Abondance et diversité acoustique des populations de poissons dans la baie de Calvi.

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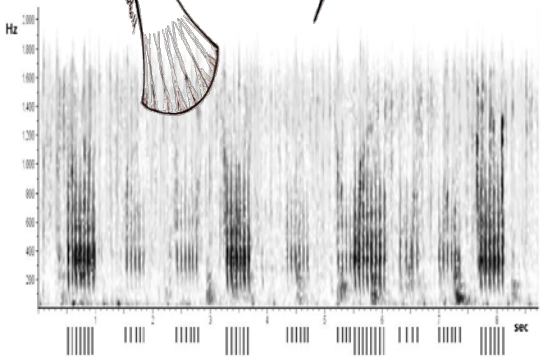
Fish acoustic communication



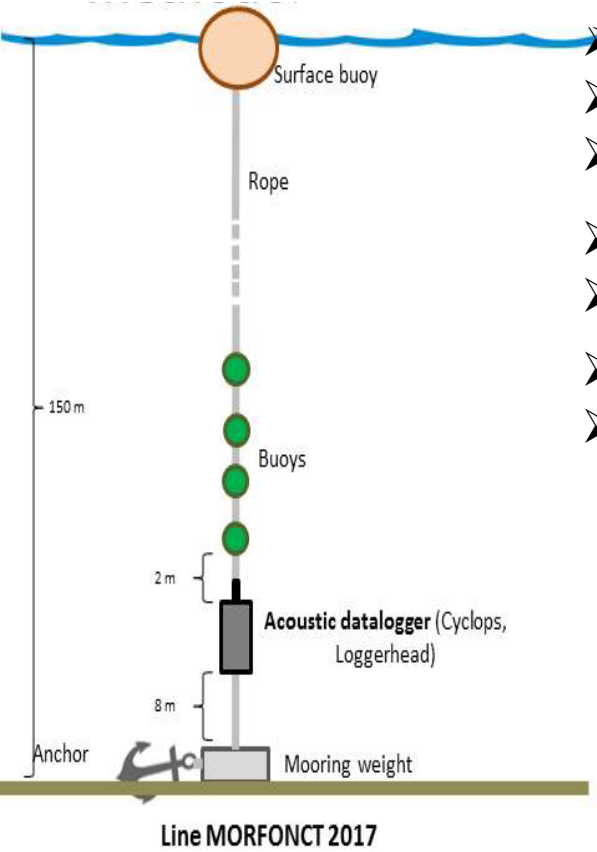
More than **800 species have evolved morphological, physiological** and **neurological adaptations** allowing them to rely on **sound** for **communication**

Fish sounds are **especially conspicuous** during the **breeding season,**
in relation to **agonistic interactions** and **mating activities**
-individual recognition, mate choice, readiness to spawn, social status assessment etc-

Intra-specific variation of fish sounds is **generally smaller** than **inter-specific variation.**

Once the sound has ben characterized, the stereotypical nature of fish sounds makes it relatively easy to **identify which species of fish vocalize in the wild.**

Using fish sounds as natural tags: Passive Acoustic Monitoring (PAM) in fishery science

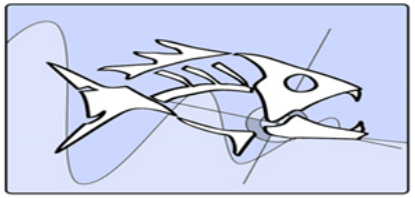


- **Non-invasive census**
- **Continuous monitoring**
- Independent of weather, time of day and human effort

- **Diel, seasonal** & **geographical pattern** of activity
- **Habitat preferences**

- **Pinpoint fish spawning grounds**
- **Evaluating the effects of man-made noise**

Conservation/ Management programs



Fish PAM:
MORFONCT at STARESO

Sound and sonic apparatus characterisation, location of vocal species in the wild

- *Carapus acus (*Parmentier et. al 2006)
- *Epinephleus marginatus* (Bertucci et et al. 2015)
- *Ophidion rochei* (Kéver et al. 2016)

Year-round characterisation of fish vocal activity

- *Ophidion rochei* (Kéver et al. 2016)

Influence of environmental conditions on fish vocal behaviour

- *Ophidion rochei* (Kéver et al. 2015)

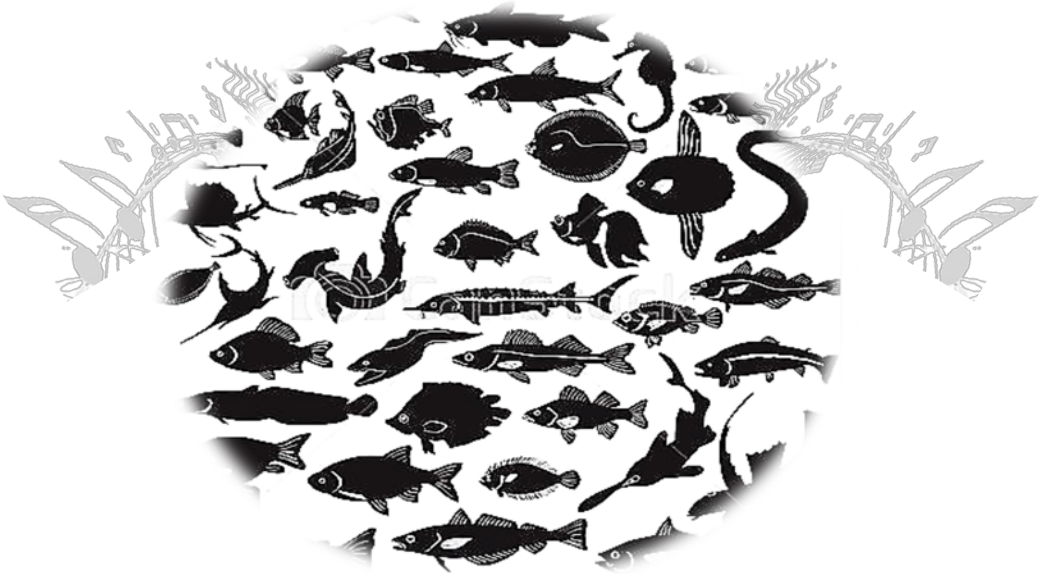
Consistency of fish call features along a Mediterranean gradient

- *Sciaena umbra* (Parmentier et al. 2017)

- Parmentier, E., Fine, M., Vandewalle, P., Ducamp, J. J., Lagardère, J. P. (2006). Acta Zoologica, 87(2), 113–119.
- Bertucci, F., Lejeune, P., Payrot, J., Parmentier, E. (2015). Journal of Fish Biology, 87(2), 400–421.
- Kéver, L., Lejeune, P., Michel, L. N., Parmentier, E. (2016). Marine Ecology, 37(6), 1315–1324.
- Kéver, L., Boyle, K. S., Parmentier, E. (2015). Journal of Fish Biology, 87(2), 502–509.
- Parmentier, E., Di Iorio, L., Picciulin, M., Malavasi, S., Lagardère, J. P., Bertucci, F. (2017). Animal Conservation doi:10.1111/acv.12362

Acoustic community

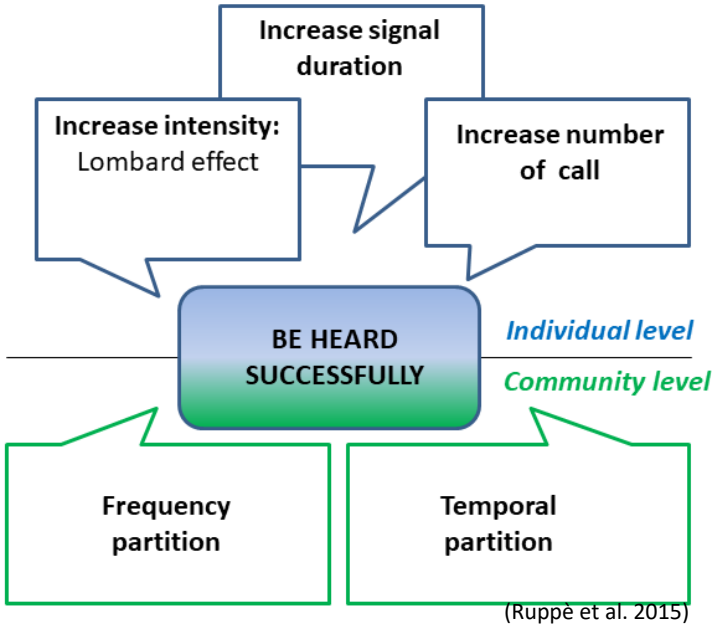
Aggregation of species that produce sounds by using internal or external sound-producing tools and which interact acoustically in a specific habitat (Farina & James, 2016).



Fish acoustic communication has rarely been studied at community level (Ruppè et al. 2015).

Acoustic niche hypothesis

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



(Ruppé 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, L., Clément, G., Herrel, A., Ballesta, L., Décamps, T., Kéver, L., & Parmentier, E. (2015). Environmental constraints drive the partitioning of the soundscape in fishes. *Proceedings of the National Academy of Sciences*, *112*(19). doi.org/10.1073/pnas.1424667112

Testing the acoustic niche hypothesis in Mediterranean fish communities

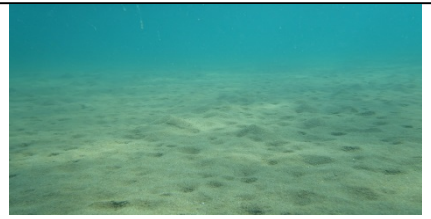
Abundance and **diversity variation** of fish sounds at different depths in STARESO (and comparison with other sites with similar environmental conditions)

-20 m

Posidonia oceanica

One month of simultaneous **recordings** in the peak of fish vocal season **(July)** in three Mediterranean **meadows (Calvi bay,** Mallorca, Crete) (2017)

-40 m

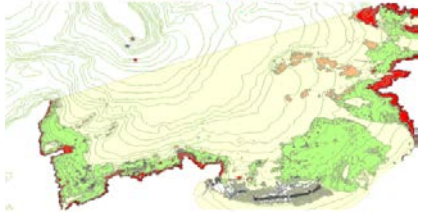


Sandy area

One year of recordings in the Calvi bay (Kéver et al. 2016)

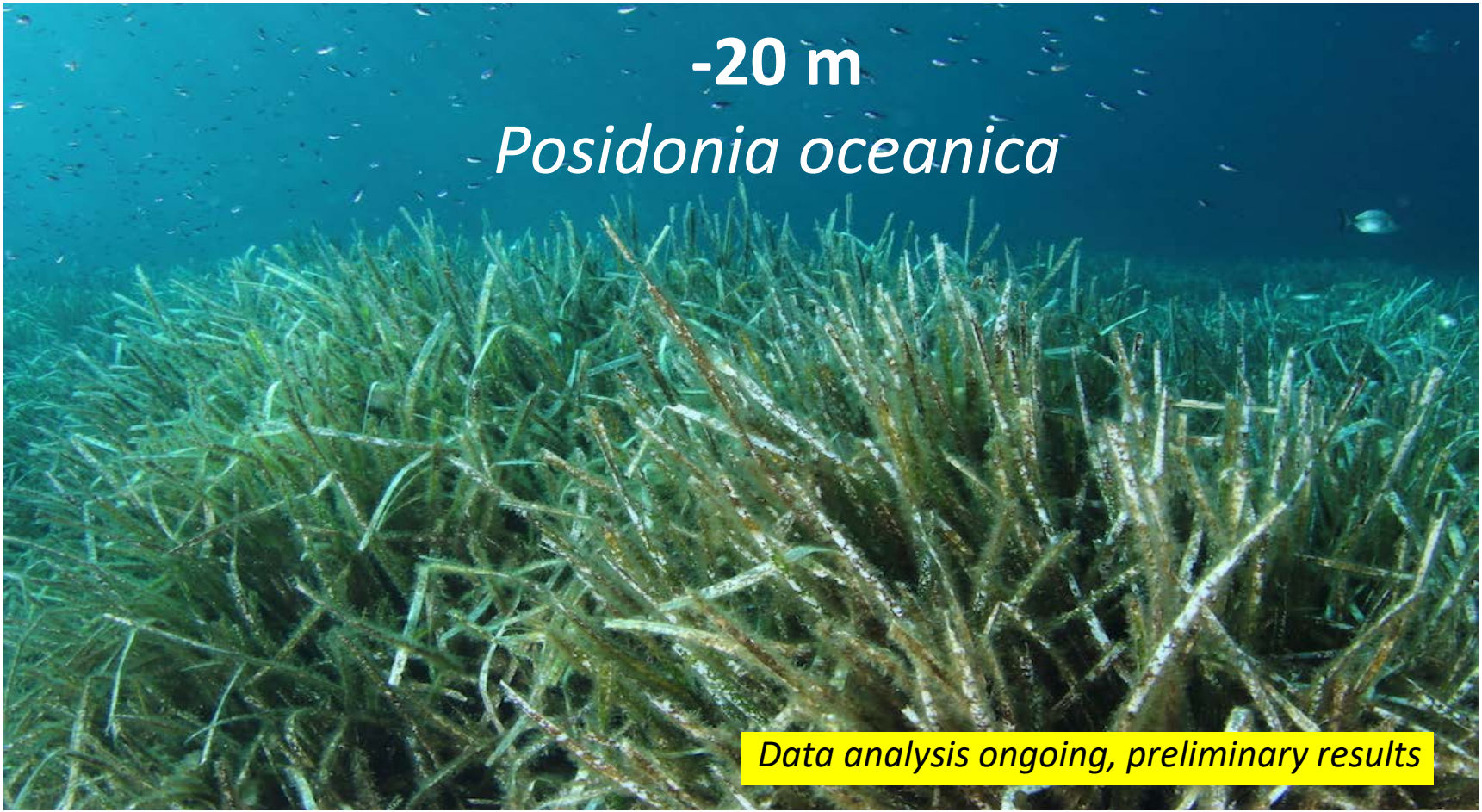
Analysis over one month (June 2013)

-125 m
-150m
-162 m

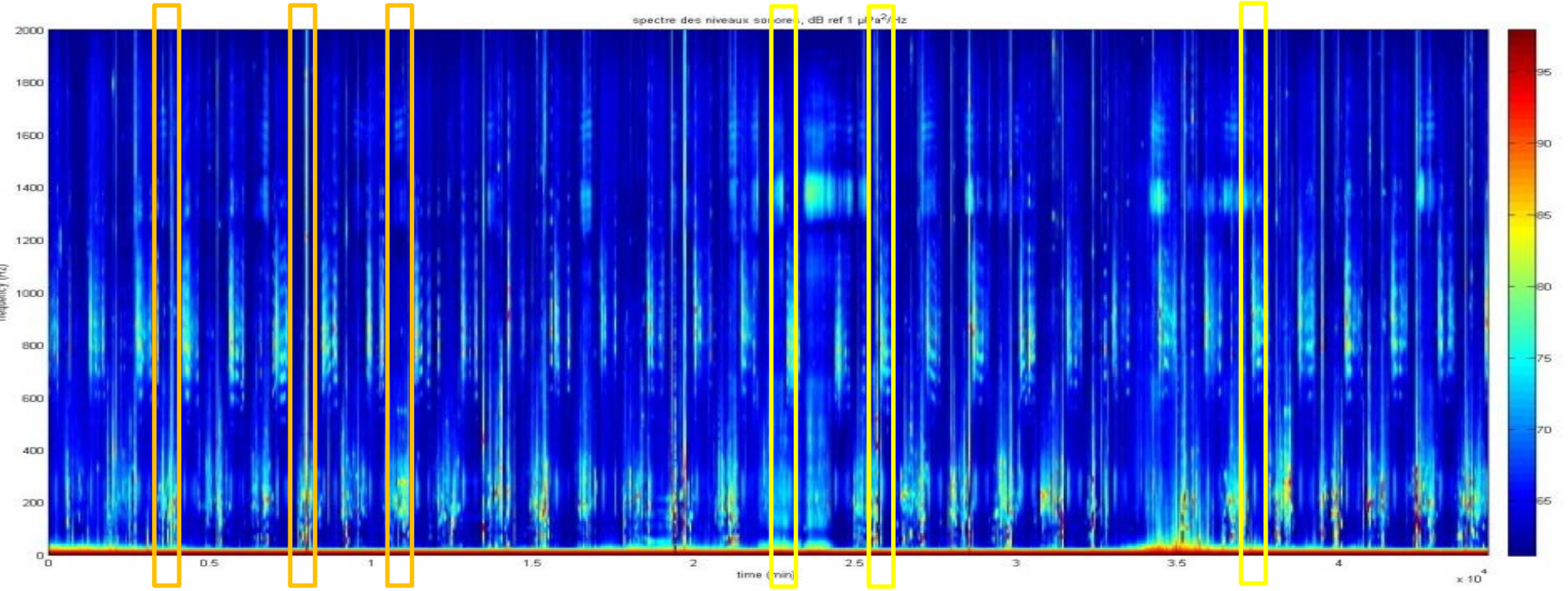


Head of the canyon

Short-term SAM during August and **October** (2016- 2107) **in the Calvi bay** (1 to 2 nights)


-20 m
Posidonia oceanica
Data analysis ongoing, preliminary results

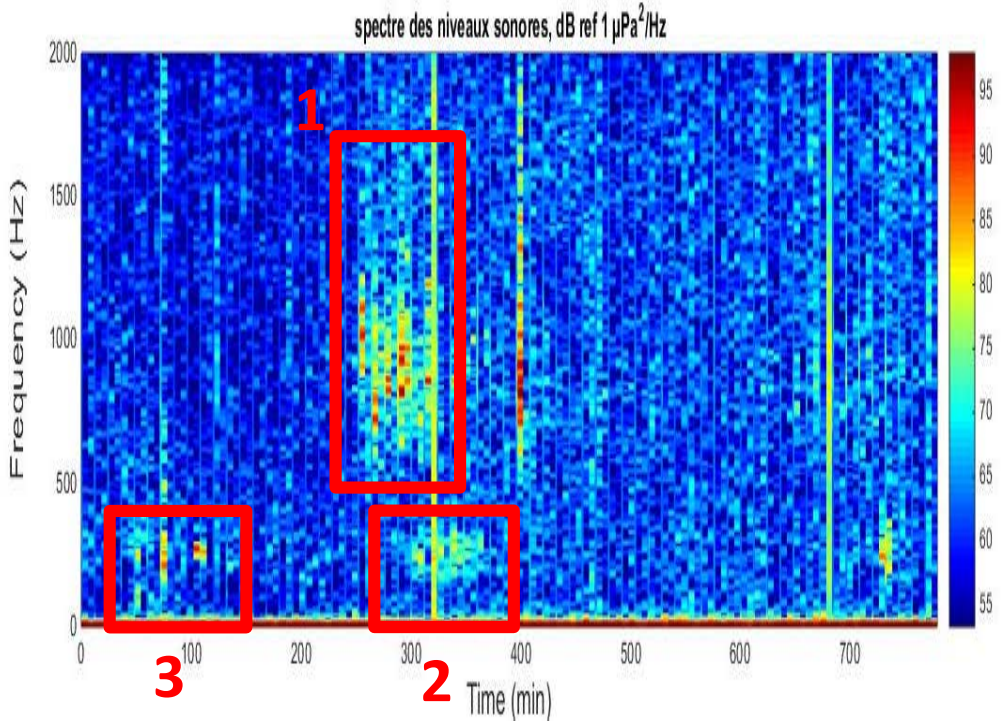
Fish active acoustic space in *P. oceanica* at -20 m: one month of recording (743 hours: July)



Day-time:
Boat traffic

Night-time:
Fish calls

STARESO, -20 m from 5pm to 6am



Most common fish sounds

1. *Kwa*

- Sound characterised in details by Di Iorio et al. (2018)
- Unknown emitter (but studies are ongoing)
- 20 times more abundant than the other fish sounds

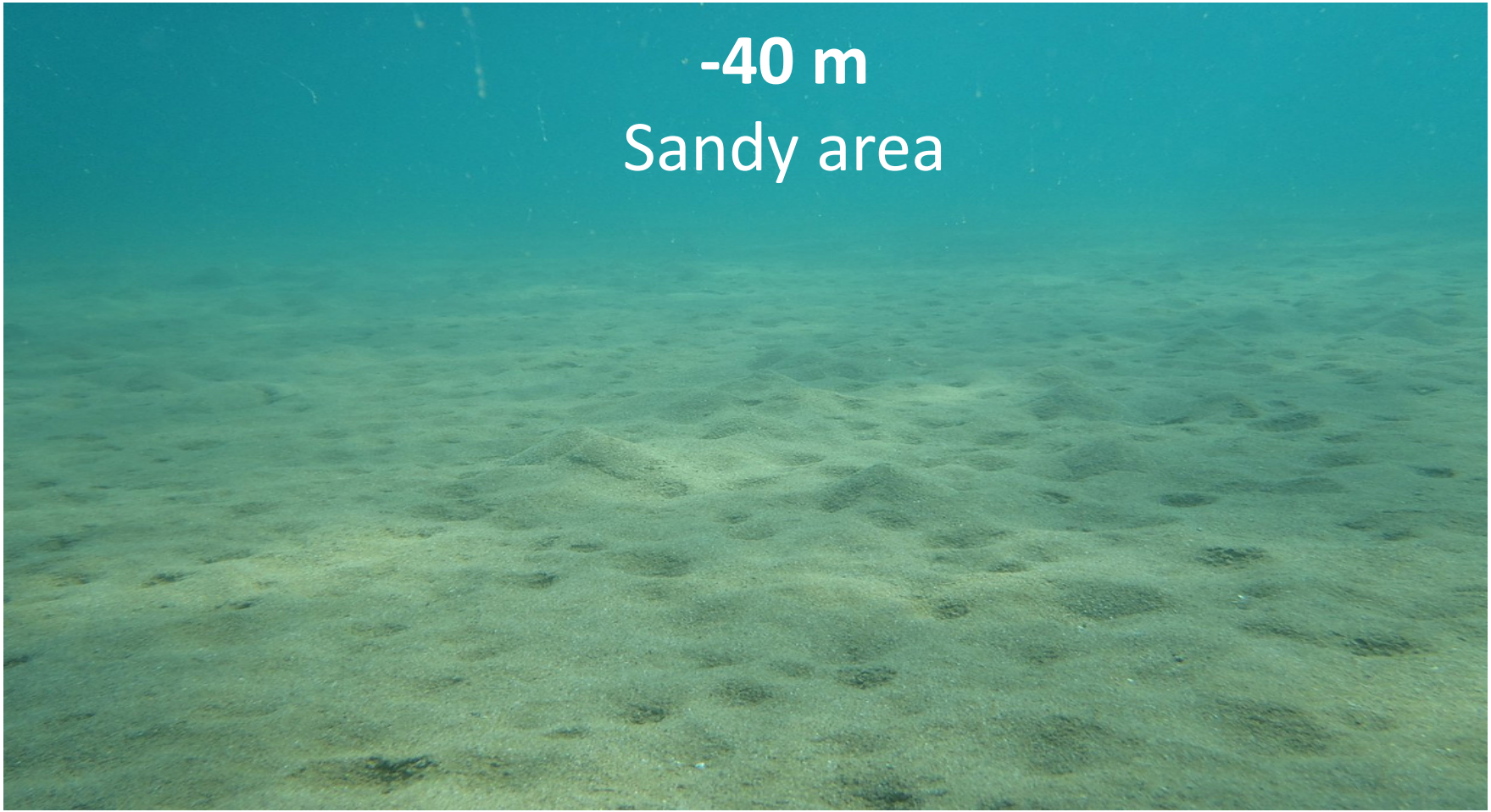
➢ ***FREQUENCY PARTITION***

2. *Ophidion rochei* male calls

3. *Sciaena umbra* calls

➢ **TEMPORAL PARTITION**

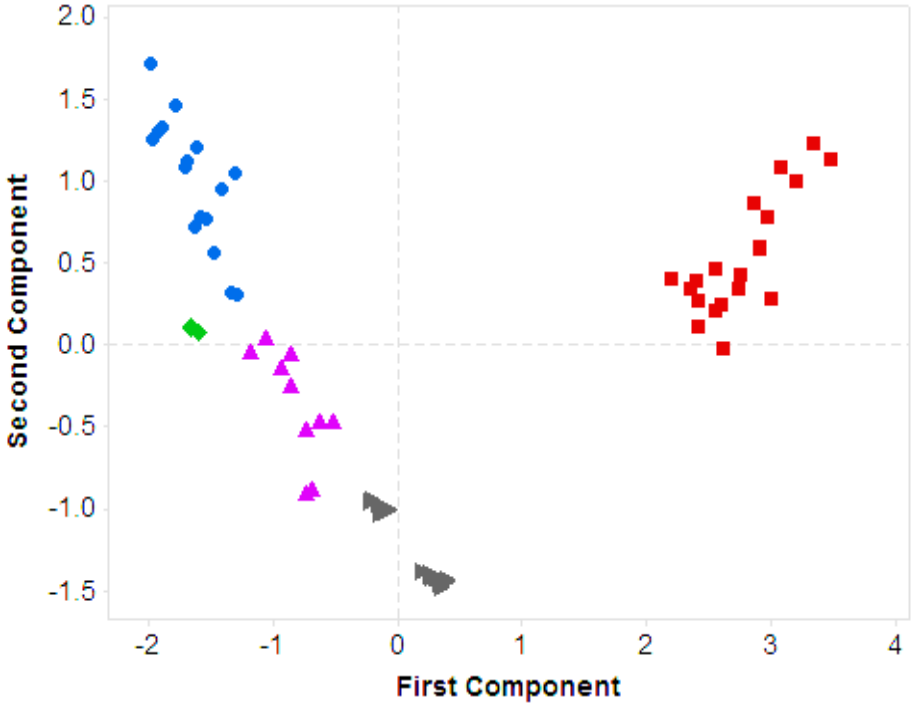
(but niche overlap can occur)


-40 m
Sandy area

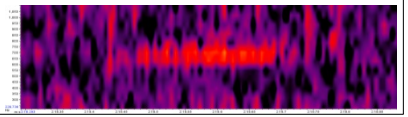
STARESO, -40 m sandy area

Analysis: one month (July)

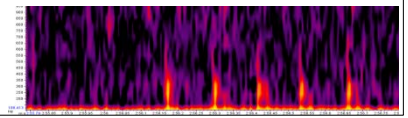
Sound diversity: five different types of fish sounds
for only two, the specific identity of the emitter is known



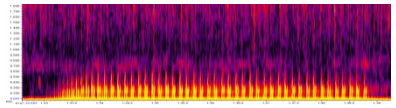
1. ● ***Kwa*** = harmonic sound of unknown origin



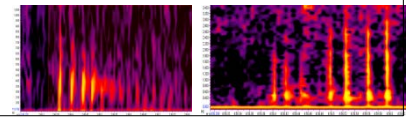
2. ▶ **S** = *Sciaena umbra* sound



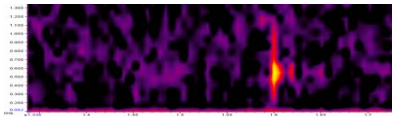
3. ■ **O** = *Ophidion rochei* sound (male)



4. ▲ **PS** = pulse series sounds of unknown origin;

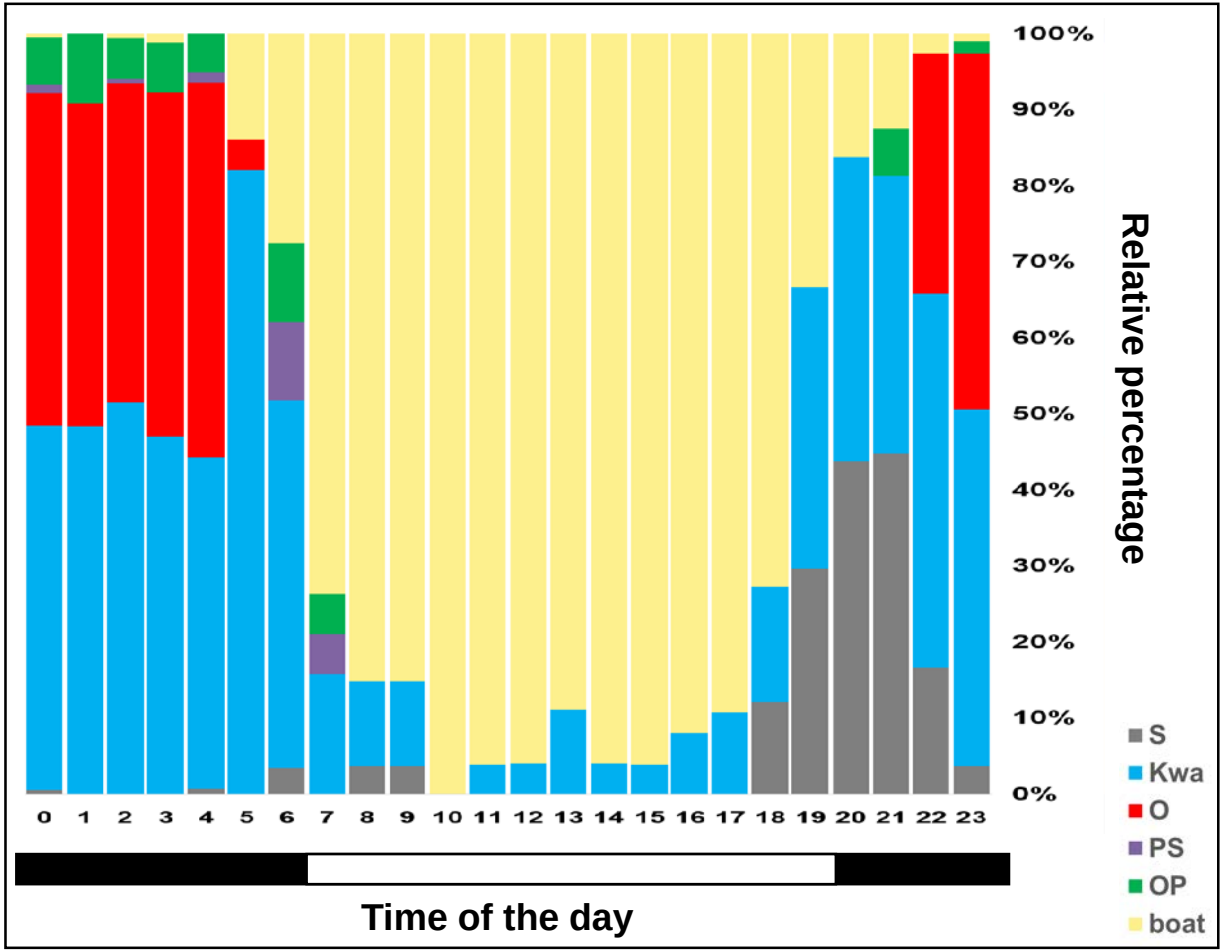


5. ◆ **OP** = single pulse of unknown origin.

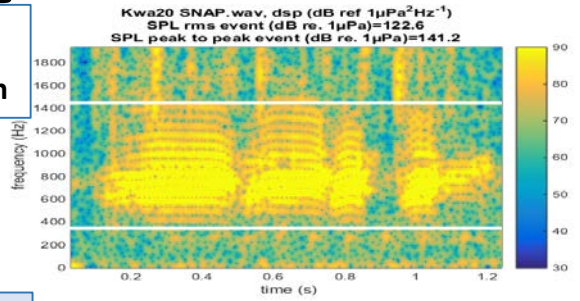


Variable	PCA1	PCA2
Peak frequency (Hz)	-0.444	0.688
Duration (s)	0.532	0.389
Pulse period (s)	0.519	-0.343
Number of pulses	0.501	0.534

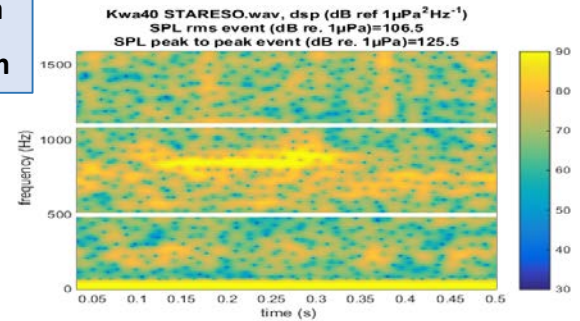
STARESO -40 m sandy area



Kwa -20m



Kwa -40m



Kwa at -40m

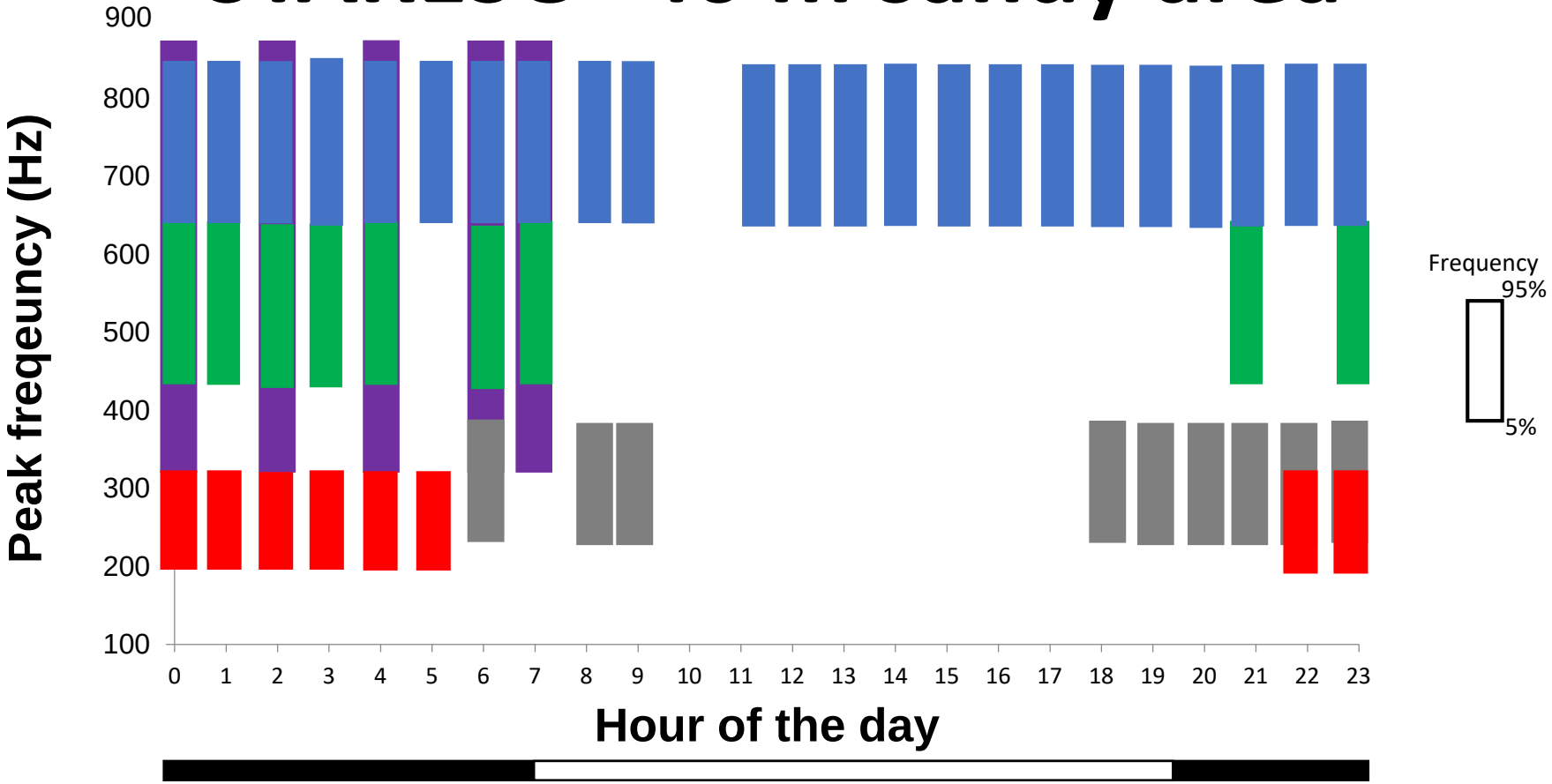
- less pseudo-harmonics
- Narrower band energy
- Weaker sound

Habitat preference

vs

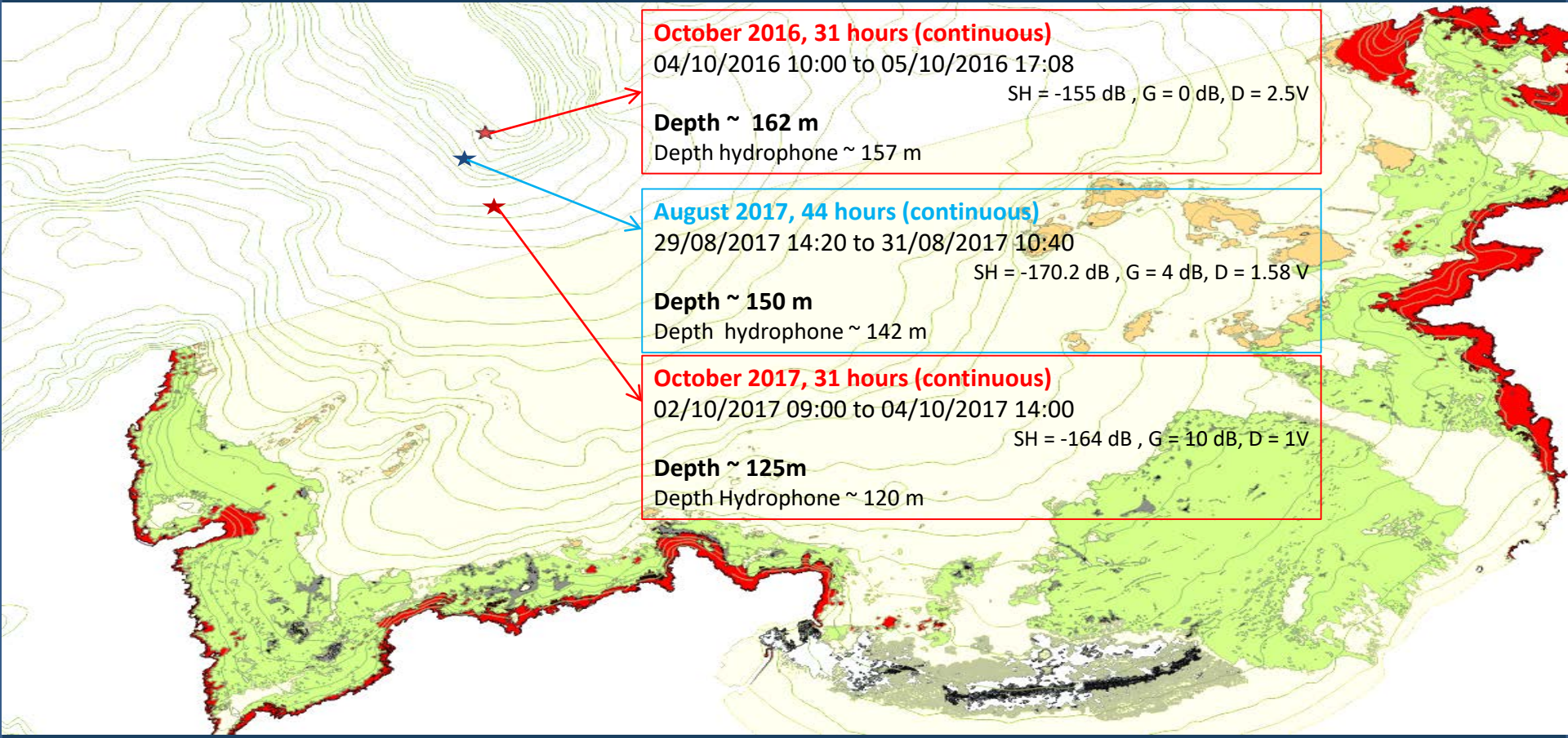
acoustic communities boundaries?

STARESO -40 m sandy area



S= *S. umbra* sounds; **O**= *O. rochei* sounds; ***Kwa*** = harmonic sounds of unknown origin; **PS** = pulse series of unknown origin; **OP** = single pulse of unknown origin.

-125 to -162 m Head of the canyon



October 2016, 31 hours (continuous)
04/10/2016 10:00 to 05/10/2016 17:08
SH = -155 dB , G = 0 dB, D = 2.5V
Depth ~ 162 m
Depth hydrophone ~ 157 m

August 2017, 44 hours (continuous)
29/08/2017 14:20 to 31/08/2017 10:40
SH = -170.2 dB , G = 4 dB, D = 1.58 V
Depth ~ 150 m
Depth hydrophone ~ 142 m

October 2017, 31 hours (continuous)
02/10/2017 09:00 to 04/10/2017 14:00
SH = -164 dB , G = 10 dB, D = 1V
Depth ~ 125m
Depth Hydrophone ~ 120 m

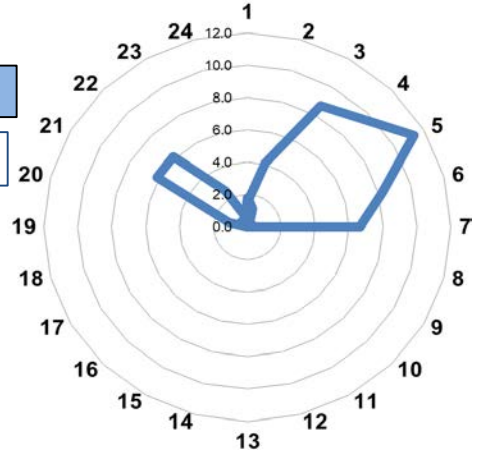
MORFONCT + CHORUS DATA

SOUND DIEL PATTERN

(n sound x min^{-1})

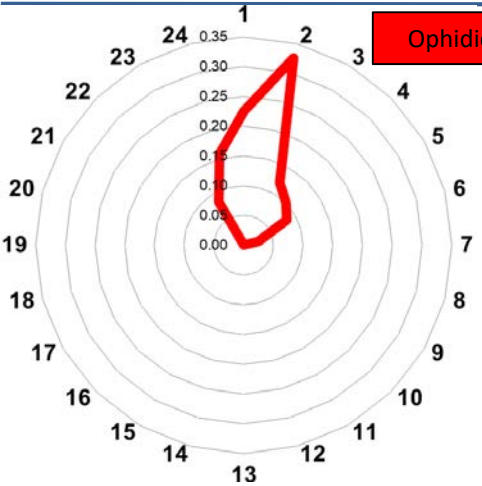
STFRP

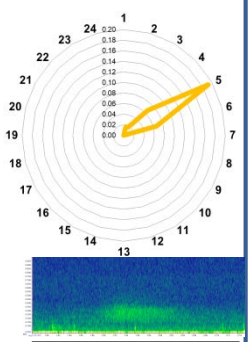
Range= **0-12** sound x min^{-1}



-125 m October

Ophidion sp.



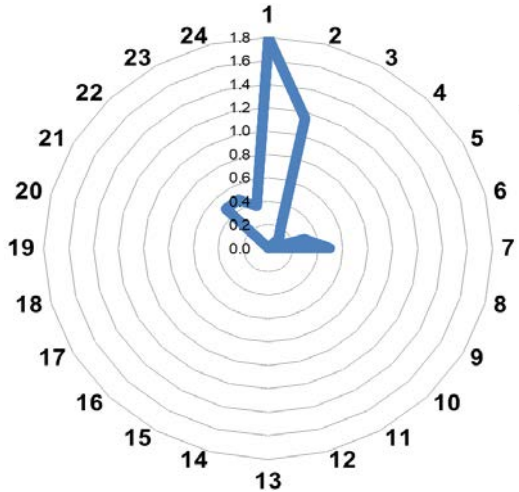


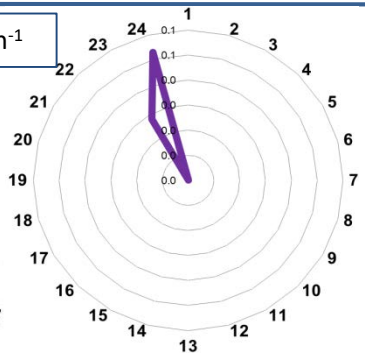
"The cloud" (fish??)

-150 m August

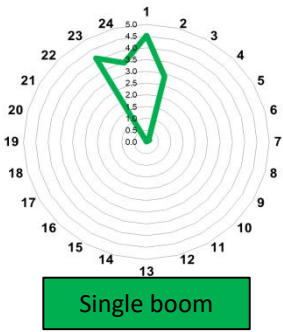
STFRP

Range= **0- 2** sound x min^{-1}





Pulse series



Single boom

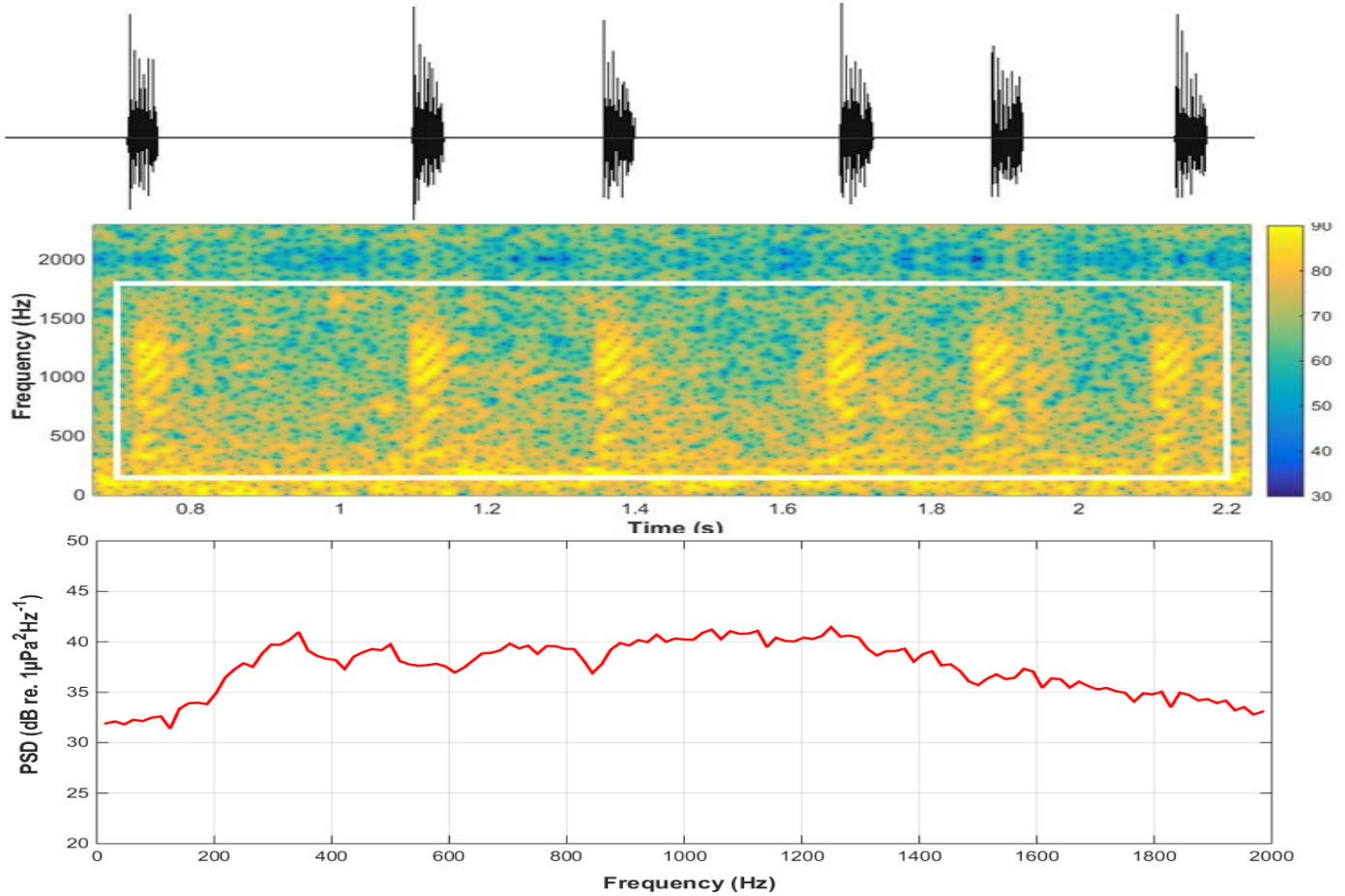
-162 m October

STFRP: Stereotyped Trains of Fast-Repeated Pulses

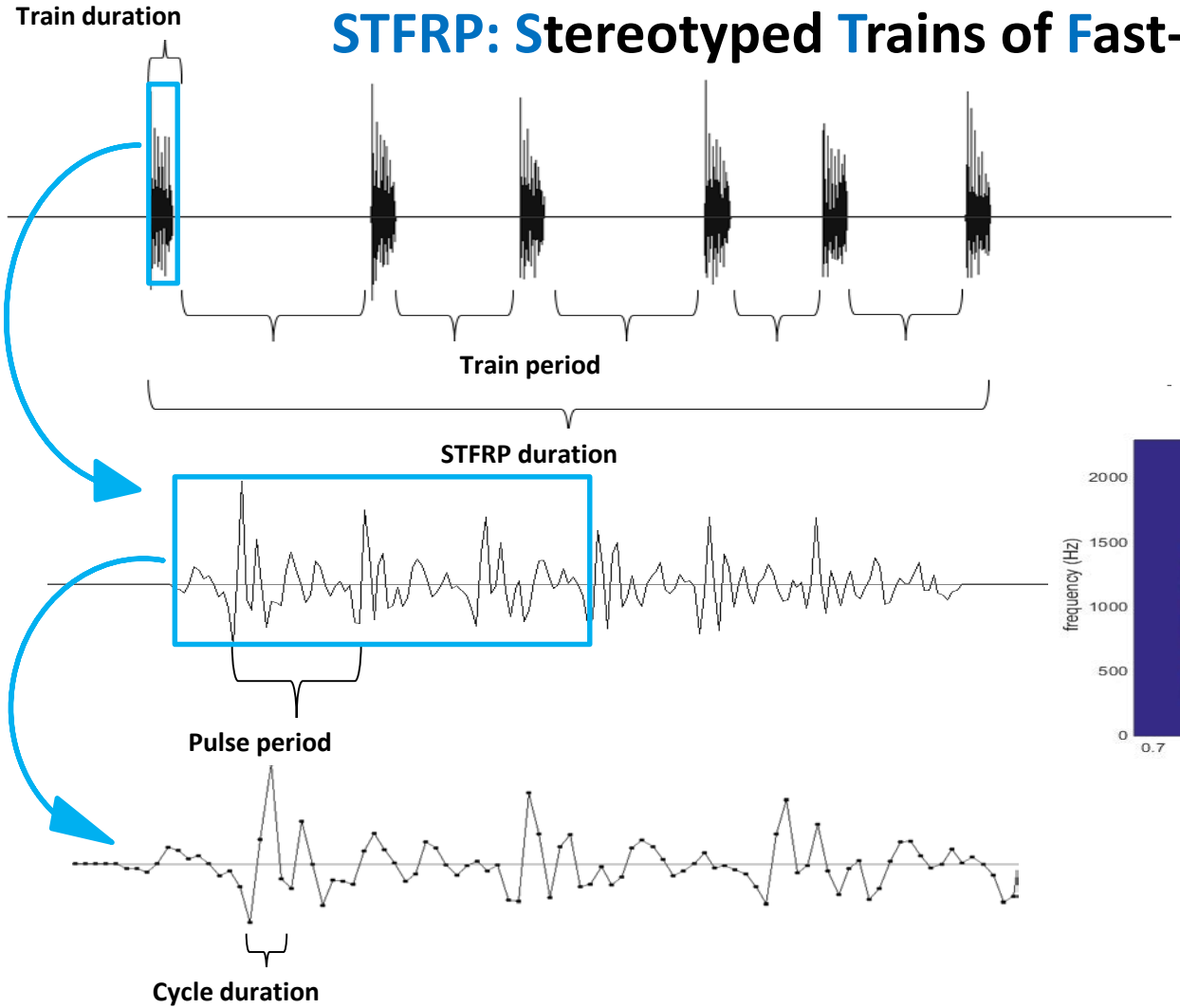
October

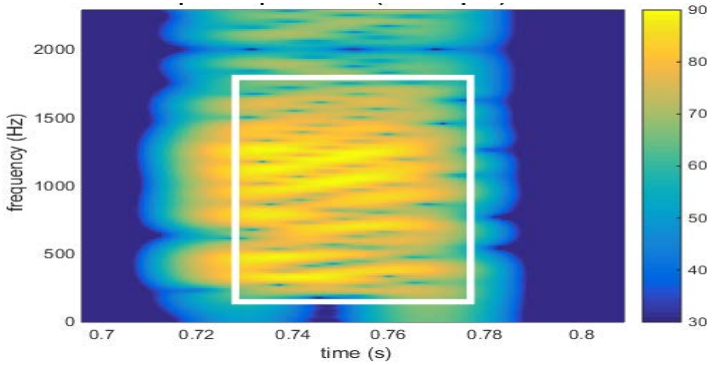
-125m

-162 m



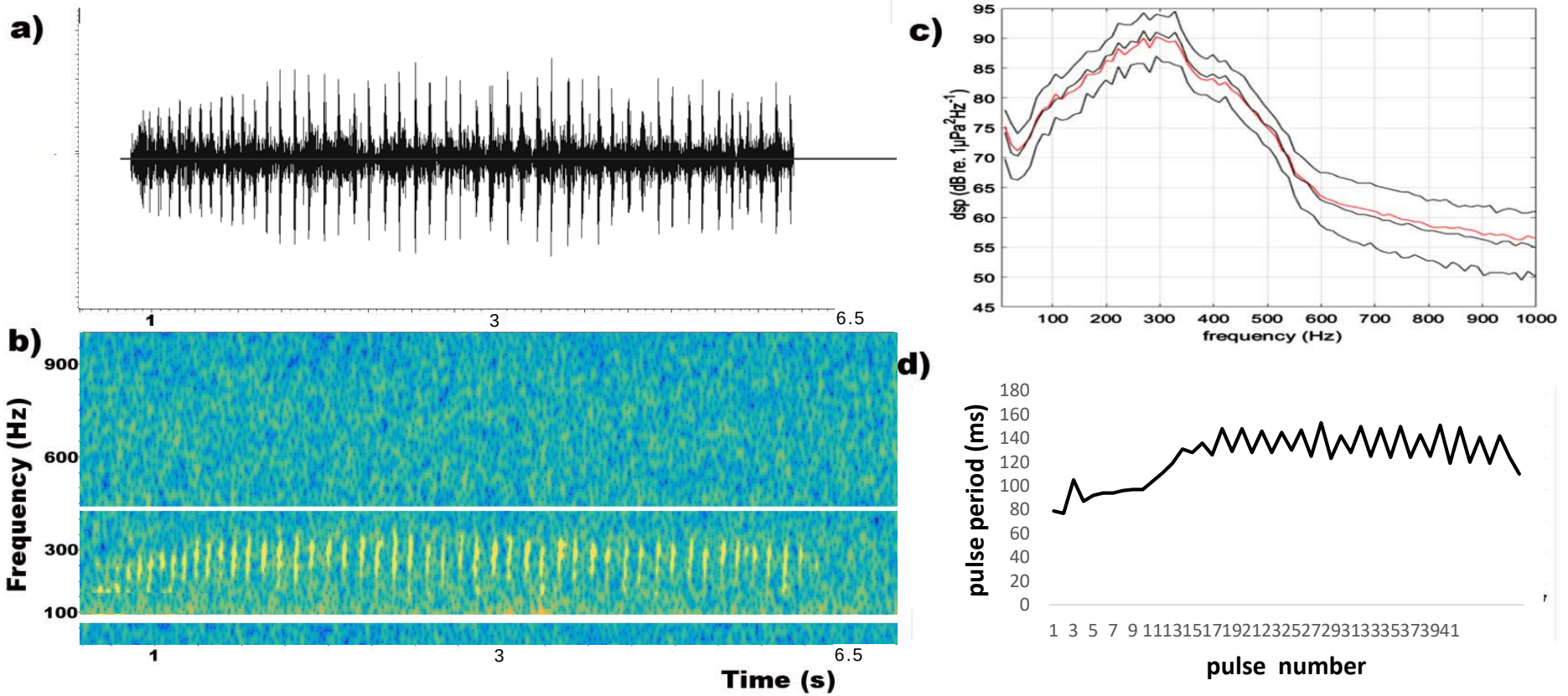
STFRP: Stereotyped Trains of Fast-Repeated Pulses





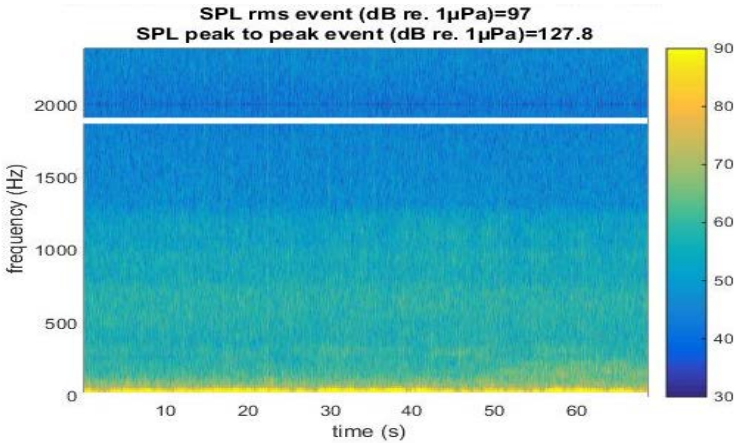
August -150 m

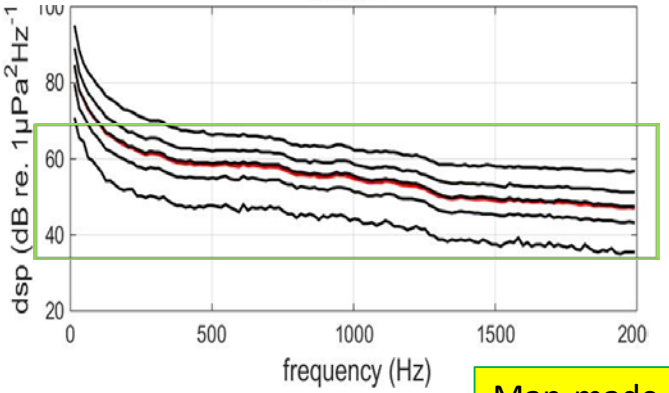
Ophidion sp.



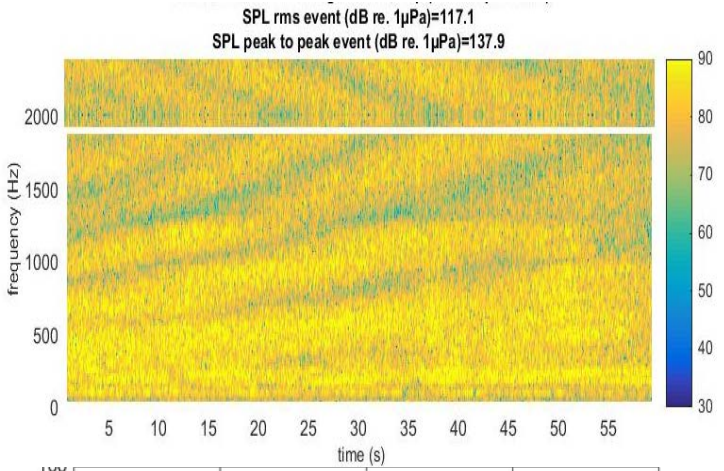
What happens during daytime hours?

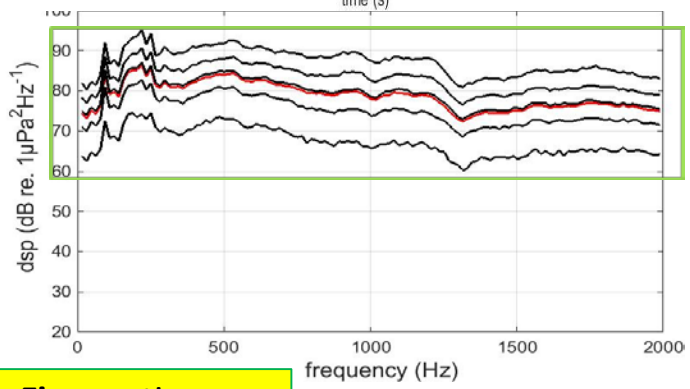
NIGHT, lower levels of man-made noise





(30 August 2017, -150 m, 1:20 am)





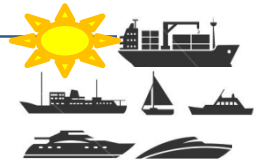
(30 August 2017, - 150 m, 7:11 am)

DAY, increase of man-made noise (boat traffic)

Man-made noise= **Lo-Fi** acoustic space

Fish acoustic communities in the Calvi bay

PAM= has the potential of providing continuous, not-invasive monitoring of fish community dynamics over large spatial and temporal scales



Coastal areas (-20, -40 m) during summer months

- Frequency partition (e.g. Kwa) and temporal partition with partial niche overlap (e.g. *Sciaena umbra* and *Ophidion rochei*)
- Differential frequency range and intensity of the same sound in different environments→ proxy for species richness/ habitat selections?

Head of the canyon (-125, -150, -162)

- Fish sounds detected with a small sampling effort→ re-inforce the H0: fish species adapted to deeper habitats exploit acoustic communication
- Different sound types at different depths
- Same sound type at different rates → proxy for habitat selection/ spawning habits?

Preliminary results: More studies are needed!

In all areas, during daytime

-increase in man-made noise
-impaired detection of fish sounds
-**Lo-Fi acoustic space**

↓

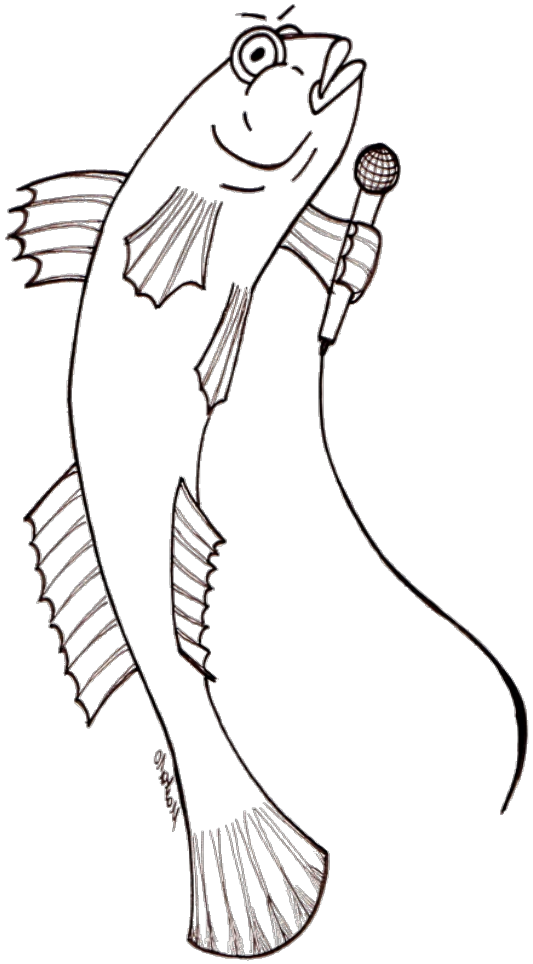
Which strategies in Lo-Fi environment?
e.g. more sounds, louder sounds (individual level)?

↓

Fish that do not have such an adaptive capacity might be most impacted by the presence of man-made noise

↓

Which effects on an evolutionary scale? No one knows…..
Precautionary approach when managing man-made noise.



Thanks for your attention!

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