TROPICAL TUNA BIOMASS INDICATORS FROM ECHOSOUNDER BUOYS IN THE EASTERN PACIFIC OCEAN

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Meeting document FAD-07-03.

Introduction

Index of abundance of juvenile skipjack tuna in the Eastern Pacific Ocean derived from echosounder buoys (2012-2022)

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

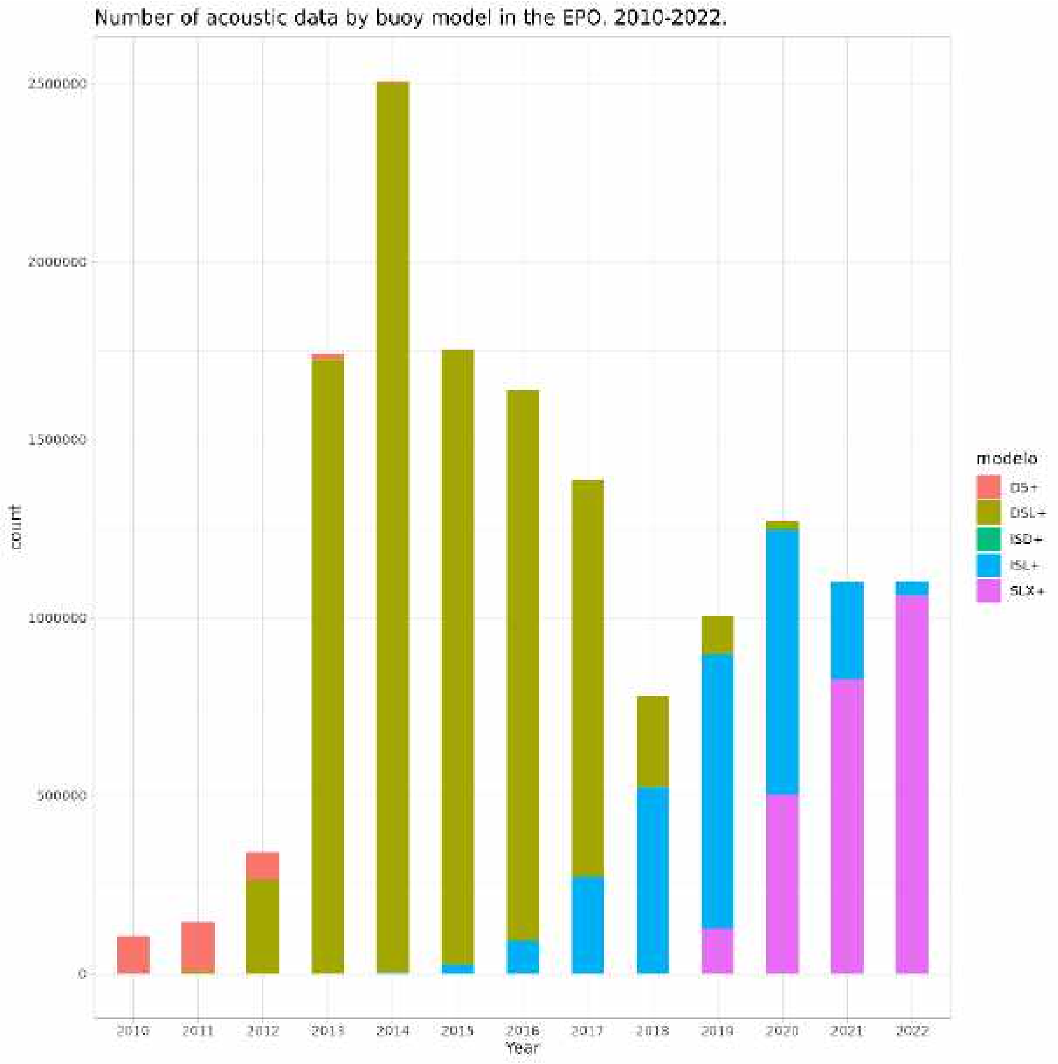
- **IOTC**

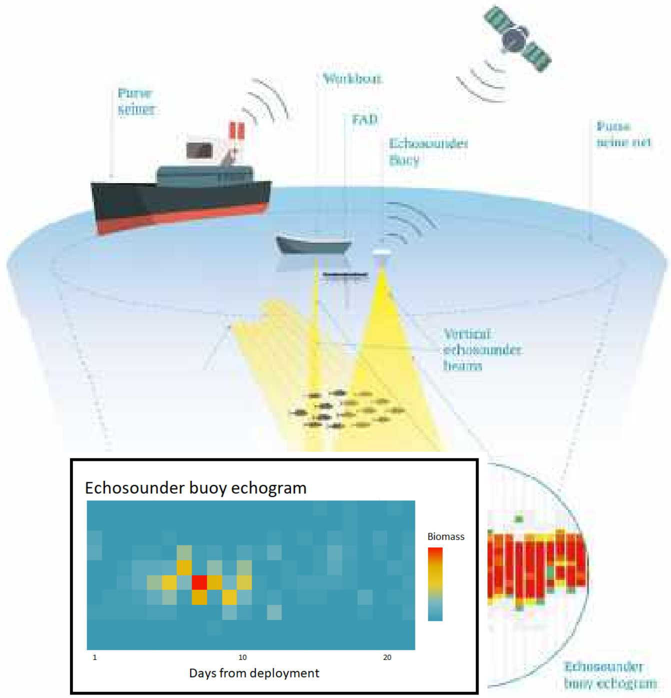
- **2019**: A novel index of abundance of juvenile yellowfin tuna in the Atlantic ocean derived from echosounder buoys
- **2020**: A novel index of abundance of skipjack in the Indian Ocean derived from echosounder buoys

- **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)**

Satellite linked echo-sounder buoys

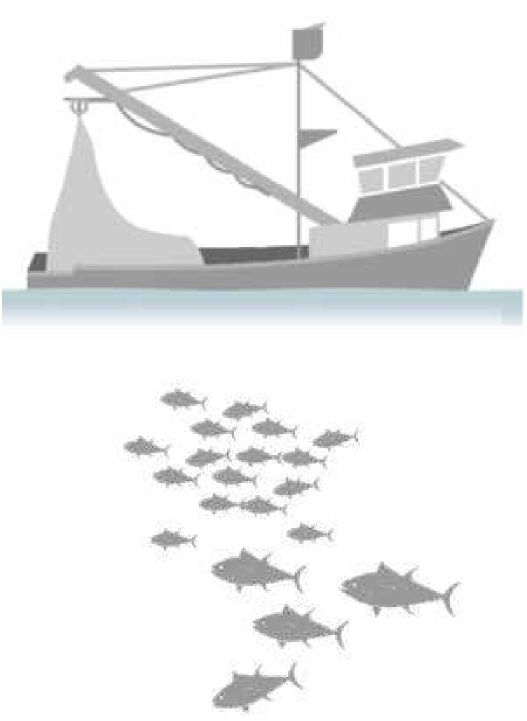


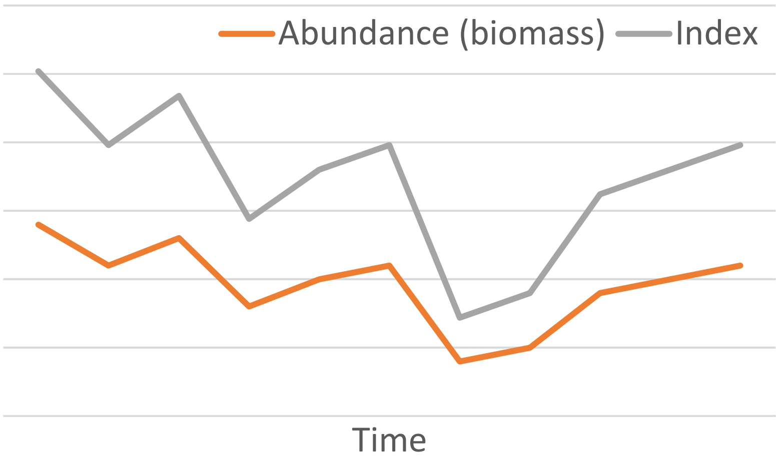


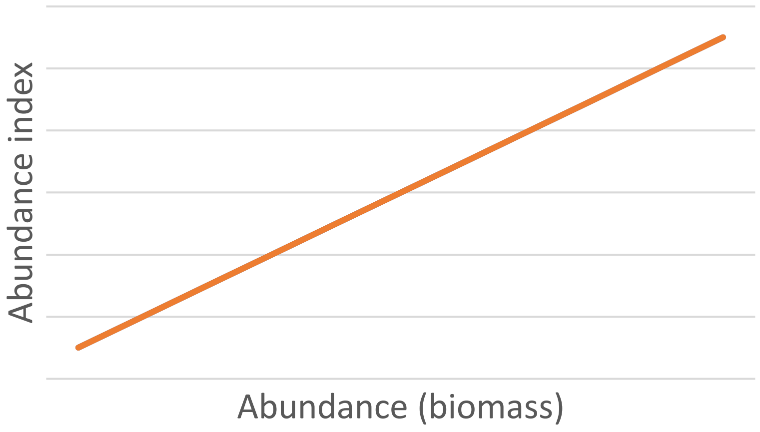
The framework of collaborative work between the Inter-American Tropical Tuna Commission (IATTC) and AZTI Foundation, together with echosounder buoy providers and tropical tuna purse seiner fishing companies operating in the eastern Pacific Ocean (EPO) (companies integrated in OPAGAC and Cape Fisheries) has facilitated the recovery of information from echosounder buoys (2010-2022).

~27,16 million acoustic records [SATLINK]

CPUE

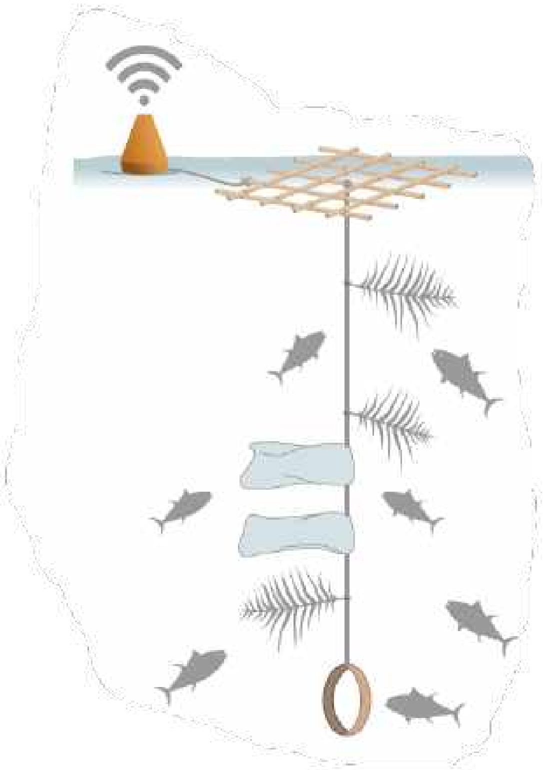






$$CPUE = q \cdot biomass$$

BAI



BAI = λ · biomass

From CPUE = q . biomass
to BAI = λ . Biomass

Key assumptions:

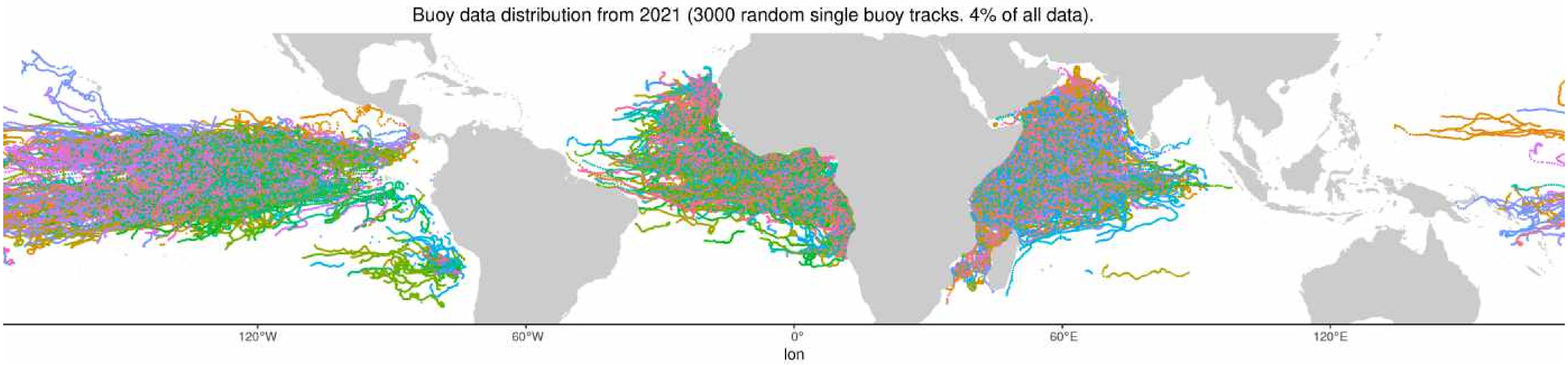
- Relationship between BAI and abundance is linear (proportional).
- The relationship doesn't change over time or space.
- The proportion of the abundance associated to FADs is proportional to the total abundance

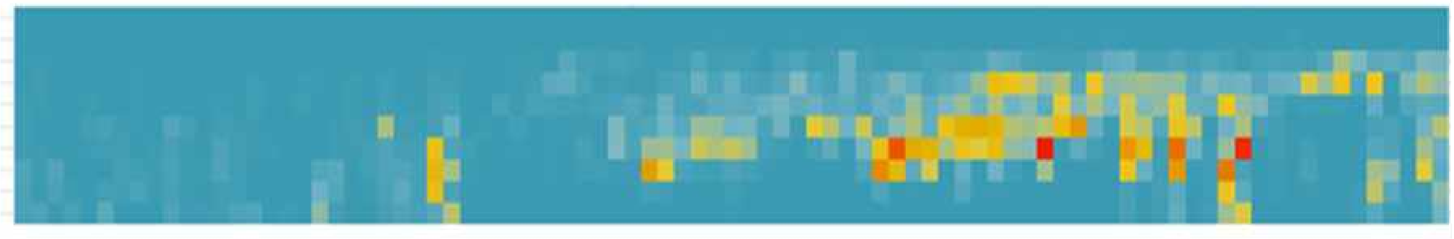
AZTI
MEMBER OF
BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

Data and methods

Index of abundance of juvenile skipjack tuna in the Eastern Pacific Ocean derived from echosounder buoys (2012-2022)

Data and methods

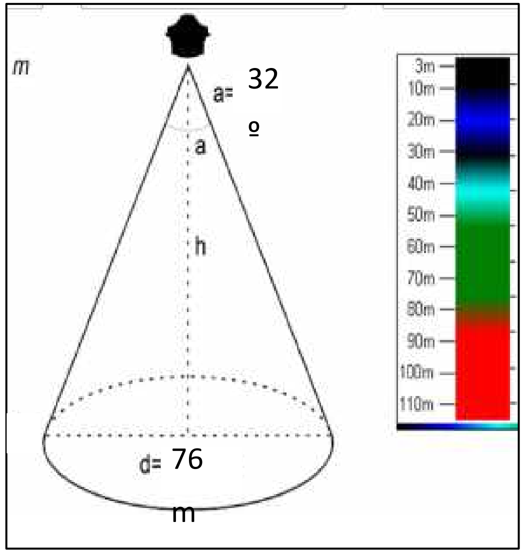


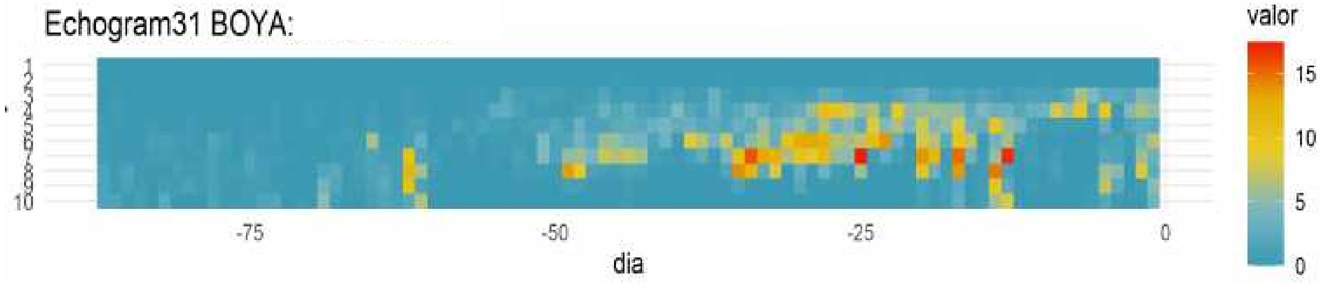


Acoustic data recorded by a single buoy echogram

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: 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

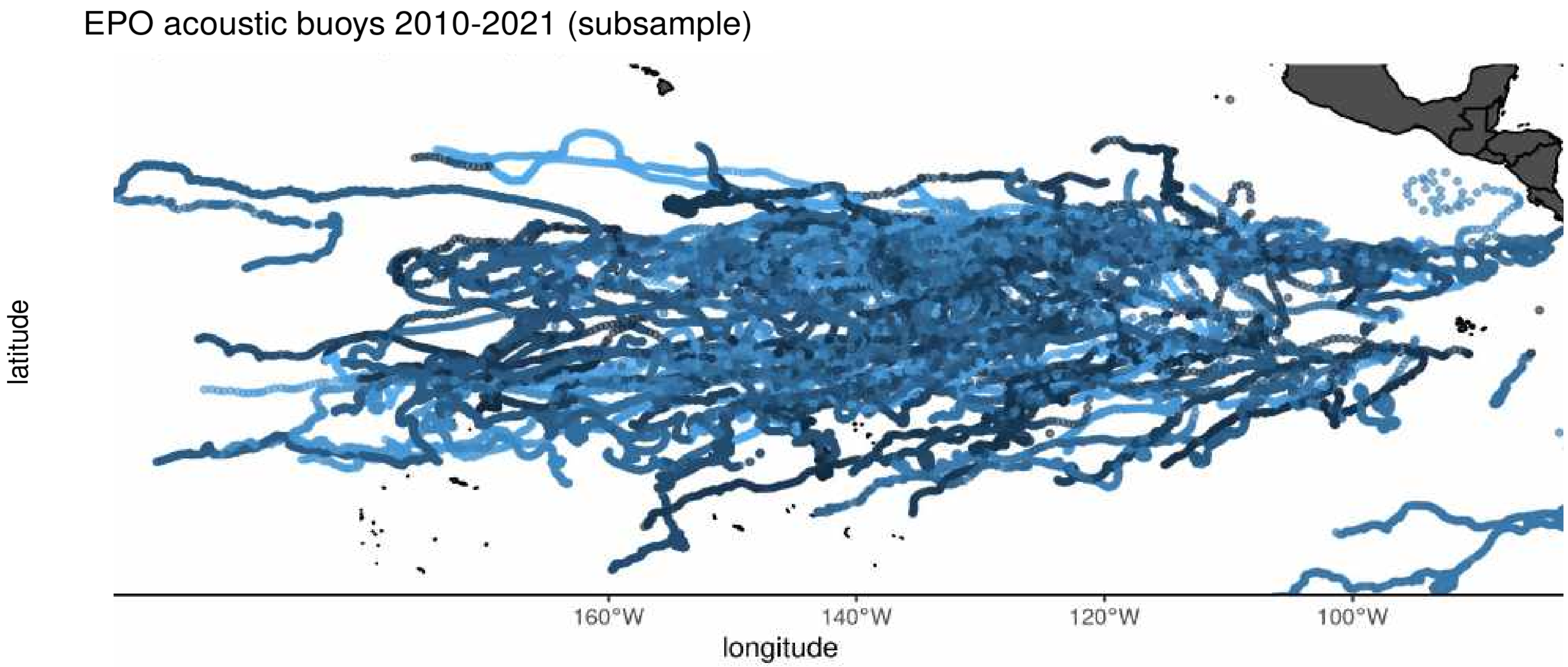
Acoustic data cleaning and filtering

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)

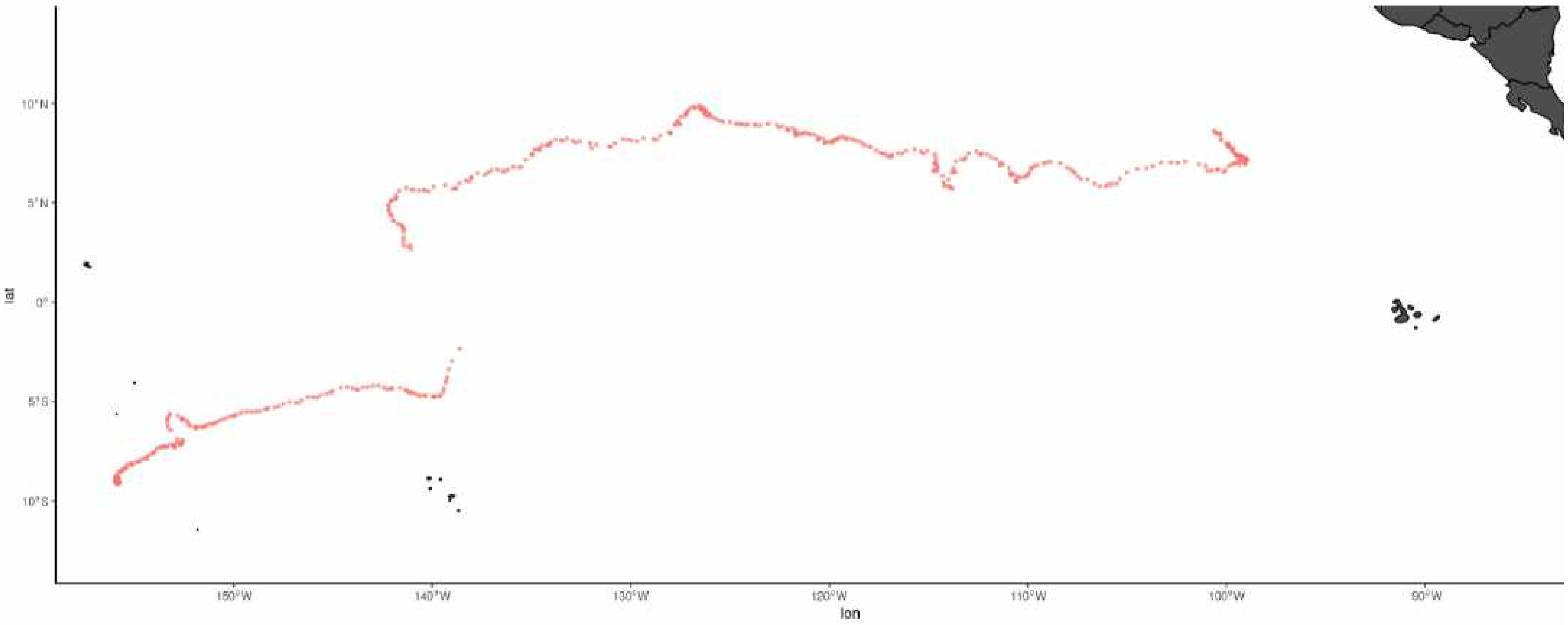
Data and methods



"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

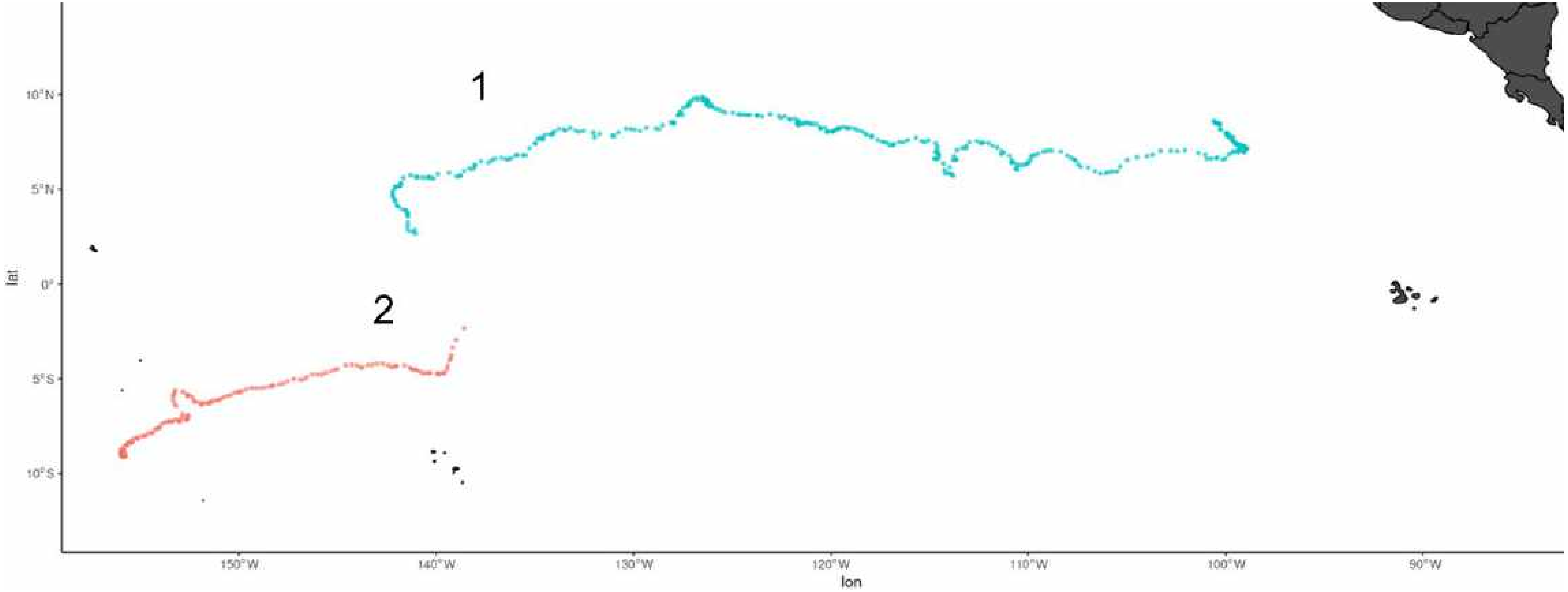
Concept of “virgin segment”



1 buoy

Data and methods

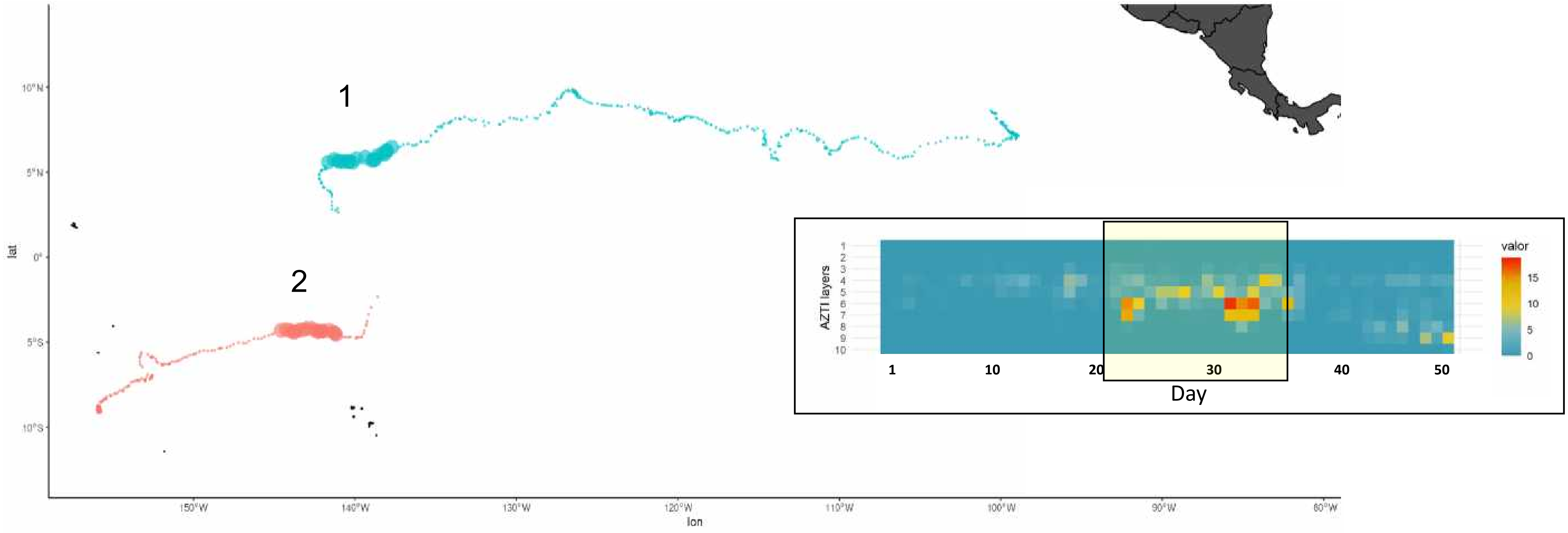
Concept of “virgin segment”



(1 buoy – 2 trajectories)

Data and methods

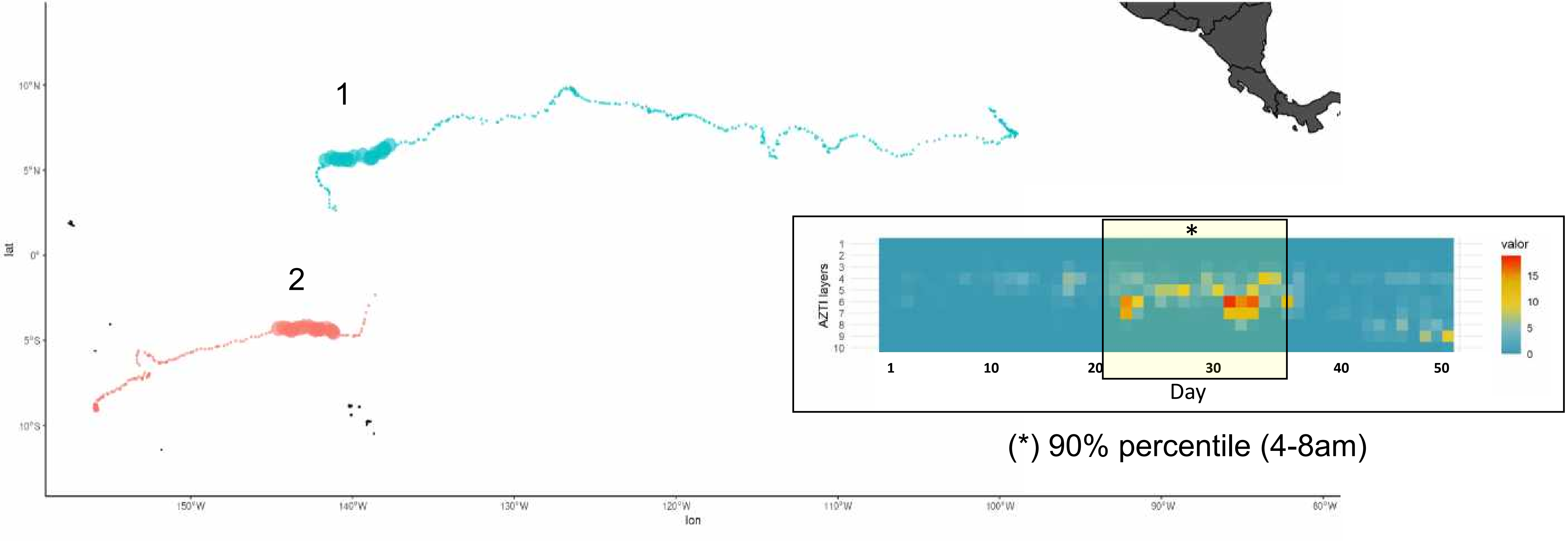
Concept of "virgin segment"



(1 buoy – 2 trajectories – 2 sections)

Data and methods

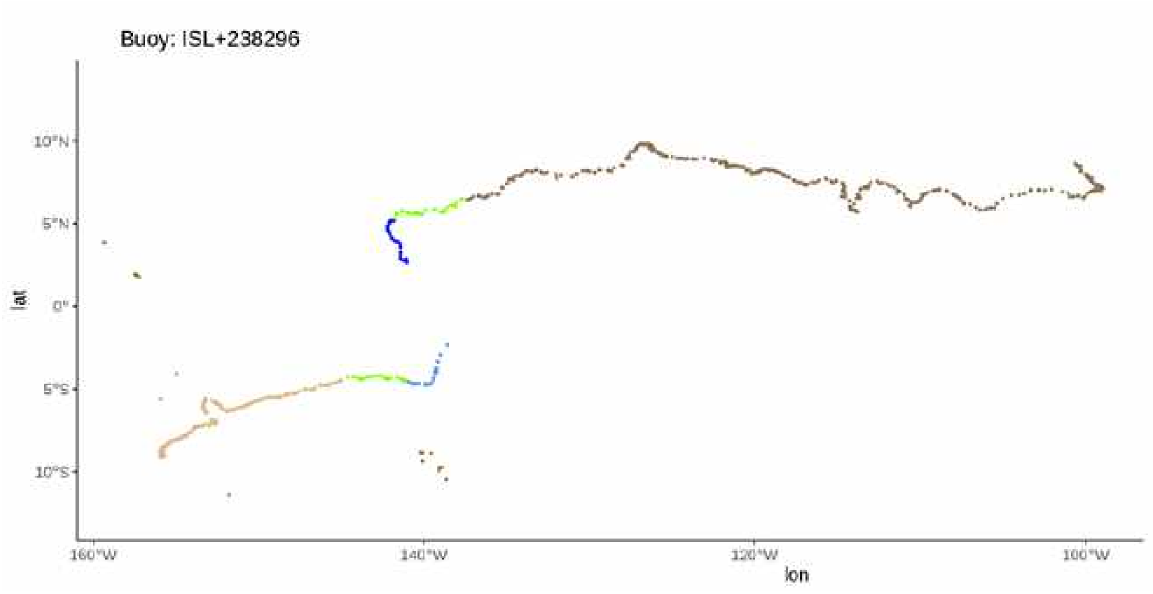
Concept of “virgin segment”

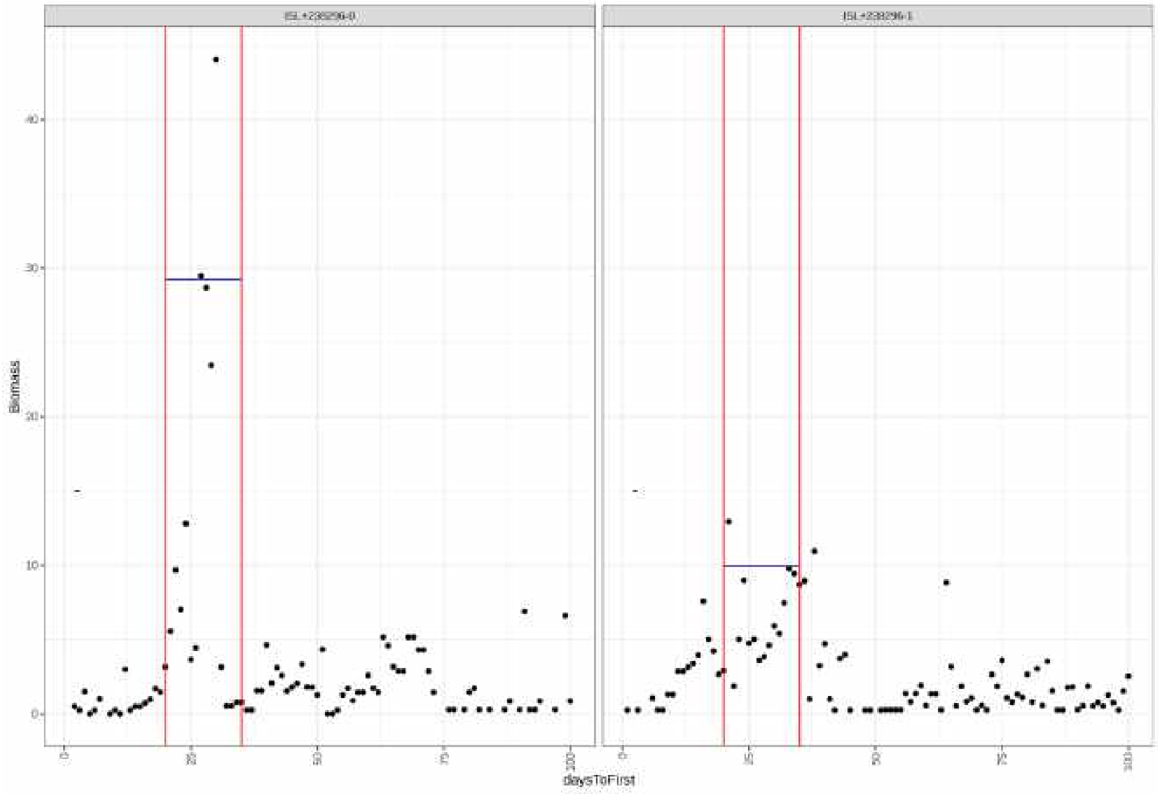


(*) 90% percentile (4-8am)

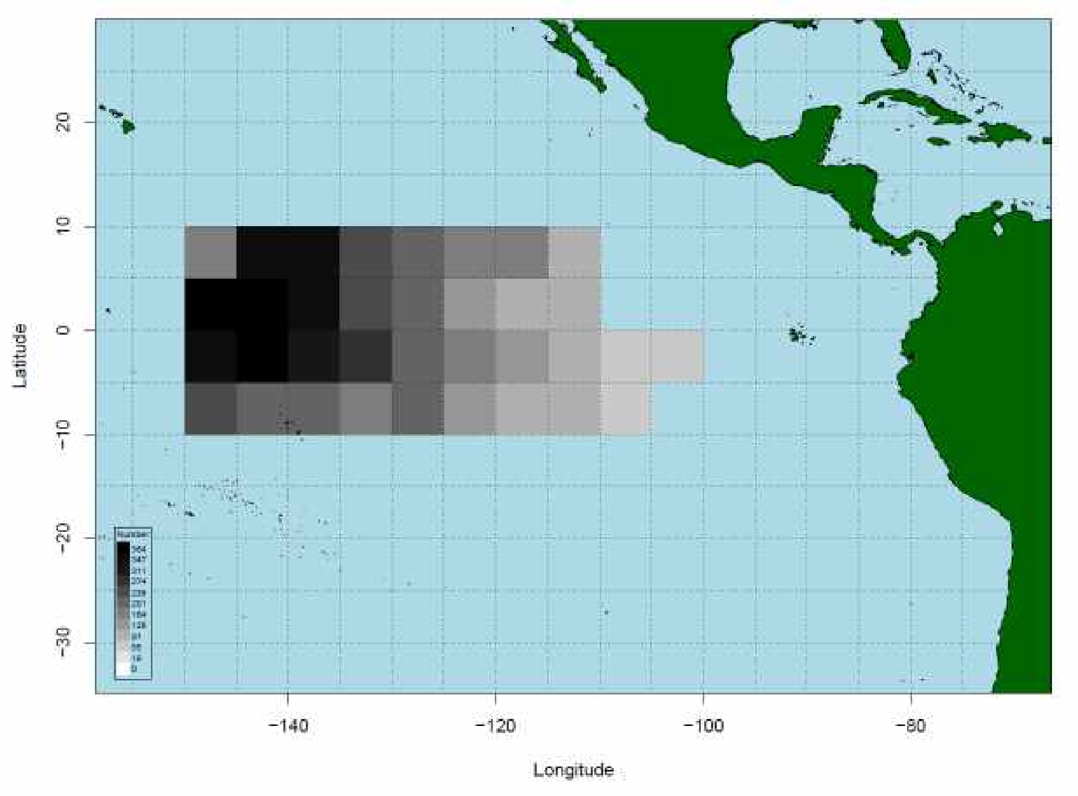
(1 buoy – 2 trajectories – 2 sections)

Data and methods

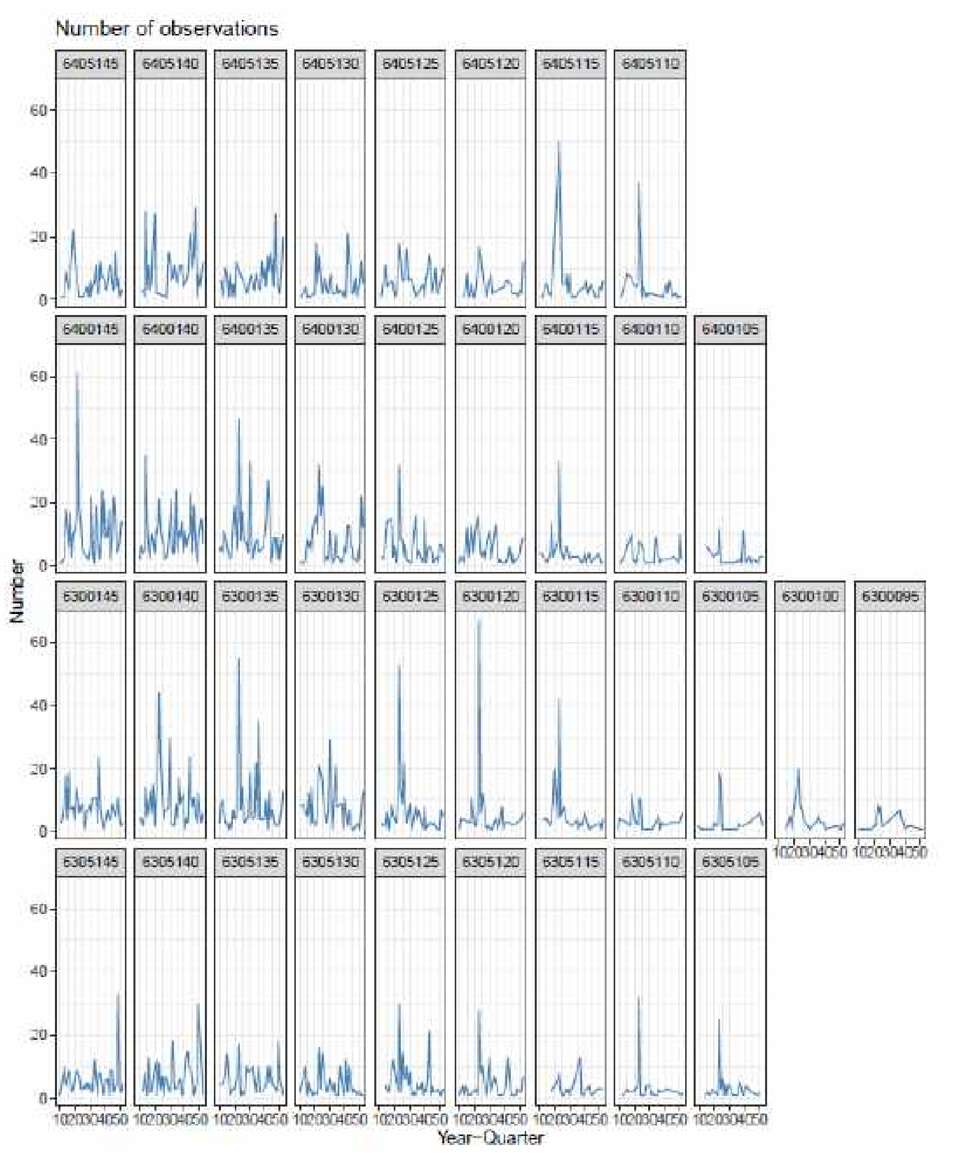




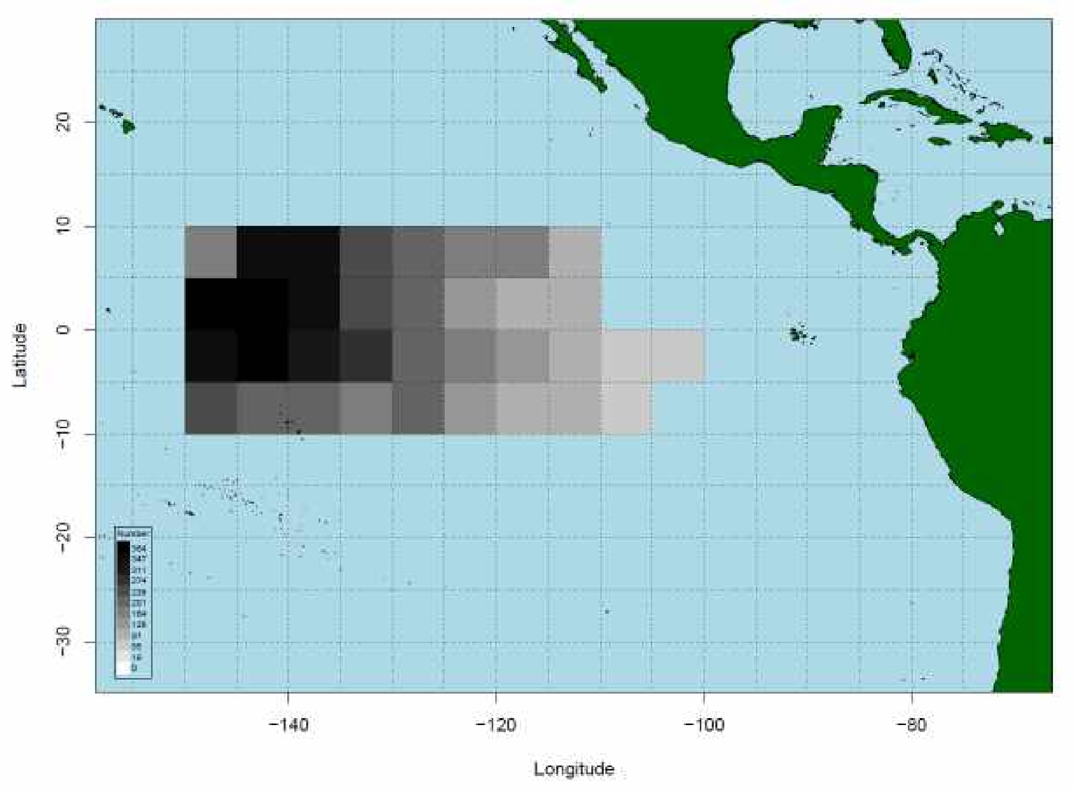
Data and methods



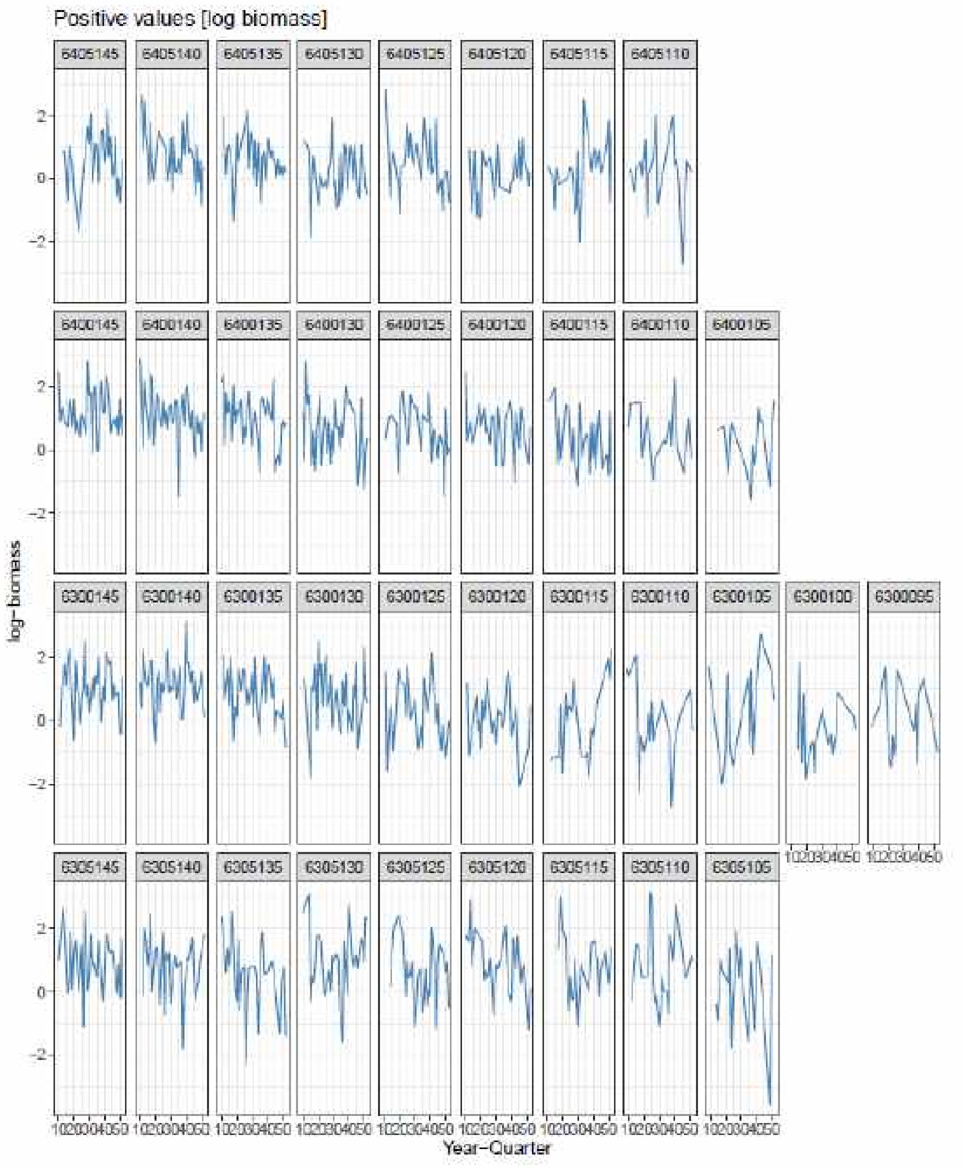
Number of observations by quarter [5ºx5º]



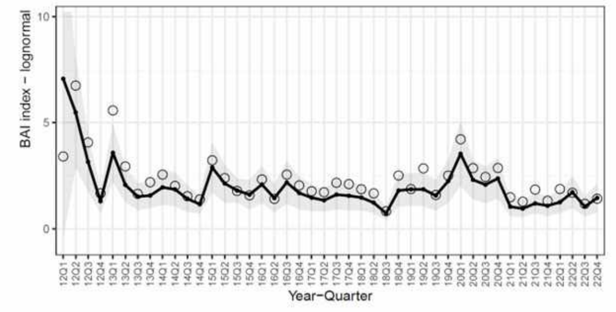
Data and methods



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: $\mathbf{BAI_t = \lambda \, . \, B_t}$
- In standardization analysis is performed. order to ensure that λ can be assumed to be constant a
- Considering the low proportion of zero values (1.58%) 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 (2012-2022)

Results

Analysis of deviance table:

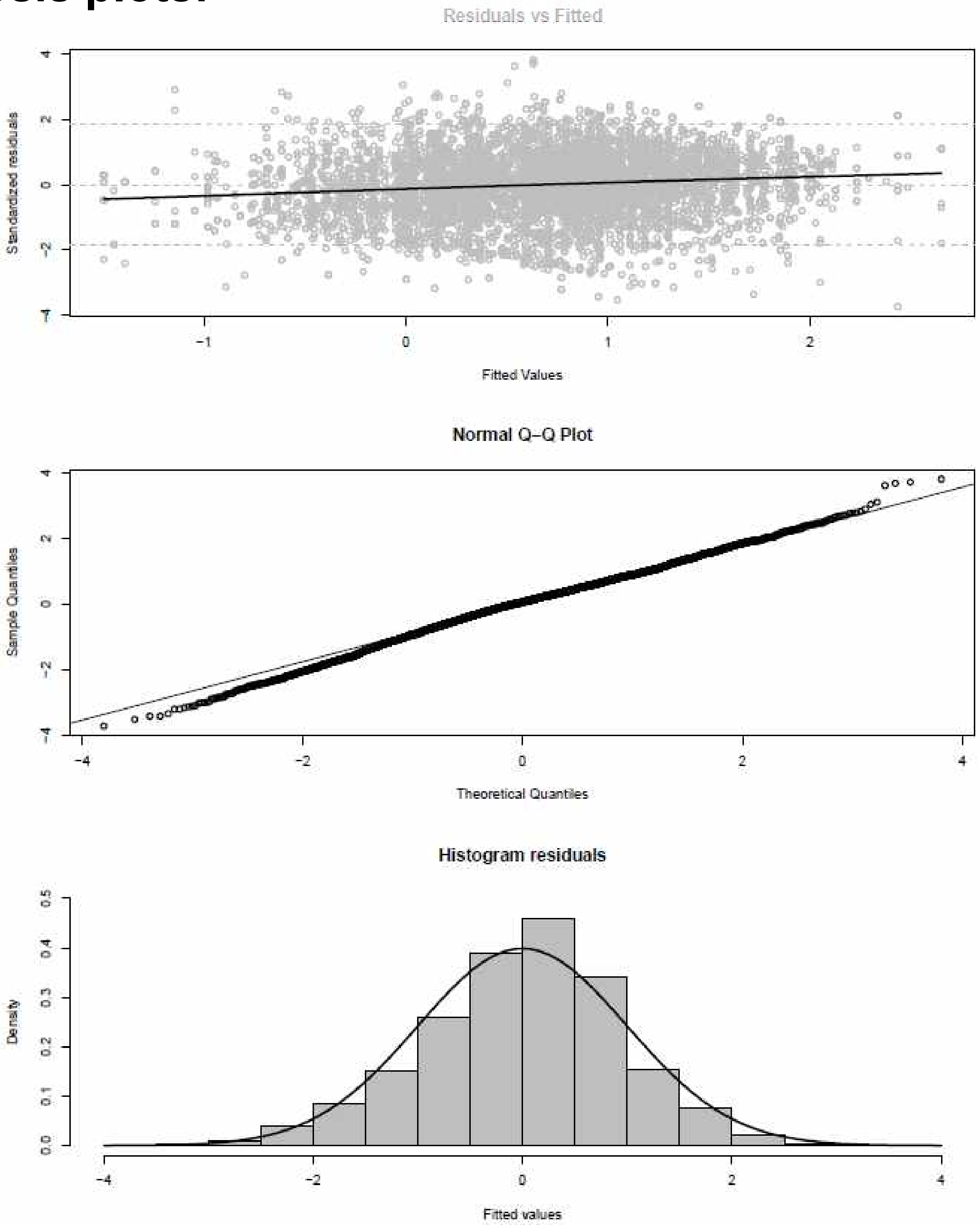
Variable	Df	Deviance	Resid..Df	Resid..Dev	F	Pr..F.	Dev..Exp
NULL	NA	NA	7074	10472	NA	NA	NA
yyqq	43	706	7031	9766	17	0.0000	6.74 %
area	36	965	6995	8801	27	0.0000	9.21 %
model	2	43	6993	8758	22	0.0000	0.41 %
den	1	22	6992	8736	23	0.0000	0.21 %
chlfront	1	38	6991	8698	39	0.0000	0.36 %
sst	1	2	6990	8696	2	0.1997	0.02 %
sstfront	1	9	6989	8687	9	0.0022	0.09 %
yyqq:area	1050	2867	5939	5820	3	0.0000	27.38 %

The proportion of deviance explained by the model was 44%.

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

Results

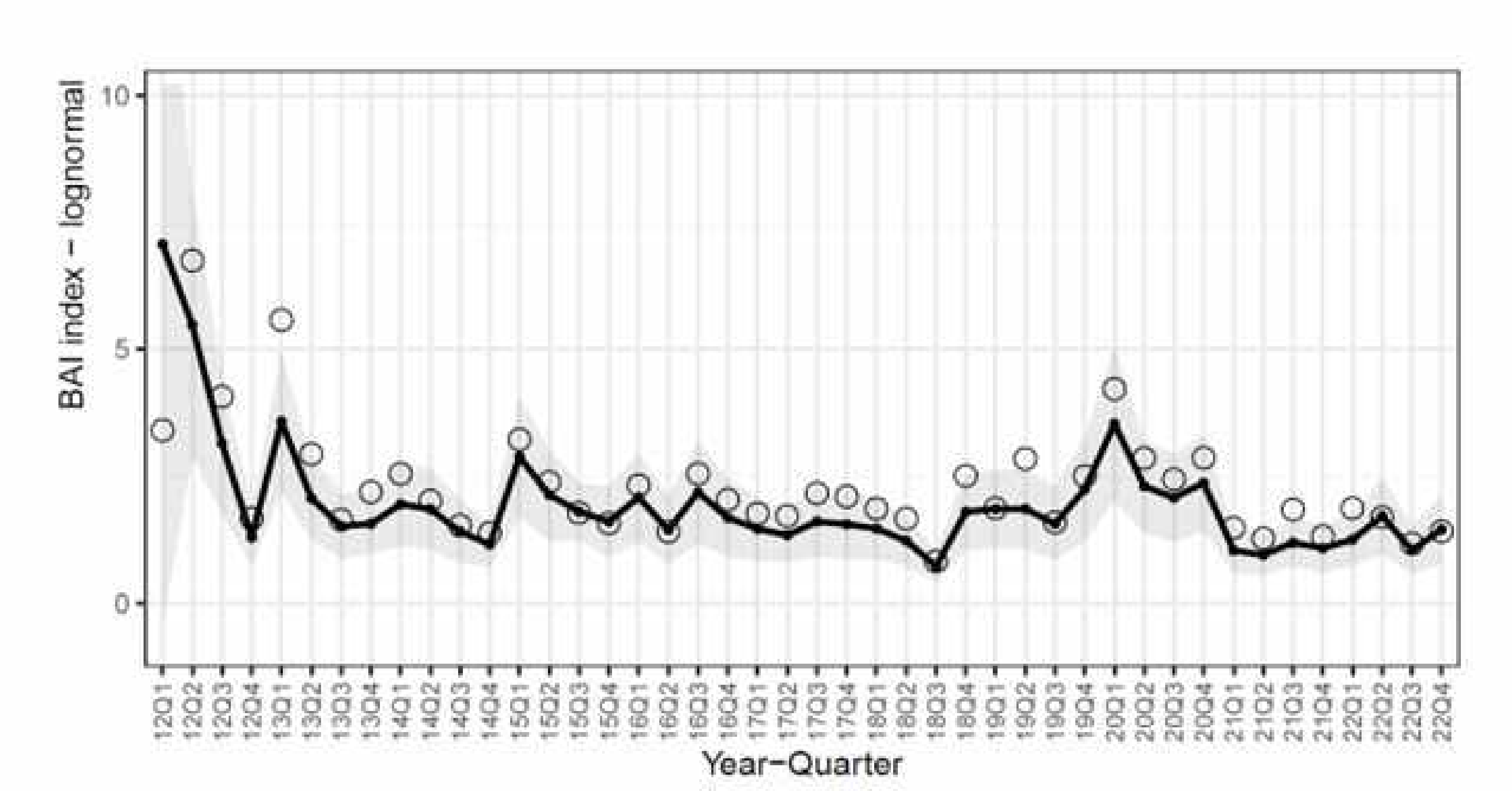
Diagnosis plots:



Diagnostics of the lognormal model selected for the period 2012-2022: 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 2012-2022 in the EPO. The 95% upper and lower confidence intervals of the standardized BAI index are shown.

Conclusions

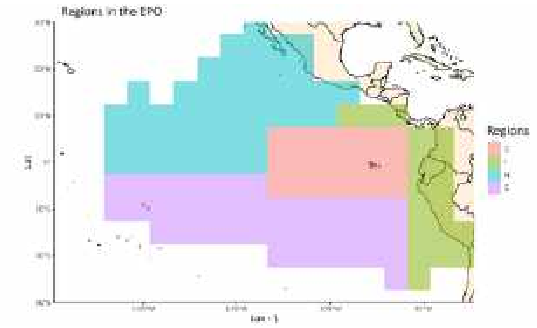
Index of abundance of juvenile skipjack tuna in the Eastern Pacific Ocean derived from echosounder buoys (2012-2022)

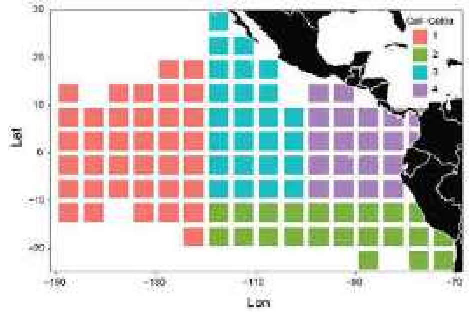
- Retrieve new historical acoustic data from new companies or associations and integrate them into latest BAI index.

- To determine whether the contribution of new data from new areas, such as that provided by TUNACONS for 2022, can produce an index that covers the same area or if it generates two different indices: one based on offshore data and the other on more coastal data.

- Integrate data from different brands to determine if acoustic data can be standardized and if it is necessary to create indices based on brands or if all data can be integrated into a standardized unique index.

- Future modifications in areas of interest and methodology highlights the need for adaptability in analysis and the ability to accommodate annual data submissions to ensure comprehensive evaluation.





- **Review and evaluate database filters** for different models' trajectories, considering specific model characteristics and prioritizing certain models if needed.

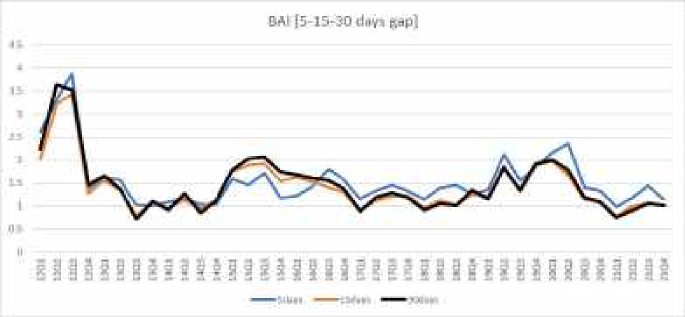
- **Update the process for assigning species percentages and size measurements to acoustic data**. Develop a protocol for assigning values hierarchically based on resolution or detail, considering factors like observers per haul, fishing logs, and 1x1-month data. Explore alternative models' potential to estimate specific compositions in space and time, testing geospatial or machine learning models. Investigate species composition correlation with colonization process and consider vertical behavior in specific areas and seasons using electronic tagging studies.

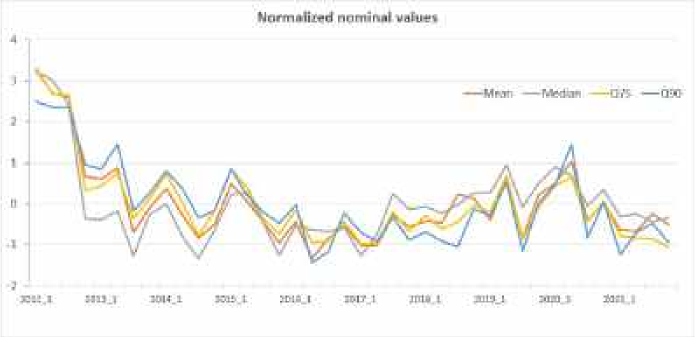
- **Reconsider the assumption that days 20-35 after new deployments are the best measure for colonization models**. Find an adaptive solution suitable for different regions and seasons of the Eastern Pacific Ocean.

- **Update b20 TS values** based on fish size using latest scientific publications.

- **Try to Integrate MarineInstruments and Zunibal buoys into the study**, carefully considering the need for independent indices or standardized data.

- **Conduct sensitivity tests on the model for exploring alternative biomass values:**

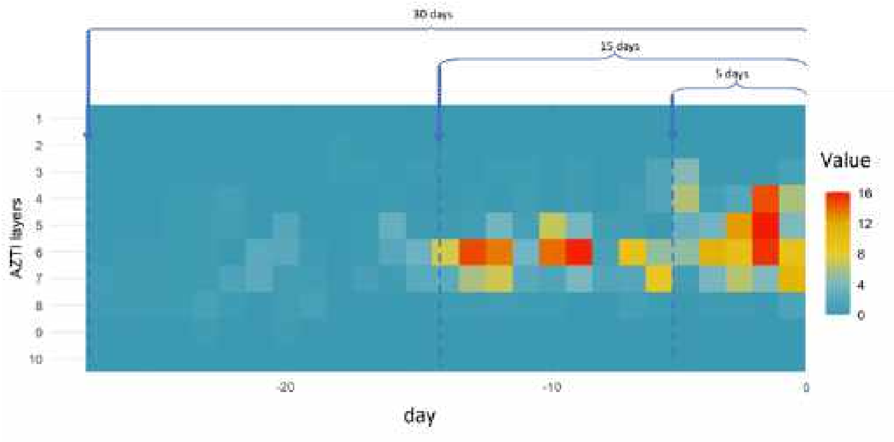


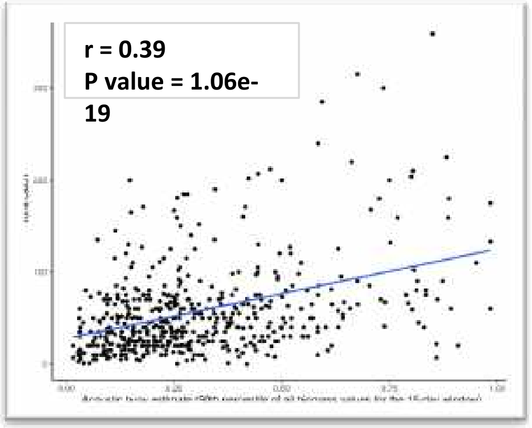


- Cross-referencing acoustic data with capture data linked to buoys is crucial for improving the methodology and ensuring robustness of the data used in this proposal.

- Switching to complete echograms of the virgin segment as input for new models and increasing the number of samples for comparison can lead to a significant qualitative improvement in species discrimination and pattern recognition.

- Further research is needed to generate relative abundance indices based on buoy acoustics, addressing the noise in the data and exploring the potential of collaborative projects with fishing vessels to collect complementary data and transform them into research platforms.





Acknowledgements

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Gracias! **Thank you!**