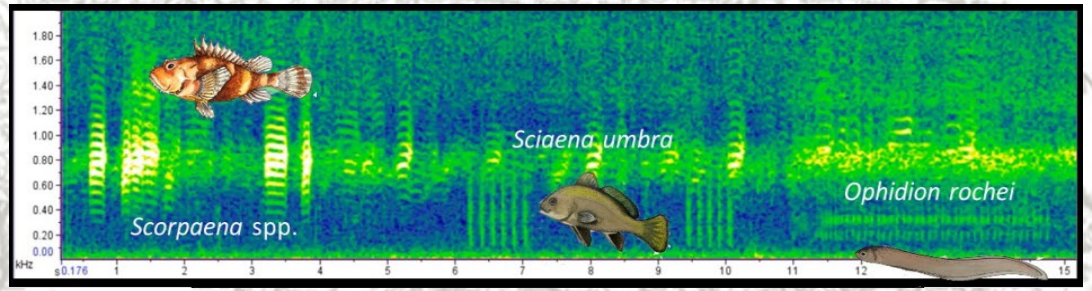
AN ACOUSTIC ODYSSEY:



CHARACTERISATION OF THE VOCAL FISH COMMUNITY INHABITING NEPTUNE SEAGRASS MEADOWS ACROSS THE MEDITERRANEAN SEA

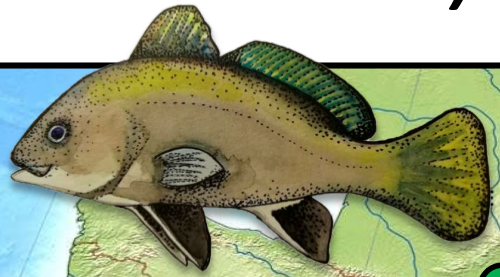
Marta Bolgan[1], Lucia Di Iorio[2], Thanos Dailianis[3], Ignacio Catalan[4], Pierre Lejeune[5] & Eric Parmentier[1]

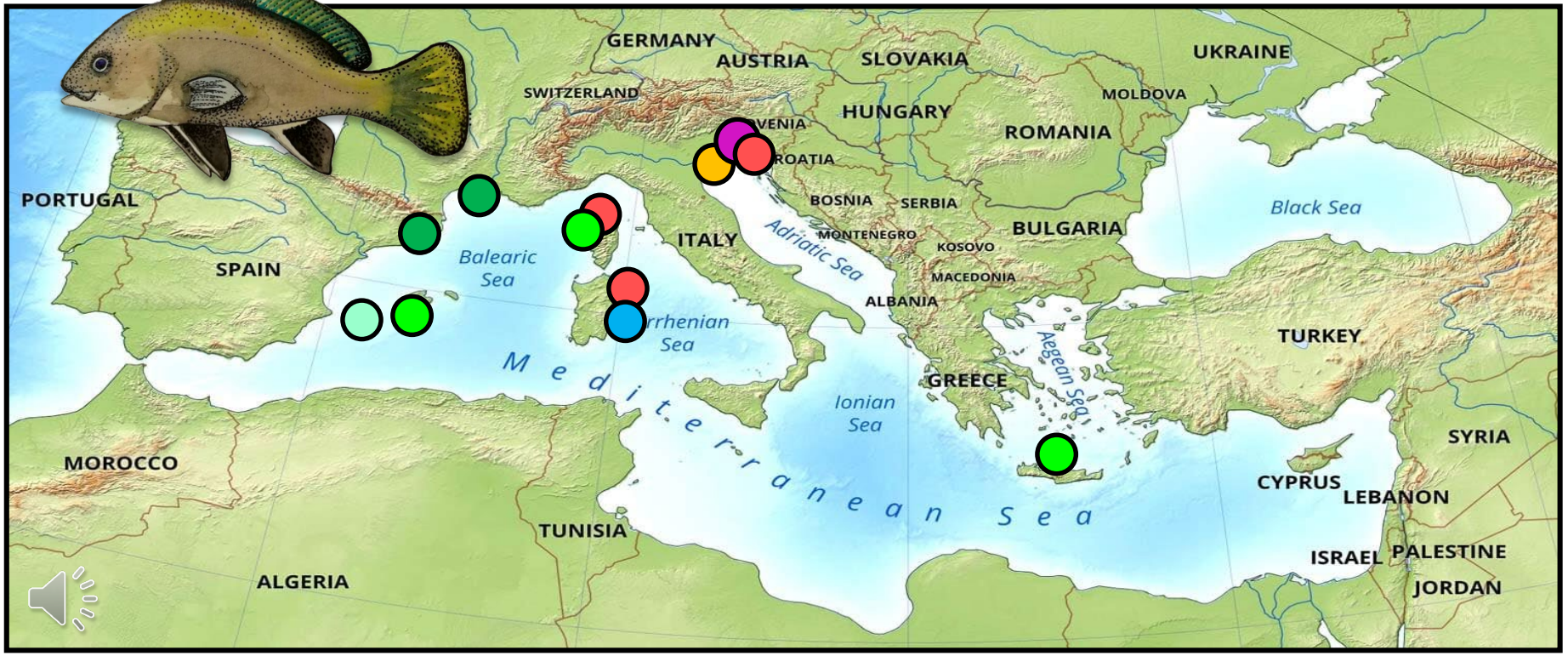
[1] **MORFONCT**,ULiège, Belgium [2] **CHORUS** Institute, France [3] **HCMR**, Greece [4] **IMEDEA**, Spain [5]**STARESO**, France

Fish Passive Acoustic Monitoring in the Mediterranean Sea

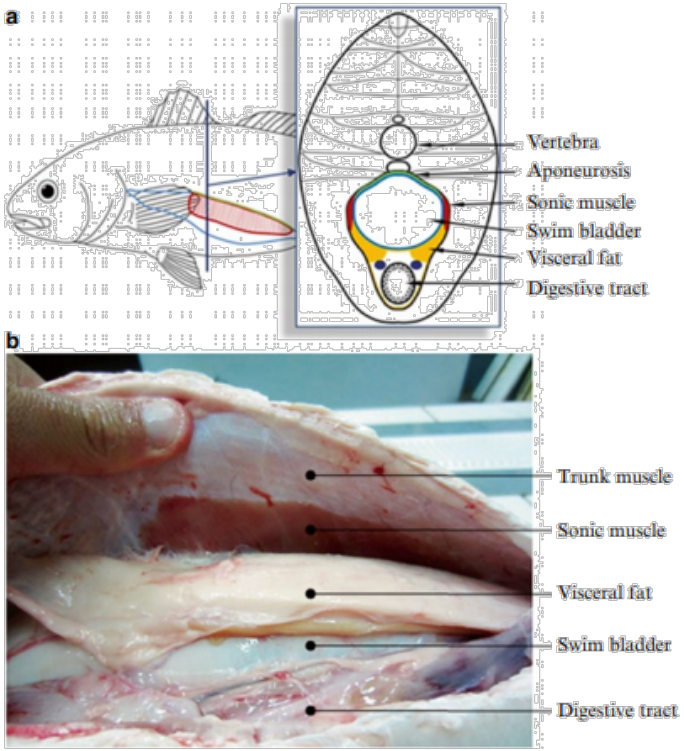
Brown meagre (Sciaena umbra)

- Bonacito et al. (2002). Bioacoustics 12, 292–294
- Codarin et al. (2012). Effects of Noise on Aquatic Life
- Picciulin et al. (2012a). Bioacoustics 2012, 1–12.
- Picciulin et al. (2012b). JASA 132, 3118–3124.
- Picciulin et al. (2013) Fish. Res. 145, 76–81.
- Parmentier et al (2018). Animal conserv, 21(3), 211-220
- Correa et al. (2018). Ocean Coast. Manage. 168, 22-34.
- Desiderà et al. (2019). MEPS 608, 183-197
- Bolgan et al. (2019) IBAC 2019
- https://chorusacoustics.com/monitoring





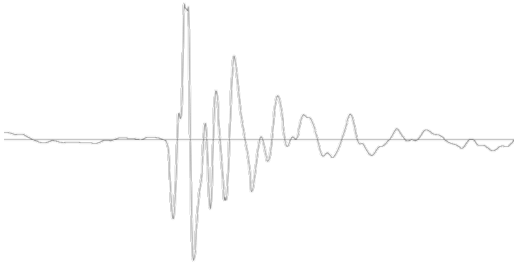
Brown meagre



Parmentier et al. (2014). Aquaculture, 432, 204-211.
Parmentier & Fine (2016). Springer.

Swimbladder forced-response model

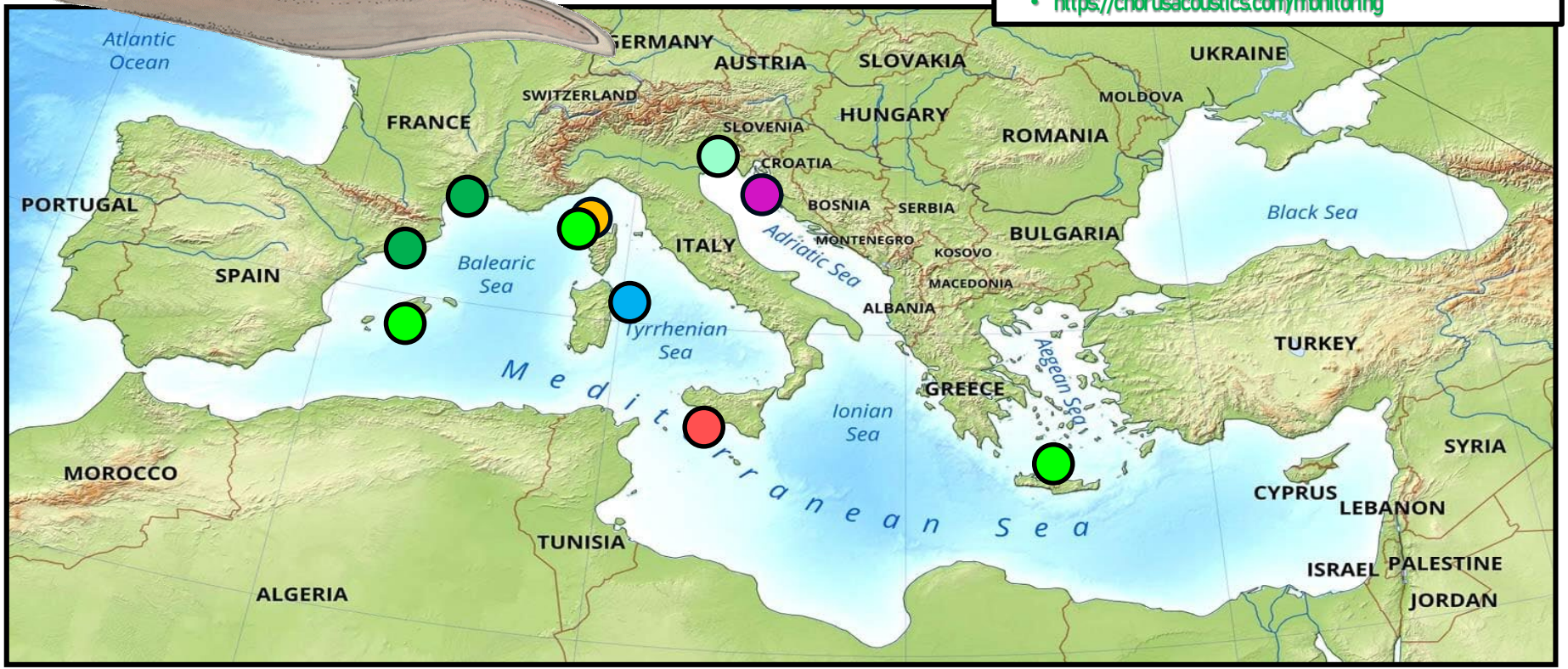
Superfast sonic muscles



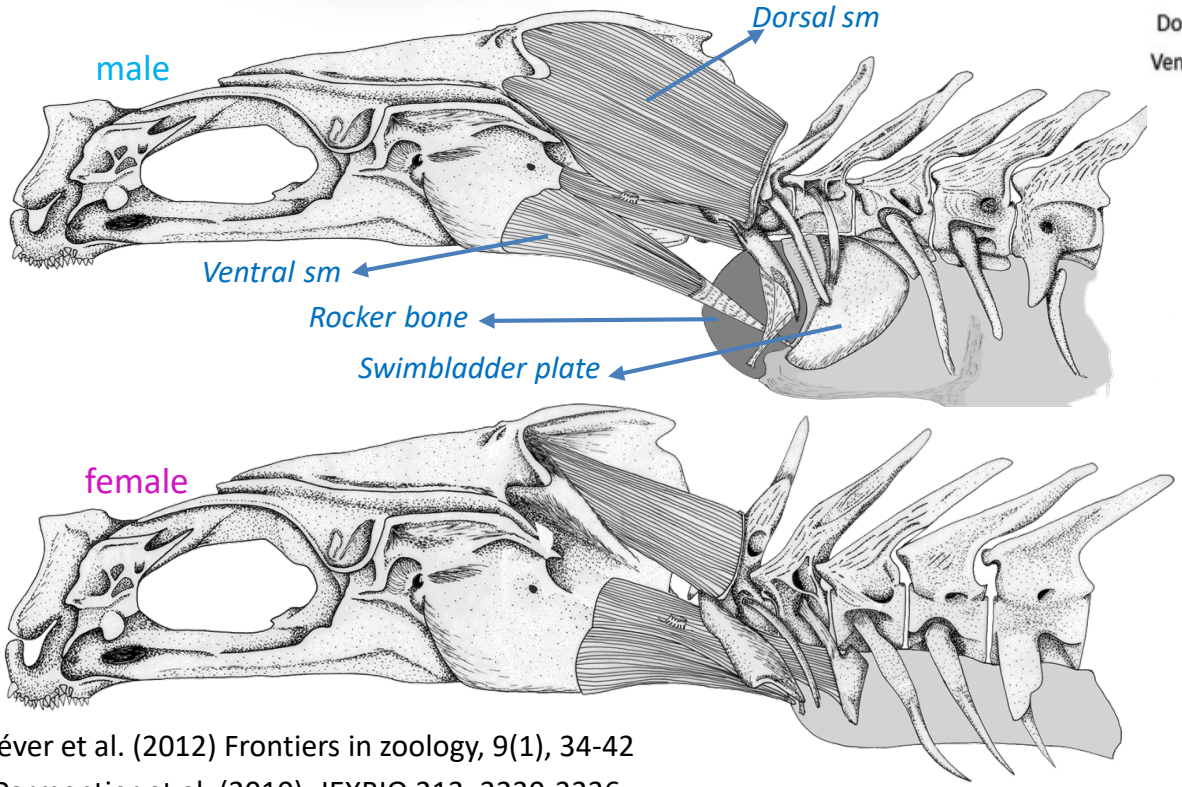
Muscle twitch *Swimbladder reverberation*

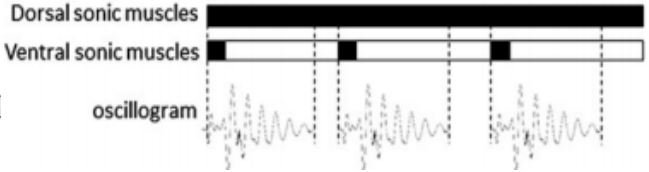
Cusk-eel
(Ophidion rochei)

- Parmentier et al (2010). JEXBIO *213*(18), 3230-3236.
- Kéver et al. (2015). JFB, 87(2), 502-509.
- Kéver et al. (2016). Mar Eco 37(6), 1315-1324.
- Ceraulo et al. (2018). Ecol ind, 85, 1030-1043.
- Picciulin et al. (2019). Aquatic Conserv, 2, 1-9
- Desiderà et al. (2019). MEPS 608, 183-197
- Bolgan et al. (2019) IBAC 2019
- https://chorusacoustics.com/monitoring



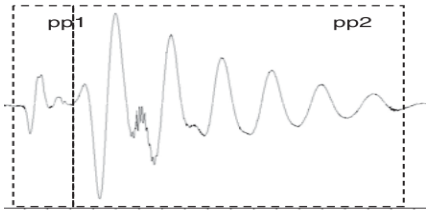
Cusk-eel





Swimbladder rebound mechanism

Sexual dimorphisms
Ontogenetic variations



Rocker bone displacement

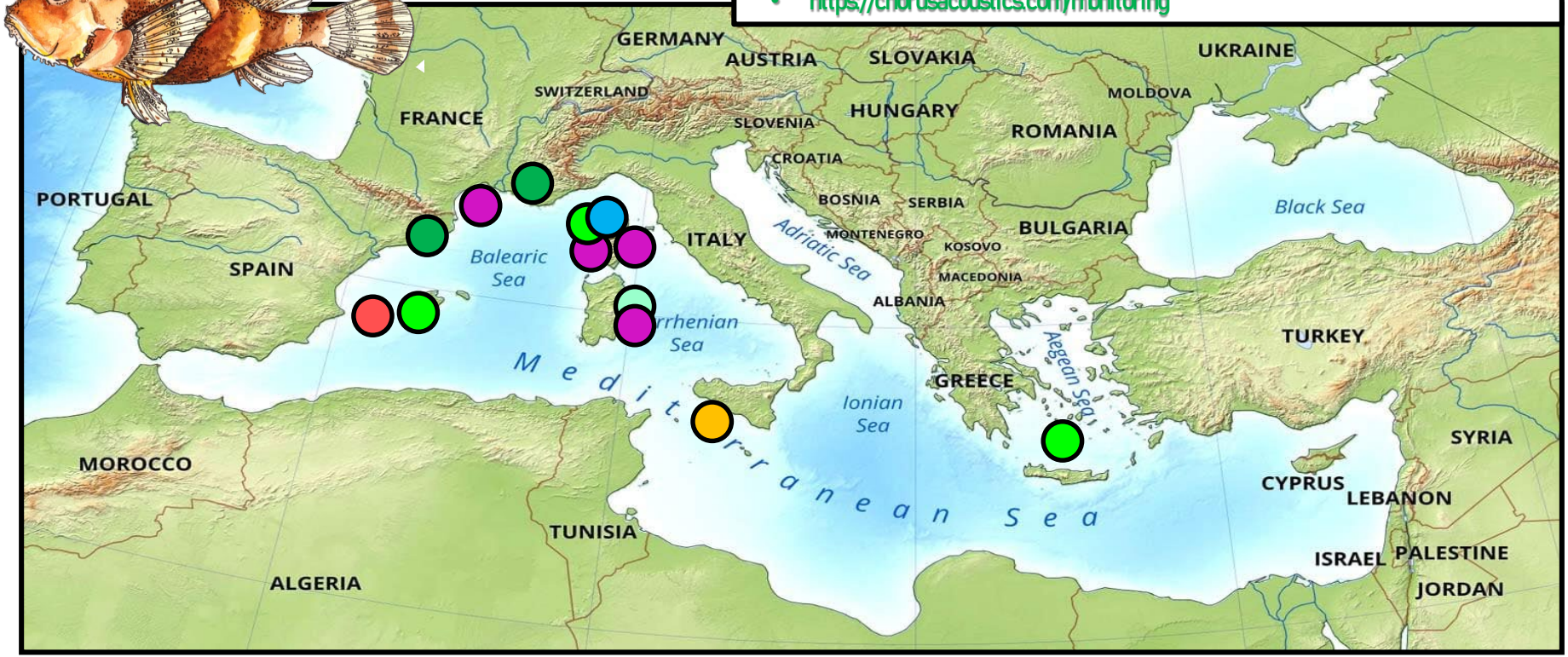
Lateral movements of the swimbladder plate

Kéver et al. (2012) Frontiers in zoology, 9(1), 34-42
Parmentier et al. (2010). JEXBIO 213, 3230-3236

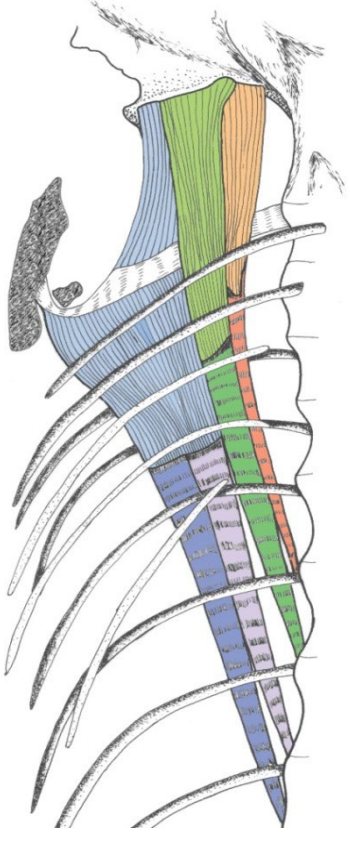
Scorpionfish

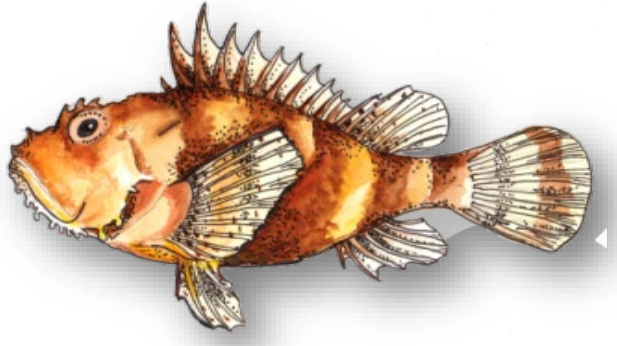
(Scorpaena spp.)

- Di Iorio et al. (2018). Remote Sens Ecol Conserv , 4, 248-263
- Ceraulo et al. (2018). Ecol ind, 85, 1030-104
- Correa et al. (2018). Ocean Coast. Manage. 168, 22-34.
- Desiderà et al. (2019). MEPS 608, 183-197
- Bolgan-Soulard et al (2019). JEXBIO 222(11), jeb196931.
- Bolgan et al. (2019) IBAC 2019
- https://chorusacoustics.com/monitoring



Scorpionfish





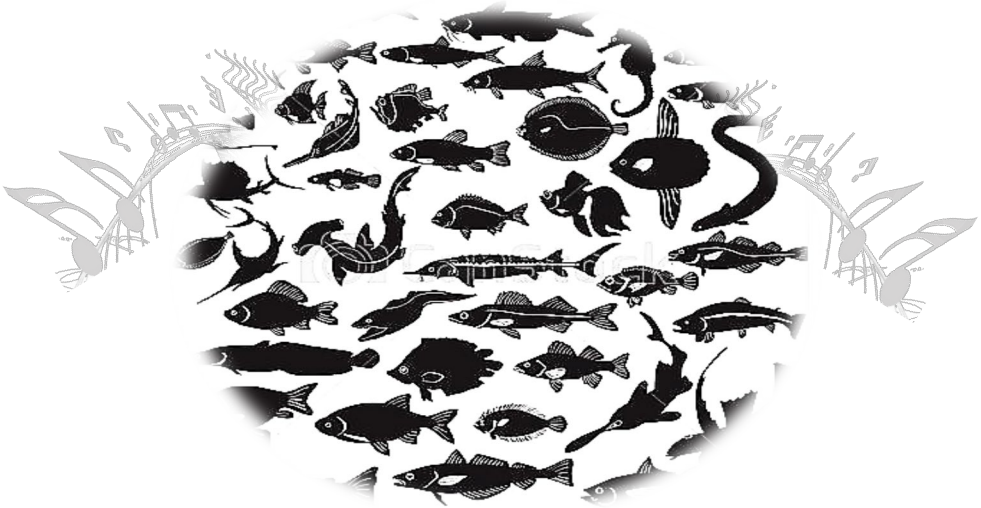
The chordophones

Lacking swimbladder
High variability within and between species
in number and length of tendons (i.e. strings)

Bolgan-Soulard et al (2019). JEXBIO 222(11), jeb196931.

Vocal community

Aggregation of species that produce sounds by using internal or external sound-producing tools and which interact acoustically in a specific habitat (Farina & James, 2016).



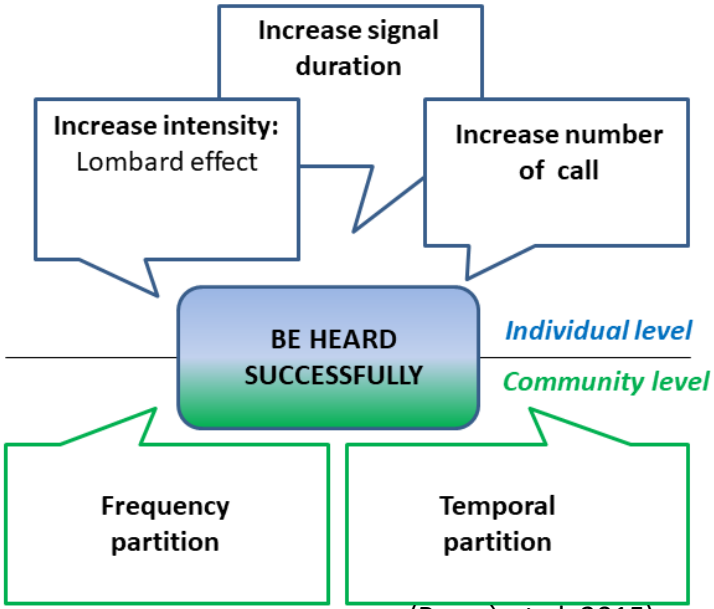
Fish acoustic communication has rarely been studied at community level

Only one study on fish vocal communities in the Mediterranean Sea (rocky reefs)

Desiderà et al. (2019). MEPS 608, 183-197

Acoustic niche hypothesis (ANH)

Individuals in acoustic communities compete for
the use of the sound resource for communication (niche competition)



(Ruppè et al. 2015)

ACOUSTIC NICHE HYPOTHESIS (Krause, 1993)

To avoid interference, fish species sharing the same acoustic space have co-evolved to **exploit different frequency bands**

- **Frequency partition**

And/ or to emit sounds at **different time of the day/ year**

- **Temporal partition**

Ruppé et al. (2015). *Proceedings of the National Academy of Sciences*, *112*(19). doi.org/10.1073/pnas.1424667112

Characterisation of the vocal fish community inhabiting *Posidonia oceanica* meadows

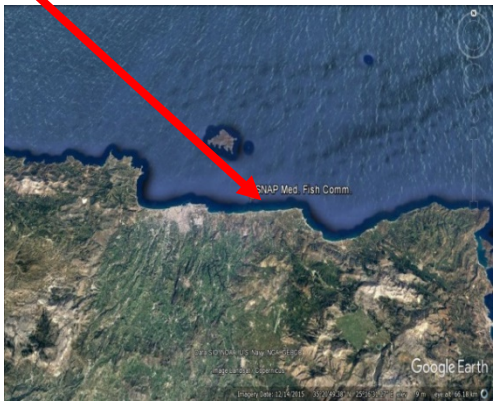
AIMS

- Characterise the **vocal fish community** of the pivotal Mediterranean environment of *Posidonia oceanica* meadows across the Mediterranean basin
- Is there any **temporal** or **spectral partition** of fish vocalizations? Testing ANH (Acoustic Niche Hypothesis)

Simultaneous Static Acoustic Monitoring (SAM)

Mallorca, Palma Bay Marine Reserve

Corsica, STARESO

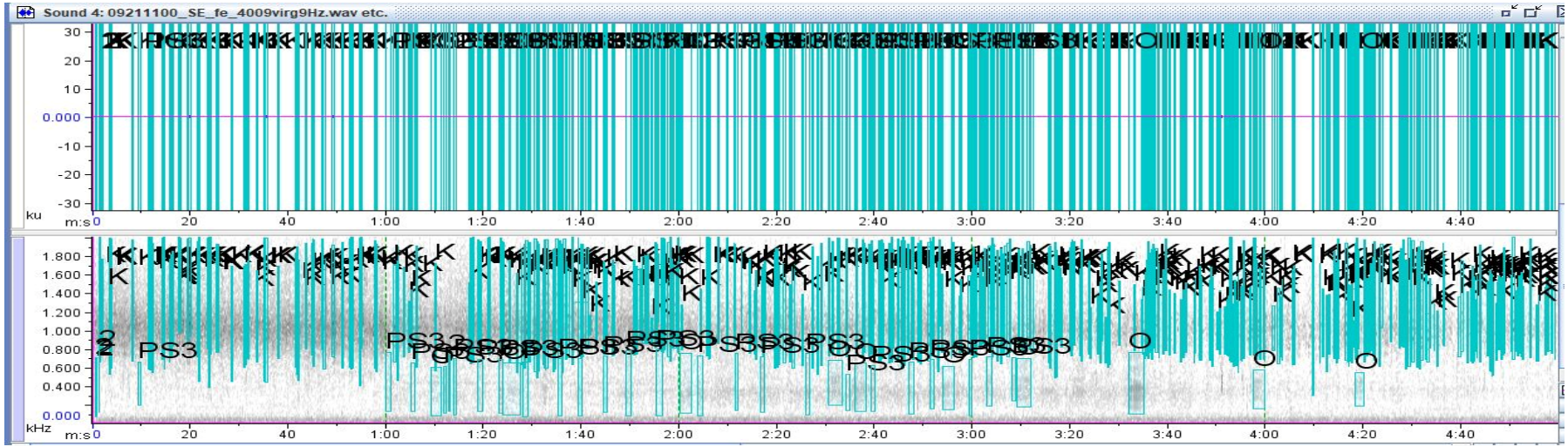


Crete, Seafloor observatory

Simultaneous Static Acoustic Monitoring (SAM)

- Synchronised recordings
- Similar environmental conditions (habitat, depth)
- One month of data during the peak of fish vocal season (July)

Characterisation of the vocal fish community



Manual scrolling (5 days per site)

Abundance evaluated on a categorical scale,
i.e. **abundance score**
ranging from 0=absence to 4=chorus

Diversity evaluated as number of sound types, i.e. **acoustic richness**

Sound types have been categorised on the basis of a dichotomous framework

see Desiderà et al. (2019). MEPS 608, 183-197

Is the pulse period succession within the call and/or the pulse amplitude modulation highly stereotyped or rather irregular?

IRREGULAR

Peak Frequency (Fp)?

Fp<200 Hz

PP<10 ms

LFPT (Low Freq. Fast Pulse Train)

Fp>200 Hz

Average pulse period (PP)?

PP<10 ms

FPT (Fast Pulse Train)

PP>80 ms

PP<20 ms

PS-4 (Pulse Series n 4)

20<PP<80 ms

PS-2 (Pulse Series n 2)

Fp<400 Hz

PS-3 (Pulse Series n 3)

400 <Fp< 600 Hz

PS-5 (Pulse Series n 5)

Fp>600 Hz

PS-1 (Pulse Series n 1)

STEREOTYPED

Does pulse period succession alternates between short and long pulse period?

NO

Are the pulses characterised by a highly stereotyped amplitude modulation and is Fp> 600 Hz?

NO

***Sciaena umbra* calls**

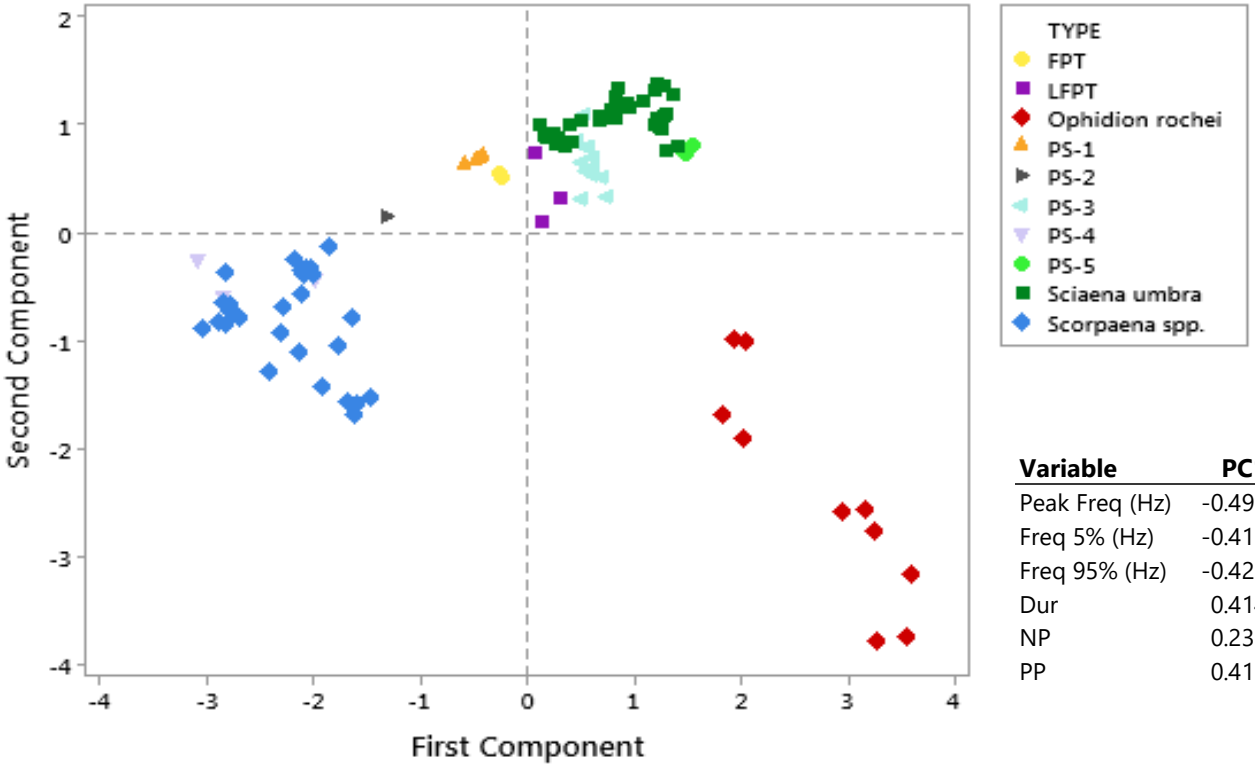
YES

Scorpaena spp. calls

YES

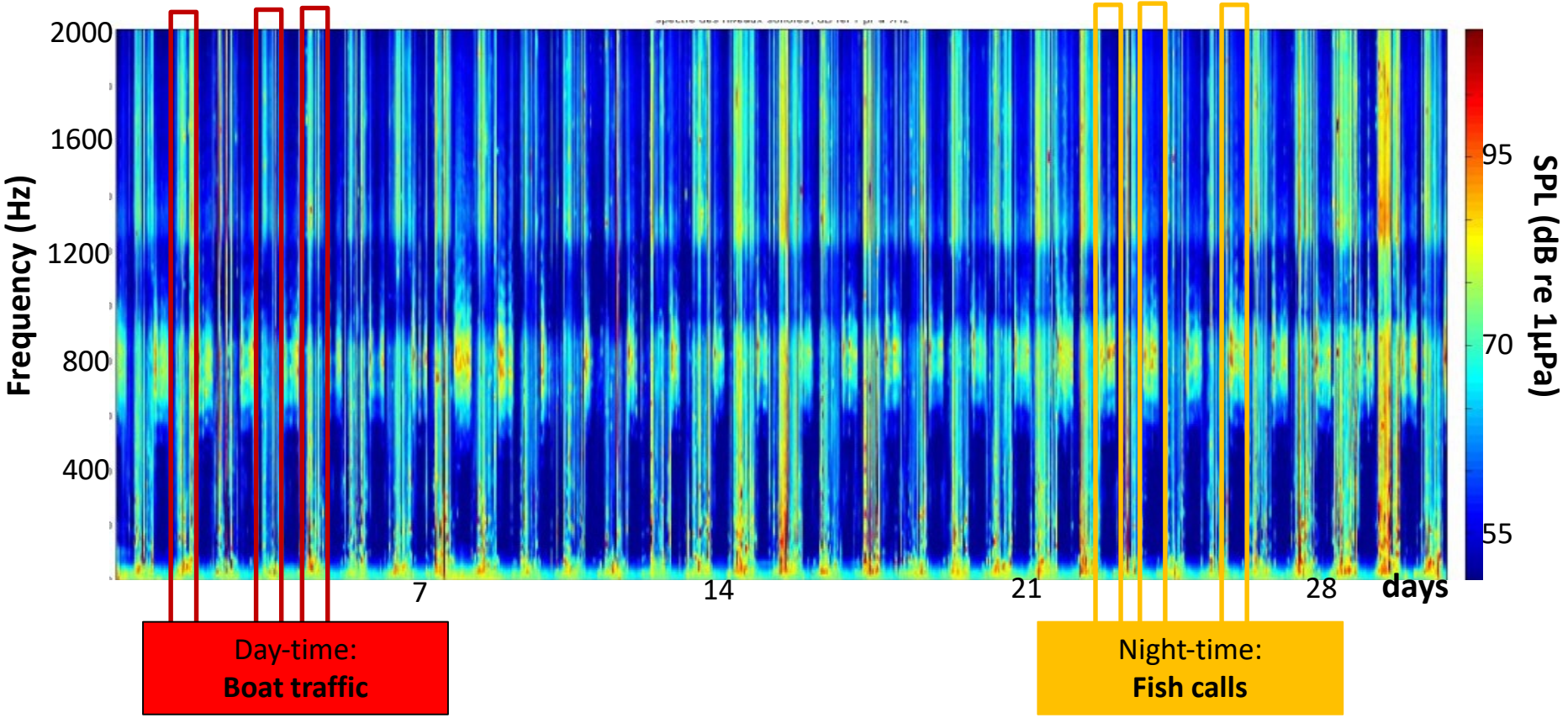
***Ophidion rochei* (male) calls**

Sound types have been categorised on the basis of a dichotomous framework

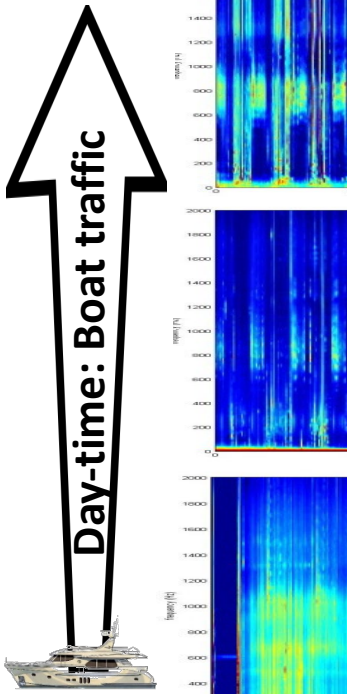


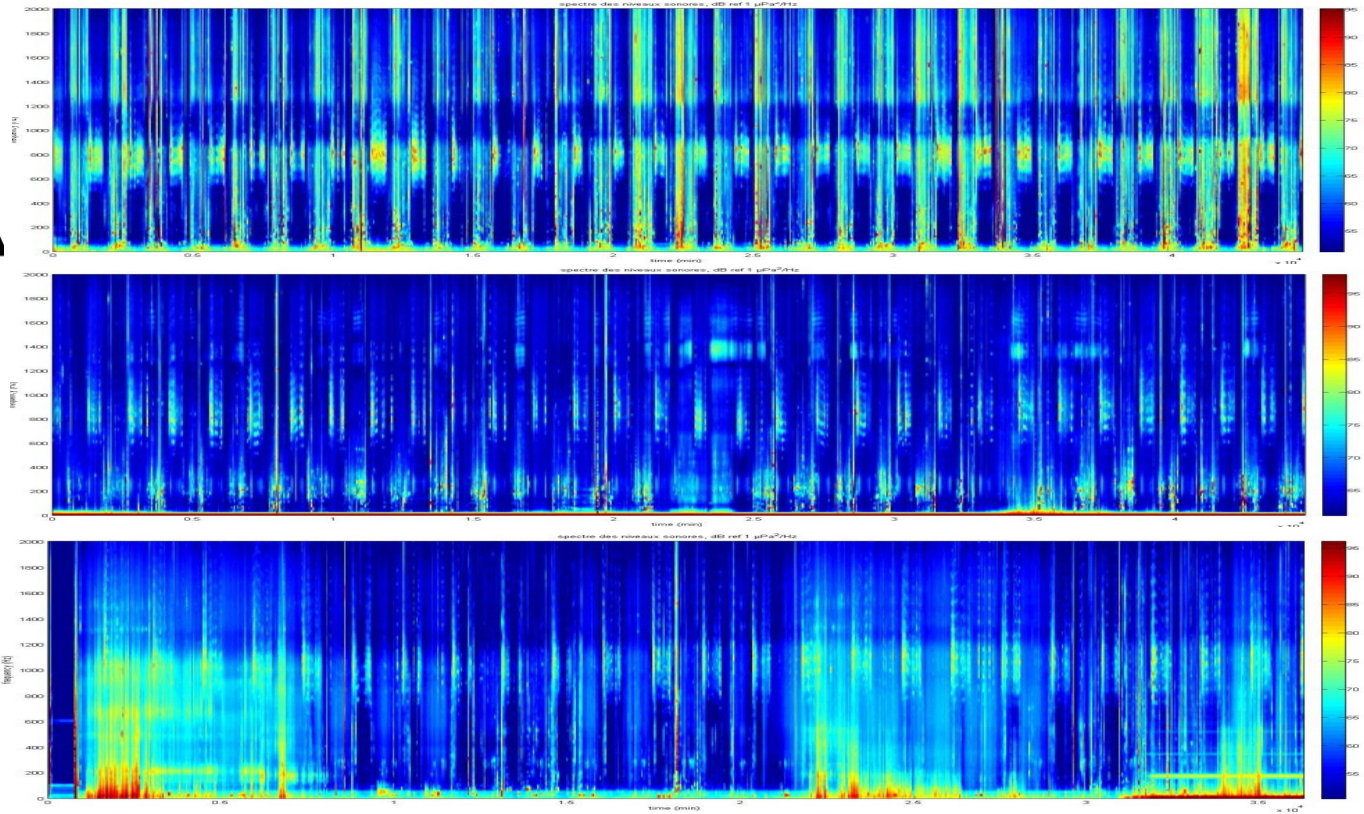
Variable	PC1	PC2
Peak Freq (Hz)	-0.499	-0.202
Freq 5% (Hz)	-0.412	-0.339
Freq 95% (Hz)	-0.426	-0.129
Dur	0.414	-0.521
NP	0.233	-0.715
PP	0.416	0.209

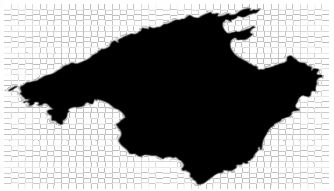
Fish active acoustic space:
one month of recording (743 hours: July)



Fish active acoustic space:
one month of recording (743 hours: July)





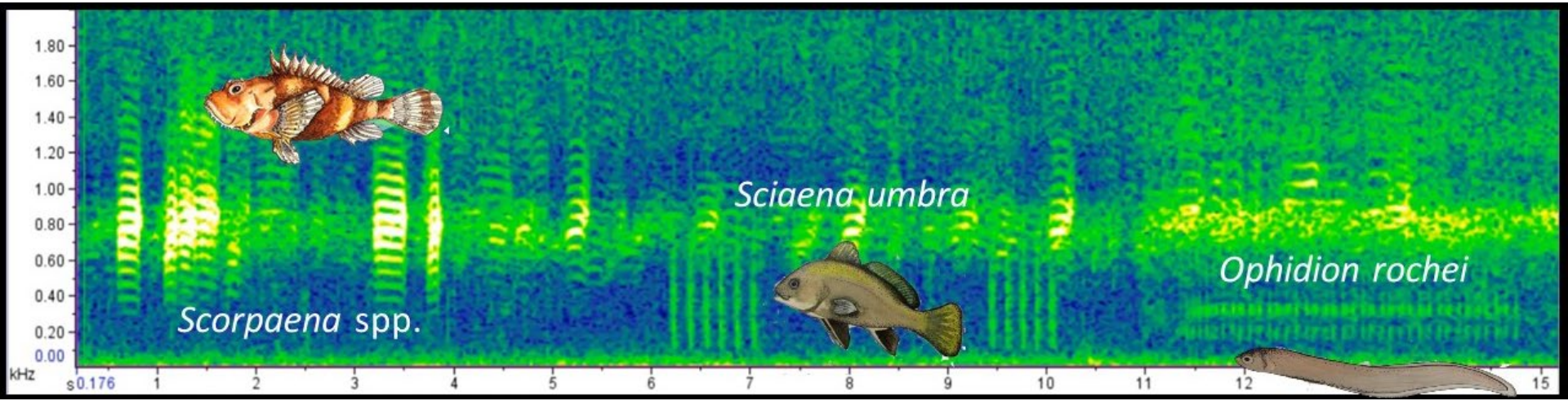


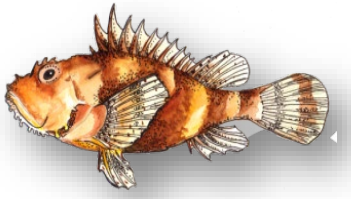
MALLORCA

CORSICA

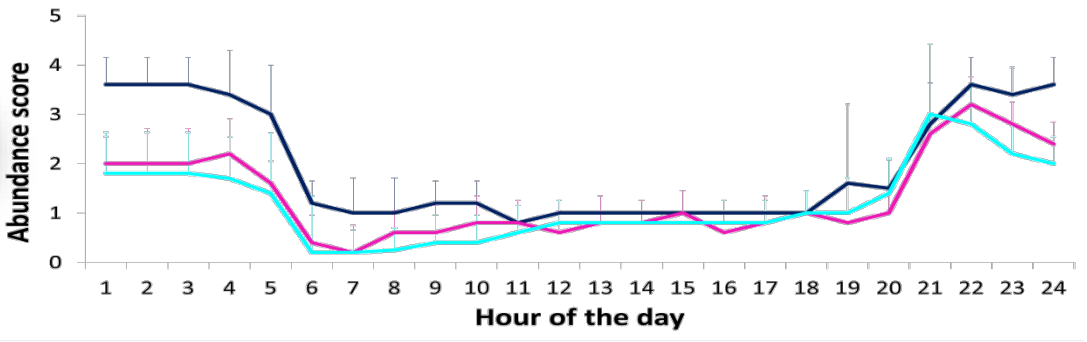
CRETE

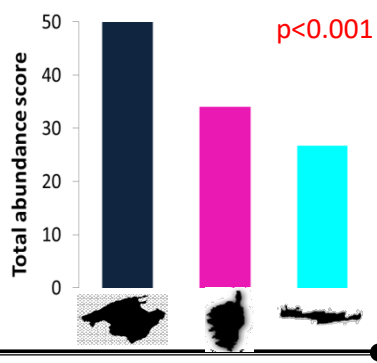
Most common fish sounds in *P. oceanica* at -20 m



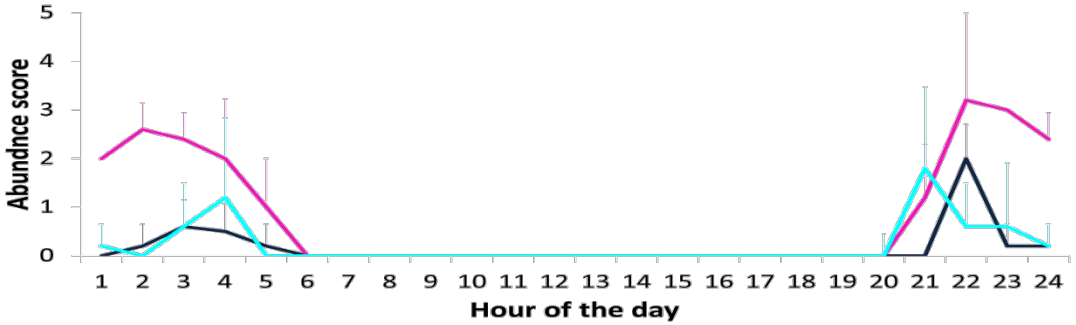


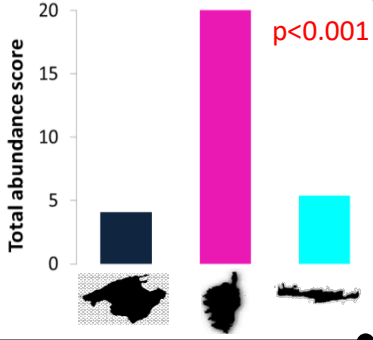
Scorpionfish



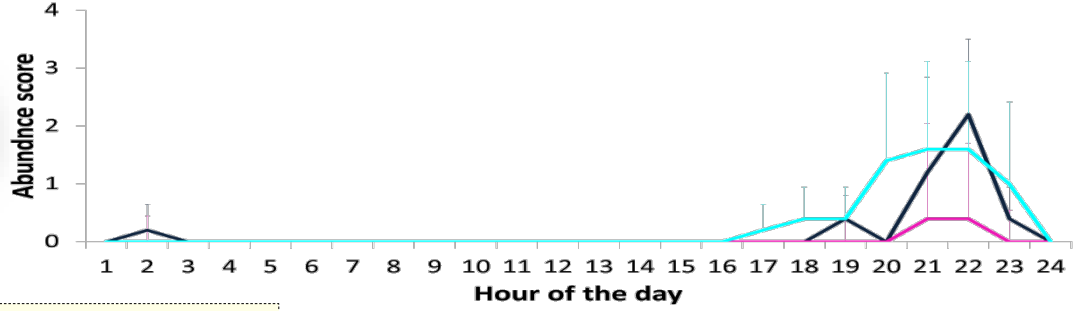


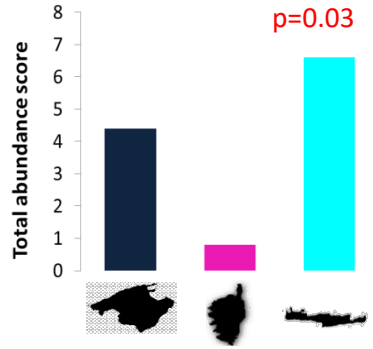
Cusk-eel





Brown meagre

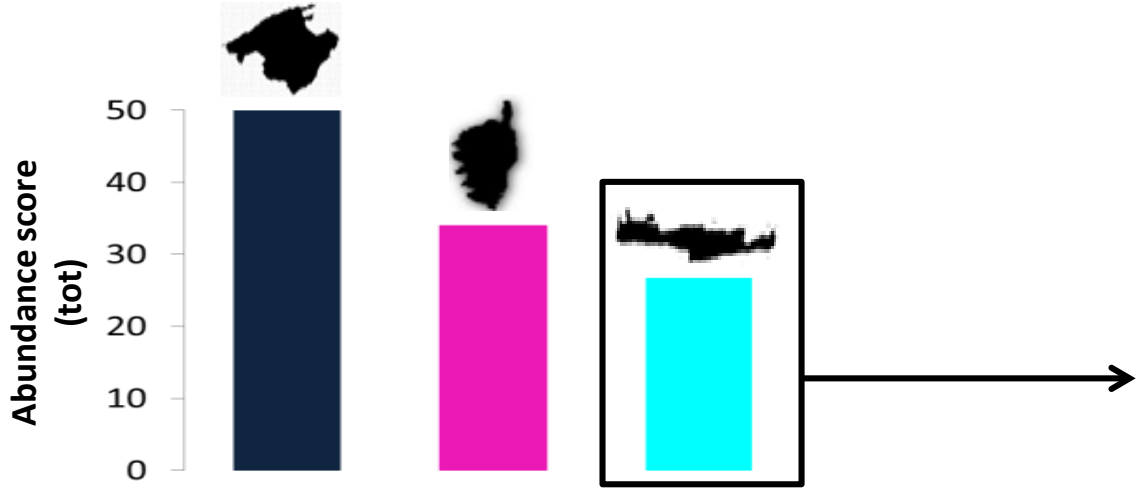


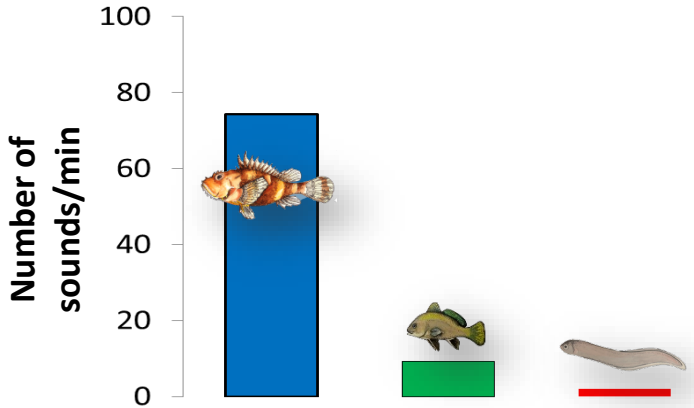


Mallorca Corsica Crete

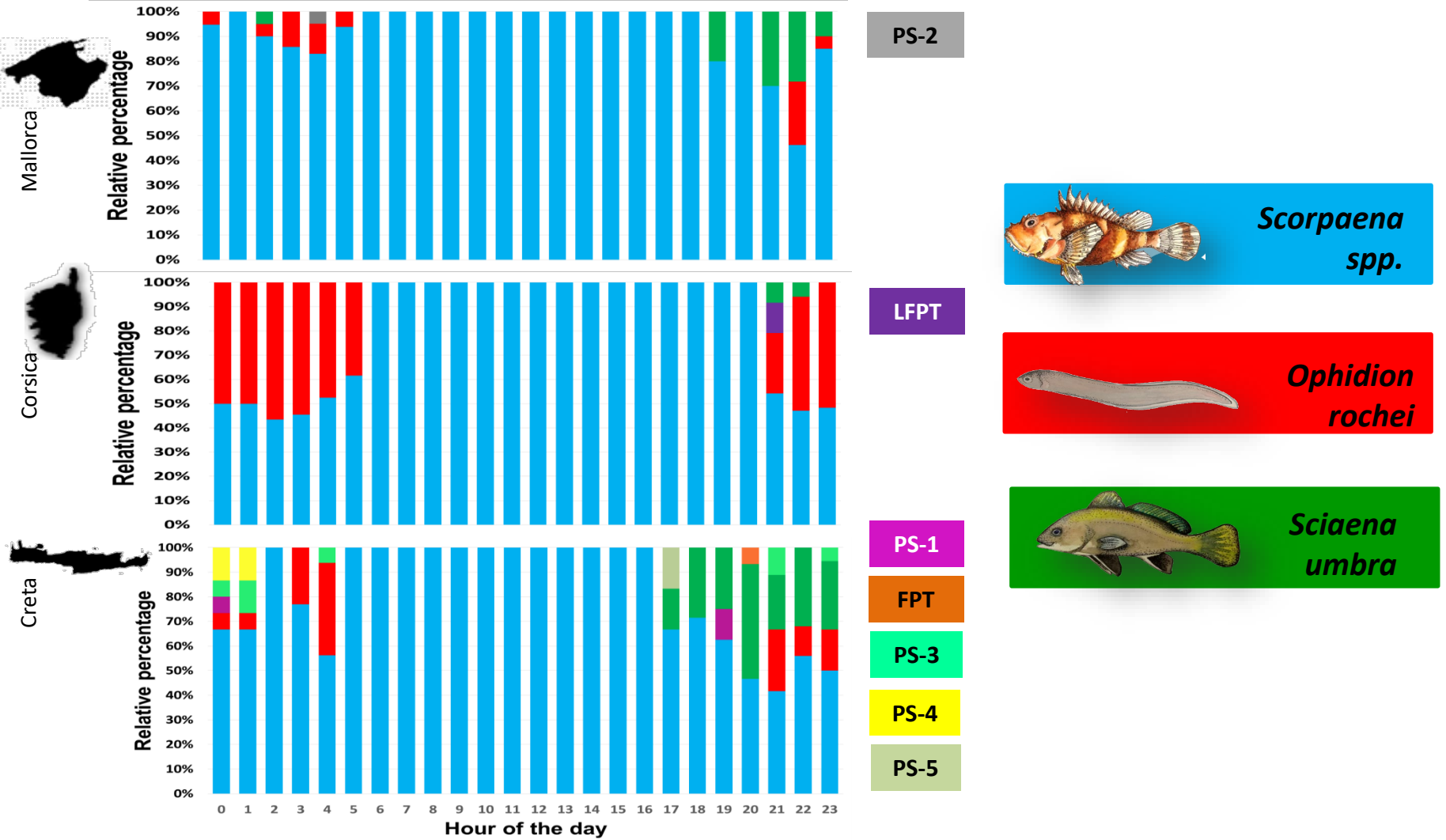
Kwa abundance
p<0.001

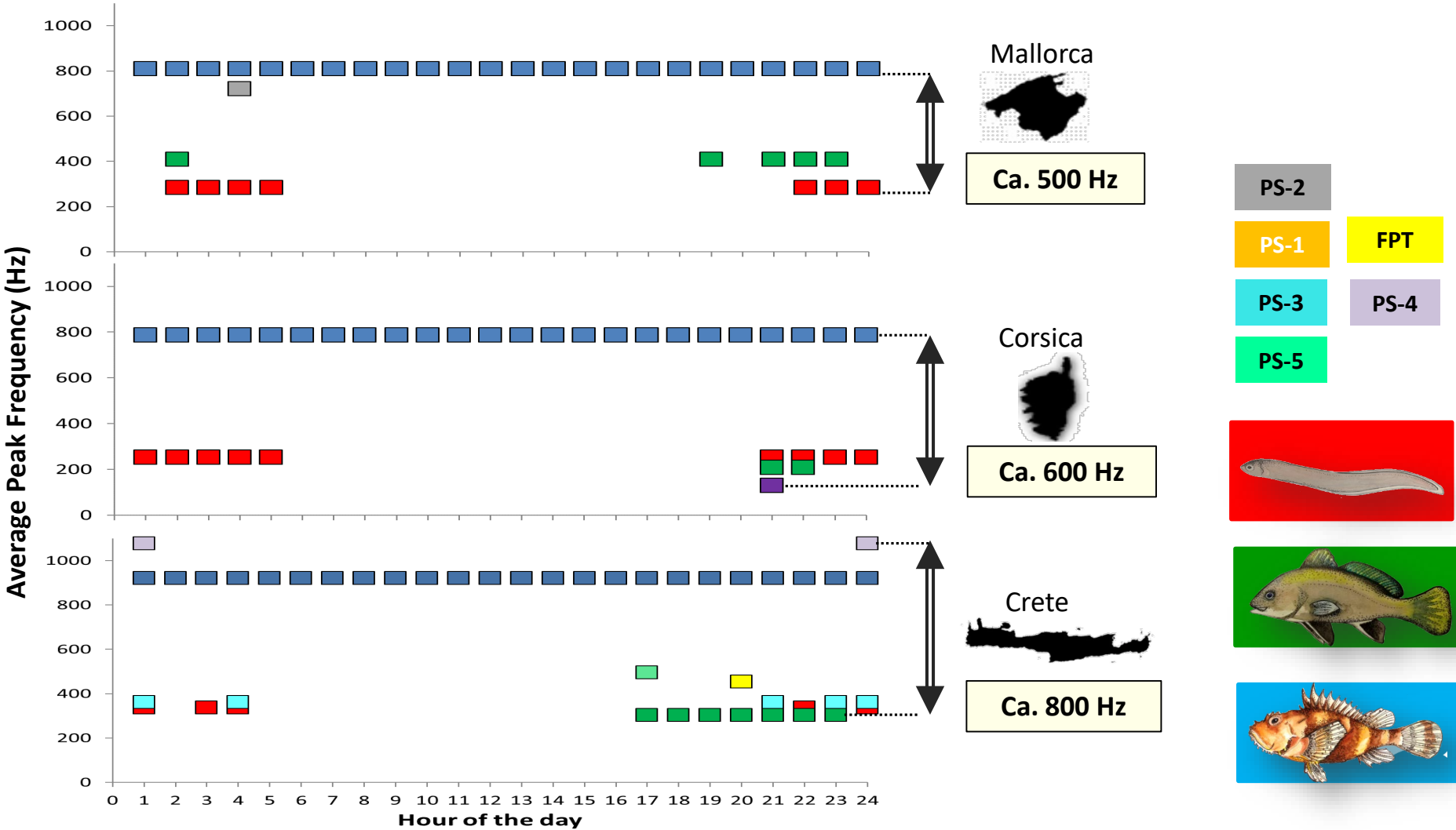
PORTUGAL
SPAIN
Balearic Sea
ITALY
Tyrrhenian Sea
Adriatic Sea
BOSNIA
SERBIA
MONTENEGRO
KOSOVO
MACEDONIA
ALBANIA
BULGARIA
Black Sea
TURKEY
Aegean Sea
GREECE
Ionian Sea
MOROCCO
SYRIA
CYPRUS
LEBANON


Abundance score (tot)
0
10
20
30
40
50


Number of sounds/min
0
20
40
60
80
100

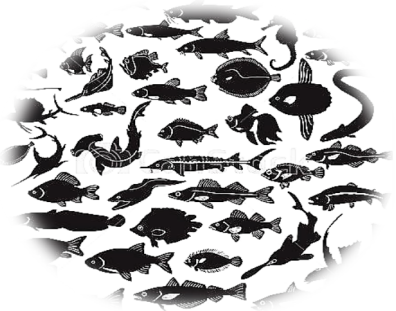
Acoustic richness


Mallorca
Corsica
Creta
Relative percentage
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hour of the day
PS-2
LFPT
PS-1
FPT
PS-3
PS-4
PS-5
Scorpaena spp.
Ophidion rochei
Sciaena umbra


Average Peak Frequency (Hz)
1000
800
600
400
200
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour of the day
Mallorca
Ca. 500 Hz
Corsica
Ca. 600 Hz
Crete
Ca. 800 Hz
PS-2
PS-1
FPT
PS-3
PS-4
PS-5

Vocal fish community of *P. oceanica* meadow: main findings

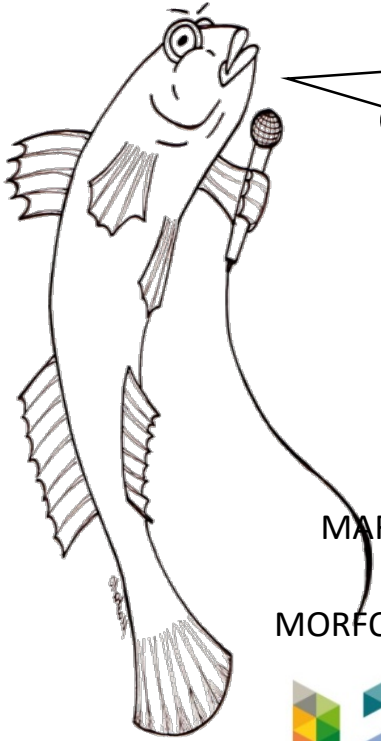
- Day-time: boat noise, decreasing West to East, only some rare Scorpaena's Kwa
- Night time: dominated in abundance by the Scorpaena's Kwa (decreasing West to East)
- Acoustic diversity increases West to East
- The spectral acoustic space exploited by fish is larger in Crete (i.e. site with highest acoustic diversity)
- We observe some degree of temporal and spectral partition overlap.
- **Acoustic niche as a hypervolume →consider more axis (e.g. tempo, rhythms etc)**



FURTHER STUDIES ARE NEEDED

Funding sources

BeIPD-Marie Curie COFUND (ULiège, Belgium)
Agence de l'Eau Rhone Mediterranee & Corse (France)



Thanks for your attention!

Marta Bolgan, Ph.D.

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&
MORFONCT - Laboratoire de Morphologie Fonctionnelle et Evolutive, ULiège, Belgique

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