TROPICAL TUNA BIOMASS INDICATORS FROM ECHOSOUNDER BUOYS IN THE EPO (2012-2020)

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Introduction

Index of abundance of juvenile skipjack tuna in the Eastern Pacific Ocean derived from echosounder buoys (2012-2020)

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

2021: A novel index of abundance of juvenile bigeye tuna in the Atlantic ocean derived from echosounder buoys

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

2020-2021: Agreement between the IATTC and AZTI for the development and implementation of a project on "developing alternative buoy-derived tuna biomass indexes"

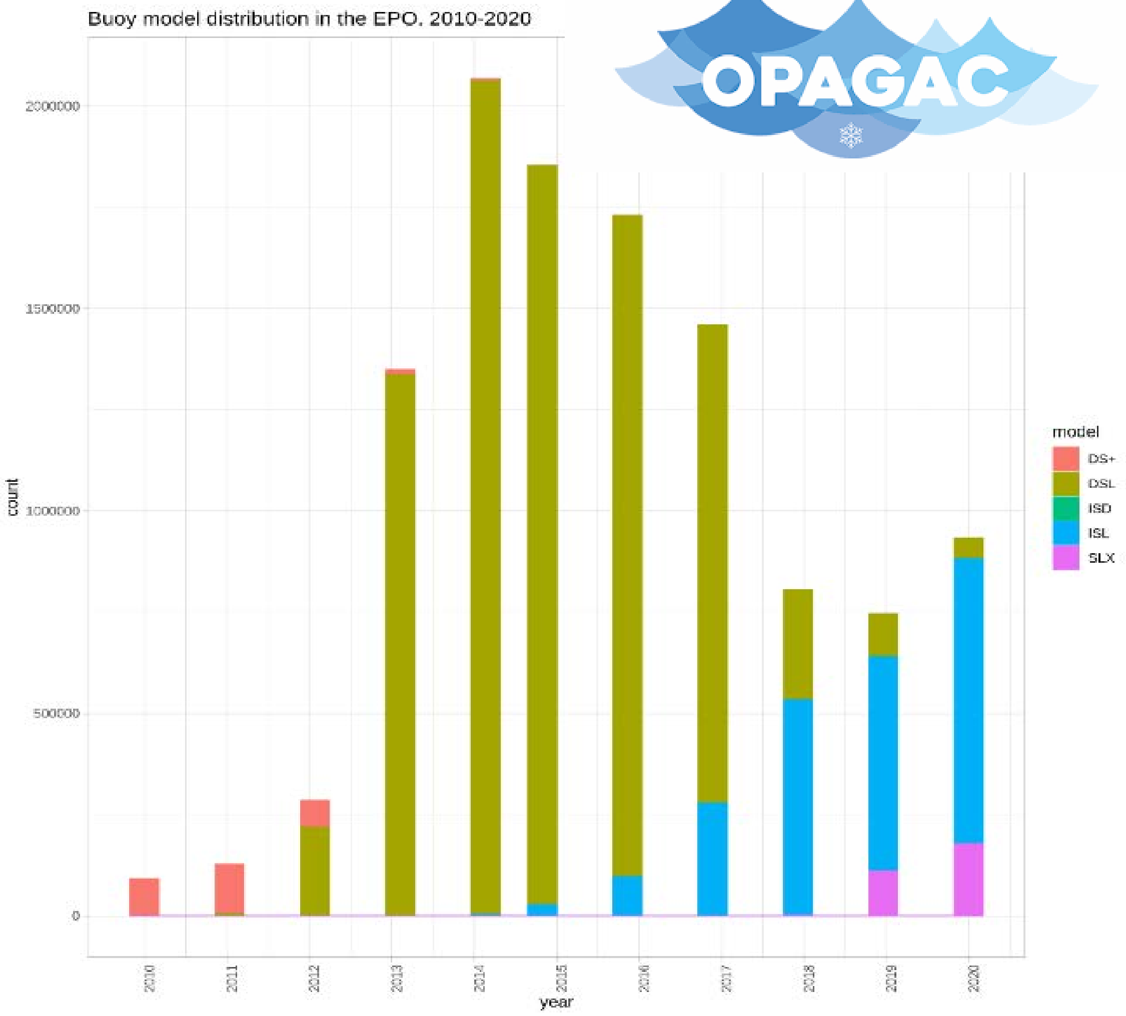
Joint t-RFMO FAD Working Group meeting
2017: Buoy derived abundance indices of tropical tunas in the Indian ocean
2019: Treatment of acoustic data obtained from echosounder buoys for tuna biomass estimates
2019: A novel approach to obtain indices of abundance of tropical tunas from echosounder buoys

CECOFAD-1
CECOFAD-2
RECOLAPE

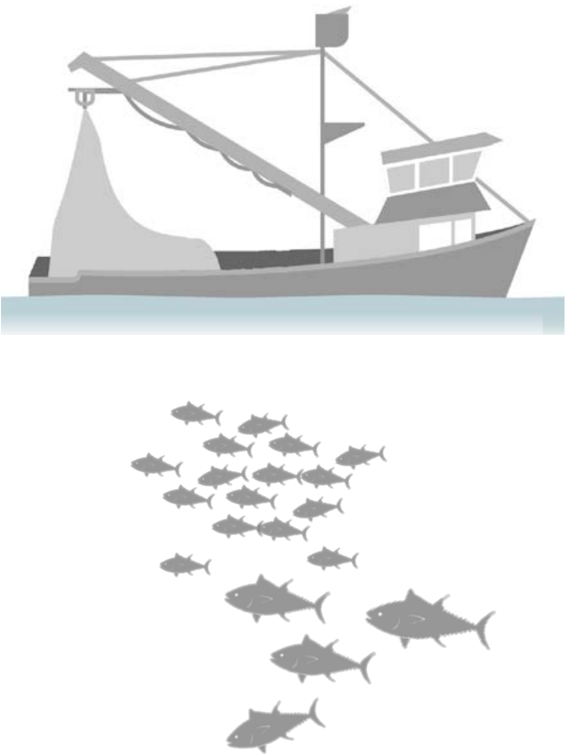
Satellite linked echo-sounder buoys

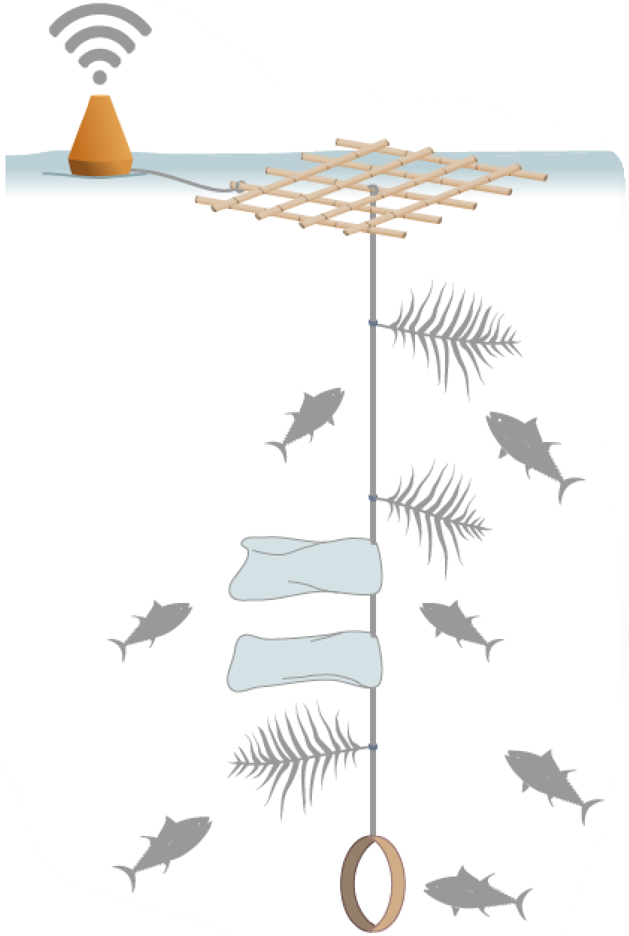
The framework of collaborative work between the **Inter-American Tropical Tuna Commission (IATTC)** and AZTI , together with **ISSF**, echosounder buoy providers (**Satlink, Marine Instruments**) and tropical tuna purse seiner fishing companies operating in the eastern Pacific Ocean (EPO) (companies integrated in **OPAGAC** and **Cape Fisheries**) has facilitated the recovery of information from echosounder buoys (2010-2020).

~8.3 million acoustic records [SATLINK]



Indices of abundance





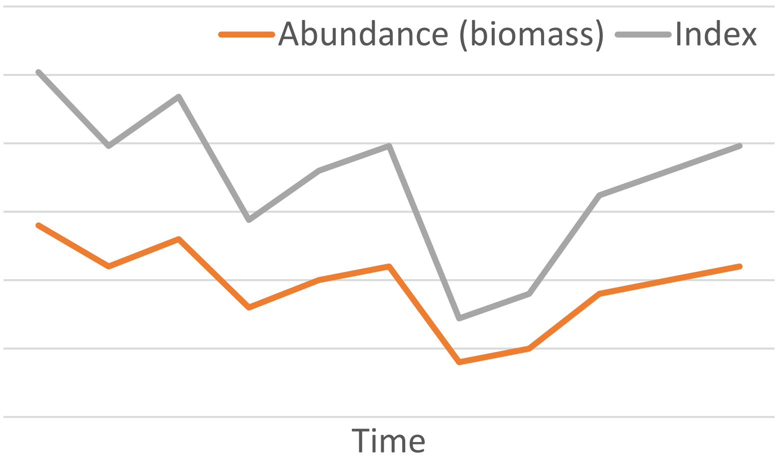
$$CPUE = q \cdot \text{biomass}$$

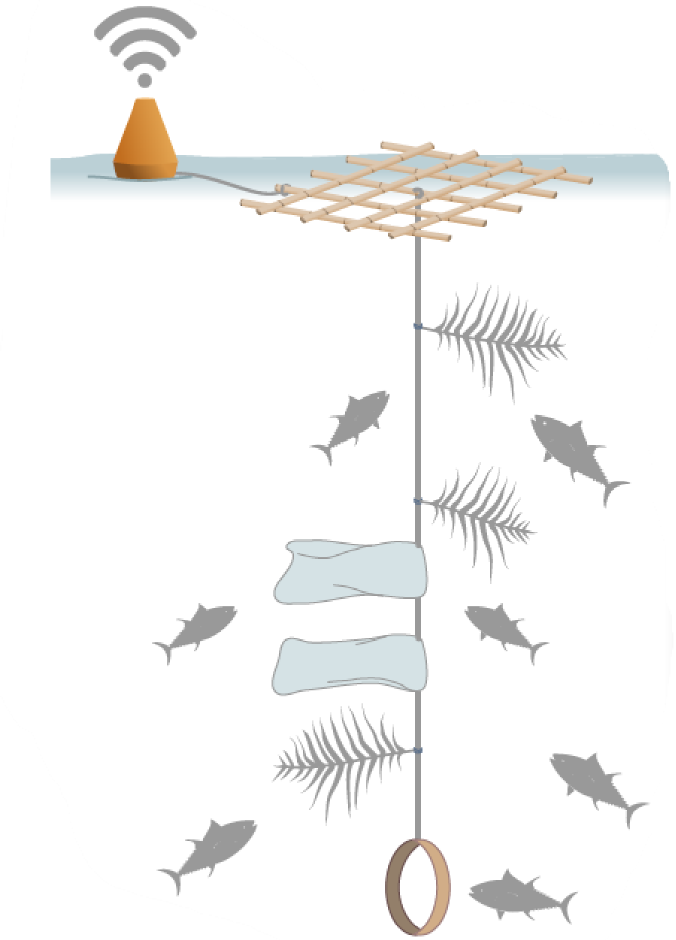
$$BAI = \lambda \cdot \text{biomass}$$

Indices of abundance

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





$$BAI = \lambda \cdot biomass$$

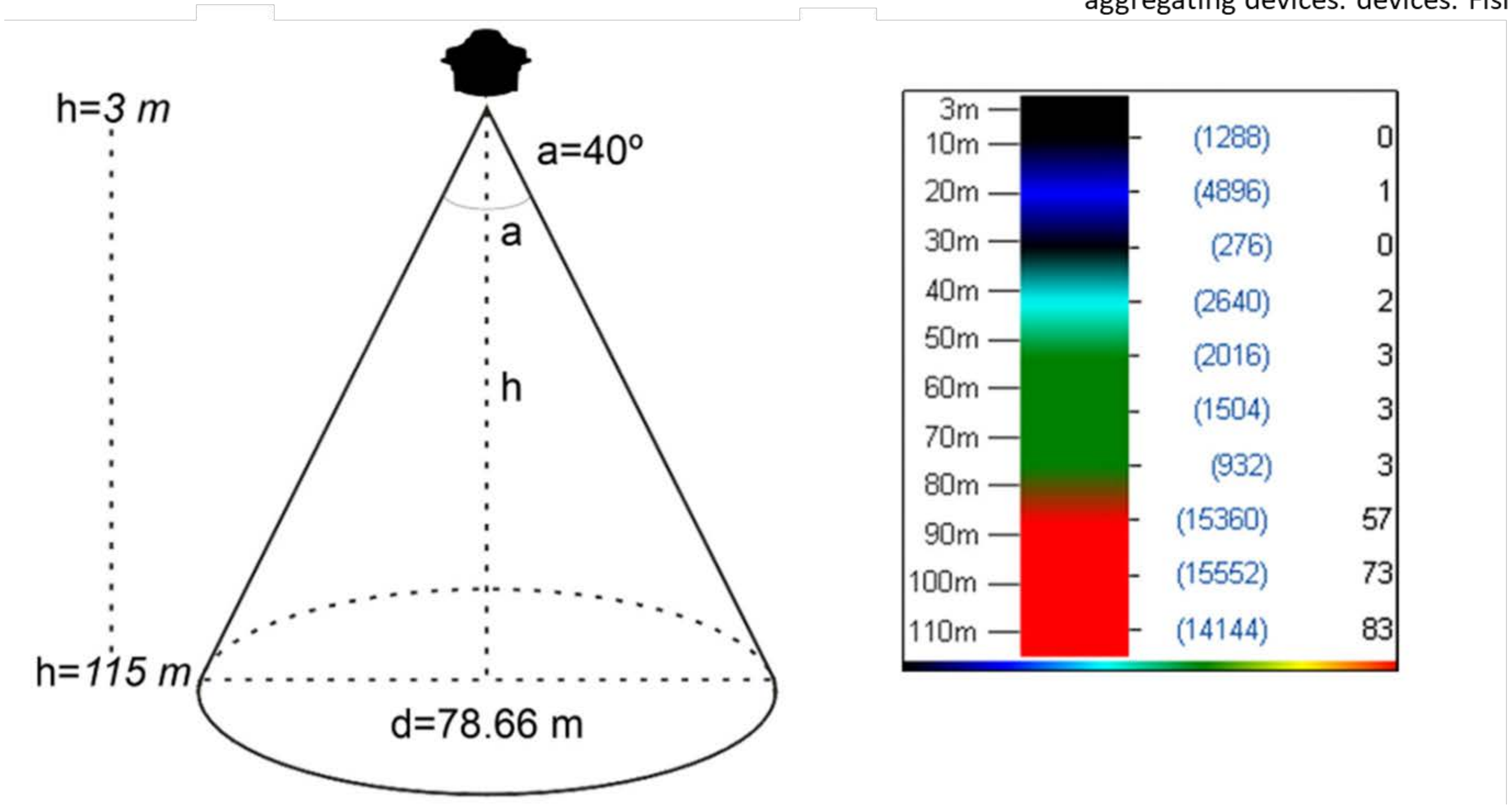
Data and methods

Index of abundance of juvenile skipjack tuna in the Eastern Pacific Ocean derived from echosounder buoys (2012-2020)

Data and methods

The acoustic (raw) data: Satlink

Lopez, J., Moreno, G., Boyra, G., Dagorn, L., 2016. A model based on data from echo- sounder buoys to estimate biomass of fish species associated with fish aggregating devices. devices. Fish. Bull. 114.



Data and methods

The acoustic (raw) data: Satlink

Units used by the buoy brand

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]

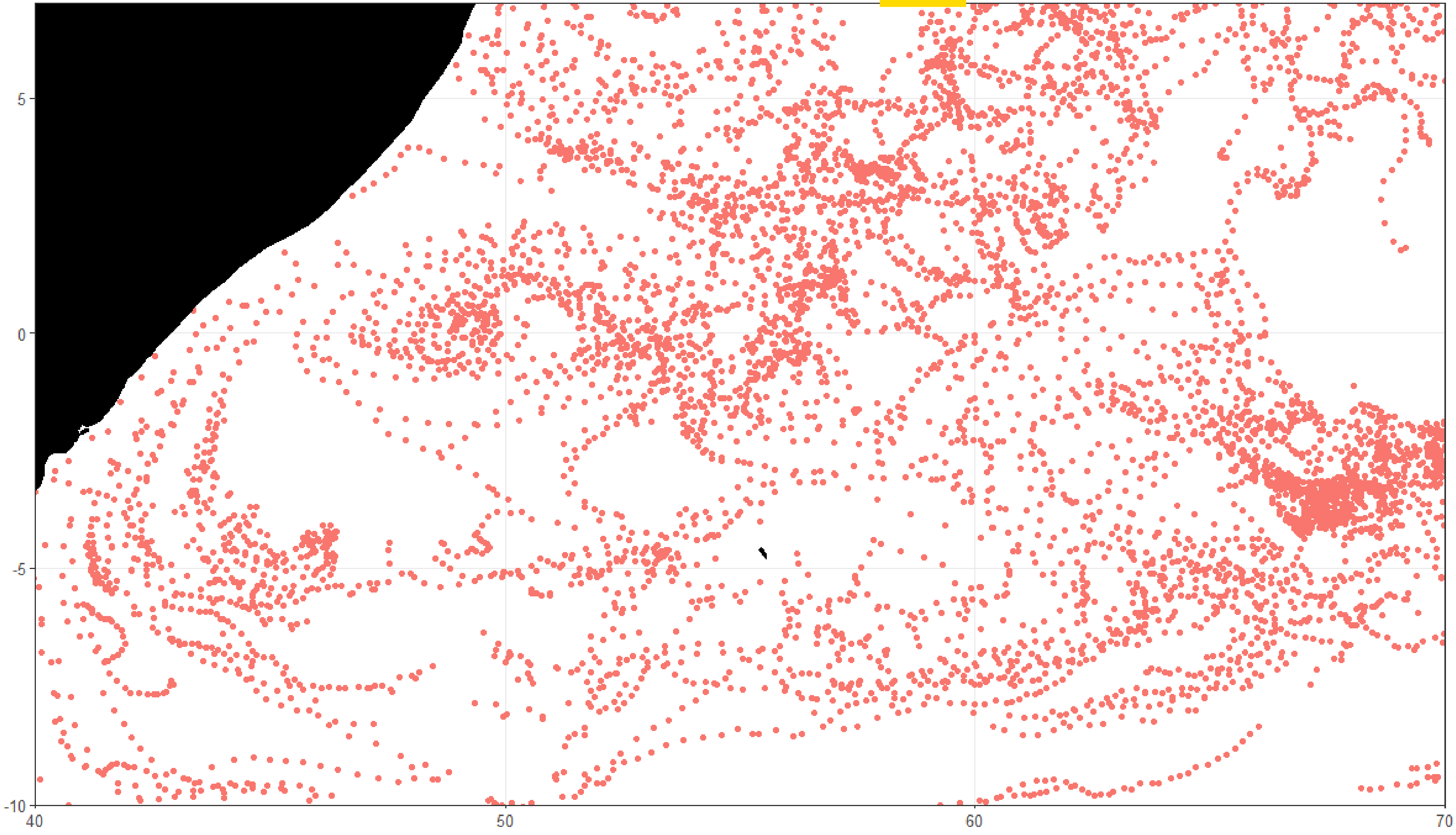
Acoustic data cleaning and filtering

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)

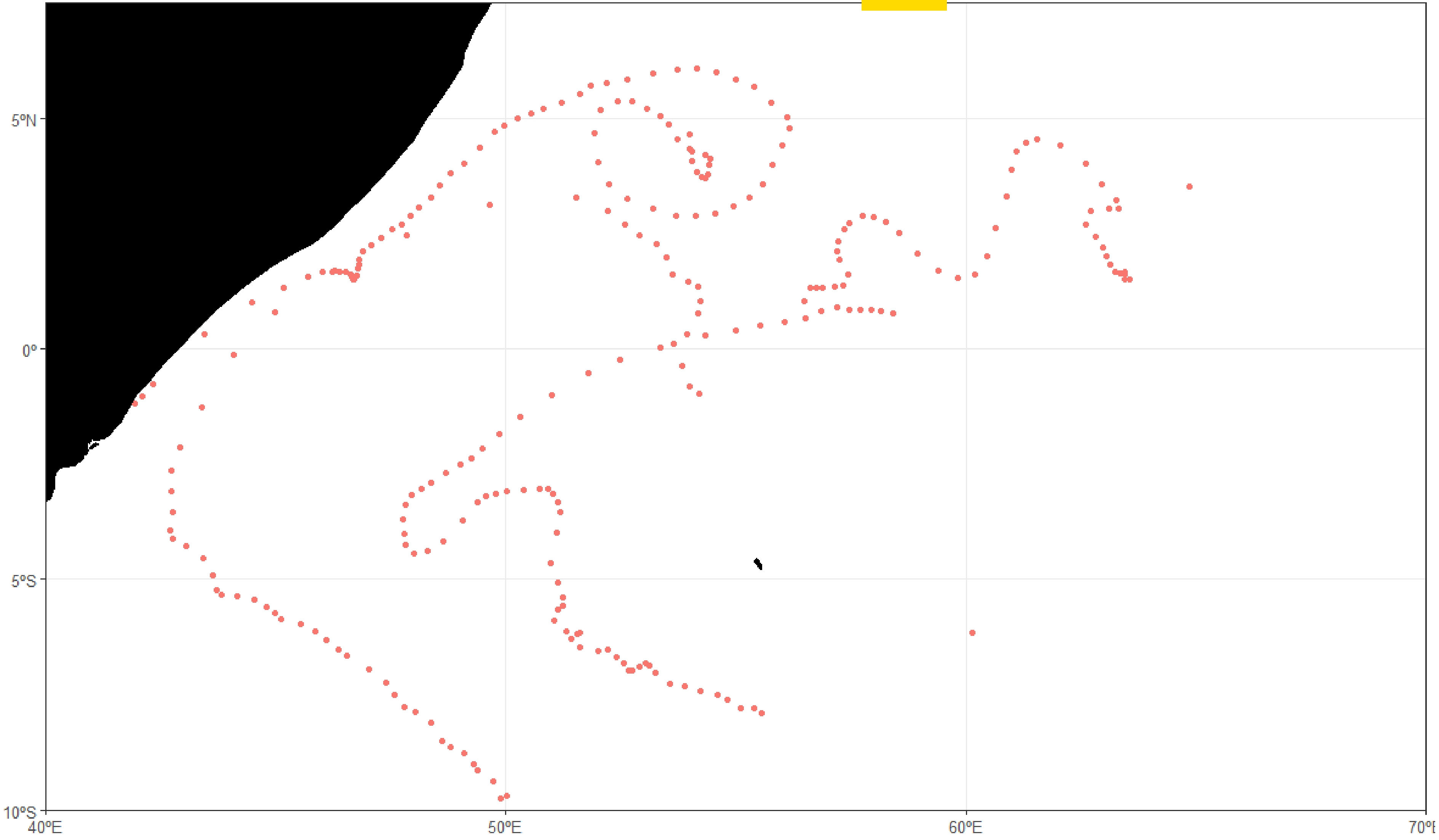
Data and methods



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**

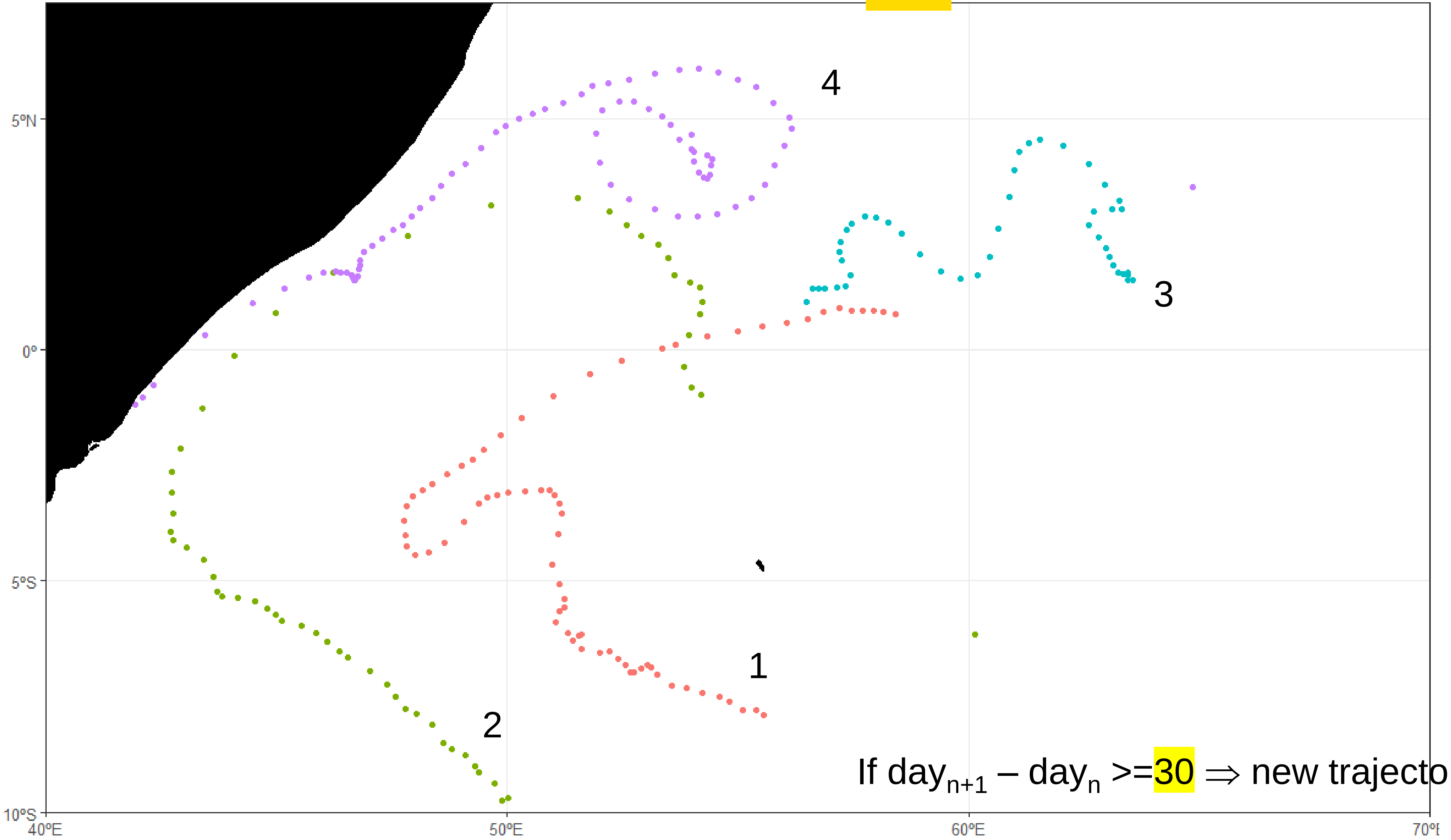
Data and methods



Concept of
“virgin segment”

1 buoy

Data and methods

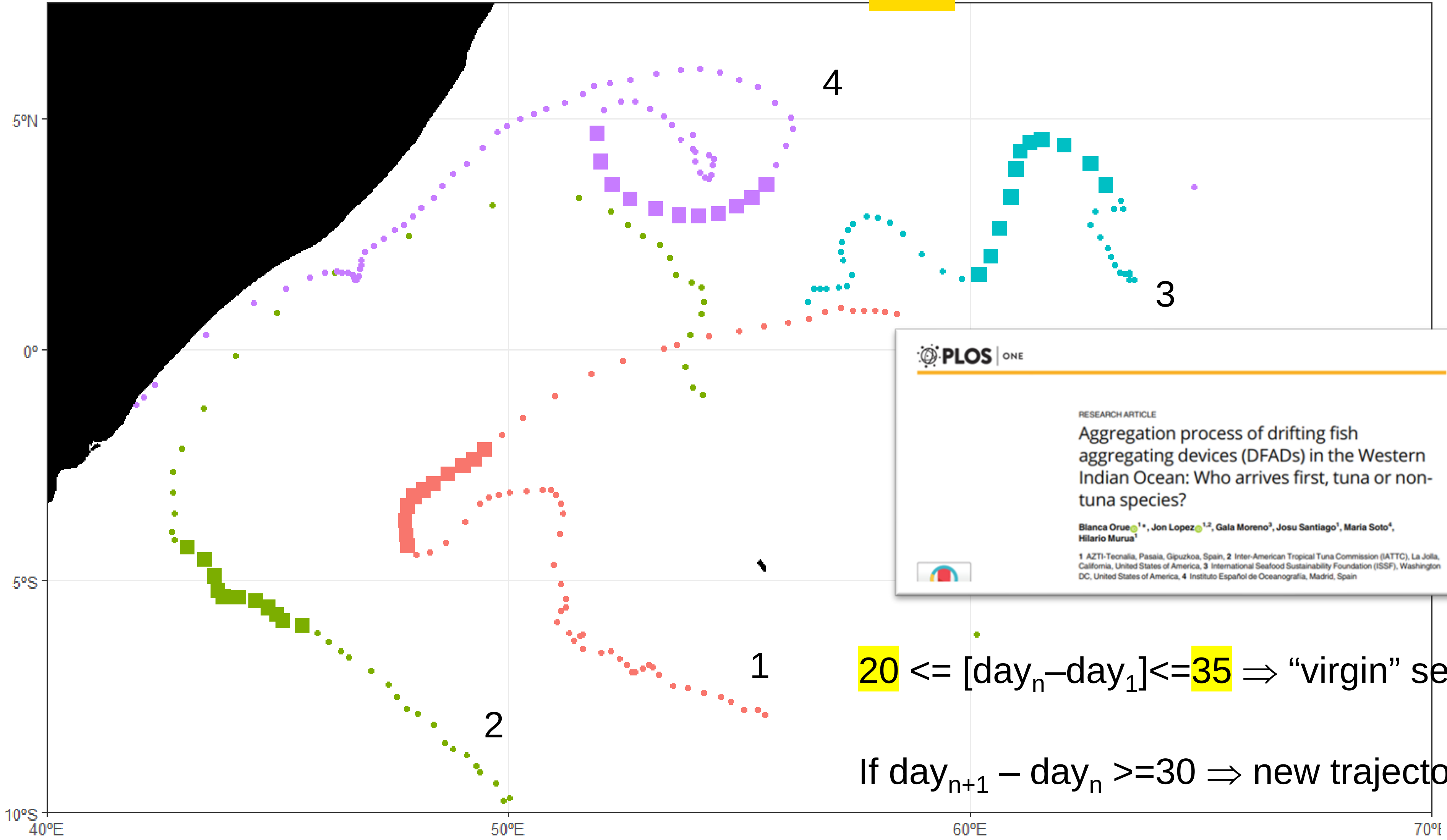


If $\text{day}_{n+1} - \text{day}_n >= 30 \Rightarrow$ new trajectory

Concept of
"virgin segment"

1 buoy – 4 trajectories

Data and methods



PLOS ONE

RESEARCH ARTICLE

Aggregation process of drifting fish aggregating devices (DFADs) in the Western Indian Ocean: Who arrives first, tuna or non-tuna species?

Blanca Orue[1]*, Jon Lopez[1,2], Gala Moreno[3], Josu Santiago[1], Maria Soto[4], Hilario Murua[1]

1 AZTI-Tecnalia, Pasaia, Gipuzkoa, Spain, 2 Inter-American Tropical Tuna Commission (IATTC), La Jolla, California, United States of America, 3 International Seafood Sustainability Foundation (ISSF), Washington DC, United States of America, 4 Instituto Español de Oceanografía, Madrid, Spain

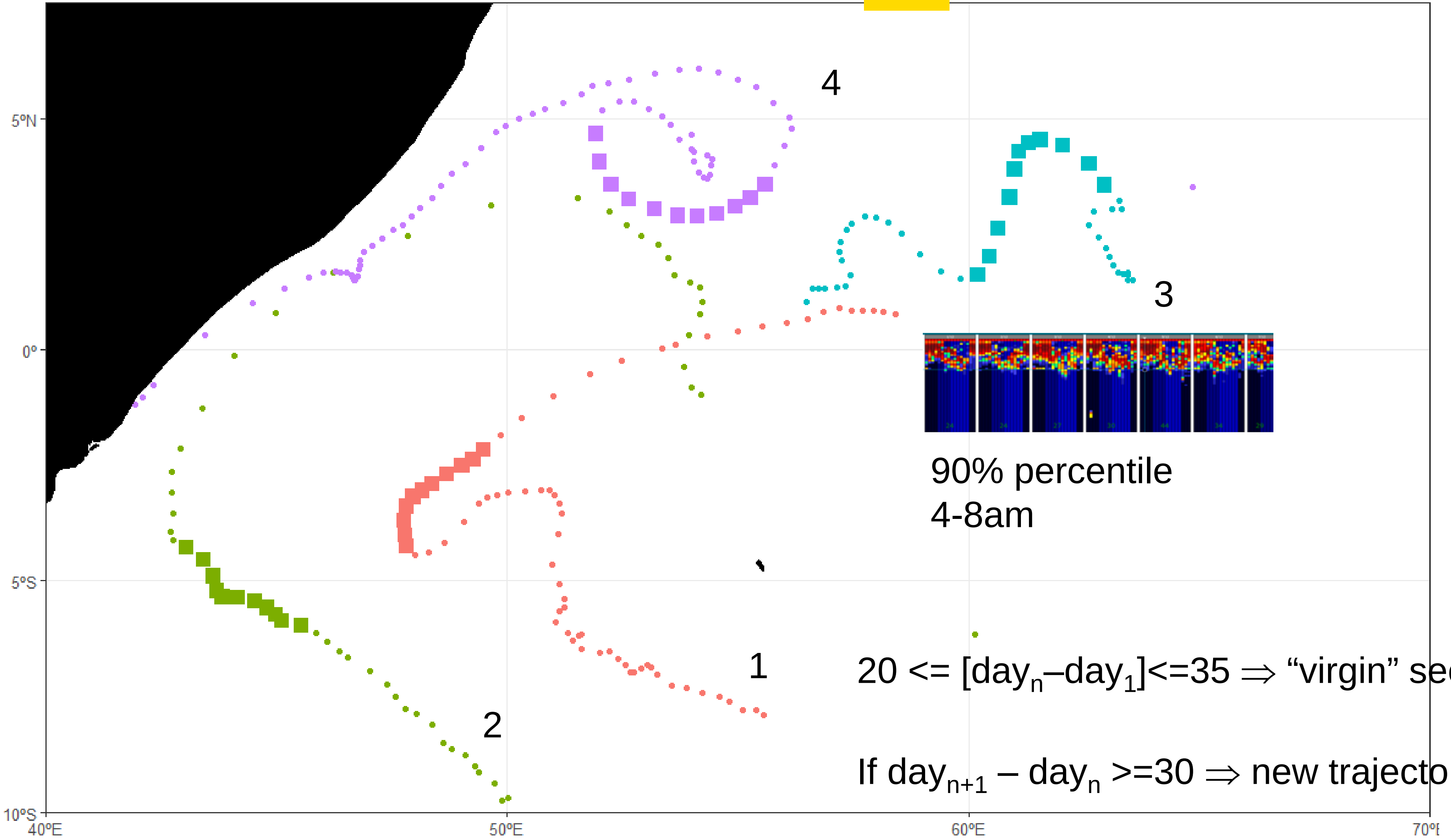
20 <= $[day_n – day_1]$<=35 ⇒ “virgin” section

If $day_{n+1} – day_n$ >=30 ⇒ new trajectory

Concept of “virgin segment”

1 buoy – 4 trajectories – 4 sections

Data and methods



90% percentile
4-8am

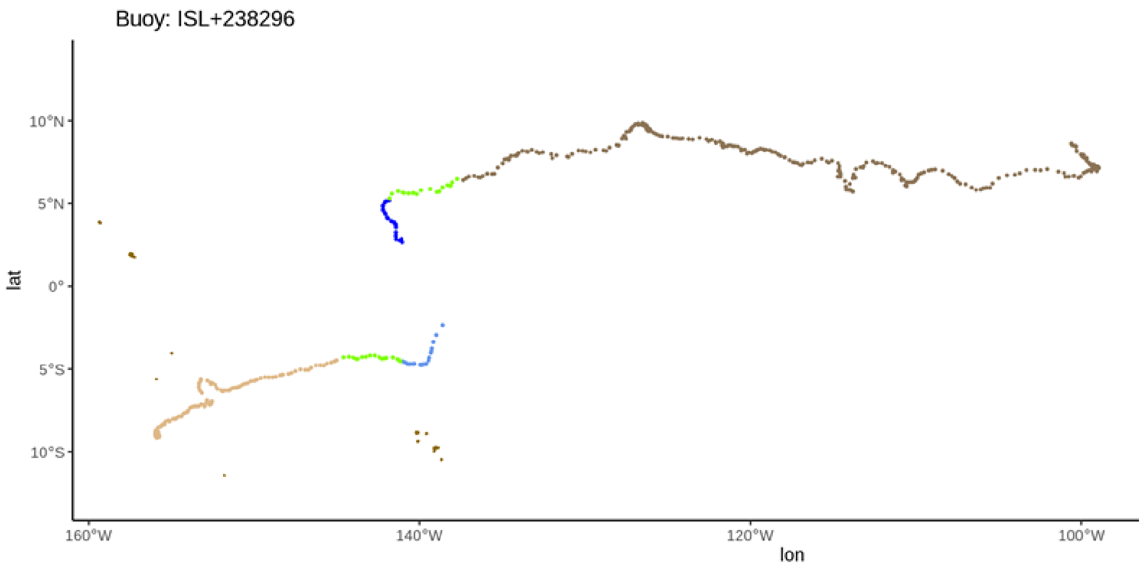
$20 <= [day_n – day_1] <= 35 \Rightarrow$ “virgin” section

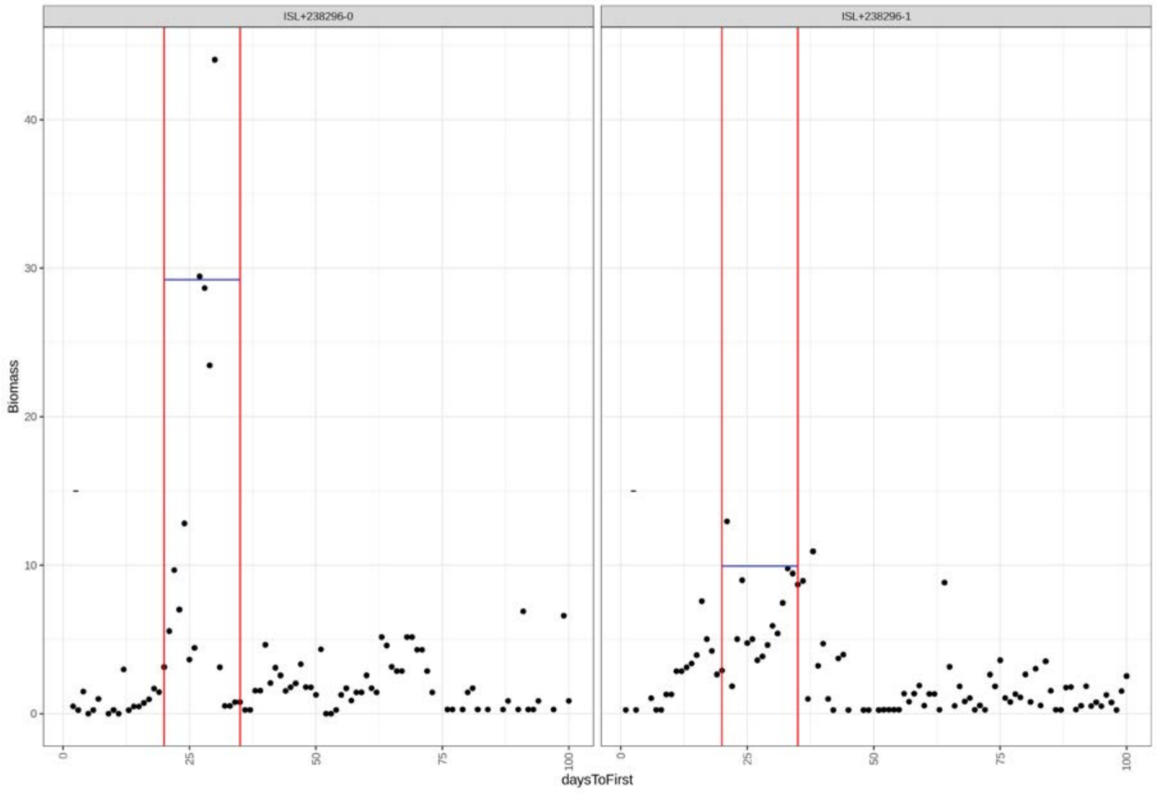
If $day_{n+1} – day_n >= 30 \Rightarrow$ new trajectory

Concept of
“virgin segment”

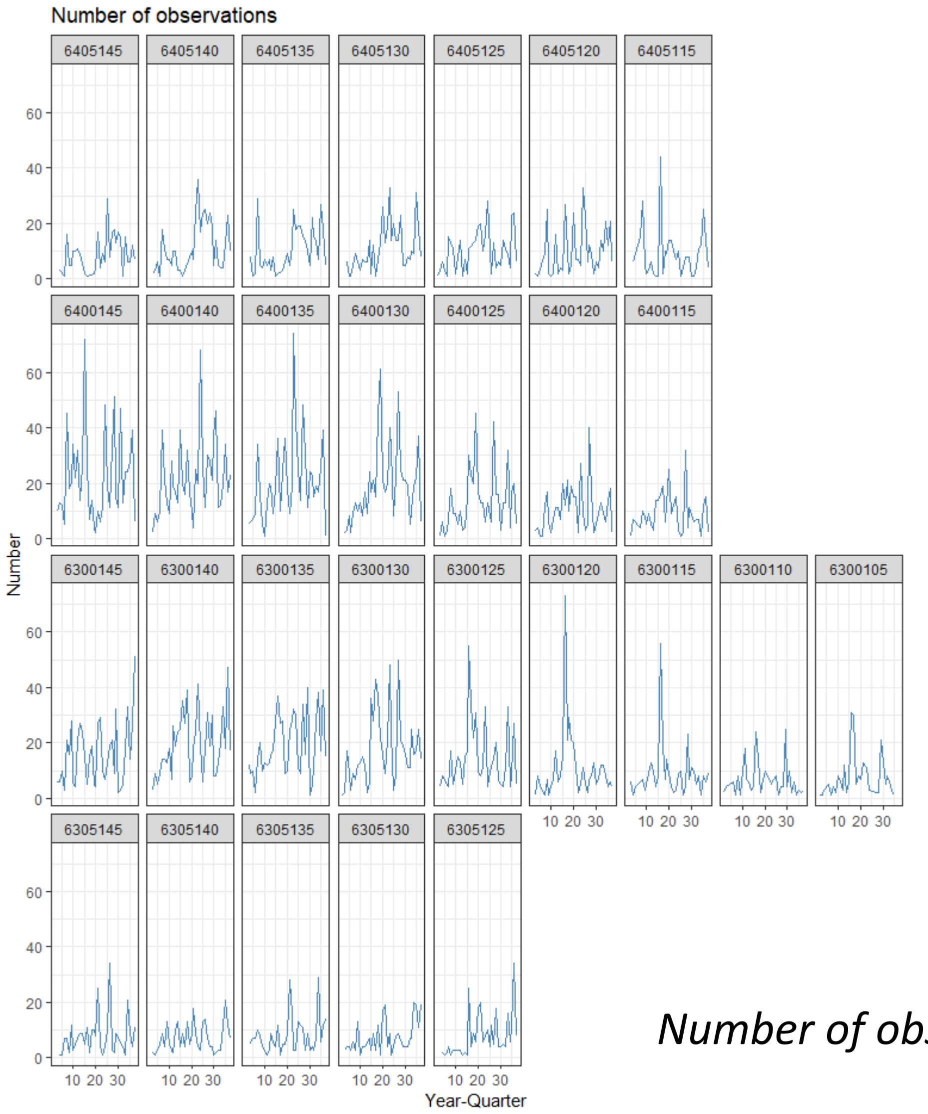
1 buoy – 4 trajectories – 4 sections

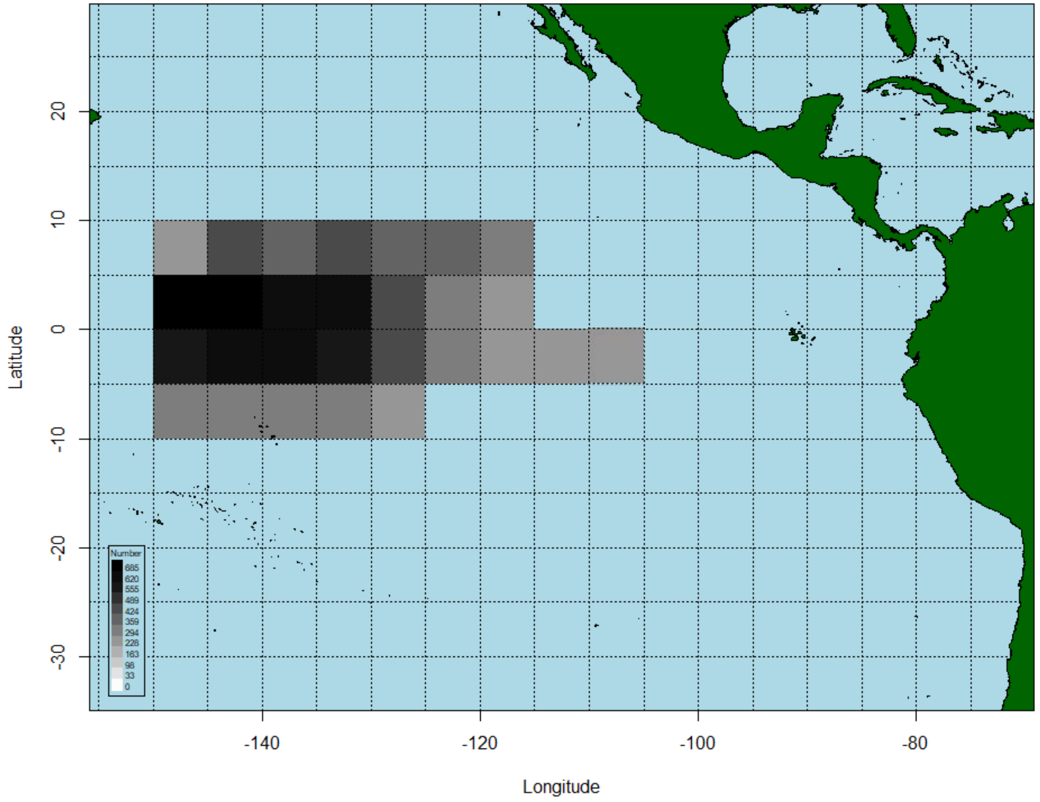
Data and methods





Data and methods

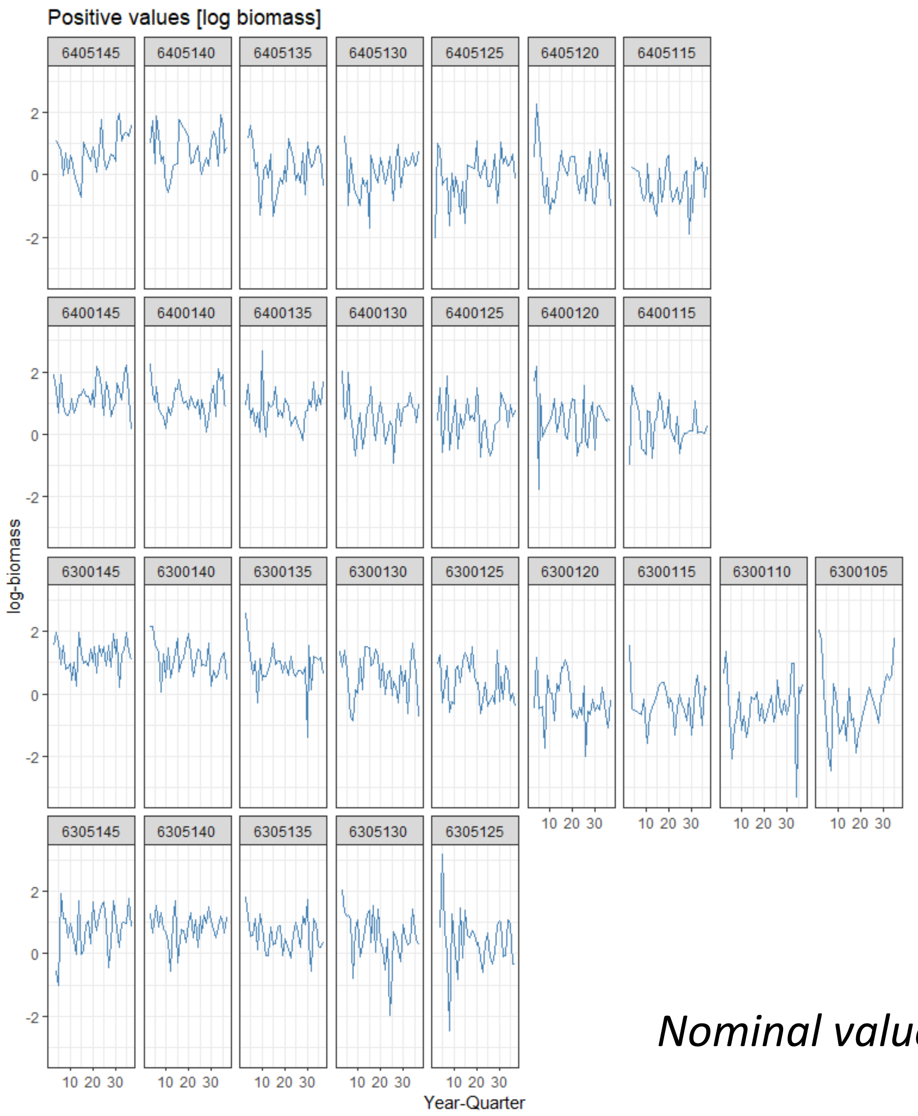


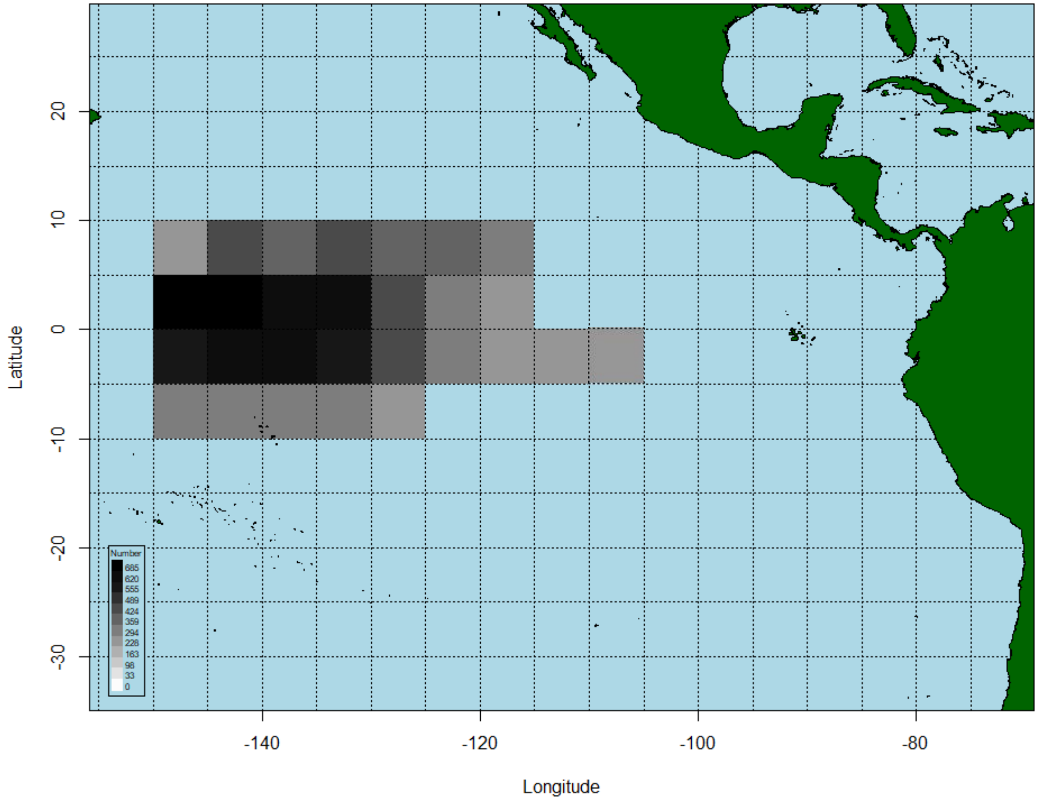


Number of observations by quarter [5ºx5º]

Buoy brand: satlink

Data and methods





Nominal values by quarter [5ºx5º]

Buoy brand: satlink

Data and methods

The BAI index: Buoy-derived Abundance Index (BAI):

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

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

- In order to ensure that λ can be assumed to be constant a standardization analysis is performed.
- Considering the low proportion of zero values (0.31%) a GLMM log-normal error structured model was applied to standardize the acoustic observations

Data and methods

Covariates for standardization:

- **Categorical**: year-quarter [yyqq], 5°x5º ICCAT areas [area], buoy model [model]
- **Continuous**:
  - velocity of the buoy [vel]
  - FAD densities [den]
  - environmental variables:
    - ✓ Ocean mixed layer thickness [mld]
    - ✓ Chlorophyll [chl] and Chlorophyll front [chlfront]
    - ✓ SST [sst] and SST front [sstfront]

Results

Index of abundance of juvenile skipjack tuna in the Eastern Pacific Ocean derived from echosounder buoys (2012-2020)

Results

Analysis of deviance table:

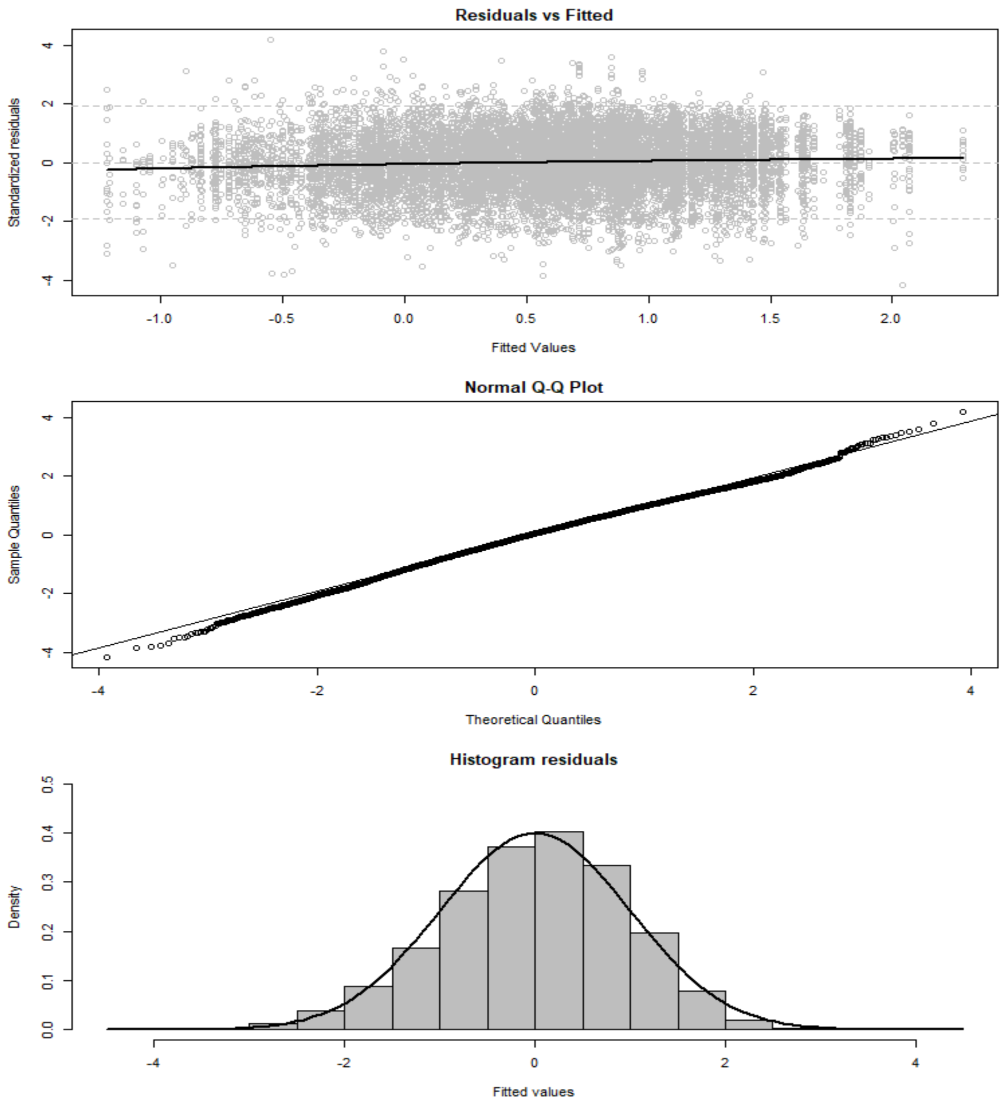
Variable	Df	Deviance	Resid..Df	Resid..Dev	F	Pr..F.	Dev..Exp
NULL	NA	NA	11300	15847	NA	NA	NA
yyqq	35	1019	11265	14828	30	0.0000	6.43 %
area	27	2170	11238	12658	82	0.0000	13.69 %
model	2	73	11236	12585	37	0.0000	0.46 %
den	1	78	11235	12507	80	0.0000	0.49 %
sst	1	0	11234	12507	0	0.5915	0 %
sstfront	1	2	11233	12505	2	0.1696	0.01 %
mld	1	1	11232	12504	1	0.2495	0.01 %
yyqq:area	867	2179	10365	10324	3	0.0000	13.75 %
yyqq:model	29	86	10336	10238	3	0.0000	0.54 %
yyqq:den	34	98	10302	10141	3	0.0000	0.62 %
yyqq:sst	35	98	10267	10042	3	0.0000	0.62 %
yyqq:mld	34	73	10233	9970	2	0.0001	0.46 %

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

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

Results

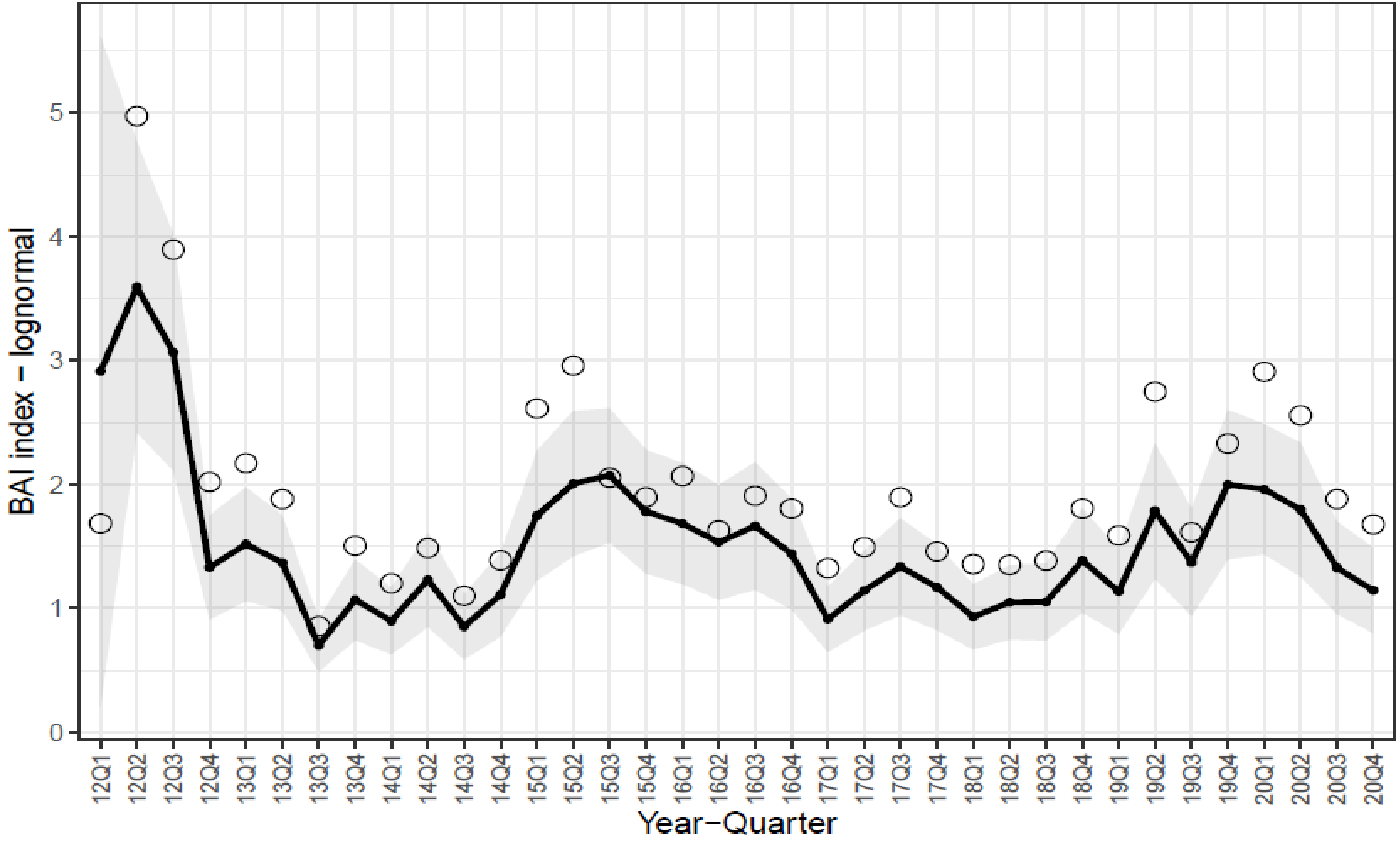
Diagnosis plots:



Diagnostics of the lognormal model selected for the period 2012-2020: 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 2012-2020 in the EPO. The 95% upper and lower confidence intervals of the standardized BAI index are shown.

Future steps

Improvement of the methodology:

- determination of **virgin segments**:
  - threshold between two consecutive observations [30 days?]
  - observer data on FAD deployments vs classification of virgin segments
  - colonization patterns in the EPO [20-35 days?]
- best spatial/temporal strata to characterize **species composition and sizes**
- **machine learning algorithms** to predict species catches from acoustic samples

Future steps

- The **involvement of the industry is fundamental** to provide these valuable indicators.
- We deeply appreciate the involvement of **OPAGAC** and **Cape Fisheries** in this project and hope that **other companies will join this initiative**, <u>**retrieving historical information and regularly providing high-resolution buoy data, including acoustic information.**</u>
- These advancements can provide significant information to complement current stock assessments of tropical tuna stocks, providing **indices less dependent on fisheries data and less affected by changes in fishing efficiency**.

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 **ISSF** for partially funding this work.