ECHOSOUNDER BUOY DERIVED TROPICAL TUNA BIOMASS INDICES IN THE EASTERN PACIFIC OCEAN

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Introduction

Index of abundance of juvenile skipjack tuna in the Eastern Pacific Ocean derived from echosounder buoys (2012-2023)

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

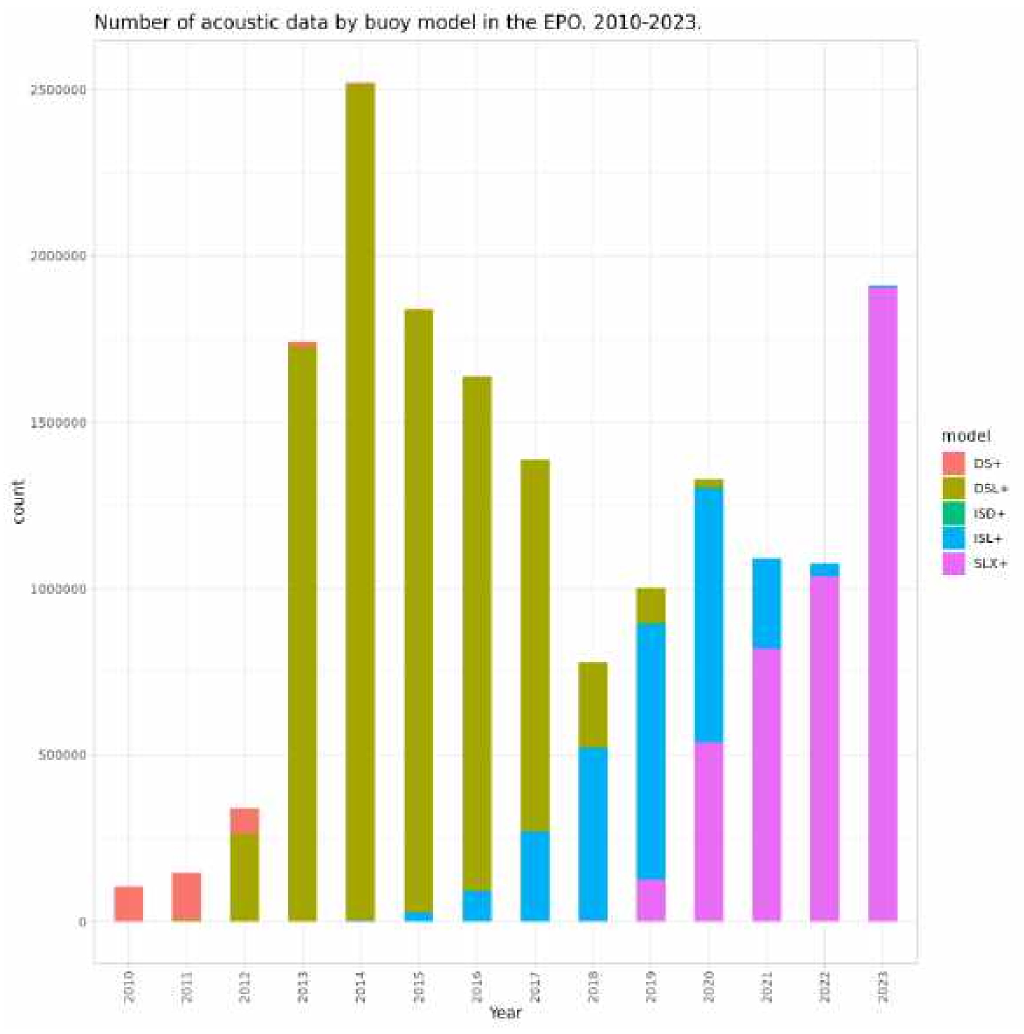
- **IOTC**

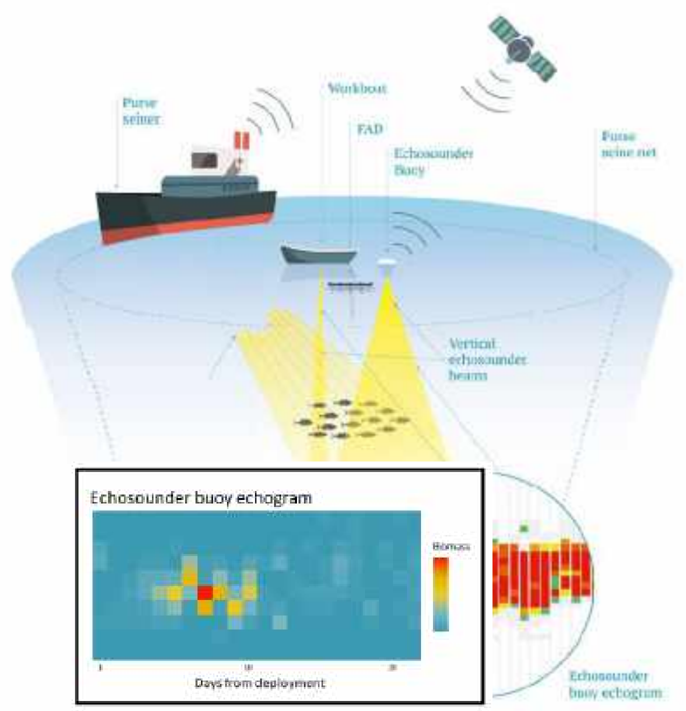
- **2019**: A novel index of abundance of juvenile yellowfin tuna in the Atlantic ocean derived from echosounder buoys
- **2020**: A novel index of abundance of skipjack in the Indian Ocean derived from echosounder buoys

- **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"
- 2022: interim skipjack assessment conducted by IATTC staff in 2022 (SAC-13-07)
- **STOCK ASSESSMENT OF SKIPJACK TUNA IN THE EASTERN PACIFIC. OCEAN: 2024 BENCHMARK ASSESSMENT (SAC-15-04)**

Satellite linked echo-sounder buoys

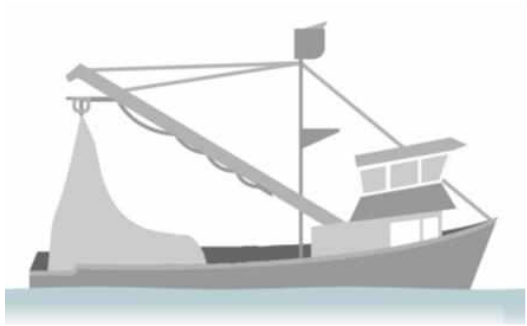


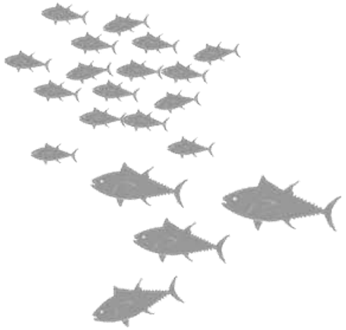


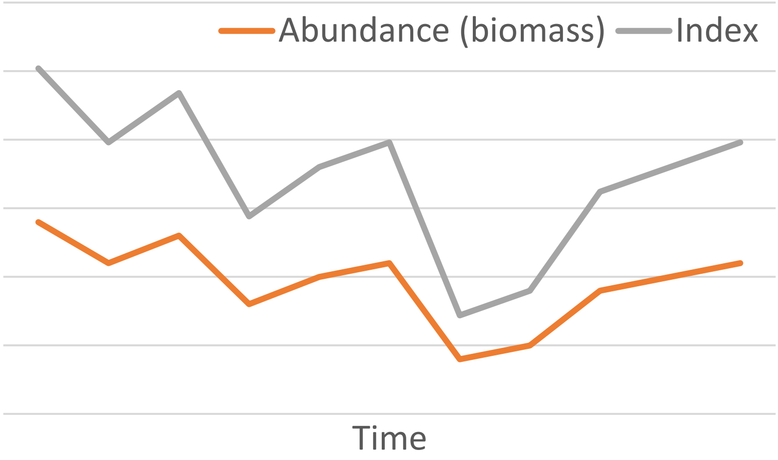
The framework of collaborative work between the Inter-American Tropical Tuna Commission (IATTC) and AZTI Foundation, together with echosounder buoy providers and tropical tuna purse seiner fishing companies operating in the eastern Pacific Ocean (EPO) (companies integrated in OPAGAC and Cape Fisheries) has facilitated the recovery of information from echosounder buoys (2010-2023).

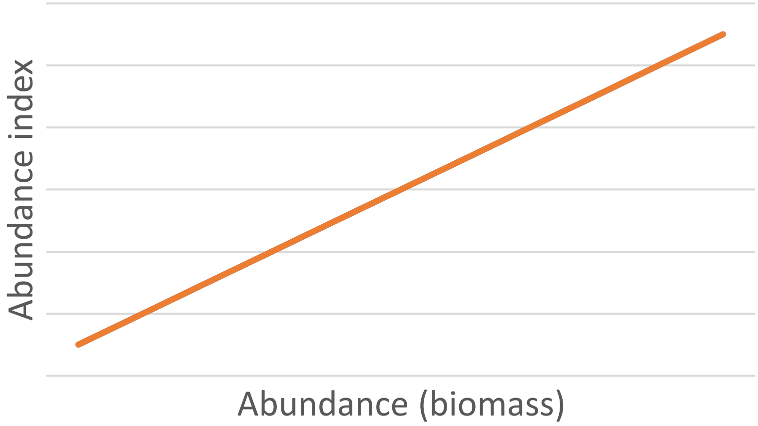
~38,9 million acoustic records [SATLINK]

CPUE



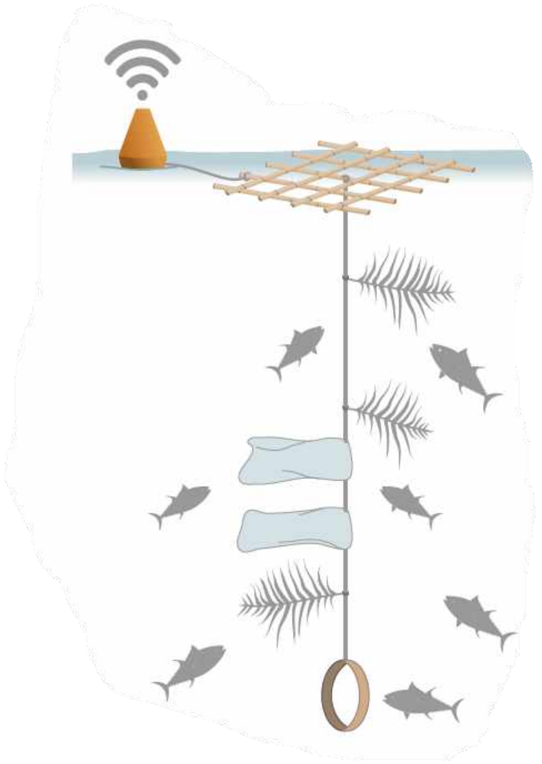






$$CPUE = q \cdot biomass$$

BAI



$$BAI = \lambda \cdot biomass$$

From CPUE = q . biomass
to BAI = λ . 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

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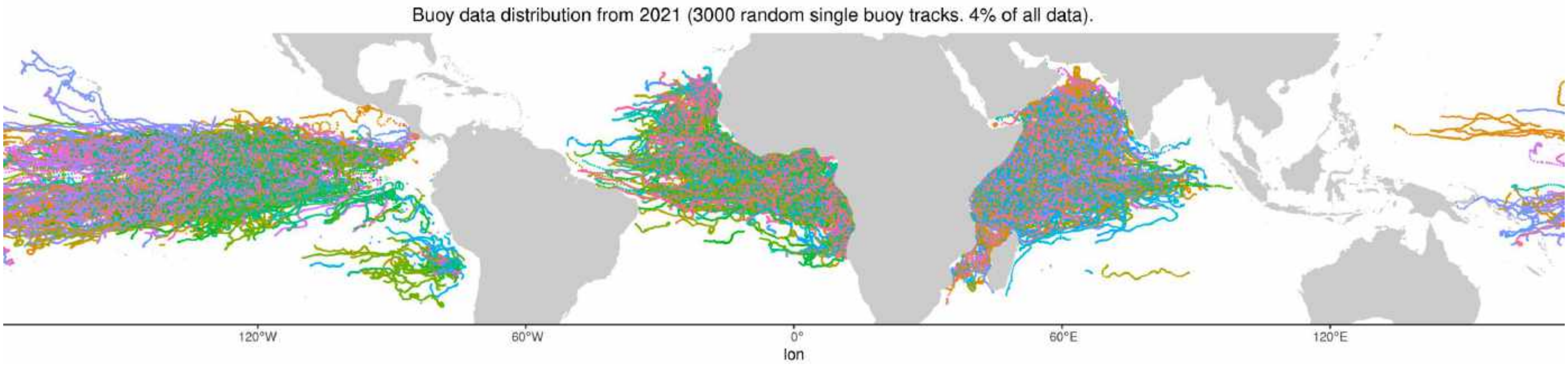
Data and methods

Index of abundance of juvenile skipjack tuna in the Eastern Pacific Ocean derived from echosounder buoys (2012-2023)

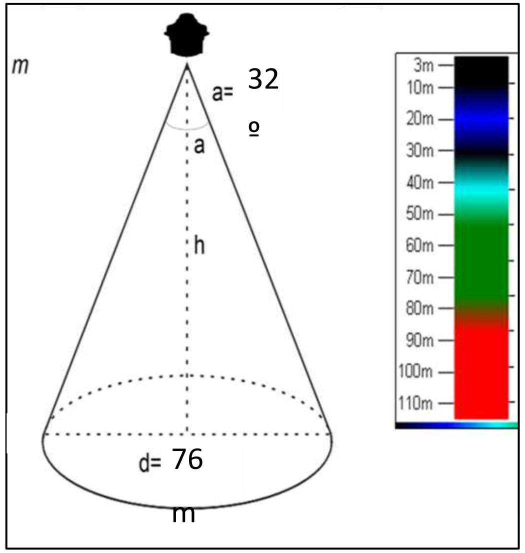
Data and methods

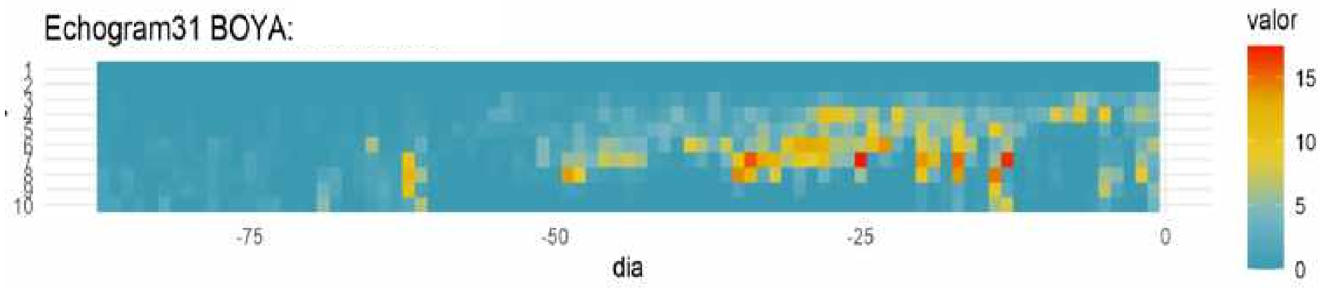


Acoustic data recorded by a single buoy echogram

Data and methods

The acoustic (raw) data: Satlink



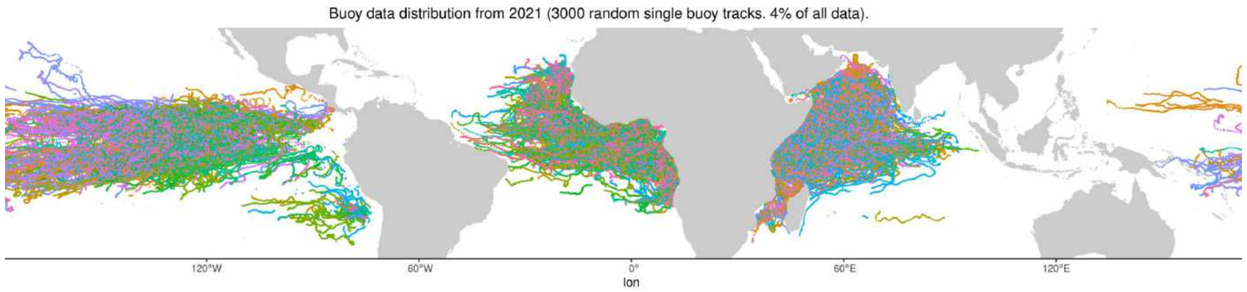


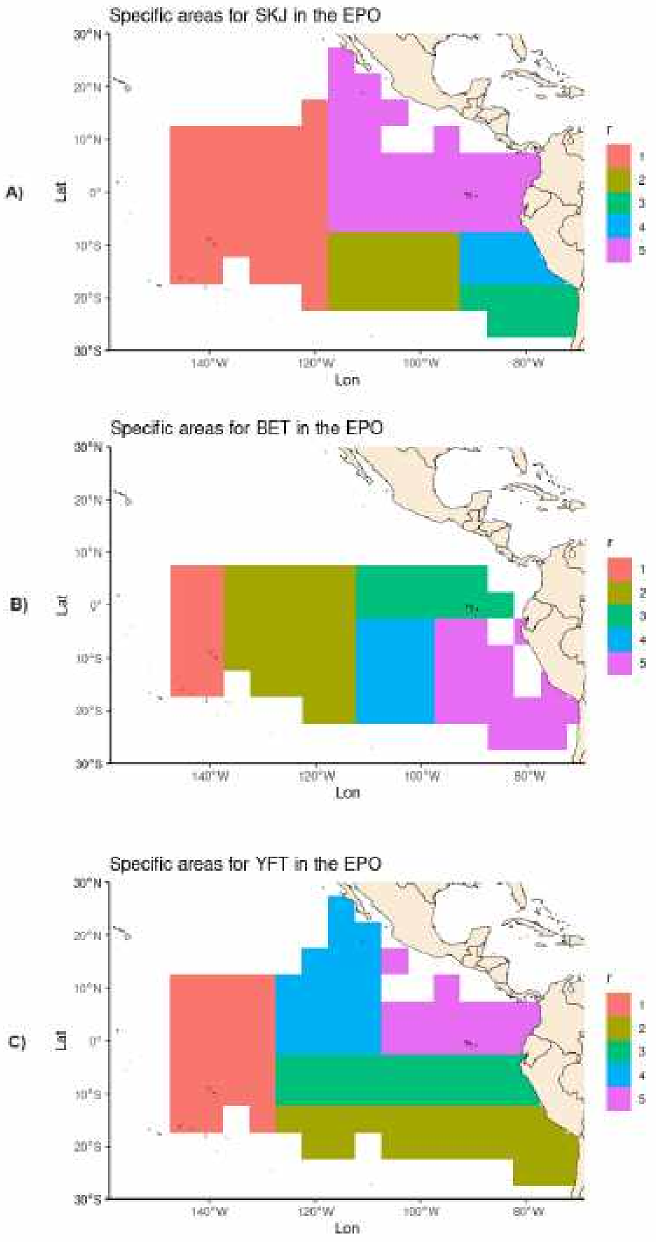
Units used by the buoy brand (0-63 tones range per layer) → Decibels → Recalculated biomass by species

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

- 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: The b20 values were obtained from Boyra et al. (2018) for SKJ, from Sobradillo et al. (2024) for YFT, and from Boyra et al. (2018) for BET.

Data and methods





Protocol for the assignment of sizes and specific composition data# to each of the analyzed acoustic records:

- **1 Step:** same 1°x1° grid, year, and month data# is used.
- **2 Step:** If this data was unavailable, data# from the same 5°x5° grid, year, and month is used.
- **3 Step:** the spatial window is expanded, and the specific areas defined by IATTC staff (A, B and C), year, and month data# is used.
- **4 Step:** data is aggregated by quarter and 5°x5° grid.
- **5 Step:** data is used at a quarterly and regional resolution.

Data and methods

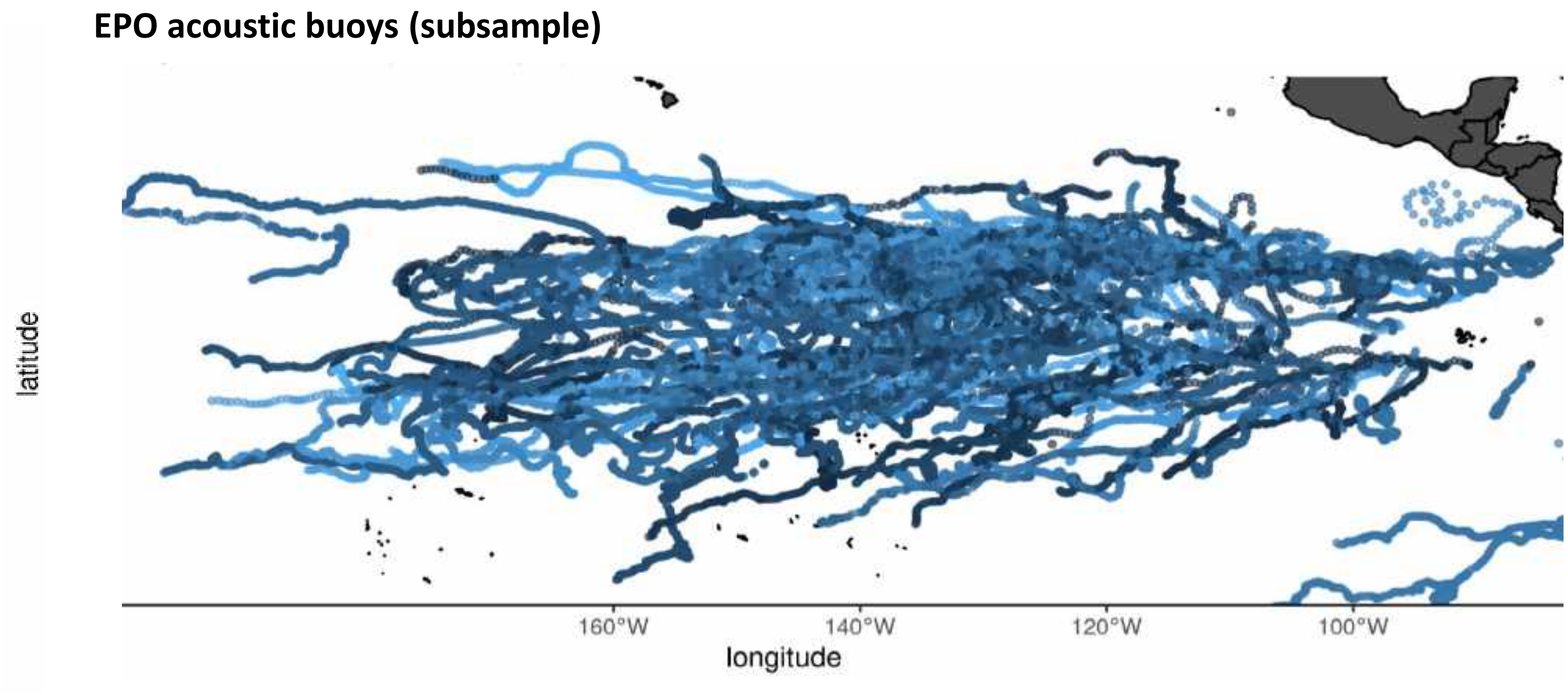
Acoustic data cleaning and filtering

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)

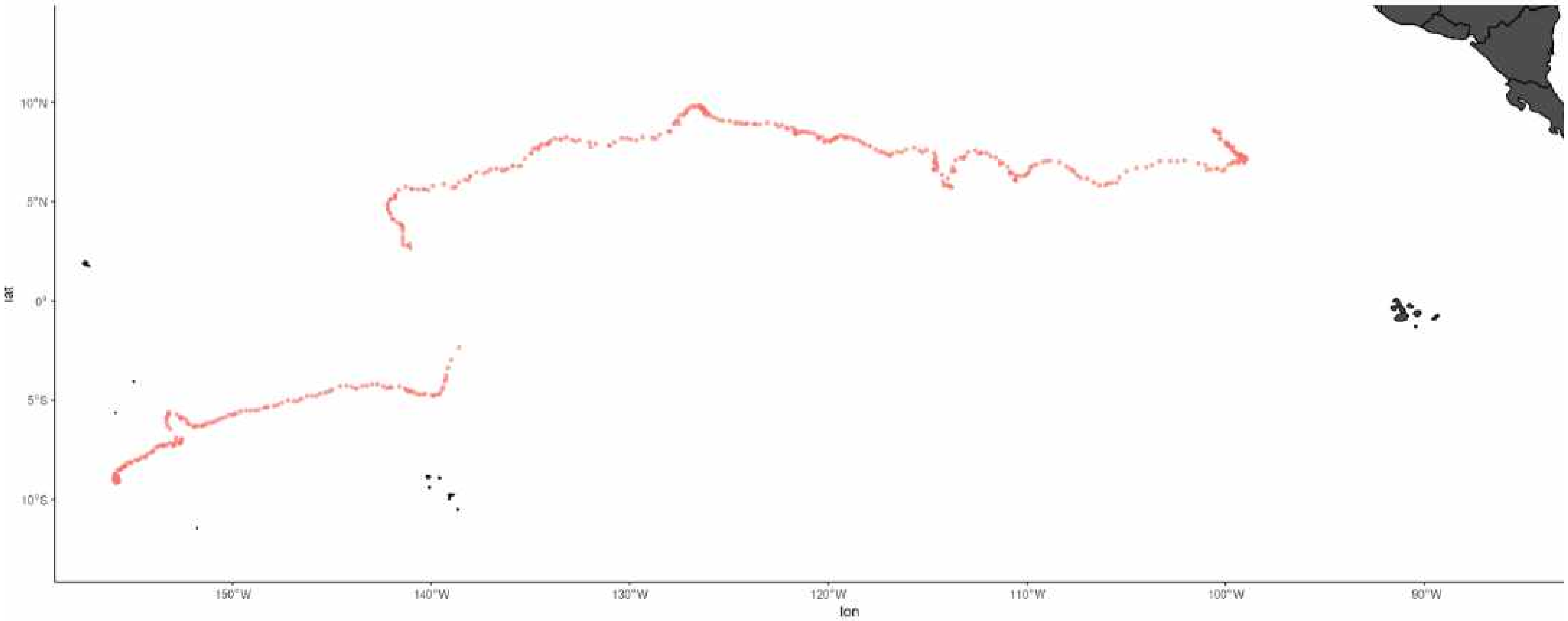
Data and methods



"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

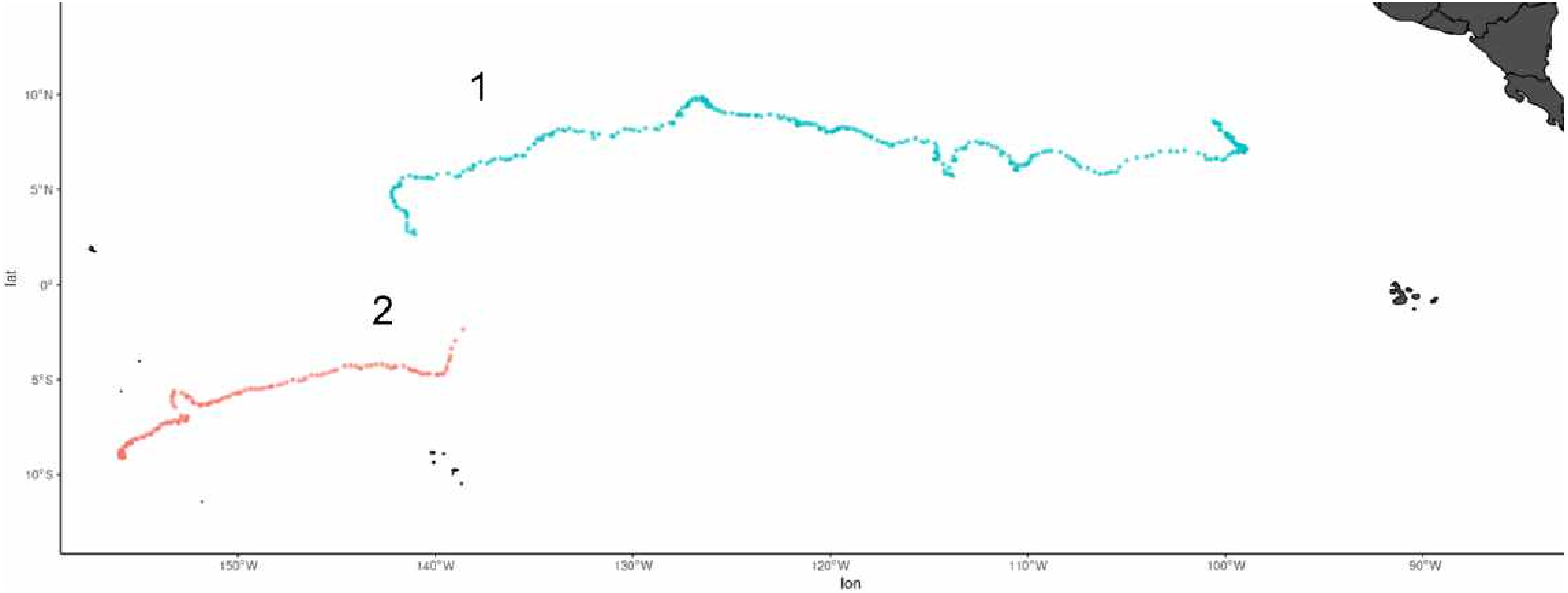
Concept of “virgin segment”



1 buoy

Data and methods

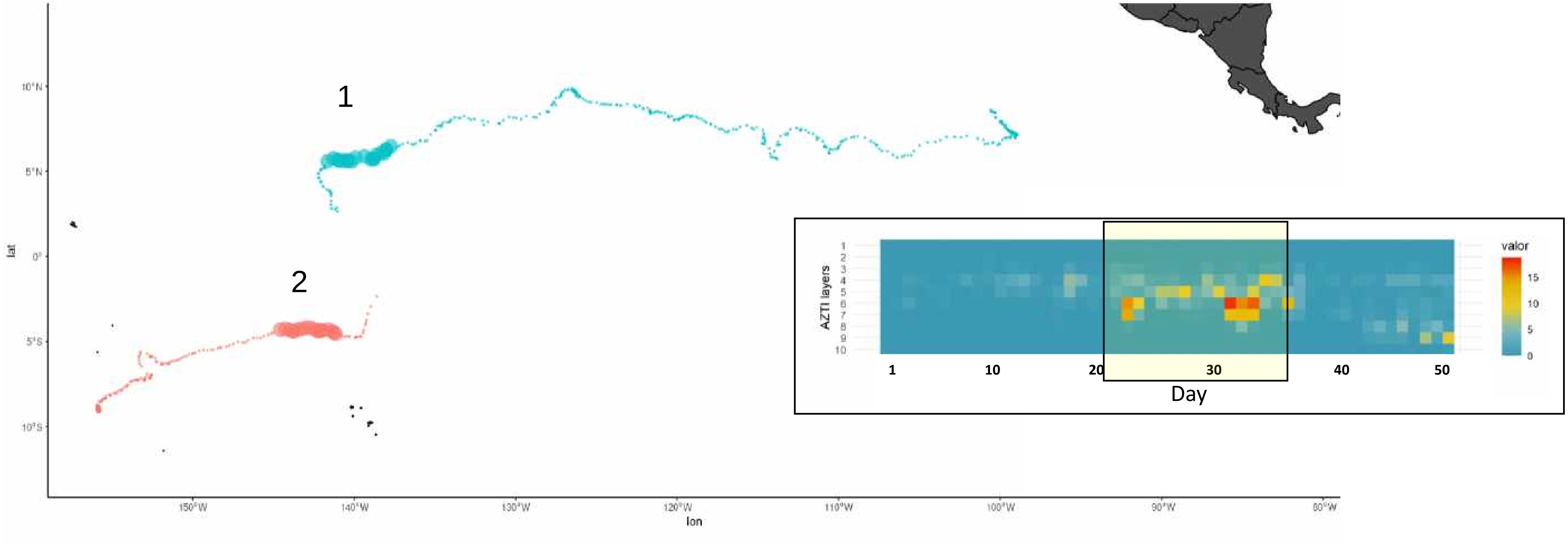
Concept of “virgin segment”



(1 buoy – 2 trajectories)

Data and methods

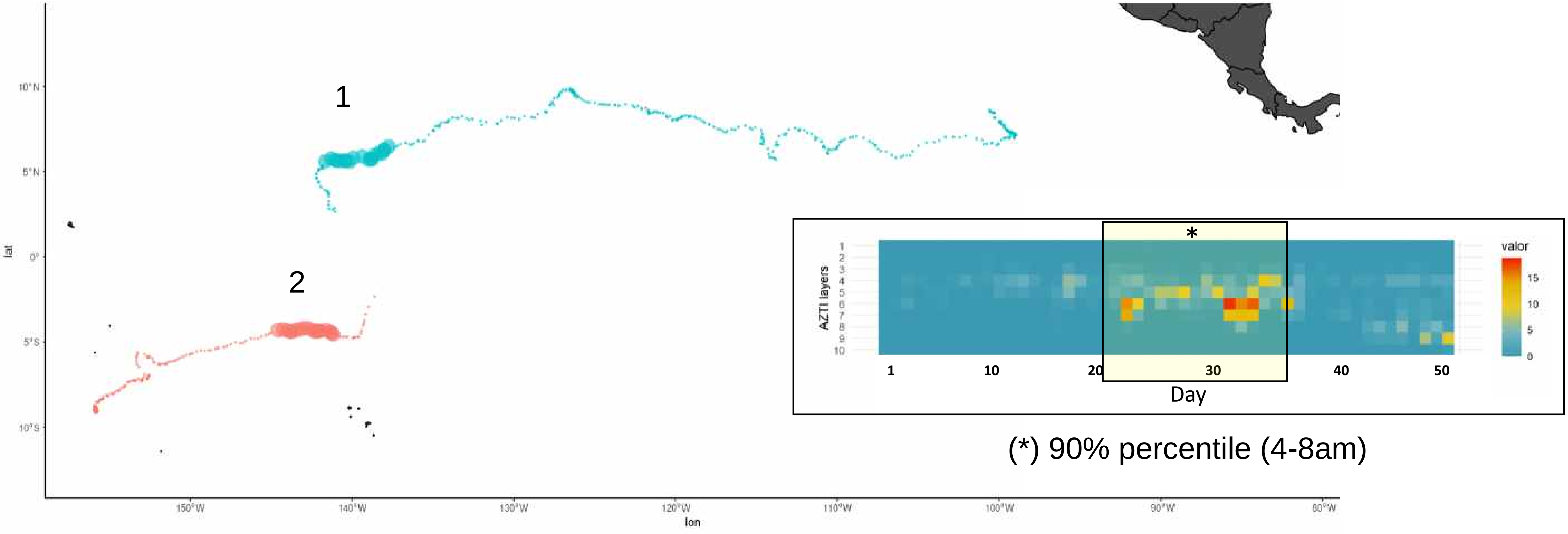
Concept of “virgin segment”



(1 buoy – 2 trajectories – 2 sections)

Data and methods

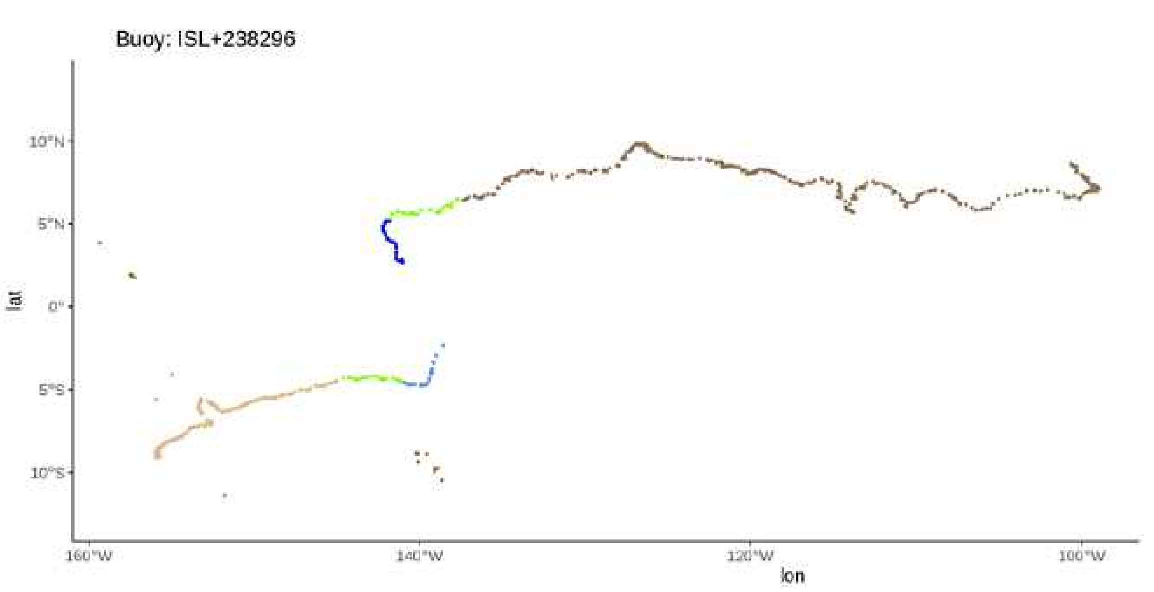
Concept of “virgin segment”

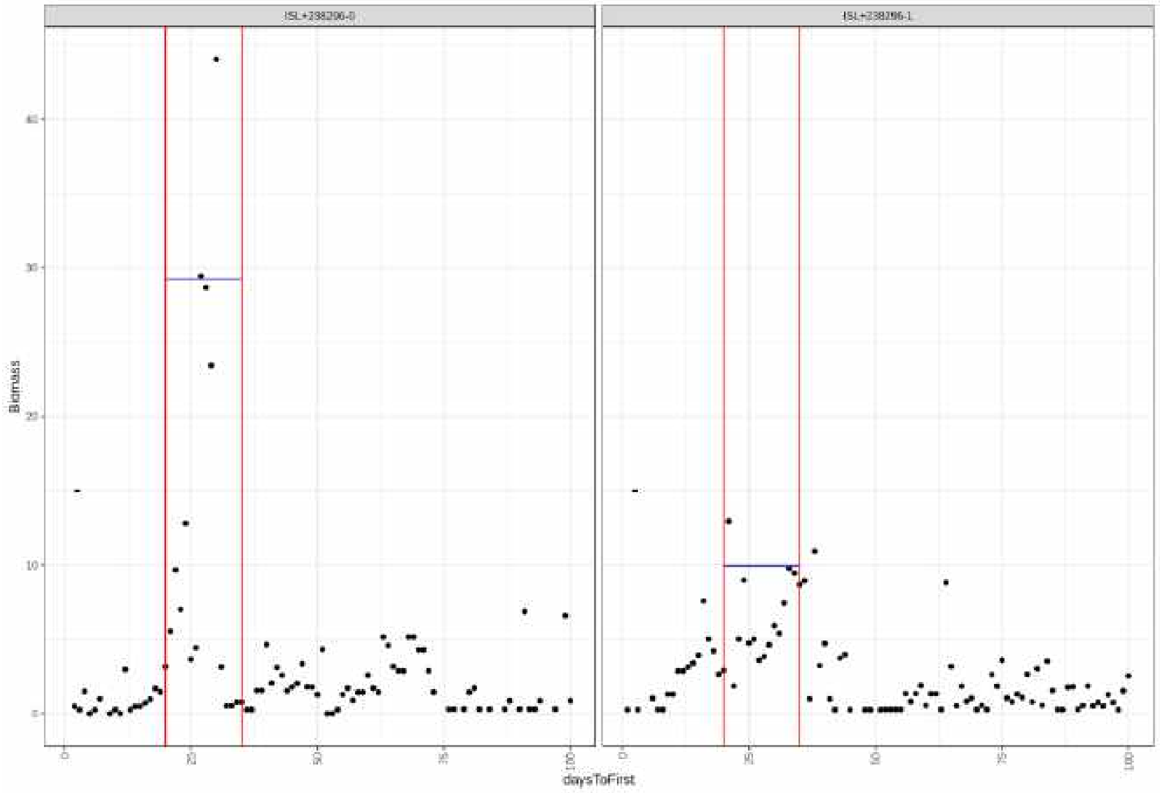


(*) 90% percentile (4-8am)

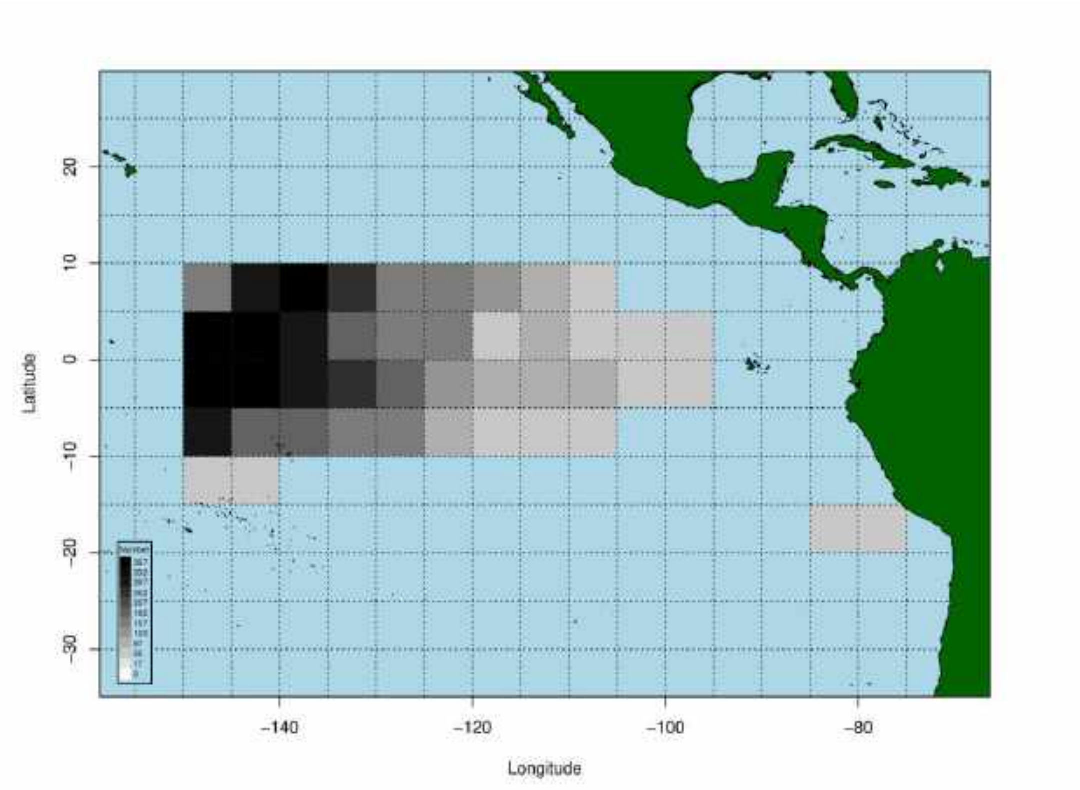
(1 buoy – 2 trajectories – 2 sections)

Data and methods

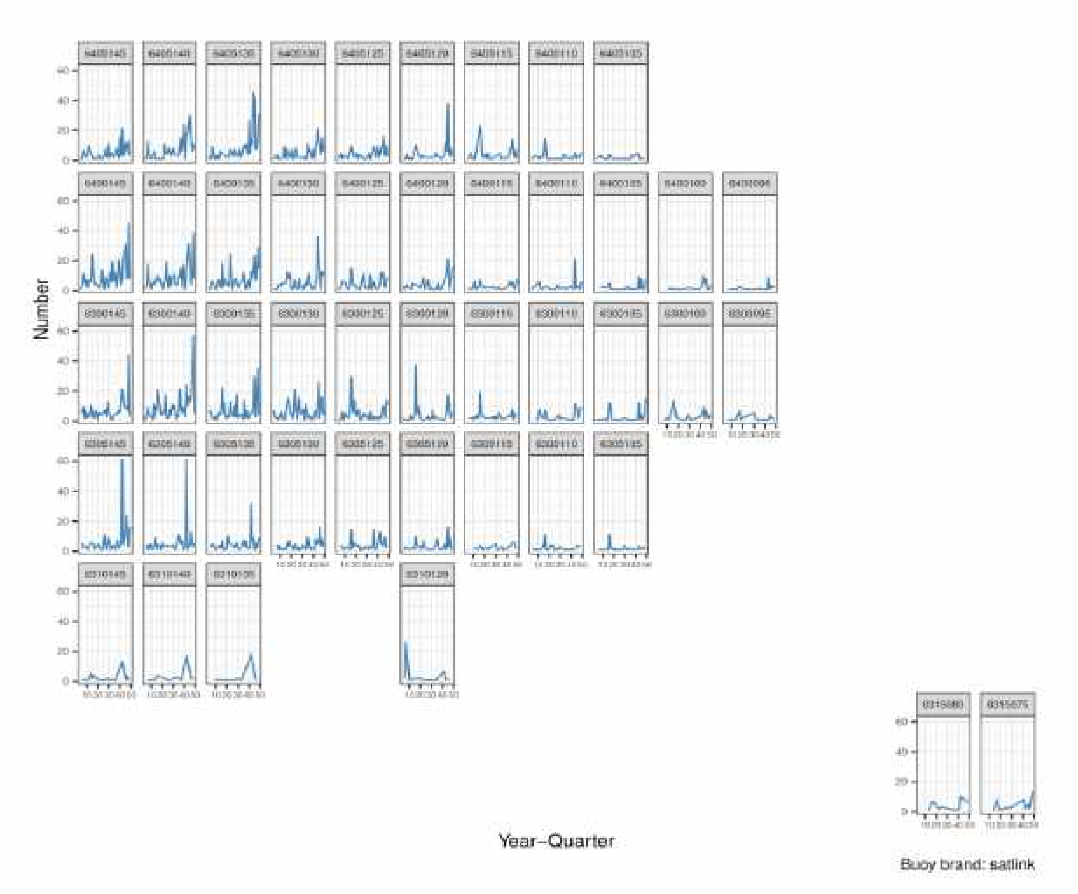




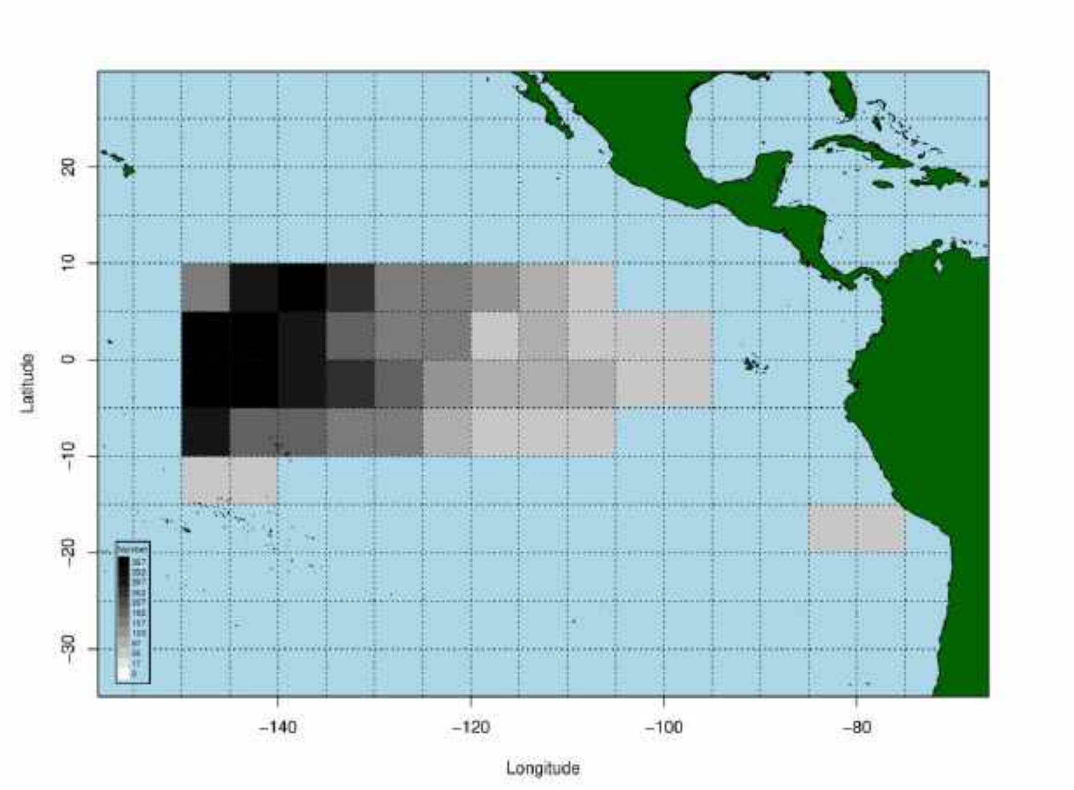
Data and methods



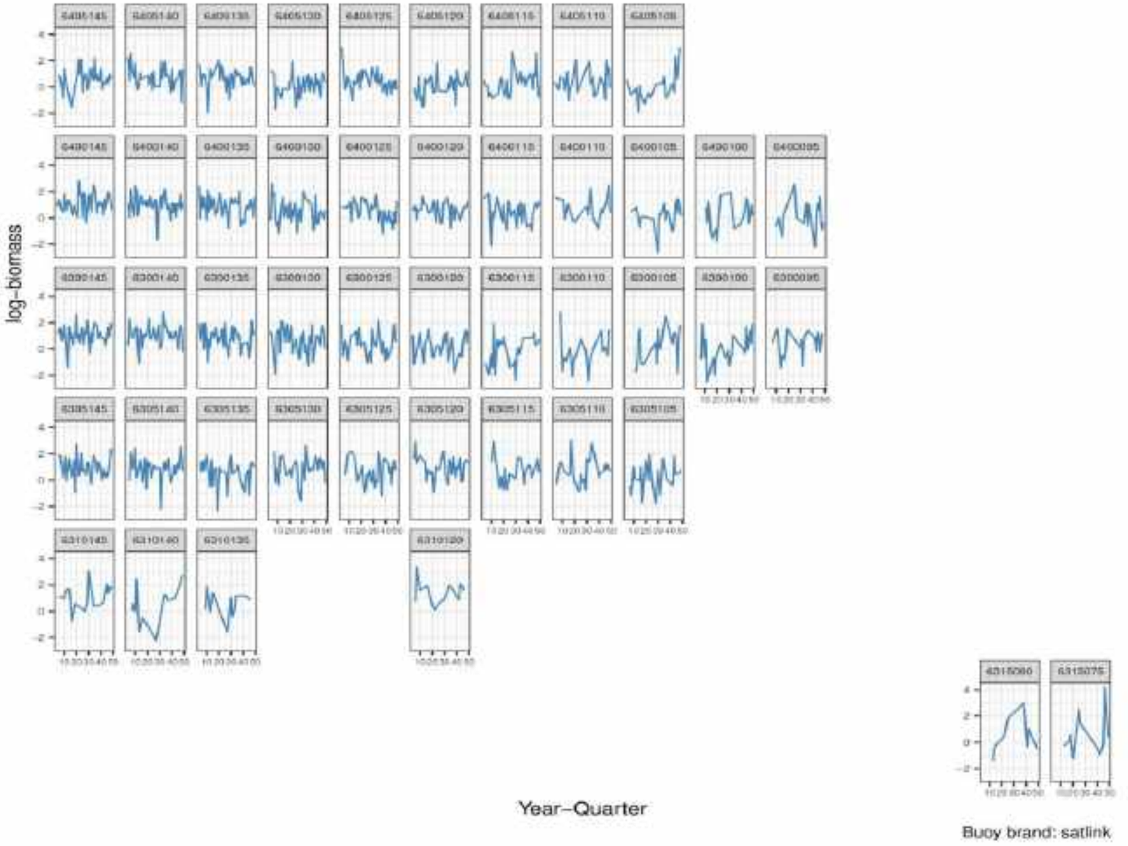
Number of observations by quarter [5ºx5º]



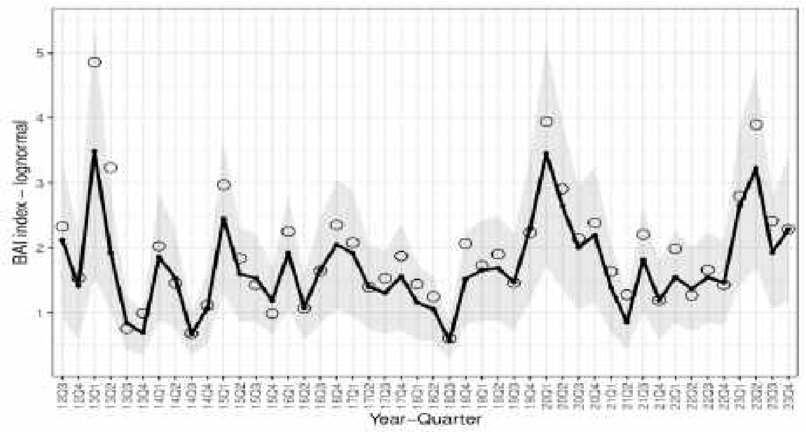
Data and methods



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: $\mathbf{BAI_t = \boldsymbol{\lambda} \,.\, B_t}$
- In standardization analysis is performed. order to ensure that λ can be assumed to be constant a
- Considering the low proportion of zero values 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 (2012-2023)

Results

Analysis of deviance table:

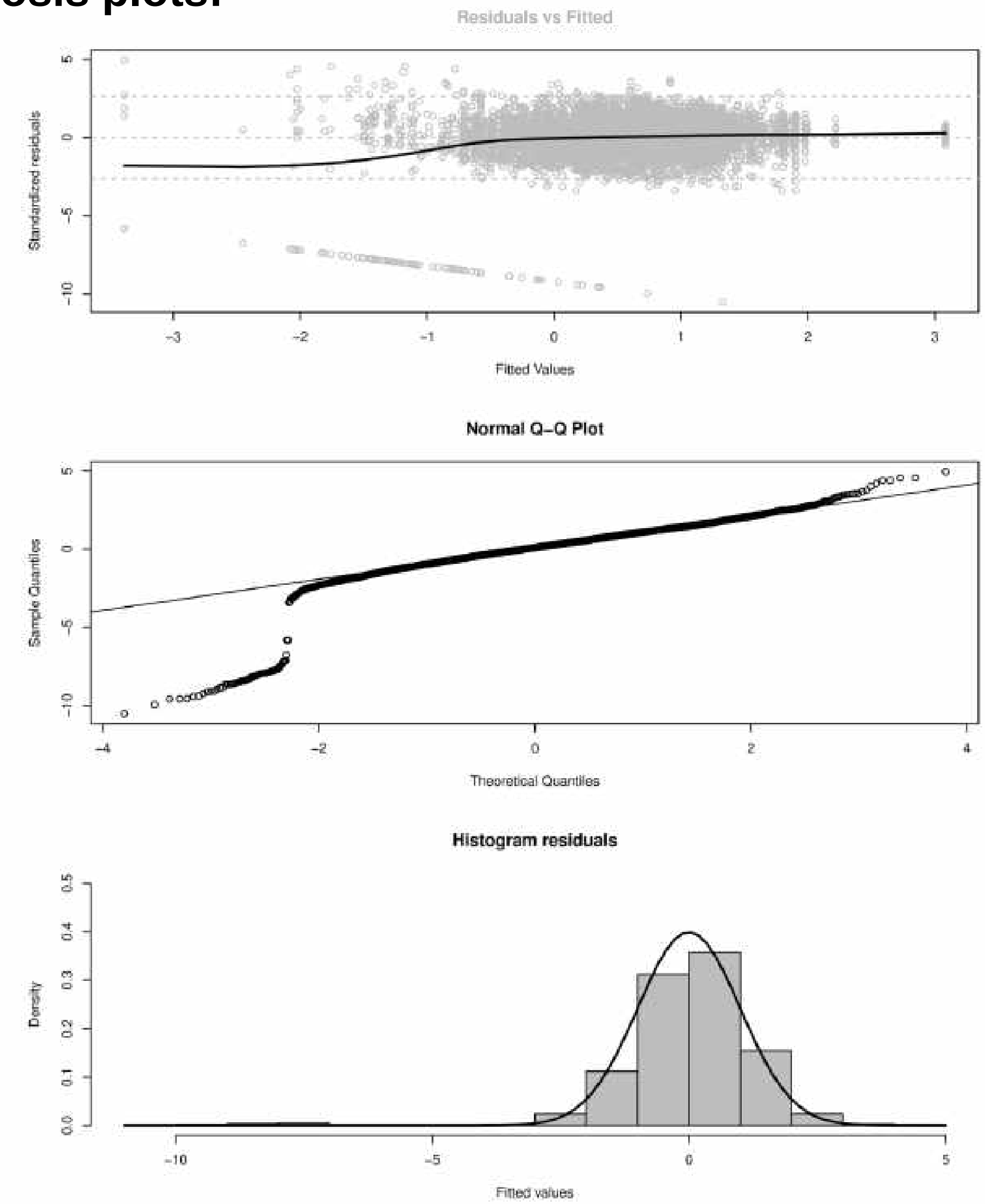
Variable	Df	Deviance	Resid..Df	Resid..Dev	F	Pr..F.	Variable	DevExp	Dev..Exp
NULL	NA	NA	6987	14555	NA	NA	NULL	NA	NA
yyqq	45	909	6942	13646	13	0.0000	yyqq	6	6.24 %
area	45	1038	6897	12608	15	0.0000	area	7	7.13 %
model	2	34	6895	12574	11	0.0000	model	0	0.23 %
den	1	25	6894	12549	16	0.0001	den	0	0.17 %
chl	1	10	6893	12539	7	0.0105	chl	0	0.07 %
chlfront	1	109	6892	12430	71	0.0000	chlfront	1	0.75 %
sst	1	5	6891	12425	3	0.0795	sst	0	0.03 %
sstfront	1	10	6890	12416	6	0.0115	sstfront	0	0.07 %
mld	1	0	6889	12416	0	0.9523	mld	0	0 %
yyqq:area	1311	3864	5578	8552	2	0.0000	yyqq:area	27	26.55 %

The proportion of deviance explained by the model was 41,2%.

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

Results

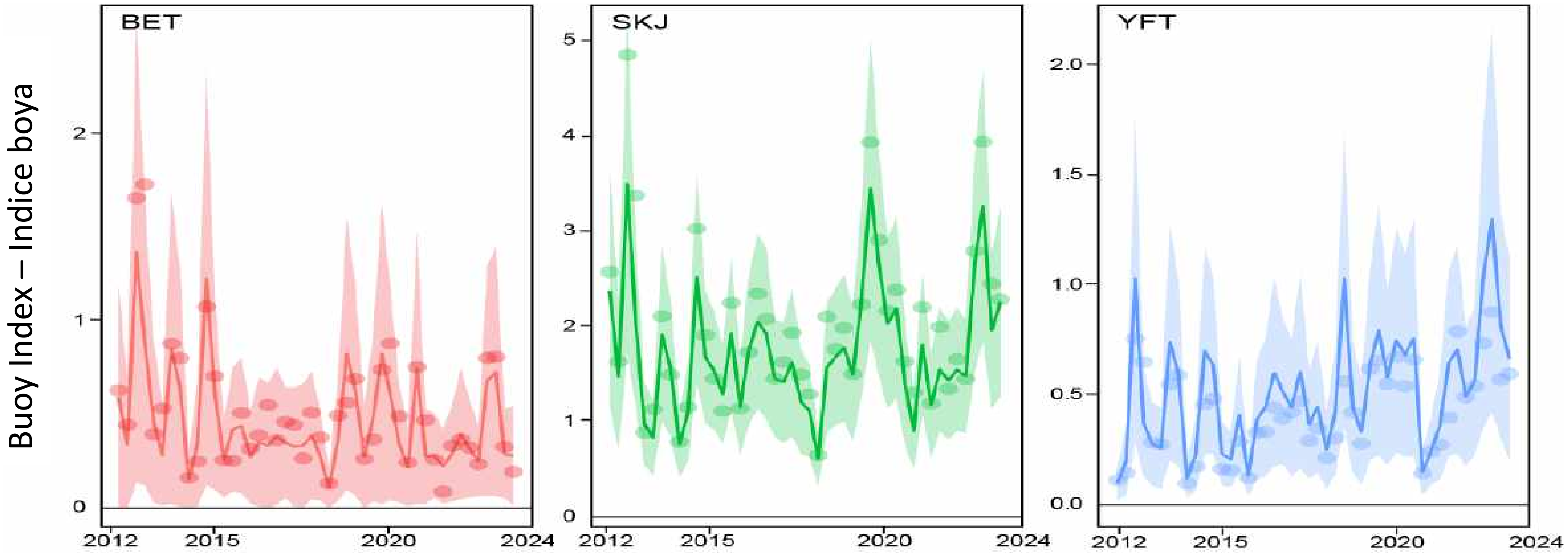
Diagnosis plots:



Diagnostics of the lognormal model selected for the period 2012-2023: residuals vs fitted, Normal Q-Q plot and frequency distributions of the residuals.

Results

BAI index:



Time series of nominal (circles) and standardized (continuous line) Buoy-derived Abundance Index for the period 2012-2023 for all three tropical tuna species. The 95% upper and lower confidence intervals of the standardized BAI index are shown by the grey shaded area.

Conclusions

Index of abundance of juvenile skipjack tuna in the Eastern Pacific Ocean derived from echosounder buoys (2012-2023)

Conclusions

- **DATA COLLECTION:** new data from new companies, associations, buoy providers. Assess the suitability offshore-coastal indexes.

- **METHODOLOGY UPDATE:** review and evaluate database filters, update the process for assigning species percentages and size measurements to acoustic data, propose new colonization windows for each specific areas of each species, Update b20 TS values ant test alternative biomass values

- **PROGRESS IN ACOUSTICS AND FUTURE LINES:** assess data robustness by cross-referencing acoustic data with capture data, testing full echograms derived from raw acoustic data for improved performance, and promoting ongoing collaborative research to refine abundance indices via buoy acoustics.

Acknowledgements

Gracias! **Thank you!**