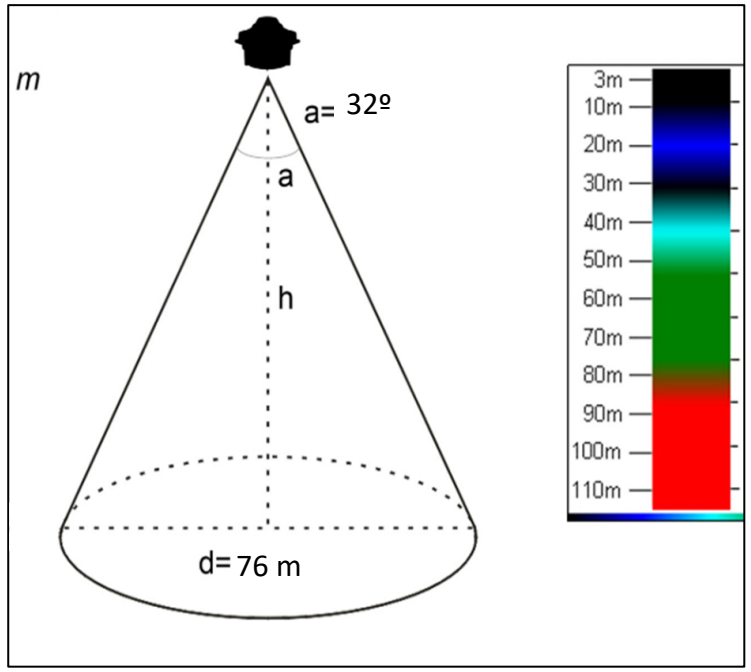
- Relationship between BAI and abundance is linear (proportional).
- The relationship doesn’t change over time or space.
- The proportion of the abundance associated to FADs is proportional to the total abundance

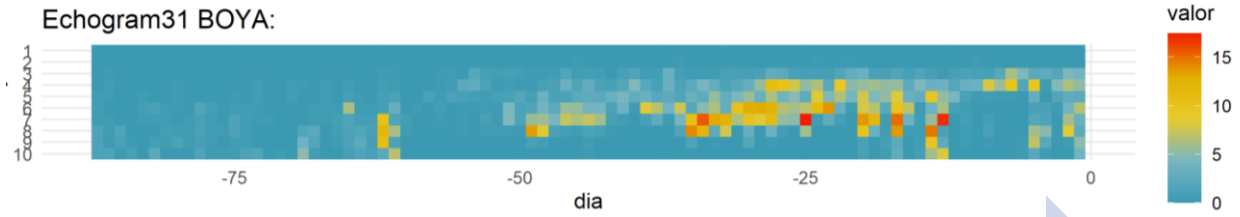
Data and methods

Index of abundance of juvenile skipjack tuna in the Eastern Pacific Ocean derived from echosounder buoys (2012-2021)

Data and methods

The acoustic (raw) data: Satlink





Units used by the buoy brand (0-63 tones range per layer)

Decibels

Recalculated biomass by species

$$Biomass_i = \frac{s_V \cdot Vol \cdot p_i}{\sum_i \sigma_i \cdot p_i} \quad ; \ \sigma_i = \frac{10^{(TS)/10}}{w_i} \quad ; TS = 20log(Li) + b20$$

- Sv is the volume backscattering strength, Vol is the sampled volume of the beam and p_i and σ_i are the proportion and linearized target strength of each species i respectively.
- TS: from (Boyra et al. 2018) for SKJ, from (Bertrand and Josse 2000; Oshima 2008)for YFT and from (Boyra et al. 2018) for BET.
- Since acoustic records do not always have information on catch composition for the same time-area strata, we followed a three-step hierarchical process to get this correspondence: 1) use species distribution data from the same 5ºx5º grid, year and month; 2) alternatively, use the same quarter and 5ºx5º grid; and finally, as a last resort 3), use the mean values of species distribution data at same quarter and region shown in Figure 3.

Data and methods


Contents lists available at ScienceDirect

Fisheries Research

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

Short Communication

From fisheries to scientific data: A protocol to process information from fishers' echo-sounder buoys

Blanca Orue[a,*], Jon Lopez[a,b], Gala Moreno[c], Josu Santiago[a], Guillermo Boyra[a], Jon Uranga[a], Hilario Murua[a]

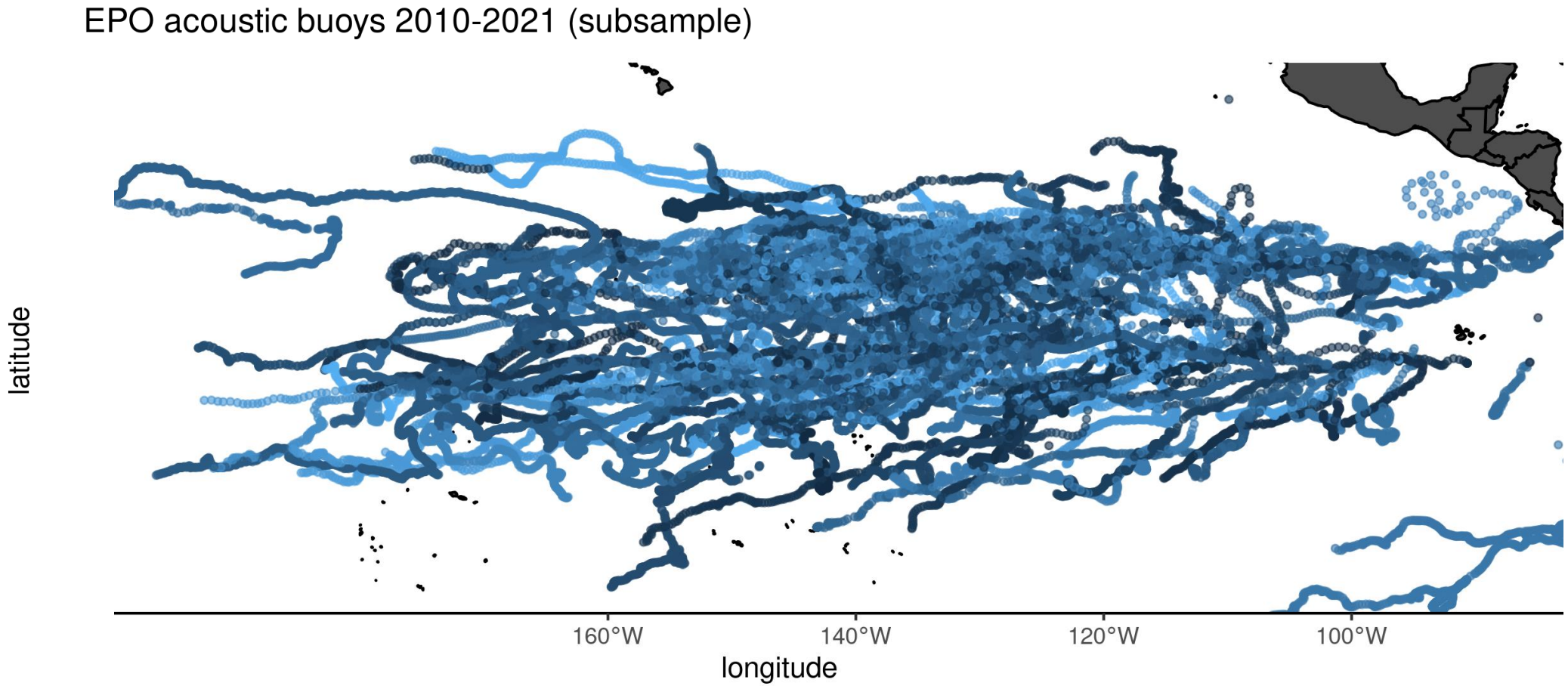
Acoustic data cleaning and filtering

DATA CLEANING: Remove records without acoustic information, outliers, bad geolocation, time, or other general variables.

DATA FILTERING:

- shallower layers of acoustic data[<25 m] discarded.
- bottom shallower than 200m discarded.
- onboard signals discarded.
- only data from 4-8 AM.
- days since deployment: only records between 20 and 35 days were used ("virgin" segments)

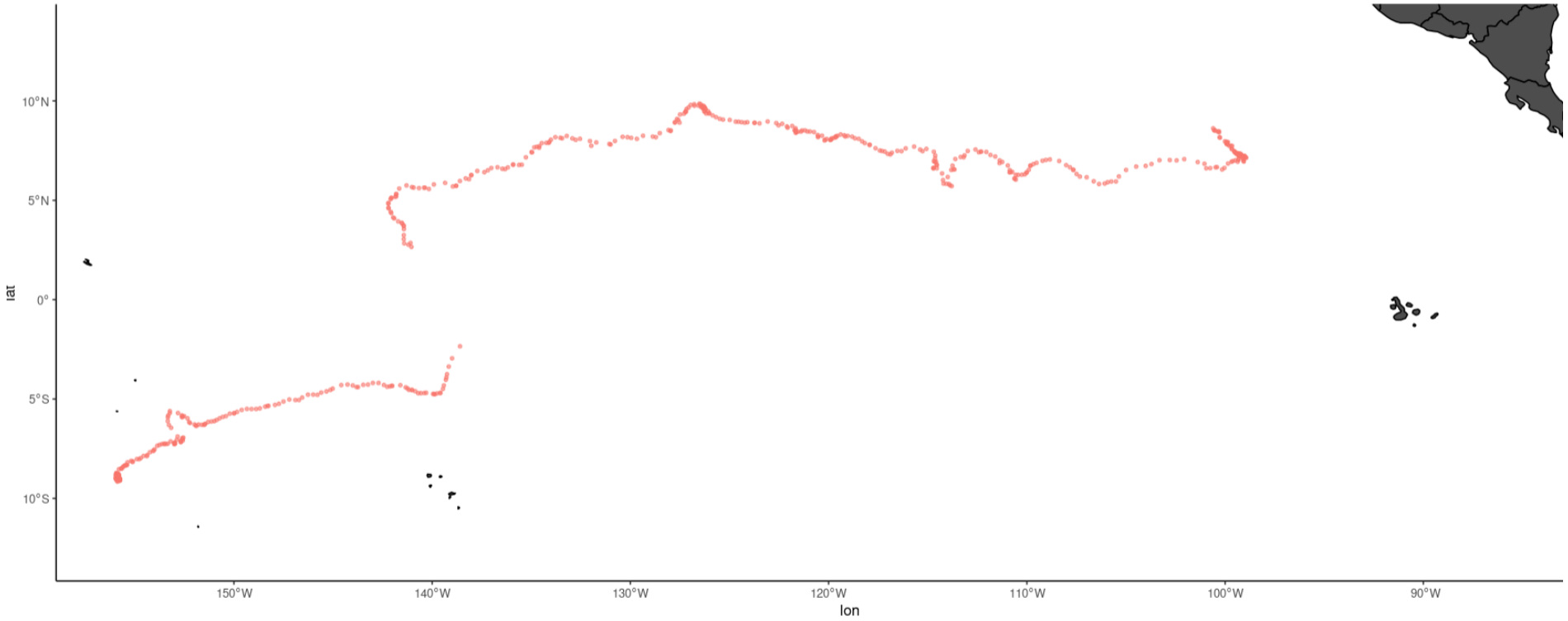
Data and methods



Concept of
“virgin segment”

segment of a buoy trajectory whose associated FAD **likely represents a new deployment or re-deployment** which has been **potentially colonized** by tuna and **probably not already fished**

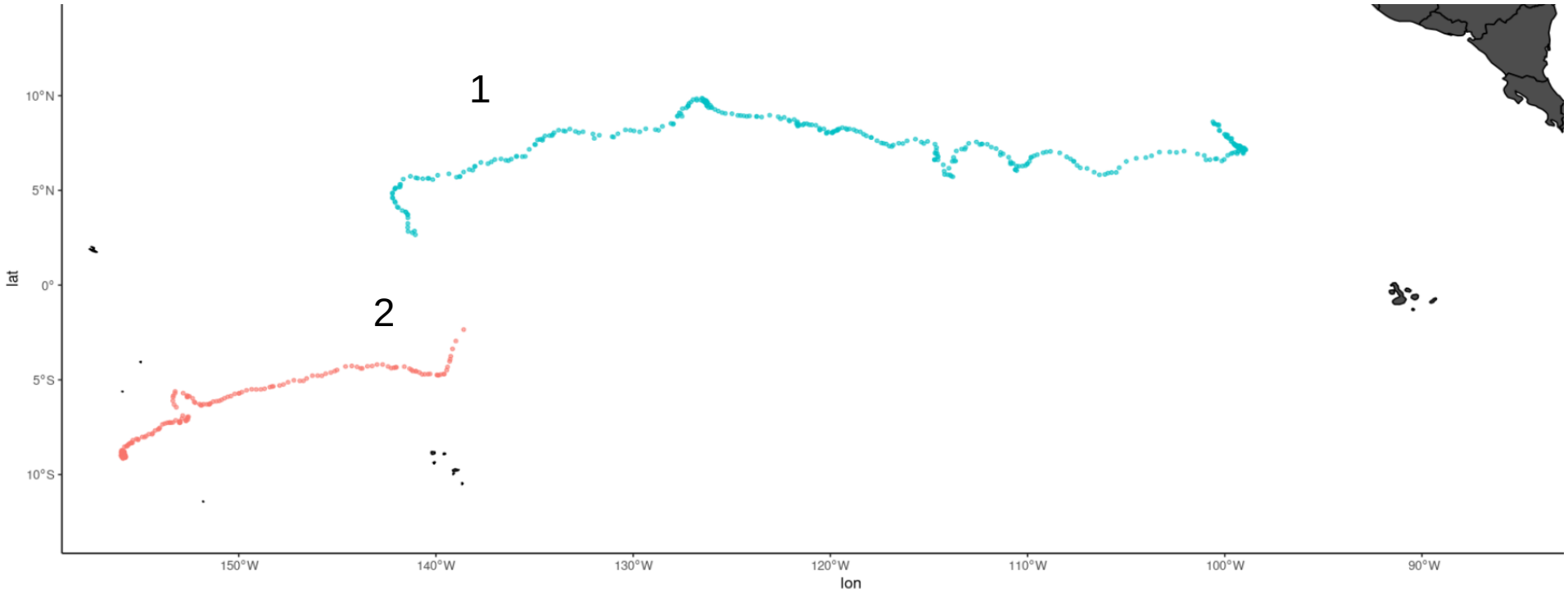
Data and methods



Concept of
“virgin segment”

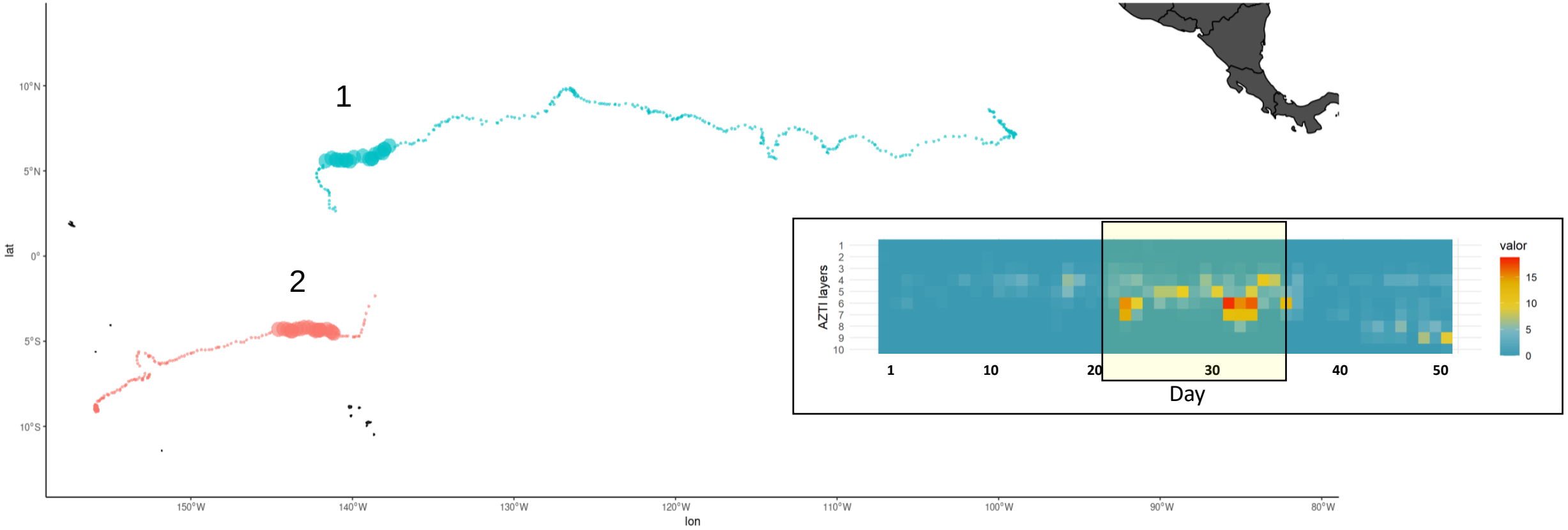
1 buoy

Data and methods



Concept of “virgin segment” If $day_{n+1} - day_n >= 30 \Rightarrow$ new trajectory (1 buoy – 2 trajectories)

Data and methods

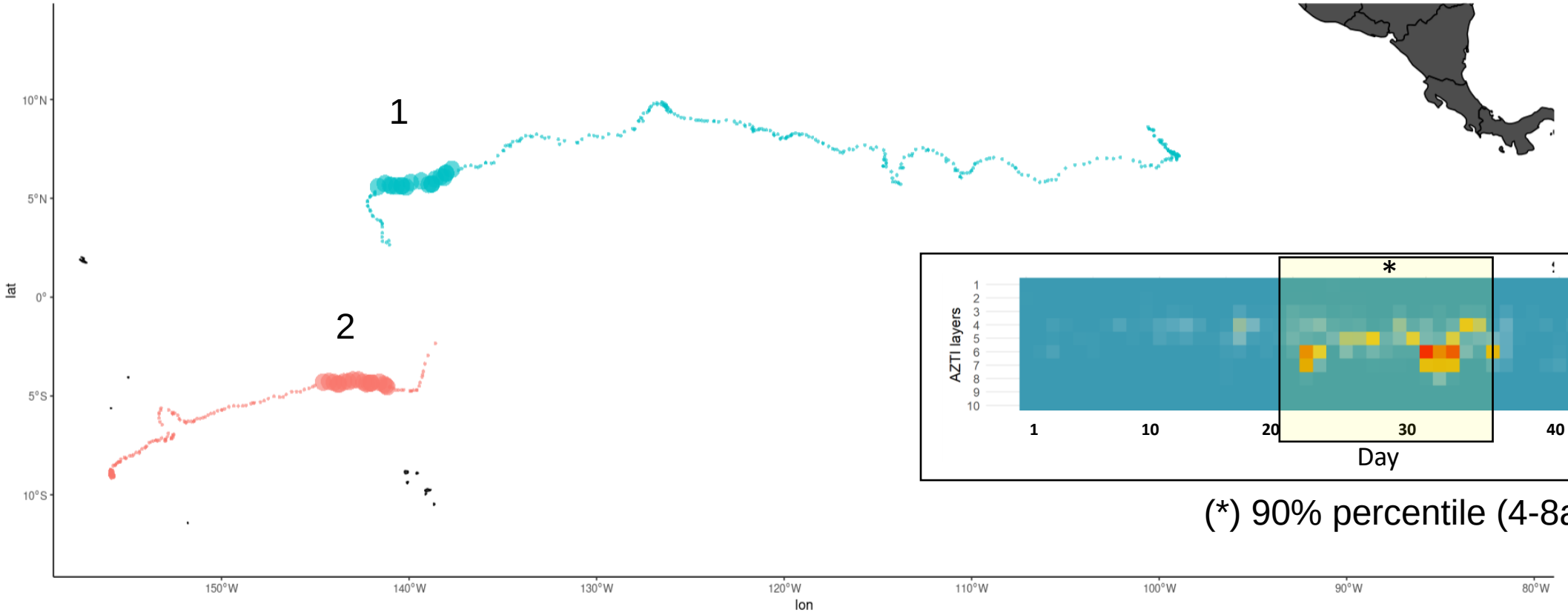


Concept of “virgin segment”

If $day_{n+1} - day_n >= 30 \Rightarrow$ new trajectory (1 buoy – 2 trajectories)

$20 <= [day_n – day_1] <= 35 \Rightarrow$ “virgin” section (1 buoy – 2 trajectories – 2 sections)

Data and methods



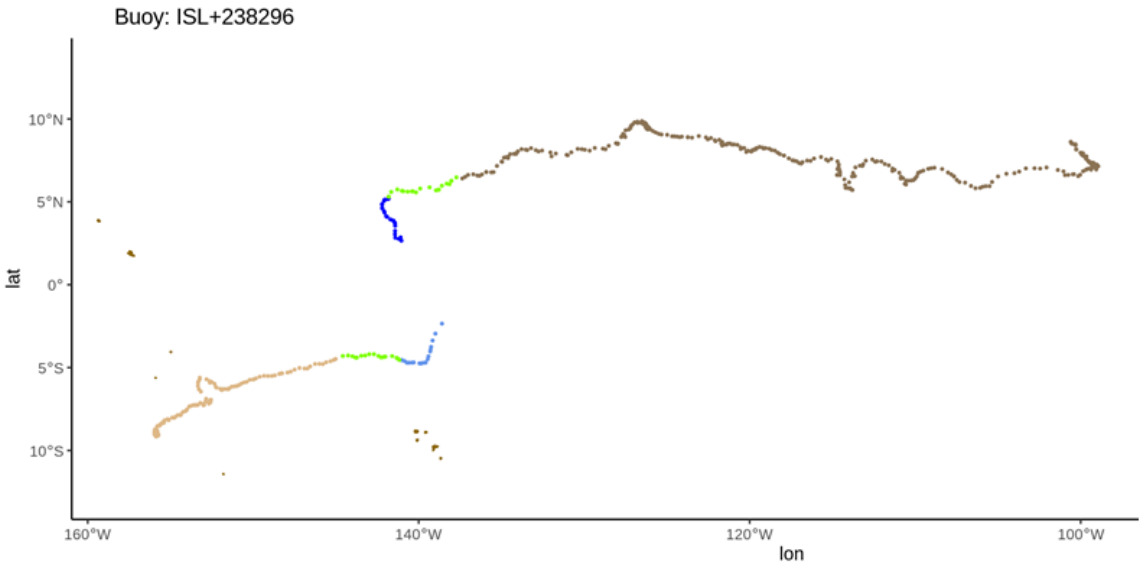
(*) 90% percentile (4-8am)

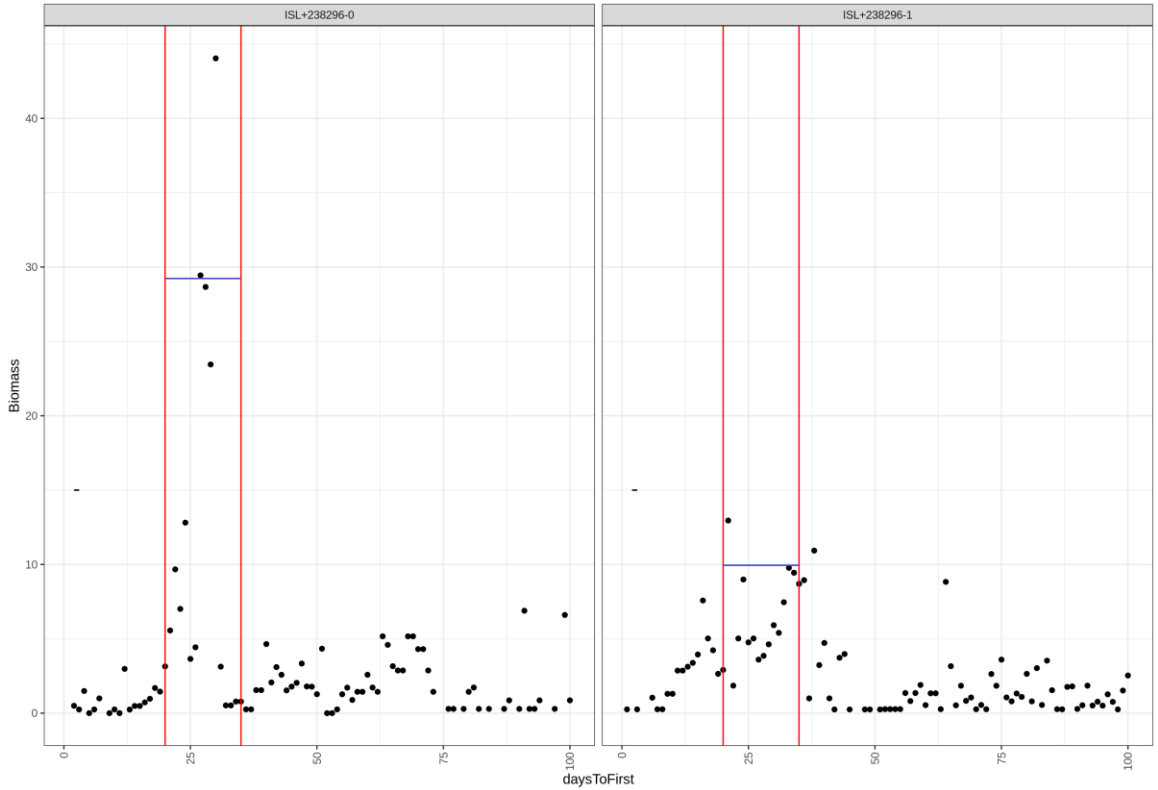
Concept of “virgin segment”

If $day_{n+1} – day_n >= 30 \Rightarrow$ new trajectory (1 buoy – 2 trajectories)

$20 <= [day_n – day_1] <= 35 \Rightarrow$ “virgin” section (1 buoy – 2 trajectories – 2 sections)

Data and methods





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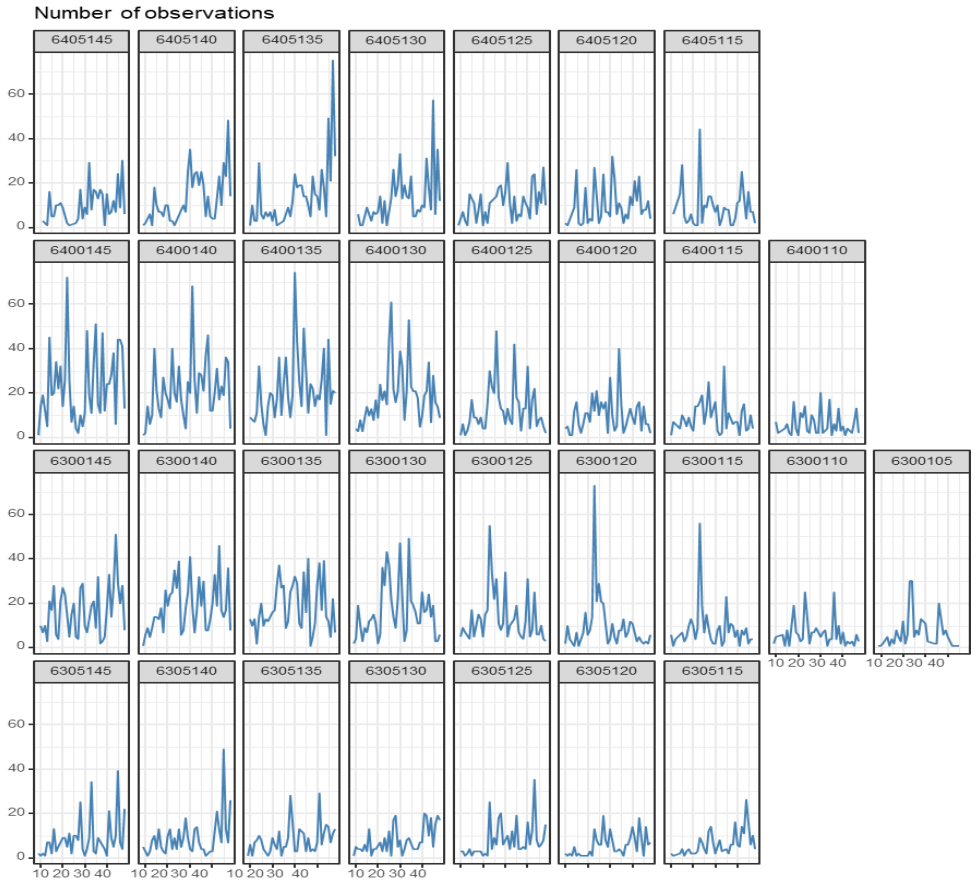
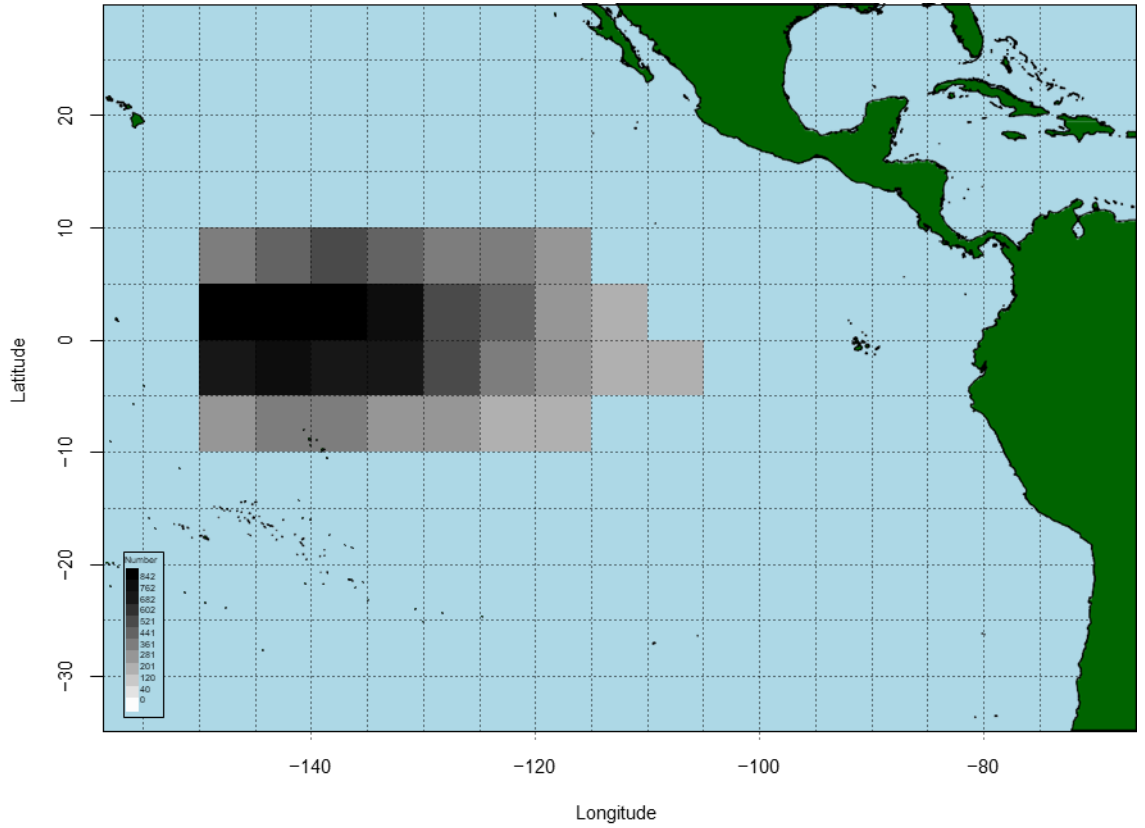
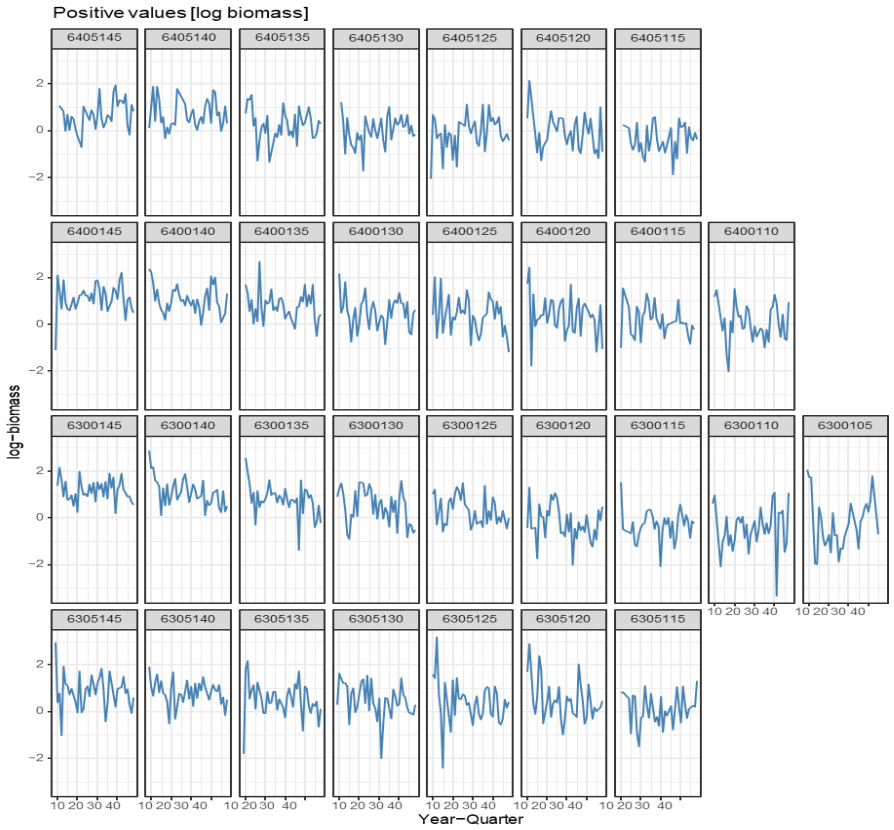
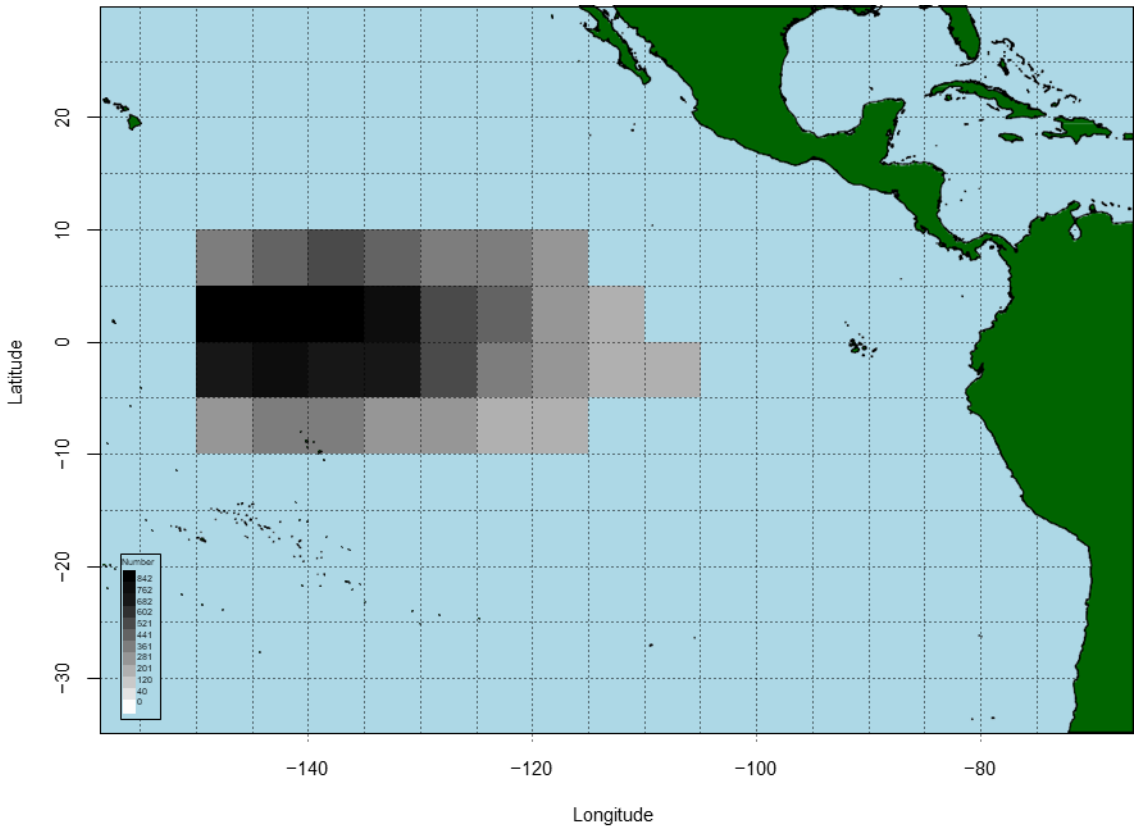




Number of observations by quarter [5ºx5º]

Data and methods





Nominal values by quarter [5ºx5º]

Data and methods

The BAI index (Buoy-derived Abundance Index) :

- Covariates used in the standardization process were:
  - Categorical: year- quarter, 5x5º area and buoy model.
  - Continuous: A proxy of 1ºx1º and monthly FAD densities (average number of unique buoys over each month in a 1x1 area), velocity of the buoy and environmental variables (Ocean mixed layer thickness, Chlorophyll and Chlorophyll front, SST and SST front)

- The signal from the echosounder is proportional to the abundance of fish:

$$\mathrm{BAI}_t = \lambda \,.\, \mathrm{B}_t$$

- In standardization analysis is performed. order to ensure that λ can be assumed to be constant a

- Considering the low proportion of zero values (0.31%) a GLMM log-normal error structured model was applied to standardize the acoustic observations

Results

Index of abundance of juvenile skipjack tuna in the Eastern Pacific Ocean derived from echosounder buoys (2012-2021)

Results

Analysis of deviance table:

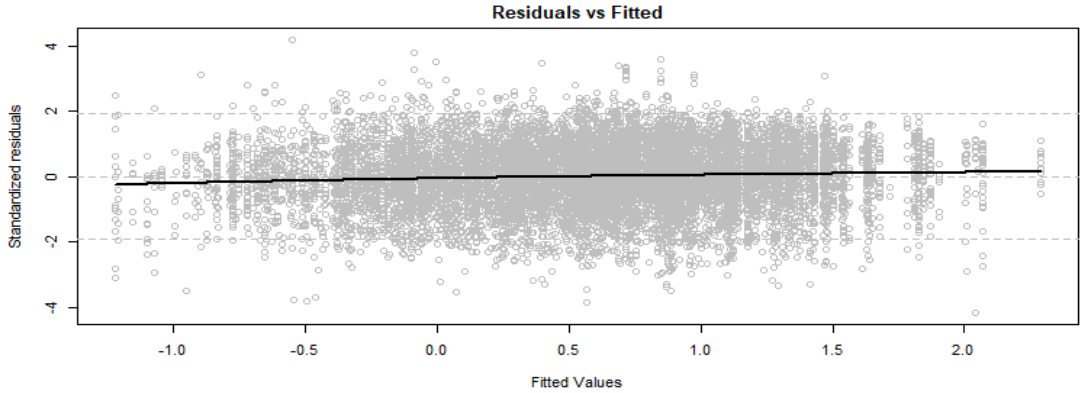
Variable	Df	Deviance	Resid..Df	Resid..Dev	F	Pr..F.	Dev..Exp
NULL	NA	NA	13867	19453	NA	NA	NA
yyqq	39	1363	13828	18089	36	0.0000	7.01 %
area	30	2527	13798	15562	86	0.0000	12.99 %
model	2	78	13796	15484	40	0.0000	0.4 %
den	1	88	13795	15396	90	0.0000	0.45 %
chl	1	9	13794	15387	9	0.0022	0.05 %
sst	1	11	13793	15376	11	0.0009	0.06 %
mld	1	97	13792	15278	99	0.0000	0.5 %
yyqq:area	1086	2569	12706	12709	2	0.0000	13.21 %
yyqq:model	34	123	12672	12586	4	0.0000	0.63 %
yyqq:den	38	103	12634	12483	3	0.0000	0.53 %
yyqq:sst	39	101	12595	12382	3	0.0000	0.52 %
yyqq:mld	39	73	12556	12309	2	0.0006	0.37 %

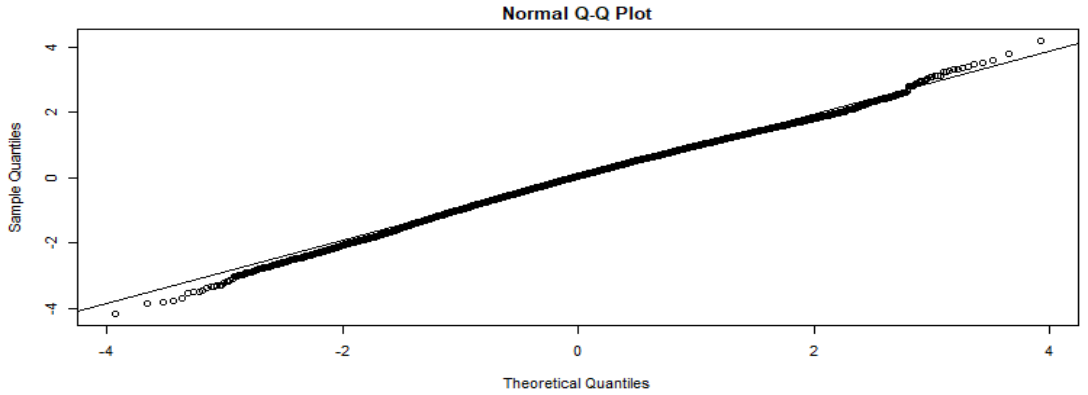
The proportion of deviance explained by the model was 37%.

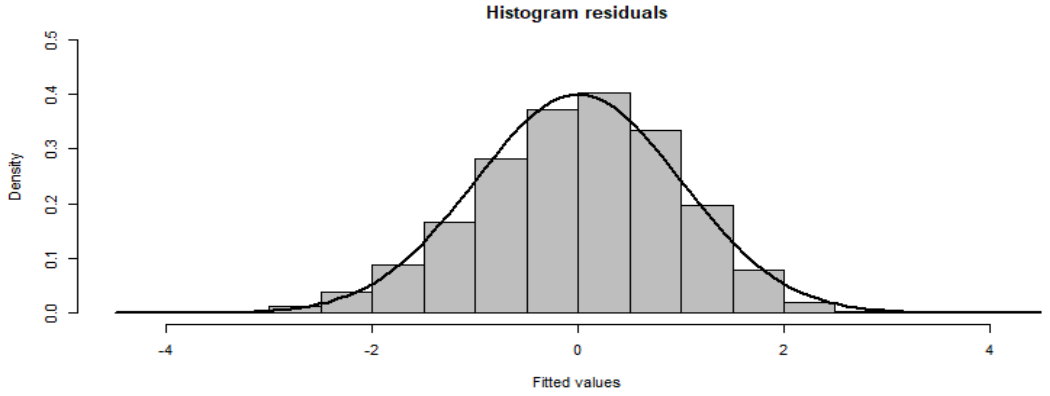
log(index)~yyqq + area + yyqq:area

Results

Diagnosis plots:





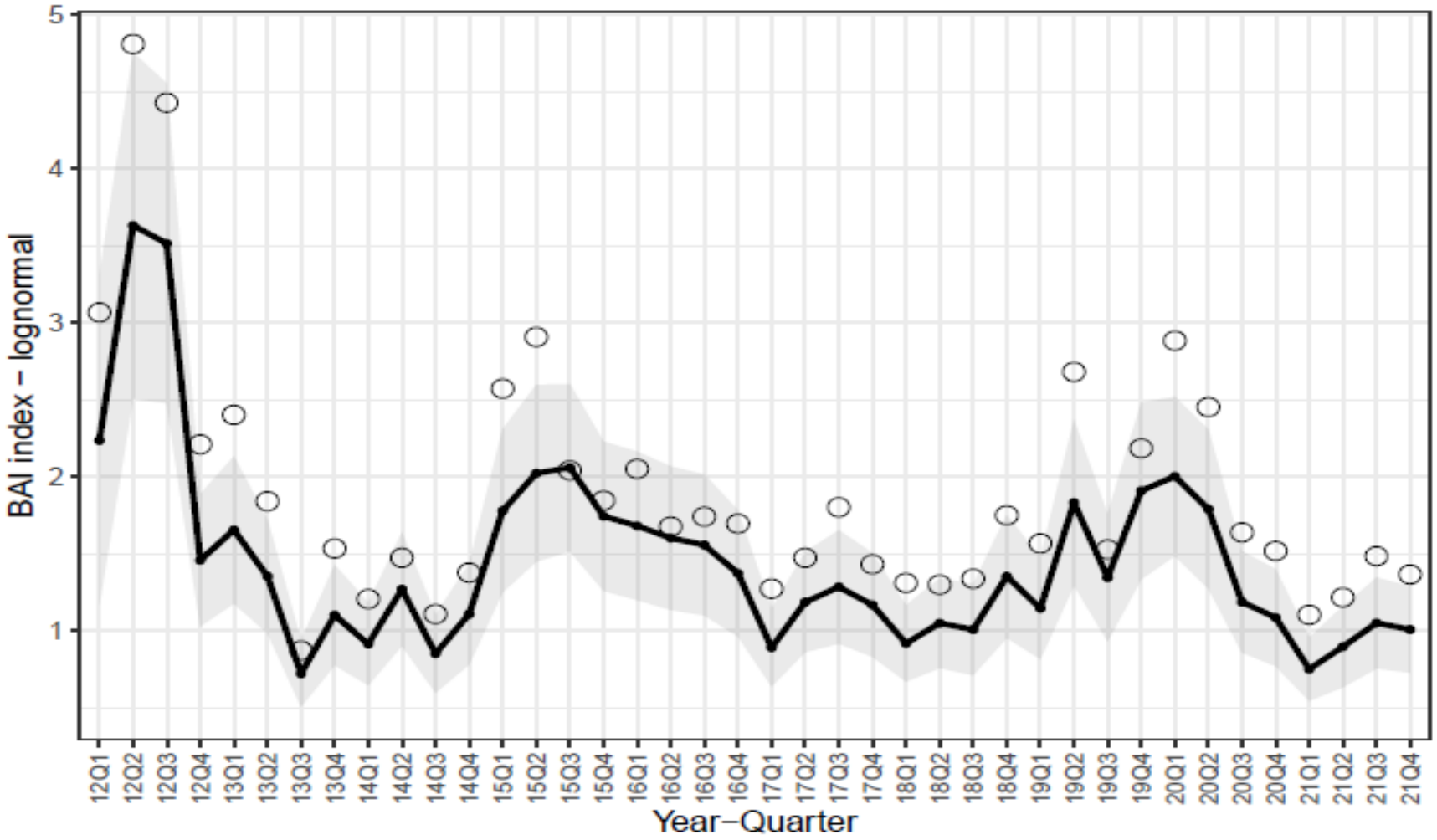


Diagnostics of the lognormal model selected for the period 2012-2021: residuals vs fitted, Normal Q-Q plot and frequency distributions of the residuals.

Results

SKJ BAI index:

Time series of nominal (circles) and standardized (continuous line) Buoy-derived Abundance Index for SKJ for the period 2012-2021 in the EPO. The 95% upper and lower confidence intervals of the standardized BAI index are shown.



Additional analyses

Index of abundance of juvenile skipjack tuna in the Eastern Pacific Ocean derived from echosounder buoys (2012-2021)

Additional analyses

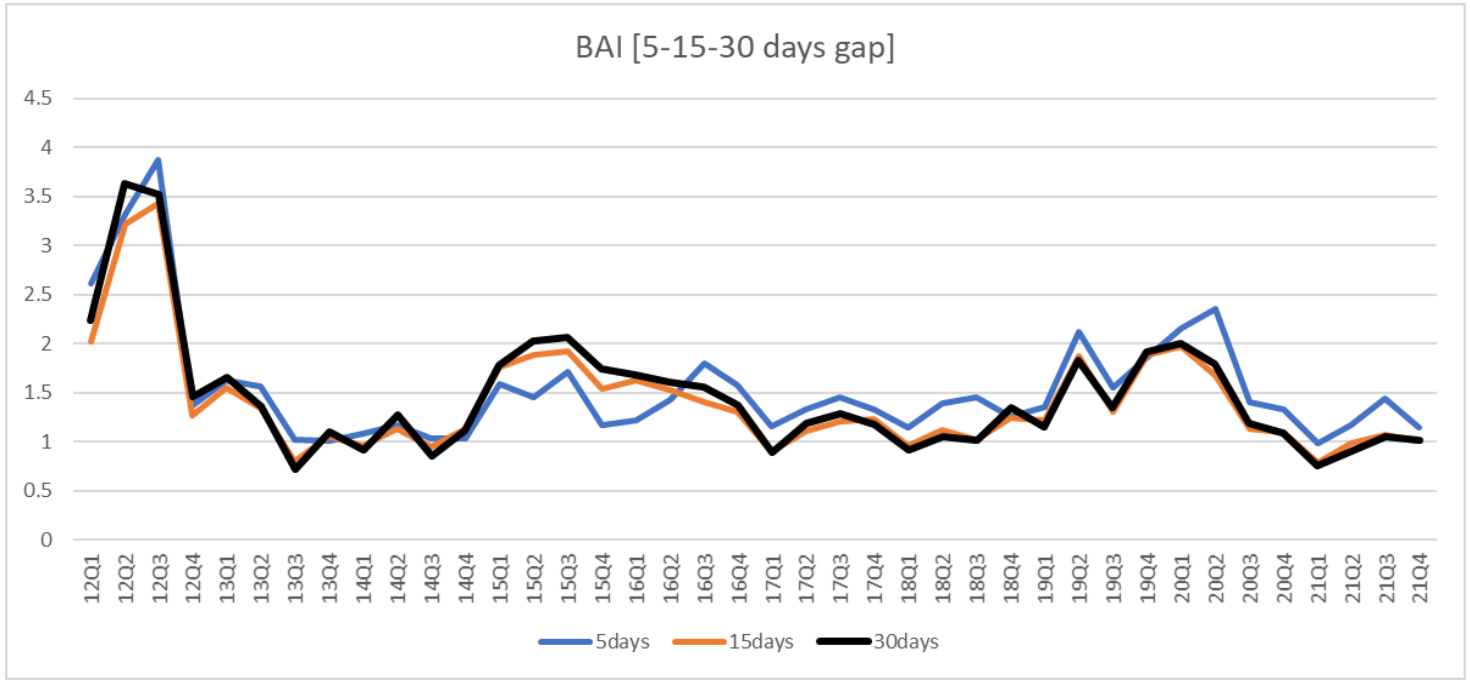
I. Improve the determination of virgin segments

II. Improve the biomass colonization models.

III. Improve the statistical modelling.

IV. Improve the characterization of species composition for the strata of interest

V. Develop a methodology to predict species composition from acoustic samples (work in progress)



(I)

Additional analyses

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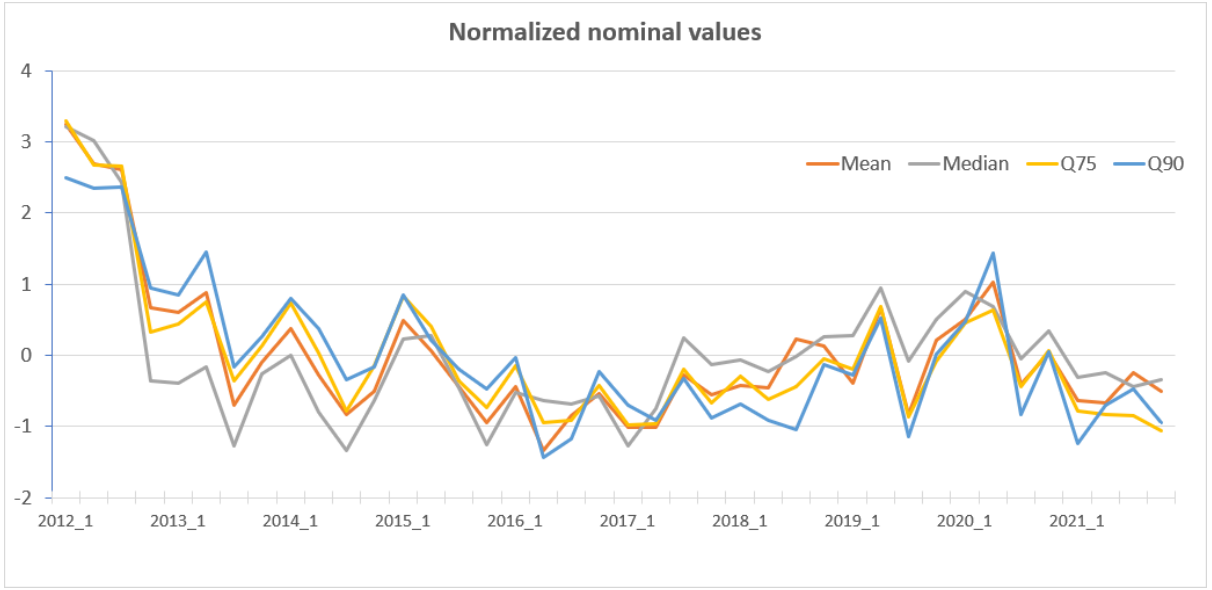

(III)

Additional analyses

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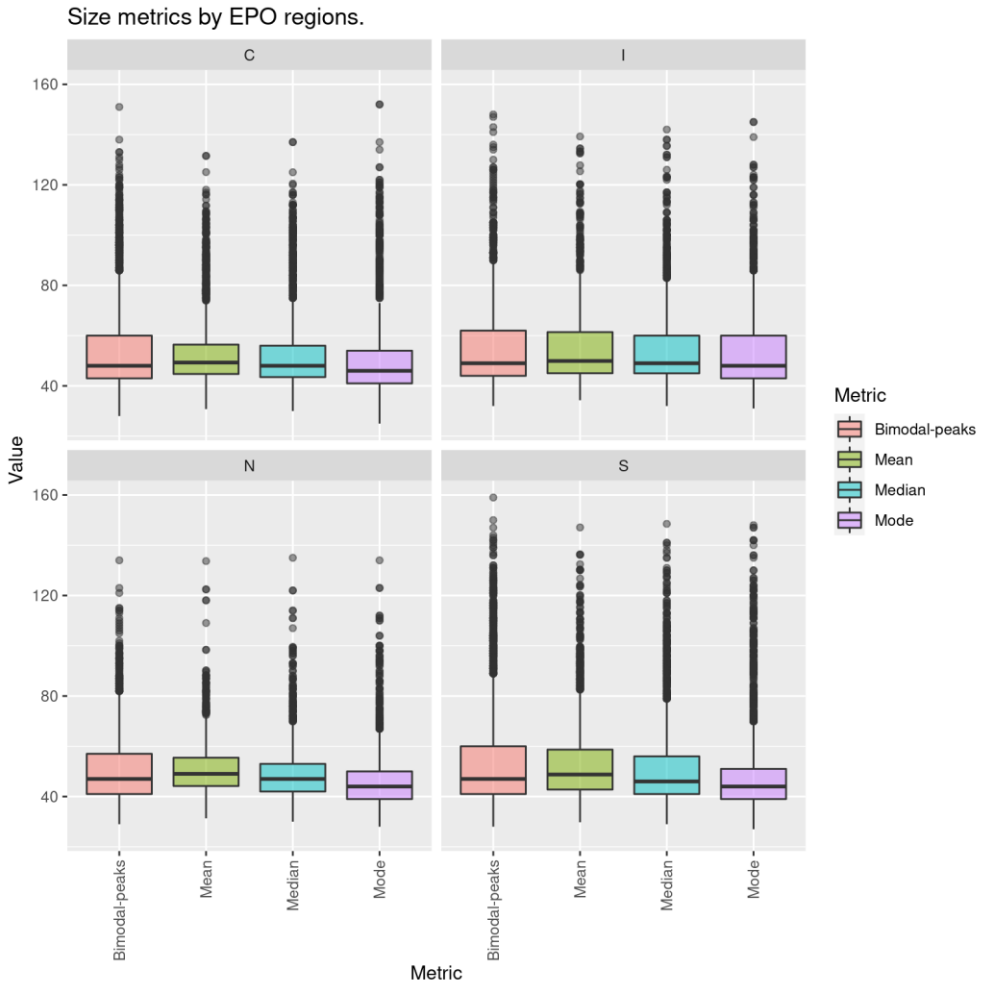

(IV)

Additional analyses

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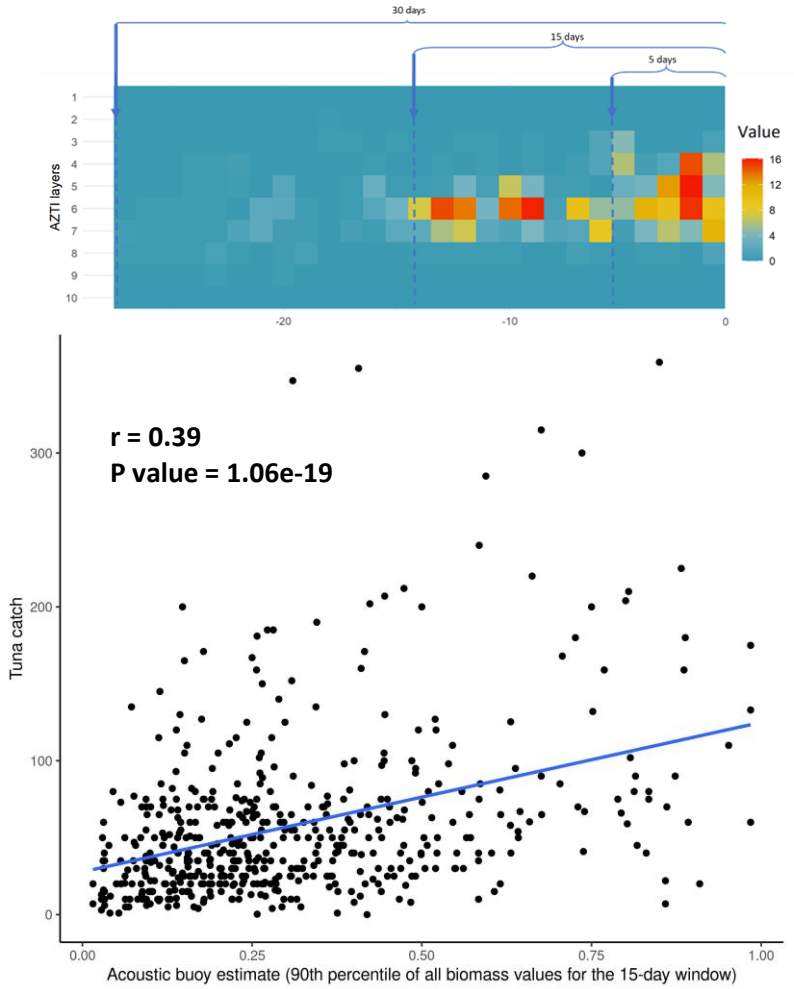

(V)

Acknowledgements

We want to express our gratitude to the following fishing companies that have provided acoustic information from their echosounder buoys: Albacora, Calvo, Garavilla, Ugavi and Cape Fisheries. And to the Basque Government and ISSF for funding this work.

Gracias! **Thank you!**