Ex-situ TS measurements of juvenile yellowfin *(Thunnus albacares)* and frequency-response discrimination of three tropical tuna species

Bea Sobradillo, Guillermo Boyra, Jon Uranga, Iker Urtizberea, Udane Martínez and Gala Moreno

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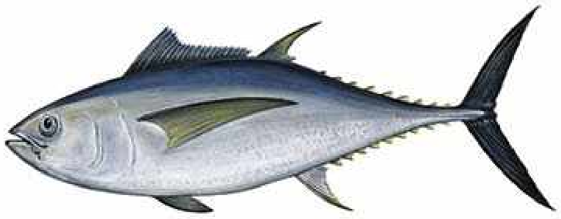
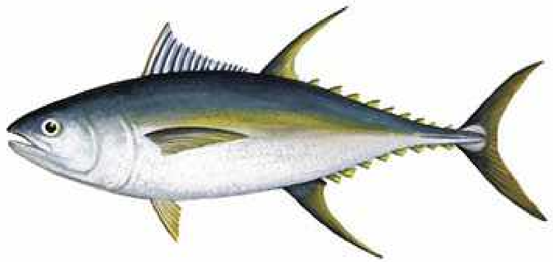
Skipjack (*Katsuwonus pelamis*)



Bigeye (*Thunnus obesus*)



Yellowfin (*Thunnus albacares*)

Tropical tuna in DFADs

More than half of the purse seine landings aiming at tropical tuna come from fishing with **Fish Aggregating Devices** (DFADs), equipped with scientific echo-sounders to provide remote information on the aggregated biomass.

Using **acoustic** equipment before the nets are set improves the **selectivity** of the catch.

There are mainly **three** tropical tuna species that can be found simultaneously aggregated in FADs.

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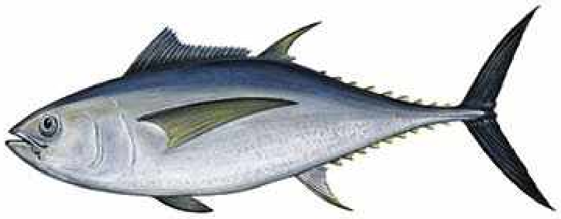

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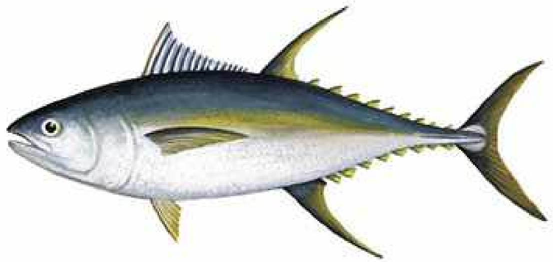

Yellowfin (*Thunnus albacares*)

Acoustic species discrimination

1. Determine sound scattering properties of each species separately, mainly the **Target strength** (dB re 1m^2)

2. Determine the **frequency response** of each species

3. Develop a **species discrimination algorithm**

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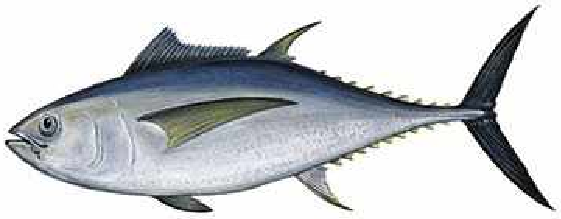

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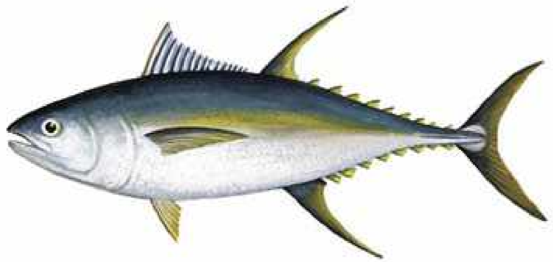

Yellowfin (*Thunnus albacares*)

Target strength: logarithmic measure of the proportion of the incident energy that is backscattered by the target (σ).

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$$TS = 10log_{10}\sigma$$

$$Number = \mathrm{Vol} * \frac{S_v}{\sigma}$$

TS is mainly affected by:

- Fish (or swimbladder) length: **b20**
- Tilt angle relative to the beam centered axis
- Depth range due to pressure effect on swimbladder
- Distance from the transducer: nearfield effect, point source violation…

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Skipjack
Katsuwonus pelamis

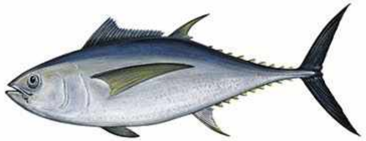
ICES Journal of
Marine Science

ICES Journal of Marine Science (2018), 75(5), 1790–1802. doi:10.1093/icesjms/fsy041

Original Article

Target strength of skipjack tuna (*Katsuwanus pelamis*) associated with fish aggregating devices (FADs)

Guillermo Boyra[1*], Gala Moreno[2], Bea Sobradillo[1], Isabel Pérez-Arjona[1], Igor Sancristobal[1], and David A. Demer[4]



Bigeye
Thunnus obesus

ICES Journal of
Marine Science

ICES Journal of Marine Science (2019), doi:10.1093/icesjms/fsz131

In situ target strength of bigeye tuna (*Thunnus obesus*) associated with fish aggregating devices

G. Boyra[1*], G. Moreno[2], B. Orue[1], B. Sobradillo[1], and I. Sancristobal[3]

PLOS ONE

RESEARCH ARTICLE

Towards acoustic discrimination of tropical tuna associated with Fish Aggregating Devices

Gala Moreno[1*], Guillermo Boyra[2], Igor Sancristobal[3], David Itano[4], Victor Restrepo[1]

1 International Seafood Sustainability Foundation (ISSF), Washington DC, United States of America, 2 Sustainable fisheries management, Marine Research, Azti-Tecnalia, Pasaia, Gipuzkoa, Spain, 3 Sustainable Management of Fisheries, Collecte Localisation Satellites (CLS), Ramonville-Saint-Agne, France, 4 Fisheries consultant, Honolulu, Hawaii, United States of America

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Acoustic species discrimination

Determine sound scattering properties of each species separately, mainly the **Target strength** (dB re 1m^2)

Determine the **frequency response** of each species

Develop a **species discrimination algorithm**

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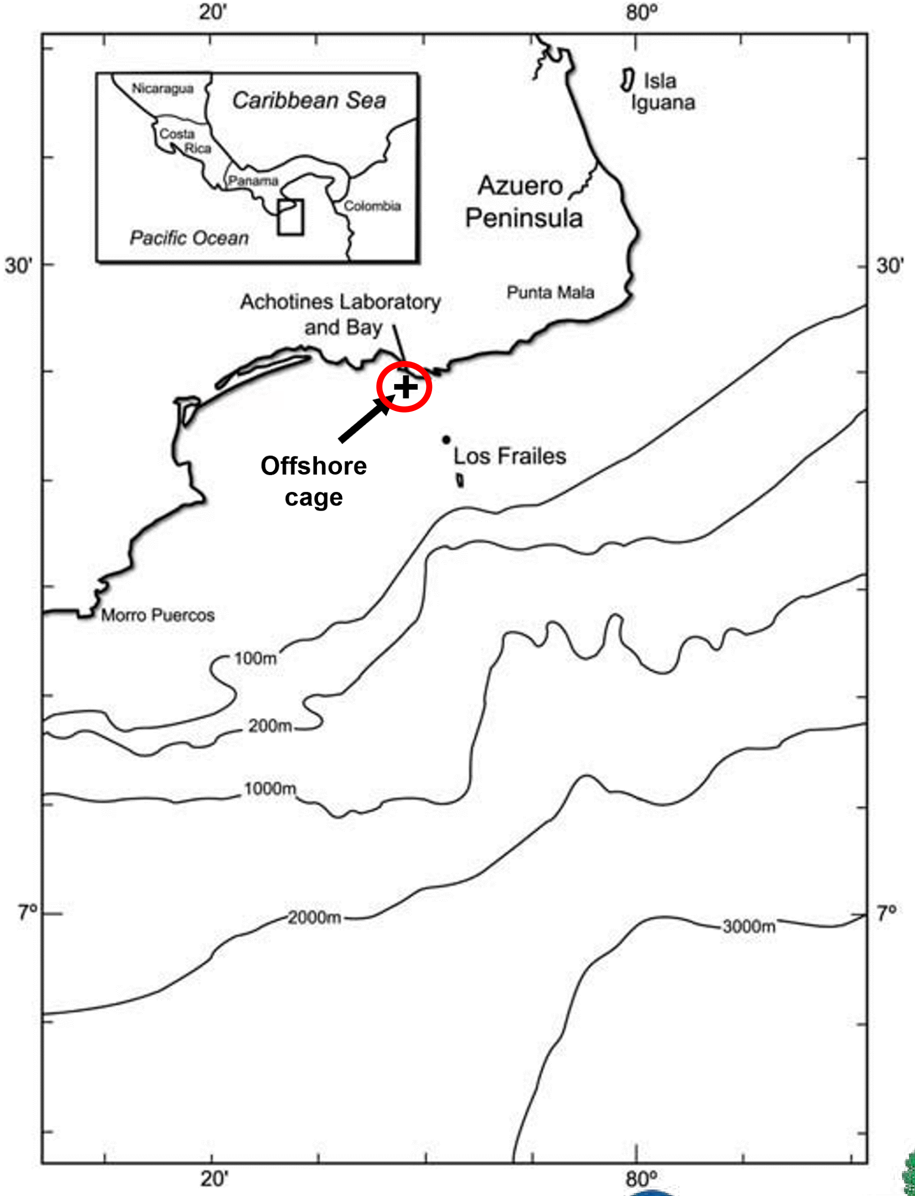
Set 1: July 2016
Set 2: May-June 2022



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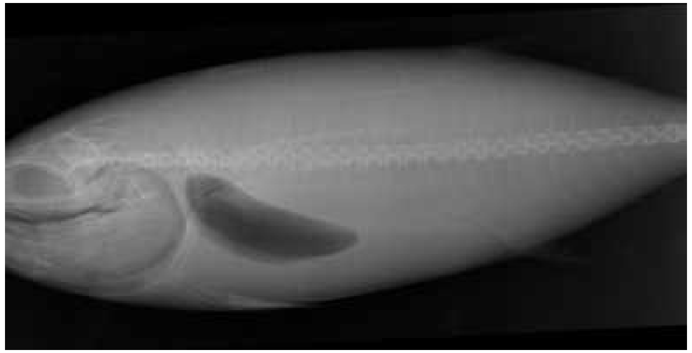
Acoustic sampling

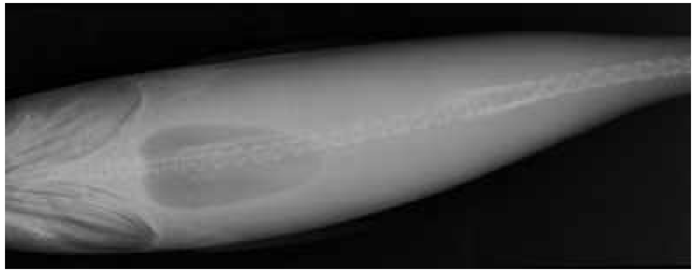
- Steel floating plate stable below surface with Simrad EK80 38, 70, 120 and 200 kHz transducers.
- Acoustic equipment (transceptors, electronic devices) installed on a vessel.
- Emitted pulse duration: 0.512 ms, CW mode
- Calibration prior to data collection (*Demer et al., 2015*)
- Depth range: 10 – 25 m
  - Nearfield:
    38 kHz transducer: **4.55 m**
    Swimbladder at 200 kHz: **3.9 m**
    } **8.45 m**
  - Beam diameter = largest fish length insonified at **7 m**
  - Point source violation avoidance

Biological sampling

Table 1. Biological measurements from fish body (TL: total length, FL: fork length, width, height and weight), and swimbladder. Z is the depth at which the diameter of the acoustic beam cross-section equals the fish or swimbladder length. Specimen marked with (*) is dead and used for controlled range experiment.

		Fish						Swimbladder			
Year	Set	TL	FL	Z	Width	Height	Weight	Length	Z	Width	Area
		cm	cm	m	cm	cm	kg	cm	m	cm	cm^2
2016	1	57	51.9	4.7	9.5	13	2.9	11.4	0.9	3.1	28.0
2016	1	70.8	64.4	5.8	11	15	3.9	12.2	1.0	4.1	38.8
2016	1	45.2	41.1	3.7	7.5	10.5	1.52	9.3	0.8	2.7	19.8
2016	1	59	53.7	4.8	10	13.5	3.16	12.5	1.0	3.8	37.6
2022	1	58	54.4	4.7	9.3	13.4	5.8	13.0	1.1	3.2	32.7
2022	1	56.2	51.4	4.6	8.5	13.2	5.25	10.7	0.9	3.4	28.6
2022	2	85.4*	77.0	7.0	14.1	19.8	8.9	13.8	1.1	5.6	60.7





- 6 live tuna
- 1 dead specimen
- Elongated swimbladder
- Sb ~ 21% of body length
- Sb tilt angle ~25±5 degrees from body horizontal axis

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Data analysis

6 live tuna for **TS-length relationship**

- **SED** for TS analysis
- **Target tracking** for fish orientation

Table 3. Parameters used in the single target detection (SED) and tracking algorithms.

SED algorithm			**Tracking algorithm**		
Pulse length determination level	dB	6	Min. number of single targets in a track		3
Min/max normalized pulse length		0.7/1.5	Max number of pings in a track	pings	3
Maximum beam compensation	dB	15	Maximum gap between single targets	pings	5
Maximum standard deviation of axis angles	degrees	0.6	Exclusion distance (major axis/minor axis/range)	m	4/4/0.1

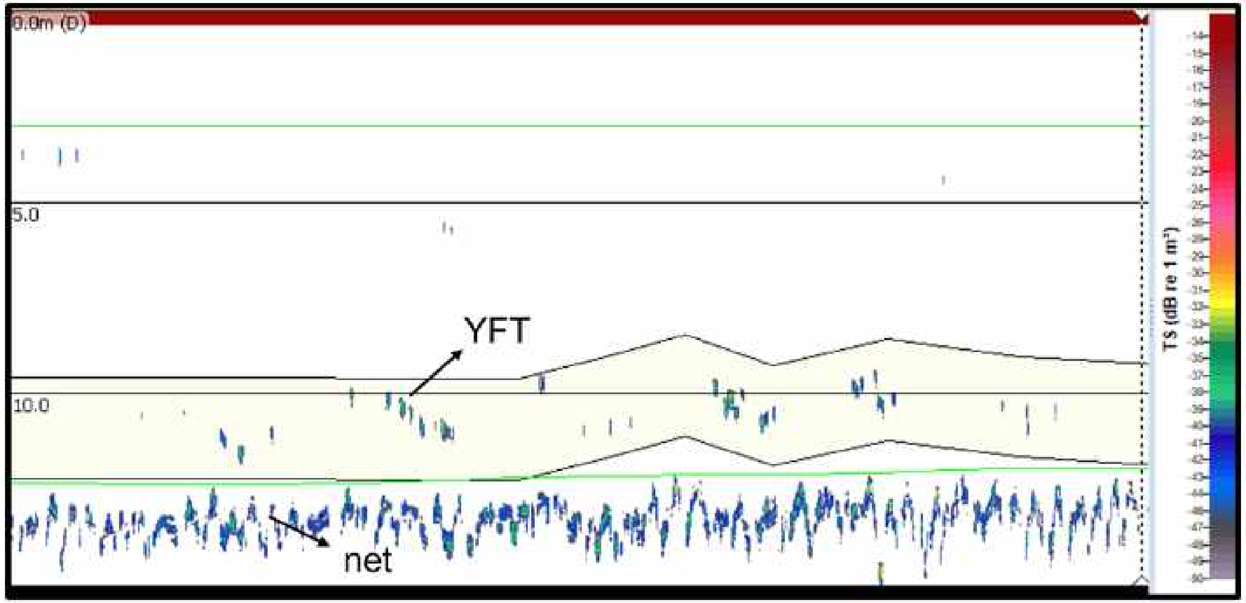
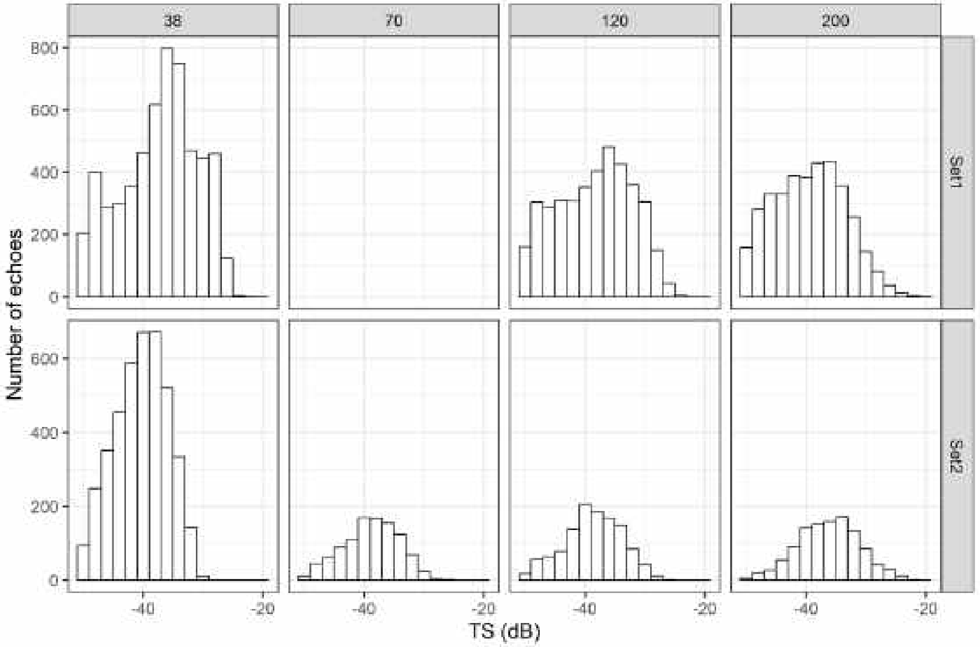


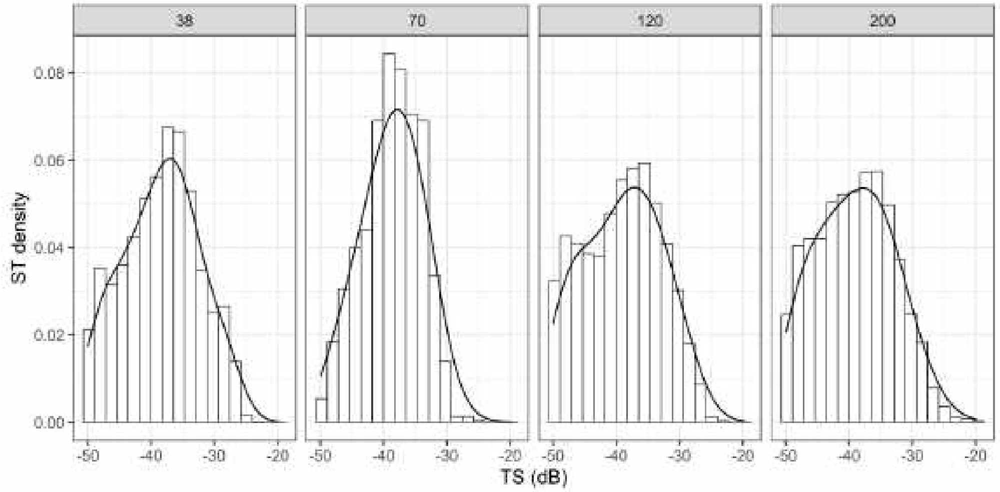
Figure 3. 38 kHz echogram showing the yellowfin tuna echoes close to the bottom of the cage.

Results

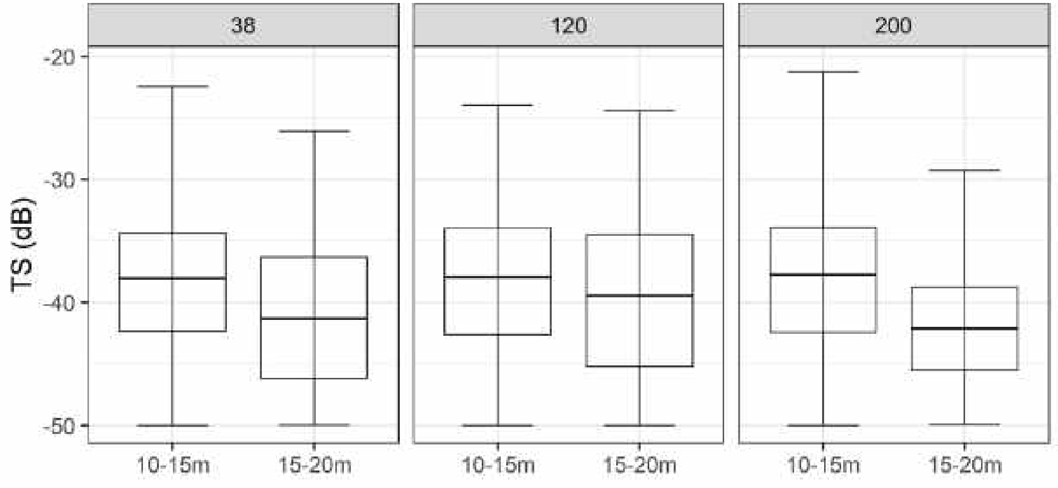
TS



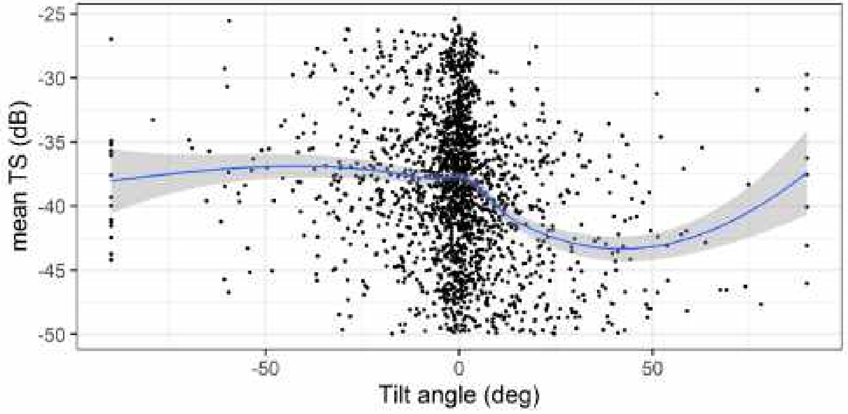
TS-smoothed



TS-depth

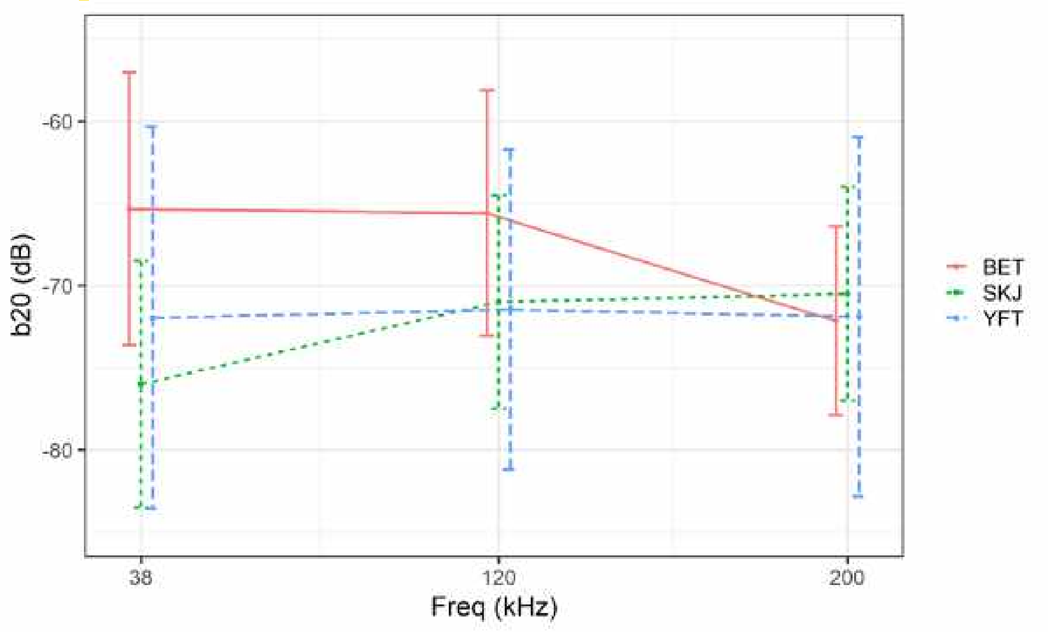


TS-tilt



Discrimination algorithm

Frequency response



$$
\begin{cases}
\boldsymbol{SKJ}, & if \begin{cases} MVBS_{38} - MVBS_{200} < \boldsymbol{A} \\ MVBS_{38} - MVBS_{120} < \boldsymbol{B} \end{cases} \\
\boldsymbol{BET}, & if \begin{cases} MVBS_{38} - MVBS_{200} > \boldsymbol{C} \\ MVBS_{120} - MVBS_{200} > \boldsymbol{D} \end{cases} \\
\boldsymbol{YFT}, & if \begin{cases} \boldsymbol{A} < MVBS_{38} - MVBS_{200} < \boldsymbol{C} \\ MVBS_{120} - MVBS_{200} < \boldsymbol{D} \end{cases}
\end{cases}
$$

Optimized thresholds

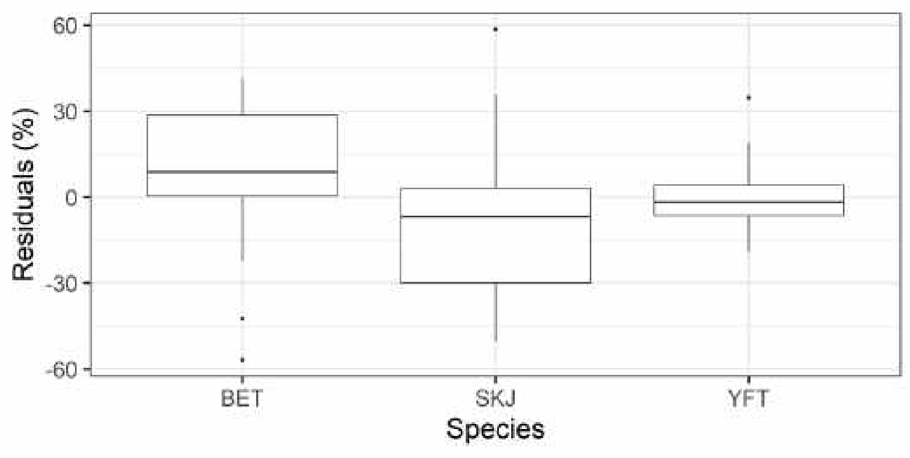
A = - 1.6

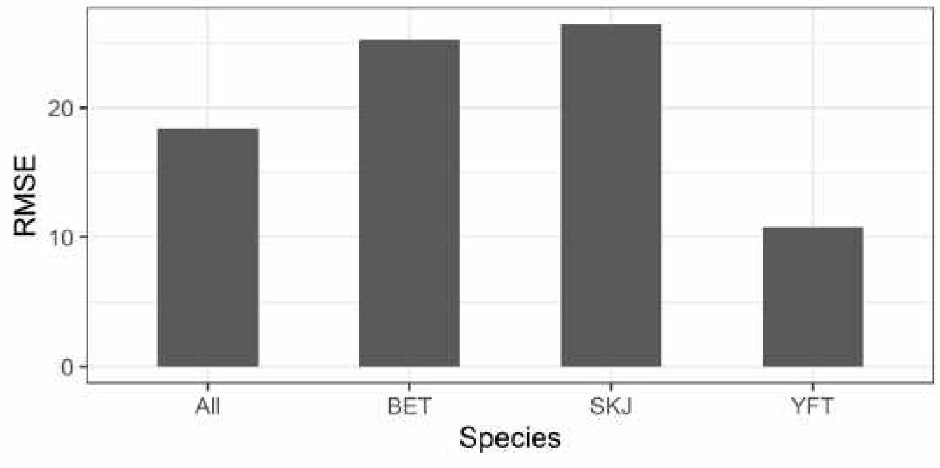
B = - 0.16

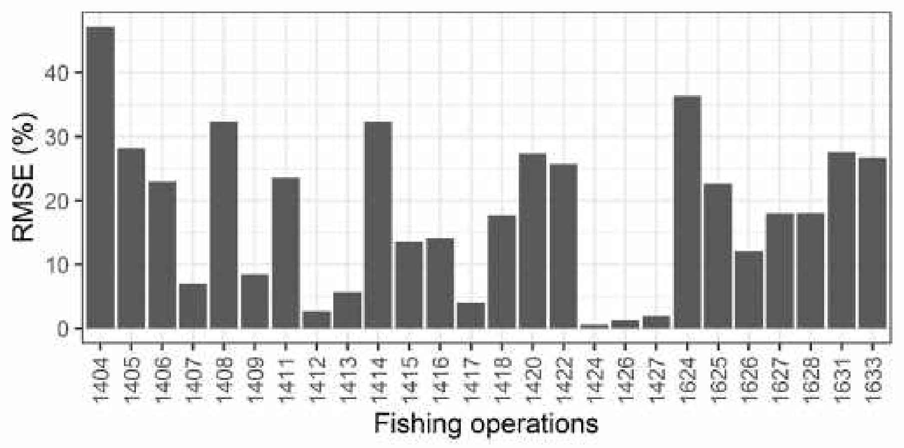
C = 0.16

D = 0.016

Discrimination algorithm

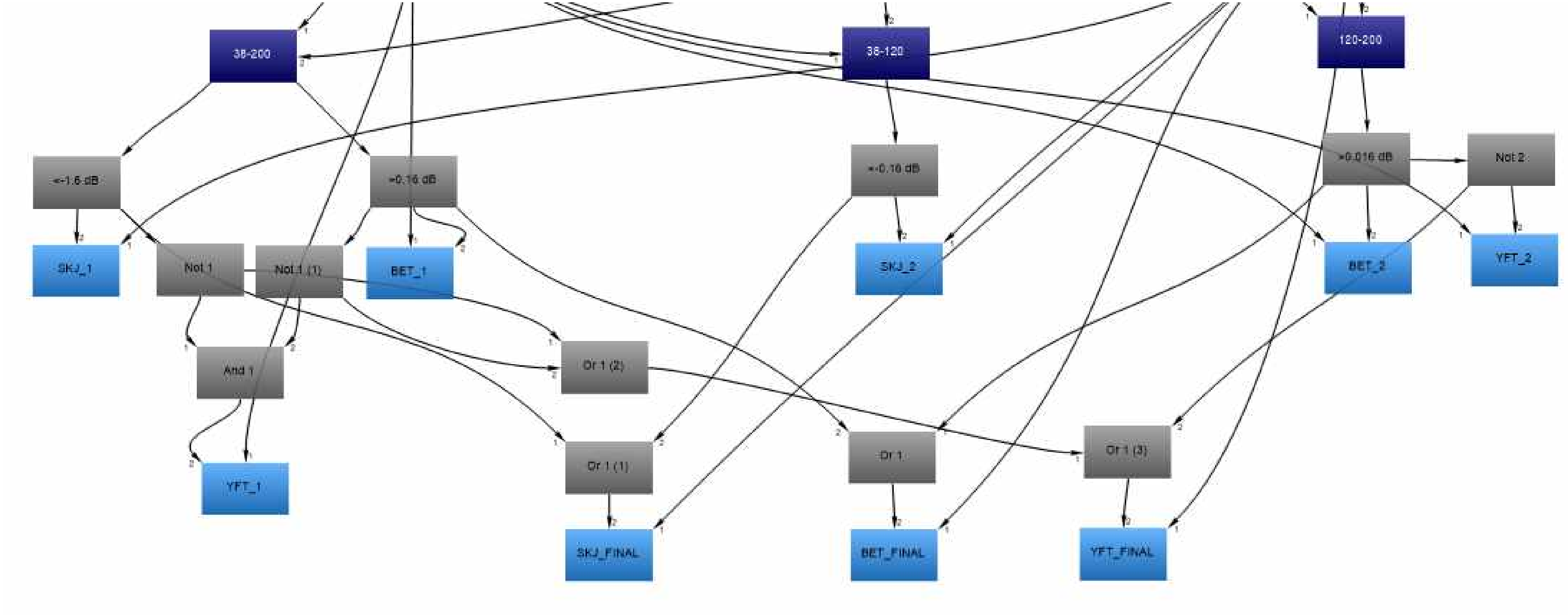




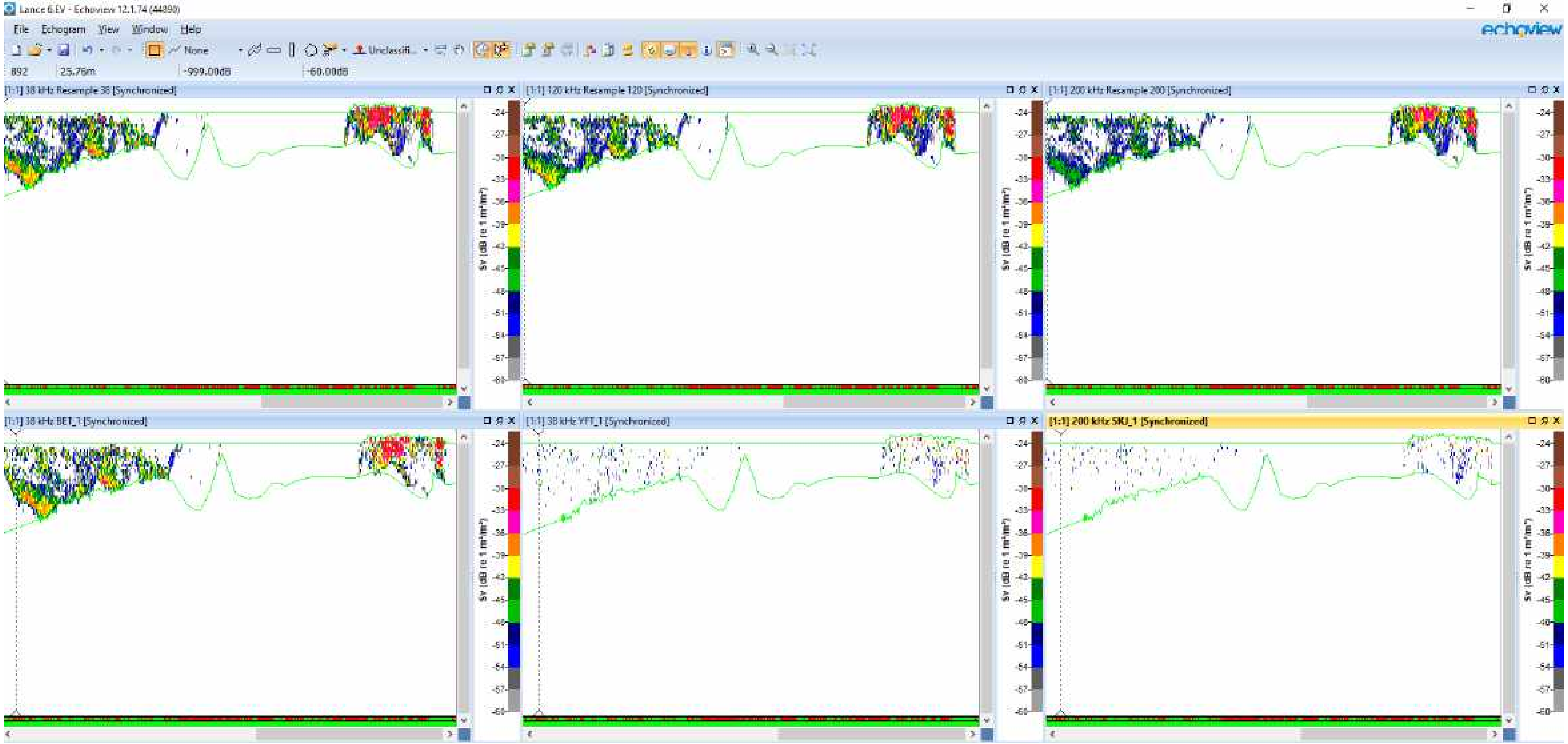


26 trawls from commercial tuna vessels to optimize thresholds by RMSE

Discrimination algorithm



Discrimination algorithm



Conclusions

- Discrimination algorithm is able to classify echoes into 3 tuna species BET, YFT and SKJ with an overall performance defined by RMSE < 25%. Of these 3 species, YFT was the most accurately classified (RMSE ~11%)

- Could be implemented on buoys and tuna vessels to allow fishermen to choose on which FAD to target or what is the species composition in the water before setting the gear, improving selectivity of the fishery.

- We hope that such studies, which promote in-depth exploration of the acoustic characteristics of the major tropical tuna species, will help to further refine and improve the new abundance indices based on acoustic data.

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BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

TEAM

BEA SOBRADILLO
Researcher at Azti
bsobradillo@azti.es

JON URANGA
Researcher at AZTI
juranga@azti.es

GUILLERMO BOYRA
Senior researcher at Azti
gboyra@azti.es

UDANE MARTINEZ
Laboratory technician at AZTI
umartinez@azti.es

IKER URTIZBEREA
Sampling technician at AZTI
iurtizberea@azti.es

GALA MORENO
Senior scientist at ISSF
gmoreno@iss-foundation.org

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